Validation Of Simulation

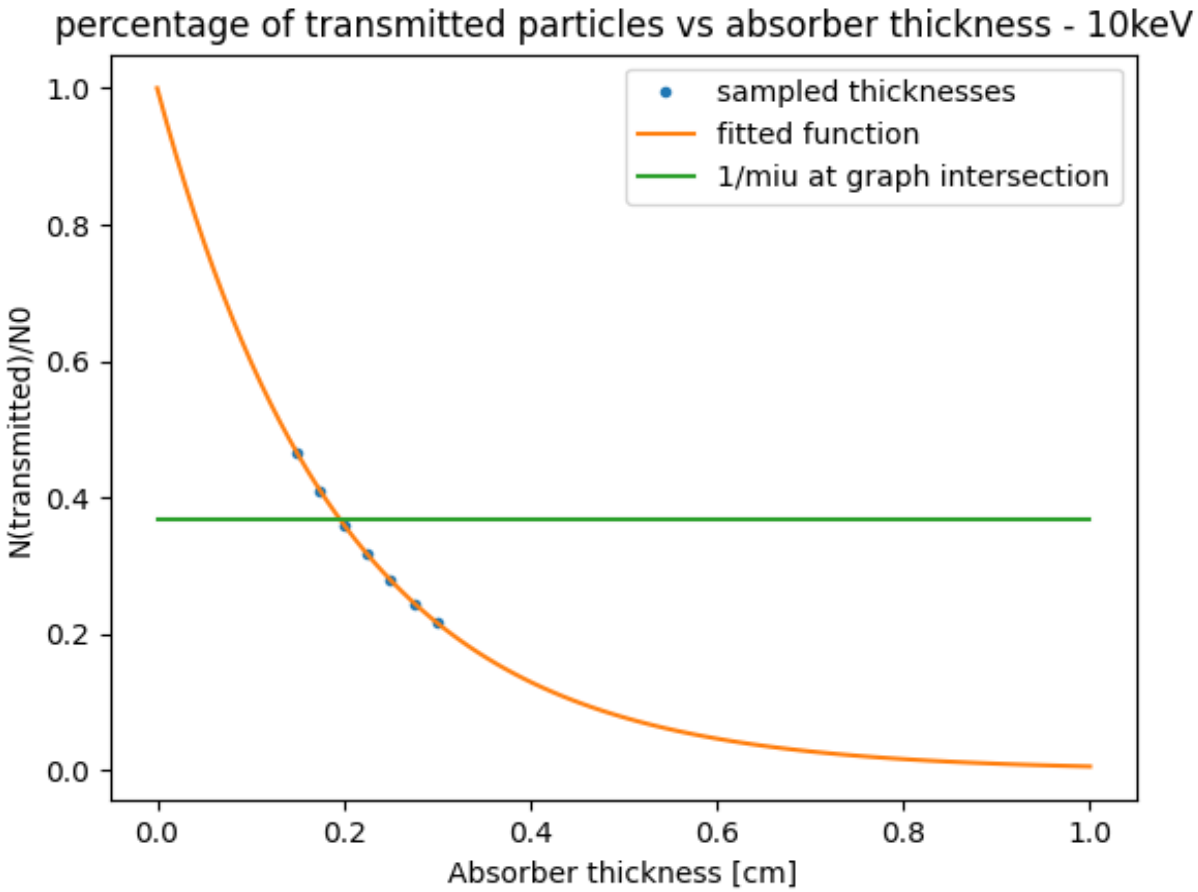
Linear Attenuation Coefficient $$I(x) = I_0 \cdot e^{-\mu x}$$

- We aim to find the Linear attenuation coefficient of photons with varying energy passing through water. The linear attenuation coefficient is defined as 1/ the distance at which $\frac{1}{e}$ particles pass through the material.

- In our simulation we set a 1 cm x 1cm square beam of equally distributed primary particles and defined a transmitted particle as a particle that passed through the absorber and stayed within the 1 cm x 1 cm square in the yz plane.
- This was done since the attenuation coefficient is defined in the literature as a one-dimensional parameter – a particle would be defined as transmitted only if it did not interact at all, while our simulation is three-dimensional and a particle not interacting at all is highly unlikely.

An example of extracting the linear attenuation coefficient

In this example we used photons with 10keV and measured what percentage of them passed through varying distances in water. We then fit the data to the function $I(x) = I_0 \cdot e^{-\mu x}$ and extracted the attenuation coefficient by the graph intersection with $\frac{1}{e}$



Linear attenuation coefficient

Next we will show a graph of the linear attenuation coefficient vs. photon energy.

The linear attenuation coefficient is calculated as a superposition of four major contributions –

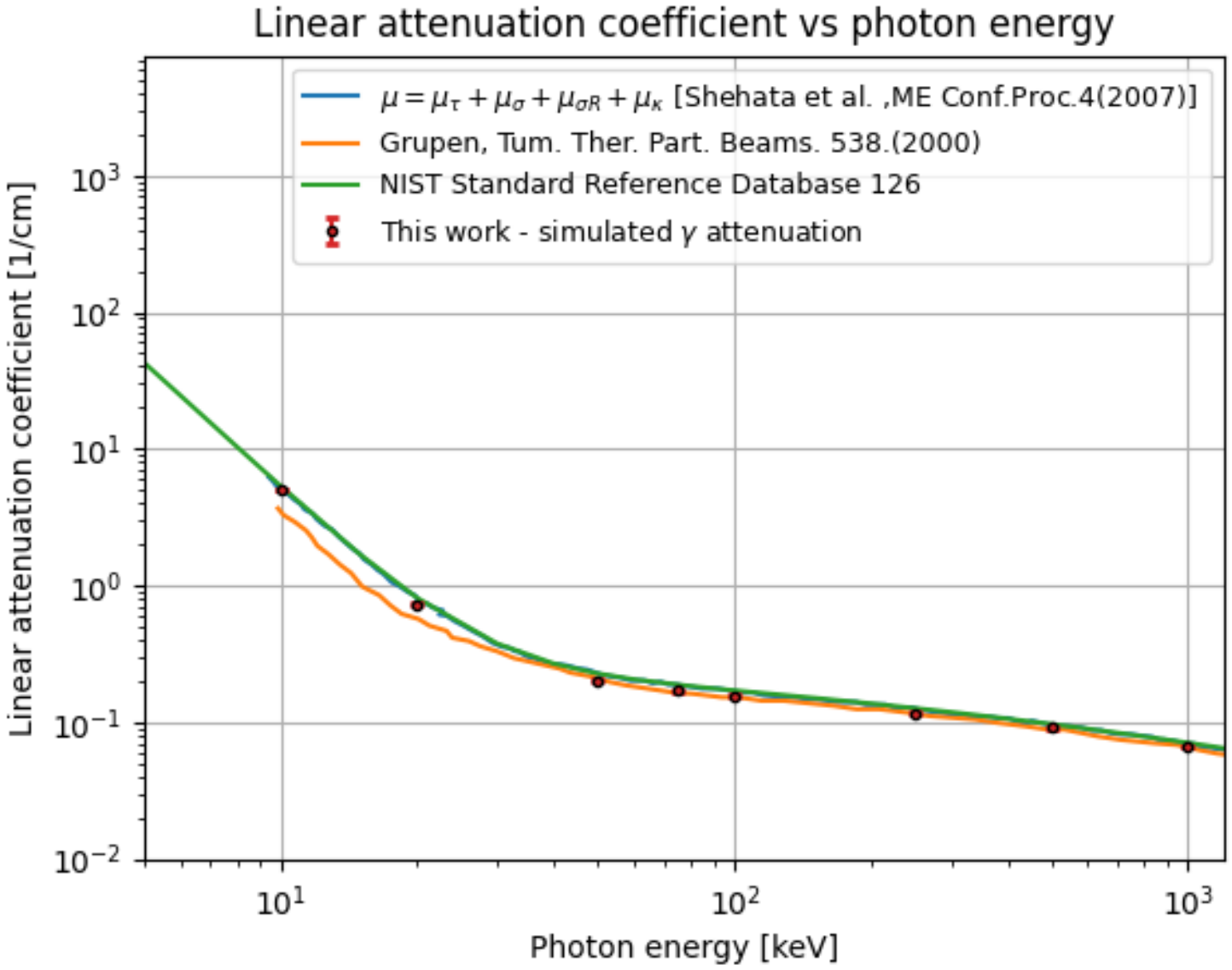
$\mu = \mu_\tau + \mu_\sigma + \mu_{\sigma R} + \mu_\kappa$ where:

- $\mu_\tau \sim Z^{4-5}$ is the Photoelectric effect
- $\mu_\sigma \sim \rho \cdot \frac{Z}{A}$ is Compton Scattering
- $\mu_{\sigma R} \sim Z^{2-3}$ is Rayleigh Scattering
- $\mu_\kappa \sim Z^2$ is Pair Production

We compare our data with Shehata et al. ,ME Conf.Proc.4(2007), extracting their graph of linear attenuation coefficient vs. energy using WebPlotDigitizer.

Link to Shehata et al. - https://www.researchgate.net/figure/The-linear-gamma-ray-attenuation-coefficient-of-oil-water-and-brine_fig5_242282405

Linear attenuation coefficient vs. Photon energy



Overall, we see a good fit of our data to literature, especially considering that the photon energy changes over 3 orders of magnitude.