# Setup for Fast Timing Measurements at the UGC-DAE CSR, Kolkata Centre

S. Kundu[1], Aditi Das[1], A. Sharma[1], Pankaj K. Giri[1], K. Basu[1], S. S. Ghugre[1], A. Das[2], M. Das[2], and R. Raut[1*]
[1]*UGC-DAE CSR, Kolkata Centre, Kolkata 700098, INDIA and*
[2]*School of Nuclear Studies and Applications,*
*Jadavpur University (Salt Lake Campus), Kolkata 700098, INDIA*

## Introduction

The advent of fast scintillators, such as $LaBr_3$(Ce), $CeBr_3$, LBC etc., with superior timing characteristics and reasonable energy resolution, has ushered a new genre of measurements that directly address nuclear level lifetimes as low as tens of ps. There is a widespread interest in this domain and experimental facilities are being developed [1, 2] across the globe to undertake research programmes on fast timing measurements. One of the aspects of these developmental endeavours has been to optimize the timing resolution of the fast scintillator setups by appropriate choice of the factors such as the photomultiplier (PMT) readout and the parameters associated with the pulse processing [3]. The contemporary facilities for nuclear spectroscopy are typically built on digitizer based pulse processing electronics and data acquisition systems wherein the key aspects of improving the timing resolution center on the sampling frequency of digitization along with the setup parameters associated with the (fast) filtering and the CFD algorithm [4]. There is a sustained need to benchmark the performance of fast scintillators, that are now of varied crystals coupled to different PMTs, and the digital processing systems being used therewith [5]. The experimental setup of fast scintillators could be used for in-beam measurements [6] as well as for offline studies [7]. The latter may be, for instance, lifetime measurements in neutron-rich species that are populated through fission of heavy nuclei and are difficult/impossible to produce otherwise. The present work pertains to optimizing a setup for fast timing measurements at the Kolkata Centre of UGC-DAE Consortium for Scientific Research (CSR) that is being readied for offline studies of decay products.

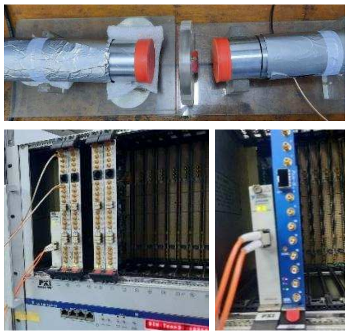

FIG. 1: (Top Panel) Setup of two B380 $LaBr_3$(Ce) detectors at the UGC-DAE CSR, Kolkata Centre. (Bottom Panel, Left) 12-bit 250 MHz PIXIE-16 digitizer modules. (Bottom Panel, Right) 12-bit 500 MHz digitizer module that has recently been added to the setup.

## Experimental Setup

The setup at UGC-DAE CSR, Kolkata Centre is being built on $LaBr_3$(Ce) scintillator detectors coupled with digital pulse processing and data acquisition system. The detectors B380 from M/s SGIPL house 2“×2” $LaBr_3$(Ce) crystals read-out by R6231-100 PMT from M/s Hamamatsu. The pulse processing and data acquisition hardware centers on 12-bit PIXIE-16 digitizer modules from

*Electronic address: rajarshi.raut@gmail.com

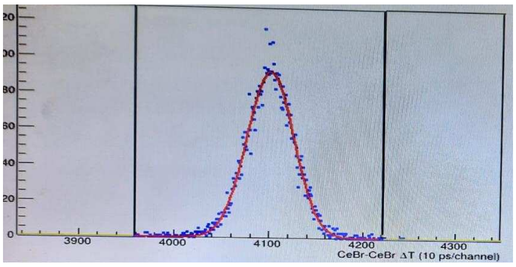


FIG. 2: Time difference ($\Delta T$) spectrum between two $LaBr_3$(Ce) detectors coupled with 12-bit 250 MHz PIXIE-16 digitizers and measuring $^{60}$Co source.

M/s XIA LLC with sampling frequencies 250 and 500 MHz. The detectors and the digital processing setup are illustrated in Fig. 1.

## Tests and Outlook

The setup of two $LaBr_3$(Ce) detectors has been characterized for the energy and the timing resolution. The latter has been optimized for the detectors coupled with 12-bit 250 MHz digitizer modules. The factors that were adjusted in the exercise include the (i) detector (PMT) bias voltage (that impacts the pulse rise times and thus the timing characteristics of the detectors) and (ii) digitizer prameters such as the (a) rise time and flat top time of the fast (trapezoidal) filter and (b) scaling and delay of the CFD. The timing resolution, conventionally, has been quantified by the full-width-at-half-maximum (fwhm) of the time difference ($\Delta T$) spectrum between the two detectors while measuring the $^{60}$Co radioactive source. The acquired data were sorted using IUCPIX [8] and analyzed using ROOT (https://root.cern). The fwhm of the $\Delta T$ spectrum, with energies gated on the 1173.2 and the 1332.5 keV $\gamma$-rays of the $^{60}$Co source, was $\sim$ 560 ps. Fig. 2 illustrates a representative $\Delta T$ spectrum acquired at the setup. The optimized resolution correspond to detector (PMT) bias voltage of +900 V, rise time and flat top of the fast (trapezoidal) filter set at 104 ns, CFD scale of 2 and CFD delay of 8 ns. It may be noted that the choice of the bias voltage was restricted by the limit on the voltage that can be used as input for the digitizer. That is known to be $\sim$ 1.5 V and the (resulting) amplitude of the detector output pulse approximately corresponded to the same value.

The 12-bit 500 MHz PIXIE-16 digitizer module has recently been added to the setup and, with improved sampling frequency, will be used towards improving the timing resolution of the facility. The setup will also be augmented with at least one HPGe detector that'll help in selecting the nuclei of interest in the ensemble of decay products as is envisaged for measurement using the setup.

SK acknowledges financial support from the UGC under the NETJRF Scheme. PKG acknowledges financial support under the SERB (DST) Project No. CRG/2021/001011.

## References

[1] S. S. Alam *et al.*, Nucl. Instr. Meth. Phys. Res. A**874**, 103(2017).
[2] M. Rudigier *et al.*, Nucl. Instr. Meth. Phys. Res. A**969**, 163967(2020).
[3] S. Bhattacharya *et al.*, Nucl. Instr. Meth. Phys. Res. A**1014**, 165737(2021).
[4] S. Saha *et al.*, Proc. DAE Symp. Nucl. Phys.**56**, 1142(2011).
[5] A. Harter *et al.*, Nucl. Instr. Meth. Phys. Res. A**1014**, 165737(2021).
[6] Md. S. R. Laskar *et al.*, Phys. Rev. C**104**, L011301(2021).
[7] S. S. Alam *et al.*, Phys. Rev. C**99**, 014306(2019).
[8] S. Das *et al.*, Nucl. Instr. Meth. Phys. Res. A**893**, 138(2018).