

The Collaboration INFN-FBK

Giovanni Ambrosi

INFN Perugia

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

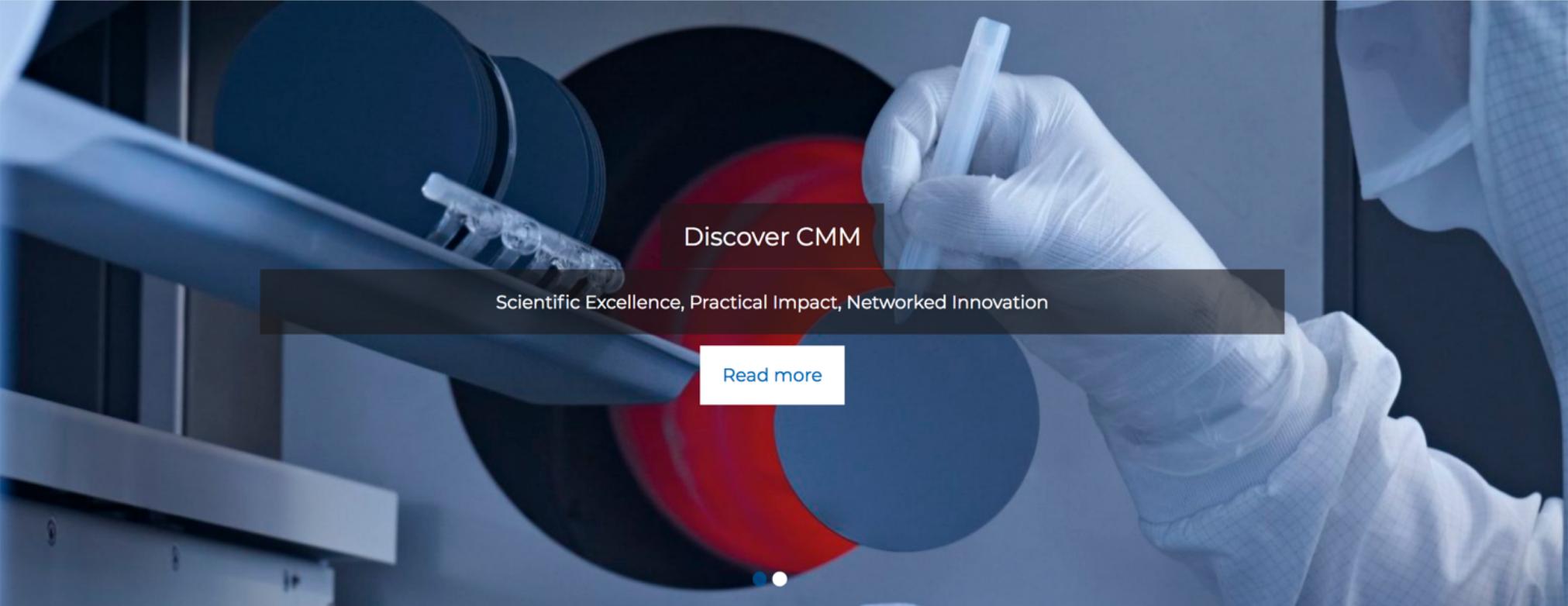


Discover Research

Research activities mainly focus on materials and interfaces, devices and microsystems, renewable energy and environment

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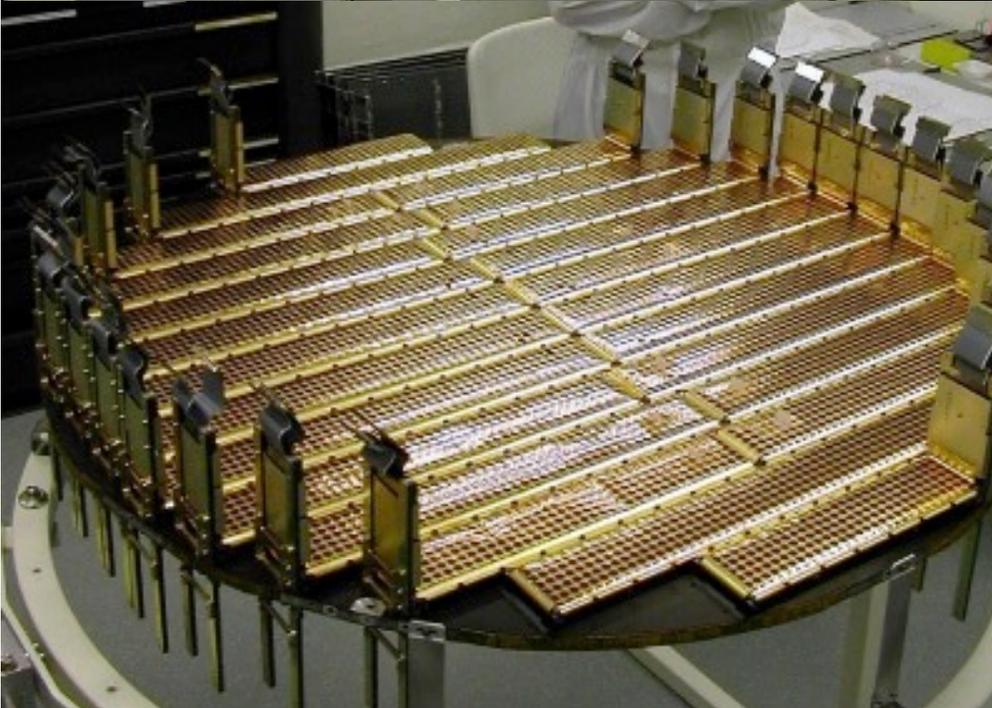
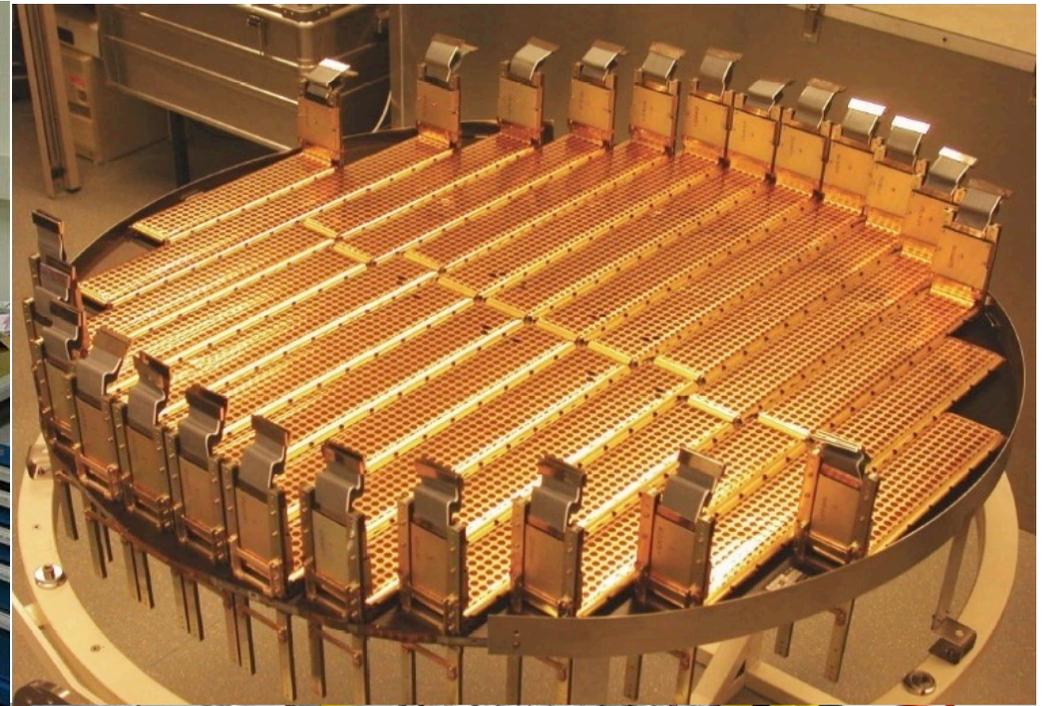
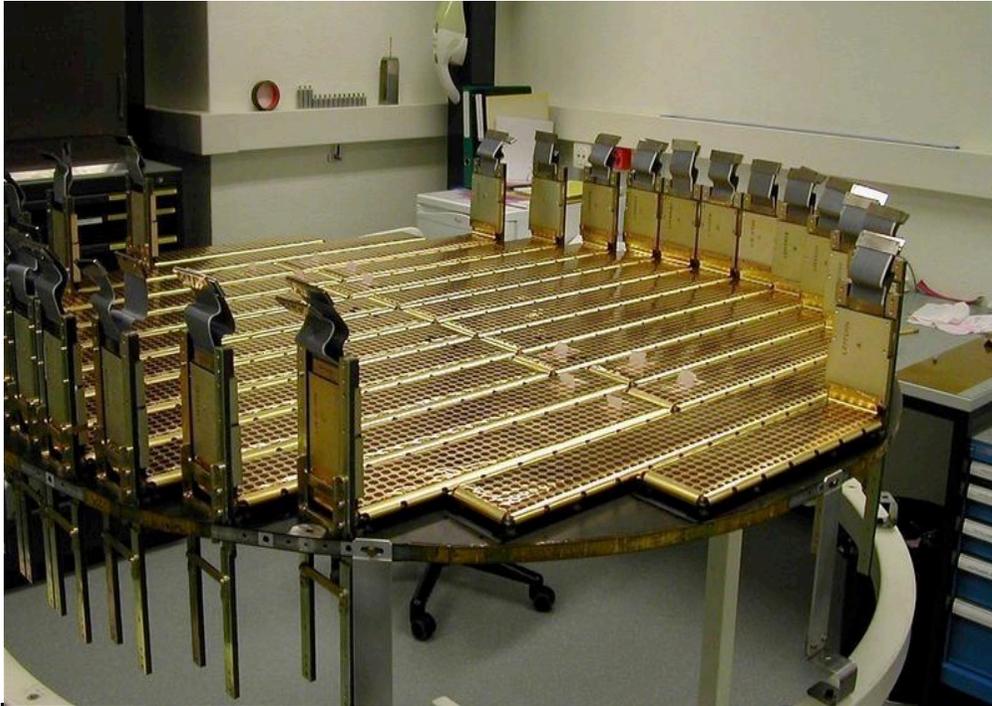


Discover CMM

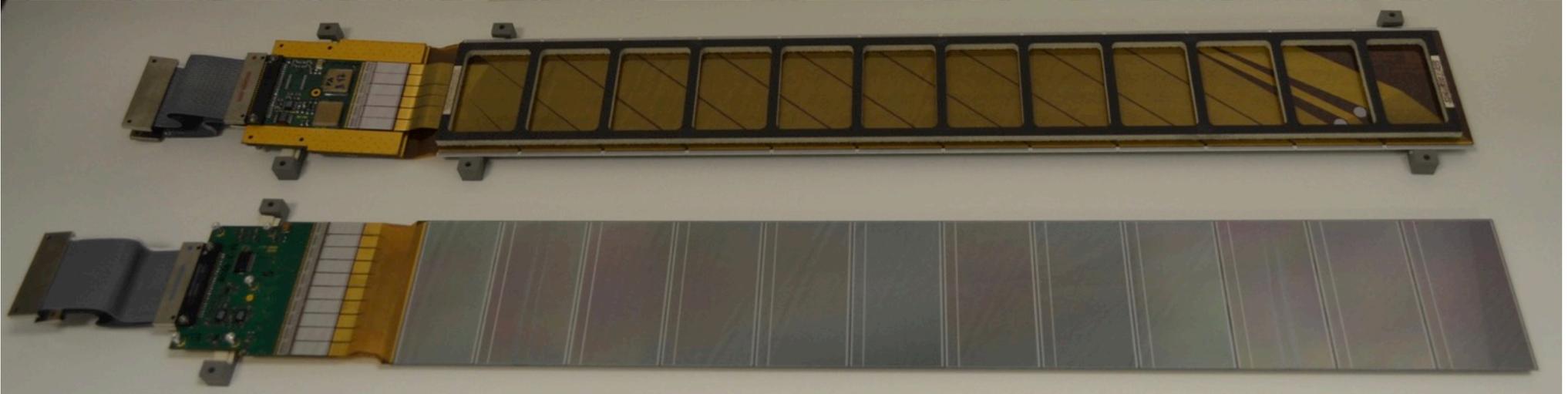
Scientific Excellence, Practical Impact, Networked Innovation

[Read more](#)

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



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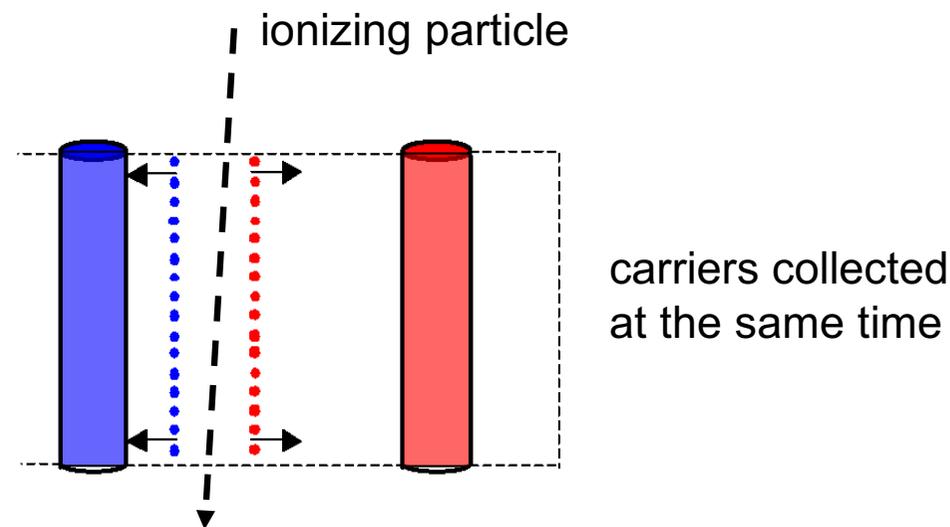
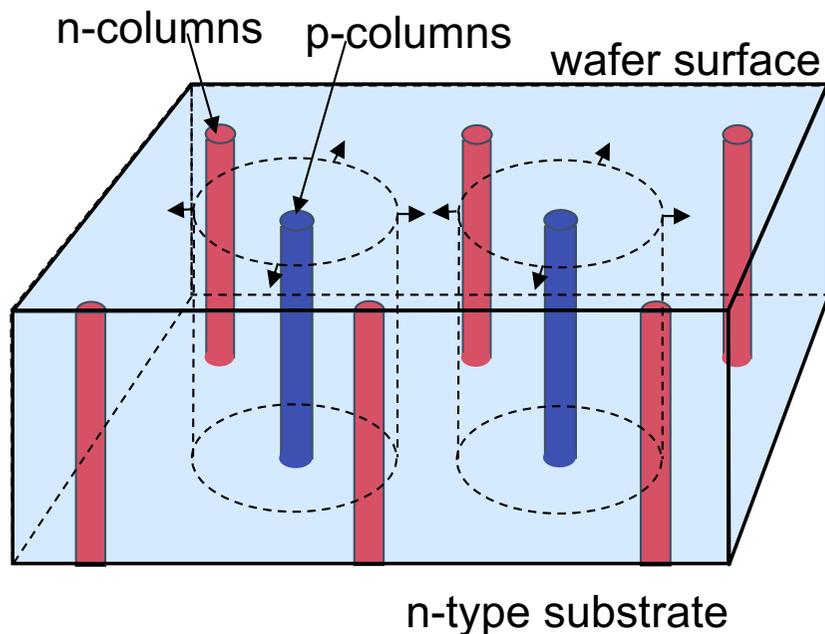
INFN-FBK collaboration projects

- Formal agreement for scientific and technological collaboration since early 2000
- Goal: to develop 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)]



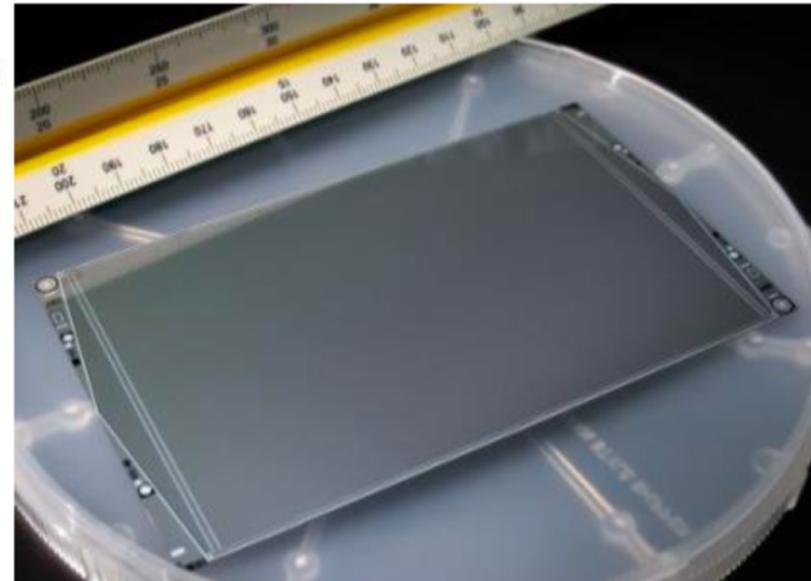
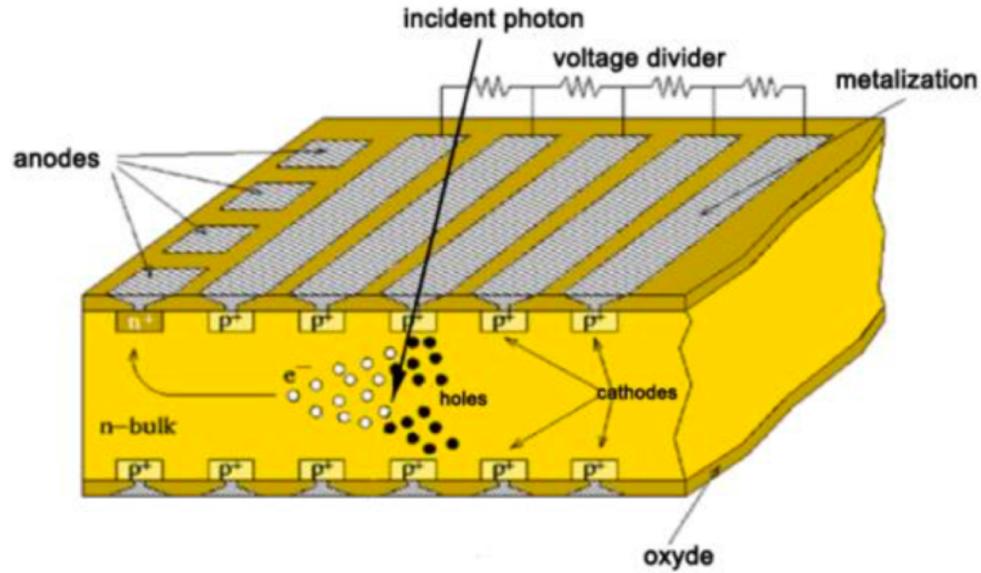
Distance between n and p electrodes can be made very short

➔ **extremely radiation hard detector**

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

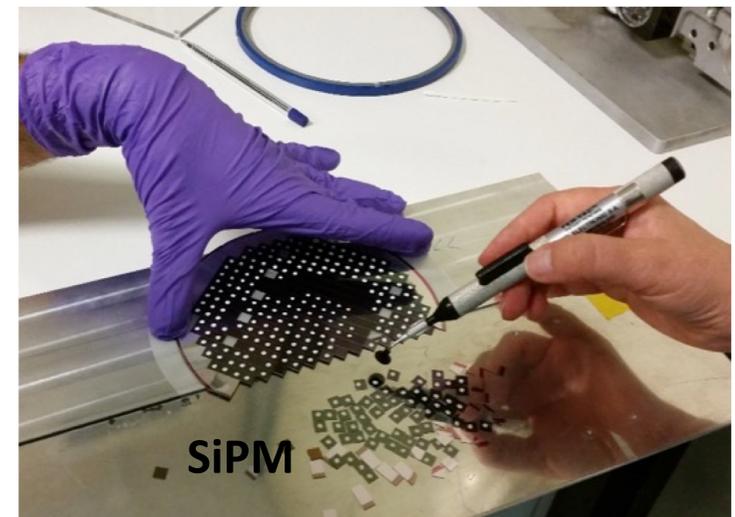
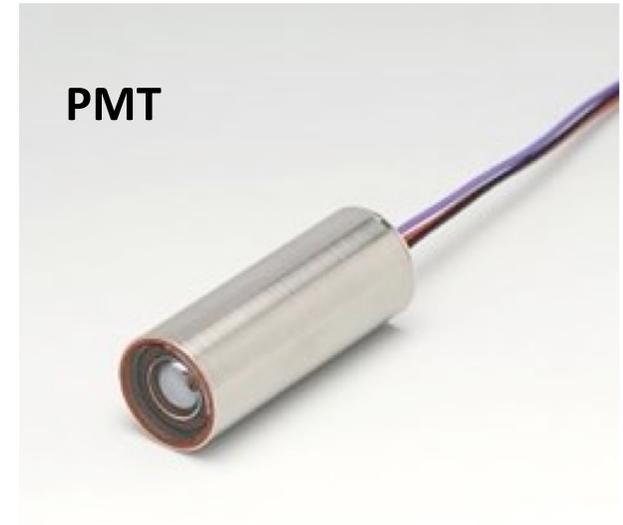
Drawbacks: - electrodes are dead regions (or partially)
- feasibility of large scale production still to be verified

Silicon Drift detectors



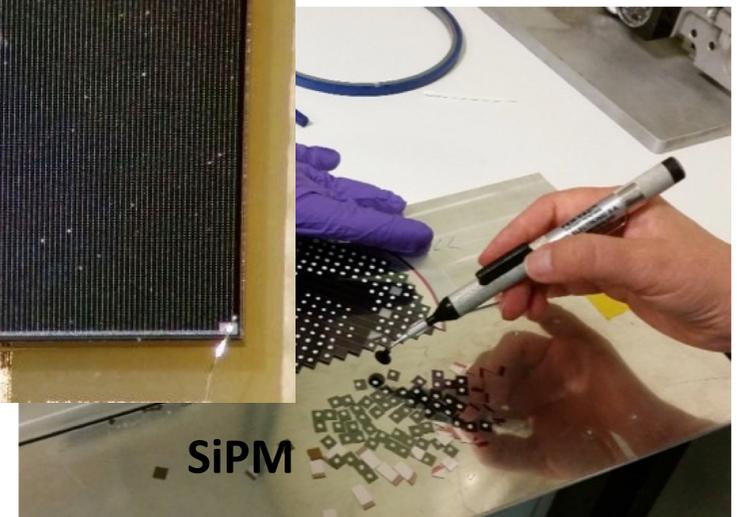
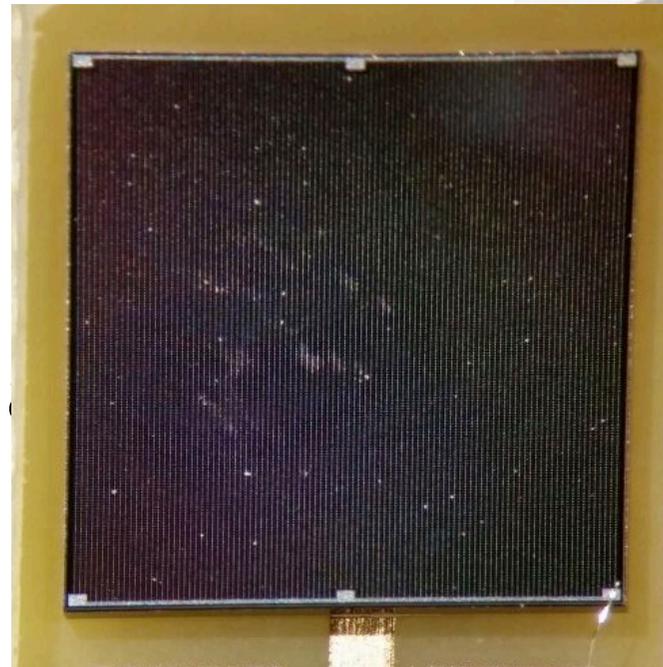
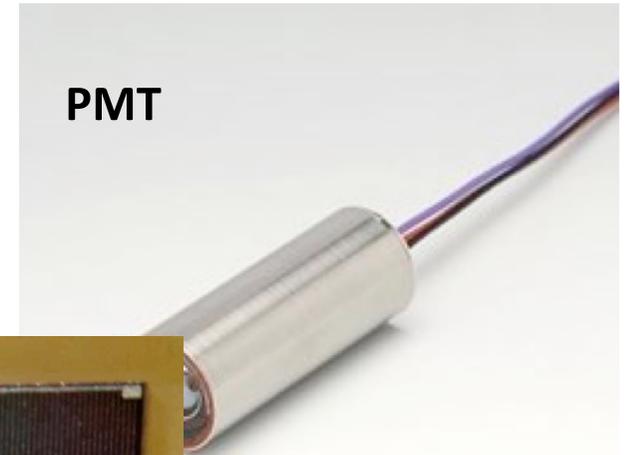
Replacing PMTs with SiPM

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



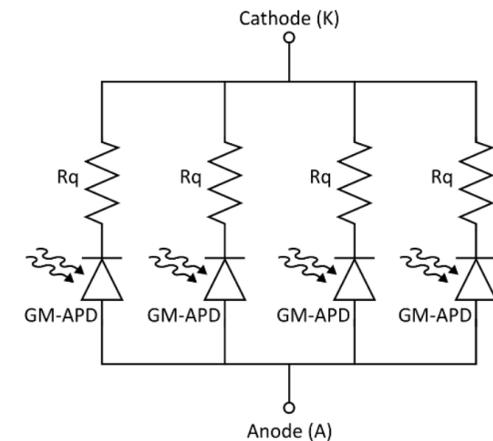
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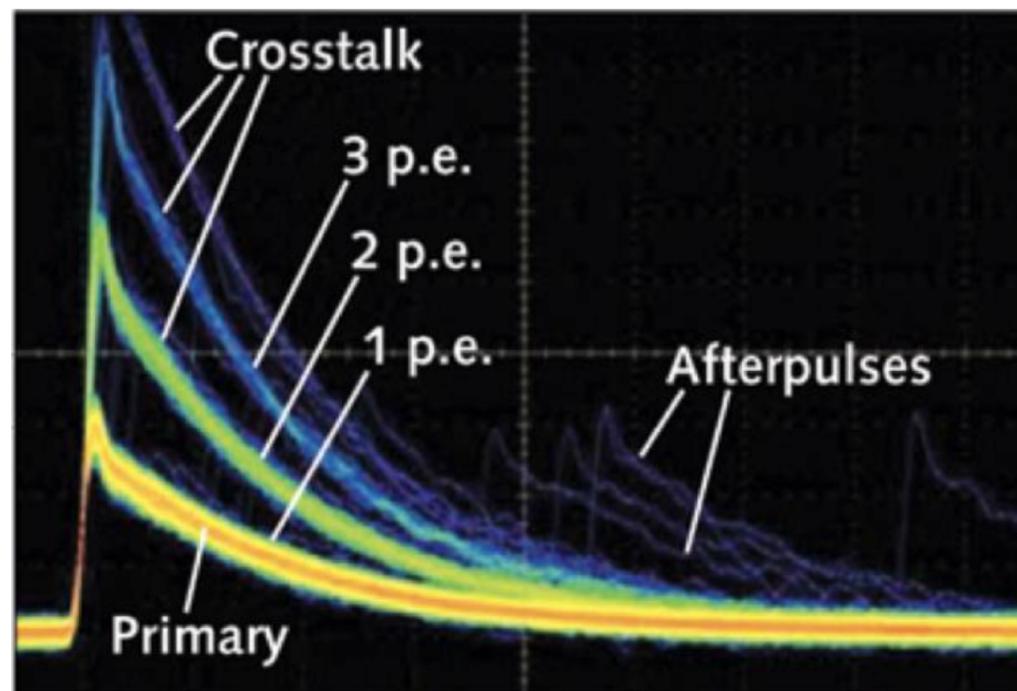
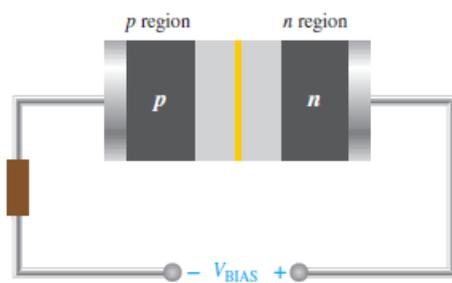
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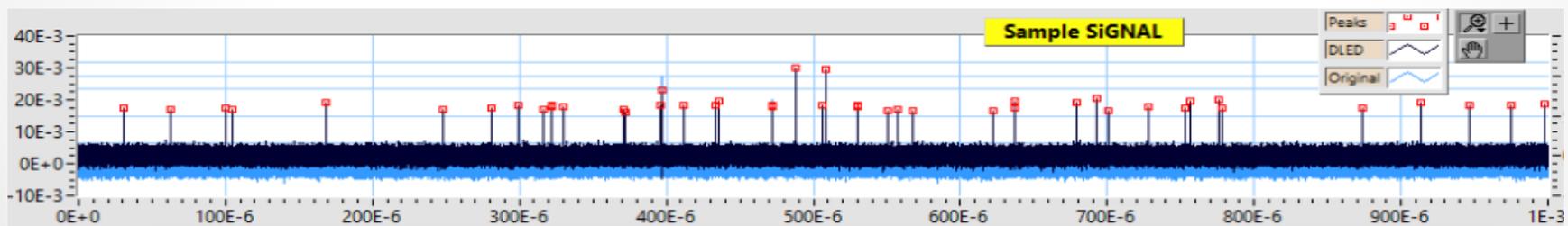
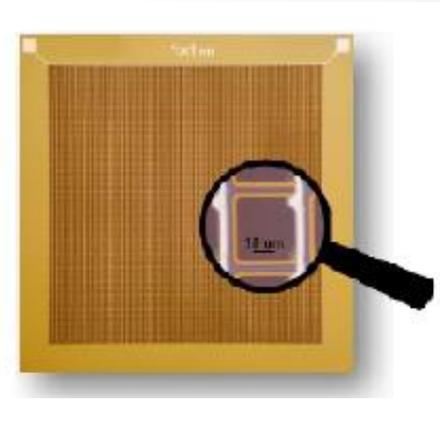
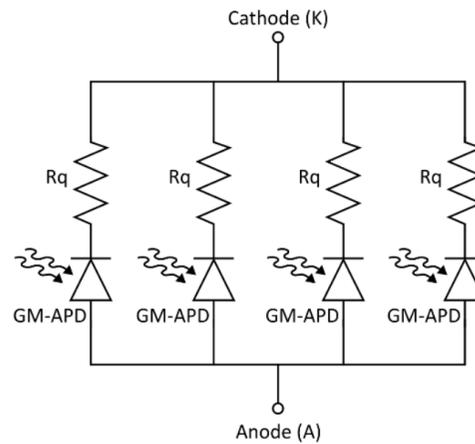
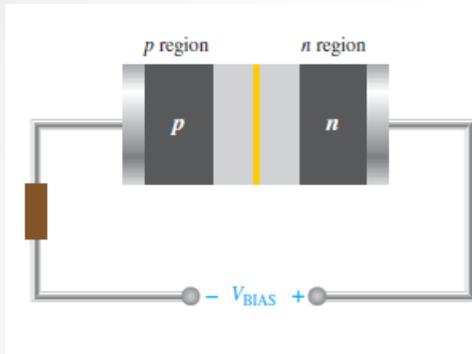
SiPM

Replacing PMTs with SiPM do not forget:

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

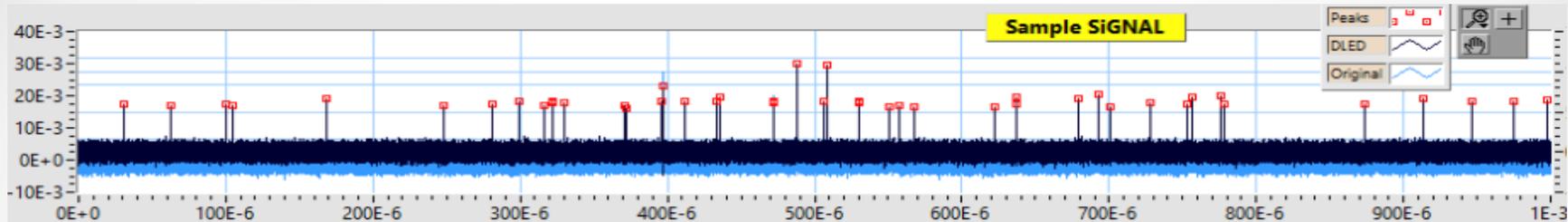


Dark measurements

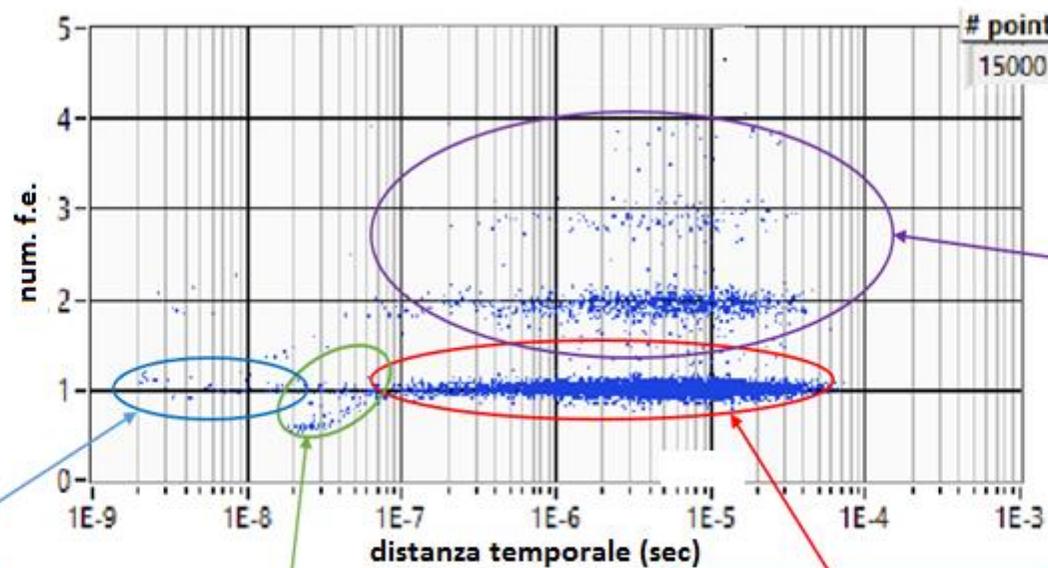


1. Output signal acquired by oscilloscope
2. Pulses identification

Dark measurements



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



Delayed CT

1 nsec - 10 nsec

After Pulse

20 μ sec - 10 μ sec

Primary Dark Counts

Direct CT

30 nsec - 10 μ sec



Use of SiPMs

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

Medical Imaging



Leading coincidence resolving time for best-in-class ToF-PET Performance.

Hazard & Threat



Excellent energy resolution for rapid isotope identification.

3D Ranging & Sensing



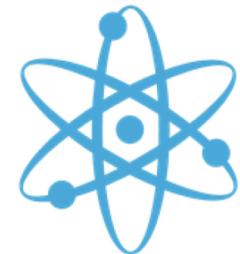
High responsivity red sensors for full daylight operation.

Biophotonics & Sciences



Ultra-low dark count sensors with high detection efficiency.

High Energy Physics

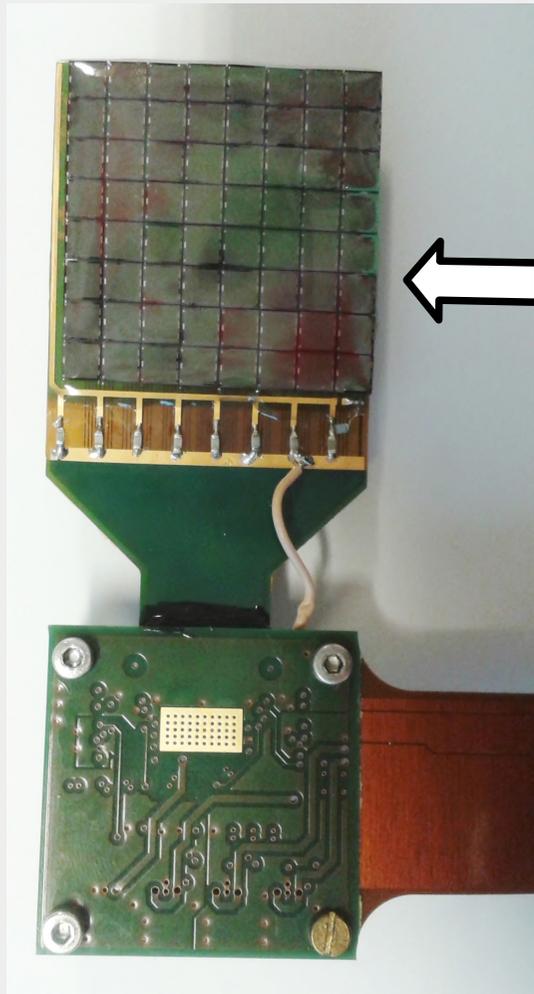


Industry-leading packaging for magnetic and radiopure environments.

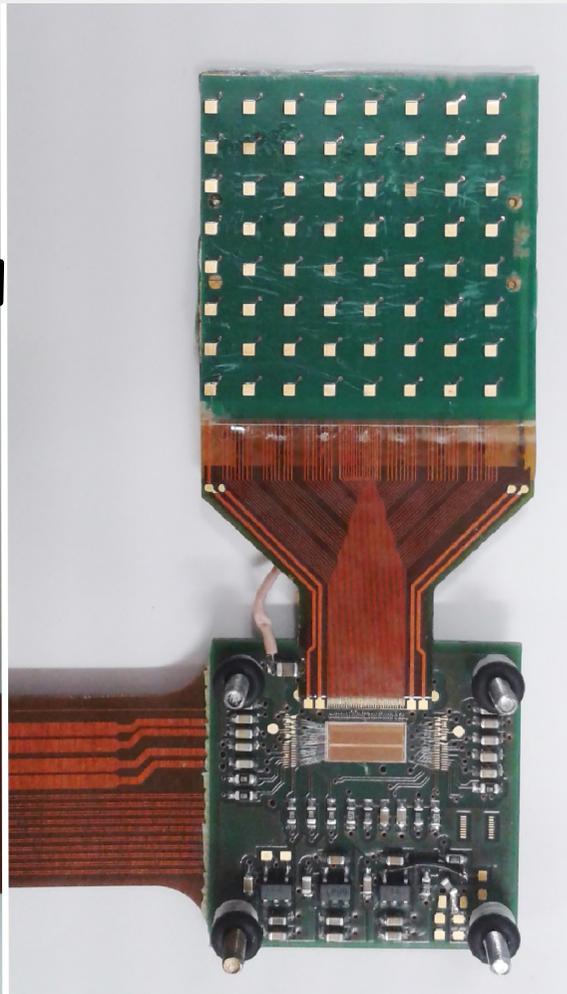
THE 4DMPET PROJECT

Structure of the Module

TOP VIEW



BOTTOM VIEW



Custom SiPM array:

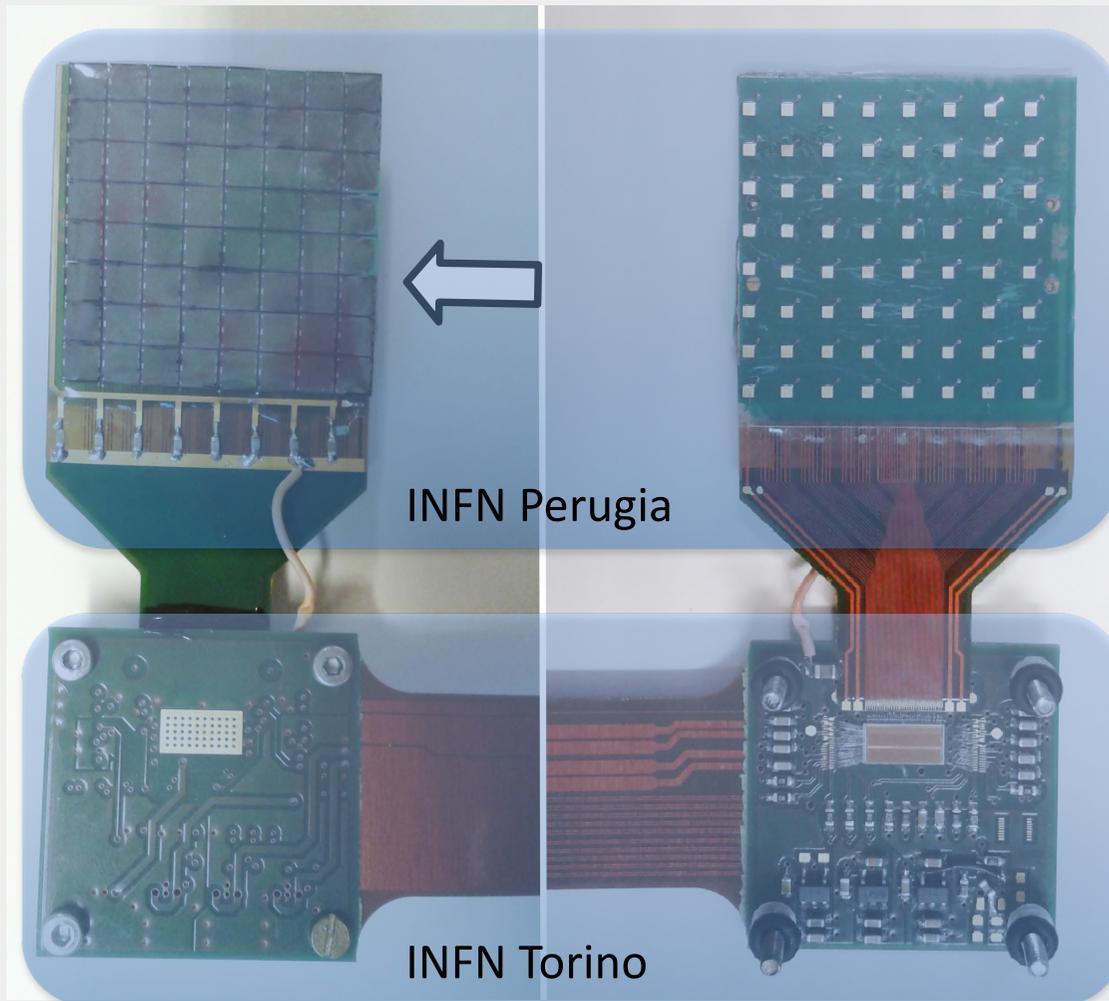
- ✓ 8 x 8 RGB SiPMs from AdvanSiD.
- ✓ 3 x 3 mm² active area
- ✓ 3.6 x 3.6 mm² pitch
- ✓ Signal read-out from the bottom side of the SiPM
- ✓ Bias in daisy chain from the top side (one on each row)
- ✓ 2 side bootable

THE 4DMPET PROJECT

Structure of the Module

TOP VIEW

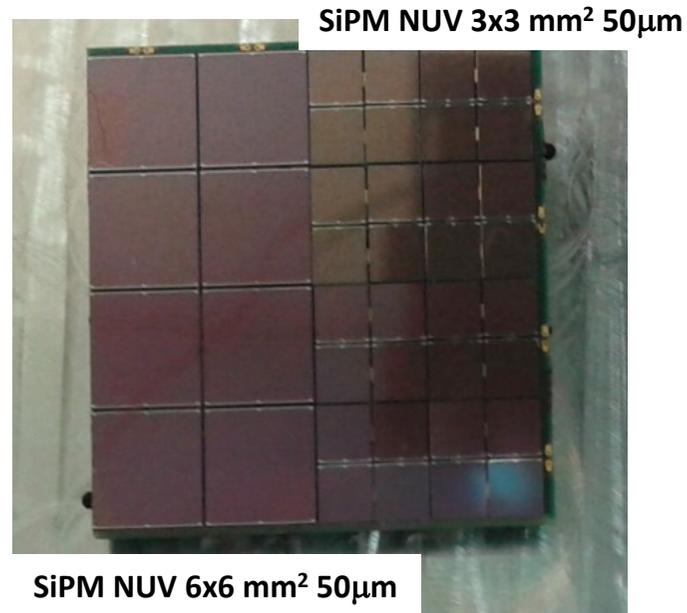
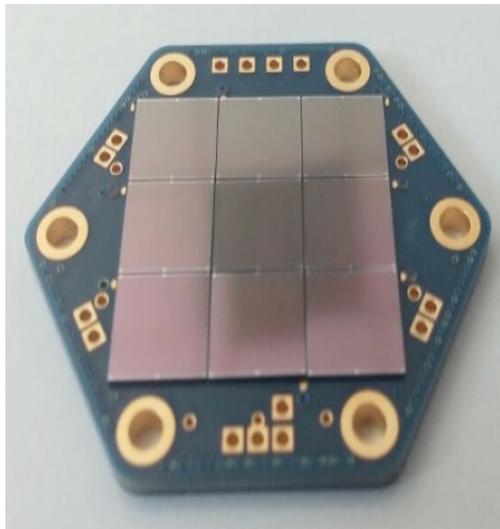
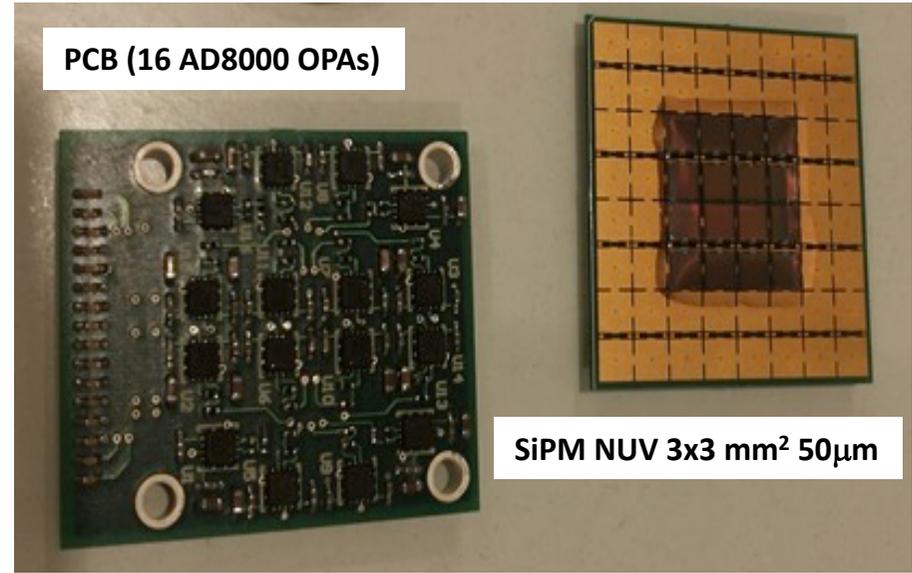
BOTTOM VIEW



Custom SiPM array:

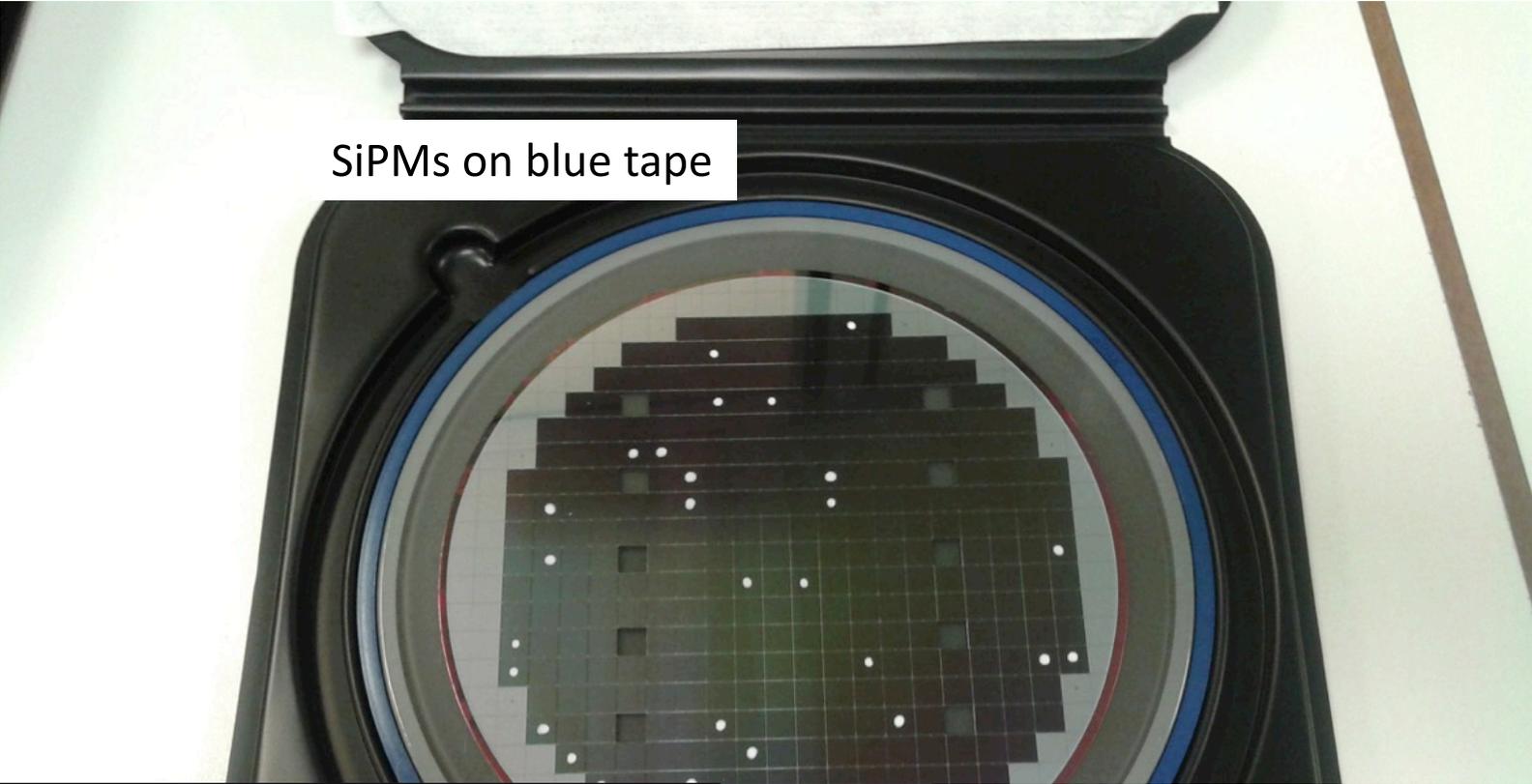
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Assembly examples

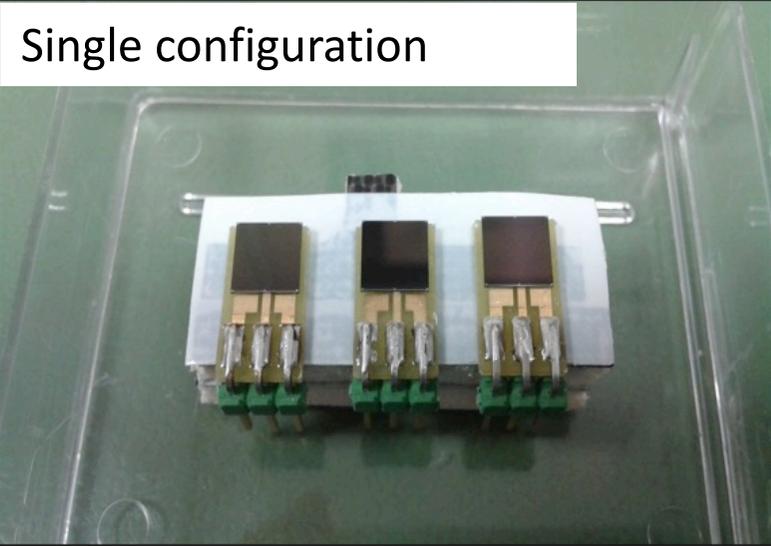


INFN Perugia

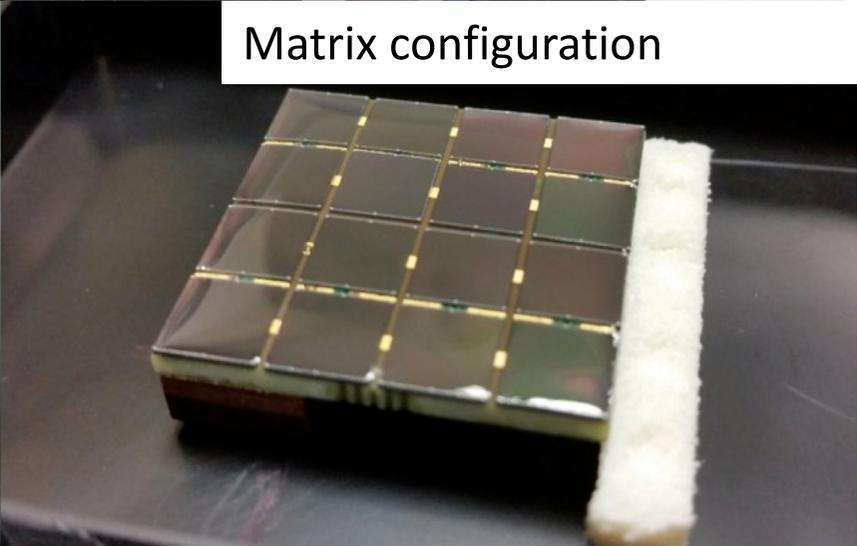
FBK SiPMs NUV – HD 30 mm cell



SiPMs on blue tape

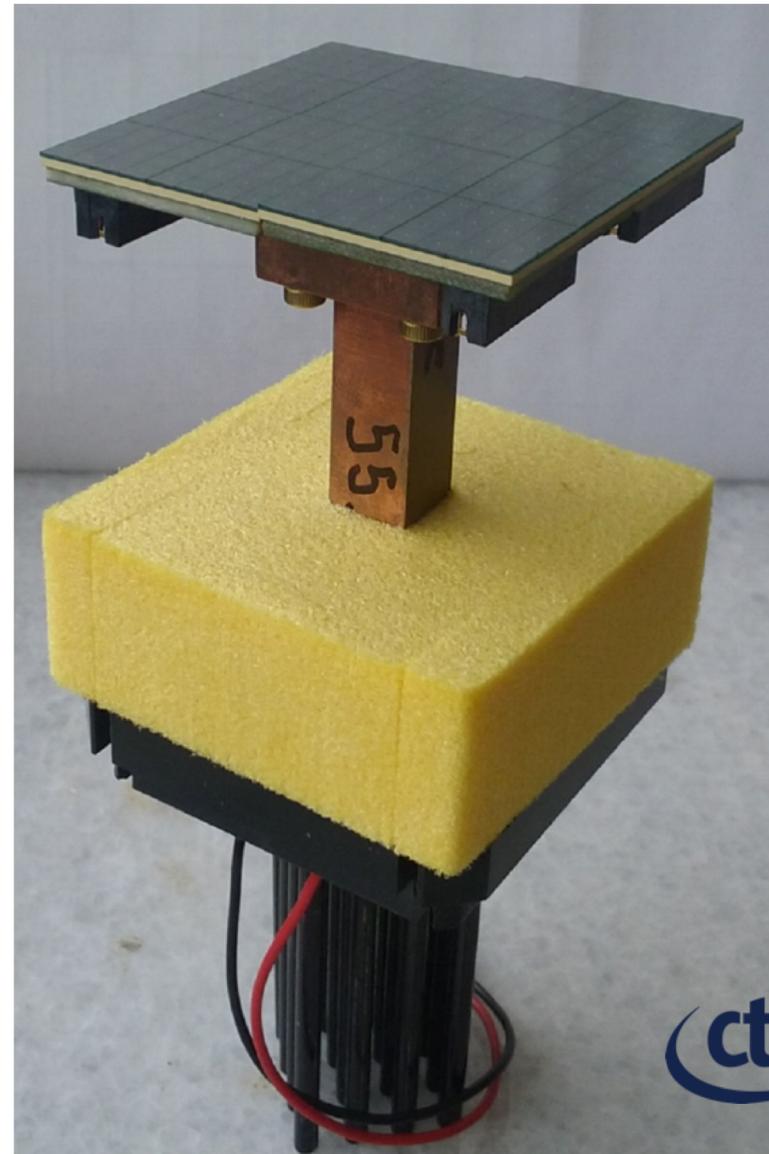
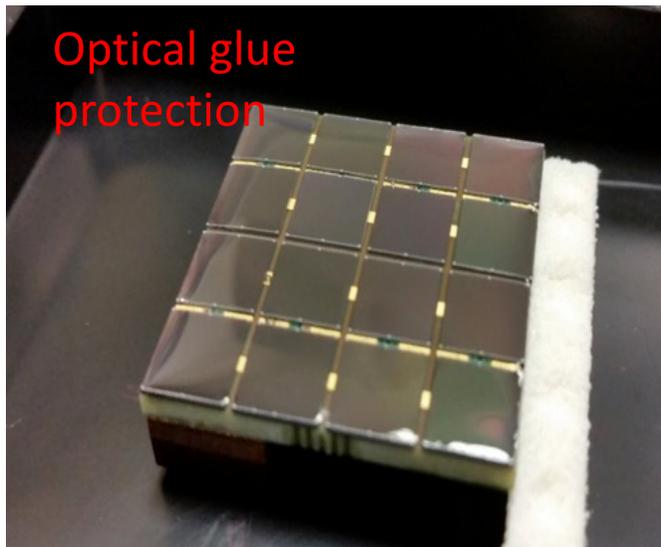


Single configuration



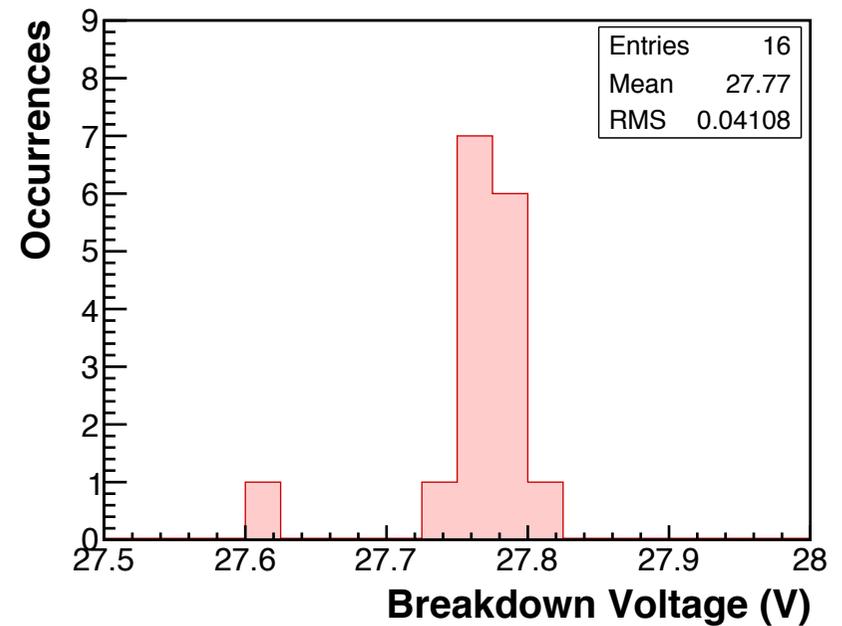
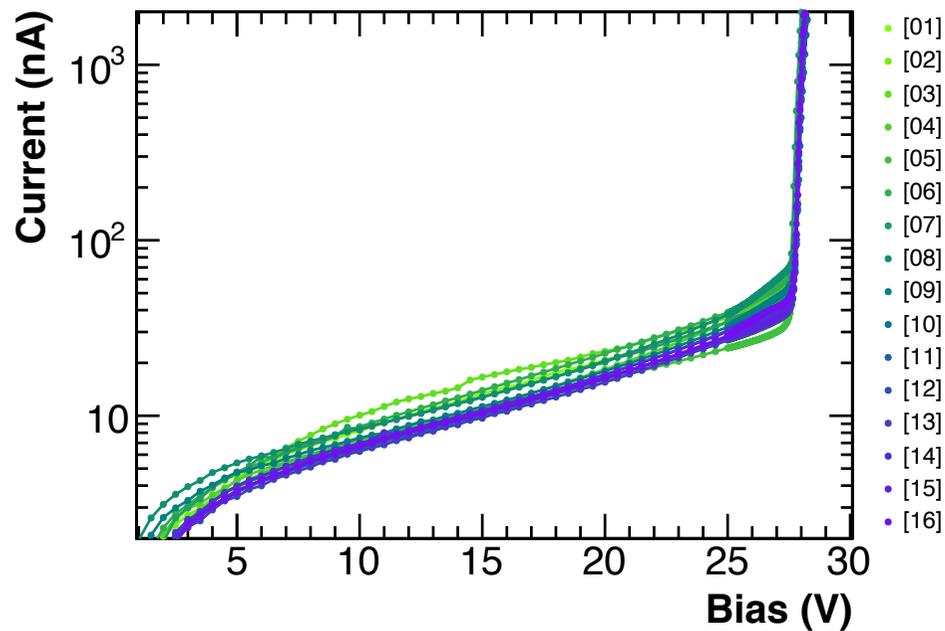
Matrix configuration

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

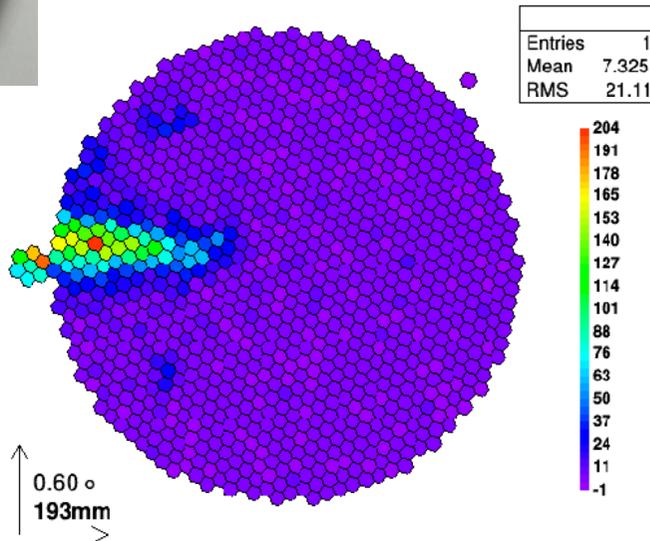
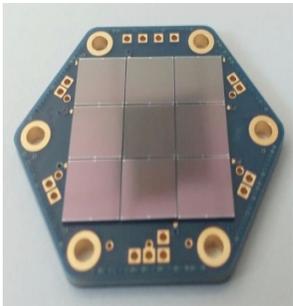
Mechanics Electronics Installation Future



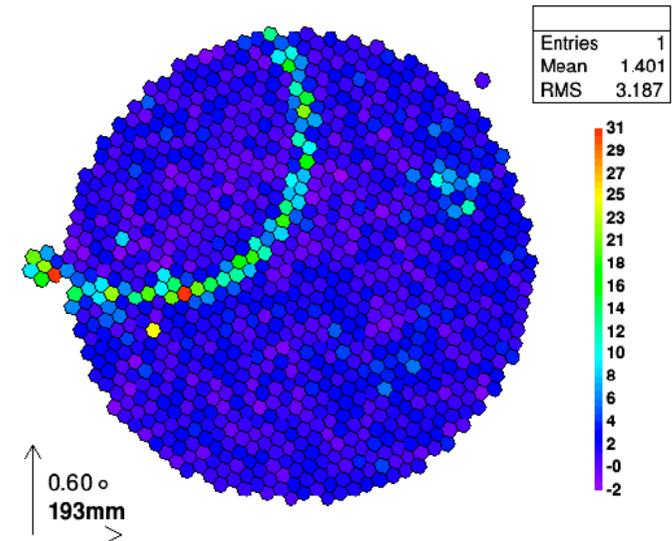
First events



Max-Planck-Institut für Physik
Werner-Heisenberg-Institut



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