



Application of GEANT4 to Ion therapy at HIBMC

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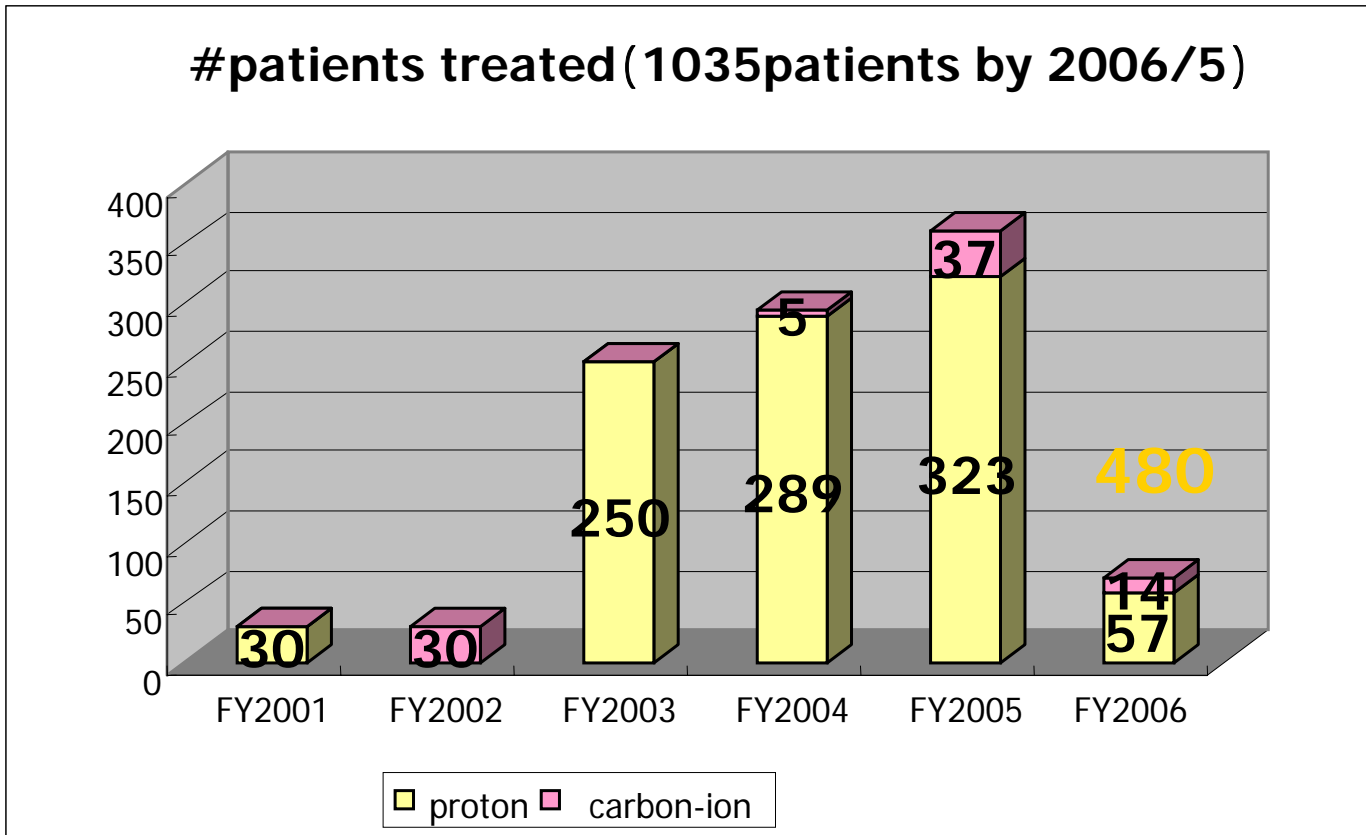
Contents

- Introduction of the facility at Hyogo
- Applications of GEANT4
- Verifications of GEANT4

Hyogo Ion Beam Medical Center (HIBMC)



Number of patients treated

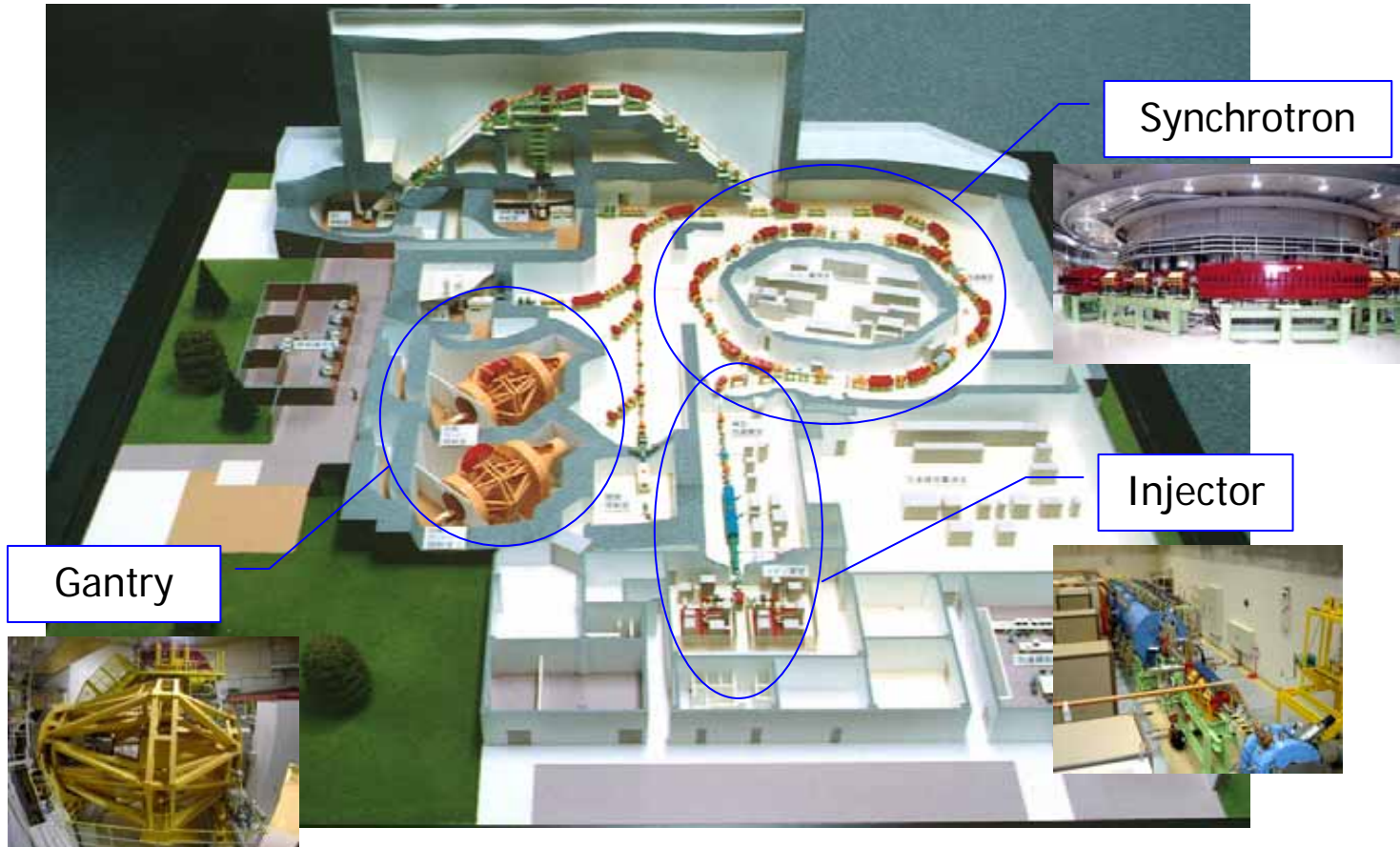




Accelerator complex

- Accelerator
 - Synchrotron
 - Protons (70-230 MeV)
 - Carbon-ions (70-320 MeV/u)
- Beam lines
 - 4 fixed-angle beam lines (proton&carbon)
 - 2 Gantries (proton only)

Accelerator complex

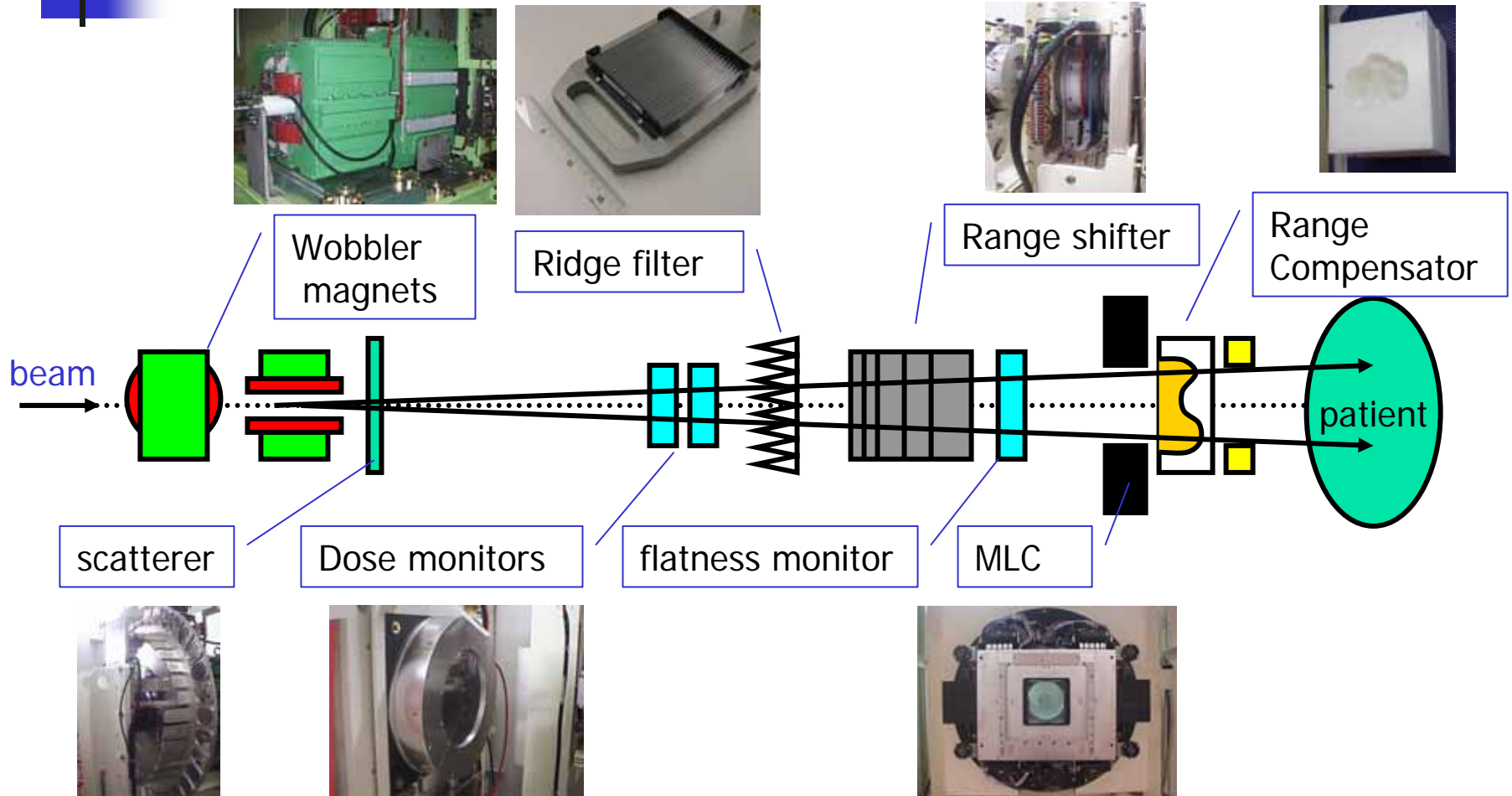




Broad-Beam delivery system

- Wobbler + scatterer as a lateral beam spreader
 - producing a laterally flat field at the isocenter
- Ridge filter as a range modulator
 - forming a SOBP
- MLC and Range compensator as beam modifying Devices
 - shaping and modifying the beam to conform the target

Broad-Beam delivery system

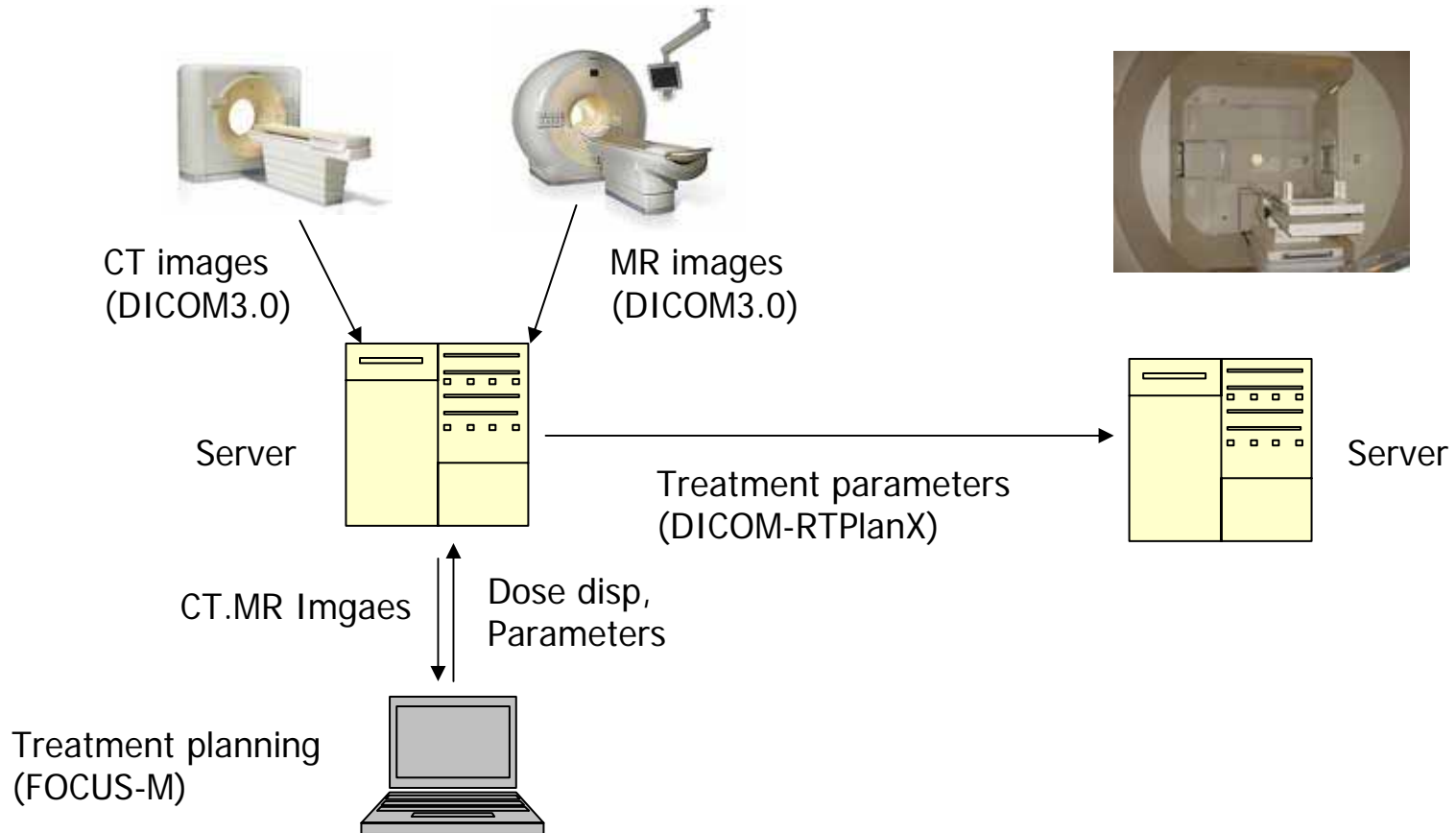




Treatment planning system

- planning software = FOCUS-M
 - GUI = FOUCS (CMS)
 - Beam design = MGH-proton
 - Dose engine = Pencil Beam algorithm (MELCO)
 - Data transfer = DICOM-RTPlanX (MELCO)

Treatment planning system





Application of G4 to Ion therapy

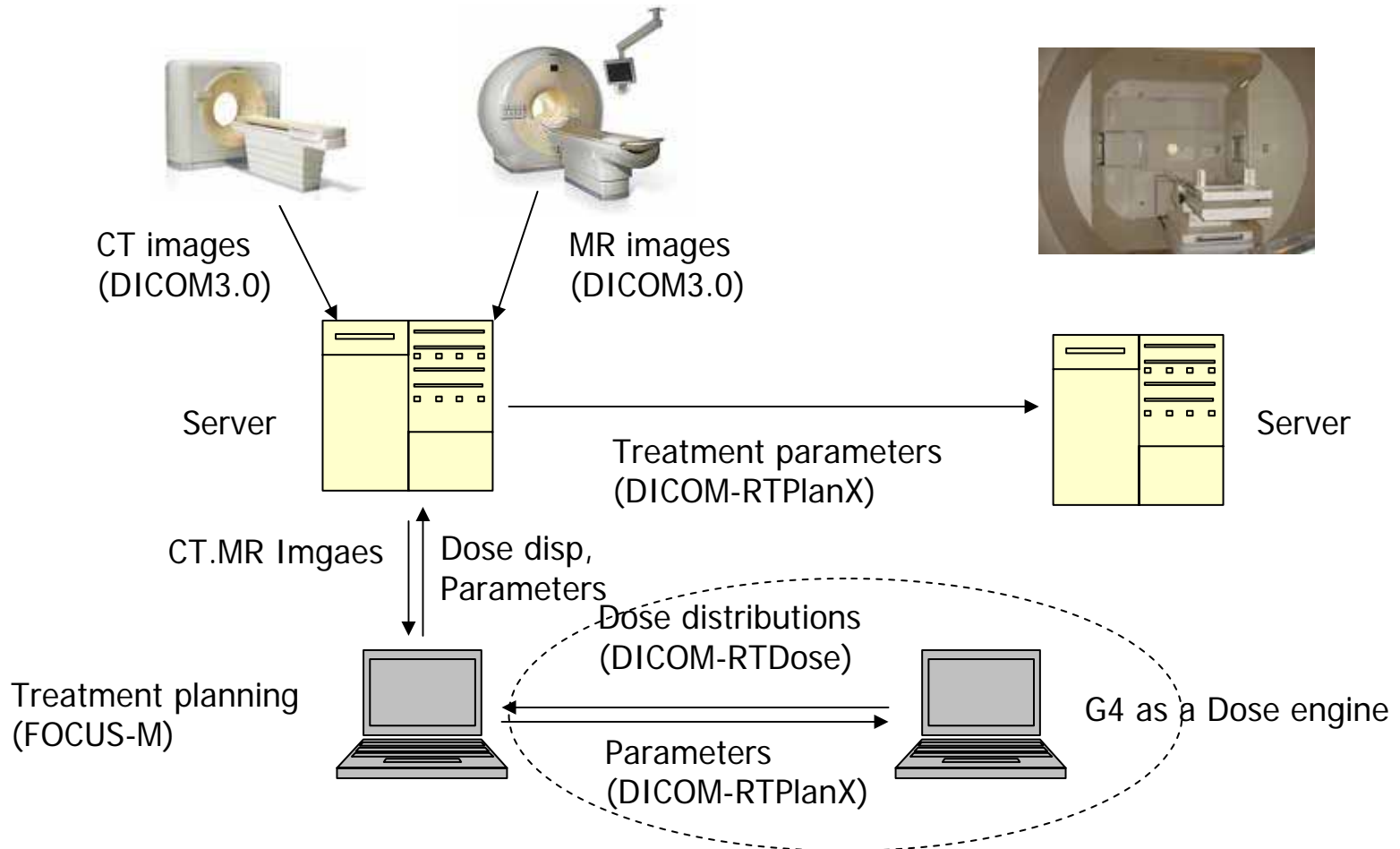
- Dose calculation in the patient
- Prediction of the machine output

Monte Carlo calculations for absolute dosimetry to determine machine outputs for proton therapy fields

H Paganetti 2006 *Phys. Med. Biol.* **51** 2801-2812

Treatment planning system

G4++





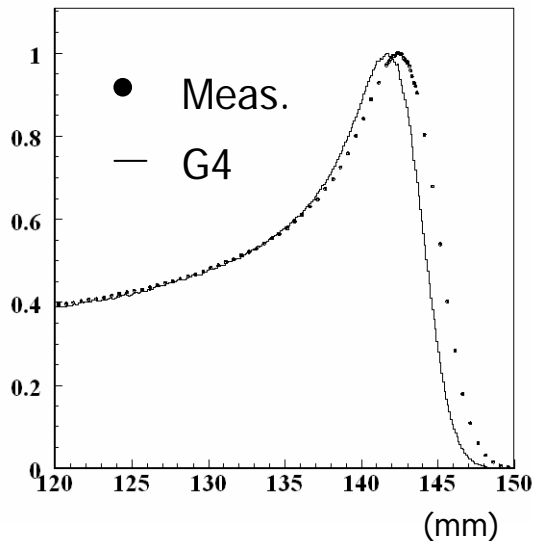
Verifications of G4 w/protons

- Physics
 - Energy loss (Range)
 - Nuclear Interactions
- DICOM-RT Interface
 - MLC
 - Range compensator (RC)

Bragg Peak

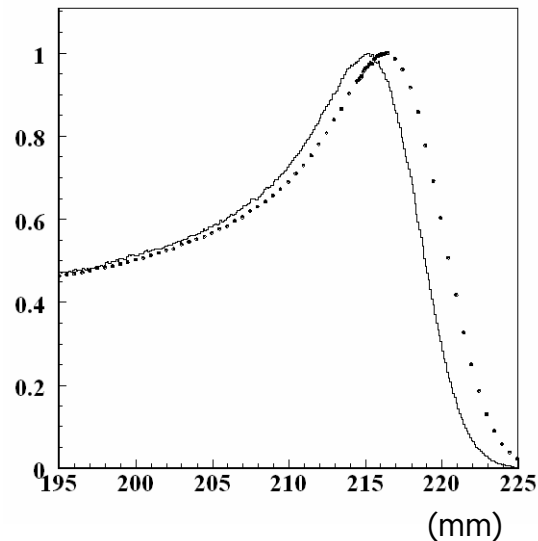
- full simulation in the nozzle and the water phantom

150MeV



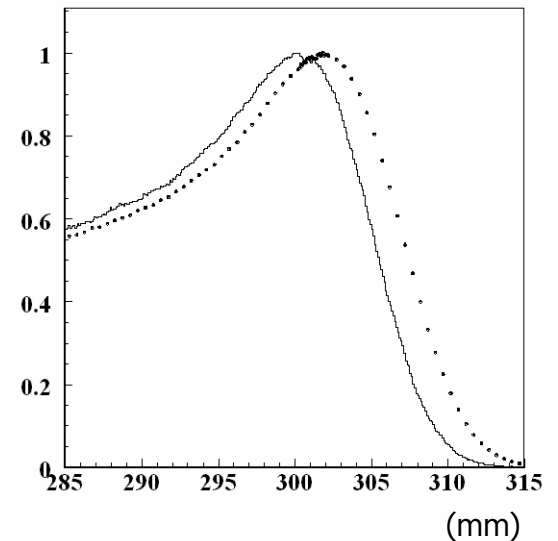
$R=0.74\text{mm}$

190MeV



$R=0.76\text{mm}$

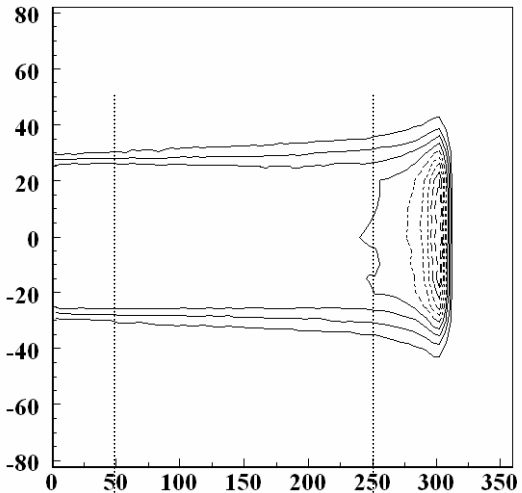
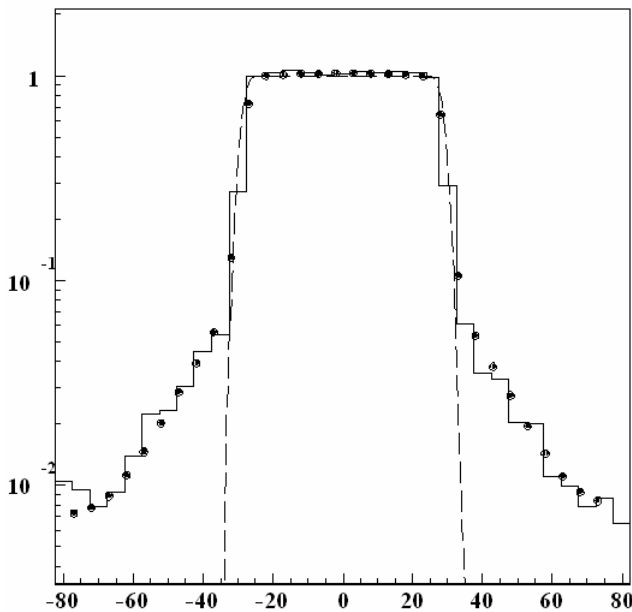
230MeV



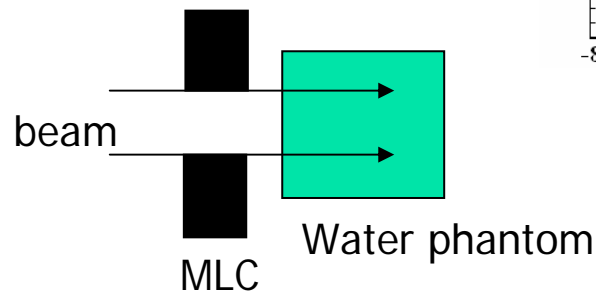
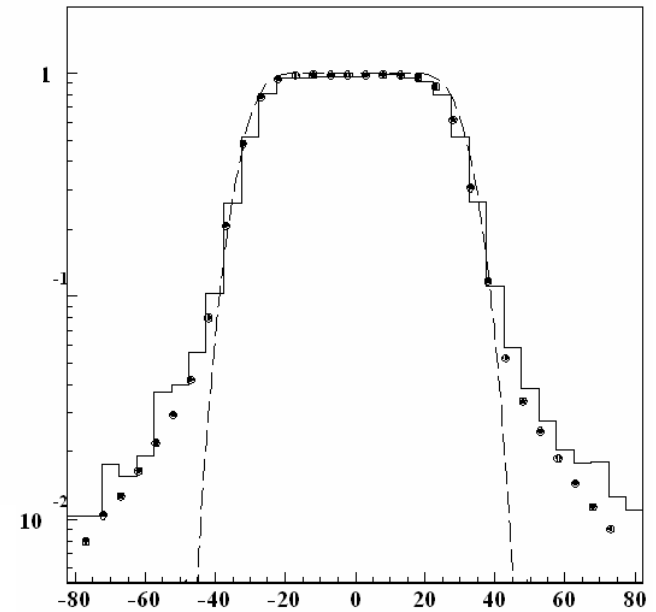
$R=1.47\text{mm}$

Effect of the Nuclear Interaction to Dose

50mm depth



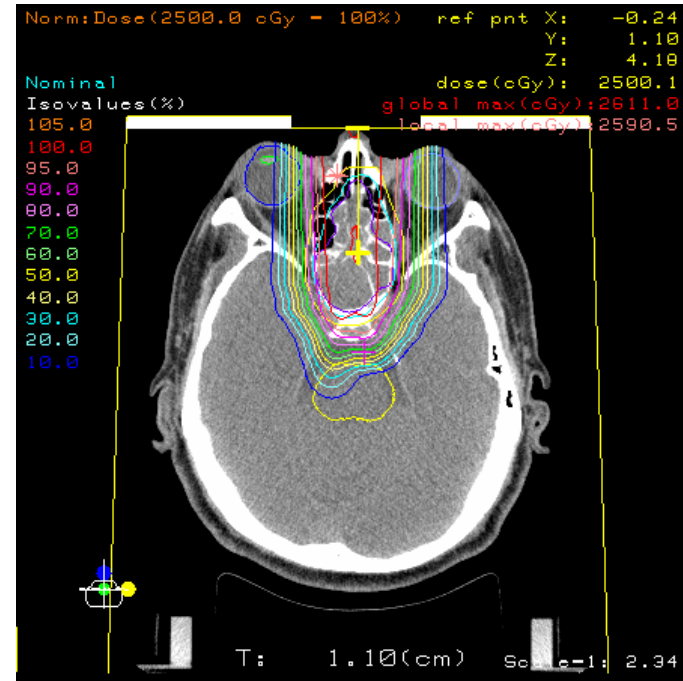
250mm depth



- : Measurements
- : TPS calculations
- : G4 (histograms)

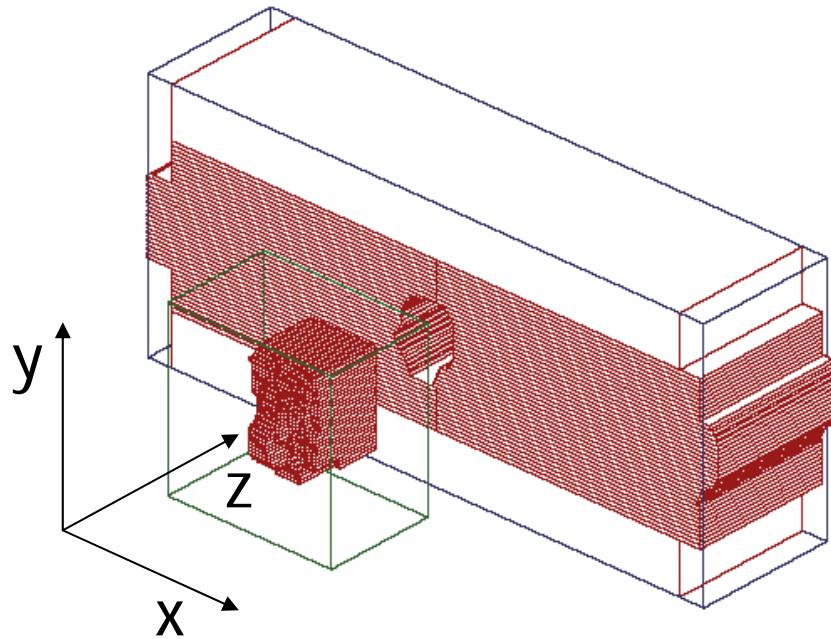
DICOM-RTPlanX Interface

- Sample patient
 - Head & Neck region
 - Gantry, 150MeV, SOBP70mm



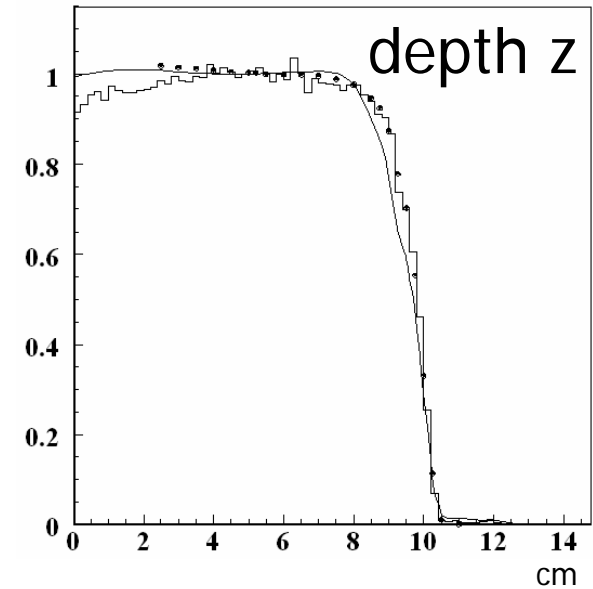
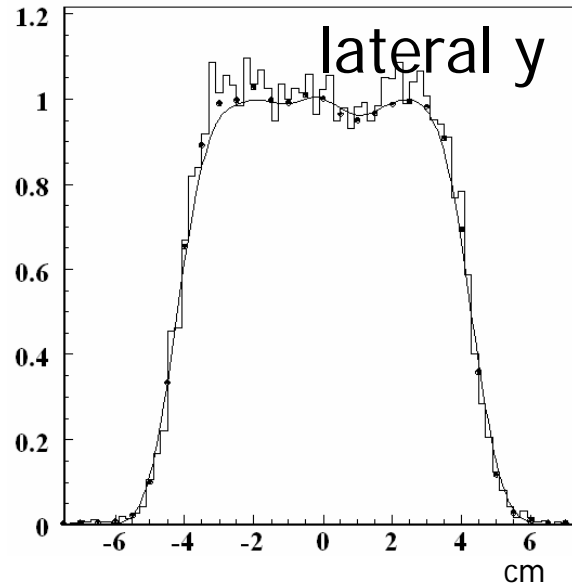
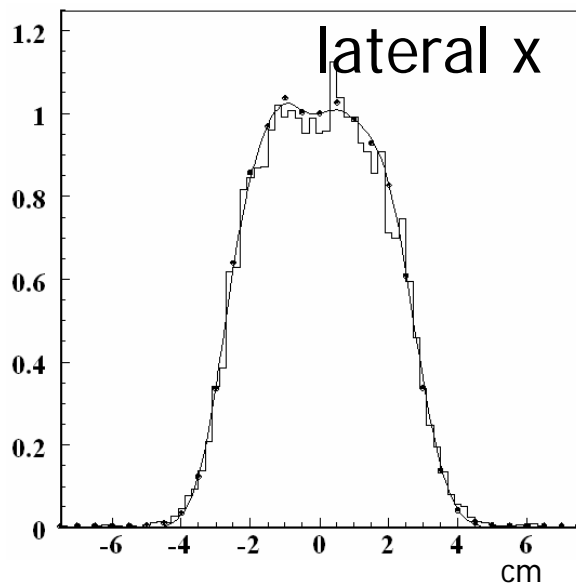
MLC, Range Compensator shapes

- Verification of the parameters transfer through RTPlanX



Dose distributions in water w/ the planned MLC and RC

Dose profiles on planes passing through the isocenter (0,0,5.2). The doses were normalized at the isocenter.



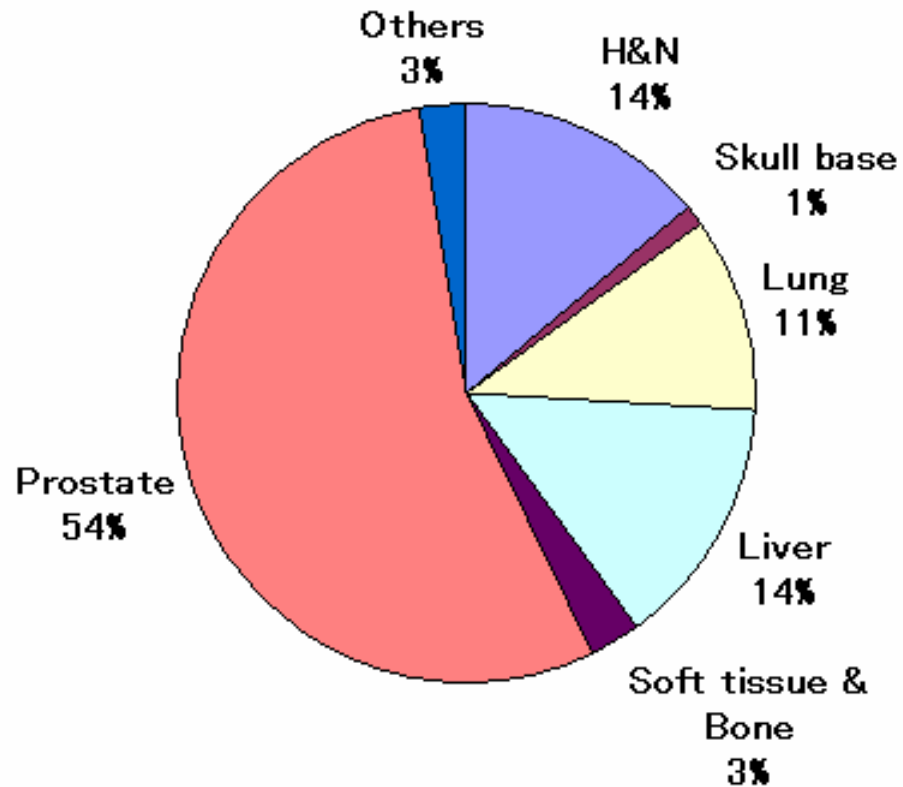
- : Measurements
- : TPS calculations
- : G4 (histograms)



Summary

- The Physics verifications of GEANT4 was done.
- The DICOM-RT interface was implemented, and works well.
- GEANT4 can be utilized to calculate dose distributions.

Anatomical sites treated (2003-2005)





Outcomes from the therapy

	H&N	Lung (stage-I)	Liver	Prostate	Skull Base
Local Control rate (4 years)	71%	97%	91%	99%	100%
Survival rate (4 years)	36%	75%	60%	98%	100%

M Murakami, News Letter I22,2006

<http://www.hibmc.shingu.hyogo.jp/aisatu/news/news22/index.html>