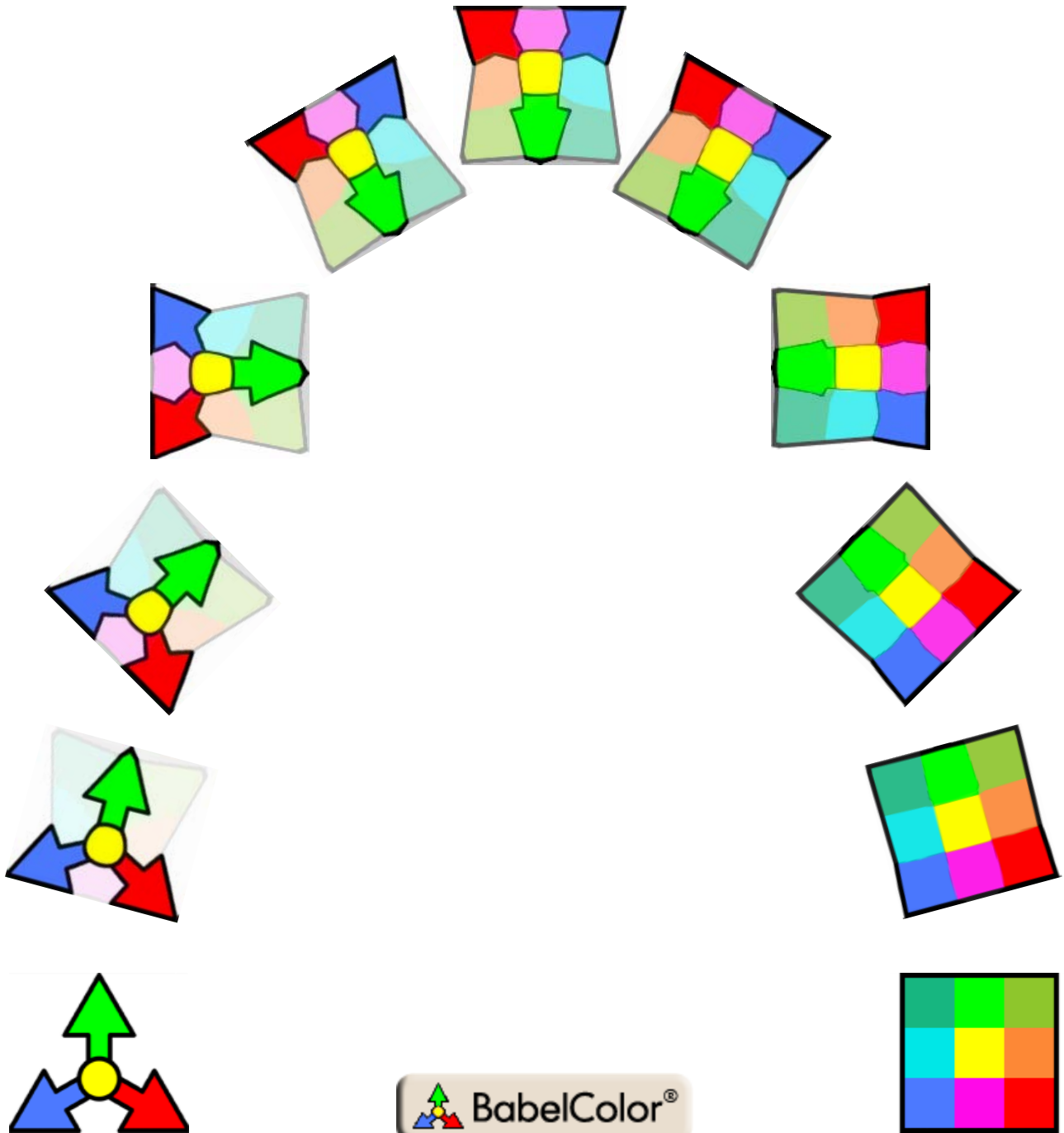


# PatchTool Help



Version 7.1.3

# PatchTool Help

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# 1. Introduction

## 1.1 What you can do with PatchTool

PatchTool is designed to import, view, edit, measure, compare, average, join, convert, and export color lists in a color-managed environment. The recognized color spaces are xyY, XYZ, L\*a\*b\*, L\*C\*h, RGB, CMYK, OSA-UCS, as well as spectral data. Click on the following links for more information:

### Import...

- Files saved in industry standard [CGATS](#), CxF (Version-1, [Version-2](#), and [Version-3](#)), and [QTX](#) color lists formats
- From user-defined lists ([plain text format](#)) created with spreadsheets or word processors
- CMYK and RGB color lists and assign them an ICC profile
- [RGB](#) data encoded in 8 bit, 15 bit, 16 bit, or scaled to 100%
- Spectral data with various scales (0-1 or 0%-100%) and ranges (380-400 nm to 700-730 nm, 10 nm BW)
- Color data saved using the Optical Society of America's Uniform Color Scales ([OSA UCS](#)) notation
- Images saved in [PNG or TIFF format](#), where each pixels becomes a PatchTool patch
- [Color swatches](#) saved in the [Adobe Swatch Exchange](#) (ASE) file format (from Adobe applications such as Photoshop and Illustrator)

### View and manipulate color lists

- View color lists as well as one CMYK profile and one RGB profile in [2D/3D graphs](#)
- [Extract patches](#) from a list to create another list
- [Copy or delete patches](#) in a list, or [add white patches](#) to fill a column
- [Join](#) two or more files to create a new file
- [Transfer](#) the ID, Name, CMYK and RGB fields from one file to another
- [Average color lists](#) using either a weighted or un-weighted method (mix lists with or without spectral data)
- [Compare a patch in a file to a patch in any other file](#), and get the color difference value
- [Compare two files](#) (with the same number of patches) in the same window
- [Obtain statistical data](#) on the differences between two files
- [Scramble color lists](#) to optimize the contrast between patches in order to print calibration targets
- [Re-order color lists](#) according to any user-selected color space coordinate (or spectral value when available)
- Assign IDs and switch between the Measured, Random and Visual layouts of [ECI2002](#) and [IT8.7/4](#) charts
- [Turn and mirror](#) patch layouts, [flip rows and columns](#), or [rename and renumber](#) all patches
- [Rename individual color patches](#)

### Export...

- To many [standard color spaces](#) (xyY, XYZ, L\*a\*b\*, L\*C\*h, RGB, CMYK)
- To [Munsell](#) HVC notation using many conversion options, and select amongst various output formats
- To [OSA UCS](#) L<sub>jg</sub> notation and [generate color lists](#) for any of the nine standard UCS data planes
- As CGATS [text files](#) or in a [simplified Tab-delimited format](#) for text reports and spreadsheets
- To the [CxF3](#) file format as well as many CxF3-compliant file types used by X-Rite's i1Profiler
- In many [IMAGE formats](#) (including TIFF-L\*a\*b\* and TIFF-CMYK, in 8 bit, 8 bit dithered, or 16 bit)
- Spectral data [scaled](#) between 0-1 or 0%-100% and in a [range](#) of either 380 to 730 nm or 400 to 700 nm
- [RGB](#) data in 8 bit, [15 bit+](#) (i.e. Photoshop "16 bit"), "true" 16 bit, or scaled to 100%
- Color lists to be used as "[Color Decks](#)" in the BabelColor *Color Translator and Analyzer* (CT&A) program (BabelColor CT&A is not included)
- Color swatches in the [Adobe Swatch Exchange](#) (ASE) file format (these files can be loaded in Adobe applications such as Photoshop and Illustrator)

### Use the [Gamut Tools](#) to...

- [Convert](#) colors using one or two ICC profiles
- Convert RGB or CMYK data assigned to a Source profile to a Destination profile
- Convert RGB or CMYK data assigned to a profile to the Profile Connection Space (i.e. L\*a\*b\*/XYZ)
- Convert L\*a\*b\* or XYZ file data to RGB or CMYK through a profile
- Check if RGB or CMYK data assigned to a Source profile is [clipped](#) by a Destination profile
- Check if L\*a\*b\* or XYZ file data is clipped by a Destination profile
- Generate device dependent [RGB](#) or [CMYK](#) color lists
- Generate [device independent color lists](#) (L\*a\*b\*/L\*C\*h/XYZ) with a gamut limited by a profile
- Determine the [gamut volume](#) of a profile using either the [PatchTool legacy](#) method or [ISO 18621-11](#)

### Use [Display-Check](#) to...

- Check a monitor calibration (White Point, gray ramp, primaries ramps) ([Quick-Test](#))
- [Measure your own color list](#) on a display
- [Send lists of RGB data directly to the display](#) (with no color management)
- Make display measurements with a [Color Correction Matrix](#)

### Use [Display-Reader](#) to...

- [Measure display colors in any order](#) with no prior knowledge of the patch number
- Automatically make display measurements at [fixed time intervals](#)
- [Export RAW data](#) that can be opened in a spreadsheet application or [Processed data](#) that can be opened like a standard color file and compared to other color lists

### Use [Emission-Reader](#) to...

- [Measure colors on a Light Box in any order](#) with no prior knowledge of the patch number
- [Characterize a Light Box non-uniformity](#) and use the data file to compensate transmissive targets measurements
- [Measure targets on a Light Box defined by a custom chart](#) and for which you have no prior color list
- [Measure targets on a Light Box which correspond to a PatchTool file](#)

### Use [Patch-Reader](#) to...

- [Measure color samples in any order](#) with no prior knowledge of the patch number
- [Measure targets defined by a custom chart](#) and for which you have no prior color list
- [Measure targets which correspond to a PatchTool file](#), which may also correspond to a [target image](#) generated with PatchTool
- With an i1Pro 2 or i1Pro 3, take measurements in M0/M1/M2 measurement conditions (ISO 13655-2009)
- With an i1Pro 3 Plus, take measurements in M0/M1/M2/M3 measurement conditions (ISO 13655-2009)

### Perform printer and monitor certification

- [Certify a proofing printer](#) according to Idealliance requirements
- [Certify a monitor](#) according to Idealliance requirements
- Assess conformance to [G7 Colorspace Pass/Fail Requirements](#)

### Perform these additional tasks

- Perform [Substrate Correction](#), i.e. convert measurements **for different backings**, or reference data **for different substrates**, or measurements **for different measurement conditions** (M0, M1, M2)
- [Generate a spectrum](#) which matches input tristimulus values (i.e. XYZ)
- Derive [Color Correction matrices](#) to improve the inter-instrument agreement of display measurements
- [Tweak color list](#) values for improved printed accuracy
- [Extract data from an ICC profile](#)
- [Extract an ICC profile](#) from an image file
- [Extract patch values](#) from targets in photographs or images (RGB, CMYK, or L\*a\*b\*)

## Behind the scene: Why PatchTool?

Color data in list form is commonly generated by software associated with colorimeters and spectrophotometers. Some of these lists strictly follow one of the various [CGATS](#) standards for color exchange formats, while others use them only as a starting point, since these standards were not designed to cover all possible combinations for color data exchange. In many cases, the standard formats are not even properly used. Lists can also be structured in a unique vendor-defined format, such as CxF, or manually created in a less structured manner with common word processor and spreadsheet programs. PatchTool offers a simple way of viewing, converting, and processing color lists from many such sources. From the imported data, you can then easily generate color lists in industry-standard or [plain text](#) formats, as well as [images](#).

Another reason why PatchTool came into existence is because of issues or limitations encountered while using other programs that manipulate color lists. For example, it could be an incompatibility with the wavelength range of the spectral data, or files which are saved without enough information; for example, is the illuminant ALWAYS D50, even when you are looking at color lists generated from display measurements? If the file contains CMYK, L\*a\*b\*, and spectral data, which data type is to be used as [reference](#)? To help clear these questions, we have included short explanations of how PatchTool processes data in the form of “**Behind the scene**” grayed-out boxes, such as this one, as well as more detailed presentations in the appendices.

## 1.2 Additional technical information

**Simple text file format:** Although PatchTool can open CGATS and CxF files, it can also open simple plain text files created with a spreadsheet or word processor. Such files can be created rapidly since the file format has minimal constraints. Please consult [Appendix A](#) for a description of the requirements and some examples.

**Color-management:** You should consult [Appendix B](#) for a detailed presentation on how color-management is handled within PatchTool.

**CxF file format:** A description of the CxF Version-2 file format (**CxF2**) is presented in [Appendix C](#). A description of the CxF Version-3 file format (**CxF3**) is presented in [Appendix D](#). PatchTool can extract data from files saved in Versions 1, 2 and 3 of this format; the specific content type that can be opened in each version is detailed in the “Input file types” section of the [Specifications](#) (see also: [Version-2 import dialog](#), [Version-3 import dialog](#)). PatchTool can export to the generic CxF3 file format (with the \*.cxf file extension) and to selected CxF3-compliant file types dedicated to X-Rite’s i1Profiler (i1Publish). Click on these links to jump to the [export dialog](#) section and to the [output file specifications](#). More information on the CxF3 export features and the differences between the various i1Profiler file types is presented in the following Application Note, available on the BabelColor [Tutorials](#) Web page:

**[AN-10 Exporting to the CxF3 and i1Profiler file formats with PatchTool.pdf](#)** .

**Munsell color system:** A description of the Munsell system is presented in [Appendix E](#). Data expressed in this system’s notation can be obtained by [export](#) only.

**OSA Uniform Color Scales (UCS):** A description of the OSA UCS system is presented in [Appendix F](#). PatchTool can [import](#), [export](#), and [generate color lists](#) expressed as per this color space notation.

**CIEDE2000:** The derivation of this color difference formula is presented in [Appendix G](#).

**CIE 170:** Support of CIE 170 cone fundamentals colorimetry (CIE 2006 and CIE 2015) in PatchTool is described in [Appendix H](#).

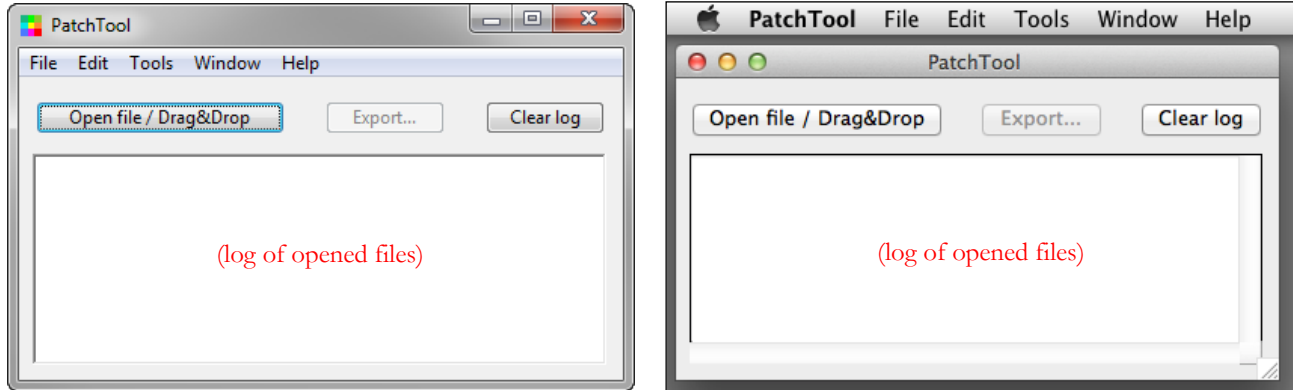
**General color theory:** This document does not contain exhaustive color theory definitions; neither does it contain equations defining and linking the various color spaces. For such information, the reader should consult the freely available Help file of the “BabelColor CT&A” program, downloadable from this Web page:

<https://www.babelcolor.com/download.htm> .



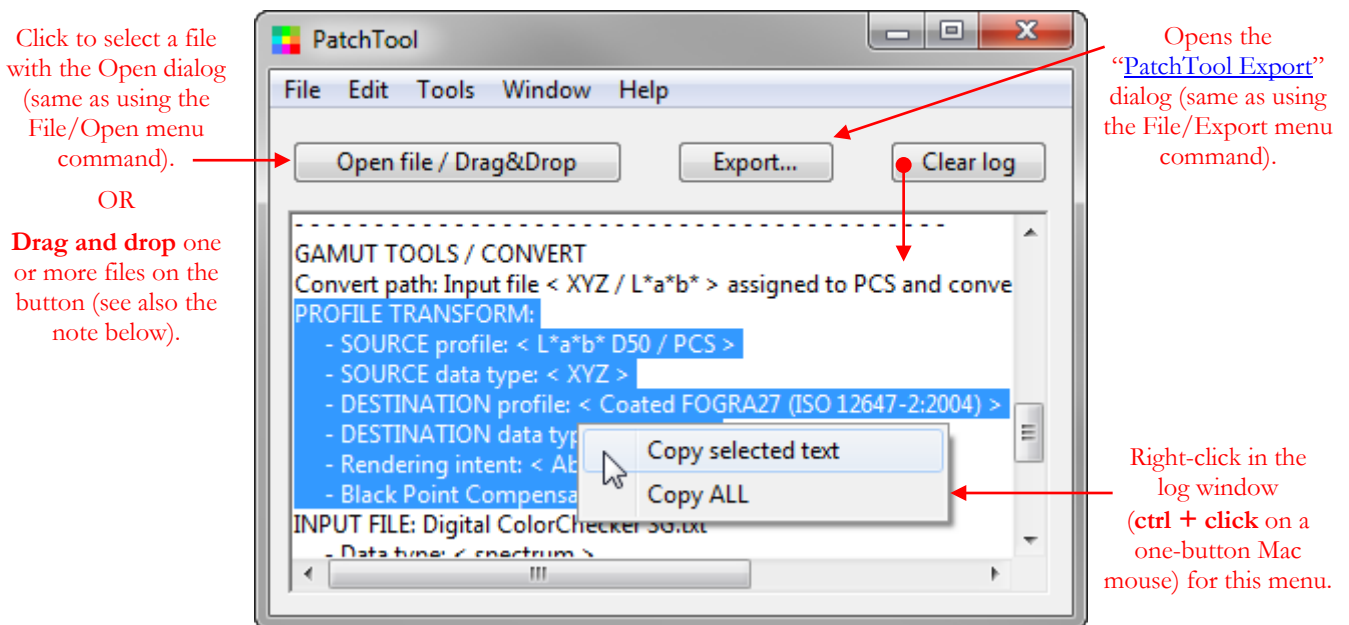
## 2. The PatchTool windows and dialogs

### 2.1 The main “PatchTool” window



The main “PatchTool” window, as it appears on the Windows 7 and Mac OS X platforms. Very simple in appearance, since it is used essentially only to open and export files, it also presents important information on opened files and tool operations, in the form of a short text log.

The log contains info such as the color space that was assigned as the best data type for import, the input and output profiles that were used in a conversion, as well as other specific information required to process the data. An example of the log for a file conversion using the [Gamut Tools](#) is shown below.



**Note (Windows):** When **drag and dropping** files on the “Open file” button, the opened files, an error message dialog, or a “Missing Info” dialog may open behind any window located in the center of your desktop; you may need to minimize or move these other windows to access the PatchTool files and dialogs.

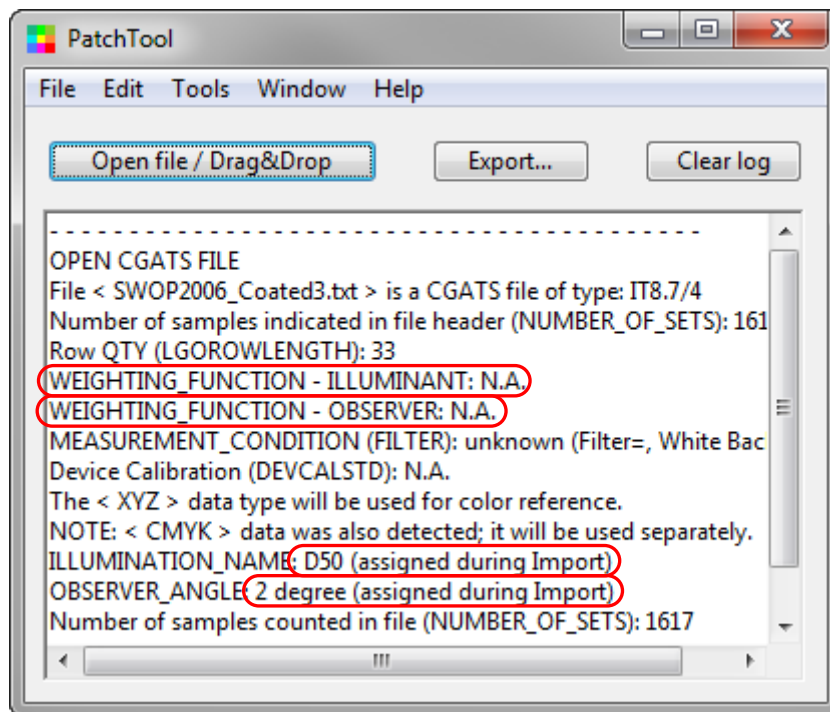
You should consult the log to check what operation was performed, or to see why an action or tool operation did not succeed. The following pages presents three logs; the first one was obtained by opening a CGATS compliant file, the second one was obtained by opening a list of RGB values in a plain text format (i.e. with no header information containing the measurement conditions), as one would get by saving a “Notepad” file in Windows, or a “TextEdit” file on a Mac, and the third one was obtained by opening a file with L\*a\*b\*, RGB and CMYK data.

The log shown below was obtained by opening the “SWOP2006\_Coated3.txt” file used in the [Idealliance Certification](#) procedure; it is formatted according to the CGATS file format standard. See the “Behind the scene: [CGATS file format](#)” box for more information on this format.

In the log text below, “WEIGHTING\_FUNCTION” is a data format identifier (a tag) which, when used in a file, should contain either the ILLUMINANT or the OBSERVER sub-tags. The standard requires that the ILLUMINANT and OBSERVER data be written in two separate lines, with proper mention of the sub-tag in each line. In this particular file, the sub-tags are not present and the illuminant and observer are written in one line:

WEIGHTING\_FUNCTION "D50, 2 degree per CGATS.5" ← Wrong syntax!

Because the WEIGHTING\_FUNCTION tag is not formatted properly, although it can be easily read by a human being, the program cannot understand it. For this reason, PatchTool will not make an assumption on the value and will show “N.A.” in the log. In addition, PatchTool will show a dialog requesting the user to select the proper Illuminant and Observer (see Section 2.6: [The “Missing Info” dialog](#)). This is why you see a comment to the effect that the ILLUMINATION\_NAME and OBSERVER\_ANGLE were “(assigned during import)”

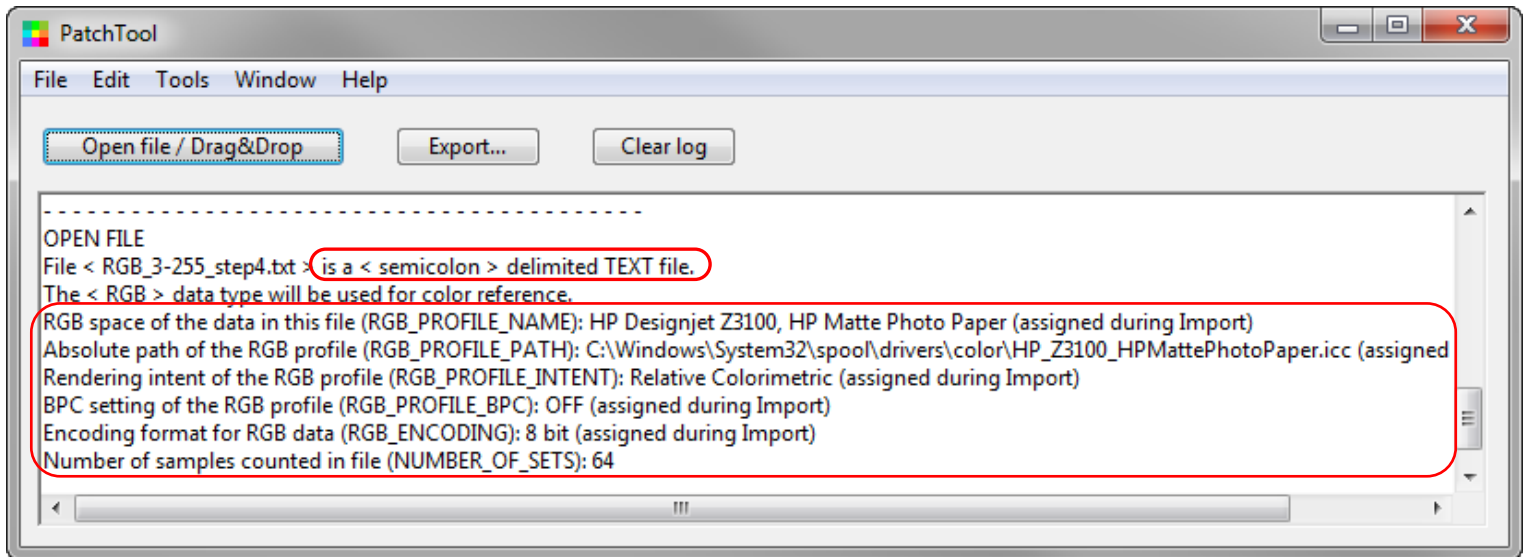


In many files, the Illuminant and Observer may not be present, or they may be assigned using another CGATS tag. For instance, it is not uncommon to find illuminant and observer angle information under the “MEASUREMENT\_SOURCE” tag, even if this tag’s real use is to indicate the original conditions under which the measurements were done, and not the illuminant and observer angle used to derive the color data inside the file. In most cases, when missing, the expected Illuminant is “D50” and the proper Standard Observer is “2 degree”, but at least you will have the opportunity to double-check. Please note that for files that contain spectral data, the “ILLUMINATION\_NAME” and “OBSERVER\_ANGLE” info is superfluous since color data can then be regenerated for any illuminant or observer, and you will not be asked to assign it if missing.

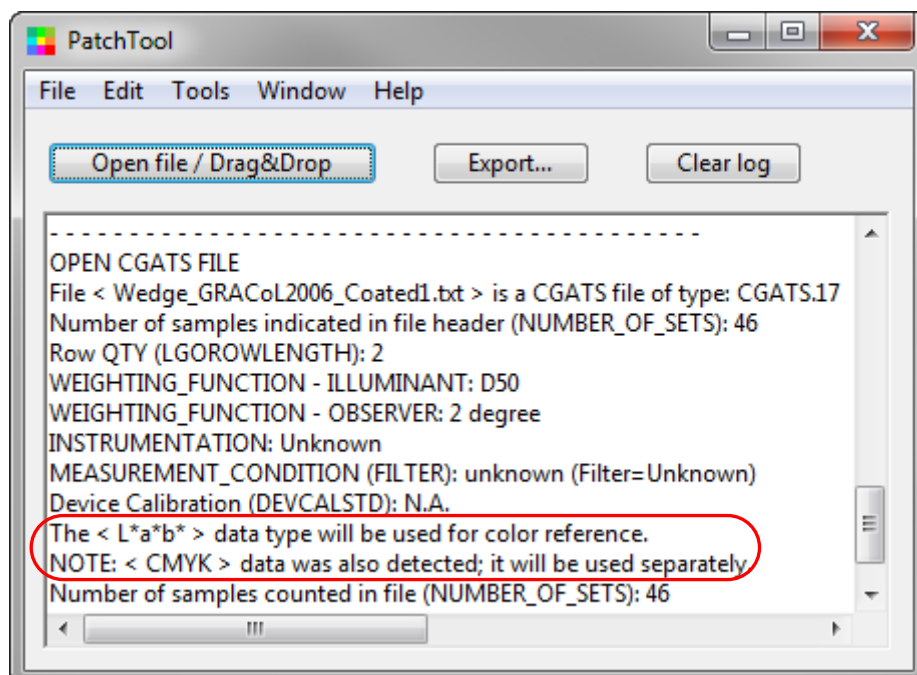
In the log above, you will see a line which indicates the “Row QTY”, usually defined as LGOROWLENGTH in CGATS type files. This is a vendor specific tag—i.e. not a standard—likely from the Logo Company, part of the GretagMacbeth Group (now X-Rite), which records the number of rows in which the list should be viewed. PatchTool always looks for this tag, which has no equivalent in the CGATS standard, since many vendors use it. In any case, the number of rows can always be re-assigned, or assigned if missing, using the “Rows” menu in the “Patch View” tab of opened files ([Section 2.2.1](#)).



In the second log example shown below, a plain text file with “semicolon” delimited RGB data was opened. Many other delimiters can be used; see [Appendix A](#) for more information on acceptable plain text file formats. The log indicates that an RGB space profile, its Rendering Intent, the Black Point Compensation setting, and the encoding format have been assigned during import, which is expected for such a file which has essentially only data, without headers. If you were to export such a file, PatchTool would add PatchTool-specific tags for all these parameters, so that you would not be requested to assign the missing information the next time you open the file. It is important to note that while a profile is associated to the RGB data, it will not be possible to change the profile settings in the opened PatchTool window, and the RGB data will always be identical to the file values; the reason is that RGB was used as color reference, as indicated in the log window, and such reference data cannot be changed once imported.



In the third log example shown below, we opened a file which contains the data definition of the GRACoL 2006 Coated Wedge. This file contains the target L\*a\*b\* values which correspond to CMYK references; the CMYK values are also included in the file. While PatchTool selects the device independent L\*a\*b\* data for color reference in this file, it also detects the CMYK data set and imports it. If RGB data was present in that file, it would also be imported. L\*a\*b\* data will always be preferred as a color reference to CMYK and RGB. See the “Behind the scene: [Selecting data for import](#)” box on the next page for a description of how data is prioritized.



### Behind the scene: Selecting data for import

Color lists files often contain color patches data in more than one data type, or color space. It is very common to find both spectral and L\*a\*b\* data; in such a case, many programs will use the L\*a\*b\* data even though spectral data is present. And what happens when a file contains CMYK plus L\*a\*b\* and XYZ data? Why would CMYK be selected over device-independent XYZ or L\*a\*b\* values? In PatchTool, spectral data has priority over all other color spaces and will always be used for import when present. The priority order in which color data is imported is:

- |                  |            |
|------------------|------------|
| 1- spectral data | 2- XYZ     |
| 3- xyY           | 4- L*a*b*  |
| 5- L*C*h         | 6- OSA UCS |
| 7- RGB           | 8- CMYK    |

Once a color spaces is selected for import, all other color spaces are recomputed from the imported data. There is, however, one exception to this rule: If CMYK or RGB data is present in addition to another data type, it will be imported separately, and not be recomputed from the color space used for import. No ICC profile needs to be assigned to this extra CMYK or RGB data although any profile information present in the file, in the form of PatchTool-specific tags, will be read by PatchTool. See “Behind the scene: [CMYK data](#)” and “Behind the scene: [RGB space](#)” for more info, as well as Section 2.6: [The “Missing Info” dialog](#).

### Behind the scene: CGATS file formats

CGATS stands for “Committee for Graphic Arts Technologies Standards” and is accredited by the American National Standards Institute (ANSI) to serve as the coordinator of graphic arts standards activities. Of those standards, the ones referred to by CGATS.5 and CGATS.17 specify file formats for saving color data. The newer CGATS.17 standard is a revision of CGATS.5, to which it adds specifications for XML based storage format. Unfortunately, files saved using CGATS.17 often need to be customized to describe many common color data types, limiting their portability. The first version of the CxF file format (CxF1) proposed by GretagMacbeth (now X-Rite) was presented to Standards groups as a superset of the CGATS.17 XML format, and as a better alternative; a consensus was not reached. Since then, CxF Version-2 (See [Appendix C](#)) and CxF Version-3 (see [Appendix D](#)) were developed, with a vastly enhanced data structure completely different from the one used in CxF1. Talks are still under way in Standards groups in order to agree to a common color data format and, of course, CxF3 is now proposed as the solution. In the field, files saved in CGATS format are ubiquitous. Files saved in CxF1 and CxF2 are relatively common while files saved using CxF 3.0 were scarce until X-Rite launched its i1Profiler application, which uses CxF3 extensively (with many different file extensions). In comparison, CGATS XML files are never seen. While an XML format imposes more rigorous requirements to the file creator than the CGATS format, thus ensuring, in principle, more accurate data exchange, browsing an XML file in a text editor is quite painful and many convert their CxF files to CGATS for this purpose.

A CGATS compatible document is structured from a small set of unique “data format identifiers”, also called “tags” or “keywords”. These tags are written without spaces, and always in uppercase in their ASCII versions (i.e. non-XML). Because of the limited set of pre-defined tags, most companies using these standards add their own usage-specific tags. This is not a problem, in theory, since a “compliant” CGATS program only has to discard the extra data, but it creates an immediate compatibility problem between vendors (sometimes, however, this is exactly what they are looking for...). To make things even more difficult, the CGATS tags are not used consistently throughout the industry; here are two examples:

Example 1 - How illuminant and observer conditions are recorded: The MEASUREMENT\_SOURCE tag is sometimes used for this, although, according to CGATS.5 and CGATS.17, it describes “*Illumination used for spectral measurements. This data helps provide a guide to the potential for issues of paper fluorescence, etc.*”, which is not the same as the illuminant used to compute colorimetric data from spectral data. For instance, many color measuring instruments use a tungsten lamp close to Illuminant A for illumination; in such a case, the MEASUREMENT\_SOURCE should be “A”. You will also see many files without illuminant and observer conditions, since many vendors assume the data is derived from Illuminant D50 and the 2 degree Observer. On the plus side, these parameters are often recorded using the ILLUMINATION\_NAME and OBSERVER\_ANGLE tags; even if these tags are not in the CGATS standards. Also, the newer CGATS.17 standard proposes the WEIGHTING\_FUNCTION tag with attributes such as ILLUMINANT and OBSERVER to record these parameters; alas, the attribute format is just given as an example, and we already see variants in its implementation.

Example 2 - Headers for spectral data: These tags should be written using the SPECTRAL\_NM format. What we can find in actual “CGATS” type files for a 400 nm tag is: SPECTRAL\_NM\_400, SPECTRAL\_400, nm420, or R\_400.

### Behind the scene: CMYK data

In a CMYK data list there is generally no information mentioning to which **device space** the data belongs. This is less of a problem in CMYK images where ICC profiles **can** be embedded with the image data. However, in both cases, without the profile information, converting CMYK values to a **device independent color space**, such as L\*a\*b\*, is bound to error. On the plus side, unassigned CMYK color lists are often defined for profile generation purposes, where the CMYK data is used to generate an image sent to an uncalibrated printer.

In PatchTool, CMYK is handled differently whether it is present in the color list file or not:

- 1- CMYK data is in the file: The CMYK data is always imported. There are two possible outcomes:
  - a. If no other data type is detected for import, as per the priority list described in the “Behind the scene: [Selecting data for import](#)” box, then CMYK is converted to XYZ using the user-assigned profile, rendering intent and Black Point Compensation settings. The profile info will be read from the file if present in the form of PatchTool-specific tags, or the program will request the user to assign it using the [Missing Info](#) dialog.
  - b. If another data type of higher priority is selected for import, the CMYK data is used separately from the other data although any profile information present in the file, in the form of PatchTool-specific tags, will be read by PatchTool.
- 2- No CMYK data in the file: In the opened PatchTool window, the CMYK data is generated from the imported data with the user-assigned profile, rendering intent and Black Point Compensation settings. For example, if L\*C\*h data is used for import, CMYK will be derived from L\*a\*b\* through the CMYK profile, with L\*a\*b\* derived from L\*C\*h.

There are three ways to verify the source of CMYK data in an opened PatchTool file. Firstly, the file log shown in the main PatchTool window will indicate the CMYK origin if this information was present in the file. Secondly, when “CMYK” is selected in the “[Info](#)” window, a small message appears below the CMYK values, indicating the data origin, which can be either from “File values” or from the currently selected CMYK profile. Thirdly, the CMYK data origin will be shown in any exported file containing such data.

### Behind the scene: RGB space

RGB colors which are to be used for illustration purposes in a computer’s native environment should be assigned the default space of the Operating System. The default spaces are sRGB for Windows and Mac OS X 10.4+; Generic RGB on Mac OS X prior to 10.4, and Apple RGB on older Macs (OS 8 and 9). However, you may also want to assign your Display profile to an RGB color list in order to verify the display’s accuracy with the [Display-Check](#) tool. In both cases you simply assign the space you desire in the “[Missing Info](#)” dialog when opening the list.

In PatchTool, RGB is handled differently whether it is present in the color list file or not:

- 1- RGB data is in the file: The RGB data is always imported. There are two possible outcomes:
  - a. If no other data type is detected for import, as per the priority list described in the “Behind the scene: [Selecting data for import](#)” box, then RGB is converted to XYZ using the user-assigned profile, rendering intent and Black Point Compensation settings. The profile info will be read from the file if present in the form of PatchTool-specific tags, or the program will request the user to assign it using the [Missing Info](#) dialog.
  - b. If another data type of higher priority is selected for import, the RGB data is used separately from the other data although any profile information present in the file, in the form of PatchTool-specific tags, will be read by PatchTool.
- 2- No RGB data in the file: In the opened PatchTool window, the RGB data is generated from the imported data with the user-assigned profile, rendering intent and Black Point Compensation settings. For example, if xyY data is used for import, RGB will be derived from L\*a\*b\* through the RGB profile, with L\*a\*b\* derived from xyY.

There are three ways to verify the source of RGB data in an opened PatchTool file. Firstly, the file log shown in the main PatchTool window will indicate the RGB origin if this information was present in the file. Secondly, when “RGB” is selected in the “[Info](#)” window, a small message appears below the CMYK values, indicating the data origin, which can be either from “File values” or from the currently selected RGB profile. Thirdly, the RGB data origin will be shown in any exported file containing such data.



## 2.2 The opened file window

A file is opened by selecting the “File/Open...” menu or by clicking on the “Open file” button of the main “PatchTool” window. The opened file window title is the file name. Each file has its own window that can be set independently of the others. The features of the “Patch view”, “[Tabular data](#)”, and “[3D graph](#)” tabs are described in the following pages. Popup menus specific to each tab can be opened with a simple mouse click or a right-click (**ctrl + click** when using a one button Mac mouse) as shown on the following screenshots.

### 2.2.1 The “Patch view” tab

Click on a patch to “freeze” it; a thicker frame is then shown around the patch. The frame color is black or white, depending on the patch color. Move the mouse to other patches to compare them against the frozen one.

Optimize /analyze the layout for target printing. See [Section 2.2.4](#) for additional info.

Click on the arrow for the Re-map popup menu. Additional options are available for ECI2002, IT8.7/4 and TC1617x targets. See [Section 2.2.2](#) for more info.

Insert a custom value for the number of Rows here. Saved as the LGOROWLENGTH tag in CGATS files.

Pre-selected Rows values. Saved as the LGOROWLENGTH tag in CGATS files.

Turn “ON” to see the patches under the selected Illuminant. Only enabled when spectral data is present. See [more info](#) in the Compare section.

Standard Observers:  
CIE 1931: 2 deg.  
CIE 1964: 10 deg.  
[CIE 170](#): 2F and 10F deg.

ICC profile identified for this window. This is updated when the window is moved on another display.

Number of patches in the file.

Use this command when you open a file where the patches IDs were incorrectly assigned to the Name tag.

Uncheck to hide the controls in the bottom and give more display area to the patches.

Check to go into patch edition mode. See [Section 2.2.3](#) for additional info.

Opens the “PatchTool Export” window. Same as using the File/Export menu command.

Click and drag on the edges and corners to adjust window and patch size.

CC\_Avg20\_spectrum\_CGATS.txt (#24) ICC: DELL U...

Patch view Tabular data 3D graph

Turn 180°  
Turn 90° CW  
Turn 90° CCW  
Flip Horizontal  
Flip Vertical  
Flip R/C  
Target Scramble/Analysis dialog...  
Analyse layout for target printing  
Fix layout rows for target printing  
Use the patch Name as the patch ID  
Renummer the IDs  
Rename the patches...  
Reset ALL changes

Re-map Edit patches More Info

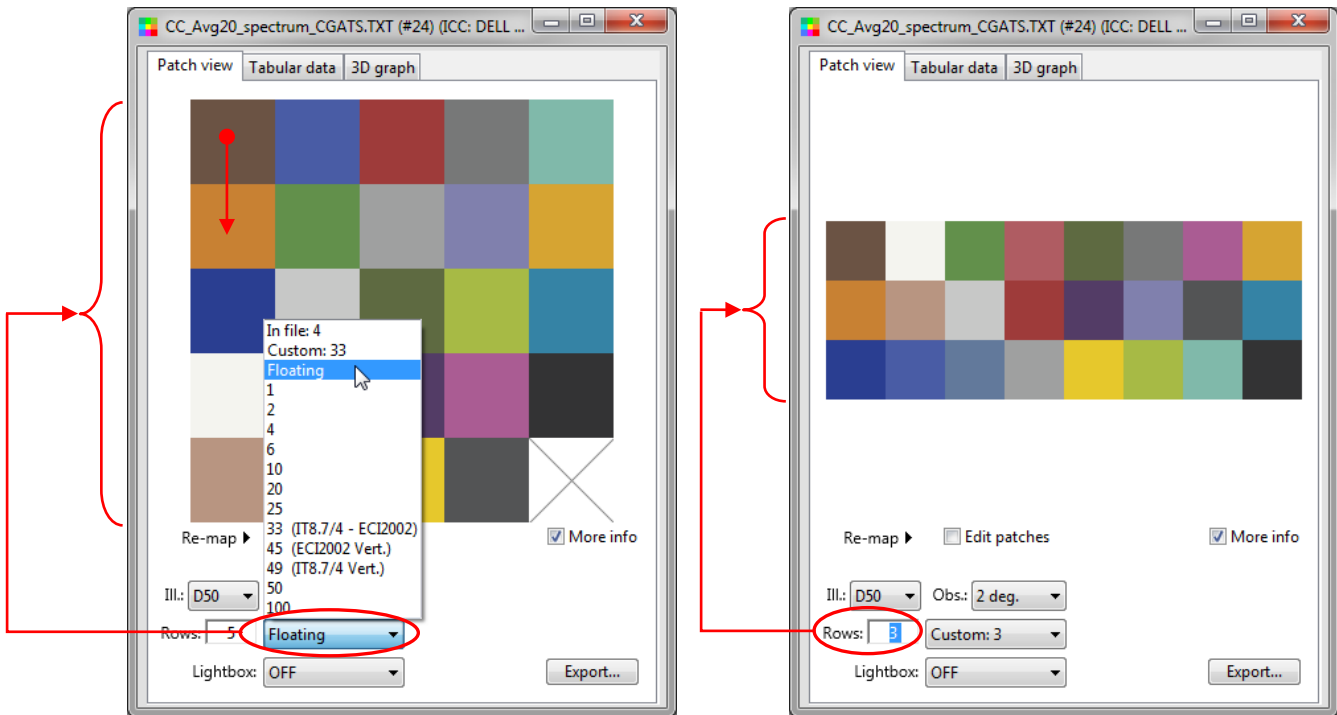
Ill.: D50 Obs.: 2 deg.  
Rows: 4 In file: 4  
Lightbox: OFF

Export...

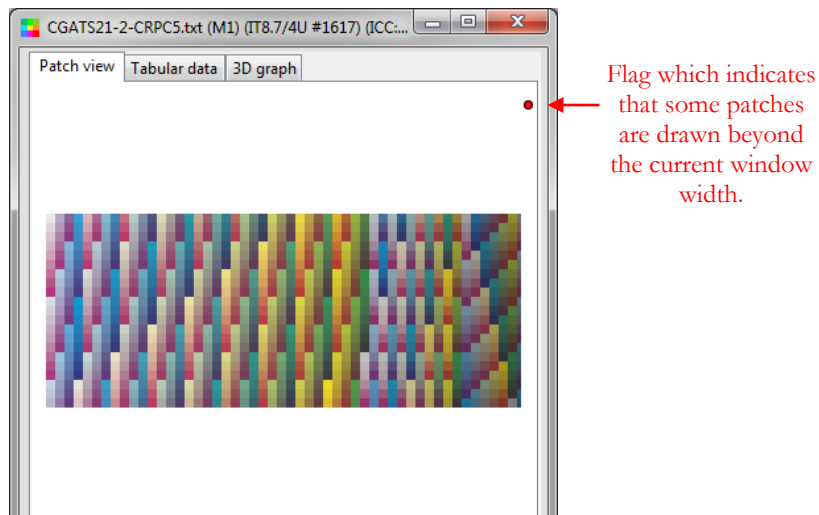
**Rows:**

The number shown corresponds to the value assigned to the LGOROWLENGTH tag in many CGATS formatted files. When this tag is not present, PatchTool sets the value to “Floating”, which means that the displayed patches are not bound to a row value and are drawn freely to fill the file window area. This is shown below in the left screenshot. The patches are drawn starting in the upper-left corner of the window. The left column is drawn first, going down until the window bottom is reached, then followed by the other columns. The draw order is always Top-Down first and then Left-to-Right.

You can also select one of the pre-defined values in the Rows popup menu, shown in the left screenshot, or assign your own value in the Rows input box, as shown below right. The patch size is automatically adjusted to “try” to insert all the patches within the window height and width. The patch size will be reduced until it reaches the minimum value set in the “Preferences” dialog. Of course, you can enlarge the window to enlarge the patch size.



If the number of patches is large and the window size is still not big enough to show the patches at the minimum size, a small red dot appears near the **bottom-left** or **top-right** edges of the window. If more display area is required, you can uncheck the “More info” checkbox to hide the controls in the bottom of the window.

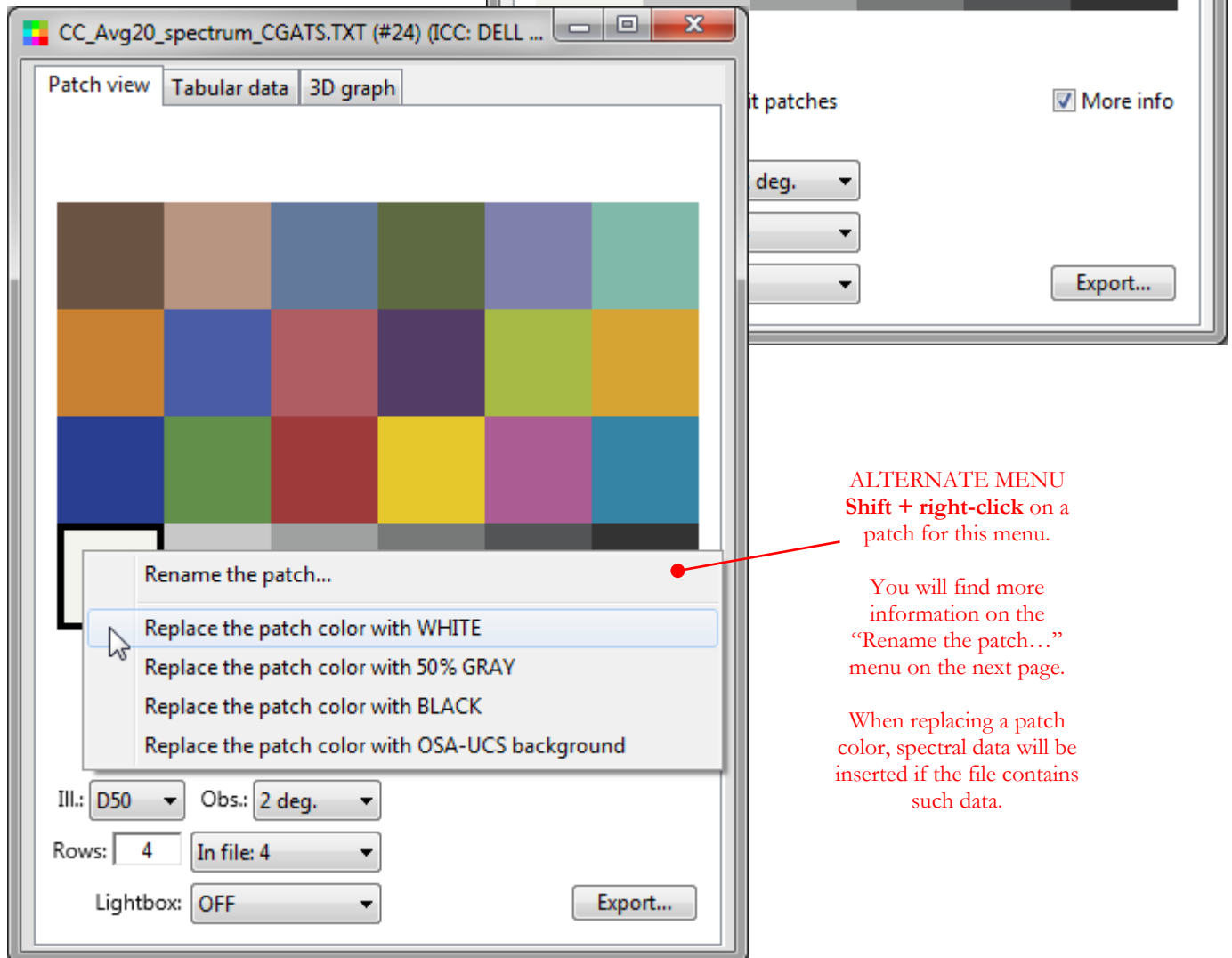
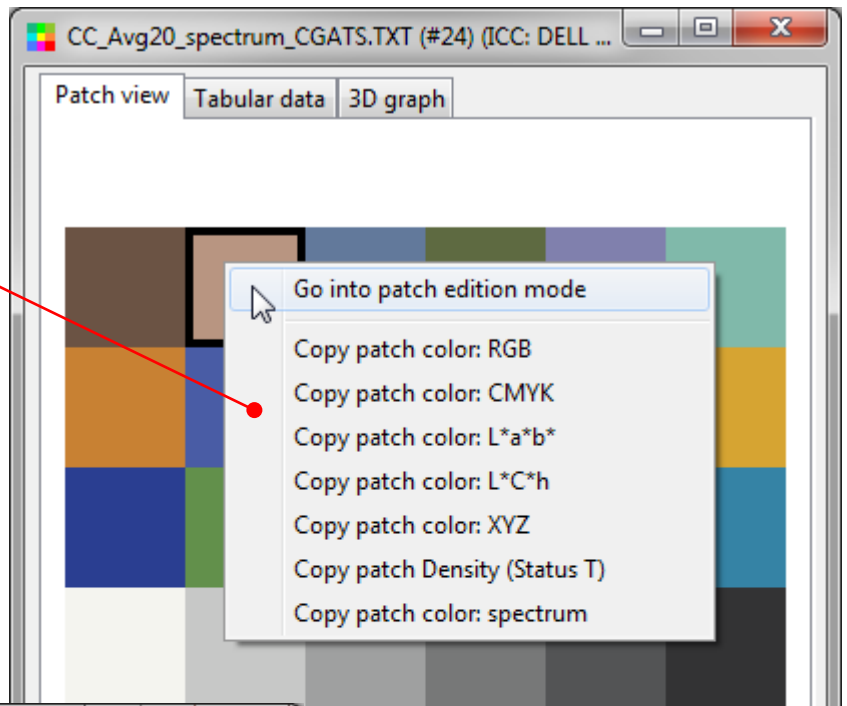


## Contextual menus

**STANDARD MENU**  
**Right-click** on a patch for this menu.

See [Section 2.2.3](#) for more information on the “patch edition mode”.

The copied color data is tab-delimited and can be pasted in separate spreadsheet columns, or in a text document.



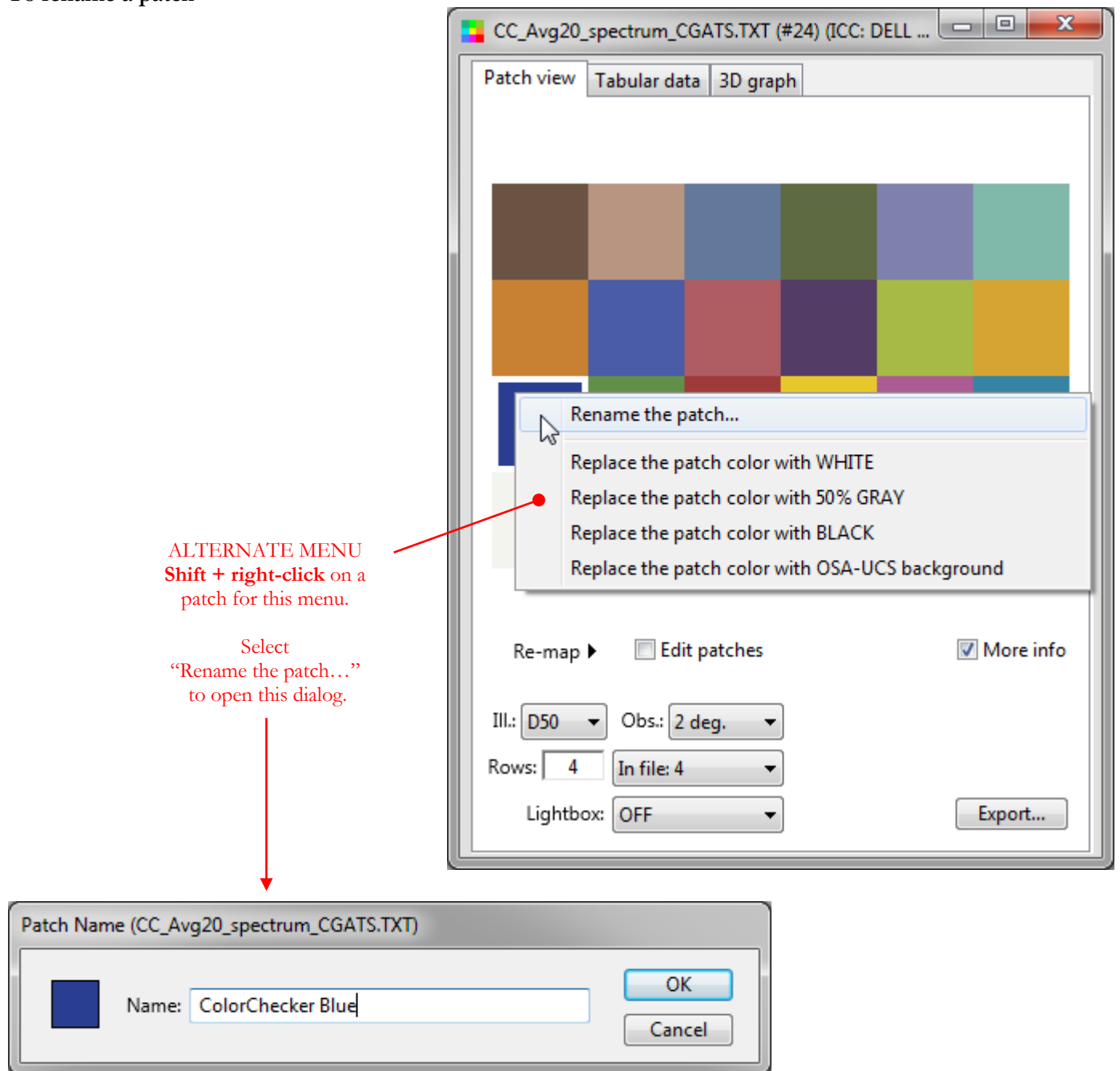
**ALTERNATE MENU**  
**Shift + right-click** on a patch for this menu.

You will find more information on the “Rename the patch...” menu on the next page.

When replacing a patch color, spectral data will be inserted if the file contains such data.



## To rename a patch



To edit a patch name, you can also click in any cell of the “[Tabular data](#)” “Name” column. To reset ALL patch name changes, use the “[Re-map/Reset ALL changes](#)” menu or the contextual menu that opens when doing a right-click in the “[Tabular data](#)” table header.



## 2.2.2 The “Patch view” “Re-map” menu

A simple click (left-click) on the black arrow besides the word “Re-map” opens a popup menu that can be used to change the patches disposition. The menu content is changed according to the opened file type/target type. The file type is based on two parameters: an identification tag present on the first line of a CGATS formatted file and the number of patches in a file. Here is a table with a list of target types, tags, and patch quantity.

File type/Target type	Tag(s)	Patch QTY
(generic, or none)	(none) or CGATS.17	(any, except 1485 and 1617)
ECI2002	ECI2002	1485
IT8.7/4	IT8.7/4, LOGO_IS126422, IS126422	1617
TC1617x - IT8.7/5	TC1617, IT8.7/5	1617

The priority is on the file type. For example, a file with the IS12642 tag will be considered an IT8.7/4 target even if it does not have 1617 patches; in fact, it may have more than 1617 patches if blank or buffer patches have been added to the target in order to fill the last column for measurements purposes.

**Note:** TC1617x files have the same number of patches as IT8.7/4 targets (=1617). We have also seen TC1617x files identified with a file type (“LOGO\_IS126422”) which is used for IT8.7/4 targets. So, unless the file is clearly identified as a TC1617x target, with “TC1617” or “IT8.7/5” appearing as the file type in the first line of a CGATS formatted file, we must also consider that any file with 1617 patches which is not identified by a file type or which appears to be IT8.7/4 may also represent a TC1617x - IT8.7/5 target. For this reason, you will also see menu items dedicated to changing TC1617x target layouts in the “Re-map” menu of the opened file “Patch view” tab.

**Note:** File types associated to IT8.7/3 targets, such as “LOGO\_IS12642” and “IS12642” are considered like “generic” CGATS file and have no custom menu items in the “Re-map” menu.

The four “Re-map” menu variants are shown on the next page. Many of the choices in the generic menu are self-explanatory; here are links to get more information on some particular menu items and on target-specific menu items:

- [“Flip R/C”](#)
- [“Target Scramble/Analysis dialog...”](#)
- [“Renumber the IDs”](#)
- [“Rename the patches...”](#)
- [ECI2002 target](#)
- [IT8.7/4 target](#)
- [TC1617x - IT8.7/5 target](#)

# Re-map menu variants vs CGATS file type

	Turn 180°
	Turn 90° CW
	Turn 90° CCW
	Flip Horizontal
	Flip Vertical
<a href="#">More info</a> →	Flip R/C
See <a href="#">Section 2.2.4.</a> →	Target Scramble/Analysis dialog...
	Analyse layout for target printing
	Fix layout rows for target printing
	Use the patch Name as the patch ID
<a href="#">More info</a> →	Renumber the IDs
<a href="#">More info</a> →	Rename the patches
	Reset ALL changes

**(generic)**

	Change layout to ECI2002 Measured
	Change layout to ECI2002 Random
	Change layout to ECI2002 Visual
	Turn 180°
	Turn 90° CW
	Turn 90° CCW
	Flip Horizontal
	Flip Vertical
	Flip R/C
	Target Scramble/Analysis dialog...
	Analyse layout for target printing
	Fix layout rows for target printing
	Assign IDs for ECI2002 Random layout
	Assign IDs for ECI2002 Visual layout
	Use the patch Name as the patch ID
	Renumber the IDs
	Rename the patches
	Reset ALL changes

**ECI2002**  
[\(more info\)](#)

	Change layout to IT8.7/4 Measured
	Change layout to IT8.7/4 Random
	Change layout to IT8.7/4 Visual
	TC1617x (iIiO) target ▶
	TC1617x (iIiSis) HOR. target ▶
	TC1617x (iIiSis) VERT. target ▶
	Turn 180°
	Turn 90° CW
	Turn 90° CCW
	Flip Horizontal
	Flip Vertical
	Flip R/C
	Target Scramble/Analysis dialog...
	Analyse layout for target printing
	Fix layout rows for target printing
	Assign IDs for IT8.7/4 Random layout
	Assign IDs for IT8.7/4 Visual layout
	Use the patch Name as the patch ID
	Renumber the IDs
	Rename the patches
	Reset ALL changes

**IT8.7/4**  
[\(more info\)](#)

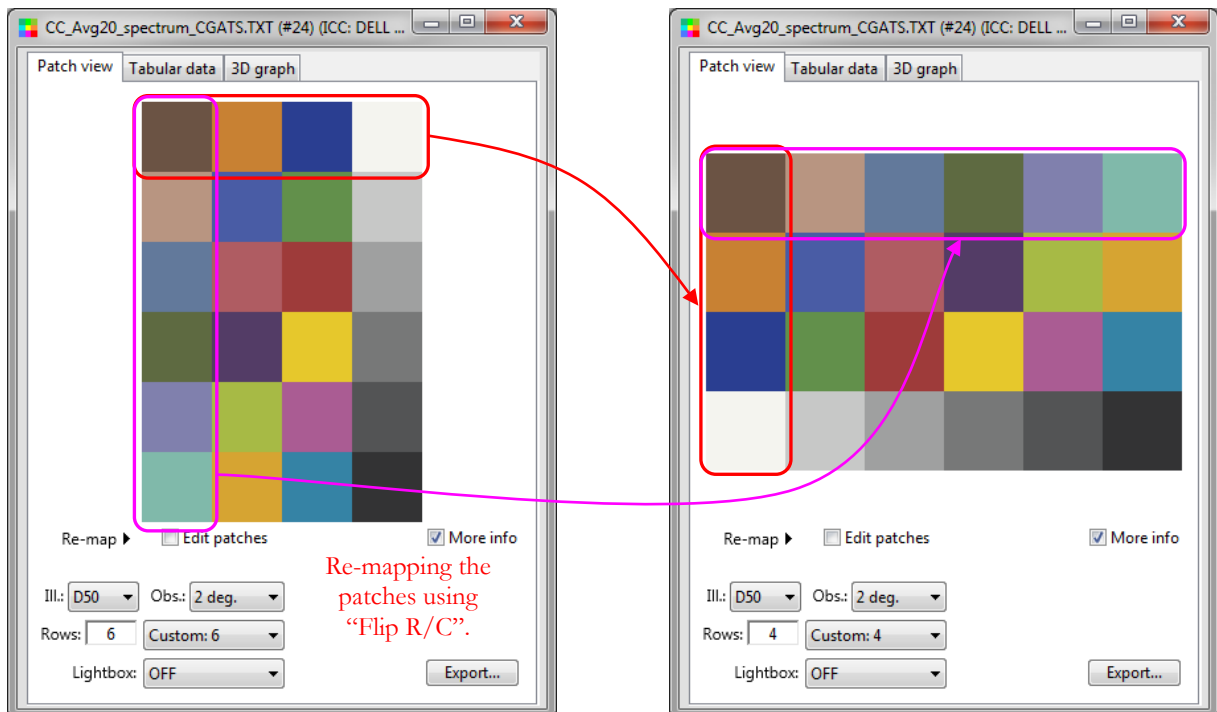
	TC1617x (iIiO) target ▶
	TC1617x (iIiSis) HOR. target ▶
	TC1617x (iIiSis) VERT. target ▶
	Turn 180°
	Turn 90° CW
	Turn 90° CCW
	Flip Horizontal
	Flip Vertical
	Flip R/C
	Target Scramble/Analysis dialog...
	Analyse layout for target printing
	Fix layout rows for target printing
	Use the patch Name as the patch ID
	Renumber the IDs
	Rename the patches
	Reset ALL changes

**TC1617x**  
[\(more info\)](#)

### Re-map: ▶ “Flip R/C”

It sometimes happens, when measuring a target, that what was thought as a column is recorded as a row. The screenshot on the left shows how measurements of a ColorChecker 24 target may appear when measuring the patches without a reference file. By comparing the measurements with the correct layout on the right, we see that the first row on the left corresponds to the first “correct” column on the right, and the second row on the left corresponds to the second column on the right, etc. As well, the first column on the left corresponds to the first row on the right, and so on. The measurements list could be re-arranged by a “Turn 90° degree CW” (Clockwise) followed by a “Flip Horizontal”, which are other items of the “Re-map” menu, but it is faster to use the “Flip R/C” command, and transform the layout in one operation.

It is important to note that any layout change done with the “Re-map” commands will also update the table data in the “Tabular data” view. See also [Section 2.2.6](#) for a description of the interaction between the “Patch view” and “Tabular data” tabs.



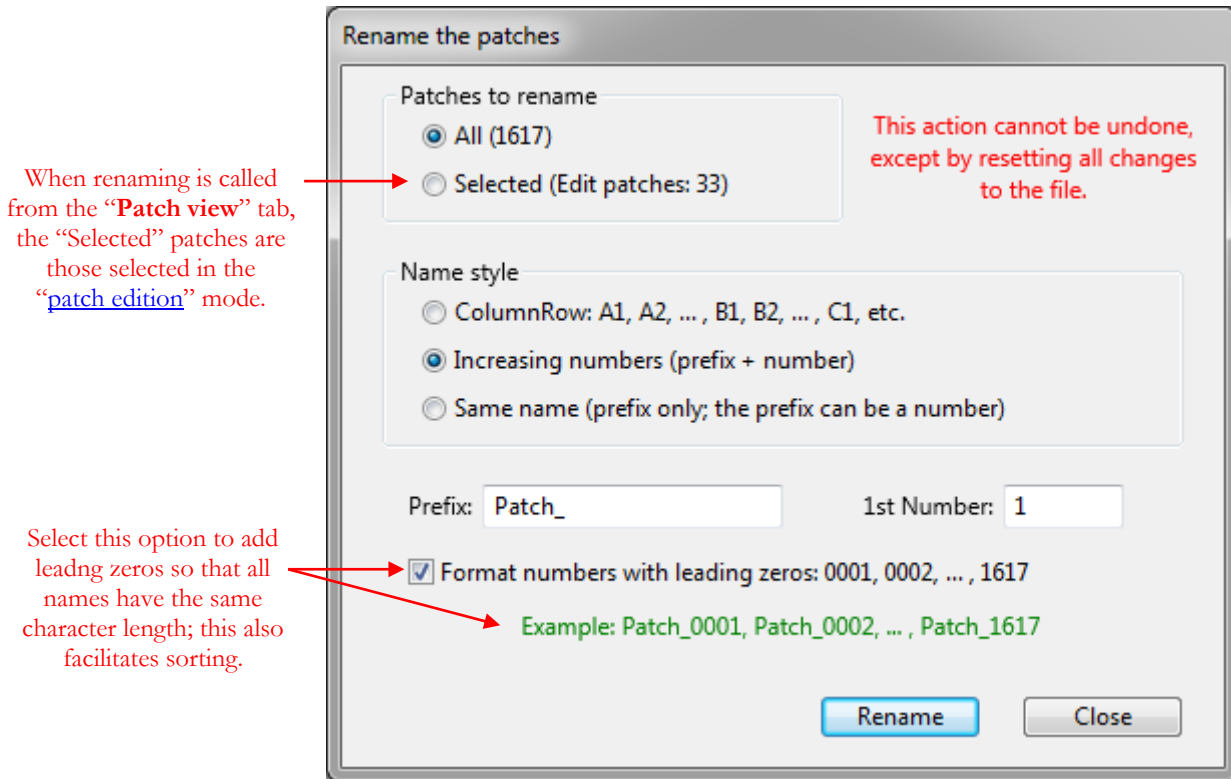
### Re-map: ▶ “Renumber the IDs”

This command will renumber the IDs as per the current layout. Renumber is done by starting in the upper left and increasing the number from the Top-Down, then from Left-to-Right, in the next columns. Since the layout may change if the “Rows” menu is set to “Floating”, we suggest assigning a “Rows” value just after renumbering (move your mouse cursor on the patch located at the bottom of the first column, then look for its ID in the “Info” window; insert this ID as a value in the “Rows” input field).

### Re-map: ▶ “Rename the patches...”

This command opens a dialog which can be used to rename either all or only selected patches. Three naming styles are available. When renaming with increasing numbers, the starting number can be assigned and the numbers can be formatted with leading zeros in order to get patch names with the same number of characters.

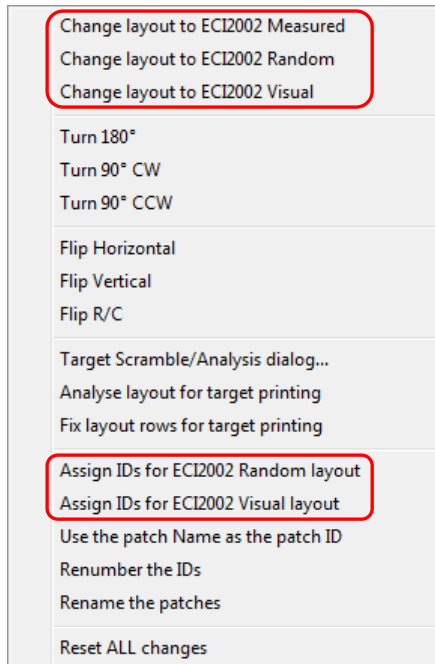
**Important:** When renaming is called from the “[Patch view](#)” tab, the “Selected” patches are those selected in the “[patch edition](#)” mode. When renaming is called from the “[Tabular data](#)” tab, the selected patches are the rows selected in the table.



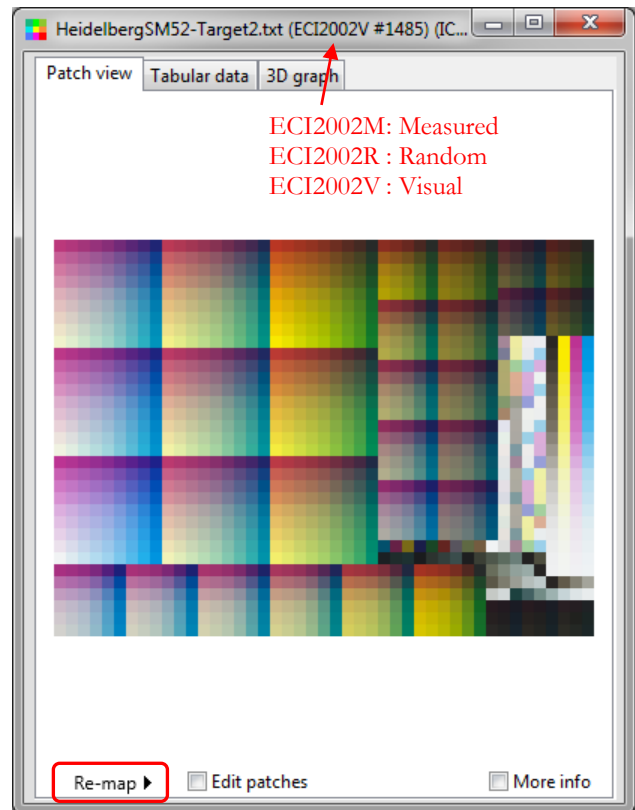
### Name styles:

- **ColumnRow:** The patches are renamed with letters identifying the columns and numbers identifying the rows, as per the current layout, with the convention used in MeasureTool. The first patch is named “A1”, “A” representing the column, and “1” the row number. The second patch below it “A2”, down to the last row. The topmost patch of the second column is labeled “B1”, with the number also increasing while going down the rows. The column letter goes up to “Z” for the 26<sup>th</sup> column, and the 27<sup>th</sup> column is identified with “2A”, with subsequent columns labeled “2B”, “2C”, etc. The third set of 26 columns starts with a column label of “3A”, and so on.  
**Note:** This naming style is available only if ALL the patches are renamed.
- **Increasing numbers:** You can define a prefix to be used for all renumbered patches and the number to be used for the first patch. As an option you can format the numbers with leading zeros so that all names have the same character length; this also facilitates sorting.
- **Same name:** You can assign the same name (i.e. prefix) to all the patches or only to the selected ones.

## Re-map: ▶ “ECI2002” specific menu items



These menu selections are added to the Re-map popup menu when an ECI2002 color list is recognized.



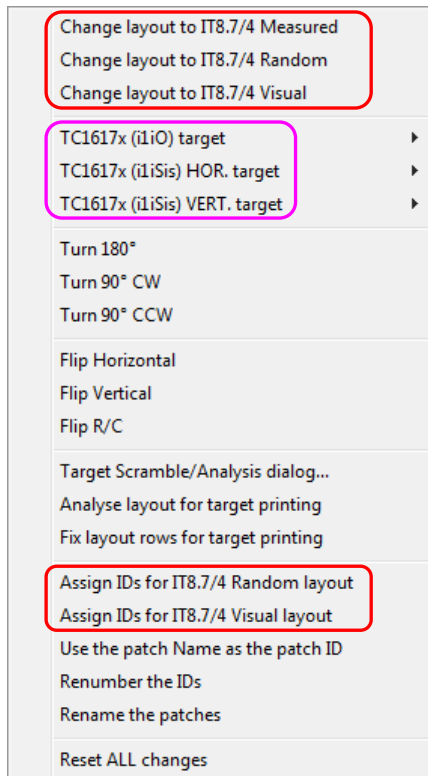
Whenever an ECI2002 tag is recognized in a CGATS file, or when an input file has 1485 patches, corresponding to the number of patches of an ECI2002 target, five selections are added in the “Re-map” popup menu. The first three selections are used to switch between the Measured, Random, and Visual layouts. Please note that proper assignment of the patch IDs is required when switching between layouts; when such IDs are not present in a file, or not in the correct order, you can assign them using one of the two other additional menu selections specific to this chart.

ECI2002 targets are often printed in a “Random” layout which distributes ink more uniformly on the paper and increases the contrast between neighboring patches. The higher patch contrast improves patch recognition when measuring the target by scanning line-by-line. In fact, the random layout is “fixed” since there is a prescribed order for displaying the patches in this view. Additional patches may be added in the printed target in order to complete lines or columns; this explains why some ECI2002 color lists have more than 1485 patches. When an ECI2002 file has more than 1485 patches in its “Measured” layout, only the nominal 1485 patches defined for ECI2002 are displayed in the “Random” and “Visual” layouts. For these files, the non-displayed patches are placed at the end of the “Tabular data” table and it is not recommended to sort the table then, since sorting will mix these extra patches with the displayed ones. If sorting is required, you should first remove the extra patches by going back to the “Measured” layout, then go in the [patch edition mode](#) to select and delete these patches.

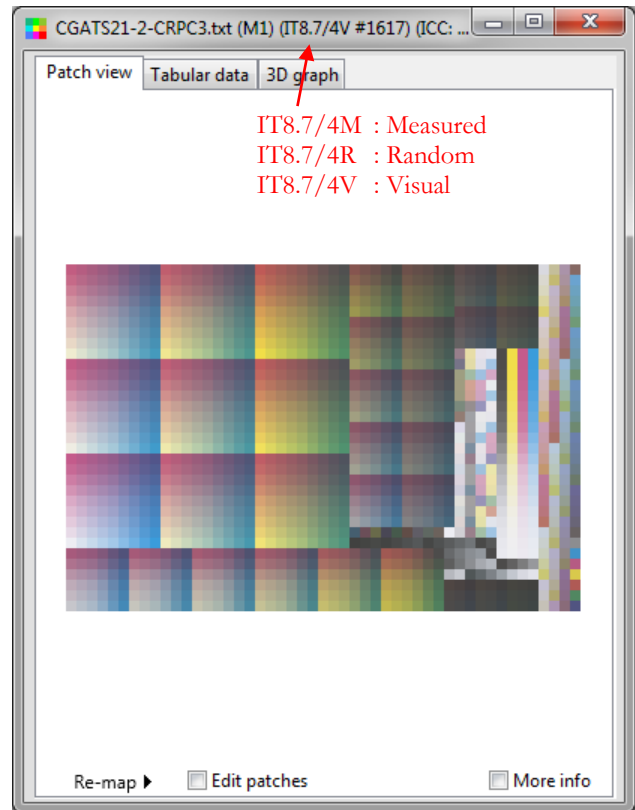


ECI2002 random layout

## Re-map: ▶ “IT8.7/4” specific menu items



These menu selections are added to the Re-map popup menu when an IT8.7/4 color list is recognized.

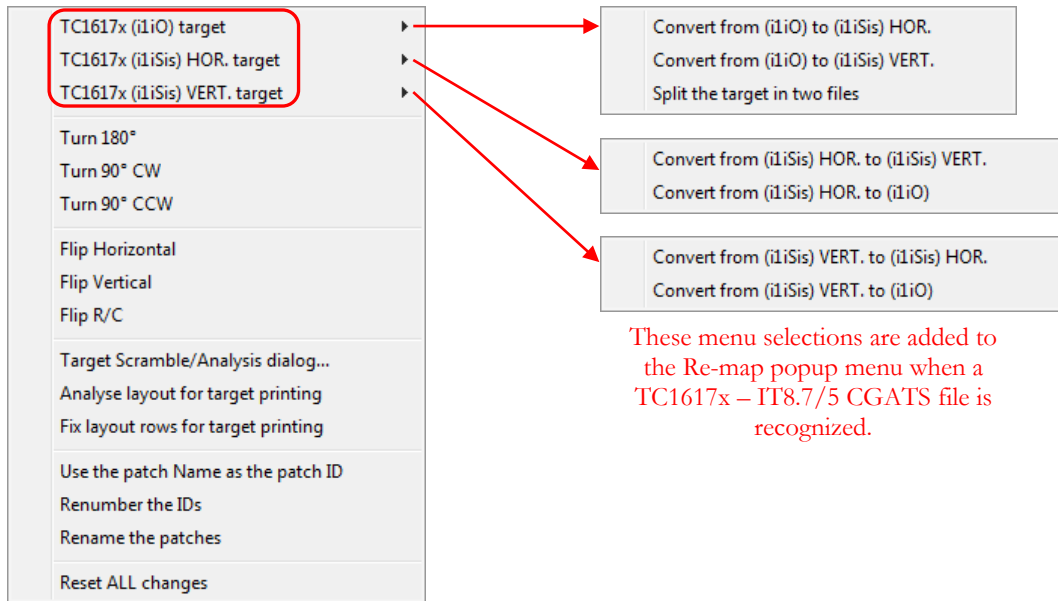


IT8.7/4 random layout  
(See the tutorial in [Section 2.5.5](#) for visual clues on how to better recognize this layout.)

Whenever an IT8.7/4 tag is recognized in a CGATS file, or when an input file has 1617 patches, corresponding to the number of patches of an IT8.7/4 target, eight selections are added in the “Re-map” popup menu. The first three selections are used to switch between the Measured, Random, and Visual layouts. The next three menu items, starting with “TC1617x”, are included because color lists defined for the TC1617x target are sometimes identified with an IT8.7/4 file type; for more information, consult the section which discusses the [“TC1617x” menu items](#). Please note that proper assignment of the patch IDs is required when switching between layouts; when such IDs are not present in a file, or not in the correct order, you can assign them using one of the two other additional menu selections specific to this chart.

IT8.7/4 targets are often printed in a “Random” layout which distributes ink more uniformly on the paper and increases the contrast between neighboring patches. The higher patch contrast improves patch recognition when measuring the target by scanning line-by-line. In fact, the random layout is “fixed” since there is a prescribed order for displaying the patches in this view. Additional patches may be added in the printed target in order to complete lines or columns; this explains why some IT8.7/4 color lists have more than 1617 patches. When an IT8.7/4 file has more than 1617 patches in its “Measured” layout, only the nominal 1617 patches defined for IT8.7/4 are displayed in the “Random” and “Visual” layouts. For these files, the non-displayed patches are placed at the end of the “Tabular data” table and it is not recommended to sort the table then, since sorting will mix these extra patches with the displayed ones. If sorting is required, you should first remove the extra patches by going back to the “Measured” layout, then go in the [patch edition mode](#) to select and delete these patches.

**Re-map: ▶ ”TC1617x – IT8.7/5” specific menu items**

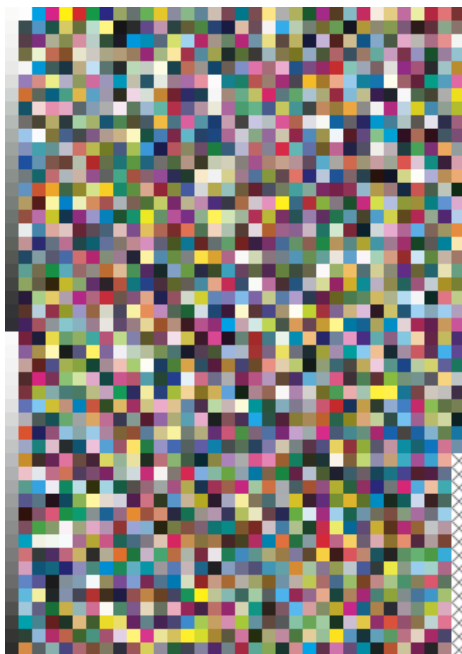


These menu selections are added to the Re-map popup menu when a TC1617x – IT8.7/5 CGATS file is recognized.

Whenever a “TC1617” or “IT8.7/5” tag is recognized in a CGATS file, three menu items with sub-menus are added in the “Re-map” popup menu. The three menu items correspond to the three layouts defined for this target. Please note that “IT8.7/5” is not a different target but simply the new name of TC1617x targets.

**Note:** These menus are also included for files identified as [IT8.7/4 targets](#) because color lists defined for the TC1617x target are sometimes identified with an IT8.7/4 tag.

In comparison with the ECI2002 and IT8.7/4 targets, there is no “Visual” layout for a TC1617x target but instead three randomized layouts to be used in association with two instruments, the X-Rite i1iO and i1iSis. All TC1617 layouts use sequential IDs. If required, you can easily re-assign them using the “Renumber the IDs” menu, assuming of course that the layout is currently in one of the three predefined TC1617x layout, as shown below.



**TC1617x (i1iO)**  
(48 rows)



**TC1617x\_H (i1iSis)**  
(49 rows)



**TC1617x\_V (i1iSis)**  
(49 rows)



We can see that the last column of the i1iO layout is not completely filled. Because of this, it may well happen that patches will be added to facilitate measurements. If this occurs, the measurement file will have more than 1617 patches (it will have 1632 patches in fact), and these patches will be visible in the “Measured” layout (the layout shown when the file is opened). If this file layout is converted to another TC1617x layout using the dedicated “Re-map” menu items, only the first 1617 patches will be displayed. In this case, the non-displayed patches are placed at the end of the “[Tabular data](#)” table and it is not recommended to sort the table then, since sorting will mix these extra patches with the displayed ones. If sorting is required, you should first remove the extra patches; this can be done by using the “Re-map/Reset ALL changes” command in order to get back the “Measured” layout, and then go in the [patch edition mode](#) to select and delete the patches.

**Note:** Charts for the i1iO and i1iSis, and characterization data for the G7 Datasets (CGATS21 ISO15339) are provided in the "characterization\_data" folder ("File/Open Sample Files" menu).

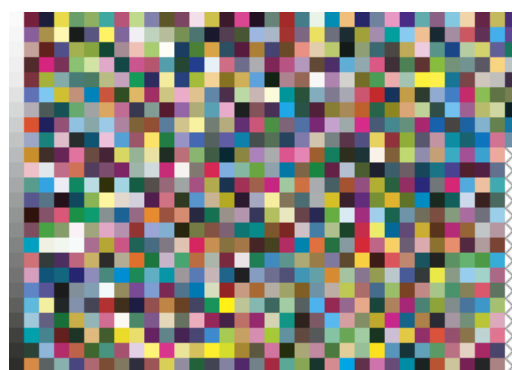
**Note:** This target, developed by [Idealliance](#), replaces the 29 duplicate patches of the IT8.7/4 target with the 29 patches in column 4 and 5 of the P2P51 target.

### Splitting the TC1617x (i1iO) layout in two pages/files

The i1iO target contains two pages in one image. This image can be splitted horizontally in the middle. You will note that in the “Re-map” menu dedicated to the TC1617x (i1iO) layout, there is a sub-menu to “Split the target in two files”; the two separated layouts are shown below:



**TC1617x (i1iO)-page1**  
(816 patches)

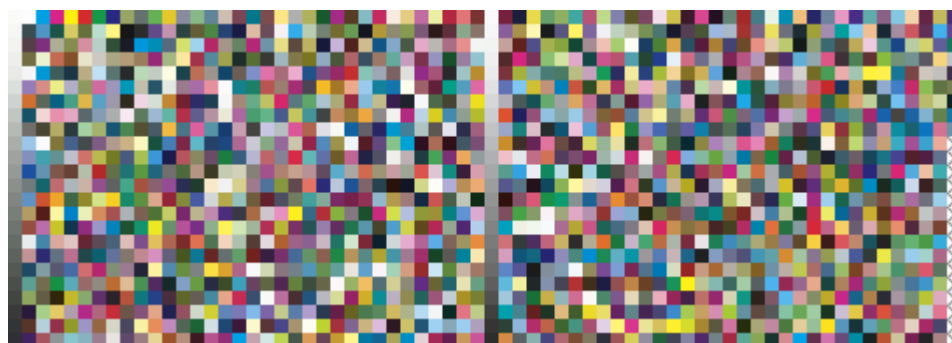


**TC1617x (i1iO)-page2**  
(801 patches)

If you use the separated layouts to perform measurements, it is important to keep the patches IDs as they are in the full layout; in other words, do not renumber the IDs in the separated layouts. These IDs are essential if you want to recombine the measurements in a single file. If, for some reason, your measurement files do not have the IDs in the correct order, you can always split the reference TC1617x (i1iO) layout and copy the IDs from each page to its corresponding measurement file using the “[File-to-File Transfer](#)” tool.

### Combining two separated pages of a TC1617x (i1iO) layout in a single layout

This can be done by first using the “[Join](#)” tool; the patches should then appear as in the layout shown below. The next steps are simply to sort the patches in ascending order using the “ID” column of the “[Tabular data](#)” table and change the “[Rows](#)” quantity in the “[Patch view](#)” tab to “48”.





### 2.2.3 The “Patch view” patch edition mode

The **patch edition mode** can be used to:

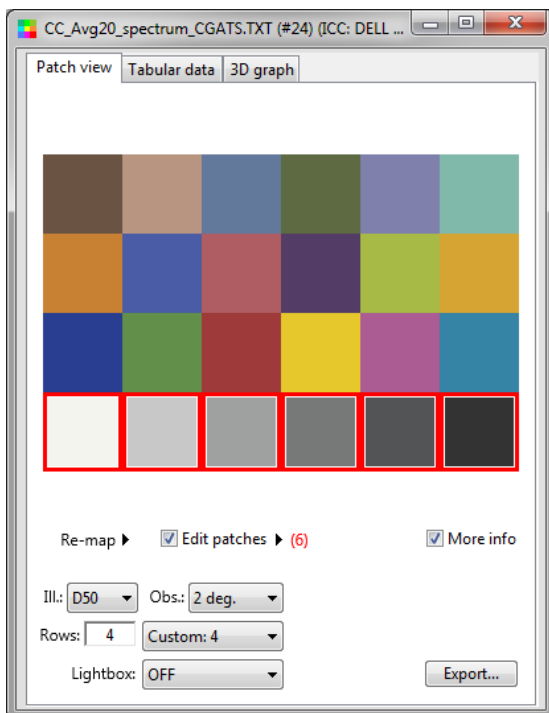
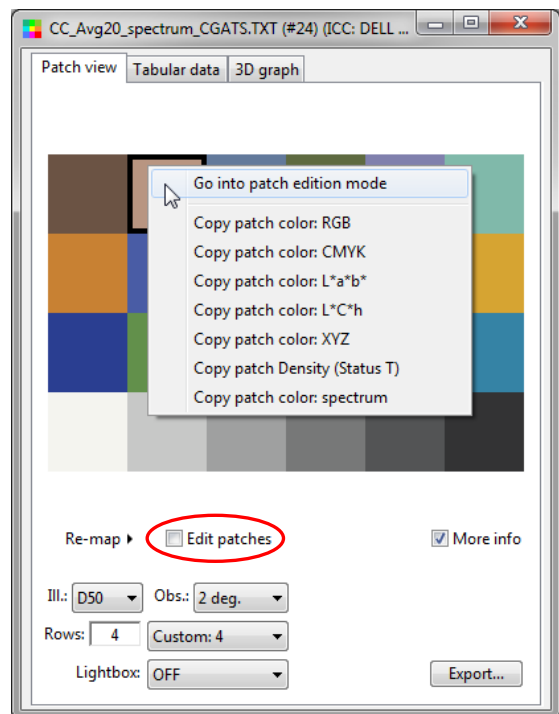
- i- Select and deselect many patches. Select /Deselect a Row, Column, or all patches.
- ii- Invert a selection (i.e. swap selected and unselected patches).
- iii- Swap two patches.
- iv- Move selected patches before or after a patch, to the first column, or to the last column.
- v- Flip the patches in a row or column.
- vi- Rename all the patches or just the selected ones.
- vii- Replace selected patches by White, 50% Gray, Black, or OSA-UCS background.
- viii- Copy selected patches to the last column.
- ix- Add White patches to fill the last column.
- x- Extract selected patches to a new file.
- xi- Delete selected patches.

There are two methods to go into this mode. You do either a right-click on the patches, and select the “Go into patch edition mode” menu item, or check the “Edit patches” box.

Similarly, to get out of this mode, you do either a right-click and select the “Get out of the patch edition mode!” menu item, or uncheck the “Edit patches” box.

Once in the patch edition mode, you can select a single patch at a time by clicking on each of them or select many patches by clicking and dragging on the layout. A red border is shown around each selected patch.

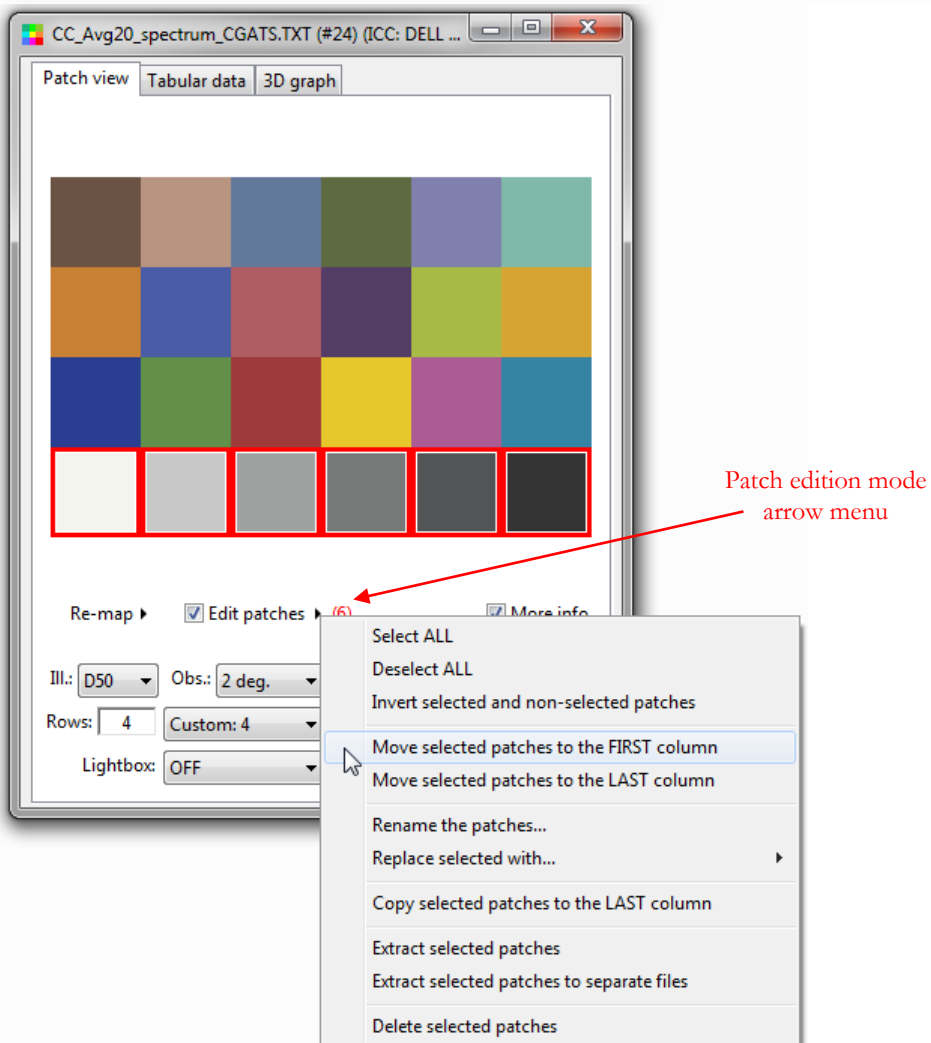
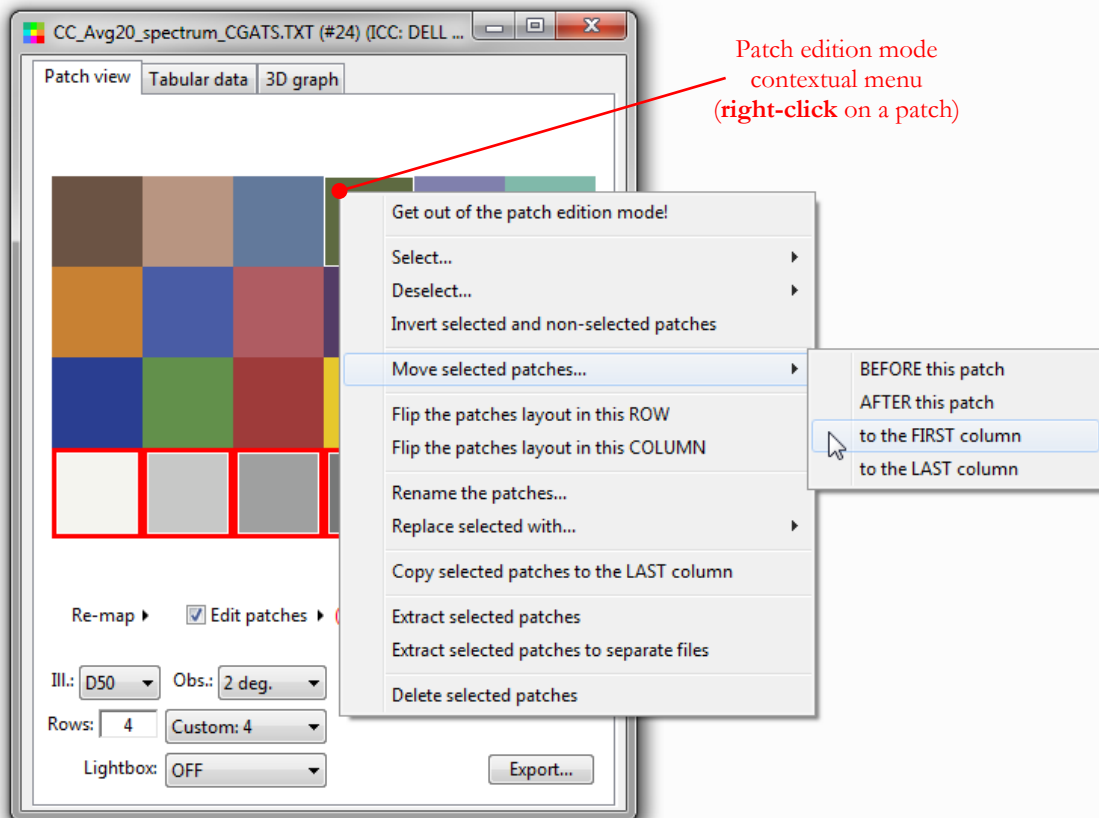
**Note:** When clicking and dragging, a patch gets selected if it was not previously selected and becomes unselected if it was previously selected.



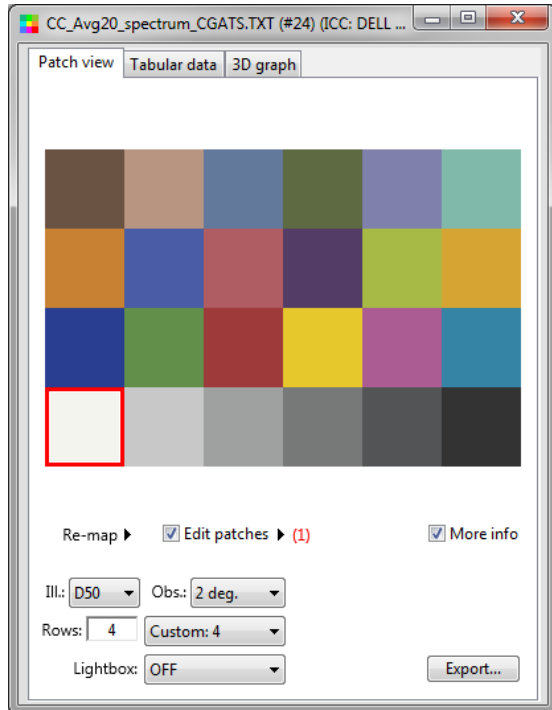
You will notice that a small arrow appears on the right of the “Edit patches” text, immediately followed by a number, in red, between parentheses. The number in red indicates how many patches are selected.

Edit patches ▶ (6)

Clicking on the arrow opens a popup menu associated to the selected patches. A similar, more complete, menu also appears if you do a right-click on the patches layout; this other menu is more complete because it contains menu commands which are dependent on the mouse position (such as “Select this ROW”). The two menus are shown on the next page.

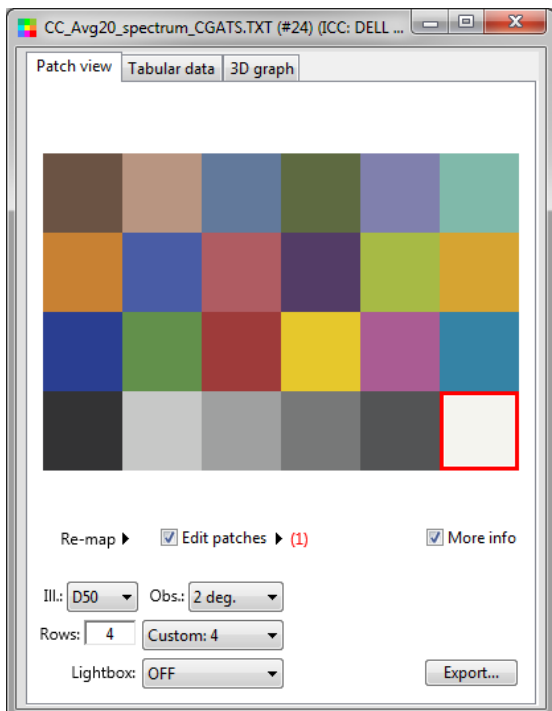
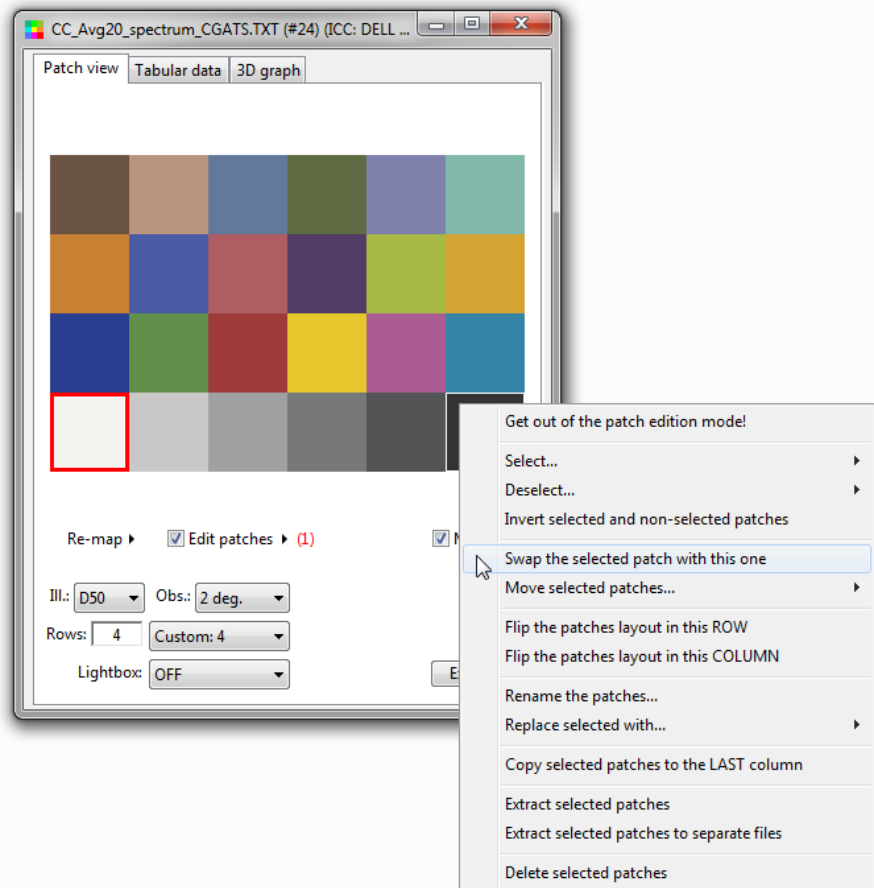


## Swapping two patches in the patch edition mode



STEP-1  
Select the first patch to swap  
(select only one patch)

STEP-2  
Do a **right-click** on the  
second patch and select the  
“Swap the selected...” menu.



RESULT after the swap

## 2.2.4 The “Target Scramble/Analysis” dialog (Re-map)

This dialog, opened from the “Re-map” menu available in every opened file, is used to scramble the patches of a target in order to facilitate its measurement when scanning row by row once printed.

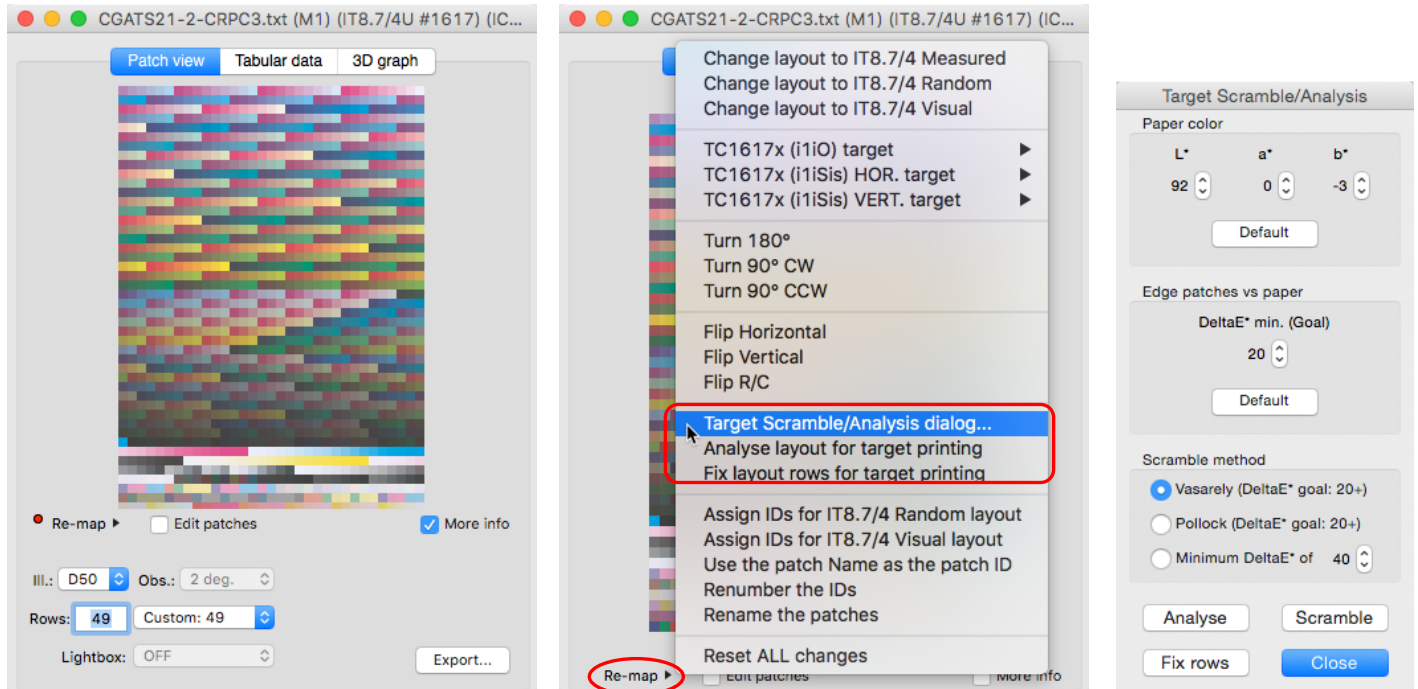
The “**Target Scramble / Analysis**” dialog can be used to:

- i- **Scramble** the patches to insure a minimal color difference between adjacent patches and between edge patches and the paper. All patches may be repositioned. Three scramble methods are proposed; they are described and examples are shown on the next pages.
- ii- **Analyze** a layout to assess the color difference between adjacent patches and between edge patches and the paper. A report is generated following the analysis, where it may be suggested to add or not contrast bars between patches or at the beginning and end of each row. The patches which do not meet the analysis goals are selected in the [patch edition mode](#) (i.e. shown with a red border).
- iii- **Fix the rows**, or to be more specific, try to fix the rows which do not meet the goals set in the dialog. With this function, the patches are kept on the same row.

This dialog can only be accessed from an opened file. For the purpose of our examples, we use an IT8.7/4 target that we have rotated 90 degrees clockwise using the Re-map menu; a screenshot is shown below on the left. You can find this file as well as other reference and characterization data files using the “File/Open Sample Files/Characterization data...” menu.

We turned the target in order to get 33 columns (by 49 rows), which will result in a printed target width that can easily fit the width of an i1Pro 2 scan ruler. Of course, this assumes that no vertical bars will be required between patches once scrambled; if this was not the case, we would need to lower the number of columns.

With the number of columns and rows set, we open the “Target Scramble/Analysis” dialog with the “Re-map” arrow menu. This dialog is shown below on the far right.



You will notice, in the Re-map menu, two other menu items associated with the Scramble/Analysis dialog. These menu items have the same function as the “Analyze” and “Fix rows” buttons of the Scramble/Analysis dialog but can be used without opening the dialog.

**Note:** There is no need to fill the last column with patches in order to scramble a target.

Before scrambling a layout, it is recommended to set your paper color and the goal for minimal color difference (DeltaE\*, CIELAB) between a patch on the edge of the target and the paper. For the i1Pro/i1Pro 2, the recommended minimum difference is 20. The same color difference is recommended between neighboring patches. Smaller inter-patch differences can be accommodated if using the i1Pro 2 or i1Pro 3 Zebra ruler or by adding vertical separation bars between each patch.

Before analyzing the layout or fixing the rows, it is recommended to set the paper color, set the goal for minimal color difference (DeltaE\*, CIELAB) between a patch on the edge of the target and the paper, and choose a scramble method.

Three scrambling methods are proposed:

- 1- **Vasarely:** This method is named this way because it often results in a layout where the colors appear ordered by an underlying 2D structure. The goal for the minimal color difference between patches is fixed at 20 DeltaE\*.
- 2- **Pollock:** The resulting patch distribution is more chaotic and reminiscent of some of the work of the artist who inspired the name of this method. The goal for the minimal color difference between patches is fixed at 20 DeltaE\*.
- 3- **Minimum DeltaE\*:** The patches are shuffled to optimize the color difference between neighboring patches one row at a time. The goal is user-adjustable. The program uses that goal in two ways: first by trying to meet the minimal color difference, and secondly by trying to keep this just high enough. By doing so, once the first patches are positioned, the remaining ones are sufficiently diverse to meet the color difference goal up to the end. This is a computer intensive process.

The “Vasarely” and “Pollock” methods are much faster than the “Minimum DeltaE\*” method, and they cannot be stopped once launched. However, the “Minimum DeltaE\*” method can take quite some time, and it can be stopped via the “Target Scramble/Analysis” dialog once in progress.

**Important:** Scrambling and row-fixing results may vary, and success is not guaranteed! The results will depend on patch colors, the target layout, and the scrambling parameters (paper color, minimal color difference for edge patches, scramble method). In some cases, we have seen different results depending on the initial patch order.

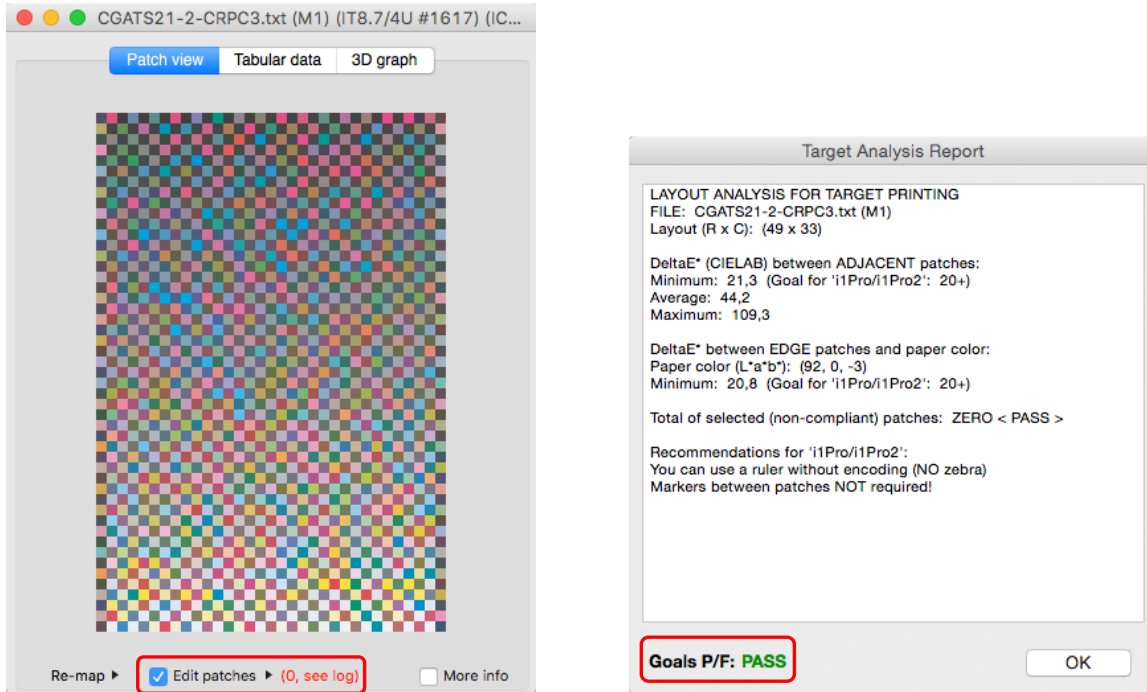
During scrambling, all patches may change position (row and column). When using the “Fix rows” function, the patches are kept in their initial row.

**Hint:** In some cases, you may be able to scramble a target and meet all goals just by “fixing the rows”.

For all scrambling methods, when the process is completed, a **Target Analysis Report** is shown in a separate window. The report presents the color difference statistics in relation with the set goals as well as recommendations for printing the layout. A global Pass/Fail assessment is shown in the bottom of the report window. If all goals are met, it generally means that a target can be printed without any contrast-enhancement bars, either on the target edges or between the patches. In case of a fail, the target can still be printed, but with some forms of contrast enhancement or by using the Zebra ruler, which can tolerate neighboring patches with lower contrast (if used with the proper software mode).

On the next pages, we see the layouts obtained with three scrambling methods starting with the IT8.7/4 target opened and rotated on the preceding page. A screenshot of the corresponding “Target Analysis Report” is included.

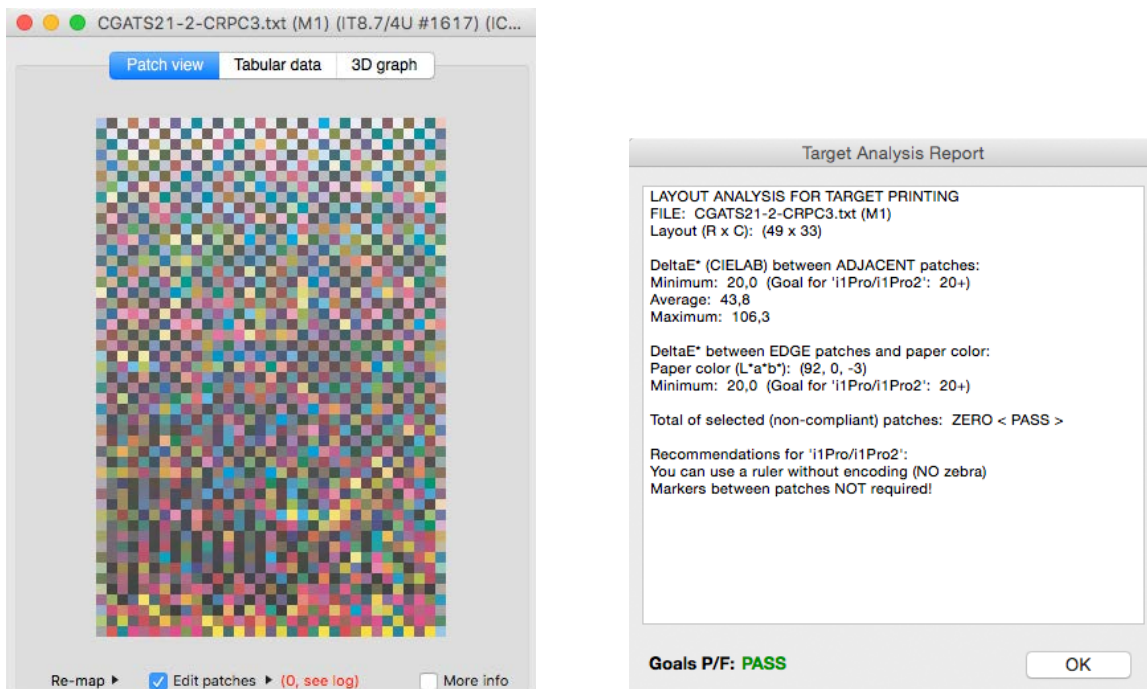
## Target Scramble/Analysis: Layout obtained with the “Vasarely” method



The report confirms that we pass the color difference goal between adjacent patches as well as the color difference goal between edge patches and the paper color. It indicates that we can use a ruler with no zebra encoding. This will also be the case for the layouts obtained with the other scramble methods.

Since we pass all goals, there are no non-compliant patches and no patches selected in the [patch edition mode](#), as can be confirmed with the selected “Edit patches” checkbox and the number (0) shown beside it.

## Target Scramble/Analysis: Layout obtained with the “Pollock” method

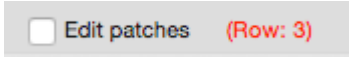




## Target Scramble/Analysis: Layout obtained with the “Minimum DeltaE\*” method

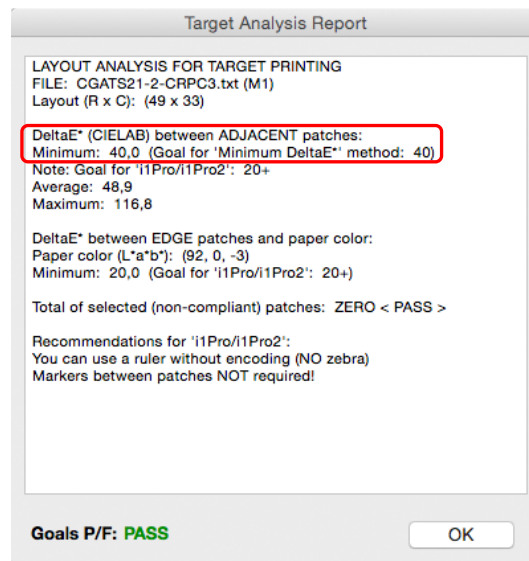
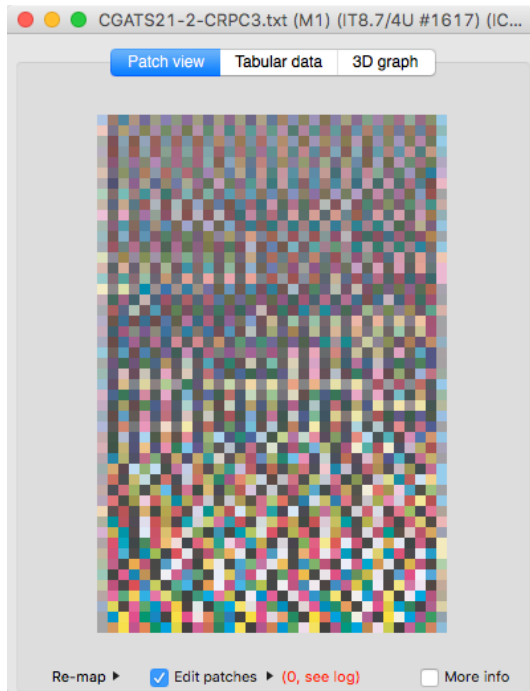
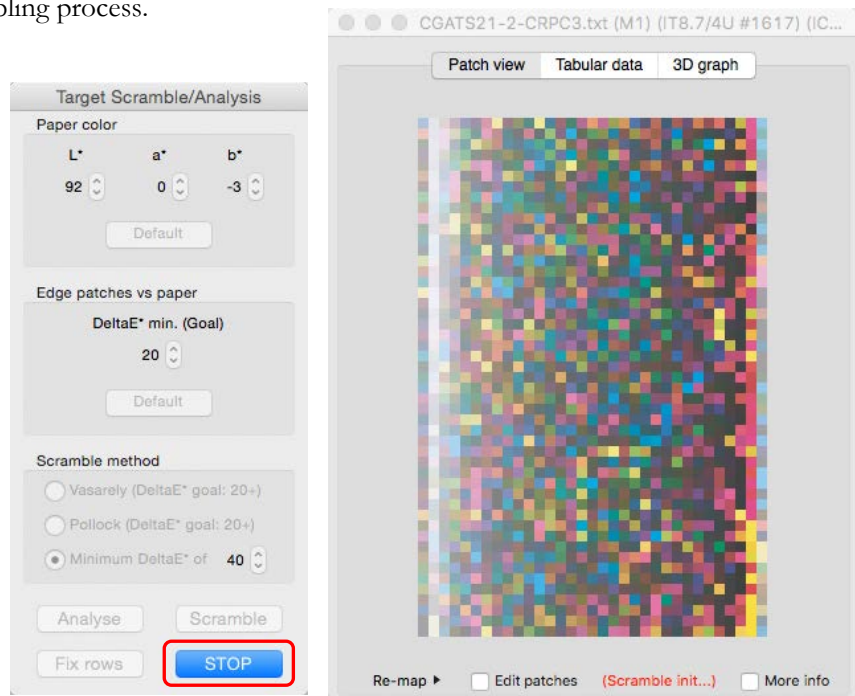
When the scramble process starts, you first see “(Scramble init...)” below the patch layout in the file window. You will also notice that The “Target Scramble/Analysis” “Close” button is replaced by a “STOP” button, and clicking on this button will terminate the scrambling process.

As the process continues, the message below the layout indicates which row is being optimized:



The initialization and the first rows take the longest time, and the process gets faster as the number of processed rows increases. Please be patient since it can take several tens of minutes to scramble an IT8.7/4 target (time to process grows exponentially with the target size).

The scrambled layout is shown below, with its report, where we can confirm that the minimum difference between neighboring patches is indeed 40 DeltaE\*ab.



**Hint:** With a mouse right-click, you can copy a part of or the complete “Target Analysis Report” from the report window if you wish. Please be aware that the report is also written in PatchTool’s Main window log, so you could copy it from there later on. In addition, you can regenerate the report by clicking on the “Analyse” button of the “Target Scramble/Analysis” dialog or by selecting the “Analyse layout for target printing” menu item in the “Re-map” menu.

## 2.2.5 The “Tabular data” tab

The menu to select the data to be displayed in this table is shown on the next page.

Click in any cell of the “Name” column to edit a patch name.

Right-click on any cell for this menu.

Select rows using:  
 1- A mouse **click** (1 row)  
 2- **Ctrl + click** ( $\pm$  1 row)  
 3- **Ctrl + click & drag**  
 4- **Shift + click** (range)  
 (Use **⌘** instead of **Ctrl** on a Mac.)

Any Illuminant or Observer change will also be done in the corresponding “Patch view” tab.

To select the CMYK space for this table.  
 Select either one of the provided profiles or any ICC profile. Shown in the “Info” window and used for export.

Click on a column Header to sort the table according to this column data in ascending or descending order.

Use these menus to select the table font and font size.

Opens the “PatchTool Export” window. Equivalent to the File/Export menu command.

To select the RGB space for this table (this is NOT the display space).  
 Select either a built-in RGB space or any ICC profile. Shown in the “Info” window and used for export.

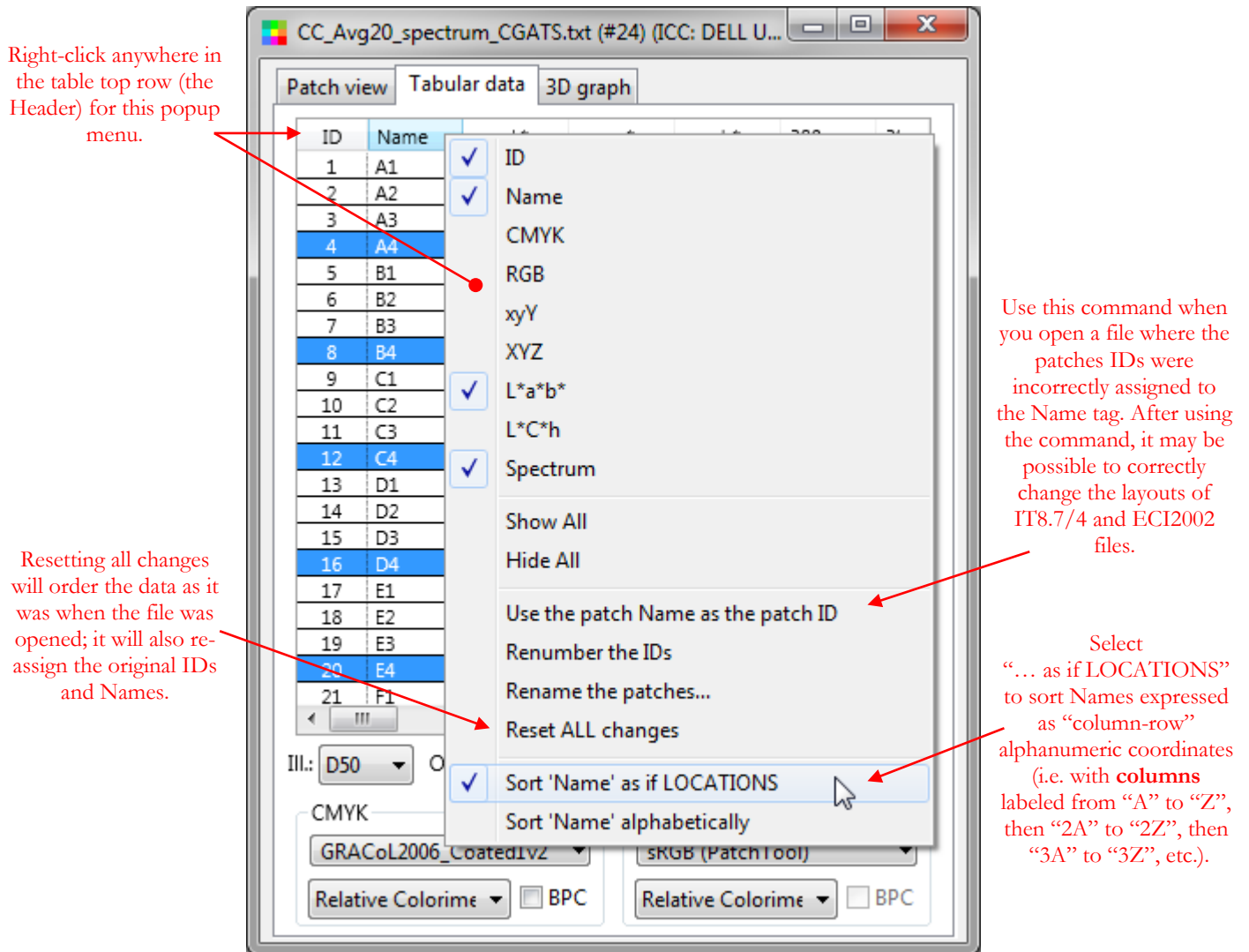
ID	Name	L*	a*	b*	380 nm	380 nm
1	A1	38,3576	13,8007	14,6478	0,05493	0,
2	A2	62,5588	35,1325	58,0519	0,05309	0,
3	A3	28,6530	15,5990	-50,5170	0,06446	0,
4	A4	96,3874	-0,4074	2,2421	0,19891	0,
5	A5	66,0557	17,7340	17,0507	0,12119	0,
6	A6	39,9144	53,9911	4,9871	0,13163	0,
7	A7	49,2501	13,7037	14,0341	0,05145	0,
8	A8	38,6214	34,4134	34,4134	0,18220	0,
9	A9	39,9144	53,9911	4,9871	0,14080	0,
10	A10	39,9144	53,9911	4,9871	0,09833	0,
11	A11	39,9144	53,9911	4,9871	0,12119	0,
12	A12	39,9144	53,9911	4,9871	0,13163	0,
13	A13	39,9144	53,9911	4,9871	0,14080	0,
14	D2	30,3750	21,1297	-20,3000	0,10867	0,
15	D3	82,2304	4,0453	79,8400	0,15820	0,
16	D4	50,8303	-0,6892	-0,2652	0,06011	0,
17	E1	55,3555	8,8889	-24,8209	0,15466	0,
18	E2	72,4918	-23,4640	57,0802	0,14533	0,
19	E3	51,8197	49,7853	-13,9011	0,14533	0,
20	E4	35,7241	-0,5221	-0,4658	0,14533	0,
21	F1	70,7003	-32,8942	-0,2372	0,14533	0,

Clicking on any column Header will sort the table according to the column data. Clicking a second time on the same Header will sort the table in reverse order. You can, for example, sort the table from spectral data at a specific wavelength. Any resulting change in the table list order will affect the “Patch view”, which is drawn according to this list. See the next section ([Section 2.2.6](#)) for instructions on how you can manipulate individual patches or group of patches using the table.

When copying rows, only the data types selected in the header will be copied. The menu to select the data to be displayed in the table is shown on the next page.

The CMYK or RGB profile controls will be dimmed (i.e. disabled) if the color reference of the opened file is CMYK or RGB respectively. The controls will also be dimmed if CMYK or RGB data was found in the file in addition to another data type which was used for import. The various appearances of the controls associated to profile selection are presented [here](#). See the “Behind the scene: [Selecting data for import](#)” box for a description of how data is prioritized for import.





**Note:** Some of the menu items shown in the screenshot above are not available if the “ID” or “Name” data fields are not selected.

### “Renumber the IDs”

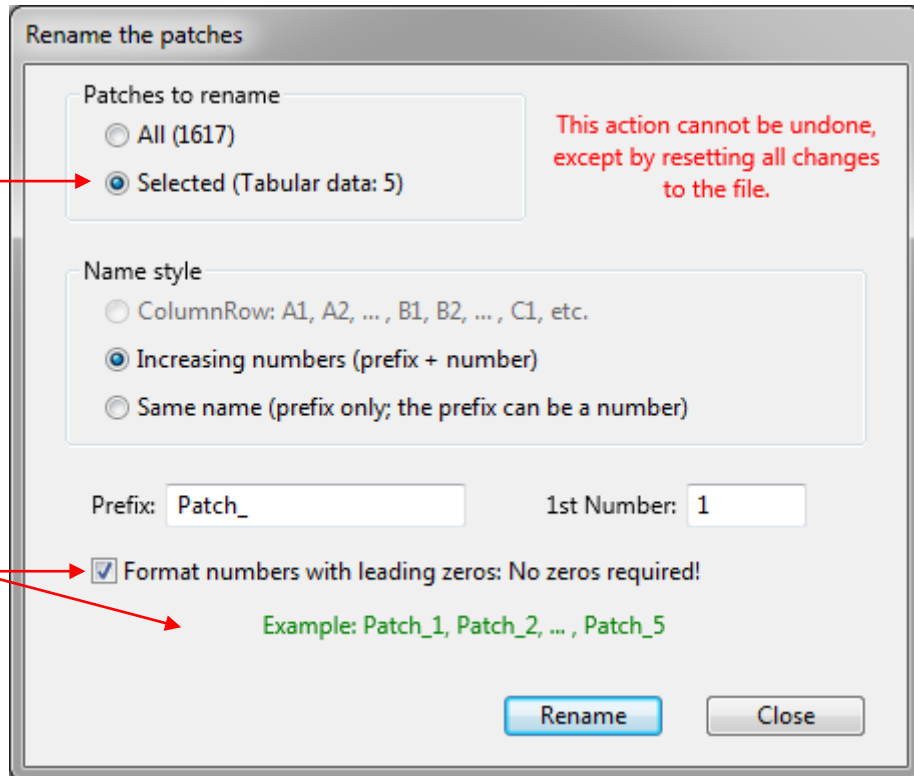
These two commands will renumber the IDs or rename the patches as per the current layout. Renumber is done by starting in the upper left and increasing the number from the Top-Down, then from Left-to-Right, in the next columns (Note: The column length is determined by the “[Rows](#)” value defined in the “Patch view” tab).

### “Rename the patches”

This command opens a dialog, shown on the next page, which can be used to rename either all or only selected patches. Three naming styles are available. When renaming with increasing numbers, the starting number can be assigned and the numbers can be formatted with leading zeros in order to get patch names with the same number of characters.

**Important:** When renaming is called from the “[Patch view](#)” tab, the “Selected” patches are those selected in the “[patch edition](#)” mode. When renaming is called from the “[Tabular data](#)” tab, the selected patches are the rows selected in the table shown above.

**Note:** Individual patch names can be edited by clicking in each Name cell.



When renaming is called from the “**Tabular data**” tab, the “Selected” patches are the rows selected in the [table](#).

No leading zeros are required since we are renaming the 5 selected patches starting with number “1”.

#### Name styles:

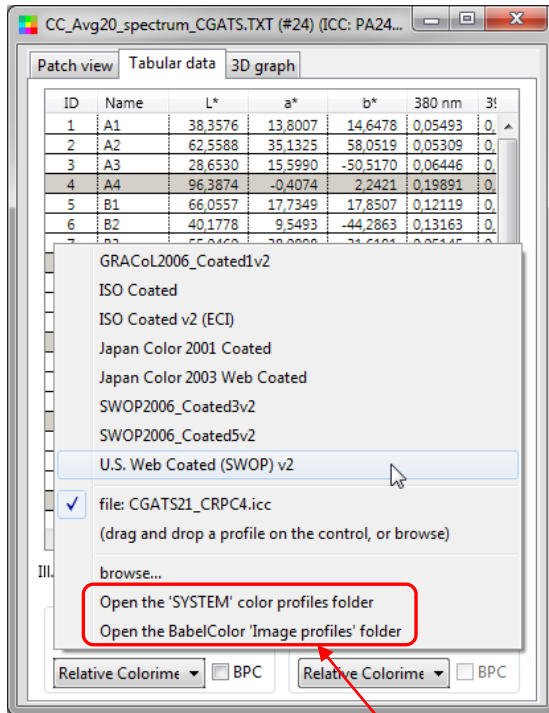
- ColumnRow:** The patches are renamed with letters identifying the columns and numbers identifying the rows, as per the current layout, with the convention used in MeasureTool. The first patch is named “A1”, “A” representing the column, and “1” the row number. The second patch below it “A2”, down to the last row. The topmost patch of the second column is labeled “B1”, with the number also increasing while going down the rows. The column letter goes up to “Z” for the 26<sup>th</sup> column, and the 27<sup>th</sup> column is identified with “2A”, with subsequent columns labeled “2B”, “2C”, etc. The third set of 26 columns starts with a column label of “3A”, and so on.  
**Note:** This naming style is available only if ALL the patches are renamed.  
**Note:** Please consult the description of the “[Rows](#)” control for more information on how the current patch layout affects renaming.
- Increasing numbers:** You can define a prefix to be used for all renumbered patches and the number to be used for the first patch. As an option you can format the numbers with leading zeros so that all names have the same character length; this also facilitates sorting.
- Same name:** You can assign the same name (i.e. prefix) to all the patches or only to the selected ones.

#### “Sort ‘Name’ as if LOCATIONS” and “Sort ‘Name’ alphabetically”

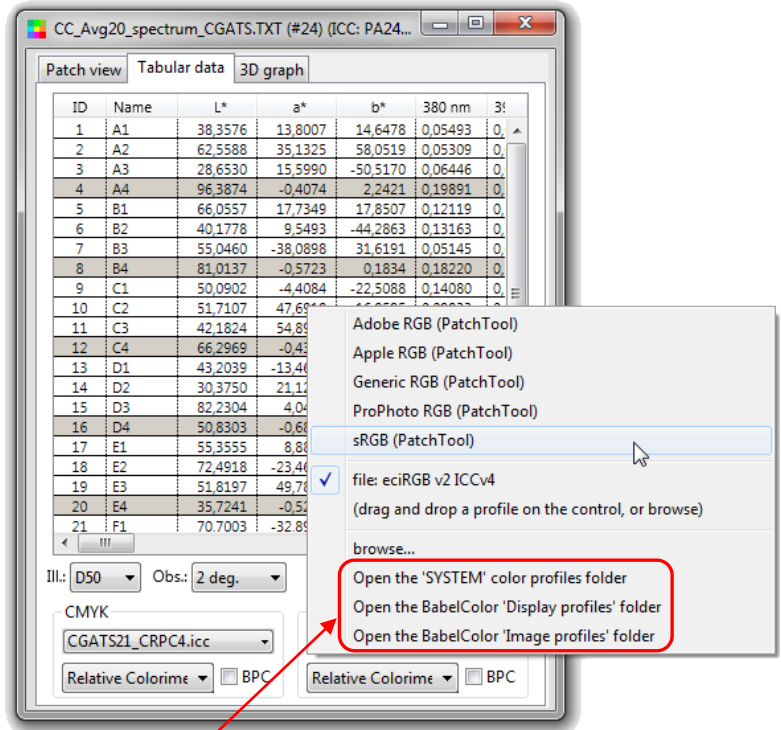
In [CGATS](#) file, patch names and patch locations are often used interchangeably. Patch locations are expressed as “column-row” alphanumeric coordinates, with columns labeled from “A” to “Z”, then “2A” to “2Z”, then “3A” to “3Z”, etc. (for example, A22, 2B3). These locations usually refer to standard targets layouts, such as IT8.7/4 or ECI2002. You can sort the name column according to the ‘Name’ type that was imported from the file.

## CMYK and RGB profile selection

### CMYK profile selection



### RGB profile selection



Use the last selections of the profile menus to open folders which contain ICC profiles. On a Mac, there are two additional menu items to open USER and LOCAL profile folders.

For the CMYK space, pick one of the provided profiles, shown above in the left screenshot, or load any ICC profile by dragging and dropping the profile on the menu control or by browsing to a profile by first selecting the “browse...” menu. The last items of the profile menus can be used to open folders which contain ICC profiles. In the left screenshot, an externally loaded CMYK profile is shown as “file: CGATS21\_CRPC3.icc”.

The provided CMYK profiles consist of actual ICC files which can be found in the “Profiles” folder located within the PatchTool application folder (In Windows, you can use the “StartMenu/BabelColor/PatchTool supplied ICC Profiles” shortcut to open this folder). These profiles can also be used in other PatchTool tools as well as in other applications; however, make sure you do not erase the profiles or move their folder since the files’ location are important for proper PatchTool operation. Of course, you can simply copy the profiles if required.

For the RGB space, you can pick one of the built-in RGB spaces profiles or load any ICC profile by dragging and dropping the profile on the menu control or by browsing to a profile by first selecting the “browse...” menu. As with the CMYK menu, the last menu items will open folders which contain ICC profiles.

**Note:** The “built-in” RGB profiles, identified by the “(PatchTool)” suffix, have no external file associated with them.

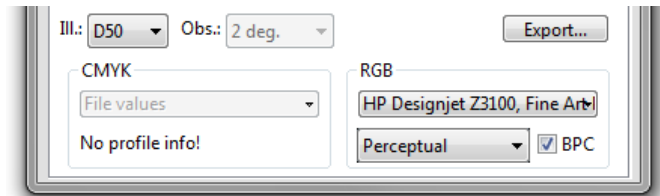
**Hint:** For your convenience, we have also included two versions of the eciRGB\_v2 space in the “Profiles” folder located within the PatchTool application folder; while these profiles are not available as built-in menu items, they can be dragged and dropped like any other profile.

The various appearances of the controls associated to profile selection are presented on the next page.

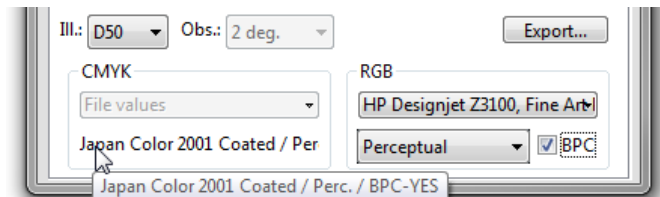
## CMYK and RGB profiles interface

These four screenshots show how the CMYK profile information is presented, depending on the data found in the opened file; the examples also apply to RGB data

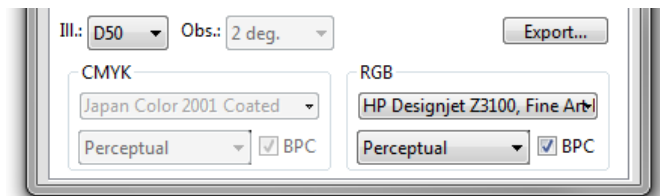
**Case 1:** In the first screenshot below, the CMYK controls are dimmed and “File values” is shown in the menu control normally used for the profile name. This means that the list contained CMYK **in addition** to the data selected for import. Also, we see “No profile info!” under the dimmed control; this in turn means that no profile information was found in the file.



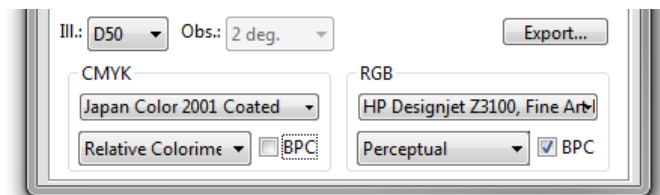
**Case 2:** In the second screenshot, we see some profile information (“Japan Color 2001 Coated...”) instead of “No profile info!”. This indicates that profile information was present in the file (Note: PatchTool adds profile information tags in a file when exporting RGB and CMYK data; however, there is usually no such information for files saved with other programs). If the profile info is too long for the profile box, just move your mouse over the clipped text and wait until a Help Tag appears with the complete content.



**Case 3:** In this third screenshot, we see that CMYK data was used for import. When CMYK or RGB is used for import, profile information is absolutely required. If profile information is not found in the file, you are requested to assign the profile in the [Missing Info](#) dialog. Whether the CMYK profile info was found in the file or assigned, it is displayed as shown below.



**Case 4:** In this fourth screenshot, the CMYK profile controls are all enabled and can be freely assigned by the user in the opened file. This case is only possible if CMYK data was NOT used for import, and if CMYK data was NOT present in the file in addition to another data type used for import. As we see, this was also the case for the RGB in all four cases.



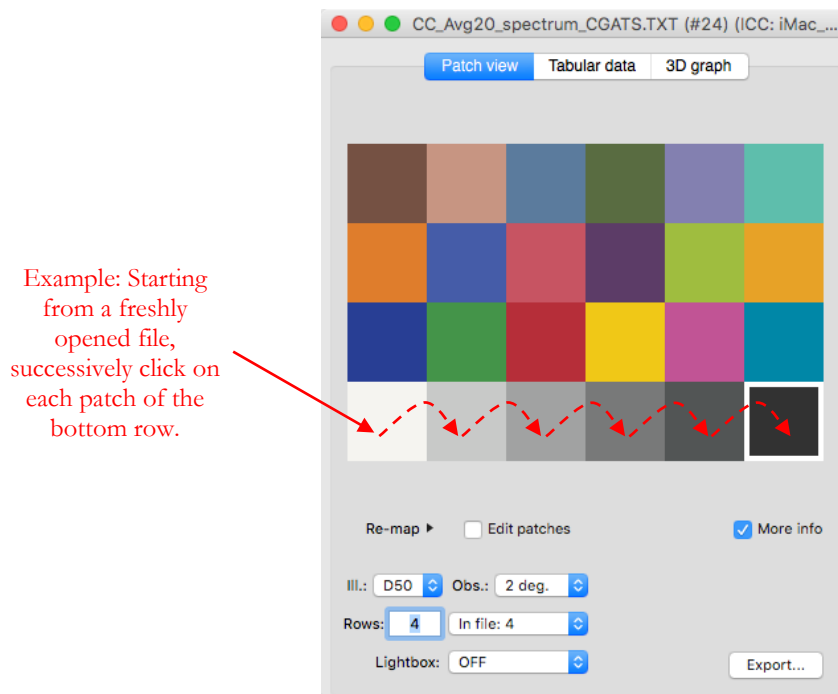
## 2.2.6 The interaction between “Patch view” and “Tabular data”

As shown in [Section 2.2.1](#), a “Re-map” in the “Patch view” mode will change the data order in the “Tabular data” view. And, as shown in [Section 2.2.5](#), sorting the table in the “Tabular data” view will change the display order in “Patch view”. The changes resulting from these commands are global, affecting all the patches simultaneously. But it is also possible to reposition individual patches, or groups of patches, and even extract data from the selection.

Whenever you click on a patch, the patch is either “frozen” or “unfrozen” depending on its state prior to clicking on it. When frozen, the patch info is correspondingly frozen in the left side of the “Info” window. A permanent black or white frame is also drawn around the patch. See [Section 2.4, The “Info” window](#), for more information on the correspondence between the file window and the Info window.

In parallel with its effect on the Info window, all mouse clicks are “recorded” in the “Tabular data” window. If you select the “Tabular data” view after clicking on many patches, you will see that the rows corresponding to the clicked patches are highlighted, and the last patch clicked is at the top of the window (or near the top for short lists).

This is illustrated with the following example, a color list of the average of 20 ColorChecker charts (standard model with 24 patches). The file can be found in the “sample\_files/Help-Manual\_files” folder of the PatchTool application folder. The “Help-Manual\_files” folder can also be opened using PatchTool’s “File/Open Sample Files/Misc. Sample Files...” menu. Just after the file is first opened, successively click on the neutral patches of the bottom row, in any order:



Now click on the “Tabular data” tab to see the data. The display should look like the screen grab on the left of the next page. From this point, in the “Tabular data” view, you can:

- i- Add individual rows to the selection by Ctrl-clicking on rows (**Ctrl + click** on Windows, **⌘ + click** on a Mac).
- ii- Copy the selected patches data, with or without column headers, with a right-click (**ctrl + click** on a one-button Mac mouse). The copied data is then in the system clipboard, from where you can paste it in a spreadsheet, a table in a text document, or directly as text.
- iii- Drag the selected rows to another position in the list. In this case, the patches positions will be changed, as you will see when returning to “Patch view”.

CC\_Avg20\_spectrum\_CGATS.TXT (#24) (ICC: iMac...)

Patch view Tabular data 3D graph

ID	Name	L*	a*	b*	380 nm
1	A1	38.3576	13.8007	14.6478	0.05493
2	A2	62.5588	35.1325	58.0519	0.05309
3	A3	28.6530	15.5990	-50.5170	0.06446
4	A4	96.3874	-0.4074	2.2421	0.19891
5	B1	66.0557	17.7349	17.8507	0.12119
6	B2	40.1778	9.5493	-44.2863	0.13163
7	B3	55.0460	-38.0898	31.6191	0.05145
8	B4	81.0137	-0.5723	0.1834	0.18220
9	C1	50.0902	-4.4084	-22.5088	0.14080
10	C2	51.7107	47.6918	16.8595	0.09833
11	C3	42.1824	54.8908	28.7870	0.04900
12	C4	66.2969	-0.4362	-0.0763	0.15176
13	D1	43.2039	-13.4658	21.7317	0.05088
14	D2	30.3750	21.1297	-20.3068	0.09534
15	D3	82.2304	4.0453	79.8461	0.05589
16	D4	50.8303	-0.6892	-0.2652	0.10867
17	E1	55.3555	8.8889	-24.8209	0.15820
18	E2	72.4918	-23.4640	57.0802	0.06011
19	E3	51.8197	49.7853	-13.9011	0.15466
20	E4	35.7241	-0.5221	-0.4658	0.06805
21	F1	70.7003	-32.8942	-0.2372	0.14533
22	F2	71.9631	19.4836	67.9997	0.06234
23	F3	50.5546	-27.9750	-28.1359	0.11387
24	F4	20.7056	0.0243	-0.4456	0.03112

Ill.: D50 Obs.: 2 deg. Export...

CMYK: SWOP2006\_Coated3v2 Relative Color... BPC

RGB: ecIRGB v2 Relative Color... BPC

Example: Table appearance after clicking on the patches of the bottom row.

CC\_Avg20\_spectrum\_CGATS.TXT (#24) (ICC: iMac...)

Patch view Tabular data 3D graph

ID	Name	L*	a*	b*	380 nm
4	A4	96.3874	-0.4074	2.2421	0.19891
8	B4	81.0137	-0.5723	0.1834	0.18220
12	C4	66.2969	-0.4362	-0.0763	0.15176
16	D4	50.8303	-0.6892	-0.2652	0.10867
20	E4	35.7241	-0.5221	-0.4658	0.06805
24	F4	20.7056	0.0243	-0.4456	0.03112
1	A1	38.3576	13.8007	14.6478	0.05493
2	A2	62.5588	35.1325	58.0519	0.05309
3	A3	28.6530	15.5990	-50.5170	0.06446
5	B1	66.0557	17.7349	17.8507	0.12119
6	B2	40.1778	9.5493	-44.2863	0.13163
7	B3	55.0460	-38.0898	31.6191	0.05145
9	C1	50.0902	-4.4084	-22.5088	0.14080
10	C2	51.7107	47.6918	16.8595	0.09833
11	C3	42.1824	54.8908	28.7870	0.04900
13	D1	43.2039	-13.4658	21.7317	0.05088
14	D2	30.3750	21.1297	-20.3068	0.09534
15	D3	82.2304	4.0453	79.8461	0.05589
17	E1	55.3555	8.8889	-24.8209	0.15820
18	E2	72.4918	-23.4640	57.0802	0.06011
19	E3	51.8197	49.7853	-13.9011	0.15466
21	F1	70.7003	-32.8942	-0.2372	0.14533
22	F2	71.9631	19.4836	67.9997	0.06234
23	F3	50.5546	-27.9750	-28.1359	0.11387

Ill.: D50 Obs.: 2 deg. Export...

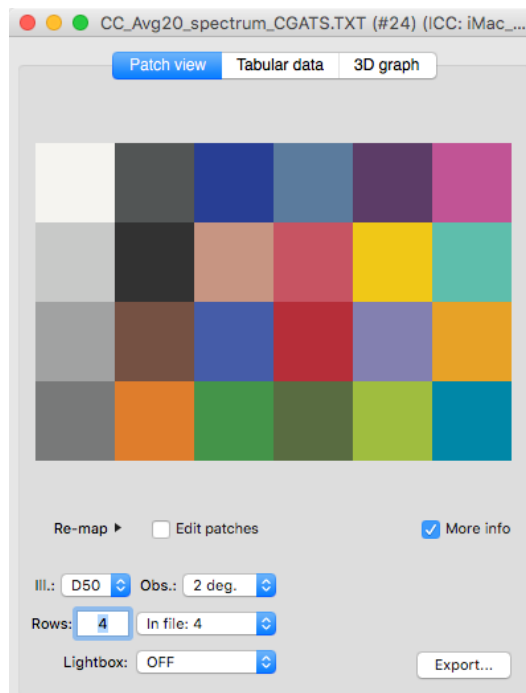
CMYK: SWOP2006\_Coated3v2 Relative Color... BPC

RGB: ecIRGB v2 Relative Color... BPC

Example: Row positions after clicking (on one of the selected rows) and dragging it to the table top.

For the purposes of the example, we have dragged the selected rows to the top of the table, as described in paragraph “iii” in the bottom of the preceding page. The resulting table is shown on the right, just above. Switching back to the “Patch view” tab, we can see that the neutral patches have moved to the first positions:

Example: The “Patch view” after dragging the selected rows as shown above. It should be compared to the layout shown on the preceding page.



In addition to the commands already presented on the preceding page, you can also:

- i- Unselect all rows by first making a simple click (left-click on a multi-button mouse) on any row, then **Ctrl + click** on the same row (**⌘ + click** on a Mac).
- ii- Select a range of rows by first making a simple click on the start of the range, then a **Shift + click** on the end of the range. Individual rows can further be added with **Ctrl + click** and **Ctrl + click & drag** (use **⌘** instead of **Ctrl** on a Mac).



## 2.2.7 The “3D graph” tab

Click and drag the mouse to change the viewing angle. Click and hold the “Shift” key and drag to change the position. Click and hold the “Alt” key and drag vertically to zoom.

Graph input selection

Color space selection. See the table on the next page for the spaces available in the 2D and 3D views.

Click to show/hide the graph tab controls.

Click on this arrow to open the popup menu shown below.

Polygons styles: wireframe; flat; smooth.

Data color

Data dot size (pixels)

Opacity

CC\_Avg20\_spectrum\_CGATS.TXT (#24) (ICC: PA24...)

Patch view Tabular data 3D graph

2D 3D Back: 127 L\*a\*b\*

<input type="checkbox"/> CMYK profile	flat	(auto)	100%
<input type="checkbox"/> RGB profile	flat	(auto)	100%
<input type="checkbox"/> spectrum input	3 px	(auto)	100%
<input type="checkbox"/> CMYK data	3 px	(auto)	100%
<input type="checkbox"/> RGB data	3 px	(auto)	100%

Copy (3D: L\*a\*b\*)

Paste

Display

Resolution

Reset

OpenGL version

Selections and position

Rendering settings

Window dimensions

All settings above

Hint: The “Display”, “Resolution”, and “Reset” controls are also available in the popup menu.

Additional settings are available when the file window is extended:

2D 3D Back: 127 L\*a\*b\*

<input type="checkbox"/> CMYK profile	flat	(auto)	100%
<input type="checkbox"/> RGB profile	flat	(auto)	100%
<input type="checkbox"/> spectrum input	3 px	(auto)	100%
<input type="checkbox"/> CMYK data	3 px	(auto)	100%
<input type="checkbox"/> RGB data	3 px	(auto)	100%

Rotation

Pitch - Pitch + Step

Yaw - Yaw + 10

Roll - Roll + (deg.)

Auto-Roll

None

Constant

Display

Axes

Axes box

2D gamut

Resolution

High

Medium

Low

Reset

Position

Rendering

All

The “3D graph” tab represents the data of the opened file in 3D or 2D views. The data selections and display settings associated to the 2D and 3D views can be different, and thus optimized, for each view

**Graph color spaces:**

- **2D:** L\*a\*b\*, xyY
- **3D:** L\*a\*b\*, xyY, XYZ, RGB

**Graph inputs:** You can select up to five graph inputs:

- 1- CMYK profile
- 2- RGB profile
- 3- **Input data used as color reference:** converted from spectral, L\*a\*b\*, xyY, XYZ, CMYK, or RGB data.
- 4- CMYK data
- 5- RGB data.

The CMYK and RGB profiles are displayed as polygons; the input, CMYK and RGB data is displayed as individual points.

Not all inputs may be available for a given file, as it depends, among other factors, on the presence or not of reference CMYK and RGB data in the opened file and the availability or not of a profile associated with the CMYK and RGB data. The table below shows the requirements for each graph input depending on the data type used for **color reference** in the file and on the selected graph color space.

File <b>Color Ref.</b>	Graph Inputs	Graph Color Space	
		L*a*b*, xyY, XYZ	RGB
<b>spectrum</b> <b>L*a*b*</b> <b>xyY</b> <b>XYZ</b>	CMYK profile	REQ. CMYK profile	REQ. CMYK and RGB profiles
	RGB profile	REQ. RGB profile	<b>YES</b>
	<b>"Color Ref." input</b>	<b>YES</b>	REQ. RGB profile
	CMYK data	REQ. CMYK profile	REQ. CMYK and RGB profiles
	RGB data	REQ. RGB profile	<b>YES (profile or extra-data)</b>
<b>CMYK</b>	CMYK profile	<b>YES</b>	REQ. RGB profile
	RGB profile	REQ. RGB profile	<b>YES</b>
	<b>CMYK input</b>	<b>YES</b>	REQ. RGB profile
	CMYK data	<b>NO (use CMYK input)</b>	<b>NO (use CMYK input)</b>
	RGB data	REQ. RGB profile	<b>YES (profile or extra-data)</b>
<b>RGB</b>	CMYK profile	REQ. CMYK profile	REQ. CMYK profile
	RGB profile	<b>YES</b>	<b>YES</b>
	<b>RGB input</b>	<b>YES</b>	<b>YES</b>
	CMYK data	REQ. CMYK profile	REQ. CMYK profile
	RGB data	<b>NO (use RGB input)</b>	<b>NO (use RGB input)</b>

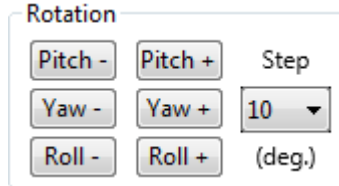
**YES** Input available. The checkbox is enabled.  
**NO** Input not available. The checkbox is disabled.  
 REQ. ... Input available if it meets the shown requirements.



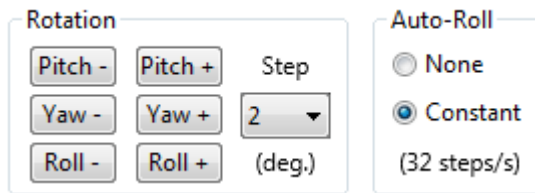
For more information on a given input, first select the window to bring it to the front, and then place your mouse cursor over the input text; after a moment, a Help tag with additional input info will appear:



**Fixed rotation steps:** Select a “Step” and click on one of the “Pitch”, “Yaw” or “Roll” buttons:



**Auto-Roll:** Select a small rotation angle step (1 to 5 deg.) and click on the” Constant” button. The targeted rotation rate is about 33 steps/s; the actual rate is shown below the “Constant” button. In the screenshot below the angular rotation rate is (32 steps/s) x (2 deg./step) = 64 deg./s or one complete turn (360 deg.) in about 5.6 seconds:



**Important:** For better comparison with other profile graphing applications, you should select “D50” as the “Illuminant” and “2 deg.” as the “Standard Observer” in the “Patch-View” or “Tabular data” tabs.

**Hint:** When RGB data is obtained from a [PatchTool built-in RGB profile](#), RGB values can exceed 255 or be less than zero. Such values represent out-of-gamut colors. For PatchTool built-in profiles, the XYZ-to-RGB and RGB-to-XYZ transforms are computed with an encoding algorithm based on the one described in [PIMA 7667:2001](#). You can readily check if RGB data points are outside of the nominal RGB gamut by selecting the “RGB” graph in the “3D graph” tab of the opened file and by selecting these two graph data checkboxes: “RGB profile” and the [third input selection checkbox](#) as presented in the table of the preceding page; this input can be labeled “spectrum input”, “L\*a\*b\* input”, “xyY input”, “XYZ input”, “CMYK input”, or “RGB input”. You will also notice that if you select the “RGB data” checkbox, the **displayed data will be clipped** to 0 and 255 even if the RGB data of the “Tabular data” tab contains negative values or values larger than 255. In other words, the **input data is NOT clipped** when displayed in the RGB space but the “RGB data” represents the clipped RGB values.

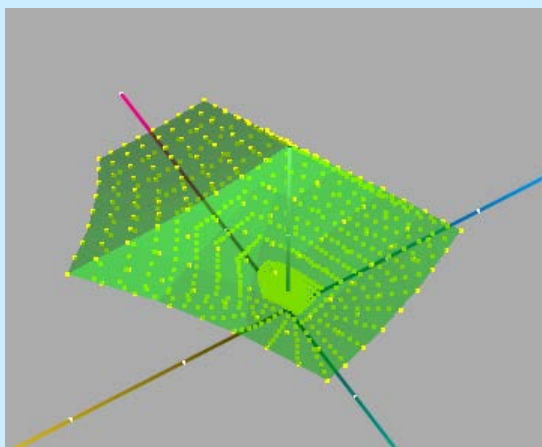
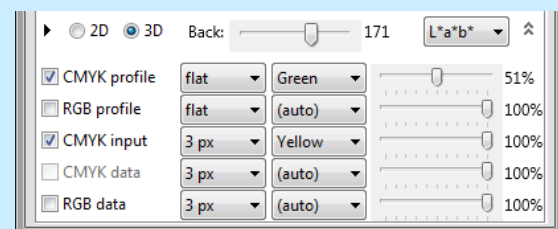
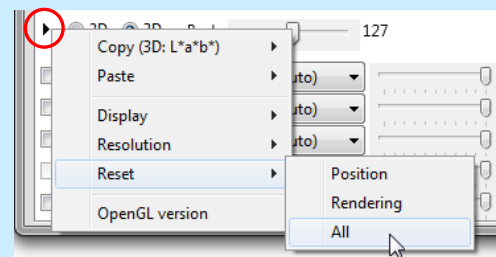
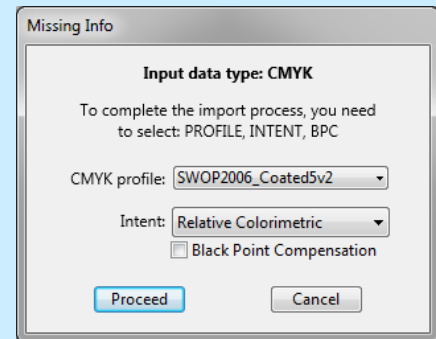
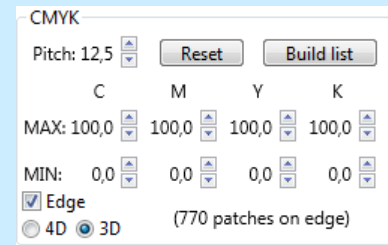
**Hint:** In each file, a maximum of one CMYK profile and one RGB profile can be viewed simultaneously. You can of course open multiple instances of the same file and associate different CMYK and RGB profiles, if applicable, in each file. Once these other files are opened, you can use the popup menu to copy and paste the “Selections and positions”, the “Rendering settings”, and/or the “Window dimension”, from one file to the others.

**Important:** If your file contains extra reference data, either RGB or CMYK, in addition to measurement data, you cannot view the extra data and the measurement data in the same graph. This is [by design in PatchTool](#) since only the “color reference” data, in this example the measurement data, can be processed through a CMYK or RGB profile and, if the file contains extra CMYK or RGB data, the extra profile processing cannot be done. To compare reference RGB or CMYK data with measurements, you should open each data type set in separate files and compare the two graphs in separate windows (separate files can be obtained with the [Export dialog](#)).

## Mini-tutorial: How to generate and view data points on the edge of a CMYK profile

In this tutorial we start with a list of CMYK points located on the edge of a CMYK profile (such a list may be used to generate and print patches which are then measured to verify the accuracy of a printing process). We open this list and assign it a CMYK profile. We visualize the data points relative to the CMYK profile and a RGB profile in the “3D graph” tab.

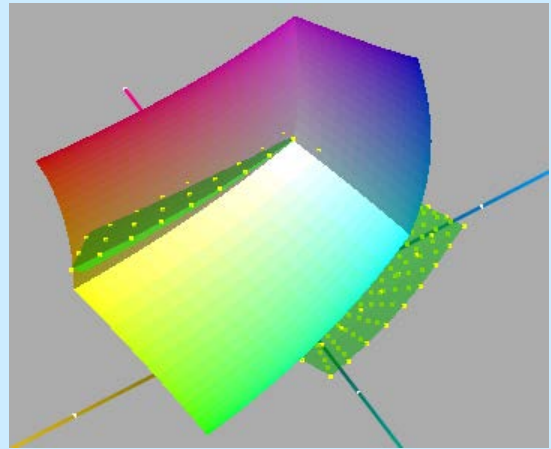
- 1- Open the “[Gamut Tools](#)” with the “Tools/Gamut Tools...” menu and click on the “[List gen.](#)” tab.
- 2- Set the CMYK list parameters as shown on the right. You will note that we have selected the “Edge” checkbox and the “3D” radio button; this selection insures that we will only get patches on the edge of the profile when visualized in the 3D L\*a\*b\* space. Selecting “4D” would result in many points **within** the 3D volume; you will find more information on the differences between the 3D and 4D selections in the section dedicated to [CMYK lists](#). When ready, click on the “Build list” button and save the file.
- 3- Close the “PatchTool Gamut Tools” dialog and open the list you generated in Step-2 by dragging the file on the “Open file / Drag&Drop” button of the main PatchTool window. When the “Missing Info” dialog opens, assign the “SWOP2006\_Coated5v2” CMYK profile with “Relative Colorimetric” intent and no Black Point Compensation.
- 4- Once the file is opened, go in the “Tabular data” tab. You will notice that the CMYK profile controls are disabled and set to the selections of Step-3. Select “sRGB (PatchTool)” in “Relative Colorimetric” for the RGB profile to be applied to the input (i.e. CMYK data). What happens here is that CMYK is used as the color reference; this input is converted to XYZ with the selected profile and it is those values which are converted to sRGB. Make sure the Illuminant is **D50**; this is important for proper rendering in the “3D graph” tab.
- 5- Select the “3D graph” tab. Reset the “Rendering” and the “Position” settings using either the “Reset/All” menu which appears when clicking on the black arrow on the left or by clicking on the “All” button located within the “Reset” control group which appears when extending the window width.
- 6- Select the “3D” graph type and the “L\*a\*b\*” color space, and then set the background level around “170” using the “Back” slider. Select “CMYK profile” and “CMYK input” as graph inputs. For the “CMYK profile”, select a “Green” color instead of “(auto)”, and lower the profile opacity to about 50%. For the “CMYK input” data, select “Yellow” for the data points color. Once the settings are done, the controls should look like the ones shown on the right.
- 7- You can optimize the graph view by changing the “camera” viewing position and the zoom angle.



- To zoom, press and hold the “Alt” key and drag the mouse cursor vertically within the graph window.
- To look around the profile, click and drag the mouse in the graph.
- To change the view point, press and hold the “Shift” key and drag the mouse cursor in the graph.

While you move around the graph you can see that the yellow data points are all located on the profile edge. This will be true for any CMYK profile that you select when opening the data list but the absolute position of the data points in L\*a\*b\* space will change according to the CMYK profile size.

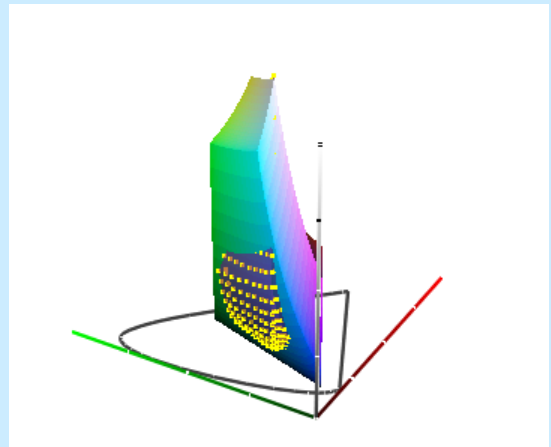
8- Now add “RGB profile” as input and change the profile resolution to “Medium” with the black arrow popup menu shown in Step-5. You will notice that some points of the CMYK profile extend outside of the RGB profile; this means that some colors within the gamut of the selected CMYK profile, in this case “SWOP2006\_Coated5v2”, cannot be exactly reproduced by the selected RGB profile (sRGB). This may be of importance if your display profile is sRGB, and essentially irrelevant if your display has an extended gamut close to Adobe RGB (try it by changing the RGB profile in the “Tabular data” tab). You could also select a printer RGB profile and do a similar check. In fact, if you intend to use a desktop RGB printer for proofing a press CMYK profile, you would be looking for an RGB profile which totally encloses the CMYK profile.



9- If you do not see the “Rotation” controls in the “3D graph” tab, increase the window width until they are visible. Now please make the following changes:

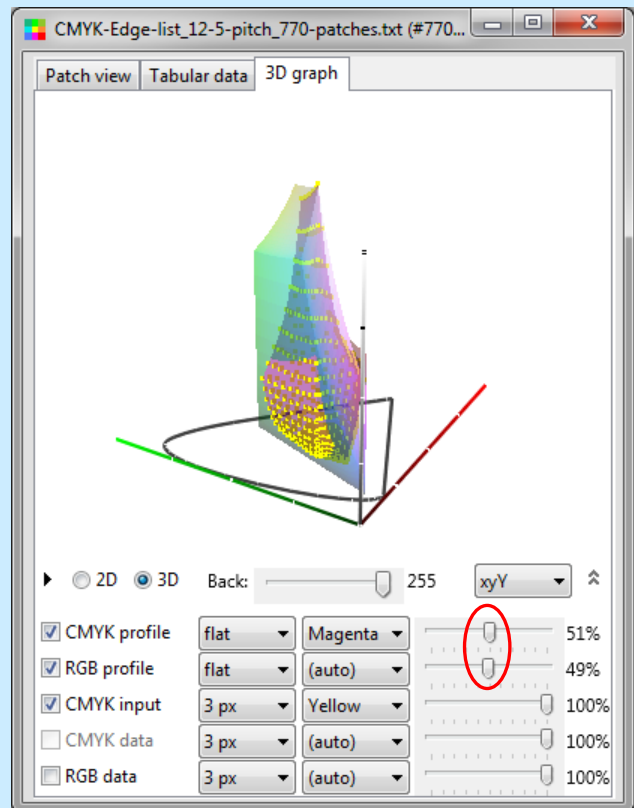
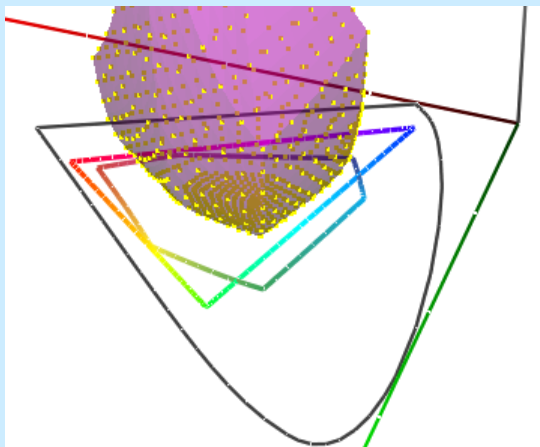
- Change the color space to “xyY”.
- Move the “Back” slider to 255 (i.e. white)
- Change the “CMYK profile” color to “Magenta”.
- Select 90 deg. in the “Step” menu (in “Rotation”).
- Click twice on the same “Roll” button.

The graph should look like the one on the middle-right.



10- Gently slide the “RGB profile” opacity setting towards zero while looking at the graph. You will notice that when the opacity of the “RGB profile” goes below the opacity of the “CMYK profile”, the CMYK profile becomes visible behind the transparent RGB profile. As a rule, the objects are rendered in increased opacity order, i.e. with the more transparent objects rendered first. Keep this rule in mind when you want to place emphasis on a particular graphic object.

11- Using the black arrow popup menu shown in Step-5, select the “Display/2D gamut” menu item. A projection of the selected profile(s) will be shown in the “xy” plane. Zoom, rotate and move the camera to get a better view. When this option is selected, you can even lower the opacity to zero and still get the projected 2D gamut. This is shown below with the RGB profile opacity at zero.





### 2.3 The “Compare” window

A “Compare” window is obtained with the “PatchTool Select Compare” dialog, with the [Display-Check](#) tool, and with a [Clip check](#) done with the [Gamut Tools](#). The window title indicates the type of compare (“PatchTool Compare-”, “Display-Check\_Compare-”, “Display-Check\_Quick-Test”, “Clip-check\_Compare-”) followed by a sequential number. In a Compare window, each patch square is made of two triangles, with the top one corresponding to the “reference” file. The bottom triangle represents the “sample”; the sample can be the file selected in the “PatchTool Select Compare” dialog, measurements made with the Display-Check tool, or the clipped data in a Clip check. Many features of the “Patch view” and “Tabular data” tabs are the same as the ones for a single file window ([Section 2.2](#)), and only the ones specific for the Compare window are presented here.

#### 2.3.1 The “Compare” “Patch view” tab

Each square is made of two triangular patches. A colored border is drawn when the color difference exceeds the selected thresholds.

reference  
sample

When the compare file is generated by the Display-Check tool, the title bar indicates the number of samples, the White Point luminance, in cd/m<sup>2</sup>, and the White Point CCT, in kelvin.

Select the thresholds to draw the colored patch borders, the border width, and the border color. Click [here](#) for more information.

To select the Delta parameter. See the [next page](#) for the list of parameters.

To select the color difference formula. Note: this selection is independent of the selection in the [Info](#) window.

The features of this window which are common to the single file window are described in [Section 2.2.1](#) (Patch view), [Section 2.2.5](#) (Tabular data), and [Section 2.2.6](#) (The interaction...).

The Lightbox can be selected either for the reference, the sample, or both. Click [here](#) for more information.

The yellow border indicates that the sample patch has a DeltaE\* difference, relative to the reference patch, larger than the user-set lower threshold of 2,0 but smaller or equal to 3,0.

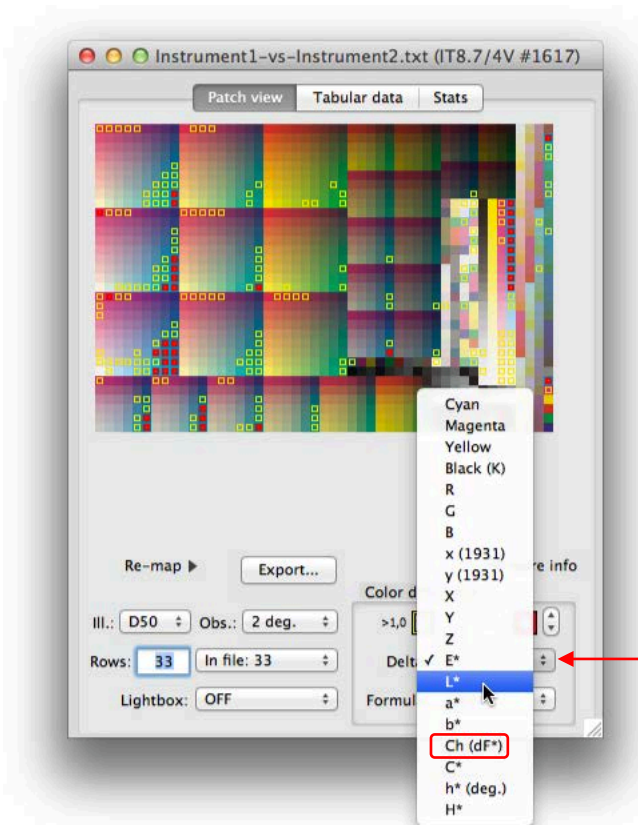
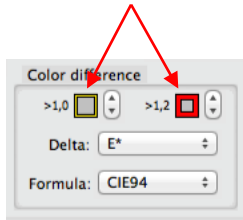
The red border indicates that the sample patch has a DeltaE\* difference, relative to the reference patch, larger than the user-set upper threshold of 3,0.



The presence and appearance of a colored border is linked to the following parameters:

- 1- The Delta parameter menu (shown below)
- 2- The DeltaE\* formula (“dE formula” menu), which affects the E\*, L\*, C\*, and H\* parameters
- 3- The thresholds values (individually adjusted for each Delta parameter, and kept as preferences)
- 4- All the settings of the “[Color difference](#)” tab in the “[Preferences](#)” dialog: CIE94/CMC reference mode, weight mode for Delta L\*C\*H\*, computation mode for Delta h, and sort using absolute Delta differences.
- 5- The Illuminant and Observer
- 6- The colored border width and color (see the options below)

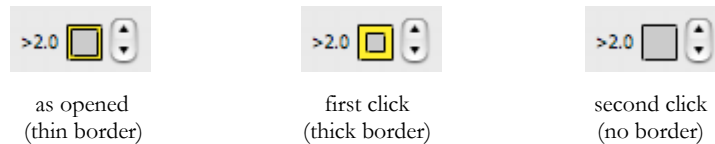
Click in the square to cycle through the border width options. Right-click (ctrl + click on a Mac) to open the color picker and change the border color.



“Ch” is the chromaticness, defined in DIN 55981, ISO 12646, and ISO/DIS 12747-8. It is better used to evaluate color differences for near neutral colors, typically with a Chroma (C\*) of less than seven. ΔCh is referred to with various symbols, such as ΔEc, ΔF\*, or Δs.

The Delta parameter menu.

The colored border width can be selected by clicking (left-click on a three-button mouse) on the threshold square. The first image on the left, below, shows the square appearance when the Compare file is opened; the setting corresponds to a thin border (the color may be different). Clicking once on the square will select a thicker border and clicking one more time will erase the border. Clicking on the square again will cycle through these three options. **Right-clicking** on a square (ctrl + click on a one-button Mac mouse) brings up the color picker where you can choose the border color.



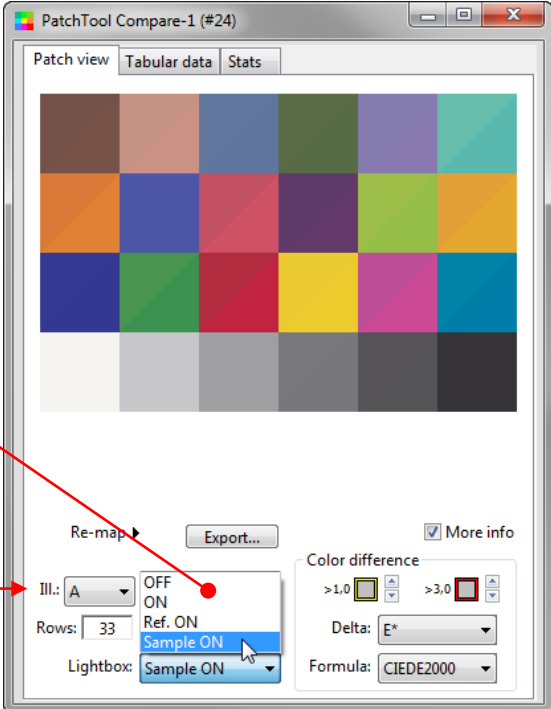
**Note:** The “[Tabular data](#)” tab identifies which patches correspond to the lower and upper thresholds selected here by assigning different colors to the table cells backgrounds.

**Note:** You can re-open the data of an [exported](#) Compare file. The re-opened Compare window should match the original window, provided you have selected enough data fields when exporting. We recommend exporting using at least the ID, Name, XYZ, spectrum (if available), and CMYK (if required) data fields. The re-opened Compare window will display all the tabs of the original file (“PatchView”, “[Tabular data](#)” and “[Stats](#)” tabs, as well as the “[Display data](#)” and “[xy graph](#)” tabs for a [Display-Check](#) made with a Quick-Test).

## Lightbox menu

Like the “Lightbox” menu present in the “Patch view” tab of single files, this tool can be useful to see how different illuminants will affect the appearance of the patches. However, when there are many patches, and because the differences can be subtle, it can be difficult to judge the changes. To facilitate this task, the “Lightbox” menu for Compare files is expanded to include the ability to select the lightbox only for the reference or only for the sample.

A typical use would be to select the same file for the reference and the sample, which requires opening the same file twice, and then selecting the “Compare” tool. Since the files are identical, there should be no differences between the patches and no colored borders around the patches. From there, we can, for example, see how the patches color would shift under tungsten lighting, or Illuminant A. By selecting “Sample ON” and Illuminant A as shown below, the bottom part of the patch is shown as if illuminated by Illuminant A and the top part as if illuminated by D50 (the reference “Lightbox” illuminant; please read the note below to see how this color is further converted for display purposes). Since Illuminant A has a higher proportion of red compared to D50, we see that the red and oranges are brighter whereas the greens and greenish-blues are darker, and the grays essentially not affected.



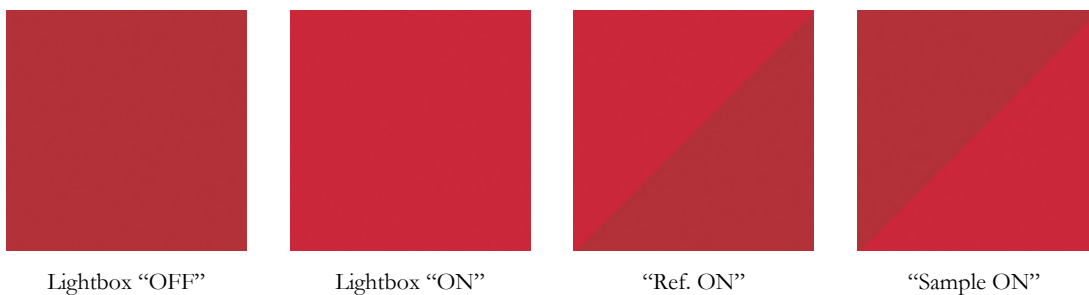
The screenshot shows the PatchTool Compare-1 (#24) window. The 'Patch view' tab is active, displaying a 4x6 grid of color patches. The bottom row of patches is split horizontally, with the top half being lighter and the bottom half being darker, illustrating the effect of the Lightbox setting. The control panel below the patches includes a 'Re-map' button, an 'Export...' button, and a 'More info' checkbox. The 'Color difference' section shows a scale from >1.0 to >3.0, a 'Delta' dropdown set to 'E\*', and a 'Formula' dropdown set to 'CIEDE2000'. The 'Lightbox' menu is expanded, showing 'Sample ON' selected. Red annotations point to the 'Lightbox' menu and the 'Sample ON' option, explaining that the 'default' illuminant is D50 and that the 'Sample ON' option is selected.

The Lightbox menu is enabled when spectral data is present for the reference and the sample.

Select the Illuminant for the Lightbox. The “default” Illuminant (i.e. Lightbox OFF) is D50.

This screenshot shows the appearance of the Compare window when the **SAME** file has been assigned to the reference and sample, and when the Lightbox is set to “Sample ON”, with Illuminant A.

The images below show the appearance of the red patch in the above screenshot resulting from the four lightbox settings:



**Note:** The “Lightbox” reference Illuminant, the illuminant used for spectral computation, is D50. This corresponds to the illuminant of the Profile Connection Space (PCS) in the [display profile](#). The display profile will perform other conversions to adapt this color to the monitor White Point. The color workflow for display purposes is further discussed in [Appendix B - PatchTool Color Management](#).

## Contextual menus

**STANDARD MENU**  
 Right-click on a patch (ctrl + click on a Mac) for this menu.  
 The Tab-delimited data can be pasted in separate spreadsheet columns or in a text document.

**ALTERNATE MENU**  
 Shift + right-click on a patch (shift + ctrl + click on a Mac) for this menu.  
 Spectral data will be inserted if the file contains such data.

**STANDARD MENU**  
 Right-click on a patch (ctrl + click on a Mac) for this menu.  
 The Tab-delimited data can be pasted in separate spreadsheet columns or in a text document.

**ALTERNATE MENU**  
 Shift + right-click on a patch (shift + ctrl + click on a Mac) for this menu.  
 Spectral data will be inserted if the file contains such data.

**STANDARD MENU**  
 Copy REFERENCE color: RGB  
 Copy REFERENCE color: CMYK  
 Copy REFERENCE color: L\*a\*b\*  
 Copy REFERENCE color: L\*C\*h\*  
 Copy REFERENCE color: XYZ  
 Copy SAMPLE color: RGB  
 Copy SAMPLE color: CMYK  
 Copy SAMPLE color: L\*a\*b\*  
 Copy SAMPLE color: L\*C\*h\*  
 Copy SAMPLE color: XYZ  
 Copy BOTH colors: RGB  
 Copy BOTH colors: CMYK  
 Copy BOTH colors: L\*a\*b\*  
 Copy BOTH colors: L\*C\*h\*  
 Copy BOTH colors: XYZ

**ALTERNATE MENU**  
 Rename the patch...  
 Assign the REFERENCE color to the SAMPLE  
 Assign the SAMPLE color to the REFERENCE  
 Replace the REFERENCE and SAMPLE with WHITE  
 Replace the REFERENCE and SAMPLE with 50% GRAY  
 Replace the REFERENCE and SAMPLE with BLACK  
 Replace the REFERENCE and SAMPLE with OSA-UCS background  
 Replace ALL patches over Delta thresholds with WHITE  
 Replace ALL patches over Delta thresholds with 50% GRAY  
 Replace ALL patches over Delta thresholds with BLACK  
 Replace ALL patches over Delta thresholds with OSA-UCS background

Color difference  
 >2,0  >4,0   
 Delta: E\*  
 Formula: CIE94

The minimum threshold is used for replacement. In the screenshot on the right, we see the result after ALL patches where DeltaE\* is larger than 2,0 have been replaced with BLACK.



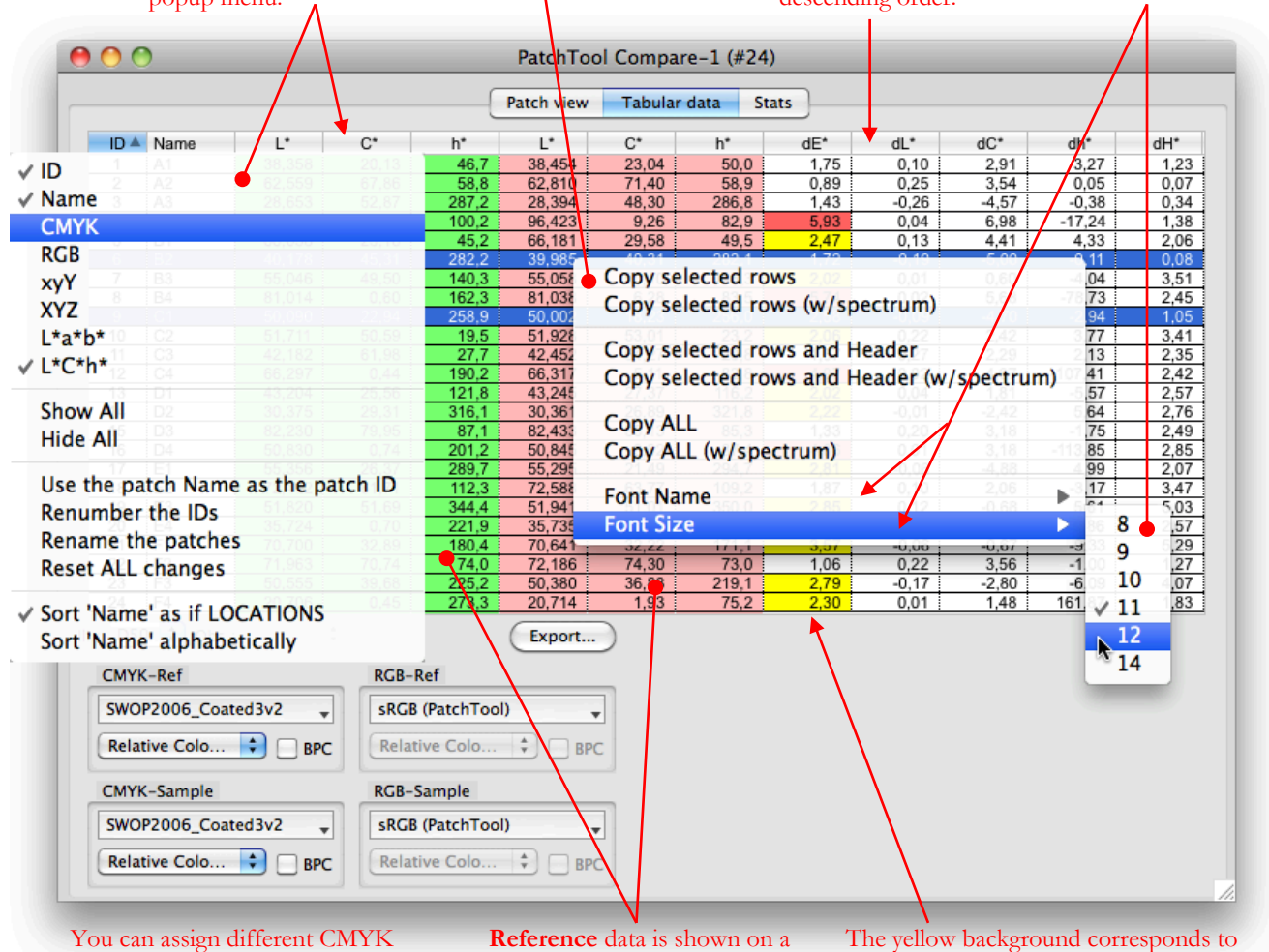
### 2.3.2 The “Compare” “Tabular data” tab

Right-click (ctrl + click on a Mac) anywhere on the table top row (the Header) for this popup menu.

Right-click on any cell (ctrl + click on a Mac) for this menu.

Click on a column Header to sort the table according to this column data in ascending or descending order.

Use these menus to select the table font and font size.



You can assign different CMYK and RGB profiles to the Reference and Sample (if data with these color spaces was not imported in a file).

Reference data is shown on a green background and sample data is shown on a light-red background.

The yellow background corresponds to the lower threshold set in the “Patch view” tab, while the red background corresponds to the higher threshold.

While it is not possible to view spectral data in the “Tabular data” table of a Compare file, this data is still used internally if present in the reference or sample files which are compared. Thus, it is possible to copy the spectrum of selected patches in the clipboard, to see it in the “Info” window, and to export it to a file.

See [Section 2.2.5](#) for more information on the menu commands which are common with the single file window. See [Section 2.2.6](#) for instructions on how you can manipulate the position of individual patches or group of patches with the table.

The values shown in the “delta” columns are affected by the following settings:

- 1- The [Delta parameter](#) menu (available in the “Patch view” and “Stats” tabs)
- 2- The DeltaE\* formula (“dE formula” menu of the “Patch view” and “Stats” tabs), which affects the E\*, L\*, C\*, and H\* parameters
- 3- All the settings of the “Color difference” tab in the “Preferences” dialog: CIE94/CMC reference mode, weight mode for Delta L\*C\*H\*, computation mode for Delta h, and sort using absolute Delta differences.
- 4- The Illuminant and Observer

### 2.3.3 The “Compare” “Stats” tab

The histogram, in orange, and its envelope, in green.

The scale for the number of samples in each bin.

The scale of the Delta differences.

The Cumulative Relative Frequency (CRF) graph and its scale. When in purple, the graph **always** corresponds to the “Max error” numbers shown below (click [here](#) for more info). In this screenshot, 50% of the samples, i.e. the median, have an error of 0,72 or less, and 95% of the samples have an error of 1,82 or less.

Check this box to view the CRF graph.

To select the stats parameter.

To select the color difference formula. Note: this selection is independent of the selection in the Info window.

The maximum error for the indicated percentile amount of the best samples.

The “Cert. report” button appears when IT8.7/4 or TC1617x (IT8.7/5) files are compared. The report is used for printer and monitor proofing certification (Section 3.14), and to check G7 Colorspace P/F requirements (Section 3.15)

Average		Sigma	
All samples:	0,82	All samples:	0,61
Best 90%:	0,67	Best 90%:	0,31
Worst 10%:	2,18	Worst 10%:	0,87

Max error	
10th perc.:	0,28
Median:	0,72
90th perc.:	1,34
95th perc.:	1,82
All samples:	5,49

No. samples: 1617

This tab shows statistical information on the differences between the reference and sample data for the selected “Delta” parameter. Any change of the delta parameter or the “dE formula” formula will also be applied to the “Patch view” and “Tabular data” tabs.

The main graph is a histogram of the difference values for the selected delta parameter. The horizontal axis is separated in “bins” of fixed sizes which are used to categorize the differences. The vertical axis represents the number of patches which fall in each bin. The bin size is shown below the graph; you can add or reduce the bin number, and thus change the bin size, by clicking on the “More bins!” and “Less bins!” buttons. A green line joins the bin values at the bin center, giving an idea of the histogram “envelope” shape.

#### Average data group

The **Average** data group shows the average for “All samples”, for the “Best 90%” of the samples, or for the “Worst 10%”. The “Best 90%” value is useful when there are a few samples with very large errors, often called “outliers”, which distort the statistics. The outliers’ presence can be judged by comparing the average of “All samples” with the one of the “Best 90%”; if these two values are very different, then you likely have a few outliers in your data set. In such a situation you can sort your data in terms of color difference by clicking in the header of the “Tabular data” tab and see if the samples are worth more consideration; if these outliers can be discarded, you should use the average value of the “Best 90%” as your result.

### Sigma data group

The **Sigma** data group shows the *Standard Deviation* associated with the samples shown in the average data group. Statistically, you should find 66% of your samples in a range equal to the average plus or minus one sigma. The sigma of the “Best 90%” of your samples will always be smaller than the sigma for all samples, since the variation for best samples is accordingly smaller. The sigma for the “Worst 10%” may or may not be bigger than the sigma for all samples since you could very well have all outliers at the same place, i.e. showing a large difference relative to the average value, but not much difference within themselves.

### Max error data group

The **Max error** data group shows the maximum error for the portion (percentile) of the samples indicated, when ordered from best samples to worst samples. Accordingly, the maximum error for the “10th perc.”, or the best 10% of the samples, will always be smaller than the error for the “Median” (the best 50% of the samples, i.e. the 50<sup>th</sup> percentile), and so on. You may be surprised that we give data for the 90<sup>th</sup> and 95<sup>th</sup> percentiles as well as for “All samples” (i.e. 100<sup>th</sup> percentile), since they are quite close to one another, but this is done for two reasons:

- i- The 90<sup>th</sup> percentile maximum error corresponds to the samples used for the “Best 90%” average and “Best 90%” sigma values.
- ii- The 95<sup>th</sup> percentile is used as a “GO/NO-GO” threshold in many protocols, including the [Idealliance proofing programs](#) for printers and monitors and the [G7 Colorspace Pass/Fail Requirements](#).

### CRF checkbox

Checking the “**CRF**” checkbox will add a graph with the *Cumulative Relative Frequency*, which is simply the sum of all the bin values; a minimum of six samples is required to show a graph. The CRF counting starting point is:

- i- The leftmost bin when the “Absolute” and “Separate Neg / Pos stats” checkboxes are NOT selected. The 100% CRF value then represents the sum of all negative and positive samples. You can see an example on the bottom-left of the next page.
- ii- The zero position on the horizontal axis when the “Absolute” and “Separate Neg / Pos stats” checkboxes are selected. If the “Absolute” box is selected, the 100% CRF scale represents the total number of samples. If the “Separate Neg / Pos stats” box is selected, then there are separate CRF graphs for the negative and positive samples, with 100% CRF representing the total number of negative and positive samples. You can see examples on the previous page and on the bottom-right of the next page.

**Important:** The values shown in the **Max error** data group correspond exactly to the CRF curve(s) when the “Absolute” or “Separate Neg / Pos stats” options are selected. As a guide, you will see that the CRF curve is of the same **purple** color as the one used to display the **Max error** numbers. Of course, **if there are only positive differences, the Max error numbers will also match the curve**, even if these two boxes are not selected; however, in this case, the CRF curve will remain gray.

The CIE94, CMC and CIEDE2000 color difference formulas weigh the L\*, C\*, and H\* differences in order to compute the total color difference. By selecting the “**L\*C\*H\* weighted**” checkbox, you can use the weighted values instead of the nominal values when computing the statistics. This is the same choice as the one offered in the “[Color difference](#)” tab of the “[Preferences](#)” dialog but it only applies to the “Stats” tab data.

Most of the delta parameters can result in a mix of negative and positive errors, with DeltaE\* a notable exception. With a mix of negative and positive values, the average error can well be near or at zero, even with large negative and positive errors; nonetheless, you can analyze your data as if considering the absolute value only by selecting the “**Absolute**” checkbox. You can also perform a separate analysis on negative and separate data by selecting the “**Separate Neg / Pos stats**” checkbox; you will then have separate averages, sigmas, and max errors for the negative and separate data sets (you can see an example on the next page). Please note that a minimum of six samples is required to obtain all statistics, and that reliable statistics require at least 20 samples or so.

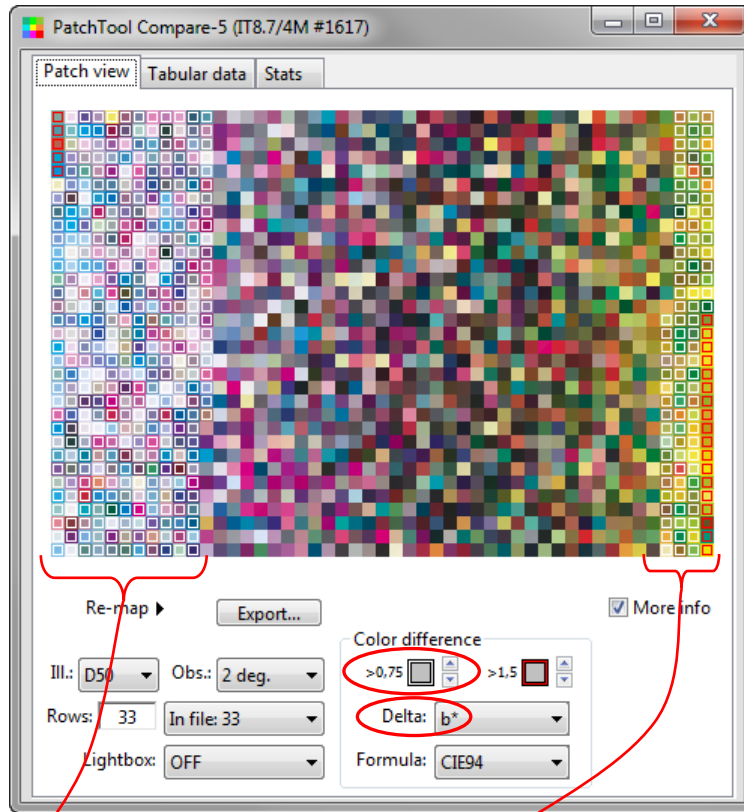
You can save a report for the currently selected Delta parameter by clicking on the “**Stats report**” button; you may want to save reports for other parameters. The “**Cert. report**” button appears when IT8.7/4 or TC1617x (IT8.7/5) files are compared; click this button to get a certification report relative to [Idealliance printer and monitor proofing \(Section 3.14\)](#) or to [G7 Colorspace Pass/Fail requirements \(Section 3.15\)](#).

**Example:**

This example compares the measurements of the same IT8 target with two spectroradiometers.

To obtain the following Patch view display, we first unchecked the “Sort using the ABSOLUTE Delta values” checkbox in the Preferences dialog. We then sorted the patches in increasing Delta-b\* order by clicking the db\* column title in the “Tabular data” tab. Finally, we checked the “Sort using the ABSOLUTE Delta values” preference, but without re-sorting the patches display.

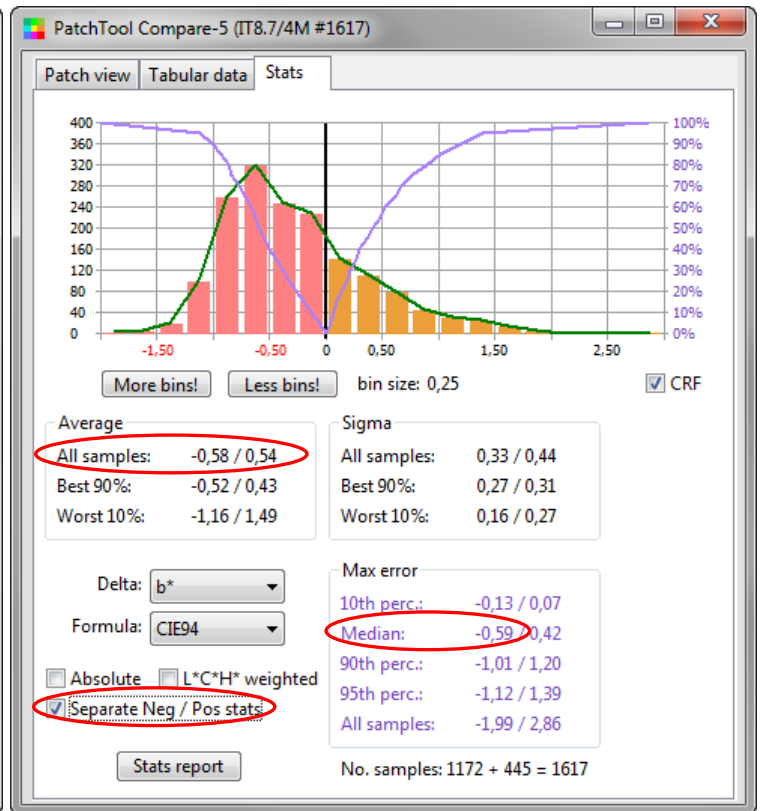
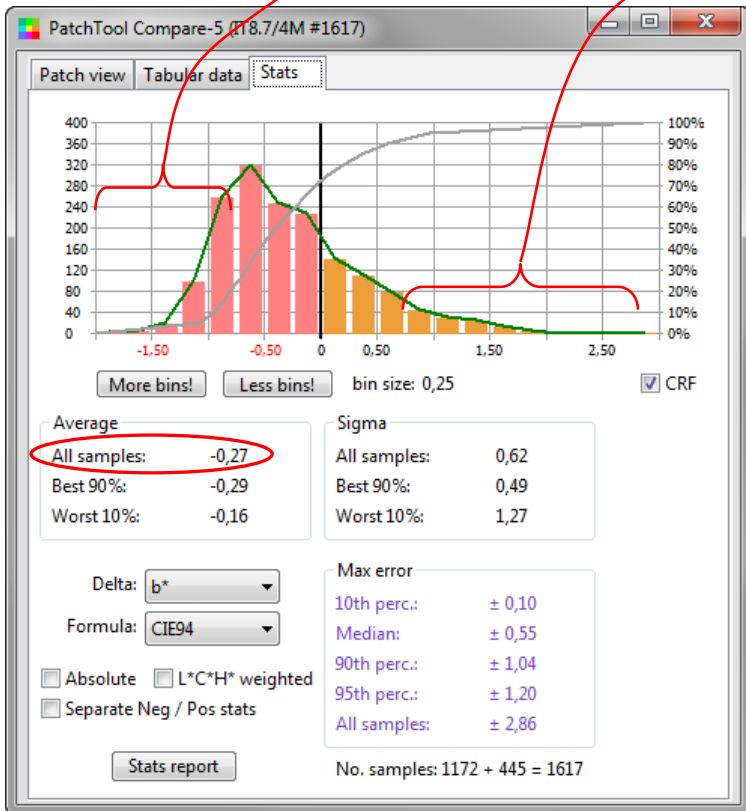
The most negative errors are on the left side while the most positive errors are on the right side. Patches with errors more negative than -0,75 or larger than 0,75 are shown with a border.



**Analysis:**

We see that the largest negative Delta-b\* errors are for bluish patches while the largest positive errors are for yellowish patches. Thus, both the blue and yellow patches are shifted in the same direction (less yellow, more blue).

The overall histogram has a clearly negative average (-0,27), which confirms the blue shift. We can also look individually at the negative and positive errors and see the statistics for each color group. As shown on the bottom-right, the average negative shift (-0,58) is about the same as the average positive shift (0,54). The average for the negative side also corresponds to the median (-0,59 for CRF=50%) and to the histogram peak for the negative side.



2.3.4 The “Compare” “Display data” tab

To select the Y-axis (measured values) for the TOP graph.

To select the Y-axis for the BOTTOM graph. The bottom graph shows data corresponding to the neutral ramp only (N only).

The White Point CCT and its luminance, the black level, and the display contrast ratio (= White luminance / black level).

Check the box to see a reference curve for the selected parameter(s) (TOP graph only).

Check this box to draw links between the data points.

Check the boxes to see the neutral and/or R, G, and B data. The RGB boxes are shown only if the primaries were measured.

To select the common X-axis (reference values) for the graphs.

The source profile used as reference.

This “Display data” tab is shown only when the compare file is generated from a **Quick-Test** [Display-Check](#).

**Note:** Starting with PatchTool Version 3.0, the “Display data” and “xy graph” tabs are re-generated when you re-open [exported](#) data from a Quick-Test.

Two graphs are shown simultaneously. The **X-axis**, representing the **reference** values, is common to both; the two **Y-axes** represent **measured** values. The graph coordinates selections are as follow:

X-axis (reference)	Y-axis (measured) TOP graph	Y-axis (measured) BOTTOM graph
1- RGB	4- RGB	8- Correlated Color Temperature (CCT)
2- L*	5- L*	9- Delta-CCT (relative to white)
3- Y	6- Yabs (absolute Y in cd/m <sup>2</sup> )	10- Delta-RGB
	7- Yrel (relative Y with Ymax = 100)	11- Delta-L*
		12- Delta-Yabs
		13- Delta-Yrel



The X-axis coordinates are determined relative to the **source profile**; the source profile name appears beside the X-axis selection menu. In addition, L\* and Y are chromatically adapted to D50.

The measured Y-axis RGB coordinates are expressed in reference to the source profile, and the L\* and Y coordinates are also chromatically adapted to D50; by doing so, the reference and measured data are compared on common grounds. Please consult [Appendix B - PatchTool Color Management](#) for more information on how the reference data is derived.

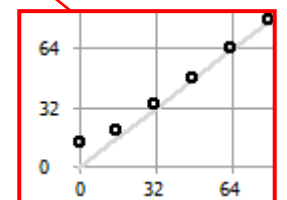
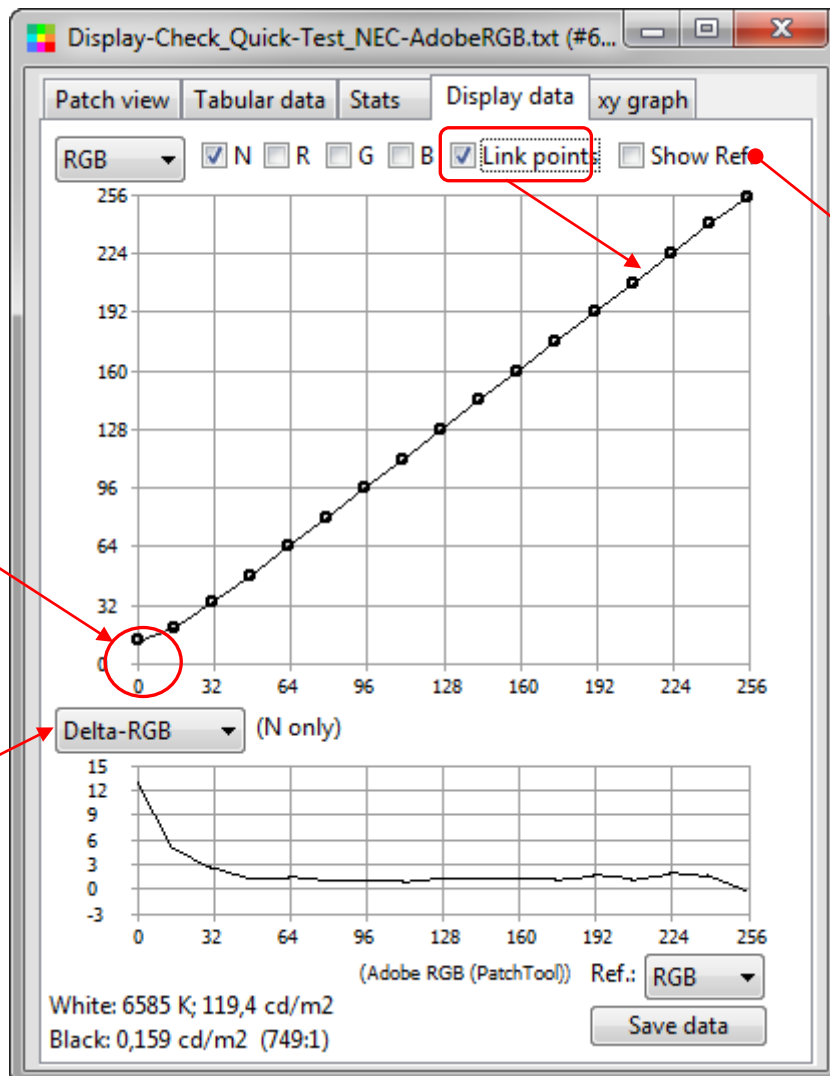
The TOP graph can display the data corresponding to the neutral gray ramp as well as the data corresponding to the individual R, G, and B primaries' ramps, if measured (RGB measurements are obtained by selecting any menu item comprising "Neutral + RGB" in the Display-Check [Quick-Test](#) menu). The BOTTOM graph only shows data relative to the neutral ramp; if required, you can also derive "Delta" data for the primaries from the numbers contained in the report generated by clicking on the "Save data" button. This report, like all PatchTool reports, can be opened in a text editor or a spreadsheet application.

Check the "Link points" checkbox to draw a line between each measured data point. You can also select the "Show Ref." checkbox to see the reference data in addition to the measured data; the reference curve will be shown as a solid line of a lighter tone. To better see the difference between the measurements and the reference, you can also select the corresponding Delta-parameter in the bottom graph, as shown in the example below and the one on the next page; this is particularly helpful for well calibrated display systems where the measurements are very close to the reference values.

**Important:** In a Display-Check, the RGB values shown in the "Patch view" tab are the values sent to the display while the measured RGB values in the "Display data" tab are derived from the measurements, and thus will show any display black point pedestal.

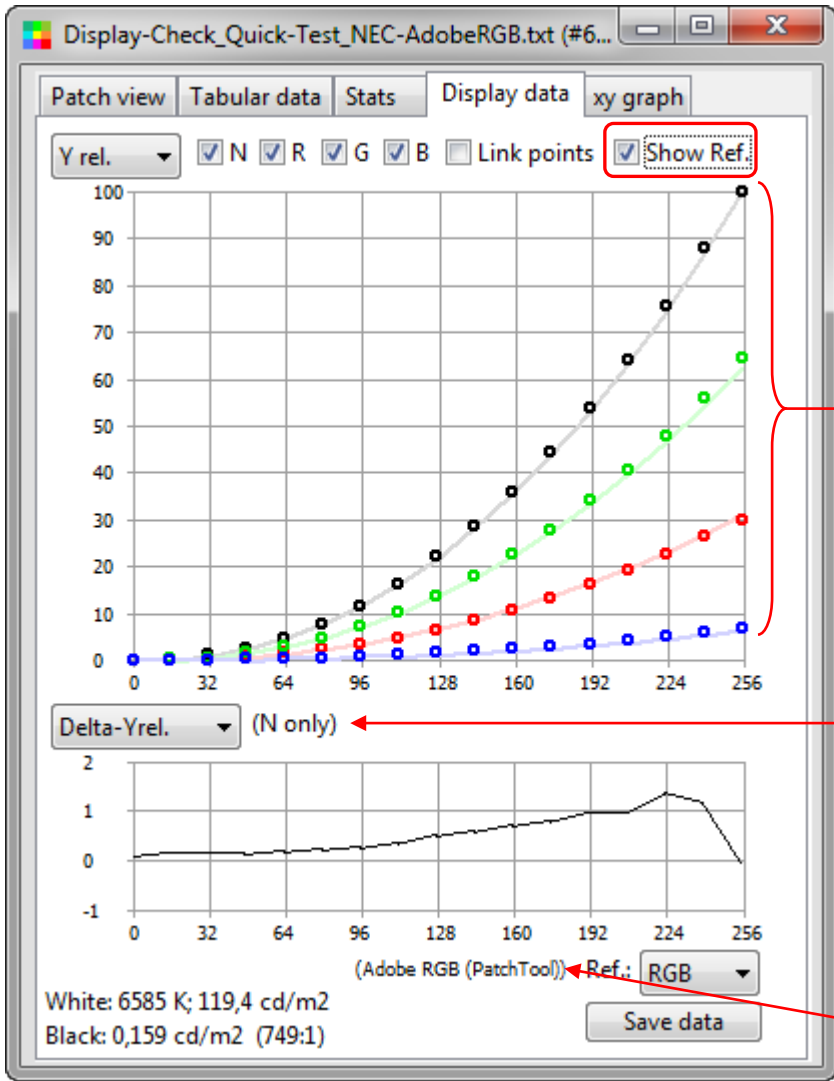
Here we see the effect of the black point pedestal.

To better evaluate the difference between the measurements and the reference, select the corresponding "Delta" menu item.



The reference is shown as a solid line of lighter tone.

In the screenshot of the previous page, you will notice that the measurement corresponding to RGB = 0 is not zero. The offset is due to the non-zero black level of the measured monitor, with RGB  $\approx$  13 as we see in the Delta-  
 RGB graph. Please consult [Appendix B - PatchTool Color Management](#) for more information on how the reference data is derived. The screenshot below shows the luminance of the neutral ramp and of each primary ramp as we increase R, G, and B (all three coordinates are equal for the gray ramp); we see a very good match between the measurements and the reference curves. This graph also nicely illustrates that the neutral ramp luminance is approximately equal to the sum of the luminance of each primary (Note: In this specific example below, the sum would be equal if we had a perfect Adobe RGB display with ideal chromaticity primaries).

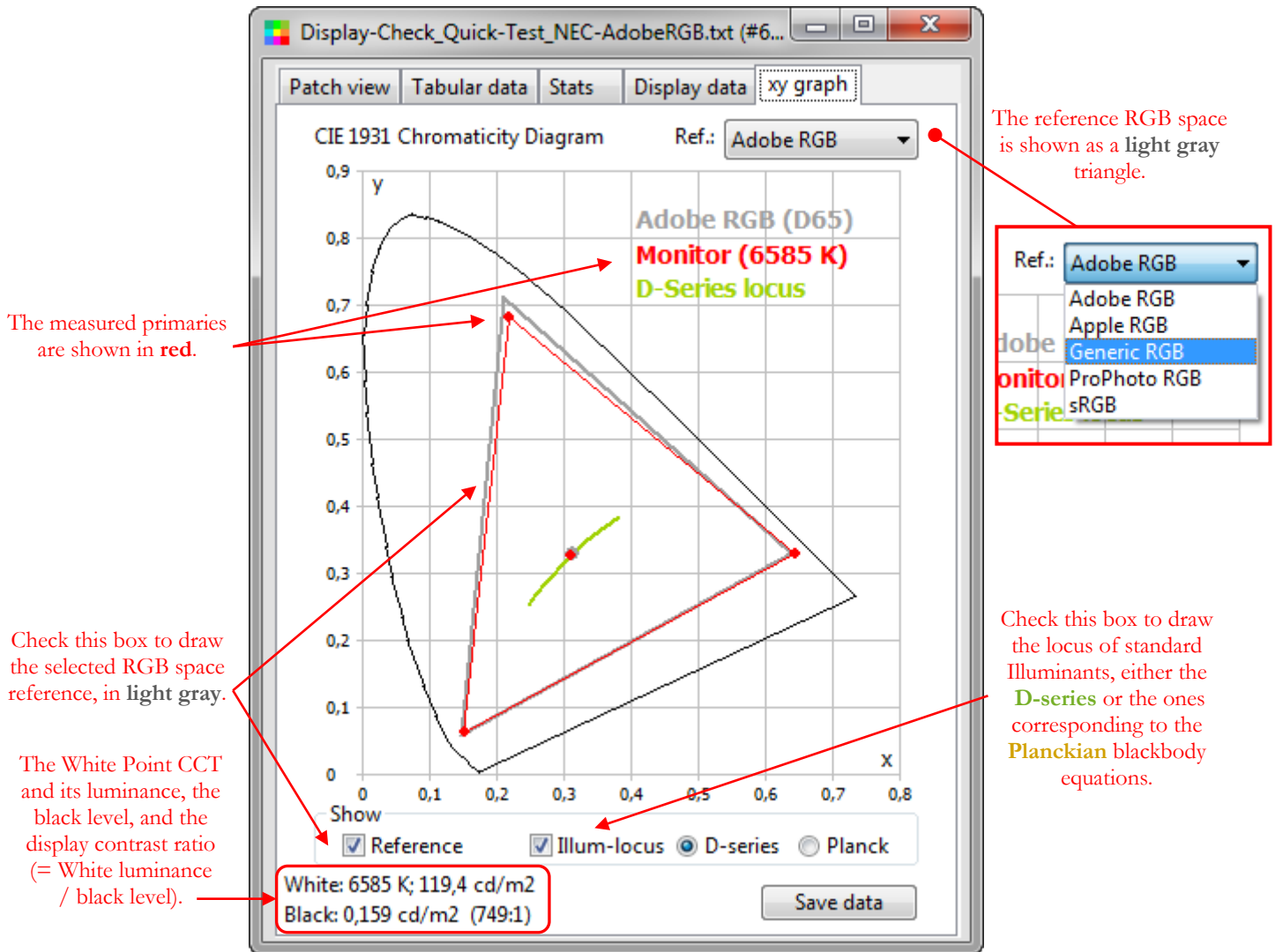


The luminance of the neutral ramp and of each primary ramp as we increase R, G, and B. The references are shown as solid lines. The closeness of the measurements relative to the references is indicative of a well calibrated display system.

To better evaluate the difference between the measurements and the reference, select the corresponding "Delta" menu item.

The source profile used as reference.

### 2.3.5 The “Compare” “xy graph” tab



This “xy graph” tab is shown only when the compare file is generated from a **Quick-Test Display-Check**, and when both neutral and RGB ramps are measured; these combined ramps are shown as “Neutral + RGB” in the Display-Check **Quick-Test** menu.

**Note:** Starting with PatchTool Version 3.0, the “xy graph” and “Display data” tabs are re-generated when you re-open [exported](#) data from a Quick-Test.

The measured primaries chromaticity coordinates and the display White Point are shown with red dots. You can compare your measurements with one of five reference RGB spaces, displayed as a light gray triangle, and see where your display White Point falls on the D-series or blackbody Illuminants loci. In this tab, the **D-series** locus (shown in the screenshot above) extends from 4000 K to 25000 K (i.e. from D40 to D250), and the **Planckian** blackbody curve extends from 2000 K to 25000 K; because it starts at 2000 K instead of 4000 K, the Planckian locus stretches farther to the right in the diagram.

The chromaticity coordinates of your display primaries should ideally be located on the vertices of the reference space triangle. Also, unless you have special requirements, your display White Point should ideally be located on the D-series locus. Please note that, by definition, the D-series locus is positioned slightly higher than the Planckian locus on the chromaticity diagram.



## 2.4 The “Info” window

File and patch info.

The CMYK profile currently selected in the file, if known.

Click on these arrows to show or hide the data displays.

The Density Status selected in the “Preferences” dialog.

Click on the arrow to show or hide the spectrum.

The LEFT sample spectrum is always drawn in green.

Frozen sample.

Mouse over another sample (NOT frozen).

The Illuminant and Observer currently selected for each patch.

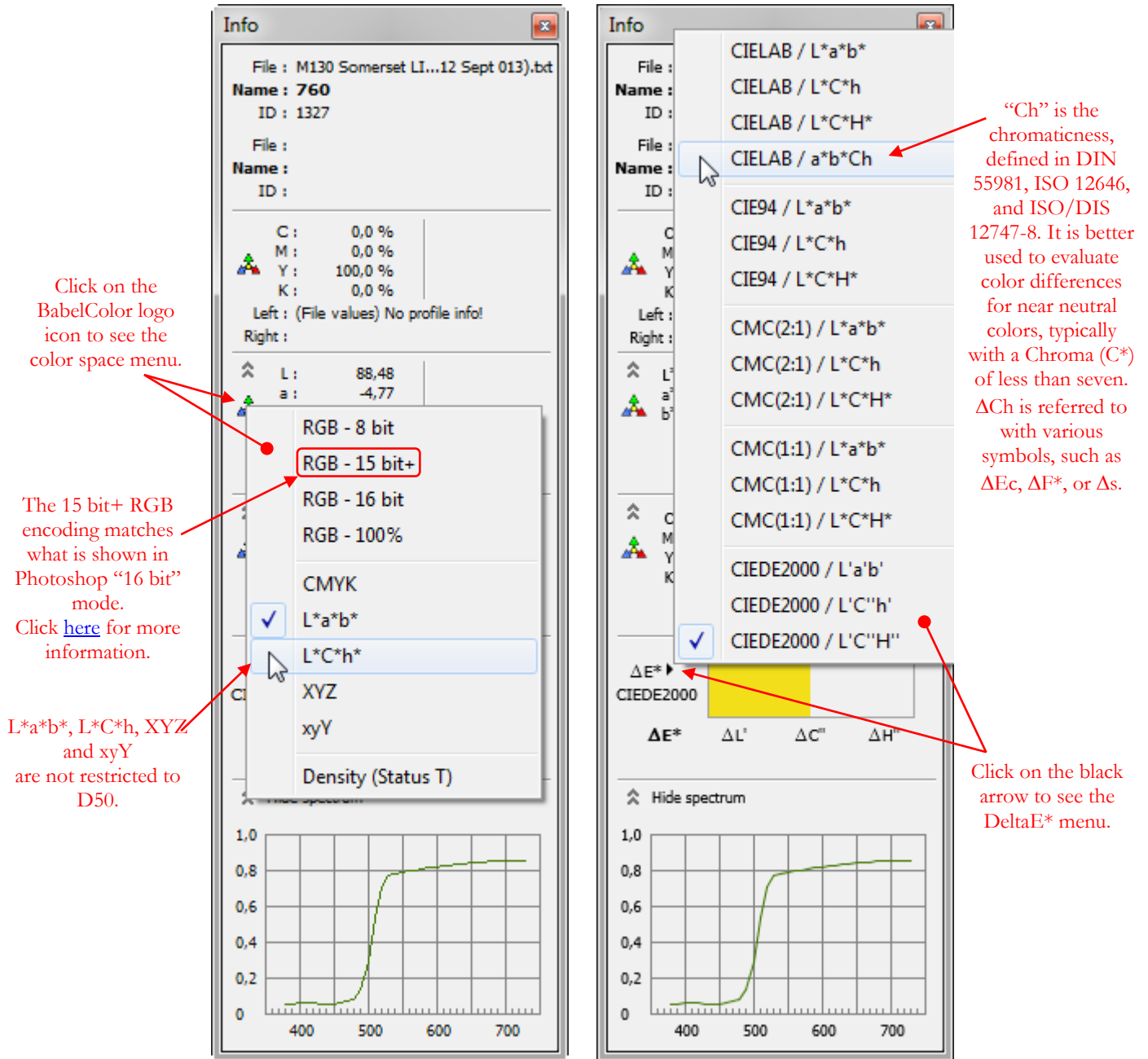
The RIGHT sample spectrum is always drawn in red.


Click and drag an edge or a corner of the window to enlarge the graph zone.

The “Info” window can show the colorimetric data of one or two patches simultaneously. These patches can be from the same file/window, or from two different files/windows, as shown in [Section 2.4.1](#). In the case of a “Compare” file, the data is always from the same “window” since a “Compare” window is a composite of two files.

The image on the left shows the info window when no patch is “frozen”, i.e. no patch has been clicked-on with the mouse. The Info data is updated as the mouse moves over the patches. The image on the right shows what happens when one patch is frozen and the mouse is moved to another patch of the same file. The frozen patch is identified in the “Patch view” tab of the file window by a slightly larger black or white border (the shade is selected according to the patch Lightness ( $L^*$ ) in order to maximize contrast). The frozen patch is ALWAYS shown on the left side of the Info window. To unfreeze a patch, just click on it. If you have some difficulty finding the frozen patch, simply click on any patch twice; the Info window will then revert to the single patch mode.

The next screenshots show the color space and color difference pop-up menus.

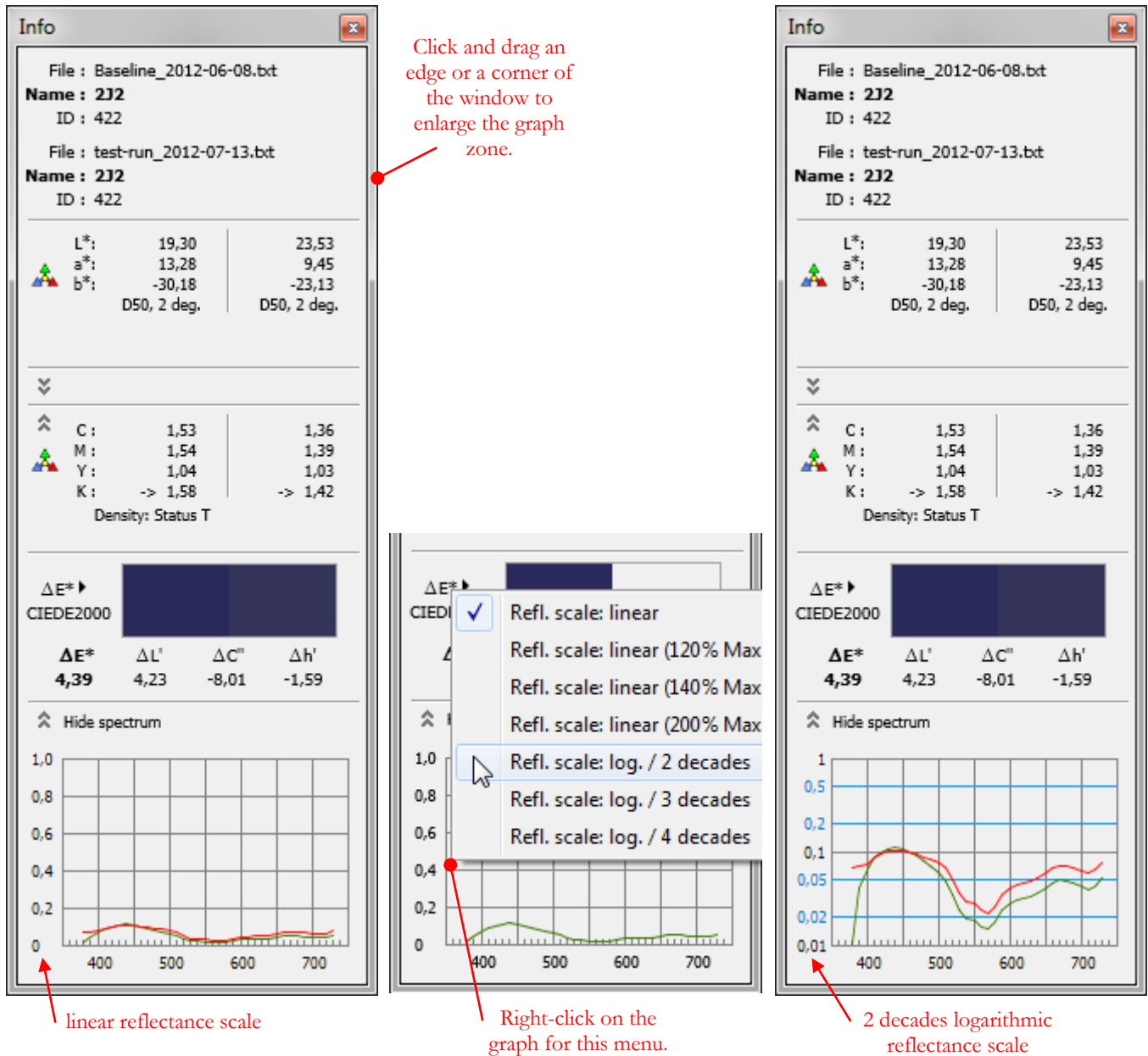


To select the color space for the display data, click on the small BabelColor icon (); this will open the popup menu illustrated on the upper-left screenshot. The "15 bit+" RGB selection displays the values as they would appear if the color list was exported as a 16 bit image and opened in Photoshop; see the "Behind the scene: ["15 bit+" RGB](#)" box for more information.

Whenever two patches are selected, their color difference is computed and displayed according to the selected DeltaE\* ( $\Delta E^*$ ) menu, which can be accessed by clicking on the black arrow located besides  $\Delta E^*$ . The DeltaE\* popup menu is illustrated on the upper-right screenshot. Additional options which affect how the color difference is computed and displayed are available in the "[Preferences](#)" dialog. See the "Behind the scene: [Color differences](#)" box for more information on the meaning of these numbers.

The spectral reflectance can be displayed using a **linear** scale or a **logarithmic** scale. To change the scale, do a right-click on the graph and select the required format from the contextual menu. There are four linear scales, with three of them extending to more than 1.0, i.e. more than 100% reflectance, to better see the effect of fluorescence.

The 2 decades logarithmic scale extends from 0,01 (i.e. 1%) to 0,1 (i.e. 10%), with blue lines defining the 2% and 5% reflectance levels, and from 0,1 to 1 (i.e. 100%) with blue lines defining the 20% and 50% levels. The 3 and 4 decades logarithmic scales go down to 0,001 and 0,0001 respectively. The logarithmic scales are useful to better discriminate the spectrum of dark colors as we see in the screenshots below, where the same patches are seen with each scale.



**Hint:** Click and drag an edge or a corner of the window to enlarge the graph.

The next section presents how to navigate between multiple windows where patches may or not be frozen. An interesting feature of PatchTool is its ability to compare patches from different files. This is done by freezing one patch in one window and moving the mouse to a patch in another window.

We will then see how to get a [screenshot](#) of the Info window.

### Behind the scene: “15 bit+” RGB

If you ever used Adobe Photoshop with 16 bit RGB images, you know that the RGB values shown in the program Info window are in fact 15 bit values. However, since the 15 bit integers are derived from 16 bit integers, rounding is required for odd values. This rounding, always to the next integer, introduces a small difference compared to values which would have been converted to 15 bit using all the available precision (of XYZ or  $L^*a^*b^*$ ).

For example, let’s see how 65535 is represented in Photoshop. This number is the maximum decimal value represented by a 16 bit number, and assigning it to R, G, and B corresponds to pure white. When this number is processed in Photoshop, it is divided by two, i.e. = 32767,5, and rounded to 32768, the next integer. If the file was in “pure” 15 bit format, this value would be impossible, since the maximum value represented by a 15 bit number is 32767. Computing the value directly in 15 bit, starting with the same high precision data, would have given us the correct maximum value of 32767; however, there is no common file format using 15 bit RGB encoding.

Overall, when you start with a high precision (non-integer) XYZ decimal number, and you first convert it to 16 bit RGB integers, and then convert it to a 15 bit value as per the procedure described in the preceding paragraph, you see that the resulting number is either equal to the one that would have been obtained with a file directly encoded in 15 bit, or plus one, thus the “+” sign we add to “15 bit”.

In practice, the difference between the exact 15 bit value and the one shown in Photoshop is not discernable. However, in order to “match” the values shown in Photoshop, the 15 bit+ values shown in PatchTool emulate the Photoshop conversion.

You will see that 15 bit+ is also offered as an encoding option when [exporting data](#) in PatchTool. This was done, again, to match the displayed Photoshop “16 bit” values. However, you should know that when such data is imported back in PatchTool, it is impossible to know which values have been “rounded up” and which ones should not have been rounded (except for 32768!). This explains why the “15 bit” encoding option shown in the “[Missing Info](#)” window has no “+”.

If you are concerned of losing precision, you can export RGB data in either 8 bit or scaled to 100%; for these two encodings, the data is not rounded to integers but exported with decimal precision

### Behind the scene: Color differences

Color differences only make sense when computed for the same illuminant and the same observer. Accordingly, PatchTool will not provide color difference values if these settings are different (Except for custom illuminants where differences are always shown.). Nonetheless, the  $L^*a^*b^*$ ,  $L^*C^*h$ , and XYZ coordinates will still be shown for comparison purposes.

Of course, you can always change the illuminant and observer in an opened file to match the settings of another file. However, please note that the observer cannot be changed when the reference data is not a spectrum (There is one exception when [importing UCS data](#)!). This is not an issue for converting between illuminants since XYZ data can be converted using a Bradford Chromatic Adaptation matrix which, while not perfect, introduces minimal error.

In order to improve the correspondence between the perceived color difference and the number obtained with the color difference formula, the CIE94, CMC and CIEDE2000 formulas propose using weights for the individual  $\Delta L^*$ ,  $\Delta C^*$ , and  $\Delta H^*$  contributions to  $\Delta E^*$ . In addition, CIEDE2000 proposes more visually uniform definitions for  $\Delta C^*$  and  $\Delta H^*$  which are defined as  $\Delta C^*$  and  $\Delta H^*$  (See [Appendix G](#) for a presentation of the CIEDE2000 formula). PatchTool can be set to show either weighted or unweighted values; this is done by selecting the “Show WEIGHTED values” in the “[Color difference](#)” tab of the “[Preferences](#)” dialog. When weighted values are selected, the “Info” window shows the Deltas divided by a weight symbol, i.e. “ $\Delta L^*/w$ ”, “ $\Delta C^*/w$ ”, and “ $\Delta H^*/w$ ” for CIE94 and CMC, and “ $\Delta L^*/w$ ”, “ $\Delta C^*/w$ ”, and “ $\Delta H^*/w$ ” for CIEDE2000 (the actual weights definitions differ in each formula, i.e. “w” is a generic representation). This preference will have a notable effect when sorting the data in a “Compare” window table using  $\Delta L^*$ ,  $\Delta C^*$ , or  $\Delta H^*$ .

While  $\Delta H^*$  (or  $\Delta H^*/w$  or  $\Delta H^*/w$ ) gives the contribution of the hue error to the total color difference,  $\Delta h$  is the actual hue error in degrees of the color circle. Mathematically, the difference in hue angle between a reference color with a hue angle of 5 degrees and a sample color with a hue angle of 355 degrees is  $(355 - 5)$ , or 350 degrees. However, this mathematically accurate computation is not representative of the perceived hue difference which is equal to  $(355 - 360) - 5 = -10$ . PatchTool can be set to either option with the “Use the complement to 360 degrees” checkbox in the “[Color difference](#)” tab of the “[Preferences](#)” dialog. This preference will also affect sorting in the “Compare” table.

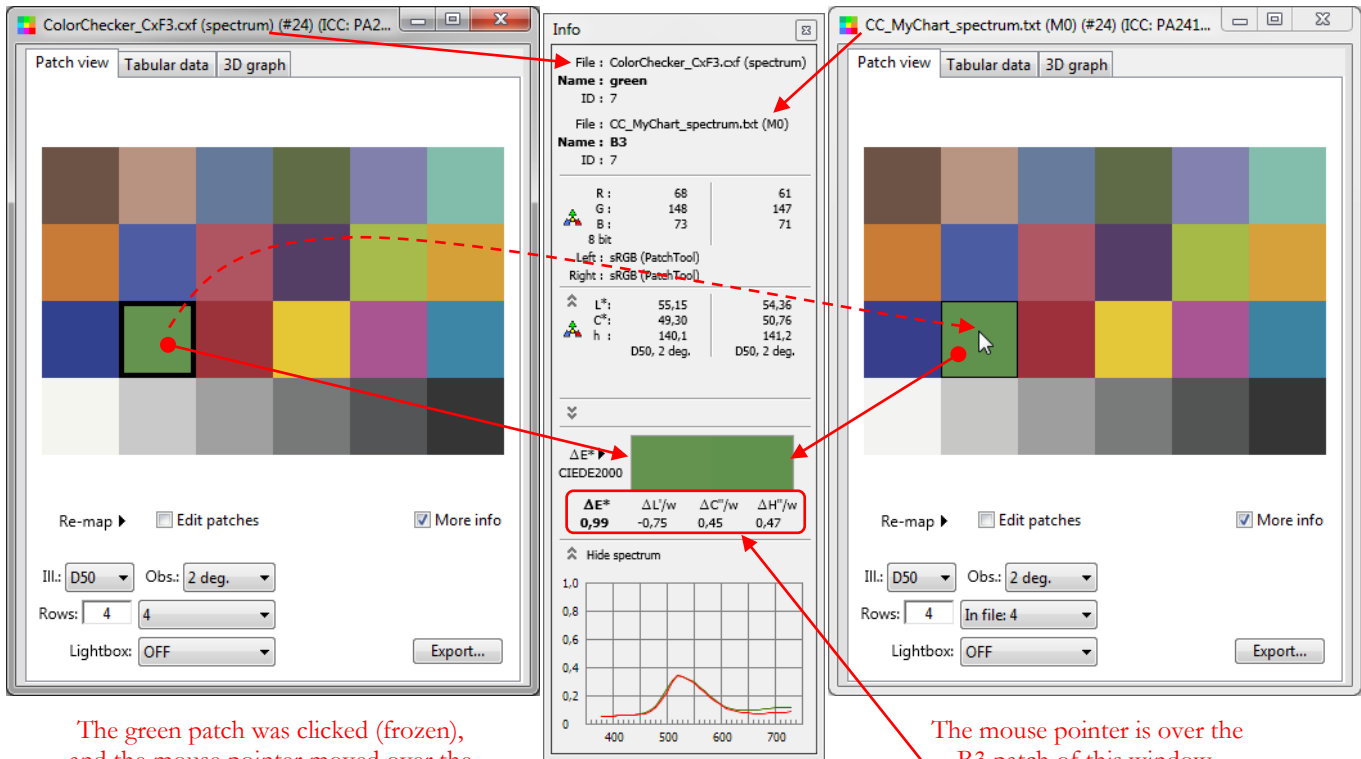
### 2.4.1 Using the “Info” window with multiple opened files

In this section we show how to navigate between many opened windows while using the “Info” window. For the purposes of the demonstration, the first file is the averaged spectral data of 30 ColorChecker charts (standard model with 24 patches), and the second one is the data from a single chart:

File on the left: **ColorChecker\_CxF3.cxf**

File on the right: **CC\_MyChart\_spectrum.txt**

These two files can be found in the “sample\_files/Help-Manual\_files” folder of the PatchTool application folder. The “Help-Manual\_files” folder can also be opened using PatchTool’s “File/Open Sample Files/Misc. Sample Files...” menu.



The green patch was clicked (frozen), and the mouse pointer moved over the B3 patch in the other file window.

The mouse pointer is over the B3 patch of this window. A color difference is shown.

In the screenshot above, you can see that we have selected D50 as the illuminant, and sRGB (shown in the “Info” window) for RGB data. We could also have selected D65 or one of many other illuminants instead of D50. In fact, the illuminant, observer, and RGB space can be different for each file. With this in mind, nothing prevents you of opening the same file twice to compare the values of the same patches for two different illuminants, or RGB spaces (or Standard Observers!).

Starting with the two opened files shown above, we open a third file which defines the colors of the ColorChecker SG (SG for semi-gloss) which has a standard ColorChecker 24 embedded within its other patches.

File: **Digital ColorChecker SG.txt**

This file can also be found in the “sample\_files/Help-Manual\_files” folder located within the PatchTool application folder. The screenshot of the three opened files is shown on the next page.

**Note:** While you can compare files with different Illuminants and/or Observers, color difference values will only be computed when these two settings match. There are two exceptions to this rule which involve the use of one or two Custom Illuminants. You will find more information in the [Custom Illuminants](#) dialog section.

In addition to the frozen patch in the file on the upper-left, we froze the same patch in the file on the right (One patch can be frozen in each opened file window). Since the data on the left of the Info window is always used for the frozen patch, it will change whenever you move between two windows which have frozen patches. To compare the green patch of the file on the upper-left with its equivalent patch in the ColorChecker SG file placed below, the mouse was first moved, without clicking, **within** the upper-left file (anywhere within the patch area is sufficient), and then positioned over the F4 patch of the ColorChecker SG. We can see a larger difference between the ColorChecker SG and the ColorChecker\_CxF3 data (CIEDE2000 DeltaE\*=4,18) than between the two top files (CIEDE2000 DeltaE\*=0,99) as shown on the previous page. This is expected since we are comparing two charts with different surface finishes.

A patch remains frozen in a window even if other patches are frozen in other windows.

This zone of the ColorChecker SG contains patches very similar to the original ColorChecker.

**Example on using the Info window with multiple files**  
The green patches of the two top files are frozen (by clicking on them). To compare the frozen patch on the upper-left with a similar patch on the bottom file, the mouse pointer is first moved over any patch of the upper-left window and then positioned over F4 (6<sup>th</sup> column, 4<sup>th</sup> row) on the bottom-left window, as shown by the red dotted line.

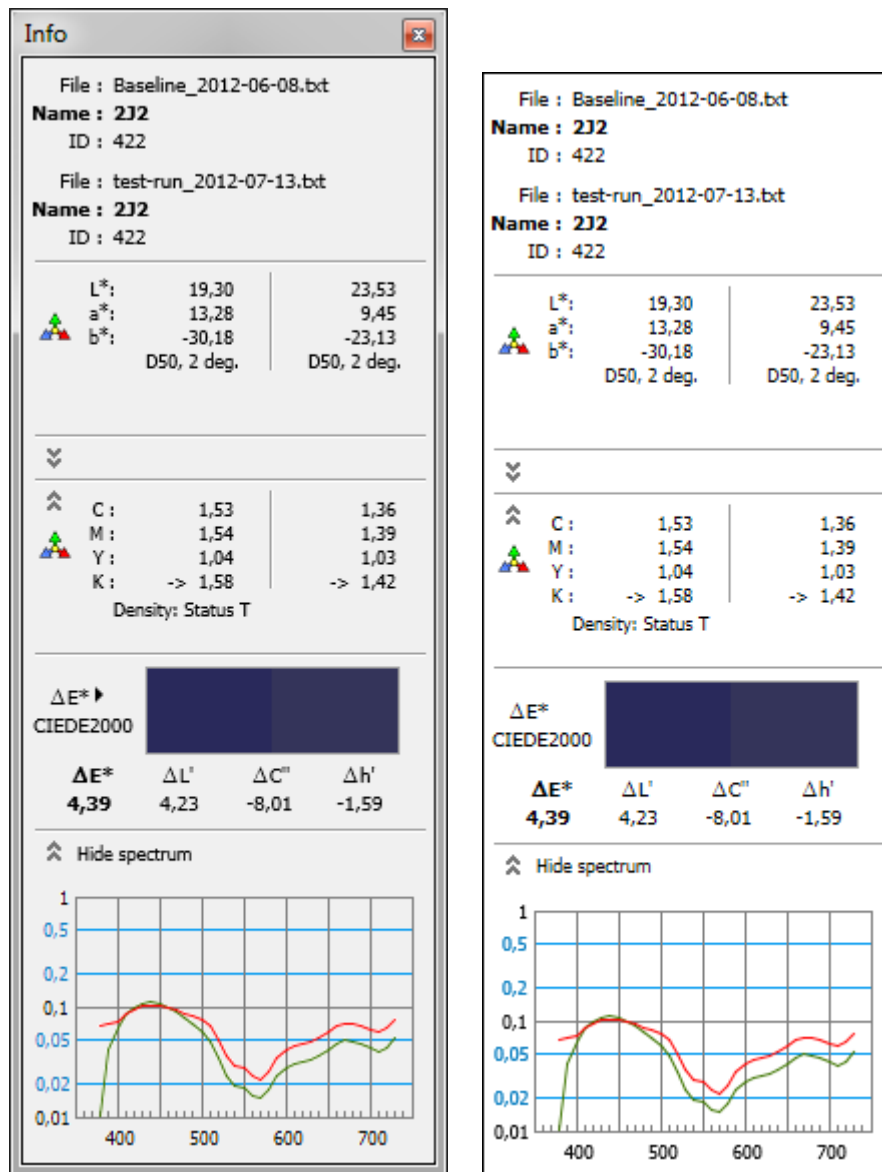
As shown above, PatchTool makes it very easy to compare patches from multiple files even if the files do not have the same number of patches. However, when the files are of the same size and when all patches in one file correspond to the patches in another files, it is possible to compare them in a single window. This is shown in Section 2.3.1 ([The “Compare” “Patch view” tab](#)).

## 2.4.2 Making a screenshot of the “Info” window

It is possible to make a screenshot of the Info window simply by pressing the “I” key (or “i”) on your keyboard. The only requirements are that the Info window should be visible and that one of the opened file windows is selected (i.e. it should have the “focus”, or be on top of the Desktop). You do not need to select a specific file (or files if the Info window shows data from two files as we have seen in the preceding section) as long as the Info window contains the information you want to grab. You can thus select one file, to bring it to the front, or even click on a patch to freeze it, and move the mouse to a patch on another window, without clicking, and then press “I” to get the screenshot.

The screenshots are saved in your “Documents” folder, within the “BabelColor/Screenshots” folder.

Below is an example (on Windows-7) of a screenshot as it appears on the display, on the left, and the corresponding saved image (in PNG format), on the right.



The window as seen on the display.

The screenshot as saved.

The saved image will correspond to your Info window layout, whether you selected one, two or three data displays and whether or not spectral data is visible.





## 2.5 The “PatchTool Export” dialog

The “PatchTool Export” dialog is opened by selecting the “File/Export” menu, by clicking the “Export...” button on the [main PatchTool window](#), or the “Export...” buttons located in the bottom of the “[Patch view](#)” and “[Tabular data](#)” tabs of each opened file.

### 2.5.1 The Export “Data” tab

The screenshot shows the "PatchTool Export" dialog box with the "Data" tab selected. The dialog is divided into several sections: "Data fields", "RGB encoding", "Spectrum scale", "Spectrum range", "File type", "Decimal separator", "File", and "Export and return here". Red arrows point from text annotations to specific controls in the dialog.

**Data fields:** A grid of checkboxes for selecting data fields. The "All" button is highlighted with a red circle. Annotations include: "Click on a checkbox to select the export data fields." (pointing to the "All" button), "OSA UCS data is available only when exporting. The file must contain spectral data or 10 degree Observer data." (pointing to the "UCS" checkbox), and "Munsell data is available only when exporting. The file must contain spectral data or 2 degree Observer data. Use the “Preferences” dialog to select the output format and other options." (pointing to the "Munsell" checkbox).

**RGB encoding:** Radio buttons for "8 bit", "15 bit+", "16 bit", and "100%". A "Round 8 bit data" checkbox is also present. Annotation: "Select the RGB encoding. You can also select to round 8 bit data; this is useful if you want to import these values in programs which discard, **without** rounding, the fractional part." (pointing to the "Round 8 bit data" checkbox).

**Spectrum scale:** Radio buttons for "0-1" and "0-100". Annotation: "Select the scale and range of the exported spectral data. You can also select the format for the tag used for spectral data in CGATS file in the “Preferences” dialog." (pointing to the "0-100" radio button).

**Spectrum range:** Radio buttons for "380 - 730 nm" and "400 - 700 nm".

**File type:** Radio buttons for "CGATS", "Plain text", and "CxF3". Annotation: "Export using the industry standard CGATS format, a plain text format, or the xml-based CxF3 format." (pointing to the "CGATS" radio button).

**Decimal separator:** Radio buttons for "Period [ . ]" and "Comma [ , ]". Annotation: "Select the decimal separator for the exported data. This setting is also available in the “Preferences” dialog." (pointing to the "Period [ . ]" radio button).

**File:** A dropdown menu showing the selected file: "3- SM102\_Pacesetter-Gloss\_LIN\_IT874\_2013-09-C". Below the menu is a frame containing file information: "Type: Single dataset", "Patch qty: 1617", "Color ref.: spectrum", "Columns: 49", "Ill. / Obs.: D50 / 2 degree", "Rows: 33", "CMYK: (File values) No profile info!", and "RGB: eciRGB v2 ICCv4 / Rel. Col. / BPC-NO". Annotation: "A reminder of the selected file settings, including the CMYK and RGB profiles." (pointing to the file information frame).

**Export and return here:** A button at the bottom of the dialog. Annotation: "Use this button to keep the “PatchTool Export” window opened after a file is saved." (pointing to the button).

The bottom part of the dialog comprises a menu with the list of opened files and various file information enclosed in a frame labeled “File”, and three buttons. These controls are common to the all dialog tabs.

The File list menu enables you to select ANY of the opened files. The information below the list menu is updated in relation with each file content and settings. In the image shown above, you know that if you export L\*a\*b\* data (or xyY, XYZ and L\*C\*h data), it will be from Illuminant D50 and the 2 degree Observer. You also see that RGB data will be associated to the “eciRGB v2 ICCv4” profile space. To change the illuminant, observer or profile settings, you need to close the dialog and go back to the appropriate file window ([File](#) or [Compare](#)).

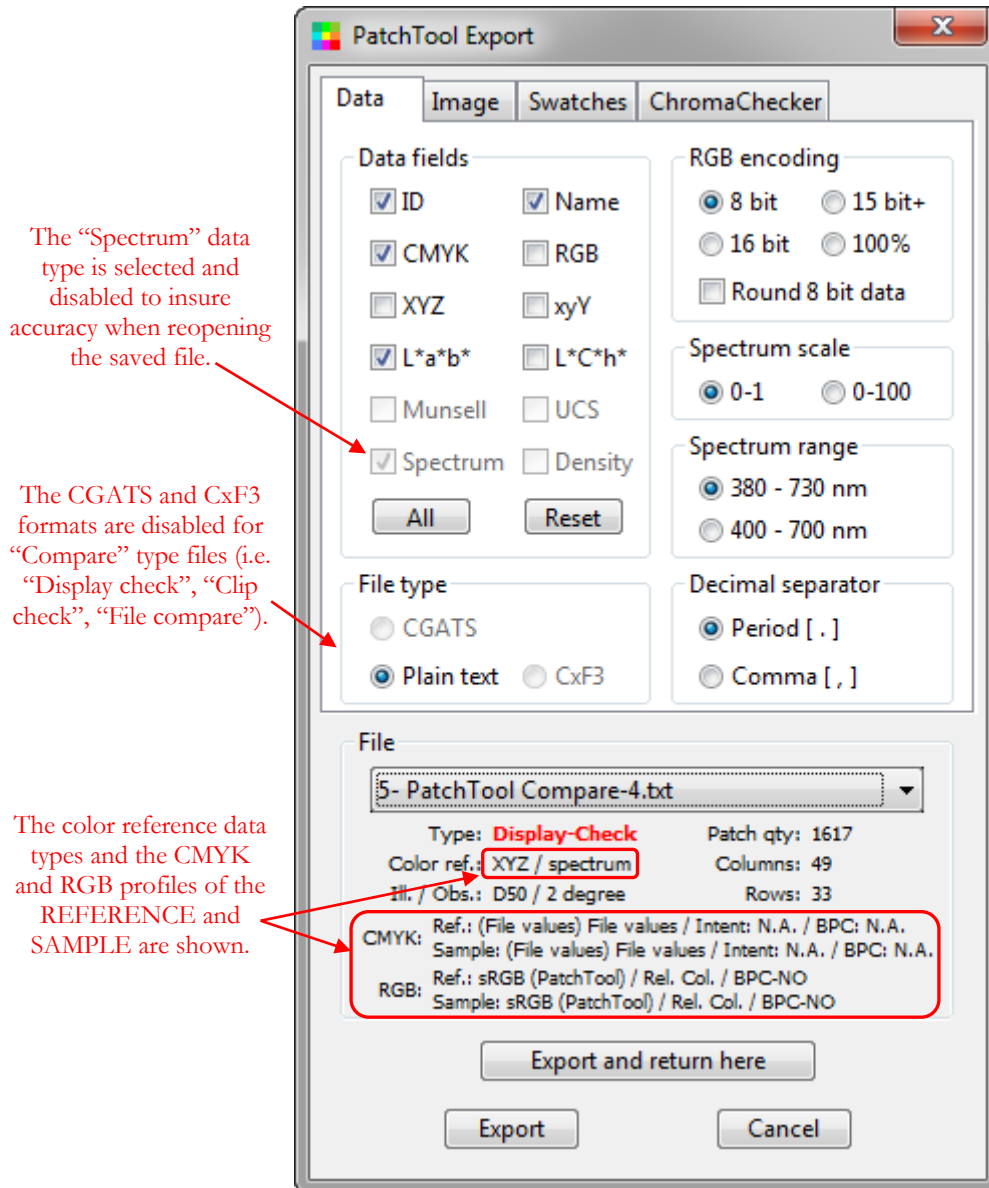
The following pages of this section contain additional information related to the “Data” tab of the “PatchTool Export” dialog. You can click on a link to jump to a specific sub-section:

- [Exporting a Compare file](#)
- [Exporting to the CxF3 format](#)
- [File settings warnings](#)
- Data field: xyY / (L<sub>MB</sub>, S<sub>MB</sub>) [MacLeod-Boynton](#) (CIE 170)
- Data field: [Munsell Color System](#)
- Data field: [Uniform Color Scales](#) (UCS)
- Data field: [Density](#)
- [RGB encoding](#)
- [Spectrum scale / Spectrum range](#)
- [Decimal separator](#)

## Exporting a Compare file

Here is the Export dialog when you select a [Compare](#) file obtained after a [Display-Check](#). Firstly, you will note that the CGATS and CxF3 data types are dimmed, i.e. they are not available; the reason is that the data in a “Compare” type file (i.e. “Display check”, “Clip check”, “File compare”) is too different from what is expected in these other file formats, and thus must be saved in another format that PatchTool will understand when reopening the file.

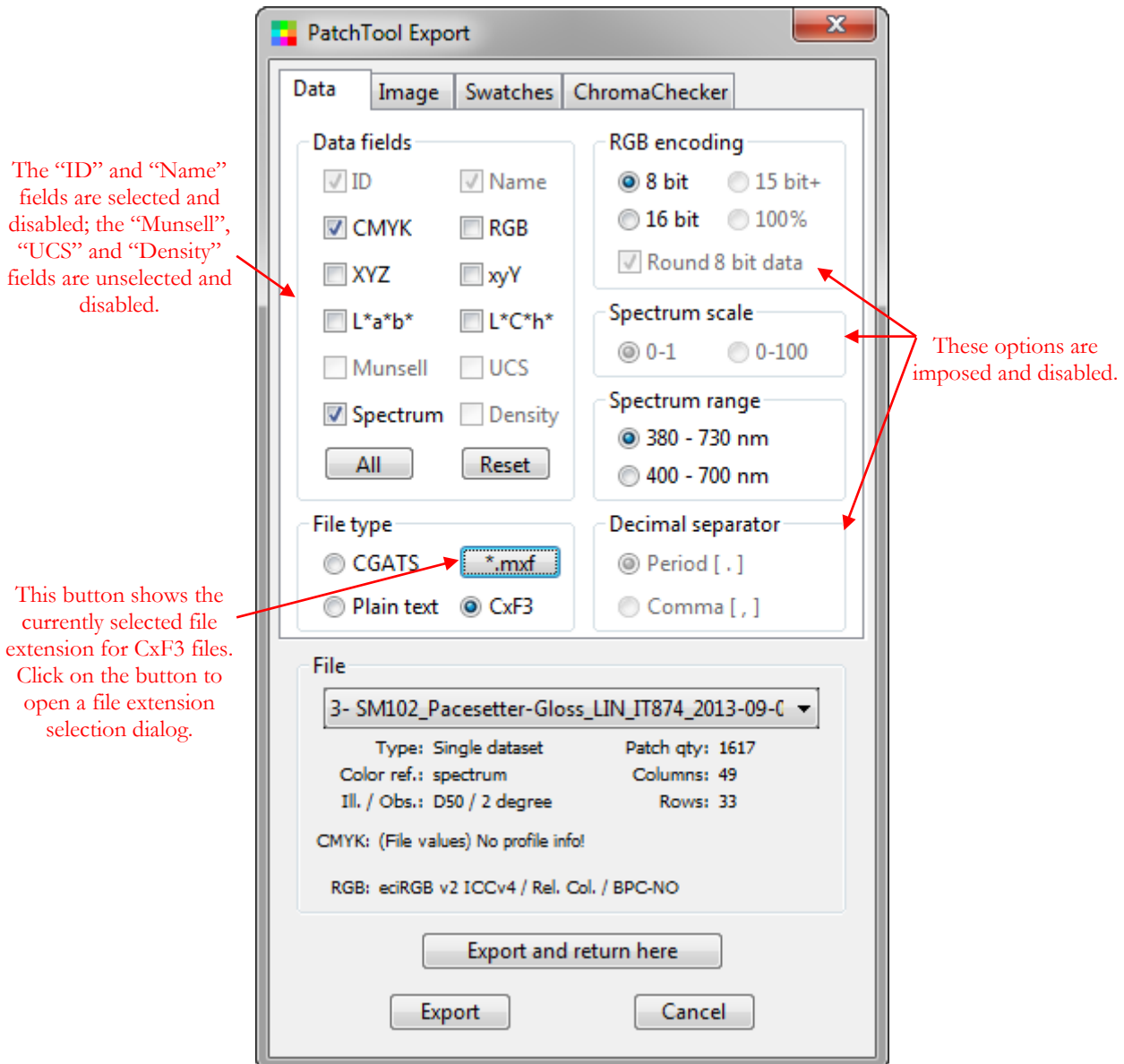
Secondly, we see two entries, one for the REFERENCE and one for the SAMPLE, in the **Color ref.** (color reference) field, which indicates the data types used when importing the file, as well as for the CMYK and RGB profiles. Thirdly, the file type (“**Display check**”) is shown in red; this is just a warning to be careful when selecting the export data types; you may want, for instance, to export RGB data as well since this is a Display-Check relative to display RGB, or you may even want to change the RGB profile. Lastly, you will note that the “Spectrum” data type is selected and dimmed, which means that it cannot be changed. This is to insure the accuracy of the file data when it will be reopened.



**Note:** While it is possible to export density data in a Compare file when spectral data is available, the “Density” field is disabled in the screenshot above because spectral data is from emission measurements (i.e. from a display). Density computation in PatchTool is valid only for reflective measurements.

## Exporting to the CxF3 format

Here is the Export dialog when you select the [CxF3](#) file type (click [here](#) for more info on the CxF3 format). The first change you will notice is the appearance of a button over the “CxF3” selection. This button shows the currently selected file extension for the file saved using this format; we will get back to this button shortly. Also, for CxF3 files, the “ID” and “Name” data fields are selected and disabled, the “Munsell”, “UCS” and “Density” data fields are unselected and disabled, RGB encoding is limited to 8 bit and 16 bit with 8 bit rounding selected and disabled, the spectrum scale is fixed to “0-1”, and the decimal separator can only be a “Period”.



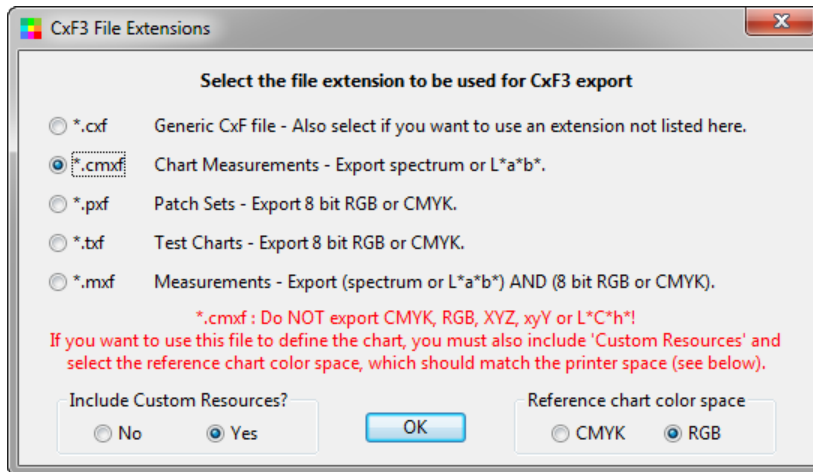
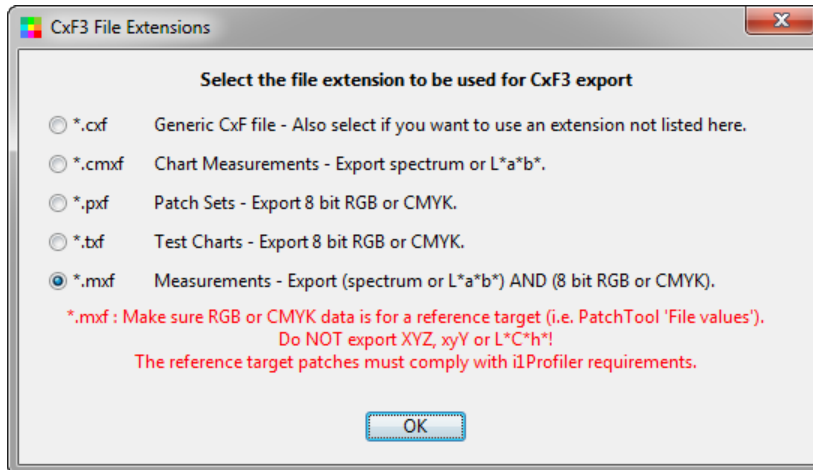
As explained in the section dedicated to [CxF3 import](#), while the default file extension for CxF3 files is “\*.cxf”, other file extensions are used, in particular by X-Rite’s i1Profiler program. These different file extension indicate that the file has a specific usage with; for example, the \*.pxf extension is used for a file which defines a patch set, and the \*.mxf extension is used for a file that contains measurements data intended to build a profile.

**Note:** Even if all CxF versions use the same generic file extension (\*.cxf), the files exported by PatchTool are compliant only with the CxF3 format.

The supported file extensions and their corresponding file types are shown in the following table.

File Extension	i1Profiler File Type
*.cmxf	Chart Measurements
*.pxf	Patch Sets
*.txf	Test Charts
*.mxf	Measurements

The extension is selected with the dialog which opens by clicking on the button which appears over the “CxF3” file type selection. The dialog is shown below as it appears when you select the “\*.mxf” and “\*.cmxf” extensions.



Please read the descriptions which appear beside each extension and select the recommended data fields. You should also read the text in red which appears over the “OK” button; it contains important recommendations for proper export to CxF3 files dedicated to i1Profiler.

You will notice that additional controls appear when “\*.cmxf” is selected; these controls are required if you want to use the exported file to define a chart layout by dragging the file onto i1Profiler’s “Define Chart” icon in the “Measure Chart” workflow. More information on PatchTool’s CxF3 export features and the differences between the various i1Profiler file types is presented in the following Application Note, available on the [BabelColor Tutorials](#) Web page:

**AN-10 Exporting to the CxF3 and i1Profiler file formats with PatchTool.pdf .**

**CxF3 export limitation:** PatchTool CxF3 export supports only the file types listed above, the export is limited to RGB and CMYK data flows (i.e. CMYK+n is not supported), and there is no support for display measurements. In addition, except for the small option with \*.cmxf files just described, there is no support for Custom Resources.

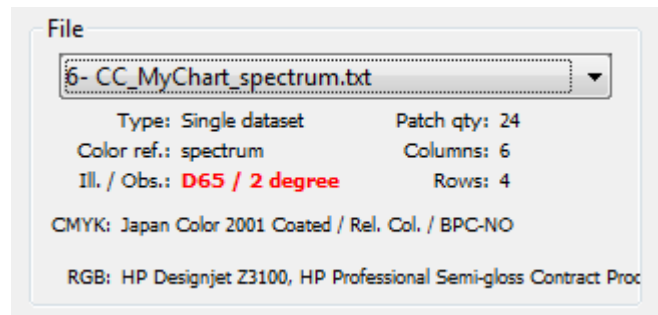
### File settings: Warnings

Most programs that export or import XYZ/xyY/ L\*a\*b\*/L\*C\*h data assume that the illuminant is D50 and the observer 2 degree. Some programs will include these settings when exporting, but many do not. As well, many programs will use Illuminant D50 and the 2 degree Observer even if the file indicates otherwise. You should thus select D50 and the 2 degree Observer if you intend to re-open a file exported with PatchTool in these programs.

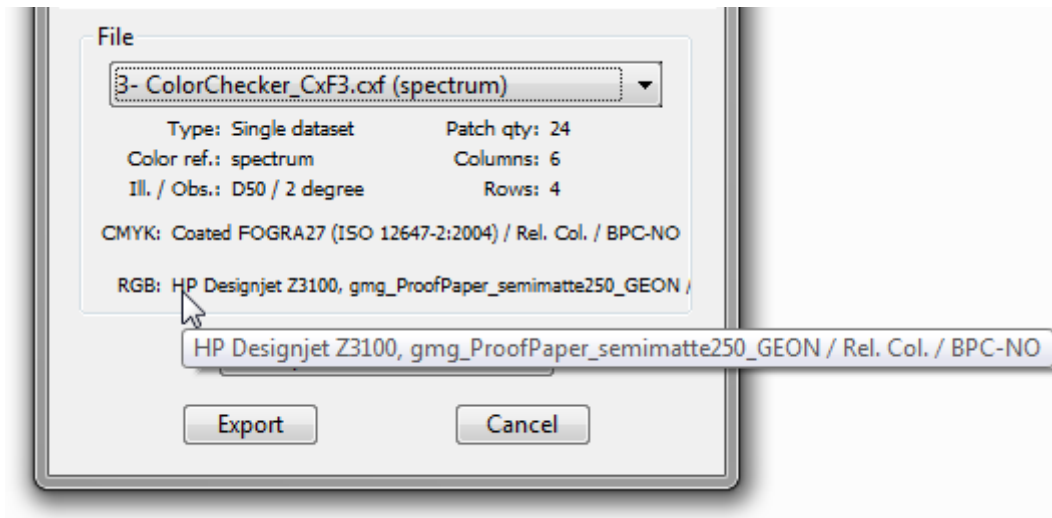
PatchTool can import and export color data using many illuminants and either the 2 degree or 10 degree Standard Observer (when applicable!); accordingly, the illuminant and observer are always included in an exported CGATS file, and properly processed when the file is re-opened.

If a file illuminant is not D50 or if the file observer is not 2 degree, the information in the field will be displayed in **red**, to be better noticed, as shown below, so that you can double-check what will be exported:. Similarly, the data in the “Color ref.” field will be in red whenever RGB or CMYK was used as input reference.

Unless you have specific requirements, we recommend that you select at least the ID, Name, XYZ (or L\*a\*b\*) and Spectrum (when available) data fields when exporting. These fields will maximize compatibility with other applications and prevent the loss of important information. You should also select the CMYK or RGB field if such data was present in the original file (for example, the CMYK data in [Idealliance](#) certification reference files).



**Hint:** If a profile description is too long to fit in the PatchTool Export dialog, just move your mouse over the description and wait until the Help tag with the complete text appears.



### Data field: xyY / (I<sub>MB</sub>, S<sub>MB</sub>) MacLeod-Boynton

Whenever a [CIE 170](#) Standard Observer is selected (“2F deg.” or “10F deg.”), you can also export the [MacLeod-Boynton Chromaticity Coordinates](#) by selecting the “xyY” data type in the export dialog. You will get the MacLeod-Boynton I<sub>MB</sub> and S<sub>MB</sub> coordinates in addition to xyY computed for the selected Observer.

MacLeod-Boynton coordinates can be exported in CGATS, plain text, and Compare files. Support of CIE 170 cone fundamentals colorimetry (CIE 2006 and CIE 2015) in PatchTool is described in [Appendix H](#).



### Data field: Munsell

By selecting this export option, you can convert a file data into the Munsell Color System. A description of this color system can be found in [Appendix E](#).

The Munsell conversion algorithm in PatchTool is based on interpolations between reference patches measured under Illuminant C and stored within a database. The selection of the best patches to be used to derive the Munsell equivalent of a given color is made with a color-difference formula, which has traditionally been CIELAB because of its simplicity. However, PatchTool is the first software that offers the possibility of selecting between the CIELAB, CIE94, CMC(2:1), CMC(1:1), and CIEDE2000 formulas. In addition, further refinement can be obtained by using, or not, weighted L\*, C\*, and H\* values when individually required by the conversion process (this refinement is effective only with the CIE94, CMC and CIEDE2000 formulas, which are based on weighted parameters).

The color difference formula is selected in the “[Export](#)” tab of the “[Preferences](#)” dialog. The use of weighted L\*, C\*, and H\* values is controlled via the “Show WEIGHTED values” checkbox in the “[Color difference](#)” tab of the “[Preferences](#)” dialog; please note that this option also controls how color differences are computed and displayed in the Compare “[Tabular data](#)” tab.

Various output format options are available since you may want to further sort your data once exported:

Munsell conversion export formats
1 column: “Hue Value/ Chroma”
4 columns: “H1”, “H2”, “V”, “C”
5 columns: “Hue Value/Chroma”, “H1”, “H2”, “V”, “C”

To select a Munsell export format, go in the “[Export](#)” tab of the “[Preferences](#)” dialog.

### Data field: UCS

By selecting this export option, you can convert a file data into the Optical Society of America (OSA) Uniform Color Scales (UCS) System. A description of this color system can be found in [Appendix F](#).

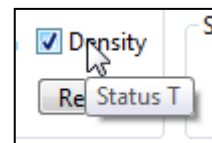
The OSA UCS is defined relative to the 10 degree Observer and Illuminant D65. The export checkbox is thus only enabled when the file contains spectral data or when non-spectral data was obtained for the 10 degree Observer. If the currently selected file illuminant is not D65, PatchTool will convert the file data to D65 before deriving the UCS Ljg coordinates.

PatchTool can open files which contain data saved in UCS coordinates, and these files can be either in [CGATS](#) format or [plain type](#) format (Click [here](#) for an example of UCS data saved in a CGATS file). However, as with all files opened by PatchTool, certain data types are preferred. See the “Behind the scene: [Selecting data for import](#)” box for a priority list. If you wish that a file be opened using the UCS coordinates, you should select only the ID, Name, and UCS data fields when exporting.

### Data field: Density

By selecting this export option, you can convert a file spectral data into reflection density values as defined in ISO 5-3. The density Status is selected in the “[Misc.](#)” tab of the “[Preferences](#)” dialog.

**Hint:** To see the currently selected density Status, just move your mouse over the “Density” field and wait until the Help tag appears.



Density export is possible only for the “CGATS” and “Plain text” file types. In addition, the export checkbox will be enabled only if the file contains spectral data.

### **RGB encoding**

Except for PatchTool, RGB encoding is always assumed to be 8 bit in programs that open CGATS files. PatchTool will add specific tags describing the RGB space (BBCRGBSPACE) and its encoding (BBCRGBENCODING) when RGB data is exported in a CGATS file. These tags will be used to automatically scale the RGB data and convert it to XYZ when the file is re-opened in PatchTool (the tags will most likely be ignored in other programs).

You can also force rounding on 8 bit RGB data by selecting the “Round 8 bit data” checkbox. This can be useful when the exported data will be opened by a program that rejects fractional RGB values without rounding. Please note that this can happen even if the proper decimal separator is used (see the **Decimal separator** section on the next page for additional info).

### **Spectrum scale / Spectrum range**

The “Spectrum scale” should be set to “0-1” and the “Spectrum range” should be set to “380 to 730 nm” for compatibility with products originally designed by GretagMacbeth. For compatibility with products originally designed by X-Rite, before they purchased GretagMacbeth, the scale should be set to “0-100”, and the range should be set to “400 to 700 nm”.

### **Decimal separator**

You can select either a comma [ , ] or a period [ . ] as a decimal separator even if your computer’s international settings is set for one or the other.

Select the “comma” decimal separator if you intend to open the exported file in a program which expects this separator. For example, if the decimal separator for your computer’s international settings is a comma, Excel will expect a comma as a separator for numerical data, and will consider numbers separated by a period as text. You will then need to replace all periods by commas in the numerical data.

On the other hand, some programs only work with periods as decimal separators even when installed on a computer where the decimal separator is a comma. Other programs will even discard the decimal information if a comma is used; they will, for example, keep 2 when the data value is 2,76, instead of rounding to 3. If you intend to use exported data in such programs, select the “period” decimal separator.

**Note:** PatchTool will properly process the data values in files saved with either a comma or a period as a decimal separator.

## 2.5.2 The Export “Image” tab

Set the Patch “Width” and “Height”. The image size is computed by taking into consideration the number of “Columns” and “Rows”, the “Resolution”, and the presence of markers and row numbers.

Select to include the profile in the image file. Enabled if an ICC profile is assigned to the data. Available for PNG and TIFF images.

Select a file for export amongst the currently opened files.

Use this button to keep the “PatchTool Export” window opened after a file is saved.

With such markers, you can measure the patches one line at the time instead of patch by patch. This option is dedicated to measurements done with the i1Pro. See [examples](#) on the next page.

Select to add row numbers to better locate patches in exported images. See an [example](#) on the next page.

Select to **dither** the patches for improved 8 bit color accuracy.

An estimate of the file size based on the selected parameters.

A reminder of the selected file settings, including the CMYK and RGB profiles.

As with the “Data” tab, the bottom part of the dialog contains useful information for setting the image parameters.

By definition:

- “Columns” x “Patch Width” = Image Width (W)
- “Rows” x “Patch Height” = Image Height (H)

However, if the “Add vertical markers before and after each patch” checkbox is selected, 1,5 mm markers are placed before and after each patch. The markers consist of a 0,75 mm white bar combined with a 0,75 mm black bar; they are designed to improve patch detection when measuring the patches one line at the time, as can be done with all i1Pro models.

**Important:** The markers have a fixed nominal width of 1,5 mm, which is rounded to the nearest integer number of pixels. Also, the size, in pixels, for the black and the white bars are always the same. As a result, the markers’ width in the final image may be slightly larger than 1,5 mm, especially if the resolution is low.

### Add vertical markers

Please note that the markers' width will remain 1,5 mm for all patch sizes. The program will increase the image width to take these vertical bars into consideration, while maintaining the patch size set by the user. Examples of images with different patch sizes, and with and without markers, are shown below.

Example 1



Patch size: 9,1 mm x 7,4 mm; no markers

Example 2



Patch size: 9,1 mm x 7,4 mm; with markers

Example 3



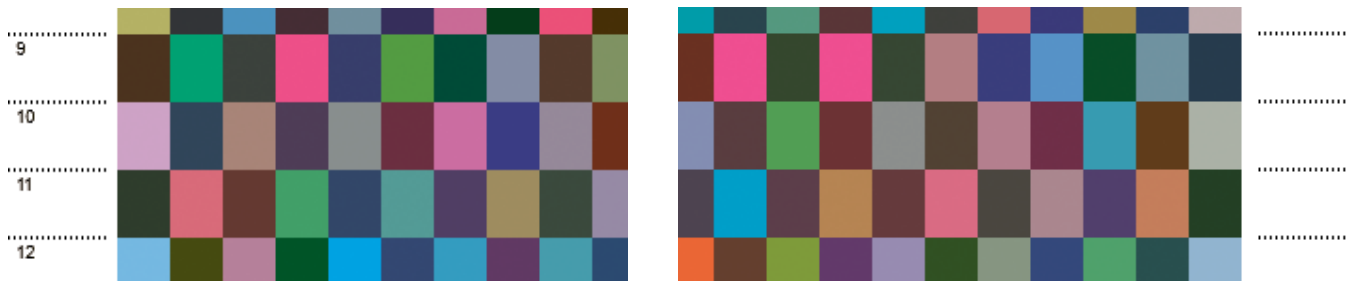
Patch size: 15 mm x 15 mm; with markers

As we see, the **Example 2** image is larger than the **Example 1** image, even if the patches are of the same size. The patches of **Example 3** are larger than those of **Example 2**, but the markers' widths are the same.

A tutorial on how to print an IT8.7/4 target in a format that can be easily measured with an i1Pro (any model) is presented [here](#). We suggest you also read the section on the tools that can be used to [scramble a target](#); by doing so, you may be able to change the patch layout so that no vertical markers are required.

### Add row numbers

Row numbers and guide lines can be added to an exported image. These features help locating a specific row when scanning a target line by line using an i1Pro ruler (any model).



#### Behind the scene: Patch size

PatchTool always make sure that the patch size is an integer number of **pixels**. Thus, in order to adjust the patch size to full pixels, small adjustments will be made to entered values in the "Patch Width" and "Patch Height" fields when the units are inches, cm or mm.

To minimize the dimensional changes due to this rounding, simply increase the "Resolution" value. We also recommend setting the resolution in "pixels/cm" when you want to specify a patch size in cm or mm; this will often prevent a resize of the patch dimensions. Similarly, you should set the resolution in "pixels/inch" when specifying a target size in inches.

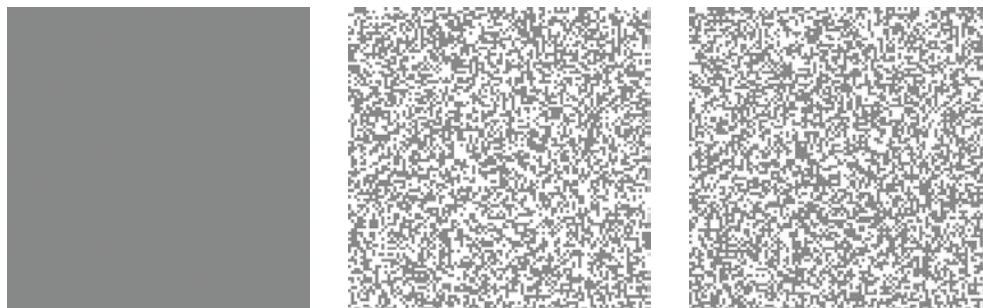
## 8 bit dithering

Select this option to generate images with essentially 16 bit accuracy while keeping an 8 bit workflow. This option is available for all file types (PNG, BMP, TIFF) and color spaces (RGB for PNG, BMP, TIFF; CMYK and L\*a\*b\* for TIFF).

**Important:** The actual accuracy improvement depends on the patch size, the printing resolution, and the area used for measurement, with this last factor also depending on the size of the measuring instrument's aperture.

The accuracy improvement obtained by dithering is important for those who strive for the utmost accuracy when printing targets. In fact, many reference targets for industry standard workflows, such as the P2P51x and TC1617x targets, are generated using dithering. The common problems with these supplied targets are that they must be used "as is" without resizing or conversion, and that they are available only in a few layouts. These are not limitations any more since, with the 8 bit dithering option, you can generate dithered targets which suit your size, file type, and layout requirements, starting from the supplied CGATS text files (or any other data file).

Dithering is performed on the Least-Significant-Bit (LSB) of each coordinate. For example, let's assume we want to print an RGB patch with a value of (135.5, 136, 136; here we need to dither only the "R" component. This can be obtained by using a pixel color of (135, 136, 136) for half the pixels and a pixel color of (136, 136, 136) for the other half, and of course distributing the two groups in a random fashion. A dithered patch of 100 x 100 pixels with a resolution of 100 pixels/cm is shown below, on the left, as generated by PatchTool. The middle image shows the same patch where the (135, 136, 136) pixels were replaced by white, and the image on the right shows the patch with (136, 136, 136) replaced by white. By looking carefully at the pixel structure we can see that the two images are the inverse of one another.



Note: Patches zoomed 4X to better show the pixel structure.

By adjusting the respective ratio of pixels with 135 and 136 values, we could also simulate any intermediate values between 135 and 136, 135.16 for instance, with high accuracy.

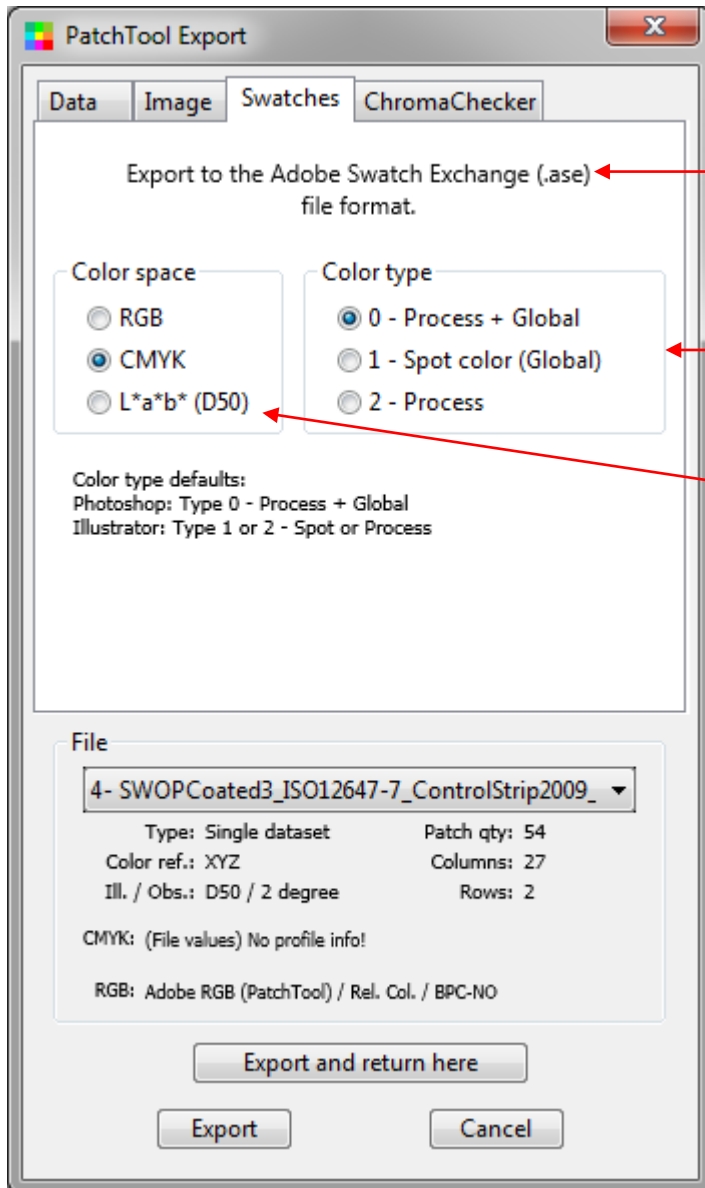
Here are a few examples where dithering can improve the accuracy of a target:

- While 8 bit RGB numbers are encoded with integer precision, you may want to generate a target whose numbers are derived from a profile, with fractional RGB values, as illustrated above.
- 8 bit CMYK values are scaled from 0 to 100% to 0 to 255, with integers used in the file. This 2.55 scaling creates imprecision by design; for example, a Cyan value of 10 is coded as 26 (25.5 rounded). And of course we may also want to generate targets with fractional CMYK accuracy.
- When encoding 8 bit L\*a\*b\* images, the pitch for the a\* and b\* coordinates is "1", as you can easily confirm by opening such a file in Photoshop, so you are effectively incorporating an error of plus or minus 0.5 DeltaE\* (CIELAB) error to each coordinate (when the error is considered individually for one coordinate; the combined error for all coordinates is somewhat less).

As we just saw, dithering can not only remove the error introduced by encoding the values in 8 bit but also enable the representation of colors with high precision.

**Hint:** You can measure the quality of a dithered target image by first using the "[Extract Target from Image](#)" tool. Once the data is extracted, use the "[Compare](#)" tool to verify it against the reference data.

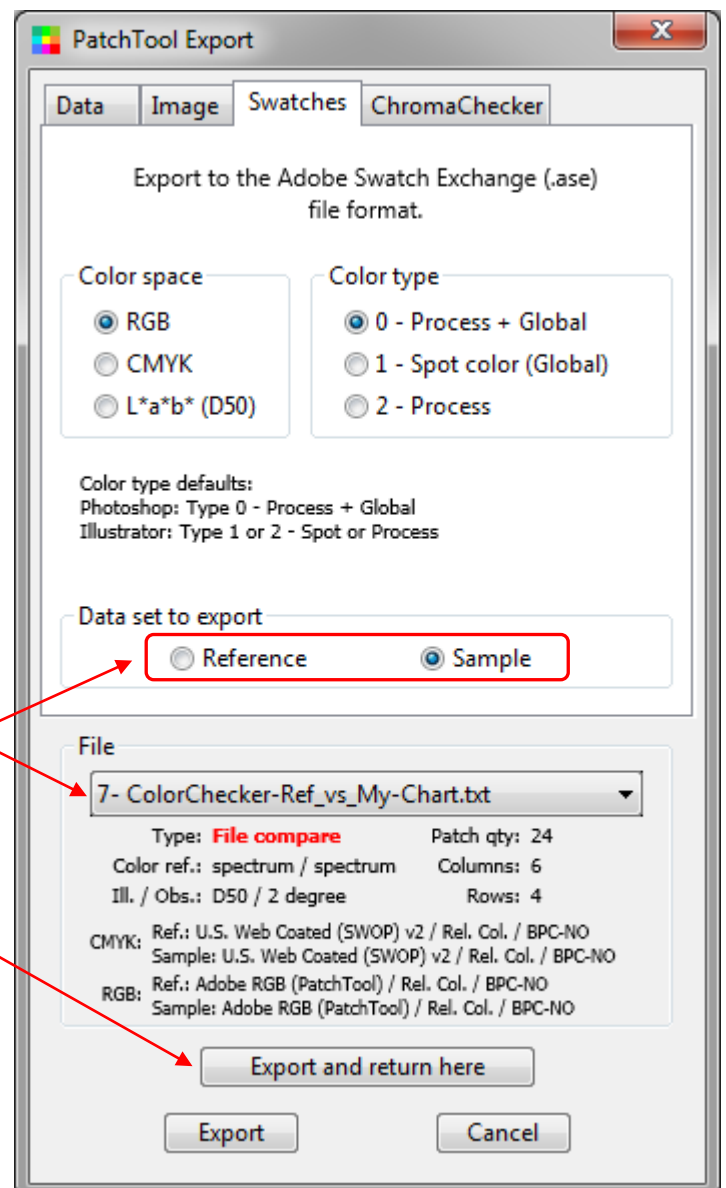
### 2.5.3 The Export “Swatches” tab



These files can be imported in Adobe applications using the “Load Swatches...” menu.

The same **color type** will be assigned to all the swatches.

Note: If D50 was not selected in the file, the data will be converted to D50 automatically.



Select a file for export amongst the currently opened files. For “Compare” files, you must also select if you export the “Reference” or the “Sample”.

Use this button to keep the “PatchTool Export” window opened after a file is saved.

Adobe Swatch Exchange (ASE) files can be [imported](#) directly in PatchTool. More information on the ASE format is presented in the “Behind the scene: [The Adobe Swatch Exchange \(ASE\) file format](#)” box.

## 2.5.4 The Export “ChromaChecker” tab

The ChromaChecker™ Corporation offers online color measurements data analysis and quality control services dedicated to the print industry. This PatchTool export tab is designed to upload CMYK references and spectral measurements to any predefined track workflow of ChromaChecker’s “**PRINT INSPECTOR**” service.

**Important:** In order to use the ChromaChecker export tab, you need a registered account with the ChromaChecker Corporation (<https://chromachecker.com/>). BabelColor is not affiliated with ChromaChecker.

Use the **SOAP account** login and password defined in your ChromaChecker account. Do not use your ChromaChecker login info.

When the SOAP account login status is valid, this section shows the parameters of the **tracks** defined in the ChromaChecker Web interface.

User-selectable and user-defined **ChromaChecker-specific** file info that will be uploaded to the ChromaChecker server. Note: Except for the Measurement condition, this information is not saved in a PatchTool file.

Upload is enabled if:

- the login status is “Valid”;
- spectral data is available;
- this is NOT a Compare file.

Upload is possible only if your ChromaChecker account status is valid.

Select the track to which you want to upload the measurements data.

Pre-selected and disabled if detected in the opened file.

Click to open the ChromaChecker home page in your default browser.

**PatchTool Export**

**Data** | **Image** | **Swatches** | **ChromaChecker**

SOAP login: my\_soap\_account  
 Password: (saved) **Go**

Uploads used: 47      Expiration: 2018-07-05 09:59:16  
 Uploads limit: 300      Status: **Valid**

Track workflow: OffsetPress\_Coated  
 Device: Offset Press  
 Track name: Coated  
 Bar Code name:  
 Press: SX 74-5      Meas. cond.: M0  
 Paper: Grade 1      Backing: white

**ChromaChecker file info**

Mode: production      Scan side: front  
 Meas. cond.: M0      Backing: white  
 Dryback: dry      Vis. judgment: N.A.  
 Job name: faces project      Job ID: 1927-1941  
 Customer: Black Hills      Operator: GB  
 Sheet #:

**File**

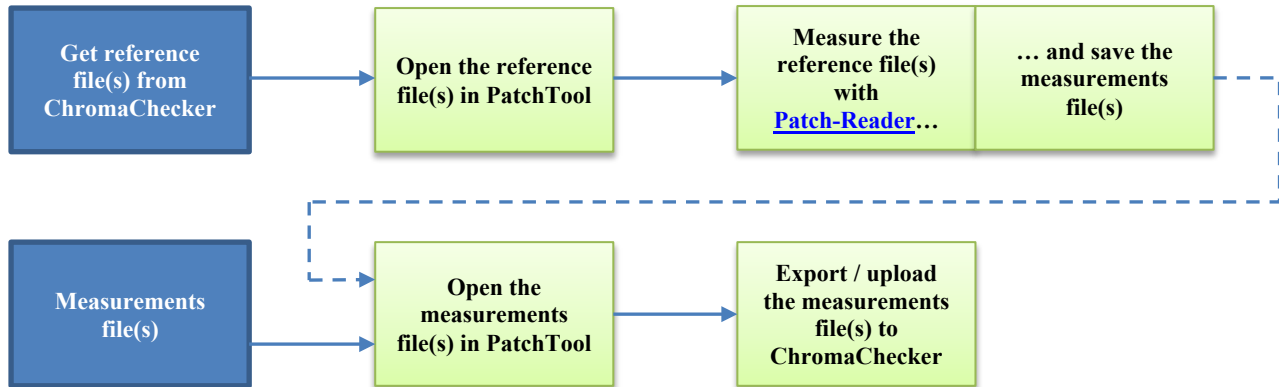
3- ChromaChecker™ TVI-21-96\_3R\_Patch-Read  
 Type: Single dataset      Patch qty: 96  
 Color ref.: spectrum      Columns: 32  
 Ill. / Obs.: D50 / 2 degree      Rows: 3  
 CMYK: (File values) GRACoL2006\_Coated1v2 / Rel. Col. / BPC-NO  
 RGB: Adobe RGB (PatchTool) / Rel. Col. / BPC-NO

**Open ChromaChecker Web page**  
**Upload**      **Cancel**



## Suggested PatchTool / ChromaChecker workflows

Here are possible workflows on how to use PatchTool with ChromaChecker.



If you are using a target which can be measured with an i1Pro (any model), you can use PatchTool [Patch-Reader](#) to get the measurements. These measurements can then be sent to the ChromaChecker server using the Export dialog. You can also export measurements performed with other instruments and software; simply open the measurements file in PatchTool.

### ChromaChecker file info

This section is to be used to assign file-specific information that will be uploaded to the ChromaChecker server. Please note that, except for the “Measurement condition” field, this information is not saved in a PatchTool file (CGATS or CxF formats).

If a “Measurement condition” is detected in a file, it will be preselected and the menu will be disabled. If no “Measurement condition” was detected in the file, “N.A.” will be shown and you should select the appropriate value (M0, M1, or M2).

While you can select any value for a file info data field, a warning (!) will be shown next to the “Measurement condition” or “Backing” selection if it does not correspond to the default value assigned for the selected track. Such a warning will not prevent the upload but you may see a similar warning in the ChromaChecker interface for this file.

The “Visual judgment” is the color matching quality of the target from the operator’s perspective.

Track workflow:

Device: Offset Press

Track name: Coated

Bar Code name:

Press: SX 74-5

Paper: Grade 1

ChromaChecker file info

Mode:  Scan side:

Meas. cond.:  ! Backing:  !

Dryback:  Vis. judgment:

Job name:  Job ID:

Customer:  Operator:

Sheet #:

## 2.5.5 Tutorial: Exporting an IT8.7/4 target to be measured using an i1Pro

This tutorial demonstrates how PatchTool can be used to generate print targets that can be scanned line-by-line with an i1Pro. Although specific numbers are derived to optimize the measurements using the original i1Pro with its non-encoded (i.e. non-Zebra) ruler, we provide reference numbers which can be used to make a target optimized for the **i1Pro 2**, **i1Pro 3**, and **i1Pro 3 Plus** with their **Zebra rulers**.

We first generate a target image from an IT8.7/4 target reference file; this target was selected since it is commonly used for profiling and print quality assessment, but any other color list could be employed as well.

The most important goal is to make sure that the length of all patches in each row is short enough so that it can be scanned in one pass with the i1Pro ruler. A secondary goal is to create a target that can fit sideways (i.e. turned 90 degrees) on a 24 inch wide printer. A third-party application, such as Adobe Photoshop, is required to print the PatchTool image, and PatchTool [Patch-Reader](#) is used to measure the printed patches.

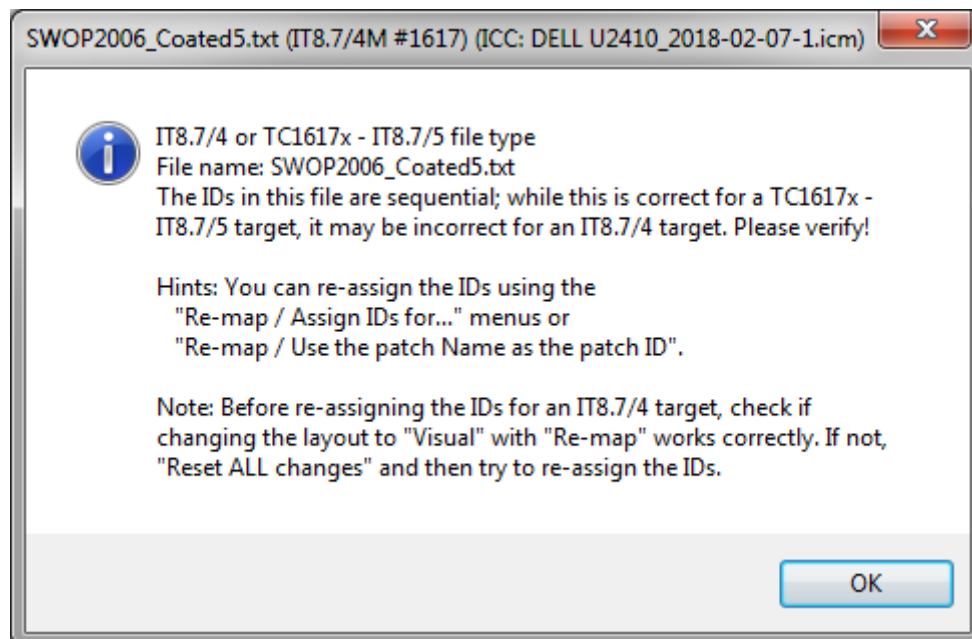
**Note:** Apart from starting from the “Random” layout of an IT8.7/4 target, this tutorial does not optimize the color difference between neighboring patches. This is why we must use vertical markers between each path. If we had optimized the layout using the “[Target Scramble / Analysis](#)” dialog, we could print more patches for the same ruler width and get an image with fewer rows.

**Step-1:** Open an IT8.7/4 reference file. A reference file with device-independent data, such as a spectrum, XYZ or L\*a\*b\*, is recommended. Files with device-dependent data (CMYK or RGB) could also be used, if properly processed in Photoshop, but this is not discussed further in the tutorial. For this example, we opened the “SWOP2006\_Coated5.txt” file located in the PatchTool application folder:

“...\[PatchTool\characterization\\_data\Idealliance\\_Proofing-Certification\\_V16\Coated5\IT8\\_7-4\SWOP2006\\_Coated5.txt](#)”

You can use the “File/Open Sample Files/Characterization Data...” menu to get to this folder. This file was selected because we know its gamut is within our printer’s gamut, although this knowledge is not required for the test. When asked, select D50 as the illuminant and 2 degree for the observer.

You should then see the following message:

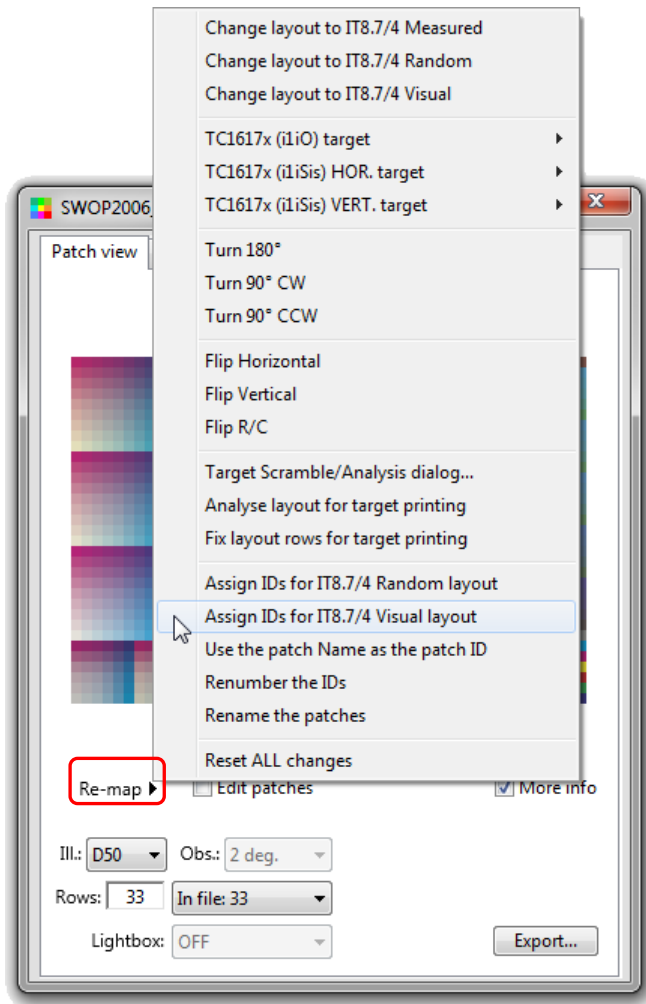


The above message is shown when the IDs in the file are sequential and the program cannot recognize the “Visual” or “Random” layout from the file ID sequence. In some cases the IDs are correct but the layout was shuffled; this is why it is suggested to “try” to change the layout to “Visual” and check if the resulting layout is indeed “Visual”.

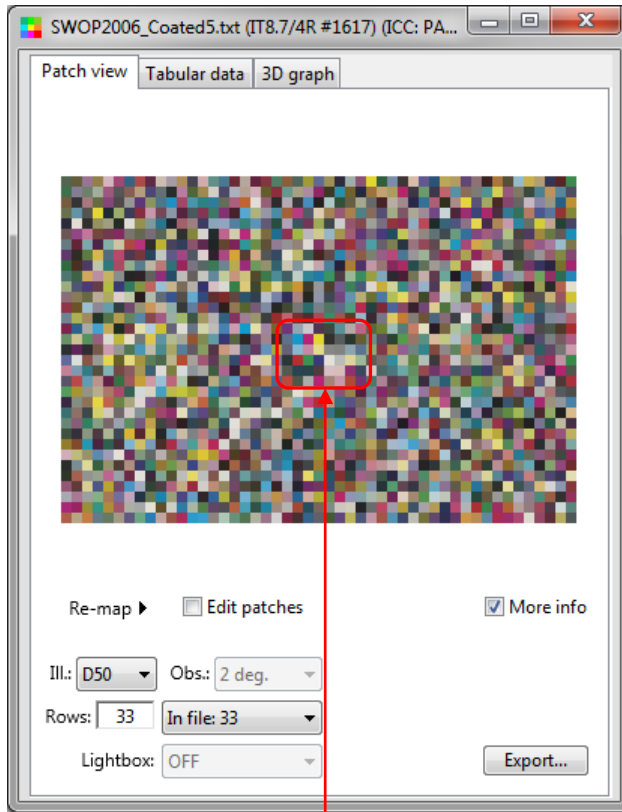
If the layout is correct, then you do not need to assign the IDs. If not, change the layout back to “Measured” or “Reset ALL changes” using the Re-map menu, and then assign the IDs, as shown in Step-2.

**Note:** TC1617x files have the same number of patches as IT8.7/4 targets (=1617). We have also seen TC1617x files identified with a file type (“LOGO\_IS126422”) which is used for IT8.7/4 targets. So, unless the file is clearly identified as a TC1617x target, with “TC1617” appearing as the file type in the first line of a CGATS formatted file, we must also consider that any file with 1617 patches which is not identified by a file type or which appears to be IT8.7/4 may also represent a TC1617x target. For this reason, you will also see menu items dedicated to changing TC1617x target layouts in the “Re-map” menu of the opened file “Patch view” tab, as shown in the following screenshot.

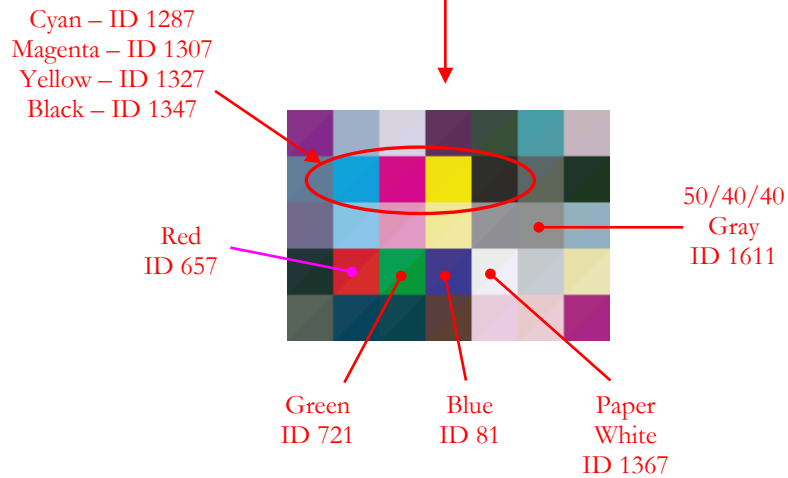
**Step-2:** Once opened, assign the IDs for the IT8.7/4 Visual target using the “Re-map/Assign IDs for IT8.7/4 Visual layout” pop-up menu as shown below. This is required since the proper IDs for the IT8.7/4 target are not included in the reference file suggested in Step-1.



You can then change the layout to “Random” using the same menu, but this time selecting the “Change layout to IT8.7/4 Random” command which is near the top of the menu. You should now see the screenshot appearing on the next page.



You can confirm that you have the correct "Random" layout by checking the patches in the layout center (they are enlarged below).



**Step-3:** We now need to re-format the layout so that a row of patches is no larger than the i1Pro measuring ruler, making sure there is enough unprinted substrate on the left and right of each row to start and stop scanning on these zones. We also want to maximize the number of patches in each row while keeping the patch width above the minimal size supported by the instrument. As well, the row width has to take into account the vertical contrast markers between each patch. And finally, we would also prefer to have a “filled” layout, if possible, with no white patches in the last column; when such patches are present, they sometimes need to be manually edited out from the measurement file (Note: Patch-Reader will handle targets where the last column is partially filled in most cases). These are a lot of parameters to juggle with, but we can easily solve the puzzle. Here are some of the requirements we must consider in order to facilitate line scanning with the various i1Pro models.

**Recommended patch sizes and row length for REFLECTANCE scanning**

Instrument	Min. PATCH width (Zebra ruler ON)	Min. PATCH width (Zebra ruler OFF)	Max. ROW length	Min. PATCH height
i1Pro / i1Pro 2	7 mm	10 mm	235 mm / 250 mm	8 mm
i1Pro 3	7 mm	10 mm	250 mm	7 mm
i1Pro 3 Plus	16 mm M3-mode: 20 mm	20 mm M3-mode: 22 mm	490 mm	16 mm

**Note 1:** The minimum patch width excludes any marker/separator width.

**Note 2:** The maximum row length is less than the maximum scan length which includes the unprinted substrate before and after each row.

In addition, when scanning,  $\Delta E^*_{ab}$  between neighboring patches must be  $> 20$  for 50%+ of the transitions for the Zebra ruler. When not using the Zebra ruler,  $\Delta E^*_{ab}$  must be  $> 20$  for all transitions. Alternately, the patches must be separated by contrast markers consisting of thin black or white bars (0,5-1,0 mm), whichever gives the maximum contrast, or combined Black/White bars (1,2-1,8 mm) before and after each patch. PatchTool uses Black/White markers with a [nominal width of 1,5 mm](#).

The IT8.7/4 target has 1617 patches. If we place 21 patches per row, this gives us exactly 77 rows (=1617/21). Considering our goal to place the 21 patches within the i1Pro ruler maximum row length (=235 mm), and removing an additional 15 mm for comfort (including pixel rounding, an extra set of vertical markers, and even more space on each row side), we can make a first estimate of the patch width.

First, we define the *total patch width* as:

$$total\ patch\ width = patch\ width + marker\ width .$$

where the *marker width* is fixed at 1,5 mm.

Then, we compute the *total patch width*:

$$total\ patch\ width = ROW\ length / 21$$

$$total\ patch\ width = (235 - 15) / 21 = 10,47\ mm (\approx 10,5)$$

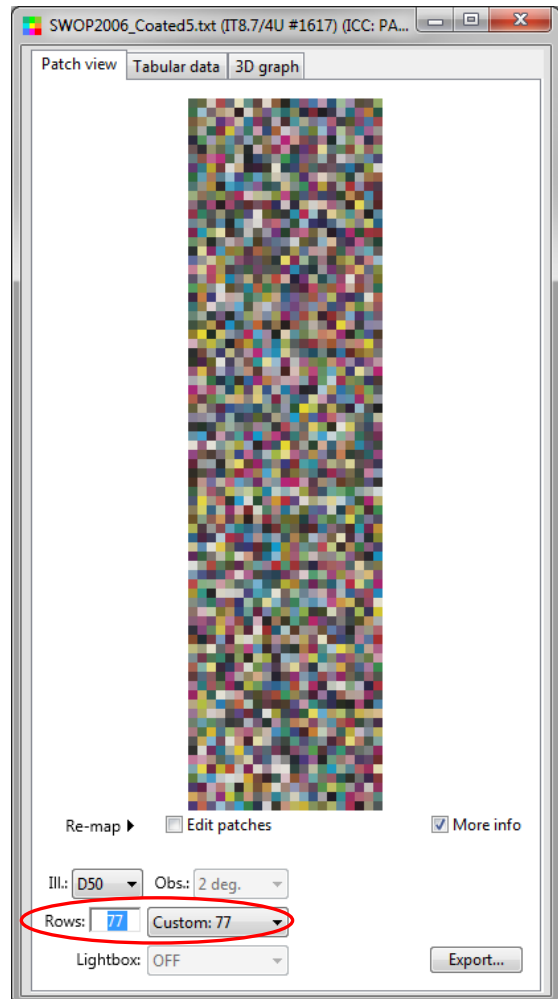
from which we get:

$$patch\ width = total\ patch\ width - marker\ width$$

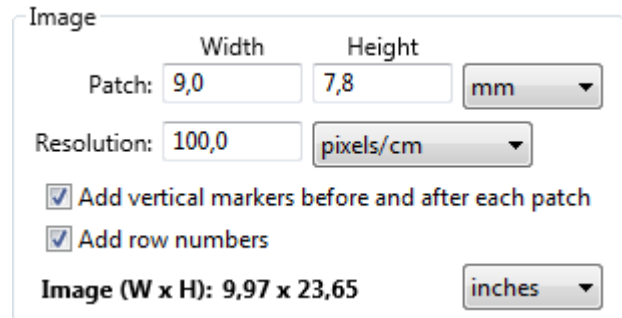
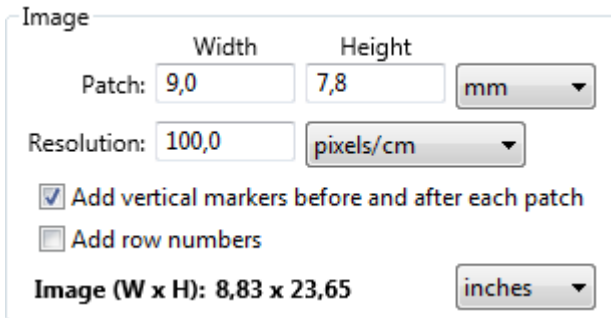
$$patch\ width = 10,5 - 1,5 = 9,0\ mm ,$$

which is quite acceptable, considering the minimal patch width requirement of 7 mm for the i1Pro as shown in the table.

We can now go back to the opened IT8.7/4 file where we set the “Rows” value to 77, which gives us the screenshot on the right.



**Step-4:** We open the [PatchTool Export](#) dialog where we first set the resolution to 100 pixels/cm. We then set the patch width to 9,0 mm and 7,8 mm in height. The patch height was selected so that 77 rows fit the printer's 24-inch printing width; at 7,8 mm in height, the patch can easily be scanned, even if a tad below the 8 mm requirement, and the image height is 23,65 inches.



Before generating the image, we selected the “Add vertical markers...” and “Add row numbers” checkboxes as seen on the screenshots above. The image width with markers only is 8,8 inches, well within the row length requirement, and 9,97 inches with row numbers. The resulting image with markers and row numbers is shown below right.

**Note:** It is suggested to set the resolution in “pixels/cm” if you want to specify a patch size in cm or mm; this will often prevent a resize of the patch size due to the requirement that patches have to be rounded to integer numbers of pixels. Similarly, you should set the resolution in “pixels/inch” when specifying a target size in inches.

We saved the image in a **TIFF / L\*a\*b\* / 8 bit** format.

**Step-5:** [Export](#) the PatchTool file **data** under another name, making sure you select the “ID”, “XYZ” and “CMYK” data fields. This file will be used by Patch-Reader, in Step-7, and again as a reference for a Compare file in Step-8. The CMYK data type is kept only for patch description, while the XYZ data will be used for computing the color difference between the reference data and the printed target. In addition, this file has the proper IDs for an IT8.7/4 target and its layout corresponds to the image that will be printed (i.e. 77 rows of 21 patches).

**Step-6:** Open the target image in Photoshop. The image is shown on the right. Print the image using the appropriate paper profile. We recommend selecting an Absolute Colorimetric rendering intent since we want to check the absolute accuracy of the printer. Let the target dry for at least 30 minutes (Note: the drying time could be much longer, up to many hours, for non-fast-dry papers).

**Step-7:** Once the printed target has dried, open the reference file generated in Step-5 in PatchTool and launch [Patch-Reader](#). In Patch-Reader, select the [PatchTool file](#) mode and select the target file; it should appear as illustrated on the screenshot on the right (without the contrast markers and row numbers!). Measure the target one line at the time using the strip measurement mode. Save your measurements once finished.

**Step-8:** Assuming the reference file from Step-5 is still opened in PatchTool, open the measurements file saved in Step-7. You can now compare the reference with the printed results using PatchTool's [Compare tool](#) (“Tools/Compare...” menu command).



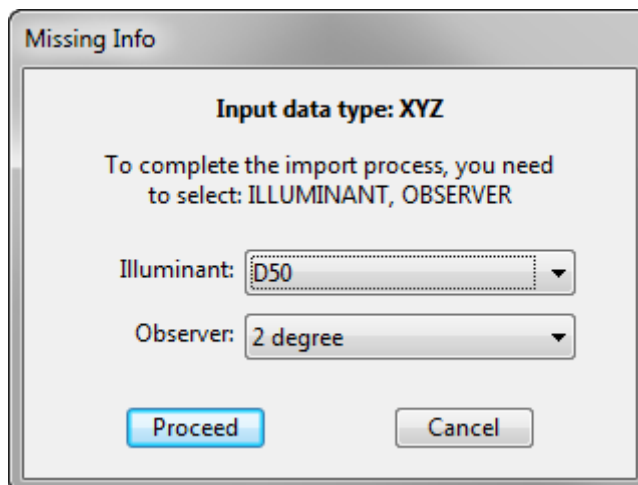
This completes the tutorial.



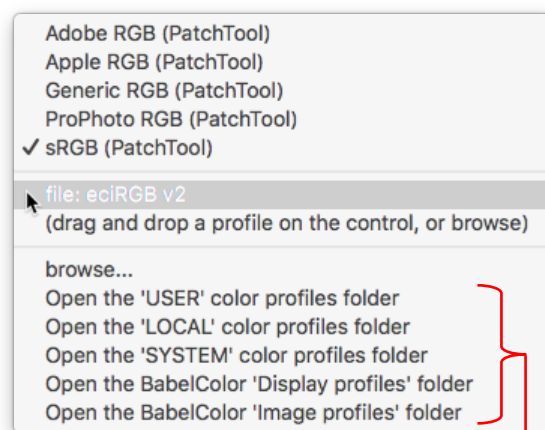
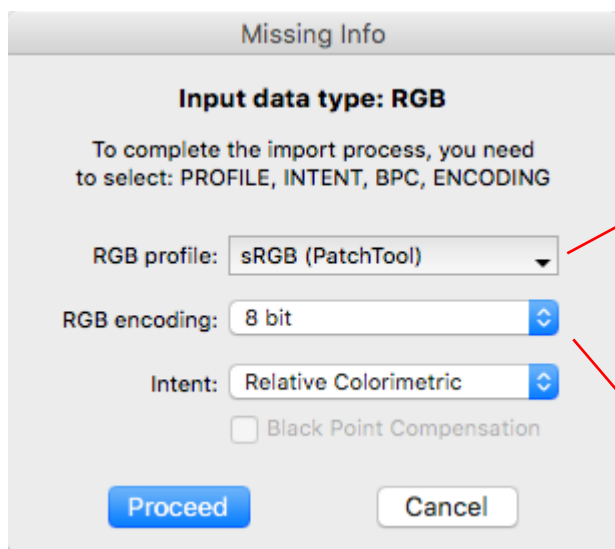


## 2.6 The “Missing Info” dialog

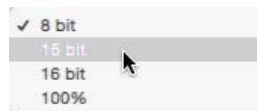
The dialog as it appears, in Windows, when Illuminant and Observer information is not found in an opened file. This information is required for L\*a\*b\*, L\*C\*h, xyY, and XYZ data.



The dialog as it appears, on a Mac, when RGB space information is required but not provided in the opened file.



Use these menu items to open folders which contain ICC profiles. The “USER” and “LOCAL” menu items (and folders) are not available in Windows.



The “Missing Info” dialog appears when measurement conditions required for imported data processing are not found in the opened file. For XYZ, xyY, L\*a\*b\* or L\*C\*h data, the missing conditions are usually the illuminant and observer. For RGB and CMYK data, a profile needs to be associated with the data\*; in addition, for RGB spaces, an encoding selection will be requested, if not specified. The dialog will not be seen when spectral data is detected in the file and used as the reference for color data.

Only the missing conditions will be queried. For example, if the “Illuminant” is found but the “Observer” is not, the “Missing Info” dialog will enable you to select only the Standard Observer. Please note that not all options are available in all cases; for instance, in the screenshot for missing RGB data just above, the “sRGB (PatchTool)” space is selected and the “Black Point Compensation” (BPC) is dimmed since this option is not supported for [PatchTool built-in RGB profiles](#). If an external ICC profile was selected, then the BPC option would be available.

\*: See the “Behind the scene: [CMYK data](#)” and “Behind the scene: [RGB space](#)” boxes for more info on how CMYK and RGB data is handled.



## 2.7 The “Import CxF2” dialog

The “Import CxF2” dialog appears whenever a CxF Version-2 (CxF2) file is opened. A single CxF2 file can contain a variety of content types, dedicated to various tasks, in one or more data sets (groups of colors). The top-level content types of a CxF2 file are:

- i- **Color Collection** (A loose collection of color measurements)
- ii- **Palettes with ColorSets** (Groups of colors associated by a common theme)
- iii- **Quality Control data** (called “ColorQualityControl” in CxF2 official literature)

Please consult [Appendix C](#) for a more complete description of the CxF2 file format.

Because a CxF2 file cannot be imported blindly, PatchTool analyses the file content and presents the following dialog to complete the import. The import dialog “CxF2 content types” selections will be enabled for all content types present in the file. The supported data types are shown in the tables, along with the Illuminant, the Standard Observer, and the number of patches corresponding to this data type. Non-supported data types found for the selected content are shown in the bottom-left of the dialog (there is none in the screenshot below).

The screenshot shows the 'Import CxF2' dialog box for a file named 'ColorChecker\_CxF2.cxf'. The dialog is titled 'Import CxF2 (ColorChecker\_CxF2.cxf)' and includes the text 'CxF creator: The BabelColor Company'. It features three radio buttons under 'CxF2 content types': 'Color Collection' (selected), 'Palettes / Color Sets', and 'Quality-Control data'. Below these is a checkbox for 'Assign the patch-ID as the patch-Name'. A table titled 'Color Collection data' lists data types with columns for '#', 'data type', 'Illuminant', 'Obs.', 'patches', and 'select'. The 'select' column has checkboxes, with the first and fourth rows checked. A green message states 'You can import RGB + another data type'. A section for 'Non-supported data types in the Color Collection' is empty. 'Proceed' and 'Cancel' buttons are at the bottom right. Red annotations with arrows point to various elements: 'Buttons are enabled when the content type is found in the file.' points to the radio buttons; 'The preferred data type to be used for import in this Color Collection.' points to the 'spectrum' entry in the table; 'In some files, the patch-ID field contains the patch-Name. Check this box to import the ID field as the Name.' points to the 'Assign the patch-ID as the patch-Name' checkbox; 'Select the data type to import, then click on the “Proceed” button.' points to the 'select' column checkboxes; and 'Note: If CMYK and/or RGB data is present, it can be imported in addition to another data type.' points to the 'Proceed' button.

Buttons are enabled when the content type is found in the file.

In some files, the patch-ID field contains the patch-Name. Check this box to import the ID field as the Name.

The preferred data type to be used for import in this Color Collection.

Select the data type to import, then click on the “Proceed” button.

Note: If CMYK and/or RGB data is present, it can be imported in addition to another data type.

#	data type	Illuminant	Obs.	patches	select
1	spectrum	N.A.	N.A.	24	<input checked="" type="checkbox"/>
2	L*a*b*	Supported	2 degree	24	<input type="checkbox"/>
3	Adobe RGB	D65	2 degree	24	<input type="checkbox"/>
4	sRGB	D65	2 degree	24	<input checked="" type="checkbox"/>

You can import RGB + another data type

Non-supported data types in the Color Collection

Proceed Cancel

**Note:** The file of the screenshot on the preceding page can be found in your installed application folder. Use the “File/Open Sample Files/Misc. Sample Files...” menu shortcut to reach the “sample\_files” folder. Open the “Help-Manual\_files” folder and select the “ColorChecker\_CxF2.cxf” file. The Color Collection for this file contains the average measurements of 20 ColorChecker charts; the Palette and Quality-Control sections contain the average data plus data from X-Rite. In particular, from the Quality-Control section, you can import both the average BabelColor data and the X-Rite data in a single Compare file; this is shown just below.

Select the data type you want to import and click on the “Proceed” button. If CMYK and/or RGB data is present in addition to another data type, it can be imported in the same file. Import from a Color Collection or a given Palette Color Set will always be done in a standard PatchTool file. For Quality-Control data, the import may be done in a standard file if only the *Standard* (also called the *reference* in PatchTool), or only the *Measurement* (also called the *sample* in PatchTool) is imported; however, if both the Standard and a Measurement Set are selected, as shown below, the data will be imported in a [Compare](#) file.

**Import CxF2 (ColorChecker\_CxF2.cxf)**

CxF2 content types

Color Collection

Palettes / Color Sets

Quality-Control data

CxF creator: The BabelColor Company

QC Set: 1 of 1 (BabelColor-Avg. vs X-Rite)

Meas. Set: 1 of 1

Assign the patch-ID as the patch-Name

**Standard data (QC Set-1)**

#	data type	Illuminant	Obs.	patches	select
1	L*a*b*	Supported	2 degree	24	<input checked="" type="checkbox"/>

**Measurement data (QC Set-1 / Meas. Set-1)**

#	data type	Illuminant	Obs.	patches	select
1	L*a*b*	Supported	2 degree	24	<input checked="" type="checkbox"/>

Non-supported data types

**Proceed** **Cancel**

Because individual measurements can be saved in different illuminant conditions, PatchTool checks if they are supported, but does not always list them. Click [here](#) for the list of supported Illuminants.

You can select only the *Standard*, or only the *Measurement Set*, or **both**. Selecting both will import the data into a [Compare](#) file.

Note: If CMYK and / or RGB data is present in the *Standard* or *Measurement Set*, it can be imported in each, in addition to another data type.

Whenever multiple data types are present, we strongly recommend importing the data using the following priority list as a guide (with the topmost data type being the most important):

- i- **spectrum**
- ii- XYZ, L\*a\*b\*, L\*C\*h, xyY
- iii- AdobeRGB, sRGB
- iv- RGB or CMYK (non-defined) (You should import RGB and CMYK as **additional** data if this data could be used or required by another application afterwards.)

If importing only non-defined RGB or CMYK data, you will be presented with a [dialog](#) asking you to select a profile to associate to the values.

Following import, you will find a synopsis of the imported data set(s) in the [Main window](#) log.



## 2.8 The “Import CxF3” dialog

The “Import CxF3” dialog appears whenever a CxF Version-3 (CxF3) file is opened. A description of the CxF3 format, which is based on XML conventions, is presented in [Appendix D](#). CxF3 files can be found with many different file extensions (the three to five characters which follow a period at the end of a file name). These extensions are used to identify the intended file usages; here are tables which associate the extension and the file usage in X-Rite’s i1Profiler:

Extension	Intended usage
*.cxf	Generic CxF file (for all CxF versions)
*.axf	Ambient Measurements
*.cmxf	Chart Measurements
*.dmxf	Display Measurements
*.dpsf	Display Profile Settings
*.dpxf	Display Profile Options
*.duxf	Display Uniformity Measurements
*.dwxf	Display Workflows
*.lxf	Lighting Parameters
*.mxf	Measurements
*.oxf	OBC Parameters
*.pwxf	Printer Profile Workflows
*.pxf	Patch Sets
*.rmxf	Reference Measurements
*.sxf	Profile Settings
*.txf	Test Charts

Extension	Transmissive workflow usage
*.lb1xf	Light Table Measurements-1
*.lb2xf	Light Table Measurements-2
*.t1xf	Transmissive Test Charts (1 <sup>st</sup> pass)
*.t2xf	Transmissive Test Charts (2 <sup>nd</sup> pass)
*.tm1xf	Transmissive Measurements (1 <sup>st</sup> pass)
*.tm2xf	Transmissive Measurements (2 <sup>nd</sup> pass)

A CxF3 file contains all its color data in a single XML element called an <cc:ObjectCollection> which comprises one or more <cc:Object> elements. Each <cc:Object> contains color data for a color patch as well as information on the patch physical attributes, and its relation to other Objects. Colors with different origins, such as “Reference” and “Samples”, are not placed in separate file structures, as they can be in a CxF2 file for instance, but are all together in the <cc:ObjectCollection>; their use is identified by an “ObjectType” attribute, a mandatory data field associated to each <cc:Object>.

**Note:** We use the “cc:” prefix and the element’s name as defined, without spaces, when we specify the element as it appears in the file, such as **cc:ObjectCollection**, but we omit the prefix and we add spaces when we make a descriptive reference to the element, i.e. the **Object Collection**. Both forms describe the same CxF3 element.

Each Object can be characterized in many different color “data types” (spectrum, L\*a\*b\*, sRGB, CMYK, etc.). Data types is a generic term used in PatchTool to represent two CxF3 Object sub-elements, <cc:ColorValues> and <cc: DeviceColorValues >, corresponding respectively to device-independent and device-dependant color spaces. Within a CxF3 file, each data type element is further associated to a <cc: ColorSpecification>; a Color Specification can be the same for all data types elements within an Object, or different. A CxF3 file thus assigns an Object Type to all Objects, and a Color Specification to each data type element.

While the Object Type can define the common characteristics of a group of Objects (i.e. a group of colors), the intended use of different Object Types in a file is not defined in the file structure as we mentioned, and will depend on what we want to do with them. This is why PatchTool analyses the file content and presents the dialog, shown on the following page. It is then up to the user to select the relevant data.



**Note:** The file used for the screenshot below can be found in your installed application folder. Use the “File/Open Sample Files/Misc. Sample Files...” menu shortcut to reach the “sample\_files” folder. Open the “Help-Manual\_files” folder and select the “ColorChecker\_CxF3.cxf” file. This file contains the average measurements of 30 ColorChecker charts as well as data derived from X-Rite L\*a\*b\* D50 data (2005).

Import CxF3 (ColorChecker\_CxF3.cxf)

CxF3 file type: Generic CxF3 format (.cxf)  
 CxF creator: The BabelColor Company  
 File description: ColorChecker Classic 24  
 File comment: This file contains measured ColorChecker color values averaged from 30 targets (compiled by BabelColor) and values derived from X-Rite L\*a\*b\* D50 data (2005)

Assign the patch-ID as the patch-Name

Move the mouse cursor over a cell to see its entire content here.

#	Object Type	data type	Color Specification	Illuminant	Observer	patches	select	notes
1	BabelColor Avg. of 30	spectrum (refl.)	CS1	N.A.	N.A.	24	<input checked="" type="checkbox"/>	
2	BabelColor Avg. of 30	sRGB	CS2	D65	2 degree	24	<input type="checkbox"/>	
3	BabelColor Avg. of 30	Adobe RGB	CS2	D65	2 degree	24	<input checked="" type="checkbox"/>	
4	BabelColor Avg. of 30	L*a*b*	CS1	D50	2 degree	24	<input type="checkbox"/>	
5	From X-Rite L*a*b* D50	sRGB	CS2	D65	2 degree	24	<input type="checkbox"/>	
6	From X-Rite L*a*b* D50	Adobe RGB	CS2	D65	2 degree	24	<input type="checkbox"/>	
7	From X-Rite L*a*b* D50	L*a*b*	CS1	D50	2 degree	24	<input type="checkbox"/>	

All the data types found in the file are shown but you are able to select only the ones supported by PatchTool.  
 You can import RGB + another data type in the same file.  
 Note: When selecting multiple data types, the number of patches must be the same for all!

Each row corresponds to a unique **Object Type/data type/Color Specification** combination.

Select the data type(s) to import, then click on the “Proceed” button.

Note: If CMYK and/or RGB data is present, it can be imported in addition to a device-independent data type.

The “Import CxF3” dialog contains a list of **all** Object Types and data types found in the file, with each data type further separated by Color Specification, if required. The Illuminant and Standard Observer, extracted from the Color Specification, and the number of patches corresponding to each combination, are also shown. However, combinations for which the data type or the Color Specification is not supported by PatchTool cannot be selected for import; in such cases, there is a short note explaining the rejection (there is none in the screenshot above).

Select the data type(s) you want to import and click on the “Proceed” button. CMYK and/or RGB data can be imported in the same file in addition to a device-independent data type (spectrum, xyY, L\*a\*b\*, etc.) Import will always be done in a standard [PatchTool window](#). If you want to compare two sets of data from the same CxF3 file, you should extract each data set separately and compare them afterwards using PatchTool [Compare](#) tool.

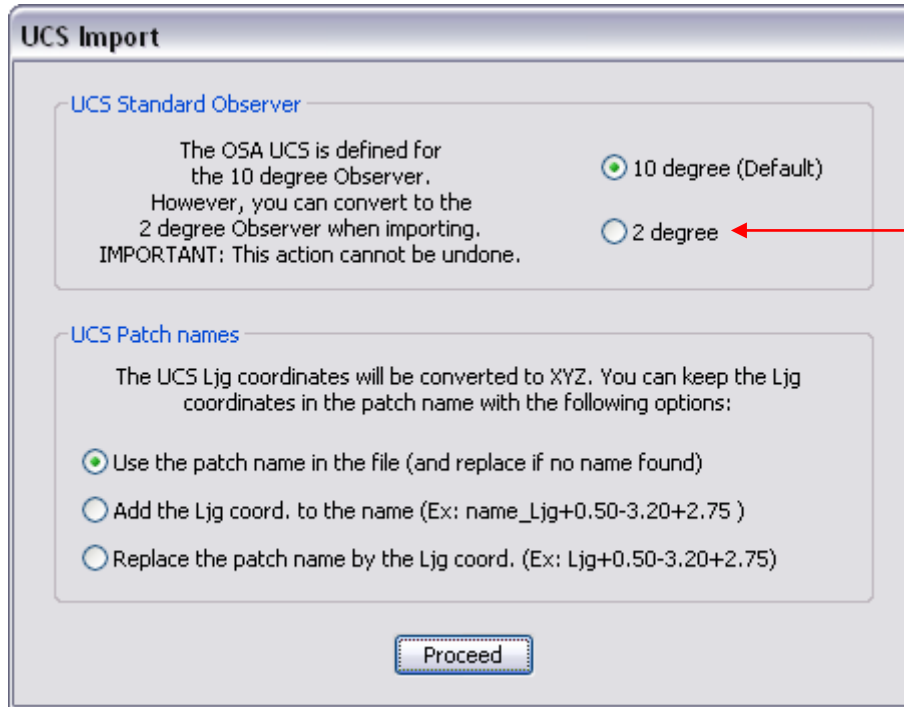
Whenever multiple data types are present, we strongly recommend importing the data using the following priority list as a guide (with the topmost data type being the most important):

- i- **Spectrum (refl.)**
- ii- XYZ, L\*a\*b\*, L\*C\*h, xyY
- iii- AdobeRGB, sRGB
- iv- RGB or CMYK (non-defined) (You should import RGB and CMYK as **additional** data if this data could be used or required by another application afterwards.)

If importing only non-defined RGB or CMYK data, you will be presented with a [dialog](#) asking you to select a profile to associate to the values. Following import, you will find a synopsis of the imported data set(s) in the [Main window](#) log.

## 2.9 The “UCS Import” dialog

The “UCS Import” dialog appears whenever the [UCS Ljg](#) data type is retained for import; see the “Behind the scene: [Selecting data for import](#)” box for the details of how color spaces are prioritized for import.



Even if defined only for the 10 degree Observer, you can convert a UCS list in 2 degree Observer coordinates.

Click [here](#) for more information on this particular conversion.

PatchTool does not keep the UCS coordinates once the file is opened. Still, you can record them in the patch name.

**Note:** Importing UCS data for the 2 degree Observer can be very helpful if you want to further analyze the data using the [Gamut Tools](#) which, being dedicated to ICC profiles, require data defined with the 2 degree Observer.

### File formats for UCS data

PatchTool can import UCS data saved in two file formats, either the CGATS format, or the [plain type](#) text format. An example of each format for the same three patches color list is shown below:

```
L, j, g
4, -6, 2
4, -6, 0
4, -6, -2
```

A simple text file obtained with a word processor or a spreadsheet, and saved in Comma-Separated-Values (CSV) format.

```
CGATS.17
ORIGINATOR   BabelColor PatchTool, version 2.7.0 b172
LGOROWLENGTH 3
CREATED      2009-09-09 # Time: 09:09:09
WEIGHTING_FUNCTION ILLUMINANT, D65
WEIGHTING_FUNCTION OBSERVER, 10 degree
# OSA UCS Ljg data is derived from Illuminant D65 and the 10 degree Observer
KEYWORD      SAMPLE_ID
KEYWORD      SAMPLE_NAME
NUMBER_OF_FIELDS 5
BEGIN_DATA_FORMAT
SAMPLE_ID    SAMPLE_NAME UCS_L UCS_J UCS_G
END_DATA_FORMAT
NUMBER_OF_SETS 3
BEGIN_DATA
1           Ljg+4-6+2  4      -6      2
2           Ljg+4-6+0  4      -6      0
3           Ljg+4-6-2  4      -6     -2
END_DATA
```

The UCS viewing conditions.

CGATS tags for UCS data.

The CGATS tags used for the UCS “Ljg” coordinates are: **UCS\_L**, **UCS\_J**, and **UCS\_G**; they were defined by BabelColor and follow the format used for other color spaces in CGATS files. These tags can be found when [exporting UCS](#) coordinates in a CGATS file and when generating a UCS color list with the [OSA UCS List tool](#).

You will find a description of the plain type format, a simple and efficient data exchange format defined by BabelColor, as well as some examples, in [Appendix A](#).

**Note:** When importing UCS data, the file illuminant will always be D65, as specified for the UCS viewing conditions. You may want to change this illuminant to D50 once the file is opened, especially if you have selected the conversion to the 2 degree Observer when importing, and if you plan to re-export the data in image processing applications.

Please consult [Appendix F](#) for a description of the UCS system.

#### **Behind the scene: Validation of the UCS (i.e. Ljg) to XYZ conversion**

While the XYZ to UCS conversion requires many equations to perform, the procedure is straightforward and ensures precise results. However, the reverse UCS to XYZ path has always been difficult to implement since the XYZ to UCS equations cannot be reversed. All methods to convert from UCS to XYZ are iterative in one or more steps, and obtaining accurate values is a challenge.

In one validation test, we started with a file containing 1124 Pantone Coated colors defined with spectral data; these colors cover a large gamut representative of most print jobs. We [exported](#) the Pantone spectral data to a file containing only UCS data; this XYZ to UCS conversion, as mentioned above, can be done with no error. We then reopened this file, selecting the default 10 degree Observer in the UCS Import dialog. We finally [compared](#) the original spectral file with the one imported from UCS data, the comparison being done with the 10 degree Observer and Illuminant D65. The average error between the two files was 0,02 DeltaE\* (CIEDE2000), with a standard deviation (sigma) of 0,01, and a maximum error of 0,06. These results demonstrate that the UCS to XYZ conversion in PatchTool is essentially lossless. Another test, with a set of colors covering the human eye gamut almost completely, gave similar results.

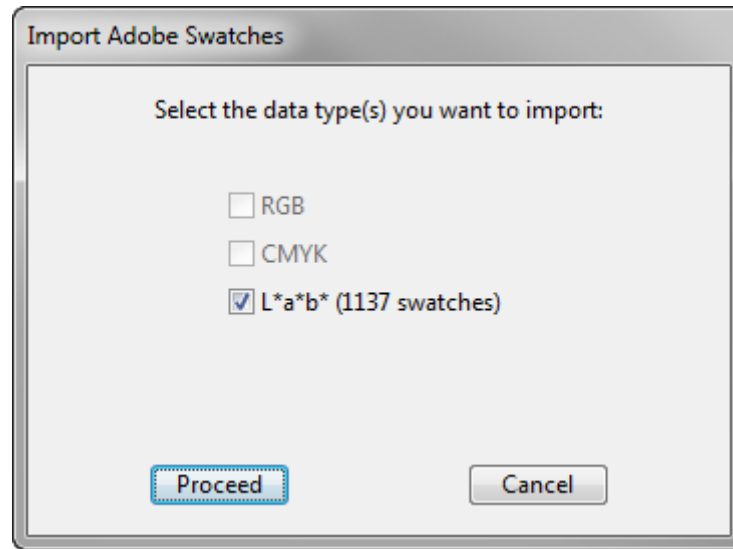
#### **Behind the scene: Validation of the 10 degree Observer to 2 degree Observer conversion**

There is no formal theory or method on how to convert tristimulus data from one Standard Observer to the other. Nonetheless, we developed a conversion algorithm which works effectively on a very large gamut. Please note that this is the only place in PatchTool where a conversion between observers is performed for tristimulus data.

For validation, we started with the same file of 1124 Pantone Coated spectrums mentioned above. We exported the spectral data to a first file containing only UCS data, and to a second file containing only 2 degree Observer XYZ data (D65); this second file was to be used for reference purposes. We immediately reopened these files, making sure we selected the 2 degree Observer in the UCS Import dialog when importing the file with UCS data. Finally, we [compared](#) the two files, both files containing only tristimulus data (i.e. no spectral data). The average error between the two files was 0,83 CIEDE2000 (D65) with a standard deviation of 0,66. The best 90% of the patches had an average error of 0,66 with a standard deviation of 0,38. Overall, 75% of the patches had a conversion error of one DeltaE\* or less, below the threshold where errors are seldom noticeable.

## 2.10 The “Import Adobe Swatches” dialog

The “Import Adobe Swatches” dialog appears whenever an “Adobe Swatch Exchange” (ASE) file, with an “.ase” file extension, is opened.



A single ASE file can contain swatches saved with RGB, CMYK, L\*a\*b\* (D50), and Gray coordinates. While all these color spaces are supported, PatchTool will create separate files for each color space if more than one color space is detected in a file. Also, Gray patches are imported as CMYK with the gray values assigned to the “K” coordinate (with C=M=Y=0).

**Note:** Data in ASE files is saved with “floating” numbers, i.e. non-integers with fractional precision. There is thus no need to assign a bit-depth (8 bit, 16 bit, etc.) to the data.

**Important:** Be careful when you use RGB and CMYK swatches. Because these coordinates can be associated to ANY profile, they thus can correspond to vastly different colors! We suggest adding the profile name in the swatch file name, such as “AdobeRGB” in order to prevent mistakes afterwards. We also suggest using L\*a\*b\* swatches instead of RGB and CMYK ones, but you have to be aware that a L\*a\*b\* color may be clipped when used in a document associated with a profile (sRGB, WebCoatedSWOP2006Grade3, etc.), which will always have a finite gamut compared to the L\*a\*b\* space.

Color groups, such as those created in Illustrator, are joined at import by PatchTool; this is the same behavior observed when importing Illustrator swatches in Photoshop. There are three color types in ASE files: **Process + Global**, **Spot color** (Global), and **Process**; while Illustrator supports all three types, Photoshop only uses the “Process + Global” type (Note: Photoshop will change a swatch color type automatically for compatibility purposes).

Any opened file can be exported as an ASE file in PatchTool using the [Export Swatches](#) dialog. You can assign any color type when exporting but the color type is the same for all exported swatches.

Please consult the documentation provided by Adobe on how to import and export ASE files in Adobe applications (Photoshop, Illustrator, etc.). Additional information on the ASE format and on the locations of user-saved swatches is presented in the “Behind the scene: [The Adobe Swatch Exchange \(ASE\) file format](#)” box on the next page.

## Behind the scene: The Adobe Swatch Exchange (ASE) file format

Over a dozen file formats can be found for color swatches, with at least six of them associated with Adobe applications. The most common, or known, file formats in Adobe applications are the Adobe Color Book (“.acb”), Adobe Color Swatch (“.aco”, or ACO), and Adobe Swatch Exchange (“.ase”, or ASE) formats, with the later being the most recent even if the others are not obsolete.

Swatches collections (ANPA, DIC, HKS, Pantone, etc.) are provided in ACO format in Adobe Photoshop, these collections can be edited, saved, and loaded in Photoshop using the ACO format but they need to be saved in the ASE format if you want to transfer them in other Adobe applications such as Illustrator. A similar situation is found in Adobe Illustrator where swatches can be saved in Illustrator “.ai” swatch format or in ASE format.

The default swatch files are located in the Adobe application folders but the custom swatches are saved elsewhere. Here are typical locations for the custom swatches. In the file paths shown below, replace “UserName” by your account/login name.

### Mac OS X custom swatches:

Adobe CS5:

Macintosh HD\Users\UserName\Library\Application Support\Adobe\Adobe Photoshop CS5\Presets\Color Swatches  
Macintosh HD\Users\UserName\Library\Application Support\Adobe\Adobe Illustrator CS5\en\_US\Swatches

Adobe CS6:

Macintosh HD\Users\UserName\Library\Application Support\Adobe\Adobe Photoshop CS6\Presets\Color Swatches  
Macintosh HD\Users\UserName\Library\Application Support\Adobe\Adobe Illustrator CS6\en\_US\Swatches

Note 1: In Mac Lion and Mountain Lion, the Library folder may be hidden but there is a simple way to access it. In the Finder, click the Go menu while pressing the Option key (i.e. the “alt” key) and select the “Library” in the menu list.

Note 2: For Adobe Illustrator, if you installed a localized version, the “en\_US” folder may be different; also, the “Swatches” folder may be named by the corresponding word in your language.

### Windows 7 – Vista custom swatches:

Adobe CS5:

C:\Users\UserName\AppData\Roaming\Adobe\Adobe Photoshop CS5\Presets\Color Swatches  
C:\Users\UserName\AppData\Roaming\Adobe\Adobe Illustrator CS5 Settings\en\_US\Swatches

Adobe CS6-32 bit:

C:\Users\UserName\AppData\Roaming\Adobe\Adobe Photoshop CS6\Presets\Color Swatches  
C:\Users\UserName\AppData\Roaming\Adobe\Adobe Illustrator CS6 Settings\en\_US\x86\Swatches

Adobe CS6-64 bit:

C:\Users\UserName\AppData\Roaming\Adobe\Adobe Photoshop CS6\Presets\Color Swatches  
C:\Users\UserName\AppData\Roaming\Adobe\Adobe Illustrator CS6 Settings\en\_US\x64\Swatches

Note 1: The “AppData” folder is normally hidden. To unhide it, open the “Folder Option” control panel and select the “View” tab. In the “View” tab “Advanced settings” section, under “Files and Folders/Hidden Files and Folder”, click on “Show hidden files, folders, and drives”, and then click “OK” to close the control panel.

Note 2: For Adobe Illustrator, if you installed a localized version, the “en\_US” folder may be different; also, the “Swatches” folder may be named by the corresponding word in your language.

### Windows XP custom swatches:

C:\Documents and Settings\UserName\Application Data\Adobe\Adobe Photoshop CS3\Presets\Color Swatches  
C:\Documents and Settings\UserName\Application Data\Adobe\Adobe Illustrator CS3 Settings\Swatches

Note: The “Application Data” folder is normally hidden. To unhide it, open the “Folder Option” control panel and select the “View” tab. In the “View” tab “Advanced settings” section, under “Files and Folders/Hidden Files and Folder”, click on “Show hidden files, folders, and drives”, and then click “OK” to close the control panel.

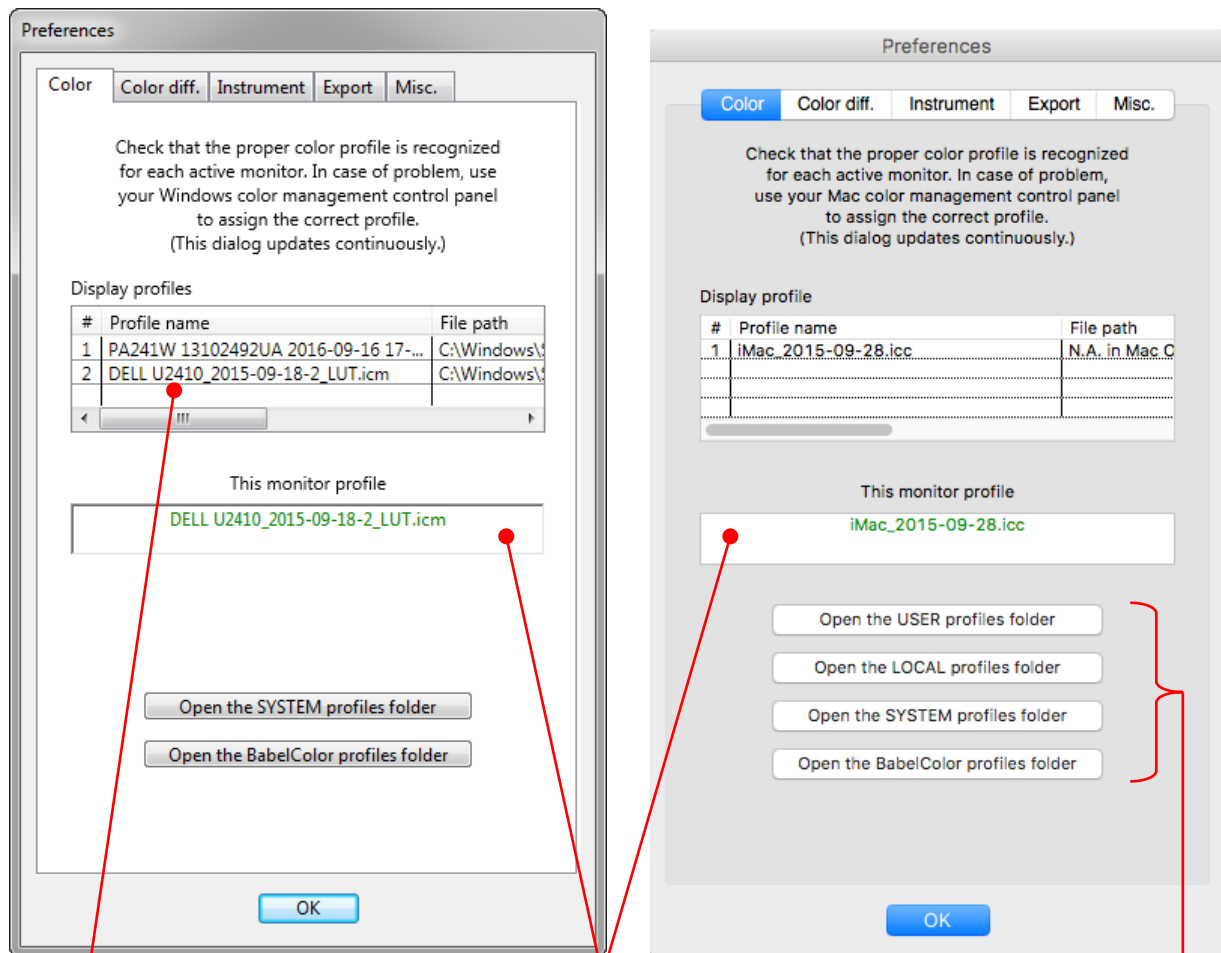
ASE files can be [imported](#) and [exported](#) with PatchTool.

## 2.11 The “Preferences” dialog

There are five tabs in this dialog; click on the links for more information:

- [Color](#)
- [Color difference](#)
- [Instrument](#)
- [Export](#)
- [Misc.](#)

### Preferences dialog: Color tab



This table shows the name and path of the profiles assigned to each display by the OS. Use the OS display control panel to change this assignment.

This field shows the profile assigned to the display on which the “Preferences” dialog is located. The content is updated continuously.

Click on these buttons to open folders which contain user and system display profiles.

PatchTool automatically detects the profile associated to the display on which a colored patch is represented. For more information on PatchTool’s color management workflows, see [Appendix B](#).

The “Color” tab of the “Preferences” dialog cannot be used to assign or select a profile but is used to check if the profiles assigned to each display are the correct ones.

**Note:** The profile file path is not shown on macOS.

**Important:** Please be careful when you change a display profile using the OS display control panel because a display profile is generally matched to its hardware settings. When you make a display profile, you are often asked to set a White Point and brightness level. This adjustment is made automatically on high end systems but remains a manual task in many calibration workflows. In any case, these hardware adjustments are linked to the resulting profile as well as to the graphic card Look-Up-Table (LUT), and sometimes also to the display LUTs if so equipped. This means that if you assign a different profile to a display, you should make sure that the hardware settings correspond to this other profile. Since these settings are often manually adjusted and not recorded, there is little chance of getting the system back to the correct state. On the plus side, we often make many profiles with the same White Point and brightness values, changing only software settings between each profile.

**Important:** Make sure the LUTs corresponding to the selected profile are loaded. In particular, for Windows computers, the LUTs are NOT updated when the display profile is changed using the display properties dialog. A dedicated [LUT loading application](#), or a reboot, is required.



## Preferences dialog: Color difference tab

The "Left" and "Right" positions are relative to the patches seen in the "Info" window.

When selected, weighted values will also be used for Munsell conversion if the CIE94, CMC or CIEDE2000 color difference formulas are selected in the "Export" tab of the "Preferences" dialog.

These preferences affect the color difference values shown in the "Info" window and in the "Tabular data" tab of a "Compare" window.

This preference has an effect only on the "Tabular data" tab of a "Compare" window.

The screenshot shows the "Preferences" dialog with the "Color diff." tab selected. The settings are: "Reference mode for CIE94 / CMC" with "Reference is mean of both patches" selected; "Delta L\*C\*H\* for CIE94 / CMC / CIEDE2000" with "Show WEIGHTED values" unchecked; "Delta h computation when > 180 deg." with "Use the complement to 360 degrees" checked; and "Delta columns sorting method" with "Sort using the ABSOLUTE Delta values" checked.

### Reference mode for CIE94 / CMC

These radio buttons affect how the CIE94 and CMC color differences are computed. Use the "Reference at Left, Sample at Right" setting for Quality Control (QC) type work; use the other setting when none of the colors has more importance than the other. The other color difference formulas offered in PatchTool, CIELAB and CIEDE2000, are symmetrical and will not result in different values when swapping the *Reference* and the *Sample*.

### Delta L\*C\*H\* for CIE94 / CMC / CIEDE2000

The CIE94, CMC and CIEDE2000 formulas apply non-constant weights to the individual DeltaL\*, DeltaC\*, and DeltaH\* contributions to DeltaE\*. When this preference is selected, the Delta L\*C\*H\* differences are shown with weighted values; more specifically, the "Info" window and the "Tabular data" table in the "Compare" windows will show the Deltas divided by a weight symbol, i.e. " $\Delta L^*/w$ ", " $\Delta C^*/w$ ", and " $\Delta H^*/w$ ".

### Delta h computation when > 180 deg.

The L\*C\*h coordinates define a color space where h is the angular position of the hue on a color circle. Since an angle of 360 degrees is the same as a zero degree angle, the maximum angle between two hues is 180 degrees. Selecting this preference assures that hue angle differences (Delta h) larger than 180 degrees are computed by removing 180 degrees to the color difference.

### Delta columns sorting method

This preference affects how the Delta columns of the Compare windows are sorted. When selected, a Delta a\* difference of -0,5, for example, will be considered equal to a difference of +0,5. Unselecting this preference can be useful to separate the patches which show a negative difference from the ones which show a positive difference.

## Preferences dialog: Instrument tab

The screenshot shows the 'Preferences' dialog box with the 'Instrument' tab selected. The dialog has five tabs: 'Color', 'Color diff.', 'Instrument', 'Export', and 'Misc.'. The 'Instrument' tab contains several settings:

- Display type - i1Display Pro:** A dropdown menu set to 'LCD'. A red arrow points to this dropdown with the text: "This setting is required for proper i1Display Pro configuration when using the Display-Check and Display-Reader tools."
- Display type - Other instruments:** A dropdown menu set to 'LCD'. A red arrow points to this dropdown with the text: "Instrument configuration setting used in Display-Check and Display-Reader. Required for: DTP94, Eye-One Display, Eye-One Display2, and Spyder2. NOT required for: i1Pro, i1Pro2, Spyder3-4-5."
- Measurement speed:** A dropdown menu set to 'FAST'. A red arrow points to this dropdown with the text: "Select the measurement speed for the i1Display Pro, Spyder2, Spyder3, Spyder4, and Spyder5 instruments."
- Adaptive measurements:** A dropdown menu set to 'NO (faster)'. A red arrow points to this dropdown with the text: "This setting can be used to improve the measurement accuracy of low luminance patches in Display-Check and Display-Reader. When selected, darker patches are measured for a longer time. It works with the i1Pro and i1Pro 2 but only when the 'i1Pro / i1Pro 2 (XRG)' driver is selected."

At the bottom of the dialog is an 'OK' button. Below the dialog, there are two paragraphs of text explaining the settings.

The settings in this tab can also be selected in the “[Instrument info](#)” dialog opened from the “[Display-Check](#)” window; however, the “Instrument info” dialog contains additional information and settings specific to each instrument.

**i1Display Pro:** When making tests with the i1Display Pro we verified that we get less noise when increasing the measurement time, as expected, but the difference is most often not significant (in particular, the noise is low for dark patches even with short measurement times). We offer two options: a FAST setting which takes a measurement about every 0,5 second, and a SLOW setting which takes a measurement about every 1,2 seconds. Select the FAST setting to start with; use the SLOW setting if you see large differences between two series of measurements done back-to-back, or when the display refresh rate is lower than 50 Hz. Always use the SLOW setting when making measurements on a CRT.

**Spyder2/Spyder3/Spyder4/Spyder5:** PatchTool offers an exclusive adaptive measurement algorithm for these instruments. In this algorithm, the measurement time is based on each patch luminance (in cd/m<sup>2</sup>), with longer times allocated for darker patches and shorter times for bright patches. Two options are proposed; the FAST setting places emphasis on speed while the SLOW setting places emphasis on precision. Depending on the display

luminance, a measurement in FAST mode can be as short as one second for very bright patches, and as long as 4 seconds for very dark patches. In SLOW mode, a measurement will never be shorter than two seconds, but can be as long as 16 seconds.

You can get an idea of the average measuring time for a large number of patches by looking at this [table](#) in the “[Display-Check](#)” help section.

### Preferences dialog: Export tab

The screenshot shows the 'Export' tab of the Preferences dialog. The 'CGATS spectral tag format' section has four radio buttons: 'nm450', 'SPECTRAL\_NM450 (i1Profiler)' (selected), 'SPECTRAL\_NM\_450', and 'SPECTRAL\_450 (ColorPort)'. The 'Spectrum scale' section has two radio buttons: '0-1' (selected) and '0-100'. The 'Spectrum range' section has two radio buttons: '380 - 730 nm' (selected) and '400 - 700 nm'. The 'Decimal separator' section has two radio buttons: 'Period [ . ]' (selected) and 'Comma [ , ]'. The 'Munsell conversion' section has a 'dE formula:' dropdown set to 'CIELAB' and an 'Export format:' dropdown set to '4 columns'. Below the 'Export format:' dropdown is a list of options: '1 column: "Hue Value/Chroma"', '4 columns: "H1", "H2", "V", "C"', and '5 columns: "Hue Value/Chroma", "H1", "H2", "V", "C"'. An 'OK' button is at the bottom.

Select the format for the tag used to identify spectral data in CGATS file.

Separator used when saving data with PatchTool tools. (Exception: Color Correction Matrices are always saved with a period). Select “Period” as the decimal separator if you intend to open the file in a program which is not “international savvy”. This setting is also available in the “[Export](#)” dialog as well as in other PatchTool export dialogs.

Select the export format for the Munsell coordinates. The formats are described just below the selection menu.

Select the color difference formula that will be used to convert file data to Munsell coordinates. For the CIE94, CMC and CIEDE2000 formulas, the conversion is also affected by the “Show WEIGHTED values” setting of the “[Color difference](#)” tab in the “Preferences” dialog.

These settings are used when saving spectral data with PatchTool tools. These settings are also available in the “[Export](#)” dialog as well as in other PatchTool export dialogs.

## Preferences dialog: Misc. tab

The screenshot shows the 'Misc.' tab of the Preferences dialog. It contains several sections: 'Patch size' with a dropdown set to '7 pixels'; 'Reflection Density computation (ISO 5-3)' with a dropdown set to 'Status T'; 'ICC monitor/display profiles (Abs-Col)' with an unchecked checkbox 'Assume FULL adaptation for display white point' and explanatory text; 'Spectral interpolation (patch data)' with radio buttons for 'Cubic spline' (selected), 'Lagrange', and 'Linear'; and 'Main window and Info window behavior' with an unchecked checkbox 'Bring to the front when clicking on a file window'. Annotations include a red arrow pointing to the 'Patch size' dropdown, another pointing to the 'Cubic spline' radio button, and a third pointing to the 'Bring to the front...' checkbox. A note on the right states: 'Note: Option available on Windows OS only! If not selected, the file window gets the focus, and goes to the front, and the Main and Info windows remain hidden behind other windows if they are already in such positions.'

Setting used in the “Patch view” tab of an opened file window.

Recommended setting

See [Appendix H](#) for more information on CIE 170 support in PatchTool.

Note: Option available on Windows OS only!

If not selected, the file window gets the focus, and goes to the front, and the Main and Info windows remain hidden behind other windows if they are already in such positions.

### Patch size

Setting used in the “Patch view” tab of an opened file window. This number is NOT the patch size used to export images in the “PatchTool Export” window.

### Reflection Density computation (ISO 5-3)

This preference affects how density values are computed throughout the program. The available density standards are defined in ISO 5-3:

- **Status A:** Should be used for measuring densities of photographic color prints.
- **Status E:** Used mostly in Europe to measure printed material. It has a wide-band color response. Equivalent to the DIN status.
- **Status I:** Has a narrow-band or interference-type filter response. Equivalent to the DIN NB and SPI statuses.
- **Status T:** The equivalent of ANSI Status E in North America. The difference with Status E is how the yellow filter is weighted

**Note:** Because density computation is based on spectral data, density values in the program interface (as in the “[Info window](#)”) are provided only for files which contain such data. Similarly, the option to [export](#) density values is available only for files which contain spectral data, and uniquely for the “CGATS” and “Plain text” file types.

### **ICC monitor/display profiles (when used with Absolute Colorimetric rendering)**

In ICC v2 the adaptation for the display white point was not specified, and there was usually NO adaptation. In ICC v4 the adaptation is set, by default, to FULLY adapted (ICC v4 is fully supported since PatchTool Version 4.5). Starting with PatchTool Version 6.0, this setting is a user preference. In PatchTool 6.x the *program* default is “NO” adaptation, which has been used historically when representing a profile in a [3D graph](#).

ICC reference documentation: [https://www.color.org/icc\\_specs2.xalter](https://www.color.org/icc_specs2.xalter)

ICC v2 & v4 differences:

[https://www.color.org/whitepapers/ICC\\_White\\_Paper\\_6\\_v2\\_and\\_v4\\_display\\_profile\\_differences-updated.pdf](https://www.color.org/whitepapers/ICC_White_Paper_6_v2_and_v4_display_profile_differences-updated.pdf)

### **Spectral interpolation (patch data)**

CIE 170 computation, required whenever the “2F” or “10F” Standard Observer is selected, is performed internally in PatchTool with 5 nm reference data. This setting is used to assign the interpolation method for input data (reflectance or emission) from a 10 nm bandwidth to a 5 nm bandwidth. The “**Cubic spline**” method, shown in bold, is the recommended setting.

For CIE 170 computation in PatchTool, a 5 nm bandwidth is also required for the Illuminant; to this effect, a 5 nm bandwidth version is automatically used when a standard PatchTool Illuminant is selected (C, D50, F11, etc.). Since Custom Illuminants can be defined with a 5 nm or 10 nm bandwidth, they also need to be interpolated to 5 nm if defined with a 10 nm bandwidth; you can select the interpolation method for the Illuminant in the [Custom Illuminants](#) dialog.

You will find more information on how CIE 170 computation is handled in PatchTool in [Appendix H](#).


### **Main window and Info window behavior (Windows OS only)**

If this option is selected, the 1st click on a file window brings the Main window, the Info window, and the selected file window to the front. The subsequent clicks can be used to interact with the file window. If not selected, the file window gets the focus, and goes to the front, and the Main and Info windows remain hidden behind other windows if they are in such positions.



## 2.12 The “Instrument info” dialog

The “Instrument info” dialog provides information relative to the selected instrument, its driver, its current status, and can be used to select or assign various instrument and measurement modes. The dialog is opened by clicking the “Info” button in the “[Display-Check](#)”, “[Display-Reader](#)”, and “[Patch-Reader](#)” windows.

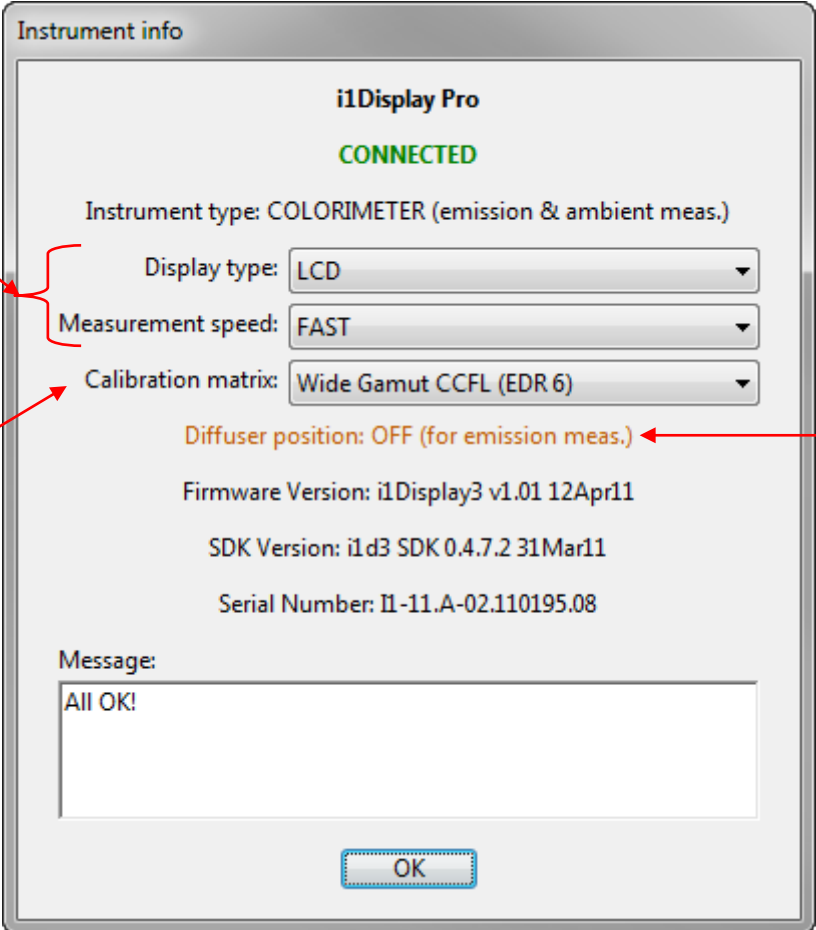
If your instrument is connected but shown as not available in Display-Check or Patch-Reader (with a red light  beside the “Instrument” menu), you should first attempt a reconnect by selecting “Try to connect again...” in the “Instrument” menu. If the instrument is still not connected, the “Instrument info” dialog may provide information on the source of the problem.

The dialog content is customized for each instrument since not all instruments support all of these settings or provide the same information. In the case of the i1Pro 2 driver, identified by “i1Pro / i1Pro 2 (XRGB)” in the “Instrument” menu, you will notice that the dialog is even different in Display-Check and Patch-Reader. You will find more info on the supported instruments in [Section 3.6.1](#) which contains a [table](#) identifying which setting is available for each instrument as well as a description of each setting.

The following screenshots show a few examples of the dialog with different tools and instruments.

### i1Display Pro (Display tools, either Display-Check or Display-Reader)

From this dialog you can select or assign: the **display type**, the **measurement speed**, and a **calibration matrix**.



These two settings can also be selected in the “[Preferences](#)” dialog.

For the i1Display Pro, this menu is only available when the instrument is connected and ready.

Note: A similar menu is available for the Spyder4. It is always available but the calibration matrix can only be set if the instrument is connected.

This information field is updated continuously so you can change the diffuser position and see if it is detected.

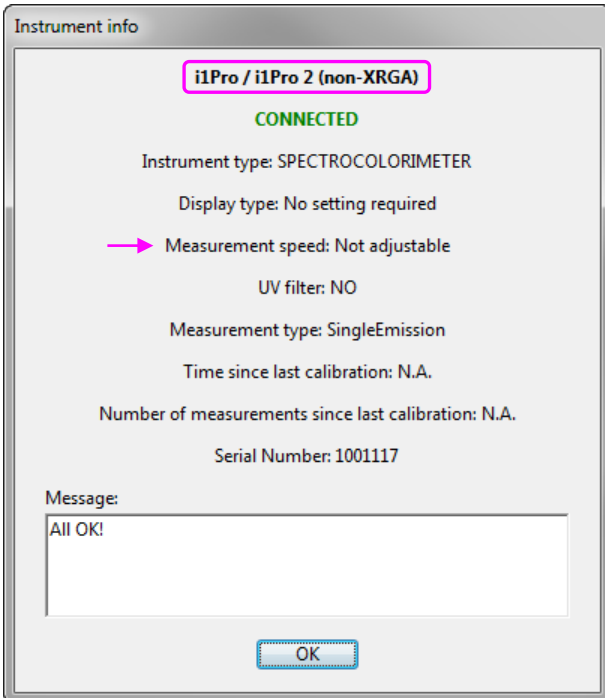
Note: The diffuser information is available only for the i1Display Pro.

**Note:** It is also possible to assign a [Color Correction Matrix](#) to any instruments. This can be done from the “[Display-Reader](#)” or “[Display-Check](#)” window.

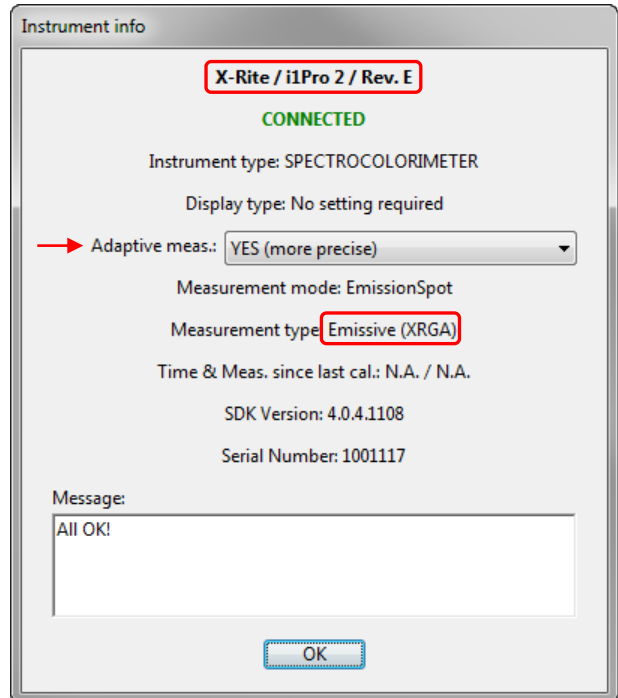


Here are four screenshots obtained with the same **i1Pro 2** in Display-Check/Display-Reader, and Patch-Reader, with either the old **i1 Pro** driver (**i1Pro/i1Pro 2 (non-XRGA)**) or the new **i1Pro 2** driver (**i1Pro/i1Pro 2 (XRGA)**).

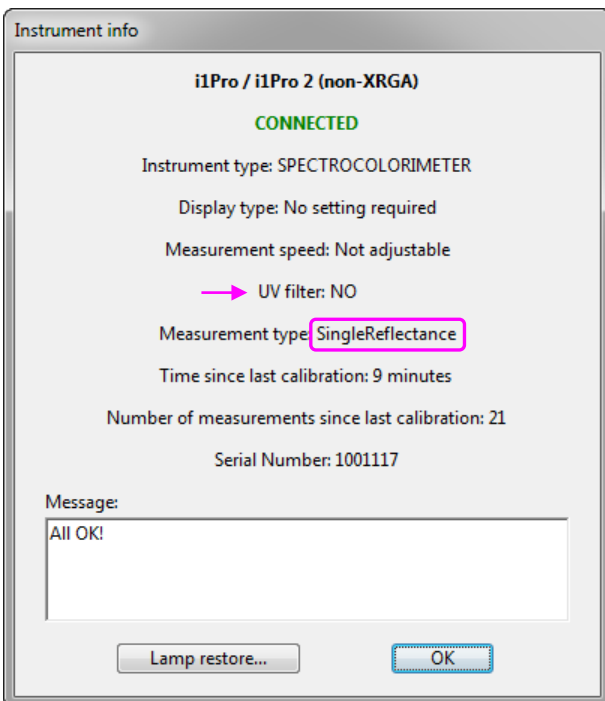
**i1Pro 2 (Display tools)** with **i1Pro/i1Pro 2 (non-XRGA)** driver



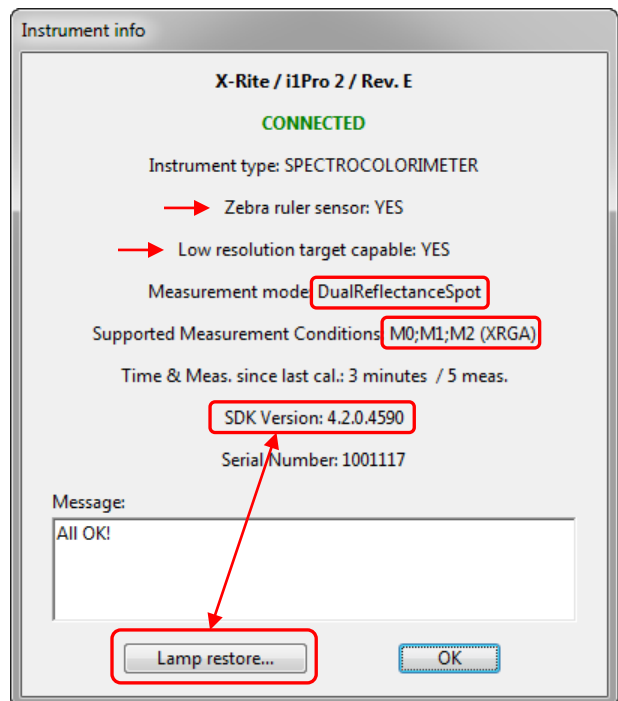
**i1Pro 2 (Display tools)** with **i1Pro/i1Pro 2 (XRGA)** driver



**i1Pro 2 (Patch-Reader)** with **i1Pro/i1Pro 2 (non-XRGA)** driver



**i1Pro 2 (Patch-Reader)** with **i1Pro/i1Pro 2 (XRGA)** driver



**Note 1:** The **i1Pro** driver (**i1Pro/i1Pro 2 (non-XRGA)**) cannot differentiate between the **i1Pro** and **i1Pro 2**; both are seen as an **i1Pro**. The **i1Pro 2** driver (**i1Pro/i1Pro 2 (XRGA)**) can identify the instrument and provide the Rev. level.

**Note 2:** The **i1Pro 2** driver resets the time since the last measurement and the number of measurements quite aggressively compared to the **i1Pro** driver. This information is often not available.

**Note 3:** In **Patch-Reader**, with the **i1Pro** driver, this **i1Pro 2** can support only the **M0** measurement condition (incandescent illumination with no UV filter). With the **i1Pro 2** driver, **M0**, **M1**, and **M2** are supported.

## i1Pro and i1Pro 2 lamp restore

Starting with Version 4.7, PatchTool includes an updated i1Pro / i1Pro 2 driver from the i1Pro SDK Version 4.2.0. This driver is used **exclusively** with the “**i1Pro / i1Pro 2 (XRGA)**” instrument selection and provides a new function to test tungsten lamp drift and restore it if required. Lamp restore is possible with both the i1Pro and i1Pro 2 instruments. According to X-Rite, restoring a lamp is infrequently necessary. However, if you suspect that your lamp has drifted, then click on the "Lamp restore..." button of the "Instrument info" dialog and follow the instructions.

**Note:** The “Lamp restore” button will appear **ONLY** when the “Instrument info” dialog is opened from the [Patch-Reader](#) tool. The reason is this is the only tool which requires reflectance measurements, and thus a lamp! Also, the “Lamp restore” button is not shown in the software packages dedicated to PowerPC Macs and Windows XP, which use an older version of the i1Pro SDK.

**Important:** Before initiating the lamp restore procedure, please do the following checks:

- i- Make sure that you are using the correct calibration tile/base for your instrument. The tile is matched to the instrument and identified with the same serial number.
- ii- Calibrate your instrument in Patch-Reader before doing a lamp restore check; this is a good indication that your USB connection is in proper working order. When there is a USB problem, you should get specific error messages to this effect when calibrating, particularly in reflectance, and typically more often with the i1Pro 2 than with the i1Pro. The yellow text box on the bottom of this page presents a more complete check-list in case of calibration failure.

Once the restore check procedure is started, the lamp will be restored automatically if a lamp drift is detected. Restoring the standard lamp condition takes about **2 minutes** and you will get a confirmation message when it is completed. If you get a message in less than 10 seconds, then restoration was not required.

**Warning:** Leave the instrument on the calibration plate until you get a confirmation message that the check or restore is completed.

**Note:** If lamp restore is required for an **i1Pro 2**, you will see a series of yellow-green flashes on the instrument at the beginning and end of the 2 minutes procedure. Because the **i1Pro** has no such lights, you should simply wait until you get a confirmation message. For both instruments, you will also see a waiting cursor while the check and restore is performed; however, please note that this cursor is visible only when the mouse cursor is over one of PatchTool’s windows.

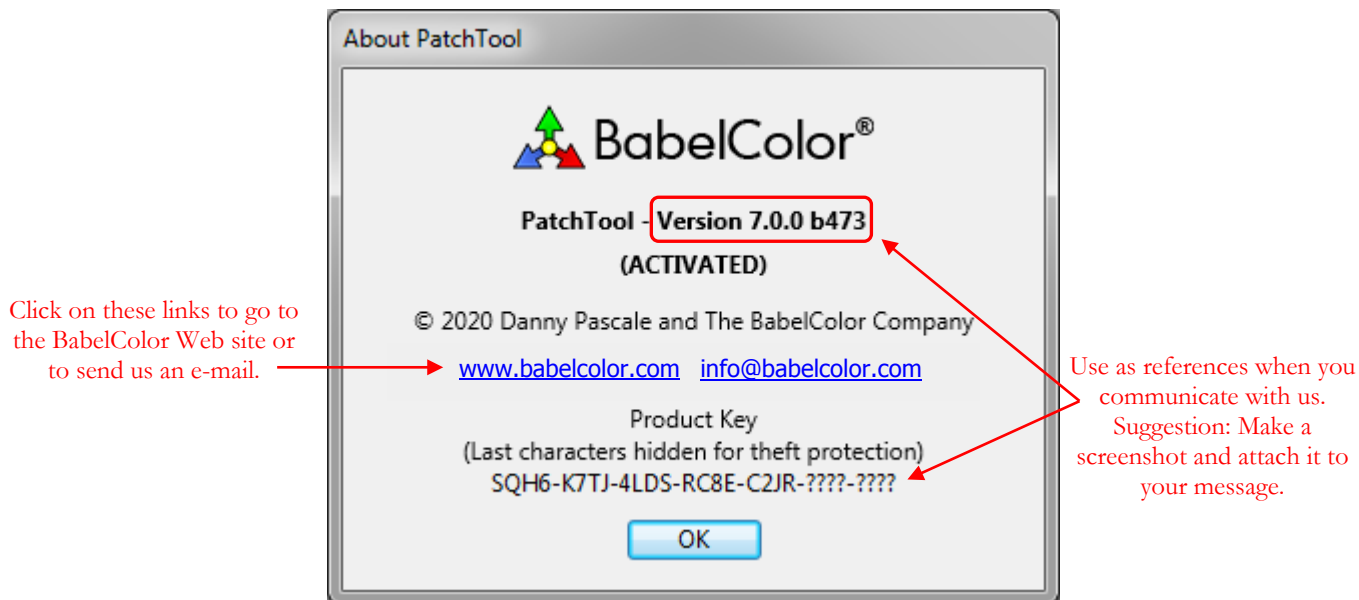
### **i1Pro/i1Pro 2 calibration failure check-list**

Calibration failure more often occurs when calibrating in reflectance mode. This can happen even if the instrument is properly detected and identified in the “Instrument info” dialog. Here are potential causes to look for:

- i- The instrument is not properly seated on the calibration tile. This may seem obvious but it is worth checking!
- ii- The calibration tile is dirty. Clean it gently with a soft tissue lightly dabbed in isopropyl alcohol.
- iii- You are using the wrong calibration tile for the instrument. The i1Pro calibration tile is matched to the instrument at the factory. You should be aware that using a tile from another instrument will very likely provide inaccurate measurements, even if you do not get an error message!
- iv- There is a bad or degraded contact between the instrument and the USB cable or between the cable and the computer USB port. If a connection is loose, you can sometimes improve it by pushing, holding, or reinserting the connector. Try another USB cable or another USB port to see if you get better results. In some extreme cases your computer USB port or your instrument connector may need to be replaced.
- v- The overall USB cable resistance is too high. This can be due to a poor quality cable, a damaged cable, a cable which is too long, or a cable with dirty connectors.
- vi- The computer USB port cannot provide enough current for calibration. This is more often a problem with external USB hubs. Try a USB port which is not used (i.e. connected and disconnected) often.
- vii- If all of the above is non-conclusive, your instrument may be due for a factory calibration or repair.



### 2.13 The “About PatchTool” window



The last characters of the Product Key are hidden to prevent a casual user from stealing your license. However, the remaining numbers are still sufficient to identify who purchased the product in case you require product support. As discussed in more details in the [Activation-Deactivation](#) section, you can deactivate PatchTool on a computer and activate the software on another computer with the same Product Key. When deactivating, you can decide to erase or not the product key. If the product key is not erased on a given computer, you can reactivate this computer without entering the Product Key (and assuming that the Product Key is not activated over its prescribed limit on other computers). If the Product Key is erased, you will need to re-enter the COMPLETE Product Key in the Activation dialog. It is thus essential to keep a copy of the e-mail that contains the Product Key, an e-mail which you received when you purchased the software.



### 3. The Tools

#### 3.1 Average

The “PatchTool Select Average” dialog is opened by selecting the “Tools/Average...” menu. The menu is enabled when there are at least two opened files.

Click anywhere on a row to select or unselect.

Left-click on the “avg.” column header to CLEAR all selections. Right-click (ctrl + click on a 1-button Mac mouse), to automatically select all compatible files.

Selected files have a checkmark and a green background.

The white background identifies the files which are compatible with the previous selection(s). Note: the remaining files *may* be incompatible between them.

Once the first file is selected, non-compatible files are grayed-out.

When you place the mouse cursor in the “color ref.” column, you can see additional information on the file data. This information is shown below the table, in green.

Only files with the same number of patches can be averaged.

#	opened files	patches	color ref.	avg.
1	CC_MyChart_measure-1.txt	24	spectrum	<input checked="" type="checkbox"/>
2	CC_MyChart_measure-2_Lab_2deg.txt	24	L*a*b* (2 deg.)	<input type="checkbox"/>
3	CC_MyChart_measure-2_Lab_10deg.txt	24	L*a*b* (10 deg.)	<input type="checkbox"/>
4	CC_MyChart_measure-3.txt	24	spectrum	<input type="checkbox"/>
5	CC_MyChart_measure-4.txt	24	spectrum	<input type="checkbox"/>
6	RGB_3-255_step4.txt	64	RGB (2 deg.)	<input type="checkbox"/>

#6 - File name: RGB\_3-255\_step4.txt  
 RGB converted to XYZ. Combine with 2 deg. files or spectral data.  
 RGB profile: sRGB IEC61966-2.1 / Rel. Col. / BPC-NO

Outlier control  
 ON | Outlier threshold (dE):  
 OFF | dE formula: CIEDE2000

Averaging method: Weighted

Average Close

The screenshot on the next page shows this window’s appearance after selecting the files on lines #2 and #4.

The “Simple” and “Weighted” averaging methods give the same result for two files, but different results for three files or more (see the “Behind the scene: [Weighted average](#)” box for more info).

PatchTool can average color lists which are defined with spectral data, tristimulus data (i.e. XYZ, RGB), data types derived from tristimulus data (i.e. L\*a\*b\*, L\*C\*h, xyY, CMYK), or a mix of these data types. Files defined with spectral data are identified by “spectrum” in the “color ref.” (i.e. color reference) column of the dialog. For files defined with tristimulus data or data types derived from tristimulus data, the Standard Observer assigned in the file is also shown in the “color ref.” column. The resulting average is a new PatchTool file window which can be used as any other opened file.

Processing is adapted to the selected files in the following manner:

- i- When the “color ref.” of all selected files is “spectrum”, the average is performed on spectral data only. There is no need to specify an illuminant or observer, which can be selected afterwards in the average file.
- ii- When averaging files with non-spectral data, the Standard Observer must be the same for all files. The non-compatible files will be excluded automatically in the dialog.

- iii- When averaging files with non-spectral data, the average is always performed using XYZ. An Illuminant menu is then provided in the dialog for convenience since the Illuminant could be different in each file. The files' data will be converted to the Illuminant selected in this dialog using a Bradford Chromatic Adaptation Transform (CAT) prior to being averaged; it is thus not necessary to change, or match, the illuminant selection in each opened file prior to opening the "PatchTool Select Average" dialog.
- iv- When the selection comprises files with spectral data mixed with other data types, the average is performed with XYZ data, and any spectral information is lost. You also need to select an illuminant to convert the spectral data into XYZ coordinates; use the Illuminant menu that appears in the dialog, as shown in the screenshot below. You should select the Illuminant which is the most appropriate for the final use since it has a slight effect on the computed color (Please see the [note](#) on the next page).
- v- For files with a CMYK or RGB "color ref.," the CMYK or RGB data is converted to XYZ using the selected profile. You should make sure that the proper profile is selected for each file **before** computing the average. Even if all selected files had an RGB "color ref.," the average would still be done using XYZ, and not RGB; this also applies if averaging files all defined with a CMYK "color ref."
- vi- The **additional** CMYK or RGB data present in a file, which can be target reference data, identified as "File values" in PatchTool, or data derived from the "color ref." with the selected profiles, is **NOT** averaged separately. It is discarded and recomputed in the average file. If specific reference CMYK or RGB data is required, you can transfer it back from one of the selected files to the average file using the "[File-to-File Transfer](#)" tool.
- vii- The "ID", "Name" and "Rows" value for the average file are copied from the **topmost** selected file. If the "ID" and "Name" of another file are required, you can transfer them to the average file using the "[File-to-File Transfer](#)" tool. (Note: The "Rows" value can be different for each selected file, as long as the patch order, as it appears in the "Tabular data" view, is the same).

The screenshot below is what the dialog shown on the previous page looks like after selecting the files on lines #2 and #4; a warning message and an illuminant selection menu have appeared. As indicated in the warning, and because of our selection of a file with no spectral data (line #2), the average will be performed with XYZ data. In addition, the file on line #3, with the "L\*a\*b\* (10 deg.," is now grayed-out. If we had selected the file on line #3 instead of the file on line #2, line #2 would be grayed-out.

#	opened files	patches	color ref.	avg.
1	CC_MyChart_measure-1.txt	24	spectrum	<input checked="" type="checkbox"/>
2	CC_MyChart_measure-2_Lab_2deg.txt	24	L*a*b* (2 deg.)	<input checked="" type="checkbox"/>
3	CC_MyChart_measure-2_Lab_10deg.txt	24	L*a*b* (10 deg.)	<input type="checkbox"/>
4	CC_MyChart_measure-3.txt	24	spectrum	<input checked="" type="checkbox"/>
5	CC_MyChart_measure-4.txt	24	spectrum	<input type="checkbox"/>
6	RGB_3-255_step4.txt	64	RGB (2 deg.)	<input type="checkbox"/>

#2 - File name: CC\_MyChart\_measure-2\_Lab\_2deg.txt  
L\*a\*b\* converted to XYZ. Combine with 2 deg. files or spectral data.

Outlier control:  ON | Outlier threshold (dE): 4.0 | dE formula: CIEDE2000

Averaging method: Weighted | Obs.: 2 deg. | Ill.: D50

WARNING: Spectral data is not available for all selected files. XYZ data will be used for average.

Average Close

Colors derived from the 10 degree Observer are not compatible with colors derived from the 2 degree Observer, and vice-versa.

This file could also be included in the average.

Use "Outlier control" to remove bad patches from computation.

An Illuminant menu appears when files with spectral data have to be converted to XYZ data (i.e. when they are mixed with files defined with non-spectral data).



The average can be performed using either a “Simple” or a “Weighted” method; the [weighted method](#) minimizes the effect of patches which are farther away from the standard (simple) average. In some cases, you may also want to just **remove** bad measurements, which are way off relative to the nominal average value, from the average computation; this is possible with the “Outlier control” settings.

To filter outliers, start by clicking on the “ON” button, then select a threshold value for the color difference between a patch color and the **simple average** color for this patch, and finally select a color difference formula. Five formulas are available: CIELAB, CIE94, CMC(2:1), CMC(1:1), and CIEDE2000. You can use outliers filtering with the simple and weighted averaging methods. Once the average file is opened, you also get a patch ID list of the outliers for each file and a list of the patches which are outliers in all files, if any, in the log of the [main PatchTool window](#).

**Note:** It is important to select the proper illuminant when converting spectral data to XYZ. The reason is that a color may be perceived to be different under different light sources, an effect called *Color Inconstancy*. This effect can only be taken into account with colors defined with spectral data and is impossible to revert once the colors are converted to tristimulus numbers. Please consult the Help Manual of *BabelColor CT&A* for more information on Color Inconstancy and how to measure the color shift with CT&A’s *Color Inconstancy Index* (CII) tool.

**Hint:** Averaging measurement files is quite often performed with the goal of building an ICC profile. However, by design, the RGB and CMYK data in the average file is not independently averaged; it is derived from the averaged data using the selectable RGB and CMYK profiles in the “[Tabular data](#)” tab of the file. In order to re-associate the target data, usually identified as “File values” in PatchTool, with the averaged measurements, you need to transfer the target RGB or CMYK data into the average file using the “[File-to-File Transfer](#)” tool. The target data may be available in one or more measurement file, or provided by standard bodies, or is contained in i1Profiler XML files (i.e. CxF3 files). You will also find more information on how to prepare a file for i1Profiler import in the “[Exporting to the CxF3 format](#)” sub-section.

### Behind the scene: Weighted average

PatchTool offers two methods to perform averaging: “Simple” or “Weighted”. The simple method is the usual way of getting an average: the data from each file is added and the sum divided by the number of files. All data samples have the same importance.

In a weighted average, the samples are classified in some order of importance. For example, in a retail store, you may want to determine the average selling price of all items sold. Let’s consider only two items, Item “a” with a 1\$ selling price, and Item “b” with a 11\$ selling price; Item “a” was sold 9 times while Item “b” was sold once. A “Simple” average of the selling price gives a  $(1\$ + 11\$) / 2 = 6\$$  average selling price per item sold. However, this average price would be valid only if equal quantities of each item were sold, which is not the case; this is where a “Weighted” average provides a better answer. The quantity of each item type sold is first multiplied by the price of each item ( $9 \times 1\$ = 9\$$ ) and ( $1 \times 11\$ = 11\$$ ), and the weighted average is obtained by dividing the total value ( $9\$ + 11\$ = 20\$$ ) by the total number of items ( $20\$ / (9+1) = 2\$$ ). In this example, the quantity of each item is the “weight”.

The problem, for color lists, is that we have no externally defined weights to apply to the various data samples. However, as the number of samples grows, it is not uncommon to see some samples grouped together, and a few samples which, while not out-of-range, are apart from the main group. In such a situation, we would have no hesitation in separating the data in two groups and assigning less importance, i.e. less weight, to these “outliers” than to the grouped data samples. However, in practice, the samples are often uniformly distributed and not grouped in easily categorized positions. Nonetheless, we can extend the above categorization method by assigning to each sample a weight which goes down continuously as the distance between the sample and the group average position increases. Expressed otherwise, a sample weight is inversely proportional to the distance between its position and the “Simple” average.

When averaging only two files, the results from the “Weighted” average method are the same as the ones obtained with the “Simple” method, but they will start to differ for three or more files. On the other hand, for a large number of samples (more than 20), the two methods should statistically provide very similar values. However, in practice, we rarely see people making more than three or four sets of measurements, and the “Weighted” method will then be the method of choice.



### 3.2 BabelColor CT&A Export

The BabelColor CT&A database file is named “ColorDecks.bbd”; it is located in the main BabelColor CT&A folder. Please see these additional [notes](#).

**IMPORTANT:** always work on a copy of the original database. Once removed, the standard Color Decks provided with BabelColor CT&A cannot be re-installed using PatchTool.

For optimal results, select the Illuminant which best matches the intended use (the “Color Decks” in the BabelColor CT&A program are not spectral based). You can always save the same file more than once using different Illuminants.

**BabelColor CT&A Export**

Open database

Database file: **ColorDecks.bbd**

#	Deck Name	chips	Illum.
1	BS 5252F	237	D65
2	FED-STD-595B	611	D65
3	Munsell	4208	C
4	RAL	210	D65
5	My color list	1124	D50
6	[available]		
7	[available]		
8	[available]		
9	[available]		
10	[available]		

Remove Deck

PatchTool file: 3- My\_data\_2007-03-06.txt

Note: 2 degree Observer imposed for export

Illuminant: D50

Deck name: My color list

Add file Close

The BabelColor CT&A database can contain a maximum of 10 Decks. The selected PatchTool file shown below has just been added as the fifth Deck.

Select a file for export amongst the currently opened files.

Click to add the selected PatchTool file to the database.

This dialog is opened with the “Tools/BabelColor CT&A Export...” menu. The BabelColor *Color Translator and Analyzer* (CT&A) software is designed to compare and convert colors between 19 RGB spaces (such as ProPhoto, Adobe RGB, and sRGB), one user-defined custom space, and four industry standard color catalogues (British Standard 5252, i.e. BS5252/BS4800/etc, FED-STD-595B, Munsell, and RAL CLASSIC), called Color Decks.

Using PatchTool, you can create additional Decks by simply exporting a color list to the “ColorDecks.bbd” file used as a database by BabelColor CT&A. The “BabelColor CT&A Export” dialog can be opened even if PatchTool is not registered; however, a registered copy of BabelColor CT&A is required to access the Color Decks.

BabelColor CT&A also accepts data from the Eye-One line of colorimeters and spectrophotometers sold by GretagMacbeth. It transforms the i1Pro into a full-featured densitometer, a powerful color-stability analyzer (virtual light booth, color inconstancy, metamerism), a multi-purpose spectrum viewer, and into a unique instrument dedicated to the analysis of monitors, light booths, transparencies illuminators, and ambient light.

For more information: <https://www.babelcolor.com/products.htm>

Important notes on how to work with the “ColorDecks.bbd” database on Mac and Windows PCs are presented on the next page.

### Exporting to the Color Decks database on a Mac

We recommend making a copy of the “ColorDecks.bbd” database **before** adding a file or removing a Deck. The ColorDecks.bbd file is normally located in the same folder as the main BabelColor CT&A program. Without a copy of the database, you will need to re-install the program if you want to revert to the original content.

### Exporting to the Color Decks database on a Windows computer

In Windows, it is not recommended to modify files located in the program folder. Such changes are possible in older versions of the OS, such as Windows 2000 and Windows XP, but are more strictly enforced on Windows Vista. Because of this, starting with BabelColor CT&A version 2.8, a **working-copy** of the “ColorDecks.bbd” database file is now located in the following folder (i.e. the **working-folder**):

“C:\Documents and Settings\user-name\My Documents\BabelColor”

where "user-name" is your account name. Thus, you should see a folder named “BabelColor” in your default “My Documents” folder, which, for proper program operation, you should not discard. In the “BabelColor CT&A Export” dialog, after clicking on the “Open database” button, navigate to this folder and select the ColorDecks.bbd file it contains.

When you make changes to the working-copy, the original ColorDecks.bbd file in the BabelColor CT&A application folder remains intact. If you remove too many Color Decks and you would like to get back the default database, simply trash the ColorDecks.bbd file in the **working folder**. BabelColor CT&A will re-copy the original database in this location the next time it is started.

If, by mistake, in **Windows XP**, you modify the database located in the **application folder**, the **working-copy** will remain unchanged and you will not see the Color Deck you just exported. If you then throw away the working-copy, BabelColor CT&A will duplicate the (original but modified) database in the application folder and place a copy in the **working-folder** the next time you start the program. Be aware that, even if this procedure works, it is not recommended since it permanently modifies the original database file.

If, by mistake, in **Windows Vista**, you modify the database located in the application folder, and Windows accepts the changes, Windows may have created, without warning, a “virtual” copy of the ColorDecks.bbd file in the following folder (which may be hidden by default):

“C:\Users\user-name\AppData\Local\VirtualStore\Program Files\BabelColor\BabelColor CT&A”

In Windows Vista, whenever the program, or the user, modifies the ColorDecks.bbd file located in the main BabelColor CT&A application folder, it is in fact the copy in the VirtualStore folder which gets modified; the original file is never changed. This is done to enhance the overall security of Windows. Of course, even more so than with Windows XP, this procedure is not recommended since it can be difficult to track the modified file. Starting with BabelColor CT&A version 2.8, the BabelColor CT&A folder located in the VirtualStore folder is no longer required, and can be safely deleted.

If you modified the database in the application folder and you want to get back the original file (and you have no backups), you need to delete the working-copy, then uninstall and reinstall PatchTool.

In short, in Windows, you should export only to the working-copy of the BabelColor CT&A Color Decks database located in your “My Documents\BabelColor” folder.

### 3.3 Compare

The “PatchTool Select Compare” dialog is opened by selecting the “Tools/Compare...” menu. The menu is enabled when there are at least two opened files.

Click anywhere on a row to select or unselect.

Only files with the same number of patches can be compared.

Selected files have a checkmark and a green background.

The white background identifies the files which are compatible with the previous selection. Note: the remaining files *may* be incompatible between them.

Non-compatible files are grayed-out.

When you place the mouse cursor in the “color ref.” column, you can see additional information on the file data. This information is shown below the table, in green.

Spectral reference data. Compare with spectral data, or with 2 deg. or 10 deg. files. Also contains imported CMYK data. No profile info!

Observer: 2 degree    Illuminant: D50

NOTE: Spectral data is not displayed in the Compare table, but still used for computation.

Compare    Close

The screenshot on the next page shows this dialog’s appearance after selecting the file on line #2.

PatchTool can compare two color lists which are defined by spectral data, tristimulus data (i.e. XYZ, RGB), or data types derived from tristimulus data (i.e. L\*a\*b\*, L\*C\*h, xyY, CMYK). The two files must have the same number of patches. The resulting “Compare” window is similar to single file windows, but contains and presents the data of both files simultaneously, and offers additional tools which facilitate data comparison.

Processing is adapted to the selected files in the following manner:

- i- When a selected file has spectral data, identified by “**spectrum**” in the “color ref.” (i.e. color reference) column of the dialog, this data is transferred in the Compare window even if the other file does not have spectral data, and it will be used for all computations. A file with spectral data is compatible with all other color reference data types.
- ii- When a selected file is defined using non-spectral data, XYZ data is transferred for comparison purposes. Selecting such a file also imposes the observer, which will not be selectable thereafter. A file defined with non-spectral data is thus compatible with other files defined with non-spectral data based on the same observer, as well as with files defined with spectral data.
- iii- When a selected file color reference is CMYK or RGB, the data is converted to XYZ using the assigned profile; XYZ data is then transferred for comparison purposes. Selecting such a file will also impose the 2 degree Observer. A file whose color reference is CMYK or RGB is thus compatible with other files defined with non-spectral data based on the 2 degree Observer, and with files defined with spectral data.
- iv- When CMYK and RGB data was imported, either as target reference data type or as additional data, in one or both files (identified as “File values” in PatchTool), it is transferred as additional data to the Compare window, and thus left unmodified.

- v- The “ID”, “Name” and “Rows” value for the Compare file are copied from the reference file (Note: The “Rows” value may be different for each selected file, as long as the patch order, as it appears in the “Tabular data” view, is the same).

The screenshot below is what the dialog shown on the previous page looks like after selecting the file on line #2; the Observer menu is now grayed-out since the sample file is based on non-spectral data defined with the 2 degree Observer. If we had selected the file on line #4, a file with a “**spectrum**” color reference, instead of the file on line #2, the Observer menu would still be enabled.

#	opened files	patches	color ref.	ref.	sample
1	CC_MyChart_measure-1.txt	24	spectrum	<input checked="" type="checkbox"/>	<input type="checkbox"/>
2	CC_MyChart_measure-2_Lab_2deg.txt	24	L*a*b* (2 deg.)	<input type="checkbox"/>	<input checked="" type="checkbox"/>
3	CC_MyChart_measure-2_Lab_10deg.txt	24	L*a*b* (10 deg.)	<input type="checkbox"/>	<input type="checkbox"/>
4	CC_MyChart_measure-3.txt	24	spectrum	<input type="checkbox"/>	<input type="checkbox"/>
5	RGB_3-255_step4.txt	64	RGB (2 deg.)	<input type="checkbox"/>	<input type="checkbox"/>

Move the mouse cursor in the 'color ref.' column for more info.  
Enlarge the window to see long file names.

Observer: 2 degree      Illuminant: D50

NOTE: Spectral data is not displayed in the Compare table, but still used for computation.

Compare      Close

Annotations:

- You could unselect this file by clicking anywhere on the row.
- Files based on a fixed 2 degree Observer, i.e. non-spectral files, cannot be compared with files based on a fixed 10 degree Observer.
- Click and drag corner to enlarge the window in order to see long file names.
- Observer selection is disabled when either the reference or the sample file do not contain spectral data.

The illuminant menu is presented for convenience since the illuminant can always be changed afterwards in the Compare window. Please note that it is not necessary to change, or match, the illuminant selection in each opened file prior to opening the “PatchTool Select Compare” dialog; the program will make the required conversions.

### 3.4 Correction Matrix

The “PatchTool Correction Matrix” dialog is opened by selecting the “Tools/Correction Matrix...” menu.

Data entry options: manual entry; paste cells from a spreadsheet, or load from a file.

Click [here](#) for more information on this dialog’s menus.

Enter data as XYZ or xyY coordinates.

**REFERENCE Instrument**  
 Name: Eye-One Pro S/N: 112135  
 Color space:  XYZ  xyY

patch	X	Y	Z
red (R)	94,53191	49,62322	3,32676
green (G)	31,45541	98,85805	15,87678
blue (B)	30,26932	14,82707	153,06459
white (W)	154,54840	160,18122	168,64785

**TARGET Instrument**  
 Name: DTP94 S/N: 035296  
 Color space:  XYZ  xyY

patch	x	y	Y
red (R)	0,6415919	0,3369240	56,30000
green (G)	0,2329227	0,6748787	108,48000
blue (B)	0,1557381	0,0734141	15,82000
white (W)	0,3301316	0,3317793	177,20000

**CORRECTION MATRIX** Compute the matrix from the instruments data or write values in each cell.  
 Matrix description:   
 Display name: Dell U2410

X'	0,890117	-0,017743	0,004189
Y'	-0,019562	0,917478	0,005888
Z'	-0,012937	0,024863	0,922266

Assign the matrix to: DTP94

You can enter data manually, paste cells from a spreadsheet, or compute a matrix from REFERENCE and TARGET data.

Save as a file that can be opened in the “Color Correction Matrix Selection” dialog which is accessed from the Display Check tool.

Directly assign a matrix to any instrument supported by PatchTool [Display Check](#).

The purpose of a Color Correction Matrix (CCM) is to help improve inter-instrument agreement in **emission** (i.e. display) measurements. In particular, a CCM can be used to correct the response of a colorimeter designed for standard LCD displays when doing measurements on a wide gamut display.

Display measurements are typically done using two instrument types: spectrophotometers and colorimeters. Spectrophotometers—such as the i1Pro—measure the display light in separate wavelength bands; these bands are usually located at five or ten nanometers (nm) intervals between 380 and 730 nm. Low cost colorimeters—such as the DTP94, the Spyder2, the Spyder3, and the Eye-One Display—typically have three sensors, whose sensitivity **roughly** corresponds to the Standard Observer XYZ tristimulus responses.



A spectrophotometer can be used to measure any display type, be it an older Cathode Ray Tube (CRT) display, a standard gamut LCD, or a wide-gamut LCD, without any need to correct the measured data. On the other hand, a colorimeter is generally tuned for a display type, with some instruments having a separate calibration for each type (see for instance the “Display type” selection in the [Instrument tab](#) of the PatchTool Preferences dialog). With the advent of wide-gamut displays, many have found that their older colorimeters could not accurately evaluate their display’s performance. A CCM is then a cost-effective solution to extend the operational life of these instruments, and it can also improve inter-instrument agreement on standard gamut displays!

**Important:** Not all colorimeters are inaccurate! In effect, some (very) high end instruments have sensitivities essentially matching the Standard Observer XYZ tristimulus responses and can be used to measure any display without correction. Unfortunately, the less expensive devices are only accurate for the measurement conditions they were designed for (i.e. to match specific CRT and LCD primaries); for other conditions, a Color Correction Matrix can significantly improve their accuracy.

A CCM is typically computed from measurements made with a higher-accuracy instrument, which acts as a REFERENCE—very often an i1Pro because of its ubiquity, but it could also be a high-end colorimeter—and measurements made with a lower accuracy colorimeter, called the TARGET.

There are essentially two methods to derive a Color Correction Matrix:

- i- **Best-fit:** Measure XYZ or  $L^*a^*b^*$  for many patches with both instruments and find a matrix by best-fit. They are variants in how the fit is obtained; one can minimize the XYZ error, or minimize the  $L^*a^*b^*$  error using a given color-difference formula (with the fit varying according to the selected formula).
- ii- **Four-Color:** Measure XYZ or  $xyY$  for four patches (red, green, blue, and white) and find a matrix with the method presented in [ASTM E1455-2010](#) (*Standard Practice for Obtaining Colorimetric Data from a Visual Display Unit Using Tristimulus Colorimeters*). This is the method used in PatchTool.

The best-fit method may provide somewhat smoother results over a display gamut if the fit is based on several “random” colors. On the other hand, the ASTM Four-Color method guarantees that the primaries will be “exactly” matched, and the method is more convenient to perform when data is gathered one patch at the time. Our tests have shown that the corrected values are essentially the same with both methods (i.e. the differences in the corrected values are non-noticeable on average). Finally, it is worth noting that former versions of the ASTM method were based on best-fit, now replaced by the Four-Color method.

If the instruments are supported by PatchTool, the REFERENCE and TARGET measurements can be obtained with PatchTool Display-Check. In addition, data from any instrument can be either manually entered, loaded from a simple text file (see an example at the [end of this section](#)), or copied from a spreadsheet using Copy/Paste. As in any display measurements, and particularly in this case where we characterize a display with only four colors, it is important to be aware of the factors which can affect the results; please consult these [guidelines](#).

#### **Mini-tutorial: Using PatchTool Display-Check to obtain Correction Matrix measurements**

- 1- Open the “RGBW.txt” file provided with PatchTool; the file content is shown at the [end of this section](#). The file is located within the PatchTool application folder: “...\**PatchTool**\correction-matrices\**RGBW.txt**”
- 2- Assign the “sRGB (PatchTool) profile and 8 bit encoding to the file. The selected profile is irrelevant as long as the SAME profile is selected as the Destination profile in Display-Check (in Step-4 below).
- 3- Open Display-Check. Select your instrument. As a REFERENCE instrument, you should use the instrument you have the most confidence in; you can **check** “Use a Correction Matrix” to perform the measurements if the reference instrument can benefit from it. When measuring the TARGET, **uncheck** “Use a Correction Matrix” since the purpose of this measurement is to derive a correction matrix for the instrument.
- 4- Select the “PatchTool file” radio button; select the “RGBW.txt” file. Select “sRGB (PatchTool)” as the Destination. By selecting the same profile for the Source and Destination, the RGB values are sent directly at the display.
- 5- Press the “Start” button and follow the instructions. When the measurements are completed, **save the RAW file**. A Compare file will open; there is no need to save it. Load the RAW file in the REFERENCE or TARGET tables of the Correction Matrix dialog.

## Correction Matrix menus

**REFERENCE Instrument**

Name:  S/N:

Color space  
 XYZ  xyY

patch	X	Y	Z
red (R)	94,53191	49,62322	3,32676
green (G)	31,45511	67,04697	14,82707
blue (B)	30,06949	14,82707	153,06459
white (W)	154,54887	168,18122	168,64785

You can write a color correction matrix to a spreadsheet cell or load it from a spreadsheet cell and have ONLY 4 columns in the table. We recommend using the following column headers:

Right-click (**ctrl + click** on a one-button Mac) on a data cell to get this menu. The same menu is available for the TARGET Instrument.

Copied data can be pasted in a spreadsheet or text editor. When copying "All", the data is separated by Tabs. Inversely, data from a spreadsheet can be pasted; if separated by Tabs, the data will be pasted in adjacent cells on the right and below the cell from which the menu was launched.

**CORRECTION MATRIX** Compute the matrix from the

Matrix description:

X'	0,890117	0,004119	0,000000	X
Y'	-0,019562	0,905888	0,000000	x Y
Z'	-0,012937	0,000000	0,987266	Z

Selecting this menu item resets the matrix to a unitary diagonal matrix. With such a matrix, the input and output XYZ values are the same.

**CORRECTION MATRIX** Compute the matrix from the

Matrix description:

X'	1	0	0	X
Y'	0	1	0	x Y
Z'	0	0	1	Z

Assign the matrix to:

- DTP94
- Eye-One Display
- i1Display Pro
- i1Pro / i1Pro 2 (non-XRGA)
- i1Pro / i1Pro 2 (XRGA)
- Spyder2
- Spyder3
- Spyder4

Once a matrix is defined, you can assign it directly to any of the instruments supported by PatchTool. An alternate method is to save the matrix in a file in this dialog, and then open the file in the "Color Correction Matrix Selection" dialog accessible from the [Display-Reader](#) and [Display-Check](#) tools.

**Additional notes:**

- i- A CCM is always assigned to a specific combination of **display + target instrument**. In particular, if your display has settings which affect its primaries, you should first adjust these settings, do a display profile, and then use the calibrated display to perform the REFERENCE and TARGET measurements.
- ii- A CCM improves the inter-instrument agreement between a REFERENCE instrument and a TARGET instrument. While this procedure may improve the absolute accuracy of the TARGET instrument, if the REFERENCE is more accurate, it does not affect the absolute accuracy of the REFERENCE instrument (Note: The accuracy of the reference instrument may itself be improved by assigning it a CCM determined with a third, higher accuracy, instrument!).
- iii- While the TARGET is often a lower accuracy device, it need not be. A CCM would still improve the inter-instrument agreement between the REFERENCE and the TARGET.
- iv- The PatchTool Correction Matrix tool can be used to determine matrices for any instrument, and these matrices may be used with any XYZ emission data measured with this instrument. Of course, only the matrices derived for instruments supported by PatchTool can be used in PatchTool [Display-Check](#).
- v- The PatchTool Correction Matrix tool can be used to derive matrices for either 2 degree or 10 degree Observer data. However, please note that only matrices computed from 2 degree Observer data can be used in PatchTool Display-Check.

**“RGBW.txt” file:** Here is the content of the “RGBW.txt” file provided with PatchTool; the color space variables and the data values are separated by a single Tab:

R	G	B
255	0	0
0	255	0
0	0	255
255	255	255

The content of the “RGBW.txt” file provided with PatchTool for Correction Matrix measurements.

The file is located within the PatchTool application folder:

“...\**PatchTool**\correction-matrices\**RGBW.txt**”

**Important:** When using PatchTool Display-Check to obtain your measurements for a Correction Matrix, always save and use the RAW data file. You should not use a Compare file in this case.

**Simple measurement data file:** Here is an example of a text file that can be imported as REFERENCE or TARGET measurements. The example shows xyY data (CIE 1931 Chromaticity) but XYZ data could be used as well. The color space variables and the data values are separated by a single Tab; the decimal separator in the example is a comma but a period works as well (the separator must be the same for all values in the file).

	x	y	Y	
<b>Red</b> →	0,640849		0,33643	49,804806
<b>Green</b> →	0,215388		0,675726	98,792537
<b>Blue</b> →	0,152704		0,074807	14,903675
<b>White</b> →	0,319823		0,33064	160,280967

It is important to order the data so that it represents, from TOP to BOTTOM, **Red**, **Green**, **Blue**, and **White** measurements. Alternatives to enter such data are entering the data manually or loading a **PatchTool RAW** file obtained with [Display-Check](#) (measured from the “RGBW.txt” color list).

### 3.5 Custom Illuminants

This “Custom Illuminants” dialog is opened by selecting the “Tools/Custom Illuminants...” menu.

Two (2) custom illuminants can be specified. Select a radio button to see the spectrum and characteristics.

“2F” and “10F” are CIE 170 Standard Observers.

Custom illuminants can be measured or loaded from a file.

Use this tool to measure or load a light source spectrum to be used as a Custom Illuminant. A file should contain only one spectrum defined with 5 nm or 10 nm spectral increments. You can drag and drop a file on the graph or on the “Load...” button.

CIE 1931 (2 deg.) and CIE 1964 (10 deg.) computation is done with 10 nm bandwidth data. CIE 170 computation (2F deg. and 10F deg.) is done with 5 nm bandwidth data. Interpolation to 5 nm or filtering to 10 nm is performed, when required, with the selected method.

	2 deg.	10 deg.	2F deg.	10F deg.
X:	99,06	99,20	99,08	99,31
Y:	100	100	100	100
Z:	85,23	84,35	83,47	84,33
CCT:	4873 K	4876 K	4860 K	4879 K
Duv:	-0,0013	-0,0007	-0,0008	-0,0007
Brightness:	1000 lux	1086 lux	1055 lux	1103 lux

You can drag-and-drop a file on the graph or on the “Load...” button. Spectral data files with 5 nm or 10 nm bandwidth are accepted.

**Spectral data** is required to define a **Custom Illuminant** in PatchTool; in other words, a Custom Illuminant cannot be defined only with XYZ coordinates in PatchTool. However, a Custom Illuminant can be assigned to files containing non-spectral data (XYZ, L\*a\*b\*, etc.). A Custom Illuminant can be measured from within this dialog with an X-Rite i1Pro (any model) fitted with an ambient adapter. Illuminant data can also be loaded from a file.

The file must be in text format; such files typically have .txt or .csv file extensions. As for the file data structure, a plain text file as described in [Appendix A](#) is accepted as well as a CGATS file. Spectral data is required between 400 and 700 nm in 5 nm or 10 nm increments. All data between 380 and 730 nm will be used. Missing data will be extrapolated to complete the 380 to 730 nm range necessary for processing. Spectral data lower than 380 nm and higher than 730 nm is discarded. The file must contain only one (1) spectrum.

**Note:** You will find files which correspond to the “default” illuminants (i.e. “B” and “5000 K”), which appear when this dialog is first used, in the “Illuminants” folder located within the PatchTool application folder. The “Illuminants” folder also contains all the standard PatchTool illuminants—such as C, D50, F11, etc.—as well as other Standard CIE Illuminants—such as FL3-1, HP4, ID50, etc.—in both 5 nm and 10 nm bandwidth versions.

**Note:** The brightness of the illuminant is irrelevant since the spectral data is normalized by the program.

## CCT, Duv, Brightness

These parameters have historically been computed only for the 2 degree (CIE 1931) Standard Observer although corresponding 10 degree (CIE 1964) values were available. When incorporating CIE 170 support into PatchTool it was decided to provide these parameters for ALL Standard Observers. Such data can also be seen in the [Display-Reader](#) tool.

Additional information:

- For self-luminous objects, the maximum value of the luminous efficacy of radiation ( $k_{10}$ ) is **683.6 lm/W** for the 10 degree (CIE 1964) and 10 degree (CIE 170, i.e. “10F” degree) standard Observers, instead of the 683 lm/W value used for the “2” and “2F” Standard Observers.<sup>1</sup>
- CCT and Duv are computed using the “uv” (CIE 1960) uniform color space. It is assumed that the conversion between the “xy” chromaticity coordinates—computed for each Standard Observer—and the “uv” space use the same equations for all Observers. In 2018 CIE Division 1 established a new research forum for “Revisiting Correlated Colour Temperature” with CCT determination using cone fundamental colorimetry (i.e. CIE 170) being a proposed research subject, so we may see changes in CCT computation in the coming years.

### (CIE 1931 and CIE 1964) vs (CIE 170)

As shown in the tool dialog:

**CIE 1931 (2 deg.) and CIE 1964 (10 deg.) computation is done with 10 nm bandwidth data.  
CIE 170 computation (2F deg. and 10F deg.) is done with 5 nm bandwidth data.  
Interpolation to 5 nm or filtering to 10 nm is performed, when required, with the selected method.**

CIE 1931 and CIE 1964 computation, required when the “2 degree” and “10 degree” Standard Observers are respectively selected, is performed internally in PatchTool with 10 nm reference data. Since Custom Illuminants can be defined with a 5 nm or 10 nm bandwidth, those defined with a 5 nm bandwidth are filtered to 10 nm by PatchTool.

CIE 170 computation, required whenever the “2F” or “10F” Standard Observer is selected, is performed internally in PatchTool with 5 nm reference data. Since Custom Illuminants can be defined with a 5 nm or 10 nm bandwidth, those defined with a 10 nm bandwidth are interpolated to 5 nm by PatchTool.

You can select the spectral filtering and spectral interpolation methods for the Illuminant in this dialog; the recommended methods are shown in bold.

For input data (reflectance or emission), you will find the setting used to select the interpolation method from a 10 nm bandwidth to a 5 nm bandwidth in the [Preferences dialog](#).

You will find more information on how CIE 170 computation is handled in PatchTool in [Appendix H](#).

**Note:** When a standard PatchTool Illuminant is selected, such as C, D50, F11, etc., dedicated 5 nm or 10 nm versions are used automatically depending on the selected Standard Observer.

**Note:** Files with 5 nm bandwidth measurements are only accepted as illuminants in the Custom Illuminants dialog; they cannot be used as input in other tools.

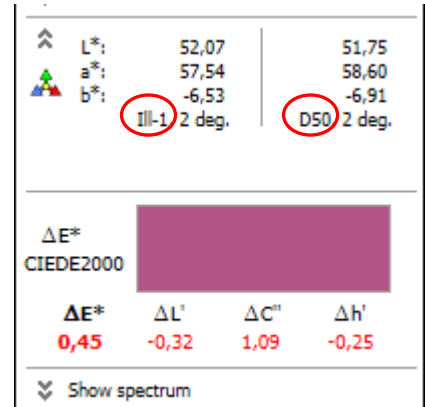
---

<sup>1</sup> *Colorimetry: Understanding the CIE System*; ed. János Schanda, Ch. 3, 2007 John Wiley & Sons, Inc.

### Custom Illuminants in the Info window

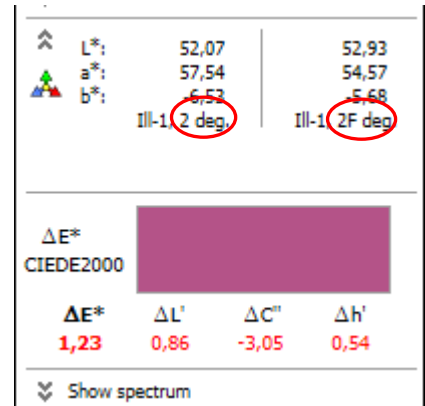
While the “Info” window will normally not show a color difference if the two patches being compared have different illuminants or different Standard Observers, there are two exceptions to this rule whenever a Custom Illuminant is used.

1. A patch from a file with a Custom Illuminant can be compared to a patch defined by any other Illuminant (including the other Custom Illuminant). There is however one restriction: both files must have the **SAME Standard Observer**! This can be useful to compare patches as seen with light sources which have the same—or close—Correlated Color Temperature (CCT) but which have different spectral contents.



2. When the **SAME Custom Illuminant** is selected for two files, it is possible to select a different Standard Observer for each file.

**Hint:** Since the standard Illuminants are available as separate files in the PatchTool install folder, in both 5nm and 10 nm bandwidth versions, you can easily assign a PatchTool standard Illuminant to a Custom Illuminant and use this feature with a standard Illuminant.

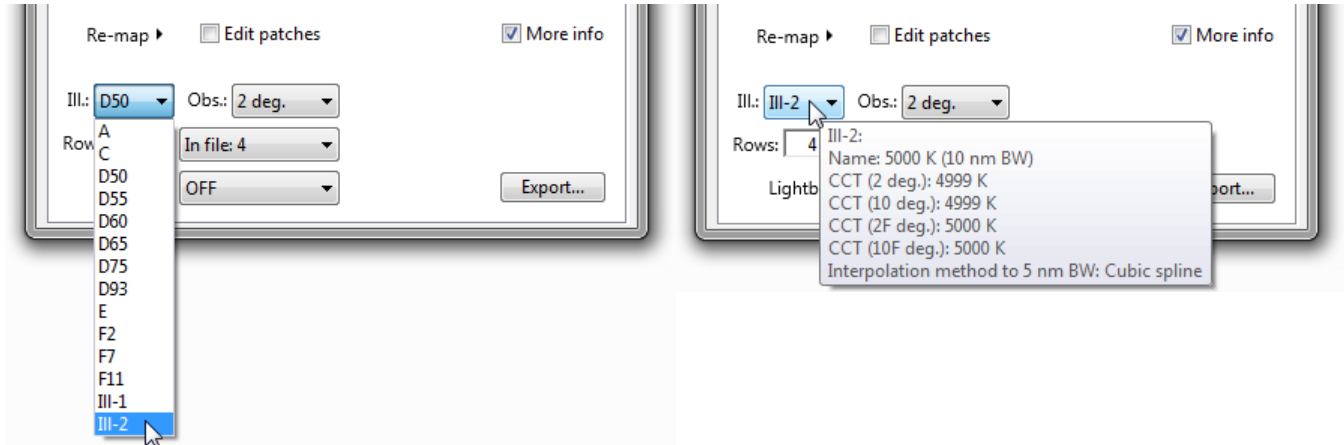


As a warning, the color difference values are shown in red when one of the above conditions is met.

### Custom Illuminants in opened files and tools

You can select a Custom Illuminant for any [opened file](#) and [Compare window](#), as well as in most dialogs which propose an illuminant selection ([Missing Info](#), [Display-Reader](#), [Select Average](#), [Select Compare](#), [Select Files to Join](#), [Spectrum Generator](#), [Substrate Correction](#), and [Tweak Target](#)). The Custom Illuminants always appear as “Ill-1” and “Ill-2” at the end of the Illuminant selection menus, as shown below on the left for an opened file.

**Hint:** There is no need to reopen the Custom Illuminants tool to get a description of the illuminant. First make sure that the window on which the Illuminant menu appears is active (i.e. in the front) and place the mouse cursor over the menu; a short description of the illuminant will be displayed in a popup message, as shown below on the right.



### Exporting data characterized with a Custom Illuminant

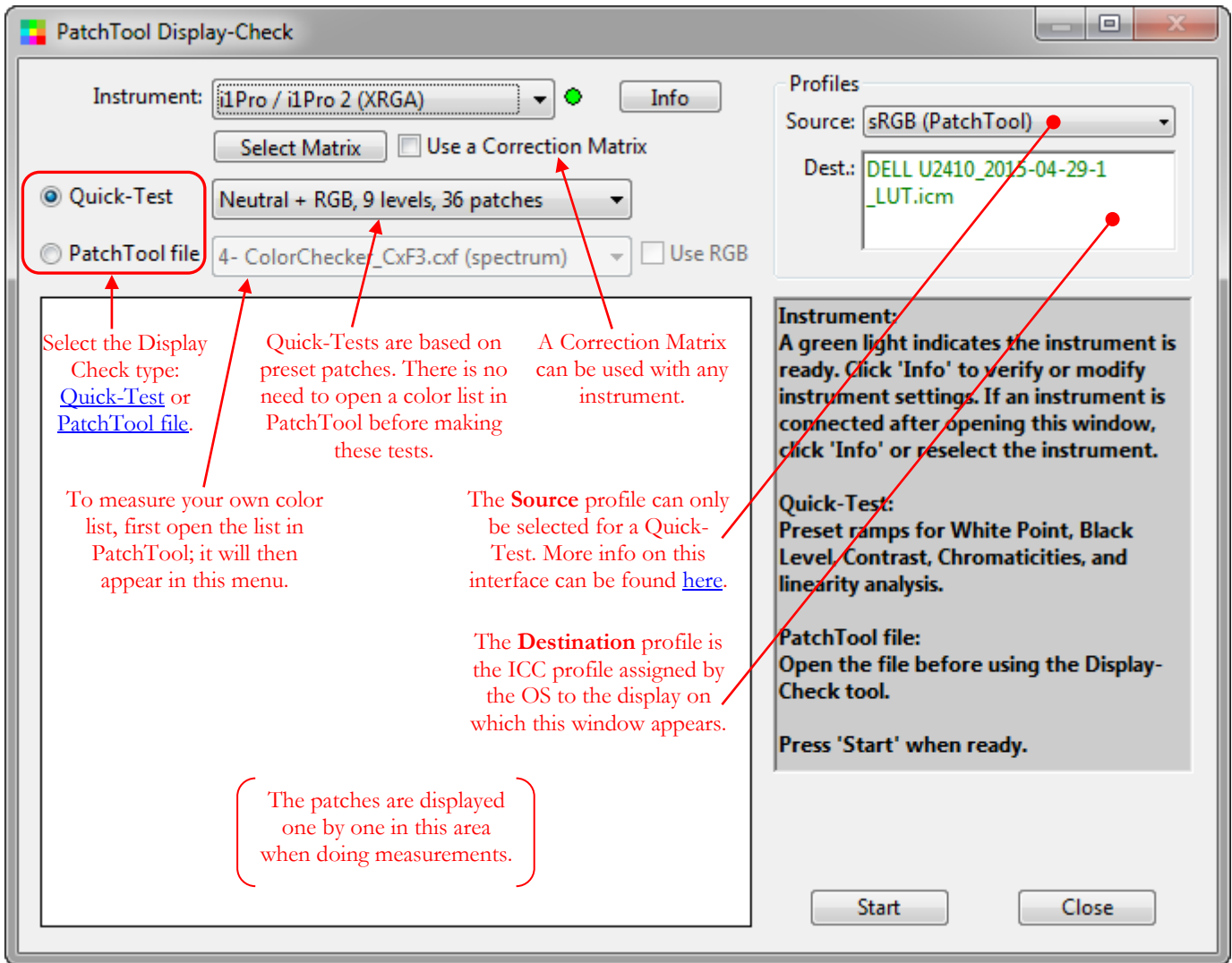
When you [export](#) xyY, XYZ, L\*a\*b\* or L\*C\*h data characterized with a Custom Illuminant in a CGATS or CxF file, PatchTool will simply identify the illuminant as “Ill-1” or “Ill-2”. The following illuminant characteristics will also appear as comments in a CGATS file: illuminant name, illuminance, CCT, Duv, and XYZ coordinates.

**Important:** If you open a file which has no spectral data and which was previously saved in PatchTool with data characterized by a Custom Illuminant, the program will show a message indicating that the data is assigned to the Custom Illuminant shown in the file (Ill-1 or Ill-2). It is up to you to make sure that the current characteristics of Ill-1 or Ill-2 in the program are those of the illuminant described in the file **BEFORE** you open the file.

**Warning:** If you open a file exported by PatchTool in another program and the file data is characterized by a Custom Illuminant, this other program may simply assume that the illuminant is D50. In general, these other programs will **ALWAYS** assume that the illuminant is D50, even if another standard illuminant such as D65 is indicated.



### 3.6 Display-Check



The “PatchTool Display-Check” window is opened by selecting the “Tools/Display-Check...” menu. This tool is used to make measurements of color lists on your display.

The Display-Check tool was developed because of the limited info provided by most display profiling programs relative to the profile quality. Some profiling applications offer a display check routine that measures the color accuracy for a small number of preset colors, with not many details on the data path used in sending the colors to the screen and on the assumptions made when measuring them. Display-Check provides dedicated tests for measuring the accuracy of the neutrals and primaries, as well as the possibility to measure user-defined color lists of any size. Please consult [Appendix B](#) for information on the internals of the Display-Check process.

Please consult the following sub-sections for more information on:

- [Supported instruments](#) (applicable to Display-Check and [Display-Reader](#));
- [The Display-Check interface](#);
- [Selecting a Quick-Test](#);
- [Doing a Display-Check with a PatchTool file](#);
- [Factors which can affect display measurements](#);
- [Display-Check examples](#);
- [Using a Color Correction Matrix in Display-Check](#).

### 3.6.1 Supported instruments (Display-Check and Display-Reader)

The supported instruments (purchased separately) are:

Instrument	PatchTool 32 bit (Windows)	PatchTool 64 bit (Mac)	Notes	Type	Manufacturer
DTP94 (MonacoOPTIX)	✓	✗	11	colorimeter	X-Rite <a href="http://www.xrite.com">www.xrite.com</a>
Eye-One Display Eye-One Display 2	✓	✗	1 to 4	colorimeter	
i1Display Pro	✓	✓	5, 6, 7	colorimeter	
i1Pro, i1Pro 2	✓	✓	3, 4	spectrophotometer	
i1Pro 3, i1Pro 3 Plus	✓	✓	3, 4	spectrophotometer	
Spyder2	✓	✗	8	colorimeter	Datacolor <a href="http://www.datacolor.com">www.datacolor.com</a>
Spyder3	✓	✗	8, 9	colorimeter	
Spyder4	✓	✗	8, 10	colorimeter	
Spyder5	✓	✓	8, 10	colorimeter	
SpyderX	✓	✓	10	colorimeter	

**Important:** The PatchTool 32 bit executable for Windows can run on 32 bit and 64 bit Windows systems. For the macOS, the program is provided in a 64 bit package. See the [System requirements](#) section for OS compatibility.

**Important (Windows OS only):** If you need USB drivers for an instrument, consult the "PatchTool\_Readme.txt" file located within the main PatchTool application folder for driver install instructions. The i1Display Pro uses the default OS USB drivers and no separate driver installation should be required. The SpyderX also uses default OS USB drivers but they may not be installed if you use Windows 7; please consult the "PatchTool\_Readme.txt" file for more information.

A description of the [Display-Check/Display-Reader instruments settings](#) follows after the table notes.

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**Note 1 (Eye-One Display 2):** The Eye-One Display 2 offered or bundled with many wide gamut monitors sold by NEC, such as the PA271W model, can be used with PatchTool. The Eye-One Display 2 is often bundled with monitors sold by other companies; it is usually a standard model which is only "re-branded", but it can also be a custom version tuned to a company's product. This special version of the NEC Eye-One Display 2 is identified as **Custom calibrated color sensor (MDSVSENSOR2)** and is available in the SVII-PRO-KIT. This custom instrument is tuned to the primaries of NEC's wide gamut monitors. For such monitors, it is not recommended to use a standard Eye-One Display 2 because the filters used in these instruments were optimized for standard gamut monitors, and measurements done on wide gamut monitors are less accurate. According to NEC, the MDSVSENSOR2 provides accurate colors for [both wide gamut and standard gamut](#) displays; all color corrections are performed internally (in the colorimeter), and the instrument provides color values which do not require further corrections when read by a program such as PatchTool. We have performed an [Idealliance certification](#) procedure on an iMac using both a standard Eye-One Display 2 and the special NEC version, and the results are identical within the inter-instrument tolerance of the instruments.

**Note 2 (Eye-One Display 2):** If an Eye-One Display 2 is properly recognized after you click on "Info" button, then it should work with PatchTool. If it is not recognized, i.e. if there is a message that the instrument is not connected, then there are good chances that it cannot be used with PatchTool. For instance, PatchTool cannot be used with the special version of the Eye-One Display 2 provided with HP DreamColor monitors.

IMPORTANT: Make sure that instrument connection is not blocked by another program such as "X-Rite Device Services" (see **Note 4**).

**Note 3 (Eye-One Display, Eye-One Display 2, i1Pro – All models):** PatchTool should be used with only **one** Eye-One/i1Pro/i1Pro 2 connected at a time and only **one** i1Pro 3 at a time. You can however connect one Eye-One/i1Pro/i1Pro 2 in addition to one i1Pro 3 and one **i1Display Pro** since these instruments use different drivers.

**Note 4 (Eye-One Display, Eye-One Display 2, i1Pro – All models):** If you installed software from X-Rite, such as **i1Profiler**, which comprises the “X-Rite Device Services” program, you may receive a message to the effect that the instrument is not connected when you click on the “Info” button. Assuming that your instrument is indeed connected, first check if the i1Profiler program from X-Rite is opened, and, if opened, close it, since PatchTool cannot be used at the same time. Early versions of i1Profiler provide a control panel named “X-Rite Device Services”, which is used to assign/unassign instruments to X-Rite software. On a Mac, the “X-Rite Device Services” control panel is located in the System Preferences dialog. The latest versions of i1Profiler still include “X-Rite Device Services” but do not include a control panel, and instrument assignment is performed dynamically when opening an X-Rite program. If using an early version of i1Profiler, you should DESELECT the i1 (Eye-One) in the “X-Rite Device Services” control panel; this will make the instrument available for PatchTool. Please note that changes in the X-Rite control panel can be done while PatchTool is opened. You should then be able to connect the instrument by selecting “Try to connect again...” in the “Instrument” menu. The early versions of i1Profiler may also open one or more dialogs asking if you want PatchTool to take ownership of the i1 peripherals; please answer “Yes” to the question(s). “X-Rite Device Services” is dedicated to X-Rite programs and is not under PatchTool’s control; any problem related to its use should be directed to X-Rite.

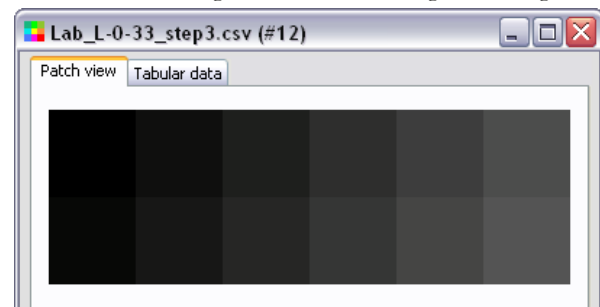
**Note 5 (i1Display Pro):** “i1Display Pro” is the name of the package that contains the “i1Display”, the actual device’s name, **plus** the i1Profiler software. However, the device is most often referred to as the “i1Display Pro” in the many reviews found on the Web, a name that differentiates it from the previous Eye-One Display models.

**Note 6 (i1Display Pro):** The i1Display Pro measurement time is adjustable by software. When making tests with this instrument we verified that we get less noise when increasing the measurement time, as expected, but the difference is most often not significant (in particular, the noise is low for dark patches even with short measurement times). We offer two options: a FAST setting which takes a measurement about every 0,5 second, and a SLOW setting which takes a measurement about every 1,2 seconds. Select the FAST setting to start with; use the SLOW setting if you see large differences between two series of measurements done back-to-back, or when the display refresh rate is lower than 50 Hz. Always use the SLOW setting when making measurements on a CRT.

**Note 7 (i1Display Pro):** In order to make display measurements with the i1Display Pro, it is required to stop the “**i1ProfilerTray**” application that may be running in the background. The i1ProfilerTray utility is part of the i1Profiler software provided by X-Rite in the i1Display Pro package; it will automatically launch each time you boot your computer. i1ProfilerTray can show reminders when a calibration is due and can monitor the ambient lighting conditions to see if the display profile should be tweaked; it can also automatically adjust the display profile following ambient illumination changes. Stopping this utility will not change your display calibration. PatchTool will display a message if i1ProfilerTray is running when you select the i1Display Pro and can stop it for you.

**Note 8 (Spyder2, Spyder3, Spyder4, and Spyder5):** PatchTool offers an exclusive adaptive measurement algorithm for these instruments. In this algorithm, the measurement time is based on each patch luminance (in cd/m<sup>2</sup>), with longer times allocated for darker patches and shorter times for bright patches. Two options are proposed; the FAST setting places emphasis on speed while the SLOW setting places emphasis on precision. This option can be selected in the “**Instrument tab**” of the “**Preferences**” dialog or in the “**Instrument info**” dialog opened by clicking on the Info button of the [Display-Check](#) or [Display-Reader](#) tool. Depending on the display luminance, a measurement in FAST mode can be as short as one second for very bright patches, and as long as 4 seconds for very dark patches. In SLOW mode, a measurement will never be shorter than two seconds, but can be as long as 16 seconds. You can get an idea of the average measuring time for a large number of patches by looking at this [table](#).

You should select the FAST option when your color list has mostly bright patches or a small proportion of very dark patches, such as in the IT8.7/4 target. You should select the SLOW option when you want more precise measurements for dark patches, such as for the L\*a\*b\* ramp (L\*=0 to 33, step 3) shown on the right. This file, as well as other files with neutral RGB and L\*a\*b\* patches can be found in the “sample\_files/RGB\_Lab\_steps” folder located within the PatchTool application folder; as a shortcut, use the “File/Open Sample Files/Misc. Sample Files...” menu.



**Note 9 (Spyder3):** In order to make measurements with the Spyder3, it is required to stop the “**Spyder3Utility**” application that may be running in the background. Spyder3Utility is part of the software provided by Datacolor for the Spyder3; it will automatically launch each time you boot your computer. This program checks the display settings and monitors the ambient lighting conditions to see if they are still within tolerance relative to the settings and conditions present when the display was last calibrated. Stopping this utility will not change your display calibration. PatchTool will display a message if Spyder3Utility is running when you select the Spyder3.

**Note 10 (Spyder4, Spyder5 and SpyderX):** In order to make measurements with these instruments, it is required to stop the “**SpyderUtility**” application that may be running in the background. SpyderUtility is part of the software provided by Datacolor for these instruments; it will automatically launch each time you boot your computer. This program checks the display settings and monitors the ambient lighting conditions to see if they are still within tolerance relative to the settings and conditions present when the display was last calibrated. Stopping this utility will not change your display calibration. PatchTool will display a message if SpyderUtility is running when you select these instruments.

**Note 11 (DTP94):** In principle the DTP94 drivers are not compatible with Windows 8 and Windows 10. However, a solution has been proposed in this forum post: <https://www.dpreview.com/forums/post/57030496>. Please consult the section titled “INSTALLING THE USB DRIVERS” in the Windows version of the *PatchTool Readme* file for more information. On the Mac, you may receive a message that you need to install “Java SE 6 RUNTIME” when you select the DTP94; please consult the section titled “Mac OS COMPATIBILITY - NEED FOR Java SE 6 RUNTIME” in the Mac version of the *PatchTool Readme* file for more information.

## Display-Check/Display-Reader instruments settings

Depending on the instrument, it is possible to select or assign: the **display type**, the **measurement speed**, a **correction matrix**, and a **calibration matrix**. The settings available for each instrument are shown below.

PatchTool instruments settings for display measurements				
instrument	display type	meas. speed	correction matrix	calibration matrix
DTP94	✓	✗	✓	✗
Eye-One Display	✓	✗	✓	✗
i1Display Pro	✓	✓	✓	✓
i1Pro/i1Pro 2 (non-XRGA) <sup>(1)</sup>	✗	✗	✓	✗
i1Pro/i1Pro 2 (XRGA) <sup>(2)</sup>	✗	(3)	✓	✗
i1Pro 3/i1Pro 3 Plus	✗	(3) (4)	(5)	✗
Spyder2	✓	✓	✓	✗
Spyder3	✗	✓	✓	✗
Spyder4, Spyder5	✗	✓	✓	✓
SpyderX	✗	✗	✓	✓

(1) i1Pro driver/SDK

(4) Adjustable emission-scan exposure in Emission-Reader

(2) i1Pro 2 driver/SDK

(5) Avail. for Display-Check and Display-Reader, N.A. in Emission-Reader

(3) Slow/Fast N.A. Adaptive meas. time in Emission and Ambient spot modes

display type
CRT
LCD

meas. speed
SLOW
FAST

i1Display Pro calibration matrices
Generic CMF (Internal)
CCFL (EDR 3)
Wide Gamut CCFL (EDR 6)
White LED (EDR 9)
RGB LED (EDR 12)
OLED (EDR 15)
Plasma (EDR 17)
RG Phosphor (EDR 18)
Projector (EDR 22)

Spyder4 calibration matrices (6)	Avail. in Spyder5 (7)
Any monitor	✓
Normal gamut LCD w/CCFL backlight	✗
Wide Gamut LCD w/CCFL backlight	✓
Normal gamut LCD w/White LED backlight	✗
Wide Gamut LCD w/RGB LED backlight	✓
Wide Gamut LCD w/CCFL2 backlight	✓

SpyderX calibration matrices
Any monitor
Standard gamut LED
Wide gamut LED
GB LED

(6) Spyder4 calibration matrix: Use “Any monitor” for a CRT, and use “Wide Gamut LCD w/CCFL2 backlight” for the Dell 2408W.

(7) Spyder5 calibration matrix: Use “Any monitor” for normal gamut monitors.

## Where to change the settings

The **display type** and **measurement speed** can be selected in the “[Preferences](#)” dialog as well as in the “[Instrument info](#)” dialog. For the i1Pro 3 and i1Pro 3 Plus, it is possible to adjust the **instrument exposure** during an emission-scan in the “[Emission-Reader](#)” tool window.

The **correction matrix** is selected in the “[Display-Reader](#)” and “[Display-Check](#)” windows; it is not available in the “Emission-Reader” window.

The **calibration matrix** can only be selected in the “[Instrument info](#)” dialog (Note: The i1Display Pro must be connected in order to be able to perform a selection).

## Display type

The **display type** is used to configure the instrument sensor so that it synchronizes itself to the display refresh rate when in CRT mode, and does not synchronize when in LCD mode; in certain instruments this setting will also select internal calibration tables optimized for CRT phosphors or LCD filters.

## Correction matrices

A **correction matrix** can be assigned to any instrument in the above list. However, since correction matrices are applied to XYZ data, and because the i1Pro series of instruments provide spectral data, we must discard the spectral data when using a correction matrix with these instruments; if required, uncorrected spectral data, as well as uncorrected and corrected XYZ data, is available in the RAW file. The correction matrices are processed within PatchTool, and not within the instruments or their libraries.

## Calibration matrices

A **calibration matrix** optimizes the response of an instrument’s sensors to the primaries of a display, for improved measurement accuracy; measurements are processed by the instrument/libraries and sent to PatchTool. The matrices are designed for specific display technologies. For the i1Display Pro, the matrices are provided in the form of external files, with an **.edr** file extension, that can be found in the “i1d3 Support Files” folder located within the PatchTool application folder; additional matrices could be added in the future without a need to reinstall PatchTool (EDR (Emissive Display Reference) numbers refer to different display technologies). For the Spyder4, Spyder5, and SpyderX, the matrices are defined within the instrument/libraries. Calibration matrices are selected in the “[Instrument info](#)” dialog.

## Correction matrix vs Calibration matrix

The **correction** and **calibration** matrices essentially perform the same function: they convert measured XYZ data to corrected/calibrated XYZ coordinates. Instruments that support multiple calibration matrices lessen, and often eliminate, the need for a correction matrix, since correction matrices are frequently used for the same purpose, i.e. optimize measurements on a large gamut display or on a display with non-traditional primaries. Still, one could use, for example, a correction matrix in addition to a calibration matrix to improve the inter-instrument matching between the i1Display Pro or the SpyderX and another instrument used as a reference.

The table below shows typical measurement times obtained when making a Display-Check with the 1617 patches of an [IT8.7/4](#) target, such as the one recommended for [Idealliance proofing certification](#).

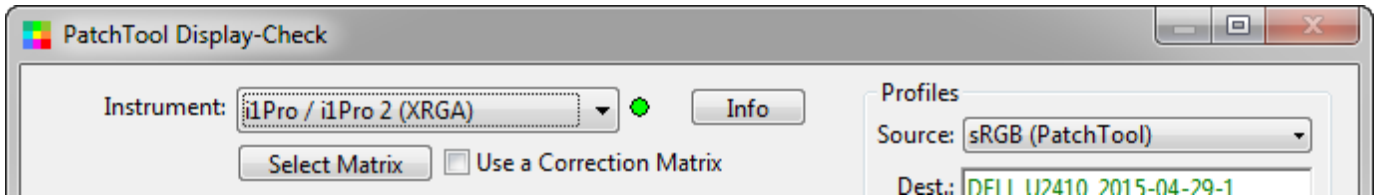
Instrument	Measurement speed		
	Default (not adjustable)	FAST	SLOW (more precise)
DTP94	94 min.		
Eye-One Display 2	38 min.		
i1Pro with i1Pro/i1Pro 2 (non-XRGA)	41 min.		
i1Pro with i1Pro/i1Pro 2 (XRGA)		41 min. (adaptive: OFF)	85 min. (adaptive: ON)
<b>i1Pro 2</b> with i1Pro/i1Pro 2 (non-XRGA)	32 min.		
<b>i1Pro 2</b> with i1Pro/i1Pro 2 (XRGA)		35 min. (adaptive: OFF)	71 min. (adaptive: ON)
i1Display Pro		13 min.	32 min.
Spyder2		66 min.	86 min.
Spyder3		56 min.	92 min.
Spyder4, Spyder5		55 min.	103 min.
SpyderX	Mac: 24 min. Windows: 37 min.		



Here are a few additional comments related to the Measurement speed table:

- i- Display luminance was between 100 and 120 cd/m<sup>2</sup>. You should get shorter measurement times for the Spyder2, Spyder3, Spyder4, and Spyder5 instruments for brighter displays and longer times for dimmer displays. Display brightness should also affect the i1Pro/i1Pro 2 (XRGA) times when the adaptive option is ON.
- ii- Your results may vary; still, except for the SpyderX, our measurements were essentially the same on Mac and Windows systems.
- iii- When the measurement speed is **not adjustable**, the same measurement time is used for all patches.
- iv- The i1Pro/i1Pro 2 (XRGA) adaptive mode and the i1Display Pro (see [Note 6](#) above), Spyder2, Spyder3, Spyder4, and Spyder5 (see [Note 8](#) above) measurement speed is selected either in the “[Preferences](#)” dialog or in the “[Instrument info](#)” dialog.
- v- The i1Pro/i1Pro 2 (XRGA) adaptive mode works with both the i1Pro and the i1Pro 2.
- vi- For the Spyder2, Spyder3, Spyder4, and Spyder5, the **average** color differences for all patches were essentially the same for the FAST and SLOW options. However, we did see, as expected, slightly higher **sigmas** (the statistical [standard deviation](#)) for the FAST option. For this specific target (IT8.7/4), FAST is the preferred option.
- vii- For the i1Display Pro, always use the SLOW setting when making measurements on a CRT.
- viii- Because of the long measuring times required for large color lists, it is particularly important to work in a stable environment. For more information: [Factors which can affect display measurements](#).



### 3.6.2 The Display-Check interface



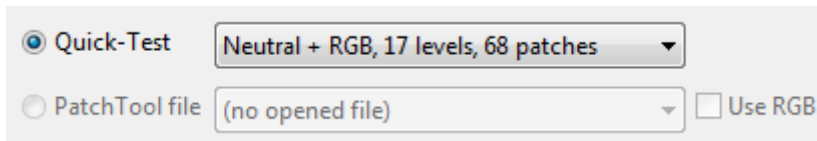
A green light  besides the instrument selection menu indicates that the instrument is recognized and ready to use; a red light  indicates that it is not available. Clicking on the “Info” button opens the “[Instrument info](#)” dialog which shows information relative to the instrument and enables you to change some [settings](#). If your instrument is connected but shown as not available, you should first attempt a reconnect by selecting “Try to connect again...” in the “Instrument” menu. If the instrument is still not connected, clicking on the “Info” button may provide information on the source of the problem.

**Note:** If the above fails, disconnect and reconnect the instrument, then select “Try to connect again...” in the “Instrument” menu. If you have an Eye-One Display or i1Pro and the problem persists, read [Note 4](#) in the [Supported instruments](#) section (the preceding section).

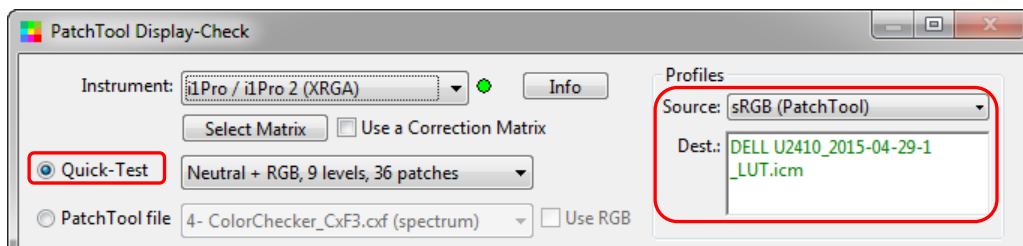
You will also notice that the instrument menu does not offer “i1Pro” and “i1Pro 2” as separate menu items. Instead, “i1Pro / i1Pro 2 (non-XRGA)” and “i1Pro / i1Pro 2 (XRGA)” are shown; these descriptions correspond respectively to the old i1Pro driver and the new i1Pro 2 driver. Both the i1Pro and i1Pro 2 instruments can be used with either driver. The i1Pro driver is NOT XRGA compliant and the i1Pro 2 driver is XRGA compliant. You can thus make measurements with your instruments with or without XRGA calibration.

**Note:** Only “i1Pro / i1Pro 2 (XRGA)” is available in the PatchTool 64 bit version because the older non-XRGA driver is not available in 64 bit libraries.

Two types of tests can be performed. The first type, called “**Quick-Test**” uses program-generated patches; it is not required to open a file before accessing the Display-Check tool. The second type, “**PatchTool file**”, uses files which are currently opened in PatchTool.



When doing a **Quick-Test**, you have to select a **Source** profile. You can choose a built-in PatchTool RGB space or assign an ICC profile, either by dragging and dropping the profile on the control, or by browsing to the profile location (Select the “browse...” item in the control menu). The **Destination** profile is the ICC profile assigned by the OS to the display on which the Display-Check window appears. On a multi-monitor computer, you will see the destination profile change when the window is moved to another monitor.

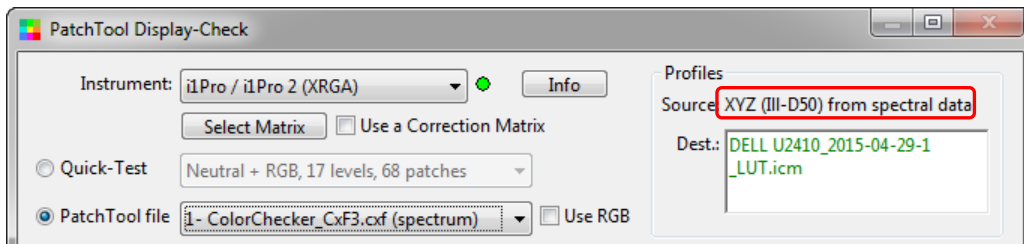
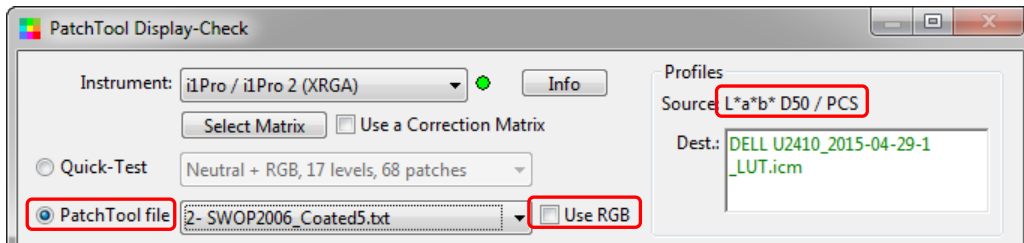




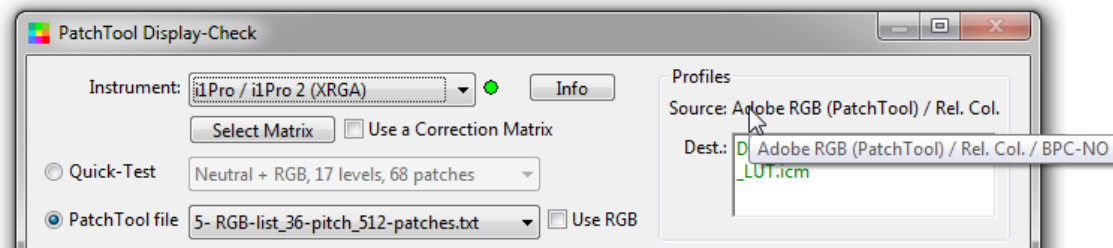
When doing a Display-Check with a **PatchTool file**, the **Source** profile **cannot be selected**. However, there is the option to use the file RGB values directly, as if there were no color management. Here are various workflows, which depend on the RGB data origin.

**“Use RGB” NOT selected (this corresponds to the workflow of PatchTool 4.x and older versions)**

Display-Check will assign XYZ/L\*a\*b\* data to the PCS, which will then be converted to the **Destination** profile. The text shown in the Source field depends on the data type selected when importing (opening) the file. If the color reference of the file is xyY, XYZ, L\*a\*b\*, or L\*C\*h, the Source is defined as “L\*a\*b\* D50 / PCS”. For a file containing **spectral data**, the Source is show as “XYZ (Ill-D50) from spectral data”.

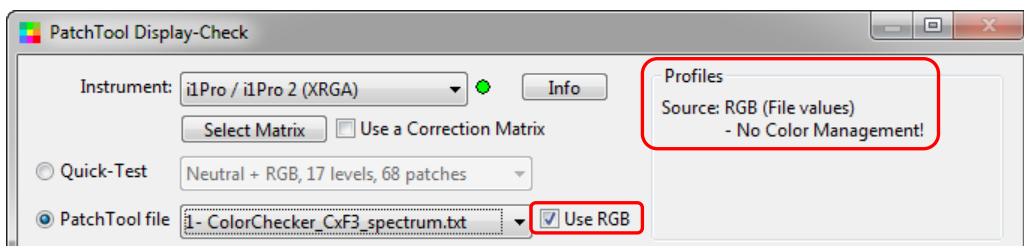


When a file color reference is CMYK or RGB, there is always a profile or color space associated with the data. This profile information thus constitutes the **Source**. If the profile information is too long for the Profiles box, just move your mouse over the description and wait until the Help tag with the complete text appears.



**“Use RGB” selected + RGB data WITHOUT profile info**

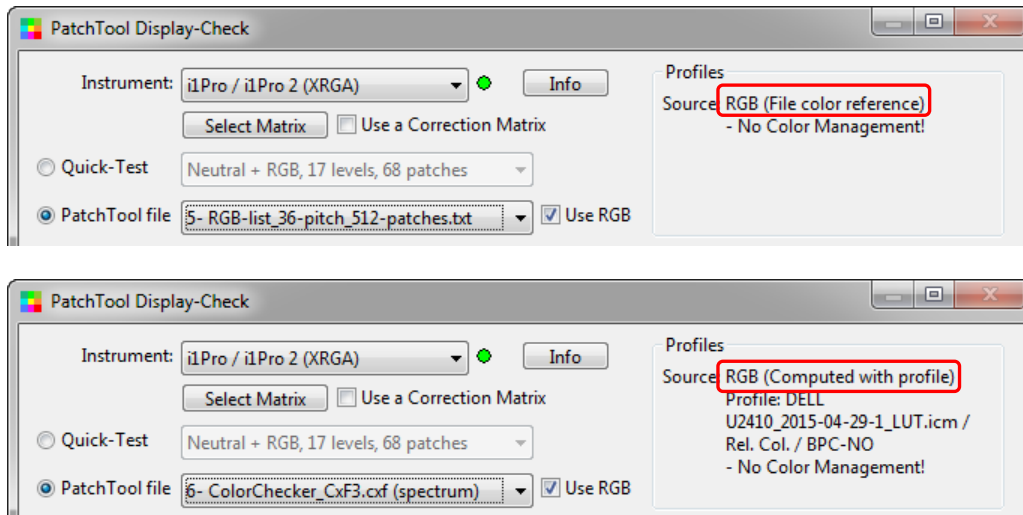
This is most often the case when you open a file which has RGB data in addition to spectral or L\*a\*b\* data. The measured data is presented in a standard file window (NOT a Compare file window). The data is computed in D50 with a Relative-Colorimetric conversion between the measured display White Point and D50 (same process as in Display-Reader when a WP is measured). This file can be COMPARED with another file if required.



**Note:** In some files, RGB imported as additional data, indicated by “**RGB (File values)**”, may also be associated with a recognized profile defined in the original file (this will happen for files saved with PatchTool). In such a case, the profile information will not appear in the Display-Check window but the program will detect it nonetheless, and the next workflow will apply automatically.

### “Use RGB” selected + RGB data WITH profile info

In this workflow, the profile info was either assigned when the file was opened, because the **file color reference** data type is **RGB**, or assigned once the file was opened, because the **file did not contain RGB** data. The measured data is presented in two files: a standard file window, as described above (RGB data WITHOUT profile), AND a Compare file. We can include a Compare file in this case because the profile enables us to obtain absolute reference data. The Compare file is similar to the file obtained with the “Use RGB” NOT selected workflow.



**Important:** In theory, for files where RGB was used as color reference, there should be no difference between the two following cases:

- a- “Use RGB” NOT selected + (Source profile = Destination profile),
- b- “Use RGB” selected.

However, there is a difference in practice. In Case “a”, the input RGB values are converted to XYZ (i.e. to the Profile Connection Space, or PCS) by using a user-assigned profile, the Source profile, which is selected here to be the same as the display profile (i.e. the Destination profile). The input conversion to the PCS is required to compute all other data types shown in the Info window. When computing the display values for Display-Check, the normal workflow is to take the PCS data and convert it to Destination RGB using the display profile. In theory, the Destination RGB values should be the same as the input RGB values, because the Source and Destination profiles are the same. However, in practice, because profile conversion is not perfect, especially on the profile gamut boundaries, case “a” may result in incorrect display values. This is why the “Use RGB” option is provided; it uses the RGB values found in the file directly, without profile conversion. Thus, if you plan to make a Display-Check with RGB values using the same Source and Destination profiles, you should select “Use RGB”.

**Important:** Once the data is measured, you are offered to save the RAW data before it is transferred in a [Compare](#) window. Because display measurements need to be chromatically adapted to the display white before being compared to a reference, the original unprocessed data is not available to the user once processed by PatchTool and the Compare window is opened. For this reason, you may want to save the RAW data whenever a measurement sequence is completed. However, the RAW file is not required for most users and it should be kept only by those who intend to process the measured data in their own application (i.e. not in PatchTool); in particular, **the RAW file should NOT be re-opened in PatchTool**. To record the Compare data in a format that can be reopened by PatchTool, simply save (Export) the Compare file with at least the “ID”, “Name”, “CMYK” (if relevant), “L\*a\*b\*”, and “Spectrum” (if available) data fields. When reopening such a Compare file, you will be able to analyze the data as if you just measured it. Please consult [Appendix B - PatchTool Color Management](#) for more information on PatchTool’s data workflows.

**Note:** Whenever you complete a Display-Check, a copy of the monitor profile, i.e. the Destination profile, is copied in your “Documents” folder (MyDocuments\BabelColor\Display profiles).

More information on Quick-Test selections is presented in the [next section](#).

More information on the how to do a Display-Check with a PatchTool file is presented [here](#).

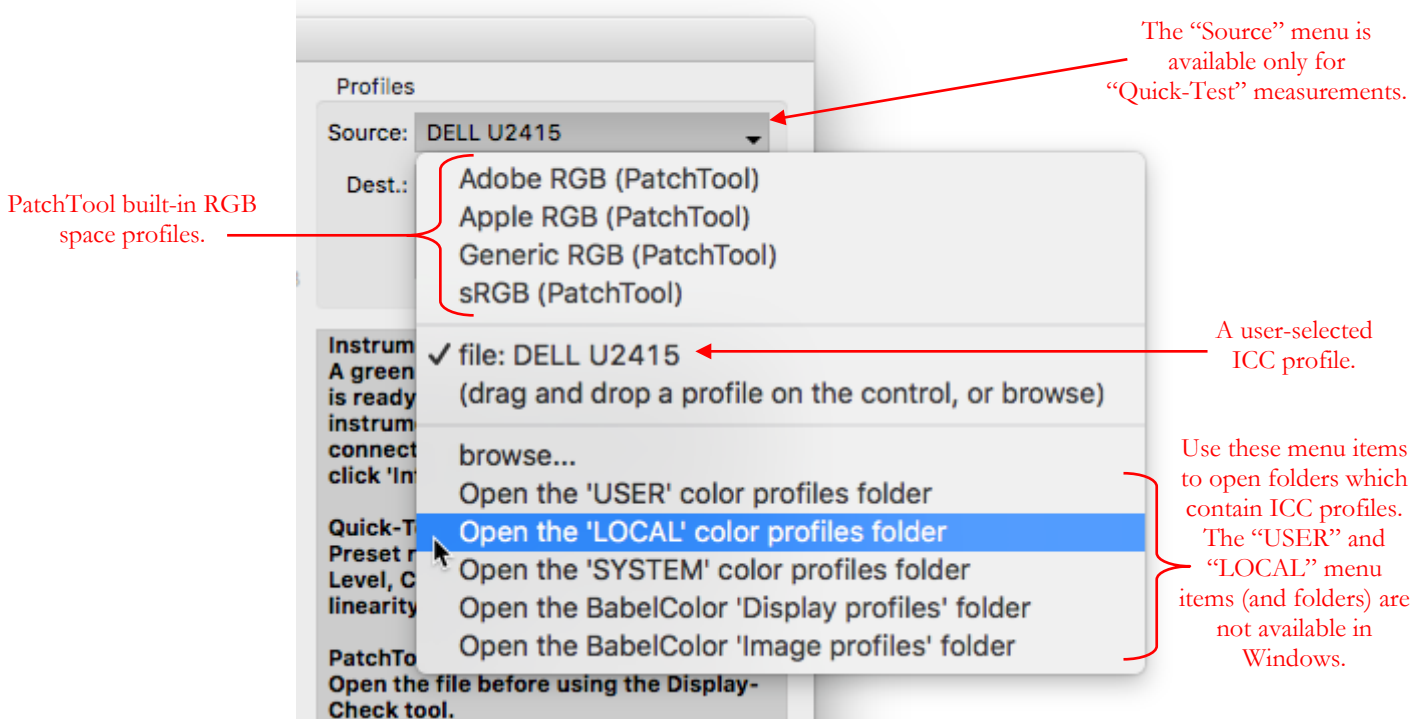
### 3.6.3 Selecting a Quick-Test

The presets available with Quick-Test are:

Menu item	Step size
Neutral patches, 9 levels	32
Neutral patches, 17 levels	16
Neutral patches, 33 levels	8
Neutral + RGB, 9 levels, 36 patches	32
Neutral + RGB, 17 levels, 68 patches	16
Neutral + RGB, 33 levels, 132 patches	8

The first three selections send gray ramps, with uniform RGB steps, with an increasing number of steps (levels). The last three selections send gray ramps plus ramps for each of the primaries. Because these data sets are fixed by the program, they can be used to derive very specific information on the display characteristics. This information is shown in the dedicated “[Display data](#)” and “[xy graph](#)” tabs of the [Compare](#) window.

The Quick-Test patches are RGB values. Use the “Source” menu to assign a profile to these values; this is equivalent to assign a “Working Space” in Photoshop. The Destination profile is not user-selectable; it is the ICC profile assigned by the OS to the display on which the Display-Check window appears.



You should select a Source profile which is smaller than the gamut of the display on which the measurements will be taken. If you select the display profile as the Source profile, the Source and Destination profiles are the same and the RGB values are sent directly to the display as if there was no color management.

**Hint:** If multiple monitors are connected to your computer, you can get a list of the profiles associated with the displays in the “[Color](#)” tab of the “[Preferences](#)” dialog.

### 3.6.4 Doing a Display-Check with a PatchTool file

To measure your own custom-defined color list, you first need to open the list in PatchTool. Because this is a PatchTool file, there is no source profile to select; the source data is either spectral data or XYZ (please consult [Section 3.6.2](#) for more information on the content of the Source profile label). This is true even if the input data type was CMYK or RGB since the input data was converted to XYZ following an assigned profile space, which was either found within the original data file, or selected with the “[Missing Info](#)” dialog when opening the file.

As a consequence, a user-selectable source profile does not make sense here since the data is essentially already converted to the Profile Connection Space (PCS, L\*a\*b\* D50). When making a Display-Check with a PatchTool file, the source profile will be labeled as either “XYZ (Ill-D50) from spectral data”, “L\*a\*b\* D50 / PCS”, or a profile description if the file color reference was CMYK or RGB.

However, there is the possibility to use the file RGB values directly, as if there were no color management. This is done by selecting the “Use RGB” checkbox; the effects of this selection on the workflow are discussed in “[The Display-Check interface](#)” section.

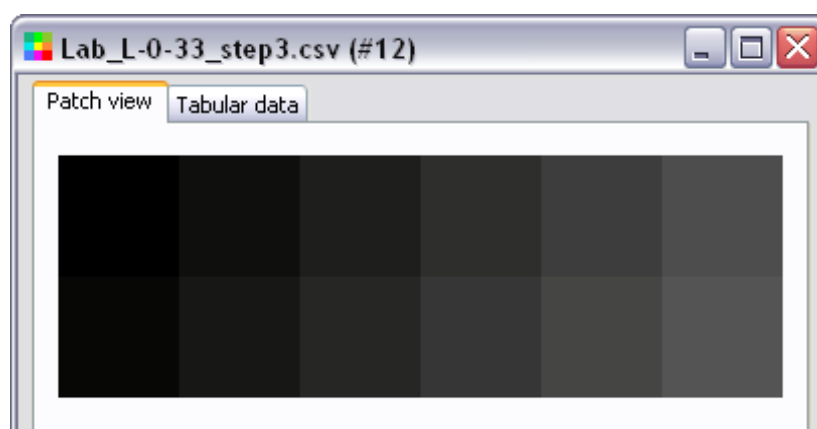
The Destination profile is also not user-selectable; it is the ICC profile assigned by the OS to the display on which the Display-Check window appears. On a multi-monitor computer, you will see the destination profile change when the window is moved to another monitor.

A Display-Check with a PatchTool file is good way to test the accuracy of colors displayed in color-managed applications, such as PatchTool and Photoshop. This test can be performed on either a standard gamut display, a display designed for the default RGB space of your OS, or on a wide gamut display. You must take make sure that your reference patches are within your display’s gamut, unless you specifically want to see which patches will be clipped (Hint: You can always perform a [Clip check](#) on your color list to identify the out-of-gamut colors).

We recommend that you do your first tests with small files, such as the ColorChecker 24 file we use in the [Display-Check examples](#) section. Once you are satisfied with the results, you could use a larger files such as one of the IT8.7/4 files provided in the **Characterization Data folder** included with the program (via the “File/Open Sample Files” menu; see also the [Idealliance certification](#) section). Finally, you could generate a custom color list that fills the Destination profile gamut; here are two suggestions to generate such a list:

- i- Generate an RGB list with the “[List gen.](#)” tab of the [Gamut Tools](#) window. Open the list in PatchTool and assign it your display’s profile in the [Missing info](#) dialog.
- ii- Generate a XYZ, L\*a\*b\*, or L\*C\*h list in the “[Device independent spaces](#)” section of the “List gen.” tools. Select your display profile as the “Target profile” and generate the list (Suggested list settings: Click the “Reset” button in the box; select CIELAB as the “dE formula” and a “Gamut threshold” of 4,0). Open the list in PatchTool.

**Note:** Files with neutral RGB and L\*a\*b\* patches at fixed steps, such as the one shown below, can be found in the “sample\_files/RGB\_Lab\_steps” folder located within the PatchTool application folder. As a shortcut, use the “File/Open Sample Files/Misc. Sample Files...” menu. These files can be helpful to check a display’s linearity.



### 3.6.5 Factors which can affect display measurements

As with any technical measurement, there is a list of things you should be aware of in order to obtain the best assessment of the display performance. The following points should be used as a checklist before doing the measurements, or when analyzing the results.



#### **Instruments and displays are not created equal**

The various instruments available for color measurements on displays are essentially of two types: colorimeters or spectrophotometers. There are pros and cons for each type of instrument. Some will prefer the colorimeter because of the perceived (and sometimes real) increased stability of the measured data. However, colorimeters can be more susceptible to changes in monitor design features such as the specific characteristics of the display primaries. A colorimeter which worked well with CRTs will not necessarily be accurate with LCD displays. Various brands and models of LCDs also use very different filters and/ or light sources which can easily affect a colorimeter's calibration; this is a problem with wide gamut LCD monitors which use a green filter quite different than the ones used in smaller gamut monitors.

When you couple the different instrument optical layouts with the numerous display types, you are bound to witness quite diverse results. For example, instruments with different Field-Of-Views (FOV) will provide different values when measuring LCD monitors with dissimilar and non-isotropic angular spread. You could well obtain matching results between instruments for some displays and non-matching results for others. For instance, on some displays, we have measured blacker black levels with a spectrophotometer than with a colorimeter.

#### **Specifications do not give the complete story**

Most instruments are specified in term of inter-instrument accuracy relative to a master instrument located at the manufacturer's plant. This inter-instrument accuracy also does not even apply between different models of the same manufacturer. So we are far from being able to compare instruments based on absolute specifications; in particular, you will have a (very) hard time finding absolute chromaticity accuracy for emission measurements.



### **Your display is NOT uniform across its surface**

If you calibrate your display by placing the instrument at a certain position and in a given orientation, use the same position and orientation to make a Display-Check (see also *Measurements on LCD displays with an i1Pro* at the [end](#) of this section). A display white point and its brightness do vary across its surface. There are sections of standards ISO 12646 and ISO 3664 dedicated to these non-uniformities (available from their Web site: <https://www.iso.org>):

ISO 12646: “Graphic technology -- Displays for colour proofing -- Characteristics and viewing conditions”

ISO 3664: “Viewing conditions - Graphic Technology and Photography”

According to ISO 12646, it is acceptable to have up to 10% brightness non-uniformity within a centered rectangular zone which covers 25% of the display area. Higher end monitors will exhibit a better uniformity than this, but the difference can still be significant (remember that we are often looking at color differences of one or two Delta-E here).

### **Your display needs to be stable before making measurements**

Whether it is a CRT or a LCD, open your monitor for at least one hour before doing critical measurements (and calibration of course!). Make sure any screen saver is disabled before leaving your system unattended. If a variation in white level is detected while doing a measurement, you will be prompted by PatchTool, and have the choice to continue or discard the measurements.

### **Your colorimeter/spectrophotometer needs to be temperature-stabilized before making measurements**

All optical sensors are subject to electronic noise. This noise varies with the instrument’s temperature, usually increasing as the temperature goes up. When calibrating, you are, in effect, indicating to the instrument’s firmware to subtract the present noise from all future measurements. To minimize any increase in noise, you should thus let your instrument stabilize by placing it anywhere on your display while your display stabilizes. This procedure was found to be effective by Idealliance while they were developing their [monitor proofing certification](#) process.

### **Control the display environment**

A strong overhead light or a nearby desk lamp will likely leak light into your darker shades measurements. In any case, whenever possible, you should work in a dimly lit environment in order to fully appreciate your display output and minimize errors due to external light contamination. Also try to maintain a uniform room temperature, which can affect the display’s response.

### **ICC profiles and Color Management Modules (CMM) are not created equal**

The content of an ICC profile varies depending on the application which generated it. You may be offered many options on what you want inside your profile. You can often select between a matrix profile and one based on LUTs, which can significantly increase a profile size, but can also offer better precision. There are also many decisions made by the program’s creators, for which you have no control. For instance, a profile creator may add some additional profile features (tags or other content) that can only be used by its other products. What will the default rendering intent be? How many different intent tables will be embedded?

To make things even more difficult to control, a given profile may or may not be handled in the same way for some intents and BPC settings by different CMM (also called color engines, such as Adobe ACE, Apple ColorSync, Microsoft ICM, Icms, and Argy). For example, how will Black Point Compensation (BPC) be handled for the different intents?

### **A display profile is matched to its hardware settings**

When you make a display profile, you are asked to set a White Point and brightness level. This adjustment is made automatically on high end systems but remains a manual task for many users. In any case, these hardware adjustments are linked to the resulting profile as well as to the graphic card Look-Up-Table (LUT), and sometimes also to the display LUTs if so equipped. See the next point for additional information on LUTs.

This means that if you select a different profile to check, you should make sure that the hardware settings correspond to this other profile. Since these settings are often manually adjusted and not recorded, there is little chance of getting the system back to the correct setting. On the plus side, we often make many profiles with the same White Point and brightness values, changing only software settings between each profile.



## **A display profile is matched to a computer's graphics card Look-Up-Tables (LUT)**

Profile calibration software use the graphics card built-in LUTs as a mean to provide neutral grays and to adjust the gamma response. Higher end monitors also have LUTs built into the monitors itself; these LUTs work in tandem with the graphics card LUTs to provide smoother tones over a large dynamic range. However, monitor LUTs are not common, and require profiling applications made specifically for such displays.

The monitor calibration (i.e. White Point and LUTs) is the first step of all display calibration procedures; because it is hardware based, it will also benefit non-color-managed applications. The display profile is then built on top of the calibrated monitor; it is thus linked to a given LUT set, and needs to be changed whenever a different profile is selected. In Windows, while the default display profile is loaded at start-up, the LUTs are not. A third party application is required, and this program is usually automatically launched at start-up; *SpectraView II Gamma Loader* (NEC), *Logo Calibration Loader* (GretagMacbeth), *ColorVisionStartup* (Datacolor) and *basICColor display4 VideoLUT Loader* (Color Solutions) are such applications. Because loading the LUTs require a dedicated third-party application, changing a Windows profile on the fly, using the display properties for instance, will not update the LUTs. For Windows XP users, there is a simple solution in the form of a small control panel, named *Color*, which can correctly assign a profile and load the corresponding LUTs without rebooting; this add-on has to be downloaded separately from the Microsoft Web site: [Color Control Panel Applet for Windows XP](#). On a Mac, changing a display profile automatically changes the LUTs. However, for all platforms, you will need a dedicated application to load monitor LUTs.

## **Measurements are not the same unless the data processing is the same**

Many profiling applications incorporate a quick profile verification procedure. The verification measurements can be presented as a graph, a data table with an average error, or a before/after image. You should be aware that when you see RGB input data, they usually mean RGB in the monitor space. Their measurements may be in D50, if presented in L\*a\*b\*, but may also be RAW emission chromaticities, relative to the actual display White, which cannot be directly compared to reference data based on standard illuminants (a Chromatic Adaptation Transform (CAT) is required for such a comparison). These validation procedures are not well documented and can only be understood by a detailed analysis. In such conditions, it becomes hazardous to compare measurements made with different programs. This is why you will find a complete description of PatchTool's data processing in [Appendix B](#); at least you will know where PatchTool's measurements come from.

## **Measurements on LCD displays with an i1Pro**

While making emission measurements with an i1Pro on an LCD display, it was noticed that different luminance and Correlated Color Temperature (CCT) values were obtained, depending on the instrument's position on the display. Luminance variations by as much as 10% were measured for the same display area when rotating the spectrophotometer by 90 degrees. This problem affects i1Pro instruments with manufacturing revisions A, B, and C (shown as REV A, REV B, REV C on the instrument). According to our own measurements on a REV D unit, this problem has essentially disappeared; this has been confirmed by other owners of a REV D i1Pro.

The problem with earlier units is related to the polarization of the light emitted from the display. In an LCD display, the intensity of each pixel is controlled by rotating the light's polarization state between crossed polarizers, and the light coming out is linearly polarized (often at a 45 degrees angle). To check this, look at your display using a photographic polarizing filter (or polarizing sunglasses), and rotate it slowly; you should see maximum and minimum transmission for angular positions separated by 90 degrees. The display light is not seen differently by the human eye whether it is polarized or not, since we only perceive the light intensity; however, polarization can affect an instrument reading.

In order to obtain reproducible and valid measurements, we recommend making all measurements with the instrument placed at the same angle that was used for calibration. If calibration is done with the instrument suspended in its cradle, as shown in the illustrations on the next page, all subsequent measurements should be done with the i1Pro placed vertically. It is acceptable to make measurements with the instrument turned 180 degrees from its calibration position, so that it is still vertical, as shown in the illustration on the left. Accordingly, in such a case, measurements should not be done with the instrument positioned horizontally, or at an angle, as shown in the illustration on the right.



**Note:** "Older" CRT displays do not emit polarized light and are thus not susceptible to errors due to instrument orientation. As for the Eye-One Display and the Spyder colorimeters, their simpler optical layout makes them immune to this effect.

After what you read in the previous pages, we are sure you will feel gratified when a Display-Check shows a low average error, since you know that such an outcome is conditional to the understanding and control of many parameters, and that not much is required to push the results out of an acceptable zone.

### 3.6.6 Display-Check examples

This section presents a series of measurements made on two freshly calibrated wide gamut displays. The first monitor is a Dell U2410 display while the other is a NEC PA241W, both with a native 1920 x 1200 pixels resolution and a 24 inch diagonal. These displays have been in constant use for many years. The NEC PA241W can be purchased with an optional colorimeter, the MDSVSENSOR, a custom i1Display II, and software calibration suite (SpectraView II) which is optimized for this display; it is used by many professionals for color-critical work (Note: in recent models, NEC displays can be purchased with an optional custom i1Display Pro colorimeter).

The Dell U2410 is not a professional monitor per se but, as you will see in the tests results, it can accurately represent colors tagged for the Adobe RGB space. An i1Pro 2 was used for profiling both the Dell U2410, using X-Rite i1Profiler, and the NEC PA241W, using SpectraView II. The nominal profiling/system parameters were:

Parameter	Value
White Point	D65 (6500 K)
White Point luminance	120 cd/m <sup>2</sup>
OS	Windows 7
Monitor mode	Adobe RGB

**Note 1:** Some of the tests presented in this section are also applicable to a standard gamut monitor while others are not. For example, “Test-1“, a Quick-Test where the Source profile is Adobe RGB, does not make sense for standard gamut monitors.

**Note 2:** While many test requirements call for a 160 cd/m<sup>2</sup> luminance, this is felt to be too high by many, especially if working in a dim environment. This is why a target luminance of 120 cd/m<sup>2</sup> was selected.

**Note 3:** It took us many trials before obtaining an acceptable profile with the Dell U2410. The U2410 offers many adjustments when you select its “Custom Color” mode instead of one of the presets (such as sRGB and Adobe RGB), but the controls are not well documented and the results we obtained were far from great (we initially failed to meet the Idealliance Monitor Certification requirements for instance). Our best results were obtained by selecting the monitor “Adobe RGB” preset mode, which unfortunately precludes fine adjustment of the display White Point; however, this limitation did not prove too bad in the end.

The tests are presented in the following table; they were all performed with an i1Pro 2. Except for **Test-5**, which takes [about 40 minutes](#), the other tests can be done quite rapidly, and can give a preliminary idea of the display accuracy. Test-5 then confirms if the display is acceptable for critical work.

#	Test name	Test type	Source profile	Dest. profile	Rendering Intent / BPC
1	Quick-Test_DispProfile	Quick-Test	display profile	display profile	Rel-Col BPC-OFF
2	Quick-Test_sRGB	Quick-Test	sRGB (PatchTool)	display profile	Rel-Col BPC-OFF
3	Quick-Test_AdobeRGB	Quick-Test	Adobe RGB (PatchTool)	display profile	Rel-Col BPC-OFF
4	PatchTool-file_CC24	PatchTool file	Spectral data (ColorChecker_CxF3.cxf)	display profile	Rel-Col BPC-OFF
5	PatchTool-file_CRPC4	PatchTool file	XYZ data (CGATS21-2-CRPC4.txt)	display profile	Rel-Col BPC-OFF

As mentioned previously, when doing a Display-Check Quick-Test, you should not select a Source profile which is significantly larger than your display profile. Since both monitors used in our examples are advertised to be wide-gamut and, more specifically, advertised to have a gamut very close to Adobe RGB, we can thus make the three Quick-Tests shown on the preceding page. Here is a short description of each test.

**Test-1:** The first Quick-Test, with a Source profile identical to the Destination profile, is equivalent to do no color management. Since the Destination profile is the display profile, we need to locate it and assign it as the Source. You can use the Preferences dialog to help you locate the display profile and you can also use the Source popup menu to open the default System folder (on Windows) or User folder (on Mac) where color profiles are located. We test the primaries and the neutral ramp without any contribution from the display profile. In other words, we test the graphic card and display Look-Up-Tables (LUT). This test should result in the lowest measurement errors.

**Test-2:** The second Quick-Test measures how the primaries of sRGB are represented once processed by the wide-gamut display profile. We select the built-in “sRGB (PatchTool)” profile as the Source profile. Since the sRGB profile is, in theory, enclosed by the Adobe RGB gamut, we should also get minimal measurements errors, with two additional causes of error. Firstly, the display primaries may not match exactly the sRGB primaries and, secondly, the profile transform may cause some errors.

**Test-3:** The third Quick-Test measures how the primaries of Adobe RGB are represented once processed. We select the built-in “Adobe RGB (PatchTool)” profile as the Source profile. This is very similar to the second test with more stringent requirements because of the green primary which is much more saturated in Adobe RGB versus sRGB. We thus expect the results of Test-1 to be better than Test-2 and those of Test-2 to be better than Test-3, in theory!

**Test-4:** (PatchTool file) This test is made using average spectral values measured from thirty ColorChecker 24 charts. The file, named “ColorChecker\_CxF3.cxf” can be found in the “sample\_files/Help-Manual\_files” folder of the PatchTool application folder. The “Help-Manual\_files” folder can also be opened using PatchTool’s “File/Open Sample Files/Misc. Sample Files...” menu. Once the file is opened, select it using the “PatchTool file” radio button and its associated file menu in the “Display-Check” window. The Source profile should be shown as “XYZ (Ill.-D50) from spectral data”.

**Test-5:** (PatchTool file) This test is made using 1617 values from the “CGATS21-2-CRPC4.txt” reference file defining an IT8.7/4 target. The file can be found in the “CGATS21\_ISO-15339\_SWOP2013” folder located within the “characterization\_data” folder of the PatchTool application folder. This folder can also be opened using PatchTool’s “File/Open Sample Files/Characterization data...” menu. Once the file is opened, select it using the “PatchTool file” radio button and its associated file menu in the “Display-Check” window. The Source profile should be shown as “L\*a\*b\* D50 / PCS”. The “CGATS21-2-CRPC4.txt” file was selected as a modern replacement of the “SWOP2006\_Coated5.txt” file recommended by Idealliance for monitor certification. These two files have patches defining a similar size gamut which is enclosed by the Adobe RGB color space. Please note that the older reference file is still available in the “characterization\_data” folder.

**Note:** In order to obtain coherent and reproducible results, you should place your measuring instrument on the same spot that was used for profiling, usually in the monitor’s center, and make sure your monitor and measuring instrument are temperature stabilized. Please consult [Section 3.6.5](#) for a presentation on the factors which can affect display measurements.

**Note:** All screenshots were obtained from previously saved data. In particular, all the tabs of a Quick-Test, “Patch view”, “Tabular data”, “Stats”, “Display data”, and “xy graph”, are regenerated from the saved file.

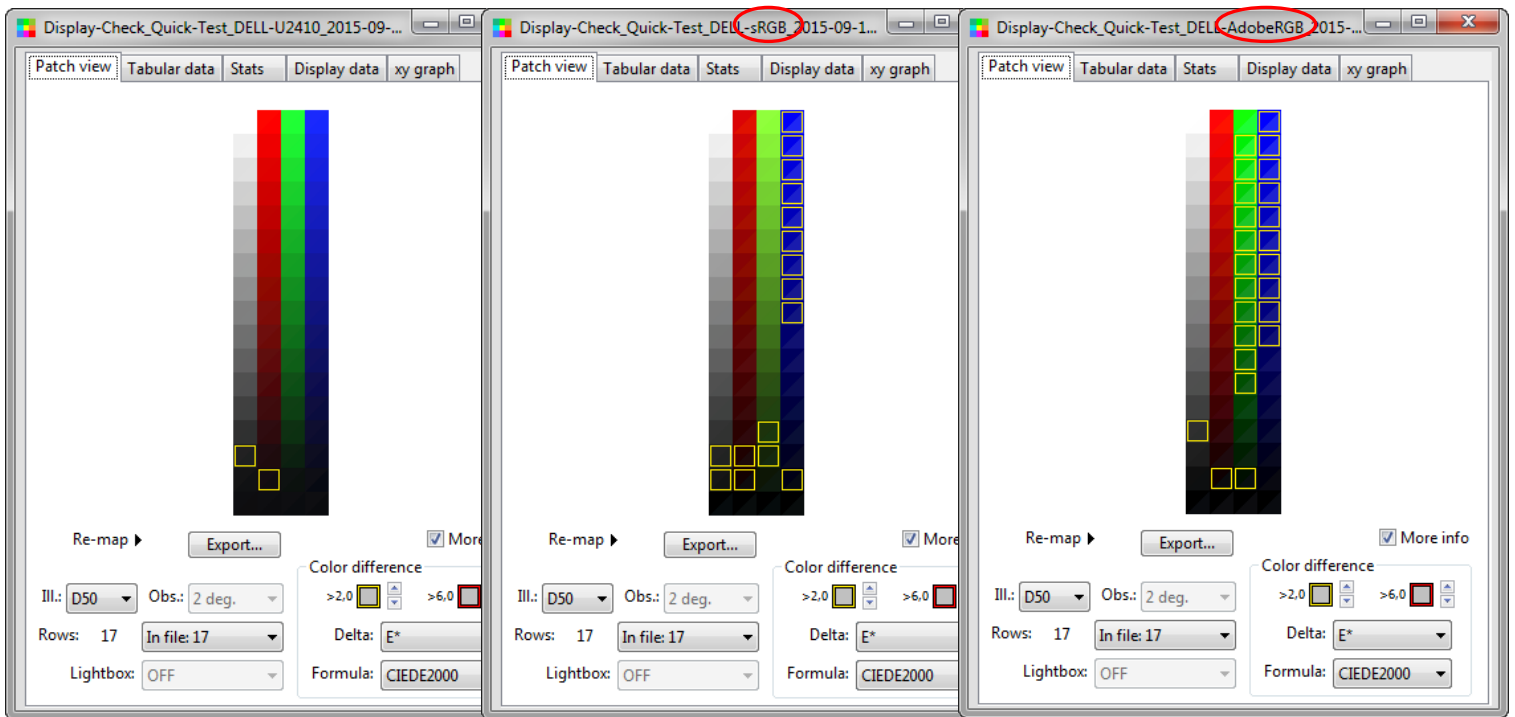
## Quick-Test examples (Tests 1 to 3): Patch view

Test-1 (Source = Destination)

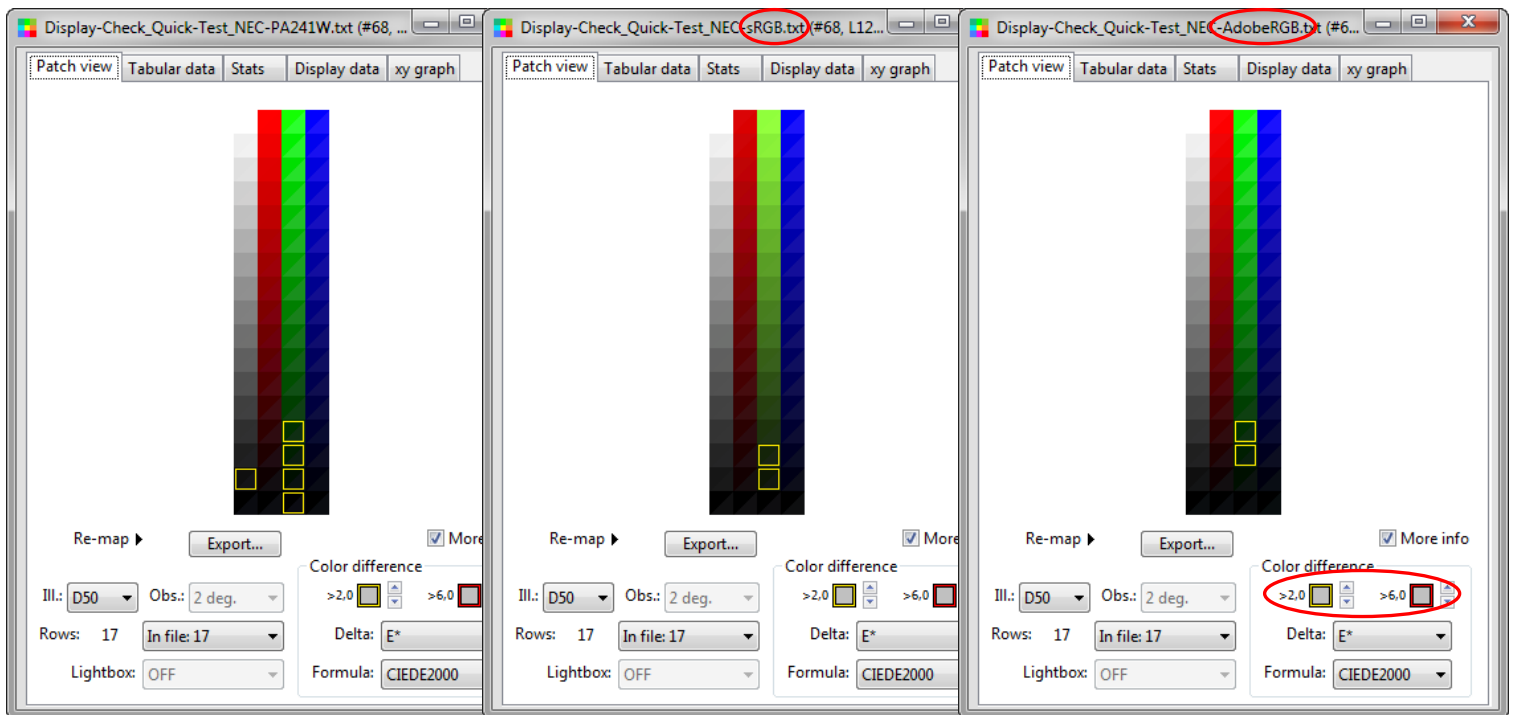
Test-2 (Source = sRGB)

Test-3 (Source = Adobe RGB)

Dell U2410 monitor:



NEC PA241W monitor:



The Patch view indicates better results obtained with the NEC. Let's see the corresponding stats on the next page. Please note the "Color difference" settings, 2.0 and 6.0 DeltaE\* CIEDE2000, which will remain the same throughout this example.

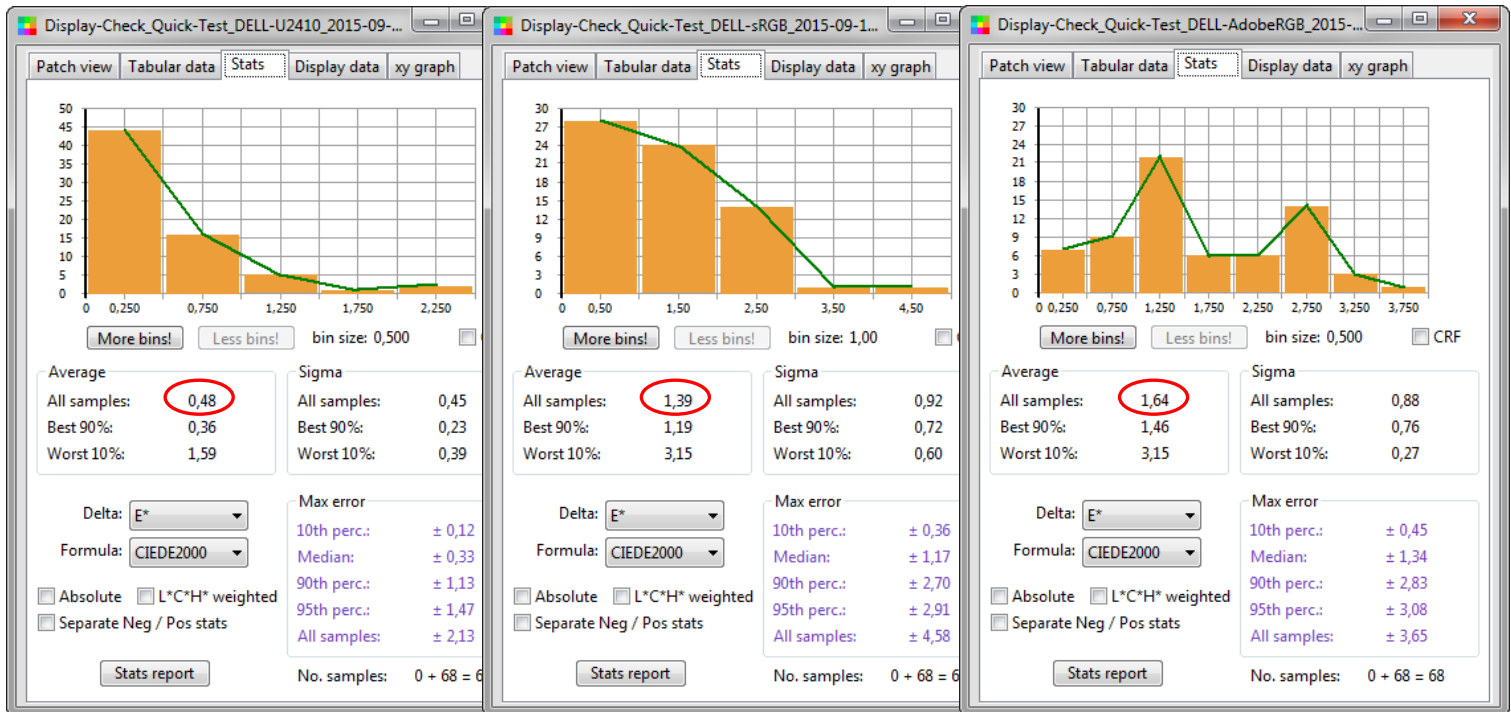
## Quick-Test examples (Tests 1 to 3): Stats

Test-1 (Source = Destination)

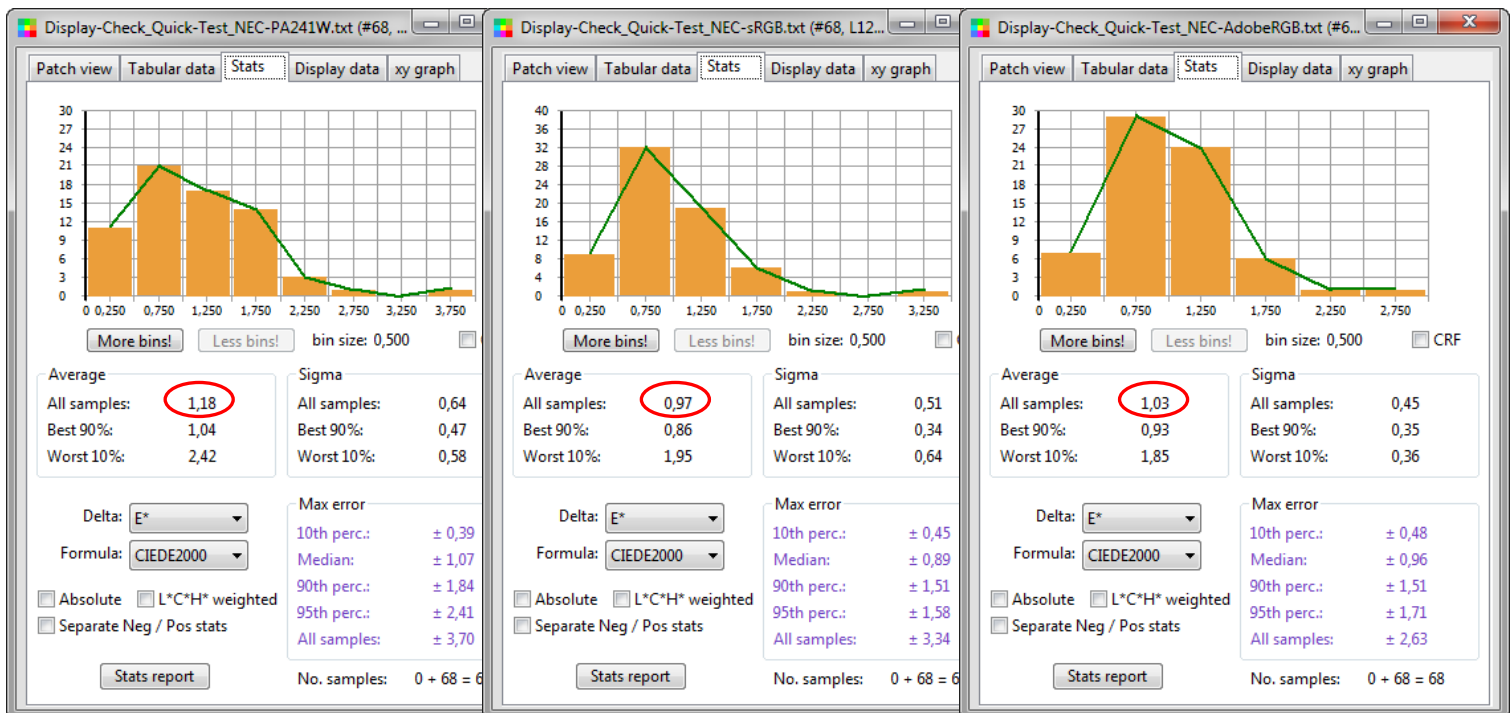
Test-2 (Source = sRGB)

Test-3 (Source = Adobe RGB)

Dell U2410 monitor:



NEC PA241W monitor:

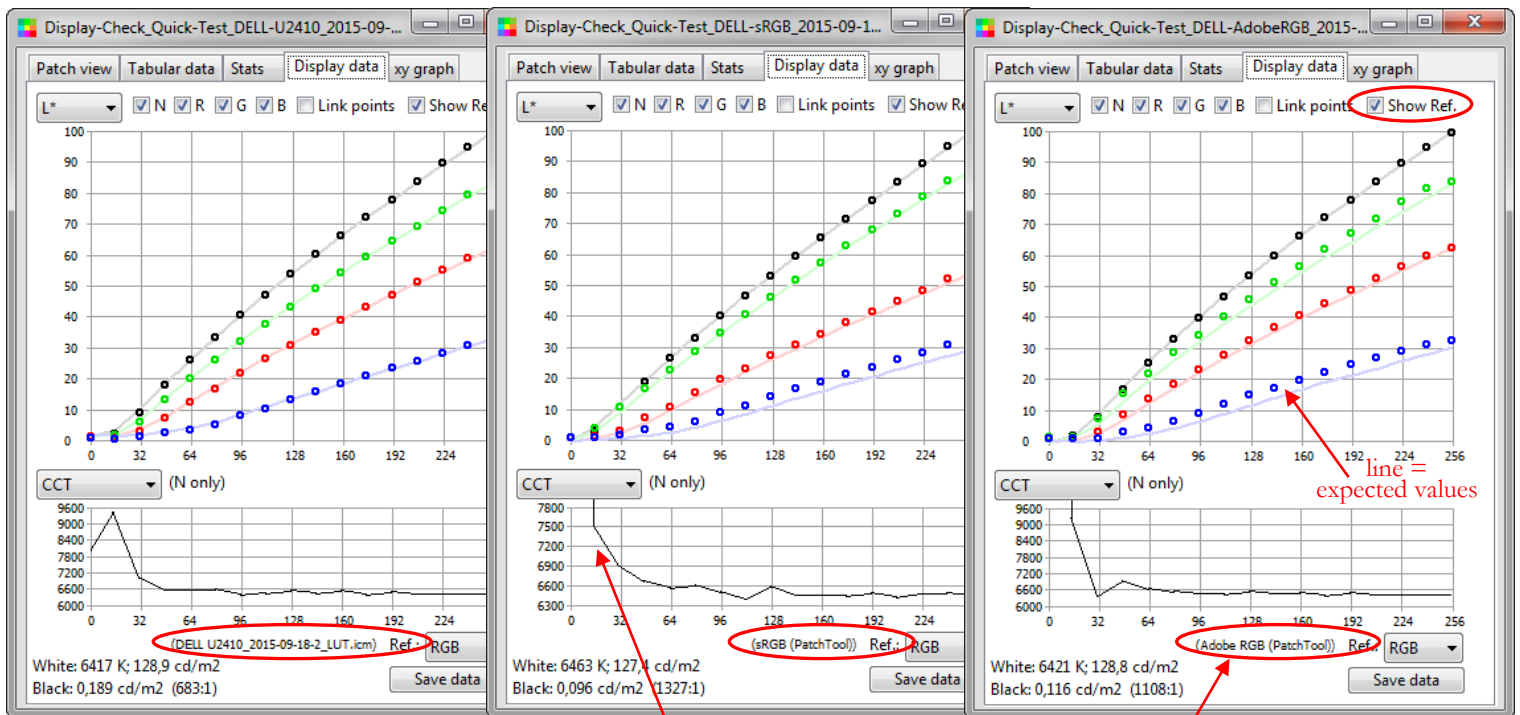


For the Dell monitor, we see a slight increase between the “No Color-Management” measurements of Test-1 and assigning sRGB as the source (Test-2), and another increase when assigning Adobe RGB (Test-3), as “expected” previously. For the NEC, the measured error remains constant, and low, for all tests, especially Test-2 and Test-3, which show better results than for the Dell monitor.

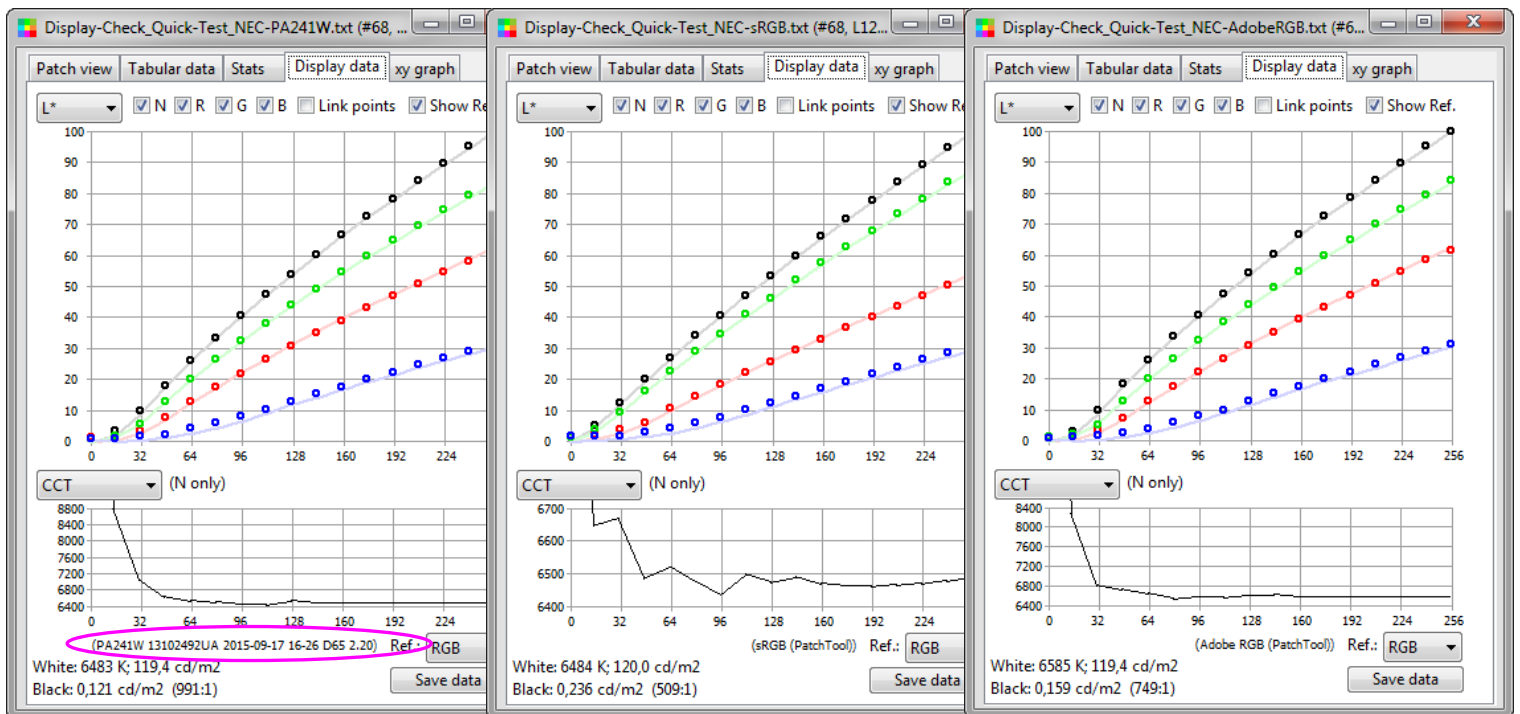


# Quick-Test examples (Tests 1 to 3): Display data

Dell U2410 monitor:



NEC PA241W monitor:



The top diagram in each screenshot shows the measured L\* versus the reference RGB values. The dots are the measurements and the reference values are shown by a dimmed colored line whose presence is controlled by the “Show Ref.” checkbox. The bottom diagram shows the measured CCT versus the reference RGB values. The distance between the reference line and the measured points correlates well with the average difference shown in the “Stats” tab on the preceding page, particularly for the blue primary.



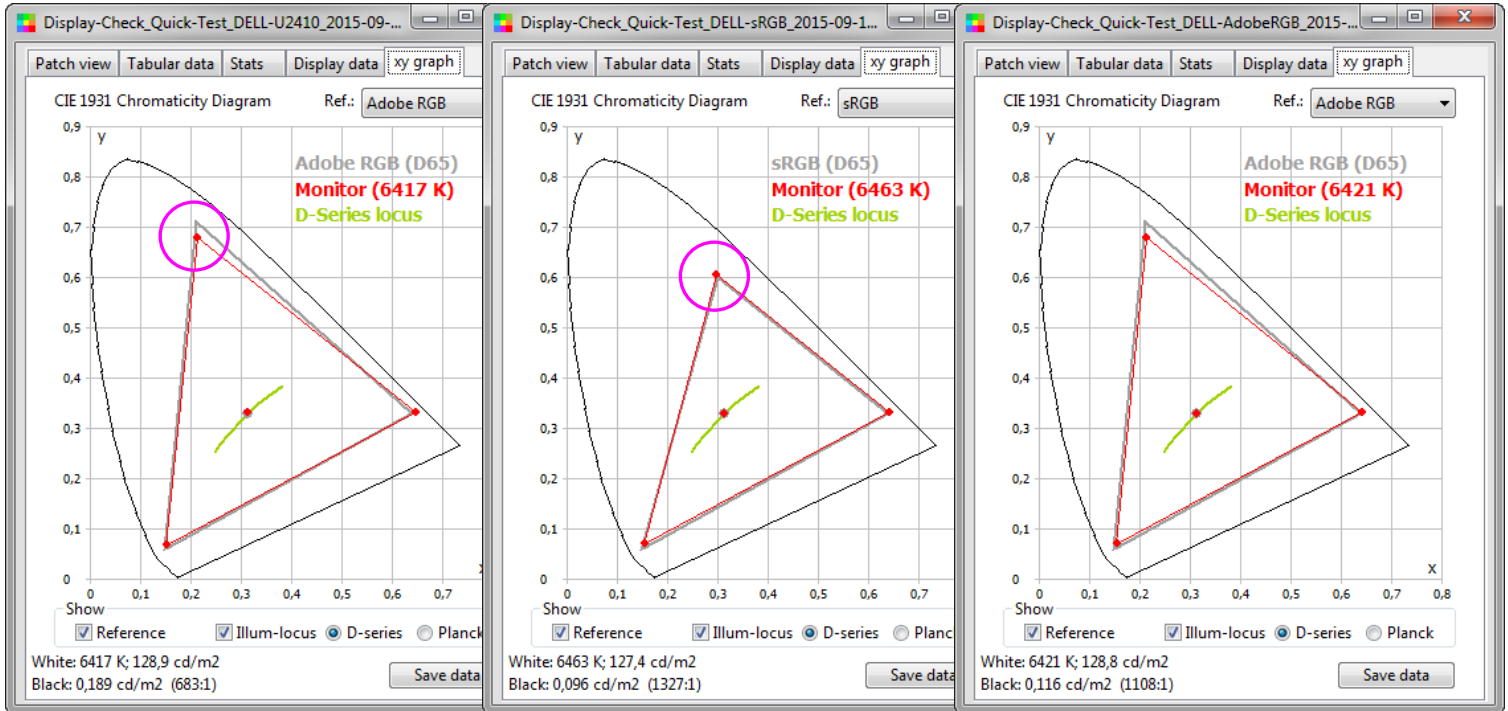
## Quick-Test examples (Tests 1 to 3): xy graph

Test-1 (Source = Destination)

Test-2 (Source = sRGB)

Test-3 (Source = Adobe RGB)

Dell U2410 monitor:



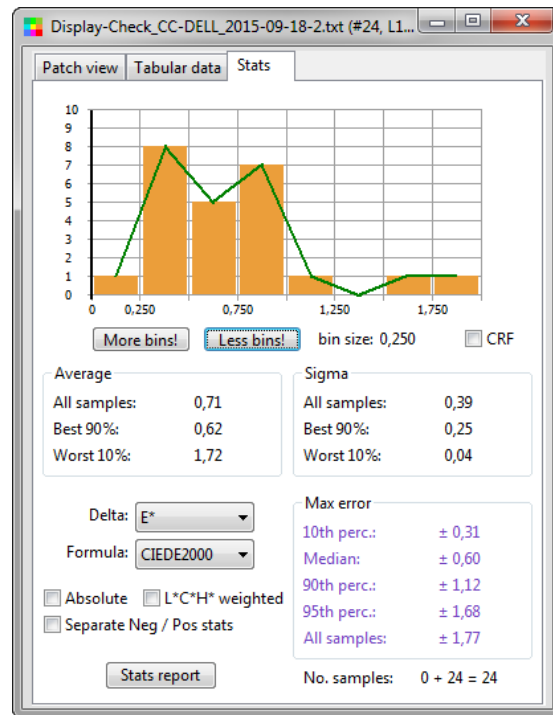
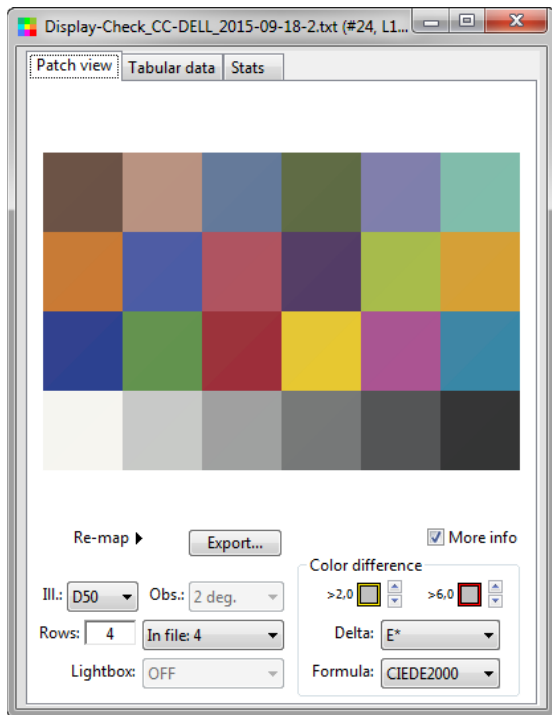
NEC PA241W monitor:



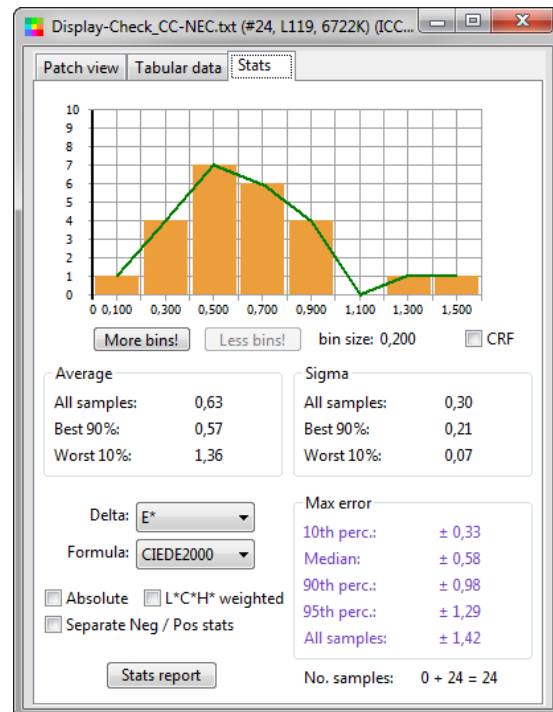
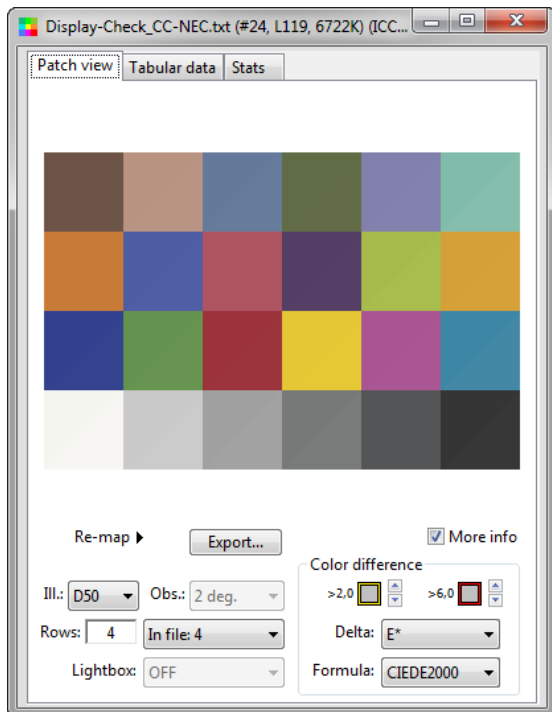
The positions of the primaries are slightly more accurate for the NEC display than for the Dell display. As expected, the position of the green primary for the sRGB Source is also better for both displays.

## Test-4: PatchTool file (ColorChecker\_CxF3.cxf)

Dell U2410 monitor:



NEC PA241W monitor:

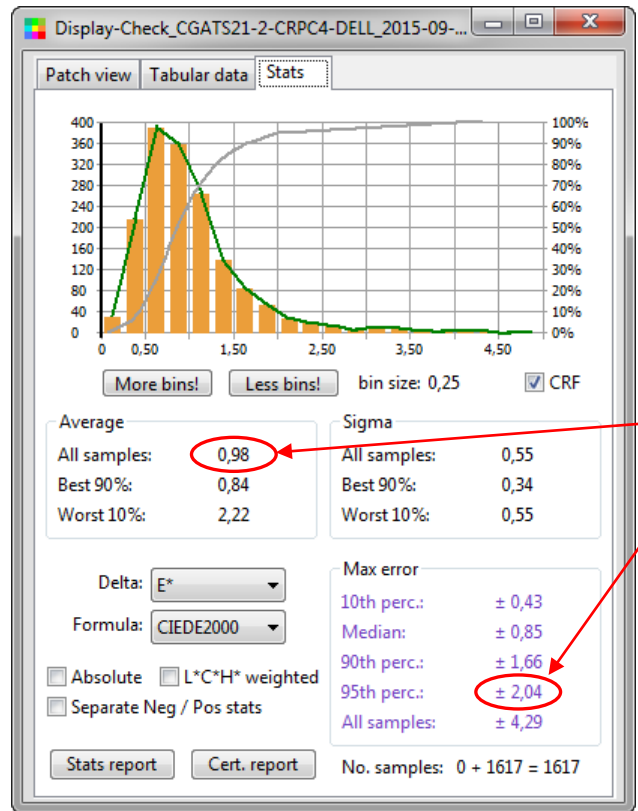
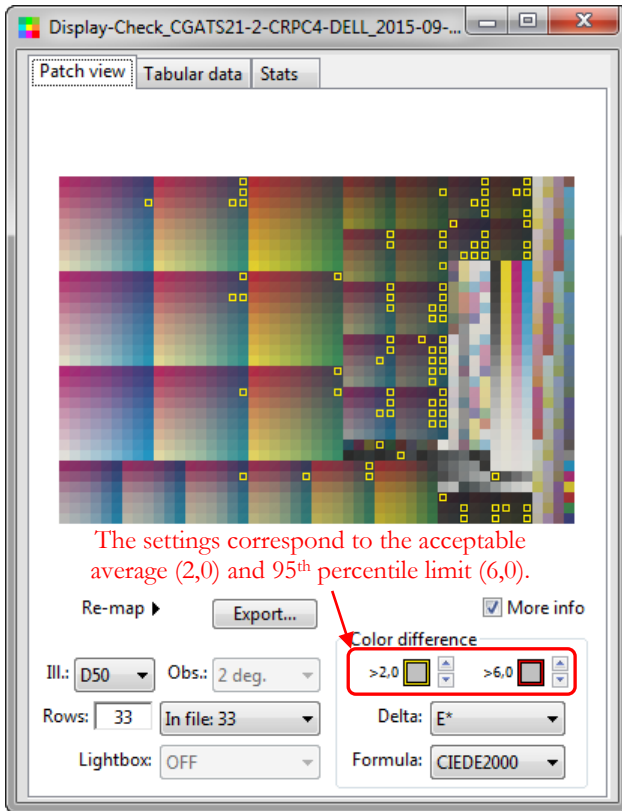


Both displays can accurately represent the ColorChecker 24 patches, which are well within the display profile gamut. There are no measurements with an error higher than 2 DeltaE\* CIEDE2000.

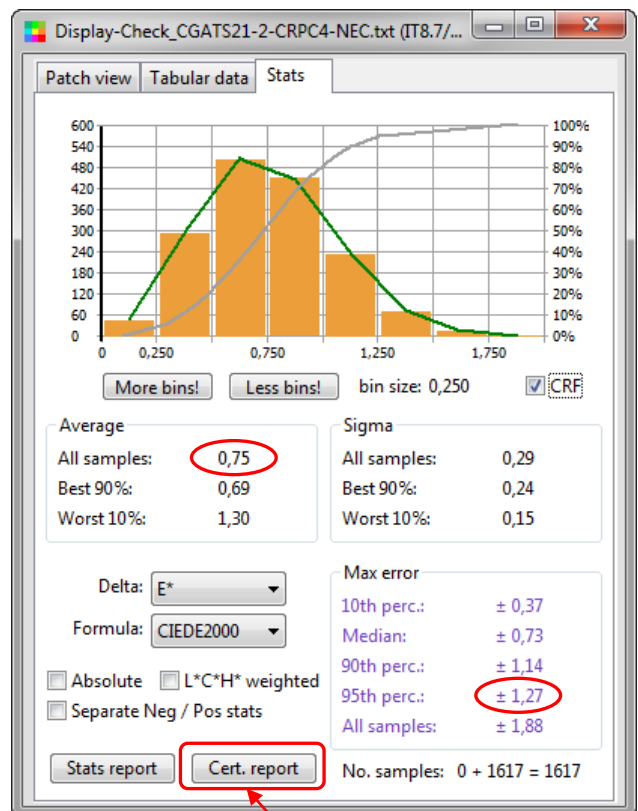
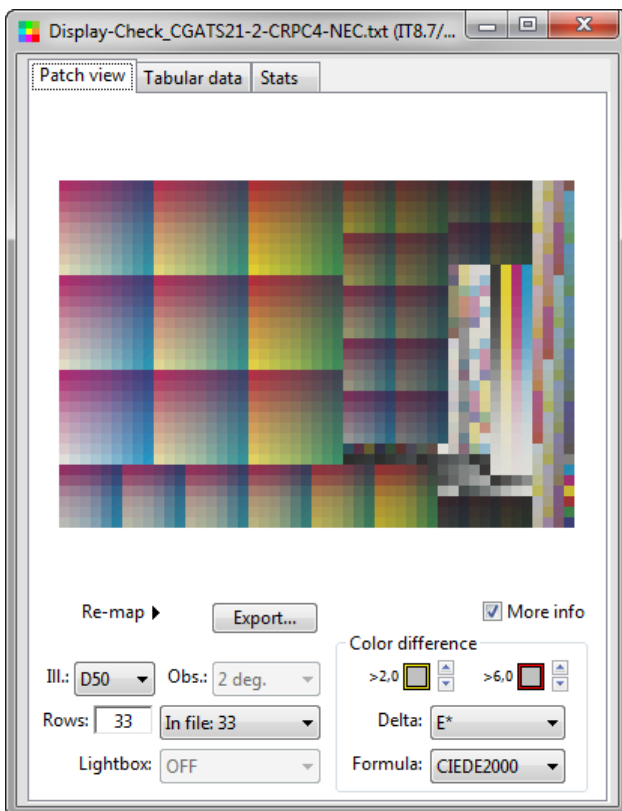
**Note:** Except for the cyan patch, the ColorChecker colors are located within the sRGB gamut. The cyan patch is clipped by about 2,6 CIEDE2000 in sRGB; it is not clipped in Adobe RGB.

Test-5: PatchTool file (CGATS21-2-CRPC4.txt)

Dell U2410 monitor:



NEC PA241W monitor:



Test-5 (continued)

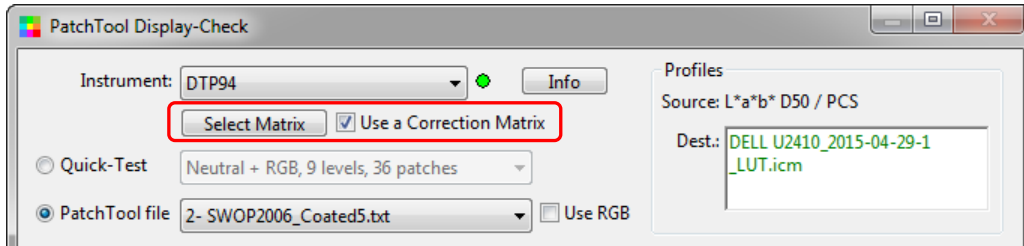
CERTIFICATION-RESULTS				
CRITERIA	PATCH	MEAS.	P/F	REQUIREMENT
Luminance	WP	118,9	Fail	160 cd/m2 plus or minus 10 cd/m2
Average_error	ALL	0,75	Pass	Average Delta-E* smaller or equal to: 2,00
95th_perc.	ALL	1,27	Pass	95th perc. Delta-E* smaller or equal to: 6,00
Solid_Cyan	1287	1,36	Pass	Delta-E* smaller or equal to: 7,00
Solid_Magenta	1307	0,21	Pass	Delta-E* smaller or equal to: 7,00
Solid_Yellow	1327	0,22	Pass	Delta-E* smaller or equal to: 7,00
Solid_Black	1347	0,73	Note	Delta-E* smaller or equal to: 7,00
Overprint_Red	657	0,41	Pass	Delta-E* smaller or equal to: 7,00
Overprint_Green	721	0,99	Pass	Delta-E* smaller or equal to: 7,00
Overprint_Blue	81	0,67	Pass	Delta-E* smaller or equal to: 7,00
50/40/40_L*	1611	0,63	Pass	Absolute Delta-L* smaller or equal to: 2,00
50/40/40_a*	1611	-0,73	Pass	Absolute Delta-a* smaller or equal to: 1,00
50/40/40_b*	1611	0,69	Pass	Absolute Delta-b* smaller or equal to: 2,00
Paper_White_L*	1367	0,45	Pass	Absolute Delta-L* smaller or equal to: 2,00
Paper_White_a*	1367	-0,24	Pass	Absolute Delta-a* smaller or equal to: 1,00
Paper_White_b*	1367	-0,03	Pass	Absolute Delta-b* smaller or equal to: 2,00
Certification:		FAIL		

The Certification fails because of low luminance, a non-issue since we adjusted the display brightness to 120 cd/m<sup>2</sup> on purpose.

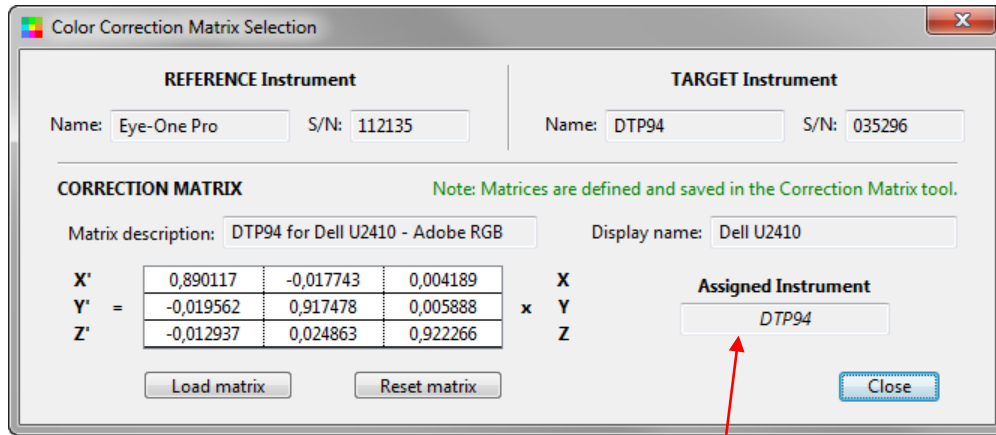
**Note:** While the errors shown in the “Stats” tab of the three **Quick-Tests (Tests 1 to 3)** are considered small here, they could be considered huge if one was looking at the accuracy of a spot color in a document. This is a question of perspective: You should not judge errors on the primaries, which are at the extreme edge of the gamut, with the same eye as errors in colors located within the gamut. For instance, colors on the gamut edge of Adobe RGB, while seen in the photographic world, particularly when processing images recorded in RAW format, are not common, and they can be very hard, or impossible, to reproduce in hard copy (this is also true for many colors well within this large space). As you perform more tests, you will get a feel of what is acceptable or not in a Quick-Test. You should make a final judgment after making checks with color patches within the gamut, as shown in Test-4 and Test-5.

### 3.6.7 Using a Color Correction Matrix in Display-Check

The purpose of a Color Correction Matrix (CCM) is to help improve inter-instrument agreement in emission (i.e. display) measurements. In particular, a CCM is often used to correct the response of a colorimeter when doing measurements on a wide gamut display. The controls related to the CCM are shown below.



Pressing the “Select Matrix” button opens the following dialog:



A unique matrix can be assigned, or loaded, for each instrument.

A Color Correction Matrix can be either assigned from the PatchTool [Correction Matrix Tool](#), or loaded from a properly formatted file. The matrix file format can be recognized by its “.ccmx” extension; this format is used by other programs for the same purpose.

**Note:** A selection of Color Correction Matrices files is available in the PatchTool application folder:

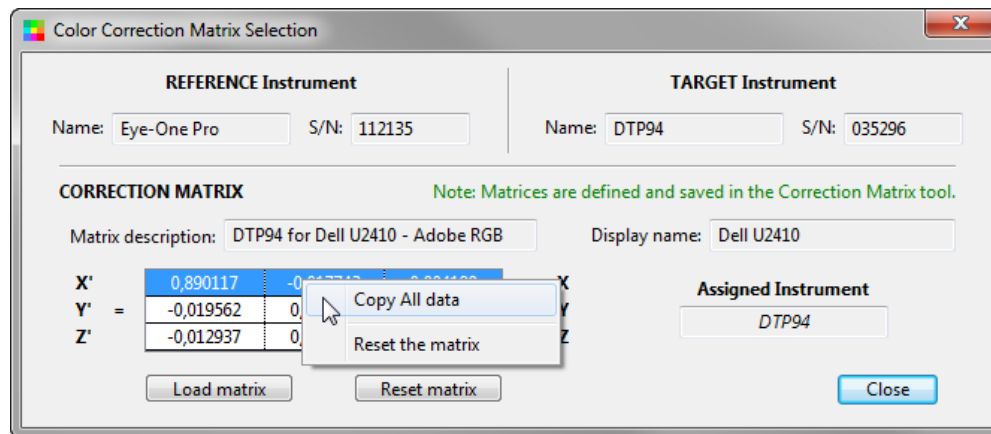
“...\[PatchTool\correction-matrices\](#)”

Please note that the data in these files was gathered from multiple sources and we cannot guarantee its accuracy. We recommend that you derive a Correction Matrix for your own setup whenever feasible.

**Important:** When using a Correction Matrix with a colorimeter, i.e. not the i1Pro, the measured XYZ values transferred to the PatchTool RAW and Compare files are the CORRECTED values. The uncorrected XYZ values are no longer shown in these files and in PatchTool; however, the Correction Matrix coefficients are saved in the RAW file.

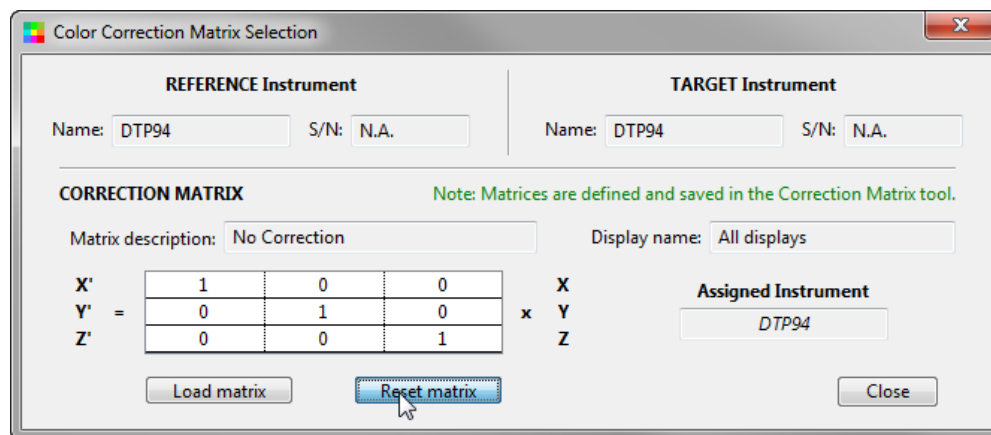
**Important (i1Pro):** Since correction matrices are applied to XYZ data, and because the i1Pro provides spectral data, we must discard the spectral data in the Compare file when using a correction matrix with this instrument. If required, uncorrected spectral data, as well as uncorrected and corrected XYZ data, is available in the RAW file.

Do a mouse right-click on the matrix table to see the following contextual menu:



The copied matrix data can be pasted in a spreadsheet or text editor; the data is contained on three lines, where the values of each line are separated by a Tab.

Pressing the “Reset matrix” button or selecting the same command in the contextual menu resets the matrix to a unitary diagonal matrix:



When using a unitary diagonal matrix, the input and output XYZ values are the same. This is equivalent to **uncheck** the [“Use a Correction Matrix”](#) checkbox in the Display-Check window.





### 3.7 Display-Reader

All Observers are available for the i1Pro/i1Pro 2/i1Pro 3.  
Only the “2 deg.” Observer is available for colorimeters.

“2F” and “10F” are [CIE 170](#)  
Standard Observers.

The screenshot shows the PatchTool Display-Reader window. It features several control panels: 'White Point' with fields for Luminance, XYZ, and CCT; 'Instrument' with a dropdown menu set to 'i1Pro / i1Pro 2 (XRGA)'; 'Color space data' with radio buttons for xyY, XYZ, and L\*a\*b\*; and 'Observer' with radio buttons for 2 deg., 10 deg., 2F deg., and 10F deg. A table with columns for #, color, x, y, Y, patch name, and graph is present. To the right is a graph showing a spectral power distribution curve. At the bottom, there is a 'Timer' section and a 'Name format...' button. Red arrows point from external text to specific elements: '2 deg.' in the Observer panel, the 'graph' column in the table, and the 'Name format...' button. A red dot on the graph is also annotated.

#	color	x	y	Y	patch name	graph

The “PatchTool Display-Reader” window is opened by selecting the “Tools/Display-Reader...” menu. This tool is designed to make unconstrained emission measurements on displays. It is essentially identical to the Unconstrained measurements mode of [Emission-Reader](#), a tool dedicated to transmissive measurement with the i1Pro 3. In comparison with the [Display-Check](#) tool, it does not require a predefined color list in order to make measurements.

The tool can be used by all instruments (colorimeters and spectrophotometers) supported by PatchTool, and with or without a Color Correction Matrix (CCM) (See this [section](#) in Display-Check for more info on CCM selection). A [description of each instrument](#) and their settings is also presented in the Display-Check section.

A green light besides the instrument selection menu indicates that the instrument is recognized and ready to use; a red light indicates that it is not available. Clicking on the “Info” button opens the “[Instrument info](#)” dialog which shows information relative to the instrument. If your instrument is connected but shown as not available, you should first attempt a reconnect by selecting “Try to connect again...” in the “Instrument” menu. If the instrument is still not connected, clicking on the “Info” button may provide information on the source of the problem.

**Note:** If the above fails, disconnect and reconnect the instrument, then select “Try to connect again...” in the “Instrument” menu. Please note that PatchTool should be used with only one Eye-One (Display, i1Pro, or i1Pro 2) connected at a time.

**Important:** If you installed software from X-Rite, such as **i1Profiler**, which comprises the “X-Rite Device Services” program, you may receive a message to the effect that the instrument is not connected when you click on the "Info" button. Assuming that your instrument is indeed connected, first check if the i1Profiler program from X-Rite is opened, and, if opened, close it, since PatchTool cannot be used at the same time. Early versions of i1Profiler provide a control panel named “X-Rite Device Services”, which is used to assign/unassign instruments to X-Rite software. On a Mac, the “X-Rite Device Services” control panel is located in the System Preferences dialog. The latest versions of i1Profiler still include “X-Rite Device Services” but do not include a control panel, and instrument assignment is performed dynamically when opening an X-Rite program. If using an early version of i1Profiler, you should DESELECT the i1 (Eye-One) in the “X-Rite Device Services” control panel; this will make the instrument available for PatchTool. Please note that changes in the X-Rite control panel can be done while PatchTool is opened. You should then be able to connect the instrument by selecting “Try to connect again...” in the “Instrument” menu. The early versions of i1Profiler may also open one or more dialogs asking if you want PatchTool to take ownership of the i1 peripherals; please answer “Yes” to the question(s). “X-Rite Device Services” is dedicated to X-Rite programs and is not under PatchTool's control; any problem related to its use should be directed to X-Rite.

In comparison with Display-Check, measurements in Display-Reader can be done with or without measuring the display White Point (WP), whereas a WP is always required in Display-Check. If you do not measure the WP, all your measurements (xyY, XYZ, and spectral data for the i1Pro and i1Pro 2) are ABSOLUTE; Y is provided in cd/m<sup>2</sup> and L\*a\*b\* values cannot be computed since they require the luminance of the WP. However, when the WP is measured you can:

- i- Compute L\*a\*b\* relative to the measured display WP.
- ii- Obtain PROCESSED data (normalized xyY and XYZ, plus L\*a\*b\*) by selecting a Standard Illuminant and an Absolute or Relative colorimetric intent. This data can easily be exported to other programs.
- iii- Get accurate patch colors because the WP luminance and its XYZ coordinates are known.

You can measure the WP and calibrate the selected instrument at any time before or during the measurements. Below is a screenshot of the tool while doing measurements.

The screenshot shows the PatchTool Display-Reader interface. Key components include:

- White Point section:** Luminance: 108,3 cd/m<sup>2</sup>, XYZ: (97,5 / 100 / 112,0), CCT: 6421 K. Includes an 'Illuminant (L\*a\*b\*)' dropdown set to 'WP' and a 'Get WP' button.
- Instrument section:** Dropdown set to 'i1Pro / i1Pro 2 (XRGA)', 'Info' button, 'Select Matrix' button, 'Calibrate' button, and a checkbox for 'Use a Correction Matrix'.
- Color space data:** Radio buttons for 'xyY' (selected), 'XYZ', and 'L\*a\*b\*'. Observer options: '2 deg.' (selected), '10 deg.', '2F deg.', and '10F deg.'.
- Table:** A table with columns: #, color, x, y, Y, patch name, graph. Rows 1-3 are highlighted in blue. A context menu is open over row 2 with options 'Delete selected rows' and 'Delete ALL rows'. Row 6 has a red dot in the 'patch name' column.
- Graph:** A spectral power distribution graph showing mW / nm / m<sup>2</sup> / sr vs wavelength (400-700 nm). It features multiple colored curves and a 'graph' column header with a checkbox.
- Y axis and Line thickness:** Y axis scale and line thickness options (1 px, 2 px selected, 3 px).
- Timer:** 'Off' (selected) or 'On' with a '30 seconds' timer.
- Buttons:** 'Name format...', 'Read', 'Stop', and 'Close' buttons.

Annotations (in red) provide instructions:

- White Point measurement is optional.
- Select the color space to be used in the table. The data is computed relative to the selected Illuminant.
- Right-click (ctrl + click) on a one-button Mac mouse) on any row for this popup menu.
- Click in any cell of the “patch name” column to enter a name.
- Recalibrate at any time while doing measurements.
- Left-click on the “graph” column header to CLEAR all selections. Right-click (ctrl + click on a one-button Mac mouse) to select all rows.
- Click on the “Read” button or on the instrument button (i1Pro and i1Pro 2) to make a measurement.
- Click on the “Stop” button to save your results in a file.

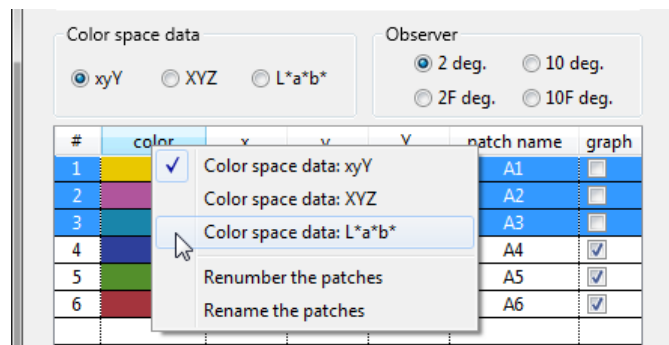
When doing measurements you can:

- i- Measure color patches in any order.
- ii- Select between the xyY, XYZ, or L\*a\*b\* color spaces (Note: It is possible to export measurements in all these spaces simultaneously in addition to spectral data, if available).
- iii- Click on a column header to sort the column in ascending or descending order.
- iv- Change one patch name or rename all patches in one step (with a right-click in the table header; see the screenshot below).
- v- In Windows, after selecting a row, add or remove rows with a **Ctrl + click** on other rows. On a Mac with a one-button mouse, use **⌘ + click**.
- vi- Select a range of rows with a mouse click on the first row and then **shift + click** on the last row. Additional ranges can be added or removed with **Ctrl + click & drag** (**⌘ + click & drag** on a Mac).
- vii- Drag the selected rows to another position in the list.
- viii- Delete selected rows or all rows with a right-click (**Ctrl + click** on a one-button Mac mouse) (shown in the screenshot above).
- ix- Enlarge the window size to obtain a larger graph and more space to write the patch name.

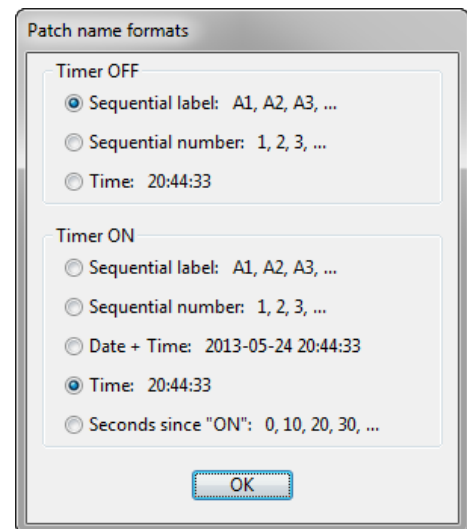
**Note:** Be aware of factors which can affect display measurements. Please consult this [section](#) for more information.

**Note:** The Eye-One Display 2 set for CRT and the Spyder2 require calibration to be done on a white patch.

New measurements are automatically shown in the graph; you can deselect them in the table afterwards. Do a left-click on the “graph” column header to deselect all measurements; do a right-click to show all spectrums. Do a right-click in the table header to show the following menu which enables you to select the color space and renumber or rename the patches.



You can use a timer to automatically trigger a measurement at fixed time intervals. You should first select the patch name format, by clicking on the “Name format” button, before you start the timer. The reason is that the “Name format” button is not available when the timer is running. Here are the patch name options; different options are offered depending if the timer is ON or OFF.



Click the “Stop” button when your measurements are completed. You will be asked if you want to save the measurements or continue. See the [next section](#) for a description of the dialog which presents the file saving options.

## CCT, Luminance

These parameters have historically been computed only for the 2 degree (CIE 1931) Standard Observer although corresponding 10 degree (CIE 1964) values were available. When incorporating CIE 170 support into PatchTool it was decided to provide these parameters for ALL Standard Observers. Such data can also be seen in the [Custom Illuminants](#) tool.

Additional information:

- For self-luminous objects, the maximum value of the luminous efficacy of radiation ( $k_{10}$ ) is **683.6 lm/W** for the 10 degree (CIE 1964) and 10 degree (CIE 170, i.e. “10F” degree) standard Observers, instead of the 683 lm/W value used for the “2” and “2F” Standard Observers.<sup>2</sup>
- CCT and Duv are computed using the “uv” (CIE 1960) uniform color space. It is assumed that the conversion between the “xy” chromaticity coordinates—computed for each Standard Observer—and the “uv” space use the same equations for all Observers. In 2018 CIE Division 1 established a new research forum for “Revisiting Correlated Colour Temperature” with CCT determination using cone fundamental colorimetry (i.e. CIE 170) being a proposed research subject, so we may see changes in CCT computation in the coming years.

You will find more information on how CIE 170 computation is handled in PatchTool in [Appendix H](#).

**Important:** In Display-Reader, non-normalized Absolute-Colorimetric data (herein called **RAW data**) is always kept internally even when you are viewing **PROCESSED data** (available after you measure the WP and select a Standard or [Custom Illuminant](#), with either Absolute-Colorimetric or Relative-Colorimetric intent). Since you are able to save both types of data in separate files, you should select the Standard or Custom Illuminant you need before clicking on the “Stop” button.

**Note:** Y data in the Display-Reader table is always shown in absolute units (cd/m<sup>2</sup>) even if the WP is measured and a Standard or Custom Illuminant is selected. The Y data will also be in absolute units in the exported RAW file. However, the data will be normalized to Yref=100 or Yref =1 in the exported PROCESSED data file.

**Note:** The Relative-Colorimetric transform is always done between the measured WP, characterized by its XYZ coordinates and described by its Correlated Color Temperature (CCT), and the illuminant selected in the menu. When the selected illuminant is “WP”, i.e. the measured White Point, selecting or deselecting the “Abs.-Col.” checkbox has no effect on the table data because, in this case, the source and destination illuminants for the intent transforms are the same.

**Note:** When the WP is not measured, the patches colors are approximated by assuming a nominal display luminance of 160 cd/m<sup>2</sup> and are represented with Absolute-Colorimetric intent relative to D65.

**Note:** When the WP is measured, the patches appearance will vary depending on the selected illuminant and the state of the “Abs.-Col.” checkbox. When “Abs.-Col.” is not selected the rendering is Relative-Colorimetric and the patch appearance should remain the same for all illuminants in the menu. If “Abs.-Col.” is selected, then the patch appearance should differ for every illuminant. For example, if the measured WP CCT is 6000 K, a white patch will appear white when D60 is selected, bluish if Illuminant-A or D50 is selected and yellowish when D75 or D93 is selected.

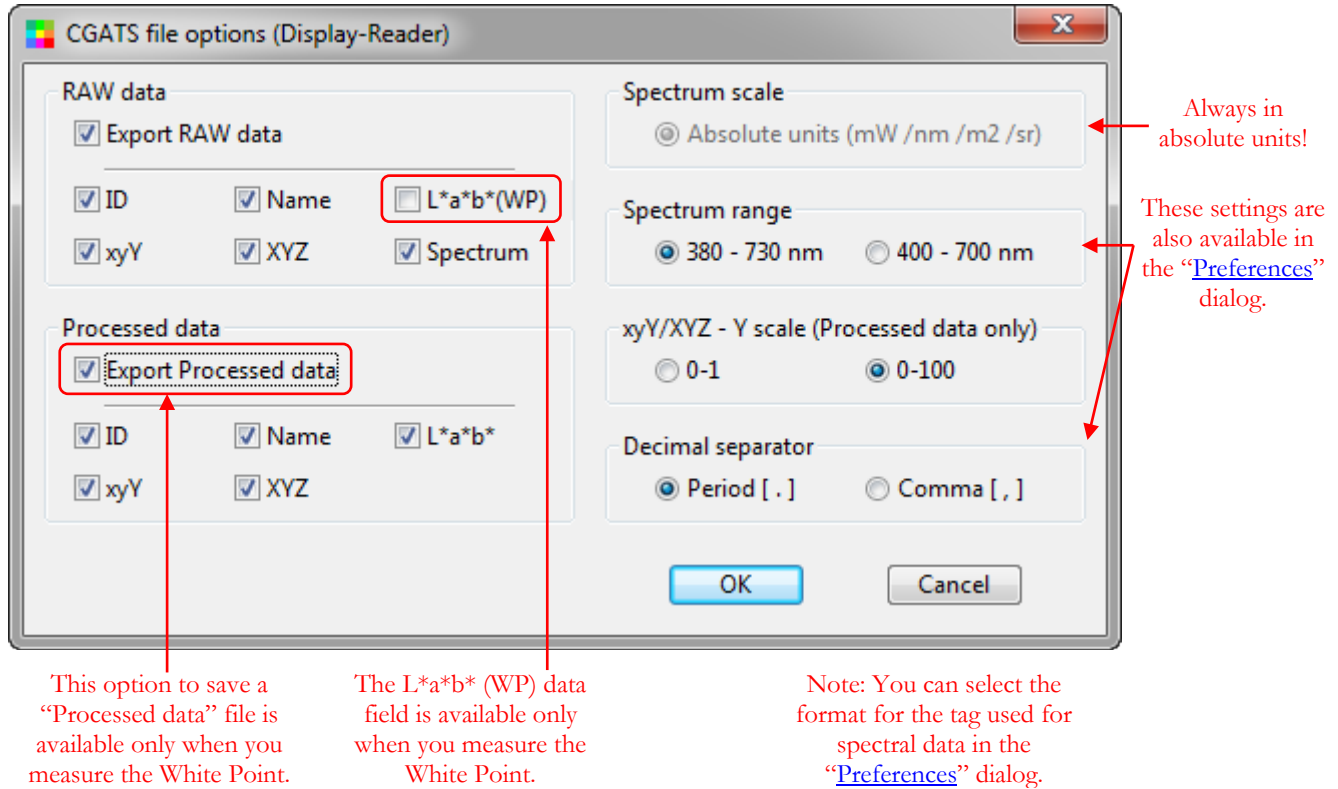
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<sup>2</sup> *Colorimetry: Understanding the CIE System*; ed. János Schanda, Ch. 3, 2007 John Wiley & Sons, Inc.

### 3.7.1 Display-Reader CGATS saving options

Whenever you decide to keep the measurements done in Display-Reader, you are presented with a dialog that contains options to be used for saving the data. The dialog appearance will vary depending on the measuring instrument, the available data and whether or not you have measured the White Point (WP).

Here is the dialog as it appears after making measurements with an i1Pro 2 and where we measured the WP.



Select “**Export RAW data**” if you want to save ABSOLUTE measurements in a file that can be opened in a spreadsheet. In this file, Y is not normalized and is saved in cd/m<sup>2</sup> units. If you selected a Correction Matrix to process the measurements, the RAW file will also contain the XYZ values measured **before** applying the matrix.

**Warning:** The RAW data file contains emission data which cannot be processed like reflectance data. As a consequence, when this file is opened by a program which expects reflectance data, the processed color values will be wrong. This file is primarily intended for those who want to process the data on their own.

Select “**Export Processed data**” if you want to save color data which can be properly understood by most programs that support CGATS compatible files. In this file, Y is normalized to 1 or 100, depending on the option you selected, and the data is relative to a Standard Illuminant; for maximum compatibility with programs from other companies, we recommend using D50. This file can be opened in PatchTool and compared to any other file.

**Important:** Because “Processed data” can only be generated for a Standard Illuminant, this option will be disabled if you select “WP” in the illuminant menu of the Display-Reader window, even if the White Point is measured.

When a [CIE 170 Standard Observer](#) (“2F deg.” or “10F deg.”) is selected in Display-Reader, you can also export the [MacLeod-Boynton Chromaticity Coordinates](#) by selecting the “xyY” data type in this export dialog. You will get the MacLeod-Boynton **I<sub>MB</sub>** and **S<sub>MB</sub>** coordinates in addition to xyY computed for the selected Observer. Support of CIE 170 cone fundamentals colorimetry (CIE 2006 and CIE 2015) in PatchTool is described in [Appendix H](#).

Once the data is saved, you will return to the Display-Reader window where you can continue doing measurements, change the illuminant menu or the rendering intent and re-export, or start a new measurement sequence.



### 3.8 Emission-Reader

The “PatchTool Emission-Reader” window is opened by selecting the “Tools/Emission-Reader...” menu.

This tool is designed to:

- Measure single patches or scan lines of patches printed on a substrate which is illuminated by a back-light, i.e. a light box, using an X-Rite **i1Pro 3** or **i1Pro 3 Plus**.
- Characterize light boxes in order to generate a uniformity compensation file that can be used to make uniformity-compensated measurements with the [Custom chart](#) and [PatchTool file](#) chart types of this tool. You can also export a processed file to view and analyze the light box non-uniformity.
- Provide PROCESSED emission measurements (see below on this page) which can be used to analyze the quality of prints on a light box.
- Provide PROCESSED emission measurements which can be used derive ICC profiles as if the measurements were done in reflectance. Such a profile can be useful if used for prints which are viewed on a light box with the same white point as the light box used for the characterization and target measurements.

**Note:** the i1Pro and i1Pro 2 are NOT supported.

**Note:** While the PatchTool light box compensation file data is essentially the same as the i1Profiler light box uniformity data saved in files with the “.lb1xp” [extension](#), it cannot be exported to i1Profiler and i1Profiler data cannot be exported to PatchTool.

**Hint:** Even if not designed specifically for monitor measurements, nothing prevents you of using this tool to measure a target line by line on a display using the Zebra ruler.

**Important:**

- The Emission-Reader tool is NOT designed to integrate with or perform specific steps of the i1Profiler TRANSMISSIVE ICC creation workflow.
- The Emission-Reader tool does NOT take into consideration the following parameters which are used in the i1Profiler transmissive ICC workflow:
  - o The substrate back-reflectance properties.
  - o The light box reflectance properties (with lights off).
  - o The viewing light box white point, if different from the light box used to make the target measurements.

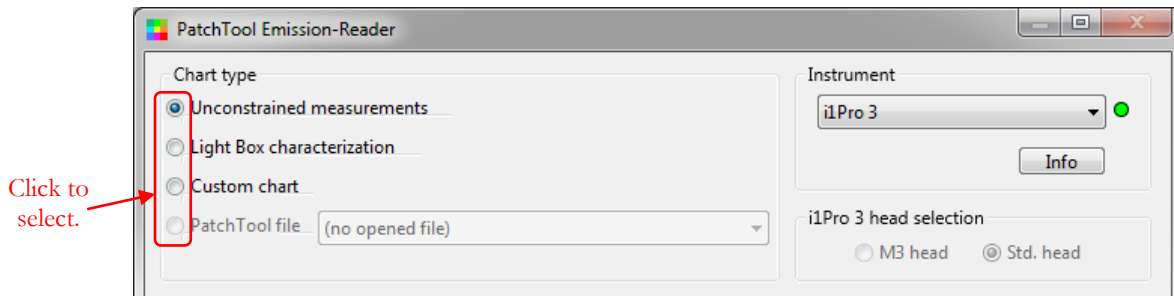
The Emission-Reader tool is a combination of [Display-Reader](#) and [Patch-Reader](#). In particular, the **Unconstrained measurements** mode of Emission-Reader is essentially a clone of Display-Reader, which also measures emission data. However, Emission-Reader also supports, for emission measurements, the [Custom chart](#) and [PatchTool file](#) measurement modes/Chart types of Patch-Reader, to which it adds a [Light Box characterization](#) mode. As in Display-Reader, the measurements are done relative to a measured White Point (WP); however, in Emission-Reader, measuring the WP is mandatory for all chart types. Of course, you can re-measure the WP at any time during the measurements.

Without a WP all measurements are ABSOLUTE and you get xyY and XYZ coordinates where Y is provided in cd/m<sup>2</sup>. Also, without a WP, L\*a\*b\* values are not available since their computation requires the luminance of the WP. With a measured WP you can:

- i- Compute L\*a\*b\* relative to the measured display WP.
- ii- Obtain PROCESSED data (normalized xyY and XYZ, plus L\*a\*b\*) relative to many Standard Illuminants and two [Custom Illuminants](#), with an Absolute or Relative colorimetric intent. This data can easily be exported to other programs. Please note that this process will discard the spectral data.
- iii- View accurate representation of the patch colors.





**Warning:** The Emission-Reader tool is complex and you should always make some tests before making “final” measurements. Emission measurements are by nature prone to errors. It can be because light boxes are susceptible to fluctuations during startup/heat-up, or because the light box has non uniform emission characteristics, or because the target substrate may be non-uniform within the measurement aperture. Optimal scan exposure may require very low speed line-scans or, more realistically, practical line-scan speeds may impose shorter exposures which result in noisier measurements.



There are four measurement modes (i.e. Chart types):

- i- **Unconstrained measurements:** Measure color patches in any order and re-order the measurements by dragging them in a list. Sort, delete, or rename any measurement. Look at any or all spectrums on a graph.
- ii- **Light Box characterization:** Measure a light box, without a target, on the area over which the target will be placed. This procedure is the same used in the **i1Profiler Transmissive Workflow** to characterize a light box. The RAW/NON-PROCESSED data can be used to compensate measurements done afterwards with the **Custom chart** and **PatchTool file** chart types. The PROCESSED data can be used to VIEW the light box uniformity in a file which can be opened like any reflectance data file.
- iii- **Custom chart:** Define a chart by assigning rows and columns numbers. Measure the patches individually (Patch mode) or line-by-line (Strip mode). You can use a timer to automatically trigger a measurement at fixed time intervals when in “Patch” mode. The Strip mode works with lines of patches which exhibit a high contrast between them or with lines of patches which have contrast markers (i.e. vertical bars). A Zebra ruler is always required for line scans.
- iv- **PatchTool file:** Select any opened file as a reference. The measured patches can be visually and numerically compared with the reference colors in the file. The other features are identical to the ones of the Custom chart.

To select a chart type/measurement mode, click on the radio button located on the top-left of the window. A green light  besides the instrument selection menu indicates that the instrument is recognized and ready to use; a red light  indicates that it is not available. Clicking on the “Info” button opens the “[Instrument info](#)” dialog which shows information relative to the instrument. If your instrument is connected but shown as not available, you should first attempt a reconnect by selecting “Try to connect again...” in the “Instrument” menu. If the instrument is still not connected, clicking on the “Info” button may provide information on the source of the problem.

**Note:** If the above fails, disconnect and reconnect the instrument, then select “Try to connect again...” in the “Instrument” menu. Please note that PatchTool should be used with only one i1Pro 3 connected at a time.

**Important:** If you installed software from X-Rite, such as **i1Profiler**, which comprises the “X-Rite Device Services” program, you may receive a message to the effect that the instrument is not connected when you click on the “Info” button. Assuming that your instrument is indeed connected first check if the i1Profiler program from X-Rite is opened, and, if opened, close it, since PatchTool cannot be used at the same time. Early versions of i1Profiler provide a control panel named “X-Rite Device Services”, which is used to assign/unassign instruments to X-Rite software. On a Mac, the “X-Rite Device Services” control panel is located in the System Preferences dialog. The latest versions of i1Profiler still include “X-Rite Device Services” but do not include a control panel, and instrument assignment is performed dynamically when opening an X-Rite program. If using an early version of i1Profiler, you should DESELECT the i1 (Eye-One) in the “X-Rite Device Services” control panel; this will make the instrument available for PatchTool. Please note that changes in the X-Rite control panel can be done while PatchTool is opened. You should then be able to connect the instrument by selecting “Try to connect again...” in

the “Instrument” menu. The early versions of i1Profiler may also open one or more dialogs asking if you want PatchTool to take ownership of the i1 peripherals; please answer “Yes” to the question(s). “X-Rite Device Services” is dedicated to X-Rite programs and is not under PatchTool's control; any problem related to its use should be directed to X-Rite.

The measurement options available for each instrument, detailed measurement procedures for each chart type, and a description of the saving options dialog are presented in the following sections. You can click on the links below to jump to the corresponding sections:

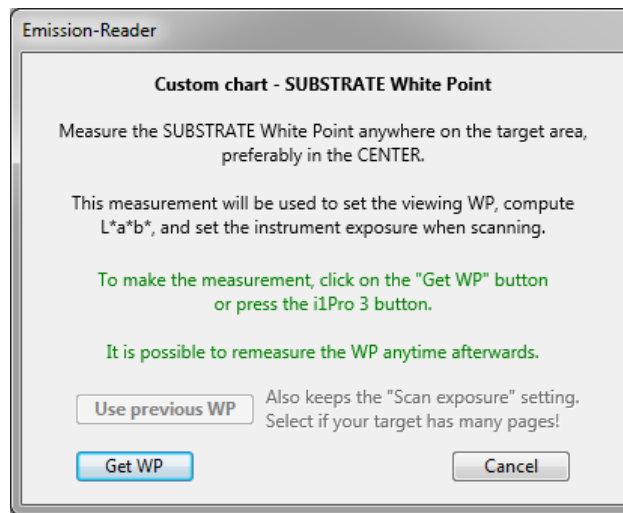
- [Emission-Reader White Point measurement dialog](#)
- [Emission-Reader Unconstrained measurements interface](#)
- [Emission-Reader Light Box characterization](#)
- [Light Box characterization procedure](#)
- [Emission-Reader Custom chart](#)
- [Emission-Reader PatchTool file](#)
- [Custom chart/PatchTool file measurement procedure](#)
- [Emission-Reader Target / Light Box OFFSET dialog](#)
- [Emission-Reader CGATS saving options](#)

Here are two mini-tutorials to be done using Emission-Reader:

- [Mini-tutorial: Light Box stabilization time](#)
- [Mini-tutorial: How to make a transmissive ICC profile with a reflectance engine](#)

### 3.8.1 Emission-Reader White Point measurement dialog

This dialog is presented for all chart types just after you click on the “Start” button.



The White Point (WP) should be measured on the SUBSTRATE when the **Unconstrained measurements**, **Custom chart** and **PatchTool file** chart types are selected. The WP should be measured directly on the LIGHT BOX when **Light Box characterization** is selected.

The recommended position is the substrate or light box center because this is usually the brightest position if the light box has a non-uniform luminance. Here are particular recommendations relative to each measurement mode.

**Unconstrained measurements** mode: If you know that your light box has a non-uniform luminance, perform all your measurements at the location where you measured the WP.

**Light Box characterization** mode: Since the entire light box area is a potential WP, you should measure the entire surface and then assign the brightest position as the WP (see the [Light Box characterization procedure](#) for more information). With this measurement mode, the ABSOLUTE/RAW spectral data can be used to define a light box uniformity compensation file.

**Custom chart and PatchTool file:** If the light box has uniform luminance across its entire surface, you can measure the WP anywhere on the substrate surface. If the light box luminance is NOT uniform, the WP value will be different for all positions. It is thus important to characterize the light box non-uniformity and then to measure the WP at a known position. This is why we recommend including a white patch in a target which is measured using the Custom chart or PatchTool file mode (or in one of the pages of a multi-pages target).

For a Custom chart and a PatchTool file with a non-uniform light box, the WP can be obtained with the following procedure:

- 1- First properly position the target on the light box and then measure the WP on the white. You can always redo this WP measurement afterwards by first selecting the “Patch” mode and then selecting the position corresponding to your white patch on the Custom chart or PatchTool file layout.
- 2- Load the **Light Box uniformity compensation** file and select the “ON” button. You can also assign an offset if required and you should always redo Step 3 whenever you change the offset afterwards.
- 3- Do a right-click on the white patch of the Custom chart or PatchTool file layout and select “**Use this patch as the White Point**” in the popup menu.

**Hint:** When measuring multiple pages targets, you should measure the page with the white patch first and measure the other pages just after you save the measurements of the first one. By doing so, the WP dialog will offer you to use the previously measured WP and scan exposure setting.

### 3.8.2 Emission-Reader Unconstrained measurements interface

Once the White Point (WP) is measured and the [WP dialog](#) is closed, you can start making measurements in no specific order. You can re-measure the WP at any time between measurements. Here is a screenshot after a few measurements.

The screenshot shows the PatchTool Emission-Reader interface. At the top, it displays White Point data: Luminance: 732,4 cd/m2, XYZ: (96,4 / 100 / 82,5), CCT: 5002 K. The instrument is set to iPro 3. The color space is L\*a\*b\* and the observer is 2 deg. The main table contains 7 rows of data with columns for #, color, L\*, a\*, b\*, patch name, and graph. A graph on the right shows spectral power distributions for the selected patches. Red arrows point to various UI elements with explanatory text.

#	color	L*	a*	b*	patch name	graph
1				0,40	A2	<input type="checkbox"/>
8				0,17	A8	<input type="checkbox"/>
3				4,94	A4	<input type="checkbox"/>
2		99,97	0,01	-0,03	A3	<input checked="" type="checkbox"/>
4		53,77	54,62	30,98	A6	<input checked="" type="checkbox"/>
5		52,18	-77,65	32,08	A7	<input checked="" type="checkbox"/>
6		43,10	-6,35	-65,23	A8	<input checked="" type="checkbox"/>
7		85,07	-14,52	96,58	A9	<input checked="" type="checkbox"/>

Annotations in the image include:

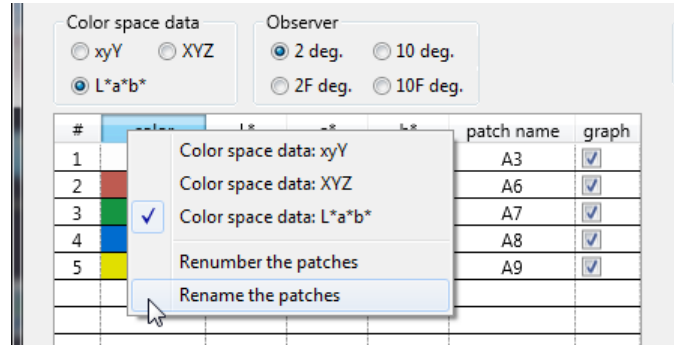
- White Point measurement is mandatory.
- "2F" and "10F" are CIE 170 Standard Observers.
- Select the color space to be used in the table. The data is computed relative to the selected Illuminant.
- Right-click on any row for this popup menu.
- Click in any cell of the "patch name" column to enter a name.
- Click for a dialog with options for "patch name" format.
- Left-click on the "graph" column header to CLEAR all selections. Right-click to select all rows.
- Click on the "Read" button or on the instrument button to make a measurement.
- Click on the "Stop" button to save your results in a file.

New measurements are automatically shown in the graph; you can deselect them in the table afterwards.

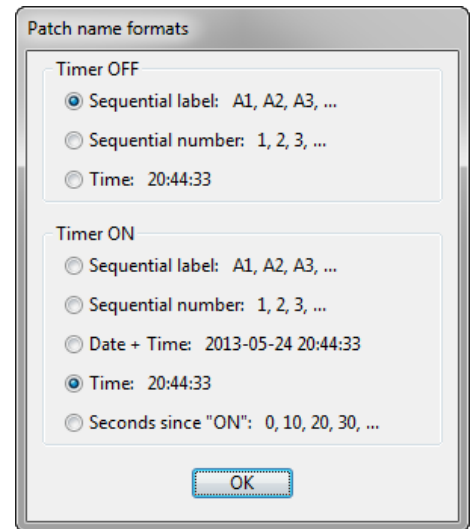
You can also:

- i- Do a left-click on the "graph" column header to deselect all measurements; do a right-click to show all spectrums.
- ii- In Windows, after selecting a row, add or remove rows with a **Ctrl + click** on other rows. On a Mac use **⌘ + click**.
- iii- Select a range of rows with a mouse click on the first row and then **shift + click** on the last row. Additional ranges can be added or removed with **Ctrl + click & drag** (**⌘ + click & drag** on a Mac).
- iv- Drag the selected rows to another position in the list.
- v- Delete selected rows or all rows with a right-click (shown in the screenshot above).
- vi- Click on a column header to sort the column in ascending or descending order.
- vii- Enlarge the window size to obtain a larger graph and more space to write the patch name.
- viii- Click in any cell of the patch name column to edit a name or rename all patches with the menu which appears when you do a right-click on the table header (shown on the next page).

Do a right-click on the table header to show the following menu which enables you to select the color space and renumber or rename the patches.



You can use a timer to automatically trigger a measurement at fixed time intervals. You should first select the patch name format, by clicking on the “Name format” button, before you start the timer. The reason is that the “Name format” button is not available when the timer is running. Here are the patch name options; different options are offered depending if the timer is ON or OFF.



Click the “Stop” button at any time when your measurements are complete. You will be asked if you wish to save your measurements and a dedicated [CGATS file options](#) dialog will be shown if you decide to do so. Once the measurements are saved, you will be returned to the tool window where you can continue making measurements.

### CCT, Luminance

These parameters have historically been computed only for the 2 degree (CIE 1931) Standard Observer although corresponding 10 degree (CIE 1964) values were available. When incorporating CIE 170 support into PatchTool it was decided to provide these parameters for ALL Standard Observers. Such data can also be seen in the [Custom Illuminants](#) tool.

Additional information:

- For self-luminous objects, the maximum value of the luminous efficacy of radiation ( $k_{10}$ ) is **683.6 lm/W** for the 10 degree (CIE 1964) and 10 degree (CIE 170, i.e. “10F” degree) standard Observers, instead of the 683 lm/W value used for the “2” and “2F” Standard Observers.<sup>3</sup>
- CCT and Duv are computed using the “uv” (CIE 1960) uniform color space. It is assumed that the conversion between the “xy” chromaticity coordinates—computed for each Standard Observer—and the “uv” space use the same equations for all Observers. In 2018 CIE Division 1 established a new research forum for “Revisiting Correlated Colour Temperature” with CCT determination using cone fundamental colorimetry (i.e. CIE 170) being a proposed research subject, so we may see changes in CCT computation in the coming years.

You will find more information on how CIE 170 computation is handled in PatchTool in [Appendix H](#).

<sup>3</sup> *Colorimetry: Understanding the CIE System*; ed. János Schanda, Ch. 3, 2007 John Wiley & Sons, Inc.

**Important:** In Emission-Reader, non-normalized Absolute-Colorimetric data (herein called **RAW data**) is always kept internally even when you are viewing **PROCESSED data** (shown when you select a Standard or [Custom Illuminant](#), with either Absolute-Colorimetric or Relative-Colorimetric intent). Since you are able to save both types of data in separate files, you should select the Standard or Custom Illuminant you need before clicking on the “Stop” button.

**Note:** Y data in the Emission-Reader table is always shown in absolute units (cd/m<sup>2</sup>) even if the WP is measured and a Standard or Custom Illuminant is selected. The Y data will also be in absolute units in the exported RAW file. However, the data will be normalized to Yref=100 or Yref =1 in the exported PROCESSED data file.

**Note:** The Relative-Colorimetric transform is always done between the measured WP, characterized by its XYZ coordinates and described by its Correlated Color Temperature (CCT), and the illuminant selected in the menu. When the selected illuminant is “WP”, i.e. the measured White Point, selecting or deselecting the “Abs.-Col.” checkbox has no effect on the table data because, in this case, the source and destination illuminants for the intent transforms are the same.

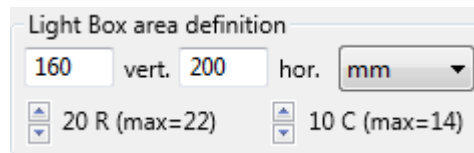
**Note:** The patches appearance will vary depending on the selected illuminant and the state of the “Abs.-Col.” checkbox. When “Abs.-Col.” is **not** selected the rendering is Relative-Colorimetric and the patch appearance should remain the same for all illuminants in the menu. If “Abs.-Col.” is selected, then the patch appearance should differ for every illuminant. For example, with “Abs.-Col.” selected, if the measured WP CCT is 6000 K, a white patch will appear white when D60 is selected, bluish if Illuminant-A or D50 is selected and yellowish when D75 or D93 is selected.

### 3.8.3 Emission-Reader Light Box characterization

The primary purpose of the **Light Box characterization** mode is to create a **compensation file** that represents a light box non-uniformity and which can be used to correct target measurements made thereafter on this light box. A characterization should be performed **before** doing measurements in the Emission-Reader [Custom chart](#) and [PatchTool file](#) measurement modes, unless you already know that your light box has a perfectly uniform luminance on its entire surface!

While the characterization data file is based on RAW, i.e. NON-PROCESSED, data, the PROCESSED data, i.e. compensated for the light box White Point, can be used to VIEW the light box uniformity in a file which can be opened like any reflectance data file.

Before starting a characterization session you should define the **Light Box area**, more specifically the height and width of the surface where the target patches will be measured and select the number of ROWS and COLUMNS that will be used to characterize the area.



The screenshot shows a dialog box titled "Light Box area definition". It contains several input fields: a text box with "160", a label "vert.", a text box with "200", a label "hor.", a dropdown menu set to "mm", a spinner box with "20 R (max=22)", and another spinner box with "10 C (max=14)".

When you enter a value in the height and width data fields, you get the maximum number of rows and columns which could be characterized for each dimension. You can then select the actual number of rows and columns that you require (a number between 1 and the maximum value, inclusively). Here are the target parameters associated to the two i1Pro 3 models when characterizing a **light box**.

#### Recommended patch sizes and row length for LIGHT BOX CHARACTERIZATION scanning

Instrument	Min. PATCH width	Min. ROW length (5 patches)	Max. ROW length	Min. PATCH height
i1Pro 3	14 mm	70 mm	250 mm	7 mm
i1Pro 3 Plus	24 mm	120 mm	490 mm	16 mm

The **Light Box area definition** interface is further discussed in Step-5 of the [Light Box characterization procedure](#) which is presented in the following section.

**Warning:** The **light box area** parameters are different from the **target area** parameters required for Emission-Reader measurements with the [Custom chart](#) and [PatchTool file](#) chart types.

#### Important Light Box characterization considerations:

- Once the light box is ON, let it stabilize for 10 minutes before making measurements.
- The light box area can be the same size or larger than the expected target area. If larger, an [offset](#) can be specified between the upper-left corner of the light box and the upper-left corner of the target when making the target measurements.
- The number of rows and columns of the Light Box area do not need to match the number of rows and columns of the target. They can be smaller or larger.
- More spatial uniformity precision can be gained by selecting a higher number of rows and columns in the Light Box area definition. However, it is not recommended to select the maximum number of columns since this places much tighter tolerances on the acceptable range of each line scan performed for characterization (i.e. more measurements may be rejected during characterization).
- Because the reverse side of the template substrate can reflect light back into the light box, light which can then bounce out all over the light box surface, you should cut your template to minimize the area it covers. Just keep a thin band at the top and on each side if you can.



### 3.8.4 Light Box characterization procedure

In this procedure, a printed template is fixed over the area of the light box which needs to be characterized. We first describe how to create the template and then how to make the measurements and save the data.

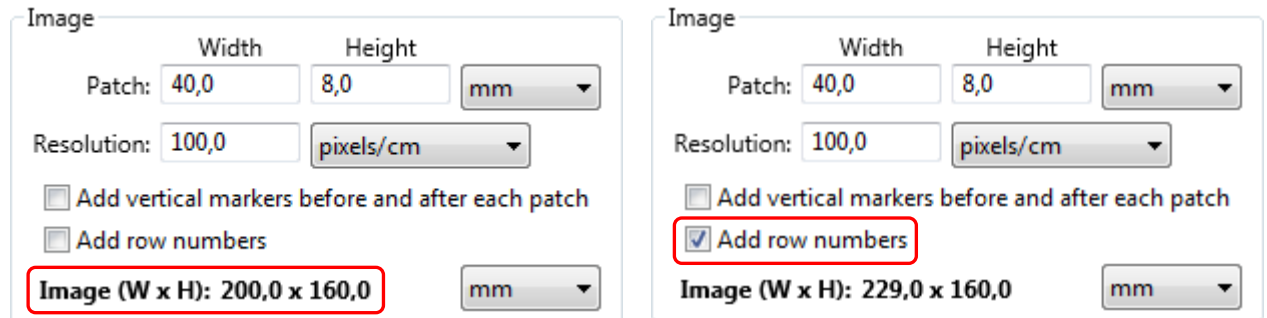
- 1- **Template generation:** We need a color list with the required number of ROWS since we will use the row guide-lines on each side of the target to measure the light box. The number of COLUMNS is not critical for template generation because we need to cut the zone where the patches are printed; in other words, we can assign a different number of columns when we **measure** the light box in another step.

The color-space is also irrelevant. You can start with an RGB or CMYK list generated with Gamut Tools' "List gen."; just make sure the number of patches is somewhat close to what you want. You can then adjust the number of patches using the Patch view [patch edition mode](#) using the "Copy selected patches..." and "Delete selected patches" functions. Set the number of rows as per your requirements. We suggest that you assign, again in the **patch edition mode**, the same neutral color to all patches using the "Select ALL" and "Replace selected with 50% GRAY" functions.

- 2- **Template printing:** Export the file of Step-1 as an image. In the "Image" Tab of the PatchTool Export dialog, set the patch Width and Height so that the total patch zone matches the Light Box area you wish to characterize.

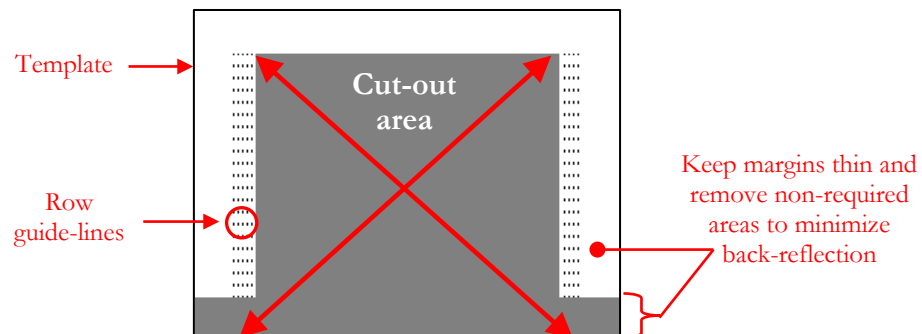
**Example:** Area to characterize on the light box: 160 mm x 200 mm (vert. x hor.)  
Color list: 20 rows x 5 columns (100 patches)  
Instrument: i1Pro 3 (min. recommended patch/row height: 7 mm)

In this example, the patch height was set to 8 mm and the total height is 160 mm (20 rows x 8 mm). The patch width was selected to fill the intended zone width (5 columns x 40 mm = 200 mm).

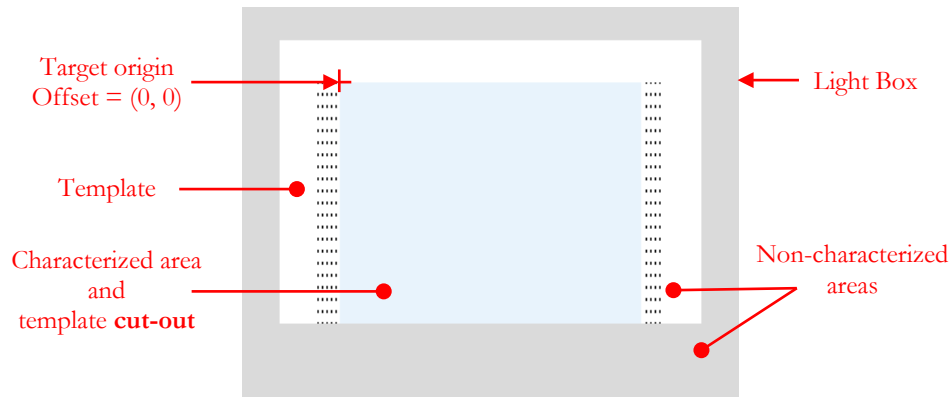


Once the patch zone is set, you should select the "Add row numbers" checkbox; this will add guide-lines on each side of the target in addition to row numbers (and slightly increase the image Width). Export the image in your preferred file format and print it.

- 3- **Template preparation:** Cut out the target area, the uniform mid-gray zone, leaving the guide-lines as well as the top of the print page. We recommend cutting the bottom part and minimizing the uncut area.

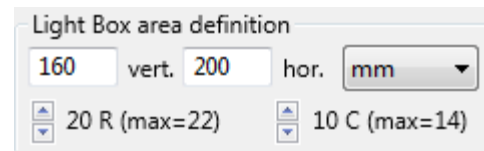


- 4- **Template installation:** Place the template on your light box and fix it with masking tape. To minimize illumination non-uniformity, you should place the template at some distance from the light box edges. We suggest that you identify the corners of the characterized light box area, i.e. the cut-out zone, with a fine marker in order to place future targets at the proper position. The light box with the template is illustrated below.



- 5- **Light Box area definition:** Launch the Emission-Reader tool. Select the **Light Box characterization** mode and set the **Light Box area definition** fields.

In the screenshot on the right we have entered the height and width of the template cut-out previously defined in Step 2. Based on the values and on the instrument model, i1Pro 3 or i1Pro 3 Plus, the program computes the maximum number of rows and columns that can be assigned.



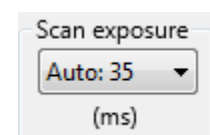
For instance, for an i1Pro 3 with a minimum patch/row height of 7 mm, there can be a maximum of 22 full rows in a 160 mm high cut-out ( $160/7=22.86$ ). Similarly, with a minimum patch width of 14 mm (for light box characterization), there can be a maximum of 14 full columns in a 200 mm wide cut-out ( $200/14=14.29$ ).

You should not hesitate to assign more rows, or rows with a different height, for light box characterization than for target rows since the light box characterization data will be interpolated to fit the target grid defined by the target patches center. However, we do not recommend using the maximum number of columns since this makes each line measurement more susceptible to overscan and underscan (see Step 7).

Here we have selected 20 rows, which correspond to the number of rows in our printed template, and 10 columns, which correspond to the number of columns we “intend” to have on our target. Please note that our target could have more or less columns, and even more than 14 columns since the recommended minimum patch width for a Custom chart or a PatchTool file is smaller than the minimum patch width recommended for light box characterization.

- 6- **White Point:** First, switch the light box “ON” and let it stabilize for 10 minutes before making measurements. Click on the “Start” button; the [White Point](#) (WP) measurement dialog will be shown. Measure the WP by placing the instrument in the middle of the light box area (we will reassign it afterwards).

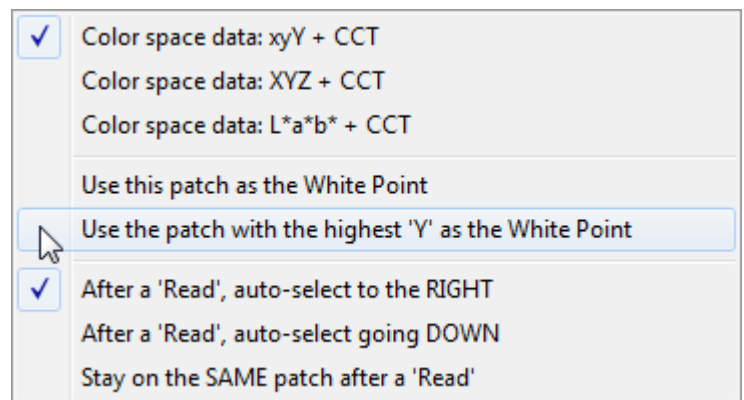
Before measuring the light box, have a look at the “Scan exposure” menu, which controls the exposure applied to **line scan** measurements, i.e. in “Strip” mode. The “Auto” value is determined by the i1Pro 3 whenever you make a WP measurement (which is done in spot/patch mode); this exposure setting is deemed optimum, in terms of signal-to-noise ratio, for the measured light source.



In practice, this means that while you move the i1Pro 3 on the Zebra ruler, the instrument will record only one measurement for every exposure time period. Since more than one measurement per patch is expected, you will readily understand why this may create problems in some circumstances. For dimmer light boxes, and even more likely when measuring the WP on a substrate in the Custom chart and PatchTool file measurement modes, the optimum exposure may be several hundred ms, up to half-a-second (500 ms) or more. Long exposures thus require either **very slow scanning** or **very large patches**. This explains, in part, the use of large patches in i1Profiler transmissive workflow. Another reason for using large patches is the non-uniformity of the substrates when viewed in transmission; this non-uniformity is minimized by using larger patches. An alternate solution is to reduce the exposure with the menu. If required, start by reducing the exposure by a factor of two (or about two), reducing it further if needed (i.e. until you do not receive error messages after a scan!).

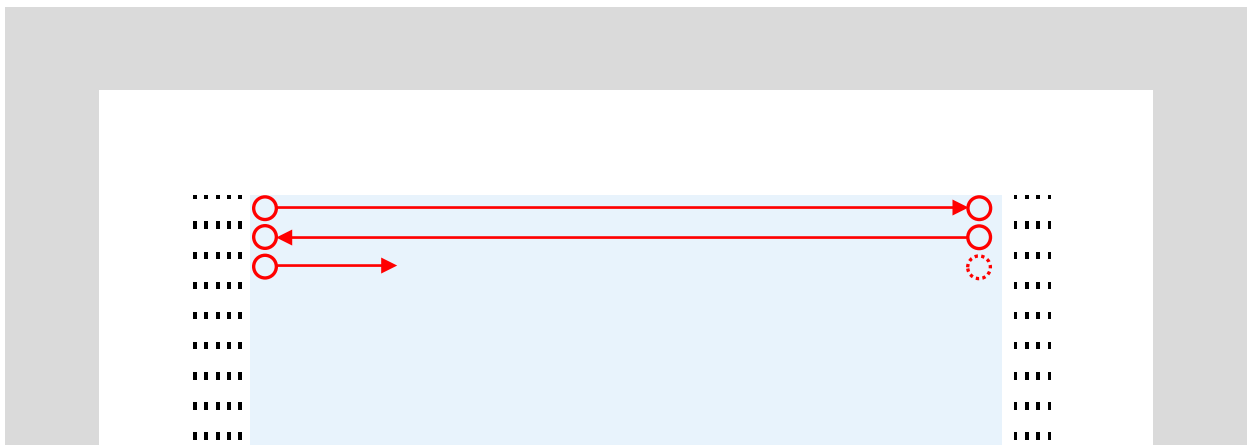
In principle we expect only one WP for a set of measurements. However, when characterizing a light box, all measurements are WPs and each of them may have a different luminance and a different CCT. When at least one position/patch is measured, you get new options to assign the WP in the menu which opens when doing a right-click over the patch grid; you can then assign any patch as the WP or ask the program to select the patch with the highest luminance (“Y”) as the WP.

While you can, and should, reassign the WP as your measurements progress, you **must** also do it once they are completed. When reassigning the WP at the end, you are sure that the patches are viewed optimally, with the WP shown as RGB=255 and all other patches with equal or smaller numbers. Please note that assigning the WP affects how the patches are viewed and how the data is PROCESSED; it does not affect the RAW/ABSOLUTE data and how this data can be used for uniformity compensation.

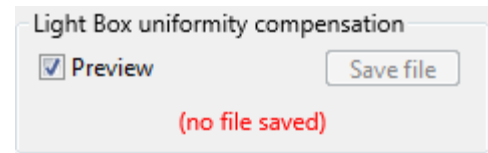


- 7- **Light Box measurements:** Once the WP dialog is closed you can start making measurements. We recommend scanning the light box line by line since measuring all positions/patches individually is quite difficult without registration marks. To go in line-scan mode, select the “Strip (w/bars or high-contrast)” menu item in the “Measurement mode” control group.

Starting with the top row, scan from left-to-right or right-to-left, making sure that the instrument aperture is always within the cut-out area, as close as possible to each edge but without placing the aperture over the template. This scanning is schematized in the illustration below.



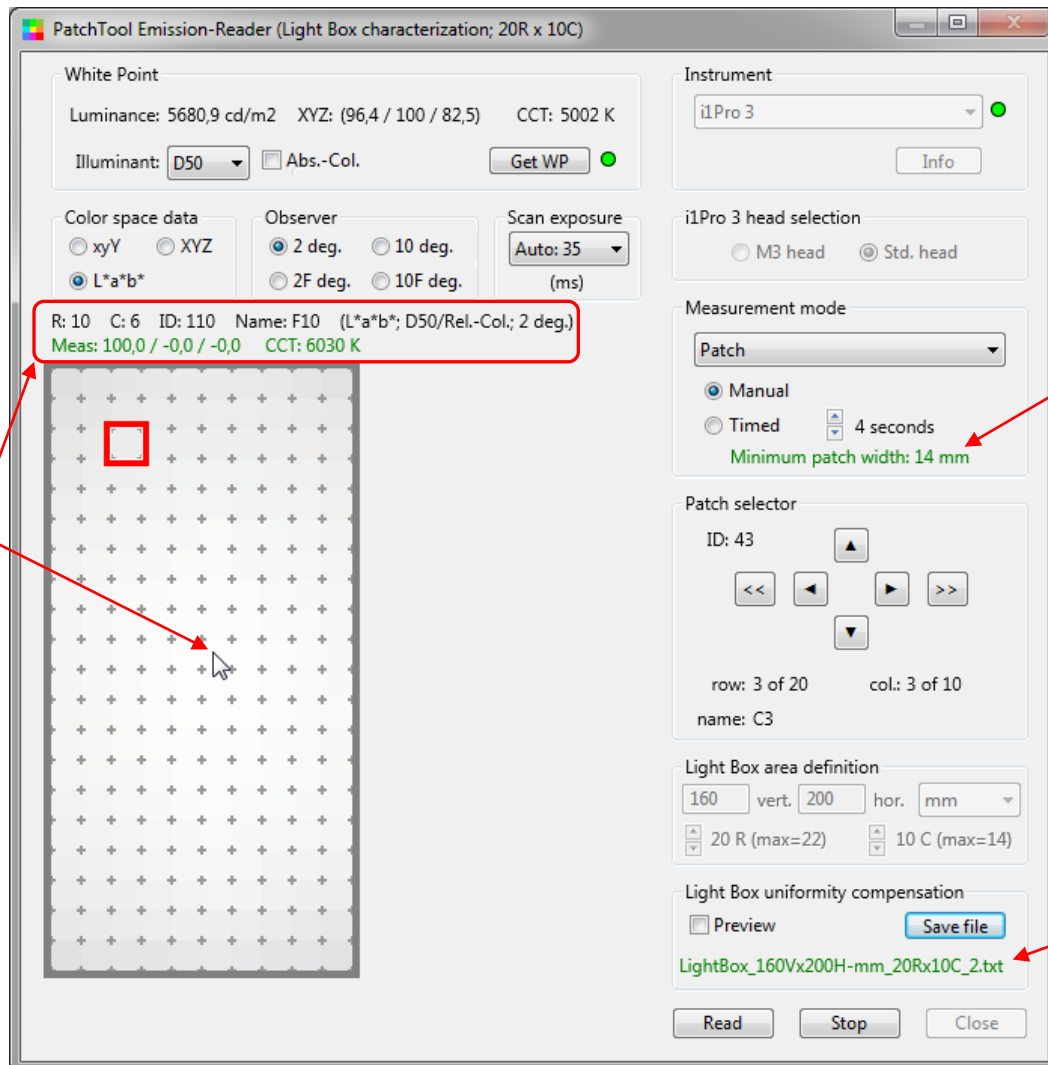
At any time while you measure the light box you can test the compensation by clicking on the “**Preview**” button of the “Light Box uniformity compensation” control group. Compensation will be computed individually for all measured patches which should then appear identical to the patch selected as the WP.



The “**Save file**” button is enabled only when all patches are measured. You will also be offered to save the measurements if you click on the “Stop” button and all positions have been measured. If saving, a dedicated [CGATS file options](#) dialog is opened. You can save the LIGHT BOX data (i.e. spectral data) or the PROCESSED data (i.e. tristimulus data), or both. Please note that the LIGHT BOX data is called RAW data in the [Custom chart](#) and [PatchTool file](#) modes. As for RAW data file, the LIGHT BOX data file is not designed to be opened by most programs which can read color files since it contains non-normalized emission measurements; however, it can be used as a **uniformity compensation file** when making Emission-Reader measurements for Custom charts and PatchTool files. The PROCESSED measurements are saved in a CGATS compatible file which can be readily opened by most programs which can read color files.

The following screenshot shows the Emission-Reader window after:

- completing the **Light Box characterization** measurements;
- assigning the patch with the highest “Y” as the WP (patch display contextual menu);
- saving the Light Box uniformity compensation data file.



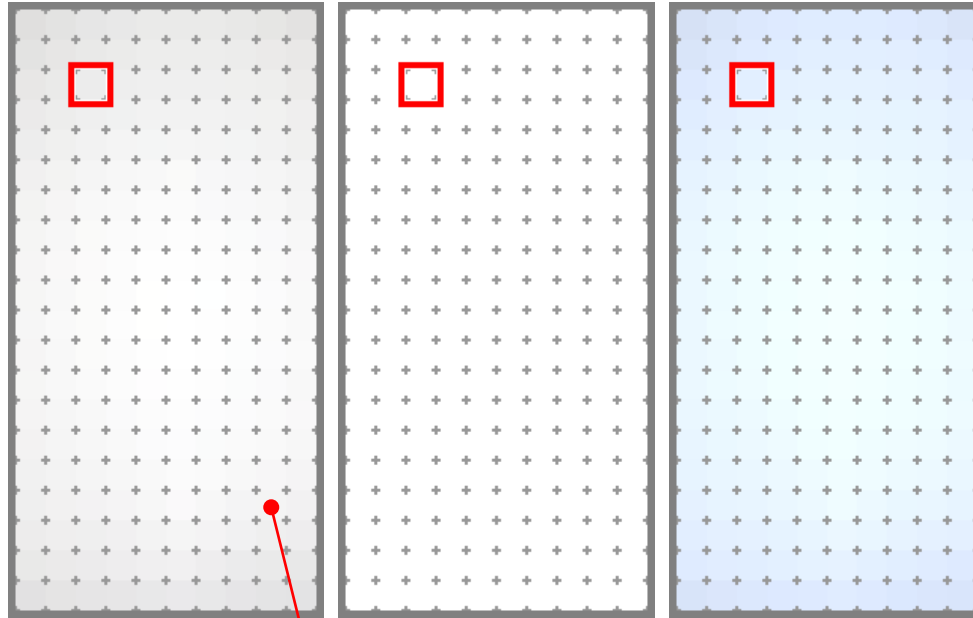
Brightest patch assigned as the WP (see the same patch on the opened PatchTool file screenshot of the next page)

The minimum patch width is shown for the selected instrument, selected chart type, and measurement mode.

Uniformity compensation file

On the Emission-Reader window screenshot of the previous page we note that the illumination drops off on the edges; we may thus not want to use this light-box over the entire characterized surface and we should, in any case, compensate measurements made with it. The mouse cursor is shown over the brightest patch and we see its corresponding  $L^*a^*b^*$  value (as converted in D50 Rel-col) as well as its original CCT. This  $L^*a^*b^*$  value and those of the other patches are saved in the [PROCESSED](#) data file; the processed data PatchTool file is shown below.

Here are various screenshots of the measurements shown on the previous page.



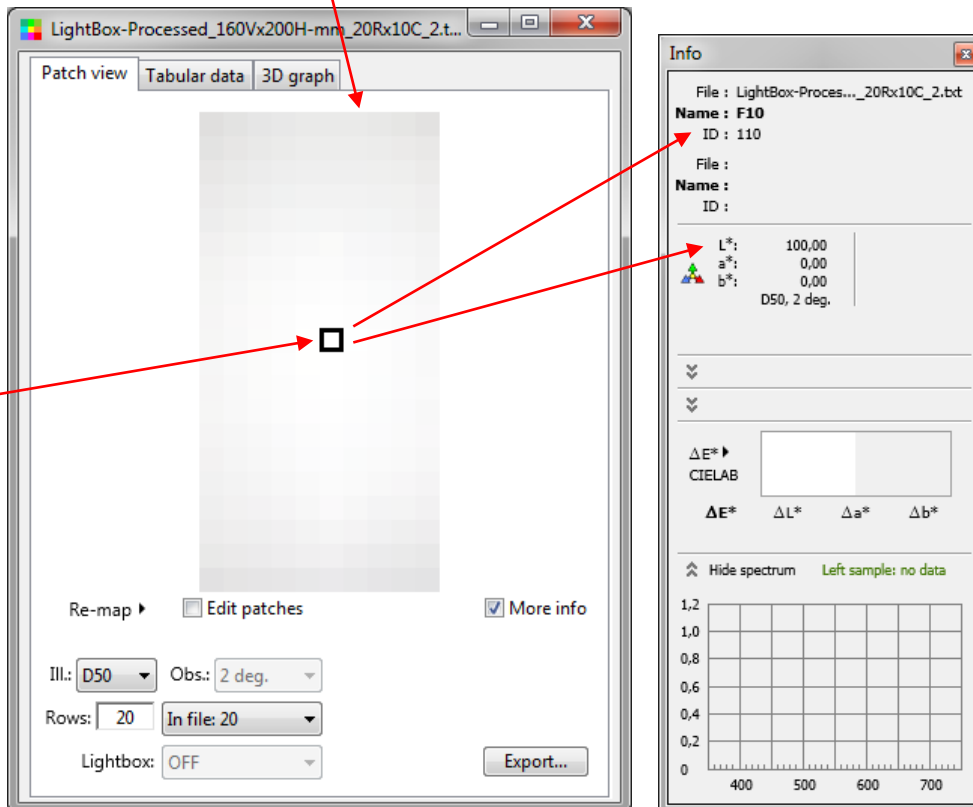
Preview  
D50 Rel-Col or  
WP (Rel-Col) / (Abs-Col)

Preview  
D50 Rel-Col or  
WP (Rel-Col) / (Abs-Col)

Preview  
D50 Abs-Col

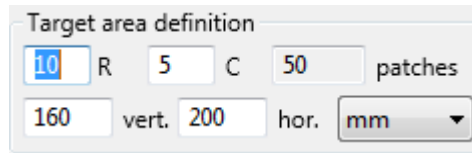
Processed data  
D50 Rel-Col

Brightest patch  
(see the same patch  
on the Emission-  
Reader tool  
screenshot of the  
previous page)



### 3.8.5 Emission-Reader Custom chart

This mode can be selected even if there is no opened file. Before stating the measurements you should define the target area, more specifically the number of ROWS and COLUMNS, and the target height and width.



The **target height** is required only if you intend to use a previously measured uniformity compensation file for this light box. The target height value will be shown in **red** and a specific “Help tag” will be seen—by leaving the mouse cursor over the field— if the entered value results in a row pitch which is less than the recommended **minimum patch height** (for line scan). The target height value will also be shown in **red** if the entered number of ROWS imposes rows too closely spaced.

The **target width** (i.e. horizontal scan length) is required for patch width validation and if you intend to use a uniformity compensation file; the **minimum patch width** depends on the i1Pro 3 model, with larger patches required for the i1Pro 3 Plus. The target width value will be shown in **red** and a specific “Help tag” will be seen if the entered value results in a patch width which is less than the recommended minimum size (for line scan). The width value will also be shown in **red** if the entered number of COLUMNS imposes patches which are too narrow.

Here is a table with the recommended target parameters for the two i1Pro 3 models when used with the **Zebra ruler**. These numbers are also applicable to Emission-Reader measurements with the [PatchTool file](#) chart type.

#### Recommended patch sizes and row length for EMISSION scanning

Instrument	Min. PATCH width	Min. ROW length (5 patches)	Max. ROW length	Min. PATCH height
i1Pro 3	7 mm	35 mm	250 mm	7 mm
i1Pro 3 Plus	16 mm	80 mm	490 mm	16 mm

In addition, when scanning with the Zebra ruler, each line must meet one of these two conditions:  $\Delta E^*ab$  between neighboring patches must be  $> 20$  for 50%+ of the transitions, or the patches must be separated by contrast markers/separation bars.

**Note:** Contrast markers consist of thin black or white bars (0,5-1,0 mm), whichever gives the maximum contrast, or combined Black/White bars (1,2-1,8 mm) before and after each patch. Single lines must not be combined with two-color bars in the same chart. You can easily create targets with contrast markers using PatchTool; please consult [Section 2.5.2](#) (The Export “Image” tab) for more information on this feature. We suggest you also read this short [tutorial](#) on how to optimize a layout for strip mode measurements.

**Hint:** If you have a file which defines your Custom chart, in any color space, you should open this file and make your measurements in the [PatchTool file chart type](#) mode instead.

**Important:** Please note that the patch width will be checked when doing line scans and that measurements of patches which are too narrow will be rejected.

Patches can also be measured individually. The minimum patch sizes are shown in the table below.

Instrument	Min. PATCH width (SPOT mode)	Min. PATCH height (SPOT mode)
i1Pro 3	6 mm	6 mm
i1Pro 3 Plus	14 mm	14 mm

The screenshot below shows the interface after:

- i- defining the **Target area**;
- ii- clicking on the “Start” button and measuring the White Point (WP) on the **white patch** (upper-left);
- iii- selecting a **Scan exposure** of 100 ms (instead of the auto-set exposure of 400 ms!);
- iv- selecting **D50** as the Illuminant and **deselecting “Abs.-Col.”**, i.e. selecting “Rel.-Col.”;
- v- measuring/scanning the first four rows;
- vi- loading the **Light Box uniformity compensation** file and activating the compensation (“ON” checkbox);
- vii- reassigning the **white patch** as the WP (patch display contextual menu), to take into account the light box non-uniformity.

Please consult [Section 3.8.7](#) for a more detailed measurement procedure.

The screenshot shows the PatchTool Emission-Reader software interface. The window title is "PatchTool Emission-Reader (Custom chart; 10R x 5C)". The interface is divided into several sections:

- White Point:** Shows Luminance: 693,8 cd/m<sup>2</sup>, XYZ: (96,4 / 100 / 82,5), CCT: 5002 K. The Illuminant is set to D50, and Abs.-Col. is unchecked. A "Get WP" button is present.
- Instrument:** Set to i1Pro 3.
- i1Pro 3 head selection:** M3 head and Std. head options.
- Measurement mode:** Strip (w/bars or high-contrast). Zebra ruler is checked. Minimum patch width is 7 mm.
- Patch selector:** Shows a grid of patches with "row 5" highlighted.
- Target area definition:** 10 R, 5 C, 50 patches. 160 vert. mm, 200 hor. mm.
- Light Box uniformity compensation:** Checked "ON". File: LightBox\_160Vx200H-mm\_20Rx10C\_2.txt (160V x 200H mm).

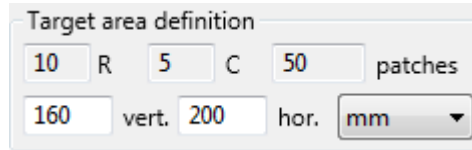
Annotations with red arrows point to specific elements:

- White patch assigned as the WP (from a menu which opens with a right-click over the chart area) - points to the top-left patch in the grid.
- Updated each time the White Point is measured. Readjust if required. - points to the "Get WP" button.
- The minimum patch width is shown for the selected instrument, selected chart type, and measurement mode. - points to the "Minimum patch width: 7 mm" text.
- Uniformity compensation file - points to the file name in the "Light Box uniformity compensation" section.



### 3.8.6 Emission-Reader PatchTool file

This mode is available when there is at least one opened file (a [Compare](#) type file can also be used). When you select a file, the number of rows and columns and the number of patches in the file are shown under the file name and in the target area definition control group. The patches are illustrated as they appear in the opened file. You should now complete the target area definition by defining the target height and width.



The **target height** is required only if you intend to use a previously measured uniformity compensation file for this light box. The target height value will be shown in **red** and a specific “Help tag” will be seen—by leaving the mouse cursor over the field— if the entered value results in a row pitch which is less than the recommended **minimum patch height** (for line scan).

The **target width** (i.e. horizontal scan length) is required for patch width validation and if you intend to use a uniformity compensation file; the **minimum patch width** depends on the i1Pro 3 model, with larger patches required for the i1Pro 3 Plus. The target width value will be shown in **red** and a specific “Help tag” will be seen if the entered value results in a patch width which is less than the recommended minimum size (for line scan).

Here is a table with the recommended target parameters for the two i1Pro 3 models when used with the **Zebra ruler**. These numbers are also applicable to Emission-Reader measurements with the [Custom chart](#) type.

#### Recommended patch sizes and row length for EMISSION scanning

Instrument	Min. PATCH width	Min. ROW length (5 patches)	Max. ROW length	Min. PATCH height
i1Pro 3	7 mm	35 mm	250 mm	7 mm
i1Pro 3 Plus	16 mm	80 mm	490 mm	16 mm

In addition, when scanning with the Zebra ruler, each line must meet one of these two conditions: DeltaE\*ab between neighboring patches must be > 20 for 50%+ of the transitions, or the patches must be separated by contrast markers/separation bars.

**Hint:** Check if a target meets the minimal contrast requirements for scanning with the [Target Scramble/Analysis](#) dialog. You can also use this dialog to attempt to meet the minimal contrast requirements.

**Note:** Contrast markers consist of thin black or white bars (0,5-1,0 mm), whichever gives the maximum contrast, or combined Black/White bars (1,2-1,8 mm) before and after each patch. Single lines must not be combined with two-color bars in the same chart. You can easily create targets with contrast markers using PatchTool; please consult [Section 2.5.2](#) (The Export “Image” tab) for more information on this feature. We suggest you also read this short [tutorial](#) on how to optimize a layout for strip mode measurements.

**Important:** Please note that the patch width will be checked when doing line scans and that measurements of patches which are too narrow will be rejected.

Patches can also be measured individually. The minimum patch sizes are shown in the table below.

Instrument	Min. PATCH width (SPOT mode)	Min. PATCH height (SPOT mode)
i1Pro 3	6 mm	6 mm
i1Pro 3 Plus	14 mm	14 mm

The screenshot below shows the interface after:

- i- defining the **Target area**;
- ii- clicking on the “Start” button and measuring the White Point (WP) on the **white patch** (Row: 14; Column: 10);
- iii- selecting a **Scan exposure** of 100 ms (instead of the the auto-set exposure of 342 ms!);
- iv- scanning **row 14** (with the white patch in the last column) (Note: this row can be scanned any time, as any other row);
- v- measuring/scanning the first five rows;
- vi- selecting **D50** as the Illuminant and **deselecting “Abs.-Col.”**, i.e. selecting “Rel.-Col.”;
- vii- loading the **Light Box uniformity compensation** file and activating the compensation (“ON” checkbox);
- viii- reassigning the **white patch** (Row: 14; Column: 10) as the WP (patch display contextual menu), to take into account the light box non-uniformity.

Please consult [Section 3.8.7](#) for a more detailed measurement procedure.

The screenshot shows the PatchTool Emission-Reader interface. The title bar reads "PatchTool Emission-Reader (Charte de 2x200 patches\_LightBox\_2020-03-18\_1of2.txt; 20R x 10C)". The interface is divided into several sections:

- White Point:** Shows Luminance: 664,9 cd/m2, XYZ: (96,4 / 100 / 82,5), CCT: 5002 K. The Illuminant is set to D50, and Abs.-Col. is unchecked. A "Get WP" button is present.
- Instrument:** Set to i1Pro 3.
- Color space data:** xyY, XYZ, and L\*a\*b\* are available. L\*a\*b\* is selected.
- Observer:** 2 deg., 10 deg., 2F deg., and 10F deg. are available. 2 deg. is selected.
- Scan exposure:** Set to 100 (ms).
- i1Pro 3 head selection:** M3 head and Std. head are available. Std. head is selected.
- Measurement mode:** Strip (w/bars or high-contrast) is selected. Zebra ruler and low resolution target are options. Minimum patch width is 7 mm.
- Patch selector:** Shows "row 6".
- Target area definition:** 20 R, 10 C, 200 patches. 160 vert. 200 hor. mm.
- Light Box uniformity compensation:** ON checkbox is checked. File: LightBox\_160Vx200H-mm\_20Rx10C\_2.txt (160V x 200H mm (File OK!)).

Red annotations highlight specific features:

- "Updated each time the White Point is measured. Readjust if required." points to the "Get WP" button.
- "The minimum patch width is shown for the selected instrument, selected chart type, and measurement mode." points to the "Minimum patch width: 7 mm" text.
- "White patch assigned as the WP (from a menu which opens with a right-click over the chart area)" points to a right-click icon on the white patch in the chart area.
- "Uniformity compensation file" points to the "Light Box uniformity compensation" section.

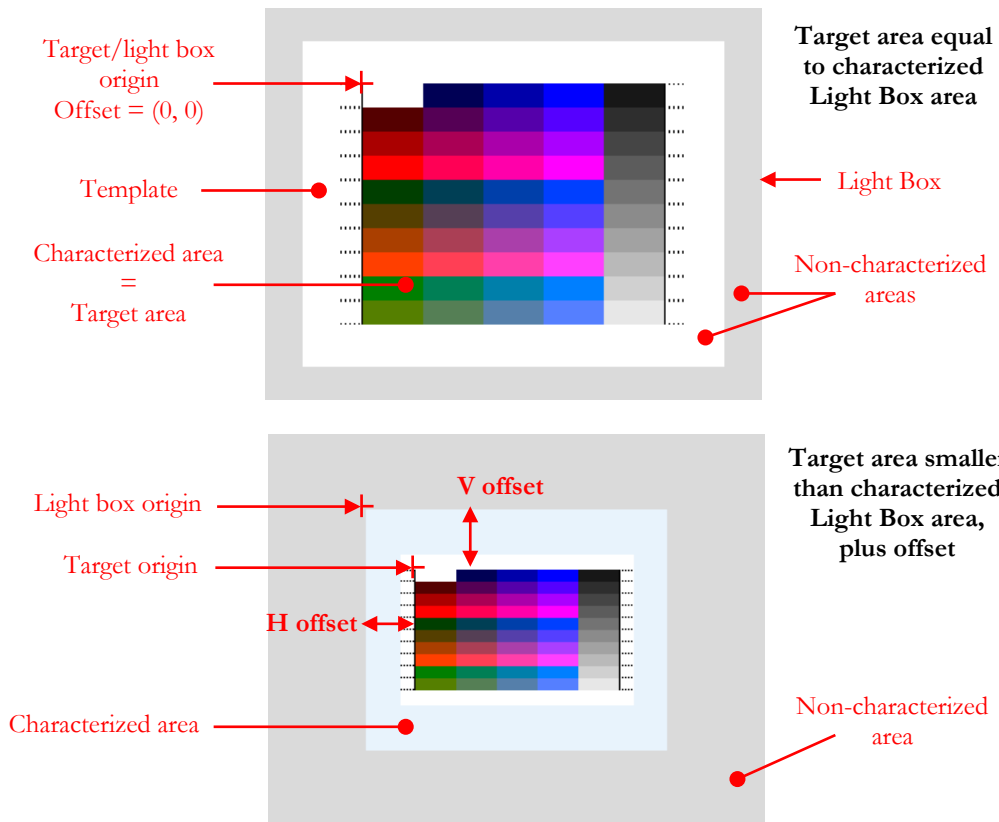
### 3.8.7 Custom chart/PatchTool file measurement procedure

This procedure applies to measurements made with a target placed over a light box. The same procedure applies to a [Custom chart](#) or a [PatchTool file](#). Please note that you should [characterize your light box](#) before starting this procedure if you suspect that your light box luminance is non-uniform.

- 1- **Target area definition:** Fill the area definition fields so that they correspond to your target. As mentioned in Sections [3.8.5](#) and [3.8.6](#), the target height and width are both required only if you intend to use a previously measured uniformity compensation file for this light box. The target width is always required for patch width validation.



- 2- **Target installation:** Place the target on your light box and fix it with masking tape. There are a few options depending on your light box luminance uniformity, target size, and characterized light box area (if not uniform).
  - i- If the light box is perfectly uniform, place the target anywhere you want on its surface. You will not require uniformity correction and thus there is no need to load a uniformity compensation file.
  - ii- If the light box was characterized for non-uniformity and your target is the **same size** as the characterized area, place it so that the target origin, the upper-left corner of the upper-left patch, is coincident with the light box origin. You can load the non-uniformity file (Step-6) once you start the measurements, in Step-4.
  - iii- If the light box was characterized for non-uniformity and your target is smaller than the characterized area, you can place it so that its origin is coincident with the light box origin or offset it relative to the light box origin. An offset may be advantageous to minimize some non-uniformity effects which are close to light box edges. You can load the non-uniformity file (Step-6) and assign an offset (Step-7) once you start the measurements, in Step-4.

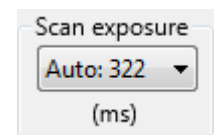


- 3- **White Point:** First, switch the light box “ON” and let it stabilize for 10 minutes before making measurements. Click on the “Start” button; the [White Point \(WP\) measurement dialog](#) will be shown. Measure the WP or assign it from a prior measurement.

**Important:** When measuring multiple pages targets, you should measure the page with the white patch first and measure the other pages just after you save the measurements. By doing so, the WP dialog will offer you to use the previously measured WP and scan exposure setting.

If the light box has uniform luminance across its entire surface, you can measure the WP anywhere on the **substrate** where white is visible. If the light box luminance is NOT uniform, the WP value will be different for all positions within the target. It is thus important to measure the WP at a known position. This is why we recommend including a white patch in the target, ideally near the middle of the target. So now place the instrument on the Zebra ruler and measure the white patch on the target. You will be able to re-measure the WP at any time during measurements or assign this patch as the WP with the menu which opens with a right-click over the patch display area; in fact, the white patch will likely be re-measured while you scan each target line. We will get back to this subject once all patches are measured.

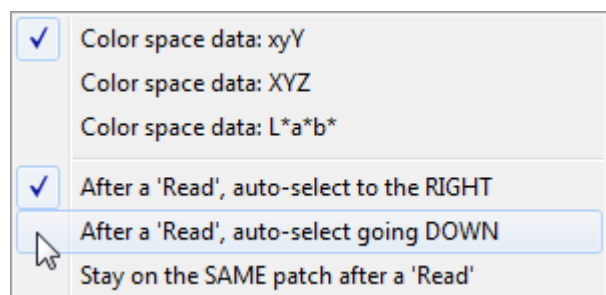
When the WP dialog is closed you can start making measurements, either one patch at a time or line by line. However, before you start, have a look at the “Scan exposure” menu, which controls the exposure applied to **line scan** measurements, i.e. in “Strip” mode. The “Auto” value is determined by the i1Pro 3 whenever you make a WP measurement (which is done in spot/patch mode); this exposure setting (322 ms in the screenshot) is deemed optimum, in terms of signal-to-noise ratio, for the measured light source.



In practice, this means that while you move the i1Pro 3 on the Zebra ruler, the instrument will record only one measurement for every exposure time period. Since more than one measurement per patch is expected, you will readily understand why this may create problems in some circumstances. When measuring the WP on an opaque substrate, the optimum exposure may be several hundred ms, up to half-a-second (500 ms) or more. Long exposures thus require either **very slow scanning** or **very large patches**. This explains, in part, the use of large patches in i1Profiler transmissive workflow. Another reason for using large patches is the non-uniformity of the substrates when viewed in transmission; this non-uniformity is minimized by using larger patches. An alternate solution is to reduce the exposure with the menu. If required, start by reducing the exposure by a factor of two (or about two), reducing it further if needed (i.e. until you do not receive error messages after a scan!). The exposure change will vary according to the patch size and how slow you are willing to scan; for example, we have used an exposure of 100 ms with success instead of 322 ms in the case of the target used for screenshot shown above.

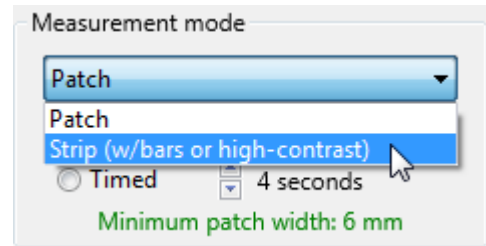
- 4- **Target measurement (patch mode):** In the “Patch” measurement mode, you can select a patch using any of the following methods:
  - i- By clicking on the arrows of the “Patch selector” control group.
  - ii- By using your keyboard arrow keys.
  - iii- By clicking directly on a patch.

Every time a single patch is measured, the next position is selected automatically. There are three options for this position; the options are presented in a menu, shown here, which appears by doing a right-click anywhere in the chart area. You can select to go to the RIGHT of the current patch, and the row will be incremented once the last patch in the row is reached, or you can go DOWN, and the column will be incremented once you reach the bottom row of the current column, or you can stay on the same patch. Using the menu just mentioned, you can also change the type of patch data shown when you move the mouse over the patches.

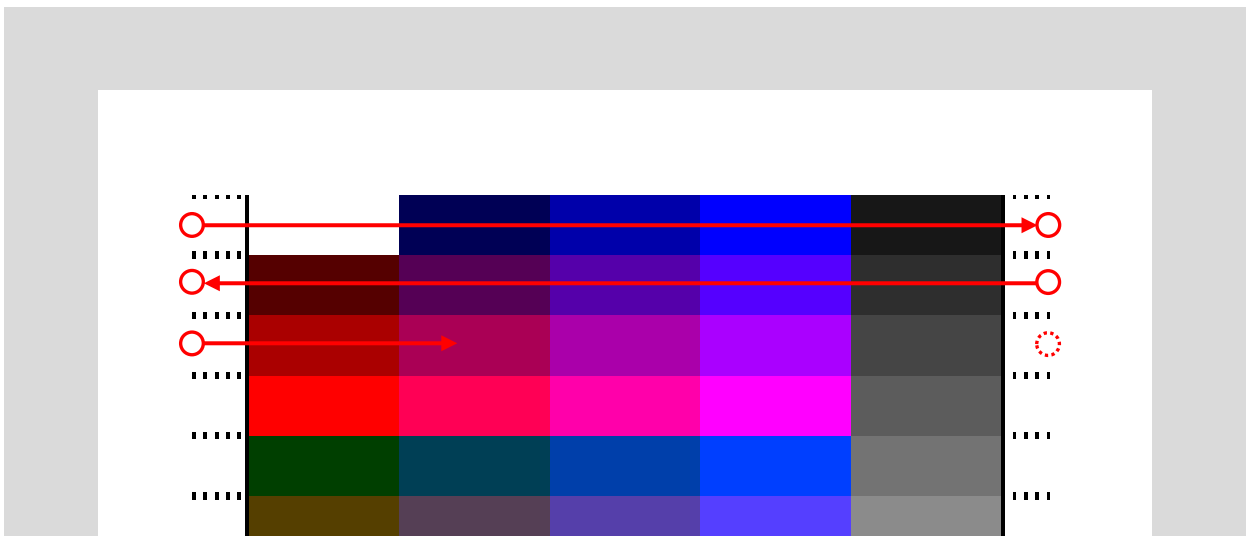


To automatically make measurements at fixed time intervals, select the “Timed” radio button and adjust the delay between each measurement. Click on the “Read” button or on the instrument button to start the automated measurements; select the “Manual” radio button (NOT the “Stop” button!) to stop the sequence. While in “Timed” mode, you can always push the instrument button to make a measurement; this will reset the timer at the start of another cycle. You can also select any patch in the layout using your mouse, the keyboard, or the navigation arrows.

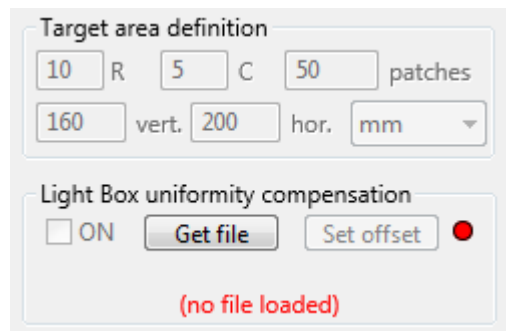
- 5- **Target measurement (strip mode):** It is also possible to take measurements one row at a time, by scanning the instrument from one side of the chart to the other. Select the Strip mode with the menu within the “Measurement mode” box. Once the Strip mode is selected, the “Manual” and “Timed” radio buttons are replaced by the “Zebra ruler” and “low resolution target” buttons (which are preset and not editable in Emission-Reader).



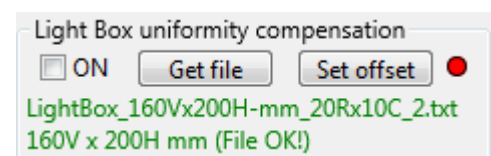
Starting with the top row, scan from left-to-right or right-to-left, making sure that the instrument aperture starts well before the first patch, on the blank substrate, and stops well after the last patch, on the substrate as well, and vice-versa. This scanning is schematized in the illustration below.



- 6- **Uniformity compensation:** You will notice, on the bottom-right of the Emission-Reader window that the “Target area definition” control group is shown with all fields disabled. Under this control group you will see the “Light Box uniformity compensation” control group; use these controls to select a light box uniformity compensation file and to set, if required and possible, an offset between the uniformity area and the target area. The uniformity compensation file has to be defined using the “Light Box characterization” mode and its covered area (i.e. width and height) must be equal or larger than the target area.




Once a uniformity compensation file is loaded, the “ON” checkbox and the “Set offset” button will be **enabled if the compensation file area and target area are compatible**. Select the “ON” checkbox to apply the uniformity correction to the current (and future) target measurements. On the screenshot you will notice that we have loaded the uniformity compensation file used as an example in



[Step-7](#) of the [Light Box characterization procedure](#) section, with the same area as the measured target but with more rows and columns. What is important for a uniformity file is that the covered area is equal or larger than the target; the number of rows and columns can differ. When these conditions are met, PatchTool will interpolate the compensation for each patch in the target.

**Important:** The saved measurements depend on the status of the “ON” checkbox. You can thus save the measurements with or without compensation.

- 7- **Uniformity compensation OFFSET:** Clicking on the “Set offset” button will open the “[Target / Light Box OFFSET](#)” dialog where you can assign an offset between the light box upper-left corner and the target upper-left corner. If the light box area and target area are the same, which is the case in our example where both areas are 160V x 200H mm, the offsets are zero and non-adjustable. Once this dialog is closed, the light at the right of the “Set offset” button will be **green**  **only if a non-zero offset is assigned.**
- 8- **White Point check:** As mentioned in Step 3, if you measured your target by scanning all rows, it is very likely that you re-measured the white patch used as the reference for the White Point even if it was measured at the beginning of your measurements. If this is the case, we recommend that you move your mouse cursor over the white patch and do a right-click; in the contextual menu which opens, select “**Use this patch as the White Point**”.

**Note:** Do not assign or re-measure the WP if the target has no white patch **and** the WP was measured on a previous target page which had a white patch.

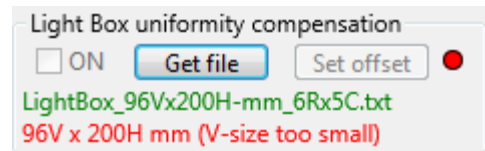
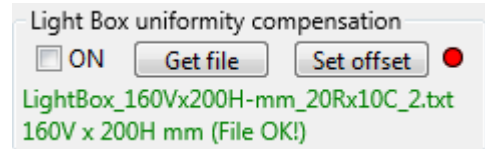
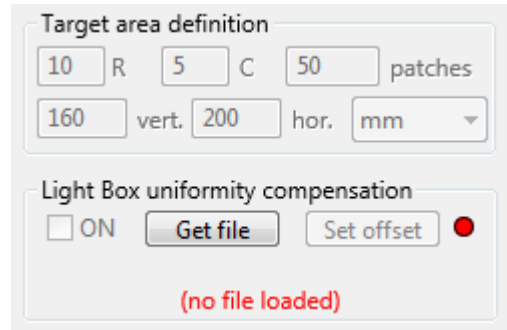
- 9- **Saving data:** You can click the “Stop” button at any time. You are then asked if you wish to save the data. If saving, a dedicated [CGATS file options](#) dialog is opened. You can save the RAW measurements (i.e. spectral data) or the PROCESSED data (i.e. tristimulus data), or both. Please note that the RAW data, while saved in a readable text file, is not designed to be opened by most programs which can read color files since it contains non-normalized emission measurements. The PROCESSED measurements are saved in a CGATS compatible file which can be readily opened by most programs which can read color files.



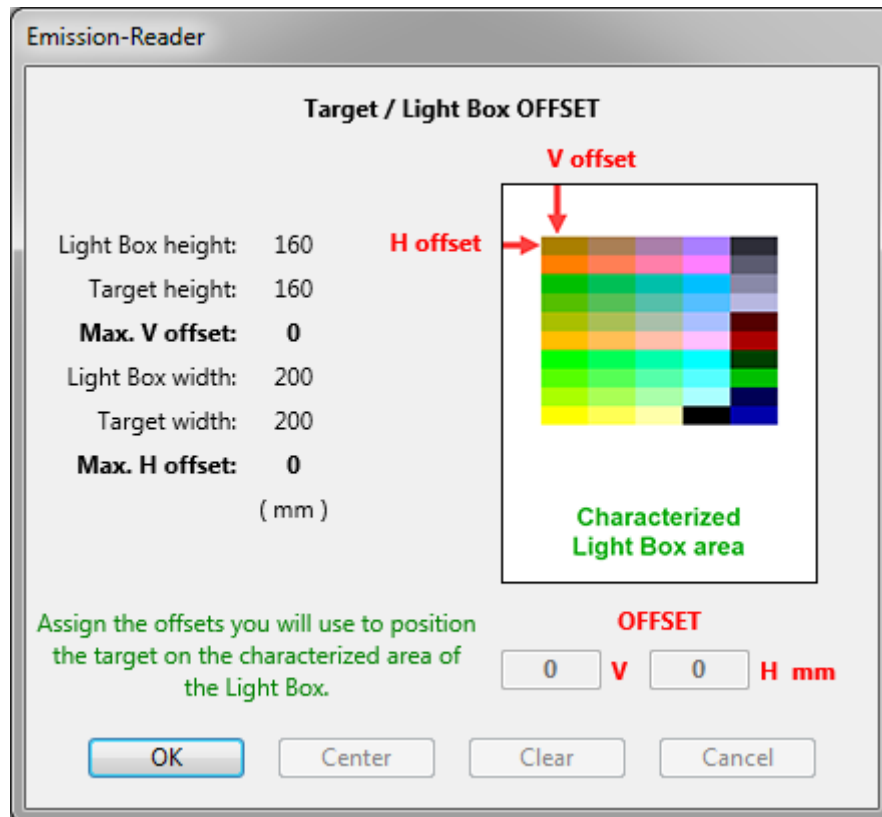
### 3.8.8 Emission-Reader Target / Light Box OFFSET dialog

When measuring targets in the Custom chart and PatchTool file measurement modes, it is possible to apply a compensation which corrects the light box non-uniformity. This compensation information is contained in a file previously generated from [Light Box characterization](#) measurements. This file can be loaded while doing measurements by clicking on the “Get file” button of the “**Light Box uniformity compensation**” control group.

Once a uniformity compensation file is loaded, the file name and the light box area covered by the file are shown. The “ON” checkbox and the “Set offset” button will be **enabled if the compensation file area and target area are compatible**. The “ON” checkbox and the “Set offset” button will be **disabled if the compensation file area is too small** and the light box area dimensions will be shown in **red**.



Click on the “Set offset” button to open the “**Target / Light Box OFFSET dialog**”.

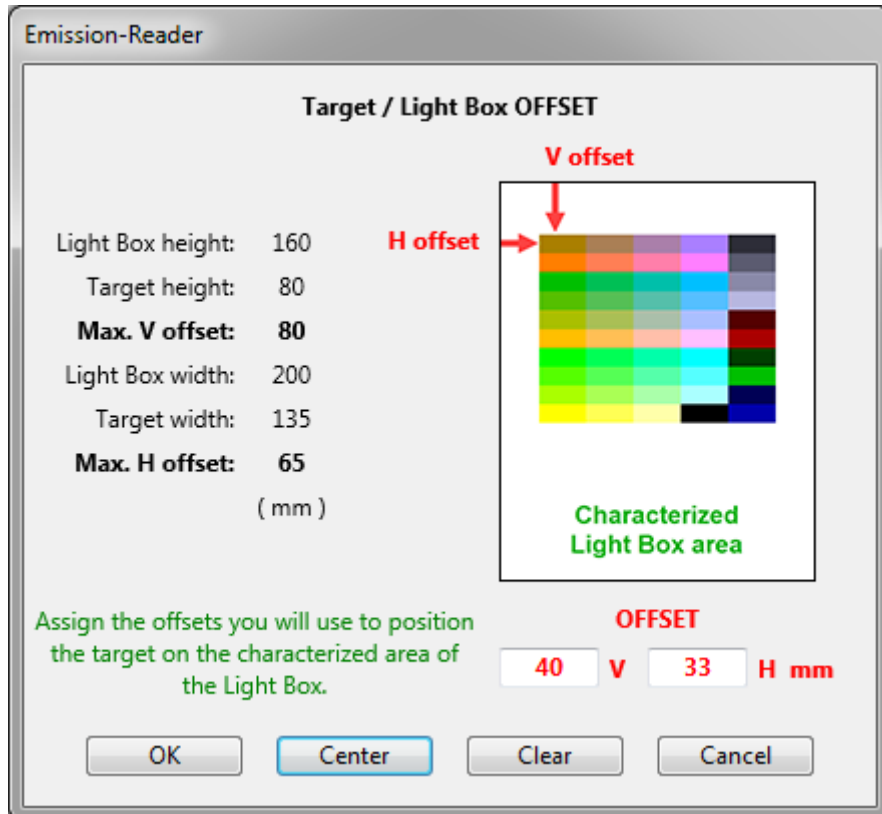
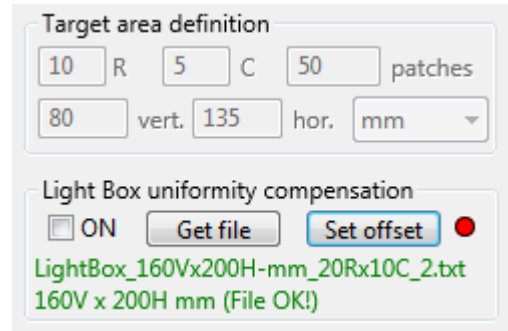


In the screenshot above, the Target area definition is the same as the light box area, 160V x 200H mm. There is thus no margin for offset and the target origin should coincide with the light box characterized area origin.

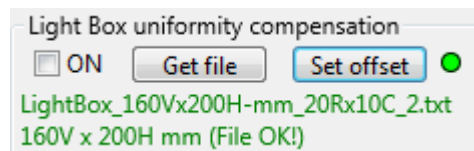


The screenshot on the right shows the Light Box uniformity compensation control group with a compensation file larger than the target area. The target area is 80V x 135H mm while the characterized light box area is 160V x 200H mm.

The “Target / Light Box OFFSET dialog” which opens when we click on the “Set offset” button is shown below. We have already clicked on the dialog “Center” button to position the target in the middle of the characterized light box area.



Once this dialog is closed, the light at the right of the “Set offset” button will be green only if a non-zero offset is assigned. It is up to you to physically position the target at the proper location on the light box.

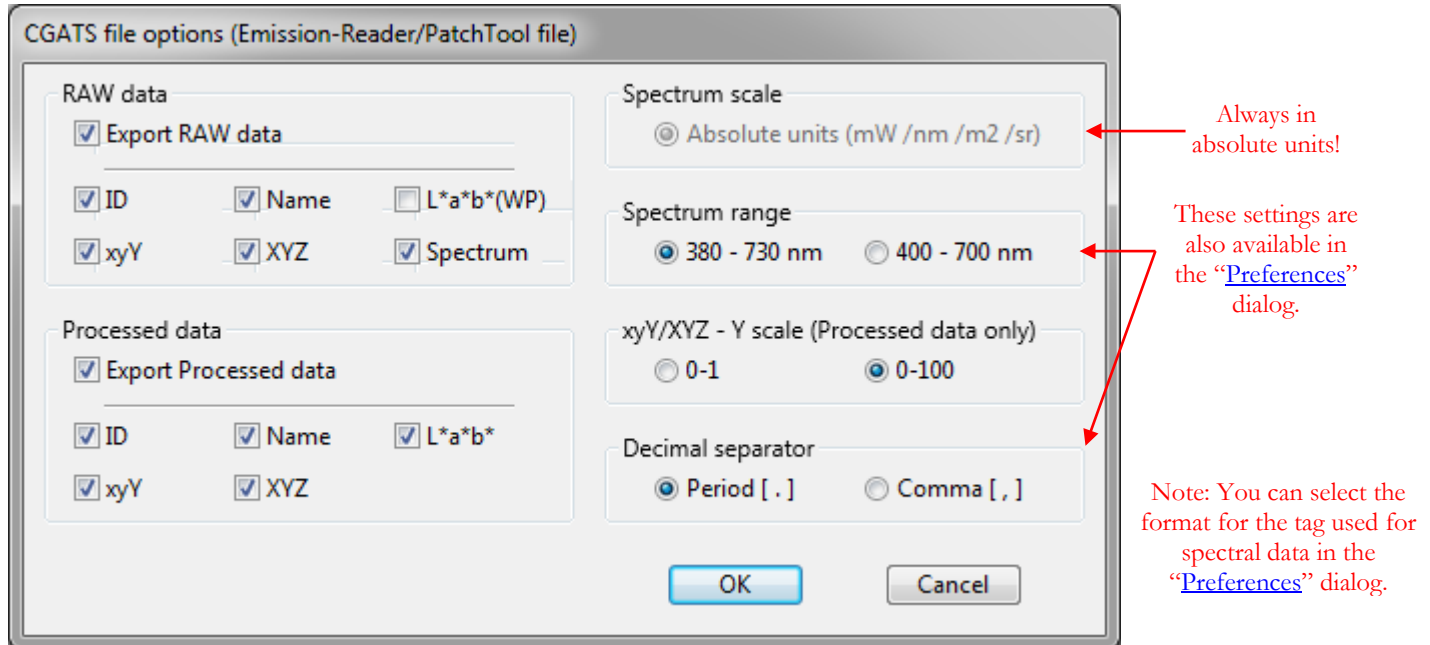


Select the “ON” checkbox to apply the uniformity correction to the current (and future) target measurements.

**Important:** The saved measurements depend on the status of the “ON” checkbox. You can thus save the measurements with or without compensation. In particular, if the White Point (WP) was assigned from a white patch on the measured target, it is important to reassign the WP after selecting or deselecting the “ON” checkbox since this will likely affect all measurements.

### 3.8.9 Emission-Reader CGATS saving options

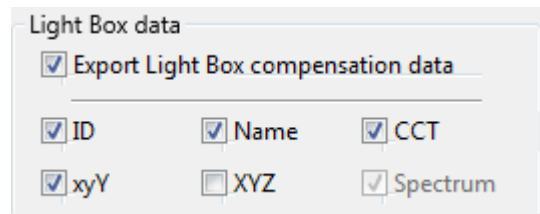
Whenever you decide to keep the measurements done in Emission-Reader, you are presented with a dialog that contains options to be used for saving the data. The screenshot below was obtained after making measurements on a [PatchTool file](#); the dialog is the same for a [Custom chart](#) but different for [Light Box characterization](#) (see below).



Select “**Export RAW data**” if you want to save ABSOLUTE measurements in a file that can be opened in a spreadsheet. In this file, Y is not normalized and is saved in cd/m<sup>2</sup> units.

**Warning:** The RAW data file contains emission data which cannot be processed like reflectance data. As a consequence, when this file is opened by a program which expects reflectance data, the processed color values will be wrong. This file is primarily intended for those who want to process the data on their own.

**Important:** When saving measurements done for “[Light Box characterization](#)”, the “RAW data” control group is renamed “Light Box data”. This data still cannot be opened by a program which expects reflectance data but it can be opened by PatchTool as a **Light Box uniformity compensation** file when doing measurements in the [Custom chart](#) and [PatchTool file](#) measurement modes.



Select “**Export Processed data**” if you want to save color data which can be properly understood by most programs that support CGATS compatible files. In this file, Y is normalized to 1 or 100, depending on the option you selected, and the data is relative to a Standard Illuminant or one of two [Custom Illuminants](#); for maximum compatibility with programs from other companies, we recommend using D50 if you have no specific requirements. This file can be opened in PatchTool and compared to any other file.

**Note:** The **processed** “Light Box characterization” measurements are to be used essentially to visualize the light box non-uniformity.

**Important:** Because “Processed data” can only be generated for a Standard Illuminant and the two Custom Illuminants, this option will be disabled if you select “WP” in the illuminant menu of the Emission-Reader window.

When a [CIE 170](#) Standard Observer (“2F deg.” or “10F deg.”) is selected in Emission-Reader, you can also export the [MacLeod-Boynton Chromaticity Coordinates](#) by selecting the “xyY” data type in this export dialog. You will get the MacLeod-Boynton **L<sub>MB</sub>** and **S<sub>MB</sub>** coordinates in addition to xyY computed for the selected Observer. Support of CIE 170 cone fundamentals colorimetry (CIE 2006 and CIE 2015) in PatchTool is described in [Appendix H](#).

Once the data is saved, you will return to the Emission-Reader window where you can continue doing measurements, change the illuminant menu or the rendering intent and re-export, or start a new measurement sequence.

### 3.8.10 Mini-tutorial: Light Box stabilization time

In this tutorial we show how to determine the stabilization time of a light box. While a nominal 10 minutes preheat time is often suggested before characterizing the light box or measuring targets on it, the actual stabilization time may be shorter or longer for your device.

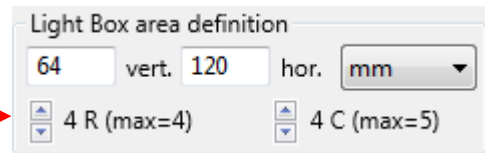
We will automatically measure the light box luminance, on the **SAME spot**, about every minute for **15 minutes**. We start by defining a layout of 4 columns and 4 rows for a total of 16 patches. Since the instrument does not move, the layout has no relation to the light box surface and could be anything you want. Once completed you can evaluate how the light output varies with time by comparing the first measurement with any other.

**Important:** Make sure the light box is “OFF” for at least **30 minutes** before starting this tutorial and do not power it until instructed to in Step-3.

- 1- Open the Emission-Reader tool window and select the [Light Box characterization](#) mode. It is assumed an i1Pro 3 or i1Pro 3 Plus is connected and ready (i.e. with a green light: ●).

- 2- Fill the **Light Box area** Height and Width fields and set the number of rows and columns as shown on this screenshot.

Max. values computed here for an i1Pro 3 Plus



**Note:** These numbers can be used for an i1Pro 3 or an i1Pro 3 Plus even if the “max” values differ.

- 3- Click on the “Start” button. When the [White Point \(WP\) measurement dialog](#) opens, place the instrument on the light box so that its aperture is approximately in the middle of the luminous surface.

Now perform these actions swiftly (within 10 seconds!):

- i- Switch the light box “ON”
- ii- Measure the WP
- iii- Switch the light box “OFF”

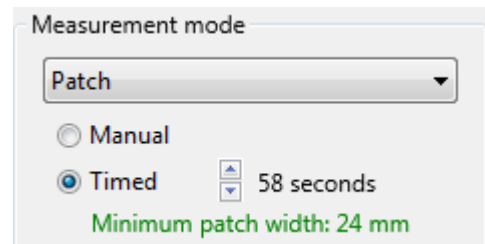
In the “White Point” control group, select “WP” in the “Illuminant” menu (the Abs-Col setting has no effect when the WP is selected). Let the light box cool for **3 to 5 minutes**.



- 4- Select “Patch” in the **Measurement mode** menu, then click on the “Timed” button and set the timer to **58 seconds**.

#### Why 58 seconds and not 60 seconds?

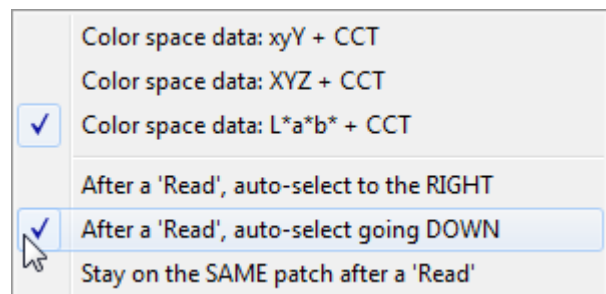
Because each measurement takes time; this was estimated to about 2 seconds in our setup. So the total time between readings is 58 + 2=60 seconds.



The measurements will not start until you click on the “Read” button, in Step-6.

- 5- Do a right-click anywhere on the **chart area** and select “Color space data: L\*a\*b\* + CCT” in the popup menu.

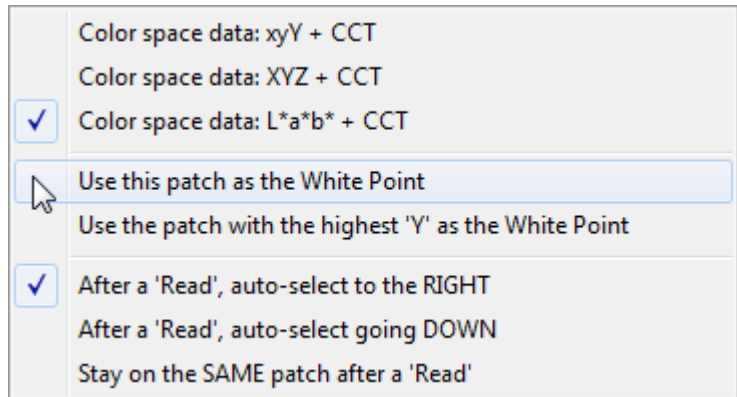
Reopen the same menu and select “After a ‘Read’, auto-select going DOWN”.



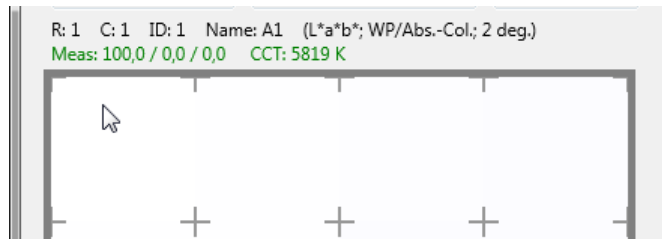
- 6- **Measurements:** First make sure your instrument is still properly positioned on the light box. Now perform these actions:
- i- Select the patch in the upper-left corner (ID=1)
  - ii- Switch the light box “ON”
  - iii- Click on the “Read” button

Let the measurements proceed until the chart is filled and the timer stops (after about 15 minutes).

- 7- Do a right-click on the upper-left corner patch and select “Use this patch as the White Point” in the popup menu.



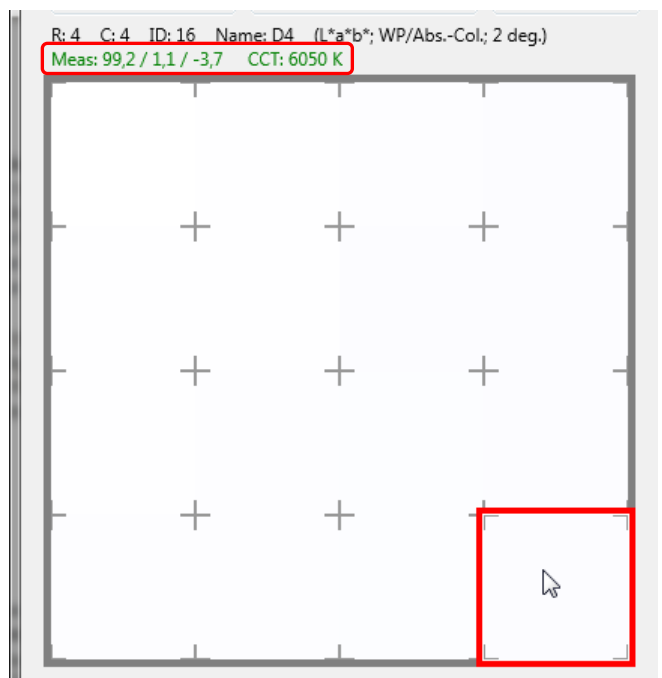
If you move the mouse cursor over this patch, you will get L\*a\*b\* coordinates of (100, 0, 0) as shown on the screenshot on the right.



- 8- **Data analysis:** Move the mouse cursor over the patches and look at their L\*a\*b\* value to see how different they are from the first measurement/patch (assigned as the WP). The time difference between each row is about one minute and the time between each column is about 4 minutes. Place your mouse cursor on the first patch in the upper-left corner and move down one row at a time in the first column, then continue from the top of the next column. You should see a patch-to-patch variation which slowly gets smaller as you get down.

Look for the point where the lightness ( $L^*$ ) varies by less than 0.1 in one minute or when the variation starts changing direction, indicating random fluctuations around a stable point. Similarly, you can also look for the time when the  $a^*$  and  $b^*$  values (of  $L^*a^*b^*$ ) vary by less than 0.1 in one minute or when the variation starts changing direction.

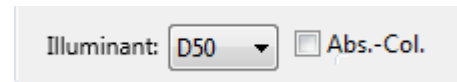
With our light box, stabilization was obtained after 15 minutes (i.e. patch ID=16). You will note that patch #16 L\*a\*b\* values show a noticeable luminance drift as well as a color shift compared to our reference patch selected in Step-7: (99.2, 1.1, -3.7) vs (100, 0, 0) and a CCT of 6050 K compared to 5819 K..



If  $L^*$  increases with time instead of decreasing, do a right-click on **any** patch and select “Use the patch with the highest ‘Y’ as the White Point” in the popup menu shown in Step-7. This will ensure that the patches are properly viewed (and not oversaturated with a display RGB > 255) and that the exported PROCESSED data (Step-9) is relative to a maximum  $L^*$  of 100.

The analysis may indicate that more time is required for stabilization; you should then redo these measurements after increasing the number of patches or increasing the delay between measurements. You could also make measurements at a faster rate, let’s say once every 30 seconds; in such a case, you could assign 2 columns for the chart and each row would correspond to one minute.

- 9- **Saving data:** Before saving the data select “D50” in the “Illuminant” menu and deselect the Abs-Col checkbox (rendering will then be Rel-Col). Changing the Illuminant is required if you intend to save PROCESSED data.



Click on the “**Stop**” button. You are then asked if you wish to save the data; click on the dialog “**Save**” button. A dedicated [CGATS file options](#) dialog will open. You can save the **Light Box data**, which are RAW measurements (i.e. spectral data), or the **Processed data** (i.e. tristimulus data), or both.

**Note:** In this tutorial, the Light Box data cannot be used for compensation purposes since the patch layout does not correspond to a light box layout. Also, while it can be saved in a readable text file, this file is not designed to be opened by most programs which can read color files since it contains non-normalized emission measurements.

The PROCESSED measurements are saved in a CGATS compatible file which can be readily opened by most programs which can read color files. Once the data is saved you can select another Illuminant, rendering intent, or Standard Observer and resave the data. You can also continue doing measurements, or stop and close the tool.

We suggest you open the PROCESSED file in PatchTool; you will be able to evaluate the color difference between any patch, i.e. any measurement performed at a one minute interval.

### 3.8.11 Mini-tutorial: How to make a transmissive ICC profile with a reflectance engine

In this tutorial we show how to make an ICC profile for a light box using a profiling engine designed for making reflectance profiles. You should consider it a proof-of-concept which has room for improvement. The rationale is that it is possible to make transmissive measurements, i.e. emission measurements, and process them so that they are normalized to a White Point of  $L^*a^*b^* = (100, 0, 0)$  and  $Y = 100$ , and any standard Illuminant, such as D50.

We use an i1Profiler RGB printer workflow in this tutorial but any printer profiling application could be used.

**Note:** X-Rite i1Profiler transmissive workflow is optimized for the noisy nature of backlit targets. In particular, it uses a two pass target generation algorithm which provides very smooth profiles (when viewed in 3D). In our experience, the method proposed here results in profiles which are more “bumpy” considering the number of patches in our target.

**Important:** As indicated in the [Emission-Reader introduction](#):

- The Emission-Reader tool is NOT designed to integrate with or perform specific steps of the i1Profiler TRANSMISSIVE ICC creation workflow.
- The Emission-Reader tool does NOT take into consideration the following parameters which are used in the i1Profiler transmissive ICC workflow:
  - o The substrate back-reflectance properties.
  - o The light box reflectance properties (with lights off).
  - o The viewing light box white point, if different from the light box used to make the target measurements.

**Hint:** Before starting this tutorial, we strongly recommend that you read the [Light Box characterization procedure](#) and [Custom chart/PatchTool file measurement procedure](#) sections.

1- **Target planning:** Here are the factors we considered when planning for this task.

- i- Instrument: i1Pro 3, with a minimum patch width and height of 7 mm.
- ii- Maximum Zebra ruler scan width of 250 mm.
- iii- A light table with maximum usable area is 7.5 x 9.5 in. (190 x 241 mm)
- iv- Two pages target if possible.

We finally settled for:

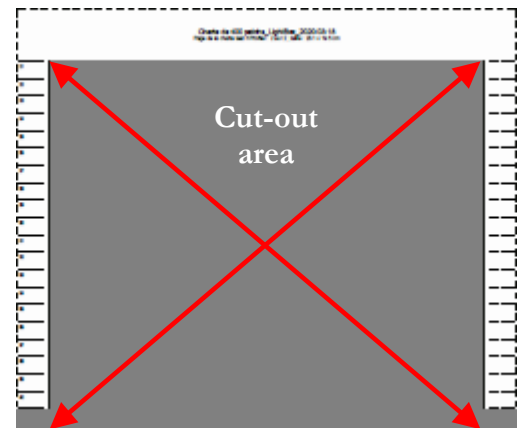
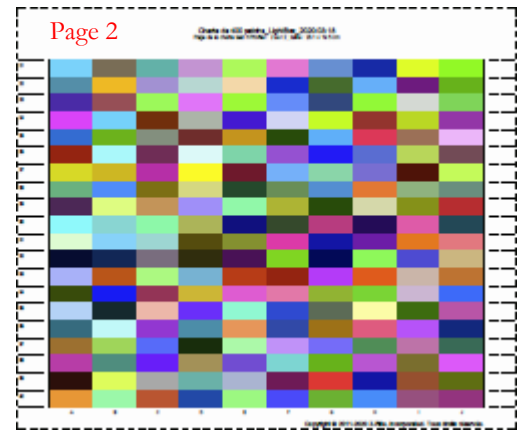
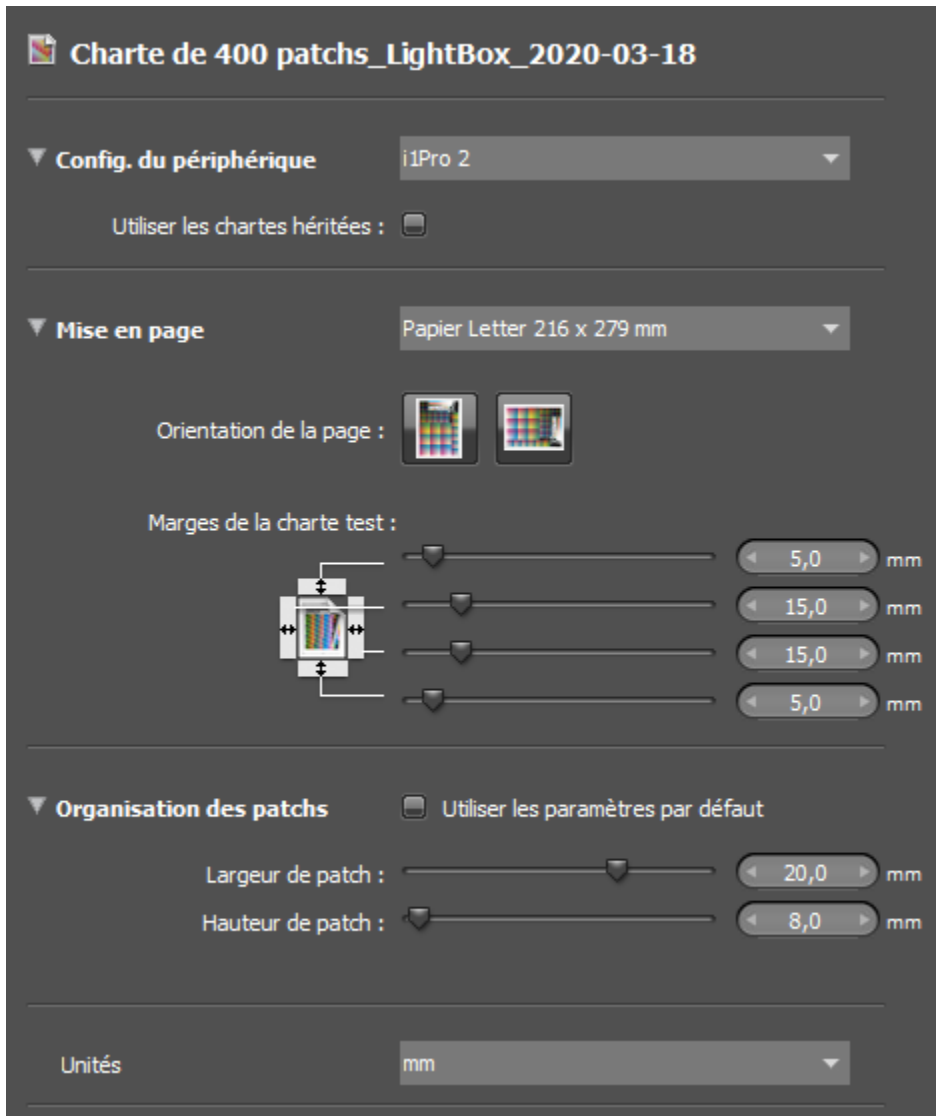
- i- 400 patches on two letter-size pages
- ii- Patch width: 20 mm, 10 patches, i.e.columns, per line.
- iii- Patch height: 8 mm, 20 rows per page.
- iv- Target area: 160 mm vertically by 200 mm horizontally.

2- **Patch set generation (i1Profiler):** In i1Profiler RGB **Printer Profiling Workflow** we generated 400 patches using the **Smart patch generator**. The checkbox to mix the patches was selected.





3- **Test chart generation (i1Profiler):** The test chart parameters were set as follow:



The two pages of the chart were printed from within i1Profiler. We printed an extra page to be used as a [light box characterization](#) template, where we removed the patches area and the bottom of the page, keeping only the row numbers and row guide-lines.

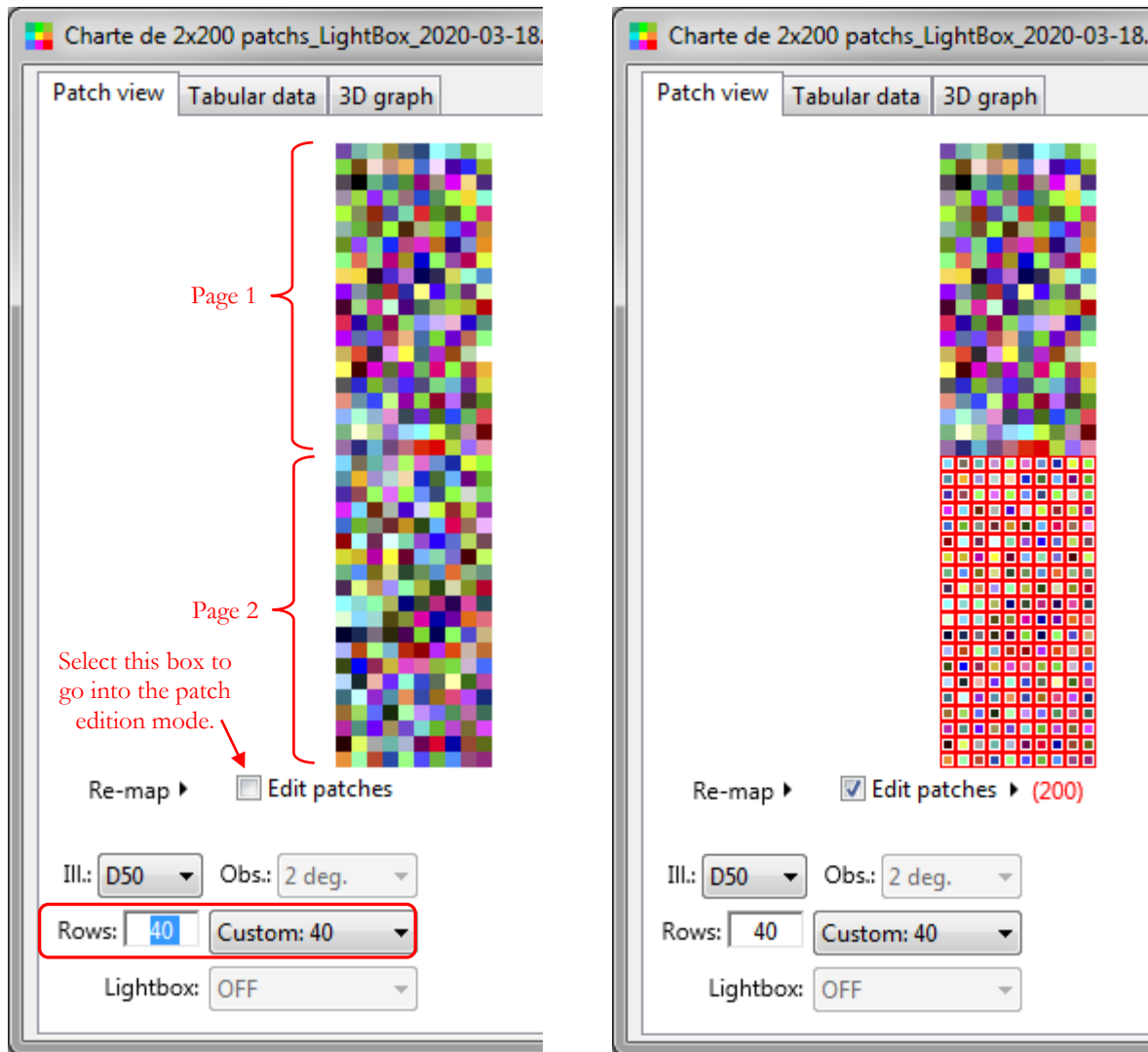
**Note:** We assigned i1Pro 2 as the instrument since our version of i1Profiler did not support the i1Pro 3, only the i1Pro 3 Plus with a larger aperture which has bigger patch width and patch height requirements.

In i1Profiler we exported the test chart with the \*.txf extension, which is based on the CxF3 format. Please note that this file contains the patches of **both** pages; in the next step we will split this file in two in PatchTool.

**Important:** You should now exit i1Profiler as it is not recommended to open two programs which can access the same instrument at the same time.

- 4- **Test chart preparation (PatchTool):** We need to split the i1Profiler reference file in two because we have distributed our patches on a two page chart. In PatchTool, open the test chart exported from i1Profiler in Step-3 (the file with the \*.txf extension). In the PatchTool “[Import CxF3](#)” dialog, select the data identified with the “**Target**” Object type (this should be the only selection available!). In the “[Missing Info](#)” dialog, assign any RGB profile, such as the built-in “sRGB (PatchTool)” profile.

**Note:** If you have a profile previously generated for the same light box you are going to profile, you should use it. By doing so, the patches reference colors will be visually closer to the measured patches (in Step-6).



In the opened PatchTool file, reassign the number of rows to correspond to the sum of the rows in each page (40 in our examples). The resulting screenshot is shown on the left. If you compare the patches with the ones of the two target pages in Step-3, you will notice that page 1 is the top part of the layout and page 2 the bottom part.

Check the “Edit patches” box to go into the [patch edition mode](#). Select all the patches of Page 2 with a mix of mouse clicking and clicking plus dragging. The layout should look similar to the screenshot above on the right.

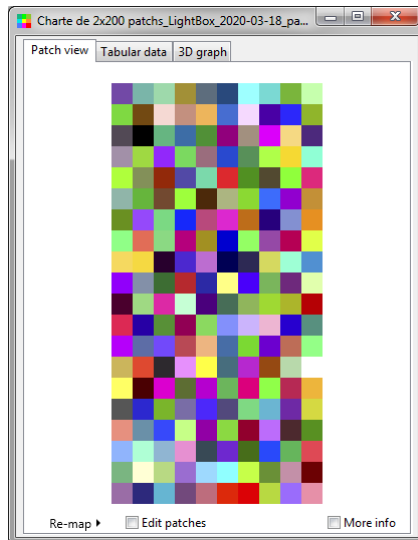
With all patches selected, do a right-click on the patch area and select “**Extract selected patches,**” then reopen the menu and select “**Delete the selected patches.**” Assign “20” in the “**Rows**” data field of the new file that was created by the extraction and also in the original file from which patches were deleted.

Save these two files with the following parameters:

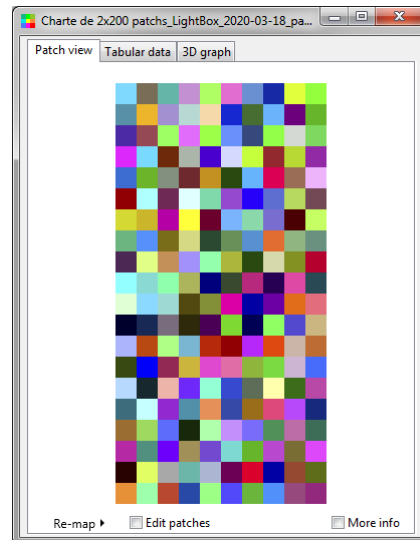
- i- Add “**page1**” and “**page2**” at the end of the file names to identify them.
- ii- Data fields: **ID, Name, RGB**
- iii- File type: **CGATS**

By selecting to export the ID and Name, we ensure that these properties are unique to all patches of both files. This will make it easy to recombine the measurement files of each chart page. The PatchTool files are shown below. We will use these files as **target definition files** when doing the measurements in **Step-6**.

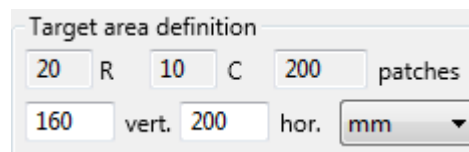
Page 1



Page 2



- 5- **Light Box characterization (PatchTool):** Unless you know that your light box is perfectly uniform in luminance, you should characterize it! This should be done before going to Step-6 of this tutorial. To characterize your light box, please follow the instructions of the [Light Box characterization procedure](#) section; you will notice that the template defined in the light box procedure matches the characteristics of the target defined in Step-1 of this tutorial, i.e. 20 rows over a 160V x 200H mm area.
- 6- **Target measurement (PatchTool):** Make sure the two **target definition files** created in **Step-4** are opened. Open the Emission-Reader tool window and select the [PatchTool file](#) mode. In the PatchTool menu, select the file corresponding to “Page 1”. Insert the height and width of the target area in the **Target area definition** data fields so that they correspond to the printed target defined in Step-1.

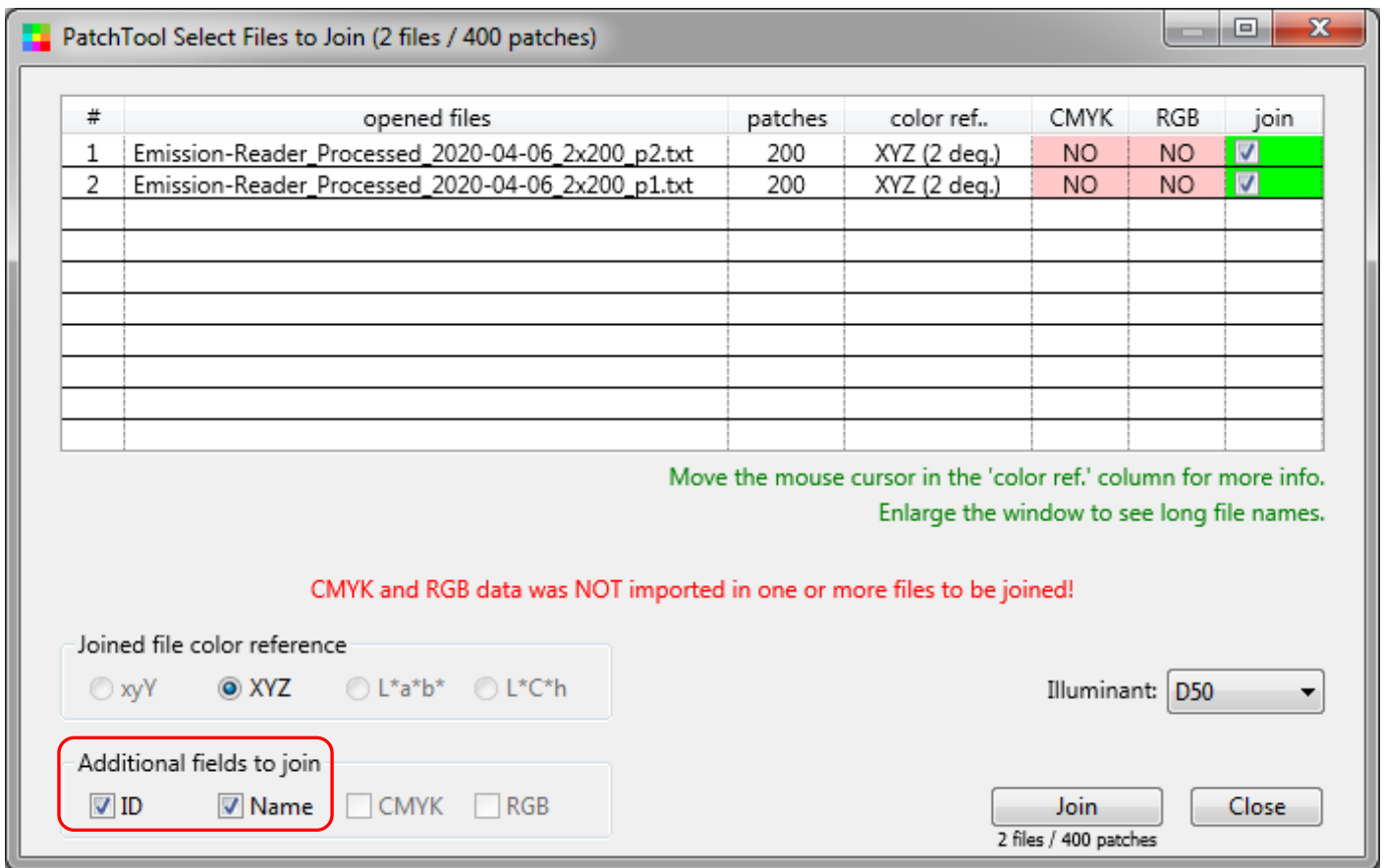


**Note:** It is assumed an i1Pro 3 or i1Pro 3 Plus is connected and ready (i.e. with a green light: ●).

The measurements are done as follow:

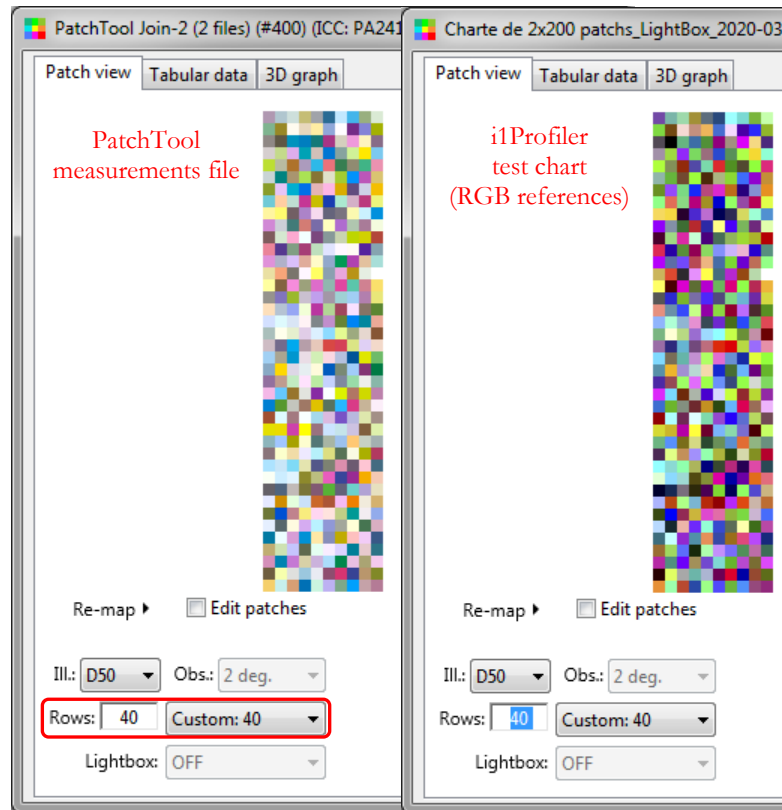
- i- **Measure Page 1:** Perform **Step-2 to Step-9** of the [Custom chart/PatchTool file measurement procedure](#) section. In our example we used a uniformity compensation file but **no offset** since the target area matched the light box area. We selected the “**ON**” checkbox for **Light Box uniformity compensation**. We assigned the **white patch** of Page 1, located in the last column, as the White Point, then selected “**D50**” as the Illuminant and **deselected** the “**Abs.-Col.**” checkbox.

- ii- **Save Page 1:** When ready to save the measurements, click on the “**Stop**” button. This opens a small dialog which asks if you wish to save the data; click “**Save**” and then export the **PROCESSED Page 1** data. You will get back to the Emission-Reader window with the measurements of Page 1. Click on the “**Stop**” button again and then click on the “**Discard**” button. You will get back to the Emission-Reader window. **DO NOT CLOSE** the Emission-Reader window if you have another target to measure, which is the case in our example.
  - iii- **Measure Page 2:** In the PatchTool file menu, select the file corresponding to “**Page 2**”. Perform **Step-2 to Step-7, and Step-9**, of the [Custom chart/PatchTool file measurement procedure](#) section. When you are shown the [White Point \(WP\) measurement dialog](#), you must select the “**Use previous WP**” button. Also, **do not reassign the WP for Page 2**.
  - iv- **Save Page 2:** When ready to save, select “**D50**” as the Illuminant and **deselect** the “**Abs.-Col.**” Checkbox, then click on the “**Stop**” button. As we did for Page 1, save the **PROCESSED Page 2** measurements.
- 7- **Combine measurement files (PatchTool):** In PatchTool, open the PROCESSED measurements files of **Page 1** and **Page 2**. Click on the “**Tools/Join...**” menu. In the “**Select Files to Join**” dialog, select the two measurements files. Select “**ID**” and “**Name**” as additional fields to join and click on the “**Join**” button.

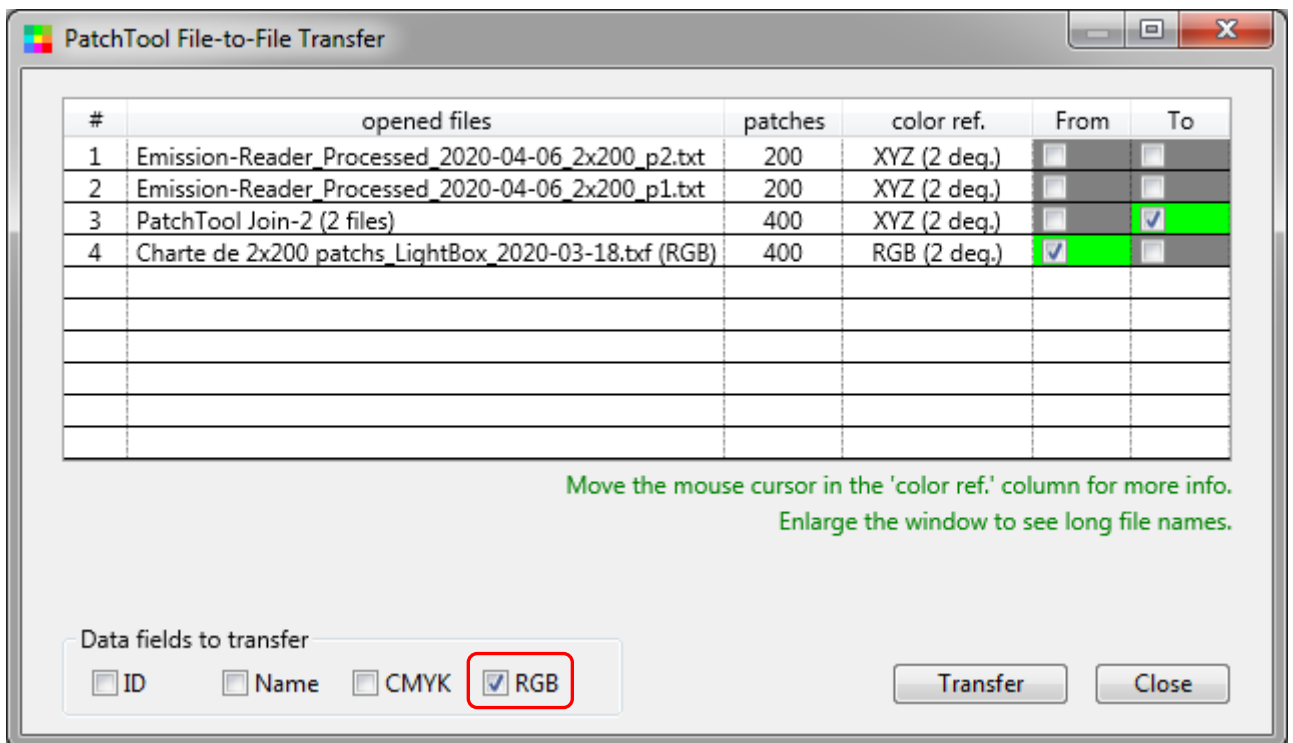


In the joined file, reassign the number of rows (40 in our example) and, in the “[Tabular data](#)” tab, reorder the patches by increasing ID by clicking on the ID column label. The file is shown on the near-right.

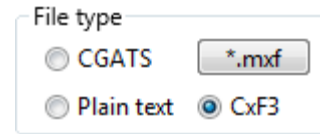
Unfortunately, by doing the measurements, we lost the original RGB values of the test chart. The RGB data in the measurements file are now derived from the measurements through an ICC profile. The problem is that i1Profiler expects **reference** RGB values (CMYK values in CMYK workflows) and not **derived** RGB values obtained through a profile. In particular, it expects a White Point which is exactly equal to RGB=(255, 255, 255), with no fractional value. We thus need to reassign the target reference RGB data. In order to do this we first need to reopen the original i1Profiler test chart (with the \*.txf extension) as we did in **Step-3**. Once the test chart is opened, we assign 40 rows so that it can be compared visually with the measurements file. Both files are shown on the right. We see that the two layouts correspond even though the actual colors differ significantly.



To combine the measurements with the reference RGB, select the “**Tools/File-to-File Transfer...**” menu. Using the “[File-to-File Transfer](#)” dialog, just transfer the RGB data of the test chart to the joined measurements file.

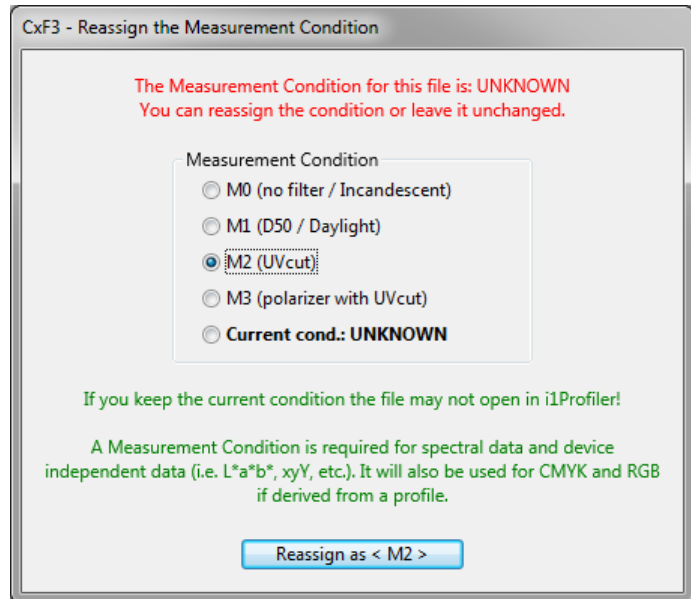


- 8- **Export to i1Profiler CxF3 measurements format (\*.mxf) (PatchTool):** The joined measurements file with the reference RGB data now contains the data required by i1Profiler in order to compute an ICC profile. In PatchTool, [export](#) the joined file using the CxF3 file type. Make sure the button which appears on top of “CxF3” indicates “\*.mxf”; if not, click on the button and select this format in the “[CxF3 File Extensions](#)” dialog. Add only the L\*a\*b\* and RGB data fields to the preselected ID and Name fields.



Click the “**Export**” button. You should edit the file name at this point to better describe the profile use. Just before you return to (or close) the Export dialog, you are shown a dialog offering to reassign the **Measurement Condition**.

Select “**M2 (UVcut)**” and click on the “**Reassign as < M2 >**” button.



You can now exit PatchTool and open i1Profiler.

- 9- **Make the profile (i1Profiler):** Go back to the RGB **Printer Profiling Workflow** we left in Step-3. The settings may be different from those when we left but this is not a problem. Drag and drop the \*.mxf measurement file you created in PatchTool on the “**Measurement**” icon of the workflow.



You will be asked if you want to overwrite the existing file; click “Yes”. If you get another dialog asking to assign a calibration standard, select “**XRGA – X-Rite**” in the menu and then “OK” to close the dialog. You should see a checkmarks under the “Measurement” icon. The “Patch set” and “Test chart” workflow icons may also be updated but there is no need to go back to them.

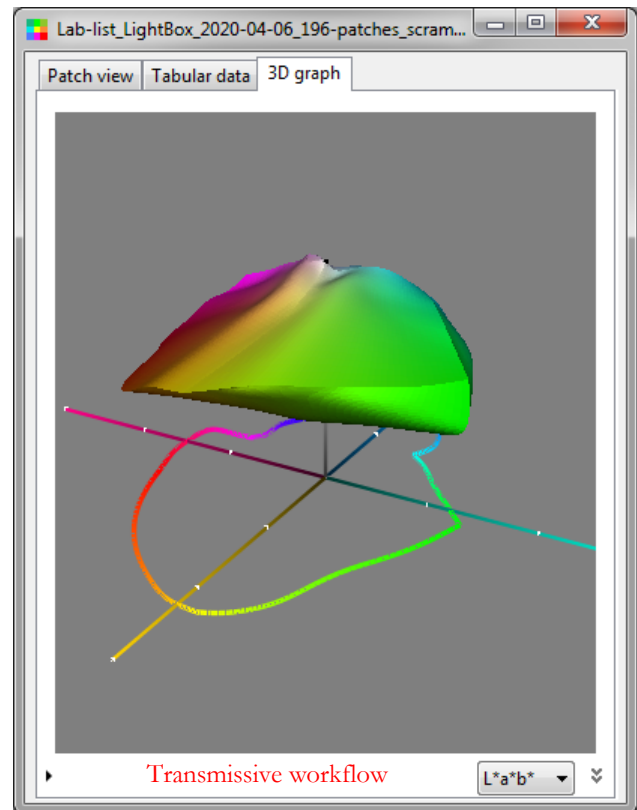
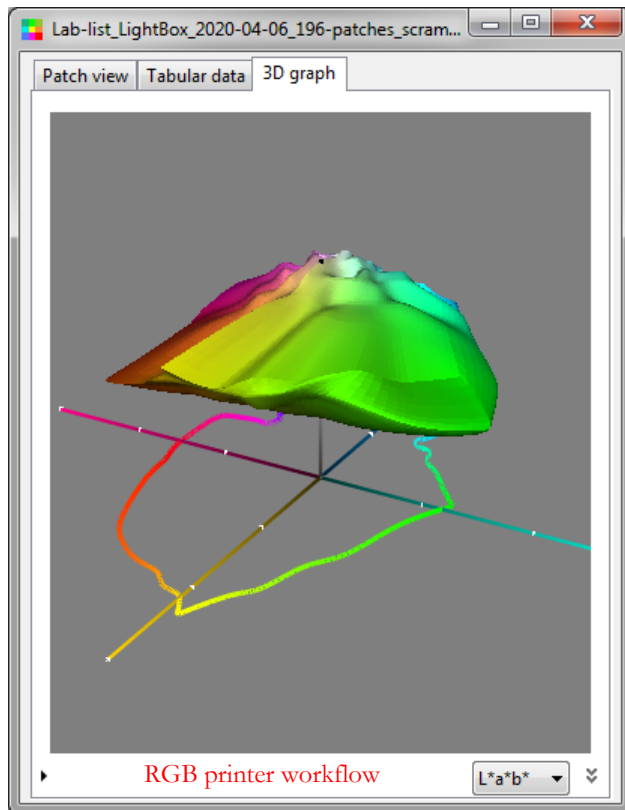


To make your profile, go through the “**Lighting**”, “**Profile settings**”, and “**ICC Profile**” steps of the i1Profiler workflow.

This completes the tutorial. On the next page we show the 3D gamut of the profile obtained with this tutorial is compared to the gamut obtained with the i1Profiler transmissive workflow.

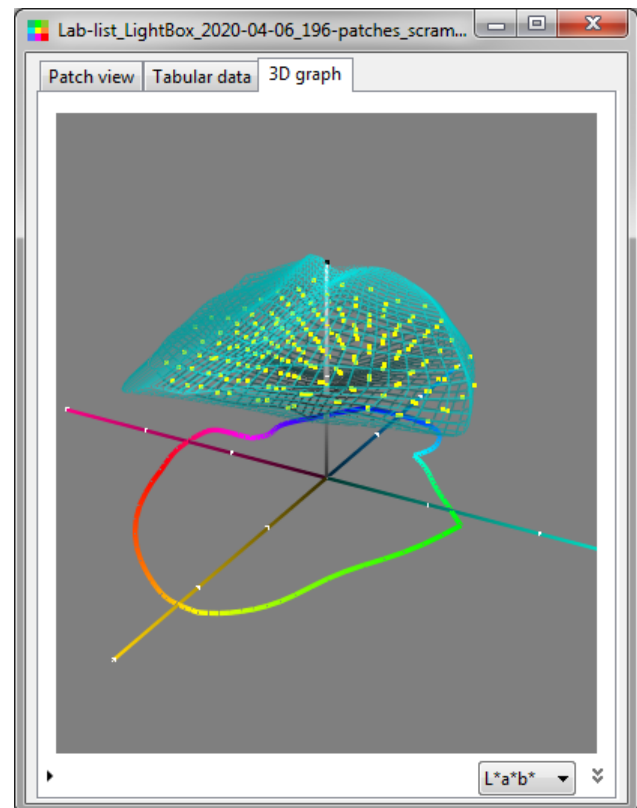
## Reflectance/Tutorial workflow vs Transmissive workflow

The screenshot on the left shows the profile obtained with the RGB printer workflow presented in this tutorial (one pass with a 400 patches target). The screenshot on the right shows the profile obtained with i1Profiler **Transmissive workflow** (2 passes with 100 patches/pass targets).



The two profiles have a similar shape and volume. However, the i1Profiler Transmissive workflow is visibly smoother, as claimed by X-Rite. Perhaps using fewer patches with the method used in this tutorial would smooth the profile; unfortunately, 400 patches is the minimum number of patches which can be assigned with the RGB printer workflow we used in i1Profiler. Nonetheless, both profiles resulted in images which were difficult to differentiate when backlit.

We also compared these profiles by printing uniformly spaced patches located **within both profiles**. The test patches are shown within the Transmissive workflow profile in the screenshot on the right. The procedure to select and print the test patches is described on the next page.

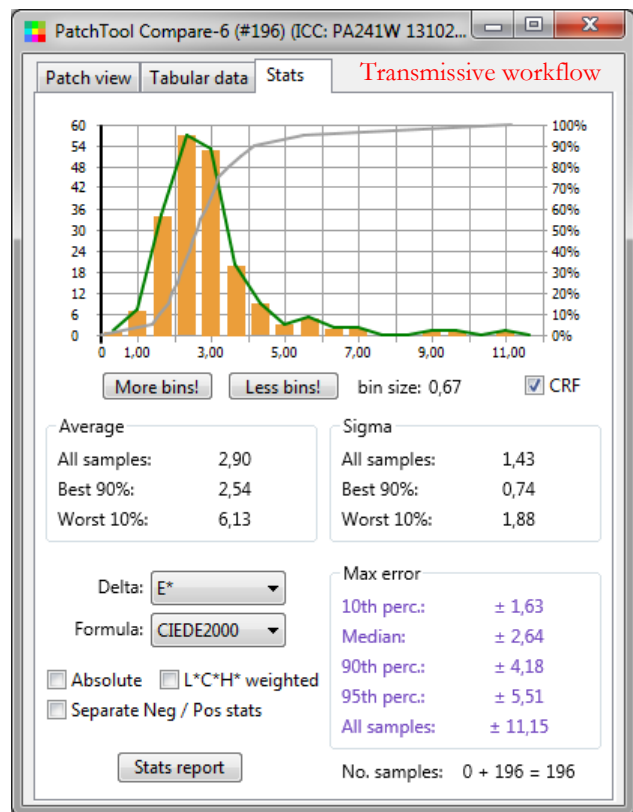
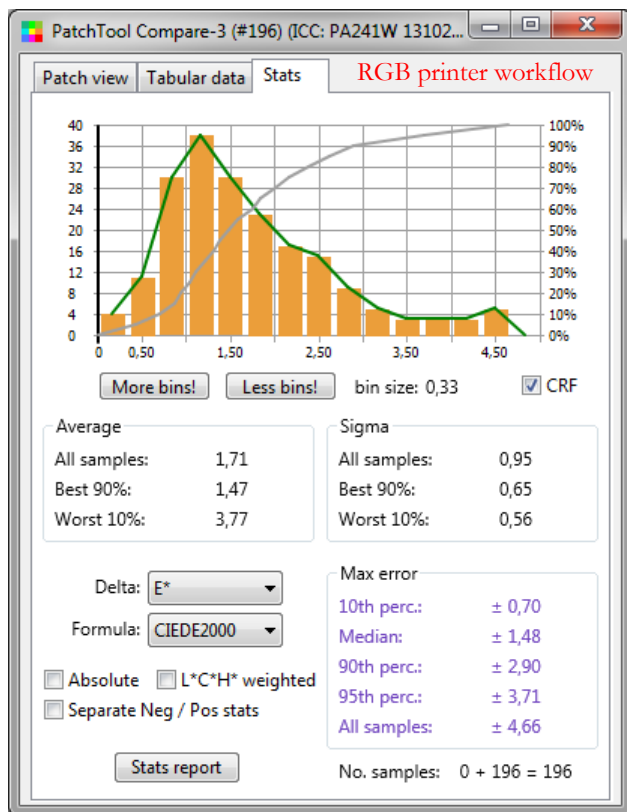




**Note:** The following procedure is more complex because we compare two profiles. However, you can also use it if you want to evaluate the quality of one profile; in such a case, you would jump over Steps “ii” and “iii” and you would keep all the patches in the list.

**Generating and printing uniformly spaced patches common to two profiles:**

- i- Use [Gamut Tools](#) “[List gen.](#)” to generate an L\*a\*b\* list limited by a profile. Repeat for each profile you want to compare. Here are the “List gen.” settings used for the screenshot of the preceding page: Pitch=13.5; L\*: 5,5 to 100; a\* and b\*: -229,5 to +229,5; Gamut threshold=2,0 CIELAB; Intent: Abs.Col.
- ii- Reopen each list in PatchTool and [export](#) only the L\*a\*b\* coordinates (select “Plain text”).
- iii- Using an external **text comparison application** (such as [Beyond Compare](#)), compare the lists and keep only the patches which are in **both** lists.
- iv- Add the L\*a\*b\*=100 patch if not present. You can add this patch in the file using a text editor or using PatchTool “[patch edition](#)” mode (copy any patch, and then replace it by White). This completes the reference patch list. In our test this resulted in 196 patches.
- v- Reopen the list in PatchTool. This list will be used to define a printed target. Assign the number of rows and columns; use the same guidelines for patch sizes and target layout discussed earlier in this tutorial. Once the layout dimensions are set, you should [scramble](#) the layout to maximize the contrast between adjacent patches.
- vi- In PatchTool, [export as an image](#), in L\*a\*b\*.
- vii- Open the image in Photoshop. Print the image twice, in Absolute-Colorimetric, making sure you assign a different light box profile for each print (you also need to disable color management in the printer’s driver).
- viii- Measure each target using the Emission-Reader **PatchTool file** mode.
- ix- Compare each target with the reference patch list of step “iv” above. The results are shown below for our example.



The results above favor the profile obtained with the RGB workflow over the one obtained with a transmissive workflow. The profiles and measurements were done at least twice, some even three times, to improve our confidence in the measurements. We cannot say however if these results are typical, a consequence of bad workflow decisions, or representative of our light box and substrate characteristics. The knowledge should improve with time!



### 3.9 Extract Data from Profile

The screenshot shows the 'PatchTool Extract Data from Profile' dialog box. It contains several input fields for profile information: File name, Internal profile name, Profile type, ICC version, Device class, Default Intent, Creation software, Preferred CMM, and Profile Copyright. A 'Data tag' dropdown menu is set to 'CxF'. Below the dropdown is a text area displaying XML content for the selected tag. At the bottom are 'Get Profile', 'Save Data', and 'Close' buttons. Red arrows and text provide annotations: one points to the 'Get Profile' button with the text 'Drag and drop a profile on the dialog or navigate to the file after clicking on this button.'; another points to the 'Data tag' dropdown with the text 'This menu contains the list of the detected data tags. Select a tag to see its content.'; a third points to the XML text area with the text 'This text area shows the content of the selected data tag.'; and a fourth points to the top text area with the text 'Classes: scanner, monitor, printer, device-link, abstract, color space, named color.'

Click on the 'Get Profile' button or drag-and-drop a profile on this dialog to see if it contains data.  
Accepted file extensions: .icc and .icm.

File name: Epson-4880\_case\_2033-patches.icm

Internal profile name: Epson-4880\_case\_2033-patches.icm

Profile type: RGB ICC version: 4.2.0

Device class: printer Default Intent: Perc

Creation software: XRCM Preferred CMM:

Profile Copyright: Copyright X-Rite, Inc.

Data tag: CxF

```
<?xml version="1.0" encoding="UTF-8"?>
<cc:CxF xmlns:cc="http://colorexchangeformat.com/CxF3-core" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
  <cc:FileInformation>
    <cc:Creator>X-Rite - Prism</cc:Creator>
    <cc:CreationDate>2013-05-08T19:09:16Z</cc:CreationDate>
    <cc:Description>Prism_CVE3 file</cc:Description>
  </cc:FileInformation>
</cc:CxF>
```

Get Profile Save Data Close

Classes: scanner, monitor, printer, device-link, abstract, color space, named color.

Drag and drop a profile on the dialog or navigate to the file after clicking on this button.

This menu contains the list of the detected data tags. Select a tag to see its content.

This text area shows the content of the selected data tag.

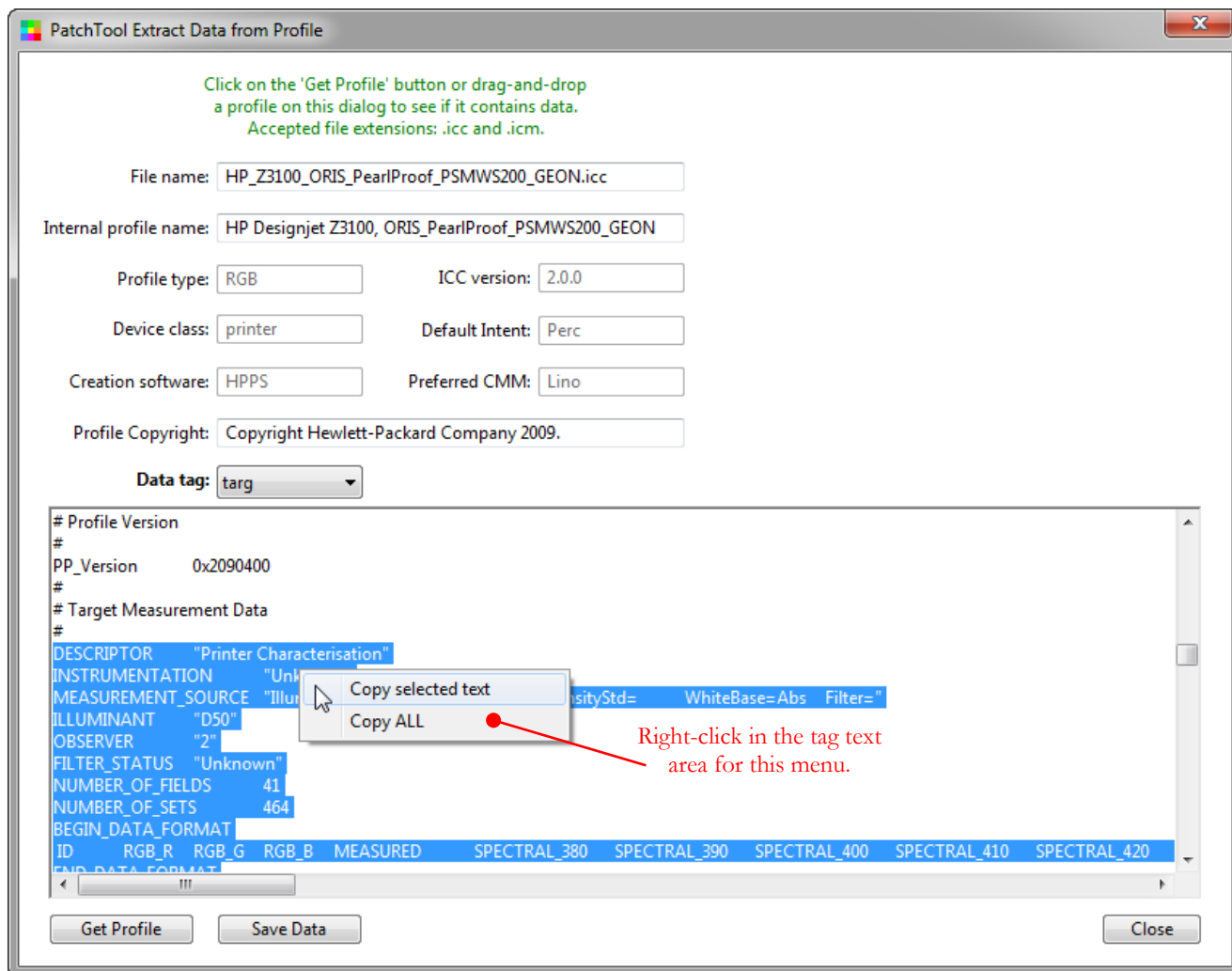
This dialog is opened by selecting the “Tools/Extract Data from Profile...” menu. The tool is dedicated to the extraction of target and measurement data which is *sometimes* included in an ICC profile within one or more specifically assigned “tags”. The accepted profile file extensions are **.icc** and **.icm**. The “Profile type” may be essentially any color space: RGB, CMYK, L\*a\*b\*, XYZ, etc. This tool can be used without a purchased license.

The program first looks for common standard and “private” ICC tags used to save data. Private tags are defined, as their name implies, by private companies for specific purposes in conjunction with their software; these tags’ specifications are generally not openly available. The data in tags may be human readable, such as CGATS or XML (i.e. CxF) text strings, or compressed to save space, or encoded in machine readable format, or a combination of formats. The compression and encoding formats may be proprietary and, while a tag known to contain data can easily be detected, its content may be impossible to decrypt; this condition will be indicated in the tag text area.

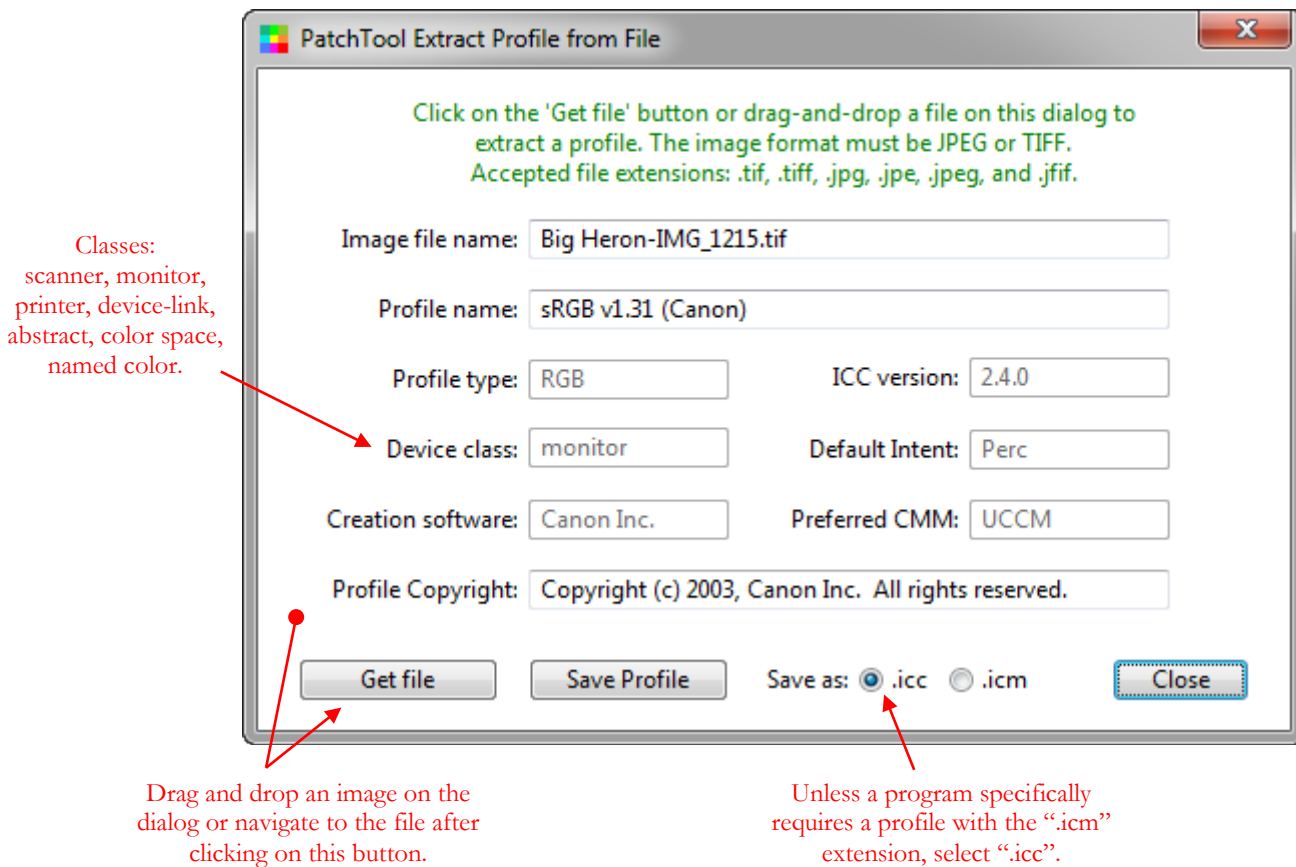
In addition, the program will look for a few tags that store the parameters used to build the profile, and for tags that contain the media white and black point XYZ coordinates. Please note that since all data tags being looked for are optional, there are profiles which contain none of them.

The extracted data can be saved in a file. When the data is formatted in CGATS or CxF format (CxF1, [CxF2](#), [CxF3](#)), the file can usually be opened in PatchTool thereafter (Note: The tool window must be closed first!).

You can extend the dialog for a better view of the tag content. You can copy any selected text in the tag content area, or all the text, with a mouse right-click; the menu is shown in the screenshot below. Copying part of the text can be useful, for example, when you want to discard additional tag data that is not normally part of a CGATS data file, and which would prevent the file from being opened. Of course, you could save the entire file and edit it afterwards.



### 3.10 Extract Profile from File



This dialog is opened by selecting the “Tools/Extract Profile from File...” menu. This tool is used to extract profiles embedded in JPEG and TIFF images. The accepted file extensions are: **.tif**, **.tiff**, **.jpg**, **.jpe**, **.jpeg**, and **.jif**. The “Profile type” may be essentially any color space: RGB, CMYK, L\*a\*b\*, XYZ, etc.

You can save the profiles wherever you wish and select either the “.icc” extension, the standard ICC profile extension, which is standard on Mac but also common on Windows, or the “.icm” extension usually found on Windows computers.

**Note:** The “Default Intent” is only an indication of how the profile was used in the image. It is not an indication of the presence or not of specific transform tables. In other words, this should not be construed as a limitation to use or not other rendering intents with this profile.



### 3.11 Extract Target from Image

This window is opened by selecting the “Tools/Extract Target from Image...” menu. This tool is designed to extract the **average** pixel value of target patches in images. You first assign the number of ROWS and COLUMNS of the imaged target; you then fit the target mask layout to the geometry of the imaged target and, lastly, tweak the patch fill-ratio. **The supported image formats are TIFF RGB, CMYK and L\*a\*b\* (8 bit/16 bit), JPG RGB and CMYK (8 bit), and PNG RGB (8 bit).** Embedded profiles are recognized and automatically extracted; the profiles are saved within the BabelColor folder located in your “Documents” folder (MyDocuments\BabelColor\Image profiles).

The screenshot shows the 'Extract Target from Image' dialog box. The title bar reads 'Extract Target from: ACardinal\_JAKain.jpg (RGB/8/With-profile)'. The main area displays a framed image of a cardinal with a 4x6 grid of target patches overlaid. A green square is at the top-left corner of the grid, and red squares are at the corners of the image frame. Below the image is a 'Target layout' section with input fields for '4 rows', '6 columns', and '24 patches', and a 'Fill ratio' of '0.70'. There are also buttons for 'Load image', 'Fit to screen', 'Extract target', and 'Close'. A 'Reset layout' button is present with a 'Corner LOCK' indicator. Annotations with red arrows point to various UI elements: the maximize button, the dialog title, the green and red squares on the target mask, the color picker square, the 'Reset layout' button, the 'Load image' button, the 'Fit to screen' button, and the 'Reset layout' button again. A green annotation points to the 'Reset layout' button with the text 'Use Shift+Click to move the image. Use Option+Click to move all.'.

Click to maximize the dialog size. You can also manually enlarge the window.

The image name, data type, and bit depth are shown in the dialog title.

The target mask is positioned using the green and red squares.

Click in this square to open a color picker and change the mask color.

Press **Option**, on Mac, or **Alt**, in Windows, and click to lock the mask to the image corners.

Use Shift+Click to move the image. Use Option+Click to move all.

Default file **profile** selection menu.

Drag and drop an image on the dialog or navigate to the file after clicking on this button.

Click on this button to reset the image size and position (NOT the target mask layout).

Click on this button to reset the target mask layout (NOT the image size and position).

**Note:** In a given session (i.e. until PatchTool is closed), the sizes and positions of the tool window, the image, and the mask will be recorded and used for the next image, but only if the image is of the same dimensions. This is useful when extracting targets from many images taken with the same setup.

**Important:** This tool is NOT designed to create ICC profiles; however, it can help you check the accuracy of a target image, and thus the accuracy of a camera profile or of the correction procedure applied to an image.

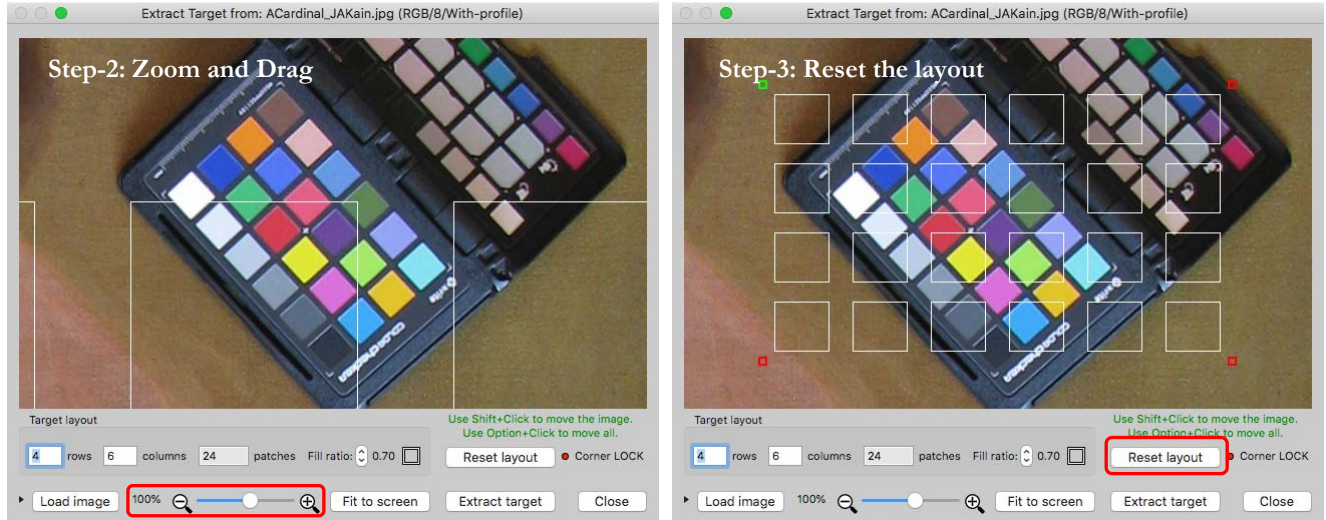


## Target extraction procedure

**Step-1:** Open an image by dragging and dropping it on the dialog, or by navigating to the file after clicking on the “Load image” button (please refer to the screenshot on the preceding page).

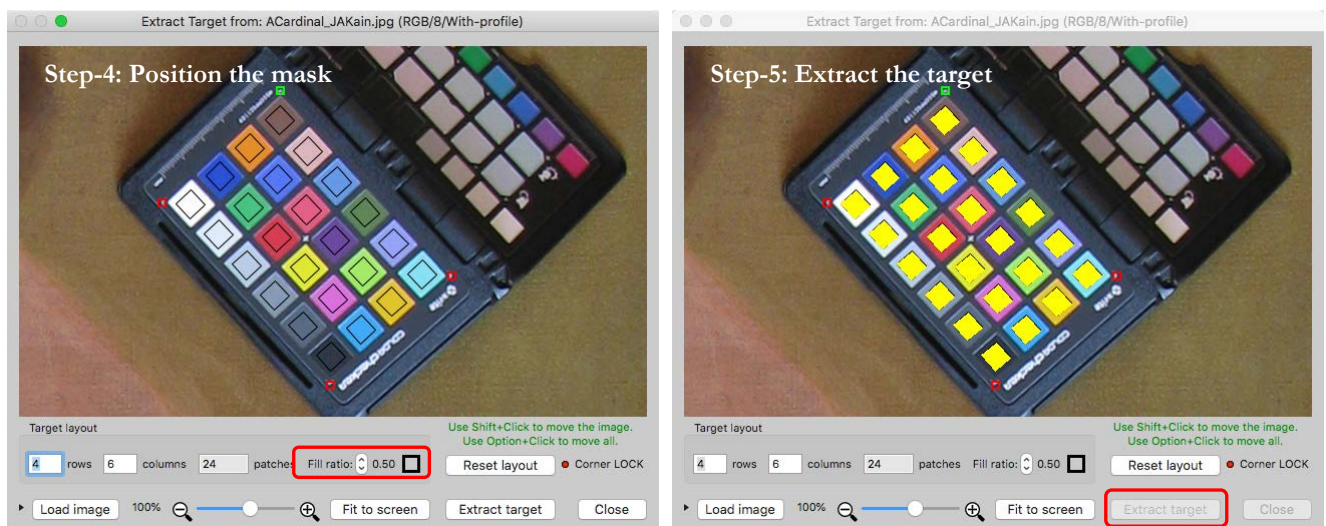
**Step-2:** Enlarge the image and center the target in the dialog. This may require alternating between zooming and moving the image. To drag the image, press and hold the “shift” key, then press and hold the left mouse button. You can change the window size by maximizing it or by dragging an edge or a corner.

**Step-3:** Click on the “Reset layout” button to resize the target mask relative to the current display.



**Step-4:** Move the mask handles (i.e. the four squares) to fit the target image. Adjust the handles in sequence; you may need to redo the sequence a few times for a best fit. You can change the mask color to maximize the contrast between the mask and the patches. Adjust the “Fill ratio” to exclude the patches borders and any shadows these borders can create. There is no need to see the target completely on your display! You can move the target AND the image by first pressing and holding the Mac “Option” key (use the “Alt” key in Windows) and then pressing and holding the left mouse button. You can also zoom the image or resize the tool window for a better view of the target.

**Step-5:** Press the “Extract target” button. The extracted zones are shown in yellow. You can accept the result, which will create a [PatchTool file](#), or come back to the dialog to re-adjust the layout.



**Note:** Data extraction is always based on the image file coordinates, and not on the zoomed display coordinates. For example, if the image is zoomed 200%, you will see extraction done one line out of two in each patch. The minimum, maximum, and average numbers of pixels per patch are shown in the [log window](#).

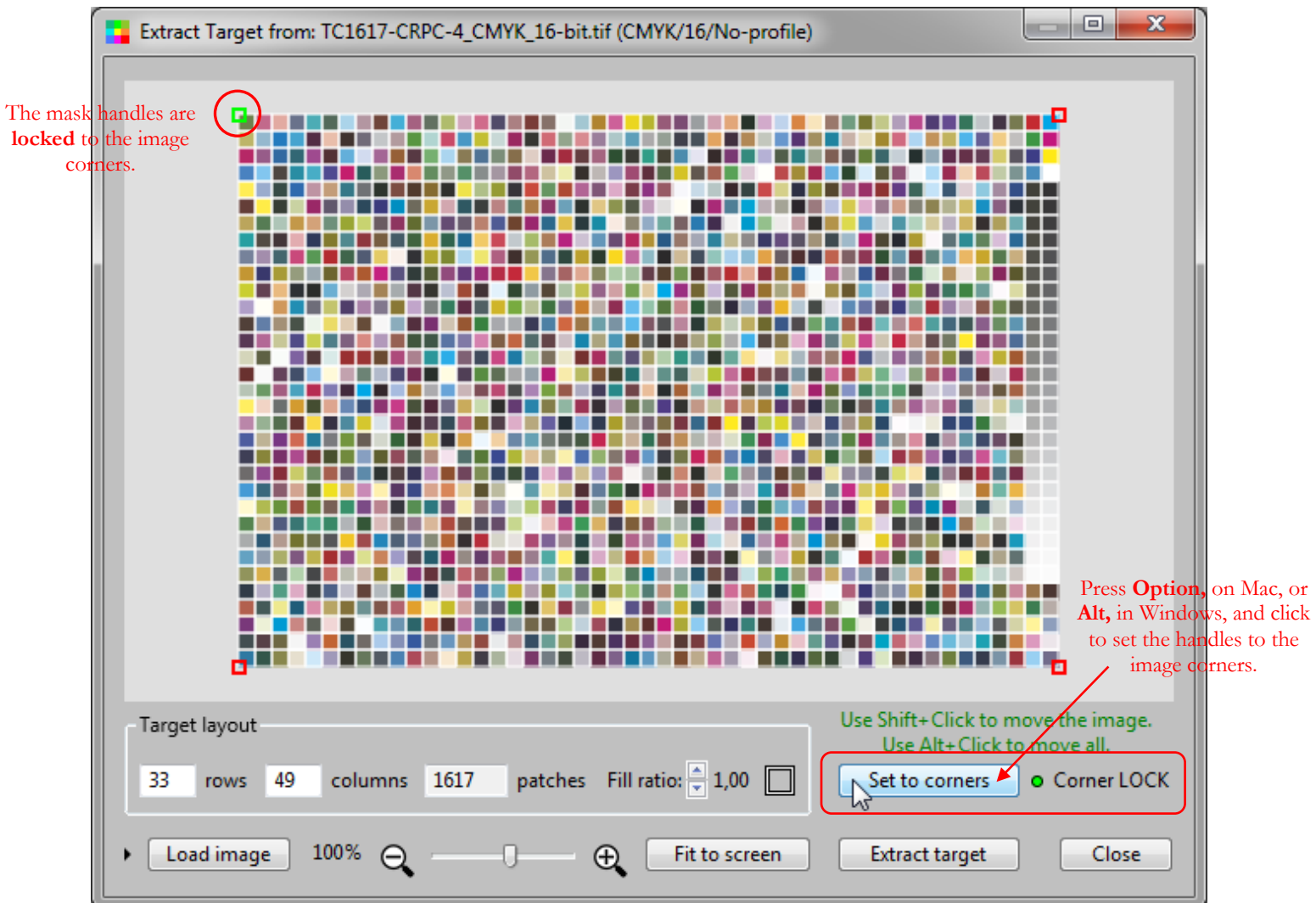
Hints for optimal extraction:

- i- Enlarge the image as much as you can. Use **Option+Click** (on Mac) or **Alt+Click** (in Windows) to move the mask with the image in order to position a handle with more accuracy, if required.
- ii- A “Fill ratio” of 1.00 is not necessarily better; in fact it can sometimes be less efficient, especially for targets with very small patches, such as in the screenshot below (because the program will exclude pixels located near the estimated junction of two patches). Start with a ratio of 0.70 and change it in either direction.
- iii- To maximize accuracy, try to improve the average numbers of pixels per patch shown in the [log window](#).

### Locking the mask to the image corners

In some cases it may be helpful to lock the mask handles to the image corners. This can happen if your images were previously cropped to show only the target, or if your image is a target reference (used for profiling a printer for instance). The screenshot below shows a TC1617 target image where each patch consists of 100 pixels (10x10 pixels). We could open this file directly in PatchTool but we would obtain 100 data points for each patch (and quite a large file!). In place, we can extract the data from the image and obtain one data point per patch.

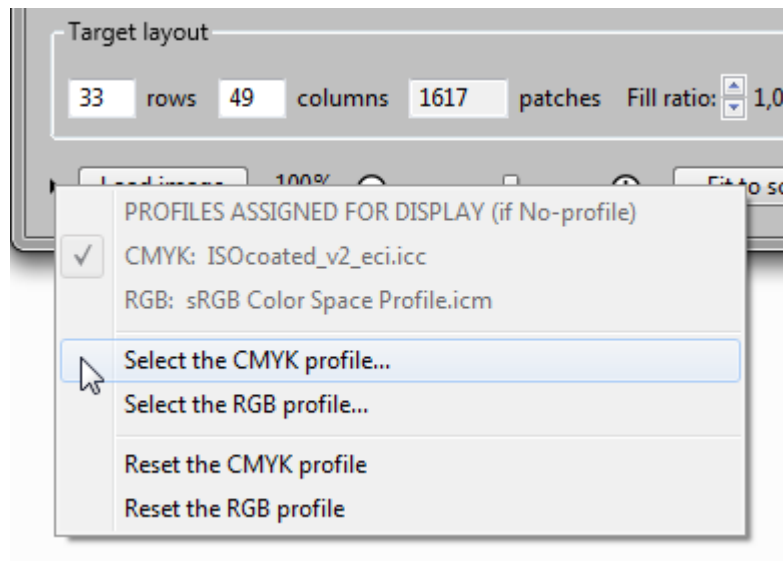
With such an image, we need to position the mask handles on each corner. You can drag them, one at a time, slightly outside of the image and the program will snap them back on the closest edge. However, it is faster to just click on the “Set to corners” button which replaces the “Reset layout” button when you press the “Option” key, on Mac, or the “Alt” key, in Windows. By using this button, not only do you position the four handles, but you also LOCK the handles in position. Without locking, rounding errors will add up if you zoom in and out repeatedly, and the corner handles will move in slightly (Note: This error build-up is much less present for handles *within* the image, i.e. not on the edges).



## Default image profile

When an image has an embedded profile, this profile is used in conjunction with the display profile to render the image on the display. This embedded profile is also assigned to the extracted data.

When an image has no profile, a default profile is assigned for display purposes; this is NOT the profile that will be assigned to the extracted data and you will be prompted for this other profile **after** the data is extracted. You can change the default profile with the menu which opens when you click on the black arrow located at the left of the “Load image” button; the menu is shown below. Of course, nothing prevents you of selecting the same profile for display purposes and for the extracted data. Please note that this default profile also has a default (!) assigned when the tool is first used and to which you can reset at all times.



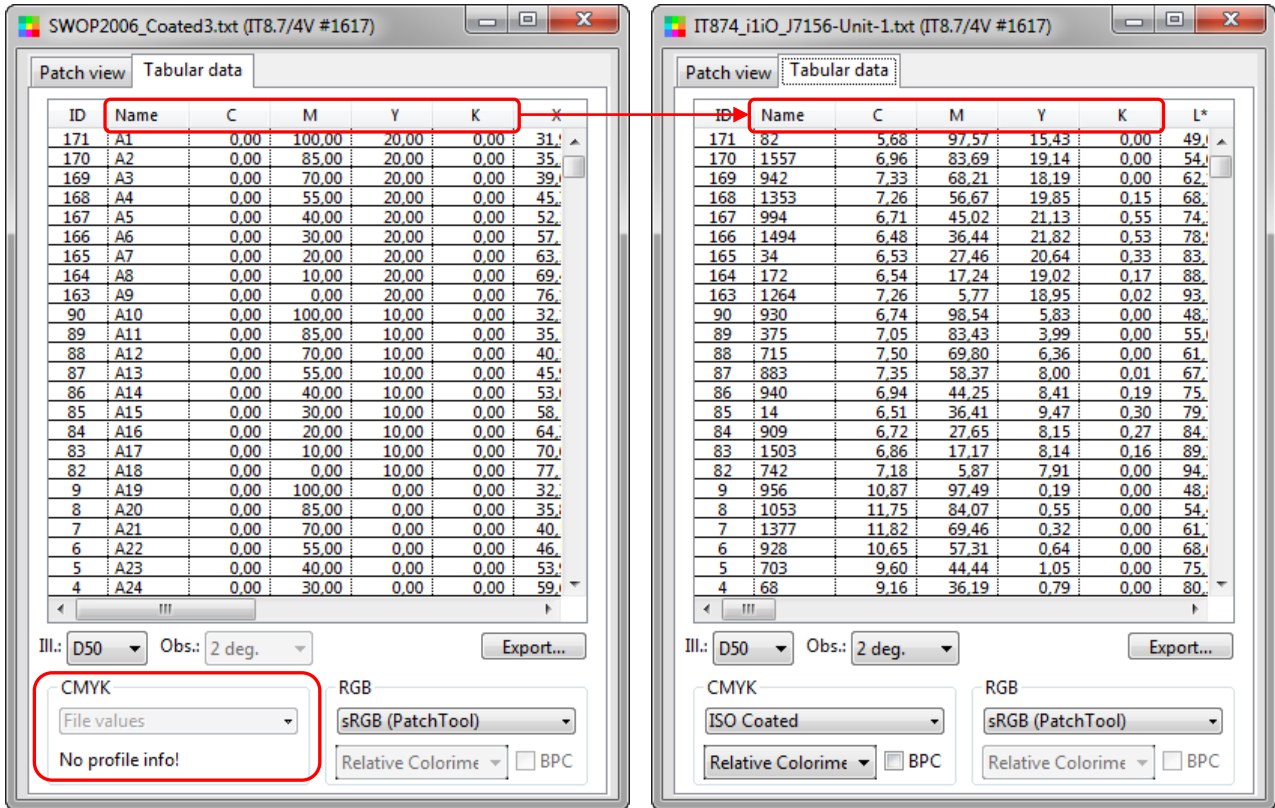
A checkmark will appear besides “CMYK” or “RGB” only if the currently loaded image has no embedded profile, indicated as “**No-profile**” in the Extract Target window title (see the screenshot on the preceding page).

**Note:** If the current file has no profile and you change the assigned profile, the file will be reloaded and reprocessed. This can take time for large files.

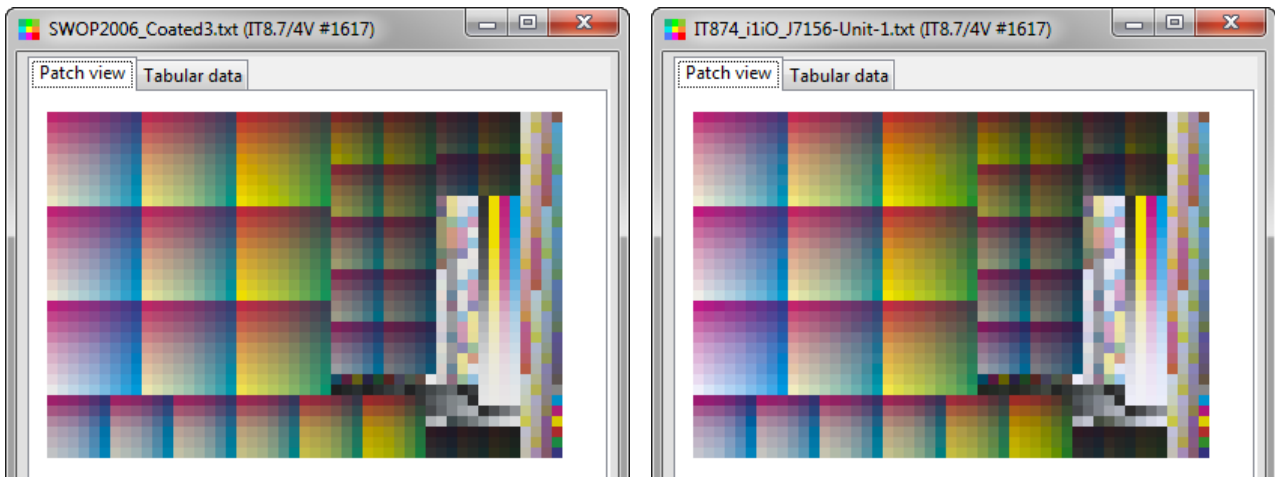
### 3.12 File-to-File Transfer

The PatchTool “File-to-File Transfer” tool is designed to copy the following data fields from one file to another: **ID, Name, CMYK, RGB**. This can be useful when you have a measurement file saved without reference CMYK or RGB data, data which is often required when you want to make a profile from it.

The screenshots below show two files opened in PatchTool. The file on the left is a reference file and the file on the right is a file obtained from measuring the printed IT8.7/4 target. You will notice that the CMYK values in the reference file cannot be changed since they were imported at the same time as the XYZ data, while the CMYK values of the measurement file will vary according to the selected CMYK profile. You will also notice that the patch names of the measurement file are numbers instead of row-column assignments. What we need to do here is transfer the Name and CMYK data from the reference file to the measurements file.



Of course, before doing a transfer, we must insure that the patches are in the same order in both files. This can be checked visually in the “Patch view” tab.



When you are ready to transfer the data, open the “PatchTool File-to-File Transfer” dialog by selecting the “Tools/File-to-File Transfer...” menu. The menu is enabled when there are at least two opened files.

Click anywhere on a row to select or unselect.

Transfers can be done only between files with the same number of patches.

Selected files have a checkmark and a green background.

The white background identifies the files which are compatible with the previous selection.

Non-compatible files are grayed-out.

When you place the mouse cursor in the “color ref.” column, you can see additional information on the file data. This information is shown below the table, in green.

**Data fields to transfer**

ID  Name  CMYK  RGB

Transfer Close

#	opened files	patches	color ref.	From	To
1	SWOP2006_Coated3.txt	1617	XYZ (2 deg.)	<input checked="" type="checkbox"/>	<input type="checkbox"/>
2	IT874_i1iO_J7156-Unit-1.txt	1617	spectrum	<input type="checkbox"/>	<input type="checkbox"/>
3	PatchTool Compare-1	1617	compare	<input type="checkbox"/>	<input type="checkbox"/>
4	Lab-list_SWOP2006_Coated3v2_1551-patches....	1551	L*a*b* (2 deg.)	<input type="checkbox"/>	<input type="checkbox"/>

#2 - File name: IT874\_i1iO\_J7156-Unit-1.txt  
 CMYK profile: ISO Coated / Rel. Col. / BPC-NO  
 RGB profile: sRGB (PatchTool) / Rel. Col. / BPC-NO

Select the “From” and “To” files, and the data fields you want to transfer, then click on the “Transfer” button. The measurement file shown in the previous page is now shown on the right with the transferred data fields. The CMYK data is now the same as the one in the reference file and it cannot be changed.

IT874\_i1iO\_J7156-Unit-1.txt (IT8.7/4V #1617)

Patch view Tabular data

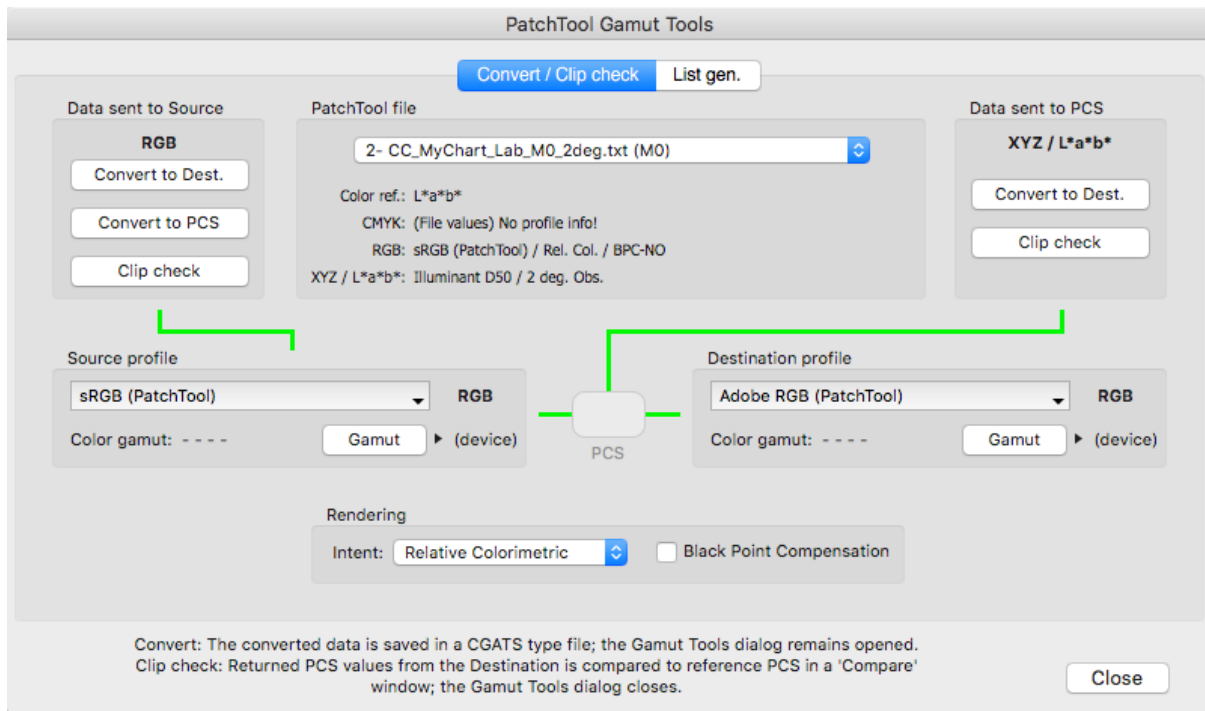
ID	Name	C	M	Y	K	L*
171	A1	0.00	100.00	20.00	0.00	49.1
170	A2	0.00	85.00	20.00	0.00	54.1
169	A3	0.00	70.00	20.00	0.00	62.1
168	A4	0.00	55.00	20.00	0.00	68.1
167	A5	0.00	40.00	20.00	0.00	74.1
166	A6	0.00	30.00	20.00	0.00	78.1
165	A7	0.00	20.00	20.00	0.00	83.1
164	A8	0.00	10.00	20.00	0.00	88.1
163	A9	0.00	0.00	20.00	0.00	93.1
90	A10	0.00	100.00	10.00	0.00	48.1
89	A11	0.00	85.00	10.00	0.00	55.1
88	A12	0.00	70.00	10.00	0.00	61.1
87	A13	0.00	55.00	10.00	0.00	67.1
86	A14	0.00	40.00	10.00	0.00	75.1
85	A15	0.00	30.00	10.00	0.00	79.1
84	A16	0.00	20.00	10.00	0.00	84.1
83	A17	0.00	10.00	10.00	0.00	89.1
82	A18	0.00	0.00	10.00	0.00	94.1
9	A19	0.00	100.00	0.00	0.00	48.1
8	A20	0.00	85.00	0.00	0.00	54.1
7	A21	0.00	70.00	0.00	0.00	61.1
6	A22	0.00	55.00	0.00	0.00	68.1
5	A23	0.00	40.00	0.00	0.00	75.1
4	A24	0.00	30.00	0.00	0.00	80.1

Ill.: D50 Obs.: 2 deg. Export...

CMYK: File values No profile info! RGB: sRGB (PatchTool) Relative Colorime  BPC



### 3.13 Gamut Tools



The “PatchTool Gamut Tools” window is opened by selecting the “Tools/Gamut Tools...” menu. This tool is used to convert data lists between profiles, check if a color list is within a profile gamut, and to generate color lists.

The “**Convert to Dest.**”, “**Convert to PCS**”, and “**Clip check**” buttons are enabled when there is at least one opened file and when all links in the conversion path are valid. Valid links between the file, the profiles and the Profile Connection Space (PCS) are shown in **green**; invalid links are shown in **red**. Please note that a “Convert to...” or “Clip check” cannot be performed with “[Compare](#)” files.

The Source or Destination profile’s **gamut volume** is obtained by clicking on their respective “Gamut” button. The volume is expressed in CIELAB units, where a unitary gamut volume is defined by a cube with dimensions of one in L\*, one in a\*, and one in b\*; this is the standard approach for determining gamut volume although the computing method may vary. Please read the “[Computing a profile color gamut](#)” section for more information on the gamut volume computing methods available in PatchTool.

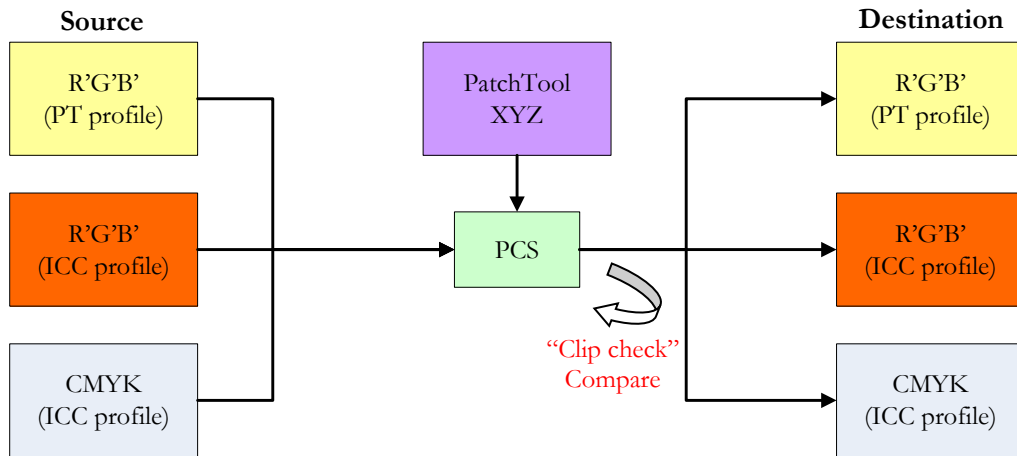
The next section presents the common interface for the “Convert / Clip check” tab; we strongly recommend that you read this section as it contains examples on how the interface interacts with the data content of opened files.

You can click on the following links to jump to the corresponding sections:

- [The “Convert / Clip check” interface, with examples](#)
- [Convert data flows](#)
- [Clip check data flows](#)
- [List gen. interface](#)
- [Computing a profile color gamut](#)
- [Gamut Tools examples](#)

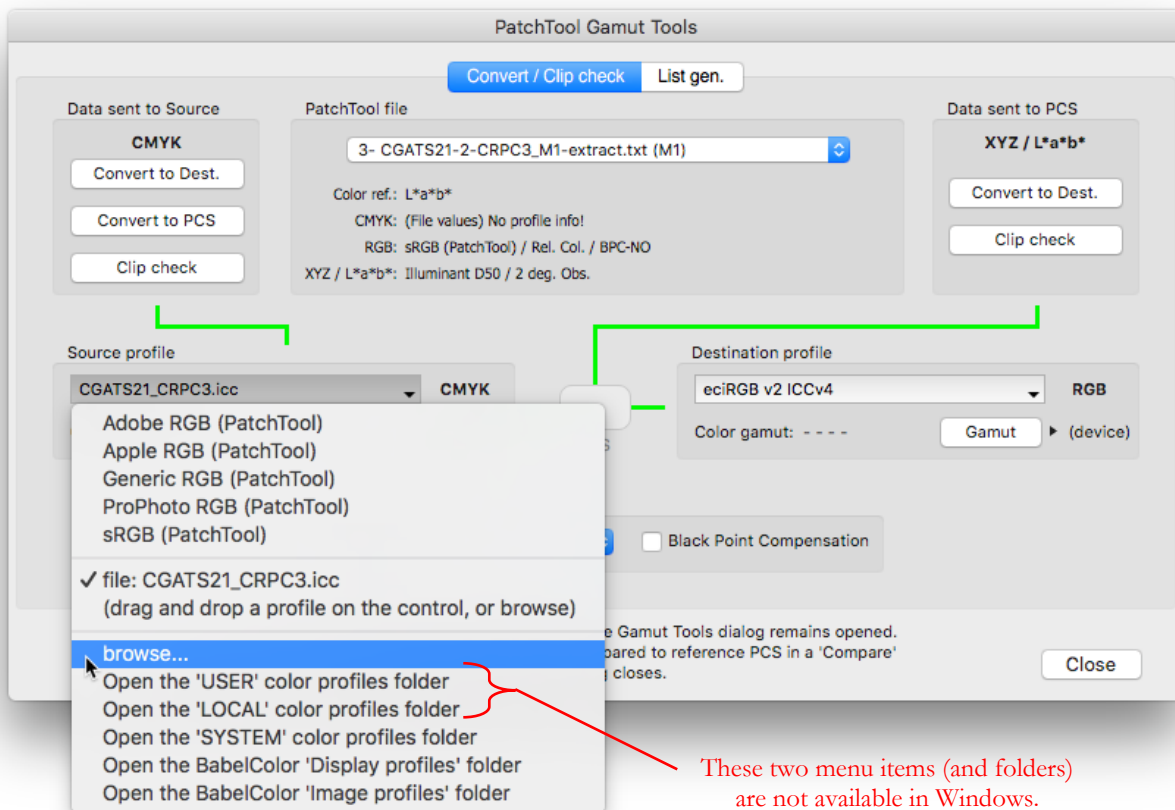
### 3.13.1 The “Convert / Clip check” tab: Common interface

The “Convert” and “Clip check” data flow paths are summarized in the illustration below:



Data from a file can be used as input for a Source profile or sent directly to the PCS. When sent to a source profile, the color space of the input data is defined by the Source profile type, either RGB or CMYK. When sent to the PCS, the color space of the input data is always XYZ (or its corresponding L\*a\*b\* values). The Destination profile type can be either RGB or CMYK, and it can be of a different type than the Source profile.

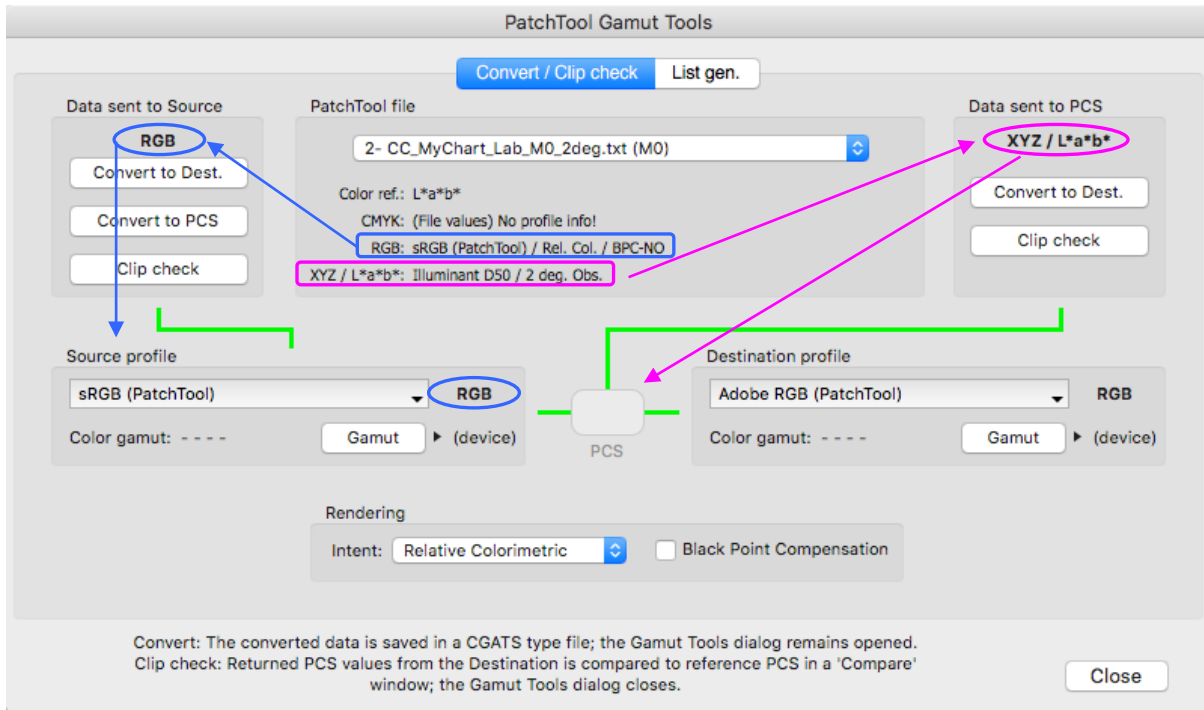
The selection menu for the Source profile is shown below; the menu is the same for the Destination profile. You can select one of the five built-in PatchTool RGB profiles, which are equivalent to the matrix-based ICC profiles for the same RGB spaces, or a user-selected profile. The user-selected profile can be any RGB or CMYK ICC profile. You can browse for the profile or simply drag and drop the file on the menu; there are also menu items to open folders which contain ICC profiles.





Here are a few examples of how file data interacts with the Source, Destination, Rendering Intent, and Black Point Compensation (BPC) settings of the dialog.

### Example 1



In the screenshot above, the color reference shown for the selected PatchTool file is “L\*a\*b\*”, which means that L\*a\*b\* data was used for import. CMYK data was also present in the original file and imported separately; this is shown as “(File values)” and no profile information is associated with the CMYK data. As for RGB data, we see that the *sRGB (PatchTool)* profile is associated with it, as well as a “Relative Colorimetric” rendering intent and no BPC; this profile is the one currently selected in the file and it could be changed if we closed the Gamut Tools dialog. Finally, we see that XYZ data in the file is currently computed using Illuminant D50 and the 2 degree Observer. Those are the data types from which we can “Convert” or “Clip check” with this file.

The selected Source profile is of the RGB type. This means that RGB data from the file will be assigned to the Source. If we had selected a CMYK profile for the Source, then the PatchTool file’s CMYK data, the *File values*, would be assigned to it. Now let’s see the path associated with each button, starting with the file data:

#### Data sent to Source (i.e. assigned to the Source):

**Convert to Dest.:** L\*a\*b\* in file converted to *sRGB (PatchTool)* in opened PatchTool file; RGB in PatchTool file assigned to Source profile (*sRGB (PatchTool)*); RGB Source converted to Destination profile (*Adobe RGB (PatchTool)*).

**Convert to PCS:** L\*a\*b\* in file converted to *sRGB (PatchTool)* in opened PatchTool file; RGB in PatchTool file assigned to Source profile (*sRGB (PatchTool)*); RGB Source converted to PCS (XYZ / L\*a\*b\* in D50).

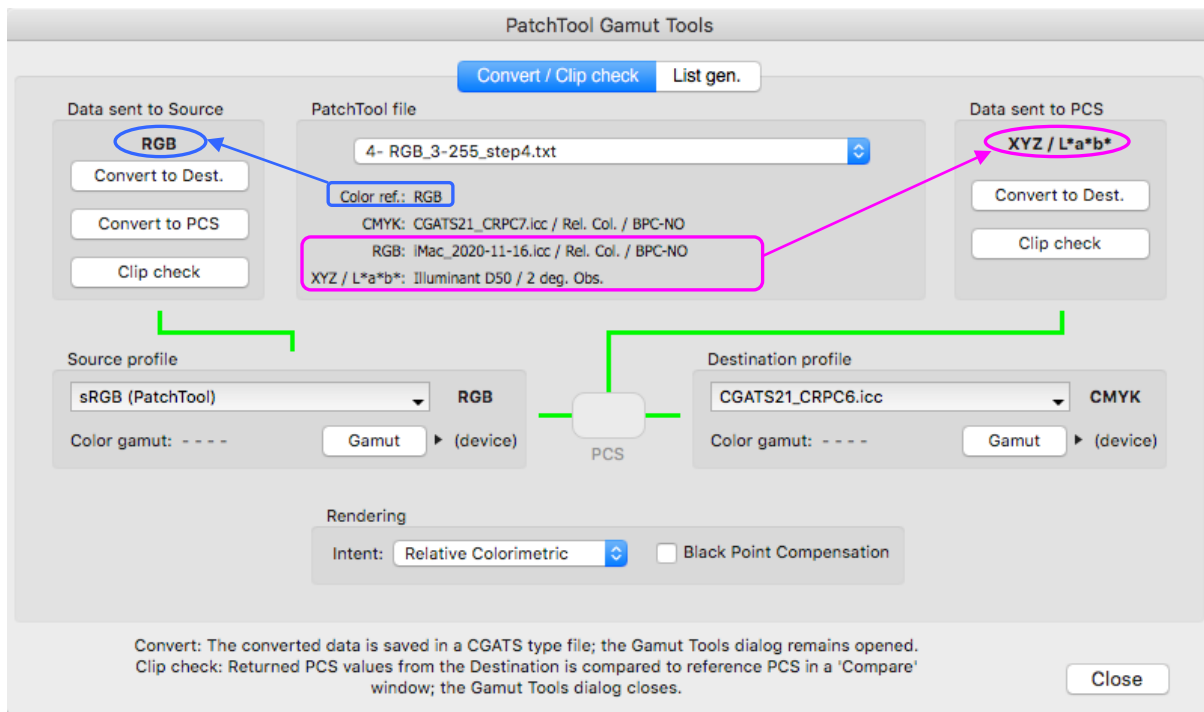
**Clip check:** L\*a\*b\* in file converted to *sRGB (PatchTool)* in opened PatchTool file; RGB in PatchTool file assigned to Source profile (*sRGB (PatchTool)*); RGB Source first converted to PCS, to be used as **Reference**, and then converted to Destination profile (*Adobe RGB (PatchTool)*); RGB Destination clipped and returned to PCS (XYZ / L\*a\*b\* in D50), to be used as **Sample**.

#### Data sent to PCS (i.e. assigned to the PCS):

**Convert to Dest.:** L\*a\*b\* D50 in file assigned to the PCS; PCS converted to Destination profile (*Adobe RGB (PatchTool)*).

**Clip check:** L\*a\*b\* D50 in file assigned to the PCS and used as **Reference**; PCS converted to Destination profile (*Adobe RGB (PatchTool)*); RGB Destination clipped and returned to PCS (XYZ / L\*a\*b\* in D50), to be used as **Sample**.

## Example 2



The color reference shown for the selected PatchTool file is “RGB”, which means that RGB data was used for import and converted to XYZ, using either a profile found in the file or, if none found, an assigned profile. This RGB profile, *iMac\_2020-11-16.icc*, cannot be changed for this file. CMYK data was not present in the original file and CMYK data was derived from XYZ using the *CGATS21\_CRPC7.icc* profile. XYZ data in the file is currently computed using Illuminant D50 and the 2 degree Observer.

The selected Source profile is of the RGB type. RGB data from the file will be assigned to the Source. In this case, the RGB profile that was assigned in the PatchTool file is irrelevant, since the RGB values of the original file will be assigned to the Source profile with no conversion whatsoever. Now let’s see the path associated with each button, starting with the file data:

### Data sent to Source:

**Convert to Dest.:** RGB in file assigned to Source profile (*sRGB (PatchTool)*); RGB Source converted to Destination profile (*CGATS21\_CRPC6.icc*), a CMYK space.

**Convert to PCS:** RGB in file assigned to Source profile (*sRGB (PatchTool)*); RGB Source converted to PCS (XYZ / L\*a\*b\* in D50).

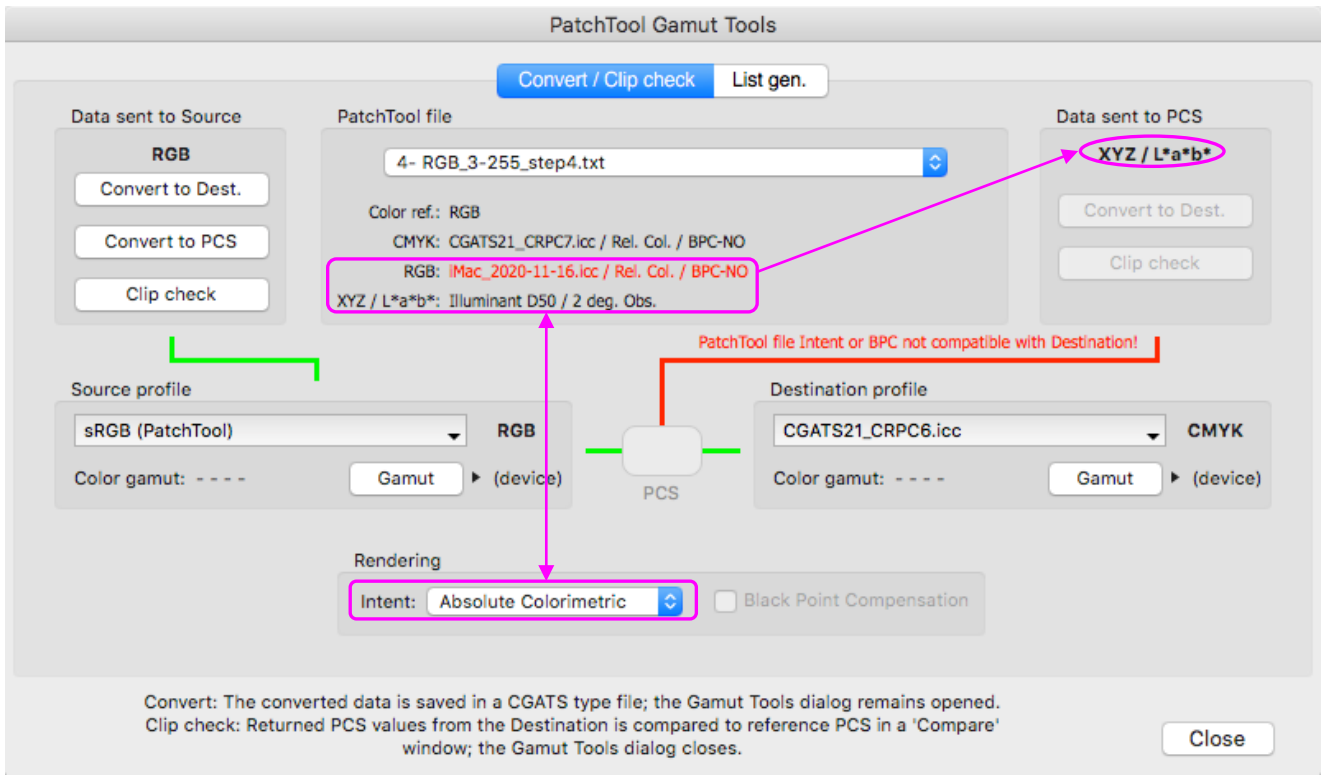
**Clip check:** RGB in file assigned to Source profile (*sRGB (PatchTool)*); RGB Source converted to PCS, to be used as **Reference**, and converted to Destination profile (*CGATS21\_CRPC6.icc*); CMYK Destination clipped and returned to PCS (XYZ / L\*a\*b\* in D50), to be used as **Sample**.

### Data sent to PCS:

**Convert to Dest.:** RGB in file converted to XYZ using the *iMac\_2020-11-16.icc* profile with Relative Colorimetric intent and no BPC; XYZ D50 in file assigned to the PCS; PCS converted to Destination profile (*CGATS21\_CRPC6.icc*).

**Clip check:** RGB in file converted to XYZ using the *iMac\_2020-11-16.icc* profile with Relative Colorimetric intent and no BPC; XYZ D50 in file assigned to the PCS and used as **Reference**; PCS converted to Destination profile (*CGATS21\_CRPC6.icc*); CMYK Destination clipped and returned to PCS (XYZ / L\*a\*b\* in D50), to be used as **Sample**.

### Example 3



The PatchTool file, the Source profile, and the Destination profile, are the same as those of **Example 2**. However, the Rendering Intent of Gamut Tools was changed from “Relative Colorimetric” to “Absolute Colorimetric”. We see that the link assigning the PatchTool file data to the PCS is now red and that the buttons in the “Data sent to PCS” box are dimmed. There is also a message indicating an incompatibility of intent or BPC in the data path.

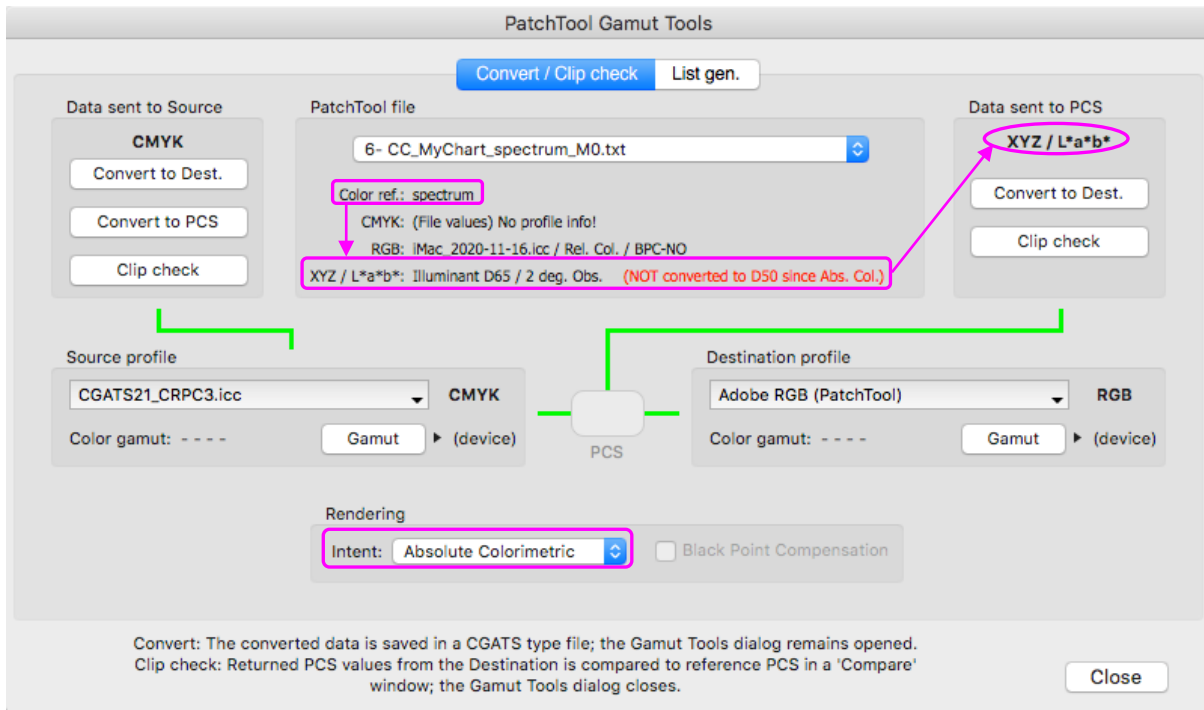
The path between the original file and the Destination profile for “**Data sent to PCS**” is:

**Convert to Dest.:** RGB in file converted to XYZ using the *iMac\_2020-11-16.icc* profile with **Relative Colorimetric** intent and no BPC; XYZ D50 in file assigned to the PCS; PCS converted to Destination profile (*CGATS21\_CRPC6.icc*) using **Absolute Colorimetric** intent and no BPC.

While in appearance this is a conversion with data assigned to the PCS, this conversion is really RGB data assigned to the *iMac\_2010-11-16.icc* **Source** profile since this is where the XYZ data in the PatchTool file came from. In order to be coherent, the intent and BPC settings must be the same for all parts of a conversion (from Source to PCS and then from PCS to Destination), and the conversion should be prevented when they are different; this is what happened here.

You will note that the links between the “**Data sent to Source**” and the **Destination** profile are green. This is expected since the RGB data in the PatchTool file is not affected by the profile associated to it in the file. The data paths are thus the same as those of Example 2, with the only change being the Rendering Intent of the Source to Destination conversion.

## Example 4



The color reference shown for the selected PatchTool file is “spectrum”. CMYK data was also present in the original file and imported separately; this is shown as “(File values)” and no profile information is associated with the CMYK data. As for RGB data, we see that the *iMac\_2020-11-16.icc* profile is associated with it, as well as a “Relative Colorimetric” rendering intent and no BPC; this profile is the one currently selected in the file and it could be changed if we closed the Gamut Tools dialog. XYZ data in the file is currently computed, from spectral data, using Illuminant D65 and the 2 degree Observer; there is a warning indicating that XYZ data will not be converted to D50 since the Rendering Intent selected in the Gamut Tools dialog is “Absolute Colorimetric”. However, all the links are green and all the buttons are enabled. The conversions data paths are:

### Data sent to Source:

**Convert to Dest.:** CMYK in file assigned to Source profile (*CGATS21\_CRPC3.icc*); CMYK Source converted to Destination profile (*Adobe RGB (PatchTool)*).

**Convert to PCS:** CMYK in file assigned to Source profile (*CGATS21\_CRPC3.icc*); CMYK Source converted to PCS (XYZ / L\*a\*b\* in D50).

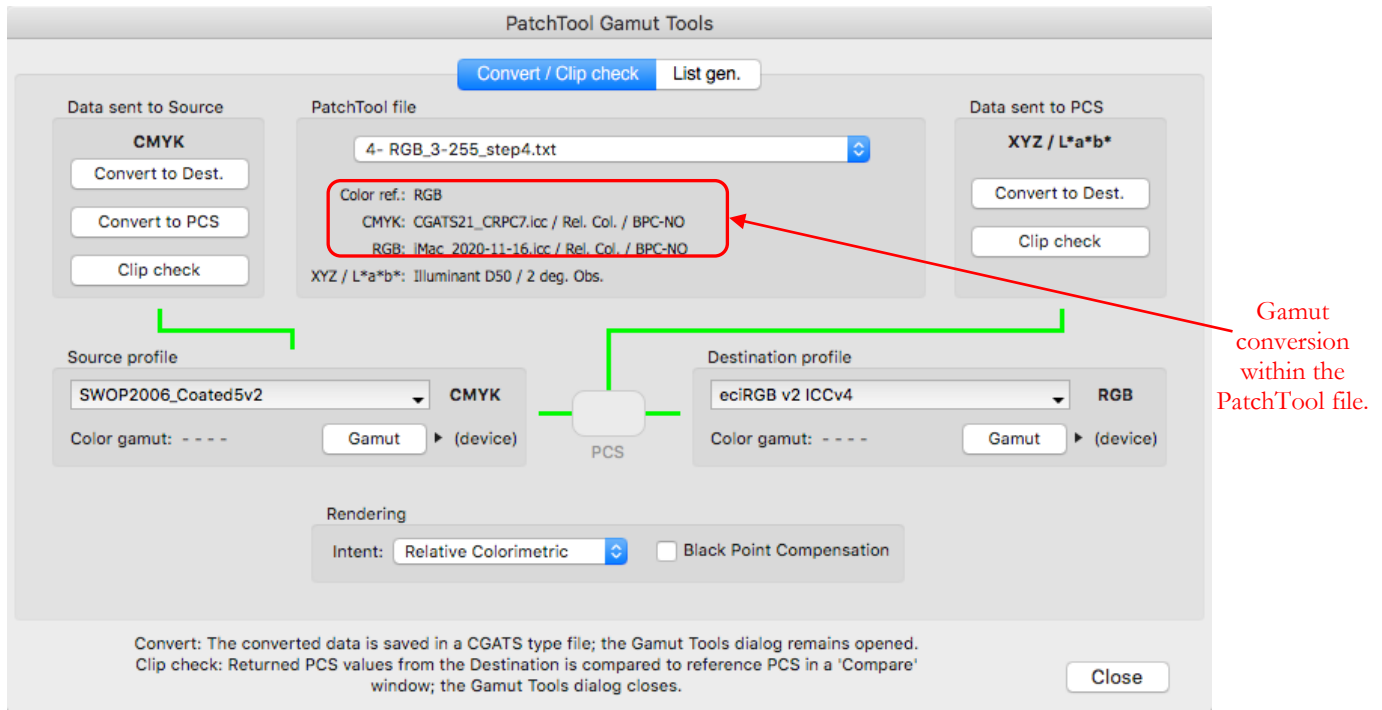
**Clip check:** CMYK in file assigned to Source profile (*CGATS21\_CRPC3.icc*); CMYK Source converted to PCS, to be used as **Reference**, and converted to Destination profile (*Adobe RGB (PatchTool)*); RGB Destination clipped and returned to PCS (XYZ / L\*a\*b\* in D50), to be used as **Sample**.

### Data sent to PCS:

**Convert to Dest.:** Spectral data in file converted to XYZ using the D65 Illuminant; XYZ D65 assigned to the PCS with no conversion to D50 since the conversion is Absolute Colorimetric; PCS converted to Destination profile (*Adobe RGB (PatchTool)*).

**Clip check:** Spectral data in file converted to XYZ using the D65 Illuminant; XYZ D65 assigned to the PCS with no conversion to D50 since the conversion is Absolute Colorimetric, and also used as **Reference**; PCS converted to Destination profile (*Adobe RGB (PatchTool)*); RGB Destination clipped and returned to PCS (XYZ / L\*a\*b\* in D50), to be used as **Sample**.

## Example 5



The color reference shown for the selected PatchTool file is “RGB”, the assigned RGB profile is *iMac\_2020-11-16.icc*; this profile was used to derive the PatchTool file XYZ data. CMYK data was not present in the original file and CMYK data was derived from XYZ using the *CGATS21\_CRPC7.icc* profile. **What we have here is a complete gamut conversion within the PatchTool file:** RGB assigned to *iMac\_2020-11-16.icc* Source and converted to *CGATS21\_CRPC7.icc* Destination with Relative Colorimetric Intent and no BPC.

Now, because the Source profile is of the CMYK type, the PatchTool file’s CMYK data will in turn be assigned to the Gamut Tools Source profile (*SWOP2006\_Coated5v2*). It is important to note that this assignment is NOT a conversion, and what we are doing here is using CMYK data computed in the *CGATS21\_CRPC7.icc* space and assign it as if it was *SWOP2006\_Coated5v2* space data. The conversions data paths are:

### Data sent to Source:

**Convert to Dest.:** CMYK in file assigned to Source profile (*SWOP2006\_Coated5v2*); CMYK Source converted to Destination profile (*eciRGB v2 ICCv4*).

**Convert to PCS:** CMYK in file assigned to Source profile (*SWOP2006\_Coated5v2*); CMYK Source converted to PCS (XYZ / L\*a\*b\* in D50).

**Clip check:** CMYK in file assigned to Source profile (*SWOP2006\_Coated5v2*); CMYK Source converted to PCS, to be used as **Reference**, and converted to Destination profile (*eciRGB v2 ICCv4*); RGB Destination clipped and returned to PCS (XYZ / L\*a\*b\* in D50), to be used as **Sample**.

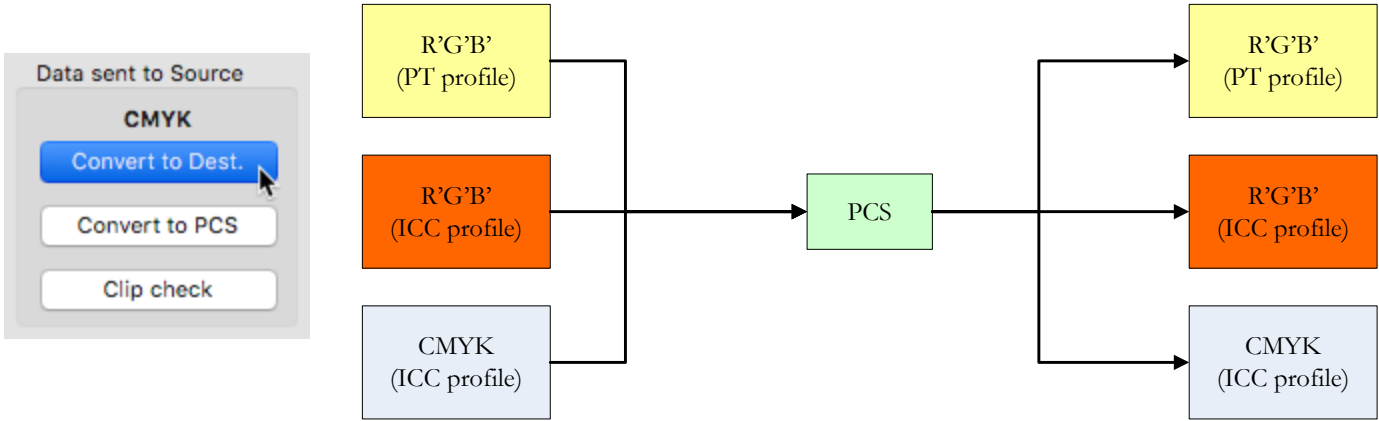
### Data sent to PCS:

**Convert to Dest.:** RGB in file converted to XYZ using the *iMac\_2020-11-16.icc* profile with Relative Colorimetric intent and no BPC; XYZ D50 in file assigned to the PCS; PCS converted to Destination profile (*eciRGB v2 ICCv4*). This is essentially a conversion between two RGB spaces.

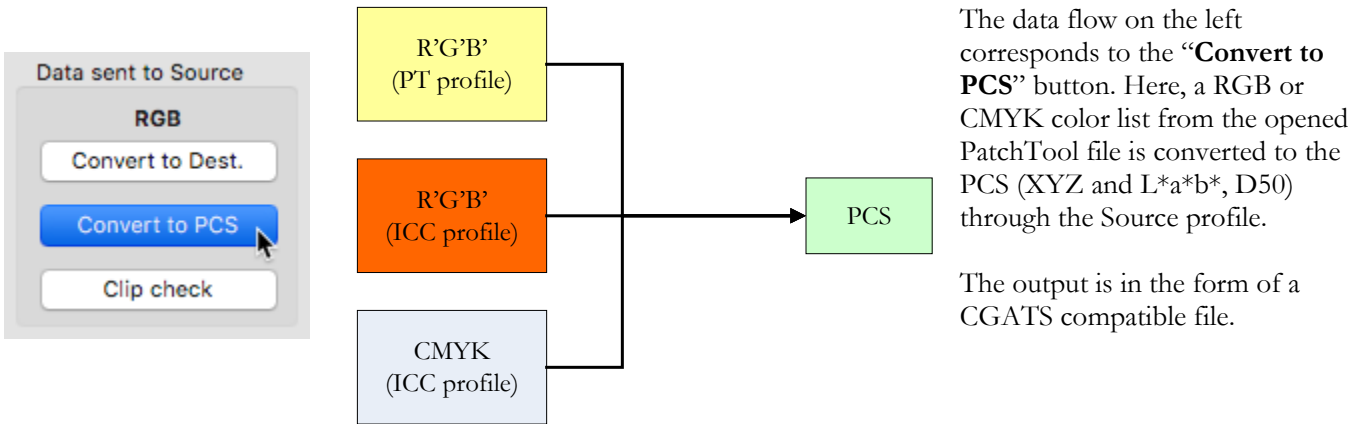
**Clip check:** RGB in file converted to XYZ using the *iMac\_2020-11-16.icc* profile with Relative Colorimetric intent and no BPC; XYZ D50 in file assigned to the PCS and used as **Reference**; PCS converted to Destination profile (*eciRGB v2 ICCv4*); RGB Destination clipped and returned to PCS (XYZ / L\*a\*b\* in D50), to be used as **Sample**. This is essentially a clip check between two RGB spaces.

### 3.13.2 The “Convert / Clip check” tab: Convert

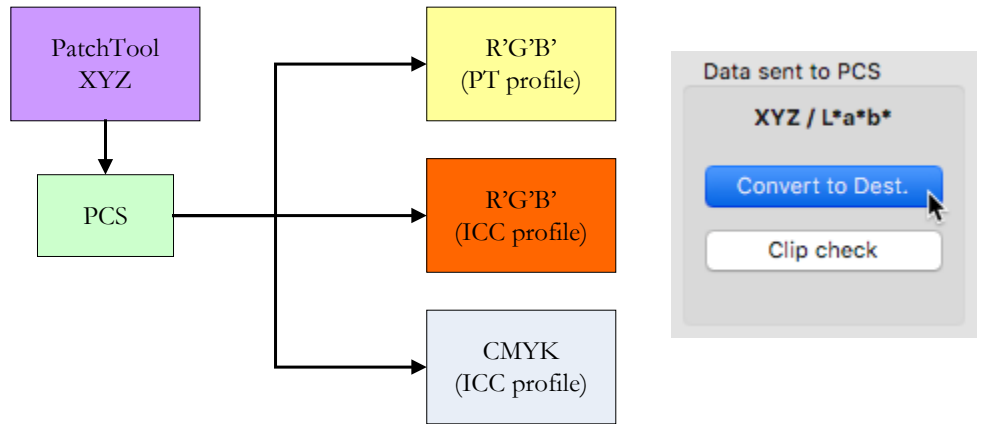
In the upper-left of the Gamut Tools window, in the box labeled “Data sent to Source”, you see either “CMYK” or “RGB” over the three buttons, depending on the Source profile’s type. The data flow path corresponding to the “Convert to Dest.” button is the following (“PT profile” is the built-in PatchTool profile available for five standard RGB spaces):



The above data flow converts a RGB or CMYK color list assigned to a Source profile to a RGB or CMYK color list assigned to a Destination profile. The output is in the form of a [CGATS](#) compatible file.



The data flow on the right corresponds to the “Convert to Dest.” button located in the upper-right of the Gamut Tools window, in the box labeled “Data sent to PCS”. This data flow takes XYZ color lists (i.e. L\*a\*b\*), assigns them to the PCS, and converts them to RGB or CMYK by going through the Destination profile.



The output is in the form of a CGATS compatible file.

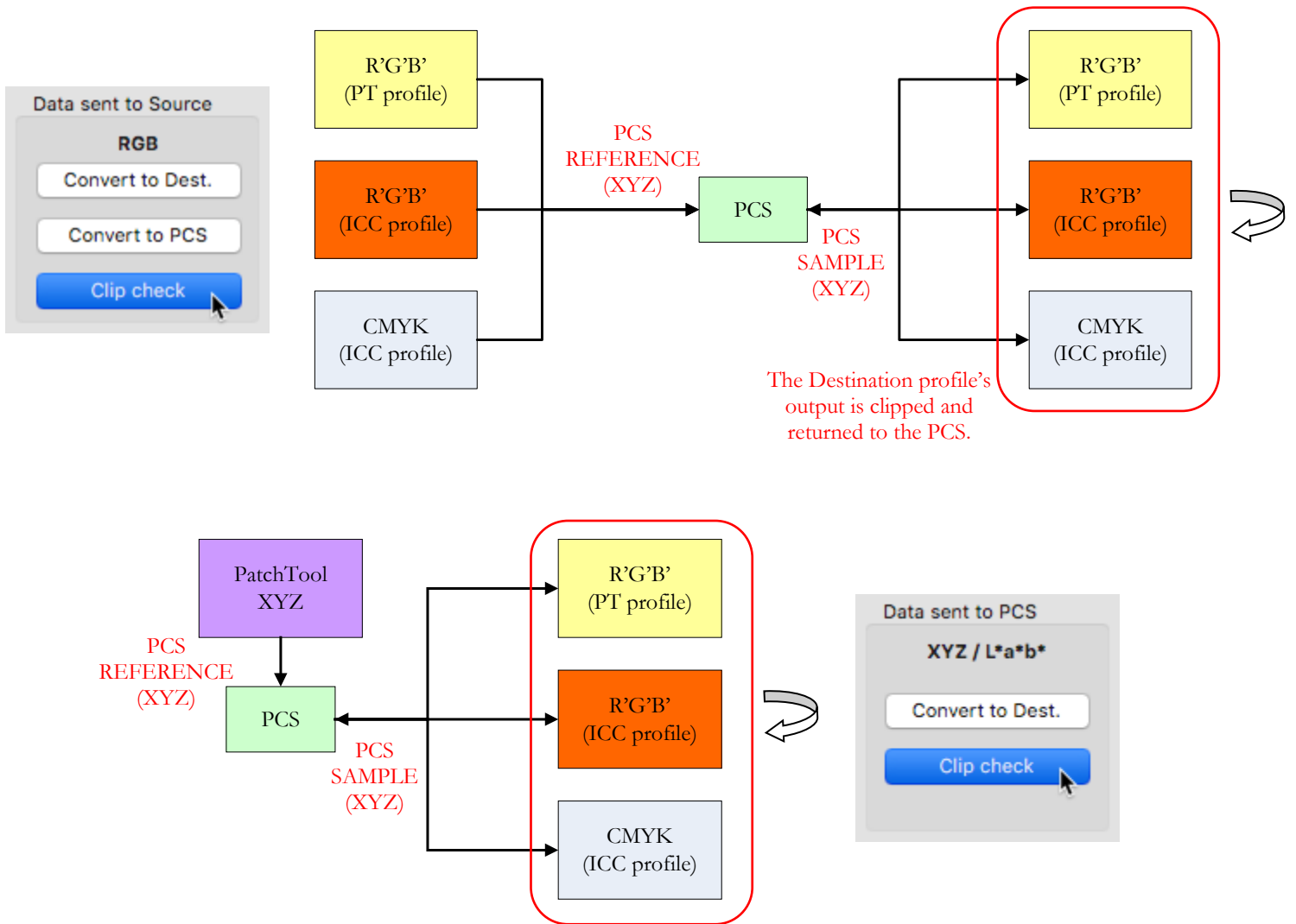


### 3.13.3 The “Convert / Clip check” tab: Clip check

A “Clip check” is used to evaluate if a color is within the gamut of a Destination profile and, if not, by how much it differs. If the Destination profile is a printer profile, an out-of-gamut color is simply a color that cannot be reproduced by your printer’s inks. Depending on the color, this clipping may be negligible or serious. By making this analysis for a color list, you will obtain the average clipping error for this list and be able to pinpoint where the error is the most important.

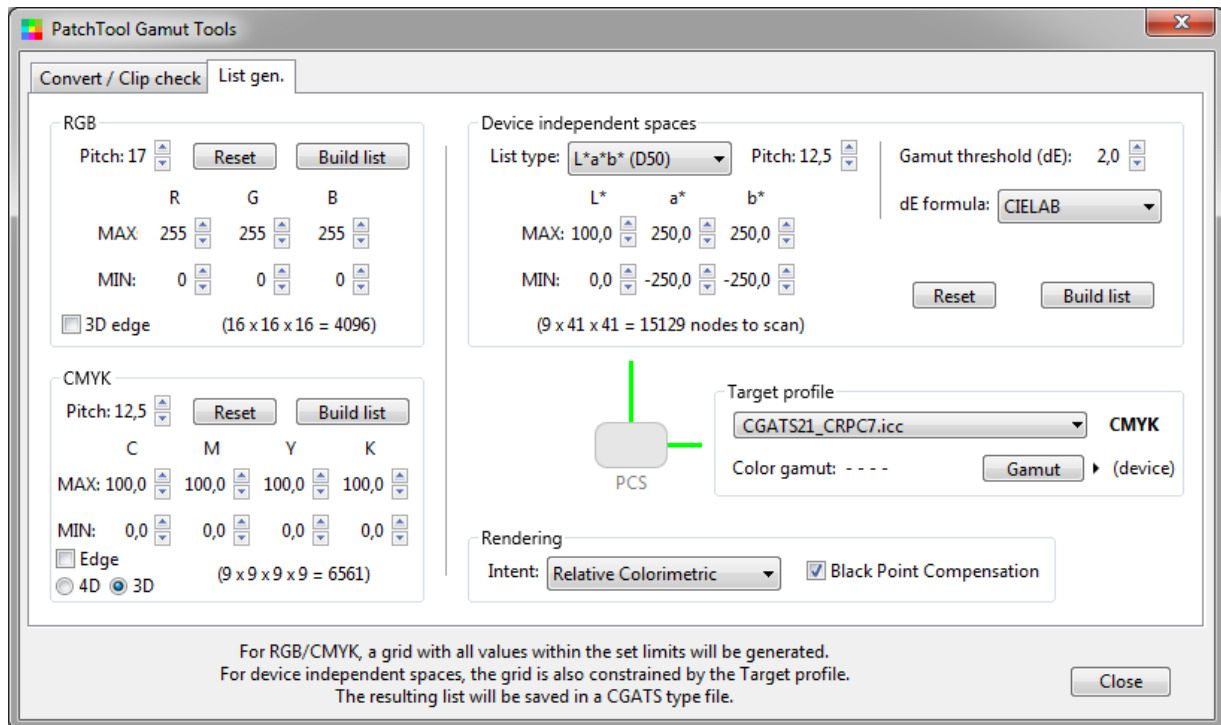
A “Clip check” can be performed by sending RGB or CMYK data to the source or by sending XYZ data to the PCS. In both cases the “reference” data are the initial PCS XYZ values and the “sample” data are the clipped values returned to the PCS from the Destination profile output (RGB or CMYK).

The reference is thus converted a first time between the PCS and the Destination profile, where it is clipped by the profile gamut. For example, if the destination profile is of the RGB type, R, G, and B values will be clipped to 255 if they exceed 255, and to 0 if they are negative; in all other cases, the profile output is rounded to the nearest integer. The profile output is then processed backward in the profile, converting the values back to the PCS, where they become the sample. The reference and sample, which are both XYZ in D50, are finally compared in a new PatchTool “Compare” window which opens at the end of the process, and where you can perform a detailed statistical analysis. Please note that when a “Clip check” is completed, the Gamut Tools window closes.





### 3.13.4 The “List gen.” tab



The tools in this tab are designed to generate fixed pitch color lists in both device dependent (RGB and CMYK) and device independent ( $L^*a^*b^*$ ,  $L^*C^*h$ , XYZ) color spaces. The adjustable pitch is used for all coordinates of a given color space. Different minimum and maximum values can be assigned to each color coordinate. The output is in the form of a CGATS compatible file which can then be opened in PatchTool.

A color list will be generated for all combinations of coordinates within the selected minimum and maximum user-selected values, thus filling the “volume” defined by these limits. You can also generate a color list containing only the coordinates on the edge of this volume, where the retained coordinates form a “shell” around the volume.

Because device independent color spaces can describe all visible colors, and because all practical color rendering devices, monitors and printers for instance, can show or print only a fraction of these, we need to further constrain how we generate color lists with such coordinates. This is done by assigning a Target profile to the list; this profile is the same as the “Destination profile” of the “[Convert / Clip check](#)” tab.

The number of color patches for RGB and CMYK is deterministic, i.e. not subject to external parameters, and can be computed directly from the specified pitch and the coordinates’ ranges.

For device independent spaces, PatchTool starts with the extremes of the user-selected coordinate ranges and checks if these color values are within the selected profile. This is not a deterministic process since the profile shape is complex, and we cannot provide the number of color patches based only on the pitch and the coordinate ranges. Here, the user-selected pitch and ranges define the total number of nodes within the scan volume, nodes that are used in finding the profile edge, by scanning from the extreme values towards the range center, i.e. scanning from the outside-in. Non-visible color values are rejected from the scan and, in practice, the program needs to probe only a fraction of the total number of nodes to find the profile edge.

This edge detection process is similar to what PatchTool does for a [Clip check](#) or when determining the “PatchTool legacy” and “ISO 18621-11 usable” [gamut volume](#): we start with PCS values, convert them to the Target profile output, check for clipping, and convert back the output to the PCS for comparison with the original color coordinates.

Because many profiles are made of Look-Up-Tables (LUTs), the profile edge is not an abrupt transition, and we need a tolerance to accept or reject the gamut edge detection. This tolerance is set by the “Gamut threshold” value and the color difference formula. To further complicate this process, we have found that many CMYK profiles are not very precise **within** the gamut, making the gamut edge detection even more challenging (PatchTool automatically increases the threshold internally in these cases).

You can have an idea of the Target profile LUTs symmetry by looking at the patch name (SAMPLE\_NAME) in the output file, which is in fact the round-trip error going from the PCS to the profile output (the B2A LUT), and then from the profile output back to the PCS (the A2B LUT). This is illustrated below, where the roundtrip error is a number preceded by “dE\_”. Most patches within the list will show a small roundtrip error, but the patches near the edge may show an error close to the specified threshold. However, for CMYK profiles, you will also see roundtrip errors higher than the threshold for color patches within the gamut.

The roundtrip error (DeltaE) is saved as the SAMPLE\_NAME.

4327	dE_00.33	65.000	10.000	40.000
4328	dE_00.34	65.000	10.000	45.000
4329	dE_00.49	65.000	10.000	50.000
4330	dE_01.03	65.000	10.000	55.000
4331	dE_01.01	65.000	10.000	60.000

Extract of a “Device independent spaces” color list.

If required, you can sort a “Device independent spaces” color list by round-trip error: First open the file in PatchTool, select “Sort ‘Name’: As text” in the “[Tabular data](#)” tab, and click on the header of the “Name” column.

### RGB lists

When defining a RGB list, you should first set the *Pitch*, then the maximum (*MAX*) for each coordinate, and finally set the minimum (*MIN*) for each coordinate. The minimum value for each coordinate is automatically adjusted when you change the pitch or the maximum of a coordinate. The pitch and maximum range values are adjustable with a precision of “1”, while the minimum range values are adjustable in steps equal to the pitch.

Please note that when you adjust the maximum value, the minimum value is also adjusted to maintain the difference between *MAX* and *MIN* to an integer number of pitch values.

The number of nodes for each coordinate is shown below the value setting arrows. The number of nodes for each coordinate is derived from:

$$\text{number of nodes for one coordinate} = ((MAX - MIN) / Pitch) + 1$$

For example, with the values indicated in the screenshot below, on the left, we obtain:

$$((255 - 0) / 17) + 1 = 16$$

The number of patches in the list is then obtained by multiplying the number of nodes of each coordinate:

$$(16 \times 16 \times 16 = 4096)$$

RGB

Pitch: 17

	R	G	B
MAX:	255	255	255
MIN:	0	0	0

3D edge (16 x 16 x 16 = 4096)

RGB

Pitch: 8

	R	G	B
MAX:	168	250	128
MIN:	0	242	128

3D edge (22 x 2 x 1 = 44)

The color list defined by the settings above on the left enclose the entire three-dimensional RGB space, with all three coordinates ranges set between 0 and 255; the RGB volume is a perfect cube, with color patches uniformly distributed both on the surface of the cube and within it. If you wish, you can restrain the ranges of any coordinate to suit a particular requirement; the settings shown above on the right define a two dimensional plane with 44 patches, where “B” is fixed at 128 for all patches, and where R an G are further limited to specific ranges.

You may also be interested in getting only the color patches which are on the surface of the cube (or on the rectangular box defined by partial ranges of each coordinate). These patches can be obtained by selecting the “3D edge” box, as shown below. We see that, compared with the screenshot of the previous page, the number of patches is now shown as (1352 patches on edge) instead of (16 x 16 x 16 = 4096). These 1352 patches are located on the six faces of the RGB cube. Because some of the patches are common to two faces, it is more convenient to indicate the total number of patches than the individual number of patches on each face.

RGB

Pitch: 17    Reset    Build list

R    G    B

MAX: 255    255    255

MIN: 0    0    0

3D edge    (1352 patches on edge)

**Note:** It is interesting to understand how an “edge” is defined. For any group of coordinates, an edge is obtained when the value of one coordinate in the group is fixed either to its maximum value or to its minimum value. Using the settings shown in the illustration above, we obtain a first face by fixing R to 255 and varying both G and B between 0 and 255 (with a pitch of 17). We obtain a second face by fixing R to 0 and again varying both G and B between 0 and 255. The other four faces of the cube are obtained by fixing the minimum and maximum of G and B respectively, and varying the other two coordinates. We will use this hindsight to better understand how edges are formed with four dimension spaces such as CMYK.

### CMYK lists

When defining a CMYK list, and similarly to RGB lists, you should first set the pitch, then the maximum for each coordinate, and finally set the minimum for each coordinate. The minimum value for each coordinate is automatically adjusted when you change the pitch or the maximum of a coordinate. The pitch and maximum range values are adjustable with a precision of “0,5”, while the minimum range values are adjustable in steps equal to the pitch. When you adjust the maximum value, the minimum value is also adjusted to maintain the difference between MAX and MIN to an integer number of pitch values.

The number of nodes for each coordinates and the number of patches is computed with the method presented in the preceding page for the RGB lists.

CMYK

Pitch: 12,5    Reset    Build list

C    M    Y    K

MAX: 100,0    100,0    100,0    100,0

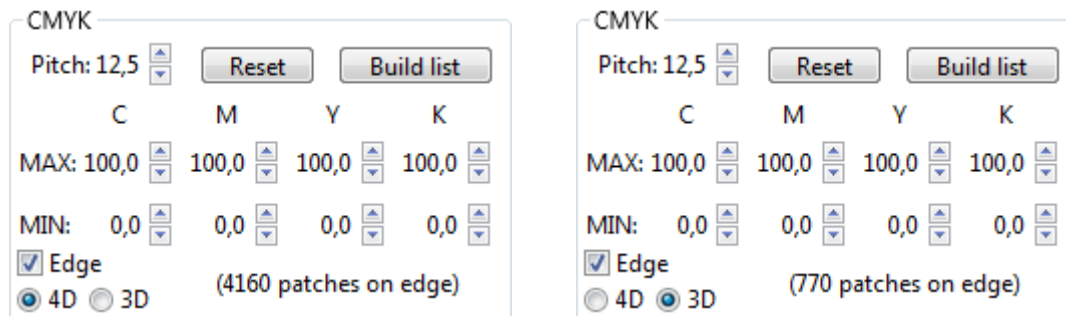
MIN: 0,0    0,0    0,0    0,0

Edge    (9 x 9 x 9 x 9 = 6561)

4D     3D

Because we most often “visualize” CMYK gamuts as they appear converted in 3D  $L^*a^*b^*$  space, we are never confronted to the fact that a CMYK space really has four dimensions (even if these dimensions are partly coupled by replacing C+M+Y by K). Visualizing a gamut in 4D is not a trivial exercise, and you may at first be confounded by the concept of edges in 4D! However, by analogy with the 3D RGB space where edges represent 2D planes, we can infer that edges of a 4D spaces are in fact 3D volumes. Let’s extend the definition of an edge, presented at the end of the [RGB list](#) section, to 4D. Using the CMYK values shown above, a first edge could be defined by fixing the C coordinate to 100 and varying M, Y, and K between 0 and 100. We can clearly see that this 4D edge is indeed a 3D volume defined by the MYK coordinates; when converted to  $L^*a^*b^*$ , these coordinates will define a 3D

L\*a\*b\* volume filled with coordinates, i.e. not only on the volume edge. Still, this 4D edge is useful when you want to generate all possible color patches corresponding only to the maximum and minimum of a given coordinate (Note: the minimum and maximum can also be the same value!). When visualized in [3D L\\*a\\*b\\* space](#), you see that a 4D edge color list has more uniformly distributed data points whereas a 4D volume has more points in the bottom part of the L\*a\*b\* volume. You thus get a color list with the same L\*a\*b\* “coverage” but with much less data points. As an example, we can compare the number of patches for the CMYK list on the preceding page (9 x 9 x 9 = 6561) with the same list restricted to a 4D edge, as shown just below on the left (4160 patches on edge).

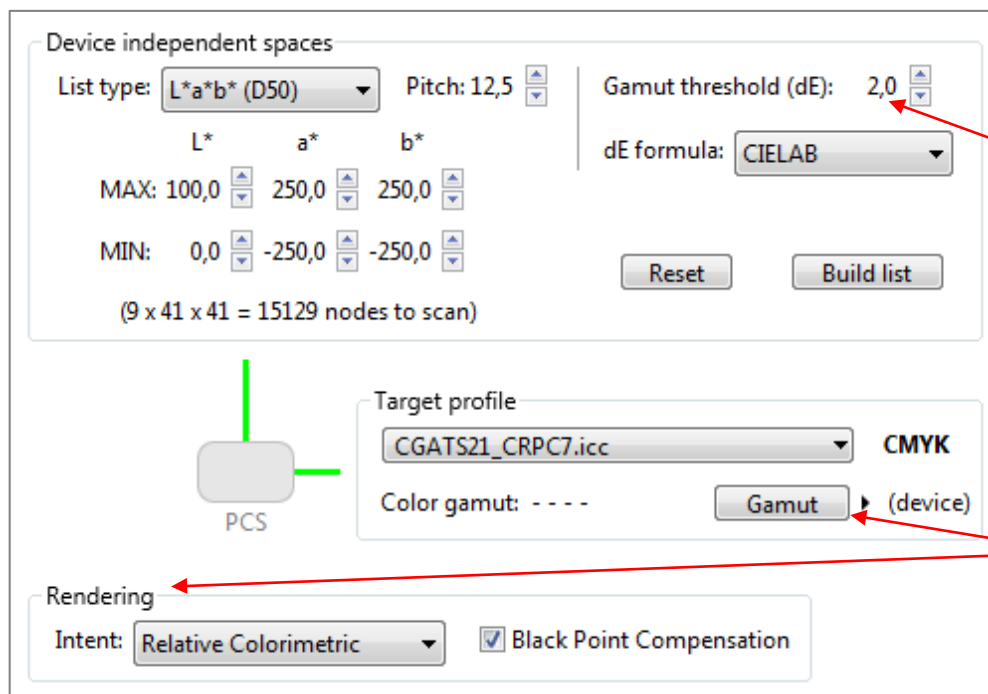


You may want to further limit the color list to the patches located on the edges in L\*a\*b\* space. This is possible by clicking on the 3D edge button and selecting the “Edge” checkbox. This 3D edge is obtained by assigning fixed minimum or maximum values to **two** CMYK coordinates and varying the two others within their assigned ranges. Visualizing such an edge in 4D is not easy, especially when the minimum and maximum values are fully adjustable, but it can be readily appreciated in 3D where it forms a closed shell. Please note that the resulting color lists have no duplicated patches, even if several patches are common to many shell faces; pruning the list is thus not required.

### Device independent spaces lists

As mentioned in the introduction for the “List gen.” tab, the lists for device independent color spaces are limited by user-selected ranges as well as by a Target profile.

The Pitch, MIN, and MAX settings are adjusted in the same way as for the RGB and CMYK lists. However, instead of indicating the number of patches in the list, the program shows the maximum number of nodes enclosed by the selected coordinate ranges.



Start with a value which is half of the “Pitch”. The value should be lowered for high quality profiles, i.e. profiles which have symmetrical A2B and B2A tables.

The gamut volume is affected by the “Rendering”. Select “Absolute Colorimetric” to better match the volume of other programs. See the [‘Computing a profile color gamut’](#) section for more info.

The available list types are shown below. The selections are L\*a\*b\*, L\*C\*h, XYZ, and “Gamut edge”, all defined relative to D50. The “Gamut edge” uses the L\*C\*h space for reference.

Device independent spaces

List type: L\*a\*b\* (D50) Pitch: 12,5 Gamut threshold (dE): 2,0

L\*a\*b\* (D50) b\*

L\*C\*h (D50)

MAX: XYZ (D50) 250,0

Gamut edge

MIN: 0,0 -250,0 -250,0

(9 x 41 x 41 = 15129 nodes to scan)

Reset Build list

In all these lists, the accuracy around the gamut edge depends on many factors:

- i- The selected “Pitch”
- ii- The “Gamut threshold (dE)”
- iii- The “dE formula”
- iv- The Target profile Look-Up-Tables (LUTs) accuracy

Using the right pitch is a compromise between the number of patches we are ready to handle and the accuracy we want on the gamut edge. You should start with a “Gamut threshold” which is about half of the “Pitch” and then reduce it for high quality profiles which have more symmetrical A2B and B2A LUTs; this is more often the case for RGB profiles than for CMYK profiles.

If you superimpose the data points generated from a Target profile, in PatchTool, with the profile shell shown in some third party software, you will notice that the “best” match for LUT-based profiles is often obtained when selecting the “Absolute Colorimetric” intent. We have also found that better visual matches for color lists generated from matrix-based RGB display profiles were obtained when using the “Relative Colorimetric” intent. This does not mean that you should only select these intents to generate color lists since it only demonstrates that these third party programs “assume” these intents when representing the gamut. You should select the intent you are going to use in your workflow or test.

**Note:** While it is possible to generate extremely large lists with a fine pitch, this is not recommended, and success will depend on system resources. Finer pitches should be selected only in conjunction with limited MIN to MAX ranges.

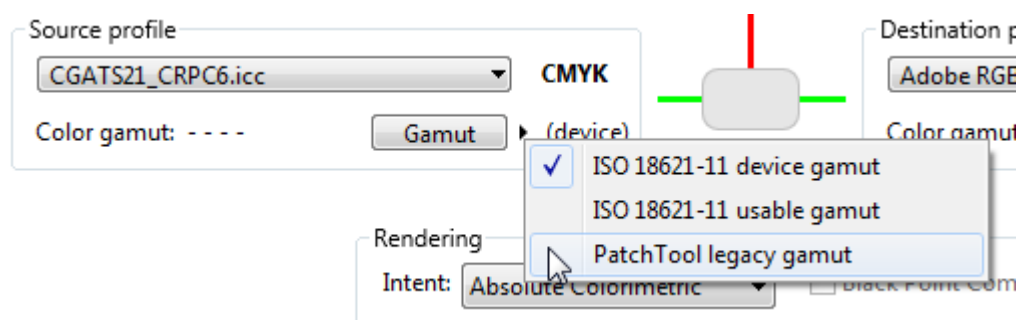
### 3.13.5 Computing a profile color gamut

Unfortunately, at this time, there are very few instruments which can capture the image of a scene and display it with all the colors humans can see. Most devices which deal with color, such as scanners, cameras, monitors, or printers, can only measure or reproduce a subset of these colors. We call this subset the device's color gamut. If we express colors in a 3D space, such as  $L^*a^*b^*$  or XYZ, the color gamut takes the form of a three-dimensional volume. For scanners and cameras, their limited gamut is a consequence of using sensors which do not duplicate the characteristics of the human eye. For monitors and printers, the gamut is limited by the purity and wavelength of the display or ink primaries. We thus need a method to evaluate gamut size.

The most common color device spaces with which we interact with are RGB and CMYK. In these spaces, the minimum color value is zero and the maximum color values are 255 for RGB (for 8 bit data format) and 100 for CMYK. The gamut edges correspond to colors where one of the primaries is either minimum or maximum, for example, all G and B combinations with R=0 or R=255 (Note: CMYK values are often further restricted to a Total Ink Limit, where the sum of C+M+Y+K must not exceed a certain value, but this does not affect the gamut). Because these gamut limits are always the same in device space, the gamut volume is also the same in RGB or CMYK units, even though they may correspond to vastly different human visible color gamuts. This is why the gamut volume is computed in a device-independent color space, which is commonly  $L^*a^*b^*$ , since  $L^*a^*b^*$  scaling is close to a uniformly perceived color space.

For a given profile, the  $L^*a^*b^*$  values are usually obtained by converting all RGB or CMYK values to the Profile Connection Space (PCS), which is generally XYZ or  $L^*a^*b^*$ , in D50. From there, the three-dimensional “volume” occupied by the converted data points represents the gamut volume. Because this requires a profile conversion, the first question is “What Rendering Intent?” We might be tempted to say “Absolute Colorimetric”, and this is a valid “default” choice. However, this is not how profiles are used all the time. Imagine that you are printing a CMYK image with an RGB printer; the conversion path here is from CMYK to the PCS, and then from the PCS to RGB. Let's further assume that the CMYK profile gamut is larger than the RGB profile gamut. In this case, you will fit more values from the CMYK image into the RGB printer gamut, without clipping, if you select the “Perceptual” intent than if you select the “Absolute Colorimetric” intent; in effect, the “Perceptual” intent will compress the image gamut to fit in the printer's gamut.

Three gamut volume computing methods are proposed in Gamut Tools, the **PatchTool legacy** method which was the only method available prior to PatchTool Version 7.1, and the “**device**” and “**usable**” methods of **ISO 18621-11**<sup>4</sup>. The method is selected with the popup menu which opens when you click on the black triangle located on the right of the “Gamut” button.



You can click on the following links to jump to the corresponding sub-sections:

- [PatchTool legacy gamut volume method](#)
- [ISO/TS 18621-11 gamut volume methods](#)
- [Additional color gamut information](#)

<sup>4</sup> [ISO/TS 18621-11:2019](#); *Image quality evaluation methods for printed matter – Part 11: Colour gamut analysis*

## PatchTool legacy gamut volume method

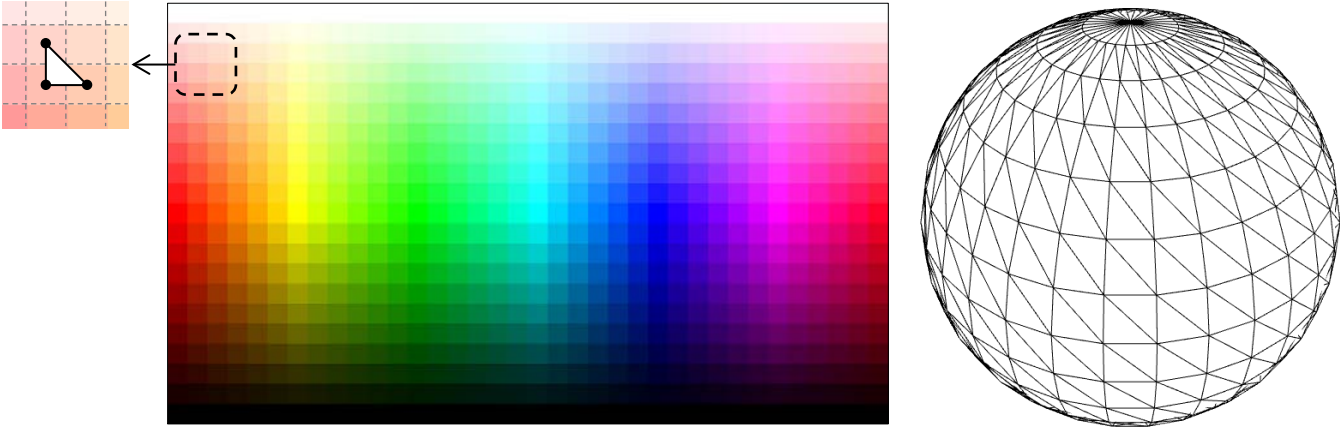
In this method, the gamut is obtained by starting with all visible  $L^*a^*b^*$  colors (well, most of them!), using these colors as input for the PCS, and checking if they result in a clipped RGB or CMYK output. We thus “scan” the profile gamut in  $L^*a^*b^*$  space, layer by layer, using a fine pitch, and then compute the volume by adding all the layers. This is similar to what is done with medical CAT scans where 3D images of the body are formed by combining scan layers. Since the clipping varies with the Rendering Intent, the gamut volume is affected by this setting; you should thus use the same Rendering Intent when comparing two profiles. You should select “Absolute Colorimetric” to better match the gamut volume derived with other programs. However, since you may often use other intents when manipulating color images, you will be surprised by how the rendering intent affects the gamut volume in some profiles.

When selecting the “Absolute Colorimetric” intent, the obtained gamut volumes are, on average, within 5% of the volume computed using the ISO 18621-11 “device” method and within 10% of the volumes obtained in other programs using proprietary, i.e. non-published, methods. The accuracy of the PatchTool legacy method, by itself, is inherently more accurate for RGB profiles, and for CMYK profiles which are well formed. However, we have found that many CMYK profiles are not perfectly symmetrical when converting from CMYK to PCS, which uses the profile’s A2B table, compared to converting from PCS to CMYK, which uses the B2A table. We also found that the “out-of-gamut” flag provided by the Color Management System (CMS), which is used by photo editing programs to tag out of gamut colors, can be unreliable on the gamut edge, and we do not use it when we can. The net effect, in some CMYK profiles, is a slight shift in the location of the gamut edge for darker shades.



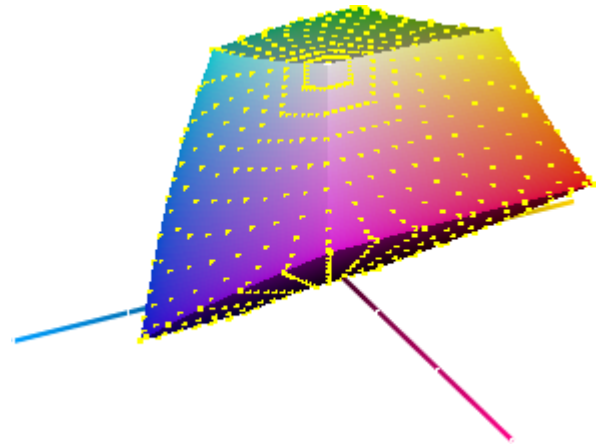
## ISO/TS 18621-11 gamut volume methods

This ISO Technical Specification describes two methods to compute the color gamut from ICC profiles; they name them “**device gamut**” and “**usable gamut**”. Both methods start with the same reference data: a closed form three-dimensional shell in device space, RGB or CMYK, which defines the gamut edge. The device coordinates are predefined and selected to be somewhat uniform once converted in  $L^*a^*b^*$  space. The image below with a rainbow of color patches displays the RGB coordinates which define the reference shell grid; each square patch of this image (not each pixel) is of the same color and represents one data point.



In the reference image, the top row represents identical white coordinates ( $RGB=255$ ) while the bottom row represents identical black coordinates ( $RGB=0$ ); all other coordinates are different. You should imagine that the reference image wraps an **idealized sphere** where the top is white, the bottom is black, and the right edge of the image meets the left edge. Neighboring coordinates are grouped in three to form triangles. One such triangle is shown besides the top-left of the reference image. An example of a sphere meshed with triangles<sup>5</sup> is shown above on the right; in this representation, each vertex<sup>6</sup> corresponds to a color, i.e. a square, from the reference image.

To compute the gamut, the shell device coordinates are converted to the Profile Connection Space (PCS)  $L^*a^*b^*$  coordinates. The image on the right shows the coordinates of the reference image, as yellow dots, in  $L^*a^*b^*$  space once converted using the Adobe RGB space profile (Relative Colorimetric Intent). We can see that the coordinates are uniformly dispersed on the surface of this profile which is represented as a colored solid. The volume of the shell in CIELAB space is then determined by adding the volumes of the tetrahedrons which are formed by each triangle and a point assigned as the gamut center. The total volume is defined as the “**device gamut**”.

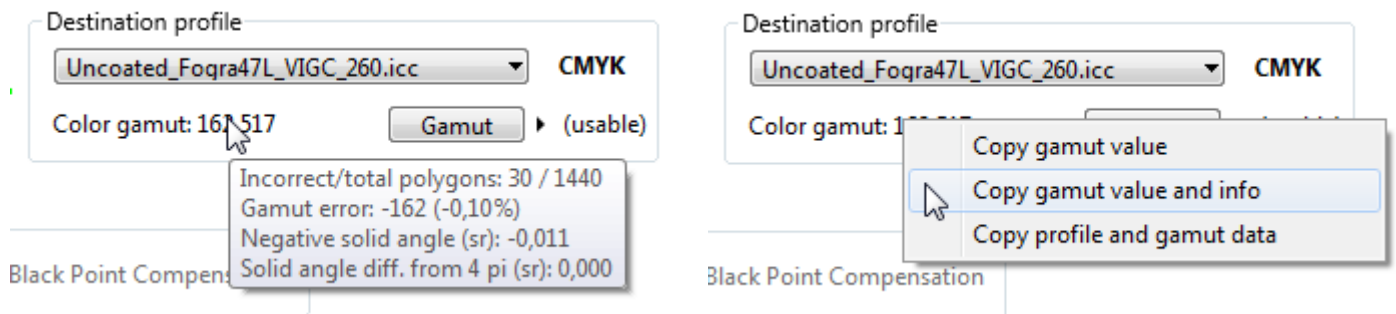


To obtain the “**usable gamut**”, the  $L^*a^*b^*$  coordinates are converted back to device coordinates, and then once again to  $L^*a^*b^*$ . This is similar to what is done in PatchTool’s Clip check and also in PatchTool legacy gamut volume method where the data is affected by the non-symmetrical effects of the A2B and B2A tables. What this means in practice is that the “usable gamut” volume will essentially be the same as the “device gamut” for RGB matrix profiles (which are precisely defined with reversible equations), that it can be somewhat different for RGB profiles based on Look-Up-Tables (LUT) which are based on interpolation, and that it will usually be different for CMYK LUT profiles depending on how CMY and K are separated.

<sup>5</sup> Meshed sphere image: Holger Ludvigsen, <https://blogg.bekk.no/procedural-planet-in-webgl-and-three-js-fc77f14f5505>.  
<sup>6</sup> The sphere image purpose is only to illustrate how the triangles are meshed; the number of rows and columns of this particular sphere do not correspond to those of the reference image.

## Additional color gamut information

Once the gamut is computed, you can obtain additional information on the gamut computation, in the form of a Help tag, by placing the mouse cursor over the gamut result field. You can also copy the data with a menu which appears when you do a mouse right-click over the gamut result field.



**Incorrect/total polygons:** A triangular polygon is considered incorrect if its tetrahedron volume is negative. This can happen if the triangle surface is tilted relative to the gamut center; as per the standard, this volume is subtracted from the total (i.e. we do not use its absolute value). The total number of polygons/tetrahedrons is a fixed value for each device space; there are 1368 polygons for RGB profiles and 1440 polygons for CMYK profiles.

**Gamut error:** The sum, in gamut units, of all negative volume tetrahedrons. As mentioned in the standard, you should use another gamut volume computing method if this error exceeds 1%.

**Negative solid angle (sr):** The solid angle, in steradian, corresponding to all negative volume tetrahedrons.

**Solid angle difference from 4 pi (sr):** The solid angles subtended by all triangles of a profile are added. Negative solid angles from negative volume tetrahedrons are subtracted to the running total. The total angle should always be  $4\pi$  steradians<sup>7</sup> whether or not there are tetrahedrons with negative volume and the difference should be zero. This information is essentially a sanity check on the computation process.

<sup>7</sup> A sphere subtends a  $4\pi$  steradian solid angle at its center.

### 3.13.6 Gamut Tools examples

Here are a few examples of what you can do with the Gamut Tools.

**Note:** Please note that the examples are presented in a compact form, with no detailed instructions, and that a good knowledge of color management workflows may be required. Some of the examples also require a third party program, such as Adobe's "Photoshop", to print a target.

#### 1- Generate a list of patches which can be printed to test a profile gamut.

**Why?** You may want to check the accuracy of a printer profile with patches which are different from the ones used for profiling. Since the same procedure can be used to generate patches to test a display profile, this example will cover both cases.

**How?** Of course you can use the [Idealliance certification method](#), which PatchTool supports. However, your target profile may be larger than the SWOP or GRACoL profiles and you may want a list which completely fills the profile. What you can do is generate a L\*a\*b\* color list from the "[List gen.](#)" tab. Select "L\*a\*b\* (D50)" from the "List type" menu of the "[Device independent spaces](#)" box, then click the "Reset" button in the box. Select CIELAB as the "dE formula" and a "Gamut threshold" of 4,0. Select your printer or display profile as the "Target profile", then select the rendering intent you will use for testing. Finally, build the list. The program will generate all L\*a\*b\* patches enclosed by the target profile which are within the set threshold of the gamut edge. You may adjust the list pitch to obtain more or less patches, depending on the profile's gamut.

To test a display, use this list with [Display-Check](#). To test a printer, generate a TIF-L\*a\*b\* image from the list with PatchTool [Export](#) and print the image using the selected rendering intent; measure the patches with [Patch-Reader](#), and [compare](#) the measurements with the original list in PatchTool.

#### 2- Convert a device dependent color list (in RGB or CMYK) to L\*a\*b\*.

**Why?** We often have a list of RGB or CMYK colors, which are device dependent, without the corresponding device independent (i.e. L\*a\*b\*) colors used. Such a list may define, for instance, color targets to be used in calibrating a printer. One reason why such combined lists are not common is that the device independent values vary according to the rendering intent. However, since you know the intent that you will use in your workflow, you may want to get the device independent values for validation purposes.

**How?** Open the target list, which we assume contains only RGB or CMYK data. Assign ANY profile to the list since this will have no effect on what follows (Of course, the list data type, RGB or CMYK, MUST match the device profile type). Select this PatchTool file in the Gamut Tools "[Convert / Clip check](#)" tab. Then select the device profile as the Source profile, assign the proper rendering intent and click on the "[Convert to PCS](#)" button located in the "Data sent to Source" box.

#### 3- Convert color lists between profiles.

**Why?** Let's say you have a CMYK color list corresponding to *SWOP2006 Coated-3* and you need the corresponding CMYK values in your custom press profile. This is essentially a device-link operation.

**How?** Open the file which contains the CMYK color list. If this file contains only CMYK data, you will be asked to assign a profile; assign ANY profile since this will have no effect on what follows. Select the *SWOP2006 Coated-3* profile as the Source and your custom press profile as the Destination. Select the appropriate rendering settings and click on the "[Convert to Dest.](#)" button located in the "Data sent to Source" box.

#### 4- Check how much clipping will result by converting from a larger gamut profile to a smaller gamut profile.

**Why?** You have images which you regularly print on your wide gamut printer and you are asked to convert these images to a smaller gamut profile, let's say *SWOP2006 Coated-5*. You would like an assessment of how much you could lose in gamut.

**How?** You should first compare the respective [gamut volumes](#) by selecting your printer's profile as the Source and the *SWOP2006 Coated-5* profile as the Destination, and then clicking on the respective profile's "[Gamut](#)" buttons. For the next step we will need a color list with a fixed pitch; from the "[List gen.](#)" tab, generate a device dependent list of the printer profile type (RGB or CMYK) which covers all the possible values (the values shown when you click the "Reset" button should be sufficient; also uncheck the "Edge" checkbox). Close the "Gamut Tools"

window and open the list you just generated in PatchTool; the assigned CMYK or RGB space is irrelevant. Open the Gamut Tools window again and, in the “[Convert / Clip check](#)” tab, select the file you just opened. Click on the “[Clip check](#)” button on the left, where either “RGB” or “CMYK” is shown below “Data sent to Source”, depending on your printer’s profile type. This will result in a new [Compare](#) window (the Gamut Tools window will close). In the compare window, use the “[Patch view](#)” tab to visually get a feel of which patches will be clipped, and the “[Stats](#)” tab to have a numerical evaluation of what portion of the gamut will be clipped, and by how much.

### 5- Check if a profile LUT tables are symmetrical when converting to and from the PCS.

**Why?** It is well known that profiles based on Look-Up-Tables (LUTs) are not symmetrical when converting “From” or “To” the Profile Connection Space (PCS). This non-symmetry is generally minor in RGB profiles but gets higher as the number of primaries grows, such as in CMYK. Printer profiles are most often used in the “PCS-to-Profile output” direction, but converting in the other direction will happen when converting between two output profiles, when you use a Device-Link for instance. So here is a way to evaluate the symmetry of the LUTs. This procedure is almost identical to the one of the previous example, except that the Source and Destination profiles are the same.

**How?** Generate a fixed pitch color list from the “[List gen.](#)” tab. Select the default parameters for the RGB or CMYK list by clicking on the “reset” button. If your profile is of the RGB type, uncheck the “3D edge” checkbox. If your profile is of the CMYK type, select the “4D” button and check the “Edge” checkbox; this will generate a smaller color list that will nonetheless fill the L\*a\*b\* space (see [here](#) for more info). Close the “Gamut Tools” window and open the list you just generated in PatchTool; assign ANY profile to the list since this will have no effect on what follows (However, the list data type, RGB or CMYK, MUST match the tested profile type). Open the Gamut Tools window again and, in the “[Convert / Clip check](#)” tab, select the list you just opened. Select the profile to be tested both as the Source and as the Destination. Click on the “[Clip check](#)” button located in the “Data sent to Source” box. This will result in a new [Compare](#) file (the Gamut Tools window will close). In this new compare file, use the “[Patch view](#)” tab to visually get a feel of which patches are affected by the asymmetry of the LUTs, and the “[Stats](#)” tab to have a numerical evaluation of the effect.

### 6- Two methods to generate a color list of patches located on a gamut edge.

**Why?** You may want to check the accuracy of your workflow only at the gamut edge. Here are two methods to get patches which enclose the gamut.

**How?**

**Method 1:** In the “[List gen.](#)” tab of the Gamut Tools window, select your target profile. In the “[Device independent spaces](#)” “List type” menu, select “Gamut edge”. Reset the parameters, set the “Pitch” to “4.0”, the “Gamut threshold” to “2,0” and the “dE formula” to CIELAB. Build a first list with these settings; you can lower the pitch for more data points and increase the pitch for the opposite result. Save the list and close the Gamut Tools window.

**Method 2:** In the “List gen.” tab of the Gamut Tools window, build an edge list corresponding to your profile type, [RGB](#) or [CMYK](#). Check the “3D edge” or “Edge” checkbox and reset the list parameters; for [CMYK lists](#), also select the “3D” button. You can then adjust the pitch until the number of patches in the list suits your needs. Build and save the list, and close the Gamut Tools window.

The differences between the two methods are:

- i- Method 1 provides a color list of fixed pitch in the L\*C\*h space whereas Method 2 provides, after being imported in PatchTool, a L\*a\*b\* color list of fixed pitch in the RGB or CMYK space.
- ii- Because of the scanning method used in finding the profile edge for device independent spaces, which is dependant on the set “Gamut threshold”, Method 1 data is more “fuzzy”, and may comprise L\*C\*h values located outside of the “hard” limits found with Method 2. This fuzziness is more pronounced for CMYK profiles.

From these lists, you may want to generate an image of the color patches using PatchTool [Export](#) dialog, print a target and measure it with an i1Pro with Patch-Reader (Other programs are required to generate targets for other measuring instruments). You could also convert the L\*C\*h color list of Method 1 to your profile data type (RGB or CMYK), or convert the RGB/CMYK list of Method 2 to L\*a\*b\*. This can all be done in the “[Convert / Clip check](#)” tab.

### 3.14 Idealliance printer and monitor proofing certification

Idealliance® is a membership organization dedicated to the digital imaging, printing, and publishing fields. It develops technical specifications and processes, and promotes them through seminars, trade shows and publications. Its Print Properties Working Group, in collaboration with GRACoL (General Requirements and Applications for Commercial Offset Lithography) and SWOP (Specifications for Web Offset Publications), which are two committees of Idealliance, has been developing the *G7 Proof-to-Print Process*, which comprises calibration, printing, and proofing process control methods. G7, contrary to previous systems, works completely “by-the-numbers”, which mean that there is essentially no visual interpretation in the certification chain.

This section explains how PatchTool can help performing the monitor and printer proofing certification processes, whose intent is to guarantee that what we see on our monitors corresponds to what we can print in-house on proofing printers, and that what we print on our proofing printers corresponds to the final press output.

Idealliance **printer** proofing certification is performed with PatchTool using the [Compare](#) tool where the Reference file is one of Idealliance characterization data sets.

Idealliance **monitor** proofing certification is performed using the [Display-Check](#) tool where the Reference file is one of Idealliance characterization data sets.

Targets and Control Strips reference files are available in the “Idealliance\_Proofing-Certification\_V16” folder located within the PatchTool application folder. You can use the “**File/Open Sample Files/Characterization Data...**” menu as a shortcut to this folder.

Please consult the “\_Read-me\_Idealliance.txt” document in the “Idealliance\_Proofing-Certification\_V16” folder for the latest status on these reference files.

The **reference document** for this section is:

*IDEAlliance PROOFING CERTIFICATION & VERIFICATION PROGRAMS (Version 16)*  
available as

[PROOFING CERTIFICATION PROCESS v16.pdf](#).

Additional characterization data files and some target images are available from the SWOP Web site:

▶ <https://www.swop.org/certification/vendors.asp>

The next section presents important notes on certification. You can click on the following links to jump to the corresponding sections:

- [Important notes on certification](#)
- [Idealliance proofing requirements](#)
- [PRINTER proofing certification procedure \(IT8.7/4\)](#)
- [PRINTER proofing certification procedure \(ISO 12647-7 Control Strip\)](#)
- [PRINTER proofing certification procedure \(ADS and FOGRA Media Wedge\) \(Obsolete\)](#)
- [MONITOR proofing certification procedure \(IT8.7/4\)](#)

### 3.14.1 Important notes on certification

Idealliance has specific requirements that the color-measuring instrumentation should meet in order to receive their approval:

- i- For printer certification, the measurements shall be performed with an X-Rite DTP70 spectrophotometer.
- ii- For monitor certification, the measurements shall be performed with an X-Rite i1Pro spectrophotometer.
- iii- The above instruments shall be “qualified” by Idealliance. For the DTP70, this means that it should be within a certain tolerance relative to the other instruments used by Idealliance to define the certification requirements. For the i1Pro, this means that it has to be within a certain tolerance relative to a secondary reference, such as the PR-650 spectroradiometer from Photo Research.

Does this mean that you cannot use another instrument, such as an iSis, an i1iO, a SpectroScan, an i1Pro, or any other instrument to check compliance? In a strict sense, no, but in practice, you will get a good assessment of your workflow as long as your measuring instrument is within its calibration requirements.

Why will I still get useful info? Well, let’s first assume you have a DTP70 which is not qualified by Idealliance. This instrument will still be within the inter-instrument agreement range of all DTP70 manufactured by X-Rite. In practice, this means that you should, statistically, see a slight increase in the measured errors relative to the official Idealliance values. In some cases, this increase will push your measured values outside the tolerance limits set out by Idealliance. If the discrepancy is larger than the inter-instrument agreement value (stated as  $0,5 \Delta E^*$  max., CIE94), then you have a good hint that your process would not be certifiable. If the error is less than the inter-instrument value, then you have a pretty good system which could likely pass official certification.

If using an instrument other than the DTP70, the difference between your measurements and those made with a “qualified” unit is likely to be higher than what it would be if you used the certified instrument. By how much? This is hard to nail down since most manufacturers specify inter-instrument accuracy (of the same brand and model), and never specify “absolute” accuracy. It could well happen that your process accuracy is so good that the errors are still within the requirements. It could also happen that the proofing printer is off in one direction and that the measuring instrument is off in the other direction, thus cancelling each other, but this is not highly probable.

The advantages of doing these certification checks yourself are:

- i- To better understand the certification process while improving your system’s performance.
- ii- To increase confidence when seeking official certification, and minimize the associated cost.
- iii- To be able to check if your proofing printer and monitor are stable and within their requirements.

And, finally, please note that the characterization data for proofing certification is WORKING DATA which has been used in the development of the GRACoL 7 and SWOP 11 specifications, which are open specifications developed by Idealliance. Please consult the Idealliance Copyright and Disclaimer on this data for additional information.

**Note:** The i1Pro inter-instrument agreement is  $1,0 \Delta E^*$  max., CIE94.



### 3.14.2 Idealliance proofing requirements

The proofing requirements are from the Idealliance **PROOFING CERTIFICATION PROCESS\_v16.pdf** document ([Idealliance Web site](#) / [pdf](#)).

The table below is a snapshot of the requirements:

	Criteria		Requirement for printers	Requirement for monitors	
1a	Must pass the general requirements of ISO 12647-7 and will meet the tolerances specified in Annex E, F, and G with UV included.		YES		
2a	Proofs will be measured against a white background as per CGATS.5-2004 (opaque; diffuse reflecting; CIELAB L* > 92; CIELAB C* ≤ 3.0; non-fluorescing)		YES		
1b	Display uniformity as per ISO 12646			YES	
2b	Display luminance			160 ± 10 cd/m <sup>2</sup>	
3	Color-difference formula		CIELAB (Delta-E* <sub>ab</sub> )	CIEDE2000	
4	IT8.7/4	4.1	Average of all patches	Average ΔE ≤ 1.5	Average ΔE ≤ 2.0
		4.2	95 <sup>th</sup> percentile	Maximum ΔE ≤ 6.0	Maximum ΔE ≤ 6.0
		4.3	Solid CMY patches	ΔE ≤ 5.0	ΔE ≤ 7.0
		4.4	Overprint RGB patches	ΔE ≤ 5.0	ΔE ≤ 7.0
		4.5	50/40/40 Gray patch	ΔE ≤ 1.5	
			L*		-2.0 ≤ ΔL* ≤ 2.0
			a*		-1.0 ≤ Δa* ≤ 1.0
			b*		-2.0 ≤ Δb* ≤ 2.0
		4.6	Paper White (excluding fluorescence)	L* a* b*	-2.0 ≤ ΔL* ≤ 2.0 -1.0 ≤ Δa* ≤ 1.0 -2.0 ≤ Δb* ≤ 2.0
5	ISO 12647-7 2007 Control Strip (see Note 1)		Color-difference for each patch between pages should be ΔE ≤ 1.5		

Ref.: ISO 12647-7 (*Graphic technology — Process control for the production of half-tone colour separations, proof and production prints — Part 7: Proofing processes working directly from digital data*) covers practical printing requirements such as file format, proof paper stability to aging and light, colorant rub resistance, margin information, control strip layout, etc.

Note 1: Version 12 of the Proofing Certification Process document recommended using the FOGRA Media Wedge plus a previous version of the ADS Proofing Certification strip; the requirement now calls for the ISO 12647-7 Control Strip only. Also, the ADS Control Strip definition has recently been changed to correspond to the ISO 12647-7 strip (they should now be considered the same).

**As specified by Idealliance, if a requirement for printing certification is not met, the proof can be re-read and, if it fails again, a second set of proofs can be read.**

Click on these links for step-by-step procedures:

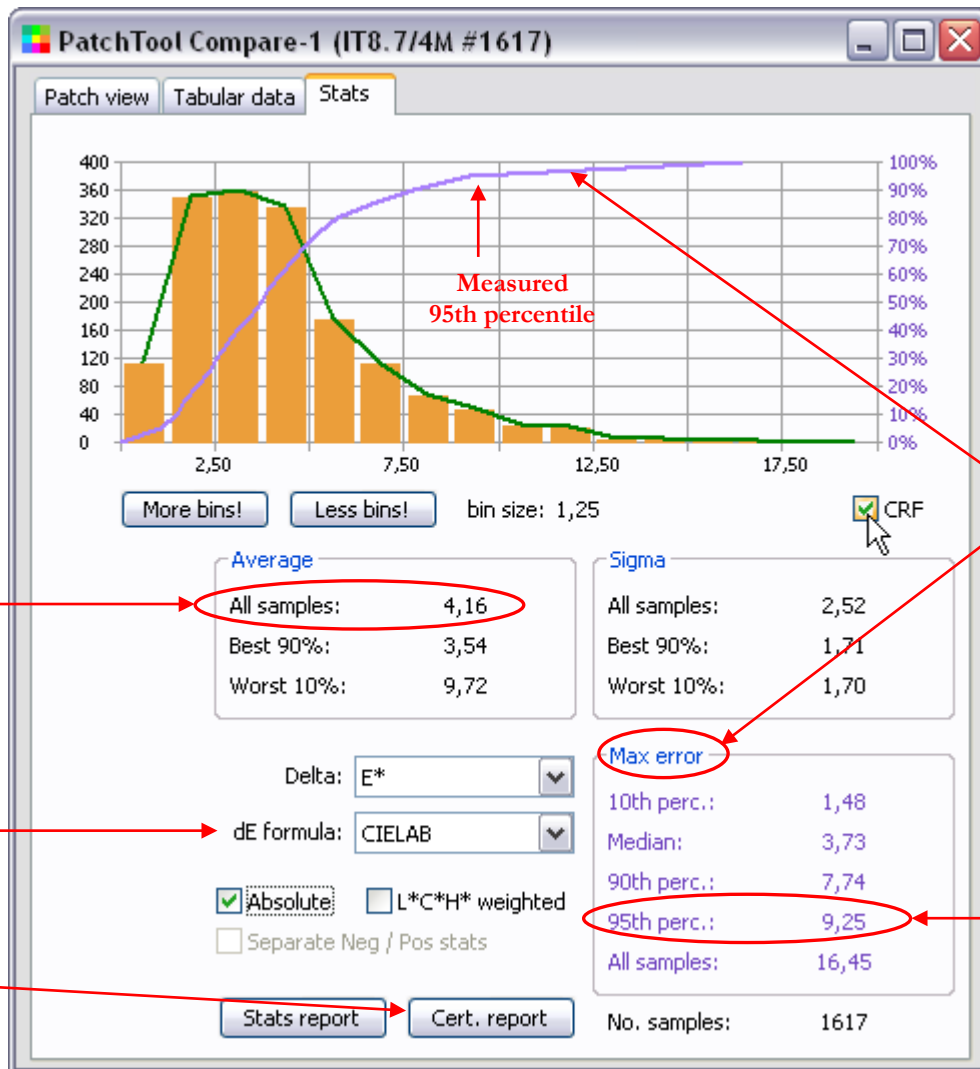
- **Printer certification:** [IT8.7/4](#) target compliance; or [ISO 12647-7](#) control strip compliance.
- **Monitor certification:** Luminance and [IT8.7/4](#) target compliance.



### 3.14.3 Printer proofing certification procedure (IT8.7/4 target)

For an even more detailed description of the procedure, please consult the following application note that can be downloaded from the [BabelColor](#) Web site: *AN-3 Using PatchTool for IDEAlliance PRINTER proofing certification.pdf*

- Open the characterization data file corresponding to the printed IT8.7/4 target paper. As a shortcut, you can use the “**File/Open Sample Files/Characterization data...**” menu. From there, open the “Idealliance\_Proofing-Certification\_V16” folder; you have the following choices:
  - **GRACoL2006\_Coated1.txt** : GRACoL Commercial, Grade 1, Coated (Ex.: Luster Gloss)
  - **SWOP2006\_Coated3.txt** : SWOP High End Publication, Grade 3, Coated (Ex.: Fortune Gloss)
  - **SWOP2006\_Coated5.txt** : SWOP Publication, Grade 5, Coated (Ex.: Monterey Gloss)
 Please note that other reference files provided in PatchTool’s “characterization\_data” folder can also be used. When asked to select an illuminant and observer; select D50 and the 2 degree Observer.
- Using the “**Re-map**” menu in the “Patch view” tab, assign the IDs corresponding to the “Visual” layout.
- Open your measurement file of the IT8.7/4 target. Make sure its layout is the same as the one of the characterization file.
- Open the “**PatchTool Select Compare**” dialog with the “Tools/Compare...” menu. Select the characterization data file as the *ref.* and the measurements file as the *sampl.* Click on the “Compare” button.
- Select the “Stats” tab of the Compare window. Select Delta-E\* and the **CIELAB** “dE formula” (This is [Requirement 3](#)). You should see a display similar to the screenshot below. The average for “All samples” and the “95<sup>th</sup> perc.” maximum error correspond to **Requirements 4.1 and 4.2**.



The maximum acceptable average is 1,5 for Hard Copy certification (Requirement 4.1). Here it fails.

CIELAB color-difference formula (Requirement 3).

Click on the button to generate a text file report presenting the certification results for Requirements 3 and 4.

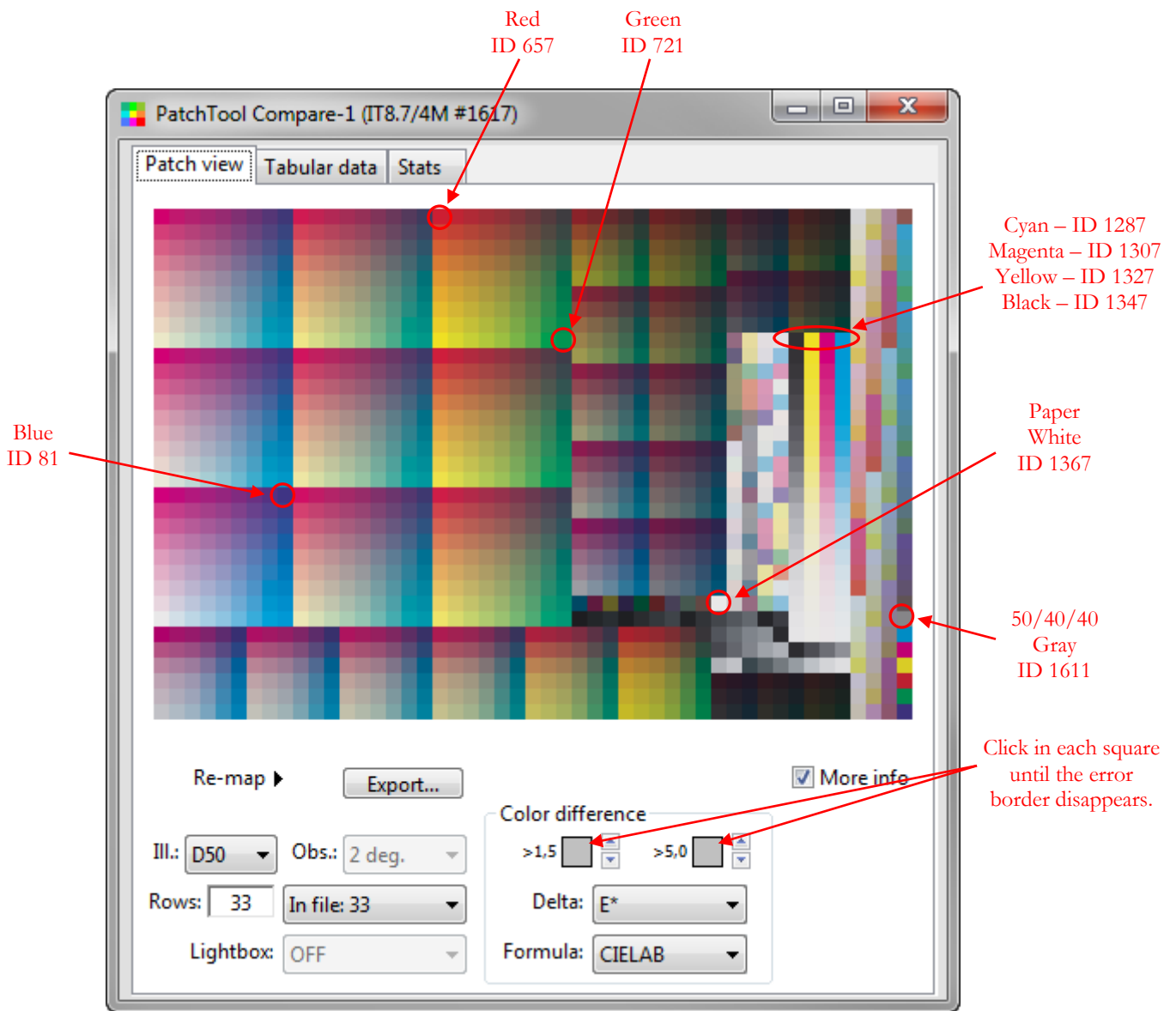
The numbers shown in the “Max error” data group correspond to specific points on the CRF curve.

The maximum acceptable value is 6,0 for the 95<sup>th</sup> percentile (Requirement 4.2). Here it fails.

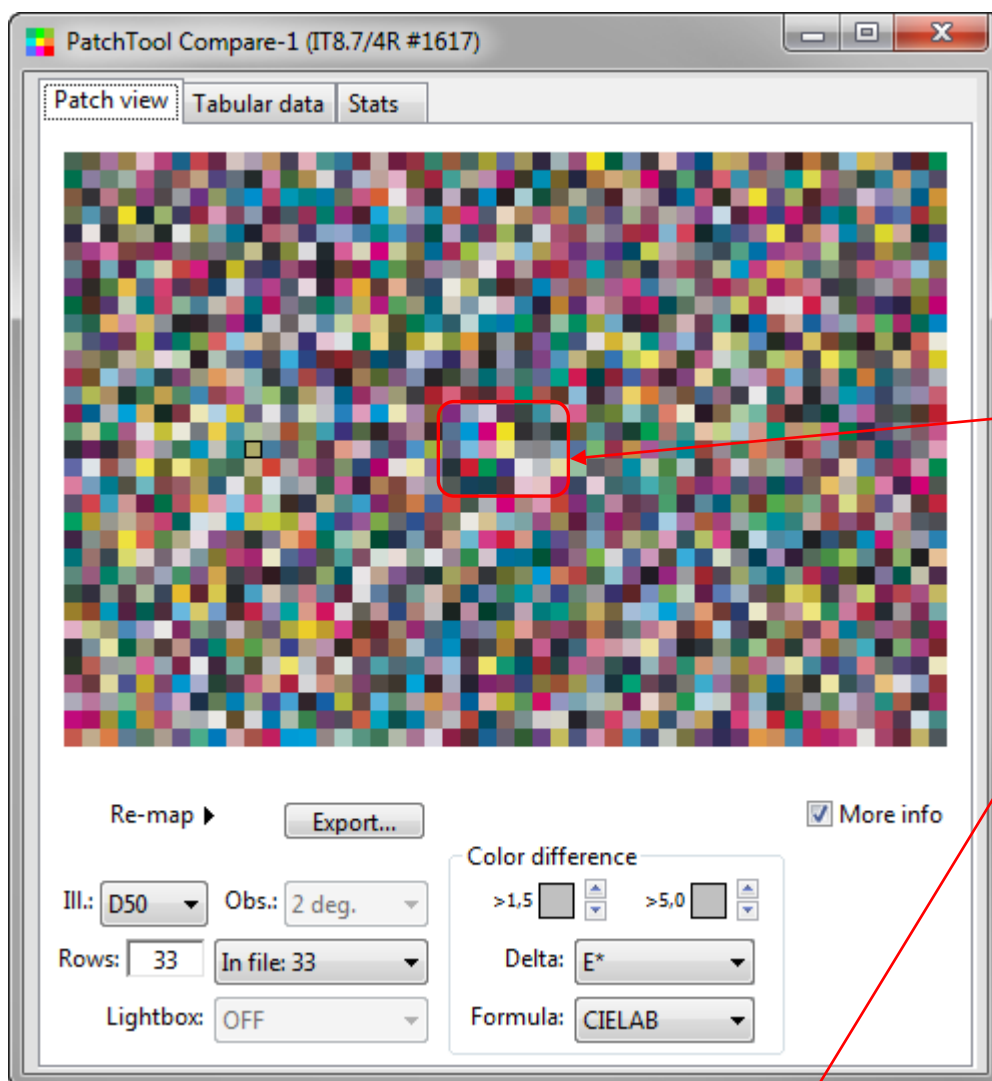
- f) To check **Requirements 4.3, 4.4, 4.5 and 4.6**, the fastest method is to click on the “**Cert. report**” button and select the “**Idealliance Hard Copy Proofing (V16)**” tolerances in the [dialog](#) which opens. This will create a text file report presenting all requirements with their result. You can also switch back to the “Patch view” tab and check these eight patches individually; their locations are shown on the screenshot below.
- g) Save (Export) the Compare window data with at least the “ID”, “Name”, “CMYK”, “L\*a\*b\*”, and “Spectrum” (if available) data fields. When reopening this Compare file, you will be able to analyze the data as if you just measured it.

This screenshot shows the locations of the CMYK solids, the RGB overprints, the 50/40/40 gray, and the paper white on the IT8.7/4 visual layout.

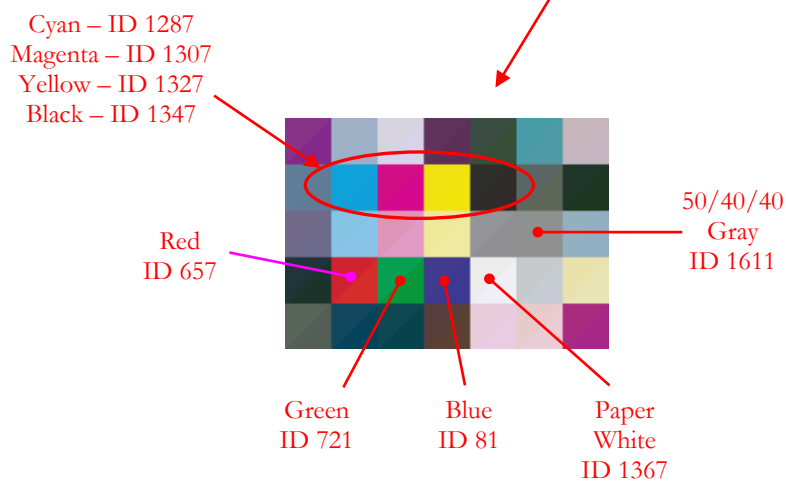
**Important:** Proper assignment of the IT8.7/4 patches’ ID is essential in order to obtain a valid certification report. If, before comparing the reference patches from the Idealliance file to the measured values, you did not re-assign the reference IDs to the ones of the IT8.7/4 Visual layout, then the patch IDs will not correspond to the numbers shown below. Nonetheless, you can still assign the IDs in the Compare window using the “Re-map” menu.



When the target IDs are properly assigned, you can easily switch between the “Measured”, “Visual”, and “Random” layouts. The screenshot below shows the locations of the CMYK solids, the RGB overprints, the 50/40/40 gray, and the paper white on the Random layout.



All the patches of interest are within this zone, which is enlarged below.



### 3.14.4 Printer proofing certification procedure (ISO 12647-7 Control Strip)

For proofing certification, the ISO 12647-7 Control Strip must be printed on each page of the test form. The number of pages is typically two or three and depends on the paper size. In this test, we need to compare the values of the patches between each pair of strips. You may be aware that the Ugra/FOGRA Media Wedge and the ADS Proofing Certification Strip were used in previous versions of the proofing procedure. These two strips were replaced by the ISO 12647-7 strip; in addition, the ADS strip has been changed and is now identical to the ISO 12647-7 strip.



A target layout for the ISO 12647-7 Control Strip is available on the Idealliance Web site; the layout and the characterization data for the GRACoL Coated-1, SWOP Coated-3 and SWOP Coated-5 paper grades were developed by Idealliance, and are freely available. The characterization data can also be found in the PatchTool “Idealliance\_Proofing-Certification\_V16” folder.

Such a strip is usually incorporated in production work for control purposes; it is positioned at numerous places, outside of the live image area. In this other context, the strip would be compared to reference values assigned by Idealliance; in such a case, the tolerances are not the same for all patches. Please consult the Idealliance Web site for more information.

The characterization data is not required for certification since two printed copies of each strip are compared against one another. However, you can also use these files to generate a target image with PatchTool; the procedure is described below.

#### Target image generation procedure

For the purpose of generating a target image, you can open any of the ISO 12647-7 characterization data files as we are only interested in the **CMYK** values, which are the same for all paper grades (The XYZ and L\*a\*b\* values are different though!).

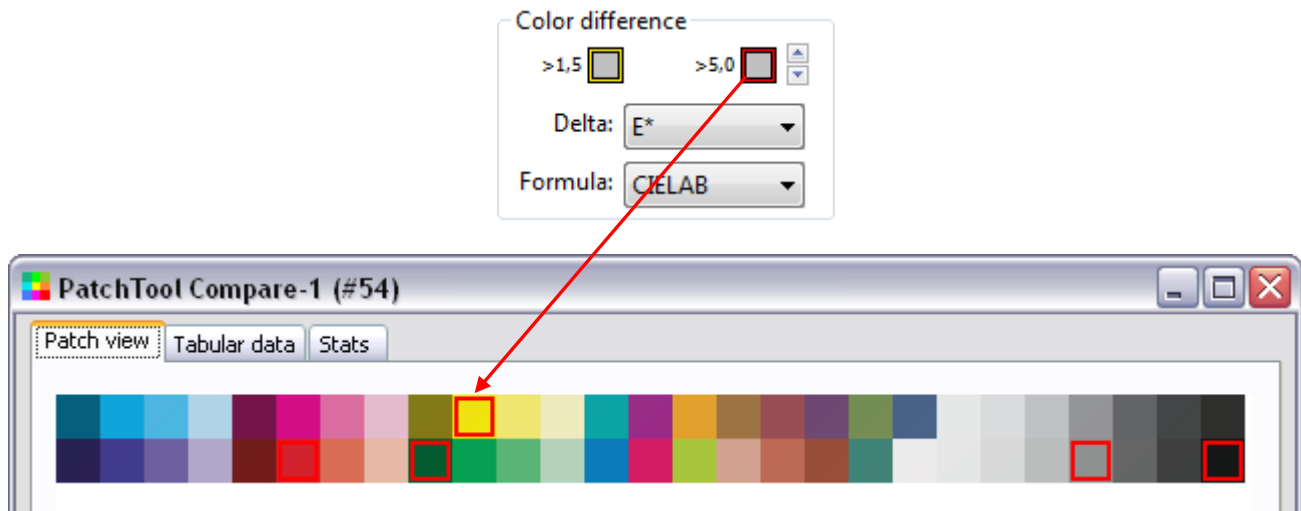
- a) Open one of the ISO 12647-7 **reference** files located in PatchTool Idealliance folder; the files are located within the “Coated1”, “Coated2” and “Coated3” sub-folders. As a shortcut, you can use the “**File/Open Sample Files/ Characterization data...**” menu. From there, open the “Idealliance\_Proofing-Certification\_V16” folder. When opening the file, you will be asked to select an illuminant and observer; select D50 and the 2 degree Observer.
- b) Once the file is opened, click on the “Export” button of the Main window (or select the “**File / Save / Export**” menu). In the “[PatchTool Export](#)” dialog, select the “[Image](#)” tab.
- c) Set the patch size to: Resolution: 100 pixels/mm (or what suits you); Width: 8 mm; Height: 8mm. If you plan to read the patches manually with an i1 Pro in strip mode, you should select a width of 7,0 mm so that the strip fits within the plastic ruler.
- d) Select the “**Add vertical markers before and after each patch**”. This will provide contrasting bars that are required for strip reading.
- e) Select the following image file characteristics: File type: TIFF; Color space: **CMYK**; Bit depth: 8 bit.
- f) Click on the “Export” button to generate the image (an example is shown below).
- g) Insert the image into your test form.



### Certification check with the ISO 12647-7 Control Strip ([Requirement 5](#))

This procedure assumes that all color strips have been previously measured and that the data was saved in a file.

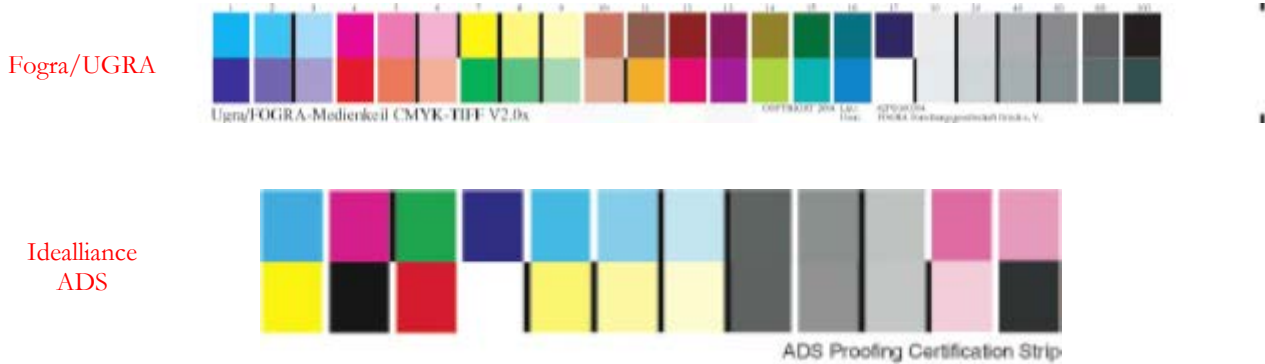
- Open the two or three **measurement** data files. When opening the file, you may be asked to select an illuminant and observer; select D50 and the 2 degree Observer. There is probably no need to re-map the layout, in order to match the patches between files, since the two measurements were likely done using the same reference file.
- Open the "[PatchTool Select Compare](#)" dialog with the "Tools/Compare..." menu. Select any measurement file as the *ref.* and another measurement file as the *sampl.* Click on the "Compare" button.
- In the "Patch view" tab of the "[Compare](#)" window. Select Delta-E\* and the CIELAB "dE formula" (This is **Requirement 3**). Set both error thresholds at 1,5, as shown here. With the thresholds adjusted in this way, any patch which shows a red border is not compliant, and the requirement is not met.



- Save (Export) the Compare window data with at least the "ID", "Name", "CMYK", "L\*a\*b\*", and "Spectrum" (if available) data fields. When reopening this Compare file, you will be able to analyze the data as if you just measured it.

### 3.14.5 Printer proofing certification procedure (ADS and FOGRA Media Wedge) (Obsolete)

For proofing certification, these two strips were replaced by the [ISO 12647-7 strip](#), which is essentially a slightly extended FOGRA Media Wedge; in addition, the ADS Control Strip definition has been changed and it is now identical to the ISO 12647-7 strip. As with the new ISO strip; both strips had to be printed on each page of the test form and we needed to compare the values of the patches between each pair of strips.



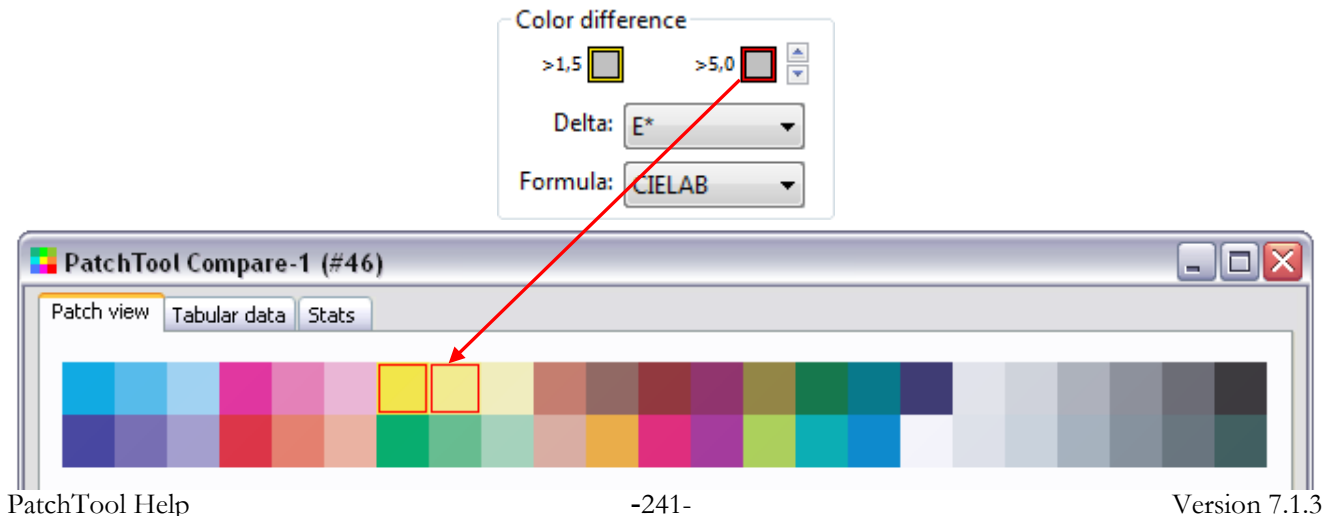
Target layouts for the Ugra/FOGRA Media Wedge in PostScript or TIFF format are available on the Idealliance and FOGRA Web sites. Please note that you will need to purchase or license these images. On the other hand, the characterization data for both strips was developed by Idealliance, and is freely available. The characterization data can also be found in the PatchTool “Idealliance\_Proofing-Certification\_V16” folder.

These strips are usually incorporated in real jobs for control purposes; they are then positioned at numerous places, outside of the live image area. In this other context, the strips would be compared to reference values assigned by Idealliance; in such a case, the tolerances are not the same for all patches. Please consult the Idealliance Web site for more information. The characterization data is not required for certification since two printed copies of each strip are compared against one another.

#### Certification check with the ADS and FOGRA Media Wedge Control Strips

This procedure assumes that all color strips have been previously measured and that the data was saved in a file.

- Open the two or three **measurement** data files for each strip. When opening the file, you will be asked to select an illuminant and observer; select D50 and the 2 degree Observer. There is probably no need to re-map the layout, in order to match the patches between files, since the two measurements were likely done using the same reference file.
- Open the “[PatchTool Select Compare](#)” dialog with the “Tools/Compare...” menu. Select any measurement file as the *ref.* and another measurement file as the *sampl.* Click on the “Compare” button.
- In the “Patch view” tab of the “[Compare](#)” window. Select Delta-E\* and the CIELAB “dE formula” (This is **Requirement 3**). Set both error thresholds at 1,5, as shown here. With the thresholds adjusted in this way, any patch which shows a red border is not compliant, and the requirement is not met.



### 3.14.6 Monitor proofing certification procedure (IT8.7/4 target)

For an even more detailed description of the procedure, please consult the following application note that can be downloaded from the [BabelColor](#) Web site: *AN-4 Using PatchTool for IDEAlliance MONITOR proofing certification.pdf*

Before going further, we recommend that you read [Section 3.6.5](#) which describes the factors which can affect display measurements. Because this procedure requires measuring many patches, and thus takes time, it is important to let your display and your measuring instrument stabilize for at least one hour. We strongly recommend that you place your measuring instrument anywhere on your monitor, as if making measurements, during the stabilization period. Typical [measurement times](#) for an IT8.7/4 target are shown in the [Display-Check Section](#).

You should also read [Section B-2.4 of Appendix B](#), which discusses how RAW display measurements need to be processed before being compared to reference data.

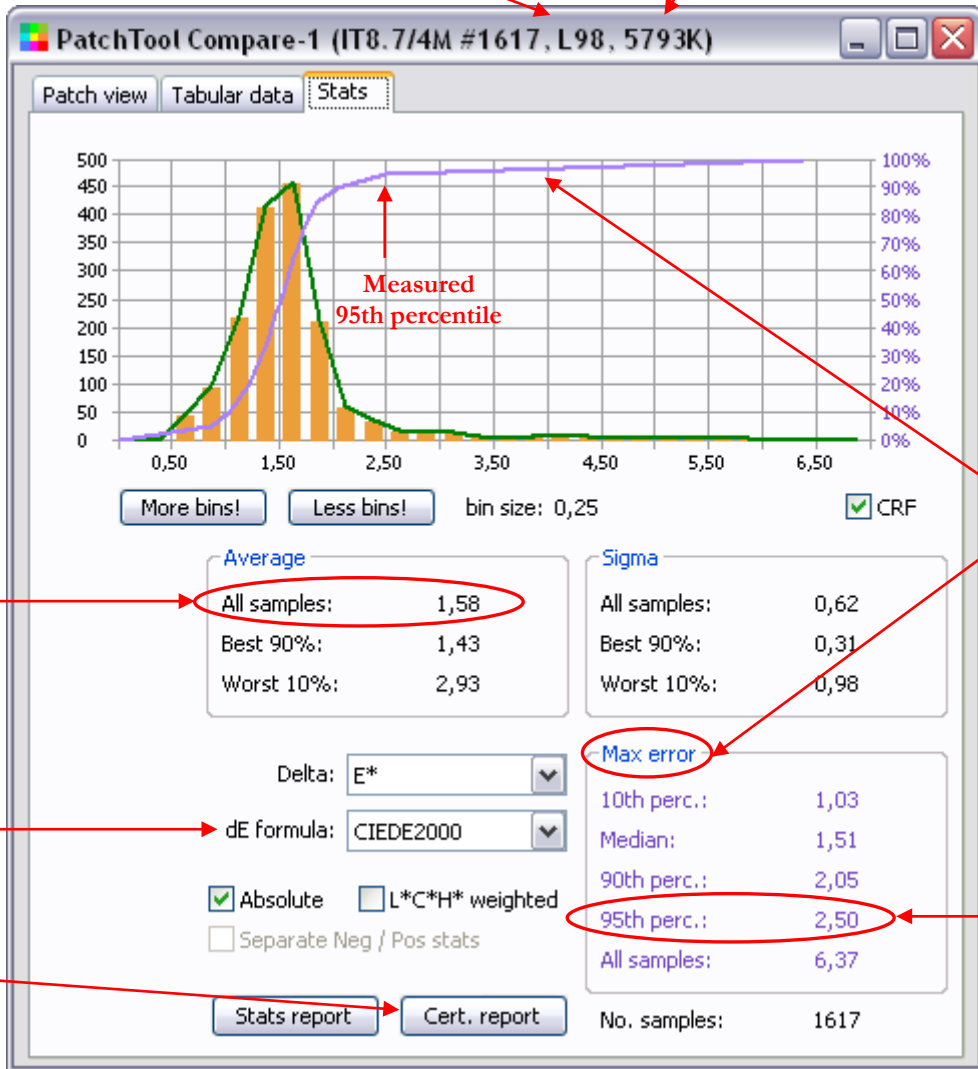
- a) Open the characterization data file corresponding to the printed IT8.7/4 target paper. As a shortcut, you can use the “**File/Open Sample Files/ Characterization data...**” menu. From there, open the “Idealliance\_Proofing-Certification\_V16” folder. You have the following choices:
  - **GRACoL2006\_Coated1.txt** : GRACoL Commercial, Grade 1, Coated (Ex.: Luster Gloss)
  - **SWOP2006\_Coated3.txt** : SWOP High End Publication, Grade 3, Coated (Ex.: Fortune Gloss)
  - **SWOP2006\_Coated5.txt** : SWOP Publication, Grade 5, Coated (Ex.: Monterey Gloss)Please note that other reference files provided in PatchTool’s “characterization\_data” folder can also be used. When asked to select an illuminant and observer; select D50 and the 2 degree Observer.
- b) Using the “[Re-map](#)” menu in the “Patch view” tab, assign the IDs corresponding to the “Visual” layout.
- c) Open the “[PatchTool Display-Check](#)” window with the “Tools/Display-Check...” menu. First select your measuring instrument, then the characterization data file in the “PatchTool file” popup menu. Position and resize the window so that the instrument will measure the monitor’s center. Click on the “Check” button next to the “PatchTool file” menu when ready. Note: The “Check” button will be disabled if the selected instrument is not connected.
- d) When the measurements are completed, you may have a warning that the monitor luminance has changed by too large an amount during the measuring sequence. You may discard all measurements but we recommend continuing, to see what the analysis will tell. When asked, you should save the RAW data in a separate file if you have a need for such data.
- e) Select the “Stats” tab of the Compare window; an example is shown on the [next page](#). Select Delta-E\* and the **CIEDE2000** “dE formula” (This is [Requirement 3](#)). Like we saw for the printer certification using the IT8.7/4 target, the average for “All samples” and the “95<sup>th</sup> perc.” maximum error correspond to **Requirements 4.1 and 4.2** of the table.
- f) The monitor luminance (**Requirement 2b**) can be found in five places: in the log text of the [main PatchTool window](#), in the RAW data file (if saved; look for the XYZ\_Y or the XYY\_CAPY value in the White point section at the end of the file), in the “[Compare](#)” window title (the number besides the “L”), in the certification report, and in the exported Compare file (see step “h”).
- g) To check **Requirements 4.3, 4.4, 4.5 and 4.6**, the fastest method is to click on the “**Cert. report**” button located in the bottom of the “Stats” tab, which will create a text file report presenting the certification results for **Requirements 2b, 3 and 4**. You can also switch to the “Patch view” tab and check these eight patches individually; their locations are the same as the ones shown for printer proofing [a few pages ago](#).
- h) Save (Export) the Compare window data with at least the “ID”, “Name”, “CMYK”, “L\*a\*b\*”, and “Spectrum” (if available) data fields. When reopening this Compare file, you will be able to analyze the data as if you just measured it.



An example of Monitor proofing results:

The number besides the “L” is the White Point luminance, in  $\text{cd}/\text{m}^2$  (Requirement 2b).

The White Point luminance Correlated Color Temperature (CCT), in kelvin.



The maximum acceptable average is 2,0 for Monitor certification (Requirement 4.1). Here it passes.

CIEDE2000 color-difference formula (Requirement 3).

Click on the button to generate a text file report presenting the certification results for Requirements 2b, 3 and 4.

The numbers shown in the “Max error” data group correspond to specific points on the CRF curve.

The maximum acceptable value is 6,0 for the 95th percentile (Requirement 4.2). Here it passes.



### 3.15 Assessing conformance to G7 Colorspace Pass/Fail Requirements

According to the Idealliance Web site ([Idealliance Web site](#)) G7® is:

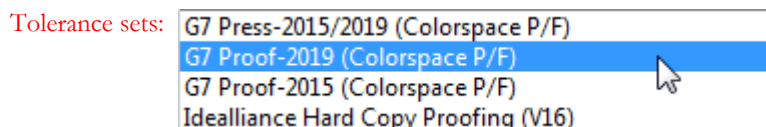
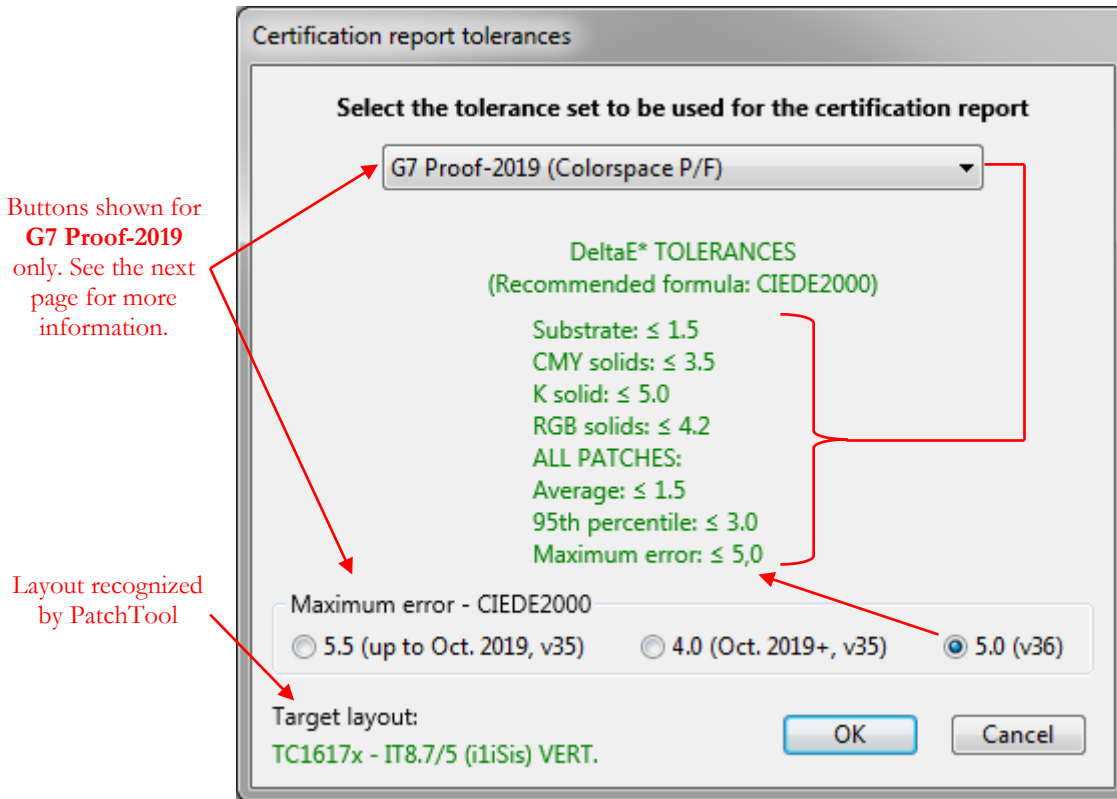
*“Idealliance’s industry-leading set of specifications for achieving gray balance and is the driving force for achieving visual similarity across all print processes.”*

The G7 program is managed by Idealliance, a membership organization dedicated to the digital imaging, printing, and publishing fields. You should start by reading their [Guide to Print Production 20th Ed.](#) Idealliance develops technical specifications and processes, and promotes them through seminars, trade shows and publications. Here are the documents from which the **G7 Colorspace Pass/Fail Requirements** were taken:

- G7 Master Pass/Fail Requirements**; For the G7 Master Program (Version 36, August 2019) (Version 35, April 2019)
- G7 Master Qualification – Updated Pass/Fail Requirements** (G7\_Master\_PassFail\_v35\_and Update Info.pdf – 2019)
- G7 Master & G7 Process Control Master Pass/Fail Requirements** (Version 31, June 2015)

While PatchTool does not have dedicated tools that cover the entire G7 process, it can perform key steps:

- i- For non-standard substrates, where the printing substrate differs from the characterization data of the reference printing condition by more than 2 but less than 5 DeltaE\* (CIEDE2000), the characterization data of the reference printing condition may be adapted using the substrate relative method. This is performed using PatchTool [Substrate Correction](#) tool.
- ii- The **Colorspace Pass/Fail Requirements** can be checked by comparing the aim characterization data (either absolute or substrate-relative) to your measurements. When any two IT8.7/4 or TC1617x (now called IT8.7/5) files are compared using PatchTool [Compare](#) tool, a dedicated button labeled “**Cert. report**” appears in the “[Stats](#)” tab of the Compare file; clicking on this button will first open a tolerances selection dialog, shown below, after which a short certification report will be generated.



In the following table, the tolerances of the first and second columns are from Section 6.1 of the 2019 *G7 Master Pass/Fail Requirements*. The tolerances of the last column (G7 Proof-2015) are from Section 5.2 of the 2015 requirements.

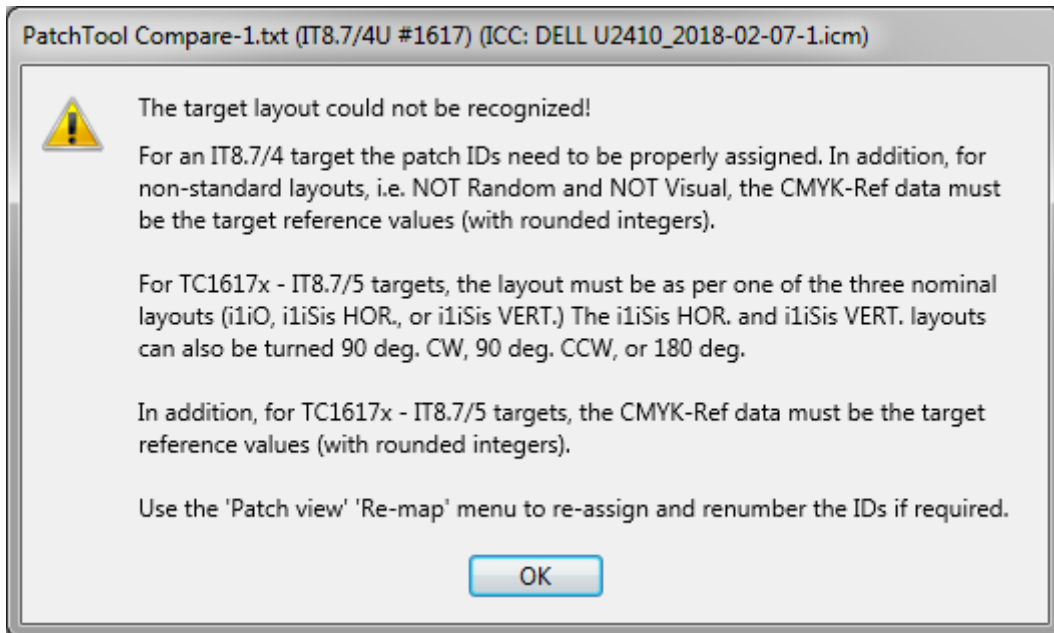
Criteria	G7 Press 2015/2019 (1)	G7 Proof-2019 (2)	G7 Proof-2015
Substrate	$\Delta E_{00} \leq 3.0$	$\Delta E_{00} \leq 1.5$	$\Delta E_{00} \leq 1.5$
CMY solids	$\Delta E_{00} \leq 3.5$	$\Delta E_{00} \leq 3.5$	$\Delta E_{00} \leq 3.5$
K solid	$\Delta E_{00} \leq 5.0$	$\Delta E_{00} \leq 5.0$	$\Delta E_{00} \leq 5.0$
RGB solids	$\Delta E_{00} \leq 4.2$	$\Delta E_{00} \leq 4.2$	$\Delta E_{00} \leq 4.2$
<b>ALL PATCHES</b>			
Average	$\Delta E_{00} \leq 3.5$	$\Delta E_{00} \leq 1.5$	$\Delta E_{00} \leq 2.0$
95 <sup>th</sup> percentile	$\Delta E_{00} \leq 5.0$	$\Delta E_{00} \leq 3.0$	$\Delta E_{00} \leq 5.0$
Maximum	N.A.	$\Delta E_{00} \leq 5.0$ (or 5.5, or 4.0) (3)	N.A.

- (1): The *G7 Press 2015/2019* tolerances have not changed between 2015 and 2019.
- (2): These requirements are effective as of May 1, 2019, with a grace period of 1 year until when the previous G7 Pass/Fail requirements can be used.
- (3): The **maximum** error for all patches is a new requirement for proofs in 2019.  $\Delta E_{00} \leq 5.0$  is from **Version 36** of the *G7 Master Pass/Fail Requirements*. Previous requirements (Version 35) were  $\Delta E_{00} \leq 5.5$  to be used up to October 2019, plus a 1 year grace period, and  $\Delta E_{00} \leq 4.0$  effective October 1, 2019.

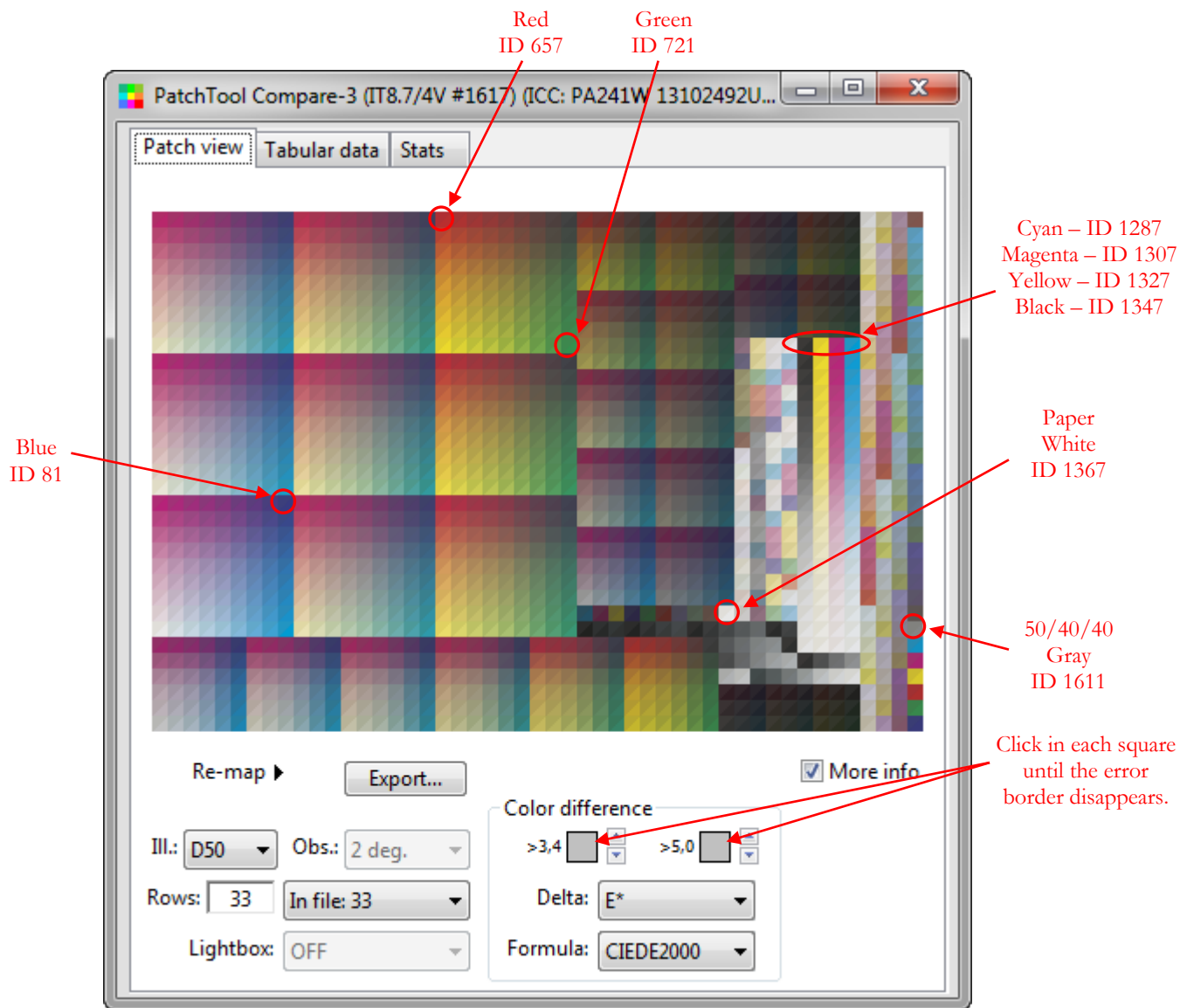
The numbers in **red** highlight the differences between the **G7 Press 2015/2019** and both **G7 Proof** tolerances. The numbers in **green** are the various proposals for the maximum proof error.

**Note:** The older *Idealliance Hard Copy Proofing (V16)* requirements are presented in [Section 3.14.2](#).

**Important:** When a certification report is requested by pressing the “Cert. report” button, the program tries to identify the layout. If the check fails, you will get this warning message:

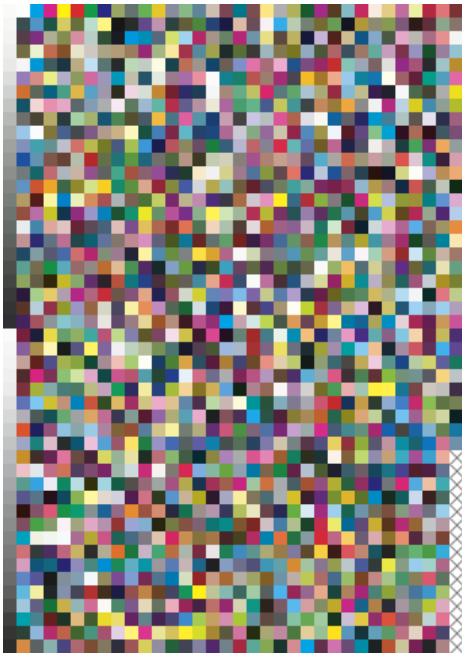


**Hints for IT8.7/4 targets:** In addition to tolerances determined from all patches, nine patches are compared individually for certification: Red, Green, Blue, Cyan, Magenta, Yellow, Black, Substrate/White, and 50/40/40 Gray. For certification purposes, identifying the Random and Visual IT8.7/4 layouts only requires checking if the IDs of the nine specific patches correspond to their nominal “standard” locations. While PatchTool will perform this check for you, you can manually verify it by moving the mouse cursor over these patches. The locations for the Visual layout are shown below (the locations for the Random layout are shown [here](#)). If the patch IDs are incorrect you can simply re-assign the IDs using the “Re-map” menu.



If the layout is neither “Random” nor “Visual”, PatchTool will try to identify the target by first locating the IDs of the nine specific patches used for certification and then check if the CMYK values associated with these patches are the correct ones. For certification, the reference CMYK data should be the IT8.7/4 target reference values. The individual C, M, Y, and K values should be integers and the “CMYK-Ref” should be identified as “File-values” in the “Tabular data” tab of the opened Compare file.

**Hints for TC1617x – IT8.7/5 targets:** Contrary to IT8.7/4 targets, there are no specific IDs assigned to TC1617x layouts. The IDs are often sequential, from 1 to 1617 for all layout variants, and thus cannot be used to identify one of this target’s standard layouts. However, for identification, PatchTool will assume that the target appears as one of its three variants shown below (i1iO, i1iSis HOR., and i1iSis VERT). For each variant, PatchTool will look for a match between the expected locations of the nine individual patches used for certification and the corresponding CMYK values.



**TC1617x (i1iO)**  
(48 rows)



**TC1617x\_H (i1iSis)**  
(49 rows)



**TC1617x\_V (i1iSis)**  
(49 rows)

**Note:** The layouts above are shown as they appear when their corresponding reference file is opened by PatchTool. The reference files can be found using the PatchTool “File/Open Sample Files/Characterization Data...” menu.

For the i1iSis HOR., and i1iSis VERT. layouts, the program will also look for “rotated” versions, at 90 deg. CW, 90 deg. CCW, and 180 deg. (i.e. one half-turn). To properly visualize the layouts you may need to reassign the “Rows” value in the “Patch view” tab; first try “48”, which corresponds to the i1iO layout, then “49” which corresponds to either i1iSis layout, and finally “33” which corresponds to an i1iSis layout rotated 90 degrees.

You will find more information on how to manipulate a TC1617x layout in the [“Patch view” “Re-map” menu](#) section.

### 3.16 Join

The “PatchTool Select Files to Join” dialog is opened by selecting the “Tools/Join...” menu. The menu is enabled when there are at least two opened files.

Click anywhere on a row to select or unselect.

The number of patches in each file can be different.

Selected files have a checkmark and a green background.

Non-compatible files are grayed-out.

The white background identifies the files which are compatible with the previous selection(s). Note: the remaining files *may* be incompatible between them.

When you place the mouse cursor in the “color ref.” column, you can see additional information on the file data. This information is shown below the table, in green.

CMYK data was NOT imported in one or more files to be joined!

#	opened files	patches	color ref..	CMYK	RGB	join
1	ColorChecker_CxF3.cxf (spectrum)	24	spectrum	NO	YES	<input checked="" type="checkbox"/>
2	RGB_6-255_step3.txt	84	RGB (2 deg.)	NO	YES	<input type="checkbox"/>
3	P2P25.txt	300	CMYK (2 deg.)	YES	NO	<input type="checkbox"/>
4	CGATS21-2-CRPC1.txt (M1)	1617	L*a*b* (2 deg.)	YES	NO	<input type="checkbox"/>
5	IDEAlliance ISO 12647-7 Control We...	84	L*a*b* (2 deg.)	YES	NO	<input type="checkbox"/>

#1 - File name: ColorChecker\_CxF3.cxf (spectrum)  
 CMYK profile: ISO Coated v2 (ECI) / Rel. Col. / BPC-NO  
 Imported RGB data: Adobe RGB (PatchTool) / Rel. Col. / BPC-NO

Additional fields to join:  ID  Name  CMYK  RGB

Buttons: Join, Close

The screenshot on the next page shows this dialog’s appearance after selecting the file on line #5.

PatchTool can join color lists which are defined by the same color reference data type. For the purpose of this tool, files with spectral data are considered compatible with xyY, XYZ, L\*a\*b\*, and L\*C\*h data types. The xyY, XYZ, L\*a\*b\*, and L\*C\*h data types are also compatible with each other. The number of patches in each file can be different. The joined file will open immediately as a new file.

Processing is adapted to the selected files in the following manner:

- i- When all selected file have spectral data, identified by “**spectrum**” in the “color ref.” (color reference) column of the dialog, the joined file will contain this spectral data and also be defined as a file of the “**spectrum**” type.
- ii- If one or more of the selected files has spectral data and one or more of the other selected files are defined by another data type, the spectral data will be converted prior to be joined with the other files. The conversion will be done according to the selected button in the “Joined file color reference” section of the dialog (shown in the next screenshot).
- iii- For the xyY, XYZ, L\*a\*b\*, and L\*C\*h data types, the Standard Observer (2 degree or 10 degree) must be the same for all files to be joined.
- iv- Files of the CMYK and RGB data types can be joined with files of the same type.



- v- If the selected files data type is not CMYK or RGB, it may be possible to join additional CMYK and RGB data if the data was imported when the file was opened. Files for which this is true are indicated by “YES” and a cell with a green background in the CMYK and RGB columns of the dialog table. Hint: If “YES” is indicated for a file, you cannot change the profile associated with this data type in the file window. In order to be able to join additional CMYK or RGB data, this data must be available for ALL files to be joined. In other words, all files to be joined must show a “YES” on a green background.

The screenshot below is what the dialog shown on the previous page looks like after selecting the file on line #5. The selection boxes for joining RGB and CMYK data are now both grayed-out since these data types were not imported in all selected files. In the “Joined file color reference” section, “L\*a\*b\*” is selected and the other options are grayed-out since this is the only color reference type selected (besides spectrum).

#	opened files	patches	color ref..	CMYK	RGB	join
1	ColorChecker_CxF3.cxf (spectrum)	24	spectrum	NO	YES	<input checked="" type="checkbox"/>
2	RGB_6-255_step3.txt	84	RGB (2 deg.)	NO	YES	<input type="checkbox"/>
3	P2P25.txt	300	CMYK (2 deg.)	YES	NO	<input type="checkbox"/>
4	CGATS21-2-CRPC1.txt (M1)	1617	L*a*b* (2 deg.)	YES	NO	<input type="checkbox"/>
5	IDEAlliance ISO 12647-7 Control We...	84	L*a*b* (2 deg.)	YES	NO	<input checked="" type="checkbox"/>

#5 - File name: IDEAlliance ISO 12647-7 Control Wedge 2013 CGATS21-2-CRPC1 Ref V.txt (M1)  
 Imported CMYK data: No profile info!  
 RGB profile: Adobe RGB (PatchTool) / Rel. Col. / BPC-NO

CMYK and RGB data was NOT imported in one or more files to be joined!

Joined file color reference:  
 xyY  XYZ  L\*a\*b\*  L\*C\*h\*

Illuminant: D50

Additional fields to join:  
 ID  Name  CMYK  RGB

Join Close  
 2 files / 108 patches

You could unselect this file by clicking anywhere on the row.

Note: Files based on a fixed 2 degree Observer, i.e. non-spectral files, cannot be joined with files based on a fixed 10 degree Observer.

This menu is shown for xyY, XYZ, L\*a\*b\*, and L\*C\*h “color ref.” files.

Click and drag on any edge to enlarge the window. This can help to see long file names.

The illuminant menu is presented when files of the xyY, XYZ, L\*a\*b\*, and L\*C\*h data types are selected. Please note that it is not necessary to change, or match, the illuminant selection in each opened file prior to opening the “PatchTool Select Files to Join” dialog; the program will make the required conversions.

**Important:** When spectral data needs to be converted, you should select the illuminant which corresponds to your final application, in order to minimize any illuminant metamerism effect.

### 3.17 OSA UCS List Generator

The “PatchTool OSA UCS Tool” window is opened by selecting the “Tools/OSA UCS...” menu. This tool is used to generate color lists based on the Uniform Color Scales (UCS) notation. A description of the UCS color system can be found in [Appendix F](#).

**General rule:** Use a TOP-DOWN sequence in this window. Start with the “**Grid options**”. Select the “Grid steps”, then select to restrict or not the patches to a plane, then select a plane type, and finally a plane value. You should then go in the “**Ljg range selection**” section and adjust the “List pitch” first, then Ljg MAX, and finally Ljg MIN. The “**Output options**” should be configured last.

**Grid options**

- Grid steps:  0.5  1
- Restrict patches to the following plane:
- UCS plane: L + g = -6
- (L MAX + g MIN) and (L MIN + g MAX)

**Ljg range selection**

- List pitch: 1
- L and g are linked to the UCS plane value
- MAX: L=8, j=20, g=4
- MIN: L=-10, j=-26, g=-14
- (19 (L and g) x 47 = 893 patches)
- (All-Even: 10 x 24 = 240) (All-Odd: 9 x 23 = 207)

**Output options**

- List only 'All-Even' and/or 'All-Odd' coordinates
- Even  Odd  Both
- Keep discarded patches (replace by gray)
- Keep 'unreal' colors (replace by gray)

**Annotations:**

- Grid steps** selects the pitch of the grid on which the values are set. This is not the pitch of the data list.
- The pitch of the data list. Select the **List pitch** first, and then set the Ljg ranges.
- Linked variables are shown in **red**. For linked variables, it is recommended to adjust the MAX and MIN of one of the linked variables only (You can select one variable or the other).
- All-Even** and **All-Odd** coordinates are recommended for UCS colors, but mixed coordinates are valid.
- Keep discarded patches** is recommended when generating lists for visual assessment.
- Restricting patches to a UCS plane affects the **Ljg range selection**. The plane equation and the plane value also affect the **Output options**.
- Press reset to maximize the range for the currently selected List pitch and UCS plane.
- A small graphic, in **red**, shows how the variables are linked by the UCS plane equation. Here, for the “L+g” plane, L MAX is linked to g MIN, and L MIN is linked to g MAX.
- The **Output options** defaults changes according to the selected UCS plane and its value.
- ‘unreal’** colors are colors outside of the chromaticity diagram. Keep them when generating patches for visual assessment.

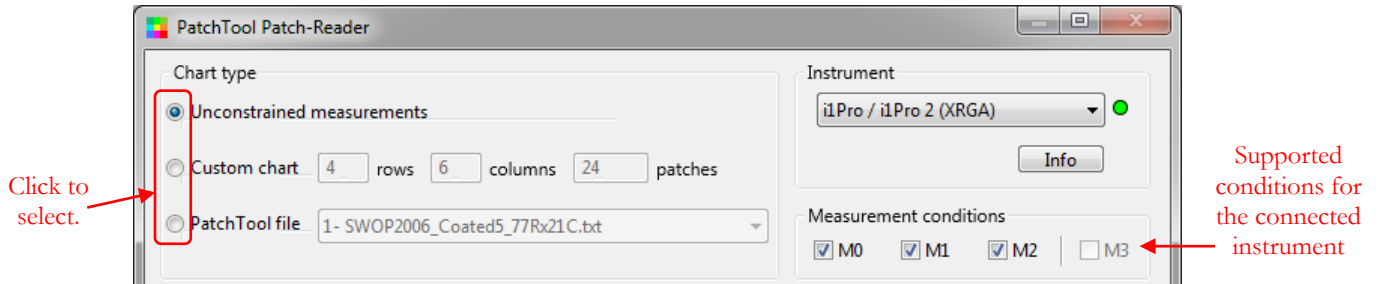
By default, for all UCS plane types except “L”, “j” and “g”, the “List only ‘All-Even’ and/or ‘All-Odd’ coordinates” checkbox will be selected when the UCS plane value is EVEN, and deselected when the plane value is ODD. The reason is that, for odd plane values, all patches will be discarded if this checkbox is selected, since all coordinates are a mix of even and odd values.

The generated lists can be opened in PatchTool (see [UCS Import dialog](#)), in a spreadsheet program, or in a word processor.





### 3.18 Patch-Reader

The “PatchTool Patch-Reader” window is opened by selecting the “Tools/Patch-Reader...” menu. This tool is designed to **measure targets or individual colors in REFLECTANCE** using an **i1Pro** (all models). Measurements are exported to a CGATS formatted file for compatibility with most applications. Please consult [Section 3.18.1](#) for a description of the measurement options offered by each instrument. See [Section 3.18.5](#) for a description of the dialog which presents the CGATS options when saving the measurements.



There are three measurement modes (i.e. Chart types). All modes enable you to immediately see measured data in XYZ, L\*a\*b\*, or L\*C\*h coordinates as well as in terms of reflection density as per ISO 5-3:

- i- **Unconstrained measurements:** Measure color patches in any order and re-order the measurements by dragging them in a list. Sort, delete, or rename any measurement. Look at any or all spectrums on a graph.
- ii- **Custom chart:** Define a chart by assigning rows and columns numbers. Measure the patches individually (Patch mode) or line-by-line (Strip mode). You can use a timer to automatically trigger a measurement at fixed time intervals when in “Patch” mode. The Strip mode works with lines of patches which exhibit a high contrast between them or with lines of patches which have contrast markers (i.e. vertical bars).
- iii- **PatchTool file:** Select any opened file as a reference. The measured patches can be visually and numerically compared with the reference colors in the file. The other features are identical to the ones of the Custom chart.

To select a mode, click on the radio button located on the top-left of the window. A green light  besides the instrument selection menu indicates that the instrument is recognized and ready to use; a red light  indicates that it is not available. Clicking on the “Info” button opens the “[Instrument info](#)” dialog which shows information relative to the instrument. If your instrument is connected but shown as not available, you should first attempt a reconnect by selecting “Try to connect again...” in the “Instrument” menu. If the instrument is still not connected, clicking on the “Info” button may provide information on the source of the problem.

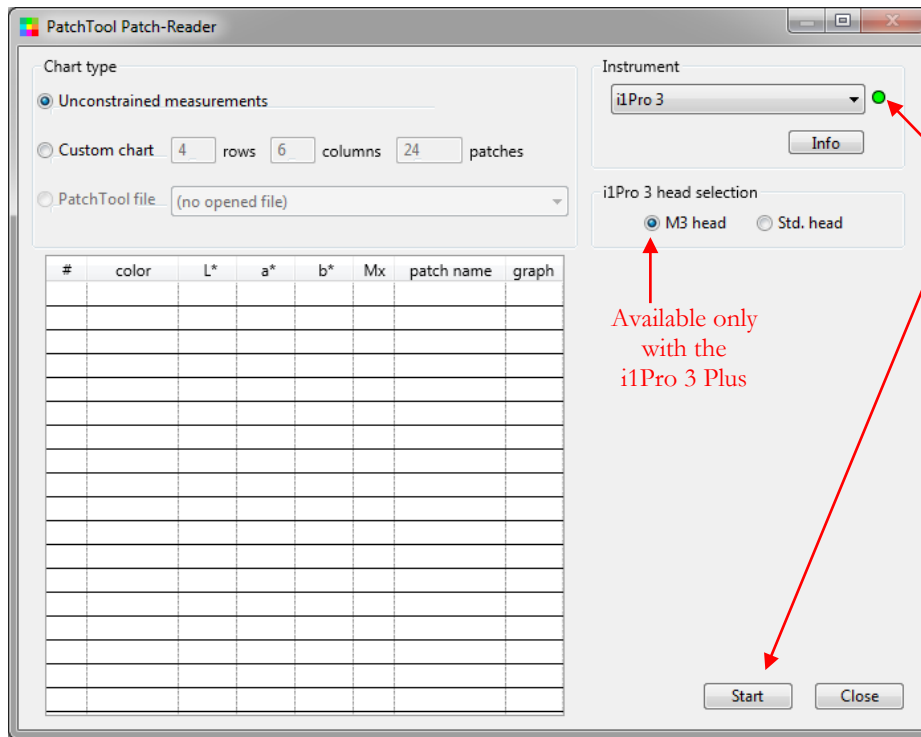
**Note:** If the above fails, disconnect and reconnect the instrument, then select “Try to connect again...” in the “Instrument” menu. PatchTool should be used with only one i1Pro or i1Pro 2 connected at a time and only one i1Pro 3 at a time. You can however connect one i1Pro/i1Pro 2 in addition to one i1Pro 3.

**Important:** If you installed software from X-Rite, such as **i1Profiler**, which comprises the “X-Rite Device Services” program, you may receive a message to the effect that the instrument is not connected when you click on the “Info” button. Assuming that your instrument is indeed connected, first check if the i1Profiler program from X-Rite is opened, and, if opened, close it, since PatchTool cannot be used at the same time. Early versions of i1Profiler provide a control panel named “X-Rite Device Services”, which is used to assign/unassign instruments to X-Rite software. On a Mac, the “X-Rite Device Services” control panel is located in the System Preferences dialog. The latest versions of i1Profiler still include “X-Rite Device Services” but do not include a control panel, and instrument assignment is performed dynamically when opening an X-Rite program. If using an early version of i1Profiler, you should DESELECT the i1 (Eye-One) in the “X-Rite Device Services” control panel; this will make the instrument available for PatchTool. Please note that changes in the X-Rite control panel can be done while PatchTool is opened. You should then be able to connect the instrument by selecting “Try to connect again...” in the “Instrument” menu. The early versions of i1Profiler may also open one or more dialogs asking if you want PatchTool to take ownership of the i1 peripherals; please answer “Yes” to the question(s). “X-Rite Device Services” is dedicated to X-Rite programs and is not under PatchTool's control; any problem related to its use should be directed to X-Rite.

We will now have a quick look at the top-level interface for each Patch-Reader chart type.

### Unconstrained measurements

If using an **i1Pro 3 Plus**, select the measurement head you intend to use before starting the measurements; the “**Std. head**” is used for taking measurements in the M0/M1/M2 conditions. The “Unconstrained” mode can be selected even if there is no opened file. See [Section 3.18.2](#) for more information.

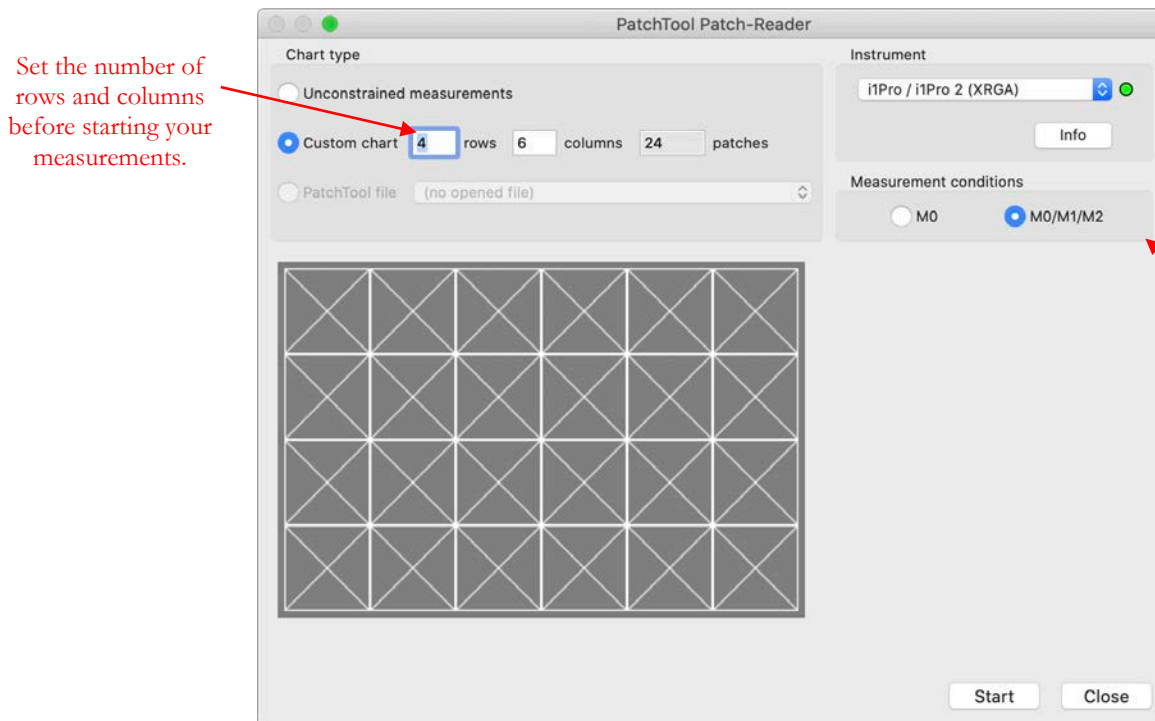


Available only with the i1Pro 3 Plus

The “Start” button is enabled only if the instrument is ready and the light is green. If the light is red, you should first attempt a reconnect by selecting “Try to connect again...” in the “Instrument” menu. If the instrument is still not connected, click on the “Info” button; the “Instrument info” dialog may provide information on the source of the problem.

### Custom chart

Before starting measuring in the “Custom chart” mode, you need to set the number of rows and columns in the chart. The chart layout corresponding to the rows and columns is shown in the window. This mode can be selected even if there is no opened file. See [Section 3.18.3](#) for more information.



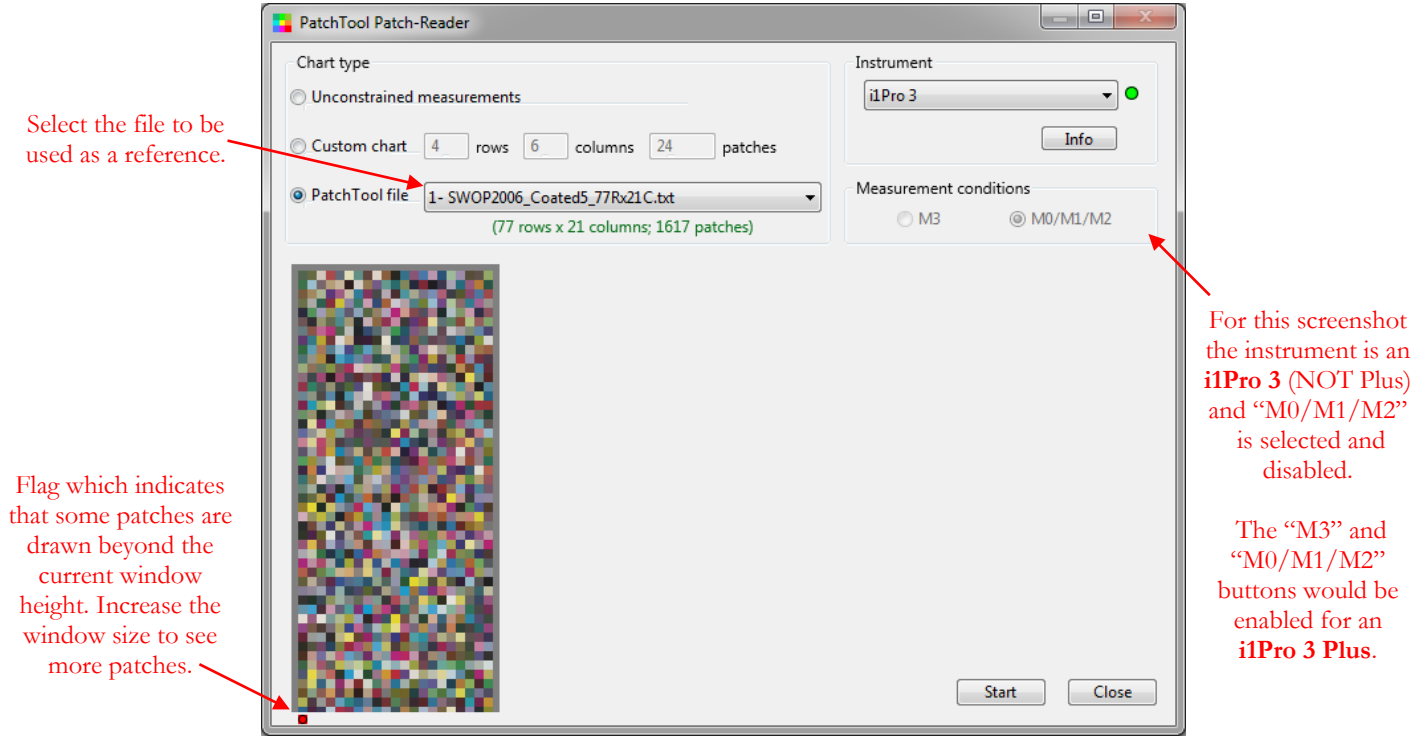
Set the number of rows and columns before starting your measurements.

Measurement conditions are shown when the instrument is connected. In this screenshot, both “M0” and “M0/M1/M2” are available because the instrument is an **i1Pro 2**.

Note: “M0/M1/M2” requires 2 scans per line for the i1Pro 2.

## PatchTool file

This mode is available when there is at least one opened file (a [Compare](#) type file can also be used). When you select a file, the number of rows and columns and the number of patches in the file are shown under the file name. The patches are also illustrated as they appear in the opened file. See [Section 3.18.4](#) for more information.



The measurement options available for each instrument, detailed instructions for each chart type, and a description of the saving options dialog are presented in the following sections. You can click on the following links to jump to the corresponding sections:

- [i1Pro/i1Pro 2/i1Pro 3 Measurement Conditions in Patch-Reader](#)
- [Patch-Reader Unconstrained measurements interface](#)
- [Patch-Reader Custom chart interface](#)
- [Patch-Reader PatchTool file interface](#)
- [Patch-Reader CGATS saving options](#)

### 3.18.1 i1Pro/i1Pro 2/i1Pro 3 Measurement Conditions in Patch-Reader

The four measurement conditions defined in [ISO 13655-2009](#) are:

- i- **M0:** Incandescent lamps with a spectral profile close to Illuminant A (2856 K). UV is not controlled under this measurement condition but the small UV content of the lamp is sufficient to create fluorescence if Optical Brightening Agents (OBAs) are present in the paper or inks.
- ii- **M1:** The spectral power distribution of the light source should match D50, particularly in the UV and visible portions of the spectrum. Two methods are accepted in order to achieve compliance with this requirement: the spectral power distribution of the instrument light source matches D50 in the sample plane OR the UV content of D50 is simulated. The first method corresponds to the use of a xenon flash lamp, and the second method to the two-pass measurement method used in X-Rite's i1 iSis and i1Pro 2.
- iii- **M2:** This measurement condition excludes the contribution of fluorescence from OBAs. The measurement source spectral power distribution is not explicitly specified. This mode has traditionally been called UV-cut, No UV, or UV filtered.
- iv- **M3:** Measurements done with a polarizing filter. This condition assumes that the requirements of the M2 measurement condition are met.

#### **i1Pro**

The i1Pro was historically available in separate models with or without a UV filter for reflectance measurements. The light source of the i1Pro is an incandescent lamp, with a tungsten filament, whose spectral profile is close to Illuminant A. In relation to the **Measurement Conditions** presented below, the two older i1Pro models correspond to M0 (Incandescent/no-filter) and M2 (UV-cut).

#### **i1Pro 2**

The i1Pro 2 supports the M0, M1, and M2 measurement conditions. The i1Pro 2 has two light sources, an incandescent lamp corresponding to M0, and a UV LED source. If only M0 measurements are required, then the UV LED is not required; this is the default measurement condition used, for instance, when connecting an i1Pro 2 to a software which supports only the i1Pro (this is called compatibility mode by X-Rite). M1 and M2 measurements are obtained by combining the measurements of the M0 source to those of the UV LED source, each measurement being taken separately. This two steps sequence is hardly noticed by the user when making single (i.e. spot) measurements; however, when scanning a chart row, a separate scan must be done for each light source. The processing that extract M1 and M2 data from M0 and UV LED measurements is performed by the X-Rite software libraries dedicated to the i1Pro 2.

The i1Pro 2 is provided with a special ruler which comprises alternating black and white stripes called "**Zebra ruler**". These stripes are read by an optical sensor located under the i1Pro 2 and enable the software to identify the scan direction and the amount of movement. The Zebra ruler is essential when making scans for the M1 or M2 conditions since two scans must be done in alternate directions. The starting direction of the first scan can be either from right-to-left or from left-to-right and the software will always order the measurements as if taken from left-to-right. The Zebra ruler is optional in PatchTool when making M0 only scan measurements since they are made in one pass; however, when measuring a Custom chart, which has no reference data, you will be able to scan each line in a different direction if you use the i1Pro 2 ruler. When measuring a Custom chart with the old i1Pro ruler, using either an i1Pro or an i1Pro 2, you must make all your measurements in the same direction.

The i1Pro 2 can also be set in a "low resolution" scan mode. This mode is useful when measuring a test chart with poor edge definition due to low output resolution, such as in large prints done with solvent printing. This mode cannot be used with the i1Pro 2 ruler, and is thus available only for the default measurement condition (M0 or M2).

You will also notice that the instrument menu does not offer "i1Pro" and "i1Pro 2" as separate menu items. Instead, "**i1Pro / i1Pro 2 (non-XRGA)**" and "**i1Pro / i1Pro 2 (XRGA)**" are shown; these descriptions correspond respectively to the old i1Pro driver and the new i1Pro 2 driver. Both the i1Pro and i1Pro 2 instruments can be used with either driver in Patch-Reader. The i1Pro driver is NOT XRGA compliant and the i1Pro 2 driver is XRGA compliant. You can thus make measurements with your instruments with or without XRGA calibration.

**Note:** The "**i1Pro / i1Pro 2 (non-XRGA)**" menu item is NOT available in the 64 bit OS software package.



### i1Pro 3

The i1Pro 3 is available in a large aperture version, the **i1Pro 3 Plus**, which supports all four measurement conditions (M0/M1/M2/M3). A smaller aperture version, simply called **i1Pro 3**, only supports the M0/M1/M2 measurement conditions.

The main improvement in the i1Pro 3 line over the i1Pro 2 is the use of a solid state (multi-LED based) light source which enables measurements in all modes with a single scan per line. Measurements with the M3 mode require installing a dedicated polarizer filter head on the instrument (the significant filter absorption is the reason for the i1Pro 3 Plus larger measurement aperture). With the polarizer installed, the instrument cannot be used for M0/M1/M2 measurements, which explains why measurements with this instrument are usually segregated in M3-only or M0/M1/M2.

As with the i1Pro 2, the i1Pro 3 can be used with or without an encoding ruler (i.e. the Zebra ruler).

At this point you may start to be confused by the number of combinations between the instrument models, their supported measurement conditions, the selected instrument driver, the use or not of the Zebra ruler, and the various measurement options. The combinations are presented in the following tables. The term SDK (Software Development Kit) describes the software (libraries and drivers) provided by X-Rite for each instrument.

### Instrument vs Measurement Conditions

ISO 13655 Measurement Conditions			
instrument	i1Pro/i1Pro 2 (non-XRGA) (i1Pro SDK)	i1Pro/i1Pro 2 (XRGA) (i1Pro 2 SDK)	i1Pro 3 (XRGA) (i1Pro 3 SDK)
i1Pro	M0 or M2	M0 or M2	
i1Pro 2	M0 or M2	M0/M1/M2 or M2-only	
i1Pro 3			M0/M1/M2
i1Pro 3 Plus			M0/M1/M2/M3

The Measurement Conditions depend on the basic instrument configuration and the SDK. The i1Pro was available in separate M0 or M2 (UV-cut) models. Most i1Pro 2 support the M0/M1/M2 conditions while some were manufactured to support M2 only. An i1Pro 2 used with the i1Pro SDK will be seen as an i1Pro, in compatibility mode (and without the new i1Pro 2 features). The i1Pro 3 and i1Pro 3 Plus both support M0/M1/M2 but the i1Pro 3 Plus adds support for M3 (Polarized mode). Let's now look at the scan modes available for each instrument in each SDK.

### Scan modes: i1Pro or i1Pro 2 with the i1Pro SDK

i1Pro or i1Pro 2 scan modes with the i1Pro SDK – i1Pro/i1Pro 2 (non-XRGA)						
chart type	meas. cond.	measurement mode	Zebra ruler	scan dir.	low res. option	scan per line
Custom chart	M0 or M2	Strip (w/bars or high-contrast)	N.A.	uni-dir.	✗	1
PatchTool file			N.A.	uni-dir.	✗	

The i1Pro 2 Zebra ruler cannot be used with this SDK. In fact, all new i1Pro 2 features are not supported by the old i1Pro SDK; as well, the low resolution target option is not available. Only one scan is required per target row and the scan direction must be the same for each row.

**Scan modes: i1Pro with the i1Pro 2 SDK**

i1Pro scan modes with the i1Pro 2 SDK – i1Pro/i1Pro 2 (XRGAs)						
chart type	meas. cond.	measurement mode	Zebra ruler	scan dir.	low res. option	scan per line
Custom chart	M0 or M2	Strip (w/bars or high-contrast)	N.A.	uni-dir.	✘	1
PatchTool file	M0 or M2	Strip (w/bars or high-contrast)	N.A.	uni-dir.	✘	1
		Strip (patch correlation)	N.A.	bi-dir.	✘	

While the i1Pro 2 SDK supports the Zebra ruler, here it is the instrument, the original i1Pro, which does not have the sensor for it. We see that we have an additional mode, “**Strip (patch correlation)**,” when measuring a chart defined by a PatchTool file. In this mode, the reference file data is used to identify the scan direction, and each line can be scanned in a different direction. This is a new feature of the i1Pro 2 SDK which can benefit i1Pro users (in addition to XRGAs support).

**Note:** While the patch correlation mode can recognize the scan direction, it is not designed to validate the measured data within a precise margin in relation to the reference values.

**Scan modes: i1Pro 2 with the i1Pro 2 SDK**

i1Pro 2 scan modes with the i1Pro 2 SDK – i1Pro/i1Pro 2 (XRGAs)						
chart type	meas. cond.	measurement mode	Zebra ruler	scan dir.	low res. option	scan per line
Custom chart	M0 or M2	Strip (w/bars or high-contrast)	<input type="checkbox"/>	uni-dir.	✓	1
			<input checked="" type="checkbox"/>	bi-dir.	✘	
	M0/M1/M2		<input checked="" type="checkbox"/>	bi-dir.	✘	2
PatchTool file	M0 or M2	Strip (w/bars or high-contrast)	<input type="checkbox"/>	uni-dir.	✓	1
			<input checked="" type="checkbox"/>	bi-dir.	✘	
		Strip (patch correlation)	N.A.	bi-dir.	✓	
	M0/M1/M2	Strip (w/bars or high-contrast)	<input checked="" type="checkbox"/>	bi-dir.	✘	2

Except for patch correlation, which is not compatible with a Zebra ruler, the Zebra ruler can provide bi-directional scanning in all measurement conditions. One pass single scan can be done when only M0 or M2, for some i1pro 2 models, is selected. You will also note that the low resolution target option is only available when deselecting the Zebra ruler. On the other hand, whenever we want “M0/M1/M2” measurements, we must select the Zebra ruler and make two scans per line.

**Note:** Because of a design limitation, the Zebra ruler can only be used, in reflectance, with charts which have at least 6 patches in a row. You should thus modify your chart layout if you need to scan these charts with the “M0/M1/M2” measurement conditions which require the Zebra ruler. If you need only the default measurement condition of the instrument (M0 or M2, depending on the model), then you can scan the chart without a ruler.

**Scan modes: i1Pro 3 and i1Pro 3 Plus scan modes with the i1Pro 3 SDK**

<b>i1Pro 3 and i1Pro 3 Plus scan modes with the i1Pro 3 SDK – i1Pro 3 (XRGA)</b>						
<b>chart type</b>	<b>meas. cond.</b>	<b>measurement mode</b>	<b>Zebra ruler</b>	<b>scan dir.</b>	<b>low res. option</b>	<b>scan per line</b>
Custom chart	M0/M1/M2 or M3 *	Strip (w/bars or high-contrast)	<input type="checkbox"/>	uni-dir.	✓	1
			<input checked="" type="checkbox"/>	bi-dir.	✗	
PatchTool file	M0/M1/M2 or M3 *	Strip (w/bars or high-contrast)	<input type="checkbox"/>	uni-dir.	✓	
			<input checked="" type="checkbox"/>	bi-dir.	✗	
		Strip (patch correlation)	<input type="checkbox"/>	bi-dir.	✓	

\* M3/Polarized mode available on the i1Pro 3 Plus only

For the i1Pro 3 and i1Pro 3 Plus, only one scan per line is required for any measurement condition. As with the i1Pro 2 SDK, the low resolution target option is only available when deselecting the Zebra ruler. For the i1Pro 3 Plus, the M0/M1/M2/M3 modes cannot be measured in a single measurement or line scan; you must select to measure either M3 alone, with the polarizer head fitted on the instrument, or M0/M1/M2 with the instrument Standard head.

### 3.18.2 Patch-Reader Unconstrained measurements interface

Once you click on the “Start” button, you are asked to calibrate the instrument. You can then make your measurements in no specific order. Here is screenshot after a few measurements.

Left-click on the “graph” column header to CLEAR all selections. Right-click (ctrl + click on a one-button Mac mouse) to select all rows.

Select the color space to be used in the table. All selections are in D50, computed with the 2 degree Observer. You can also display the reflection density as defined in ISO 5-3.

Right-click (ctrl + click on a one-button Mac mouse) on any row for this popup menu.

Select M0, M1, and/or M2 for each measurement. M3 is available only for the i1Pro 3 Plus.

A single click can give you the fluorescence characteristics of a paper!

Click on the “Read” button or on the instrument button to make a measurement.

Click on the “Stop” button to save your results in a file.

#	color	L*	a*	b*	Mx	patch name	graph
1		94,01	0,33	-5,93	M0	A1	<input checked="" type="checkbox"/>
2		94,17	0,62	-7,87	M1	B1	<input checked="" type="checkbox"/>
3		93,90	-1,00	-1,76	M2	C1	<input checked="" type="checkbox"/>
4		59,83	-25,60	-48,09	M0	A2	<input checked="" type="checkbox"/>
5		59,98	-25,07	-49,15	M1	B2	<input checked="" type="checkbox"/>
6		59,72	-27,34	-45,71	M2	C2	<input checked="" type="checkbox"/>
7		54,85	0,72	-4,79	M0	A3	<input checked="" type="checkbox"/>
8		66,20	52,26	-9,48	M1	B3	<input checked="" type="checkbox"/>
9		66,11	51,32	-5,79	M2	C3	<input checked="" type="checkbox"/>
10		66,20	52,26	-9,48	M0	A6	<input checked="" type="checkbox"/>
11		66,30	52,48	-11,20	M1	B6	<input checked="" type="checkbox"/>
12		66,11	51,32	-5,79	M2	C6	<input checked="" type="checkbox"/>
13		89,13	-7,84	70,85	M0	A7	<input checked="" type="checkbox"/>
14		89,18	-7,88	70,06	M1	B7	<input checked="" type="checkbox"/>
15		89,11	-7,98	72,45	M2	C7	<input checked="" type="checkbox"/>

You can change the measurement conditions for each measurement. The program adds a label corresponding to the measurement condition of the data in the “Mx” column. New measurements are automatically shown in the graph; you can deselect them in the table afterwards. Do a left-click on the “graph” column header to deselect all measurements; do a right-click to show all spectrums.

You can also:

- i- In Windows, after selecting a row, add or remove rows with a **Ctrl + click** on other rows. On a Mac with a one-button mouse, use **⌘ + click**.
- ii- Select a range of rows with a mouse click on the first row and then **shift + click** on the last row. Additional ranges can be added or removed with **Ctrl + click & drag** (**⌘ + click & drag** on a Mac).
- iii- Drag the selected rows to another position in the list.
- iv- Delete selected rows or all rows with a right-click (**Ctrl + click** on a one-button Mac mouse) (shown in the screenshot above).
- v- Except for the “Mx” column, click on a column header to sort the column in ascending or descending order. Clicking on the “Mx” column will group the data by measurement condition type or sort them back to the original measurement sequence (this is shown on the next page).
- vi- Enlarge the window size to obtain a larger graph and more space to write the patch name (also shown on the next page).
- vii- Change one patch name or rename all patches in one step.

Click the “Stop” button at any time when your measurements are complete.

The screenshots on the following pages demonstrate some of the features of the interface.

PatchTool Patch-Reader (Unconstrained measurements)

Instrument: iPro / iPro 2 (XRG) Info

Measurement conditions:  M0  M1  M2  M3

Display data (D50; 2 deg; Status T)

XYZ  L\*a\*b\*  L\*C\*h\*  Density

color	L*	a*	b*	M <sub>sk</sub>	C	M	Y	K	patch name	graph
94,01	0,33	-5,93	M0	0,08	0,07	0,04	0,07	Bright White P...	<input type="checkbox"/>	
94,17	0,62	-7,87	M1	0,08	0,06	0,02	0,07	Bright White P...	<input type="checkbox"/>	
93,90	-1,00	-1,76	M2	0,08	0,07	0,06	0,07	Bright White P...	<input type="checkbox"/>	
59,83	-25,60	-48,09	M0	1,01	0,38	0,15	0,64	A2	<input type="checkbox"/>	
59,98	-25,07	-49,15	M1	1,01	0,38	0,14	0,64	B2	<input type="checkbox"/>	
59,72	-27,34	-45,71	M2	1,01	0,38	0,17	0,64	C2	<input type="checkbox"/>	
66,20	52,26	-9,48	M0	0,14	0,71	0,39	0,39	A3	<input checked="" type="checkbox"/>	
66,30	52,48	-11,20	M1	0,14	0,70	0,37	0,39	B3	<input checked="" type="checkbox"/>	
66,11	51,32	-5,79	M2	0,14	0,71	0,42	0,39	C3	<input checked="" type="checkbox"/>	
89,13	-7,84	70,85	M0	0,10	0,13	0,75	0,11	A4	<input type="checkbox"/>	
89,18	-7,88	70,06	M1	0,10	0,13	0,74	0,11	B4	<input type="checkbox"/>	
89,11	-7,98	72,45	M2	0,10	0,13	0,77	0,11	C4	<input type="checkbox"/>	

Line thickness:  1 px  2 px  3 px

Read Stop Close

Check this box to see the density data. The density standard (here "Status T") is selected in the "Preferences" dialog.

PatchTool Patch-Reader (Unconstrained measurements)

Instrument: iPro / iPro 2 (XRG) Info

Measurement conditions:  M0  M1  M2  M3

Display data (D50; 2 deg; Status T)

XYZ  L\*a\*b\*  L\*C\*h\*  Density

Enlarge the window to get more space to write the patch name as well as a larger graph area.

Click in any cell of the "patch name" column to enter a name.

#	color	L*	a*	b*	M <sub>sk</sub>	patch name	graph
1	94,01	0,33	-5,93	M0	Bright White Paper	<input checked="" type="checkbox"/>	
4	59,83	-25,60	-48,09	M0	A2	<input checked="" type="checkbox"/>	
7	66,20	52,26	-9,48	M0	A3	<input checked="" type="checkbox"/>	
10	89,13	-7,84	70,85	M0	A4	<input checked="" type="checkbox"/>	
2	94,17	0,62	-7,87	M1	Bright White Paper	<input checked="" type="checkbox"/>	
5	59,98	-25,07	-49,15	M1	B2	<input checked="" type="checkbox"/>	
8	66,30	52,48	-11,20	M1	B3	<input checked="" type="checkbox"/>	
11	89,18	-7,88	70,06	M1	B4	<input checked="" type="checkbox"/>	
3	93,90	-1,00	-1,76	M2	Bright White Paper	<input checked="" type="checkbox"/>	
6	59,72	-27,34	-45,71	M2	C2	<input checked="" type="checkbox"/>	
9	66,11	51,32	-5,79	M2	C3	<input checked="" type="checkbox"/>	
12	89,11	-7,98	72,45	M2	C4	<input checked="" type="checkbox"/>	

Line thickness:  1 px  2 px  3 px

Select the line thickness for the graph.

Read Stop Close

You can group the data by measurement condition type by clicking on the “Mx” column header or sort them back to the original measurement sequence by clicking again on “Mx” (even if not all measurements were taken with all conditions). Because you can save the patches in a different file for each measurement condition, sorting using the “Mx” column can help to make sure that the measurements are in the same order in all files.

#	color	L*	a*	b*	Mx	patch name	graph
1		94,01	0,33	-5,93	M0	A1	<input checked="" type="checkbox"/>
2		94,17	0,62	-7,87	M1	B1	<input checked="" type="checkbox"/>
3		93,90	-1,00	-1,76	M2	C1	<input checked="" type="checkbox"/>
4		59,83	-25,60	-48,09	M0	A2	<input checked="" type="checkbox"/>
5		59,98	-25,07	-49,15	M1	B2	<input checked="" type="checkbox"/>
6		59,72	-27,34	-45,71	M2	C2	<input checked="" type="checkbox"/>
7		66,20	52,26	-9,48	M0	A6	<input checked="" type="checkbox"/>
8		66,30	52,48	-11,20	M1	B6	<input checked="" type="checkbox"/>
9		66,11	51,32	-5,79	M2	C6	<input checked="" type="checkbox"/>
10		89,13	-7,84	70,85	M0	A7	<input checked="" type="checkbox"/>
11		89,18	-7,88	70,06	M1	B7	<input checked="" type="checkbox"/>
12		89,11	-7,98	72,45	M2	C7	<input checked="" type="checkbox"/>

#	color	L*	a*	b*	Mx	patch name	graph
1		94,01	0,33	-5,93	M0	A1	<input checked="" type="checkbox"/>
4		59,83	-25,60	-48,09	M0	A2	<input checked="" type="checkbox"/>
7		66,20	52,26	-9,48	M0	A6	<input checked="" type="checkbox"/>
10		89,13	-7,84	70,85	M0	A7	<input checked="" type="checkbox"/>
2		94,17	0,62	-7,87	M1	B1	<input checked="" type="checkbox"/>
5		59,98	-25,07	-49,15	M1	B2	<input checked="" type="checkbox"/>
8		66,30	52,48	-11,20	M1	B6	<input checked="" type="checkbox"/>
11		89,18	-7,88	70,06	M1	B7	<input checked="" type="checkbox"/>
3		93,90	-1,00	-1,76	M2	C1	<input checked="" type="checkbox"/>
6		59,72	-27,34	-45,71	M2	C2	<input checked="" type="checkbox"/>
9		66,11	51,32	-5,79	M2	C6	<input checked="" type="checkbox"/>
12		89,11	-7,98	72,45	M2	C7	<input checked="" type="checkbox"/>

The screenshot shows the PatchTool Patch-Reader window. The 'Instrument' is set to 'i1Pro / i1Pro 2 (XRGA)'. Under 'Display data (D50; 2 deg.; Status T)', 'L\*a\*b\*' is selected. The 'Measurement conditions' section has checkboxes for M0, M1, M2, and M3, with M0, M1, and M2 checked. A table is displayed with columns for #, color, L\*, a\*, b\*, Mx, patch name, and graph. A right-click context menu is open over the table, with options: 'Color space data: XYZ', 'Color space data: L\*a\*b\*' (checked), 'Color space data: L\*C\*h\*', 'Density (Status T)', 'Renumber the patches', and 'Rename the patches'. Red arrows point from the text on the right to the 'Mx' header and the context menu.

Right-click (ctrl + click on a one-button Mac mouse) anywhere on the table top row (the Header) for this popup menu.

When you rename all the patches, the sequential numbers for which there are no more measurements are removed (Ex.: C1-C2-C6-C7 becomes C1-C2-C3-C4). The same sequential numbers is assigned to all measurement conditions of a given measurement (Ex.: A7-B7-C7 is now A4-B4-C4).

#	color	L*	a*	b*	Mx	patch name	graph
1		94,01	0,33	-5,93	M0	A1	<input checked="" type="checkbox"/>
4		59,83	-25,60	-48,09	M0	A2	<input checked="" type="checkbox"/>
7		66,20	52,26	-9,48	M0	A3	<input checked="" type="checkbox"/>
10		89,13	-7,84	70,85	M0	A4	<input checked="" type="checkbox"/>
2		94,17	0,62	-7,87	M1	B1	<input checked="" type="checkbox"/>
5		59,98	-25,07	-49,15	M1	B2	<input checked="" type="checkbox"/>
8		66,30	52,48	-11,20	M1	B3	<input checked="" type="checkbox"/>
11		89,18	-7,88	70,06	M1	B4	<input checked="" type="checkbox"/>
3		93,90	-1,00	-1,76	M2	C1	<input checked="" type="checkbox"/>
6		59,72	-27,34	-45,71	M2	C2	<input checked="" type="checkbox"/>
9		66,11	51,32	-5,79	M2	C3	<input checked="" type="checkbox"/>
12		89,11	-7,98	72,45	M2	C4	<input checked="" type="checkbox"/>

Here is a screenshot of the four files, reopened in PatchTool, which were generated from the measurements shown on the preceding pages. A dialog with [CGATS file options](#) appears when you click on the “Stop” button and choose to save the measurements. In this example we selected one file for each measurement condition (M0, M1, and M2) plus one file with all twelve measurements.



This is the file with all the measurements. The order in which the patches are saved matches the order in which the measurements were listed in the Patch-Reader window.



### 3.18.3 Patch-Reader Custom chart interface

Once you click on the “Start” button, you are asked to calibrate the instrument. The calibration takes a few seconds more than a simple reflectance calibration because it also calibrates the instrument for scanning reflectance (i.e. Strip mode).

The screenshot shows the PatchTool Patch-Reader interface. At the top, a table displays patch data for Row 1, ID 5, Name C1 (D50; 2 deg.; Status T):

Row: 1	ID: 5	Name: C1	(D50; 2 deg.; Status T)
M0: L*a*b*:	81.6 / 3.1 / 87.0	D(CMYK):	0.13 / 0.26 / 1.14 / 0.20
M1: L*a*b*:	81.7 / 3.0 / 86.8	D(CMYK):	0.13 / 0.26 / 1.14 / 0.20
M2: L*a*b*:	81.6 / 3.0 / 87.3	D(CMYK):	0.13 / 0.26 / 1.15 / 0.20

Annotations include:

- Patch data corresponding to the mouse position is shown in the top of the window.** (Points to the data table)
- Select this button to automatically take measurements at fixed time intervals. Adjust the delay between each measurement.** (Points to the 'Timed' radio button and the '4 seconds' delay field)
- The minimum patch width is shown for the selected instrument and measurement mode.** (Points to 'Minimum patch width: 6 mm')
- Click on the “Read” button or on the instrument button to make a measurement.** (Points to the 'Read' button)
- Click on the “Stop” button to save your results in a file.** (Points to the 'Stop' button)
- The next measurement will be assigned to the patch with the red border and the red X.** (Points to a patch in the chart area)

You can select a patch using any of the following methods:

- i- By clicking on the arrows of the “Patch selector”.
- ii- By using your keyboard arrow keys.
- iii- By clicking directly on a patch.

Once a patch is measured, the next position is user-selectable with a menu, shown below, which appears by doing a right-click anywhere in the chart area. You can select to go to the RIGHT of the current patch, and the row will be incremented once the last patch in the row is reached, or you can go DOWN, and the column will be incremented once you reach the bottom row of the current column, or you can stay on the same patch.

Using the menu just mentioned, you can also change the type of patch data shown when you move the mouse over the patches.

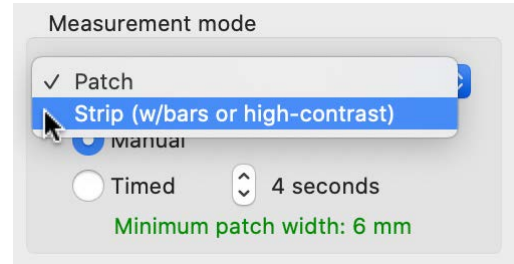
To automatically make measurements at fixed time intervals, select the “Timed” radio button and adjust the delay between each measurement. Click on the “Read” button or on the instrument button to start the automated measurements; select the “Manual” radio button (NOT the “Stop” button!) to stop the sequence. While in “Timed” mode, you can always push the instrument button to make a measurement; this will reset the timer at the start of another cycle. You can also select any patch in the layout using your mouse, the keyboard, or the navigation arrows.

The context menu shows the following options:

- Color space data: XYZ
- Color space data: L\*a\*b\*
- Color space data: L\*C\*h
- Density (Status T)
- ✓ L\*a\*b\* and Density (Status T)
- Meas. conditions: M0
- Meas. conditions: M1
- Meas. conditions: M2
- Meas. conditions: M0/M1
- Meas. conditions: M0/M2
- Meas. conditions: M1/M2
- ✓ Meas. conditions: M0/M1/M2
- ✓ After a 'Read', auto-select to the RIGHT
- After a 'Read', auto-select going DOWN
- Stay on the SAME patch after a 'Read'

You can click the “Stop” button at any time. The measurements are saved in a [CGATS type file](#) which can be readily opened by most programs which can read color files.

It is also possible to take measurements one row at a time, by scanning the instrument from one side of the chart to the other. Select the Strip mode with the menu within the “Measurement mode” box. Once the Strip mode is selected, the “Manual” and “Timed” radio buttons are replaced by “Zebra ruler” and “low resolution target” buttons.



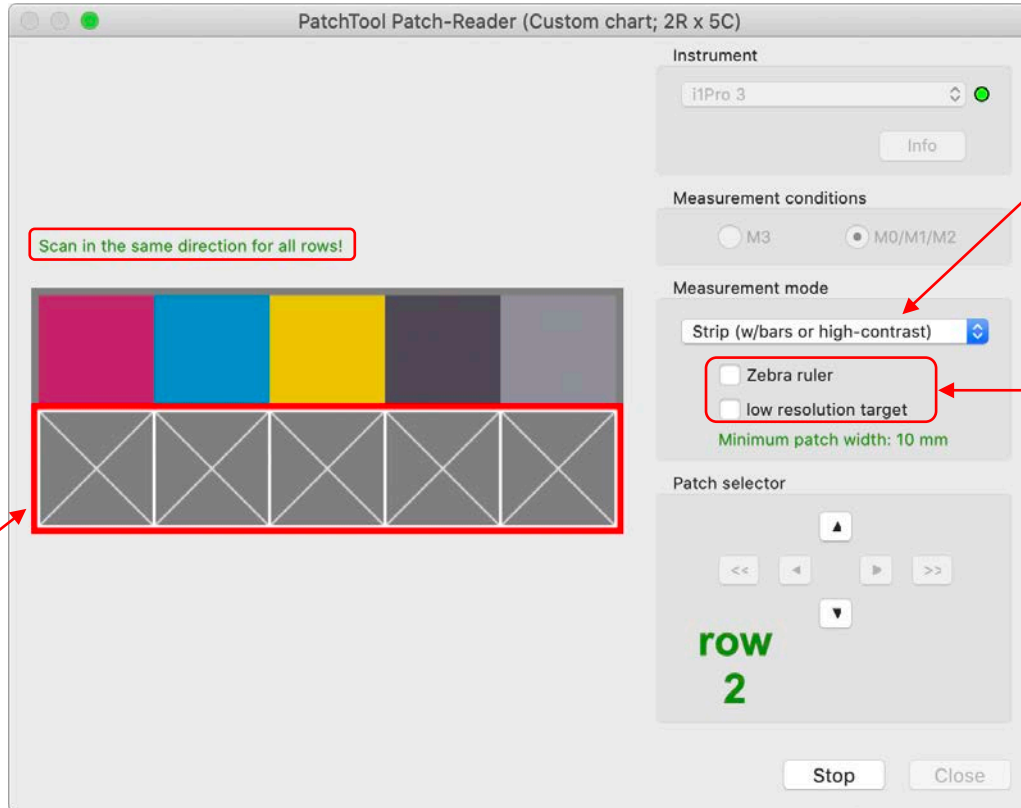
For successful results in strip mode, the printed patches must fulfill a few requirements; these are shown in the table below.

### Recommended patch sizes and row length for REFLECTANCE scanning

Instrument	Min. PATCH width (Zebra ruler ON)	Min. PATCH width (Zebra ruler OFF)	Max. ROW length	Min. PATCH height
i1Pro / i1Pro 2	7 mm	10 mm	235 mm / 250 mm	8 mm
i1Pro 3	7 mm	10 mm	250 mm	7 mm
i1Pro 3 Plus	16 mm M3-mode: 20 mm	20 mm M3-mode: 22 mm	490 mm	16 mm

**Note 1:** The **minimum patch width** excludes any marker/seperator width.

In addition, when scanning, DeltaE\*ab between neighboring patches must be > 20 for 50%+ of the transitions for the Zebra ruler. When not using the Zebra ruler, DeltaE\*ab must be > 20 for all transitions. Alternately, the patches must be separated by contrast markers consisting of thin black or white bars (0,5-1,0 mm), whichever gives the maximum contrast, or combined Black/White bars (1,2-1,8 mm) before and after each patch (Note: Single lines must not be combined with two-color bars in the same chart).



The “Strip” mode is selected; input has to be done by scanning one row at the time.

These checkboxes are disabled when the i1Pro does not support these modes.

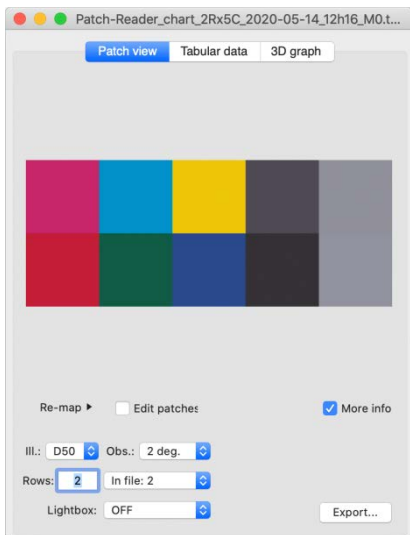
The data of the next scanned line will be assigned to the row identified by a red border.

When scanning Custom charts without a Zebra ruler, always start from the same side; the specific side does not matter as long as you do not change direction within a target. If you scan from right to left however, you may need to flip the patches horizontally ([Re-map/Flip Horizontal](#)) once the measurements are saved.

**Hint:** You can easily create targets with contrast markers using PatchTool; please consult [Section 2.5.2](#) (The Export “Image” tab) for more information on this feature. We suggest you also read this short [tutorial](#) on how to optimize a layout for strip mode measurements.

Scanning a line is done in the following sequence (Note: In this example we could measure in the M0/M1/M2 conditions in a **single-pass** because we used an i1Pro 3; a dual-pass sequence, required when measuring M0/M1/M2 conditions with an i1Pro 2, is described in the [middle of the next section](#)):

- a) Position your instrument outside the printed target, usually on white paper stock, just beside the first patch. Push on the instrument button, without moving, until you hear a “beep” (With speaker ON!).
- b) While keeping the button pressed, slide the instrument across the patches, with constant speed (about 2 to 4 inch (5 to 10 cm) per second for a Rev. A i1Pro; a Rev. B-D i1Pro or an i1Pro 2 can go twice as fast and an i1Pro 3 even faster).
- c) Move the instrument until it goes beyond the patches, and then release the button as you stop. You should hear another “beep”. In case of error, you will hear three beeps and an error message will be shown in the window.
- d) Repeat a) to c) for each chart row. While the row will be automatically incremented when a scan is successful, you can always select another row or re-measure one that was previously done.



Shown on the left is the file corresponding to the Patch-Reader example of the preceding page, which we completed by scanning the second row. Please note that for this target, printed with no markers between the patches, we could have scanned both lines because the contrast between patches is high enough.

**Note:** Because of a design limitation, the Zebra ruler can only be used, in reflectance, with charts which have at least 6 patches in a row. If your patches have sufficient contrast between them, you can scan the line without using the Zebra ruler features, i.e. by not selecting the “Zebra ruler” checkbox. This is how the measurements for the screenshot above were taken; we could also have used the older i1Pro ruler.

### 3.18.4 Patch-Reader PatchTool file interface

Once you click on the “Start” button, you are asked to calibrate the instrument. The calibration takes a few seconds more than a simple reflectance calibration because it also calibrates the instrument for scanning reflectance (i.e. Strip mode). An example of measurements made in Strip mode is presented farther in this section.

Patch data corresponding to the mouse position is shown in the top of the window.

The top part of the window duplicates the selected row.

The top triangle shows the reference and the bottom triangle the measurement (when done).

The next measurement will be assigned to this patch.

In this screenshot, all the patches of the first two rows were measured, as well as the first two patches of row 3.

Measurements will be taken with the M0, M1, and M2 measurement conditions.

Select this button to automatically take measurements at fixed time intervals. Adjust the delay between each measurement.

Click on the “Read” button or on the instrument button to make a measurement.

Click on the “Stop” button to save your results in a file.

You can select a patch using any of the following methods:

- i- By clicking on the arrows of the “Patch selector”.
- ii- By using your keyboard arrow keys.
- iii- By clicking directly on a patch.

Once a patch is measured, the next position will automatically be selected; the direction is user-selectable with a menu, shown on the right, which appears by doing a right-click anywhere in the chart area. You can select to go to the RIGHT of the current patch, and the row will be incremented once the last patch in the row is reached, or you can go DOWN, and the column will be incremented once you reach the bottom row of the current column, or you can stay on the same patch.

Using the menu just mentioned, you can also change the type of patch data shown when you move the mouse over the patches.

Color space data: XYZ (Ref. vs Meas.)

✓ Color space data: L\*a\*b\* (Ref. vs Meas. and DeltaE\*)

Color space data: L\*C\*h (Ref. vs Meas. and DeltaE\*)

CMYK (Ref.) vs Density (Status T) (Meas.)

L\*a\*b\* and Density (Status T) (Meas. only)

---

Meas. conditions: M0

Meas. conditions: M1

Meas. conditions: M2

Meas. conditions: M0/M1

Meas. conditions: M0/M2

Meas. conditions: M1/M2

✓ Meas. conditions: M0/M1/M2

---

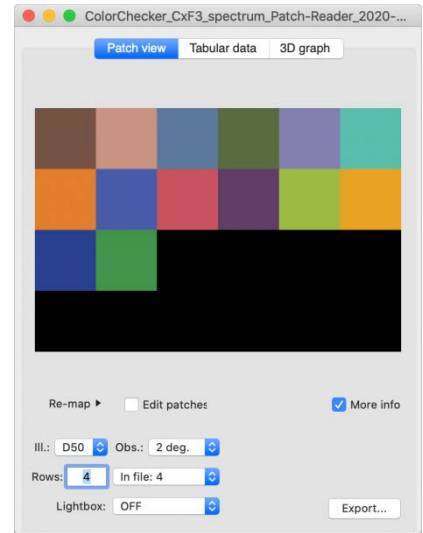
✓ After a 'Read', auto-select to the RIGHT

After a 'Read', auto-select going DOWN

Stay on the SAME patch after a 'Read'

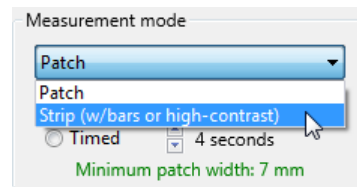
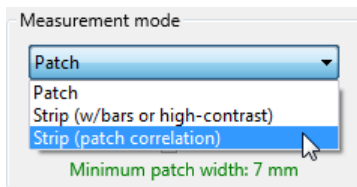
To make measurements at fixed time intervals, select the “Timed” radio button and adjust the delay between each measurement. Click on the “Read” button or on the instrument button to start the automated measurements; select the “Manual” radio button (NOT the “Stop” button!) to stop the sequence. While in “Timed” mode, you can always push the instrument button to make a measurement; this will reset the timer at the start of another cycle. You can also select any patch in the layout using your mouse, the keyboard, or the navigation arrows.

You can click the “Stop” button at any time; the non-measured patches will be black. The measurements are saved in a [CGATS type file](#) which can be readily opened by most programs which can read color files. The screenshot on the right corresponds to the measurements illustrated on the preceding page.



It is also possible to take measurements one row at a time, by scanning the instrument from one side of the target to the other. When using a PatchTool file as a reference for measuring a chart, the “Measurement mode” menu will display two or three menu items depending on the selected instrument and the selected measurement conditions. For example, for the i1Pro 2, the menu will offer three selections if the instrument’s default measurement condition is selected (M0 or M2, depending on the instrument model) and two selections if all three M0/M1/M2 measurement conditions are selected. The reason for removing the “correlation” menu is because the i1Pro 2 requires two scans per line for M0/M1/M2 measurements. The two menus are shown below.

Measurement mode menu when the instrument’s default measurement condition is selected (M0 or M2).



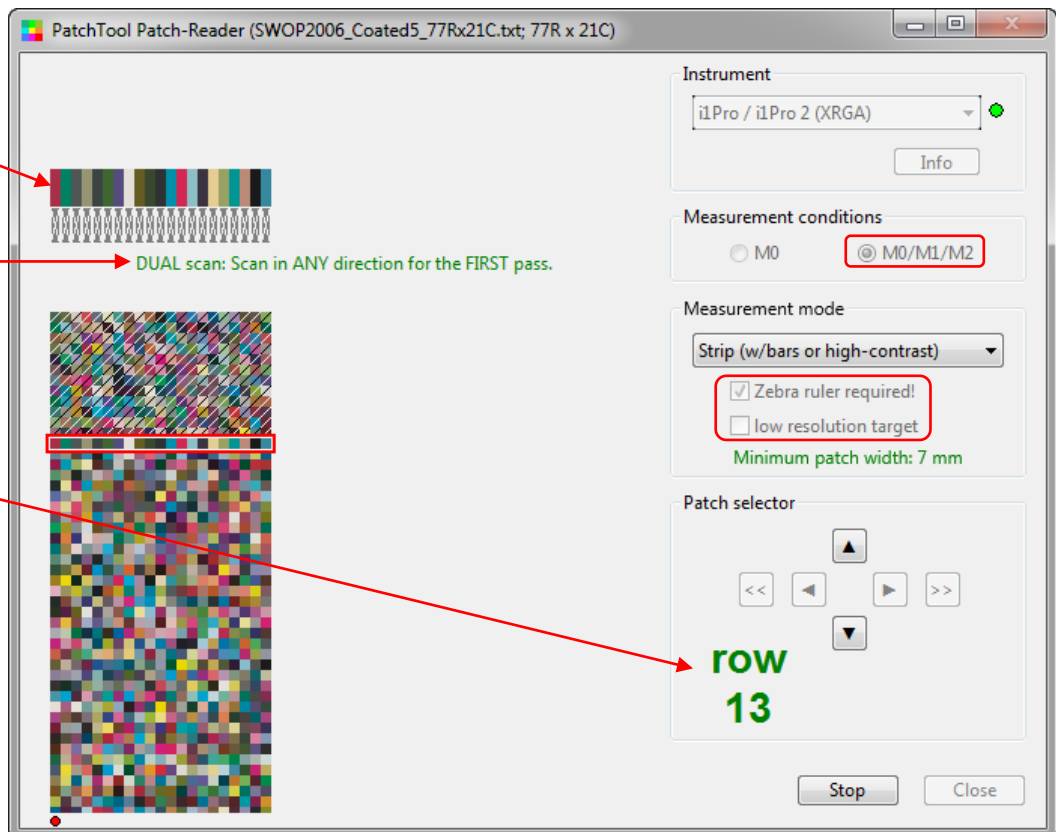
Measurement mode menu when M0/M1/M2 selected. (i1 Pro 2)

For the next example starting below, we have selected an i1Pro 2 that we use to scan a target line by line. Because we selected the M0/M1/M2 measurement conditions, which require two measurement passes per line, the Zebra ruler is selected (and disabled) and the low resolution target option is not available. In the screenshot we see that the first twelve rows have been measured and that the next measurements will be assigned to row 13.

The next row to be scanned is also shown here.

Message shown before doing the FIRST pass of a two passes scan.

The next row to be scanned is highlighted by the program and the row number is shown in a large font.





For successful results in strip mode, the printed patches must fulfill a few requirements; these are shown in the table below.

### Recommended patch sizes and row length for REFLECTANCE scanning

Instrument	Min. PATCH width (Zebra ruler ON)	Min. PATCH width (Zebra ruler OFF)	Max. ROW length	Min. PATCH height
i1Pro / i1Pro 2	7 mm	10 mm	235 mm / 250 mm	8 mm
i1Pro 3	7 mm	10 mm	250 mm	7 mm
i1Pro 3 Plus	16 mm M3-mode: 20 mm	20 mm M3-mode: 22 mm	490 mm	16 mm

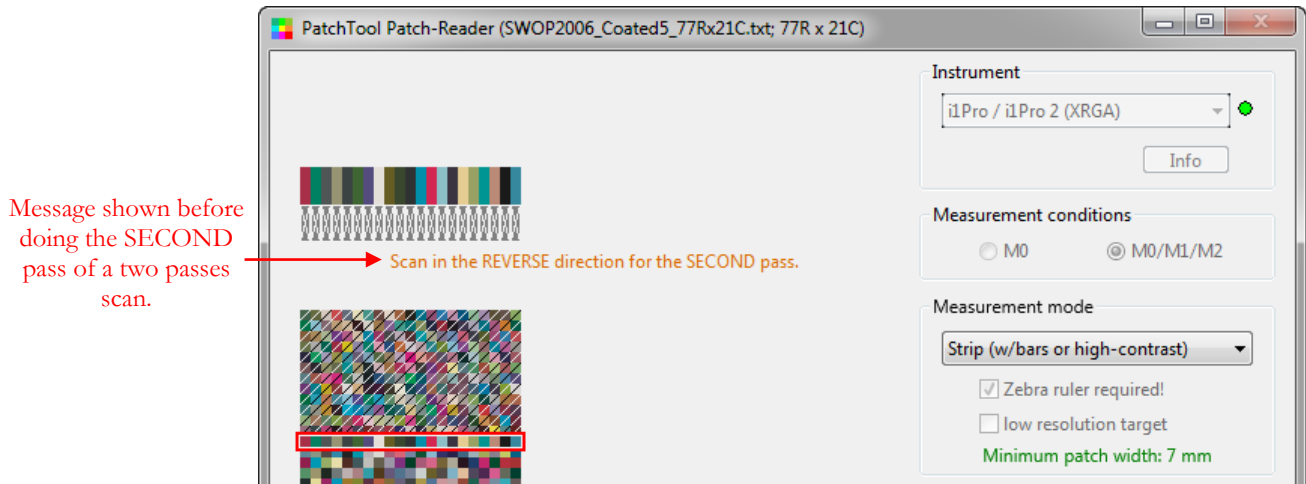
**Note 1:** The **minimum patch width** excludes any marker/separator width.

In addition, when scanning,  $\Delta E^*_{ab}$  between neighboring patches must be  $> 20$  for 50%+ of the transitions for the Zebra ruler. When not using the Zebra ruler,  $\Delta E^*_{ab}$  must be  $> 20$  for all transitions. Alternately, the patches must be separated by contrast markers consisting of thin black or white bars (0,5-1,0 mm), whichever gives the maximum contrast, or combined Black/White bars (1,2-1,8 mm) before and after each patch (Note: Single lines must not be combined with two-color bars in the same chart).

**Hint:** You can easily create targets with contrast markers using PatchTool; please consult [Section 2.5.2](#) (The Export “Image” tab) for more information on this feature. We suggest you also read this short [tutorial](#) on how to optimize a layout for strip mode measurements.

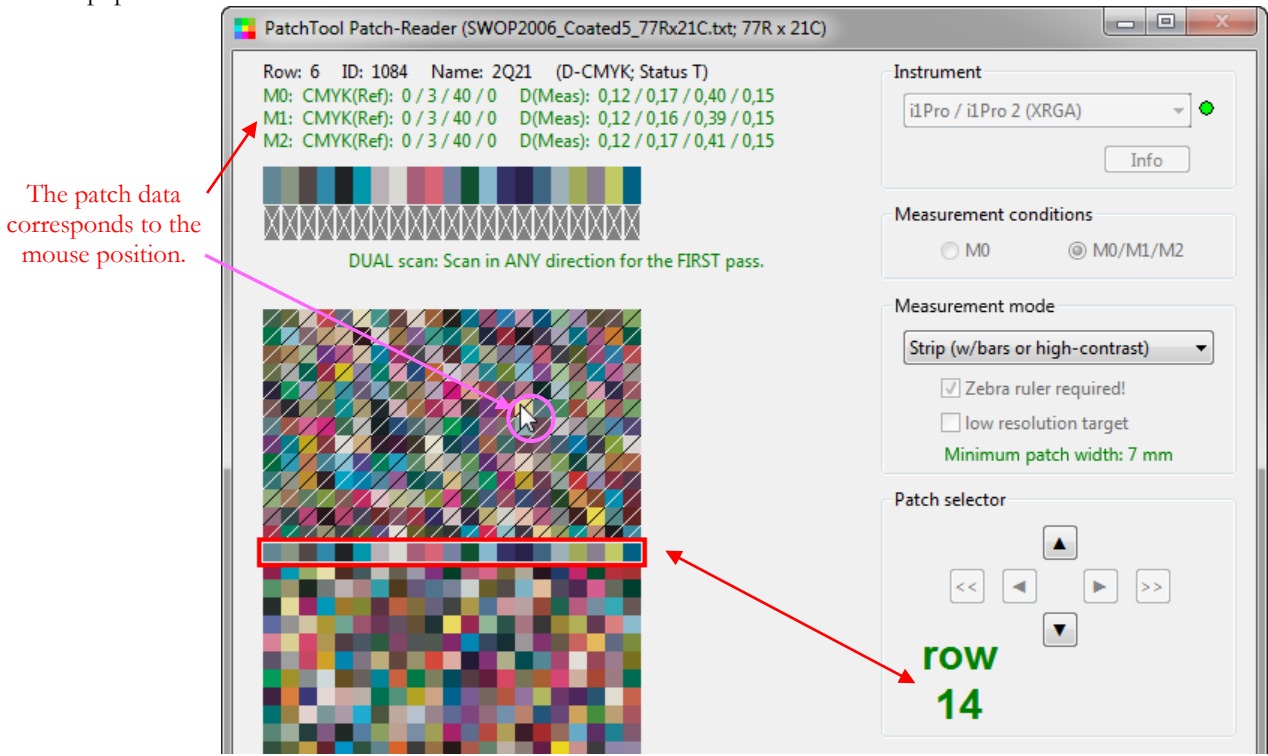
When scanning with a Zebra ruler you can start on either side of your chart; the measurements will always be presented as if measured from left-to-right. Scanning a line is done in the following sequence (Note: This example with an i1Pro 2 calls for a **dual-pass** sequence, as required for the M0/M1/M2 measurement conditions):

- Position your instrument outside the printed target, usually on white paper stock, just beside a patch. Push on the instrument button, without moving, until you hear a “beep” (With speaker ON!).
- While keeping the button pressed, slide the instrument across the patches, with constant speed (about 4 to 8 inch (10 to 20 cm) per second for an i1Pro 2).
- Move the instrument until it goes beyond the patches, and then release the button as you stop. You should hear two “beeps” if everything is OK; you will see a slowly flashing blue LED indicating the direction of the next scan and the message should be as in this next screenshot. In case of error, you will hear three beeps and an error message will be shown in the window.

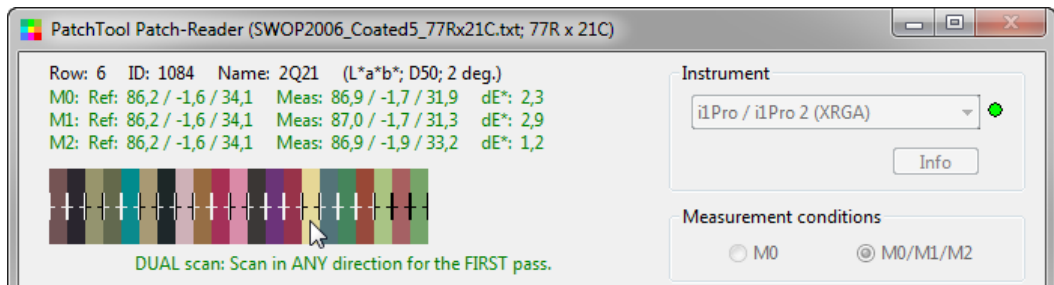
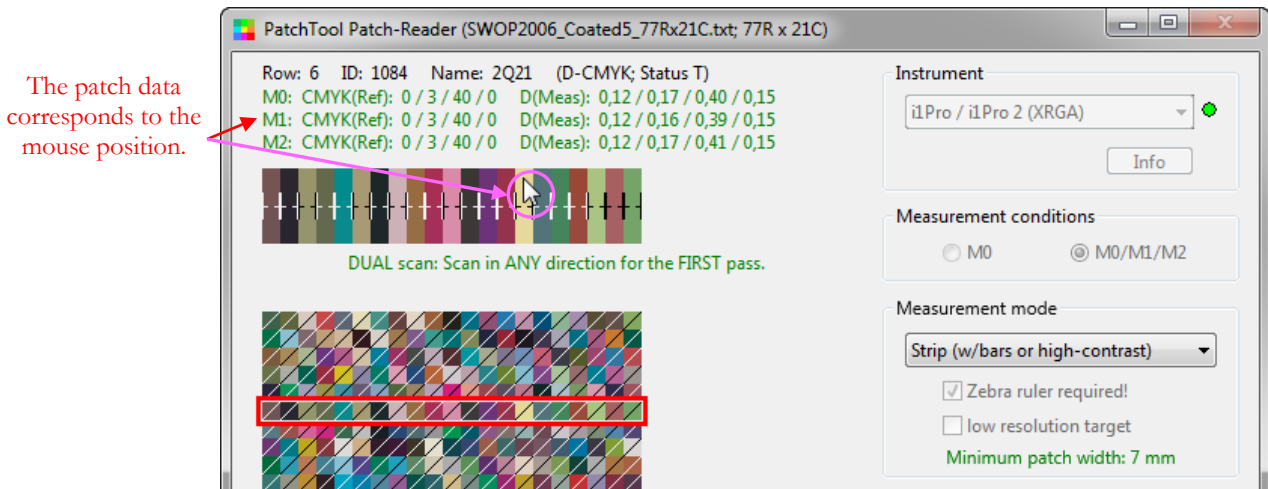


- Redo a scan in the other direction ON THE SAME ROW as you did in steps a) and b). On success you will hear a single “beep” and see the two LED bars on the i1Pro 2 flash twice in green. In case of error, you will hear three beeps and an error message will be shown in the window.
- Repeat a) to d) for each chart row. While the row will be automatically incremented when a scan is successful, you can always select another row or re-measure one that was previously done.

At any time during the measurements you can check the patch data by moving the mouse over a patch. Shown below is the data of a patch on row 6 (ID: 1084) which can be obtained while row 14 is still selected. You will notice that the densities are different for each measurement conditions, an indication of the use of a fluorescent paper.



On the next two screenshots we have selected row 6 and we compare the patch colors in the top display. We can also change the data type as we saw in the beginning of this section; the last screenshot shows the reference and measured  $L^*a^*b^*$  values as well as  $\Delta E^*$  (CIELAB).

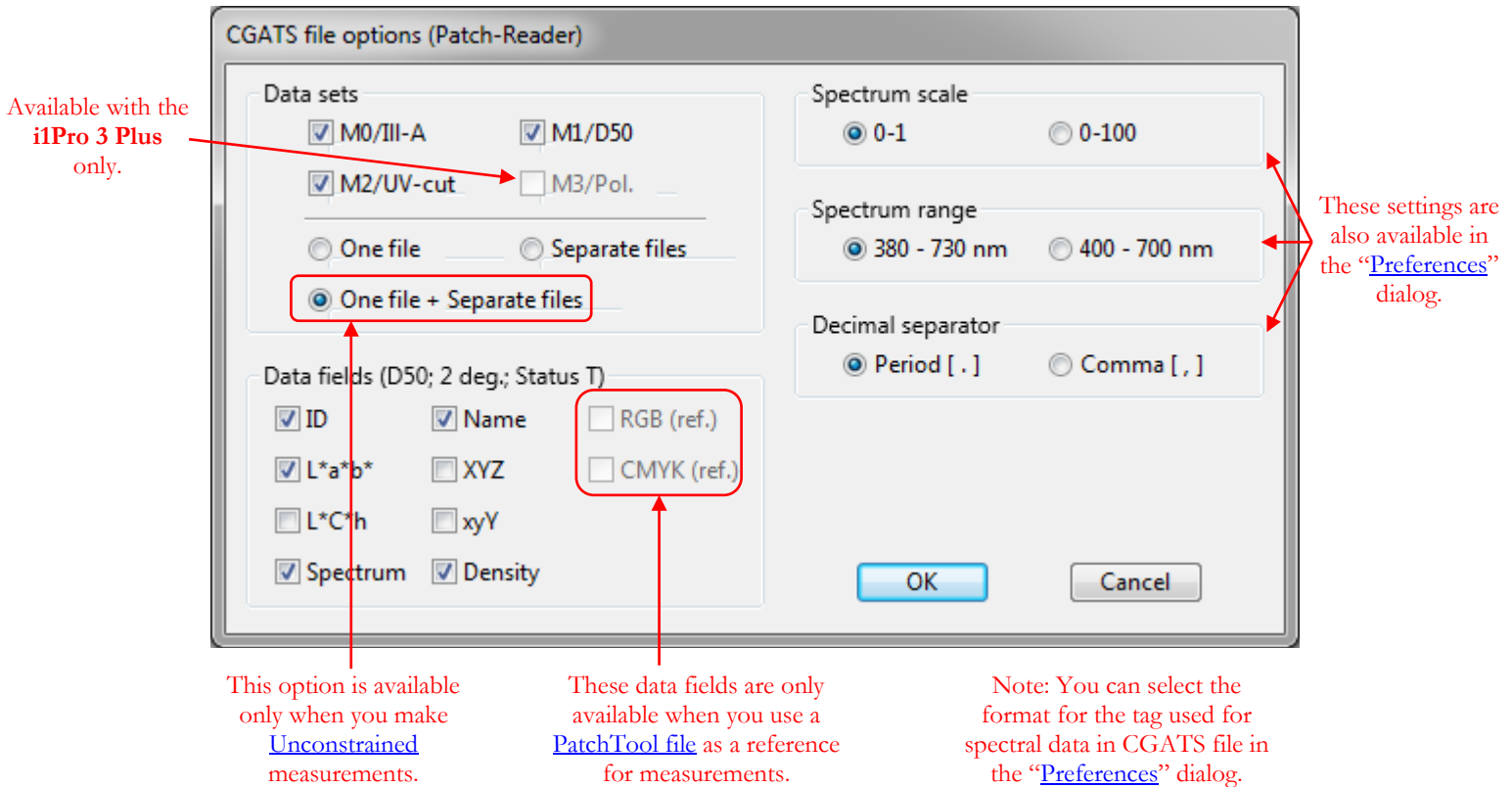




### 3.18.5 Patch-Reader CGATS saving options

Whenever you decide to keep the measurements done in Patch-Reader, you are presented with a dialog that contains options to be used for saving the CGATS compatible file. The dialog appearance will vary depending on the available data and on the selected Patch-Reader chart type.

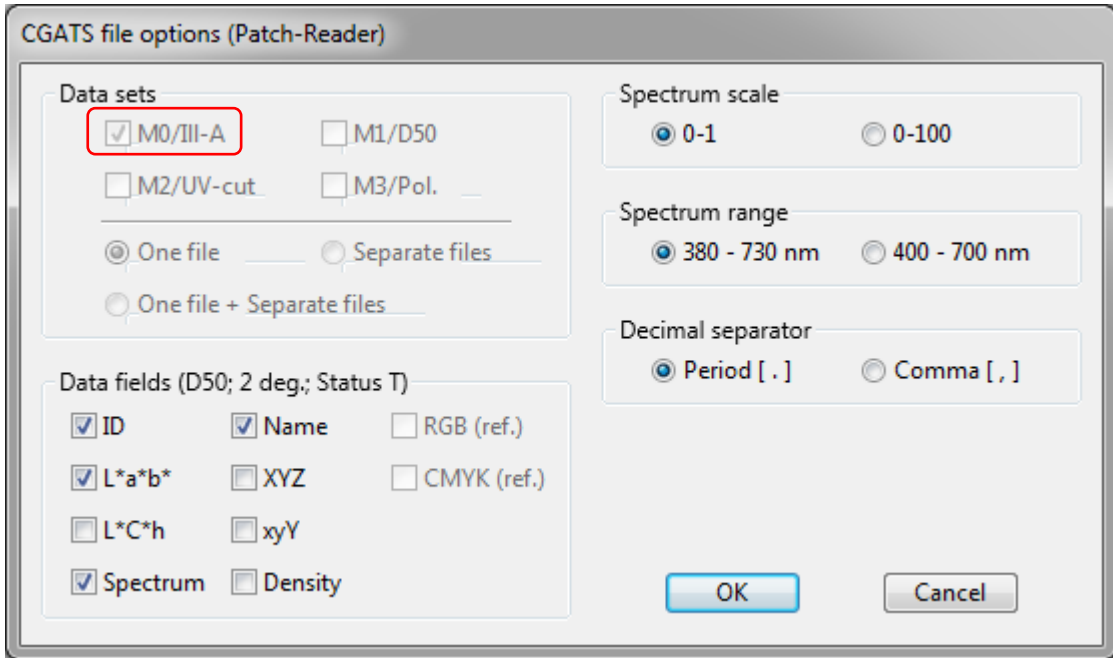
Here is the dialog as it appears after making [Unconstrained](#) measurements in M0, M1, and M2 measurement conditions. You can export the data in a single file, with all measurements taken in all measurement conditions, or you can save the measurements in a separate file for each measurement condition, or even in a single file in addition to separate files. The RGB and CMYK checkboxes are available only when you use a PatchTool file as reference to make Patch-Reader measurements since the RGB and CMYK values are taken directly from the reference file and NOT derived from the measured data.



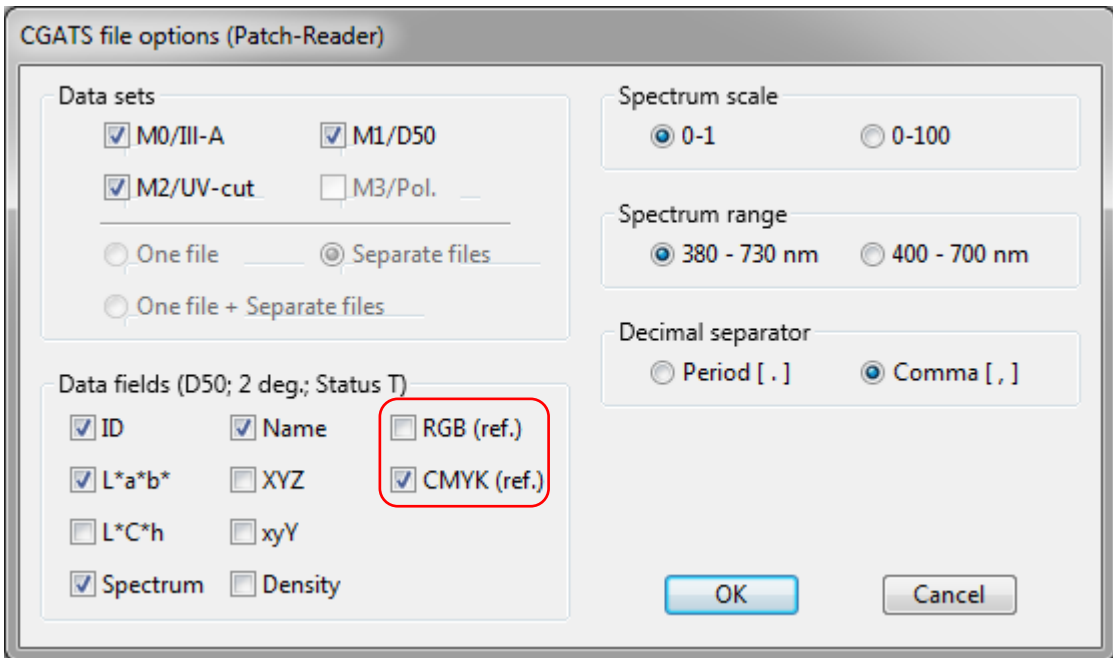
**Hint:** In this export dialog, the tristimulus data and the derived color spaces (XYZ, L\*a\*b\*, L\*C\*h, xyY) are always computed for Illuminant D50 and the 2 degree Standard Observer. If you wish to obtain tristimulus data for another Illuminant or another Standard Observer, you must, for maximum accuracy, export the spectral data. You should then reopen the file in PatchTool, change the Illuminant and/or Standard Observer, and finally re-export the file.

**Hint:** If you export Density data, it will be computed with the Density standard selected in the "[Misc.](#)" tab of the "[Preferences](#)" dialog, and which is shown as a reminder in the "Data fields" title (here we see "Status T"). If this is not the Density standard you prefer, you must absolutely export the spectral data, reopen the file in PatchTool, change the Density standard, and re-export the file.

Here is the dialog as it appears after making measurements on a [Custom chart](#) with the M0 measurement condition only. This is the dialog you would see, for instance, when making measurements with an old non-UV-Cut i1Pro. If we had used a UV-cut i1Pro, only the “M2/UV-cut” checkbox would be selected.



Here is the dialog as it appears after making measurements with an i1Pro 2 or i1Pro 3 with the M0/M1/M2 measurement conditions on a chart defined by a [PatchTool file](#). The data can be saved only in separate files and you can select which measurement conditions you want to keep. The RGB and CMYK checkboxes are enabled; the RGB and CMYK values are taken directly from the reference file.

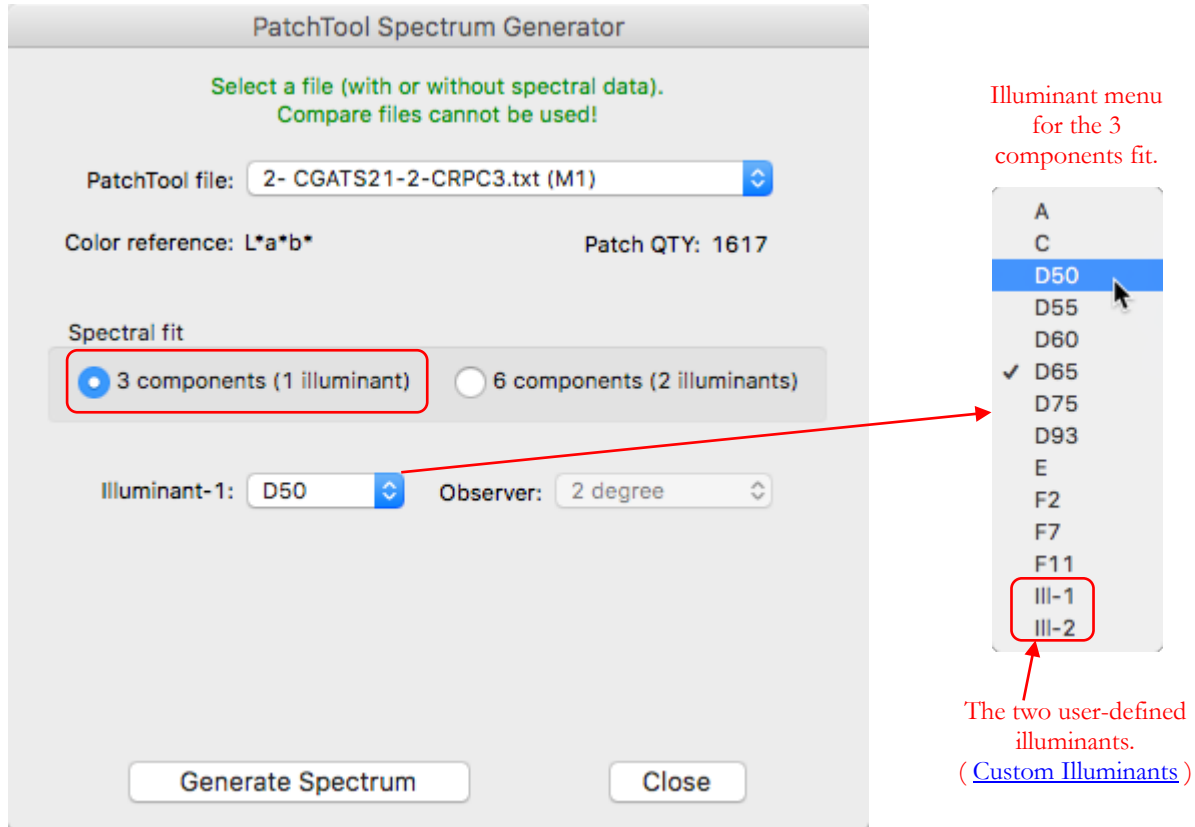


**Note:** With an **i1Pro 3 Plus** you can make measurements either with the M0/M1/M2 conditions together or only with the M3 condition.

### 3.19 Spectrum Generator

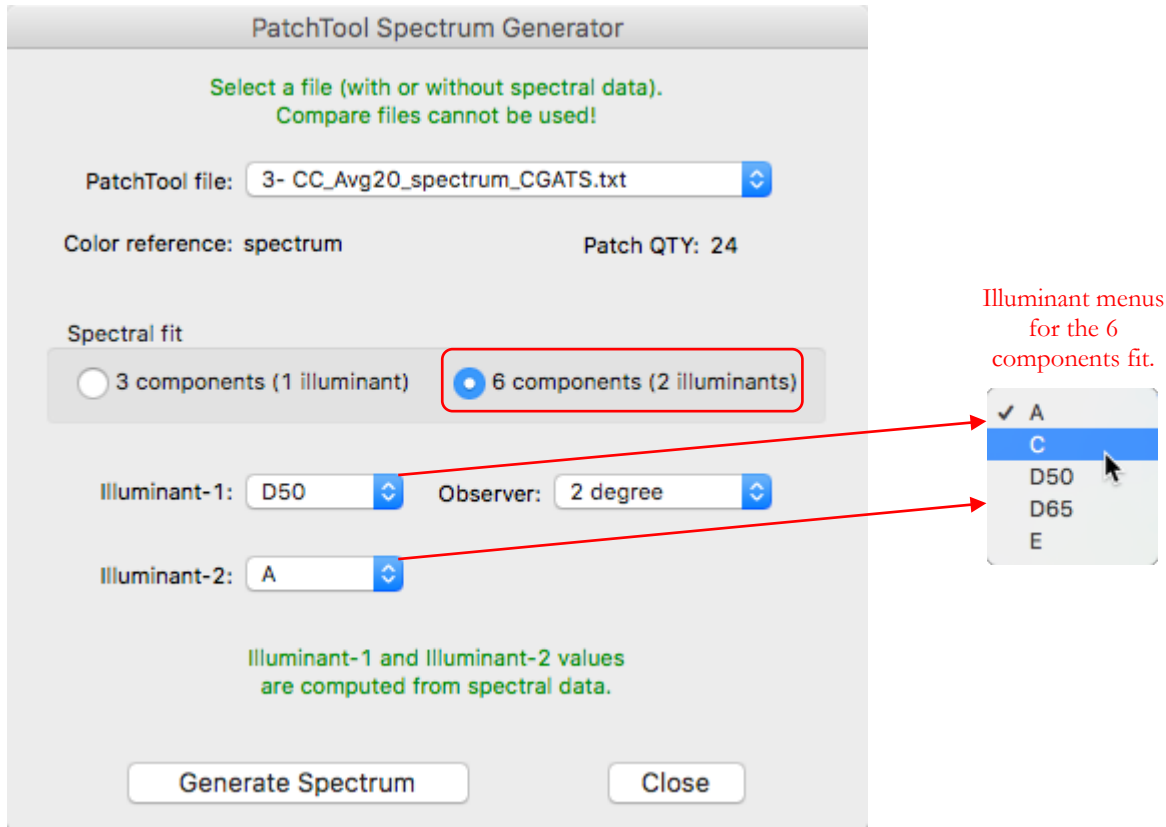
The “PatchTool Spectrum Generator” tool is opened by selecting the “Tools/ Spectrum Generator ...” menu. The menu is enabled when there is at least one opened file. This tool’s purpose is to generate a spectrum which matches input tristimulus values (i.e. XYZ) for a given illuminant and Standard Observer.

Any opened file can be used as input. The input file may or may not contain spectral data. If the input file does not contain spectral data, the Standard Observer is imposed by the one found in the file but the target illuminants for the generated spectral data can be selected. If the input file contains spectral data, you can select the target illuminants and the Standard Observer.



The method used in this tool to convert tristimulus data to spectral data is based on Principal Component Analysis (PCA). PCA is a mathematical process by which a few spectral components (or base vectors), typically three to six, are extracted from a large number of spectrums forming a reference dataset. The goal of the process is that any spectrum (i.e. color) from the dataset can be obtained by adding the principal components in various proportions, with these proportions derived using the tristimulus values for one or more illuminant. The accuracy of the synthesized spectrum will generally increase as more components are used. However, because of how the math works, we can obtain only the first three proportions, the most important ones, using the tristimulus values of one illuminant, and we can obtain the proportions for six components if we have tristimulus values for two illuminants.

The reference dataset used for component extraction is selected to cover a large gamut and is usually representative of a given group of pigments. The principal components of this tool were extracted from measured samples of the NCS, Munsell, and OSA-UCS color order systems. What this means in practice is that, for the same color coordinates, a spectrum generated by this tool is likely to be more similar to a NCS, Munsell, or OSA-UCS spectrum than to the spectrum of a Pantone chip.



You will readily appreciate that we can easily determine tristimulus values if we start with spectral reflectance data but this is less obvious if we start with  $L^*a^*b^*$  D50 data for example. One could try to obtain tristimulus data for the second illuminant using a Chromatic Adaptation Transform (CAT), a Bradford transform for instance, but this would not work. The reason why is because the Bradford transform is essentially a linear mix of the original tristimulus data, and this is not exactly the same value that would be obtained using spectral calculation (in other words, the CAT does not include the effect of illuminant metamerism). Thus, instead of a standard CAT, we use a custom non-linear approximation to estimate the tristimulus values for the second illuminant when the input data is tristimulus.

**Important:** Because of how the PCA is defined, the tristimulus values obtained with the output spectrum and the selected illuminant(s) should exactly match the input tristimulus values; in other words, the color difference should be zero. There are however two exceptions to this rule. The first one is when the input reference color is outside of the gamut covered by the reference dataset; in this case, the resulting spectrum may contain negative values, which mathematically meet the PCA requirements, i.e. the derived XYZ values will match if used as is, but will result in fit errors once these unreal values are clipped to zero. This **Gamut Warning** condition is flagged by adding “\_GW” to the patch name; you should check these spectrums carefully as the effect may be negligible. The second case is when selecting a six components spectral fit when the input data is **not** from spectral data. Because the fit data for the second illuminant is estimated instead of computed from spectral data, the output spectrum will usually be more accurate for the first illuminant. You will also note that we limit the illuminants selection for the six components fit, as shown in the screenshot above.

### 3.20 Substrate Correction

The “PatchTool Substrate Correction Tool” dialog is opened by selecting the “Tools/Substrate Correction...” menu. The menu is enabled when there is at least one opened file.

This tool is designed specifically to perform these tasks:

- 1- **Substrate correction**, more specifically correcting a reference file containing colorimetric aims specified for a given substrate so that it better corresponds to a measured substrate characteristics. This procedure is proposed in ISO/PAS 15339-1.
- 2- **Backing correction**, more specifically correcting measurements made with a given backing so that they correspond to measurements done with another backing. This procedure is proposed in ISO 13655-2009.
- 3- **Convert between Measurement Conditions** defined in [ISO 13655-2009](#); for example, convert your bank of reference M0 data to M1. While this use may not have been thought of when the procedure was first devised, we have seen it recommended for this task.

These tasks are grouped because they are based on the same Tristimulus Linear Correction method and the same equations (the correction is done on XYZ coordinates). In this method, the only inputs required for conversion are the “Paper White” and “Minimum patch” of the reference substrate (or the measurements on the first backing), and the “Paper White” of the “Measured substrate” (or the measurements on the second backing).

The *Reference substrate/Backing-1* data is usually a file with many patches while the *Measured substrate/Backing-2* data essentially requires only one patch, which can be manually specified. The conversion is always done on the Reference substrate/Backing-1 data and results in a *corrected file* which opens in PatchTool.

**Reference substrate / Measured data (Backing-1)**

Substrate correction / Backing conversion  
(ISO/PAS 15339-1 / ISO 13655:2009)

PatchTool file: 2- SWOP2013C3 CRPC5 IT8.7-5 (TC1617).t...

Illuminant: D50    Observer: 2 degree

**Paper White**

Get MAX L\* from file    ID: 1

L\* 92,000    a\* -0,002    b\* 0,004

**Minimum patch (Max TAC)**

Get MIN X, Y, Z from file     Set L\*a\*b\*

Get MIN L\* from file     Select ID

X 0,989    Y 0,900    Z 0,644

ID: N.A.

**Measured substrate / Measured data (Backing-2)**

Data origin:  PatchTool file     User input

DeltaE\* formula:  CIELAB     CIEDE2000

Paper White: 1- IT874\_i1iO\_J7156-Unit-1.txt

Illuminant: D50    Observer: 2 degree

Get MAX L\* from file    ID: 1

L\* 94,788    a\* 1,553    b\* -4,824

L\* 2,788    a\* 1,555    b\* -4,828

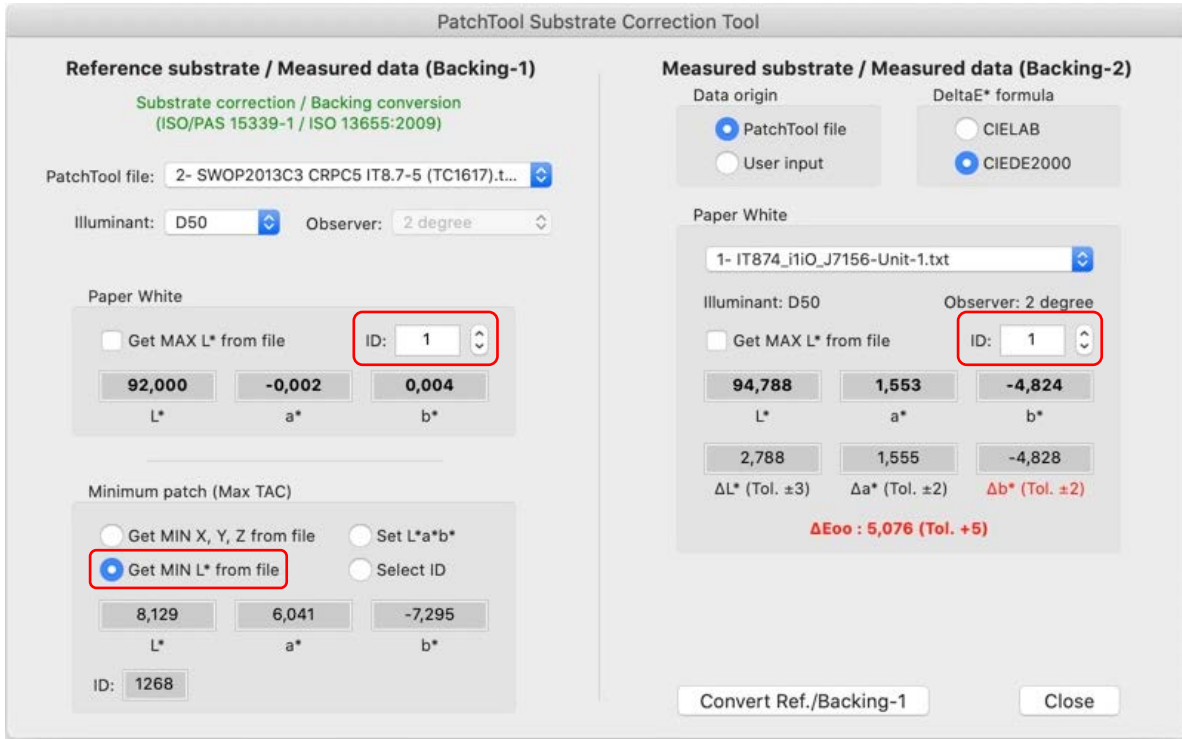
$\Delta L^*$  (Tol.  $\pm 3$ )     $\Delta a^*$  (Tol.  $\pm 2$ )     $\Delta b^*$  (Tol.  $\pm 2$ )

**$\Delta E_{00}$  : 5,076 (Tol. +5)**

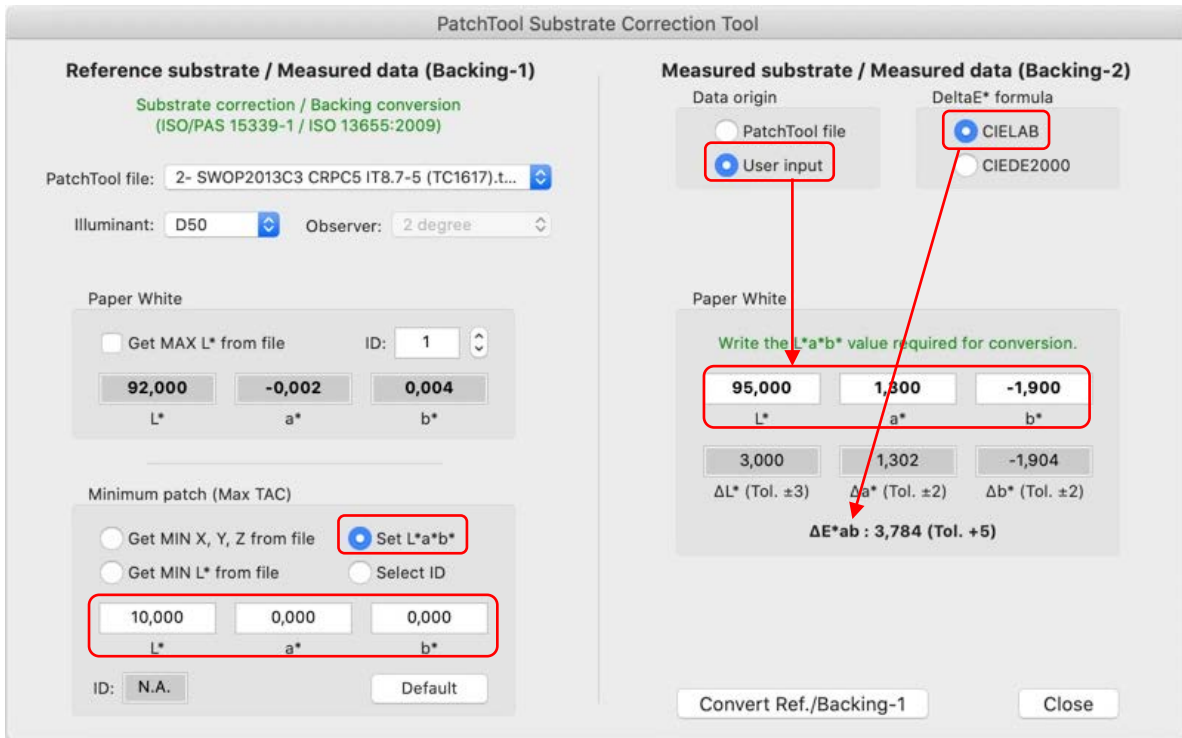
Buttons: Convert Ref./Backing-1, Close

As per Idealliance  
SCCA Calculator V-24.

You can let PatchTool find the patch with maximum L\* or assign the maximum from a specific patch ID. There are four options for the minimum patch: let PatchTool find the minimum (X,Y,Z) in the selected file, as per the latest Idealliance guidelines (SCCA calculator V-24); find the minimum L\* as recommended in previous Idealliance guidelines; set the minimum L\*a\*b\* directly; or select the minimum with the patch ID.



Uncheck a "Get..." checkbox and change the patch ID with the arrows. You can also write a patch number in the ID field.



Write the L\*a\*b\* values in their respective fields.

**Note:** ISO/PAS 15339 is a rapidly evolving document and may be subject to change. Please consult the latest version for recommendations and best usage.

**Important:** BabelColor cannot guarantee results nor provide technical assistance in the use of the corrected data.



### 3.21 Tweak Target

The “PatchTool Tweak Target” window is opened by selecting the “Tools/Tweak Target...” menu. The “Tweak Target...” menu will be available when there are at least two files opened in PatchTool. This tool’s purpose is to improve the accuracy of printed color patch lists by successive approximations; the original color list is modified in one or two iterations. A typical use would be to print a target, a ColorChecker for example, where we want the print to be as close as possible to the reference values.

**Important:** This tool is NOT designed to edit or change an ICC profile. This tool will enable you to print more accurate patches for specific printer/paper/printing-settings conditions. The tweaked files may not be used with other printers or with other papers on the same printer.

**Important:** This tool is designed to improve the accuracy of spot colors. It cannot be used to improve the accuracy of images, unless these images are made of spot colors whose color values are manually corrected using the tweaked values obtained with this tool.

Before using the tool you need to open at least a reference color list, selected as **ref.** in the dialog shown below, and at least one measurement file (**meas.1**) obtained from a print of this reference. In the screenshot below, we see that a first tweaked file was obtained and that a second measurement file is available; we can thus perform a second tweak iteration using the reference and the two measurement files. The tool procedure is illustrated on the next page. A mini-tutorial is presented [here](#).

The “...Tweak-1.txt” file was obtained in a first tweak iteration using the “...CGATS.txt” (**ref.**) and “...meas1.txt” files.

The “...Tweak-1.txt” file was **printed and measured**; the measurements are contained in the “...meas2.txt” file.

#	opened files	patches	color ref.	ref.	meas.1	meas.2
1	CC_Avg20_spectrum_CGATS.txt	24	spectrum	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	CC_Avg20_spectrum_CGATS_meas1.txt	24	spectrum	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
3	CC_Avg20_spectrum_CGATS_Tweak-1.txt	24	L*a*b* (2 deg.)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4	CC_Avg20_spectrum_CGATS_meas2.txt	24	spectrum	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

Move the mouse cursor in the 'color ref.' column for more info.  
Enlarge the window to see long file names.

Tweak threshold (CIEDE2000): 0,7    Observer: 2 degree    Illuminant: D50

**NOTE:** This tool creates a list which contains L\*a\*b\*data only. Spectral data is not transferred!

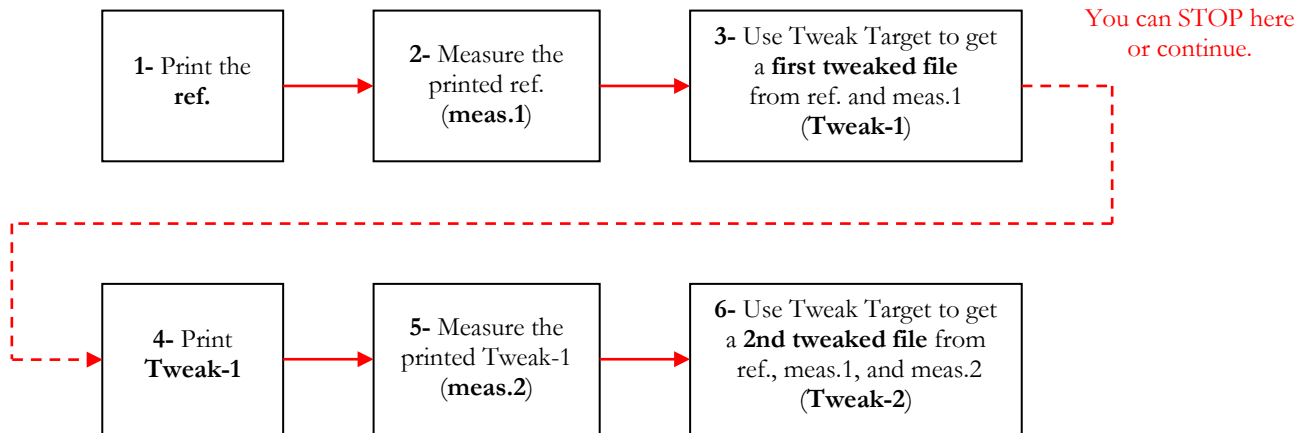
Tweak with 3 files    Close

A 0,7 CIEDE2000 threshold is recommended for an 8 bit printing path; a lower value could possibly be used if you print through a 16 bit path (with true 16 bit print drivers!).

You can tweak printed color lists with one or two iterations (respectively requiring 2 or 3 files). A **meas.2** file cannot be used as a **meas.1** file!



The Tweak Target tool procedure is schematized below:



#### Additional notes:

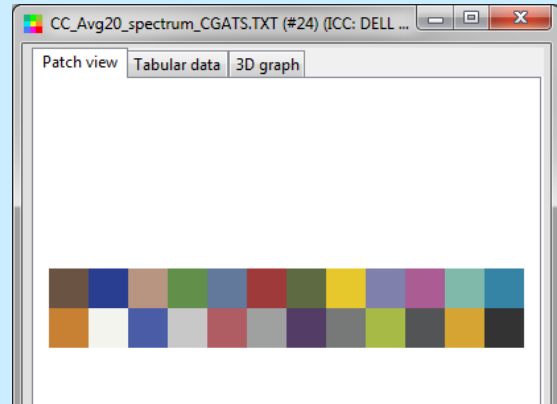
- i- Quantify the improvement by comparing the **ref.** file with **meas.1** using PatchTool [Compare](#) tool; this is your starting point. You can then compare the **ref.** file with **meas.2**; this is your color list after one tweak iteration. Then compare the **ref.** file with a print from the second tweak iteration; we suggest identifying this measurement file with **meas.3**. A bigger improvement should be seen between the reference and the first tweaked file than between the first and second tweaked file.
- ii- Your results may vary! The procedure can cut the average printing error by half, or even more in certain cases, with most of the improvement coming from the first iteration. This improvement is similar to the one obtained in RIPs that have optimization procedures; as in RIPs, the incremental improvement goes down as you do more iterations. In practice, the improvement between the second and third iteration is minimal; this is why this tool is limited at two iterations.
- iii- Be realistic in your expectations! For instance, in respect with the tutorial of the next page, you should not expect matching the ColorChecker white patch if your paper does not have enough brightness.
- iv- Out-of-gamut patches will remain out-of-gamut! You can easily identify the out-of-gamut patches relative to a profile using the [Gamut Tools' Clip check](#).
- v- You shall NOT use a **meas.2** file as if it was a **meas.1** file! The tweak algorithm requires that a **meas.2** file be used in conjunction with a **meas.1** file.
- vi- The results will vary depending on the quality of the profile! A better profile to start with will enable even better tweaking. If your average printing error between the **ref.** and the file printed from that reference (i.e. **meas.1**) is higher than 5 DeltaE (CIEDE2000), then certain patches may be very difficult to tweak, even if improvement will be seen on average. On the other hand, we have seen average errors of 2.5 CIEDE2000, before tweaking, go down to about 0.5 after tweaking (for patches within gamut of course!).
- vii- Some difficult to tweak patches may be better in the first tweaked file (**Tweak-1**) than in the second one. The “Tweak threshold” can help minimize this effect.
- viii- We have obtained similar results using RGB or L\*a\*b\* images when comparing prints after one iteration (i.e. comparing **meas.2** files with the **ref.**). We have seen slightly better results using L\*a\*b\* file when comparing prints after two iterations (i.e. comparing prints from **Tweak-2**, which we could call **meas.3**, with the **ref.**). L\*a\*b\* coordinates are not subjected to clipping like RGB coordinates, so a tweak may be easier to achieve near the profile gamut limit.
- ix- Never use your tweaked files as references!

## Mini-tutorial: How to print an accurate ColorChecker using the Tweak Target tool

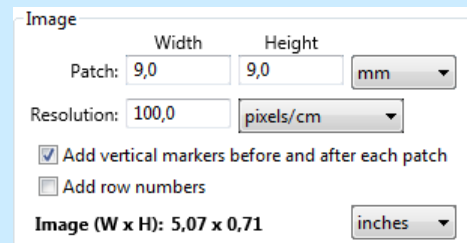
This tutorial shows how to use the Tweak Target tool to improve the printed colors of a ColorChecker based on reference data. The same procedure can be applied to targets or color list of essentially any size. While the procedure may seem cumbersome at first sight, it will be readily appreciated by those who have attempted to match even a single print color by trial and error that it can save a lot of time even for small color lists.

Please note that some steps of this tutorial require the use of an image processing application for printing images.

- 12- Open the “CC\_Avg20\_spectrum\_CGATS.TXT” file located in the “... \PatchTool\sample\_files\Help-Manual\_files” folder. You can use the “File/Open Sample Files/Misc. Sample Files...” menu to get to the “sample\_files” folder directly. This file is the reference (**ref.**) to be used in the Tweak Target dialog.
- 13- In the opened file window, change the “Rows” value to 2. The purpose of this change is to have a simpler layout for the image that will be printed and measured. There is no need at this point to print using the size and layout of the final image.



- 14- In the “Tabular data” tab, select “Adobe RGB (PatchTool)” as the [RGB space](#). This step is not required if you export the patches in a “L\*a\*b\*” image in Step-5, but required if you export in a RGB image.
- 15- Click on the “Export” button and select the “Image” tab in the “PatchTool Export” dialog. Select the “CC\_Avg20\_spectrum\_CGATS.TXT” file if not already done.
- 16- If you have an i1Pro, select the patch dimensions as shown on the right. Export the image in the TIFF format, with the RGB color space, 8 bit depth, and [8 bit dithering](#) (to improve accuracy). Because we selected the Adobe RGB space in Step-3, the RGB data is relative to this color space. This can be confirmed by looking at the space associated to RGB below the file name in the [Export](#) dialog. You could also save the image in the L\*a\*b\* space, if this suits you better (We prefer using L\*a\*b\* image files).



- 17- Open the image you just generated with PatchTool in an image processing program; Photoshop will be assumed for the purpose of this tutorial. If you open the RGB image, first assign the Adobe RGB profile using the “Edit/Assign profile...” menu command; there is no need to assign a profile if opening the L\*a\*b\* image.
- 18- Print the image.  
**Photoshop print settings:** Color Handling: Photoshop Manages Colors. Printer Profile: select the printer/paper profile. Rendering Intent: Absolute Colorimetric.  
**Printer settings:** Disable the printer’s color management, but do not forget to select the proper paper type.
- 19- Measure the printed image. If you have an i1Pro, you can use [Patch-Reader](#). Before opening Patch-Reader; make sure the reference file as seen in Step-2 is still opened; this will enable you to make the measurements in only two strip-readings. Save the measurements; add “meas1” at the end of the file to identify them. Close the Patch-Reader dialog and open the file you just saved.
- 20- Open the Tweak Target dialog. Select “CC\_Avg20\_spectrum\_CGATS.TXT” as your **ref.**, and your measured file. Set the “Tweak threshold” at 0,7, the Observer at 2 degree, and the Illuminant at D50. This threshold is recommended for an 8 bit printing path; a lower value can be tried for a dithered 8 bit image or if you print a 16 bit image with *true* 16 bit print drivers.
- 21- Press the “Tweak” button. A corrected file will open. This is the first tweaked file (i.e. **Tweak-1**); we recommend that you save this file now, before continuing. We will now print this tweaked file as we did with the reference. Redo Step-4 to Step-8 **with the tweaked file**. In Step-8, use “meas2” instead of “meas1” when saving the measurements.
- 22- Open the Tweak Target dialog. Select “CC\_Avg20\_spectrum\_CGATS.TXT” as your **ref.**, your first measurement file as **meas.1** and your second measurement file as **meas.2**. The Tweak threshold, Observer, and Illuminant are the same as in Step-9. Press the “Tweak” button. The file that opens, **Tweak-2**, is optimized with both measurement files. Use **Tweak-2** to print more accurate colors of the reference file.
- 23- Once you have tweaked colors, use these coordinates to finalize your project. You may want to print a larger target with the proper layout, or replace the reference colors with the tweaked colors.



## 4. Technical data

### 4.1 Specifications

General specifications:

- Illuminants: A, C, D50, D55, D60, D65, D75, D93, E, F2, F7, F11, plus 2 [custom illuminants](#) (spectral data, 5 nm or 10 nm increments). This selection is not available for all file types and tools; please consult the *Input files types*' specifications below and the individual tools sections for more information.
- Observers: 2° (CIE 1931), 10° (CIE 1964), 2° and 10° (CIE 170 : CIE 2006 - CIE 2015)
  - See [Appendix H](#) for more information on CIE 170 support.

Input files types:

- [Adobe Swatch Exchange](#) (“*.ase*”) file
  - Supported color spaces: RGB, CMYK, and L\*a\*b\* (D50). Because an ASE file can contain swatches in all color spaces, PatchTool will create separate files for each color space.
- CxF Version-1
  - File extensions: Generic *.cxf* files. In addition, *.xml* files will also be opened and checked for compatibility with the CxF1 format.
  - Supported data types (reflectance data only): spectrum, L\*a\*b\*
- [CxF Version-2](#)
  - File extensions: Generic *.cxf* files. In addition, *.xml* files will also be opened and checked for compatibility with the CxF2 format.
  - Supported CxF2 content types: Color (i.e. a Color Collection), Palette/ColorSet, ColorQualityControl (Quality-Control data with Standard and Measurement)
  - Supported data types (reflectance data only): spectrum, XYZ, L\*a\*b\*, L\*C\*h, xyY, AdobeRGB, sRGB, RGB (non-defined), CMYK (non-defined)
  - Supported Illuminants: A, C, D50, D55, D65, D75, D93, E, F2, F7, F11
- [CxF Version-3](#)
  - File extensions: Generic *.cxf* files as well as files with content-specific data, such as *.axf*, *.cmxf*, *.dmtx*, *.dpsf*, *.dpxf*, *.duxf*, *.dwx*, *.lxf*, *.mxf*, *.oxf*, *.pwx*, *.pxf*, *.rmxf*, *.sxf*, and *.txf*. In addition, *.xml* files will be opened and checked for compatibility with the CxF3 format.
  - Supported top level Resources: Object Collection, Color Specification Collection
  - Supported device-independent data types: Reflectance Spectrum, L\*a\*b\*, L\*C\*h, XYZ, xyY, AdobeRGB, sRGB
  - Supported device-dependent data types: RGB, CMYK
  - Non-supported elements: Custom Resources, Profile Collection, Tag Collection, and others
  - Spectral range: Start between 360 nm and 400 nm, end between 700 nm and 730 nm, with 10 nm increments.
  - Supported Illuminants: A, C, D50, D55, D60, D65, D75, 9300, E, F2, F7, F11
- [CGATS](#)
  - File extensions: *.txt* and *.csv* files are preferred. PatchTool will also open color lists saved using other file extensions, as the program will search for standard file tags and color space data names. In particular, PatchTool will open files opened in spreadsheet programs and resaved with the “*.csv*” extension.
  - Supported data types: XYZ, xyY, L\*a\*b\*, L\*C\*h, [OSA UCS Ljg](#), RGB, CMYK, spectral data
  - Accepted data delimiters: Tab-Delimited-Format (TDF), Comma-Separated-Values (CSV; either “;” or “;”), Space delimited data
  - Spectral data: Scaled either between zero and one or between 0% and 100%.
  - Spectral range: Data is required between 400 and 700 nm in 10 nm increments. All data between 380 and 730 nm will be used. Missing data will be extrapolated to complete the 380 to 730 nm range necessary for processing. Spectral data lower than 380 nm and higher than 730 nm is discarded.
  - RGB encoding: 8 bit, [15 bit](#), or 16 bit format, or scaled between 0 and 100%.
  - Recognizes ECI2002 color lists; switch between the Measured, Random, or Visual layouts.
  - Recognizes IT8.7/4 color lists; switch between the Measured, Random, or Visual layouts.

## Input files types (continued):

- [Plain text](#)
  - File extensions: \*.txt and \*.csv files are preferred. PatchTool will also open color lists saved using other file extensions, as the program will search for standard file tags and color space data names. In particular, PatchTool will open files opened in spreadsheet programs and resaved with the “.csv” extension.
  - Supported data types: XYZ, xyY, L\*a\*b\*, L\*C\*h, OSA UCS Ljg, RGB, CMYK, spectral data
  - Accepted data delimiters: Tab-Delimited-Format (TDF), Comma-Separated-Values (CSV; either “,” or “;”), Space delimited data
  - Spectral data: Scaled either between zero and one, or between 0% and 100%.
  - Spectral range: Data is required between 400 and 700 nm in 10 nm increments. All data between 380 and 730 nm will be used. Missing data will be extrapolated to complete the 380 to 730 nm range necessary for processing. Spectral data lower than 380 nm and higher than 730 nm is discarded.
  - RGB encoding: 8 bit, [15 bit](#), or 16 bit format, or scaled between 0 and 100%.
  - See [Appendix A](#) for detailed information on plain text file format.
- PatchTool **Compare** file
  - Any [exported](#) Compare file obtained from “[Select Compare](#)”, “[Display-Check](#)”, or “[Clip check](#)”.
- QTX Version-1 (Datacolor format)
  - File extension \*.qtx is preferred. Files with a \*.txt extension will also be opened as QTX files if the specific “STANDARD\_DATA” keyword is recognized.
  - Supported measurements types: STANDARD\_DATA, BATCH\_DATA (reflectance only)
  - Supported data type: spectral data (STD\_R and BAT\_R)
  - Spectral data: Scaled either between zero and one, or between 0 and 100%.
  - Minimum spectral range: 400 nm to 700 nm
  - Supported spectral bandwidths: 5, 10, and 20 nm. 5 nm data is filtered to a 10 nm bandwidth. 20 nm data is interpolated to a 10 nm bandwidth.
  - Note: STANDARD data and BATCH data are opened in separate files. There is only one STANDARD data group in a QTX file. There can be zero or multiple batches identified by batch number in each BATCH section. The batch data is grouped by batch number; the first 20 batches of a file are opened.
- **PNG image file**
  - Supported image format: RGB; 8 bit
  - Maximum image size: none. However, because each pixel becomes one patch, opening large images (64KB+ pixels) is not recommended, since success will depend on system resources.
- **TIFF image file**
  - Supported image formats: TIFF RGB, CMYK and L\*a\*b\*; all in 8 bit and 16 bit
  - Maximum image size: none. However, because each pixel becomes one patch, opening large images (64KB+ pixels) is not recommended, since success will depend on system resources.

## Info display:

- Patch file, patch name, and patch ID
- View the values of three colorimetric data types simultaneously.
- View the data for two samples simultaneously.
- Colorimetric data types: RGB, CMYK, L\*a\*b\*, L\*C\*h, XYZ, xyY, reflection density as per ISO 5-3 (Status A, Status E, Status I, Status T)
- CMYK spaces: any ICC profile
- RGB spaces: any ICC profile, plus five built-in spaces (Adobe RGB, Apple RGB, Generic RGB, ProPhoto RGB, sRGB)
- Displays the names of the RGB and CMYK profiles when these data types are selected.
- RGB options: 8 bit, 15 bit+ (as shown in Photoshop “16 bit”), “true” 16 bit, or 100% scale
- Color-difference between two samples (more info below)
- Graph of the two samples’ spectral data (when available)
- Make a screenshot of the Info window

#### Color-difference:

- Supported formulas: CIELAB, CIE94(1:1), CMC(2:1), CMC(1:1), [CIEDE2000](#)
- DeltaE\* Info display options: DeltaE\* plus Delta L\*a\*b\*, Delta a\*b\*Ch, Delta L\*C\*h, or Delta L\*C\*H\*
- Delta L\*, C\*, and H\* can be viewed weighted or un-weighted (CIE94, CMC, and CIEDE2000)
- Delta h: When larger than 180 degrees, the difference can be shown as computed or as the complement of 360 degrees.
- In the “Compare” window: Delta C, M, Yellow, K, R, G, B, x, y, X, Y, Z, E\*, L\*, a\*, b\*, Ch, C\*, h, **and** H\*
- In the “Compare” window: Sort the patches using absolute or non-absolute color-differences.

**Note:** “Ch” is the chromaticness, defined in DIN 55981, ISO 12646, and ISO/DIS 12747-8. It is better used to evaluate color differences for near neutral colors, typically with a Chroma (C\*) of less than seven.  $\Delta$ Ch is referred to with various symbols, such as  $\Delta E_c$ ,  $\Delta F^*$ , or  $\Delta s$ .

#### 2D and 3D graphs in [standard](#) files:

- 3D graph spaces: L\*a\*b\*, xyY, XYZ, RGB
- 2D graph spaces: L\*a\*b\*, xyY
- Up to five selectable graph inputs: CMYK profile; RGB profile; input data used as color reference (converted from spectral, L\*a\*b\*, xyY, XYZ, CMYK, or RGB data); CMYK data; RGB data.
  - Note: Not all inputs may be available for a given file, as it depends, among other factors, on the presence or not of reference CMYK and RGB data in the opened file and the availability or not of a profile associated with the CMYK and RGB data.
  - Note: In each file, a maximum of one CMYK profile and one RGB profile can be viewed simultaneously. You can of course open multiple instances of the same file and associate different CMYK and RGB profiles, if applicable, in each file.
- The data selections and display settings associated to the 2D and 3D views can be different.
- Requirements: The computer must support OpenGL Version 1.1.

#### Statistical data in [Compare](#) files:

- Histogram of the selected parameter
- Graph and data of the Cumulative Relative Frequency (CRF)
- Selectable parameter: Delta C, M, Yellow, K, R, G, B, x, y, X, Y, Z, E\*, L\*, a\*, b\*, Ch, C\*, h, **or** H\*
- DATA
  - Average: For all samples; the best 90%; and the worst 10%
  - Sigma (standard deviation): For all samples; the best 90%; and the worst 10%
  - Maximum error: For the 10<sup>th</sup> percentile; the median (50<sup>th</sup> perc.); the 90<sup>th</sup> and 95<sup>th</sup> perc.; and for all samples
- Compute stats on absolute values or on actual values (mix of negative and positive values)
- Compute separate negative and positive stats or compute the stats on mixed values

#### Out-of-gamut RGB values with [PatchTool built-in RGB profiles](#):

- When converting to an RGB space defined by a built-in PatchTool profile, RGB values are not clipped to zero or 255; negative values and values higher than 255 are kept and saved. Likewise, these values will not be clipped when used as input with a built-in PatchTool RGB profile.
- Negative values and values higher than 255 are computed with an encoding algorithm based on the one described in the **PIMA 7667:2001** Standard: “Photography – Electronic still picture imaging – Extended sRGB color encoding – e-sRGB” (PIMA: Photographic and Imaging Manufacturers Association).



## Output / Export files types:

- DATA (Text-based formats)
  - CGATS and “plain text”: User selectable data: ID, Name, XYZ, xyY, L\*a\*b\*, L\*C\*h, RGB, CMYK, Munsell Hue-Value-Chroma, [OSA UCS](#) Ljg, spectral data, Density (Status A, Status E, Status I, Status T, as defined in ISO 5-3)
  - [MacLeod-Boynton chromaticities](#) ( $I_{MB}$  and  $s_{MB}$ ). Exported by selecting “xyY” in the [export dialog](#) for data computed using a [CIE 170](#) Standard Observer (CGATS, plain text, and Compare files).
  - CMYK spaces: values corresponding to any ICC profile
  - RGB spaces: values corresponding to any ICC profile, plus five built-in spaces (Adobe RGB, Apple RGB, Generic RGB, ProPhoto RGB, sRGB)
  - RGB encoding: 8 bit, 8 bit rounded, [15 bit+](#) (as shown in Photoshop “16 bit”), “true” 16 bit, or 100% scale
  - Spectral data – Range: 380 to 730 nm or 400 to 700 nm
  - Spectral data – Scale: 0-1 or 0-100%
  - Decimal separator: Period [ . ] or comma [ , ]
- DATA (CxF Version-3 format, i.e. [CxF3](#); an xml-based format)
  - Warning: The CxF3 format is not compatible with CxF Version-1 and CxF Version-2.
  - Export to the generic CxF3 file format (with the \*.cxf file extension) and to four CxF3-compliant file types dedicated to X-Rite’s i1Profiler (i1Publish).
  - [Supported i1Profiler file types](#): Chart Measurements (\*.cmxf), Patch Sets (\*.pxf), Test Charts (\*.txf), Measurements (\*.mxf). It is up to the user to make sure that the selected data fields and their content is compliant with i1Profiler’s requirements.
  - Always exported data: ID, Name
  - User selectable data: XYZ, xyY, L\*a\*b\*, L\*C\*h, RGB, CMYK, and spectral data
  - CMYK spaces: values corresponding to any ICC profile; profile info not recorded
  - RGB spaces: In generic CxF3 files, Adobe RGB and sRGB data is saved as “Color Values” specific to these two spaces. In i1Profiler file types, all RGB data is saved as “Device Color Values” and the profile info is not recorded.
  - RGB encoding: 8 bit rounded, “true” 16 bit
  - Spectral data – Range: 380 to 730 nm or 400 to 700 nm
  - Spectral data – Scale: 0-1
  - Decimal separator: Period [ . ]
  - i1Profiler export limitation: i1Profiler support is limited to RGB and CMYK reflectance workflows (For instance, CMYK+n workflows and display measurements are not supported). In addition, except for a small option with \*.cmxf files, there is no support for Custom Resources. Additional features may be added in future versions as knowledge is gained and need is expressed by user feedback.
- IMAGES
  - PNG (.PNG): RGB; 8 bit
  - Bitmap (.BMP): RGB; 8 bit
  - TIFF (.TIF): RGB, L\*a\*b\*, or CMYK; all in 8 bit or 16 bit
  - Option to save the profile in the image if an ICC profile is assigned to the data. Available for PNG and TIFF images.
  - Option to dither 8 bit images for improved color accuracy in an 8 bit workflow.
- COLOR SWATCHES
  - [Adobe Swatch Exchange](#) (“.ase”) file. Supported color spaces: RGB, CMYK, and L\*a\*b\* (D50). Supported color types: Process + Global (only type supported in Photoshop), Spot color (Global), and Process; the color type is the same for all PatchTool exported patches.



## Supported instruments:

**Important (32 bit and 64 bit OS support):** An instrument can be supported by a program only if a Dynamic Link Library (DLL, on Windows) or Framework (on Mac) is provided by the instrument manufacturer. Furthermore, 32 bit and 64 bit programs require specific DLLs/Frameworks compiled for their bit depth. The instruments are listed below by measurement type and OS bit depth. A table showing 32 bit and 64 bit support for each instrument can also be found in the Display-Check “[Supported instruments](#)“ section.

For **display** measurements (**macOS 64 bit and Windows OS 32/64 bit**):

- **i1Display Pro colorimeter** (X-Rite retail version, part #EODIS3-XR). Generic models sold by other companies (third parties, or OEM, part #EODIS-OEM) should also be compatible. Custom models sold by other companies may be supported if the instrument is recognized to be an i1Display Pro by PatchTool.
- **i1Pro** (X-Rite, formerly GretagMacbeth). Supported models: Rev A-D.
- **i1Pro 2** (X-Rite). Supported models: i1Pro 2 M0/M1/M2, i1Pro 2 M2 only.
- **i1Pro 3** (X-Rite). Supported models: i1Pro 3 and i1Pro 3 Plus.
- **Spyder5** (Datacolor). Supported models: Spyder5ELITE, Spyder5PRO, Spyder5EXPRESS.
- **SpyderX** (Datacolor). Supported models: SpyderX Elite, SpyderX Pro.

For **display** measurements (**Windows OS 32/64 bit**):

- **DTP94** (X-Rite, formerly MonacoOPTIX). In principle the DTP94 drivers are not compatible with Windows 8 and Windows 10. However, a solution is proposed in this forum post: <https://www.dpreview.com/forums/post/57030496>  
Note: You will find the DTP94 V-3.1.0.0 drivers in the “drivers” folder of the PatchTool application folder; the files all start with “XrUsb...”
- **Eye-One Display and Display 2** (X-Rite, formerly GretagMacbeth)
- **Eye-One Display 2 bundled with a monitor:** If an instrument is recognized to be an Eye-One Display or Eye-One Display 2 by PatchTool, then it can be used in the program and will provide accurate measurements. Example-1: The MDSVSENSOR2, which is part of the SVII-PRO-KIT sold by NEC for their wide gamut Spectraview displays, such as the PA271W model, is compatible with PatchTool; please consult the [Display-Check](#) section for more information. Example-2: The Eye-One Display offered with HP DreamColor monitors is NOT compatible with PatchTool.
- **Spyder2** (Datacolor)
- **Spyder3** (Datacolor)
- **Spyder4** (Datacolor). Supported models: Spyder4ELITE, Spyder4PRO, Spyder4EXPRESS.

For **reflectance** measurements (**macOS 64 bit and Windows OS 32/64 bit**):

- **i1Pro** (X-Rite, formerly GretagMacbeth). Supported models: Rev A-D.
- **i1Pro 2** (X-Rite). Supported models: i1Pro 2 M0/M1/M2, i1Pro 2 M2 only.
- **i1Pro 3** (X-Rite). Supported models: i1Pro 3 M0/M1/M2, i1Pro 3 Plus M0/M1/M2/M3.

For **transmissive scan** measurements (**macOS 64 bit and Windows OS 32/64 bit**):

- **i1Pro 3** (X-Rite). Supported models: i1Pro 3 and i1Pro 3 Plus.

**Note (macOS):** The “**i1Pro / i1Pro 2 (non-XRGA)**” instrument menu selection is not available in the macOS version.



## 4.2 System requirements

**32 bit vs 64 bit OS:** The PatchTool 32 bit executable for Windows can run on 32 bit and 64 bit Windows systems. For the macOS, the program is provided in a 64 bit package.

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### Windows OS

Minimum:

- Windows 7
- 1.0 GHz
- 2 GB RAM
- 1024 x 768, 32 bit color

Recommended:

- Compatible with Windows 7 / Windows 8.1/ Windows 10.
- 1.0+ GHz
- 2+ GB RAM
- 1280 x 1024, 32 bit color
- Calibrated display

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### macOS

Minimum:

- Intel Mac: Mac OS X 10.10.5 (Yosemite)
- 1.0 GHz
- 2 GB RAM
- 1024 x 768, 32 bit color
- OpenGL support required

Recommended:

- Compatible from Mac OS X 10.10.5 (Yosemite) to macOS 10.15.7 (Catalina).
- 1.0+ GHz
- 2+ GB RAM
- 1280 x 1024, 32 bit color
- Calibrated display

macOS 10.15 Catalina support:

- At the time of writing this manual no issues were found while using PatchTool with macOS 10.15.7 Catalina. However, Apple has announced that OpenGL is deprecated, i.e. allowed but not recommended, in macOS 10.15. As a replacement, they propose the Apple developed “Metal” graphics renderer libraries. Please note that there is currently no plan for PatchTool to support Apple’s Metal renderer and if Apple completely removes OpenGL support in future OS versions, PatchTool may become incompatible. Please consult the [macOS compatibility page](#) on the BabelColor Web site for more information and the current status.

## Help file

- Requires a PDF file type reader. A free “Acrobat Reader” application, from Adobe, is available at the following Web site:

<https://www.adobe.com/acrobat/pdf-reader.html>

**Note:** Acrobat Reader is now available in two distribution modes, called “tracks”: “Continuous track” and “Classic track”. The Continuous track, offered by default, is a “cloud” version which gets updated as required, without user control. The Classic track is similar to the older program version which gets updated at fixed intervals. If you prefer the older version, you can locate the download file by searching for “DC Classic Track Release” with your favorite search engine. This link contains more information:

<https://www.adobe.com/devnet-docs/acrobatetk/tools/AdminGuide/whatsnewdc.html>

### 4.3 Version history

#### Version 7.1.3 b486 (2022-04-22) (Maintenance release)

New features:

- [QTX import](#): Now records the batch name as the sample name when present in the file.
- [CxF3 import](#): The program now opens a CxF3 file when an [Object](#) “Object Type” attribute is BLANK.

Improvement:

- [Spectral data in CGATS and TEXT files](#): In the past, if 380 nm data was detected, 730 nm data was required; also, if spectral data started at 400 nm, the program looked only for 700 nm data. Now, data is required between 400 and 700 nm. Any valid data between 380 and 730 nm will be used. Missing data will be extrapolated to complete the 380 to 730 nm range necessary for processing. Spectral data lower than 380 nm and higher than 730 nm is discarded.

Bug fixes:

- [Emission-Reader](#) and [Patch-Reader](#): Now stops the patch selector at the top or bottom rows when in “Strip Measurement mode”.
- Fixed the link to the BabelColor Web Store page when clicking on the “Buy” button of the activation dialog.

Other:

- New compiler version with revised APIs. This compiler improves compatibility with recent OSs.

#### Version 7.1.2 b481 (2021-11-03) (Maintenance release)

Bug fixes:

- TIFF images from PatchTool can now be opened in [Photoshop CC 23](#): TIFF images from [PatchTool Export Image](#) dialog now include the specific data required by CC 23. Adobe may also have fixed the issue so that TIFF images from previous PatchTool versions will also open.
- [QTX import](#): The program now properly processes files when the user system is set to use a period as a separator for thousands.
- (Windows OS) “Window/Arrange” menu: This command now properly re-arranges the windows as it did before.

Other:

- [i1Pro 2 and i1Pro 3](#) instruments (from X-Rite): The libraries/DLL (Windows) and Frameworks (macOS) have been updated to their latest versions.

#### Version 7.1.1 b480 (2021-01-13) (Maintenance release)

Bug fixes:

- (macOS Big Sur 11) Improved program stability when resizing the opened files windows.
- (macOS Big Sur 11) The popup arrows/disclosure triangles are visible again.

Improvement:

- [Extract Target from Image](#) tool: Extraction is now performed in a separate thread.

## Version 7.1.0 b478 (2020-11-23)

New features:

- [Gamut Tools](#): Added [color gamut computation](#) of ICC profiles as per [ISO/TS 18621-11:2019](#).
  - Get the “**device gamut**” or the “**usable gamut**”.
  - Additional gamut information: Number of incorrect polygons and the corresponding error on the color gamut; the solid angle corresponding to incorrect polygons (i.e. negative tetrahedrons volume); a check of the total solid angle relative to 4 pi steradians (computational check).
- [Extract Target from Image](#) tool: Added support for CMYK JPG images. Although the JPG format is not ideal for accurate target representations, CMYK JPG images are commonly found in press workflows.
- Opened files “[Patch view](#)” tab:
  - Added a menu item to copy the density in the [contextual menu](#) (mouse right-click).
  - Added a menu item to extract all selected patches to a separate file in the [patch edition mode](#).

Improvements:

- [Extract Target from Image](#) tool:
  - All input image formats are now color-managed.
  - It is possible to select default CMYK and RGB profiles to be used when the image has no embedded profile.
  - The code has been refactored and is now more tolerant to file and image errors.

## Version 7.0.1 b474 (2020-10-07)

Bug fix:

- (Mac 64 bit only) Display profile recognition: Now properly identifies the profile of additional displays connected to a given computer instead of assigning the main display profile. This bug affected the rendering of patches on secondary displays, including the patches generated for Display-Check.

## Version 7.0.0 b473 (2020-05-15)

New features:

- Added support for the X-Rite [i1Pro 3](#) and [i1Pro 3 Plus](#) spectrophotometers.
  - These instruments are available in the following tools: [Custom Illuminants](#), [Display-Check](#), [Display-Reader](#), [Emission-Reader](#) (new!), and [Patch-Reader](#).
  - Reflectance measurement modes (i1Pro 3): M0/M1/M2 (in Patch-Reader)
  - Reflectance measurement modes (i1Pro 3 Plus): M0/M1/M2/M3 (in Patch-Reader)
  - Assign a Color Correction Matrix (Display-Check and Display-Reader).
- [Emission-Reader](#): A new tool to perform single patch and line-scanned emission measurements on light boxes (transmissive measurements).
  - Supported instruments: X-Rite i1Pro 3 and i1Pro 3 Plus
  - Measurement modes/chart types: [Unconstrained measurements](#), [Light Box characterization](#), [Custom chart](#), [PatchTool file](#)
  - [Unconstrained measurements](#): Single patch measurements. Get absolute data and processed data relative to a measured White Point.
  - [Light Box characterization](#): Single patch or line-scan measurements. View and characterize the emission uniformity of a Light Box. The absolute data/RAW file can be used as a compensation file to correct **Custom chart** and **PatchTool file** measurements. The processed data is used to record the Light Box non-uniformity for future analysis.
  - [Custom chart](#): Single patch or line-scan measurements. Select this chart type when you do not have a file which represents the measured target. The patch contrast should meet the X-Rite target requirements; patches may be separated by vertical bars to improve patch recognition. Measurements can be compensated for the Light Box non-uniformity (measured in the Light Box characterization mode).
  - [PatchTool file](#): Single patch or line-scan measurements. Select this chart type if you have a file which represents the target in the same patch layout as the measured target. The patch contrast requirements are relaxed since measurements are correlated to the expected patches within the scanned line. Measurements can be compensated for the Light Box non-uniformity.
  - [Export formats](#): Get absolute data (i.e. RAW data) and processed data relative to a measured White Point; both files can be opened in a spreadsheet. A RAW file should not be opened by a program which expects reflectance data since it contains emission data. A processed data file contains tristimulus data normalized relative to many Standard Illuminants or two Custom Illuminants, in Absolute-Colorimetric or Relative-Colorimetric intents; this file can be opened as a reflectance file.
  - ABSOLUTE measurements: xyY, XYZ, spectral data.
  - PROCESSED data: xyY and XYZ (Y normalized); L\*a\*b\*, relative to many Standard Illuminants or two Custom Illuminants, in Absolute-Colorimetric or Relative-Colorimetric intents.
  - Standard Observers: CIE 1931 (2 deg.), CIE 1964 (10 deg.), and [CIE 170](#) 2 deg. and 10 deg. cone fundamentals. In PatchTool, the CIE 170 Observers are identified as “2F” and “10F”.
  - Adjustable instrument exposure when scanning a line.
  - A timer can be used to take measurements at fixed time intervals.
  - **Note**: While some emission measurements could be used to build an ICC profile, PatchTool does not build profiles; an external application is required.
- [Compare](#) files [certification reports](#): Addition of an option to select a maximum error of 5.0 DeltaE\* (CIEDE2000) as the **G7 Proof-2019 Colorspace Pass/Fail Requirements** tolerance in the [Certification report tolerances](#) dialog. This tolerance, now the default value, is defined in Section 6.1 of the “*G7 Master Pass/Fail Requirements; For the G7 Master Program; Version 36, August 2019*” document.
- [Substrate Correction](#) tool: Added a method to determine the **Minimum patch** in the **Reference substrate**. This new minimum patch is defined using the XYZ color space; it is determined from the lowest X, Y, and Z of all patches where X, Y, and Z can be taken from different patches. This method is used in versions 23 and 24 of the Idealliance SCCA Calculator. The previous methods are still available.
- CGATS.21-2 reference data for the IT8.7-5 (IC1617) test chart: We now provide an additional data set which matches the data used in versions 23 and 24 of the Idealliance SCCA Calculator. The changes are in the K and CMY ramps which are specific to the IT8.7-5 target and thus not present in the IT8.7-4 target.



#### Improvements:

- (Windows) [Info window screenshot](#): The saved image now includes the display profile. In multiple display systems the Info window must be located on the same display as the file(s) from which the patches are displayed.

#### Bug fixes:

- (Mac 64 bit only) [Display-Check](#): Solved an issue which happened when making “PatchTool file” measurements with an **i1Display Pro**. The problem was seen only on the 64 bit version of the program running on macOS 10.14 and 10.15. When making measurements with big patches, i.e. with an enlarged Display-Check window, the measurement sequence sometimes stopped with a message indicating it could not get the XYZ data from the instrument; the error did not happen when the minimal Display-Check window was used. The problem occurred only with very dark patches and was also dependent on the instrument measurement speed setting.
- (Mac) [Info window screenshot](#): In previous versions, the default macOS **Generic RGB** profile was attached by the OS to the saved image. The saved profile is now the display profile. In multiple display systems the Info window must be located on the same display as the file(s) from which the patches are displayed.
- Now shows the correct patch ID when moving the mouse over the patches for the “PatchTool file” chart type in [Patch-Reader](#).

#### Other:

- (Mac 64 bit only) The provided 64 bit install files are compliant with current Apple [notarization requirements](#). Notarization is required for some software in macOS 10.14.5 and is mandatory for all software starting with macOS 10.15. Please note that any software meeting notarization requirements may not be fully compatible with a given OS version; see the PatchTool [system requirements](#) for more information.
- (Mac) The program is now released in a 64 bit package only. This change main effect is to drop support of legacy instruments for which 64 bit DLLs/Frameworks are not available. Please consult the [specifications](#) and the Display-Check “[Supported instruments](#)” section for more information.

## Version 6.6.5 b466 (2019-11-26)

### New feature:

- (Mac 64 bit only) The 64 bit package now supports the Datacolor [Spyder5](#) colorimeter. The instrument was previously available only in the 32 bit package.

### Bug fixes:

- (Mac 64 bit only) Fixed a bug affecting all windows showing color-corrected patches. The bug generated a NilObjectException error message before shutting down the program. The problem affected the most recent macOS versions (Yosemite, Catalina).
- (Mac Retina) Fixed a bug where the (OpenGL) graphs shown in the “[3D graph](#)” Tab of opened files were not scaled appropriately in Retina displays.
- (macOS 10.15 Catalina) We offer a workaround for the bug that makes the program crash when calling the OS color picker twice. A simple color picker is proposed until the bug is fixed either at the compiler level or at the OS level. A color picker is used in the following cases:
  - To select a color for the target grid in the [Extract Target from Image](#) tool.
  - To select the patch borders identifying color difference thresholds in [Compare](#) files.

### Other:

- Improved file support of the M3 Measurement Condition:
  - The program will now also look in the “MEASUREMENT\_SOURCE” tag when opening a CGATS file.
  - The program now offers more choices to reassign the Measurement Condition if not well defined when exporting to the CxF3 format.
- macOS 10.15 Catalina support: At the time of writing this manual no issues were found while using this version of PatchTool with macOS 10.15.1 Catalina. Please see the PatchTool [system requirements](#) for other OS requirements.

## Version 6.6.0 b464 (2019-09-09)

### New features:

- Added support for the Datacolor [SpyderX](#) colorimeter:
  - This instrument is currently used in the [Display-Check](#) and [Display-Reader](#) tools.
  - Supported models: SpyderX Elite, SpyderX Pro.
  - Select any of the four Datacolor-provided calibration matrices: Any monitor, Standard gamut LED, Wide gamut LED, GB LED.
- [Compare](#) files [certification reports](#): Addition of the revised **G7 Colorspace Pass/Fail Requirements** tolerance set described in “*G7 Master Pass/Fail Requirements; For the G7 Master Program; Version 35, April 2019*” to the [certification report dialog](#).
  - File formats for certification: The TC1617x target/file format (now called IT8.7/5) is supported in addition to the IT8.7/4 file format.
- Opened files ([standard files](#) and [Compare files](#)): The ‘[Rename the patches](#)’ menu now opens a dialog which offers options to rename only selected patches or all patches.
  - Name styles: ColumnRow (MeasureTool convention, all patches only); Increasing numbers (user-defined prefix plus number); Same name (user-defined prefix).
  - Numbers format: user-defined starting number with the option of adding leading zeros (i.e. 001, 002, ... , 010, ... , 100).
  - Selected patches vary according to the file type and the selected window tab. In the “Patch-View” tab of a standard file, the selected patches are those selected in the “[patch edition](#)” mode. In the “Tabular data” tab of standard files and Compare files, the selected patches are those selected in the [table](#).

### Improvements:

- [Info window](#):
  - The spectrum graph can now be enlarged by enlarging the window.
  - Three additional linear scales were added to the graph to better see samples subject to fluorescence. The maximum reflectances of these new scales are 120%, 140%, and 200%.
- RGB profiles with no B-to-A tables (PCS to RGB) are now accepted in opened files and when assigned in the [Tabular data tab](#) of opened files. Such profiles are most often found in scanner and camera profiles.
- The file name is now included within the file when [exporting Patch-Reader measurements](#).
- (Windows) The [Main window](#) and the [Info window](#) can now be brought to the front when an opened file window is clicked-on, instead of just bringing the file window to the front. This behavior is similar to what happens on the Mac OS. The behavior can be controlled in the user [Preferences dialog](#).

### Bug fixes:

- [Target Scramble/Analysis dialog](#) (accessible from the ‘Re-map’ menu): Corrected a bug which made the program crash when an error message was shown at the end of a scramble performed with the “Minimum DeltaE\*” method.
- [Extract Target from Image](#) tool: The program no longer crashes when an image has an embedded profile which has no B-to-A tables (PCS to RGB).
- Edit patches/Extract selected patches (Patch view): The Standard Observer is now properly set, instead of being unassigned, in the “Patch view” and “Tabular data” tabs for patches extracted using the “[patch edition](#)” mode.

### Other:

- (Mac 64 bit only) The provided 64 bit install files are compliant with current Apple [notarization requirements](#). Notarization is required for some software in macOS 10.14.5 and will be mandatory for all software starting with macOS 10.15. Please note that any software meeting notarization requirements may not be fully compatible with a given OS version; see the PatchTool [system requirements](#) for more information.

## Version 6.5.0 b456 (2019-05-17)

### New features:

- Added support for CIE 170 cone fundamental Observers (CIE 170-1:2006, also referred to as CIE 2006, and CIE 170-2:2015, also referred to as CIE 2015).
  - Support of the 2 deg. and 10 deg. cone fundamentals. In PatchTool, the CIE 170 Observers are identified as “2F” and “10F” in the Observer menus of opened files.  
Note: Variable field sizes and age dependent Observers are not supported.
  - CIE 170 computation is performed internally with a 5 nm bandwidth. Interpolation of 10 nm bandwidth spectral input data can be done with these methods: Cubic spline, Lagrange, Linear (selected in the [Preferences dialog](#)). Note: All standard PatchTool Illuminants are now defined internally with dedicated 5 nm and 10 nm versions.
  - Import and export tristimulus data. CIE 170 Observers are identified as “2F” and “10F” in CGATS and Compare files; they are identified as “2F\_degree” and “10F\_degree” in CxF3 files.
  - Export MacLeod-Boynton chromaticity coordinates ( $l_{MB}$ ,  $s_{MB}$ ) by selecting the “xyY” data type in the [PatchTool Export](#) dialog (Available in CGATS, plain text, and Compare files) or in the [Display-Reader CGATS file options](#) dialog.
  - Tools with full CIE 170 support: **Custom Illuminants, Average, Compare, Join, Tweak Target, Display-Reader, File-to-File Transfer, Substrate Correction.**
  - Tools with partial CIE 170 support: **Gamut Tools, Spectrum Generator.**
  - See [Appendix H](#) of the PatchTool Help manual for more information.
- [Custom Illuminants](#): This tool now accepts files with 5 nm bandwidth spectral data.
  - Illuminants with 5 nm bandwidth data are best used for CIE 170 computation while Illuminants with 10 nm bandwidth data are best used for CIE 1931 (2 deg.) and CIE 1964 (10 deg.) computation.
  - Files of standard PatchTool Illuminants and Standard CIE Illuminants with 5 nm and 10 nm bandwidth spectral data are provided in the PatchTool install folder.
  - You can select the interpolation method to be used with a 10 nm bandwidth Illuminant when CIE 170 computation is required. The interpolation methods are: Cubic spline, Lagrange, Linear.
  - You can select the spectral filtering method to be used with a 5 nm bandwidth Illuminant when CIE 1931 / CIE 1964 computation is required. The filtering methods are: Extract 10 nm values, Triangular filter.
  - The tool now computes the CCT, Duv, and brightness for all Standard Observers (“2”, “10”, “2F”, “10F”) instead of just for the CIE 1931 (2 deg.) Observer.
- [Display-Reader](#): The tool now computes the CCT and luminance for all Standard Observers (“2”, “10”, “2F”, “10F”) instead of just for the CIE 1931 (2 deg.) Observer.

### Improvements:

- [Adobe Swatch Exchange export](#): Now shows a context specific message dialog when the export conditions are not as required.
- Now shows a more precise message when opening a file whose data is relative to a [Custom Illuminant](#).

### Bug fixes:

- [Display-Reader CGATS export](#): Now properly processes the data types selections for “Processed data” instead of using the data types selected for the “RAW data”. The output values were always correct.
- When selected, the [3D graph](#) of opened files is now properly refreshed after a change in the Custom Illuminants dialog.
- The 3D graph of an opened file is now properly refreshed when pasting the window dimensions of another 3D graph.

### Other:

- A “Forced deactivation...” menu item is added to the Help menu. This procedure may be helpful when the status of the Product Key activation is ambiguous (i.e. when the “Activate” menu is available even if the program was known to be activated on this specific computer).

## Version 6.1.0 b441 (2019-02-15)

New features:

- Open QTX Version 1 formatted text files used by Datacolor products.
  - File extension \*.qtx is preferred. Files with a \*.txt extension will also be opened as QTX files if the specific “STANDARD\_DATA” keyword is recognized.
  - Supported measurements types: STANDARD\_DATA, BATCH\_DATA (reflectance only)
  - Supported data type: spectral data (STD\_R and BAT\_R)
  - Spectral data: Scaled either between zero and one, or between 0 and 100%.
  - Minimum spectral range: 400 nm to 700 nm
  - Supported spectral bandwidths: 5, 10, and 20 nm. 5 nm data is filtered to a 10 nm bandwidth. 20 nm data is interpolated to a 10 nm bandwidth.
  - Note: STANDARD data and BATCH data are opened in separate files. There is only one STANDARD data group in a QTX file. There can be zero or multiple batches identified by batch number in each BATCH section. The batch data is grouped by batch number; the first 20 batches of a file are opened.
- Added the CMC color difference formula.
  - Select between the CMC(2:1) and CMC(1:1) versions.
  - The CMC formula is available in the [Info window](#), [Compare windows](#), the [Average](#) selection dialog, the [Gamut tools “List gen.” tab](#), and for [Munsell conversion](#).

Bug fixes:

- [Info window screenshot](#): Corrected a bug causing the screenshot to be incomplete.
- [File view “3D graph” tab](#): The OpenGL viewport is now scaled in accordance with the HiDPI setting. For instance, a wrong scale was used for the viewport with a Windows 10 display scale set larger than 100%.

## Version 6.0.5 b437 (2018-10-05)

Other:

- This version was compiled in 32 bit executable files (Mac and Windows) and a 64 bit package is also available for Mac.
- (Mac 64 bit only) Instrument support changes:
  - The following instruments/drivers are no longer available: DTP94, Eye One Display, i1Pro / i1Pro 2 (non-XRGA), Spyder2, Spyder3, Spyder4, Spyder5.  
Note: One or more of these instruments may be supported again if 64 bit Frameworks become available.
  - The following instruments/drivers remain available: i1Display Pro, i1Pro / i1Pro 2 (XRGA).
- (Mac) The minimum system requirement is now Mac OS X 10.9.5 (Mavericks).

## Version 6.0.0 b433 (2018-04-11)

### New features:

- [3D graph](#) tab for opened files ([standard files](#)): A new tab dedicated to 2D and 3D graphs presentations of the file data and the selected CMYK and RGB profiles.
  - 3D graph spaces: L\*a\*b\*, xyY, XYZ, RGB
  - 2D graph spaces: L\*a\*b\*, xyY
  - Up to five selectable graph inputs: CMYK profile; RGB profile; input data used as color reference (converted from spectral, L\*a\*b\*, xyY, XYZ, CMYK, or RGB data); CMYK data; RGB data.  
Note: Not all inputs may be available for a given file, as it depends, among other factors, on the presence or not of reference CMYK and RGB data in the opened file and the availability or not of a profile associated with the CMYK and RGB data.  
Note: In each file, a maximum of one CMYK profile and one RGB profile can be viewed simultaneously. You can of course open multiple instances of the same file and associate different CMYK and RGB profiles, if applicable, in each file.
  - The data selections and display settings associated to the 2D and 3D views can be different, and thus optimized, for each view.
  - Requirements: The computer must support OpenGL Version 1.1.
- [Preferences \(Misc. tab\)](#) – Adaptation setting: It is now possible to select either “FULL” adaptation or “NO” adaptation when converting with Absolute Colorimetric intent with a RGB monitor/display profile. In ICC v2, the adaptation was not specified, and there was usually NO adaptation. In ICC v4, the default is FULLY adapted. The PatchTool 6.0 default is “NO” adaptation, which has been used historically in many profile graphing programs.

### Improvements:

- [Built-in PatchTool RGB profiles](#):
  - Absolute Colorimetric intent is now available in addition to Relative Colorimetric when selecting a built-in PatchTool RGB profile for an [opened file](#) (the Absolute Colorimetric intent for PatchTool built-in RGB profiles was previously available only in [Gamut Tools](#)).
  - In order to better match the results obtained with ICC profiles, a D50 PCS is now used before or after performing the internal XYZ to RGB and RGB to XYZ conversions. In the past, conversion to XYZ was done directly to the space Illuminant (for instance when converting spectral data to a D65 RGB space).

### Bug fix:

- [Activation](#): Fixed an issue where an OutOfBoundsException message was shown if attempting activation when the computer Ethernet cable was not connected to a router. The [OFFLINE activation](#) dialog is now shown.

### Other:

- This version was compiled in 32 bit executable files (Mac and Windows). Nonetheless, it incorporates many internal changes in preparation for 64 bit, including the use of a more recent version of the compiler. While efforts are being made to develop 64 bit executables, their availability cannot be guaranteed at the moment and, if offered, will likely not support older instruments for which a 64 bit Dynamic Link Library (DLL, on Windows) or Framework (on Mac) is not available.

## Version 5.5.0 b422 (2017-10-02)

### New features:

- [Spectrum Generator](#) tool: Generate spectral data from tristimulus coordinates (i.e. XYZ, L\*a\*b\*).
  - Perform the spectral fit using 3 components, computed from one illuminant, or using 6 components, computed from two illuminants.
  - Illuminants for 3 components fit: A, C, D50, D55, D60, D65, D75, D93, E, F2, F7, F11, plus two user-defined illuminants (see [Custom Illuminants](#)).
  - Illuminants for 6 components fit: A, C, D50, D65, E
  - Supported Standard Observers: 2 deg. and 10 deg.
- [Average](#) tool: It is now possible to filter outliers when averaging data files.
  - Select a threshold value for the color difference between a patch color and the (simple) average color for this patch.
  - Color difference formulas: CIELAB, CIE94, CIEDE2000
  - You can use outliers filtering with the simple and weighted averaging method.
  - In the log window, get a patch ID list of the outliers for each file and a list of the patches which are outliers in all files, if any.
- [Export Image](#) (8 bit dithering): There is now an option to dither all 8 bit images.
  - Generate images with essentially 16 bit accuracy while keeping an 8 bit workflow (results depend on patch size, resolution, and area used for measurement).
  - Dithering is performed on the Least-Significant-Bit (LSB) of each coordinate.
  - File types: PNG, BMP, TIFF
  - Color spaces: RGB (for PNG, BMP, TIFF), CMYK and L\*a\*b\* (for TIFF)
- [Patch-Reader](#): There is now a menu option to select the direction in which the next patch is selected after a single patch measurement in the "Custom chart" and "PatchTool file" modes. In previous versions, the next patch was always selected to the RIGHT of the current patch, effectively measuring the chart line by line. It is now possible to select the patch going DOWN from the current patch, effectively measuring the chart column by column.

### Improvements:

- [CxF3 Export](#): Now groups data by Object Type. This change improves human readability of the output file and can generate smaller file sizes, particularly when exporting using the generic \*.cxf file type.
- Faster data transfer operations. Most operations which require transferring or copying data between opened files, or saving data to a disk, are now sensibly faster.

### Bug fixes:

- (Mac) Fixed an issue where PatchTool would crash if the program lost the user focus, for example by clicking on another program window, while a long process was running. Examples of long processes are averaging many measurements files or saving a large file. Before the fix, the workaround was simply to wait until the process was completed.
- [Substrate Correction](#) tool: Fixed a bug which made the program crash after a combination of events which included selecting a patch ID with the DOWN-arrow control when the ID value and the number of patches in the previous file was larger than the number of patches in the current file. The problem did not occur when getting the ID automatically or when writing any value in the ID field, or when using the UP-arrow.



## Version 5.3.0 b415 (2017-07-12)

New features:

- [ChromaChecker upload](#): It is now possible to upload measurements files to the ChromaChecker Web server directly from the [Export dialog](#) (A ChromaChecker subscription is required; <https://chromachecker.com/>).
  - Supported ChromaChecker service: PRINT INSPECTOR
  - Measurements are uploaded using the ChromaChecker SOAP account login and password.
  - Get your account info: uploads, uploads limit, expiration, account status.
  - Upload CMYK references and spectral measurements to any predefined track workflow.
  - Supported file info data fields: production mode, scan side, measurement condition, backing, dryback, visual judgment, job name, job ID, customer name, operator, sheet number.
- [TC1617x target support](#): This target, developed by [Idealliance](#), replaces the 29 duplicate patches of the IT8.7/4 target with the 29 patches in column 4 and 5 of the P2P51 target. It is available in three layouts optimized for the X-Rite i1iO and i1iSis instruments.
  - [Dedicated menus](#), using "[Re-map](#)", to convert the layouts between the i1iO target and the i1iSis horizontal and vertical targets. You can also split the i1iO target in two pages.
  - Charts for the i1iO and i1iSis, and characterization data for the G7 Datasets (CGATS21 ISO15339) are provided in the "characterization\_data" folder ("File/Open Sample Files" menu).

## Version 5.2.0 b411 (2017-03-10)

New feature:

- [Display-Check](#): Following a display measurement, the program now saves a copy of the display profile in the "MyDocuments/BabelColor/Display profiles" folder.

Improvements:

- [Preferences – Color tab](#): The dialog now includes buttons which open various folders where user and system display profiles are stored.
- [Profile selection menu](#) (RGB): These menus now include a selection to open the "BabelColor/Display profiles" folder.
- [Profile selection menu](#) (Mac): These menus now include selections for "Mac/LOCAL" and "Mac/SYSTEM" profile folders.
- Now uses the "dscm" tag for the profile name in Apple's localized V2 profiles.

Bug fixes:

- [Display-Check \(Mac\)](#): Fixed the issue where the text field with the tool instructions stole the focus from the Start/Stop button, preventing keyboard input.
- [Extract Data from Profile](#): Fixed an issue where the program did not propose the proper file type when saving data extracted from a profile.
- [Drag-and-drop on profile selection menus \(Win\)](#): Fixed a bug where drag-and-drop was not possible on profile selection menus. Note: Browsing to the profile was always possible.
- Fixed a bug where a divide-by-zero condition was not detected when computing [CIEDE2000](#). The result was displayed as "-nan" in the Info window and could also make the program crash when [assigning White, Grey, or Black](#) to both the Reference and Sample in a Compare file.

Other:

- [Preferences – Color tab](#) (Mac): Because Apple ColorSync is deprecated, it is no longer possible to provide the path of a display profile. The name of the profile assigned to a monitor is still available.
- Windows OS: Windows Vista is no longer supported.
- i1Pro DLL (Windows): Version 4.2.3 of the library (i1Pro.dll) is now provided with the program.

## Version 5.1.0 b409 (2016-11-14)

### New features:

- Added support for [Custom Illuminants](#):
  - Added a dedicated tool to measure, load, and save the spectrum of two (2) Custom Illuminants.
  - Compatible instruments: X-Rite i1Pro or i1Pro 2 with an ambient adapter
  - File input: CGATS or plain text file; 380-730 nm or 400-700 nm, with 10 nm increments
  - You can select these illuminants for any opened file (with or without spectral data).
- Added support for the Datacolor [Spyder5](#) colorimeter:
  - This instrument is currently used in the [Display-Check](#) and [Display-Reader](#) tools.
  - Supported models: Spyder5ELITE, Spyder5PRO, Spyder5EXPRESS.
  - PatchTool can select any of the four Datacolor-provided calibration matrices specifically designed for various display technologies, and which provide improved measurement accuracy.
  - Select between two measurement speeds.

### Improvements:

- [Info window](#): Added options for 3 and 4 decades logarithmic scales for the reflectance axis in the contextual popup menu of the spectrum graph.
- [Gamut Tools](#): The gamut volumes of the PatchTool built-in RGB spaces now better match the volumes obtained with their equivalent matrix-based ICC profiles.
- The CIEDE2000 color difference is now computed with the alternate three terms form equation in which the fourth term associated with rotation ( $R_T$ ) is now integrated with the chroma and hue differences. The two formulas provide the same Delta-E\* values and are identical relative to the lightness difference; however, beside the disappearance of the rotation term, Delta-C' and Delta-H' are respectively replaced by Delta-C'' and Delta-H'', and  $k_C S_C$  and  $k_H S_H$  are respectively replaced by  $S''_C$  and  $S''_H$ . Please refer to [Appendix G - The CIEDE2000 Color Difference Formula](#) for more information.

### Bug fixes:

- (Mac) [Info window screenshot](#): Will now generate the "Info" window screenshot (by pressing the "I" key) even if the "Rows" data field of an opened file window has the focus.
- Display-Reader / Display-Check with the i1Display Pro: Will now perform measurement correction as requested when computing the display White Point (WP) if "Use a Correction Matrix" is selected for this instrument. In saved RAW files, the WP data was wrong but the individual measurements were correct (i.e. properly processed by the Correction Matrix). Please note that there was no WP error if a Correction Matrix was also selected for the "Eye-One Display." The workaround, prior to this fix, when making a display measurement was thus to:
  - 1- In the Display-Reader tool, select the "Eye-One Display" (instrument NOT required)
  - 2- For the "Eye-One Display", click the box to "Use a Correction Matrix" (Note: you do not need to edit or change the Eye-One Display Correction Matrix values)
  - 3- Reselect the "i1Display Pro" and make sure the box to "Use a Correction Matrix" is selected. (Note: Measurements were always processed with the Correction Matrix assigned to the i1Display Pro; the values of the Eye-One Display Correction Matrix were NOT used)
- [Gamut Tools List gen.](#): When building a patch list for the "Gamut edge" of a [Device Independent space](#), the patch name is the PCS to Profile-output to PCS roundtrip error. Before this fix, the written patch name was wrong for in-gamut patches (the shown roundtrip error was generally too high). This problem has been corrected. Please note that the problem did not affect the patch selection process.

### Other:

- (Mac) The downloadable install file is now in Disk Image format (\*.dmg) and is digitally signed for easier installation. It is recommended to keep a backup of the Disk Image on a separate computer once installation is completed.

## Version 5.0.0 b397 (2015-10-13)

New features:

- [Join](#) files tool:
  - Join two or more opened files to create a new file.
  - Joins files of the same color reference type: (spectral/xyY/XYZ/L\*a\*b\*/L\*C\*h), RGB, CMYK.
  - Select if you also join the ID and Name data fields of each file.
  - When joining files of the tristimulus/spectral type, you can also join their RGB and CMYK data if it was also present in each file when it was opened.
- [Patch view](#) tab of opened files (standard files):
  - Added a set of functions to [edit the patch list](#): Select/Deselect a Row, Column, or All. Invert selection. Swap two patches. Move selected patches before or after a patch, to the first column, or to the last column. Flip the patches of a row or column. Replace selected patches by: White, 50% Gray, Black, OSA-UCS background. Copy selected patches to the last column. Add White patches to fill the last column. Extract selected patches to a new file. Delete selected patches.
  - Added a [target generation and analysis](#) dialog (accessible from the 'Re-map' menu): Scramble a layout by selecting: the paper color, the minimum color difference between the paper and the patches on the edges, and one of three scrambling methods. The first two scrambling methods have a goal of 20 DeltaE\* (CIELAB) for the color differences between adjacent patches while the third one has an adjustable goal. Analyze a layout to see its compatibility with i1Pro target measurement requirements. You can also (try to) fix the rows of a layout for improved contrast.
- [Display-Check](#): Added a checkbox, called 'Use RGB', to force RGB pass-through for a PatchTool file. When selected, the program uses the RGB data directly. Different workflows are possible depending on the RGB data origin, which is either found in the file or obtained from a user-selected profile.
  - 'Use RGB' selected + RGB data WITHOUT profile info: This is most often the case when a file has RGB data in addition to spectral or L\*a\*b\* data. The measured data is presented in a standard file window (NOT a Compare file). The data is computed in D50 with a Relative-Colorimetric conversion between the measured display White Point and D50 (same process as in Display-Reader when a WP is measured). This file can be COMPARED with another file if required.
  - 'Use RGB' selected + RGB data WITH profile info: The measured data is presented in two files: a standard file window, as described above, AND a Compare file. The Compare file is similar to the file obtained with the 'Use RGB' NOT selected workflow.
  - 'Use RGB' NOT selected (the old workflow): The measured data is presented in a Compare file.
  - RAW (i.e. non-processed) data is available in all cases.
- [Compare](#) files: The 'Cert. report' button now appears in the 'Stats' tab when comparing any two IT8.7/4 files. This certification report can be used, and should be used only, for assessing conformance to [G7 Colorspace Pass/Fail requirements](#), and for '[IDEAlliance PROOFING CERTIFICATION & VERIFICATION PROGRAMS \(Version 16\)](#)'. For printed targets, the report tolerance options are:
  - Idealliance Hard Copy Proofing (V16)
  - G7 Sheetfed Offset Print (Colorspace P/F)
  - G7 Proof (Colorspace P/F)
- [Substrate Correction](#) tool: Added the option to select the CIEDE2000 formula when computing the color difference between paper whites.
- [Extract Target from Image](#) tool: This tool can now extract targets from 8 bit PNG images.
- Open PNG image files as patch files:
  - Supported image format: RGB; 8 bit
  - Maximum image size: none. However, because each pixel becomes one patch, opening large images (64KB+ pixels) is not recommended, since success will depend on system resources.
- [Export Image](#) dialog:
  - The PNG and BMP image export formats are now available on both Mac and Windows.
  - You can include an ICC profile in exported PNG and TIFF images. The profile must be defined by an external file; internal PatchTool RGB profiles are not supported.
  - You can add row numbers to better locate patches in exported images.

#### Improvements:

- [Display profile](#):
  - When rendering a color patch, the program uses the profile assigned to the display corresponding to the window position. If the window is moved to another display, the patches are rendered with the new display profile; there is no need to manually select a profile in multi-display systems.
  - The [Preferences dialog](#) now shows the names and file locations of the profiles assigned to all connected displays. It also shows the profile corresponding to its location.
- All profile selection menus now include [menu items](#) to open the system profile folder and the folder used by PatchTool to save profiles extracted from images.
- [Display-Check](#): The Destination profile is now tied automatically to the display profile. This simplifies the interface and the complexity of the [workflows](#), in particular for the Quick-Test measurements references.
- The 'File/Open Sample Files' menu now offers to open the 'Characterization Data' folder which contains reference and characterization data files for many print standards (Idealliance, CGATS21, ISO 12647, ISO 15339, FOGRA, and others).
- [Gamut Tools List gen.](#): The minimum pitch was reduced for RGB, CMYK and Device independent spaces (L\*a\*b\*, L\*C\*h, XYZ) lists. While it is now possible to generate extremely large lists, this is not recommended, and success will depend on system resources. The intent of this change is to enable finer pitch lists in limited ranges.
- A 'Cancel' button was added to the status windows shown when opening files or generating lists.
- Open TIFF image files as patch files: The image size limitation was removed. While opening large images (64KB+ pixels) is now possible, it is not recommended since success will depend on system resources.
- [Compare](#) files: Now proposes more specific file names when creating Compare files.
- Minor tweaks to the CCT computing code and a better match with the results of CT&A Version 4.2+.
- (Mac) The program is now compiled using the 'Cocoa' Framework instead of the 'Carbon' Framework, which was made possible by dropping support for PowerPC. Some of the effects of this change are:
  - GUI appearance; for instance, the windows can now be resized by dragging any edge.
  - More accurate color rendition with wide gamut displays, and, for all displays, a better match with the numbers shown by the Mac 'Digital Color Meter' Utility.

#### Bug fixes:

- The measurements table in Display-Reader is now properly updated when the measurements are shuffled. The problem did not affect the saved data.
- The colors of the displayed patches in the Display-Reader measurements table are now correctly computed when using the assumed (non-measured) White Point.

#### Other:

- [New licensing system](#):
  - Licensing is now based on a 'Product Key' which is used to activate a specific computer.
  - You can transfer a Product Key to another computer by deactivating the first computer and activating the second one. If you are connected to the Internet, this process is free and you can repeat it as you require. If the computer is not connected to the Internet, offline activation and deactivation is possible but a service fee is required for each activation; this fee can be paid from the BabelColor Web site.
  - The same key can be used for the Mac and Windows versions (one computer at a time!).
  - Once a Product Key is activated on a computer, an Internet connection is not required.
- The JPG format is no longer available as an EXPORT format for images. It remains available for target extraction.
- Color management workflows: The Help manual [Appendix on Color Management](#) has been rewritten to reflect the changes in display-profile handling affecting patch viewing and the [Display-Check](#) tool.
- (Mac) The minimum system requirement is Mac OS X 10.7 (Lion). As previously announced, PatchTool Version 4.7 was the last version to support PowerPC.
- (Windows) The minimal system requirement is now Windows Vista. As previously announced, PatchTool Version 4.7 was the last version to support Windows XP.

## Version 4.7.0 b362 (2014-10-02)

### New features:

- [Extract Data from Profile](#) tool: Extract and save the measurement data provided in dedicated tags within an ICC profile. The data can be in the form of a CGATS file, an XML file, or a compressed CxF3 file (ZXML tag). This tool can be used with the program in demo mode.
- [Extract Target from Image](#) tool: This tool can now extract targets from 8 bit and 16 bit TIFF L\*a\*b\* images.

### Improvements:

- [Extract Target from Image](#) tool:
  - Added a 'Set to corners' button to lock the target mask on the image corners; this is useful when the target fills the image.
  - The tool now provides more accurate extraction at low zoom values and high patch-fill ratios. In particular, the program will reject image pixels located at, or near, a patch edge and will not process the same edge pixel for two patches.
  - Faster target extraction.
- [Patch view](#) tab of opened files (standard files and Compare files):
  - The patch layout is now in the center of the window.
  - Now draws unused patches, in the bottom part of the last column, with a cross.
  - Now shows the current row quantity when changing the window size in 'Floating' mode. This is useful when you want to manually assign and lock the row quantity after a resize.
  - (Mac) The patch layout is resized in real time while changing the window size.
- [i1Pro and i1Pro 2](#):
  - Now supports the i1Pro 2 SDK Version 4.2.0.
  - Added a button in the Instrument Info dialog (when called from [Patch-Reader](#)) to check i1Pro / i1Pro 2 lamp restore. Lamp restoration is performed, if required, when this check is requested.
  - Note: Lamp restore is not available in the PowerPC and Windows XP packages, which still use the older SDK.
- New improved-accuracy table-based algorithm to compute the CCT. The acceptable isotemperature zone is between 1000 K and 100,000 K. A warning is issued when calibrating an instrument with a white patch if  $Duv$  (CIE1960) is not within plus or minus 0,05 ( $Duv$  data not provided).

### Bug fixes:

- Fixed a bug where out-of-gamut profile transforms are properly detected. The problem affected only some functions of the Gamut Tools, more specifically the 'Gamut volume' computation and the 'Device independent spaces' list generator. This bug mostly happened with CMYK profiles and ICC V4 RGB profiles.
- Fixed a bug where the 'Stats' tab of opened Compare files is properly updated when changing the preference for the 'CIE 94 reference mode' or the preference for 'Delta h computation...' in the Preferences dialog.
- Fixed a bug where the DTP94 colorimeter was not properly detected by pressing the 'Info' button in the 'Display-Check' or 'Display-Reader' tool windows if the instrument was connected after opening 'Display-Check' or 'Display-Reader'.

### Other:

- Version 4.7 is the last version which supports Mac computers with PowerPC processors.
- Version 4.7 is the last version which supports OS X 10.6; future versions will require at least OS X 10.7 (Lion).
- Version 4.7 is the last version which supports Windows XP; future versions will require at least Windows Vista.



## Version 4.6.0 b349 (2014-03-03)

### New features:

- [Info window](#):
  - You can see a patch reflection density as defined in ISO 5-3 (Status A, Status E, Status I, Status T).
  - A third data display was added to the Info window and you can, for example, see the CMYK, L\*a\*b\* and Density values of a patch at the same time. You can also hide two of the three data displays if desired.
  - Get a [screenshot](#) (PNG format) of the Info window simply by pressing “P” on the keyboard.
- [Patch-Reader](#) tool:
  - You can now display the reflection density of a measured patch as defined in ISO 5-3 for all chart types (Unconstrained measurements, Custom chart, PatchTool file).
  - As with Unconstrained measurements, you can now see XYZ, L\*a\*b\* or L\*C\*h values of any measured patch for a Custom chart or a chart defined by a PatchTool file.
  - When measuring a chart while using a PatchTool file as a reference, you can compare L\*a\*b\* and L\*C\*h values between the reference file and the measurements and get the CIELAB color difference (DeltaE\*). You can also compare CMYK from the reference with the measured density.
  - Whenever available, display the data for any mix of M0, M1, or M2 Measurement conditions.
  - Added the Density data field in Patch-Reader CGATS export dialog.
- [Export](#) dialog: You can now export Density values for any opened file which contains spectral data (File types: CGATS, plain text).

### Improvements:

- [Patch-Reader](#) tool: Improved patch navigation, selection and display when measuring patches with the ‘Custom chart’ and ‘PatchTool file’ chart types.

### Bug fixes:

- Fixed a bug where a measuring instrument would not connect immediately when opening the Display-Check, Display-Reader or Patch-Reader tool. The problem happened when ‘Eye-One Display’ or ‘i1Pro / i1Pro 2 (non-XRGA)’ were the previously selected instruments.
- Fixed a bug where an OutOfBoundsException would sometimes happen when switching from a ‘Custom chart’ to a ‘PatchTool’ file in Patch-Reader.
- Fixed a bug where a message referring to ‘DUAL scan’ would be shown in the Patch-Reader window when measuring patches on a strip with the ‘i1Pro / i1Pro 2 (non-XRGA)’ instrument driver. Only the message was wrong and it did not affect the measurements.
- Fixed a bug where an OutOfBoundsException would happen in Display-Check when making measurements just after opening the ‘Instrument info’ dialog. The problem was associated only to the following colorimeters: DTP94, Eye-One Display, and i1Display Pro.
- (Mac) Fixed a bug where an IOException was raised when saving a profile while importing patches from a TIFF image or extracting a target from an image. The problem occurred if the profile was already in use in another opened PatchTool file.
- (Mac) Fixed a bug in the ‘Extract Target from Image...’ tool where the target layout was not properly positioned when extracting targets from images of the same size one after the other.
- (Mac) The file names are now properly defined when exporting multiple files from the Patch-Reader export dialog.

### Other:

- Contrary to prior notice, Version 4.6 still supports Mac computers with PowerPC processors.

## Version 4.5.0 b332 (2013-10-02)

### New features:

- [CxF3 Export](#): Added options to export to the generic CxF Version-3 ([CxF3](#)) file format (\*.cxf) as well as to four CxF3-compliant file types dedicated to X-Rite's i1Profiler (i1Publish).
  - Supported data fields: ID, Name, XYZ, xyY, L\*a\*b\*, L\*C\*h, RGB, CMYK, and spectral data
  - Supported i1Profiler file types: Chart Measurements (\*.cmxf), Patch Sets (\*.pxf), Test Charts (\*.txf), Measurements (\*.mxf).
  - i1Profiler export limitation: i1Profiler support is limited to RGB and CMYK reflectance workflows (i.e. CMYK+n and display measurements are not supported). In addition, except for a small option with \*.cmxf files, there is no support for Custom Resources. Additional features may be added in future versions as knowledge is gained and need is expressed by user feedback.
- Color Management Module (CMM) changed from LCMS 1.19 to LCMS 2.5. This change has an impact on all profile-based color conversions. Here are a few of the consequences of this change:
  - Full support of ICC v2 and ICC v4 profiles (LCMS 1.x had partial support of ICC v4 profiles).
  - Important notice: Because LCMS 2.x was almost completely re-written, you should not expect to obtain EXACTLY the same numerical results as the ones obtained with LCMS 1.x, although the LCMS author is confident that the newer version is more accurate.
  - [Gamut Tools](#): Computed gamut volumes may be different from those computed in previous versions.

### Improvements:

- [Extract Target from Image](#) tool: Improved mask layout management.
  - The mask layout is scaled and positioned to follow changes in the tool window size and in image scaling.
  - Maximum scaling has been increased to 3200% to better see single-pixel-per-color targets.
  - You can now move the image and the mask at the same time by pressing the “Alt” key (on Windows; use the “Option” key on Mac) while doing a mouse drag.
  - In a given session (i.e. until PatchTool is closed), the tool window, the image, and the mask sizes and positions will be recorded and used for the next image, if the image is of the same dimensions. This is useful when extracting targets from many images taken with the same setup.
  - The mask cannot be positioned outside of the image; the mask will snap to the image edges.
  - Any embedded profile will now be copied as is instead of being reconstructed from captured data.
- [Extract Profile from File](#) tool:
  - Added these fields to the tool interface: Creation software, Preferred CMM, Profile Copyright.
  - Any embedded profile will now be copied as is instead of being reconstructed from captured data.
- Improved xy to CCT algorithm. The algorithm is now more accurate over a larger chromaticity area. The acceptable isotemperature zone is between 2000 K and 1 MK. A warning is issued when calibrating an instrument with a white patch if Duv is not within plus or minus 0,05 (Duv data is not provided).
- [Patch view](#) tab: Added entries for Horizontal and Vertical layouts of the IT8.7/4 and ECI2002 targets in the “Rows” menu.

### Bug fixes:

- Extract Target from Image and Extract Profile from File tools: Fixed the bug where an embedded ICC v4 profile was saved as an ICC v2 profile.
- [Patch view](#) tab of opened files (standard files and Compare files): Corrected a bug where the RGB values are properly replaced when using the “Replace the patch color with...” contextual command (Shift + mouse Right-Click) and the file data was derived from imported RGB values.
- Patch view tab of [Compare](#) windows: Corrected a bug where the CMYK values are properly replaced when using the “Replace the patch color with...” contextual command (Shift + mouse Right-Click) and the file data was derived from imported CMYK values.

### Other:

- Contrary to prior notice, Version 4.5 still supports Mac computers with PowerPC processors.



## Version 4.1.0 b321 (2013-06-03)

### New features:

- [Display-Reader](#) tool: Perform unconstrained emission measurements on any display, even one not connected to the computer on which the program is running.
  - This tool can be used with all PatchTool [supported colorimeters and spectrophotometers](#).
  - Measurements can be done with or without a [Color Correction Matrix](#).
  - Measurements can be done with or without measuring the display White Point (Note: The Eye-One Display 2 set for CRT and the Spyder2 require calibration to be done on a white patch).
  - Obtain ABSOLUTE measurements: xyY, XYZ, spectral data (for the i1Pro and i1Pro 2). If you measure the White Point, you can also get L\*a\*b\* data relative to this White Point.
  - When you measure the White Point, you can also obtain PROCESSED data (xyY and XYZ, with Y normalized, and L\*a\*b\*, relative to many Standard Illuminants, in Absolute-Colorimetric or Relative-Colorimetric intents).
  - [Export ABSOLUTE measurements](#) in a RAW file that can be opened in a spreadsheet.
  - [Export PROCESSED data](#) in a CGATS compatible file which can be opened in most programs that support this format. This file can be opened in PatchTool and compared to other color lists.
  - A timer can be used to take [measurements at fixed time intervals](#).
- [Substrate Correction](#) tool: Use this tool to convert measurements taken on a backing material, a black substrate for example, as if they were taken on another backing, a white substrate for example, as described in ISO 13655:2009, Annex A. You can also use it to convert standard or custom colorimetric aims data sets, the aims of ISO 12647-2 for example, when your substrate/paper is not within tolerance, as described in ISO/DIS 15339-1.
  - Let the program find the patch with MAX Lightness (L\*) in your reference data or assign any patch with its ID.
  - Let the program find the patch with the MIN L\* in your reference data, assign any patch with its ID, or write-in the L\*a\*b\* values.
  - Specify the target data using either an opened PatchTool file or write-in the L\*a\*b\* values. If using an opened file, let the program find the patch with MAX Lightness (L\*) in your target data or assign any patch with its ID. The CIELAB difference between the reference and the target is shown as well as the individual L\*, a\*, and b\* differences.
  - The tool can be used with files of any size (i.e. number of patches).
- [File-to-File Transfer](#) tool: Transfer any of the ID, Name, CMYK, and RGB data fields between two files opened in PatchTool. This tool is particularly useful to copy reference CMYK or RGB data into a measurement file when you intend to generate a profile from this file.

### Improvements:

- Will now detect when importing xyY or XYZ data where Y is scaled between zero and one (0-1) instead of the more traditional zero to one-hundred range (0-100). A dialog is presented to confirm rescaling.
- i1Display Pro: Added support for the new 'Burst' measurement mode dedicated to displays which have pulsing characteristics, such as plasma screens. The [EDR files](#) were updated, with additional files for RG-Phosphor, Plasma, and OLED displays.
- The items of the 'Tools' menu were reordered and grouped in categories.
- Measuring instruments: Instrument detection and connection is more robust.

### Bug fixes:

- Fixed an issue in Patch-Reader when exporting unconstrained measurements without selecting the patch name in the exported file. In these circumstances, an additional data separator was introduced in the data section. This extra separator had no consequence when the files were opened in PatchTool.
- Removed redundant information text in the 'Select Compare' and 'Tweak Target' windows.
- Fixed the issue where the PCS graphics were improperly redrawn in the Gamut Tools.

### Other:

- Contrary to prior notice, Version 4.1 still supports Mac computers with PowerPC processors.

## Version 4.0.0 b312 (2012-09-17)

New features:

- Added support for the X-Rite [i1Pro 2](#) spectrophotometer.
  - This instrument is used in the [Display-Check](#) and [Patch-Reader](#) tools.
  - Supported models: i1Pro 2 M0/M1/M2, i1Pro 2 M2 only.
  - Supports the M0, M1, and M2 measurements mode for reflectance measurements.
  - Supports X-Rite's XRGa calibration standard for reflectance measurements.
  - Assign a Color Correction Matrix to the i1Pro 2.
  - The i1Pro 2 can be used in PatchTool on a PowerPC Mac with the older i1Pro driver; in this configuration, the i1Pro 2 behaves as an i1Pro. The new i1Pro 2 features are available only in conjunction with the new i1Pro 2 driver, which requires an Intel Mac with OS X 10.5.8+.
- i1Pro and i1Pro 2:
  - Both the older i1Pro and the new i1Pro 2 drivers are provided. The i1Pro and i1Pro 2 instruments can be used with either driver in Display-Check and Patch-Reader. The i1Pro 2 driver is XRGa compliant and the older driver is NOT XRGa compliant. The new driver is referred to in PatchTool as 'i1Pro / i1Pro 2 (XRGa)'; the older driver is referred to as 'i1Pro / i1Pro 2 (non-XRGa)'. You can thus make measurements with your instruments with or without XRGa calibration.
  - Calibration with the 'i1Pro / i1Pro 2 (XRGa)' driver always require that the instrument be positioned on its white calibration tile, even for measurement modes other than reflectance.
  - You can assign a different Color Correction Matrix to each driver.
- [Patch-Reader](#) tool: Patch-Reader gives access to the i1Pro 2 features, with support for the M0/M1/M2 measurement conditions and for its Zebra ruler optical reader. Even the older i1Pro benefits from the new i1Pro 2 driver, with the capability to use the "patch correlation" mode with a PatchTool file.
  - New [CGATS export dialog](#): When saving measurements from any Patch-Reader mode, you are now presented with a dialog which enables you to select file options. These options include: a selection of data fields, spectrum scales, spectrum ranges, and decimal separators. If making measurements with multiple measurement conditions, the dialog also offers options to save the data in one or more files.
  - [Unconstrained measurements](#): Select any combination of M0/M1/M2 measurement conditions for each measurement., and get up to three spectrums, one per measurement condition, each time you push the i1Pro 2 button. You can thus see in one click the susceptibility of a paper to fluorescence. If you did measurements in multiple measurement conditions, you can export the measurements in a single file, in a separate file for each measurement condition, or in separate files plus a single file.
  - [Custom charts](#) and [PatchTool file](#): There are new options for strip measurements: an option to use or not the i1Pro 2 ruler, and an option to set the instrument to better recognize low resolution targets. These options' availability depends on the instrument, the selected driver, and the selected measurement conditions. In addition, when measurements are made in reference to a PatchTool file, you can now select to make measurements in a 'patch correlation' mode, without an i1Pro 2 ruler, where the file values are used to do a fast check on the validity of the measured data and to detect the direction of the scan. If you did measurements in multiple measurement conditions, you can select which data you want to keep, in a separate file for each measurement condition.
- [Display-Check](#): When using the 'i1Pro / i1Pro 2 (XRGa)' driver with either the i1Pro or the i1Pro 2, you can select an 'Adaptive measurement' mode for emission measurements in the [Instrument Info](#) dialog. When selected, the measurement time is longer for low luminance patches in order to provide more accurate measurements.
- [Extract Target from Image](#) tool: This tool, designed to directly extract the average of target patches in full size photographic images, now supports 8 bit and 16 bit TIFF CMYK images.

#### New features (continued):

- Open [CxF Version-3](#) files, such as the ones generated by the X-Rite i1Profiler program:
  - Open generic \*.cxf files as well as files with content-specific data, such as \*.axf, \*.mxf, \*.txf, etc.
  - Import a collection of device-independent data type measurements, plus RGB and CMYK, when available, into a [PatchTool file](#). The measurements collections must have the same number of patches to be imported in the same file.
  - Supported top level Resources: Object Collection, Color Specification Collection.
  - Supported device-independent data types: Reflectance Spectrum, L\*a\*b\*, L\*C\*h, XYZ, xyY, AdobeRGB, sRGB.
  - Supported device-dependent data types: RGB, CMYK.
  - Non-supported elements: Custom Resources, Profile Collection, Tag Collection, and others.
- [Compare](#) window: Added DeltaCh (dCh), the chromaticness difference, in the list of available deltas. These deltas are used to compute individual differences between each pair of compared patches, in the Tabular data tab, and for global statistics in the Stats tab. The chromaticness, defined in DIN 55981, ISO 12646, and ISO/DIS 12747-8, is better used to evaluate color differences for near neutral colors, typically with a Chroma (C\*) of less than seven. dCh is referred to with various symbols, such as dEc, dF\*, or ds. The chromaticness difference is now included in a saved Compare file whenever L\*a\*b\* data is selected for export.
- [Info window](#):
  - Added xyY as a selection in the color space menu.
  - Added the 'CIELAB / a\*b\*Ch' menu item to the DeltaE\* menu. With this selection, you can easily get the chromaticness difference (dCh) between any two patches of opened files.
  - It is now possible to select, with a contextual popup menu, either a linear scale or a logarithmic scale for the reflectance axis of the spectrum graph.
- [Export](#) dialog: Added an option to round 8 bit RGB data when exporting data. This option is useful when exporting RGB data for programs which reject the fractional part of RGB values without rounding.
- [Preferences](#) dialog new settings:
  - An 'Adaptive measurements' setting for Emission measurements done with the 'i1Pro / i1Pro 2 (XRG)' driver; with this driver, adaptive measurements can be made with an i1Pro or i1Pro 2.
  - An additional 'SPECTRAL\_NM450' CGATS tag format to use when exporting CGATS file. This tag format is used by i1Profiler.
  - System wide settings for the spectrum scale and the decimal separator.

#### Improvements:

- Will now record separately the last folder used when opening or saving different file types (patch file, ICC profile, image, etc.).
- Better uniformity of the Open file dialogs and review of each dialog's preferred file formats.

#### Bug fixes:

- CxF2 import: Will now correctly import the patches names and IDs from a CxF2 Palette when the number of patches is different for each data type within the Palette.
- Patch-Reader window: Corrected a bug where the Display-Check window opened when clicking on the Patch-Reader 'Info' button.

#### Other:

- Version 4.0 is the last version which supports Mac with PowerPC processors; future versions will support Mac with Intel processors only.

### Version 3.7.0 b275 (2012-02-20)

New features:

- Added support for the Datacolor [Spyder4](#) colorimeter.
  - This instrument is currently used in the [Display-Check](#) tool.
  - Supported models: Spyder4ELITE, Spyder4PRO, Spyder4EXPRESS.
  - PatchTool can select any of the six built-in calibration matrices specifically designed for various display technologies, and which provide improved measurement accuracy.
  - Select between two measurement speeds.
- [Correction Matrix](#) tool: It is now possible to assign a Color Correction Matrix to the i1Pro.

Improvement:

- You can now open one or more files with a drag and drop on the [Main window](#) 'Open file' button.

### Version 3.6.0 b268 (2011-12-14)

New features:

- Added support for the X-Rite [i1Display Pro](#) colorimeter.
  - This instrument is currently used in the [Display-Check](#) tool.
  - Supported models: i1Display Pro hardware sold by X-Rite (i.e. the retail version, part #EODIS3-XR). Generic models sold by other companies (third parties, or OEM, part #EODIS-OEM) should also be compatible. At this time we cannot say if we will support or not custom models sold by other companies since separate agreements with these parties may be required. More specific info will be provided as new models are released.
  - PatchTool can load and assign calibration matrices (contained in X-Rite Emissive Display Reference (EDR) files) specifically designed for various display technologies, and which provide improved measurement accuracy. Five [EDR files](#) are supplied; additional files could be added in the future without a need to reinstall PatchTool.
  - Select between two measurement speeds.
  - Note: On Mac, OS X 10.5+ is required (Mac Intel tested, PowerPC TBD).

Improvements:

- Display-Check [Instrument Info](#) dialog:
  - Revised interface: You can now assign the instrument preferences without going back to the program Preferences' dialog.
  - More robust code to improve the connection to an instrument if this instrument is not connected when the Display-Check window is opened.
- (Mac) Replaced PICT by PNG as an image export format.

Bug fixes:

- Exporting images: Fixed a bug where a reddish, yellowish, or orangish tint could be seen in 16 bit TIFF L\*a\*b\* patches when a\* and/or b\* was negative with a value between zero and -0,001953.
- Display-Check RAW file: Now shows correct L\*a\*b\* D50 Source data. The problem was seen when the reference data was XYZ, L\*a\*b\* or L\*C\*h and the destination profile was an external ICC profile. The problem did not occur for RGB, CMYK, and spectral reference data, and when the destination was an internal PatchTool profile; as well, RAW measurements were never affected.
- Now shows the correct Hardware and Driver versions for the Spyder2 and Spyder3 in the Display-Check Info dialog.

## Version 3.5.0 b255 (2011-06-01)

### New features:

- [Extract Target from Image](#) tool: This tool is designed to directly extract the average of target patches in full size photographic images.
  - Target size: User-assigned ROWS and COLUMNS. The patch fill-ratio is adjustable. The tool enables adjustments for almost any target perspective.
  - Supported image formats: TIFF RGB (8 bit and 16 bit), and JPG.
  - Embedded profiles are recognized and automatically extracted.
- [Extract Profile from File](#) tool: Extract a profile from a TIFF or JPEG image; save the profile with an ICC or ICM extension. The tool shows the profile name, type, ICC version, device class, and default intent.
- [Tweak Target](#) tool: Improve the accuracy of printed color patch lists by successive approximations. The original color list is modified in one or two iterations. Important: This tool is NOT designed to edit or change a profile.
- [Correction Matrix](#) tool: Determine a Color Correction Matrix between two instruments according to ASTM E1455-2010. A Color Correction Matrix helps improve inter-instrument agreement in emission (i.e. display) measurements. The matrix is computed by making measurements of the primaries and white of a given display using a reference instrument (often a spectrophotometer) and a target instrument (often a colorimeter). The measurements can be obtained with PatchTool Display-Check, if the instrument is supported by PatchTool, or data from any instrument can be entered or loaded into the tool. A matrix is always assigned to a specific combination of display + target instrument.
- [Display-Check](#) tool: Now supports the use of [Color Correction matrices](#). Improve inter-instrument agreement and the accuracy of colorimeters on wide-gamut displays.
- [Import](#) and [Export](#) Adobe Swatch Exchange (ASE) files. This file format is used to exchange color swatches between Adobe applications such as Photoshop and Illustrator.
  - Supported color spaces: RGB, CMYK, and L\*a\*b\* (D50). Because an ASE file can contain swatches in all color spaces, PatchTool will create separate files for each color space.
  - Color groups, such as those created in Illustrator, are joined at import.
  - Supported color types: Process + Global (only type supported in Photoshop), Spot color (Global), and Process; the color type is the same for all PatchTool exported patches.
- Open TIFF images and assign one patch per pixel. This tool is useful to open target files saved as one pixel per patch, as well as small image files.
  - Supported image formats: TIFF RGB, CMYK and L\*a\*b\*; all in 8 bit and 16 bit.
  - Maximum image size: 65536 pixels (which results in 65536 patches).
- Added “Use the patch Name as the patch ID” command in the Patch view Tab [Re-map menu](#) and in the Tabular data tab [contextual menu](#). This command was added after it was noticed that patch IDs were now incorrectly assigned to the Name tag in exported CGATS files from X-Rite’s ColorPort 2.0. After using the command, it is possible to correctly change the layouts of IT8.7/4 and ECI2002 files.
- Added “Assign the patch-ID as the patch-Name” checkbox in the “[Import CxF2](#)” dialog. In some CxF2 files, the patch-ID field contains the patch-Name; by checking this box, you can import the ID field as the Name.

### Improvements:

- The saved/exported file name is now shown in the file window title after the file is saved.
- A check is now made on the patch IDs of ECI2002 and IT8.7/4 files to see if they match the expected values; a message is shown to the user if the check fails.
- [Patch view](#) tab of opened files: You can rename a patch using the [alternate contextual menu](#) (Shift + right-click).
- [Tabular data](#) tab of opened files: You can rename a patch by clicking in the Name column.
- The [Info window](#) now shows the beginning and end of long file names.

#### Bug fixes:

- Will now deselect any selected Name cell when renaming the Unconstrained Patch-Reader patches.
- Now properly sets the rows when changing the layout of [ECI2002](#) and [IT8.7/4](#) files.
- Added Exception handling when opening and re-opening a file which is locked by another application.
- (Windows) A Display-Check sequence will now stop when pressing the Stop button.
- Will now correctly interpret CxF2 input values when the program runs in an international environment where the “thousands” separator is a period.

#### Version 3.0.0 b228 (2011-01-10)

#### New features:

- [Patch-Reader](#) tool: This tool is designed to measure targets or individual colors in reflectance (i1 Pro only). Measurements are exported to a CGATS type file for compatibility with most applications. There are three measurement modes:
  - [Unconstrained measurements](#): Measure color patches in any order; select between the XYZ, L\*a\*b\*, or L\*C\*h color spaces. You can re-order the measurements by dragging them in a list; you can sort, delete, or rename any measurement. Look at any or all spectrums on a graph.
  - [Custom charts](#): Define a chart by assigning rows and columns numbers. Measure the patches individually (Patch mode) or line-by-line (Strip mode). You can use a timer to automatically trigger a measurement at fixed time intervals when in “Patch” mode. The Strip mode works with lines of patches which exhibit a high contrast between them or with lines of patches which have contrast markers (i.e. vertical bars).
  - [PatchTool file](#): Select any opened file as a reference. The measured patches can be visually compared with the reference colors in the file. The other features are identical to the ones of the Custom chart.
- CMYK data can now be assigned to an ICC profile. When [opening a file](#) consisting only of CMYK data, you can assign any ICC profile to this data. When a file has no CMYK data, you can [select any CMYK ICC profile](#) to convert the imported colors to CMYK. Note: As in previous versions, when a file has CMYK data in addition with another color reference, such as XYZ or L\*a\*b\*, CMYK is imported as is.
- RGB data can now be assigned to an ICC profile in addition to the standard RGB spaces of the previous version. When [opening a file](#) consisting only of RGB data, you can assign any ICC profile to this data. When a file has no RGB data, you can [select any RGB ICC profile](#) or the built-in RGB spaces to convert the imported colors to RGB. Note: When a file has RGB data in addition with another color reference, such as XYZ or L\*a\*b\*, RGB is imported as is.
- Compare files saved from Display-Check Quick-Test measurements will now re-open with the “[xy graph](#)” and “[Display data](#)” tabs.
- Export of spectral data in CGATS files: You can now select between [three data tags types for spectral data](#): nm450, SPECTRAL\_450 (used in ColorPort), and SPECTRAL\_NM\_450.

#### Improvements:

- [Display-Check](#) tool:
  - Revised interface.
  - When making a test using a PatchTool file, and when applicable, the tool shows information on the RGB or CMYK profile that was used to derive the file XYZ data.
- [Gamut Tools](#) Convert / Clip check:
  - Revised interface.
  - When you select a file, you get the data type used for import, the profile information associated with the CMYK and RGB data, and the currently selected Illuminant and Observer settings.
- [Average](#) tool:
  - When applicable, the tool shows information on the RGB or CMYK profile that was used to derive the file XYZ data.
  - The tool dialog can be resized for long file names.



- [Compare](#) tool:
  - When applicable, the tool shows information on the RGB or CMYK profile that was used to derive the file XYZ data; it also indicates if the file contains imported CMYK or RGB data.
  - The tool window can be resized for long file names.
- [Patch view](#) tab of opened files: Revised interface.
- [Tabular data](#) tab of opened files:
  - Revised interface.
  - You can now associate any CMYK or RGB profile to the computed values of these spaces (if the file did not contain CMYK or RGB data). In a Compare file, separate profiles can be associated with the REFERENCE and SAMPLE.
- [Missing info](#) dialog: Now supports the selection of ICC profiles for CMYK and RGB data.
- [CxF2 import](#) dialog: When importing non-defined RGB and CMYK data, the Missing info dialog is used to assign an ICC profile.
- [Export](#) dialog:
  - When you select a file, you now get the data type used for import, the profile info for CMYK and RGB data in the file.
  - The dialog automatically imposes some data types when exporting Compare files obtained with Display-Check.
- [Munsell](#) export:
  - New database which results in better conversion precision.
  - The conversion speed is typically 2X faster.
- All reports and export files now contain more information and comments that describe the data in the file.

#### Bug fixes:

- Will show a warning message and not an error message when trying to save a file which is opened by another application, or locked.
- It is not required to restart the program if an Eye-One Display is disconnected and replaced by an i1Pro, and vice-versa, in order for the program to recognize the new instrument in the Display-Check tool.

### Version 2.8.0 b182 (2010-01-28)

#### New feature:

- [Display-Check](#) tool: Added a chromaticity diagram to show the measured primaries locations relative to the ones of standard RGB spaces. This diagram is generated when performing a [Quick-Test](#) with a neutral ramp plus R, G, and B ramps.

#### Improvements:

- A dialog is now presented to the user when a Version-1 CxF file is not Standalone. The user can select between letting the program try to parse it, or cancel the import (cancelling import was imposed in prior versions).
- Display-Check tool: The sections of the Help manual describing the tool options were rewritten and [examples](#) were added.
- Revised the [Appendix on Color Management](#) in the Help manual.

#### Bug fixes:

- Now properly retrieves the black level when generating a report in the Compare window “Display data” tab; the problem occurred when doing a Quick-Test with just a neutral ramp.
- Now properly resets the Minimum and Maximum “L” values when clicking on the “Default” “Grid options” button of the [OSA UCS tool](#).

#### Other:

- The default choice is now to discard the measured RAW data after a Display-Check, and NOT to save it.



## Version 2.7.0 b173 (2009-09-23)

### New features:

- Added support for the Optical Society of America Uniform Color Scales ([OSA UCS](#)):
  - [Import UCS](#) color lists defined as Ljg coordinates into a [PatchTool file](#).
  - Generate [UCS color lists](#) for any of the nine standard UCS data planes.
  - [Export](#) any opened file (with spectral data or 10 degree Observer data) as UCS coordinates.

### Improvements:

- Added “D93” and “E” in the illuminant list.
- Added an alternate contextual menu to the “Patch view” tab. This new menu can be used to reassign the color of a single patch ([single files](#) and [Compare files](#)) or of a range of patches (Compare files only).
- Minor interface changes in the Gamut tools window and in the Export dialog.

### Bug fixes:

- (Mac OS X 10.6 Snow Leopard) Fixed a compatibility problem which made the program crash on startup.
- Disabled Munsell export for files defined only with the 10 degree Observer.

## Version 2.6.0 b154 (2009-04-06)

### New features:

- Open [CxF Version-2](#) files, such as the ones generated by the X-Rite ColorMunki:
  - Import a Color Collection, or a Color Set within a Palette, into a [PatchTool file](#).
  - Import Quality Control standard or measurement data into individual files, or import both the standard and one measurement set into a PatchTool [Compare](#) window.
  - Support for the following reflectance color spaces: L\*a\*b\*, L\*C\*h, XYZ, xyY, AdobeRGB, sRGB, RGB, CMYK, plus spectral data.

### Improvements:

- Added menu shortcuts to folders containing sample files and Idealliance reference files.
- Added a “Recent Open” menu where the last 10 files that were opened can be accessed directly.
- Added keyboard shortcuts to all tools, for window organization functions, and for the Help file.
- Added the 2009 versions of the [ISO 12647-7](#) reference files in the Idealliance files folder and restructured the [Idealliance help](#) documentation.

### Bug fixes:

- Fixed the contextual copy-data menu in the Compare window “Patch view” tab, where only the Reference data was copied.
- Fixed the problem in the Average tool where the average of spectral data was sometimes scaled incorrectly.
- Fixed issues with the previous keyboard shortcuts.
- Now correctly computes the size of the vertical markers, used to separate patches in a target image, when a change is made in the resolution field of the Image tab in the Export window.
- (Windows XP) Fixed the problem where some popup menus would not work properly in the Traditional Chinese version of the OS.

## Version 2.5.0 b142 (2009-01-26)

New features:

- [Gamut Tools](#):
  - [Convert](#) RGB or CMYK data assigned to a Source profile to a Destination profile
  - Convert RGB or CMYK data assigned to a profile to the Profile Connection Space (i.e. L\*a\*b\*/XYZ)
  - Convert L\*a\*b\* or XYZ file data to RGB or CMYK through a profile
  - Check if RGB or CMYK data assigned to a Source profile is [clipped](#) by a Destination profile
  - Check if L\*a\*b\* or XYZ file data is clipped by a Destination profile
  - Generate device dependent [RGB](#) or [CMYK](#) color lists
  - Generate [device independent color lists](#) (L\*a\*b\*/L\*C\*h/XYZ) with a gamut limited by a profile
- L\*a\*b\* data contained in CxF files (CxF 1.0) can now be imported (in addition to spectral data).
- The [patches width and height](#) can now be separately assigned when exporting patches as images. In previous versions, the width and height were always the same.
- Contrast [markers](#) can be added between patches when exporting an image; these markers enable scanning of the printed image one line at the time instead of patch by patch (this feature is designed specifically for i1Pro instruments).

Improvements:

- Export image dialog: The interface used to specify the patch and image sizes was redone. Also added “cm” units to the patch and image sizes.
- Will now open CxF files (CxF 1.0) which do not contain a description of the CxF file structure, also called the Document Type Definition (DTD), since the DTD is not inserted in the file by all applications.

## Version 2.3.0 b109 (2008-06-16)

New features:

- Added support for X-Rite [DTP94](#) (MonacoOPTIX) colorimeter.
- PatchTool Compare files can be re-opened within PatchTool for further analysis.
- Now records the measuring instrument Serial Number in exported files and reports.

Other:

- There is no more a requirement to be a system administrator in Windows XP; this change also makes the program better compliant to Windows Vista security requirements.
- Windows 98 is no longer supported; the last compatible version for this OS is 2.2.0.

## Version 2.2.0 b102 (2008-04-14)

New features:

- Added support for Datacolor's [Spyder3](#) colorimeter. PatchTool uses an exclusive [adaptive algorithm](#) to speed-up data-acquisition while minimizing noise. The measurement time is based on the patch display luminance, and there are two [user-selectable modes](#) which place emphasis on either SPEED or PRECISION.

Improvements:

- Display-Check measurements with the Spyder2 are now done with an adaptive measurement algorithm similar to the one used for the Spyder3. In SPEED mode, [measuring the 1617 patches](#) of an IT8.7/4 target can now be done 2.4X times faster than with previous PatchTool versions, with negligible effect on the measurements statistics.
- The [decimal separator](#) for exported data can now be forced to a period (0.0) even when the program runs in an international environment where the decimal separator is a comma (0,0). This option facilitates data exchange with applications that are not international-savvy.

## Version 2.1.0 b098 (2008-03-25)

### New features:

- PatchTool has a new feature which helps to fulfill the requirements set forth by [Idealliance](#) for printer and monitor [proofing certification](#). In particular, when Idealliance proofing reference data of an IT8.7/4 target is compared to measured data, a report can automatically be [generated](#). This report covers the statistical analysis of all IT8.7/4 patches as well as the comparison of specific patches of the chart.
- An [IT8.7/4](#) chart layout can now be changed between “Measured”, Random” and “Visual”. You can also assign the official IT8.7/4 patch IDs if they were not in the opened file.
- For [ECI2002](#) charts, you can now assign the official ECI2002 patch IDs if they were not in the opened file.

### Bug fixes:

- (Mac) New drivers are provided for the Datacolor Spyder2 colorimeter. The old drivers freeze the application when a Spyder3, a more recent model, is connected. There is no problem when a Spyder2 is connected.
- Fixed the issue where display measurements made with the Eye-One Display, the Eye-One Display 2, or the Spyder2, were corrupted. The i1Pro was not affected by the problem.
- The program will now react properly if the previous default display profile is missing at program start.

## Version 2.0.0 b091 (2007-12-06)

### New features:

- PatchTool display output is color-managed and can be set to use the system default display color profile, a built-in color profile, or any user-assigned ICC profile.
- [Display-Check](#) tool:
  - Measure your display characteristic within PatchTool using the Datacolor Spyder2 or the X-Rite Eye-One line of instruments (i1Pro or Eye-One Display).
  - Export the RAW display measurements for independent analysis.
  - Check your display performance using built-in Quick-Test patches. The reference patches and their measured values are shown in a Compare window. For these patches, you also get a dedicated “Display data” tab with additional comparative data.
  - Check your display performance using any color list opened in PatchTool and compare the reference list with the measured values.
- Compare tool statistical tab (“Stats”):
  - Extract statistical data from compared files using any color-difference parameter.
  - Select between “Absolute”, combined Neg./Pos., or separate Neg./Pos. statistics.
  - Obtain graph and data of the Cumulative Relative Frequency (CRF), which is helpful in establishing SWOP/GRACoL Idealliance certification.
- Export color lists in [Munsell](#) “*Hue Value/Chroma*” notation. Select the color-difference formula used for conversion. Select from three output formats (number of columns).

### Bug fixes:

- (Windows Vista) Windows Vista incorporates a Data Execution Prevention (DEP) feature which monitors how applications access memory. In most Vista Home systems, the DEP setting is set, by default, to check only the system programs and services; in this case, even before the fix, PatchTool started correctly. However, the DEP setting can be changed by the user, either globally or on a program by program basis, and its default setting may also vary for other OS configurations. PatchTool did not start when the DEP was assigned to all applications, or to PatchTool only; this has been fixed.

### Improvements:

- (Mac) The program is now offered in Universal and Intel versions.

### Version 1.1.1 b057 (2007-05-21)

#### Bug fixes:

- Fixed the crash that happened when exporting the XYZ data of Compare files that do not have spectral data.
- Fixed a data corruption problem which affected XYZ data when sorting the data table.
- Fixed a display rendering problem caused by a combination of the Lightbox setting with other commands which affect the patches order.

#### Improvements:

- More robust parser for CGATS and [plain text](#) files.

#### Other:

- Changed the Color Decks database format used for [export to BabelColor CT&A](#).

### Version 1.1.0 b052 (2007-03-26)

#### New features:

- Compare tool:
  - Compare two files (with the same number of patches) in the same window.
  - Sort patches according to the difference in any of the following parameters: C, M, Yellow, K, R, G, B, x, y, X, Y, Z, E\*, L\*, a\*, b\*, C\*, h, or H\*.
- Import RGB data encoded in 8 bit, 15 bit, 16 bit, or scaled to 100%.
- Recognizes ECI2002 color lists and can display their data in the Measured, Random, or Visual layouts.
- Export RGB data encoded in 8 bit, 15 bit+ (i.e. Photoshop “16 bit”), “true” 16 bit, or scaled to 100%.
- Export spectral data in either 0-1 or 0-100% ranges.
- Export spectral data with either a 380 to 730 nm range or a 400 to 700 nm range.

#### Bug fixes:

- (Mac) Corrected 16 bit export for TIFF images.
- (Mac) Fixed crashes which happened when clicking on the top window action buttons while the program was busy.
- Corrected the case, for non-spectral color lists, where data was corrupted when exported to the BabelColor CT&A database.

#### Improvements:

- Better handling of files which were saved with numbering formats (i.e. decimal and thousands separators) which do not correspond to the computer’s Regional settings.
- More internal precision that enables handling of 16 bit RGB and higher accuracy in obtaining RGB values close to zero.
- Faster and higher quality JPEG export. QuickTime not required anymore on Windows for JPEG export.
- Many other improvements.

### Version 1.0.0 b026 (2007-01-03)

First released version for Windows and Mac.

## 5. Purchasing, Upgrades, Activation-Deactivation, Legal info

Click on a link to go directly to the sub-section:

- [Purchasing](#)
- [Upgrades](#)
- [Activation-Deactivation](#)
- [Legal notice](#)
- [Copyrights and Trademarks](#)

### 5.1 Purchasing

#### Important:

- You need to purchase a license in order to receive a **Product Key** which enables all PatchTool features.
- The software will remain in a limited-features mode as long as it is not activated with the **Product Key**.

If you decide to purchase PatchTool, please go to our Web site and look for the link to our "Software Purchase" page. This page will provide detailed instructions, and a link to our secure third party payment processor. To purchase, click on the following link to open a Web-browser window:

- ▶ <https://www.babelcolor.com>

If you have a problem with the Web purchasing process or if you have special requirements, click on the following link to send us an e-mail:

- ▶ [info@babelcolor.com](mailto:info@babelcolor.com)

### 5.2 Upgrades

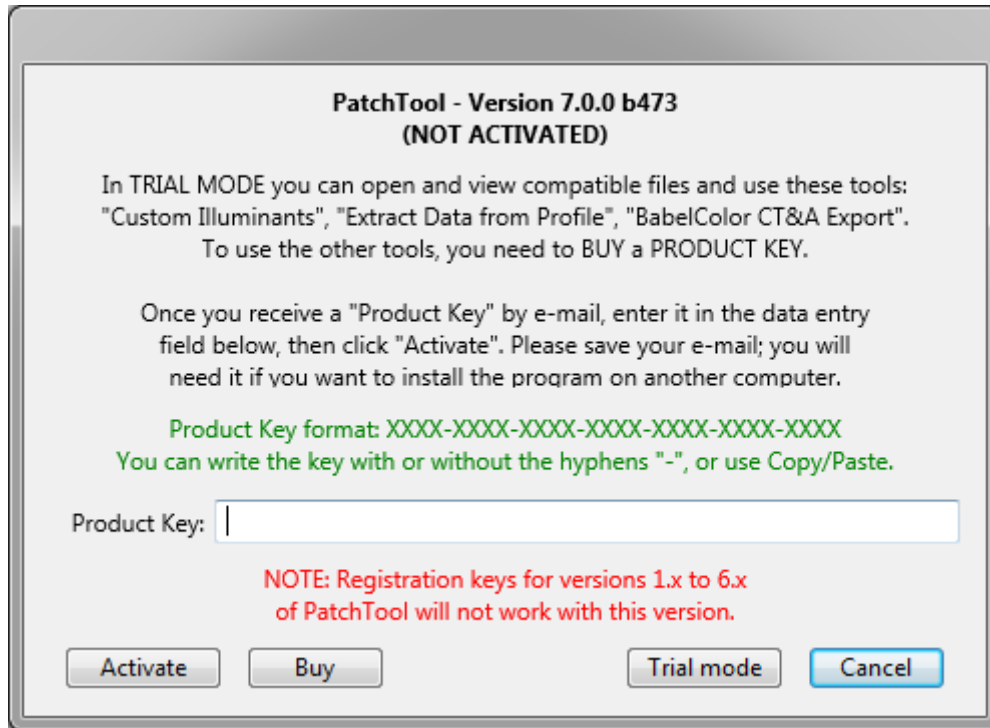
A **Product Key** remains valid for fractional changes in the software version. For example, it will be possible to use the same key for versions 7.0.0 up to, but not equal to, 8.0. For this reason, you should keep the e-mail containing your **Product Key** in a secure place; you will also need this information if you install the program on another computer. Please note that no other **Product Key** will be sent if you lose it or if it gets stolen.

Upgrading from version 7.x to version 8.x may require additional purchasing.



### 5.3 Activation-Deactivation

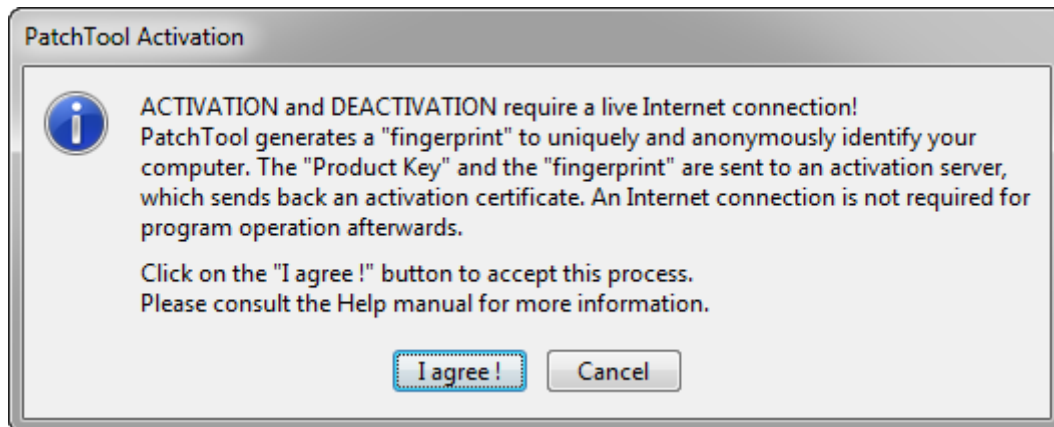
Following your purchase of PatchTool, you will receive an e-mail confirming the transaction; this e-mail also contains your **Product Key**. This key is **valid for both the Mac AND Windows** versions! When the program is not activated, the following dialog is shown each time the program is started; please copy the Product Key you received in this dialog. This dialog can also be opened with the “Help/Activate...” menu command.



Copy/Paste shortcuts:

- **Windows:** To copy, press the **Ctrl + C** keys; to paste, press the **Ctrl + V** keys.
- **Mac:** To copy, press the **Command (⌘) + C** keys; to paste, press the **Command (⌘) + V** keys.

When you click on the “Activate” button, the following **activation agreement** dialog opens:



If you know that you DO NOT have an Internet connection, you should still click on the “**I agree !**” button; the program will try to communicate with the activation server and will open an [offline activation dialog](#) if the communication fails. Offline activation and deactivation is discussed later in this section.

You can check if your program is properly activated with the “[About PatchTool...](#)” menu.



**Note:** No personal data is used to generate the fingerprint. The activation server will also record network related data from where the request comes from. The activation server is managed by a third-party provider.

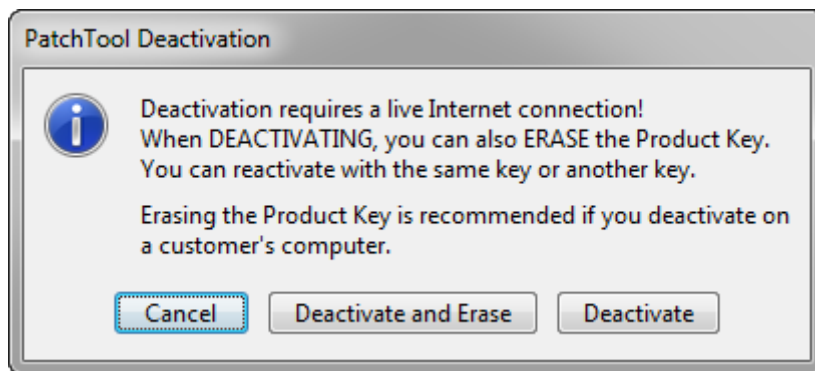
**Note:** If you have an Internet connection and activation fails, you may need to unblock some specific communications ports used by the program. Activation requires that **ports 80 and 443** be open. Please consult your company's network specialist for help.

Here are shortcuts to sub-sections discussing specific dialogs used to manage your Product Key:

- [Deactivation / Transfer](#)
- [Reactivation](#)
- [Offline activation](#)
- [Offline deactivation](#)

### Deactivation / Transfer

If you wish to use the program on another computer, you must first deactivate the computer on which your key is being used. To deactivate, select the “Help/Deactivate...” menu command; you will get the following dialog.



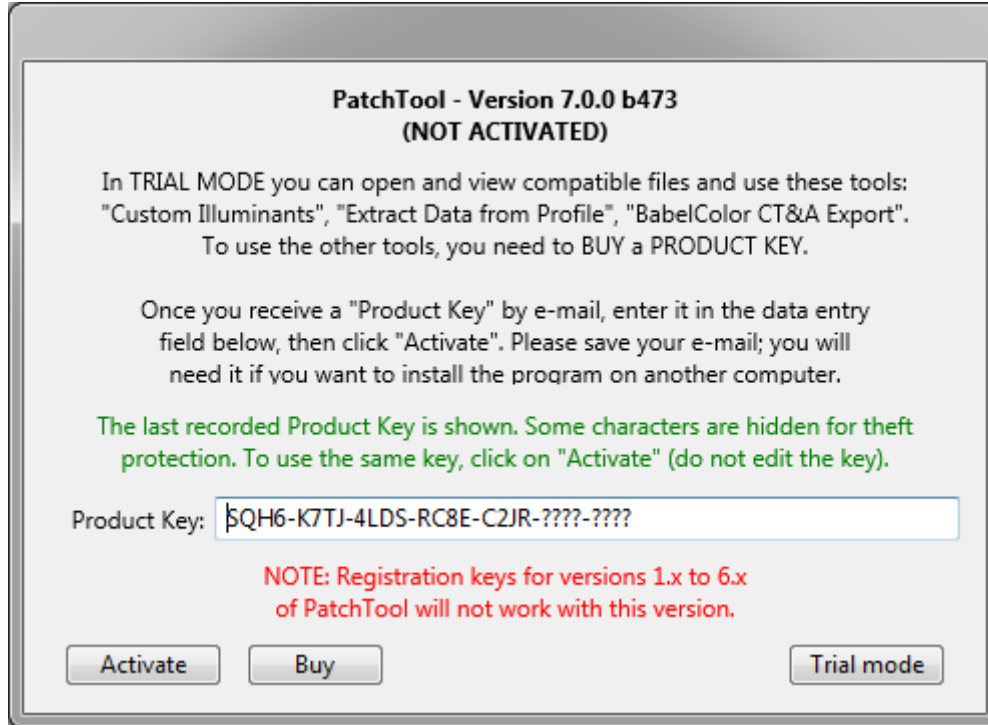
When deactivating, you have the choice to erase or not the Product Key. As indicated in the dialog, erasing the key is recommended if you temporarily installed the program on a customer's computer. You would similarly erase the key if the program was installed on a computer which will foreseeably not be used with PatchTool in the future. On the other hand, if you intend to reuse PatchTool on this computer soon or on a regular basis, you should just deactivate without erasing the key.

If you know that you DO NOT have an Internet connection, you should still click on either the “Deactivate and Erase” button or the “Deactivate” button; the program will try to communicate with the activation server and will open an [offline deactivation dialog](#) if the communication fails. Offline activation and deactivation is discussed later in this section.

**Important:** If your Product Key is valid for one (1) license, it is your responsibility to deactivate a computer before activating another one with the same key. BabelColor cannot remotely deactivate a computer, so make sure your first computer is deactivated before moving to the second computer.

## Reactivation

When you re-activate a computer on which the key was not erased, you get the following activation dialog.

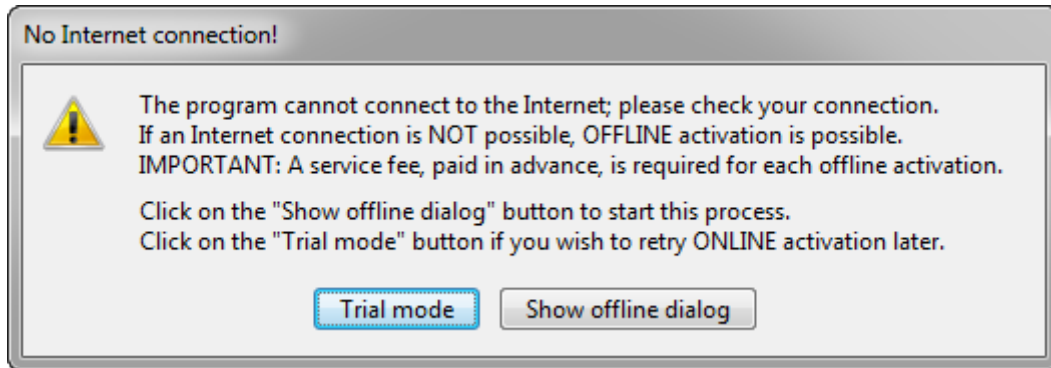


This dialog is the [same](#) which appeared when the program was installed and not activated, except that the first characters of the Product Key are now shown, with the last characters hidden. The last characters are hidden for theft protection, to prevent a casual user from copying the key. However, you do not need to replace the interrogation points (?) with the correct values to reactivate; just click on the "Activate" button. As you see, you can use the same key to activate the program on many computers. Please note that you can only simultaneously activate a number of computers corresponding to the number of licenses assigned to the key; if you purchased one license, then you can activate one computer at a time.

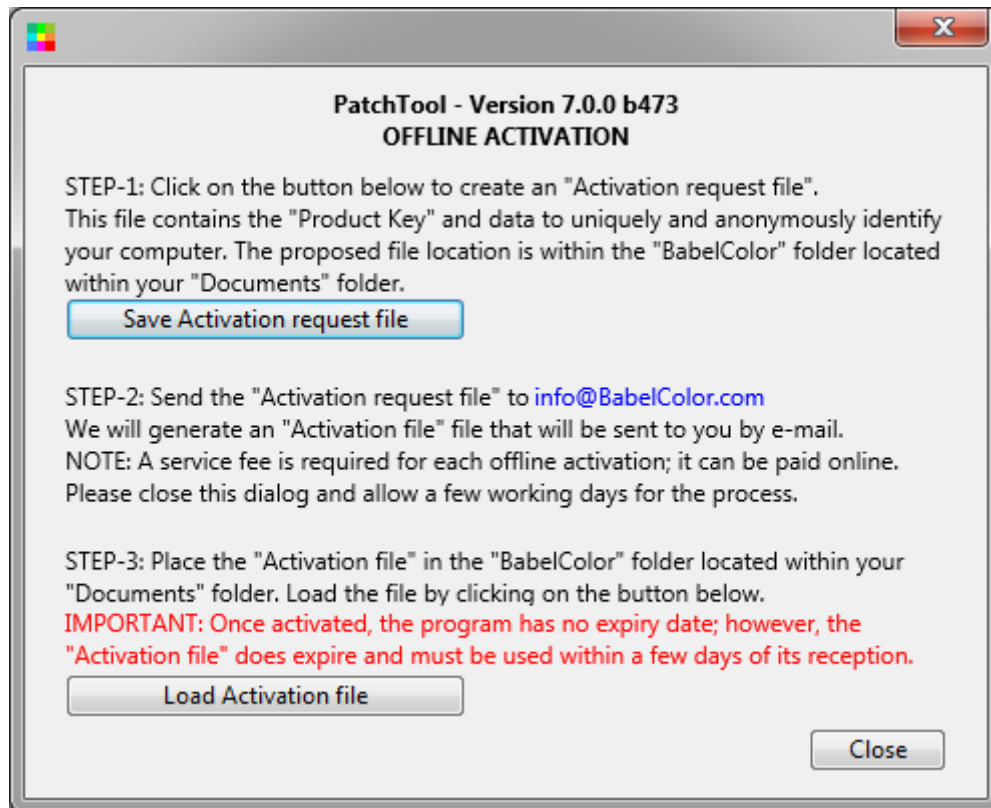
**Important:** If your Product Key is valid for one (1) license, it is your responsibility to deactivate a computer before reactivating another one with the same key. BabelColor cannot remotely deactivate a computer, so make sure your first computer is deactivated before moving to the second computer.

## Offline activation

If you do not have an Internet connection and you want to activate the program, you should still click on the “I agree !” button of the [activation agreement dialog](#). Following a communication check, if the absence of Internet connection is confirmed, you will see this dialog:



As mentioned in the dialog, a service fee is required for each offline activation. This fee covers the time to manually process the request and set the activation server. The activation fee can be purchased online on the [BabelColor Web Store page](#). The fee is not required to view the offline dialog, which is shown below and which appears when you click on the “Show offline dialog” button.



The first step is to save an “Activation request file”. The default location proposed by the program is the “BabelColor” folder located within your “Documents” folder. The file name will start with “**ActivationRequest-PT7\_**” followed by the first characters of your Product Key.

As indicated in STEP-2, you must send the file to BabelColor. We will verify that you purchased the activation service fee and we will generate an “Activation file” by e-mail. You can now close this dialog; the program will start in evaluation mode, with limited features. Please allow a few working days to complete the process.

**Hint:** When you receive the “Activation file” which is simply named “**ActivationResponse.xml**” (Note: The file name may also contain additional information to better identify its targeted Key), place the file in the “BabelColor” folder located within your “Documents” folder. This is the default location the program will use when opening it.

To perform STEP-3, you should redo the activation process from the beginning, either by starting the program or with the “Help/Activate...” menu command. When you get to the offline activation dialog, load the “Activation file” by first clicking on the corresponding button. You will get a confirmation message once the “Activation file” is processed; you can also check if your program is properly activated with the “[About PatchTool...](#)” menu.

**Important:** When you receive the “Activation file” you should use it promptly since this file is valid for a few days only. However, please note that the activated program has no expiry date.

### **Transferring a license from an offline computer**

Transferring a license requires **deactivating the first** computer and **activating the second** computer. To deactivate a computer activated offline, you have two options:

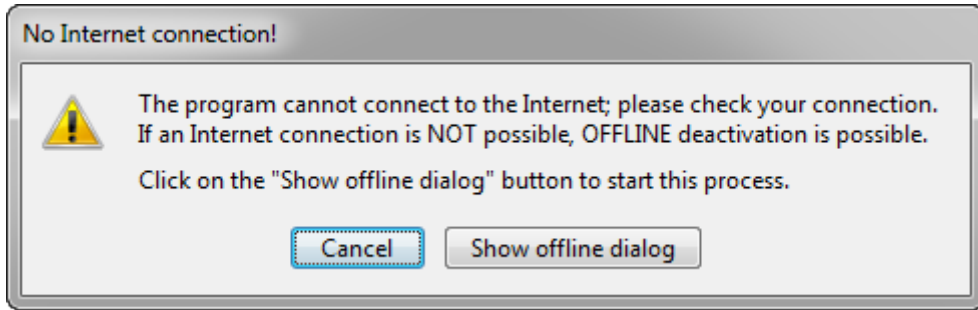
- If the **first** computer is still not connected to the Internet, you must do an [offline deactivation](#).
- If the **first** computer now has access to the Internet, you can [deactivate online](#).

To activate the second computer you also have two options:

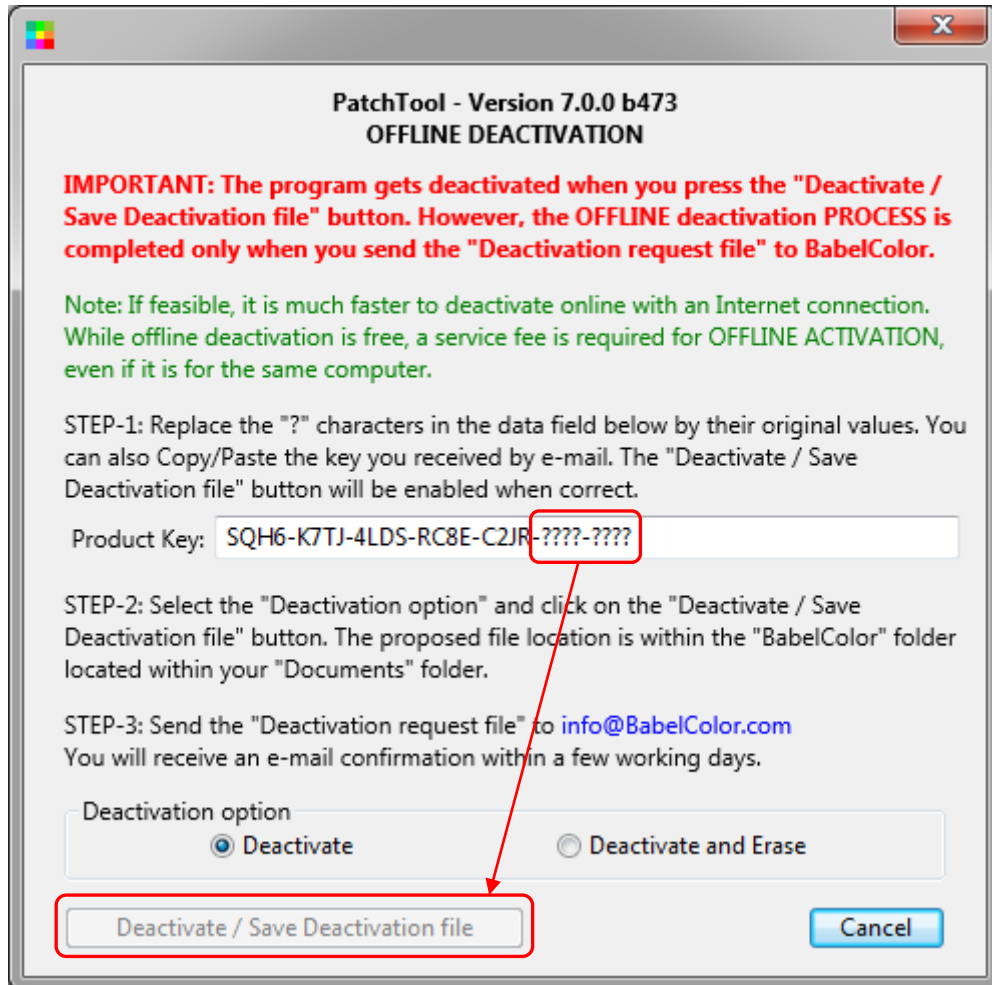
- If the **second** computer is not connected to the Internet, you must do another [offline activation](#).
- If the **second** computer has access to the Internet, you can [activate online](#).

### Offline deactivation

If you try to deactivate using the “Help/Deactivate...” menu command and there is no Internet connection, you get the following message:



The offline deactivation dialog is shown below:



The “**Deactivate/Save Deactivation file**” button will be enabled when the missing characters of the Product Key are replaced by their correct values. You will find the complete key in the e-mail you received when you purchased the software. This procedure insures that a casual user will not deactivate the program by mistake.

**Important:** In fact, the program gets deactivated when you SAVE the “Deactivation request file” after pressing the “Deactivate/Save Deactivation file” button; this gives you one last chance to cancel deactivation. However, even if the program is deactivated, the deactivation **process** is not completed until you send the “**Deactivation request file**” to BabelColor.

**Note:** While there is no fee required to perform the offline deactivation, we strongly recommend performing the deactivation online if you can temporarily connect the computer to the Internet, since this could save you time.

The deactivation options are the same as those available when you deactivate with a live Internet connection. Erasing the key is recommended if you temporarily installed the program on a customer's computer. You would similarly erase the key if the program was installed on a computer which will foreseeably not be used with PatchTool in the future. On the other hand, if you intend to reuse PatchTool on this computer soon or on a regular basis, you should just deactivate without erasing the key.

The "Deactivation request file" file name will start with "**DeactivationRequest-PT7\_**" followed by the first characters of your Product Key. Once the "Deactivation request file" is saved, you get a message confirming deactivation; the message will also specifically mention that the Product Key was erased if you selected this option. You should now send the deactivation request file to BabelColor to complete the offline deactivation process.

**Important:** It is mandatory to send the "Deactivation request file" to BabelColor if you intend to ACTIVATE another computer OFFLINE with the same Product Key. We will not issue a new offline "Activation file" for the same Product Key if we do not receive first the "Deactivation request file" from the previous computer. However, nothing prevents you from deactivating ONLINE if you can connect the computer to the Internet; this is equivalent to a complete offline deactivation procedure.





## 5.4 License Agreement / Legal notice

### IMPORTANT NOTICE

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### LICENSE GRANT

The BabelColor Company ("BabelColor") grants you a non-exclusive license ("License") to use the PatchTool software, and any associated documentation (the "Software"), as indicated herein.

You MAY:

- a) install and use the Software in evaluation mode with limited features as long as you wish;
- b) after purchasing a License and receiving a **Product Key** (also called a License Code), activate the software with the Product Key and use the activated Software, with all features, on a single (one) computer per purchased License (a single Product Key may correspond to one or more Licenses);
- c) for a Product Key valid for one License, activate your Product Key on another computer as long as you first deactivate the computer on which the program is currently activated;
- d) for a Product Key valid for two or more Licenses, activate and deactivate computers **from the same Company** as long as the number of activated computers does not exceed the number of purchased licenses.

### RESTRICTIONS

You MAY NOT:

- a) sell or resell this Software package;
- b) transfer a License;
- c) distribute or offer for download the Software without a written agreement with BabelColor;
- d) cause or permit reverse engineering, disassembly, decompilation or alteration of this Software;
- e) remove any product identification, copyright notices, or other notices or proprietary restrictions from this Software;
- f) copy the documentation accompanying the Software.

### DATA EXCHANGE

In the activation process, the Software generates a "fingerprint" from hardware components to uniquely and anonymously identify the computer. The Product Key and the "fingerprint" are sent to an activation server which sends back an activation certificate. The activation server will also record network related data from where the request comes from.

### INTERNET CONNECTION REQUIREMENTS

You may activate and deactivate a Product Key any number of times for free (i.e. at no cost for you) as long as the computer on which the activation or deactivation is performed is connected to the Internet. If an Internet connection is not available or not possible, the Software can still be activated and deactivated offline but a service fee may be required for each offline activation; in addition, you should allow a few working days for the offline process. An Internet connection is not required once the Software is activated.

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## DISCLAIMER OF DAMAGES

BabelColor assumes no liability for damages, direct or consequential, which may result from the use of the Software, even if BabelColor has been advised of the possibility of such damages.

## Characterization DATA – COPYRIGHT

The characterization data (“Characterization data”) found in the “characterization\_data” folder, located in the PatchTool application folder, may be copyrighted by their respective creators. In particular, the Idealliance proofing characterization data found in the “Idealliance\_Proofing-Certification\_V16” folder and other folders located in the PatchTool application folder is Copyright 2006 Idealliance.

## Characterization DATA - DISCLAIMER OF WARRANTIES

The Characterization data is supplied "AS IS". BabelColor disclaims all warranties, expressed or implied, including, without limitation, the warranties of merchantability and of fitness for any purpose. The user must assume the entire risk of using the data.

## Characterization DATA - DISCLAIMER OF DAMAGES

BabelColor assumes no liability for damages, direct or consequential, which may result from the use of the Characterization data, even if BabelColor has been advised of the possibility of such damages.

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- “SWOP” is a registered trademark of SWOP, Inc. Since 2005, SWOP is a Program within Idealliance.
- “Windows” is a registered trademark of Microsoft Corporation.
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## 6. Technical support

### FOR INFORMATION, COMMENTS, SUGGESTIONS, PROBLEMS OR BUG REPORTS

If you cannot find the information you need in this Help manual, please consult our Web site's FAQ. You can also check if a new version of the program was released. Click on the link to open a Web-browser window:

▶ <https://www.babelcolor.com>

If you still do not find an answer to a problem, or if you want to send us your comments and suggestions, click on the link to send an e-mail:

▶ [info@babelcolor.com](mailto:info@babelcolor.com)

### TO REPORT A PROBLEM

Please write a succinct description of the problem and include any information that could help in solving the issue:

- If the program stops with an error message, please note the message as well as the error code, if any.
- If the problem is data related and the program still operates when the problem is seen, export the current data in either text or image form, and attach a copy to your e-mail.
- If the problem affects the display, you can make a copy of the PatchTool screen by:

#### In Windows:

1. Activating the specific PatchTool window which displays the problem by clicking on it.
2. Pressing simultaneously on **Alt + Print-Screen** on the keyboard to copy an image of the selected window to the clipboard (Note: If PatchTool is frozen, press **Print-Screen** to copy the entire desktop).
3. Pasting the window image (usually the "Edit/Paste" menu command) in a graphic edition program or a word processor.

#### With Mac OS X:

1. Pressing simultaneously on **⌘ + shift + 3** on the keyboard to create a picture file of the entire desktop, or pressing simultaneously on **⌘ + shift + 4** to create a picture file of a screen area (after pressing and releasing the key combination, click and drag the mouse over the screen area you want to take a picture of, or press the space bar and then select an individual window).
2. The file will be saved on the Desktop in the Portable Network Graphics (PNG) image format.

OR

1. Launching the "Grab" application located in the "Applications/Utilities" folder.
2. Capturing the entire screen or a portion of it and saving as a "tiff" file.

You then attach the file containing the image to your e-mail.

- Provide any of the following information that you may find useful to describe the problem:

#### PatchTool related information:

- The sequence of events that resulted in the problem
- A copy of the PatchTool log window (the log window text can be copied by selecting it and using the Edit/Copy menu command).
- A copy of the input file.
- The specific PatchTool window, window tab, control or command name.

#### Computer environment information:

- Computer brand and model.
- Operating system (Windows 10, Windows 8.x, Windows 7, Vista; macOS 1x.x); indicate the service pack level or the exact version number, if known.
- Processor type and speed (Intel, AMD, M1).
- Amount of RAM.
- International language settings.
- Display resolution and bit depth (number of colors).
- Display appearance settings; for Windows: DPI value (96 (100%), 120 (125%), etc.).
- Graphic card brand and model if applicable.



# Appendix A

## PatchTool plain text format for color data

### Introduction

In addition to its capabilities to read CxF and CGATS type files, PatchTool was designed to read color list data written in “minimally formatted” form. By “minimally formatted” we mean with just sufficient information to be recognized as standard color data AND for short term usage. So this is not a data EXCHANGE format per se, but a WORKING format used to rapidly create, process, and use color list data.

### Intended use

The **imported** data is likely to come from a simple manually typed text file (in .txt or TEXT format), a spreadsheet file saved in Tab-delimited or CSV format, or from the output file of a user-written program. Using such a method, you can rapidly design targets lists that can be later saved in the CGATS format once opened in PatchTool.

The data **exported** in plain text format will likely be used in a table within a written report, as data pasted within a spreadsheet, or as a Tab-delimited file opened with a spreadsheet or a user-written program. It is expected that the user will note or specify the measurement conditions, such as the illuminant and observer, in the destination document since this information is not included in an exported plain text file.

### Format description

The accepted tags are:

- For ID: \*ID\* (i.e. any label with “ID” in it; numeric data)
- For Name: \*NAME\* (i.e. any label with “NAME” in it; alpha-numeric data)
- For L\*a\*b\* data: L, A, B  
L\*, A\*, B\*  
LAB\_L, LAB\_A, LAB\_B
- For L\*C\*h data: L, C, H  
L\*, C\*, H\*  
LAB\_L, LAB\_C, LAB\_H
- For XYZ data: X, Y, Z  
XYZ\_X, XYZ\_Y, XYZ\_Z
- For xyY data: x, y, Y  
XYY\_X, XYY\_Y, XYY\_CAPY
- For [OSA UCS](#) data: L, j, g  
UCS\_L, UCS\_J, UCS\_G
- For CMYK data: C, M, Y, K  
CMYK\_C, CMYK\_M, CMYK\_Y, CMYK\_K
- For RGB data: R, G, B  
RGB\_R, RGB\_G, RGB\_B
- For spectral data: \*380\* to \*730\* (range used for processing)  
\*400\* to \*700\* (minimum range; missing data is extrapolated)  
“\*” represents one or more letters, or can be blank (ex.: 380nm)  
Spectral steps: 10 nm (5 nm also accepted for [Custom Illuminants](#))

In addition, the tags can be written in either uppercase or lowercase. For instance, both xyY and XYY will be interpreted as xyY.

The following requirements also apply:

- i- The header information, containing the data tags, shall always be located on the first line.
- ii- The labels containing “ID”, “NAME”, and spectral data numbers shall be written without spaces.
- iii- Once a color space tag type is selected, (L, A, B) for example, it shall not be combined with the other tag variants of the same color space, (L\*, A\*, B\*) or (LAB\_L, LAB\_A, LAB\_B) in this case.
- iv- The tags shall be disposed in the order shown above. For example, xyY data should not be presented as Yxy.
- v- If more than one color space data type is present in the file, only one type will be used for import. The priority order for import is shown in the “Behind the scene: [Selecting data for import](#)” box.

The “ID” data is treated as numerical data, usually in the form of a sequential number. The “NAME” data can be alpha-numeric; it can be used, for example, to describe the color patch “column/row” position, i.e. “B23”, or for purely descriptive purposes, such as “logo-green”.

Data delimiters can be either “tabs”, “commas” or “semicolons” (.CSV), or “spaces”. Whenever you select a data delimiter, it is important to be consistent. For example, it is not recommended to use “tabs” to further separate data when you use commas.

**Example 1:** A simple Comma-Separated-Values (CSV) text file:

You will find a copy of the text just below in the PatchTool “sample\_files” folder located in the PatchTool application folder. Look for a “.txt” file named “plain-text\_example1.txt”.

```
Patch_name, r, g, b
patch_No1, 125.45, 125.55, 200.8
patch_No2, 200.8, 125.55, 260
patch_No3, 200.8, 200, 125.55
patch_No4, 200.8, 200, -31
```

When the file is opened with PatchTool, you are asked to assign a RGB space in the “Missing Info” window; select “Adobe RGB (PatchTool)”, one of the [built-in RGB profiles](#).

There are a few things to note in the above example:

- i- RGB data can be fractional. In effect, when imported, the fractional data is used to first generate XYZ values based on the selected RGB space, which is then used to generate xyY, L\*a\*b\*, L\*C\*h, and CMYK.
- ii- When used in conjunction with a PatchTool built-in RGB profile, RGB values can exceed 255 or be less than zero. Such values represent out-of-gamut colors. PatchTool computes the corresponding XYZ values with an encoding algorithm based on the one proposed for “Extended sRGB, i.e. e-sRGB” as described in [PIMA 7667:2001](#). You can readily check that two data points of the example are outside of the nominal RGB gamut by selecting the “RGB” graph in the “3D graph” tab of the opened file and by selecting these two graph data checkboxes: “RGB profile” and “RGB input”.
- iii- The patch names (ex.: patch\_No2), use an underscore instead of a space to separate the word “patch” from “No”. This is preferred since many file parsers will simply remove spaces from all fields. However, many programs will also replace the underscore by spaces when displaying the patch name, as can be seen in the PatchTool “Info” window.

**Example 2:** A Tab-delimited file from a spreadsheet:

This example shows one method on how to use a spreadsheet to generate color lists that can be opened with PatchTool. The two files of the example can be found in PatchTool’s “sample\_files” folder as “plain-text\_example2a.txt” and “plain-text\_example2b.txt”. You should not save your list in the standard spreadsheet format but in one of the “plain text” formats available, such as Tab-delimited, this example, Comma-Separated-Value (CSV) format, or even Mac or DOS text. When opened with PatchTool, the “test-Name” column is recognized as a “NAME” tag, and L\*a\*b\* data is recognized as the color space.

The two tables contain the same data, but the first one contains a few formatting “deficiencies”, which are corrected in the second file. Screen shots from a Microsoft Excel screen are shown below:

**What NOT to do:**

DO NOT leave empty fields in the middle of a table.

	A	B	C	D	E	F	G	H
1	press	test	test-Name	time	L	a	b	notes
2	plant-B		reference		89	-4,1	56,9	
3	plant-B	1	2006-12-01-1-01	7h30	88,3	-4,38	56,5	
4	plant-B	2	2006-12-01-1-02	9h15	88	-3,77	56,2	new roll
5	plant-B	3	2006-12-01-1-03	11h30	87,3	-2,25	55,3	alarm
6	plant-B	4	2006-12-01-1-04	14h	89,6	-4,3	59,15	
7	plant-B	5	2006-12-01-1-05	end of shift	89,4	-4,17	57,8	
8								

DO NOT leave spaces within data fields.

**What you should do:**

Fill all fields with data. This is optional for the last column.

	A	B	C	D	E	F	G	H
1	press	test	test-Name	time	L	a	b	notes
2	plant-B	ref	reference	N.A.	89	-4,1	56,9	
3	plant-B	1	2006-12-01-1-01	7h30	88,3	-4,38	56,5	
4	plant-B	2	2006-12-01-1-02	9h15	88	-3,77	56,2	new_roll
5	plant-B	3	2006-12-01-1-03	11h30	87,3	-2,25	55,3	alarm
6	plant-B	4	2006-12-01-1-04	14h	89,6	-4,3	59,15	
7	plant-B	5	2006-12-01-1-05	end-of-shift	89,4	-4,17	57,8	
8								

Replace spaces in text data by hyphens or underscores.

**What you CAN also do:**

- Leave the **last** column field empty on some rows
- Include additional data columns which are required for your project but not for color lists purposes
- Position your color data in any column (as long as it is in order, i.e. “L”, then “a”, then “b” in this example)
- Write numerical data with variable decimal precision (i.e. a fixed format is not imposed)





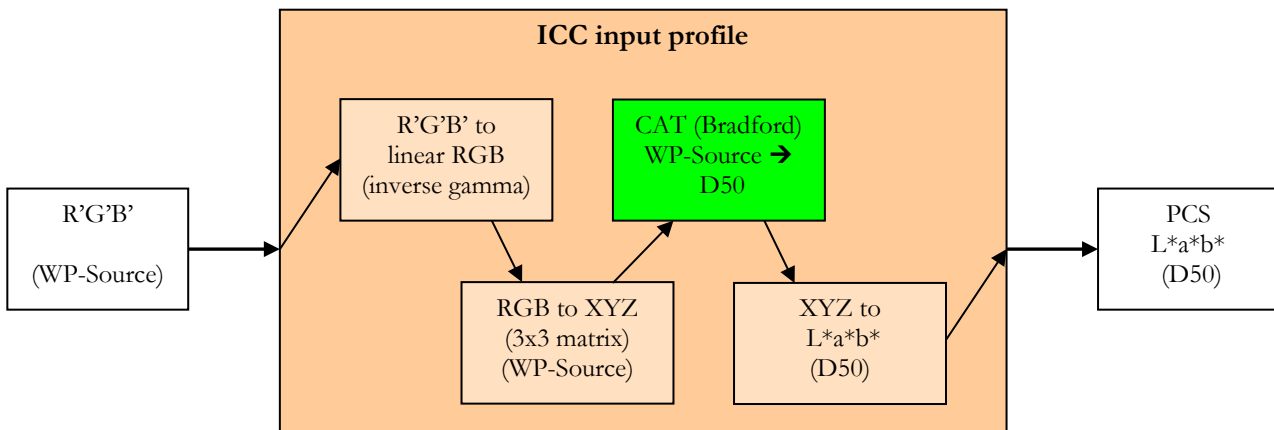
## Appendix B

### PatchTool Color Management

#### B-1. Introduction

All devices which manipulate color data, a digital camera or a display for instance, do so in their own, uniquely defined, color space. The main reason why this happens is that the primaries for each device are usually different; for example, a camera Red, Green and Blue primaries are often more saturated than the primaries of most common displays. This means that the camera gamut is larger than the gamut of these displays, i.e. the camera can capture more colors than what the display can show. Since the colors of each device are defined in relation to the RGB primaries, we can see that the same RGB coordinates can represent different colors; some sort of conversion or adaptation is thus required between these devices.

One method of converting color coordinates between devices is by using color profiles as defined by the International Color Commission (ICC). An ICC profile acts as a color translator between a device space (ex.: camera or display) and a common space called the Profile Connection Space (PCS). The PCS is usually  $L^*a^*b^*$  data (sometimes XYZ) computed relatively to Illuminant D50 and the 2 degree Standard Observer. This reference was selected in view of the ICC profiles' main application sectors, which are the graphic arts and printing industries. The data processing going on within an RGB-space profile is schematized below for an input profile; an output profile simply goes from the PCS to R'G'B' in the reverse direction.



The non-linear R'G'B' is first linearized using either an inverse gamma function or a Look-Up-Table (LUT; the gamma function is also called a Tone Response Curve). The conversion from linear RGB to XYZ is usually done with a 3x3 matrix in profiles defined for standard RGB-spaces, but can also be a three-dimensional LUT. If the White Point of the input space (WP-Source) is not D50, which is almost always the case, the XYZ data is chromatically adapted to D50, the PCS reference illuminant. This is most often done with a Bradford Chromatic Adaptation Transform (CAT). Finally, the XYZ data is transformed into  $L^*a^*b^*$ . A similar profile can be defined for other data types, such as CMYK.

Because of the common PCS, we can easily link an input profile, characterizing the **Source**, to an output profile, characterizing the **Destination**. These linked profiles define an ICC TRANSFORM; this is how we could obtain the RGB coordinates of a display from the RGB coordinates of a camera.

PatchTool can use either built-in RGB profiles, or any compatible ICC profile you select. The built-in RGB profiles correspond to the principal RGB spaces in use nowadays: Adobe RGB, Apple RGB, Generic RGB, ProPhoto RGB, and sRGB. These profiles are essentially identical to the ICC profiles of the same spaces in regards to in-gamut transforms, but they are a few differences which are shown in the table on the next page.

PatchTool built-in RGB profiles vs Standard ICC profiles	PatchTool RGB profiles	ICC profiles
Color Management Module (CMM)	PatchTool	lcms
Supported RGB spaces	Adobe RGB, Apple RGB, Generic RGB, ProPhoto RGB, sRGB	Any RGB profile
Gamma	Single value or multi-segments function as required (i.e. sRGB)	Single value, multi-segments function, or defined by a Look-Up-Table (LUT)
Chromatic Adaptation Transform (CAT)	Bradford	Bradford or other
Rendering Intents	Relative Colorimetric in Display-Check. Relative Colorimetric and Absolute Colorimetric in opened files and Gamut Tools.	Relative Colorimetric in Display-Check. Relative Colorimetric, Absolute Colorimetric, Saturation, and Perceptual in opened files and Gamut Tools.
Black Point Compensation (BPC)	No	Yes or No
Data range / clipping	No clipping. Negative values and values higher than 255 processed with an algorithm based on <a href="#">PIMA 7667:2001</a> .	Data range: 0 to 255 Negative values clipped to 0. Values higher than 255 clipped to 255.
Device classes	monitor/display	scanner/input monitor/display printer/output

Please note that the Black Point Compensation (BPC) setting has NO effect on a PatchTool RGB profile; this is also the case in most RGB ICC profiles for standard display spaces. However, custom (user-made) display profiles, as well as most printer profiles may have a non-zero black point. Finally, it is important to note that, very often, not all rendering intents may be defined separately within an ICC profile (with a Look-Up-Table); in such cases, the conversion is processed through a default table or matrix-based transform defined within the profile.

### Behind the scene: Generic RGB

Generic RGB, contrary to what its name suggests, is a well-defined RGB space devised by Apple. It has a gamma of 1,8 and is based on Illuminant D65, like Apple RGB, but the chromaticities of its primaries are very close to the ones of ColorMatch. In any case, these chromaticities are, except for the green, quite close to the original Apple RGB values; the only “valid” reason for the change is a mention by Apple that “Apple RGB” is in fact proprietary to Adobe, and thus does not belong to Apple!

According to Apple literature (Technical Q&A QA1430):

“Mac OS X will assume a Generic RGB color space for legacy untagged images that may have been created with an assumed Apple RGB color space.”

This means that “Generic RGB” will be assumed to be the source profile by ColorSync and converted to the current screen profile. Please note that the assumed source profile does not necessarily correspond to the assumed default display space. Here are the default RGB spaces for the various versions of the Mac OS:

Mac OS 9 and below:	Apple RGB (1,8 gamma; D65)
Mac OS X before 10.6:	Generic RGB (1,8 gamma; D65)
Mac OS X 10.6+:	sRGB (2,2 gamma; D65) (see Note below)

**Note:** sRGB is defined by a multi-segment Tone Response Curve (TRC) where different functions are associated to low and high luminance colors. The TRC can be approximated by a single value gamma of 2,2.

### Calibrated display = Calibrated monitor + display profile

A *calibrated display* is a combination of at least two elements: a *calibrated monitor* AND a *display profile*. By calibrated monitor we mean adjusting its White Point, as well as adjusting the individual Look-Up-Tables (LUT) for the RGB primaries. These LUTs are loaded in the graphics card, and it is from them that you get most of your neutral grays. As for the display profile, it will make sure that “all other colors” are accurate. High-end displays also incorporate LUTs in the display, but not all display profiling packages take advantage of this feature.

The White Point setting is done first, often manually adjusted by the user, under guidance from the calibration wizard. The LUTs definitions and the measurements required to derive the profile are usually done automatically as second and third steps respectively. The various steps of this process are more or less hidden from the user, depending on the software package.

### Color Management Module (CMM)

In PatchTool, the ICC profile computations are done using the free **lcms** (Little Color Management System, or LittleCMS) software libraries developed by Marti Maria ( <https://www.littlecms.com> ). Thank-you Mr. Maria!

#### Behind the scenes: Loading the LUTs

In Windows, while the default display profile is loaded at start-up, the LUTs are not. A third party application is required, and this program is usually automatically launched at start-up; *SpectraView II Gamma Loader* (NEC), *Logo Calibration Loader* (GretagMacbeth), *ColorVisionStartup* (Datacolor) and *basICColor display4 VideoLUT Loader* (Color Solutions) are such applications. Because of this sequence, changing a Windows profile after boot-up may not update the LUTs, unless you use an application dedicated for this task.

**Note:** There is a *Color* control panel available for Windows XP which can correctly load the LUT without rebooting; this little add-on can be downloaded from the Microsoft Web site: [Color Control Panel Applet for Windows XP](#). If the file is not available from the Microsoft Web site, other download sites have been found with Google using the following search string: “*microsoft color control panel applet for windows xp*”.

On a Mac, changing a display profile automatically loads the LUTs.

## B-2. PatchTool Color Workflows

The following pages present the principal color processing workflows used in PatchTool for display and display-measurements processing. The rendering intent is Relative-Colorimetric (No Black Point Compensation, i.e. No BPC) in all cases.

Task / Workflow	Source / Destination
<b>Display:</b> <a href="#">Patch view</a> tab and other patch displays	Source: spectral data or XYZ Destination: ICC display profile: R'G'B'
<b>Display:</b> Display-Check <a href="#">PatchTool file</a>	Source: spectral data, XYZ, or R'G'B' Destination: ICC display profile: R'G'B'
<b>Display:</b> Display-Check <a href="#">Quick-Test</a>	Source: R'G'B' Destination: ICC display profile: R'G'B'
<b>Display measurements</b>	IN: spectral data or XYZ, relative to the display White Point OUT: XYZ D50 (PCS)

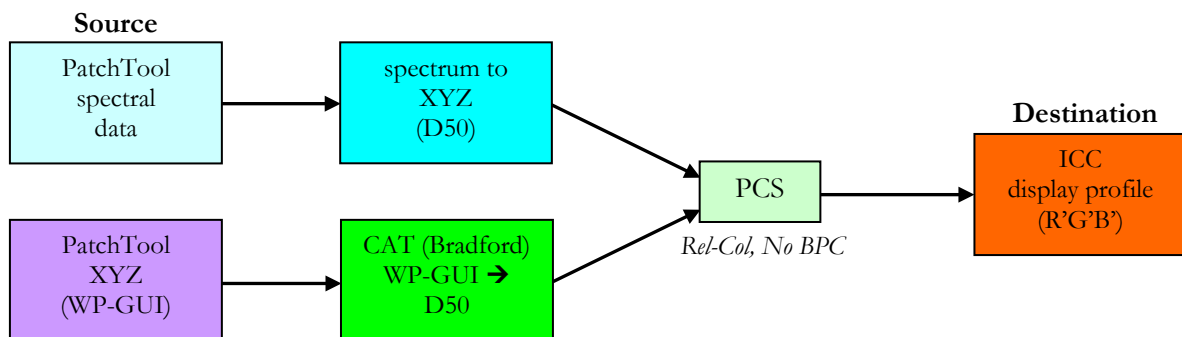
### B-2.1 Display: Patch view tab and other patch displays workflow

In a PatchTool file, the reference data is either spectral data, if available, or XYZ values derived from whatever data was originally in the file (RGB, L\*a\*b\*, CMYK, etc.). So, when displaying patches in the “Patch view” tab, as well as in the various tools, the **Source**, we first need to identify the reference data type.

In the XYZ case, we have data which is already quite close to what is required by the PCS (L\*a\*b\* D50), with perhaps only a chromatic adaptation required to convert the data to D50. For spectral data, we first need to obtain the XYZ data before going into the PCS. In both cases, we see that we are not in a full ICC world and we need to “prepare” the data before converting it in the destination profile.

#### Display: Patch view tab and other patch displays workflow

Source: spectral data or XYZ  
Destination: ICC display profile (R'G'B')



The illuminant identified as **WP-GUI** is the user-selected illuminant in the opened file window. If the selected illuminant is D50, then the Chromatic Adaptation Transform (CAT) is a unitary matrix (diagonal terms equal to 1 and other values equal to zero); in other words, the XYZ values shown in the file are used directly for the PCS input.

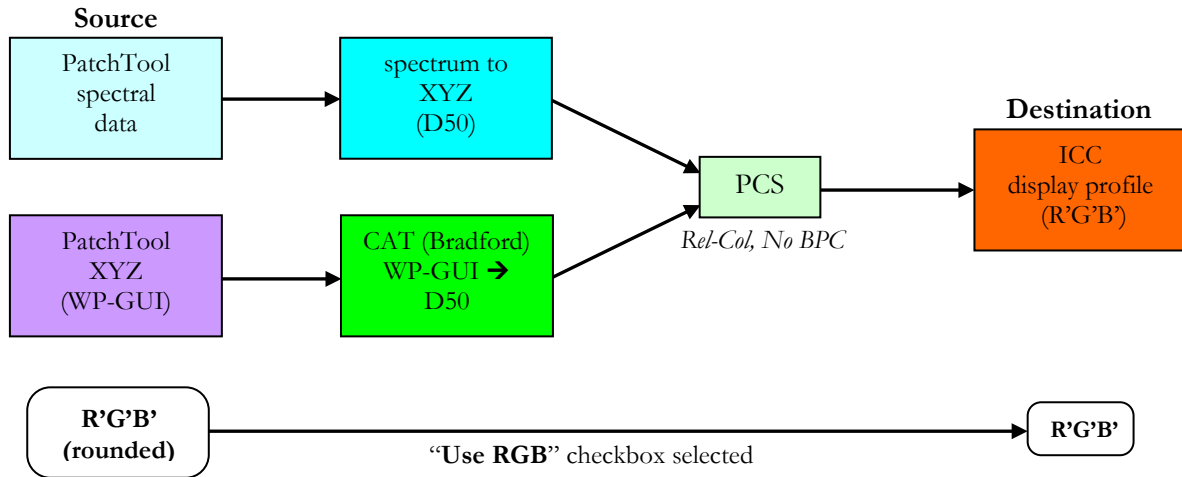
The **Destination** profile is the ICC profile assigned by the OS to the display on which a program window appears. In opened files windows, the profile name is shown at the right of the file name in the window title. On a multi-monitor computer, you will see the destination profile change when the window is moved to another monitor.

## B-2.2 Display: Display-Check (PatchTool file) workflow

Except for a special case discussed below, the workflow for doing a Display-Check from patches defined in an opened file is essentially the same as when viewing these patches on the display (discussed in [Section B-2.1](#)). The workflow below shows only the “display” part. Please consult [Section B-2.4](#) for the workflow used to process the measured data, and [Section B-3.1](#) for the workflow describing how the measurements references are derived.

### Display: Display-Check (PatchTool file) workflow

Source: spectral data, XYZ, or R'G'B'  
 Destination: ICC display profile (R'G'B')



**Special case:** If you open an R'G'B' color list—with no spectral data or no other tristimulus data that could be used for color reference—and you assign the **display profile** to this list, this is equivalent to send R'G'B' values directly to the display, as if there were no color-management. In effect, the Source and Destination profiles are the same.

**R'G'B' (display profile) → (XYZ/L\*a\*b\*/PCS) → R'G'B' (display profile)**

However, in practice, because profile conversion is not perfect, especially on the profile gamut boundaries, the display R'G'B' values may slightly differ from those in the file. This is not critical for viewing purposes but is of more concern when checking a display. For this reason, the Display-Check workflow (shown above) supports a special case where R'G'B' values are passed through directly to the display; this mode is selected with the “**Use RGB**” checkbox located near the PatchTool file name in the Display-Check tool window.

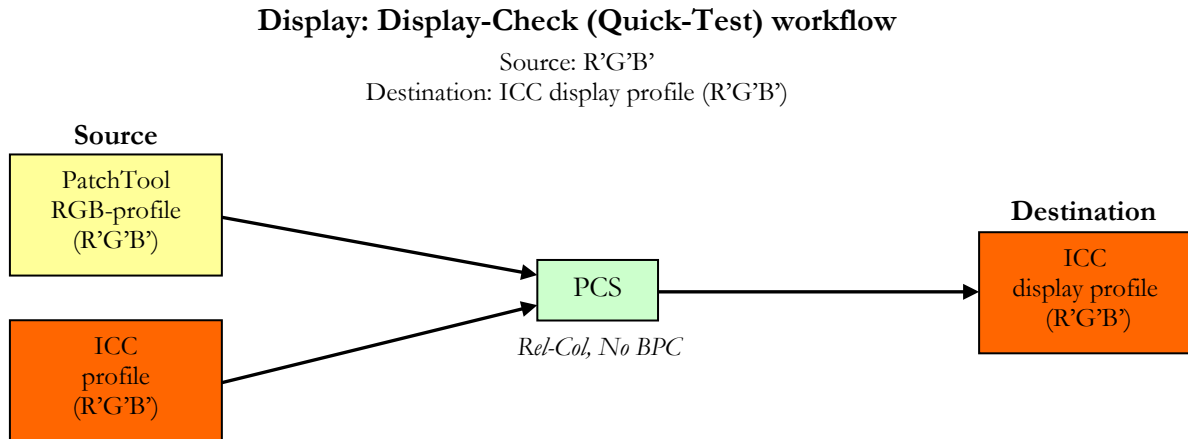
### B-2.3 Display: Display-Check (Quick-Test) workflow

The Display-Check Quick-Test is used to test a display calibration (White Point, grays, primaries) by sending predefined R'G'B' data from a source profile to the display profile. The predefined data comprises RGB ramps of various lengths; you can select either a gray (i.e. neutral) ramp only, or a neutral ramp followed by ramps of the primaries (R, G, and B). The *source profile* in this case acts the same way as an RGB working space in Photoshop.

You should select a source profile which is smaller or of a similar size as the Destination/Display profile. You should NOT select a source profile which has a gamut much larger than the display profile. You could, for example, see how a sRGB Source profile performs with a wide-gamut Destination profile (a near Adobe RGB display profile for instance).

The workflow below shows only the “display” part. Please consult [Section B-2.4](#) for the workflow used to process the measured data, and [Section B-3.3](#) for the workflow describing how the measurements references are derived.

**Note:** The Quick-Test uses the source profile for the measurements references.



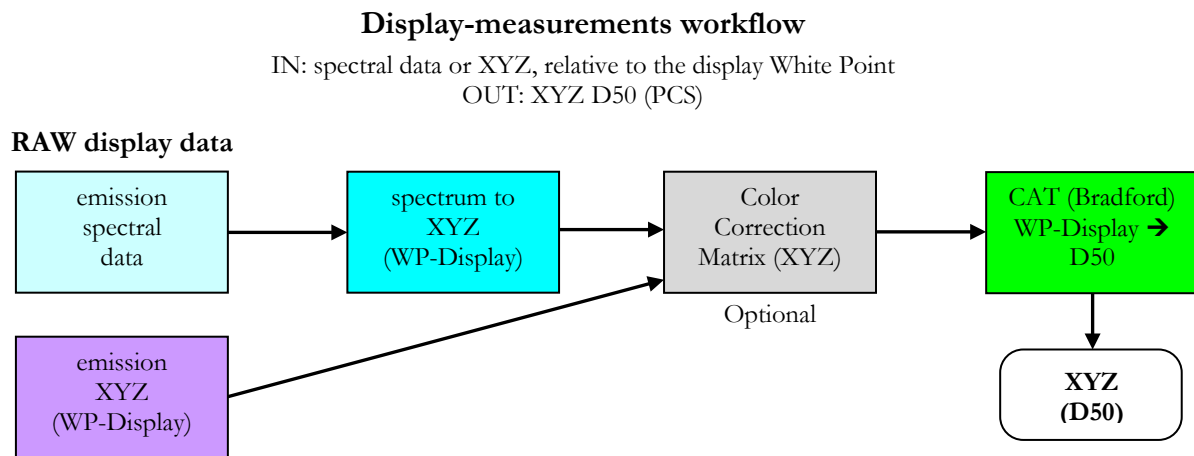
If you select the **display profile** as the **Source** profile, the source and destination R'G'B' values are identical. This is equivalent to “NO-COLOR MANAGEMENT”, or to “Proof/Monitor” with Adobe Photoshop. However, there is a very good reason why you would select such a combination: Since you are effectively not seeing the effect of your display profile, this is equivalent to check ONLY the monitor calibration, i.e. the monitor White Point and the LUTs, which define your primaries linearity (and gray ramp). In other words, this check will measure how your display behaves for non-color managed applications, which do not use the display profile to correct their output colors. In theory, for a perfectly calibrated display, the compare error should be zero (or, more realistically, very small) for all patches. This is a simple and precise method to see how your profile ages.



## B-2.4 Display measurements workflow

The workflow shows how display measurements are processed before being compared with the reference data. The measurements are generated either from a Quick-Test or from a Display-Check with a PatchTool file data, as described in the preceding sections. The workflows by which the references to these measurements are derived are presented in [Section B-3](#).

The display White Point is ALWAYS measured for display measurements, since this is the white to which the user's eyes will most likely adapt (we assume minimal "interference" from external light sources here, i.e. low ambient light levels). All other colors are then seen relative to this White Point. The White Point may correspond to the illuminant of standard RGB spaces, D50 or D65, but, for LCD displays, it will often be the "natural" White Point of the display, i.e. whatever the "as manufactured" White Point is. This situation arises because most LCD displays do not have the capabilities, which come at a cost, to adjust their white without compromising the smoothness of the tones, and it is not uncommon to see displays of the same model with different natural White Points.



Now, since we want to compare the measured data with reference data based on a standard White Point, we need to convert the data so that it matches the reference illuminant. In PatchTool, this is done using a Bradford Chromatic Adaptation Transform (CAT) which converts the measured data from the measured display White Point (WP-Display) to D50.

This workflow is identical to the one used in a Proofing RoundUp organized by Idealliance:

*IPA Proofing RoundUP Results 2007; "Appendix K — Methodology for Calculation and Normalization of Monitor Colorimetry"*

The document can be purchased from the IPA Web site: <https://www.ipa.org>.

**Note:** The above document recommends pro-rating the XYZ display measurements by the ratio of the **target** White Point XYZ coordinates over the **display** White Point XYZ coordinates. This pro-rating method is better known as the "wrong Van Kries" method, which is a CAT method most likely proposed because of its mathematical simplicity. In comparison, the Bradford CAT used in PatchTool is considered more accurate.

Because display measurements need to be chromatically adapted to the display white before being compared to a reference, the original unprocessed data is not available to the user once processed by PatchTool and the Compare window is opened. For this reason, a dialog asks you if you wish to save the RAW data at the end of each measurement sequence.

**Important:** The RAW file is not required for most users; it should be kept only by those who intend to process the measured data in their own application (i.e. not in PatchTool); in particular, the RAW file should NOT be re-opened in PatchTool. To record the Display-Check data in a format that can be re-opened by PatchTool, simply save (Export) the Compare file with at least the "ID", "Name", "CMYK" (if relevant), "L\*a\*b\*", and "Spectrum" (if available) data fields. When reopening such a Compare file, you will be able to analyze the data as if you just measured it.

### B-3. Measurements References

Measurements references are required for all Display-Check workflows. The workflows vary according to the required task and how the results are presented:

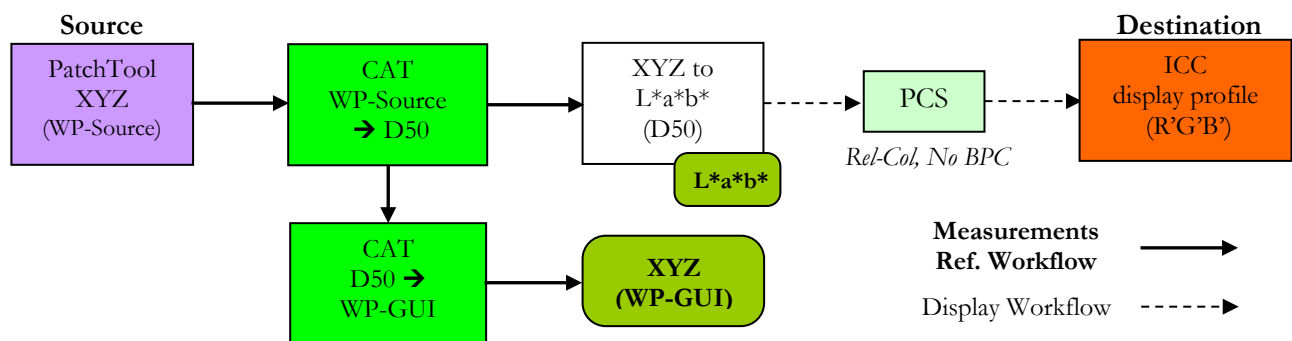
- i- PatchTool file as reference (Compare file);
- ii- PatchTool file as reference and “Use RGB” selected(Standard + Compare File);
- iii- Quick-Test (Compare file).

The workflows corresponding to the above tasks are presented in the following sections. The **Measurements Reference Workflow** is shown in a bold solid line while the *Display Workflow*, provided for reference, is shown as a dotted line.

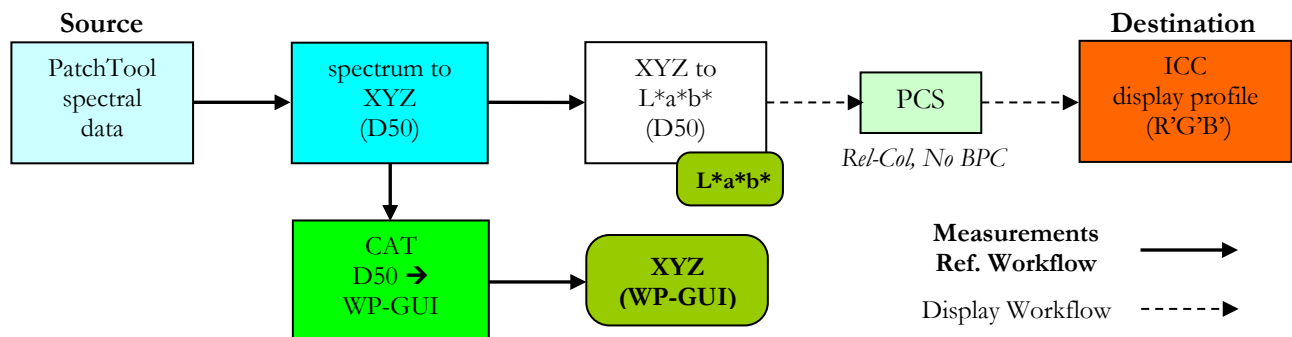
#### B-3.1 Measurements references with PatchTool file as reference

In the “[Tabular data](#)” tab of a Compare file, the measurements references are always XYZ. These references are used to compute the color-difference to the “[Stats](#)” tabs. This is true even if the references were derived from a PatchTool file containing spectral data (see the workflow on the bottom of the page) or for a Quick-Test based on R’G’B’ data associated to a Source profile. (See [Section B-3.3](#)).

“PatchTool file” workflow for **Measurements References** (Compare file)  
 “RAW file” data (L\*a\*b\* D50) and “Tabular data” (XYZ in WP-GUI)



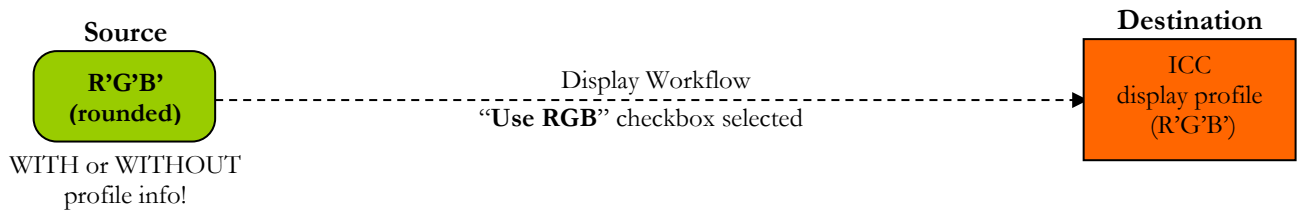
In the above workflow, if the illuminant of the reference file (WP-Source) is D50 and the user-selected illuminant in the Compare file (WP-GUI) is also D50, then the two Chromatic Adaptation Transforms (CAT) are unitary diagonal matrices. In this case, the XYZ values of the Compare file are the same as those of the reference file.



Note: WP-GUI is the user-selected illuminant in the Compare window.

### B-3.2 Measurements references with PatchTool file as reference and “Use RGB” selected

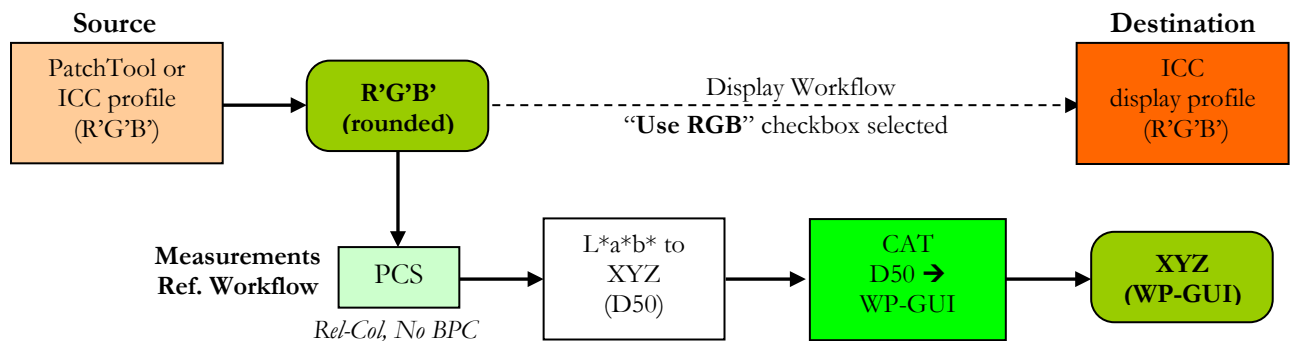
“PatchTool file” “Use RGB” workflow for **Measurements References** (Standard file)  
 “RAW file” data (R’G’B’) and “Tabular data” (R’G’B’)



When the “Use RGB” checkbox is selected, there is always a standard file generated. It contains the XYZ measurements adapted from the Display White-Point to D50 (see the measurements workflow section) and the R’G’B’ references are provided as extra data. You can always compare this measurements file to another file which contains absolute references using the Select Compare tool.

This file is generated even if there is no profile associated with the R’G’B’ data. On the other hand, if a profile can be associated to the R’G’B’ data, an absolute reference (i.e. XYZ or L\*a\*b\*) can be computed and a Compare file is generated. This is illustrated in the next workflow.

“PatchTool file” “Use RGB” workflow for **Measurements References** (Compare file)  
 “RAW file” data (R’G’B’) and “Tabular data” (XYZ in WP-GUI)



**Note:** The RAW data file is the same as the one generated for the Standard file. There is only one RAW file generated since the Standard file and the Compare file result from the same measurements.

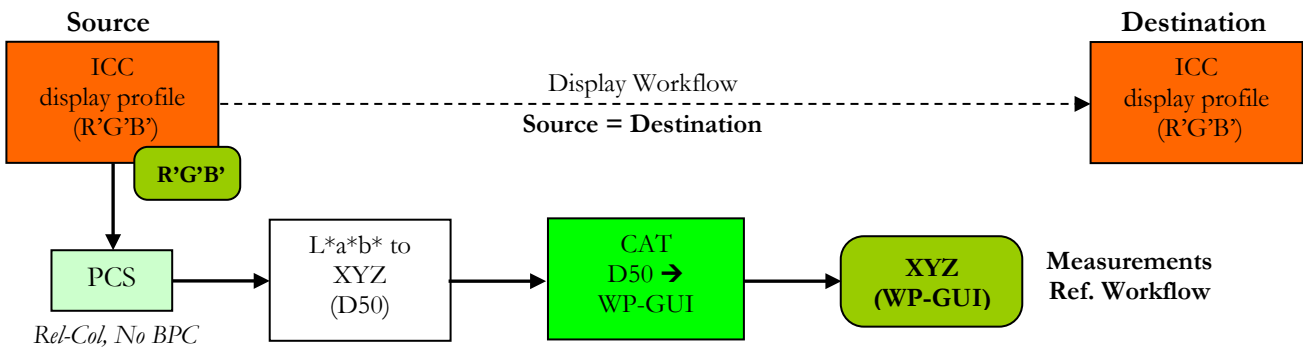
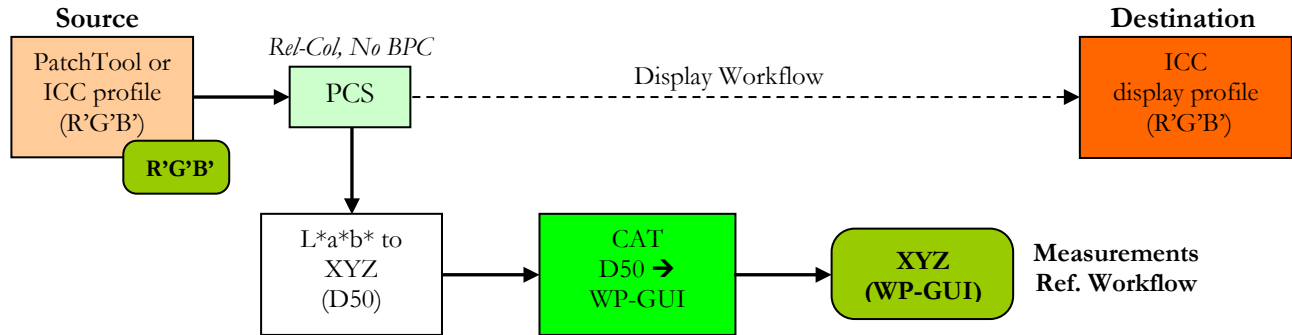
In this workflow, the R’G’B’ data is sent to the display with no color management, as if the Source and Destination profiles were the same. However, unless you specifically assigned the display profile to the Source RGB, they may well be different profiles. While this changes nothing in the displayed R’G’B’ values and their measurements, it has quite some importance when determining the **measurements references** in the Tabular data tab of the Compare file since it is the **Source** profile which is used to derive the XYZ values.

### B-3.3 Measurements references with Quick-Test

When doing a Quick-Test, the Compare window has an additional tab, labeled “[Display data](#)”, which present a graphical analysis of the measurements. In this tab, the measurements are compared to the reference using either R’G’B’, L\*, or Y coordinates, where R’G’B’ is in the same color space as the source data and where L\* and Y are in D50. This specific workflow is shown in the bottom of the page.

“Quick-Test” workflow for **Measurements References** (Compare file)

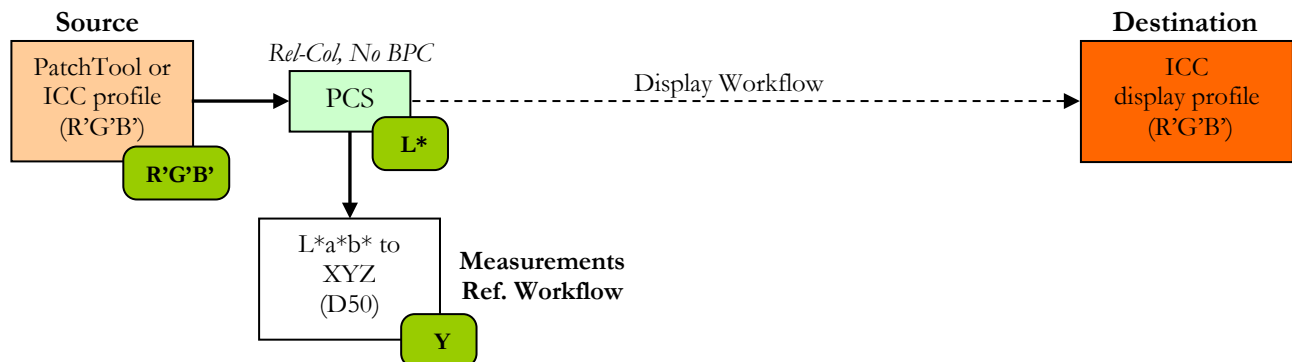
“RAW file” data (R’G’B’) and “Tabular data” (XYZ in WP-GUI)



Note: WP-GUI is the user-selected illuminant in the Compare window.

“Quick-Test” workflow for **Measurements References** (Compare file)

“Display data” (R’G’B’ Source, plus L\* and Y in D50)



## Appendix C

### The CxF Version-2 file format (CxF2)

#### C-1. Introduction

This Appendix is a short presentation of the CxF Version-2 file format, abbreviated as CxF2, a format designed for storage and exchange of color data.

Even though the CxF2 file format belongs to X-Rite, it can be freely used, and, like the first version of the CxF format (CxF1), X-Rite was promoting it to be adopted as an International Standard. CxF1 failed to be adopted, and significant changes were put into CxF2 in order to get a consensus. The result is a much more thorough, and complex, format capable of storing color information for essentially any purpose. However, this was done at the expense of Version-1 compatibility, and the older version cannot be opened by a program designed to open CxF2 only (PatchTool has dedicated code for each version). X-Rite efforts to convince the industry to adopt this second version of the CxF file format also failed, and a third attempt is being made with the CxF3 format described in [Appendix D](#). This said, we have seen multiple instances of CxF1 and CxF2 usage by companies other than X-Rite.

For users, the CxF2 format is both a blessing and a curse. It is a blessing because the format imposes strict documentation requirements, including the measurement conditions, the instrument model, geometry, and settings, the illumination conditions, the Standard Observer, etc. In practice, this format should minimize data misuses.

It is also appreciated because it is XML based, and as such will store all data in human-readable text form (i.e. not in binary form) in a file that can be opened by any word processor. However, this is also where the curse comes in. Like in all XML files, and similarly to HTML documents, all information is presented between “tags”, such as

`<CxF:L>38.358</CxF:L>`

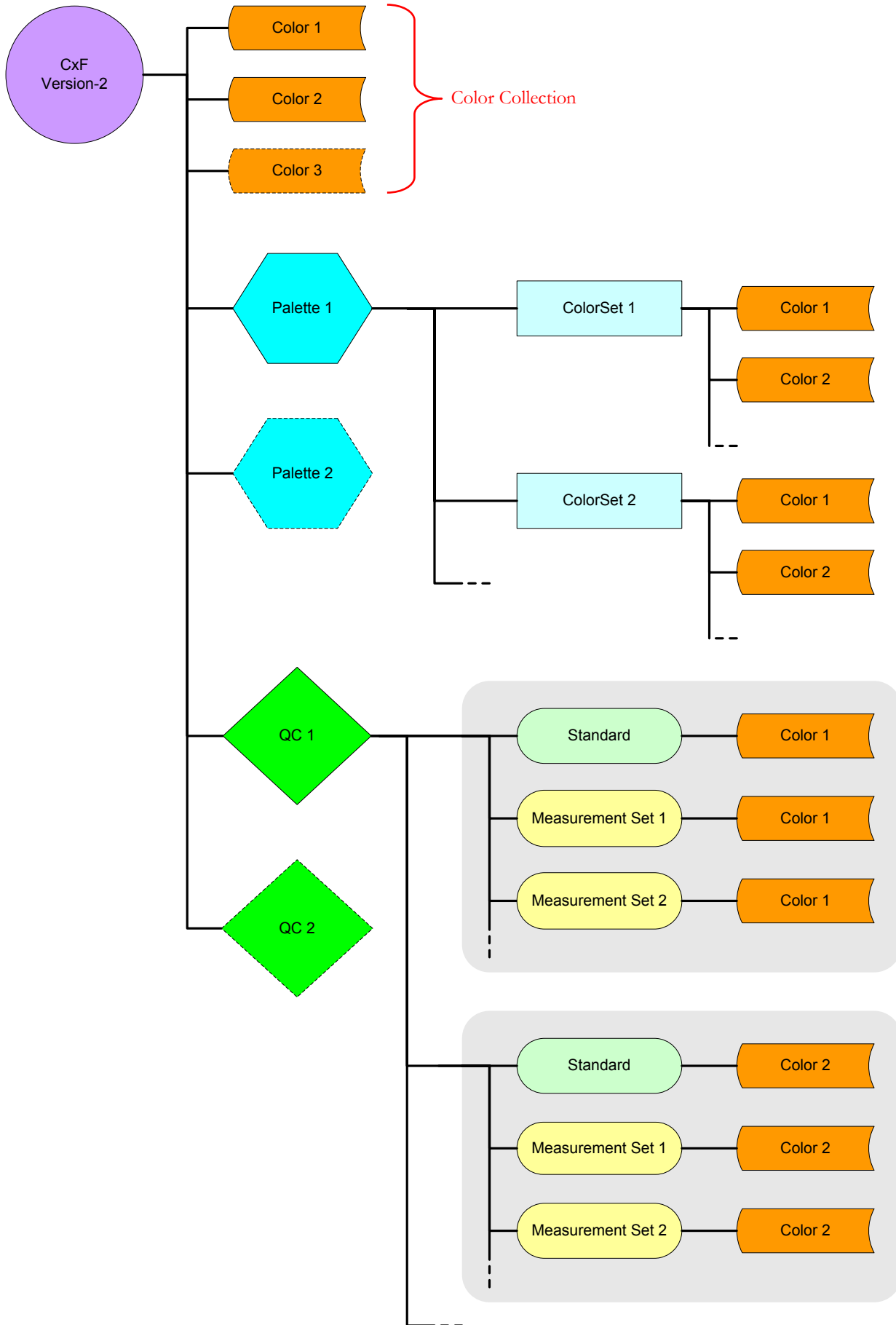
where `<CxF:L>` is the opening tag and `</CxF:L>` is the closing tag for the  $L^*$  value of a  $L^*a^*b^*$  coordinate set. Such tags ensure that the data can be unambiguously recognized and processed. While this is great for machine-processed text, the resulting files are very large, with sparse data content, where it is nearly impossible to browse data. For this reason, many convert CxF files into the simpler and still more common non-XML version of the CGATS format, even if this format is [far from perfect](#); as well, many applications still prefer the CGATS format, and it is thus likely that the CGATS format will coexist with some version of CxF for a while.

#### C-2. CxF2 Data Structure

All XML files have a tree structure. By this we mean that top-level elements contain sub-elements which themselves contain sub-sub-elements, etc. In a CxF2 file, there are three top-elements which can contain color data. These elements are:

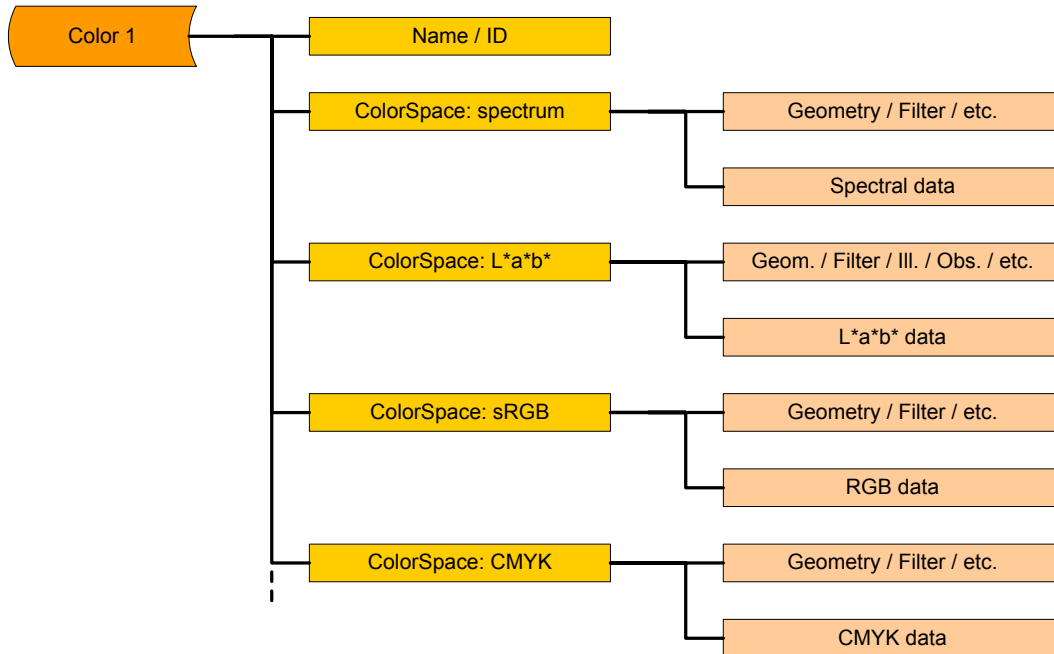
- i- **<CxF:Color>**: A loose collection of Color elements, i.e. color measurements, also called a “Color Collection”. These Color elements are located at the top-level.
- ii- **<CxF:Palette>**: A group of colors associated by a common theme. A Palette has one or more **ColorSet**, which can be thought as a sub-group of colors, in which the color data is located.
- iii- **<CxF:ColorQualityControl>**: Called Quality-Control (QC) data in PatchTool; this data structure is made of a *Standard* plus any number of *Measurement* Sets for each Color.

These three elements correspond to the “CxF2 content types” shown in the PatchTool “[Import CxF2](#)” dialog. The CxF2 tree structure is illustrated on the next page.



## <CxF:Color>

A CxF:Color element describes the color of one color patch. This color can be expressed in many color spaces; for example, the same color can be described by spectral data and by L\*a\*b\* values for a given illuminant and observer. The Color element is a container for all possible color spaces.



The various color spaces requires different defining parameters; for spectral data, this includes the instrument geometry and information on the presence or not of filters such as UV-Cut or polarizers, while L\*a\*b\* values also require information on the illuminant and observer used to derive the data.

Every ColorSpace sub-element thus contains all the background information required to interpret the values. This means that it is theoretically possible to have a Color Collection where all elements are measured in different conditions and different data types. In practice, we see that while different data types are used, the same data types are often used for all elements of a Collection.

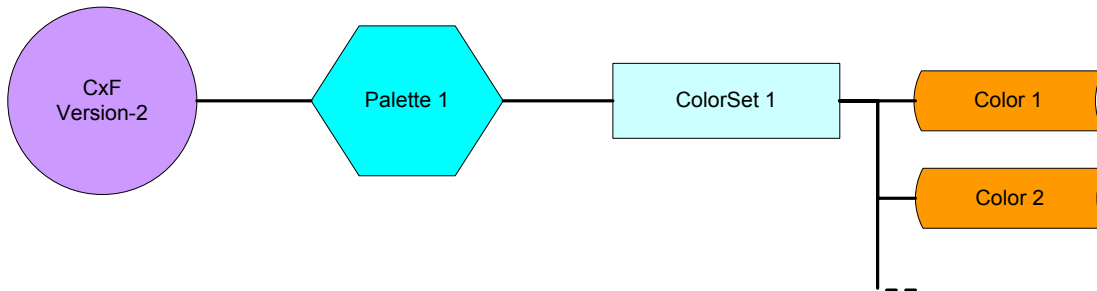
It is important to note that the data structure of the Color element shown above is the same for the Color elements contained in a ColorSet, a Quality-Control Standard or a Quality-Control Measurement. It is the element position in the file tree that determines its relation with other Color elements. Usually, in a Color Collection located at the top-level, the colors do not have any relationship to each other.



### <CxF:Palette>

A Palette can contain one or more ColorSets, with each ColorSet containing a different number of Color elements. A CxF2 file can contain any number of Palettes. For example, a clothing designer could save each season's colors into its own Palette (i.e. four Palettes), and use separate ColorSets for Men and Woman clothing colors in each season.

In its simplest form, you could have a file with a single Palette and a single ColorSet. This is illustrated below and corresponds to the form most often seen in CxF2 files at this time (for instance, for colors measured with an X-Rite ColorMunki and saved with the utility program the instrument comes with).



The difference between a Color Collection in a ColorSet and a Color Collection at the top level, as seen in the previous page, is that the color space definitions (of spectral data, L\*a\*b\*, etc.) can be located in the ColorSet header, where they act as defaults which apply to all Color elements within the ColorSet. These definitions do not need to be repeated in each Color, which results in smaller file sizes. As well, if the Palette has many ColorSets, the color space definitions can also be placed in the Palette header, where it will apply to all ColorSets, and all Color elements within.

Of course, if file size is not an issue, nothing prevents the file creator of also including the color space definitions in all Color elements, where they would be redundant, or saving the color information with a different color space definition, lets say with a different illuminant for L\*a\*b\* data, for just a few of the Color elements. You can thus see how flexible a CxF2 file format can be, but you can also appreciate that it can make the job of extracting data from it more involved!

### <CxF: ColorQualityControl>

The ColorQualityControl element is designed, as its name says, to hold Quality-Control type data. A file can contain one or more Quality-Control (QC) Set. It is the most complex of the elements presented here. This complexity stems from the way that QC data is generated and used. First, a **Standard**, also called a *reference* in PatchTool, is measured. Then, one or more **Measurements**, called *samples* in PatchTool, are taken.

A Standard-and-Measurements set is thus required for **each** Color element within a QC Set; it comprises one *Standard* value per Color, and one or more *Measurements* Sets. Of course, the data from different Measurement Sets should not be interchanged, but the measurements could well be averaged in a separate step.

The CxF2 standard allows for the presence, or not, of a Standard, and the presence, or not, of a Measurement Set. PatchTool handles all cases and can input a Standard plus a Measurement Set in a single [Compare](#) file.

## Appendix D

### The CxF Version-3 file format (CxF3)

#### D-1. Introduction

This Appendix is a short presentation of the CxF Version-3 file format, abbreviated as CxF3, the third iteration of a format designed by X-Rite for storage and exchange of color data. We suggest that you read [Appendix C](#), which presents the CxF2 format, to better understand the references we do to this previous format and the changes done in CxF3. You should also consult [The “Import CxF3” dialog](#) section in this manual which describes the specific PatchTool interface to CxF3 files, but we strongly recommend that you read this appendix first! For more technical documentation, please consult this Web page from X-Rite:

<https://www.xrite.com/categories/digital-color-standards/color-exchange-format-cxf>

While more powerful than CxF1, the CxF2 format has a complex and rigid file structure which forced many vendors to add customized attributes in the core of the CxF2 structure, in a way that made the file format less universal (or less vendor-agnostic!), going against the goal of having a “universal” format. Also, the complex and rigid structure, plus the use of long tag names—HTML type labels placed before and after a piece of data—made for difficult to read files. For example, in a CxF2 file, the values of a reflectance spectrum measured between 380 and 730 nm could be saved as:

CxF2 example for reflectance data

```
<CxF:ColorSpaceSpectral>
<CxF:ChangeHistory>0001-01-01T00:00:00-05:00</CxF:ChangeHistory>
<CxF:ColorSpaceSpecificationSpectrumSpectral xsi:nil="true"/>
<CxF:ReflectancePoint Wavelength="380">0.219414333</CxF:ReflectancePoint>
<CxF:ReflectancePoint Wavelength="390">0.2179244763</CxF:ReflectancePoint>
(...)
<CxF:ReflectancePoint Wavelength="530">0.8869524519</CxF:ReflectancePoint>
<CxF:ReflectancePoint Wavelength="540">0.8963655776</CxF:ReflectancePoint>
(...)
<CxF:ReflectancePoint Wavelength="720">0.9428778206</CxF:ReflectancePoint>
<CxF:ReflectancePoint Wavelength="730">0.9441989188</CxF:ReflectancePoint>
</CxF:ColorSpaceSpectral>
```

As you can see, the reflectance value at each wavelength, shown in bold face for viewing purposes, occupies a small portion of the total file content; in other words, there is a lot of overhead. The same data in a CxF3 file could be saved as:

CxF3 example for reflectance data

```
<ReflectanceSpectrum ColorSpecification="CS2" StartWL="380">
0.219414333 0.2179244763 (...) 0.8869524519 0.8963655776
(...) 0.9428778206 0.9441989188</ReflectanceSpectrum>
```

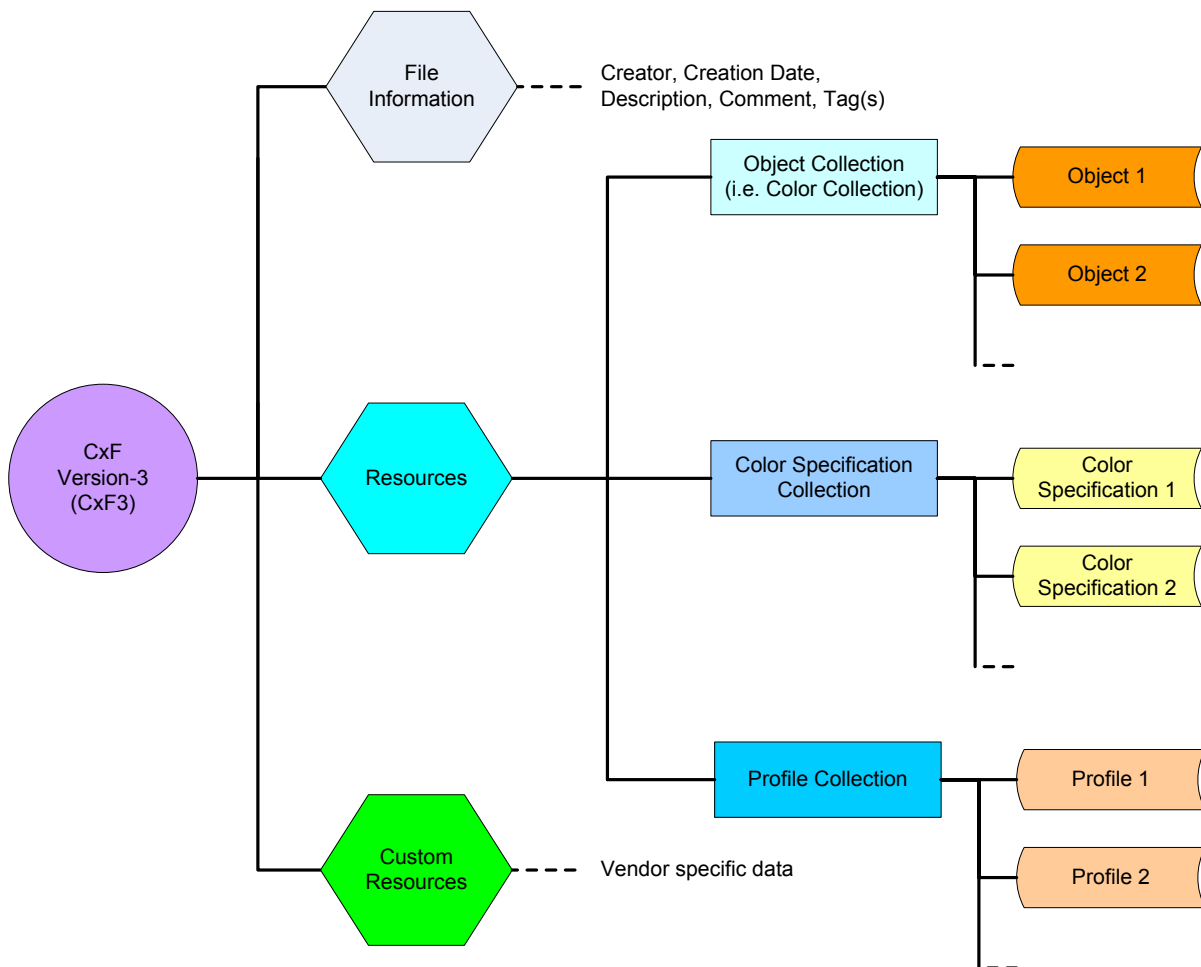
In each example, the 13 data points between 390 and 530 nm and the 17 data points between 540 and 730 nm are not shown, but the space saving of the CxF3 format is already quite obvious. This simple example also makes it clear that data cannot be extracted in the same way in a CxF2 file than in a CxF3 file, and that any software designed for the CxF2 format is essentially useless for the CxF3 format.

## D-2. CxF3 Data Structure

The CxF3 tree structure is illustrated below. In a CxF3 file, like in the CxF2 format, there are three top-elements, but there are big differences already at this level. These elements are:

- i- **<cc:FileInformation>**: Information on the file origin and content (Creator, Creation Date, Description, Comments, Tag(s).
- ii- **<cc:Resources>**: This element contains the **Object Collection**, **Color Specification Collection**, and **Profile Collection** sub-elements. It is important to note that in a CxF3 file, an “Object” is an abstraction which represents a physical or virtual “color object”, which includes its color description as well as its physical attributes, and its relation to other Objects.
- iii- **<cc:CustomResources>**: Vendor-specific data that is not part of the standard. Such resources may become de-facto standards if used in a consistent manner, and if documented. Examples: CxF3-Colorpage which defines the arrangement of printed objects (i.e. colors) in terms of page/column/row; CxF3-QualityControl, which defines the relationships between Standards and Samples.

**Note:** We use the “cc:” prefix and the element’s name as defined, without spaces, when we specify the element as it appears in the file, such as **cc:ObjectCollection**, but we omit the prefix and we add spaces when we make a descriptive reference to the element, i.e. the **Object Collection**. Both forms describe the same CxF3 element.

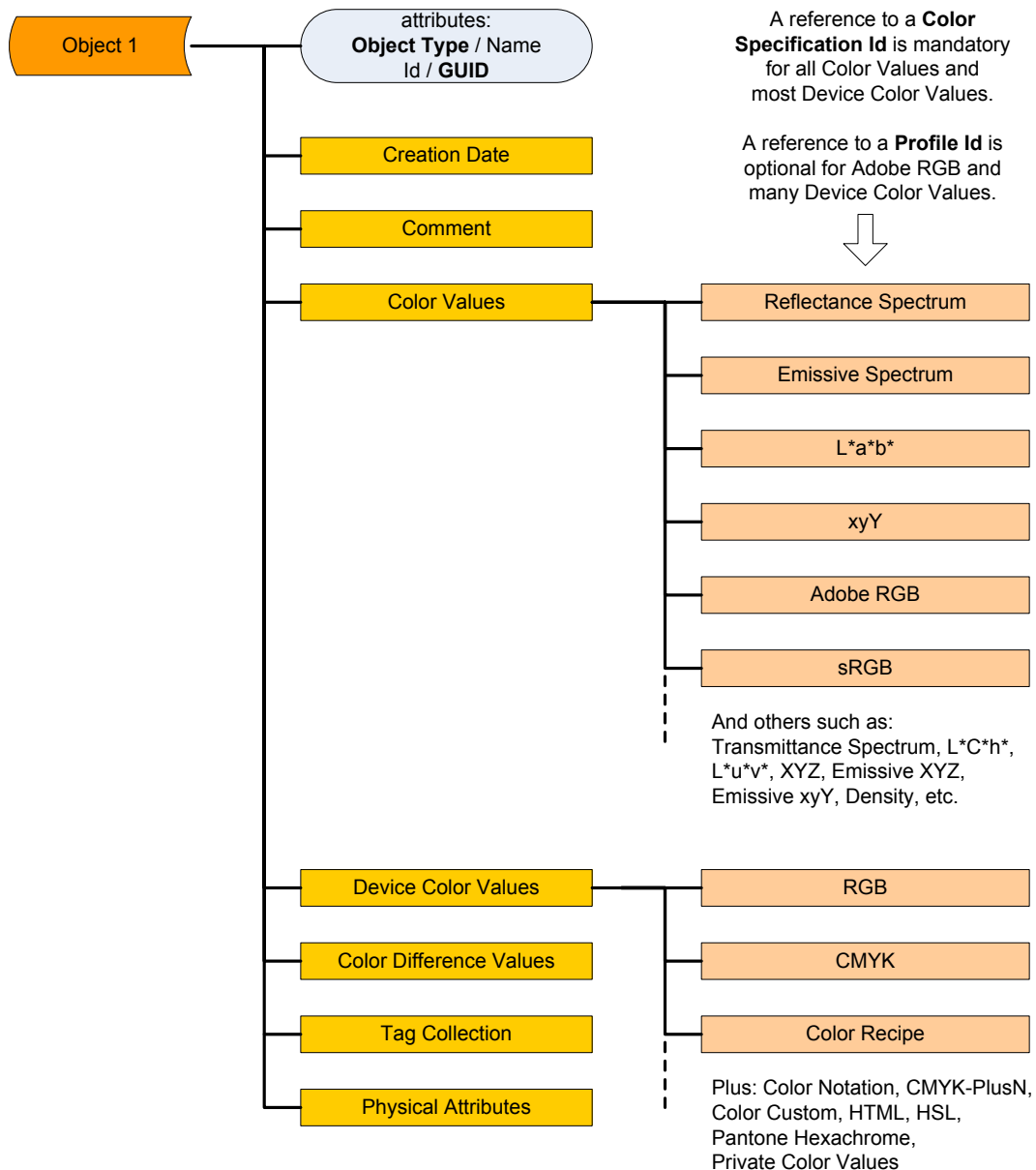


The **Resources** element is thus the only place where we should find color data, with the other elements bringing additional information on the document (**File Information**) and additional information on the Resources (**Custom Resources**). In comparison, it is possible to find color data in all three top levels of a [CxF2](#) file (i.e. in the Color(s), Palette, and ColorQualityControl elements).

A CxF3 file can have a maximum of one Resources element and one Custom Resources element. Similarly, there can be only one **Object Collection** (a concept similar to the CxF2 Color Collection), one **Color Specification Collection**, and one **Profile Collection** in a Resources element. However, there can be any number of **Objects** elements (i.e. colors) in an Object Collection. As well, there can be any number of Color Specifications in a Color Specification Collection, and any number of Profiles in a Profile Collection.

The content of the **Object** element is shown below. All the elements which may be included in an Object are shown but we have only included details for the **attributes** and for the sub-elements of the **Color Values** and **Device Color Values** elements.

An Object has three mandatory attributes, the Object Type, the Name and the Id, and one optional attribute, the GUID. The **Object Type**, which describes what the Object represents, is particularly important since this description is used as a relational link with all other Objects of the same document which are saved with the same Object Type. For example, the Object Type may be specified as “Standard”, “Sample”, or any other meaningful name. The optional **GUID** is a globally unique identifier which is used to distinguish an object from any other Object, including Objects of the same Name and Id; this identifier may be used to associate Objects in the same file or in different files.



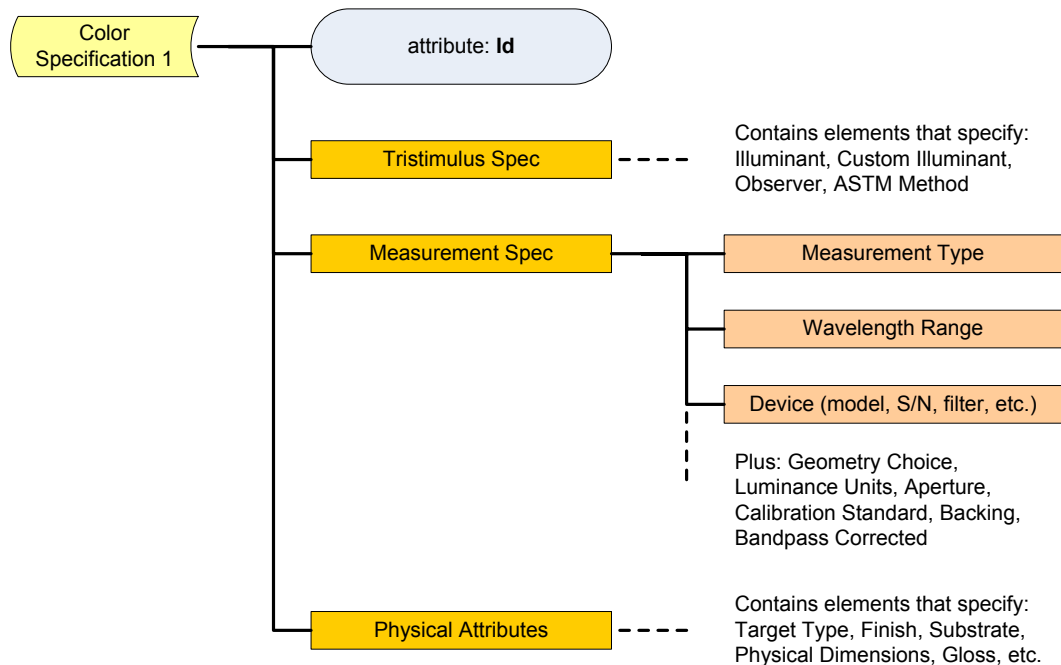
The **Color Values** element contains color data which is device-independent, i.e. data which does not need to be defined in association with display or printer characteristics. Adobe RGB and sRGB are included here since they are standard color-spaces with well-defined characteristics (primaries, White-Point, gamma). A reference to a **Color Specification Id** is mandatory for all Color Values elements; a Color Specification with this Id must of course be included within the Color Specification Collection (the CxF3 example on the [first page of this appendix](#) shows how the Color Specification Id is referenced in a Reflectance Spectrum). This is another example of a relational link within the CxF3 format. The structure of a Color Specification element is shown below.

The **Device Color Values** element contains data which is device-dependant, such as the RGB or CMYK values of an image. A reference to a Color Specification Id is mandatory for most Device Color Values elements, the exception being for a Color Recipe, for which it is optional. Many Device Color Values elements may contain an optional reference to a **Profile Id**; similarly to the Color Specification Id, this is a relational link to a Profile that must be included within the Profile Collection.

The **Color Difference Values** element contains one or more color-differences parameters ( $dE^*_{ab}$ ,  $dL^*$ ,  $da^*$ ,  $db^*$ ,  $dE^*_{94}$ ,  $dE^*_{00}$ , custom differences, etc.) computed between the Object and one or more Objects implied as references.

A **Tag Collection** may contain tags (i.e. name/value pairs) which provide additional information on the Object and its properties. This information can be an alternate name or the location of the color in a multi-page target (page/column/row).

The **Physical Attributes** element—which contains elements that specify the Target Type, Finish, Substrate, Physical Dimensions, Gloss, etc.—can be documented in each Object but it is also possible to define them globally within a Color Specification, as shown here.



Let’s get back to our comparison between the CxF2 and CxF3 formats. In the CxF2 standard, the format structure imposes different locations to save the data depending on their intended use. For instance, a group of colors used as a standard can only be saved in the prescribed CxF2 **Standard** element within a CxF2 **ColorQualityControl** element (ColorQualityControl/Standard/Color), even if this group of color could be described essentially the same way as part of a CxF2 **ColorSet** within a CxF2 **Palette** (Palette/ColorSet/Color). In a CxF3 file, you just have to assign the same word, such as “Standard” or “my-REF”, to many Objects so that these objects become unified.

A CxF3 file is thus structurally simpler than a CxF2 file because its XML tree has fewer branches, but it can be more difficult to extract data from it since a group of “unified” Objects in a CxF3 file does not have a precise use, as it had in CxF2. A program which opens a CxF3 file must thus have an idea of what it contains. This is probably why X-Rite assigns different file extensions—the three to five characters placed after a period at the end of file—in their i1Profiler software, depending on the file usage. Here is a partial list of these extensions and their use in i1Profiler:

<b>Extension</b>	<b>Intended usage</b>
*.cxf	Generic CxF file (for all CxF versions)
*.axf	Ambient Measurements
*.cmxf	Chart Measurements
*.dmxf	Display Measurements
*.dpsf	Display Profile Settings
*.dpxf	Display Profile Options
*.duxf	Display Uniformity Measurements
*.dwxf	Display Workflows
*.lxf	Lighting Parameters
*.mxf	Measurements
*.oxf	OBC Parameters
*.pwxf	Printer Profile Workflows
*.pxf	Patch Sets
*.rmxf	Reference Measurements
*.sxf	Profile Settings
*.txf	Test Charts

<b>Extension</b>	<b>Transmissive workflow usage</b>
*.lb1xf	Light Table Measurements-1
*.lb2xf	Light Table Measurements-2
*.t1xf	Transmissive Test Charts (1 <sup>st</sup> pass)
*.t2xf	Transmissive Test Charts (2 <sup>nd</sup> pass)
*.tm1xf	Transmissive Measurements (1 <sup>st</sup> pass)
*.tm2xf	Transmissive Measurements (2 <sup>nd</sup> pass)

From what we have seen so far, all the files saved with the above file extensions are fully CxF3 compliant, and the only difference is the intended use. While this segmentation of the CxF3 standard for specific applications can promote use of the data by third party programs, a format alone does not give all the information on a file’s data usage. This is why, when opening a CxF3 file, PatchTool first analyses its content and presents all the data that was found in the “[Import CxF3](#)” dialog. From this snapshot of the file content, the user is better positioned to select the data to be extracted.





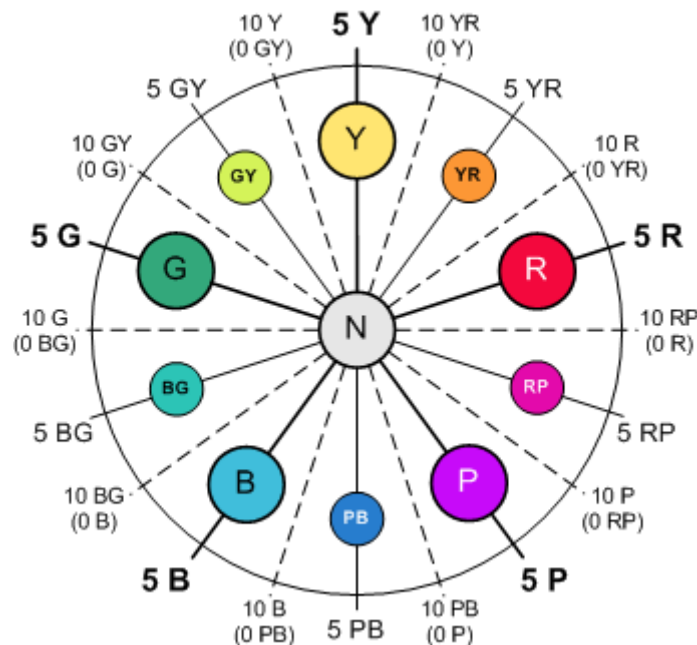
## Appendix E

### The Munsell Color System

Originally developed in the early 20th century by the American artist Albert H. Munsell (1858-1918), this is the first widely accepted color order system. It proposes collections of painted samples in either matte or glossy finish, which form the **Munsell Book of Color**. In this system, colors are identified with three parameters: *Munsell Hue*, *Munsell Chroma* and *Munsell Value*, or **Munsell HVC** for short; they are presented in the form:

#### Hue Value/Chroma.

The *Munsell Hue* is separated in 10 hue ranges (please refer to the illustration below). For each hue range, there is a major hue located at the range center. The major hues are Red, Yellow, Green, Blue and Purple, as well as the five hues located between them and named by combining the names of the hues on each side. For example, the hue located between Yellow and Red is called Yellow-Red, instead of Orange; this naming convention minimizes the number of color names one has to deal with.



Each hue range is further divided in 10 sub-zones defined by 11 radii labeled from zero to 10. The major hues are labeled **5R**, **5YR**, **5Y**, **5GY**, **5G**, **5BG**, **5B**, **5PB**, **5P**, **5RP**. The color circle is, in effect, separated in 100 hue segments where each hue separation is perceptually uniform. A zero to 100 number can be used to describe the *Munsell Hue* but it is seldom seen (the zero is at 10RP, the numbers increase when going counter-clockwise, up to 100, also at 10RP).

The radius labeled "10" in one zone corresponds to the "0" radius of the next zone (the 10Y hue is the same as 0GY); in practice, the 10Y notation is the preferred one.

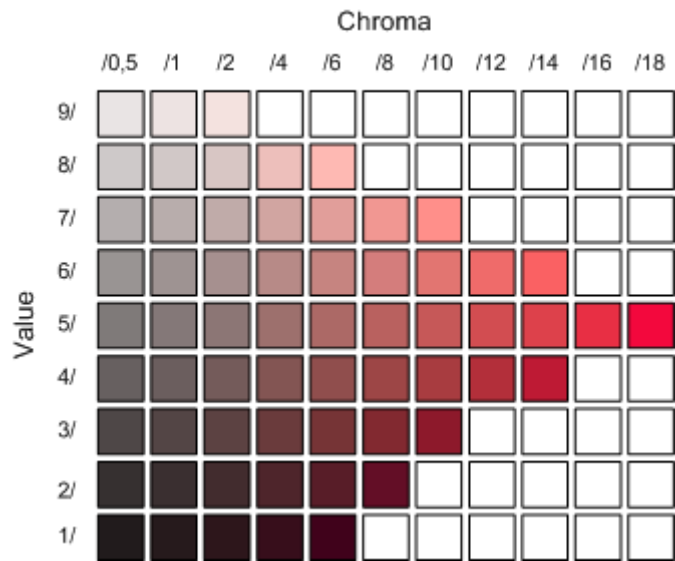
The Munsell Book of Color has samples with hues located at every 2,5 hue steps. For example: 10RP / 2,5R / 5R / 7,5R and 10R for the red hue range.

The *Munsell Chroma*, like the  $C^*$  of the  $L^*C^*h$  representation, can be considered an approximate counterpart of perceived color saturation, while the *Munsell Value* is associated to the lightness ( $L^*$ ) of the color. The perceived chroma and value increase uniformly with each unity step. For example, the perceived difference between a

**Chroma 1** and a **Chroma 2** sample is the same as the one perceived between **Chroma 4** and **Chroma 5** samples; similarly, the perceived difference between a **Chroma 1** and a **Chroma 3** sample is the same as the one perceived between **Chroma 4** and **Chroma 6** samples.

The illustration on the right presents samples at specific value and chroma intervals for the **5R** hue. Only samples that fall within the sRGB gamut are shown; this explains why the maximum chroma is different across the value range. Please note that not all chroma intervals represent unitary steps.

The most saturated sample in the illustration is "**5R 5/18**". Neutral colors are presented in the form "**N 5/**" with "**N**" written for the neutral hue, and no number for chroma since there is zero chroma. Fractional values are possible for each parameter, and "**5,2R 4,8/17,5**" is a valid Munsell notation. According to the ASTM D1535 standard (<https://www.astm.org/>), the estimated precision with which a color can be characterized visually is 0,5 hue step, 0,1 value step and 0,4 chroma step.



First devised as a color description teaching aid, the Munsell Color System was quantitatively formalized in the 1940s. The analysis led to small adjustments in the samples color in order to improve the spacing uniformity between them. This "renotated" system is the one we now use. The Munsell Color System is an international reference, defined in ASTM D1535 and other standards, that is used in many fields of work, from archaeology, when describing the colors of artifacts, to medical studies, when comparing the color of skin affections, to hobby activities such as accurately depicting the colors of scaled vintage airplanes.

A great tool to learn and practice the Munsell system is *The New Munsell Student Color Set*, which combines a color-primer book with color chips and a three-ring binder to store the chips; this tool is produced by Jim Long and Joy Turner Luke (Fairchild Books and Visuals (2001), ISBN 1563672006).

Additional information and data on the Munsell Color System can be found on the Munsell Color Science Laboratory (MCSL) Web site: <https://www.rit.edu/science/pocs> . This laboratory is part of the Rochester Institute of Technology.

## Appendix F

### The OSA Uniform Color Scales

#### F-1. Introduction

The first model which mathematically formalizes the complete process of how colors are perceived by the human eye is the CIE 1931 Standard Observer, with its accompanying chromaticity diagram. However, this model did not stand unchallenged for long. In its seminal 1942 article<sup>8</sup>, David L. MacAdam had shown that, when selecting a given color on the chromaticity diagram, other colors of constant perceived color differences around this color were not at the same distance relative to the reference color. These neighboring colors formed ellipses of varying sizes and shapes, depending on the color selected as the reference, and not circles of the same sizes, as would be expected of a uniform system. This meant that the distance between any two colors on the chromaticity diagram (measured on a straight line, also called the Euclidian distance) could not be used as a uniform measure of the perceived color difference.

Work to solve that problem started immediately, and culminated, many years later, in the CIELAB and CIELUV color space. We now know that CIELAB (as well as CIELUV) are more uniform but still far from perfect. The color difference metric associated with CIELAB, the well-known  $\Delta E^*_{ab}$  formula, has been further improved over the years with the CMC, CIEDE94, CIEDE2000, and many other less well known variants.

In early 1947, Deane B. Judd, a color scientist working at the American National Bureau of Standards and one of the architects of the CIE 1931 System, had informal discussions with colleagues on the possibility of forming a committee that would study the problem of uniform color spacing. These discussions quickly turned into a formal research program during a meeting of the National Research Council in June 1947, which was thereafter adopted as an Optical Society of America project in October 1947. The system became known as the OSA Uniform Color Scales (UCS). This committee was formed by many prominent color scientists of the time:

Deane B. Judd (Chairman)	Isay A. Balinkin	Carl E. Foss	L. G. Glasser
Walter C. Granville	G. L. Howett	Richard S. Hunter	G. W. Ingle
David L. MacAdam	Hugh R. Davidson	S. M. Newhall	Dorothy Nickerson
C. D. Reilly	Gunter Wyszecki.		

The most uniform color system in use at the time was the Munsell system. However, in the Munsell system, it is not guaranteed that one step in Hue, one step in Value, and one step in Chroma represent the same size of perceptual difference. Also, being based on polar coordinates, such a system does not express hue differences as a function of chroma accurately (the distance between adjacent Hues becomes larger as the Chroma increases).

The UCS committee wanted a color space uniform in all directions; they also wanted a notation that would provide a color-difference metric that would match this uniformity. This was not a simple task, and a lot of work was performed over the following 30 years. Unfortunately, the complexity of the human visual system cannot be easily simplified and it proved impossible to reach all goals. Nonetheless, what was obtained is a very uniform color system (under some defined viewing conditions), which presents color scales in a novel and visually innovative way.

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<sup>8</sup> David L. MacAdam; *Visual Sensitivities to Color Differences in Daylight*; JOSA; Vol. 32; No. 5; May 1942; 247-274

## F-2. The UCS development

The UCS development covered such a long time span (from 1947 to 1977) that many developments in color theory happened in parallel. These developments influenced the committee members, which incorporated some of them in the project. A detailed description of this committee's work would require a book in itself. What is shown in this section is a snapshot of key UCS concepts with minimal background information. Many scientific articles were published on the UCS, of which the following three are must-read for a minimally complete understanding of the system's inner workings.

- David L. MacAdam; *Uniform color scales*; JOSA; Vol. 64; No. 12; December 1974; 1691-1702
- Dorothy Nickerson; *OSA Uniform Color Scale Samples: A Unique Set*; COLOR research and applications; Vol. 6; No. 1; Spring 1981; 7-33
- Fred W. Billmeyer Jr.; *On the Geometry of the OSA Uniform Color Scales Committee Space*; COLOR research and applications; Vol. 6; No. 1; Spring 1981; 34-37

The committee started with a relatively small sample of 59 colored tiles of *approximately* the same perceived luminous reflectance ( $Y \approx 30$ ) and separated with *tentatively* uniform chromaticity differences; the chromaticities were based on Munsell colors, further corrected for the deviations measured by MacAdam in 1942. The emphasis on *approximately* and *tentatively* in the preceding sentence is to point out that their starting color data was not uniform! They asked 76 observers to grade 128 perceived color differences between these tiles and, from a statistical analysis of the results, derived formulas which describe a uniform space. As years went by, the following parameters were defined:

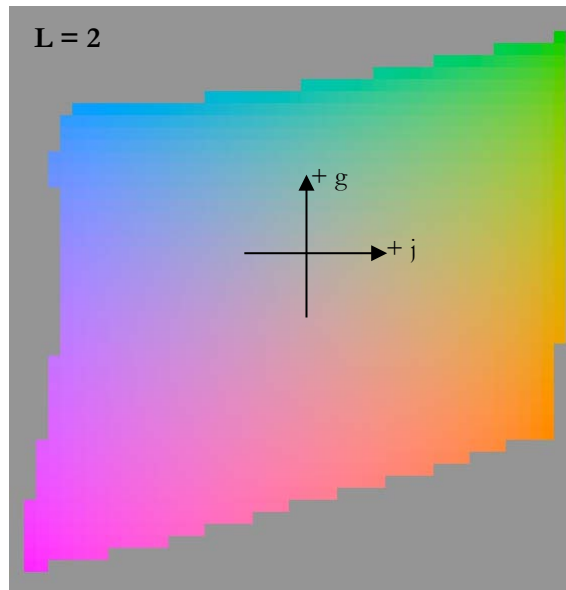
- The coordinates of the reference colors are characterized with the 10 degree Observer and Illuminant D65. These choices corresponded to the most appropriate observation conditions for the early 1970s, when the specifications were finalized. Of course, this creates a problem whenever a conversion to 2 degree based data is required, such as with all ICC based colorimetry, and it may be one important reason why the UCS is not that well known.
- A relatively complex set of conversion equations between XYZ coordinates (10 degree, D65) and the UCS geometry was defined. In a way, what was done here is similar to the transformations done to obtain the CIELUV space and its associated chromaticity diagram; however, the UCS conversion incorporates more perception phenomena than CIELUV. These equations can be used over the entire visual gamut, which is an enormous feat considering that the color set used in the initial studies was far from covering this range. However, this also means that we should exert caution when dealing with very saturated colors. Unfortunately, these equations are impossible to reverse, i.e. there are no equations that go directly from UCS coordinates to XYZ, and an iterative method is required; we start with some XYZ coordinates which are tweaked until we get the required UCS values.
- A reference background with a uniform 30% reflectance over all wavelengths was selected. This is a neutral gray where Y (of CIE XYZ) equals 30, where  $L^*$  (of CIE  $L^*a^*b^*$ ) equals 61,65 (with  $a^*=b^*=0$ ), and which corresponds to Munsell N 6/. It was assigned a UCS Lightness value of zero ( $L=0$ ). Lighter (brighter) shades have positive L values while darker shades have negative L values. All UCS colors shall be viewed on this background.



- The UCS color space basic geometry was borrowed from the one used in characterizing face-centered cubic crystals. The particular selected geometry (rhombohedra) is the one obtained by stacking round balls of the same size over a plane. The balls place themselves in a way that maximizes the packing density and it can be shown that the distance between each ball is the same. By associating the spatial distance to uniform color differences, the resulting color space is both visually and numerically uniform.

- v- The Lightness coordinates of UCS is assigned as a vertical axis. The UCS “L” is similar in concept, but not in scale, to the  $L^*$  of  $L^*a^*b^*$ ; it is also different by the fact that it includes a compensation for the reference background lightness. Note: This correction, called the Semmelroth formula, should have been included in CIELAB but was not, due to a mix of time constraints and the difficulty in getting CIELAB approved internationally. The L range goes from about +8 to -10.
- vi- The “j” and “g” coordinates were selected for the chromatic axes (see the illustration below). The UCS L, j, and g axes are perpendicular to each other, as in the XYZ and  $L^*a^*b^*$  color spaces. “j” stands for “jaune”, yellow in French, and is a yellowish to bluish axis, where +j is more yellowish and -j is more bluish. “g” stands for “green” and is a pinkish to greenish axis, where +g is more greenish and -g is more pinkish. “j” was selected to prevent potential confusion with the “y” of the CIE 1931 chromaticity coordinates. It is tempting to associate the “j” and “g” axes to the “a\*” and “b\*” ones of  $L^*a^*b^*$ , but they do not correspond to the same colors, and the progressions between the two axes end are different; for instance, there is no hue circle per se in UCS. The j and g ranges go from about +20 to at least -26 (even more negative values are possible). As we can infer from the maximum ranges of the L, j and g coordinates, the UCS space is neither perfectly round nor square, or even symmetrical; this was not the goal of the system designer since they concentrated their efforts on maintaining a perceived uniform color difference between colors.

In the illustration below,  $L=2$  for all data points. The area represented by the illustration, including the gray background, goes from -12 to +11 in j, and from -14 to +10 in g. The j and g axes cross at  $j=g=0$ , i.e.  $L_{jg} = (2, 0, 0)$ ; this is a light gray. We only show the patches which are within the sRGB gamut.

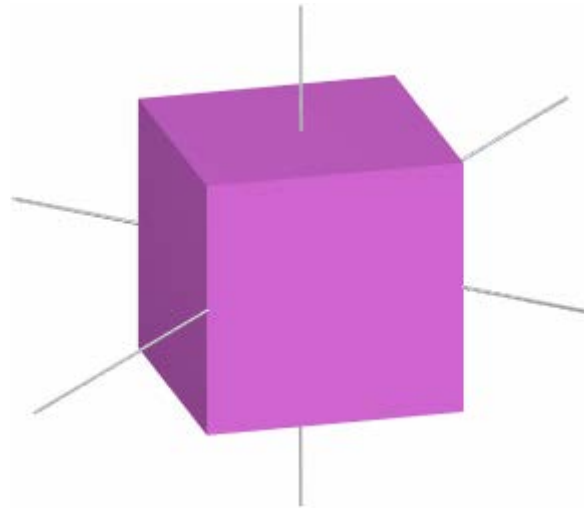


- vii- The number of colors for a proof-of-concept with real samples was estimated at 500. Additional constraints were that the proof-of-concept gamut was limited by the available acrylic paint pigments, and that the pigments did not contain hazardous materials. In the end, 558 samples were produced. 424 samples had colors located at uniformly separated color differences from one another. The other 134 samples were located around the neutral axis, at mid-points between uniform samples of the UCS coordinates. The samples were sold by the OSA until the stocks were depleted.

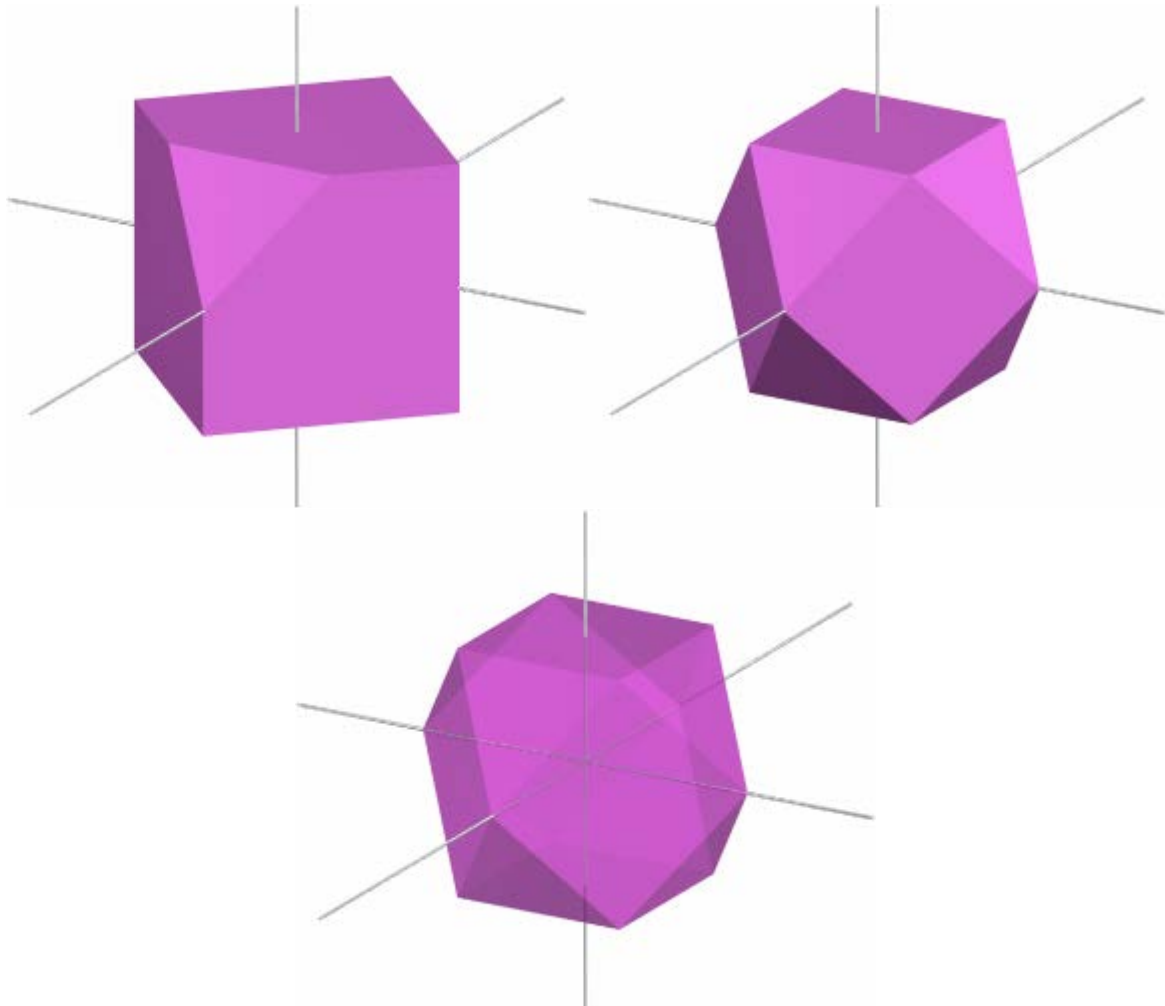
In 1967, after analyzing correlation data for many models under study, the committee was convinced that a perfectly uniform color space with a rhombohedral geometry could not be obtained for any fixed background. They nonetheless committed to produce the best approximation of such a space for a 30% neutral background. This stubbornness paid off. In 1972, after further studies which provided improved correlation results, the committee was finally ready to write specifications for proof-of-concept samples. These samples were ready in 1977, three years after the committee’s final report! Since then, many articles were published, analyzing the UCS performance, confirming its better overall uniformity characteristics compared to the Munsell system and even using it for independent validation of other color spaces uniformity.

### F-3. The UCS geometry

This UCS basic geometry is known under various names, such as a regular rhombohedral, a cubo-octahedron (or cuboctahedron), or face-centered cubic. One way to obtain this geometry is to start with a cube. As shown below, the cube is centered on the three-axis system's origin and its vertical edges are aligned on the two horizontal axes.

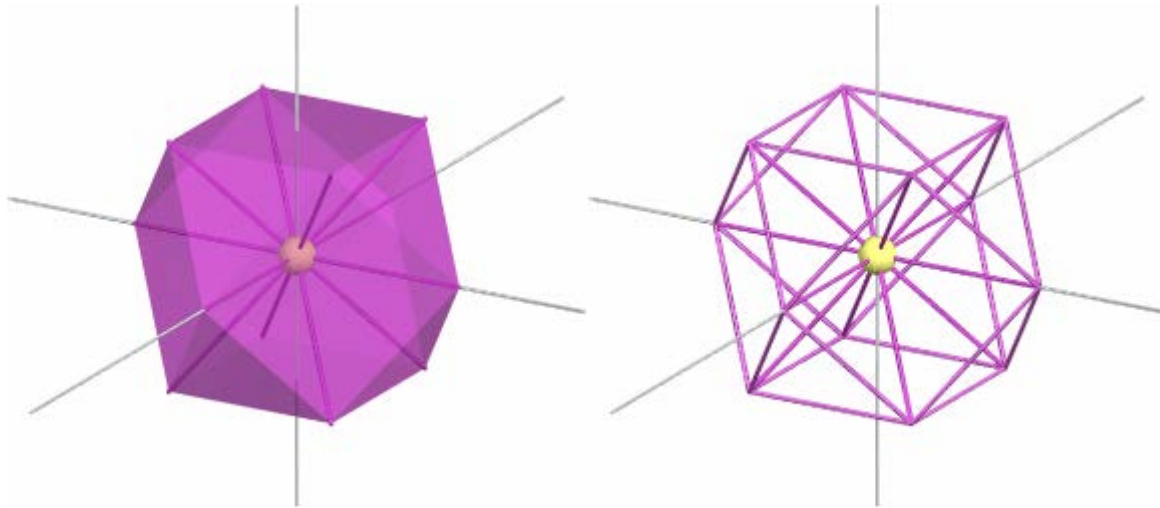


We then cut all eight corners in the manner illustrated below. The illustration on the left shows the first cut, which extends half-way on three edges of the cube. The illustration on the right shows the cube after the eight cuts, where it has become a cuboctahedron, with 12 vertices and a surface made of same-size squares and same-size equilateral triangles. The cuboctahedron on the bottom is semi-transparent, so that we can see the axes within the shape.



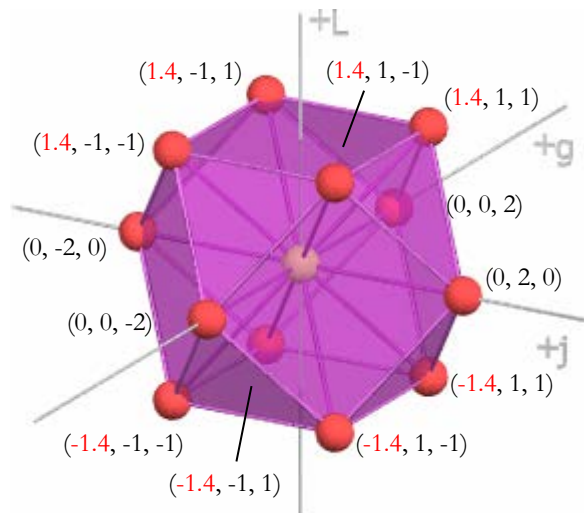


If you assign a color to the cube center, illustrated below by a yellow ball, it can be shown that the 12 vertices are located at the same distance from the center, as shown by the tubular links going out of the center in the illustration on the left. As well, the distances between the nearest neighbor vertices are the same as the distance from the center; this is illustrated on the right where all distances which are uniform, either between two vertices or between the vertices and the center, are shown with links.

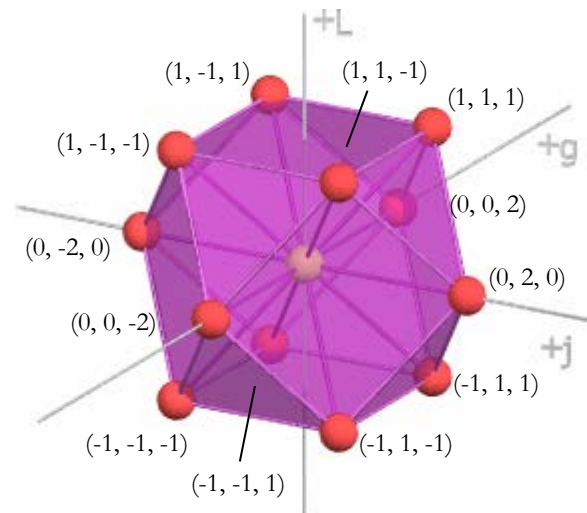


In the next step we will assign a color to each vertex, represented by a red ball, and show each color coordinates. Until now, we have never mentioned any dimensions for this shape. Let's assume that the **diagonals of each face of the original cube was 4 units** long (cm, inches, etc.); with such dimensions, we obtain the coordinates shown below left. We can easily find the original cube dimensions by looking at either the *j* or *g* coordinates in the  $L=0$  plane. For the *j* axis, the vertices are located at  $(0, -2, 0)$  and  $(0, 2, 0)$ , and the distance between these points is 4.

We see that the *L* coordinate for all the vertices on the two horizontal planes above and below the origin is "1,4" (the exact value is  $\sqrt{2} = 1,4142$ ). It would be awkward to use such a pitch for identifying the *L* plane and the UCS committee decided to rescale the "L" axis by assigning a pitch of one between each *L* plane, as shown on the bottom right. Now, if one was to use the rescaled coordinate values "as is" to measure the distance between the vertices, the distances would not be equal; to resolve this issue, we only need to add a scaling factor for *L* in the color-difference equation (shown on the next page). Since we rescale the axis numbers and NOT the axis dimensions, the cuboctahedron shape is unchanged. The visual spacing between each color, i.e. the measured distance, remains uniform in all directions and now corresponds to the computed color difference, maintaining one of the important goals of this new color space.



BEFORE rescaling the L axis



AFTER rescaling the L axis



The **UCS color difference formula** is defined as:

$$\Delta\text{UCS} = \{(\sqrt{2} * \Delta L)^2 + (\Delta j)^2 + (\Delta g)^2\}^{1/2} = \{2 * (\Delta L)^2 + (\Delta j)^2 + (\Delta g)^2\}^{1/2}$$

where the  $\sqrt{2}$  factor takes into account the rescaling done to the L axis coordinates discussed on the previous page. With this formula, **the difference between two neighbors is always equal to two (2)**. Here are a few examples of color-differences for neighbors and non-neighbors.

Example-1 (neighbors)

The color difference between the (1, -1, -1) and (1, 1, -1) points located on the top-front of the cluster, is:

$$\Delta\text{UCS} = \{(0)^2 + (2)^2 + (0)^2\}^{1/2} = 2 .$$

Example-2 (neighbors)

The color difference between the (1, -1, -1) on top, and the (0, 0, -2) point on the g axis, is:

$$\Delta\text{UCS} = \{2*(-1)^2 + (1)^2 + (-1)^2\}^{1/2} = \{4\}^{1/2} = 2 .$$

Example-3 (non-neighbors)

The distance between the two opposite corners on the top of the cluster, located at (1, -1, -1) and (1, 1, 1), is:

$$\Delta\text{UCS} = \{(0)^2 + (2)^2 + (2)^2\}^{1/2} = \{8\}^{1/2} = 2,8284 .$$

Example-4 (non-neighbors)

The distance between the (1, -1, -1) and (-1, -1, -1) points located on the top and bottom of the cluster respectively, on its left side, is:

$$\Delta\text{UCS} = \{2*(-2)^2 + (0)^2 + (0)^2\}^{1/2} = \{8\}^{1/2} = 2,8284 .$$

The three points used for Examples 1 and 4, (1, -1, -1), (1, 1, -1) and (-1, -1, -1), are collocated on a vertical plane characterized by  $g = -1$ . This plane is not aligned to one of the surfaces of the basic UCS cluster but we will see later that it is positioned in such a way that it can be useful to look at groups of colors in the UCS space.

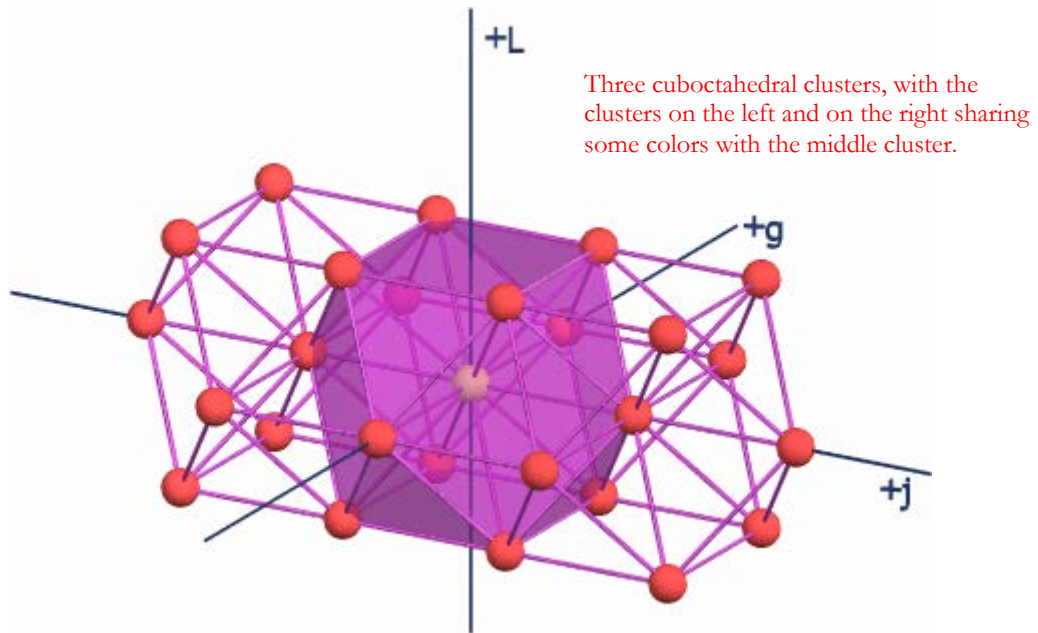
**Note:** The color-difference of 2 between each UCS neighbors corresponds to a CIELUV  $\Delta E^*_{uv}$  of 14,5 on average (CIELAB data is N.A.). The CIELUV difference varies significantly depending on the actual patches selected since the UCS space was designed to be more uniform than CIELUV and CIELAB.

**Important:** The (very cautious!) UCS committee did not claim that the UCS equations and the derived color-difference formula would provide an accurate method of computing large color differences for all visible colors. They made some measurements that suggest that a non-Euclidian formula may be required (a non linear correction with the same intent as what is done in CIEDE94 and CIEDE2000). They also noted that the UCS color-difference formula had not been designed or tested for small differences, i.e. for colors which almost match. In any case, it is certainly worthwhile to test UCS formula limits, as it may nicely complement the CIEDE94 and CIEDE2000 formulas which have been optimized for small color differences but are not considered reliable for large color differences.

**Important:** While not obvious at this point, because we strived to use only integer coordinates so far, it is important to realize that there can be UCS colors located anywhere between the vertices or within the volume defined by this unitary cluster of points, and that the vertices only represent the basic structure of the UCS space. Also, not all coordinates with integer coordinates are located on vertices.

At this point, we have defined the geometry of a basic UCS cluster and shown how, starting from a single color, we can position 12 neighboring colors at the same distance, thus forming a uniform geometrical shape we called a cuboctahedron. We have also seen that the neighbors are themselves at the same distance from the other closest neighbors. We have also defined a coordinate system which characterizes the position of each color and presented a color-difference equation which links the color coordinates with the perceived color-difference between these colors. With the basic UCS structure now in place, we can extend it to represent all colors.

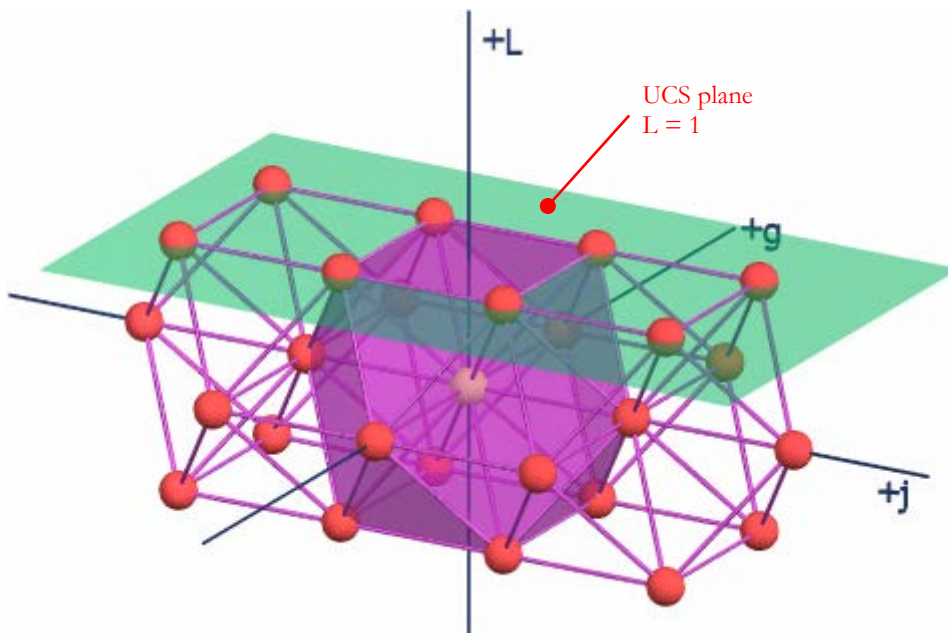
We can extend the basic cuboctahedral cluster in many ways. In the illustration below we have added colors on each side of our original cluster until we got three clusters, with some of the colors shared by the original cluster. When the space is filled around a color, the resulting structure is uniform in 6 directions and this color has 12 nearest neighbors located at the same distance. It is along these directions that we find *Uniform Color Scales*.



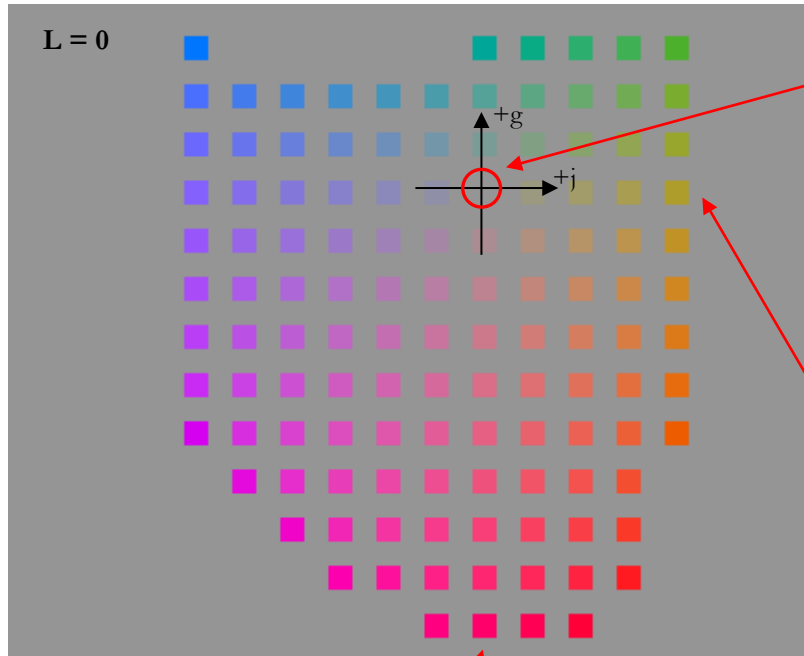
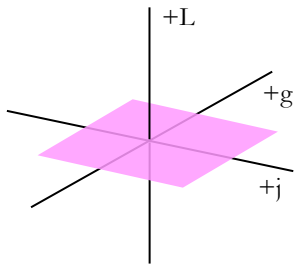
With such a repetitive structure, we can easily group colors which have a common value for one coordinate, or which have two coordinates linked by a simple mathematical equation. Expressed otherwise, there are colors which share a common plane in the same way as atoms in crystals share the same crystallographic plane. The simplest planes we can identify are the ones defined by the following relations:

$$\begin{aligned} L &= \text{constant} \\ j &= \text{constant} \\ g &= \text{constant} \end{aligned}$$

where the *constant* can be either positive or negative. The plane for  $L=1$  is illustrated below:



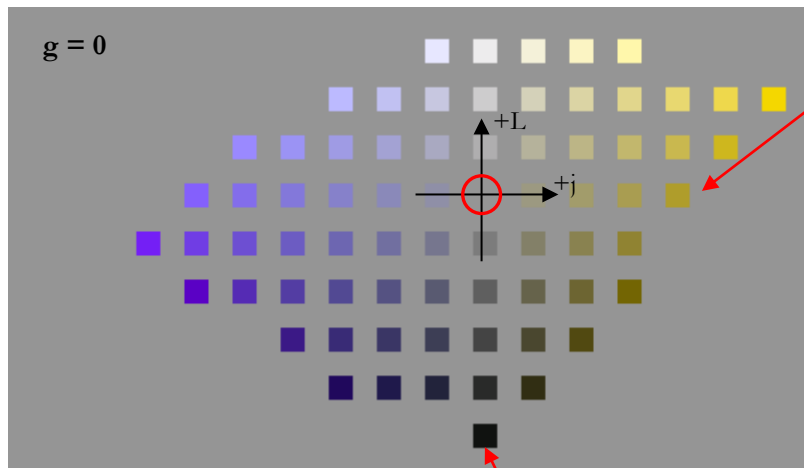
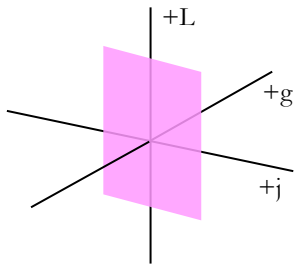
On the next page you can see the colors on three perpendicular planes corresponding respectively to  $L=0$ ,  $j=0$  and  $g=0$ . Only the patches which are inside the gamut of the sRGB space are shown. The  $j=0$  and  $g=0$  planes are two vertical planes that pass through the neutral axis.



$L_{jg} = (0, 0, 0)$   
 The patch color is the same as the UCS background. This patch is also identified by a red circle in the other two planes.

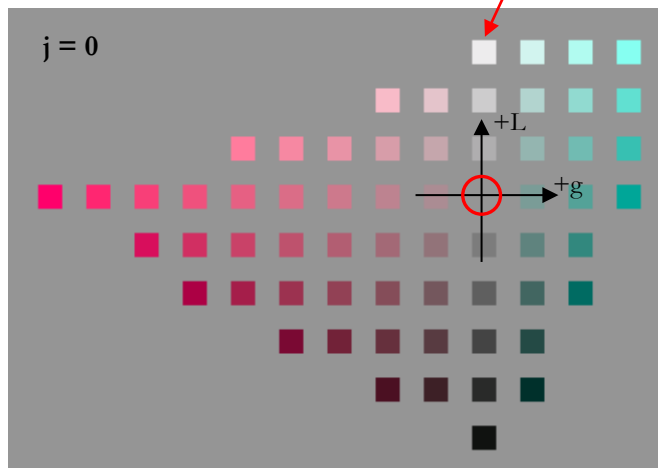
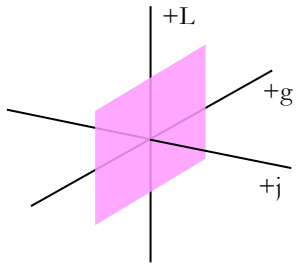
This column is the same as the  $L = 0$  row in the  $j = 0$  plane.

These two rows are the same



Note: As per the UCS color-difference equation, the **vertical** separation between each color for the  $g=0$  and  $j=0$  planes is 2,8284.

Neutral axis  
 $j = g = 0$



This row is the same as the  $g = 0$  column in the  $L = 0$  plane.

You will notice that the patches do not fill the planes completely but are separated by areas of color similar to the background; this is because only the locations which correspond to the cuboctahedron vertices were selected when generating the color list with PatchTool's [UCS Tool](#). The patches on L=constant, j=constant and g=constant planes have Ljg coordinates which are either all even or all odd; for the L=0, j=0 and g=0 planes, the coordinates are all even.

In the L=0 plane, all horizontal or vertical neighbors are separated by the nominal UCS color-difference of 2. In the j=0 and g=0 planes, all horizontal neighbors are separated by a color-difference of 2 while all vertical non-neighbors are separated by a distance of  $2,8284 (= 2 * \sqrt{2})$ . This is also true for all planes where g=constant as well as all planes where j=constant. These planes are uniform but the vertical steps are larger than the nominal UCS separation between neighbors by a factor of  $\sqrt{2}$ . Thus, in all these planes, and even if the j=0 and g=0 plane are not aligned to one of the surfaces of the basic UCS cluster, each row or column is a uniform color scale.

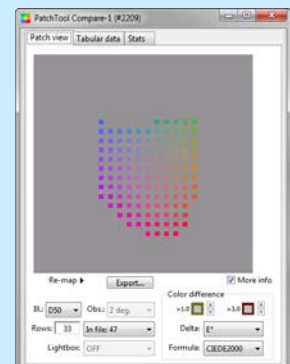
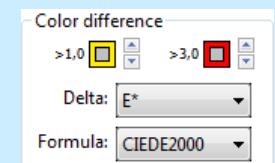
In the L=0 plane each row and column represents a color scale between two hues; all patches have the same UCS Lightness. While not as we are used to see, the transition between hues is very smooth (you can also look at the illustration of the [L=2 plane](#) a few pages ago for a similar view). In the j=0 and g=0 planes, each row represent a color scale between two hues of the same UCS lightness, and each column is associated to a single hue. At first glance, you may not consider the j=0 and g=0 planes scales as bringing a new perspective on color harmony, and you would be right, but we will get back to this aspect later. What we can notice though, is that the scales in these two planes are remarkably uniform when compared to what you would obtain with other color spaces.

**Note:** Color samples which have equal UCS lightness may not have the same Y (of XYZ), or the same L\* (of L\*a\*b\*), or the same Munsell Value.

### Mini-tutorial: How to generate a gamut-limited UCS color list

Illustrations such as the ones presented on the previous page can rapidly be obtained with PatchTool by first generating a UCS color list and then using the Clip check function in Gamut Tools. The procedure is as follow:

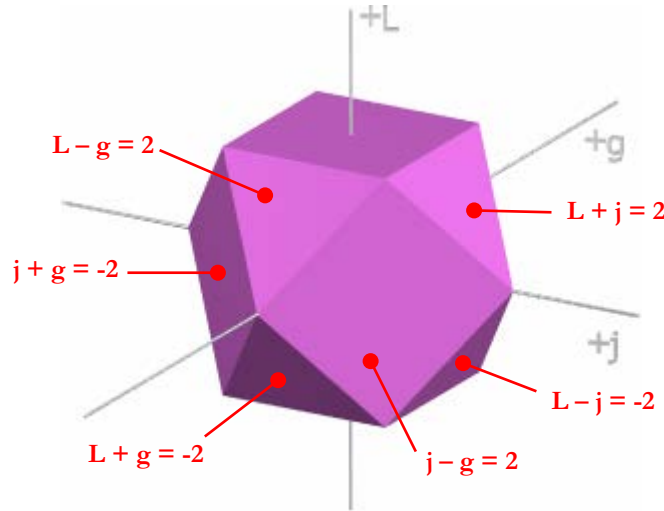
- 1- Open the [UCS Tool](#) dialog with the “Tools/OSA UCS...” menu.
- 2- Select “Grid steps” of 1; check the “Restrict patches to the following plane” checkbox; select the UCS “L” plane and set the plane value to 0 (zero).
- 3- Select a “List pitch” of 1. Click on the “Reset” button to maximize the range.
- 4- In the “Output options”, check the “List only ‘All-Even’ and/or ‘All-Odd’ coordinates” check box; click on the “Even” radio button; check the box to keep the discarded patches and check the box to keep “unreal” colors.  
Hint: Click on the “Default” button if you are not sure of the preferred settings.
- 5- Click on the “Build list” button and save the file when prompted.
- 6- Close the UCS Tool and open the list you just generated with PatchTool. In the [UCS Import](#) dialog, select the **2 degree Observer**. You can also open the list in a word processor or spreadsheet to see the information it contains. In particular, you will find all the settings used to generate the list.
- 7- Open the PatchTool [Gamut Tools](#) dialog “Tools/Gamut Tools...” menu and select the “Convert / Clip check” tab. Make sure the UCS list appears as the selected file.
- 8- In the “Destination profile” menu, select “sRGB (PatchTool)”. Set the rendering intent to “Relative Colorimetric” and uncheck the Black Point Compensation box.
- 9- Click on the “**Clip check**” button located in the “Data sent to PCS” box, on the upper-right of the dialog. The dialog will close and a Compare file will open.
- 10- In the Compare file, select “DeltaE\*” as the Delta parameter and adjust the thresholds so that the minimum threshold, the one on the left, is “>1,0” (the maximum threshold can be set to any larger value). Select CIEDE2000 as the dE formula. The “Color difference” settings of the Compare window should look as shown above right.
- 11- With the mouse cursor located on any patch, press on the shift key and on your mouse right-button (press shift + ctrl + mouse-click if using a one button Mac mouse) to show the [alternate contextual menu](#). In this menu, select “Replace ALL patches over Delta thresholds with the OSA-UCS background”. All the remaining “colored” patches are within the sRGB gamut with a maximum error of 1 DeltaE\*. The screenshot on the right shows the patches after the replacement.



In addition to the three planes series corresponding to each coordinates being a constant, the UCS system has six other series of planes defined by the following equations which link two coordinates together:

$$\begin{aligned}
 & \mathbf{j + g = constant} \\
 & \mathbf{j - g = constant} \\
 & \mathbf{L + j = constant} \\
 & \mathbf{L - j = constant} \\
 & \mathbf{L + g = constant} \\
 & \mathbf{L - g = constant}
 \end{aligned}$$

for a total of nine “cleavage” planes, in crystallographic parlance. Here also, the *constant* can be either positive or negative. These planes correspond to the faces of the basic cuboctahedron cluster shown previously:



Each of the visible faces of the cuboctahedron is parallel to a similar hidden face described by the same plane equation, but with a different constant. All these planes can pass through the origin ( $Ljg = (0, 0, 0)$ ) when the constant is set to zero.

We have seen previously that we can start from any given point and obtain a perceptively uniform suite of colors in six directions. You will notice that some planes consist of equilateral triangles where uniform patches can be found in three directions, along each edge of the triangle, while other planes are made of squares, where the patches are uniform in two directions. In these six plane series, the color-difference step in all the directions is 2.

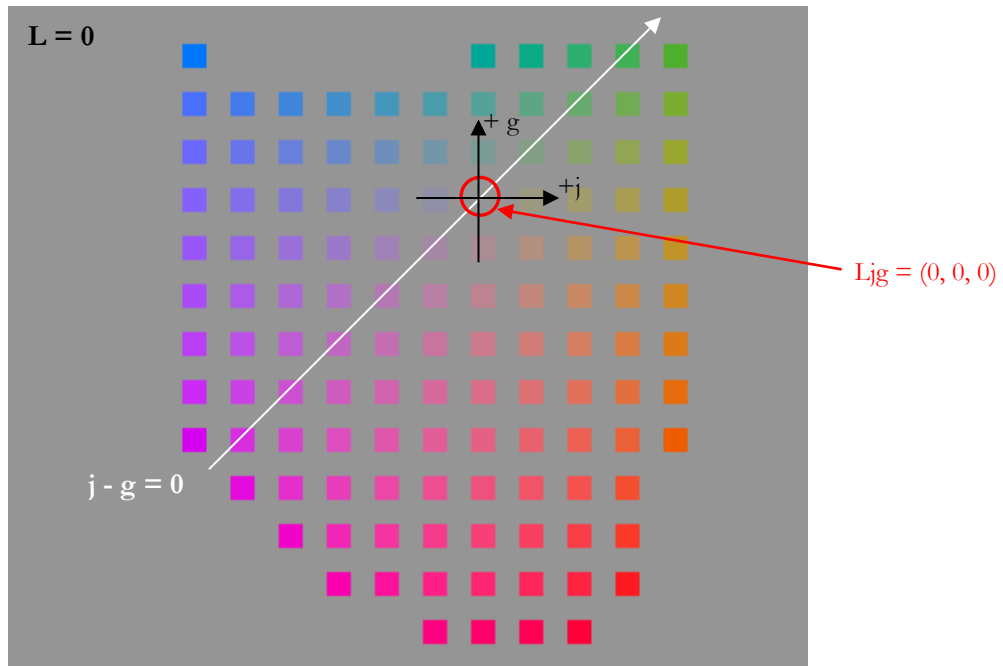
It is worth nothing that while the  $j+g=constant$  and  $j-g=constant$  planes are vertical planes, like the  $j=constant$  and  $g=constant$  planes seen previously, they are also aligned to faces of the basic UCS cluster. As a consequence, the colors appearing on such planes are uniform and of equal color-difference steps of 2 in two directions; however, these directions are not aligned horizontally and vertically, but along 45 degrees diagonals, following the edges of the basic cluster faces.

By selecting a plane, a plane constant, and a direction, one can obtain a very large array of *Uniform Color Scales*. We will now look at a few of these scales.

## F-4. Navigating in the Uniform Color Scales space

This section presents a few examples on what to expect and what to look for when navigating in the UCS space. This is far from being an exhaustive presentation since the nine UCS plane types can each be set to a large range of *constants*, resulting in hundreds of potential views; however, it should give the reader an idea of what the UCS offers. Files for some examples are provided with PatchTool; they can be found with the “Open Sample Files” menu.

Our first example is better understood if we start with the illustration of the L=0 plane previously shown, and reproduced below. In it we identify the location of the j-g=0 plane, which cuts vertically through the white line. With a constant equal to zero, this plane must pass by the space origin ( $L_{jg}=(0, 0, 0)$ ) with a 45 degrees angle.



The j-g=0 plane is shown below. It is vertical, with columns oriented parallel to the L scale, as illustrated on the previous page. Expressed otherwise, each row has the same L value, being located on a L=constant plane.

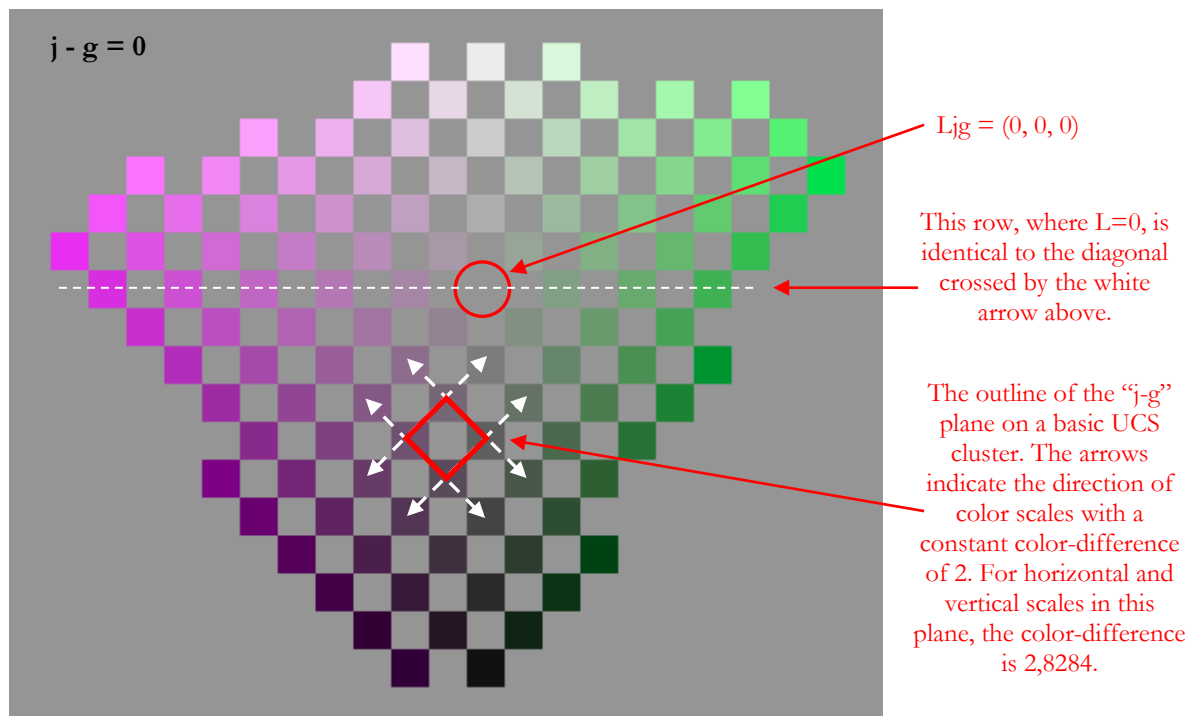
UCS L = constant  
in each row

Each column represents a  
single hue.

The saturation decreases  
as we get close to the  
neutral axis.

The colors on each side  
of the neutral axis are  
fairly complementary.

The file for this UCS  
color list is provided with  
PatchTool. Use the  
“Open Sample Files/  
Misc. Sample Files...”  
menu; then open the  
“Help-Manual\_files”  
folder.



As with all the vertical planes which pass through the origin, the tints on the left side of the neutral axis look complementary to the tints on the right, but one should be careful in making such statements since the UCS space was not designed around this concept. Exact complementary pairs would be accidental, even if somewhat true in practice!

**Note:** The patches shown here are limited by the extent of the sRGB space. The number of patches would be much bigger if we had limited the patches to the gamut of the Adobe RGB color space, but few monitors nowadays have such a gamut. We could also have decided to keep only the patches within the gamut of a printer profile; this would have been required if we wished to print the patches with a minimum of accuracy.

**Note:** The patches in the sample UCS files provided with PatchTool are NOT limited by a space or profile.

**Note:** We could also have looked at finer pitch scales, generated with a 0,5 pitch in each coordinate value, even if these coordinates do not fall on the vertices of UCS clusters. In such scales, the colors change more gradually, which is useful when selecting a color.

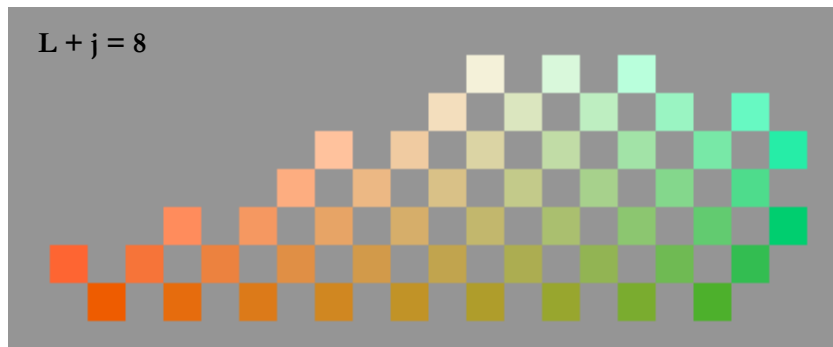
Our second example shows the  $j+g=6$  plane; this is also a vertical plane, with columns oriented parallel to the L scale. As with all perfectly vertical planes ( $j=\text{constant}$ ,  $j-g=\text{constant}$ , etc.), a column is associated with a unique hue; however, the horizontal and diagonal color scales produced by this plane type are quite different (and interesting!).

The file for this UCS color list is provided with PatchTool. Use the “Open Sample Files/ Misc. Sample Files...” menu; then open the “Help-Manual\_files” folder.



By selecting a plane which does not cross the neutral axis, one can obtain color scales where the hue changes significantly, but still in a uniform manner, between each column.

In the next example, we see the  $L+j=8$  plane; this plane crosses the L and j axes at an angle and it is parallel to the g axis. In the image below, the g axis goes from left (-g) to right (+g). Like in the example above, each row has the same L value, but here each column is not associated with a unique hue; this is due to the slanted orientation of this plane and we see a mix of Lightness and hue change. You will notice that while both planes shown on this page display greenish to orangish colors, they offer a different perspective on close neighbor's variations.



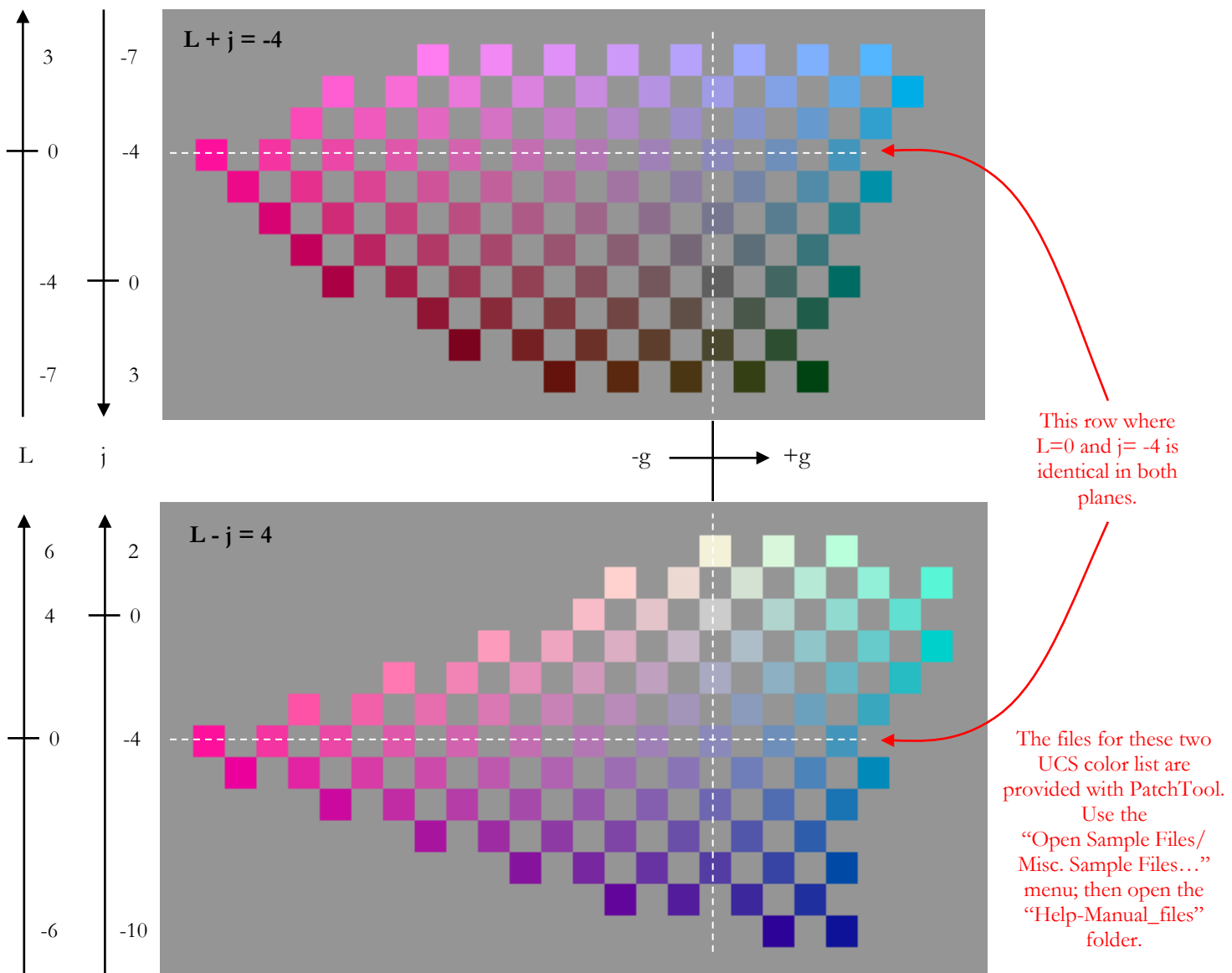
Because of the “L+j” plane orientation, the hue changes within each column.



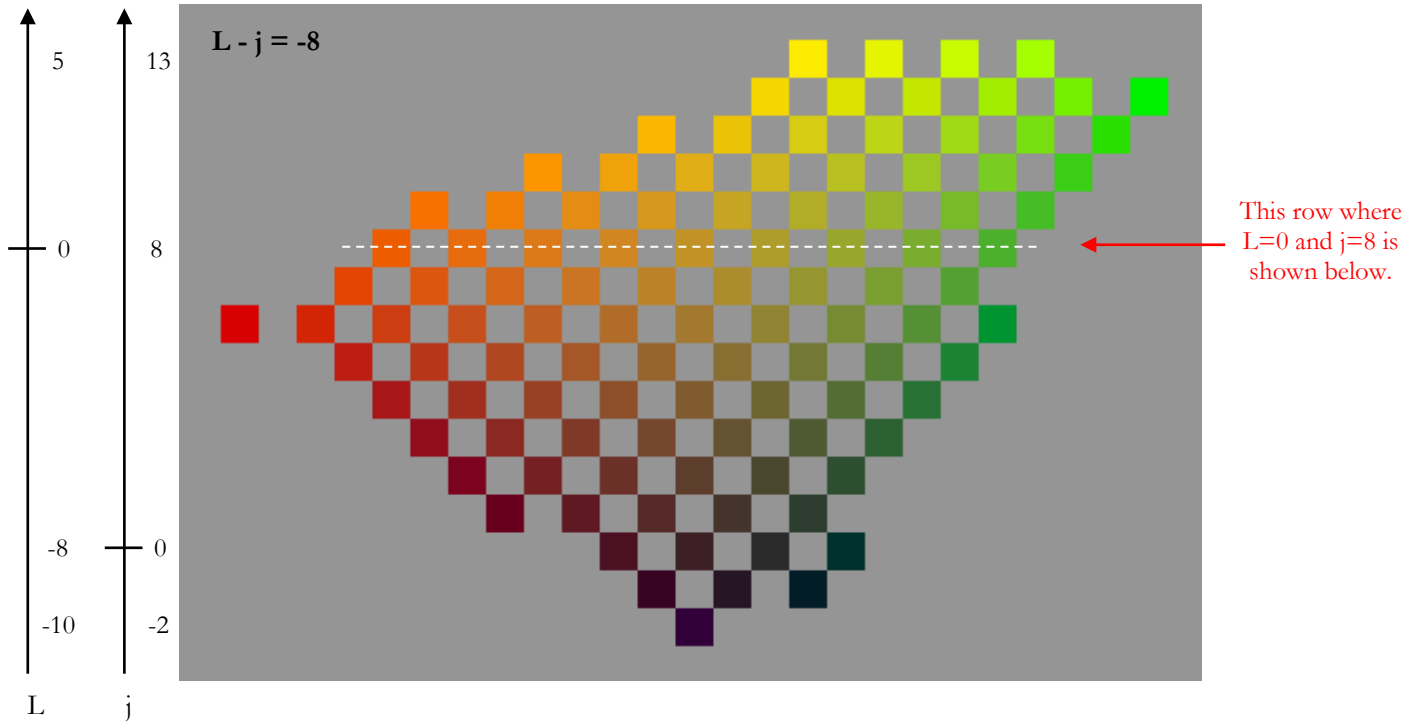
The next two planes,  $L+j=-4$  and  $L-j=4$ , both cross the  $L$  and  $j$  axes at an angle, and are parallel to the  $g$  axis. You can refer to the illustration of the [UCS planes](#) shown previously to better visualize their orientation. Also, in both, the values of  $j$  and  $L$  are the same for all patches of a given row. They even have an identical row (identified below); this common row is the intersection of the two planes where  $L=0$  and  $j=-4$ . However, because the planes are oriented differently in the UCS space, the rows above and below this common row are very different. As for  $g$ , it increases from left to right and is the same value in each column; it is also independent of the other two variables.

In order to meet the requirements of the  $L+j=-4$  plane equation,  $j$  is negative for brighter patches ( $j=-7$  for  $L=3$  for the top row in the example), and  $j$  is positive for darker patches ( $j=3$  for  $L=-7$  for the bottom row). Thus, to validate the equation,  $j$  varies from  $-7$  to  $3$  from the top row going down, and  $L$  changes from  $3$  to  $-7$  in the same direction; here, while  $j$  increases,  $L$  decreases, and vice-versa. With a similar reasoning for the  $L-j=4$  plane,  $j$  varies from  $2$  to  $-10$  from the top row going down, and  $L$  changes from  $6$  to  $-6$  in the same direction; in this plane,  $L$  and  $j$  increase and decrease in sync.

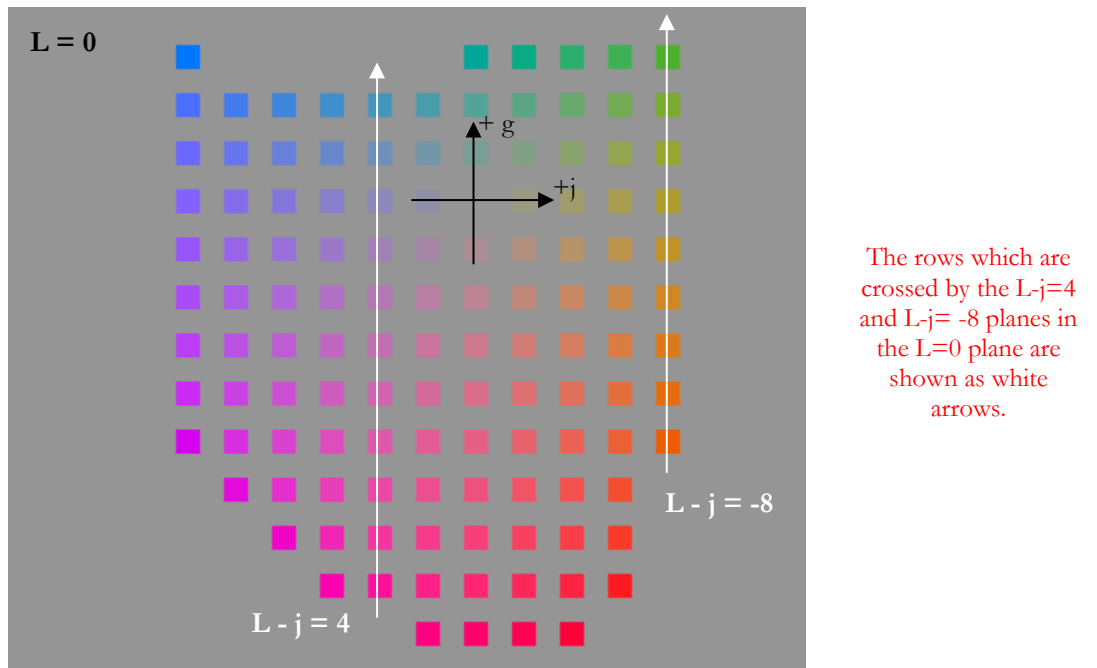
As in the previous example, these planes are not parallel to the  $L$  (neutral) axis, the color scales of the columns do not correspond to a single hue and we see a mix of Lightness and hue change. This is particularly striking in the  $L+j=-4$  plane because the colors near the top of the illustration are more saturated. The  $L+j=-4$  plane also shows interesting scales between kaki and cyan in the diagonals on the bottom-right of the illustration, while the  $L-j=4$  plane shows purplish to cyan scales in the same region.



The  $L-j = -8$  plane below should be compared with the  $L-j=4$  plane on the bottom of the preceding page. While being both  $L-j$  type planes, their plane constants are such that they represent very different hue regions. The  $L-j=4$  plane is on the bluish side of the  $j$  axis and the  $L-j = -8$  plane is on the yellowish side of the  $j$  axis. The rows which these planes cross on the  $L=0$  plane are shown on the bottom of this page.

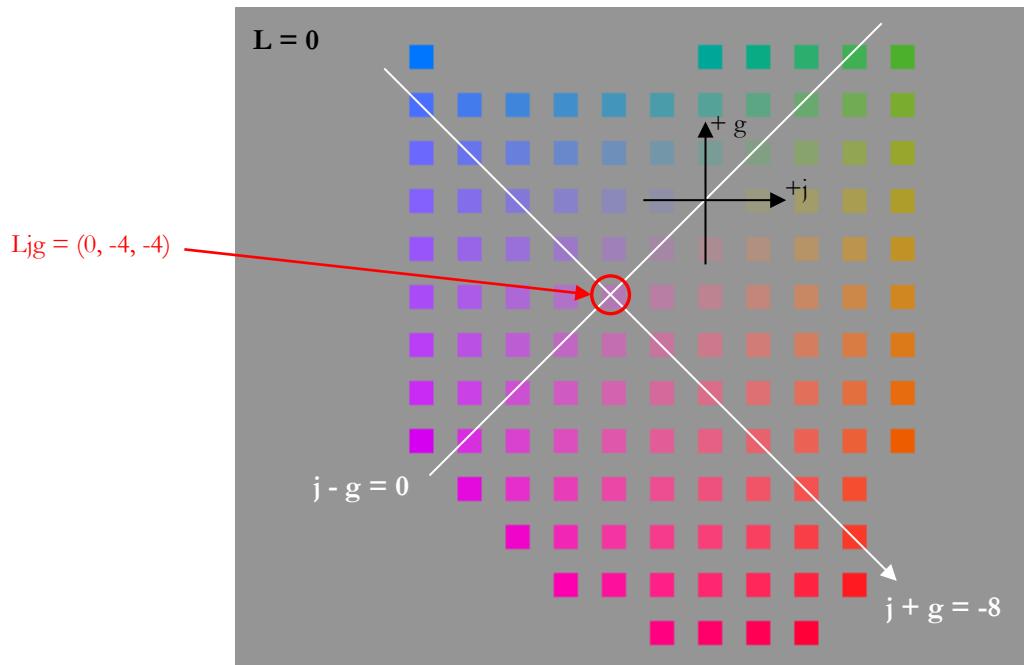


From these row positions we see that increasing  $j$  above the  $L=0$  plane means going to the right of each white arrow. For the  $L-j=4$  plane, this brings us towards the neutral axis, and since  $L$  increases at the same time as  $j$ , the patches tend effectively towards bright unsaturated colors (i.e. white). For the  $L-j = -8$  plane, increasing  $j$  brings us toward brighter and more saturated colors; these saturated colors are not present in the  $L=0$  plane but the image above tells us that they extend up to  $j=13$  in the  $L=5$  plane.

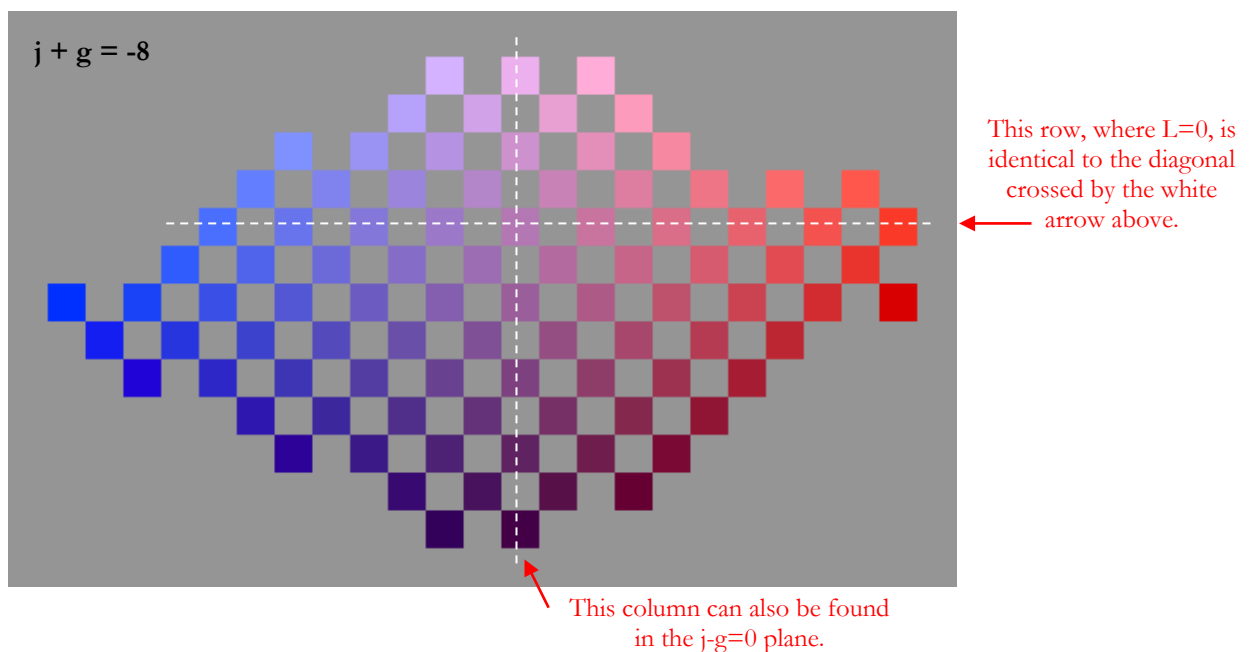


The rows which are crossed by the  $L-j=4$  and  $L-j = -8$  planes in the  $L=0$  plane are shown as white arrows.

For the last example, we look at red-to-blue color scales defined with the  $j+g = -8$  plane. We will use the  $L=0$  plane once more to locate this vertical plane. The position of the  $j-g=0$  plane used for the first example is also shown. As we see, they have one column which intersects; it is the column defined by  $j=g = -4$ . We can easily confirm that these are the correct coordinates by using them with each plane equation ( $j+g = -8$  and  $j-g=0$ ).



The  $j+g = -8$  plane is shown below. The column which intersects the  $j-g=0$  plane is identified, and you can find the same column in the [j-g=0](#) illustration. Once you have a basic understanding of the way planes and coordinates are linked in the UCS, it becomes quite easy to navigate in various directions. In particular, once you know the coordinates of a color, you can determine the nine UCS planes where it can be located. For example, let's start with the  $Ljg=(0, -4, -4)$  patch located on the  $L=0$  plane above, and for which we already know that it is also located on the  $j-g=0$  and  $j+g = -8$  planes. If you would like to see this patch in a  $L+j$  type plane, you would find the plane constant by simply inserting the patch coordinates in the plane equation, or  $L+j=0 + (-4) = -4$  for this plane. For the  $L-g$  plane type you would select the  $L-g=0 - (-4)=4$  plane. You would also find this color in the  $j=-4$  plane, the  $g=-4$  plane, the  $L-j=4$  plane, and the  $L+g = -4$  plane.

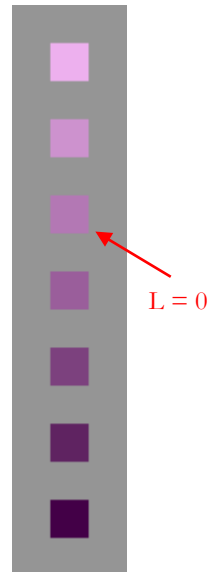


## F-5. A comparison: A UCS color ramp vs a CIE 1931 color ramp

At this point you should be convinced that the UCS space is one of the most, if not the most, uniform color space available! Still, we have not shown one comparison between a color scale derived from it and a more traditional color space. This is what we will present in this section.

We will start by isolating a particular scale. We have selected the column located at the intersection of the  $j=g=0$  and  $j+g=-8$  planes discussed in the last example on the previous page. It is shown on the right. The column coordinates are  $j=g=-4$  and  $L$  varies from  $+4$  to  $-8$ . This column can be found in the following **vertical** planes:  $j+g=-8$ ,  $j-g=0$ ,  $j=-4$ , and  $g=-4$ . We would not find this column in the other five planes since we are looking for the **entire column**, and not only a single color. A mini-tutorial is presented below if you want to generate this column with PatchTool.

We have selected this scale because it shows a light to dark ramp for a single hue. In the CIE 1931 chromaticity diagram, a single hue is represented by a unique set of  $x$  and  $y$  coordinates, which remains the same for all luminance or Lightness levels (the  $Y$  of  $xyY$  or the  $L^*$  of  $L^*a^*b^*$ ). We can then easily compare the ramps of the two systems. We first need a reference point in both systems, where the two colors should perfectly match. The chosen reference is the patch with  $L=0$  in the UCS space, which corresponds to  $L^*=58,5$  in the CIE system, about midway in the luminance scale. By selecting a midpoint reference, we can better assess how the systems compare above and below the reference point, and without benefiting one system over the other.



### Mini-tutorial: How to generate a single color scale with PatchTool

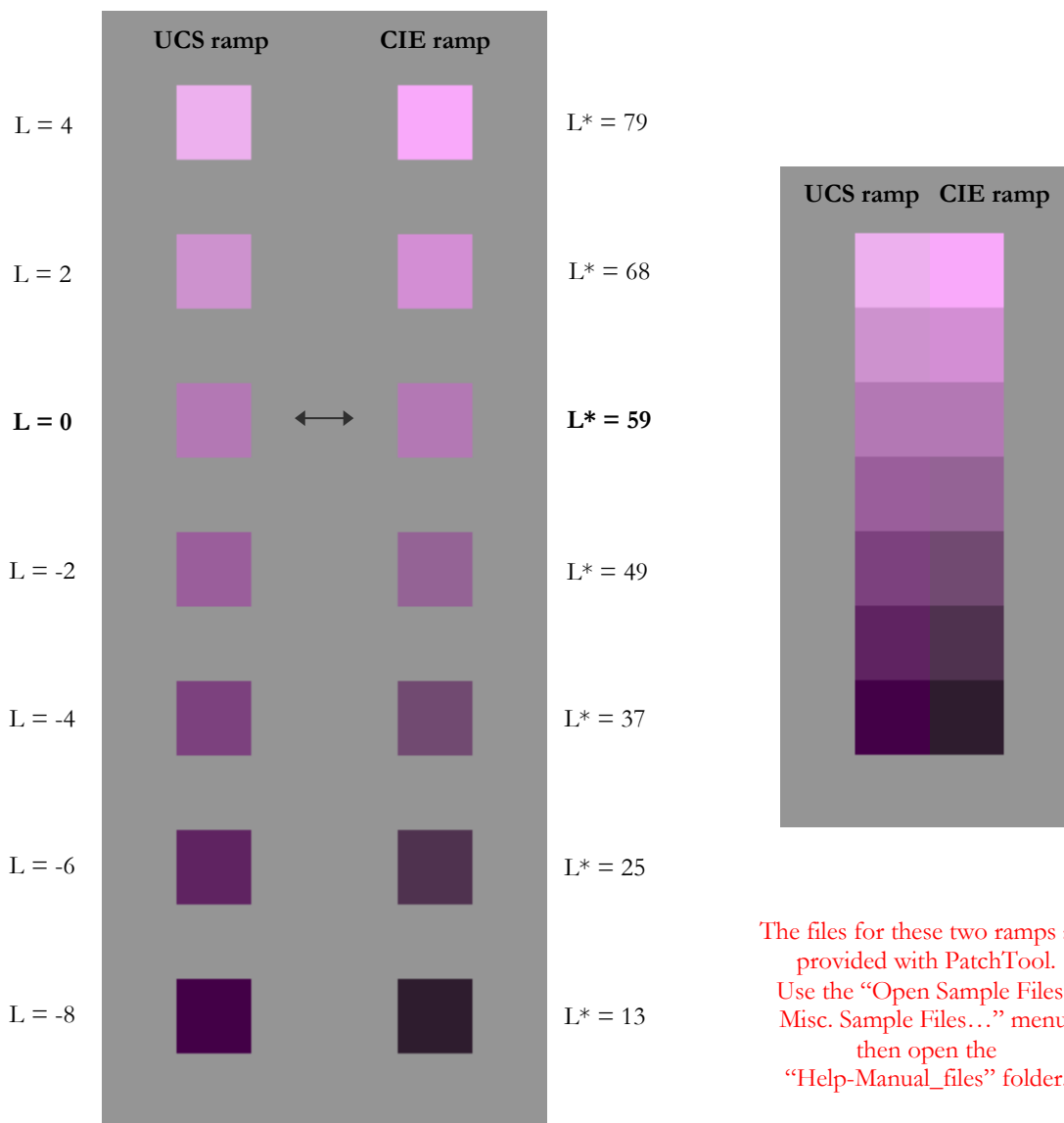
The following procedure can be used to generate the single column color scale presented in this section (shown just above this Tutorial box). We want to see the patches where  $L$  varies between  $+4$  and  $-8$  for  $j=g=-4$ . We will generate the list in such a way that we have a gray border around and between the patches.

- 1- Open the [UCS Tool](#) dialog with the “Tools/OSA UCS...” menu.
- 2- In ‘Grid options’, click on the “Default” button. Check the “Restrict patches to the following plane” checkbox; select the UCS “ $j + g$ ” plane and set the plane value to  $-8$  (**minus 8**).
- 3- Select a “List pitch” of 1. Click on the “Reset” button to maximize the range.
- 4- First adjust  $L$  MAX to 5, and then  $L$  MIN to  $-9$ ; these limits are one step higher and lower than the required range but we will use the extra range as gray background.
- 5- First adjust  $j$  MAX to  $-3$ , and then  $j$  MIN to  $-5$ . As with  $L$ , we selected more range than required to generate patches around our color scale. You will notice that  $g$  MIN also changes when  $j$  MAX is set, and that  $g$  MAX is changed when  $j$  MIN is set; these changes are required in order for the  $j$  and  $g$  coordinates to meet the selected plane equation and plane constant. For our settings,  $j$  MAX +  $g$  MIN =  $j$  MIN +  $g$  MAX =  $-8$ . A small drawing at the right of the range selection controls shows a cross under  $j$  and  $g$ , as a reminder of how the coordinates are linked.
- 6- Under the range selection controls you should now see that the list will consist of 45 patches.
- 7- In the “Output options”, check the “List only ‘All-Even’ and/or ‘All-Odd’ coordinates” check box and click on the “Even” radio button. We specifically do not want to see colors in the patches with “odd” coordinates located on the adjacent columns; they will be replaced with gray patches. Select the box to keep discarded patches.
- 8- Keep “unreal” colors. Note: The “unreal” check is redundant since all list colors are within the human eye gamut, but it is a good habit to select it when generating color lists for which it is important to maintain the visual layout.
- 9- Click on the “Build list” button, save the file when prompted, and close the UCS Tool. Before opening the file in PatchTool, you may want to open the list in a word processor or spreadsheet to see the information it contains. You will see that over two third of the data consists of patches with the UCS background color  $L_{jg}=(0, 0, 0)$ .
- 10- Open the list you just generated with PatchTool. In the [UCS Import](#) dialog, select the **2 degree Observer**. You should select the 2 degree Observer if you intend to use the color values in printed images or with an ICC managed program (essentially all printing and graphic design tasks), as we do here.
- 11- If required, you can export this list as an image. If exporting RGB data, you should first select the RGB space in the opened file “Tabular data” Tab. We have selected “sRGB (PatchTool)” for the example above. Then click on the “Export” button or select the “File / ‘Save / Export...’” menu.
- 12- In the “Image” Tab of the “PatchTool Export” dialog, set the image parameters as per your requirements. We selected an RGB file type with 8-bit; you can verify the RGB space in the file below the file name.  
Note: The illuminant shown under the file name is irrelevant for RGB data since the prescribed RGB space illuminant will always be used.

The UCS ramp, imported using the 2 degree Observer, is on the left side of each illustration below; the CIE ramp is on the right side of each illustration. The identical patch in each ramp is the third from the top. The CIE patches were determined as follow:

- The CIE reference was set to UCS patch  $L_{jg}=(0, -4, -4)$ , which corresponds, for Illuminant D65 and the 2 degree Observer, to  $XYZ=(33.71, 26.46, 46.66)$ ,  $xyY=(0.31558, 0.24767, 26.46)$ , and  $L^*a^*b^*=(58.47, 32.94, -22.39)$ .
- For all other CIE ramp patches, the x and y coordinates were kept constant and their CIE luminance (Y) was matched to the CIE luminance of the UCS patches (this is also true for the Lightness  $L^*$ ).

We see that the patches in the **CIE ramp** are **more saturated** than in the UCS ramp **for patches with UCS  $L>0$** , and are **less saturated** than in the UCS ramp **for patches with  $L<0$** . If we drew the corresponding CIE xy chromaticity of the UCS patches, we would see that they are farther from the illuminant for darker patches and that they get closer as UCS L increases; of course the two ramps match at  $L=0$  because this is the selected reference.



The darkest CIE ramp patch is almost black compared with the UCS patch, and the other darker patches have a muddled look. The darkest UCS patch is somewhat too saturated when not fully surrounded by a gray background, in the right illustration, but looks better with the background, on the left illustration. Overall, the UCS ramp is arguably more uniform than the CIE ramp. This is amazing since its equivalent CIE chromaticities are different for each patch; in the CIE reference frame, this means that we *should* see different hues for each UCS patch, but we definitely don't!

## F-6. UCS usage

The stock of the original UCS color set made of 558 samples has long been depleted and is no longer available from the OSA. It was recently estimated that preparing the pigments and mixing the paints with a similar precision would be cost prohibitive. Fortunately, because the space was formally mathematically defined, we can regenerate and view these colors on monitors. Also, with modern ink-jet printers, we can print these patches with excellent accuracy and over a greater gamut than the one used in the original development.

The OSA UCS has obvious use in any study related to the perception of uniform colors. However, the complexity of the conversion between UCS L<sub>jg</sub> and CIE XYZ and the lack of equivalent values for the 2 degree Observer may have limited such studies. It is hoped that the import, export, conversion, and list generation tools in PatchTool can help foster UCS use.

For graphic design and artistic painting applications, the unique color scales that can be found in the UCS space offer new possibilities in color harmony. The possibility of getting CIE L\*a\*b\* values for the 2 degree Observer will facilitate the transfer of UCS color scales data in all ICC based applications.

And what can the UCS do specifically for color-management people?

Here are two such applications, in the form of mini-tutorials. They are presented on the following pages.

- [How to check a MONITOR profile with a UCS list filling its gamut](#)
- [How to compare the gamut of two devices with a UCS list](#)

## Mini-tutorial: How to check a MONITOR profile with a UCS list filling its gamut

We suggest you also read the following application note available from the BabelColor Web site:

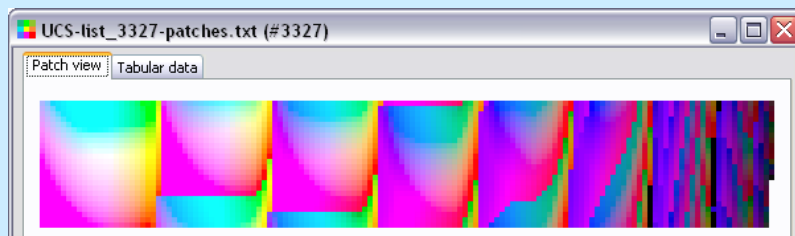
[AN-4a Using PatchTool for Idealliance MONITOR proofing certification](#)

There are a few differences between the above document and this tutorial. The Idealliance proofing certification uses predefined color lists which cover the gamut of standard press processes, where the color values correspond to standard printing targets, such as IT8.7/4, and where it is important that all colors in the list are **within** the gamut of the monitor used to proof images that will be sent to press. In this tutorial, we take many steps to generate a **custom list** which **completely fills** the monitor gamut with a **very uniform** sampling. You should note that the same procedure can be used to create color lists for any device which is defined by an ICC profile, such as printers or presses.

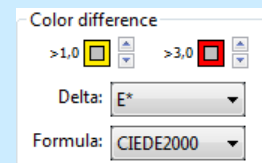
You can also generate a color list that fills a device gamut with equally spaced  $L^*a^*b^*$ ,  $L^*C^*h$  or XYZ coordinates in the [Gamut Tools](#) (Look for the “[Device independent spaces](#)” section in the “[List gen](#)” Tab). As in this procedure, the list is constrained by a device profile. Such lists are less uniform than UCS lists, but they can be generated much faster.

Please note that some steps of this tutorial require the use of a spreadsheet application.

- 1- Open the [UCS Tool](#) dialog with the “Tools/OSA UCS...” menu.
- 2- In ‘Grid options’, click on the “Default” button. The “Restrict patches to the following plane” checkbox should remain **unselected**.
- 3- Select a “List pitch” of 2. Click on the “Reset” button to maximize the range.
- 4- In the “Output options”, the “List only ‘All-Even’ and/or ‘All-Odd’ coordinates” check box should be disabled. Now **uncheck** the “Keep ‘unreal’ colors (replace by gray)”. These output options will generate colored patches covering the entire plane and will discard unreal colors which are outside of the visible gamut. The maximum number of patches is shown under the range selector. Do not be too concerned by the large number of patches at this point because there are many unreal colors and most of the remaining colors are outside of the profile gamut.
- 5- Click on the “Build list” button, save the file when prompted, and close the UCS Tool.
- 6- Open the list you just generated with PatchTool. In the [UCS Import](#) dialog, select the **2 degree Observer** since we intend to use to process the list via an ICC profile which is designed to work only with 2 degree Observer data.

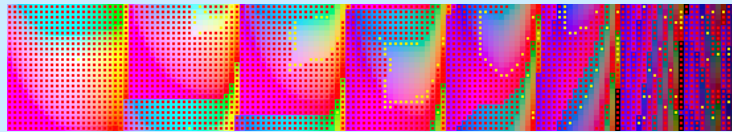


- 7- If you wish, change the illuminant from D65, the prescribed UCS illuminant, to D50, the default ICC illuminant and the illuminant used for Photoshop  $L^*a^*b^*$ .  
Note: In ICC conversions, the data is always converted from the current file illuminant, D65 or another, to D50.
- 8- Open the [Gamut Tools](#) from the Tools menu. Select the “Convert / Clip check” Tab. If not already selected, select the color list you just generated in the PatchTool file menu.
- 9- In the **Destination profile** menu, select your monitor profile. If your profile is not present, either browse or drag and drop your profile on this menu control. The menu also offers shortcuts to folders which contain ICC profiles.
- 10- Select the “Relative Colorimetric” rendering intent with NO “Black Point Compensation”.
- 11- Click on the “**Clip check**” button located in the “Data sent to PCS” box, on the top-right of the dialog. The dialog will close and a [Compare](#) file will open.
- 12- In the Compare file, click in the “More info” checkbox if not selected. Select “Delta E\*” and the CIEDE2000 dE formula. Set the left threshold to “>1,0” and the right threshold to “>3,0”. Click once in both threshold border selectors so that thick borders are shown. The “Color difference” settings of the Compare window should look as follow:



Most of the patches in the Compare file should have red borders (or the color selected for the high threshold if you changed it) and very few patches should have yellow borders. The patches with no borders all returned from the clip check with errors smaller than the lowest threshold. They are usually grouped in clusters, as we see on the next page.





- 13- We will now replace all patches over threshold with black patches. With the mouse cursor located on any patch, press on the shift key and on your mouse right-button (press shift + ctrl + mouse-click if using a one button Mac mouse) to show the [alternate contextual menu](#). In this menu, select “Replace ALL patches over Delta thresholds with BLACK”. All the remaining “colored” patches are within the monitor profile gamut with a maximum error of 1 DeltaE\* (i.e. the value we selected as the lower threshold).



- 14- Go in the “Tabular data” Tab of the file and click on the “Y” (of XYZ) column title of the Reference (Reference data are on a green cell background). If XYZ data is not available, do a right-click on the table header and select “XYZ”. Note: Be sure NOT to click on the “Y” of CMYK. Sorting will take time since there are many similar patches with Y=0. Once sorted, the “Patch view” should look like this:



We now need to remove the black patches and keep the colored ones.

- 15- Export the Compare file. The “PatchTool Export” dialog is opened by clicking on the “Export...” button of the [Main window](#), or the buttons of the same name shown in the “Patch view” and “Tabular data” tabs of the file, or via the “File / Save / Export...” menu. Select only the “ID”, “Name” and “XYZ” data fields, and click on the “Export” button when ready. The proposed file name will start with “Clip-check\_Compare-...”. The next four steps have to be done in a spreadsheet program, Microsoft Excel or other.
- 16- Open the saved Compare file in a spreadsheet. **Delete columns “F” plus.** If you have followed the instructions precisely when exporting the data, and if the file is properly opened in the spreadsheet application, you should **keep** columns “A”, “B”, “C”, “D”, and “E”, and **delete** columns “F”, “G”, “H”, “I”, “J”, “K”. We just kept the *Reference* XYZ values and discarded the other *Reference* data as well as all the *Sample* data returned from the Clip check.
- 17- **Delete the header rows;** these are the first thirty rows or so, **including** the row where many cells contain the words “Ref”, but **not including** the row with “ID”, “Name”, “X”, “Y”, and “Z”.
- 18- **Delete all the rows containing black patches,** easily identified by Y values of zero. The top of the shortened spreadsheet should look like this (the actual ID numbers and data values will differ):

	A	B	C	D	E	F	G
1	ID	Name	X	Y	Z		
2	3327	Ljg-10+0+0	0.537757	0.582740	0.447789		
3	3284	Ljg-8-6+2	1.773902	1.049996	7.893570		
4	3285	Ljg-8-6+0	2.272867	1.158597	7.683273		
5	3293	Ljg-8-4+2	1.461653	1.331860	5.440899		

- 19- **Save** the spreadsheet under the **same format** (.txt or Tab-Delimited) but under **another name**. Important: Close the file in the spreadsheet application. It may be impossible to open the file in PatchTool if it is still opened in the spreadsheet application.
- 20- Open the file you saved from the spreadsheet in PatchTool. Assign D50 and the 2 degree Observer on import. The opened file should have between 450 and 600 patches for standard gamut Mac or Windows monitors (more for wide gamut monitors), and should look somewhat like the screenshot on the right (shown in a much reduced size).
- 21- Open the PatchTool [Display-Check](#) from the Tools menu. Select the measuring instrument. The Destination profile is always the profile assigned by the OS to the display on which the Display-Check dialog is located; in a multiple display system, you can move the dialog between monitors and see the Destination profile change. Select the “PatchTool file” radio button and make sure the shortened UCS list is selected in the menu; click on the “Start” button when ready.
- 22- A Compare window will open at the end of the measuring sequence. Looking at the [“Stats”](#) Tab, you will get a detailed evaluation of your monitors’ accuracy.

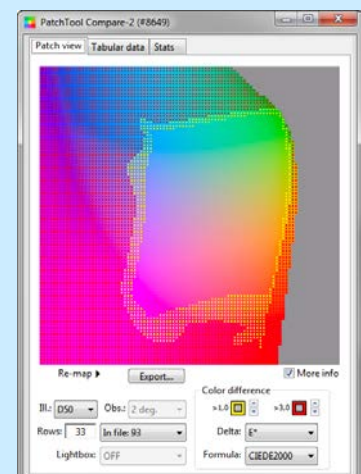
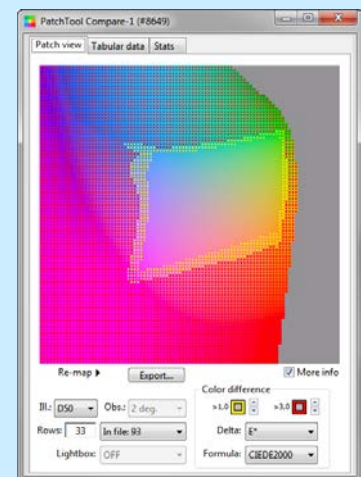


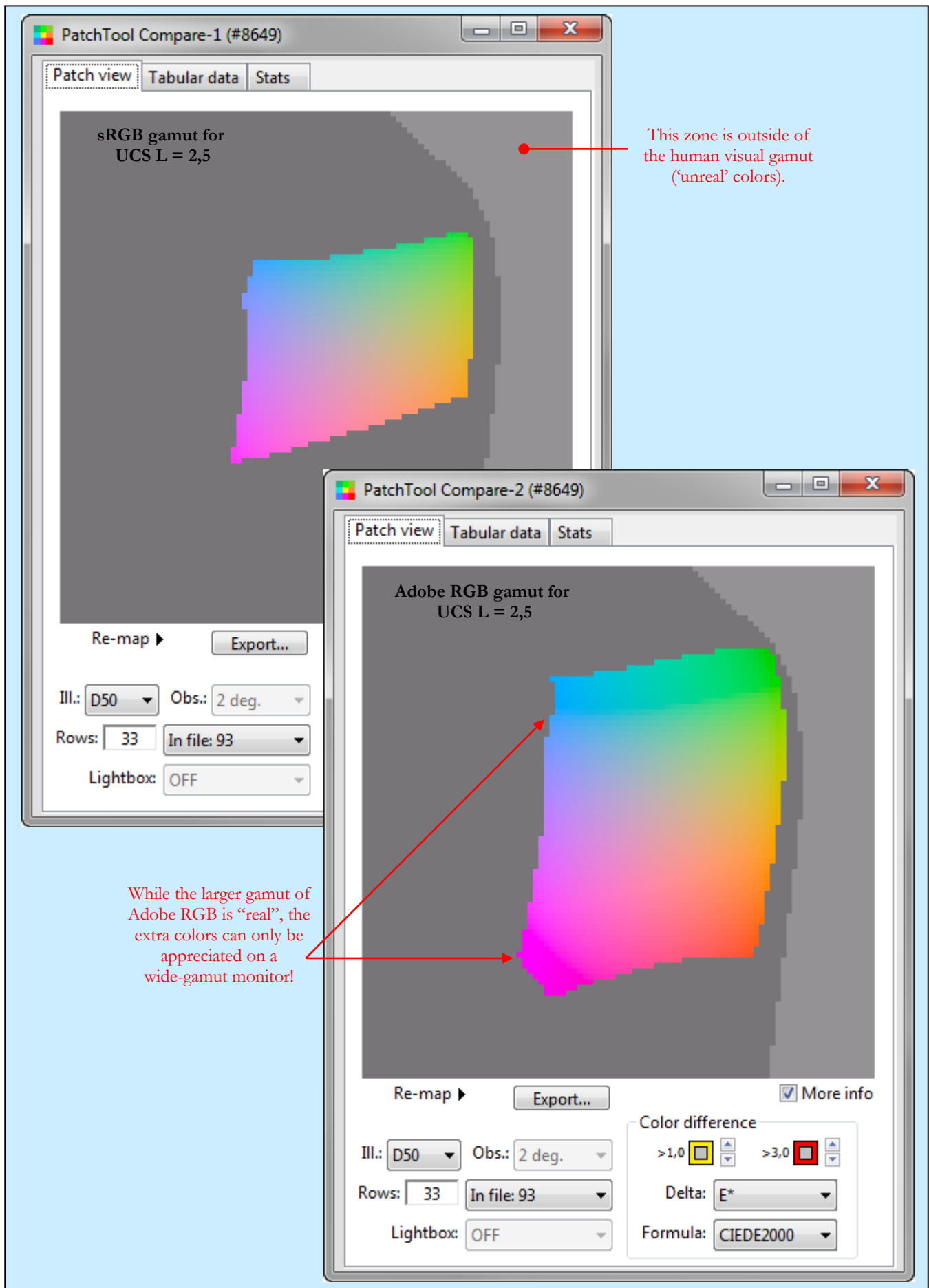
- END -

## Mini-tutorial: How to compare the gamut of two devices with a UCS list

Here we give a procedure that can be used to rapidly visually compare the gamut of two devices. By “visually” we do not mean comparing only the “envelope”, or the edge of the gamut, but also the colors that are affected. For the purpose of the example, we compare the sRGB and Adobe RGB color spaces in the UCS L=2,5 plane, which contains a wide range of bright color. We could have compared these profiles with any other UCS plane, with the L= -4 plane for instance, if we were interested in darker shades, or the j+g= -8 plane for a detailed look at the red-blue range. As well, we could also have compared two printer profiles instead, to see which one is better suited to print specific color ranges.

- 1- Open the [UCS Tool](#) dialog with the “Tools/OSA UCS...” menu.
- 2- In ‘Grid options’, select “Grid steps” of 0,5. Check the “Restrict patches to the following plane” checkbox; select the UCS “L” plane and set the plane value to +2,5 (**plus 2,5**).
- 3- Select a “List pitch” of 0,5. Click on the “Reset” button to maximize the range. This will generate a list with more than 8000 patches. We could restrict the j and g ranges to lower the number of patches, but we will leave it as is since we do not know before hand how large the device gamut will be.
- 4- In the “Output options”, the “List only ‘All-Even’ and/or ‘All-Odd’ coordinates” check box should be disabled. Now **check** the “Keep ‘unreal’ colors (replace by gray)”. These output options will generate colored patches covering the entire plane and will keep unreal colors which are outside of the visible gamut. This will enable us to better judge how the device gamut covers the human eye gamut.
- 5- Click on the “Build list” button, save the file when prompted, and close the UCS Tool.
- 6- Open the list you just generated with PatchTool. In the [UCS Import](#) dialog, select the **2 degree** Observer since we intend to use to process the list via an ICC profile which is designed to work only with 2 degree Observer data.
- 7- Open the [Gamut Tools](#) from the Tools menu. Select the “Convert / Clip check” Tab. If not already selected, select the color list you just generated in the PatchTool file menu.
- 8- In the **Destination profile** menu, select the built-in “sRGB (PatchTool)” profile. Select the “Relative Colorimetric” rendering intent with no BPC. You should not be concerned with the message, below the file name, which indicates that XYZ D65 data will be converted to D50 when sent to the PCS, since this is exactly what we want.
- 9- Click on the “**Clip check**” button located in the “Data sent to PCS” box, on the top-right of the dialog. The Gamut Tools will close and a [Compare](#) file will open.
- 10- In the Compare file, click in the “More info” checkbox if not selected. Select “Delta E\*” and the CIEDE2000 dE formula. Set the left threshold to “>1,0” and the right threshold to “>3,0”. Click once in both threshold border selectors so that thick borders are shown. Please look at [Step-12](#) of the previous tutorial to see how the “Color difference” settings should look. The Compare window should appear as shown on the right (We suggest reducing the minimum “Patch size” to 4 pixels in the [“Preferences”](#) dialog). The gray patches on the right side represent “unreal” colors, colors which are outside of the human visual gamut. Most patches have a red border, indicating that these patches are outside of the sRGB gamut by 3 DeltaE\* or more. The patches with a yellow border are out of the sRGB gamut by a DeltaE\* varying between 1 and 3. All patches with no border are within the gamut or just outside by less than 1 DeltaE\*.
- 11- Redo Steps-7 to 10. You may need to reselect the UCS color list in the Gamut Tools dialog. When redoing Step-8, select the “Adobe RGB (PatchTool)” instead of the previously selected sRGB profile. Click on the “**Clip check**” button to obtain a second Compare file.
- 12- The new Compare file should be configured like we did in Step-10, and look as shown on the bottom-right. The difference in gamut can be directly assessed by comparing the relative area covered by each space because the UCS is scaled more uniformly; such a comparison would produce a significant error with most other color spaces, including L\*a\*b\*. If you have a large gamut display, you will also be able to see the extra colors of the Adobe RGB space (all patches are visible on a lower gamut monitor but they are saturated and/or presented with a large error).
- 13- We can keep only the in-gamut patches and discard the other ones, as we have done in most of the illustrations of this document. With the mouse cursor located on any patch, press on the shift key and on your mouse right-button (press shift + ctrl + mouse-click if using a one button Mac mouse) to show the [alternate contextual menu](#). In this menu, select “Replace ALL patches over Delta thresholds with the 50% GRAY”. All the remaining “colored” patches are within the selected gamut with a maximum error of 1 DeltaE\*. The “cleaned” versions of these images are shown on the next page.





## F-7. Conclusion

This document's goal was to familiarize the reader with the Optical Society of America Uniform Color Scales (OSA UCS). We hope that we have shown enough of its features to entice the reader to look at it further, and maybe even use it! Like with all other color spaces, one needs to spend some time using the UCS before feeling at ease with it. The UCS unusual geometry may rebuff many at first sight, but it becomes surprisingly straightforward to navigate within its planes and color-scales directions after a few trials. This said, a 100% percent understanding of its idiosyncrasies is not required to take advantage of what it offers, and one could well generate, use, and appreciate its color scales without a perfect grasp of the mathematics behind it.

When looking at the images of the tutorial on the preceding page, one is reminded of a geographic map with uncharted territories. This is quite analogous to where the UCS stands in the color world. Many studies were performed during its conception, but the exceptionally long time it took to finalize its specifications had a toll on the patience of its creators as well on how it was perceived by others. Some may argue that it is useless to spend time on the UCS when it is now acknowledged that a color system based on only three parameters cannot describe uniformly all the colors humans can perceive. Yet, there are recent publications which continue the analysis of this space, and others which use it as uniform color space reference. And we could add that we do spend a lot of time everyday with color spaces which are much worse! As a minimum, the UCS can provide a different perspective on color, which, while not new because it has been with us in its final form for over thirty years, is still mostly unknown.

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September 20, 2009

I would like to thank Mrs. Joy Turner Luke who recently presented me a meticulously assembled binder containing an index of the UCS in the form of thousands of small tiles ordered as per the geometry of the standard UCS planes. We are talking here of many thousands of tiles, because a given UCS color can be found in up to 9 planes, and thus nine pages of the index!

Joy has spent a large part of her life promoting color to all who would benefit from a greater knowledge of it. She is the co-author of a best-selling book on the applications of the Munsell Color System; she has long been involved with numerous professional societies devoted to color and still participates in international standards committees. She worked with, and knew personally, many of the UCS committee members, and it is thus not a surprise to see her promote the UCS. When I first saw these color scales, I immediately notice their originality, a first impression which is maintained after many hours of observation. The discussions we had thereafter incited me to support the UCS space and add dedicated tools for it in PatchTool.

For those interested in the history of the UCS, you will find fascinating that the tiny patches used in the indexes assembled by Joy were saved from oblivion by someone who carefully recuperated and classified the clippings of the 558 tiles of the 1977 UCS proof-of-concept. These clippings, of irregular shapes and sizes, were smaller than the original 2 in by 2 in (50 mm x 50 mm) tile size required for the issue, and thus rejected; they were given to Joy by Jarus Quinn, OSA's first Executive Director. By cutting the clippings down to about 0,250 to 0,375 inch (6 to 10 mm), there are now enough mini-tiles to generate a few dozens indexes. If you have an interest in acquiring an index made from the original UCS samples, please send me an e-mail and I will forward it to her.

Danny Pascale

[info@BabelColor.com](mailto:info@BabelColor.com)



## Appendix G

### The CIEDE2000 Color Difference Formula

#### G-1. Introduction

CIEDE2000 (also referred to as DE2000 or  $\Delta E_{00}$ ) is the most recent color difference formula recommended by the Commission Internationale de l'Éclairage (CIE):

**ISO/CIE 11664-6:2014 (CIE S 014-6/E:2013)**

<https://www.iso.org/standard/63731.html>

Similarly to CIE94 and CMC(l:c), it includes weighting functions for *lightness*, *chroma*, and *bue*. Among the differences, it proposes a scaling factor to  $a^*$  for low chroma colors, to improve the formula performance near the illuminant. It also comprises a factor,  $R_T$ , called the *rotation term*, which is affected by the chroma and hue differences, with the goal of improving the performance for blue colors (for hue angles around 275 degrees).

The formula is available in two forms. The original form has a fourth term associated to  $R_T$ . The alternate form has three terms, with the rotation term effect integrated in the individual contributions of the chroma and hue differences. More information on the alternate form can be found in this document from the CIE Web site:

**CIE R 1-39 Alternative Forms of the CIEDE2000 Colour-Difference Equation**

<https://files.cie.co.at/524.pdf>

This Appendix presents the equations for both forms of the formula.

The original four terms formula, based on  $L^*a^*b^*$  data, is:

$$\Delta E_{00} = \left[ \left( \frac{\Delta L'}{k_L S_L} \right)^2 + \left( \frac{\Delta C'}{k_C S_C} \right)^2 + \left( \frac{\Delta H'}{k_H S_H} \right)^2 + R_T \left( \frac{\Delta C' \Delta H'}{k_C S_C k_H S_H} \right) \right]^{1/2}$$

where  $\Delta L'$  is defined as in CIELAB:

$$L' = L^* \quad \text{and} \quad \Delta L' = \Delta L^* = L_S^* - L_R^*$$

and where the subscripts  $R$  and  $S$  correspond to the *Reference* and *Sample* respectively.

The alternate three terms formula is:

$$\Delta E_{00} = \left[ \left( \frac{\Delta L'}{k_L S_L} \right)^2 + \left( \frac{\Delta C''}{S''_C} \right)^2 + \left( \frac{\Delta H''}{S''_H} \right)^2 \right]^{1/2}$$

which can be further be simplified to

$$\Delta E_{00} = [(\Delta L_{00})^2 + (\Delta C_{00})^2 + (\Delta H_{00})^2]^{1/2} .$$

The two formulas provide the same  $\Delta E_{00}$  values and are identical relative to the lightness difference; however, beside the disappearance of the rotation term,  $\Delta C'$  and  $\Delta H'$  are respectively replaced by  $\Delta C''$  and  $\Delta H''$ , and  $k_C S_C$  and  $k_H S_H$  are respectively replaced by  $S''_C$  and  $S''_H$ . The three terms formula can clearly be helpful if we are interested in specifically minimizing the contributions of chroma or hue to the total error in a given process.

The equations required to derive the CIEDE2000 color difference with the four terms formula are presented in the next section (G-2). The **additional** equations required for the three terms formula are presented in the last section (G-3).

## G-2. Equations for the four (4) terms CIEDE2000 formula

In the following equations, you will notice that the weighting functions (i.e.  $S_L$ ,  $S_C$ , and  $S_H$ ) as well as the scaling functions (i.e.  $G$ ,  $T$ ,  $\Delta\theta$ ,  $R_C$  and  $R_T$ ) are based on the arithmetical mean of many of the *Reference* and *Sample* characteristics, such as  $L^*$ ,  $C^*_{ab}$ ,  $C'$  and  $b'$ . This explains why the color difference value is the same when the *Reference* and *Sample* are swapped.

$\Delta C'$  is obtained from:

$$a' = (1 + G)a^*$$

$$C' = (a'^2 + b'^2)^{1/2}$$

$$\Delta C' = C'_S - C'_R$$

where  $G$  is determined from (be careful not to confuse the  $C^*$  (C-star) and  $C'$  (C-prime) variables):

$$C^*_{ab} = (a^{*2} + b^{*2})^{1/2}$$

$$C^*_{ab\ mean} = \frac{(C^*_{ab\ R} + C^*_{ab\ S})}{2}$$

$$G = 0.5 - 0.5 \left( \frac{C^{*7}_{ab\ mean}}{C^{*7}_{ab\ mean} + 25^7} \right)^{1/2} .$$

$\Delta H'$  is obtained from:

$$h' = \arctan(b^*/a')$$

$$\Delta h' = h'_S - h'_R$$

$$\Delta H' = 2(C'_R C'_S)^{1/2} \sin(\Delta h' / 2) \quad \text{if } \Delta h' \leq 180^\circ .$$

In order for  $\Delta H'$  to be of the proper sign—you may recall that it is always positive in older formulas—you should subtract 360 degrees from  $\Delta h'$ , in the  $\Delta H'$  formula, if it is larger than 180 degrees:

$$\Delta H' = 2(C'_R C'_S)^{1/2} \sin((\Delta h' - 360^\circ) / 2) \quad \text{if } \Delta h' > 180^\circ .$$

The  $S_L$  weighting function is obtained from:

$$L^*_{mean} = \frac{(L^*_R + L^*_S)}{2}$$

$$S_L = 1 + \frac{0.015(L^*_{mean} - 50)^2}{(20 + (L^*_{mean} - 50)^2)^{1/2}} .$$

The  $S_C$  weighting function is obtained from:

$$C'_{mean} = \frac{(C'_R + C'_S)}{2}$$

$$S_C = 1 + 0.045C'_{mean} .$$



The  $S_H$  weighting function is obtained from:

$$h'_{mean} = \frac{(h'_R + h'_S)}{2} \quad \text{if } abs(h'_S - h'_R) \leq 180^\circ, \text{ and}$$

$$h'_{mean} = \frac{(h'_R + h'_S - 360^\circ)}{2} \quad \text{if } abs(h'_S - h'_R) > 180^\circ;$$

$$T = 1 - 0.17 \cos(h'_{mean} - 30^\circ) + 0.24 \cos(2h'_{mean}) + 0.32 \cos(3h'_{mean} + 6^\circ) - 0.20 \cos(4h'_{mean} - 63^\circ)$$

$$S_H = 1 + 0.015C'_{mean}T \quad .$$

Finally, the rotation term  $R_T$  is obtained from:

$$\Delta\theta = 30 \exp \left[ - \left( \frac{h'_{mean} - 275^\circ}{25} \right)^2 \right] \quad \text{if } h'_{mean} \geq 0, \text{ and}$$

$$\Delta\theta = 30 \exp \left[ - \left( \frac{h'_{mean} - 275^\circ + 360^\circ}{25} \right)^2 \right] \quad \text{if } h'_{mean} < 0;$$

$$R_C = 2 \left( \frac{C'^7_{mean}}{C'^7_{mean} + 25^7} \right)^{1/2}$$

$$R_T = - \sin(2\Delta\theta) R_C \quad .$$

The three control parameters,  $k_L$ ,  $k_C$  and  $k_H$ , are, simply enough, equal to one in the general case.

The above equations are all you need if you want to compute  $\Delta E_{00}$  with the four terms formula. However, if you are interested in the individual contributions of the lightness, chroma and hue differences, this is where the additional equations of the three term formula become useful. These equations are shown in the next section.

### G-3. Equations specific to the three (3) terms CIEDE2000 formula

Obtaining the individual terms of the three terms formula requires that you first perform all the computations of the four terms formula (Section G-2), so there is no advantage to start reading at this point!

The next step is to obtain an angle ( $\phi$ ) from the following equation:

$$\tan(2\phi) = R_T \frac{(k_C S_C)(k_H S_H)}{(k_H S_H)^2 - (k_C S_C)^2} .$$

**Important:** The  $\phi$  angle is expressed in radians and not in degrees like we did with  $b'$ .

We then use  $\phi$  to derive the remaining parameters of the three terms formula:

$$\Delta C'' = \Delta C' \cos(\phi) + \Delta H' \sin(\phi)$$

$$\Delta H'' = \Delta H' \cos(\phi) - \Delta C' \sin(\phi)$$

$$S''_C = (k_C S_C) \left[ \frac{2(k_H S_H)}{2(k_H S_H) + R_T(k_C S_C) \tan(\phi)} \right]$$

$$S''_H = (k_H S_H) \left[ \frac{2(k_C S_C)}{2(k_C S_C) + R_T(k_H S_H) \tan(\phi)} \right]$$

to finally obtain:

$$\Delta L_{00} = \frac{\Delta L'}{k_L S_L} \quad \Delta C_{00} = \frac{\Delta C''}{S''_C} \quad \Delta H_{00} = \frac{\Delta H''}{S''_H} .$$

# Appendix H

## Support of the CIE 170 (CIE 2006 / CIE 2015) Cone Fundamentals

### H-1. Introduction

In the last several decades, the computation of how colors are perceived by the human eye was essentially based on two Standard Observers, referred to as CIE 1931 and CIE 1964, which characterize the eye response to spectral illumination. CIE 1931 is based on the response of a 2 degree Field Of View (FOV) subtending about half of the eye fovea, where there is the highest density of color sensitive cones and which also corresponds to the zone of highest acuity. CIE 1964 is based on the overall response of a 10 degree FOV subtending about half of the macula (which contains most of the cones). Historically, the CIE 1931 Standard Observer has been used in the printed graphics and imaging display fields where high resolution color is essential while the CIE 1964 Standard Observer has seen more usage in the paint and decoration field where large colored surfaces are the norm.

During all these years, alternate Observers were devised and the validity of the Standard Observers was challenged. While some improvements could be seen, the changes were not significant enough to convince the scientists and the industry to switch to new standards. It is interesting to note that in essentially all experiments dedicated to the color characterization of the human eye, the measurements are indirect, being based on asking a subject to match a projected color by adding the colors of three primary lights. In effect, how a color is perceived is a combination of the characteristics of the eye lens (yellowing with age), the retina (encompassing the macular pigmentation, the response of the three cone types, and the effect of the retinal neurons), and the brain. From these indirect measurements, one can deduce the well-known Color Matching Functions (CMF) of the Standard Observers as well as the actual spectral response of each cone. You will readily understand that the resulting cone response is subject to variations in each of the physiological elements of the measurement chain and could be lacking in details.

Towards the end of the 1990's a series of measurements<sup>9</sup> were made taking into account variations in eye-lens density and macular pigmentation. In order to minimize the effect of the cones spectral sensitivity overlap—cones are sensitive over a wide spectral range—many measurements were done with subjects lacking one or two cone types (i.e. subjects with various types of color-blindness). This work resulted in two CIE Technical Reports:

CIE 170-1:2006; *“TECHNICAL REPORT - Fundamental Chromaticity Diagram with Physiological Axes – Part 1: Definition of CIE 2006 Cone Fundamentals”*

CIE 170-2:2015; *“TECHNICAL REPORT - Fundamental Chromaticity Diagram with Physiological Axes – Part 2: Spectral Luminous Efficiency Functions and Chromaticity Diagrams”*

You will find a very complete set of characterization data on the “Color & Vision Research Laboratory” Web site maintained by Andrew Stockman: <http://www.cvrl.org/>

The CIE 170 reports describe Standard Observers based on cone fundamentals and physiologically-relevant CMFs. Specific tables are presented for 2° and 10° field sizes and a procedure is provided to derive characterization data for field sizes between 1° and 10°. This procedure takes into consideration the optical density of the eye lens and the optical density of the macular pigment as they vary with age, so an age dependent Observer can be obtained.

Usage of CIE 170 has increased recently as it may explain some discrepancies seen between measured data and perceived colors when the CIE 1931 and CIE 1964 Observers are used. Time will tell if this is indeed the case.

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<sup>9</sup> Stockman, A., Sharpe, L.T., Fach, C.C., 1999. *The spectral sensitivity of the human short-wavelength sensitive cones derived from thresholds and color matches*. Vision Res., 39, 2901-2927, 1999.

Stockman, A., Sharpe, L.T., 2000. *The spectral sensitivities of the middle- and long-wavelength-sensitive cones derived from measurements in observers of known genotype*. Vision Res., 40, 1711-1737, 2000.

## H-2. CIE 170 support in PatchTool's tools

The following table indicates which tools support the 2° and 10° Standard Observers defined in the CIE 170 Technical Reports. The tools are presented in the order in which they appear in the “Tool” menu.

Tool	CIE 170 support
Custom Illuminants	<b>YES</b>
Average	<b>YES</b>
Compare	<b>YES</b>
Join	<b>YES</b>
Tweak Target	<b>YES</b>
Display-Check	<b>NO</b> (Note 1)
Display-Reader	<b>YES</b>
Patch-Reader	Note 2
File-to-File Transfer	<b>YES</b>
Gamut Tools	Note 3
Substrate Correction	<b>YES</b>
Extract Data from Profile	<b>NO</b> (Note 1)
Extract Profile from File	<b>NO</b> (Note 1)
Extract Target from Image	<b>NO</b> (Note 1)
BabelColor CT&A Export	<b>NO</b>
Correction Matrix	N.A.
OSA UCS	N.A.
Spectrum Generator	<b>YES</b> (Note 4)

**Note 1:** ICC profiles usage is essentially based on the 2 degree (CIE 1931) Observer.

**Note 2:** While the measurements in the tool window are based on D50 and the 2 degree Observer (CIE 1931), the saved measurements can be processed with any Observer, including those of CIE 170.

**Note 3:** In the Gamut Tools “Convert / Clip check” tab, files with a fixed “2F” degree Observer are accepted but used as if the data was derived from a “2” degree Observer. In the “List gen.” tab, RGB and CMYK lists are not affected by Standard Observer selection. List generation with “Device independent spaces”, i.e. relative to a target ICC profile, is performed with the “2” degree CIE 1931 Observer only.

**Note 4:** When a CIE 170 Standard Observer is selected, spectral fit is possible only with 3 components, and thus 1 illuminant.

## H-3. CIE 170 implementation in PatchTool

### CIE 170 identification convention

We have seen in the literature CIE 170-1:2006 being referred to as CIE 2006 colorimetry, particularly before Part-2 of the CIE 170 report (CIE 170-2: 2015) was published. Now that Part-2 is published, the overall content of the CIE 170 reports is sometimes referred to as CIE 2015 colorimetry. This is rather confusing since there was no change per se between the basic parameters of Part-1 and Part-2, with Part-2 being an extension of Part-1. Thus, to minimize confusion, and until a consensus is established, we typically use only CIE 170 when we refer to “Cone-Fundamental-Based” Standard Observers.

PatchTool supports the default CIE 170 2° and 10° field sizes, with no adjustments available for age. In PatchTool, the CIE 170 Standard Observers are identified as “2F” and “10F”, with a capital “F”, associated to “Fundamental”, added as a suffix. These Standard Observers are also identified as “2F” and “10F” in saved CGATS and Compare files; they are identified as “2F\_degree” and “10F\_degree” in CxF3 files.

**Important:** BabelColor uses “2F” and “10F” to identify the CIE 170 Standard Observers in the user interface (GUI); other representations may be used by other vendors or products.

**Warning:** BabelColor uses “2F” and “10F” to identify the CIE 170 Standard Observers in CGATS files and “2F\_degree” and “10F\_degree” in CxF3 files; other representations may be used by other vendors or products.

### Spectral Bandwidth

CIE 170 data is available with spectral bandwidth resolutions of 0,1 nm, 1 nm, and 5 nm (<http://www.cvrl.org/>). This is to be compared with the 10 nm bandwidth used in most instruments and applications dedicated to graphic design. You may recall that the ASTM E308 standard contains weight tables dedicated to bandwidths of 10 and 20 nm. A 20 nm bandwidth is now considered too large for many uses.

On the other hand, working with a 10 nm bandwidth still has much use for applications which involve smoothly varying spectrums, which is often the case in the print field. Of course, the large availability of 10 nm bandwidth instruments makes the decision to compute color measurements with a 10 nm bandwidth an easy one. This is particularly true when weight tables are available for improved accuracy (weight tables can be tricky to derive while computation at bandwidths of 5 nm or less can be done without them). There has been a tendency in later years to interpolate 10 nm bandwidth data to 5 nm (or even to 1 nm) and compute color with smaller bandwidth reference data. This is done for instance in BabelColor CT&A when computing the various Color Rendering Index (CRI) metrics and the Metameric Index (MI, ISO 23603) for which the reference data is only defined at 5 nm intervals. Of course, interpolating 10 nm measurements to 5 nm is not as precise as using a 5 nm bandwidth instrument to start with but the results are not as off as you would expect; an Application note<sup>10</sup> describing the effects is available on the BabelColor Web site.

This said, because the CIE 170 reference data is available with a (maximum) bandwidth of 5 nm, all CIE 170 computations are done with a 5 nm bandwidth. The 5 nm input data (in reflectance or emission) is interpolated with a method (Cubic spline, Lagrange, Linear) that can be selected in the [Preferences dialog](#). A 5 nm bandwidth is also required for the Illuminant; to this effect, a 5 nm bandwidth version is automatically used when a standard PatchTool Illuminant is selected (C, D50, F11, etc.). Custom Illuminants from files defined with a 5 nm bandwidth are used as is. As for Custom Illuminants defined with a 10 nm bandwidth, either from files or measured with an i1Pro/i1Pro 2, you can select the interpolation method in the [Custom Illuminants](#) dialog.

**Note:** Files with 5 nm bandwidth measurements are only accepted as illuminants in the Custom Illuminants dialog; they cannot be used as input in other tools (which expect a 10 nm bandwidth).

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<sup>10</sup> *AN-11 The effects of a 10 nm bandwidth on data derived from spectrophotometer measurements*  
<https://www.babelcolor.com/tutorials.htm>

## CCT, Duv, Illuminance/Brightness

These parameters have historically been computed only for the 2 degree (CIE 1931) Standard Observer although corresponding 10 degree (CIE 1964) values were available. When incorporating CIE 170 support into PatchTool it was decided to provide these parameters for ALL Standard Observers. Such data can be seen in the [Custom Illuminants](#) tool and in the [Display-Reader](#) tool.

Additional information:

- For self-luminous objects, the maximum value of the luminous efficacy of radiation ( $k_{10}$ ) is **683.6 lm/W** for the 10 degree (CIE 1964) and 10 degree (CIE 170, i.e. “10F” degree) standard Observers, instead of the 683 lm/W value used for the “2” and “2F” Standard Observers.<sup>11</sup>
- CCT and Duv are computed using the “uv” (CIE 1960) uniform color space. It is assumed that the conversion between the “xy” chromaticity coordinates—computed for each Standard Observer—and the “uv” space use the same equations for all Observers. In 2018 CIE Division 1 established a new research forum for “Revisiting Correlated Colour Temperature” with CCT determination using cone fundamental colorimetry being a proposed research subject, so we may see changes in CCT computation in the coming years.

## MacLeod-Boynton Chromaticity Coordinates

The MacLeod-Boynton chromaticity diagram is used to show cone excitation by stimuli of equal luminance.<sup>12</sup> The chromaticity coordinates (**l<sub>MB</sub>** and **s<sub>MB</sub>**) can be obtained in PatchTool exported files whenever a CIE 170 Standard Observer is selected (“2F deg.” or “10F deg.”). To export the MacLeod-Boynton Chromaticity Coordinates, select the “xyY” data type in the [PatchTool Export](#) dialog or in the [Display-Reader CGATS file options](#) dialog. You will get the MacLeod-Boynton **l<sub>MB</sub>** and **s<sub>MB</sub>** coordinates in addition to xyY computed for the selected Observer.

Additional information:

- There is a third MacLeod-Boynton coordinate, **m<sub>MB</sub>**, which, like the “z” of xyz, is rarely provided since it can be deduced from l<sub>MB</sub>. In effect these two coordinates are complimentary:  $l_{MB} + m_{MB} = 1$ .
- xyY for the 2° CIE 170 Observer (i.e. “2F” degree in PatchTool) are usually shown as ( $x_F, y_F, Y_F$ ) in the literature.
- xyY for the 10° CIE 170 Observer (i.e. “10F” degree in PatchTool) are usually shown as ( $x_{F,10}, y_{F,10}, Y_{F,10}$ ) in the literature.
- The file formats in which MacLeod-Boynton coordinates can be exported are: CGATS, plain text, and Compare files.

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<sup>11</sup> *Colorimetry: Understanding the CIE System*; ed. János Schanda, Ch. 3, 2007 John Wiley & Sons, Inc.

<sup>12</sup> Robert M. Boynton, *History and current status of a physiologically based system of photometry and colorimetry*, J. Opt. Soc. Am. A/ Vol. 13, No. 8/August 1996, 1609-1621. See also CIE 170-2:2015.

### **The BabelColor Company**

Founded in 2003, *The BabelColor Company* develops and sells software dedicated to the measurement and analysis of color.

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