CHARACTERIZATION OF PARIS-PHOSWICH DETECTORS UPTO 22 MeV

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The PARIS detector - an array of $LaBr_3$(Ce) + NaI(Tl) phoswich detectors with a common PMT for readout, is being developed to study high energy γ-rays (E_γ) from nuclear reactions in radioactive and stable beam facilities [1]. In order to understand the performance of the detector array, the characterization of two PARIS phoswich detector elements has been carried out at TIFR. The detector response is investigated over a wide range of E_γ using radioactive sources and employing $^{11}B(p,\gamma)$ reaction at E_p = 163 keV (ECR source, TIFR) and E_p = 7.2 MeV (Pelletron Linac Facility, TIFR). One of the main concerns with $LaBr_3$ is the non-linearity in energy calibration at high E_γ [2]. Therefore, measurements have been carried out for different voltage divider configurations as a function of the applied PMT voltage. Given the composite nature of the pulse, digital processing is best suited for the phoswich detector. The acquisition system using CAEN make digitizers (250 MS/s-12 bit, 1 GS/s-10 bit) is optimized to get best energy and time resolution. Non-linearity of two detectors is found to be different. The energy resolution is extracted by fitting the observed lineshape to the simulated energy spectrum generated using GEANT4 [3]. For $LaBr_3$ part of the phoswich, energy resolution at 4.44 MeV and 22.56 MeV are found to be ~ 3.1% and ~ 1%, respectively. The efficiency of one phoswich detector was measured to be 0.25% for a 4.44 MeV (Am-Be) source at 5.5 cm from detector face. The relative full-energy-peak efficiency of 11.68 MeV is estimated to be ~ 24% w.r.t. 4.44 MeV. The measured efficiency data with radioactive sources are in good agreement with GEANT4 based simulation. Time resolution of the phoswich detector is measured with ^{60}Co source after implementing CFD algorithm in the digitizer (CAEN N6751 - 1GS/s) and is found to be excellent (σ ~ 140 ps). In order to study the effect of count rate on detectors, the centroid position and width of the peak were measured with two different voltage divider circuits (standard E5859-15 and modified voltage divider made by Strasbourg group [4]) for 2-220 kHz count rate. The modified voltage divider gives better results. The observed peak shift is less than 0.4% at 10 kHz in the linear regime, which worsens to 1.3% at 220 kHz. The long term stability of the detector gain is monitored and is found to be within 1.2%. For understanding the energy addback mechanism in the phoswich detector, different pulse shapes originating at different interaction points were recorded for high energy γ-rays using standard wave dump firmware of the digitizer. Improvements in the high energy response due to $LaBr_3$(Ce)-NaI(Tl) energy addback as well as from neighbour addback are being investigated.

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