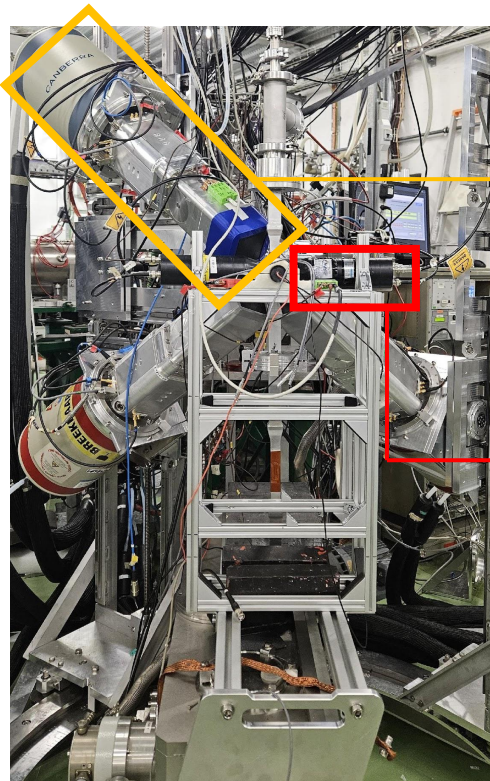# Optimization of 500MHz Pixie-16 for Fast Time Measurement

Jooyoung Lee

Why Fast Time Measurement?

- Lifetimes of excited nuclear states is used to understand **Nuclear Structure** and **Transition Matrix Elements**
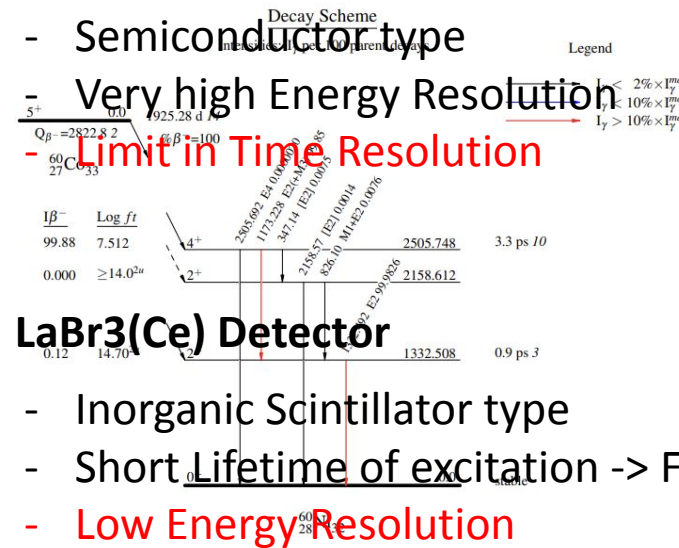- Magnitude of lifetime is in wide range: femtoseconds (10^{-15}) to years

Clover Detectors (HPGe)

- Semiconductor type
- Very high Energy Resolution
- Limit in Time Resolution

LaBr3(Ce) Detector

- Inorganic Scintillator type
- Short Lifetime of excitation -> Fast Time Measurement!
- Low Energy Resolution

Analogue & Digital Data Acquisition

Analogue

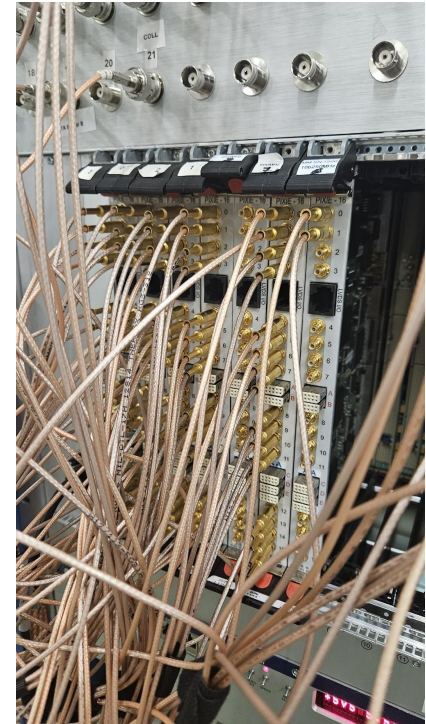Higher Time Resolution
(Charge & Discharge of Capacitor)

$O(n^2)$ complexity for n detectors

Digital

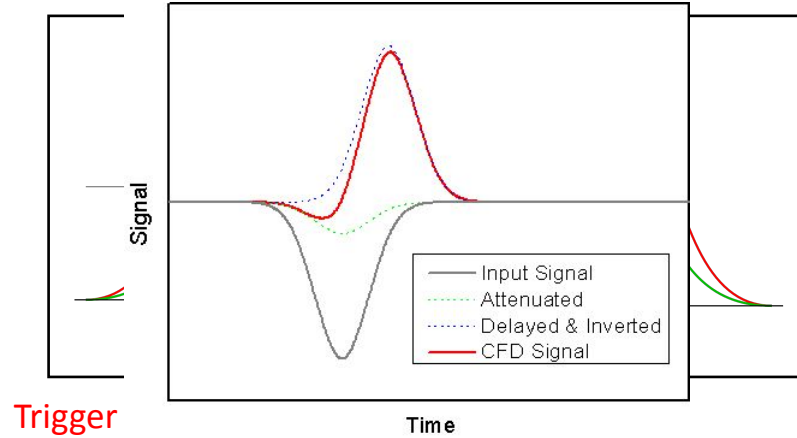Flexibility & Scalability

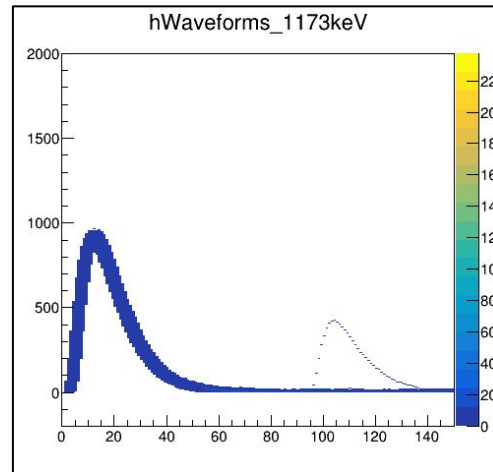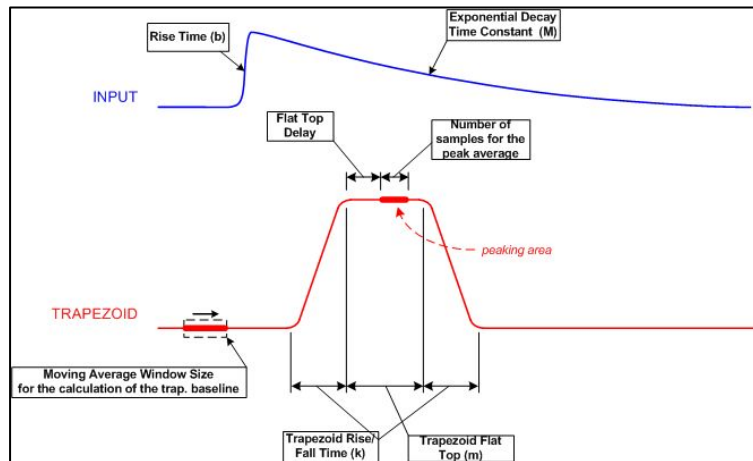Time Resolution should be optimized

How Data are Collected

- CFD and Trapezoidal Filter

- What is a "Good Parameter"?

CFD & Trapezoidal Filter

Time?

Trigger

Energy?
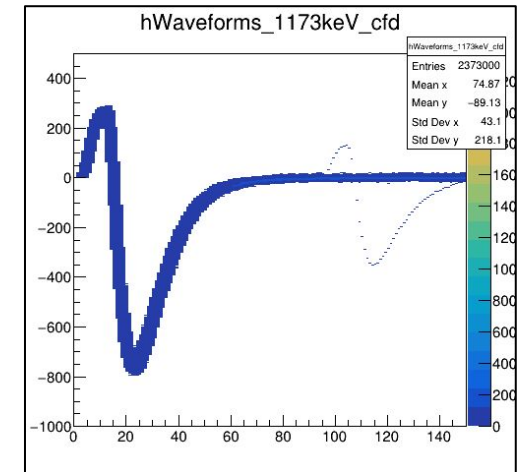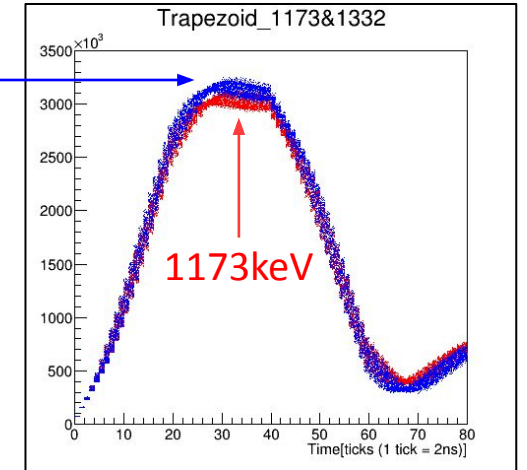
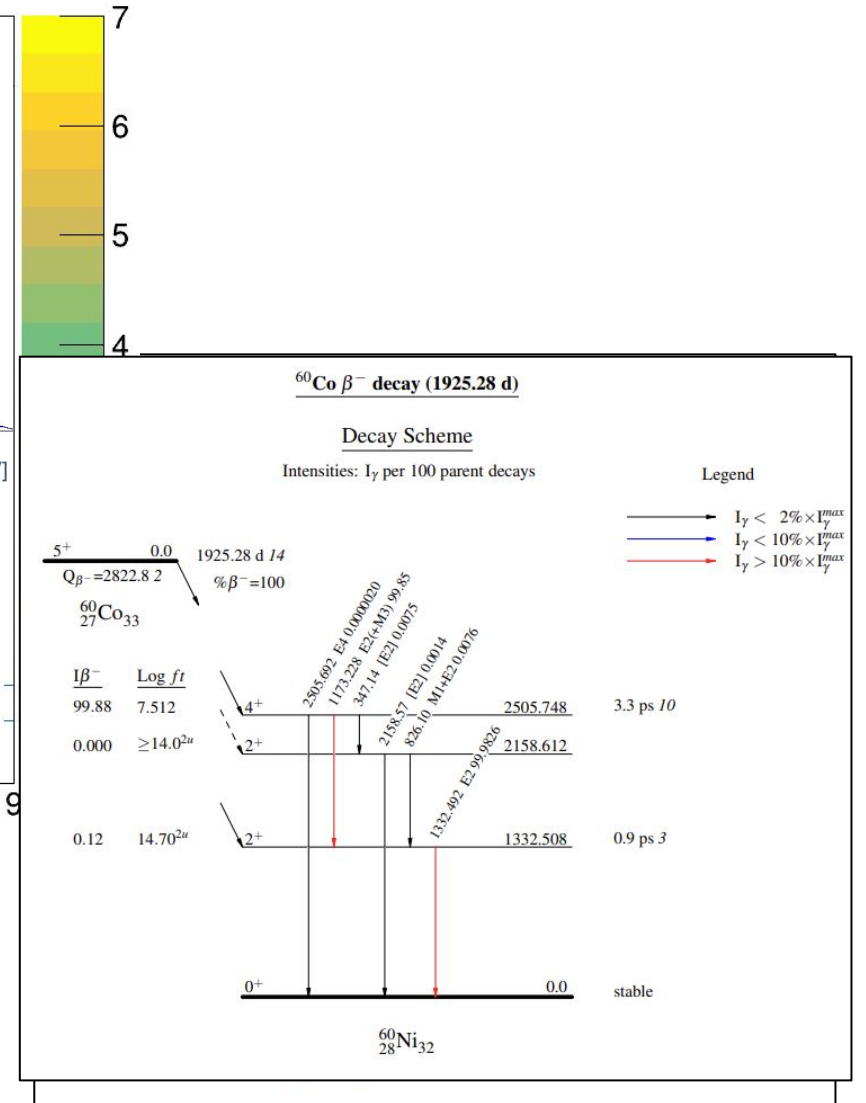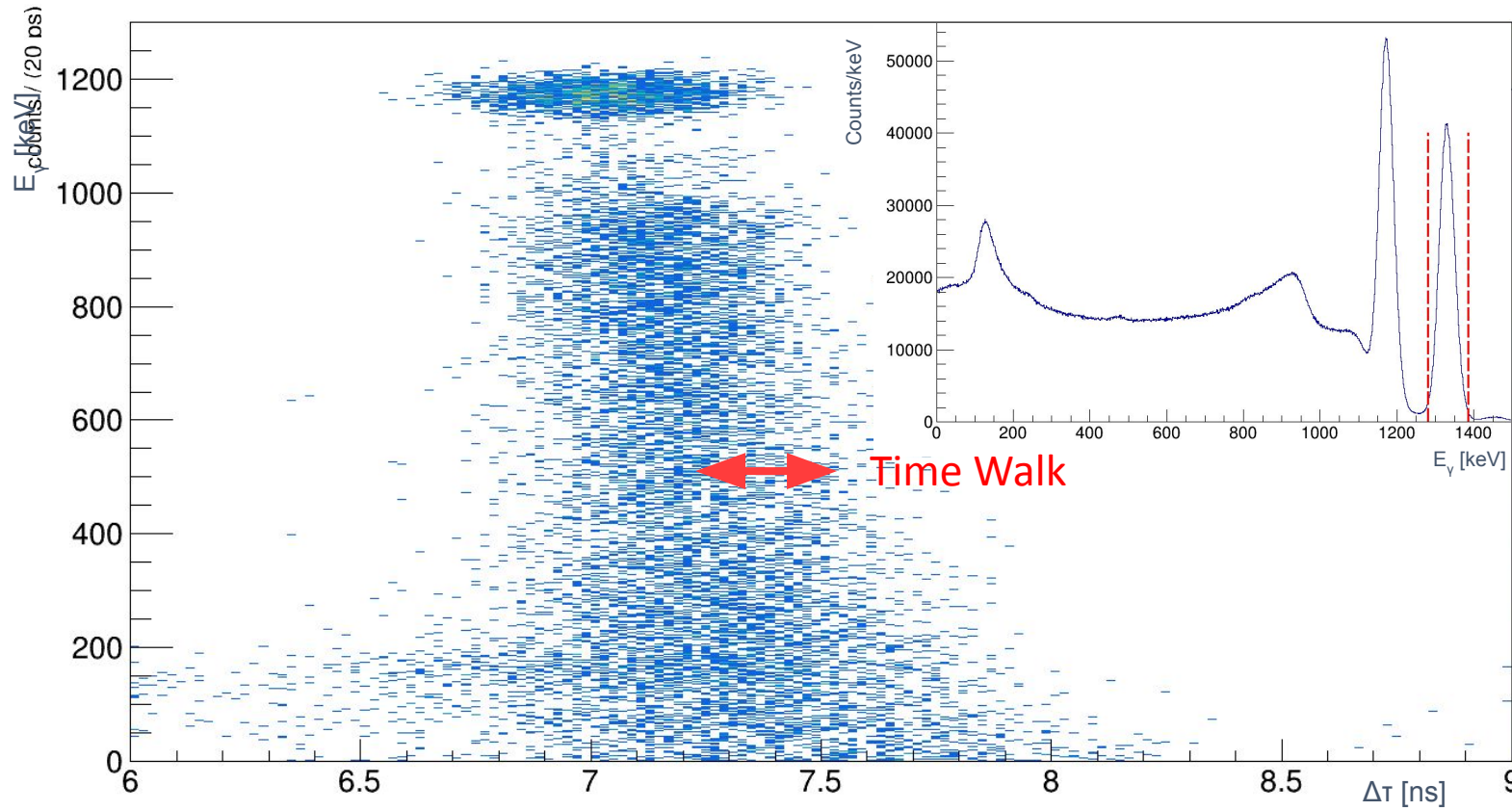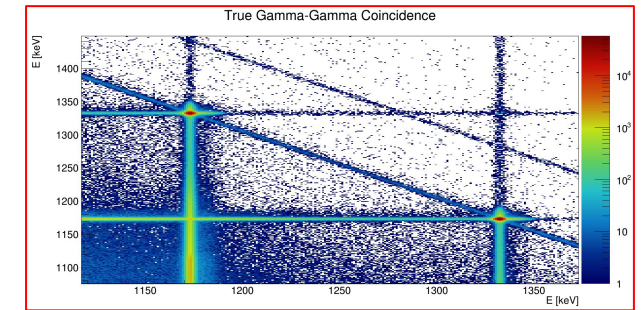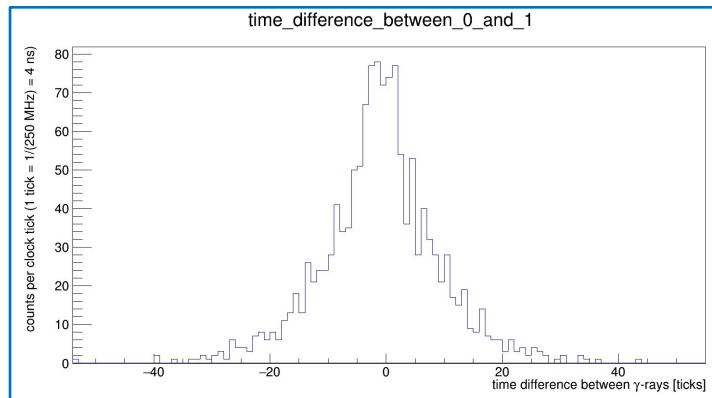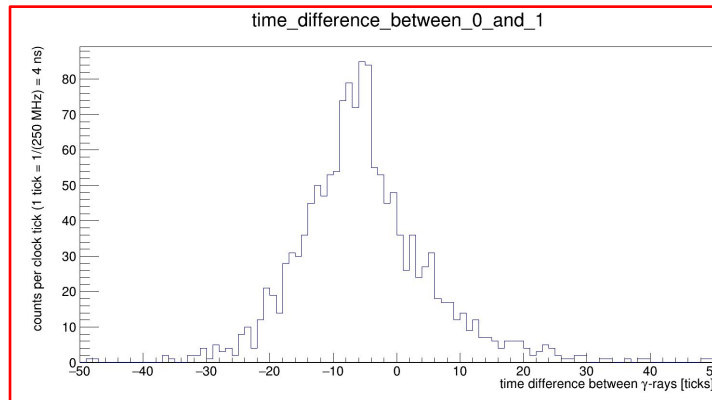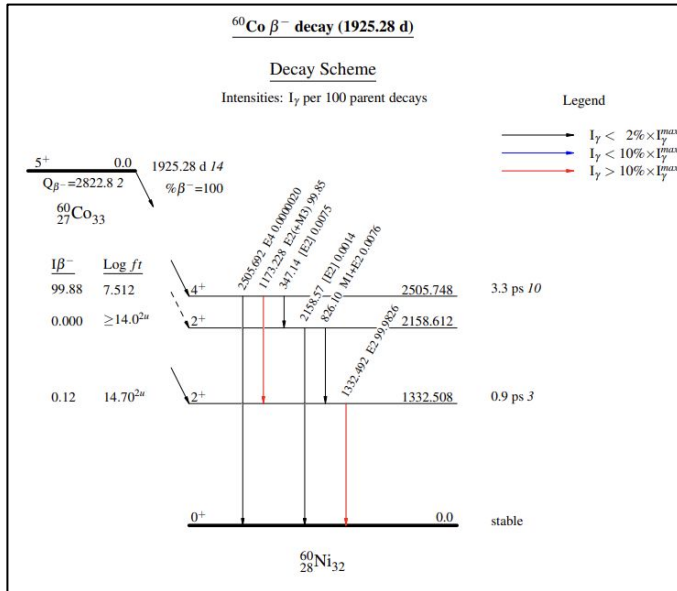# What is a "Good Parameter"?

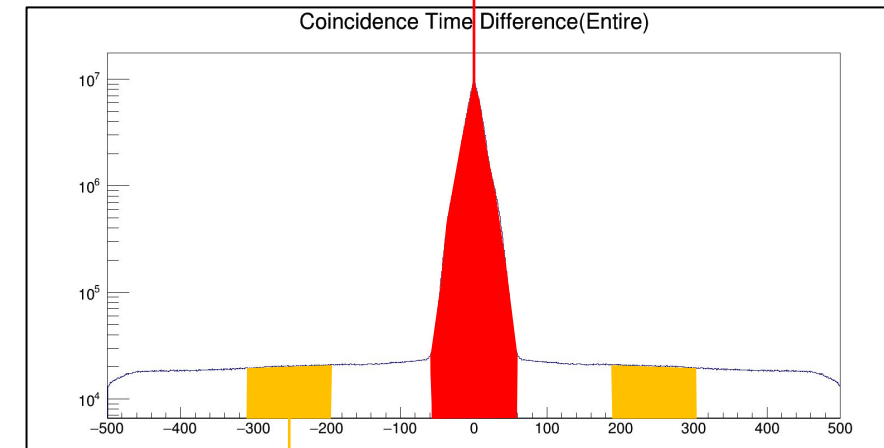# How Data are Calibrated

- Time Calibration

Time Calibration (^{60}Co)

γ-γ Coincidence of ^{60}Co source is used for time calibration
Data gathered in a specified time interval (TIM_REF) are considered as one event

Prompt Time Gate

Background Time Gate
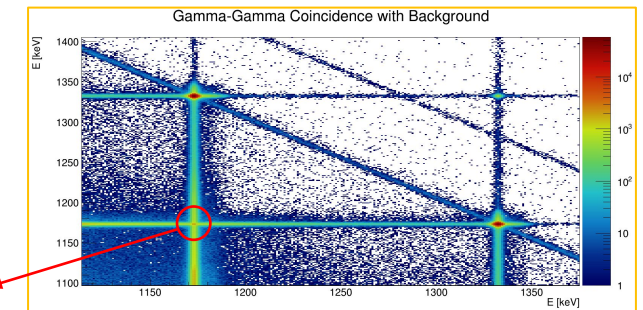
Self-Coincidence: Evidence of Background

Time Calibration (^{60}Co)

Finally, by applying Energy gate, true coincidence spectrum can be obtained

True Gamma-Gamma Coincidence

Coincidence of 1173 keV w/ Background

True Coincidence of 1173 keV

❏ Compton Effect

❏ Plateau of Compton Effect

❏ Photopeak

Can also check the accuracy of efficiency curve

Summary

- Lifetimes of excited nuclear states is used to understand **Nuclear Structure** and **Transition Matrix Elements**
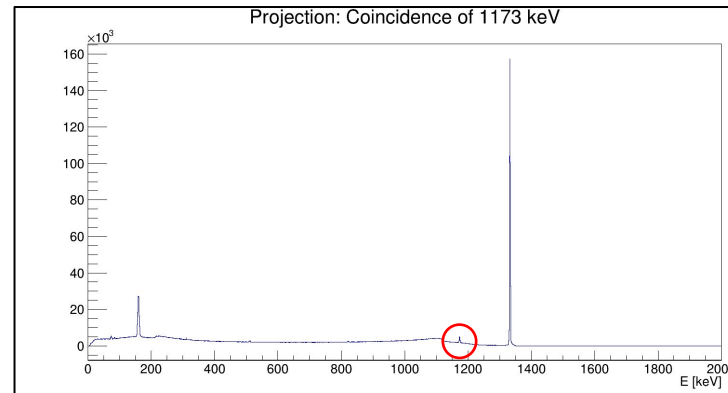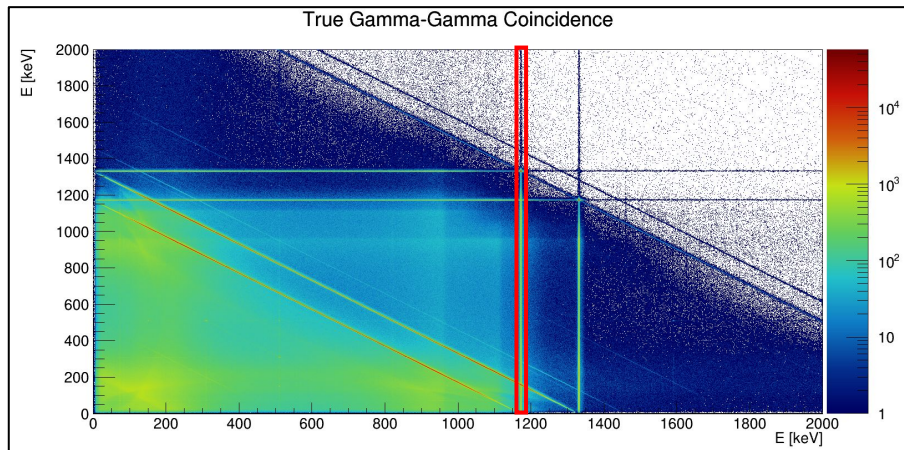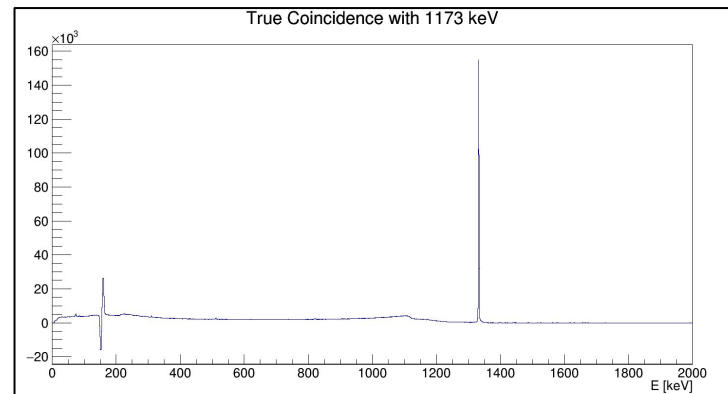
- LaBr3(Ce) is a good detector for fast time measurement

- Digital system is considered to be used for its convenience, but has tradeoff of resolution

- Time resolution & Energy resolution of data can be optimized by CFD & Trapezoidal Filters
    - Search for Optimization Criteria and Optimization is being done

- After getting the good data, calibration is rather simple! (and familiar)
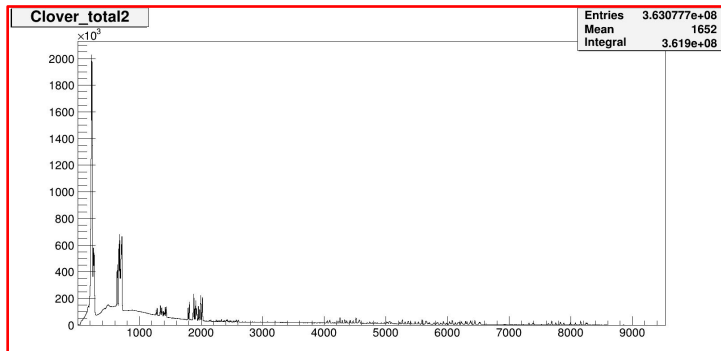
Thank you for Your Attention

Any Question?

Backup Slides

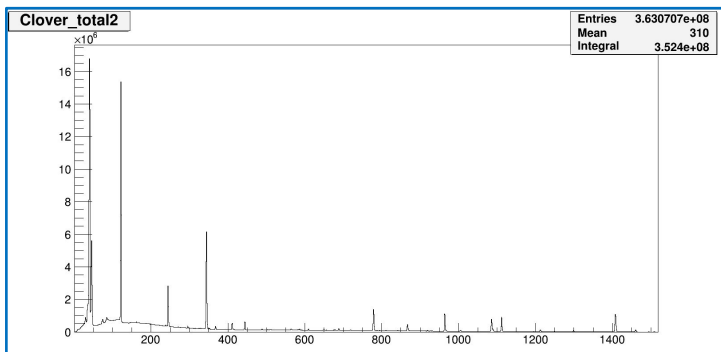Just in Case

Energy Calibration (^{152}Eu) & Efficiency Curve
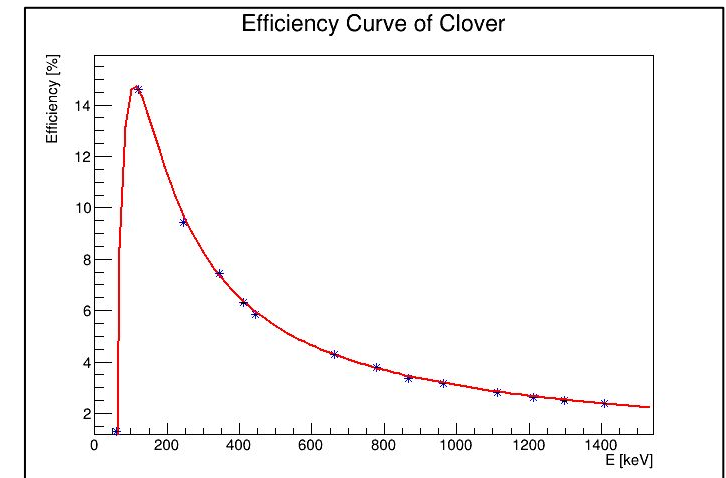
It is basically matching channel no. with known spectrum energy

<Uncalibrated 152Eu Data>

<Calibrated 152Eu Data>

$$\epsilon(E) = \frac{P_1 + P_2 \ln(E) + P_3 \ln(E)^2 + P_4 \ln(E)^3 + P_5 \ln(E)^4}{E}$$

I. A. Alnour, H. Wagiran, N. Ibrahim, S. Hamzah, W. B. Siong, M. S. Elias; New approach for calibration the efficiency of HpGe detectors. *AIP Conference Proceedings* 12 February 2014; 1584 (1): 38–44. https://doi.org/10.1063/1.4866101
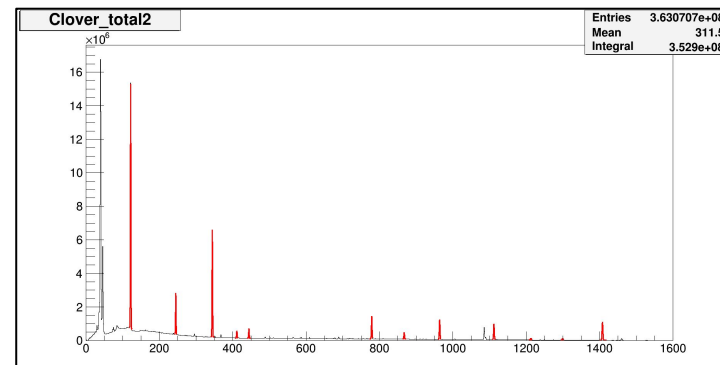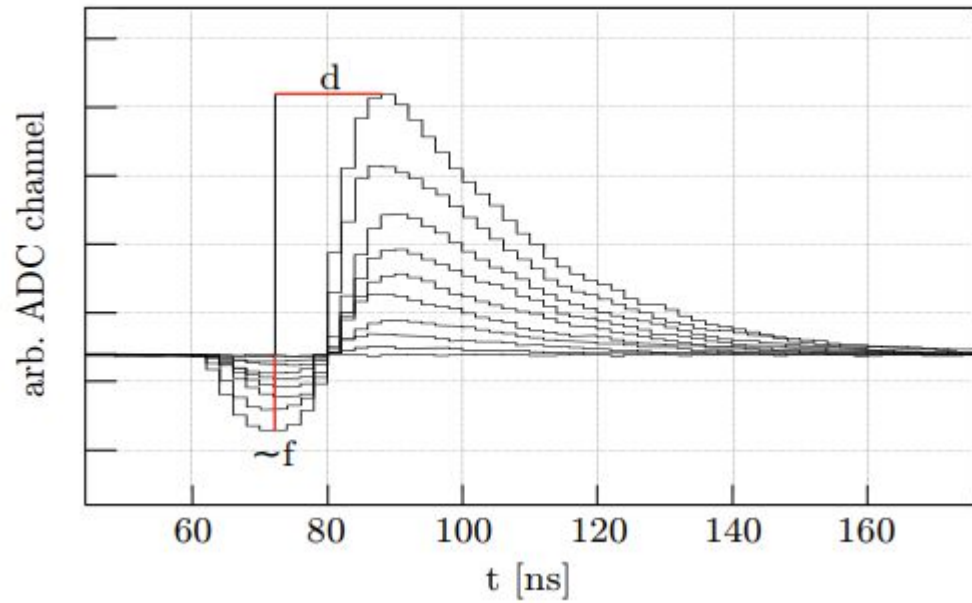
Several digitally CFD shaped signals recorded by a CAEN V1730 digitizer module

Reference 2D Histogram for CFD Optimization

Harter, Andreas & Weinert, M. & Knafla, Lukas & Régis, J.-M & Esmaylzadeh, Arwin & Ley, M. & Jolie, J.. (2023). Investigating timing properties of modern digitizers utilizing interpolating CFD algorithms and the application to digital fast-timing lifetime measurement.