Background measurements at the DHRUVA reactor site for feasibility studies towards antineutrino detection from reactors

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Introduction

Due to improved calculations of the neutrino flux from reactors, the ratio of the observed to expected neutrinos from reactors at very short distances using the data collected from various experiments has a value less than unity ($\phi_{obs}/\phi_{calc} = 0.943 \pm 0.023$) [1, 2]. The oscillation of the electron antineutrino to a sterile neutrino at such short distances may be an explanation to the observed anomaly. It has also been shown that the antineutrinos coming from reactors can be used to monitor reactors remotely [3]. It was proposed to setup a detector at the DHRUVA reactor facility at BARC for sterile neutrino search and remote reactor monitoring. For the feasibility studies, some background measurements were done at the site at a distance of ~13 m from the reactor using a BGO (Bismuth Germanium Oxide) detector having a hexagonal crystal and Plastic scintillator bar of dimension $100 \times 6 \times 6$ cm^3 having 2 in PMTs at both ends.

1. Measurements with plastic scintillator bar

Data was taken with the bar trying various combinations of shielding using Borated Rubber (40 % boron) and Lead. The bar was wrapped with a 25 μm thick Gd coated (4.8 mg/cm^2) aluminized mylar foil manufactured by Euro Collimators, UK. Fig. 1 shows the pulse height spectra of the bar from the two ends kept inside a castle of 5 cm thick Lead and 5 mm thick Borated Rubber. We observe an asymmetry in the spectra. The bar was placed in such a way that the line from the centre of the reactor was perpendicular to the length of the bar. Fig. 2 shows the position of the bar with respect to the reactor. The spectrum in black corresponds to the left PMT and the spectrum in blue corresponds to the right PMT. The left PMT was seeing more counts compared to the right PMT even though their gains were matched using standard gamma sources.

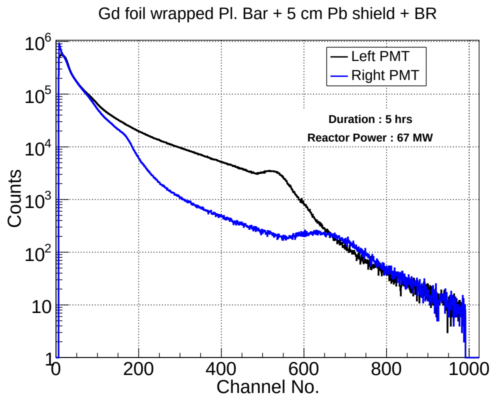

FIG. 1: Pulse height spectra of the Gd wrapped plastic scintillator bar.

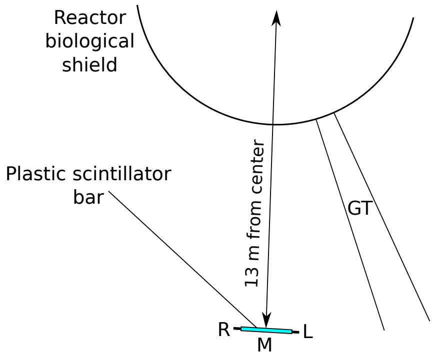

FIG. 2: The position of the bar with respect to the reactor

2. Measurements with BGO

To understand the asymmetry observed in the spectrum of the Gd foil wrapped plastic scintillator bar, we collected data using a BGO kept at three positions in front of the plastic bar: left, middle and right. The position of the bar with respect

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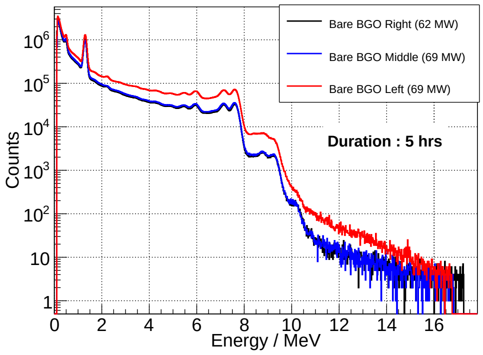

FIG. 3: Background spectra measured by the BGO kept at 3 positions in front of the bar.

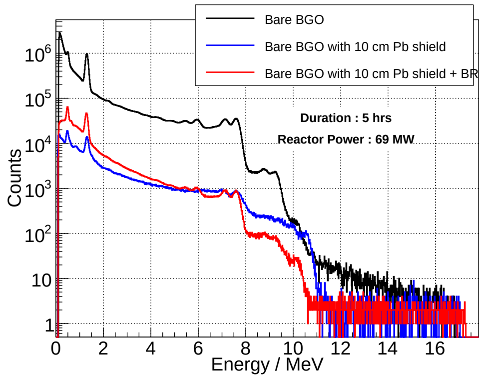

FIG. 4: BGO inside different shielding combinations.

to the reactor, positions Left(L), Middle(M) and Right(R) are shown in Fig. 2. In Fig. 3, the spectra of the BGO kept at the three positions are shown. We can clearly see that there is certainly some source of radiation that is causing the increased count rate in the left side of the Plastic scintillator bar (Red). Middle (Blue) and Right (Black) are more or less the same. The left side of the bar was close to a neutron guide tube. This may be the reason for the higher counts on the left side of the bar.

To see the reduction in the background different shielding combinations were tried with the BGO. It was put inside a Pb shield of 10 cm thickness and later an additional shielding of Borated Rubber (BR) to shield from thermal neutrons. Fig. 4 shows the spectra with the shielding combinations. Bare BGO : Black, BGO inside 10 cm thick Lead shield : Blue, BGO kept inside both 10 cm Lead and 5 mm BR shield : Red. It is observed that the high energy gamma (> 6 MeV) has been reduced when BR is present (Red), but the low energy background has increased. This has to be understood. We also measured the background when the reactor was off. The comparison of the background when the reactor is ON and OFF is shown in Fig. 5. The high energy background is almost completely reduced as expected since the high energy background is due to the radiative capture of neutrons by the materials in the environment.

3. Conclusions and Outlook

The background at the reactor site when the reactor is on is mainly due to neutrons and the ra-

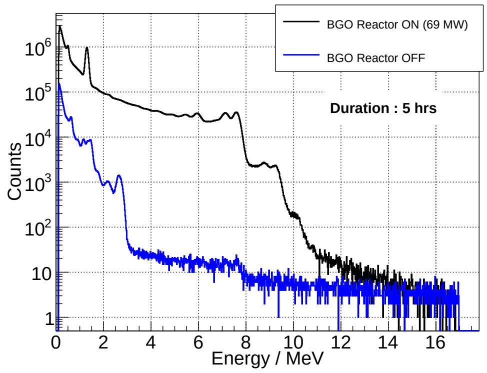

FIG. 5: Background when reactor is ON and OFF

diative capture of the neutrons by the materials in the nearby environment. Measurements with increased thickness and combinations of shielding need to be done. Experiments with delayed coincidences of the inverse neutron decay type using multiple plastic scintillator bars will further help in estimating the background.

References

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[3] A Porta et al, IEEE Transactions on Nuclear Science, Vol. 57, No. 5, October 2010.