In-beam test of PARIS mini-cluster

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Introduction

A Photon Array for the Studies with Radioactive Ion and Stable beams (PARIS) is being developed to measure the high energy γ rays [1, 2]. The PARIS detector element is made up of $2''\times$ $2''\times 2''$ $LaBr_3$(Ce) crystal optically coupled to a $2''\times$ $2''\times 6''$ NaI(Tl) crystal followed by a single PMT for signal readout. In addition to this, the possibility of $LaBr_3$ coupled to silicon PMT together with the NaI+PMT is also being explored. Therefore, at TIFR, a mini-cluster comprising of two phoswich and two $LaBr_3$ detector ($2''\times$ $2''\times 2''$) is set up. In-beam tests with this cluster were carried out to study the performance of V1730 digitizer for high energy γ and timing measurement. A schematic set-up of mini-cluster array is shown in Fig 1.

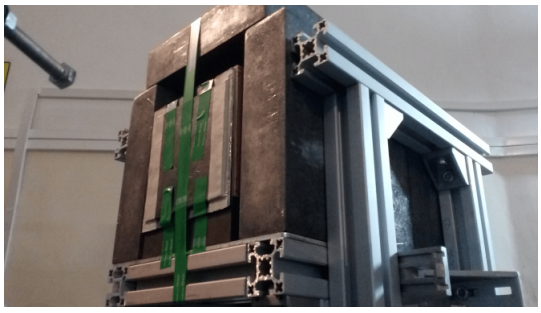

FIG. 1: A schematic diagramme of mini-cluster array.

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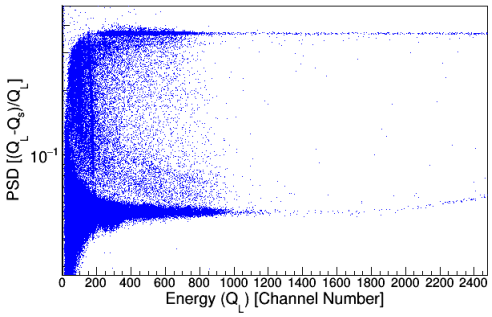

FIG. 2: Pulse Shape Discrimination spectrum of one phoswich detector. Lower band is for $LaBr_3$ crystal and the upper band is for NaI crystal.

Experimental details

The experiment was performed at TIFR, Mumbai using pulsed beam of ^{16}O from Pelletron Linac Facility (PLF) bombarding ^{12}C target (400 μg/cm^2) at 125 MeV energy populating the ^{28}Si compound nuclei. The array was placed at 45^0 with respect to the beam direction in forward angle and at a distance of $\sim$50 cm from the target position. The array was shielded with 5 cm thick lead. A 3 mm thick lead sheet was kept in front of the array to cut the low energy γ-rays and X-rays.

Data was taken using a V1730 digitizer (16 channel, 14 bit, 500 MS/s, 2 Vpp) and digiTES-4.2.6 data acquisition software [3]. This digitizer has an in-built CFD algorithim and gives the time stamp, pulse shape discrimination and energy information [3]. For phoswich detector to separate the $LaBr_3$ and NaI events, the charges with short and long gate (Q_S and Q_L, respectively), corresponding to E_{LaBr_3} and E_{NaI}, are recored by integrating the output pulse from PMT for a

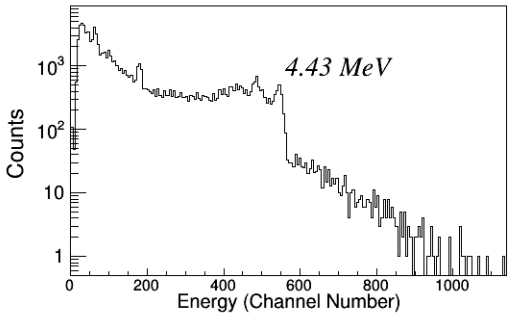

FIG. 3: ^{241}Am-^{9}be 4.43 MeV spectrum in $LaBr_3$ detector for calibration.

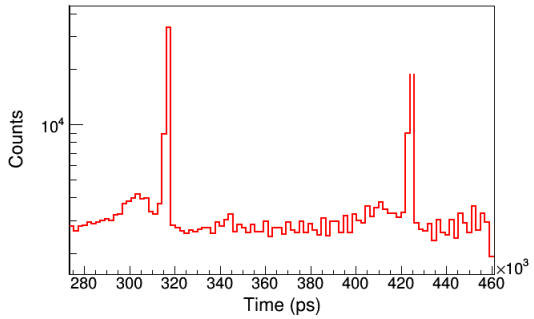

FIG. 4: A typical time-of-flight spectrum of $LaBr_3$ detector in the array.

gate width of 300 and 900 ns. The $LaBr_3$ and NaI events in the phoswich detector were separated by PSD spectrum as shown in Fig 2. The detectors were calibrated using laboratory standard low energy γ-ray sources ^{60}Co (1.17 MeV, 1.33 MeV), ^{241}Am-^{9}be (4.43 MeV). The 4.43 MeV γ-ray spectrum in $LaBr_3$ detector is shown in Fig 3. In order to separate neutron-γ by time-of-flight (TOF), it is necessary to record the RF corresponding to beam pulse. RF signal was filtered with 'OR' of all the detector signals derived from V1730 digitizer using appropriate trigger masking. A typical TOF spectra of $LaBr_3$ detector is shown in Fig 4. The time resolution of the $LaBr_3$ detector was found to be $\sim$ 1.2 ns.

In offline, the data was preliminary analyzed in ROOT platform [4]. A preliminary

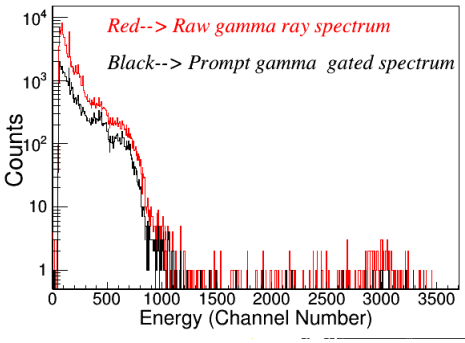

FIG. 5: A preliminary high energy γ-ray spectrum for $LaBr_3$ detector in the array.

high energy γ-ray spectrum with and without prompt γ-gated is shown in Fig 5. The CAEN-make V1730 digitizer has been successfully demonstrated for multi-parameter with multi-detector with RF gating.

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