Studies of the PMTs response in LAr

Calibration of the 3x1x1 light detection system.

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Overview

- There is NOT a calibration system for the light detection system in the 3x1x1. There will be one in the 6x6x6.
- The 5 PMTs used in the 3x1x1 have not been calibrated at cryogenic temperature, but only at room temperature (in 2015).
- We are aimed to equalize the response of all PMT, and to do that, I looked for a way to construct a SPE spectrum.
- I will try to determine the gain of the 5 PMTs with an off-line analysis of the waveform, the results obtained must fit with the expected behaviour at cold:
  - $Gain_{COLD} \sim (0.19 \pm 0.08) * Gain_{WARM}$

Overview

				Expected[2]
Channel	PMT	Voltage[1] (V)	Room T (10^6)	In LAr (10^6)
0	FA0093	1500	9.6±0.3	1.8±0.8
1	FA0092	1500	12.9±0.4	2.5±1.0
2	FA0090	1320	7.1±0.2	1.3±0.6
3	FA0094	1300	31.6±0.9	6.0±2.5
4	FA0091	1400	5.2±0.2	1.0±0.4

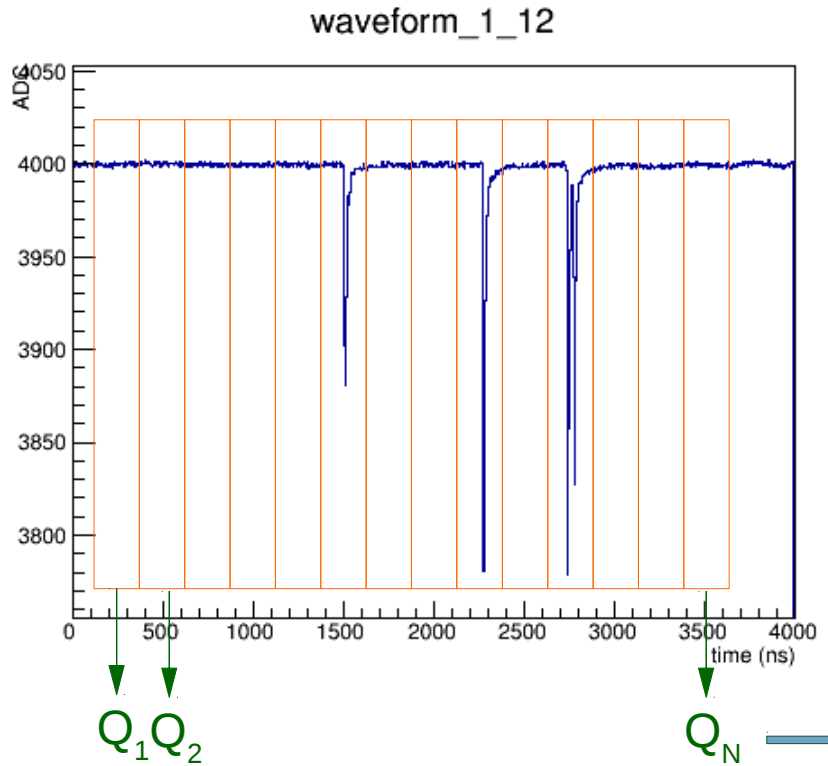
1: Operating voltages applied now in the detector.
2: Value of the gain expected assuming a decrease similar to the one observed in the lab at LN temperature for the 40 6x6x6 PMTs (G_{COLD}~0.19±0.08 G_{WARM}).

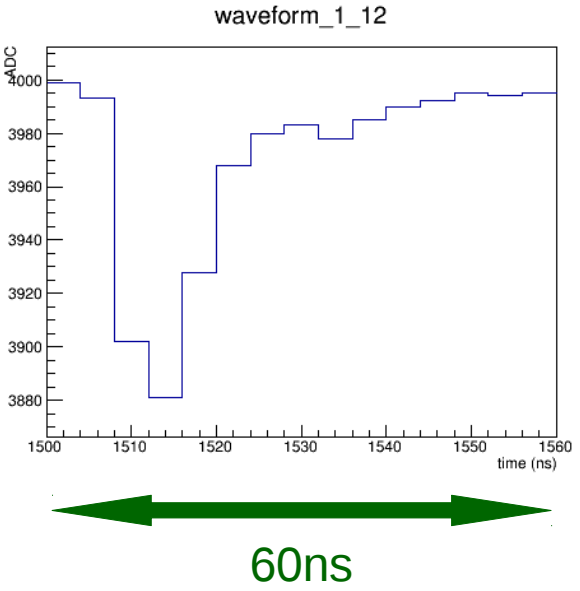
Description of the data

- Use of a pulser as an external trigger connected to the DAQ (square signal of 100Hz and 1V amplitude).
- 4 runs (914, 919, 920 & 921) taken on June 20th, applying different PMT voltages. Extraction grid was off. http://lbnodemo.ethz.ch:2500/3x1x1/268
- Around 100k events each run, 250MHz sampling and 4μs read-out window.

Description of the analysis

- Every 4μs event was divided in shorter windows of 60ns length, which is around the SPE lenght.
- Then, each 60ns window was integrated, adjusting the pedestal, and reconstructing the charge spectrum.

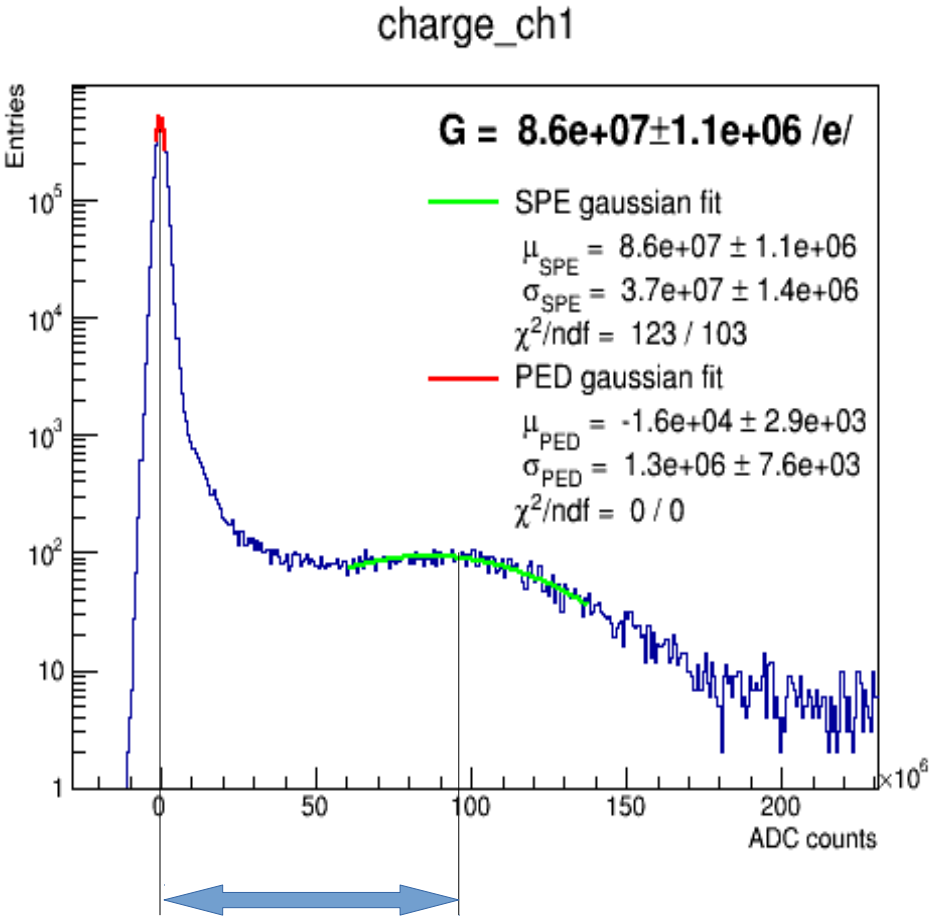




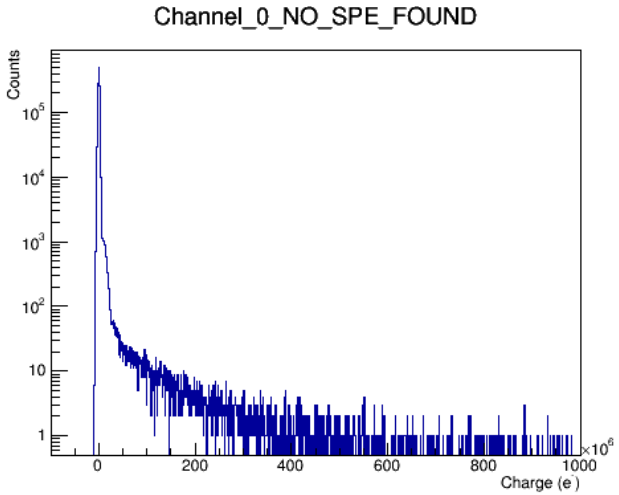
Charge histogram

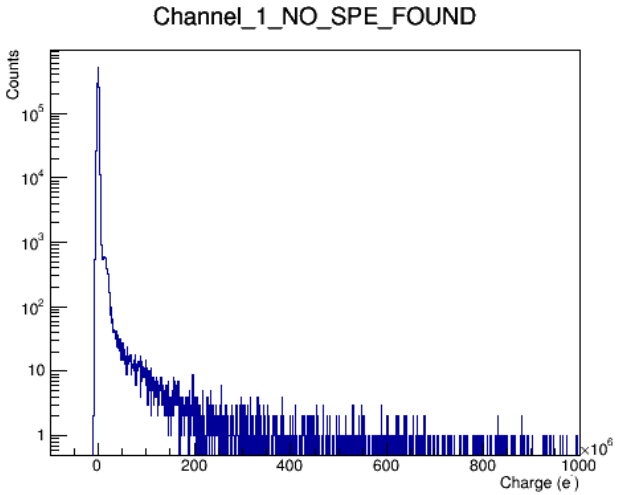
Description of the analysis

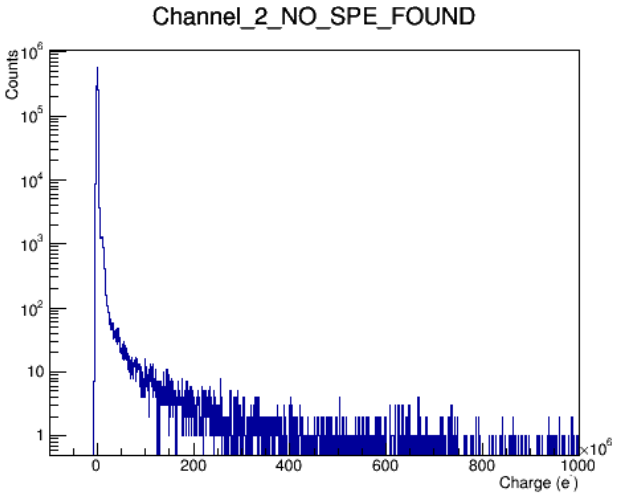
- Once obtained the charge spectrum, we look for a maximum in the charge histogram, that "**looks like a SPE**", and a Gaussian fit is performed in the bins around the maximum.
- Also a Gaussian fit is performed around the pedestal (in 0 by definition).
- We get the '**Gain candidate**' of the PMT, by the difference of both values.
- I also tried to reconstruct the SPE gain, selecting singles in the waveform (with no pedestal), and compatible results with this method were obtained.

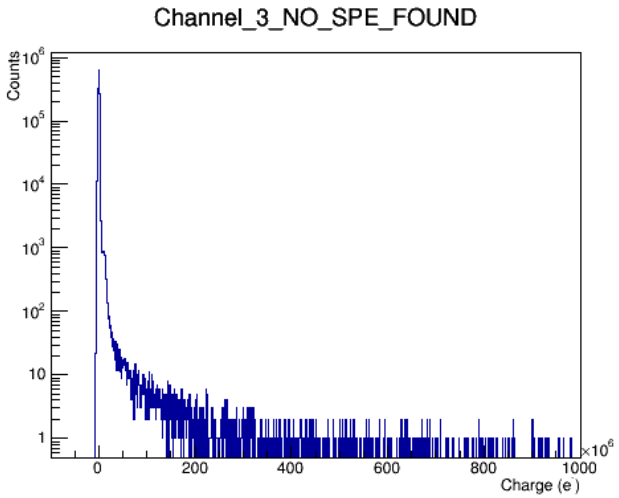


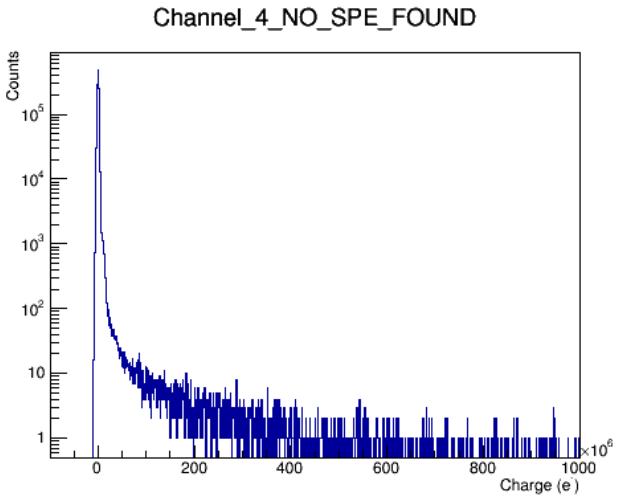
Run 914





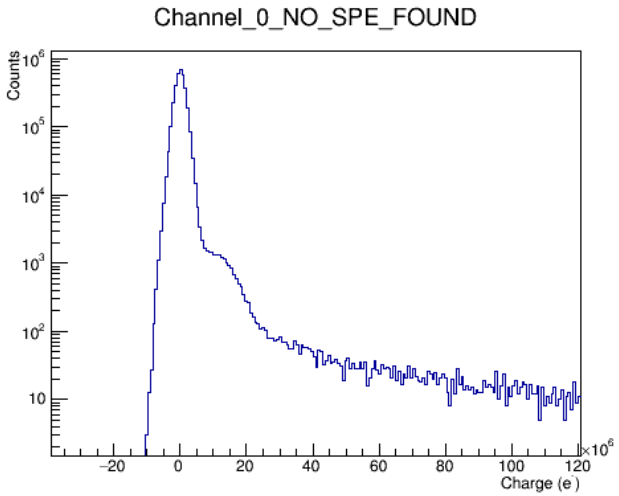


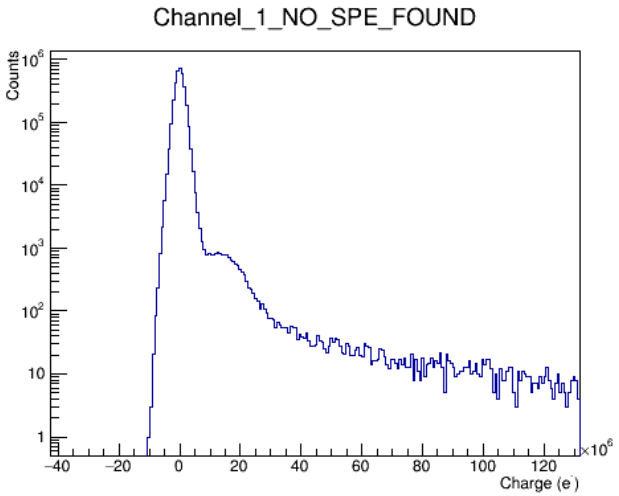


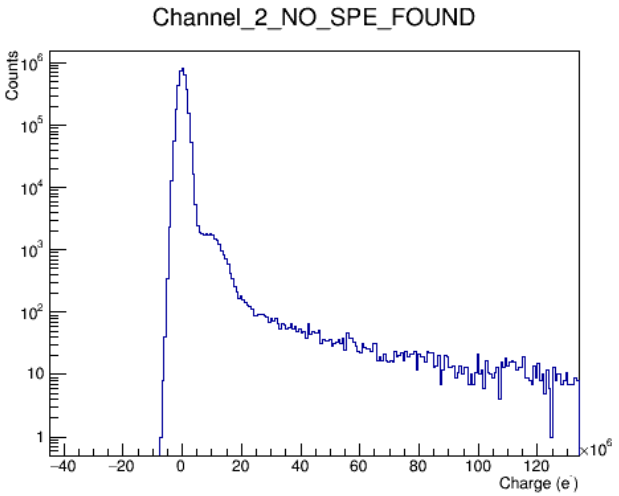


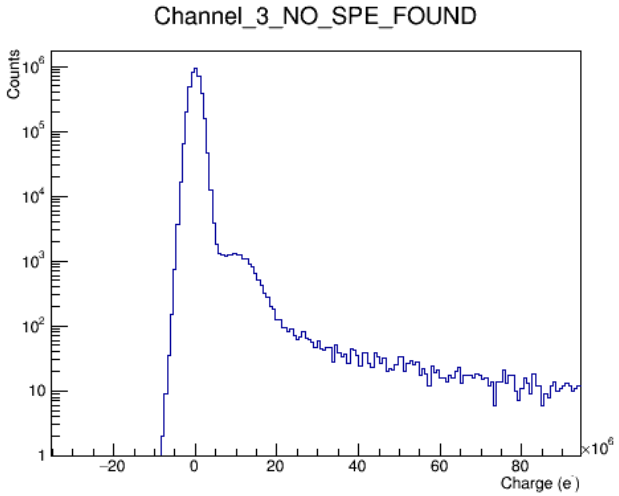
- Ch0: 1500V
- Ch1: 1500V
- Ch2: 1320V
- Ch3: 1300V
- Ch4: 1400V

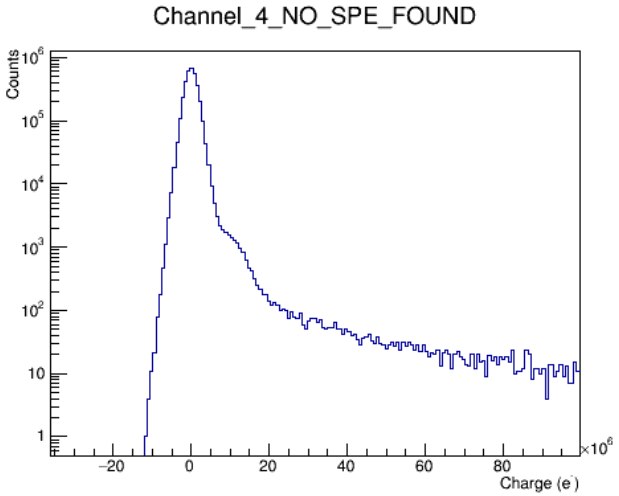
Run 194 – Zoom





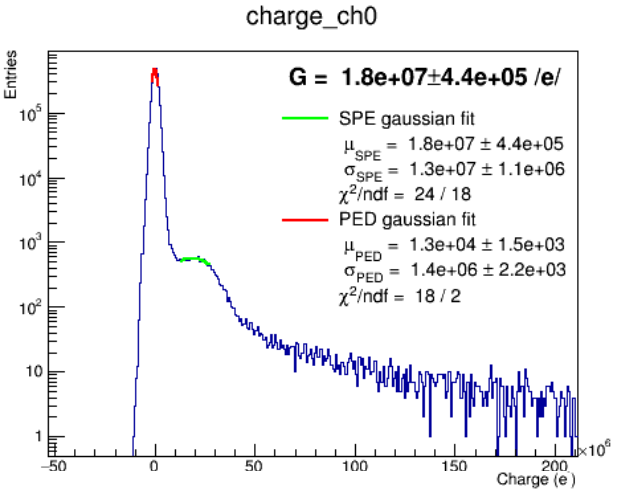


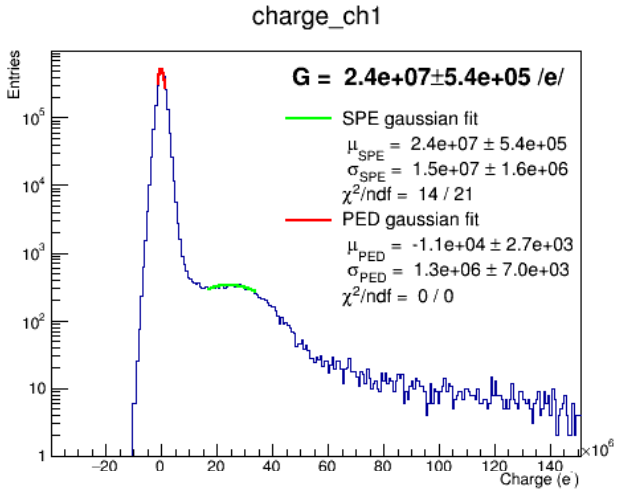


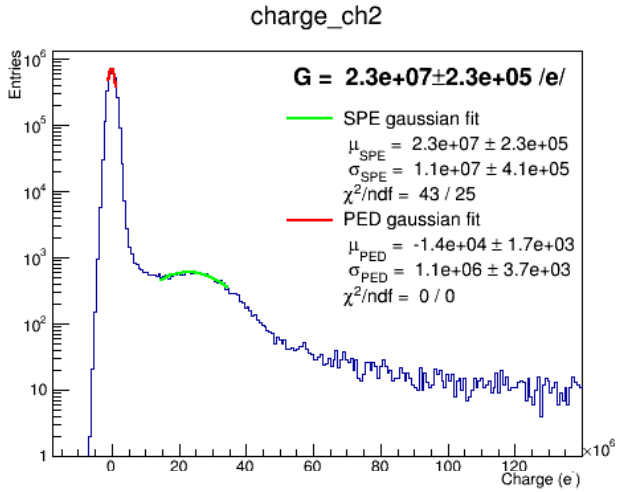


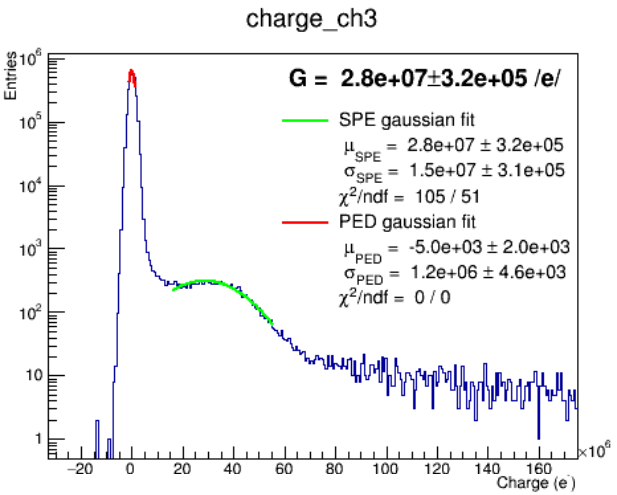
- Ch0: 1500V
- Ch1: 1500V
- Ch2: 1320V
- Ch3: 1300V
- Ch4: 1400V

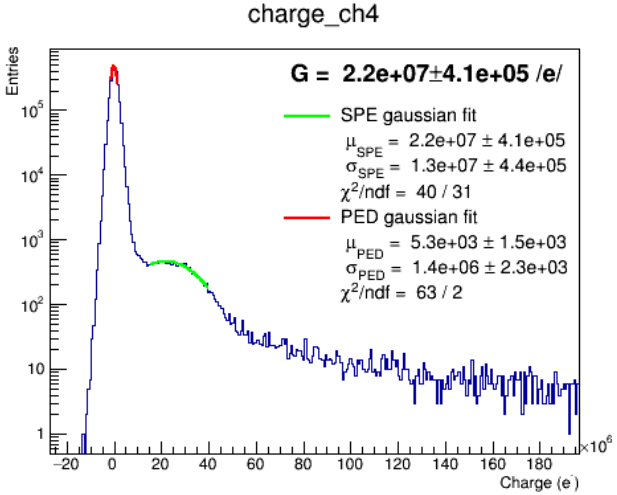
Run 919





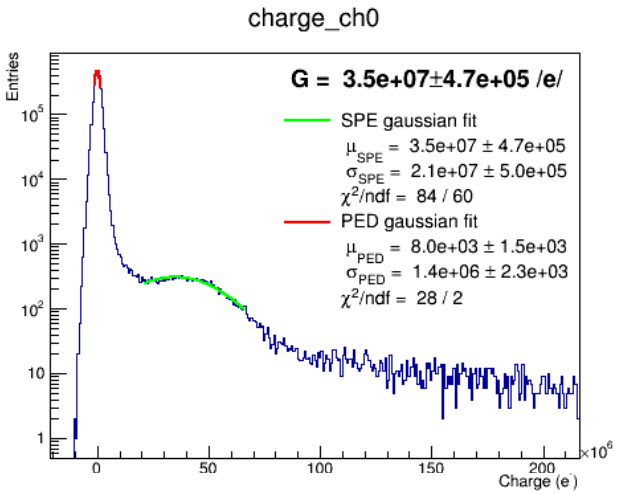


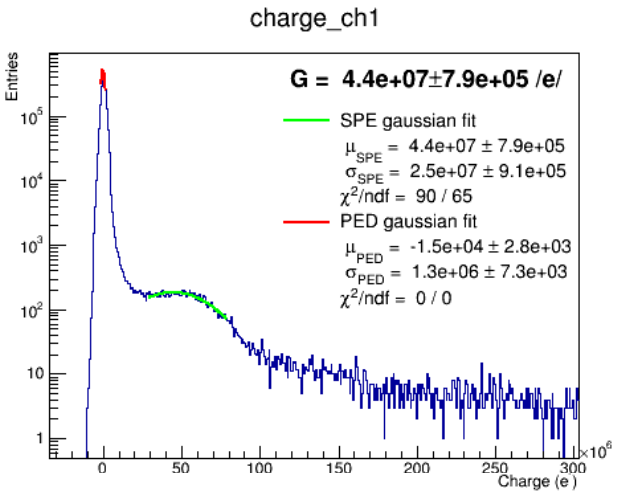


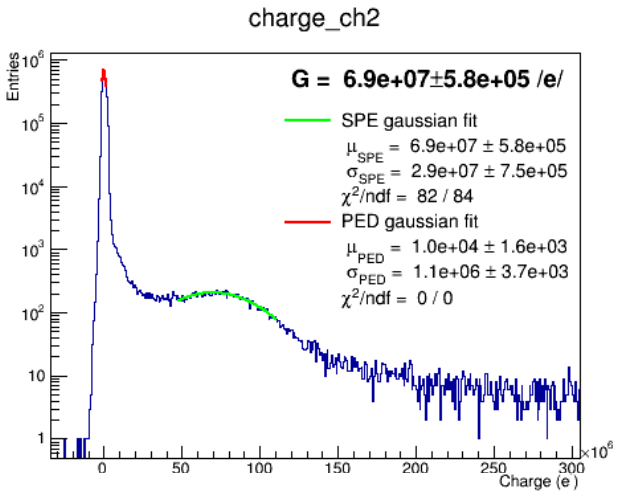


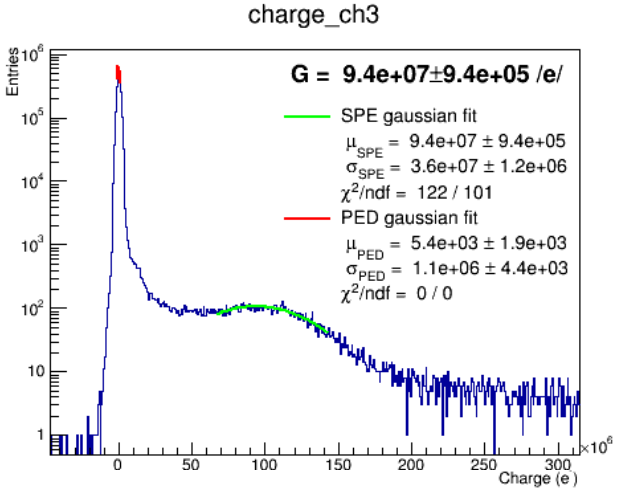
- Ch0: 1600V
- Ch1: 1600V
- Ch2: 1450V
- Ch3: 1450V
- Ch4: 1550V

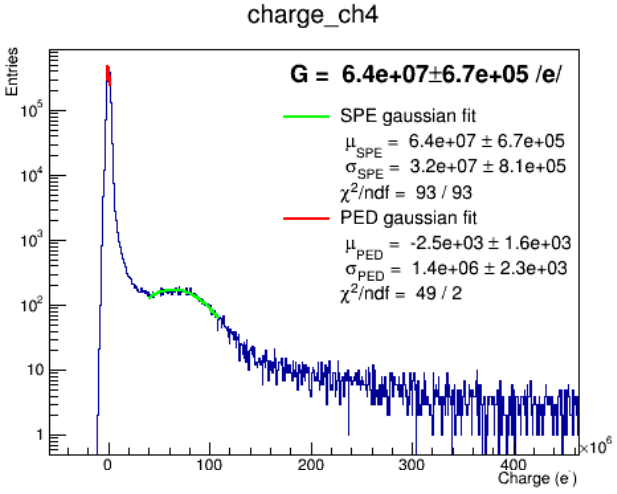
Run 920





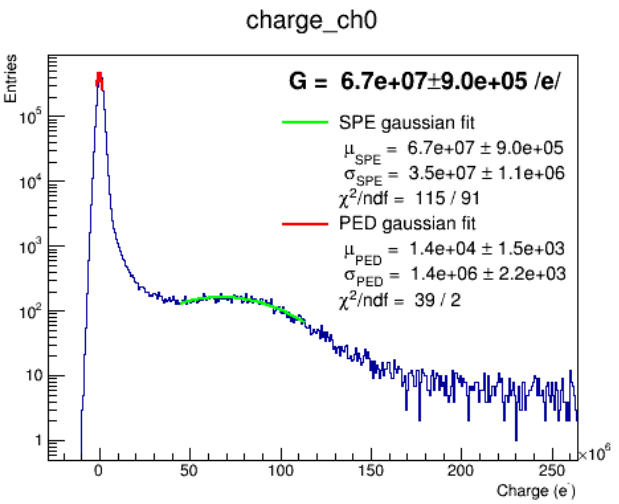


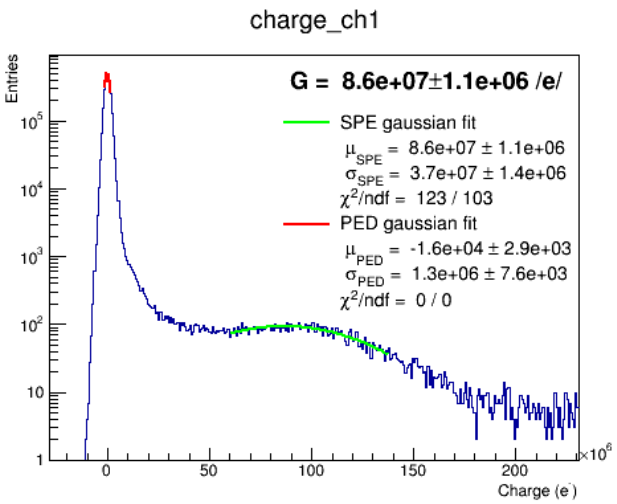


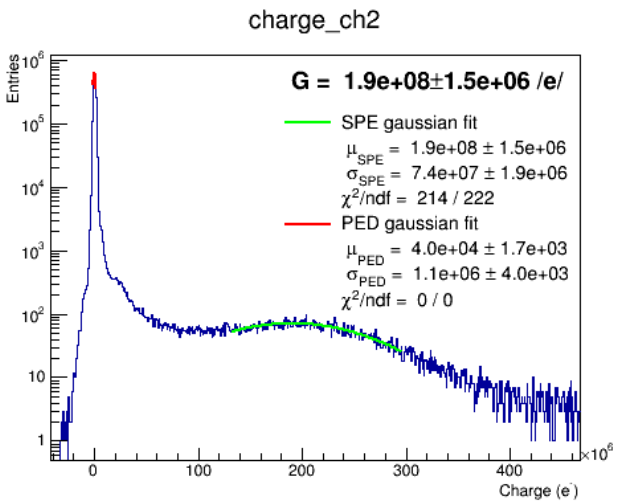


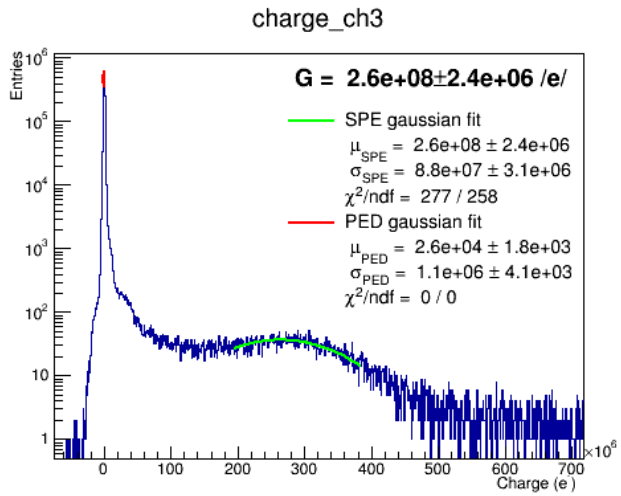
- Ch0: 1700V
- Ch1: 1700V
- Ch2: 1600V
- Ch3: 1600V
- Ch4: 1700V

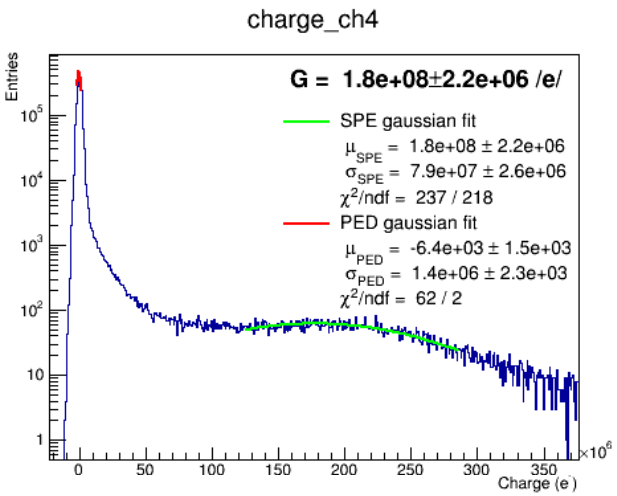
Run 921







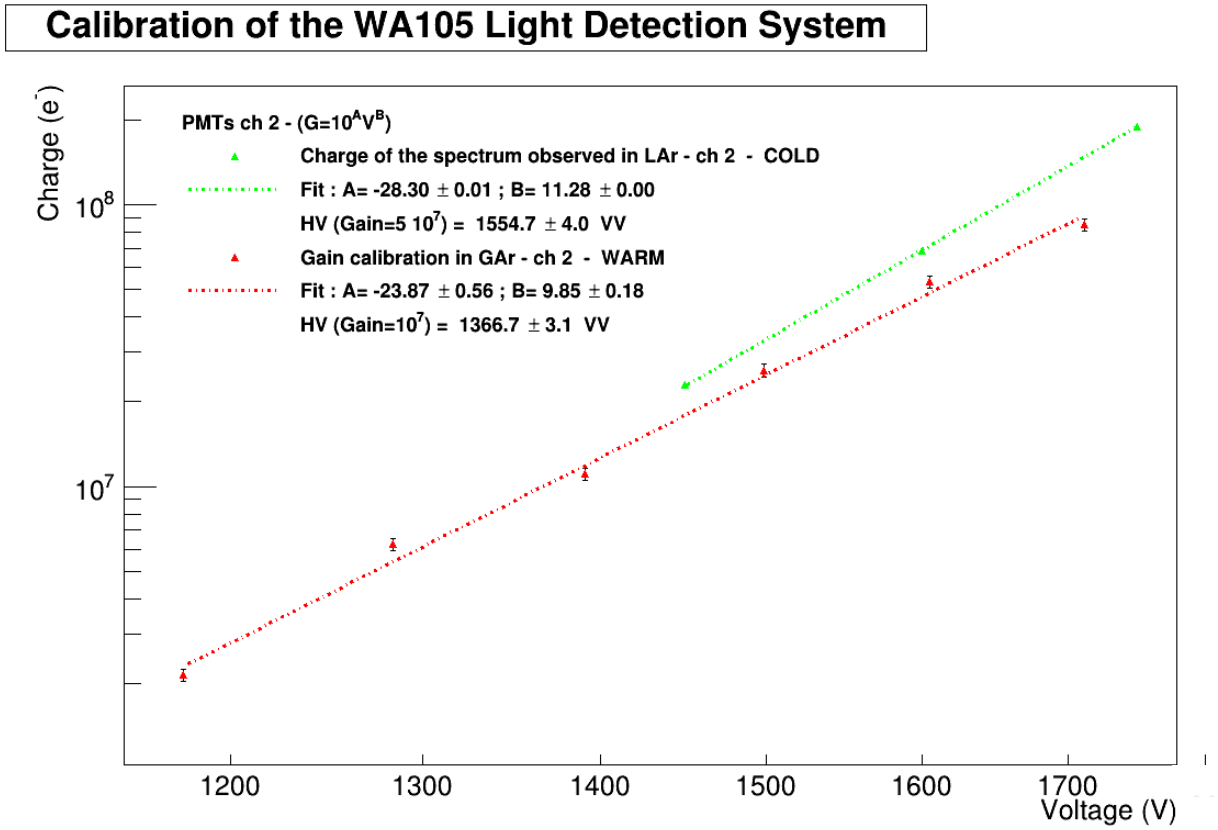




- Ch0: 1800V
- Ch1: 1800V
- Ch2: 1750V
- Ch3: 1750V
- Ch4: 1850V

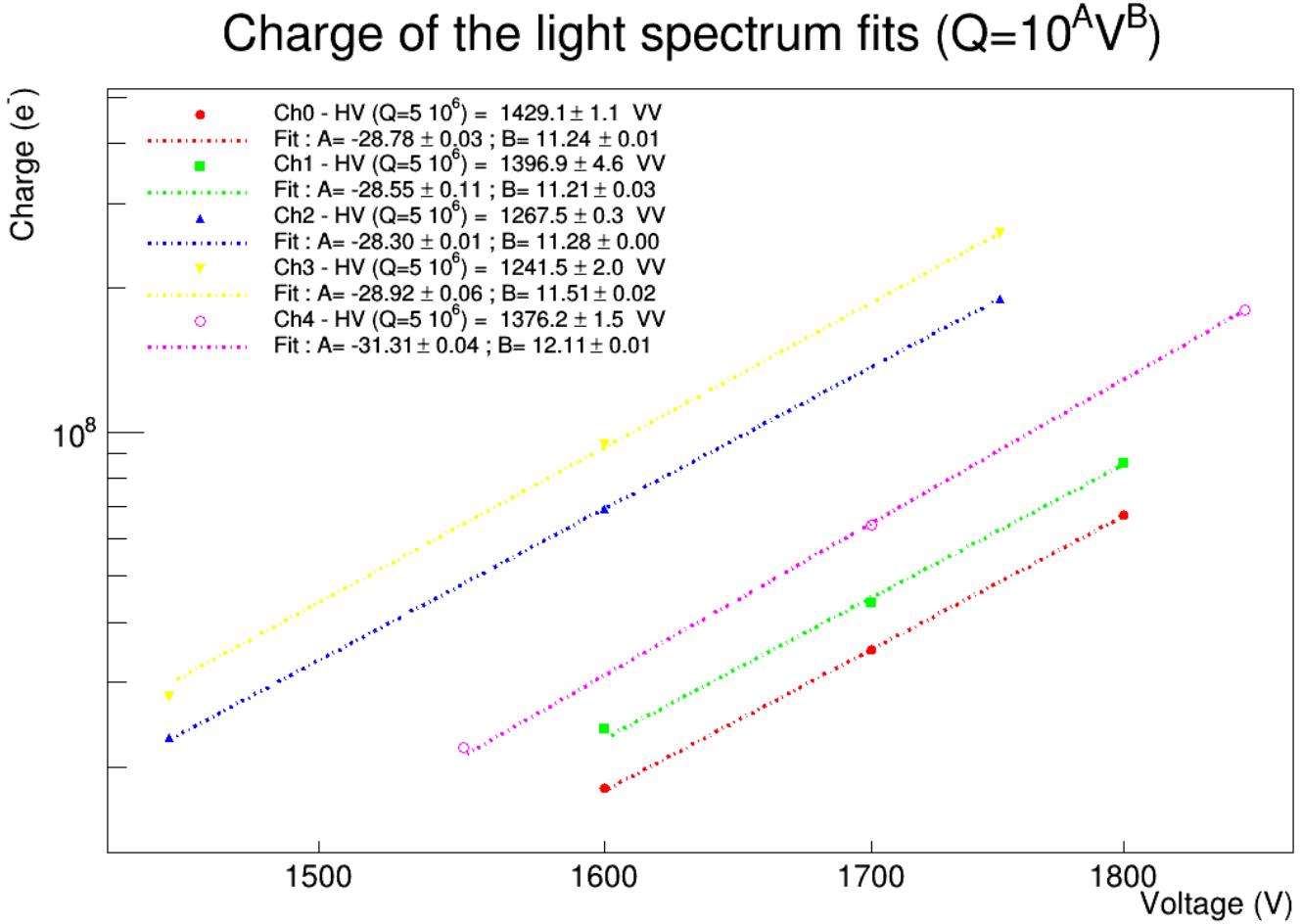
Results

- Usually gain measurement at cryogenic temperature shows a lower gain in cold than the gain measured at warm (also confirmed by measurement currently ongoing at CIEMAT).
- If we compare the values of the charge gain estimated in this work (green) with the calibration curves in Gar (red), we observe an unexpected higher gain.
- This suggest that the lowest signal we are observing in the 3x1x1 in LAr is higher than the SPE, i.e. there is too much light to being able to observe SPE.
- Unfortunately, it seems we are not able to perform an absolute calibration of the gain in the 3x1x1.



Results

- Anyway, we have provided standard method to perform a relative calibration of the PMT response, that allow us to equalize the response of the 5 PMTs.



Results

Channel	PMT	V(Q=10^6) (V)	V(Q=5 10^6) (V)	V(Q=10^7) (V)
0	FA0093	1238.5±0.9	1429.1±1.1	1520.0±1.1
1	FA0092	1210±4	1397±5	1486±5
2	FA0090	1099.0±0.3	1267.5±0.3	1347.9±0.3
3	FA0094	1080±2	1242±2	1319±2
4	FA0091	1204.9±1.3	1376.2±1.5	1457±2

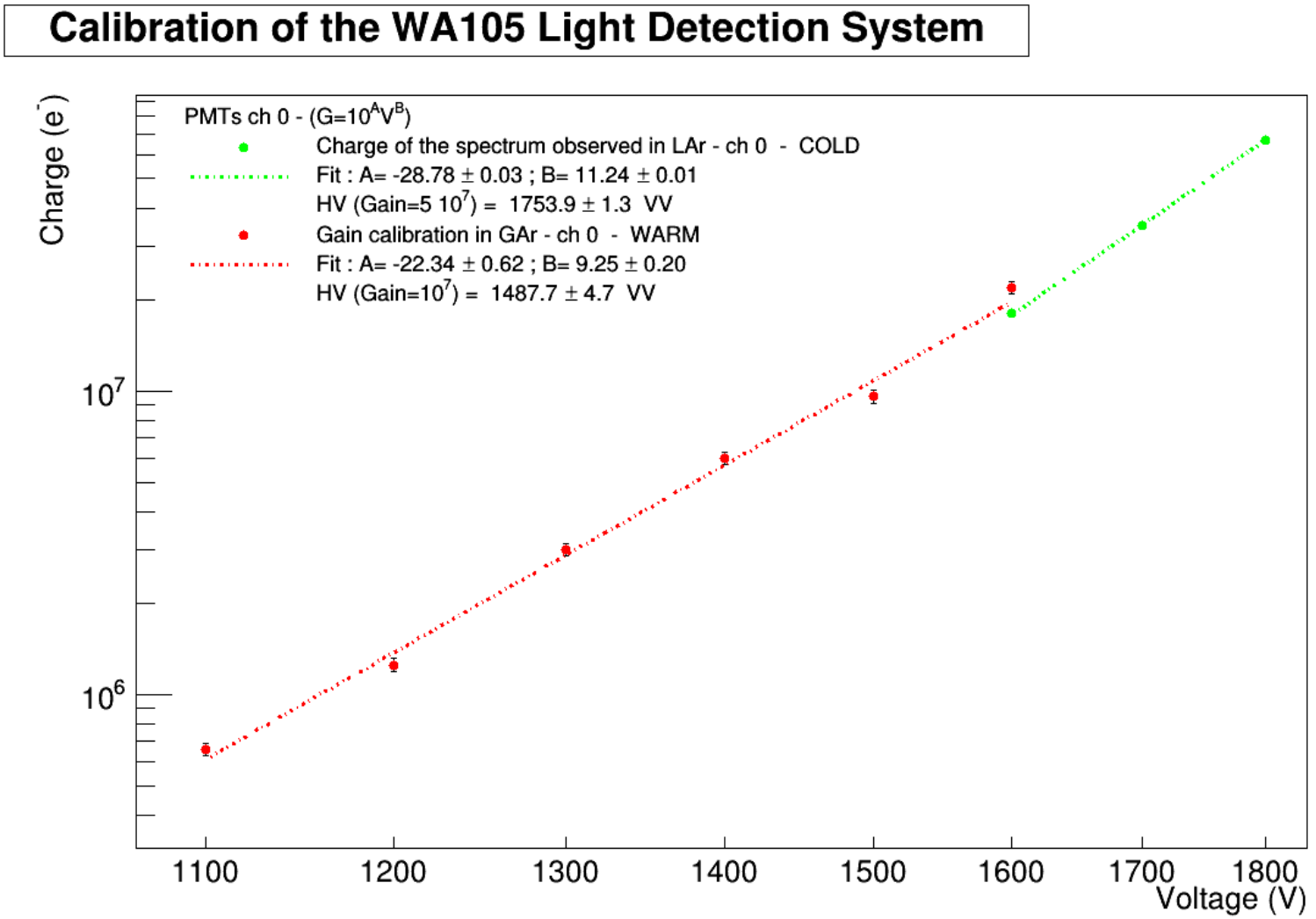
Table of voltages interpolated in the previous fit, to provide an equalized response of all PMTs, with a maximum centered in a charge of value Q.

Conclusions:

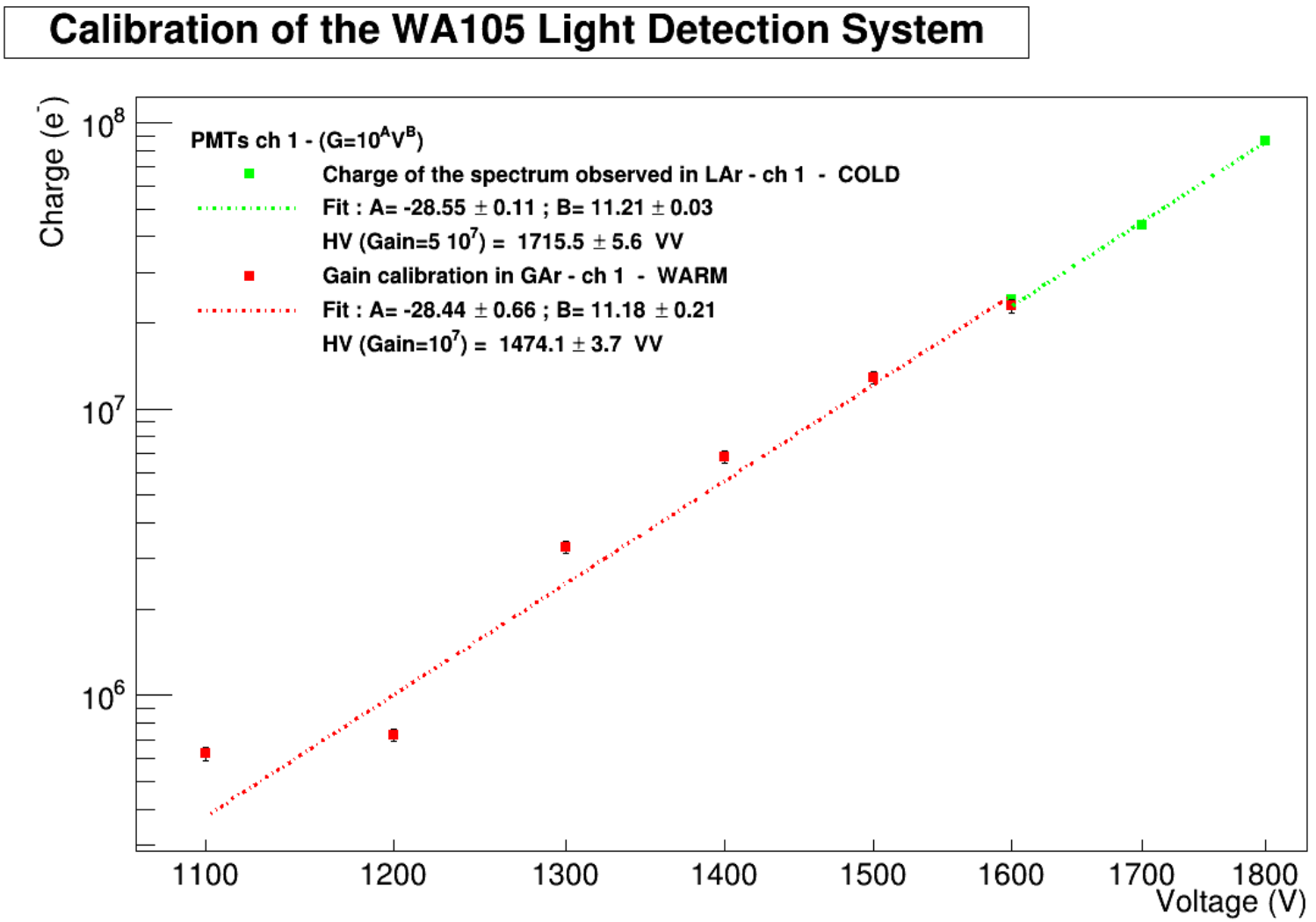
- We are able to calculate a voltage to equalize the response of all PMTs.
- Any new voltage can be calculated interpolating in the previous fits.
- Some test varying the quantity of light are ongoing (varying the voltage of the grid and the cathode).
- We won't have this issue in the 6x6x6, as there will be a dedicated calibration system.

Thank you.

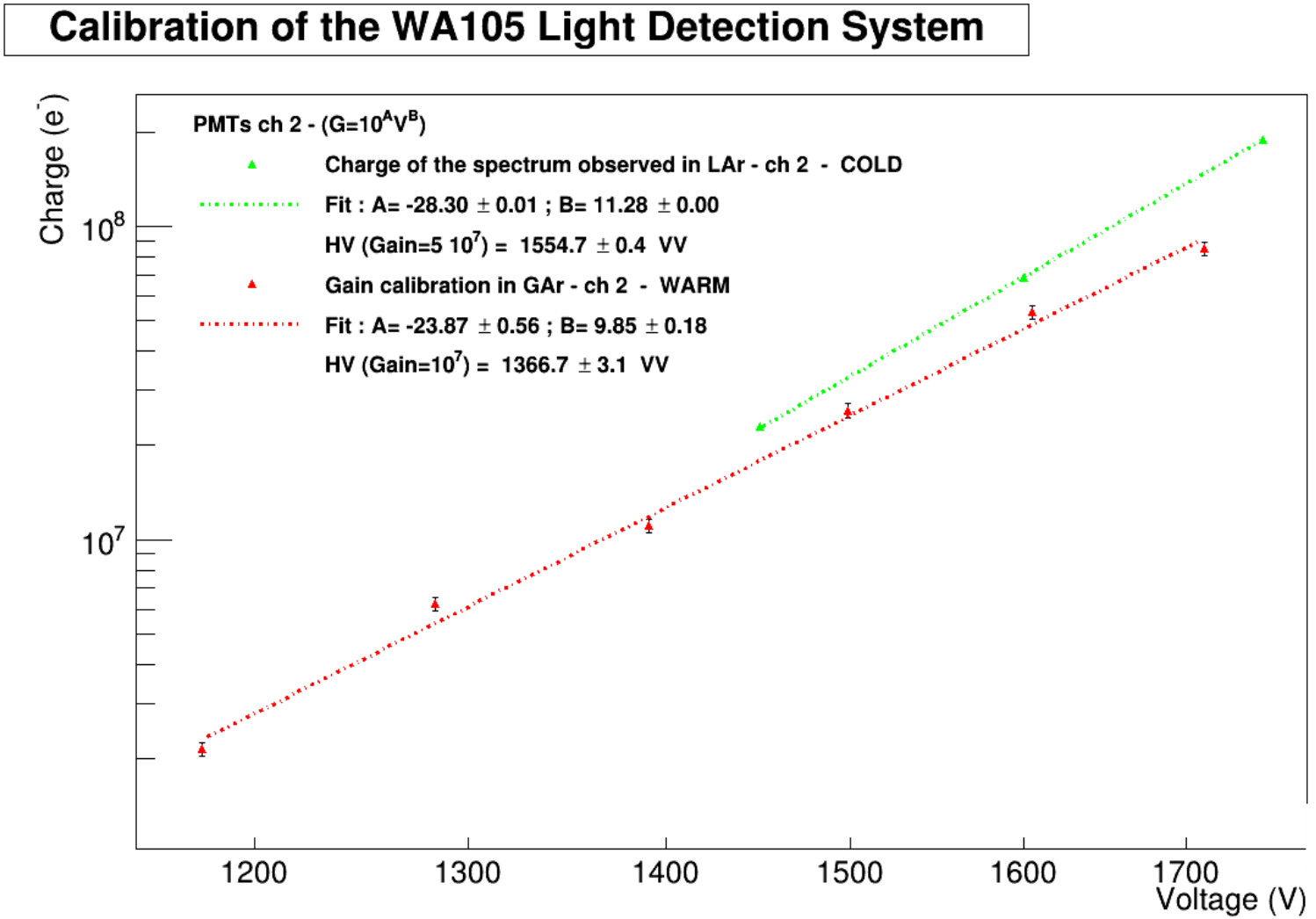
Back-up


Calibration of the WA105 Light Detection System
PMTs ch 0 - (G=10^A V^B)
Charge of the spectrum observed in LAr - ch 0 - COLD
Fit : A= -28.78 ± 0.03 ; B= 11.24 ± 0.01
HV (Gain=5 10^7) = 1753.9 ± 1.3 VV
Gain calibration in GAr - ch 0 - WARM
Fit : A= -22.34 ± 0.62 ; B= 9.25 ± 0.20
HV (Gain=10^7) = 1487.7 ± 4.7 VV
Charge (e^-)
10^7
10^6
1100
1200
1300
1400
1500
1600
1700
1800
Voltage (V)

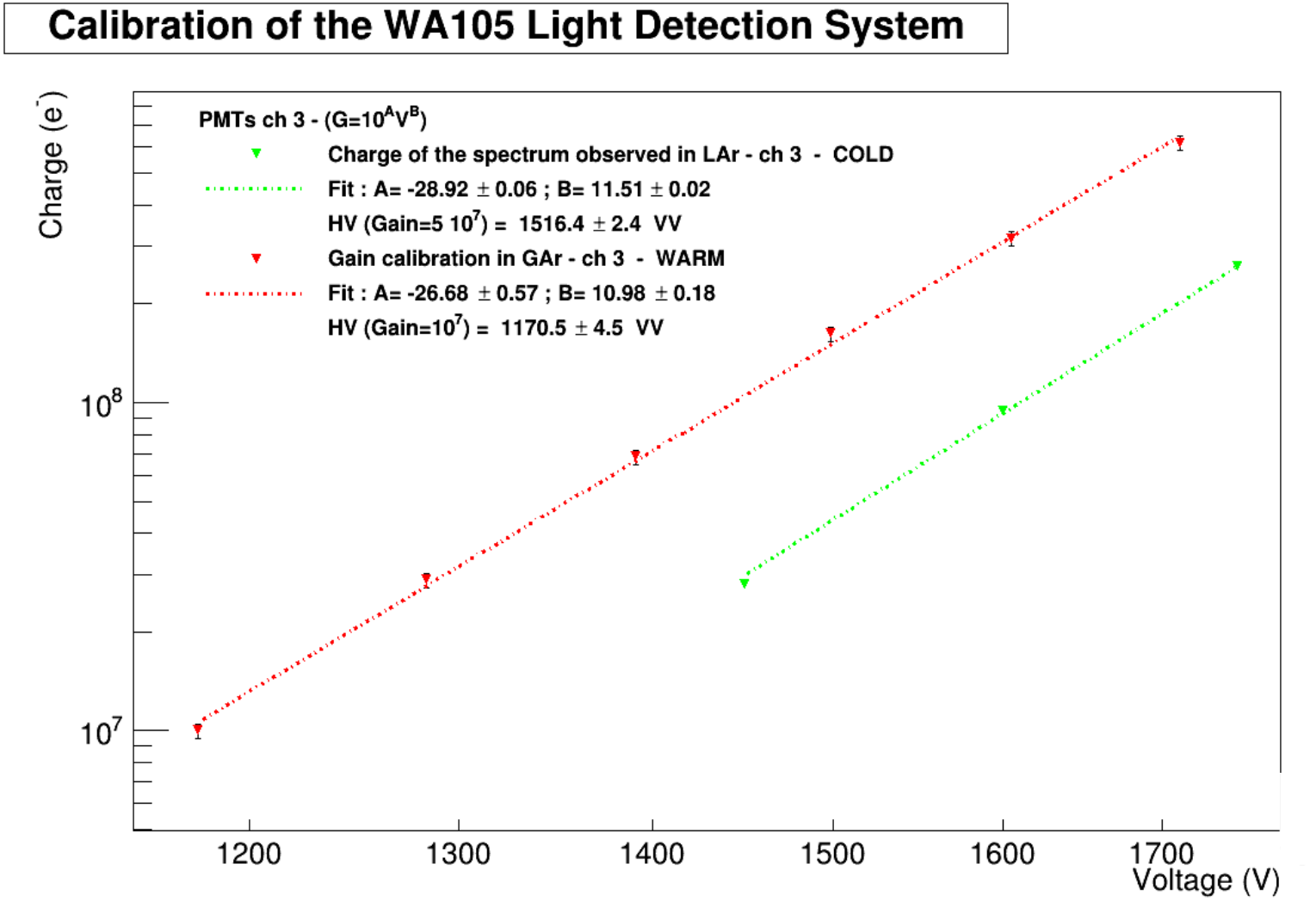
Back-up


Calibration of the WA105 Light Detection System
PMTs ch 1 - (G=10^A V^B)
Charge of the spectrum observed in LAr - ch 1 - COLD
Fit : A= -28.55 ± 0.11 ; B= 11.21 ± 0.03
HV (Gain=5 10^7) = 1715.5 ± 5.6 VV
Gain calibration in GAr - ch 1 - WARM
Fit : A= -28.44 ± 0.66 ; B= 11.18 ± 0.21
HV (Gain=10^7) = 1474.1 ± 3.7 VV
Charge (e⁻)
10^8
10^7
10^6
1100
1200
1300
1400
1500
1600
1700
1800
Voltage (V)

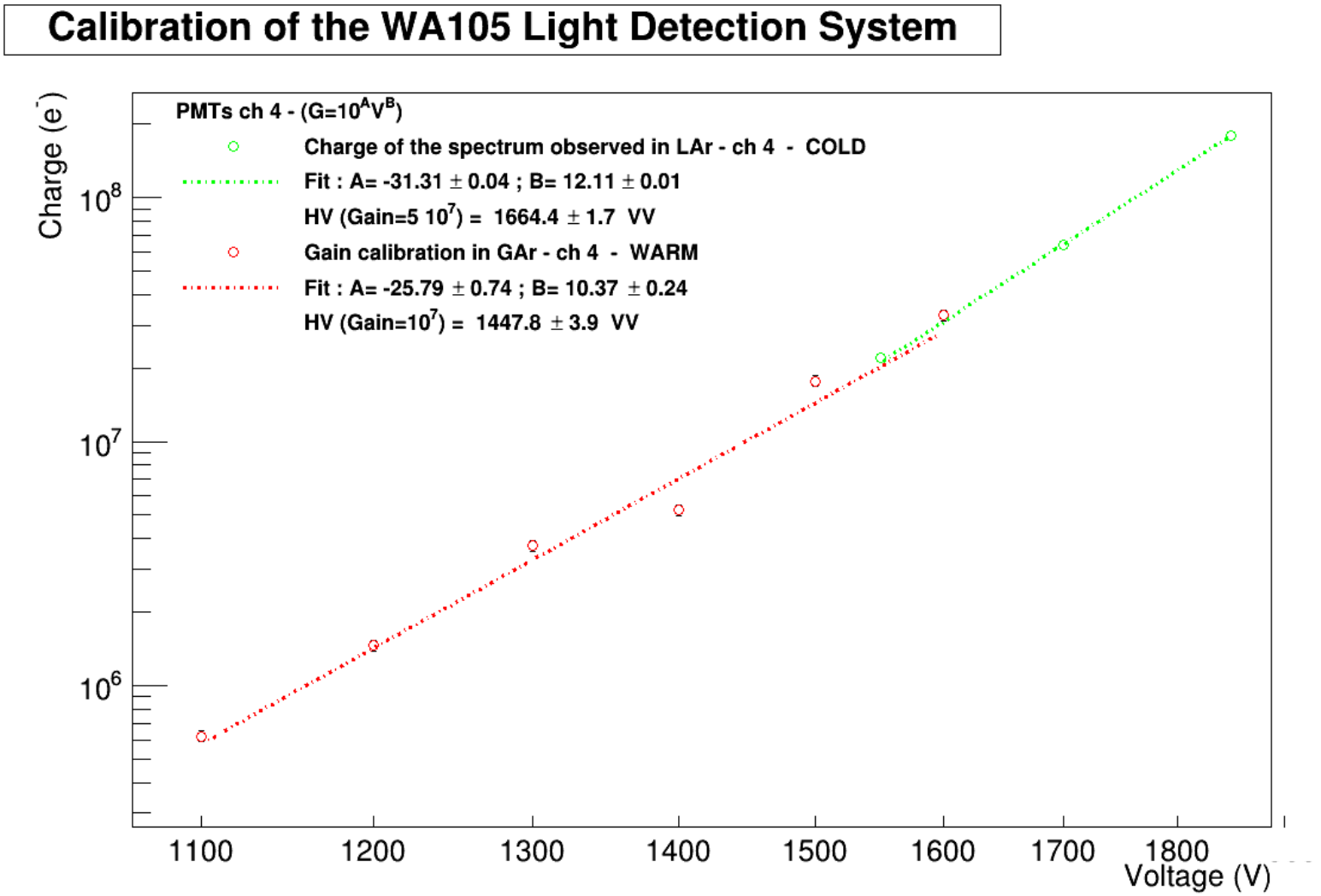
Back-up


Calibration of the WA105 Light Detection System
PMTs ch 2 - (G=10^A V^B)
Charge of the spectrum observed in LAr - ch 2 - COLD
Fit : A= -28.30 ± 0.01 ; B= 11.28 ± 0.00
HV (Gain=5 10^7) = 1554.7 ± 0.4 VV
Gain calibration in GAr - ch 2 - WARM
Fit : A= -23.87 ± 0.56 ; B= 9.85 ± 0.18
HV (Gain=10^7) = 1366.7 ± 3.1 VV
Charge (e^-)
10^8
10^7
1200
1300
1400
1500
1600
1700
Voltage (V)

Back-up


Calibration of the WA105 Light Detection System
PMTs ch 3 - (G=10^A V^B)
Charge of the spectrum observed in LAr - ch 3 - COLD
Fit : A= -28.92 ± 0.06 ; B= 11.51 ± 0.02
HV (Gain=5 10^7) = 1516.4 ± 2.4 VV
Gain calibration in GAr - ch 3 - WARM
Fit : A= -26.68 ± 0.57 ; B= 10.98 ± 0.18
HV (Gain=10^7) = 1170.5 ± 4.5 VV
Charge (e⁻)
10^8
10^7
1200
1300
1400
1500
1600
1700
Voltage (V)

Back-up


Calibration of the WA105 Light Detection System
PMTs ch 4 - (G=10^A V^B)
Charge of the spectrum observed in LAr - ch 4 - COLD
Fit : A= -31.31 ± 0.04 ; B= 12.11 ± 0.01
HV (Gain=5 10^7) = 1664.4 ± 1.7 VV
Gain calibration in GAr - ch 4 - WARM
Fit : A= -25.79 ± 0.74 ; B= 10.37 ± 0.24
HV (Gain=10^7) = 1447.8 ± 3.9 VV
Charge (e⁻)
10^8
10^7
10^6
1100
1200
1300
1400
1500
1600
1700
1800
Voltage (V)