# Monte Carlo simulations of radiation transport

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## I. Experimental

Source number 0 (parallel beam) was kept, the parallel beam source was put to have a radius of 3 cm. The geometry was a single slab with thickness and radius of 10 cm. The medium was chosen to be H20521ICRU from 1 to 10 Z, and R. For the Monte Carlo 10 histories were saved. The iwatch option under the I/O tab was put to graph. After the source was put to 0.1 MeV photons, the y and z-coordinates of particle number 1 were extracted and plotted with a python script from the .egsgph file. This analysis was repeated for a 5 MeV electron source.

For the next part, the beam was narrowed to 1 cm. The number of histories was increased to 10000 to get an error below five percent in dose. The first plane had a radius of 10 cm and a thickness between 0.5 and 2.5 mm. The second plane had a 10 cm radius and a thickness between 99.95 and 99.75 cm. The last plane had a radius and thickness of 0.5 cm. Then the first medium air was put to all the planes. Then copper over the air for plane number one. At last water in the third plane. Then five measurement of the dose was taken from .egslst in the third plane of water with the changes in copper from 0.5 and 2.5 mm with monoenergetic 0.250 MeV photons being the source. The same was repeated with a 0.250 MeV X-ray spectrum.

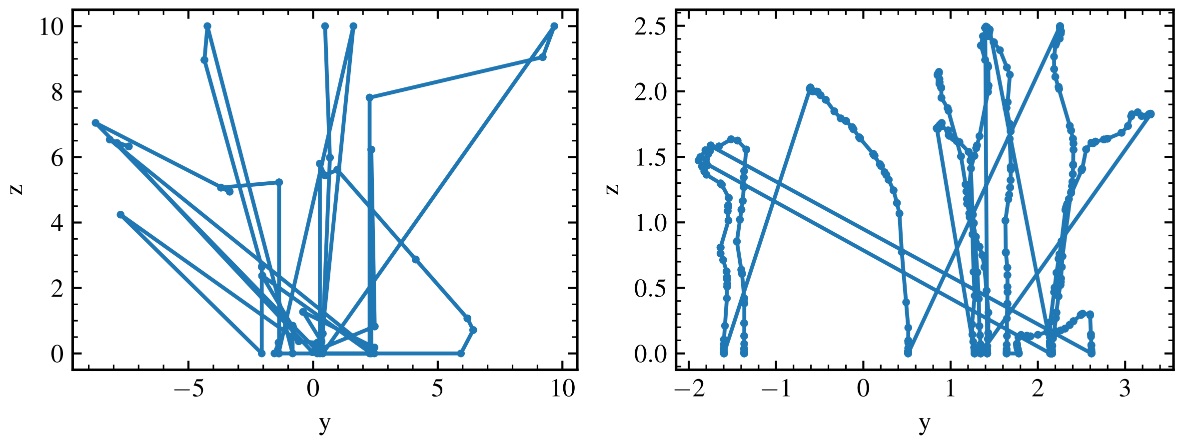
The geometry was set up as instructed in the assignment for the longitudinal and lateral dose of 1 MeV and 10 MeV photons. Under I/O control output option was changed to dose summary. The histories were increased to 2000000 for this part. For the electron dose, 1000000 histories were used, with energies of 5 and 20 MeV.

An air cavity was placed in plane number eight and cylinder number one, then the dose was found in the cavity from a 1 MeV photon source and a 10 MeV electron source.

The air cavity was, removed to see what happens with the longitudinal dose in water as a function of source beam radius. In other words, producing the same geometry as the Longitudinal and lateral dose deposition characteristics task. The Monte Carlo was run with 5 MeV electron beam with radius of 0.5, 1.0, 2.0, 3.0 and 5.0 cm.

# II. Results

The .egsgph file with the resulting particles and their position and energies after an interaction were opened with Excel. The fixed with import option was chosen. The particle charge, region, x position and energy tabs were deleted. This did not correctly import the numbers since the width was not constant. In the rows where there were errors the data was checked against the original file and fixed. A phyton script pulled out the position of particle number one and plotted its position. The result is in Figure 1, with the dots on the lines being an interaction.




**(a)** Starting 0.1 MeV photon.

**(b)** Starting 5 MeV electron.

**Figure 1.** Path of primary particles in a cylinder with length and radius of 10 cm in a medium of water. The source was a parallel beam with radius 3 cm of 0.1 MeV photons (1a) and 5 MeV electrons (1b).

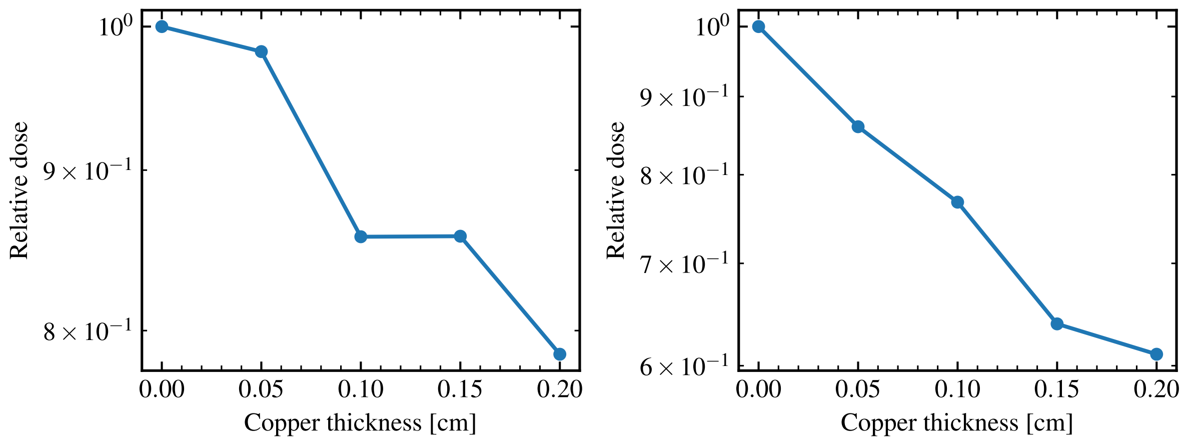
The dose was copied from .egslst into an array, that were divided by the first measurement to get the relative dose. The first measurement with a 0.5 mm copper plane was put as the primary filter, with the increase from that point being the copper thickness. Linear regression was done on the results in Figure 2 to get the linear attenuation coefficient. This resulted in 1.2(4) and 2.6(4) per cm for a 250 keV monoenergetic and X-ray source respectively. With a density of copper of 8.96 per cm squared the Mass Attenuation coefficients are 0.13(5) (monoenergetic) and 0.29(5) (spectrum). The half-value layer is

$$HVL = \frac{\ln(2)}{1.2 \pm 0.4\,\mathrm{cm}^{-1}} = 0.6 \pm 0.2\,\mathrm{cm} \tag{1}$$

for the monoenergetic source and

$$HVL = \frac{\ln(2)}{2.6 \pm 0.4\,\mathrm{cm}^{-1}} = 0.27 \pm 0.04\,\mathrm{cm} \tag{2}$$

for the 250 keV X-ray spectrum.

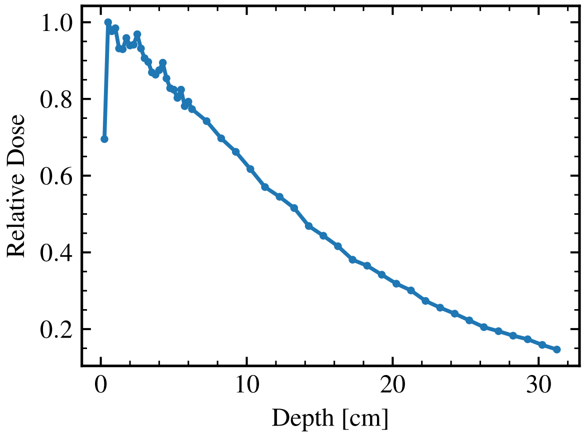



**(a)** 250 keV monoenergetic photons.

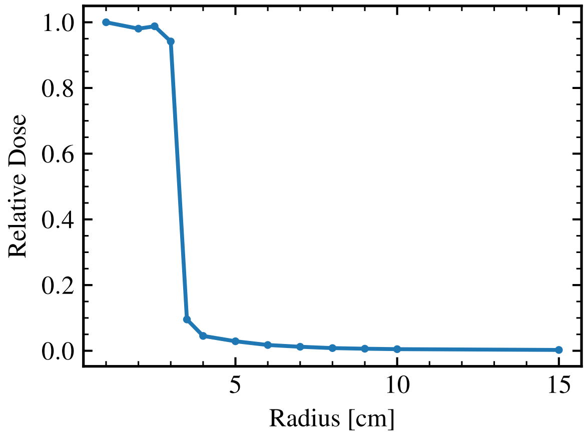
**(b)** 250 keV X-ray spectrum.

**Figure 2.** Dose in a 0.5 cm cavity 1 m from the source with 0.5 mm primary copper filtration as a function of increasing secondary copper shielding. The dose was calculated from Monte Carlo with a 250 keV monoenergetic photon source and a 250 keV X-ray source.

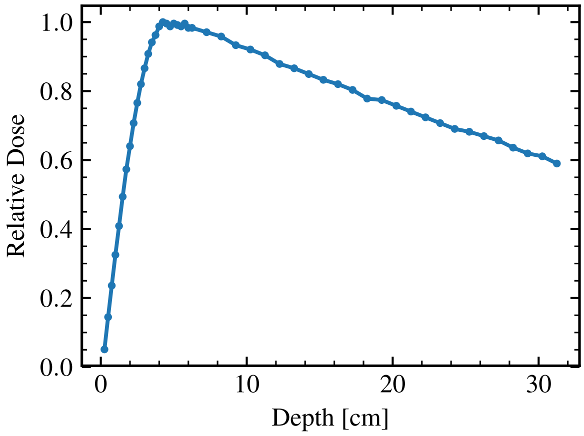
With excel the .egslst file was narrowed down to the plane number, cylinder number, and dose. For the longitudinal dose cylinder number 1 was used. With the lateral dose being plane number 20 for photons, and plane number 8 for electrons. The dose was extracted with an if loop either for the plane number (lateral) or cylinder number 1 for longitudinal dose. The resulting plots for the photon source are in Figure 3 and for the electron source Figure 4.



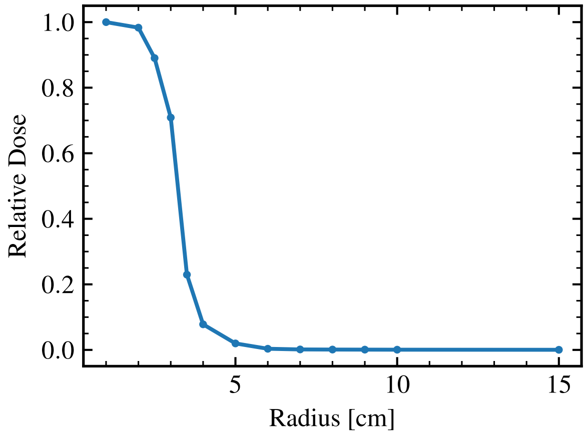

**(a)** Longitudinal dose at center from a 1 MeV monoenergetic photon source.




**(b)** Lateral dose 5 cm from the source of 1 MeV monoenergetic photons.

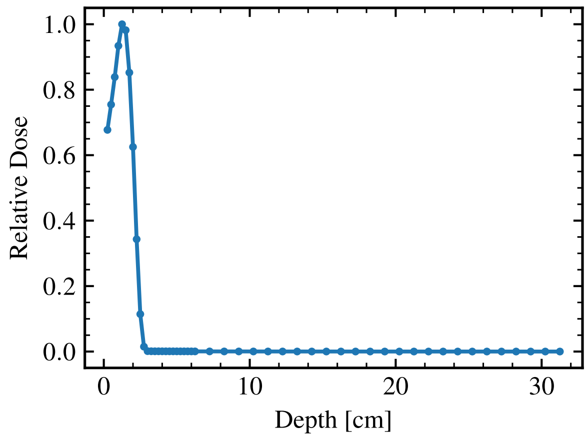



**(c)** Longitudinal dose at center from a 10 MeV monoenergetic photon source.

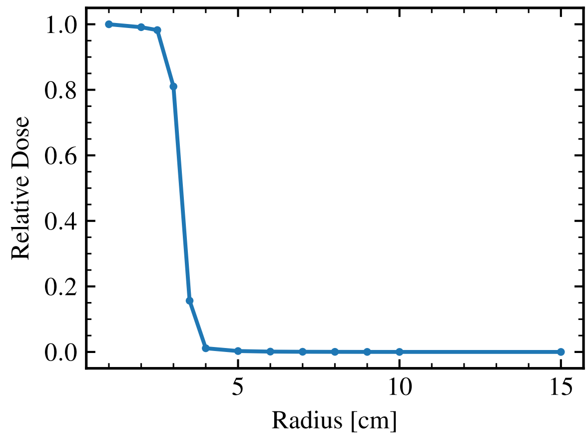



**(d)** Lateral dose 5 cm from the source of 10 MeV monoenergetic photons.

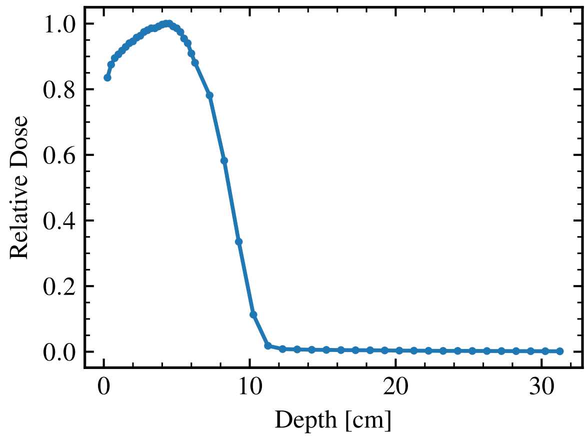
**Figure 3.** The difference in dose distribution longitudinal and lateral with changing energy from a photon source.



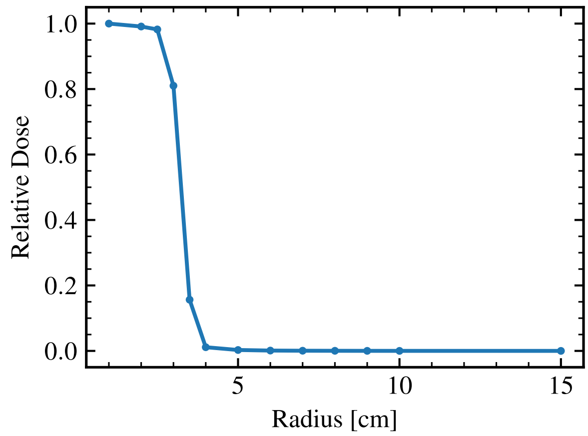

**(a)** Longitudinal dose at center from a 5 MeV monoenergetic electron source.




**(b)** Lateral dose 5 cm from the source of 5 MeV monoenergetic electrons.




**(c)** Longitudinal dose at center from a 20 MeV monoenergetic electron source.




**(d)** Lateral dose 5 cm from the source of 20 MeV monoenergetic electrons.

**Figure 4.** The difference in dose distribution longitudinal and lateral with changing energy from a electron source.

1 MeV photon dose water $4.81 \times 10^{-12}$ Gy/fluence

1 MeV photon dose air $4.31 \times 10^{-12}$ Gy/fluence

10 MeV electron dose water $1.53 \times 10^{-11}$ Gy/fluence

10 MeV electron dose air

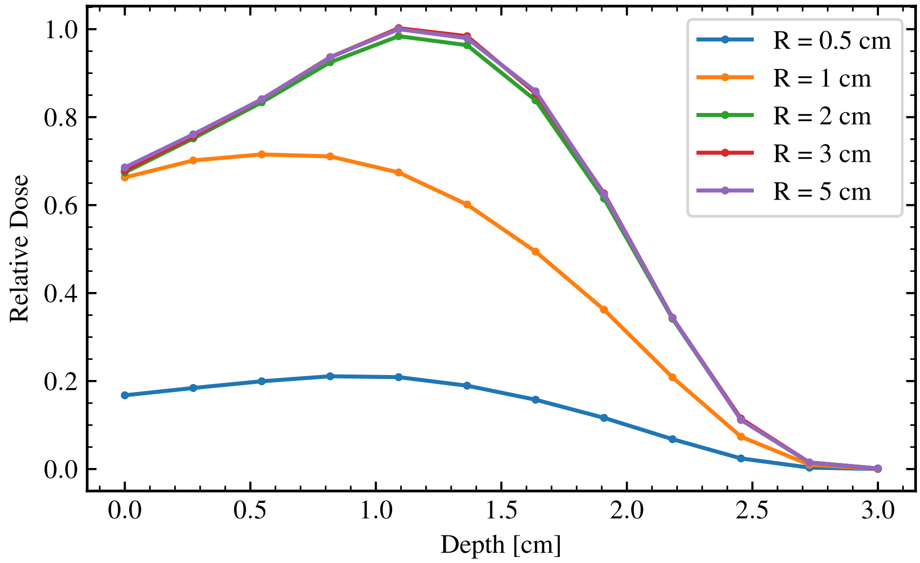



**Figure 5.** Central longitudinal dose as a function of beam radius

# III. Discussion

# IV. Conclusion