Digital signal processing in gamma spectroscopy

GDED

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Young Researchers & Young Engineers Days - 2024

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1. Introduction

Few words about GDED …

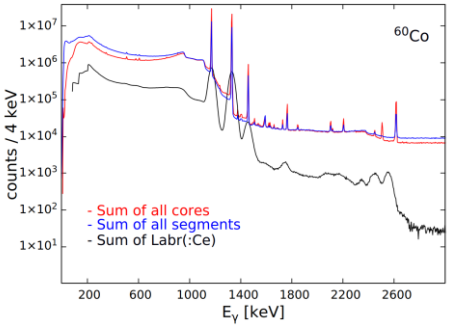
HPGe

Scintillators

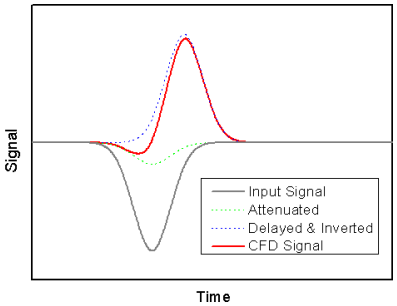
Types of detectors

- ELIADE: 8 HPGe + 4 $LaBr_3$ scintillators
- ELIGANT-GN: 15 $LaBr_3$ + 19 $CeBr_3$+22 Li-glass scintillators

Why are they important

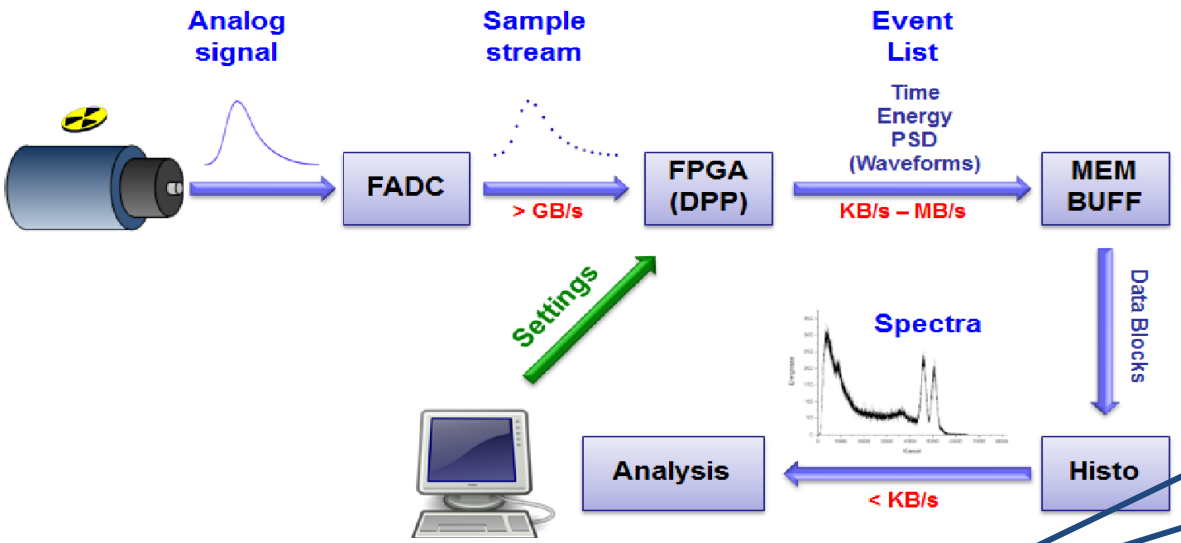


Energy



Timing

2.Motivation

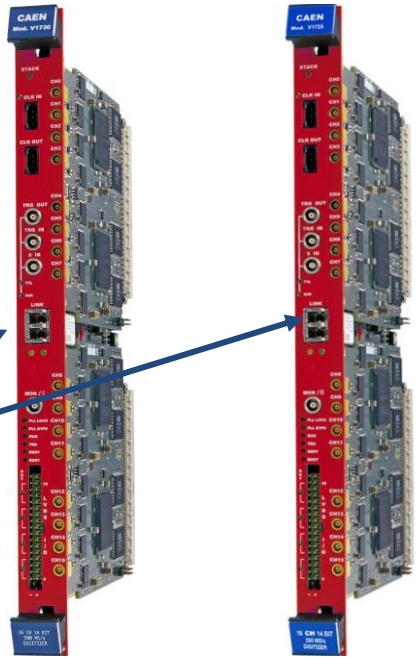


Main objectives:
- ➤ Reliability
- ➤ Optimization
- ➤ Cost reduction

the algorithms are not accessible

Pulse Height Analysis (DPP-PHA)

Pulse Shape Discrimination (DPP-PSD)



14-bit @ 500 MS/s

14-bit @ 250 MS/s

3. Experimental setup

Pulse generator /

Detector (Scintillator)

Radioactive source

CAEN Digitizer(V1725/30)

raw data

processed data

Data acquisition System (CoMPASS)

ROOT Data Analysis Framework

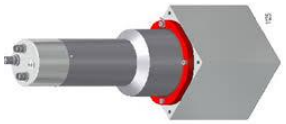
The incident photon from the radioactive source is captured by the detector and converted into an electrical signal.

The signal is transmitted to the digitizer, and the data will be collected using the CoMPASS data acquisition system.

CoMPASS will save the raw and filtered signal, and then we will process it using the ROOT framework (C++) and compare the results.

4.1. Pulse Shape Discriminator[1/3]

Pulse Shape Discrimination (PSD) - is technique used to discriminate between signals of different types of radiation



$$PSD = \frac{Q_{long} - Q_{short}}{Q_{long}}$$

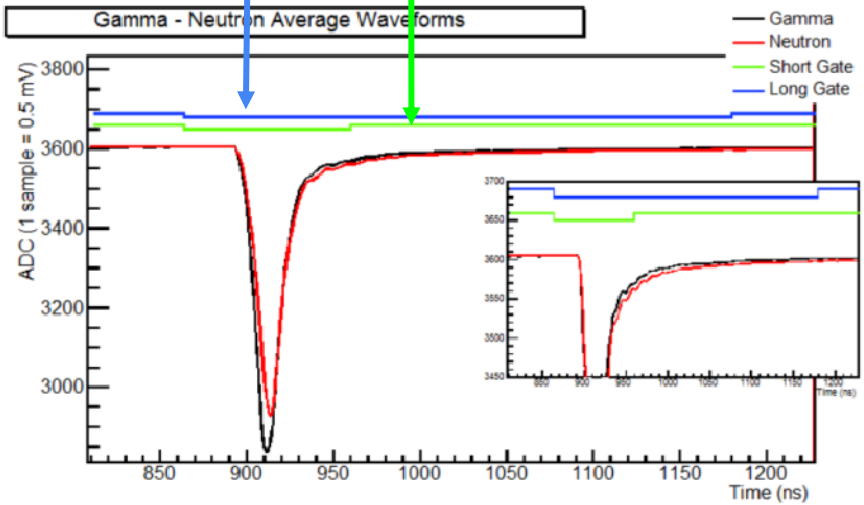


Fig.1 : Neutron-gamma discrimination

- long gate : duration of the signal gate for integrating the total electrical charge (= energy)
- short gate : duration of the signal gate for integrating the electrical charge of the fast component

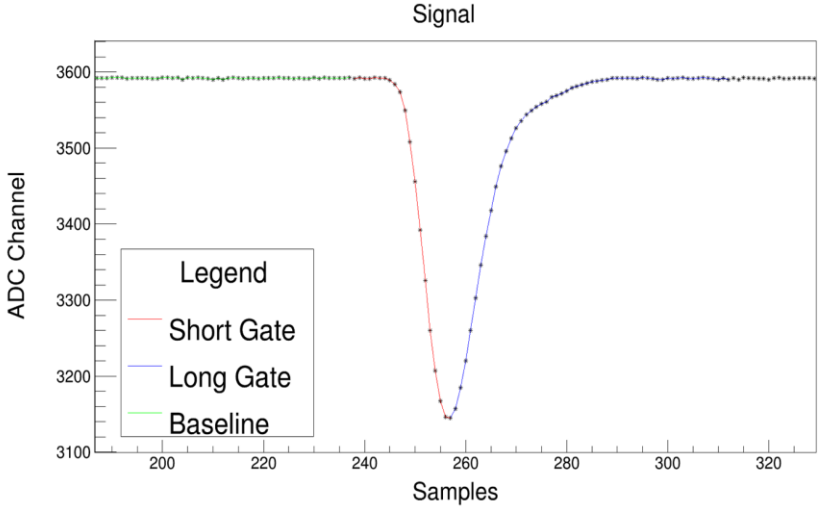


Fig.2 : Our signal with parameters

4.1 Pulse Shape Discriminator[2/3]

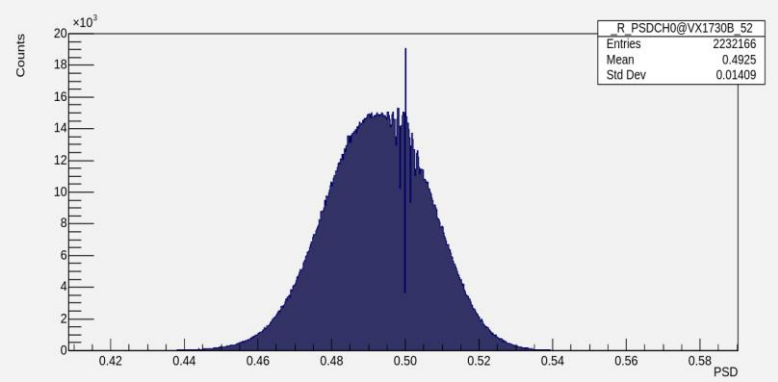


Fig.3 : PSD histogram by digitizer

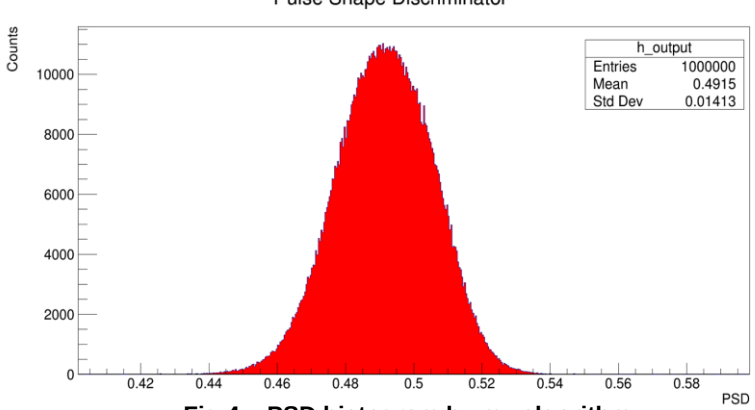
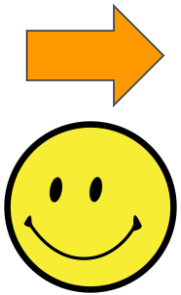


Fig.4 : PSD histogram by my algorithm

Results :

PSD_digitizer = 0.464

PSD_computed = 0.463



The algorithm's consistent and highly comparable results confirm its accurate and effective functioning.

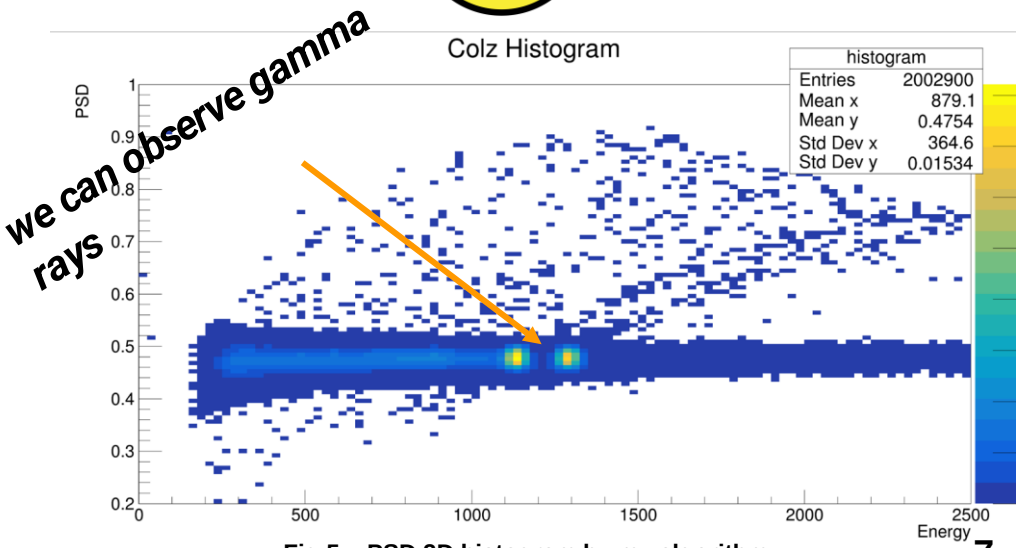


Fig.5 : PSD 2D histogram by my algorithm

4.1 Pulse Shape Discriminator (Energy Spectrum)[3/3]

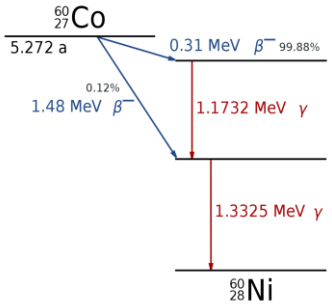


Fig.6 : 60Co decay scheme

$$Energy\ resolution(\%) = \frac{FWHM}{Centroid} * 100$$

where :

$$FWHM = 2\sqrt{2ln2}\sigma \approx 2.355\sigma$$

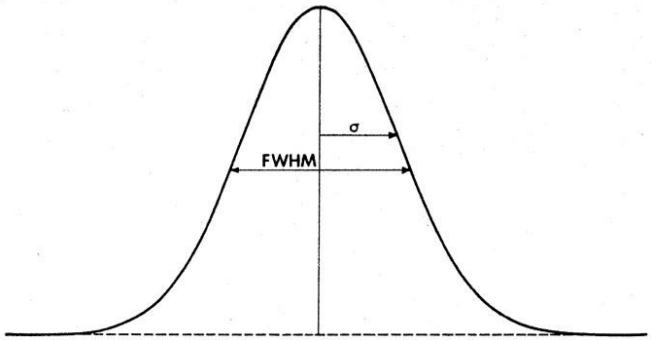


Fig.8 : Gaussian fit

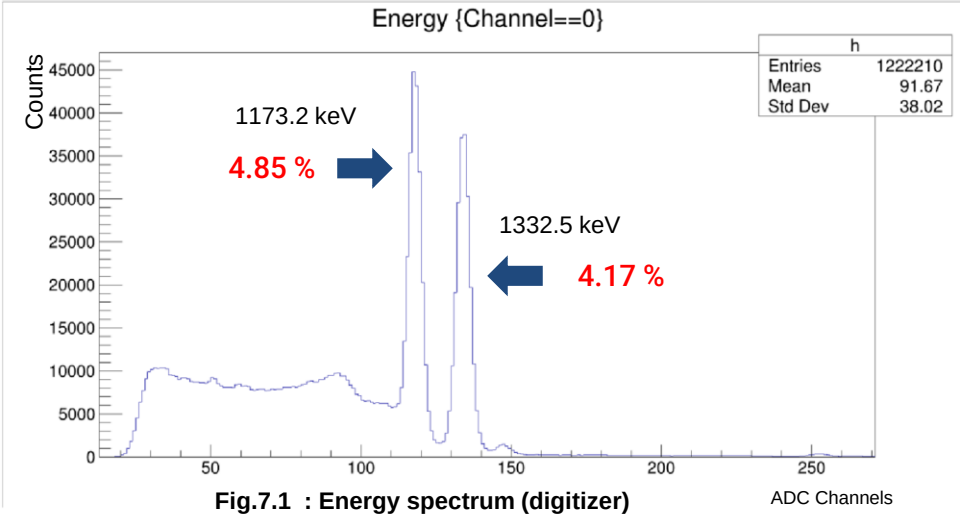


Fig.7.1 : Energy spectrum (digitizer)

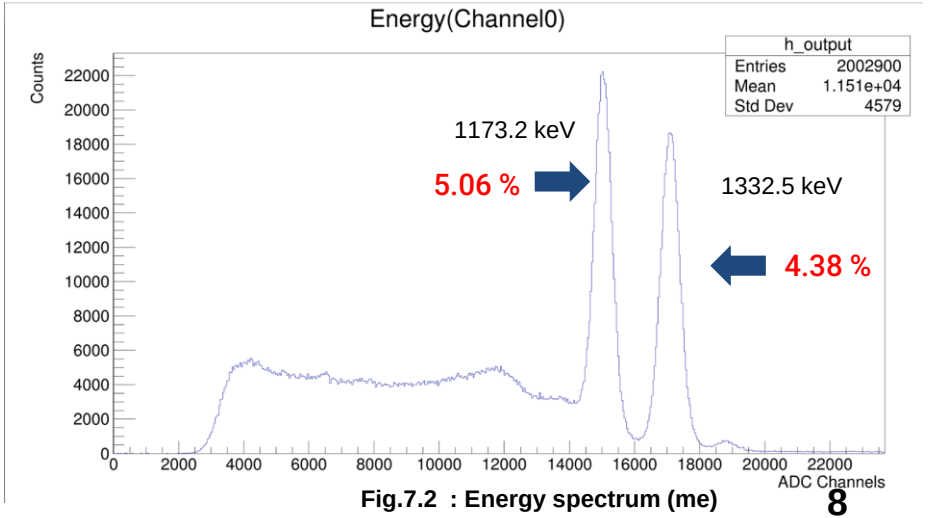


Fig.7.2 : Energy spectrum (me)

4.2 Timing algorithms[1/2]

- A timing discriminator main function is to accurately mark the arrival time of detected events.

- Achieving **optimal time resolution** is critical

Leading Edge

- it detects the point at which the signal rises above a certain threshold

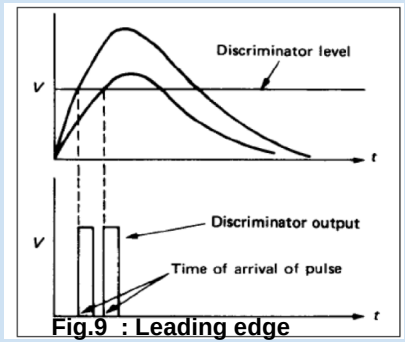


Fig.9 : Leading edge

Problem : Time walk

CFD (Constant Fraction Discriminator)

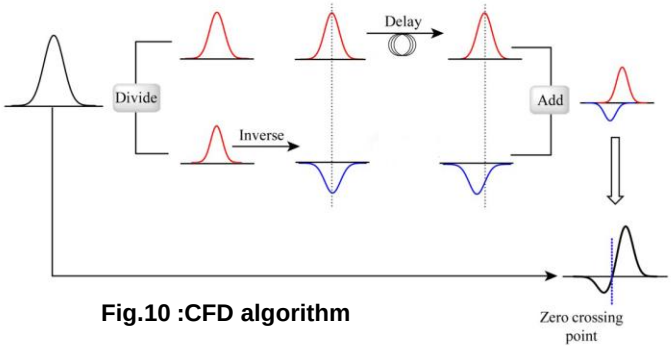


Fig.10 :CFD algorithm

CFD method calculates the time of arrival based on a fraction of the pulse amplitude

Linear interpolation

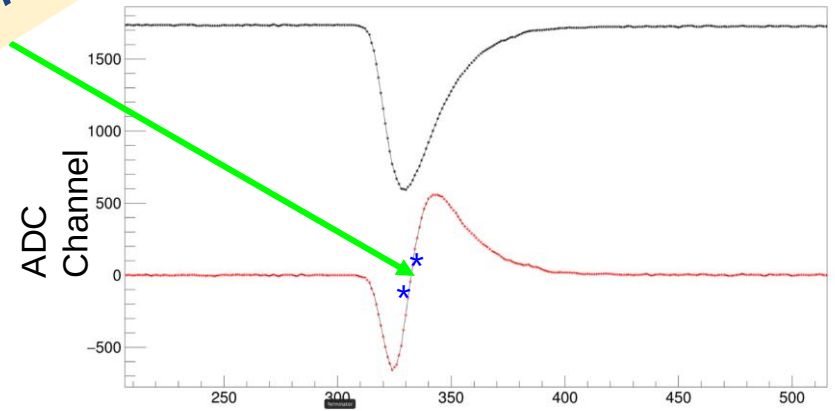
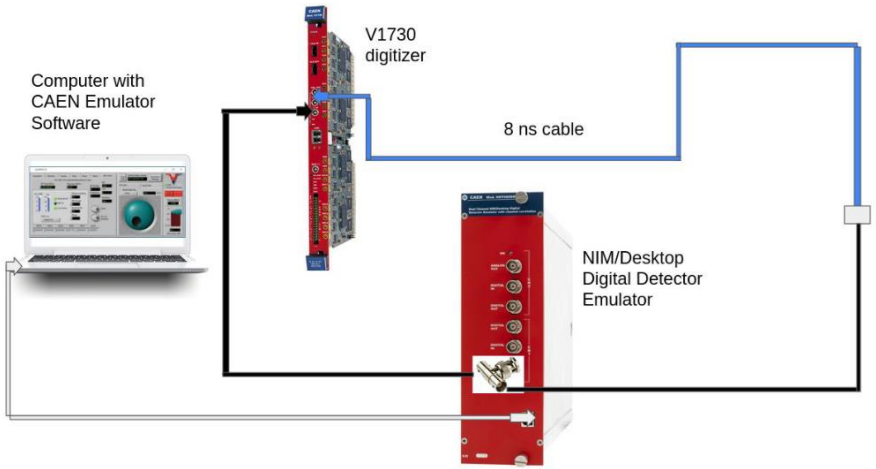


Fig.11 :Raw signal (black) and CFD signal (red) computed by me

4.2 Time difference[2/2]

Fig.12 : Pulser Set-up



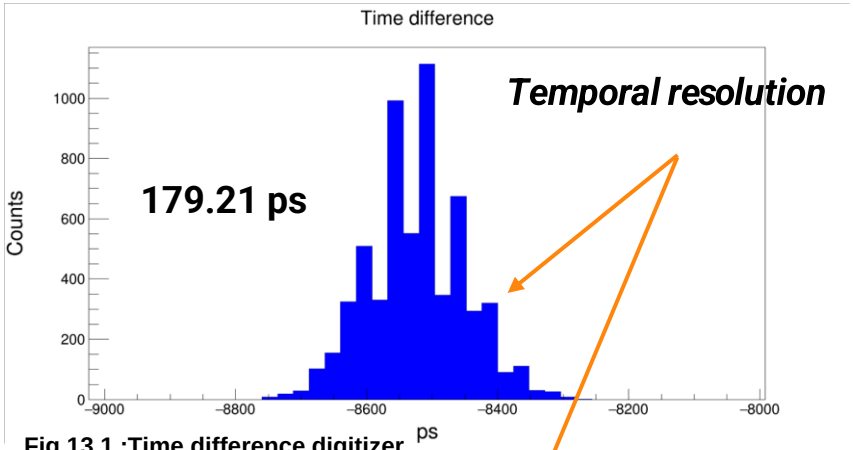


Fig.13.1 :Time difference digitizer

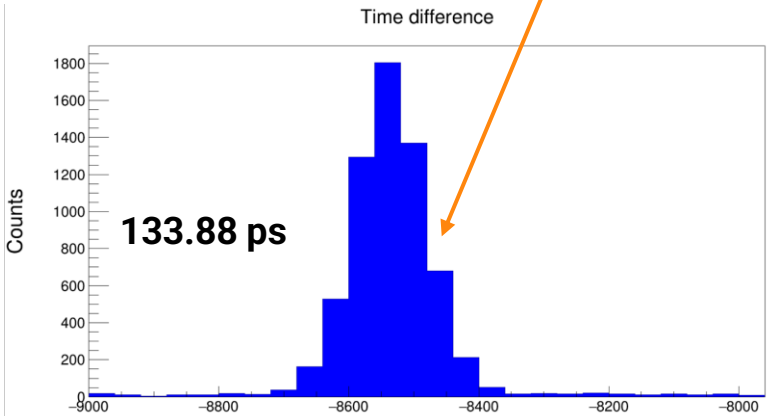
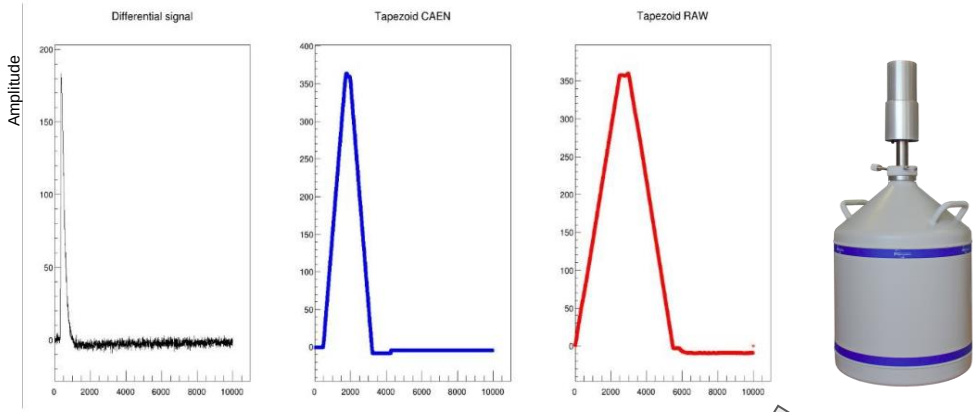


Fig.13.2 :Time difference my algorithm

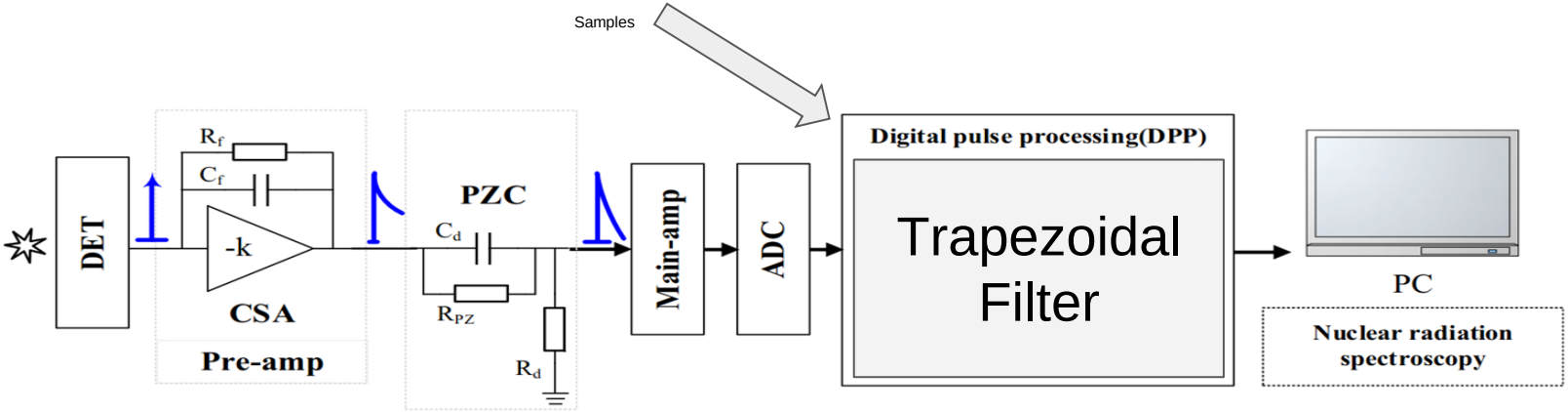
Time coincidence

is an experimental design through which particle detectors register two or more simultaneous measurements of a particular event through different interaction channels.

5. Conclusion and future work[1/2]



- Running the trapezoidal filter on multiple events
- Checking the energy resolution
- Performing the timing algorithm



- analyzing the data in real-time
- improving the filters

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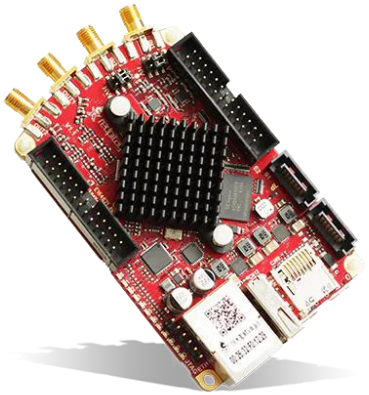

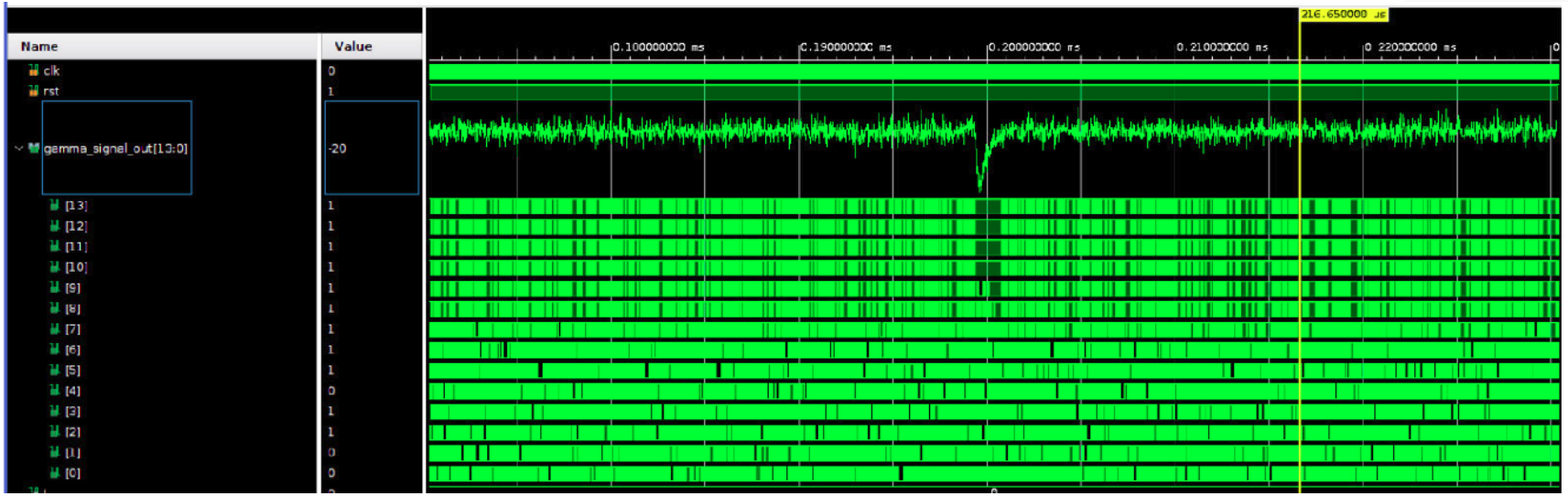

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Thank you !

Do you have any questions?

Additional Slide