Calo PD read-out system: a brief activity summary.

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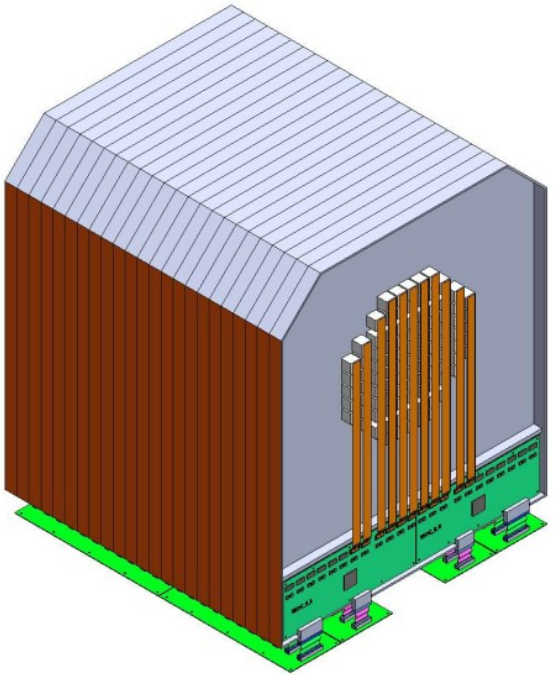
Introduction

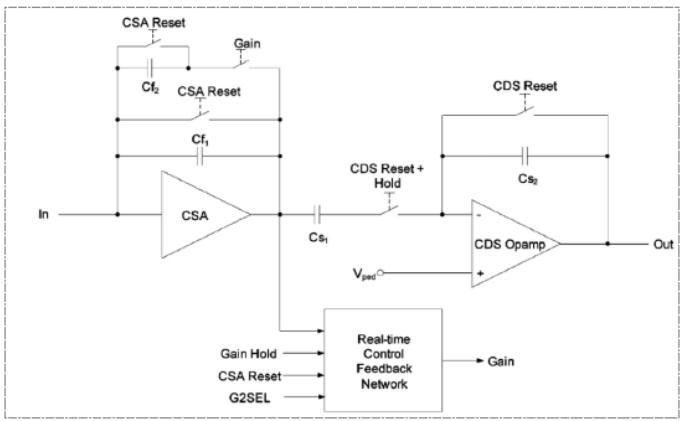
- The basic idea is the design of a **double read-out system** for the HERD Calorimeter.
- The IHEP system $\rightarrow$ WaveLengthShifter fibers read-out with Imaging Intensifier + IsCMOS.
- The CaloCube system $\rightarrow$ photo-diodes (PDs) read-out with HiDRA chips: 2 PDs with different active areas are glued to the cube.
- Current main activities for the development of PD system for HERD:
  - Characterization of new sensors, i.e. PDs inside monolithic package (INFN FIrenze)
  - Developed of electronics (INFN Treiste, CIEAMAT)
  - Integration with the WLS system: looking forward to the next beam test @ SPS. (IHEP, INFN, CIEMAT, ….)

PD system, general scheme.

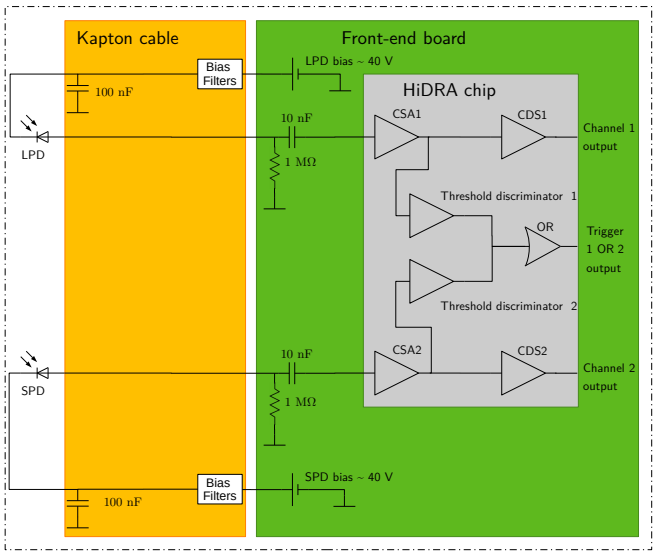


- Main components:
  - PDs and kapton cables.
  - FEE chip: HiDRA.
  - Logics: TROC (0,1,2).
  - ...

Single HiDRA channel scheme



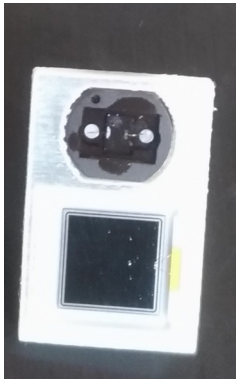
LPD and SPD connection scheme

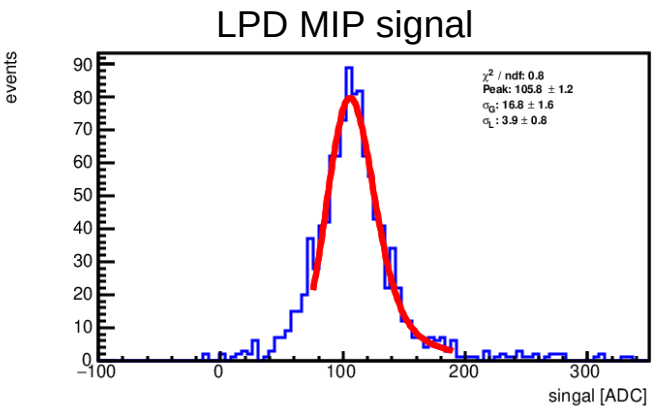


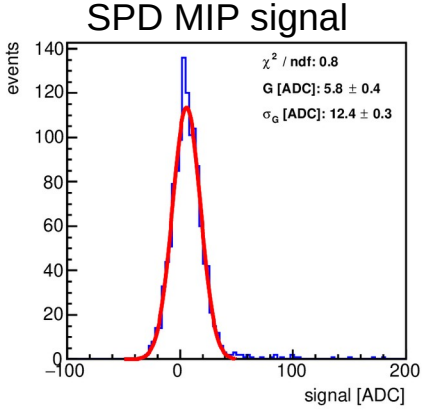
PD and package: home-made package.

- A large PD (LPD) and a Small PD (SPD): active area 25 mm^2 and 1.6 mm^2

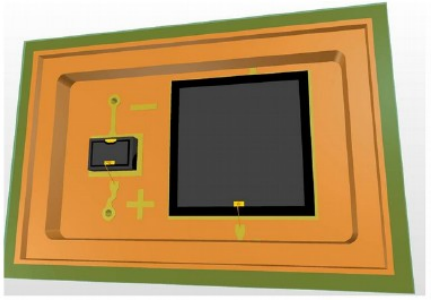
- First we assembled PDs in a monolithic package made by INFN Firenze:
  - PDs response is validated with MIP signals (see plot below), low energy particle beams, high energy beam at SPS.





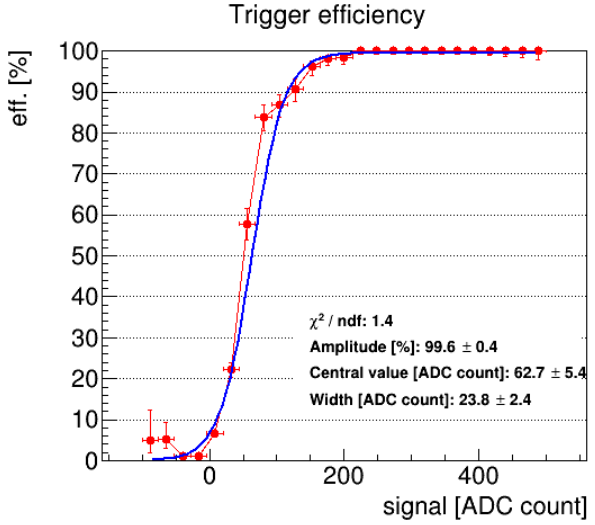


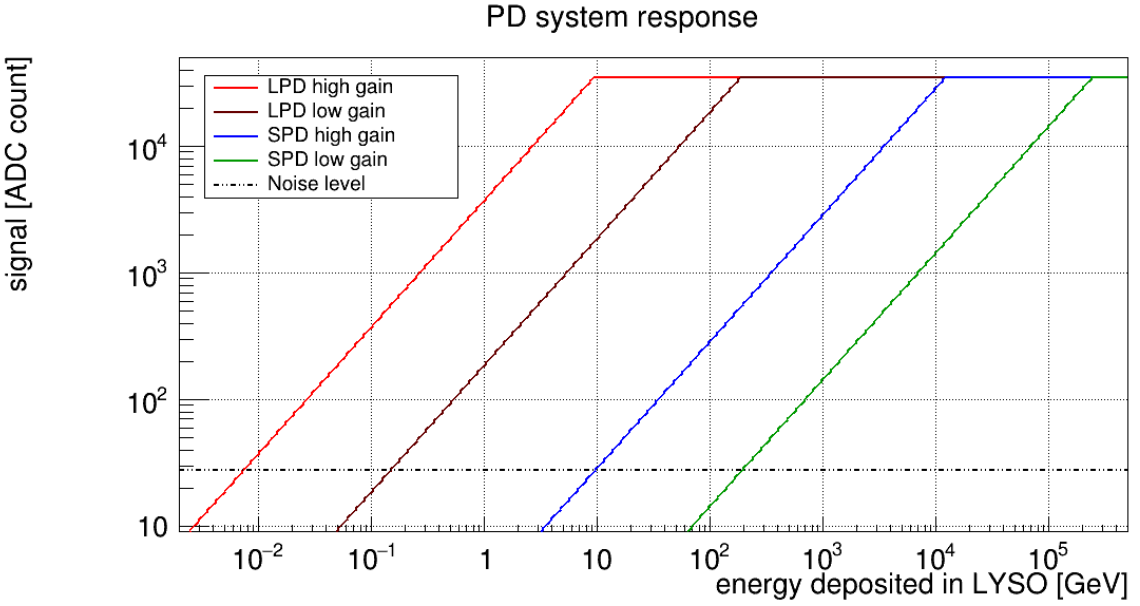
Preliminary design of package which will be made by Excelitas



Expected performance of PD system.

- Using home-made packages, HiDRA2 chips, first version of TROC1-2 boards.
- Laboratory test and low energy beam results allow us to characterize the system.
- Main reference: O. Adriani et al 2022 JINST 17 P09002.

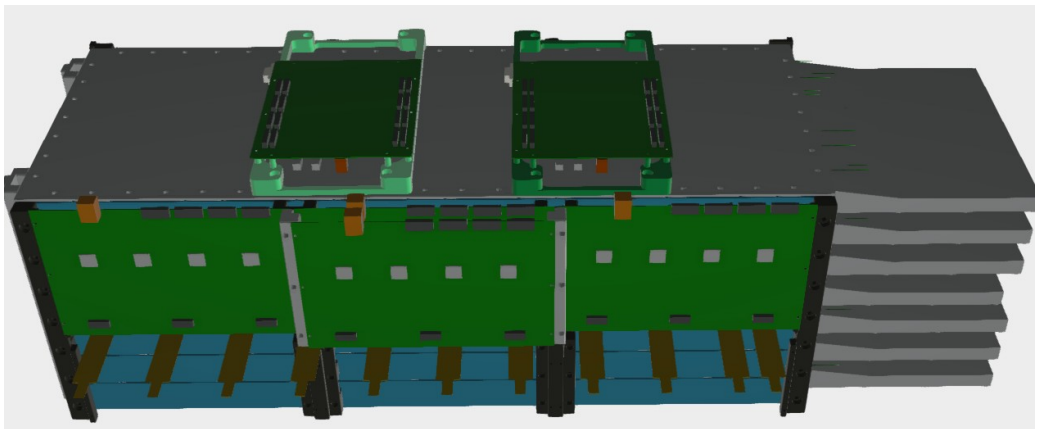


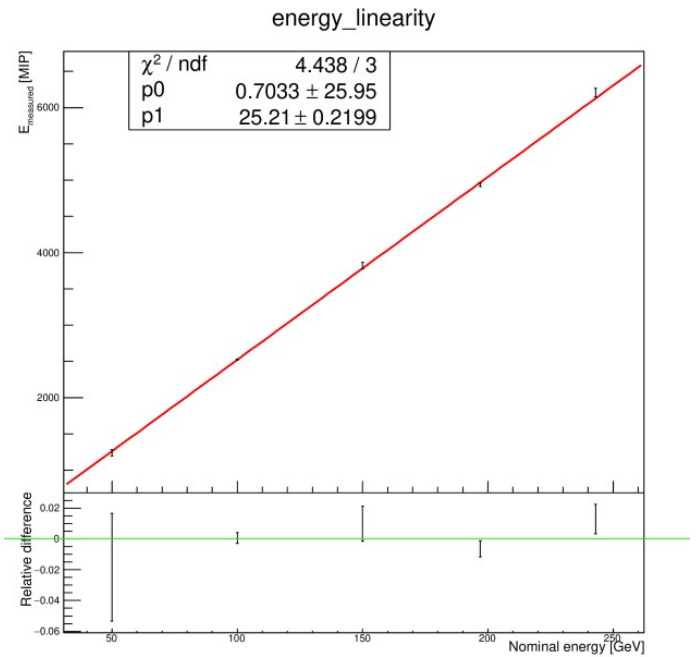


SPS 2021 beam test

- First test of double read-out: ~60 crystals with PD and WLF
- Results of the test presented by Pietro Betti during TB meetings.

Design of the SPS 21 prototype

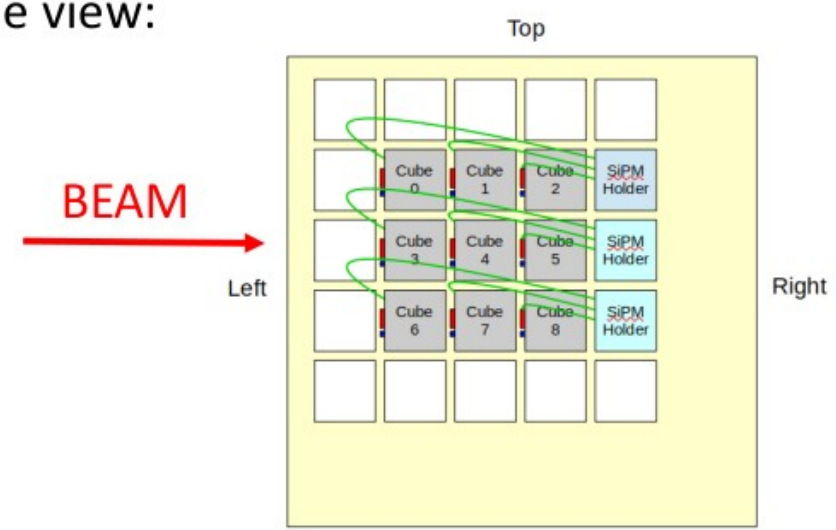




SPS 2022 beam test

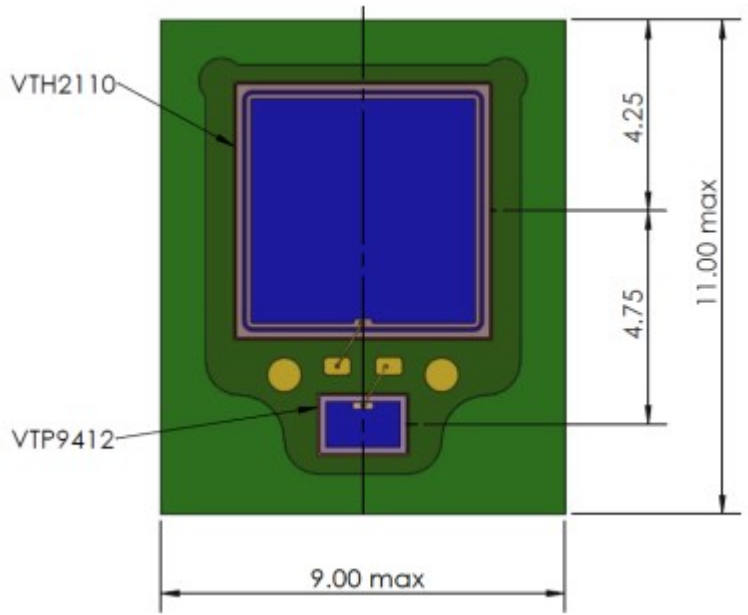
- Using Firenze small prototype.
- Main goal of PD system: study the non-linearity of crystal light emission.
- Analysis ongoing (by Cecilia Pizzolotto, INFN Trieste).

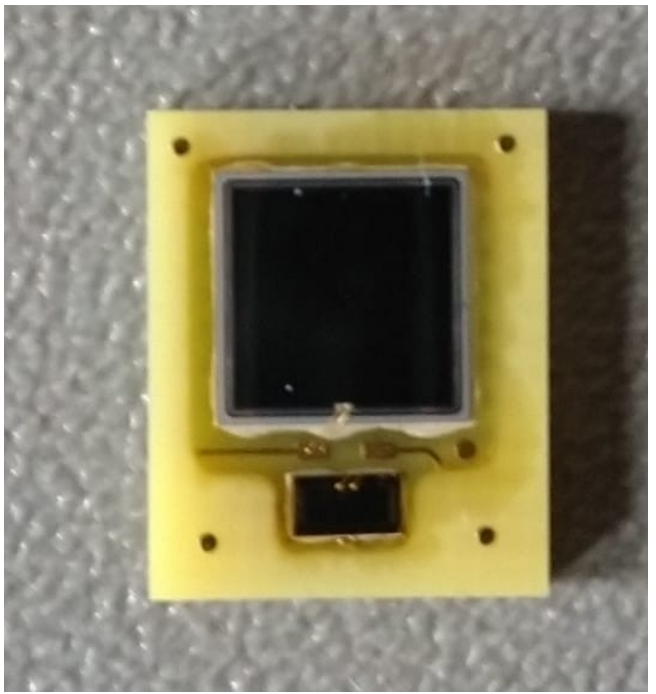
Side view:



New PDs and monolithic package by excelitas

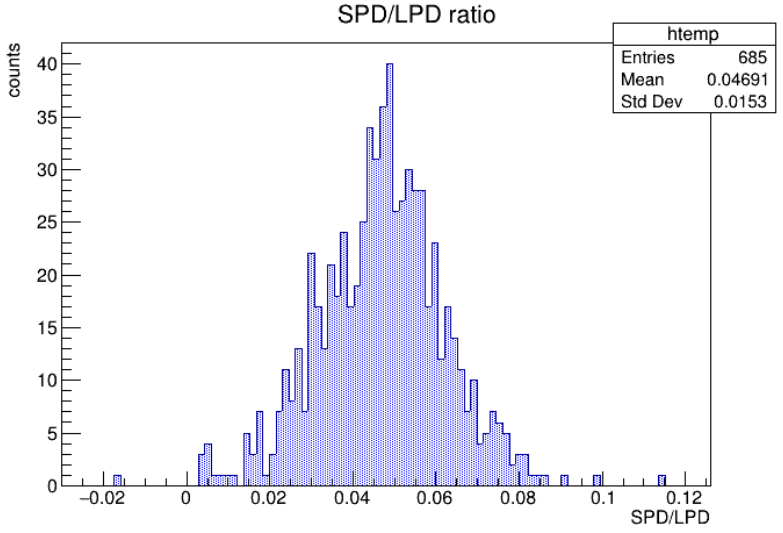
- Large PD (LPD) 1: active area 5x5 mm2 (VTH2110) no optical filter.
- Small PD (SPD): active area 1.6 mm2 (VTP9412), optical filter transmittance must be $\sim$ 1.5% @ 420 nm.





First tests of the first small production of new PDs

- Expected ration LPD/SPD signals: ~1300
- Measured ratio between LPD/SPD signal in Florence: ~50
  - using blue LED, IR laser, low energy photons, etc..
- Excelitas confirmed that the SPD signal is not consistent with the expected one so, they started a new production.



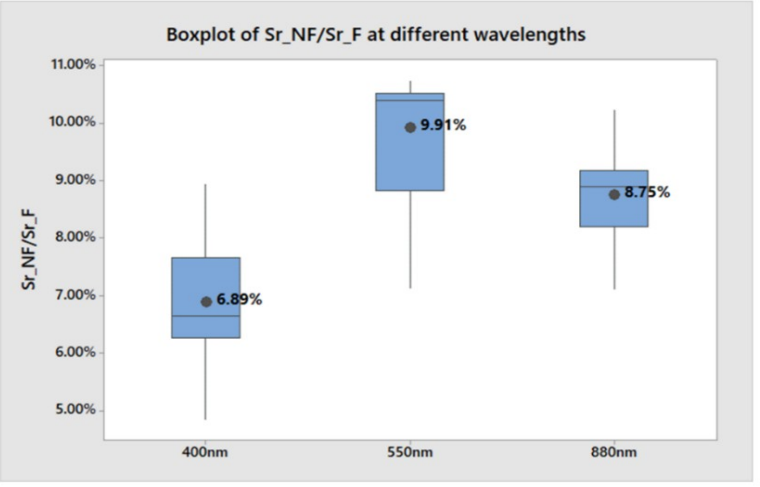
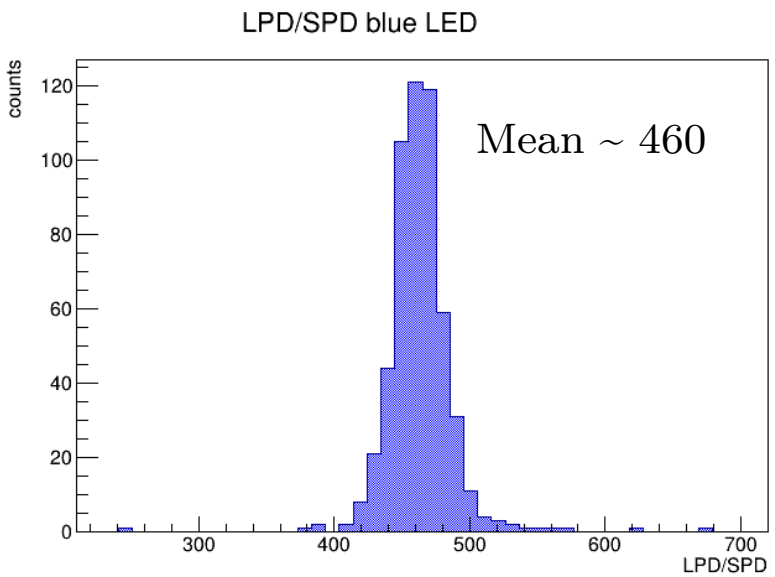
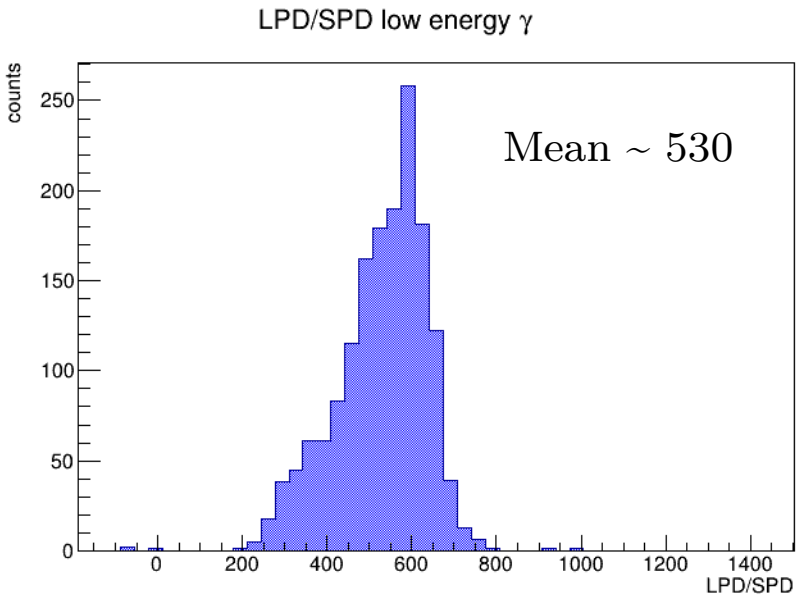


Figure 6 Filter transmission ratio at various incident wavelengths

New production PDs.

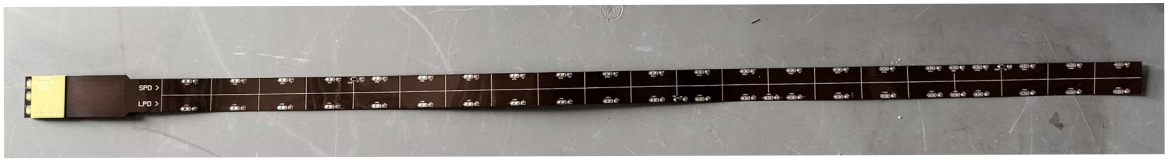
- Expected ration LPD/SPD signals: ~1300, ratio with previous produtcion ~ 50.
- Measured ratio between new LPD and SPD signal in Florence: ~500
  - using blue LED, IR laser, low energy photons, etc..
- A difference between expected and measured ratio is still present: we are in contact with Excelitas.

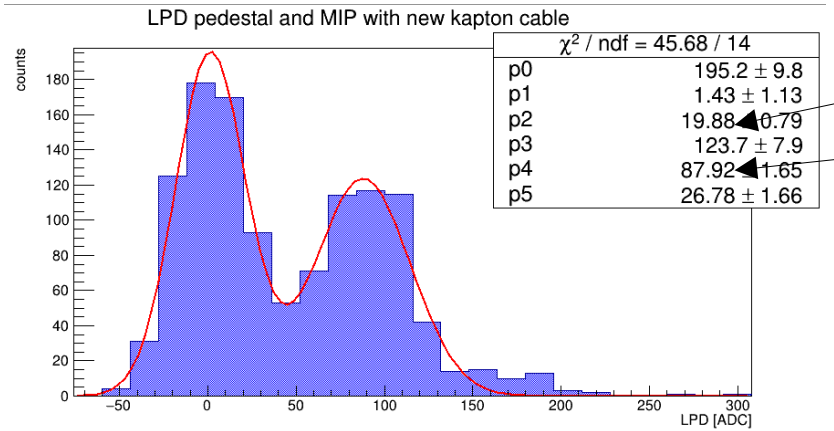




New kapton cable

- New kapton cables has been tested with the old HiDRA2 chips with custom adapters.
- The noise of several channels was measured, while MIP was acquired with a single LYSO cube.

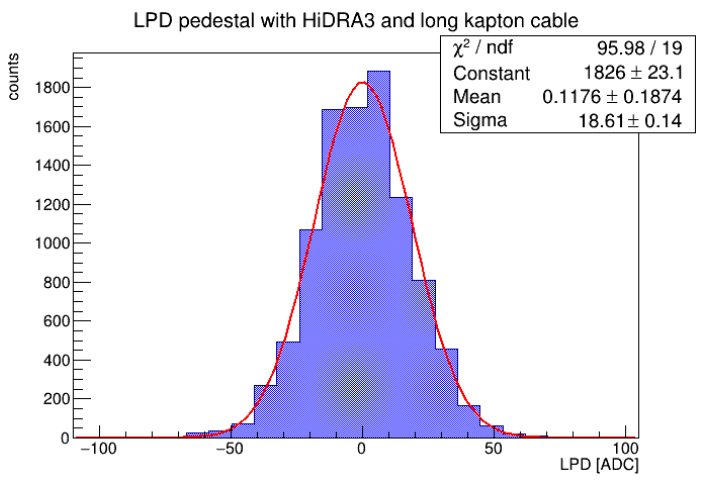


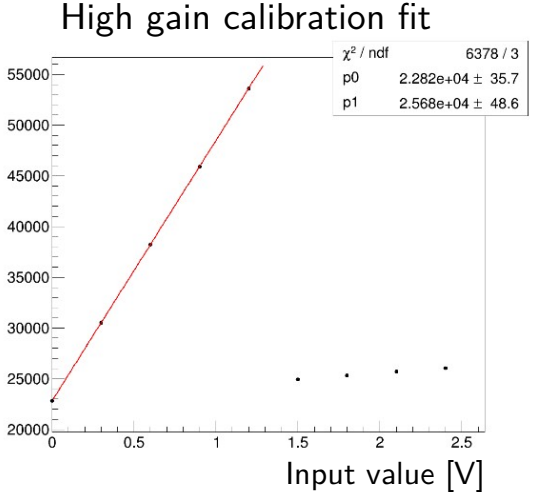


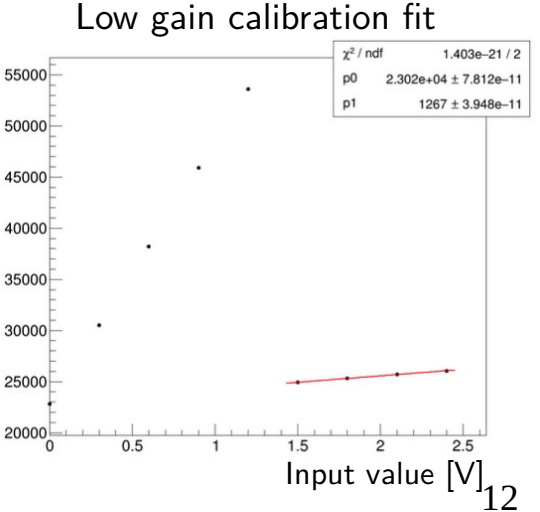
- The noise with HiDRA 2 chip is $\sim$ 19 ADC, better than the expected: we estimated in our paper a noise of $\sim$ 25 ADC with long kapton cables.
- The MIP peak is $\sim$ 90 ADC, as expected.

First tests of new HiDRA3 chip and new TROC2s

- Promising results obtained with a joint laboratory session with Jesus, Gustavo, Gianluigi and the Florence team, which includes a new engineer, Monica Scaringella.
- The noise of the system with then new HiDRA3 chip and TROC2 board is $<\sim$ 20 ADC.
- The gain switching circuit works as expected.
- Standard acquisition and calibration modes were was tested: a reasonable linearity and high/low gain ratio are confirmed.





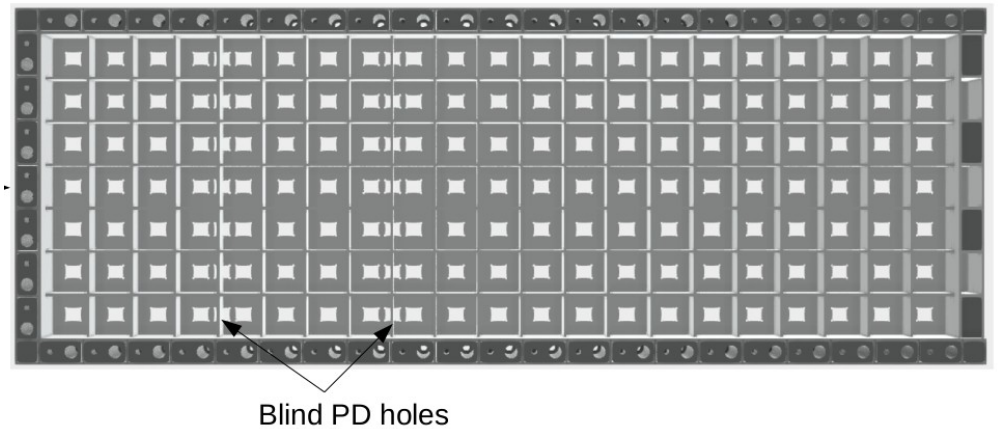


New electronics: next steps

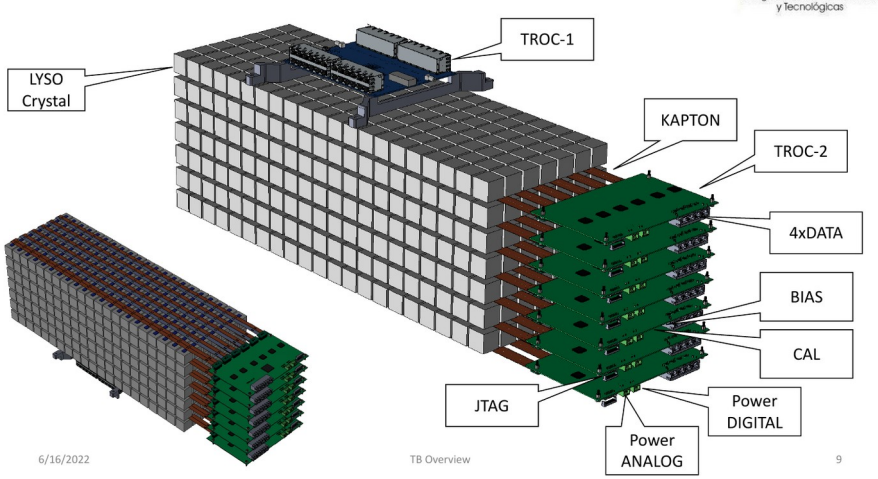
- The firs test results are very promising.
- As expected, some minor questions are still opens:
  - ADC data checksum errors are sometime presents,
  - anti-saturation circuit must be tested and a proper anti-saturation threshold is not clear,
  - the gain and saturation bit are not properly decoded,
  - a major update of the documentation (data format, schematics, etc..) is needed
  - The buffer mounted on the HiDRA3 output must be updated, etc...
- These issues should be solved before the BTF (Frascati) beam test:
  - The test will start on May 29th.
  - The beam consists of high multiplicity, low energy electrons, $<$500 MeV.
  - Details related to the detector configuration for BTF will be discussed in future meetings.

Looking forward SPS 2023

- All the crystals will be read-out with both PDs and WLF systems.



- General TB Overview



- The last PD production will be employed, even if the LPD/SPD ratio is not the expected one, these sensors can be used for SPS prototype.
- The PDs will be glued to LYSO with 93-500 silicone.
- It will be possible to remove the PDs from the LYSO cubes in future.

Time schedule for SPS 2023

- 15 PDs of the first production has been sent to IHEP in December 2022
- 1050 PDs of the new production will arrive in IHEP at the end of April.
- This package has just left Florence, it also include 93-500 and 184 silicone glues.
- Oleksandr and Lorenzo will stay in Beijing from May 7^{th} to 14^{th} in order to start the gluing procedure and PD tests.
- Kapton cable and few TROC2 boards should arrive in IHEP early June
- PD team will stay in Beijing during June for one week to start the soldering procedure, assmbly of TROC2 boards and to test the PD system.
  - We should define the exact period asap (e.g. from June 26^{th} to July 1^{st})
- The complete set of TROC2 boards will arrive in IHEP early July.