Performance of waveform digitizers as a compact data acquisition system for the ISMRAN experiment

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Introduction

The Indian Scintillator Matrix for Reactor Anti-Neutrino (ISMRAN) detector is proposed at the Dhruva reactor, BARC, to measure the anti-neutrinos ($\bar{\nu}$) for the purpose of reactor monitoring and sterile neutrino search. A one ton detector, consisting of 100 plastic scintillator bars (10cm×10cm×100cm), wrapped with the Gadolinium (Gd) coated mylar foils and coupled with photomultiplier tubes (PMT) at both ends, is planned for this purpose. One of the key components for such an experiment is the development of a dedicated and economical data acquisition system (DAQ) for the detector setup. The FPGA based waveform digitizers are suitable for this purpose, where data from a large number of detectors need to be read out simultaneously. This effectively reduces the burden of the intermediate conventional pulse processing electronics between the detectors and the DAQ. We have procured the CAEN made 16 channel, model V1730, 14bit, 500 MS/s VME based waveform digitizers [1] for this purpose. A series of measurements have been carried out to evaluate the performance of the digitizers. We are also working on the related auxiliary software and data format to be used extensively for ISMRAN DAQ.

Pulse shape discrimination (PSD)

The digitizers are acquired with the pre-installed Digital Pulse Processing (DPP) - PSD firmware [1]. We have used a 5″ diameter, NE213 liquid scintillator for demonstrating the separation of neutron and γ from an Am-Be source, using the PSD technique. The setup was employed, later, in the reactor hall to assess the fast neutron and γ background rates at the experimental site. We have also demonstrated the PSD between α particles and γ from the Am-Pu source using a CsI(Tl) crystal coupled with a PMT. The PSD parameter was obtained by evaluating the ratio of the integrated charge from the anode pulses in suitable short (Q_s) and long (Q_l) gates.

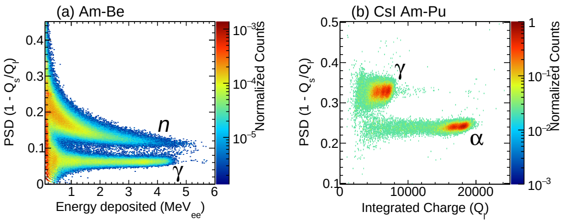

FIG. 1: PSD between neutron and γ in NE213 and between α particles and γ in CsI(Tl).

Figure 1 shows the PSD between neutron and γ in NE213 and between α particles and γ in CsI(Tl) crsytal. A clear separation between detected particles and γ is obtained over a reasonable range of Q_l.

Energy response in BGO and timing in Plastic scintillators

Figure 2 shows the pulse height (Q_l) spectrum of a BGO detector in the presence of a ^{22}Na source. The resolution of the photo peak due to the 511 keV γ, as acquired through the digitizer, is ∼10%. It is important to know the position information of events detected at various locations along the length of the plastic bars. This is related to the difference of the measured time (ΔT) taken by the scintillation light to travel to the PMT's at both

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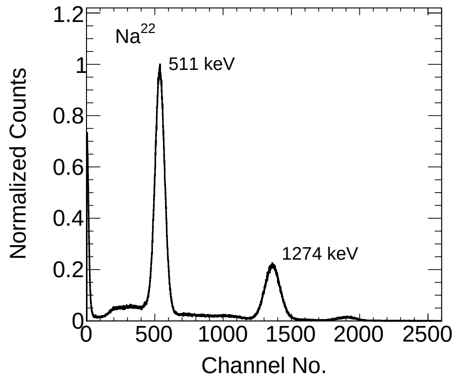

FIG. 2: Pulse height response of a BGO detector in the presence of ^{22}Na source.

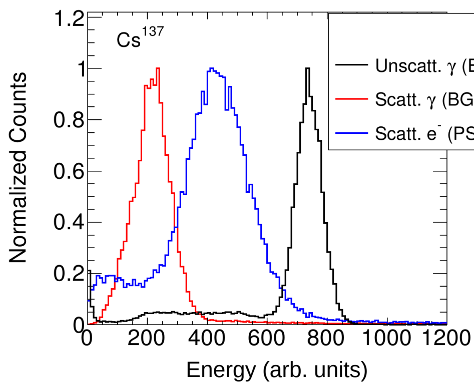

FIG. 4: Compton scattered γ and electron pulse height spectra from ^{137}Cs in BGO and plastic.

ends of the bar, from the place of detection. We have measured ΔT by shining with a collimated ^{137}Cs source at various known positions along the bar. Figure 3 shows the plots of various ΔT's for a typical plastic bar irradiated with ^{137}Cs source, from which, position information can be deduced.

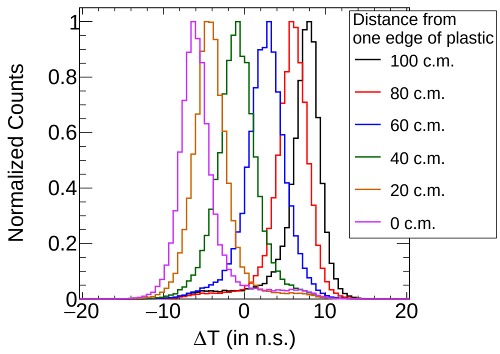

FIG. 3: Position information along a plastic bar from the timing response in the detector.

Compton scattered, monoenergetic electron in plastic bars

The plastic detectors for the ISMRAN experiment need to be characterized in the laboratory before installation at the reactor hall. It is important to understand the response and calibrate the plastic bars in the presence of monoenergetic electrons [2]. This was performed by observing the Compton scattered γ from a collimated ^{137}Cs source in a properly shielded and collimated BGO detector and measured in coincidence with the corresponding monoenergetic, recoiling electron, generated and detected in the plastic bars. The results of this measurement, in a typical bar, is shown in Fig. 4 along with the unscattered γ from ^{137}Cs in the BGO detector. This needs to be performed for various scattering angles and discrete γ energies for all the plastic bars.

Summary

Detailed measurements are being performed to understand the functioning of the V1730 waveform digitizers from CAEN. We are currently working with the CAEN made VME and FPGA based trigger logic unit, Mod. V1495 [1] and twenty plastic bars, in the non-reactor, laboratory environment to formulate the most suitable trigger scheme for the ISMRAN measurement. Together, this would help in realizing a sophisticated, economic and accurate DAQ for the ISMRAN set up.

Acknowledgments

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References

[1] http://www.caen.it/
[2] P. C. Rout *et. al*, NIM **A**, 598 (2009), 526.