Simulation of Radioactive Backgrounds in an Enriched 57 Crystal HPGe Array

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The Majorana experiment's most difficult challenge is to identify and mitigate its backgrounds. A critical step in achieving this goal is to estimate the contributions to the signal region of interest (ROI) from the different backgrounds. A comprehensive Monte Carlo study of these backgrounds has been initiated, using the combined Majorana/Gerda simulation package, MaGe. The simulations are performed at the PDSF facility at NERSC. This effort includes quantitative estimates of background contributions to the ROI from cosmogenic neutrons, (α,n) neutrons, surface alpha production and bulk contamination of radioactive isotopes.

The simulated detector geometry consists of 57 enriched, 1.1 kg HPGe crystals arranged in 3 layers in a close-packed geometry. The simulation includes support structures, shielding and electronics, since radioactive contamination from these can contribute to the background. The simulation also includes shields and the surrounding underground experimental hall.

Shown below are examples from the simulation program. Figure 1 shows a spectrum of ^{208}Tl decaying in the inner copper shield. The simulation showed that ^{208}Tl (from primordial ^{232}Th) in the inner copper shield is a serious concern for Majorana and the levels will have to be tightly controlled to the 1 μBq/kg. Level.

Figure 2 is a demonstration of a surface sampling algorithm developed by the MaGe group to generate a set of uniform points on surfaces in the detector.

Figure 1: Simulated spectra of ^{208}Tl decaying in the inner copper shield. The different colors correspond to specific analysis cuts used to reduce backgrounds.

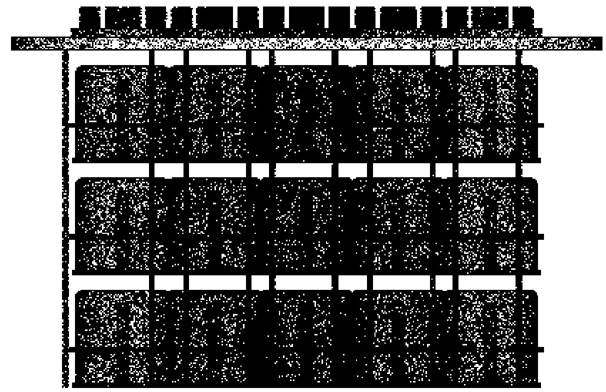

Figure 2: Surface points sampled on internal detector surfaces

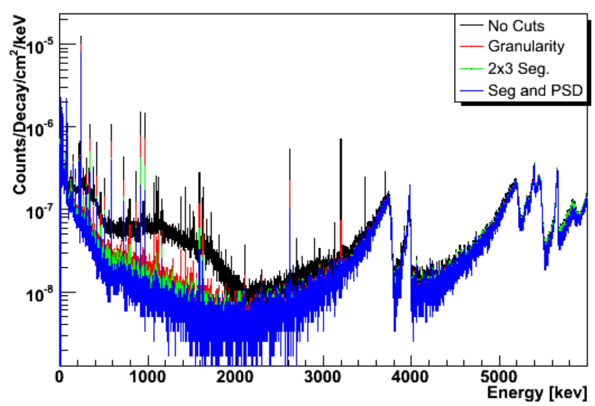

Figure 3: Simulated ^{208}Tl decay chain spectra with analysis cuts. The alpha spectra are visible at the higher energies.

This is critical for simulating the effect of surface alpha contamination. Figure 3 shows an example of a simulated ^{232}Th chain decays with alphas on all internal surfaces of the detector. The study of surface alpha decays placed a cleanliness requirement similar to that of the SNO-NCD's on the inner surface of the detector.

The study of muon-induced neutrons and neutron interactions inside the detector are still ongoing and we anticipate to complete it in the next year.