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A GEANT4-based simulation of cosmic rays background and secondary beams analysis for nuBDX-mini experiment

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This work represents a comparison of experimental cosmic radiation data obtained at the laboratory of the INFN Genova section and GEMC simulations. GEMC is an interface to the GEANT4 library developed and used at Jefferson Lab. The cosmic radiation was measured by an inorganic scintillating detector (Caesium Iodide Thallium-doped crystal) 6x6x32 cm in size. The detector is surrounded by an active plastic veto, which allows it to track events and put them in coincidence with the crystal. The simulations were normalized to the daily expected number of events, and a realistic geometry was implemented. This work is also useful to optimize the shielding design aimed to be used with the nuBDX-MINI detector that will be deployed at Jefferson Lab (USA). nuBDX is the electron beam-dump experiment aimed to measure coherent elastic neutrino nucleon scattering (CEvNS) using neutrinos produced by the interaction of an intense 11 GeV energy electron beam with the experimental Hall-A dump in a fixed target experiment. nuBDX-MINI is a prototype of the final detector made by a CsI crystal surrounded by an active plastic scintillator veto.
The nuBDX setup is unique since neutrino flux produced in electron-dump interaction has the maximum in the decay-at-rest (DAR) energy spectrum in the 1-100 MeV range, optimal to access CEvNS. On the other hand, the low energy of incoming neutrino and the small recoil induced by the coherent nucleus scattering require low-threshold (10-200 keV) target detectors to detect low nuclear recoils.
The optimum way to shield the low-threshold detector from a neutron background was considered. Based on the calculations, the most functional composition and shape of neutron radiation protection were determined. A shielding consisting of several layers, including a thick layer of lead and water was deployed. An active veto surrounding the crystal provides further rejection capability. Lead foil covering the scintillator to shield from gamma radiation produced in the external lead layer by primary neutron flux was also added.

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