

# GEANT4 radiation dose simulations to extend the bremsstrahlung endpoint energies at the MAL's medical electron linear accelerator

Jack Gallant in collaboration with Jessica Mayer

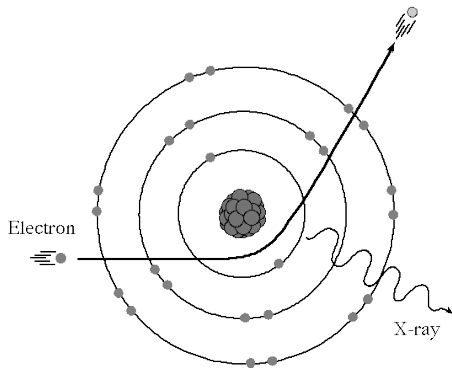
Research Advisors: Drs. Adriana Banu and Scottie Pendleton



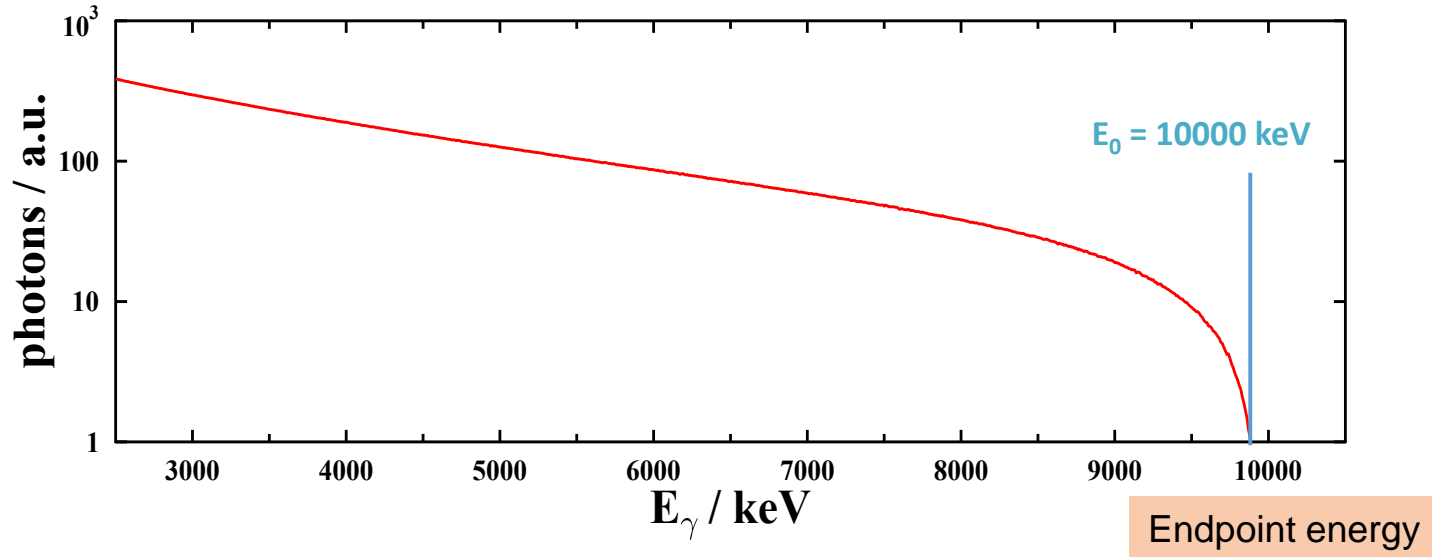
Undergraduate Physics Research Symposium

March 23, 2019

# Bremsstrahlung



- Production by stopping of **electron beam** with energy  $E_0$
- Continuous-energy **photon spectrum** with max. energy  $E_0$

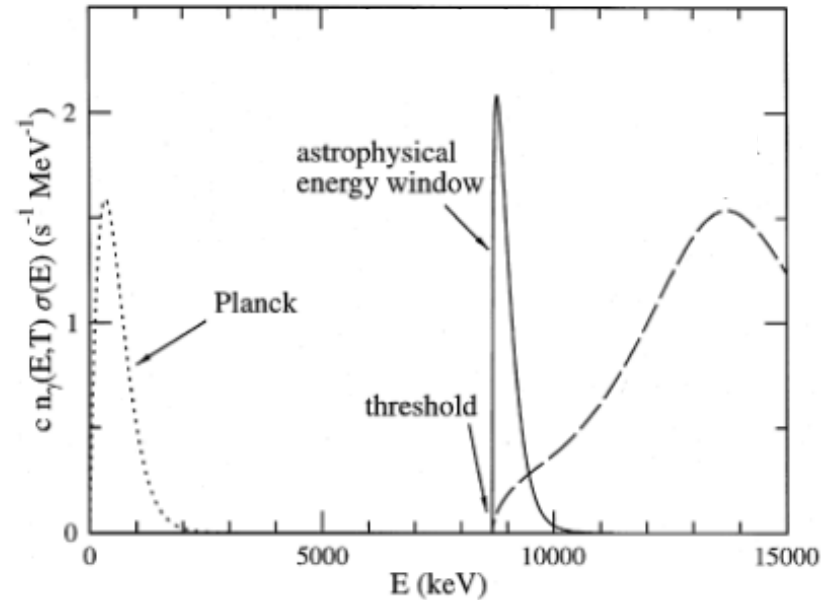


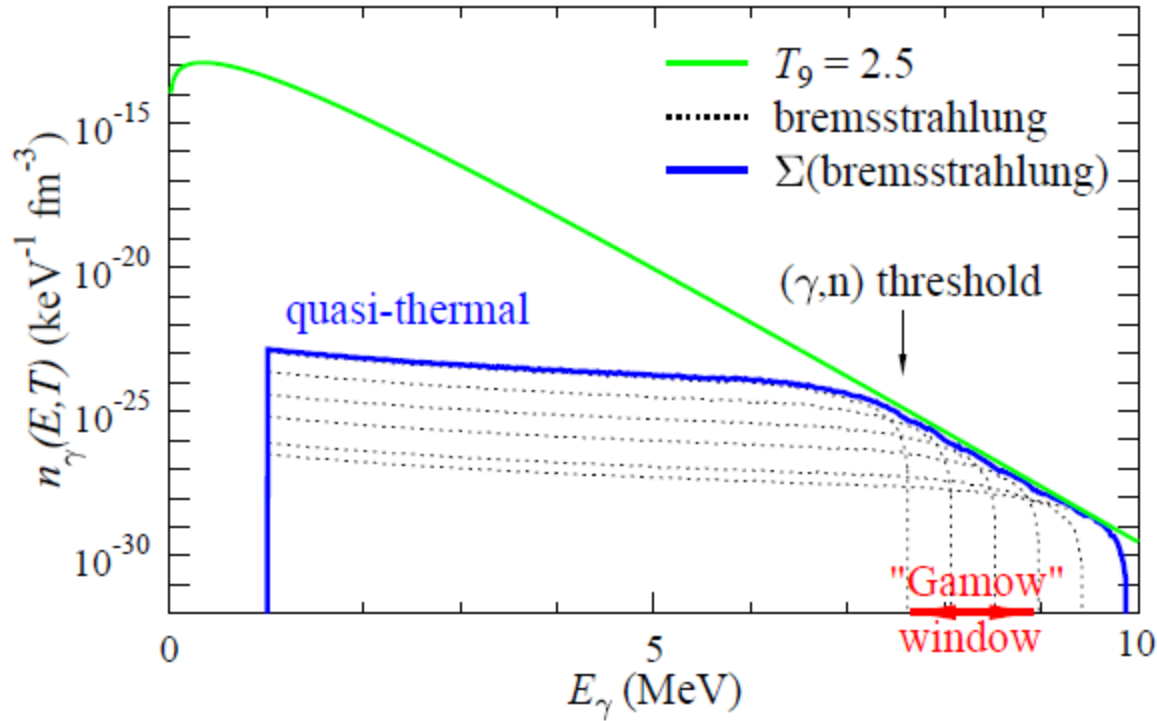
# Astrophysical Photodisintegration Reaction Rates

The reaction rate for a photodisintegration reaction

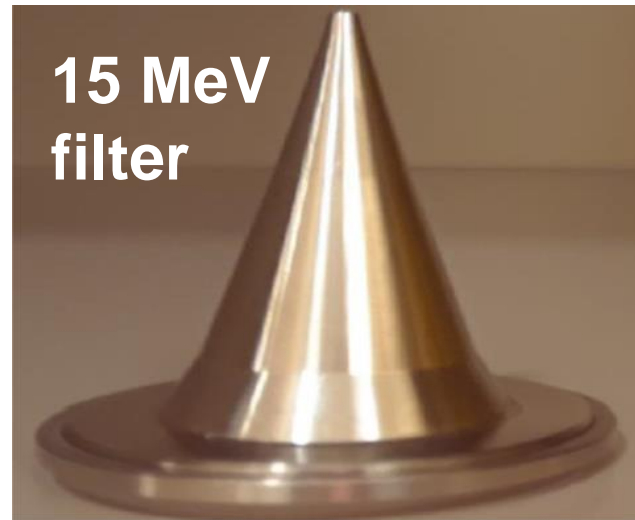
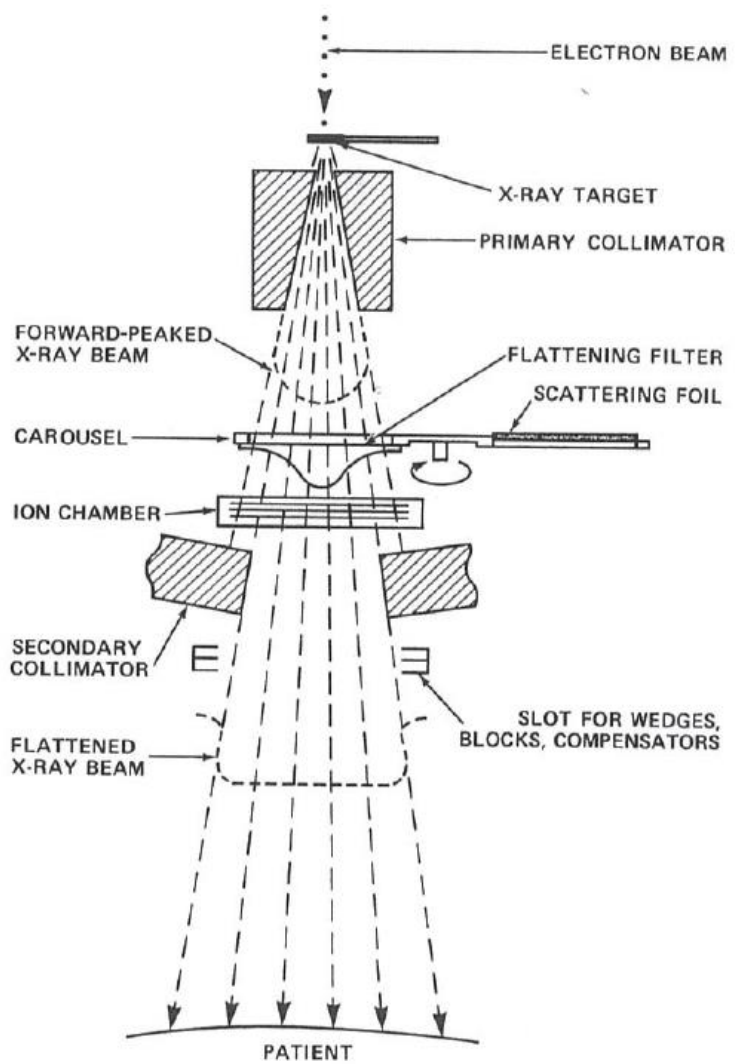
$$\lambda(T) = \int_0^{\infty} c n_{\lambda}^{Planck}(E, T) \sigma(E) dE$$

$$n_{\gamma}^{Planck}(E, T) = \left(\frac{1}{\pi}\right)^2 \left(\frac{1}{\hbar c}\right)^3 \frac{E^2}{\exp(E/kT) - 1}$$

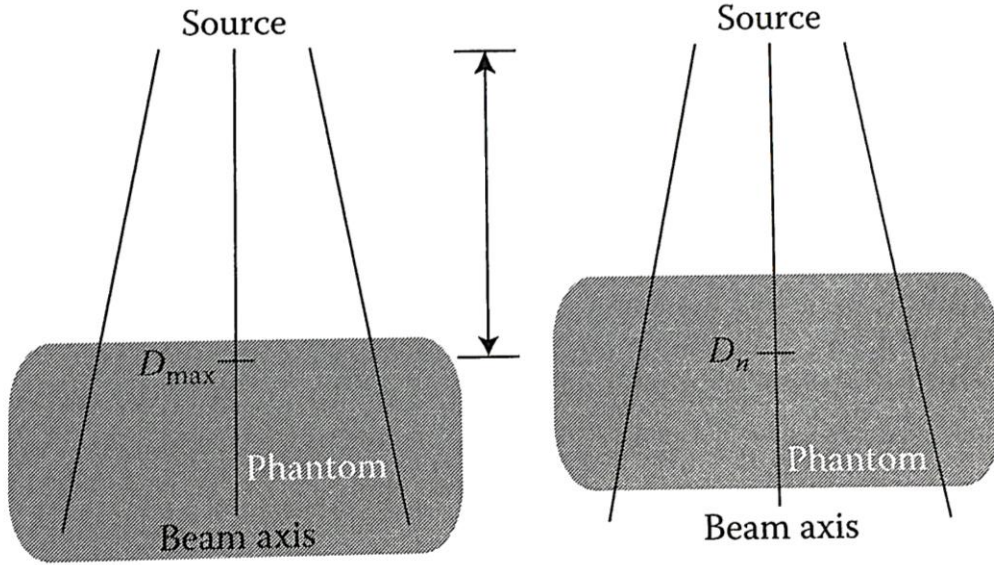




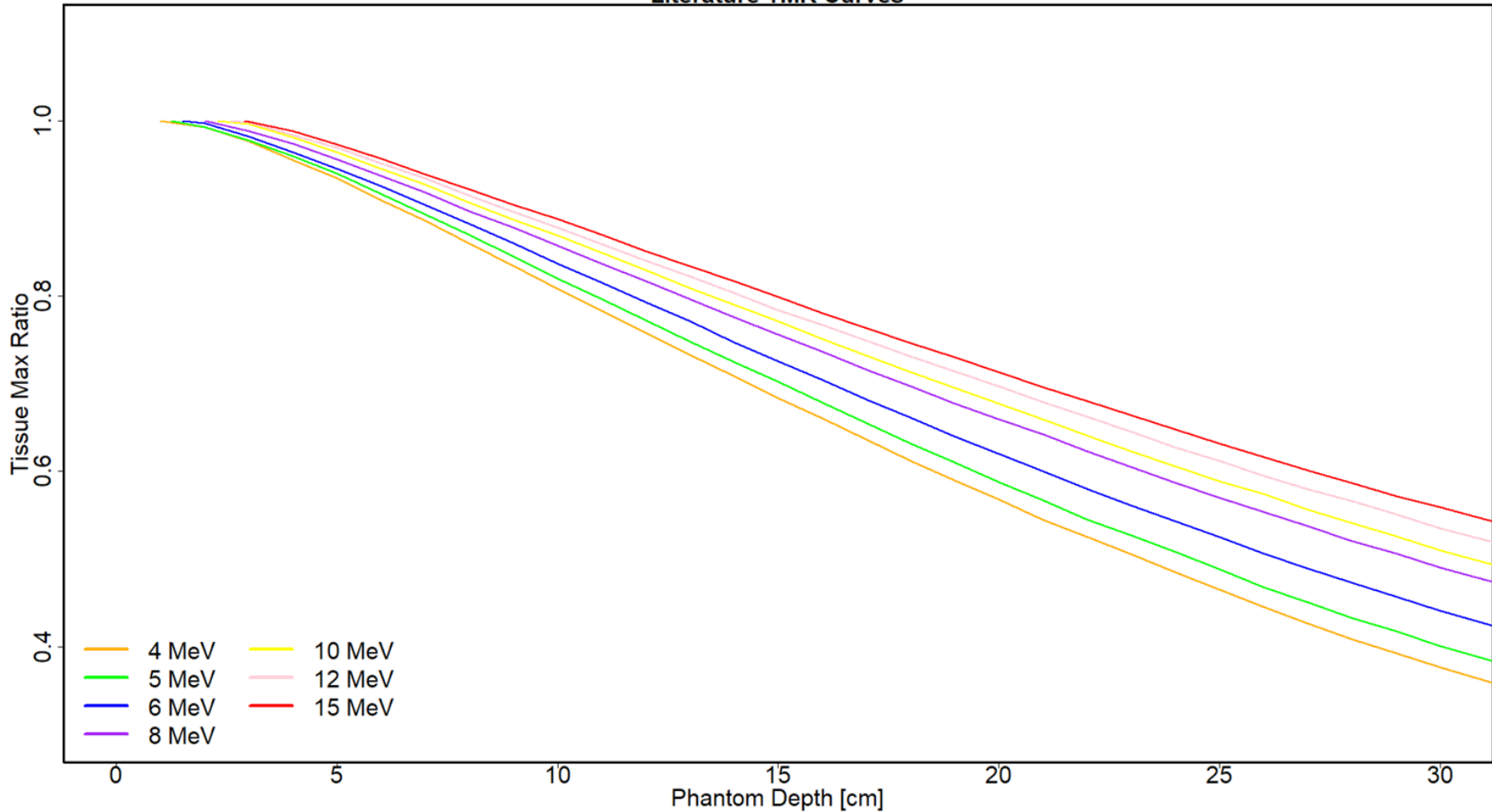
$$cn_\gamma^{\text{Planck}}(E, T) \approx \sum_i a_i(T) \Phi_\gamma^{\text{brems}}(E, E_{\text{max},i})$$

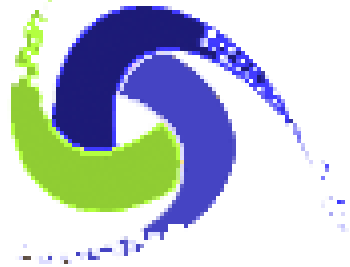


$$TMR = \frac{\text{dose at depth } n}{\text{dose at max depth}}$$



Literature TMR Curves





# GEANT4

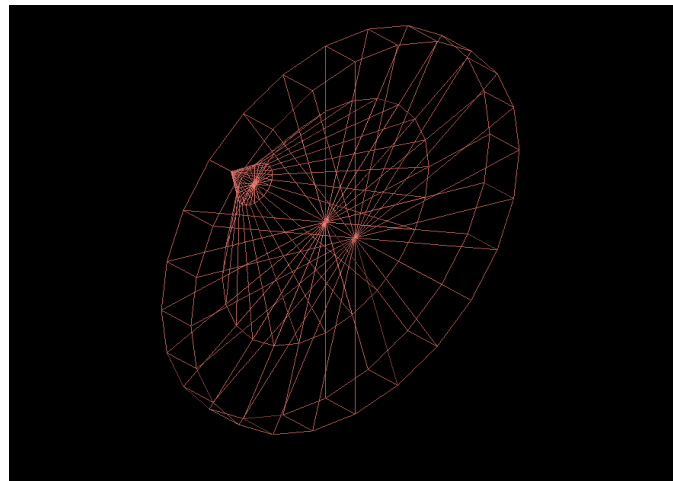
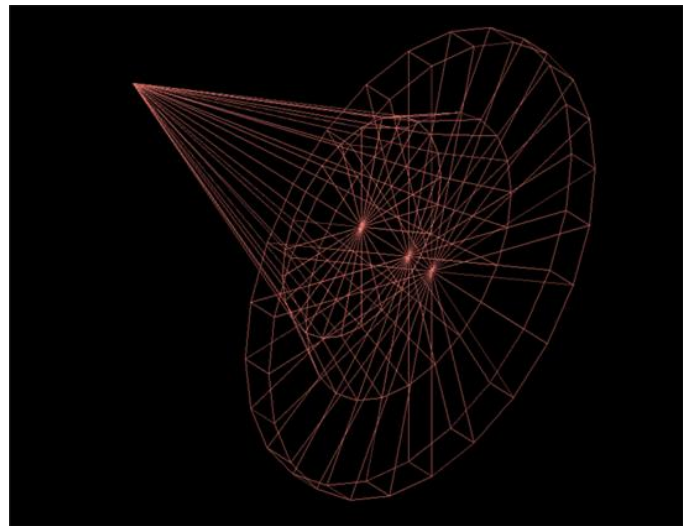
A SIMULATION TOOLKIT

<https://geant4.web.cern.ch/>

Geant4 is a toolkit for the simulation of the passage of particles through matter.

Its areas of application include high energy, nuclear and accelerator physics

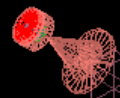




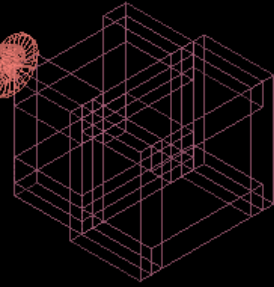
$e^-$  source



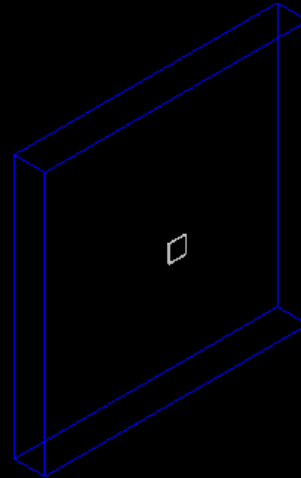
target



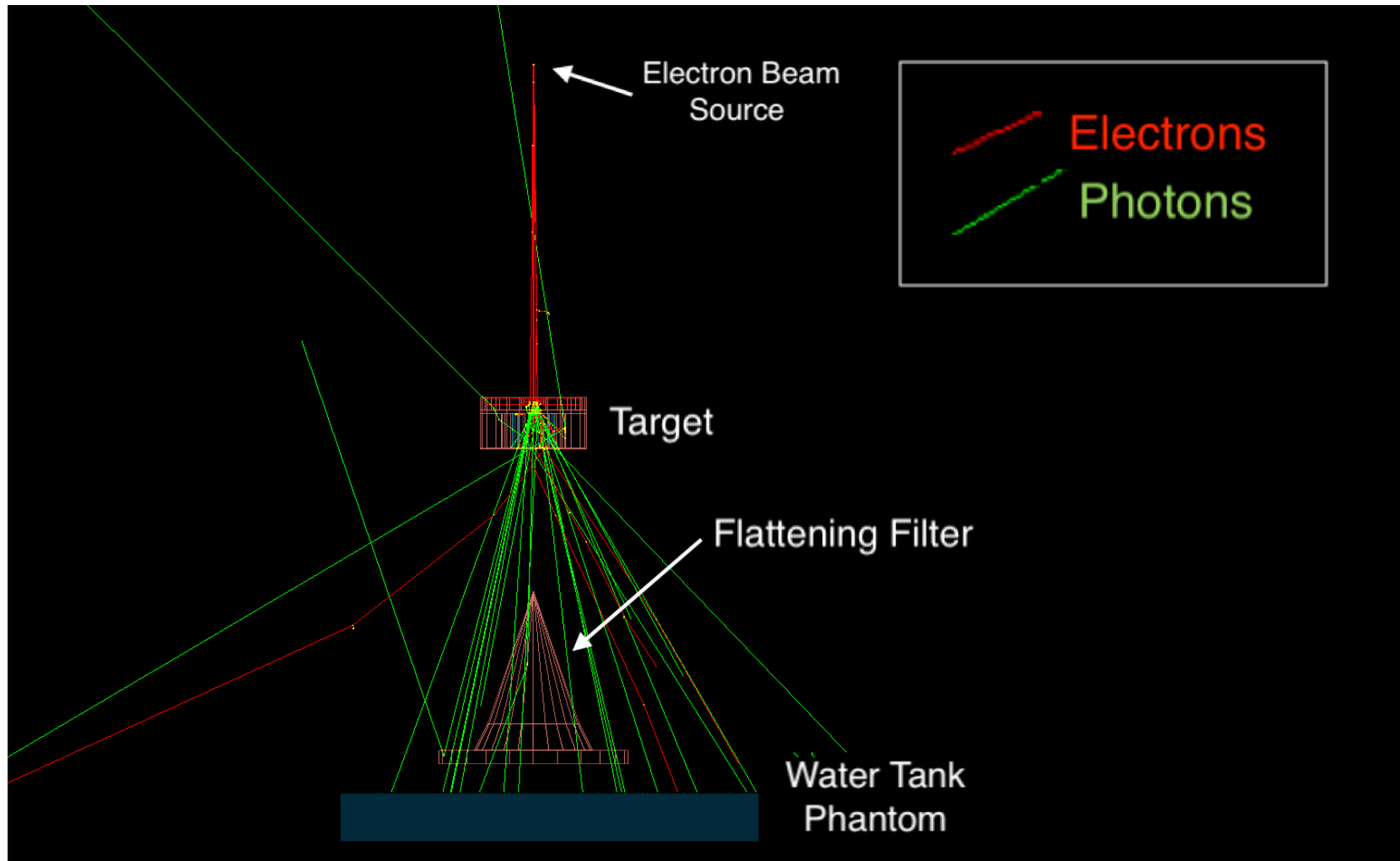
filter



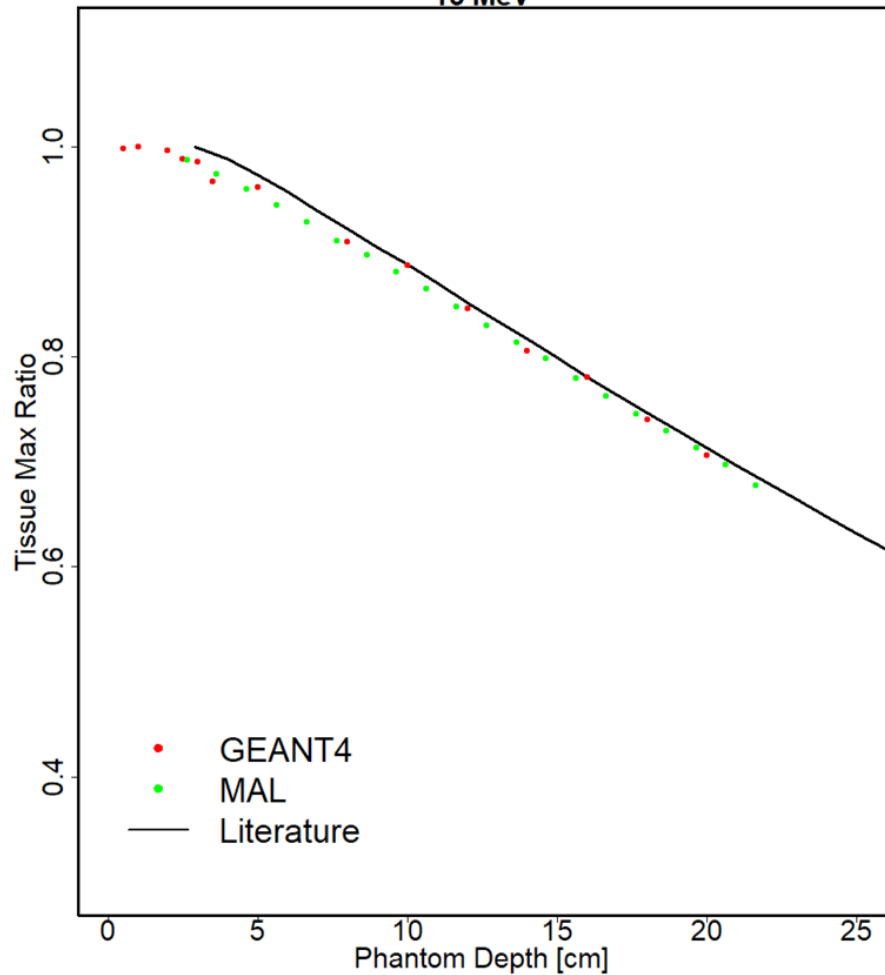
collimator



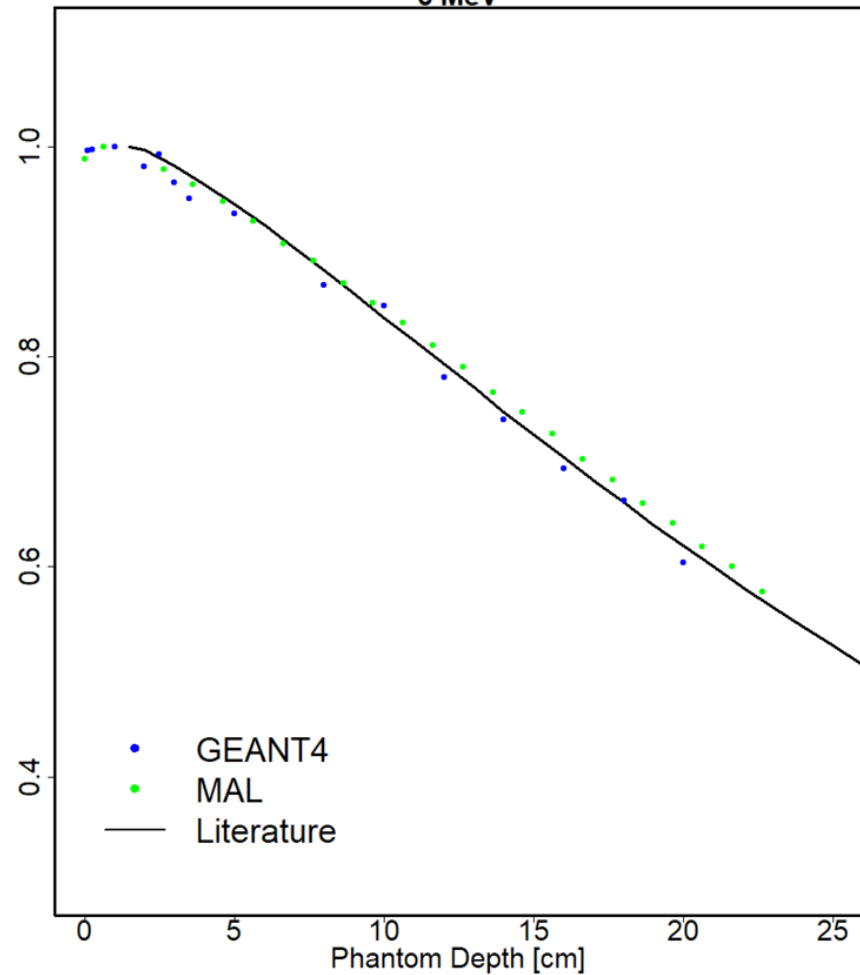
water phantom/detector



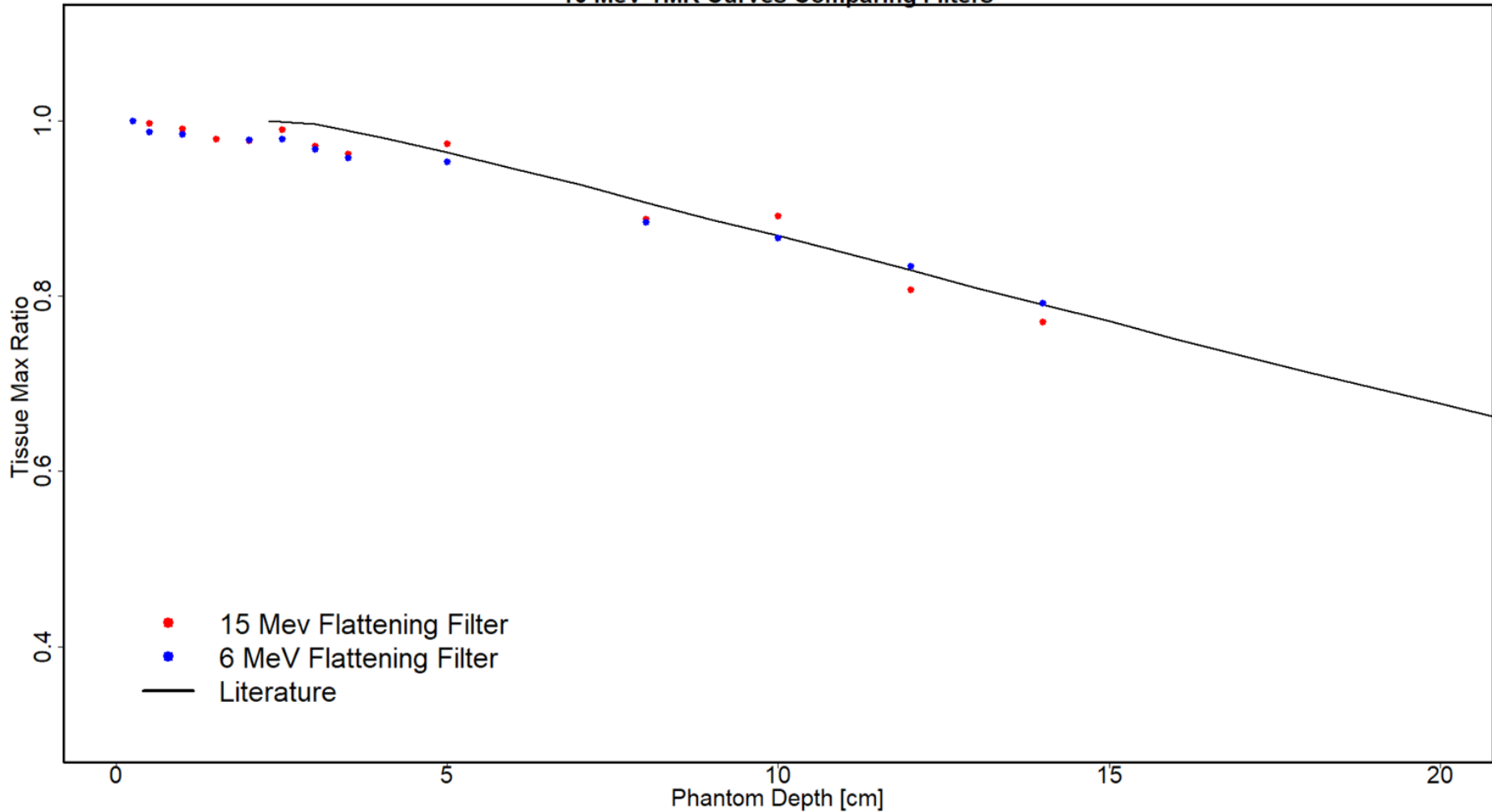
15 MeV



6 MeV



10 MeV TMR Curves Comparing Filters



**Thank You!**

$$cn_{\gamma}^{\text{Planck}}(E, T) \approx \sum_i a_i(T) \Phi_{\gamma}^{\text{brems}}(E, E_{\max, i})$$

$$\lambda_{(\gamma, n)}^{\text{gs}}(T) \approx \sum_i a_i(T) \int_{E_{\text{thr}}}^{E_{\max, i}} \Phi_{\gamma}^{\text{brems}}(E, E_{\max, i}) \sigma_{(\gamma, n)}(E) dE$$

$$\lambda_{(\gamma, n)}^{\text{gs}}(T) \approx \sum_i a_i(T) I_{\sigma_{(\gamma, n)}, i}$$

