New R&D results from Ferrara

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Outline

- Introduction
- The R&D setup
- First bunch of tests and results
  - SiPM calibrations
  - fiber-SiPM coupling studies (I): geometry
  - fiber-SiPM coupling studies (I): optical coupling
  - FNAL vs ITEP scintillators
- Future plans

Why more R&D is needed

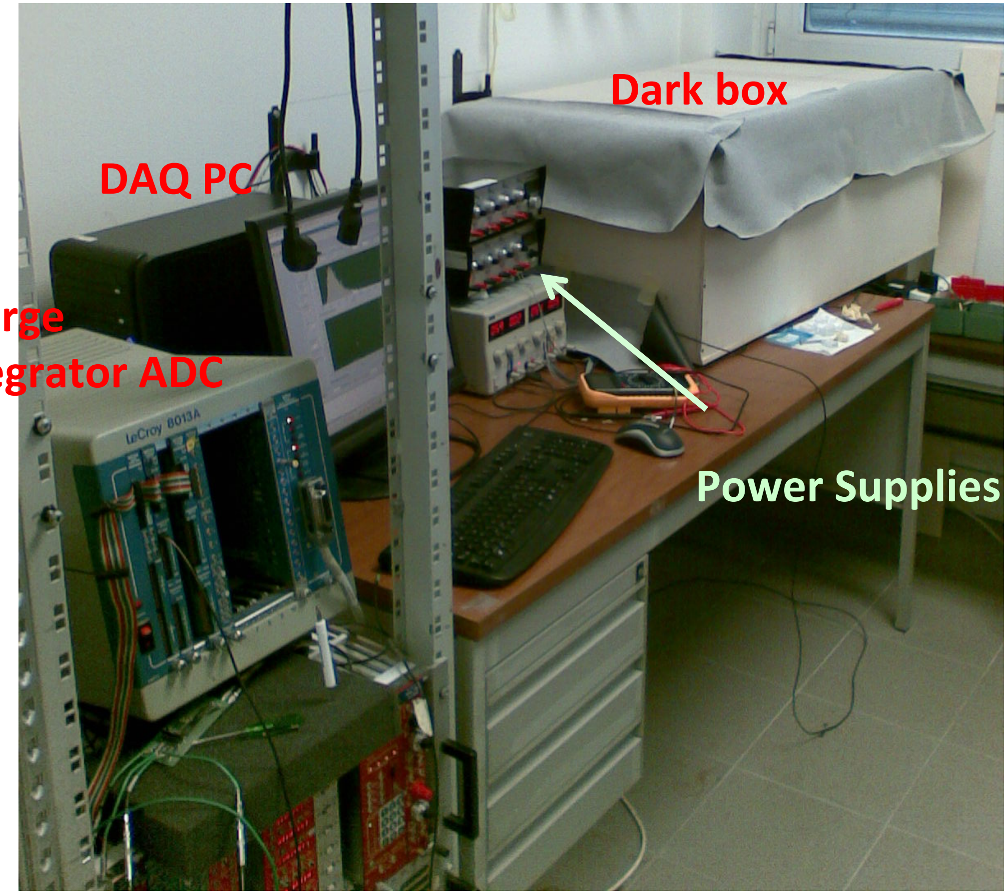
- Having dropped the time readout option and redesigned the barrel readout, studies on the new baseline are needed to finalize the detector layout.
- Many things can be re-discussed:
  - Photodetector choice (Hamamatsu, FBK, SensL, other…)
  - Dimension of Z scintillator strips
  - Optimal number of fibers per strip
- In addition other details must be addressed and optimized:
  - best mechanical layout
  - couplings
  - thresholds
- Other possibilities on the market:
  - Russian scintillator

The experimental setup

We spent quite a lot of time optimizing the setup, to make it flexible enough to perform different kind of studies

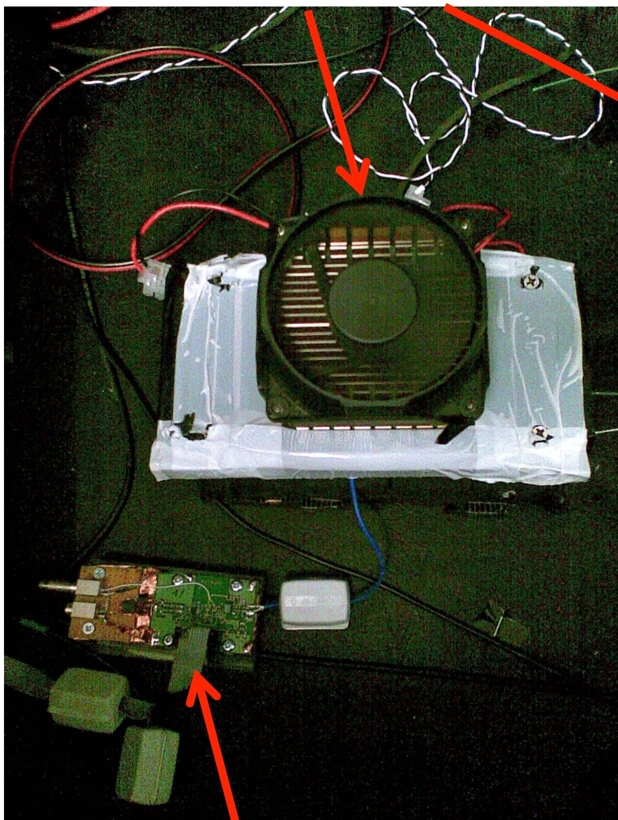
- SiPM characterization
- light yield measurement of different detector prototypes with cosmics
- readout electronics tests

Further improvements are planned

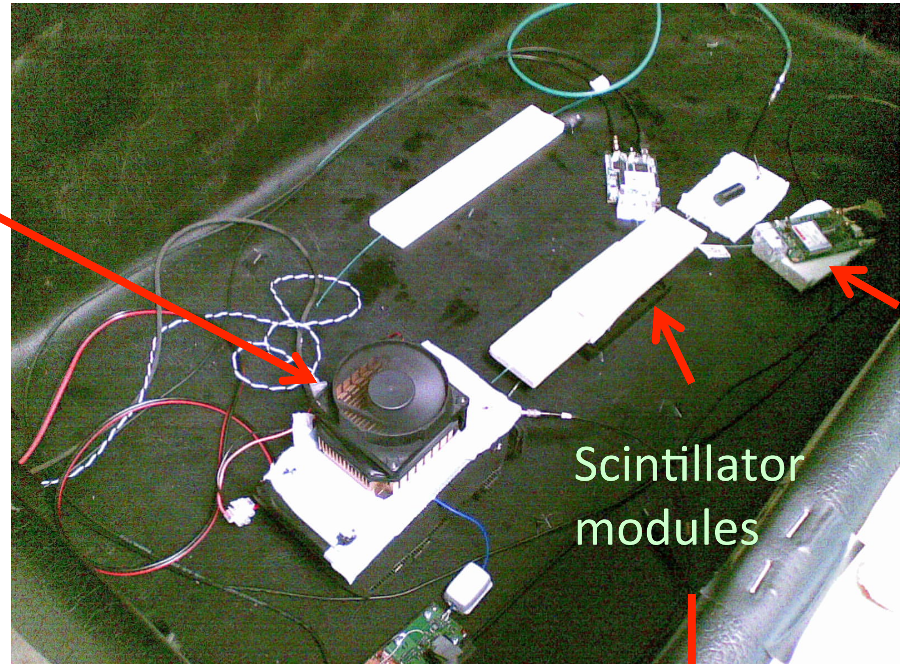


Inside the box

Peltier cell for temperature stability

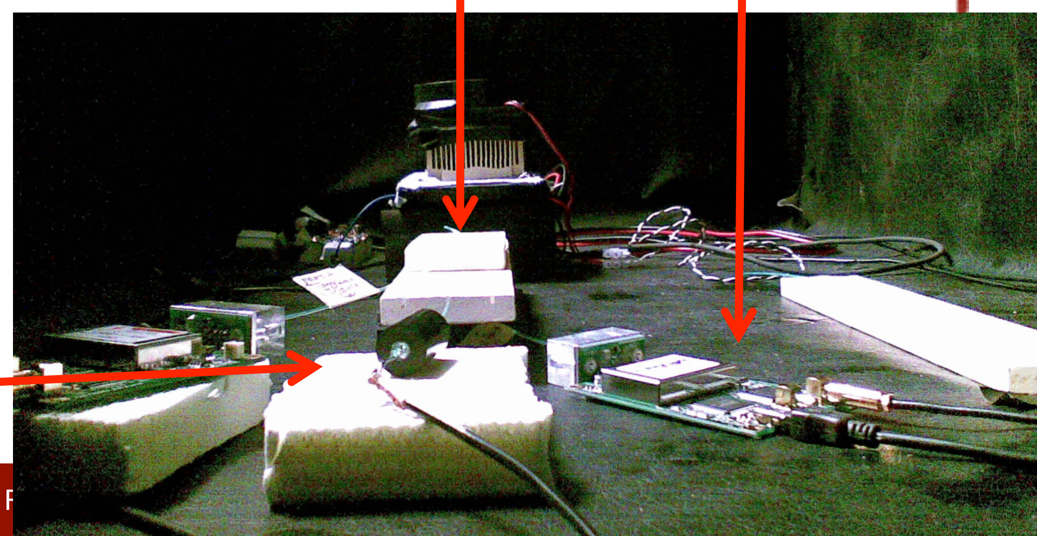


new SiPM readout



MPPC modules for trigger

LED for SiPM characterization



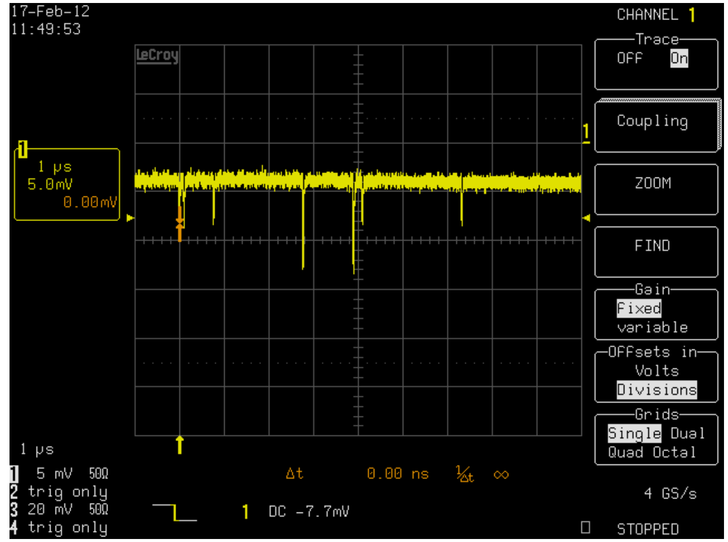
SiPM pantry

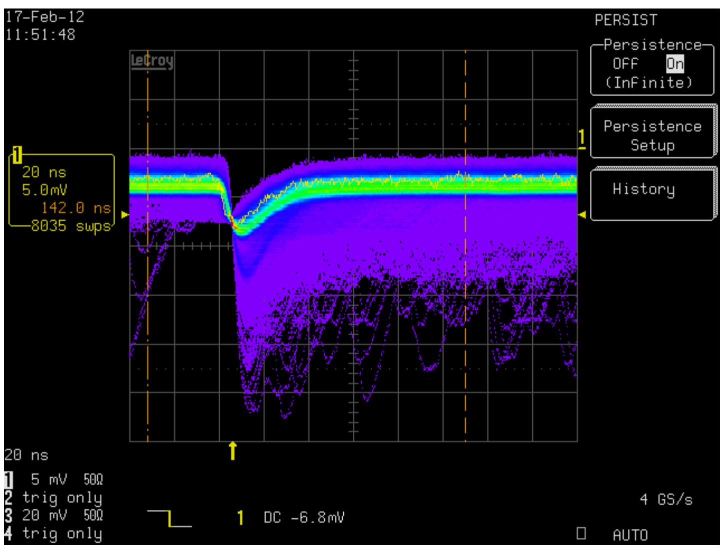
- Hamamatsu
  - Different pixel size with TO18 package (1x1mm^2)
  - Different pixel size with plastic package (1.3x1.3mm^2)
  - 3x3mm^2
- SensL
  - Different pixel size with TO18 package (1x1mm^2)
  - 3x3mm^2
- FBK
  - Few samples of new improved production (TO18 and PCB)
  - More to come

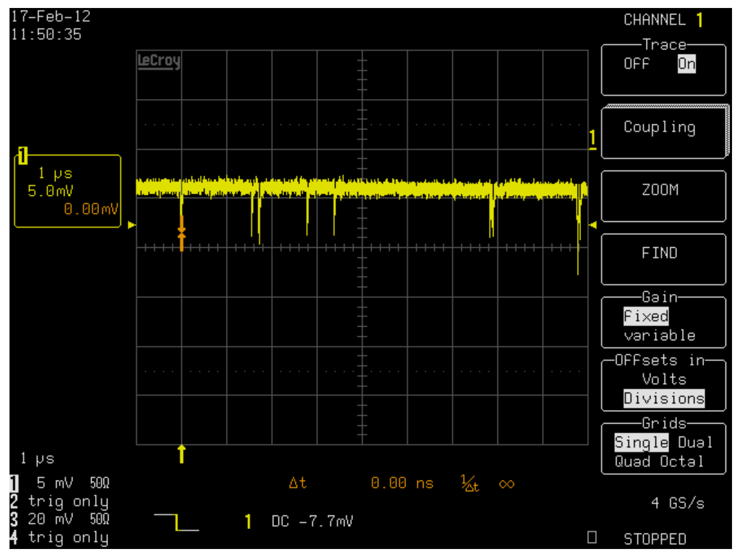
SiPM characterization

Among the different photodetectors we have, for this run of test we decided to use only Hamamatsu MPPC to understand the setup and to perform some comparative analysis on different detection modules.

These are signals from dark noise (dark count ~400 kHz at 0.5pe at room temperature).

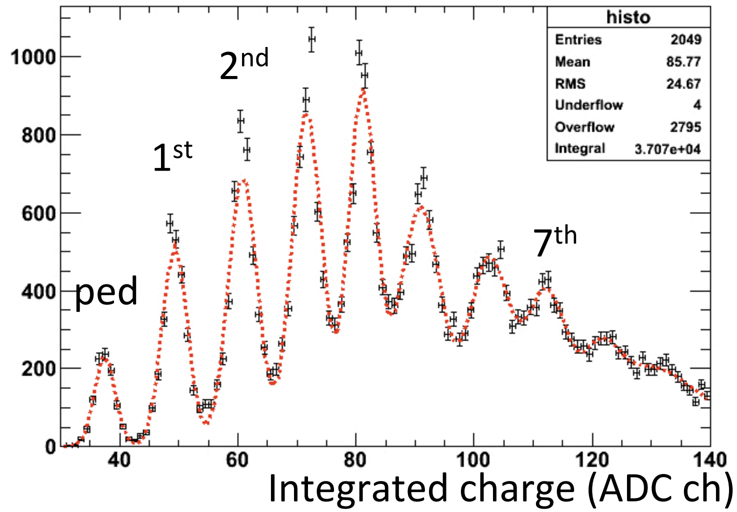




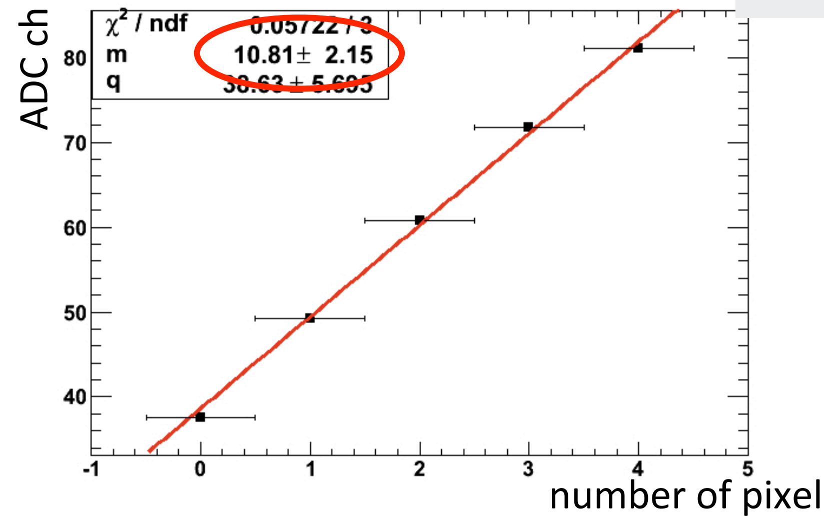


Hamamatsu MPPC - 1mm² (T018)

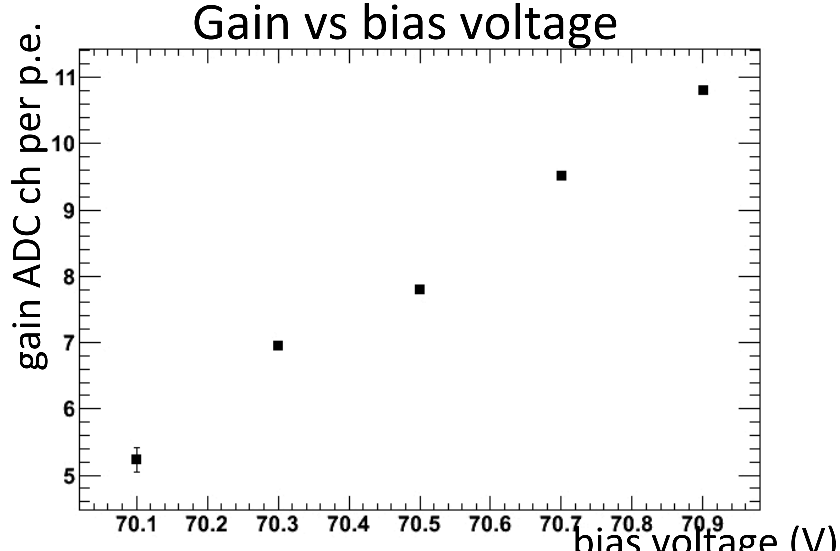
LED calibration



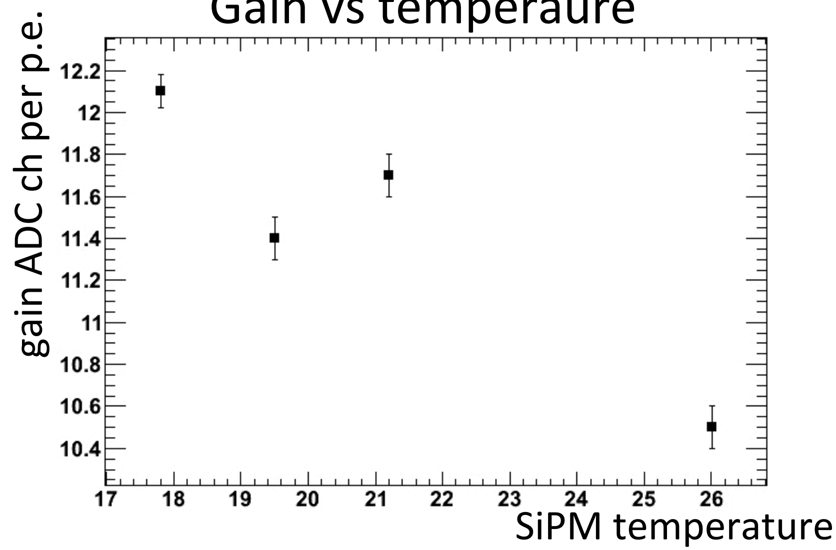
Gain measurement with LED



Gain vs bias voltage

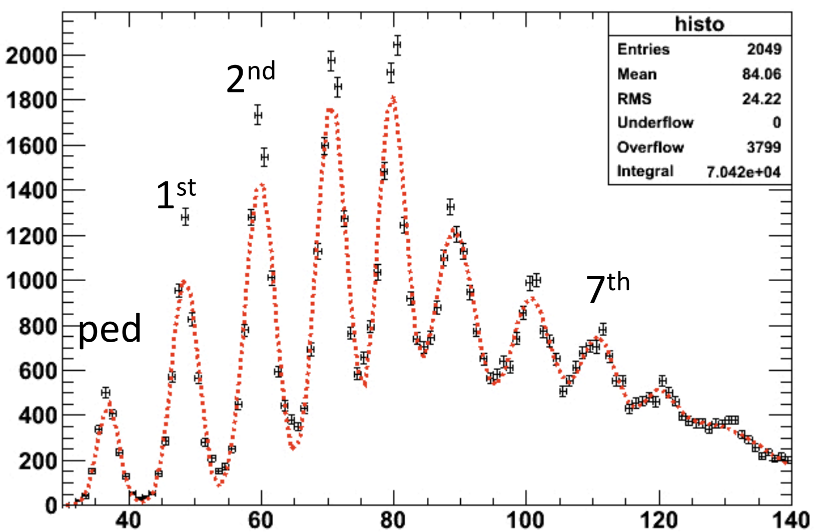


Gain vs temperaure



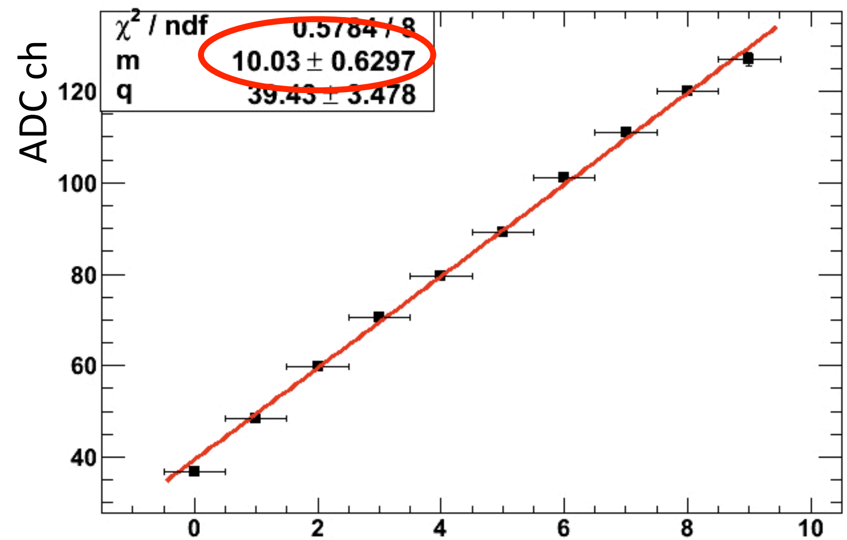
Hamamatsu MPPC - 1.69 mm² (plastic)

LED calibration



Integrated charge (ADC ch)

Gain measurement with LED

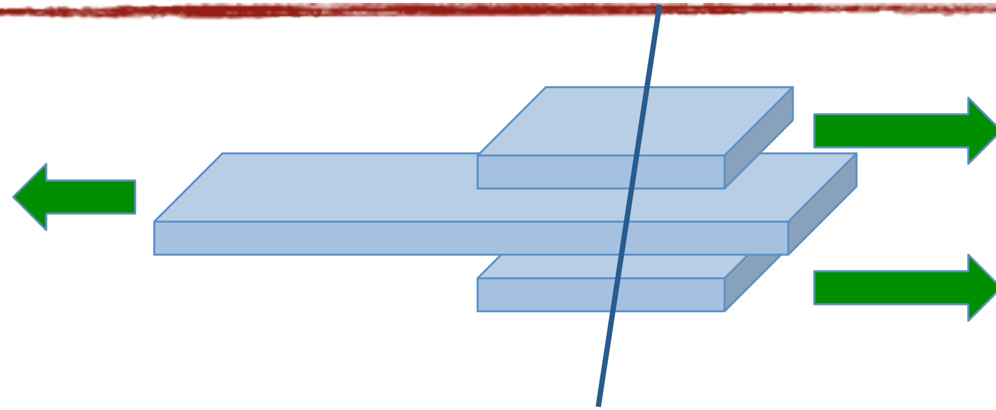


number of pixels

"Comparative" studies with cosmics

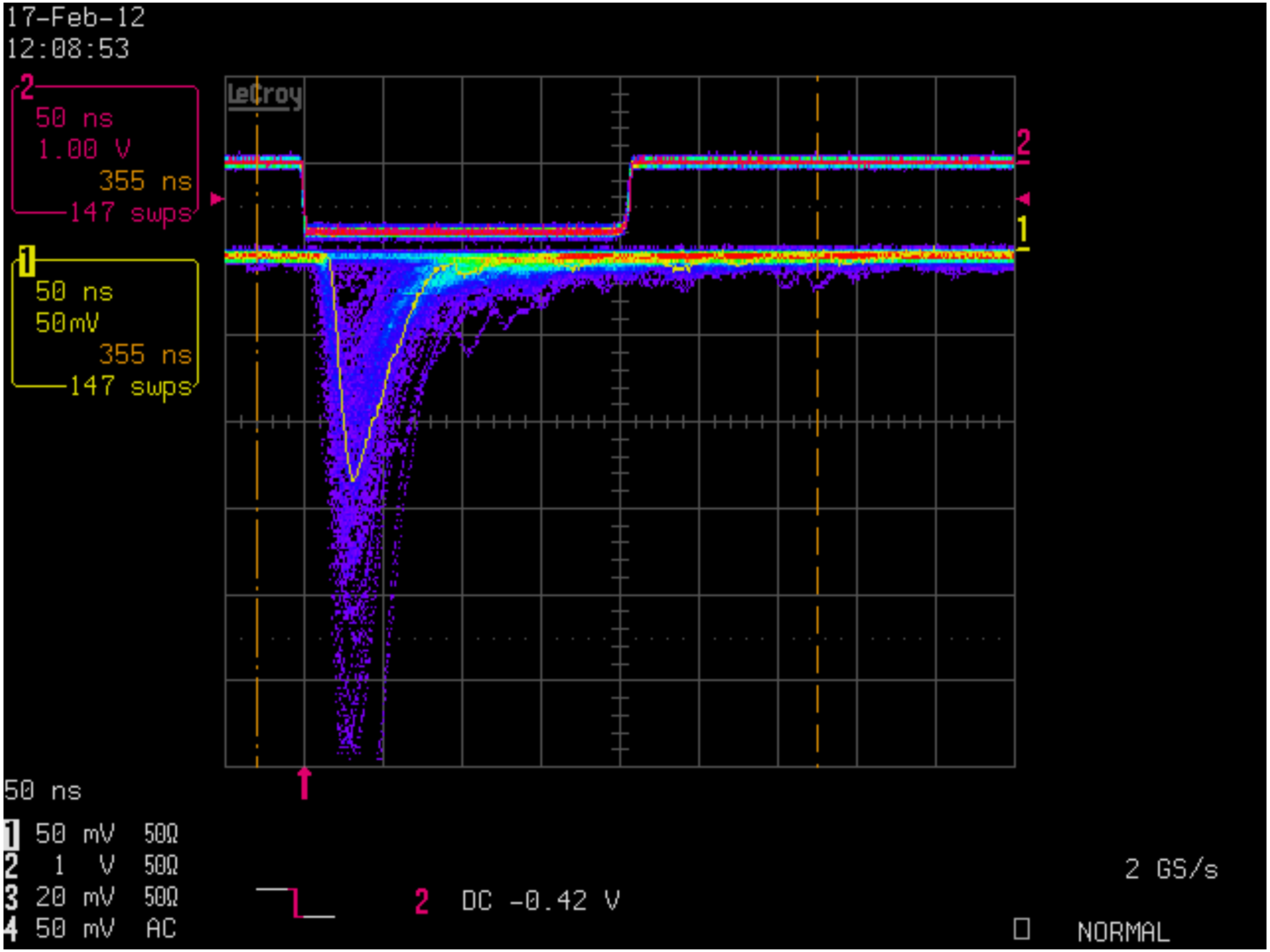
- No "standards" have been decided for the R&D and the results are influenced by small different in the setups (optical couplings, components, photodetectors operating parameters)
- Under these circumstances it's rather difficult to have a precise absolute comparison of the results from different setups.
- Therefore we perform studies by comparing different configuration where only one parameter is changed every time.
- Nevertheless the order of magnitude of the results must be not too far away from what is found in other setups and the tests give a good estimate of the light yield.
- Beside measuring the light yield on different prototype, the first set of measurements we have done is mainly focused on understand the effect of the setup on the results.

Cosmic run setup



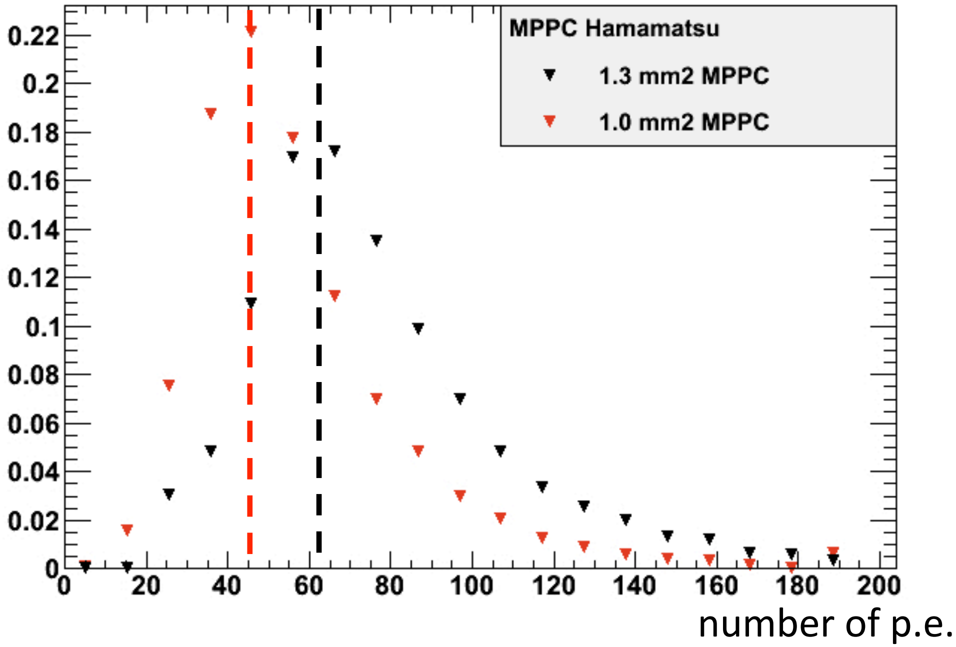
- Fibers are Kuraray Y11(300), diamond polished on the photodetector end, not aluminized on the other end. Scintillators have the same size than the one used by Bologna ($25x1x4cm^3$).
- The coupling between scintillator and fiber is done with optical grease, on top of the fiber there's an aluminum foil.
- The coupling between fiber and SiPM is also done with optical grease.
- During the test the photodetectors have been kept at 71.1V, at a quite constant temperature of about 21 degrees.
- Each set of measurement has been done more than once disassembling a reassembling the apparatus to spot sistematic errors due to the setup.

Signals from cosmics



Mechanical coupling effect

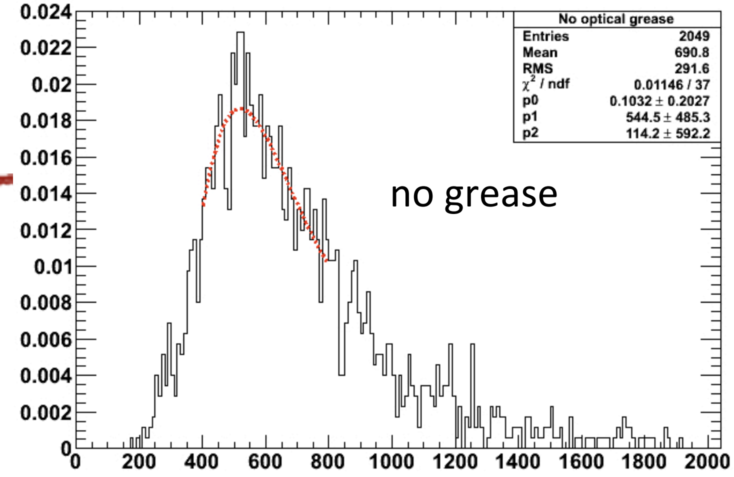
- First we tested the effect of mechanical and geometrical coupling using two different Hamamatsu sensors:
  - 1x1mm^2 on TO18 package (50um cells)
  - 1.3x1.3mm^2 on plastic package (50um cells)

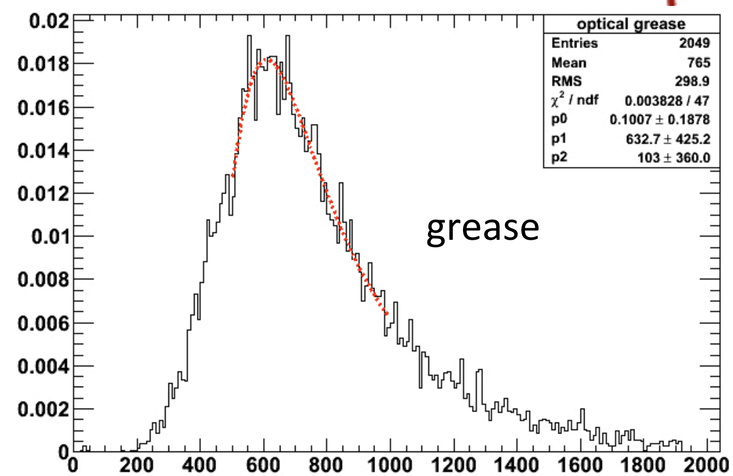


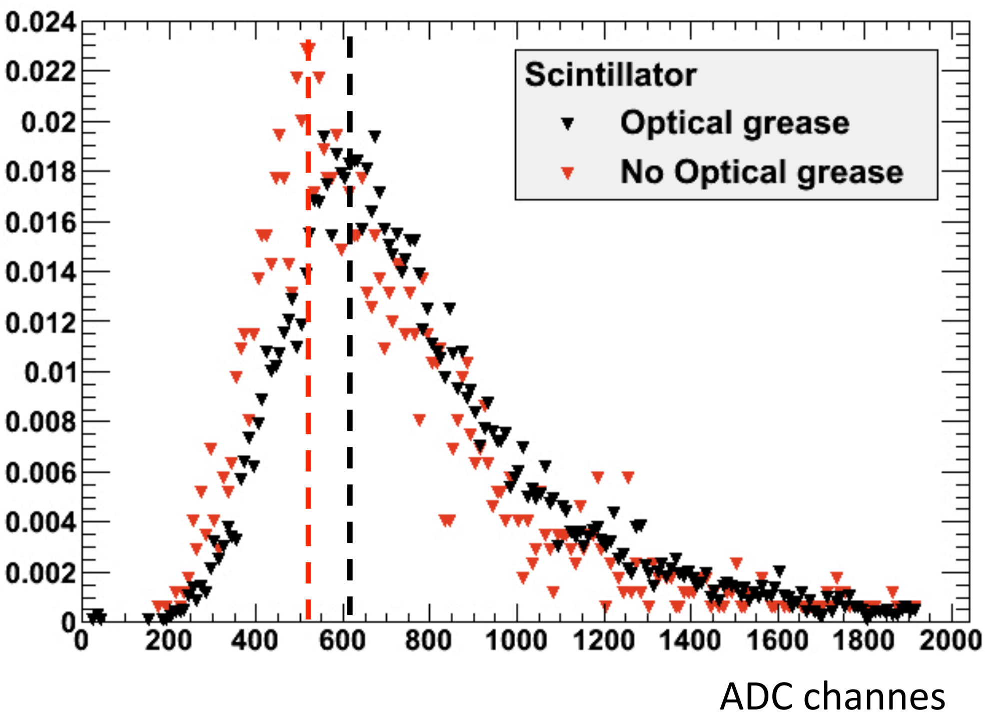
- The latter SiPM has a larger area and allow to go with the fiber on closer to the sensor (~300um).
- The light yield changes from 46 to 62 p.e.

Optical coupling effect

- Then we tested the effect of the optical grease in the optical coupling between fiber and SiPM.



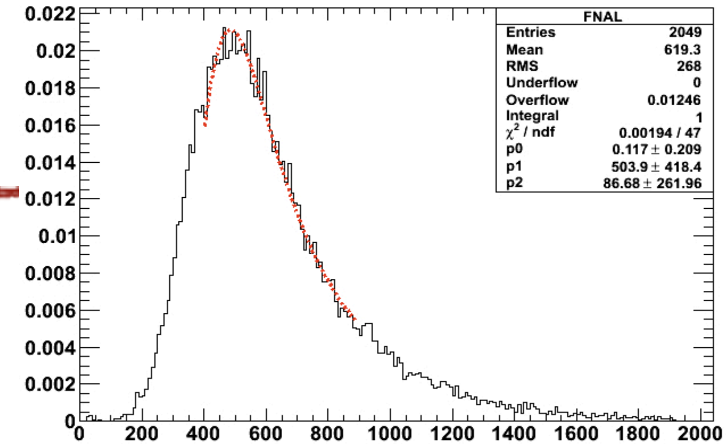


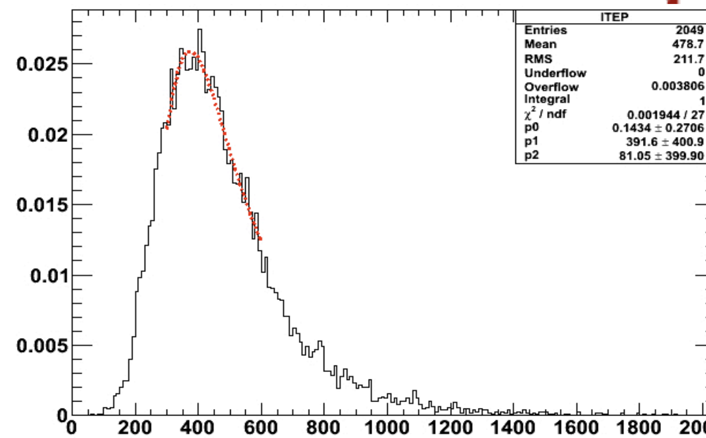


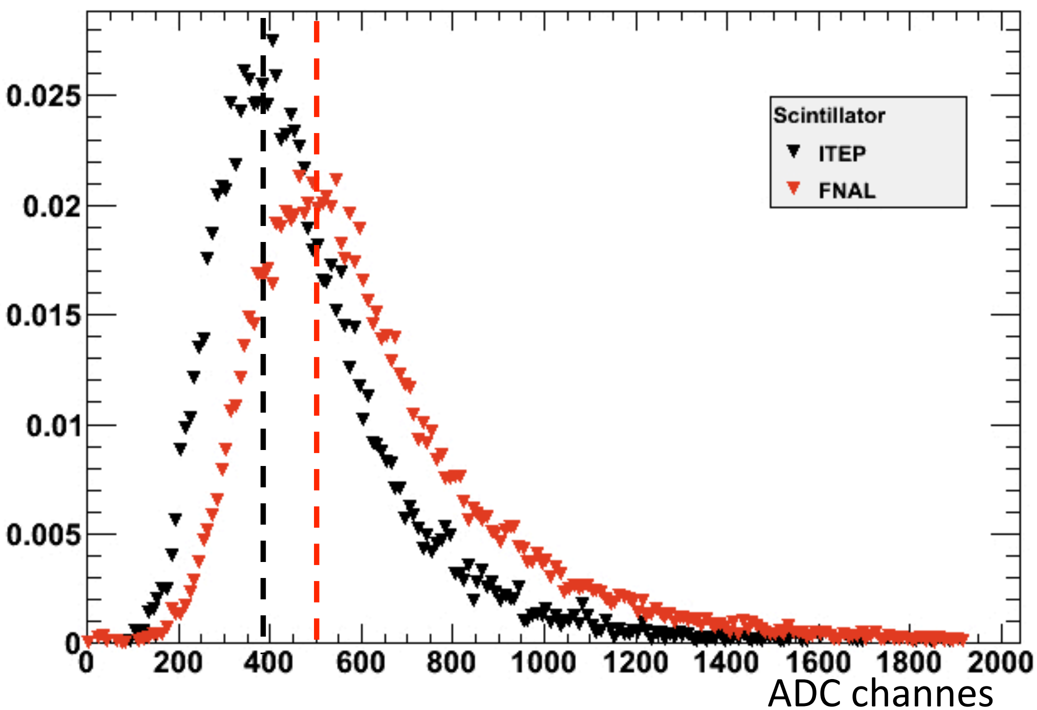
- The light yield changes from 54 to 63 p.e.

Different scintillators

- Here we tested the light yield from different scintillators.
- One from FNAL-NICADD and the other provided by the ITEP group (produced Vladimir factory).







- The number of p.e. is 46 for the FNAL scintillator and 36 for the ITEP one.
- The difference can be due to the non optimal coating of the Russian scintillator that can be improved.

Test on 10cm strips

- The 10cm strips are currently under test and results will be shown in the near future.
- We are testing this geometry using the ITEP scintillators since the FNAL ones have too many holes that modify the light path and can have a large impact on the effective signal.

R&D agenda

- Test on detection modules
  - Test with longer fibers up to 2.5 meters
  - Aluminize fibers on one end
  - Check the light yield with more than one fiber
  - Test additional coating on the ITEP scintillator
- SiPM evaluation
  - test FBK, SensL and compare with Hamamatsu
  - Noise evaluation
  - Neutron irradiation tests
- Draw some sort of conclusion and build our "best" prototype

Summary

- Setup very flexible and optimized.
- Characterized different photodetectors, up to now for different reasons only Hamamatsu have been used.
- First results on detection modules show
  - light yield ranging from 36 to 62 p.e. with one fiber at ~25 cm from the trigger, in agreement with the Bologna results (but with some differences in the setup)
  - Geometric coupling and distance from the photodetector is found to be very important (~30% difference in the light output).
  - Optical grease on the SiPM-fiber interface improve the light of something like 15%.
  - The light from the FNAL scintillator is 25% higher than the ITEP one but improvements can be done with coating.
  - In any case the detection efficiency is >99% with 4.5p.e. cut.
- The R&D agenda is very tight.