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Radiation Modeling and Shielding Design for the Mu2e Branching Ratio Normalization Detectors

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The Mu2e experiment will search for Beyond-the-Standard-Model, Charged Lepton Flavor Violation (CLFV) in the neutrinoless muon-to-electron conversion process $\mu^- + \mathrm{Al} \rightarrow e^- + \mathrm{Al}$. The number of muons stopped and captured by the aluminum Stopping Target is measured by the Stopping Target Monitor (STM) using muon atomic capture x-rays and muon nuclear capture γ-rays. An HPGe detector with $\sim$ 0.8 keV Gaussian resolution at 662 keV, and with an estimated photon rate capability of $\sim$ 100 kcps along with a $LaBr_3$ detector with Gaussian energy resolution of 7 keV at 662 keV, with an estimated photon rate capability $\sim$ 800 kcps are used to report the muon capture rate. In one beam-on second, 2.3×10^{13} protons hit the Production Target, 3.7×10^{10} muons are stopped in the Stopping Target and together, generate an energy flux of 3.2×10^{8} TeV cm^{-2} sec^{-1} consisting of muons, electrons, neutrons, x-rays, and γ-rays, with mean particle energy $\sim$ 10 MeV. In order to measure the number of stopped muons in the experiment, the energy flux must be reduced by a factor of $5{\times}10^8$ for the $LaBr_3$ detector and $3{\times}10^9$ for the HPGe detector. In order to accomplish this reduction, a detector shielding house is placed 35 m from the target, downstream of a beam line consisting of poly absorbers and a sweeping magnet, and containing a tungsten collimator with 0.5 cm^2 apertures. A combination of lead, tungsten, copper and aluminum are layered to achieve the shielding goals. Borated polyethylene is used to absorb neutrons. Separate protection plans are made for the HPGe detector and the $LaBr_3$ detector because of their different rate and radiation sensitivities. Rate and energy flux requirement for the detectors are shown to be satisfied using Geant4 simulations.

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Yes

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