Fast-timing with a $LaBr_3$-Gammasphere hybrid system

NU-BALL workshop, Orsay, 2016

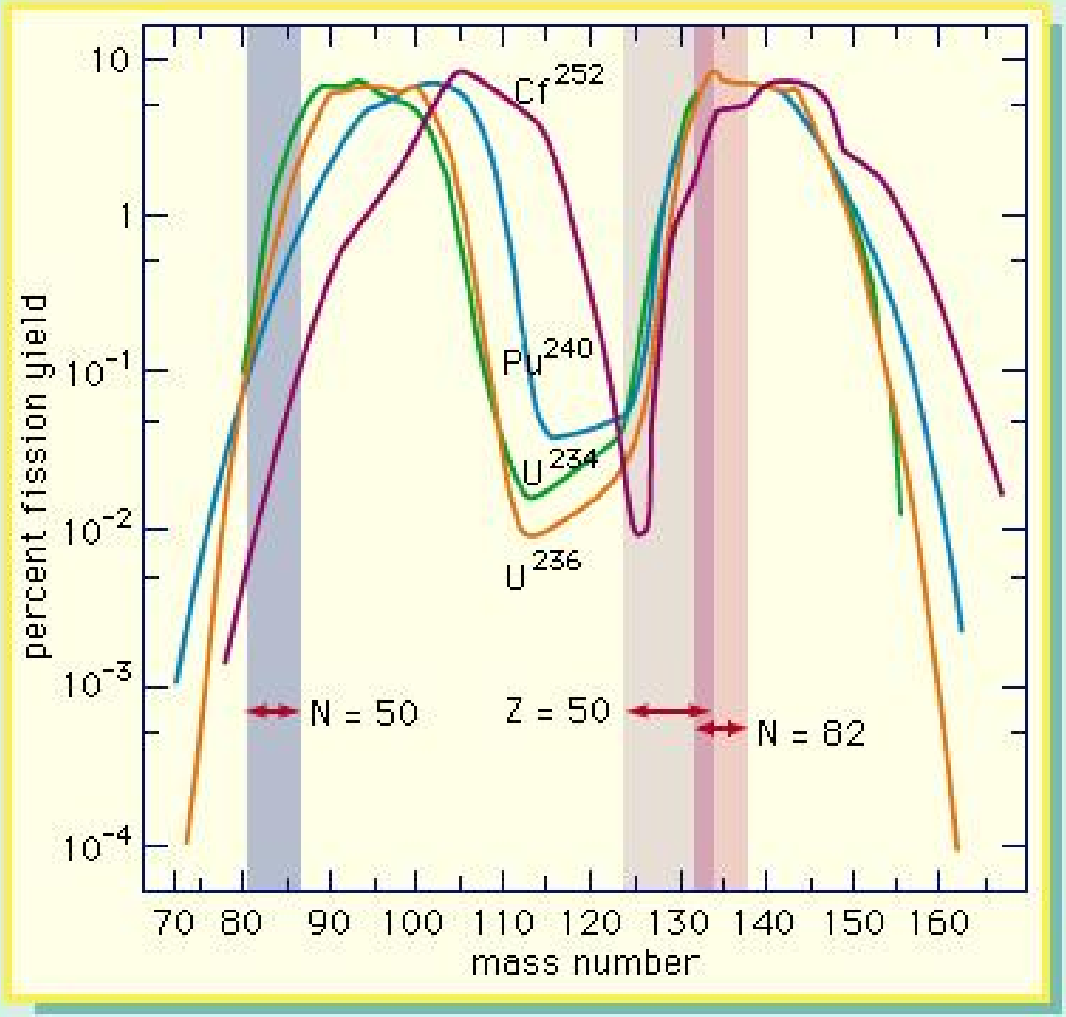
Matthias Rudigier

19. Mai 2016

Fast-timing with a $LaBr_3$-Gammasphere hybrid system

1. **Fast timing with ^{252}Cf source**
2. **Data acquisition system**
   - Stand-alone system
   - Integration with Digital Gammasphere
3. **First results with this setup**
4. **Outlook: VME V1751 digital CFD firmware**

^{252}Cf fission source



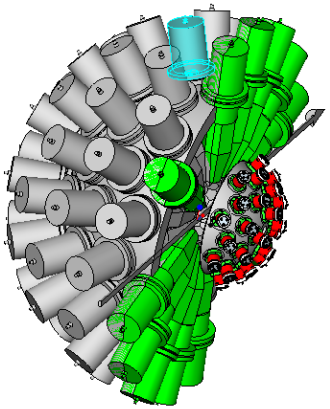
The light mass group shifts to higher masses as the mass of the fissioning nucleus increases, while the heavy group remains nearly stationary. The shaded areas show the location of the closed shells of 50 protons, 50 neutrons, and 82 neutrons (see text).

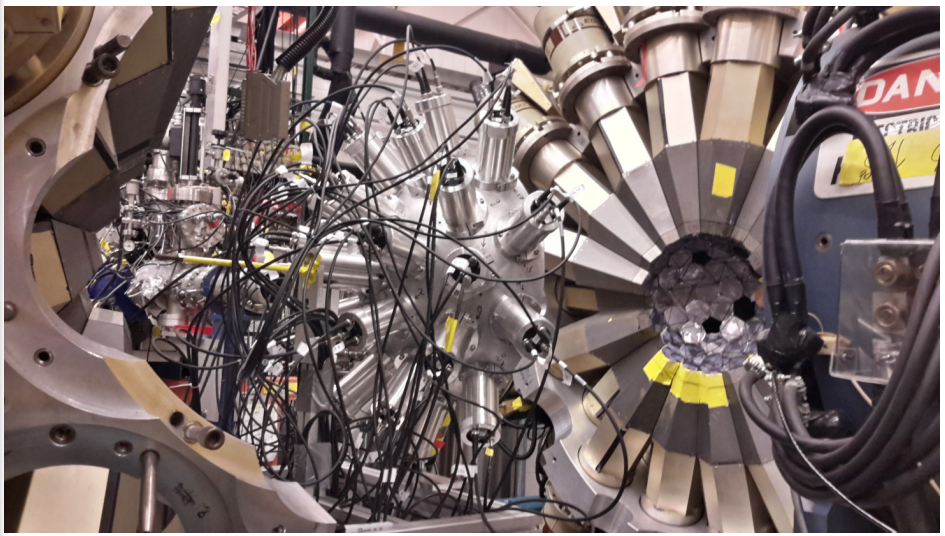
www.britannica.com

Fast timing at Argonne

FATIMA + digital Gammasphere

- 50 GS detectors
- 25 FATIMA detectors
- Measured ^{252}Cf fission source over christmas 2015
- First test of new DAQ under "real" conditions
- First integration of new DAQ into another system

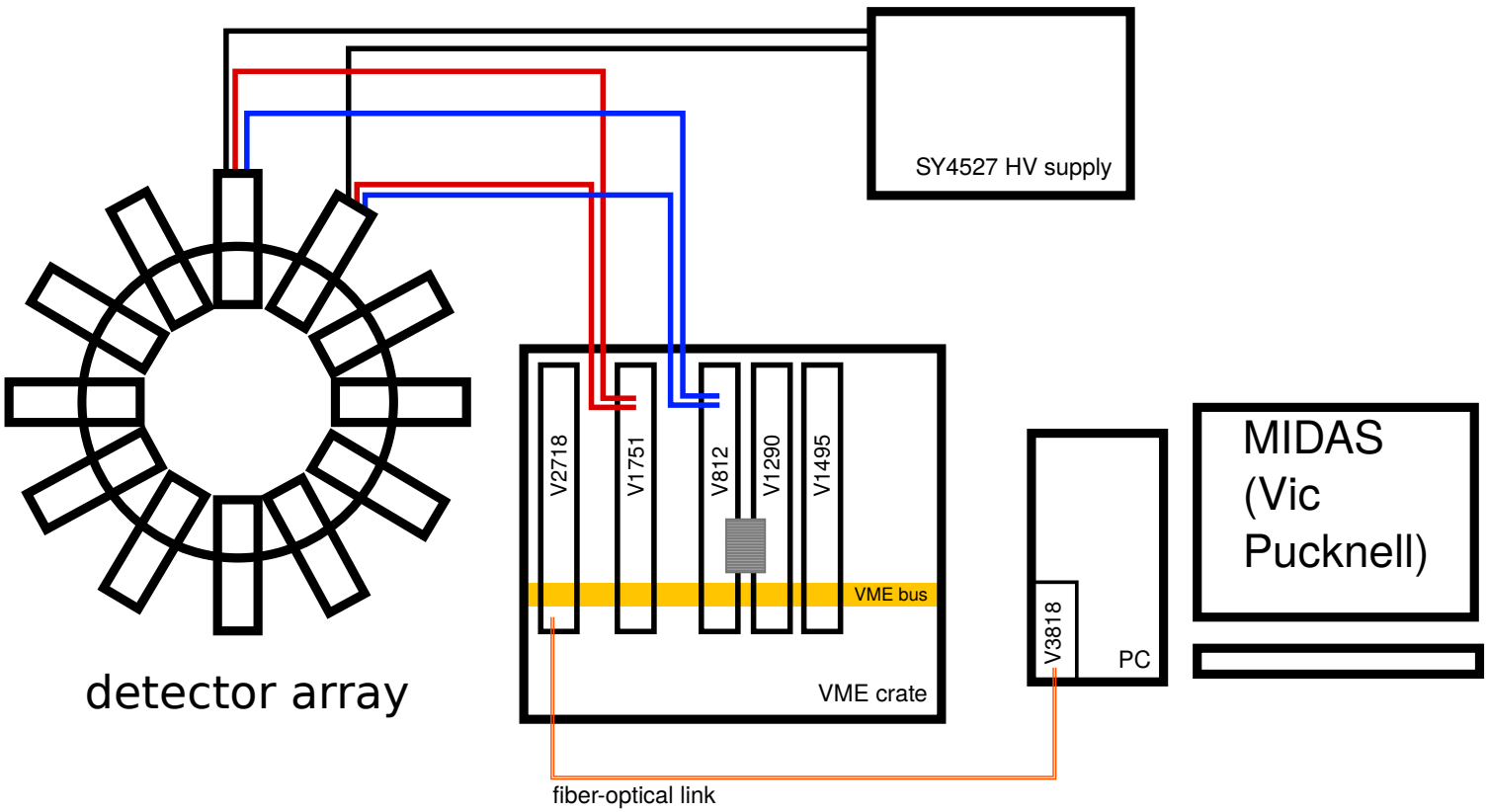




VME based data acquisition - stand-alone

#	Module	
5	V1751	Digitizer (QDC)
		DPP-PSD firmware
3	V812	CFD
2	V1290A	TDC
1	V1495	Logic module
1	V2718	Controller

VME based data acquisition - stand-alone



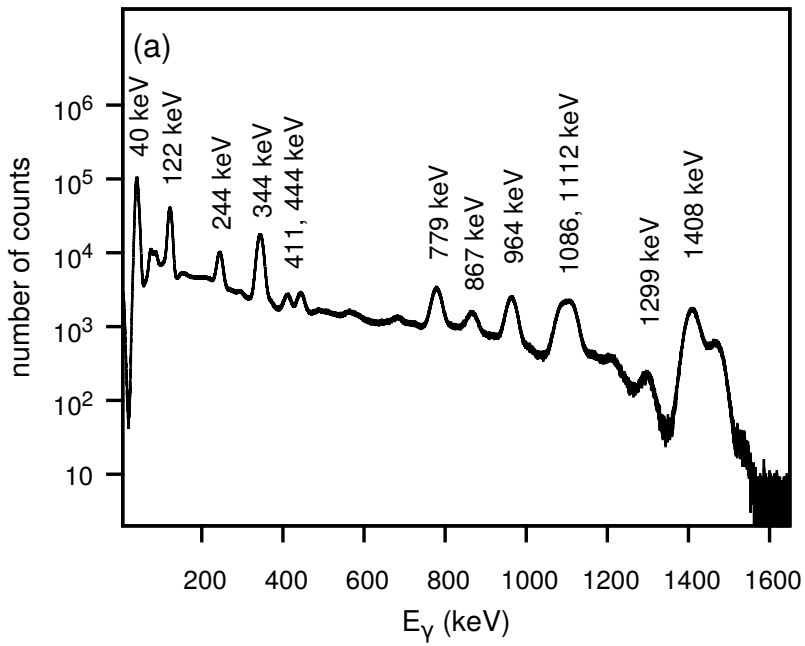
V1751 digitizer

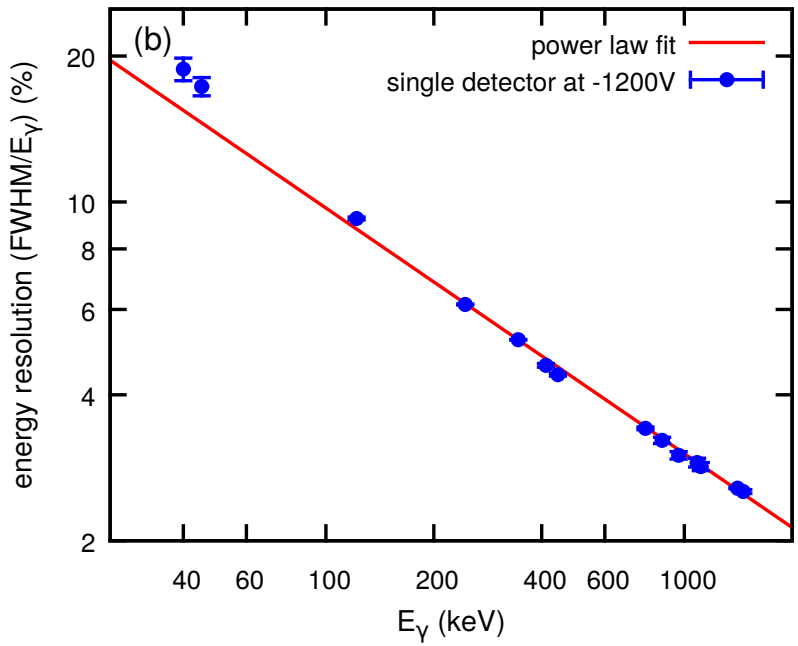
Features

- 8 channels
- 1GS/s, 10 bit resolution
- PLL clock distribution
- CAEN DPP-PSD firmware
- QDC good for scintillator signal
- Long and short integration window

Energy resolution

^{152}Eu source



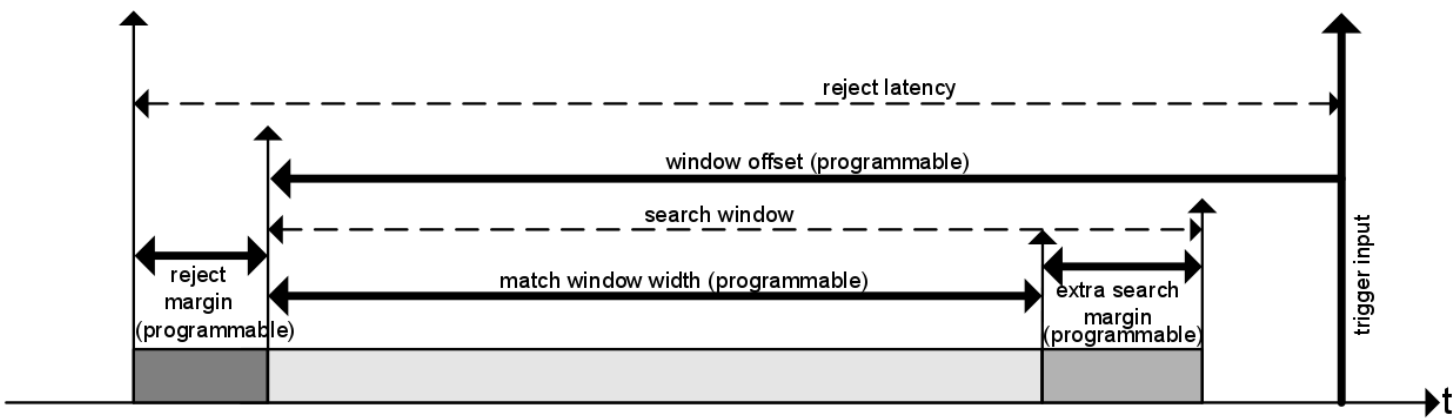


V1290 TDC

Features

- 32 channels
- ECL input
- muti-hit TDC
- coarse clock (25ns tics, for trigger)
- fine clock (25ps tics, stored as 21 bits)

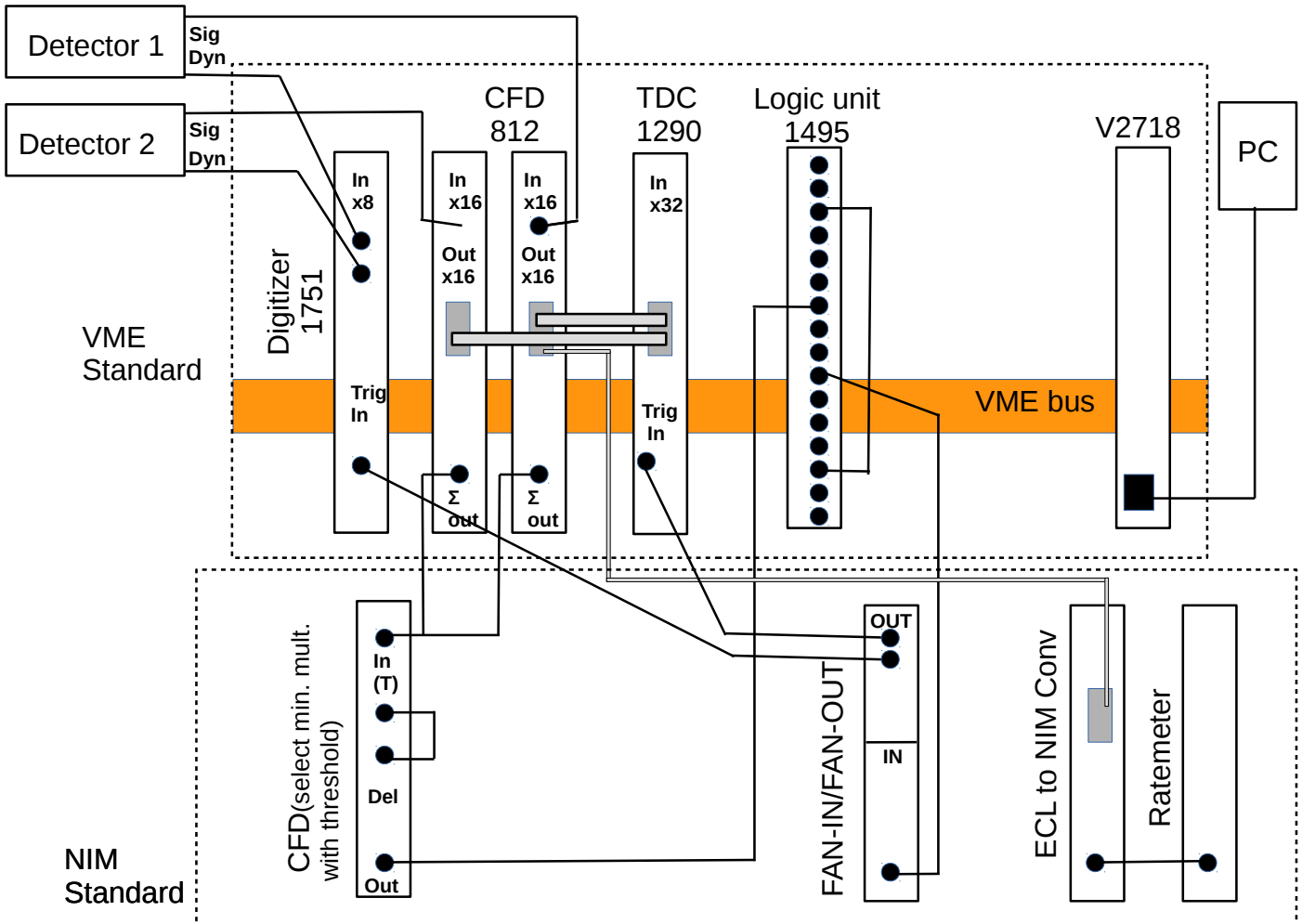
Difference to classic TAC:
We measure a 25ps LSB timestamp, not immediately a time difference between detector signals!



V1290 manual, www.caen.it

Correlating energy and time measurements

Event based data acquisition system

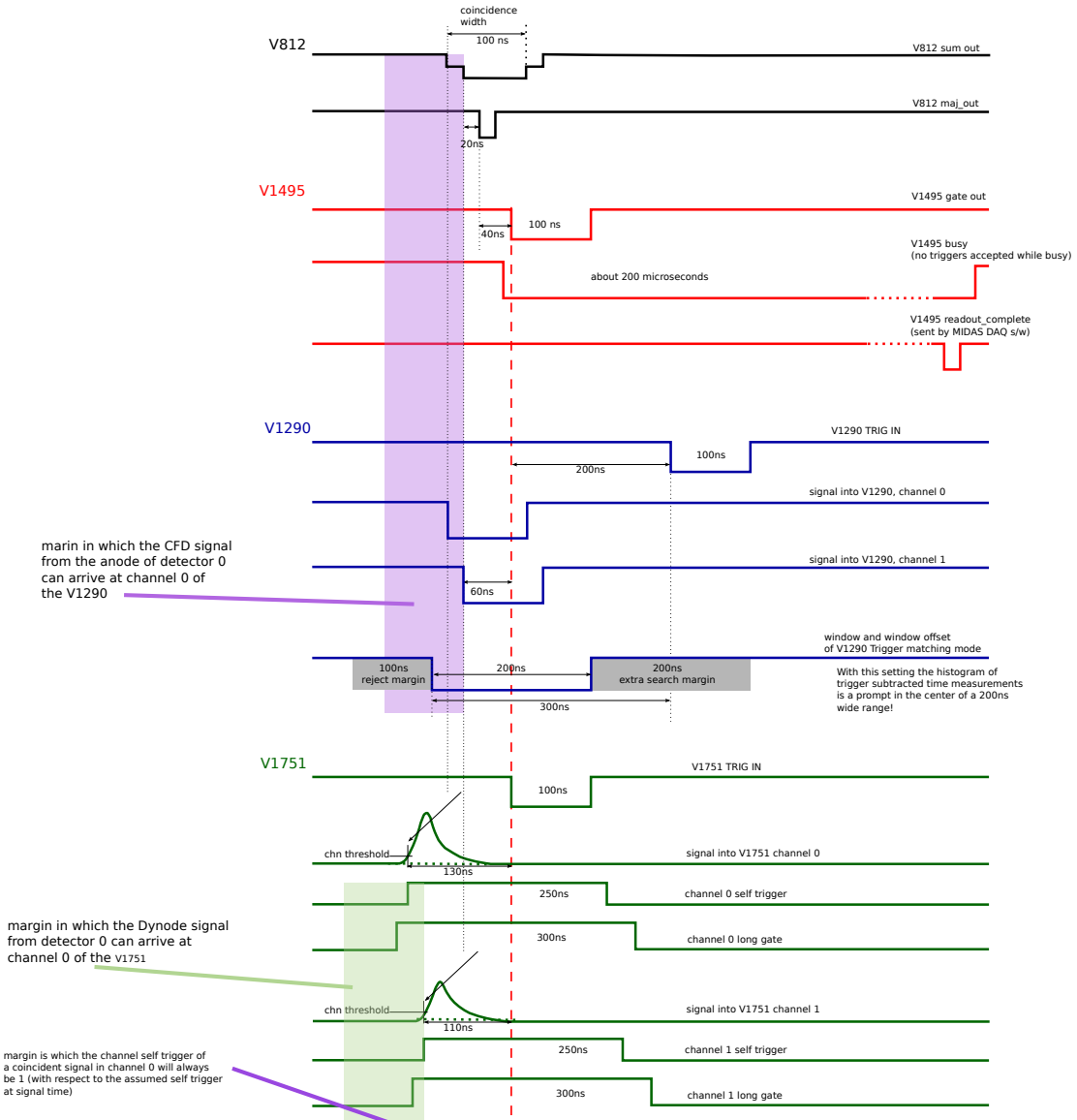


V1495 firmware by Ian Lazarus

Correlating energy and time measurements

Event based data acquisition system

In this diagram the signal from detector 1 arrives after that of channel 0. Therefore when a signal arrives at channel 1 of the CFD, the maj_out of the V812 (which is set to 2) fires. This signal is used as trigger for the V1495. The V1495 produces a gate which is 40ns delayed with respect to the original trigger. As the coincidence width is set to 100ns the signal of detector 0 can not occur more than 100ns before that of channel 1. This time range is indicated by the coloured stripes in order to see if signals from detector 0 will hit the gates.



marin in which the CFD signal from the anode of detector 0 can arrive at channel 0 of the V1290

margin in which the Dynode signal from detector 0 can arrive at channel 0 of the V1751

margin is which the channel self trigger of a coincident signal in channel 0 will always be 1 (with respect to the assumed self trigger at signal time)

Correlating energy and time measurements

Read-out of modules via VME bus is controlled by MIDAS and written to shared memory/disk

Raw data structure:

...

V1495 Event number, additional info

V1751 Channel, QDC, time stamp

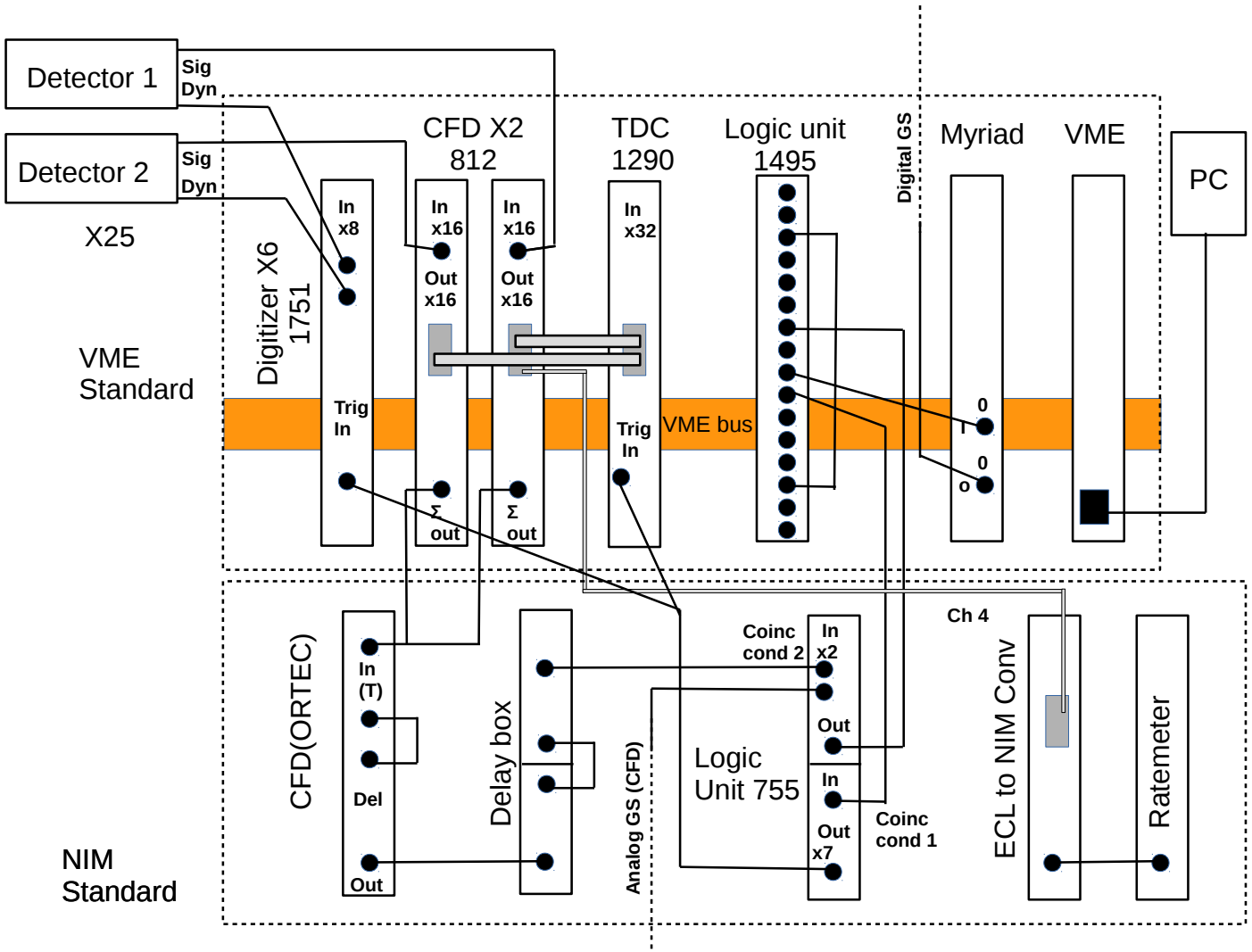
V1290 Channel, TDC measurement

V1495 Event number, additional info

...

Integration with Digital Gammasphere

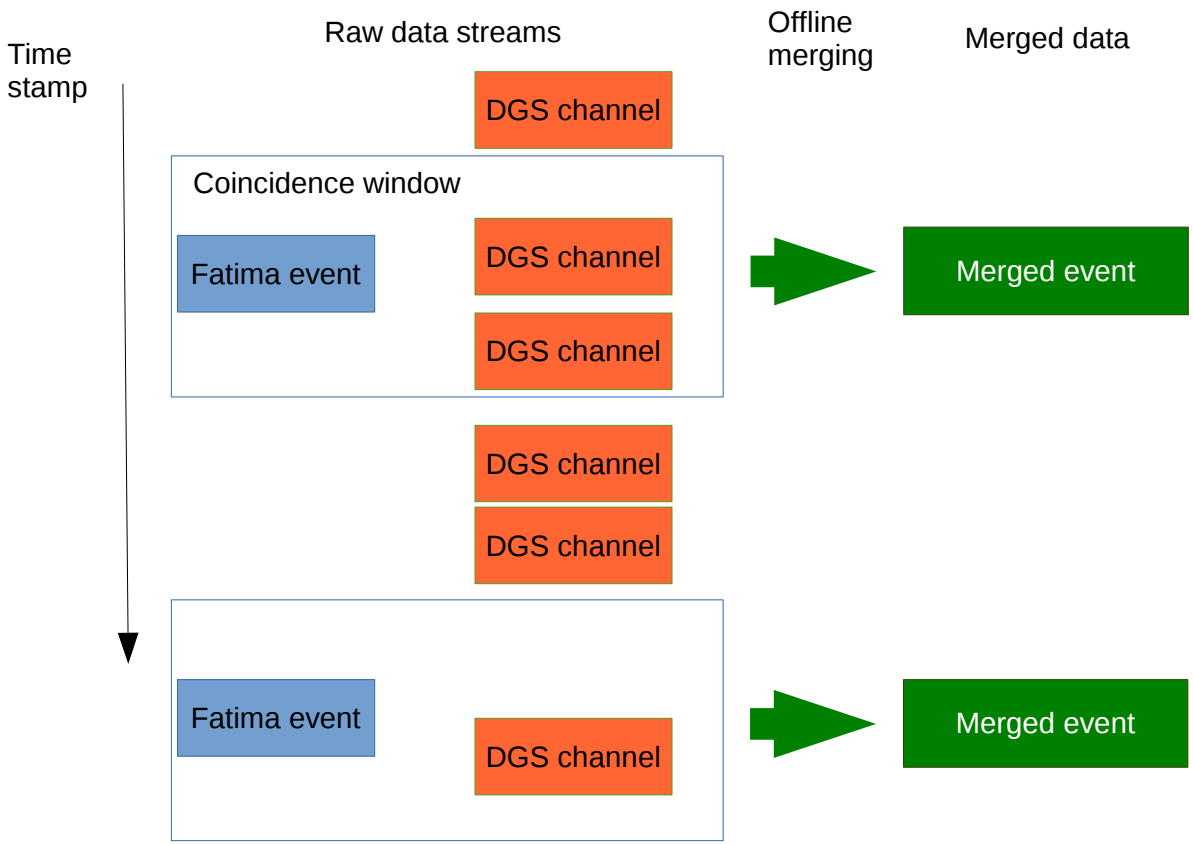
Get event DGS timestamp from MyRIAD module.



DGS accepted two trigger - FATIMA and DGS majority >1.

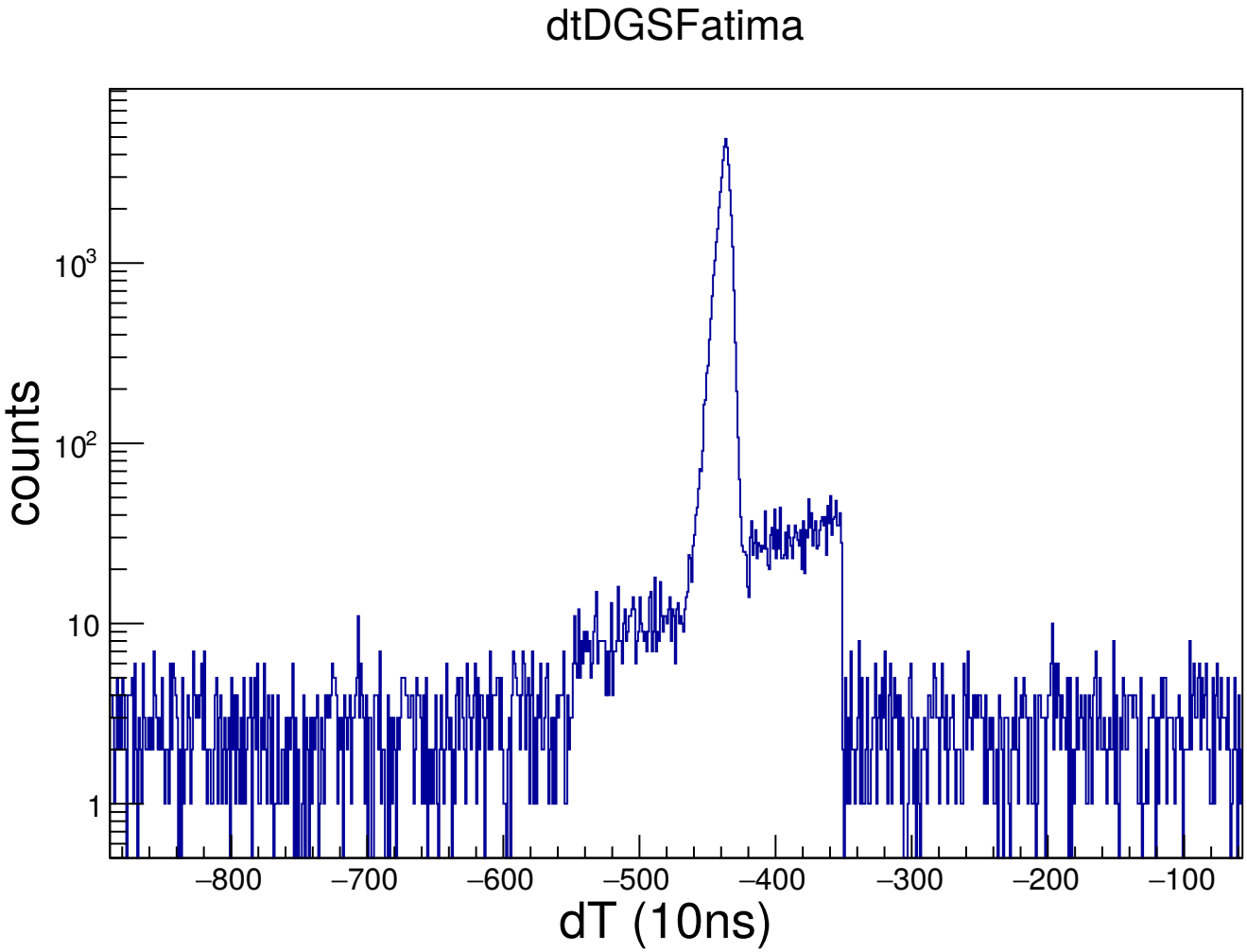
Integration with Digital Gammasphere

Merge FATIMA and DGS data offline

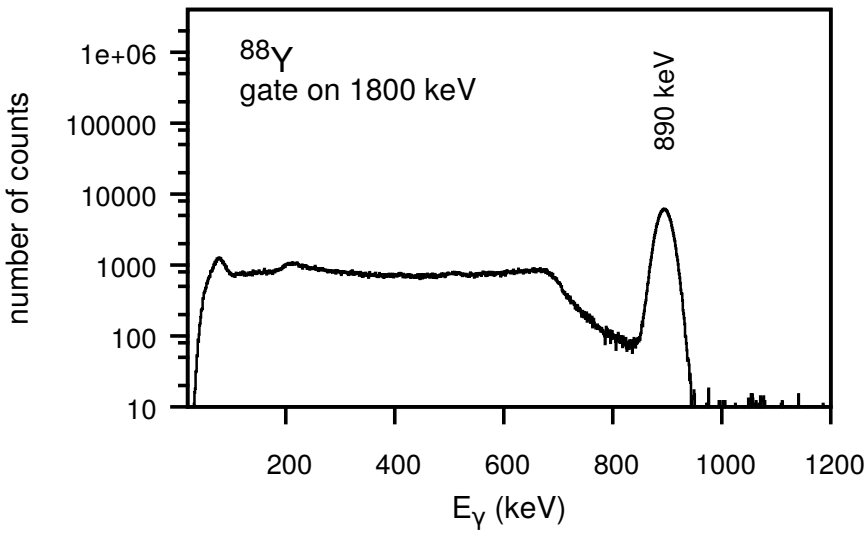


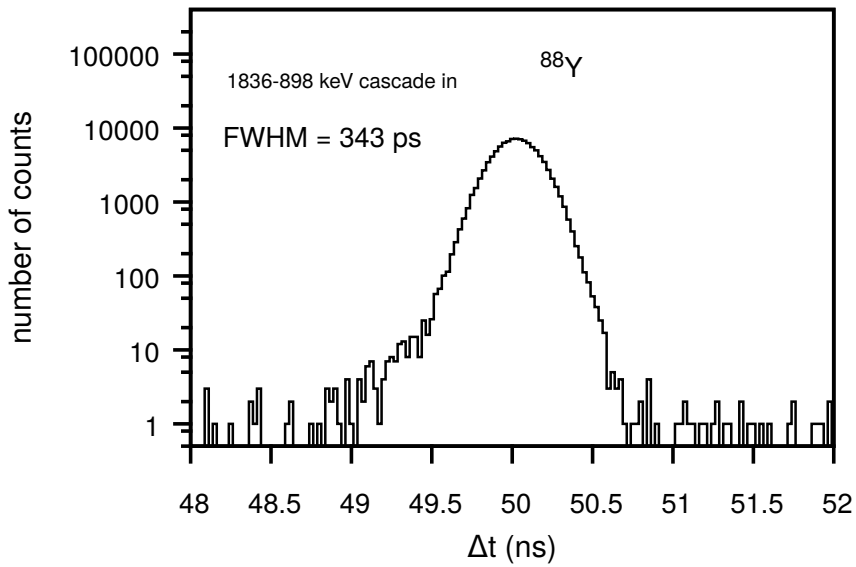
Integration with Digital Gammasphere

Coincidence peak

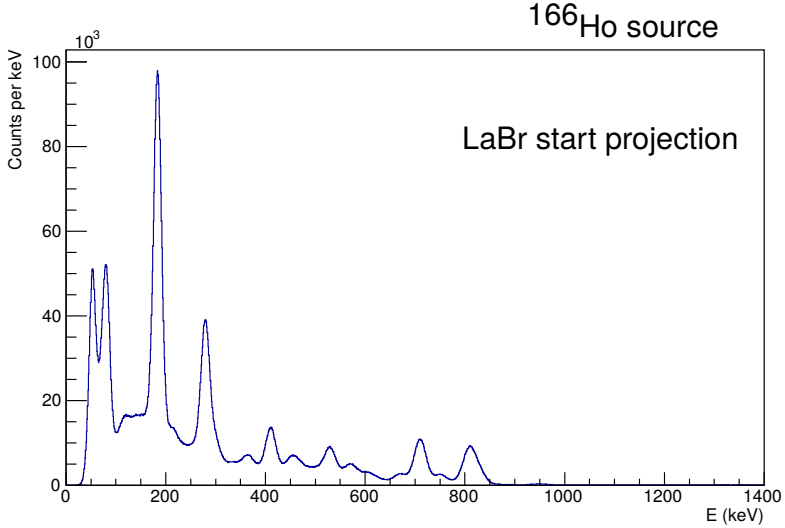


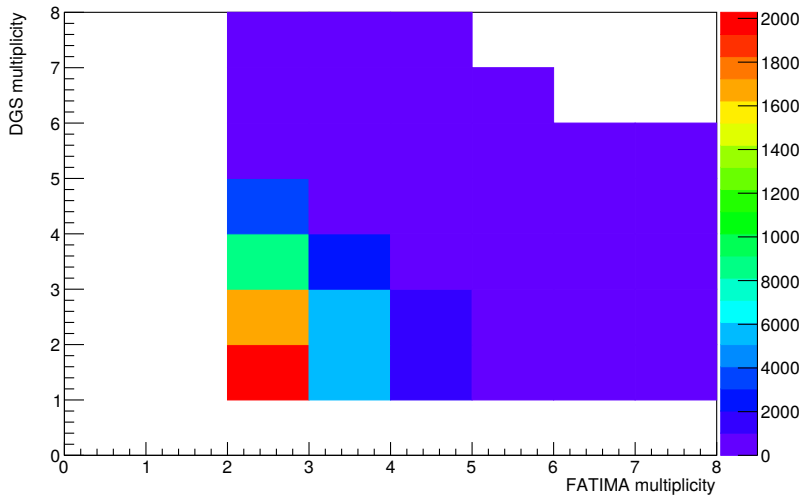
^{88}Y source

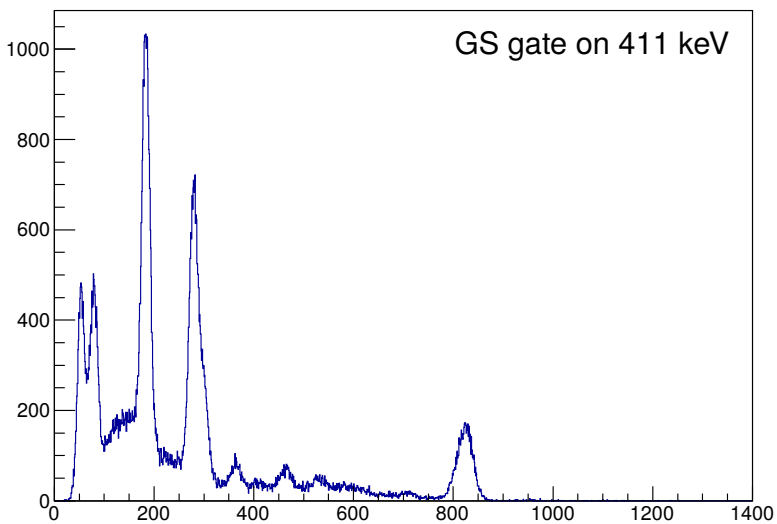

88Y
gate on 1800 keV
890 keV
number of counts
1e+06
100000
10000
1000
100
10
200
400
600
800
1000
1200
Eγ (keV)

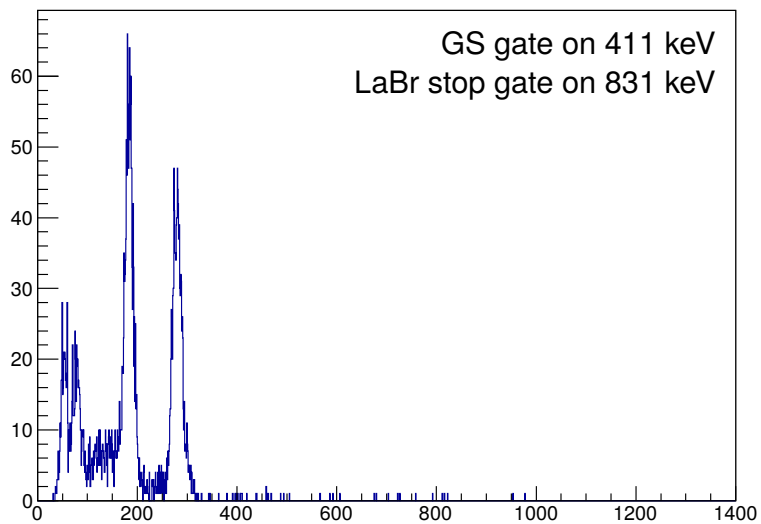

1836-898 keV cascade in
88Y
FWHM = 343 ps
number of counts
100000
10000
1000
100
10
1
48
48.5
49
49.5
50
50.5
51
51.5
52
Δt (ns)

^{166}Ho source

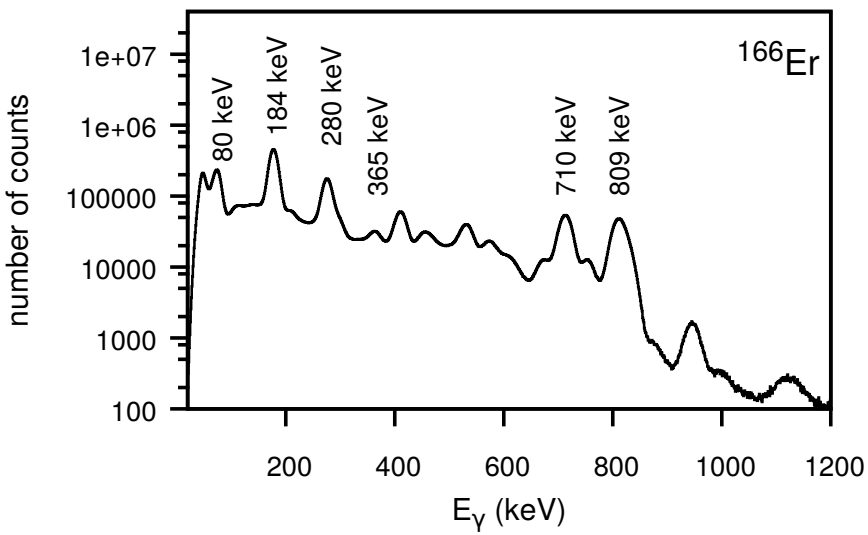


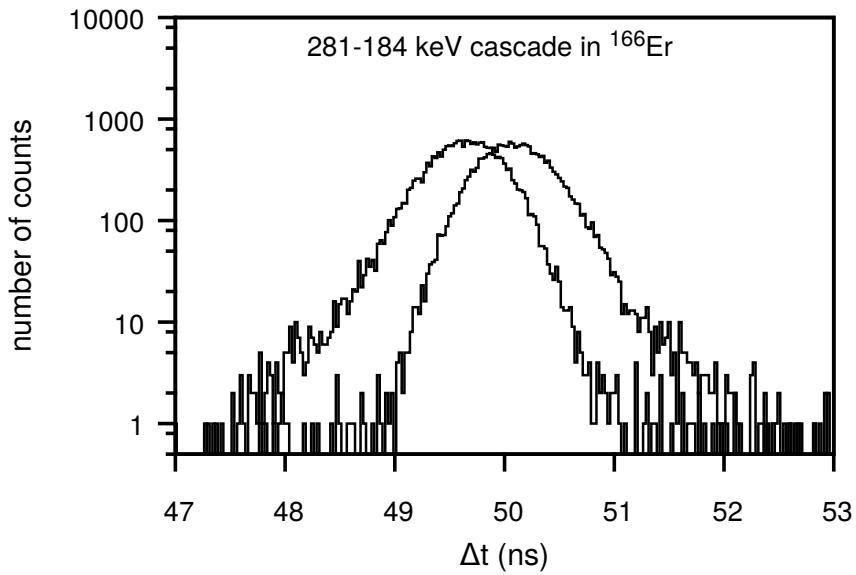




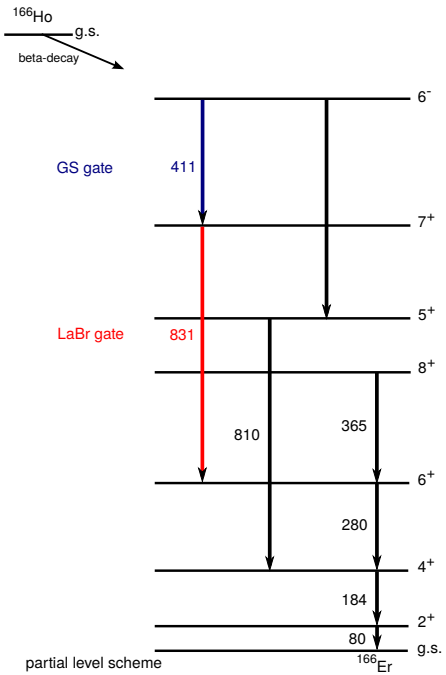


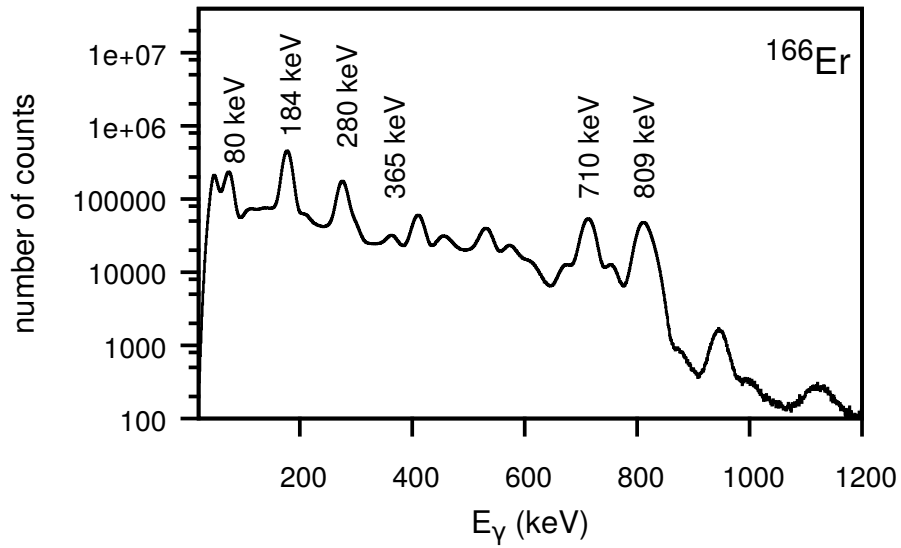
^{166}Ho source

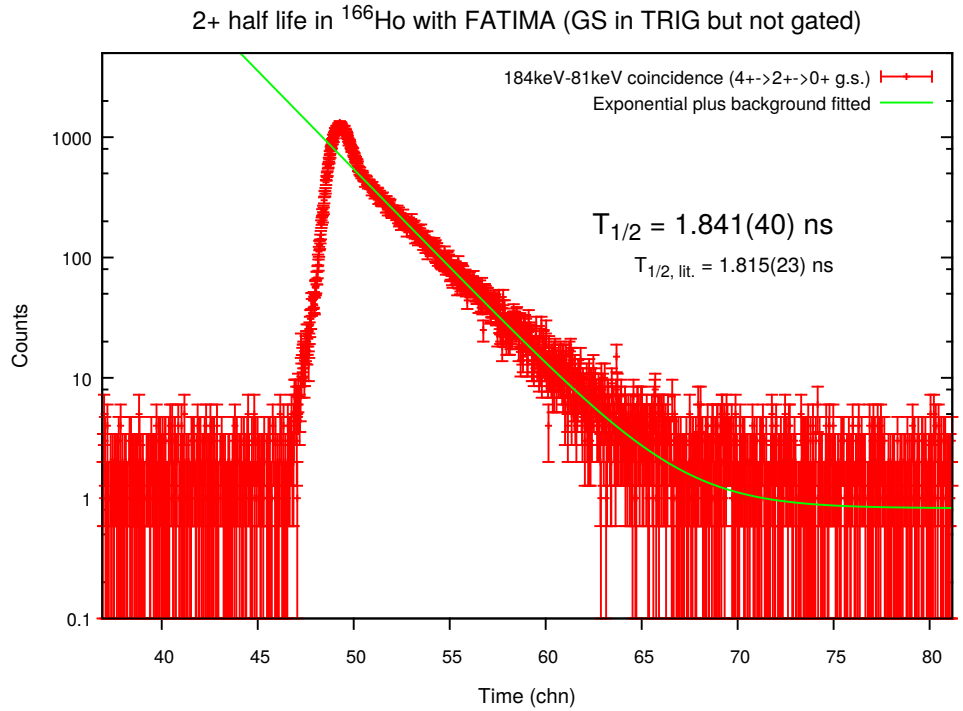




Test case ^{166}Er



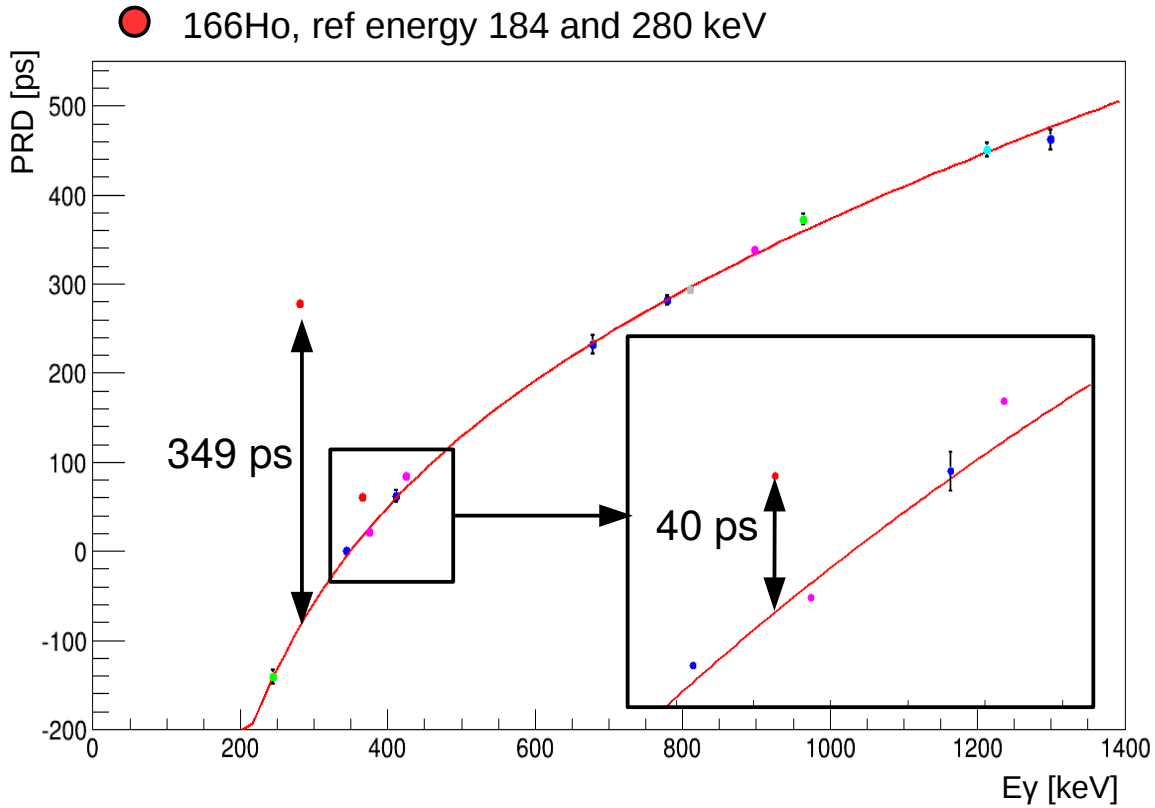




Test case ^{166}Er

Analysis using Generalized Centroid Difference method.

PRD calibration done with ^{152}Eu source. Checked using ^{88}Y and ^{166}Ho source



For energy level at 265 keV

$t_{1/2}$ = 121 ± 5 ps

$t_{1/2\ Lit}$ = 118 ± 4 ps

For energy level at 545 keV

$t_{1/2}$ = 14 ± 5 ps

$t_{1/2\ Lit}$ = 15.0 ± 0.8 ps

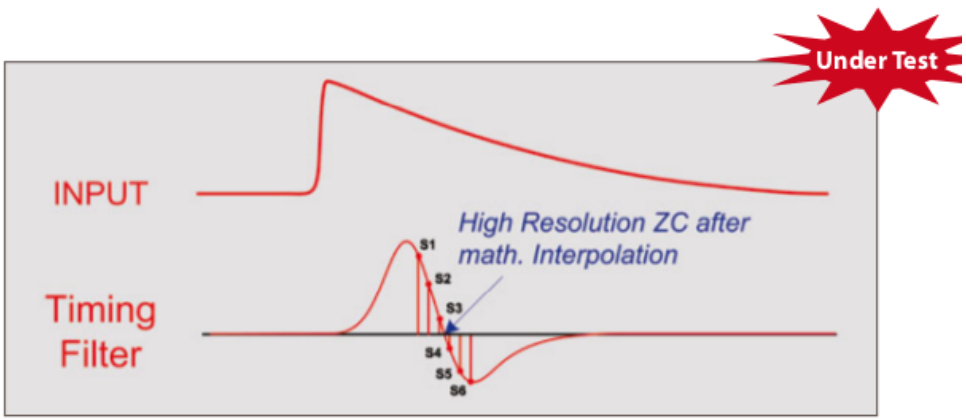
- 152Eu, ref energy 344 keV
- 152Eu, ref energy 444 keV
- 152Eu, ref energy 244 keV
- 88Y + Compton Bg
- 166Ho, ref energy 711 keV

CAEN V1751 digital CFD firmware

DPP for Time Measurements

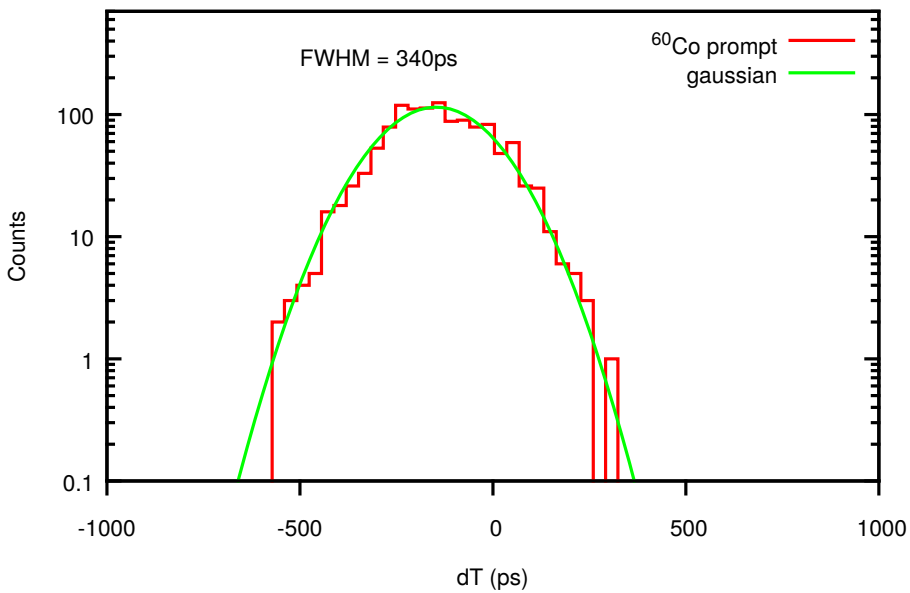
Study of Digital algorithms for Timing Analysis

- Positive/negative pulses digitally transformed into bipolar pulses
- The Zero Crossing doesn't depend on the pulse amplitude
- Timing filters: CR^N or Digital CFD
- Optional RC filter (mean filter) to reduce the HF noise
- ZC interpolations: Linear (2 points) / Cubic (4 points) / Best fit line or curve (4 or more points)

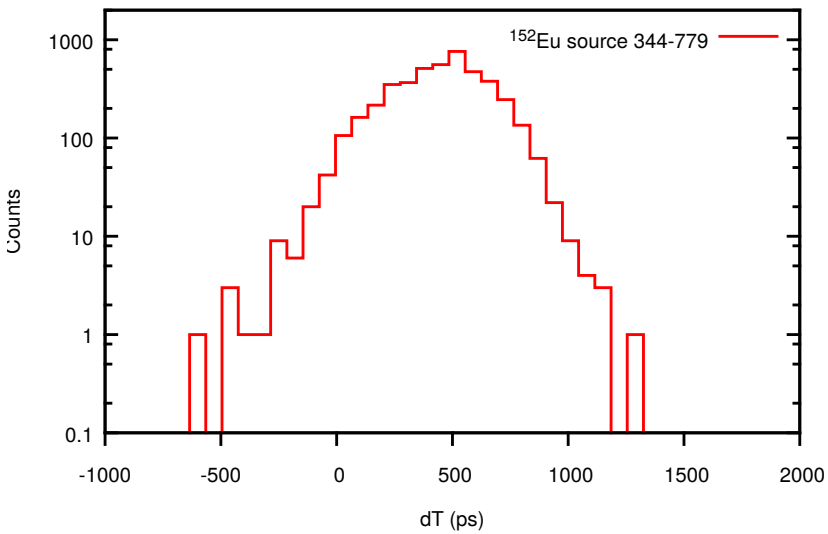


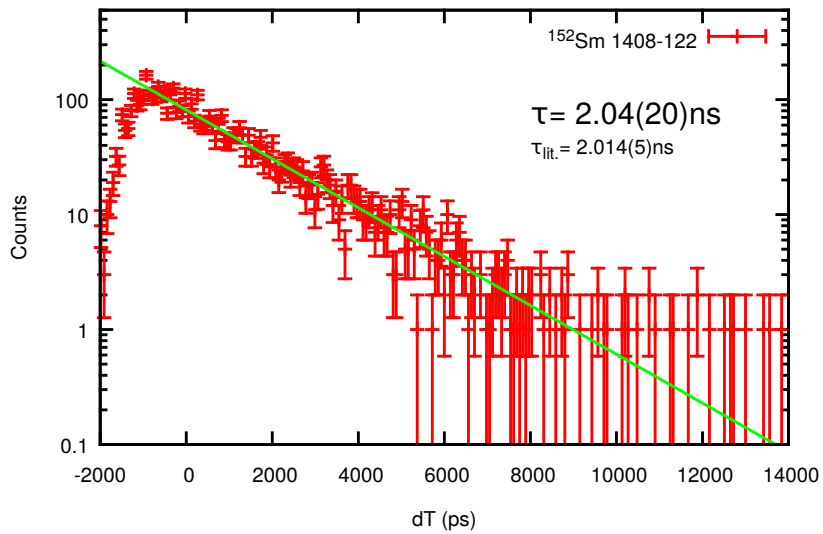
CAEN DPP overview, www.caen.it

First ^{60}Co prompt time distribution

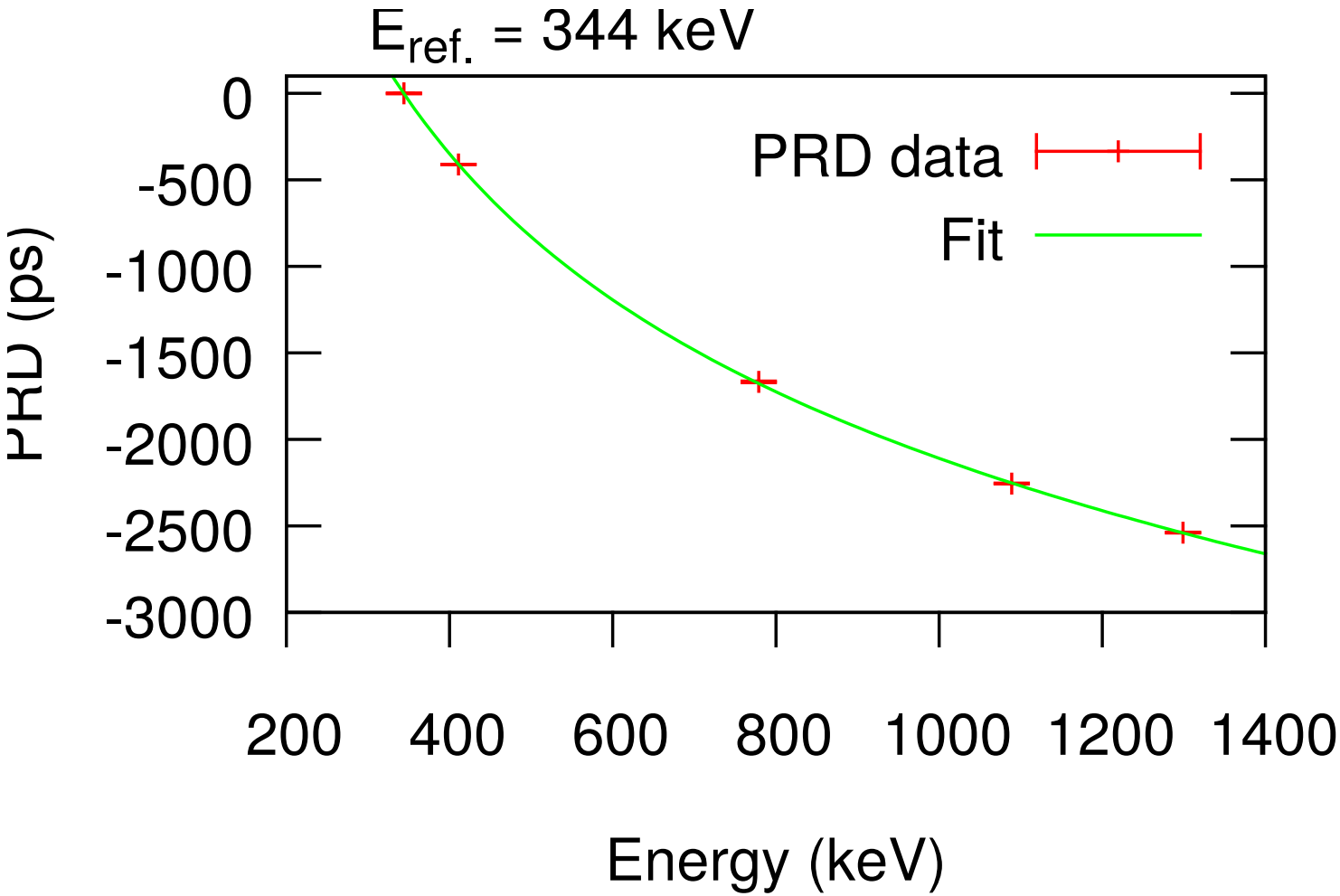


With ^{152}Eu


152Eu source 344-779
Counts
dT (ps)
1000
100
10
1
0.1
-1000
-500
0
500
1000
1500
2000


152Sm 1408-122
τ= 2.04(20)ns
τlit.= 2.014(5)ns
Counts
dT (ps)
100
10
1
0.1
-2000
0
2000
4000
6000
8000
10000
12000
14000

How does the PRD look?

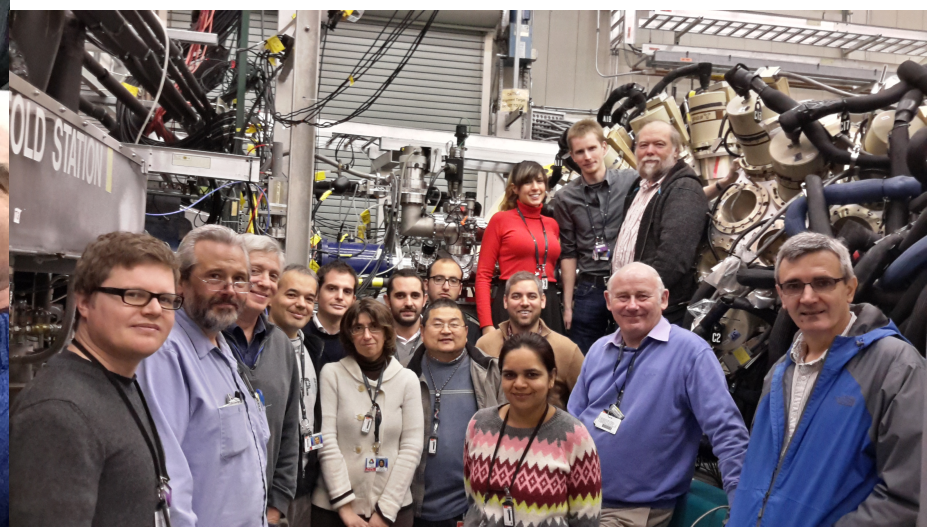


Not good. But very preliminary. Can probably be improved.

Summary

- Frame and hardware ready
- 36 detectors ready to use
- Data Acquisition system
  - working system using V1290 TDC
  - as is high dead time due to read-out
  - used for test measurements (more in progress)
  - implementantion with DGS successful
- successful measurement of half lifes between 1ns and 20ps with sources

Thank you

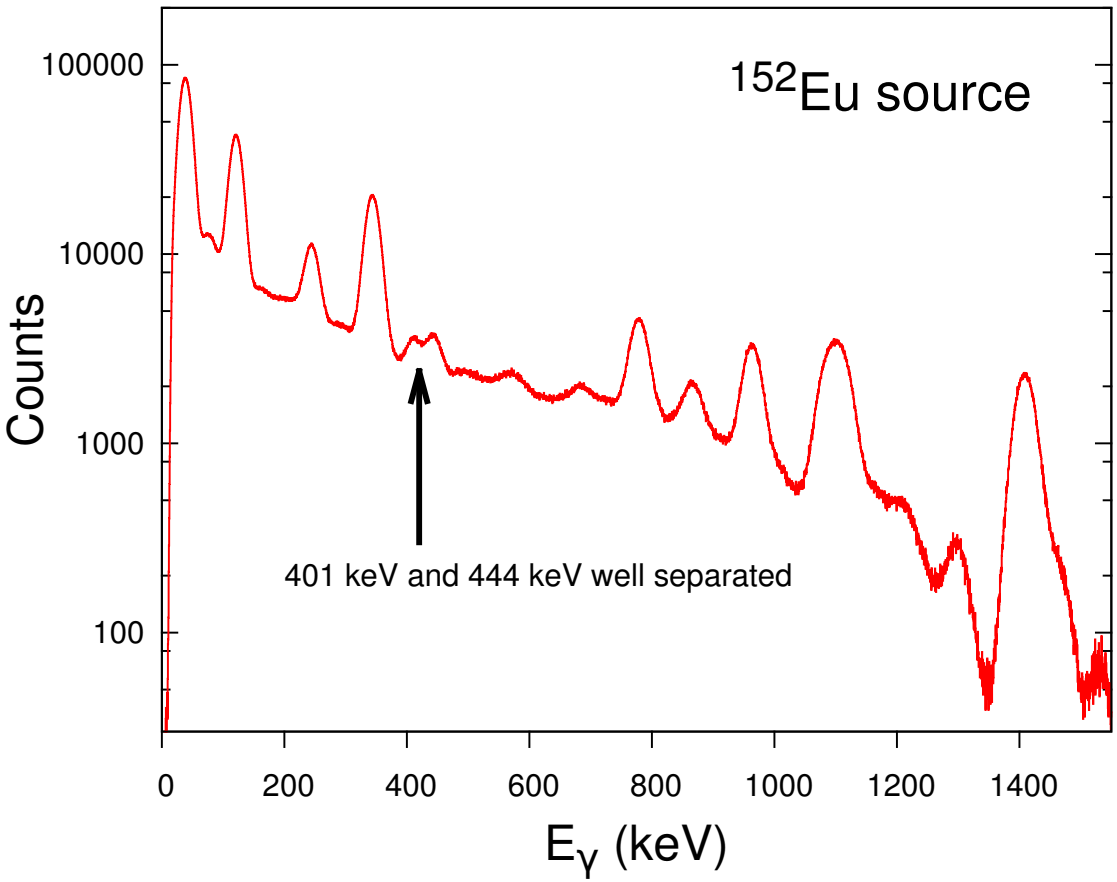


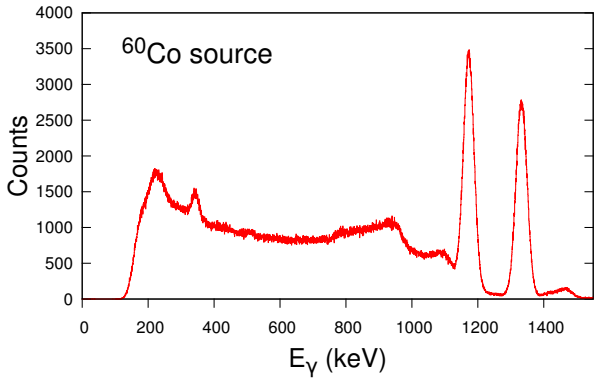
Thank You!

Stefan Lalkovski[1], Zsolt Podolyak[1], Patrick Regan[1], Allison Bruce[2], Eugenio Gamba[2], Ian Lazarus[3], Vic Pucknell[3], John Simpson[3]
[1] *University of Surrey, Guildford, Surrey, GU2 7XH, United Kingdom*
[2] *School of Computing, Engineering and Mathematics, University of Brighton, Brighton, BN2 4GJ, United Kingdom*
[3] *CLRC Daresbury Laboratory, Daresbury, Warrington, Cheshire WA4 4AD, United Kingdom*

and all others from the
FATIMA Collaboration

V1751 digitizer with DPP firmware





Energy resolution:

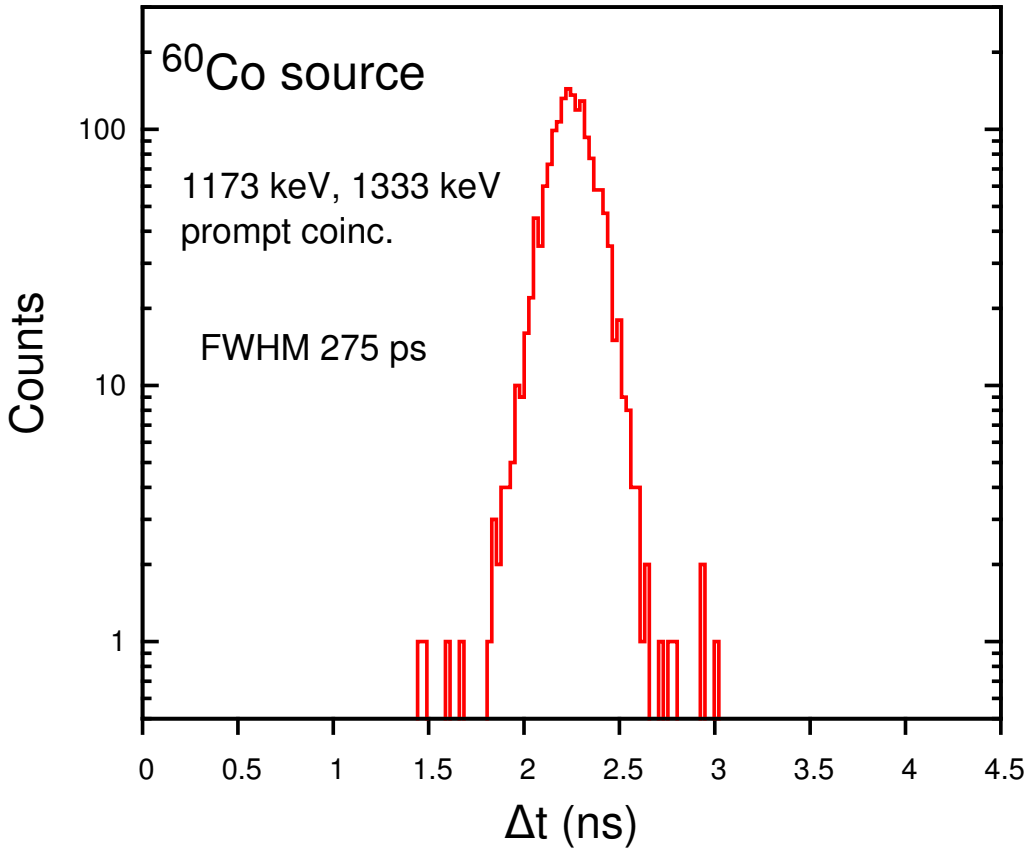
19% at 121 keV
8% at 344 keV
4% at 779 keV
3% at ^{60}Co lines

PMTs operated at 1250 V

V812 CFD and V1290A TDC

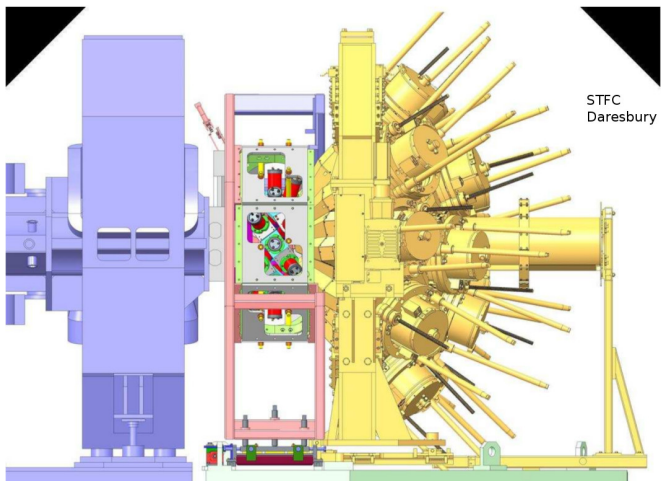
First result

- 24 ps/chn time resolution (matches 25 ps LSB)
- prompt from ^{60}Co source
- CFD delay 8 ns
- no correlation with V1751 yet
- "gated" with CFD threshold
- comparable to earlier test with analog electronics (FWHM 291 ps)



Integrations with other systems

Layout for array at GANIL



2015/2016 Proposals accepted at

- GANIL with AGATA and VAMOS

  (2_1^+ half life of ^{190,192}W, P.R. John *et al.*)

- Argonne with Gammasphere 32 LaBr detectors

  (^{252}Cf source, S. Lalkovski *et al.*)