Intensity variation of X-ray peaks in nGe detector

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Introduction

Dark matter is among the most important and long standing open problems in modern physics. Various dark matter candidates have been proposed by several models in support of the dark matter but till date dark matter candidate is not yet discovered. The Weakly Interacting Massive Particles (WIMPS) are the most accepted candidates for dark matter. TEXONO collaboration used Germanium ionization detectors, which is capable of observing rare weakly interacting particles by discriminating them from all known type of background particles and radiations including low energy neutrons[1–3].

Germanium ionization detectors are novel techniques offering kg-scale radiation sensors with sub-keV sensitivities. Germanium ionization detectors have been used for the studies of neutrino interactions and properties as well as to search for light WIMP Dark Matter[1–3]. In this report, we will focus on the intensity variations of the X-ray peaks at 10.37 keV and 9.66 keV arises due to the germanium activation by both thermal and fast cosmogenic neutrons[1–4].

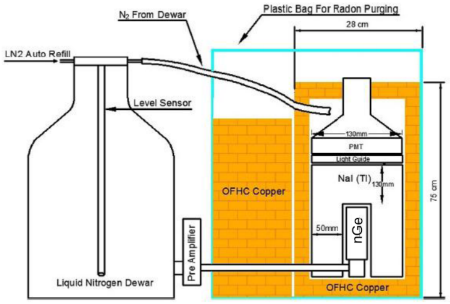

FIG. 1: Schematic diagram of the experimental set-up [1].

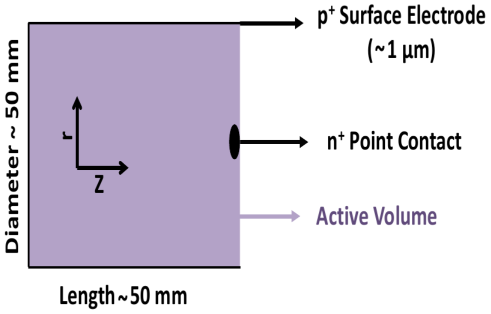

FIG. 2: Schematic crystal configurations of the nGe detector [1].

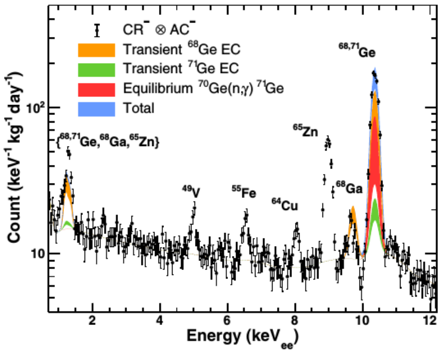

FIG. 3: Measured $AC^{-} \otimes CR^{-}$ spectra taken with the nGe detector at KSNL. The contributions of various ^{71}Ge, ^{68}Ge characteristic K X-ray, L X-ray peak and the ^{68}Ga K X-ray peak, based on predictions using the measured equilibrium neutron capture rates, are superimposed [4].

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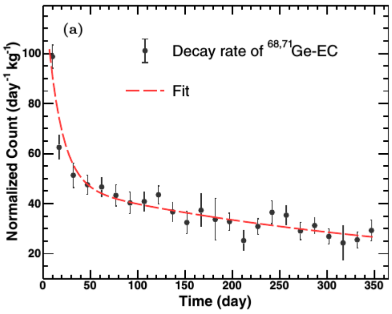

FIG. 4: Intensity variation of 10.37 keV (X-ray) peak with respect to time[4].

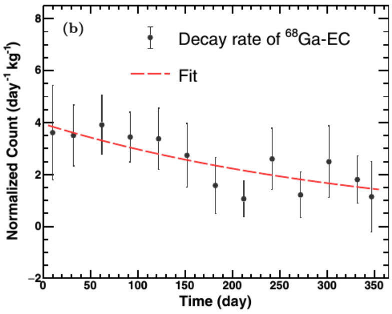

FIG. 5: Intensity variation of 9.66 keV (X-ray) peak with respect to time[4].

Experimental Overview

At the experimental site the nGe detector was enclosed by an NaI(Tl) detector as an anti-Compton (AC) detector and copper passive shielding inside a plastic bag purged by nitrogen gas evaporated from the liquid nitrogen dewar. This setup is shown in figure 1. Further this setup was put inside the passive shielding house [1–3]. This whole structure was surrounded by cosmic-ray (CR) veto panels made of plastic scintillators read out by photomultiplier tubes [1–3]. The characterization, calibration and background rejection is described in details in Ref.[1–3]. In this article we follow, the notations as reported in our earlier works [1–3], where CR and AC denotes the cosmic-ray veto systems and anti-Compton detector respectively, while the superscript +(-) corresponds to coincidence (anti-coincidence) with the nGe detector signals.

Result and Discussion

After using all the well-developed techniques for the data analysis summarized in Ref. [1–3], we get the energy spectrum as shown in figure 3. Figure 3 shows the $AC^- \otimes CR^-$ spectra of nGe in which the different components of Ge X-ray lines are superimposed. Figure 4 and 5 show the variation of the X-ray peaks at 10.37 keV and 9.66 keV respectivly, for the 347 days of data taking at the KSNL with nGe detector.

These isotopes are primarily produced by neutron capture channels $^{70}Ge(n,\gamma)^{71}Ge$, followed by the electron capture in $^{71}Ge(e^-,\nu_e)^{71}Ga$ and $^{70}Ge(n,3n)^{70}Ge$, again followed by $^{68}Ge(e^-,\nu_e)^{68}Ga$ and $^{68}Ga(e^-,\nu_e)^{68}Zn$ [4]. It can be seen from figure 5 that the equilibrium yield of the 9.66 keV line and hence in situ production of $^{70}Ge(n,3n)^{68}Ge$, are consistent with zero. While the equilibrium yield of the 10.37 keV line is due exclusively to in situ production of $^{70}Ge(n,\gamma)^{71}Ge$. This measured rate is used to fix the normalization of the epithermal neutron component [4].

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