

Simulation of HIMAC beamline for heavy ion therapy

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Objective

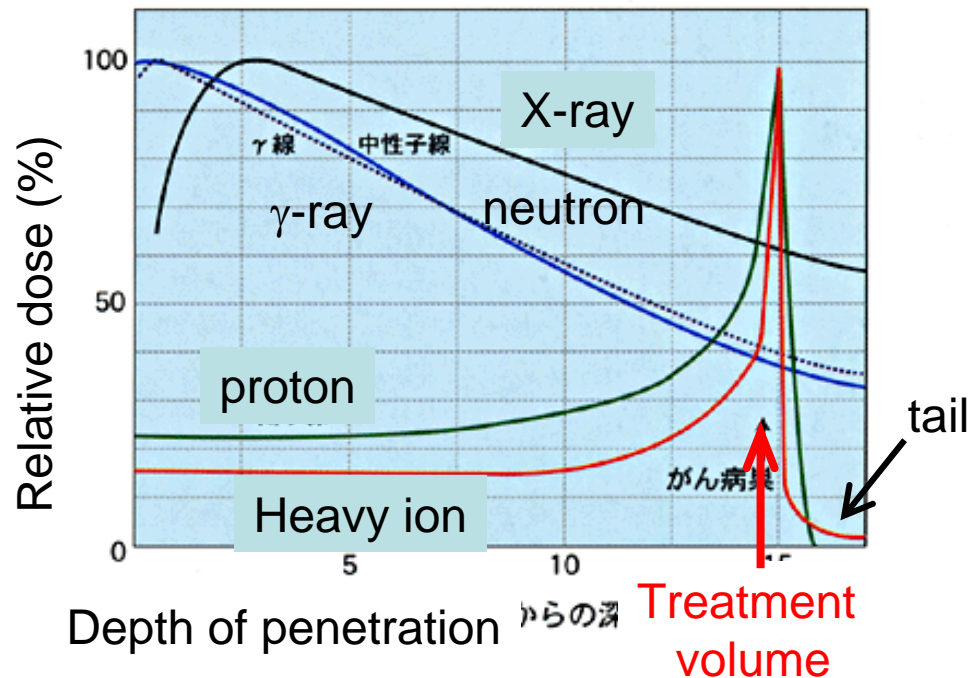
- To establish reliable simulation framework based on Geant4 for heavy ion therapy to extract the parameter of specialized instruments to optimize clinical effect (treatment planning)
- To implement the geometry of a heavy ion beamline of NIRS-HIMAC in Geant4, and assess the usability of the simulator through comparison with experimental data

Radiation therapy (of cancer)

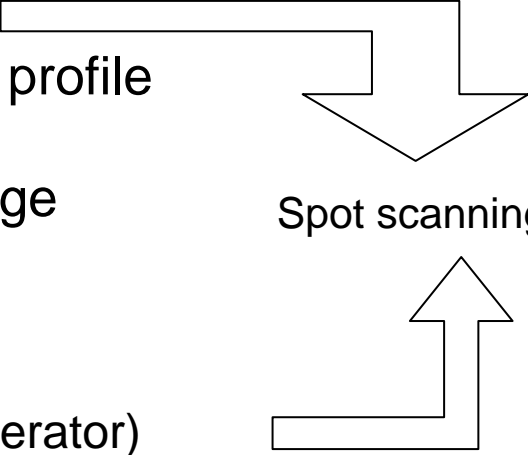
- Important 'local treatment' (as well as surgery)
- Photon beam (X-ray or gamma ray)
 - Flux attenuates exponentially in matter with increasing depth
- Unavoidable exposure of surrounding normal tissue limits tolerable dose

Physical (dis)advantage of heavy ion beam

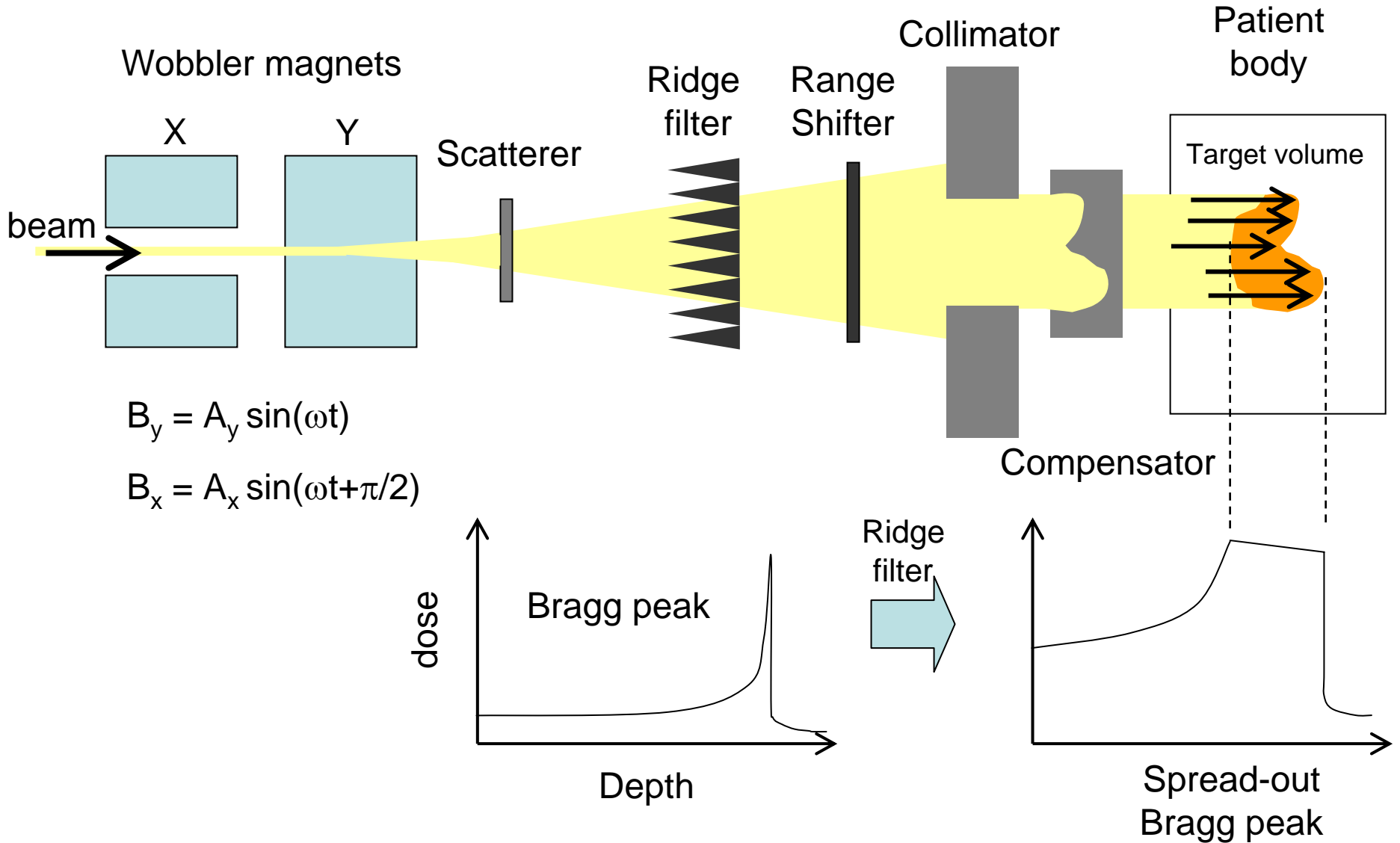
- Dose-localizing capability (Bragg peak)
- High biological effect (cell-killing capability)
- Beam fragmentation



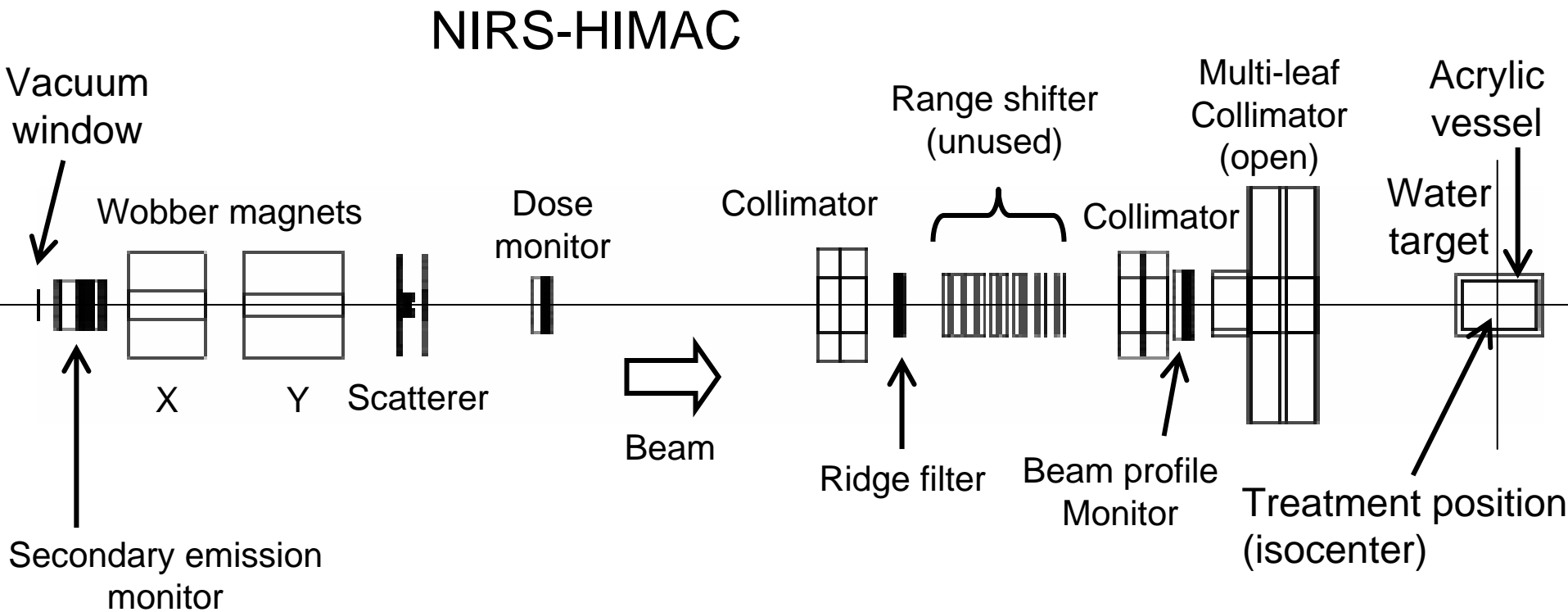
Instruments for heavy ion therapy

- Devices to spread beam laterally
 - Broad beam method (describe in the next slide ...)
 - Wobbler magnet
 - Scatterer
 - Dynamic beam delivery
 - Devices to shape lateral beam profile
 - Collimator
 - Devices to modulate beam range
 - Range shifter
 - Ridge filter
 - Compensator (Bolus)
 - Dynamic modulation (by accelerator)
 - Detector
 - Dosimeter
 - Beam profile monitor
- 
- The diagram consists of two large, hollow, L-shaped arrows. The top arrow points downwards and to the left, with the text 'Spot scanning method' positioned to its right. The bottom arrow points upwards and to the left, with the text 'Spot scanning method' positioned to its left. These arrows are positioned between the 'Dynamic beam delivery' and 'Collimator' items of the first list and the 'Range shifter' through 'Dynamic modulation' items of the second list.

Broad beam method



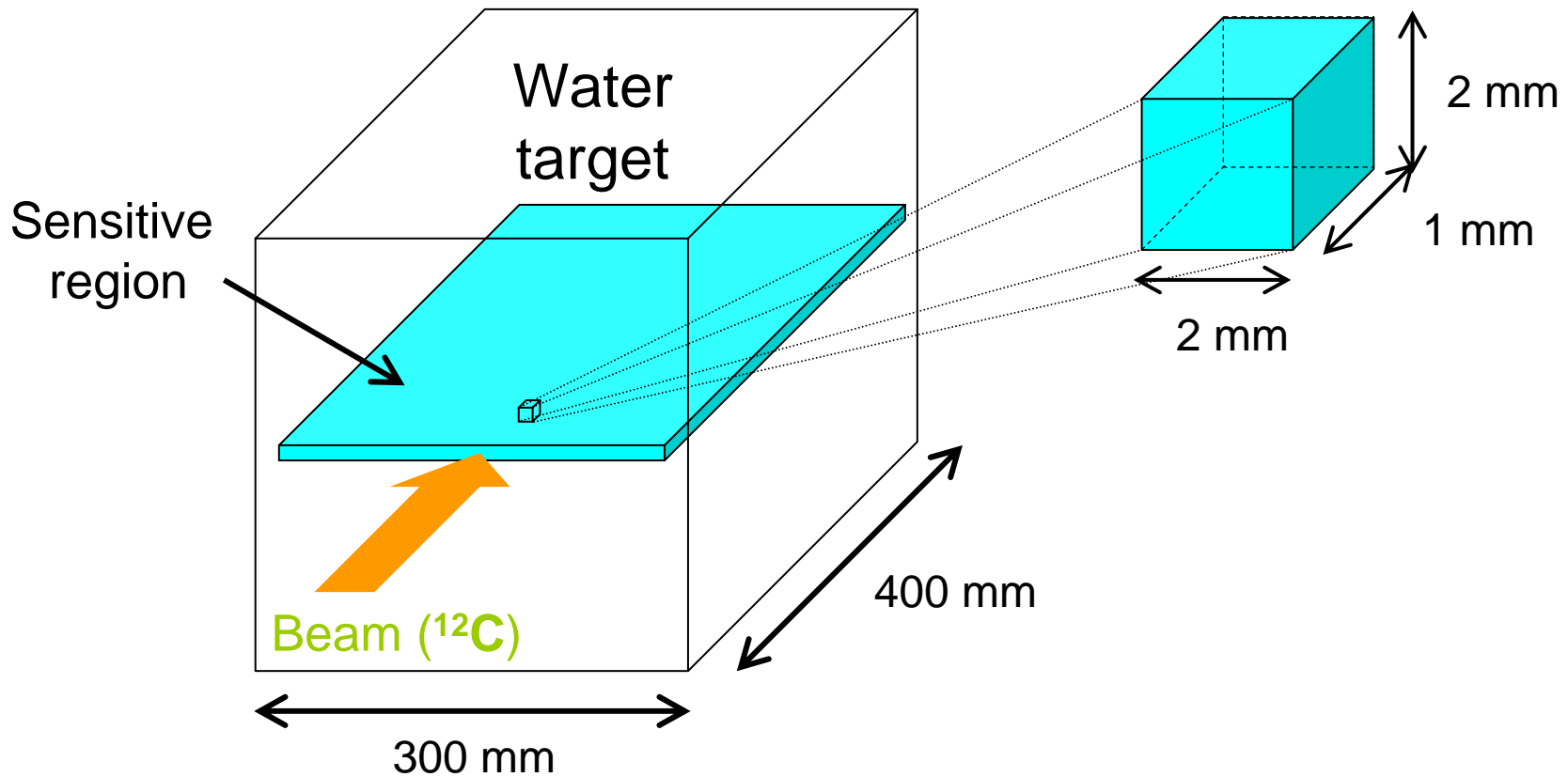
Experimental setup / Geometry implementation in Geant4 simulation



Physics configuration in Geant4

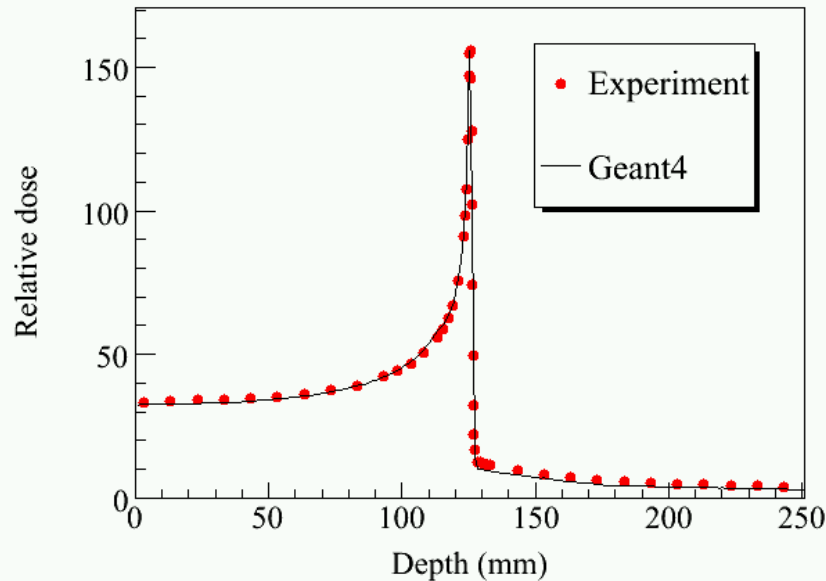
- Ions
 - Ionization (G4hLowEnergyIonization)
 - Multiple scattering (G4MultipleScattering)
 - Inelastic (G4BinaryLightIonReaction)
 - Radioactive Decay (if decay scheme data are available)
- Other particles
 - Standard EM
 - Hadron physics etc ...
- Production cut = 0.01 mm

Target / sensitive detector



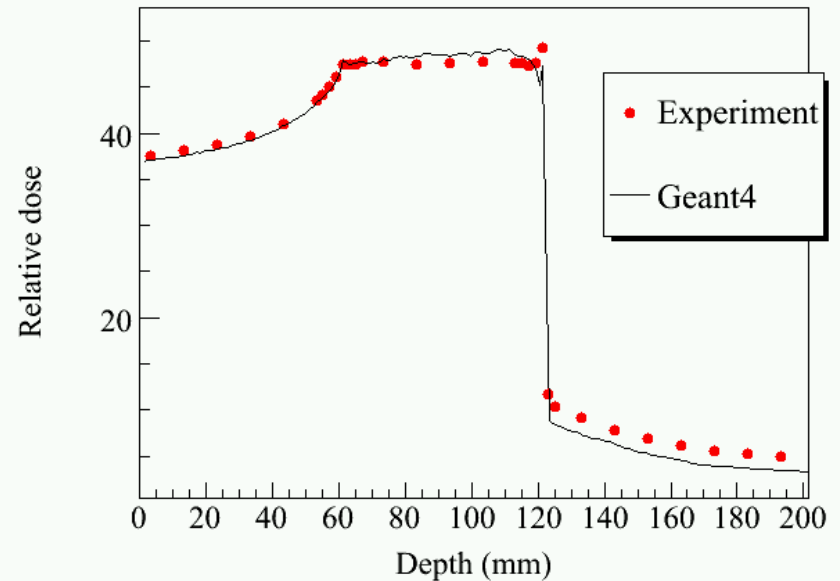
Results (^{12}C 290 MeV/n)

Single Bragg peak
wo/ ridge filter



Offset = - 0.8 mm

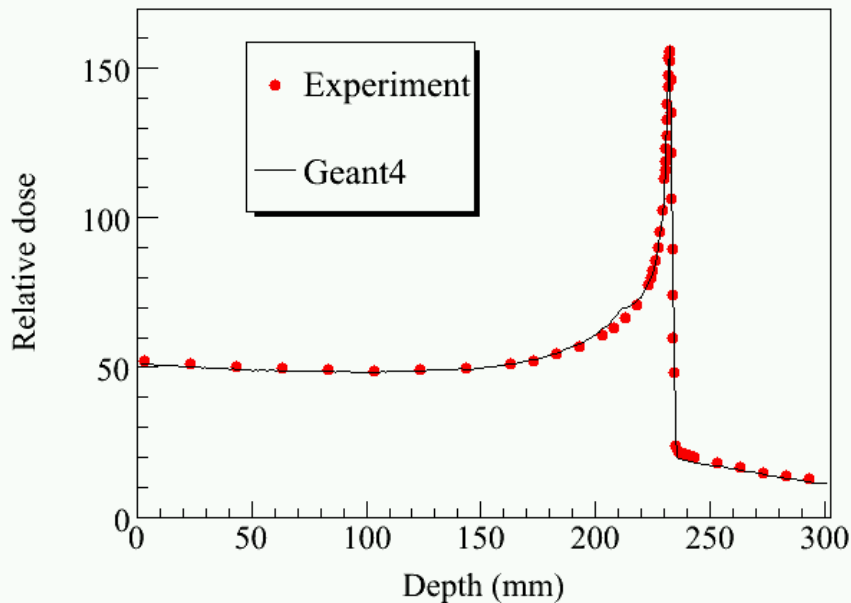
Spread-out Bragg peak
w/ ridge filter



Offset = -1.0 mm

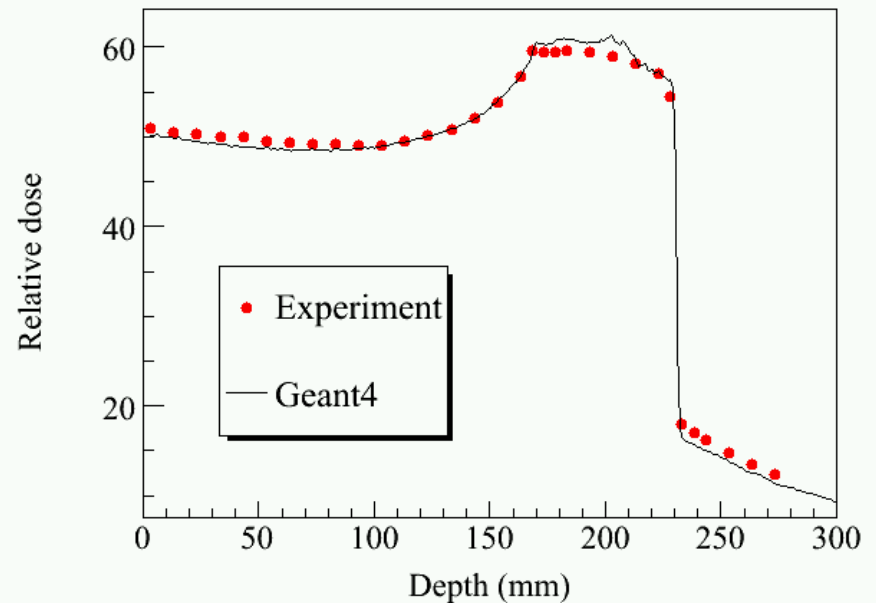
Results (^{12}C 400 MeV/n)

Single Bragg peak
wo/ ridge filter



Offset = -1.2 mm

Spread-out Bragg peak
w/ ridge filter



Offset = -2.8 mm

Summary

- Geometry of new beamline of NIRS-HIMAC was implemented in Geant4.
- (Single) Bragg peak is well reproduced by Geant4 simulation
- Geant4 tends to underestimate the beam fragmentation cross section.
- Further investigation is required to validate physics models for heavy ion reaction in Geant4

Spare

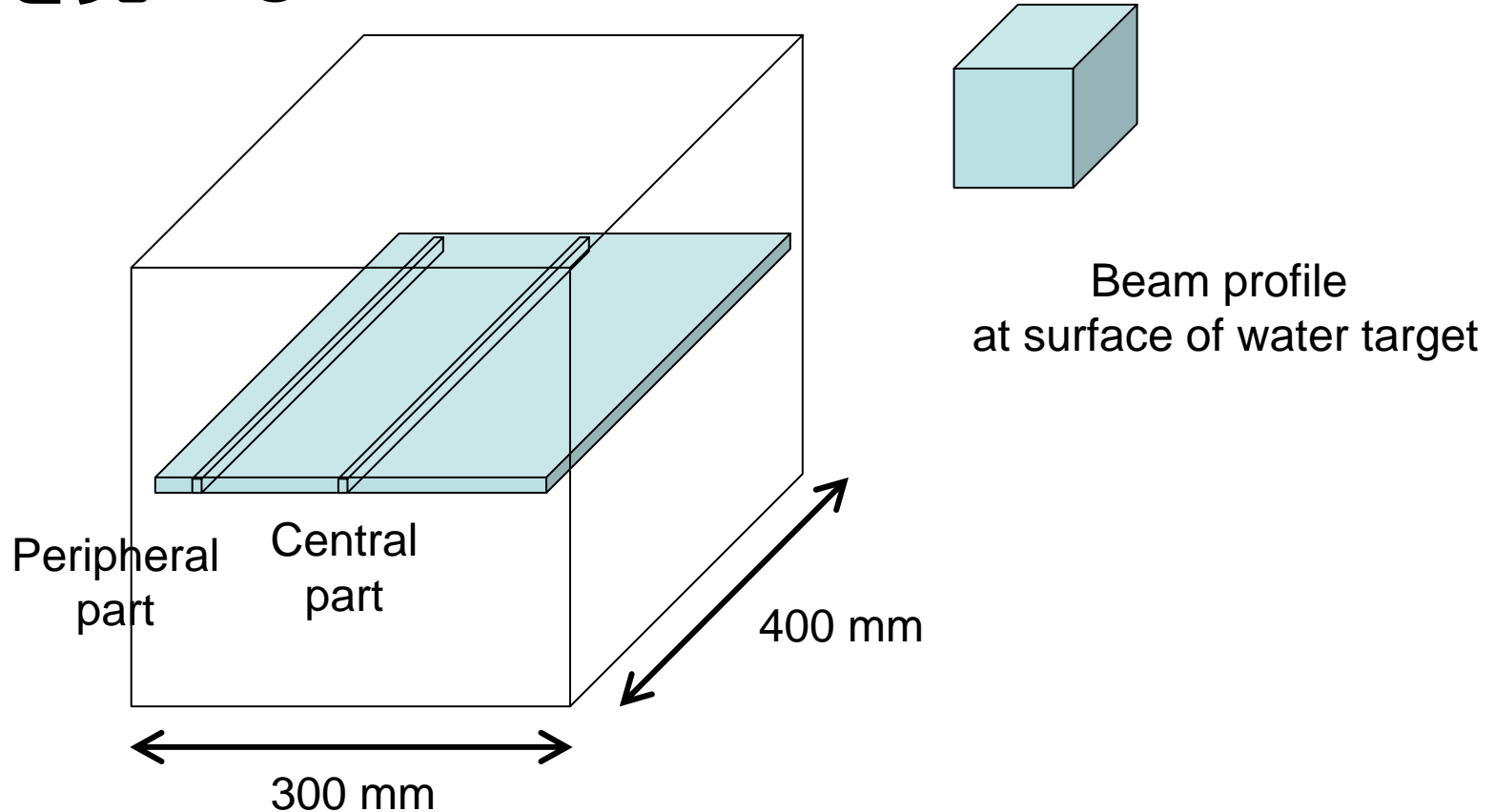
OHPs

Wobbler-scatterer system

- Wobbler magnets + scatterer + ridge filter

Results

- この絵と一緒に(isocenterでの) beam profile
を見せる



Implementation of the beamline geometry in the simulation

- Show the output of viewer

