Status Report on the Survey and Alignment efforts at DESY

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IWAA 2008 KEK Japan

Major New Projects @ DESY

- XFEL: European X-ray Free Electron Laser

- Rebuild of Petra:
  conversion from a pre-accelerator and former storage ring
  to a dedicated synchrotron radiation source

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PETRA III will be a new high-brilliance synchrotron radiation source

- Total investment of 225 million €
  - German Federal Government (90%)
  - City of Hamburg (10%)
- Conceptual design in 2002
- Final approval of the project in May 2005
- Reconstruction of the storage ring began on July 1, 2007.
- PETRA III will commence user operation in 2009.

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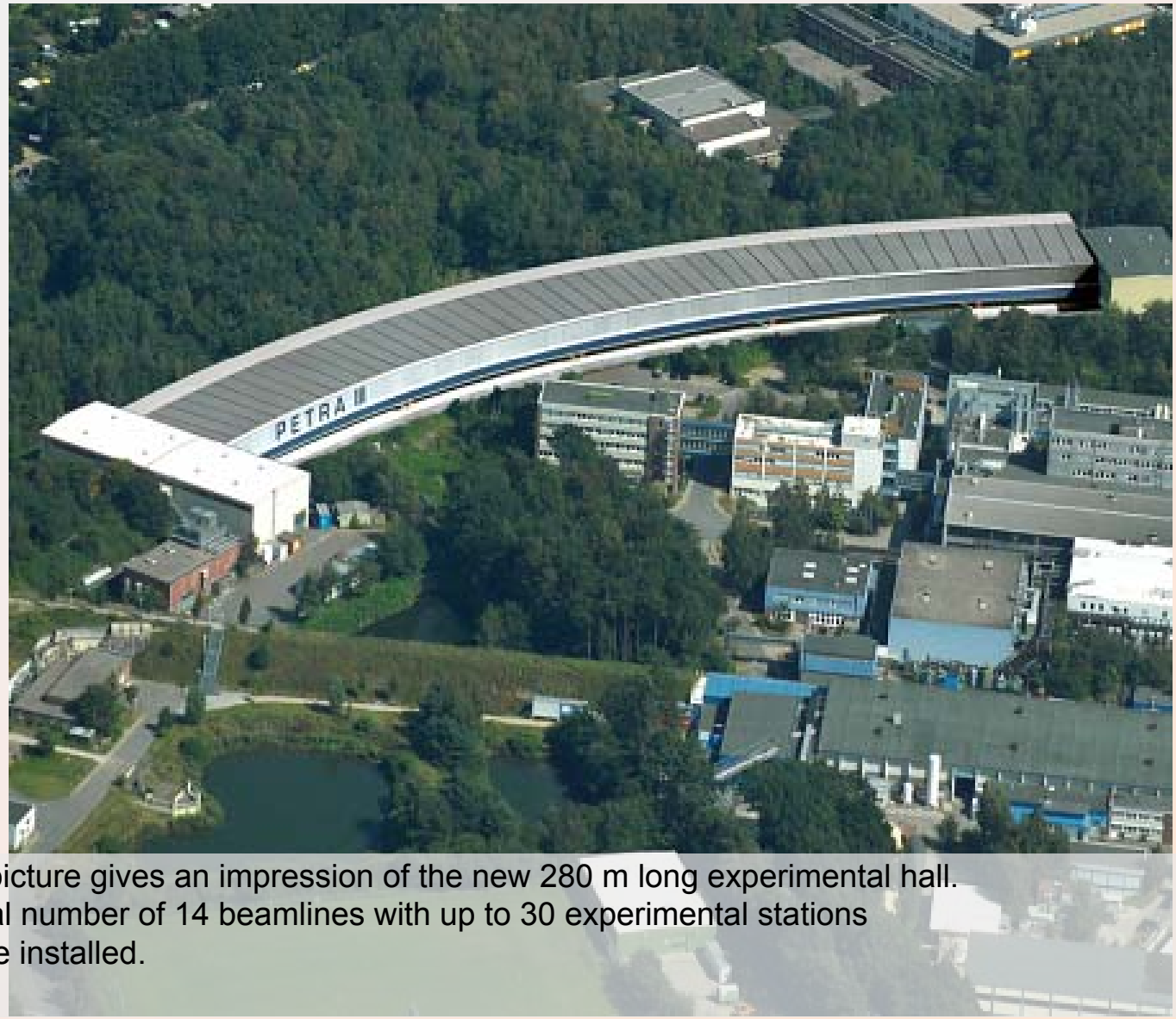

The picture gives an impression of the new 280 m long experimental hall.
A total number of 14 beamlines with up to 30 experimental stations will be installed.

Stations of reconstruction:

Preparation phase / reference grid :

•Transfer of aboveground coordinates into the tunnel via plumbing

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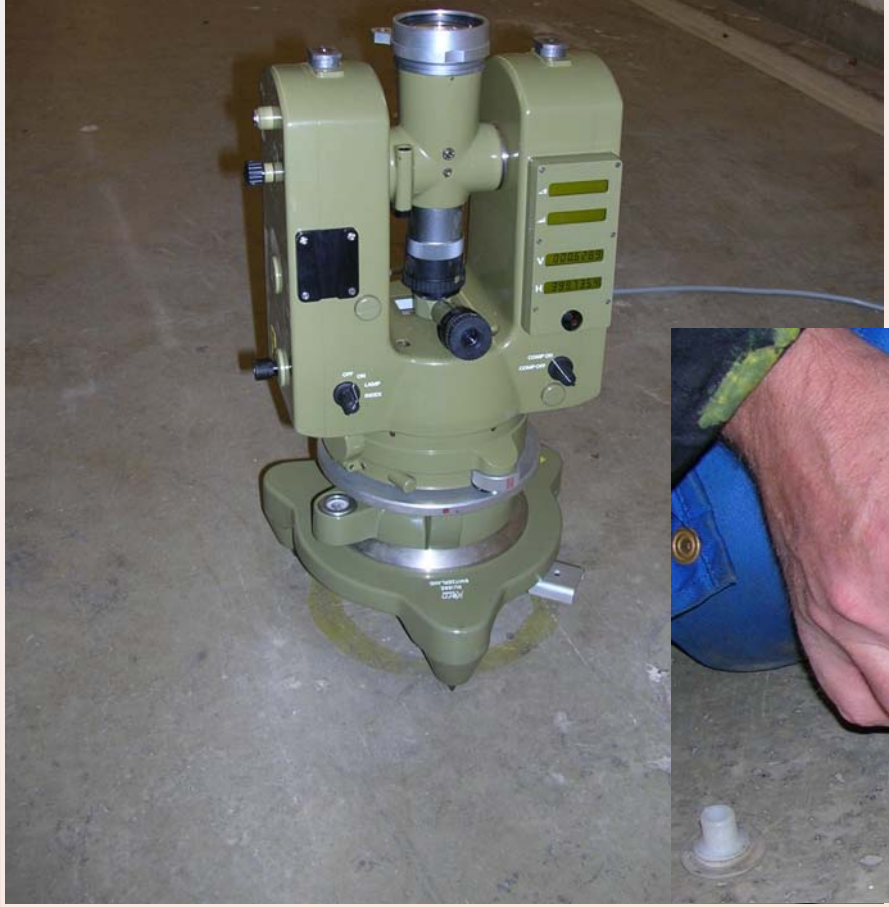

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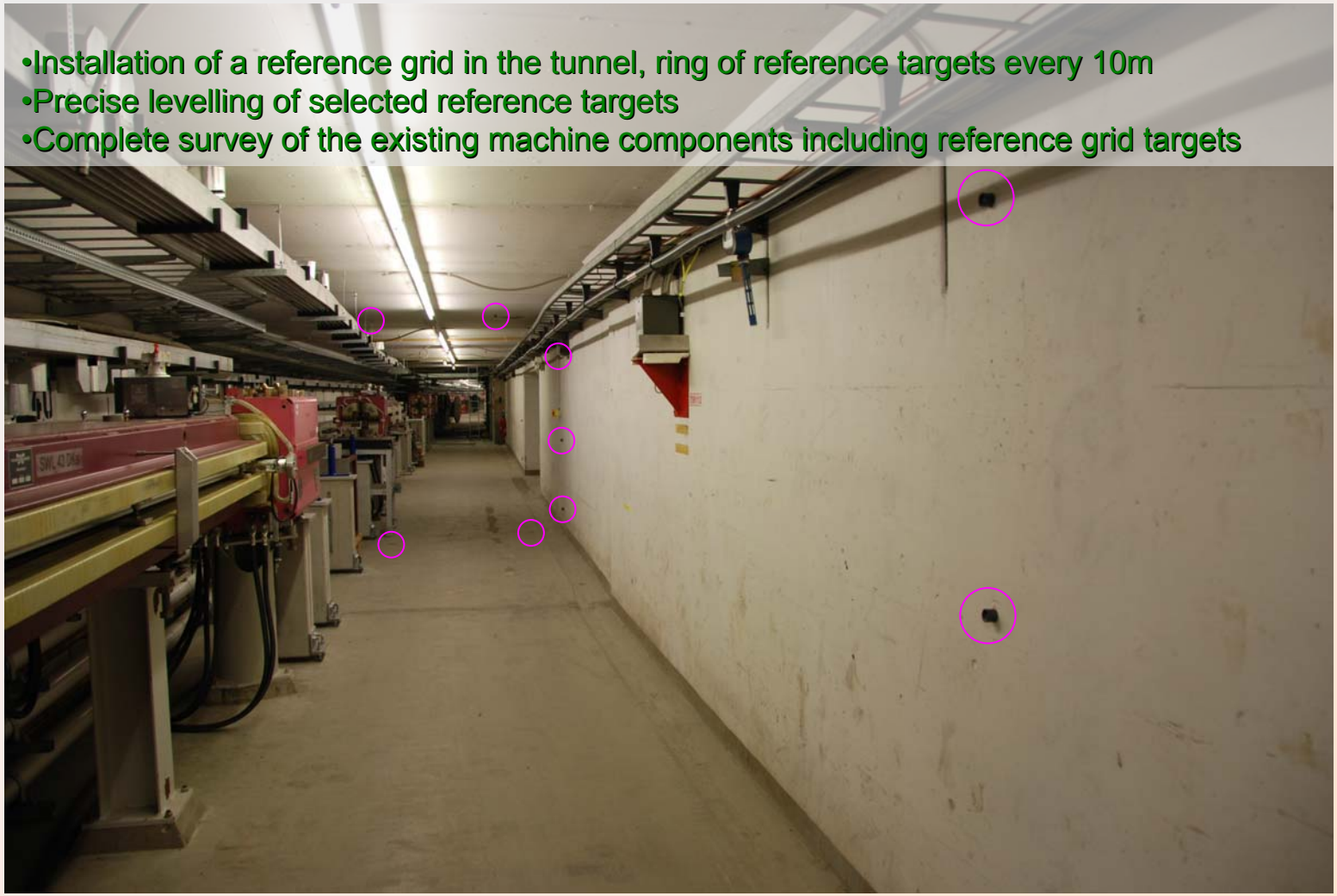
- We‘ve built 5 additional pillars at the construction site and determined its coordinates in the Petra3-system
- Construction survey for new experimental hall has been done by a contractor

Stations of reconstruction:

Reconstruction of the old 7 octants :



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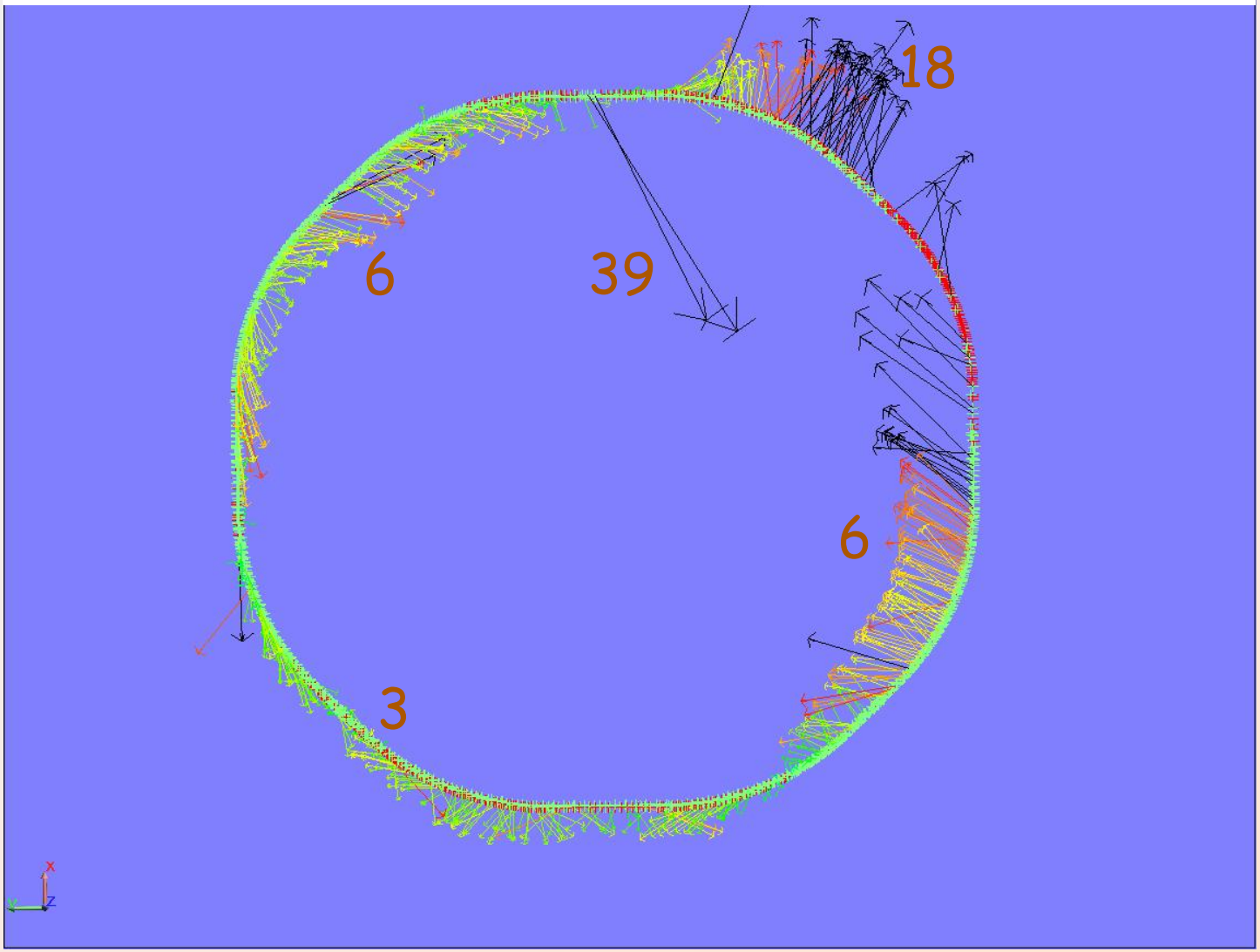
Error of old magnet positions relative to new geometry



Stations of reconstruction:

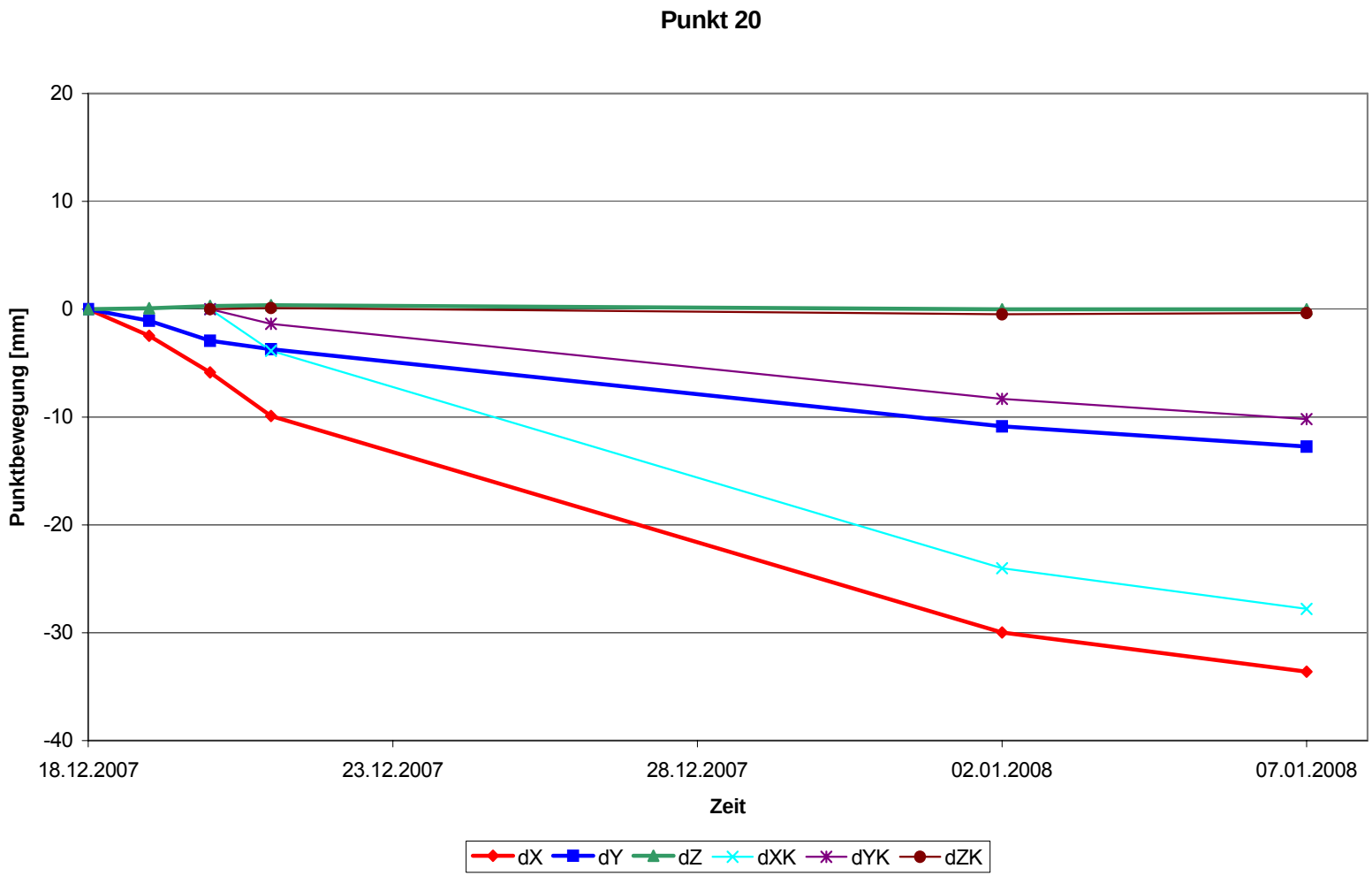
Reconstruction of the old 7 octants :

- Survey of the old pedestals, matching with new machine geometry
- Pegging out new pedestals for additional components, vacuum chambers, valves, BPM etc.
- Adjusting the new pedestals, marking of beam axis on pedestals
- Coarse adjustment of magnets prior to further installation of other departments

- Fine adjustment of all components after completion of every installation

Construction of the new experimental section:

Shrinkage of the floor slab during setting of concrete, P3 experimental hall



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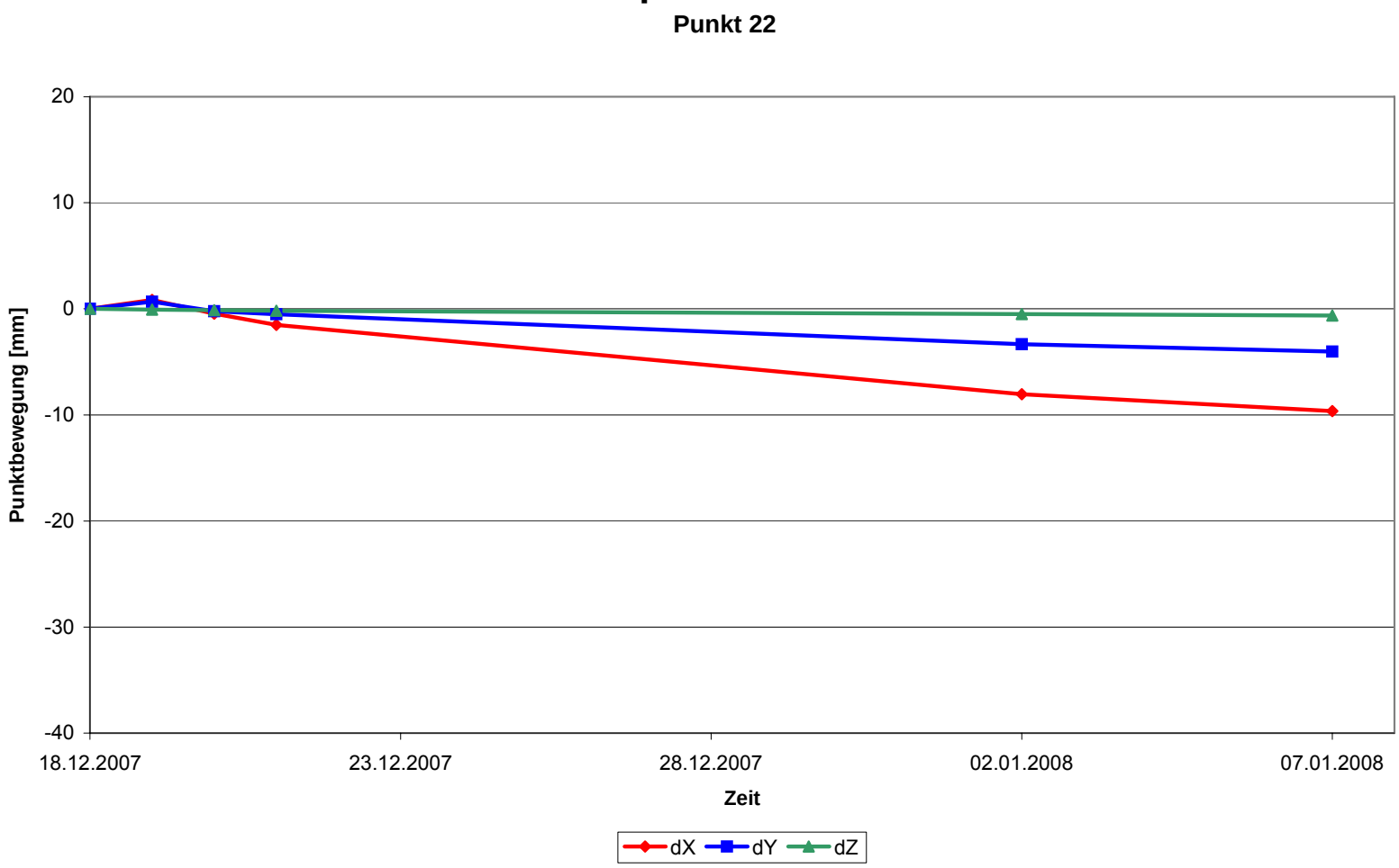

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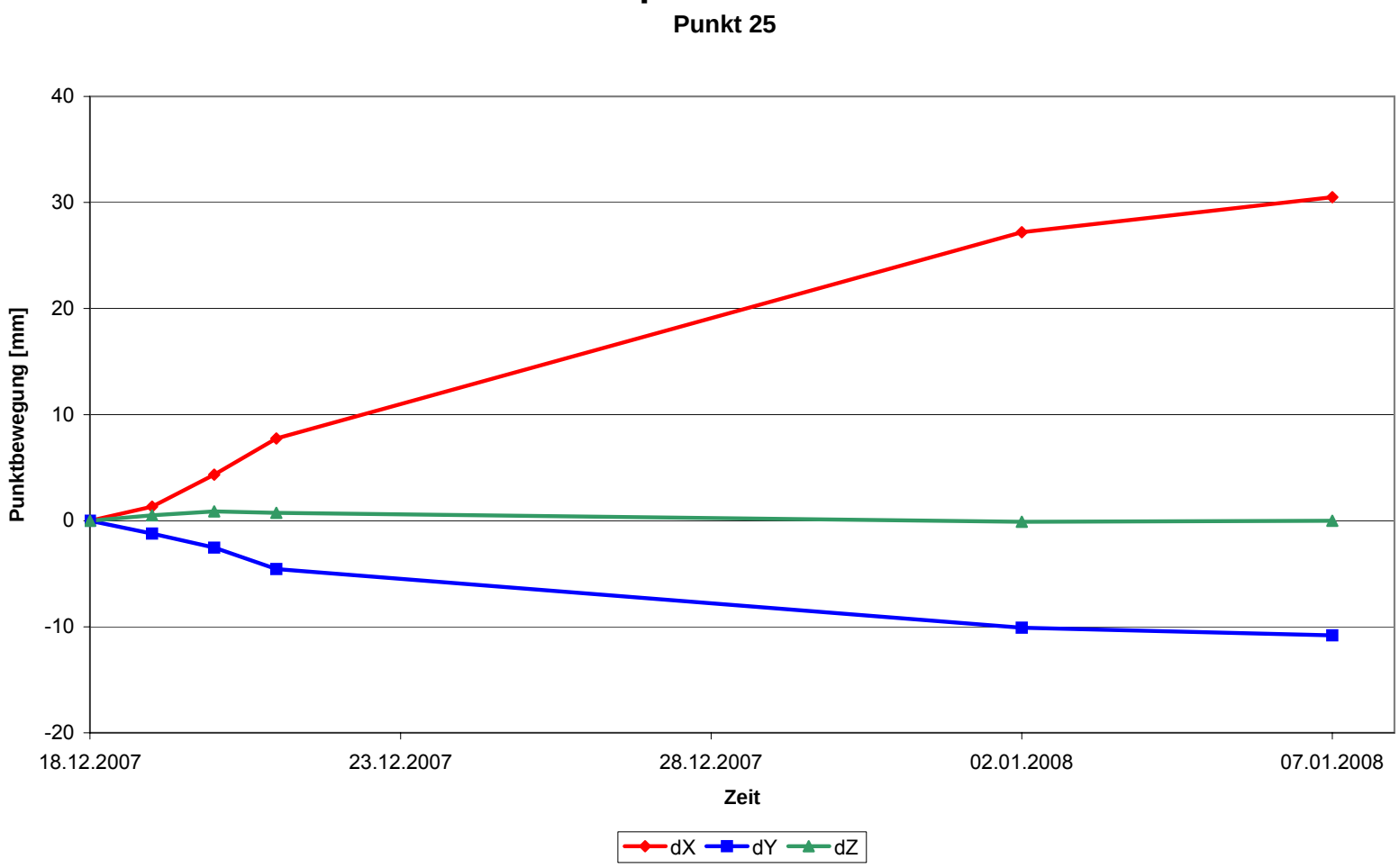

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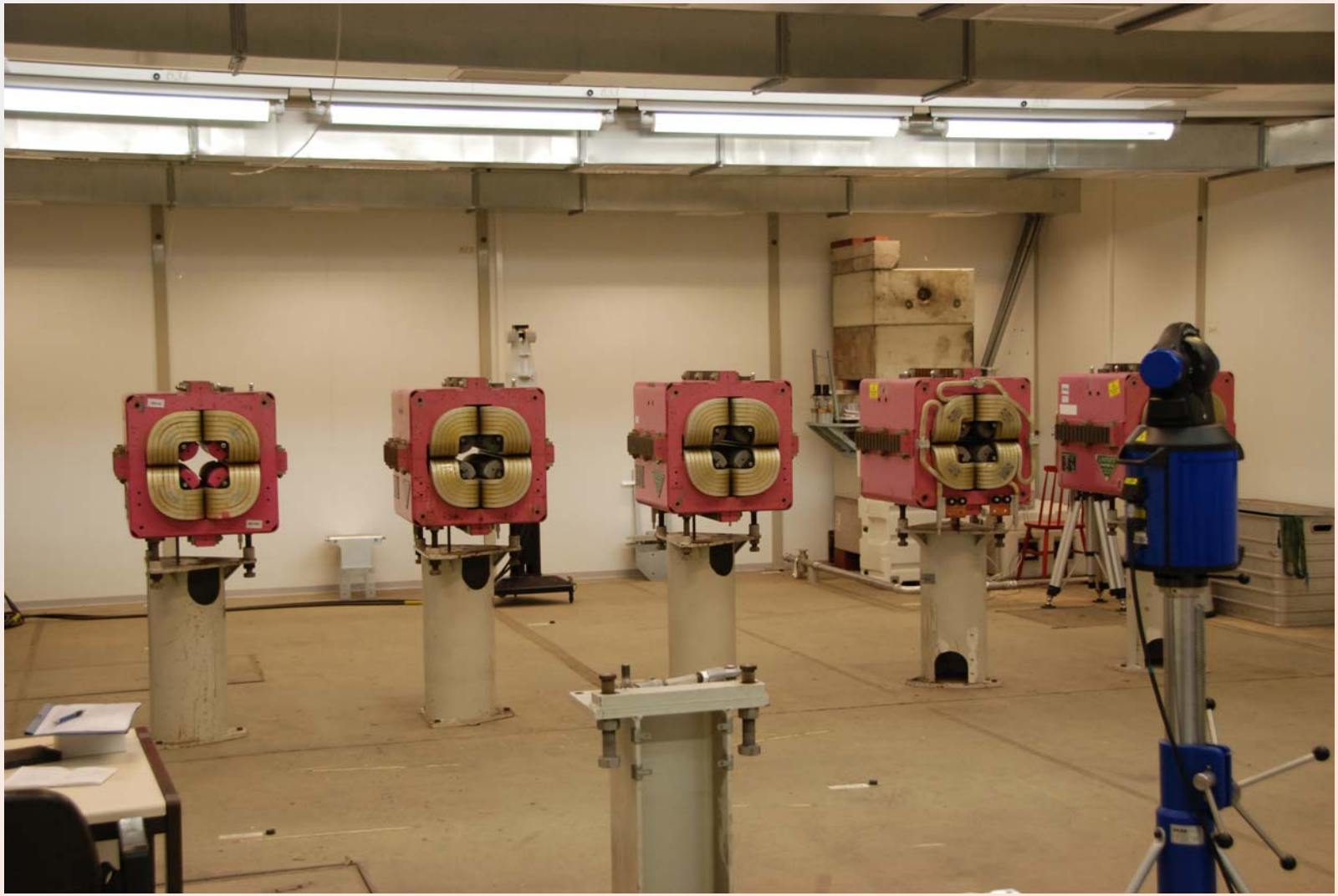
- Fiducialization of target marks on every component



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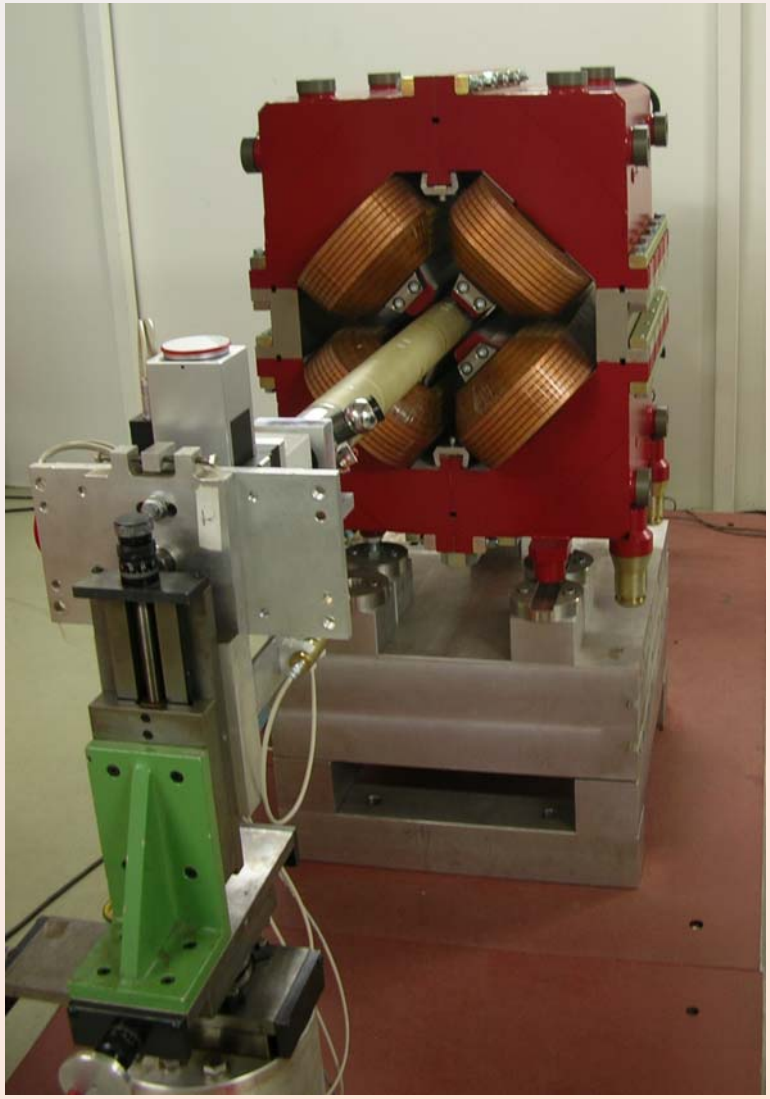

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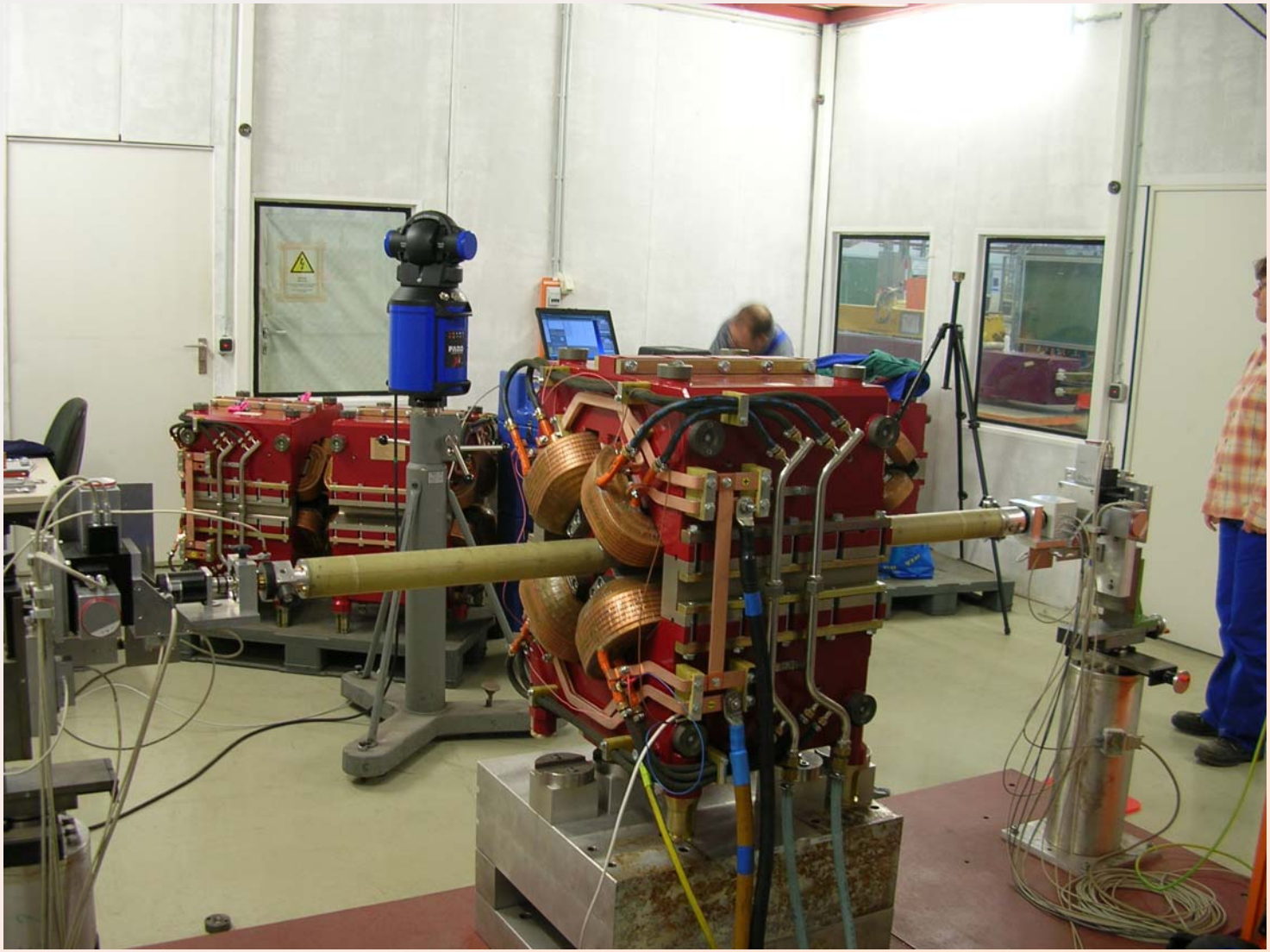


Testing the new girders

- Testinstallation and alignment of a Girder Prototype
- Coarse alignment of Girders prior to further installation

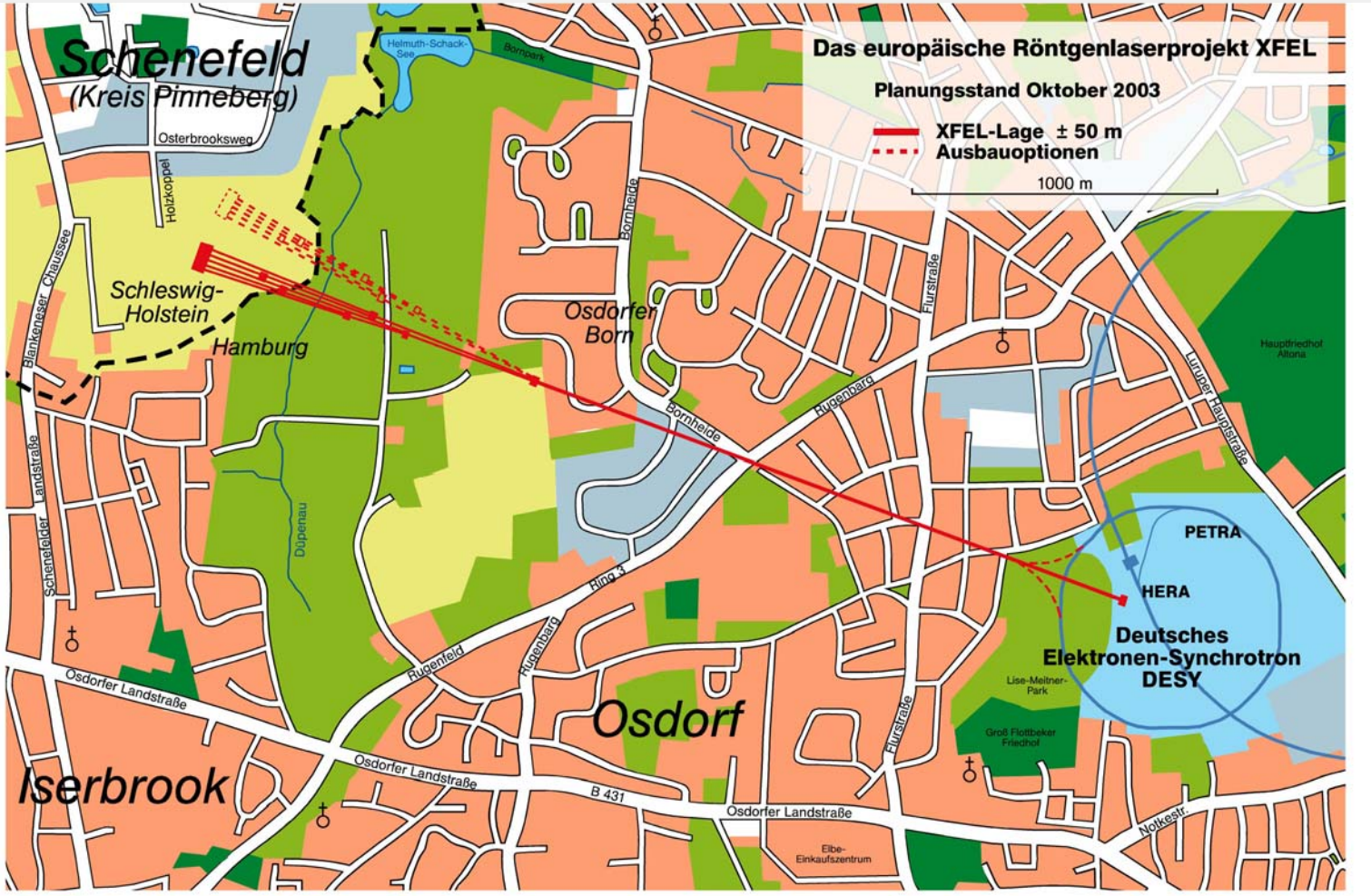
Status of reconstruction:

- more than the half of the old components have been reinstalled
- # of refurbished magnets:
- 261 dipoles, 198 quadrupoles, 161 sextupoles in the old octants
- # of new magnets:
- 94 Quadrupoles, 20 dipoles for the new octant

- the new experimental hall will be commissioned by April 2008
- Pegging out of the new beamlines
- Fine alignmnet of girders in the climatic chamber

The European X-Ray Free Electron Laser Project

The X-ray laser is a 3.4-km-long facility which runs essentially underground and comprises three sites above ground. It will begin on the DESY site and runs mostly underground to the XFEL research site, which is to be erected south of the town of Schenefeld .



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The European X-Ray Laser Project: XFEL

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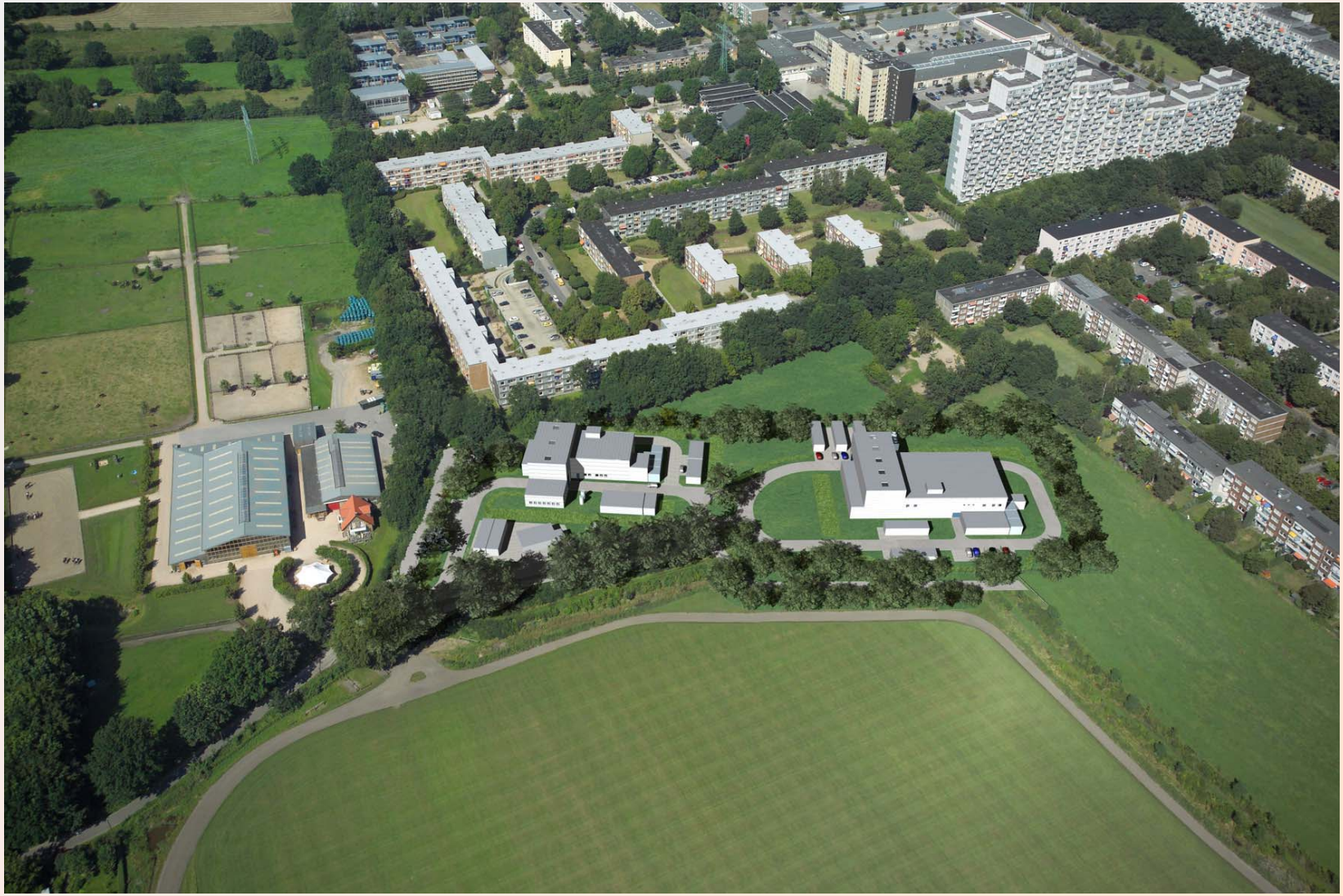

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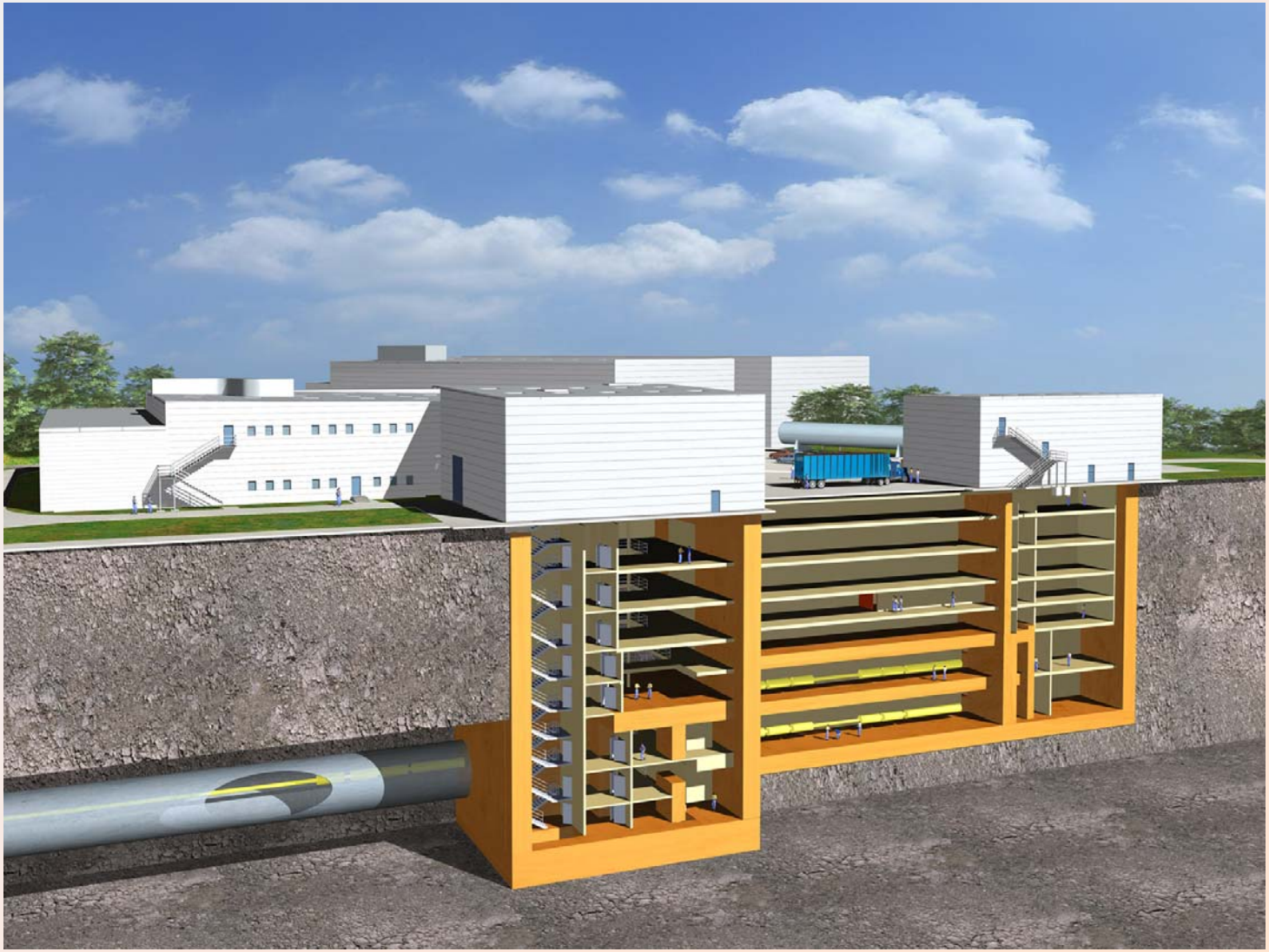

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The European X-Ray Laser Project: XFEL

- **A Mock-Up Tunnel has been built**
  - to test installations and important sections
  - To test the survey and alignment procedures

- **Tasks to come next:**
  - Creating the reference pillars at the construction sites
  - Further development of the SLRS

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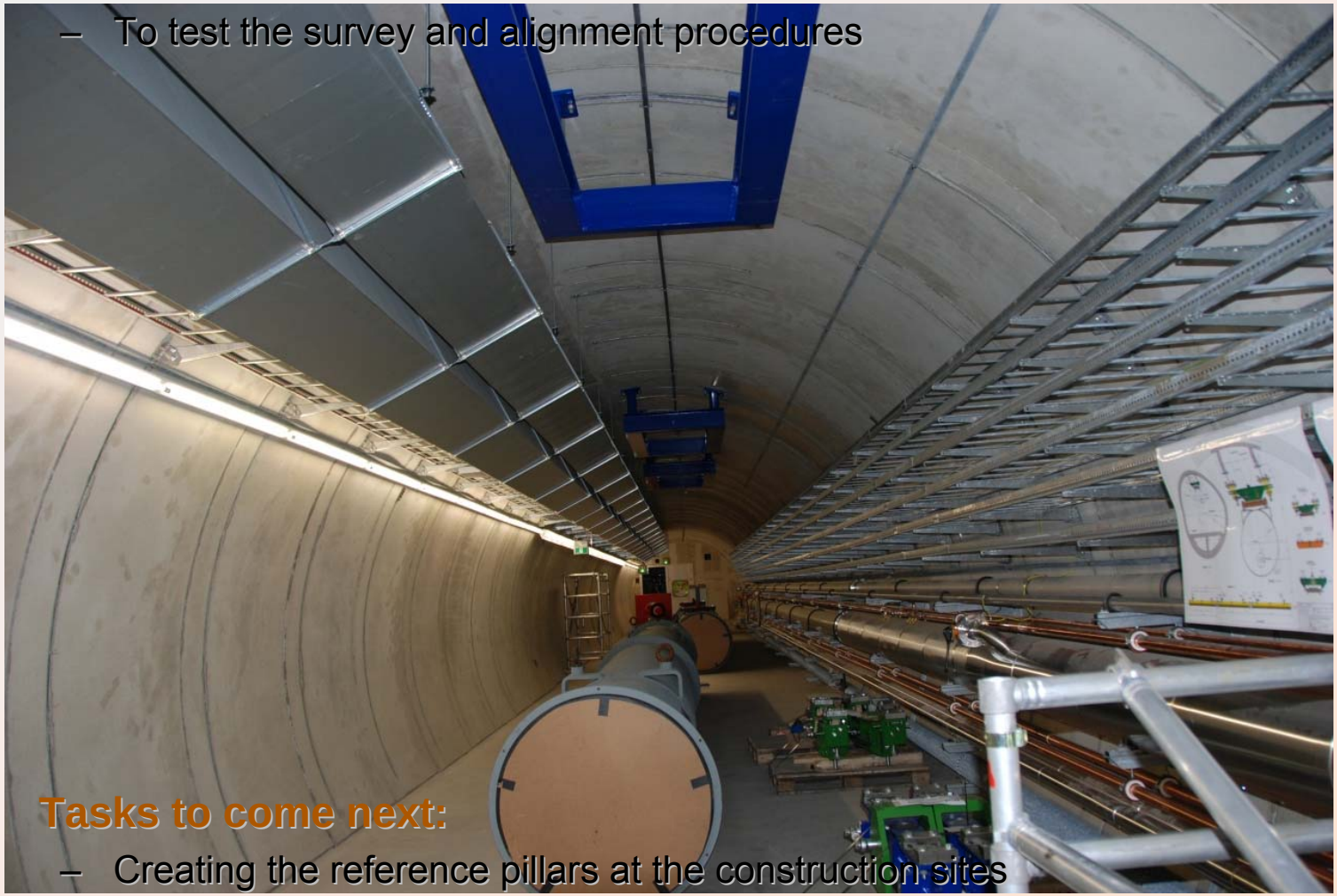

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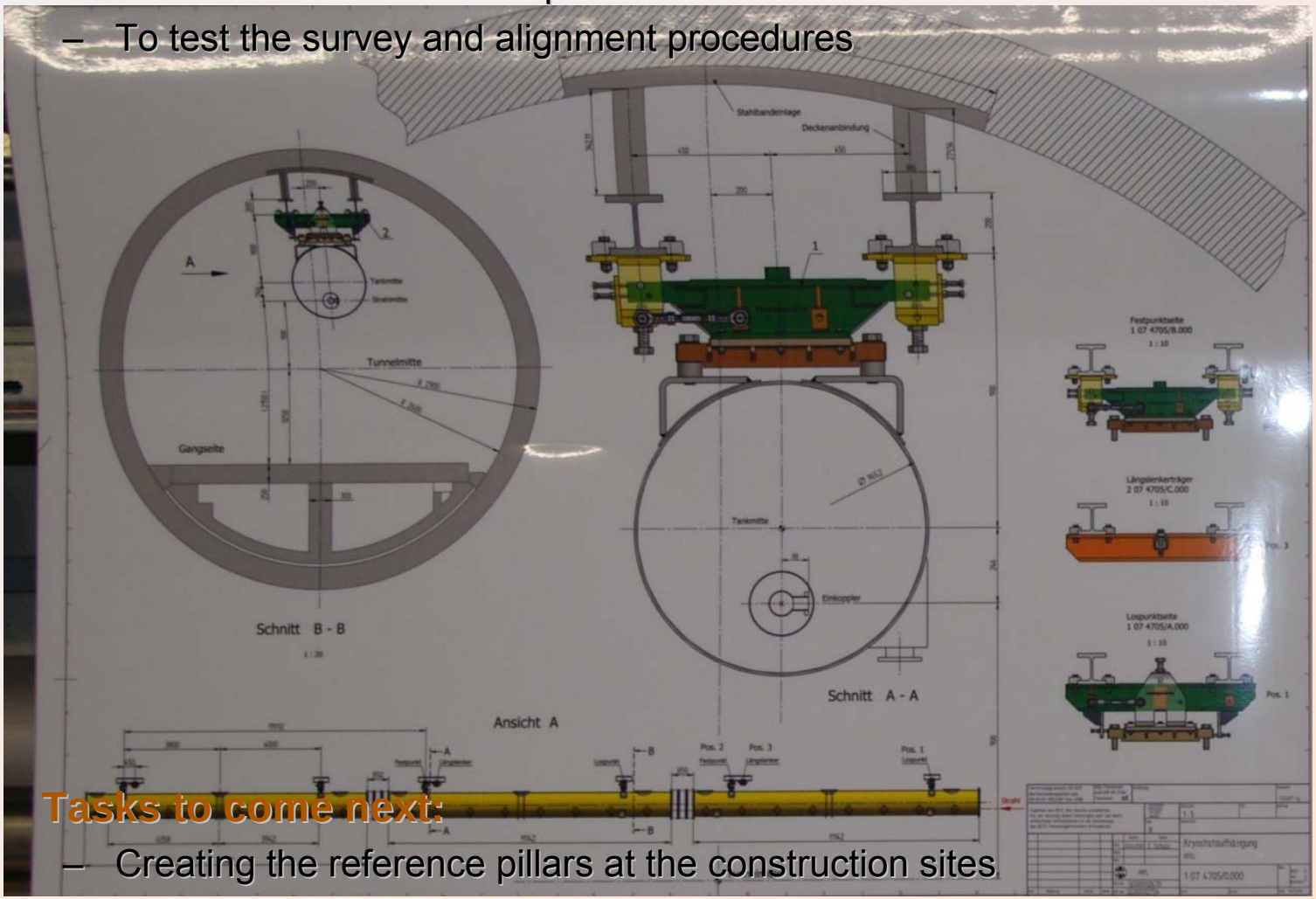

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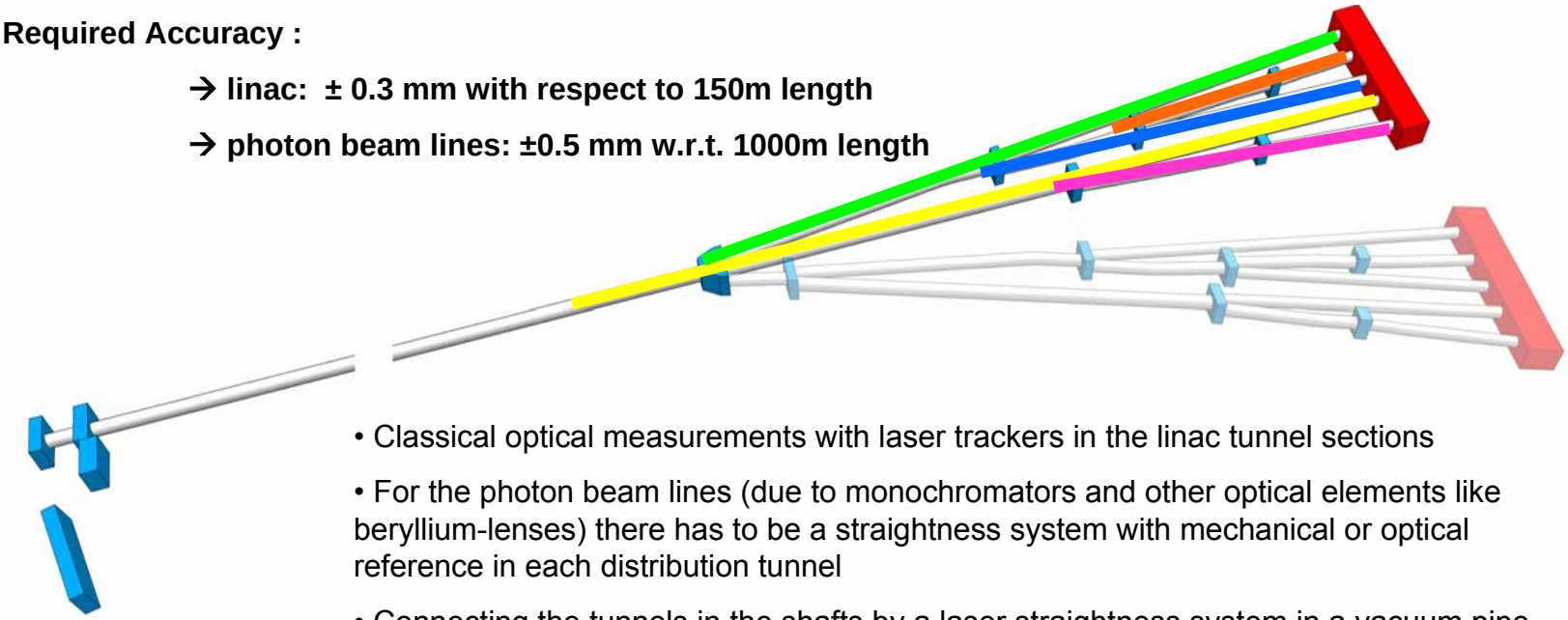
XFEL Survey Concept:

Required Accuracy :

→ **linac: ± 0.3 mm with respect to 150m length**

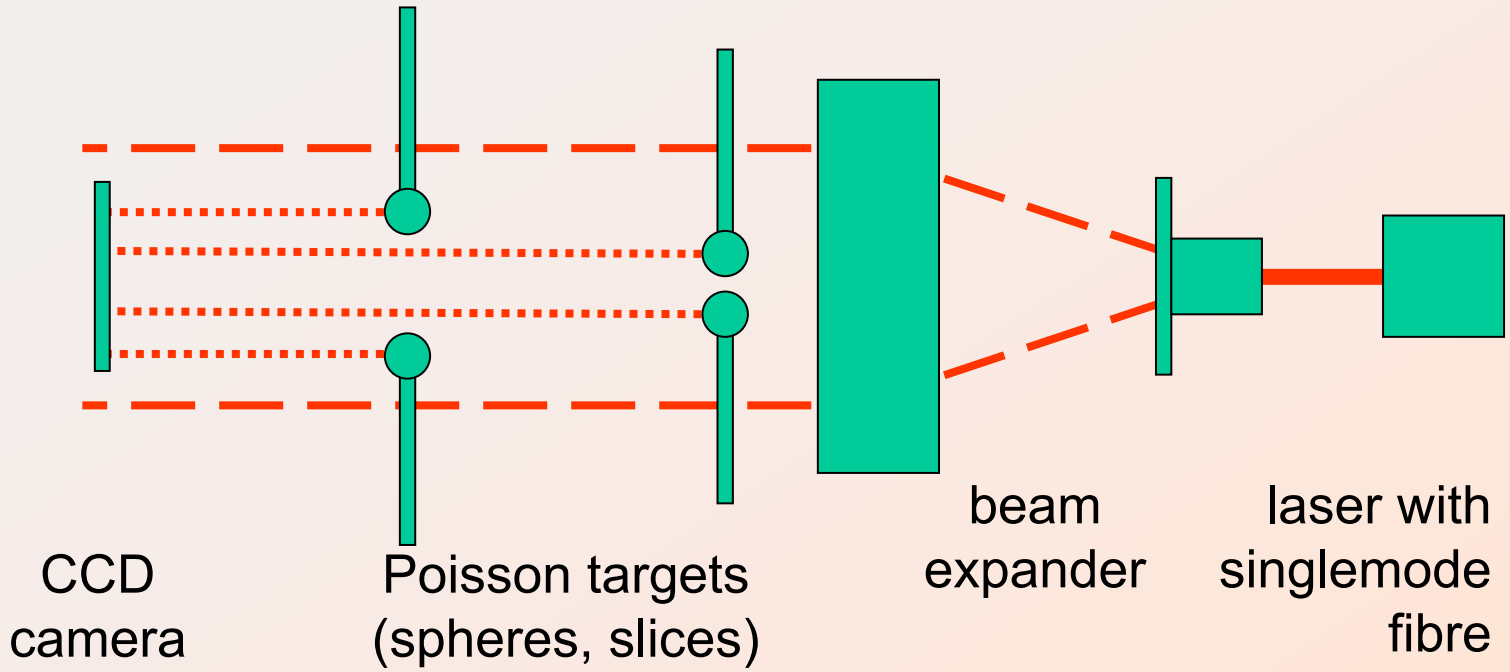
→ **photon beam lines: ±0.5 mm w.r.t. 1000m length**



- Classical optical measurements with laser trackers in the linac tunnel sections
- For the photon beam lines (due to monochromators and other optical elements like beryllium-lenses) there has to be a straightness system with mechanical or optical reference in each distribution tunnel
- Connecting the tunnels in the shafts by a laser straightness system in a vacuum pipe
- Alternative : Wire measurement system and HLS
- up to five SLR-Systems from 150m to 1000m in length

General data:
Total length of facility: approx. **3,4 km**, linac ~2km, 10 experimental stations, upgradeable to 20 stations
Wavelength of X-Ray radiation: **6 down to 0,085 nanometer**
Length of light pulses: < 100 femtoseconds

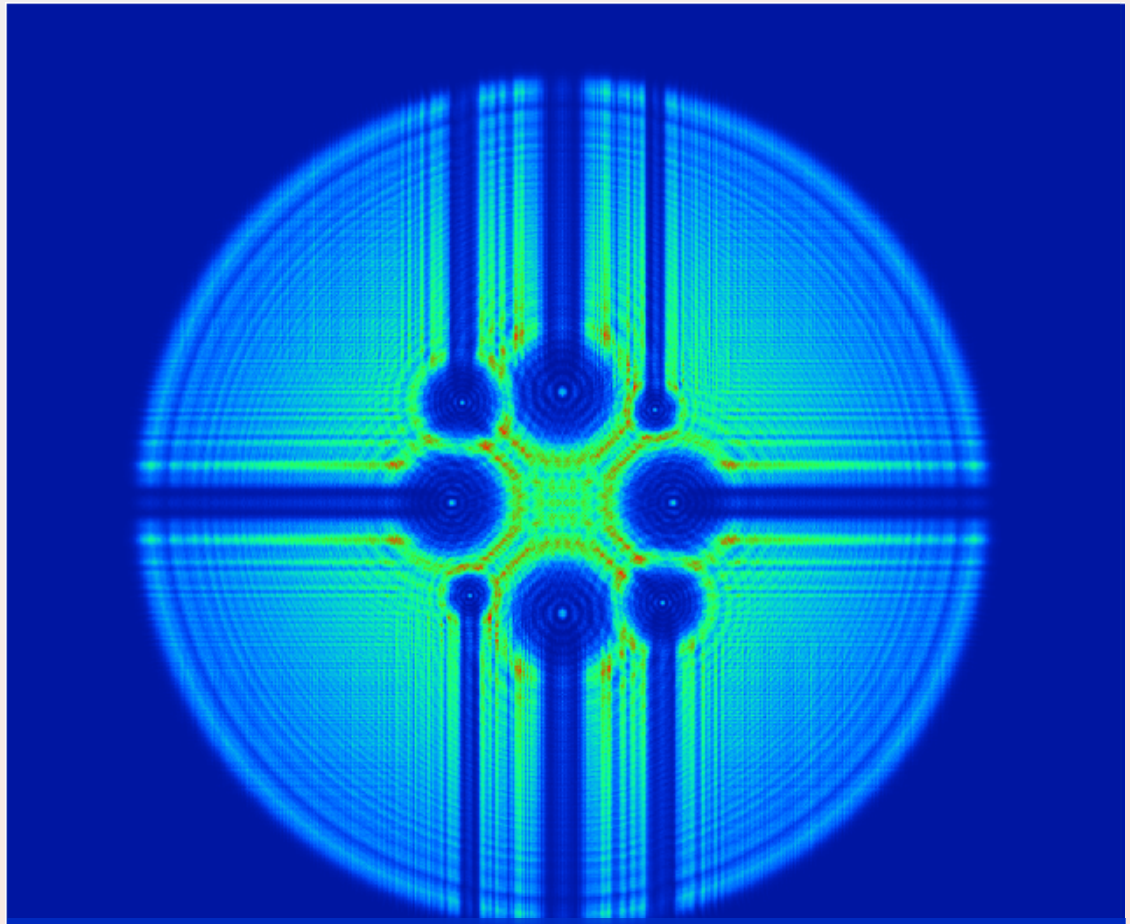
Assembly of the Poisson Spot System



Simulations

Poisson-Alignment-System

Various states of simulated images (ZEMAX)



the size and quality of the Poisson spot depend on:

- the diameter of the sphere or slice
- their respective distance to the detector

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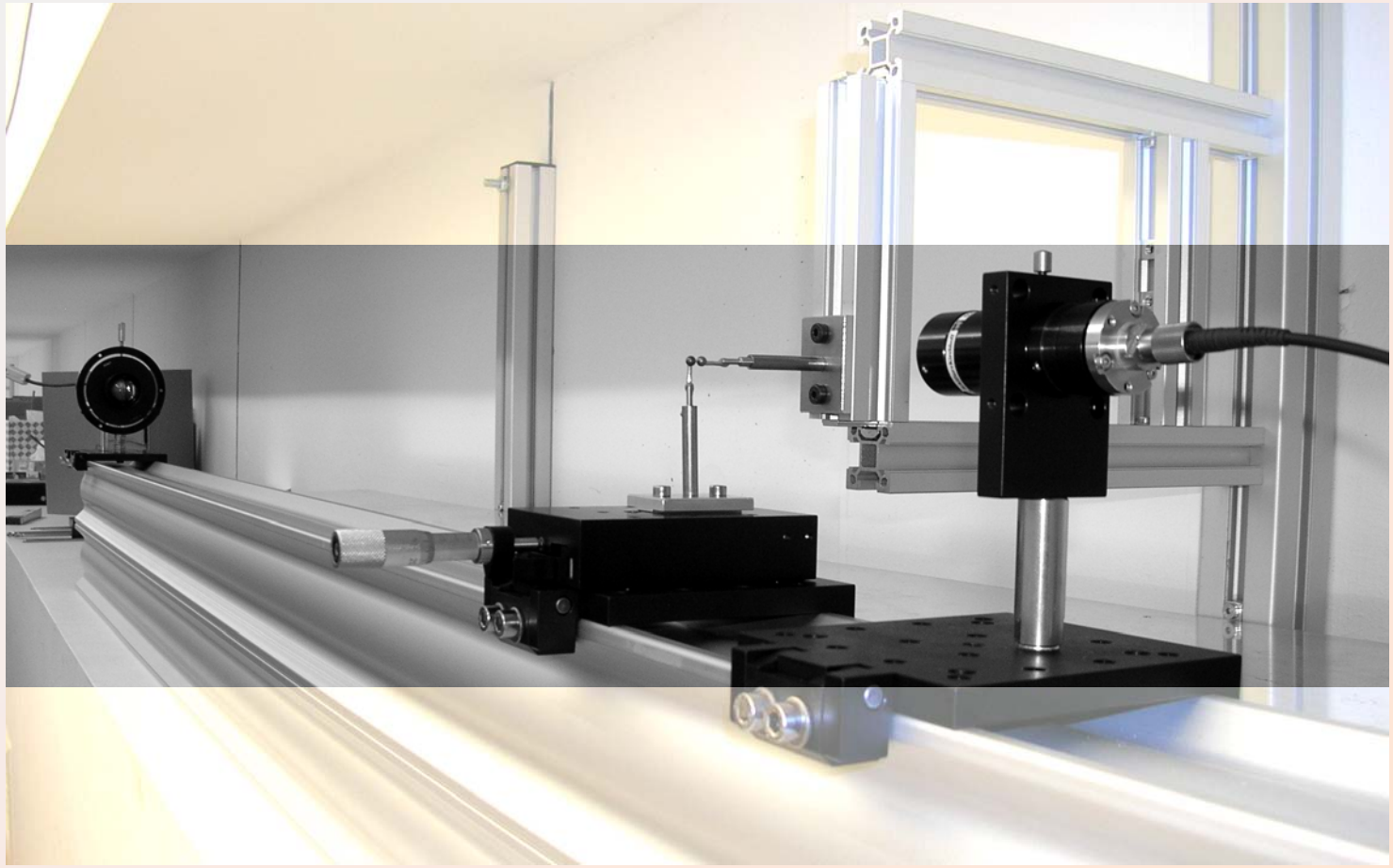
setup with two poisson spots, distance target to camera: 1,7m, expanded 10mm collimated laser beam



micrometer stage and two spheres with a diameter of 4mm

Calculation of the target displacement by calculation of a correlation and subsequent subpixel estimation

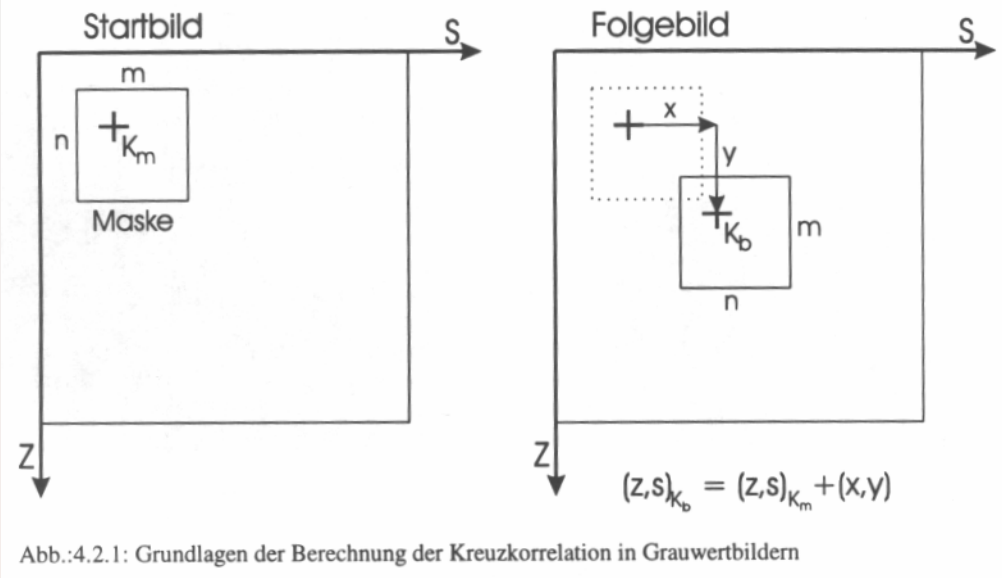


Abb.:4.2.1: Grundlagen der Berechnung der Kreuzkorrelation in Grauwertbildern

The correlation is derived from the covariance of two variables, which is a measure for the dependency of the two variables.

Here the similarity of two ROI (regions of interest) is described by means of correlation. The coefficient gets standardized by adding the variances of the variables. It is calculated for every position of the regions (integer pixel).

$$\rho_{ij} = \sigma_{ij} / (\sigma_i \sigma_j), \quad -1 \leq \rho_{ij} \leq 1$$

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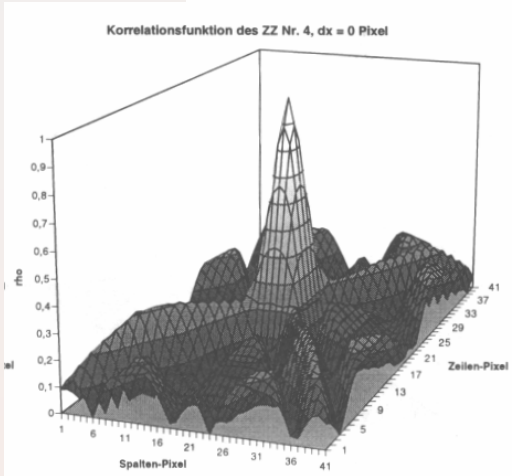

Abb. 5.7.4: Korrelationsfunktion des Zielzeichens Nr. 4

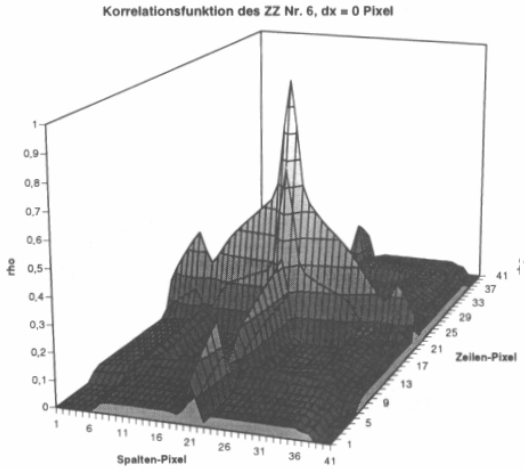

Abb. 5.7.5: Korrelationsfunktion des Zielzeichens Nr. 6

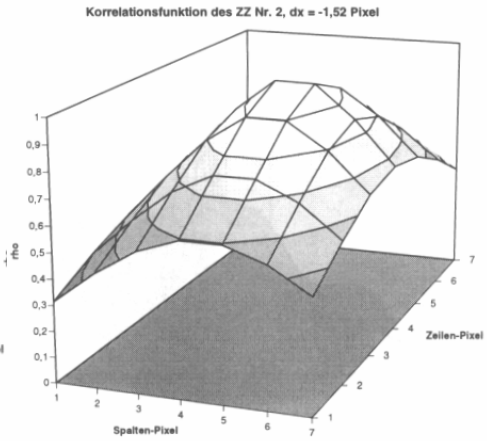

Abb. 5.7.8: Korrelationsfunktion des Zielzeichens Nr. 2, dx=1,5 pix

- Sketches of the **correlation functions** of some target marks,
- subpixel estimation is done by **calculating the maximum** of the correlation function.

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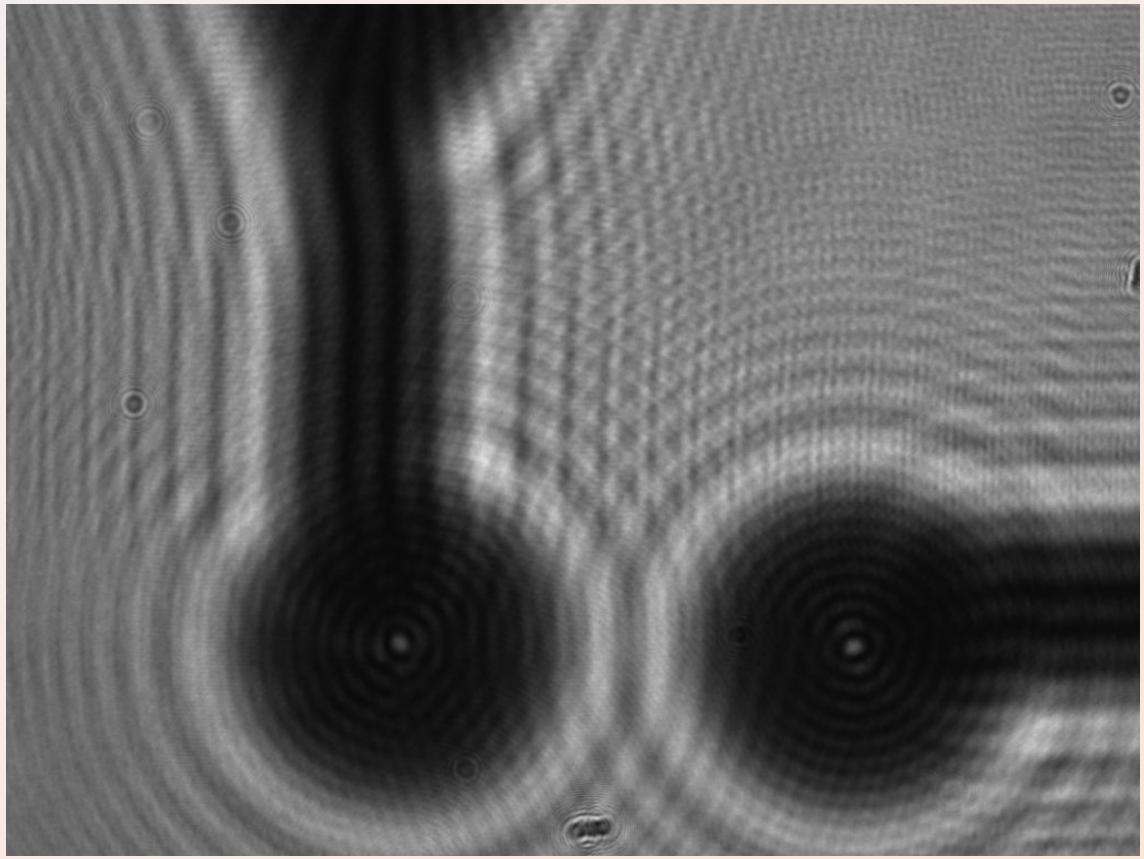

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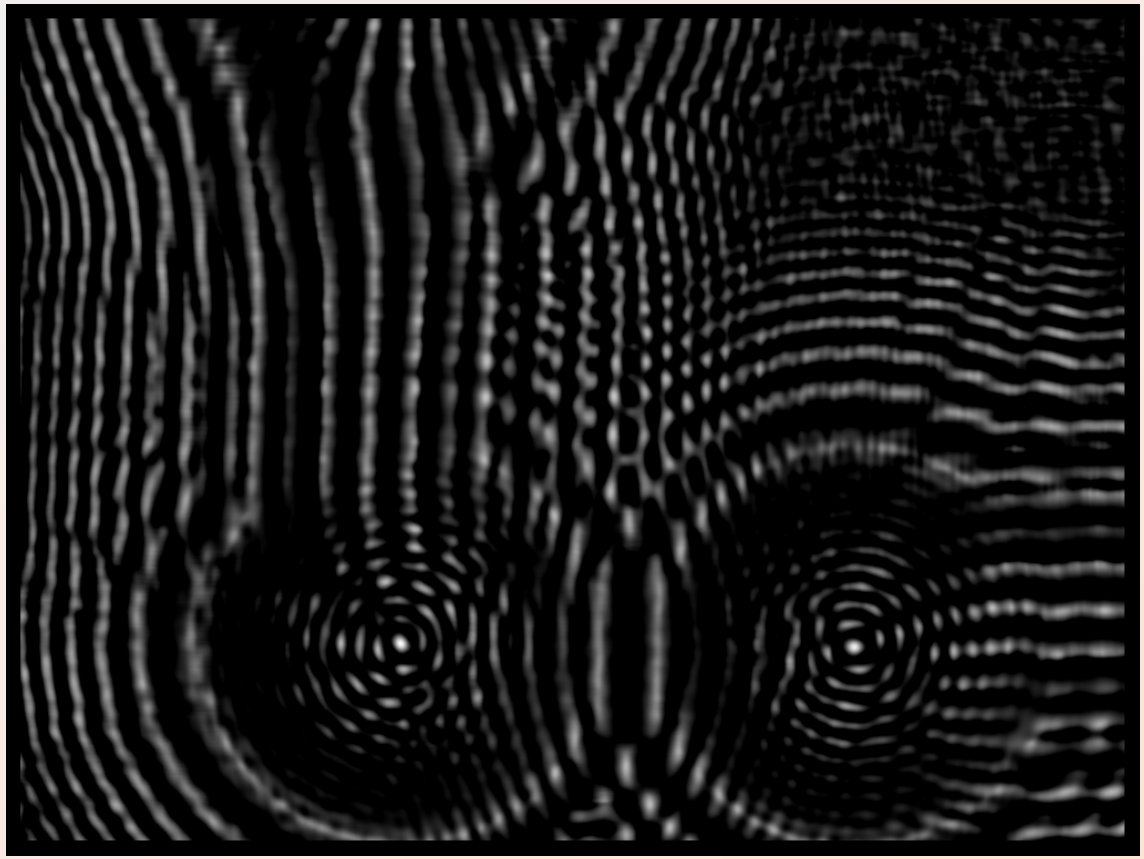
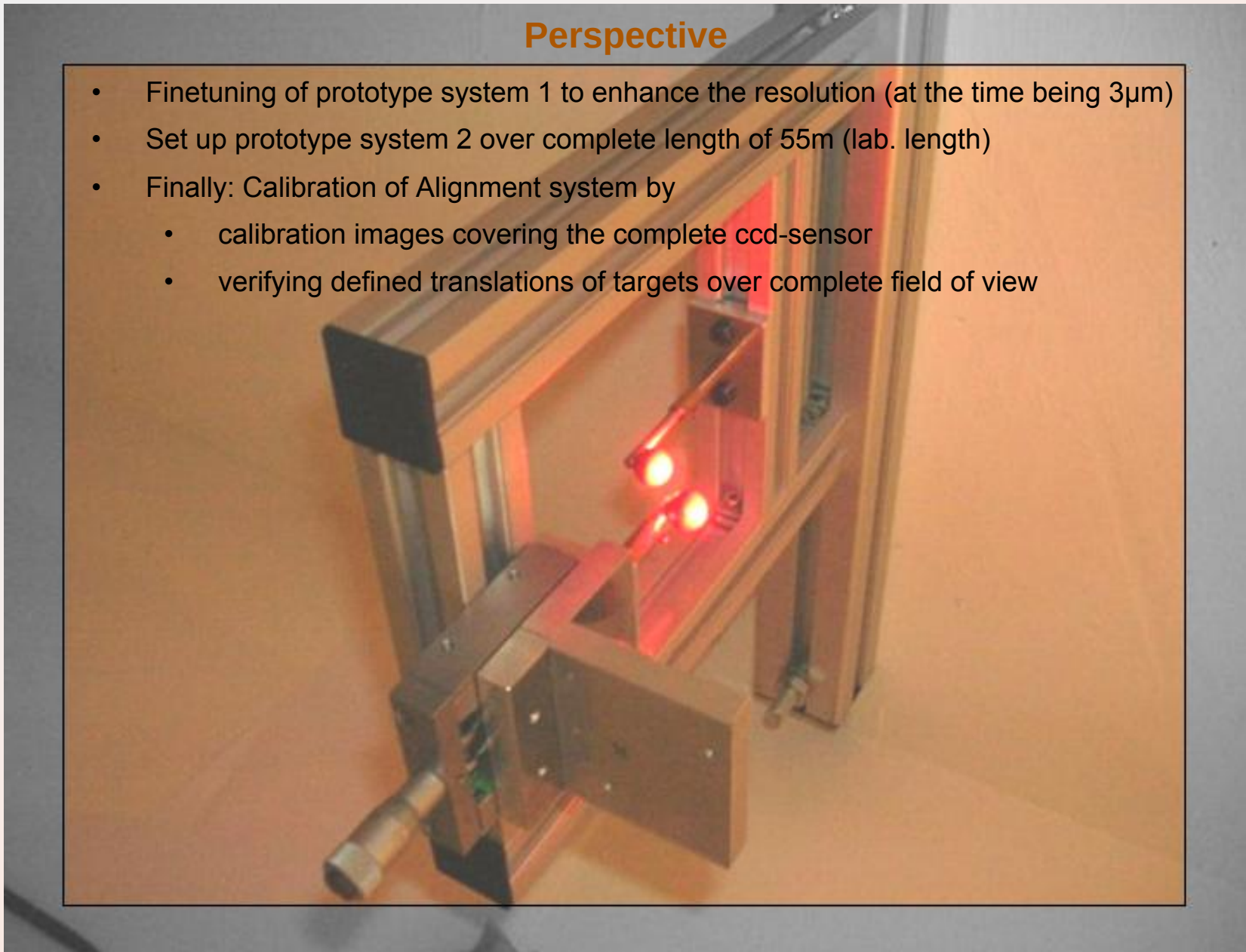


Perspective

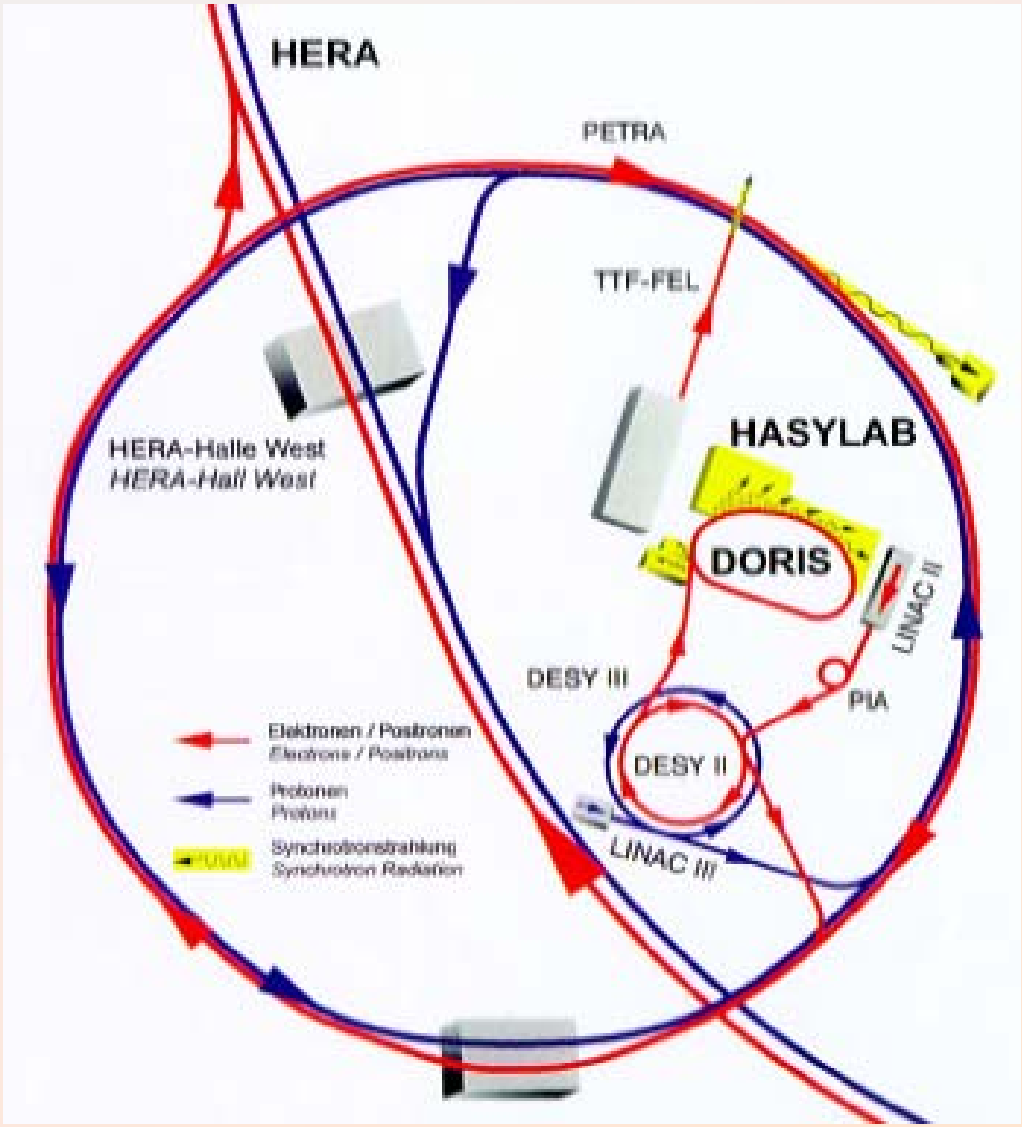
- Finetuning of prototype system 1 to enhance the resolution (at the time being 3µm)
- Set up prototype system 2 over complete length of 55m (lab. length)
- Finally: Calibration of Alignment system by
  - calibration images covering the complete ccd-sensor
  - verifying defined translations of targets over complete field of view



Accelerators running from 2009 – 2014:

Only electron accelerators:

LINAC II
DESY II
PETRA III
Flash (TTF-FEL)



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Thanks for your attention !

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