Shielding Optimization for a Neutron Source Using Monte Carlo Methods

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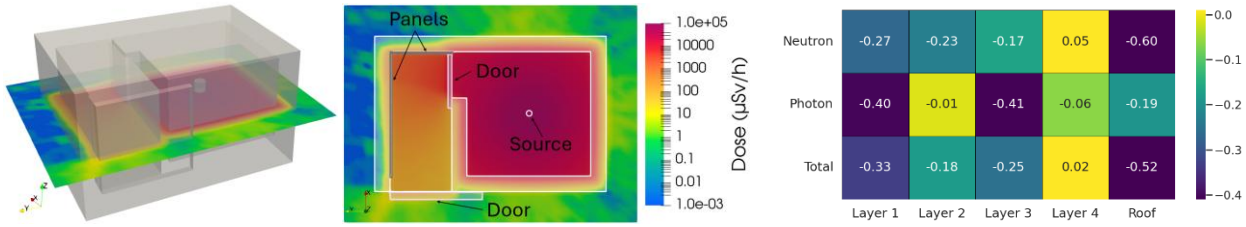
This work presents a systematic optimization study of neutron source shielding for a dedicated multilayer bunker designed to house a cylindrical inertial electrostatic confinement (IEC) neutron source within the framework of the LIBRA project. LIBRA aims to investigate lithium deuteride (^{6}LiD) as a tritium breeding material for future nuclear fusion applications.

The bunker design must guarantee dose rates below 2 µSv/h at 1 m from the external wall to limit radiation exposure to personnel. The optimization process is carried out using the Monte Carlo neutron transport code OpenMC. A parametric sweep methodology is employed to explore a wide range of shielding configurations, systematically varying material selection and layer thicknesses. The methodology begins with the evaluation of individual shielding materials, followed by a comprehensive parametric exploration of the complete bunker geometry that considers all relevant material and thickness combinations and includes skyshine contributions. The analysis is completed by evaluating the impact of additional radiation-mitigation features, such as absorbing panels and the access doors.

The results show the influence of individual materials and thicknesses to be quantified, revealing key trends and their impact on dose reduction and overall shielding performance. The suggested methodology provides a robust and flexible framework for shielding design in fusion-related neutron facilities and can be readily extended to similar experimental platforms.



(a) (b) (c)

Figure 1. (a–b) Dose rate maps for the bunker configuration including the access doors and absorbing panels. (c) Pearson correlation matrix illustrating the impact of the different shielding layers on the resulting dose levels for a selected material combination.

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