

Light in the 3x1x1

Ciemat

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IFAE^R

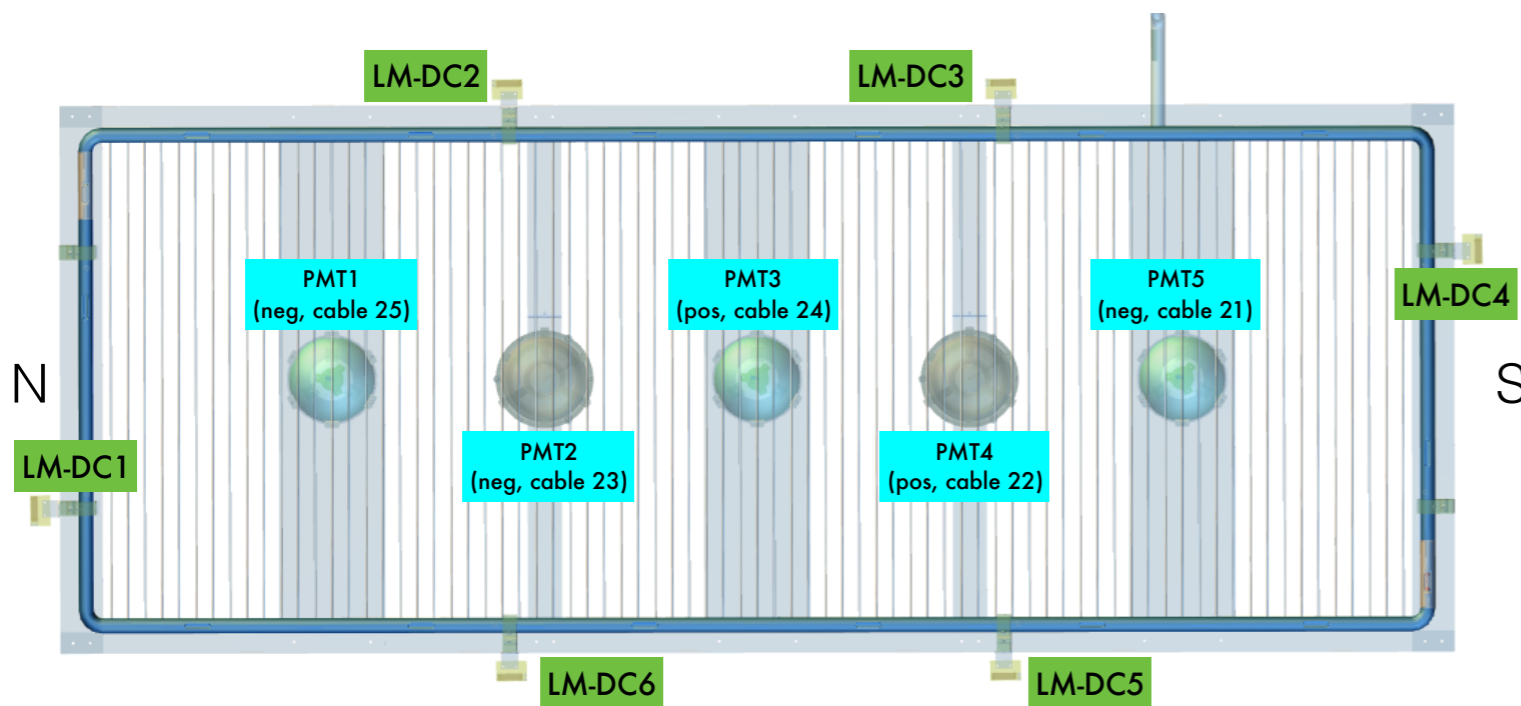
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LAPP

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PMT setup

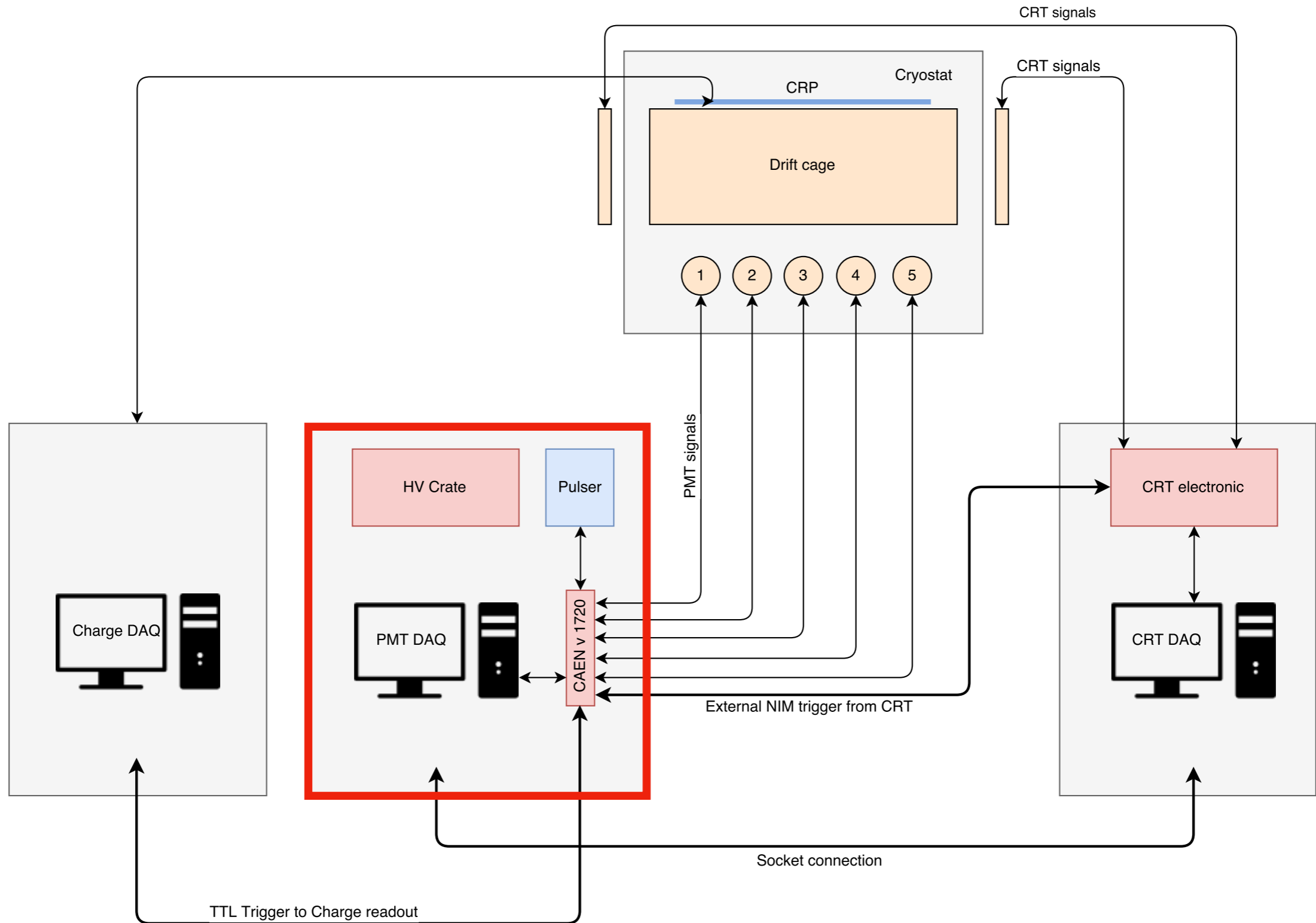
- 5 8” Hamamatsu PMT (R5912-02MOD)
- Different TPB coating and polarisation
- Installed below the cathode



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	-1200 V	-1200 V	+1150 V	+1150 V	-1200 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

Manhole
corner

PMT-centric readout schematic



PMT readout and digitisation

- The readout Board: CAEN V1720
 - 8 channels, 12 bit ADC, 250 MS/s, 2 V input range
 - Buffer memory 1.25 MS/ch (up to 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

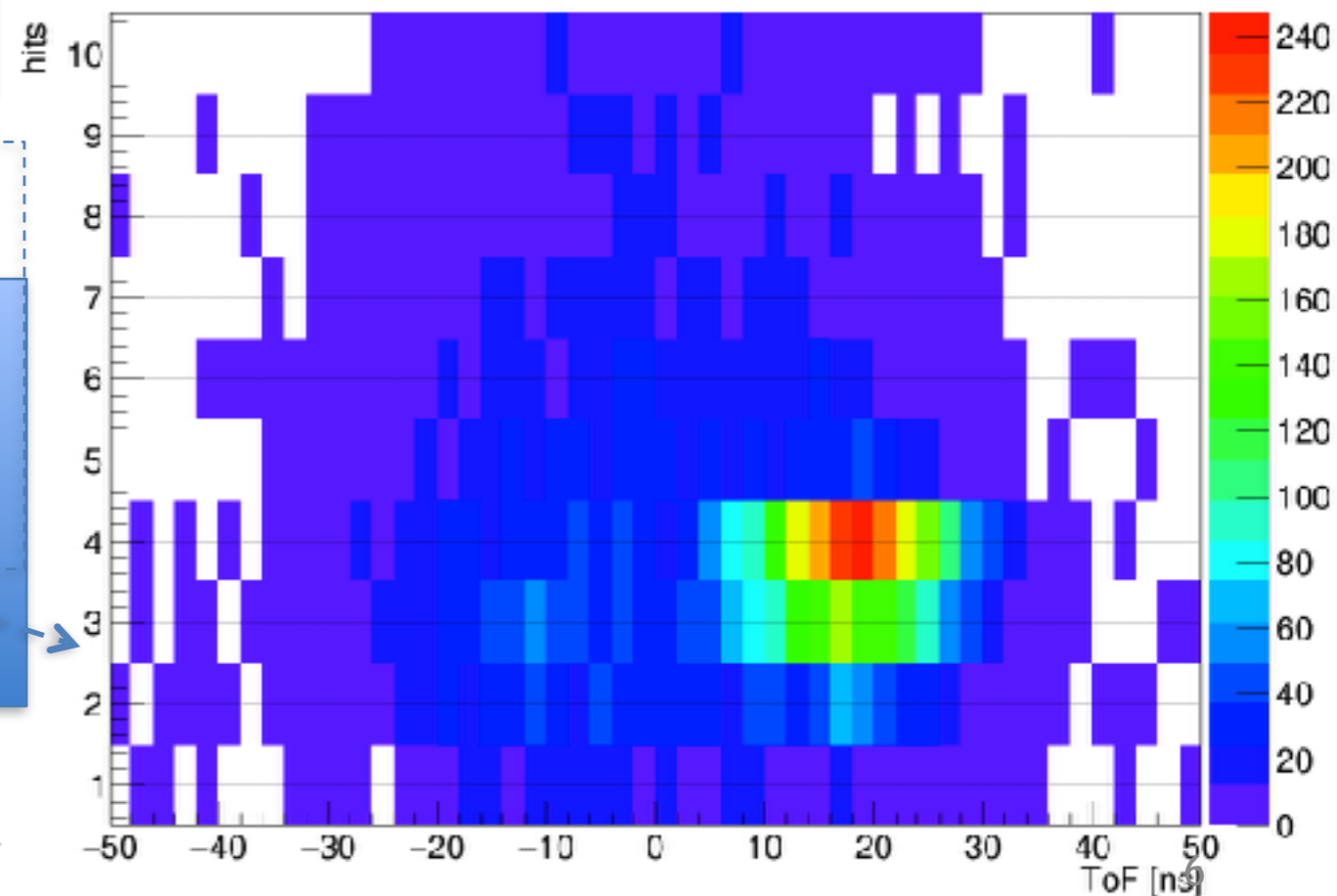
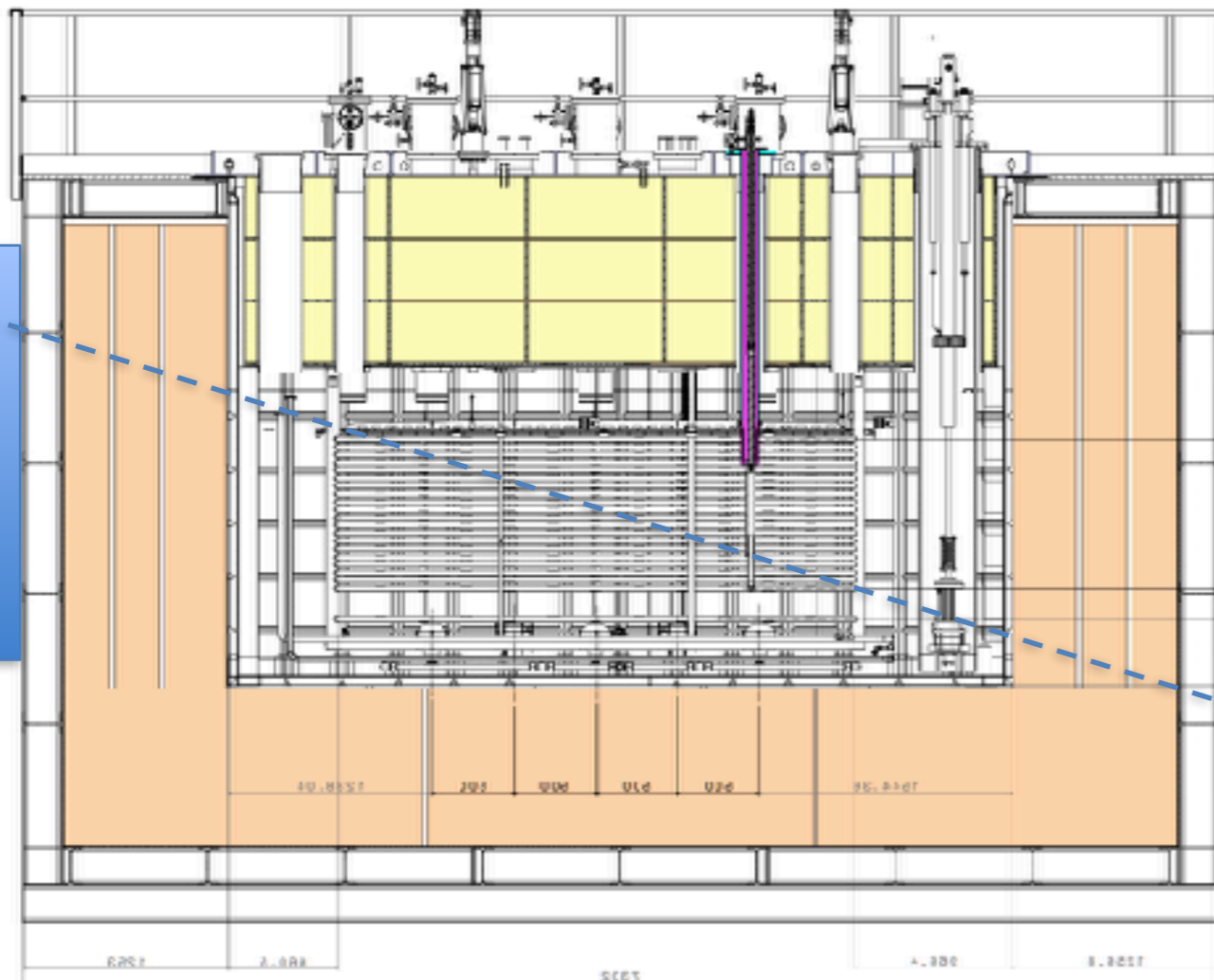


Trigger configuration

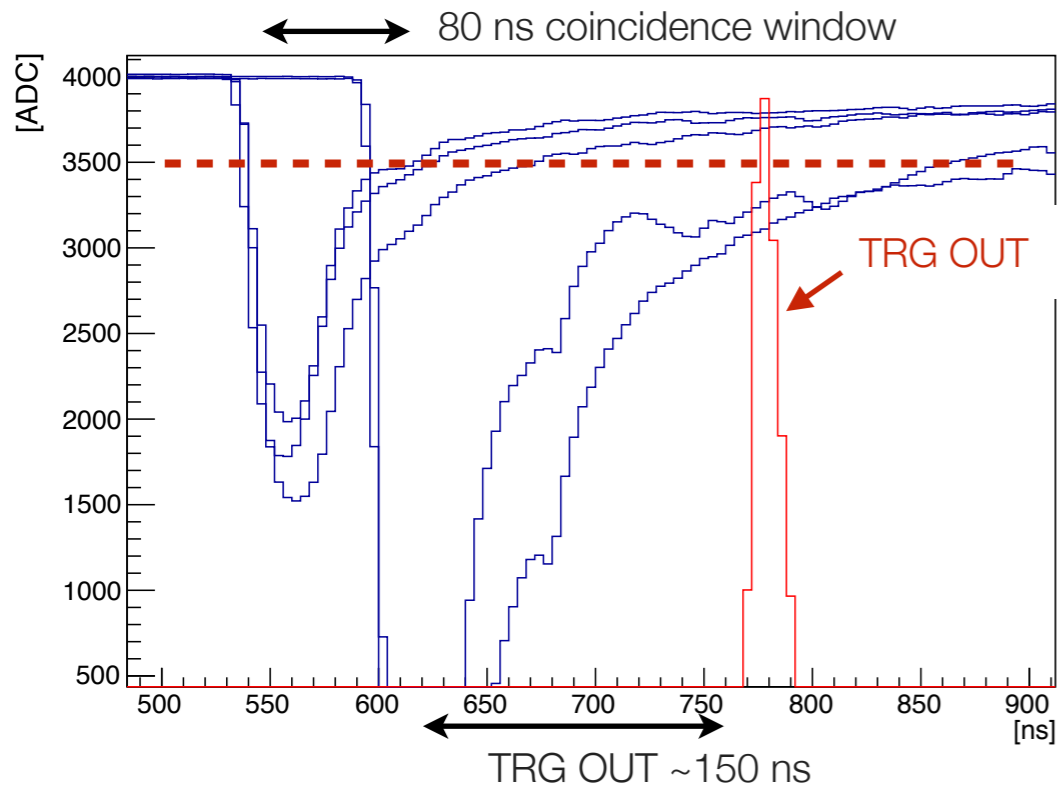
- External trigger from CRT panels ~ 0.3 Hz
 - Muon showers and horizontal tracks
 - Online event matching via socket connection
- PMTs self-trigger ~ 3 Hz
 - Muon showers and vertical tracks
 - Coincidence of 5 PMTs with threshold @ 125 mV
- External configurable pulser
 - For PMTs calibration purposes

Cosmic Ray Trigger

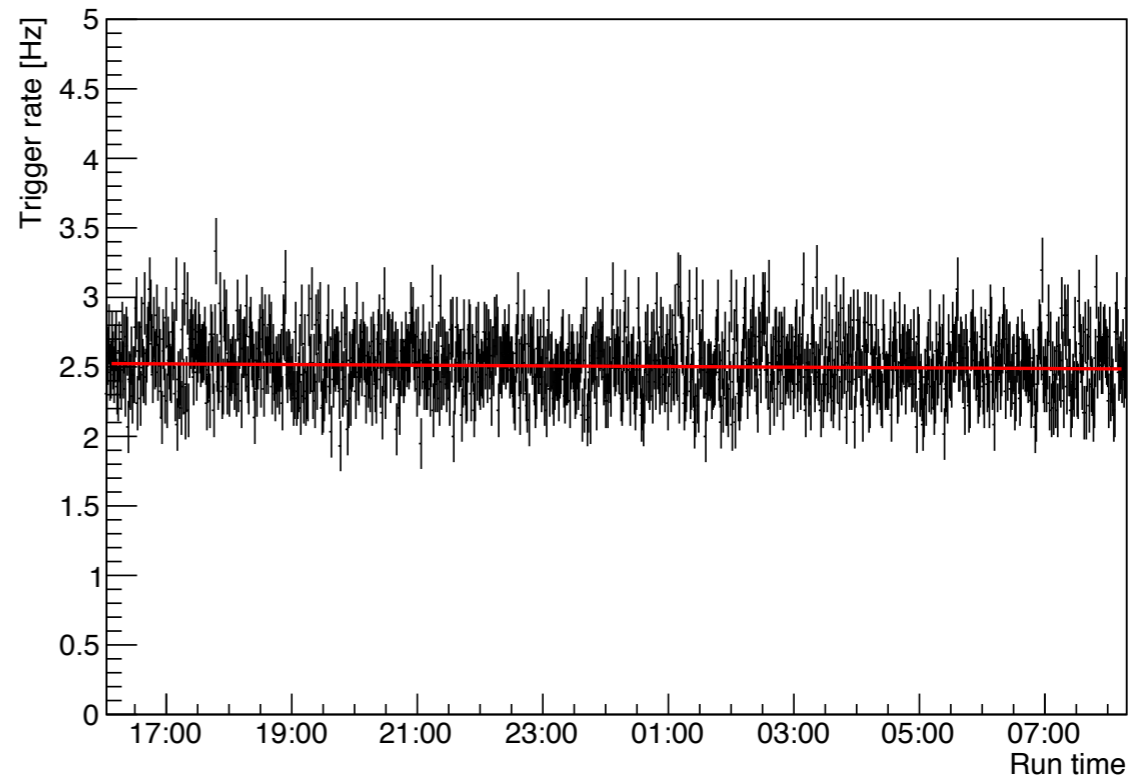
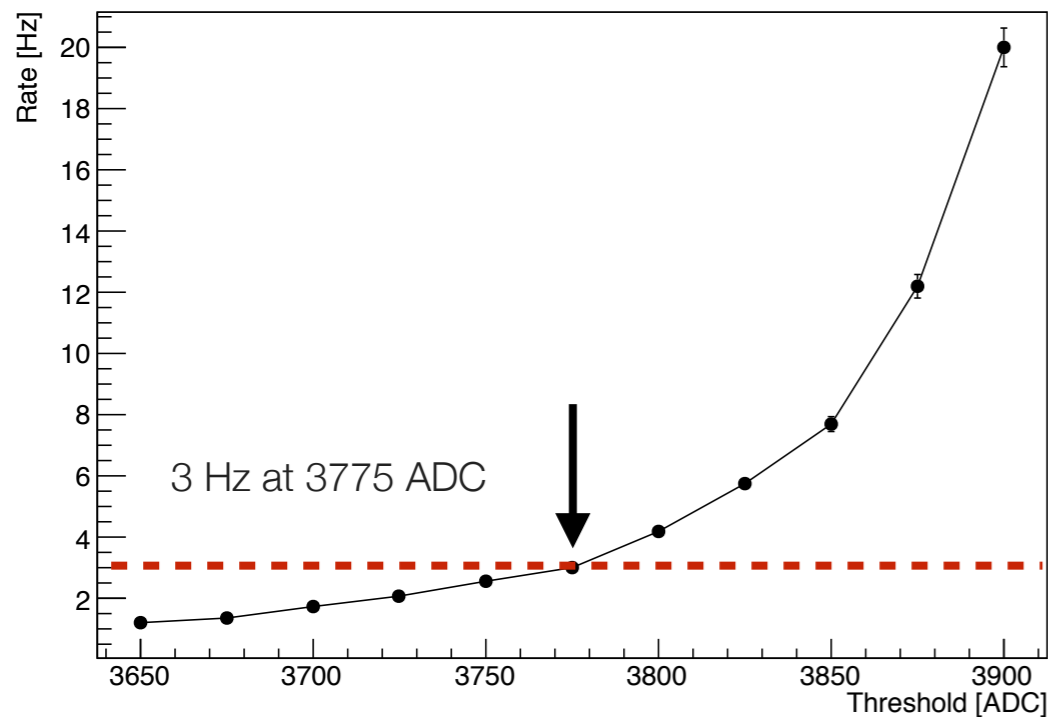
- Single muons are selected by requiring one hit per panel on the 4 CRT panels.
- This selects events where the ToF is compatible with a traversing particle



PMT-self trigger

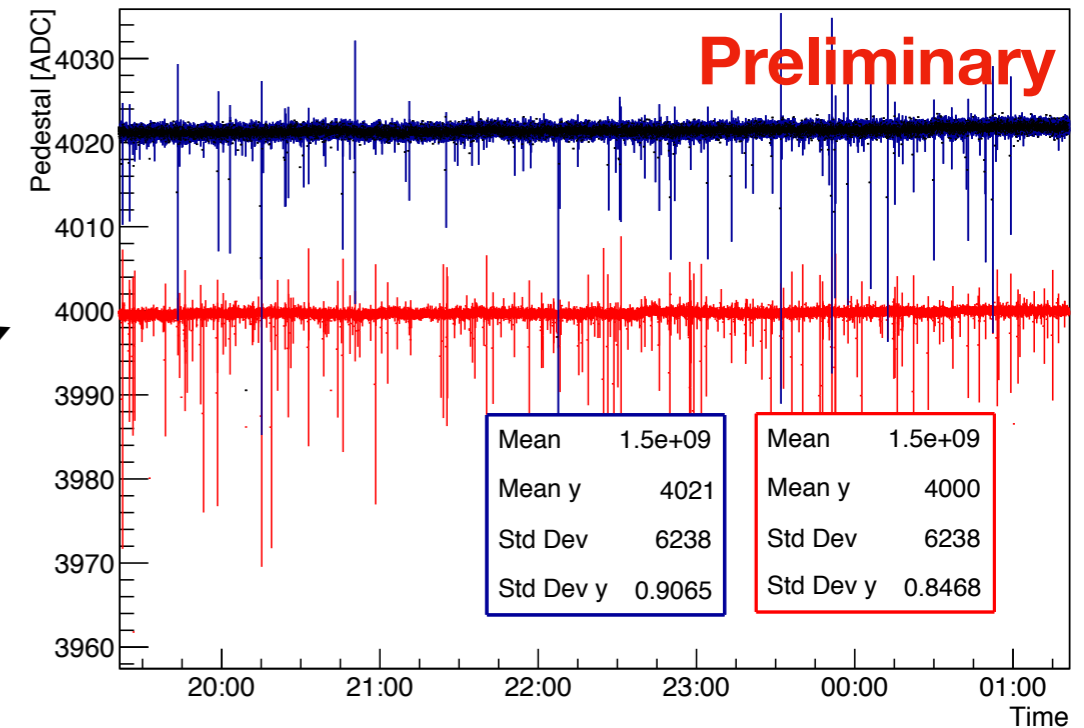
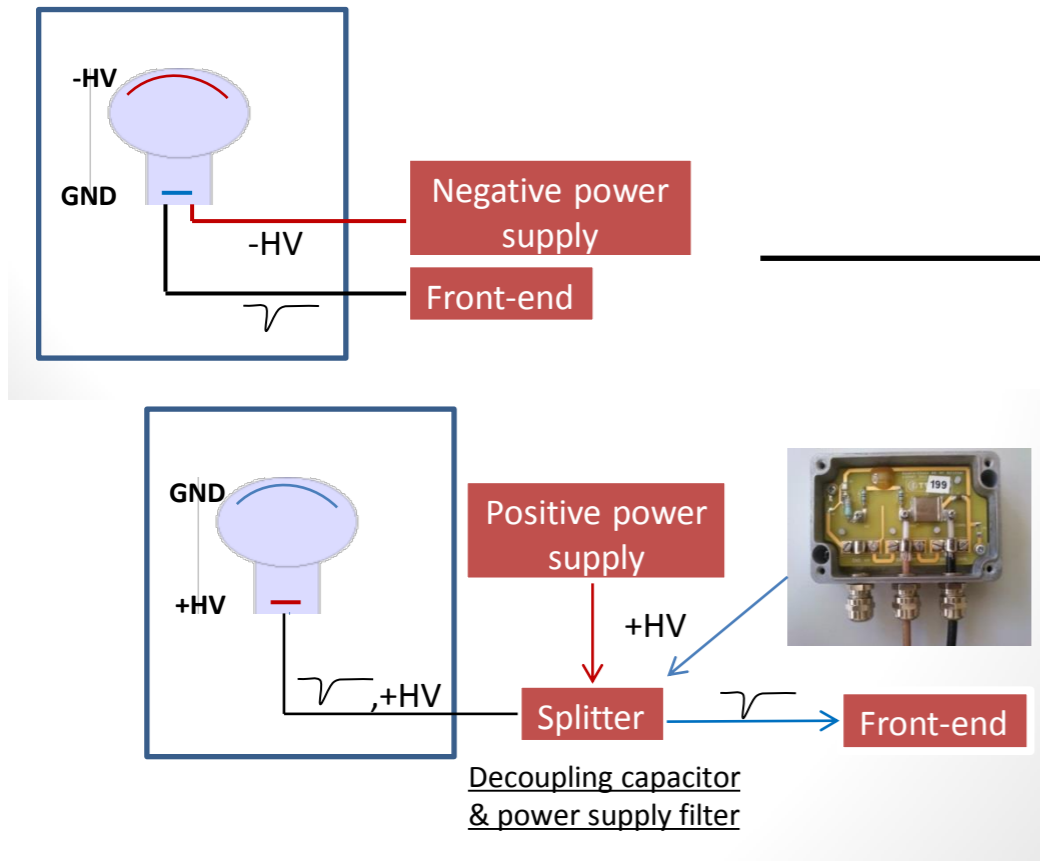


- Charge requirement: TTL trigger @ ~3 Hz max
- Proposed solution: Trigger on 5 fold coincidence on a given threshold
- Signals from negative basis arrive ~60 ns earlier
- Set a coincidence window of 80 ns to allow trigger on the 5 PMT

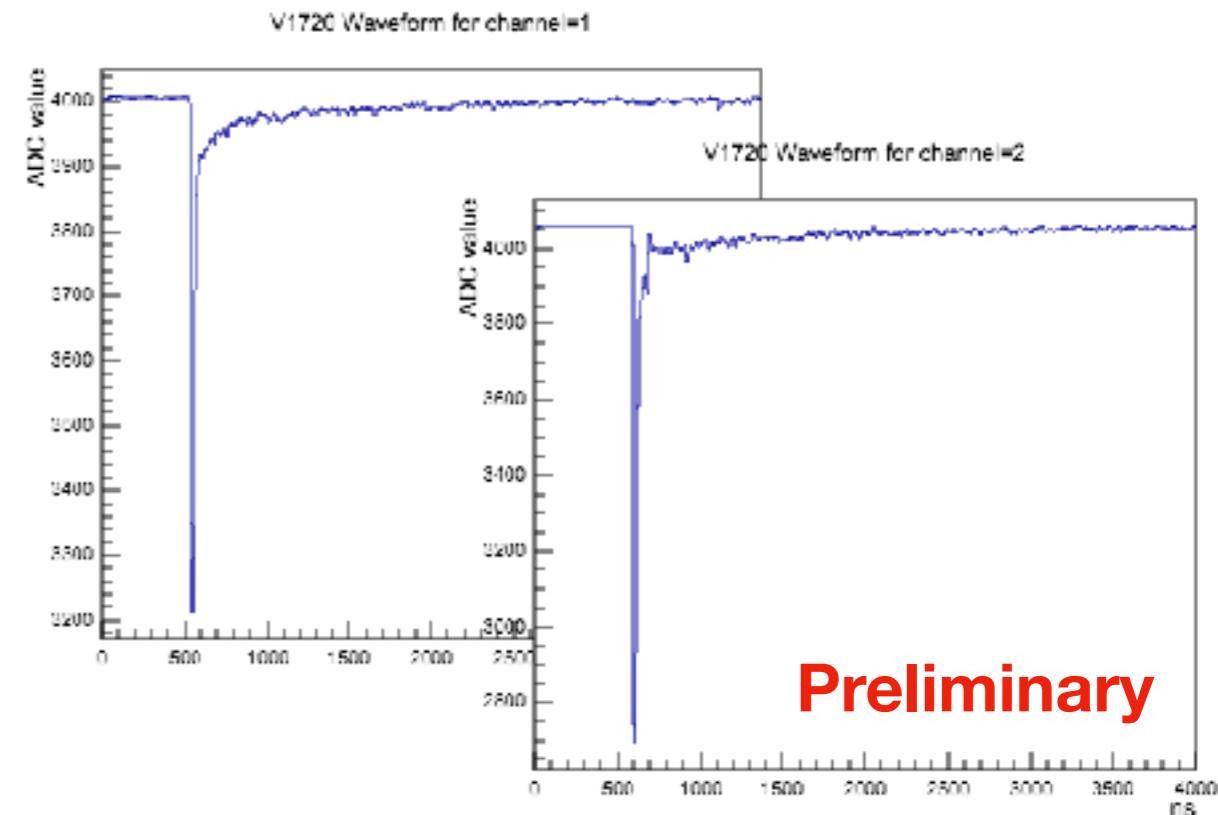


Positive/Negative PMT

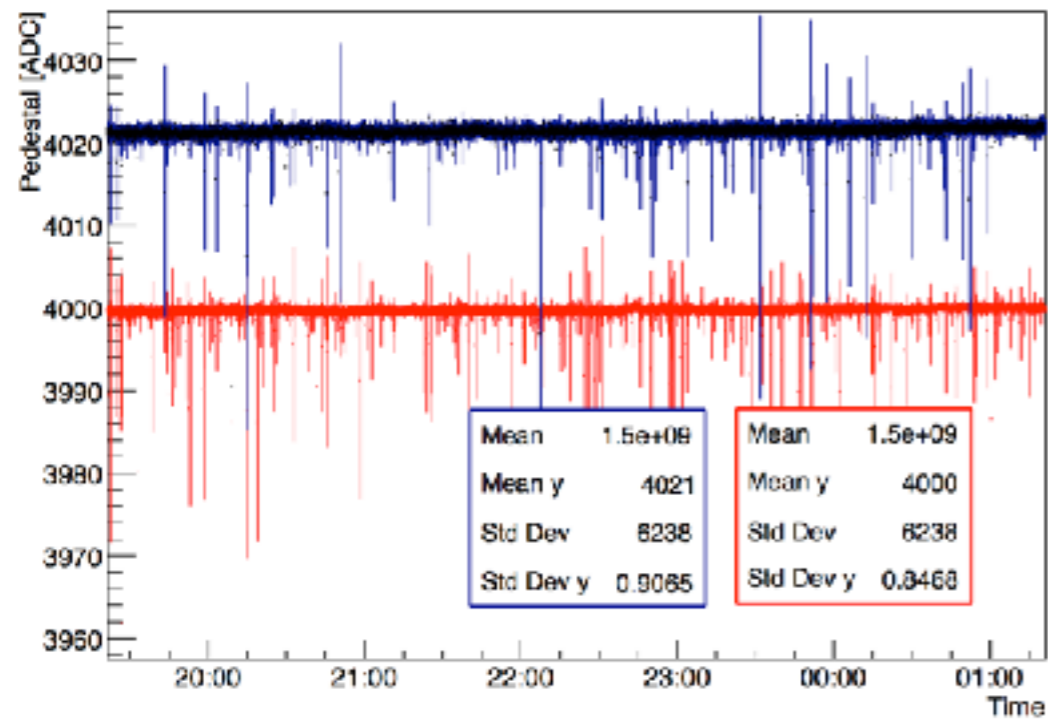
basis



- Positive biased PMT show reduced pedestal fluctuation without drift field
- Impedance mismatch on the feedthrough create a reflection of the signal at a constant position
- Only positive bases in the 6x6x6

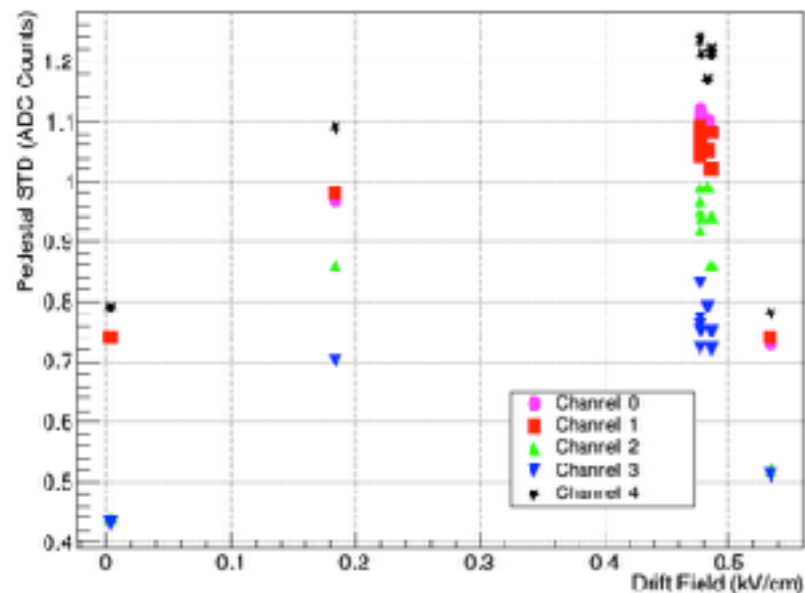


Operation Stability

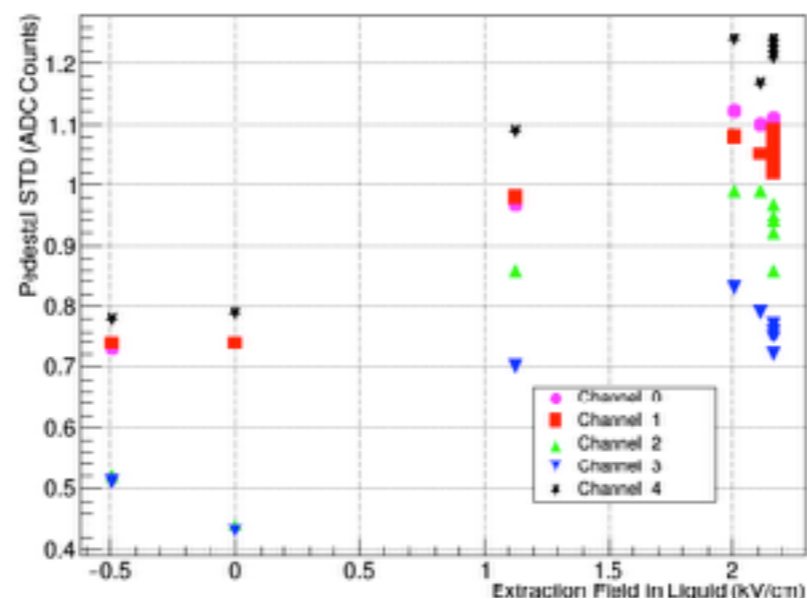


- Baseline variation is below 1 ADC count during entire data taking and for different operation conditions
- Pedestal widths remain below ≈ 1 ADC count even under high amplification fields

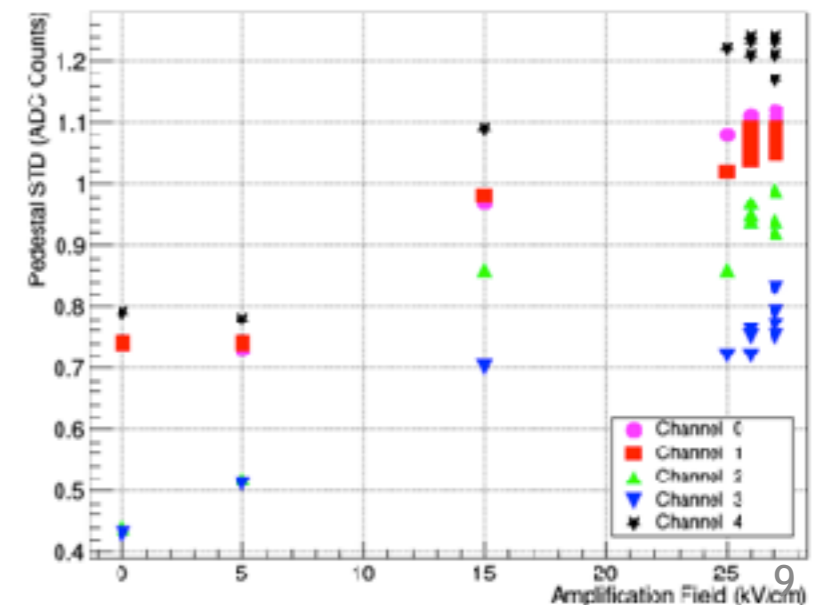
Varying Drift Field



Varying Extraction Field

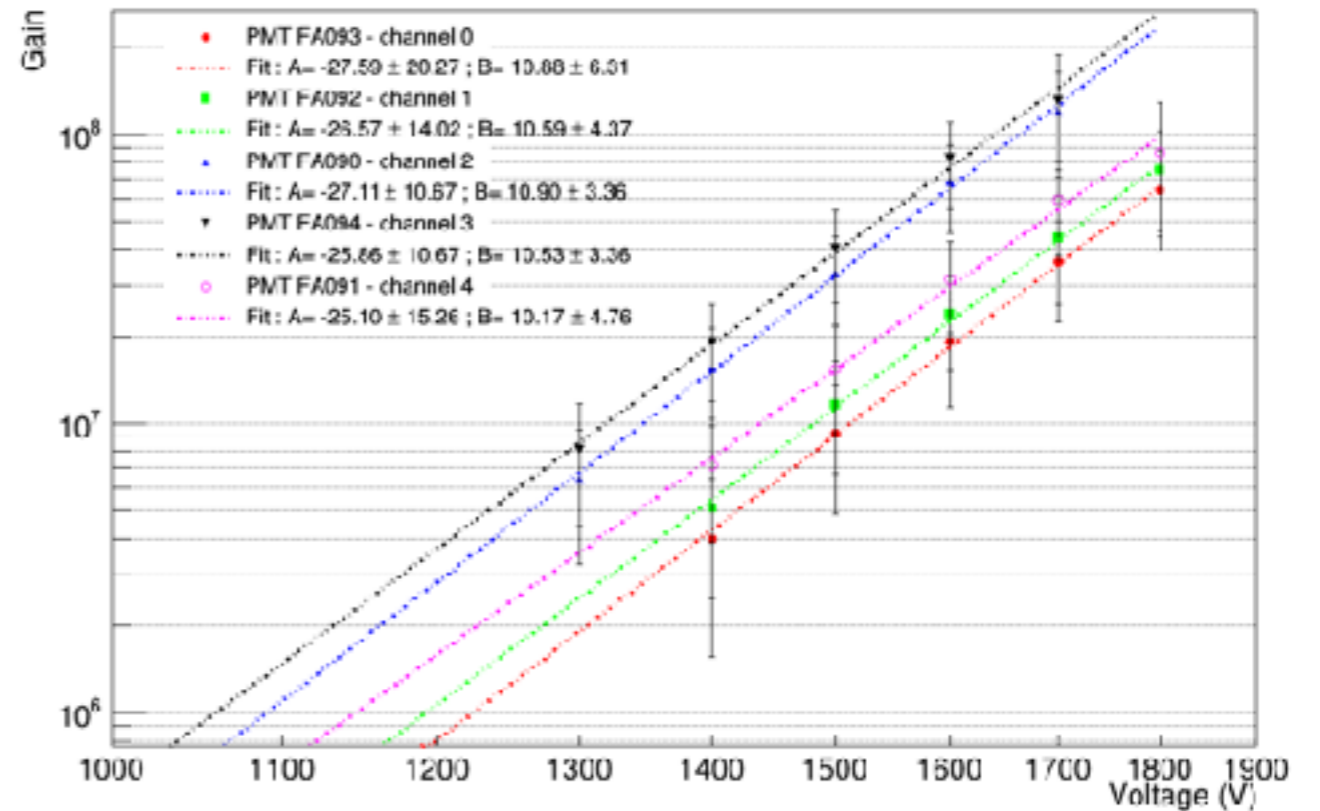
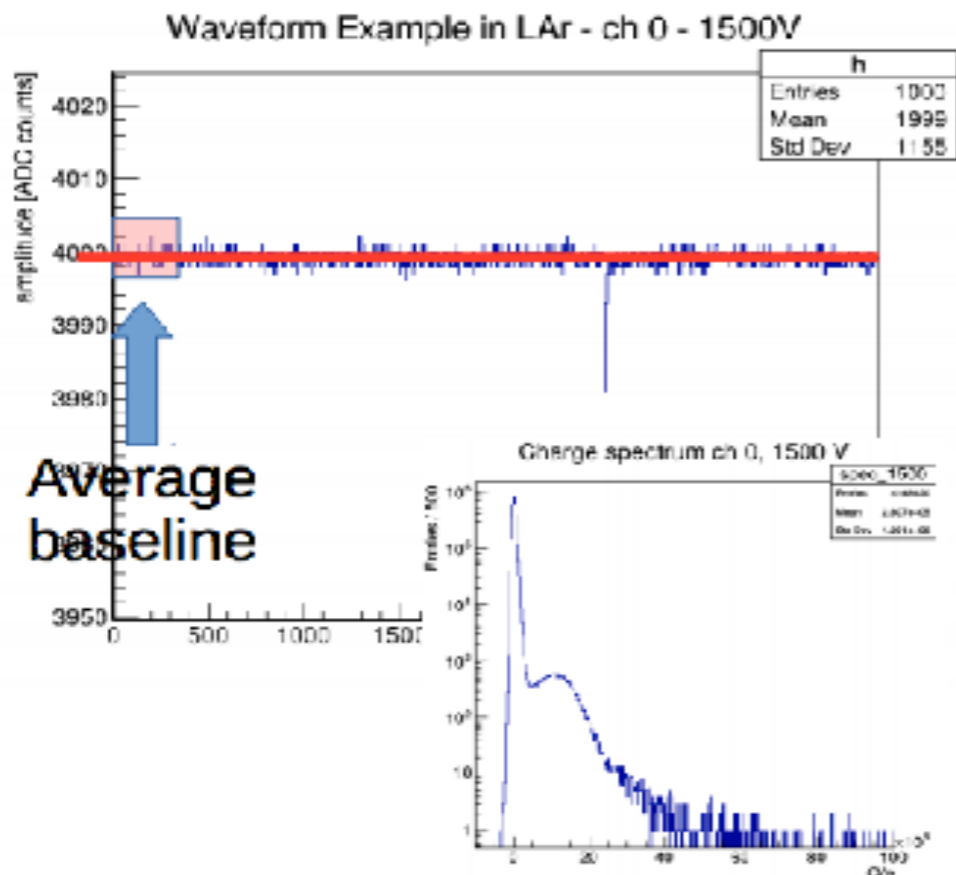


Varying Amplification Field



PMT SPE calibration

- No available PMT calibration system
- SPE spectrum from random trigger

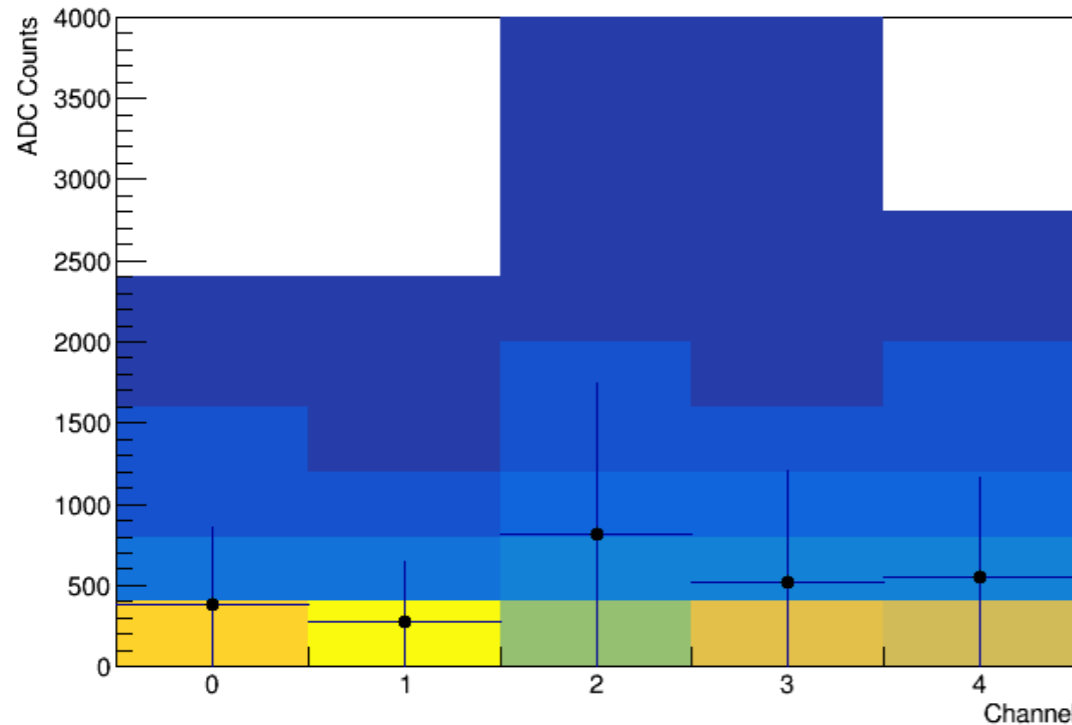


- For calibration purpose, in the 6x6x6, it would be important to see SPE signal

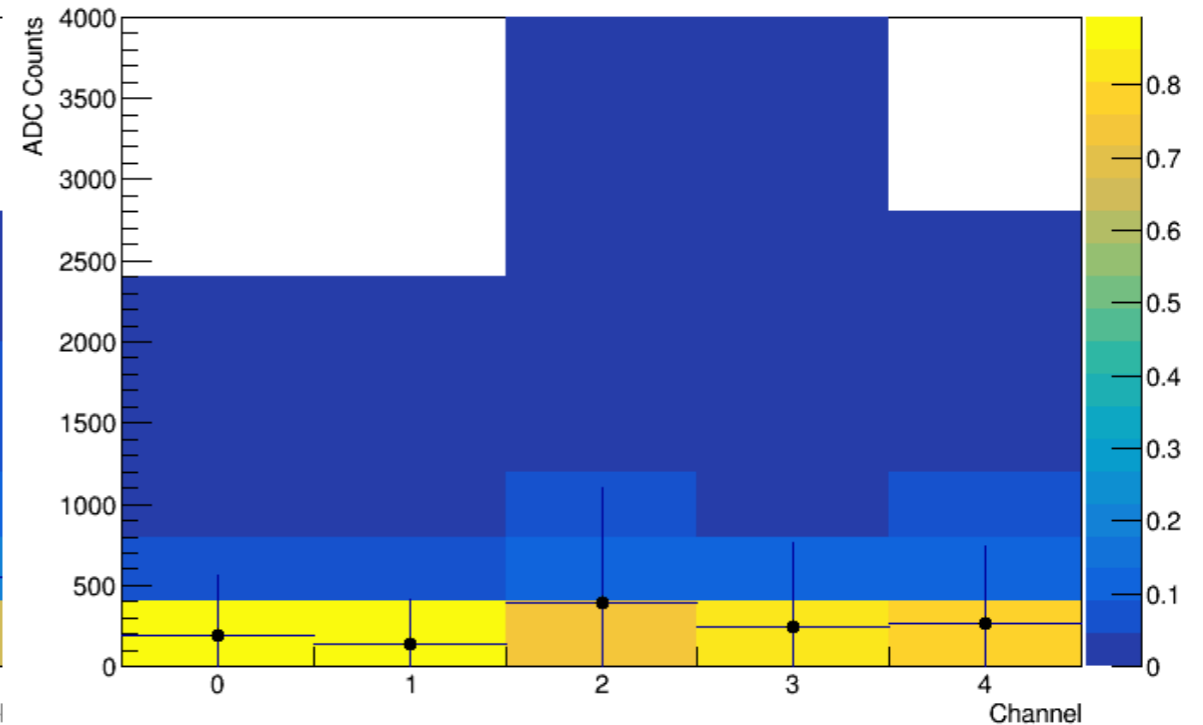
Voltage (V)	Gain (10 ⁶)	Q (1PE) [pC]
1200	0.8±1.6	0.1±0.3
1200	1.1±1.4	0.2±0.2
1150	1.8±1.6	0.3±0.3
1150	2±2	0.4±0.3
1200	1.6±2.3	0.3±0.4

S1 signals with CRT trigger

No Drift Field
Signal Amplitude vs Channel - Run 1610

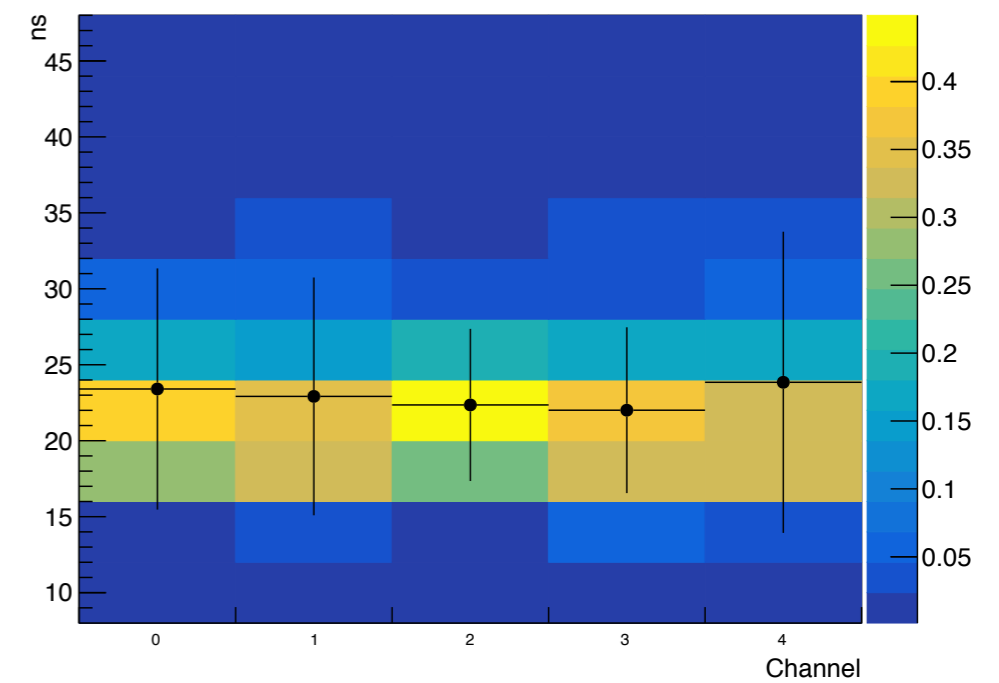


Drift Field 0.53kV/cm
Signal Amplitude vs Channel - Run 1618



As the drift field increase, the S1 amplitude is reduced, since less recombination occurs.

Width distribution

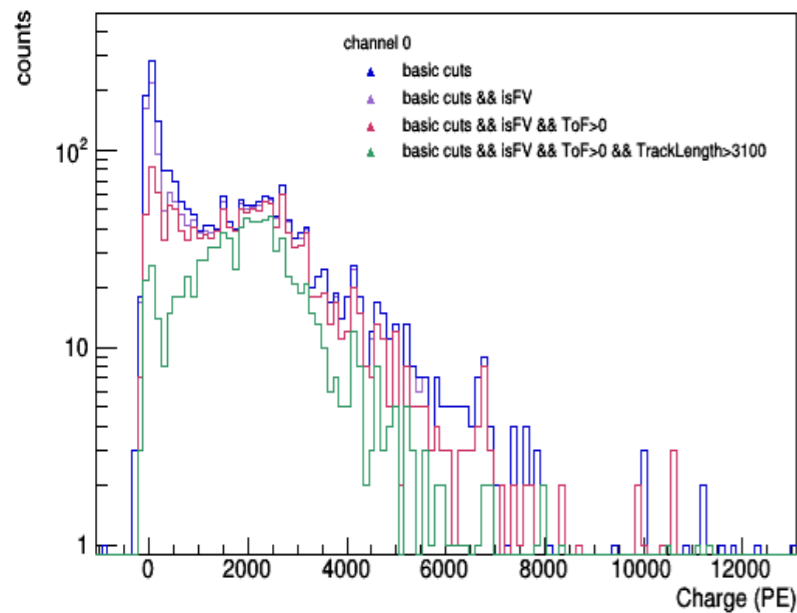


- Signal from + biased PMTs tends to be narrower with higher amplitude than - biased PMTs

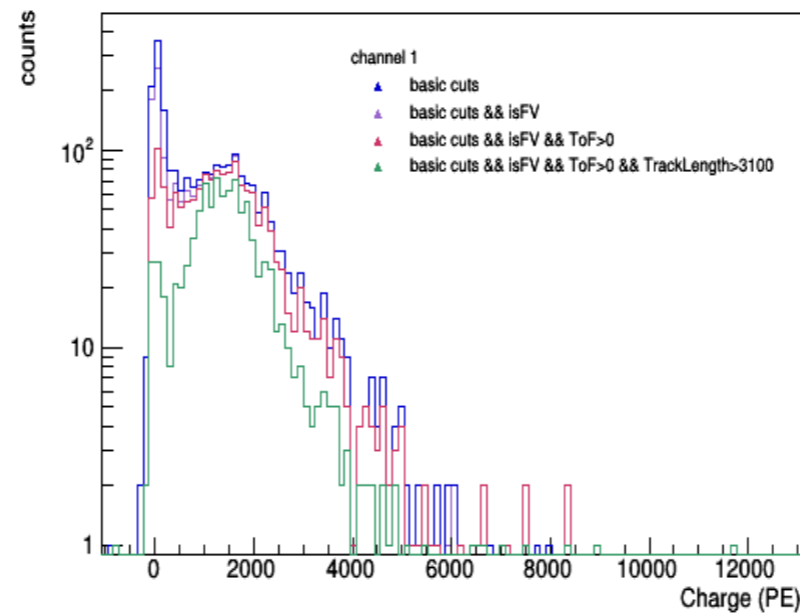
PMT charge vs Track Topology

- Selections reducing fraction of event with \approx zero charge
 - Track cross entire FV volume : maximum scintillation production
 - ToF>0 : reduce triggers due to “muon bundles”

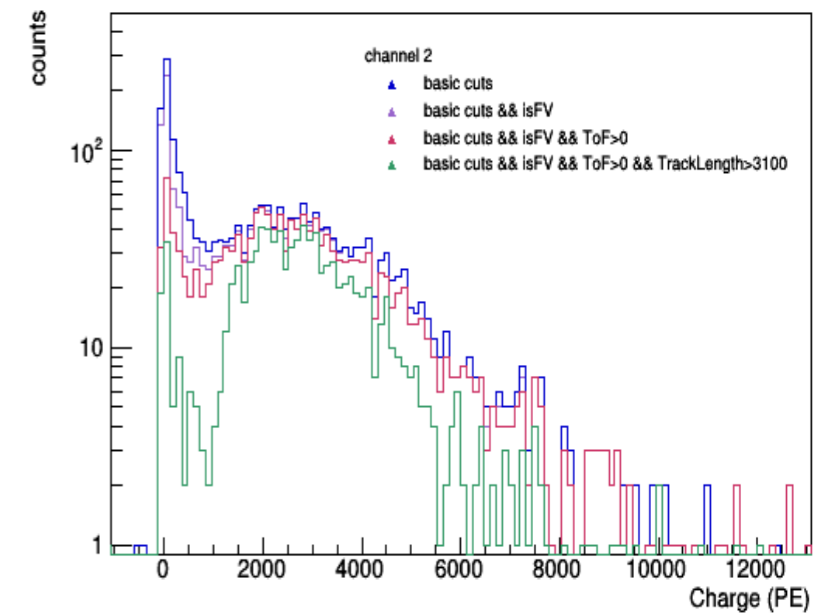
Charge [PE]- channel 0



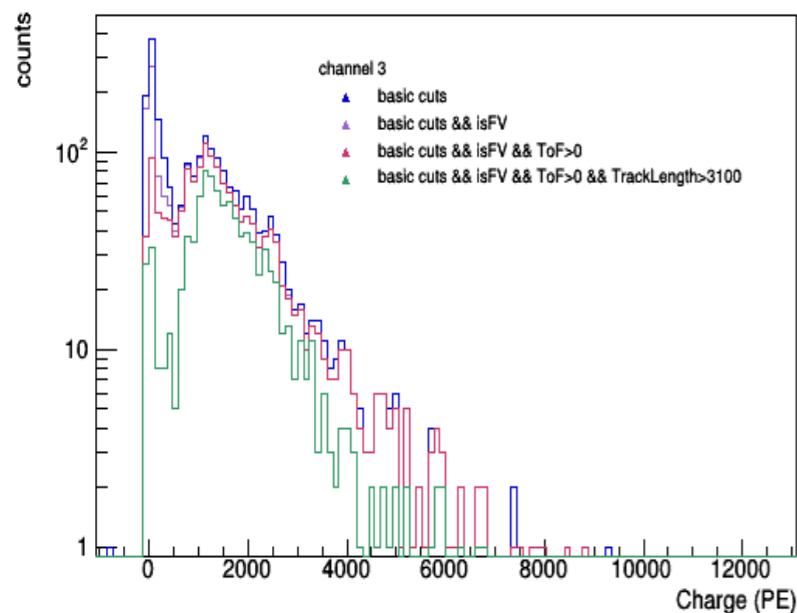
Charge [PE]- channel 1



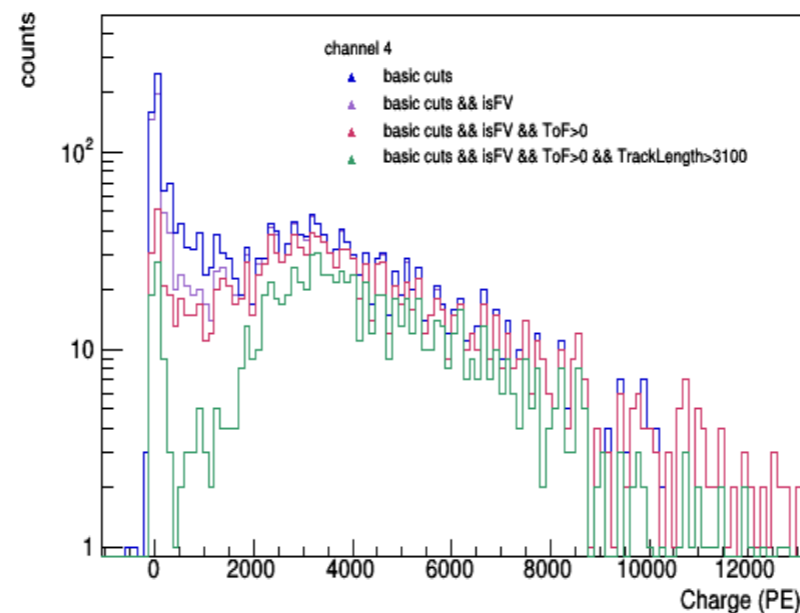
Charge [PE]- channel 2



Charge [PE]- channel 3

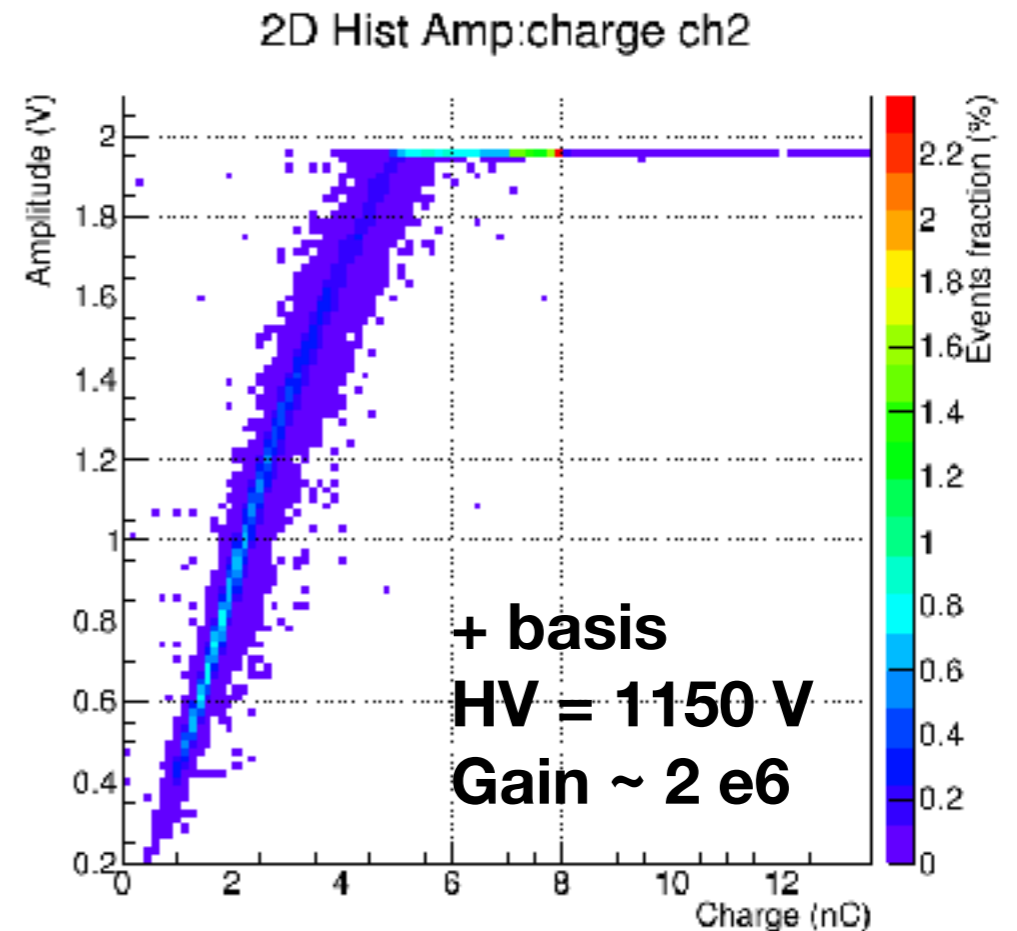
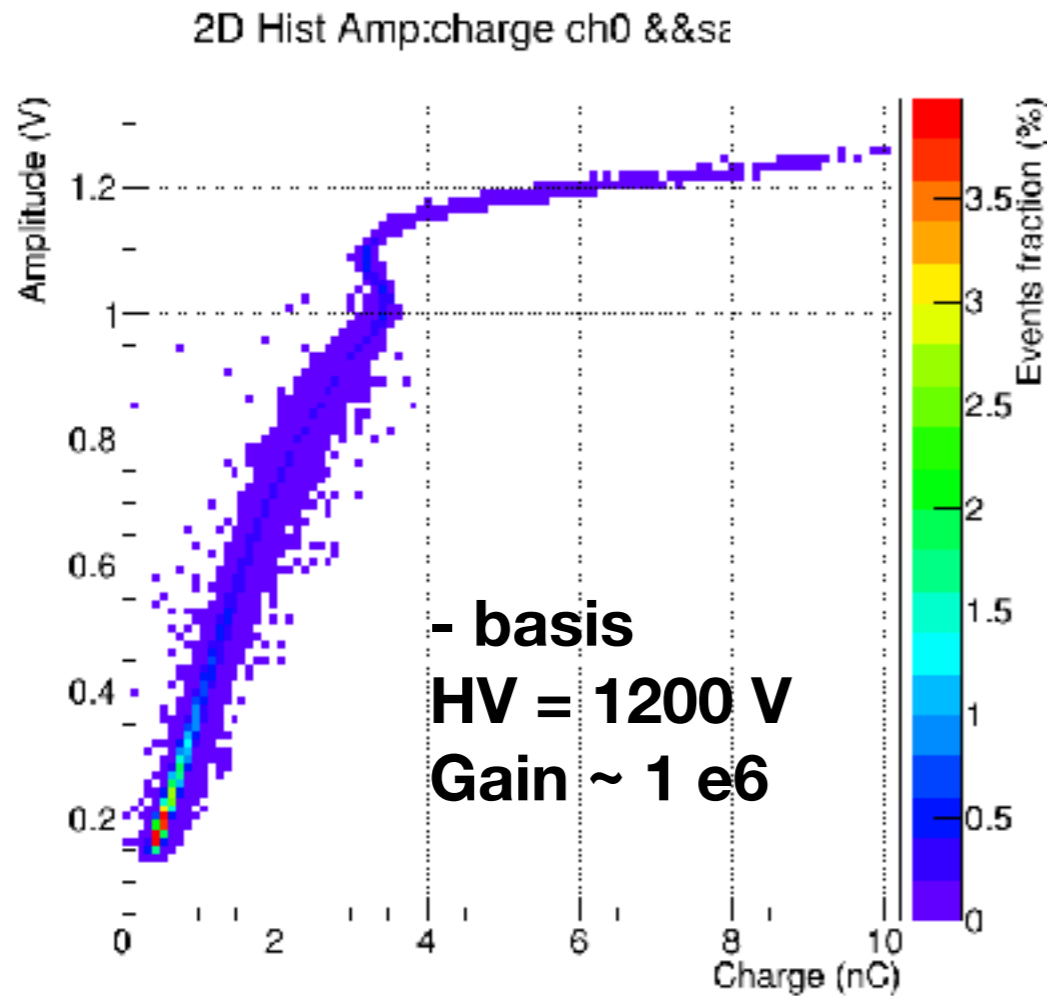


Charge [PE]- channel 4



basic cuts: PMT event matched with a CRT event

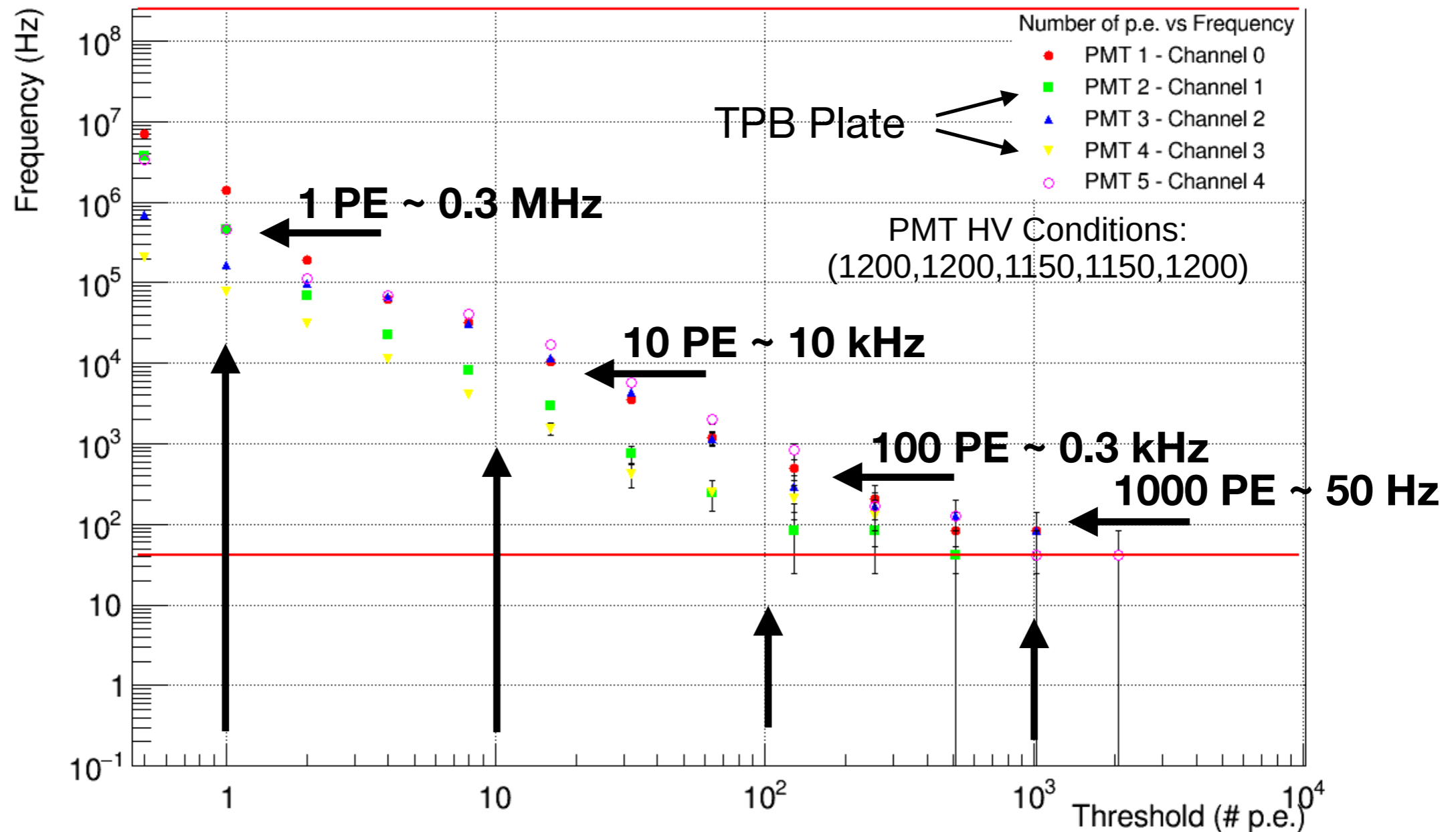
PMT charge linearity



- PMT response seems linear up to ~ 2-4 nC
- Other PMTs show a similar behaviour

Light freq vs # p.e.

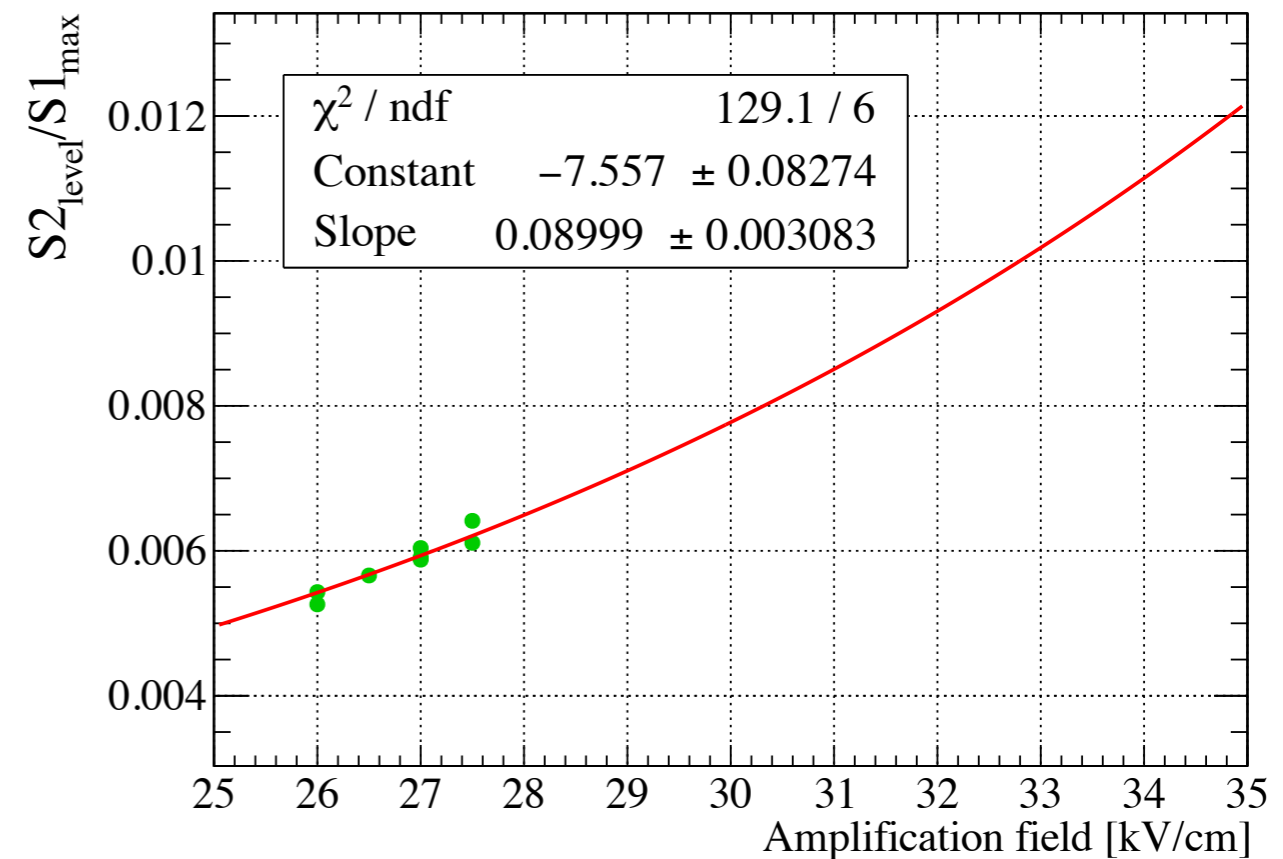
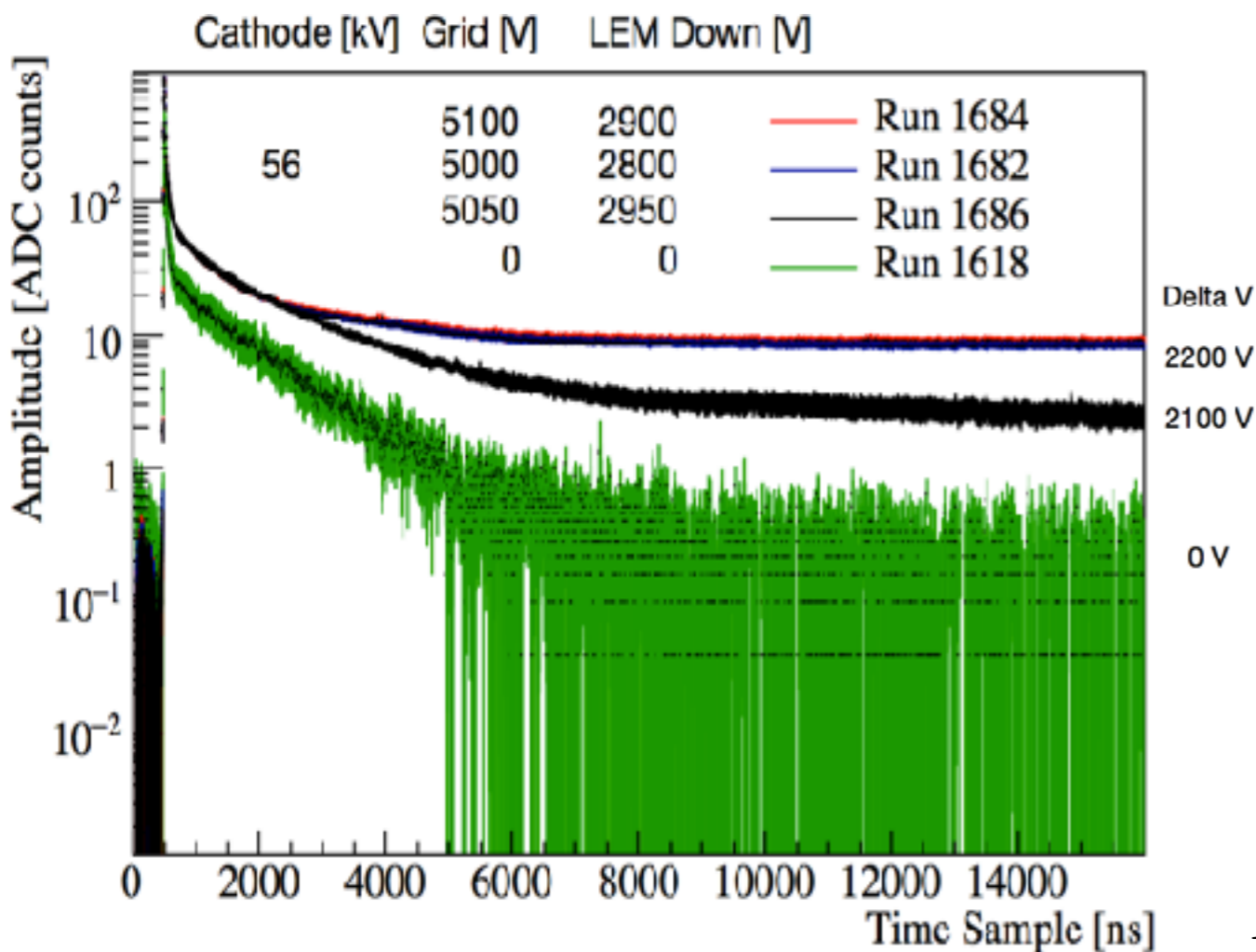
Study of the quantity of light vs frequency - Run 1068



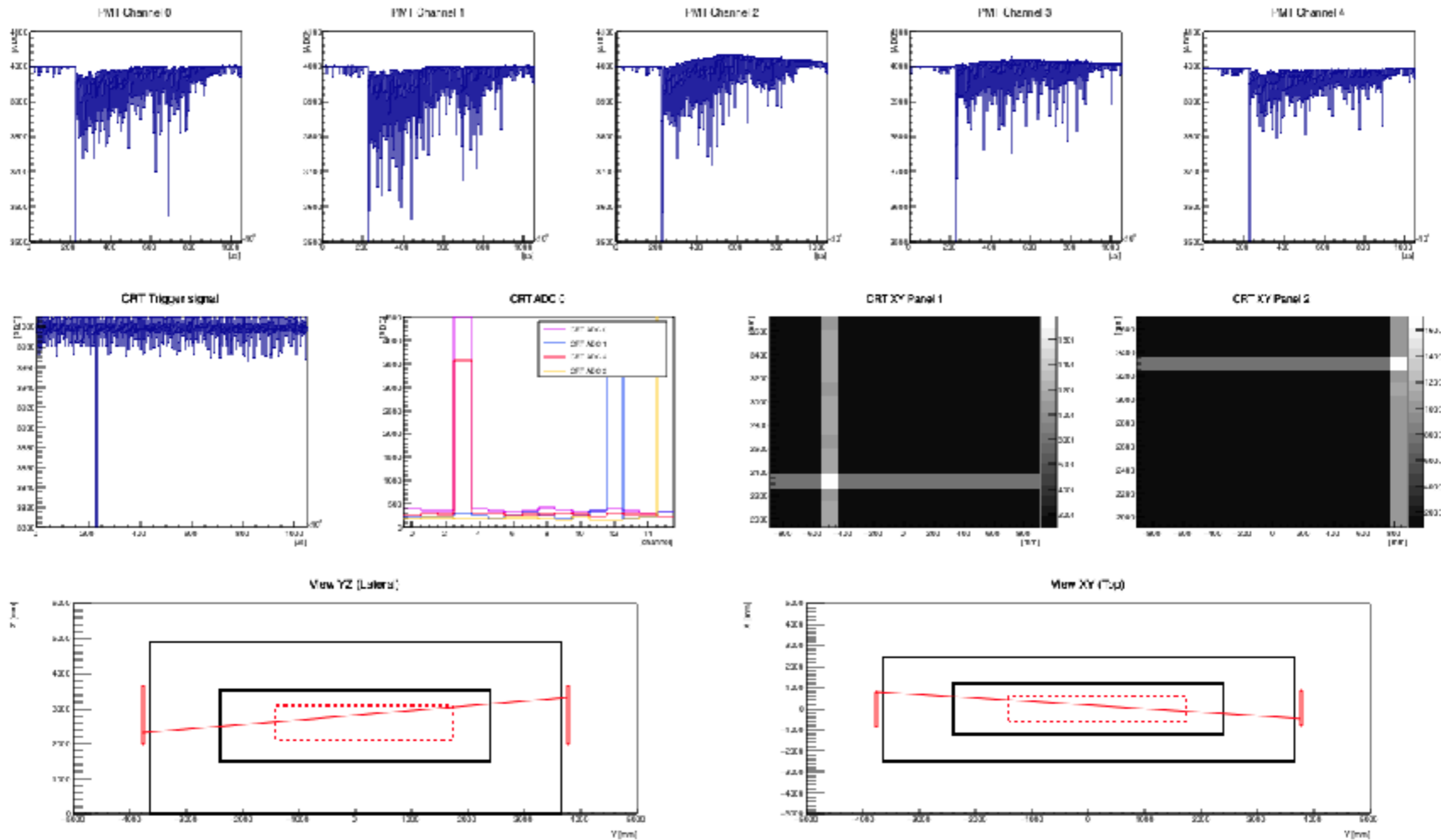
Lines in red are the sensitivity limits (*up*: 250MHz from the DAQ, *down*: frequency of only one event).

S2/S1 vs Amplification and Extraction Fields

- Measuring the ratio of S2 mean amplitude to S1 maximum amplitude
 - ✓ proportional to the Amplification Field
 - ✓ almost constant w.r.t. the Extraction Field



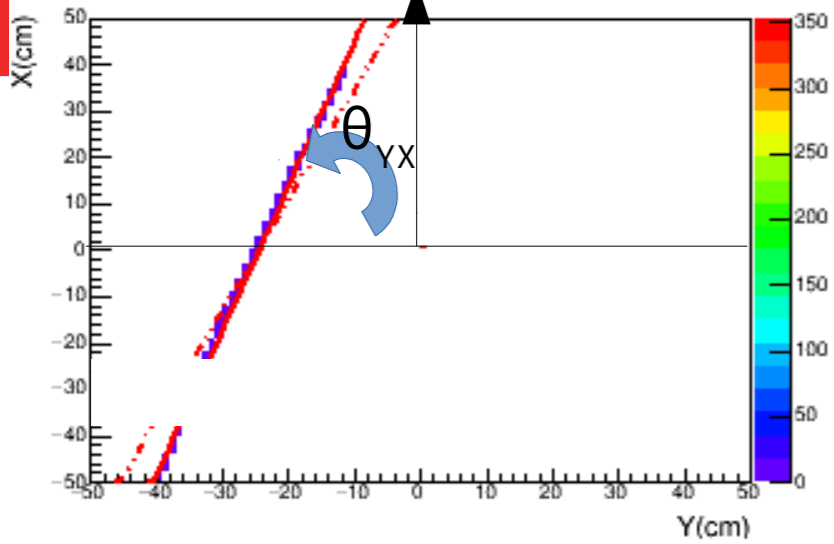
Preliminary S2 studies



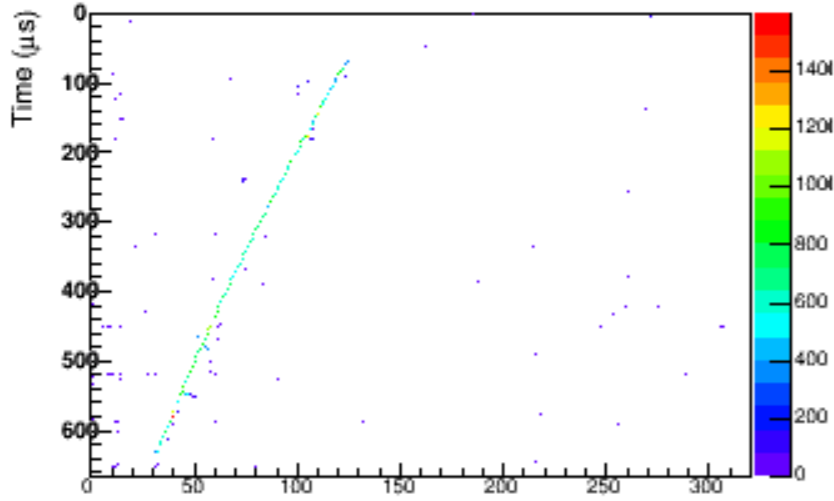
Event no.1610, Time Stamp Thu, 15 Jun 2017 21:04:22 CEST

Charge Event (Run,SubRun,ev): (988,5,219) - Light Event: (Run,ev): (1670,7141) $\delta t = -0.724s$

3D TRACK - YX Plane - Transversal view (from the Wall)



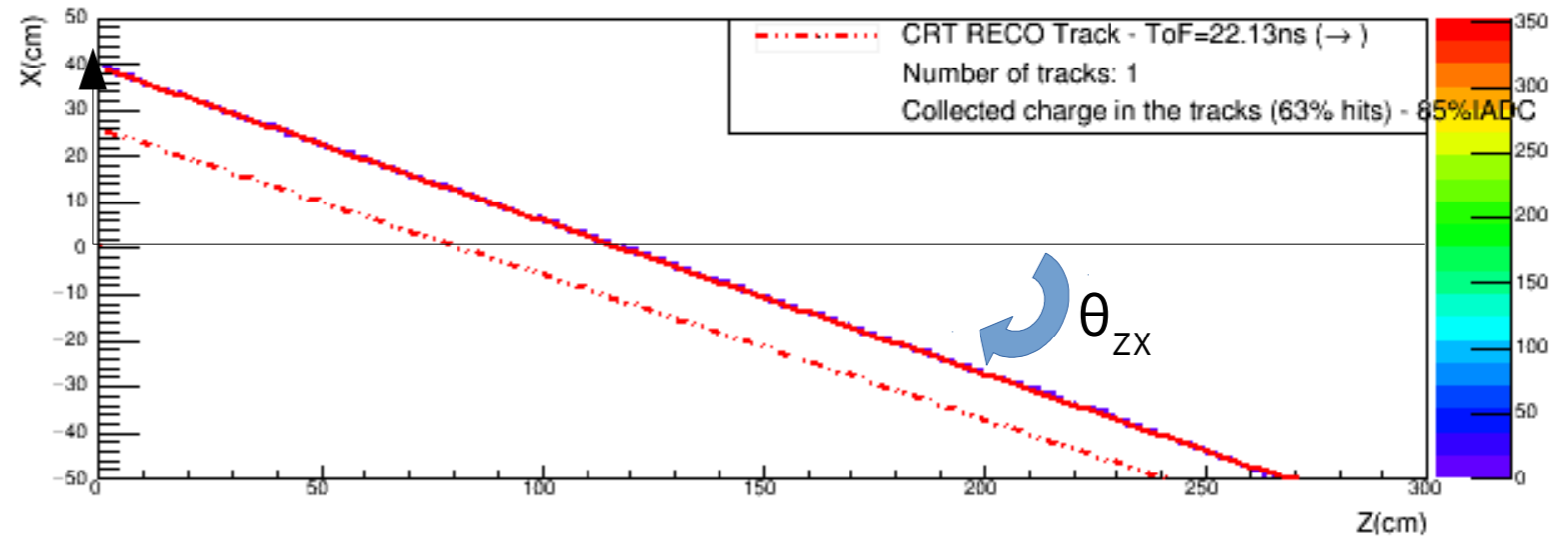
Charge Reco HITS View 0



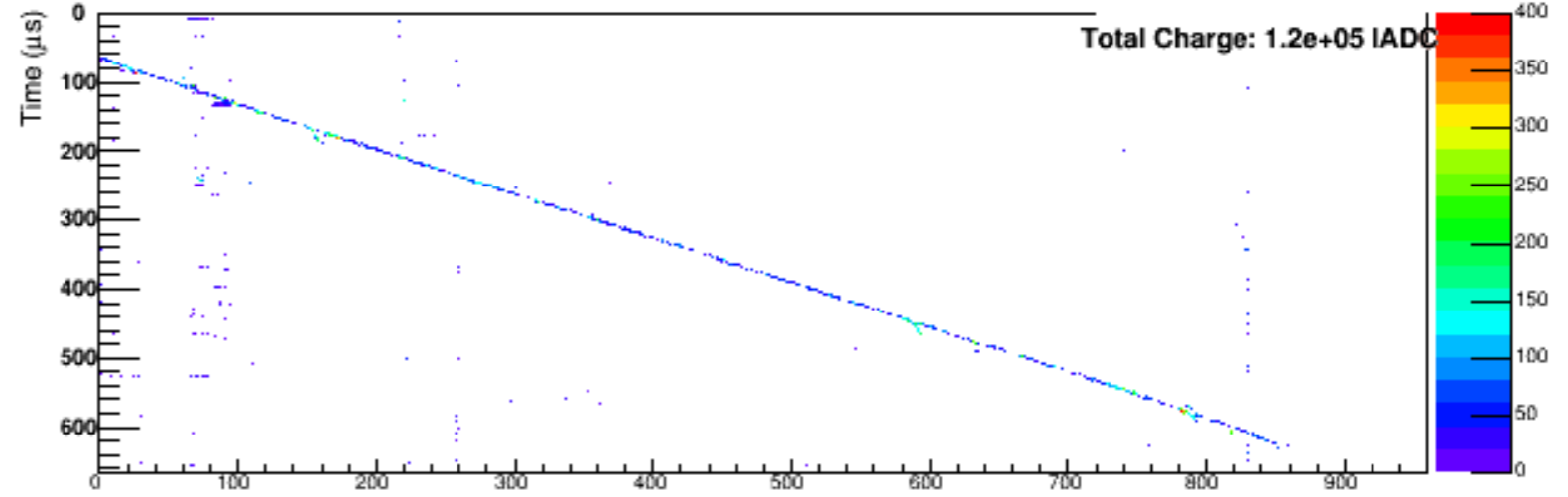
Channel 0

Channel 1

3D TRACK - ZX Plane - Transversal view (from the Clean Room)



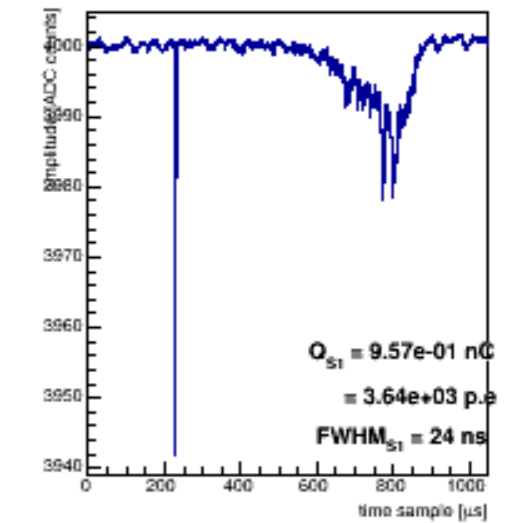
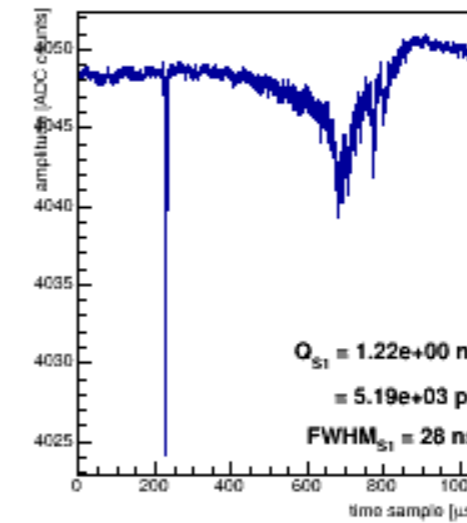
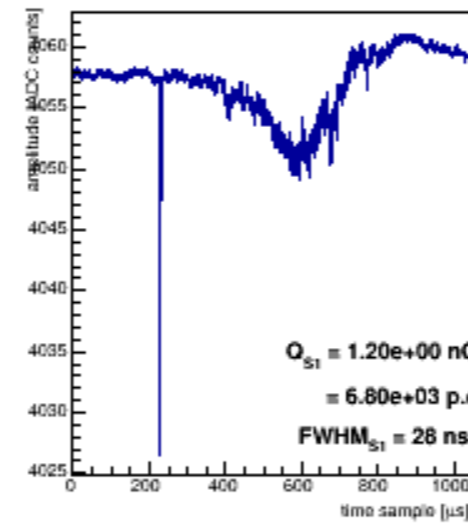
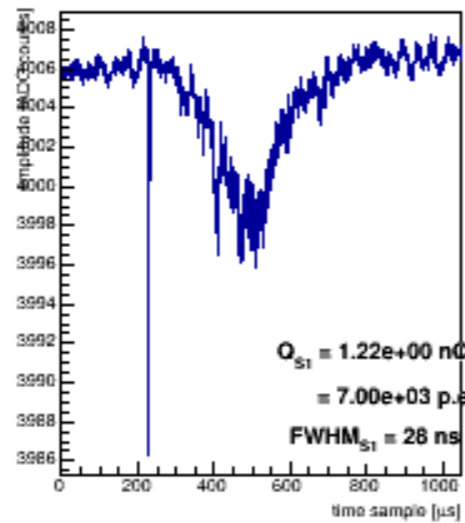
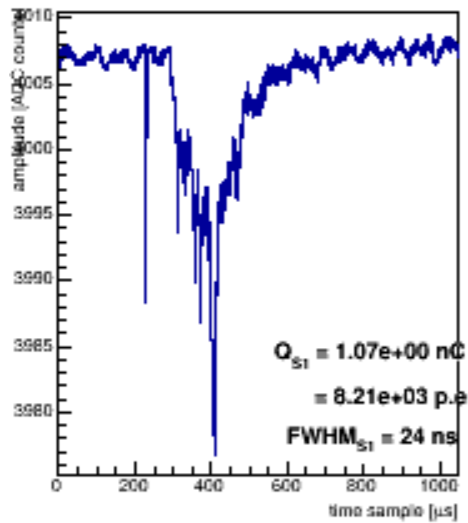
Charge Reco HITS View 1



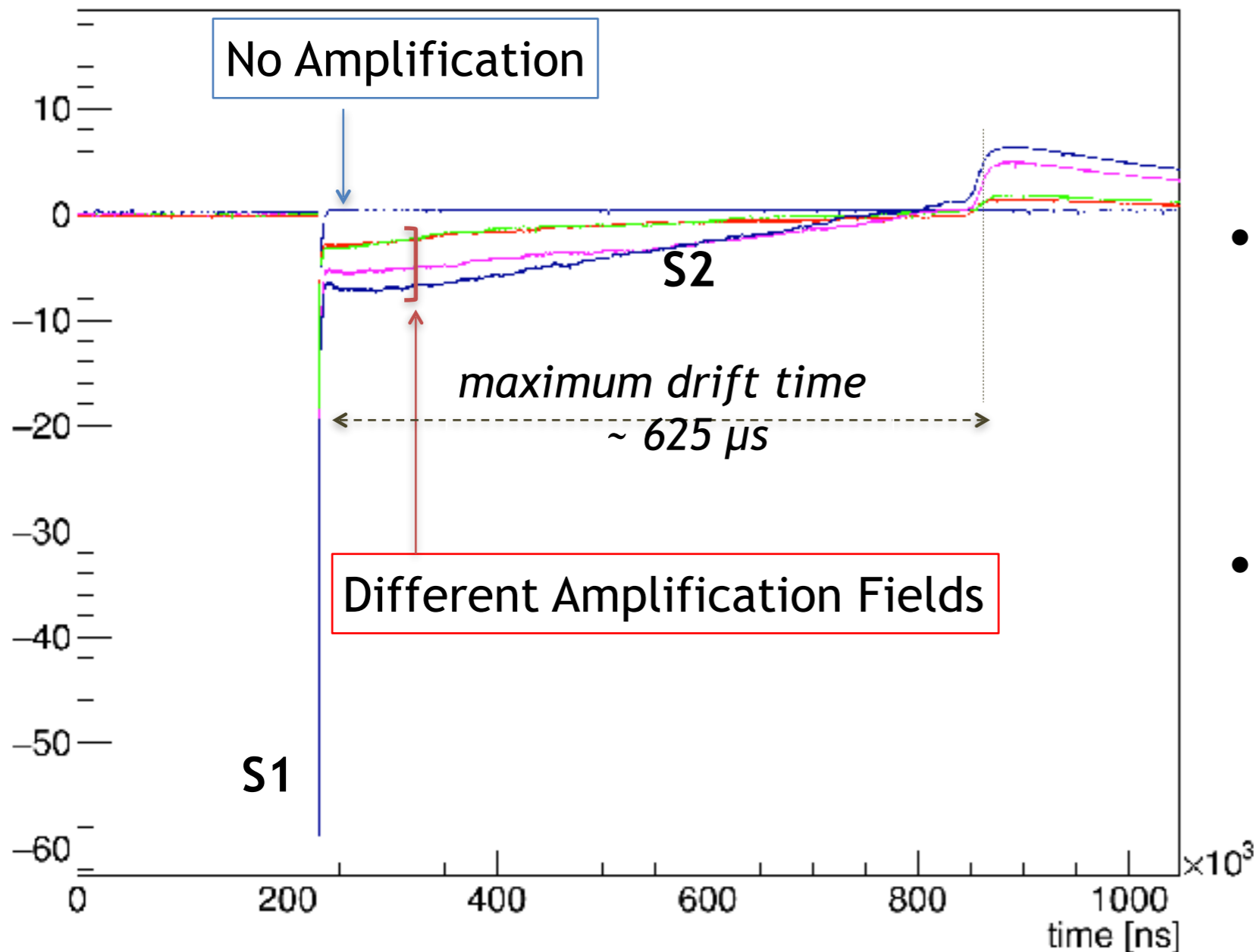
Channel 2

Channel 3

Channel 4



Drift velocity from secondary light signals



- S2 trailing edge allow to measure the maximum drift time and drift velocity
- At 0.5 kV/cm expected maximum drift time is 625 μs

Conclusions

- During the short life of the 311 we manage to cumulate a good amount of light data in different configuration
- PMT response in LAr have been characterised to the best of our capacity
- We perform a rough gain calibration using random trigger in July and in October. Consistent results have been found.
- PMT behaviour and calibration have been found to be stable over the operation period
- The light level is $\sim 2\text{k PE/channel}$ per horizontal muon crossing the field cage ($\sim 3\text{m}$)
- Given the light level observed and the limited dynamic range of the ADC we had, we did not manage to run the PMT at $g \sim 1\text{e}7$ as expected.
- We studied S1 and S2 for different configuration of the drift, extraction and amplification field