# Response of thermal neutrons in a Gd-wrapped scintillator matrix

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## Introduction

Measurement of the reactor anti-neutrino ($\bar{\nu}_e$) spectrum at short distances ($\sim$ 10 m) from the core is gaining worldwide momentum due to the following possibilities:

1. To investigate the existence of the proposed sterile neutrino and
2. Remote monitoring of the reactor.

A typical detector setup for this purpose may comprise of plastic bar detectors coated with Gadolinium (Gd) [1]. The $\bar{\nu}_e$ from the reactor interacts with the detector material as

$$\bar{\nu}_e + p \longrightarrow n + e^+. \qquad (1)$$

The neutron is thermalized and captured in the Gd with the emission of a cascade of $\gamma-$rays adding up to 8 MeV, whereas, the $e^+$ loses its energy in the detector medium before annihilating into two 511 keV photons.

The present experiment investigated the performance of a Gd wrapped plastic detector (1m $\times$ 6 cm $\times$ 6 cm) with respect to the neutron thermalization and capture.

## Experiment

Twelve plastic scintillators were arranged in a 3$\times$4 matrix (Fig. 1) and two (front and back bar as shown in Fig. 1) of them were powered. One of the detectors was wrapped with Gd coated mylar and placed inside the matrix to facilitate thermalization of neutrons. The coating of Gd (up to 12 $\mu$m) on alumnized mylar was achieved by electron beam evaporation technique at A & MPD, BARC. A source of fast neutrons (Am$-$Be) was placed near the front bar to generate the trigger.

Negative high voltages were applied to the photomultiplier (PMT) tubes coupled at both ends of the two bars. The dynode and anode pulses were processed electronically, as shown in Fig. 2, for the purpose of recording the pulse height and timing information. The electronically OR-ed signals from both PMT's of the active detector in the front plane provided the START and the corresponding signal from the Gd wrapped bar at the back provided the STOP for the Time-to-Amplitude converter (TAC). The range of the TAC was

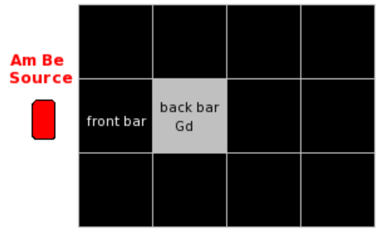


FIG. 1: Sideview of the scintillator matrix.

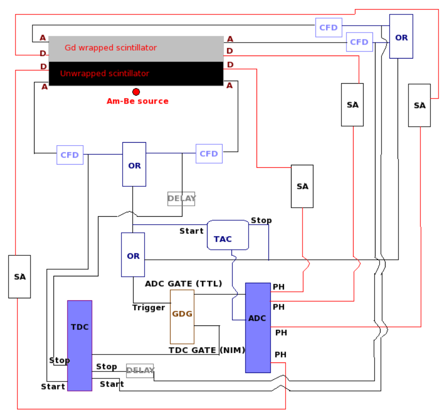


FIG. 2: Electronics block diagram for the measurement.

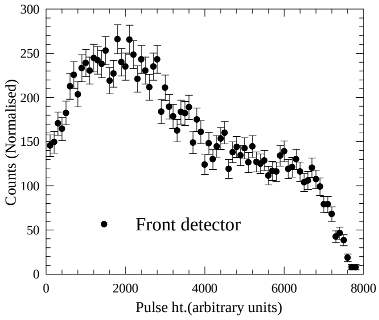


FIG. 3: Position independent pulse ht. spectrum from the front bar.

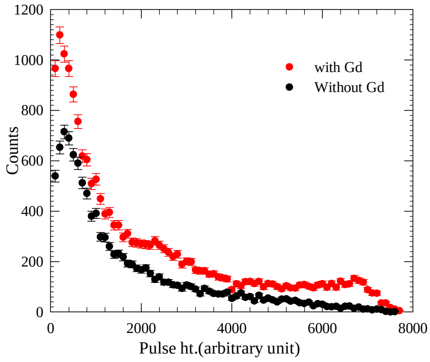


FIG. 4: Position independent pulse ht. spectra from the back detector with and without Gd wrapping.

set to 1 milli second. The prompt signal from the front detector was also used to trigger the acquisition system with a gate of width 1 milli second.

## Results and discussion

Fig. 3 shows the position independent pulse height spectrum obtained in the unwrapped front bar. Fig. 4 shows the spectra as recorded in the back detector, both with and without the wrapping of the Gd coated mylar. All the spectra are background corrected and normalized with respect to the time of the acquisition. It is evident from Fig. 4 that the pulse height spectrum from the GD wrapped scintillator showed a greater yield compared to its unwrapped configuration. This indicates a larger energy deposition (due to the ∼ 8 MeV

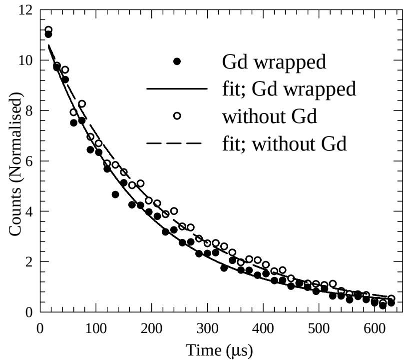


FIG. 5: The capture time (TAC) distribution for the two configurations.

TABLE I: Comparison of detection efficiency of the two configurations.

| Configuration | Ratio(TAC/Singles) | % change |
|---|---|---|
| Only Scintillator | 3.2 $\times 10^{-4}$ | – |
| Gd wrapped | 4.9 $\times 10^{-4}$ | ∼ 56 |

cascade $\gamma$−ray) in the back detector, when wrapped with Gd, compared to that in the unwrapped scintillator(∼ 2.2 MeV $\gamma$−ray).

Fig. 5 shows the capture time distributions obtained for both the cases. Although the efficiency of the configuration, when the rear bar was wrapped with Gd, is ∼ 56 % higher than the unwrapped case (Table 1), the capture time distribution is found to be essentially independent of the presence of Gd in the matrix.

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## References

[1] M. Battaglieri *et al.* Nuclear Instruments and Methods in Physics Research **A 617** (2010) 209213