Background measurements and detector response studies for ISMRAN experiment

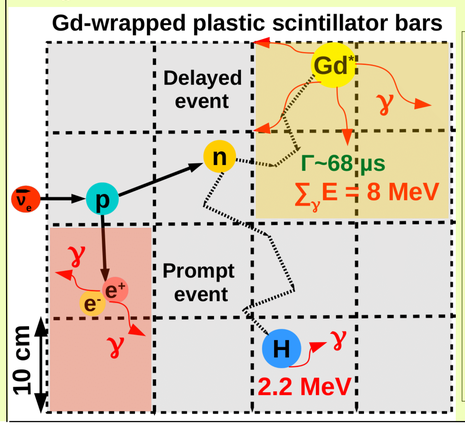
R.Dey[a,*], P. K. Netrakanti[a], D. K. Mishra[a], S. P. Behera[a], R. Sehgal[a], V. Jha[a] and L. M. Pant[a]

[a] Nuclear Physics Division, Bhabha Atomic Research Centre, Mumbai, 400 085, India.

*Email : ronidey@barc.gov.in

1. Introduction

- Anti-neutrinos from reactors are excellent probes for monitoring reactor power and its core composition as well as for sterile neutrino searches, as also being planned with "Indian Scintillator Matrix for Reactor Anti-Neutrino" - (ISMRAN).
- Apart from reactor related background, cosmogenic neutrons and muons related background will also be encountered inside the reactor hall.
- A good understanding of cosmogenic background in Plastic Scintillator Bars (PSBs) in a matrix, is an essential prerequisite for understanding the non-reactor background to estimate their uncertainties.



Inverse Beta Decay (IBD)

$\bar{\nu}_e + p \rightarrow n + e^+$

Prompt e^+ signal :
Energy loss plus Annihilation

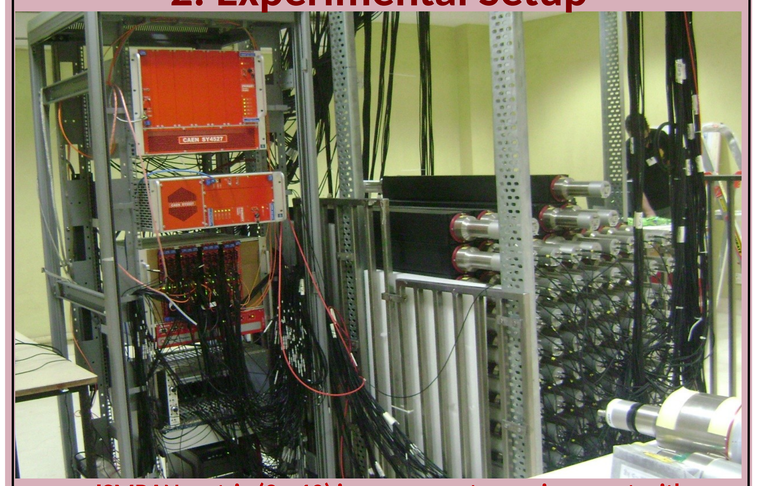
$e^+ + e^- \rightarrow 2\gamma$

Delayed neutron signal :
thermal neutron capture on Gd

$n + Gd^{155} \rightarrow Gd^{156*} \rightarrow Gd^{156} + \gamma s$

$n + Gd^{157} \rightarrow Gd^{158*} \rightarrow Gd^{158} + \gamma s$

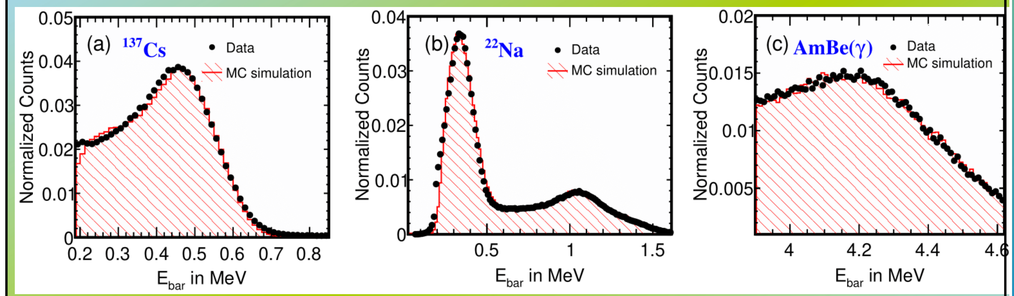
2. Experimental Setup



ISMRAN matrix (9 x 10) in a non-reactor environment with High Voltage Power Supply and Digitizers.

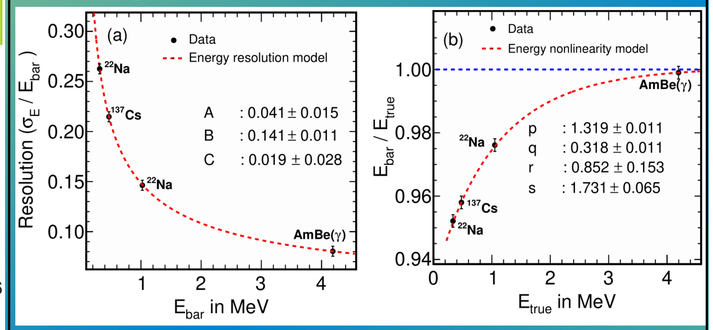
- Each PSB is 100 cm long with a cross-section of (10 × 10) cm^2, wrapped with Gadolinium Oxide coated on aluminized mylar foils.
- Three inch diameter, PMTs are coupled at the both ends of each PSB.
- The data acquisition system (DAQ), a CAEN VME based 16 channels waveform digitizers (V1730) of 500 MS/s, has been used for pulse processing and event triggering from each PSB independently.

3. Detector response of plastic scintillator bar(PSB)



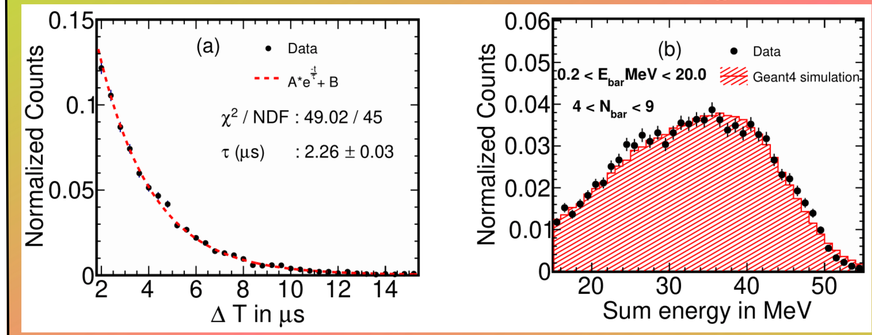
Panels (a), (b) and (c) show the comparisons of the calibrated E_{bar} distribution, in a single PSB, between data and MC simulation from ^{137}Cs, ^{22}Na and γ-ray Am/Be radioactive sources, respectively.

4. Energy resolution & non-linerity of PSB



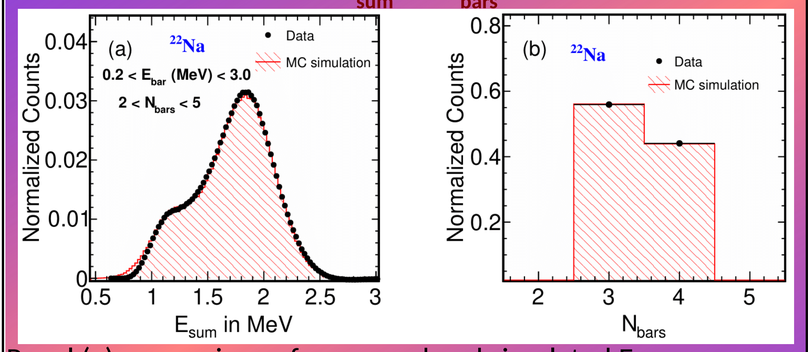
Panel (a) shows the energy resolution as a function of reconstructed γ-ray energy and panel (b) shows the non-linear response of scintillating energy in PSB obtained from the true Compton energies of γ-rays originating from different radioactive sources.

5. Measurements of muon induced background



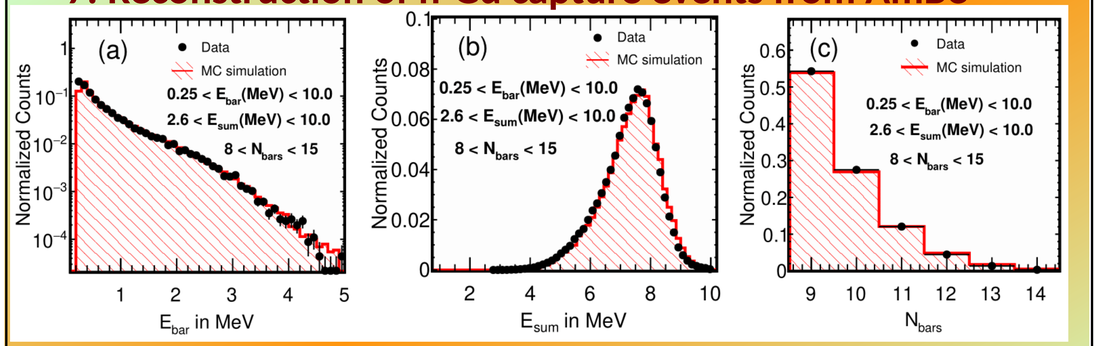
Panel (a) Measured cosmic muon decay time distribution fit with an exponent, panel (b) Comparison of reconstructed sum energy distribution for delayed events (Michel electron) between data and MC simulation.

6. Reconstruction of E_{sum} & N_{bars} variables from ^{22}Na



Panel (a) comparison of measured and simulated E_{sum} distribution and panel (b) comparison of N_{bars} distribution for ^{22}Na source, placed at the center of ISMRAN array.

7. Reconstruction of n-Gd capture events from AmBe



Panels (a), (b) and (c) shows the comparison of measured data (solid) and MC simulated (shaded) individual E_{bar}, E_{sum} and N_{bars} distributions for cascade γ-rays from n-Gd capture events for an Am/Be source placed on top of ISMRAN array, respectively.

8. Conclusion & outlook

- Description of the energy resolution and energy non-linearity are obtained for the PSBs for different radioactive γ sources and are compared with GEANT4 based Monte Carlo simulations.
- E_{sum} and N_{bars} variables have been validated by comparing with GEANT4 based Monte Carlo simulations for radioactive γ-ray source ^{22}Na and n-Gd capture cascade γ-ray events from AmBe source.
- The full scale ISMRAN experiment has been installed and commissioned in the Dhruva reactor hall on a movable base structure and the physics data campaign has started at the end of year 2021.

ICHEP 2022, 41 th international conference on High Energy Physics, Bologna (Italy), 6-13 July 2022.