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

Michael Galonska

on behalf of the
HIT commissioning team

Introduction

Heidelberg Ion Therapy Center:

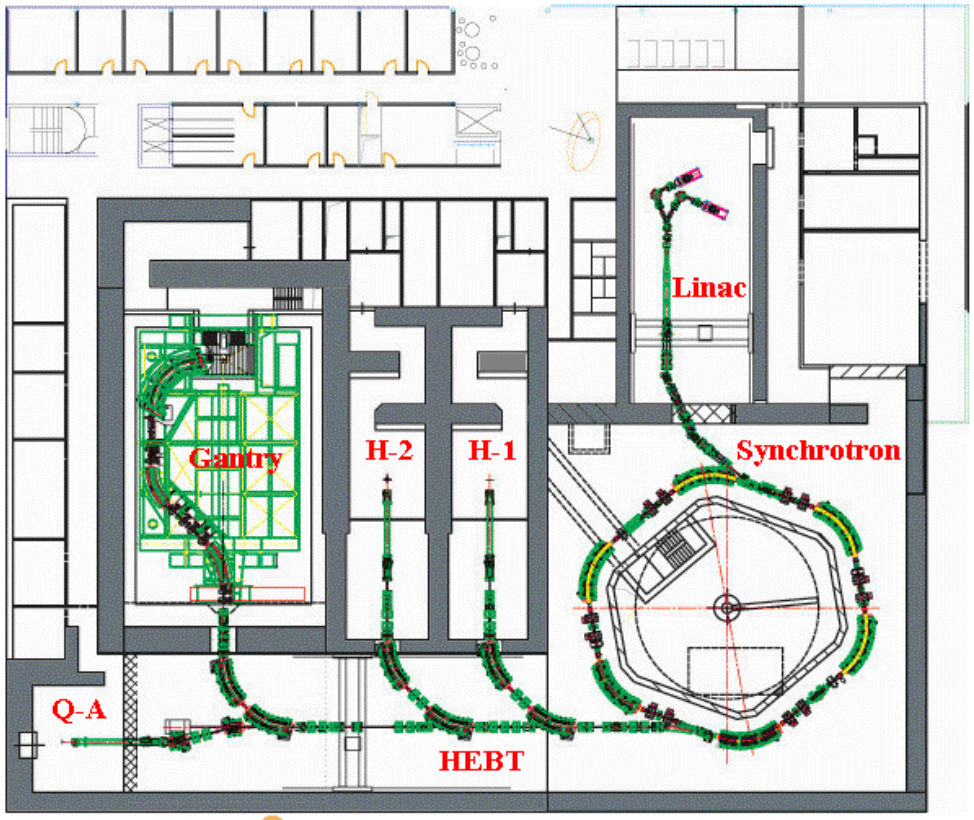
- First dedicated particle therapy facility in Europe
- 3D intensity controlled raster scanning
- Worlds first scanning heavy ion gantry
- Patient treatment since 2009
- R & D in a broad range of disciplines

Outline

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

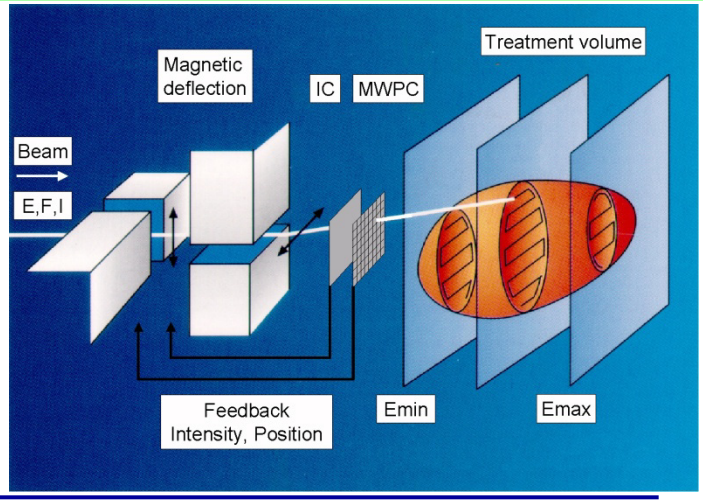
www.klinikum.uni-heidelberg.de

The HIT facility



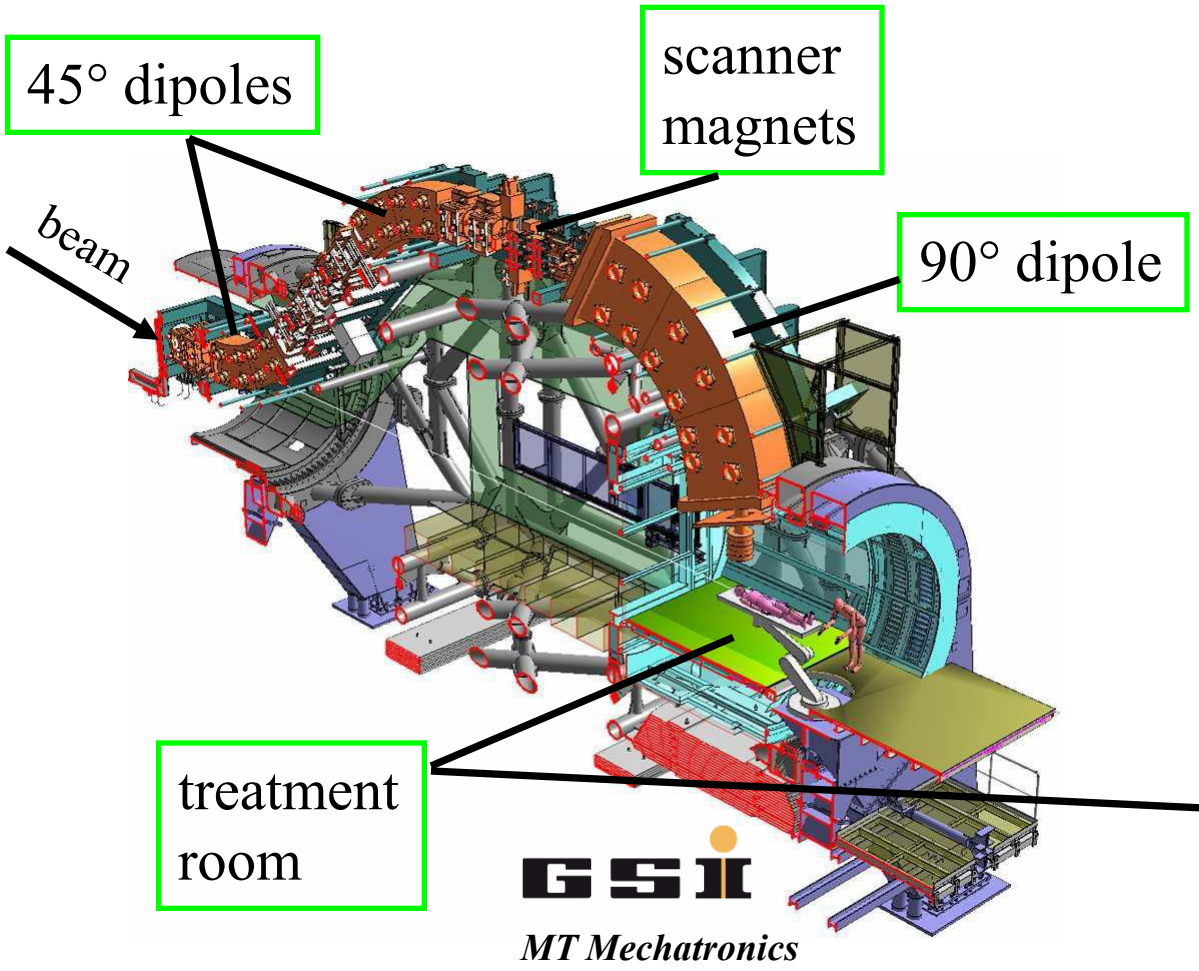
GSI

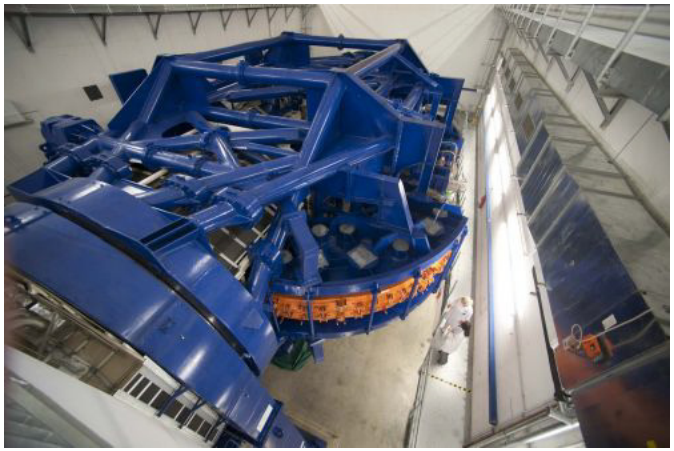
- 2 ECR ion sources (p, C, O, He..)
- Compact 7 MeV/u LINAC
- Compact Synchrotron:
  Circumference 65 m
  KO-extraction
  Spill interruptions
  Energy variation
- 3 treatment rooms (3D intensity controlled raster scanning)
- Isocentric scanning heavy ion gantry
- Q-A: quality assurance and R & D



T. Haberer et al., NIM A330 (1993)

The Heidelberg Gantry





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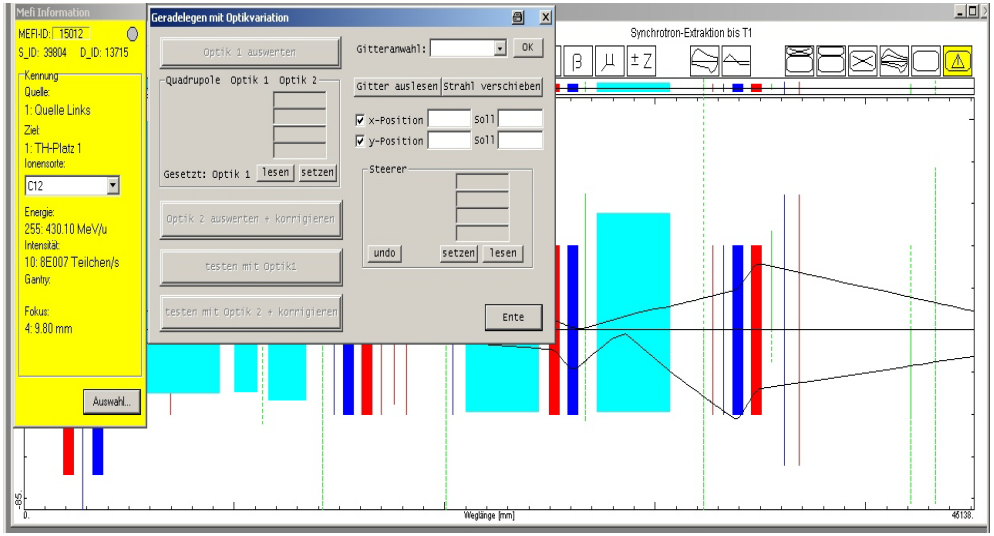
Pencil Beam Library

Pencil Beam Library

ion species	C, p, O, He,...	Steps
energy	50 – 430 MeV / u	255
focus	4 – 13 mm	4 (6)
intensity	10^7 – 10^{10} / spill	10
gantry angle	0° – 360°	36



MIRKO: B. J. Franczak in: Computing in accelerator design and operation, Springer, Berlin, 1984

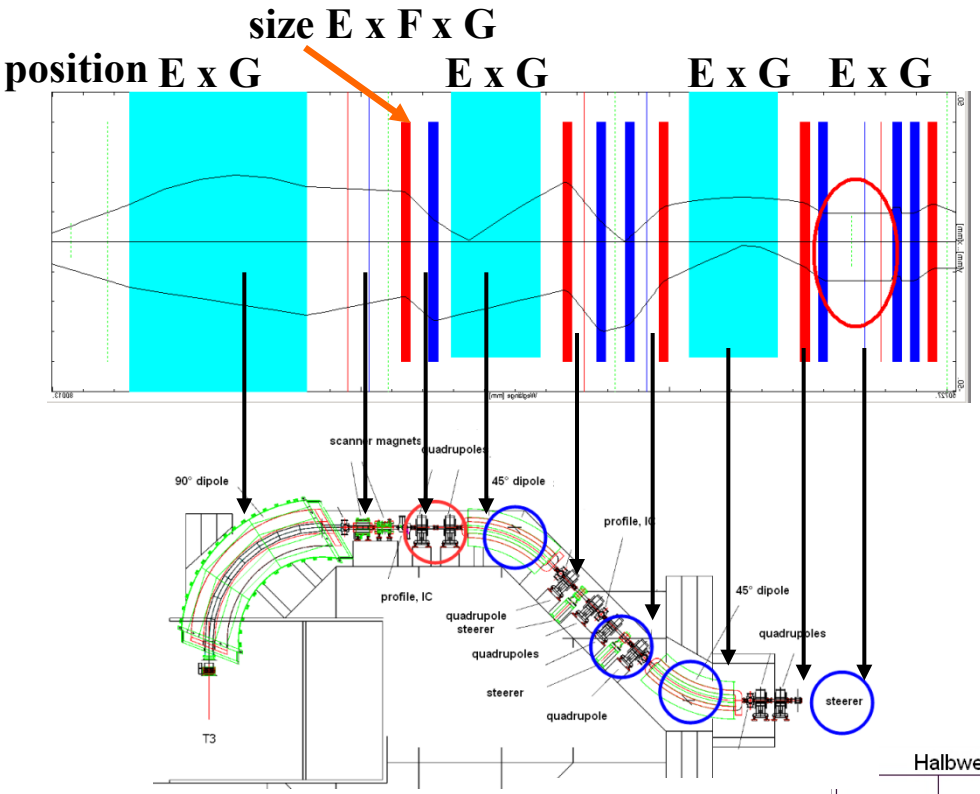
37 000 combinations / ion type

- **Automated standard procedures for setting and determination of beam quality / beam diagnostics**
- **Ion optical program MIRKO**

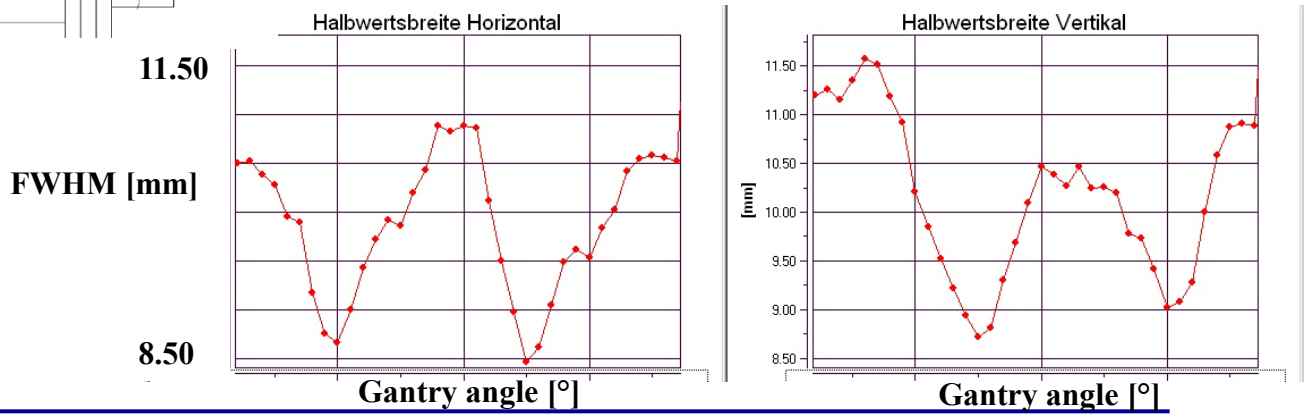
<u>control system aspects</u>

- **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)**

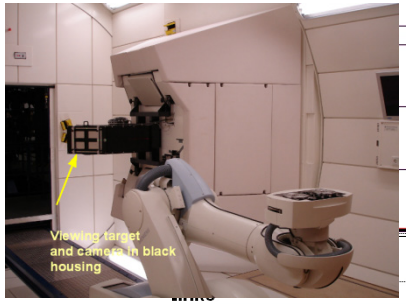
Setting Concept

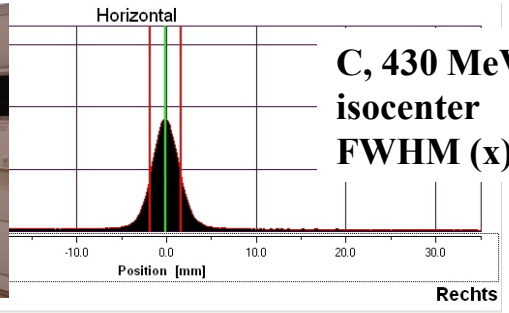


- **Full transmission (beta function within limits)**
- **Basic setting (gantry and gantry injection!) for all angles keeping variation of beam width inde-pendent of gantry angle**
- **Compensating effect of coupling of hor. and vert. phase space under gantry rotation**
- **Beam size adjustment with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

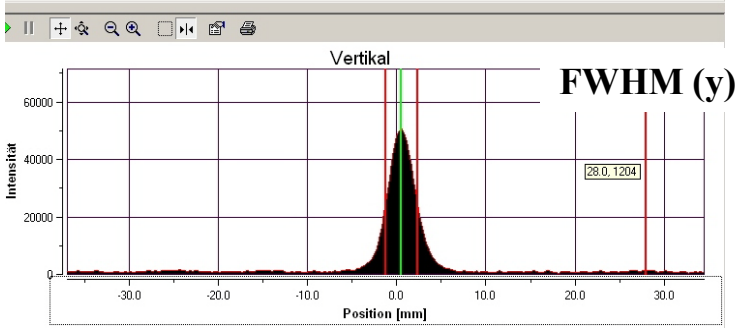


Beam Size Control

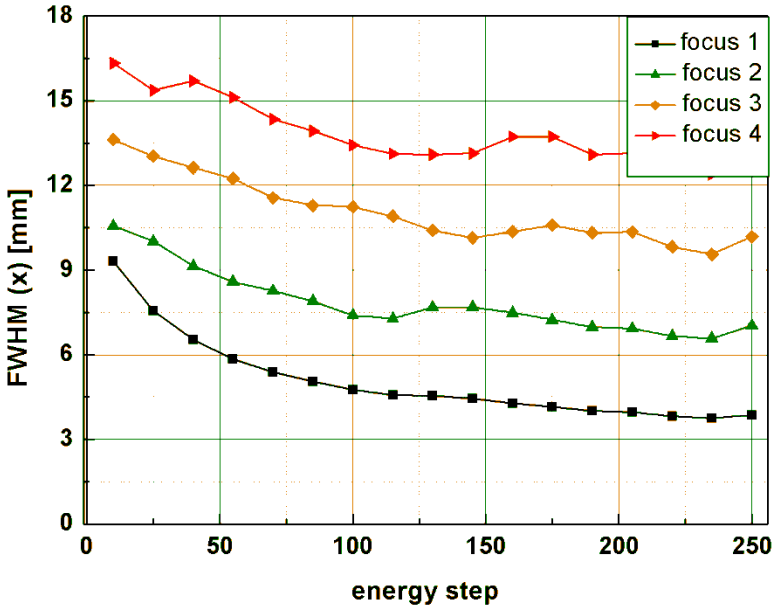




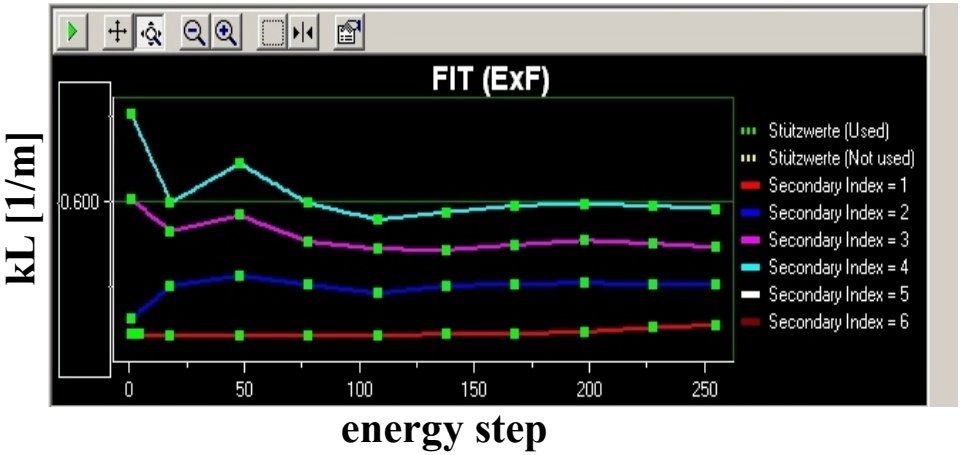
C, 430 MeV/u
isocenter
FWHM (x) = 3.5 mm



FWHM (y) = 3.5 mm

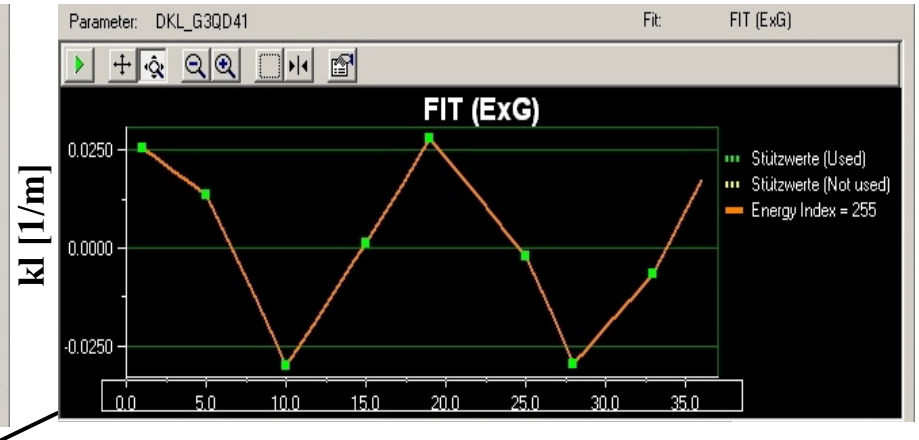


- Energy and angle dependent settings of focusing quadrupoles (beam width)
- Energy and angle dependent settings of dipoles/steerer (beam position)
- Spline interpolation over base points

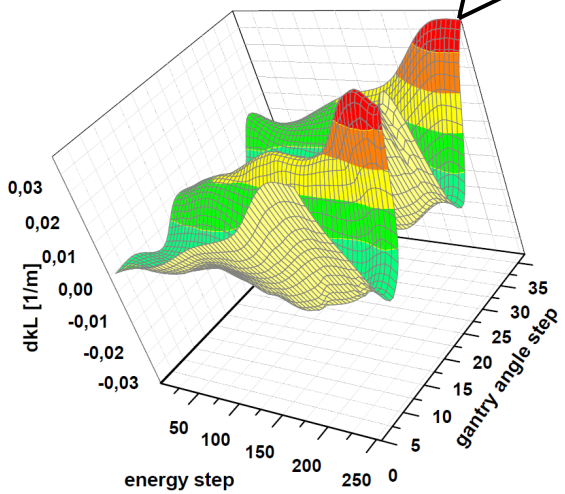


Interpolation

energy step



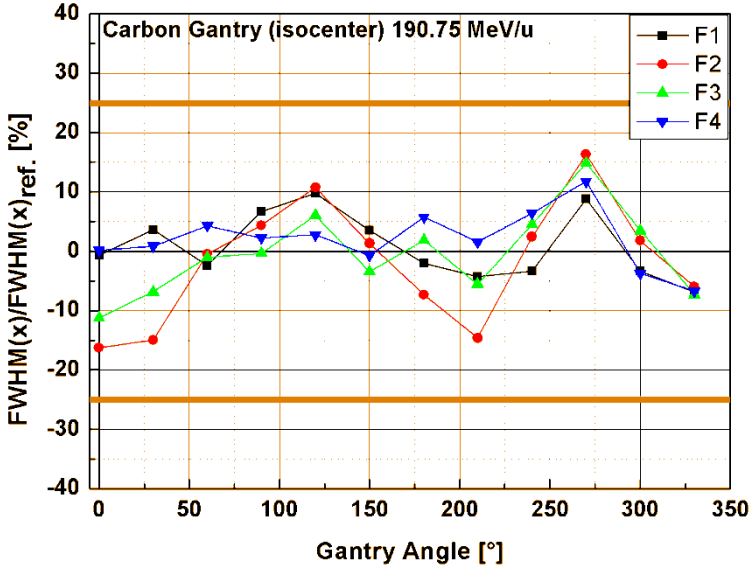
gantry angle step

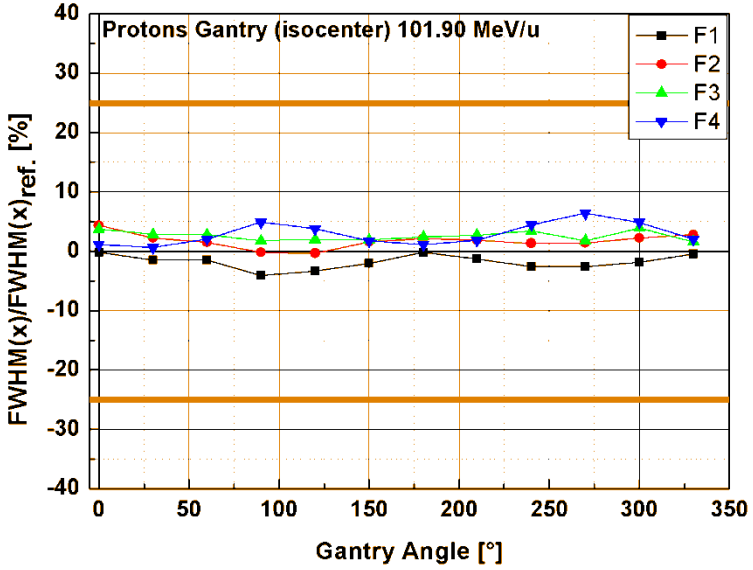


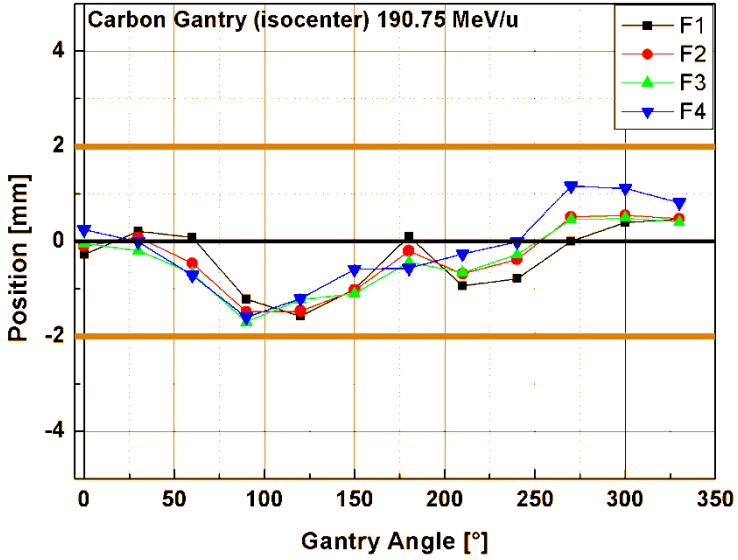
- **Energy and angle dependent settings of focusing quadrupoles**
- **Spline interpolation over base points**

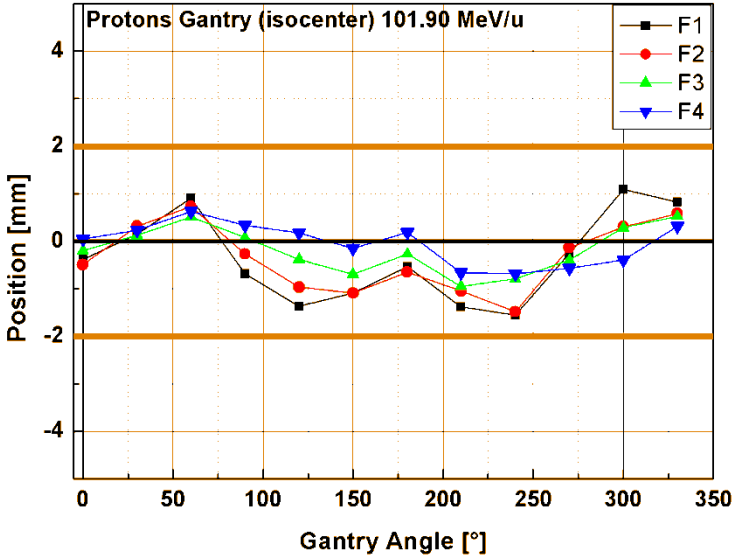
Approx. 1 % of overall combinations as interpolation points

Beam Size and Position









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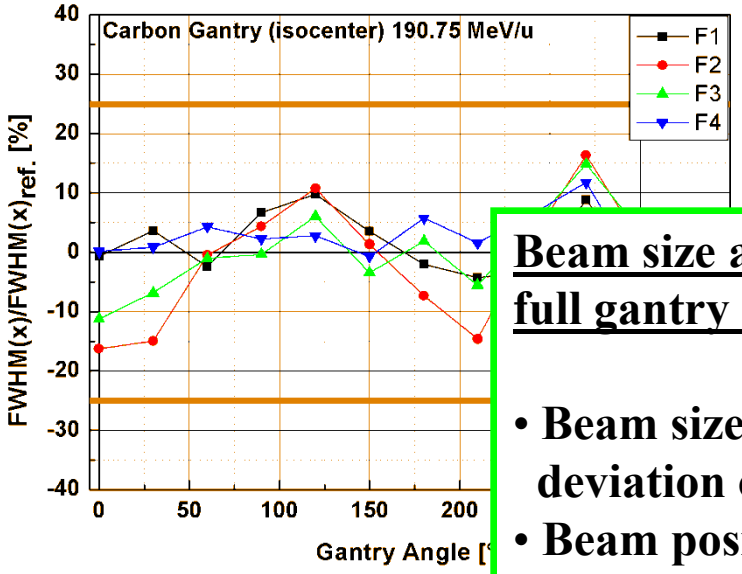
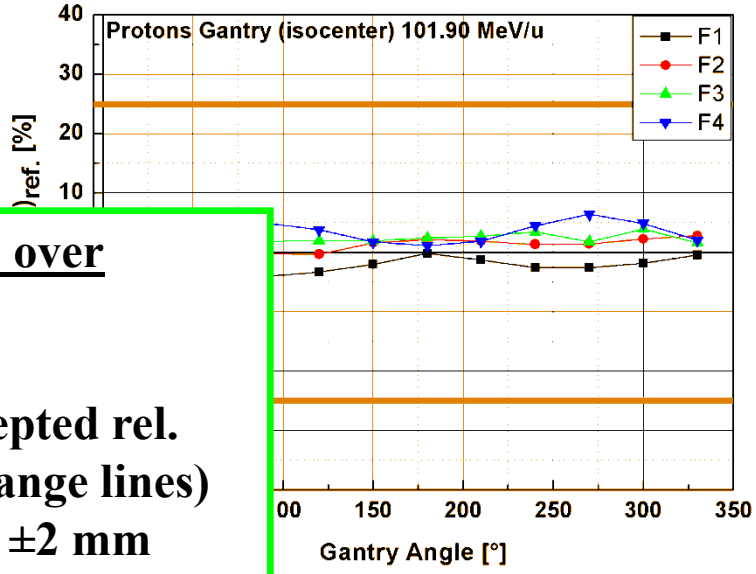
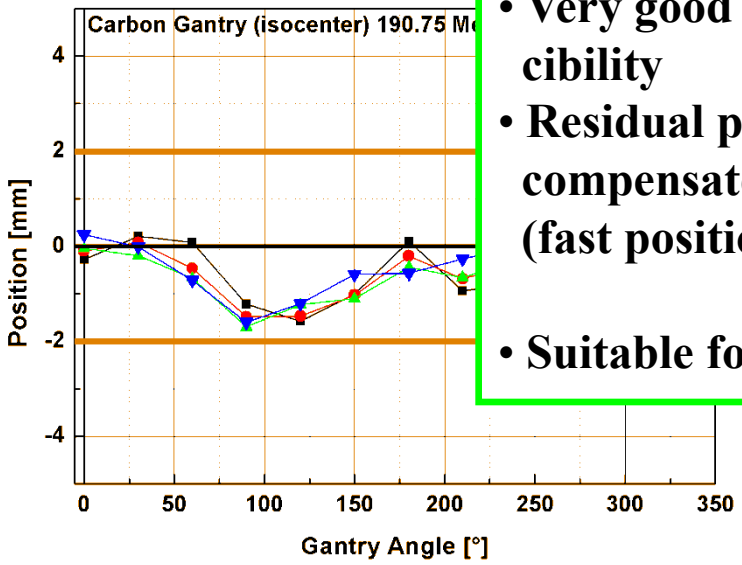


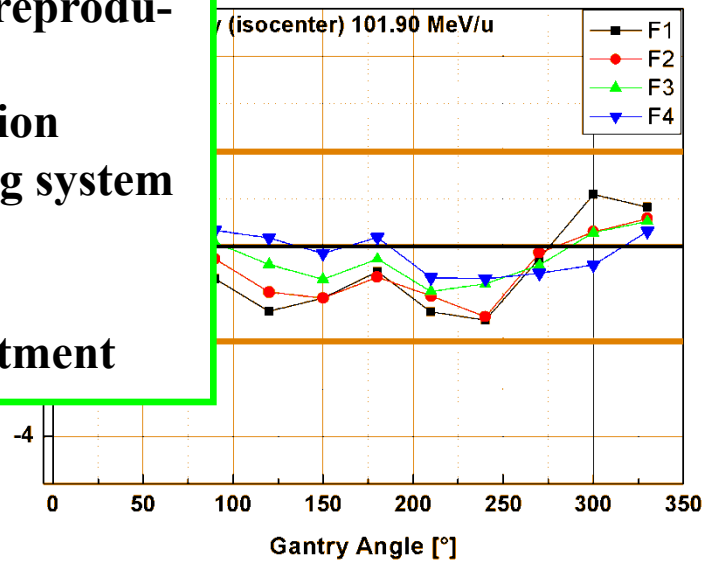


Beam size and position over full gantry rotation:

- 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





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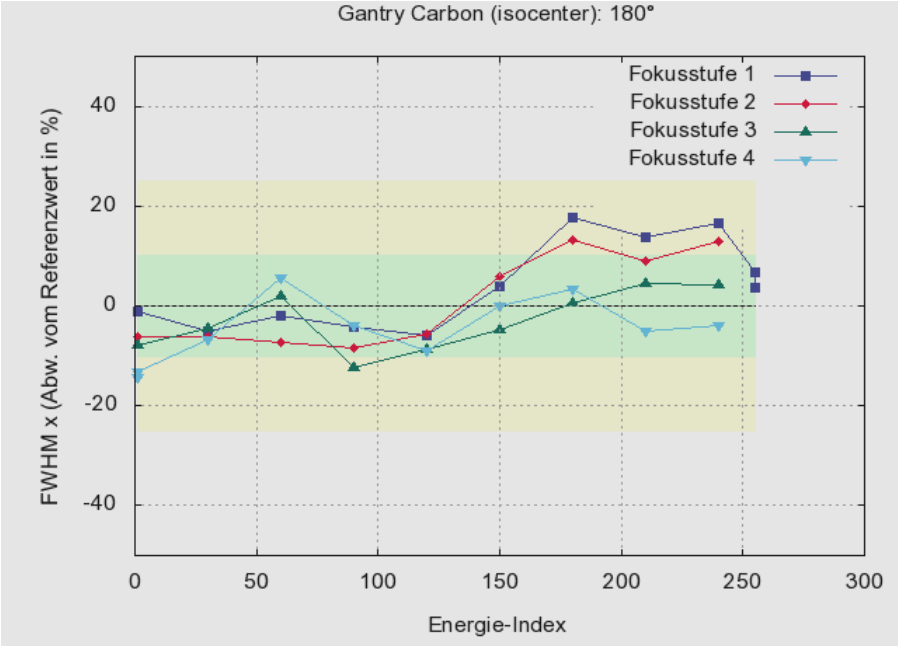
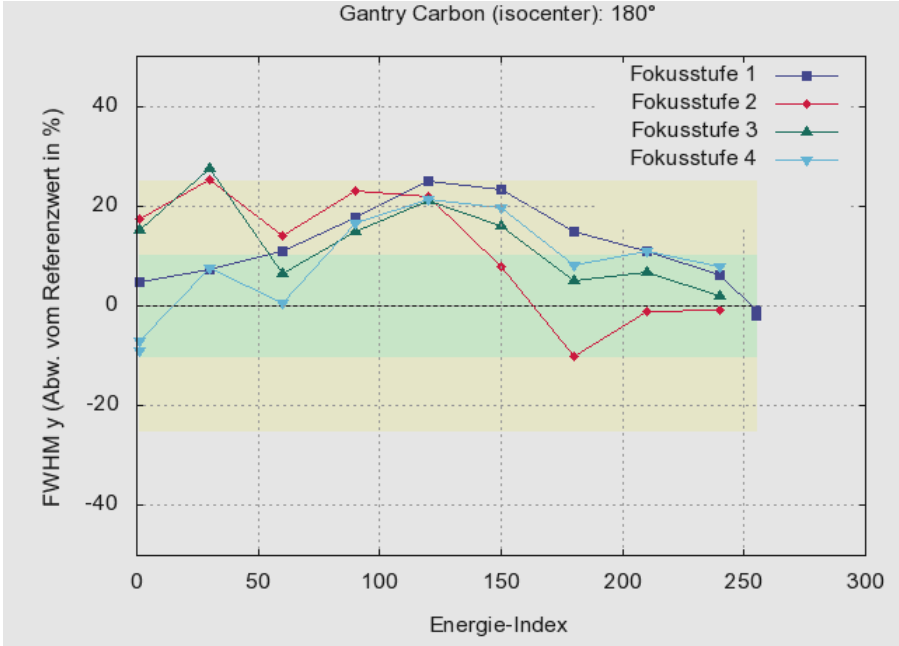
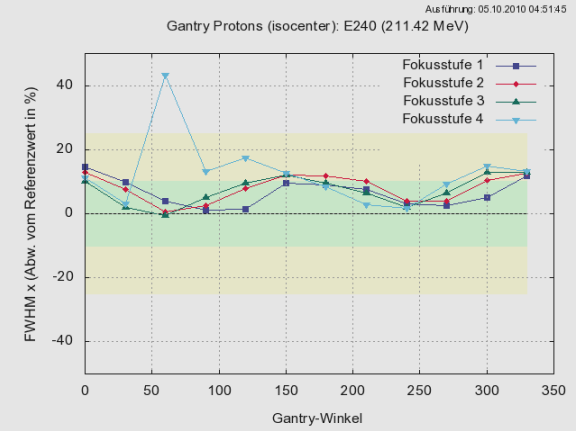


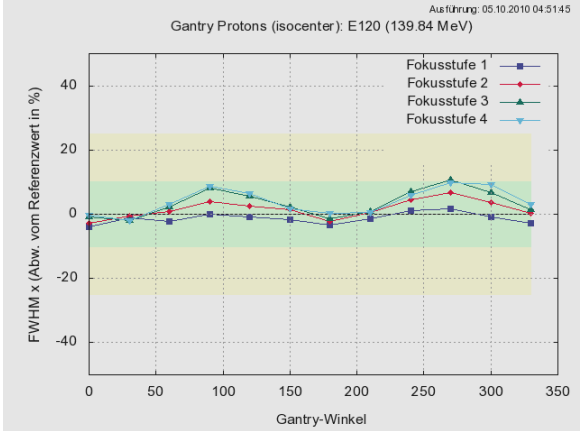


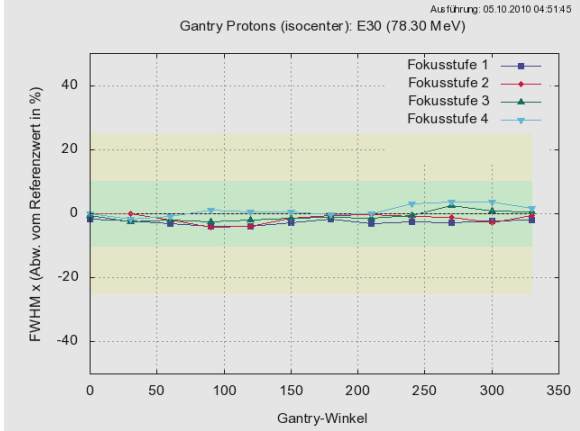
Carbon:

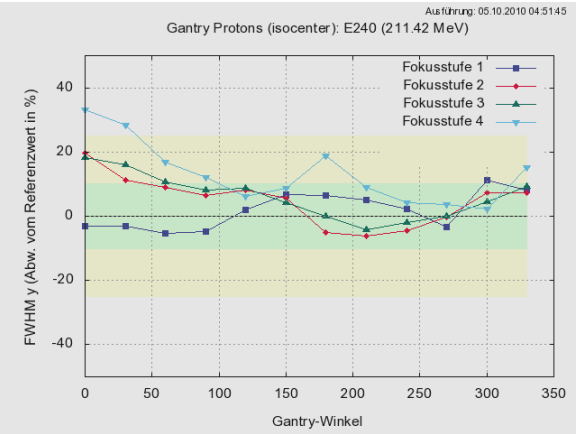
- **Beam size within accepted rel. deviation of 25 %**
- **Beam position within ±2 mm in isocenter, ≤ 10 % within ±3 mm**

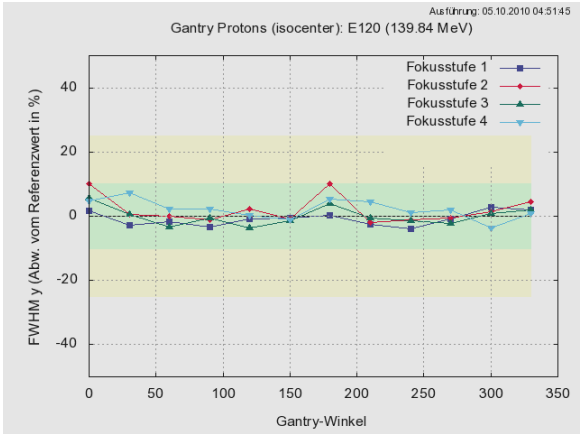
Beam Size and Position

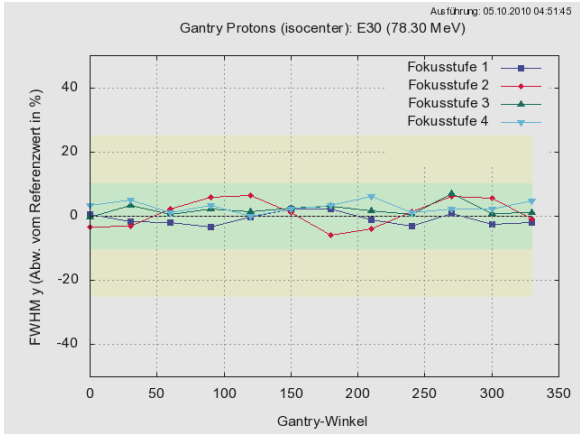












Protons:

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

Summary / Outlook

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 / Outlook

courtesy of A. v. Knobloch, SAG

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Thanks!