Background Modelling for the TEXONO Experiment

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Introduction

TEXONO collaboration is pursuing a research program on low energy neutrino and dark matter physics at the Kuo-Sheng Neutrino Laboratory (KSNL). The KSNL is located at a distance of 28 m from a 2.9 GWt (thermal) reactor core with arond 30 MWE (meter water equilvant) overburden [1]. The current goal of collaboration is to develop novel detectors with kg scale target mass, 100 eV sensitivity and extremely low-background to study the neutrino-nucleus coherent scattering. The main detector of TEXONO experiment is point-contact High Purity Germanium (PCGe), which is widely used for various experimental investigations, such as dark matter experiments, neutrino experiments and double beta-decay experiments.

We present a background model for PCGe that is located in the KSNL under 50-ton passive shielding house. The model includes background contributions from both internal and external contamination. The surrounding and the different components of the HPGe detector are the major sources of α, β, γ and neutron. It is impossible to completely remove the background events, but the background level can be suppressed by employing proper shielding material. The background analysis of the detector plays a pivotal role in finding the contaminants present in the different components of the detector, shielding around the detector and the surrounding.

We adopt the Geant4-based simulation framework to develop the background model, taking into account all contributions from the real set-up and the environment in the experimental site. The dimensions of the shielding, the detector and the detector components considered in simulation are same in comparison to the reactor set-up at KSNL.

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Experimental Setup

The schematic view of the PCGe detector and anti-Compton detector Sodium Iodide NaI(Tl) is depicted in Figure 1. The PCGe detector is placed inside the vacuum cylindrical Copper (Cu)-shell. The PCGe detector is further covered with the NaI(Tl) to suppress the ambient gamma-background. All coincident events between PCGe and NaI(Tl) detector were veto using the NaI(Tl)-detector energy spectrum. A horizontal copper tube is connected to the copper shield of the detector for cryogenic purpose. The detector and its whole components have been shielded with Cu-shielding. This whole structure has been placed inside the 50-ton passive shielding house.

In order to construct the experimenrtal geometry, the following parameters have been adopted:

1. HPGe detector (Length(L) = 50 mm, Diameter (D) = 50 mm), 2. Thickness of Germanium dead layer (T) = 0.7 mm), 3. Copper shielding (L = 236 mm, T = 1 mm), 4. NaI(Tl) detector (L = 220 mm, T = 57.5 mm), 5. PMT (base part) (L = 94 mm, D = 161 mm), 6. PMT (upper part) (L = 33 mm, D = 81 mm), 7. Outside copper shielding (L = 457 mm), 8. Horizontal copper tube (L = 304 mm, D = 40 mm) and 9. Copper box (L = B = H = 1060 mm)

Source confinement and event recording

There are two main sources of photon background, environmental radioactivity and cos-

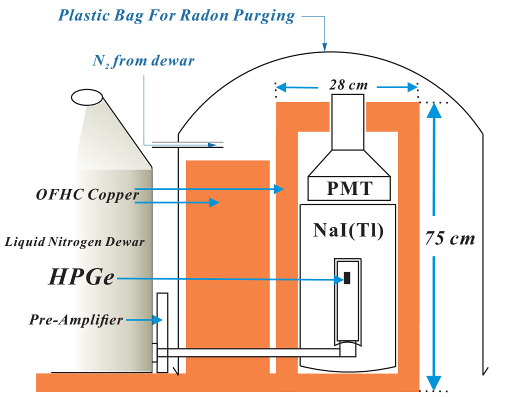

FIG. 1: Schematic view of the PCGe detector, anti-Compton detector as well as inner shielding and radon purge system.

mic ray induced photons. The main cause of environmental radioactivity at KSNL is the natural occurrence of Uranium (^{238}U), Thorium (^{232}Th) and Potassium (^{40}K) in construction, shielding and detector mounting materials. We have identified nine radioactive nuclides: ^{40}K, ^{208}Tl, ^{210}Pb, ^{212}Bi, ^{212}Pb, ^{214}Bi, ^{226}Ra, ^{228}Ac, and ^{234}Th from the experimental reference data [2]. We have also confined the airborne radioactive nuclides such as ^{135}Xe, ^{135m}Xe, ^{133}Xe and ^{226}Ra in the air surrounding the copper shielding of the detector. ^{60}Co and ^{54}Mn have been confined on the surface of cryogenic copper tube. These two nuclei exist as point like contaminant in the reactor. The events have been recorded utilising ROOT framework and all the spectra have been combined to get the final spectrum from the simulation.

Fig. 2 represents the comparison between simulation spectrum and experimental spectrum.

Results and Discussions

In both experimental and simulated spectra, except the photo-peak at 2614 kev (for ^{208}Tl) there are two peaks at 2103 kev and at 1592 keV. These two peaks are single escape peak and double escape peak of ^{208}Tl respectively. These two peaks arise due to the small

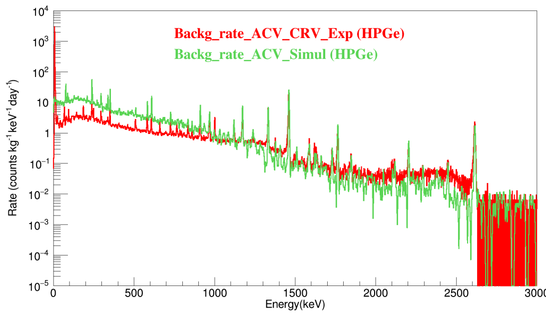

FIG. 2: Comparison of simulation spectrum and experimental spectrum.

size of the detector. The energy peak of energy 249.8 keV in experimental spectrum has been identified as the gamma peak of ^{135}Xe.

The total activity of these nine nuclides and reactor related airborne radioactive nuclides is not enough to explain the observation as shown in figure 2. The cosmic ray induced long-lived radioactive impurities in the detector material might be activated due to exposure of hadronic component of cosmic ray at sea level and even more during the transportation in air. In order to include the cosmic ray induced background, intensive studies are in progress.

Acknowledgments

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