WLS signal attenuation

Cube 1

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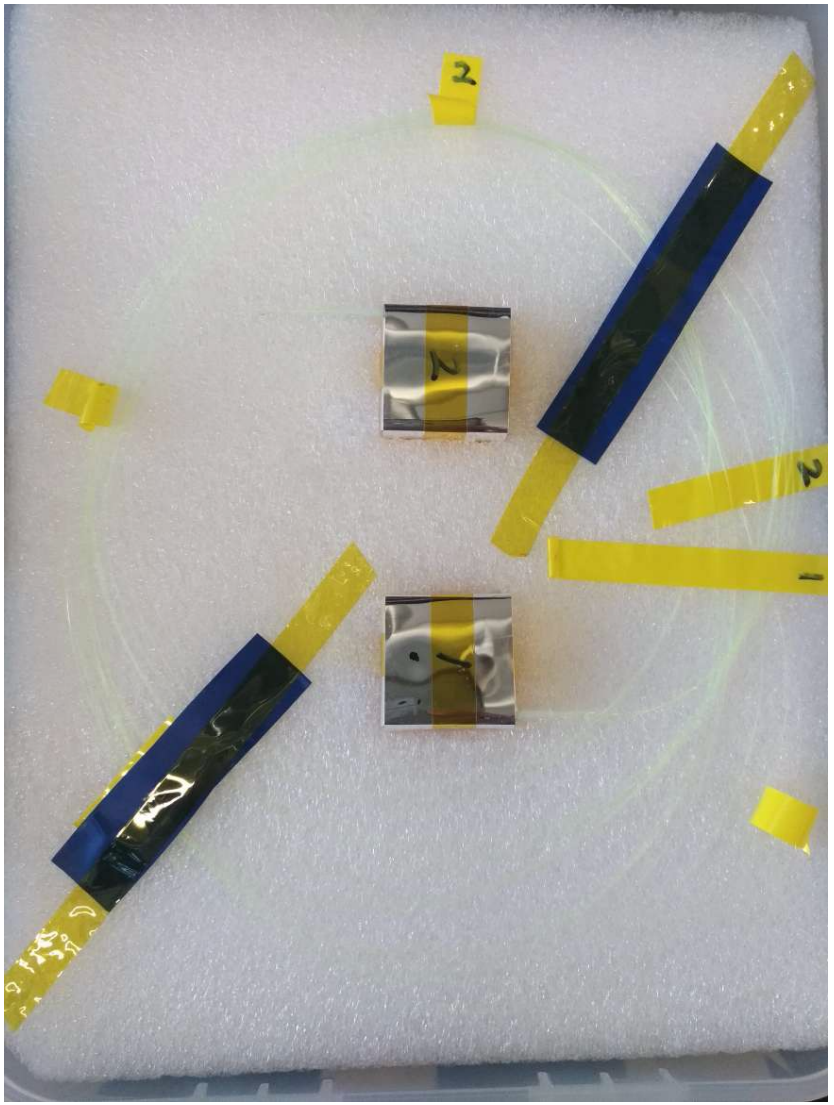
Overview



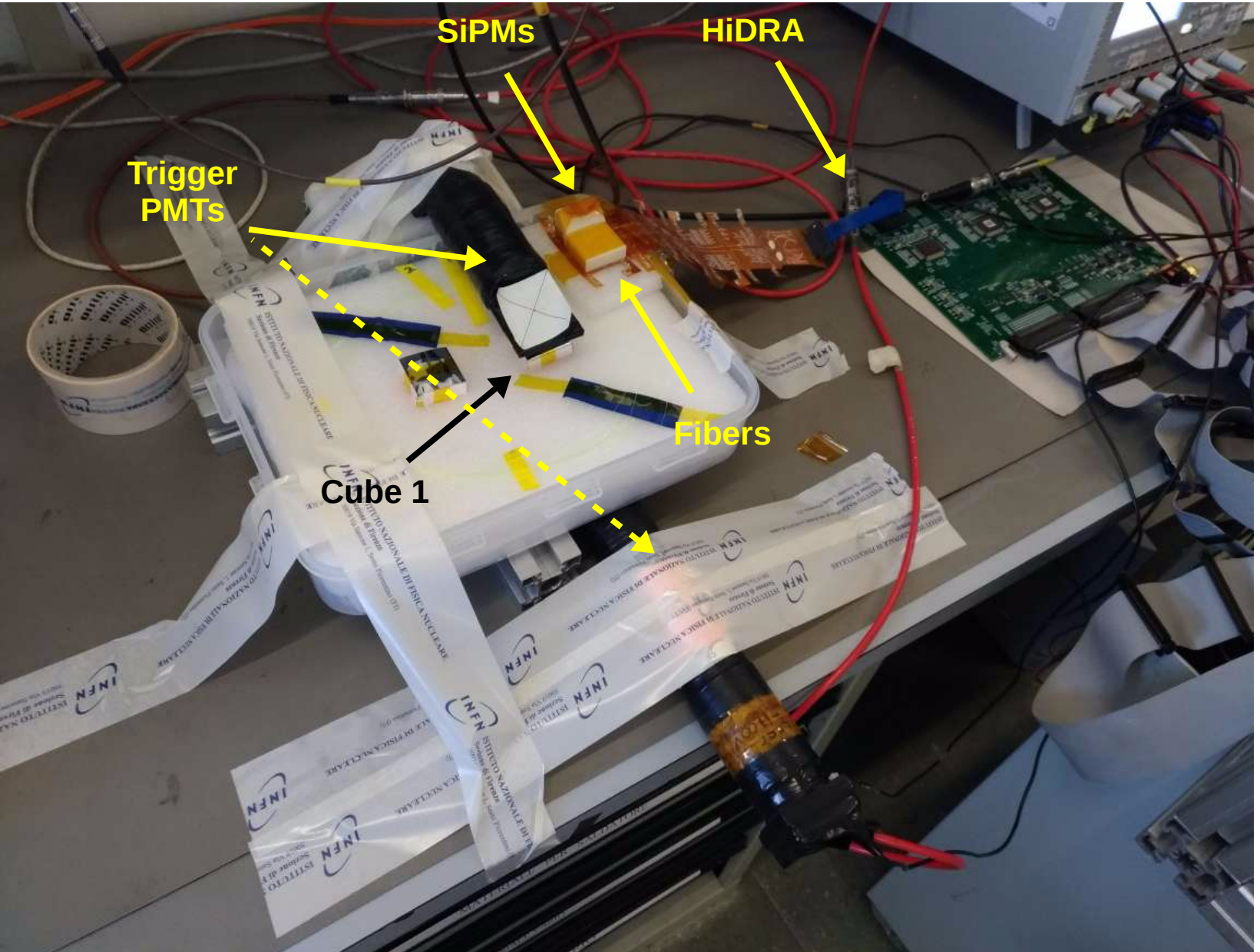
<u>Objective</u>: Understand which is the reduction of the signal in WLS due to the presence of large PD (VTH2090)

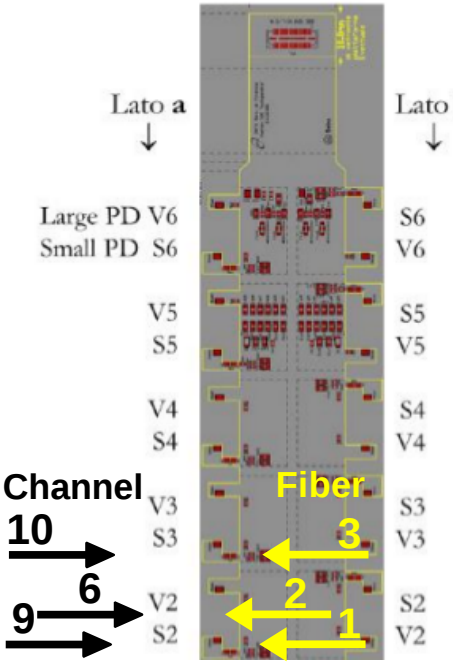
For this purpose, we used **Cube 1**, connecting the 3 fibers to 3 different **SiPMs** (ASD-RGB1C-P):

- 673 cells
- 40 μm x 40 μm cell size
- 1.13 mm^2 effective (circular) area

HiDRA boards were used for SiPMs readout (same readout system employed for PDs)

Set Up


SiPMs
HiDRA
Trigger PMTs
Fibers
Cube 1

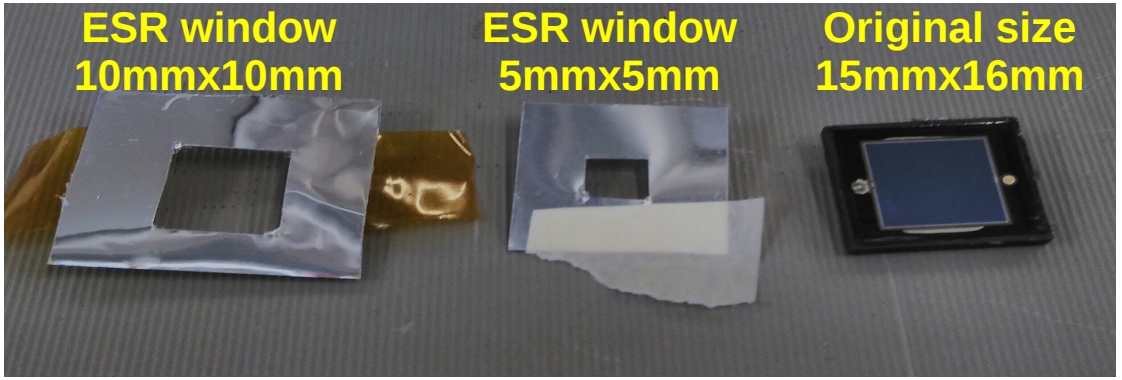

Lato a
Lato
Large PD V6
Small PD S6
S6
V6
V5
S5
S5
V5
V4
S4
S4
V4
Channel
Fiber
V3
S3
S3
V3
10
6
9
V2
S2
S2
V2
3
2
1

Data taking

We acquired **cosmic muons data** using trigger from PMTs coincidence.

The acquisition was divided into **several samples** where we changed the crystal configuration trying to affect as less as possible the experimental system and, in particular, without touching the fiber-SiPM coupling.

For this purpose, we considered the original configuration with WLS only and three different **configurations corresponding to different area of ESR windows used to place the PD on the crystal** in order to simulate the attenuation due to different *dark area* size (15x16, 10x10 and 5x5 mm^2).

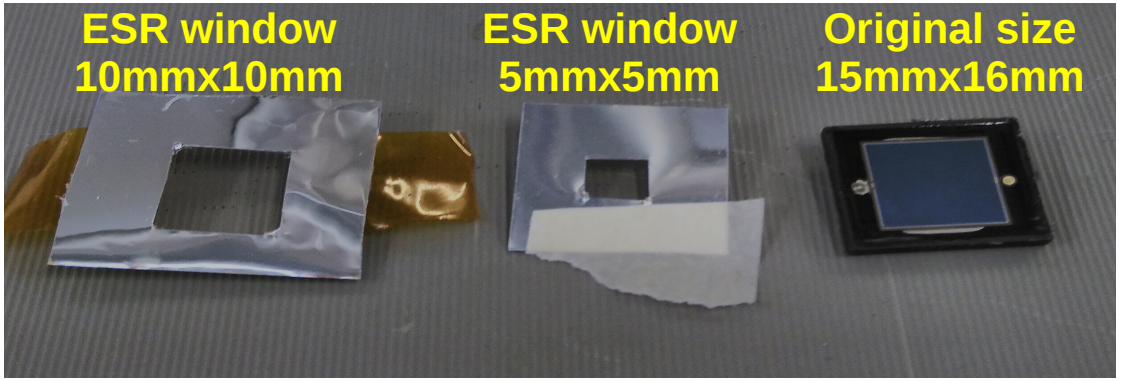


NB PD was placed on the crystal without any glue or optical grease and, therefore, signal loss in WLS maybe larger than the one measured here.

Crystal configurations

The order of data taking configurations is as follows:

ESRA -> PDA -> ESRB1 -> ESRB2 -> PDB -> PD5x5 -> ESRC -> PD10x10A -> PD10x10B -> ESRD



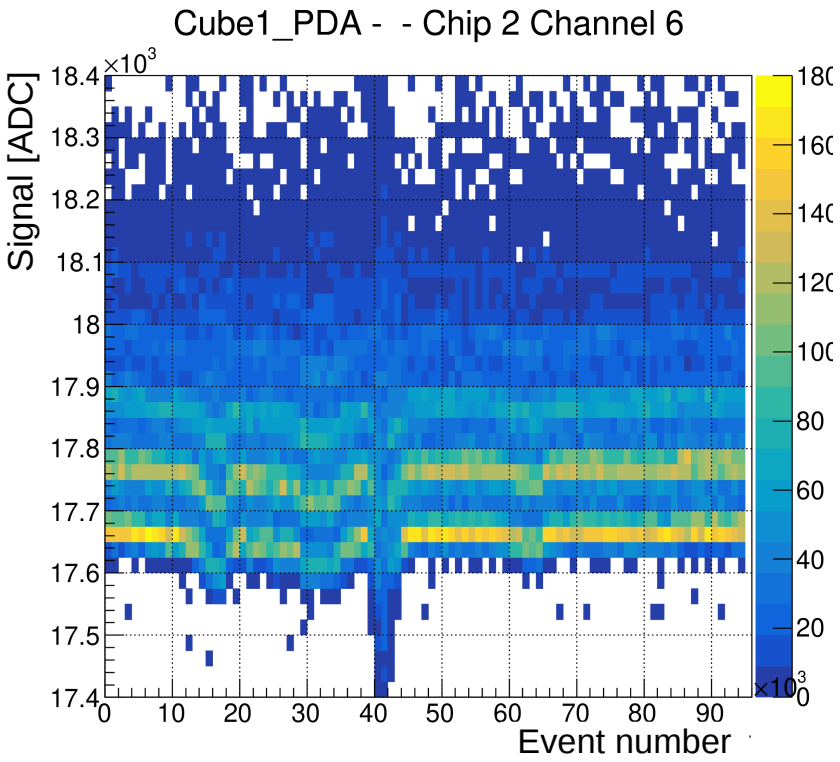
where

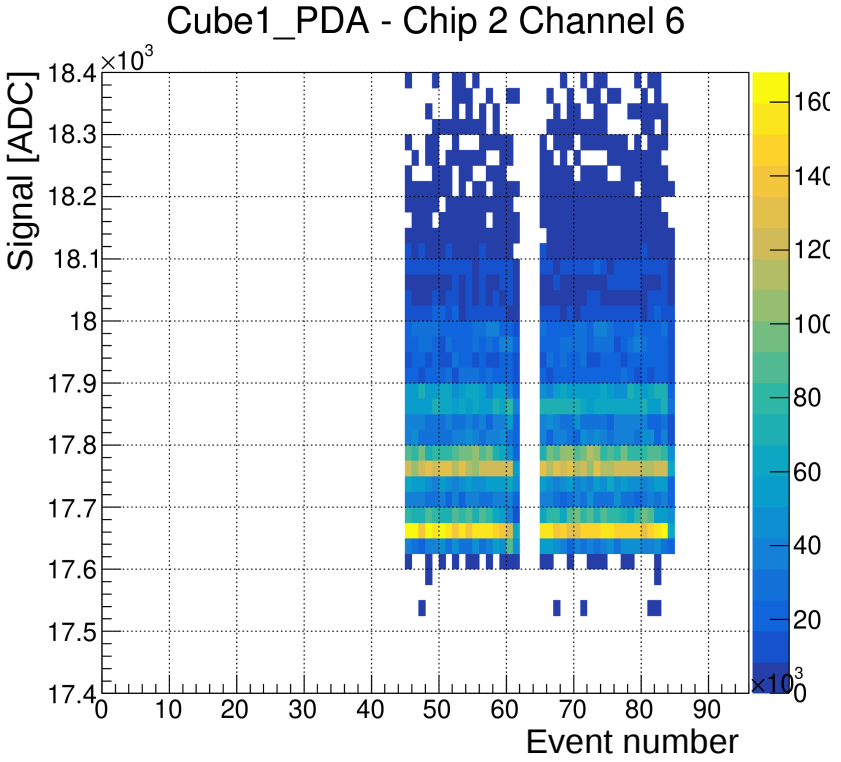
- ESR**X** - Cube 1 is wrapped with ESR (WLS only)
- PD**X** - VTH2090 is attached to Cube 1 (WLS+PD), so that the equivalent dark *area* is 15x16mm^2
- PD5x5/PD10x10 - as before, but we cut a ESR square in order to reduce the dark *area* to 5x5 and 10x10 mm^2

SiPM gain calibration procedure [I]

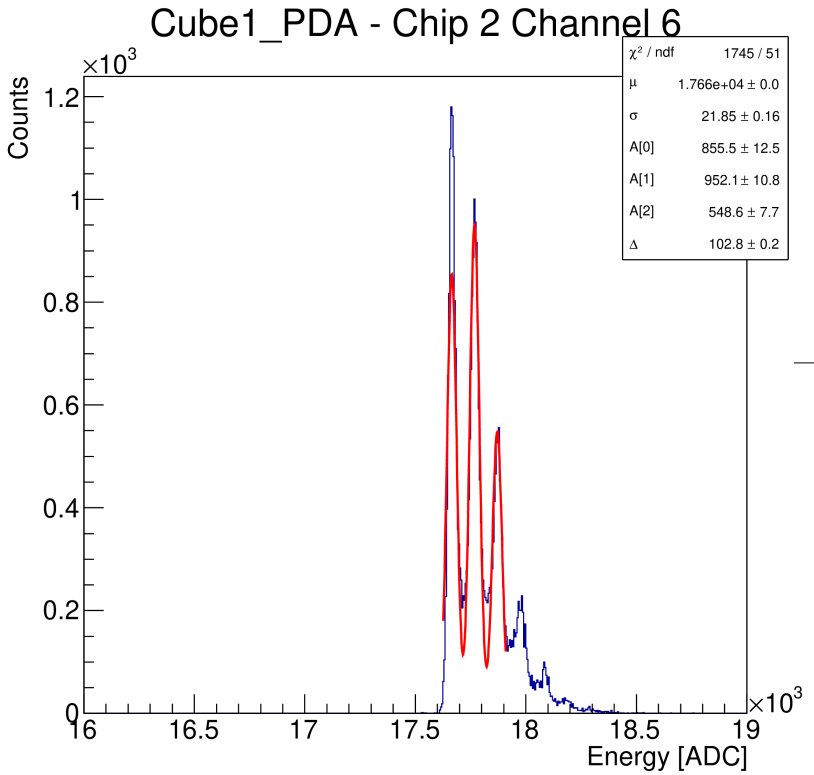
SiPMs gain strongly depends on temperature and, being event rate quite low and data taking quite long, we must consider this variation.

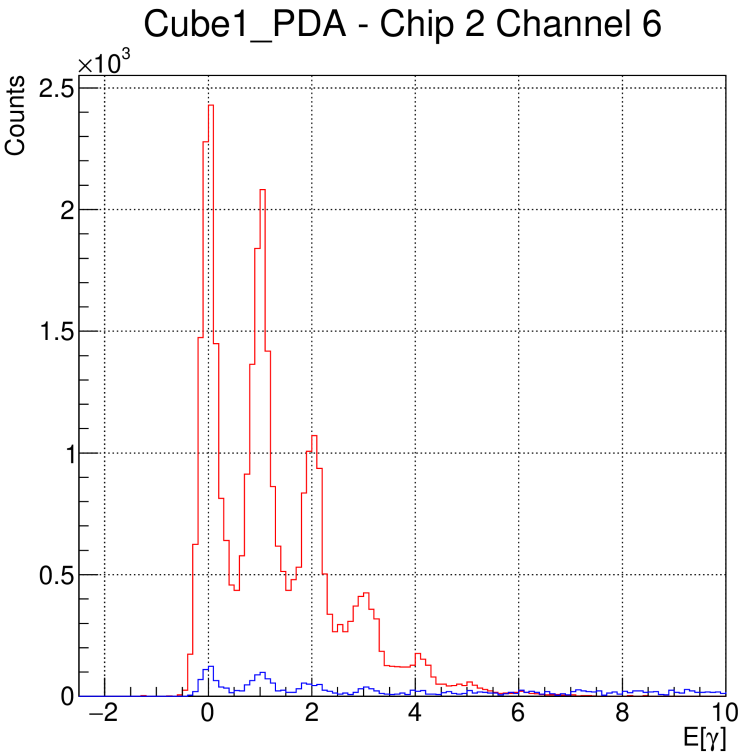
At first, we look for dark count photoelectrons and select only events interval **where the gain is sufficiently stable to allow calibration.**

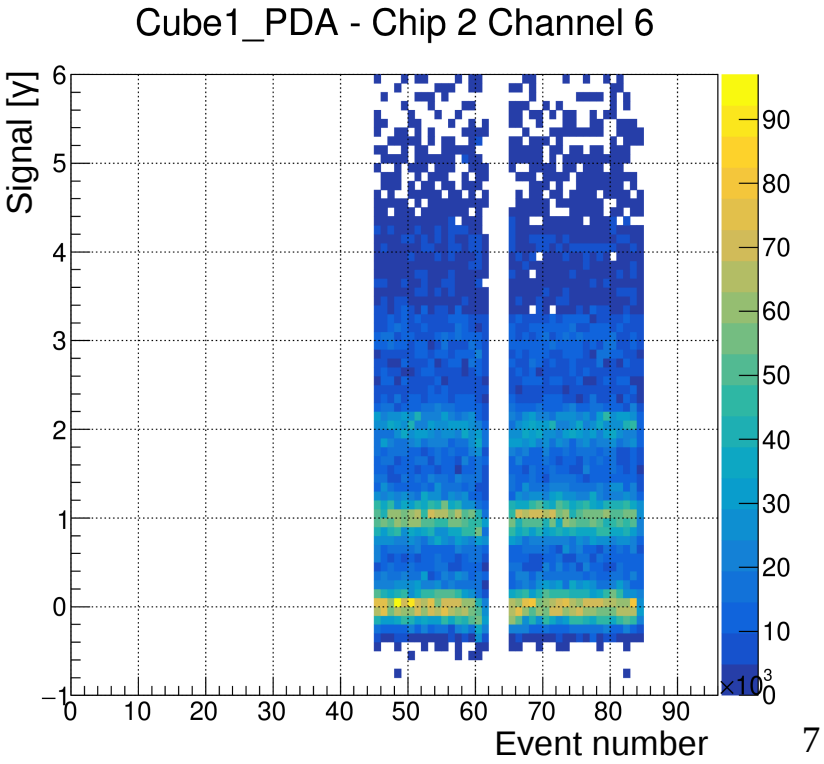




SiPM gain calibration procedure [II]

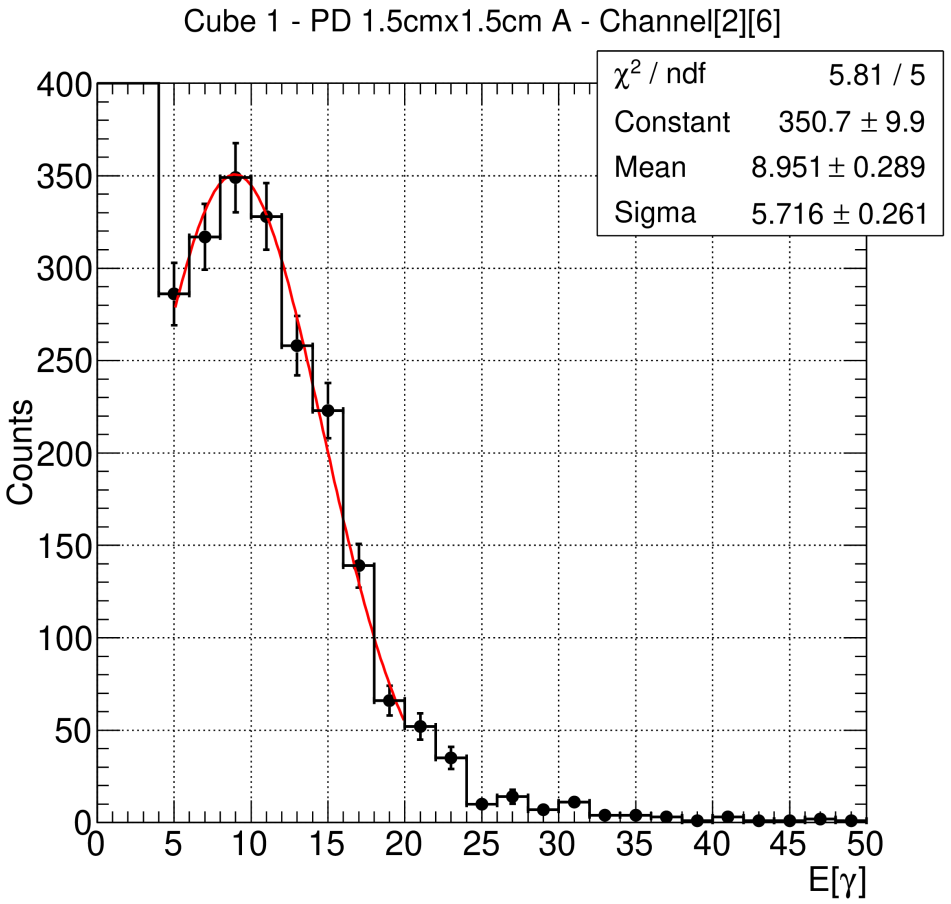






Then, still using dark count photoelectrons, we **perform a multi-gaussian fit to estimate SiPM gain** and check that the result is reasonable.

Determination of fiber gain



Finally, we build the distribution relative to the energy deposit expressed in terms of SiPM photoelectrons and we measure the **fiber gain** using as best value the mean given by a a simple **gaussian fit** on this distribution.

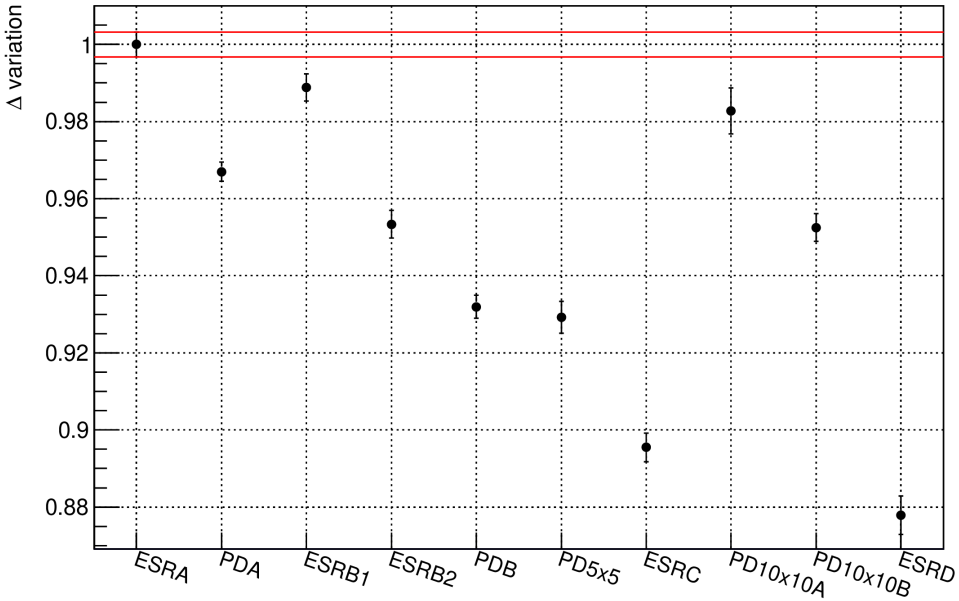
The whole procedure was repeated for the all three channels in all different crystal configurations.

Photopeak gain [Relative]

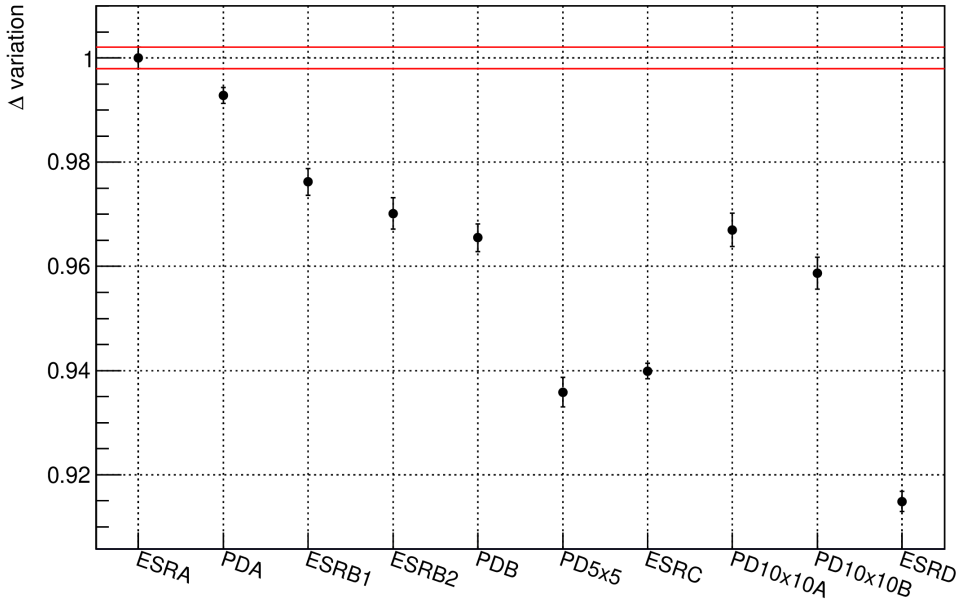
Variation should be mainly due to temperature variation:

measures started on May 15th and ended on June 5th

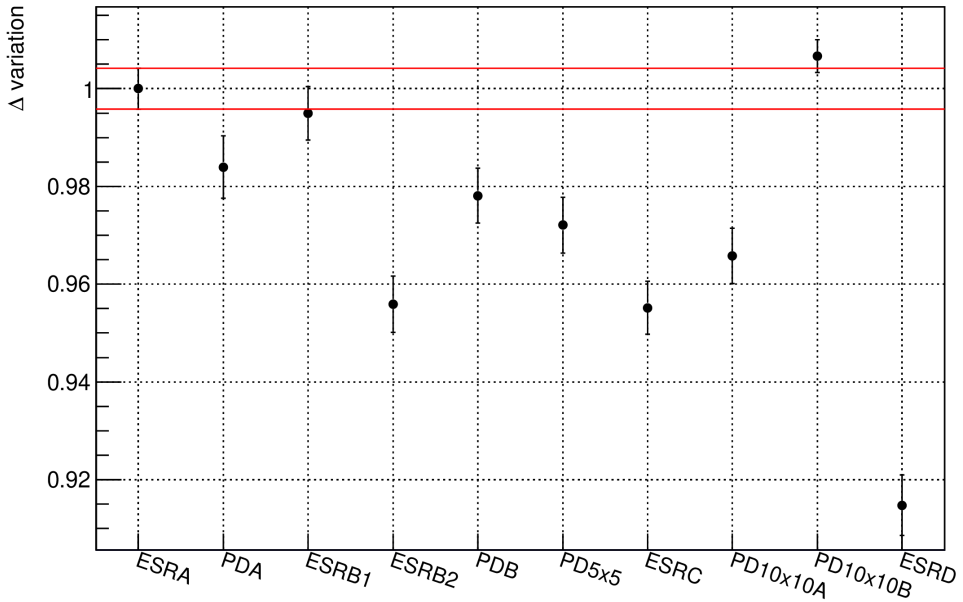
Channel[2][9] Fiber 1



Channel[2][6] Fiber 2



Channel[2][10] Fiber 3

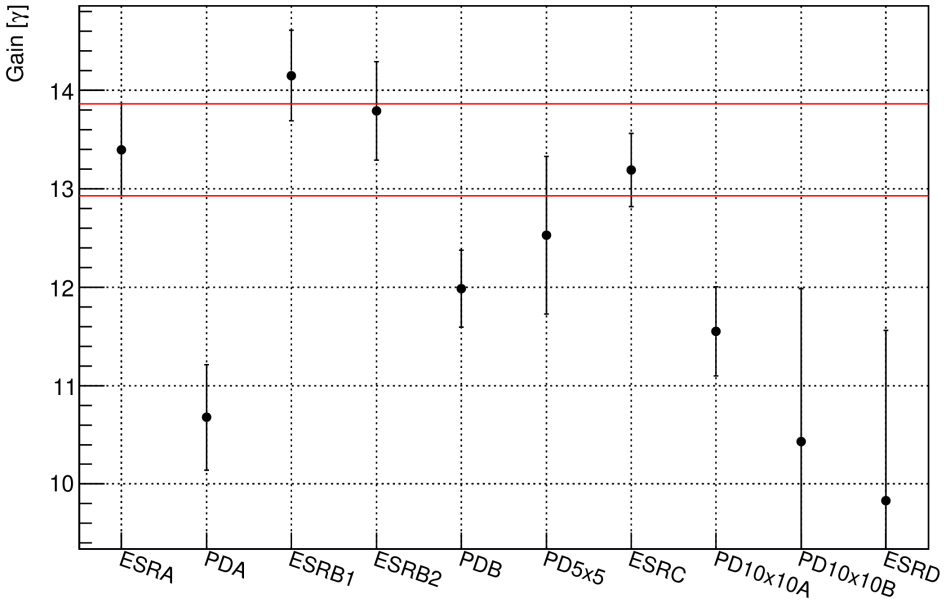


Fiber gain [Absolute]

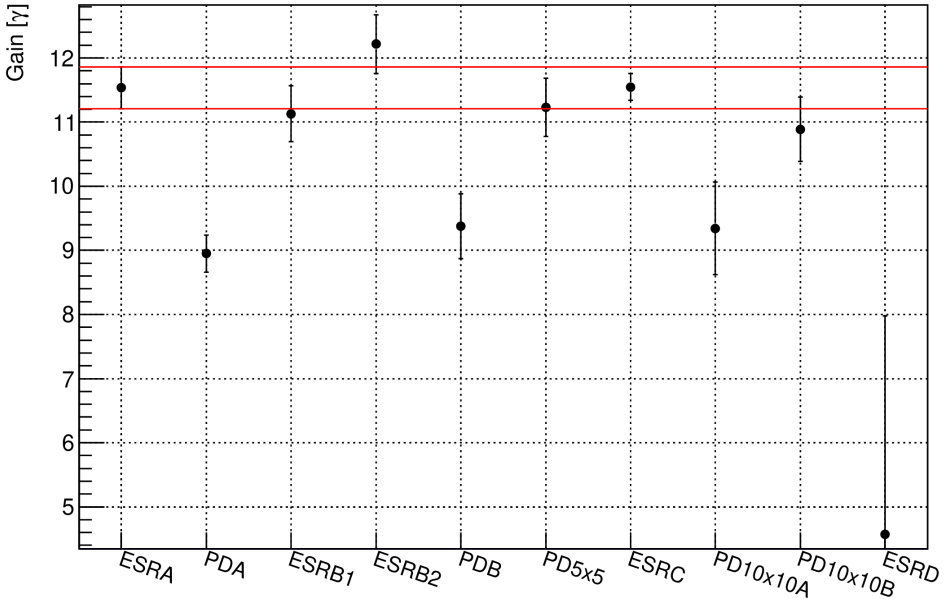
Fiber 1 and 2 gains are about 10-15 γ, whereas Fiber 3 gain is about 30-40 γ.

We found this behavior independently from the SiPM used for readout.

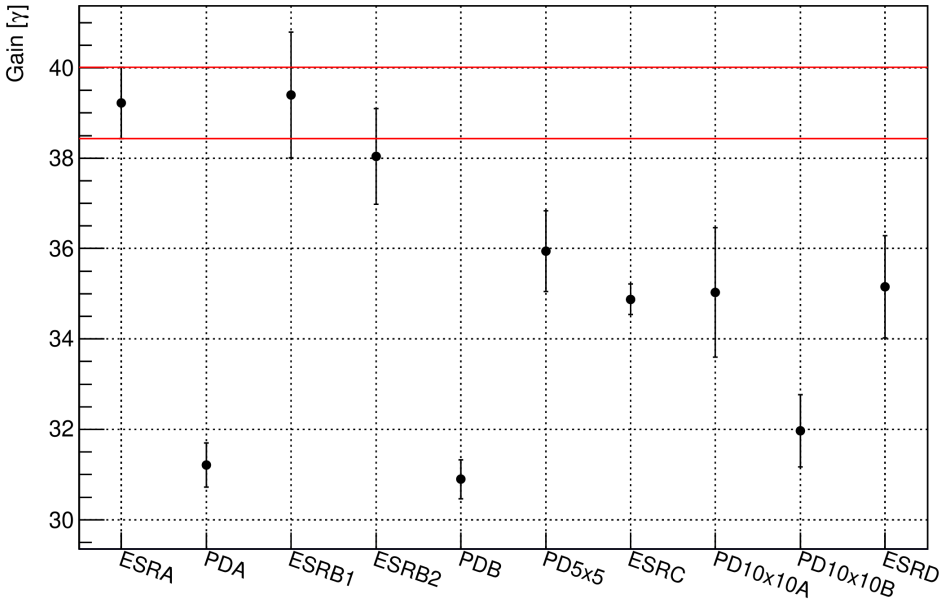
Channel[2][9] Fiber 1



Channel[2][6] Fiber 2



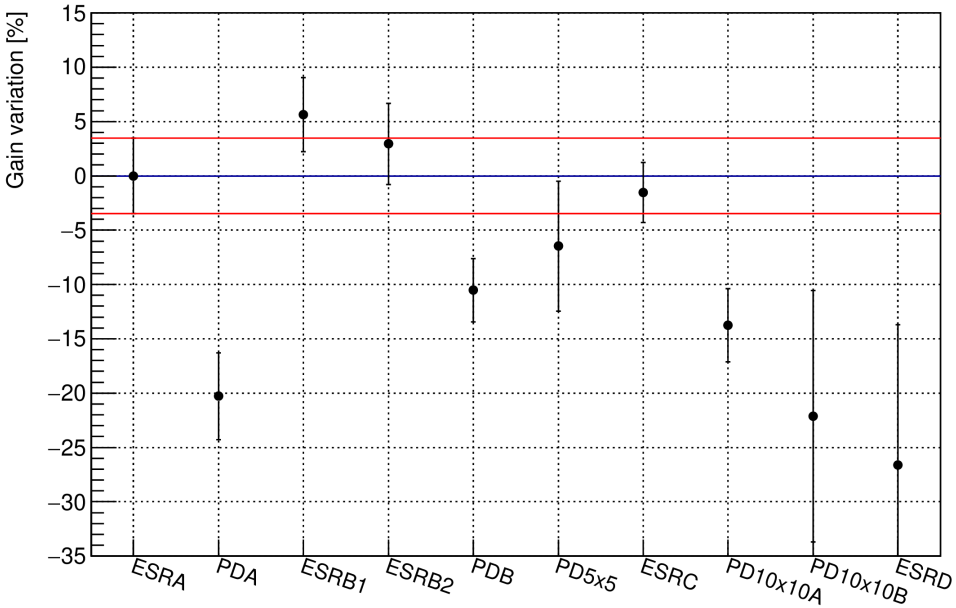
Channel[2][10] Fiber 3



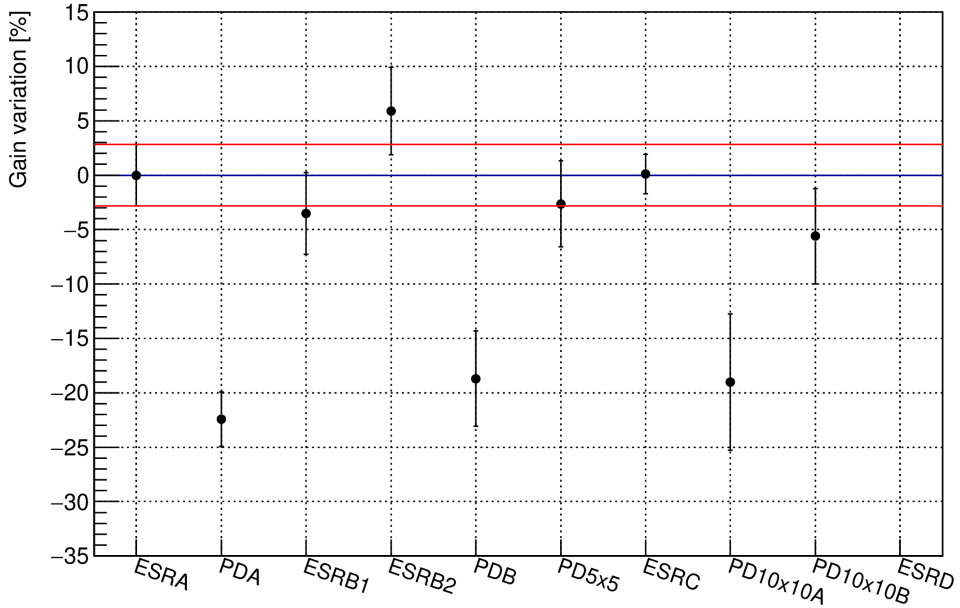
Fiber gain [Relative]

NB The error bars consider only the fit uncertainty, whereas the other uncertainties (SiPM calibration, system reproducibility...) are not considered

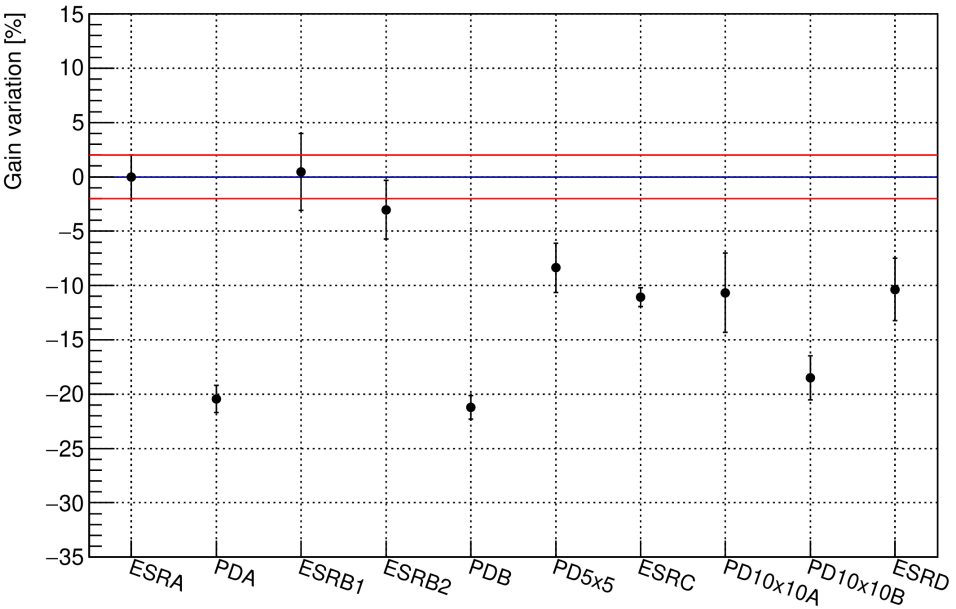
Channel[2][9] Fiber 1



Channel[2][6] Fiber 2



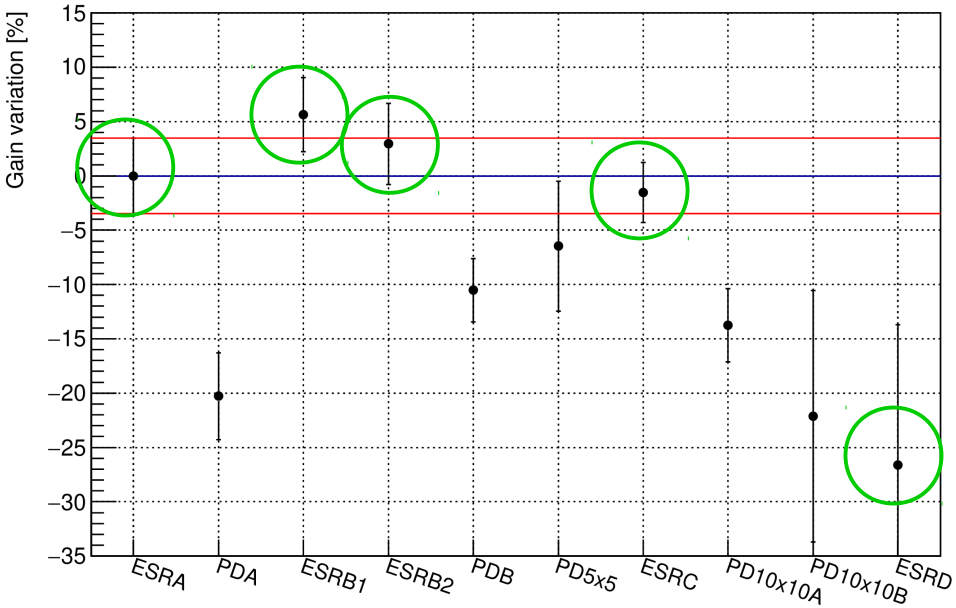
Channel[2][10] Fiber 3



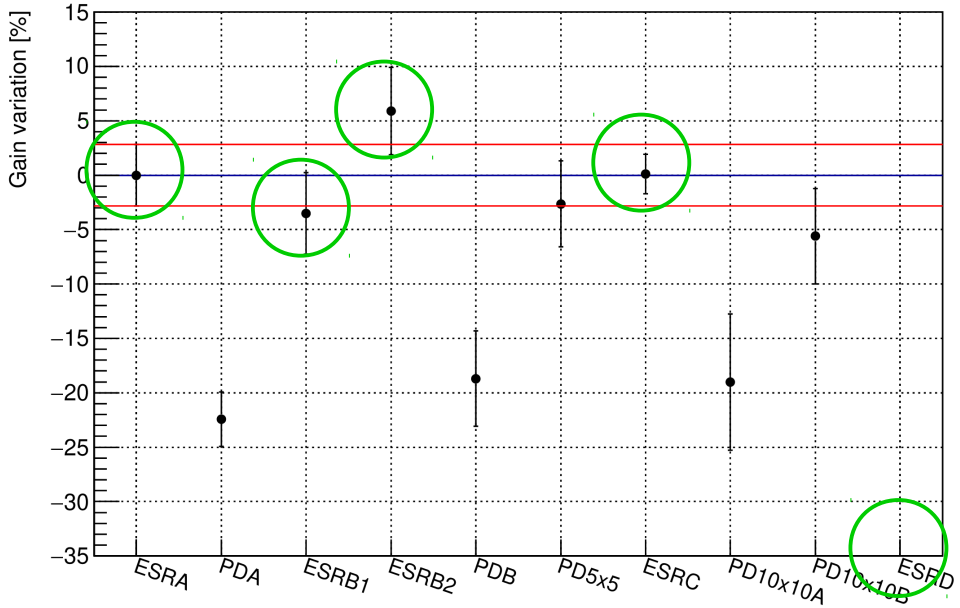
ESR configurations

Good reproducibility of ESR configuration apart from ESRD (due to small SiPM gain) and ESRC (but only on Fiber 3)

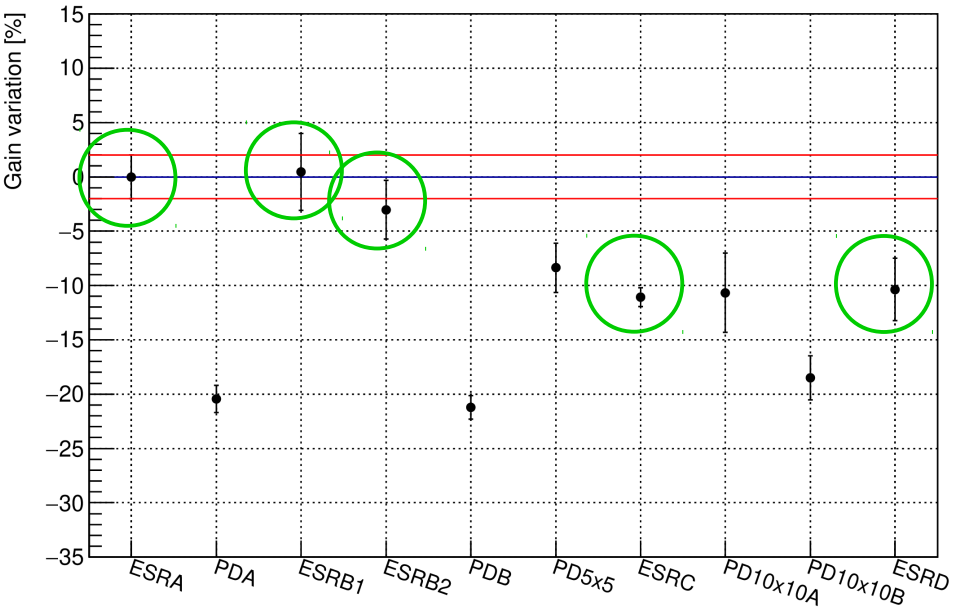
Channel[2][9] **Fiber 1**



Channel[2][6] **Fiber 2**



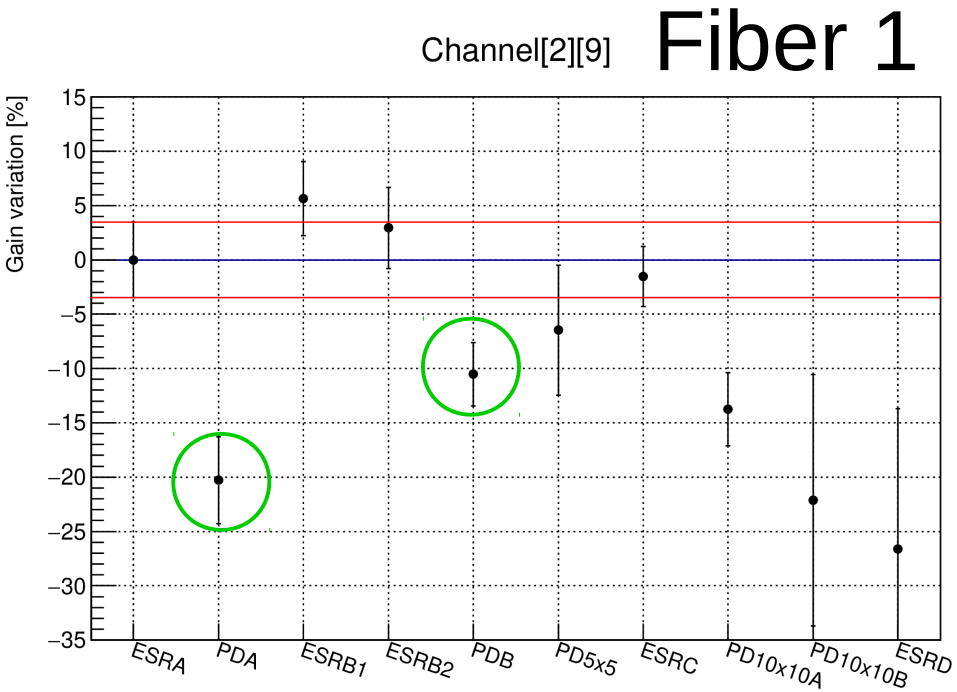
Channel[2][10] **Fiber 3**

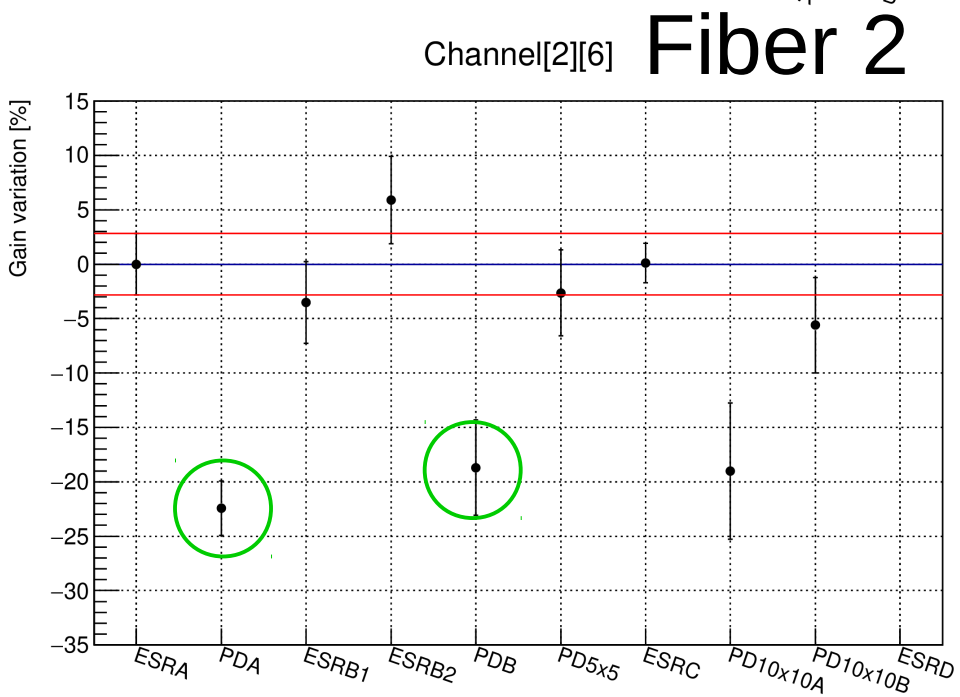


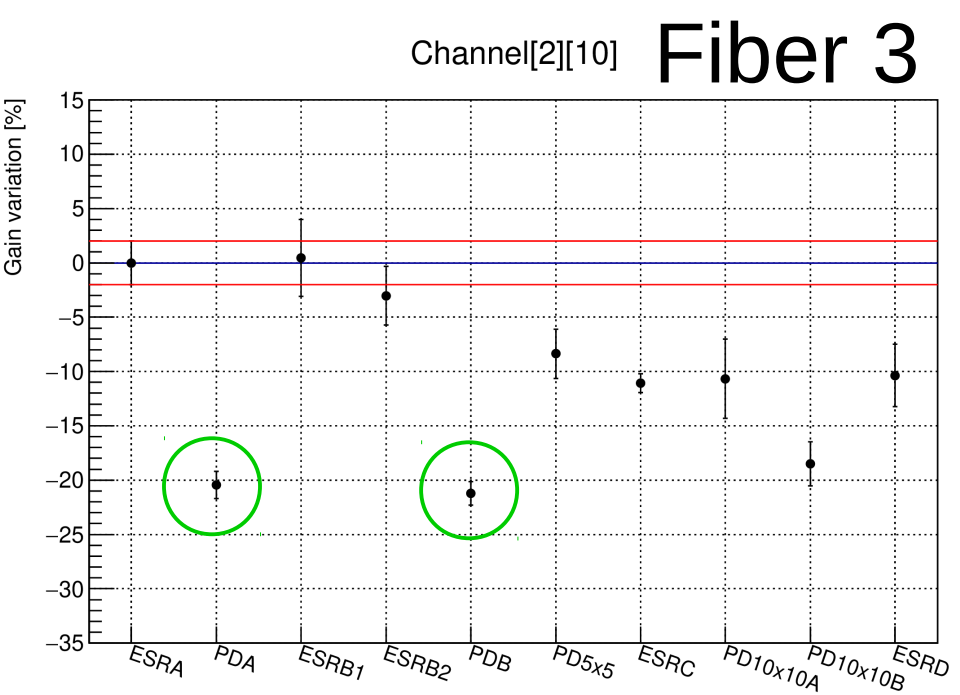
PD 15mmx16mm configuration

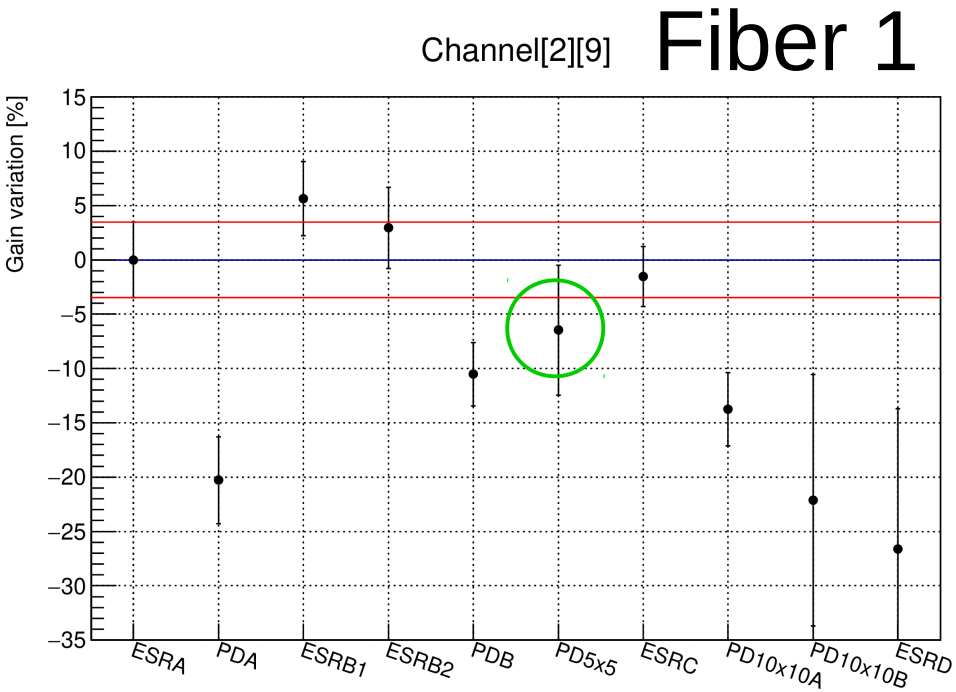
Good reproducibility apart from Fiber 1

Expected loss of about 20.0 ± 2.5%



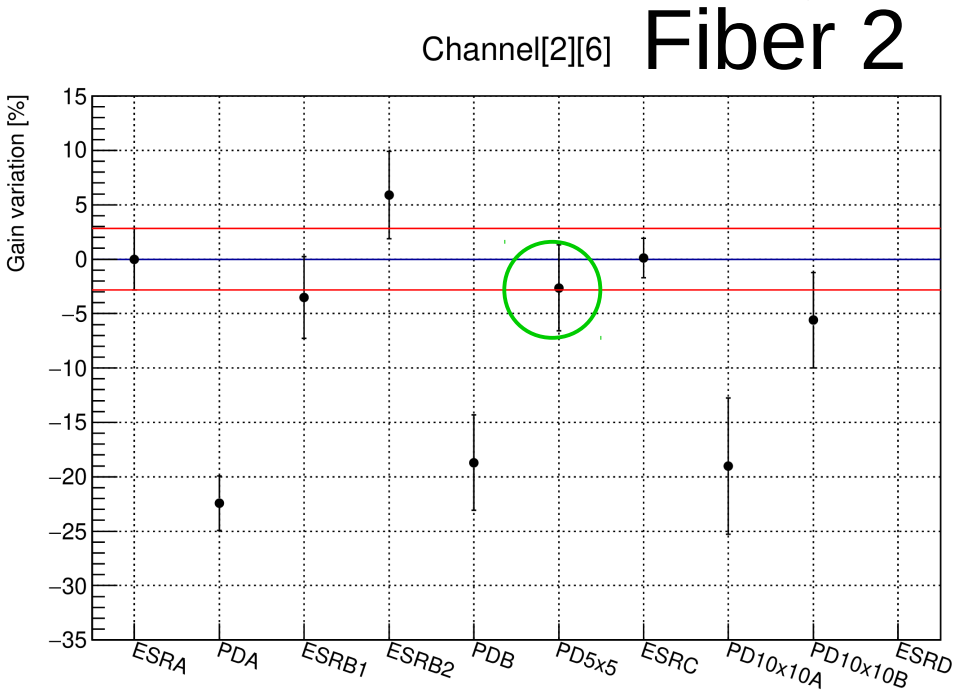


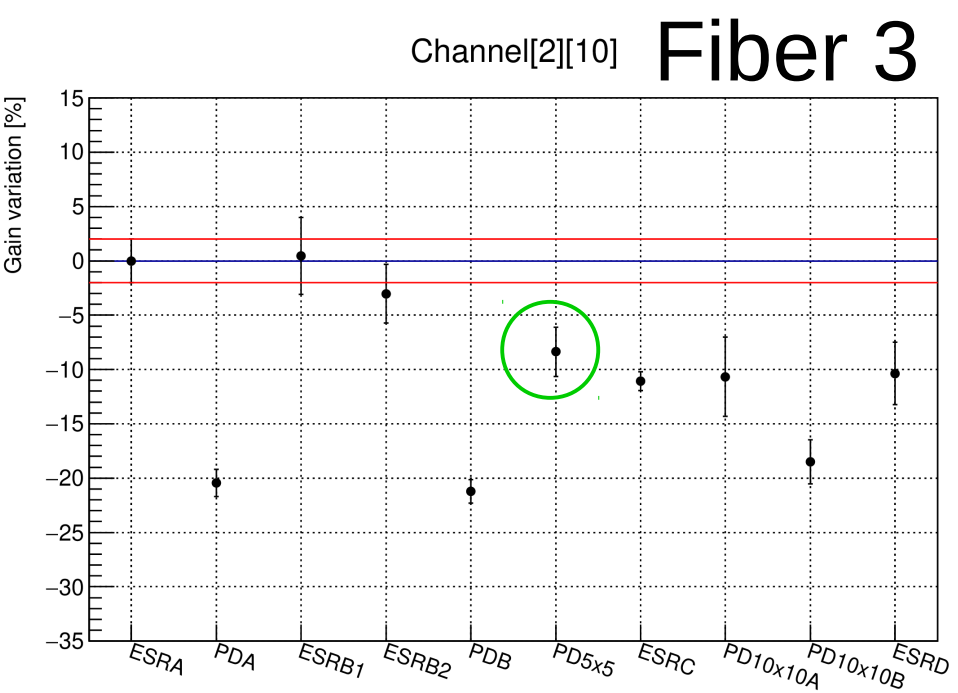




PD 5mmx5mm configuration

Expected loss of about 5.0 ± 2.5%



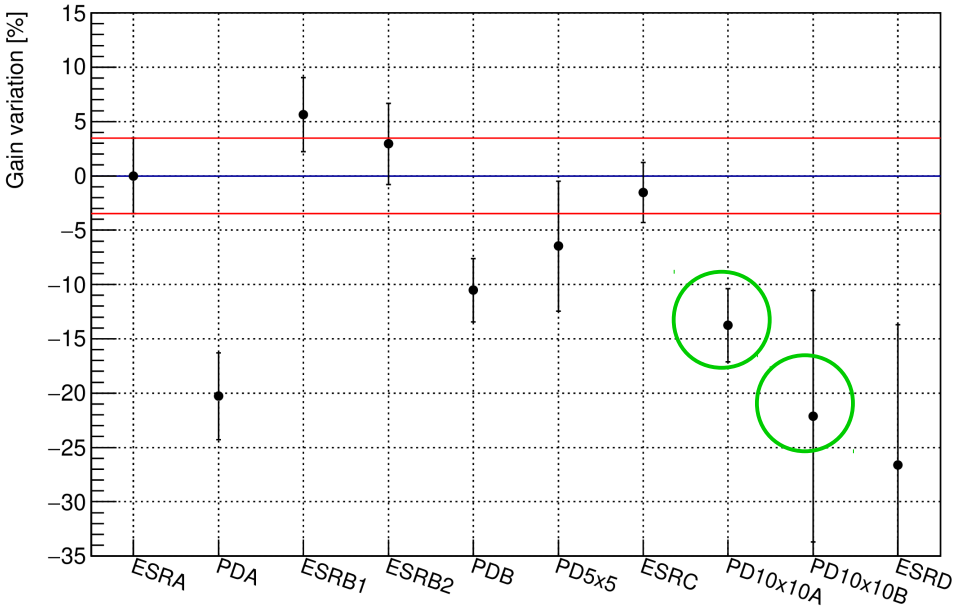


PD 10mmx10mm configuration

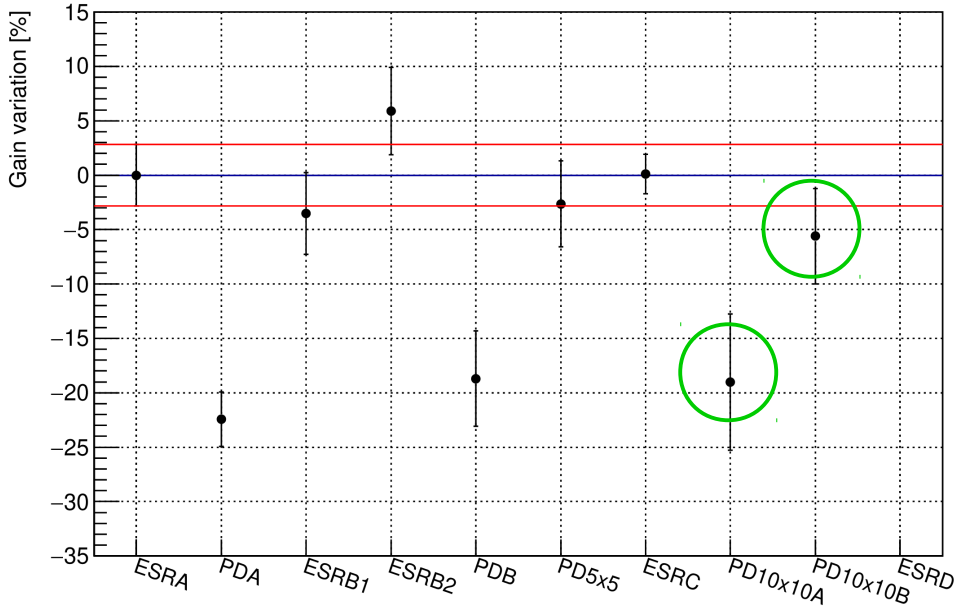
Bad reproducibility

The loss seems intermediate between the other two configurations but it is difficult to be more quantitative.

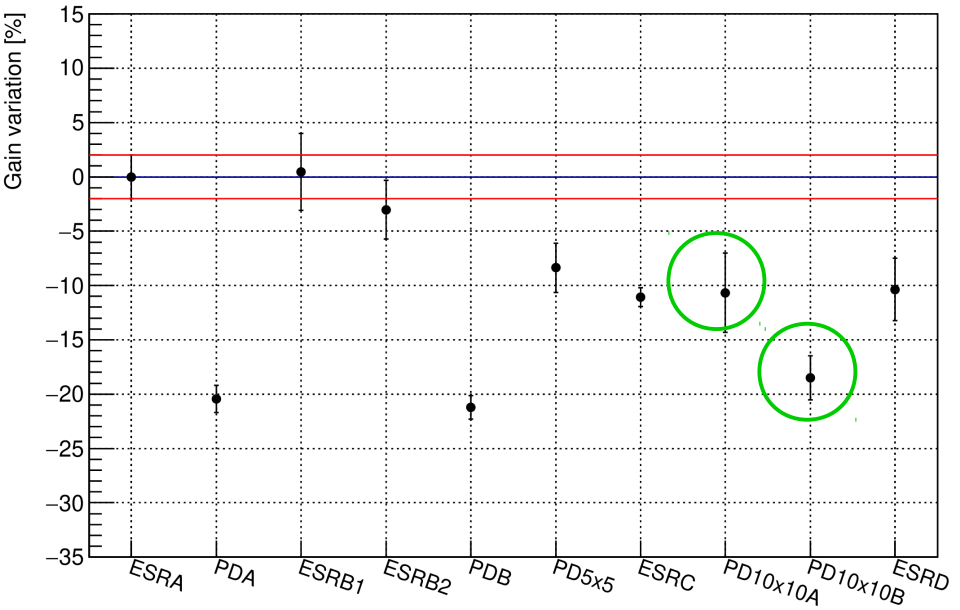
Channel[2][9] Fiber 1



Channel[2][6] Fiber 2



Channel[2][10] Fiber 3



Summary

Attenuation of WLS signal due to the presence of a PD of different areas on the LYSO crystal have been tested using cosmic muons signal and a readout based on AdvanSid SiPMs + HiDRa boards.

The system resulted to be enough stable for almost all data taking time.

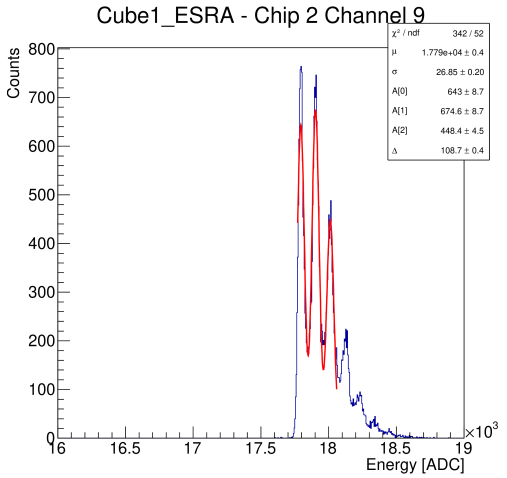
Attenuation on WLS signal as a function of PD *dark area* is about **20% (15mmx16mm)** and **5% (5mmx5mm)** [no clear conclusion for 10mmx10mm, where it seems that the attenuation is around 15%].

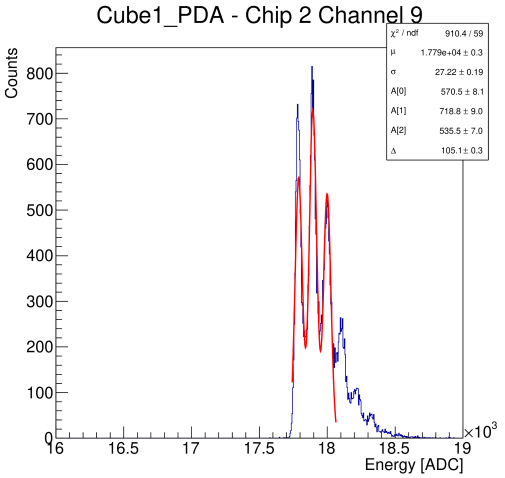
Further tests are needed to confirm this number:

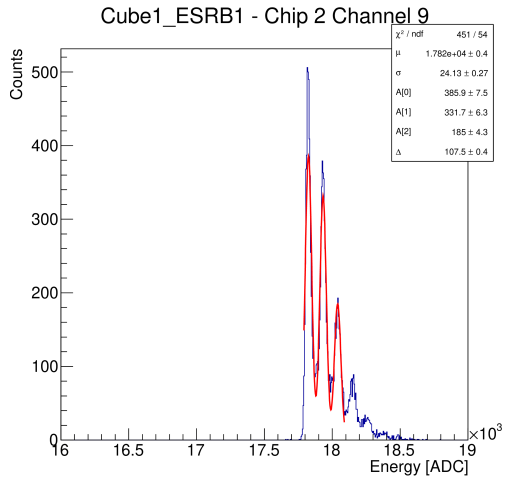
- using a different cube
- improving the stability of WLS+SiPM coupling
- improving the stability of SiPM gain
- coupling SiPM to LYSO using glue or grease?

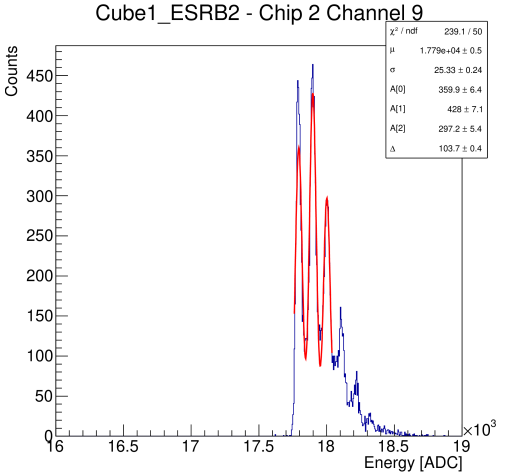
Back Up

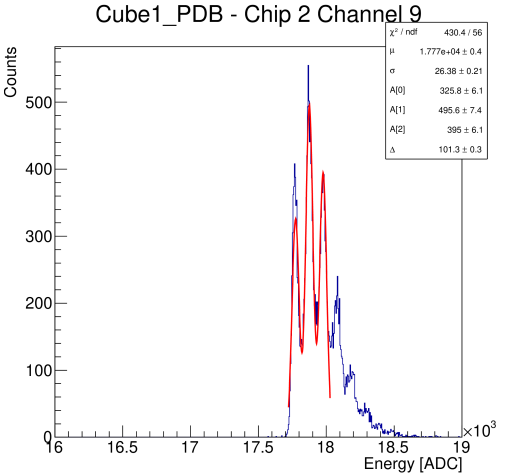
Photopeak fit - Fiber 1

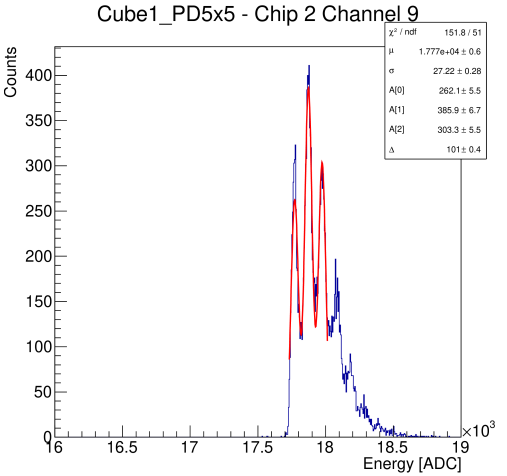


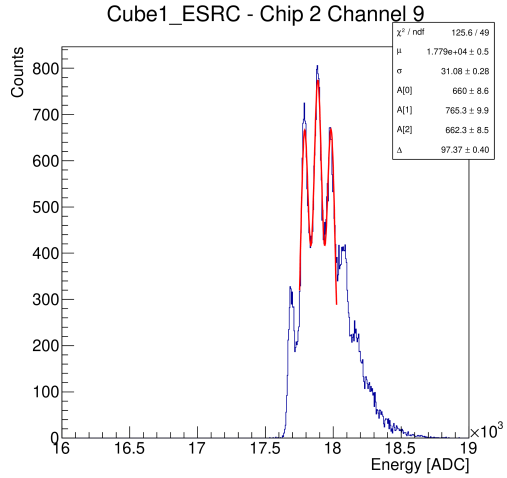


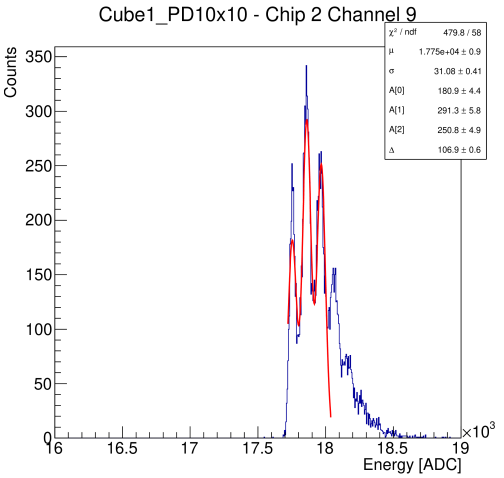


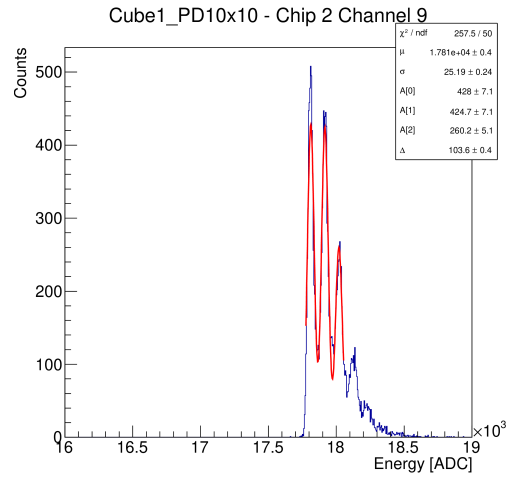


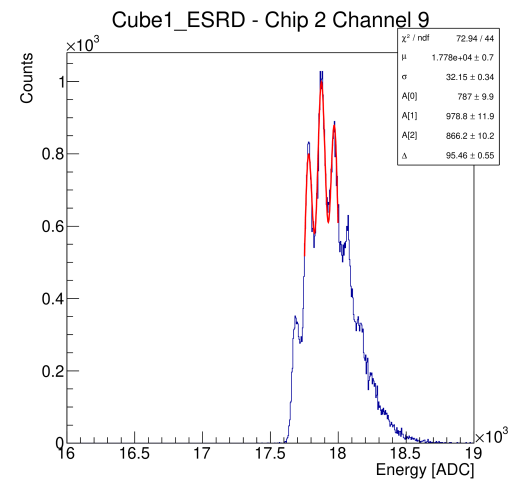




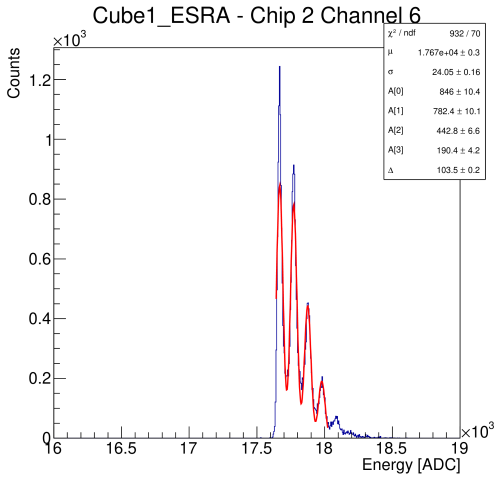


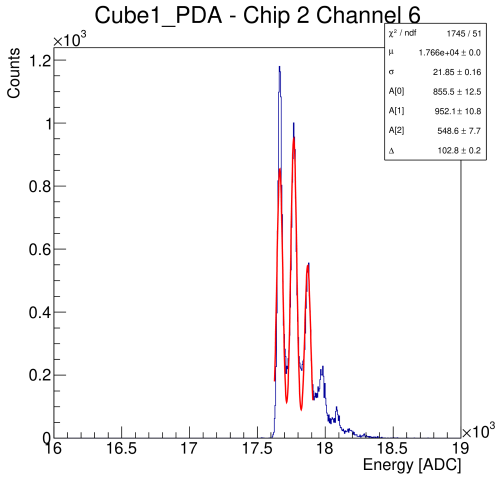


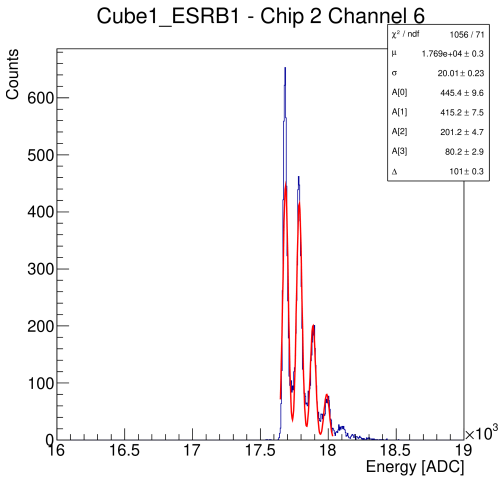


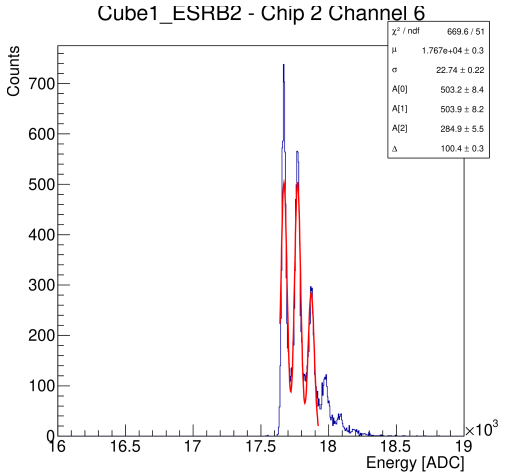


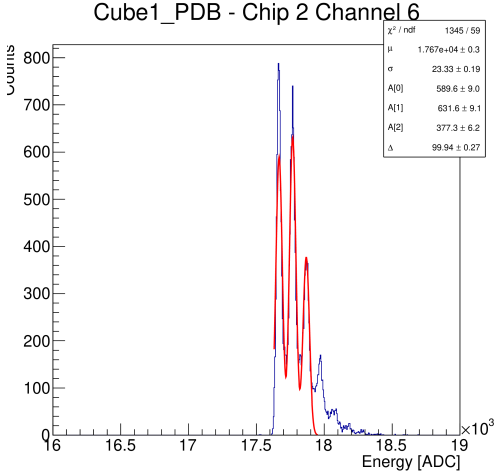
Photopeak fit - Fiber 2

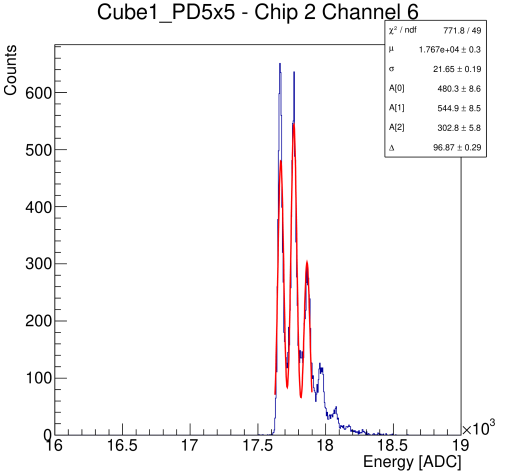


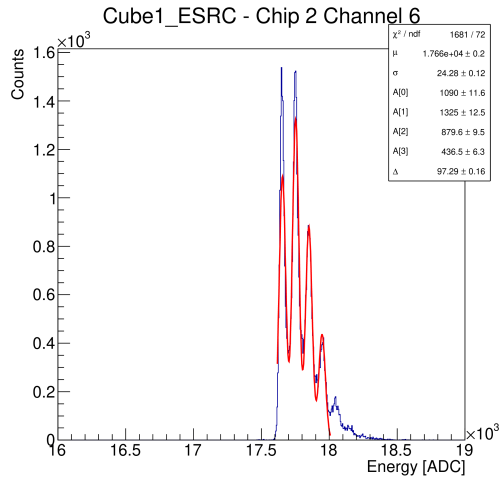


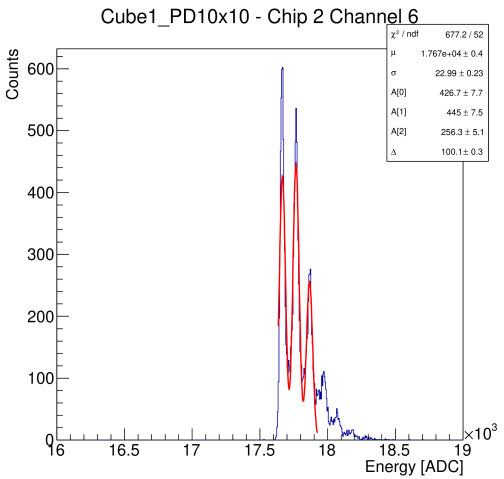


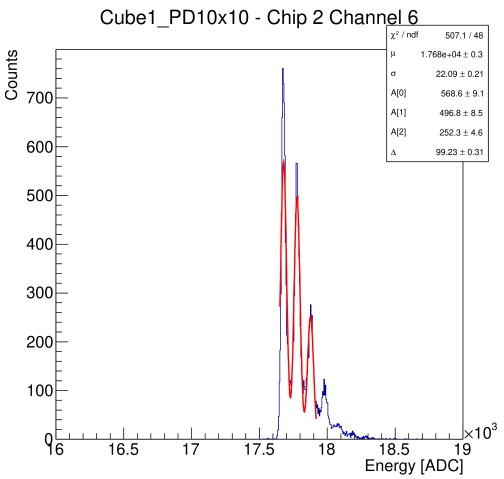


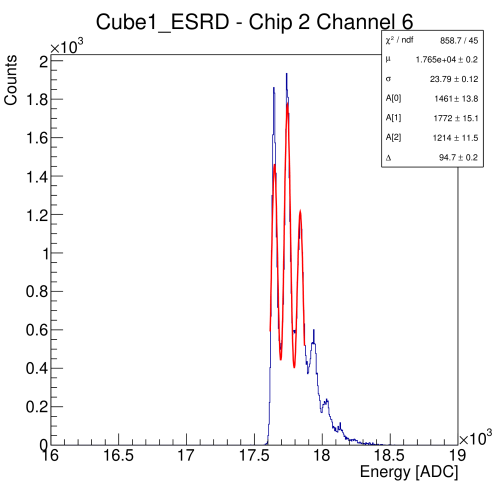




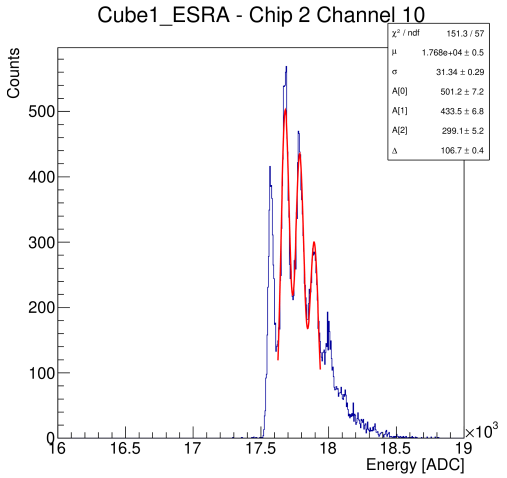


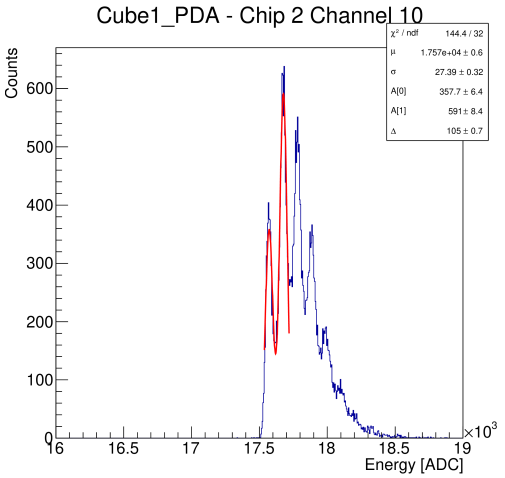


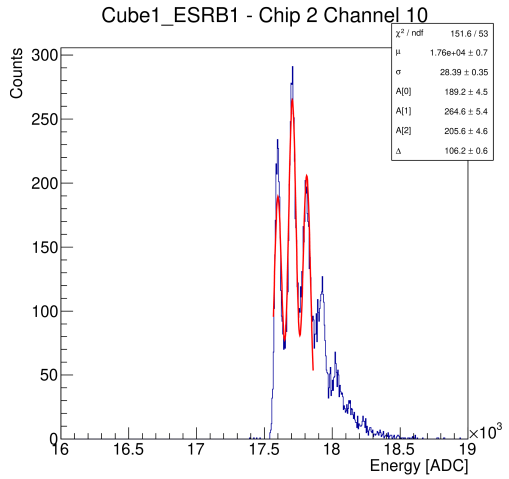


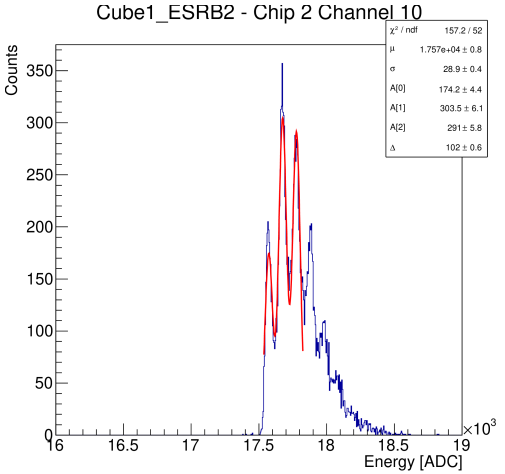


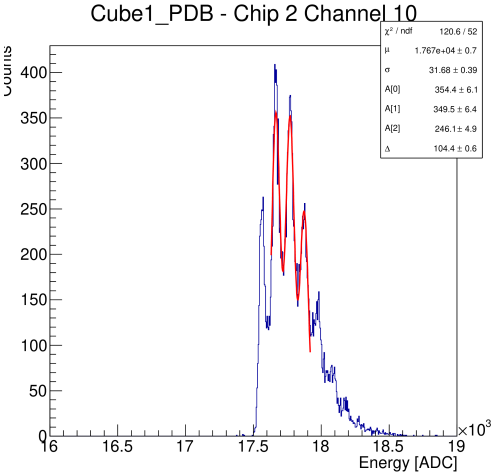
Photopeak fit - Fiber 3

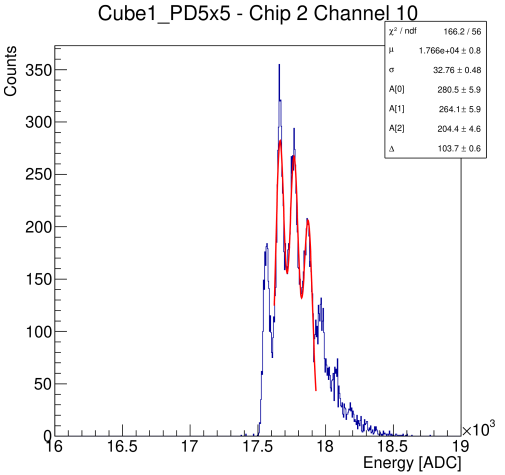


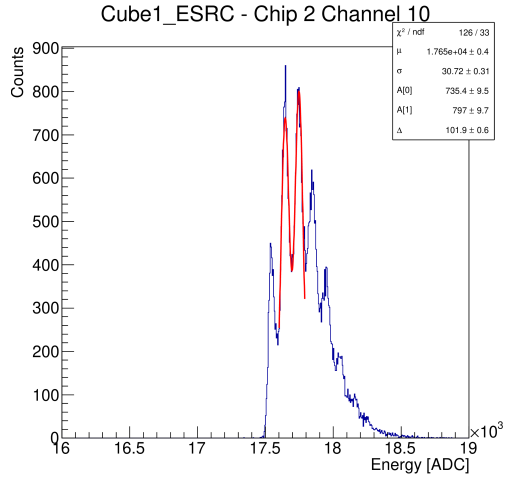


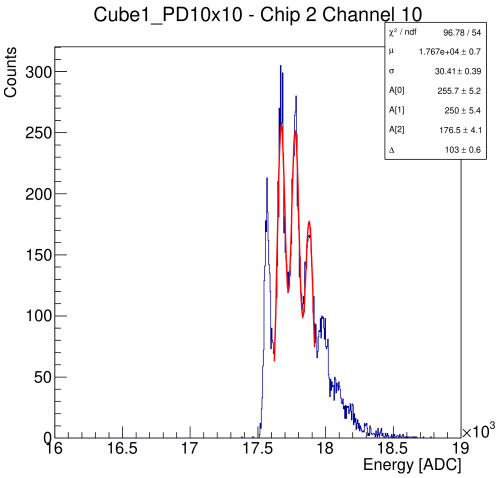


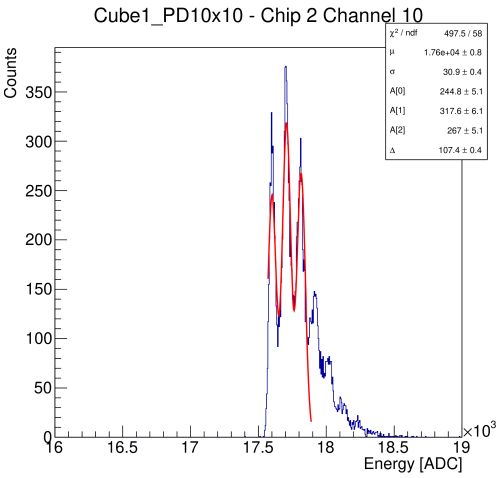


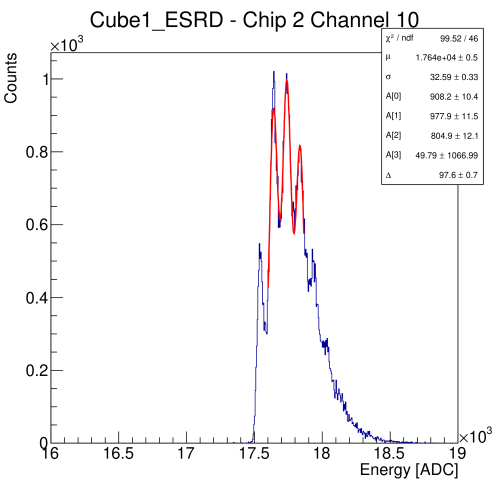




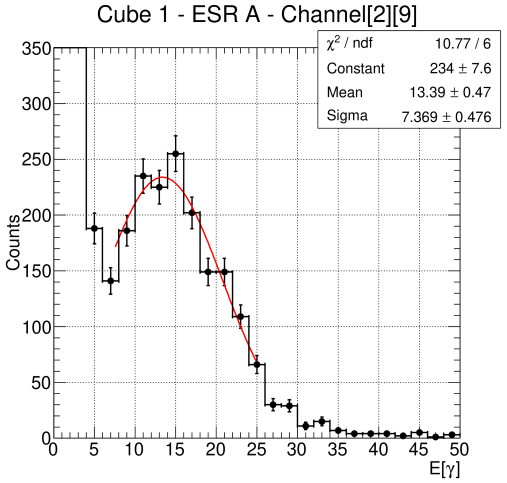


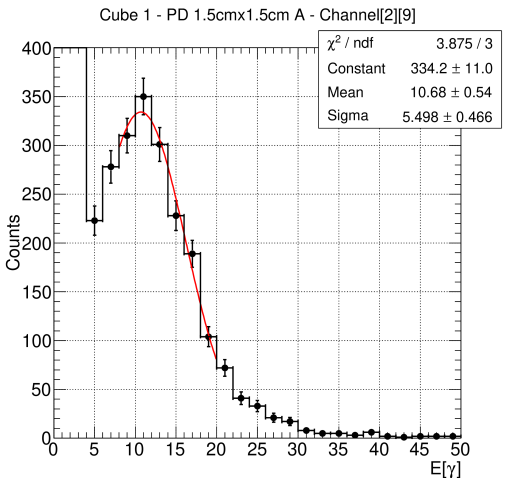


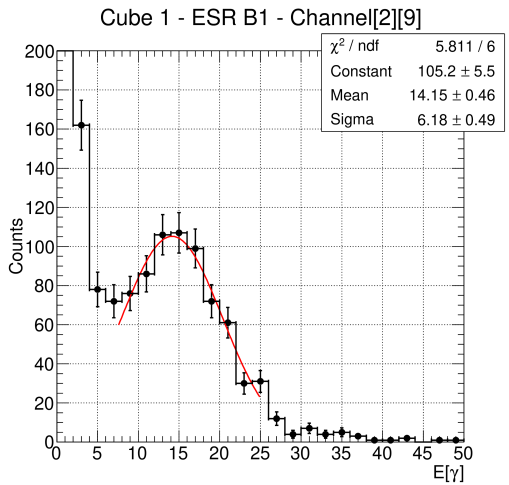


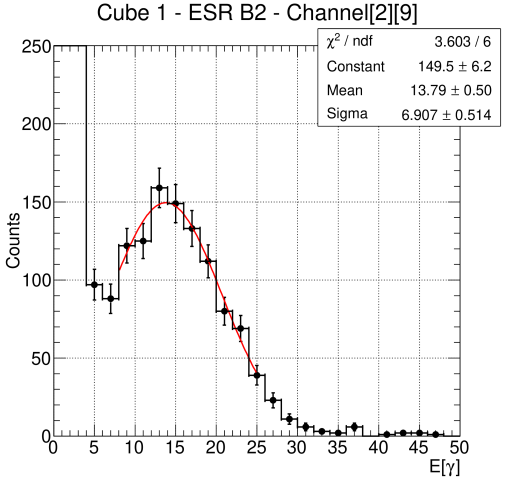


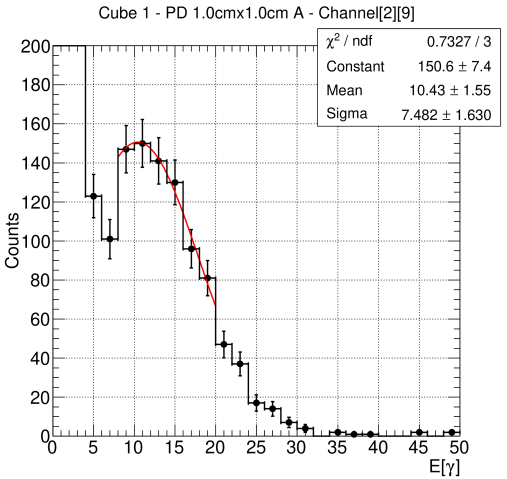
Gain fit - Fiber 1

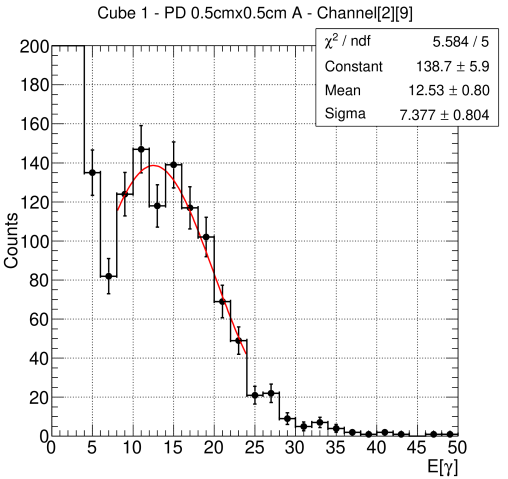


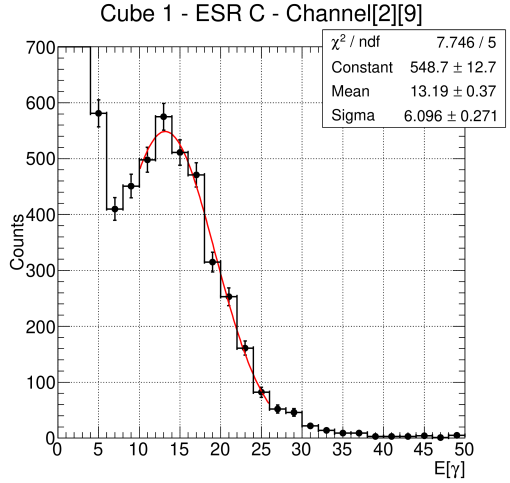


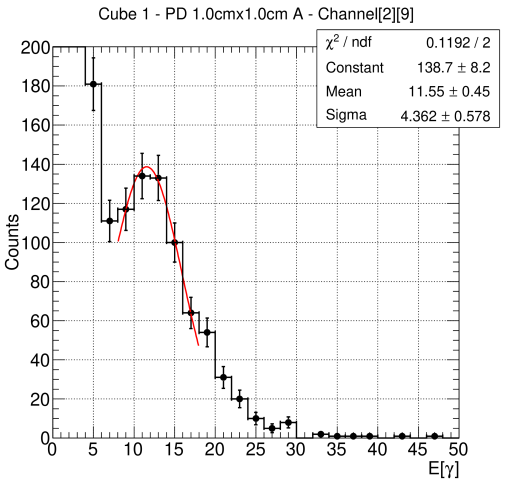


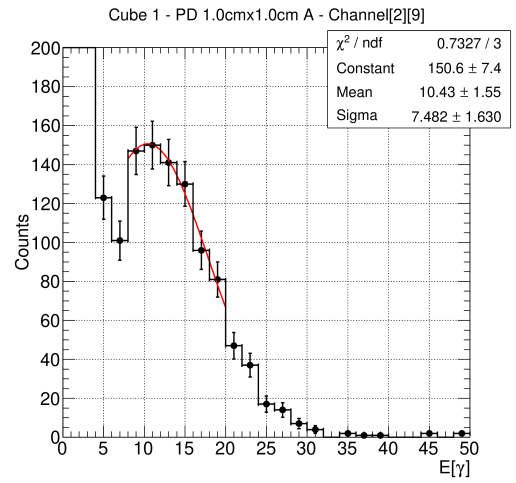


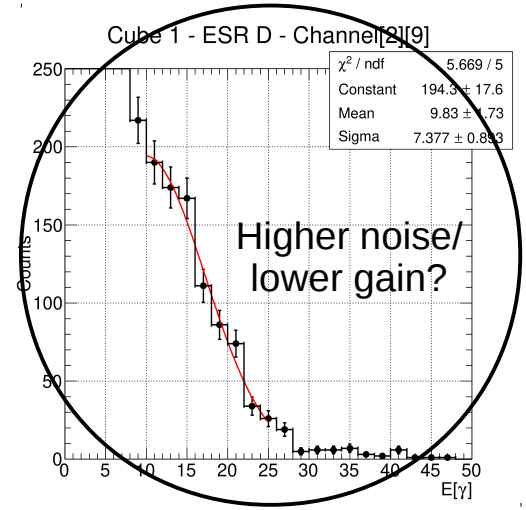




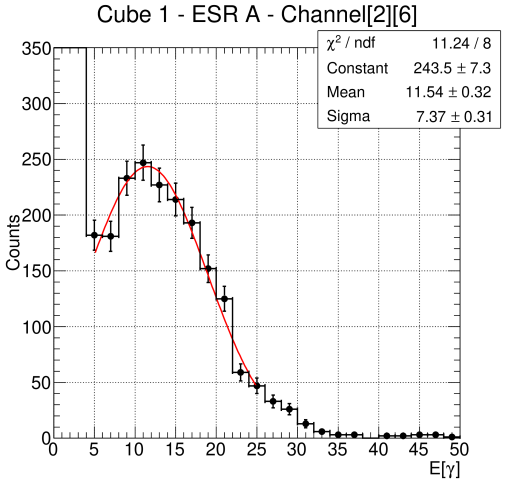


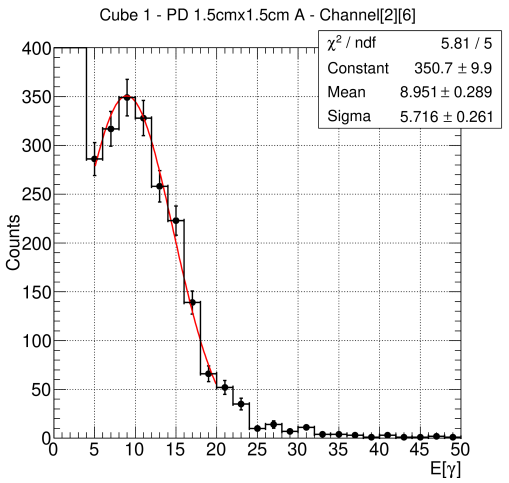


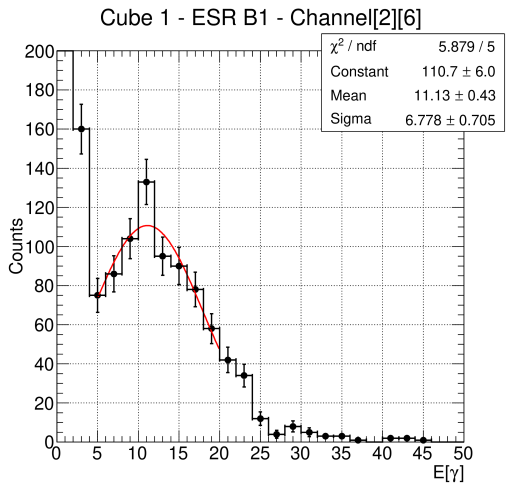


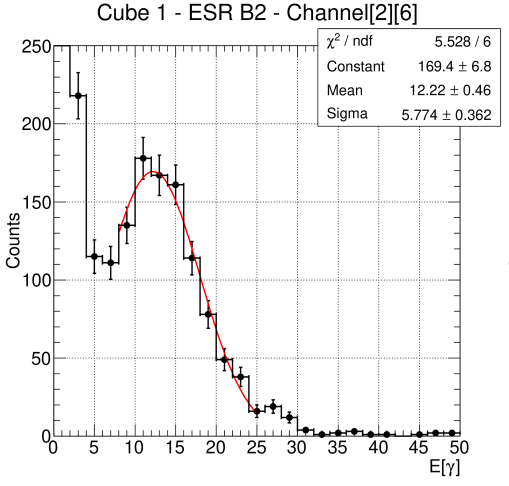


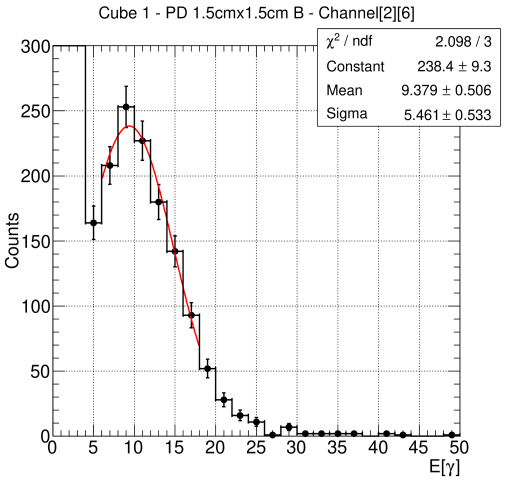
Gain fit - Fiber 2

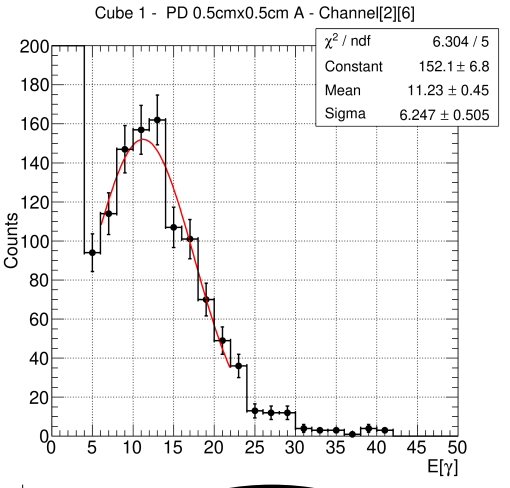


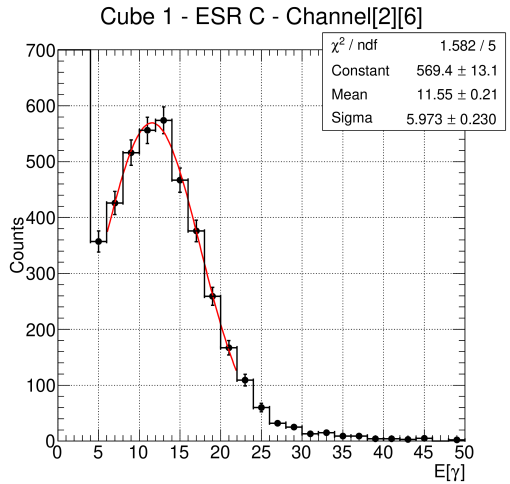


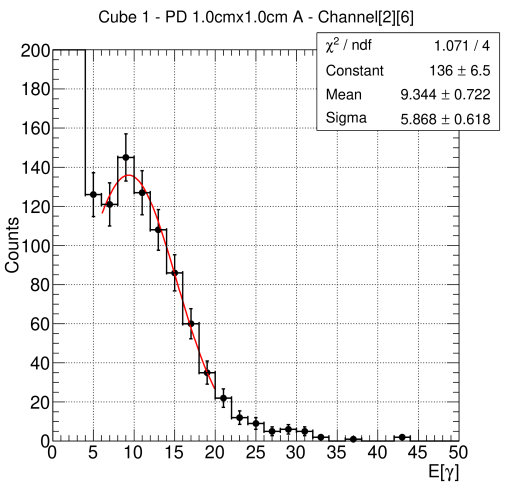


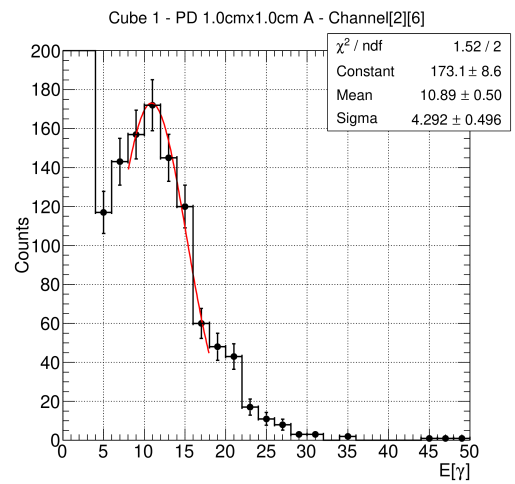


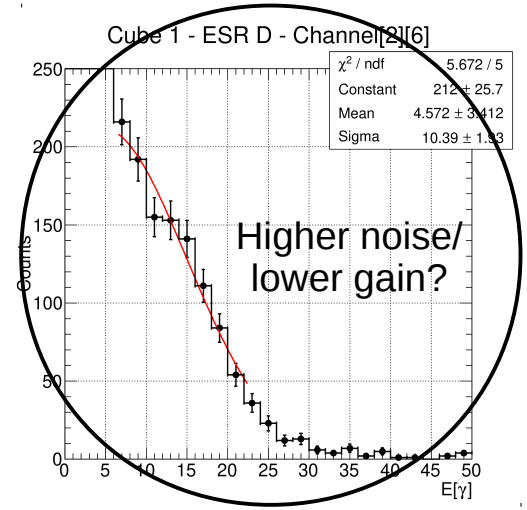




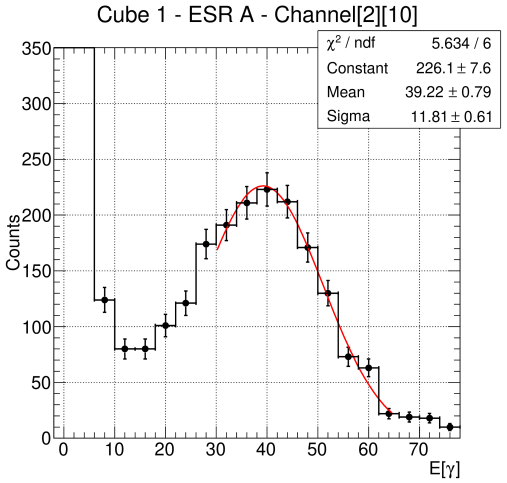


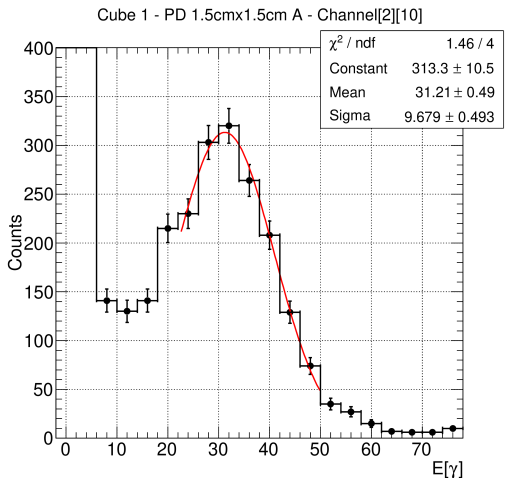


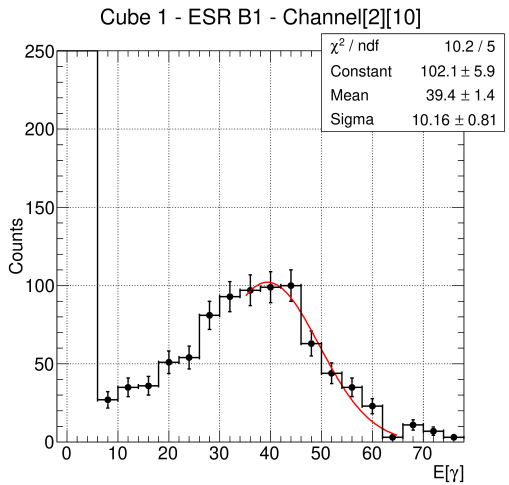


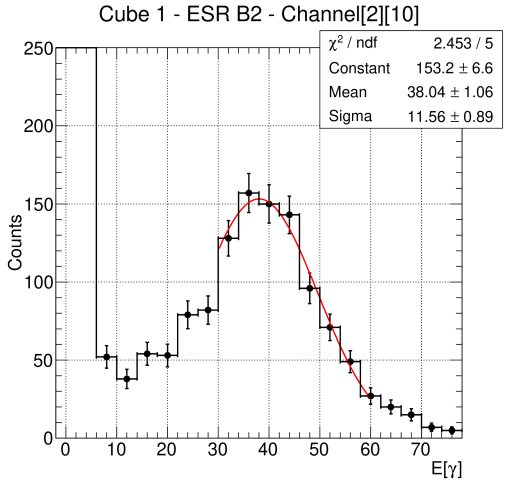


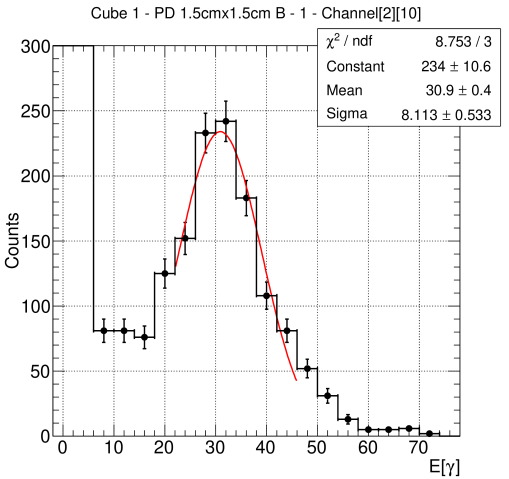
Gain fit - Fiber 3

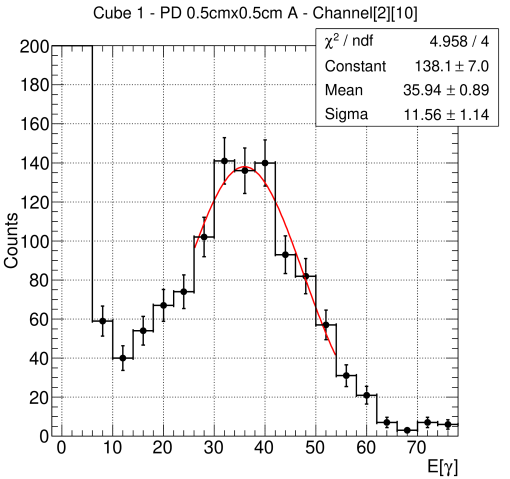


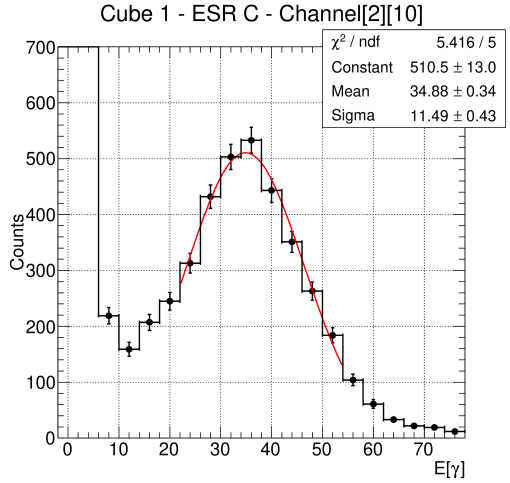


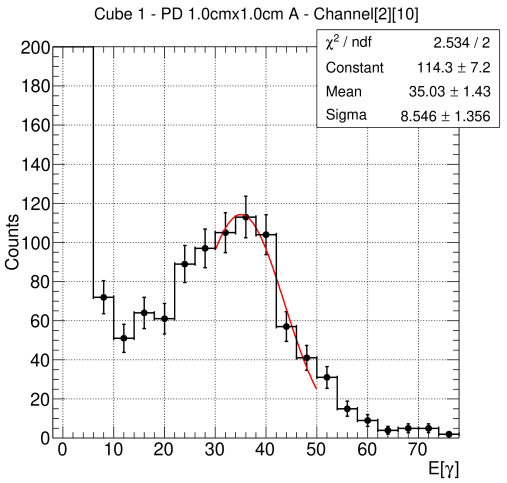


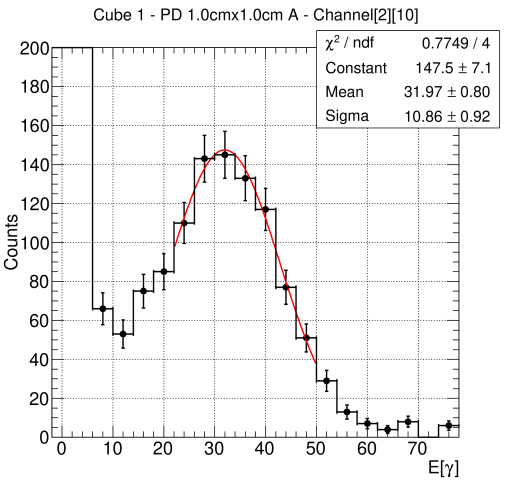


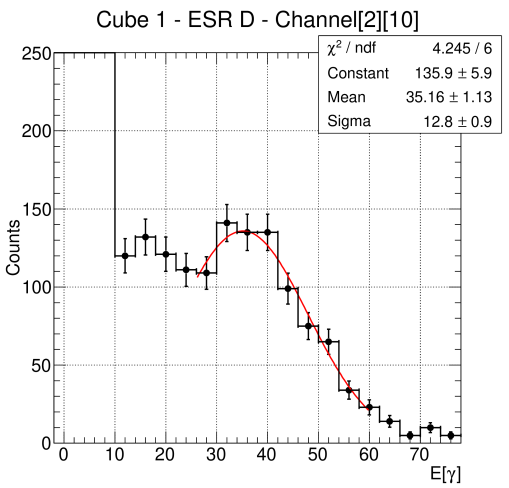






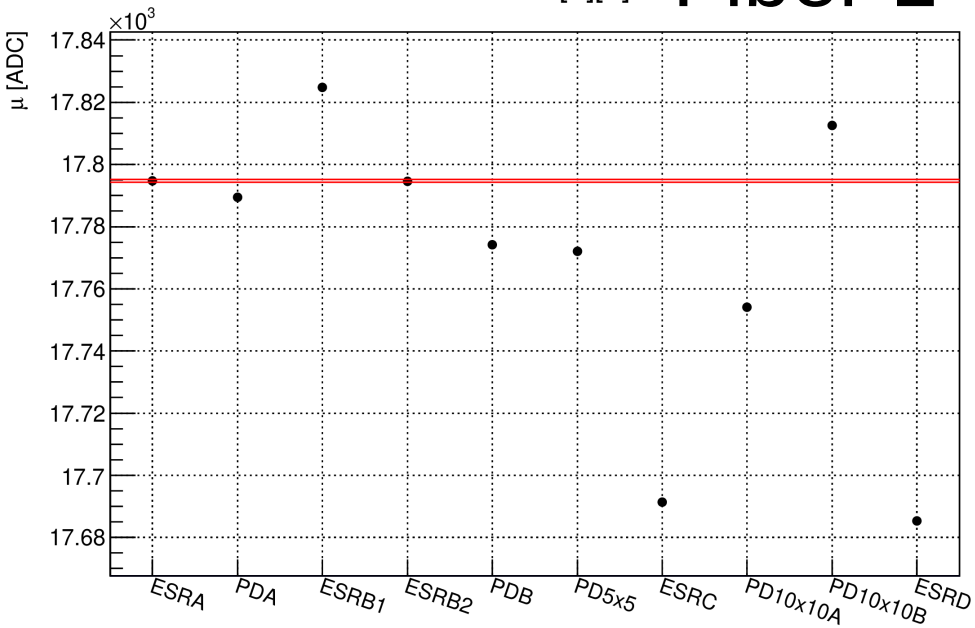




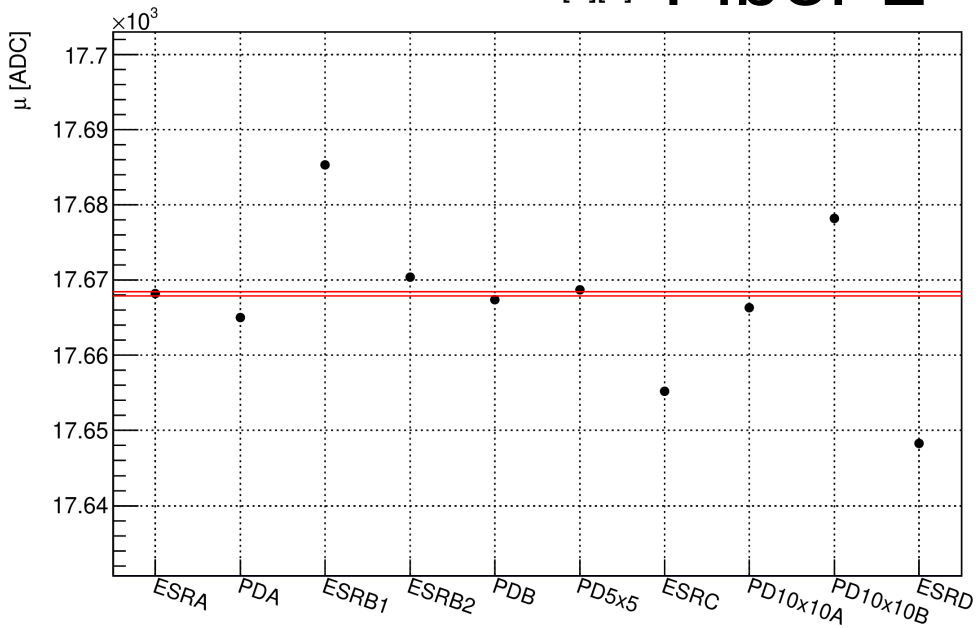


Position of first dark count peak [Absolute]

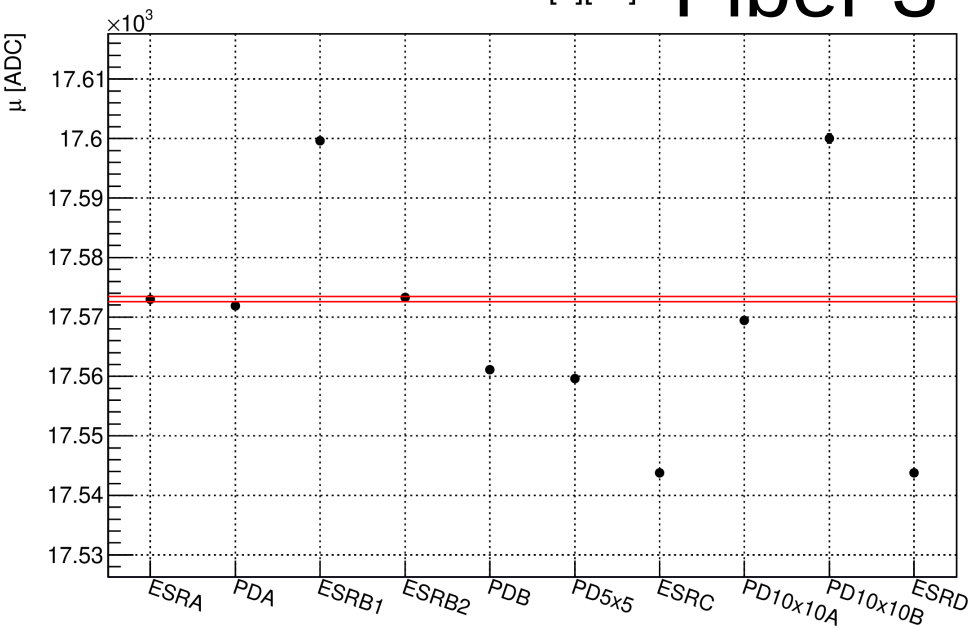
Channel[2][9] Fiber 1



Channel[2][6] Fiber 2

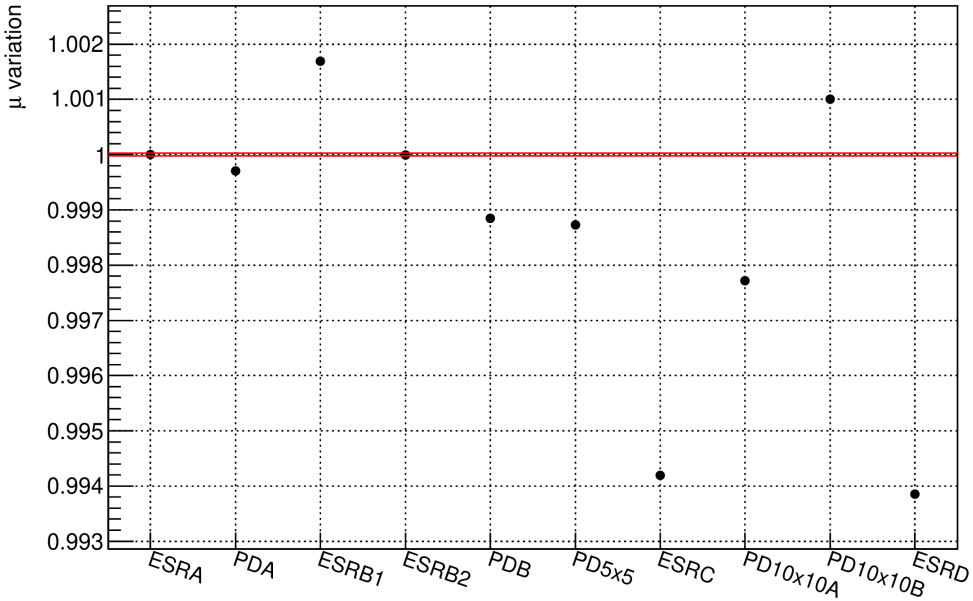


Channel[2][10] Fiber 3

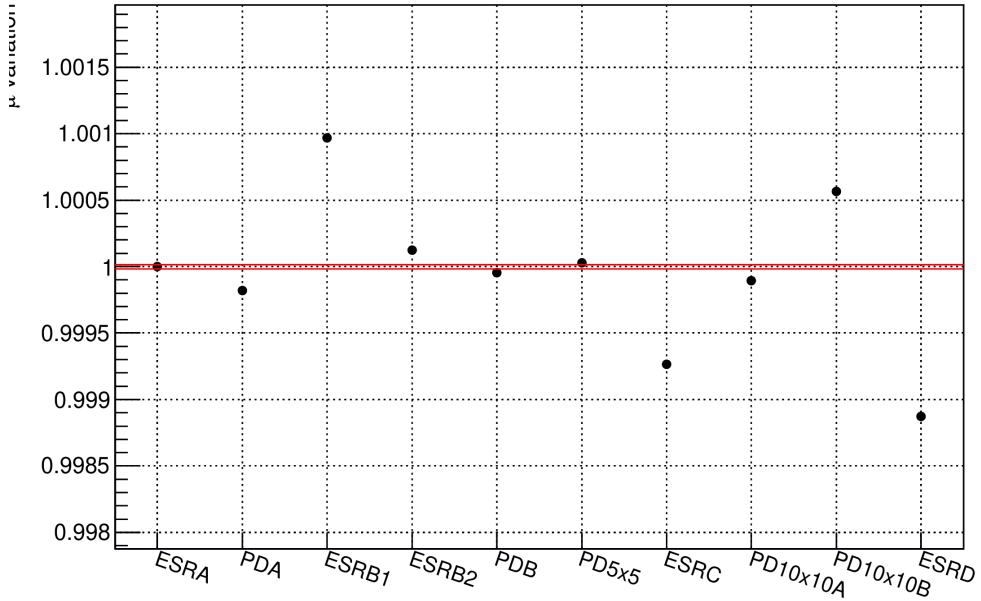


Position of first dark count peak [Relative]

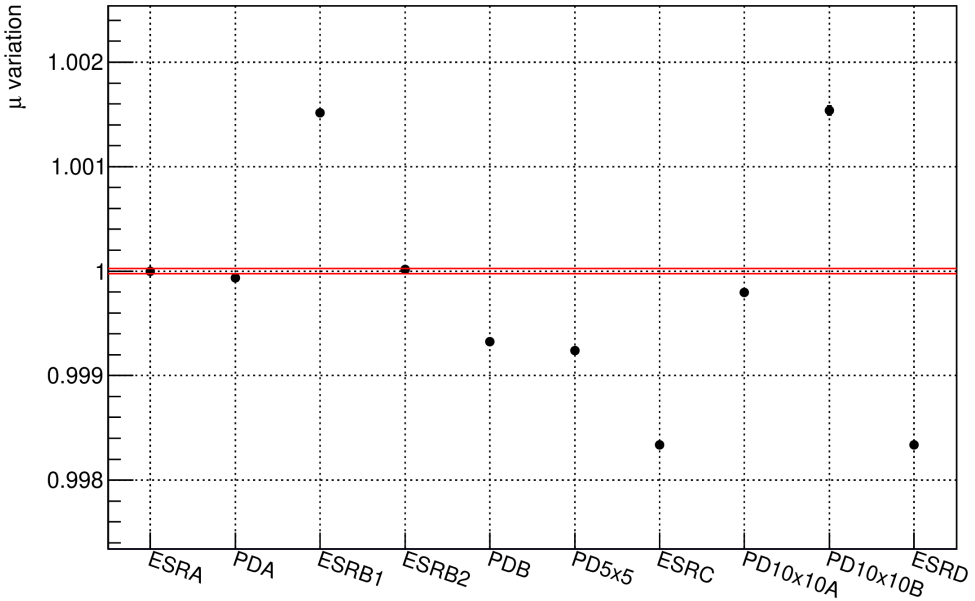
Channel[2][9] Fiber 1



Channel[2][6] Fiber 2



Channel[2][10] Fiber 3

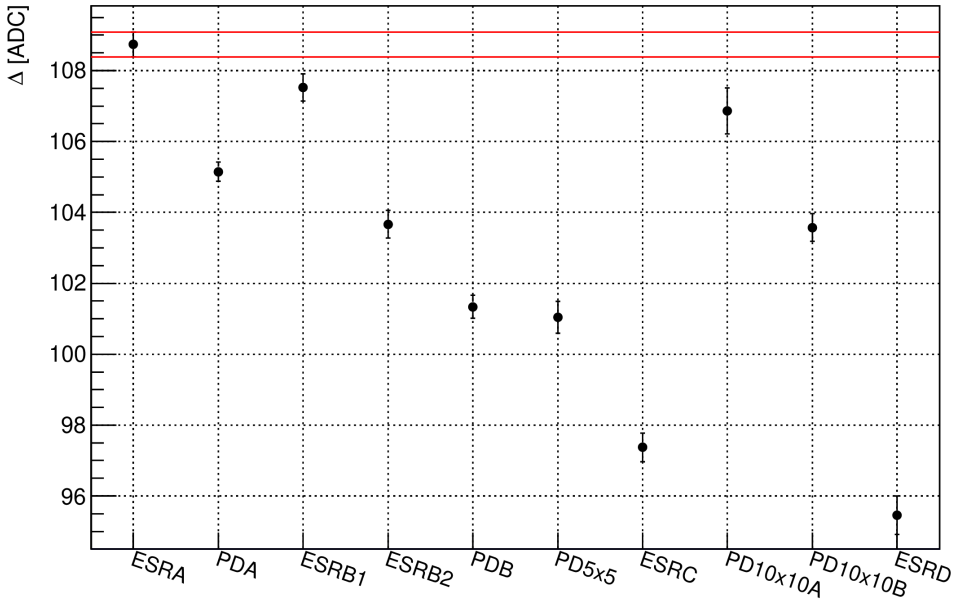


Photopeak gain [Absolute]

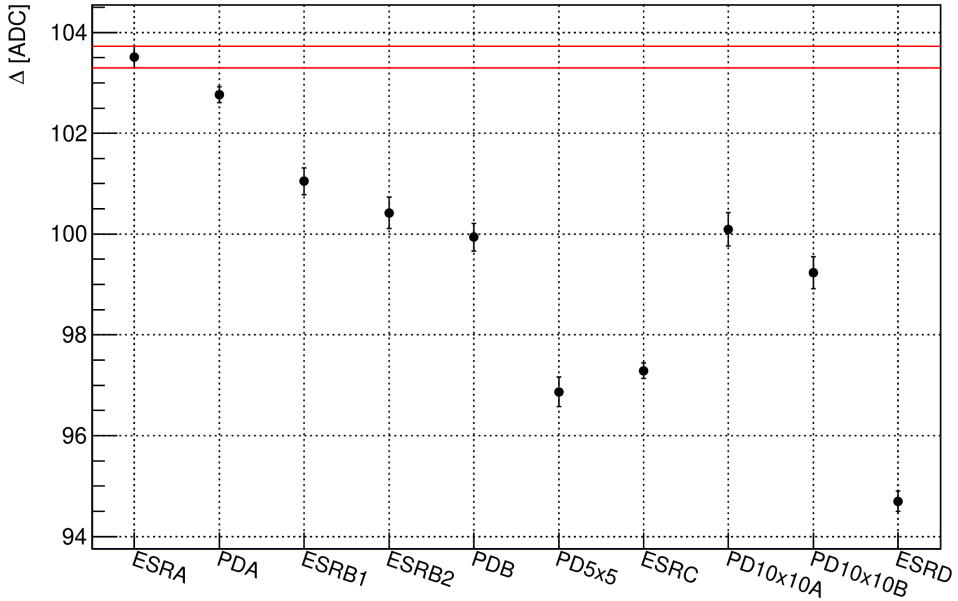
Variation should be mainly due to temperature variation:

measures started on May 15th and ended on June 5th

Channel[2][9] Fiber 1



Channel[2][6] Fiber 2



Channel[2][10] Fiber 3