Study of a SiPM-based WLS fibers read-out system for the new calorimeter prototype in Firenze

27 November 2019

Summary from last meeting

In the last meeting (19 June 2019) we discussed the status of the tests carried out in Firenze to study the dual read-out of a LYSO crystal using WLS fibers and photodiodes at the same time.

Those results can be summarized as follows:

- The attenuation of light signal in WLS due to PD is roughly 20%
- The signal of WLS can be read using SiPM and HiDRA boards (same front-end electronics developed for PD)
- The best SiPM for our application is **Hamamatsu MPPC S12571-010C**, which has the following performances at V_{bias} = 69V:
  - A MIP in the crystal corresponds to about 8 detected photons
  - The signal-to-noise ratio is S/N = 6.5 for a MIP in the crystal
  - Saturation is expected at 340 MIP (10 GeV)

What happened in the meanwhile

- Our colleagues from ***Trieste*** sent us the new **HiDRA front-end boards**, which will be used to read signals both from PD and SiPM
- In June, our colleagues from ***Spain*** came to Firenze to bring the new **read-out control board** (T-ROC1 and T-ROC2) for HiDRA electronics
- In July, our colleagues from ***China*** came to Firenze to help us in the **assembly and quick test** of WLS and PD on all LYSO crystals

All tests carried out on each component of the detector confirmed that the system is working as expected and is **compatible with the requirements** we have to investigate its performances for a future beam test...

...At the moment, all components of the detector (mechanics, scintillators, sensors and electronics) are **ready for prototype assembly**, except a small missing point that we are going to discuss in the following.

Attenuation of light signal in SiPM

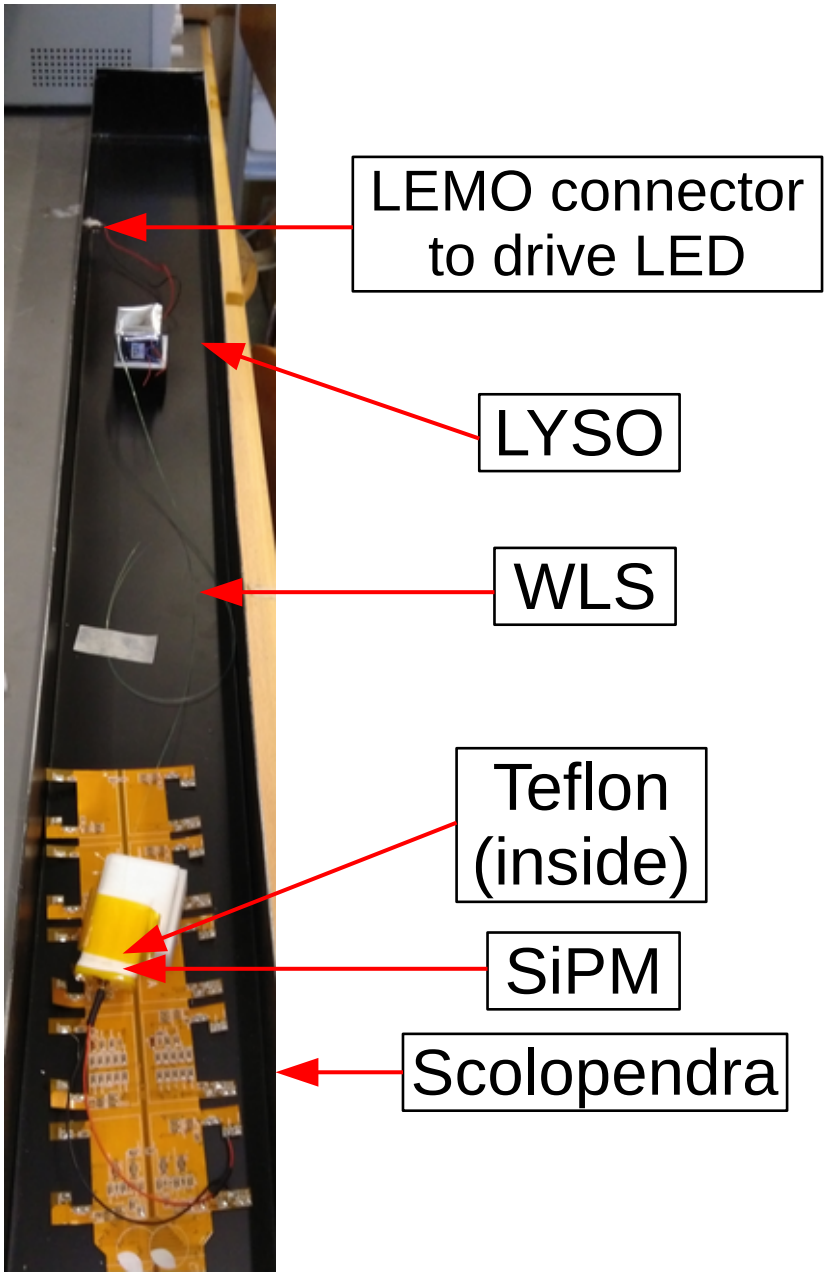
To simplify biasing we decided to bias both PD and SiPM to the same voltage (69 V, the SiPM bias voltage).

In this configuration, the MIP signal is about 350 ADC counts for Large PD and about 5000 ADC counts for SiPM.

However, HiDRA chip saturates at about 600000 ADC, which is less than the intrinsic saturation of SiPM.

If we want to cover the same dynamic range with both sensors we need to attenuate the light signal in SiPM.

For this purpose, we illuminated the crystal with a LED applying teflon between WLS and SiPM.

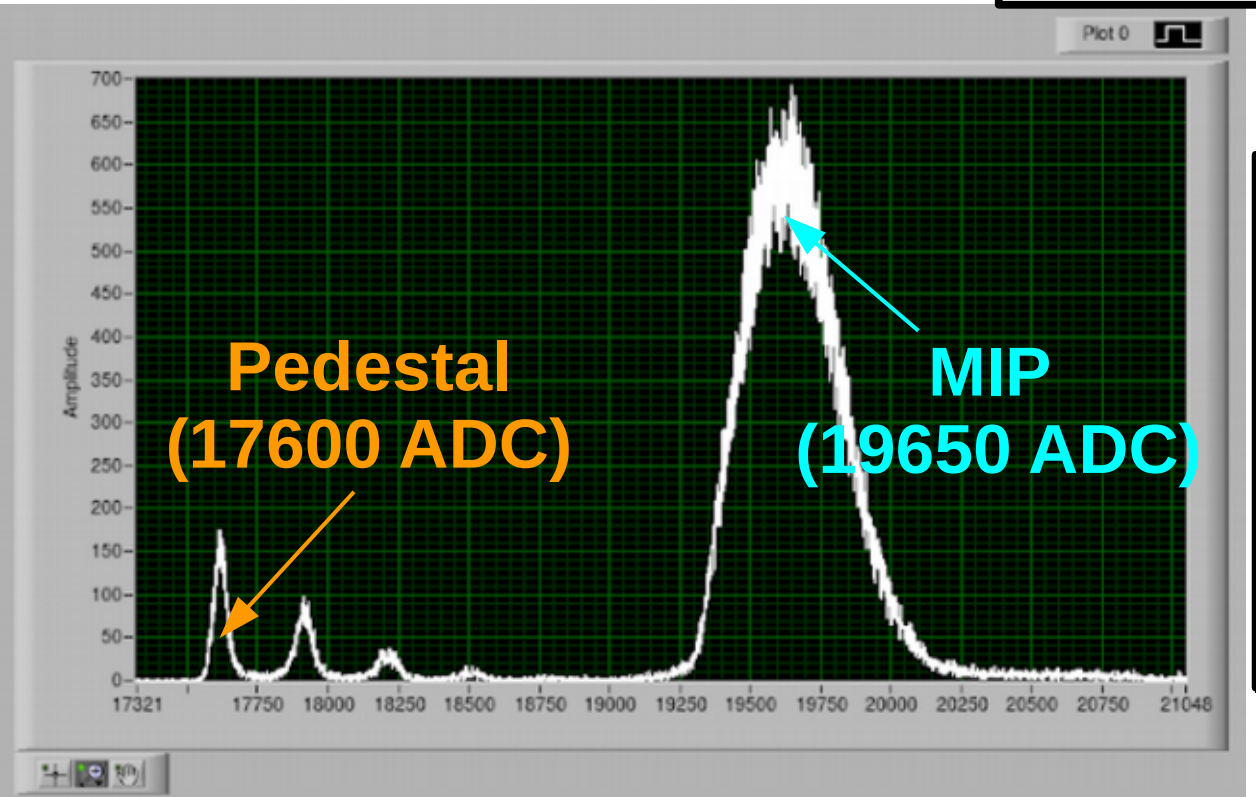


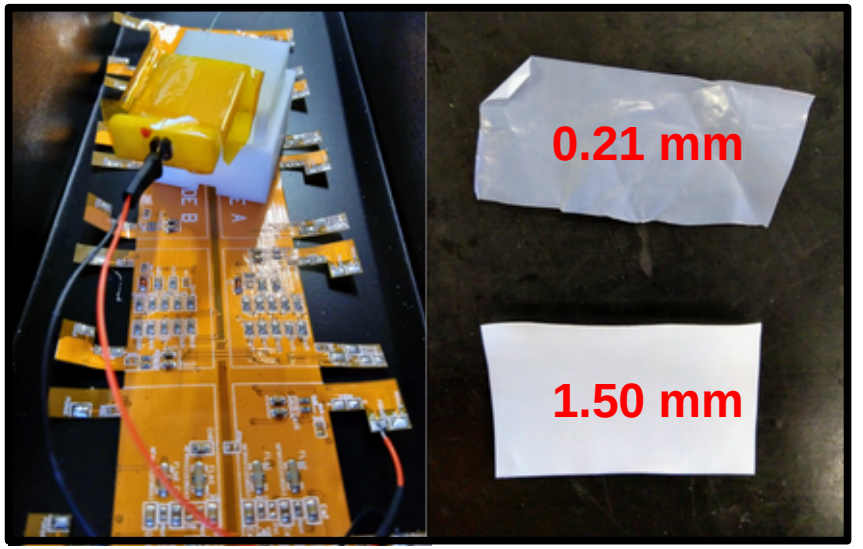
Attenuation measurements

The attenuation is clearly higher for **lower biasing voltage** and for **larger teflon thickness**

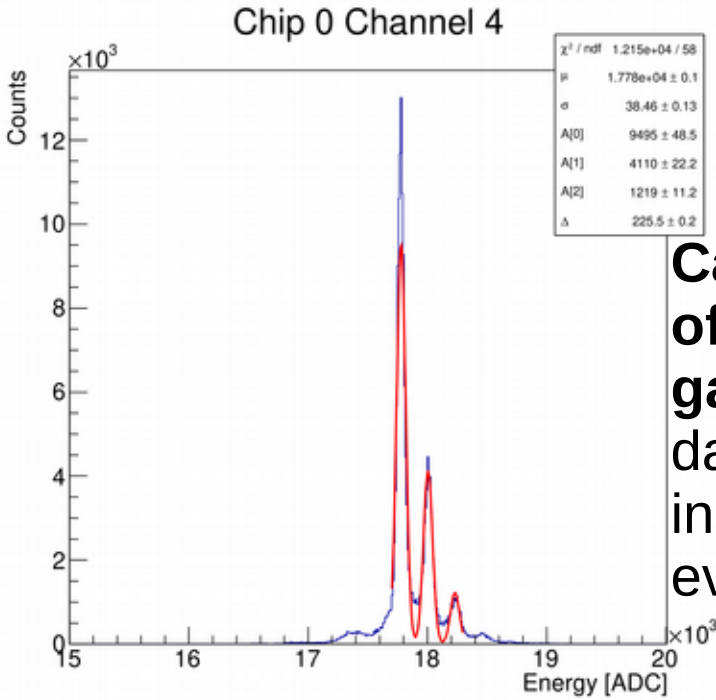
Reproducibility of SiPM-WLS coupling is much better with than without Teflon (below 10%)

Configuration	SiPM bias (V)	MIP peak (ADC)	Attenuation Factor
No attenuation	69	14000	-
Single Teflon (0.21 mm)	69	41000	2.93
Triple Teflon (0.63 mm)	67.5	3000	0.29
Single Teflon (1.50 mm)	69	5900	0.42
Single Teflon (1.50 mm)	67.5	1900	0.14

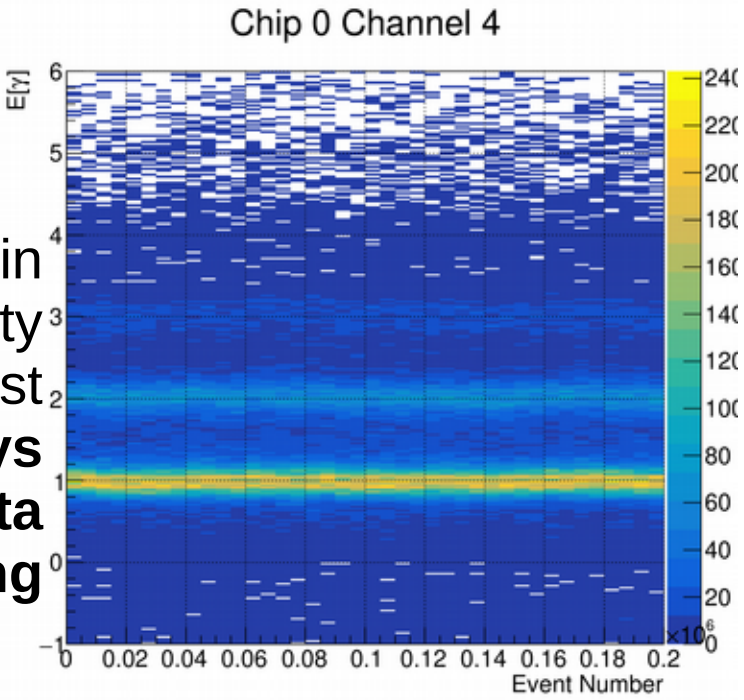




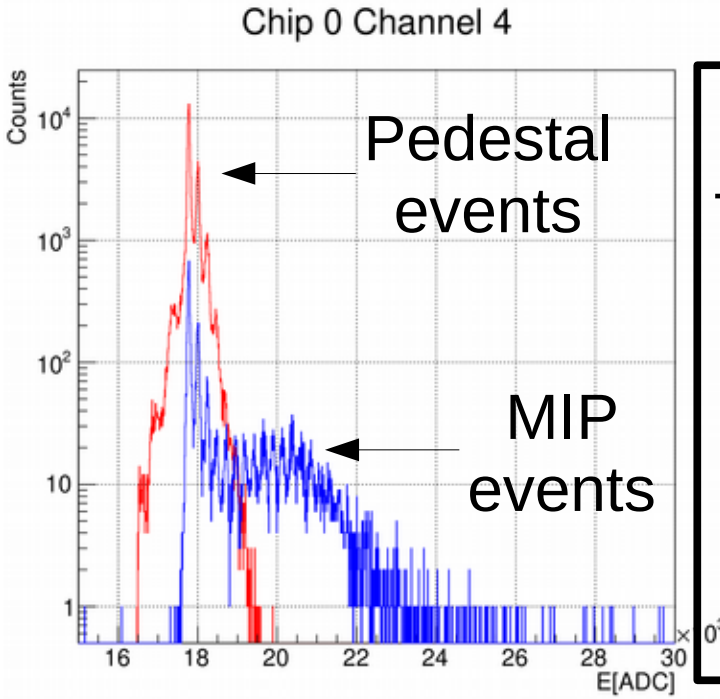
MIP signal



Calibration of SiPM gain using dark count in pedestal events



Good gain stability over almost **three days of data taking**



Triple Teflon

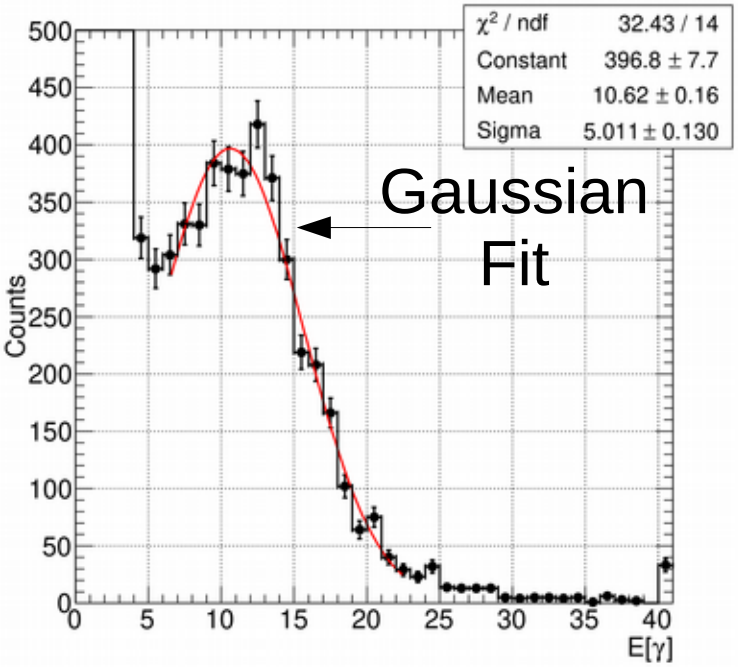
Thickness = 0.63 mm

V_{bias} = 68 V

Δ = 225 ADC

Mean = 10.62

MIP = 2400 ADC



NB: Common noise not subtracted

Summary

- Thanks to the effort of teams from Trieste, Spain and China, we were able to complete almost all steps necessary for the assembly of the new calorimeter prototype in Firenze
- The **read-out of WLS fibers using SiPM** coupled to the HiDRA chip has been deeply studied and resulted to be valid to investigate WLS+PD double read-out in a future beam test
- In order to read WLS fibers using SiPM, the light signal must be attenuated and several attenuation tests were made
- Using **Teflon** between WLS and SiPM surfaces, we obtain two results at the same time: **attenuation** of the light signal and improvement of **coupling** reproducibility (below 10%)
- We are waiting for a 0.5 mm thick Teflon tape for an additional attenuation test and later we will decide the best configuration (in terms of thickness and bias) for the prototype