# Timing characteristics of fast scintillating 2″×2″ $LaBr_3$(Ce) detectors

Dhananjaya Sahoo,* S. S. Tiwary, and A. Y. Deo†
*Department of Physics, Indian Institute of Technology Roorkee, Uttarakhand - 247667, INDIA*

## Introduction

An ideal scintillator with high density exhibiting fast time response as well as good energy resolution is always of commercial interest because of its excellent applications in gamma-ray spectroscopy, medical diagnosis and imaging, and lifetime measurements. One of such fast scintillators commercially available till date is $LaBr_3$(Ce) detector. It has been preferred for sub-nanosecond lifetime measurements of atomic nuclei because of its superb timing properties, which is very important for nuclear structure studies [1].

This paper presents the study of time response of $LaBr_3$(Ce) detectors using analogue and digital constant fraction discrimination methods. CAEN digitizer was used for digital setup. The analysis has been performed with CoMPASS [2], a multiparametric data acquisition (DAQ) software. The time response of the detectors is influenced by a number of factors such as type of photo-multiplier tube (PMT), its bias voltage, crystal size and shape, length of the connecting cables and associated electronics [3]. In our case, we have tried to investigate the variation of time resolution with CFD delays.

## Experimental Details

The present work involves coincidence based fast timing measurements using two cylindrical 2″×2″ $LaBr_3$(Ce) scintillators, manufactured by M/S Saint Gobain, coupled to Hamamatsu R2083 photo-multiplier tubes (PMT). The time response of both the detectors were studied using analogue as well as digital DAQ. In the analogue setup, as shown in the Fig. 1, the two detectors were kept about 7 cm apart and the $^{22}$Na $\gamma$-ray source was positioned in the middle. Further signal processing was complemented by standard NIM front-end electronics. The anode signals (with decay time, $\tau$ ∼ 40 ns) from each PMT were fed into Canberra Quad Constant Fraction Discriminators (CFD's). The output of the CFDs were connected to the Start and Stop of the Canberra Time-to-Amplitude Converter (TAC). The signal fed to the Stop was delayed using a nanosecond delay module. The threshold of the CFDs were optimized with the dynode signals for detection of time correlated events due to 511 keV $\gamma$-ray. The TAC signal, indicating the time difference between the Start and Stop, was fed to a Multi Channel Analyzer (MCA). Later, the experiment was also performed using digital data acquisition system, CAEN Digitizer DT5751 (2/4 Channel 10 bit 1 GS/s). The digital setup consisted of identical positioning of detectors and the source as used in the

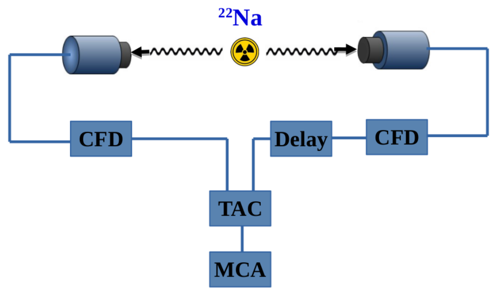


FIG. 1: The analogue setup for timing characterization of $LaBr_3$(Ce) detectors.

*Electronic address: dhananjaya.ph@sric.iitr.ac.in
†Electronic address: ajay.deo@ph.iitr.ac.in

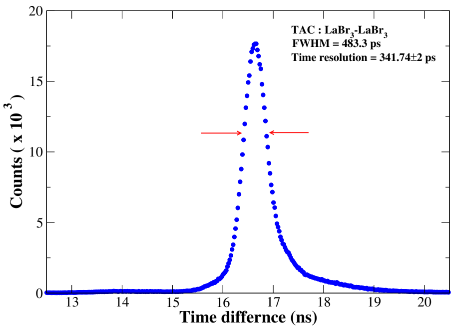


FIG. 2: Time distribution spectrum at 16 ns CFD delay using the analogue setup.

analogue case. The anode signals were first fed to Canberra Timing filter Amplifiers (TFA) and then the output signals of TFAs were sent to the two channels of the CAEN Digitizers. The analysis was performed using the CoMPASS software. The CoMPASS software based CFD and TAC had been optimized with the external delay to obtain the best time resolution of the two $LaBr_3$(Ce) detectors.

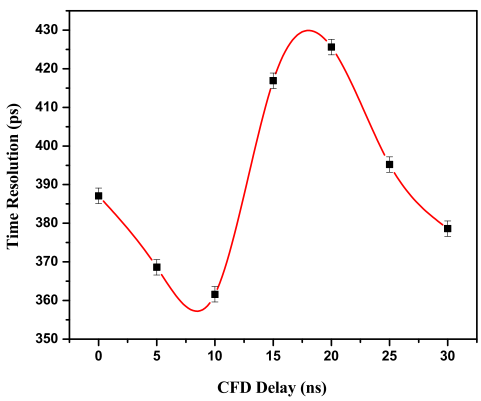


FIG. 3: Variation of time resolution with CFD delays using digitizer.

## Results and Discussions

Time resolution of $LaBr_3$(Ce) detectors has been measured for different CFD delays as shown in the Table I. The time spectrum of detectors for 16 ns delay between the Start and Stop using the analogue setup is shown in Fig. 2. The variation of time resolution against the CFD delays using digitizer is depicted in Fig. 3. The best value of timing resolution of both the detectors could be observed for 7.5 ns to 10 ns of external CFD delay using digital data acquisition. When the external delay is less than 10 ns, the triggering is similar to Leading Edge Discriminator which gives a good timing resolution independent of external delay. This is possible because the rise time of incoming pulse is very sharp and shows a low level of jitter [1]. Therefore, the best time response of the two $LaBr_3$(Ce) detectors could be obtained between 7.5-10 ns of CFD delay using digital data acquisition. Currently, the work is in progress and the results will be presented in the symposium.

TABLE I: Time Resolution of $LaBr_3$ in ps

| Delay (ns) | Analogue | Digital |
|---|---|---|
| 10 | 408.0±2.0 | 362.6±2.0 |
| 16 | 341.7±2.0 | 421.1±2.0 |
| 22 | 338.5±2.0 | 412.5±2.0 |

## Acknowledgments

Dhananjaya Sahoo and A. Y. Deo would like to acknowledge the financial support by SERB (DST) vide grant no. CRG/2020/002169.

## References

[1] V. Vedia *et al.*, Nucl. Instru. and Meth. A **795**, 144–150 (2015)
[2] https://www.caen.it/products/compass/
[3] P. Lecoq *et al.*, IEEE Trans. On Nucl. Sc. **57**, 5 (2010)