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Characterisation of the Bucharest $LaBr_3$:Ce-HPGe Fast-timing gamma-ray Array

Experiment at the Bucharest Tandem

Thamer Alharbi

Outline

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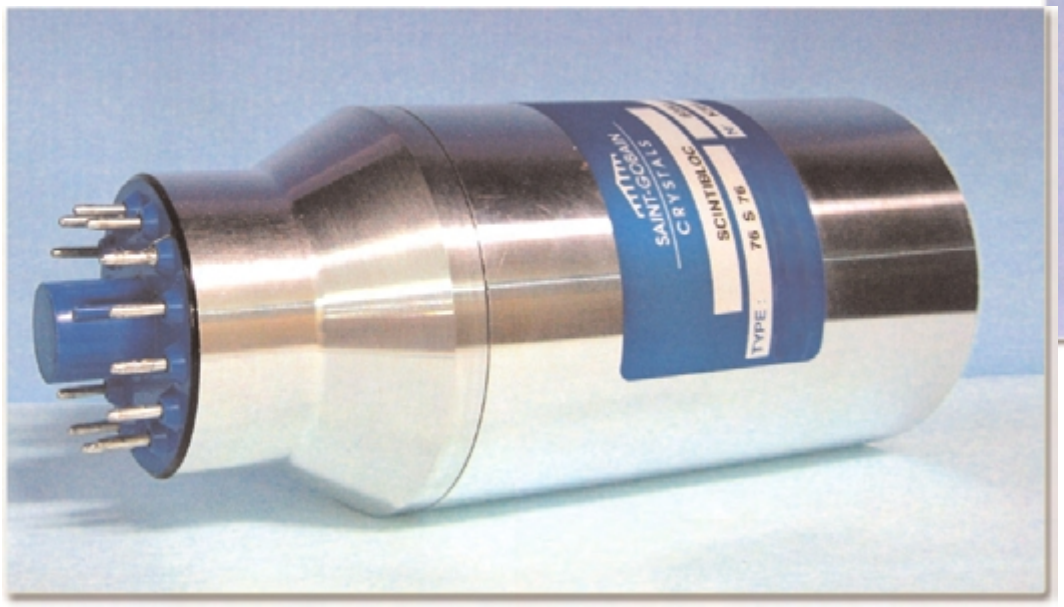
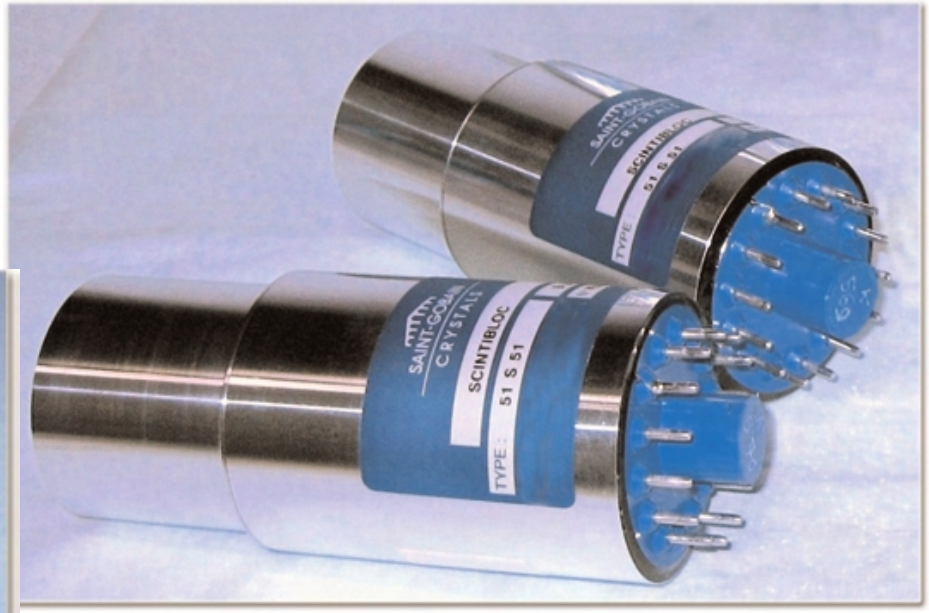
Introduction





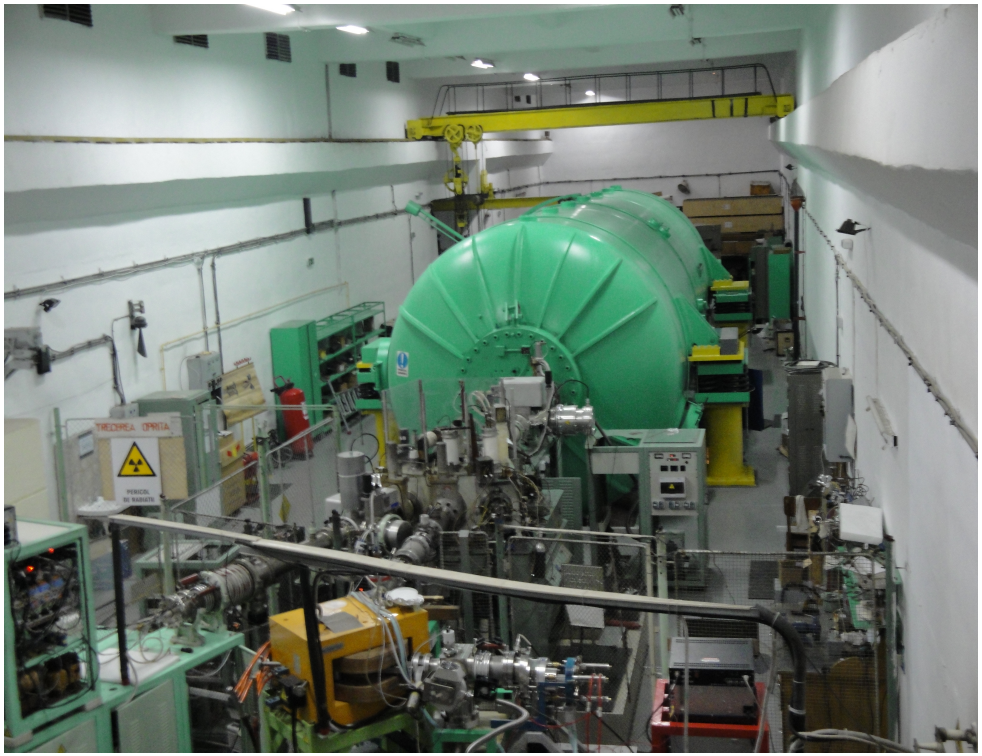
- A new generation of inorganic scintillators.
- Very good timing resolution ~ 5ns (FWHM) Ge, ~200ps (FWHM) $LaBr_3$.
- Good energy resolution ~3% at 1MeV.
- The combination of high light yield (63000 ph/MeV), short rise time (16 ns) and high density (ρ = 5.3 g/cm3) makes the $LaBr_3$ one of the best scintillators.

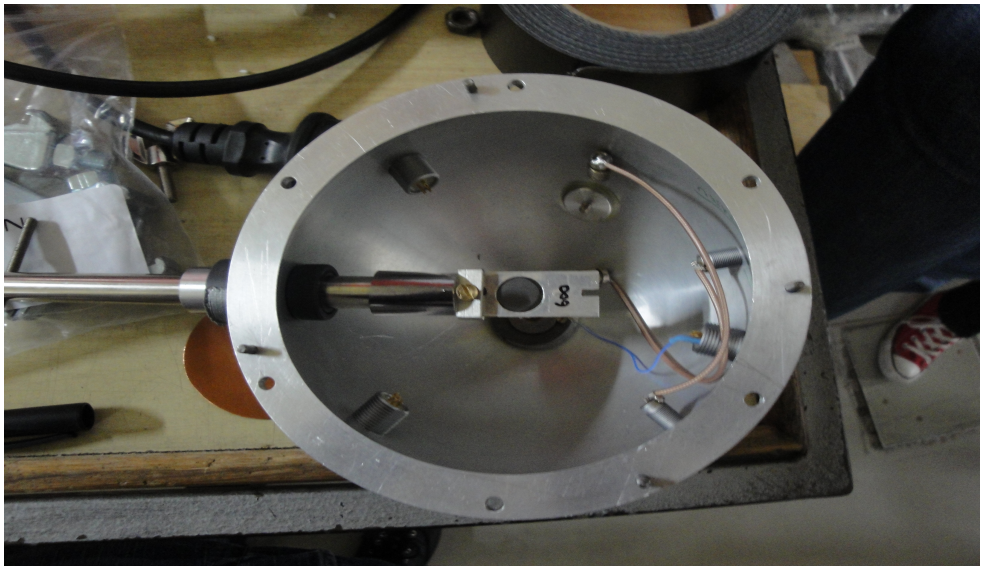
E.V.D Van Loef *et al.* "High-Energy-Resolution-Scintillator" *Appl. Phys. Lett.* Vol **79**, pp 254-258, 2001

Experiment

- Nuclei of interest were populated through the $^{18}O+^{18}O$ fusion-evaporation reaction at the Tandem accelerator at IFIN-HH, Bucharest, Romania.
- 50 mg/cm^2 $Ta_2{}^{18}O_5$ enriched target.
- 36 MeV ^{18}O beam from Bucharest Tandem (typical beam current ~20 pnA).
- Measure reaction gammas from array of 8xHPGe and 7x$LaBr_3$ detectors.
- Master gate, either 2x$LaBr_3$ OR 3xHPGe for a valid event.

P.J.R Mason et al. results





Array Set-up

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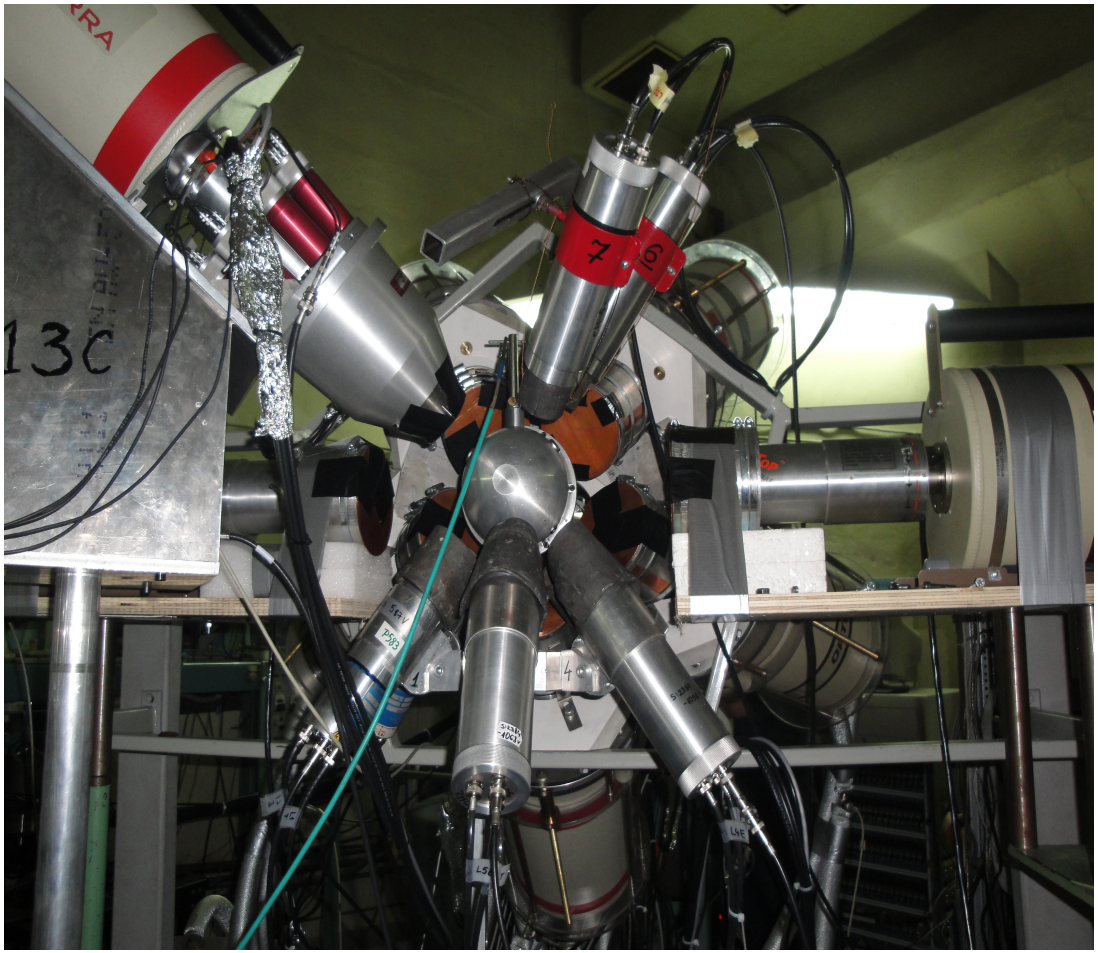
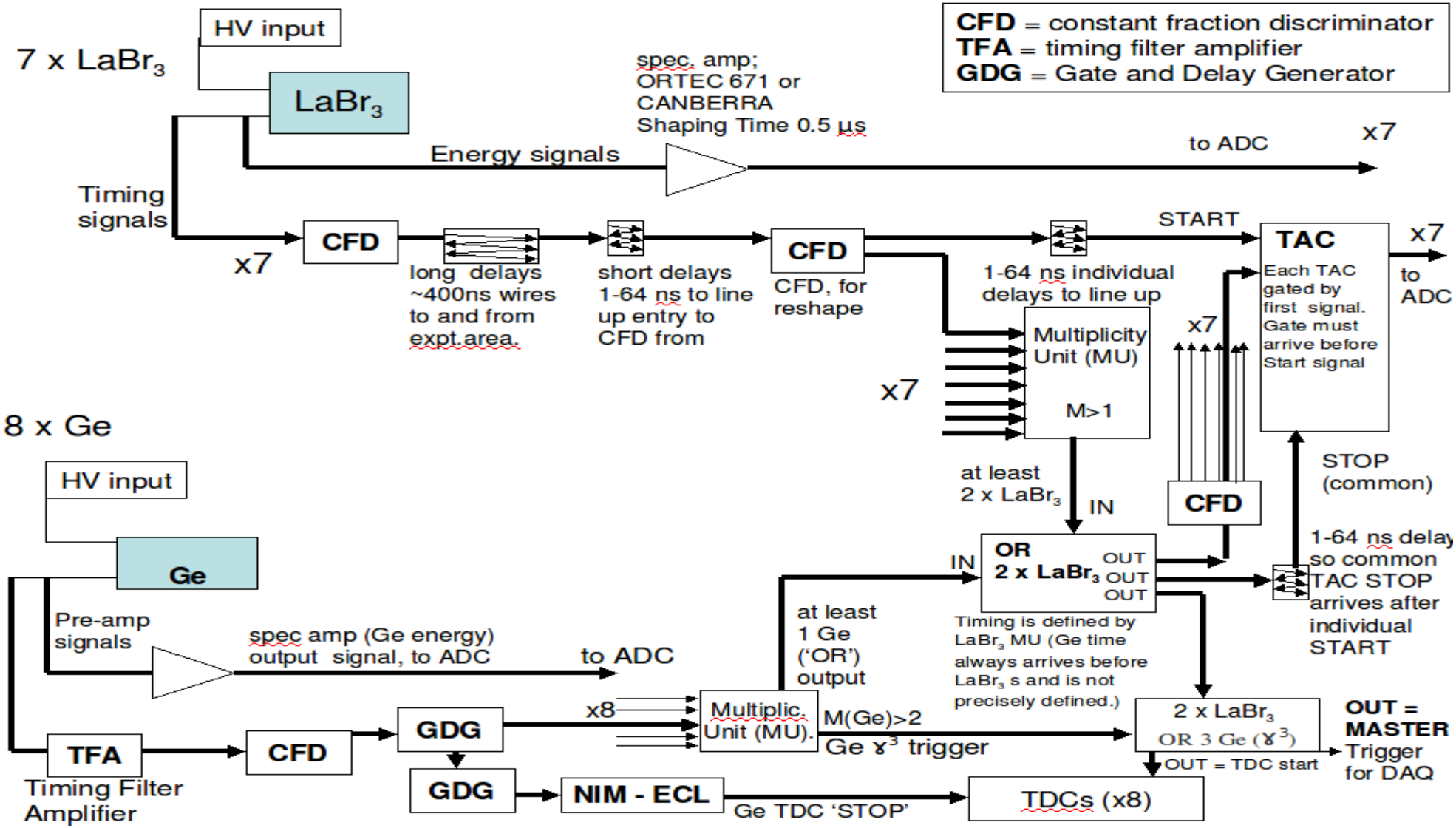
- The detection of gamma-rays was made with 8 HPGe detectors each with relative efficiency around 50%, six of them were placed at 35°, two at 90°.
- The $LaBr_3$:Ce detectors were placed at 45°.
- Three different geometry were used of the $LaBr_3$:Ce

  2”x2” (three) (Cylindrical)
  1.5”x1.5” (two) (Cylindrical)
  1.5”x1.5” (two) (Conical)



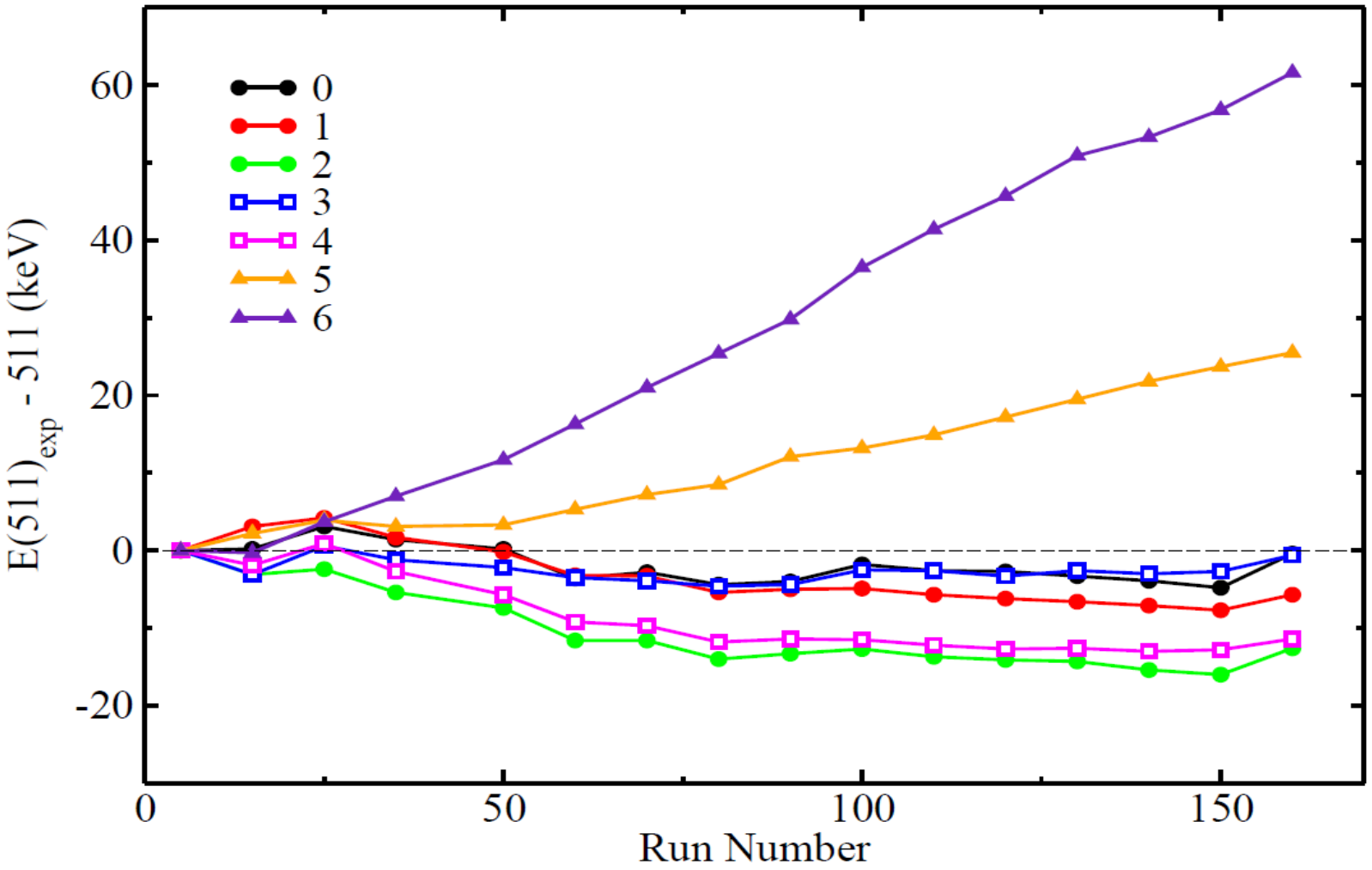
Delayed coincidences fast-timing method

- A delayed triple γ-coincidences technique was applied in the experiment with a condition of at least 2 $LaBr_3$ OR 3 Ge fired.
- Dynode from each $LaBr_3$ was used for the timing and the last anode for energy signal.

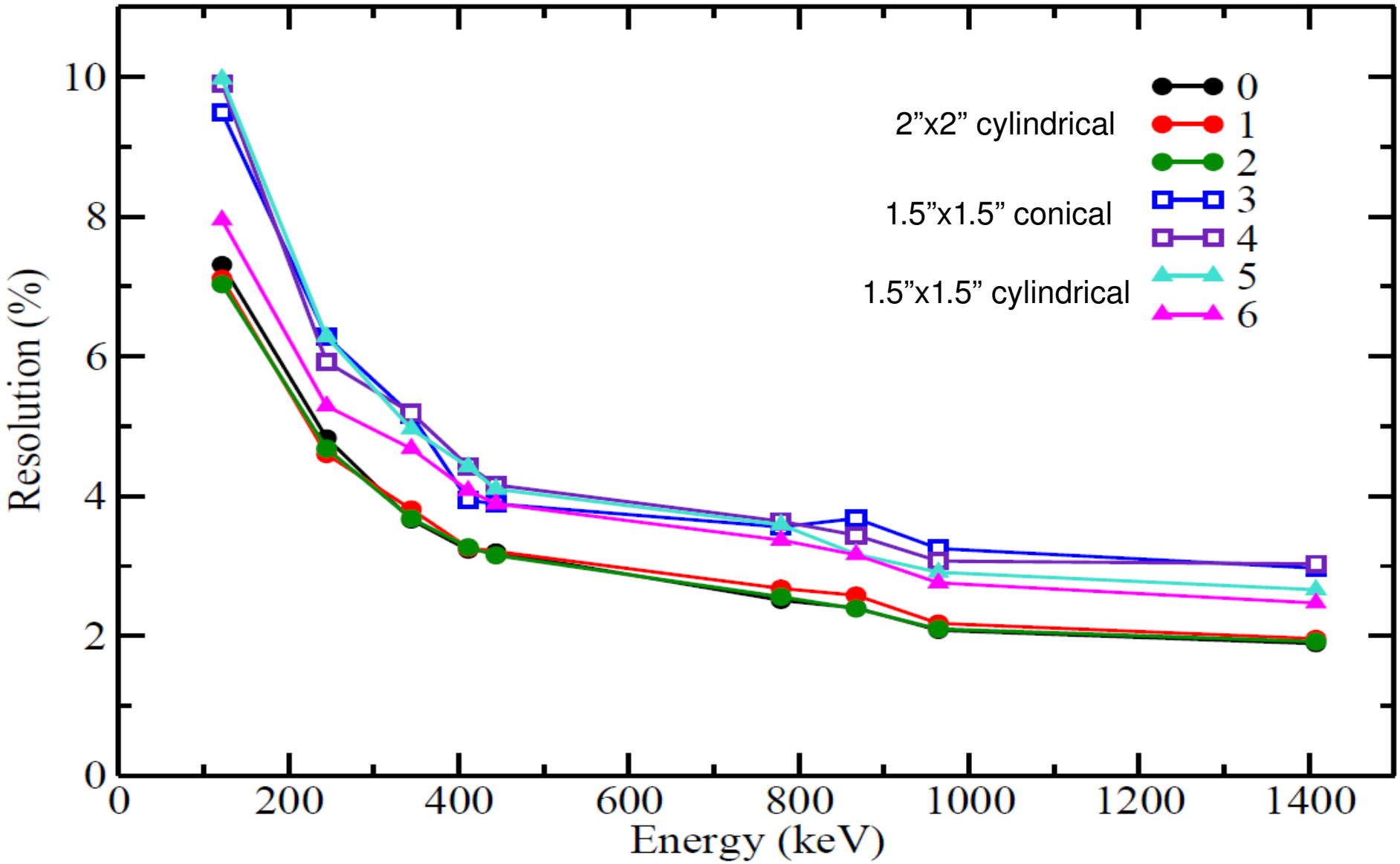


Detector Performance

Substantial gain drift through-out experiment requires run-by-run gainmatching

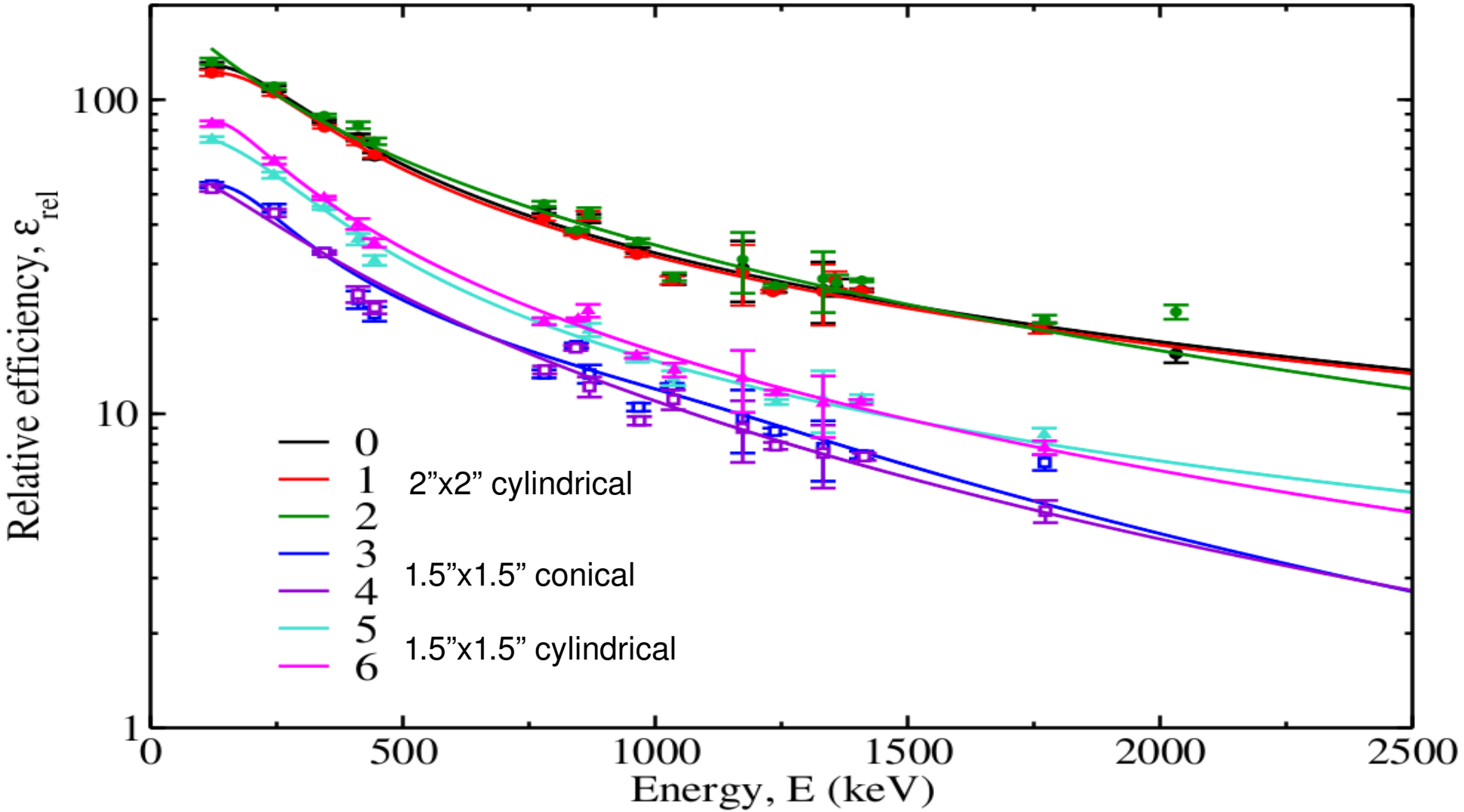


Resolution

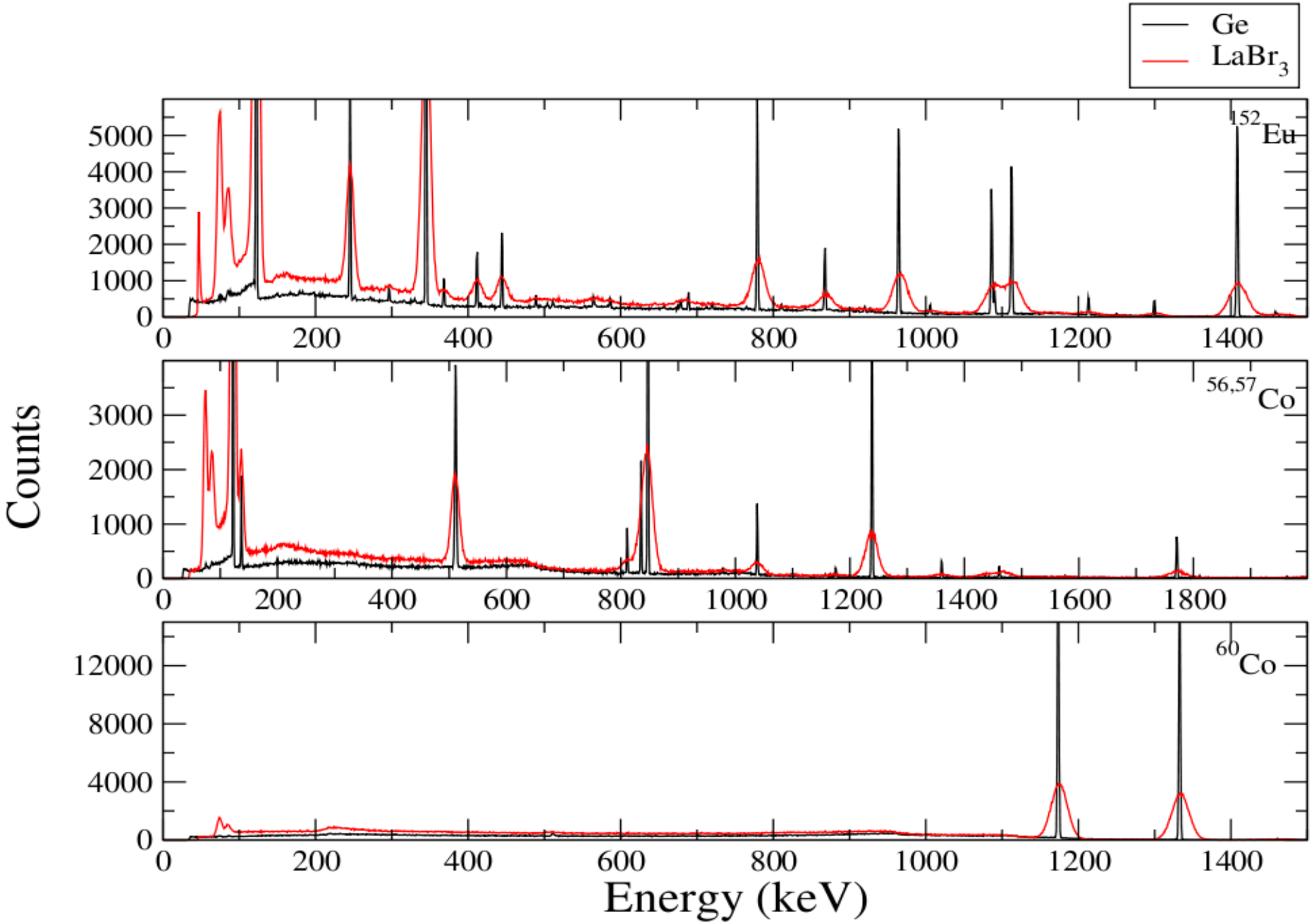

Resolution (%)
Energy (keV)
0
2
4
6
8
10
0
200
400
600
800
1000
1200
1400
2"x2" cylindrical
1.5"x1.5" conical
1.5"x1.5" cylindrical
0
1
2
3
4
5
6

Relative Efficiency

The relative efficiency of these different $LaBr_3$:Ce detectors were measured using data from ^{152}Eu, $^{56,57}Co$ and ^{60}Co sources.

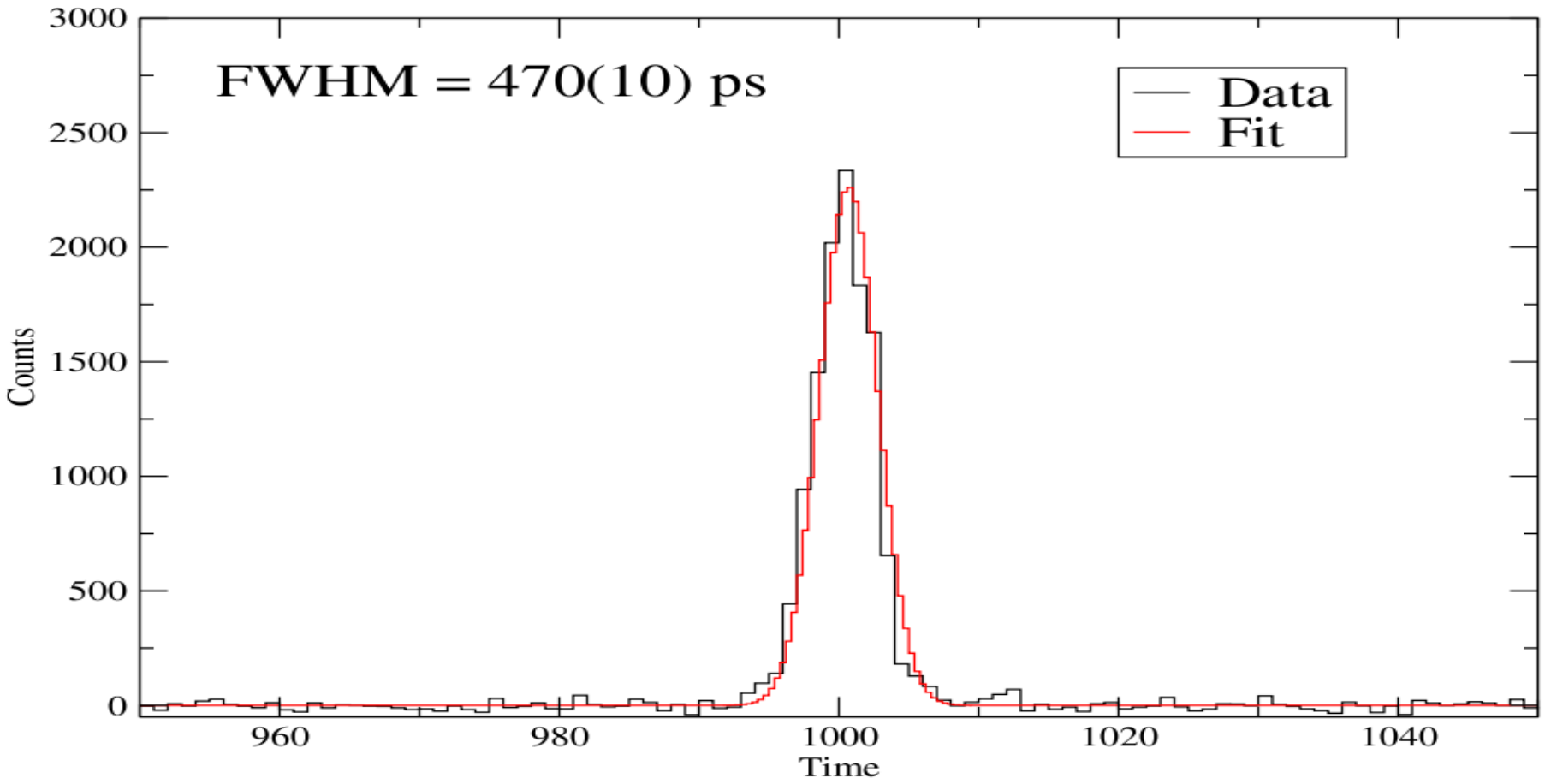


Detector Performance

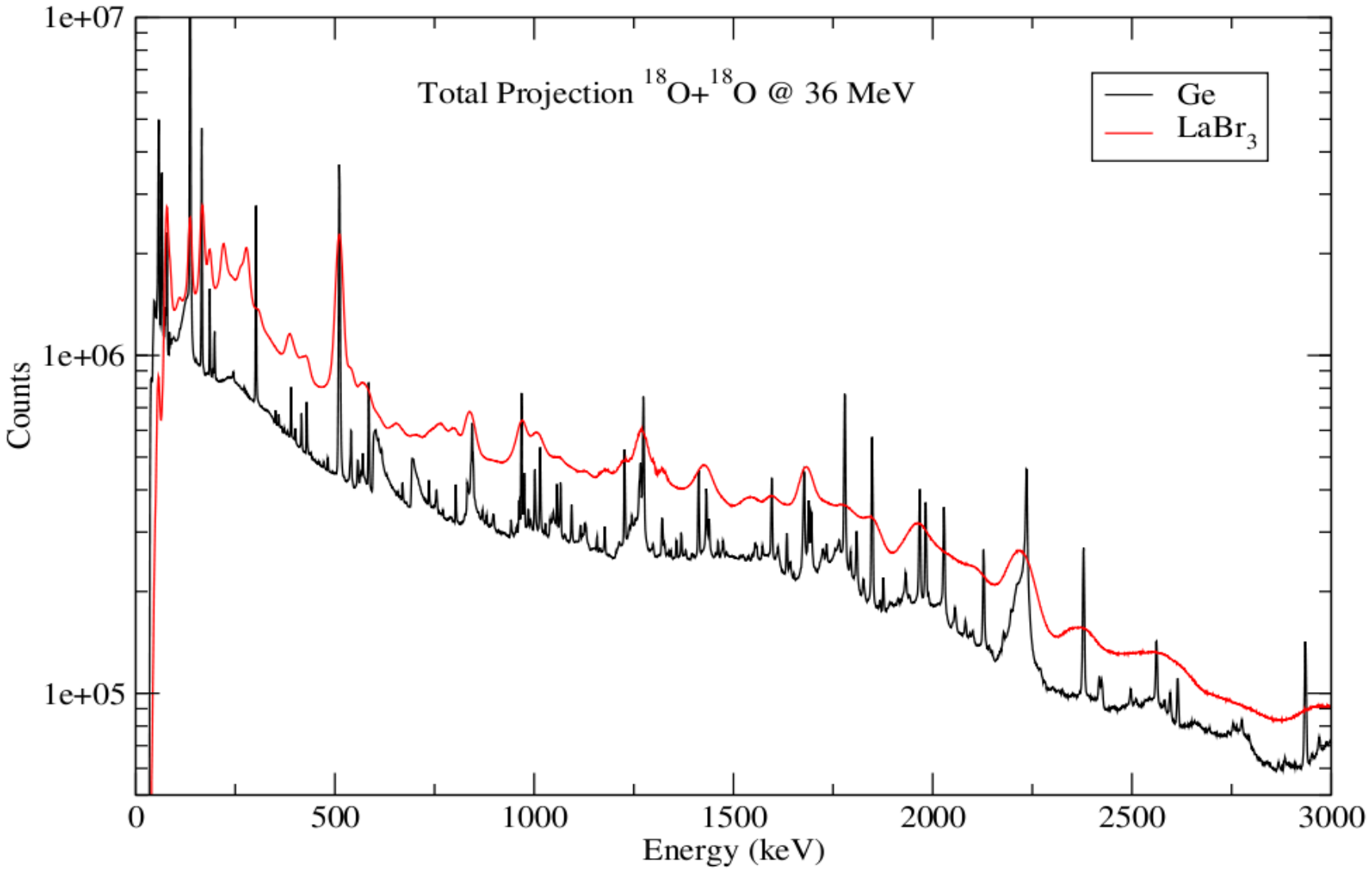


Timing Resolution

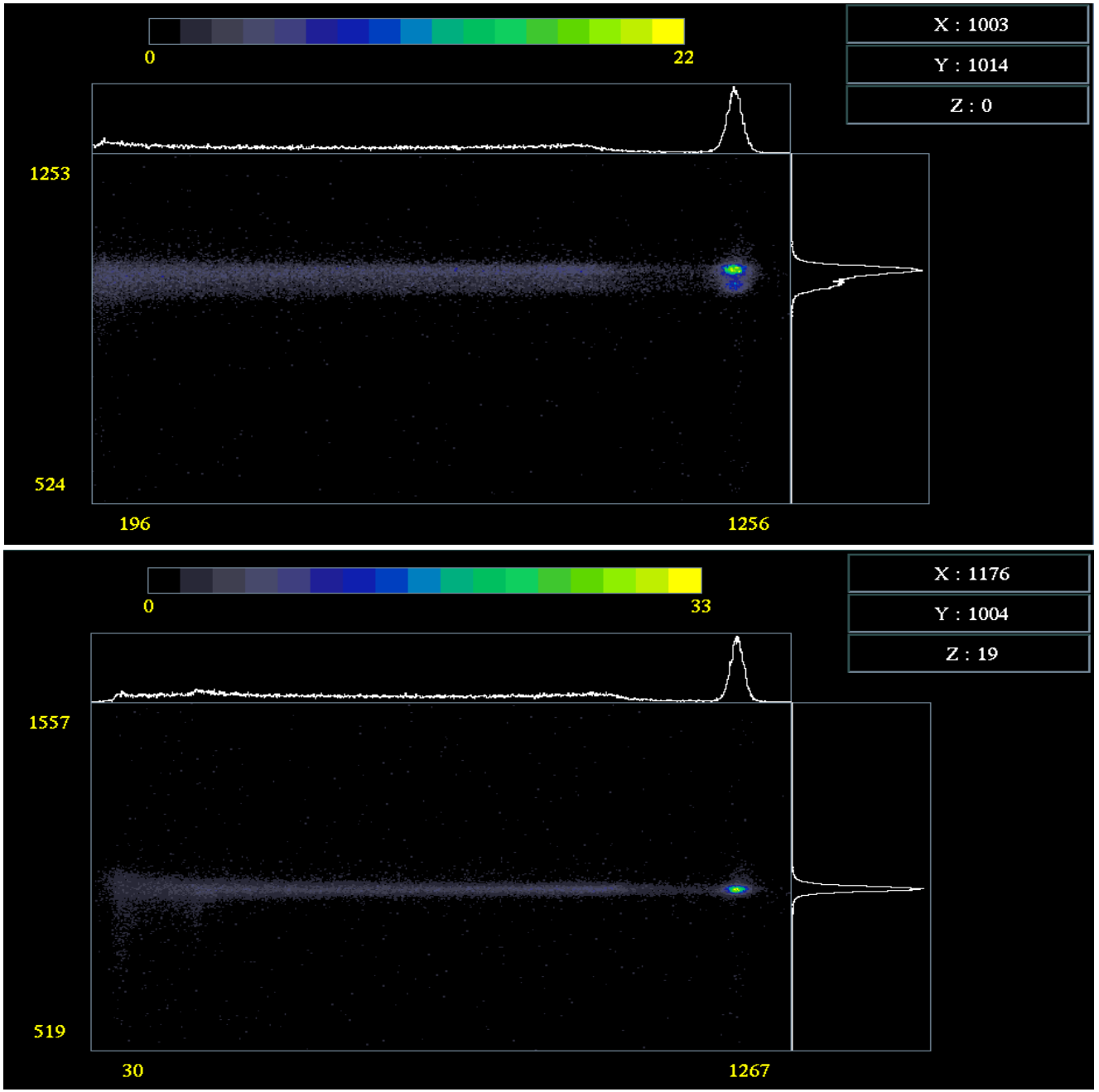
Typical time resolutions (FWHM, for the ^{60}Co source peak-to-peak coincidences)
Were about 150 ps for (1”x1”) detectors
180 ps for (1.5”x1.5”) detectors N. Mărginean, *et al* Eur. Phys. J. A 46, 329–336 (2010)
300 ps for (2”x2”) detectors



Detector Performance



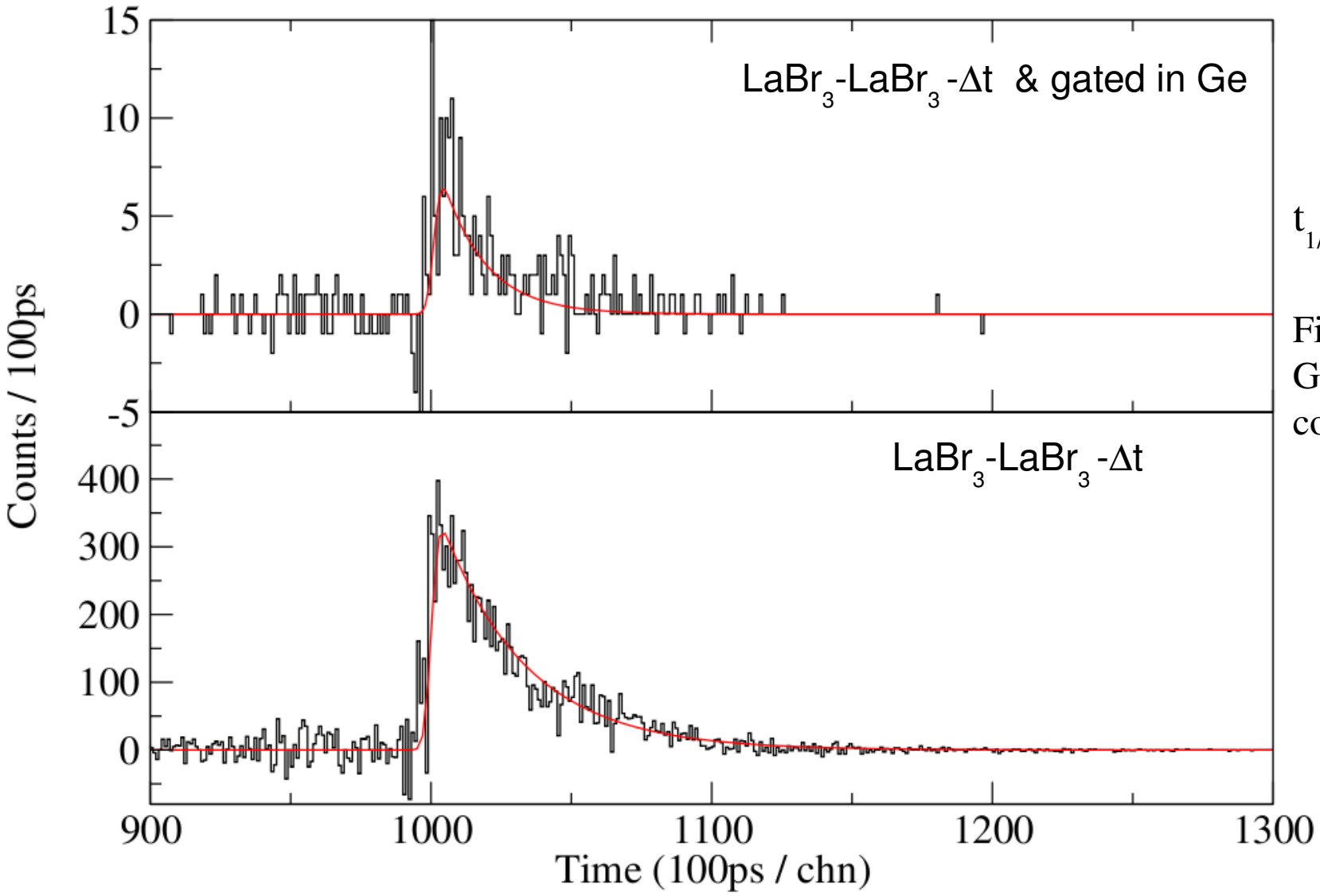
Time-walk Correction



- The instrumental time response for each combination of a $LaBr_3$ detector and a CFD requires a correction because of the time walk.
- ^{60}Co placed at target position.
- One $LaBr_3$ taken as time reference.
- Then, for each of the rest detectors build a matrix between E_γ and Δt with respect to the reference detector.
- Time reference detector gated on 1332 keV full-energy peak.

Results

PRELIMINARY



$t_{1/2}$ ~ 2ns(0.2)

Fitted with Gaussian-exponential convolution

Thank you

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