Background Radiation Measurements at the INO site

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Introduction

The India-based Neutrino Observatory (INO) is an upcoming underground facility at Pottipuram in Bodi West Hills (BWH) of Theni district in Madurai, Tamil Nadu. The INO will have a rock overburden of $\approx$ 1200 m and will house experiments like ICAL to study the atmospheric neutrinos, the Neutrinoless Double Beta Decay experiment (NDBD), etc.

Experimental Details and Analysis

The background radiation study was carried out at the INO site on 26$^{\text{th}}$ January, 2011 using a portable $LaBr_3$ detector integrated with digital counting system. The spectra were recorded for half an hour each at four different positions, namely, at base (position 1), close to portal (position 2) and two positions on the rock (position 3 and 4). The background spectrum was also recorded at TIFR laboratory (P-306) for reference. Since the $LaBr_3$ detector has internal radioactivity (^{138}La and ^{227}Ac background), the intrinsic background spectrum of the detector was measured by placing the detector inside a 10 cm thick low activity lead ($<$ 0.3 Bq/kg) shield at TIFR and data was corrected for this.

Fig. 1 shows the comparison between the spectra at Bodi West Hill and TIFR. This is indicative of the higher contribution from ^{40}K and natural radioactivity of actinides. Variation in the rock composition corresponding to positions 3 and 4 has been shown in Fig. 2. Table I gives a comparison of integral counts in the energy regions of about 1390-1520 keV and 2545-2685 keV. The background level is higher at the INO site as compared to the TIFR laboratory over the energy region of interest (1-3 MeV). Significant variation in the yield of 2615 keV is seen at different BWH rock positions 3 and 4 which were actually 2 m apart.

A rock sample (weight = 22.882 g) bored

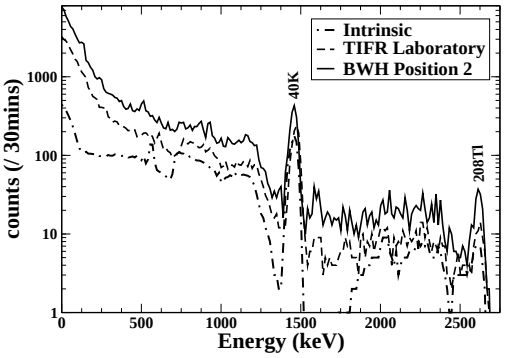

FIG. 1: Background spectra at different positions.

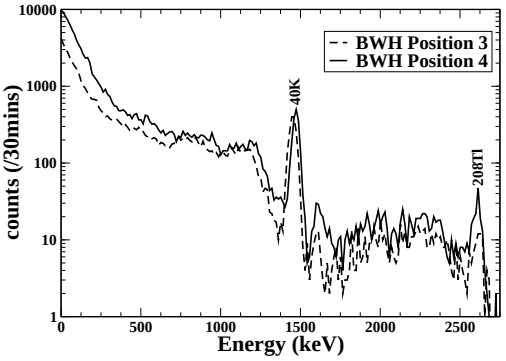

FIG. 2: Comparison of background spectra at BWH Positions 3 and 4.

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TABLE I: Comparison of background levels, counts are in units of /100 keV/hr.

Location		< 1460 > keV	< 2615 > keV
BWH 1	Lat. 9.94463°N Long. 77.28066°E Alt. 449m	985(78)	133(21)
BWH 2	Lat. 9.94596°N Long. 77.27943°E Alt. 471m	1301(62)	181(20)
BWH 3	Lat. 9.94786°N Long. 77.28012°E Alt. 473m	1299(62)	42(12)
BWH 4	Lat. 9.94786°N Long. 77.28012°E Alt. 473m	1432(64)	165(20)
TIFR	Alt. 0m	234(23)	27(6)

from the depths of BWH was counted in a close geometry in the low background set-up at TIFR [1]. The sample was kept on a 1.2 mm thick Teflon plate at a distance of 1 cm from the face of the detector. BWH rock sample together with the background (scaled to 0.1) are shown in Fig. 3. Efficiency in close

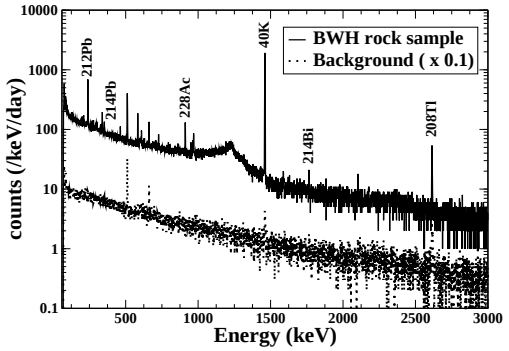

FIG. 3: BWH rock spectra in the low background set-up, scaled background is also shown for comparison.

geometry is estimated from Monte Carlo simulations using Geant4. Background due to the Teflon plate has been subtracted. Further, the BWH rock sample was powdered and Neutron Activation Analysis (NAA) was performed. The sample was irradiated for 1 minute at DHRUVA Reactor, BARC with a neutron flux $1.5 \times 10^{13}\mathrm{cm}^{-2}\mathrm{s}^{-1}$.

TABLE II: Estimation of activity of some isotopes in the BWH rock sample [2].

Isotope	Activity (mBq/g)
^{40}K	863(346)
^{208}Tl	1.5(0.9)
^{212}Pb	9.5(3.8)
^{214}Pb	1.5(0.7)
^{214}Bi	5.5(2.4)
^{228}Ac	9.4(3.8)

TABLE III: The composition of BWH rock using NAA.

Element	Gamma ray of Activation Prod.(keV)	Concentration (ppm)
Na	1368.5	28473(429)
K	1525	50139(952)
Mn	847	133(2)
Sc	889	4.80(0.07)
Fe	1099	22191(421)
Zn	1115	28.8(1.4)
Th	312	17.5(0.7)

Summary

The background radiation was measured at the INO site (BWH). The primordial radioactivity, ^{40}K is the highest contributor to the background. Higher concentration of ^{40}K was also found in rock samples from PUSHEP [3]. This information will be helpful in design of radiation shielding of the detector at the INO cavern.

Acknowledgments

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References

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