Pulse processing electronics for γ–γ fast timing array at VECC

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Introduction

VECC array for **N**uclear fast **T**iming and ang**U**lar cor**RE**lation studies (VENTURE) has been developed at VECC, Kolkata for the measurement of γ–γ fast timing and angular correlation studies [1]. This is the first such timing array in India and the first array with $CeBr_3$ detectors made for the purpose of γ–γ fast timing measurement.

The Generalized Centroid Difference (GCD) technique [2] is used for the measurement of nuclear level lifetime down to few picoseconds and an adequate resolving power of the array is a prerequisite for such precision measurements. Also, an appropriate pulse processing electronics is required for the determination of true time difference between two γ-rays in a γ–γ coincidence and for deciding the optimum electronics setup for a large dimension of the array with large number of detectors.

Till date, most of the work with GCD method has used the 'Multiplexing' electronics [2] and the first GCD measurement with a 'Common Start' timing electronics has been done in our work during the development of VENTURE array [1]. A γ–γ fast timing measurement has also been done with 'Common Stop' electronics [3]. However, in the later work did not follow the GCD method and the detailed description neither on generating the γ–γ time difference between each set of detectors nor the correction for prompt response is provided. The pulse processing methodology might have implications also in case of gathering the γ–γ coincidence information to be used in Time Differential Perturbed Angular Correlation (TDPAC) technique. In order to compare the different pulse processing electronics and data analysis procedure for the GCD method, data has been gathered in all the above three modes by using standard sources like ^{152}Eu, ^{106}Ru and ^{181}Hf, that provides an wide dynamic range of the γ-ray energies and a variety of nuclear level lifetimes.

Experiment:

The measurement has been carried out with six 1" x 1" $CeBr_3$ detectors coupled to Hamamatsu R9779 Photo Multiplier Tube (PMT). The detectors are operated at a bias voltage of -1200 Volts to the PMT and the dynode pulses have been used for deriving energy information of the detected γ-rays with conventional high resolution spectroscopy amplifiers. The anode pulses were processed to extract the time difference between two γ-rays in a γ–γ cascade by using the 'Common Start', 'Common Stop' and 'Multiplexing' modes. In the first two modes, the time information for a particular detector was obtained with respect to a reference time pulse generated from the 2-fold multiplicity logic by using a time to amplitude converter (TAC). The time difference between any two detectors was then obtained with event by event subtraction of these time information from all the six detectors. In the remaining case, the γ–γ time difference between any two detectors were directly derived by using the TAC modules and multiplexing between different time signals were done for reducing the number of TAC modules to be used in the circuit.

The raw time difference spectra, without any normalization or linear shift, obtained from a particular set of detectors (det1-det6) and for a particular γ–γ cascades, are compared in Fig. 1

as obtained from three different sets of data. In Fig. 2, the total time difference spectra obtained from the array, after the required delay matching between individual TACs, are compared for 'Common Start' and 'Multiplexing' modes of pulse processing electronics. The time resolution for individual sets of detectors and for the total array have been tabulated in Table 1, as obtained with different electronics.

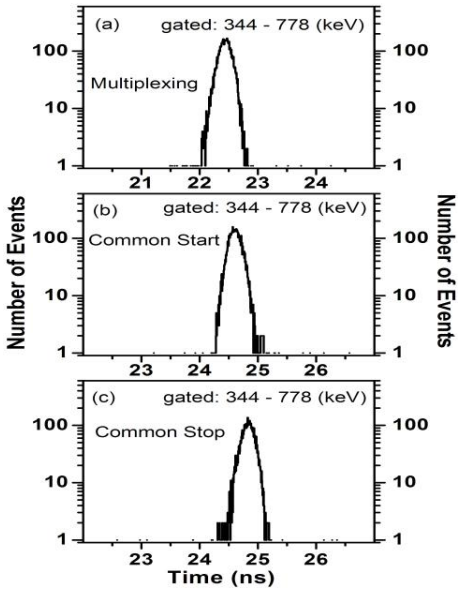

Fig. 1 *TAC spectra obtained between first and sixth detectors in the array from all the pulse processing setup.*

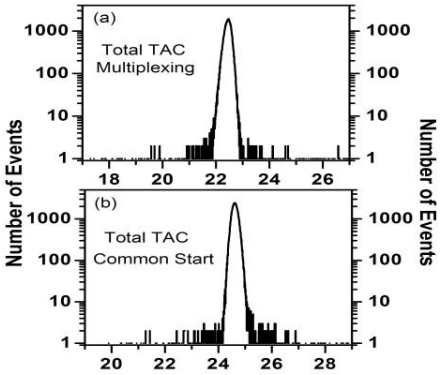

Fig. 2 *The total TAC spectra obtained in the present work from the 'Common start' and 'Multiplexing' modes of pulse processing.*

The comparison of total time resolution of the array implies that the 'time jitter' (standard deviation of the threshold crossing time) introduced through the pulse processing electronics, subsequent delay matching or any other contribution from the configuration of the array has significant effect on the time resolution and the resolving power of the array. The Prompt Time Distribution (PRD) curves are generated for the comparison of standard errors obtained in three set ups using the datasets with similar statistical significance.

Table 1: Time resolution compared for 334-778 keV cascade

Method	τ_{FWHM} (d1-d6) (ps)	τ_{FWHM} (array) (ps)
'Common Start'	259(2)	270(1)
'Common Stop'	256(2)	-
'Multiplexing'	245(2)	279(1)

Acknowledgement:

S. S. Alam acknowledges the support of BRNS through the PRF project (Sanction No. 2013/38/02- BRNS/1927 for PRF, BRNS, dated 16 October 2013).

References

[1] S. S. Alam et al., Nuclear Inst. and Methods in Physics Research A **874**, 103 (2017).
[2] J.M. Régis, et al., Nucl. Instrum. Methods Phys. Res. A **823** (2016) 72.
[3] N. Mărginean, et al., Eur. Phys. J. A **46** (2010) 329