Fast timing characteristics with 1.5"x1.5" $CeBr_3$ detectors

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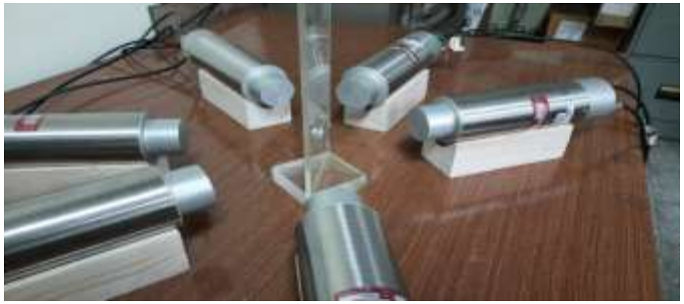
Fast Timing Scintillators – $CeBr_3$ detector

New generation inorganic scintillator detectors ($LaBr_3$(Ce), $CeBr_3$) has opened up new horizon to measure the lifetime in sub-nanosecond range

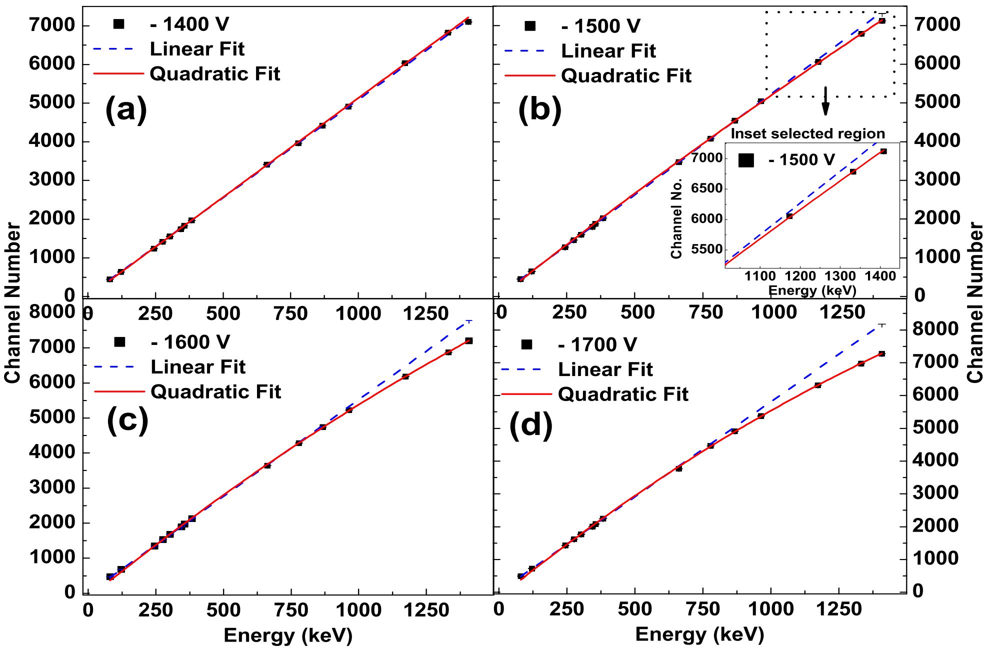
- **$CeBr_3$ scintillators: emerged as potential alternative to $LaBr_3$(Ce)**
  - ✓ **Time resolution comparable to $LaBr_3$(Ce) (~ 100 – 300 ps for ^{60}Co)**
  - ✓ **Energy resolution slightly poor compared to $LaBr_3$(Ce) (~3% at 1332)**
  - ✓ **No internal activity**
  - ✓ **Less costly compared to $LaBr_3$(Ce)**

At VECC → 13 Nos. of 1.5"x1.5" $CeBr_3$ coupled with new Hamamatsu PMT R13089-100



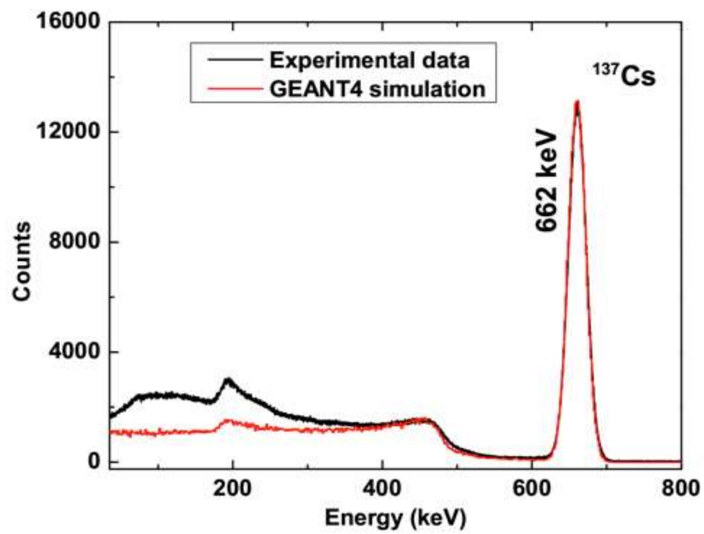
Characterization and lifetime measurement using MSCD

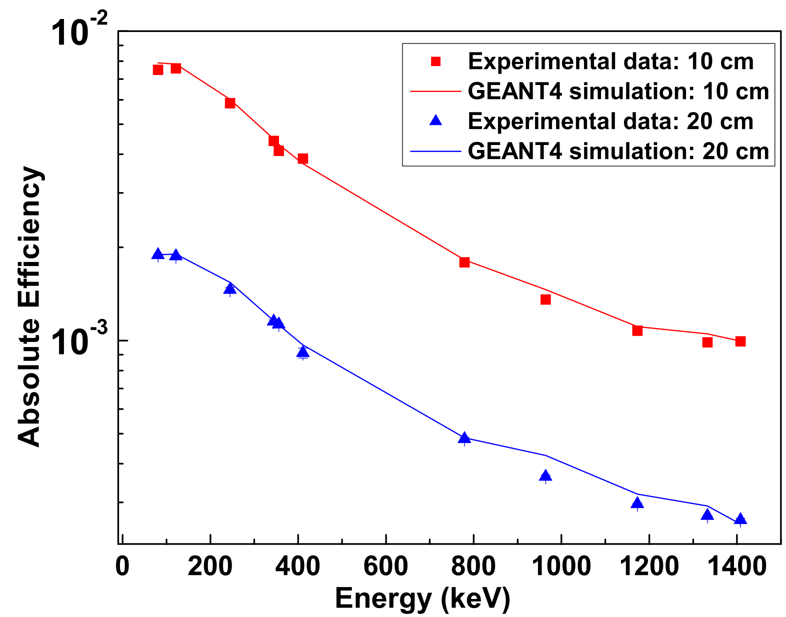
Energy Response of 1.5"x1.5" $CeBr_3$ Detector



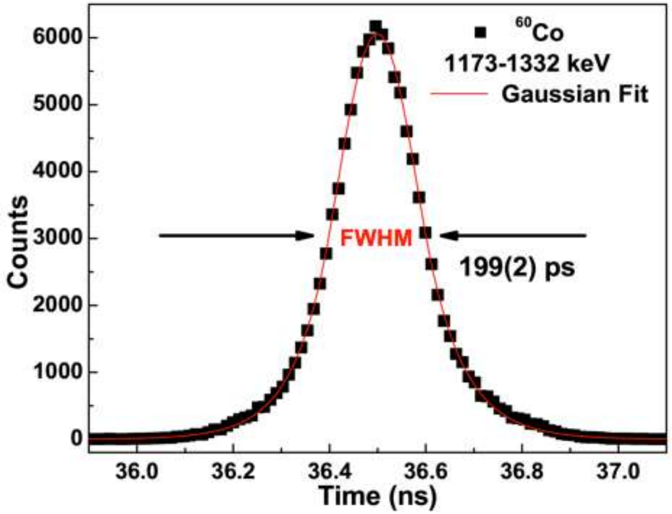
PMT Hamamatsu R13089-100 is linear upto 1400V

Typical energy resolution
4.1% @ 662keV (^{137}Cs)
2.9% @ 1332keV (^{60}Co).



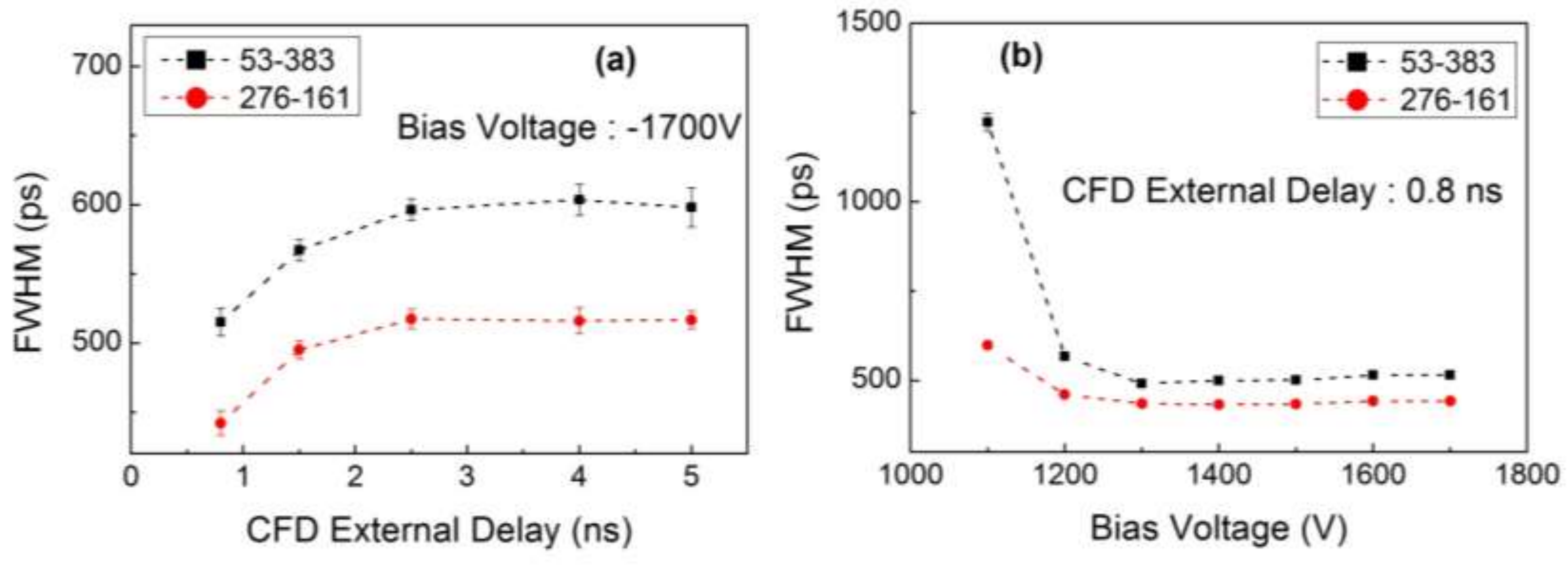


Time Response of 1.5"x1.5" $CeBr_3$ Detector

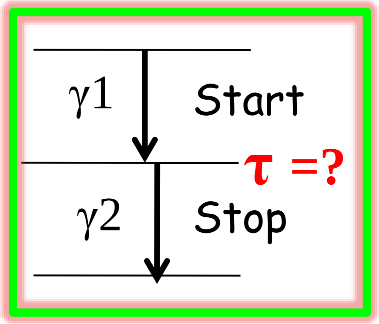


The best time resolution (FWHM) between two 1.5"X1.5" $CeBr_3$ detectors for 1173-1332 keV : 199(2) ps at HV= -1700V.

Time resolution at lower energies for ^{133}Cs source
a) 53-383 keV cascade
b) 276-161 keV cascade

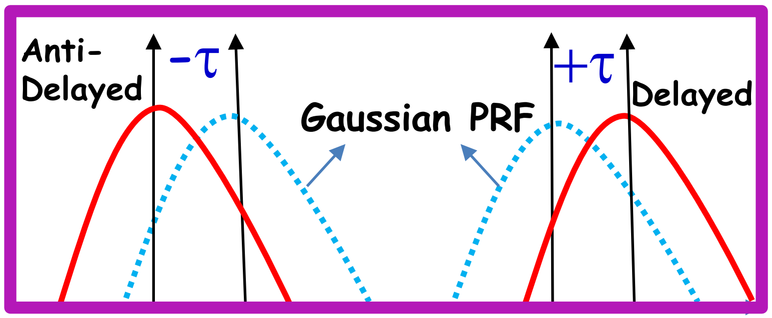


Mirror Symmetric Centroid Difference (MSCD) method



Lifetime of a state is the shift of delayed centroid from the corresponding prompt at that energy

$\tau = C(D) - C(P)$



$C(D)_{stop}$: Delayed time distribution
E_{feeder} (start) – E_{decay} (stop)

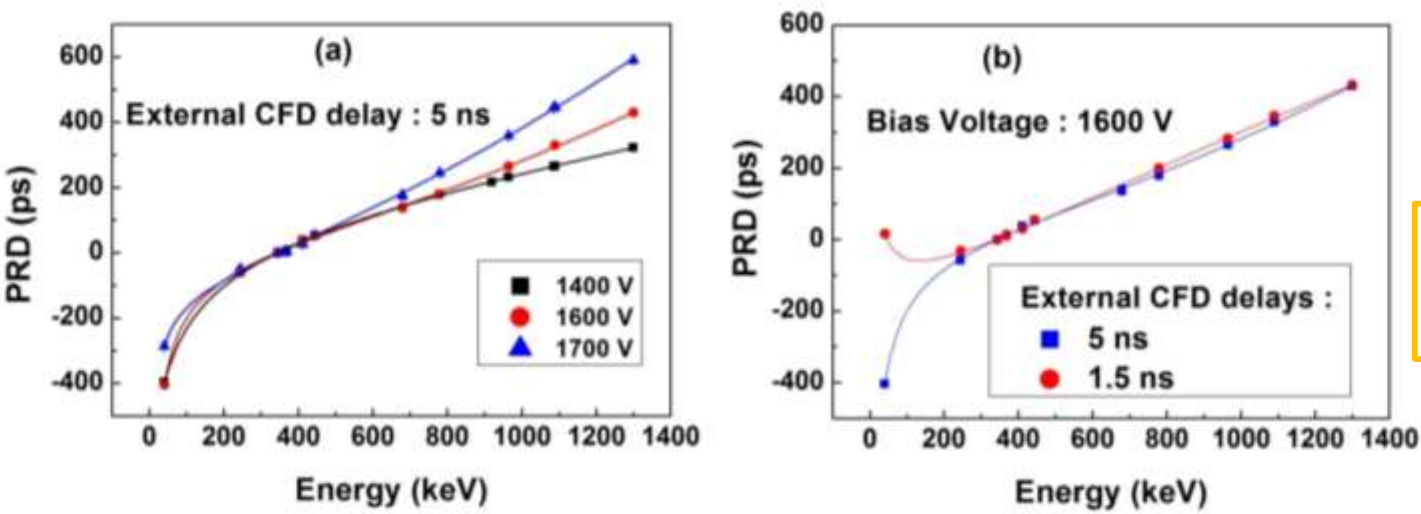
$C(D)_{start}$: Antidelayed time distribution
E_{decay} (start) – E_{feeder} (stop)

Centroid Difference: $\Delta C = C(D)_{stop} - C(D)_{start}$

Prompt Response Difference: : $PRD = C(P)_{stop} - C(P)_{start}$

$$\Delta C = PRD + 2\tau$$

Variation of time-walk response at different experimental set-up

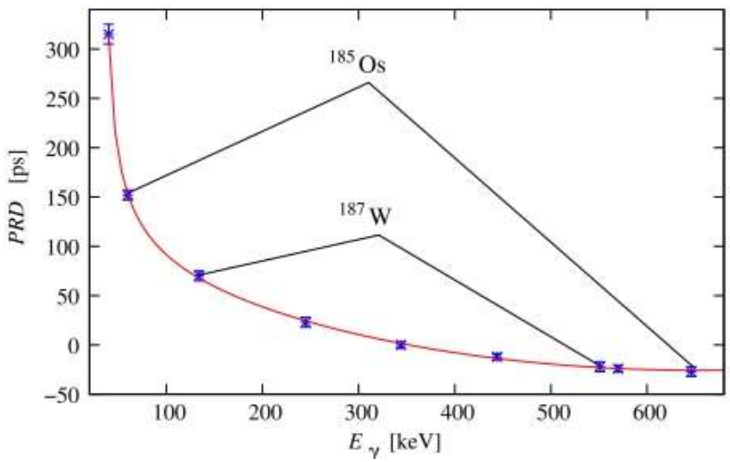


Sneha Das *et al* *JINST* 17 P09012 (2022)

At higher bias voltage, PRD fitted with:

$$\mathrm{PRD}(E_\gamma) = \frac{a}{\sqrt{E_\gamma}} + bE_\gamma + cE_\gamma^2 + d$$

lower energy time-walk responses improves at higher bias voltage and lower CFD delays.



40 keV point at lower energy only monitors the variation of the PRD curve.

For precise time-walk calibration at lower energy, more low energy points are required for PRD calibration.

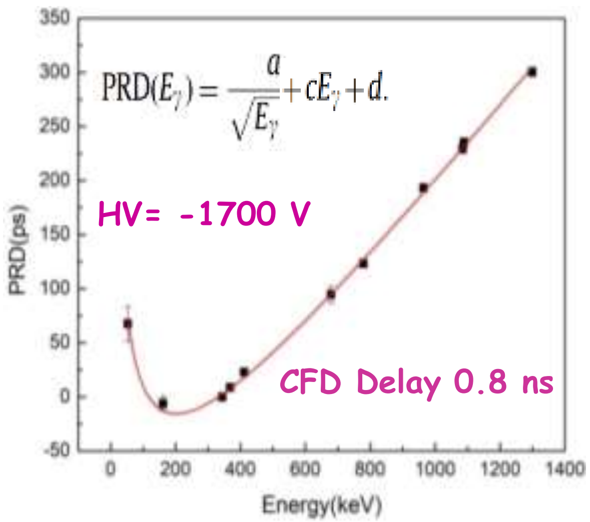
Measurement of Lifetime of 11/2$^-$ state of ^{209}Po from decay

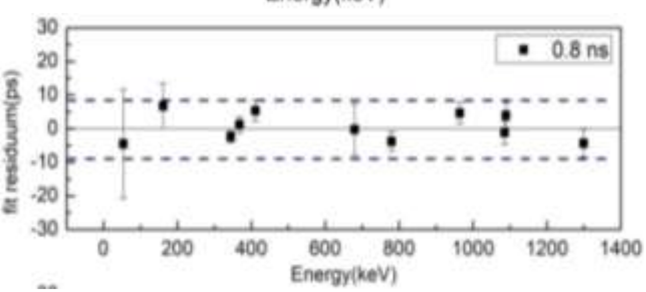
^{209}Bi(α,4n)^{209}At @ 52 MeV

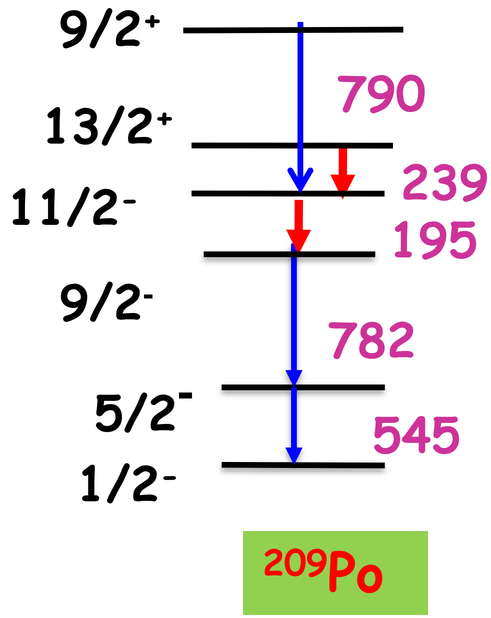
Alpha beam from K-130 cyclotron at VECC, Kolkata.

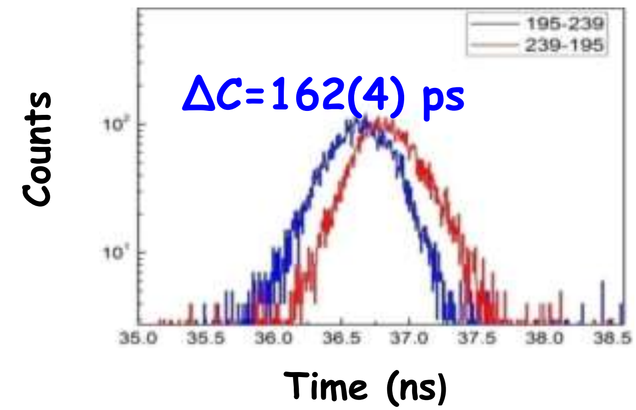
(Production cross section ~ 1500 mb)

^{209}At → ε decay (95.9%) $T_{1/2}$ = 5.42 hr → ^{209}Po









(feeder, decay)	ΔC_{Exp}	ΔC_{corr}	$\tau_{11/2^-}$
(239,195)	162(4) ps	188(4) ps	98(6) ps

Summary

1.5"x1.5" $CeBr_3$ detectors coupled to new PMT Hamamatsu R13089-100

- ✓ MSCD technique with two 1.5"x1.5" detectors
  - ✓PRD calibration with ^{152}Eu
- ✓ Lifetime of $11/2^-$ state of ^{209}Po following offline decay
  - ✓The result is in good agreement with a recently reported value.

References

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NIM A 1014, 165737(2021)
2. J.-M.Regis, et al.,NIM A 684, 36 (2012)
3. J.-M. Régis et al., NIM A 955, 163258 (2020)
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5. Sneha Das et al ,JINST 17 P09012 (2022)
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!!! THANK YOU !!!