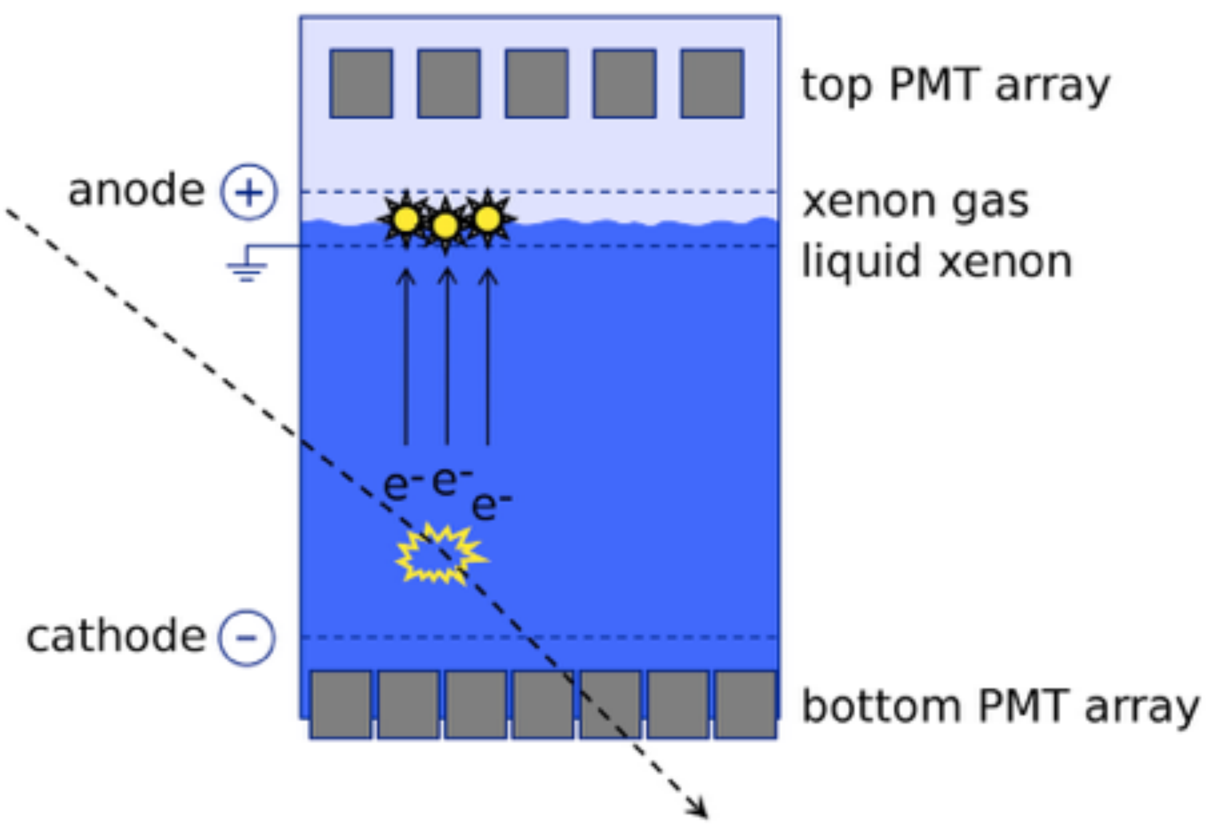
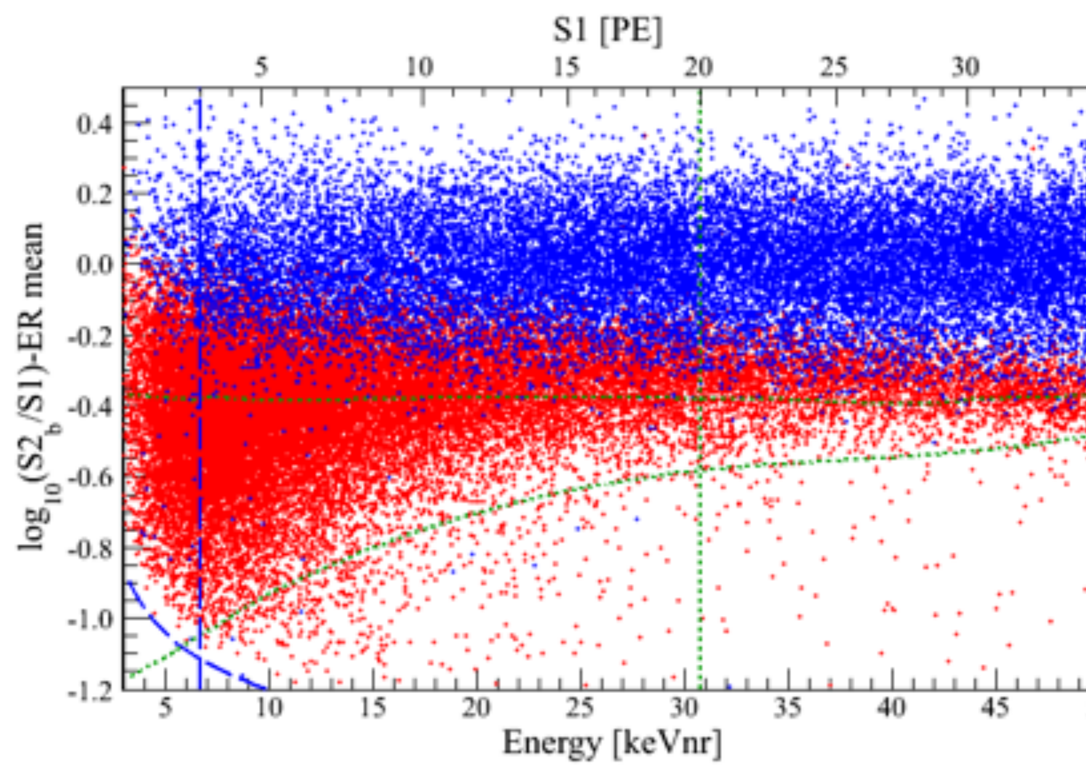
Characterization of the R11410 PMTs to be used in the XENON1T

Susnata Seth
Ander Simón Estévez

XENON 1T

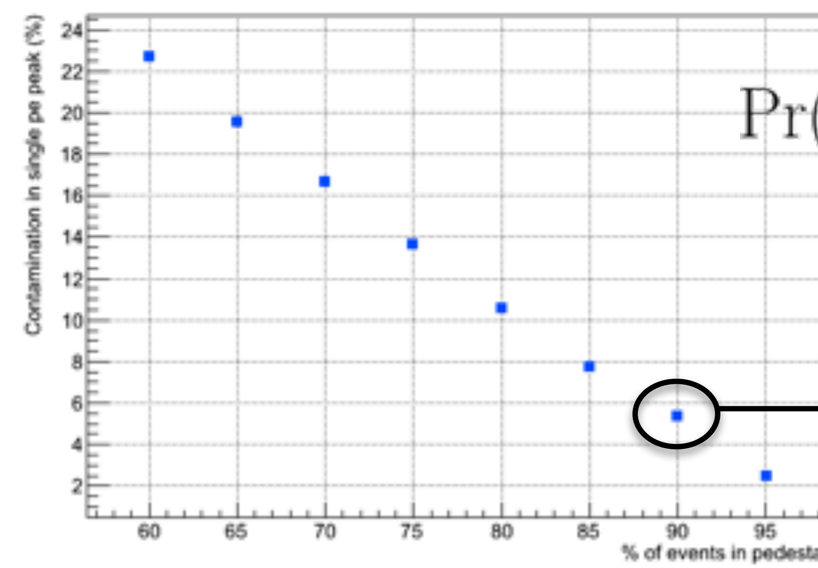
- XENON searches for dark matter in dual phase xenon time projection chamber.
- S2/S1 used for signal identification.
- 3D position of events.





Experimental setup

- Closed chamber. Light of blue LED gets inside through optical fiber.
- Pulse generated with Lecroy 9211. External trigger synchronized with LED light emission
- LED voltage 2.3V, width of 20 ns
- CAEN V1724 for data acquisition.

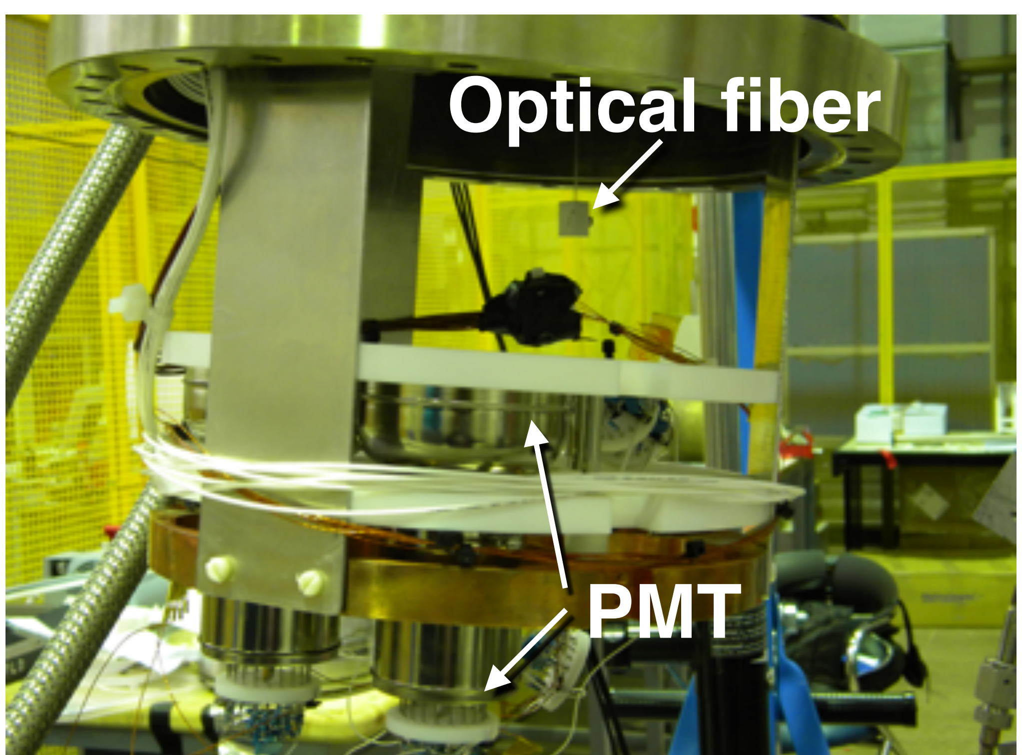


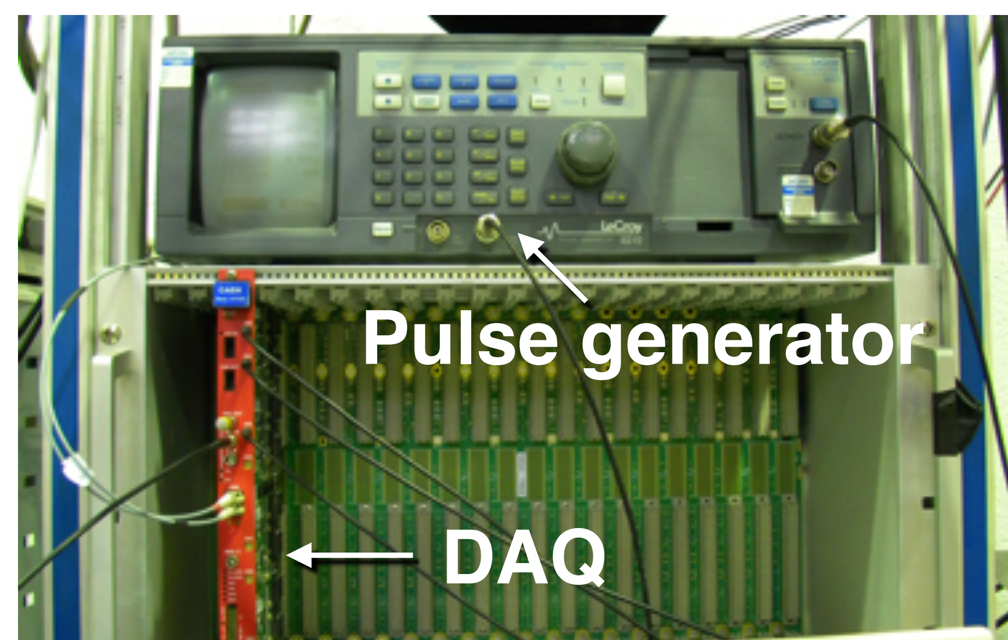
$$\Pr(n, \mu) = \frac{\mu^n e^{-\mu}}{n!}$$

2.3V

PMT1 = 91.8%

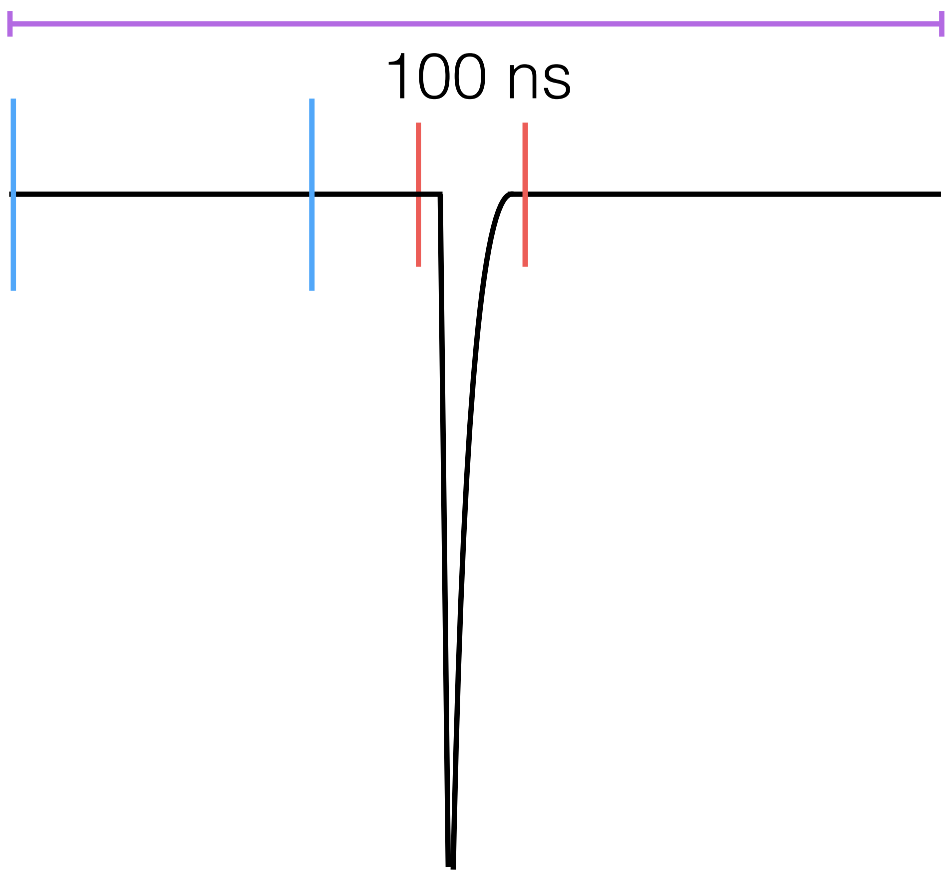
PMT2 = 90.2%





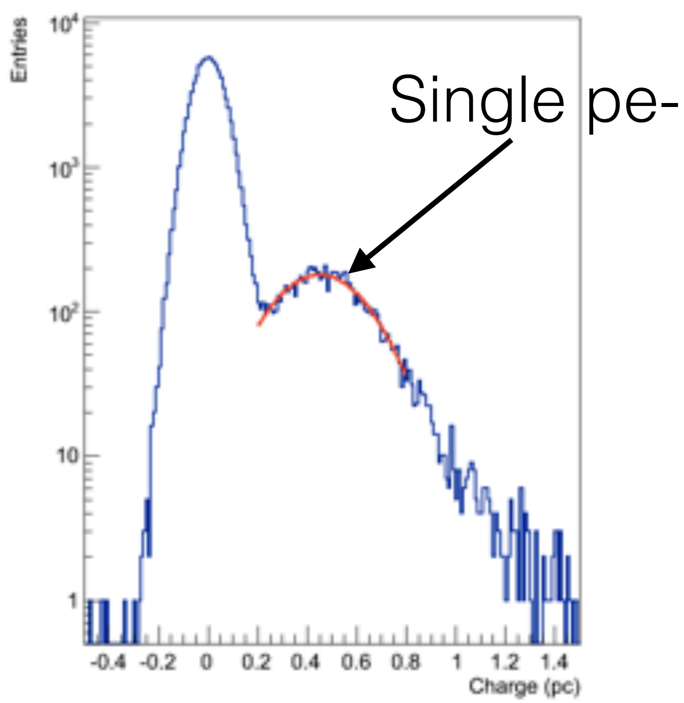
Signal preprocessing

- Signal identification
  - 100 ns window (binning of 10 ns)
  - Search for minimum.
- Baseline subtraction
  - Gaussian fit to distribution of ADCs.
  - Mean value in the first 1μs.
- Charge calculation
  - Integrate area in 100 ns window around signal.
  - Transform into charge (1 ADC channel = 0.03 mV, digitizer resistance = 50 ohm)

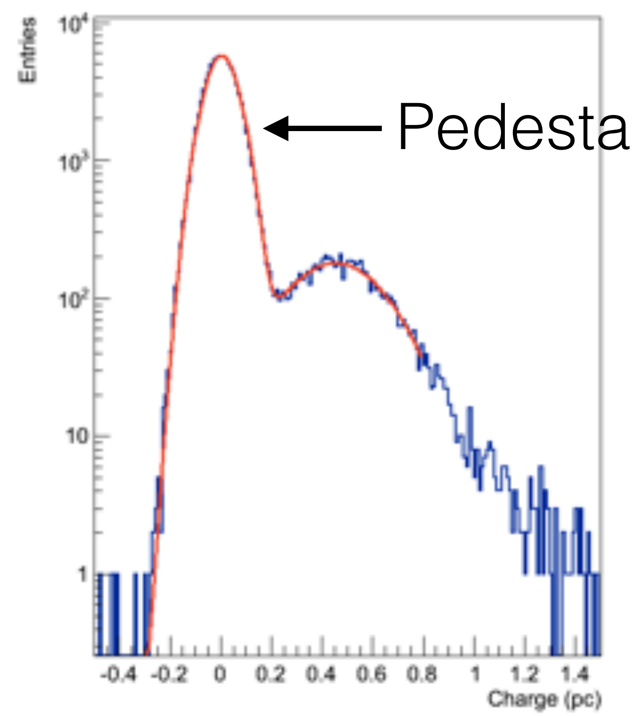


Gain determination

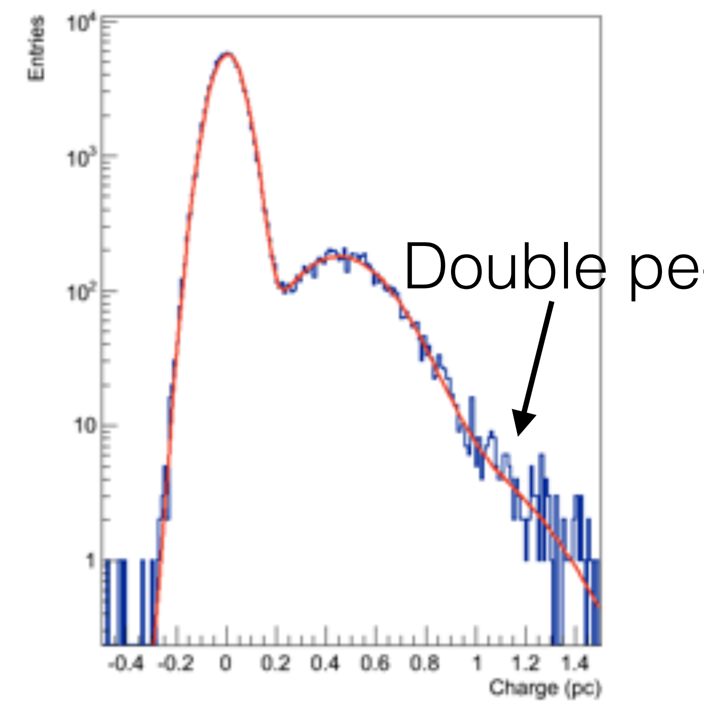
Fit to 1 gaussian



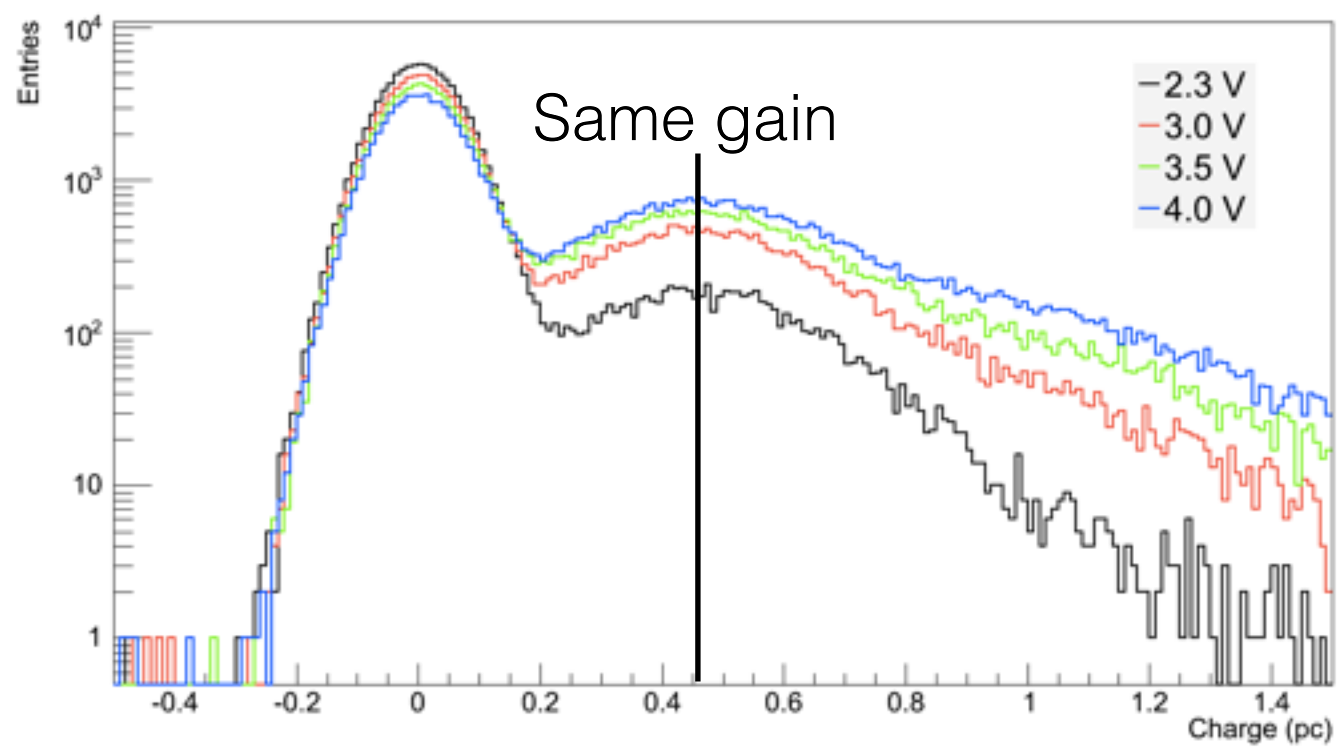
Fit to 2 gaussians



Fit to 3 gaussians



	Single pe- charge(10e-1)	Gain (10e6)
1 gauss	4.49 ± 0.03	2.79 ± 0.02
2 gauss	4.52 ± 0.03	2.81 ± 0.02
3 gauss	4.49 ± 0.03	2.79 ± 0.02

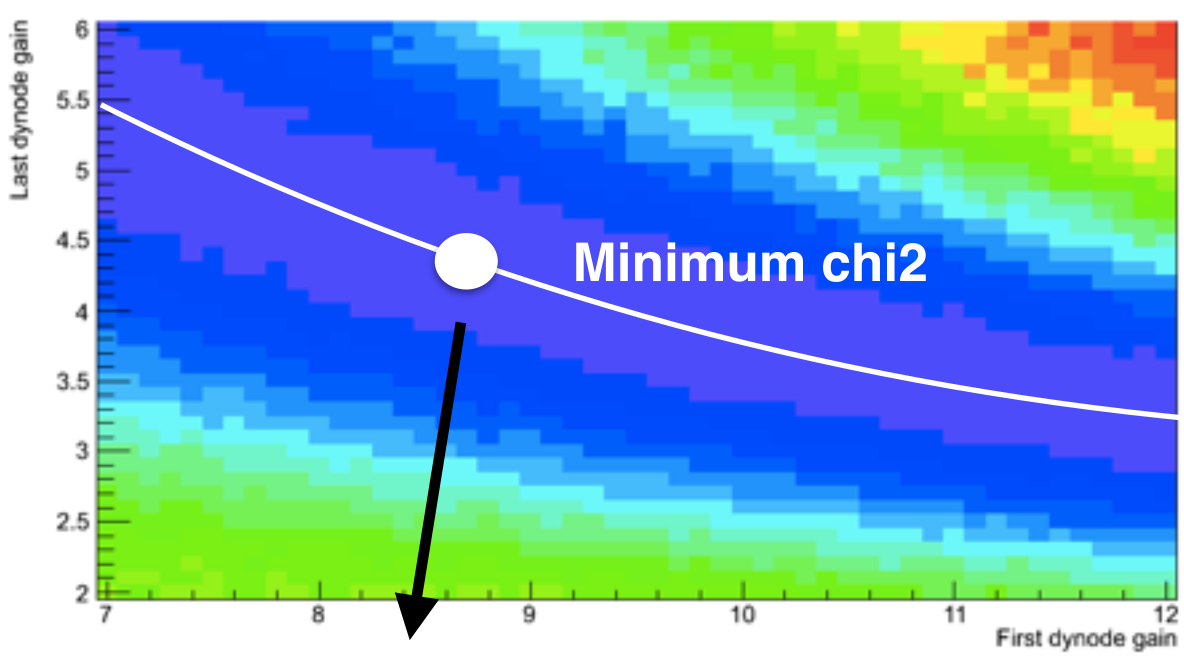


Data - MC comparison

Parameters of the MC:
- 12 PMT dynodes but only first and last were considered as free.
  - First dynode gain impacts greatly to the shape and the position of the single pe- pulse.
  - Last dynode gain is less significant and can be used as fine-tuning.
- The number of photoelectrons. Photon detecting in a PMT follows a Poisson distribution with a given mean. This mean (μ) is the parameter that defines the number of pe-.
- Width of the 0 photoelectron response. (fixed at 0.06336, obtained through data)

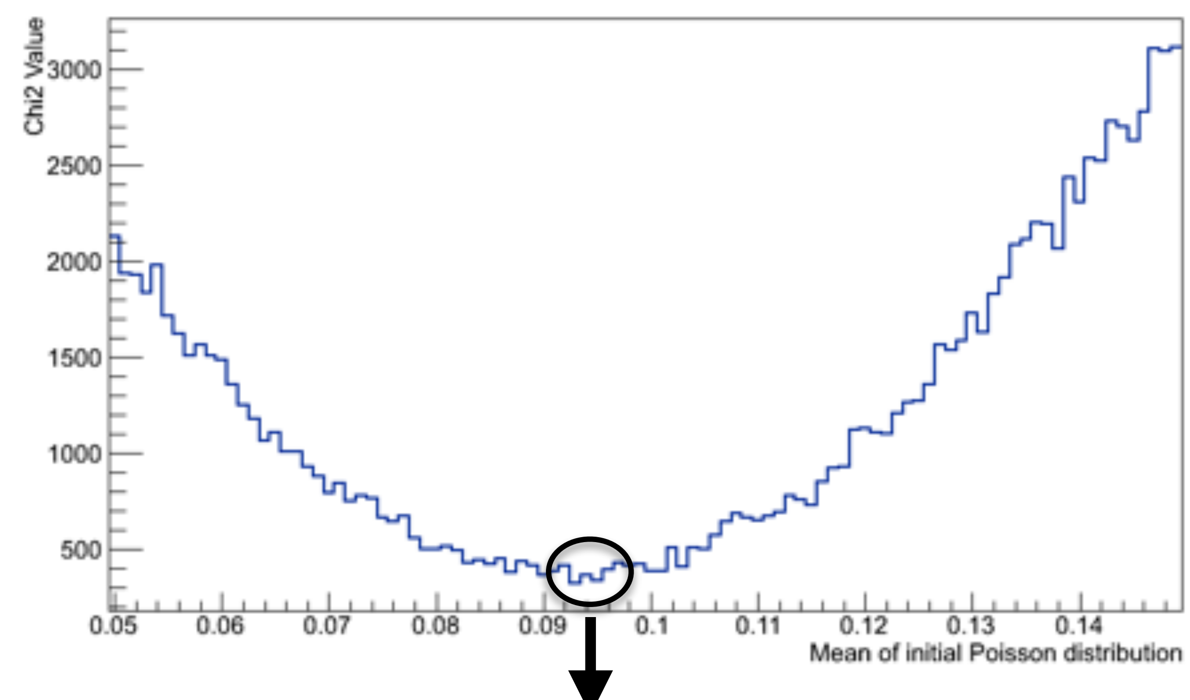
Chi2 distribution

Fixing μ = 0.1



First dynode gain = 8.7
Last dynode gain = 4.4

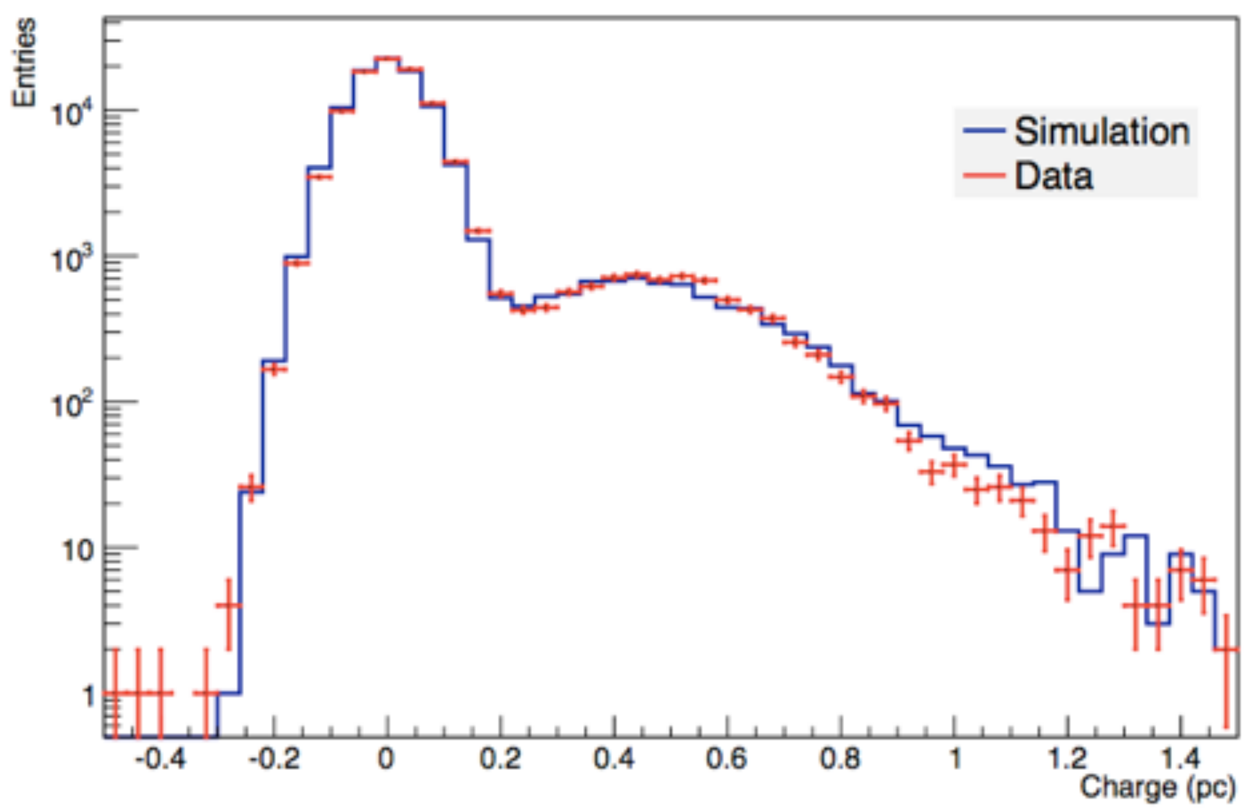
Fixing:
first dynode gain = 8.7
last dynode gain = 4.4



***μ* = 0.093**

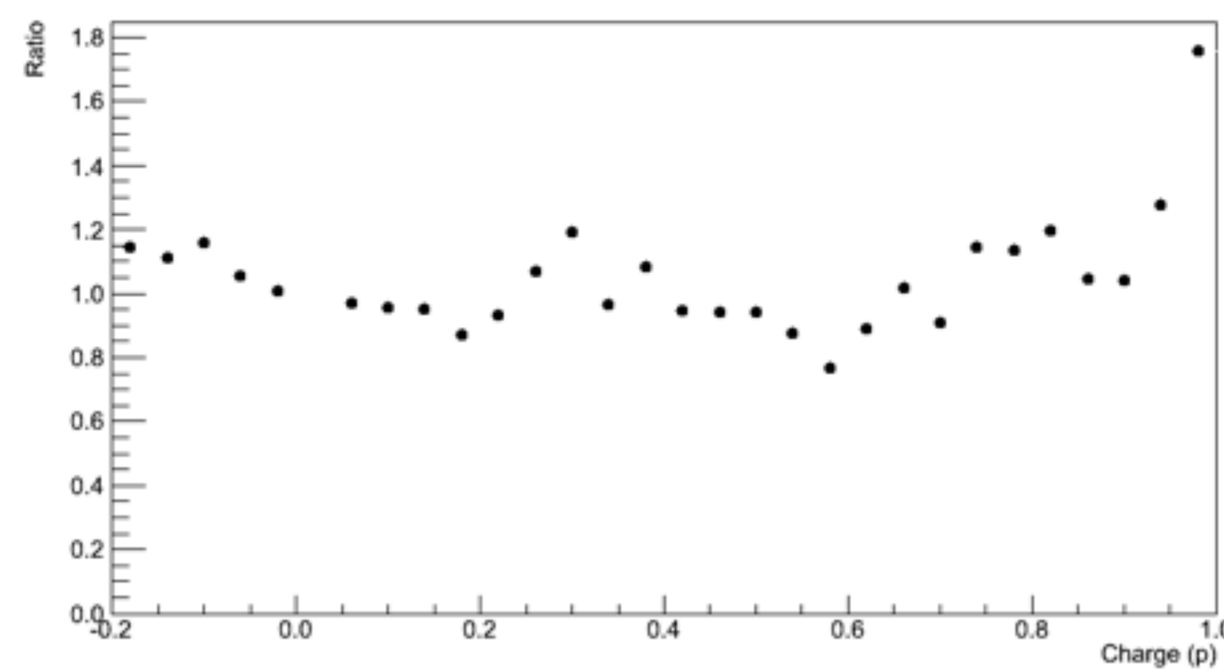
Data - MC comparison

Parameters of the MC:
- 12 PMT dynodes gain = {8.7, 3.8, 3, 3, 3, 3, 3, 3, 3, 3, 3, 4.4}.
- Mean (μ) of the initial Poisson distribution = 0.093.
- Width of the pedestal = 0.06336.



Charge according to best fit: 0.457 pC
Charge according to data: 0.449 +- 0.03 pC

Nº Sim events / Nº Data events



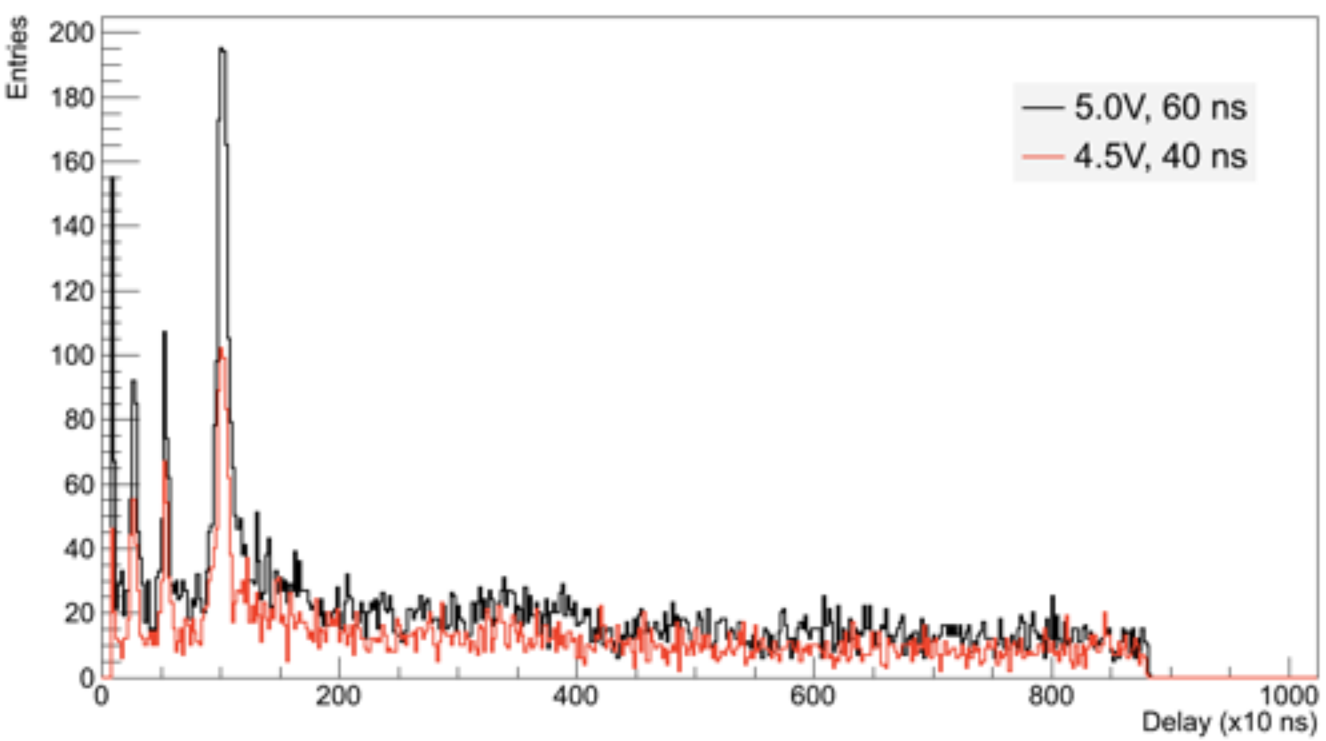
The ratio between entries for each bin is ~1

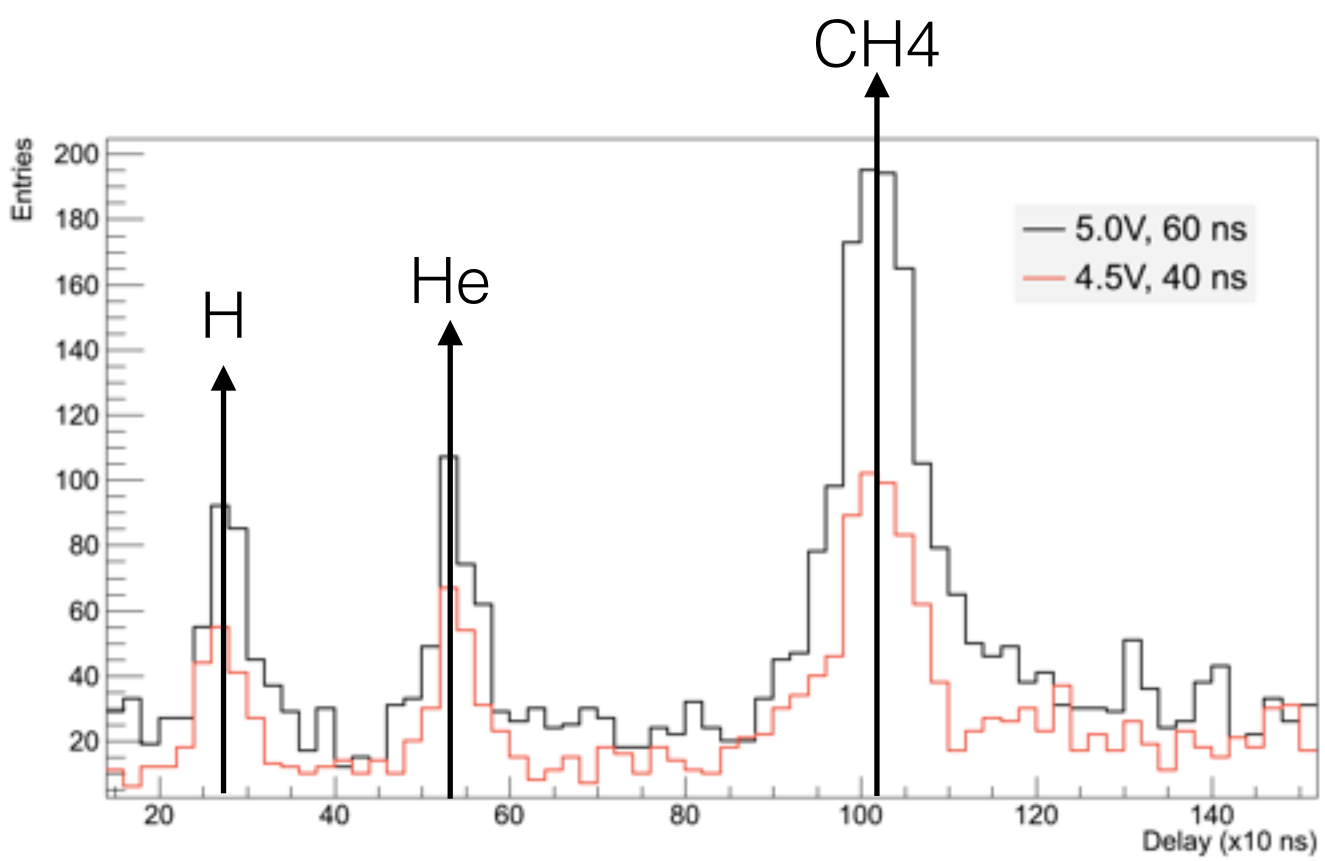
Afterpulsing

- Ionization of gas impurities inside the PMT volume. Causes a delayed signal after an actual one.

- The delay depends on the operation voltage and on the molecular mass of the impurities (mass spectroscopy).

- Statistics depends on the intensity of the prompt signal that causes the afterpulsing.





Conclusions

- Characterization of PMTs is basic in order to be able to reconstruct the events properly.
- Gain can be easily measured with a gaussian fit on the single photoelectron peak.
- Good agreement between the outcomes of toy MC of the amplification chain and measured charge distribution.
- Analysis of afterpulsing provides detailed information of the impurities inside the PMTs.