Lecture on near-IR astronomy

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The Near-IR Sky

ASIAA - November 2007

H-Band, 420 frames of 15-sec, 1.75hr, at zenith

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The Near-IR Sky

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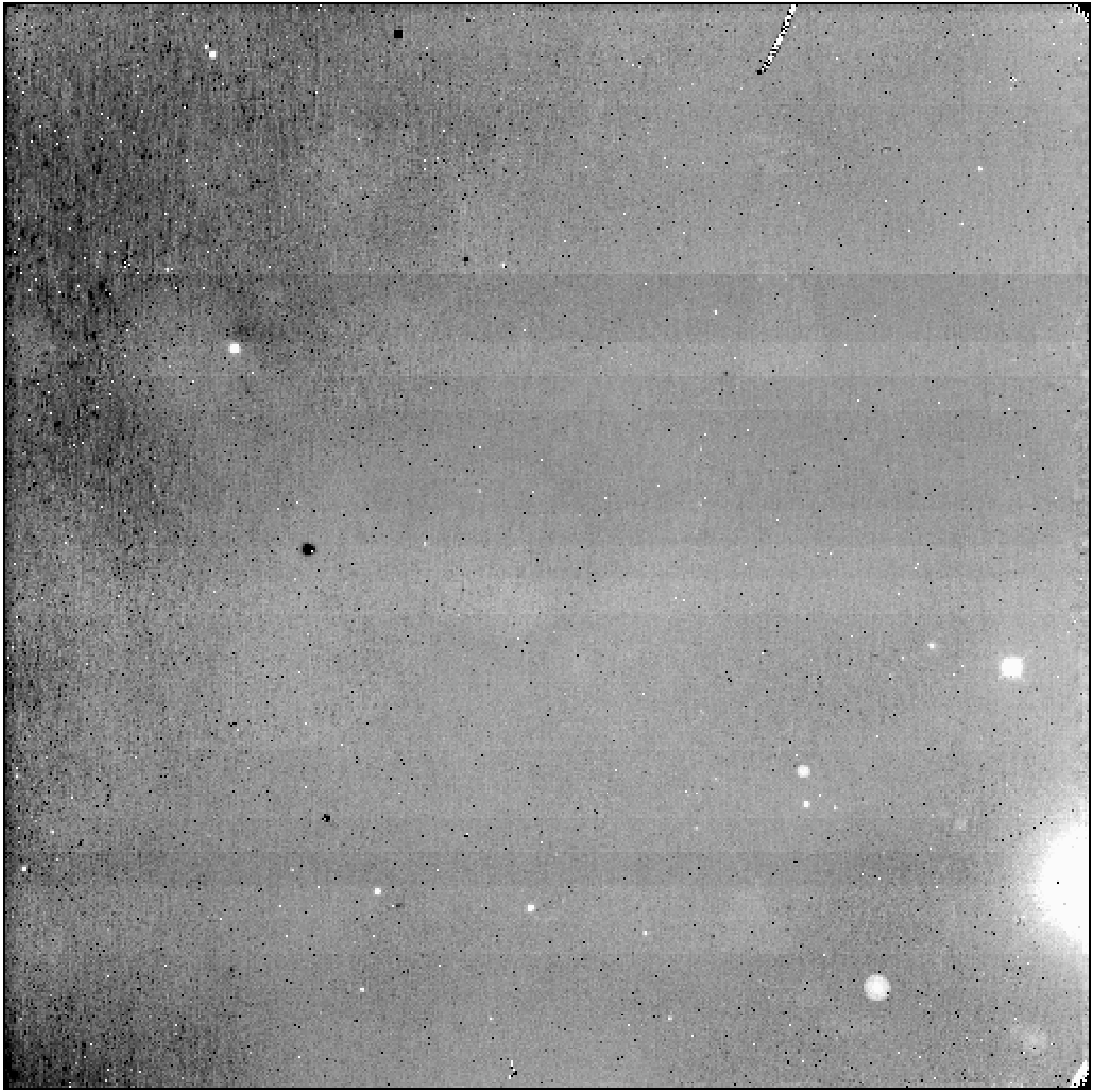
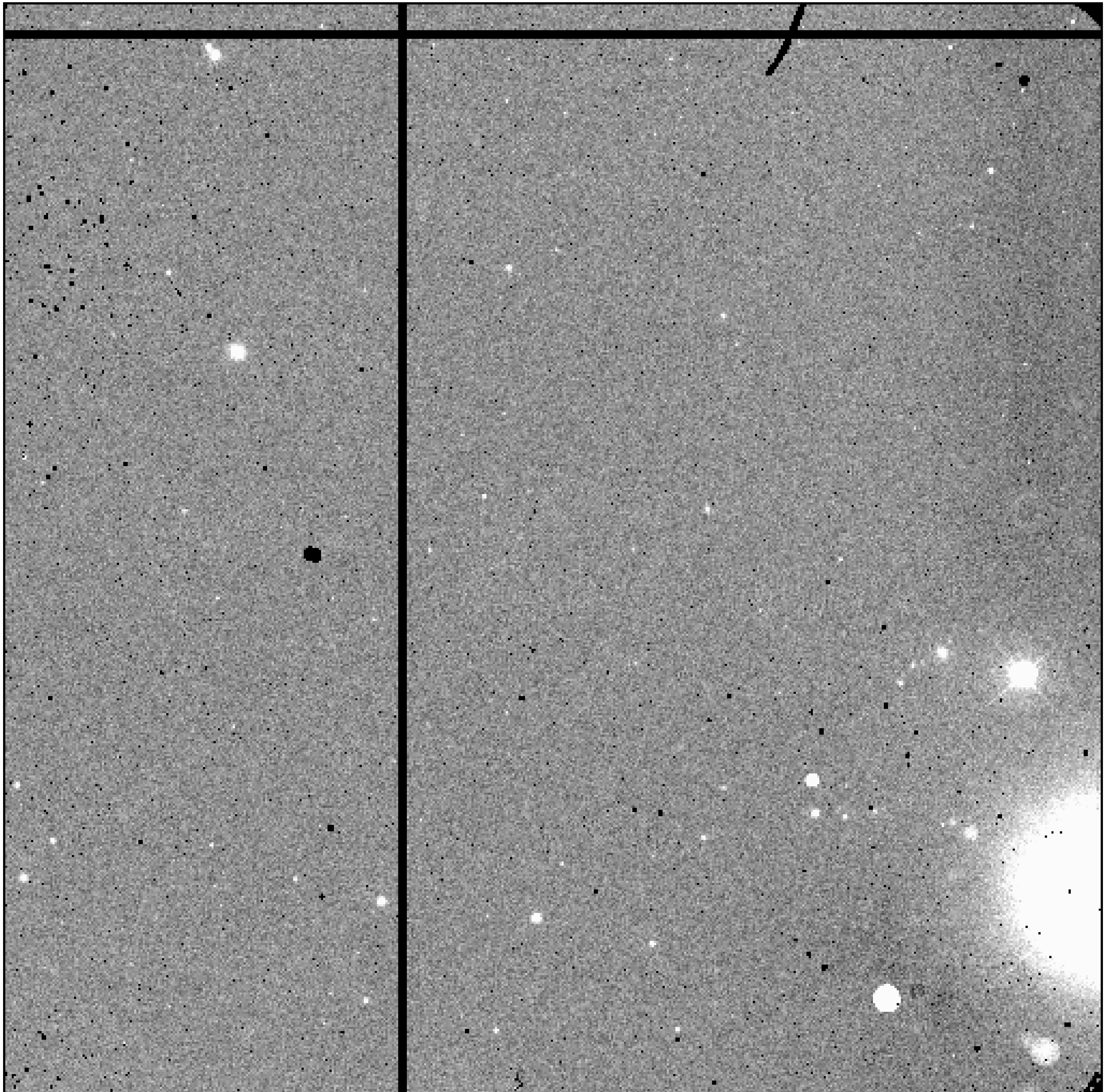
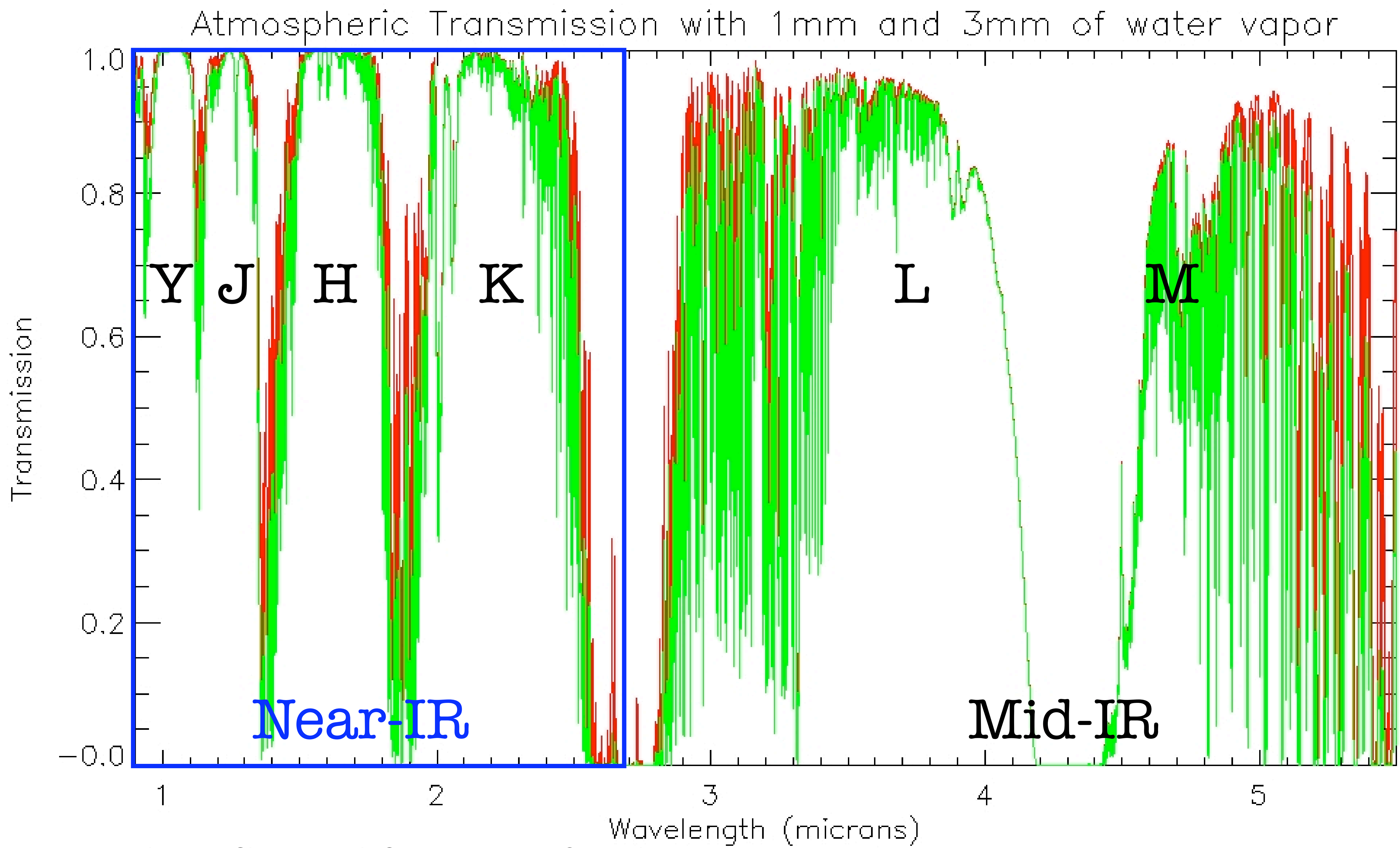


unprocessed image



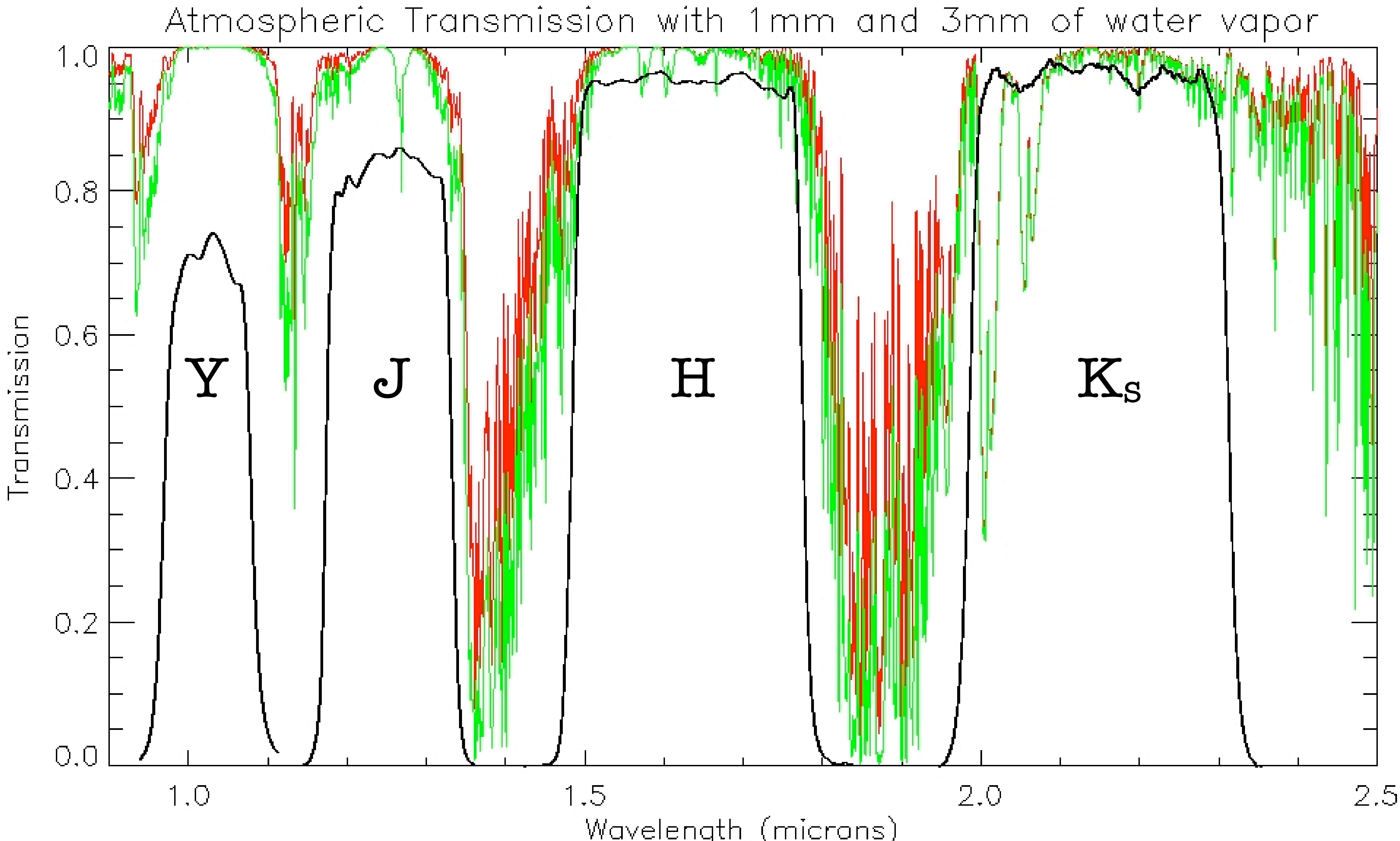
processed image

Atmospheric Transmission



http://www.gemini.edu/sciops/ObsProcess/obsConstraints/ocTransSpectra.html

Atmospheric Transmission



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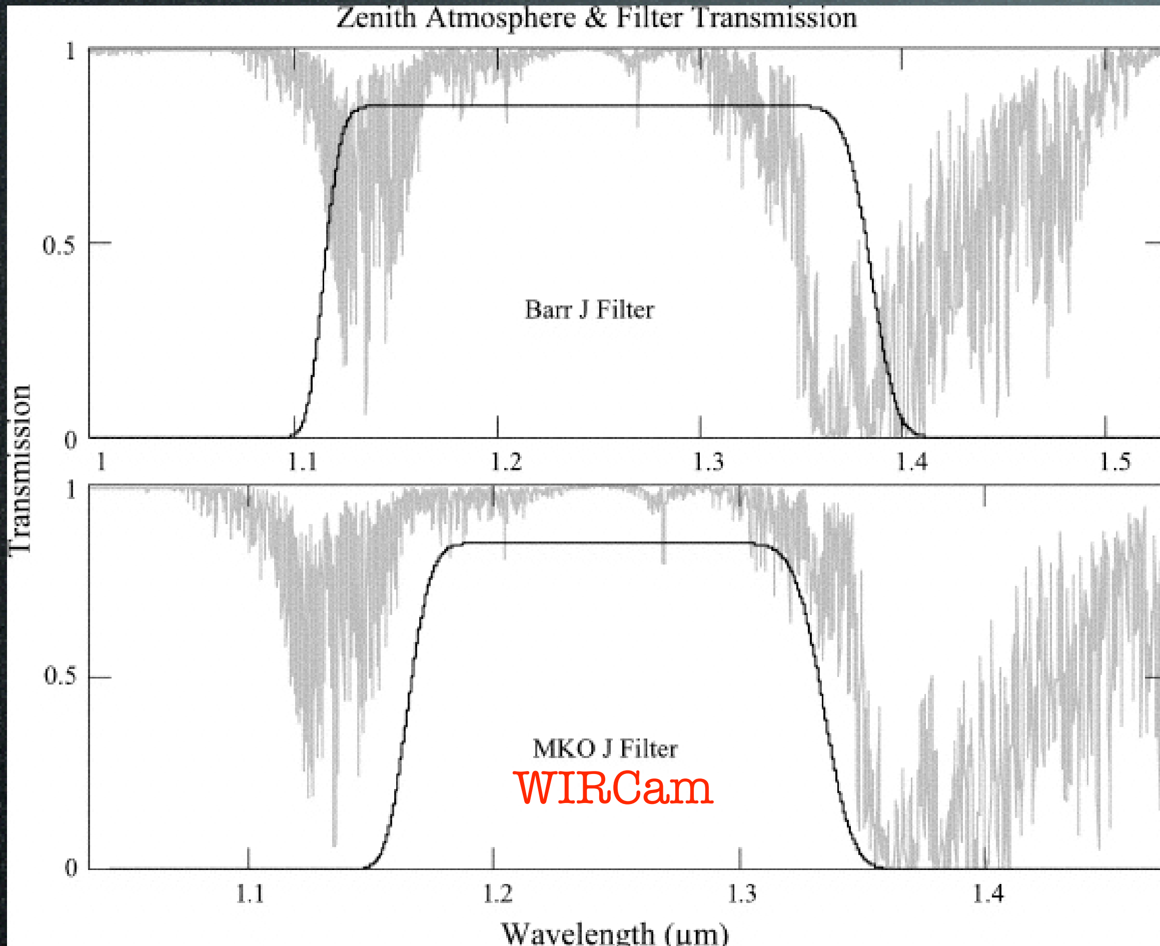
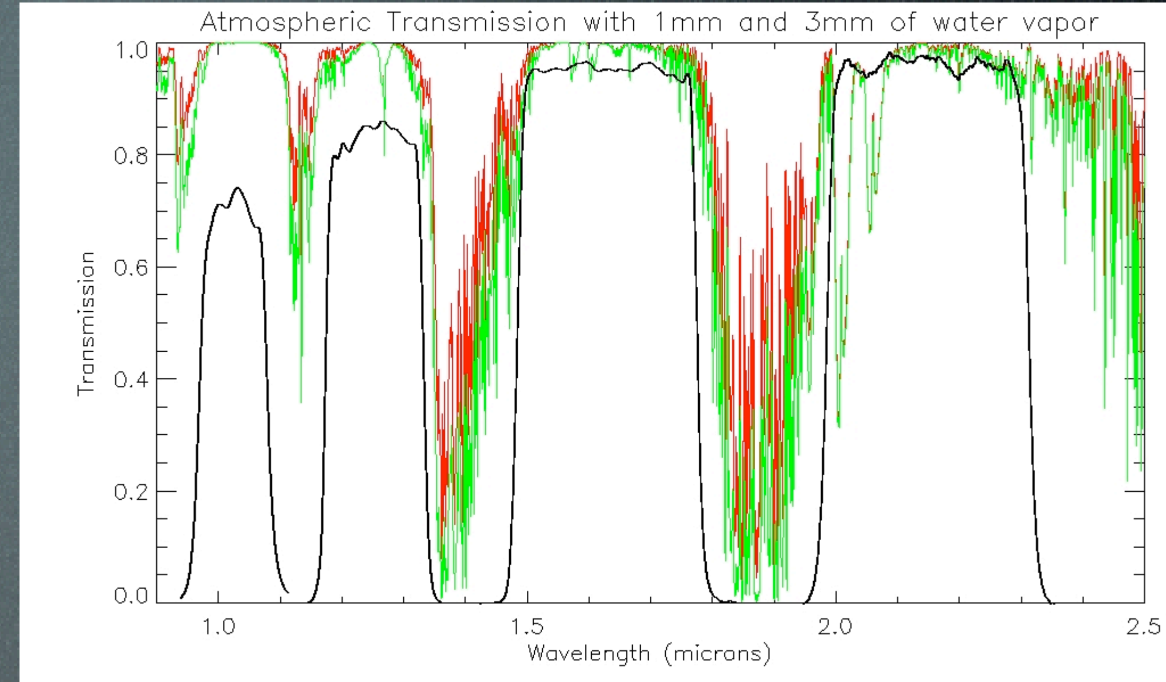
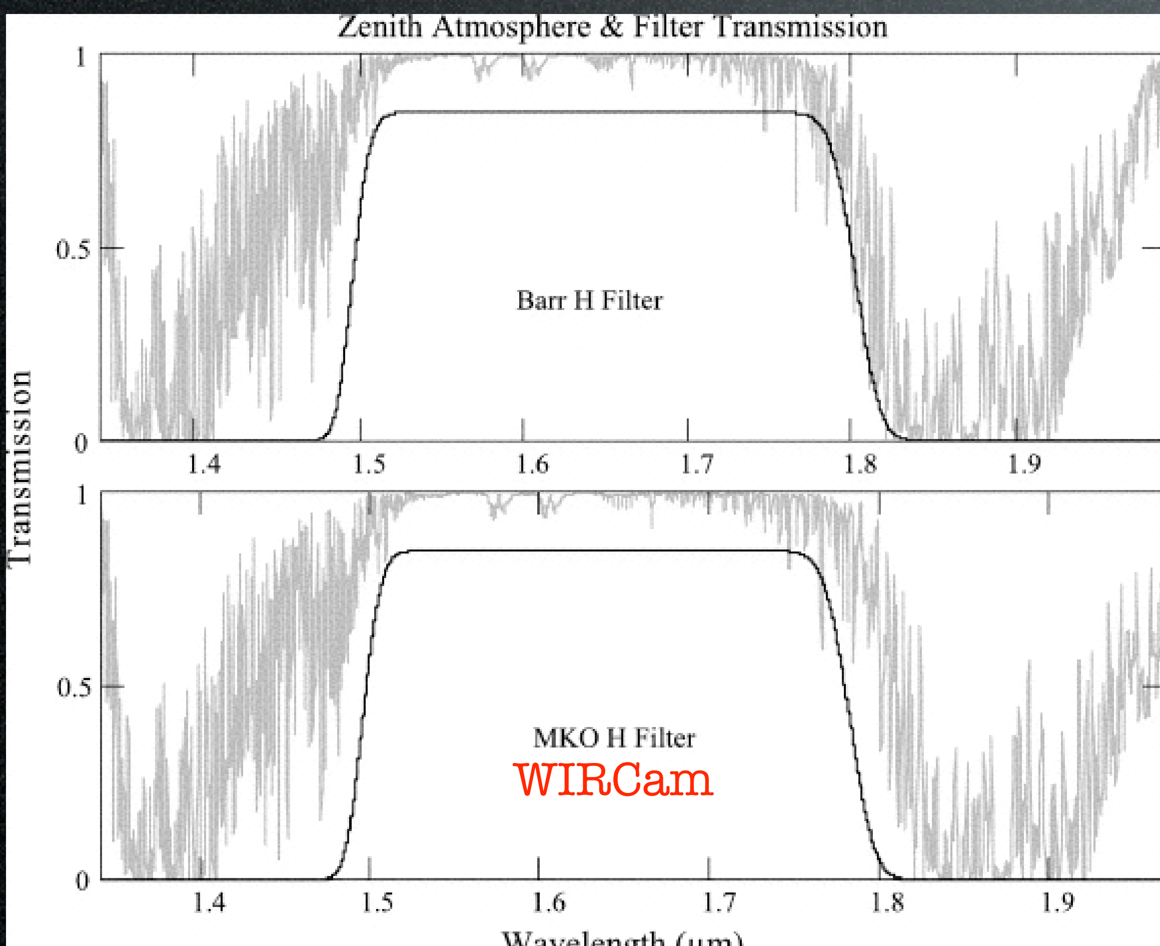
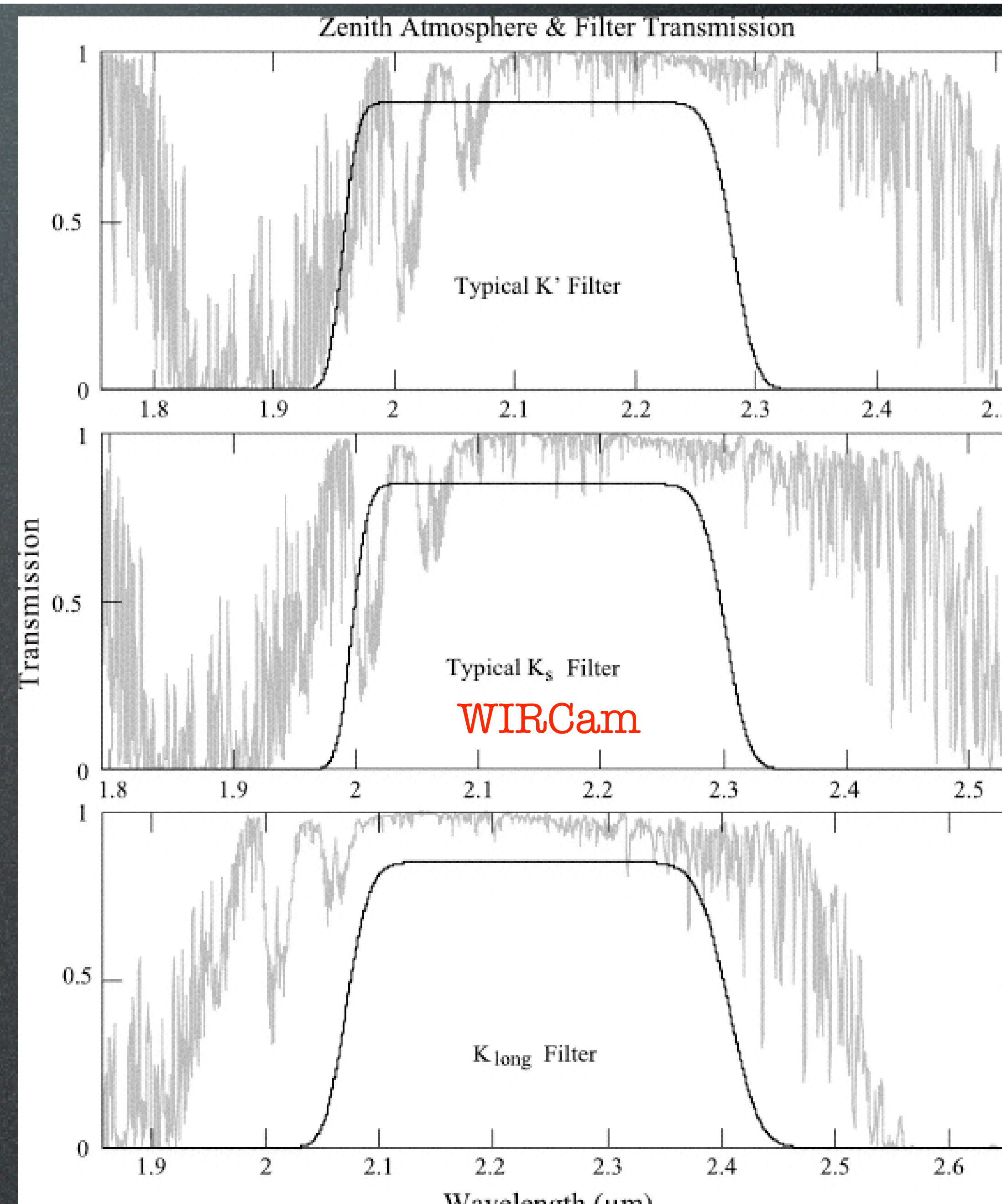


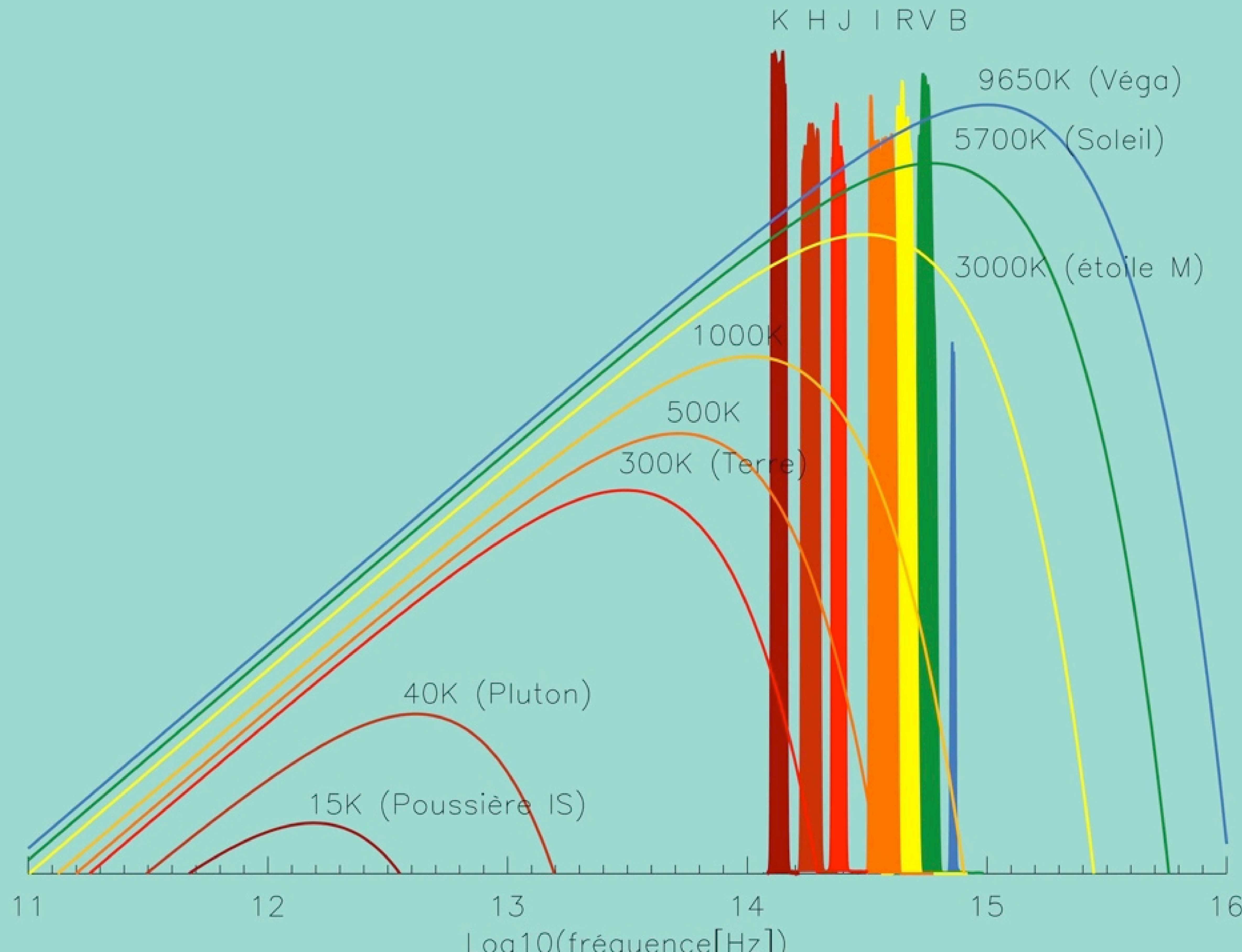




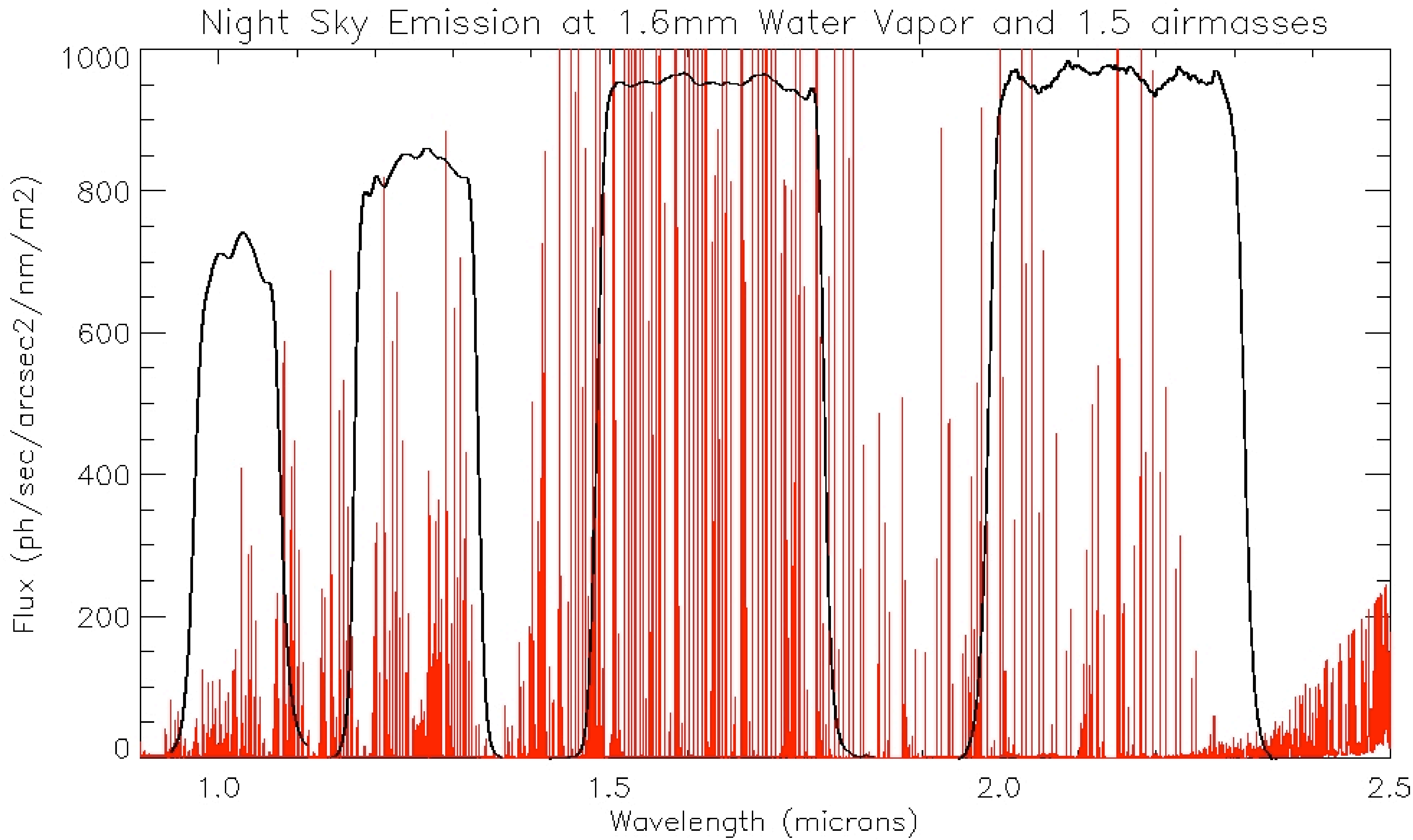


Simons & Tokunaga, 2002, PASP 114, 169

Black Body Thermal Emission



Night Sky Emission & Thermal Emission



http://www.gemini.edu/sciops/ObsProcess/obsConstraints/atm-models/nearIR_skybg_16_15.dat

Mostly OH^-, some O_2 at 1.27um, H_2O in red K

See Ramsay & al. 1992, MNRAS 259 751

Non-Thermal Emission

- See Ramsay & al. 1992, mnras 259 75.
- Airglow arises from vibrational-rotational levels of the OH-radical.
- Mostly Hydroxil (OH^-), some O_2 at 1.27um, H_2O in red K.
- Short period variations, of the order of a few minutes to an hour, are connected with the passage of gravity waves through the ionosphere at an altitude of 80-105 km which produce density and temperature variations.
- These causes changes in the reaction rate and column densities of the constituents and a corresponding variation in the OH-emission intensity.
- Excitation: $H + O_3 \Rightarrow OH^* + O_2$, Relaxation: $OH^* + O \Rightarrow H + O_2$
- Horizontal wavelengths of ~25 km, phase speeds of ~100km/h, time periods of ~10-15 minutes.
- Minor constituents density profile variations explain the 50% drop in the first hours after sunset.

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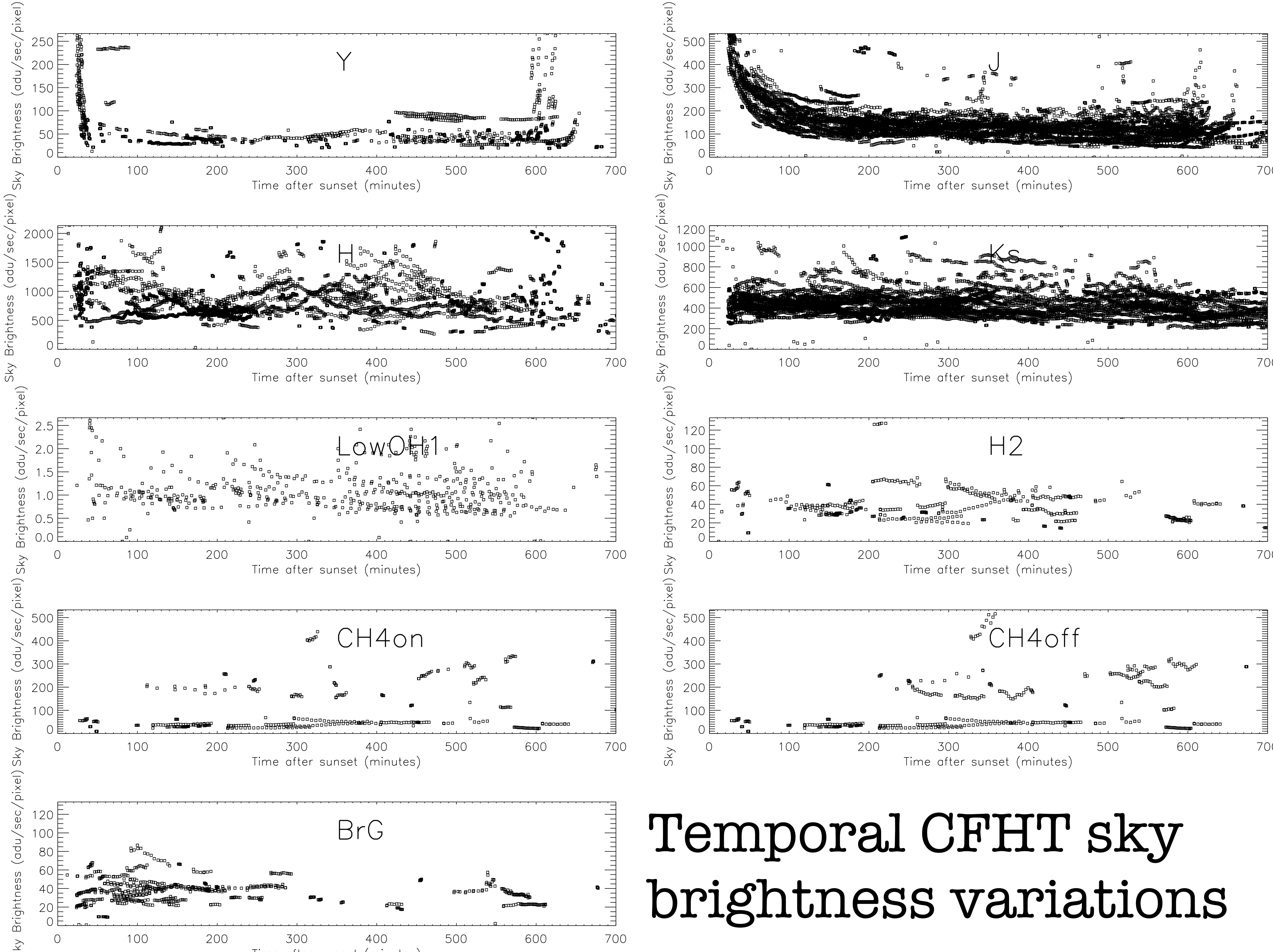
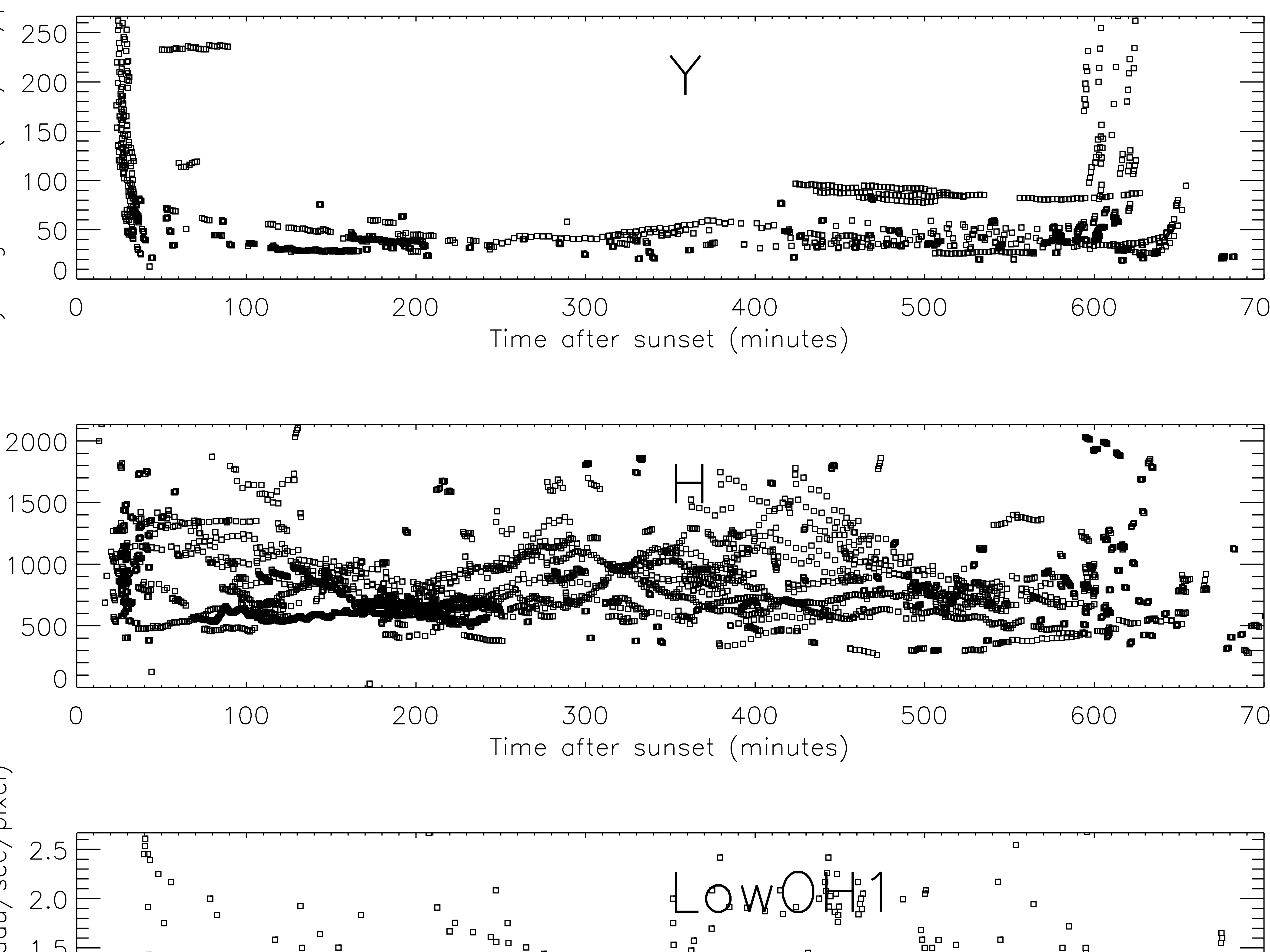
Temporal CFHT sky brightness variations




Y
250
200
150
100
50
0
0
100
200
300
400
500
600
70
Time after sunset (minutes)
H
2000
1500
1000
500
0
0
100
200
300
400
500
600
70
Time after sunset (minutes)
LowOH1
2.5
2.0
1.5

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Pre 2MASS test - 1996

Measuring the airglow with 9x9 deg camera.

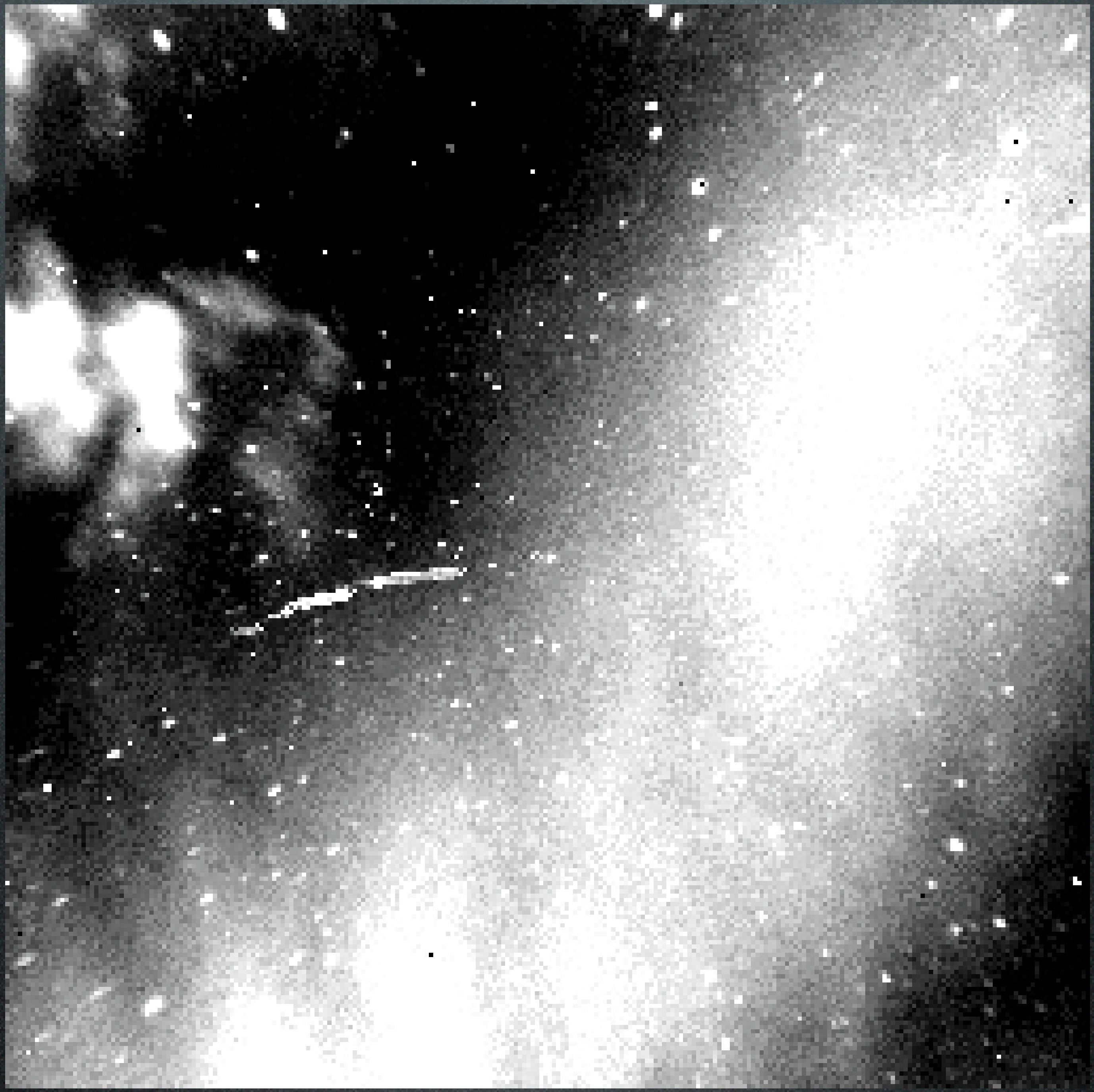
Joe Adam & Mike Skrutskie

See web page:

http://astsun.astro.virginia.edu/~mfs4n/2mass/airglow/airglow.html

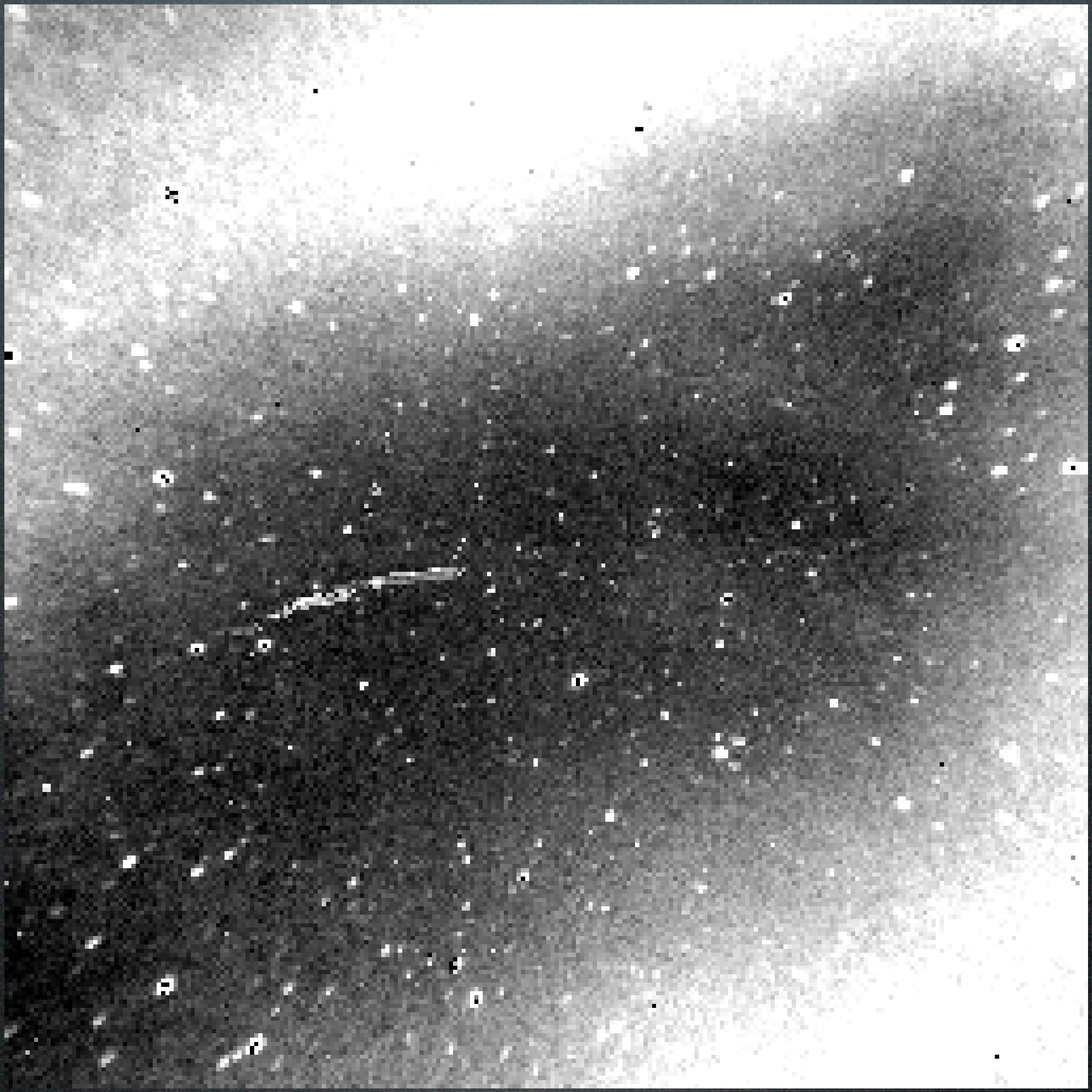
On 7 and 8 June 1996 UT we (Joe Adams and Mike Skrutskie -- pictured above) cooled the 2MASS prototype camera and observed the airglow in a 9-degree field at J and H-band. To achieve this field-of-view they placed a 140mm focal length lens in front of the dewar window. The scale is about 120 arcseconds/pixel or 9 degrees across. To follow are flat-fielded images of the near-zenith sky. The peak to valley variations are about 15%. One could watch these patterns drift across the screen and change in intensity over the course of a few minutes. yes, these frames have been flat fielded! Each frame is a 15 second exposure.

H-Band, 240 frames of 15-sec, at zenith



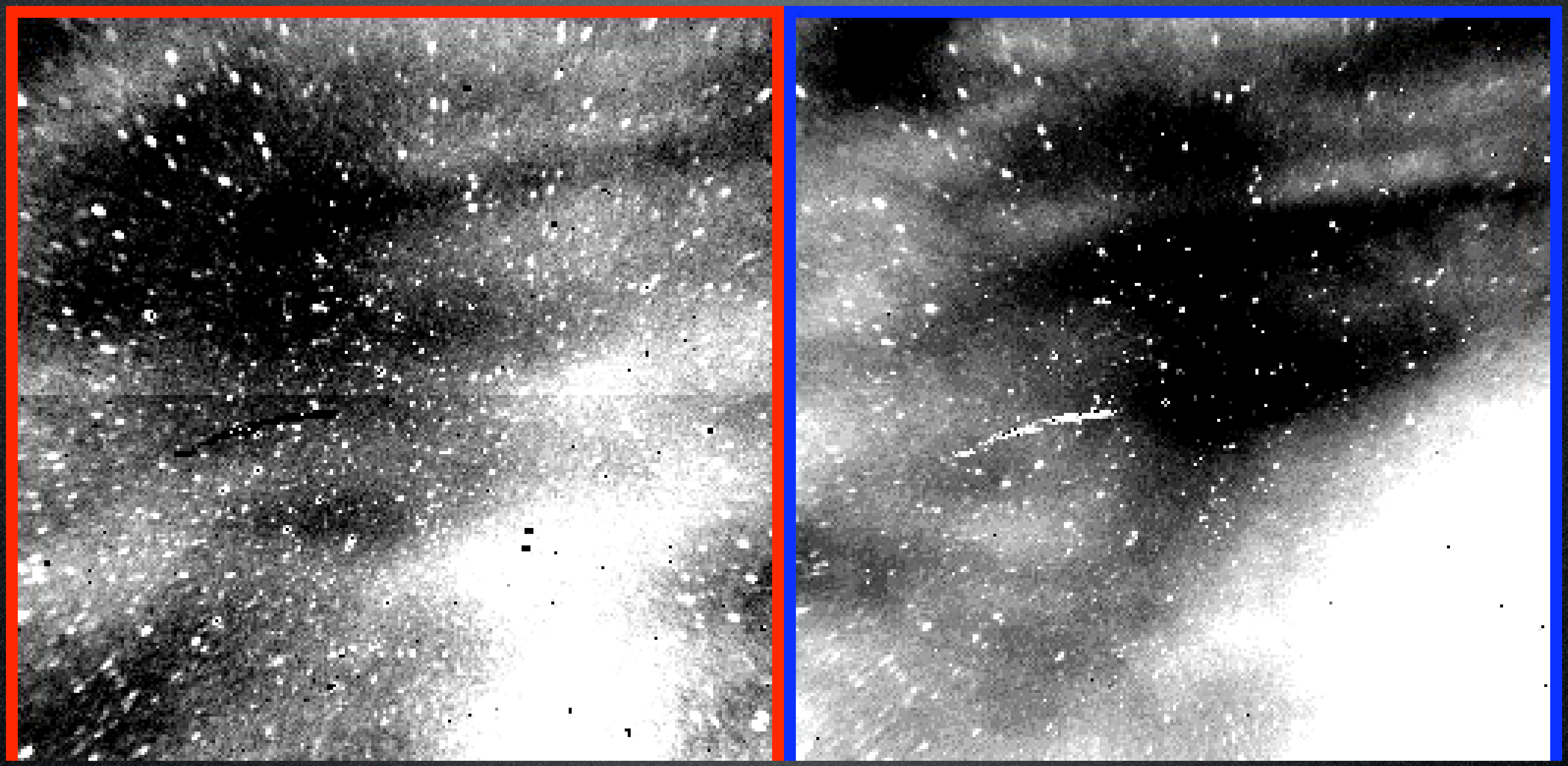
H-Band, 420 frames of 15-sec, 1.75hr, at zenith

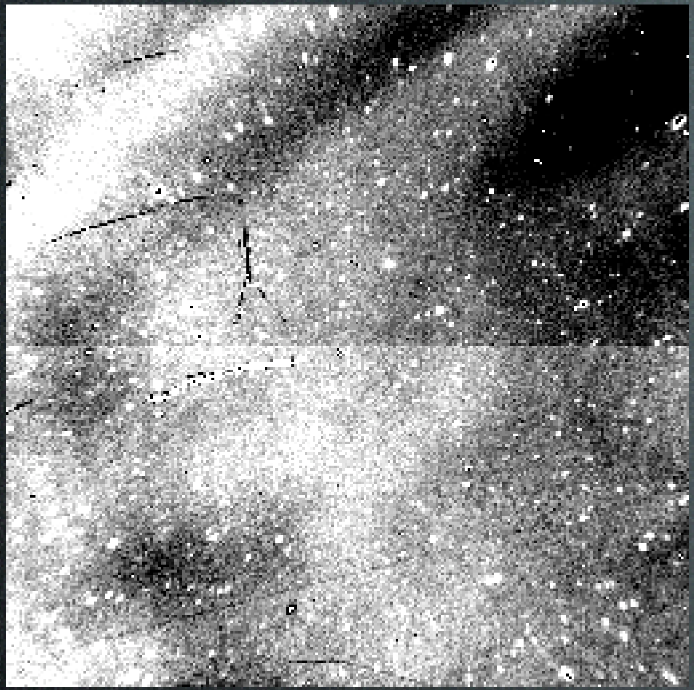
J-Band, 180 frames of 15-sec, 45 min, at zenith



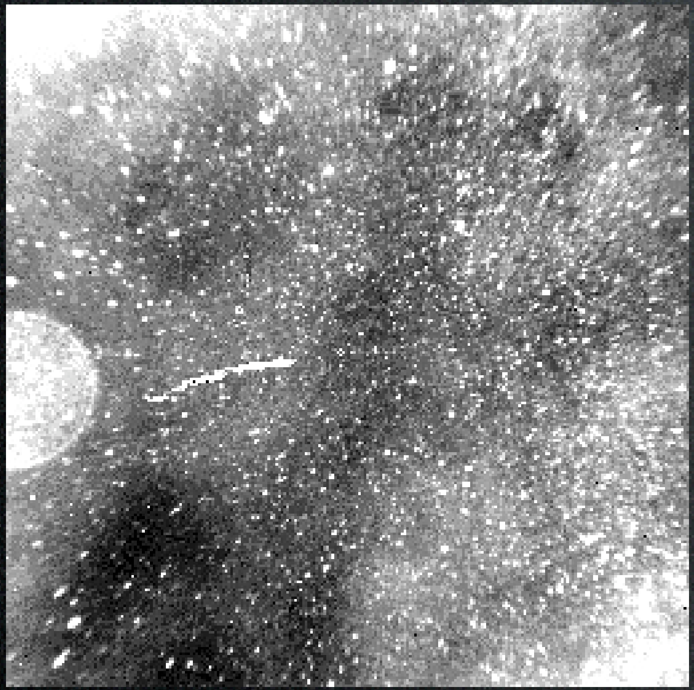
Galactic Plane Transit

J and H Bands almost simultaneous (1 min lag)





Passing Clouds (J-Band)



Moon Ghost (H-Band)

The sky and its subtraction

- As a canonical rule, the sky brightness amplitude varies by 10% in 10 minutes.
- The sky structure is rarely a smooth function and can often vary on large and small spatial scales (depending on the instrument).
- Subtraction of the sky also removes 2nd-order flat fielding residues.

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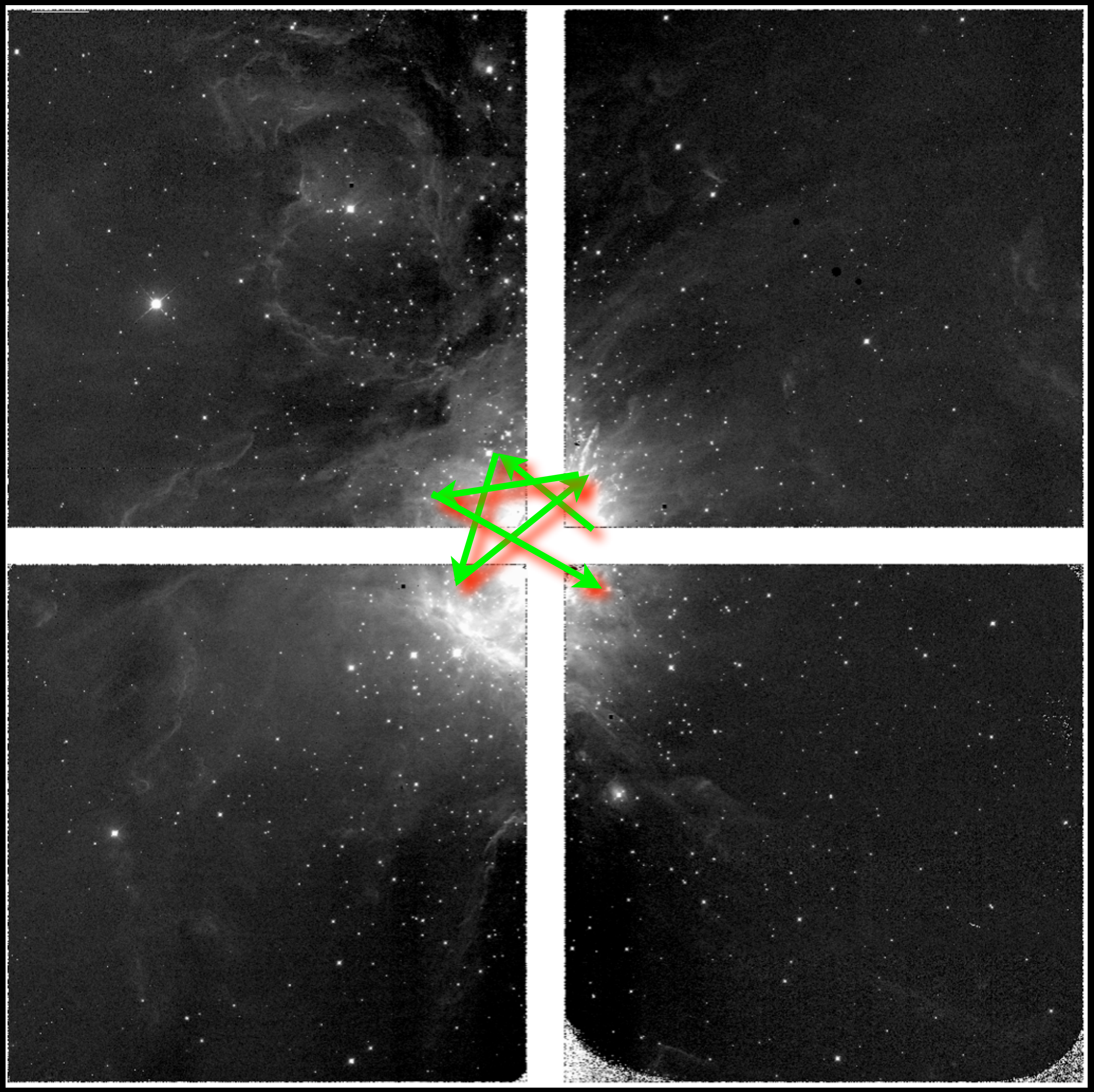
Default Strategies

Standard dithering pattern



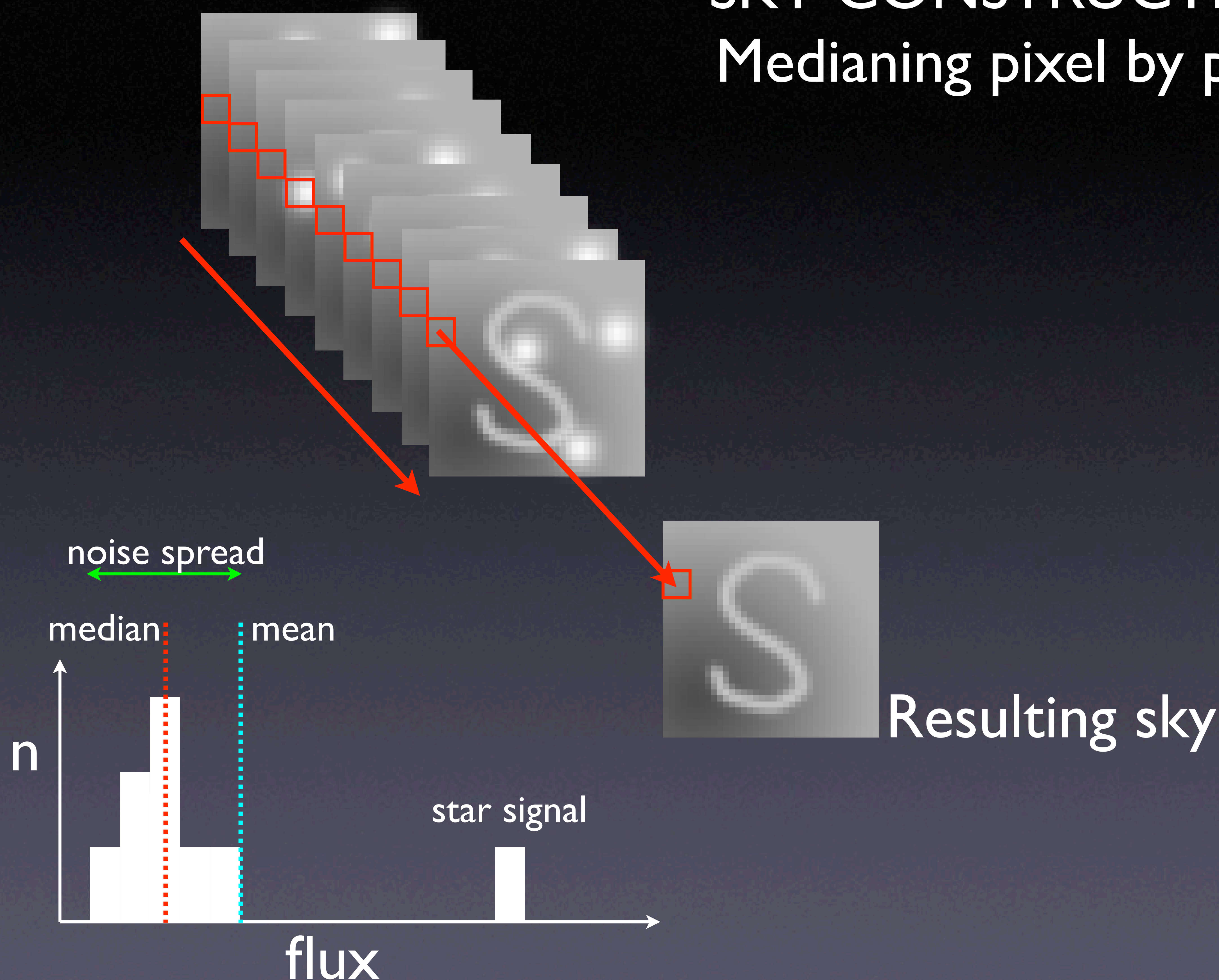
Why dither?

1. Fill the gaps between detectors.
2. Median out stars to build and subtract a sky frame.

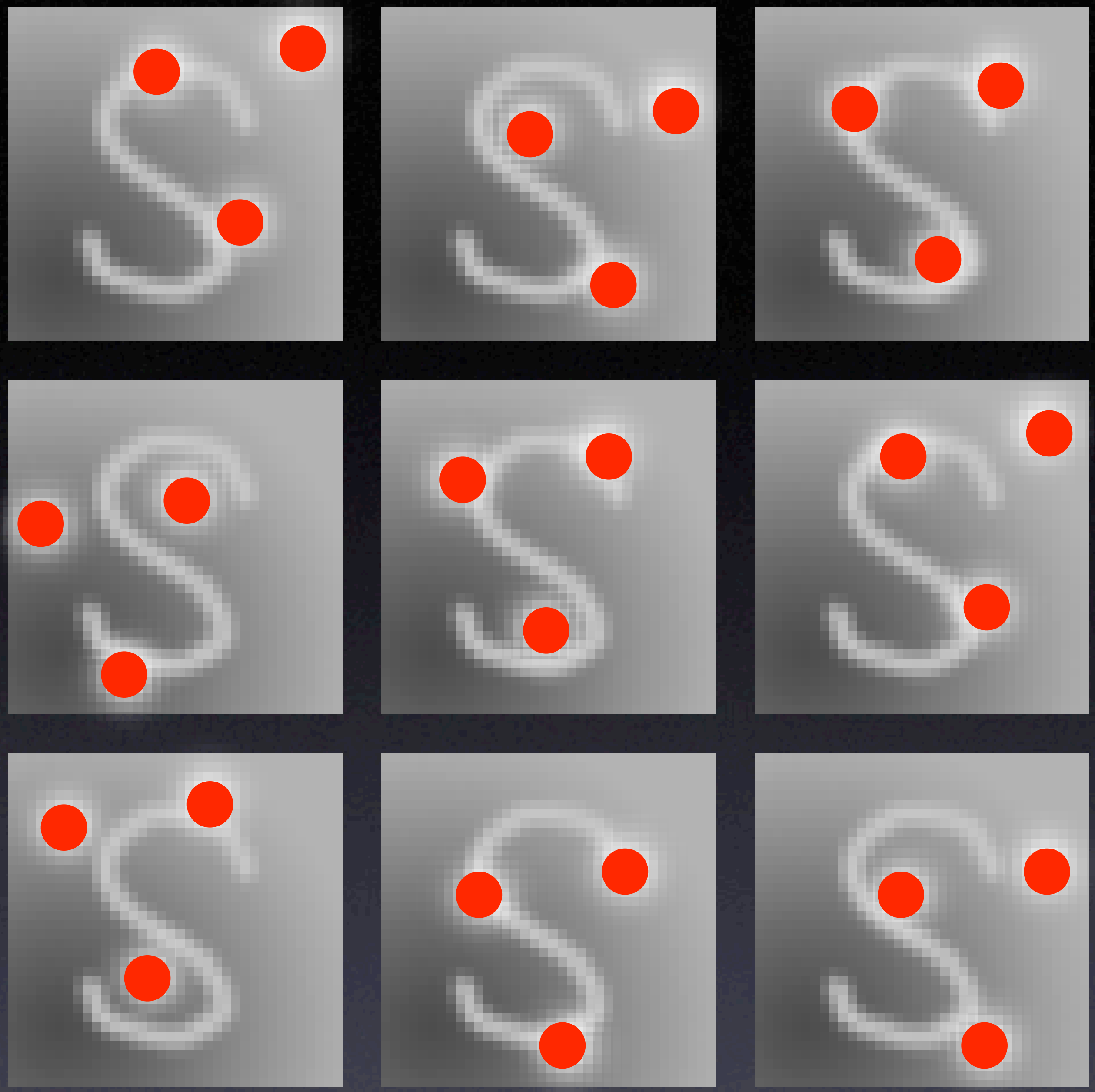
Detrended images of a DP9 dithering pattern

Detrended images
of a DP9
dithering pattern
AFTER
NORMALIZATION

SKY CONSTRUCTION
Medianing pixel by pixel

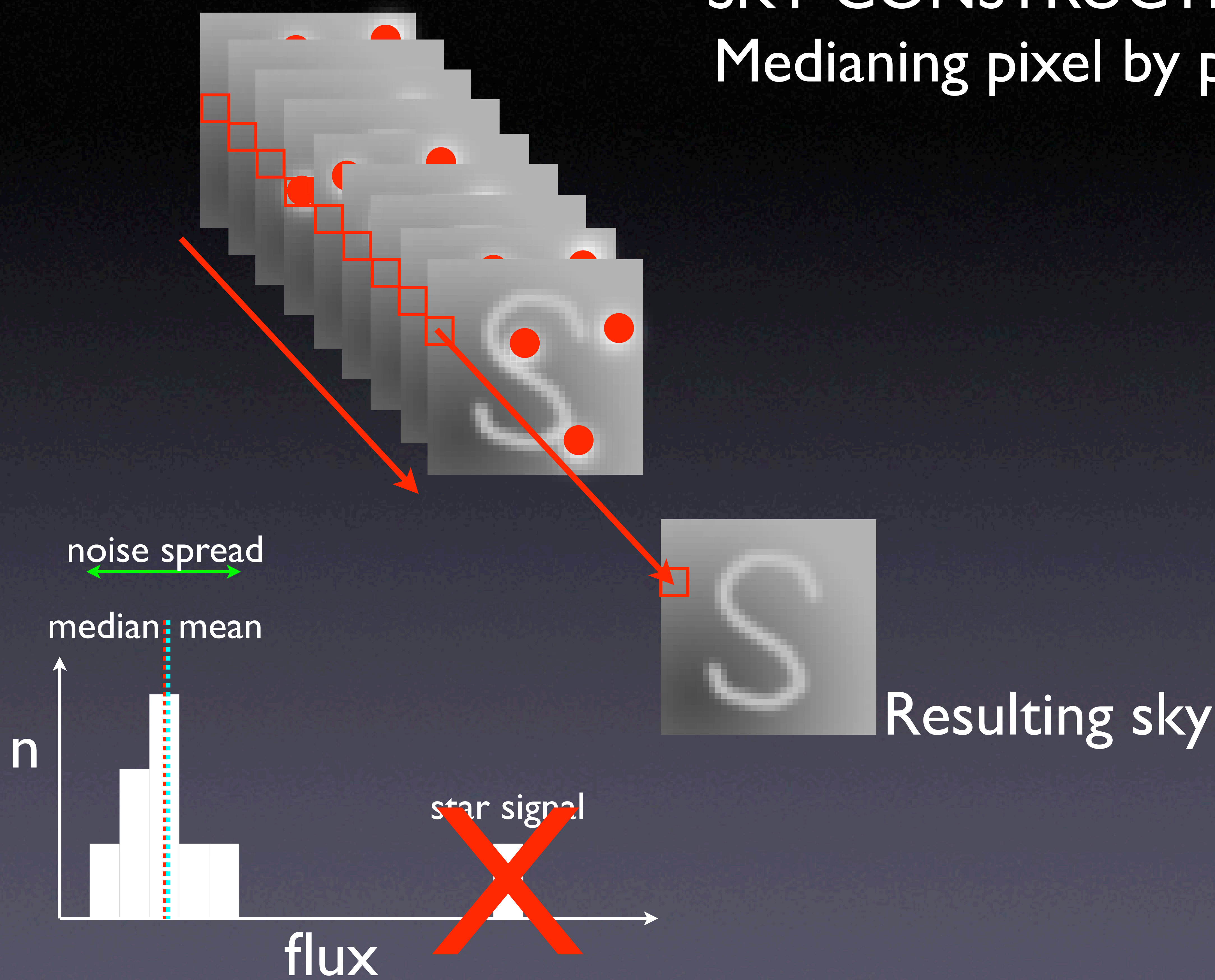


Detrended images
of a DP9
dithering pattern
AFTER
NORMALIZATION



Detrended images
of a DP9
dithering pattern
AFTER
NORMALIZATION
&
MASKING

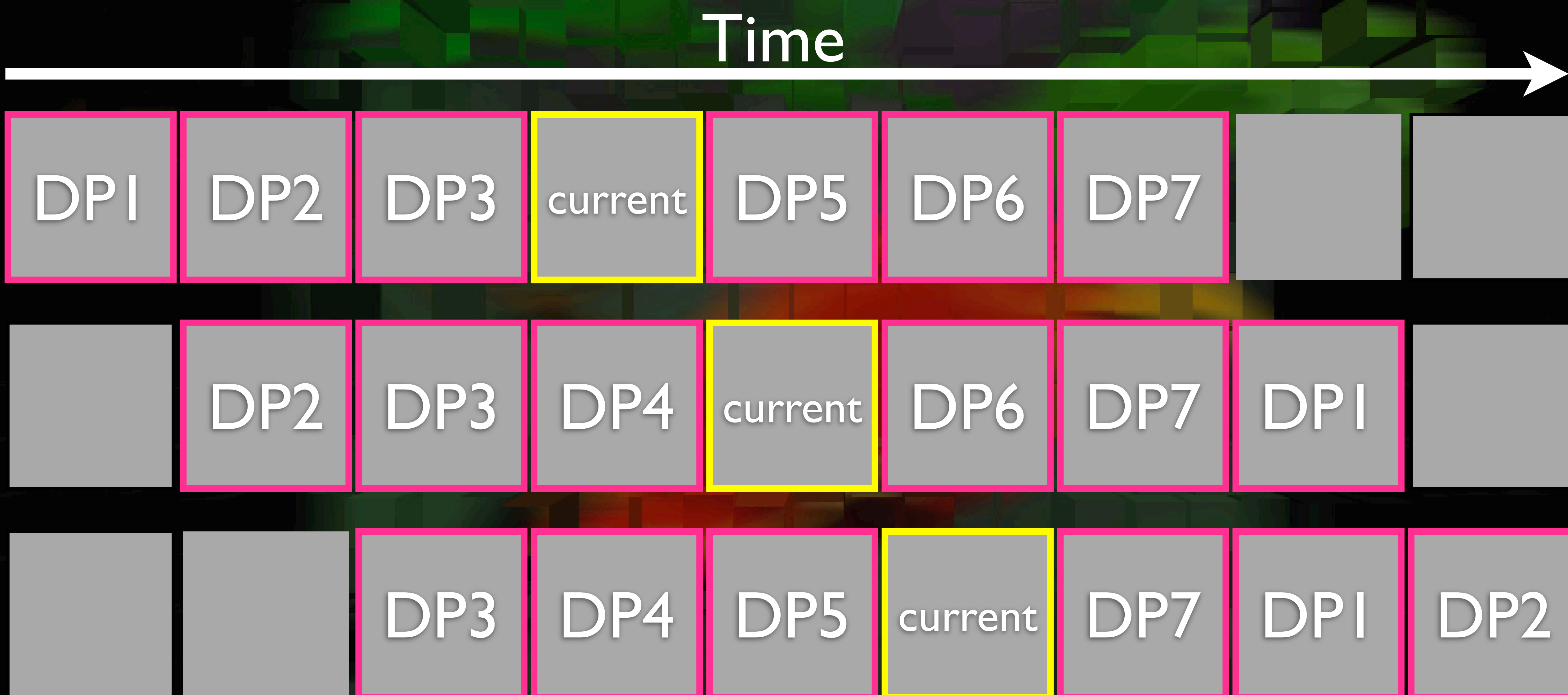
SKY CONSTRUCTION
Medianing pixel by pixel



"Sky intensity varies by 10% in 10 minutes..."

-canonical rule

Sky Construction - sliding median with source masking



Adjustable constraints in time and number of DPs:

example: use images taken no more than 15 minutes away and with sky positions different by at least 15"

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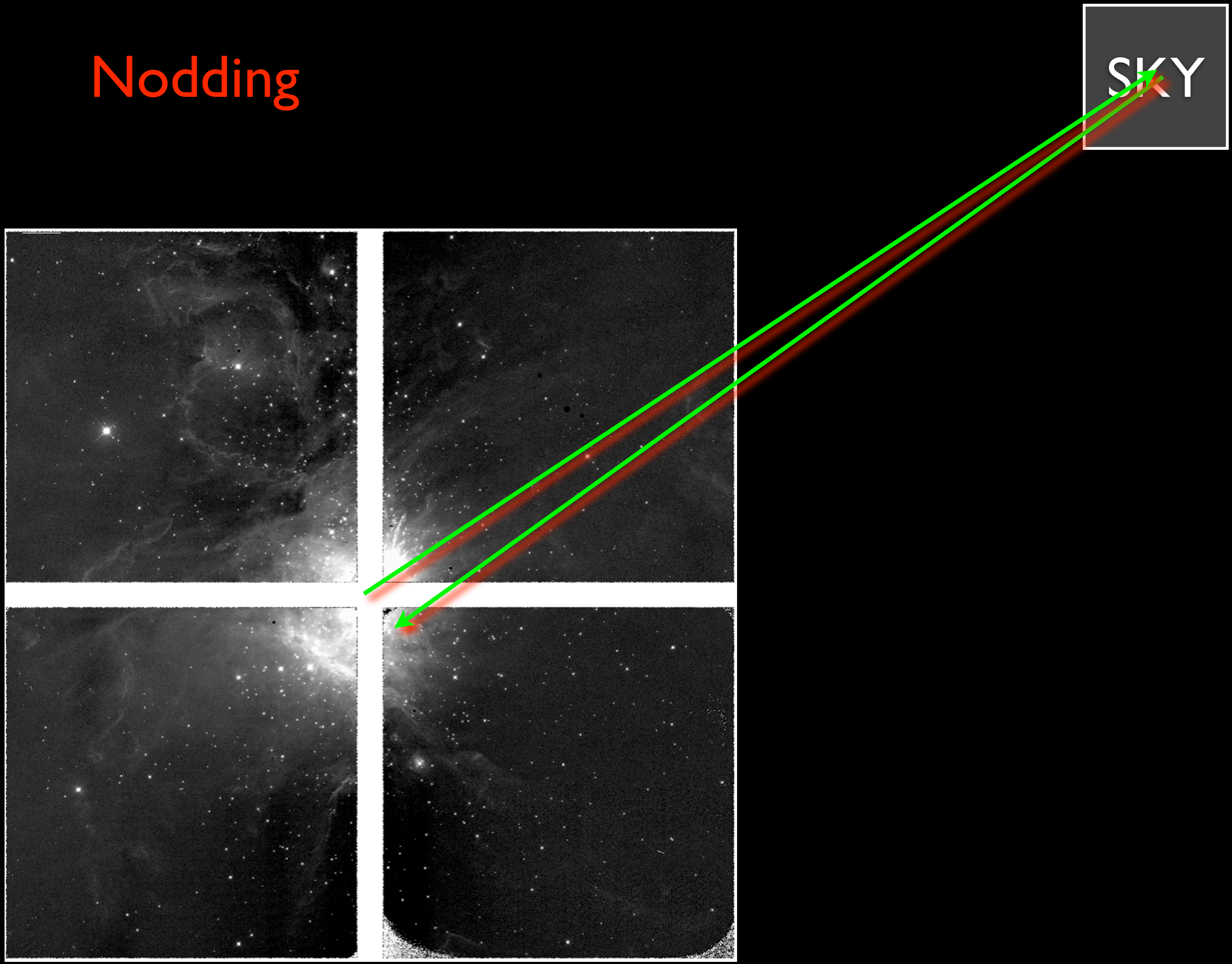
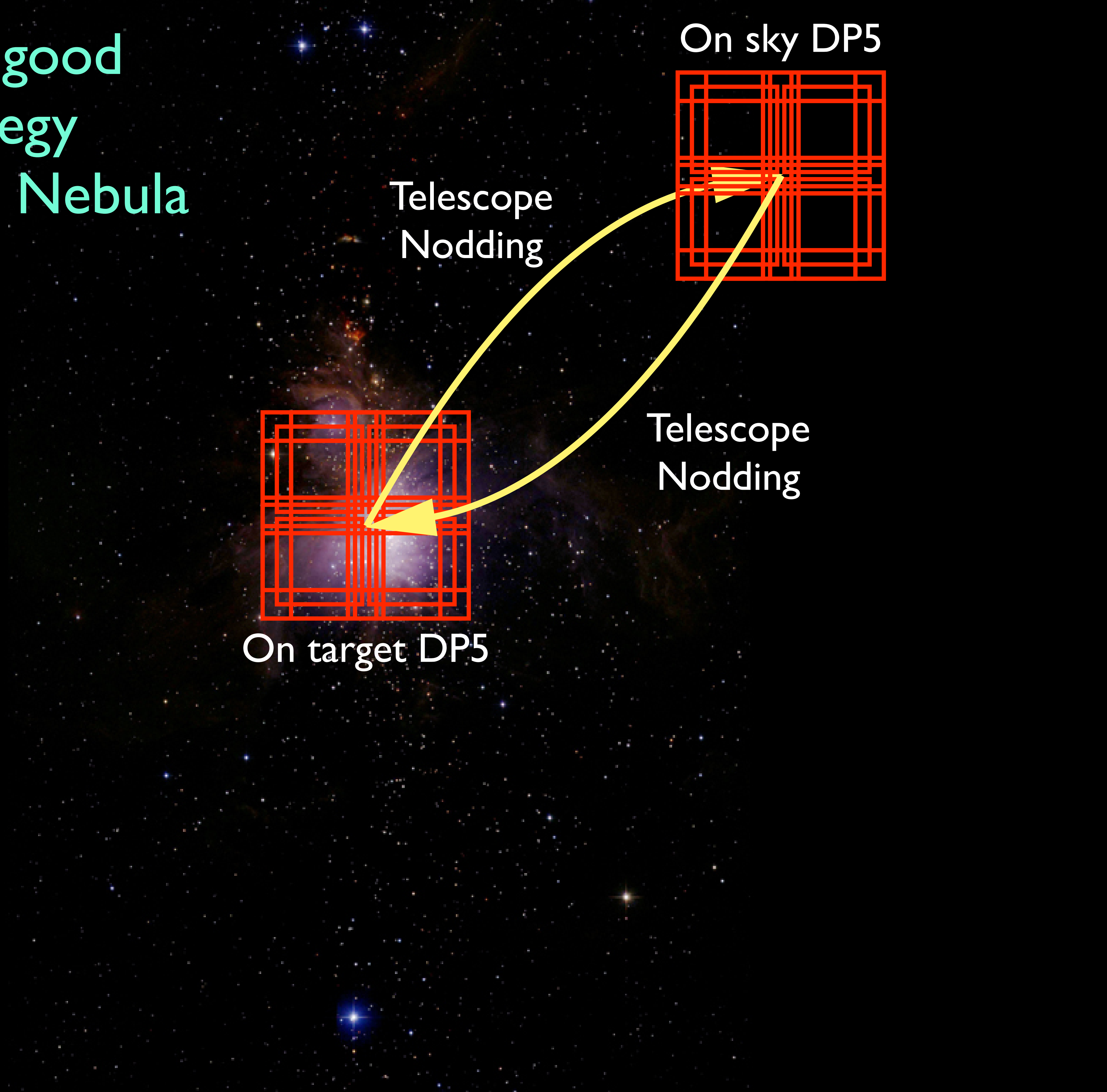
Nodding



Example of a good nodding strategy on the Orion Nebula



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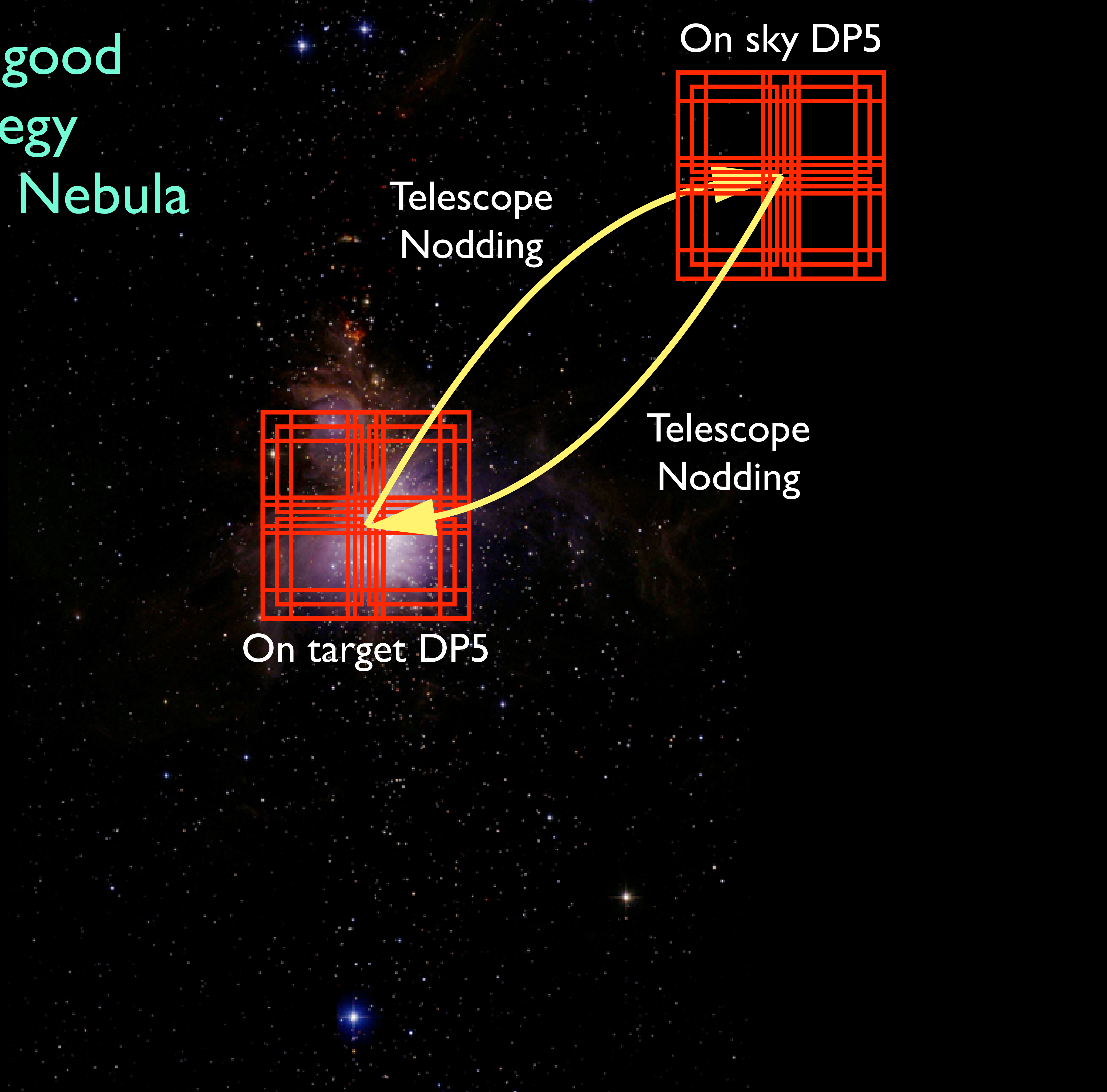

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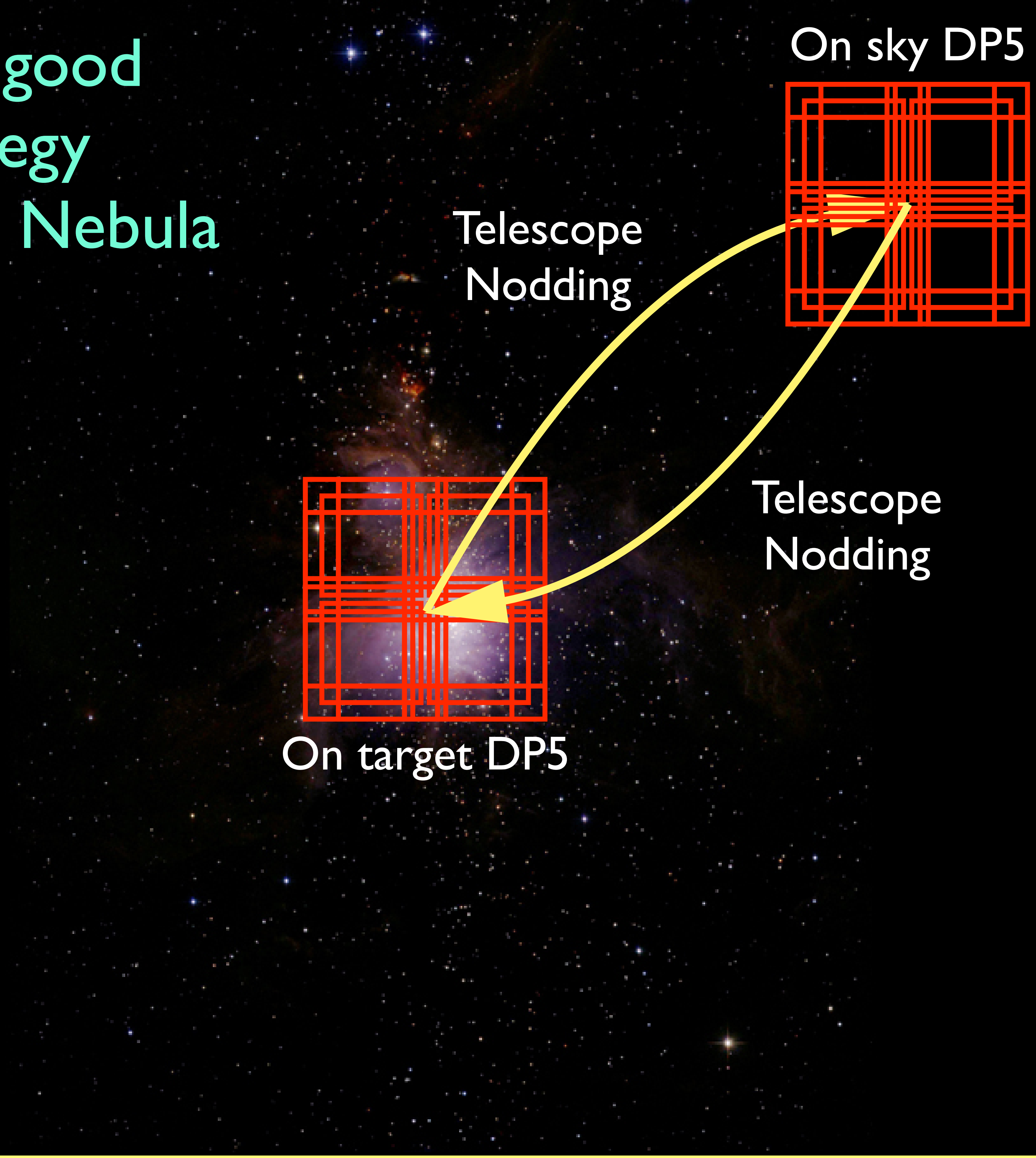

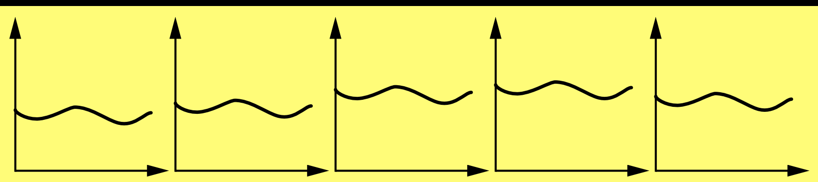

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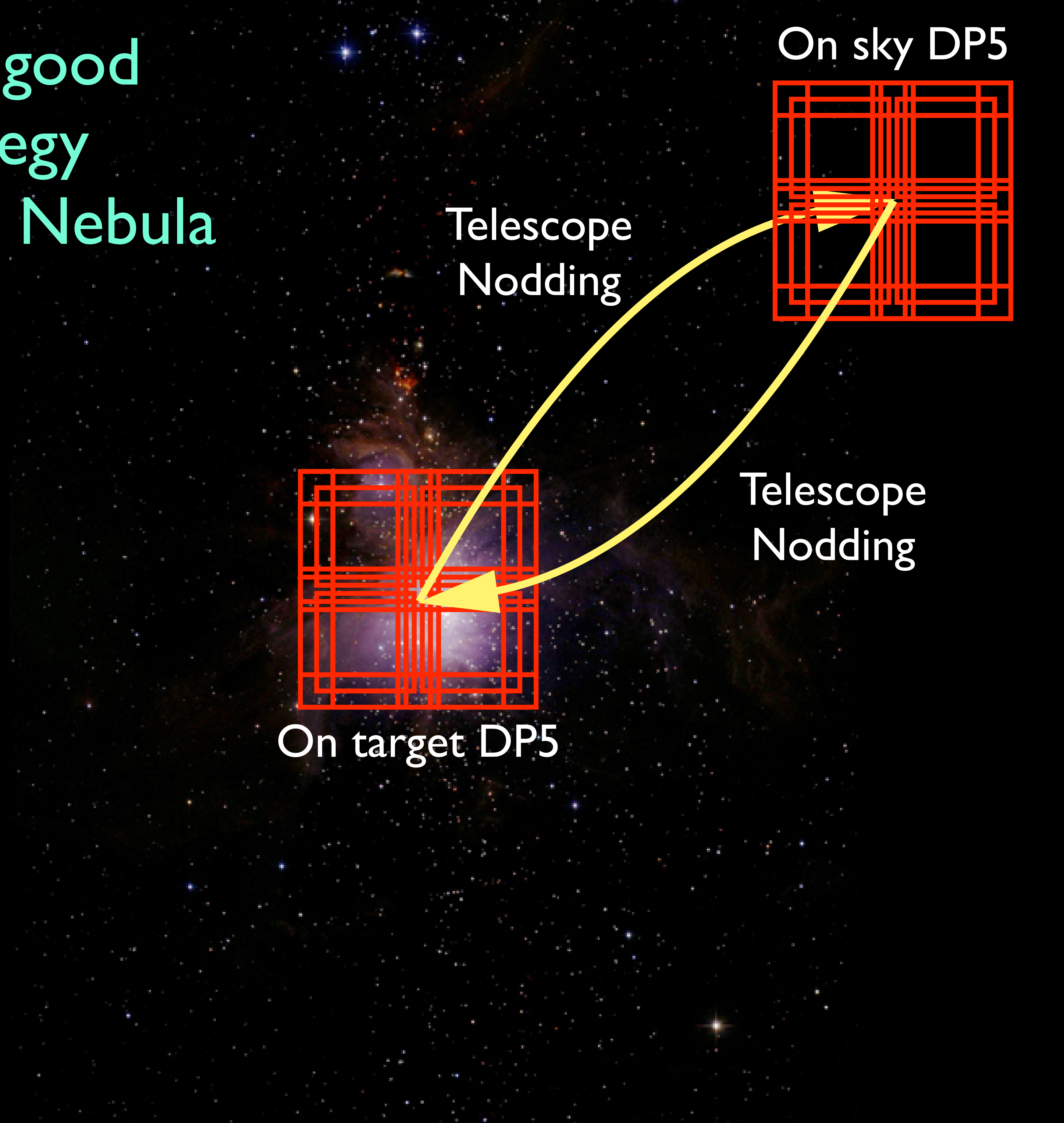

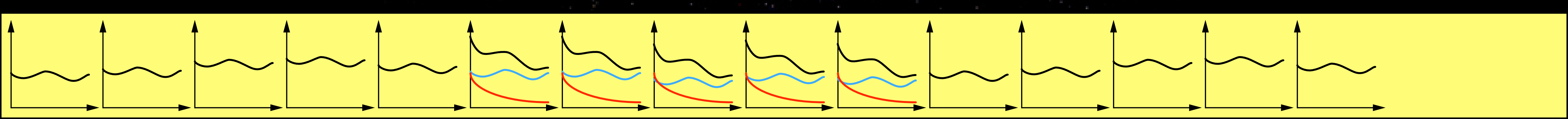

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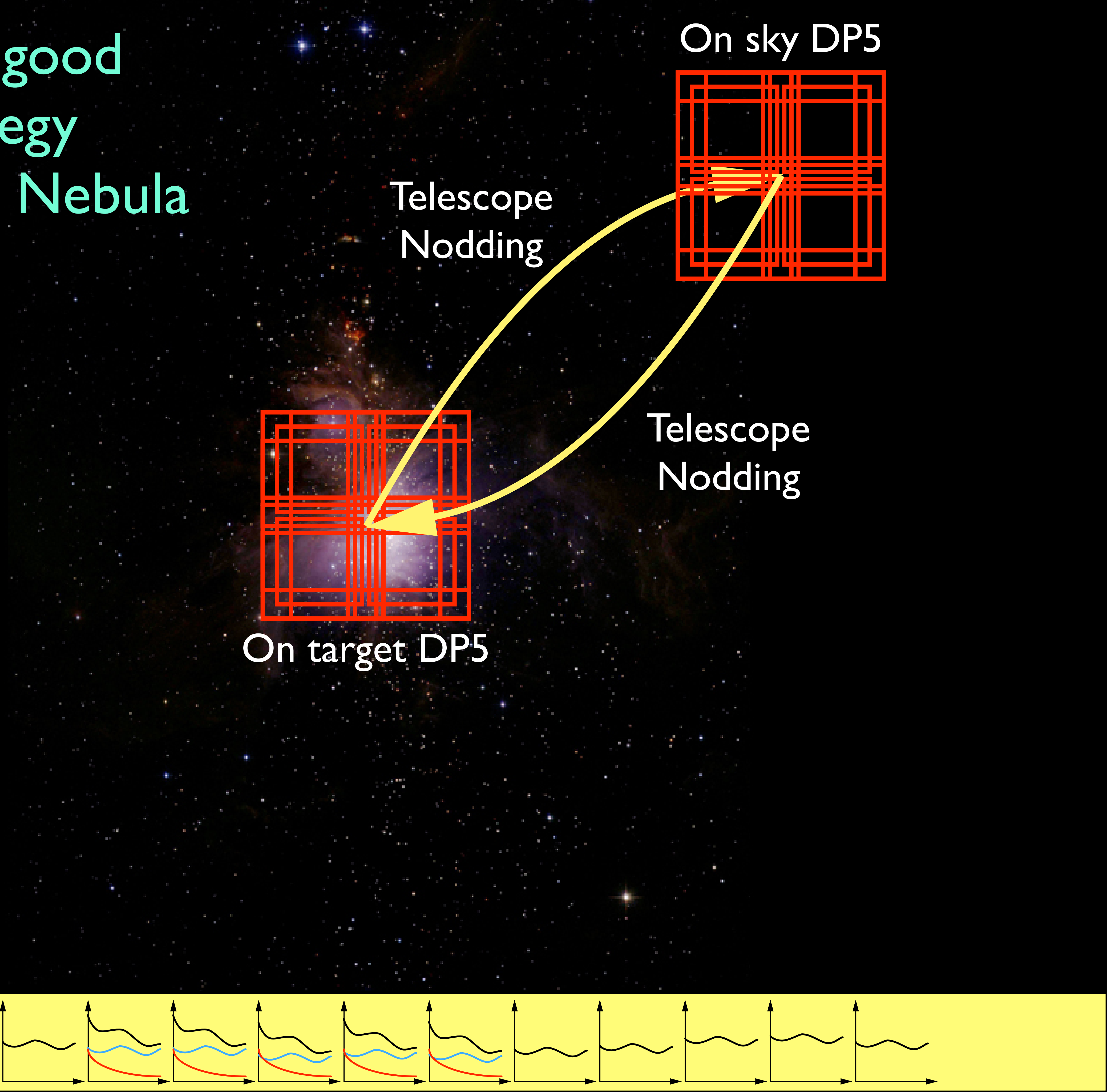
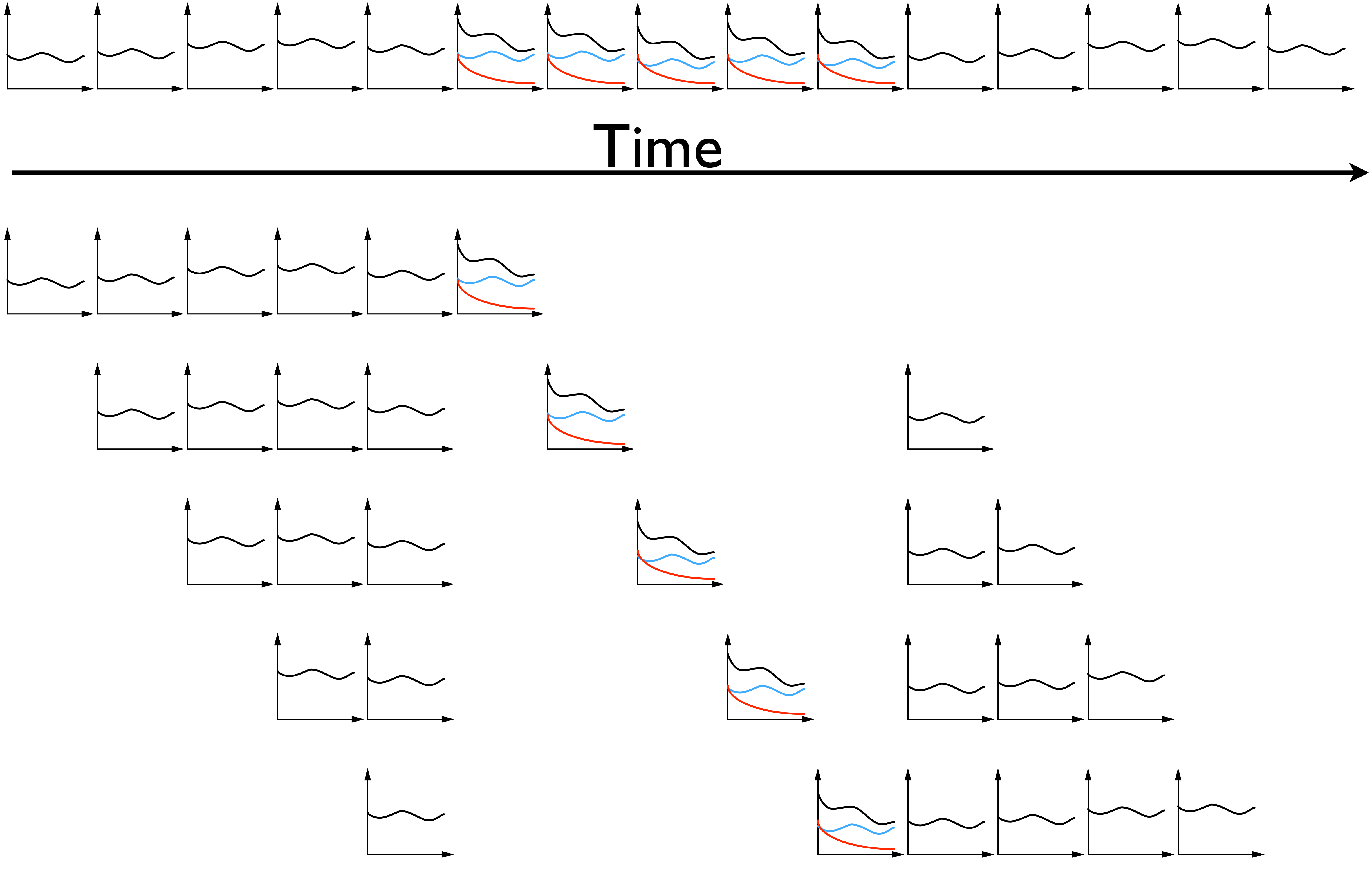
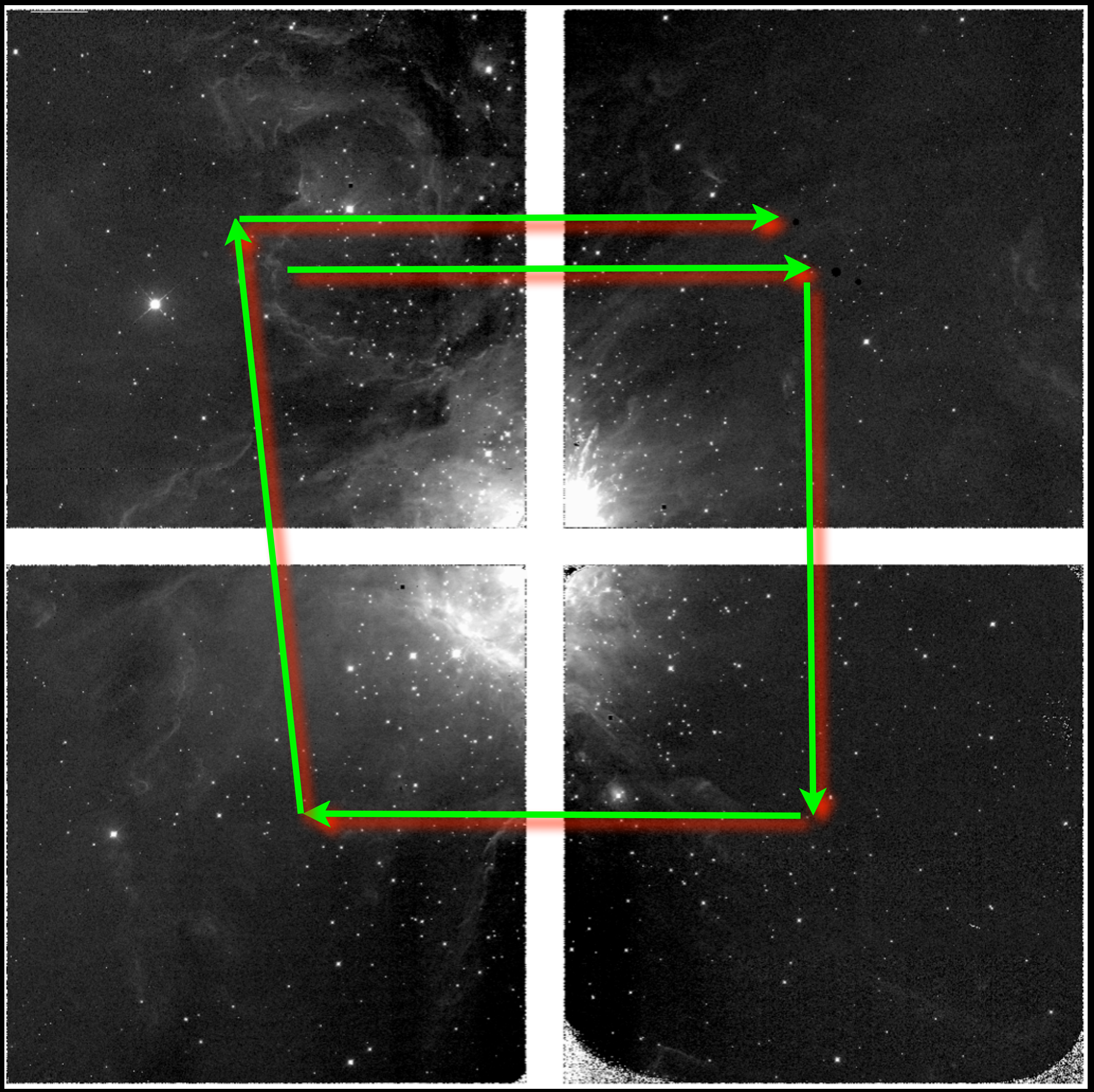



Time

Wide Dithering Pattern (WDP)

-works for targets < 10 arcmin

-100% of time on target



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Common errors with standard dithering pattern observations

- Doing a large number of coadds between each DP (example 06BC98 on M81).
- Using a dithering scale smaller than the largest object of interest in the field (example DP scale of 30″ when the target is 45″ wide).

Golden rules for nodding observations

- Need at least a DP3 on the sky positions, ideally DP5, to do a clean median as often as possible.
- Ideally obtain sky images at the beginning and end of the sequence, to better interpolate sky levels.

What not to do!!!

07AC05 on M82 - dithering by only 5″ with crowded galaxy field.

07AD92/93 - 60″ target, no dithering at all but coadds of 16 at the same position. A DP16 with a scale of ~75″ would have been perfect.

but wait! there is more!

07ATxx - 2 sky DP only! i.e. on extended target for 4 dithers then on sky for one single exposure of sky1, then 4 more dithers on target, finally one single exposure on sky2.

07BK02 - sometimes only 1 sky DP!

Common errors for nodding observations

- No nodding at all!!!
- Only DP1 or DP2 used on sky (the equivalent of not dithering the telescope).
- A sky field too distant (>5 deg) from the target field (sky maybe different there).
- Define a sky in PH2 the same as a target (they could be observed on different nights!)