CIEMAT Data Acquisition System

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CIEMAT

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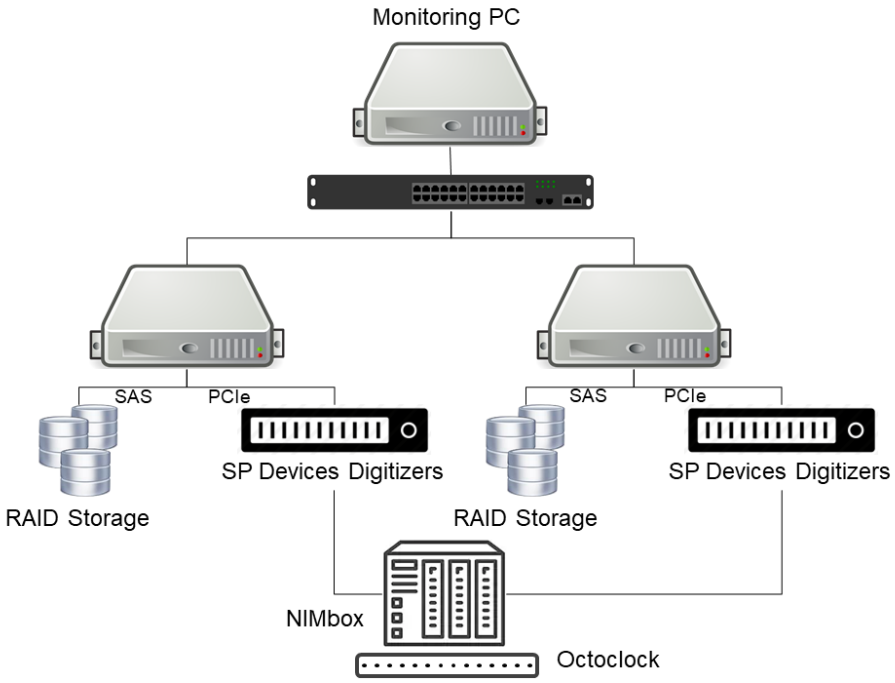
Hardware

Introduction

- CIEMAT DAQ has been developed to perform different types of nuclear physics experiments.
- The most demanding in terms of hardware requirements are beta delayed experiments
- Presently, the system consists on:
  - 14 ADQ14 SP Devices cards
  - 1 Counter/Timer PCIe6612 National Instruments card
  - 3 High Performance computers for data acquisition + 1 High Performance computer for online analysis
  - 3x96 TB + 1x48 TB RAID 6 JBOD disk controllers
  - 2 Octoclock high precission clocks for synchronization
  - 3 Wiener NIM/TTL Programmable modules (20 channels)
  - Large number of detectors tested (Liquid Scintillators, HPGe, NaI, LaBr3, He-3,…)

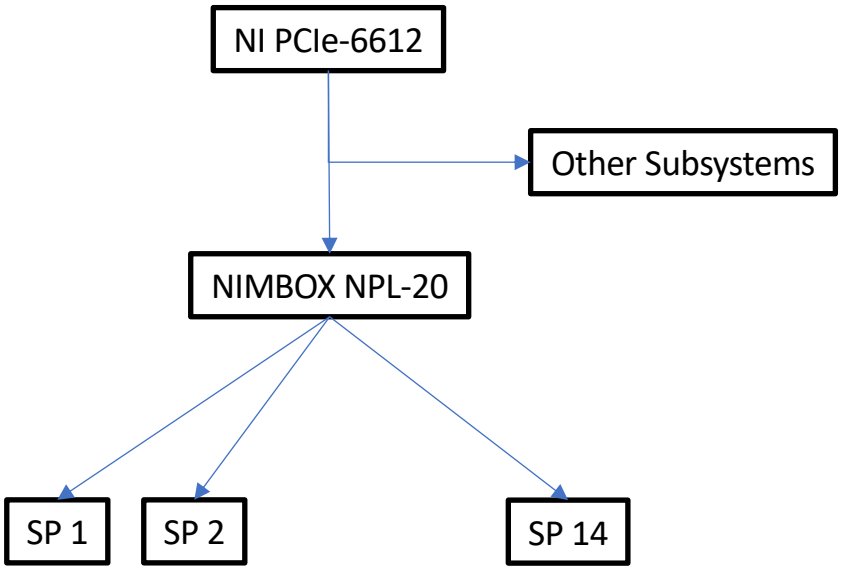


Clock Distribution

- The clock distribution which guarantees that all cards operate using the same clock is performed with 2 Octoclock-G CDA-2990
- The advantage of this system is that it is capable to operate with the 10 MHz signal provided by BUTIS (clock of White Rabbit)

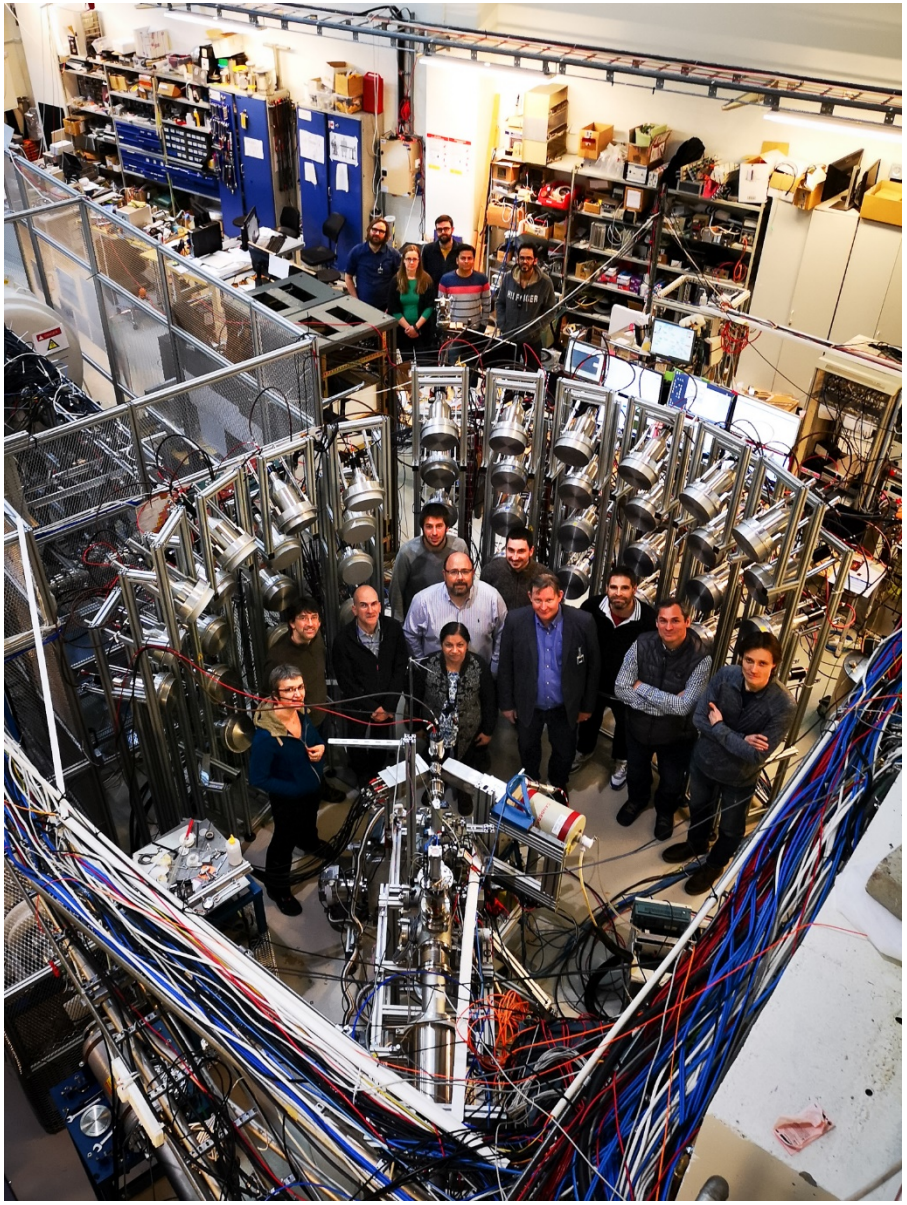
Timestamping

- The synchronization among the different SP Devices cards is performed using a common signal generated with the Counter/Timer PCIe-6612 of National Instruments
- The signal is distributed using Wiener NIMBOX NPL-20 programmable logic cards
- This signal can be used to synchronize different subsystems if they have timestamping capabilities and share the same clock (Butis or similar)



Modes of operation

- ADQ14 SP Devices cards have the option to operate using different firmware
- Depending on the firmware, the mode of operation changes:
  - Triggered mode (FWDAQ)
    - There is a unique trigger for the 4 channels
    - This is the default firmware
  - Triggerless mode (FWPD)
    - Each channel triggers independently
    - The length of the frame can be fixed or variable
    - It is possible to calculate a small baseline before the signal
    - This is a special firmware
- Both firmware allow the trigger to be vetoed



MONSTER

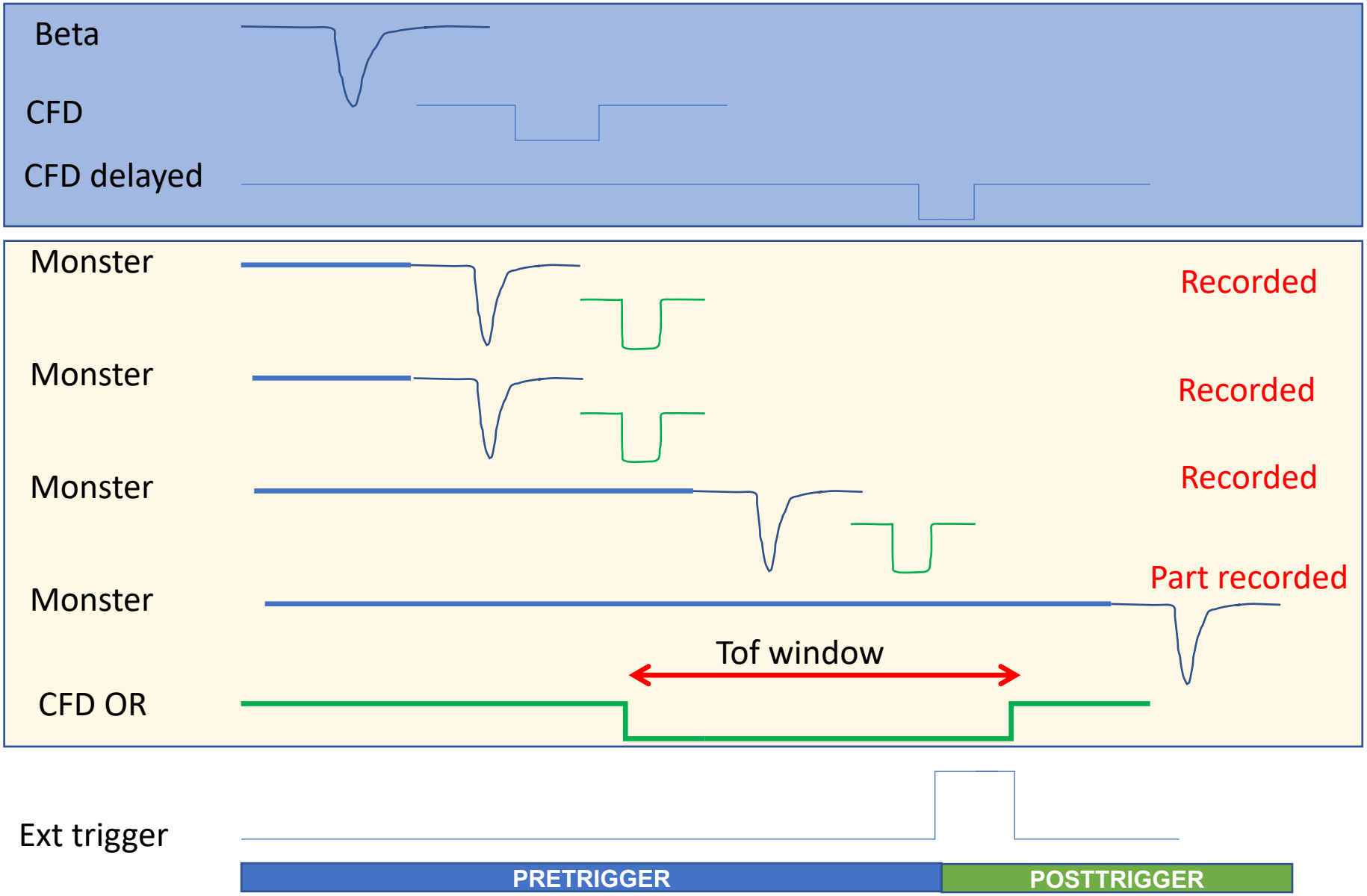
MOdular Neutron SpectromeTER

CIEMAT, VECC (India), JYFL (Finland), IFIC (Valencia), UPC (Barcelona)

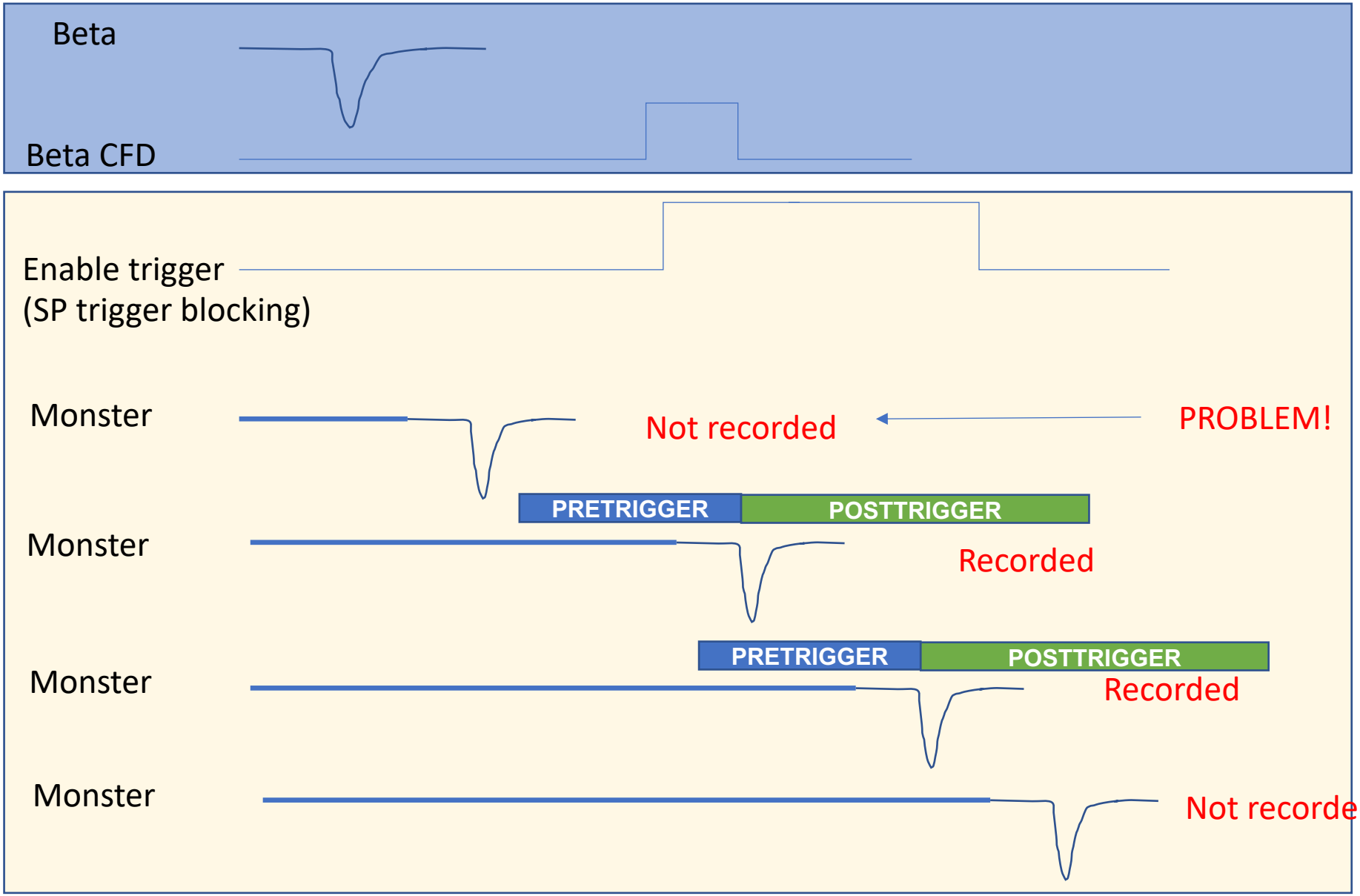
Measurement of beta delayed neutrons: β-γ-n correlations (β-particles are the trigger)

Prompt fission neutron spectra: FF-n correlations (FF are the trigger)

Triggered (FWDAQ) MONSTER experiments

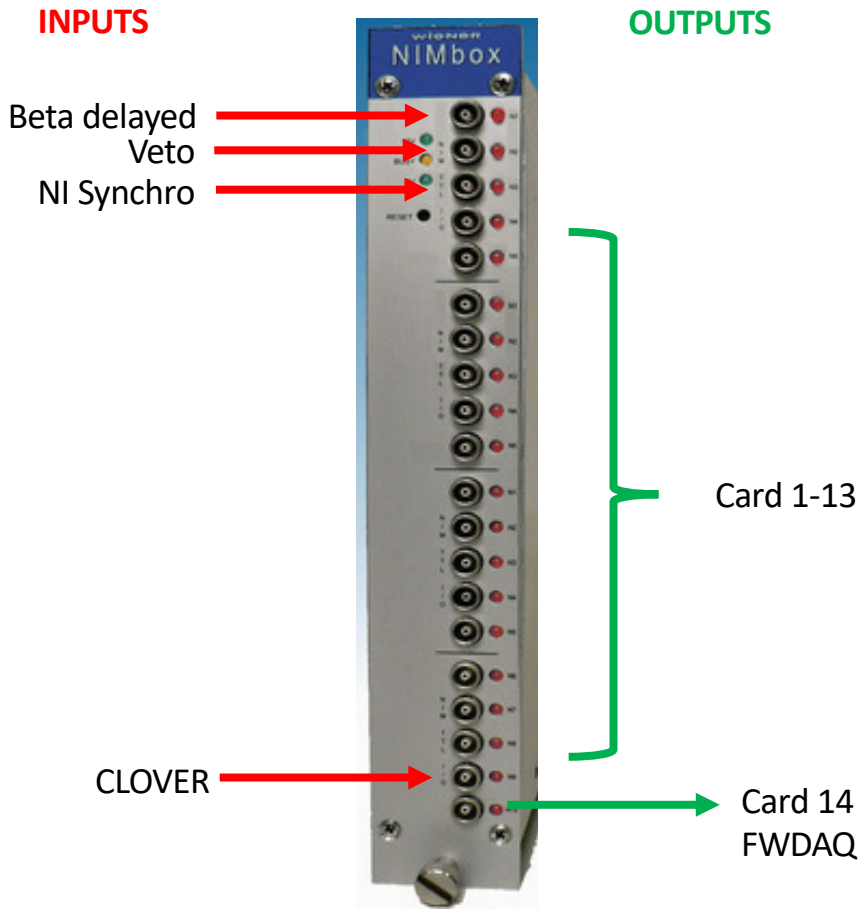


Triggerless (FWPD) MONSTER experiment



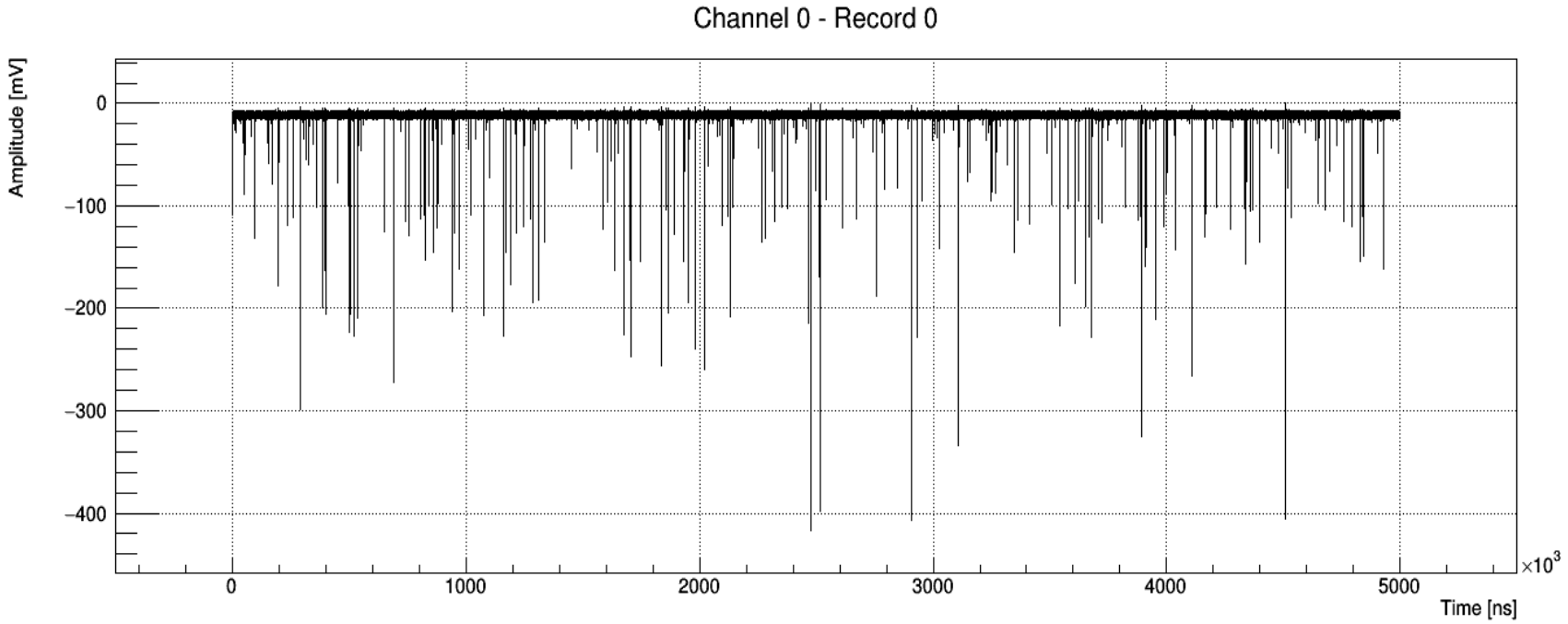
Complex Triggering

- ADQ14 cards (PCIe format) have one easily accessible digital entry (Ext Trigger)
- The trigger and the synchronization shares this connector
- The Weiner logical programmable TTL/NIM module manages the:
  - Synchro signal
  - Veto signals
  - Blocking Triggers
  - Detector triggers (FWDAQ)

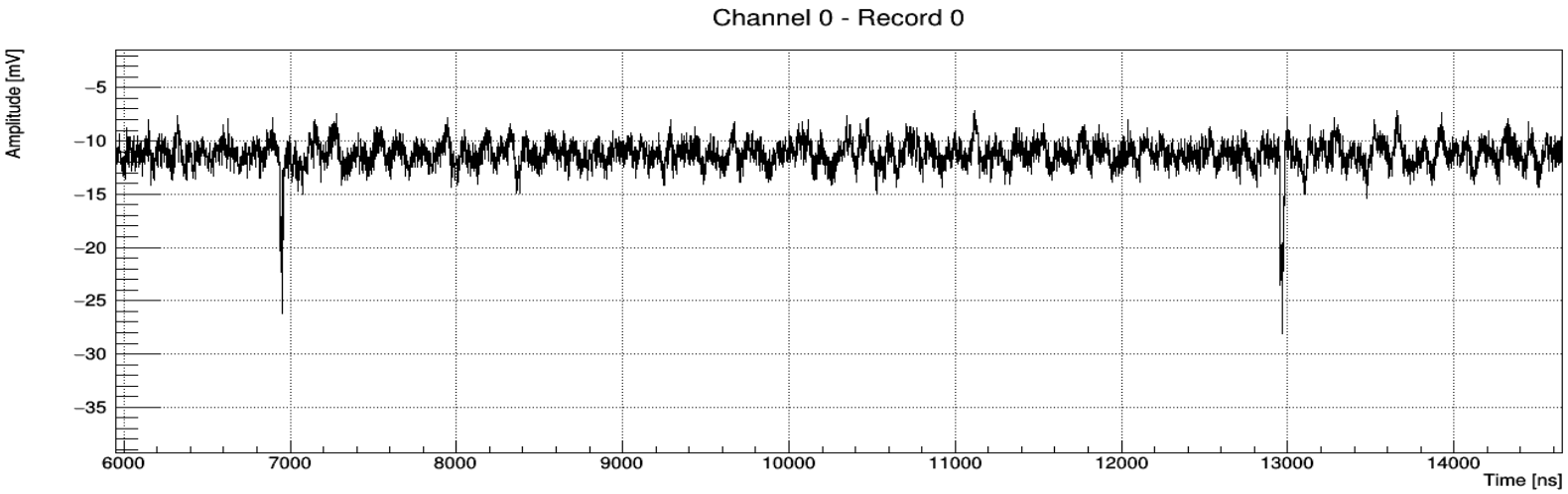


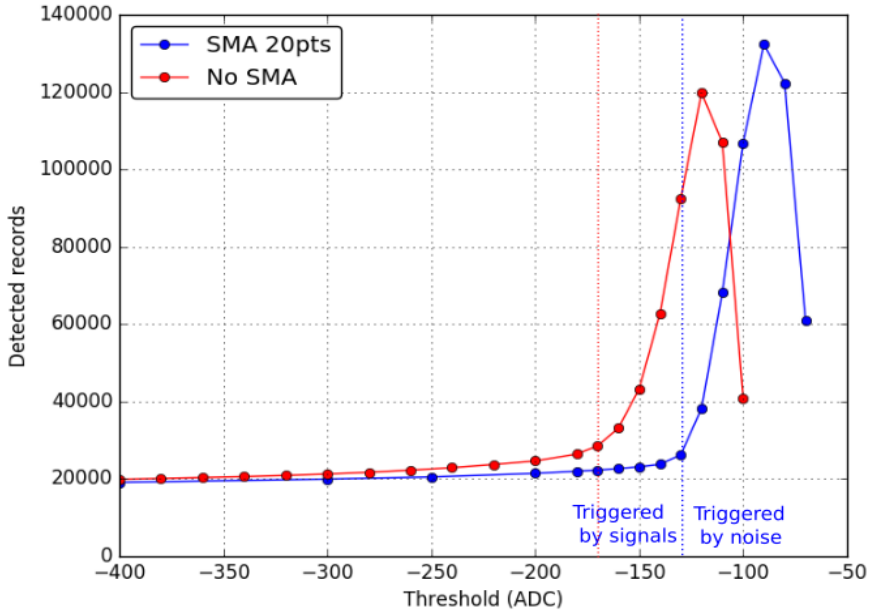
Possible developments (1/3)

- We have reproduced the FWPD algorithm (offline) and tested it in noisy electronic conditions to study the minimum threshold achievable with the FWPD
- We have compared it with an algorithm using a short moving average instead of a single crossing point
- The results show a much better performance in the later case



Possible developments (2/3)





Possible developments (3/3)

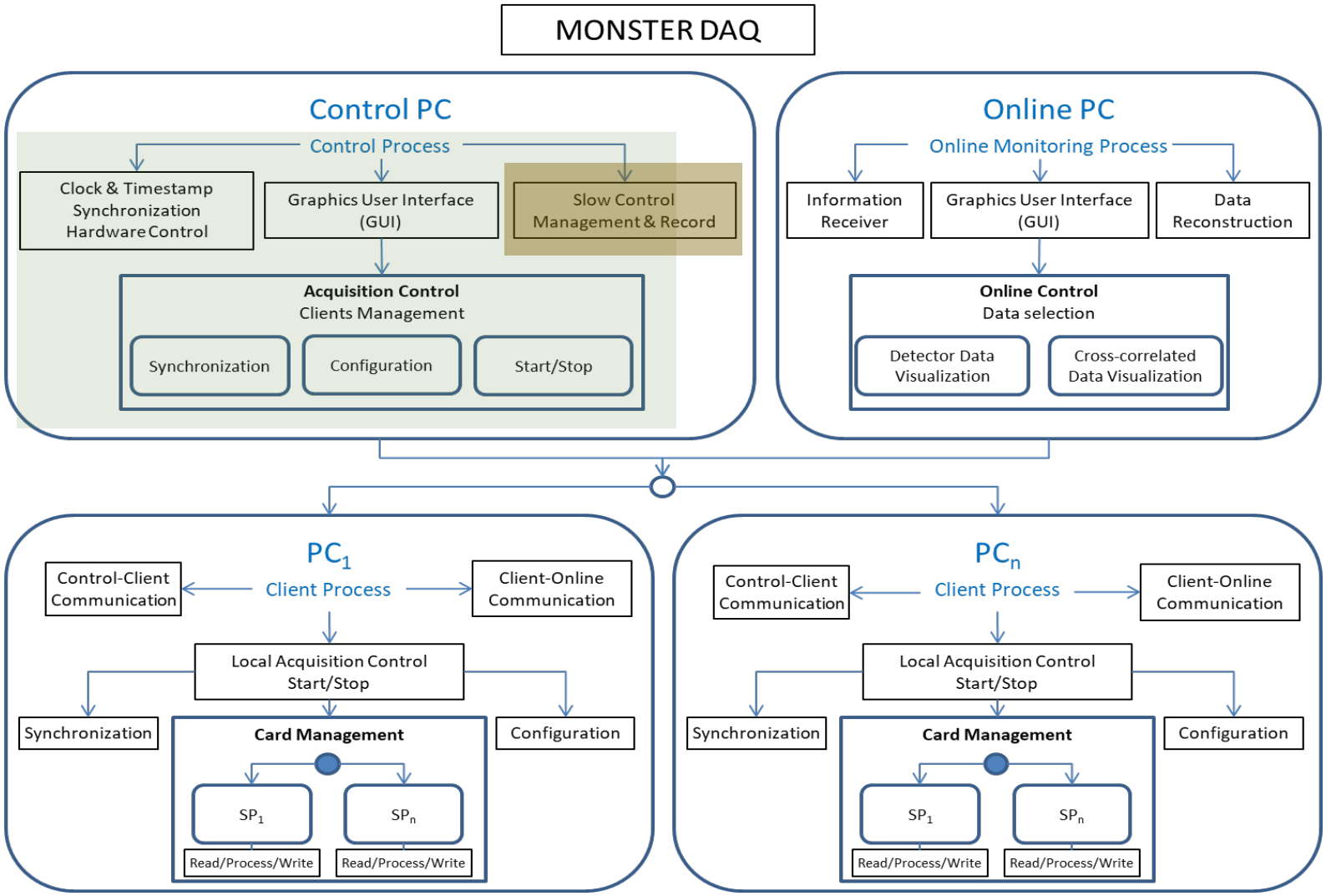
- We are facing two problem when using the coincidence window function of the ADQ14:
  - It is not possible to use the external trigger to define the coincidence window
  - The coincidence window must be extended in a range from a few microseconds to several milliseconds (in the worst case)
- We have proposed SP Devices to deal with this problem including an intermediate FIFO in the digitizing channels to force a delay in the data
- SP Devices has answered that all these demands can be implemented, although they will cost money

Software

Introduction

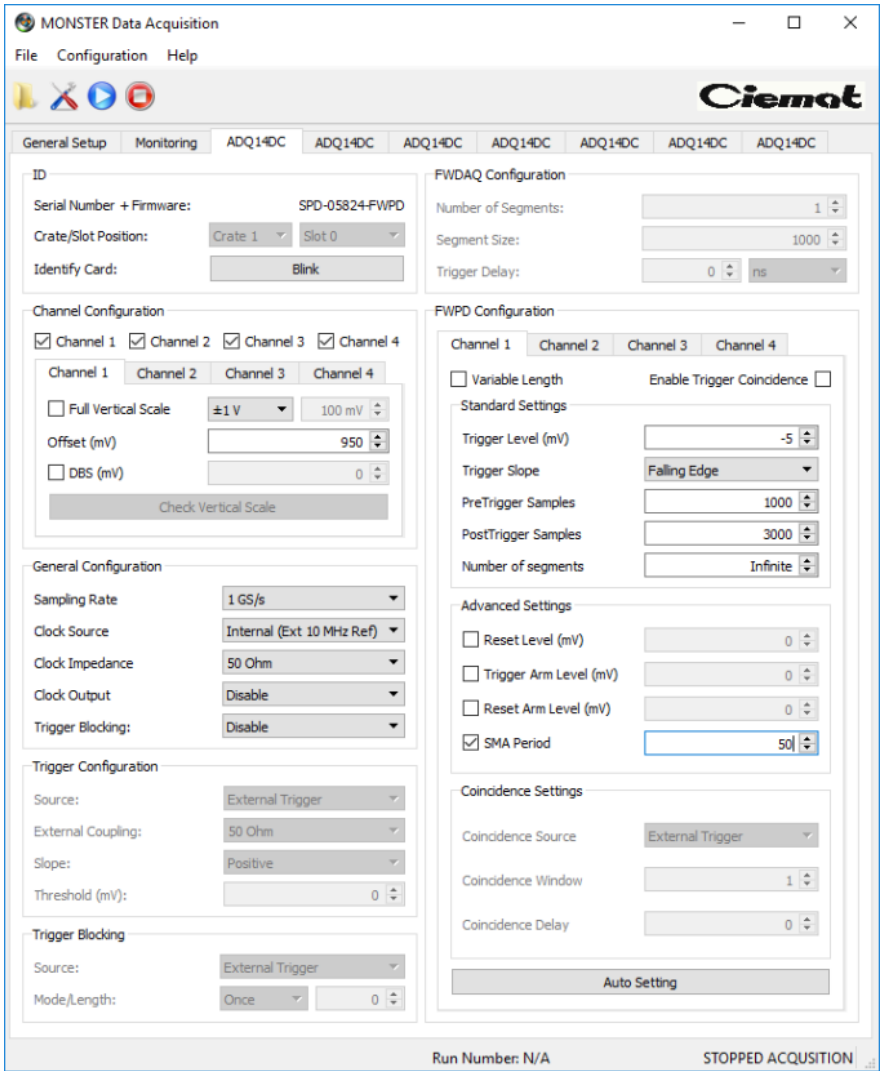
- CIEMAT DAQ software has been built taking into account the great disparity of setups typical of nuclear physics experiments
- It can operate from beta delayed experiments (high counting rate/tens of detectors) to underground measurements (few counts per hour/few detectors)
- Data can be stored either in raw format or processed. It has the capability to load a user defined library with online analysis routines to process signals from HPGe, LaBr3, plastic detectors, liquid scintillators, He-3…
- Finally, it has an external program to monitor online different parameters of the signals (counting rates, amplitude, area, rise time, combination of signal parameters…)

General scheme



Client operation

- The client running in each acquisition PC controls its SP cards
- Every card run in a different thread
- The Read, Process and Write functions run in its own threads
- A double buffer reduces the number of bottlenecks
- The processing can be performed in Xeon Phi coprocessor cards
- The maximum raw data rate processed has been 1600 MB/s
- If raw data is stored, this number is reduced to 600 MB/s

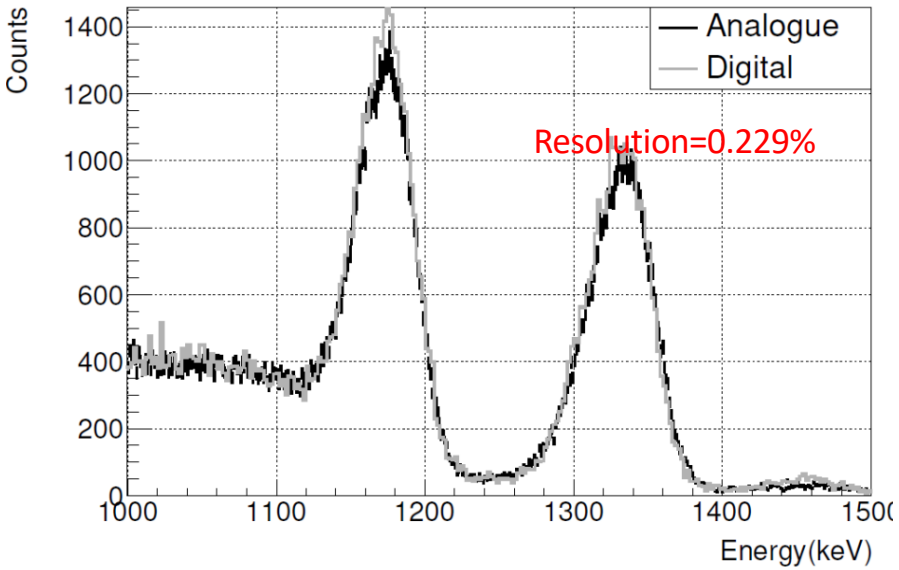


The analysis library (1/3)

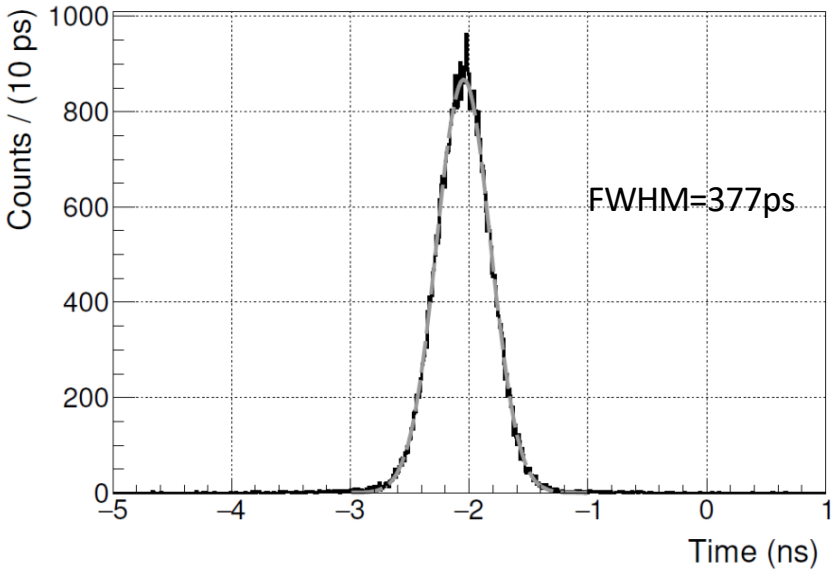
- It is possible to load a user-defined library to process the raw data
- It works either online and offline
- We have developed our own library
- Main Functions:
  - Baseline
  - RC and RC4 filters
  - CFD
  - Rise Time
  - Amplitude
  - Ranged Area
  - True Shape fitting

The analysis library (2/3)

HPGe (Co-60) using a digital CR-RC4 filter

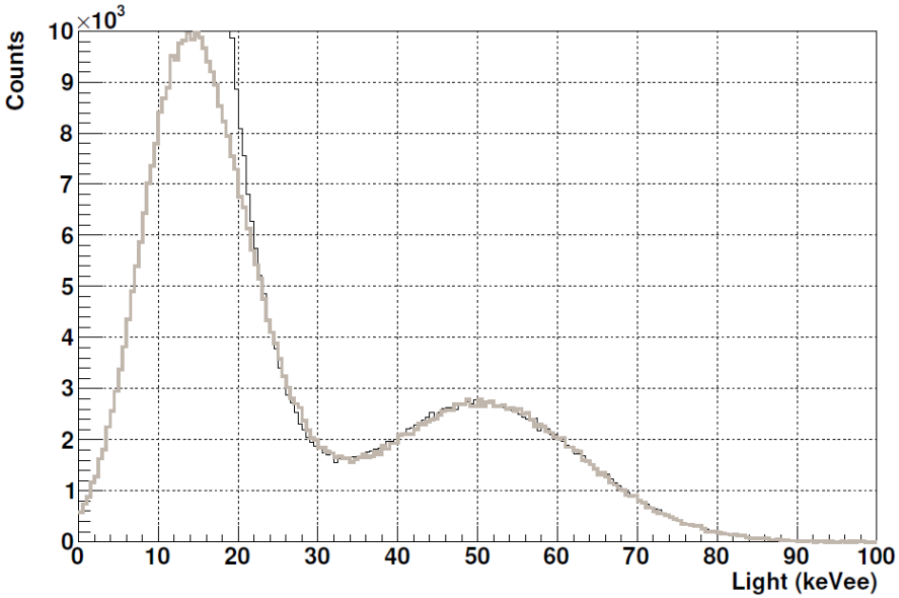


Time resolution of (5cm x 5 cm x 10 cm) $LaBr_3$ using digital CFD

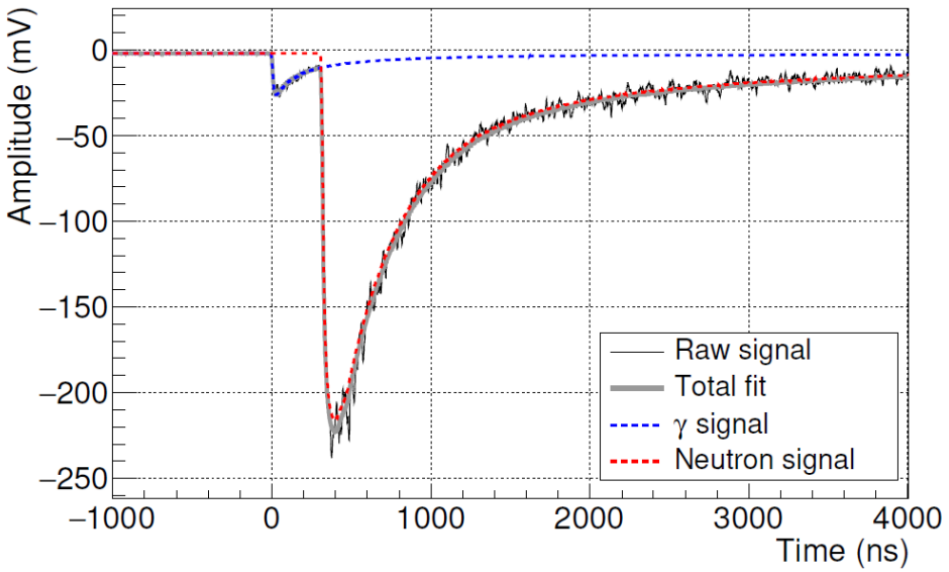


The analysis library (3/3)

Am-241 measured with a liquid scintillator using a 10 MeVee range and digital RC filter compared with simulation



Fit to True Shape of a pile-up



Online monitoring (1/2)

- The client running in each acquisition PC controls its SP cards
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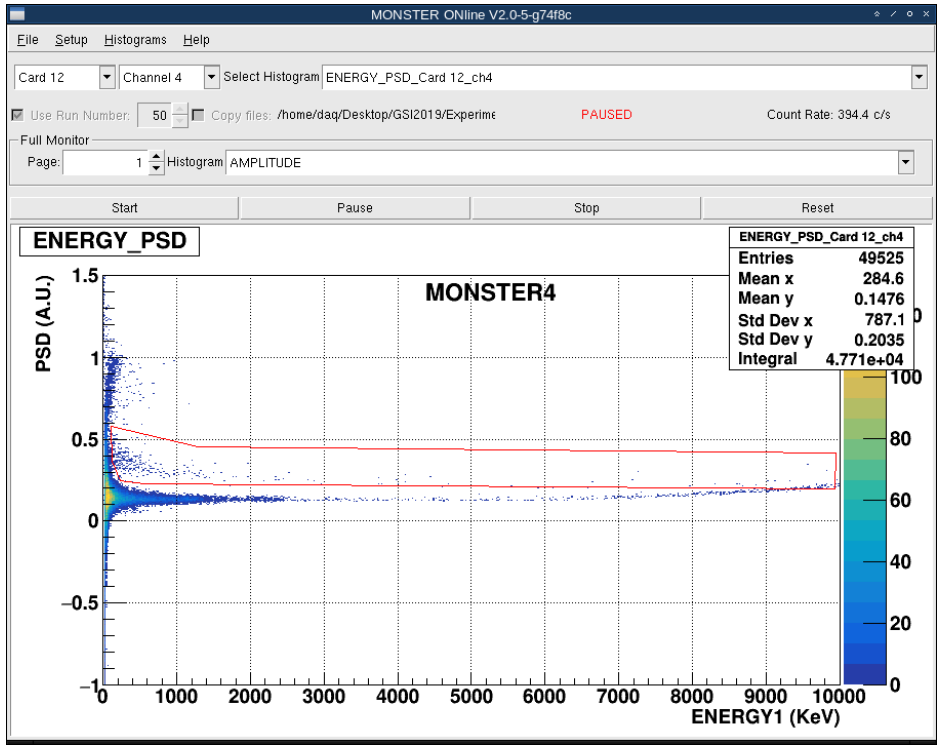
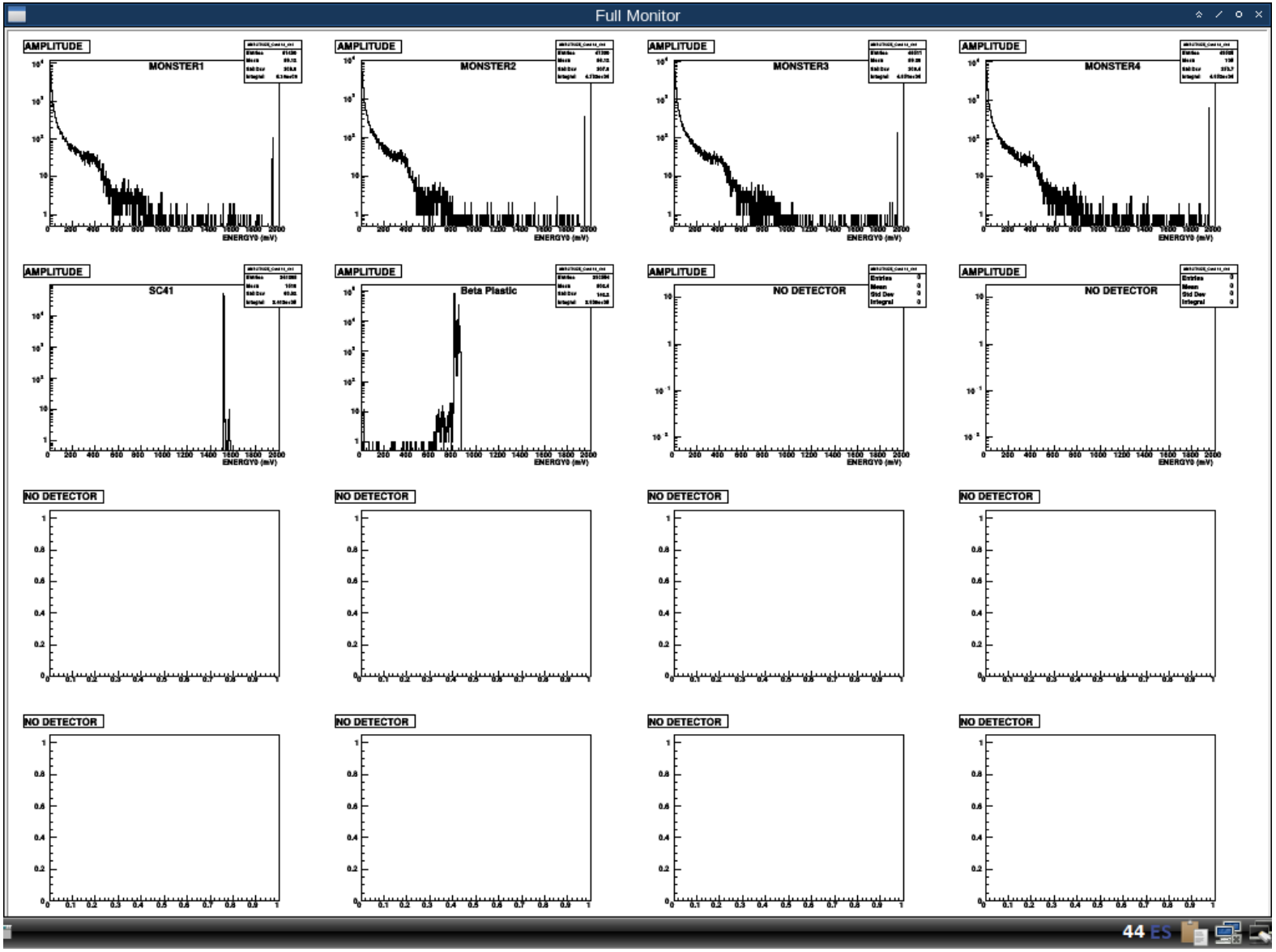
- The processing can be performed in Xeon Phi coprocessor cards



Online monitoring (2/2)



Future developments

- We are developing the Master program to control all PC clients from a centralized computer
- Our intention would be to include different algorithms inside the FPGA: baseline, CFD, RC, RC4 and true shape fitting. However, we lack the manpower/knowledge to do it