

Light readout performance

WA105 Collaboration meeting 22/03/2017

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on behalf of the CIEMAT and IFAE groups

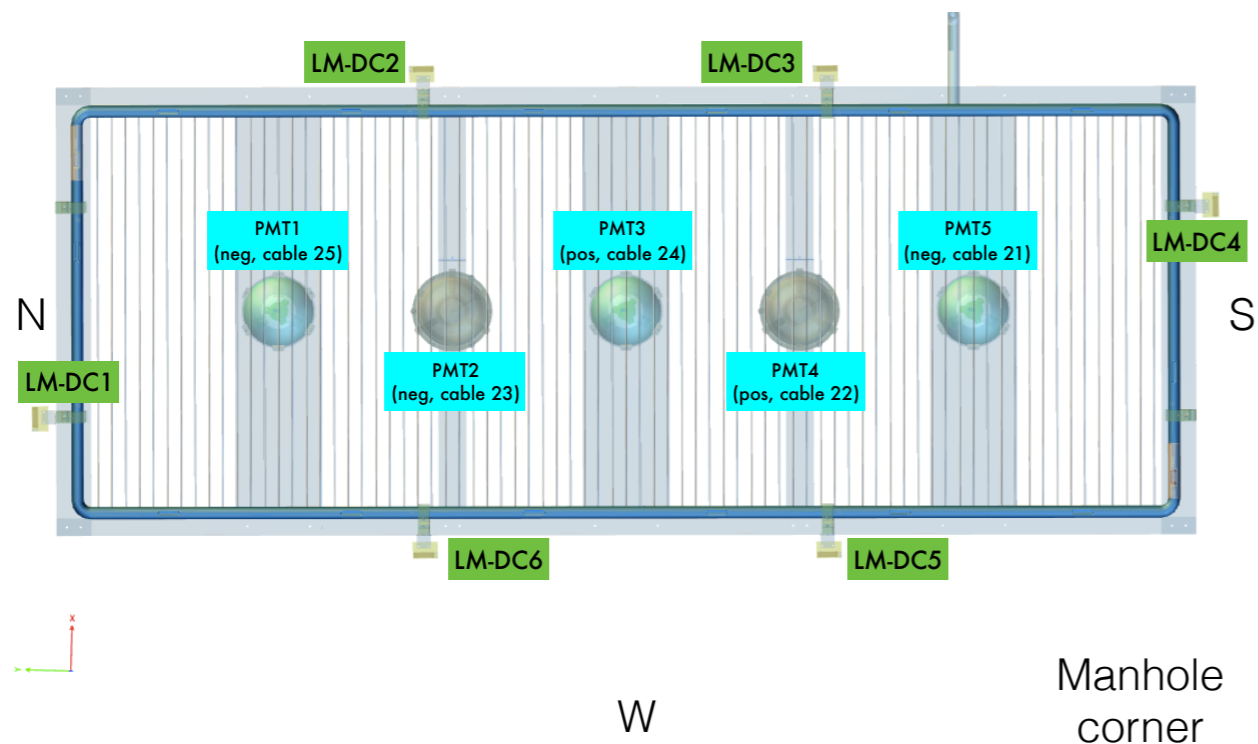
Overview

- Status of the Light readout system for the 3x1x1
 - PMT & DAQ installation
 - Pre-commissioning activities
 - First look at some data in warm GAr
- Plans for the light readout commissioning and data taking

Summary of PMTs installation

June 2016 by Antonio Verdugo and David Redondo

- Signal and HV connection to the PMT
- Mechanical installation of the PMTs
- Cable routing up to feed-through
- Test with oscilloscope after installation



Name	PMT1	PMT2	PMT3	PMT4	PMT5
PMT #	FA0093	FA0092	FA0090	FA0094	FA0091
ADC channel	0	1	2	3	4
Pos/Neg	— (2 wires)	— (2 wires)	+ (1 wires)	+ (1 wires)	— (2 wires)
operating HV	-1500 V	-1500 V	+1300 V	+1100 V	-1500 V
HV cable #	25	23	24	22	21
Signal cable #	3	2	none	none	16
TPB	direct coating	plate	direct coating	plate	direct coating
Base	KEK	KEK	CIEMAT	CIEMAT	KEK

*All PMTs were tested at CERN before installation

Readout configuration

September 2016 by Thorsten Lux and Federico Sanchez

- The readout Board: CAEN V1720
 - 8 channels, 12 bit ADC, 250 MS/s, 2 V input range
 - Buffer memory 1.25 MS/ch (5 ms time window)
 - External NIM trigger
 - Software configurable self-trigger logic
- The DAQ Software:
 - MIDAS: linux based DAQ developed by PSI & TRIUMF
 - Easy setup + web based interface for data taking
- Storage: 2TB local USB disk + 1TB storage on EOS

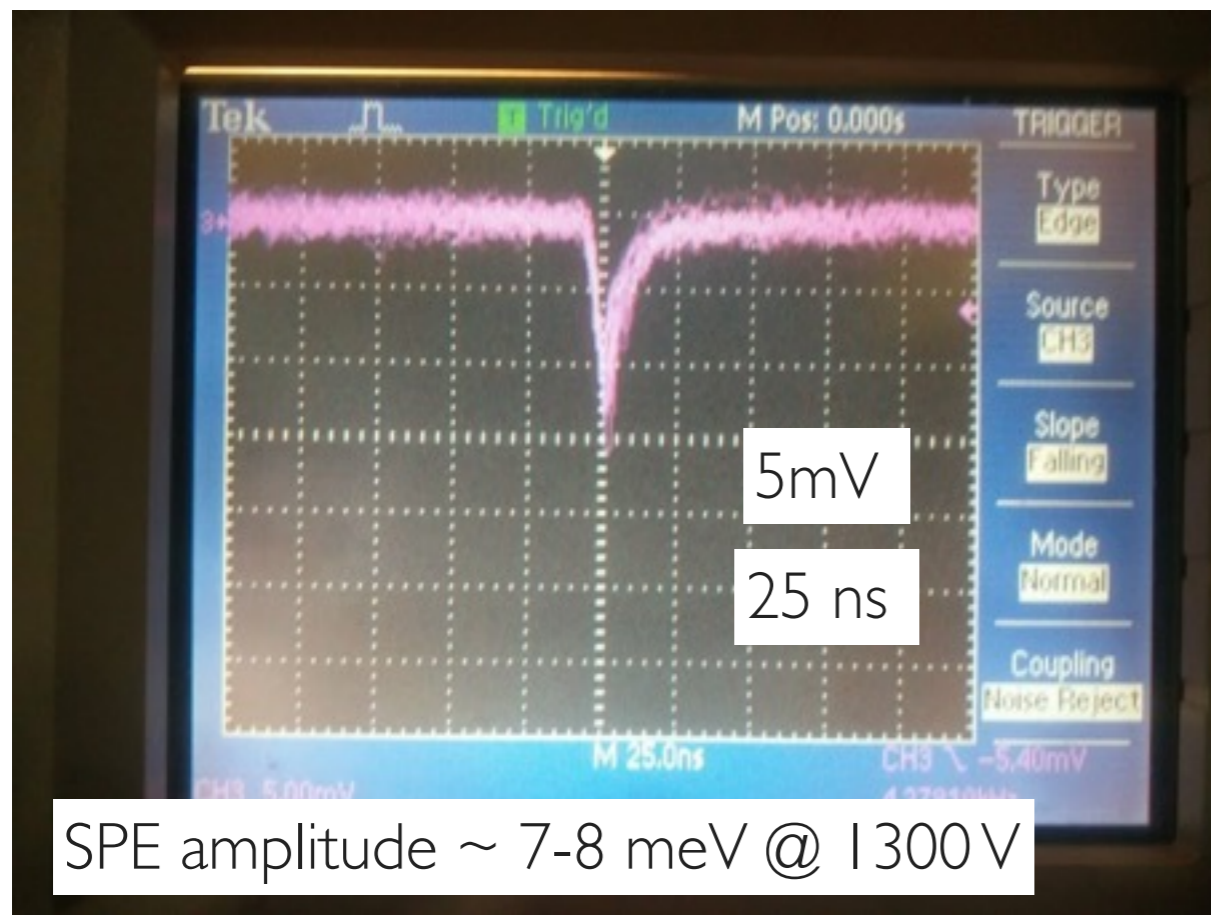


PMT pre-commissioning (mid-February)

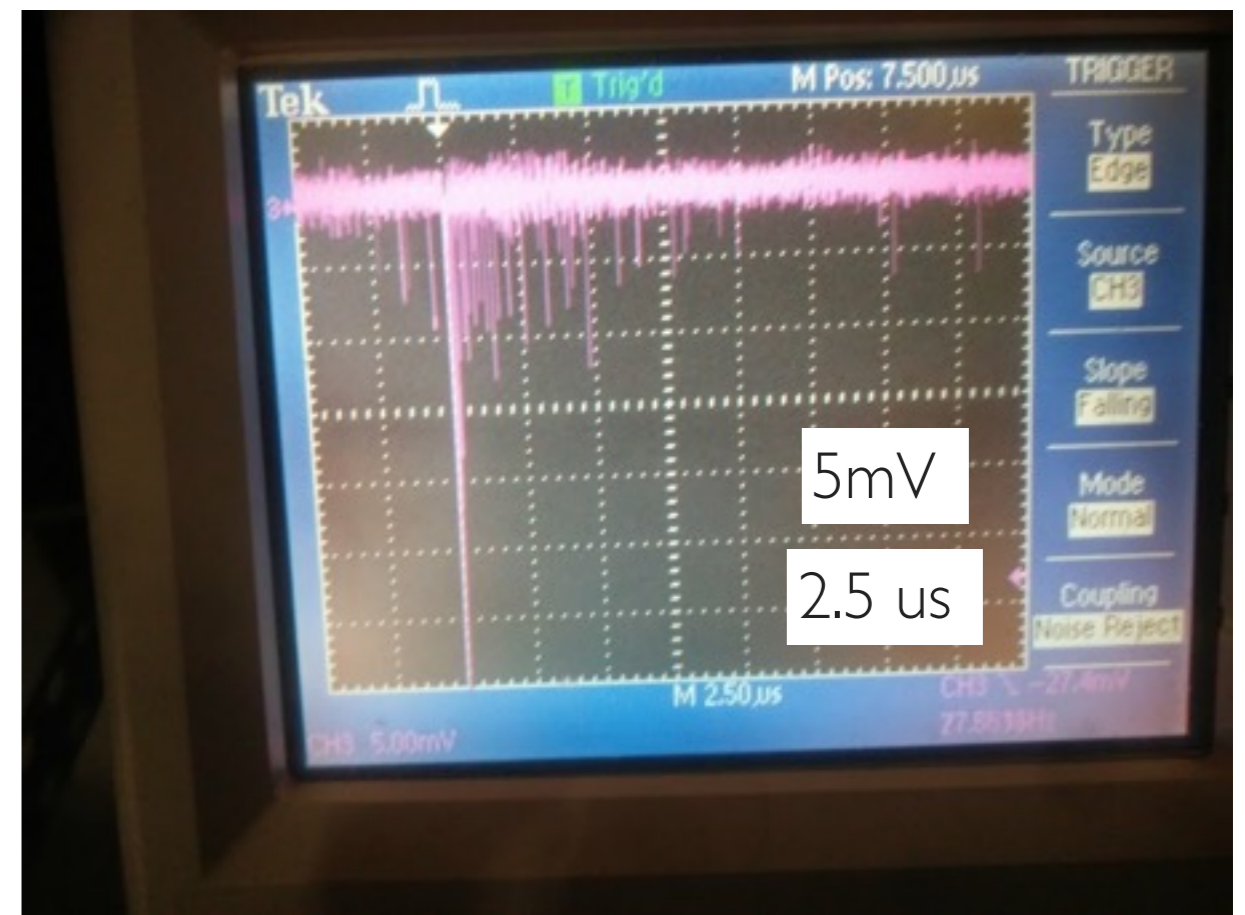
Alberto, Silvestro, Laura M.B., Cosimo, Yann

- Check HV and signal connections
- Switch on PMTs (one by one) up to ~80-90% nominal voltage
 - Check SPE signal from dark current and scintillation light in GAR

PMT1 Vset = -1300 V



PMT1 Vset = -1300 V



DAQ pre — commissioning (March)

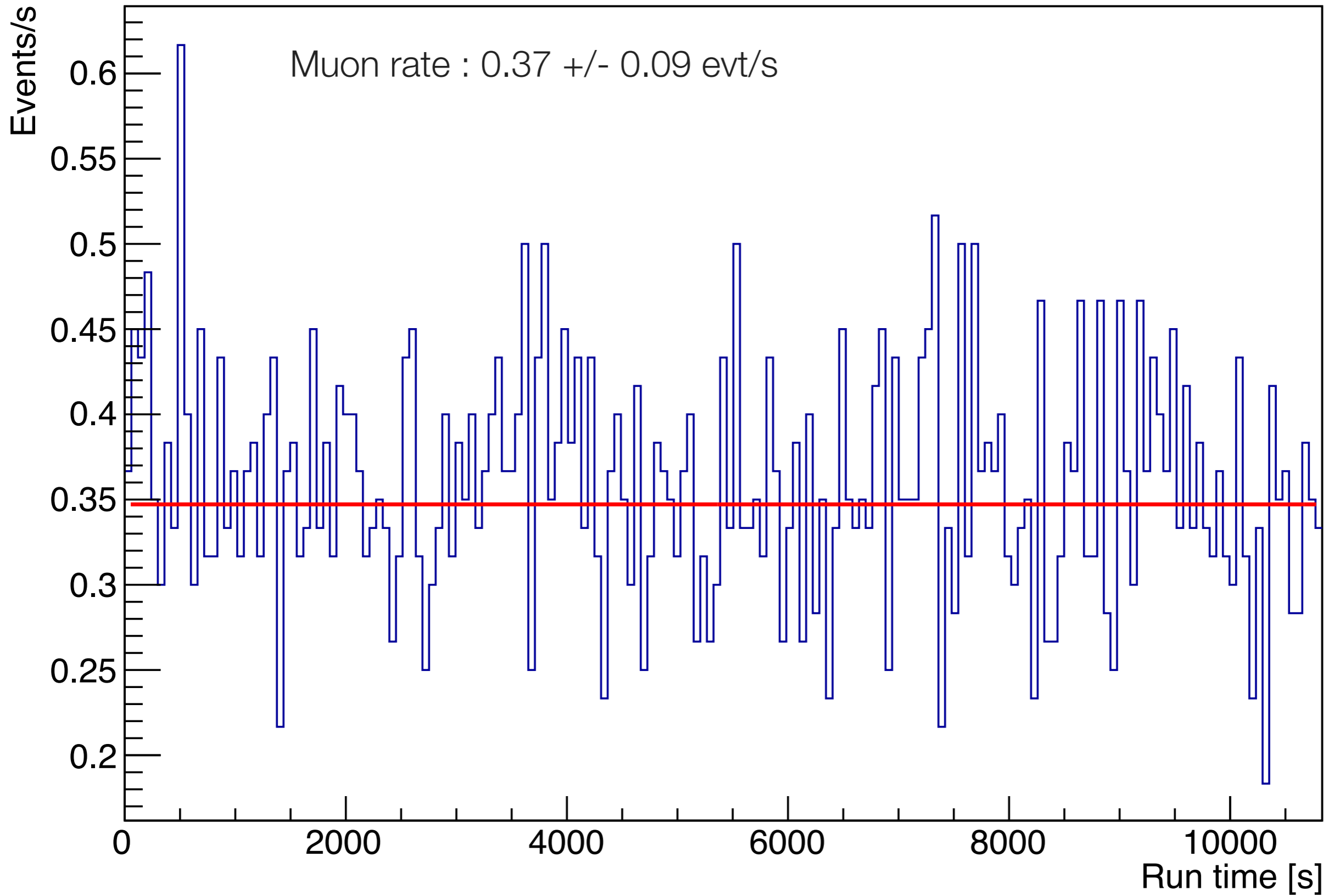
Alberto, Silvestro, Federico

- External trigger from CRT in place
- Optical link between FADC and DAQ PC in place and working
- DAQ start up and loop correctly on dry-run (HV off)
- Fine tuning of the pedestal and trigger position on the ADC
- Set up automatic Raw data to ROOT format conversion
 - Evt.no, time, PMT waveforms, CRT waveforms (preliminary format)
- PMT & DAQ ready for commissioning
- DAQ software stable and ready for regular data taking
- Few hours of run have been taken in warm GAr

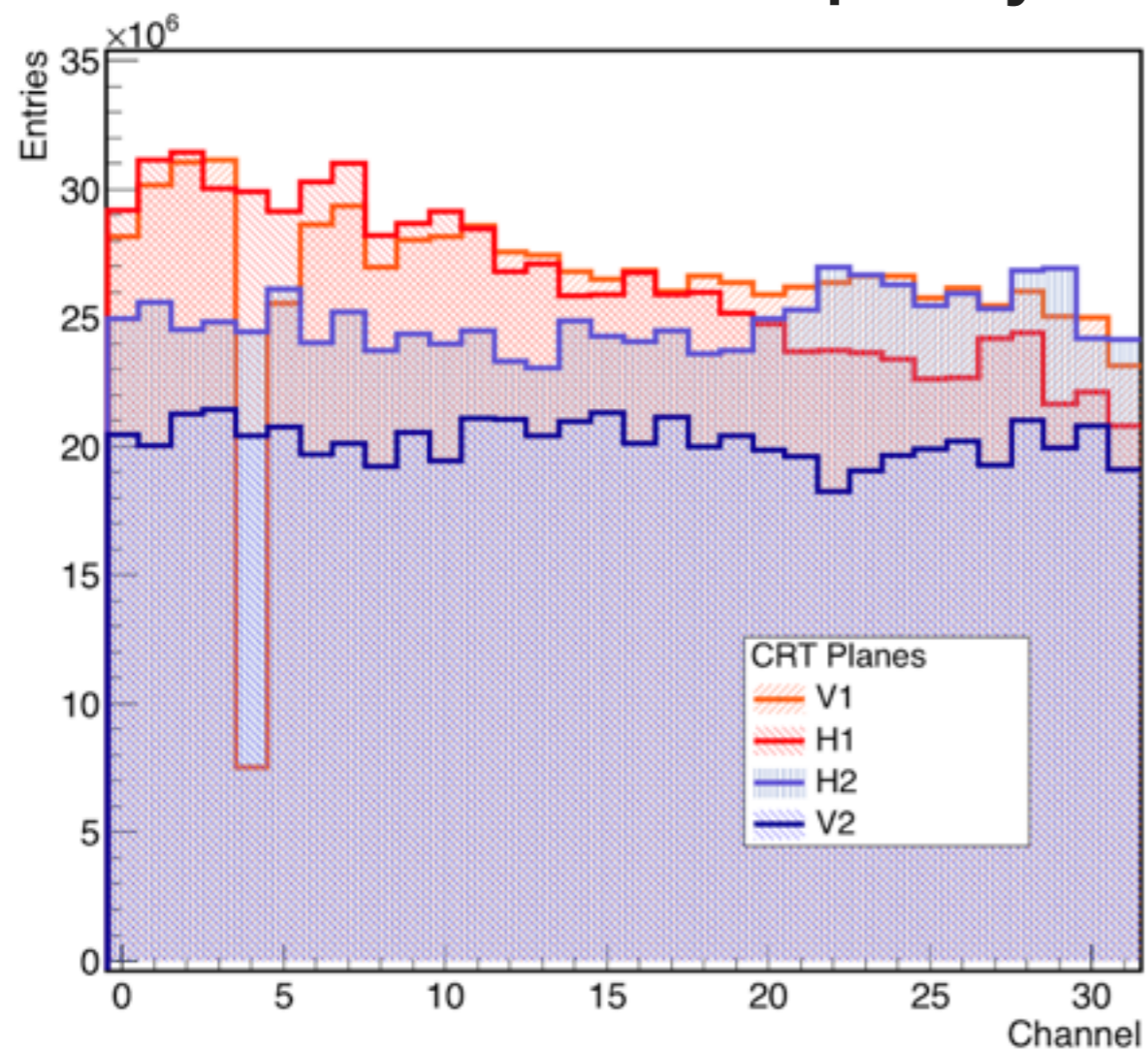
First look at some data

- Date: 06/03/2017 at 15h30
- Run number: 211
- Shifters: Alberto, Federico, Silvestro
- Run time: ~3h
- Total events read-out: 3913
- Run condition:
 - External trigger from CRT
 - HV set to values reported in slide 3
 - GAr warming up
- **PMT OPERATION NOT YET OPTIMISED** (i.e. no gain calibration)

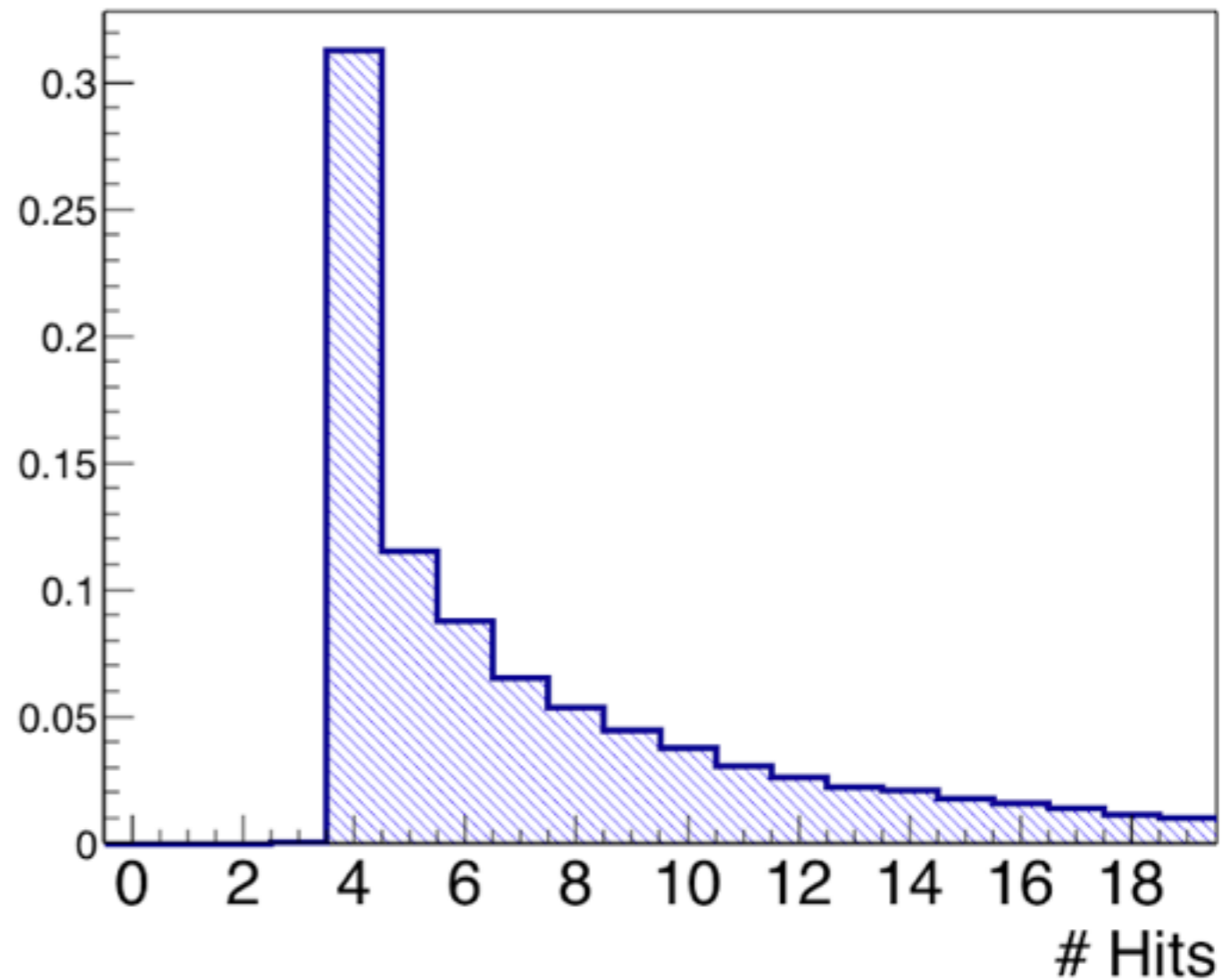
Event rate from external CRT trigger



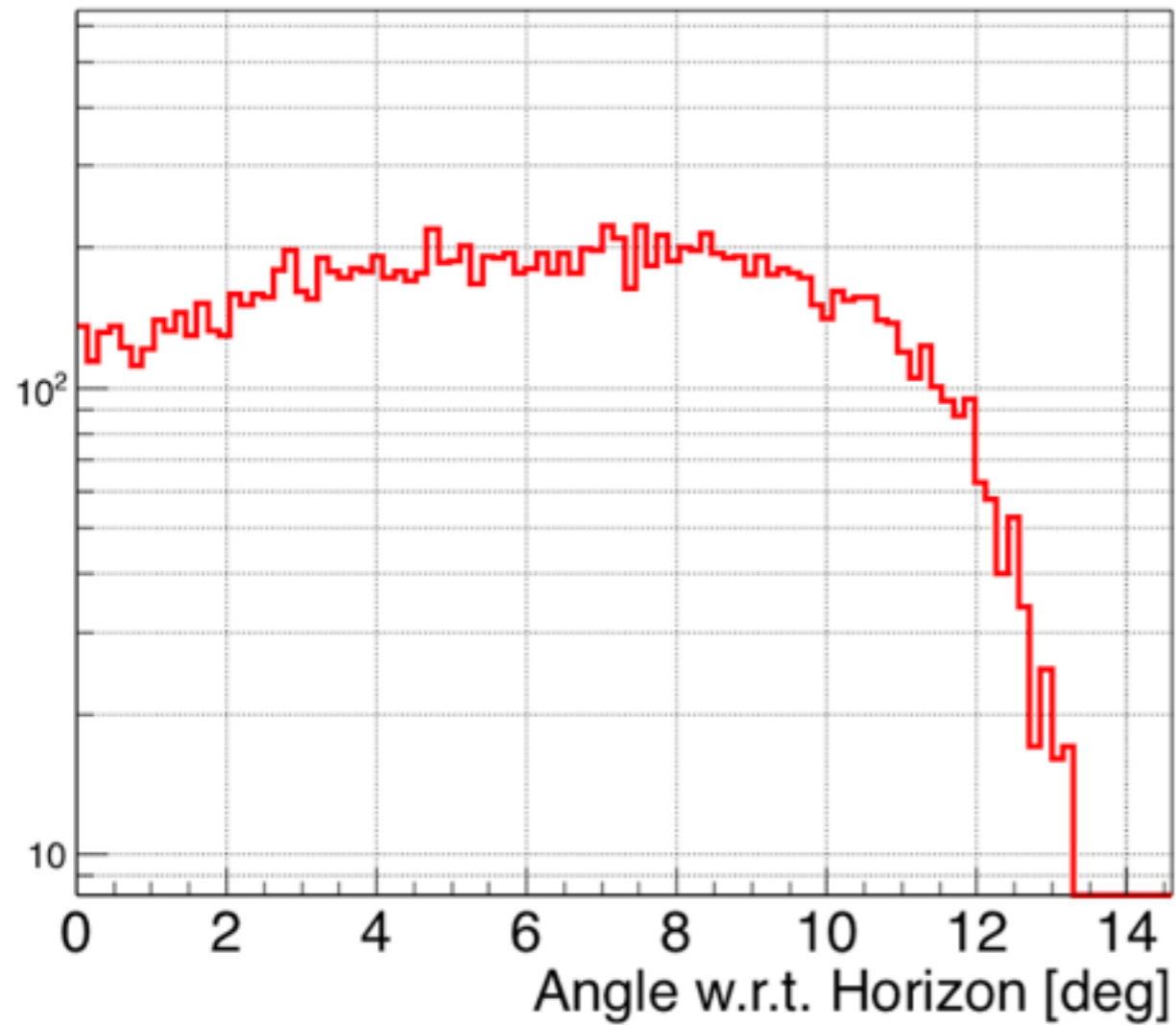
CRT Channel occupancy



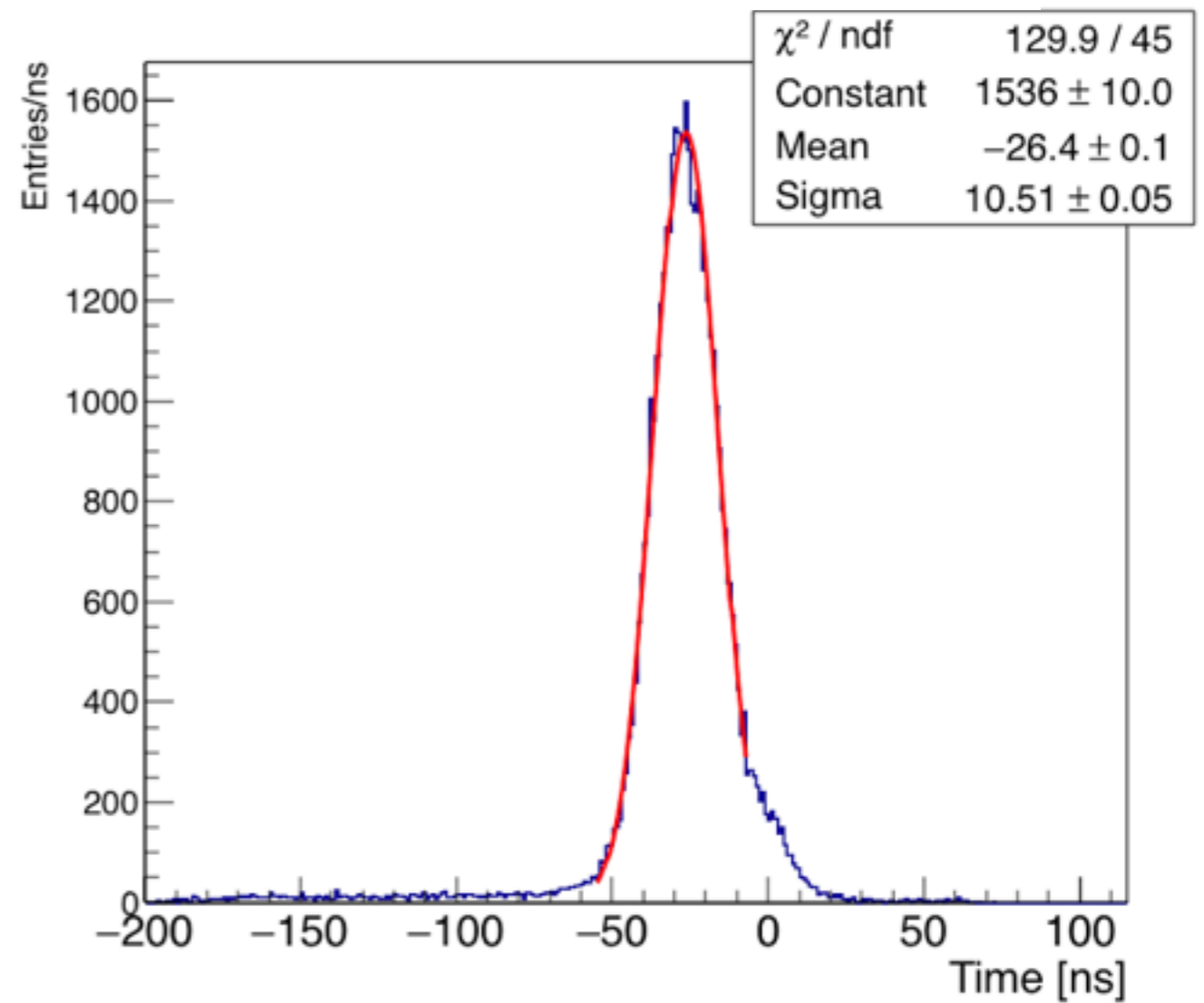
CRT Hit multiplicity



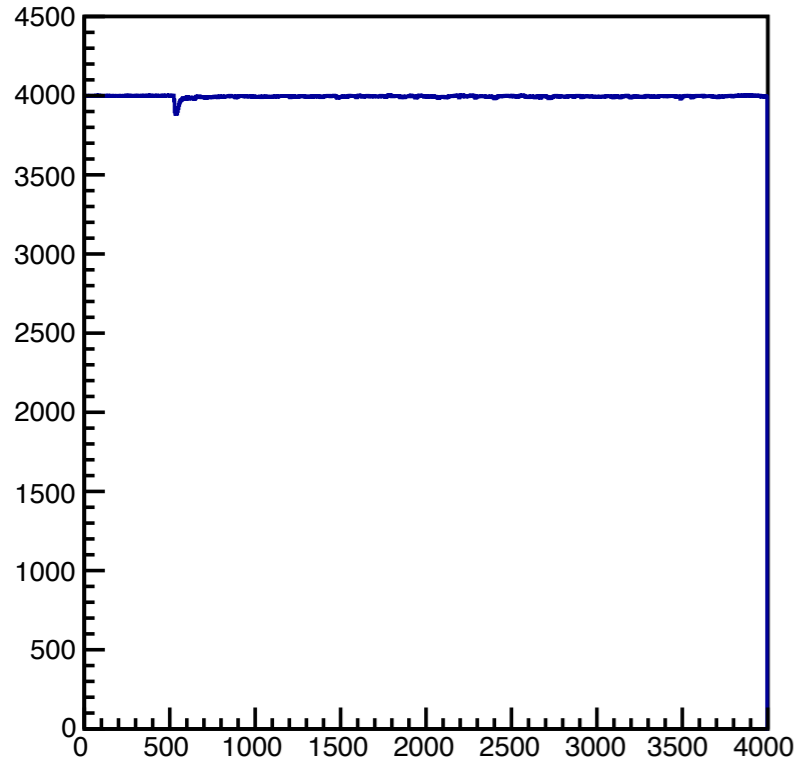
Reconstructed muon direction



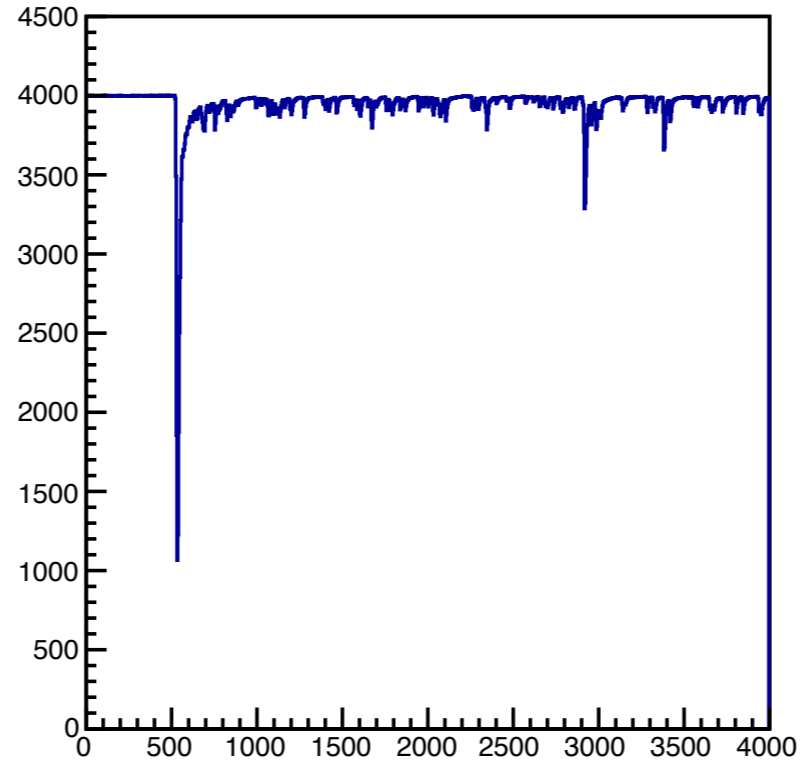
Reconstructed muon ToF



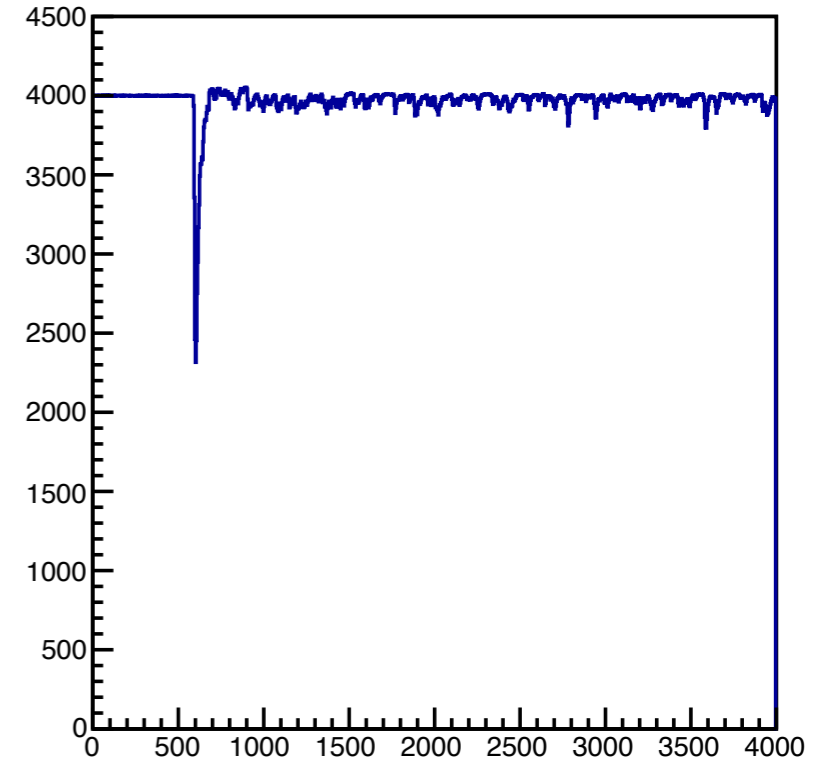
waveform_0_307



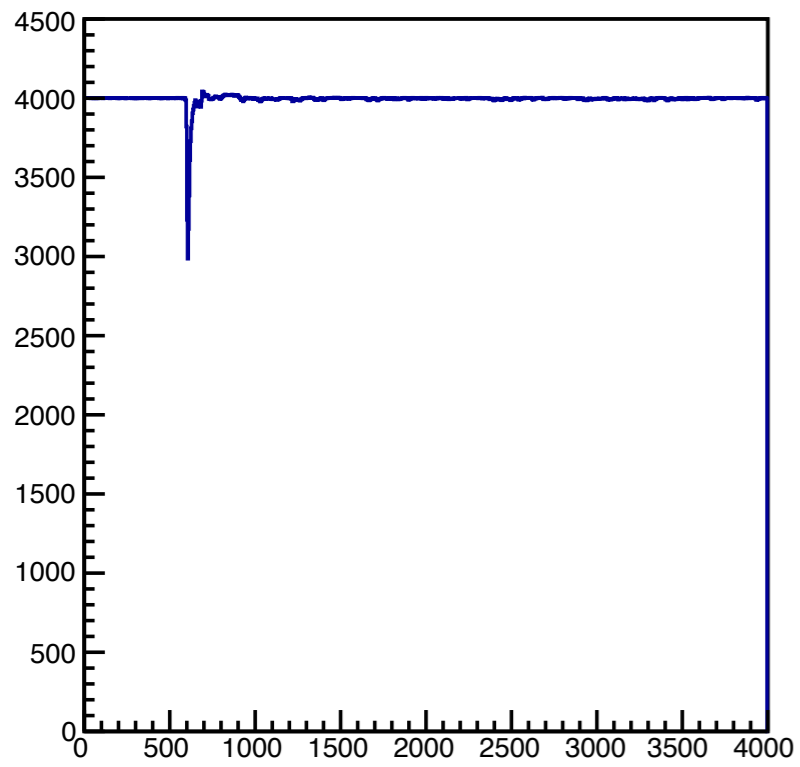
waveform_1_307



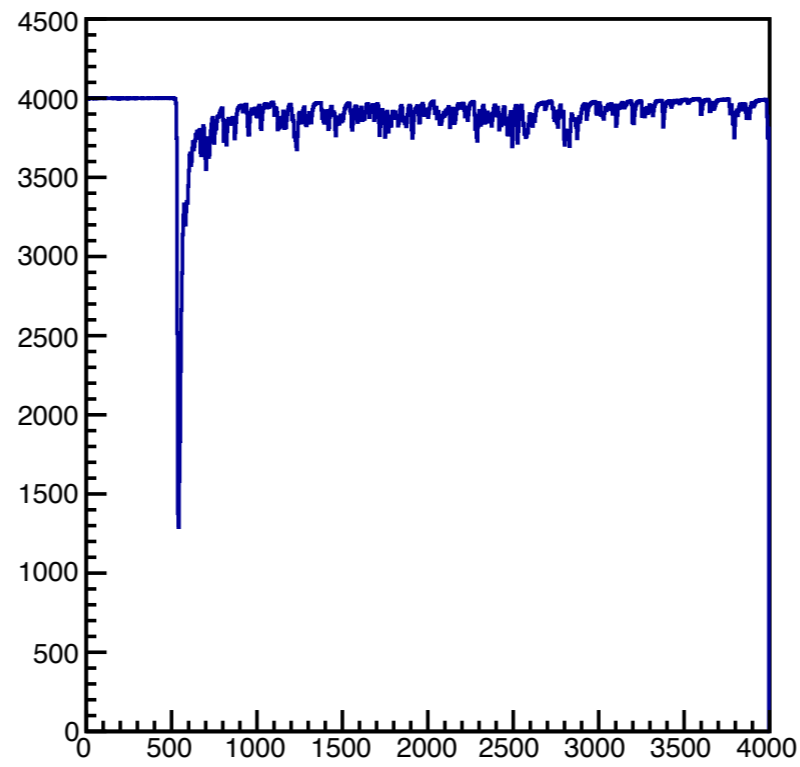
waveform_2_307



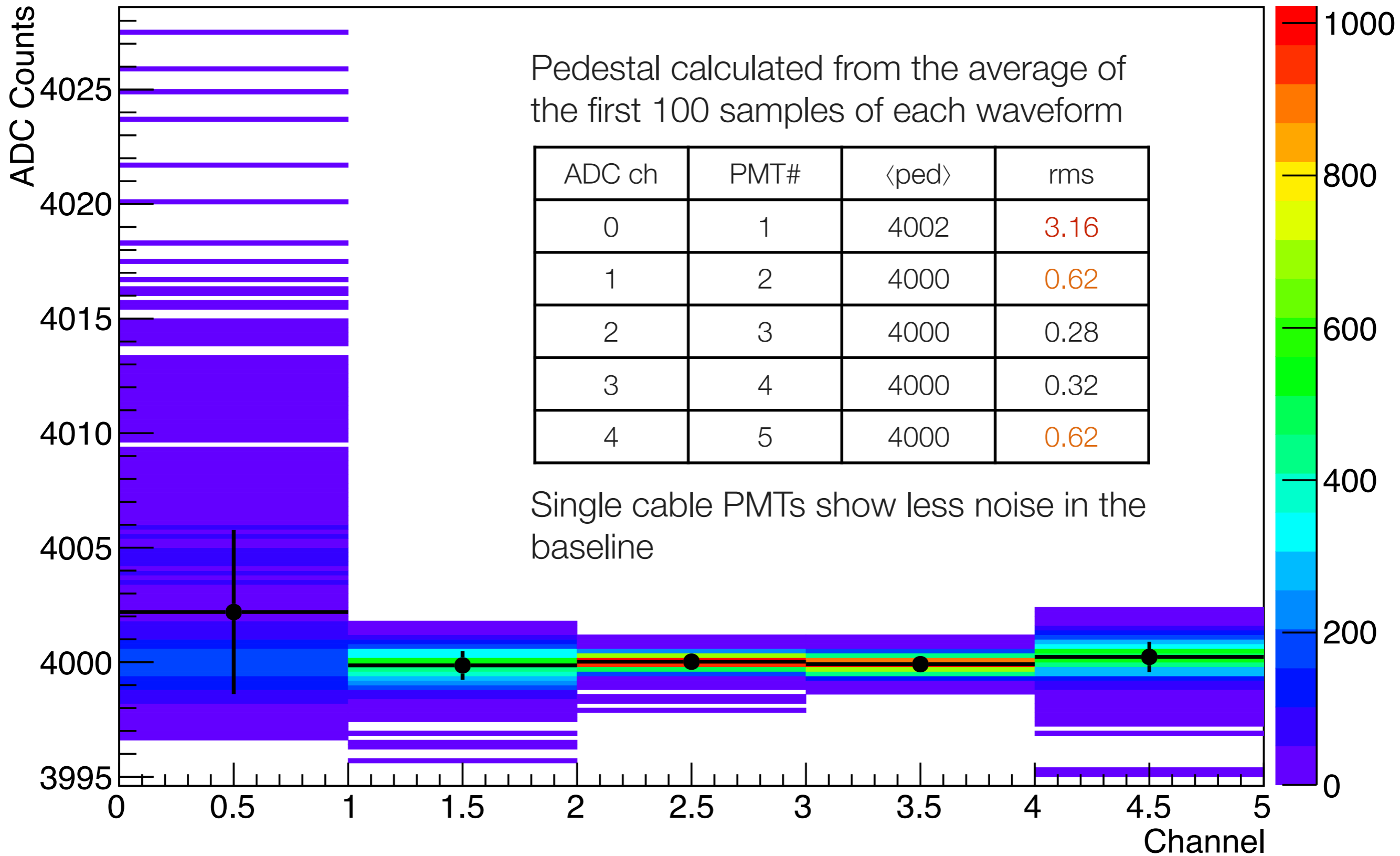
waveform_3_307



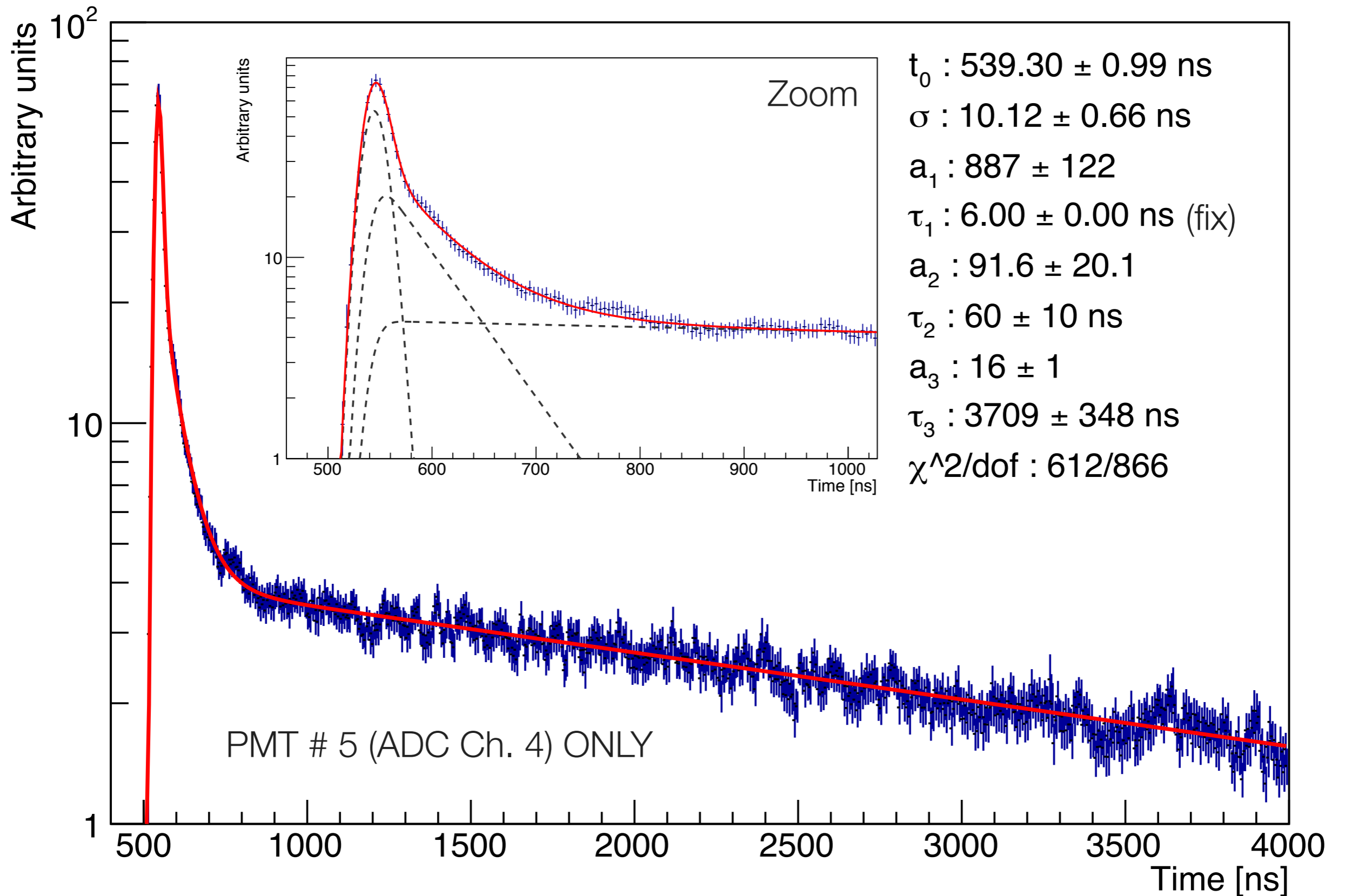
waveform_4_307



Pedestal vs channel distribution



Scintillation time in GAr (1000 mBar, 215 K)



Light readout performance so far

Some preliminary data confirms the PMT and the DAQ are working as expected:

- All 5 PMTs are alive
- CRT synchronisation is working
- Scintillation time response of the detector as expected

- Software tools are being developed to process and analyse PMT data
- The system is ready for the commissioning

(Preliminary) plans for the PMT commissioning

- Channel by channel noise chasing
- PMT self-triggering configuration and setup (threshold and multiplicity)
- PMT HV scan for gain calibration
- Electric Field scan for S1 studies
- LEM HV scan for S2 studies

- Some coordination would be required for the LEM HV and Field drift scan
- Depending from the duration of the scans, we could consider 1 or 2 weeks for the commissioning
- A detailed document has been prepared and shared with the operation group

(Preliminary) plans for the PMT data taking

PMT response stability:

- One or more hours/d at stable HV operation with PMT self trigger
- Studying light behaviour as a function of time, compare response from different PMTs

Muon run:

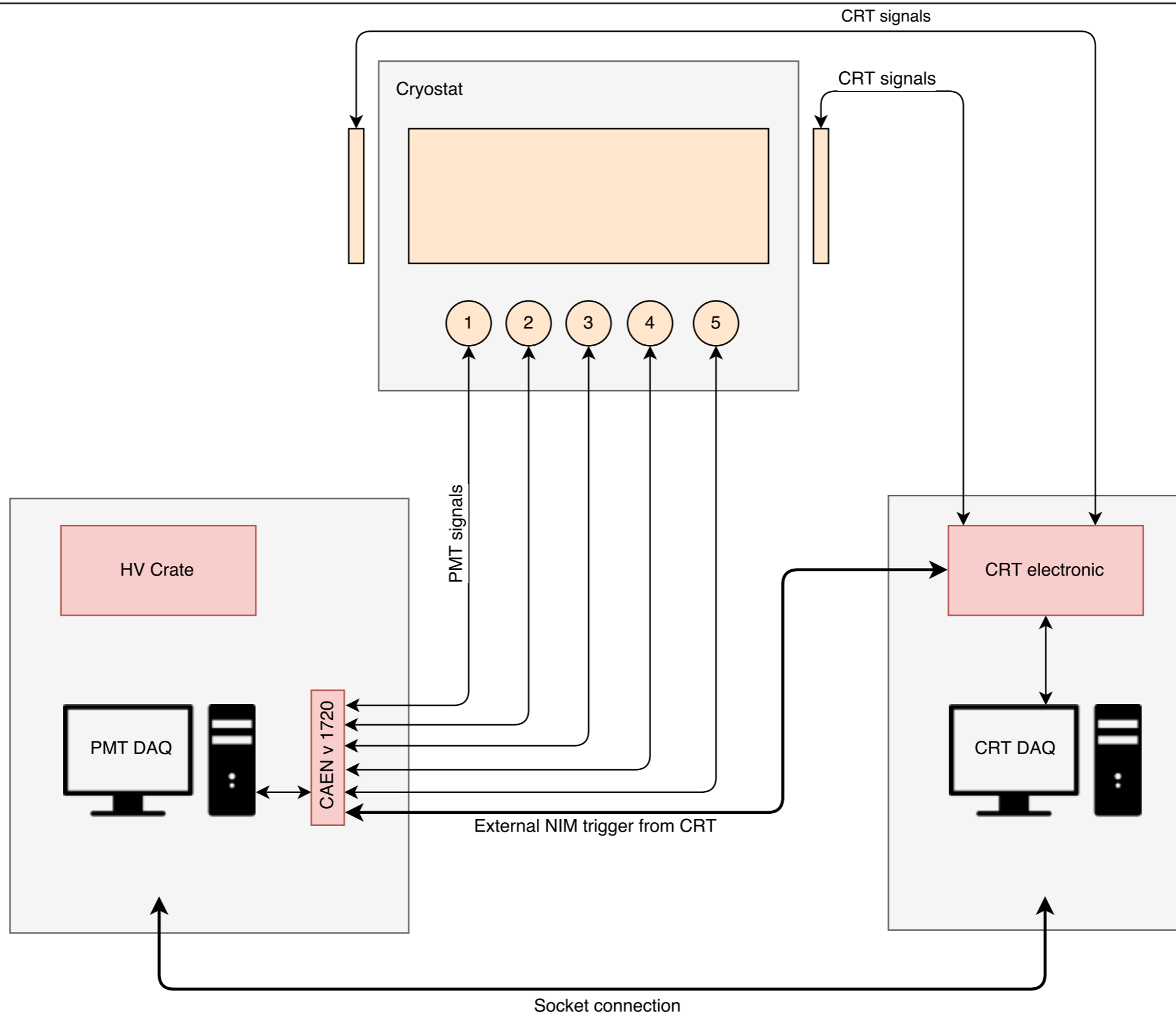
- One or more hours/d with the CRT external trigger
- Studying light produced by muons

Light & Charge:

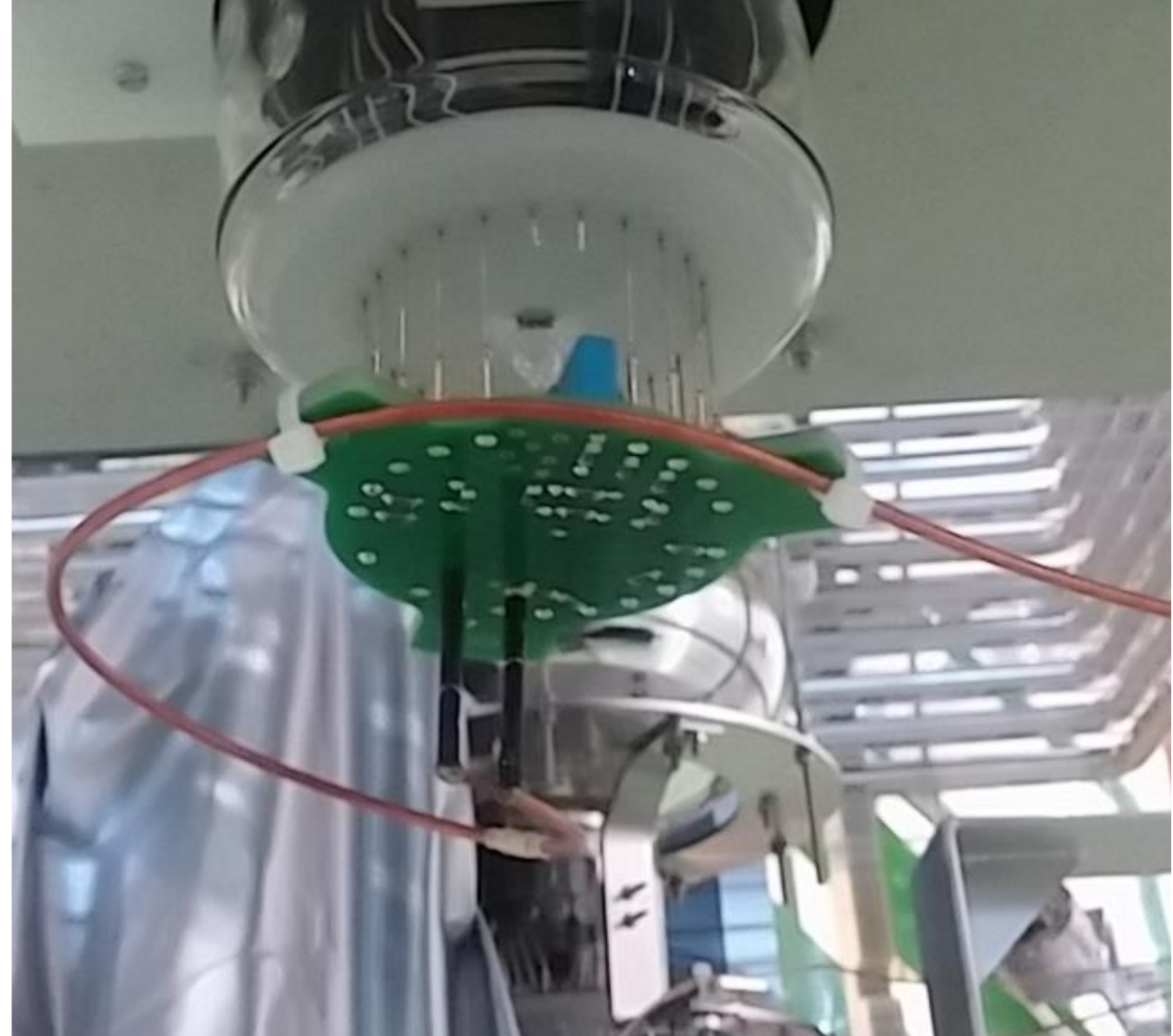
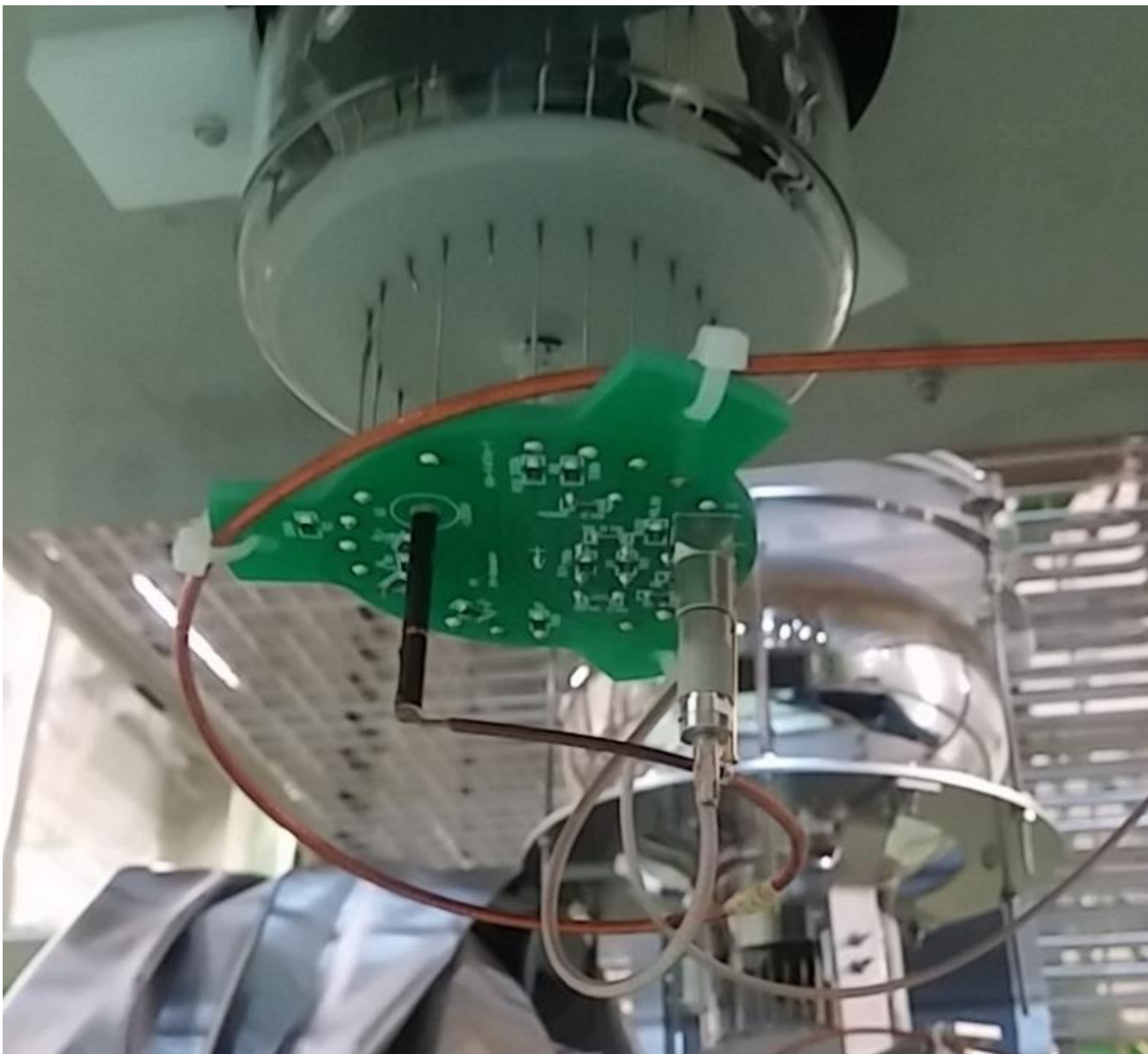
- One or more hours/h with the CRT external trigger, running in parallel with the charge readout
- Try to correlate light and charge at offline level using the muon time stamp

Backup

Current PMT DAQ design



Details of the cable connections



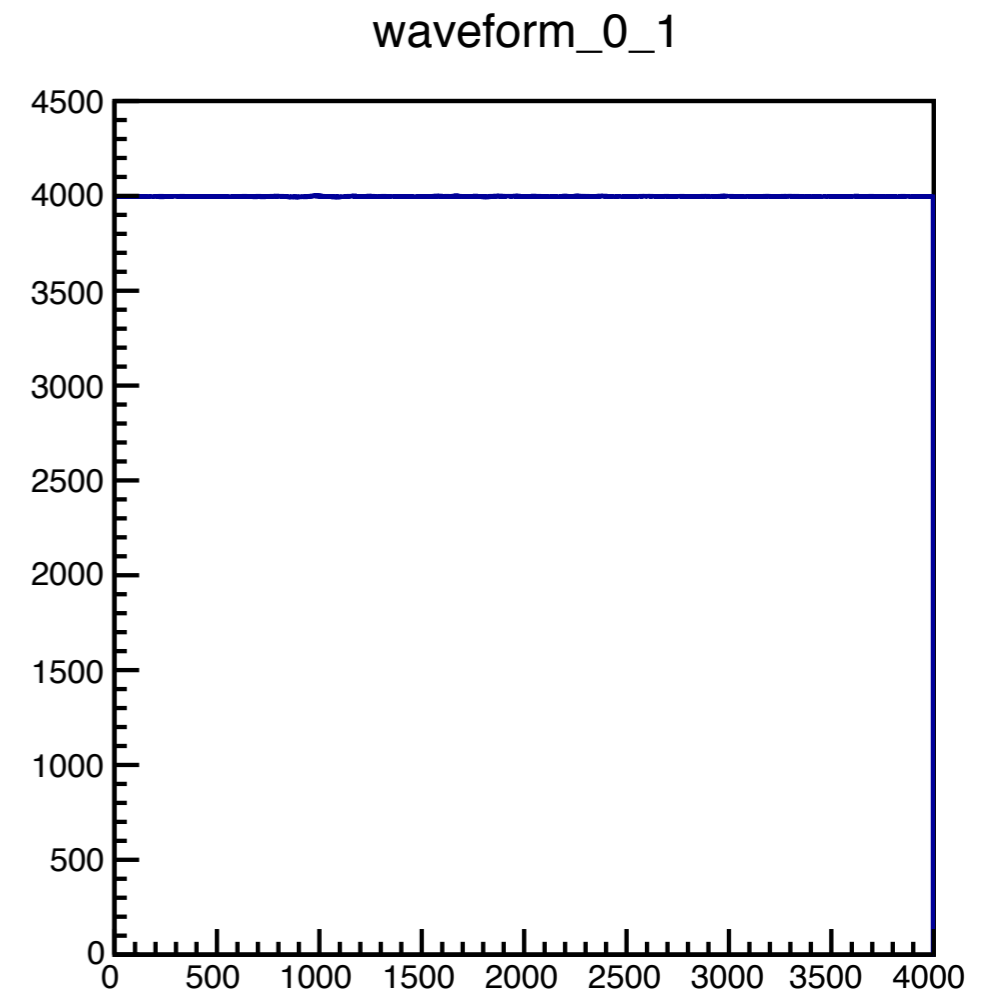
Improvised solution to allow to disconnect the cables from the PMTs

Solution not advised to the 6x6x6: make connection quite fragile

Current DAQ configuration

Alberto, Silvestro, Federico

- External trigger provided by the CRT
- No Self-trigger available yet
- Waveform in [0; 4096] ADC (12 bit)
 - Pedestal set @ 4000 ADC
 - Leave 96 ADC count for overshooting
- Trigger set at 500 ns
 - first 125 samples for pedestal calculation

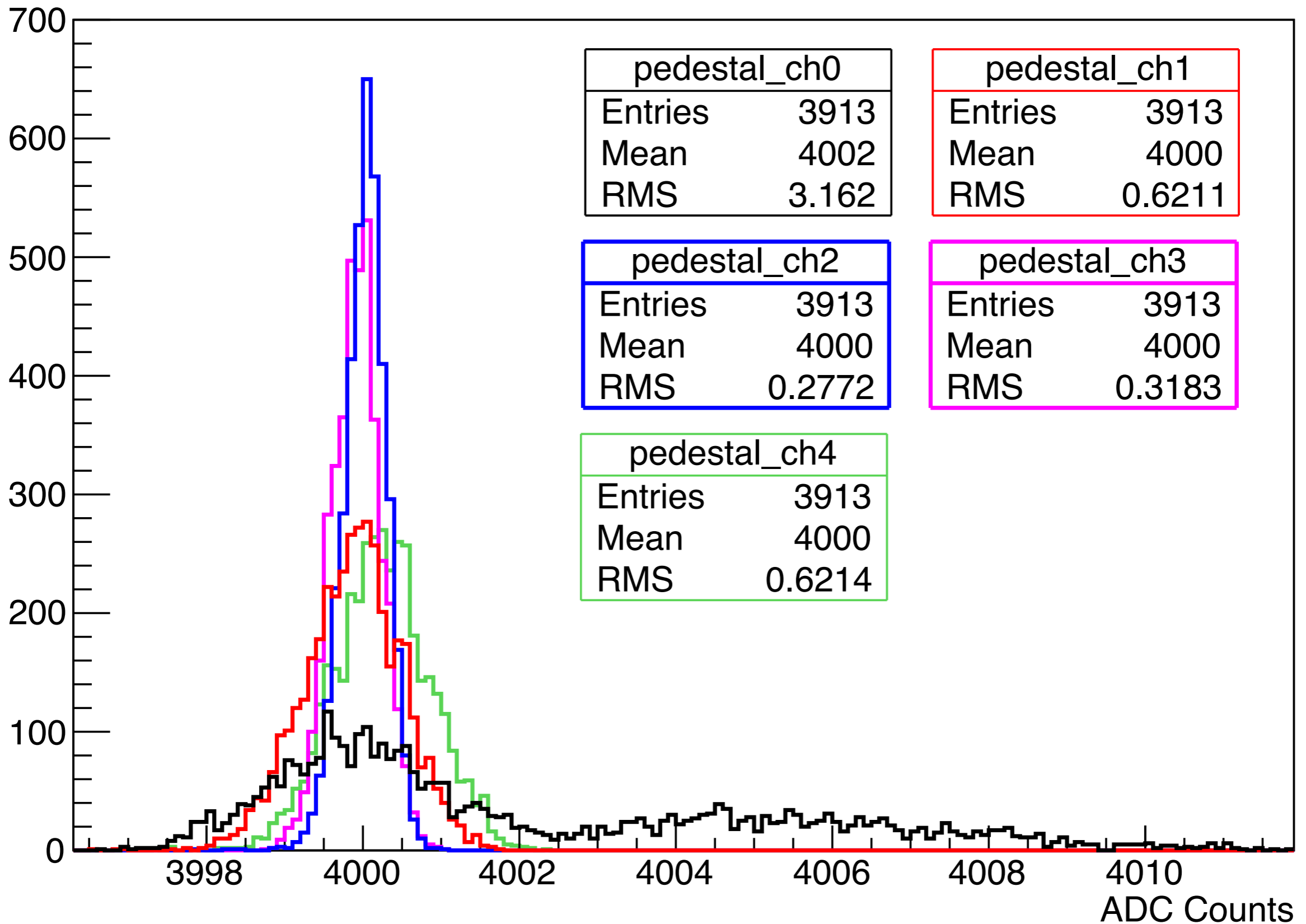


Current status

Alberto, Silvestro

- Few hours of run have been taken in warm GAr, for example:
 - Run 211: ~3h run in warm GAr with PMT ON
 - Run 223: ~2h run in warm GAr with PMT ON
 - Run 240: ~63h dry run to test CRT sync
- Data available [here](#) (temporary solution)

Pedestal distribution

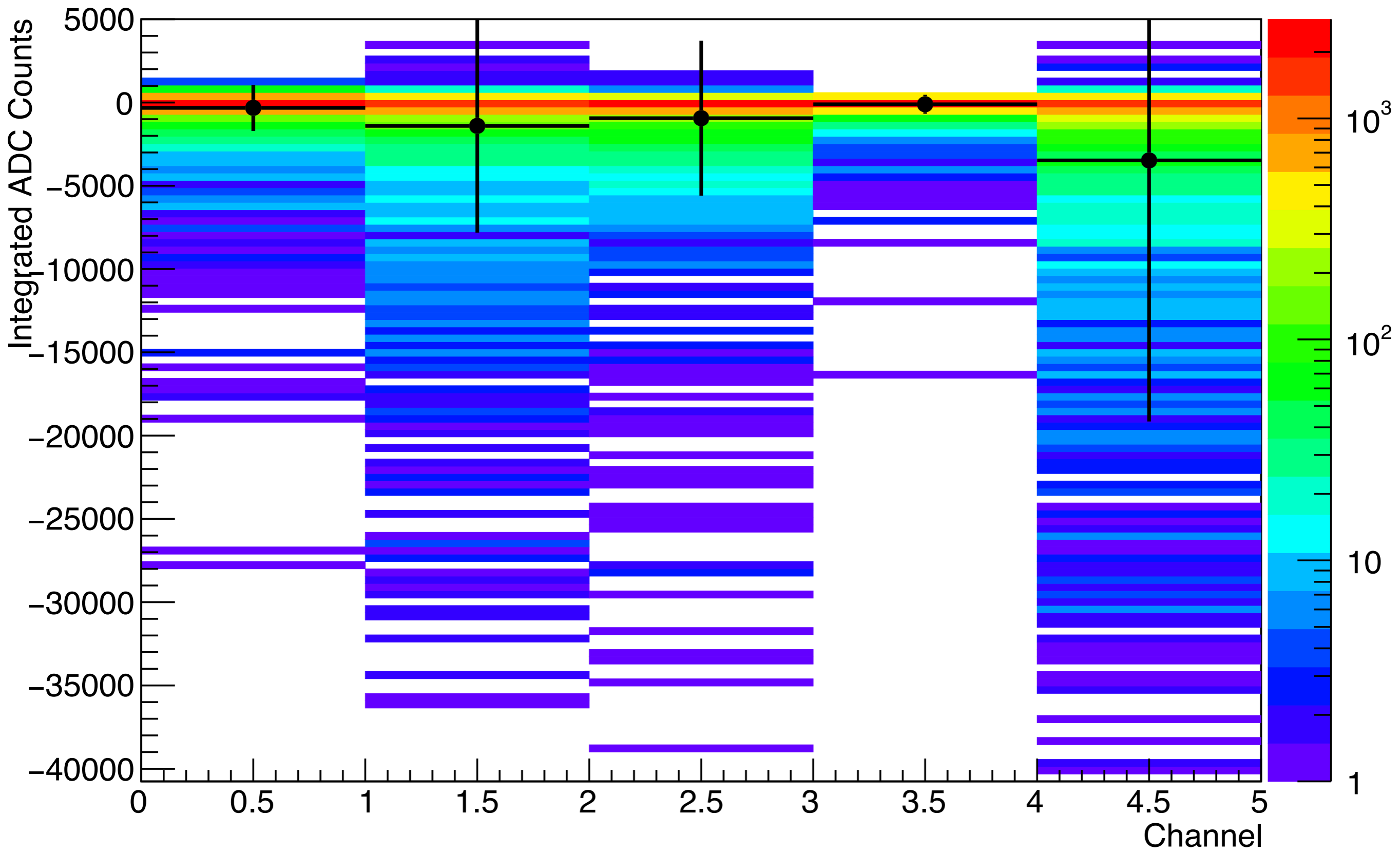


Scintillation time in GAr

- Average the non saturated waveforms from ch4 upon baseline subtraction
- Fit with 3 exponential convolved with a gaussian function
 - 2 exponential for the fast and the slow scintillation component
 - 1 exponential to improve the fit in the fast/slow transition region
 - Gaussian function to model the detector response to a muon crossing the detector

$$f(t) = G(t - t_0, \sigma) \otimes \left[\sum_{i=1}^3 \left(\frac{a_i}{\tau_i} \times e^{-\frac{t-t_0}{\tau_i}} \right) \right]$$
$$= \sum_{i=1}^3 \left\{ \frac{a_i}{\sqrt{2\pi\sigma}} e^{\left(\frac{\sigma^2}{2\tau_i^2} - \frac{t-t_0}{\tau_i} \right)} \times \left[1 - \text{Erf} \left(\frac{\sigma^2 - \tau_i (t - t_0)}{\sqrt{2} \sigma \tau_i} \right) \right] \right\}$$

Charge vs channel distribution



Expected data volume with the external trigger

- Based on data volume of run 211 (3h run):
 - Raw file 42 MB + ROOT file 15 MB
- Expecting ~ 30 MB/h (overestimating the ROOT file size)
- Assuming continuous 24h running (overestimating again)
 - ~ 1 GB/d , ~ 30 GB/month, ~ 1 TB total