Optimization of 500MHz Pixie-16 for Fast Time Measurement

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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”?
Constant Fraction Discriminator

CFD & Trapezoidal Filter

Energy?

Time?

Trigger

1332keV

1173keV


What is a “Good Parameter”? 

\[ \tau \text{ [ns]} = 1.41(3) \text{ ns} \]

\[ T_{1/2} \text{ [ns]} = 1.403(11) \text{ ns} \]

\[ E_{\gamma} \text{ [keV]} \]

Counts/keV

Time Walk

[Graph and diagram showing decay scheme with energy levels and time intervals]
Current Status

\[ \Delta t \] between Coinciding Gammas of 60Co

Ex 1) CFD Scale = 0.4 / CFD Delay = 7 ns

Ex 2) CFD Scale = 0.7 / CFD Delay = 50 ns
How Data are Calibrated

- Time Calibration
Data gathered in a specified time interval (TIM_REF) are considered as one event even though they are not simultaneous in reality.

$\gamma$-$\gamma$ Coincidence of 60Co source (1173 keV & 1332 keV) is used for time calibration.
Time Calibration ($^{60}$Co)

If the time gate is properly set, true coincidence spectrum can be obtained by gating in energy.

- 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 ($^{152}\text{Eu}$) & Efficiency Curve

It is basically matching channel no. with known spectrum energy

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

Several digitally CFD shaped signals recorded by a CAEN V1730 digitizer module

Reference 2D Histogram for CFD Optimization