WaveCatcher analysis software development and applications (Part 1)

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Outline

1. Introduction

- Features of native software – small experiment.

2. Standalone software for data analysis

- Software structure
- Merging with other subsystems
  - UNIXTIME (off-line)
  - **MATLAB (on-line)** second part of presentation by **Andrii Natochii**

3. CORTO - large number of WaveCatcher channels

Features of native software.

Within the first part of the presentation we are refereeing only to native DAQ software.

- Have a lot of different features
  - Which information is saved
    - Full waveform
    - Measurements (time, charge, amplitude ...)
  - Measurements performed in different way :
    - Software
    - Firmware
  - Format of the output data
    - ASCII
    - Binary
    - Single/multiple files

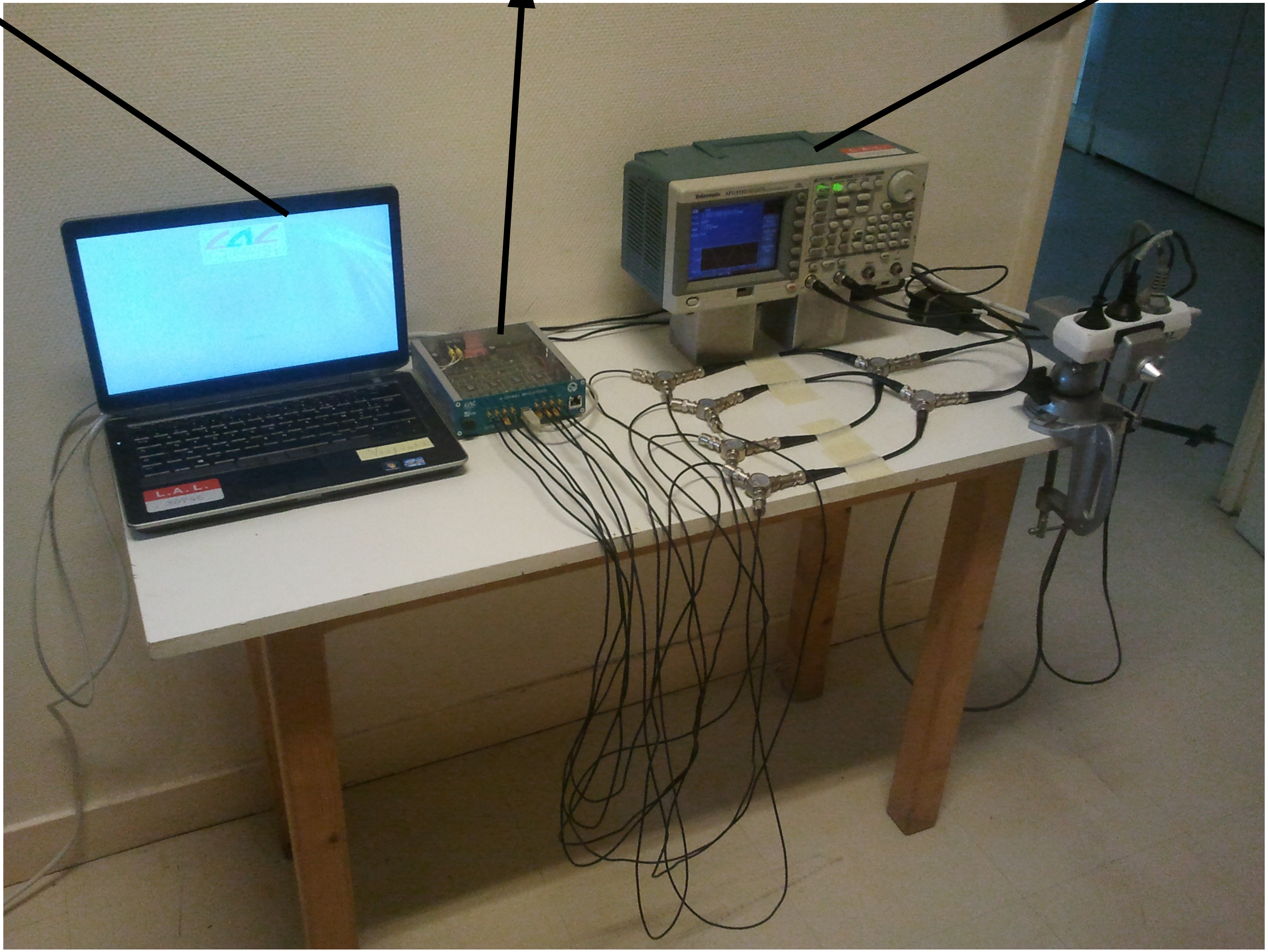
- To study this features the small experiment have been performed.

Experimental setup.

DAQ Laptop with WaveCatcher Software (windows)

8 channels WaveCatcher

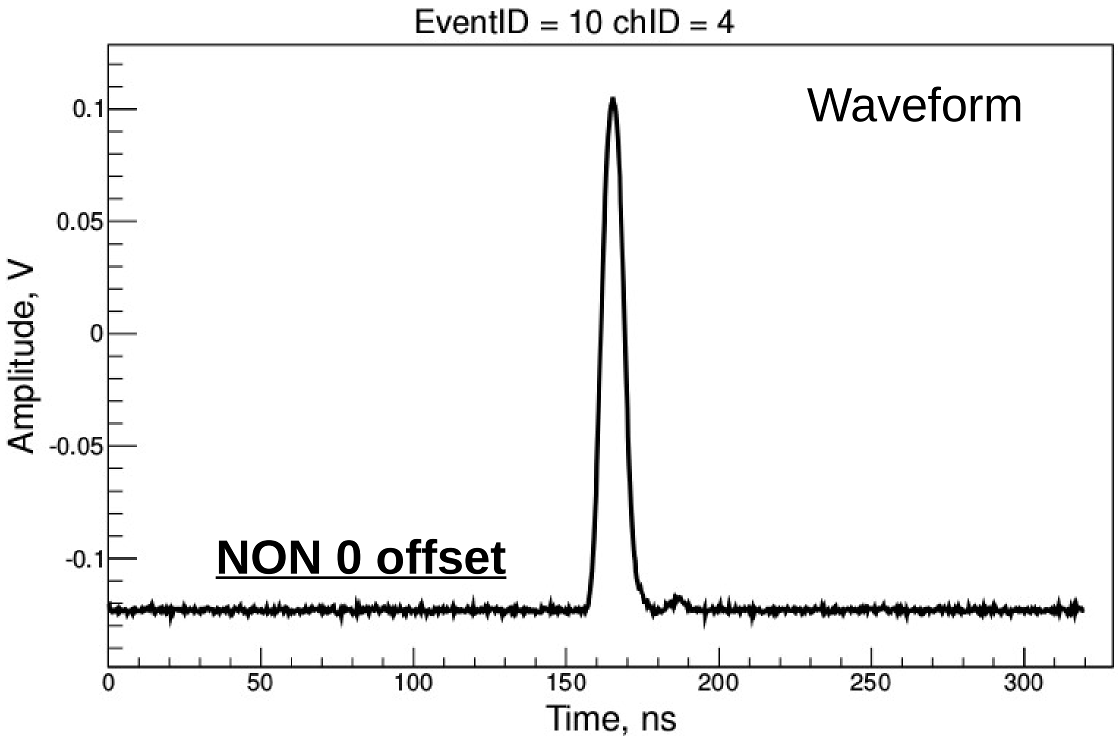
Pulse generator



Runs with different conditions

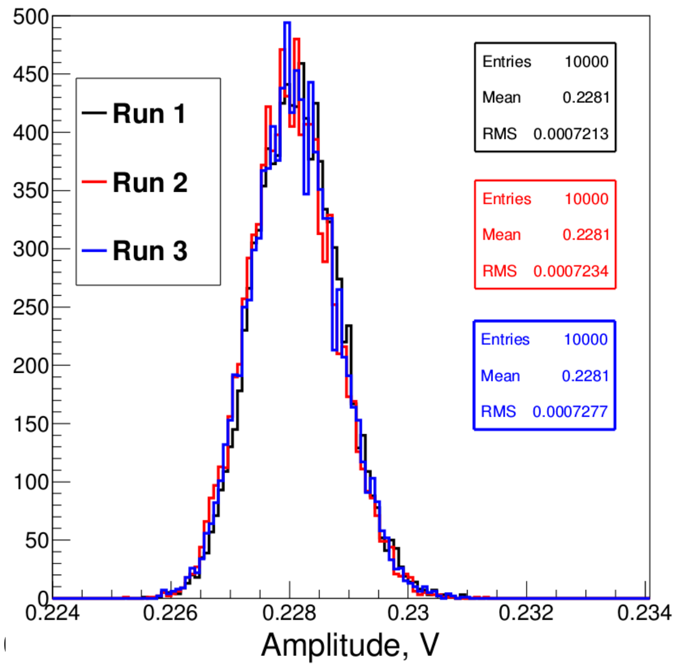
Run ID	Description
1	ASCII format. No measurements in separate file.
2	ASCII format. Measurements in separate file. For charge measurements we have choose 0 - 16 bin.
3	Binary format. Same setups as for Run 2.
4	Firmware measurements. Binary format. Same setups as for Run 2.
5	Same as Run 4. 10^5 events.
6	Only measurements. Same setup as Run 4.
7	5000 events per file. Only measurements. Same setup as Run 4.
8	All events in one file. Only measurements. Same setup as Run 4.
9	ASCII format. 500 events per file software measurements.
10	ASCII format. Pulse withs 100 ns.

Waveform. Measurements of the amplitude software/firmware.

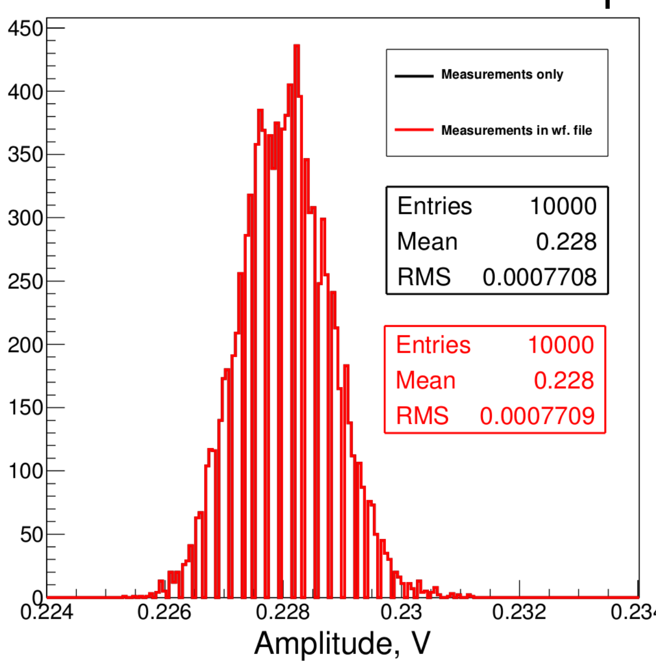


- Effect of 12 bit ADC can be seen for firmware measurements.
- Precision is very good (**RMS = 0.8 mV**).
- Comparable with 1 bit size 2.25 V/4096 = **0.55 mV**

Software measurements of amplitude



Firmware measurements of amplitude

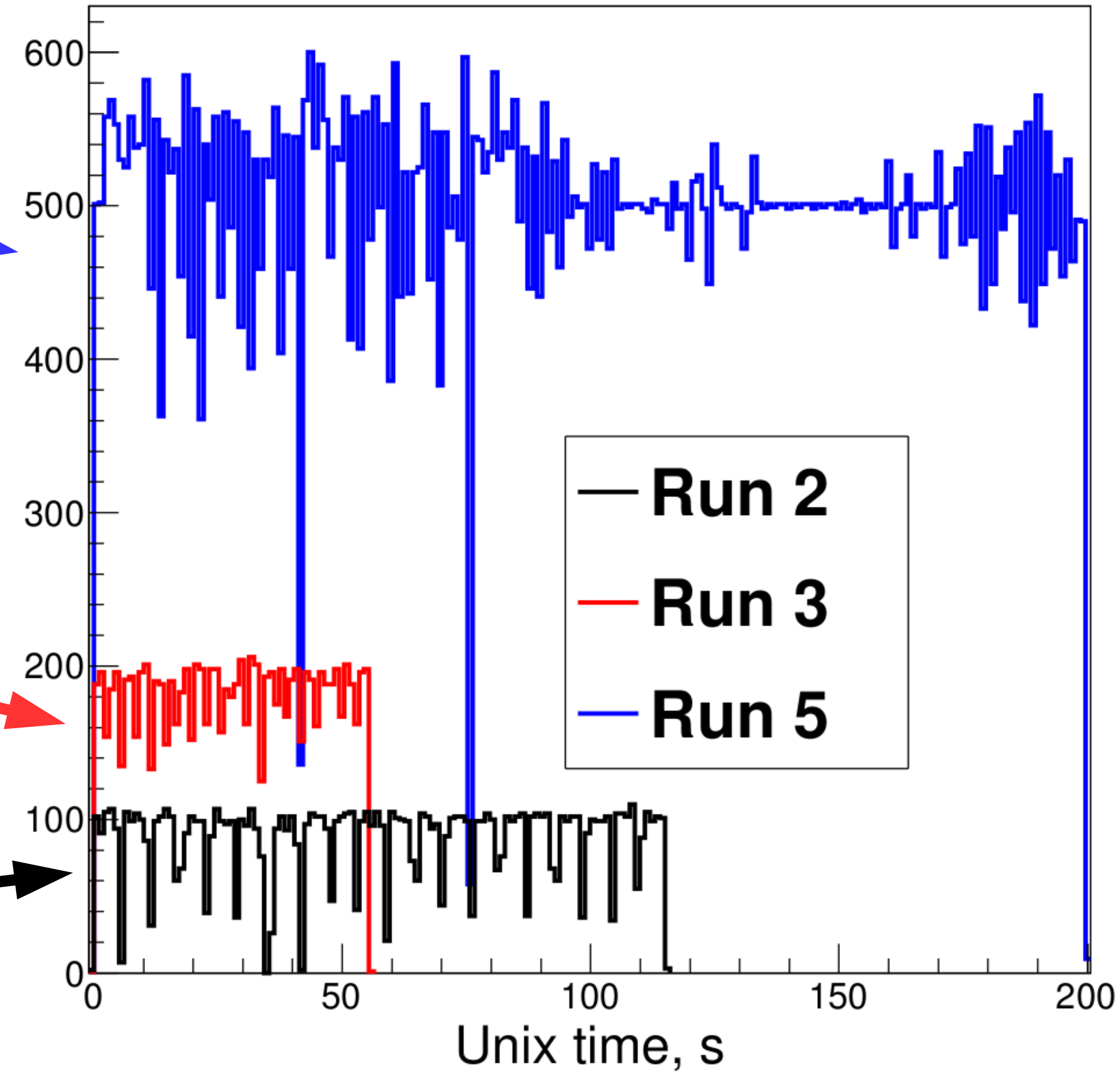


Acquisition speed

Waveform and **firmware** measurements
Binary format

Waveform and **software** measurements
Binary format

Waveform and **software** measurements
ASCII format



- Measurements done with firmware increase by factor three the speed of acquisition.
- Binary format increase the acquisition speed by factor two.

Raw data file sizes.

File sizes. Number of GB per 100000 events per channel.

Measured.

ASCII Wf.	ASCII Meas.	Binary Wf.	Binary Meas.
0.95	0.0073	0.2	0.0037

Estimated.

ASCII Wf.	ASCII Meas.	Binary Wf.	Binary Meas.
0.82	0.004	0.2	0.002

➡ Binary format decrease by factor five the size of the data.

Standalone software for data analysis.

- For wavecatcher data treatment stand alone software have been developed.
- The software based on **c++ with root libraries** and run via **bash script language.**
- The analysis consist of tree main steps :
  - 1) Conversion of WaveCatcher raw data into the root format.

Binary format

convertUSBWC2root8ChannelsBin.cc	→	To convert the waveforms
convertUSBWCMeas2root8ChannelsBin.cc	→	To convert the measurements
convertUSBWCRates2root8ChannelsBin.cc	→	To convert rates

ASCII format

convertUSBWC2root8Channels.cc	→	To convert the waveforms
convertUSBWCMeas2root8Channels.cc	→	To convert the measurements
convertUSBWCRates2root8Channels.cc	→	To convert rates

  - 2.1) Waveform analysis : consist of two main c++ classes

    anaL1Bin → Work with root files (read/write)

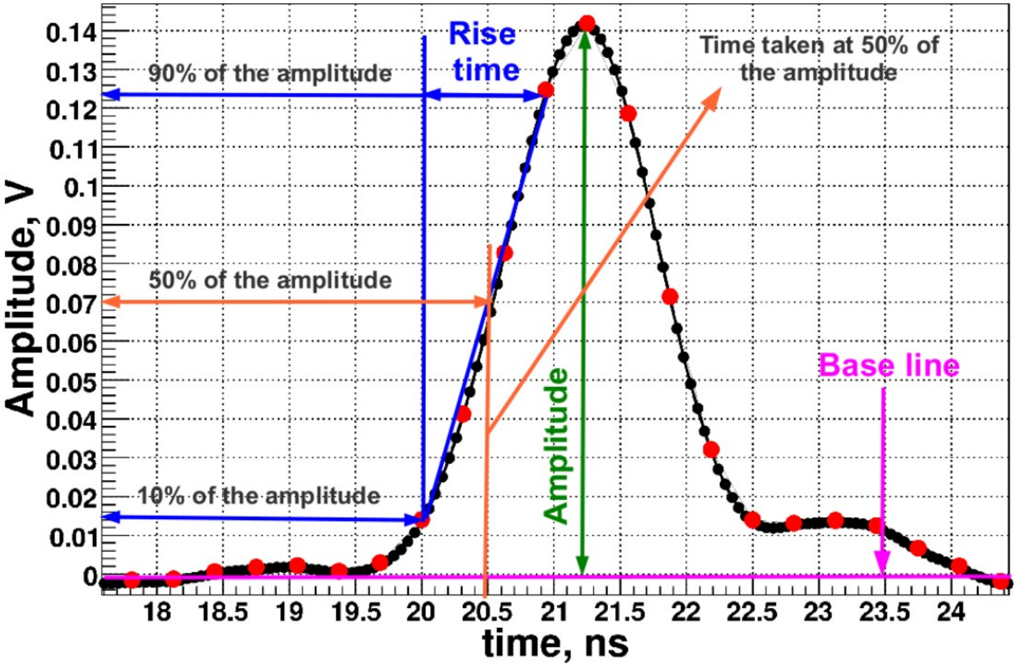
    waveformSimple → Waveform analysis **(See next slide for more details)**

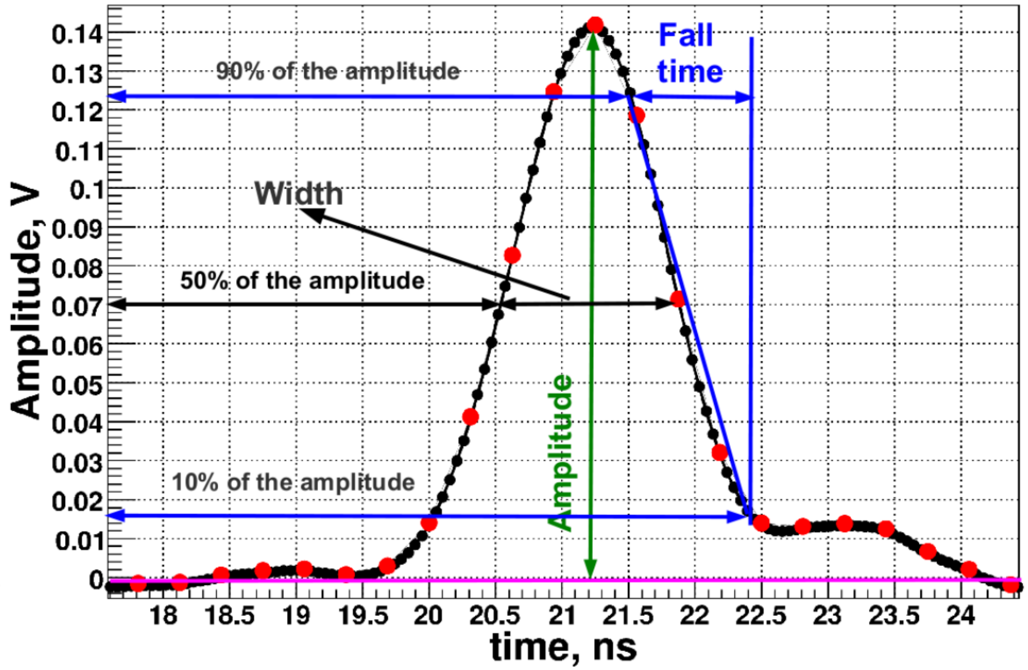
  - 2.2) Off-line merging the data into a common root file with data from another subsystems : translation stage, temperature or other sensors (if needed).
    - One can use a Unix time for merging the data from different subsystems **(See more detail below in the presentation)**
  - 3) Histogram and plots production : consist of one class and root macros to produce plots

    anaL2 → Produce the histograms and save them in to a root format

    plots.C → root macros to produce plots.

Standalone Waveform analysis.

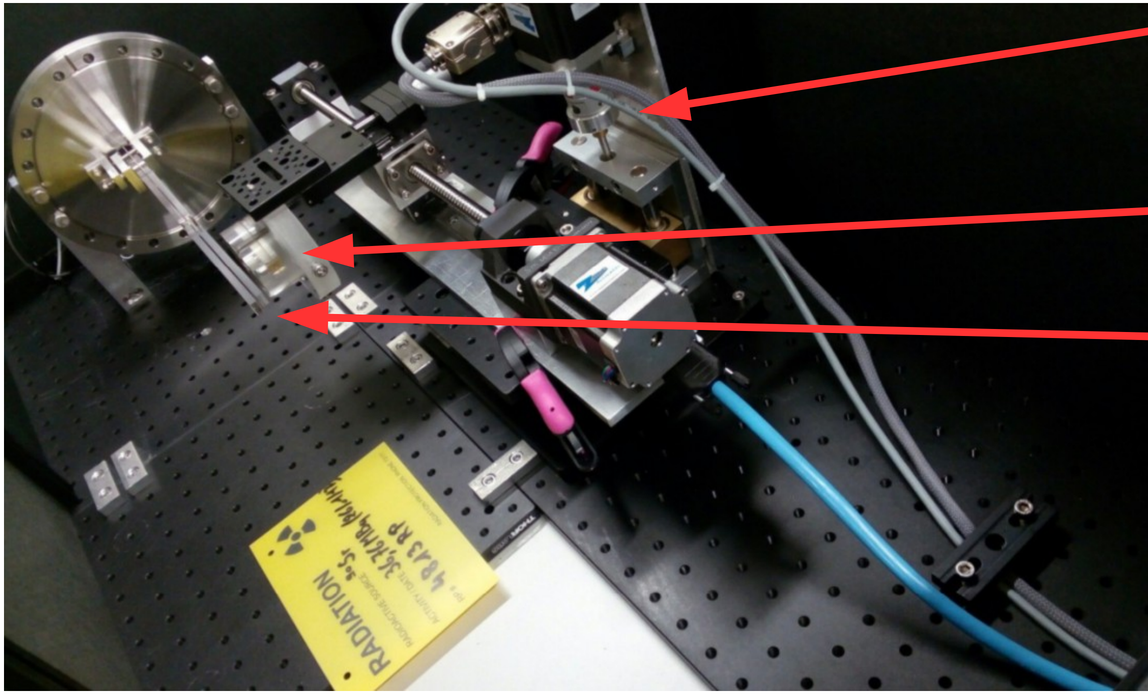




- We can add n (free parameter) additional equidistant points in between two sampling points, which are then joined by a straight line.
- We use the first n (free parameter) sampling points to compute the average baseline amplitude, which is then subtracted from the waveform.
- For waveform we define quantities : (see plots from the top for more details)
  - Baseline
  - Amplitude
  - Constant fraction time
  - Fall time
  - Rise time
  - Charge

Off-line merging the data into a common root file

→ One example : Sr90 test of the extracted from SPS CpFM.



3D translational stage
- Two – controlled by the PC
- One – manual control

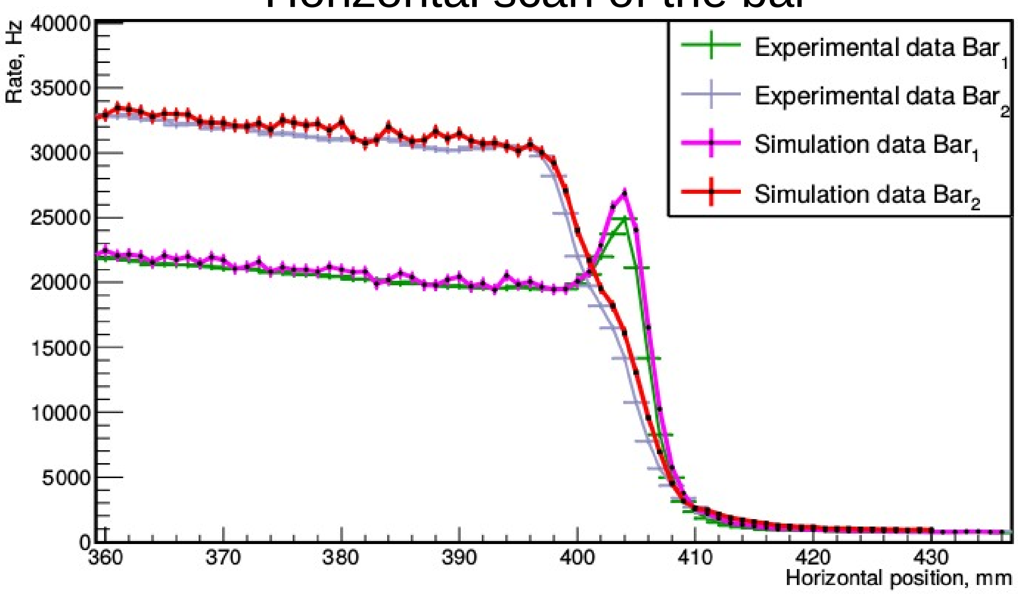
36 MBq Sr90 betta source

CpFM extracted from SPS

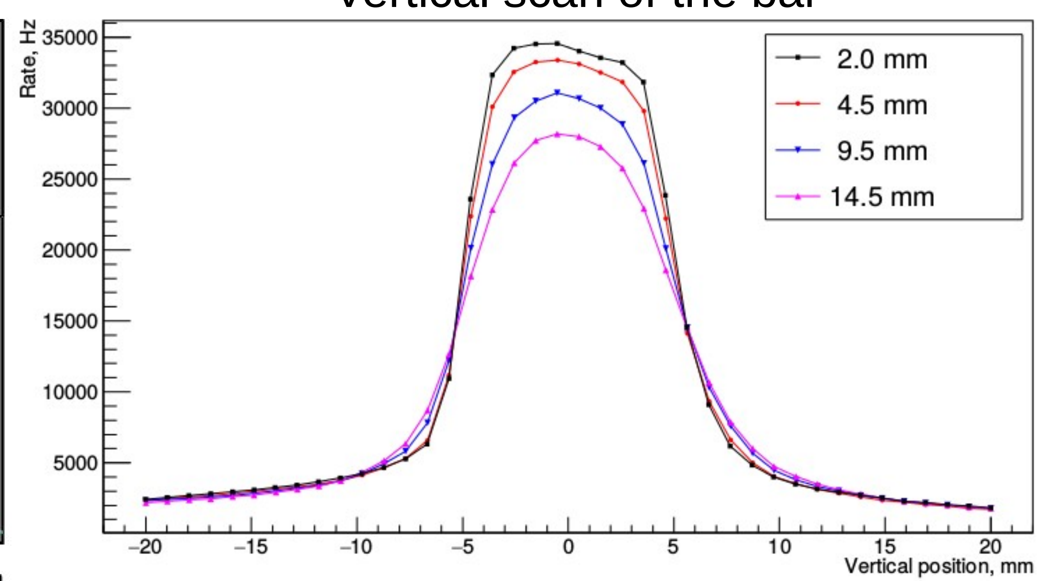
[The Rate of the CpFM measured with WaveCatcher](#)

We use **Unix time** to synchronize the data from WaveCatcher

Horizontal scan of the bar



Vertical scan of the bar



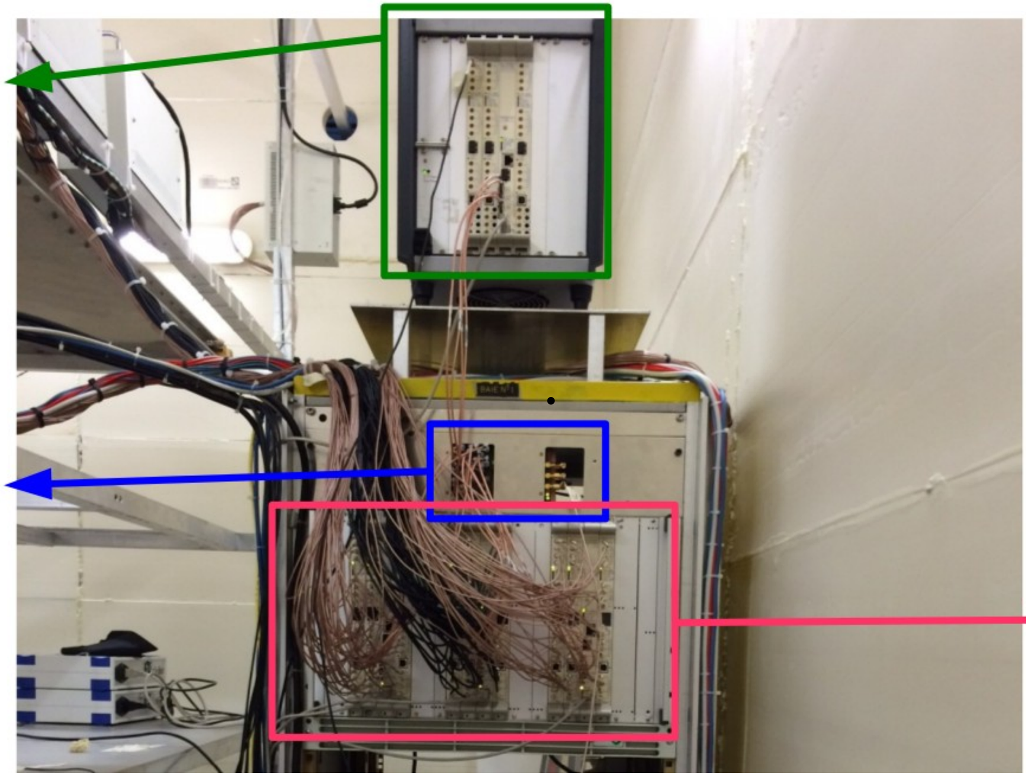
CORTO - large number of WaveCatcher channels

- Usually during beam test we are working with 8 channels WaveCatcher.

- But we have as well larger system which contain 192 channels to readout MRPC's from CORTO.

48 channels USB-WC electronics for user

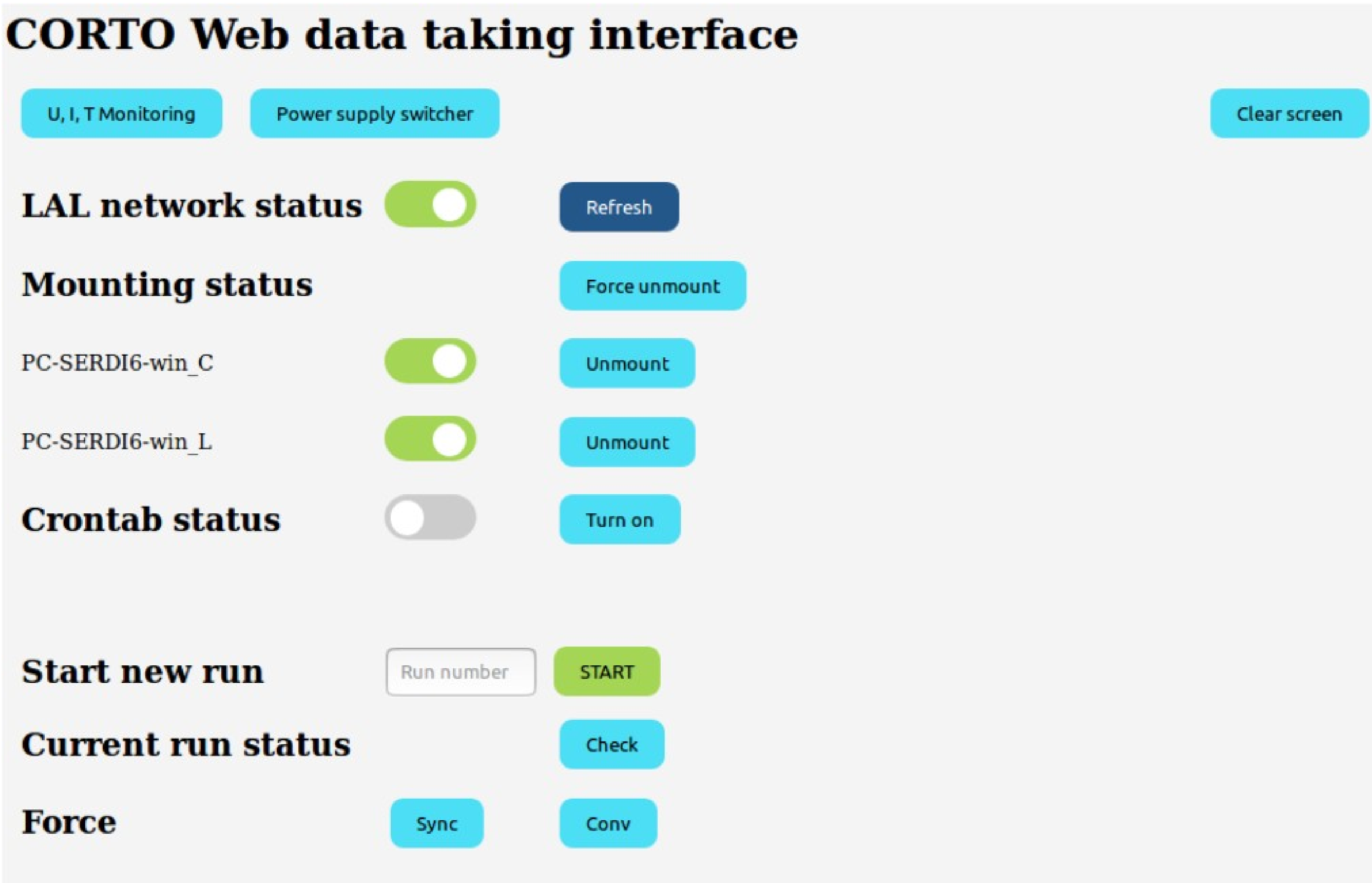
Main control board of USB-WC



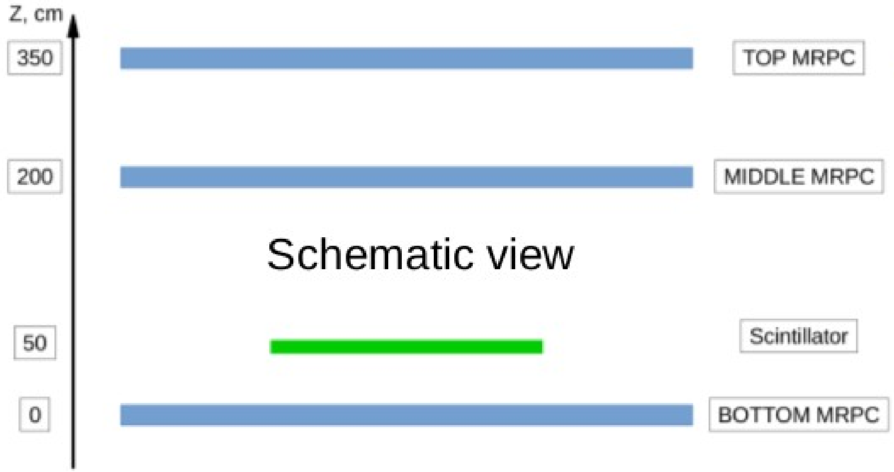
3 x 48 channels USB-WC electronics to readout MRPC

WEB-GUI for data treatment from CORTO

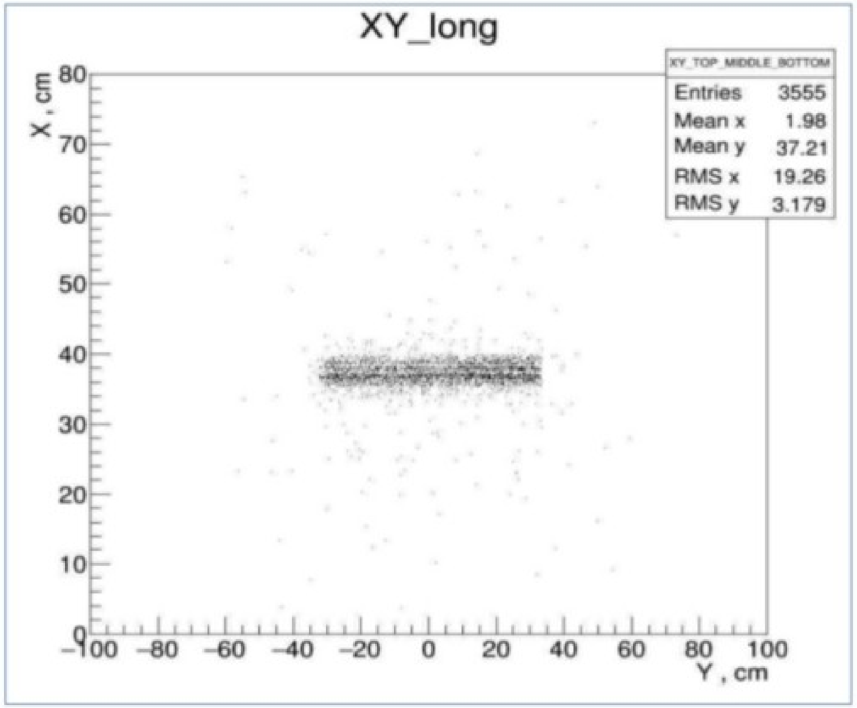
- The overall structure of analysis software is similar to the 8 – channel WaveCatcher.
- However a lot of additional bash scripts have been written to run the c++ programs.
- We decided to create WEB user interface to simplify routine analysis procedure.



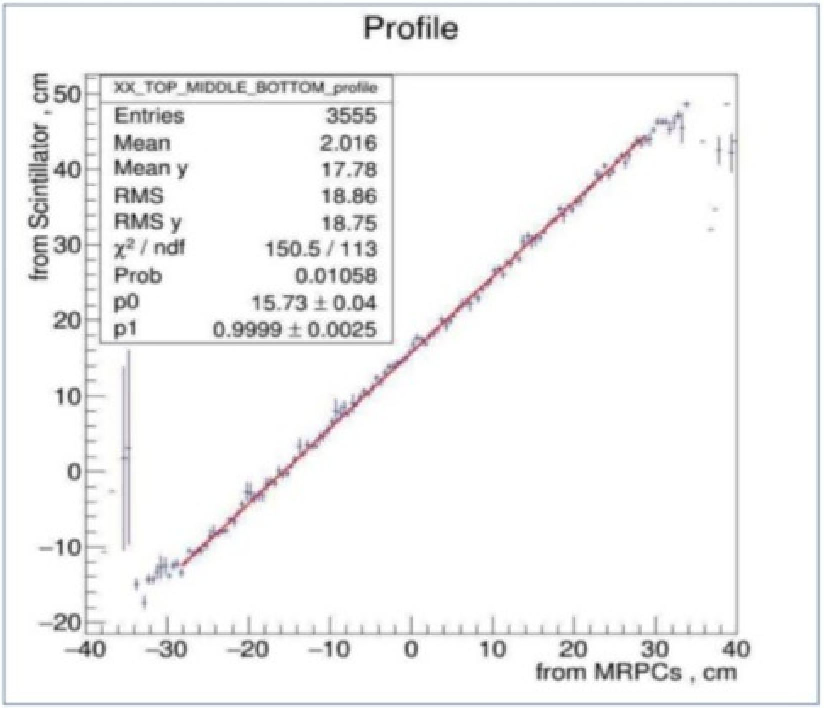
Validation of the track reconstruction algorithm



- For this we use long trigger counter 60 x 3 x 3 cm^3 plastic scintillator + PMT
- We reconstruct detector geometrical sizes (X vs Y histogram)
- We reconstruct track position with CORTO and long trigger counter (profile)



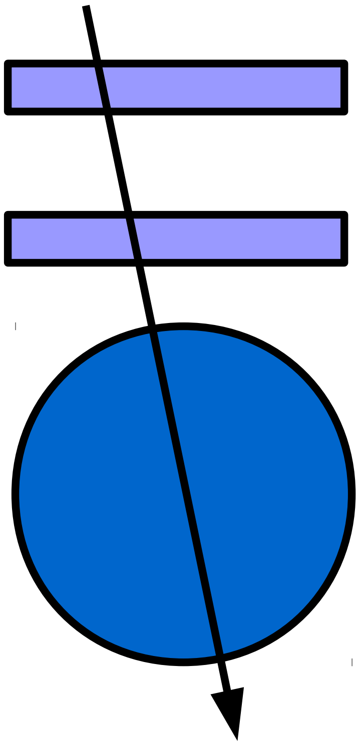
XY position of the Long scintillator.



Profile.

8-Channels USB- WaveCatcher demonstration

Muon



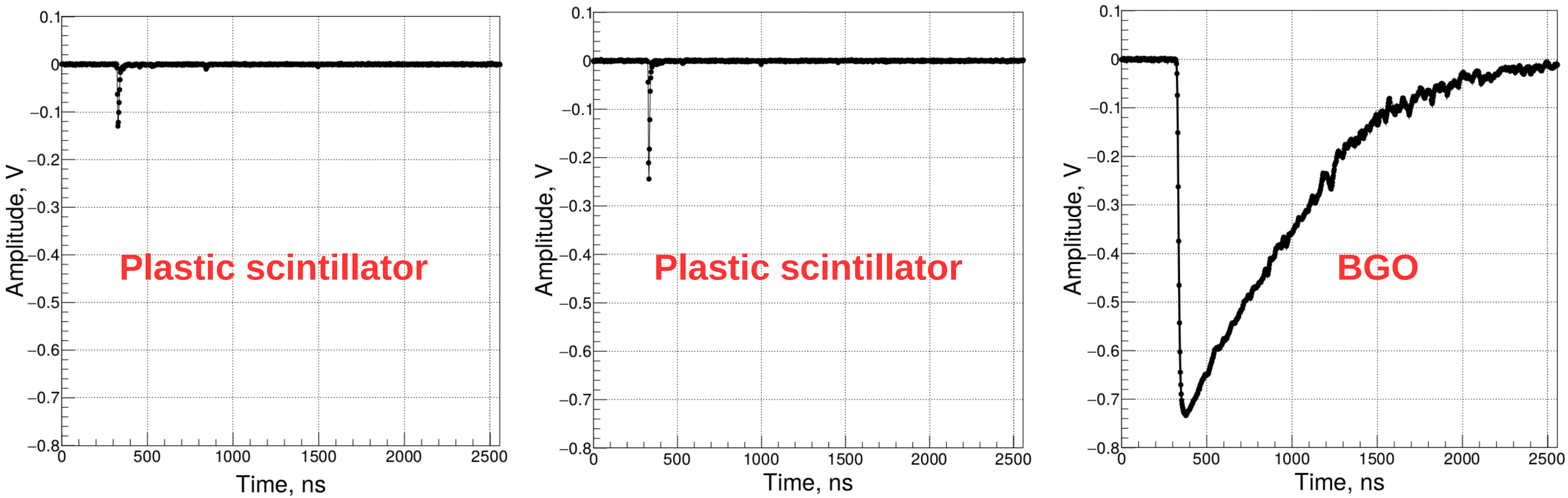
Plastic scintillators
5 x 5 x 2 cm^3

Plastic scintillators
5 x 5 x 2 cm^3

BGO scintillator crystal
5 x 15 cm^2
Decay Time 300 ns

PMT tube

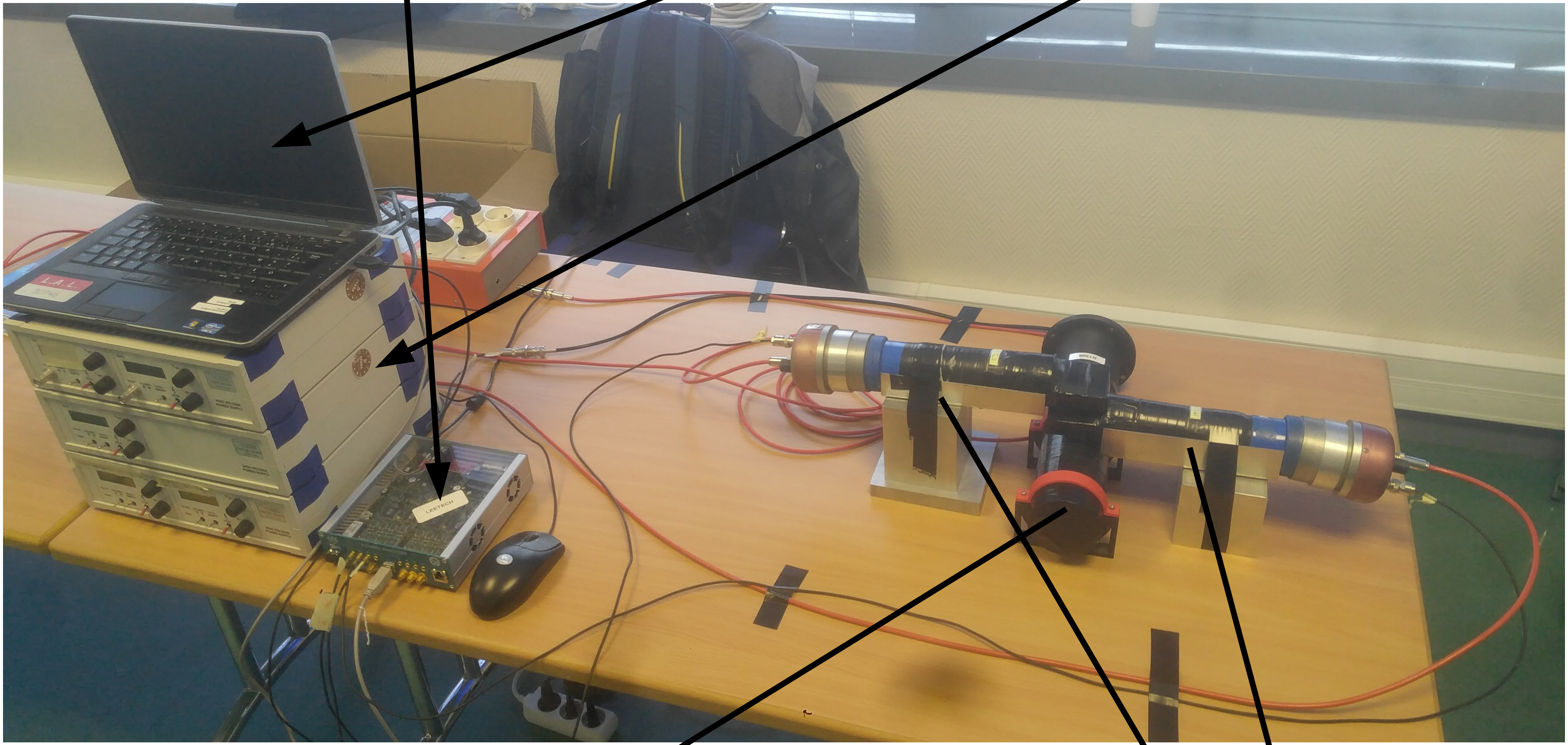
Waveform recorded by WaveCatcher



Thank you to IPN instrumentation team for the system

8-Channels USB-WaveCatcher demonstration : setup

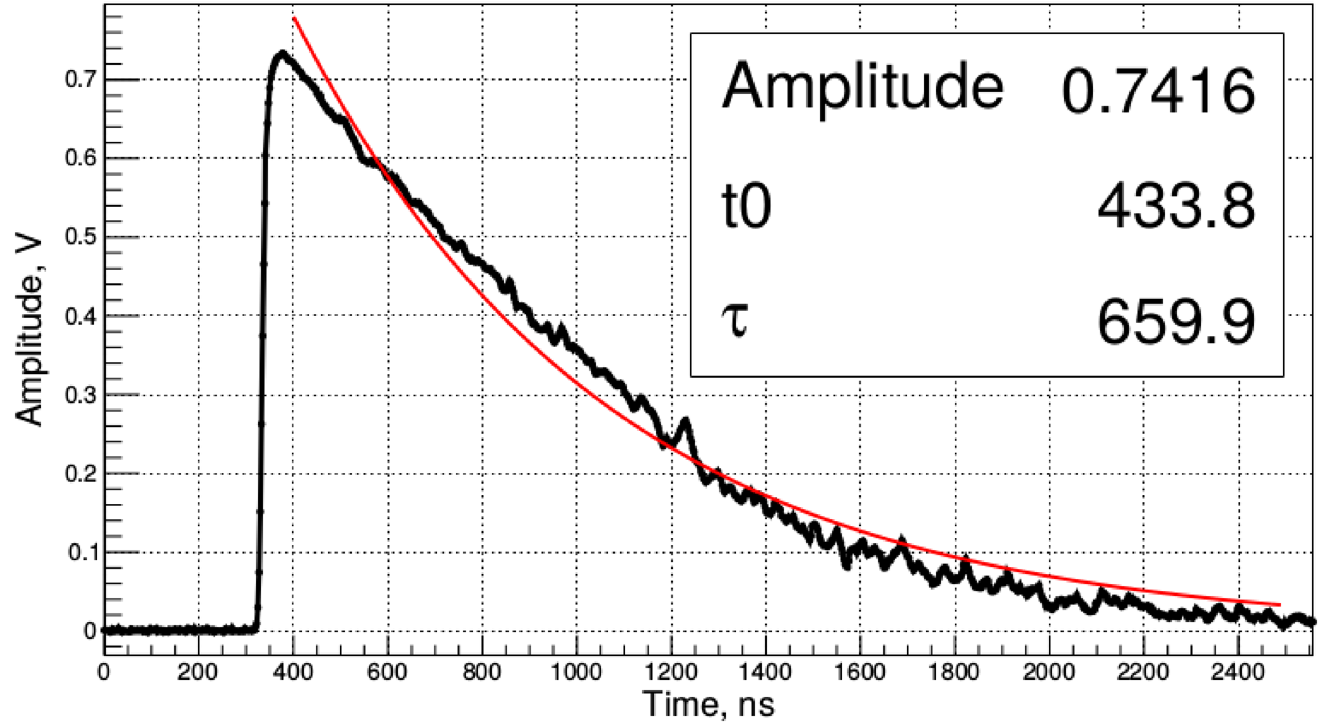
8-channels USB-WaveCatcher **DAQ laptop** **PMT power supply**

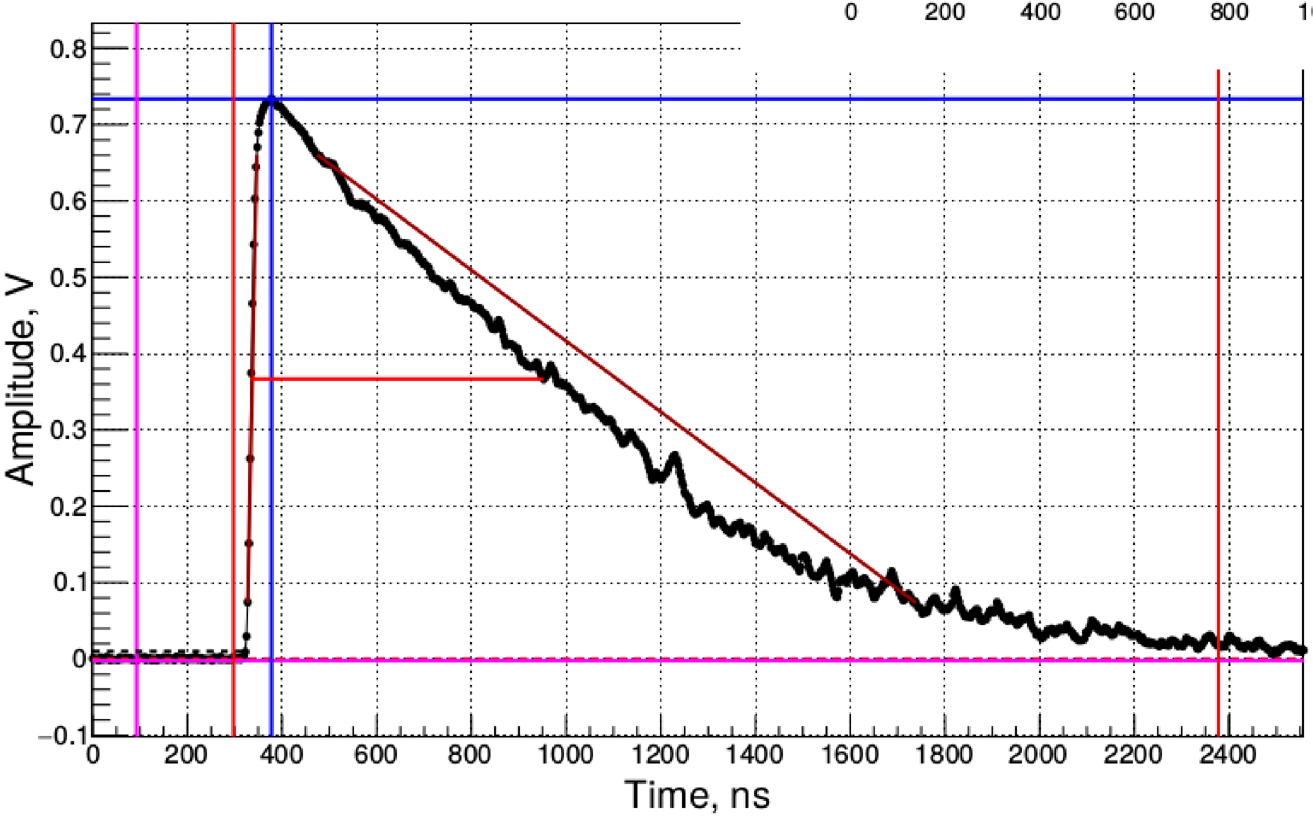


BGO scintillator **Plastic scintillator triggers**

Exercise 1 : fitting decay time of BGO wf – analysis

- Waveform is stored
- Please note the wf is inverted

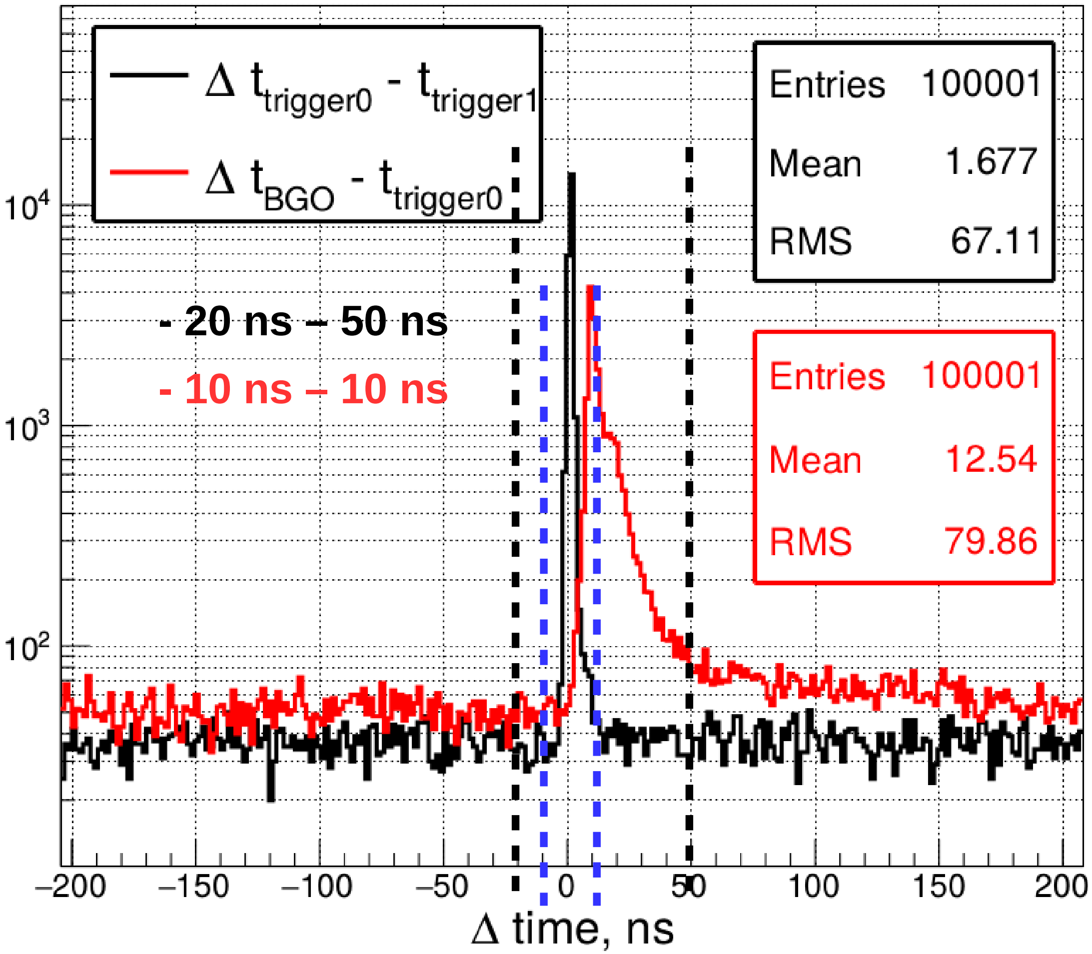


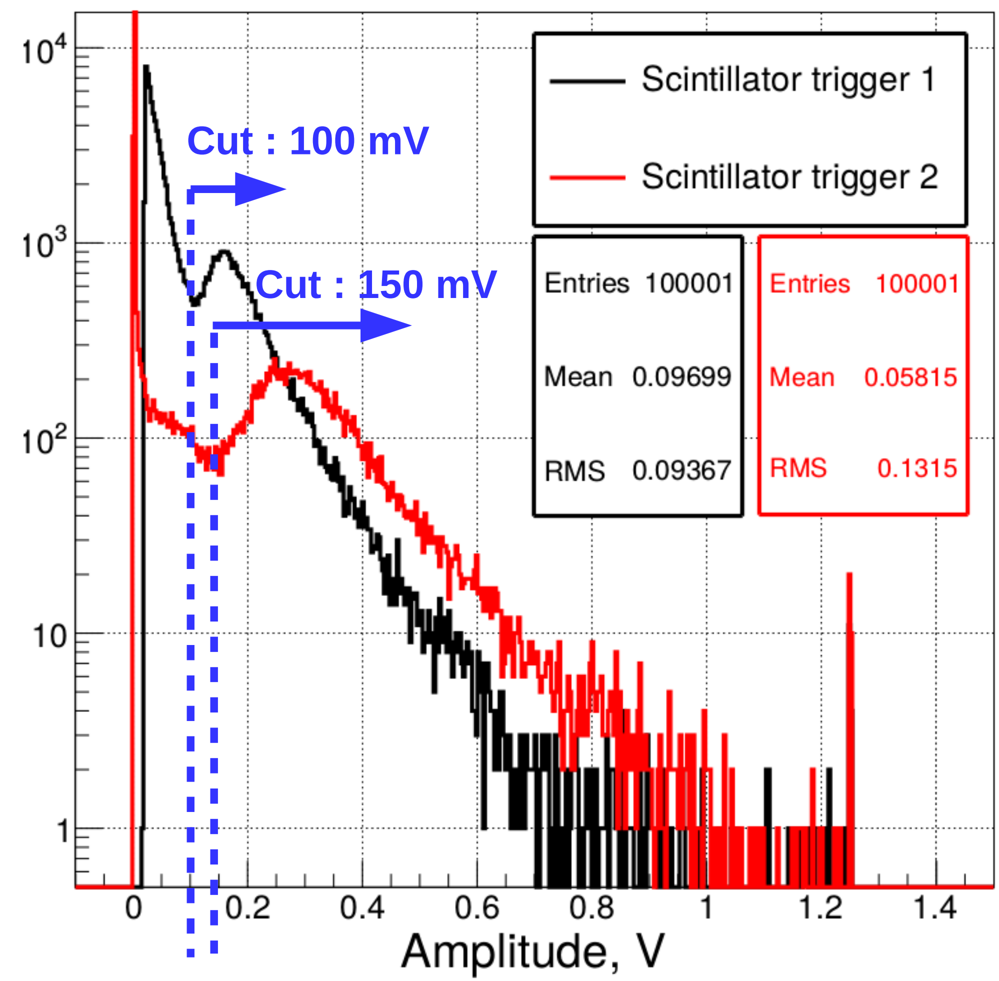


_sigWidth = 616.855
_sigRise = 19.0817
_sigFall = 1264.23
_timeCFD = 334.829
_chargeInW = 525.711
_timeConstThreas = 322.582

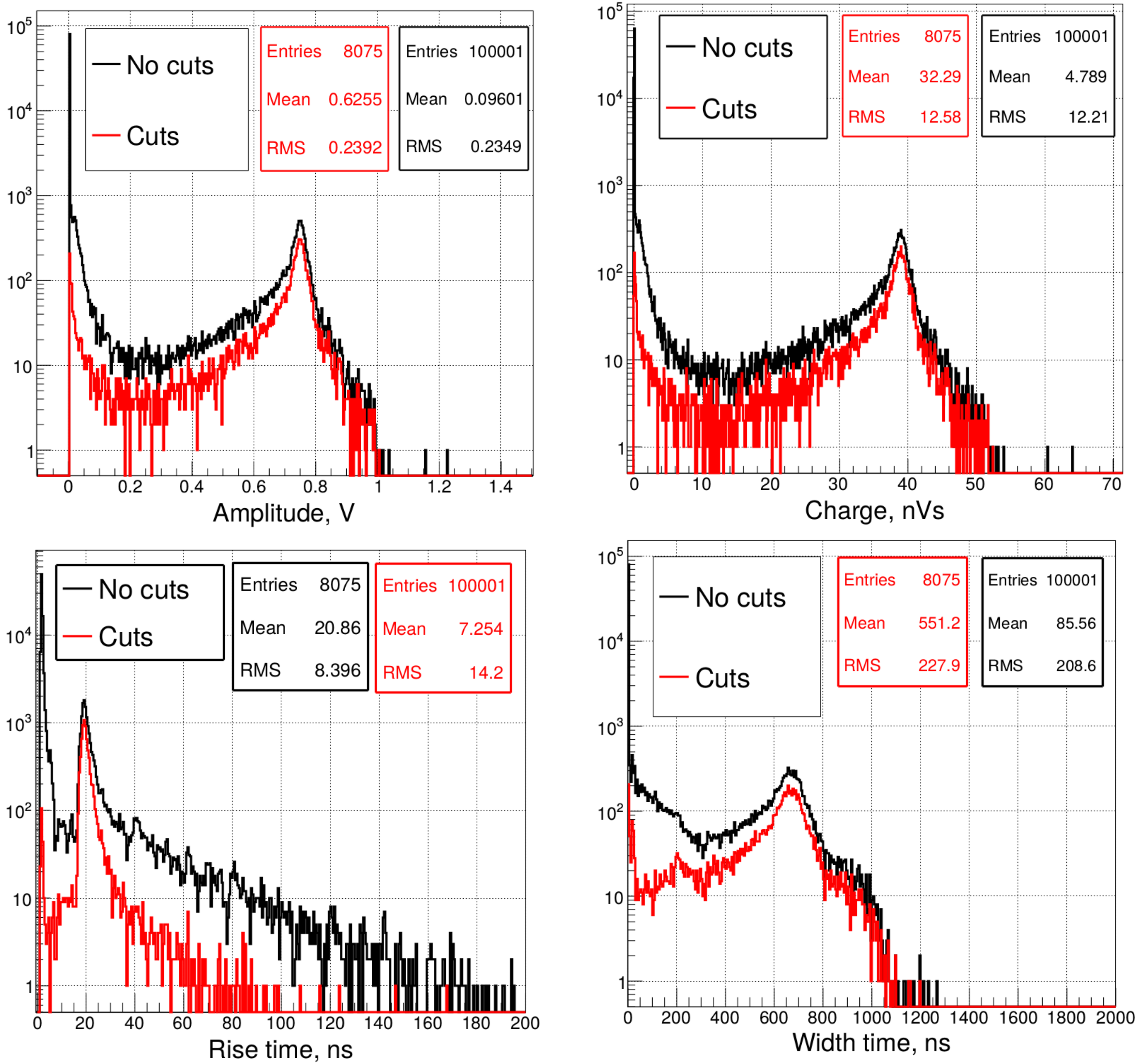
Exercise 2 : simple analysis

- Off-line cuts on :
  - Amplitudes of plastic scintillators.
  - On delta time of plastic scintillators.
  - On delta time of plastic scintillator ch 0 and BGO.





Exercise 3 : Results BGO



Second part of presentation would be presented by :

Andrii Natochii