## Fast timing characteristics of $1.5^{\circ} \times 1.5^{\circ}$ CeBr<sub>3</sub> - Lifetime measurements



Sneha Das<sup>a,b</sup>, Soumik Bhattacharya<sup>a,b</sup>, S. Bhattacharyya<sup>a,b</sup>, R. Banik<sup>a,b</sup>, Shabir Dar<sup>a,b</sup>, D. Pandit<sup>a,b</sup>, A. Choudhuri<sup>a</sup>, K. Banerjee<sup>a,b</sup>, Debasish Mondal<sup>a,b</sup>, S. Mukhopadhyay<sup>a,b</sup>

> <sup>a</sup>Variable Energy Cyclotron Centre, 1/AF Bidhan Nagar, Kolkata, INDIA. <sup>b</sup>Homi Bhabha National Institute, Anushaktinagar, Mumbai, INDIA.



## Introduction

□ For nuclei near <sup>208</sup>Pb region, in most of the cases, the experimental B(E2) values are missing apart from the isomeric states.

The experimental B(E2) values for low-lying spin states are very much important to understand the nuclear structure in this region.

This makes important to measure the lifetime of the states other than the isomeric ones which are in sub nanosecond ranges.

□ Fast timing technique with new generation inorganic scintillators (LaBr<sub>3</sub>(Ce), CeBr<sub>3</sub>) can be applied to measure lifetime in this region with direct electronic method.

 $\checkmark$  Time resolution comparable to LaBr<sub>3</sub>(Ce) CeBr<sub>3</sub> scintillators:  $\checkmark$  Energy resolution slightly poor compared to LaBr<sub>3</sub>(Ce) potential alternative to  $LaBr_3(Ce)$ ✓No internal activity

12 _		
14		

## $\checkmark$ Less costly compared to LaBr<sub>3</sub>(Ce) -1400V 1332 keV (<sup>60</sup>Co) Characterization of $1.5'' \times 1.5''$ CeBr<sub>3</sub> + PMT R13089-100 1200 1600 Experimental set-up ■ <sup>60</sup>Co High Voltage (V) 6000 (a) 1173-1332 keV Typical energy resolution Gaussian Fit 4.1% @ 662keV (<sup>137</sup>Cs) 4000 Gate & 3000 Counts The best time resolution Delay 2.9% @ 1332keV (60Co) 199(2) ps between two Enaray /ka\/ Energy: Det 1 $1.5'' \times 1.5'' CeBr_3$ Linearity Test <sup>152</sup>Eu spectrum Energy: Det 2 4x10<sup>4</sup> at -1700V,0.8 ns delay 7000 ■ - 1400 V - 1500 V AND/OR Master Linear Fit - - Linear Fit Radioactive Logic 6000 6000 36.8 36.4 36.6 37.0 gate 36.2 Quadratic Fit - Quadratic Fit source Time (ns) Unit 5000 5000 (b) (a) AND →199(2) ps ■ <sup>22</sup>Na 4000 4000 14000 -(b) 511-511 keV Stop for 1173-1332 CeBr3+PN 3000 3000 Gaussian Fit 12000 2000 2000 10000 1000 1000 운 unts 8000 Gate & 327(3) ps Energy (keV) → 327(3) ps 1000 1250 Delay 8000 250 500 750 1000 1250 250 500 750 8000 **O** 6000 - 1600 V ■ - 1700 V 7000 for 511-511 HV د 7000 Linear Fit Linear Fit Energy (KeV) **6000** - Quadratic Fit - Quadratic Fit 5000 (C) (d) 4000 Geant4 Simulation: 10 cm ✓Manufacturer reported HV = -900V Experimental data: 10 cm 3000 3000 ---- Geant4 Simulation: 20 cm 36.2 37.0 36.6 36.8 36.4 2000 ✓Detector + PMT linear upto = -1400V Experimental data: 20 cm 2000 Time (ns) 1000 1000 ✓Non-linearity starts from -1500V Soumik Bhattacharya, 500 750 1000 1250 750 1000 1250 0 Energy (keV) Energy (keV) Sneha Das, et al., S. Das, et al., NIM A 1014, 165737 (2021) CeBr<sub>3</sub> Efficiency Proc. of DAE-BRNS Symp. on Nucl. Phys. 2019 Energy (ke) PRD Calibration and Lifetime measurement in <sup>209</sup>Po $\tau = C(D) - C(P)$ Lifetime of a directly measurable state

**Physics motivation** 



 $\Box$  The energy resolution of CeBr<sub>3</sub> scintillator detector obtained from present work is 4.1% at 662 keV of <sup>137</sup>Cs.

□ The lifetime for two states- 3/2<sup>+</sup> and 5/2<sup>+</sup> of <sup>133</sup>Cs are well reproduced using Fast timing MSCD method.

 $\Box$  The lifetime of 11/2<sup>-</sup> state of <sup>209</sup>Po has been extracted with two 1.5" x 1.5" CeBr<sub>3</sub> detectors.

## Acknowledgement

- ✓ All members of Experimental Nuclear Physics Division, VECC, Kolkata.
- ✓ CSIR for providing financial support to Ms. Sneha Das.