Commissioning of the ion beam gantry at the Heidelberg Ion Beam Therapy Center (HIT)

Michael Galonska

on behalf of the HIT commissioning team
Heidelberg Ion Therapy Center:
- First dedicated particle therapy facility in Europe
- 3D intensity controlled raster scanning
- Worlds first scanning heavy ion gantry
- Patient treatment since 2009
- R & D in a broad range of disciplines

Outline
- HIT accelerator
- Gantry
- General beam quality / requirements
- Gantry beam quality
- Outlook

www.klinikum.uni-heidelberg.de
The HIT facility

- 2 ECR ion sources (p, C, O, He..)
- Compact 7 MeV/u LINAC
- Compact Synchrotron: Circumference 65 m
  - KO-extraction
  - Spill interruptions
  - Energy variation
- 3 treatment rooms (3D intensity controlled raster scanning)
- Isocentric scanning heavy ion gantry
- Q-A: quality assurance and R & D

T. Haberer et al., NIM A330 (1993)
The Heidelberg Gantry

45° dipoles
scanner magnets
90° dipole

beam
treatment room

MT Mechatronics

www.klinikum.uni-heidelberg.de
Pencil Beam Library

<table>
<thead>
<tr>
<th>ion species</th>
<th>C, p, O, He,...</th>
<th>Steps</th>
</tr>
</thead>
<tbody>
<tr>
<td>energy</td>
<td>50 – 430 MeV / u</td>
<td>255</td>
</tr>
<tr>
<td>focus</td>
<td>4 – 13 mm</td>
<td>4 (6)</td>
</tr>
<tr>
<td>intensity</td>
<td>$10^7 – 10^{10}$ / spill</td>
<td>10</td>
</tr>
<tr>
<td>gantry angle</td>
<td>$0^\circ – 360^\circ$</td>
<td>36</td>
</tr>
</tbody>
</table>

37 000 combinations / ion type
- Automated standard procedures for setting and determination of beam quality / beam diagnostics
- Ion optical program MIRKO

control system aspects
- Physical input parameters (accelerator model) set to control values (data supply model)
- Settings stored in DB and device controller for data recall (beam request)
- Fast and reliable data handling
- Interpolation algorithm (energy and gantry angle dependence)

Setting Concept

- Full transmission (beta function within limits)
- Basic setting (gantry and gantry injection!) for all angles keeping variation of beam width independent of gantry angle
- Compensating effect of coupling of hor. and vert. phase space under gantry rotation
- Beam size adjustment with last quadrupole doublet

**Position Parameters**

- **E x G**
- **E x F x G**

**Graphs**

- **FWHM [mm]**
  - Horizontal: 11.50
  - Vertical: 8.50

- **Gantry angle [°]**
  - Horizontal Graph
  - Vertical Graph
Energy and angle dependent settings of focusing quadrupoles (beam width)
- Energy and angle dependent settings of dipoles/steerer (beam position)
- Spline interpolation over base points
Interpolation

- Energy and angle dependent settings of focusing quadrupoles
- Spline interpolation over base points

Approx. 1% of overall combinations as interpolation points
Beam Size and Position

Carbon Gantry (isocenter) 190.75 MeV/u

Protons Gantry (isocenter) 101.90 MeV/u

Position [mm]

Gantry Angle [°]

F1, F2, F3, F4

FWHM(x)/FWHM(x)ref. [%]

Gantry Angle [°]
Beam Size and Position

- Beam size within accepted rel. deviation of 25 % (orange lines)
- Beam position within ±2 mm
- Very good stability and reproducibility
- Residual position deviation compensated by scanning system (fast position feedback)
- Suitable for patient treatment
**Carbon:**

- Beam size within accepted rel. deviation of 25 %
- Beam position within ±2 mm in isocenter, ≤ 10 % within ±3 mm
Beam Size and Position

Protons:

- Beam size within accepted rel. deviation of 25%
- Beam position within ±2 mm in isocenter
Summary

• Pencil beam commissioning completed for subsequent preclinical testing (med tech)
• Efficient standard routines and tools for semi-automated beam setting and interpolation developed

Outlook

➢ Presently scanning dose delivery under test aiming for clinical use in early 2012
Summary

- Pencil beam commissioning completed for subsequent preclinical testing (med tech)
- Efficient standard routines and tools for semi-automated beam setting and interpolation developed

Outlook

- Presently scanning dose delivery under test aiming for clinical use in early 2012
Summary
• Pencil beam commissioning completed for subsequent preclinical testing (med tech)
• Efficient standard routines and tools for semi-automated beam setting and interpolation developed

Outlook
➢ Presently scanning dose delivery under test aiming for clinical use in early 2012

Thanks!