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

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# Linear Energy Transfer (LET) calculation

- LET is one of the important factors in determining the biological effects of proton radiation therapy[1,2]
- 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

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[1] JJ Wilkens, U Oelfke, Z Med Phys, 14 (2004) 41-46.
[2] D Sanchez-Parcerisa, MA Cortes-Giraldo, D Dolney, et. al., Phys Med Biol, 61 (2016) 1705-1721.

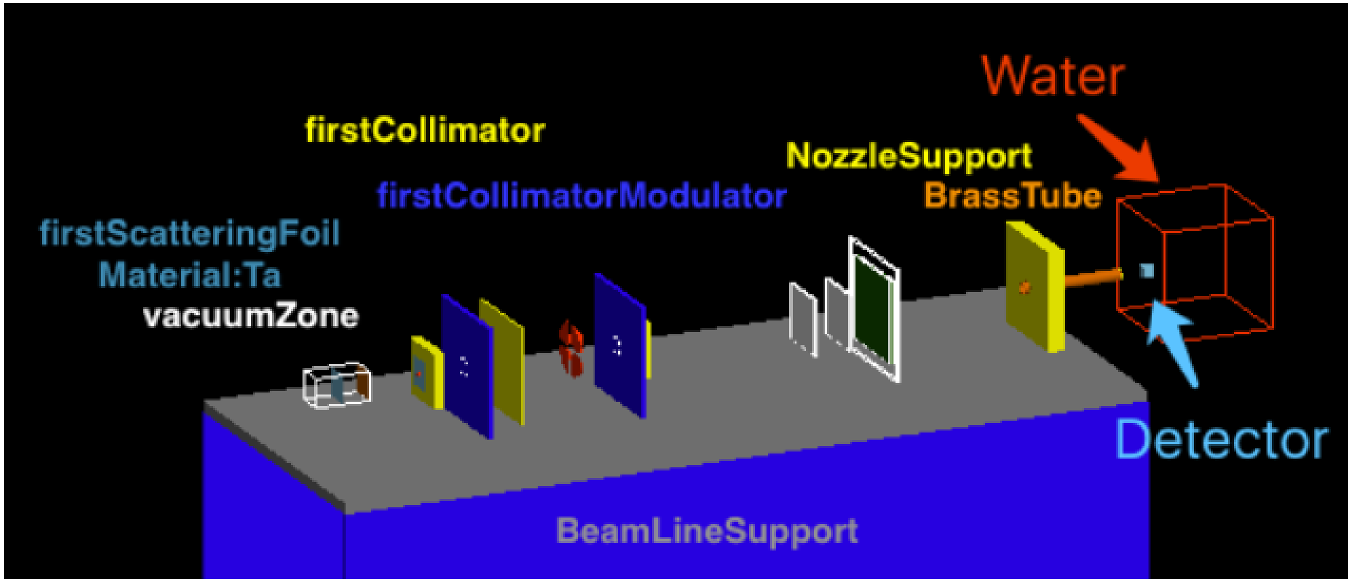
# Hybrid method to calculate LET

- 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

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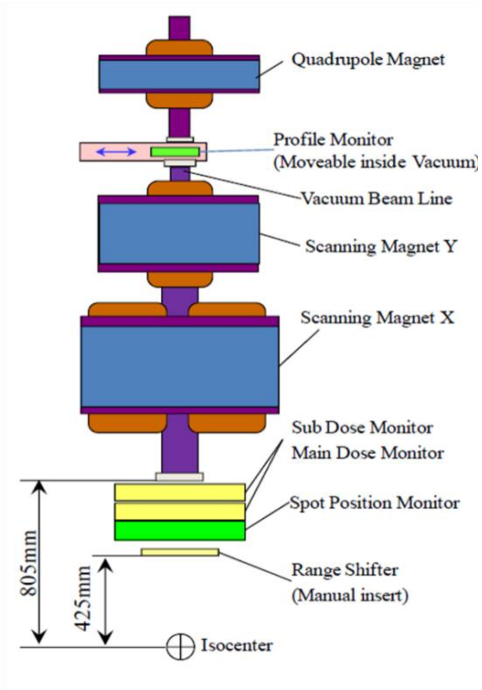
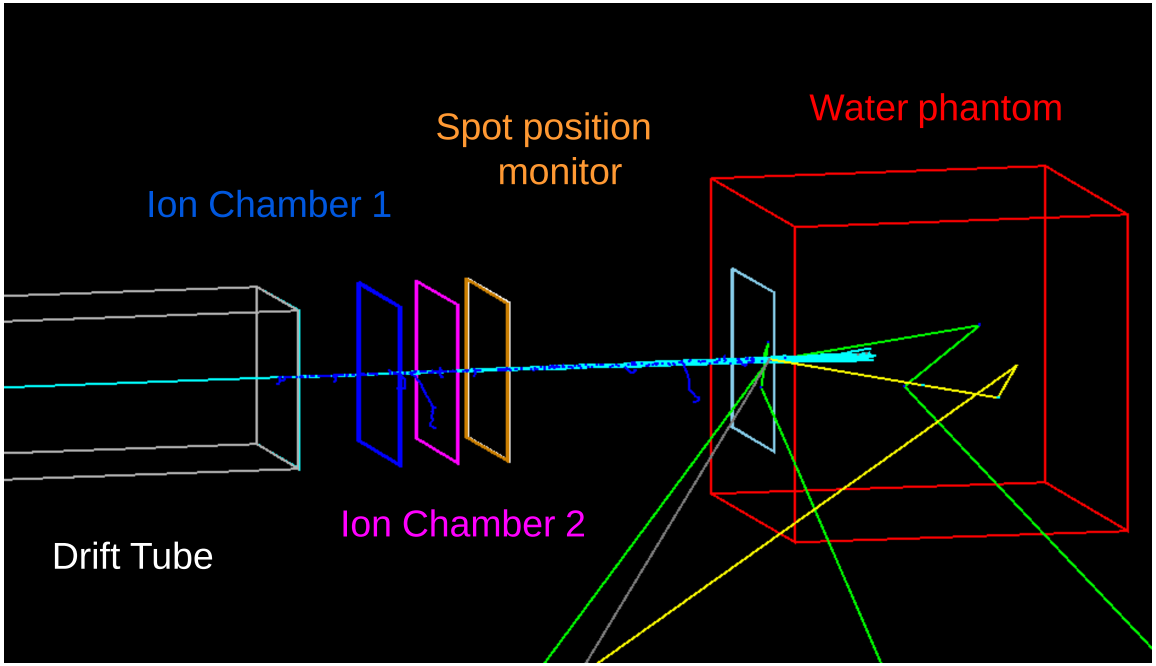
# Mayo Clinic proton nozzle



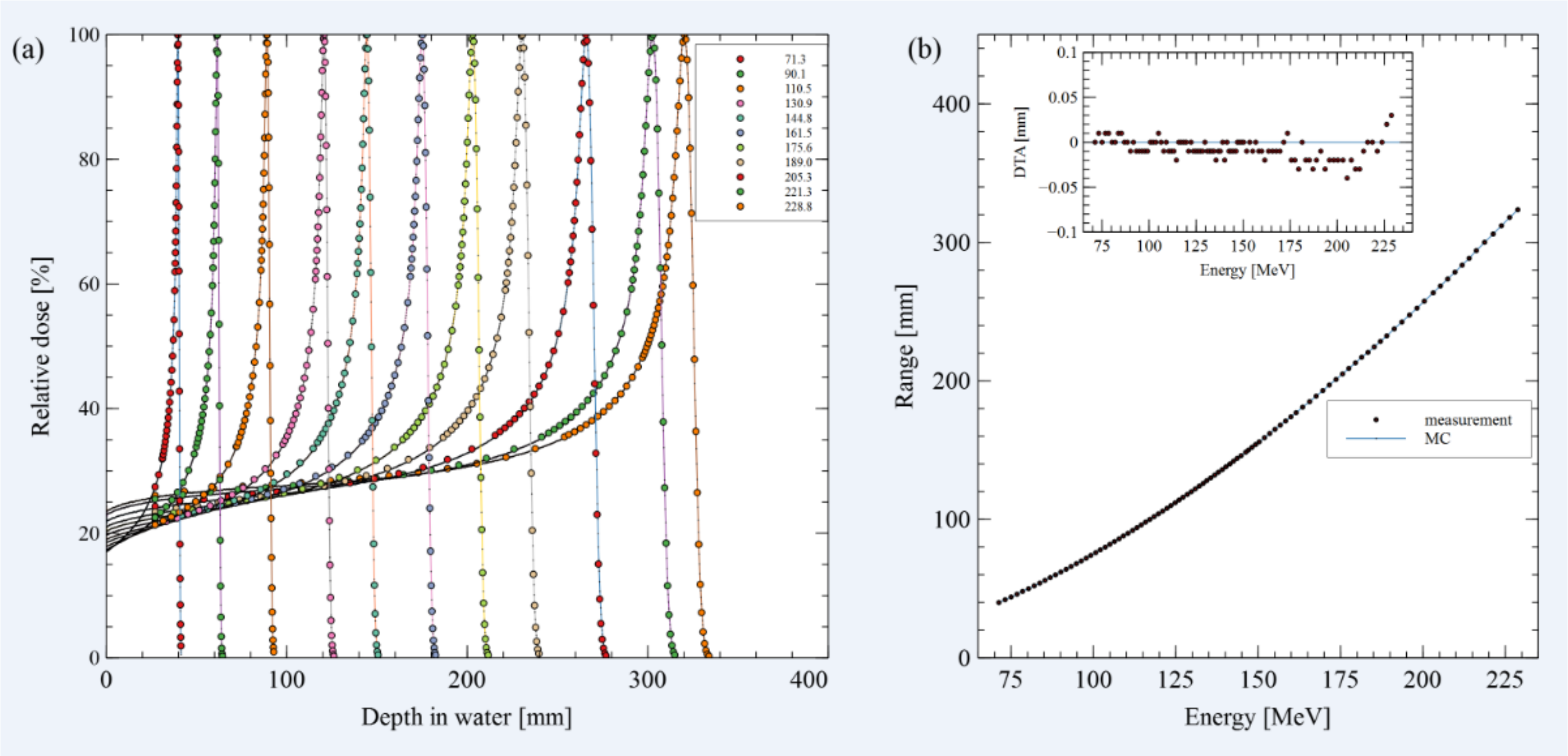





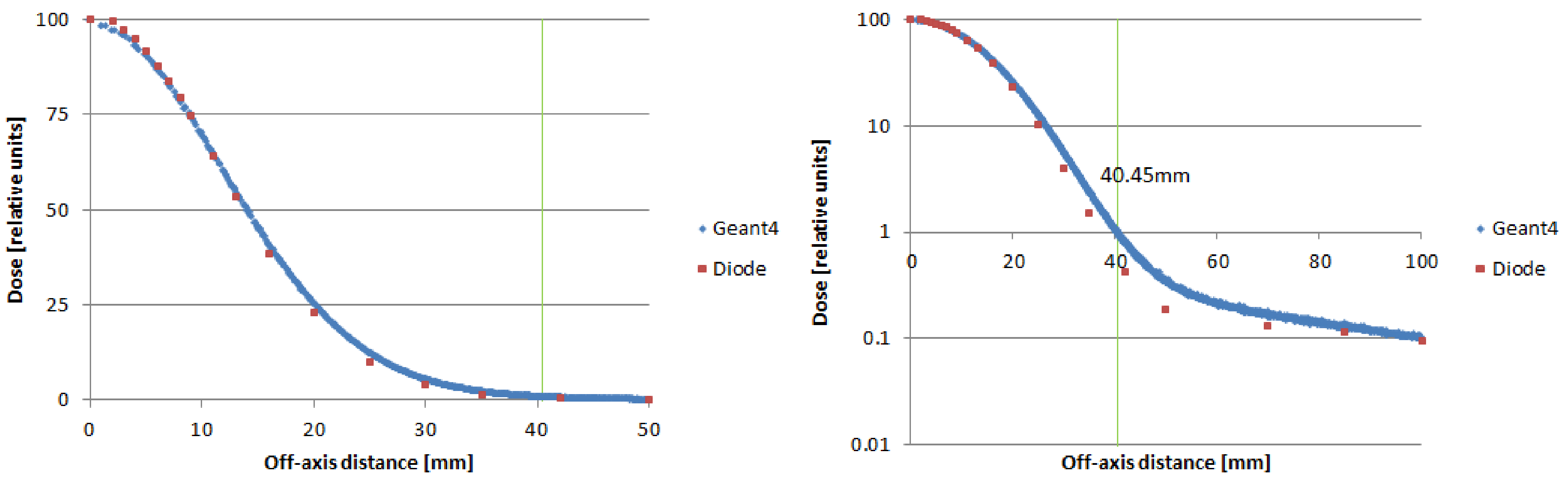

[3] GAP Cirrone, G Cuttone, F Di Rosa, et. al., 2009 IEEE Nuclear Science Symposium Conference Record, 4186-4189.

# Validation by measurement:
## (1) IDD comparison



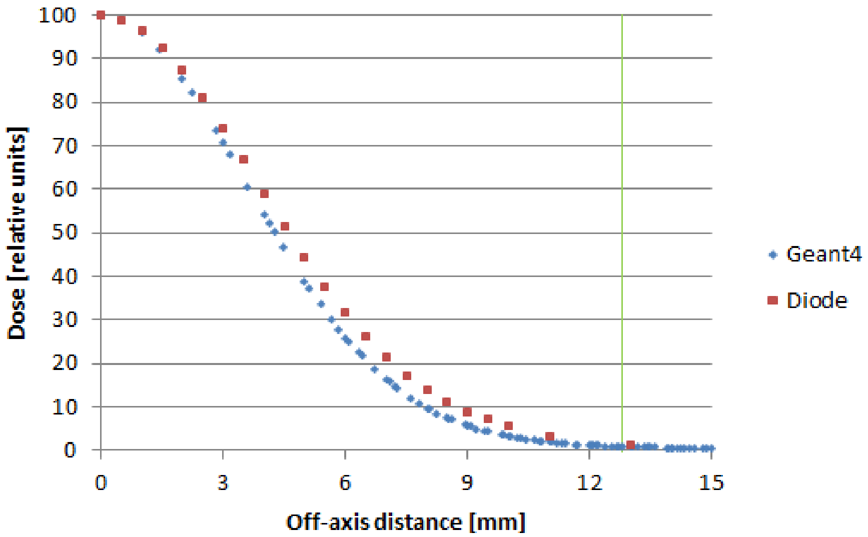
# Validation by measurement:
## (2) In-air profile comparison

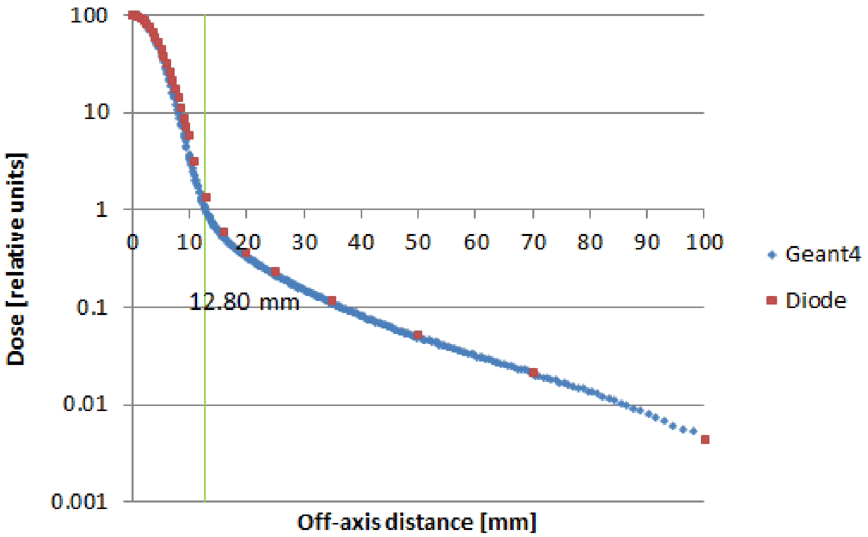



90.1 MeV with RS-45 @ Isocenter

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

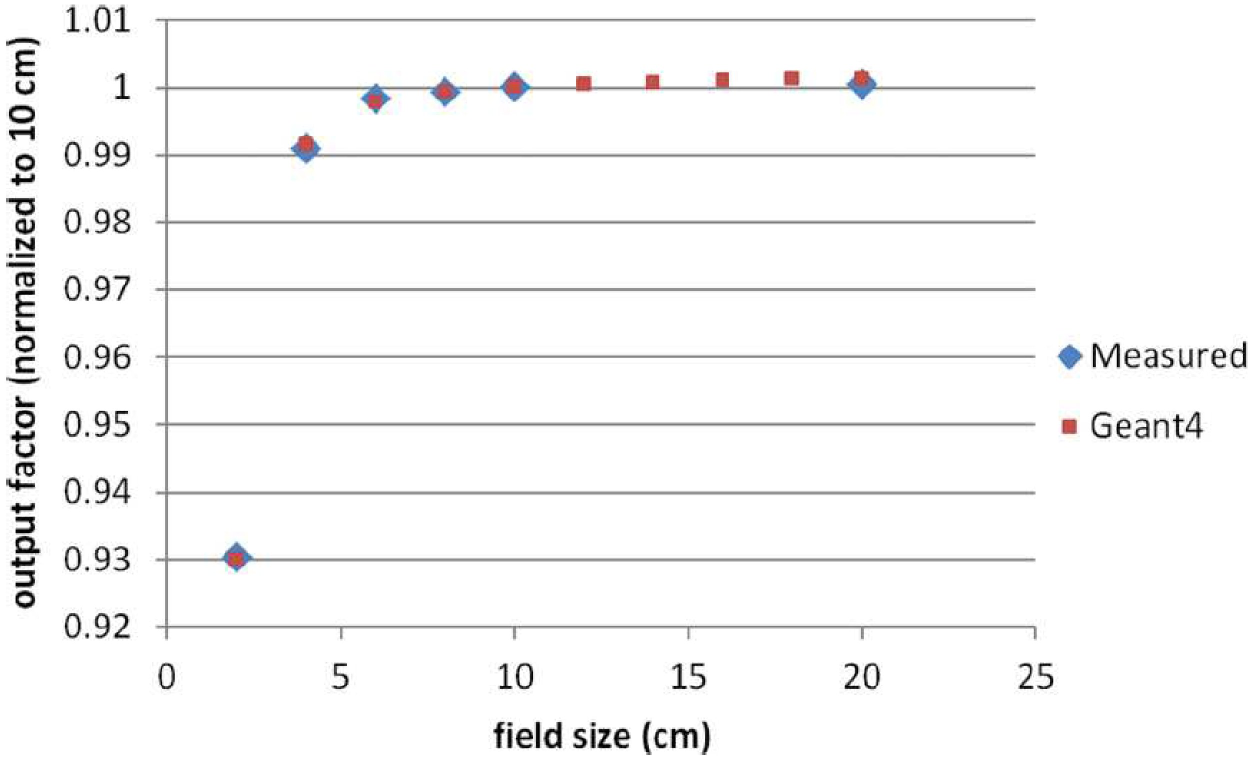



228.8 MeV @ depth 210.5 mm

# Validation by measurement:
## (4) FSF comparison[4]

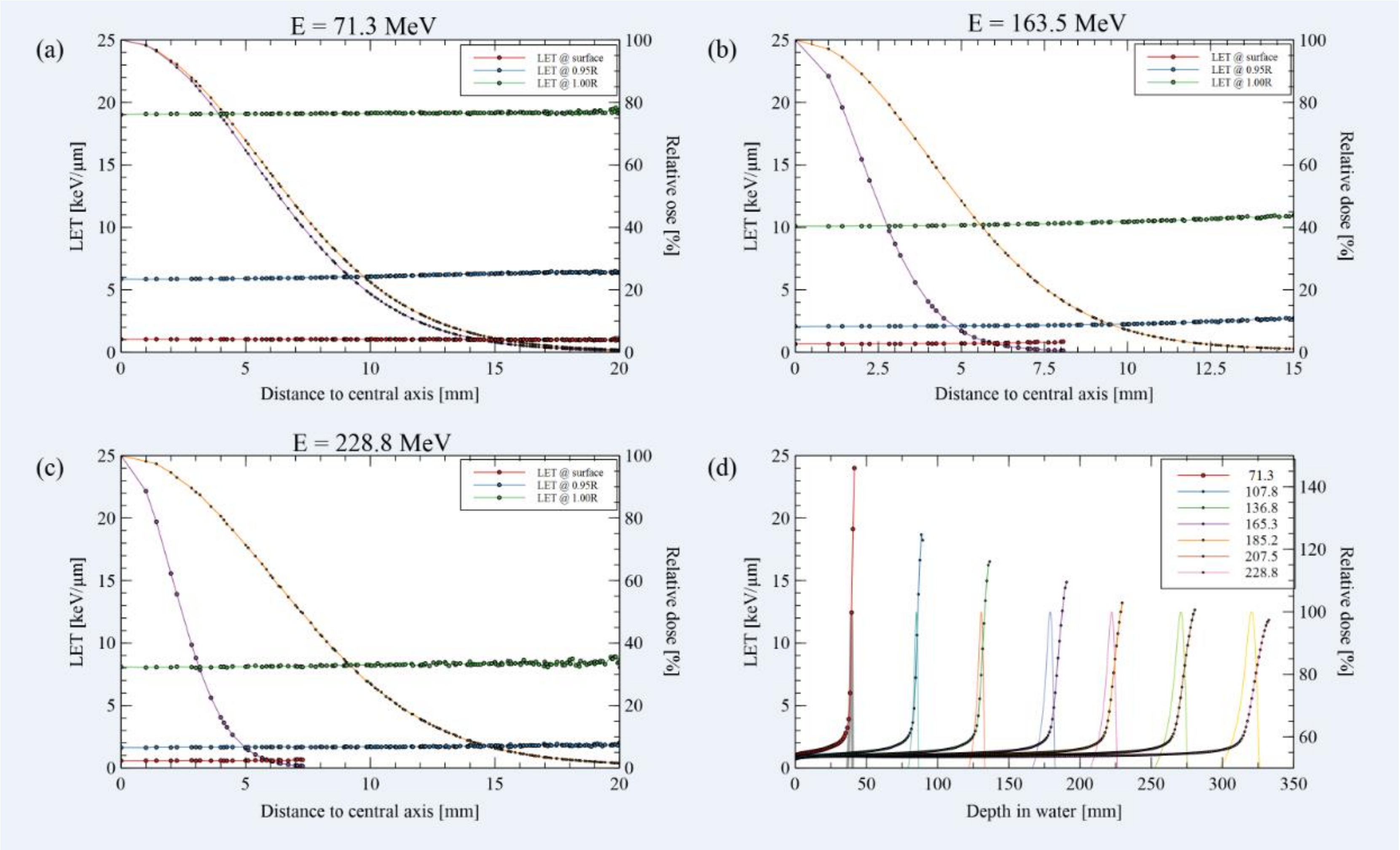



[4] J Shen, JM Lentz, Y Hu, et. al., Radiat Oncol, 12 (2017) 52.



# Generation of LET kernels ($LET_d$)

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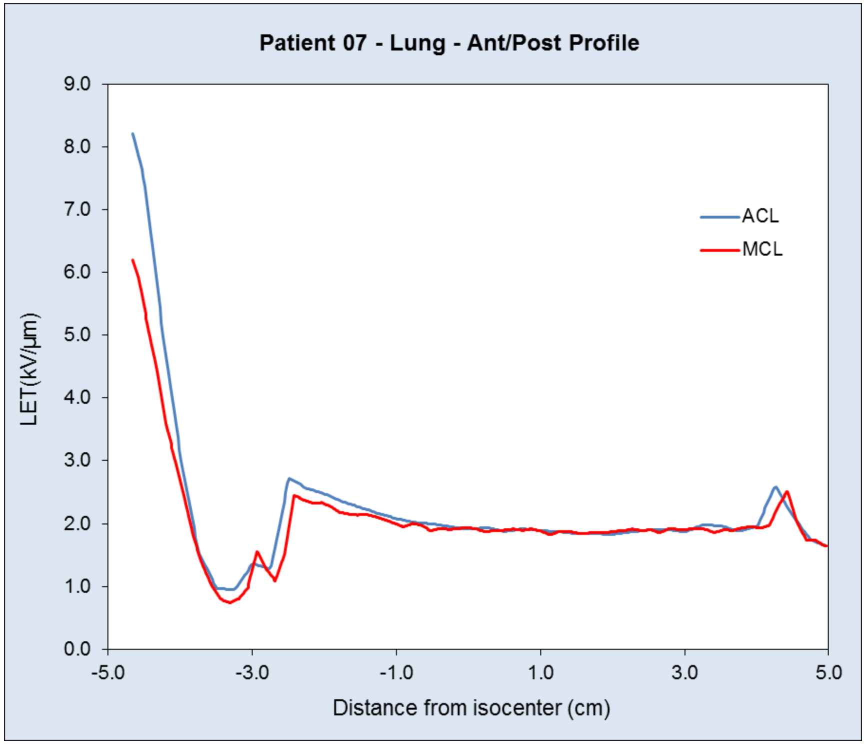
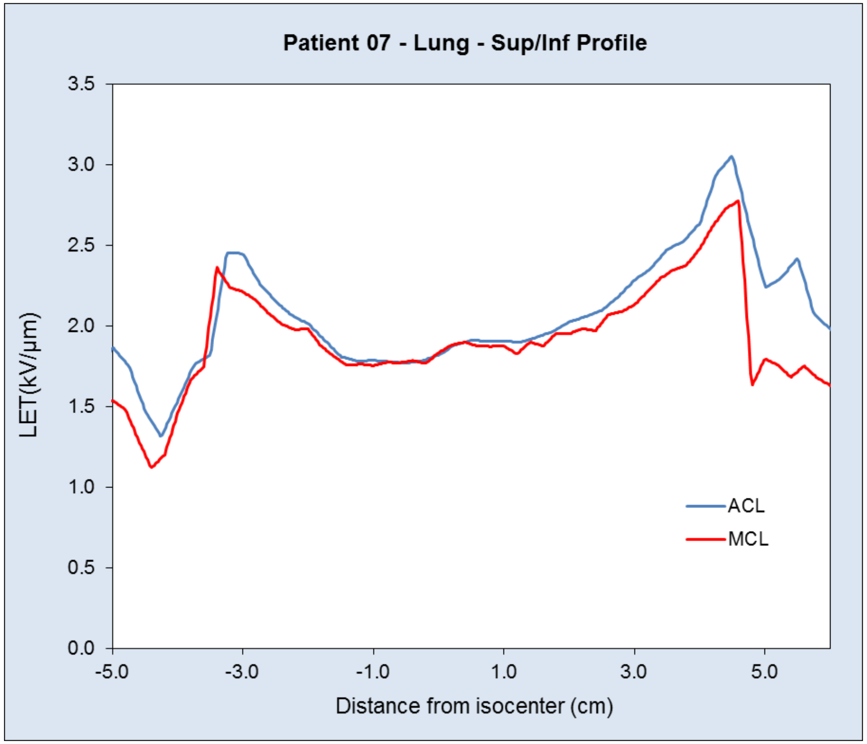
# Comparison between hybrid and full MC method[5]:
## (1) Two lateral profiles through a lung tumor

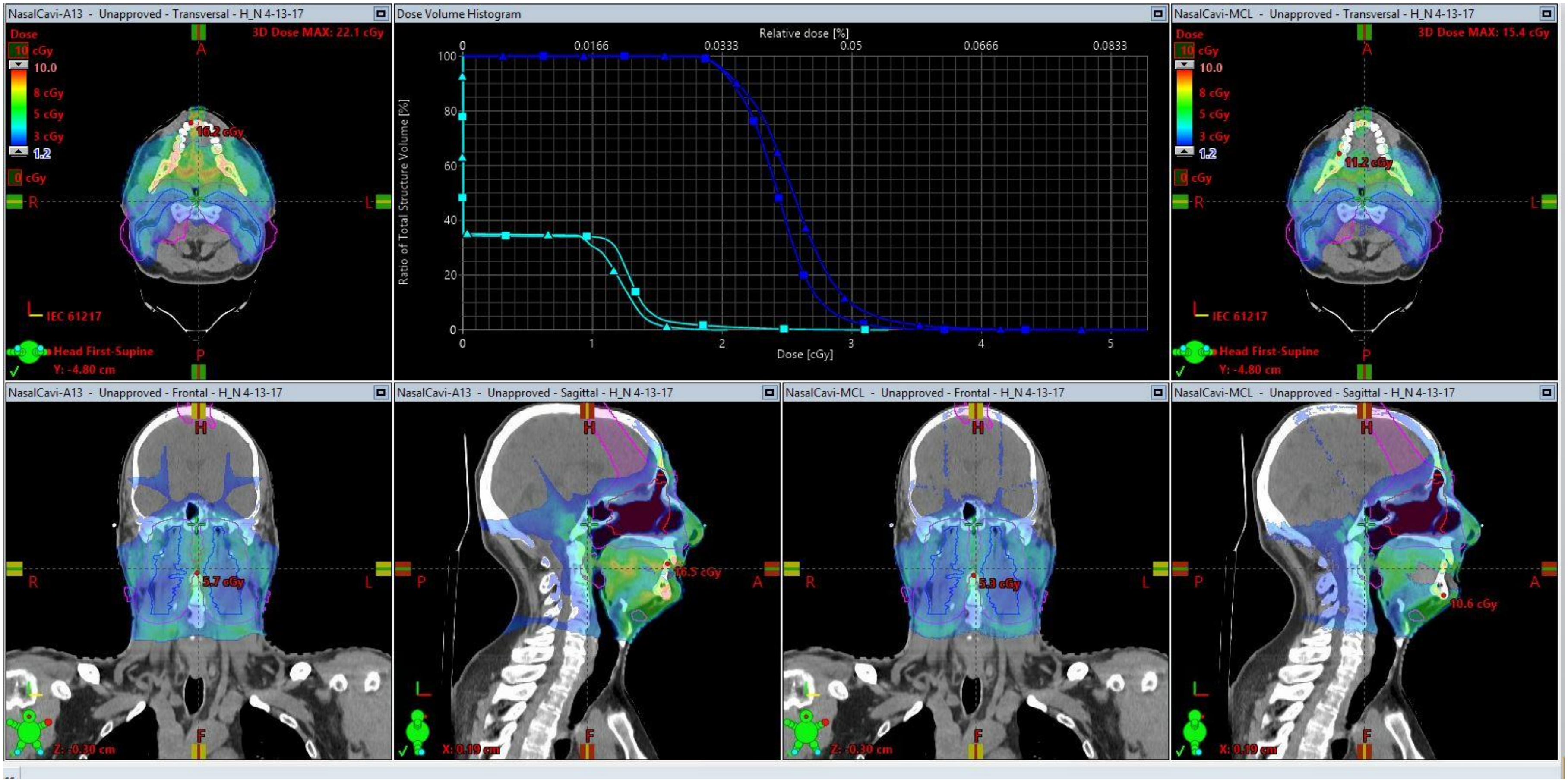



[5] H Wan Chan Tseung, J Ma, C Beltran, Med Phys, 42 (2015) 2967-2978.

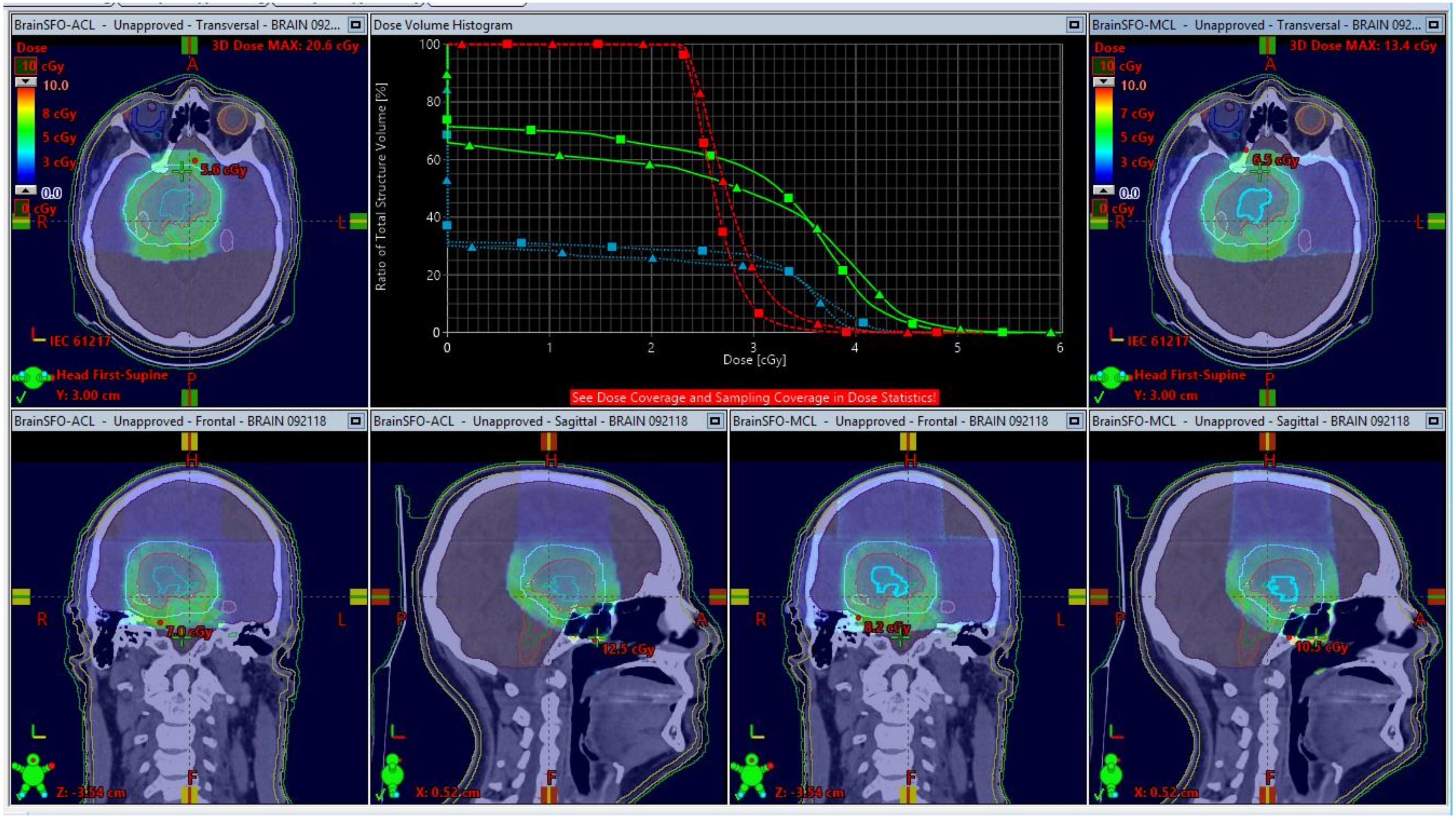
# Comparison between hybrid and full MC method:
## (2) LET deposition and LET-volume histograms for a H-N case





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

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# 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

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# Questions & Discussion