# Geodetic Coordinate Database at DESY.

**Still looking for a nice acronym… Maybe GC-DaD, or GeCoDa?**

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Geodetic Coordinate Database at DESY
IWAA 2016, Grenoble, 04.10.-07.10.2016

HELMHOLTZ ASSOCIATION

DESY

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# History

> Accelerators and number of adjustable components

| Accelerator | Year | No. of components | Fiducialised individually | Method of data keeping |
|---|---|---|---|---|
| DORIS | 1974 | 108 | No | Paper /ASCII-File |
| HERA | 1991 | 1594 | No | ASCII-File |
| TTF | 1992 | 44 | Yes | ASCII-File |
| TTFII / FLASH | 2005 | 142 | Yes | Excel-File / DB |
| PETRA III | 2010 | 1019 | Yes | DB |
| XFEL | 2016 | ~2000 | Yes | DB |

> Individual Fiducialisation was not in vogue at DESY until TTF.

> Before TTF, fiducialisation data was only derived from construction drawings for **Types of Magnets**.

> ORACLE is used as DB, because it is provided by the IT-Department

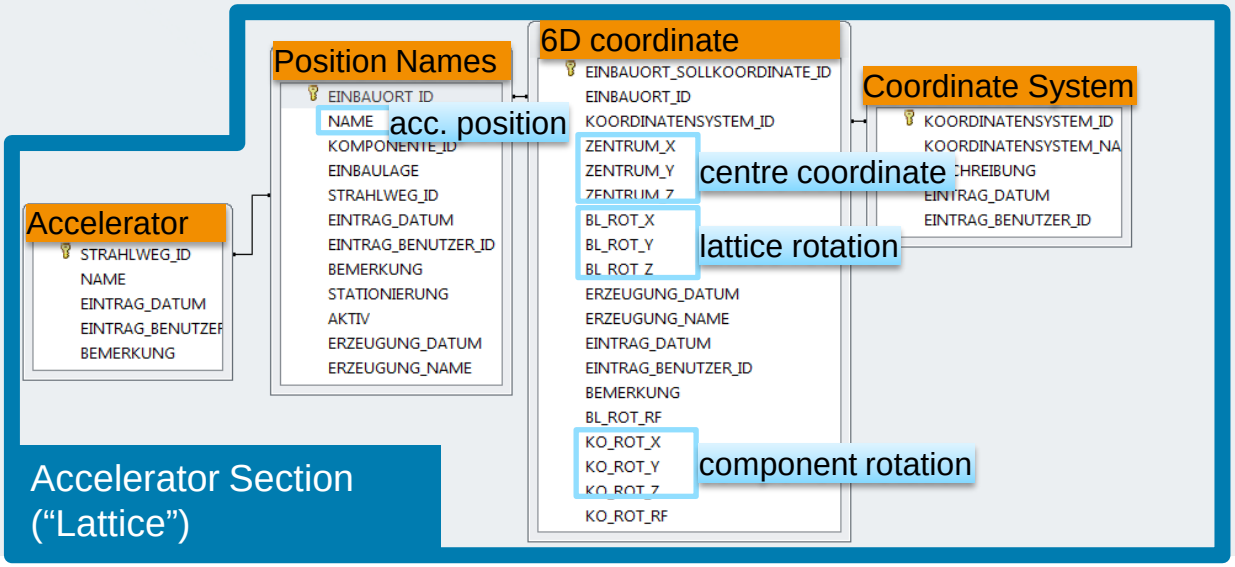
# Database Content (I)

- Accelerator Section (Lattice)
  - Name of installation position
  - 3D center coordinate
  - 3 rotation angles
  - Supplemental data
- Component Section + Fiduzialisation Section
  - Name of Component
  - 3D position of each fiducial in component coordinate system
  - Tilt data (if applicable)
  - Date of measurement (!)
  - Supplemental data

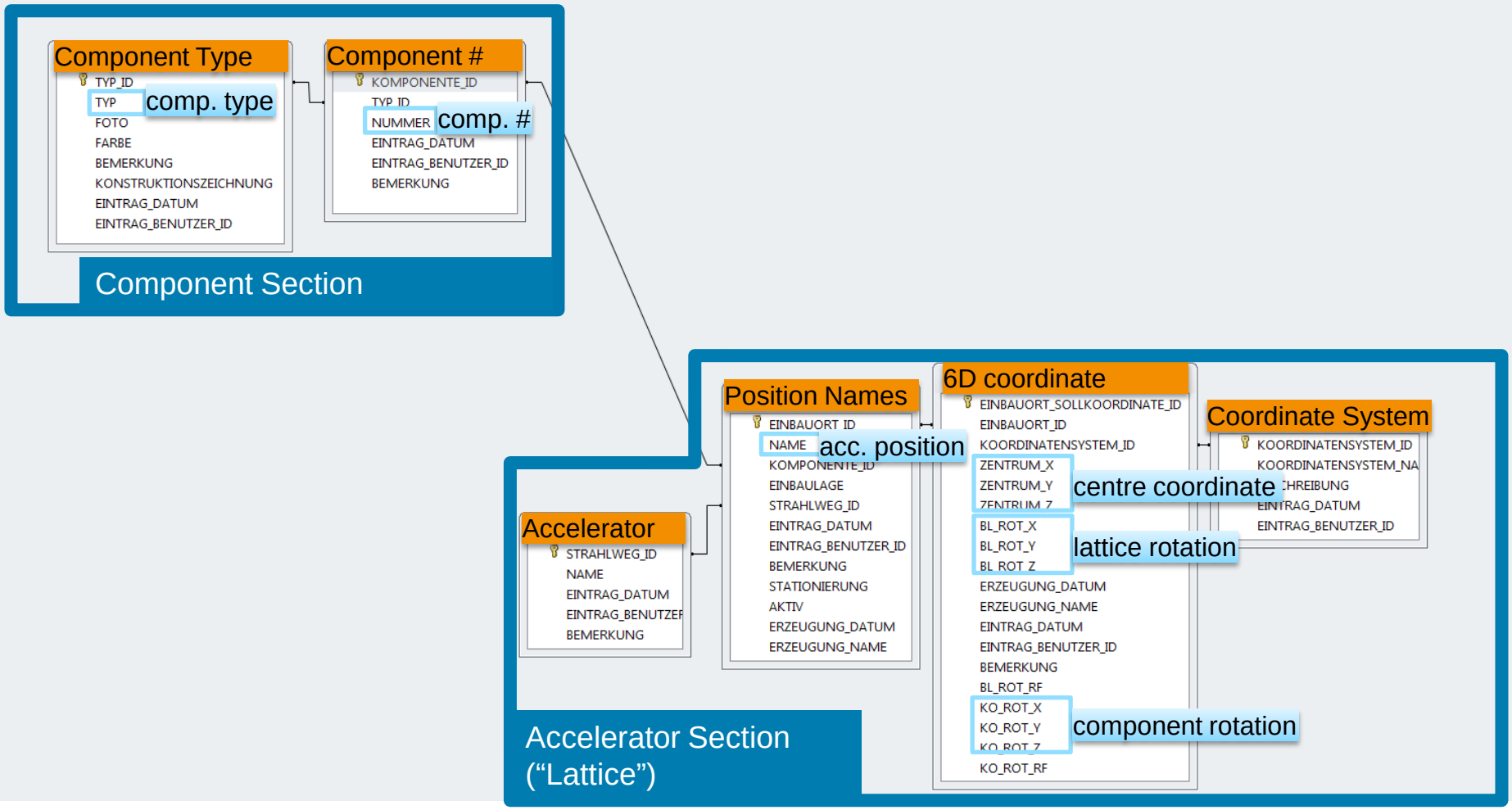
# Database Content (II)

- Actuals Section
  - Name of Installation position
  - Actual 3D coordinates of all fiducials
  - Tilt measurements (if applicable)
  - Supplemental Data
- (Coordinates of reference points)
  - Name of monument
  - 3D coordinate
  - Date of measurement
  - Supplemental Data

# Database Structure



# Database Structure



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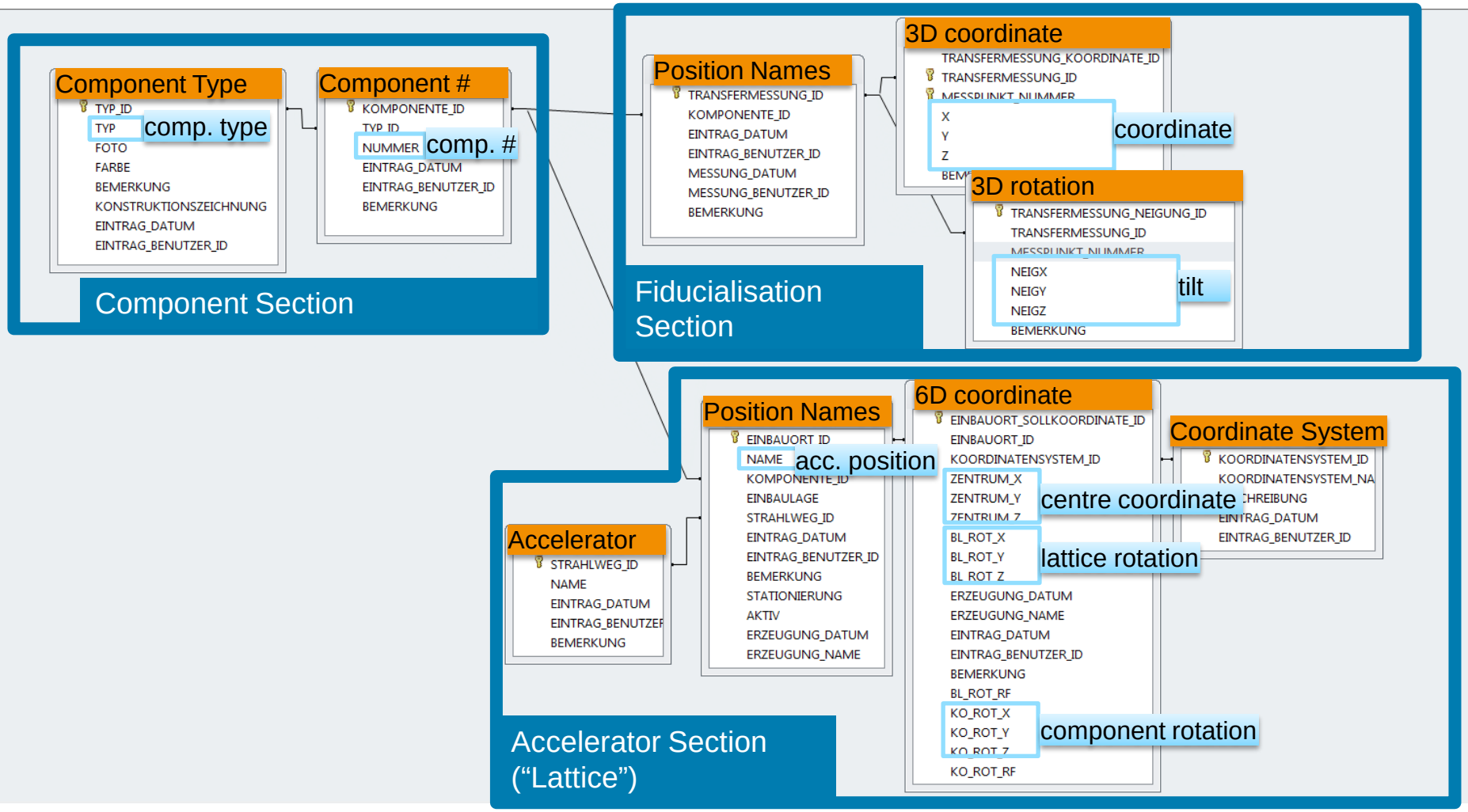

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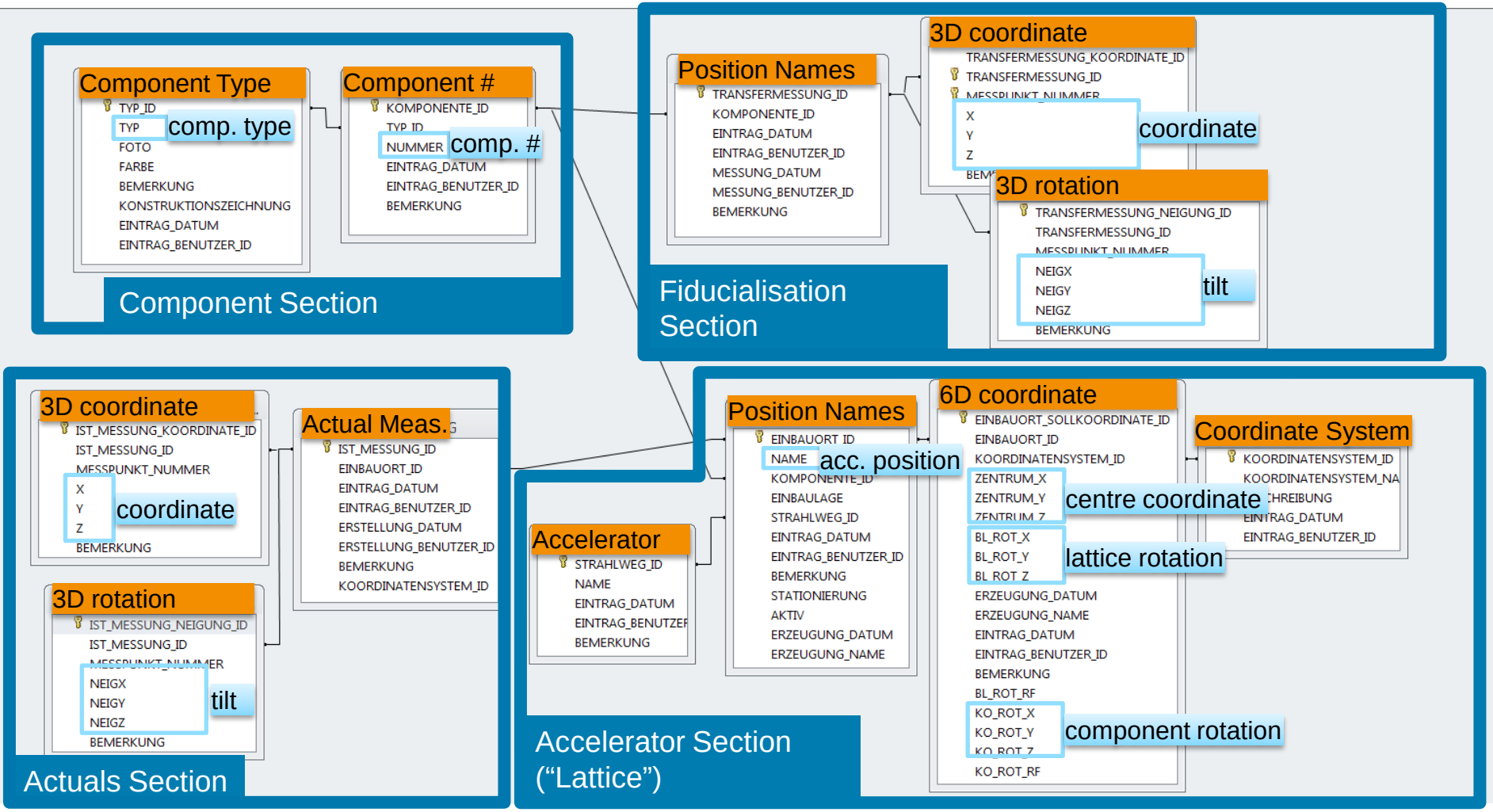
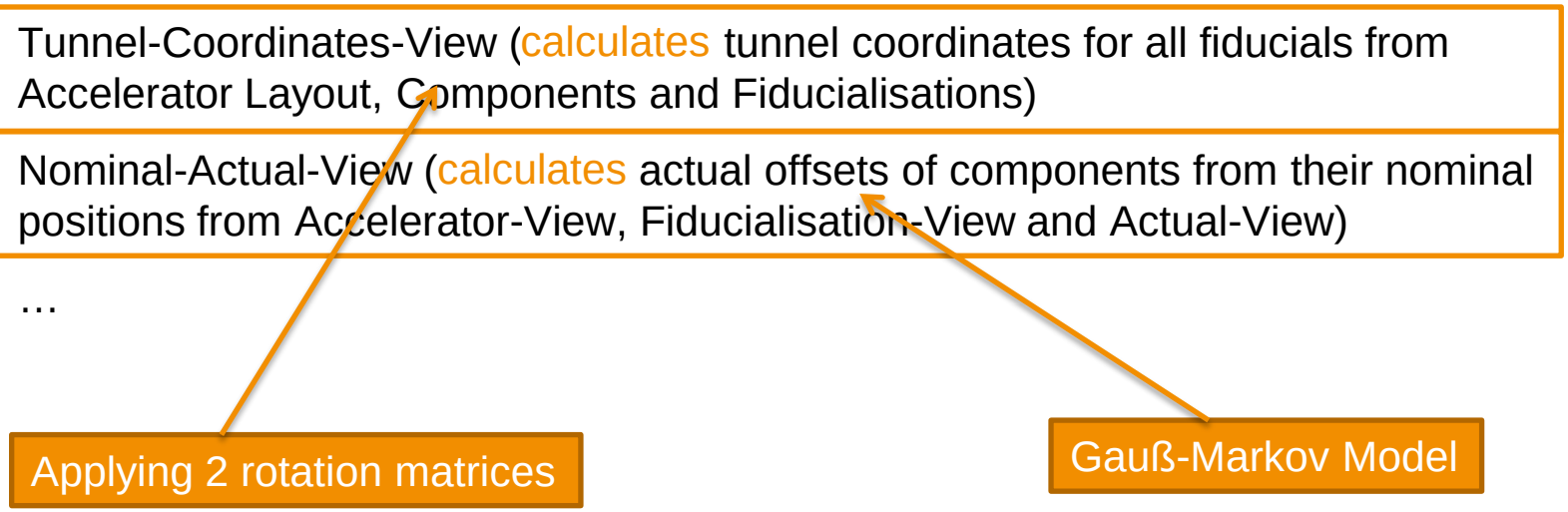


# Database Views

- Various Tables have to be combined to form Views for everyday use
  - Accelerator-View (adds Component Names to Accelerator Layout)
  - Whereis-View (finds installation positions for component)
  - Double-View (finds components installed twice – oops…)
  - …
  - Tunnel-Coordinates-View (calculates tunnel coordinates for all fiducials from Accelerator Layout, Components and Fiducialisations)
  - Nominal-Actual-View (calculates actual offsets of components from their nominal positions from Accelerator-View, Fiducialisation-View and Actual-View)
  - …



# Mathematics inside the DB

- Prerequisites
  - Procedural programming functionality is available through PL/SQL
  - Mathematical functionality is also available
  - Matrix calculus functionality is available through UTL_NLA package
- Doing Mathematics inside the Database has advantages
  - No local Software Installation required (MatLab, Octave, etc.)
  - ORACLE guarantees (well, not explicitly) upward compatibility
- However, there are some disadvantages
  - Cumbersome programming Interface, debugging, etc.
  - Relatively slow, because Hardware is not optimized for floating point operation

You have to bear with it

Not of concern,
because of modern hardware

# Mathematics & UTL_NLA

- Mathematical functions are included in PL/SQL itself
  - Basic arithmetic
  - Trigonometric functions
  - Power functions
  - …
- UTL_NLA is a supplemental package provided by ORACLE
  - Selected functions from BLAS library (Basic Linear Algebra Subprograms)
  - Selected functions from LAPACK library (Linear Algebra PACKage)

# BLAS and LAPACK

- BLAS (Basic Linear Algebra Subroutines)
  - Optimized for various Hard- and Software
  - Level 1 (Vector operations) $y \leftarrow \alpha x + y$
  - Level 2 (Vector-Matrix operations) $y \leftarrow \alpha A x + \beta y$
  - Level 3 (Matrix operations) $C \leftarrow aAB + \beta C$

    GEMM (TRANSA, TRANSB, M, N, K, ALPHA, A, LDA, B, LDB, BETA, C, LDC)

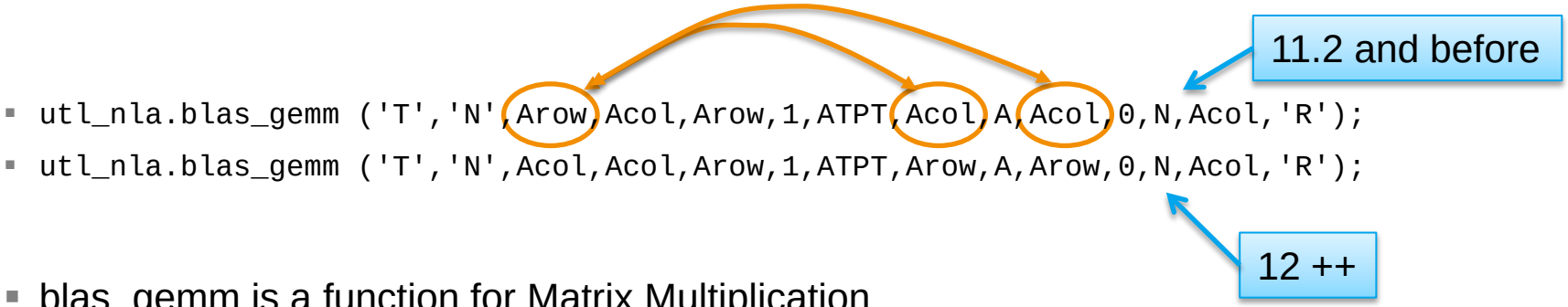
- LAPACK (Linear Algebra PACKage)
  - Uses BLAS functionality
  - Eigenvalues $A\,v = \lambda\,v$

    GEEV (JOBVL, JOBVR, N, A, LDA, WR, WI, VL, LDVL, VR, LDVR, PACK)
  - Matrix Inversion $A\,A^{-1} = A^{-1}A = I$

    GELS (TRANS, M, N, NRHS, A, LDA, B, LDB, INFO, PACK)

# Upward Compatibility

- ORACLE normally maintains upward compatibility across versions
- Coordinate database was put in operation in 2009, with ORACLE 10
- Two Software updates
  - 2011: 10 ⇒ 11.2
  - 2015: 11.2 ⇒ 12
- Only one minor update of the code was necessary due to an error correction in the UTL_NLA library in 2015




  - blas_gemm is a function for Matrix Multiplication

# Data Transfer

- Coordinate Files are created by an ASCII-Export on request
  - component coordinate file (contains all fiducials of all components on an accelerator in a given coordinate system)
  - network coordinate file (contains all network monuments in a given coordinate system)

- Fiducialisation data and Measurement data from the tunnel is imported directly from SA using a measurement plan
  - Function is “Put to ODBC Database”
  - Pros: Integration in the measurement software, easy to use
  - Cons: Slow, Import of several data sets at once is not possible

# Hardware, Backend, Runtime

## > Database Hardware at DESY

- 4 SunFire 4270, 2 Intel Xeon CPU X5570, 2,93GHz
- Infiniband Inter-Connect
- NetApp Storage
- Oracle Enterprise Linux x86_64

## > Runtime

- All jobs but two are done “instantly”, with no noticeable delay

| Job | Runtime [s] (Average) |
|---|---|
| Export tunnel coordinates of all XFEL components | 4.3 |
| Export deviations between nominal and actual positions of all XFEL components | 40.5 |

# Examples

## > Accelerator Layout View

| Einbauort | Stationierung | KompTyp | KompNR | Einbaulage | Justierbar | HatTM | Strahlweg | Aktiv | KS | X | Y | Z | bl_roty | bl_rotz | bl_rotRF | ko_rotx |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SA.2067.T1 | 2044600 | XSAm18 | 01 | R | 1 | JA | XFEL-T1 | 1 | XFEL-LA | 2067457.409 | 781.991 | -2441.325 | 0.020917 | 0.950059 | YXZ | 161.50 |
| BPMA.2068.T1 | 2046036 | XBPMA | 999 | | 1 | JA | XFEL-T1 | 1 | XFEL-LA | 2068893.393 | 805.804 | -2441.849 | 0.020917 | 0.950059 | YXZ | 180.00 |
| QF.2069.T1 | 2046511 | XQF | 62 | | 1 | JA | XFEL-T1 | 1 | XFEL-LA | 2069368.328 | 813.680 | -2442.023 | 0.020917 | 0.950059 | YXZ | 180.00 |
| CFX.2069.T1 | 2046981 | XCF-H | 11 | R | 1 | JA | XFEL-T1 | 1 | XFEL-LA | 2069838.263 | 821.478 | -2442.194 | 0.020917 | 0.950059 | YXZ | 180.00 |
| IP.2071.T1 | 2048913 | XIP | 026 | R | 1 | JA | XFEL-T1 | 1 | XFEL-LA | 2071778.210 | 852.990 | -2443.070 | 0.020920 | 0.950054 | YXZ | 180.00 |
| IP.2076.T1 | 2053763 | XIP | 033 | R | 1 | JA | XFEL-T1 | 1 | XFEL-LA | 2076627.790 | 932.310 | -2444.840 | 0.020920 | 0.950054 | YXZ | 180.00 |
| BD.2077.T1 | 2054750 | XBD-H | 03 | R | 1 | JA | XFEL-T1 | 1 | XFEL-LA | 2077605.600 | 951.378 | -2445.030 | 0.020916 | 1.117018 | YXZ | 0.00 |
| BD.2079.T1 | 2056250 | XBD-H | 04 | | 1 | JA | XFEL-T1 | 1 | XFEL-LA | 2079105.221 | 984.984 | -2445.578 | 0.020913 | 1.450936 | YXZ | 0.00 |
| IP.2079.T1 | 2056990 | XIP | 035 | R | 1 | JA | XFEL-T1 | 1 | XFEL-LA | 2079854.970 | 1004.310 | -2446.020 | 0.020920 | 1.617890 | YXZ | 0.00 |

## > Nominals vs. Actuals View

| Name | Station | X [mm] | Y [mm] | Z [mm] | rotx [°] | roty [°] | rotz [°] | Date of coordinate | vx [mm] | vy [mm] | vz [mm] | vrotx [mrad] | vroty [mrad] | vrotz [mrad] | Date of measurement |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MIAC.726.L3 | 703306 | 726191.640 | 0.000 | 0.000 | 0.0000 | 0.0000 | 0.0000 | 14.07.2016 | -0.2 | 0.2 | 0.0 | 0.5 | 0.0 | 0.0 | 15.09.2016 |
| MIAC.738.L3 | 715298 | 738183.340 | 0.000 | 0.000 | 0.0000 | 0.0000 | 0.0000 | 14.07.2016 | 0.0 | 0.3 | 0.0 | 0.5 | 0.0 | 0.0 | 14.09.2016 |
| MIAC.750.L3 | 727290 | 750175.040 | 0.000 | 0.000 | 0.0000 | 0.0000 | 0.0000 | 14.07.2016 | 0.0 | 0.3 | 0.1 | 0.2 | 0.0 | 0.0 | 14.09.2016 |
| MIAC.762.L3 | 739281 | 762166.740 | 0.000 | 0.000 | 0.0000 | 0.0000 | 0.0000 | 14.07.2016 | 0.2 | 0.1 | 0.1 | 0.2 | 0.0 | 0.0 | 14.09.2016 |
| CSC.769.L3 | 746566 | 769451.520 | 0.000 | 0.000 | 0.0000 | 0.0000 | 0.0000 | 14.07.2016 | 0.7 | 1.1 | 0.3 | 0.9 | -0.1 | -0.1 | 14.09.2016 |

# Summary

- Database concept is able to hold all geodetic accelerator data.
- Database Administration done by IT department.
  - No additional work for the geodesists
- All necessary operations, including mathematics, are done by the database host
  - No external software installation needed, like Matlab, etc.
  - Upward compatibility is nearly 100% up to now
- Web-Interface, based on APEX is planned for the future.

# Thanks for your attention!

# Relational Database

**Information to store**

| UPID | Name | Department | Address |
|---|---|---|---|
| 1 | Petra | Administration | A-Street |
| 394 | Fred | Directorate | B-Street |
| 2 | Scott | Human Resources | C-Street |
| 4422 | Willy | Administration | F-Street |
| 4423 | Scott | Human Resources | C-Street |

# Relational Database

**Employee**

| UPID | Name | Department | Address |
|---|---|---|---|
| 1 | Petra | Administration | A-Street |
| 394 | Fred | Directorate | B-Street |
| 2 | Scott | Human Resources | C-Street |
| 4422 | Willy | Administration | F-Street |
| 4423 | Scott | Human Resources | C-Street |

**Department**

| UDID | Department |
|---|---|
| 2 | Administration |
| 3 | Directorate |
| 394 | Human Resources |

# Relational Database

**Employee**

| UPID | Name | DID | Address |
|---|---|---|---|
| 1 | Petra | 2 | A-Street |
| 394 | Fred | 3 | B-Street |
| 2 | Scott | 394 | C-Street |
| 4422 | Willy | 2 | F-Street |
| 4423 | Scott | 394 | C-Street |

1:n

**Department**

| UDID | Department |
|---|---|
| 2 | Administration |
| 3 | Directorate |
| 394 | Human Resources |

# Relational Database

**Employee**

| UPID | Name | DID | Address |
|---|---|---|---|
| 1 | Petra | 2 | A-Street |
| 394 | Fred | 3 | B-Street |
| 2 | Scott | 394 | C-Street |
| 4422 | Willy | 2 | F-Street |
| 4423 | Scott | 394 | C-Street |

**Department**

| UDID | Department |
|---|---|
| 2 | Administration |
| 3 | Directorate |
| 394 | Human Resources |

**Address**

| PID | Date | Address |
|---|---|---|
| 1 | 01.01.1980 | A-Street |
| 394 | 01.01.1980 | B-Street |
| 394 | 10.12.2015 | B1-Street |
| 2 | 09.04.2016 | C-Street |

# Relational Database

**Employee**

| UPID | Name | DID | Addres |
|---|---|---|---|
| 1 | Petra | 2 | A-Str |
| 394 | Fred | 3 | B-Stree |
| 2 | Scott | 394 | C-Stree |
| 4422 | Willy | 2 | F-Str |
| 4423 | Scott | 394 | C-Street |

**Department**

| UDID | Department |
|---|---|
| 2 | Administration |
| 3 | Directorate |
| 394 | Human Resources |

**Address**

| PID | Date | Address |
|---|---|---|
| 1 | 01.01.1980 | A-Street |
| 394 | 01.01.1980 | B-Street |
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| 2 | 09.04.2016 | C-Street |

# Relational Database

**Employee**

| UPID | Name | DID |
|---|---|---|
| 1 | Petra | 2 |
| 394 | Fred | 3 |
| 2 | Scott | 394 |
| 4422 | Willy | 2 |
| 4423 | Scott | 394 |

Normalised Database Scheme

**Department**

| UDID | Department |
|---|---|
| 2 | Administration |
| 3 | Directorate |
| 394 | Human Resources |

**Address**

| PID | Date | Address |
|---|---|---|
| 1 | 01.01.1980 | A-Street |
| 394 | 01.01.1980 | B-Street |
| 394 | 10.12.2015 | B1-Street |
| 2 | 09.04.2016 | C-Street |