



Survey and alignment of the world's largest gantry for cancer therapy

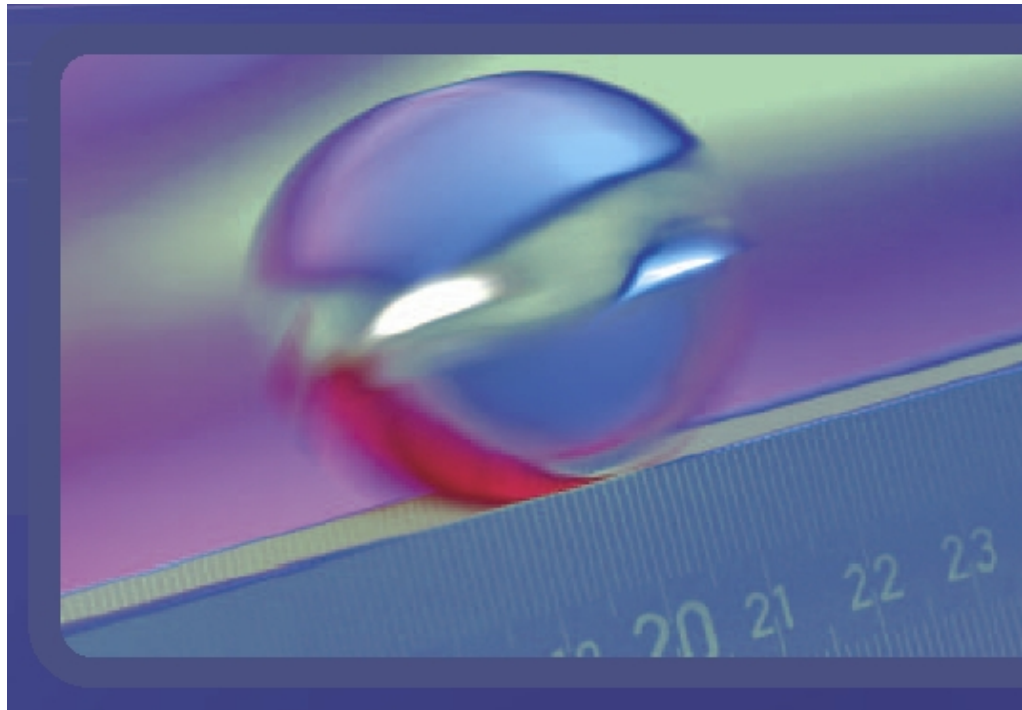
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10th International Workshop on Accelerator Alignment - IWAA 08

KEK - Tsukuba - Japan, February 11-15, 2008

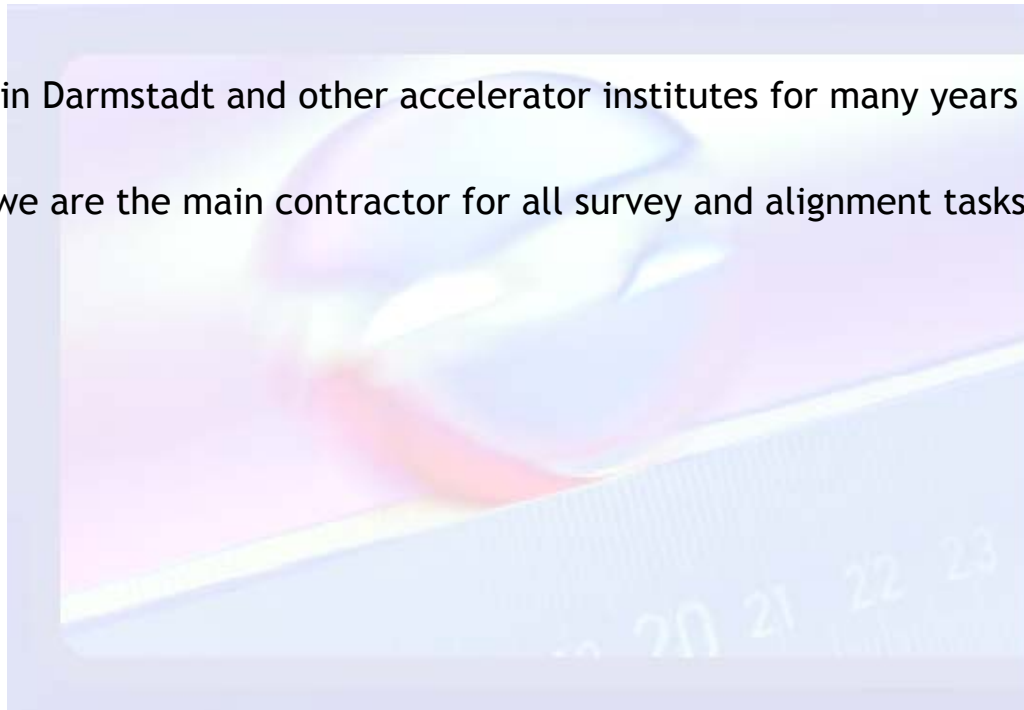
The company

- Metronom stands for longtime experiences, professionalism and steadiness in the field of industrial measurements
- The company is located in Mainz, near Frankfurt, and our attainment includes conceptual design, development, implementation, service and support of measuring systems
- Key aspects are the automation of measuring- and evaluation processes



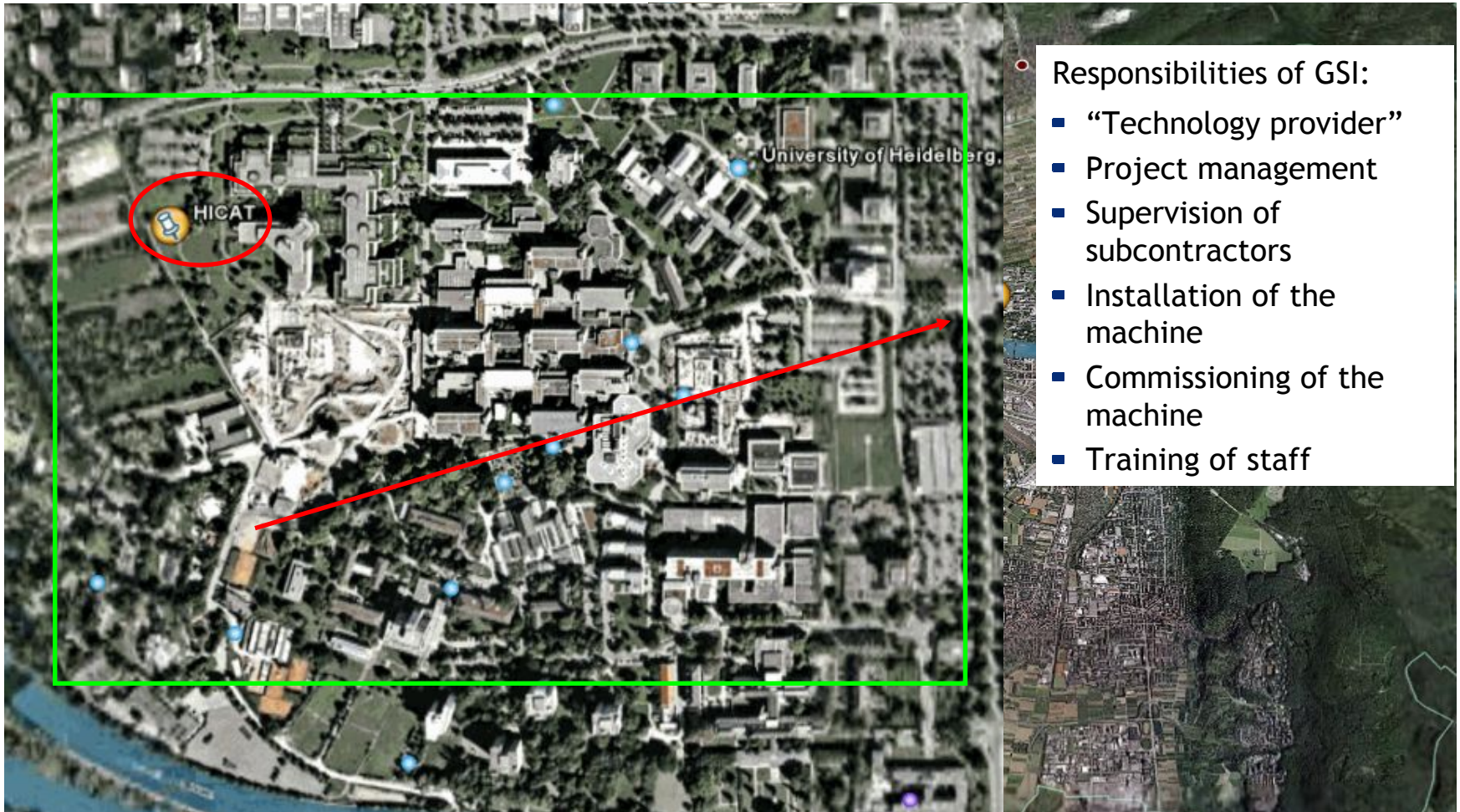
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- Key aspects are the automation of measuring- and evaluation processes
- We work for GSI in Darmstadt and other accelerator institutes for many years
- For this project we are the main contractor for all survey and alignment tasks, supervised by GSI



HICAT in Heidelberg

- The University Hospital of Heidelberg has built in co-operation with GSI Darmstadt a new Heavy Ion Cancer Therapy accelerator (HICAT)

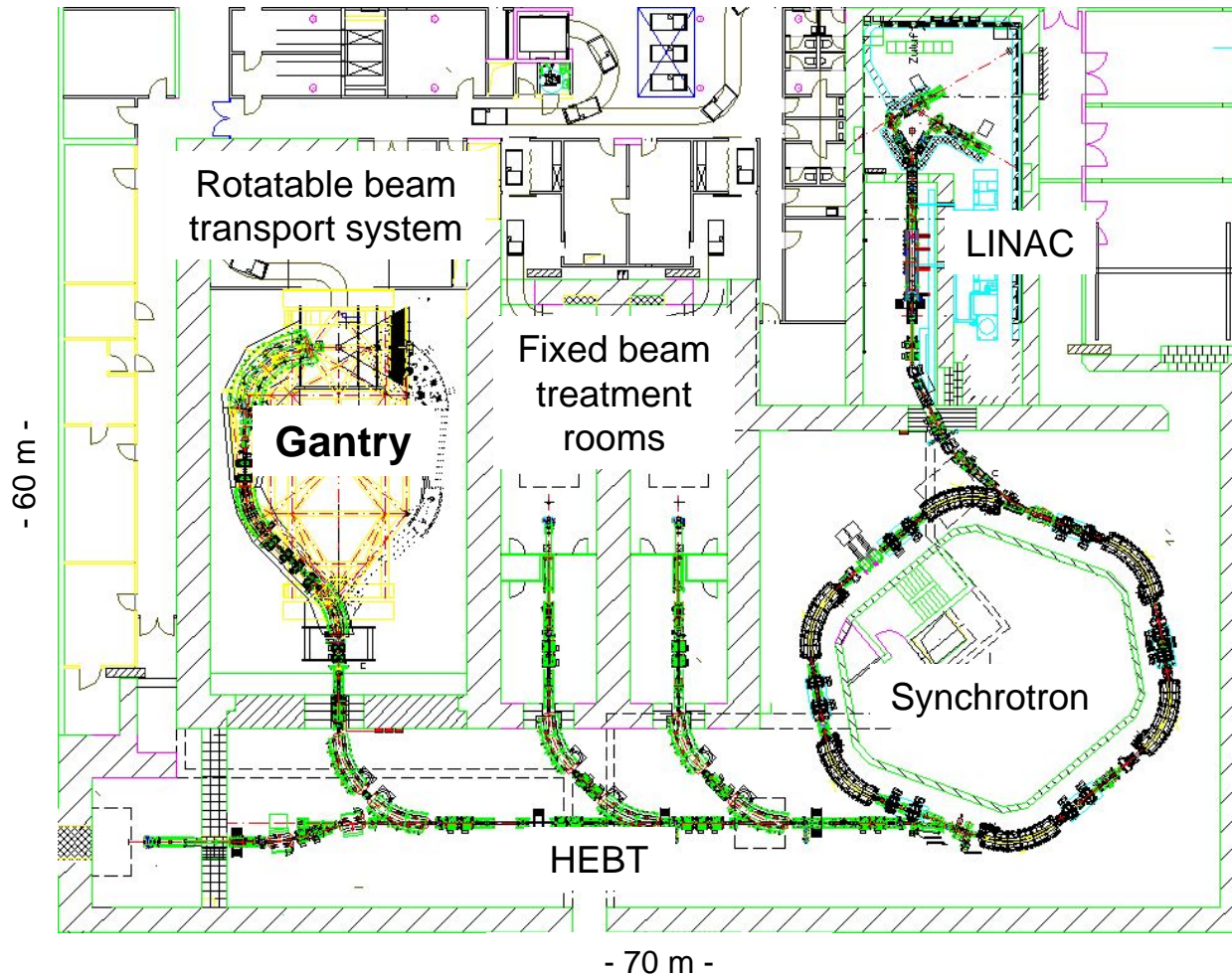


HICAT in Heidelberg

- The University Hospital of Heidelberg has built in co-operation with GSI Darmstadt a new Heavy Ion Cancer Therapy accelerator (HICAT)
- First heavy ion treatment in Europe for up to 1.000 patients a year, therefore it has three treatment rooms and one station for quality assurance
- It is a commercial project in co-operation with SIEMENS and MT Mechatronics (MAN)
- The costs of a treatment are taken over from the health insurance companies
- High healing chance with lower adverse effects for the patients
- Ten more cancer therapy accelerators are requested in order to fulfill the total demand in Germany

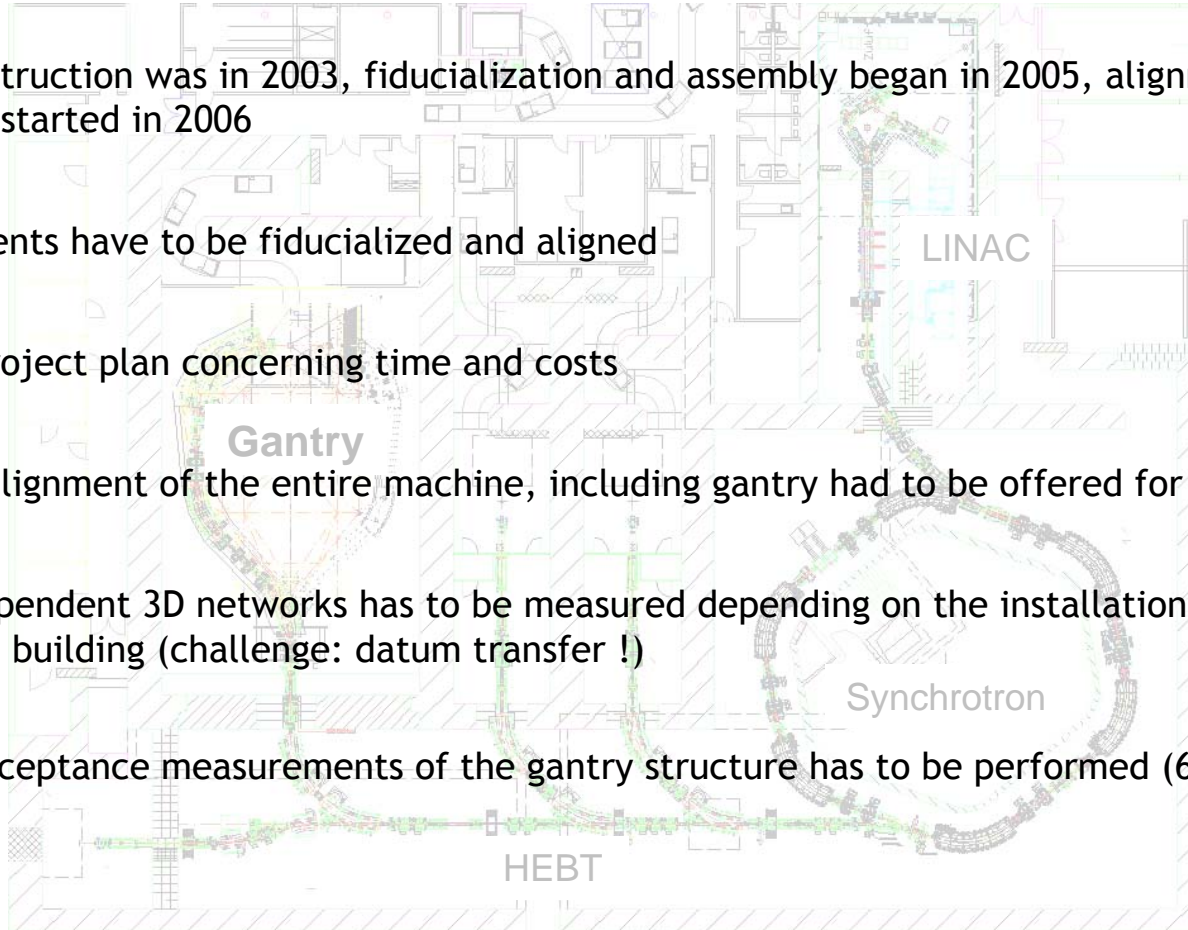
The HICAT project

- The therapy accelerator consists of a linear accelerator with two sources, a synchrotron and three treatment rooms. One of them is equipped with a large rotatable gantry construction.



The HICAT project

- The therapy accelerator consists of a linear accelerator with two sources, a synchrotron and three treatment rooms. One of them is equipped with a large rotatable gantry construction.
- Start of construction was in 2003, fiducialization and assembly began in 2005, alignment of components started in 2006
- 150 components have to be fiducialized and aligned
- Very tight project plan concerning time and costs
- Survey and alignment of the entire machine, including gantry had to be offered for a fixed price
- Several independent 3D networks has to be measured depending on the installation progress of the machine and building (challenge: datum transfer !)
- Extensive acceptance measurements of the gantry structure has to be performed (6-DOF!)

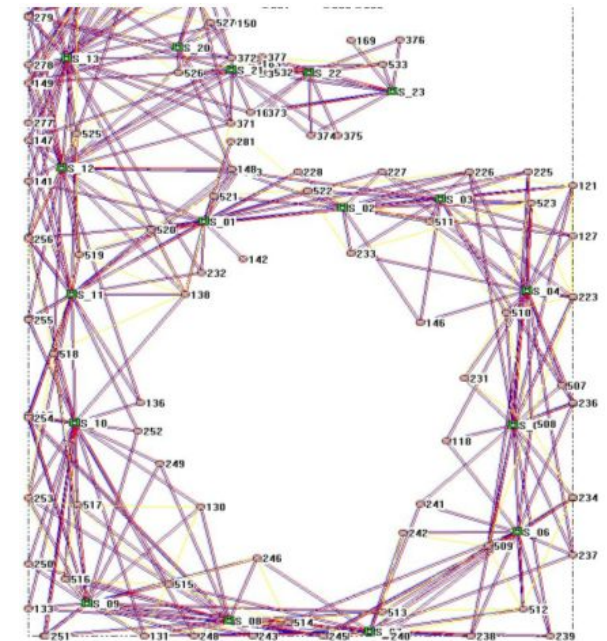


HICAT - Survey and Alignment

- Reference network with 500 fixed wall and floor monuments (one nest design “yellow caps” fits for all applications)
- Network measurements with Laser Tracker (FARO SI-2) and Digital Level (Leica DNA03)
- Combined network adjustment with Metronom TASA and SLAC LEGO software
 - Standard deviation of a point ≤ 0.02 mm

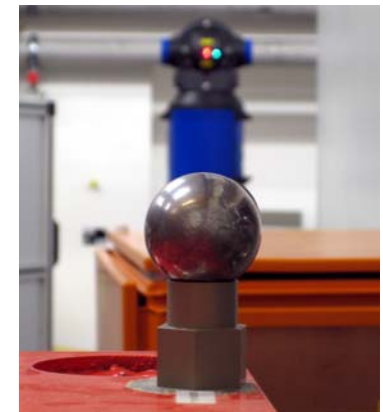


- Acts and facts of the network measurements
 - Six local reference networks
 - 140 stations
 - 3800 measured distances and angles with the Laser Tracker in two faces
 - 1000 height differences with Digital Level



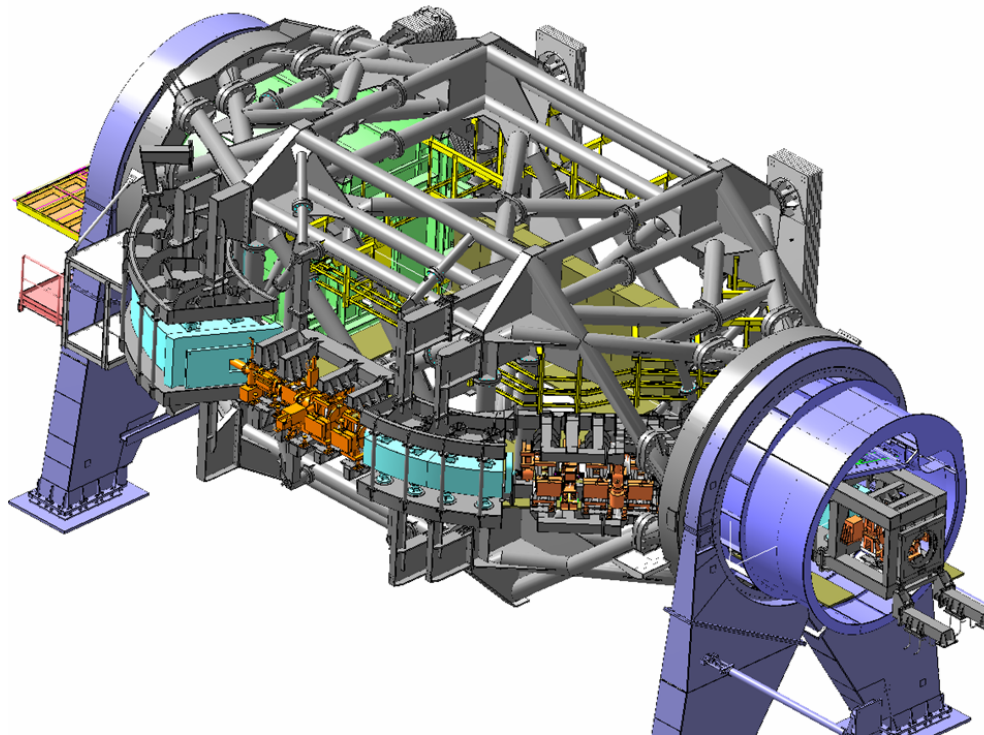
HICAT - Survey and Alignment

- Transfer measurements performed with Laser Tracker and in some cases combined with Theodolite (Kern E2) on a 3D-support
- Installation of at least four permanent nests as fiducial points on each component
- 3D alignment on site with Laser Tracker
 - Allowed positioning error for beam axis:
0.1 to 0.3 mm in transversal and vertical axis, depending on the component
 - Allowed tilt error:
0.1 to 0.5 mrad roll angle, depending on the component
 - Calculation and control of the position of the beam axis on every alignment step
- Standard deviation of the stations (best fit) = 0.04 mm

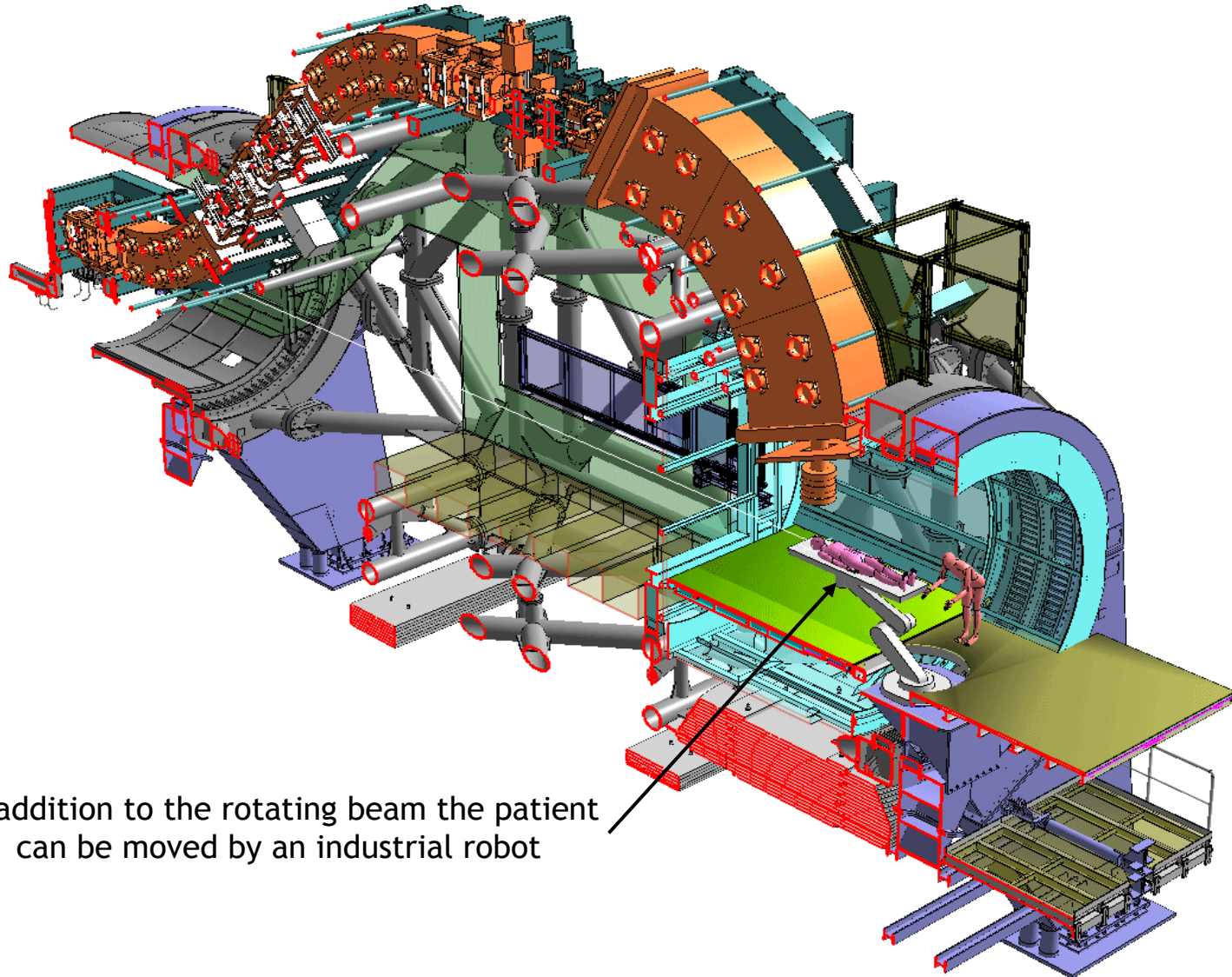


Isocentric Gantry

- Facts of the 3D-Scanning Gantry:
 - Allows patient treatment from different directions, the gantry can be rotated $\pm 180^\circ$ with a max. speed of 3° per second
 - Dimension: 25 m long and 13 m in diameter
 - Weight: 600 tons, the rotating parts have 420 tons, the magnets have 140 tons
 - Requested beam reproducibility in the isocenter with all influences (!): ± 0.5 mm



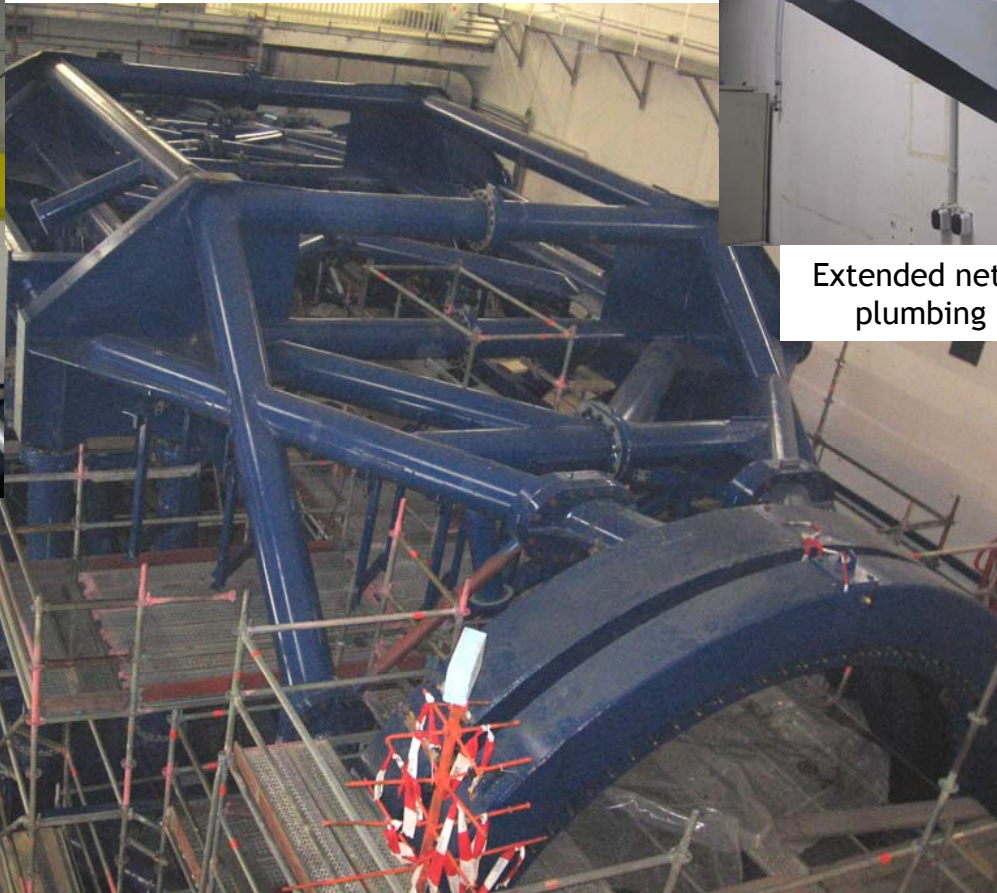
Isocentric Gantry



- In addition to the rotating beam the patient can be moved by an industrial robot

Survey and alignment of the Gantry

- Planning, design and simulation of all gantry measurements
- Alignment of the rotating axis and of all components
- Acceptance test measurements (6-DOF)



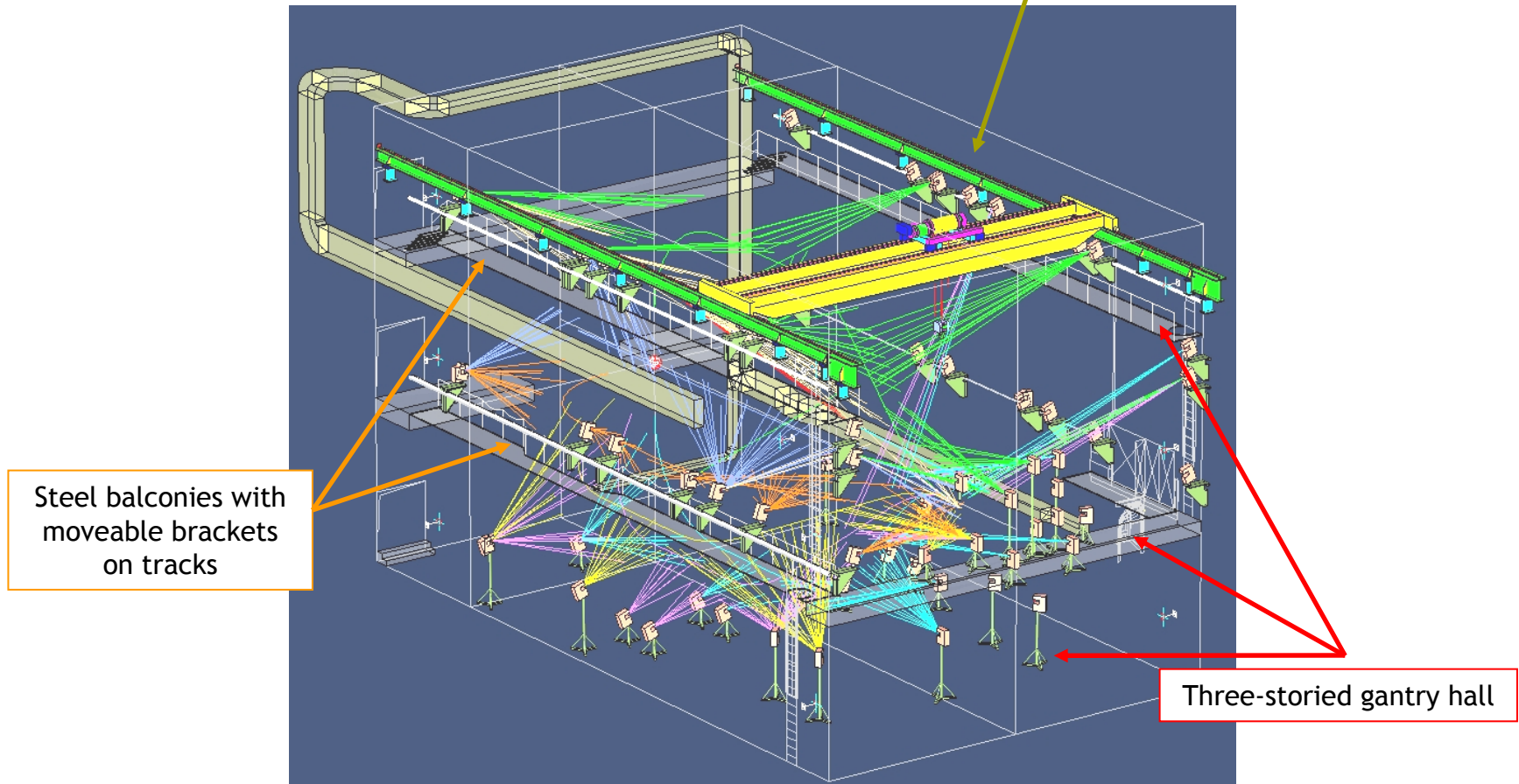
Extended net points /
plumbing points



Moveable bracket on track
with tilt adapter to increase
vertical working range

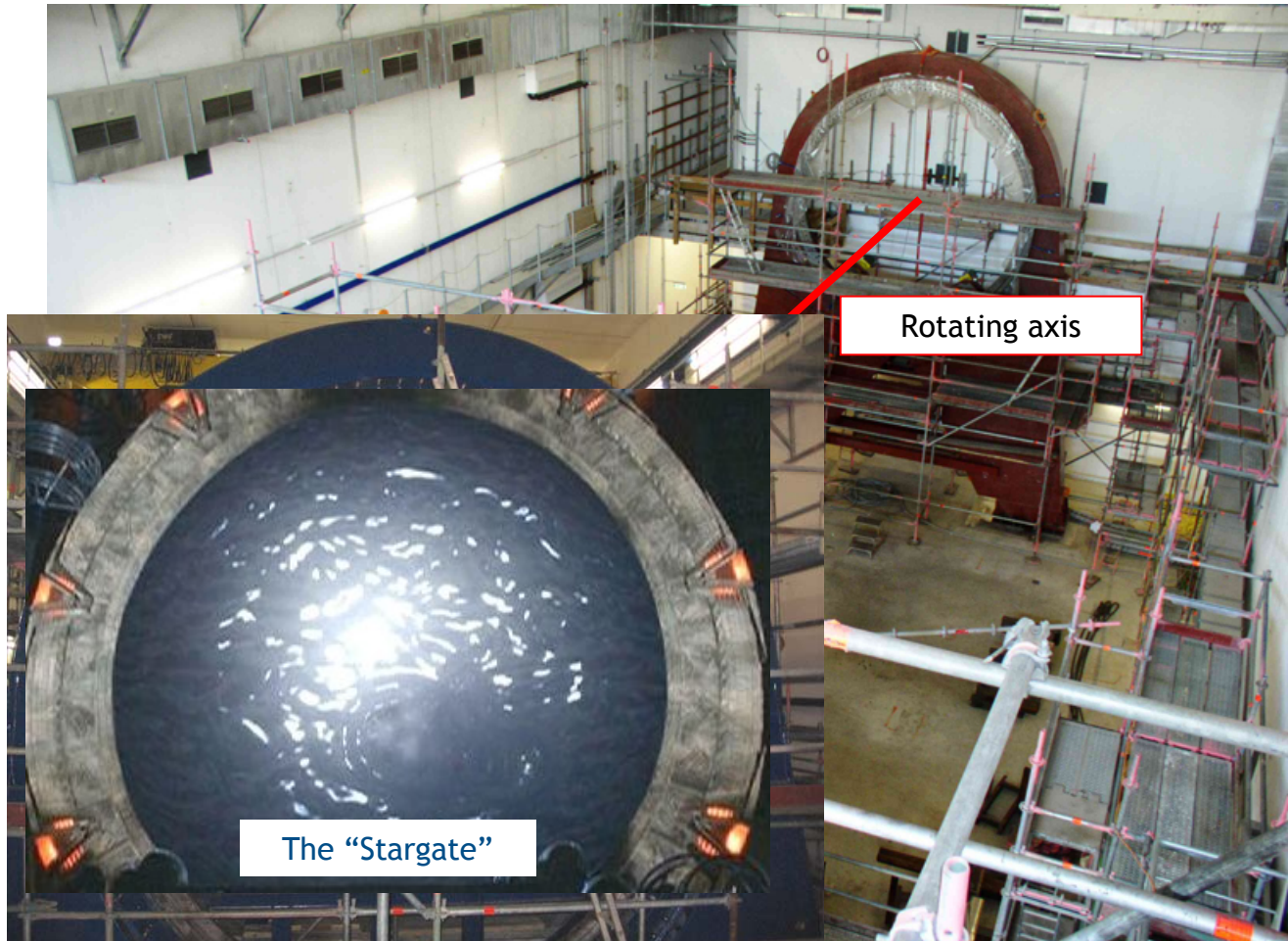
Survey and alignment of the Gantry

- Planning, design and simulation of all gantry measurements
 - Line-of-sight simulation to ensure that all components on the gantry can be seen with the Laser Tracker in all different angle positions. With this CAD-simulation the position and number of stations and all fiducial points of each magnet was defined.



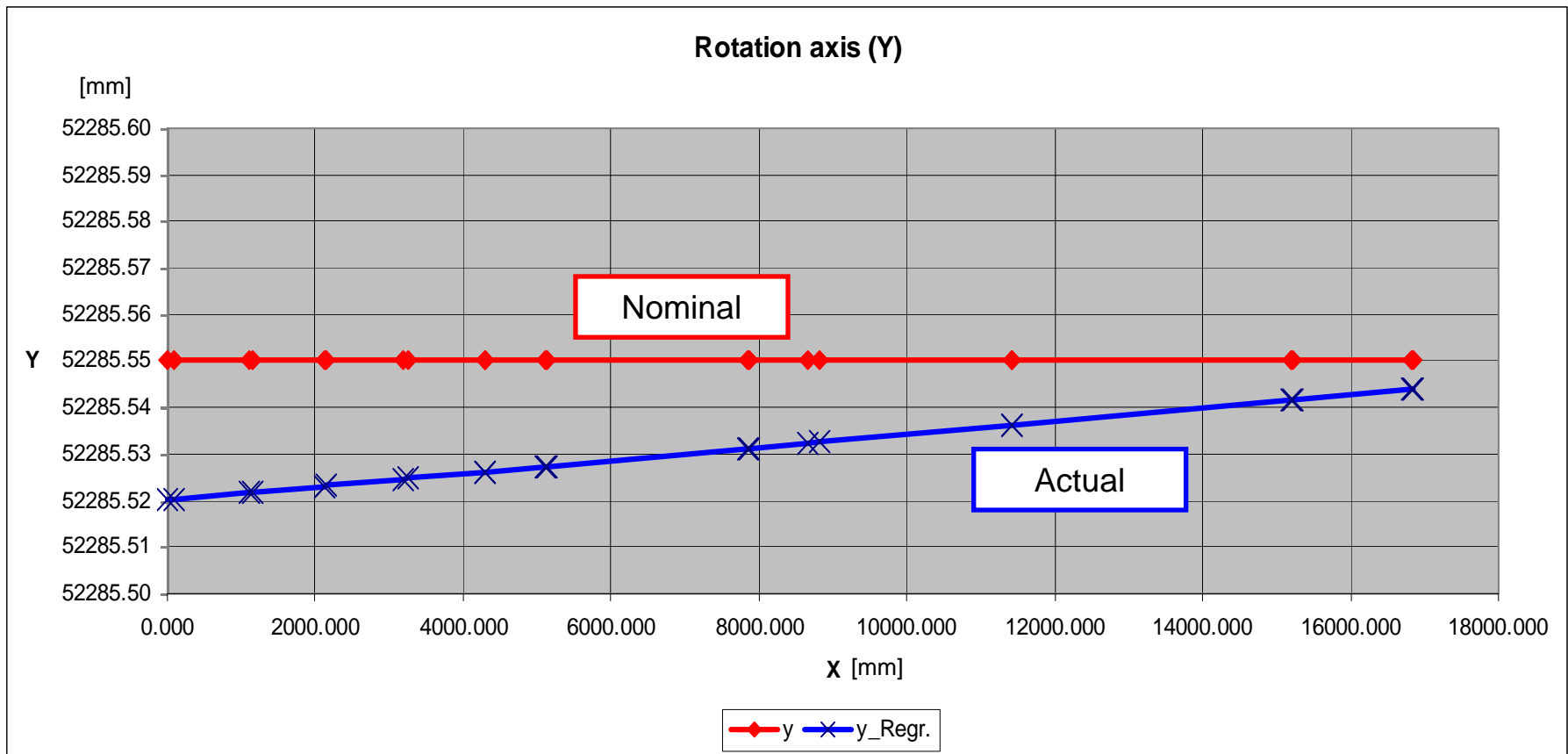
Survey and alignment of the Gantry

- Alignment of the rotating axis
 - After the construction of the bearing supports we have to align them to the rotating axis



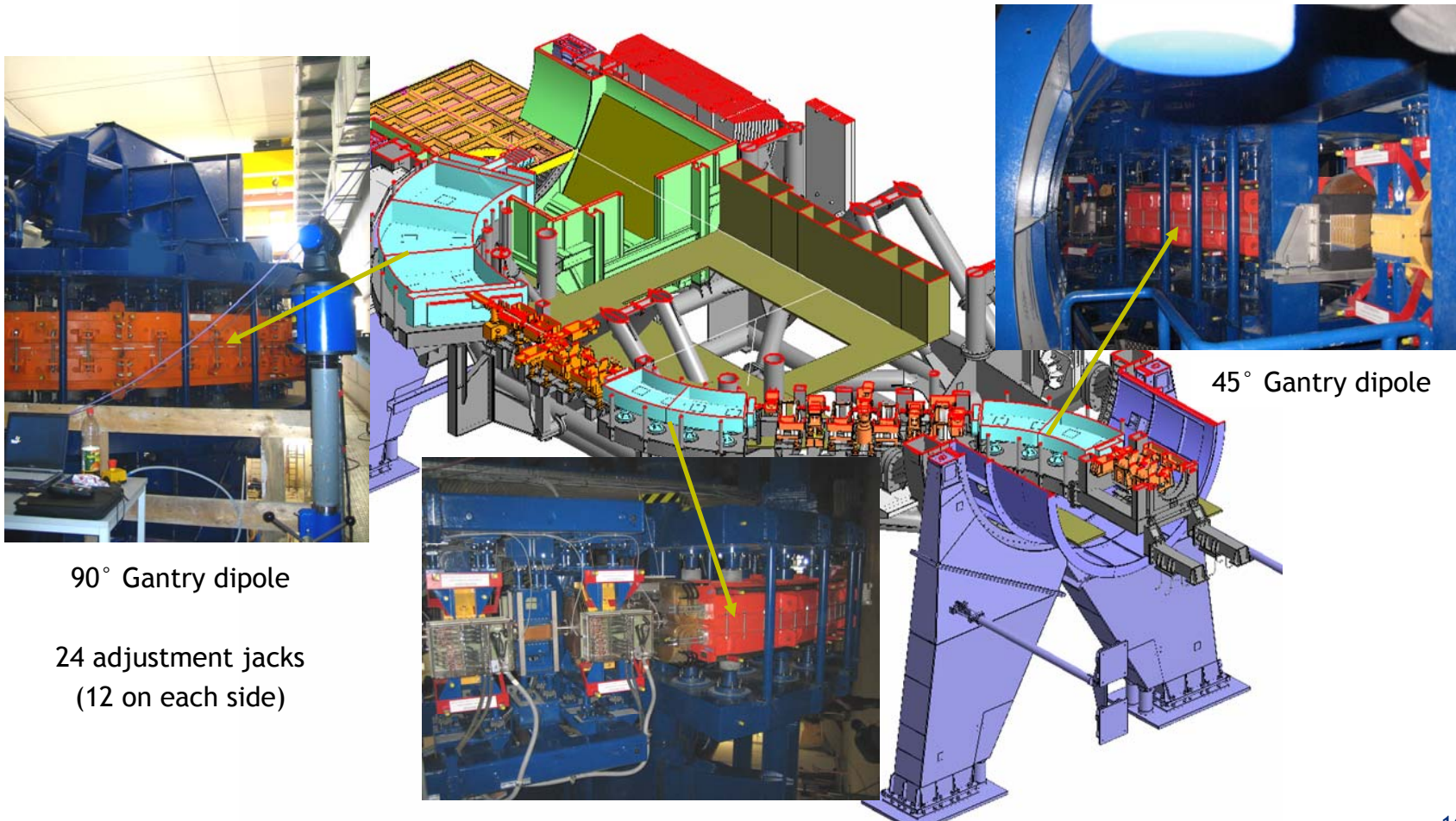
Survey and alignment of the Gantry

- Alignment of the rotating axis
 - After the construction of the bearing supports we have to align them to the rotating axis
 - In the same way also the main structure has to be aligned to the rotating axis (absolute tolerance 0.1 mm)



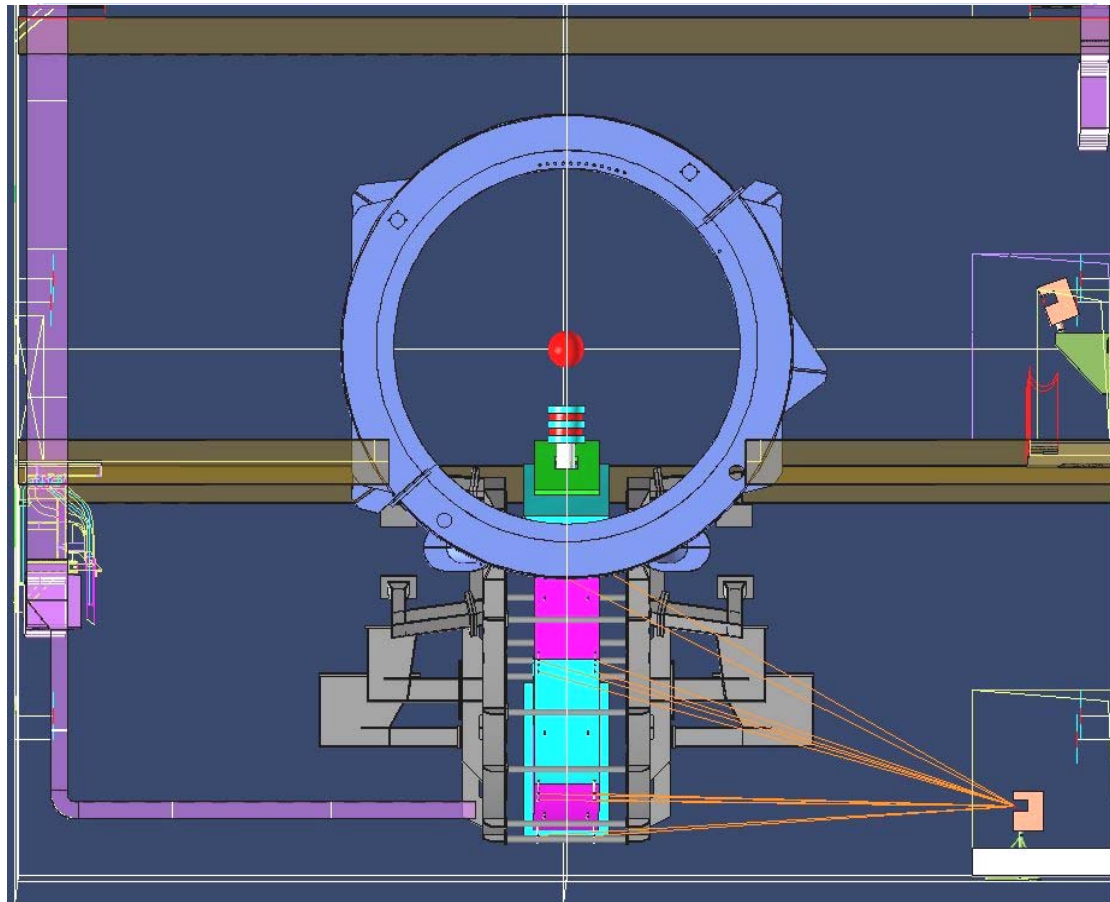
Survey and alignment of the Gantry

- Alignment of all components on the gantry structure in 90° position
 - On site measurements with the Laser Tracker and calculation of the beam axis position on every alignment step for each component



Survey and alignment of the Gantry

- Acceptance test measurements (6-DOF)
 - Control of the position and orientation of each component in different angles of the gantry every 30°



It's a "three-storied"
house that will be
rotated

Survey and alignment of the Gantry

- Acceptance test measurements
 - Some impressions of the measurements



third floor



second floor

Different
Laser Tracker
positions



first floor

“minimal floor
adapter”

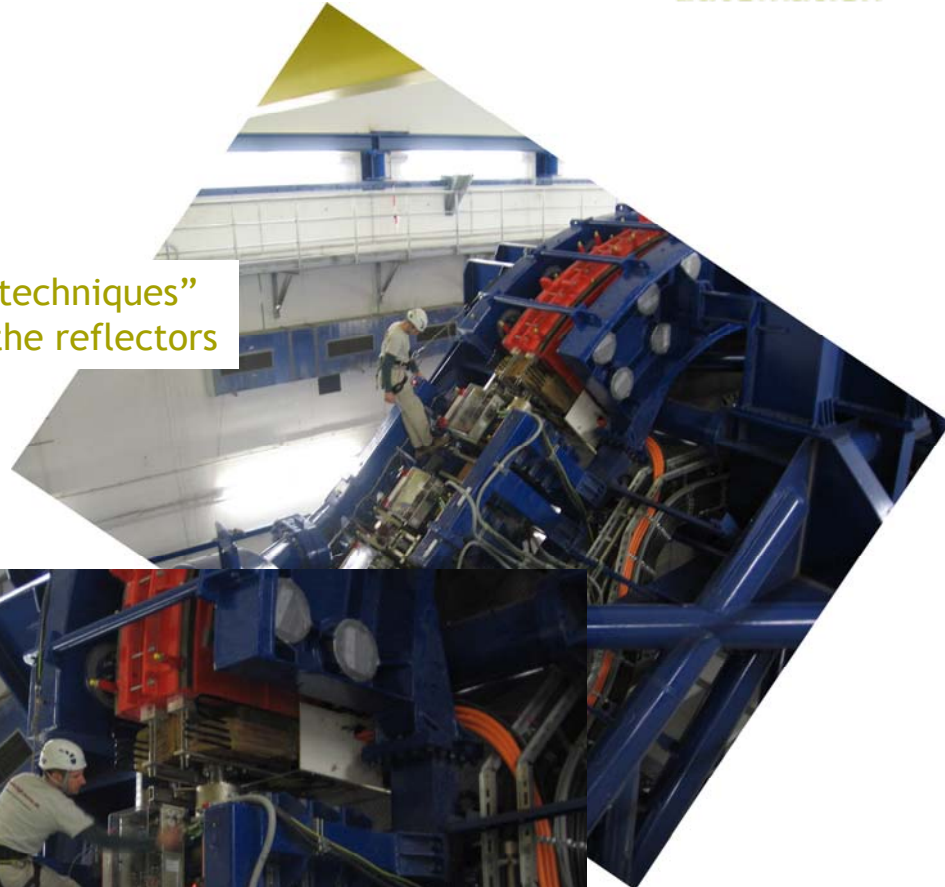
Survey and alignment of the Gantry

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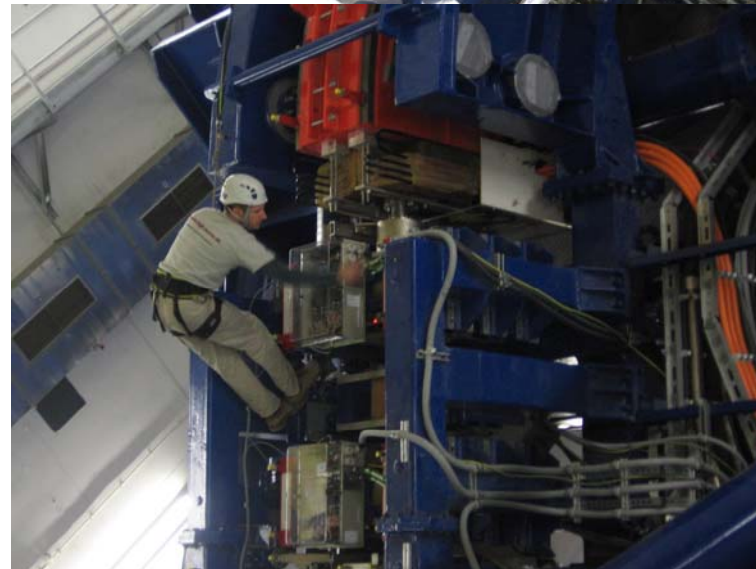


The “cage”

Special “techniques”
to install the reflectors



Industrial climber

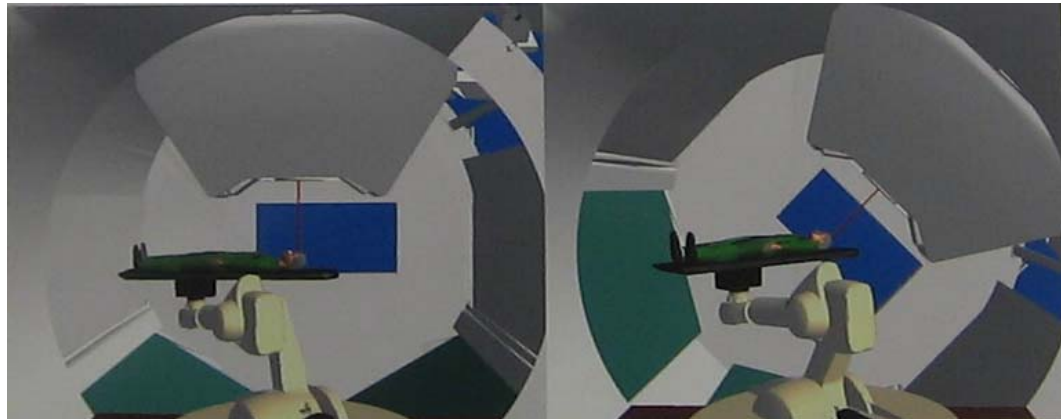


Survey and alignment of the Gantry

- Acceptance test measurements (6-DOF)
 - 50 stations for the measurement of all angle positions of the gantry
 - 6 days with two Laser Tracker teams
- Three iterations of alignment and acceptance test measurements
 - Compromise between the deformation of the gantry structure and the motion of the components in the different gantry angle positions
- The final result of the acceptance test measurement is that the deviation of each component ≤ 0.3 mm in all different angle positions of the gantry

Laser-alignment

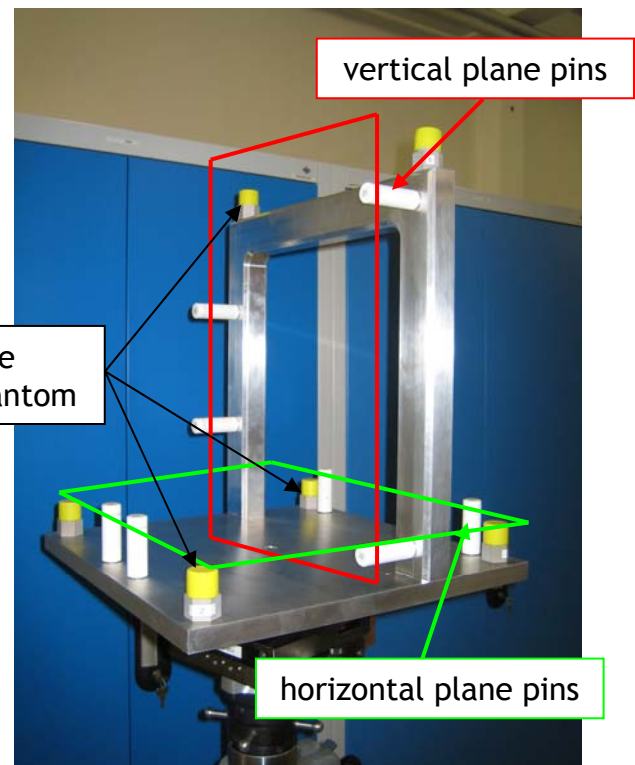
- Alignment of crosshair lasers within the gantry treatment room



For the positioning of the patient and the visualization of the isocenter, several lasers has been installed into the rotating treatment room

(Source: Siemens AG)

Laser-phantom for the positioning and alignment of Lasers



Reference points for the positioning of the Laser-phantom

six axis adjustment of the crosshair lasers



Crosshair Laser for the positioning of the patient in the treatment room

Press review

- The HICAT project has a high public resonance, also the biggest daily boulevard paper in Germany has reported about the “Beam-cannon” against cancer

So groß wie ein halbes Fußballfeld
**Deutsche bauen Strahlenkanone
gegen Krebs**
Heidelberg – Sie ist h
Fußballfeld und ver
Kleinstadt. Doch sie
Krebskranke!

Thank you for your attention!



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