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Projected Backgrounds Simulation in the RELICS Experiment

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The REactor neutrino LIquid xenon Coherent Scattering experiment (RELICS), leveraging liquid xenon time projection chamber (LXeTPC) technology, aims to investigate the CEνNS process by detecting antineutrinos interacting with xenon nuclei. This study details the design and optimization of the RELICS detector and shield to achieve an optimal signal to background ratio. Backgrounds from the Cosmic Muons, radioactivity of detector and shield materials are all considered in the simulation package developed based on GEANT4. Background mitigation through active Xenon veto and multiple scatters within the LXeTPC are applied to the simulated datasets. Within a fiducial mass of 32 kg, the single scatter electronic recoil (ER) background is estimated to be $(22.7\pm0.2)\times10^{-3}(\mathrm{kg\cdot day\cdot keV})^{-1}$ in ER equivalent energy region of [0, 100] keV, dominated by gammas from the detector materials. The nuclear recoil (NR) background is $(1.54\pm0.08)\times10^{-2}(\mathrm{kg\cdot day})^{-1}$ in NR equivalent energy region of [0.1, 1] keV, dominated by cosmic Muon-induced neutrons. The expected CEνNS event rate is two orders of magnitude higher than the background level estimated above, enabling RELICS a high discovery potential of CEνNS signals from reactor neutrinos.

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