Commissioning of the Heidelberg Ion Beam Therapy Centre

Jacksonville, May 2008

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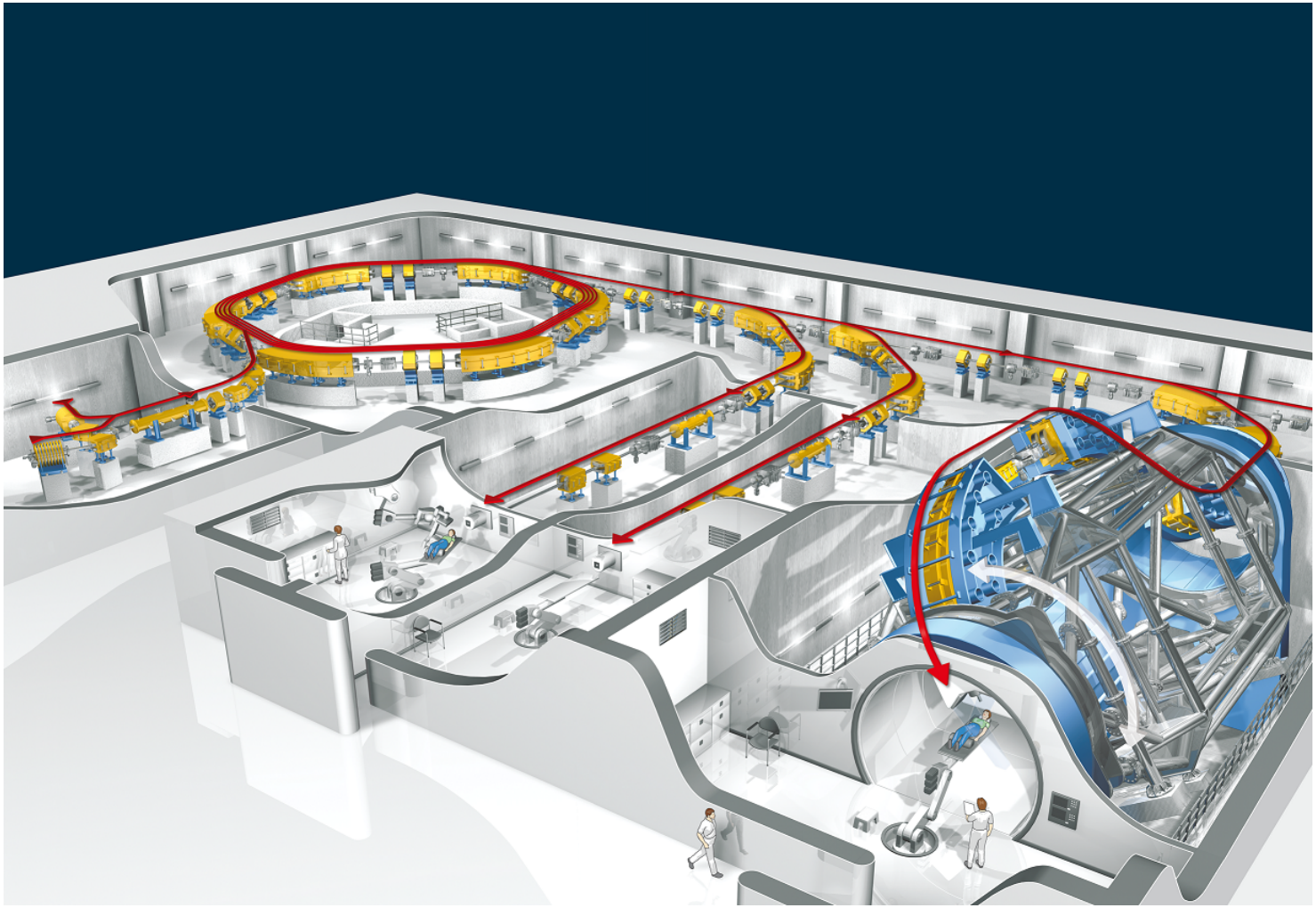
HIT
Heidelberger Ionenstrahl-Therapiezentrum

UniversitätsKlinikum Heidelberg
IonenStrahl TherapieZentrum

Heidelberg Ion Beam Therapy Center

- Compact Synchrotron
- 2 Horizontal beams
- Scanning Gantry
- QA- Room
- p,He,C,O,...
- E<430MeV/u (~30cm range)

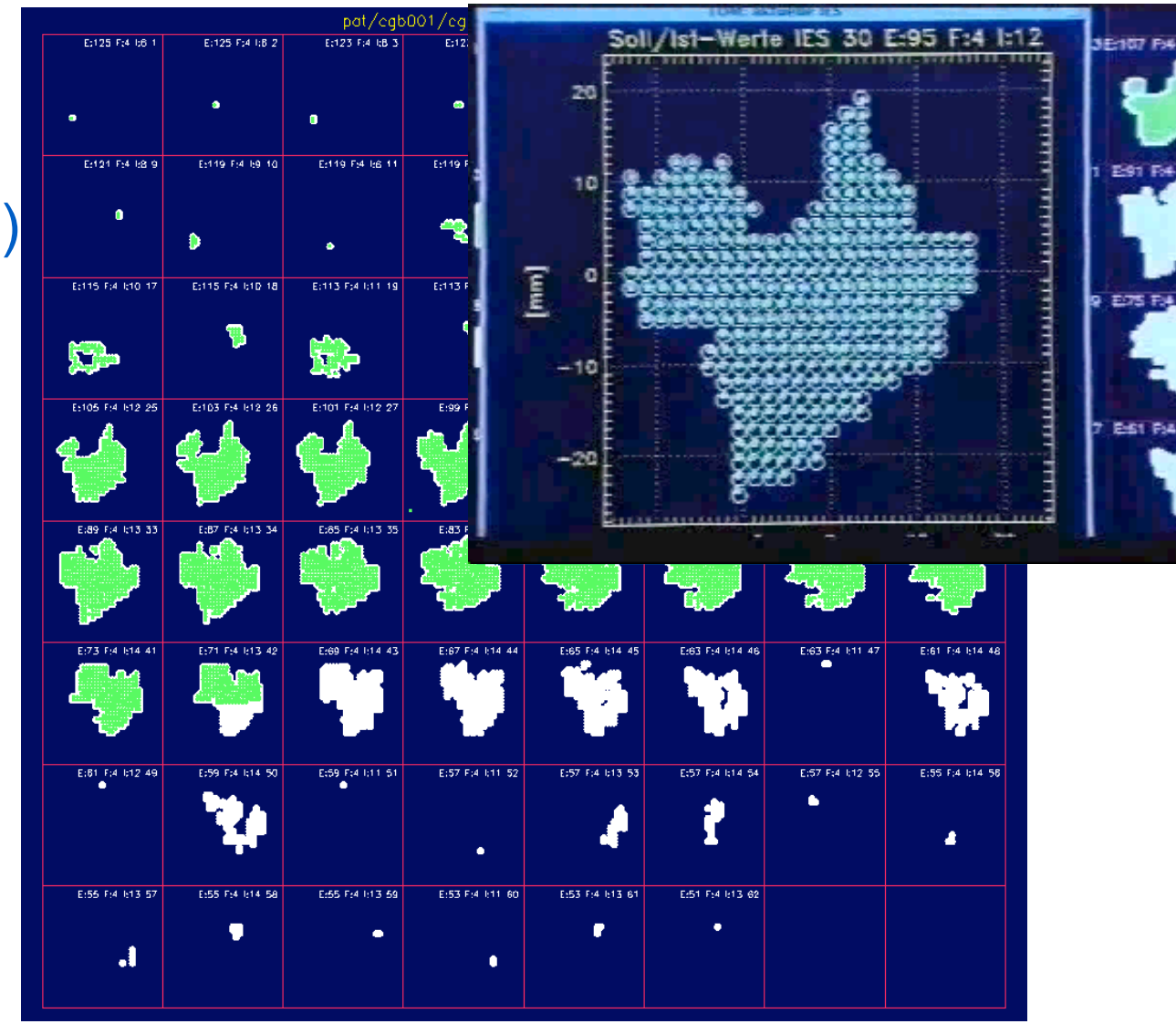


Magnetic Rasterscanning

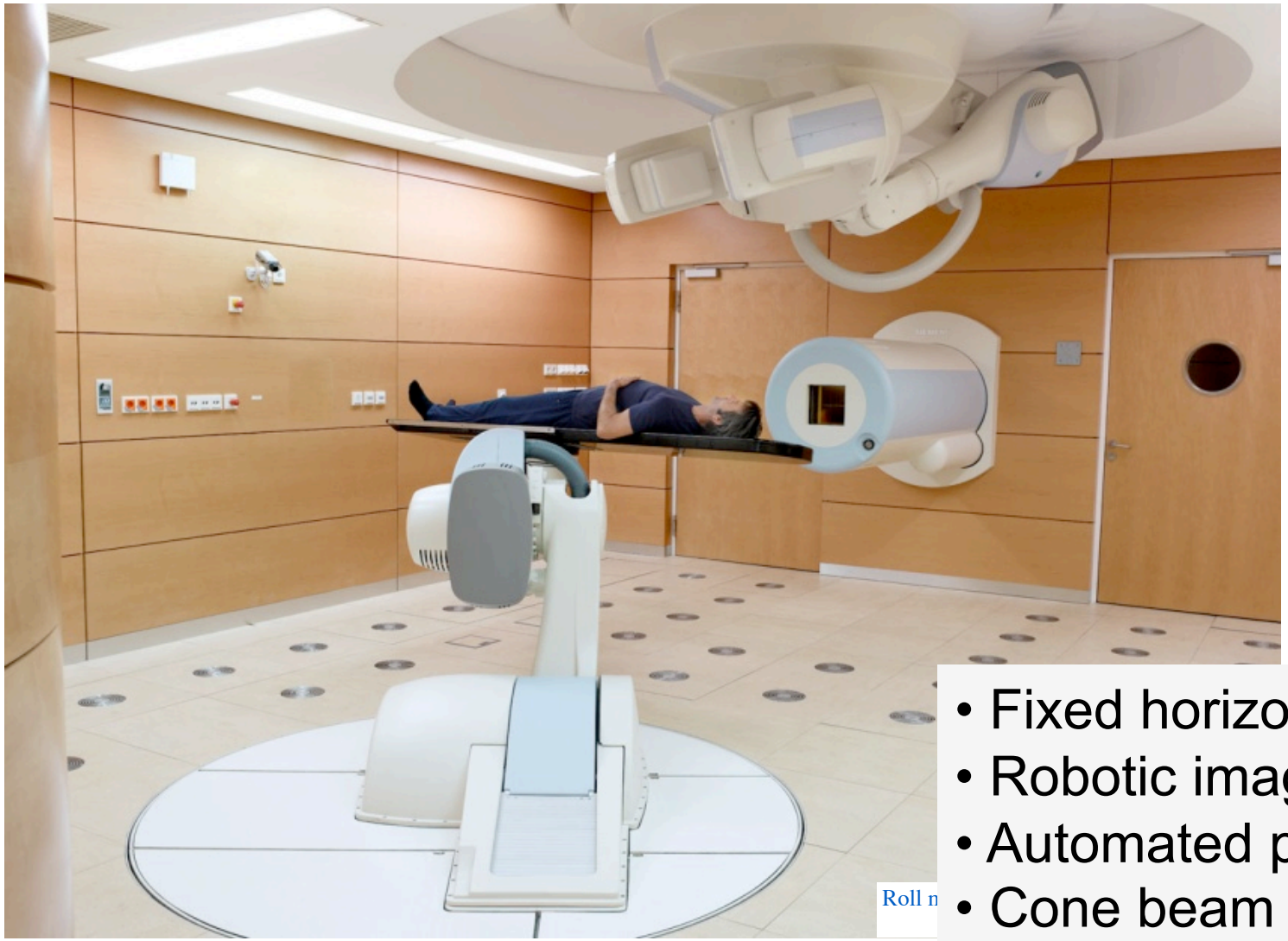
Beam Parameters

- Beam Energy:
  255 Energies (1mm Steps)
- Beam width:
  4 steps, 4mm-10mm
- Particle numbers:
  10^4 – 10^7 per Scan Spot
- Ion Species:
  p, $^{3}He^{2+}$, $^{12}C^{6+}$, $^{16}O^{8+}$

Therapy Online Monitor (TOM)



Horizontal beam room @ HIT



- Fixed horizontal beam
- Robotic imaging (30Hz)
- Automated position
- Cone beam CT optional correction

Milestones and Status of the Project

- Start of construction : 11 / 2003
- Building ready: 10 / 2005
- 1st beam in accelerator 2 / 2007
- Gantry installed 6 / 2007
- 1st Beam in Gantry 1 / 2008
- Horizontal beams commissioned 3 / 2008
- QA cave operational 6 / 2008
- Start of Clinical Operation ~10 / 2008
- Gantry commissioned 7 / 2009

QA System for acceptance & constancy tests

- ***Patient imaging***: Imaging quality parameters of the CT and MR
  Focus on geometric distortions and constancy of CT -HU
- ***Treatment planning:*** Accuracy of dose algorithm
  Measurements of the absorbed dose in various phantoms
  Numerical bench mark tests
- ***Treatment delivery:*** Checks of beam scanning (geometry and dose)
  Stability and performance of the beam monitoring system
  Variations of beam parameters for all machine settings
- ***Patient positioning:*** Geometric accuracy of positioning and imaging devices;
  Accuracy of matching algorithms
  Imaging quality of the X-ray system and cone beam CT
- ***Safety & control system:*** Check of all interlock chains, user interfaces
  Correct setting of the required machine parameters
- ***Integral tests:*** Check complete treatment workflow with phantoms
  Check of all different workflows
  Check complete treatment planning process, including dosimetric treatment plan verification

Optimize and automate QA procedures developed for GSI
Start of acceptance tests for TPS in June

Measurement of data base for TPS

I) Depth dose curves:

- 255 energies
- p and C-12 ions
- w/o Rifi (p), w. 3/4 mm Rifi (C-12)

III) Beam widths:

- 4 focus sizes (4-10mm), 15mm, 20mm
- 255 energies
- p and C-12 ions
- w/o Rifi (p), w. 3/4mm Rifi (C-12)
- at isocenter and in air gap (p)

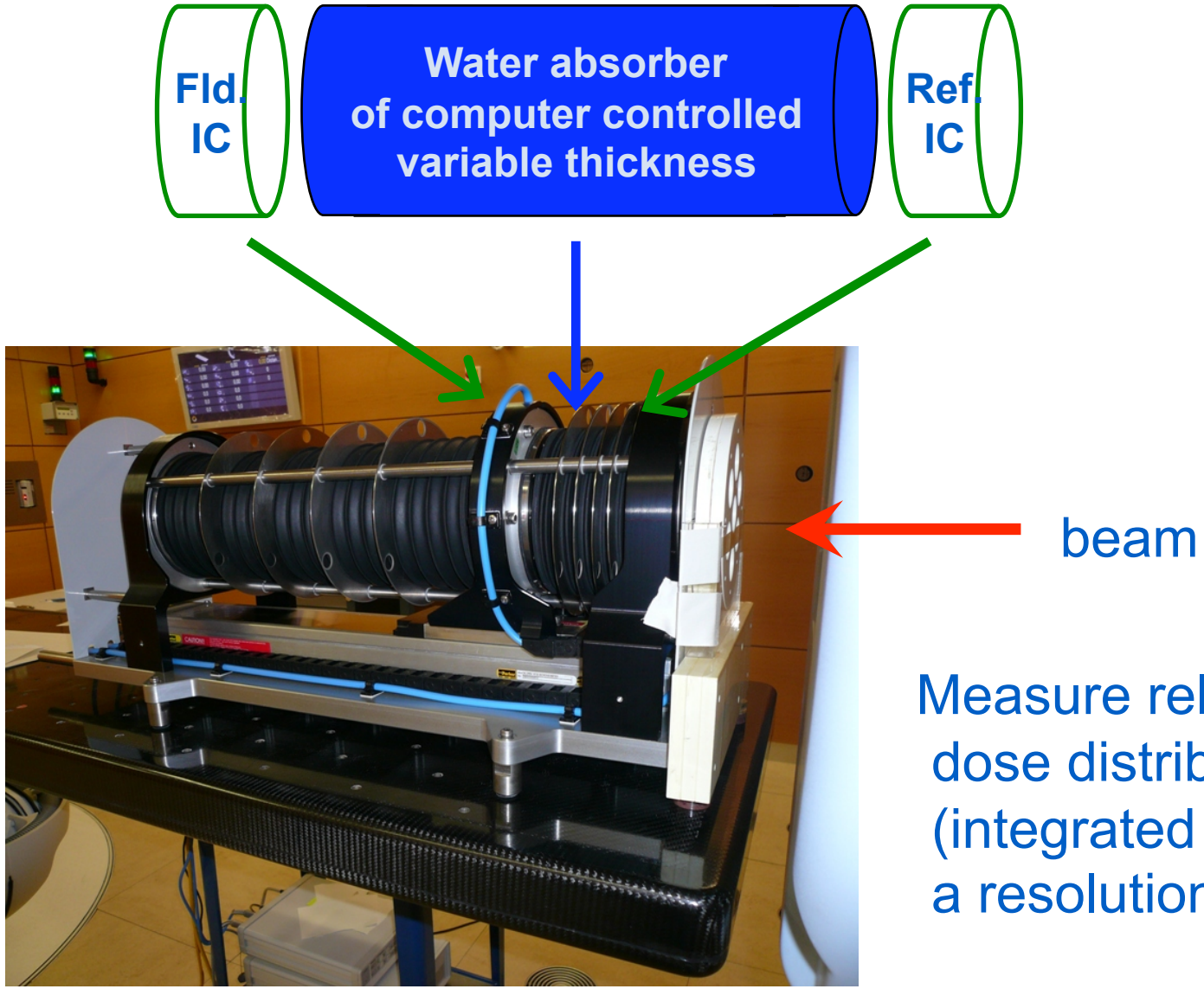
IV) Other parameters:

- differences in beam-line: 2 fixed beams, QA room, Gantry
- 10 intensity levels of accelerator

Monte Carlo generation (FLUKA) of data base
Validation against exp. Data for representative settings

Measurement of depth dose curves

Peakfinder © PTW, Freiburg

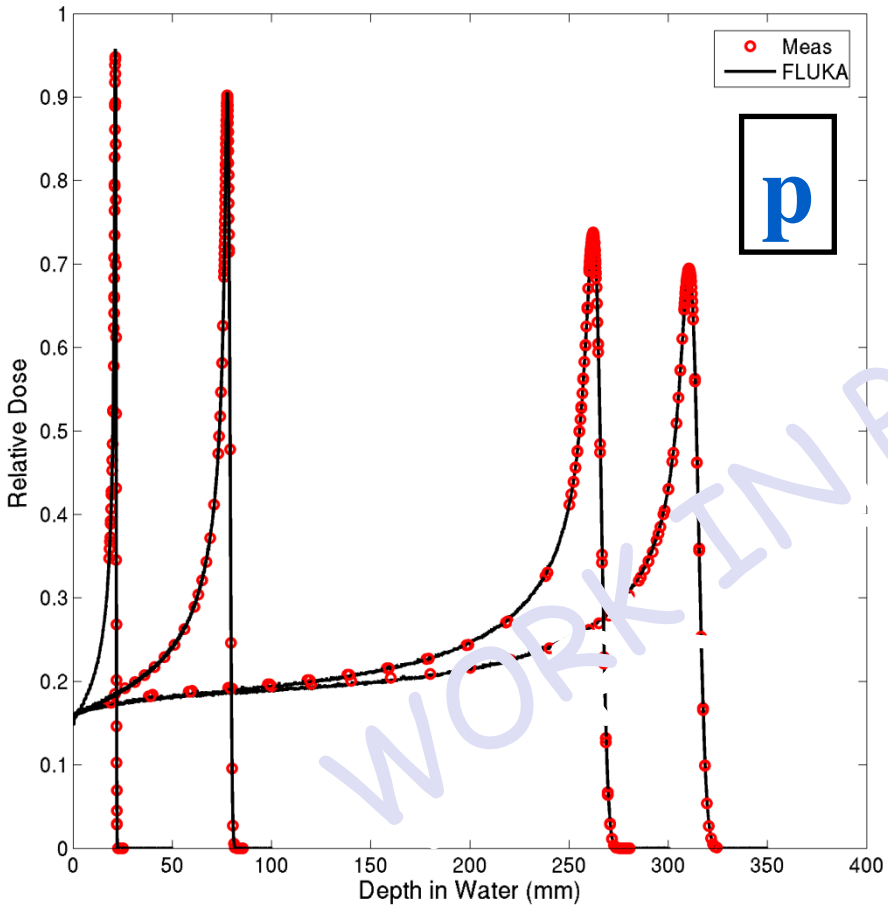


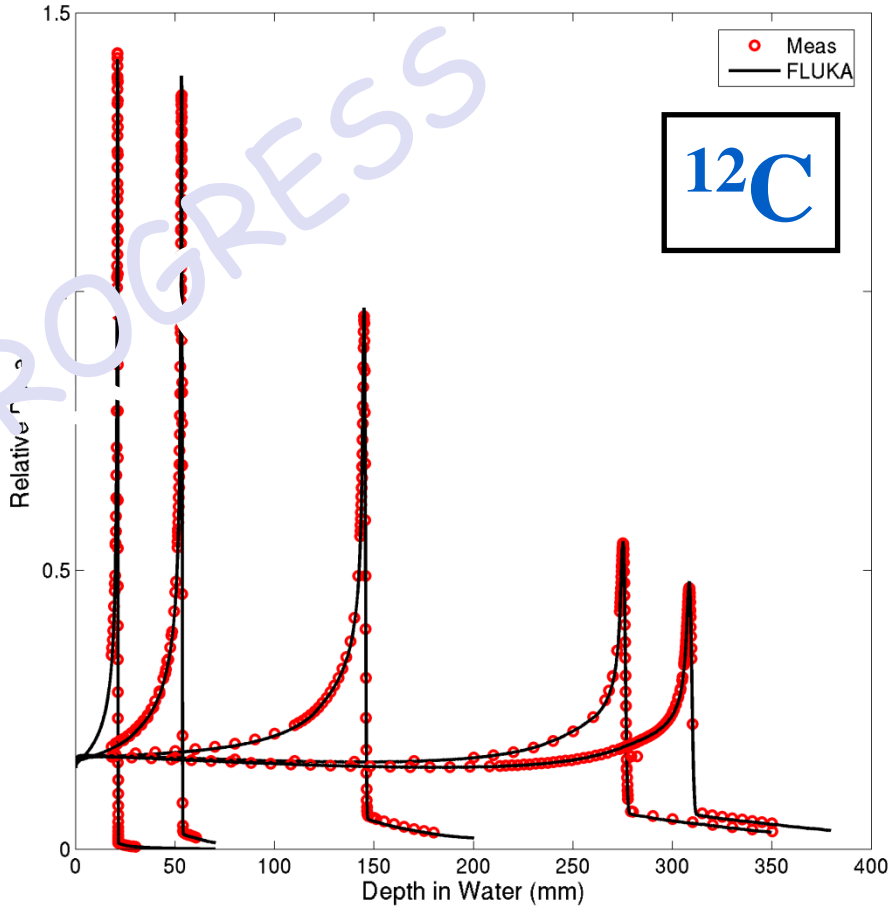
Measure relative depth dose distribution (integrated laterally) with a resolution of 10 µm.

Measured depth dose curves

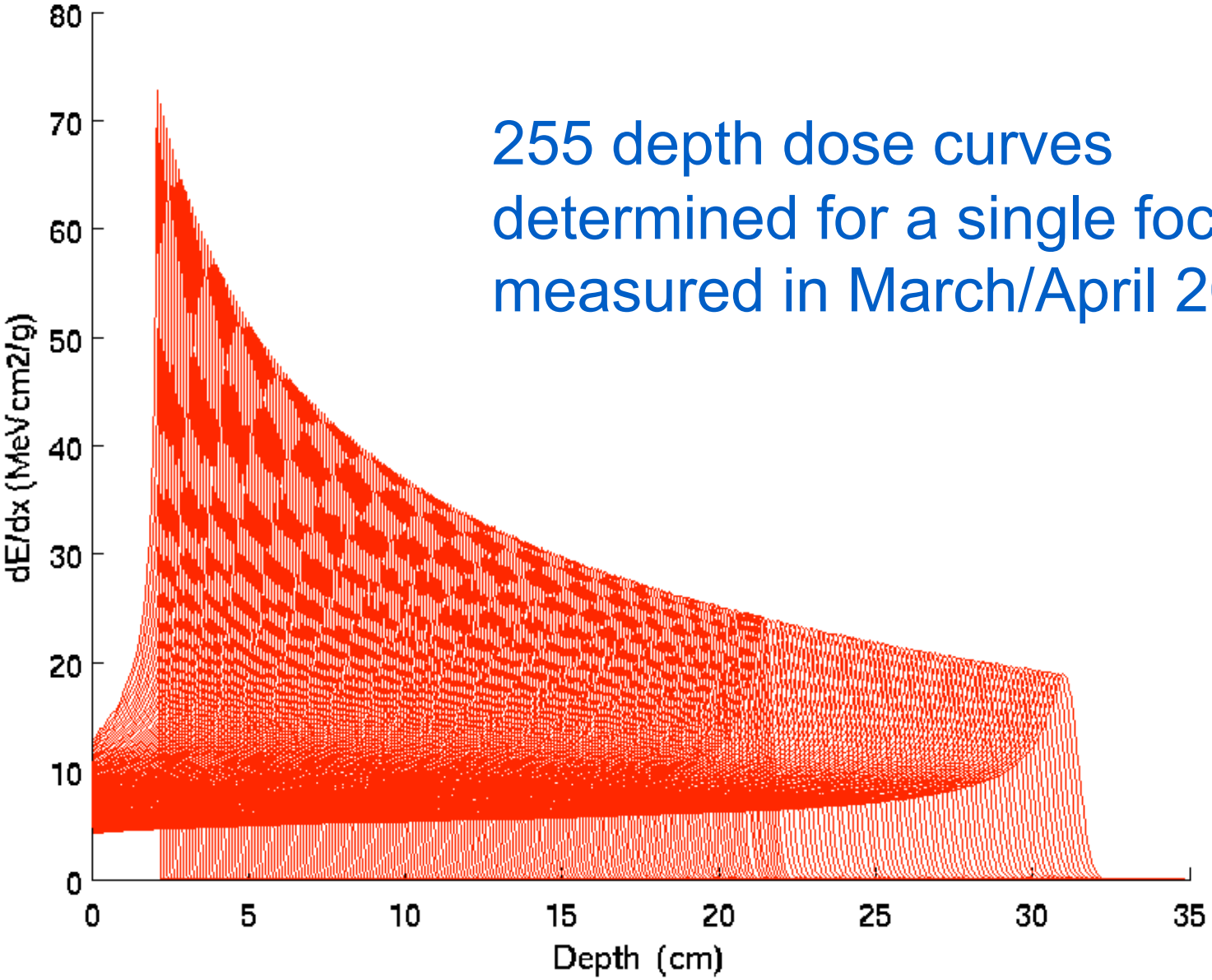
Measured vs. FLUKA simulations

- Monte Carlo simulation of experimental setup
- Simulation of RiFi, airgap, ...
- Agreement of absolute depth < 0.2mm





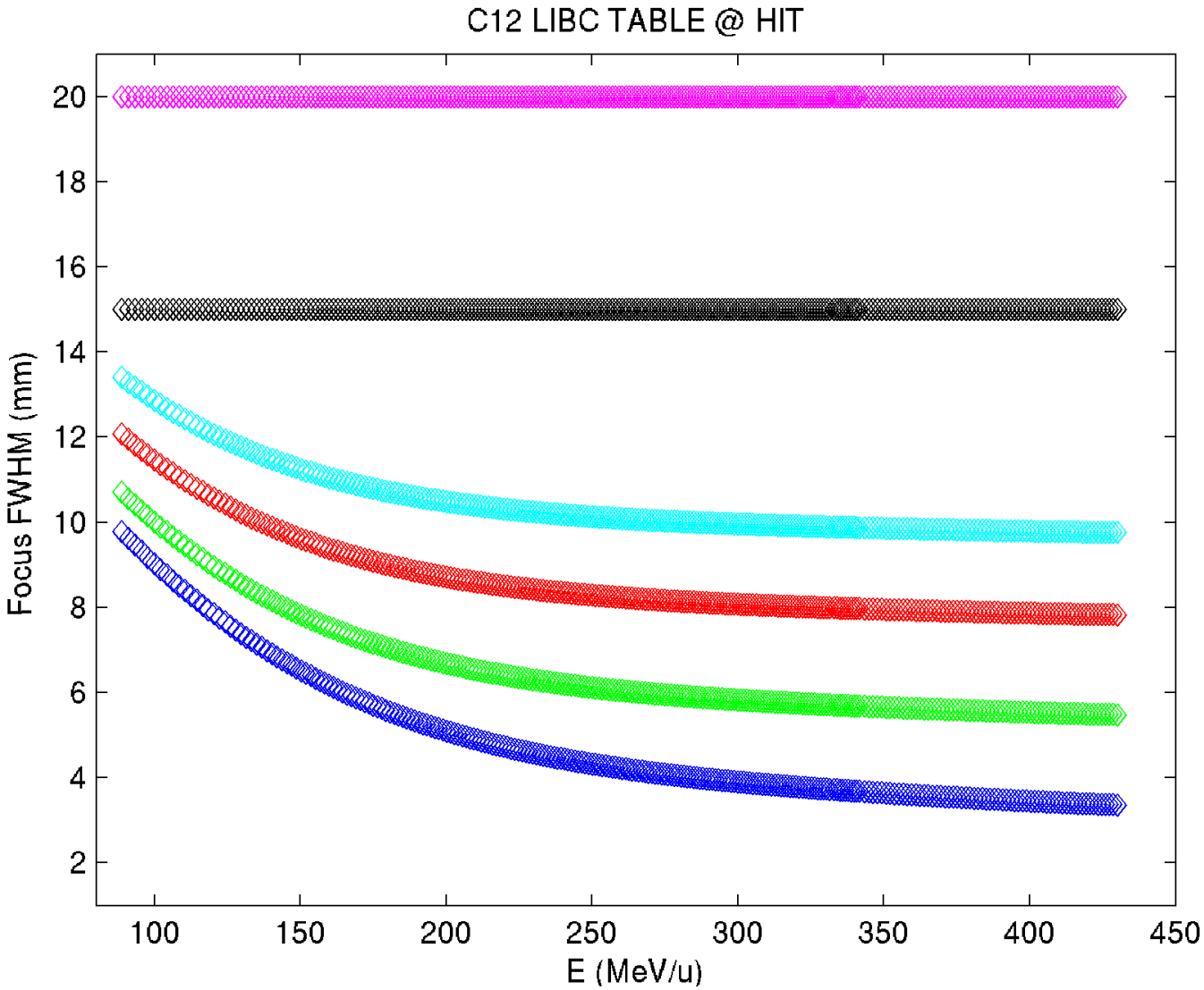
Result: Proton depth dose curves for HIT



255 depth dose curves determined for a single focus size measured in March/April 2007

Results: Focus library for C-12 at HIT

Values of the 6 focus steps at 255 energies

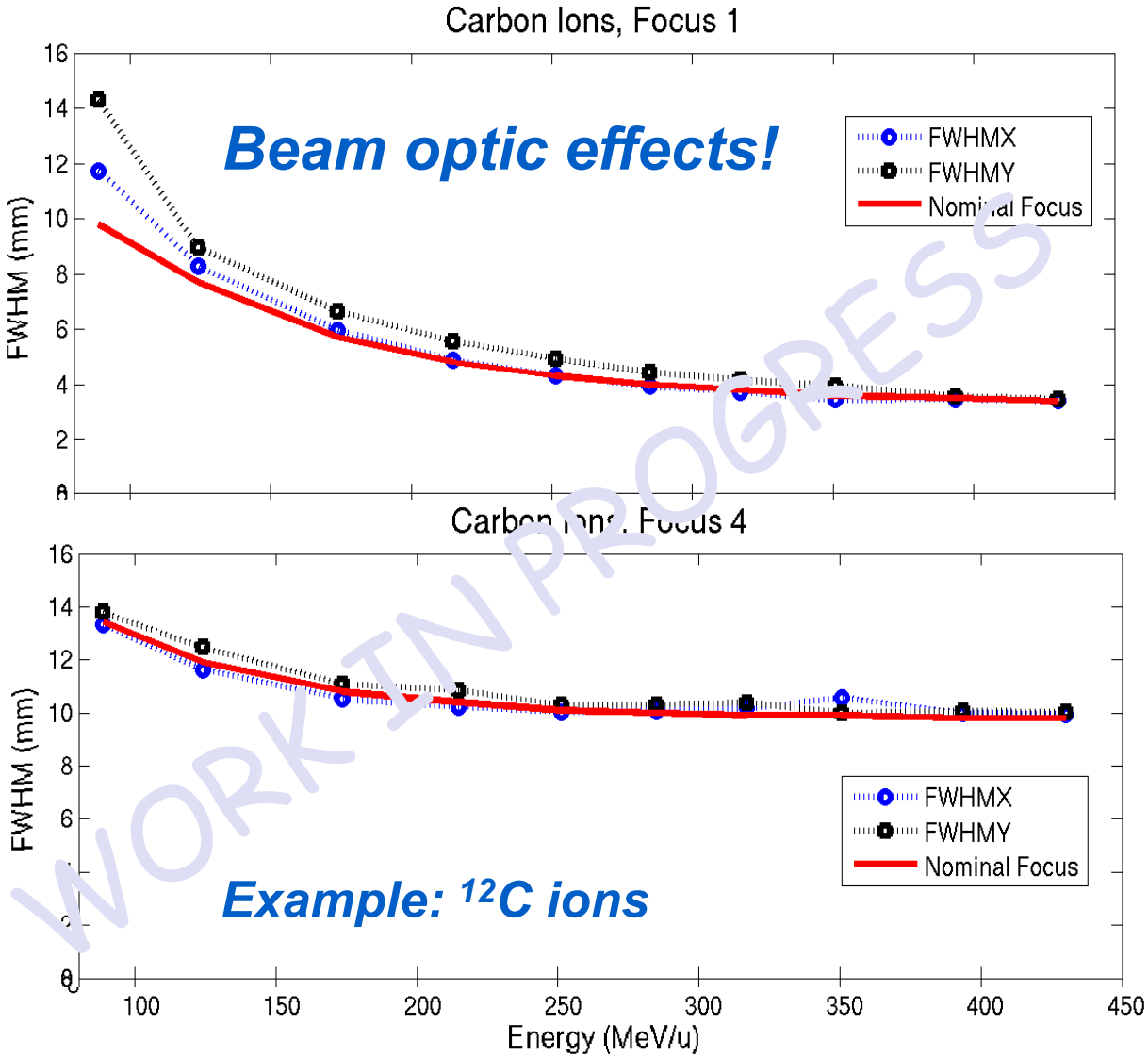


Measured beam profiles (using multi-wire chambers, films)

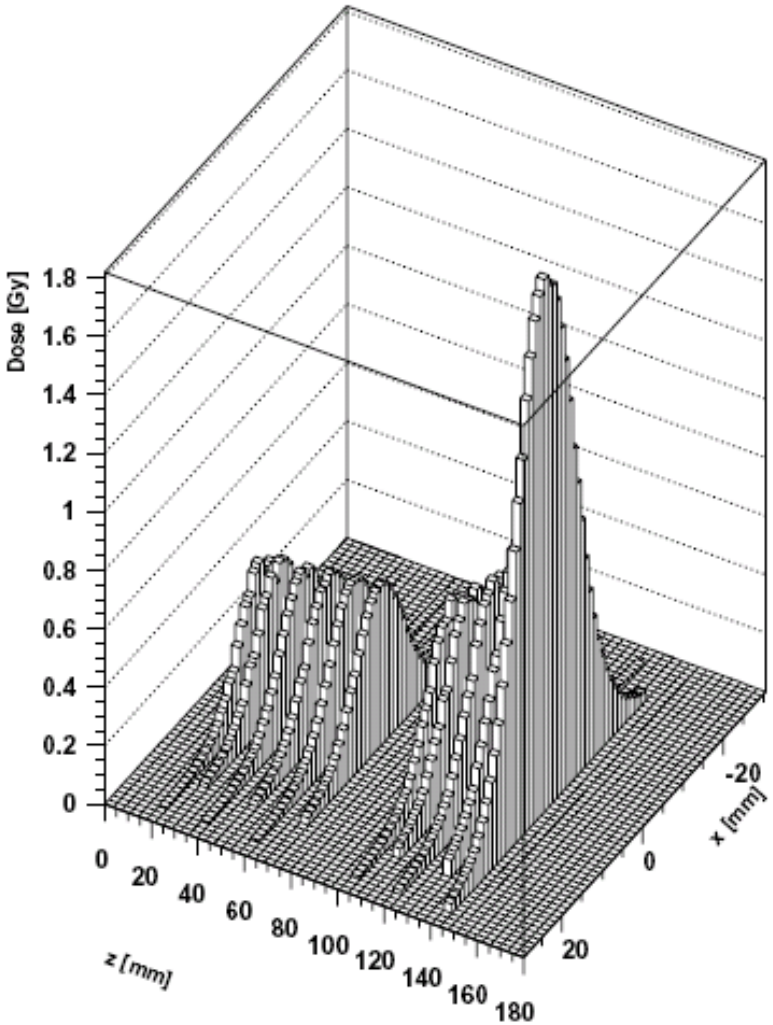
Measured vs. nominal focus values

FLUKA calculations take into account:

- Desired focus size (4-10 mm at isocenter for higher energies)
- Physical limitations from scattering in monitor system and air
- Distance nozzle-patient



Ongoing: Validation of Monte Carlo/TPS Beam profiles as function of depth in water

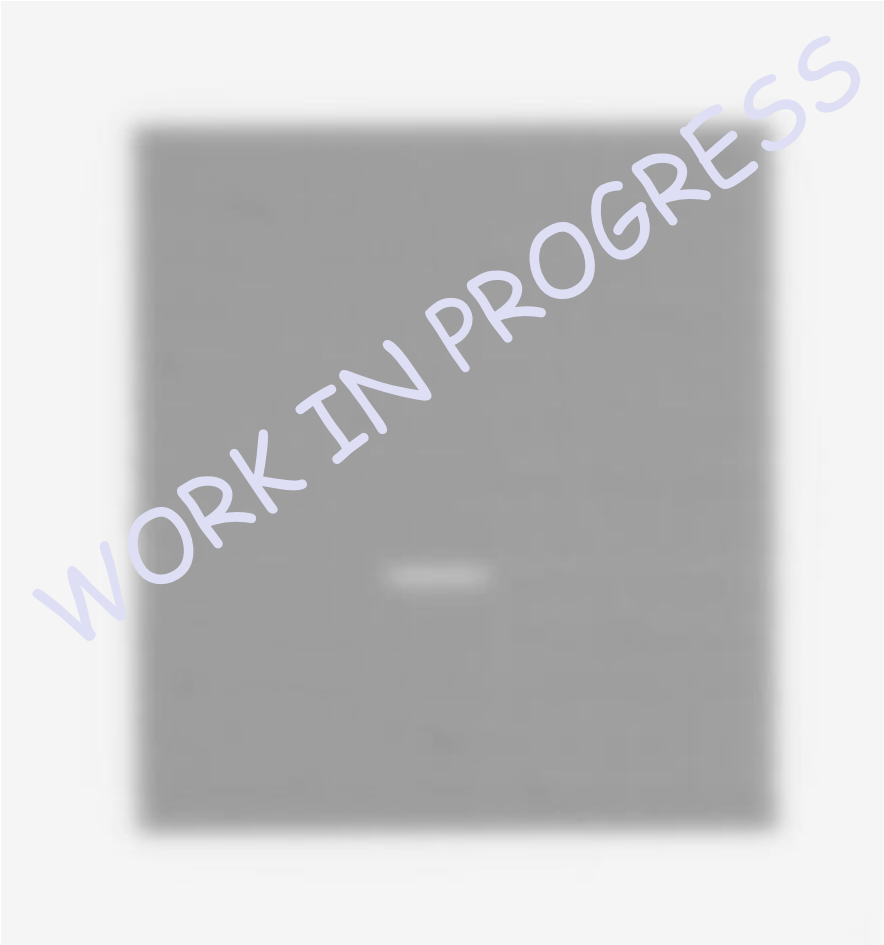


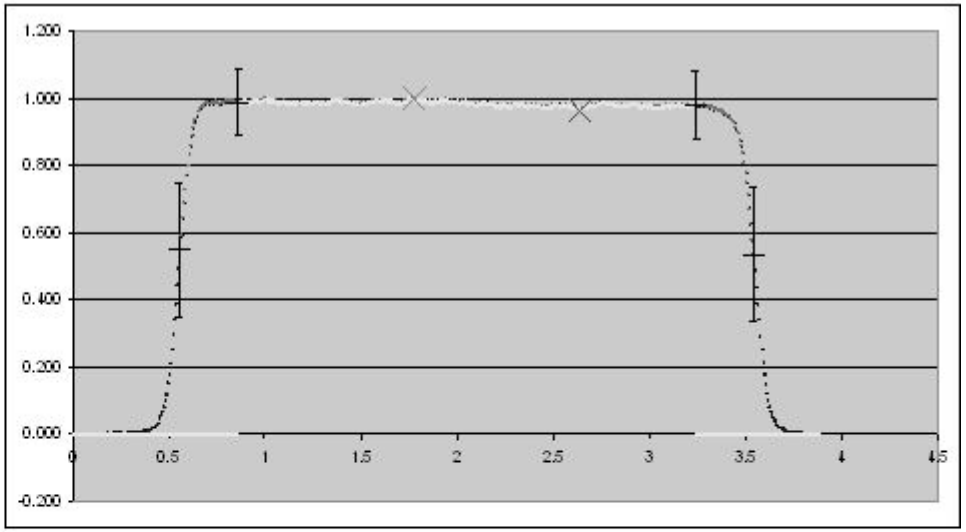
F = 4

Measurement using Multichannel Dosimeter And Pin-point IC's

HIT-H2 (24.1.2008)
protons
(E=143MeV/u, F=4)

Commissioning of raster scan system





3.735%	Dmax-Dmin
1.903%	(Dmax-Dmin)/(Dmax+Dmin)
103.880%	Dmax/Dmin
7.58	cm field width

Preliminary scanner commissioning result:

- Carbon ions @ H2
- Maximum energy recorded in a verification film
- **no position feedback loop**

(courtesy S.O. Grözinger et al., Siemens Healthcare)

Summary and Outlook

Heidelberg Ion-Beam Therapy Center

- Beam with therapy quality in both rooms with fixed beam
- Beam at isocenter of gantry (tuning started)
- Beam in QA room (tuning started)

Ongoing / next steps

- Commissioning starts in June: raster scanner, beam monitoring system, treatment planning system, …
- **Start of pre-clinical operation in summer 2008** (radiobiology with cells and animals)
- Certification, clinical admission procedures
- **Start of clinical operation winter 2008**

Future research

- Clinical trials to compare clinical efficacy of proton and ion beams
- Clinical implementation of Intensity Modulated Ion Therapy
- Development of methods to manage organ movement
- Radiobiological experiments

Thank you for your attention !

Intensity modulated raster scan on radiographic film at GSI