MAYO CLINIC

A hybrid method calculating linear energy transfer for intensity modulated proton therapy

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ENSAR2 workshop: GEANT4 in nuclear physics
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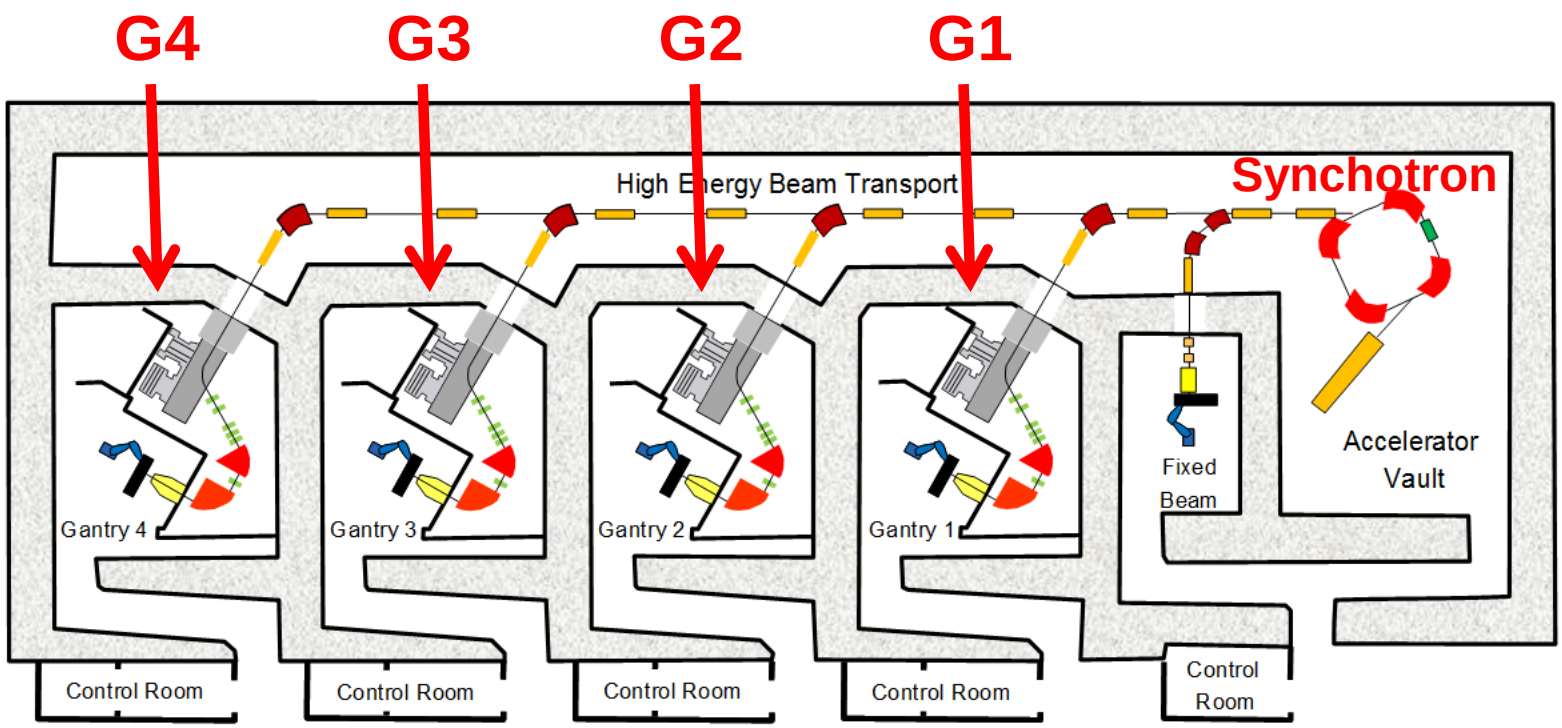
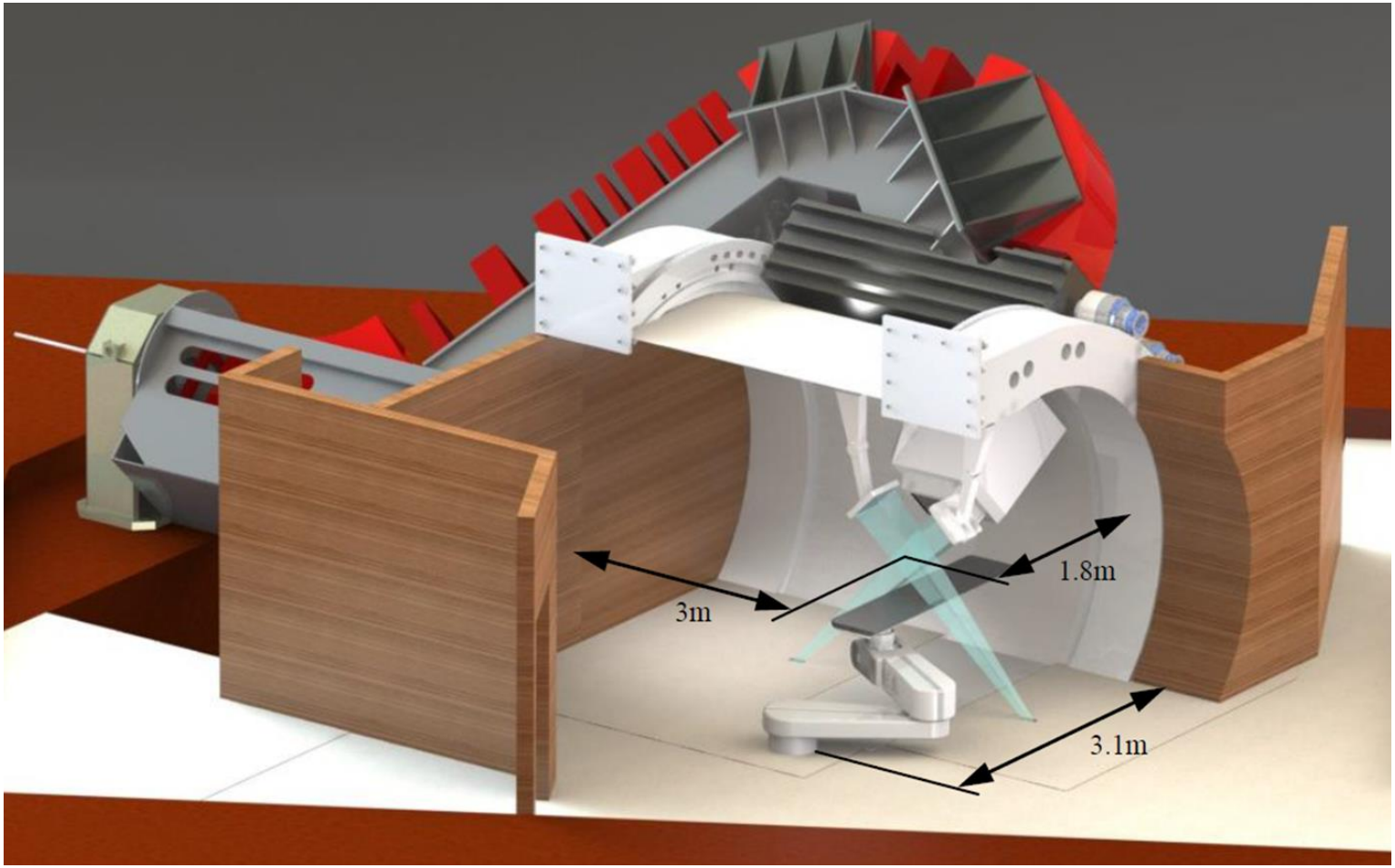
Facility Layout



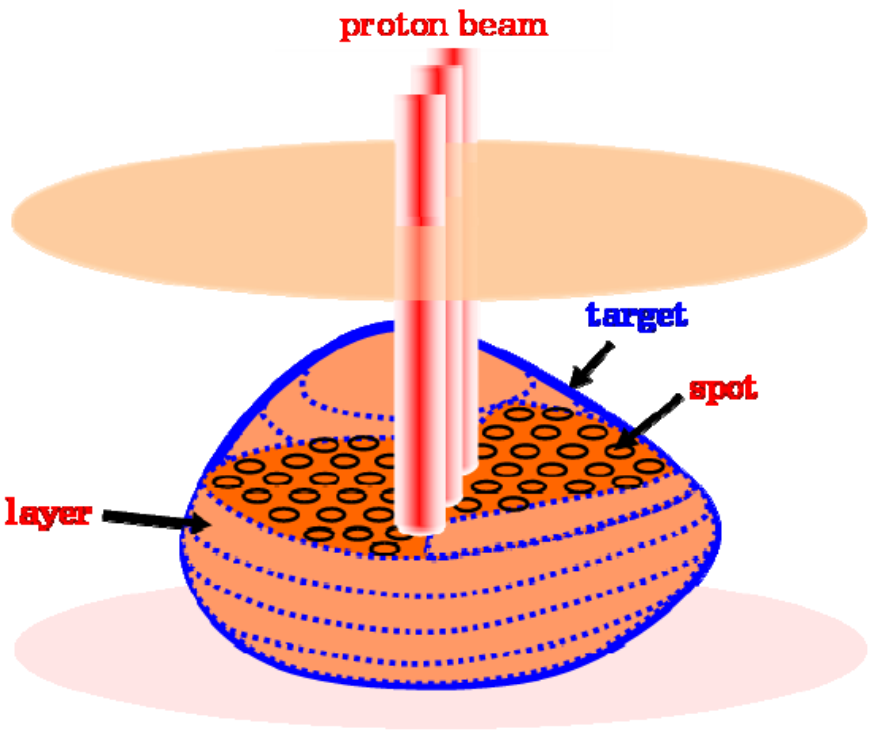
Treatment Room



Daniel Robertson

Pencil Beam Scanning

- Layer by layer (energy switching)
- Spot by spot (magnetic deflection)



Linear Energy Transfer (LET) calculation

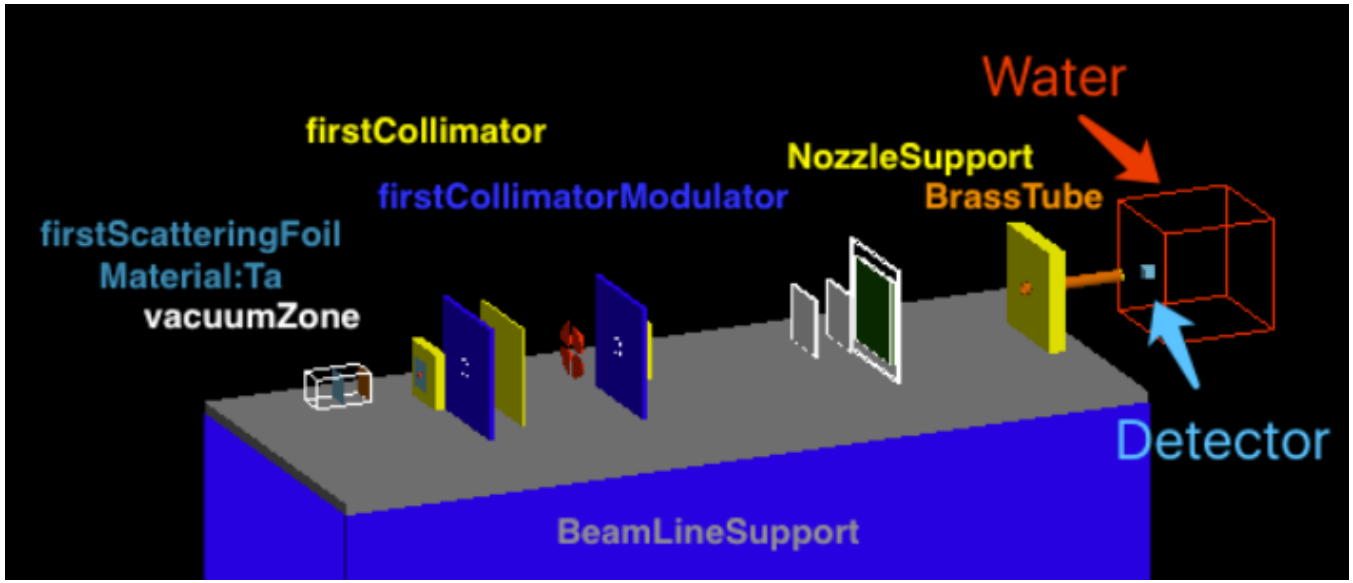
- LET is one of the important factors in determining the biological effects of proton radiation therapy
- No commercial Treatment Planning System (TPS) offers an LET calculation
- We developed a hybrid method to calculate LET distributions in real patient geometries
- The hybrid method was implemented in our in-house TPS and has been in routine clinical use for 2 years

Hybrid method to calculate LET

- Developed a Geant4 MC code to model the proton therapy nozzle
- Generated the LET kernels by the MC code
- Incorporated the kernels into our in-house treatment planning system

Developed a Geant4 MC code

1. Started from an example (hadrontherapy) from the Geant4 example set
2. Wrote the geometry (proton nozzle) based on the vendor's documentation
3. Default physics model QGSF_BIC_EMY
4. Parameterized proton source (energy, momentum, position) to match measurement
5. Validated the MC code by measurement (IDD, profile, and FSF)



hadrontherapy

AUTHORS:

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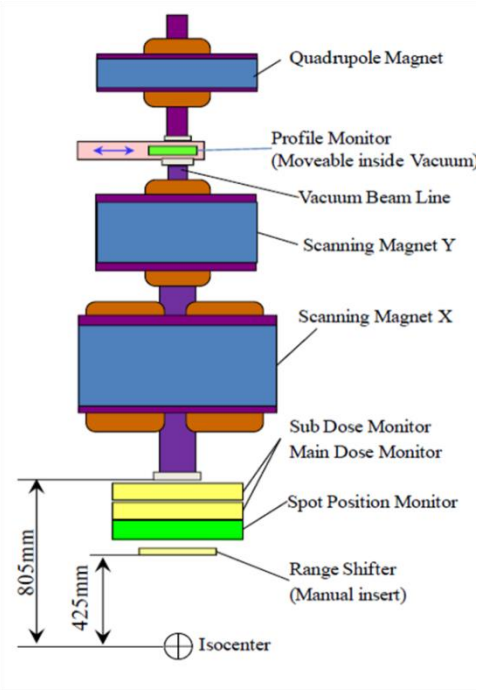
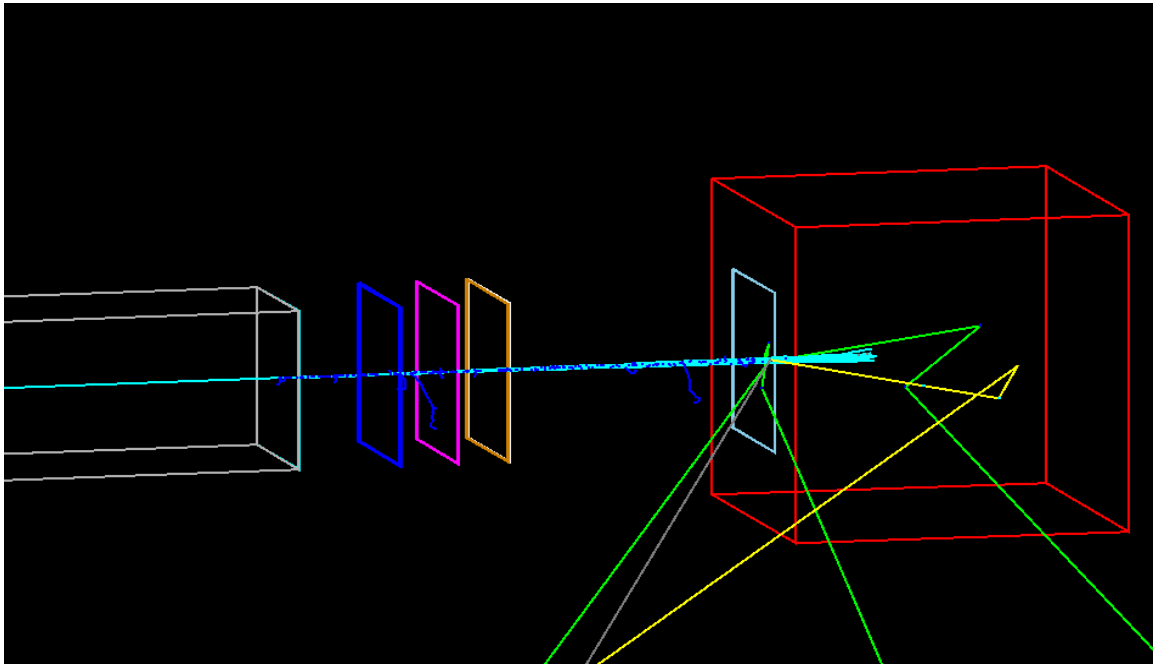
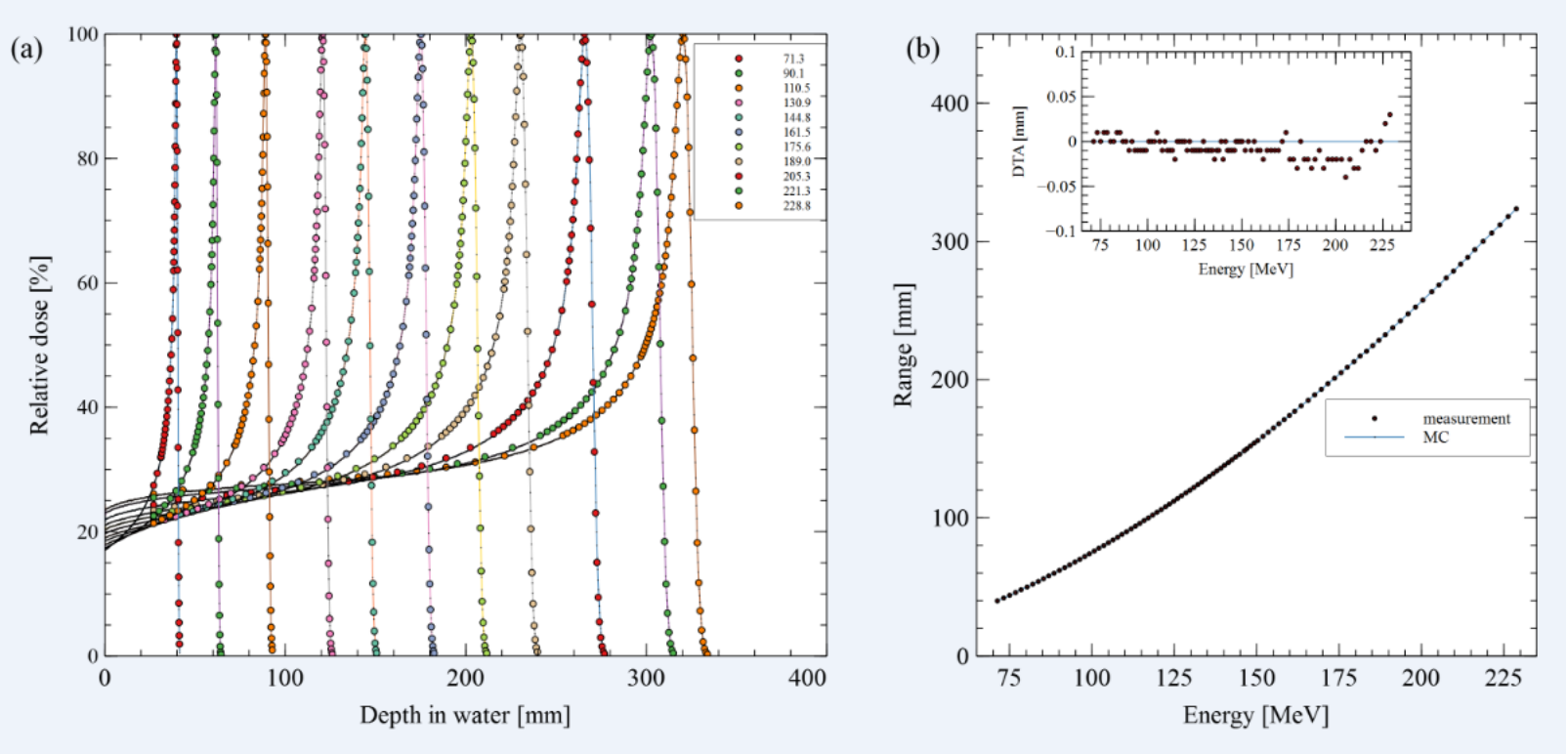
Mayo Clinic proton nozzle



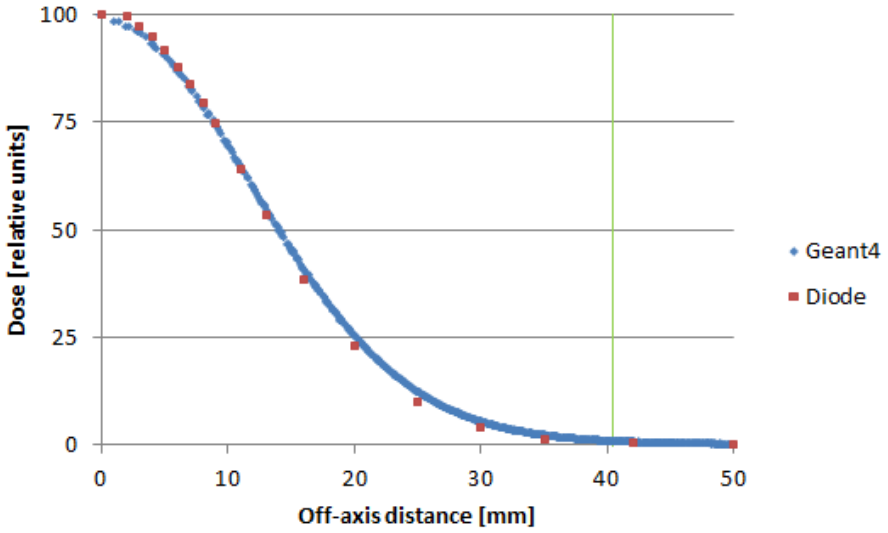


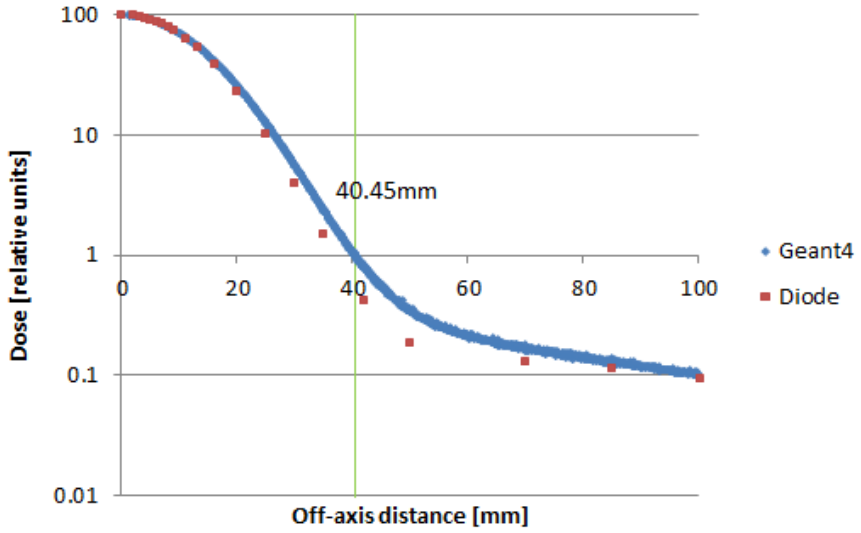
[1] G.A. Pablo Cirrone, Giacomo Currone, Franceso Di Rosa, Santi E. Mazzaglia, Francesco Romano, Andrea Attili, Faiza Bourhaleb, Germano Russo, Pekka Kataniemi, Aatos Heikkinen, Flavio Marchetto and Shin Jungwook. Hadrontherapy: An open source, Geant4-based application for proton-ion therapy studies, 2009 IEEE nuclear Science Symposium Conference Record

Validation by measurement:
(1) IDD comparison



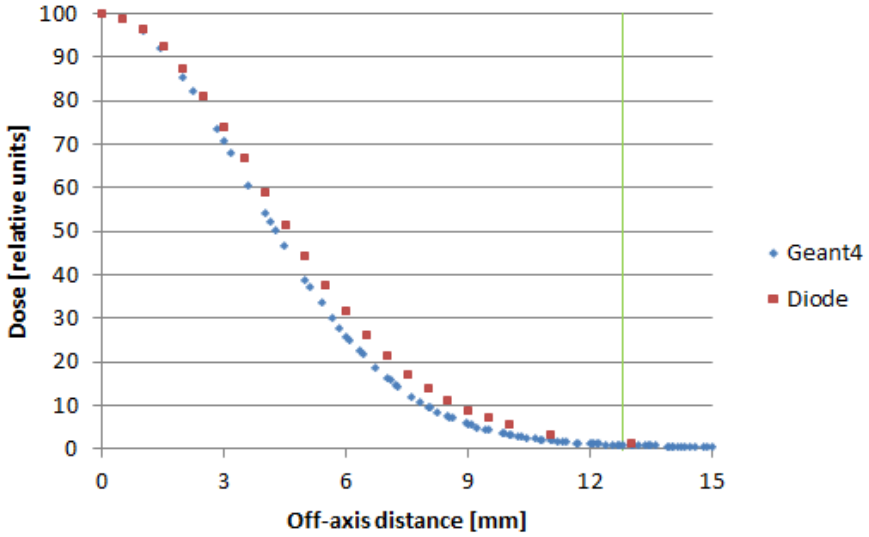
Validation by measurement:
(2) In-air profile comparison

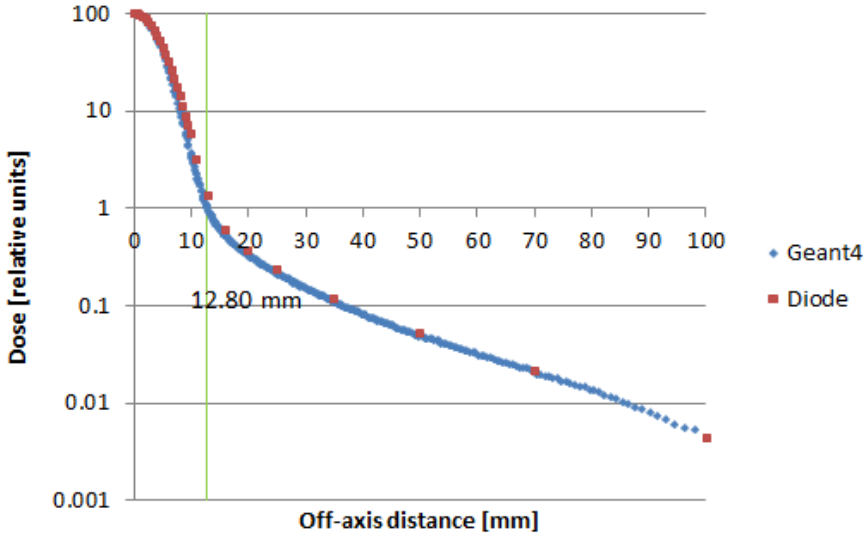




90.1 MeV with RS-45 @ Isocenter

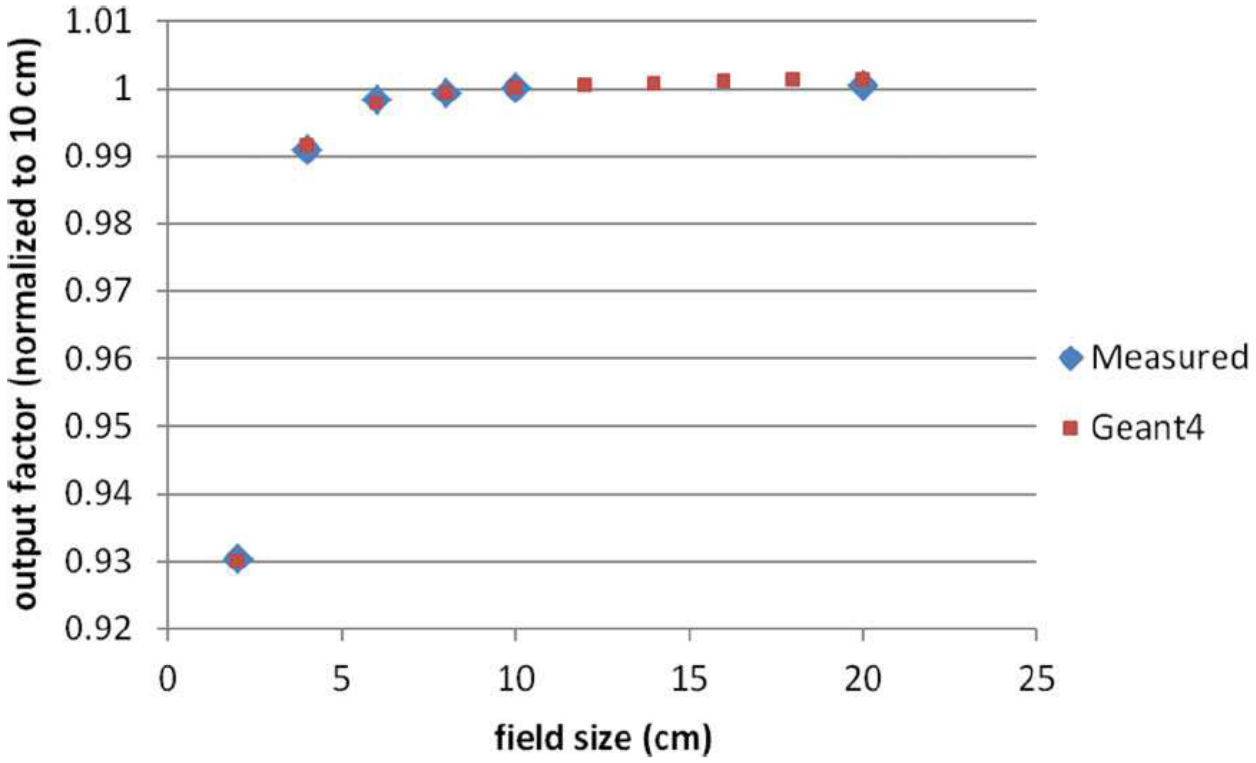
Validation by measurement:
(3) In-water profile comparison



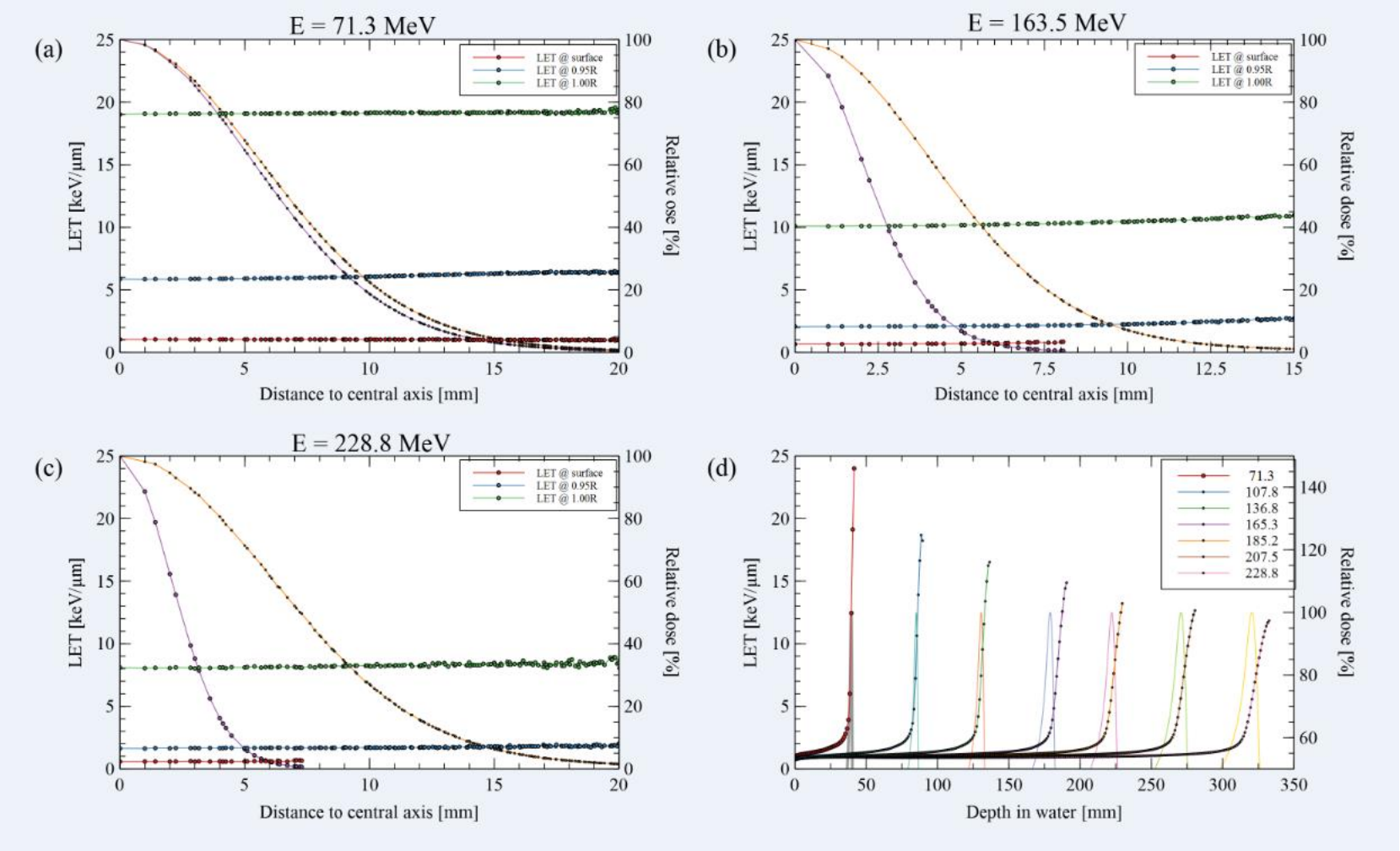


228.8 MeV @ depth 210.5 mm

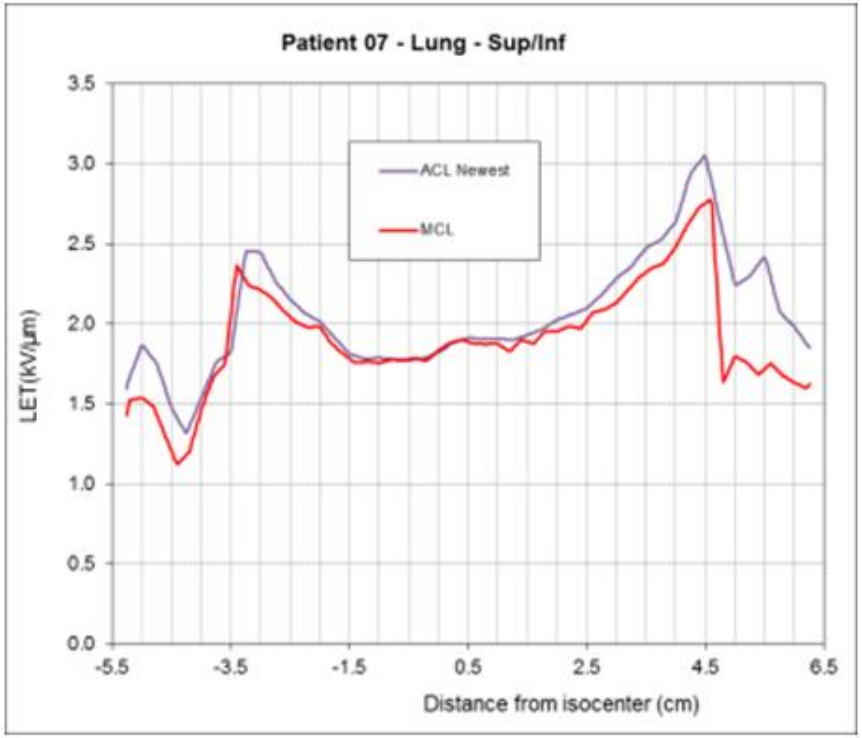
Validation by measurement:
(4) FSF comparison



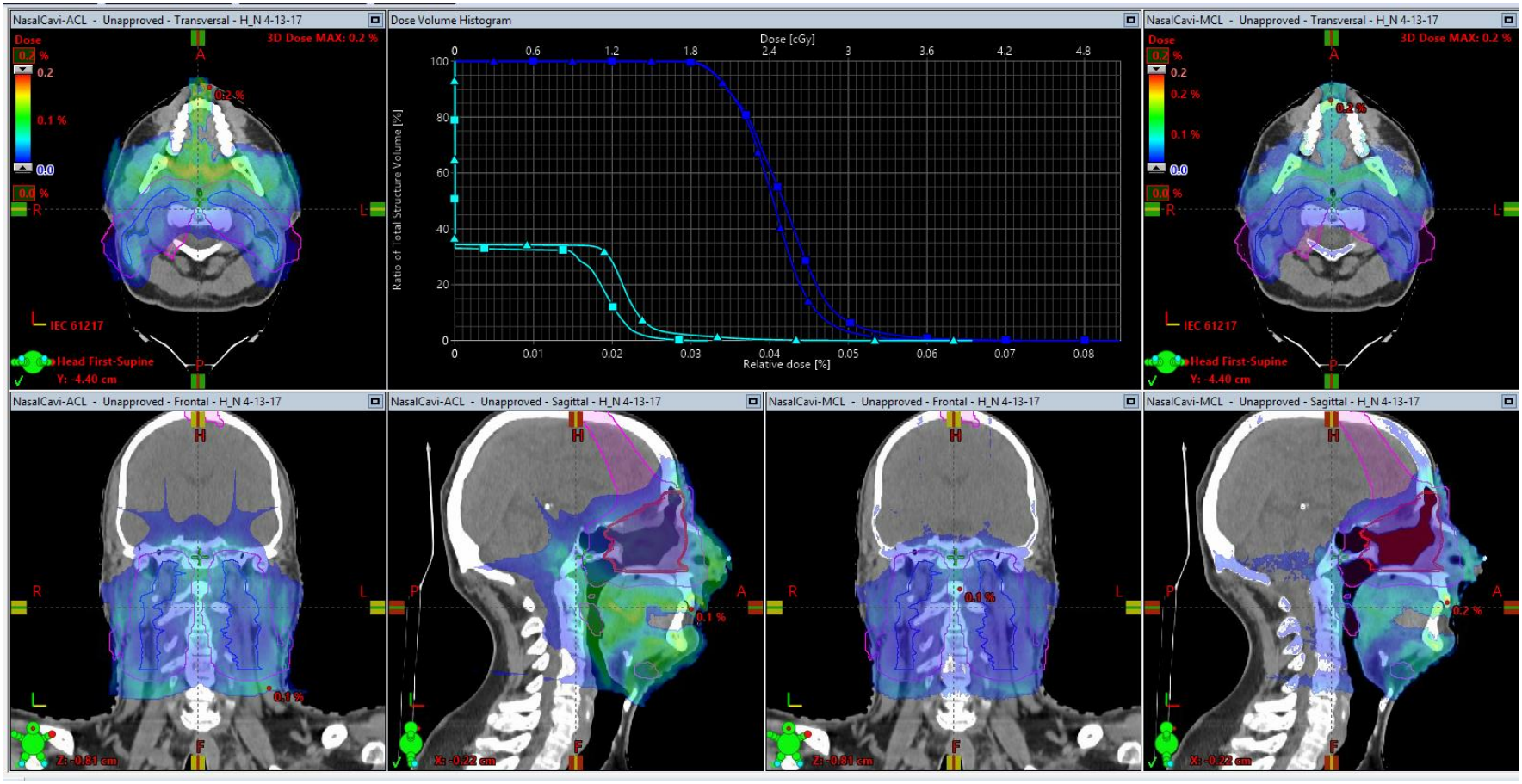
Generation of LET kernels (LET_d)



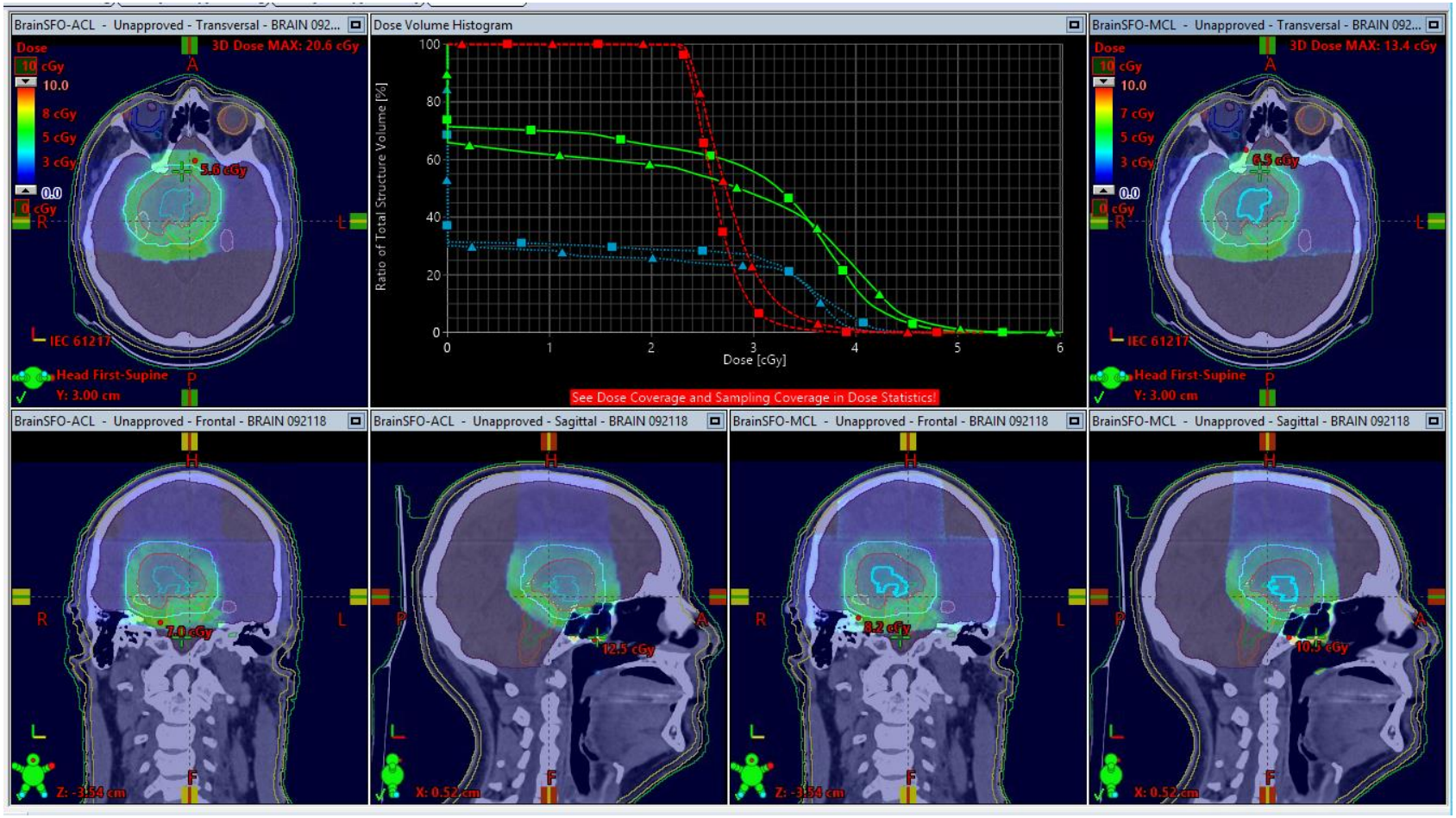
Comparison between hybrid and MC:
(1) Two lateral profiles through a lung tumor



Comparison between hybrid and MC:
(2) LET deposition and LET-volume histograms for a H-N case



Comparison between hybrid and MC:
(3) LET deposition and LET-volume histograms for a Brain case



Conclusions

- Geant4 MC code can be used to calculate LET data for proton radiation therapy
- The hybrid method can be used to calculate LET distribution for real patient geometry accurately and efficiently

Questions & Discussion