An Energy-Adaptive Finite Element Angular Discretization Towards a Fast Deterministic Dose Calculation in Magnetic Fields

Alberta Health Services | UNIVERSITY OF ALBERTA

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Date and Time: 07/31/2018 | 4:30PM – 6:00PM

Session Title: Dose Calculation, Delivery and Measurement Techniques

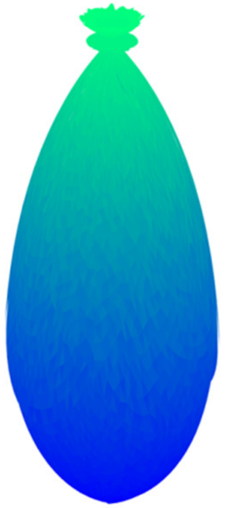
Linear Boltzmann Transport Equation with Magnetic Fields [St-Aubin *et al*, 2015, 2016]

$$\underbrace{\hat{\Omega}\cdot\vec{\nabla}\Psi(\vec{r},E,\hat{\Omega})}_{\text{streaming}}+\underbrace{\frac{q_e}{|\vec{p}|}\vec{\tau}(\vec{B},\hat{\Omega})\cdot\vec{\nabla}_{\Omega}\Psi(\vec{r},E,\hat{\Omega})}_{\text{magnetic field}}+\underbrace{\sigma_t(\vec{r},E)\Psi(\vec{r},E,\hat{\Omega})}_{\text{removal}}-\underbrace{\frac{\partial}{\partial E}\left(\beta_r(\vec{r},E)\Psi(\vec{r},E,\hat{\Omega})\right)}_{\text{CSDA operator}}=\underbrace{\int dE'\int d\hat{\Omega}'\sigma_s(\vec{r},E'\rightarrow E,\hat{\Omega}\cdot\hat{\Omega}')\Psi(\vec{r},E',\hat{\Omega}')}_{\text{downscatter + inscatter}}+\underbrace{q(\vec{r},E,\hat{\Omega})}_{\text{source}}$$

Electron Angular Fluence

$$\Psi_e(\vec{r},E,\hat{\Omega})$$

(beam direction)



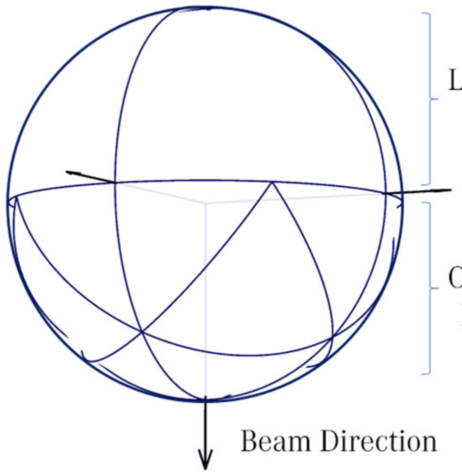
6MeV

10keV

Angular FEM Mesh Strategy

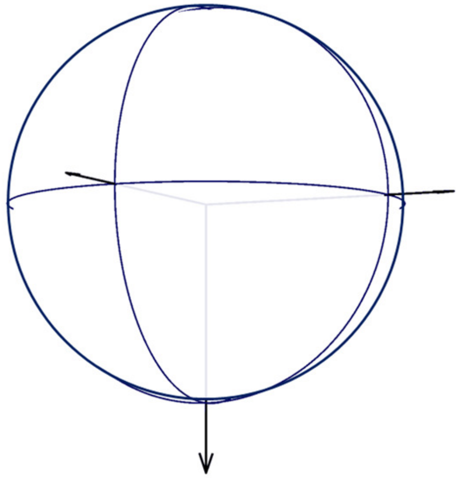
Forward-peaked angular finite element mesh

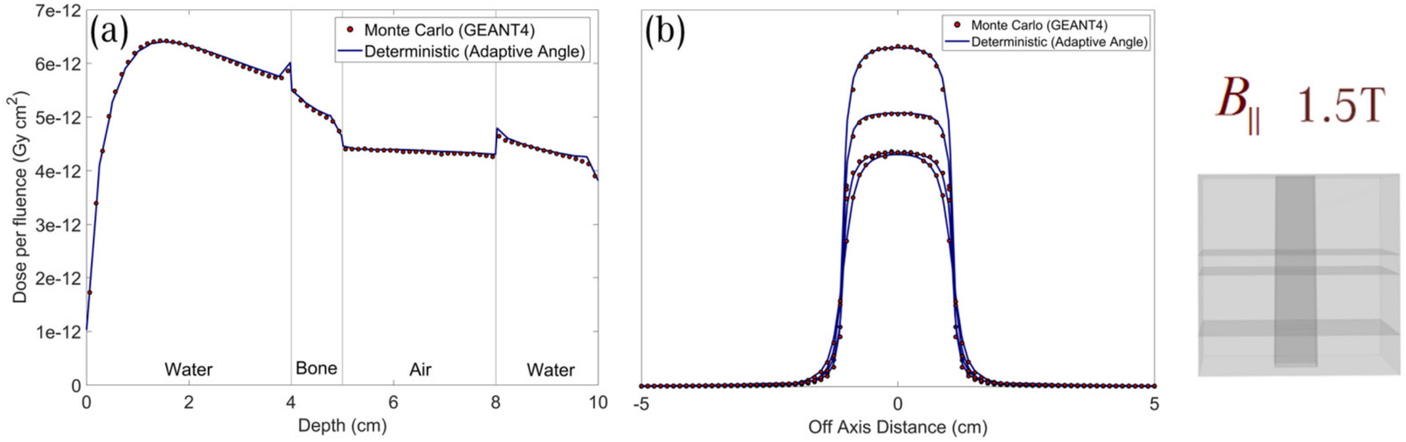
Isotropic angular finite element mesh

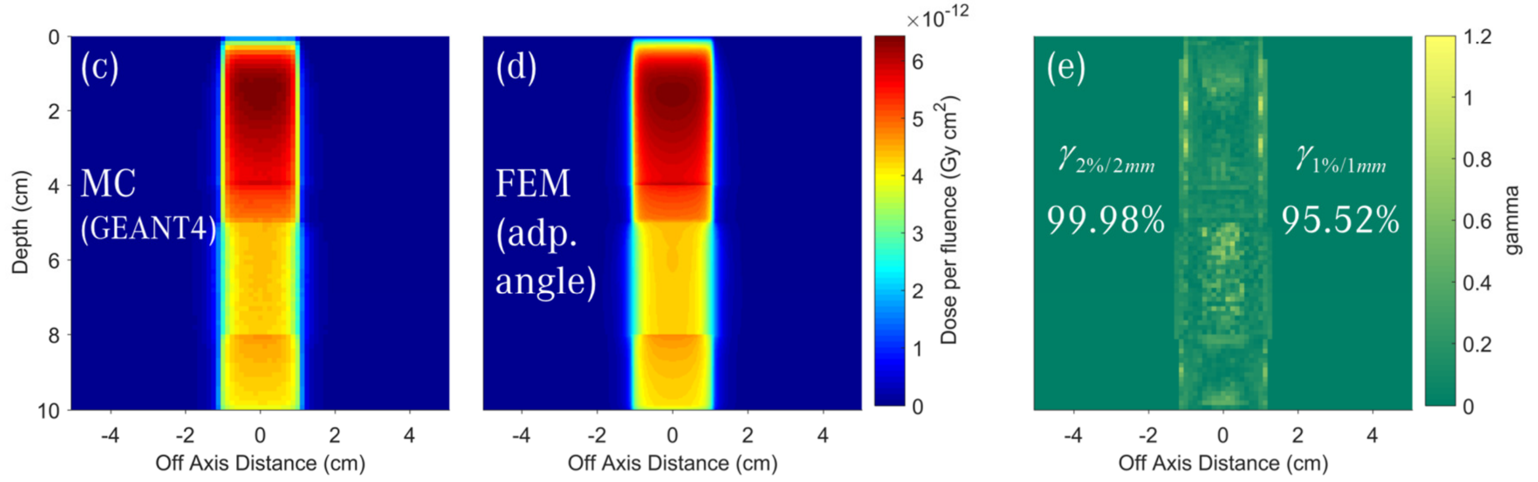


Linear / Quadratic Basis Functions

Quadratic / Cubic Basis Functions







Comparing dose distribution obtained by Deterministic code using angular adaptive mesh to Monte Carlo (a) PDD, (b) profiles through each material, (c) coronal slice of Monte Carlo, (d) coronal slice of Deterministic, (e) gamma map

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[1] St-Aubin J, Keyvanloo A, Vassiliev O and Fallone B G 2015 A deterministic solution of the first order linear Boltzmann transport equation in the presence of external magnetic fields Med. Phys. 42 780–93

[2] St-Aubin J, Keyvanloo A and Fallone B G 2016 Discontinuous finite element space-angle treatment of the first order linear Boltzmann transport equation with magnetic fields: application to MRI-guided radiotherapy Med. Phys. 43 195–204