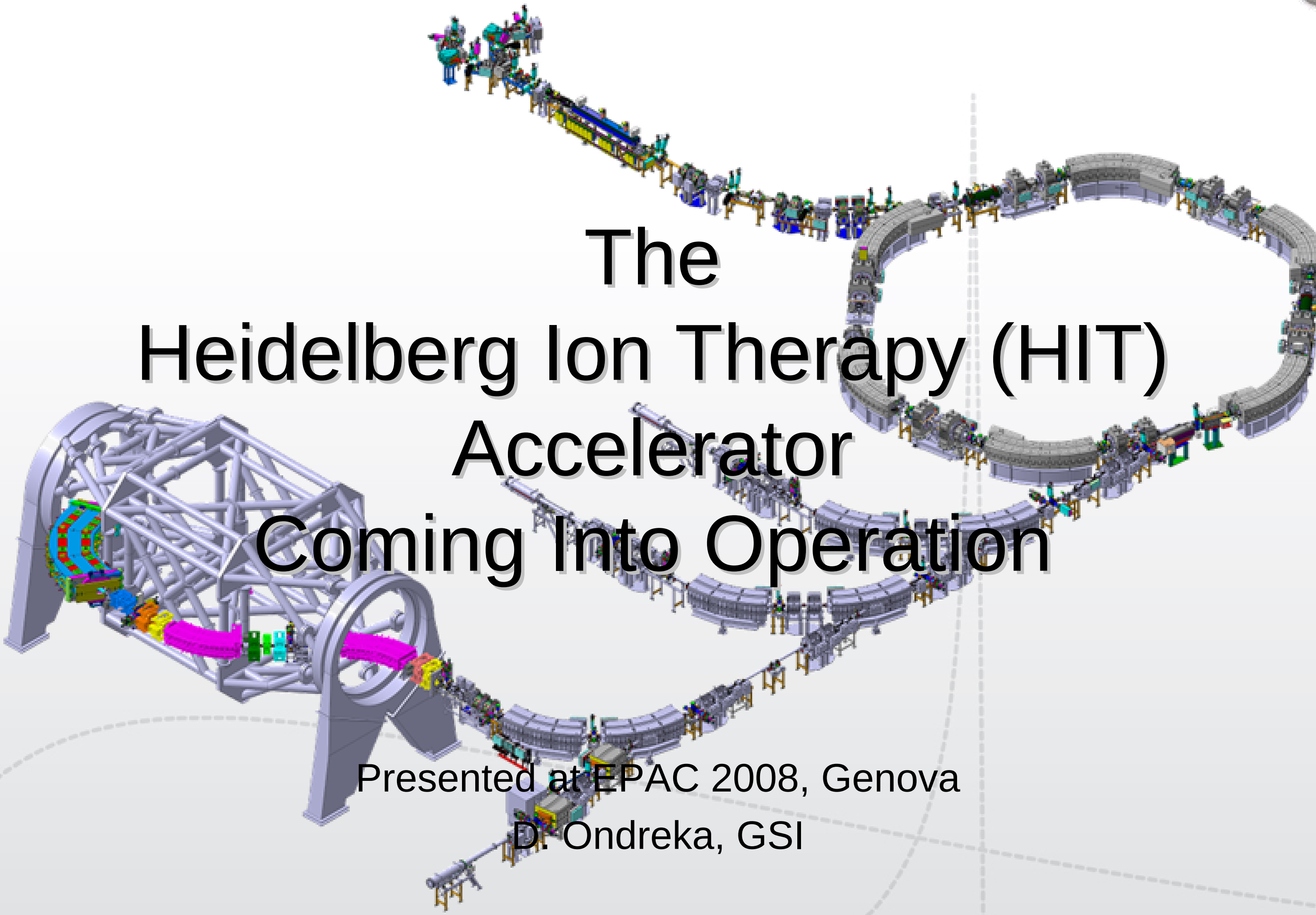
The
Heidelberg Ion Therapy (HIT) Accelerator
Coming Into Operation



Presented at EPAC 2008, Genova

D. Ondreka, GSI

Introduction

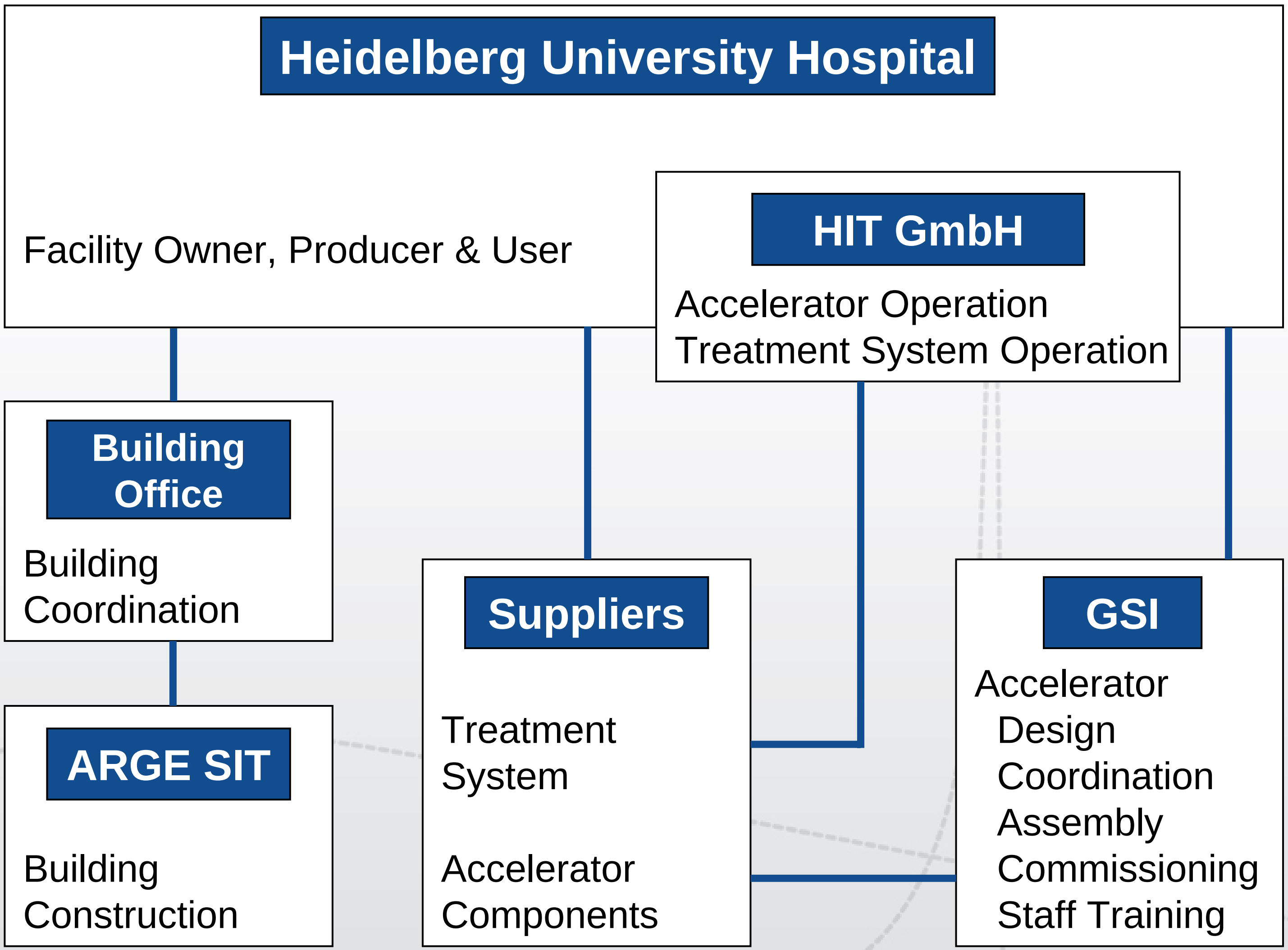
Heidelberg **I**on **T**herapy Centre:

- Europe's first dedicated particle therapy facility
- World's first carbon 3D rasterscan therapy facility
- World's first carbon gantry
- 1000 Patients / year

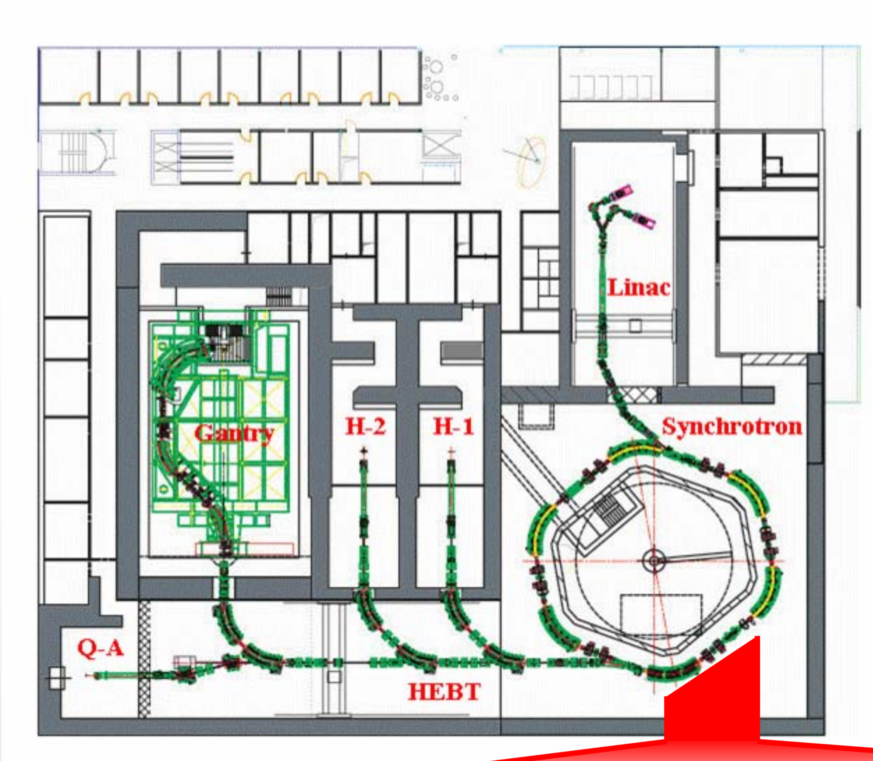
Outline

- Overview of HIT
- 3D Rasterscanning
- Beam performance
- Outlook

Project Organization

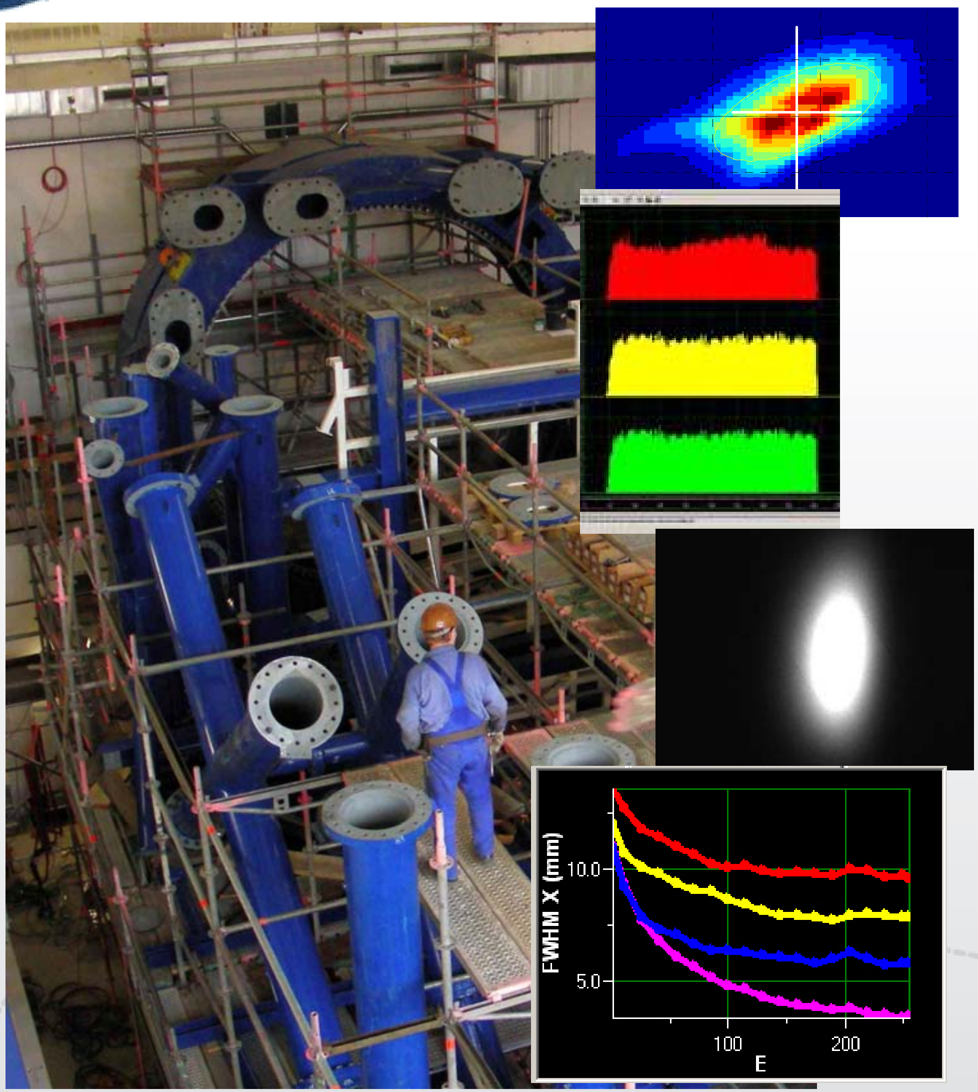


Facility Layout



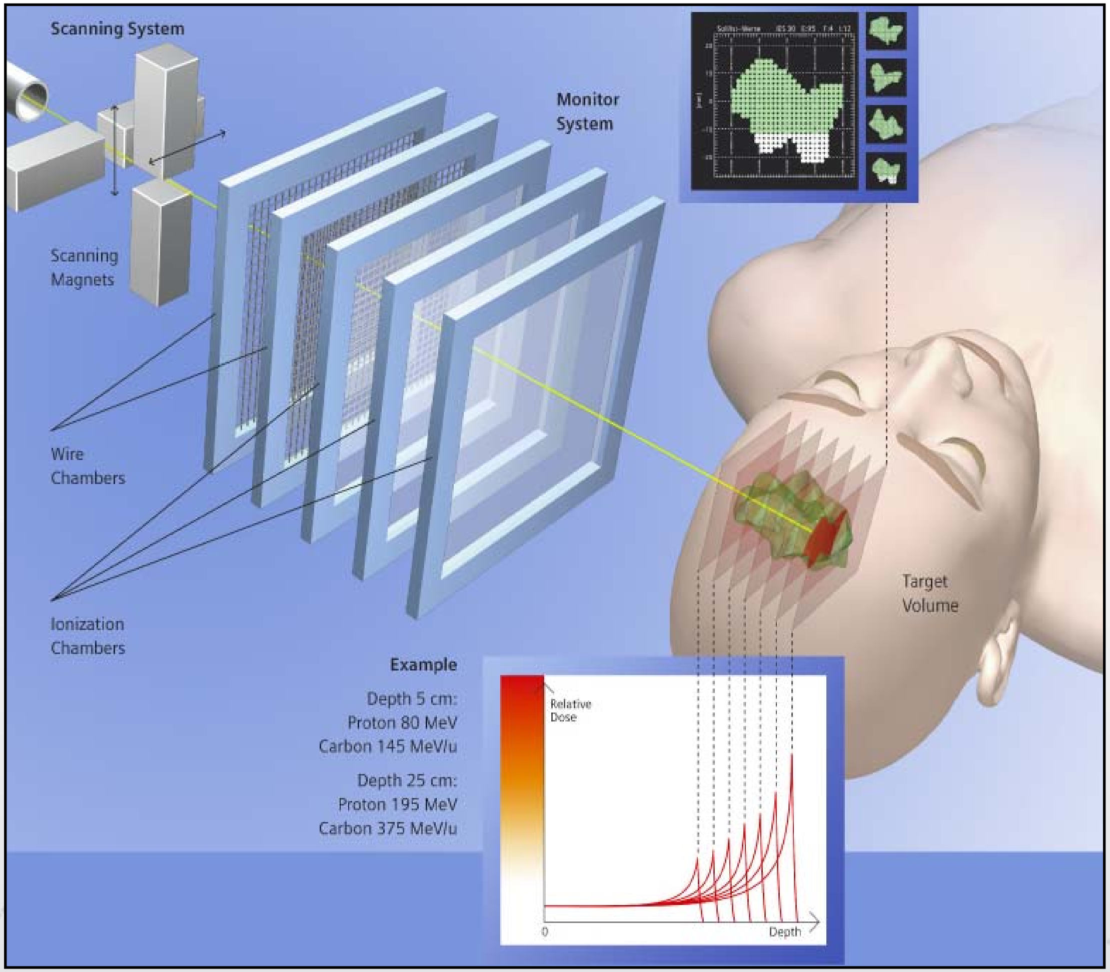
- 2 ECR ion sources (p, C)
- 7 MeV/u injector linac
- Compact synchrotron
  - Circumference 65 m
  - KO extraction (bunched)
  - Extraction time 5 s
  - Spill interruptions
- 3 treatment places
  - 2 horizontal fixed beam
  - 1 isocentric gantry
- 1 research & QA place

Accelerator Milestones



Start accelerator assembly	10/2005
First beam ion sources	4/2006
First beam linac	12/2006
Start gantry assembly	1/2007
First beam treatment place	3/2007
Patient beam places H1 + H2	12/2007
First beam gantry	1/2008
Patient beam QA place	4/2008

Rasterscan Method



Intensity-Controlled Rasterscan Technique, Haberer et al., GSI, NIM A,1993

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

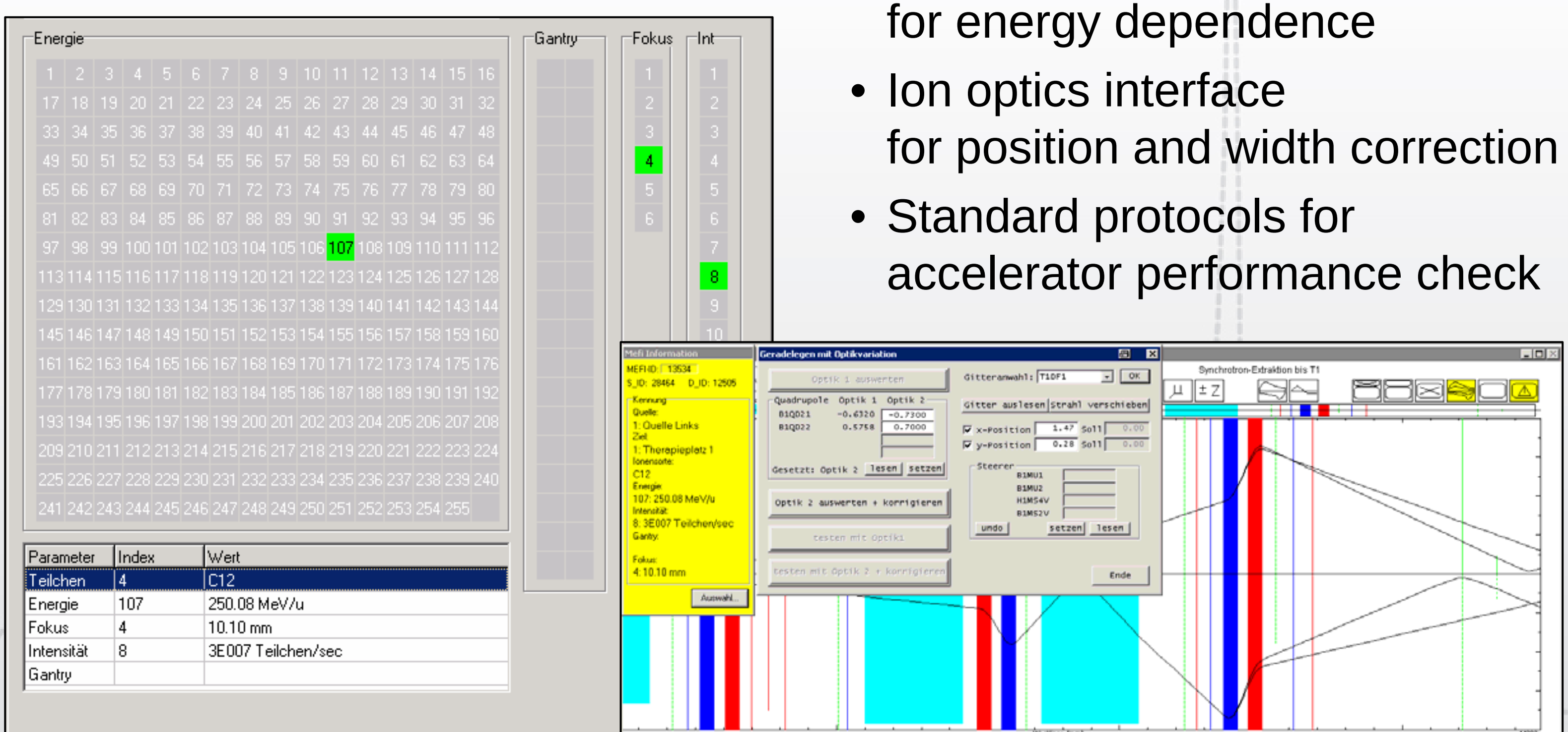
Control System Aspects

Pencil Beam Library

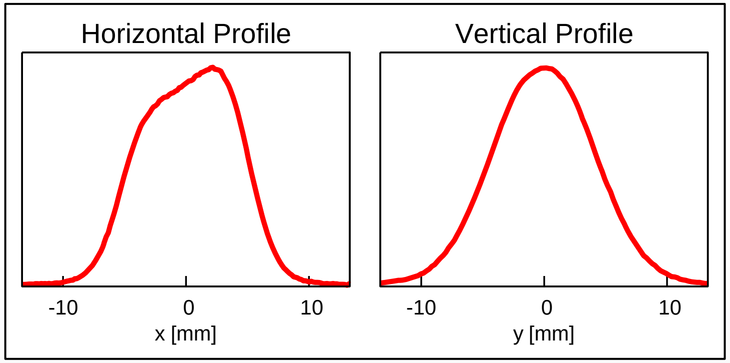
C^{6+}	Range	Steps
Energy	88 – 430 MeV/u	255
Focus	4 – 10 mm FWHM	4 [6]
Intensity	$10^7 – 4{\cdot}10^8$ Ions/Spill	10 [15]

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

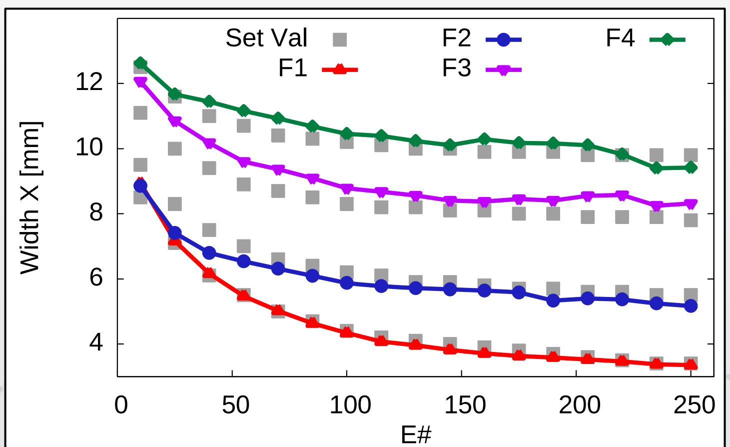


Beam Spot Sizes

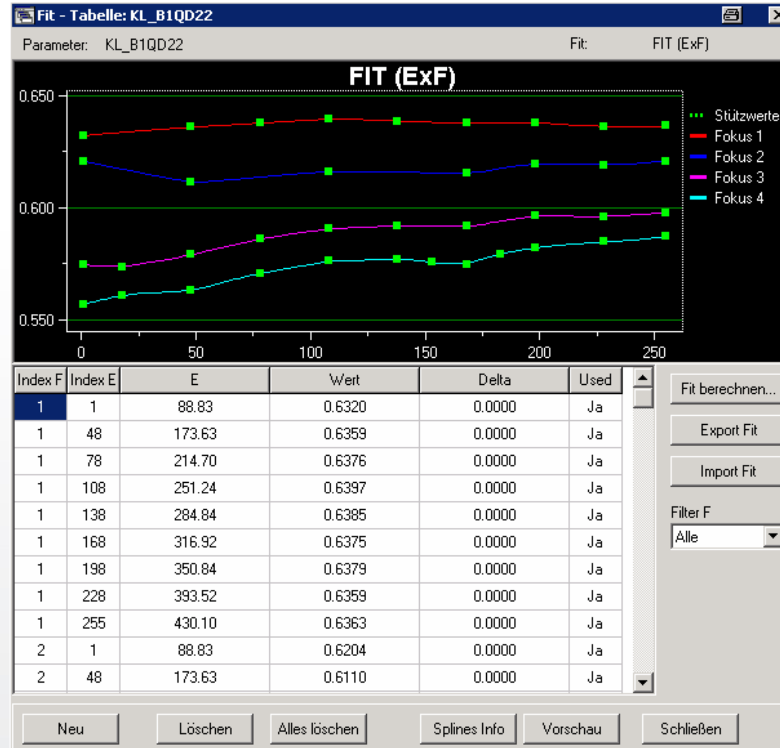


Beam profiles in isocenter

(C, 250 MeV/u, 10 mm FWHM)



Adjusted size in isocenter (C)

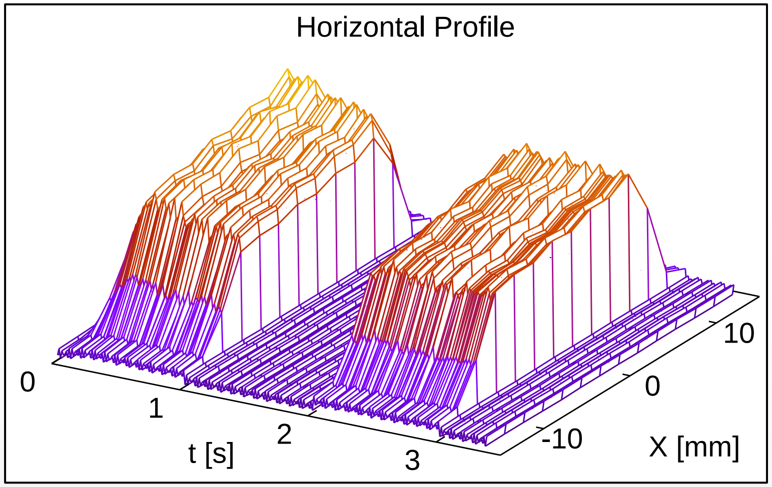


Index F	Index E	E	Wert	Delta	Used
1	1	88.83	0.6320	0.0000	Ja
1	48	173.63	0.6359	0.0000	Ja
1	78	214.70	0.6376	0.0000	Ja
1	108	251.24	0.6397	0.0000	Ja
1	138	284.84	0.6385	0.0000	Ja
1	168	316.92	0.6375	0.0000	Ja
1	198	350.84	0.6379	0.0000	Ja
1	228	393.52	0.6359	0.0000	Ja
1	255	430.10	0.6363	0.0000	Ja
2	1	88.83	0.6204	0.0000	Ja
2	48	173.63	0.6110	0.0000	Ja

Energy dependent settings of focusing quadrupole:

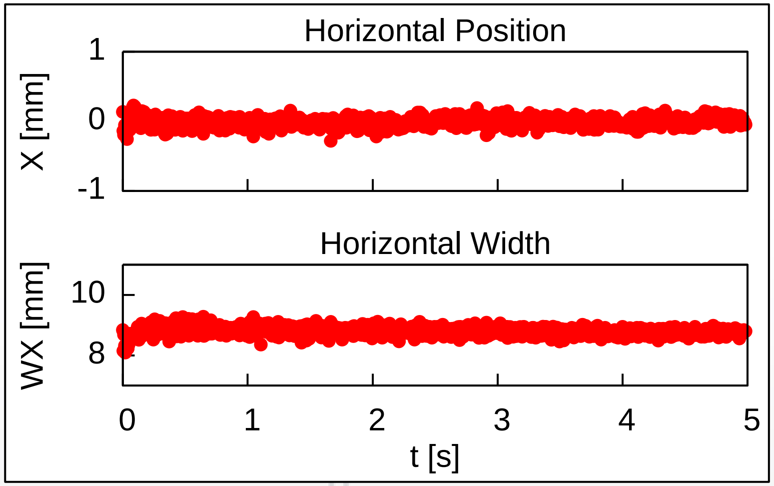
Cubic spline interpolation over base points

Beam Stability



MWPC in beam line

(C, 250 MeV/u, one interruption)



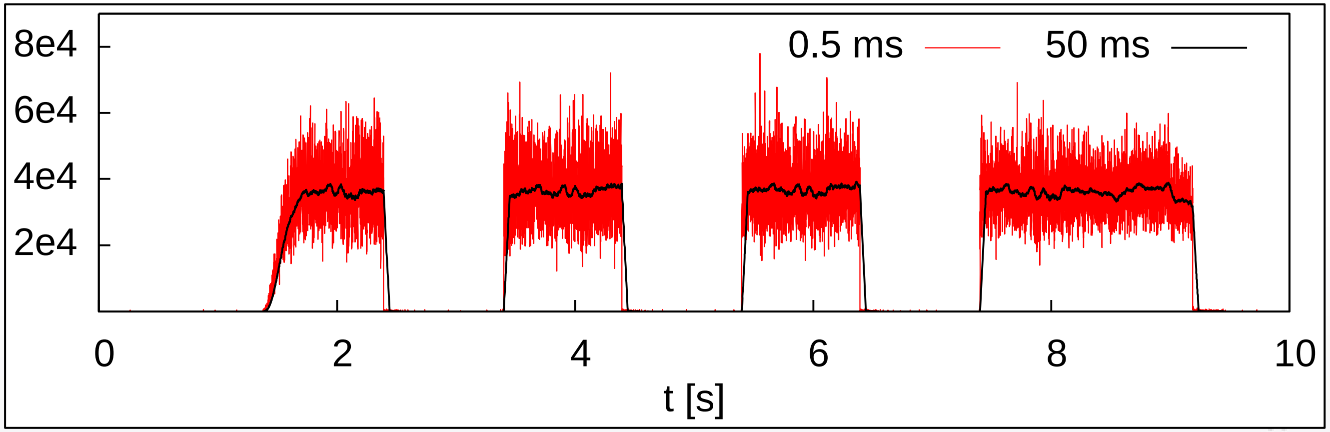
Treatment monitoring system

(C, 250 MeV/u, no interruption)

- 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



Max/Avg	≤ 2
Duty factor	95%
Rel. intensity in interruption	$5 \cdot 10^{-4}$

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

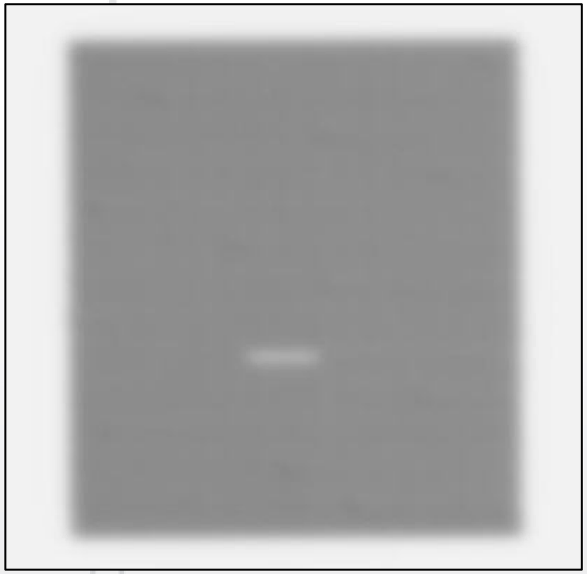
cf. Poster: "Spill Structure Measurements at HIT", A. Peters, HIT, TUPP127

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!