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Test and Optimization of the IDS Fast-Timing Electronics

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Outline

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  - ISOLDE and IDS
  - Fast-Timing Method in Nuclear Spectroscopy
  - Fast-Timing Electronics
- Objectives
- Actual work
- Results & Conclusion

ISOLDE and IDS

ASPIC

MINIBALL

NICOLE

COLLAPS

CRIS

ISOLDE

WITCH

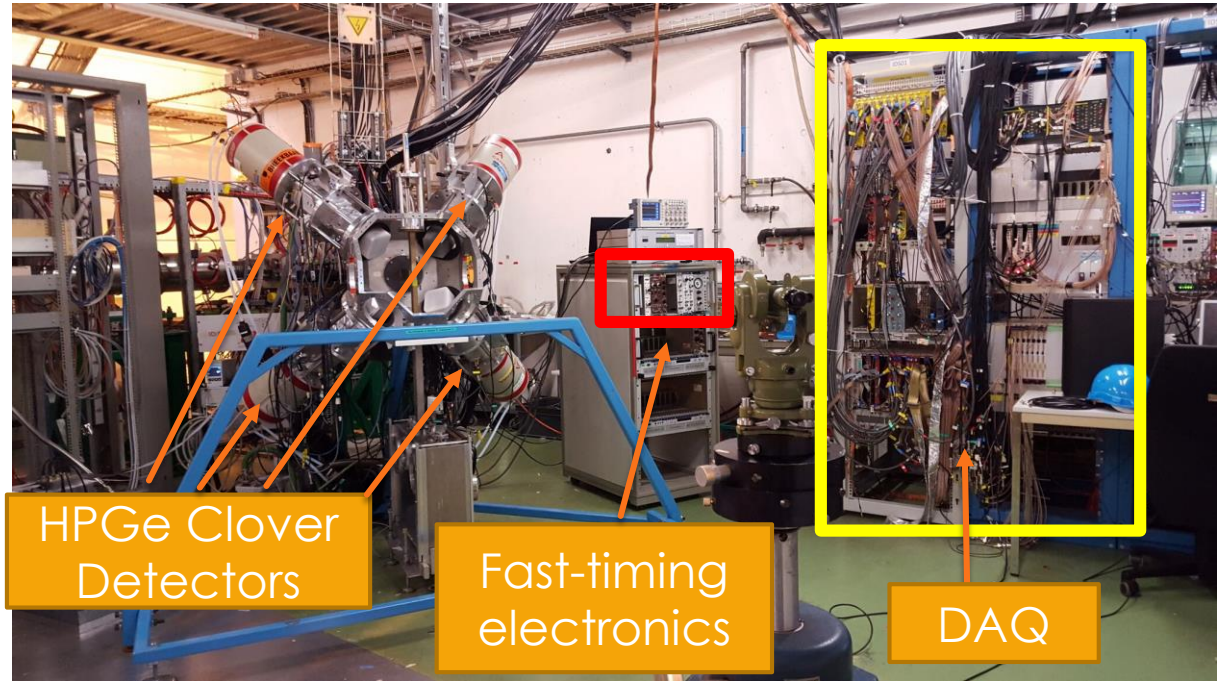
ISOLDE Decay Station

ISOLTRAP

LUCRECIA

Picture from google map

ISOLDE Decay Station(IDS)



IDS = ISOLDE Decay Station

To study about

- decay properties of radioactive nuclei with applications in nuclear engineering and astrophysics

Fast-Timing Method in Nuclear Spectroscopy

Purpose = measuring nuclear half-lives for nuclear scheme studies based on $\gamma-\gamma$ or $\beta-\gamma-\gamma$ coincidence

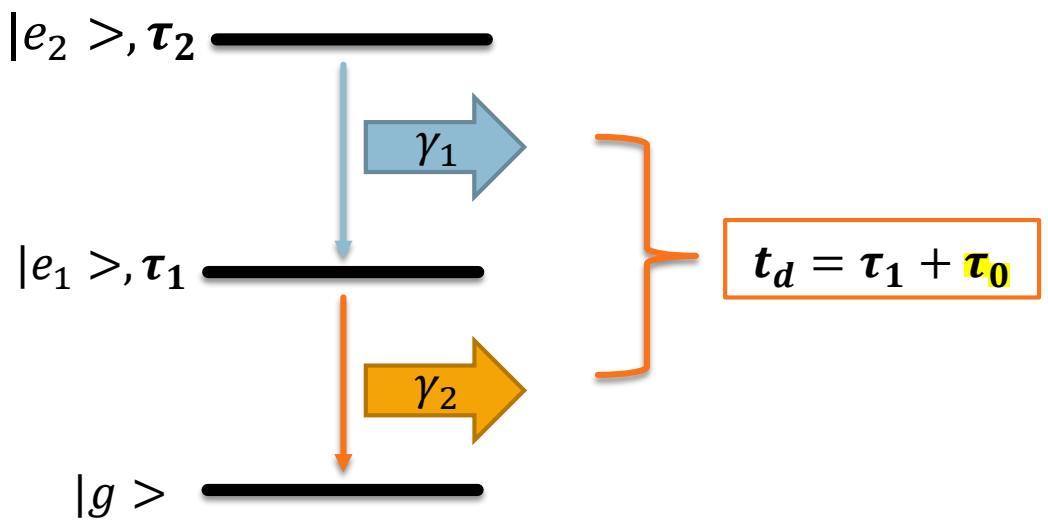
$$\lambda = -\frac{dN/dt}{N}$$

$$\tau = \frac{t_{1/2}}{ln2} = \frac{1}{\lambda}$$

λ is decay constant.

$t_{1/2}$ is half-live.

τ is mean lifetime.

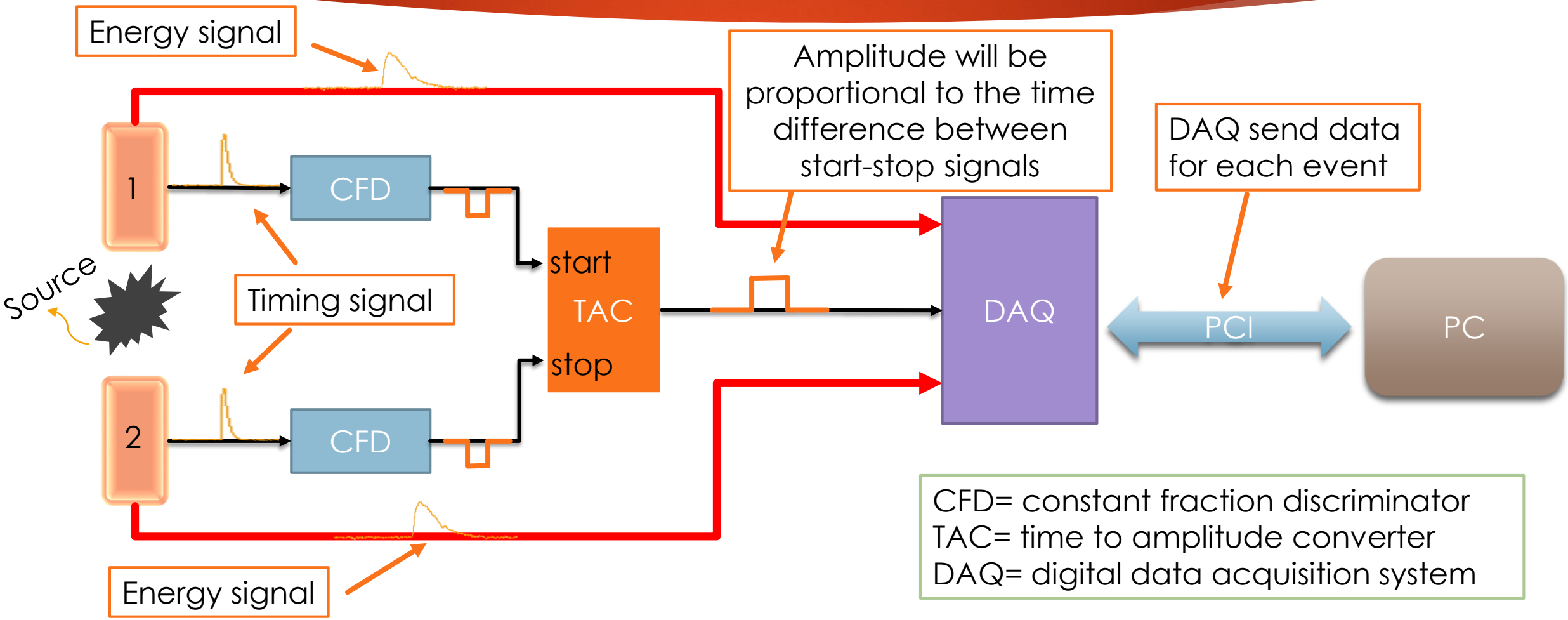


$\boldsymbol{t_d}$ is time delay between γ_1 and γ_2.
$\boldsymbol{\tau_0}$ is a time delay between fast-timing detectors.

To extract mean lifetime of nuclear levels

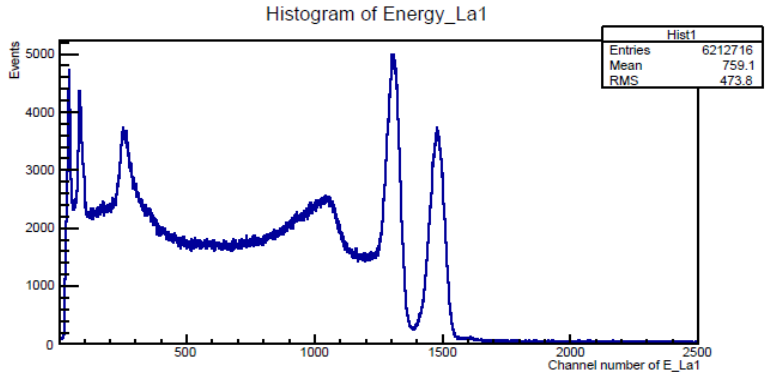
1. Measure $\boldsymbol{\tau_0}$ by using a source, which $\boldsymbol{\tau_1 \sim 0}$ and known energy levels.
2. Measure time delay by using a radioactive source that we will study.
3. Analyze data to get mean lifetime.

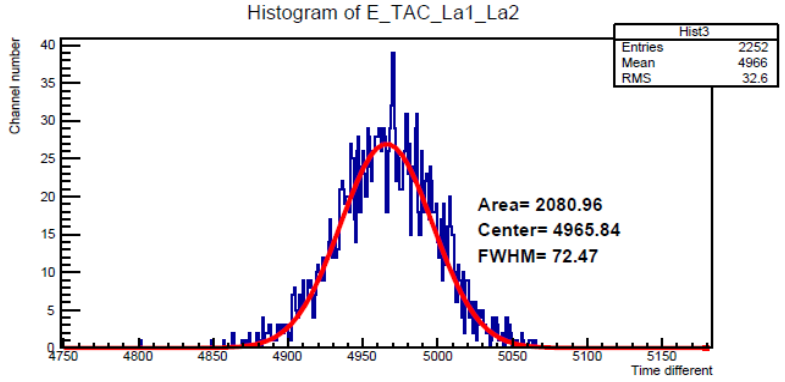
Fast-Timing Electronics

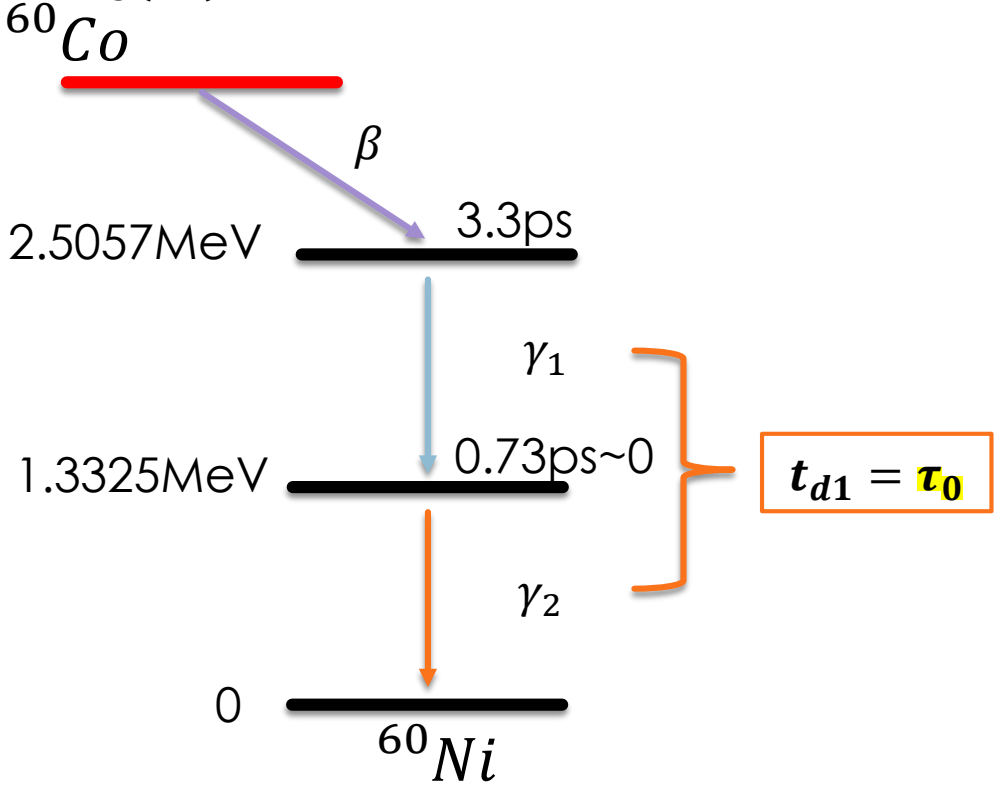


Objectives

1. Characterize and improve the energy resolution of $LaBr_3(Ce)$ detectors
2. Characterize and improve the time response.



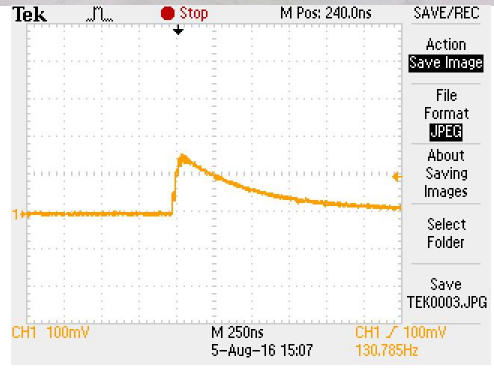




τ_0 is a time delay between fast-timing detectors

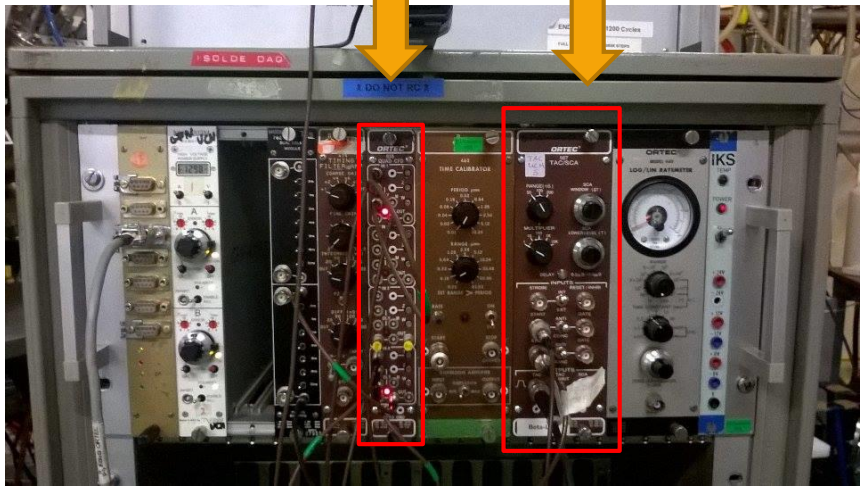
Actual work

$LaBr_3(Ce)$ crystals with fast-timing photomultiplier tubes



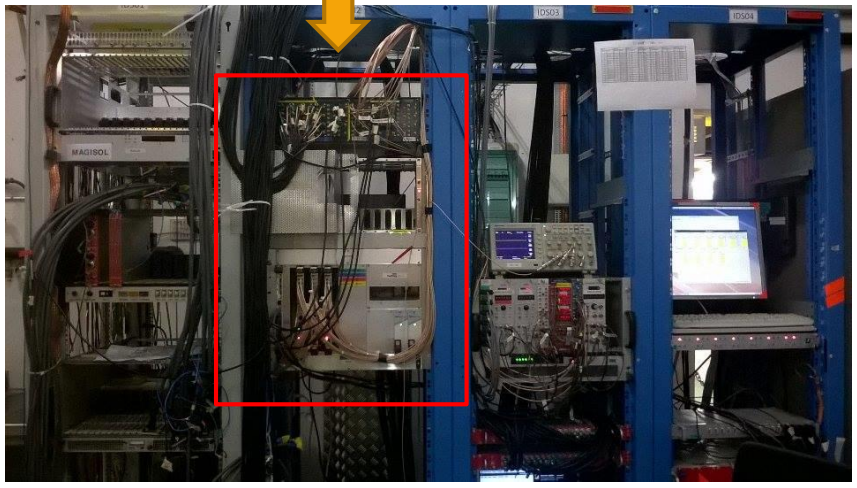
CFD

TAC



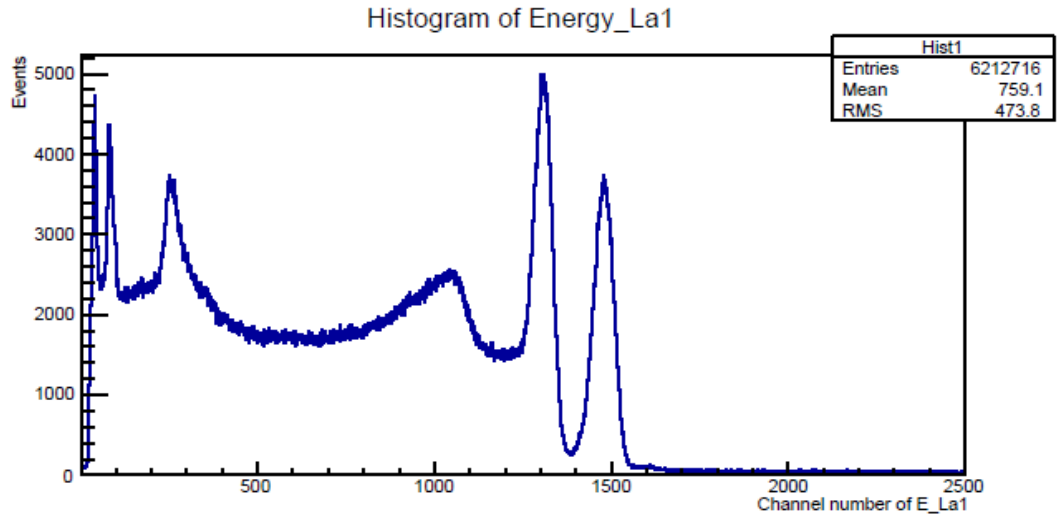
For timing signal will go to CFD and than go to TAC. Output from TAC will go to DAQ

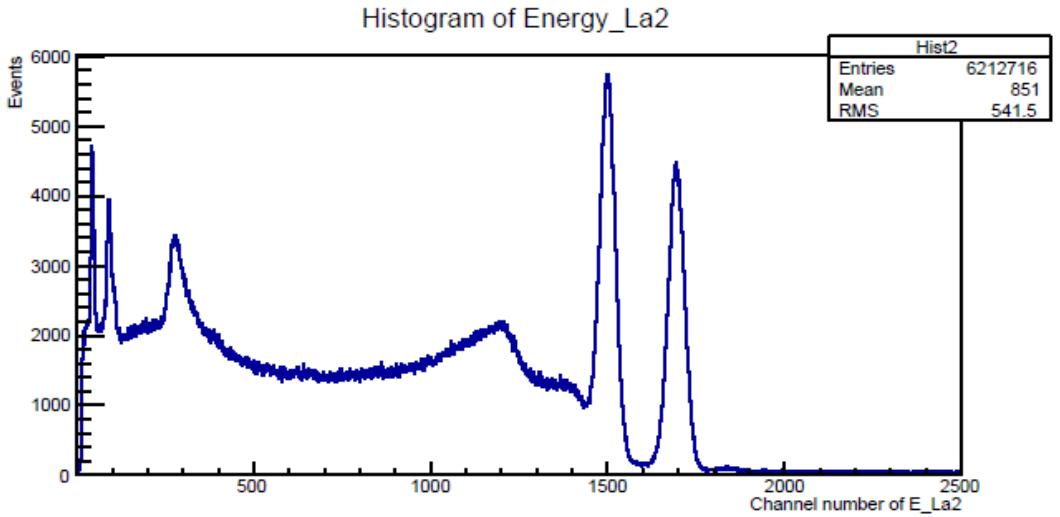
DAQ

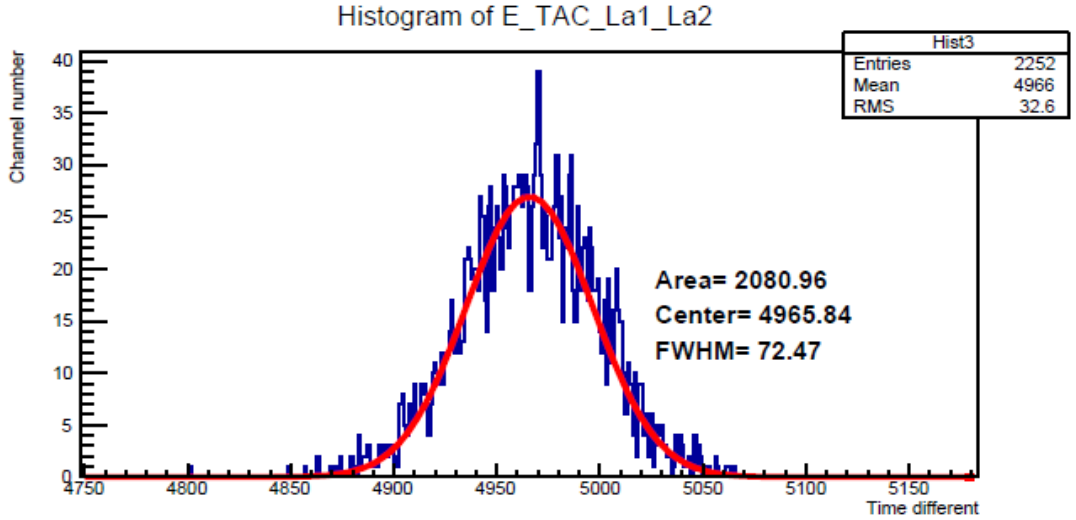


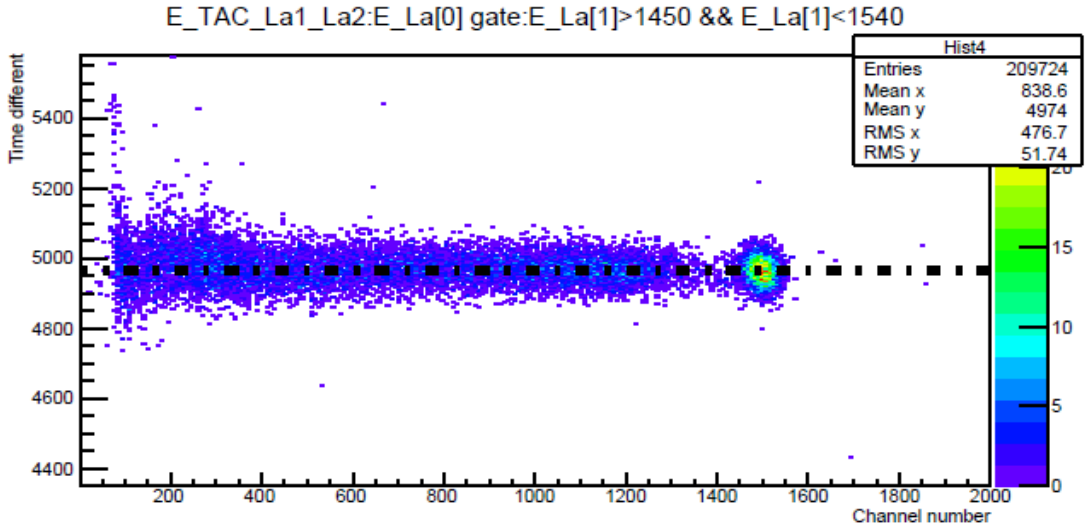
Energy signal and signal from TAC will be collect by DAQ

Actual work


Histogram of Energy_La1
Hist1
Entries 6212716
Mean 759.1
RMS 473.8
Events
Channel number of E_La1

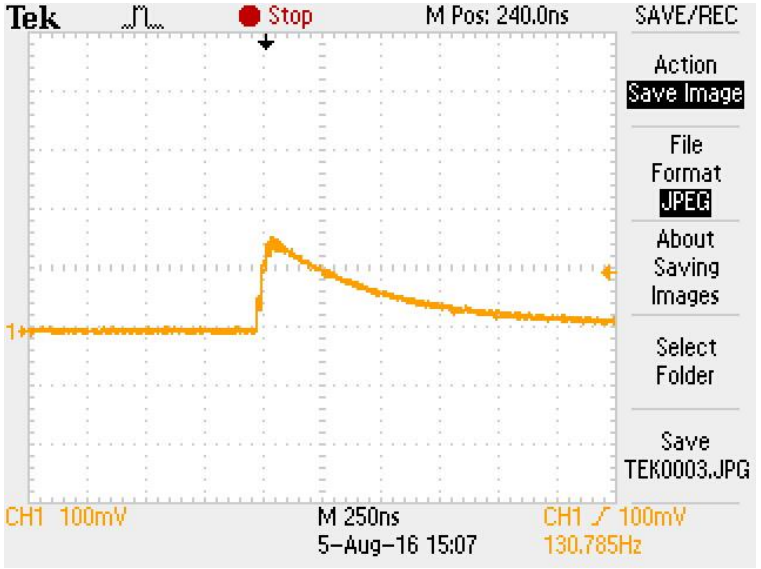

Histogram of Energy_La2
Hist2
Entries 6212716
Mean 851
RMS 541.5
Events
Channel number of E_La2


Histogram of E_TAC_La1_La2
Hist3
Entries 2252
Mean 4966
RMS 32.6
Area= 2080.96
Center= 4965.84
FWHM= 72.47
Channel number
Time different

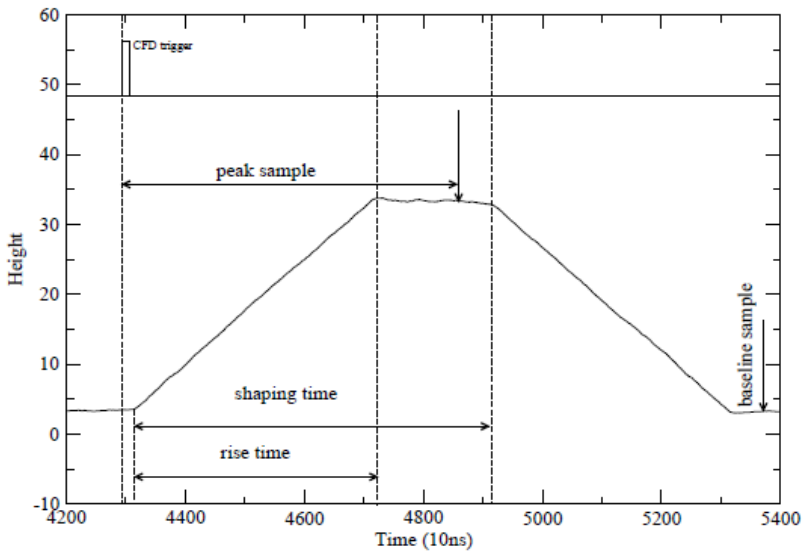

E_TAC_La1_La2:E_La[0] gate:E_La[1]>1450 && E_La[1]<1540
Hist4
Entries 209724
Mean x 838.6
Mean y 4974
RMS x 476.7
RMS y 51.74
Time different
Channel number

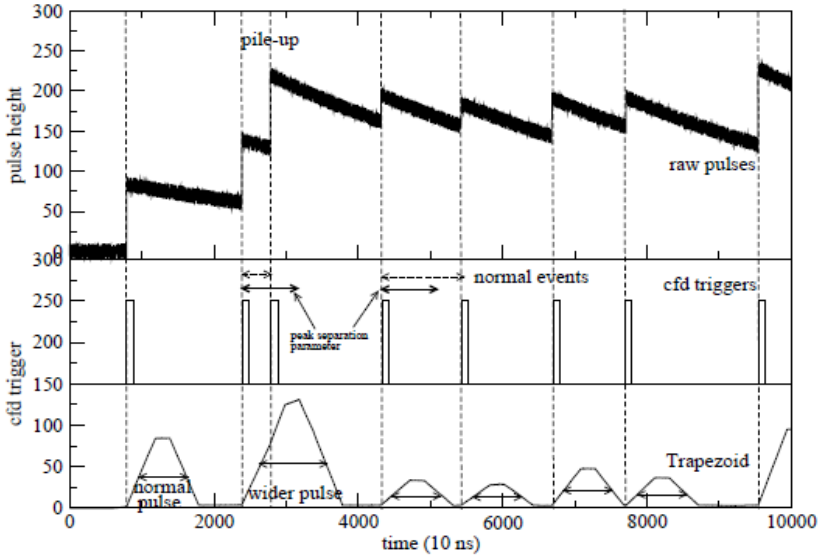
DAQ

Raw signal



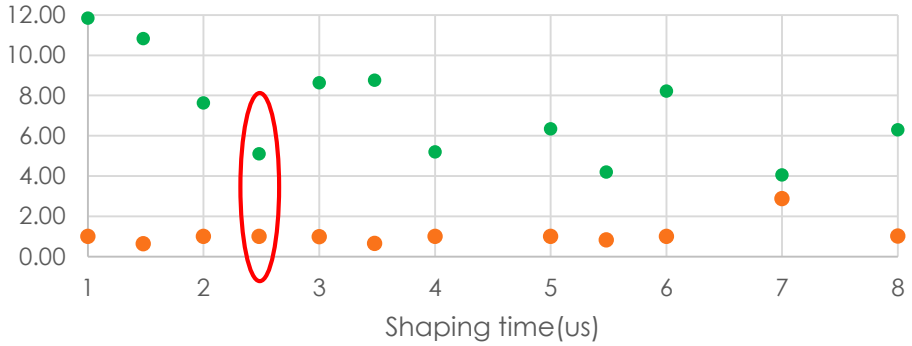
Signal after shaping



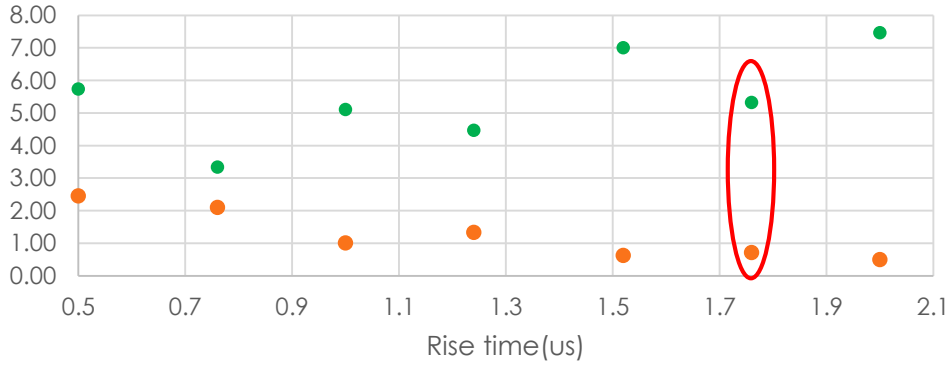


Results & Conclusion

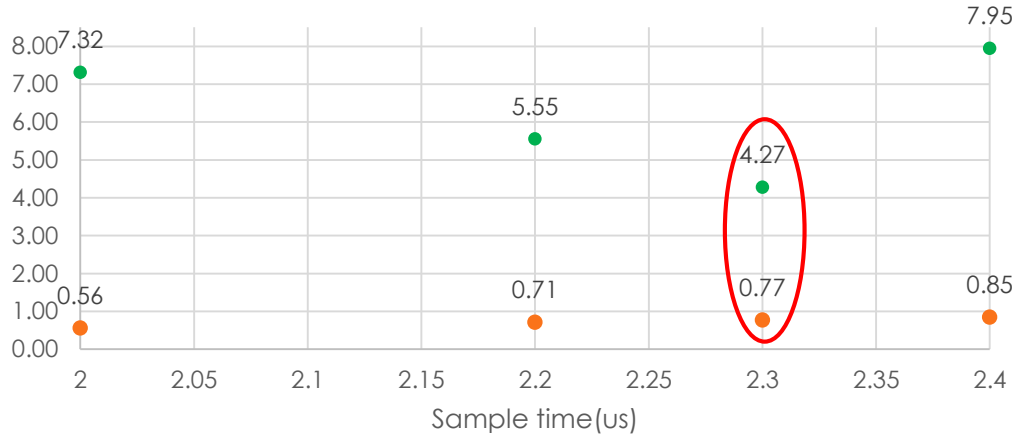
Optimization of E_La1



Shaping time = 2.48 us



Shaping time=2.48us & rise time=1.76us



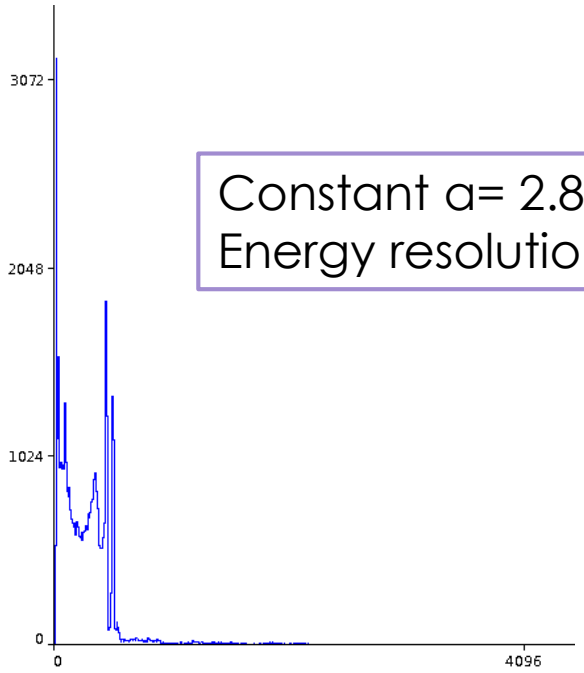
• energy resolution • constant a

Energy(MeV)=a*Energy(channel)+b

$$\text{Energy resolution} = \frac{\Delta E}{E}$$

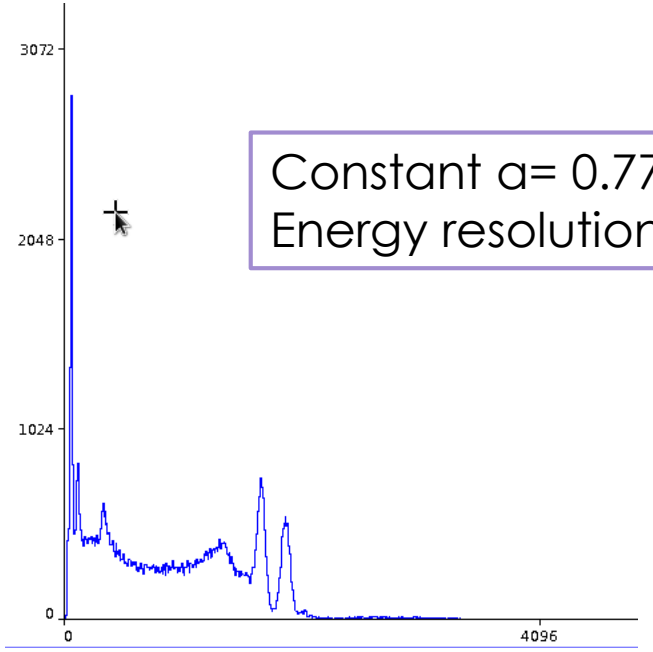
Results & Conclusion

Before optimization



Constant a= 2.84
Energy resolution= 3.63%

After optimization

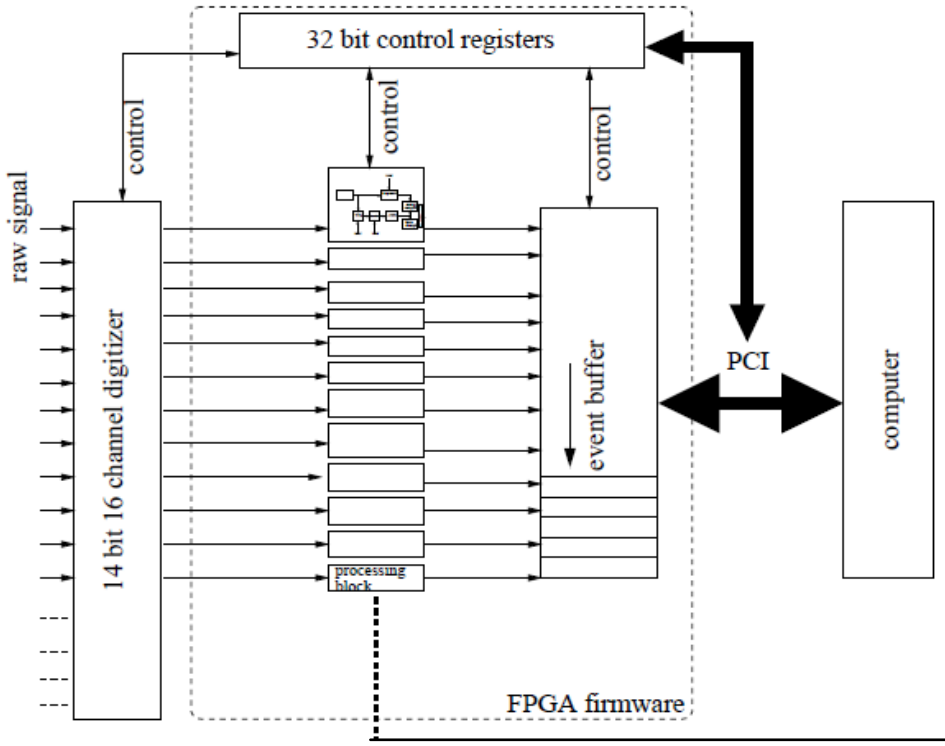


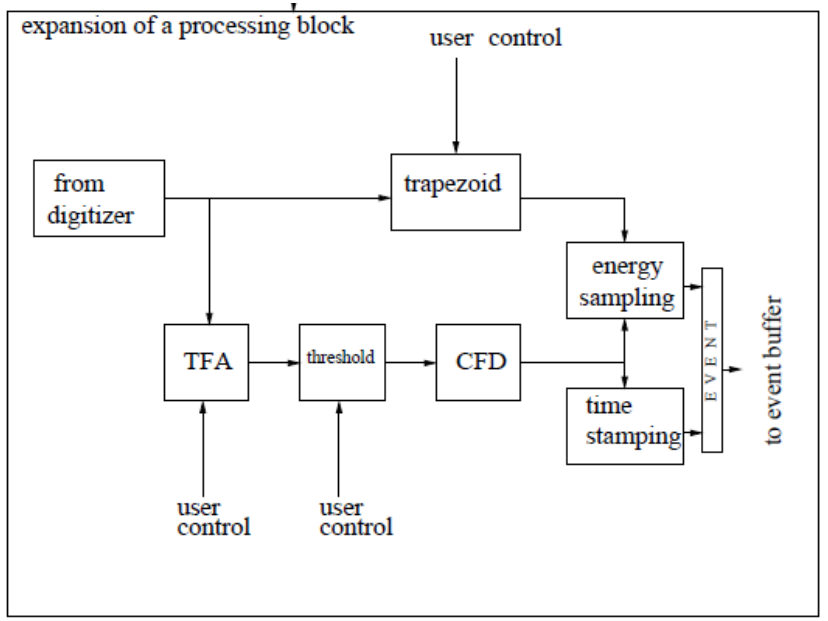
Constant a= 0.77
Energy resolution= 4.27%

References

- H. Mach, R.L. Gill and M. Moszynski, A method for picosecond lifetime measurements for neutron-rich nuclei, Nuclear instruments and methods in Physics research A280(1989)49-72
- http://isolde-ids.web.cern.ch/isolde-ids/
- http://isolde.web.cern.ch/
- Manual for Lyrtech digital data acquisition system
- Nuclear radiation detection, measurements and analysis, K. Muraleedhara Varier
- Razvan Lica, Analysis algorithm for digital data used in nuclear spectroscopy. Bachelor thesis, University of Bucharest, 2012

DAQ


32 bit control registers
control
control
control
raw signal
14 bit 16 channel digitizer
event buffer
processing block
PCI
computer
FPGA firmware


expansion of a processing block
user control
from digitizer
trapezoid
energy sampling
TFA
threshold
CFD
time stamping
EVENT
to event buffer
user control
user control