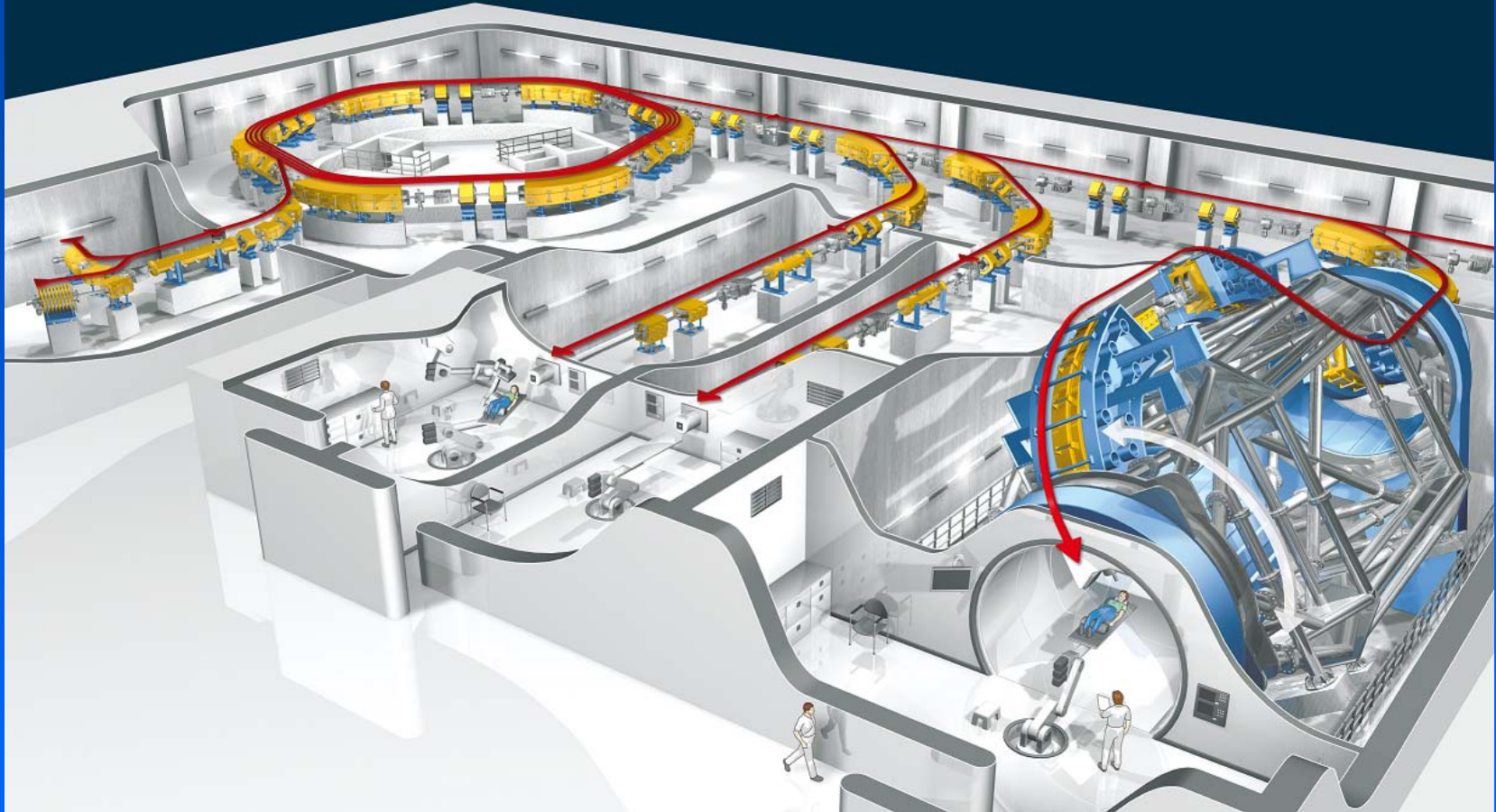


Longantry @ HIT

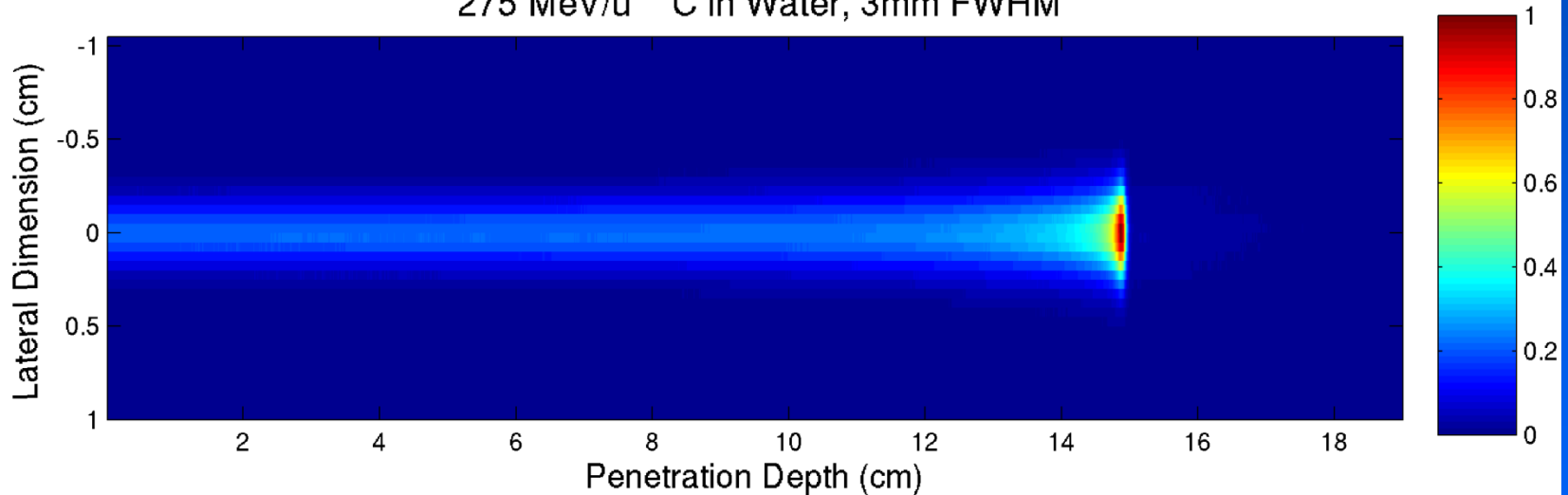


Prof. Dr. Thomas Haberer
Scientific-technical Director
Heidelberg Iontherapy Center

Goal

The key element to improve the clinical outcome is **local control!**

275 MeV/u ^{12}C in Water, 3mm FWHM



entrance channel:

- low physical dose
- low rel. biol. efficiency

tumour:

- high physical dose
- high rel. biol. efficiency

Rasterscan Method

**scanning of
focussed
ion beams
in fast
dipole magnets**

**active variation
of the energy,
focus and
intensity in the
accelerator and
beam lines**

Synchrotron
(Particles up to
70% of light speed)

Ion Source
Carbon

Ion Source
Proton

Linear Accelerator

Scanning System

Monitor
System

Scanning
Magnets

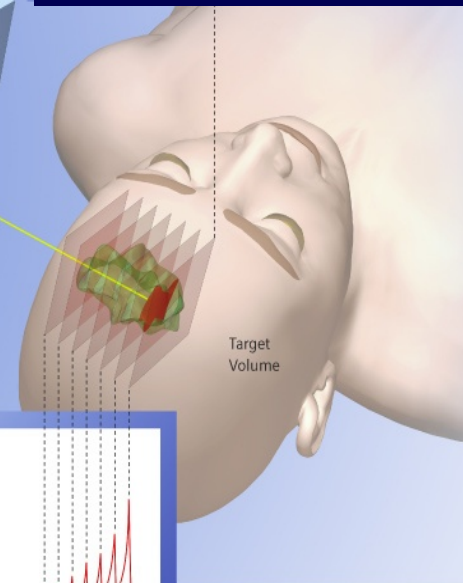
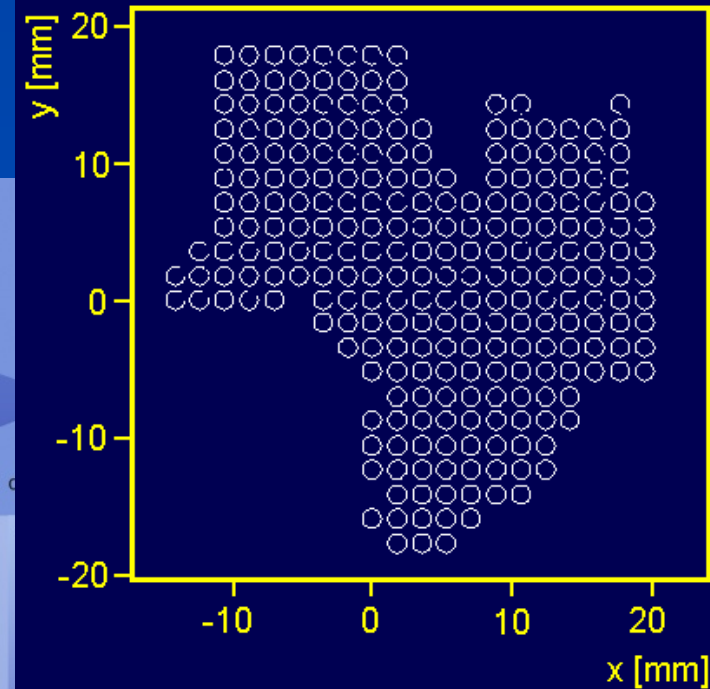
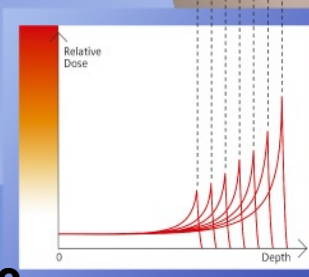
Wire
Chambers

Ionization
Chambers

Example

Depth 5 cm:
Proton 80 MeV
Carbon 145 MeV/u

Depth 25 cm:
Proton 195 MeV
Carbon 375 MeV/u



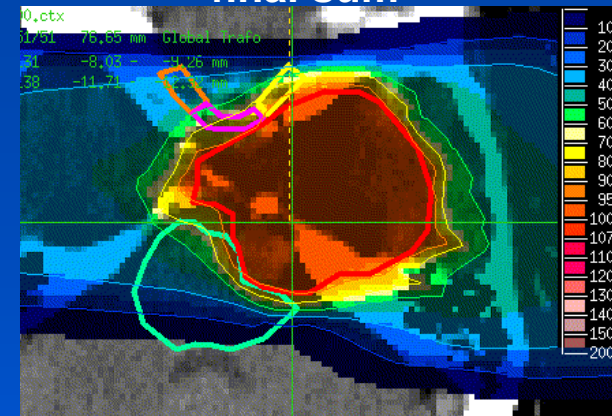
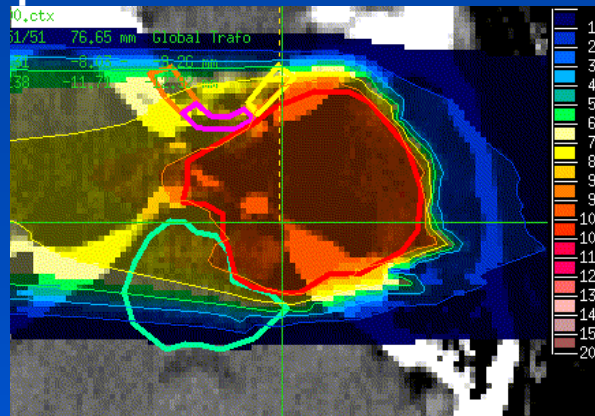
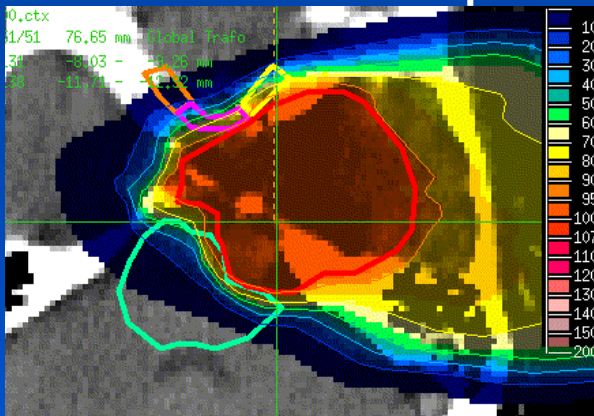
Haberer et al., NIM A , 1993



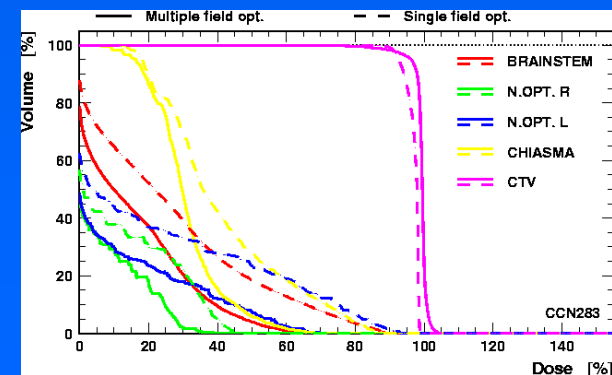
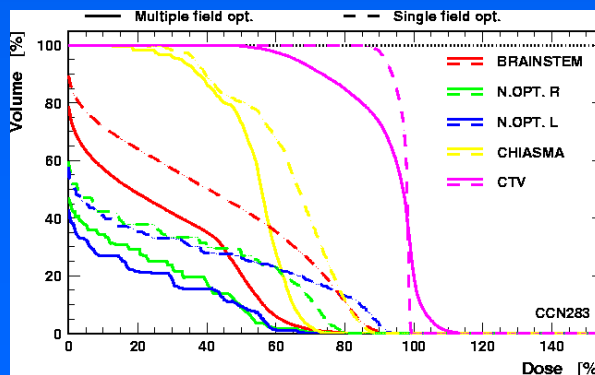
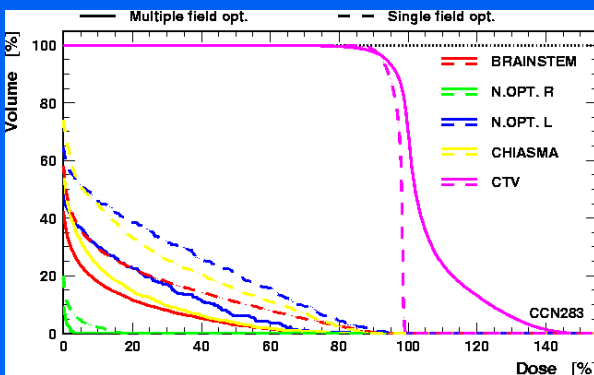
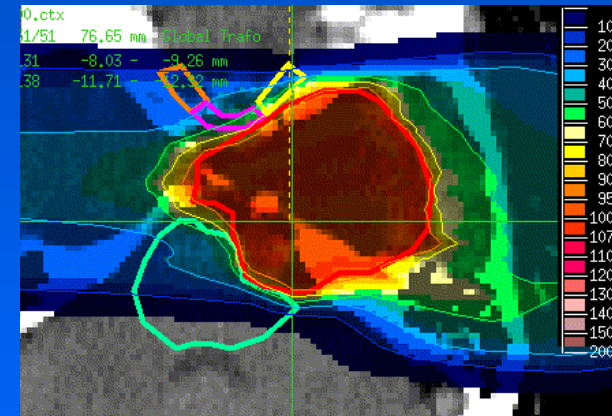
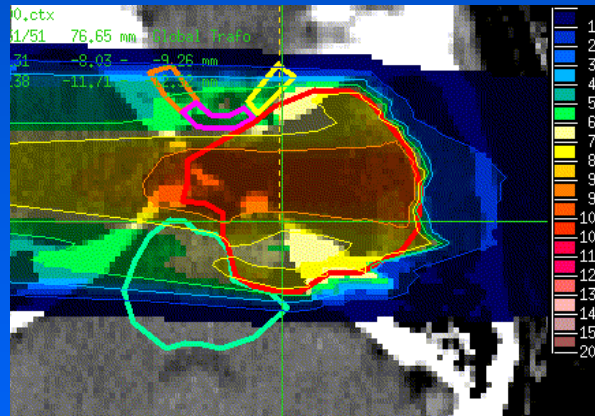
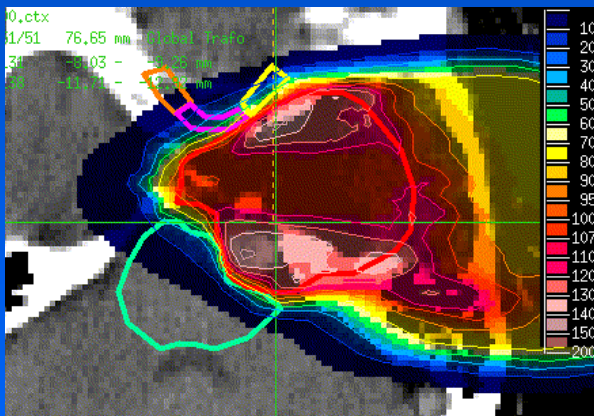
Multi-field optimization

separate optimization

final sum



simultaneous optimization



Scanning Ion Gantry / Rationale

TPS studies (beam scanning only) give:

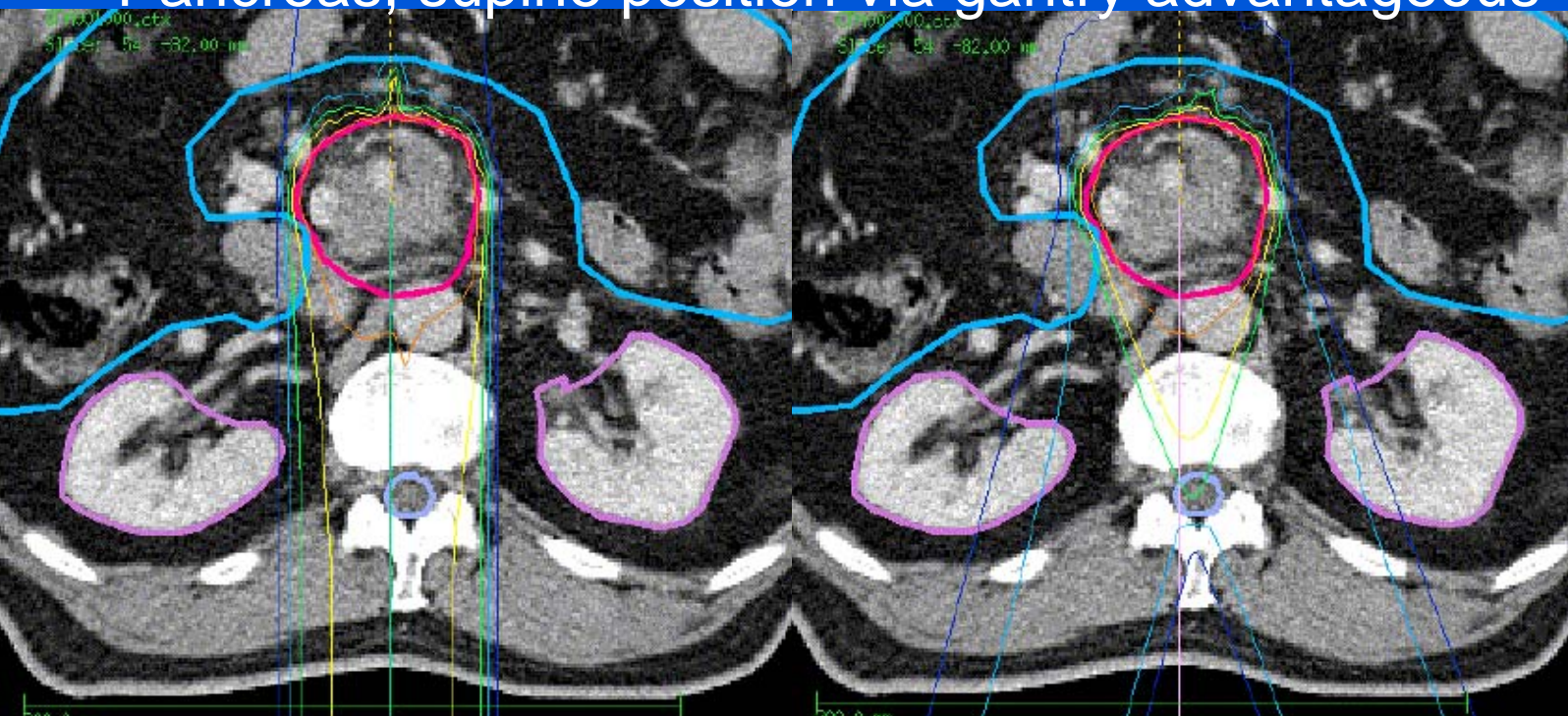
- Benefits for ~20% of skull base tumors
- Spinal/cervical chordoma benefit significantly (robustness of plans)
- Pancreatic/retroperitoneal tumors can be treated with a vertical beam but with a gantry improved treatments can be realized
- Some lung tumor situations may benefit
- **No** benefit for prostate/pelvic tumors was found

Motivation Gantry

Advantage of a
rotating
beamline



Pancreas, supine position via gantry advantageous



Scanning Ion Gantry / Requirements

Clinical:

- Isocentric set-up and a fixed floor
- Identical field size in all beamlines of 20 cm x 20 cm
- Integration of fluoroscopy systems in two planes (IGRT, organ movement)

Technical / financial:

- Normal conducting elements (field quality of about 10^{-4} in 90-degree bending magnet, price, 330 days 24/7 op.)
- Full rotation (clinical workflow, minor saving)
- Barrell-type (less bending than cork-screw)
- Scanning upstream to the last bending (radius vs. weight)
- Edge focussing (large SAD)
- Truss-based structure

Gantry Design Study @ GSI

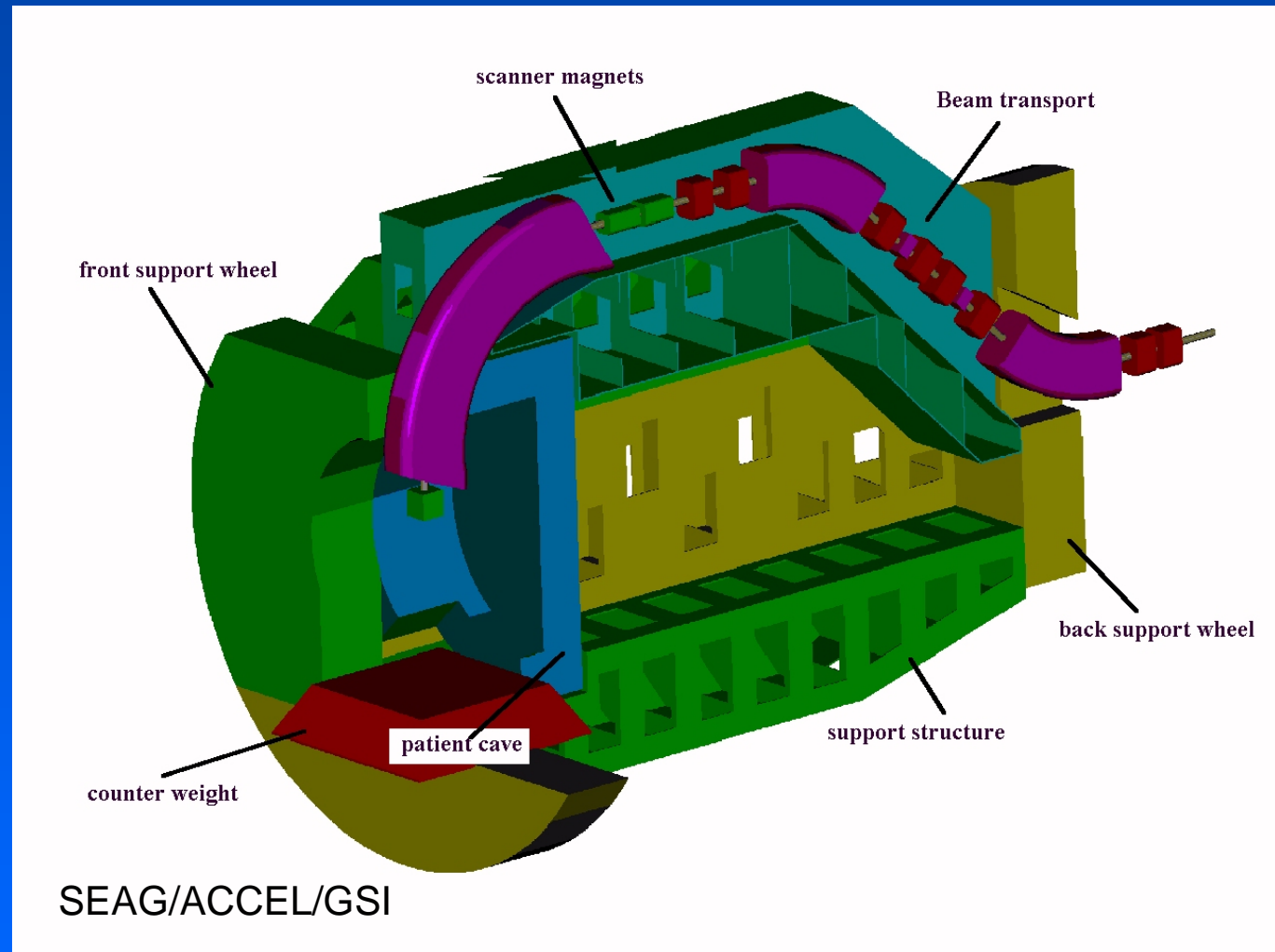
barrel-type

box-girder
construction
20mm walls (center)

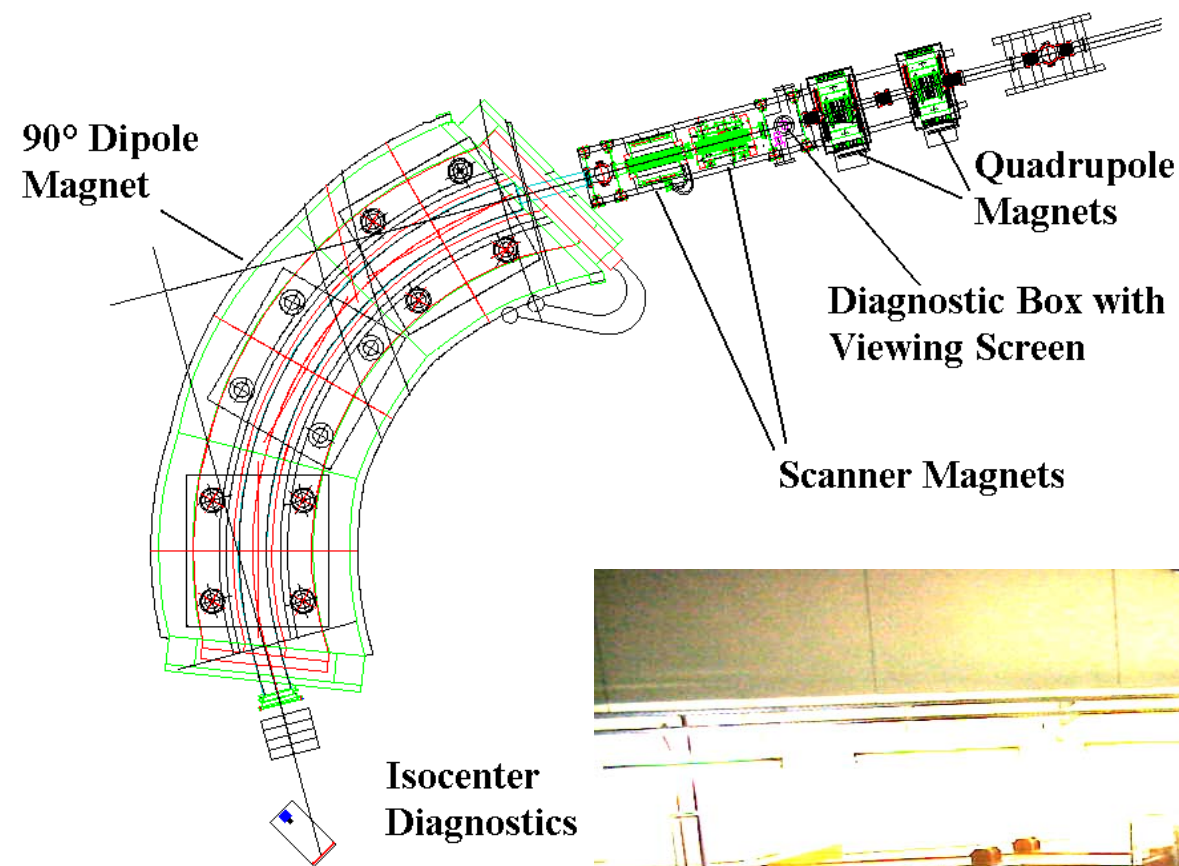
675 to

max. lateral
deformation 0.3mm

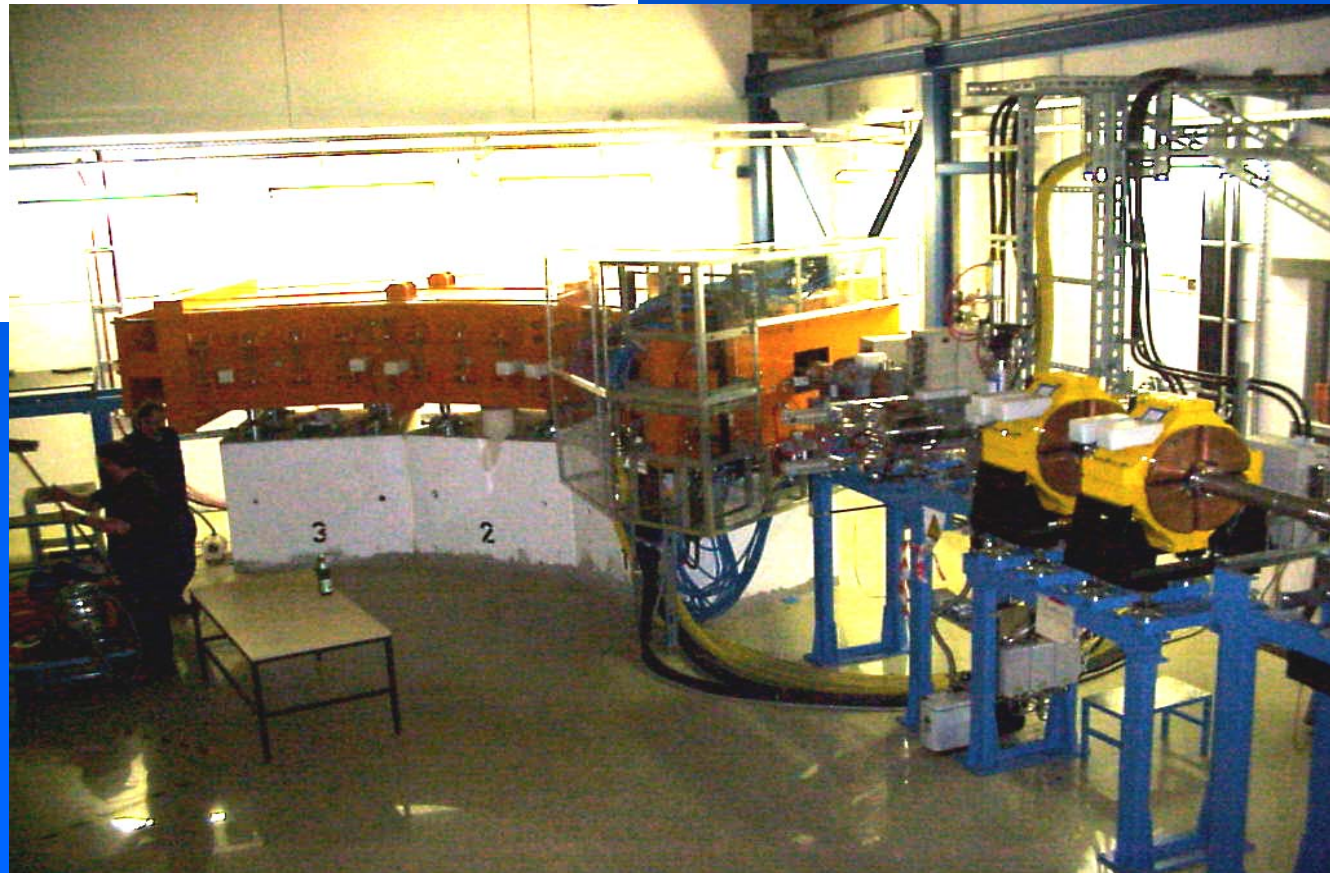
temp. coefficient
0.2mm / °C



Gantry Segment Prototype @ GSI

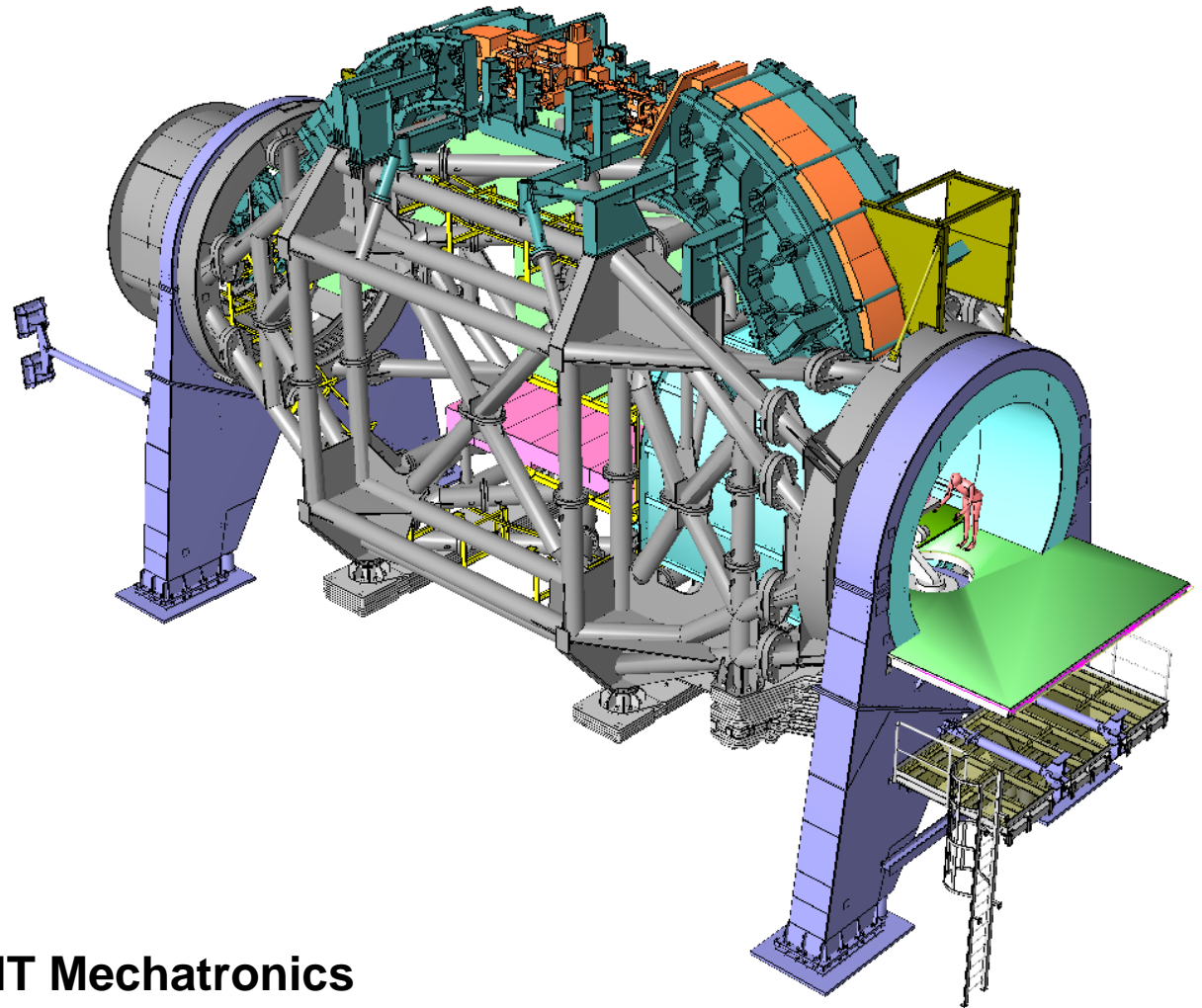


test of scanning gantry segment at GSI



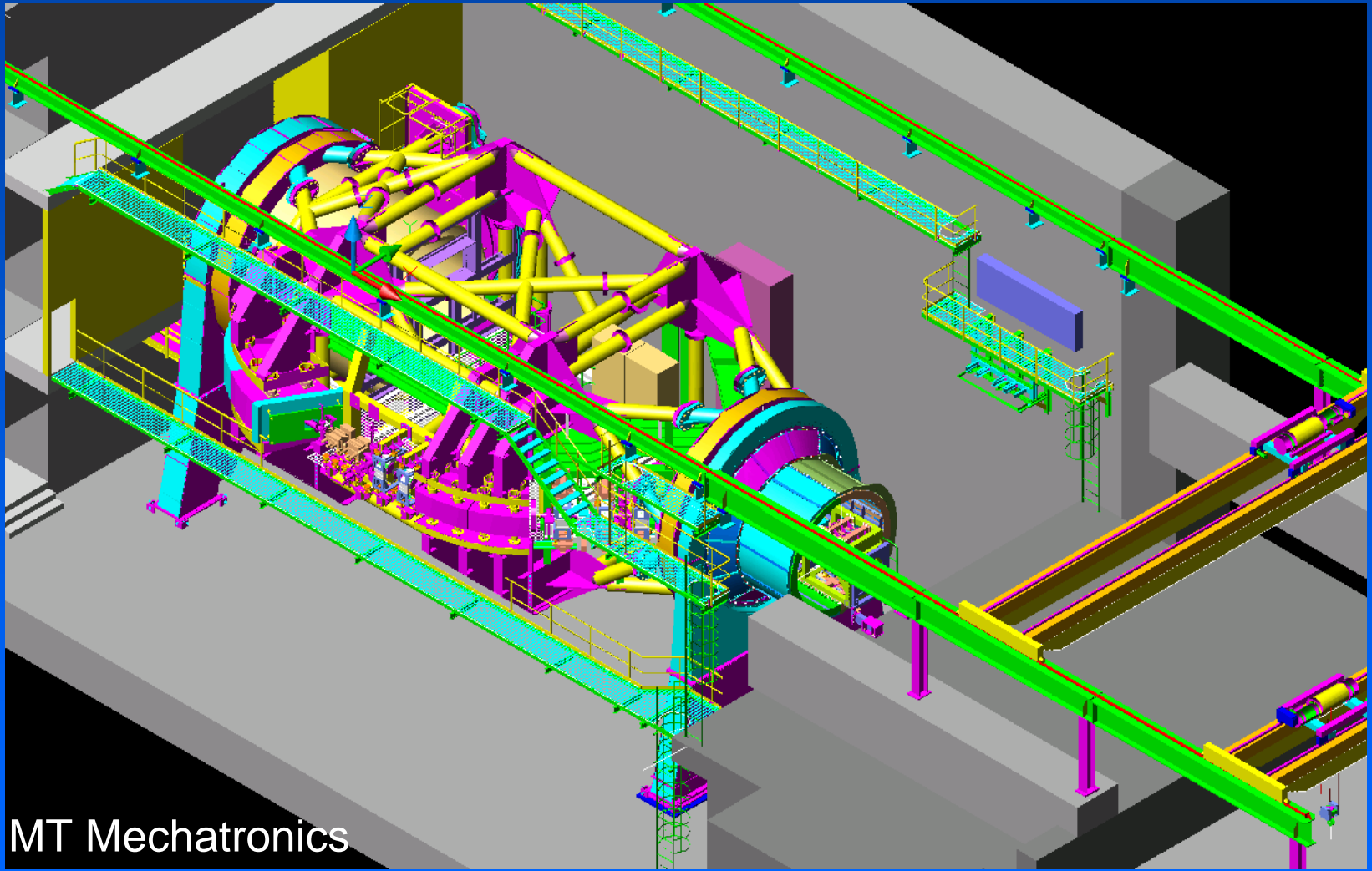
Design for HIT

- isocentric barrel-type
- world-wide first ion gantry
- 2D beam scanning upstream to final bending, almost parallel due to edge focussing
- $\pm 180^\circ$ rotation
3° / second
- 13m diameter
25m length
600 to rotating
(145 to magnets)



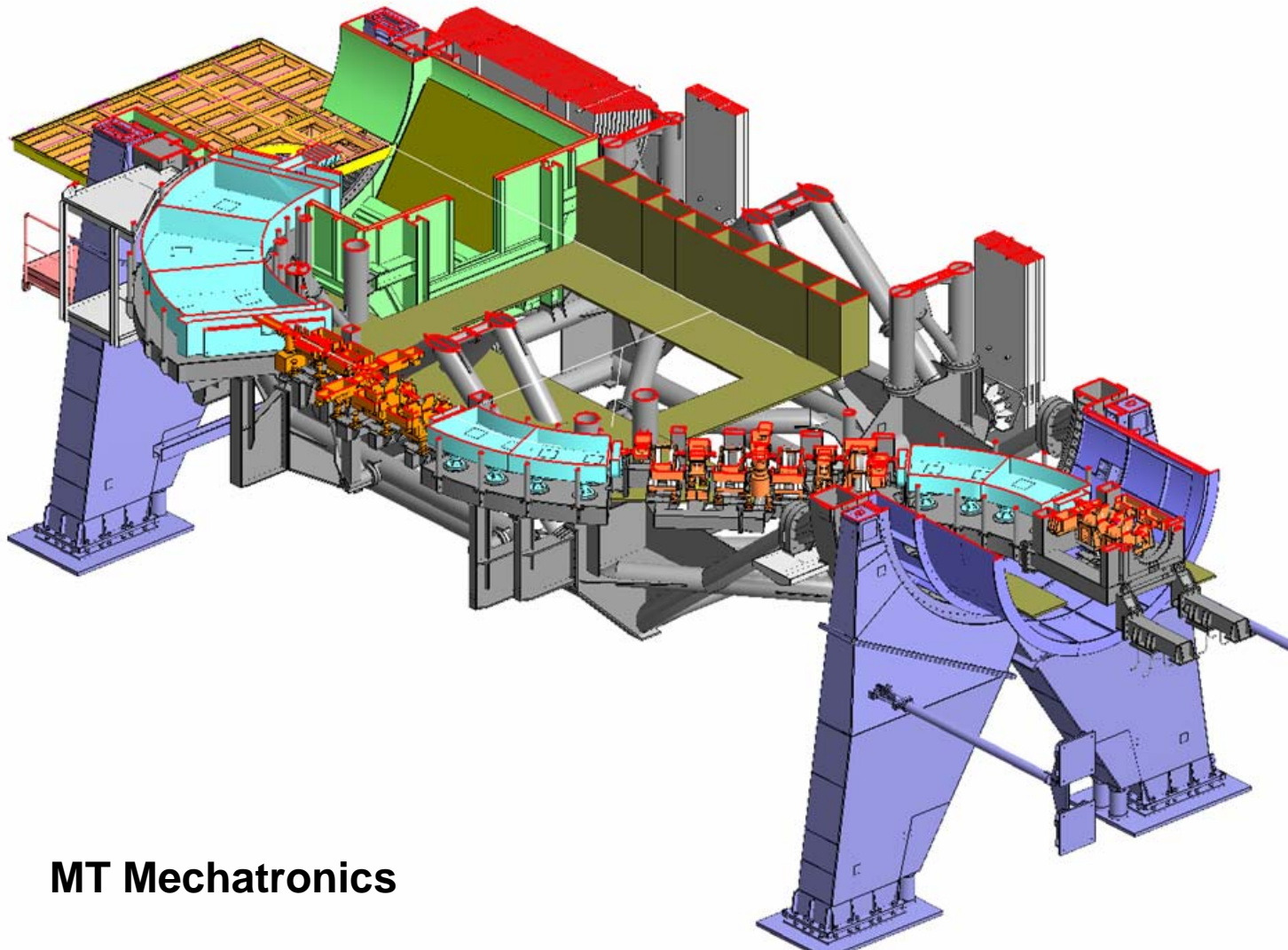
MT Mechatronics

HIT-Gantry: Building Interface



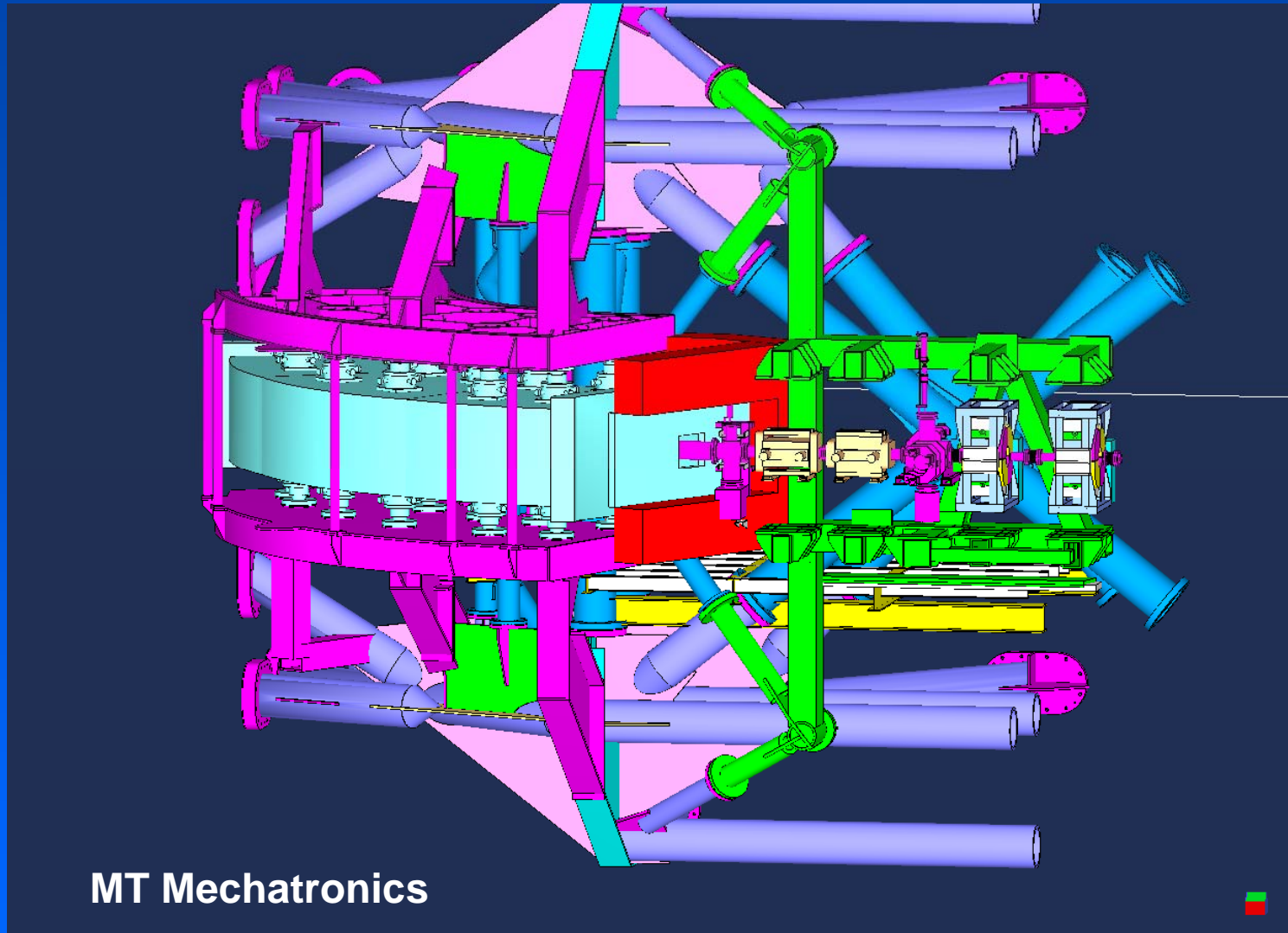
MT Mechatronics

HIT-Gantry: Maintenance Position

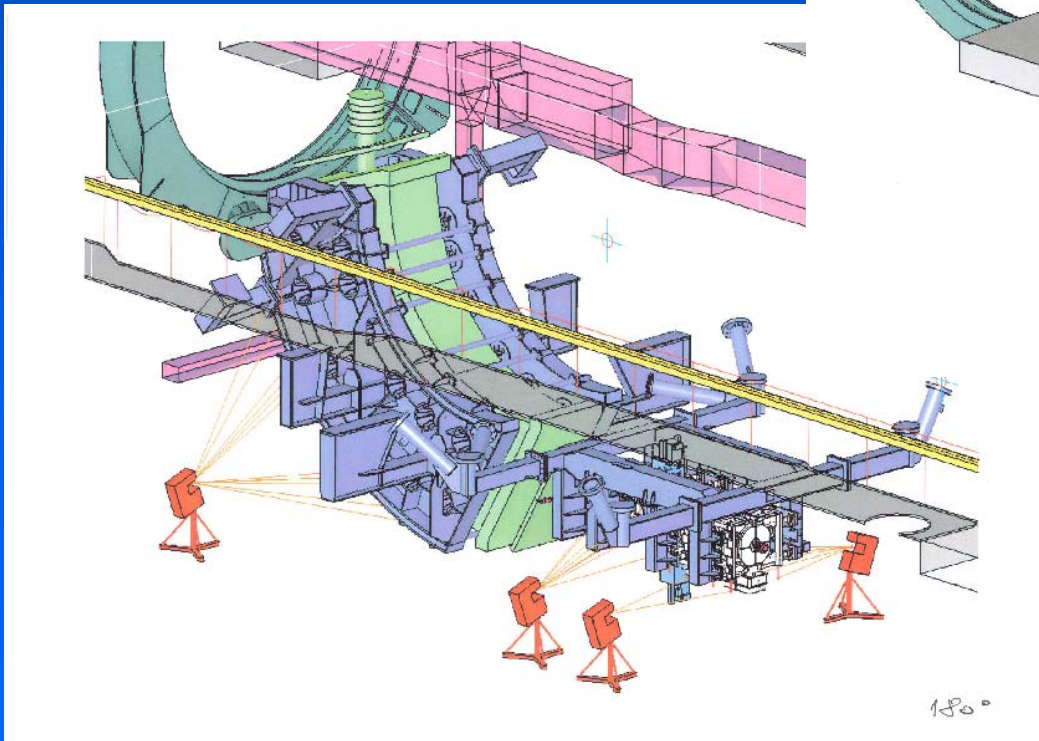
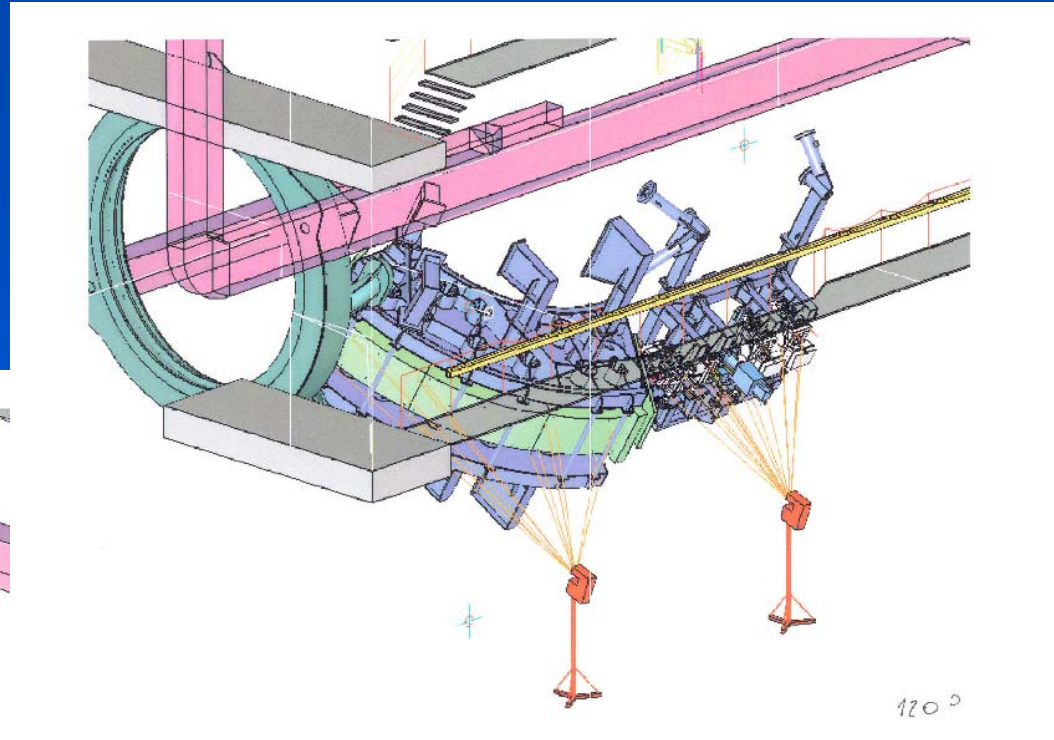


MT Mechatronics

Integration of 90°-bending Magnet



High Precision Component Positioning

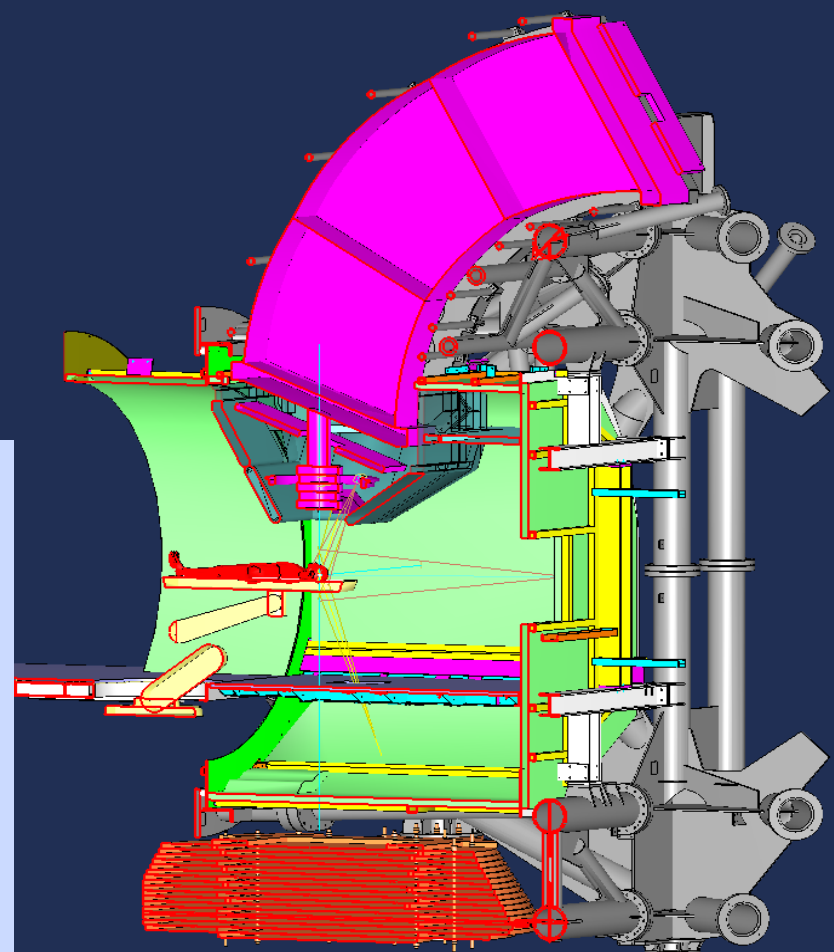
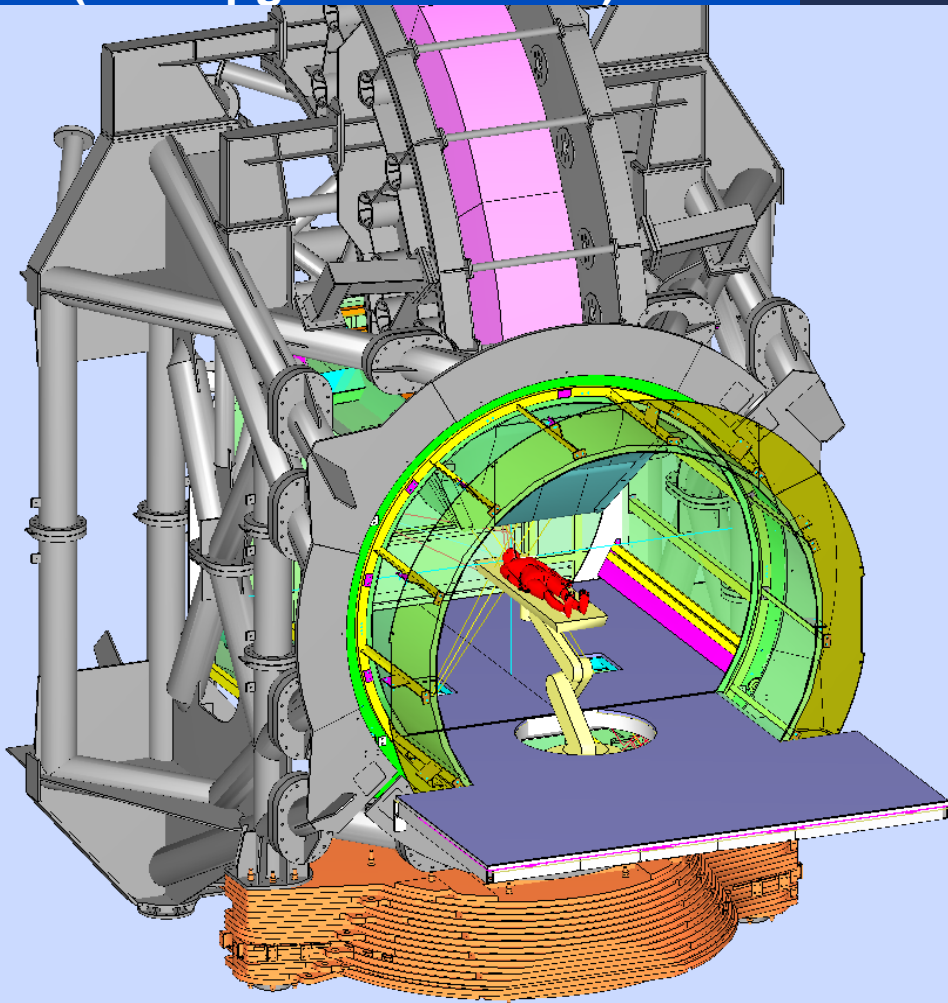


MT Mechatronics

Medtech

integration of

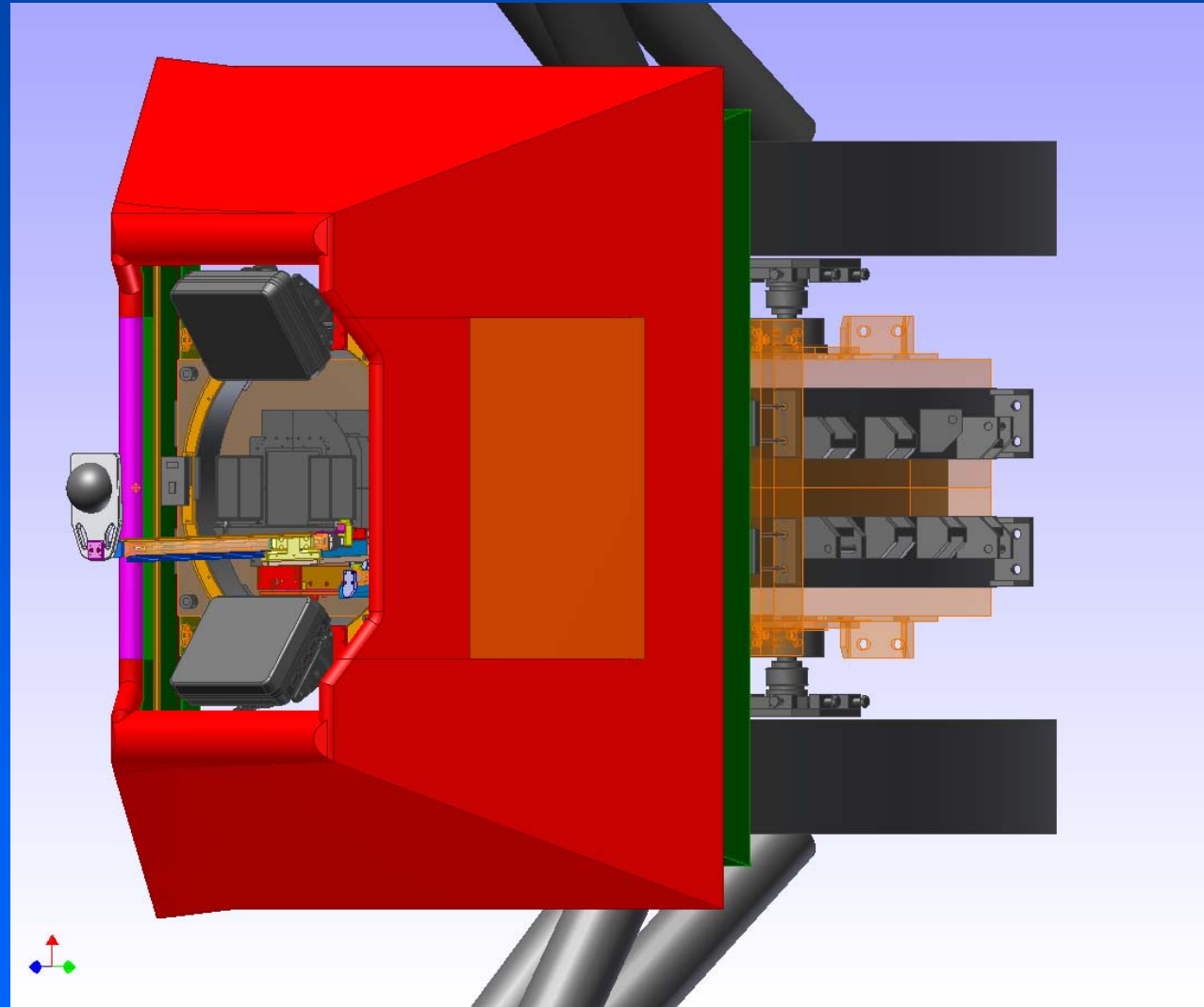
- robotic patient positioner
- digital X-ray systems (30Hz)
- stereotactic equipment (PET-upgrade available)



MT Mechatronics

Patient Environment / Nozzle

- challenging interfaces
- balance functionality and workflow with safety
- collision avoidance:
 - coupled controls of gantry and robot
 - soft bumpers
 - laser curtains
- isocenter definition:
 - room-fixed vs.
 - rotating reference



Siemens Medical Solutions

MT Mechatronics

Patient Environment / Nozzle

Patient Gantry Room November 2007

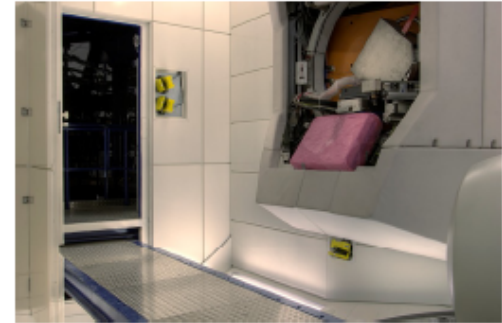


Tilt floor, pending on
Gantry position

Nozzle

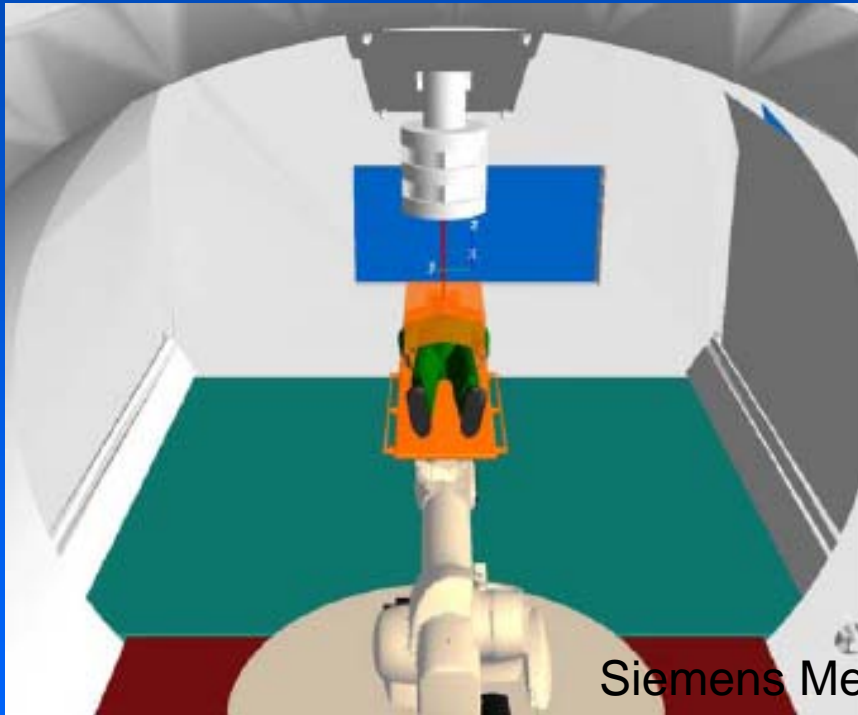
Bumper mats

Patienttable,
Roboter

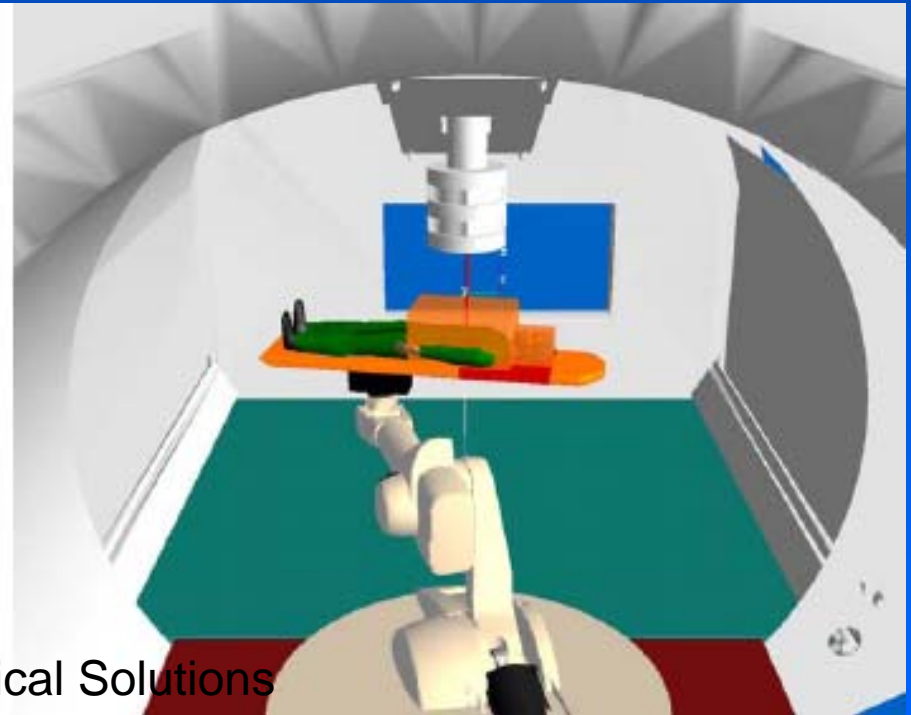


Emergency Analysis

In case of severe problems, how fast do we have to be (20s ... 60s)?



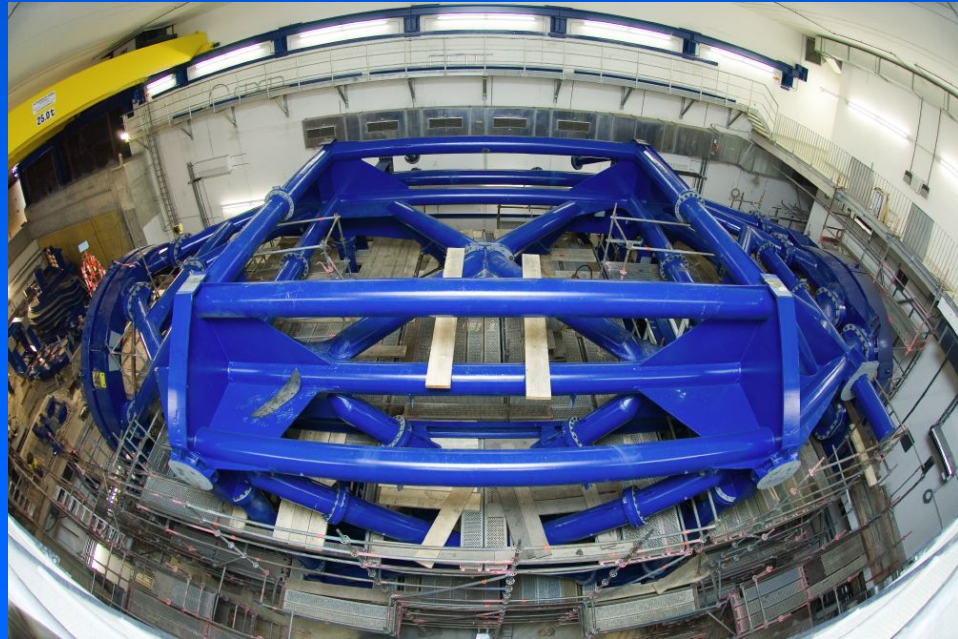
best case



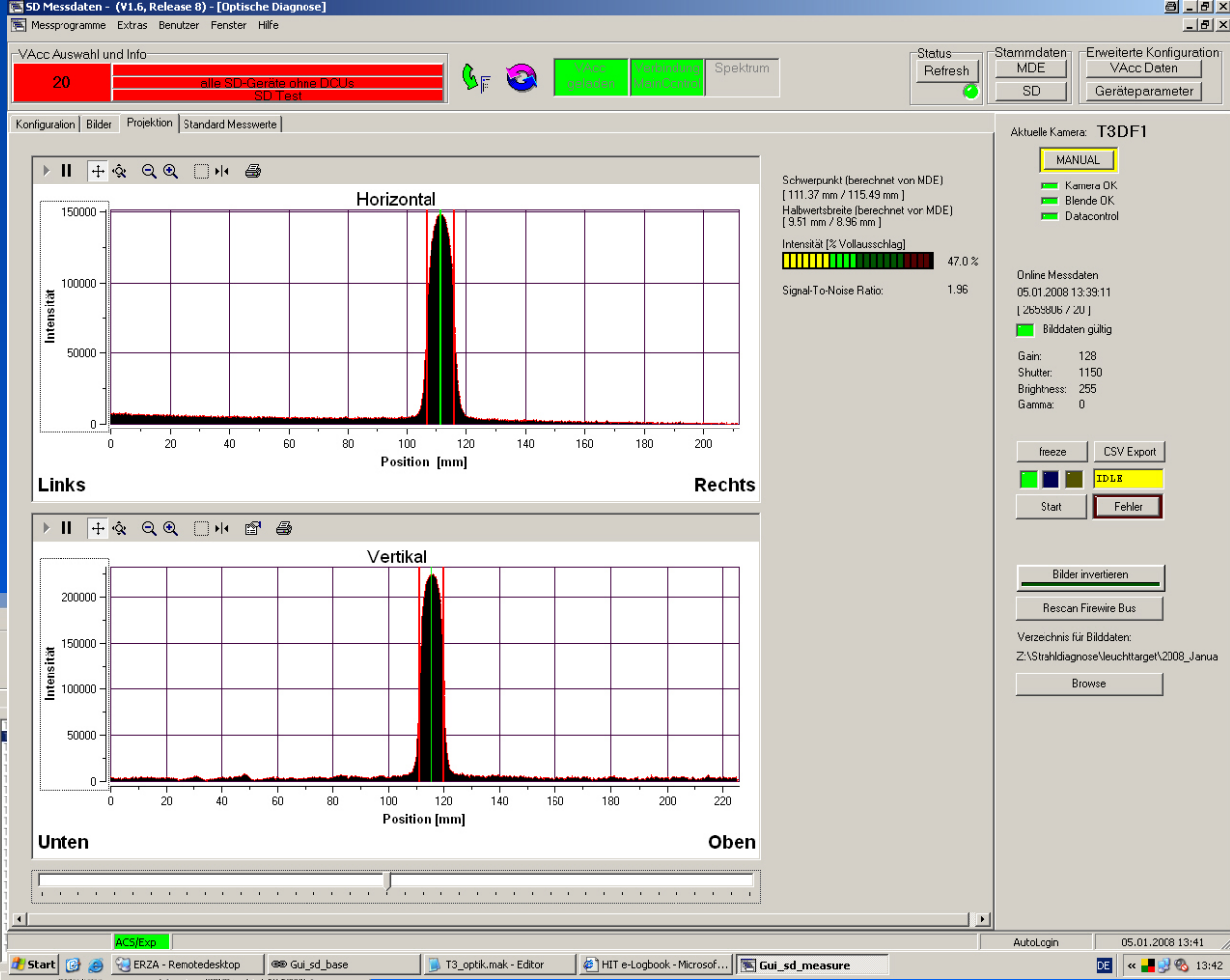
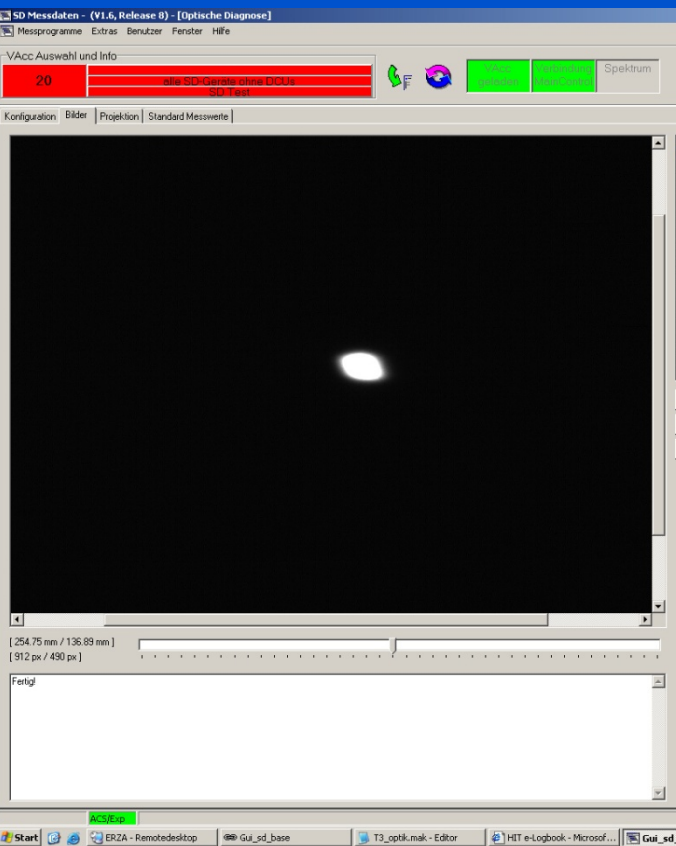
worst case

Siemens Medical Solutions

Assembly and Mounting



Gantry: first beam at the isocenter



January 4th, 2008

Thank you for your attention !



(Intensity modulated raster scan,
 ^{12}C at 430 Mev/u, October 15th 2007)