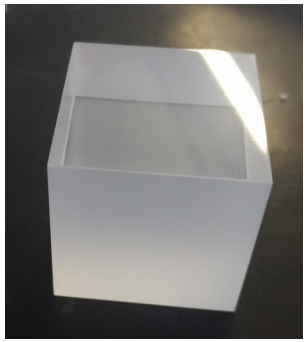
Dual read out of LYSO crystals with PDs and wave length shifter read-out by SiPMs

Lorenzo Pacini (lorenzo.pacini@fi.infn.it)

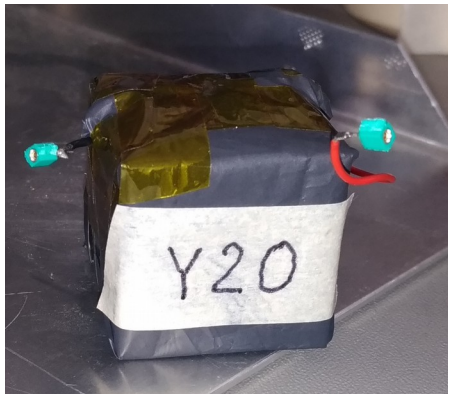
Purpose of these tests

- 1) Evaluate the S/N ratio of the MIP signal with LYSO cube, using the large PD (LPD VTH2090) read-out with the HIDRA boards (see CaloCube publications).
  - Expected result:
    - S/N for CsI(Tl) in CaloCube is $\sim$ 10.
    - Nγ(CsI) $\sim$ 20MeV/MIP * 55k/MeV $\sim$ 1100k
    - Nγ(LYSO) $\sim$ 30MeV/MIP * 30k/MeV $\sim$ 9000k
    - QE(VTH2090) $\sim$ 0.33 (CsI) and 0.25 (LYSO)
    - S/N LYSO $\sim$ 60% S/N for CsI(Tl) $\rightarrow$ **6**
- 2) Test the SiPM with the LYSO+fiber system, using the HIDRA for the read-out of the SiPM
  - SiPMs: Hamamatsu S12571-010, pitch 10 or 15 µm.

1) MIP signal with LYSO + LPD

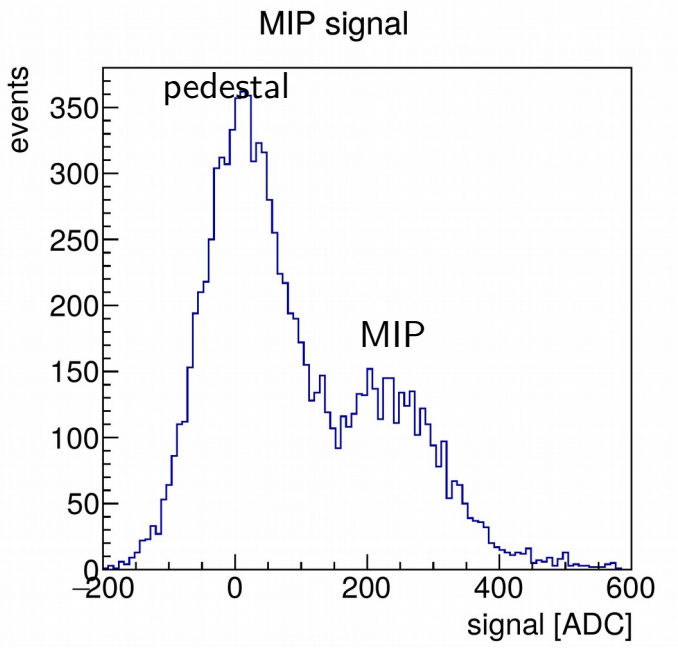


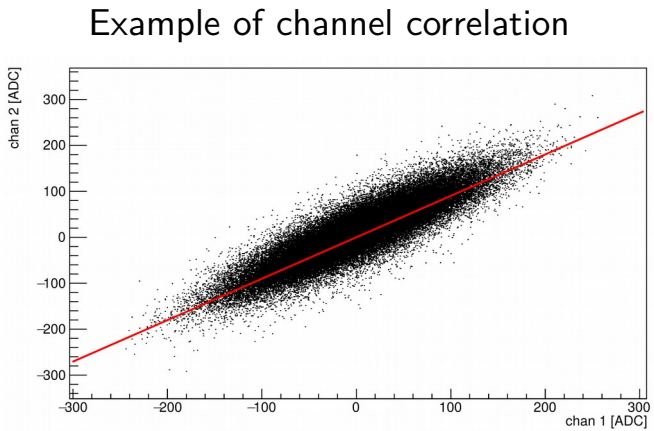
- LYSO crystal Y20, form the 29 crystals without fibers and ESR
- Different configurations tested (there are not fibers glued to the cube):
  - LPD on the polished face, with optical greases
  - LPD on a not polished face, with optical greases
  - LPD on a not polished face, without optical coupling (air)
  - LPD with silicone sealant (Dow Corning - 3145)
- The cube is wrapped with ESR, and Tedlar film, for an additional shield from external light.

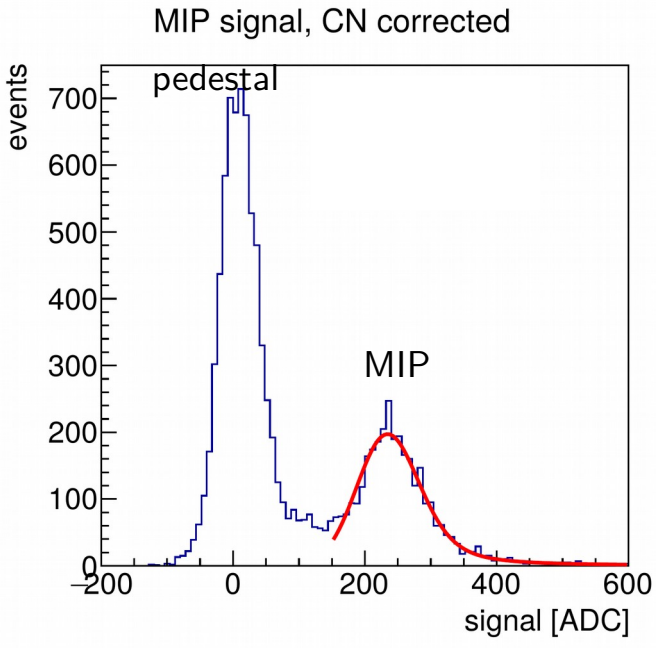


Acq. and analysis procedure

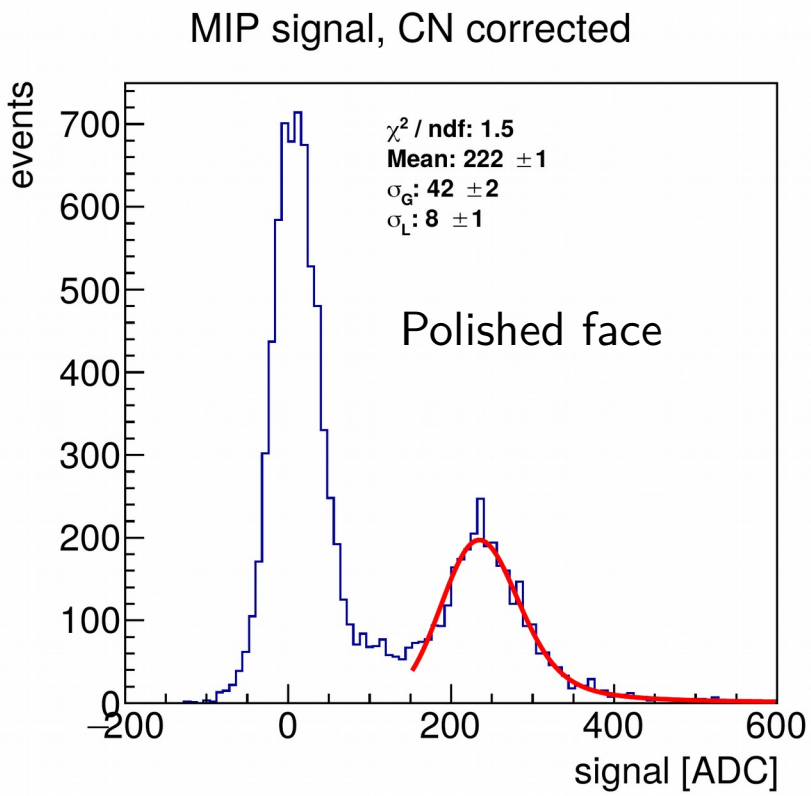
- Two plastic scintillator (5x5 cm2) used for the MIP trigger.
- Both pedestal (using a random trigger) and MIP signal are acquired.
- A common noise subtraction is needed in order to increase the S/N.

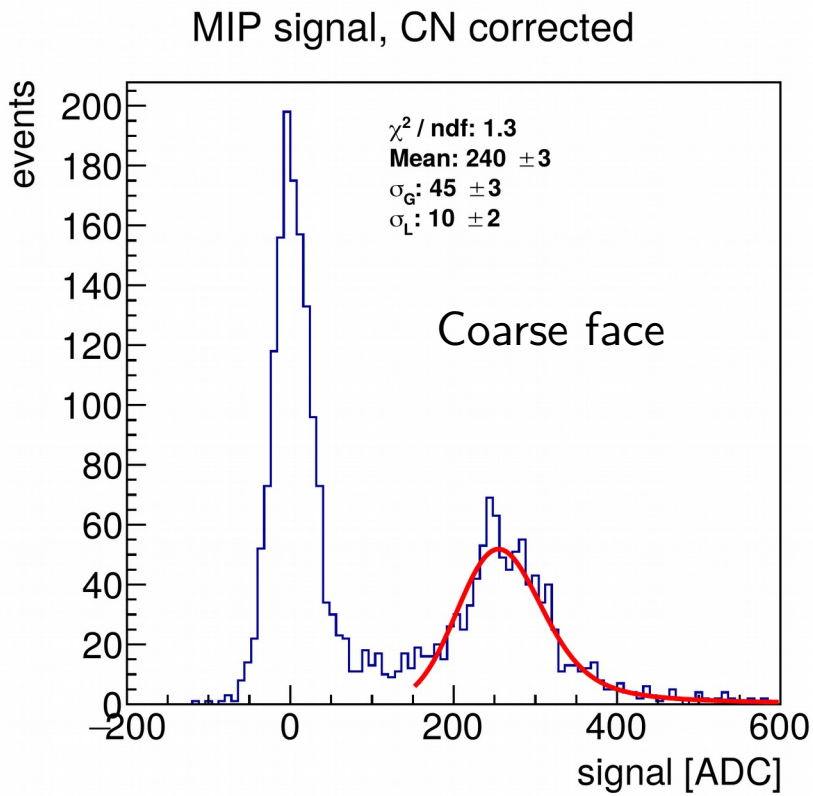






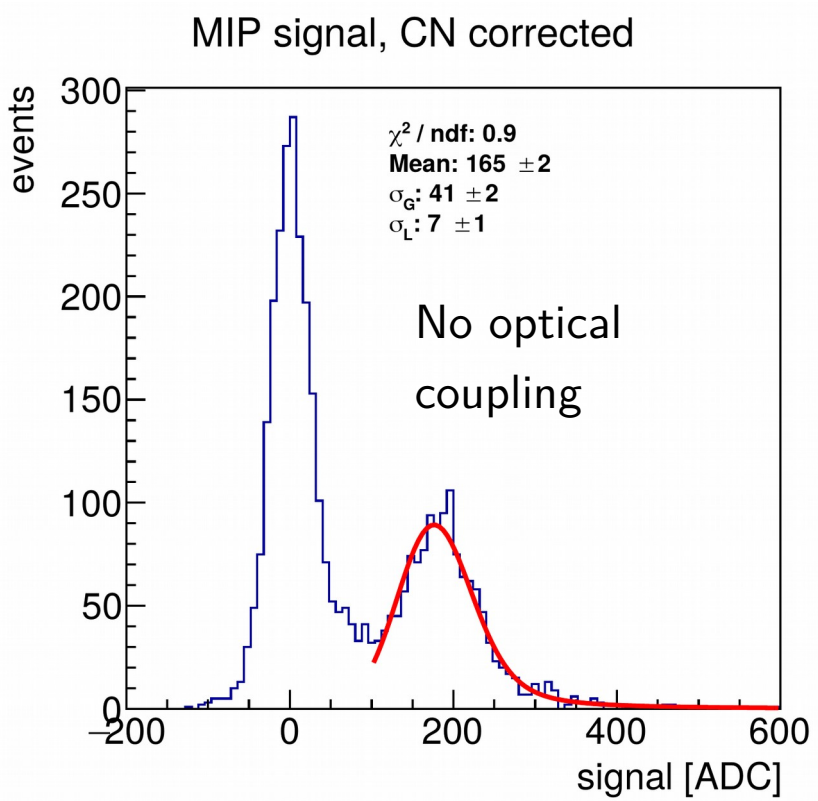
Using optical greases

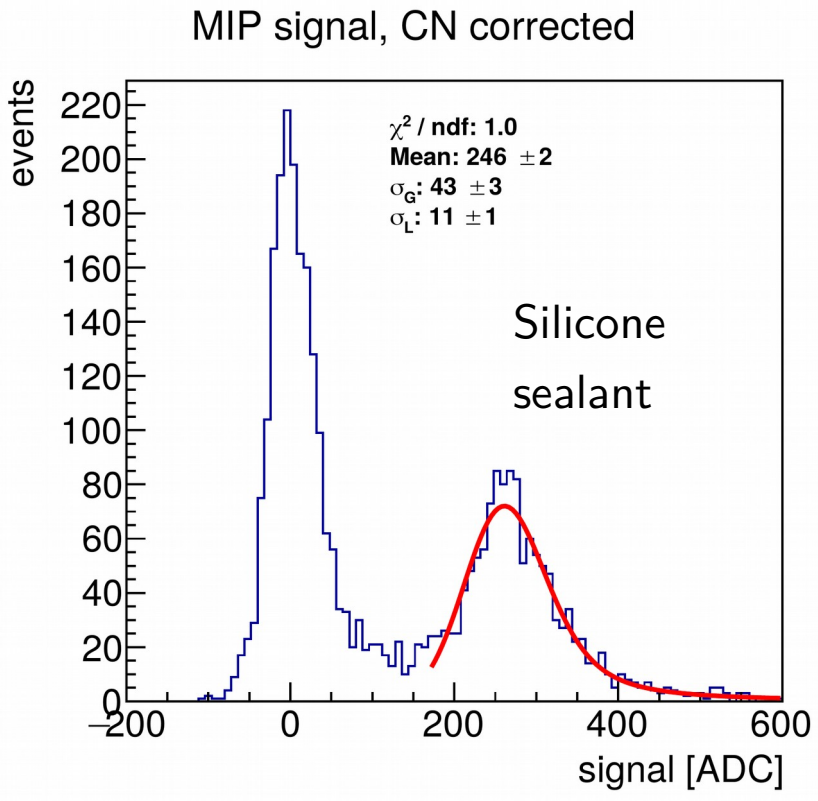




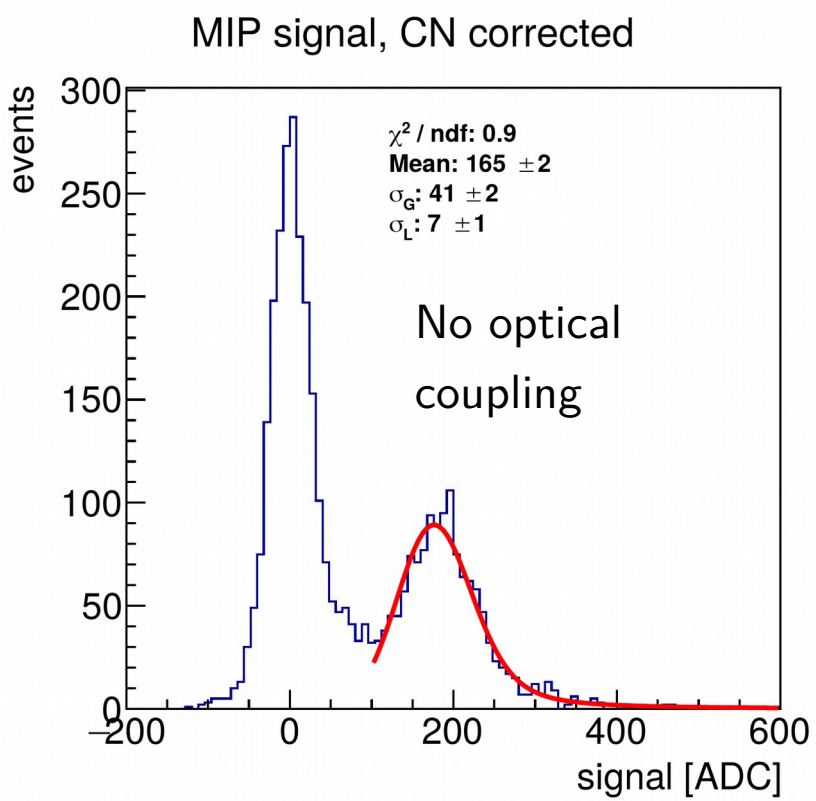
- Using Landau function convoluted with Gaussian to evaluate the peak.
- The peak is slightly higher with the PD on the coarse face, the S/N ratio is >6. (with CsI(Tl) it is ~ 10)

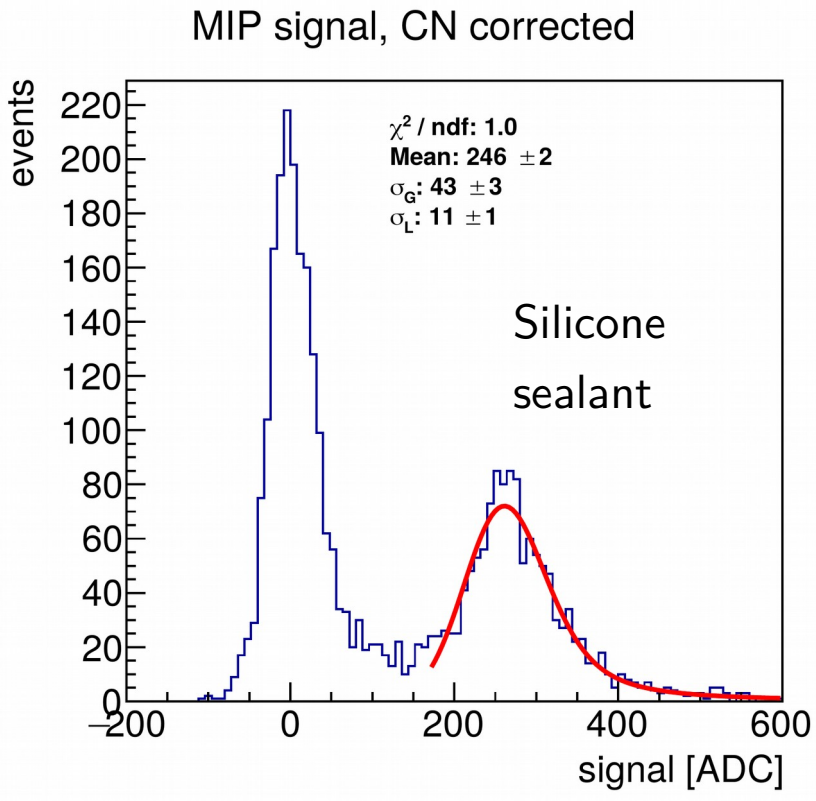
Without optical greases





- Using Landau function convoluted with Gaussian to evaluate the peak.
- The peak is slightly higher with the PD on the coarse face.





- Using Landau function convoluted with Gaussian to evaluate the peak.
- The peak is slightly higher with the PD on the coarse face.

Summary of LPD+LYSO tests

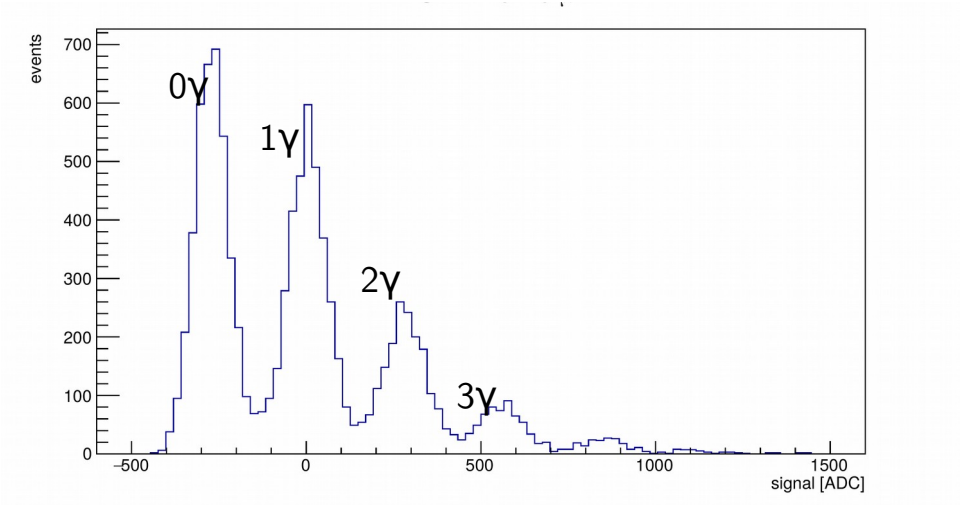
Test number	Face	Opt. coupling	MIP [ADC]	MIP (% test 1)
1	Polished	Optical greases	222	100
2	Course	Optical greases	240	108
3	Course	Air	165	74
4	Course	Silicone sealant	246	111

- Silicone sealant seems a good solution since it can be removed using different products, e.g. Saratoga VIA.SIL

The used surface seems really clean after the treatment

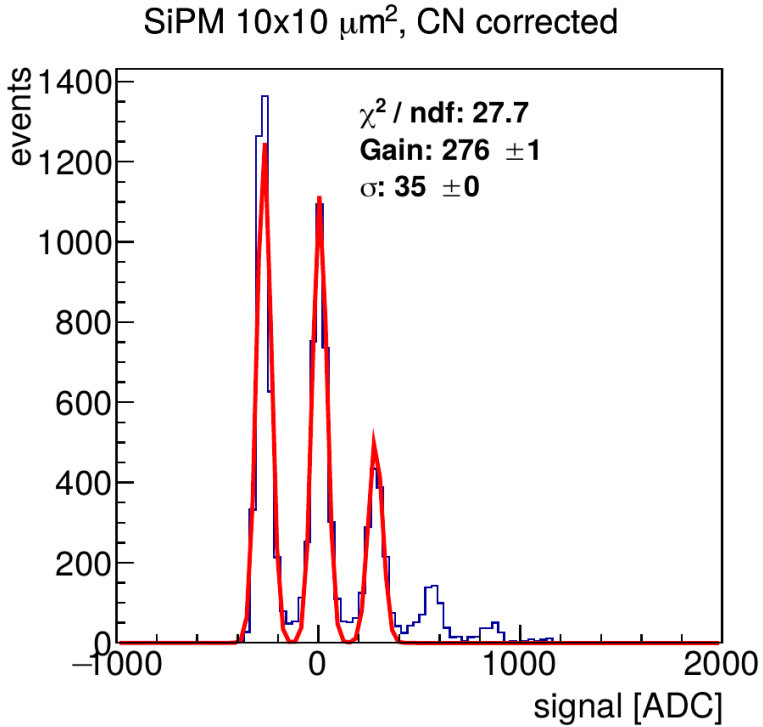
SiPM + HIDRA read-out

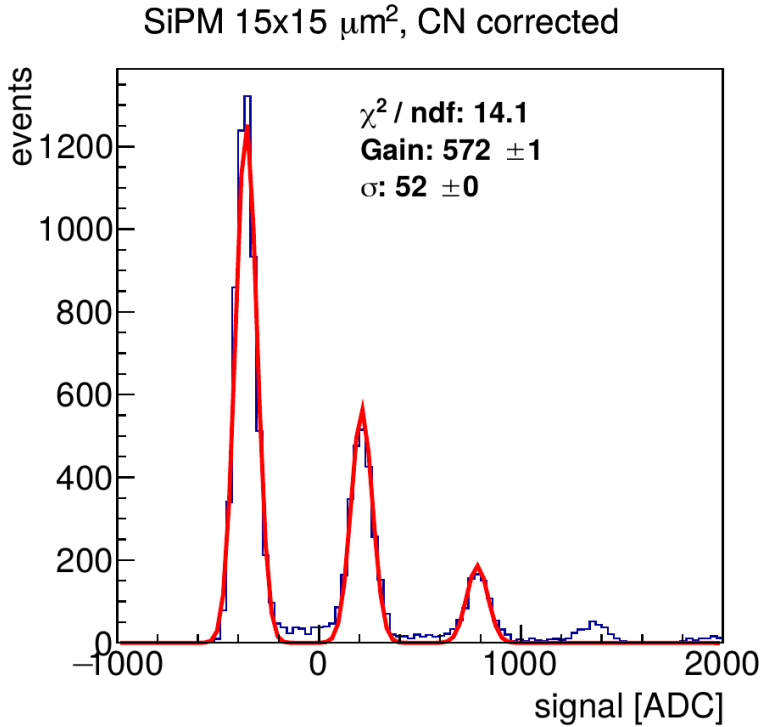
- HIDRA is a charge amplifier which integrates for a selected amount of time (see below).
  - This chip is not studied for SiPM, thus the performance is not optimized.
  - Minimum integration window width (used for SiPM): 10 μs.
- Pedestal acquisition with random trigger: a large number of events contains at least one photo-peak due to the SiPM dark counts. (~100KHz)
- The photo-peaks acquired during the random trigger can be used to check the SiPM gain during the data-taking



SiPM + HIDRA gain

- SiPM+HIDRA gain is defined as the distance between two photo-peak.
- Can be found using Gaussin fit of 3 peaks.





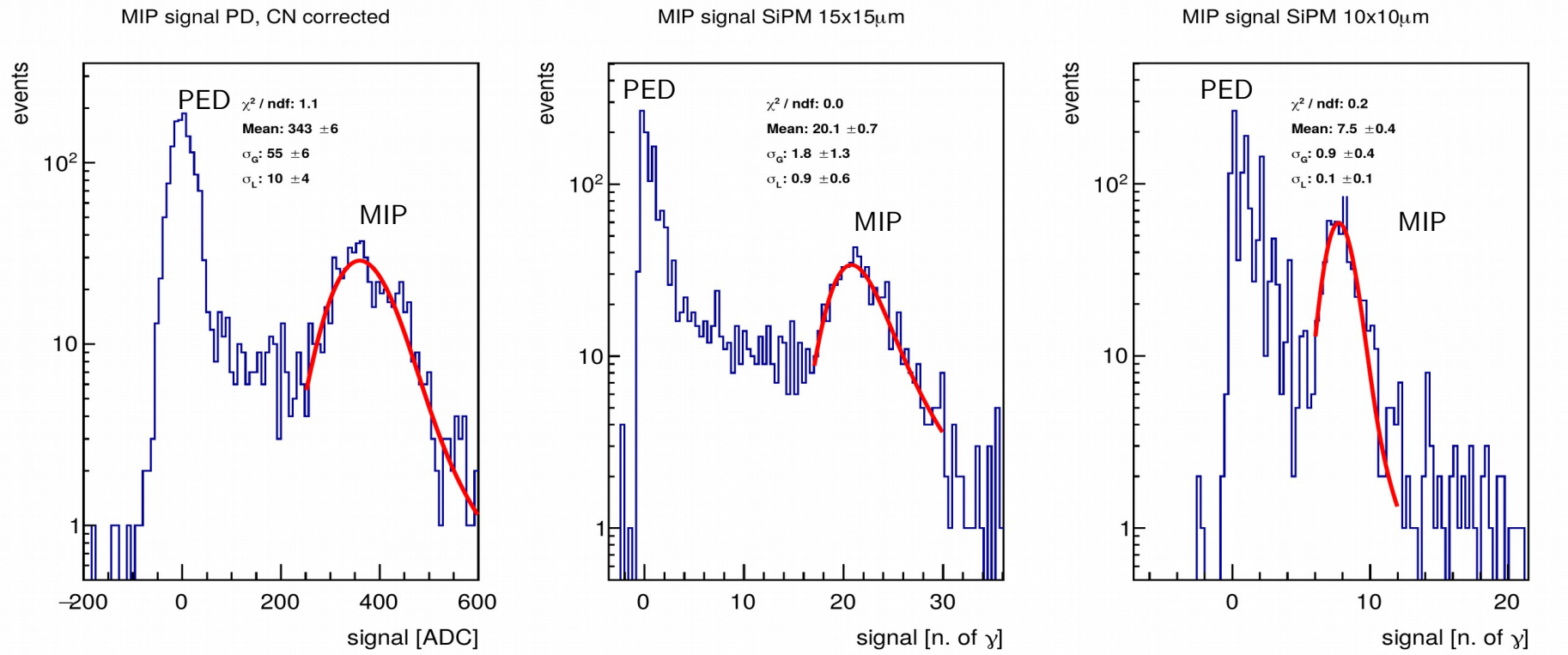
- The gain of 10 μm SiPM is smaller with respect to the 15 μm SiPM, as expected.

SiPM-fiber + LPD on LYSO crystal

- Using one of the 3 crystals which have the fibers glued to the polished surface.
- The crystal is wrapped with ESR.
- LPD is connected to the HIDRA board using a dedicated kapton cable
- 2 SiPMs are connected to 2 fibers, and connected to the HIDRA board with a different kapton cable.
- The PD bias is 40 V
- The SiPM bias is 69 V

- Expected signal of SiPM:
  - Fiber signal ~ 100 photons (To be checked after the meeting)
  - PD attenuation ~ 20%
  - SiPM 10 μm efficiency: ~10%
  - SiPM 15 μm efficiency: ~25%
- SiPM 10 μm MIP $\rightarrow$ 8γ
- SiPM 15 μm MIP $\rightarrow$ 20γ
- This computation does not take into account the efficiency of optical coupling.

SiPM-fiber + LPD MIP values



- SiPM signals are compatible with the expected ones
- PD signal 40% bigger than the one obtained in previous tests: it can be due to the different wrapping procedure or to the presence of the wave length-sifter.

Summary and expected saturation values

- Is it possible to read-out both the PDs and the SiPM using the HIDRA front-end electronics
- We decided to use the SiPM 10 µm to increase the expected range, which is calculated with:
  - the MIP value obtained in previous test,
  - ,the saturation of HIDRA chip (which is $>=$ 30000 ADC * 20).
  - Large PD saturation $\sim$ 1800 MIP $\sim$ 54 GeV, [S/N(MIP) $\sim$ 7]
  - Small PD saturation $\sim$ 100 * LPD $\sim$ 5 TeV
  - SiPM 15 µm $\sim$ 50 MIP $\sim$ 1.5 GeV, [S/N(MIP) $\sim$ 8]
  - SiPM 10 µm $\sim$ 340 MIP $\sim$ 10 GeV. [S/N(MIP) $\sim$ 6.5]
- We are ready to start the assembling of the calorimeter, in few weeks the crystals will be wrapped with ESR and the PDs will be glued to the course faces.