Low background radiation measurement at IIT Ropar

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Introduction

In Neutrinoless Double Beta Decay ($0\upsilon\beta\beta$) investigations, the minimization of background radiation is very crucial because it ultimately determines the minimum detectable radiation level [1]. Recently, Dokania *et al*., studied low background radiations at TIFR Mumbai in connection with the search for $0\upsilon\beta\beta$ in ^{124}Sn. In order to minimize the background radiations, the amount and nature of the background radiations need to be investigated. The present work is a baby step to quantify the natural background radiations and to assign the decay chains of their origin. The findings of the present work will be used as an input for our efforts to setup a facility for investigation of $0\upsilon\beta\beta$ events.

It may be pointed out that the background radiations may arise from building materials, surroundings, ancillary equipments and from the detector itself [2]. A major component of the background radiations arises from the secondary radiations produced by the cosmic interactions in the Earth's atmosphere. In addition, the products of atmospheric fallout, like; ^{95}Zr, ^{95}Nb, ^{106}Ru, ^{125}Sb and ^{144}Ce may be seen.

As a part of our initiative to setup low background counting system to investigate rare decays, we setup a counting system using standard HPGe detector and MBS electronics. A brief account of the experimental setup and findings is giving in the following sections.

Experimental Details

A p-type HPGe detector (model: GC2018) with a relative efficiency of 20% and a resolution of 1.8keV at 1332.5keV gamma-line of 60-Cobalt has been coupled with a hybrid, VME+NIM based, data acquisition system. Block diagram of the experimental setup used in the present measurements is given in Fig.1. The nominal size of the germanium crystal was 6.22cm diameter and 3.25cm length as stated by the manufacturer [3]. No shielding has been used in the entire experiment. Experimental data have been collected using GO4 and analyzed in ROOT and RADware frameworks. In order to characterize the detector, three different type of scans, (i) *Distance Scan*, (ii) *Radial Scan*, and (iii) *Lateral scan*, around the detector have been performed. Radial and lateral scans have been carried out with ^{60}Co, ^{57}Co, ^{137}Cs, and ^{22}Na sources.

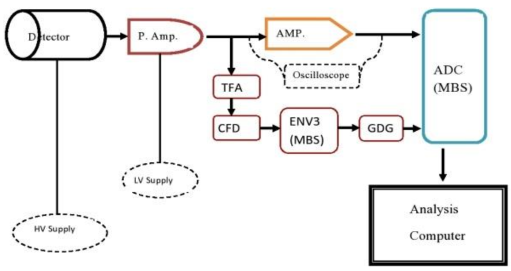

Fig. 1 Block diagram of the experimental setup used in the present measurements

Results and Analysis

The distance scan was made to calculate different performance parameters. Energy calibration was performed with ^{152}Eu & ^{60}Co sources for all scans. Relative efficiency and Peak to Compton ratio were found to be 24% and 46:1, respectively for 1332.5 keV peak of ^{60}Co. To further verify the crystal position and its behavior, radial and lateral scans have also been performed. Lower detection limit can be achieved with high efficiency & good energy resolution of the germanium crystal [4].

After the proper characterization of the detector, the setup was employed to record background radiations for a longer time.

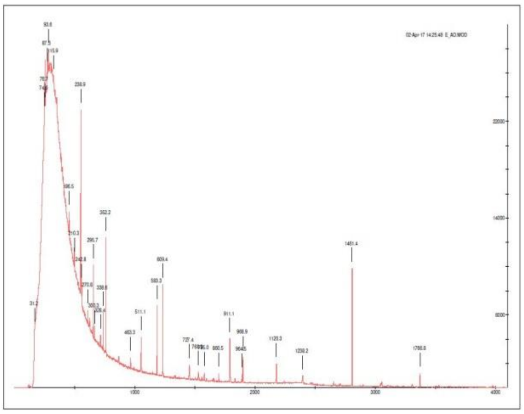

Fig. 2 The Ambient spectra of different BG sources.

Background data recorded for a fairly longer time have been analyzed using ROOT and Radware where the characteristic gamma-lines have been marked and assigned to different decay chains.

In order to calculate the radio activity of different elements, efficiency calibration of the detector has been done using Logarithmic interpolation expressed below.

$$\ln[\varepsilon(E)] = \ln(\varepsilon_1) + \frac{[\ln(E)-\ln(E_1)]*[\ln(\varepsilon_2)-\ln(\varepsilon_1)]}{[\ln(E_2)-\ln(E_1)]}$$

where; ε_1 and ε_2 are the known efficiencies of ^{137}Cs & ^{60}Co corresponding to given energies E_1(661.65 keV) & E_2(1173.228 keV) and ε is being calculated corresponding to some energy E taken from the above shown spectrum. The activity of the detected elements has been calculated using the standard formulation.

$$A_t = \frac{N_0}{\varepsilon * t * I\gamma}$$

where; N_0 is the net peak area, ε the above calculated efficiency, t the lapse time and $I\gamma$ the emission probability of given gamma ray energy, which is set as 1(max) because minimum activity was supposed to be calculated.

Conclusions & Summary

Three major scans were performed to understand, characteristics of the HPGe detector, using standard γ-ray sources. Standard parameters, like; energy resolution, relative efficiency, full energy peak efficiency, peak to Compton ratio and their behavior with the energy of the radioactive sources, have been studied. The radial and lateral scan were performed around the detector to look for regular pattern of efficiency as a function of distances. We have identified more than 60 radio-isotopes on the basis of their characteristic gamma-lines, and their activities have been calculated. ^{40}K has shown maximum activity among all detected isotopes, and ^{214}Bi has been found to be minimum.

Details of the present work will be presented during the symposium.

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