Five Years of Accelerator Operation Experience at HIT

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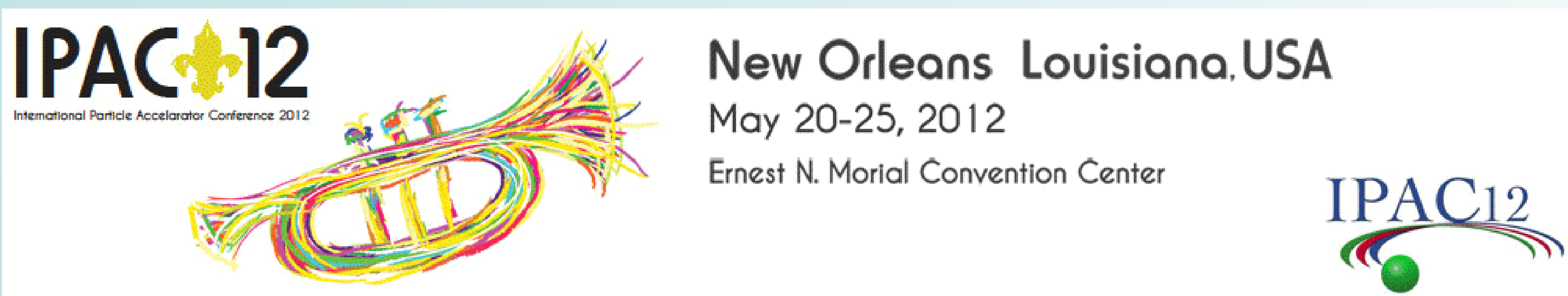
Head Accelerator Operations



HIT Betriebs GmbH am
Universitätsklinikum Heidelberg

http://www.hit-centrum.de

Outline

- The HIT Facility – A Short Overview
- From Commissioning by GSI to Operation by HIT
- Five Years of HIT Accelerator Operation at a Glance
- Continuous Improvement Process – Examples:
    - Ion Source and RFQ Test Bench
    - Magnetic Field Control in the Synchrotron
    - ACS Optimization
    - Dynamic Intensity Control
- Acknowledgements

The HIT Facility – A Short Overview

HIT: Heidelberg Ion Beam Therapy Centre

University Campus
„Im Neuenheimer Feld“

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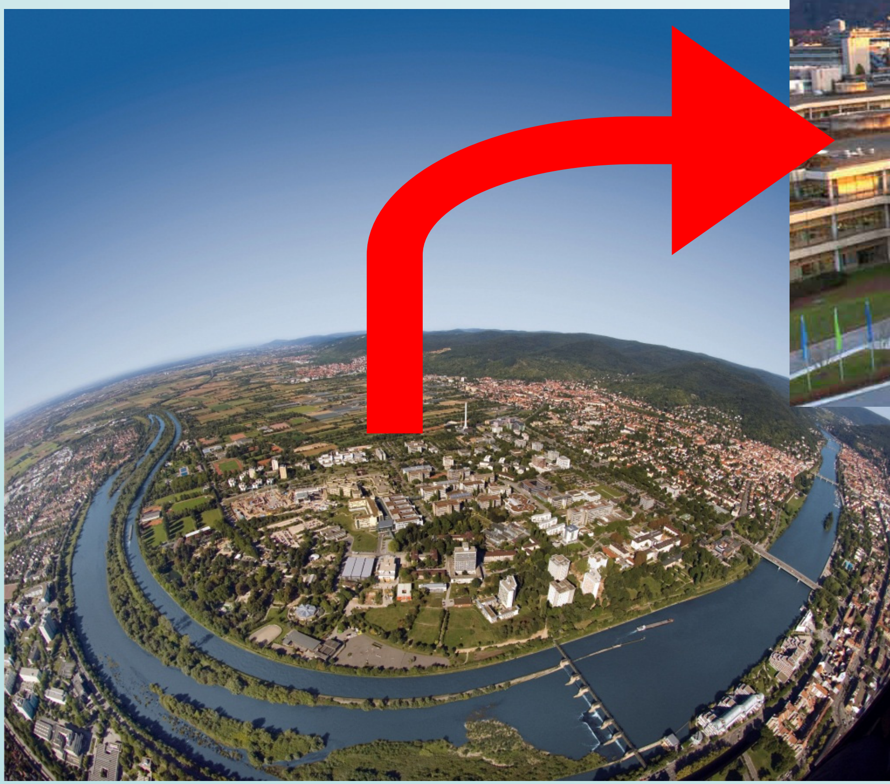

HIT is located directly beside the National Centre for Tumour Diseases (NCT) and university hospitals

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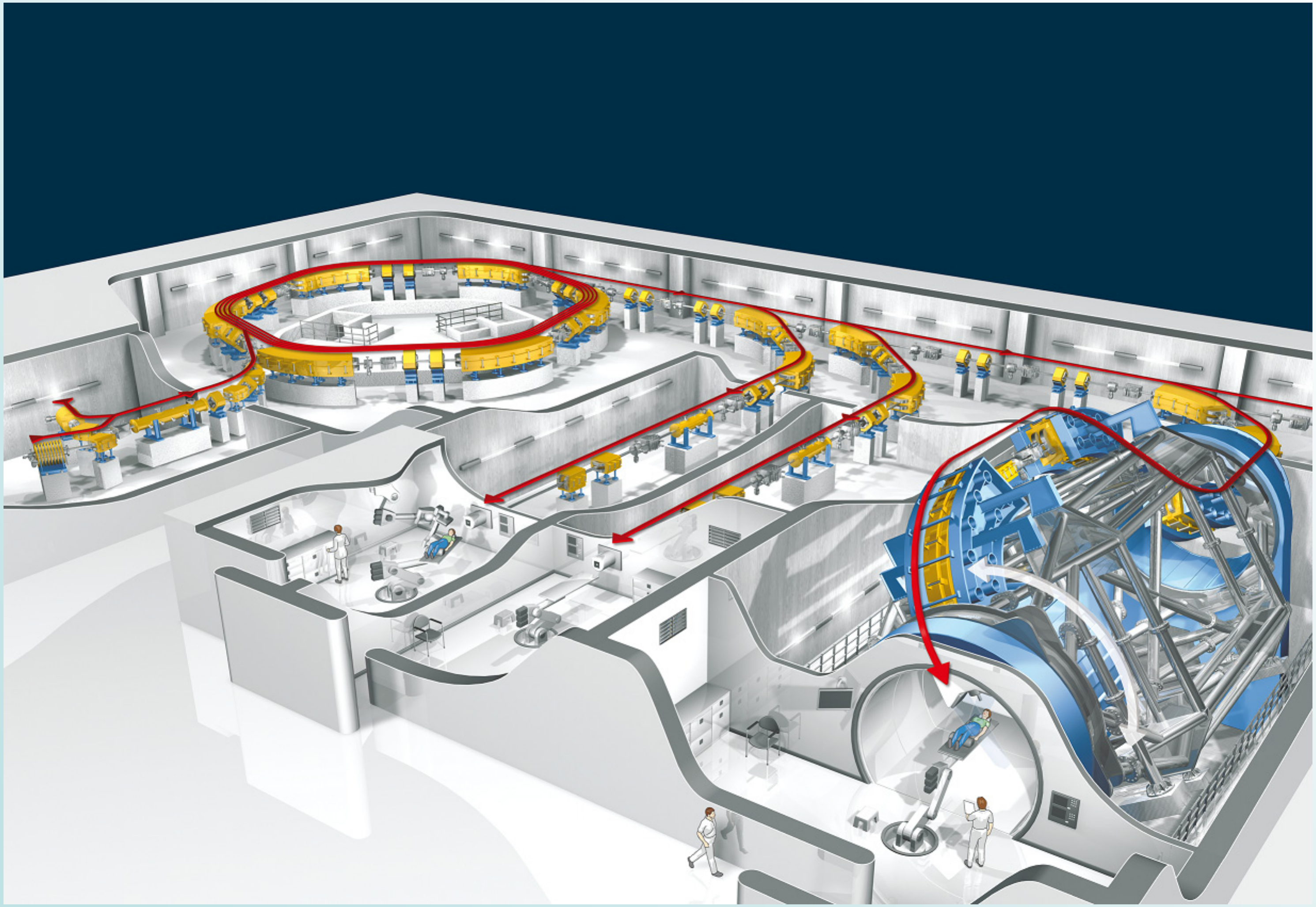
The HIT Facility – A Short Overview



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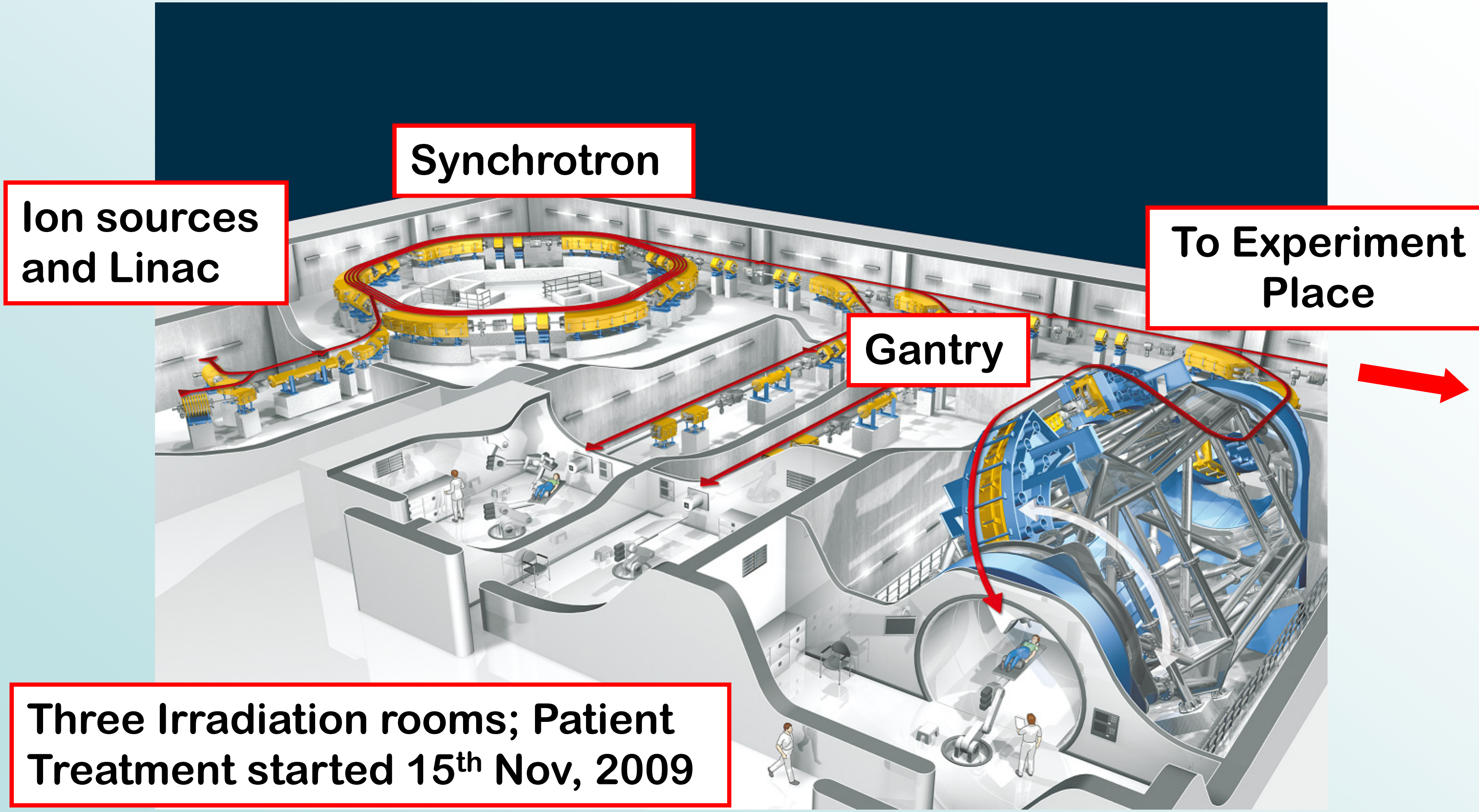
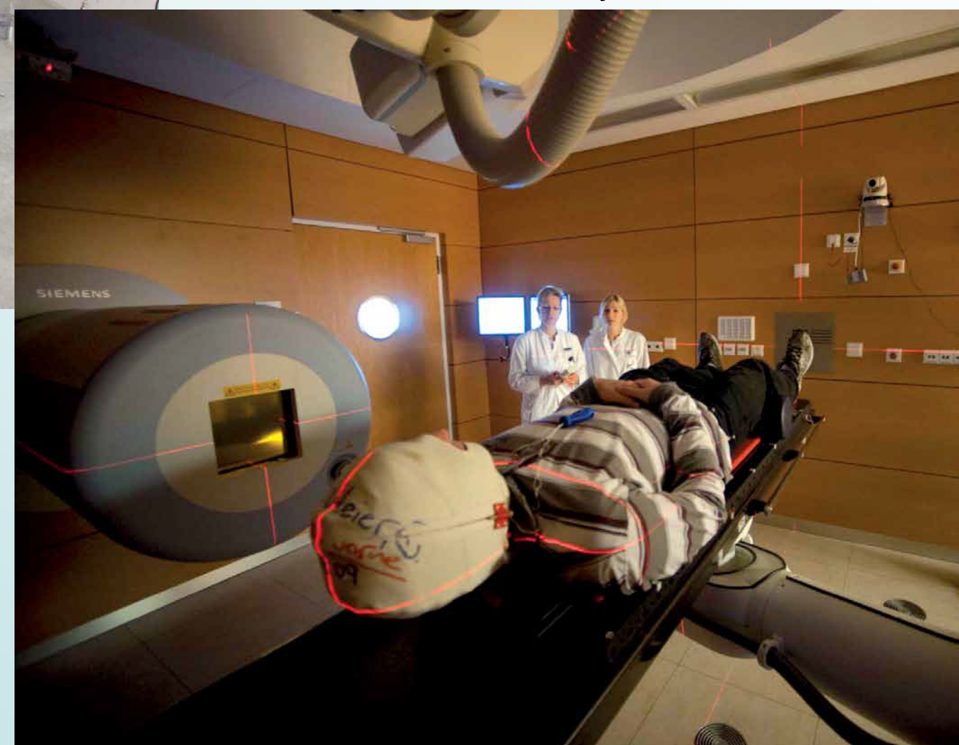


The HIT Facility – A Short Overview

HIT synchrotron
p: 48 – 221 MeV
C: 88 – 430 MeV/u
(255 energy steps, also for O and He)



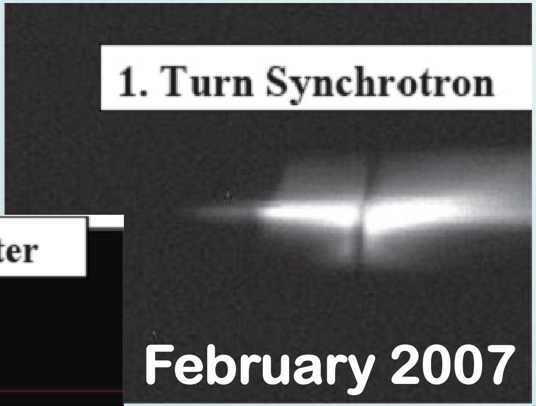
Patient positioning in horizontal treatment room (medical equipment IONTRIS by Siemens)

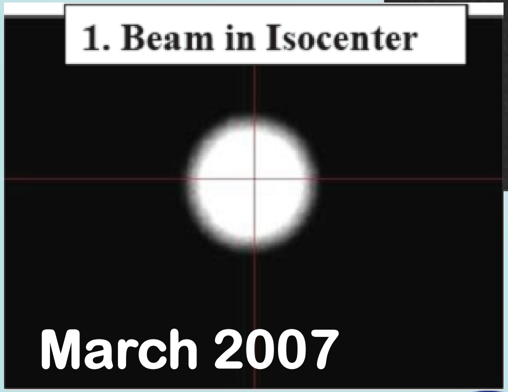
From Commissioning by GSI to Operation by HIT

Commissioning Steps:

2006 Ion Sources and Linac
Hand-over to HIT: 06/2007

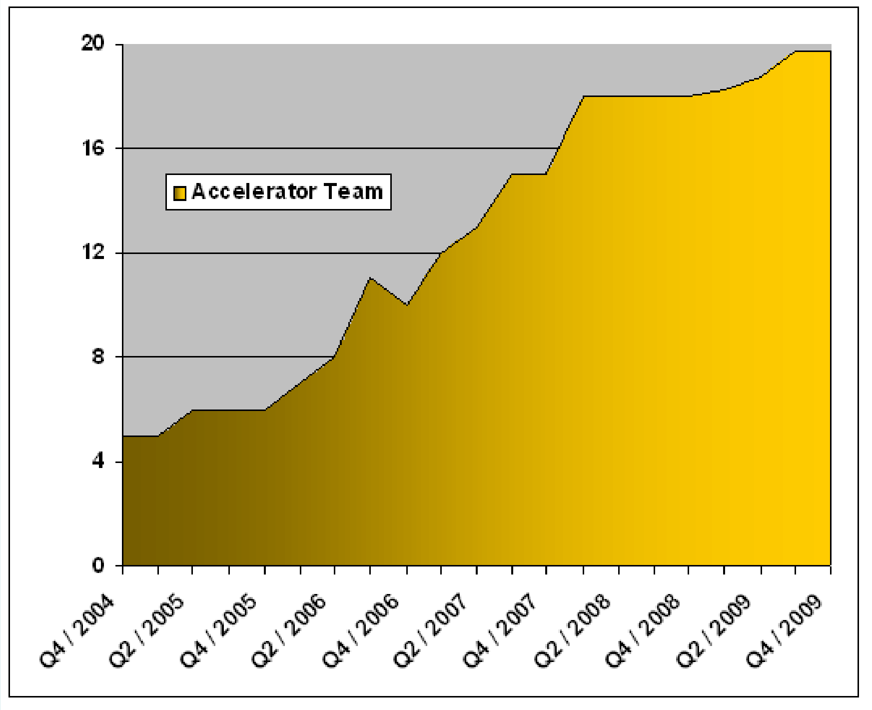
2007/08 Synchrotron and HEBT Lines
Hand-over to HIT: 04/2008





Five Years of HIT Accelerator Operation

- Building up of the team from a core to the full operating crew
- Training of the team done by GSI, companies and "in-house"
- Internal organization of three technical teams
- Establish regular shift operation from 16/5 to 24/7 for further commissioning steps including therapy control system evaluation



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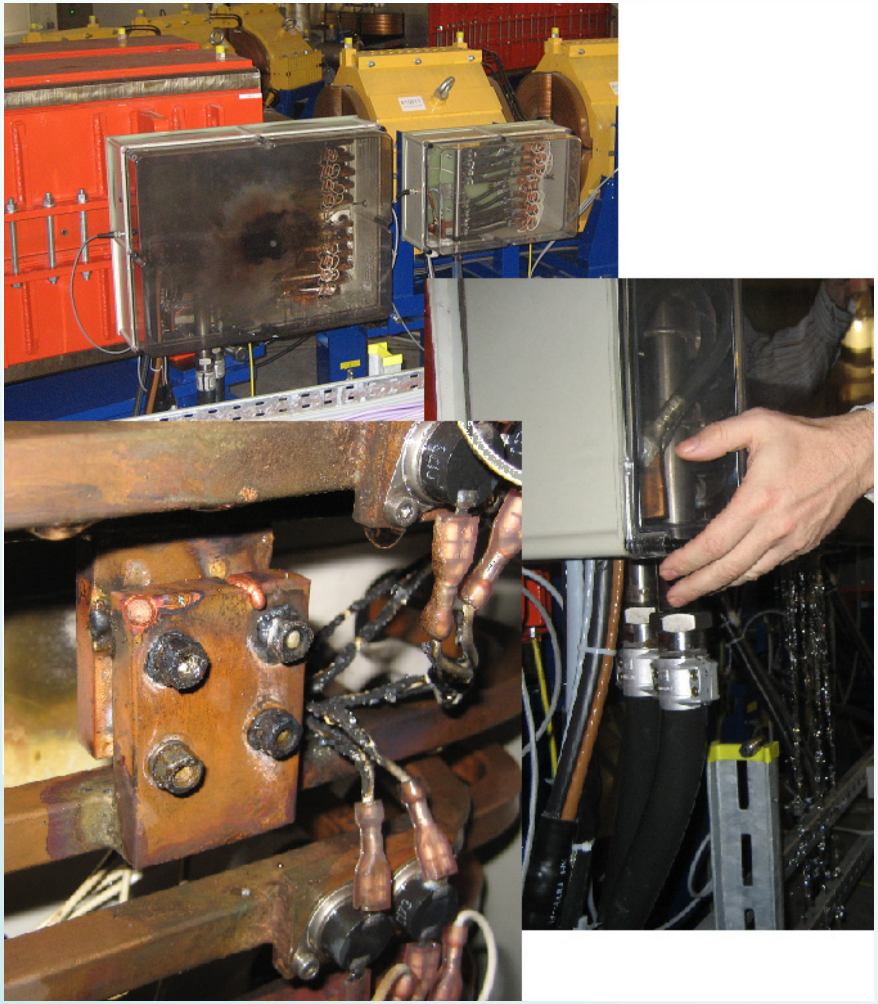
- Troubleshooting: e.g. a destroyed magnet connection box – repair within two days



2006 2007 2008 2009 2010 2011 2012

Five Years of HIT Accelerator Operation

- Establish routine operation of the accelerator, especially consolidation of control system
- Achieved availability of about 98% in average – no longer break than 3 hours at daytime
- Daily Accelerator QA → retuning of linac, synchrotron and HEBT only every 3 – 4 months except intensity readjusting (weekly)

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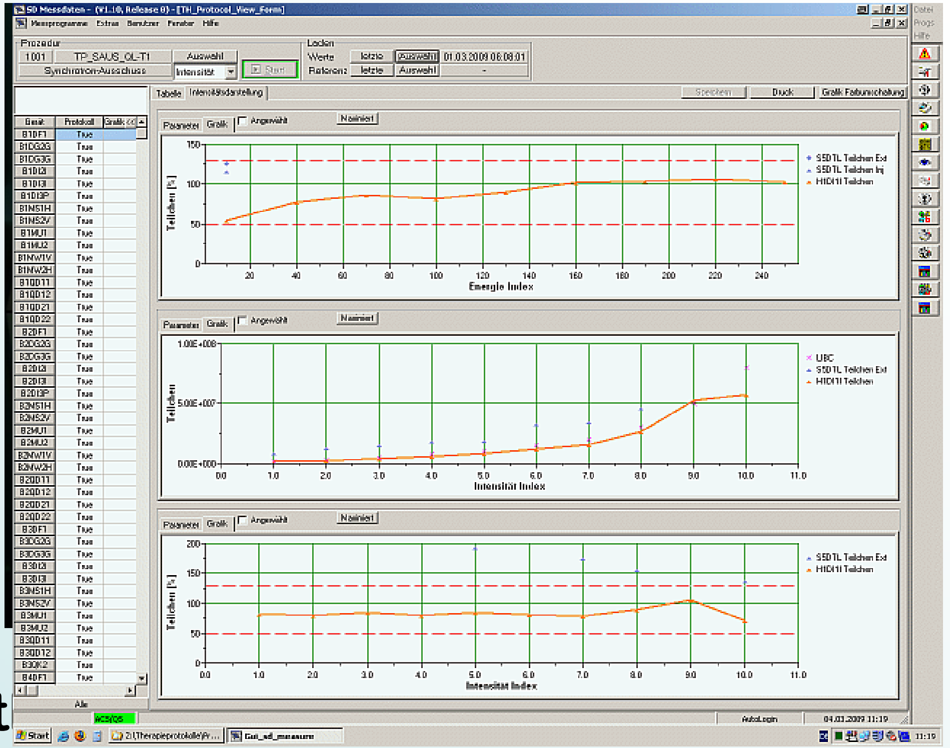

Daily intensity checks (position and profiles)

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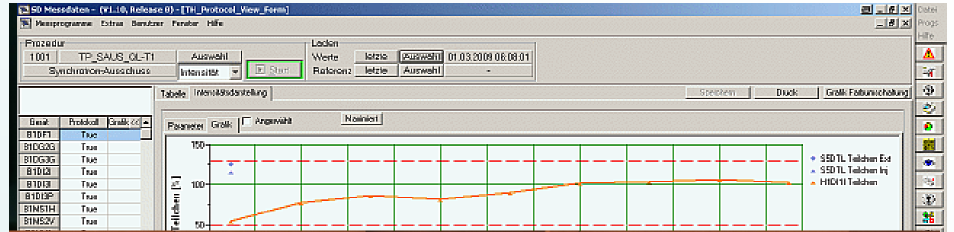

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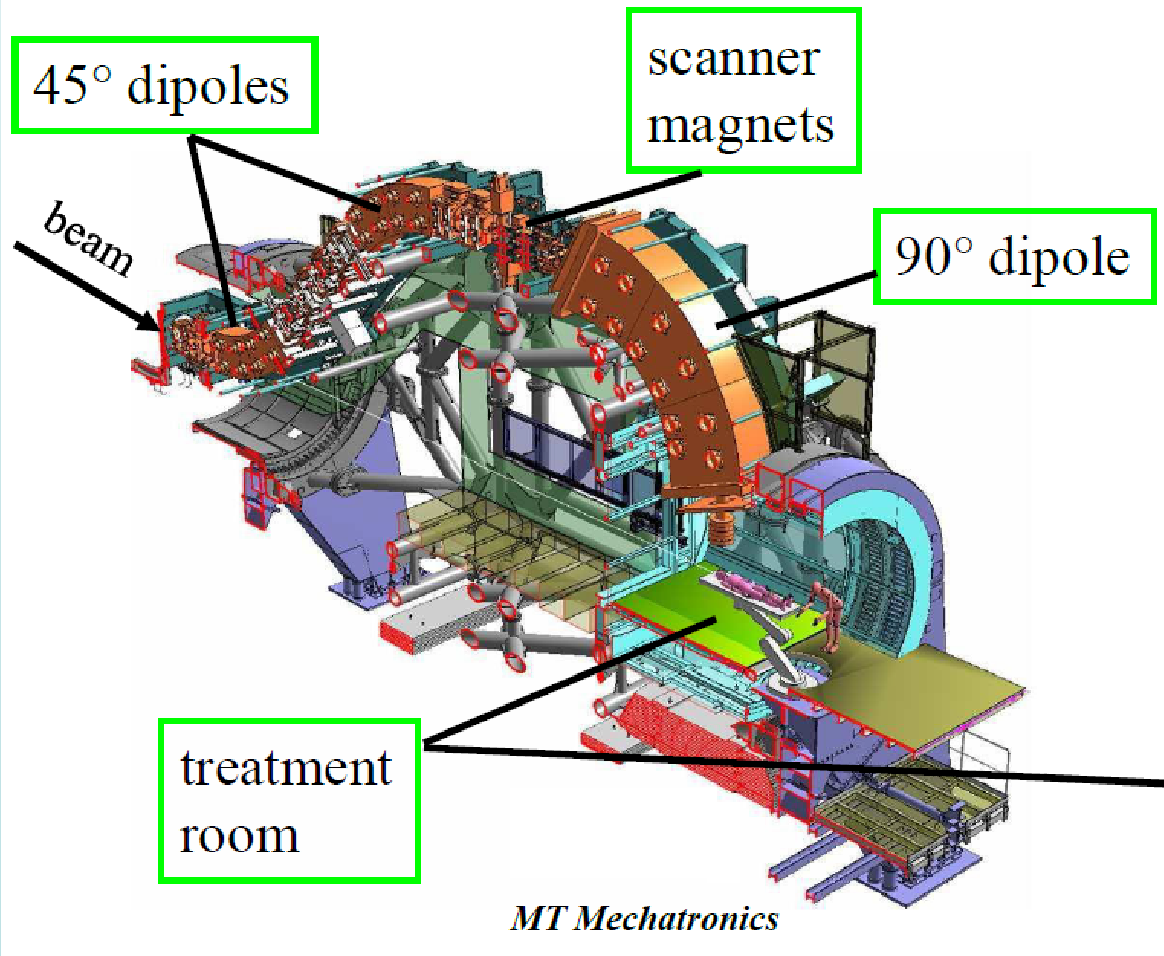

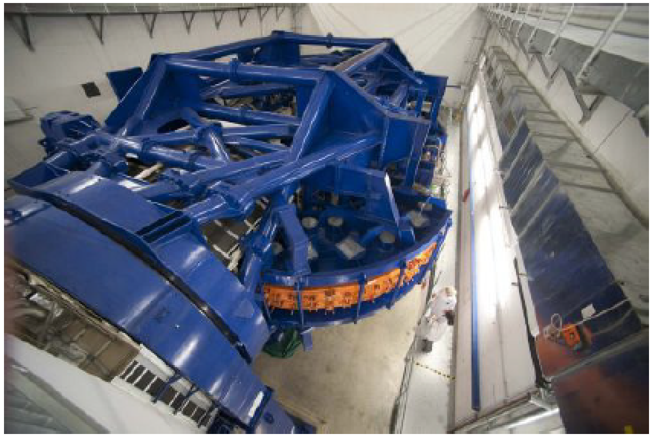

Five Years of HIT Accelerator Operation

- Restart of beam optical commissioning of the gantry after solving severe problems with the drag chain

2006 2007 2008 2009 2010 2011 2012

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- Restart of beam optical commissioning of the gantry after solving severe problems with the drag chain
- 37,000 settings per ion needed, but only ~ 1% interpolation points are needed – adjustment sustained by an ion optical code (MIRKO by GSI)

2006 2007 2008 2009 **2010** **2011** 2012

Five Years of HIT Accelerator Operation

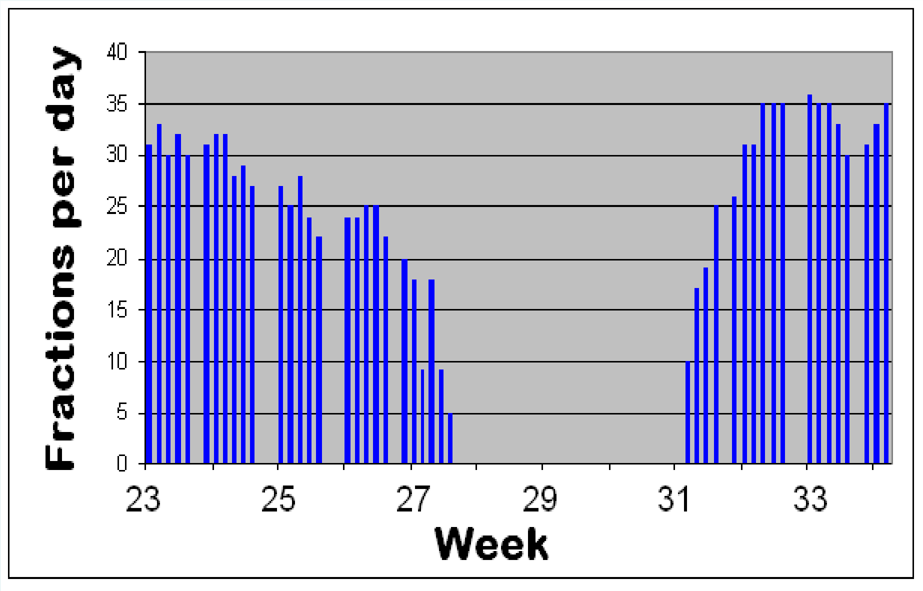
- Restart of beam optical commissioning of the gantry after solving severe problems with the drag chain
- 37,000 settings per ion needed, but only ~ 1% interpolation points are needed – adjustment sustained by an ion optical code (MIRKO by GSI)
- Accuracy achieved: Pencil beam within limits for scanning → possible treatment field 180 x 180 mm^2; long-term stability under test now

Courtesy by A.v.Knobloch, Siemens

Five Years of HIT Accelerator Operation

- "2012 – Year of the Gantry": Patient treatment start scheduled for end of October
- Major change in shutdown strategy – during longer maintenance breaks of 2-3 weeks patients have to be phased out →"Ramping down" and "ramping up" necessary
- Since 2012 instead of two long shutdowns now six short maintenance periods of four days each (effectively 2.5 days) →Feasibility was successfully demonstrated!

(Summer 2011)



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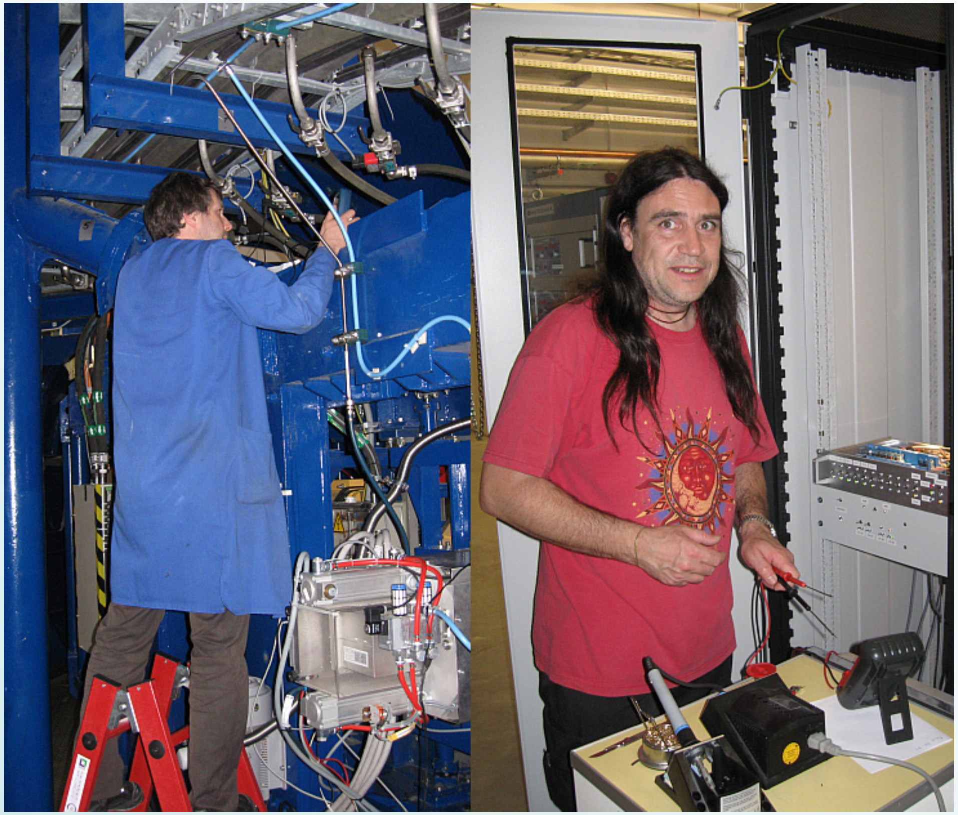

HIT accelerator team members during May shutdown

2006 2007 2008 2009 2010 2011 2012

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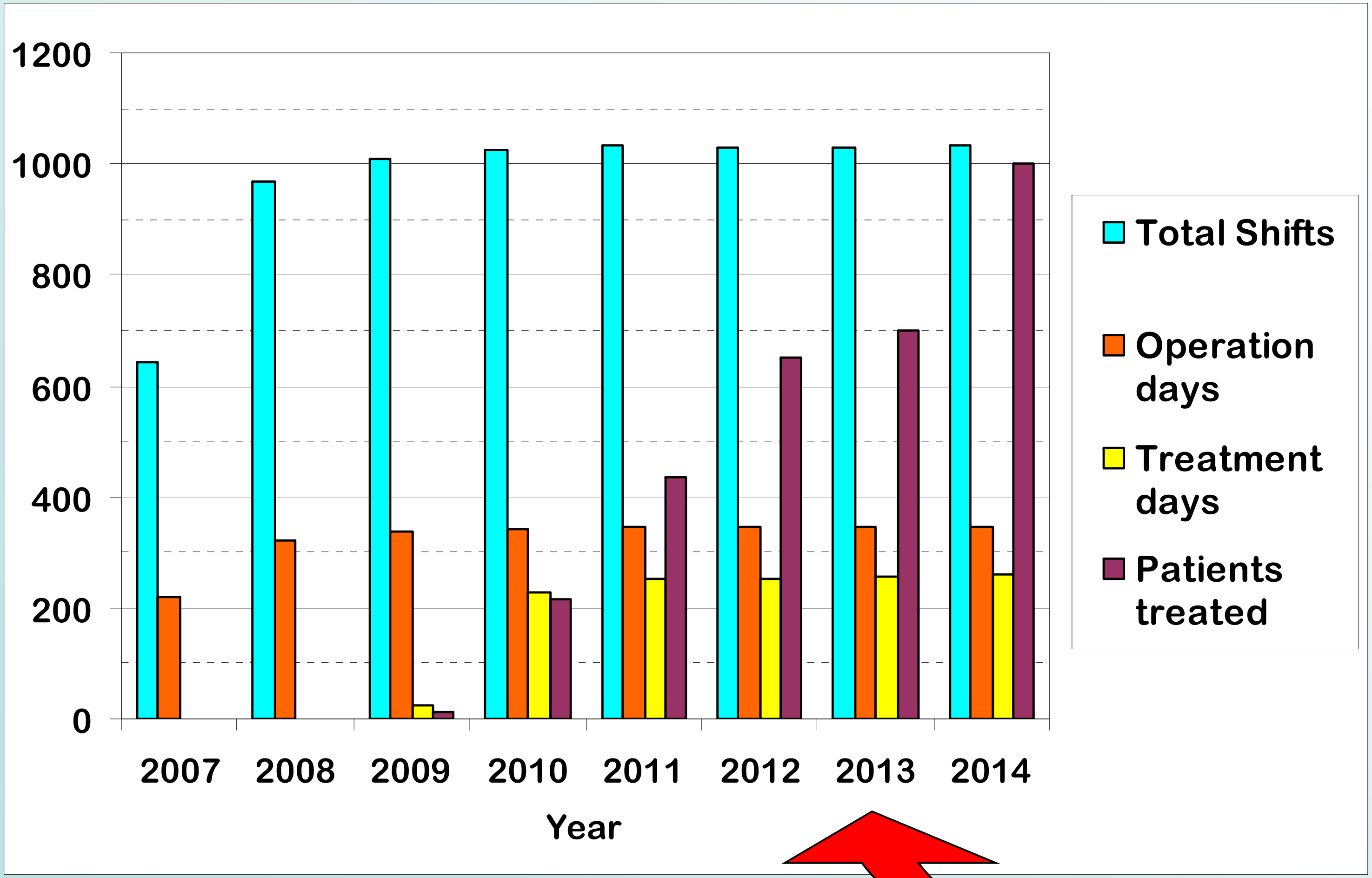
Five Years of HIT Accelerator Operation - Statistics

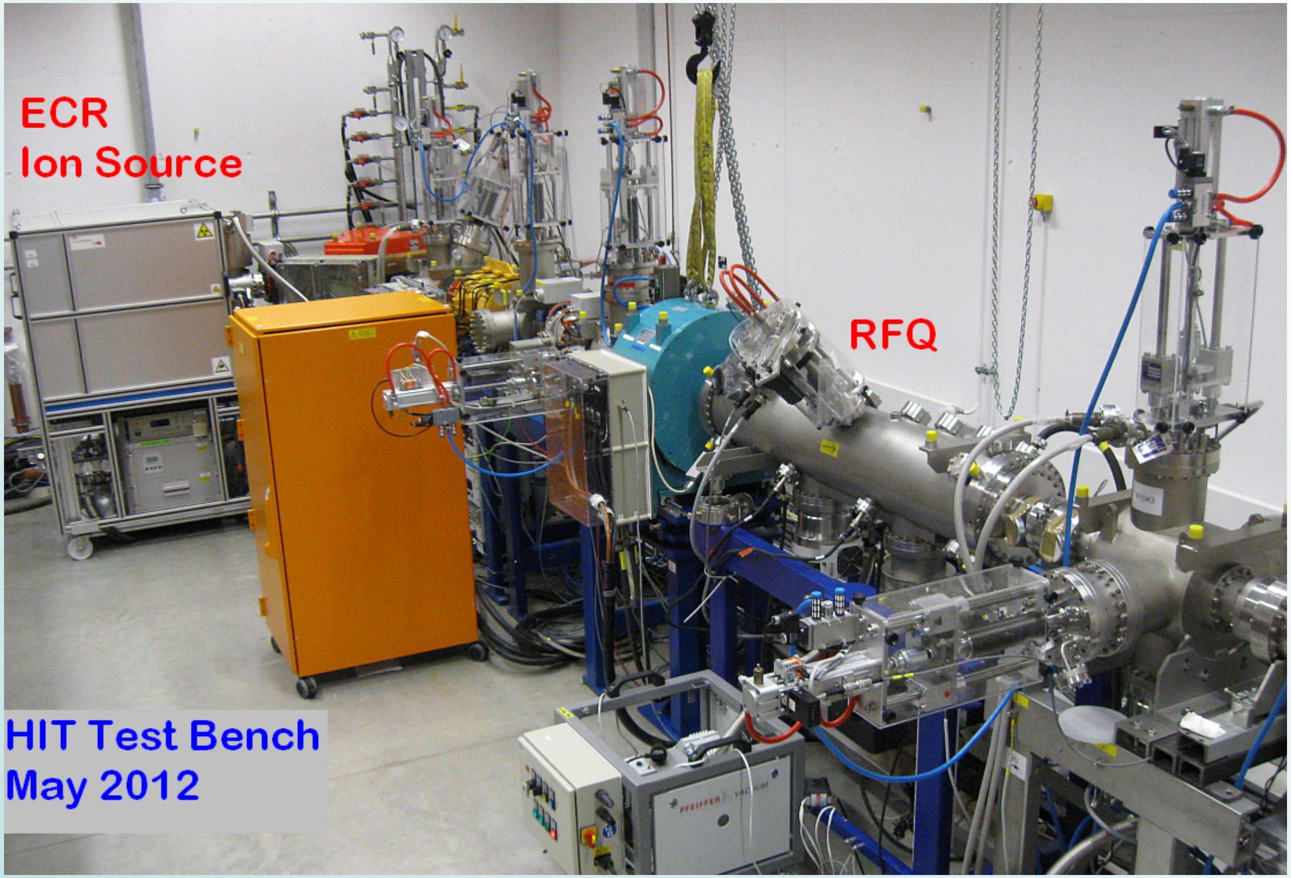


(Numbers for 2012-2014 estimated)

2013: Major Upgrade of IONTRIS Treatment Software

Ion Source and RFQ Test Bench

- A test bench was set-up to study a very compact ion source/LEBT version for proton and He beams to minimize space charge effects
- Introducing a four electrode extraction system in the ion source lead to more brilliant beams → Modification of one ion source branch in the production machine already done in 2011



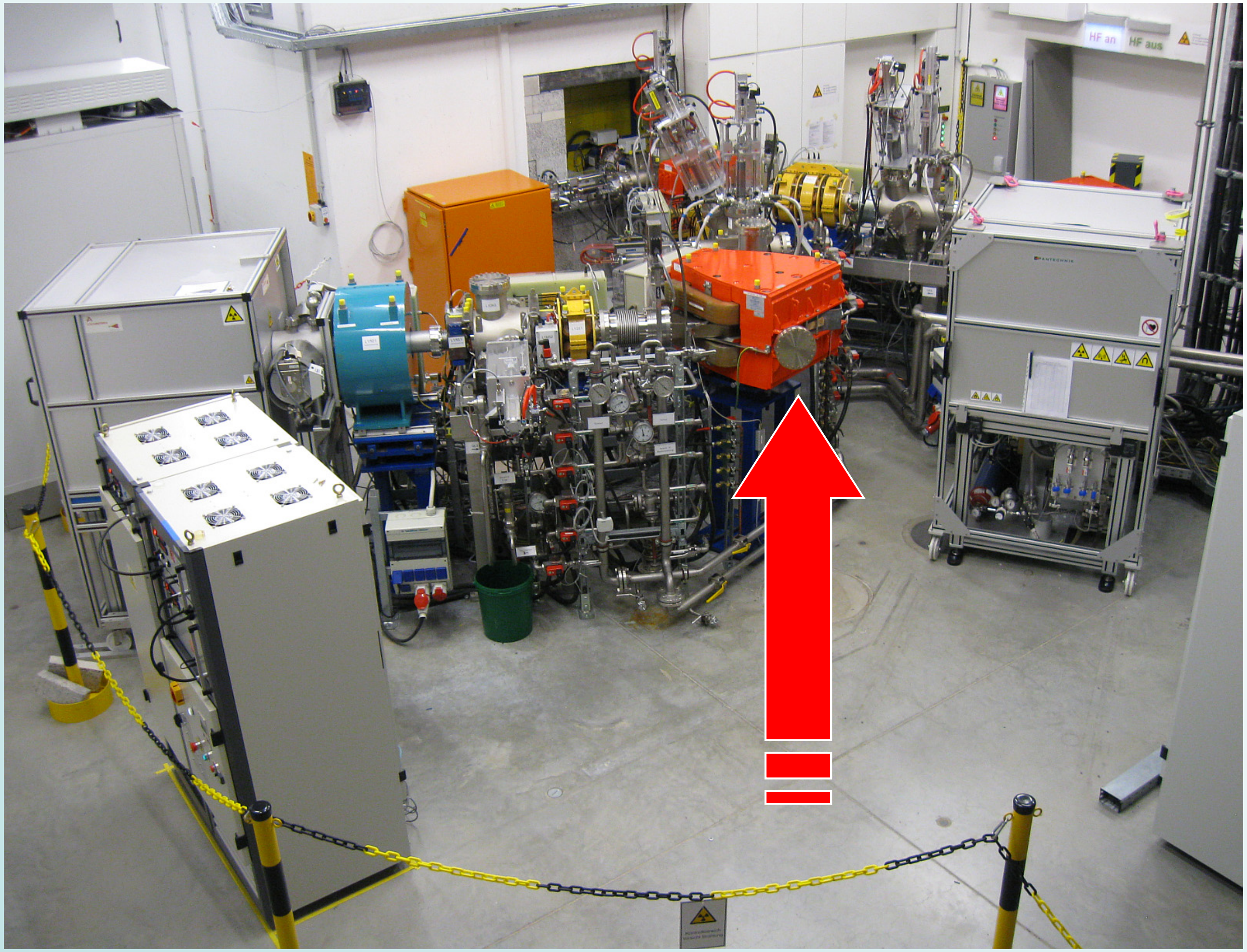
Ion Source and RFQ Test Bench

Before Upgrade

Ion Source and RFQ Test Bench

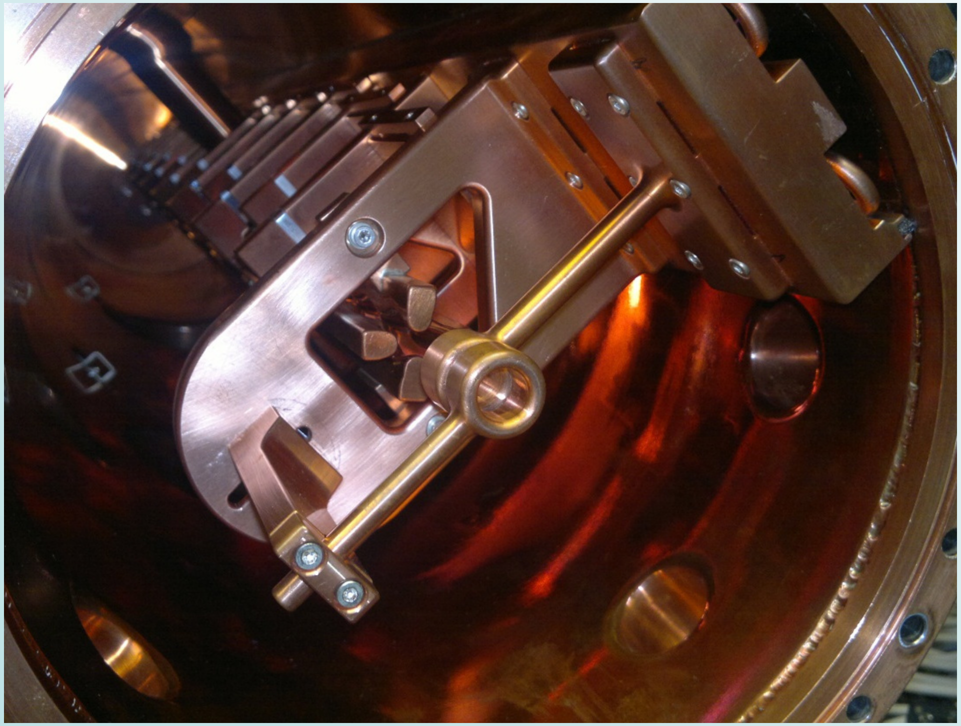
Before Upgrade

After Upgrade



Ion Source and RFQ Test Bench

- After the ion source tests the enhanced RFQ version with a new input radial matcher (design: GSI) and better alignment was installed.



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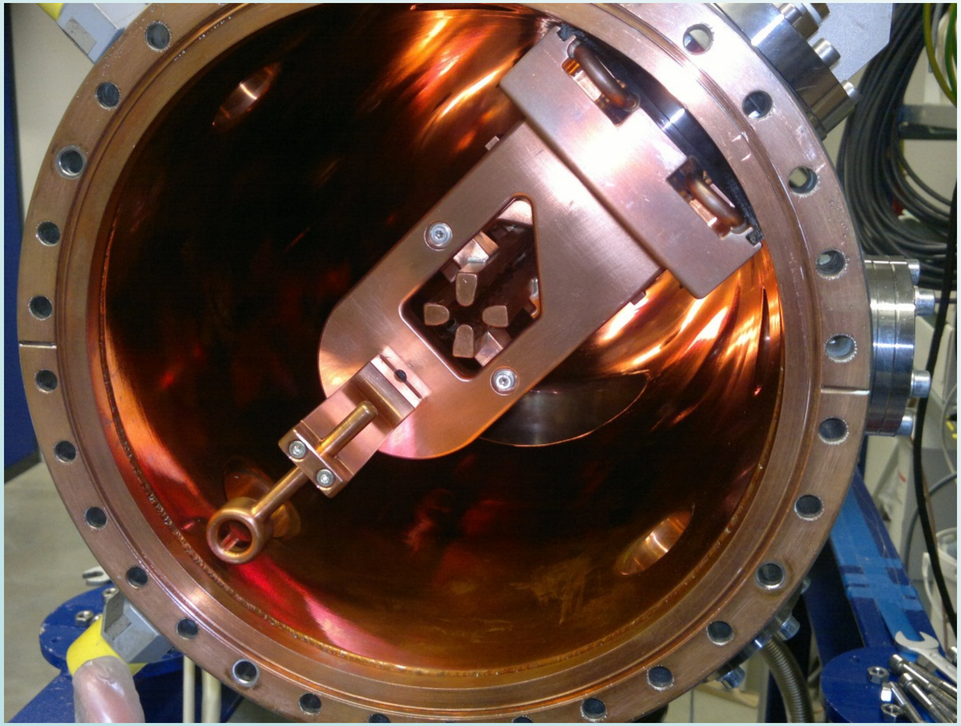

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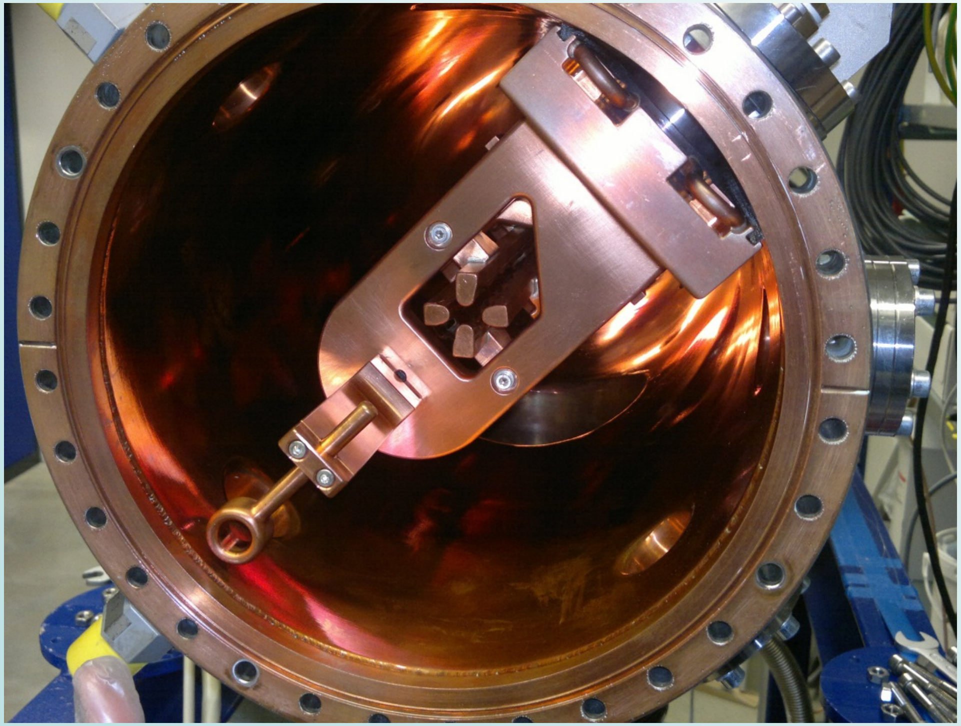
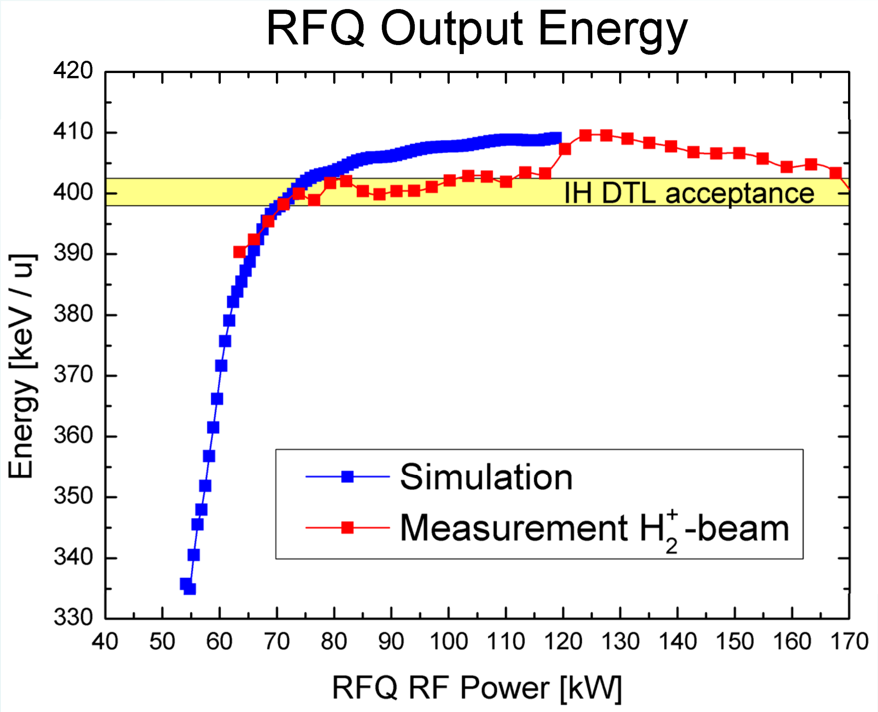
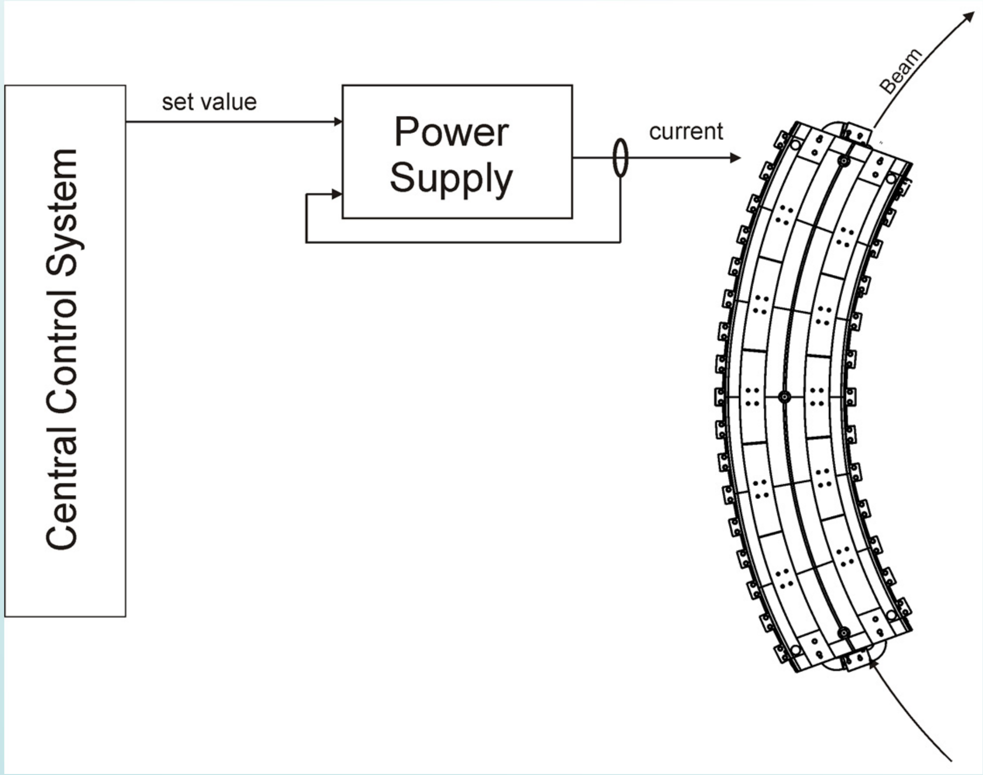




- First tests in April May this year – with rebuncher at first in “dummy position” – showed promising results with transmissions up to 60% - the investigations are ongoing.

Magnetic Field Control in the Synchrotron

- Magnetic effects cause dead times:
  Dipoles → Eddy currents have to die out before extraction process
  → Development of high sensitive measuring and feedback system



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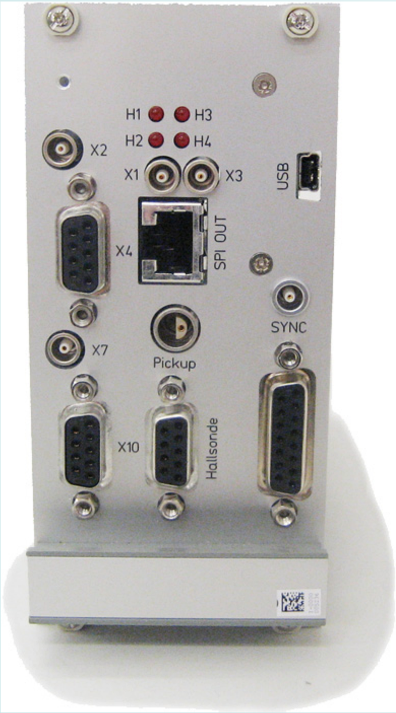
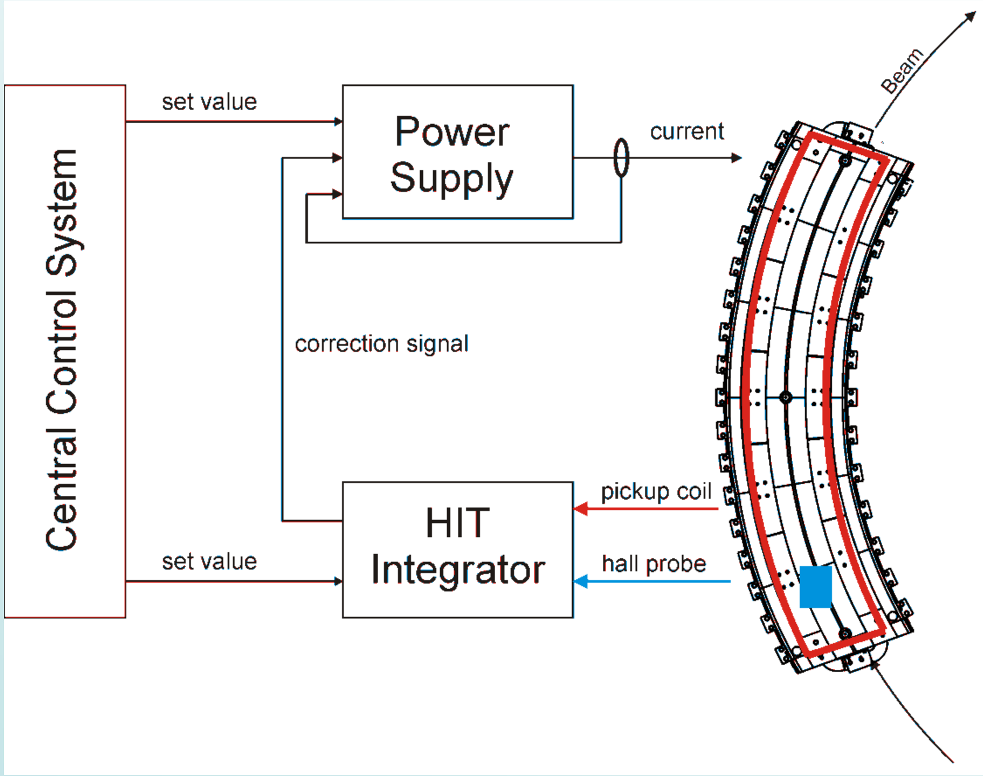


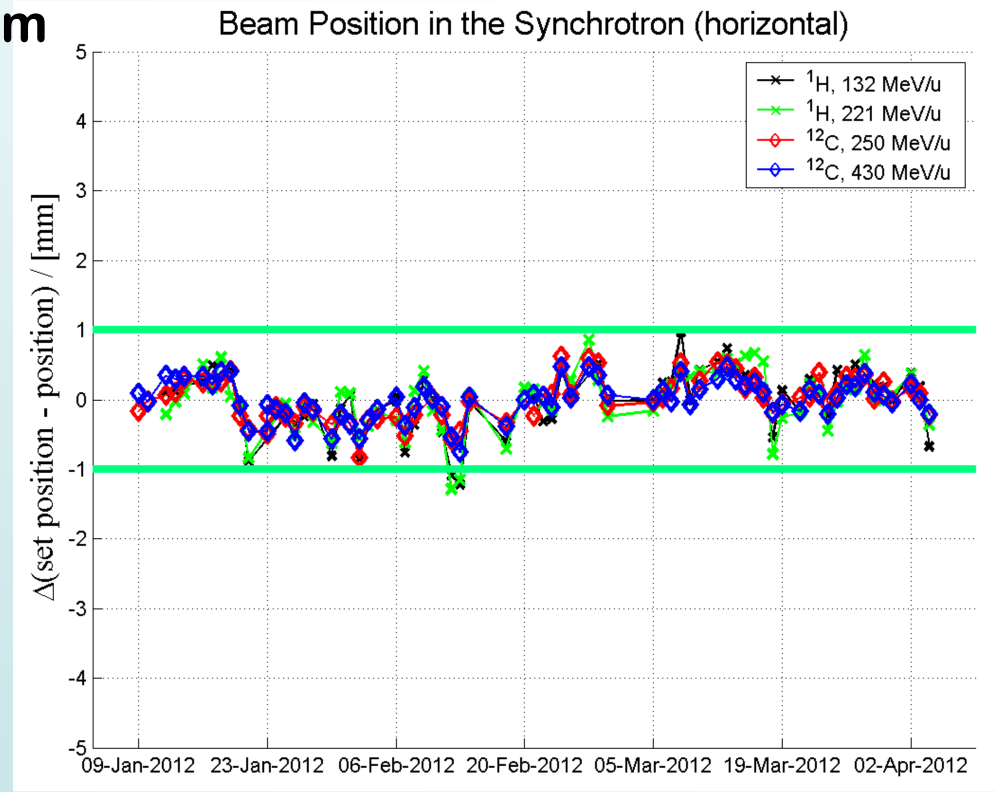


Magnetic Field Control in the Synchrotron

- Magnetic effects cause dead times: Dipoles → Eddy currents have to die out before extraction process → Development of high sensitive measuring and feedback system
- System in use since end of 2011: Long-term stability successfully demonstrated; time saving per synchrotron cycle: 600 ms

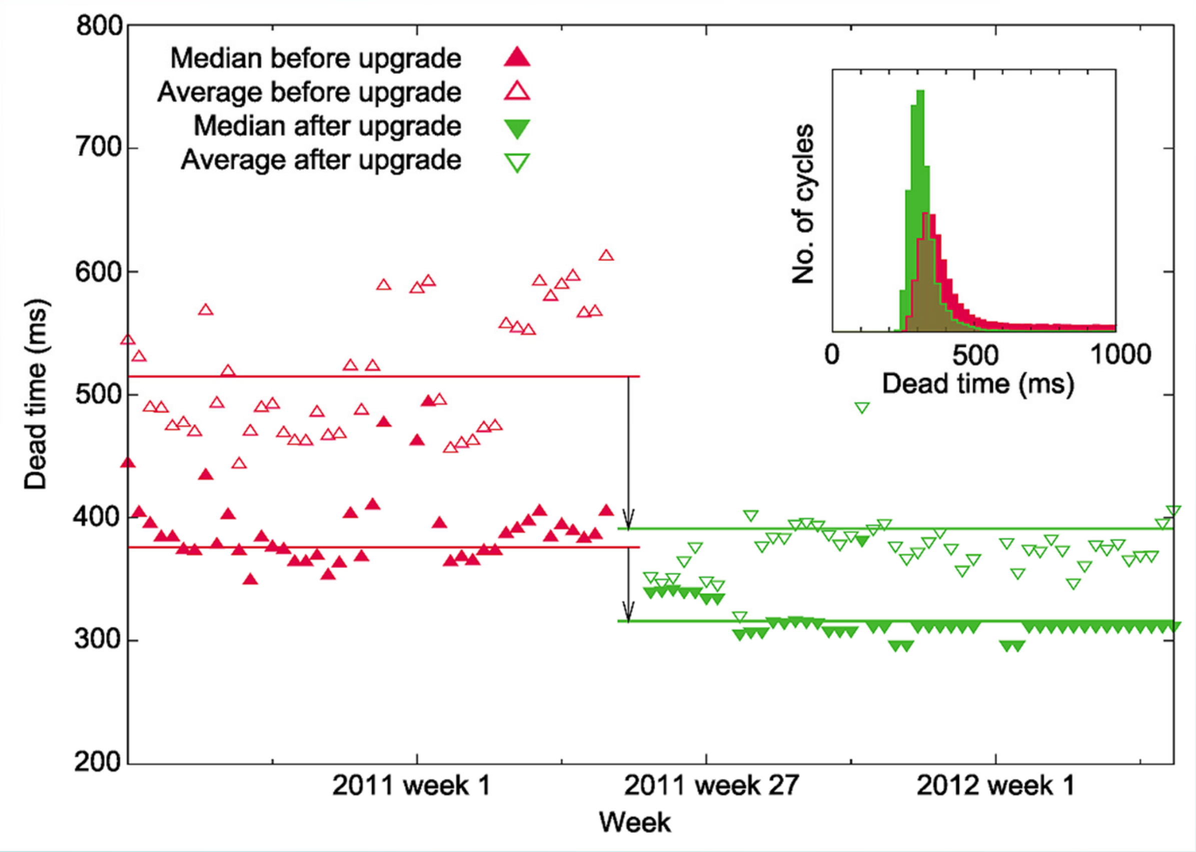
  See poster THPPD002 for more details!

- A similar system will be used for the quadrupoles to avoid “washing procedures” needed because of hysteresis effects



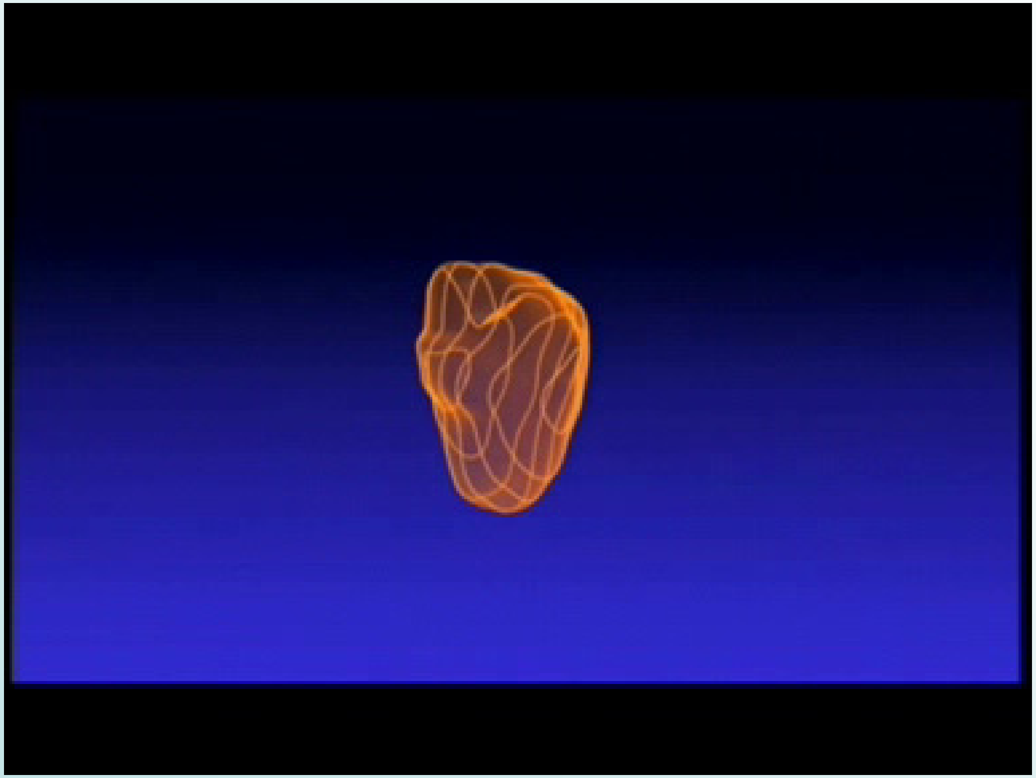
ACS Optimization

- After running the accelerator for some time an initiative was started to optimize the control system while maintaining the high safety level needed for patient treatment
- Example: Shortening of the dead time between machine cycles --> huge amount of database operations take place. Detailed analysis lead to optimized table structures and access strategies. In addition, server hardware significantly updated.
  → Saving: ~100 ms



Dynamic Intensity Control

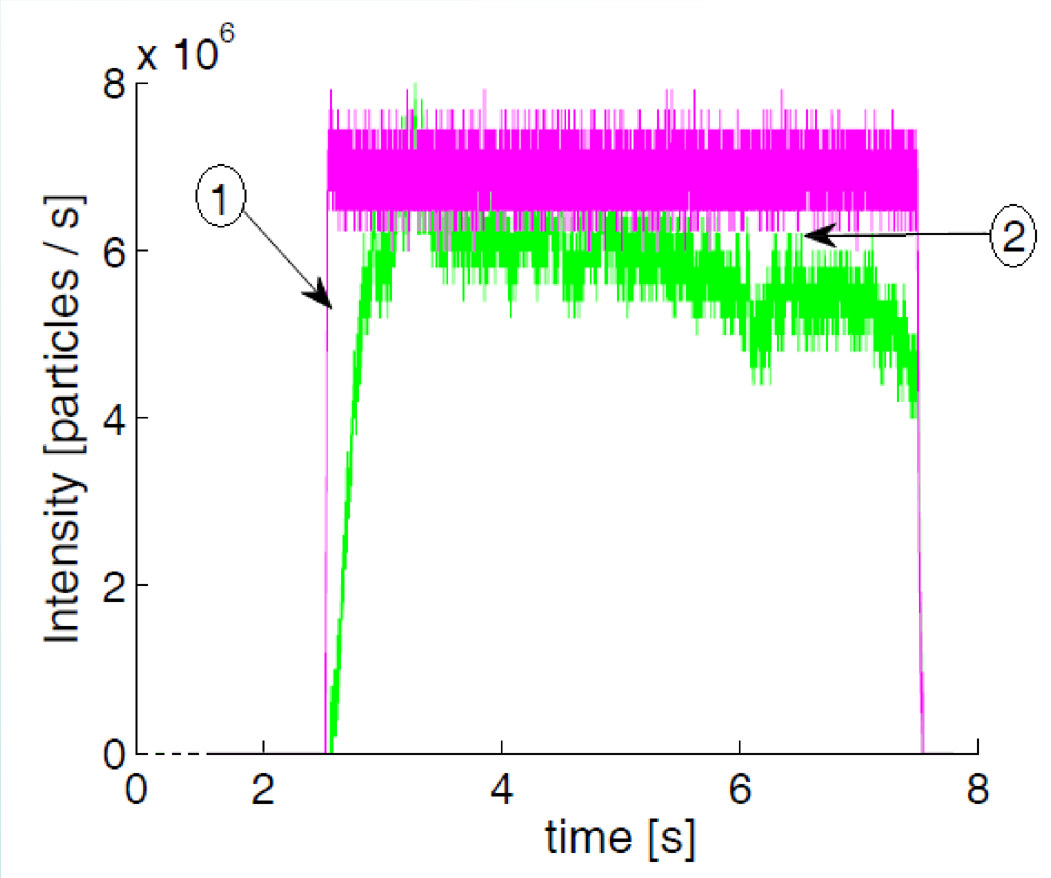
- HIT uses scanned beams for tumour treatment



Treatment time per voxel ~ some ms
(Animation by courtesy of Siemens)

Dynamic Intensity Control

- HIT uses scanned beams for tumour treatment
- Adjustable but predefined amplitude curve drive the transverse RF-knockout exciter producing more or less rectangular shaped spills.
- A feedback loop has been implemented to avoid imperfections → see ①②.
- Next step: A dynamic intensity adaptation during one spill with respect to the particular treatment plan is under investigation.



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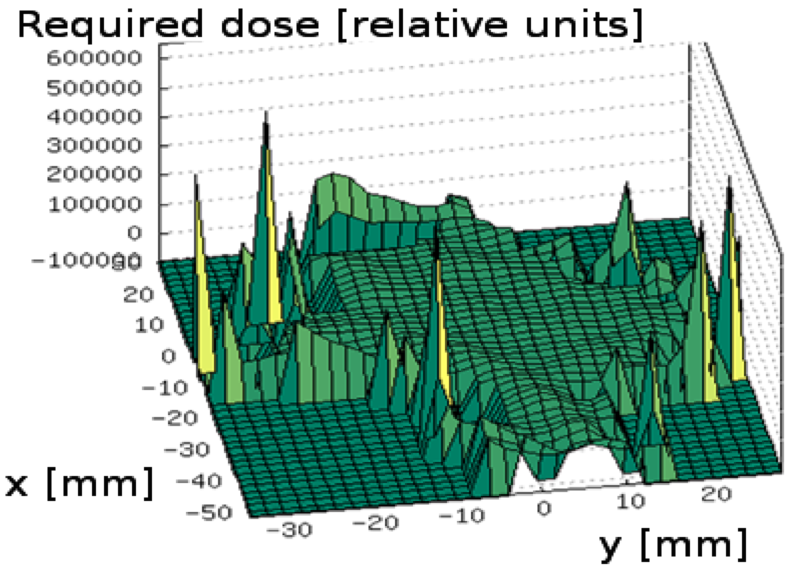
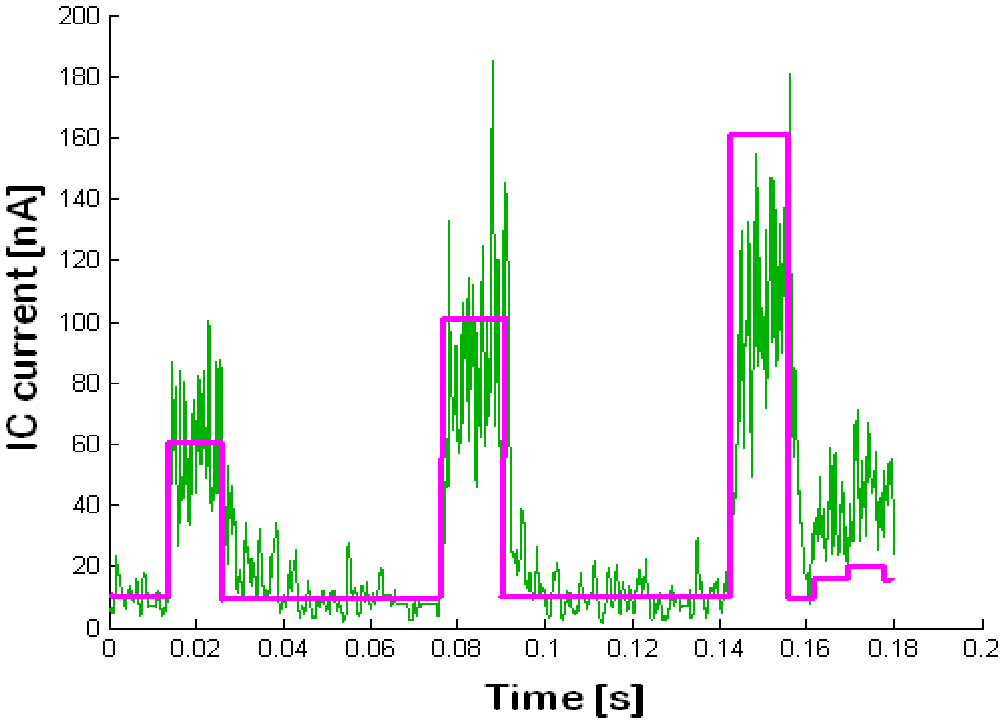


See THEPP06 for more details!



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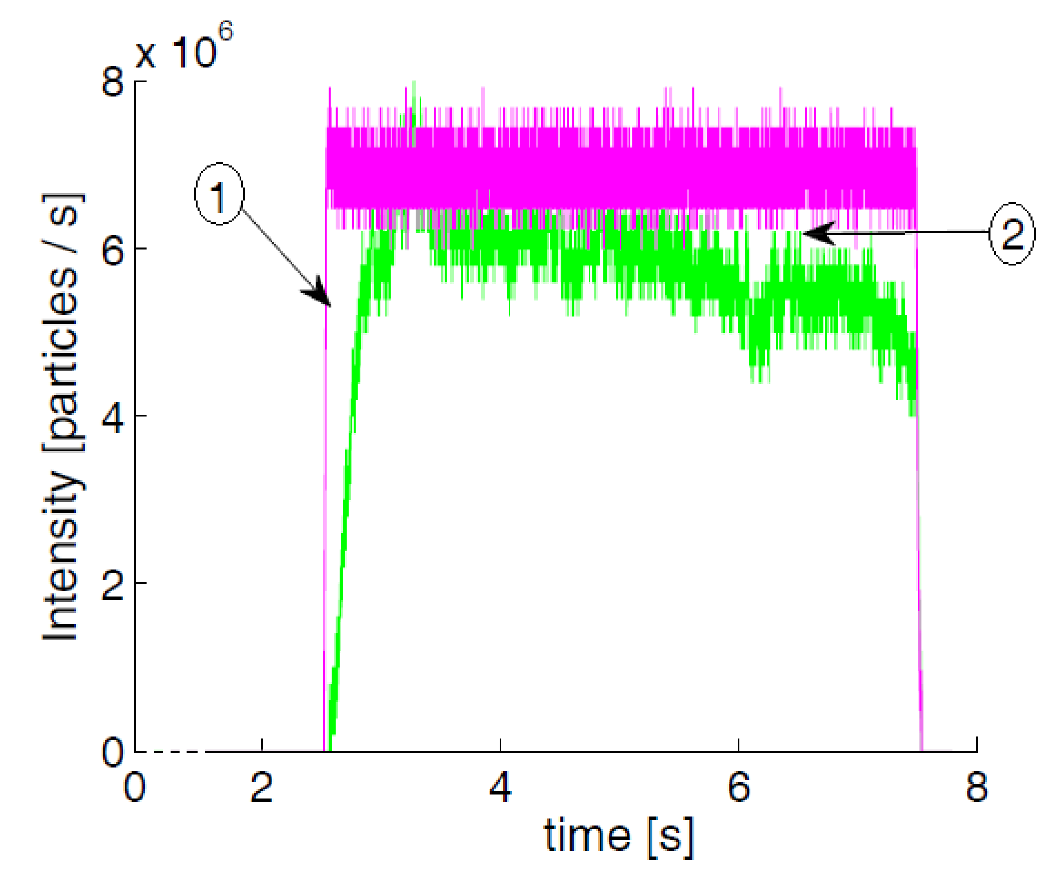
- ***Shortening of treatment times of 20 – 40% possible!***



Acknowledgement

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And thank you for your attention!