Recent results from ISMRAN experiment for the detection of Reactor Anti-neutrino

R. Dey[1 2],* R. Sehgal[1 2], S. P. Behera[1], P. K. Netrakanti[1], D. K. Mishra[1], V. Jha[1 2], and L. M. Pant[2 3]

[1] *Nuclear Physics Division, Bhabha Atomic Research Centre, Mumbai - 400085, INDIA*
[2] *Homi Bhabha National Institute, Anushakti Nagar, Mumbai - 400094, INDIA and*
[3] *Technical Physics Division, Bhabha Atomic Research Centre, Trombay, Mumbai - 400085, INDIA*

Introduction:

Indian Scintillator Matrix for Reactor Anti-Neutrinos (**ISMRAN**) is an above-ground reactor anti-neutrino ($\overline{\nu}_e$) experiment at very short baseline located at Dhruva research reactor facility in Bhabha Atomic Research Centre, Mumbai. ISMRAN is a ∼1 ton detector setup by volume placed at a distance of ∼ 13m from the reactor core and can address the physics of sterile neutrino searches and reactor anti-neutrino anamoly (RAA) [1]. It is also sensitive for monitoring the reactor thermal power in a non-intrusive way. Reactor $\overline{\nu}_e$'s are indirectly detected by measuring the response of positron and neutron signals inside the ISMRAN volume which are created by inverse beta decay (IBD) process of $\overline{\nu}_e$ interaction with the plastic scintillator bars (PSBs), which is shown in fig. 1(a). In this article, we present the measurement details with ISMRAN since its installation. Further, we discuss the in-situ calibration of detectors with known radioactive γ and neutron sources such as ^{22}Na and AmBe at reactor OFF (ROFF) condition to understand the uniformity among the PSBs over the period of time.

Experimental setup:

The ISMRAN setup consists of 90 PSBs, arranged in an array of 10×9 (10 rows and 9 columns), as shown in Fig. 1(b). Each PSB is wrapped with Gadolinium Oxide (Gd_2O_3) coated aluminized mylar foils and is 100 cm long with a cross-section of 10×10 cm^2. Three inch diameter, PMTs are coupled at the both ends of each PSB. For data acquisition system, CAEN V1730 16 channel 500MS/s frequency VME based waveform digitizer has been used for pulse processing and event triggering. Full scale ISMRAN, which was installed and commissioned in Dhruva reactor hall in November 2021, has been acquiring data in the round-the-clock mode.

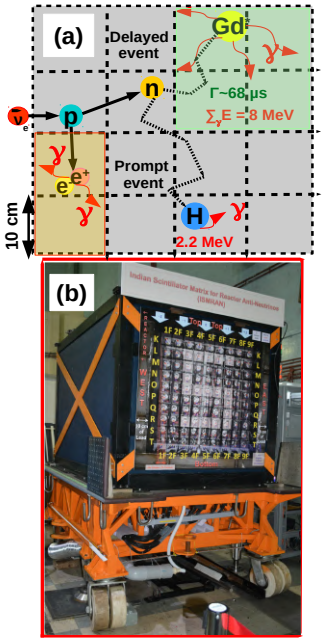

FIG. 1: Panel (a) shows the schematic representation of IBD event generating prompt and delayed event signatures in prototype (mini-ISMRAN) array. Panel (b) shows the full scale ISMRAN detector on the base structure installed inside Dhruva reactor hall.

*Electronic address: ronidey@barc.gov.in

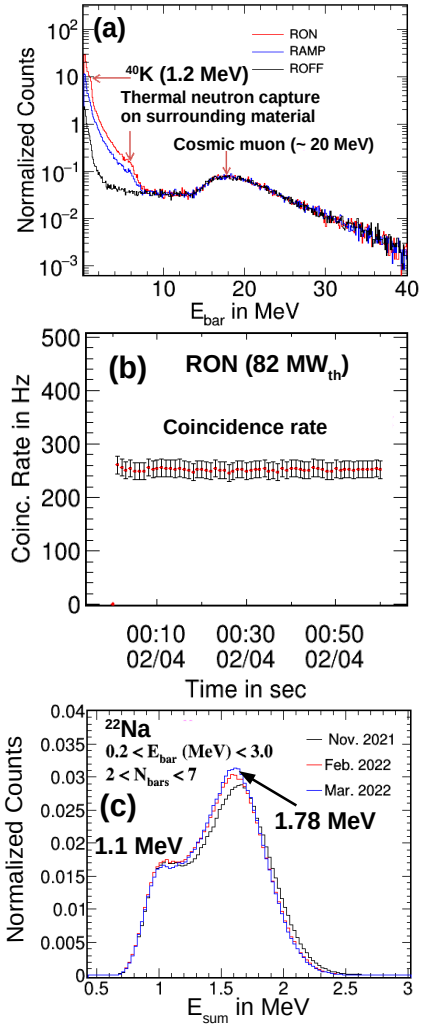

FIG. 2: Panel (a) shows the comparisons of single bar energy (E_{bar}) deposition in the center bar of ISMRAN at different reactor thermal power conditions. Panel (b) shows the coincidence rate of the center bar of ISMRAN at reactor ON condition. Panel (c) shows the reconstructed sum energy (E_{sum}) distributions of ^{22}Na source, placed at the center of ISMRAN array.

Results and discussion:

Figure 2(a) shows the comparison of single bar energy (E_{bar}) deposition in the center bar of ISMRAN array at reactor ON (RON), ROFF and during the ramp up of reactor thermal power (RAMP) conditions. Below 3 MeV, the dominant background in ROFF condition is due to the natural radioactive background and the dominant source of background above 3 MeV in RON condition is from γ-ray coming from the thermal neutron capture on the structural matrial around the ISMRAN setup. In RON condition the average rate is around $\sim$ 250 Hz in the fiducial volume at 82 MW_{th} thermal power of reactor, which is shown in Fig 2(b) and the average rate in all PSBs is around $\sim$ 30 Hz in ROFF condition. Figure 2(c) shows the comparison of the reconstructed sum energy (E_{sum}) distributions for the deployment of the ^{22}Na source at the center of the ISMRAN array to understand the uniformity of the detector response over the period of time. The number of bars hit is required to be in the range of 3 to 6, to avoid the natural radioactive background. As it can be seen from Fig 2(c), a peak at $\sim$1.78 MeV corresponds to the coincidence of γ-ray and positron events and the feature at $\sim$1.1 MeV corresponds to the γ-ray of energy 1.274 MeV originating from ^{22}Na source [2].

Conclusion:

In summary, we have performed the comparative study of response of PSB in RON, ROFF and RAMP conditions in terms of single bar energy deposition. We have also studied the uniformity of detector response by reconstructing E_{sum} for ^{22}Na source when it is kept at the center of the ISMRAN and it is observed that the reconstructed peaks are constant over the period of time. We will also discuss about the ongoing efforts on the measurements of the anti-neutrino signals from the full scale ISMRAN setup.

References

[1] S. P. Behera et al. ,**Physical Review D**,102 (2020),013002.
[2] R.Dey et al.,https://arxiv.org/abs/2208.03499.