Investigating Thermal Neutron Radiation Shielding Features of B2O3 and Gd2O3-doped Material (Quartz, Glasses, Al, W): A Monte Carlo Simulation

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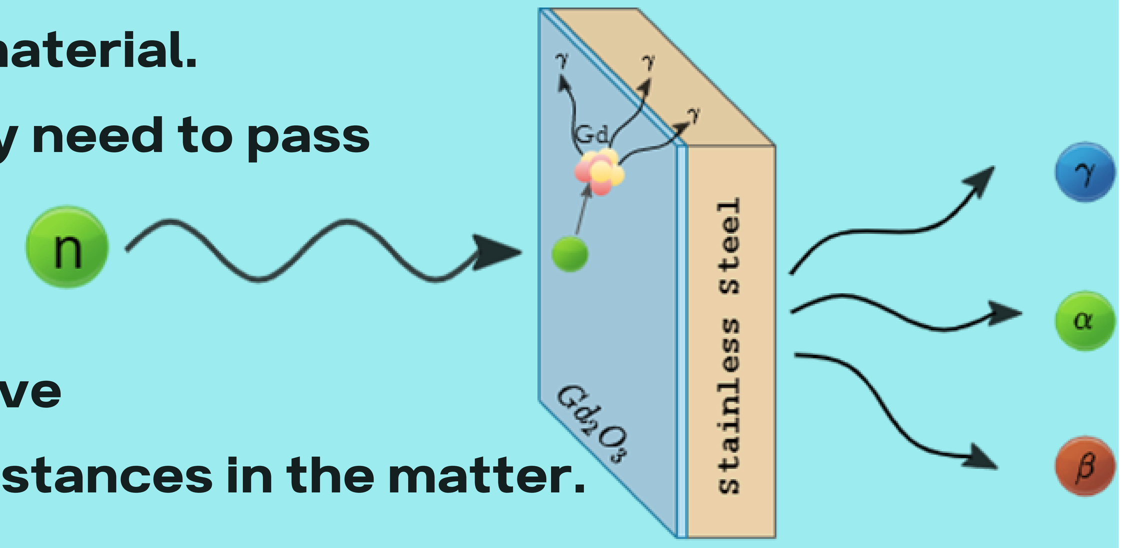
Introduction

Neutrons have no net electric charge so they cannot be affected or stopped by electric forces.

- Neutron interaction energies from 1 eV to 100 MeV.
- No interaction with the atomic electrons of the material.
- They interact with the nuclei of the atoms so they need to pass closer to the nuclei.
- The nucleus radius is about 10^(-13) cm.
- Due to the smallness of the nucleus, neutrons have low probability of interaction and long traveling distances in the matter.



Motivation

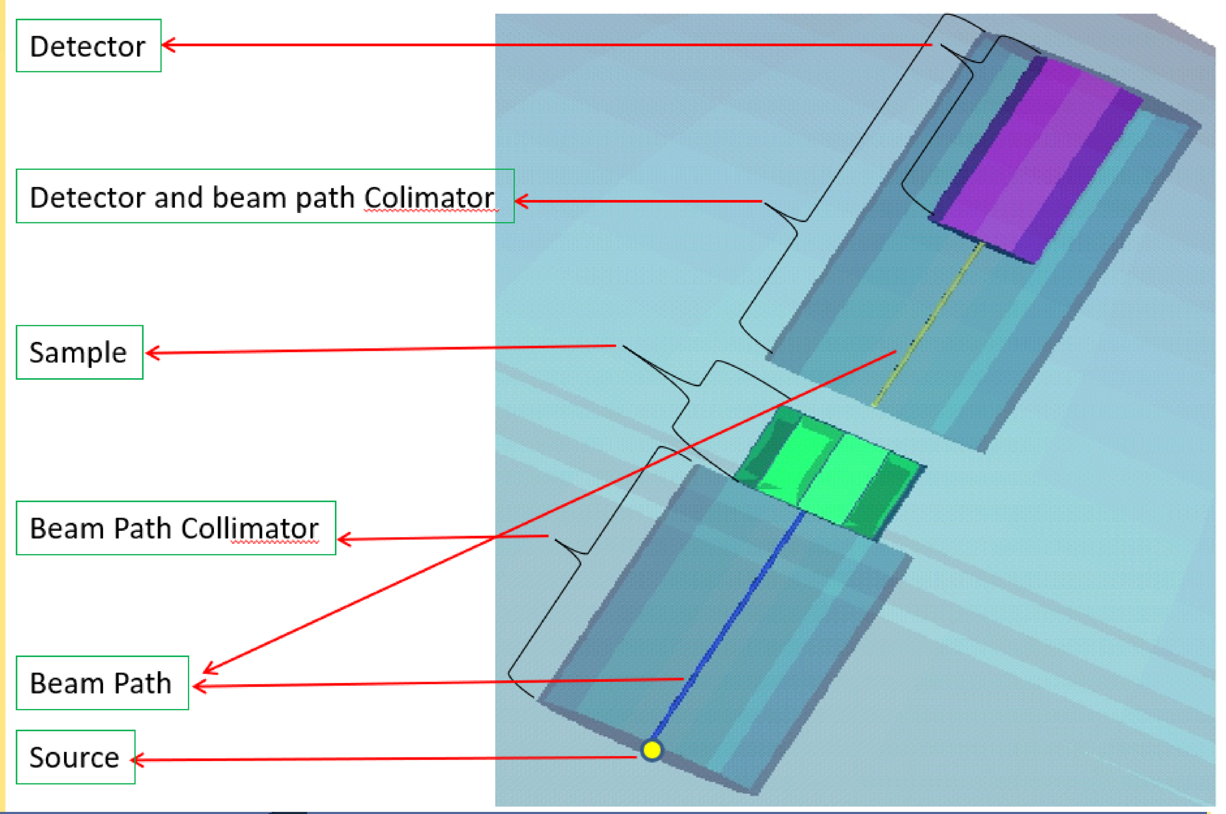
The motivation for this study is twofold:

- Studying the behavior of various materials against gamma and neutron radiation and the calculation of the effect of distance.
- Monitoring the behavior of neutrons for which the interaction mechanism has not yet been established on a mathematical basis.

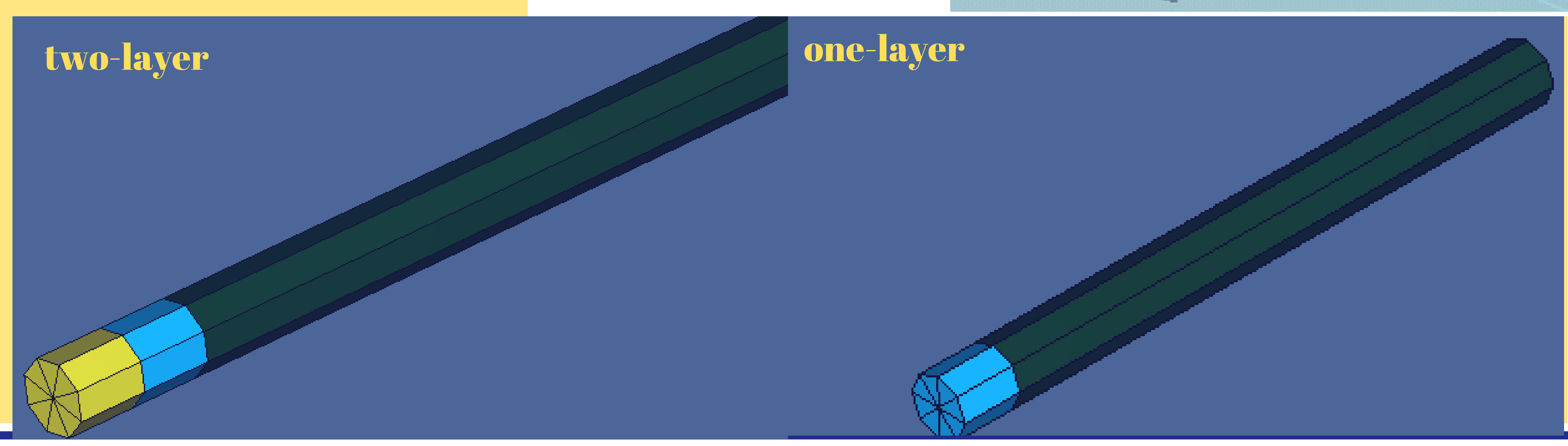
MC Simulation Method

- In this study, MCNP6.2 was used for generating and transporting radiation particles through material geometry.
- MCNP can handle interactions and estimate output quantities.
- MCNP was developed in Los Alamos National Laboratory for general-purpose radiation interactions and offers the ability to transport various types of particles in 3D geometries.

The experimental setup created using MCNP6.2



B2O3 and Gd2O3 doped Material both one-layer and two-layers.



Results

- Like gamma radiation, neutrons undergo scattering and absorption interactions with matter.
- These interactions form the basis for methods used to shield and measure neutron radiation.
- Neutron interactions are obtained by considering all interaction mechanisms.
- The results obtained by using the equations below are shown in the Tables for the materials.

$$\sum_R = \sum_i \rho_i \left(\sum R/\rho\right)_i$$

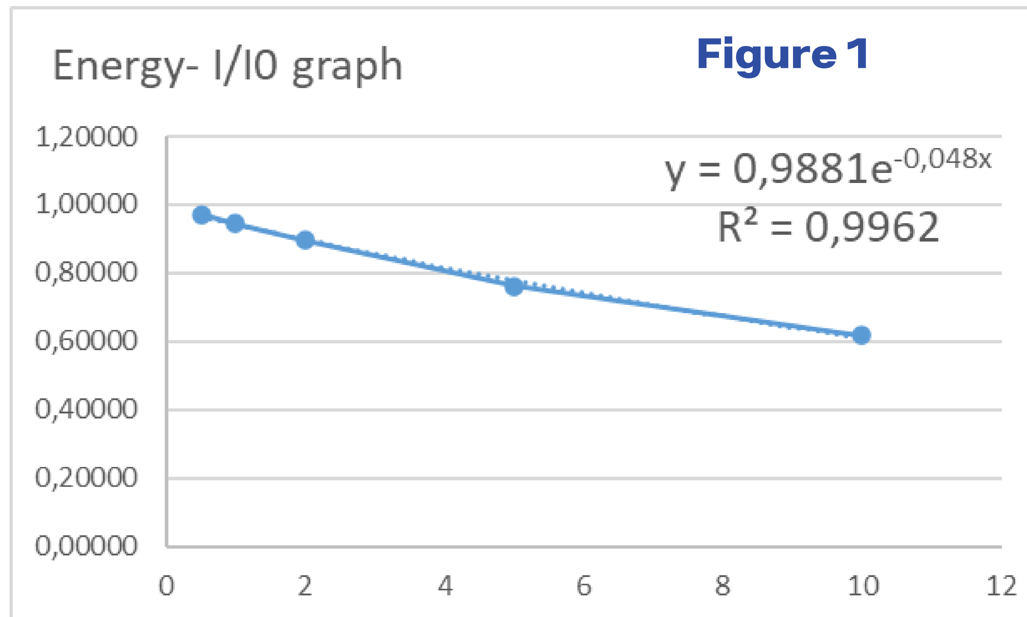
$$\sum_R /\rho = \sum_i W_i \left(\sum R/\rho\right)_i$$

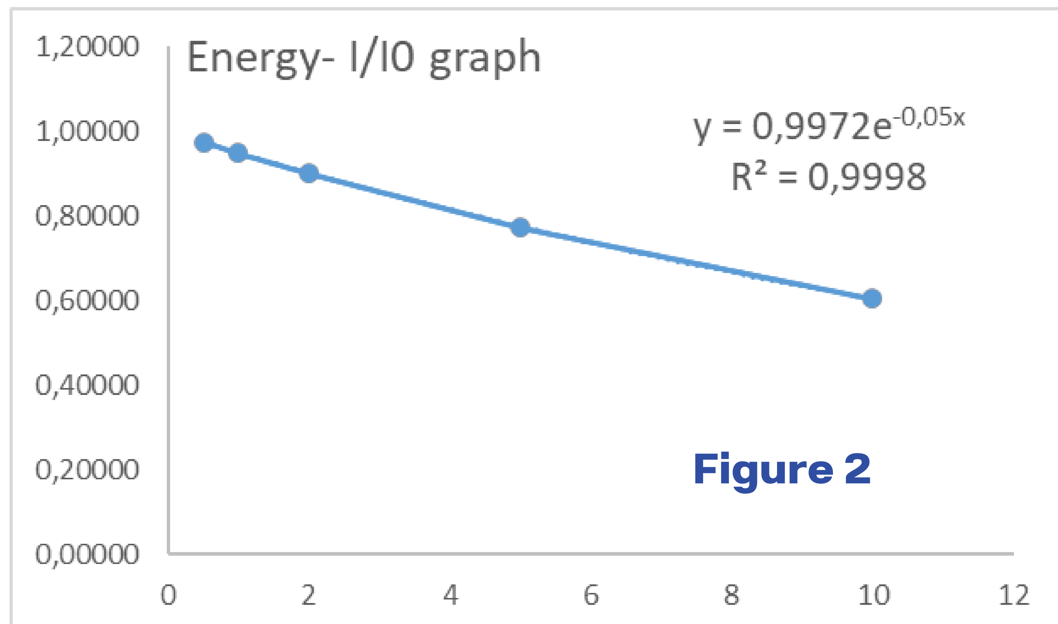
Material	∑R (cm^{-1})
Al	0,07911
W	0,0297
Stainless Steel	0,154039
PEN	0,095786
PET	0,096538
Quartz	0,082512

Glasses	∑R (cm^{-1})
C0	0,120686
C1	0,118975
C2	0,117855
C3	0,11684

Conclusion

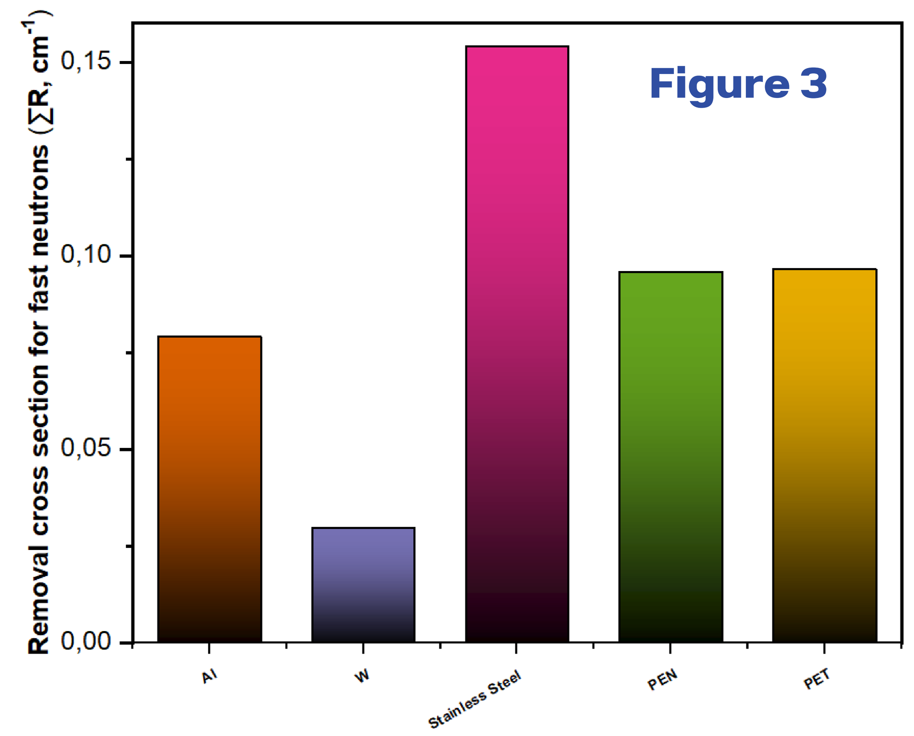
- The tungsten (W), which has a high atomic number shows the best performance in the study.
- Among the glasses, C0 glass was found to have the highest neutron radiation protection feature.
- The simulation studies and analysis is still ongoing for more materials and mixtures to choose the best materials for calorimetric studies.

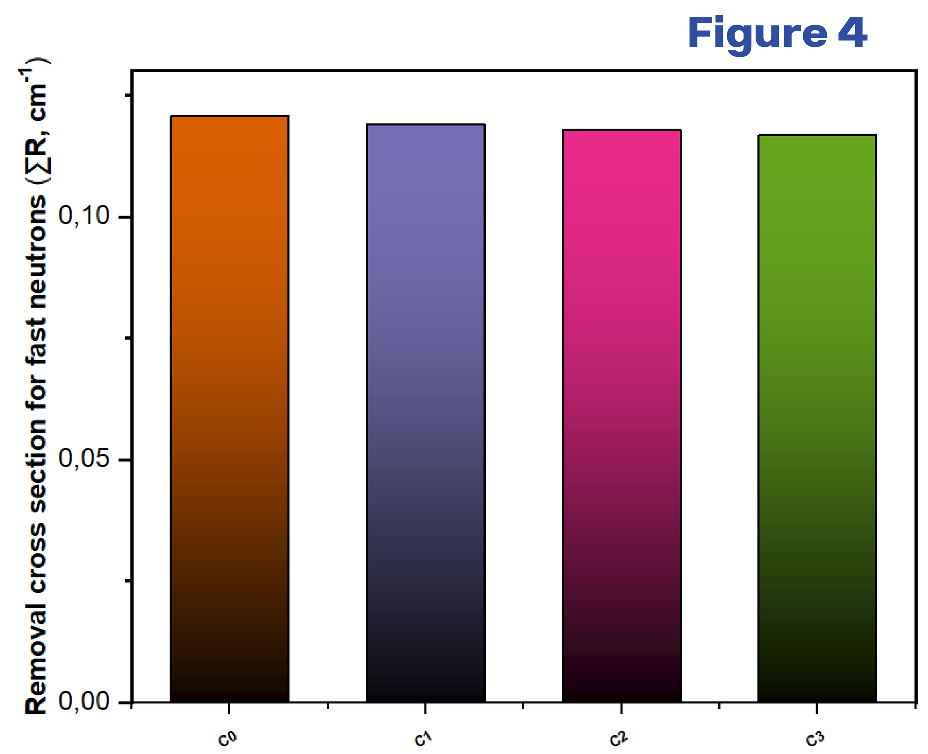




The removal cross-sections ∑R for fast neutrons for the investigated materials and glasses are in Figure 3 and 4.

The energy- I/I0 values obtained as a result of the simulation are given in Fig. 1 and 2.





- It can be seen that Gd2O3 and B2O3-doped materials have an important role in nuclear studies.
- Total atomic cross-sections ∑R offer a great opportunity to compute the energy range of heavy particles in B/Gd-doped glasses.

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