The Collaboration INFN-FBK

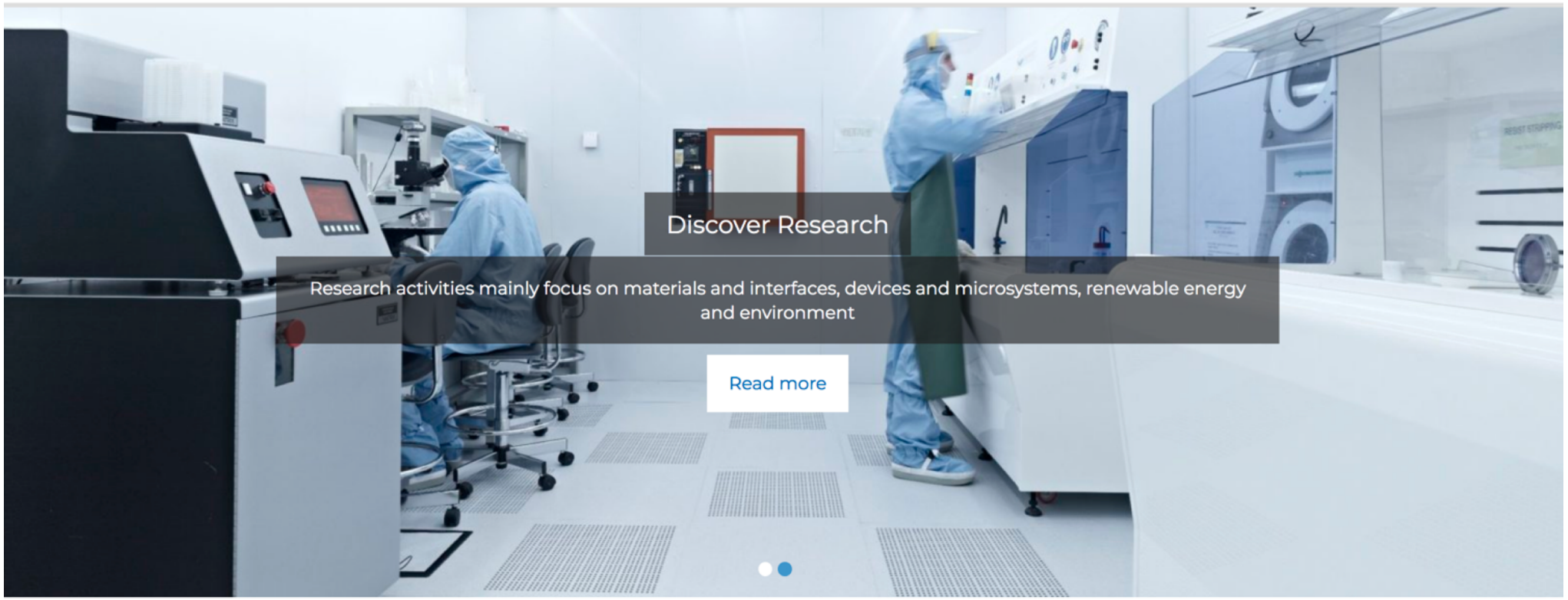
Giovanni Ambrosi

INFN Perugia

SiPM Technologies and Space Experiments
GSSI, May 8th 2018, L'Aquila

FONDAZIONE BRUNO KESSLER

CMM
CENTER FOR MATERIALS AND MICROSYSTEMS



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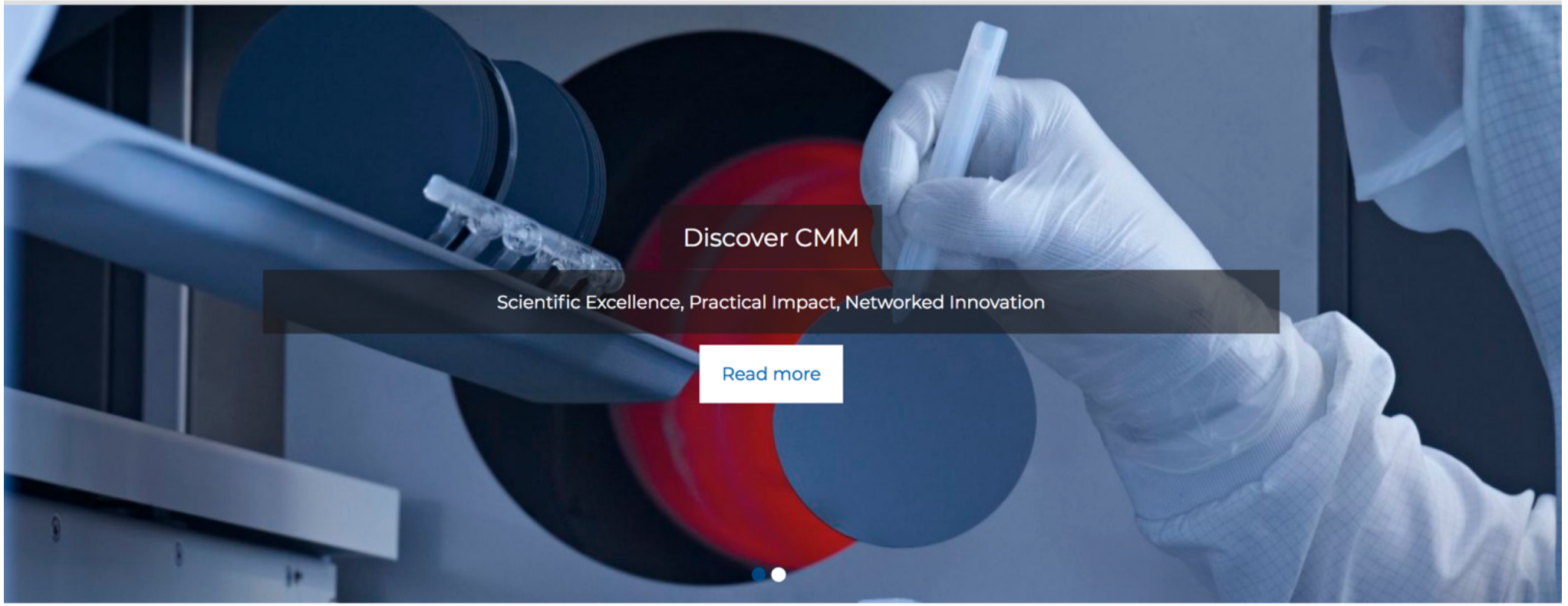
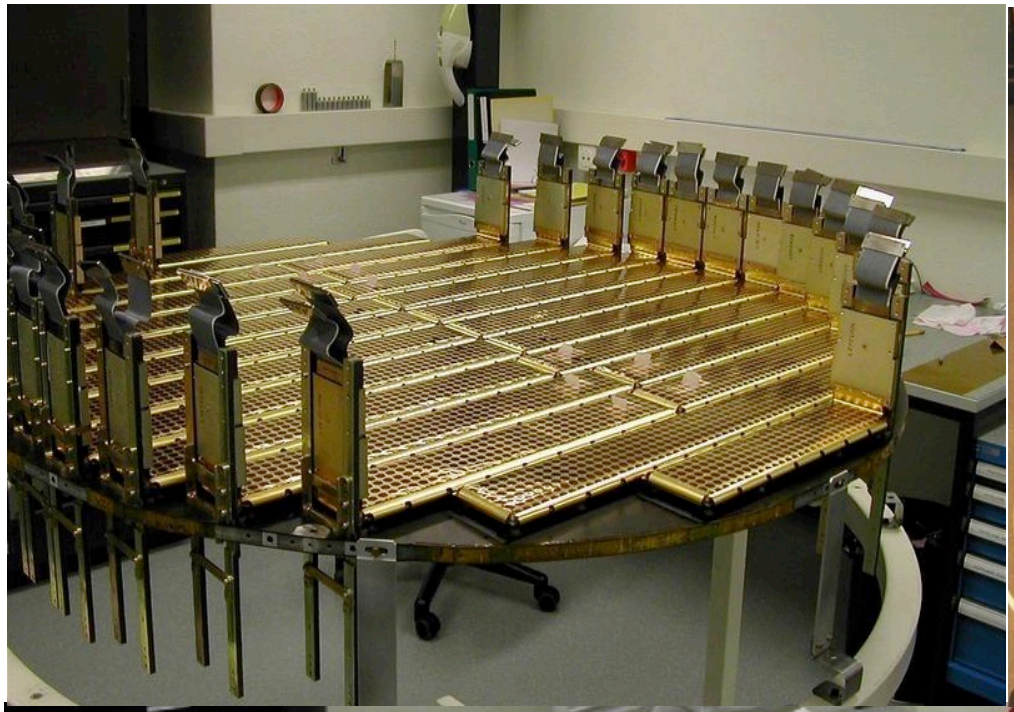
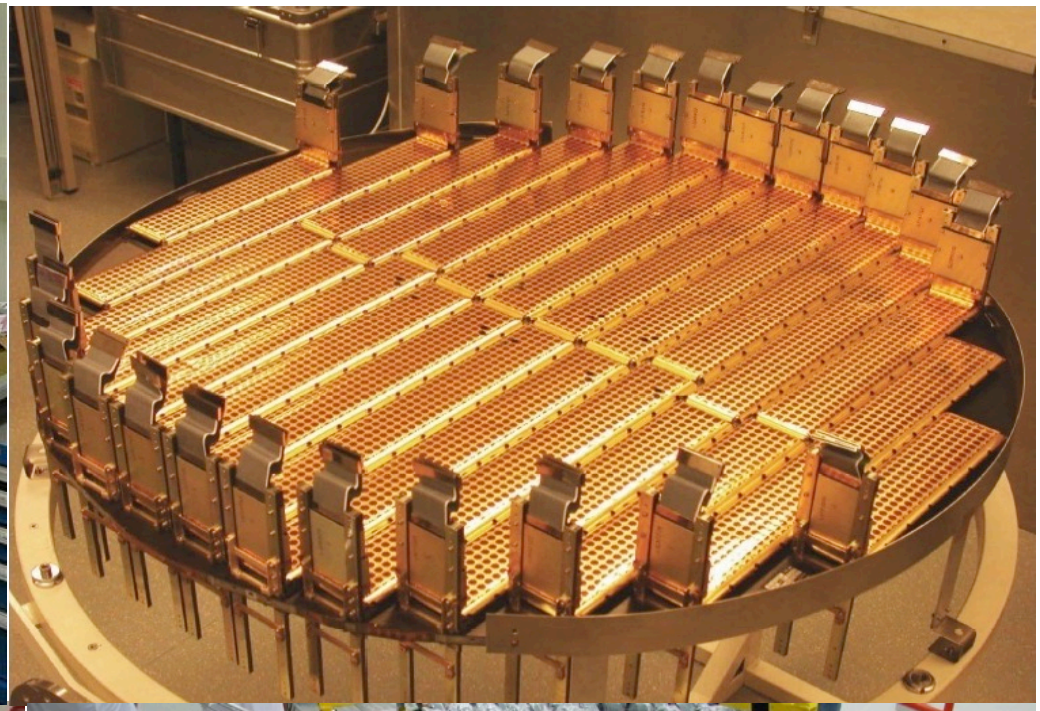
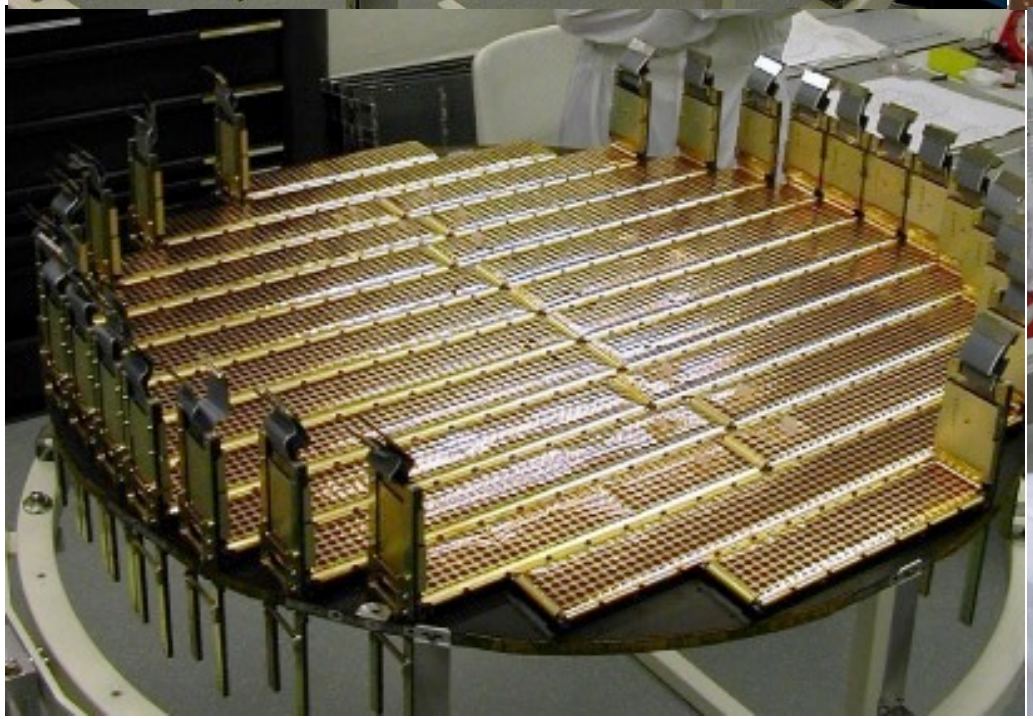


AMS-02: 9 planes with 200k channels, ~2500 Si detectors







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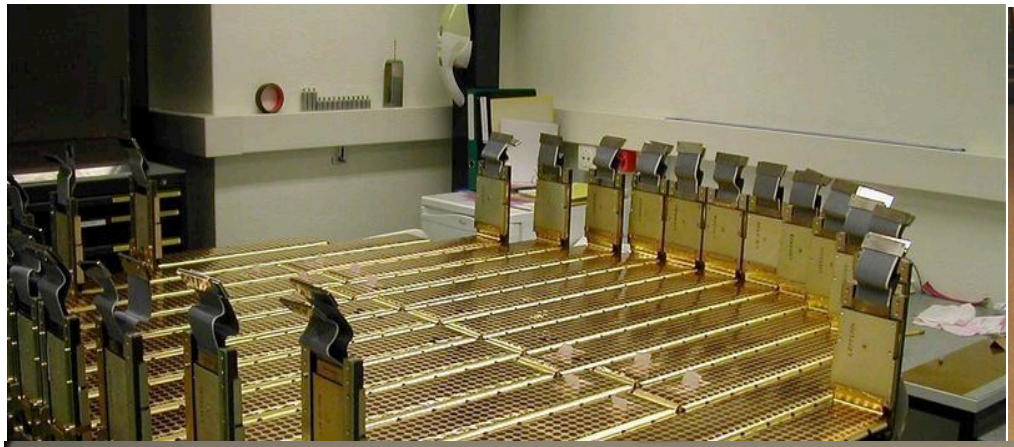
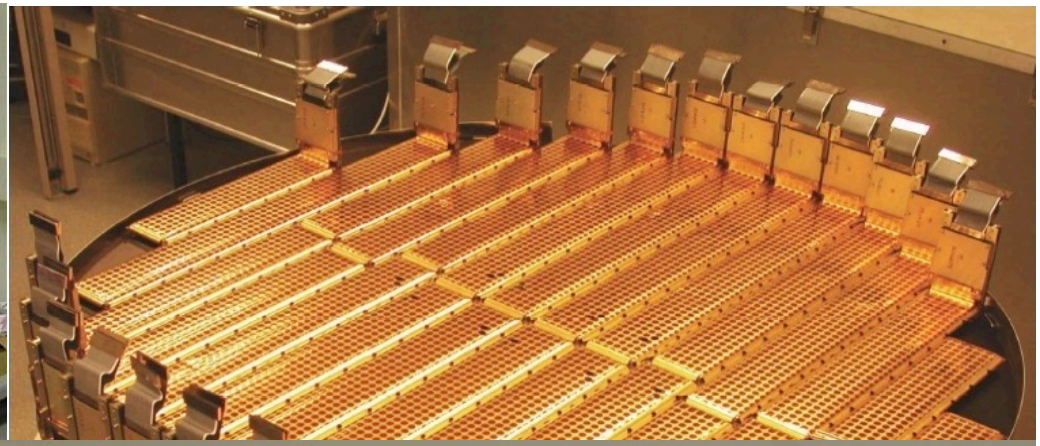




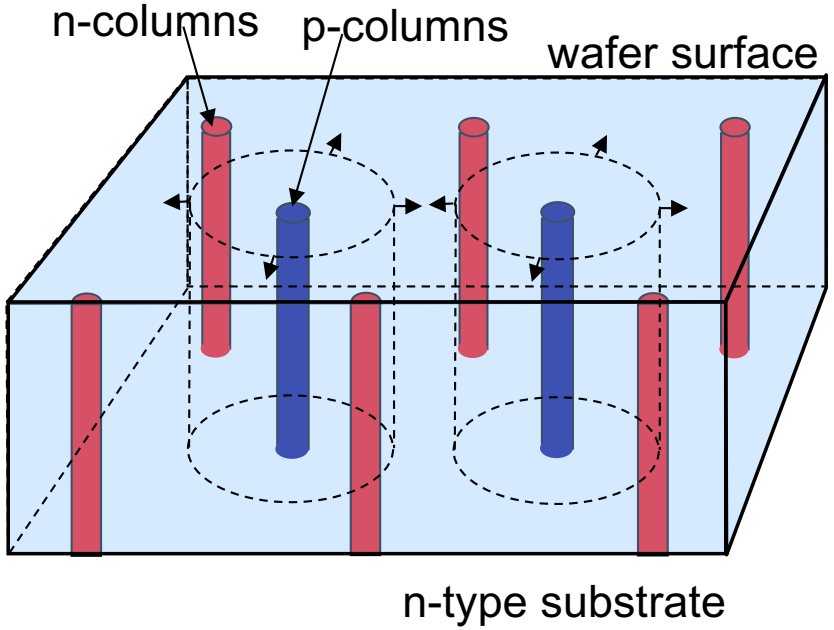
INFN-FBK collaboration projects

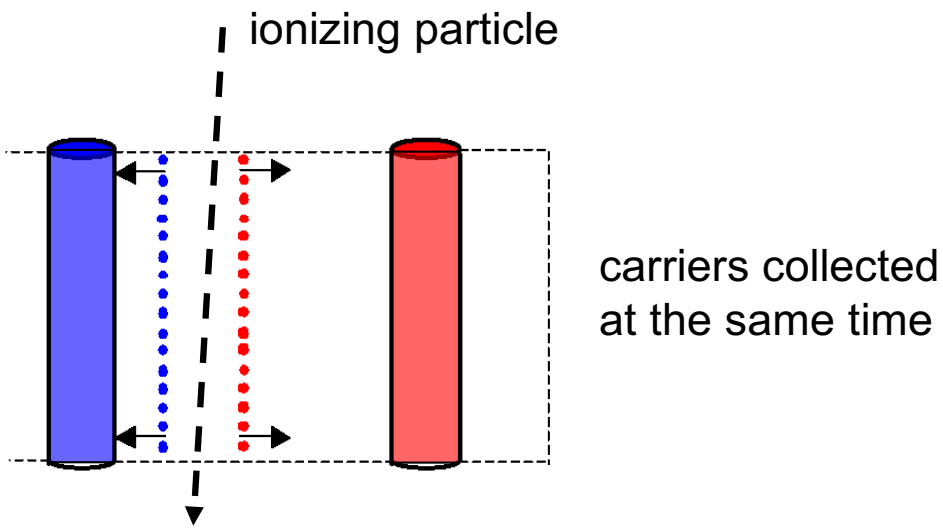
- Formal agreement for scientific and technological collaboration since early 2000
- Goal: to develope advanced systems (detectors) based on MEMS* technologies
- Different detectors:
  - 3D, thick detectors, bolometers, silicon drift, LGAD etc.
- SiPM happen to be the biggest part of the work

* Microelectromechanical systems consist of extremely tiny mechanical elements, often integrated together with electronic circuitry.

“Standard” 3D detectors - concept

[Parker et al. NIMA395 (1997)]





Distance between *n* and p electrodes can be made very short

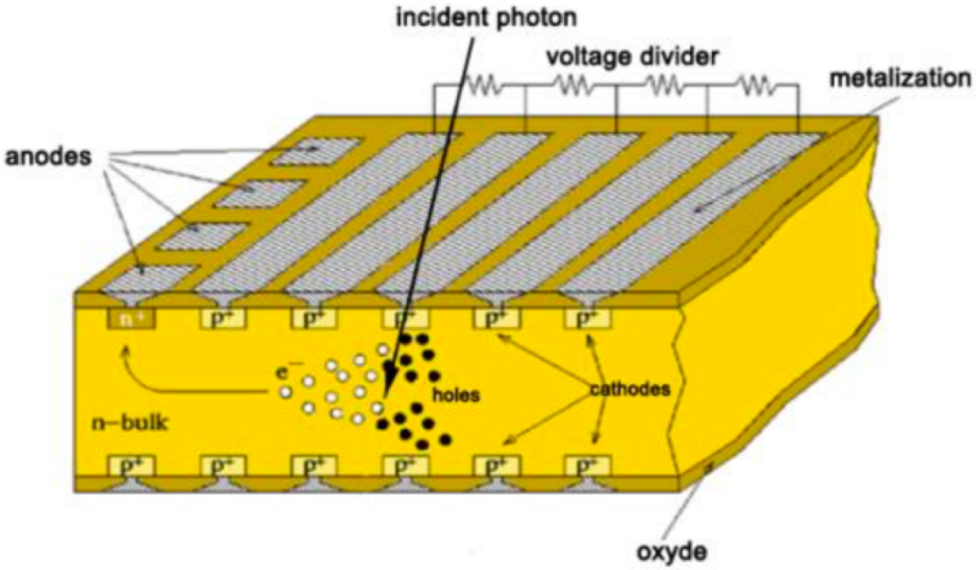
➡ **extremely radiation hard detector**

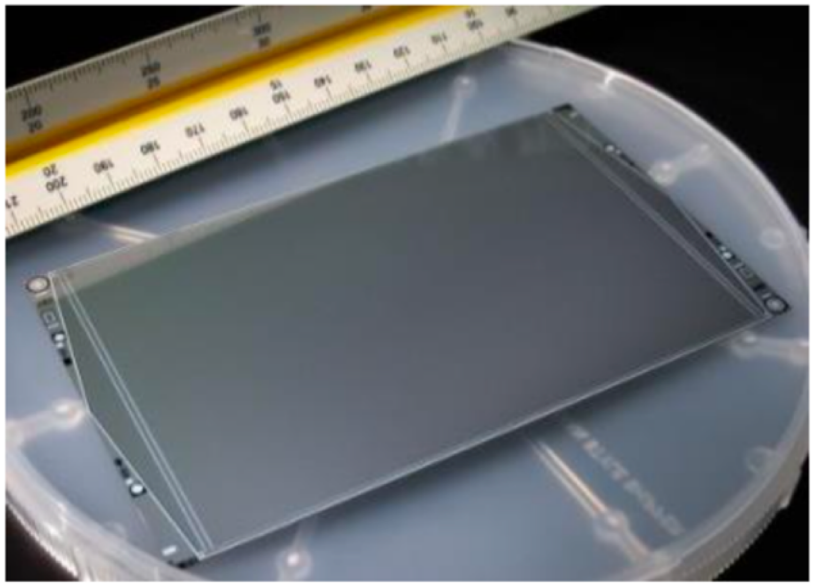
(low full depl. volt. and high CCE even at very high fluences)

Drawbacks: - electrodes are dead regions (or partially)

- feasibility of large scale production still to be verified

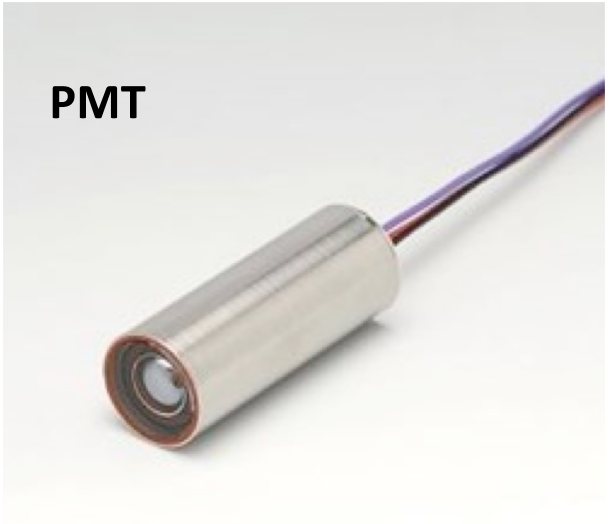
Silicon Drift detectors

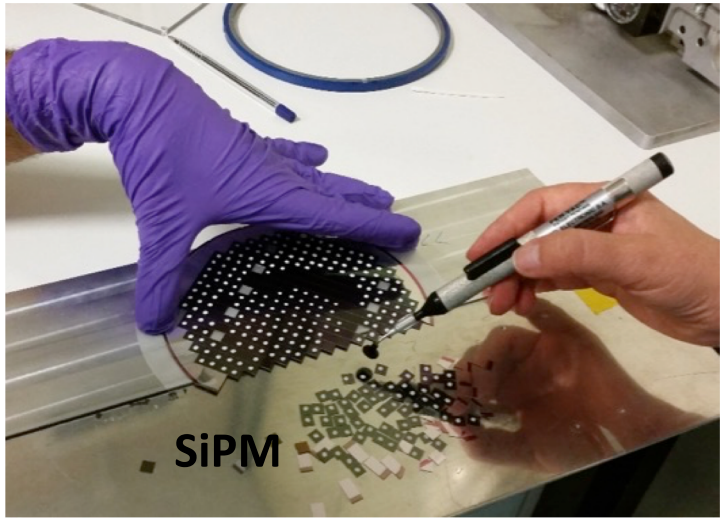




Replacing PMTs with SiPM

- No high voltage
- Immunity to magnetic field
- High gain
- High efficiency
- Robustness (?)
- Small amount of material
- Sustain high flux





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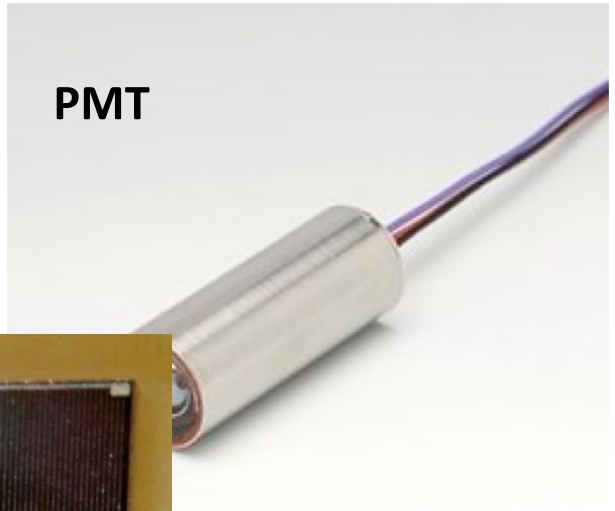

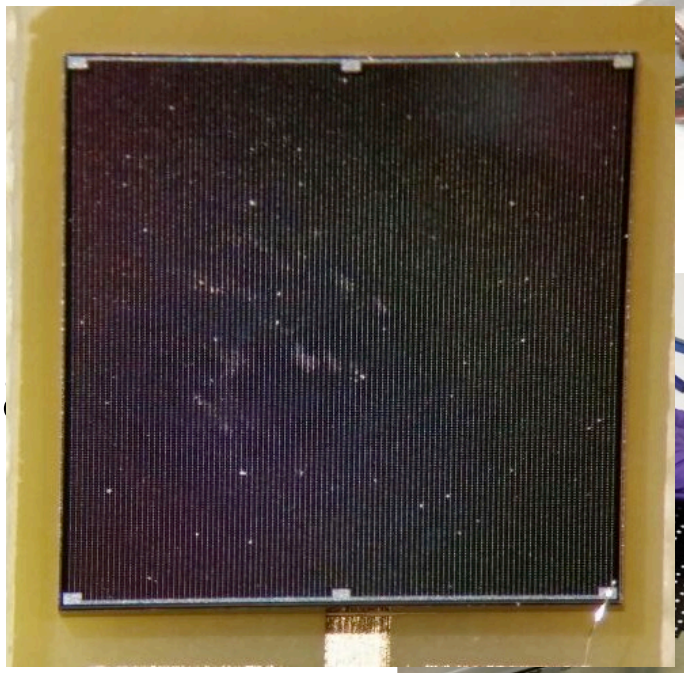

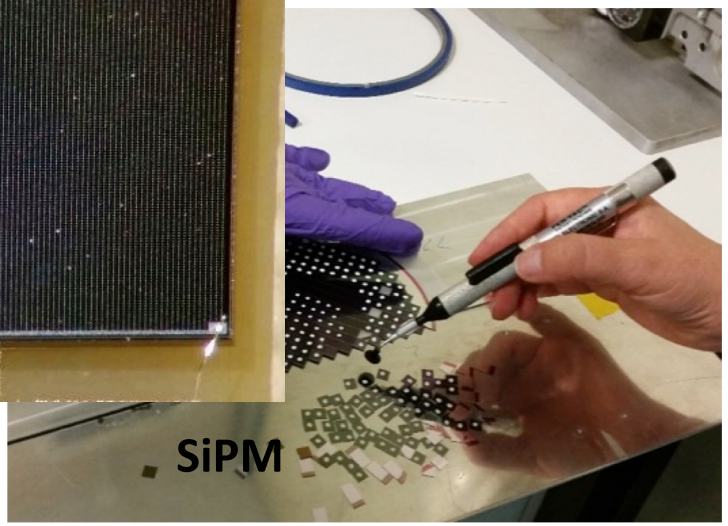

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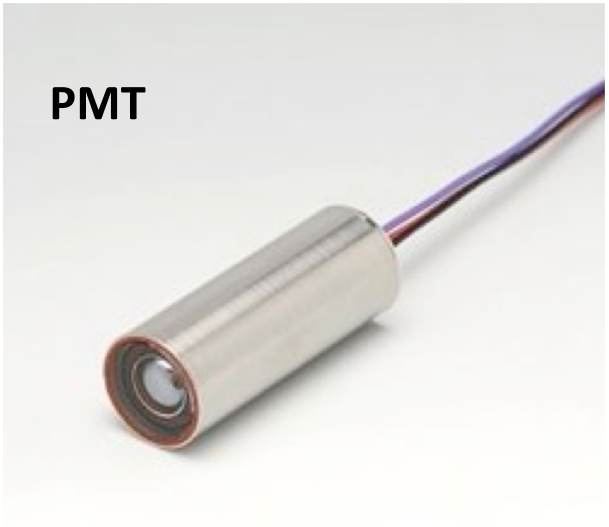
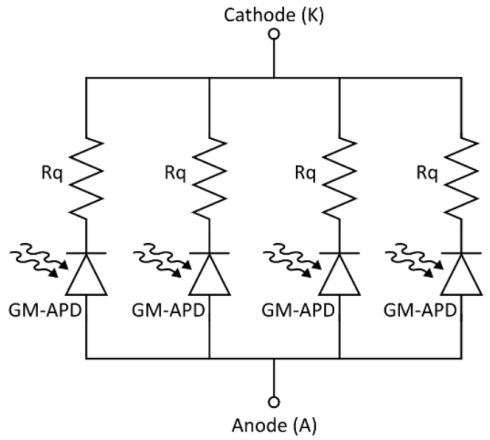
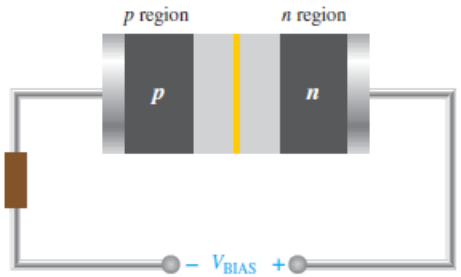


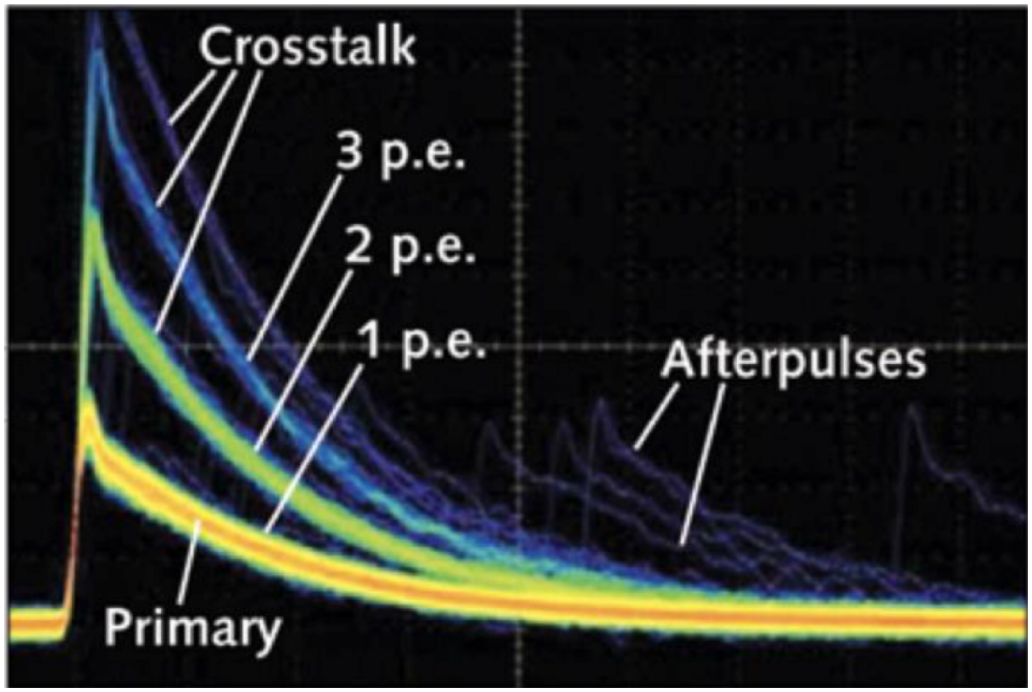


SiPM

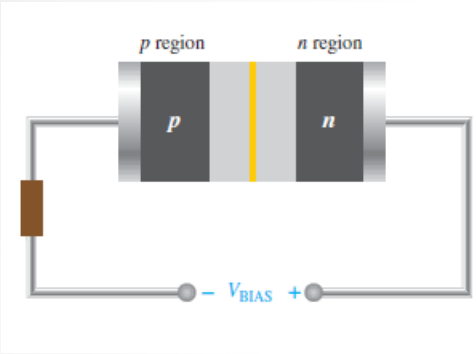
Replacing PMTs with SiPM do not forget:

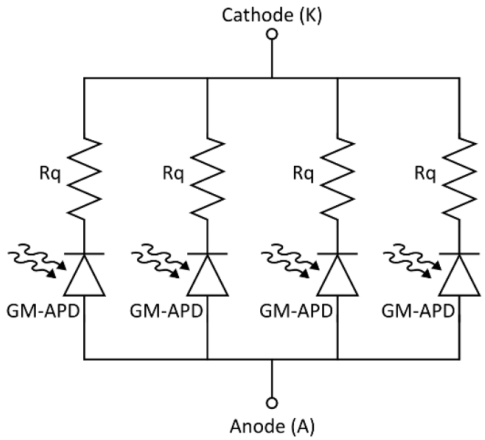
- High capacitance
- ‘Noisy’ detector:
  - High dark count rates
  - Crosstalk
  - Afterpulse

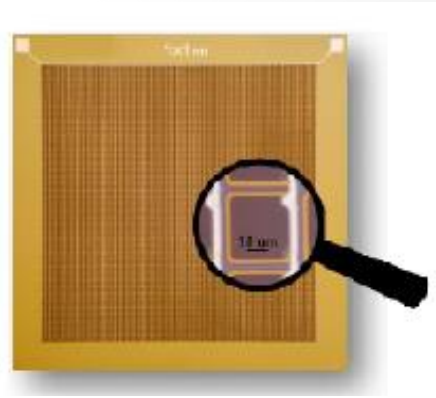


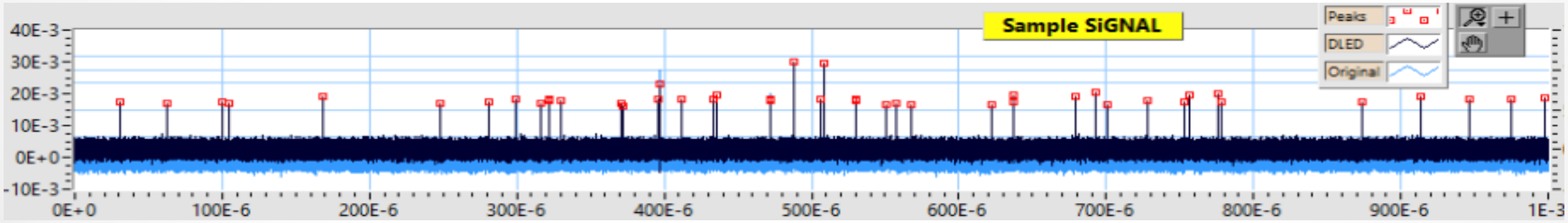


Dark measurements



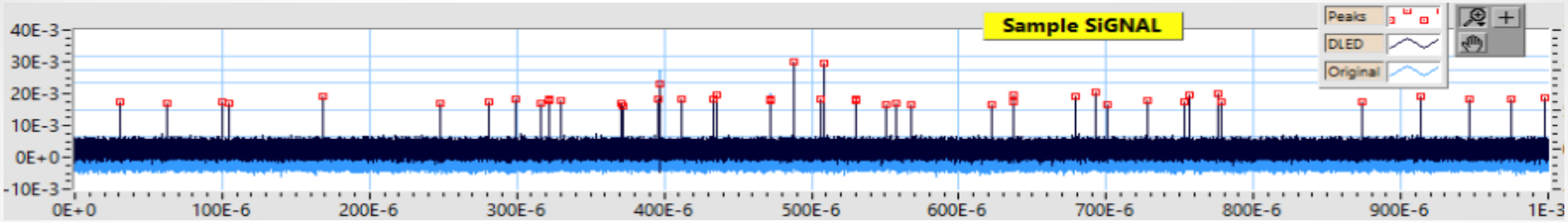




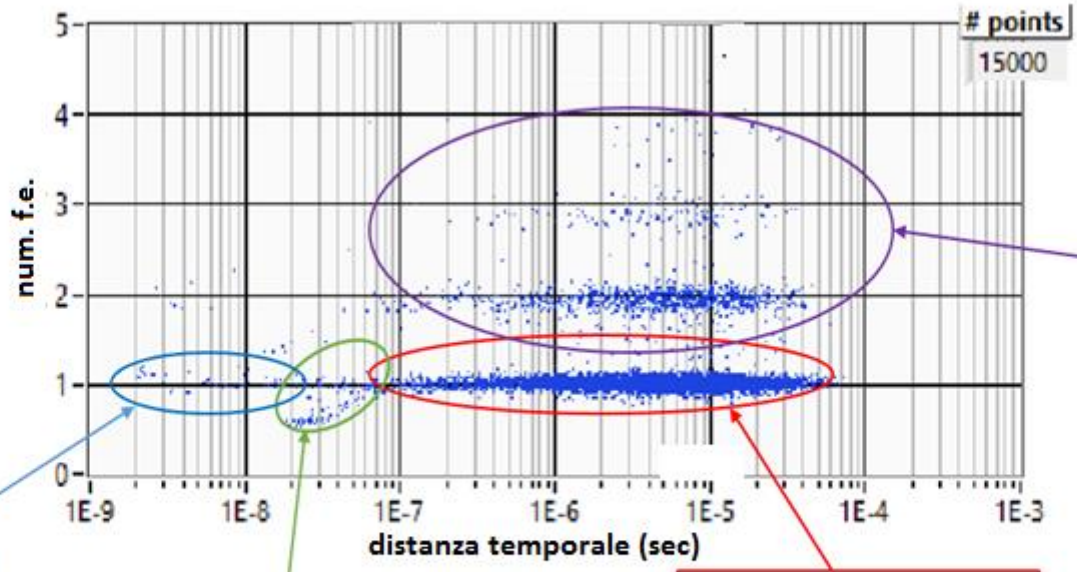


1. **Output signal acquired by oscilloscope**
2. **Pulses identification**

Dark measurements



1. Output signal acquired by oscilloscope
2. Pulses identification
3. Scatter plot of Amplitude vs. inter-times



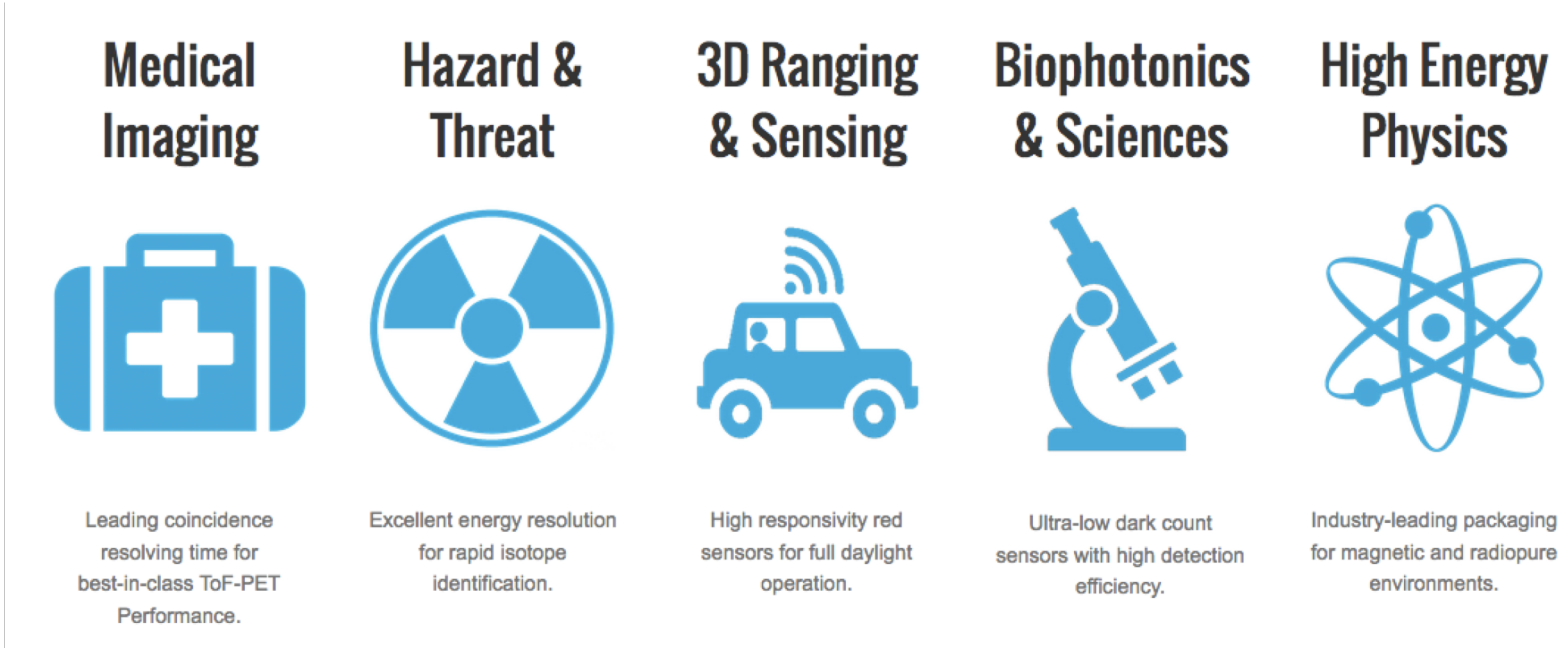
30 nsec - 10 μsec

1 $nsec$ - 10 $nsec$

20 μsec -10 μsec

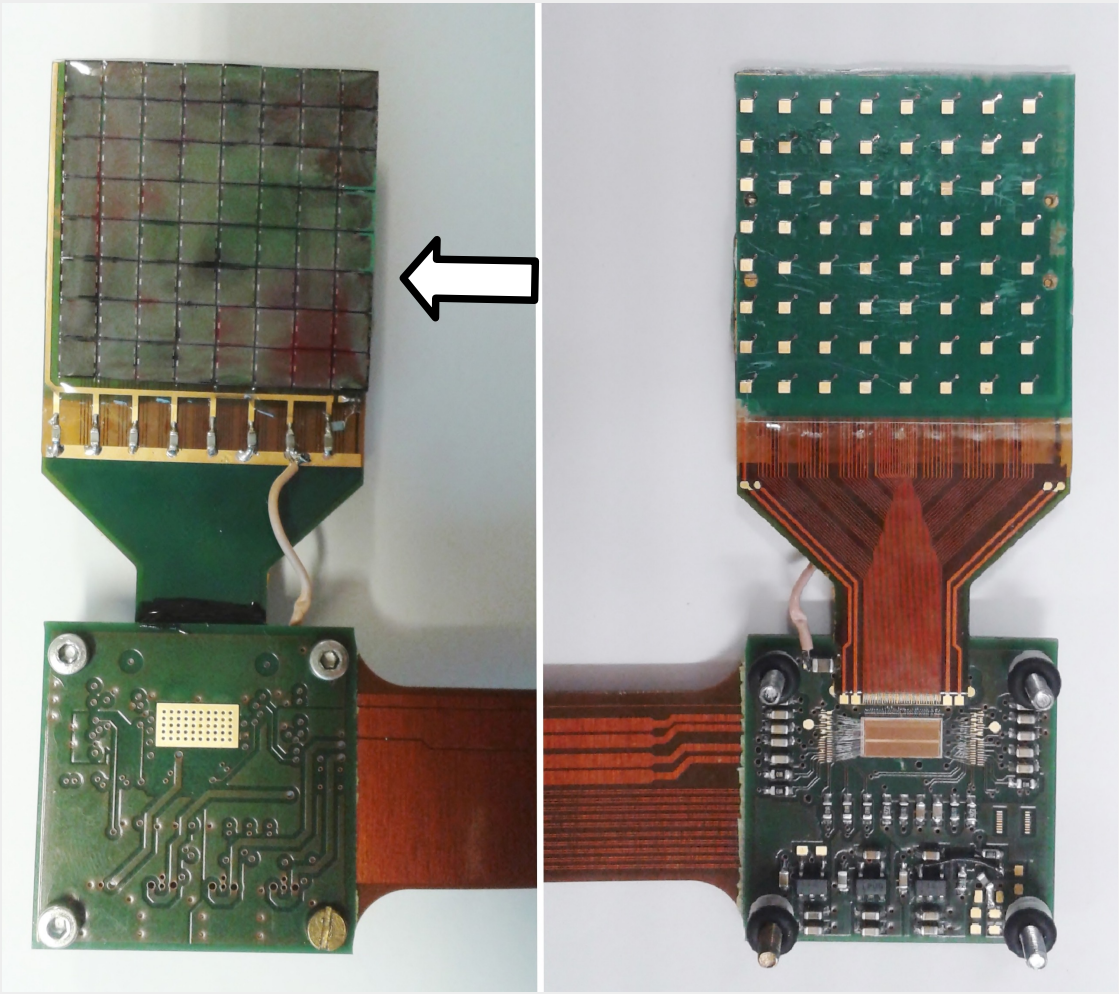
Use of SiPMs

- Medical imaging (PET)
- IACT (CTA)
- cryogenic liquid detectors (DarkSide)
- …



Structure of the Module

TOP VIEW **BOTTOM VIEW**



Custom SiPM array:

- ✔ 8 x 8 RGB SiPMs from AdvanSiD.
- ✔ 3 x 3 mm^2 active area
- ✔ 3.6 x 3.6 mm^2 pitch
- ✔ Signal read-out from the bottom side of the SiPM
- ✔ Bias in daisy chain from the top side (one on each row)
- ✔ 2 side bootable

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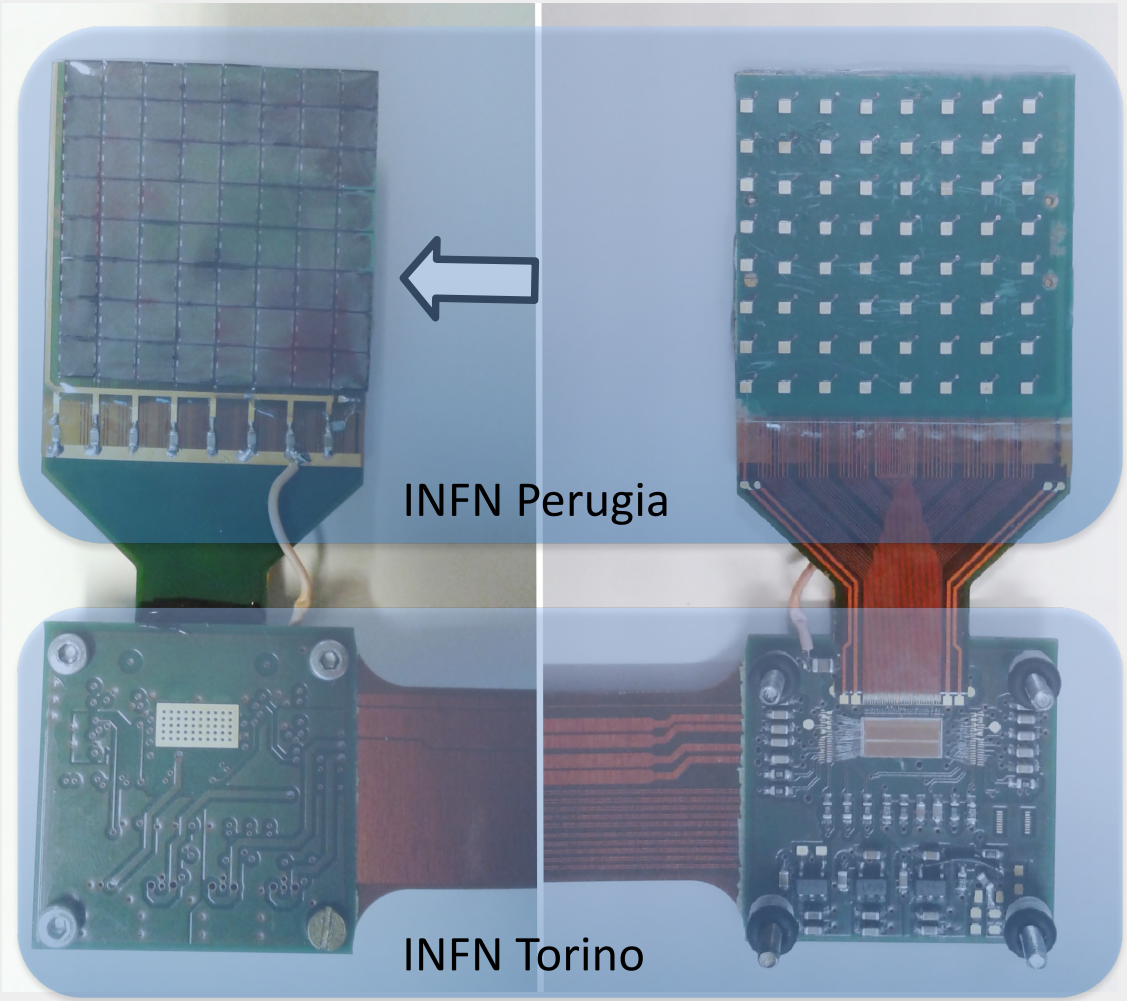

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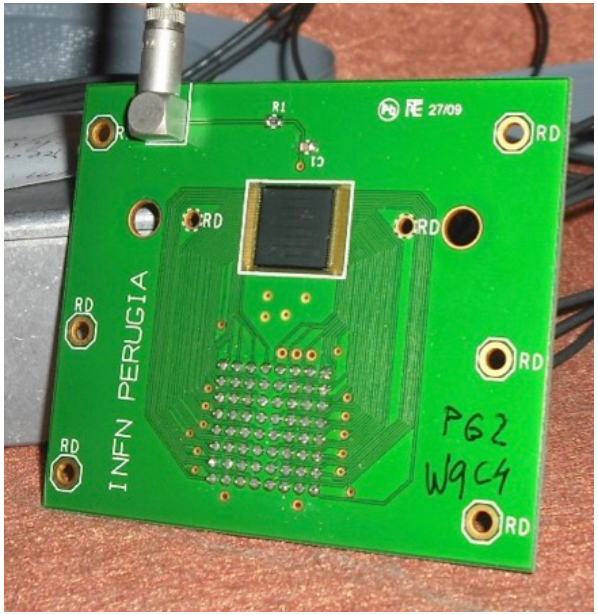
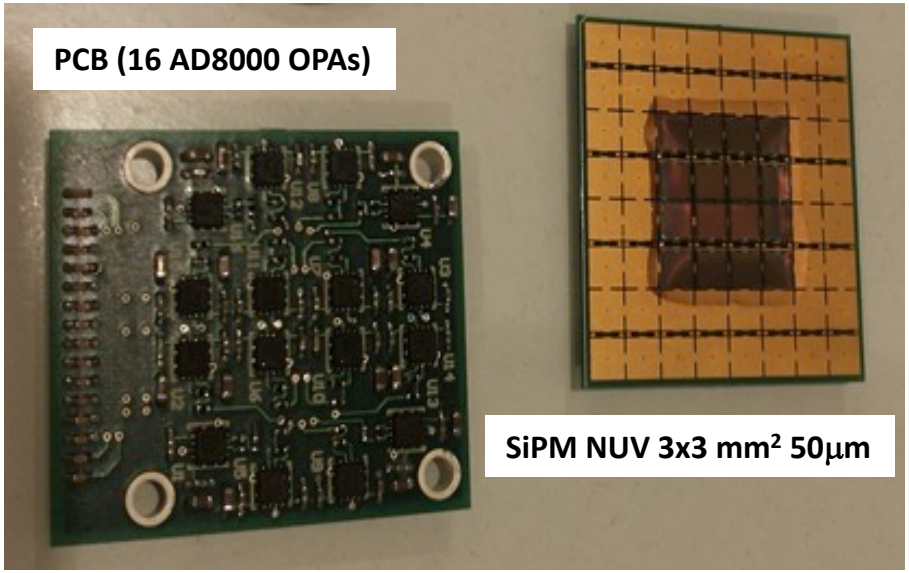
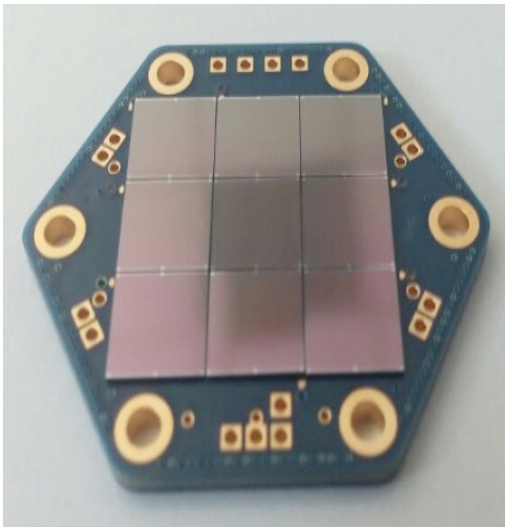
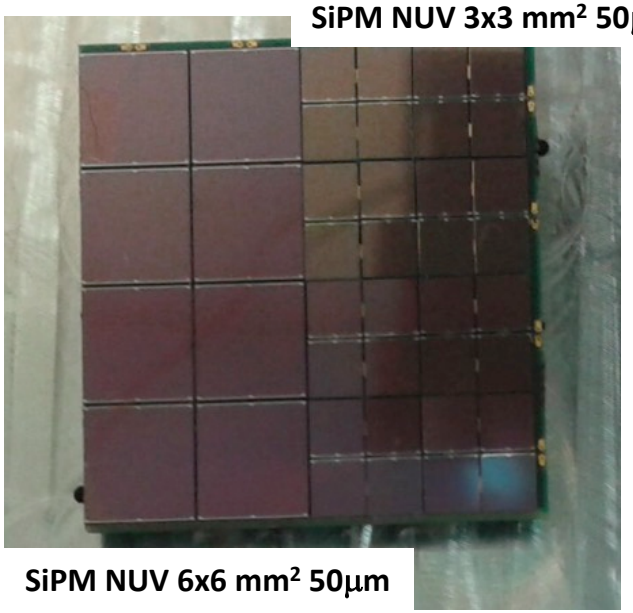
Assembly examples







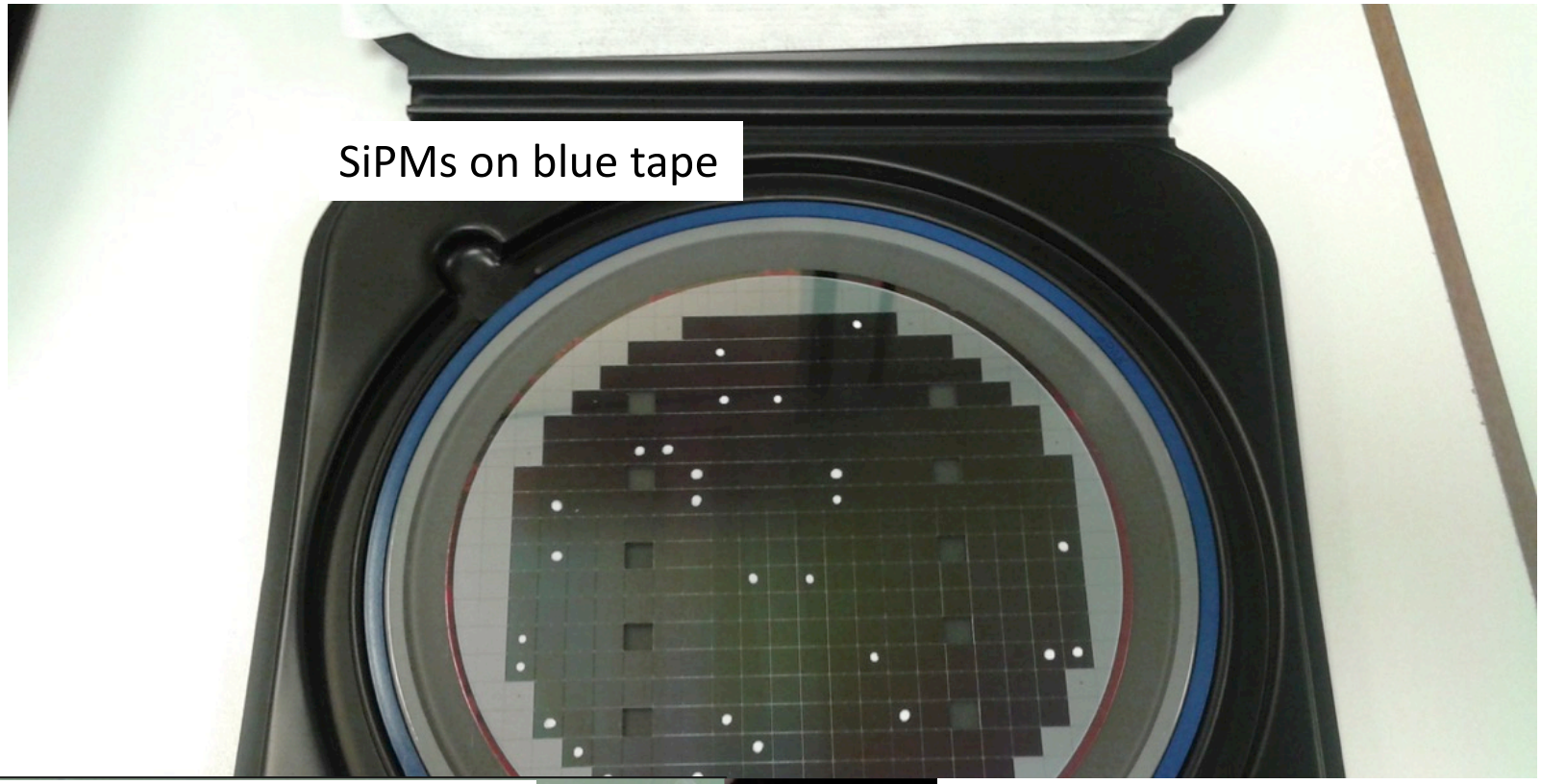
SiPM NUV 3x3 mm² 50µm



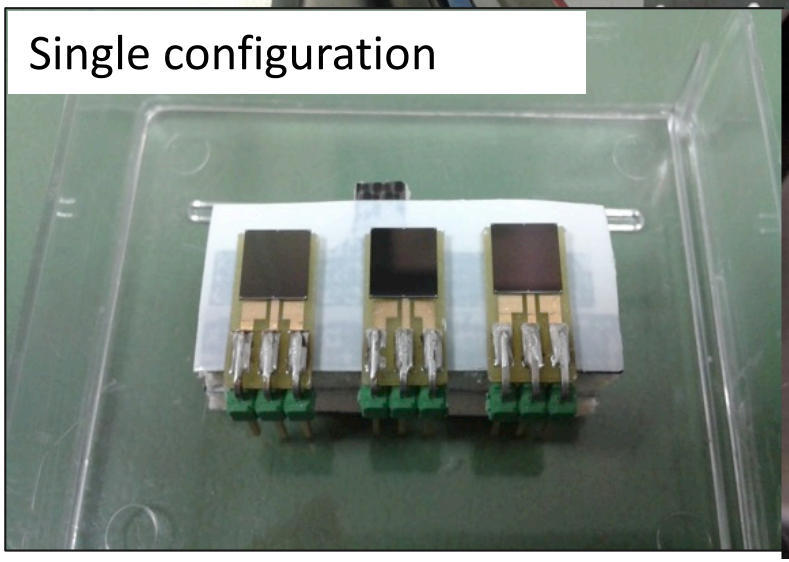
SiPM NUV 6x6 mm² 50µm

INFN Perugia

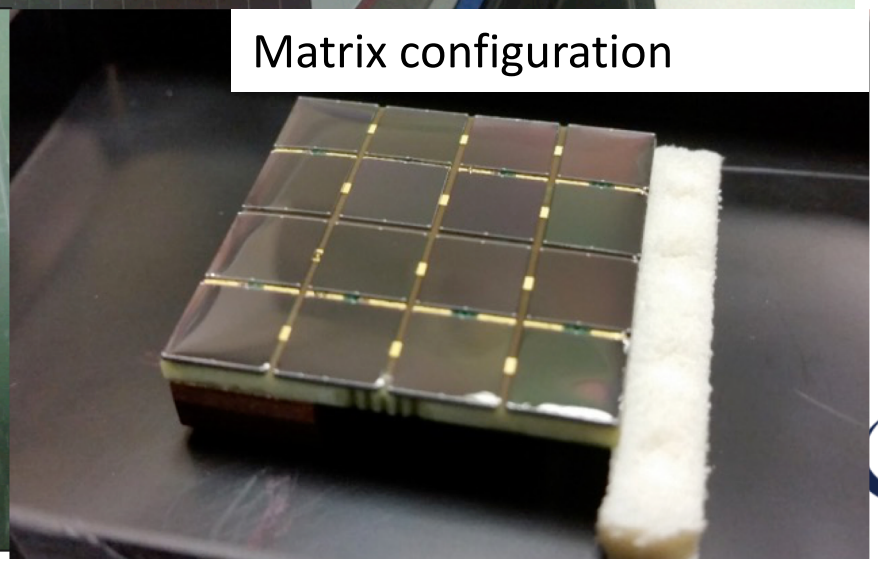
FBK SiPMs NUV – HD 30 mm cell



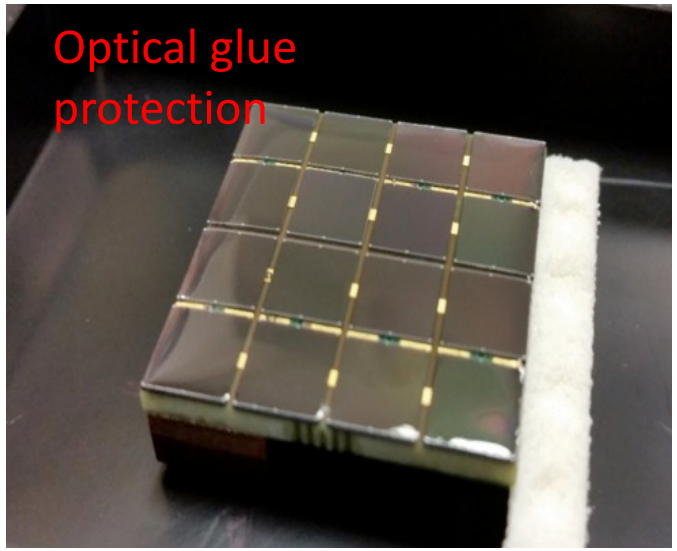
Single configuration

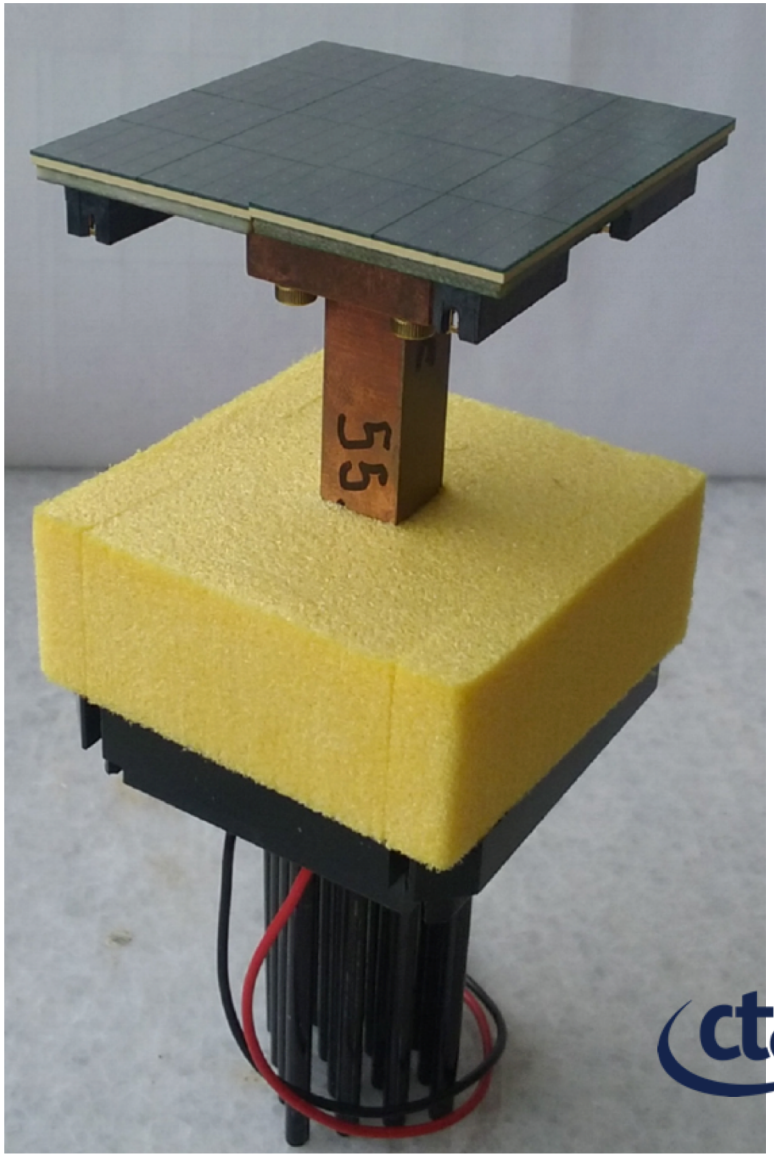


Matrix configuration



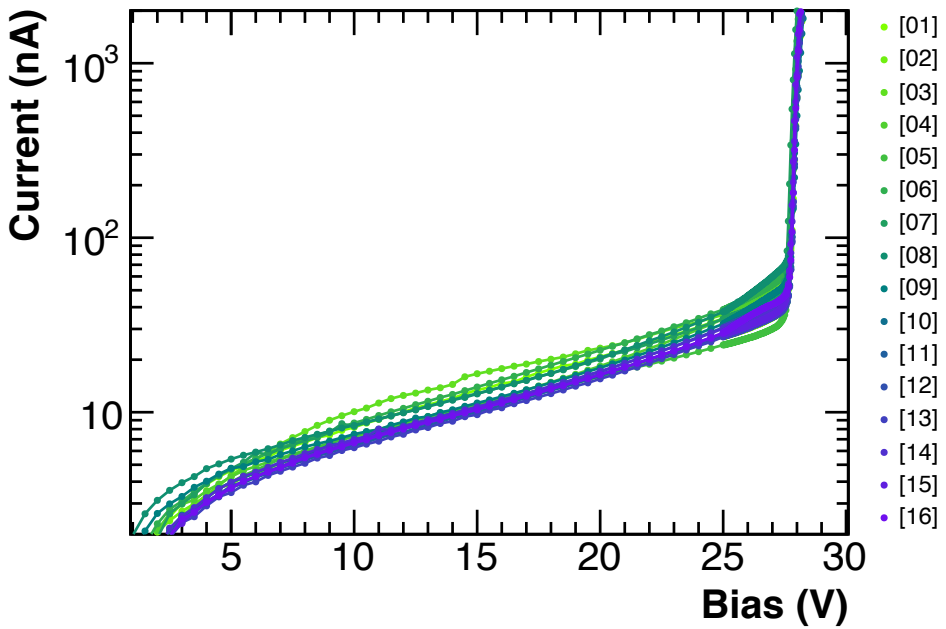
Pre-production with good and dummy SiPM

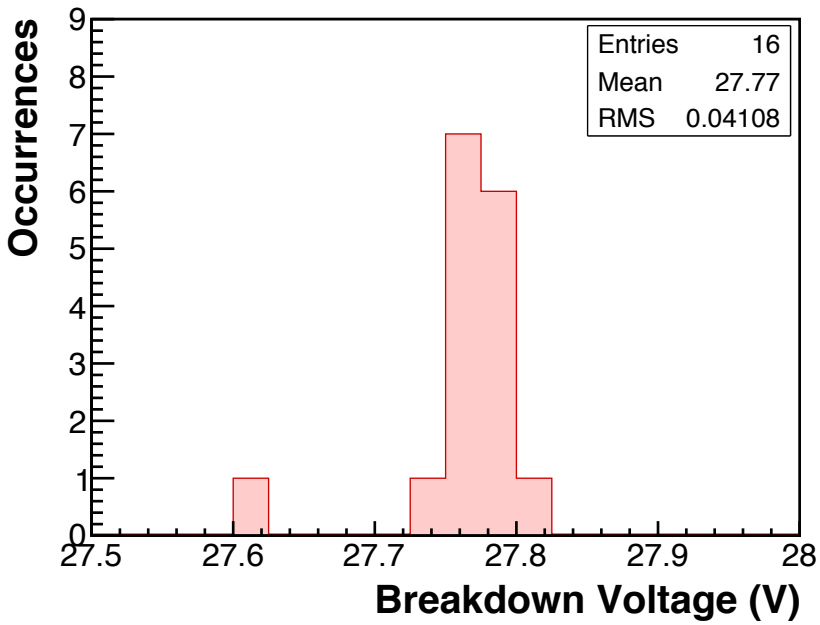




pSCT module tests

SiPM placed on PCB with pick&place machine for mass production.
The quality of the assembly and the sensor alignment have been tested

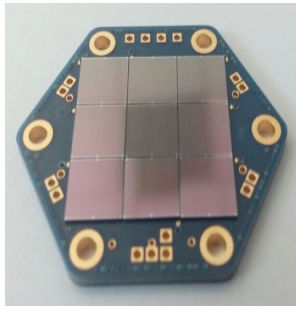


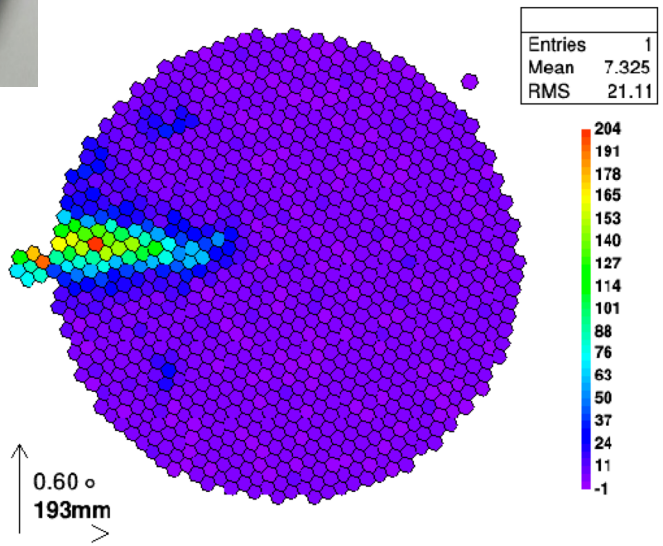


MAGIC cluster with SiPM

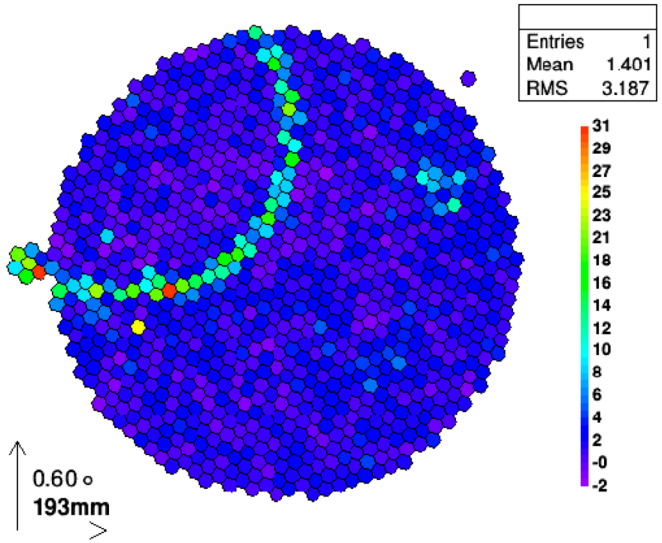
Mechanics Electronics Installation Future

First events





Gamma shower recorded by the MAGIC telescopes including the new SiPM cluster



Recorded muonring

Conclusions

- SiPM technology is mature to be used in (big) experiments
- SiPM technology is continually improving
- Fine tuning of the parameters (geometry, fill factor, Rq, etc.) can help to improve the performance
- Keep an eye at the ‘system level’: the SiPM itself will not make the work by itself