The Heidelberg Ion Therapy (HIT) Accelerator Coming Into Operation

Presented at EPAC 2008, Genova
D. Ondreka, GSI
Heidelberg Ion Therapy Centre:
- Europe's first dedicated particle therapy facility
- World's first carbon 3D rasterscan therapy facility
- World's first carbon gantry
- 1000 Patients / year

Outline
- Overview of HIT
- 3D Rasterscanning
- Beam performance
- Outlook
Project Organization

Heidelberg University Hospital

Facility Owner, Producer & User

HIT GmbH
Accelerator Operation
Treatment System Operation

Building Office
Building Coordination

ARGE SIT
Building Construction

Suppliers
Treatment System
Accelerator Components

GSI
Accelerator Design
Coordination
Assembly
Commissioning
Staff Training
- 2 ECR ion sources (p, C)
- 7 MeV/u injector linac
- Compact synchrotron
  - Circumference 65 m
  - KO extraction (bunched)
  - Extraction time 5 s
  - Spill interruptions
- 3 treatment places
  - 2 horizontal fixed beam
  - 1 isocentric gantry
- 1 research & QA place
# Accelerator Milestones

<table>
<thead>
<tr>
<th>Event</th>
<th>Date</th>
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<tbody>
<tr>
<td>Start accelerator assembly</td>
<td>10/2005</td>
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<tr>
<td>First beam ion sources</td>
<td>4/2006</td>
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<tr>
<td>First beam linac</td>
<td>12/2006</td>
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<tr>
<td>Start gantry assembly</td>
<td>1/2007</td>
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<tr>
<td>First beam treatment place</td>
<td>3/2007</td>
</tr>
<tr>
<td>Patient beam places H1 + H2</td>
<td>12/2007</td>
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<tr>
<td>First beam gantry</td>
<td>1/2008</td>
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<tr>
<td>Patient beam QA place</td>
<td>4/2008</td>
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Rasterscan Method

Medical Requirements:
- High dose conformality
- Steep lateral fall-off
- Minimal treatment time

Treatment System:
- Lateral scanning with fast scanning magnets
- Intensity control

Accelerator:
- Variation of energy, focus and intensity
- High stability over spill
- High spill duty factor
- Spill interruptions

D. Ondreka, GSI
EPAC 2008, Genova
Control System Aspects

Pencil Beam Library

<table>
<thead>
<tr>
<th>C⁶⁺</th>
<th>Range</th>
<th>Steps</th>
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<tbody>
<tr>
<td>Energy</td>
<td>88 – 430 MeV/u</td>
<td>255</td>
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<tr>
<td>Focus</td>
<td>4 – 10 mm FWHM</td>
<td>4 [6]</td>
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<tr>
<td>Intensity</td>
<td>10⁷ – 4·10⁸ Ions/Spill</td>
<td>10 [15]</td>
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10000 Combinations / Place demand:
- Integration of beam diagnostics
- Efficient, performant and reliable data handling
- Interpolation mechanism for energy dependence
- Ion optics interface for position and width correction
- Standard protocols for accelerator performance check
Beam Spot Sizes

Beam profiles in isocenter (C, 250 MeV/u, 10 mm FWHM)

Adjusted size in isocenter (C)

Energy dependent settings of focusing quadrupole:
Cubic spline interpolation over base points
Beam Stability

- Excellent stability of beam size and position at treatment place due to KO extraction (constant optics)
- No profile distortions due to spill interruptions ➔ Very homogeneous lateral dose distributions

*cf. Poster: "Beam Diagnostics for the HIT Accelerator", M. Schwickert, GSI, TUPC095*
Spill Time Structure

IC in beam line
(C, 250 MeV/u, 3 \cdot 10^8 ions, 3 interruptions)

- Excellent time structure due to bunched KO extraction
  ➔ Fast scanning speed
- Spill interruption generated by switching off KO and shifting synchrotron RF
- Clean start of interruption requires fast spill abort magnet

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<tr>
<td>Max/Avg</td>
<td>\leq 2</td>
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<tr>
<td>Duty factor</td>
<td>95%</td>
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<tr>
<td>Rel. intensity in interruption</td>
<td>(5 \cdot 10^{-4})</td>
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cf. Poster: "Spill Structure Measurements at HIT", A. Peters, HIT, TUPP127
Beam Verification

Preliminary scanner commissioning results: Verification films
(courtesy S. Grözinger et al., Siemens Medical Solutions)

- p, 220 MeV/u, treatment monitor
- no position feedback
- no intensity feedback
- field size 18 x 10 cm

- C, 430 MeV/u, isocenter
- no position feedback
- field size 7 x 8 cm
- dose flatness ±2%
Summary and Outlook

- Accelerator commissioning finished for fixed beam places
- Accelerator now operated by HIT Staff (7/24)
- Gantry commissioning interrupted due to technical problems
- Presently preparations for patient treatment (HIT, Siemens)
  - Commissioning of treatment systems
  - Acceptance tests
  - Certification process
- First patient treatment in winter 2008
- Continuation of gantry commissioning in winter 2008
- Linac intensity upgrade in progress

cf. Posters:
"Assembly of the HIT Gantry", U. Weinrich, GSI, TUPP133
"Commissioning of the HIT Gantry", U. Weinrich, GSI, TUPP134
"Intensity Upgrade for the HIT Linac", R. Cee, HIT, TUPP113
Acknowledgements

• To all GSI colleagues involved in the HIT project, esp.
  – U. Weinrich, B. Franczak, A. Dolinskii, H. Eickhoff
  – the GSI commissioning team
• To the HIT colleagues
  – for good team play during commissioning
  – for many useful discussions about rasterscan therapy
• To Siemens Medical Solutions
  – for providing helpful information

Make it a real HIT!