ECal amplification chain: simulation, measurements and characterization

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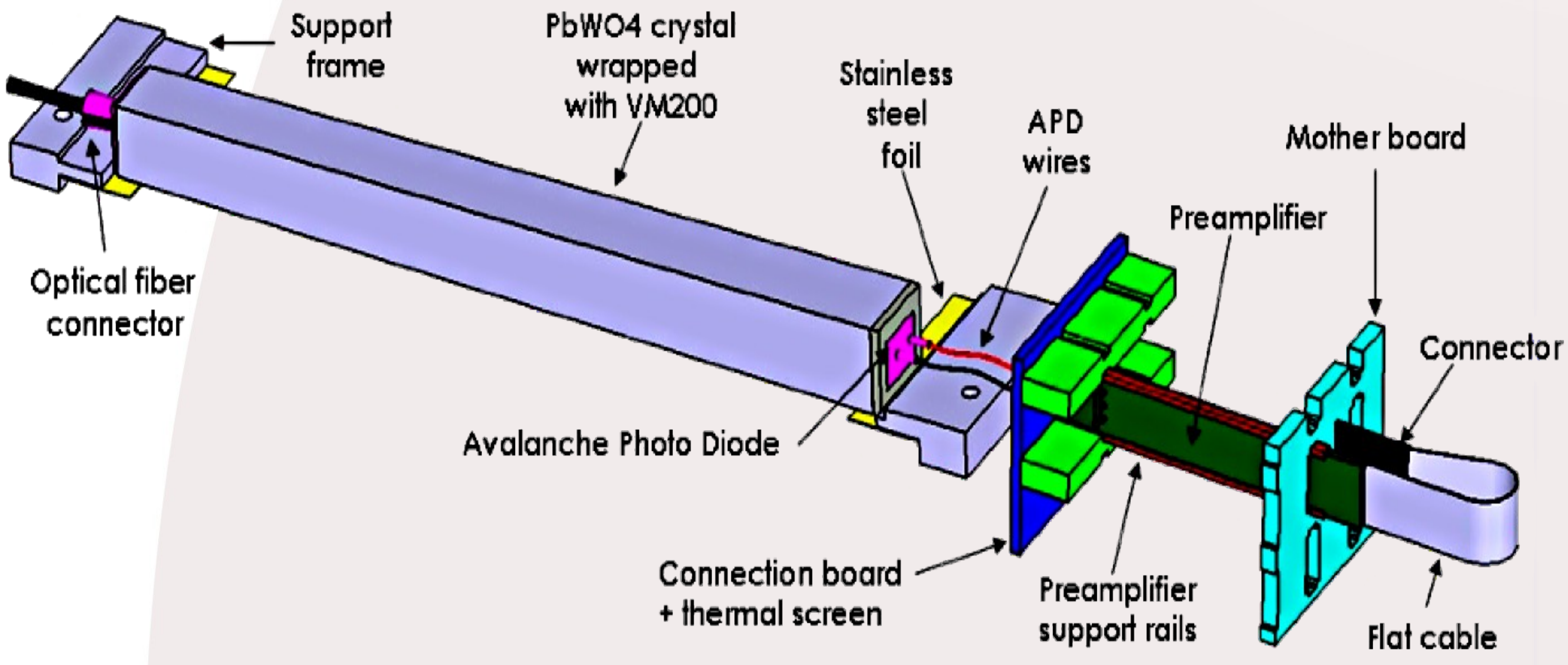
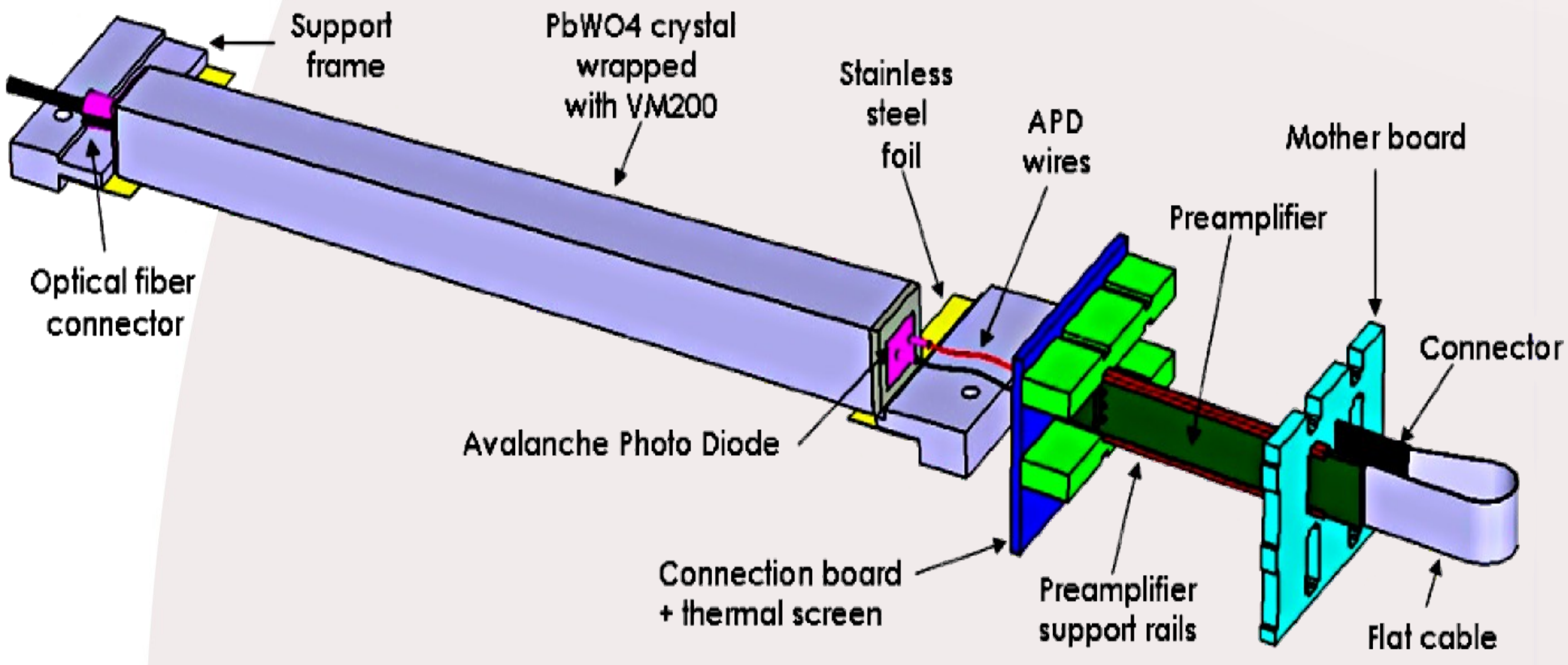
Ecal amplification chain



Aims:

- characterize the preamplifiers in terms of gain and noise
- determine the light yield

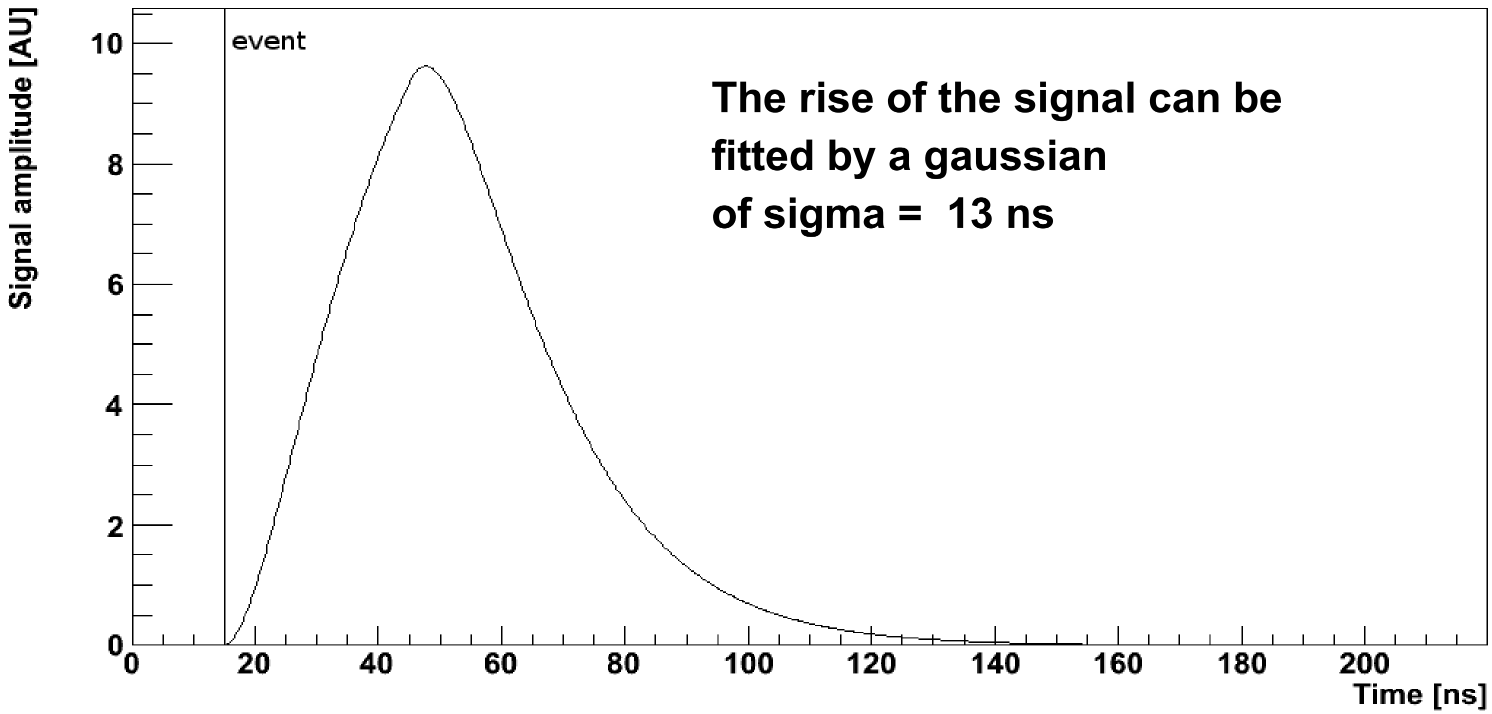
Ecal amplification chain



Aims:

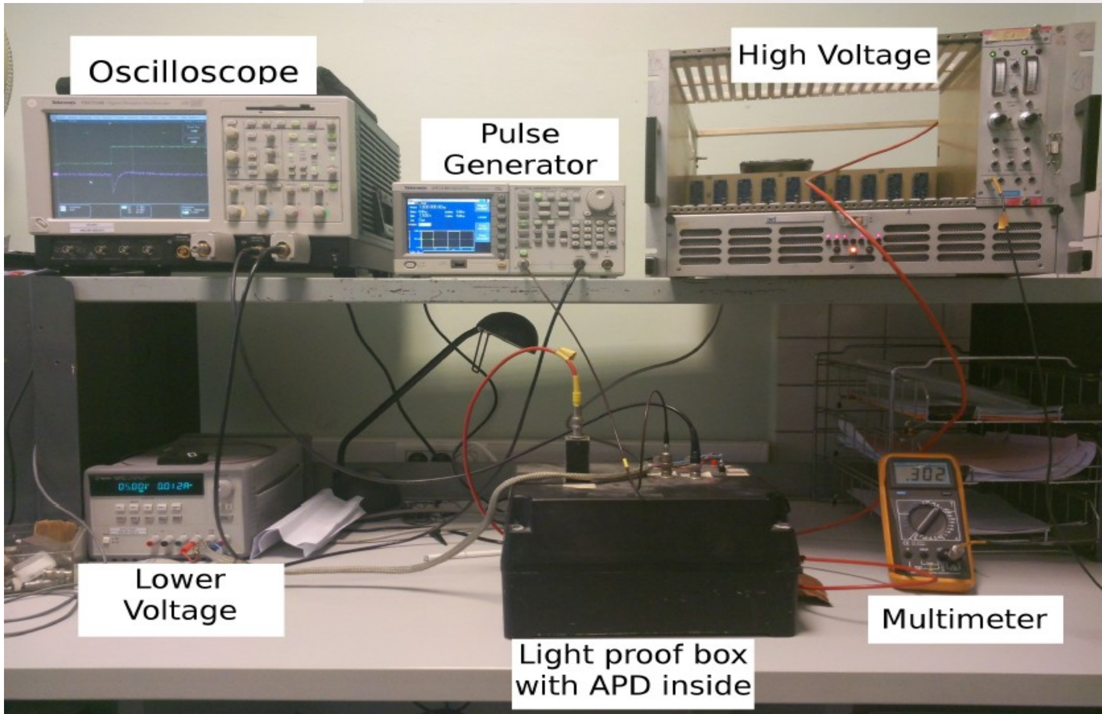
- **characterize the preamplifiers in terms of gain and noise**
  - **necessary to know the input shape of the signal**
- **determine the light yield**

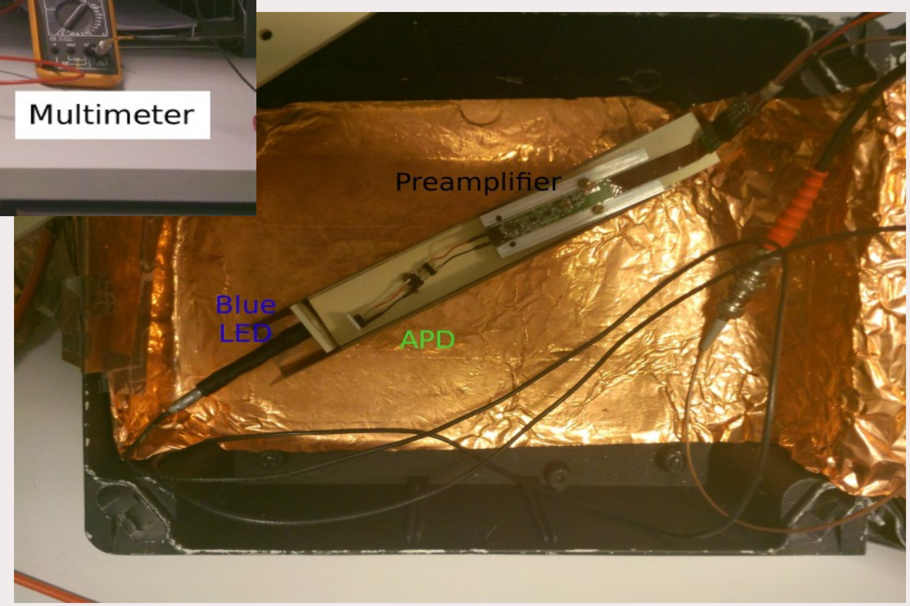
Crystal + APD simulation



Simulation of the shape of the input signal, by convoluting the time response of the crystal and of the APD.

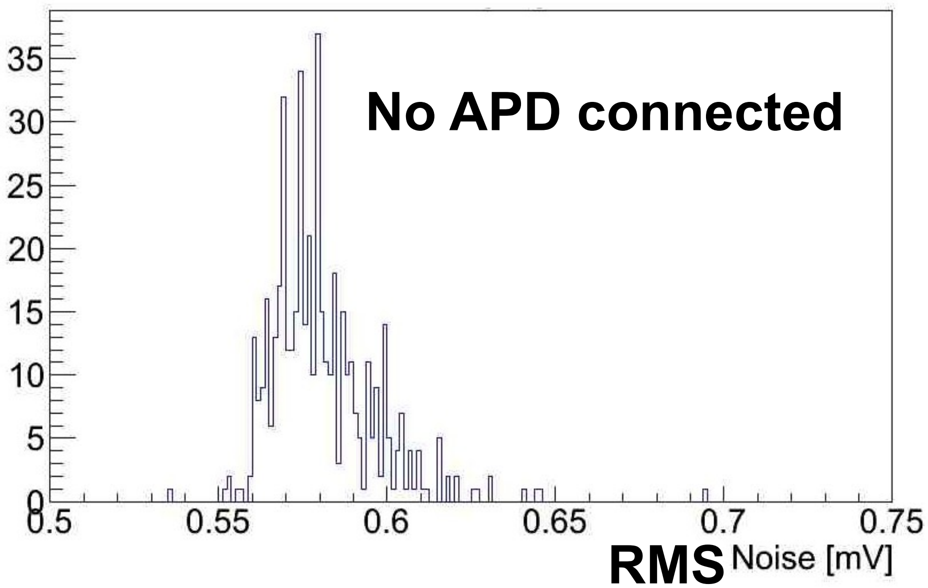
Characterization setup





Except for the test of the APD itself, for the characterization, the preamplifier was directly connected to the pulse generator.

APD noise variations



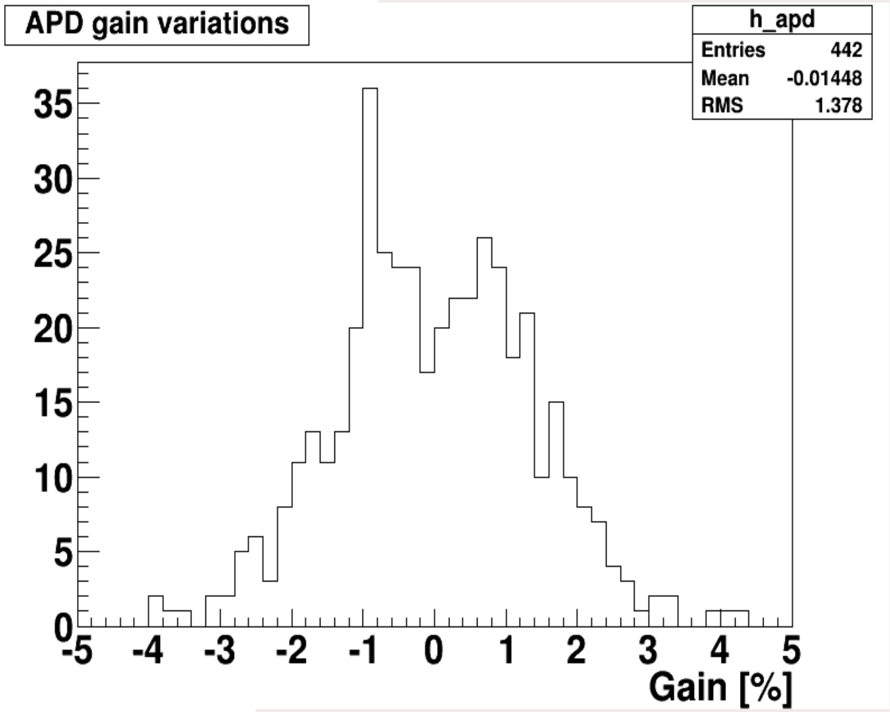
When a capacitor is connected to the preamplifier to simulate the APD, the spread remains identical while the most probable value is 1.14 mV (around 3.3 MeV)

The theoretical threshold can be deduced:

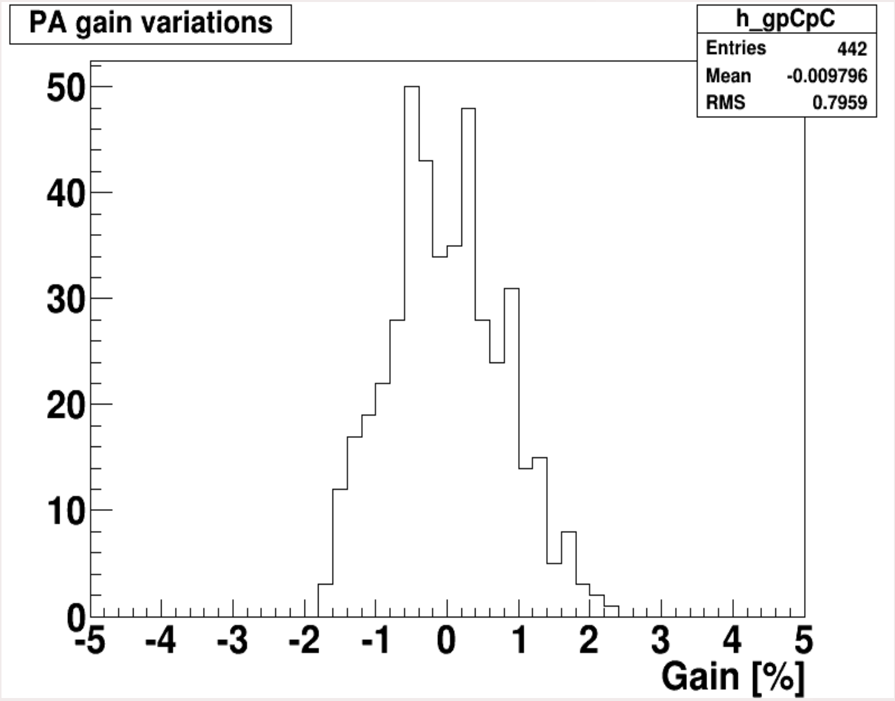
$$\sigma_{noise} = \sqrt{1.3^2 + 3.3^2 + E/N_{\gamma_e}}$$

FADC fluctuations (↑ 1.3^2) **Nphe fluctuations** (↑ N_{γ_e})

APD and preamplifier gain variations

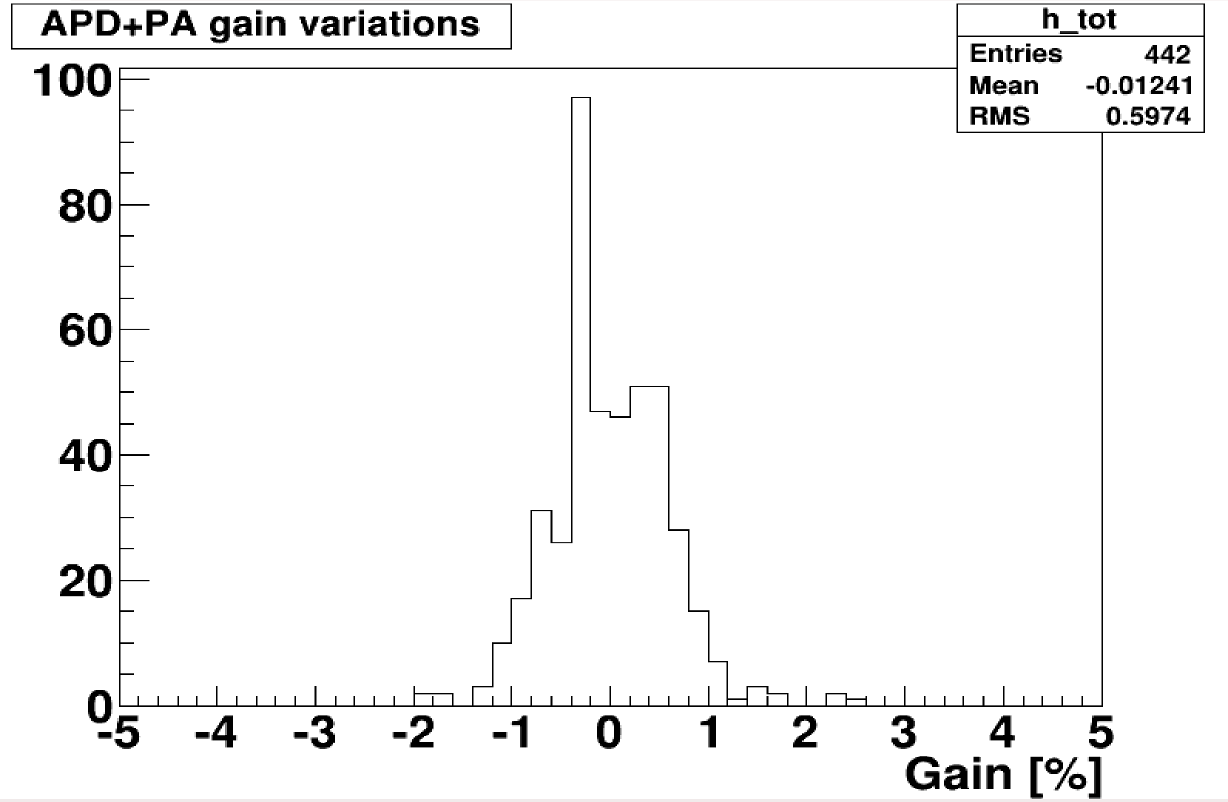


Provided by : see Michel's talk



Mean value is around 225 pC/pC

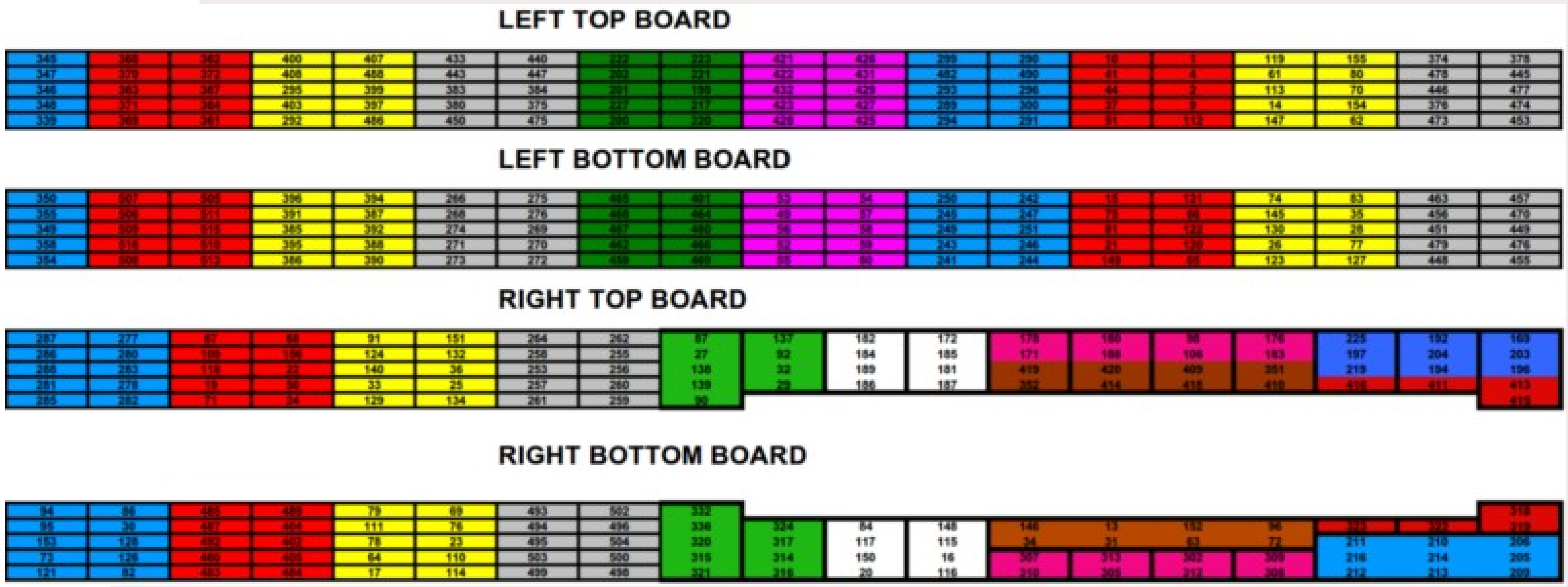
Total gain variations



The APDs and the preamplifiers are coupled to reduce the variations as much as possible.

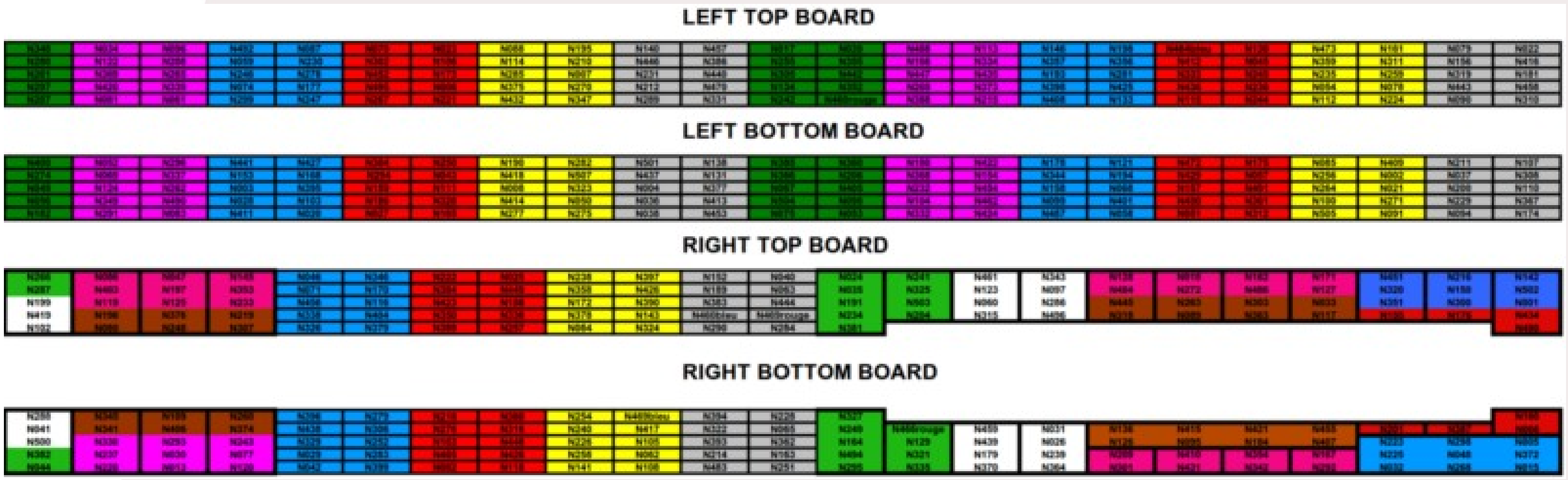
Most of the couples APD+PA have gain variations below 1% of the mean value.

APDs mapping



Provided by : see Michel Garçon's talk

Preamplifiers mapping



V. Iurasov

These two maps will be used next week to install the crystals and the preamplifiers.

Total gain mapping

V. Iurasov

This gain map can be loaded into the software database.

It could also be used to compare with the calibration but the variations are very small.

Measurements: setup

Andrea Celentano

Trigger is composed of three scintillators+PM

Temperature of the crystal kept stable at 18 deg C

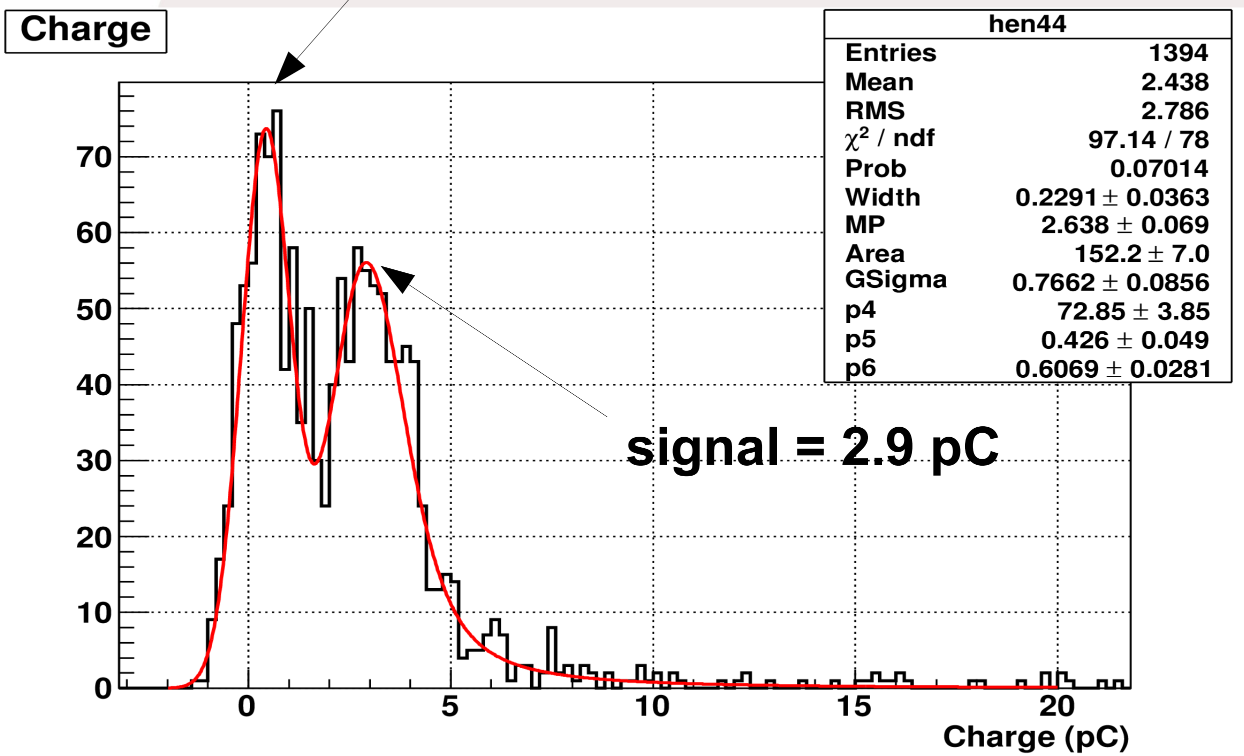
The crystal is placed horizontally

Simulations have shown that the average energy deposition in this configuration is 15 MeV

Measurements: results

Andrea Celentano

Pedestal = 0.4 pC



The most probable energy deposition is thus: 2.5 pC

This is compatible with a light yield of 120 ph/MeV and a preamplifier gain of 220 pC/pC

Conclusion

- All the preamplifiers have been characterize in terms of noise and gain
- The preamplifiers have coupled to APDs to reduce the gain spread over the Ecal
- Map of preamplifier has been produced to install the preamplifiers (next week)
- Map of gain has been produced, can be used in the simulation
- Measurements with a single crystal have shown the consistency of the gain and light yield expectations

Internal technical note with all the details will be published very soon.

LY calculations

$$Q_{MP} = 2.487\,pC$$

From this, one can derive the crystal light-yield by converting the charge in the number of electrons and dividing this by the gain of the amplifier, the gain of the APD, and the most probable energy deposition:

$$LY_{phe} = \frac{Q_{MP}}{e \cdot G_{APD} \cdot G_{Ampli} \cdot E_{MP}} = 30.8 \text{ phe / MeV}$$

One can also derive the light yield, in optical photons emitted per deposited MeV, by taking into account the APD quantum efficiency ($QE \simeq 0.7$) and the ratio of the APD surface to crystal surface ($S_R = 0.3906$), getting:

$$LY_{\gamma} = \frac{LY_{phe}}{QE \cdot S_R} \simeq 112.6 \text{ photons / MeV}$$

This number is close to the one used in the amplification chain model (120 photons / MeV).