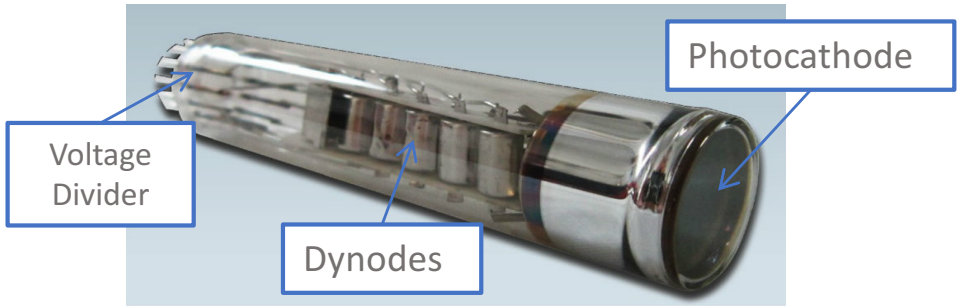
RICH 2018 - MOSCOW

Another step in photodetection innovation: the 1-inch VSiPMT prototype

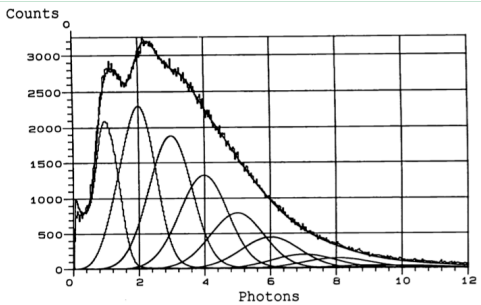
F.C.T. Barbato

Photodetectors: state of the art

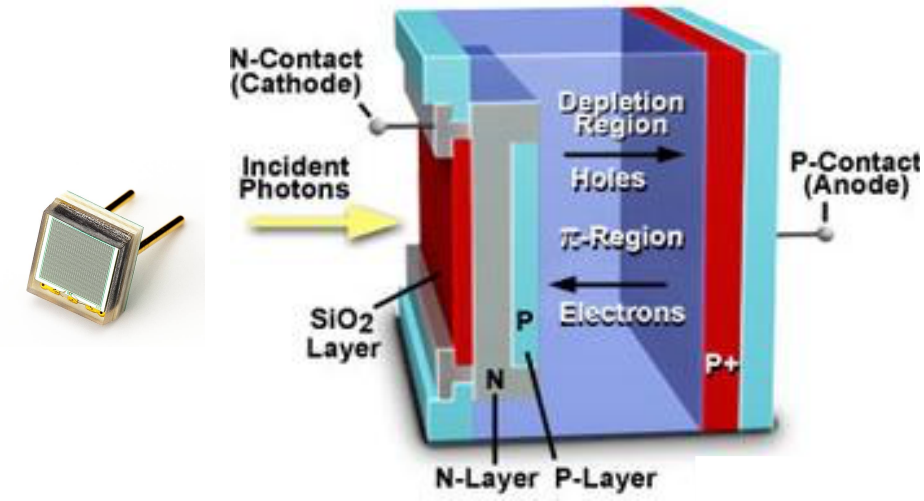
PMTs



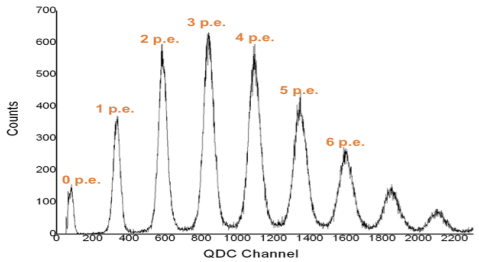
SERIAL GAIN: obtained by multiplying the photoelectrons in the dynodes



SiPMs

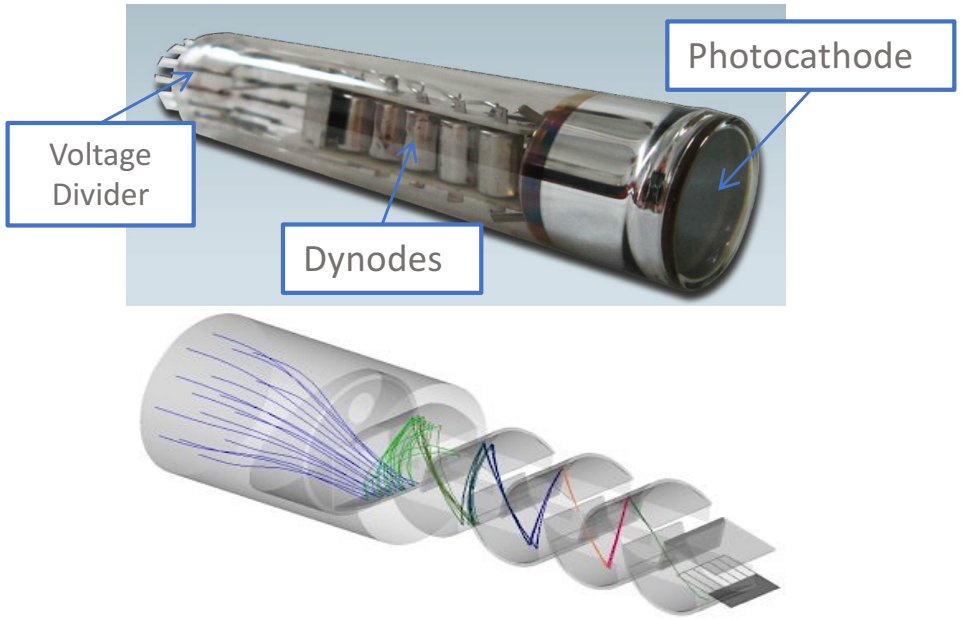


PARALLEL GAIN: obtained with the Geiger-avalanche generated in the p-n junction



Photodetectors: state of the art

PMTs

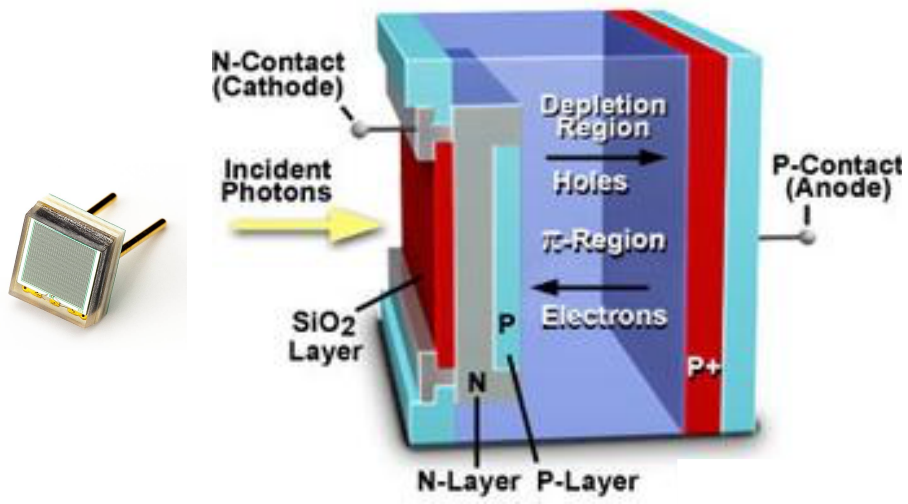


SERIAL GAIN: obtained by multiplying the photoelectrons in the dynodes

CHARACTERISTICS:

- Large sensitive surface (~cm^2)
- Good time performances
- Poor resolution

SiPMs



PARALLEL GAIN: obtained with the Geiger-avalanche generated in the p-n junction

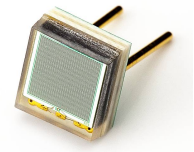
CHARACTERISTICS:

- Small sensitive surface (~mm^2)
- Good time performances
- Excellent resolution

The goal: increase the SiPM surface

PMT

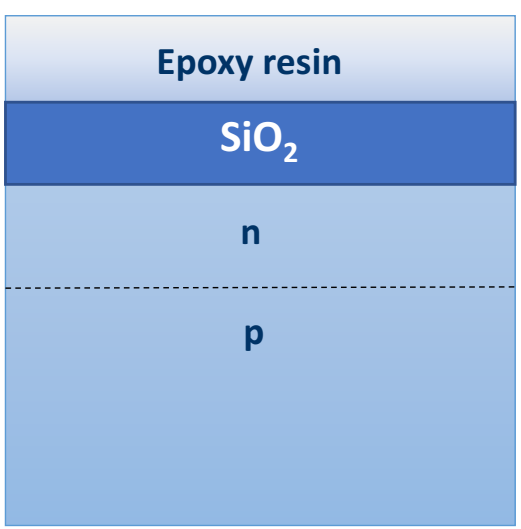
SIPM

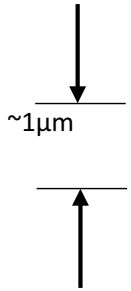


VacuumSiliconPhotoMultiplierTube:
an hybrid solution for a large area photodetector with excellent performances

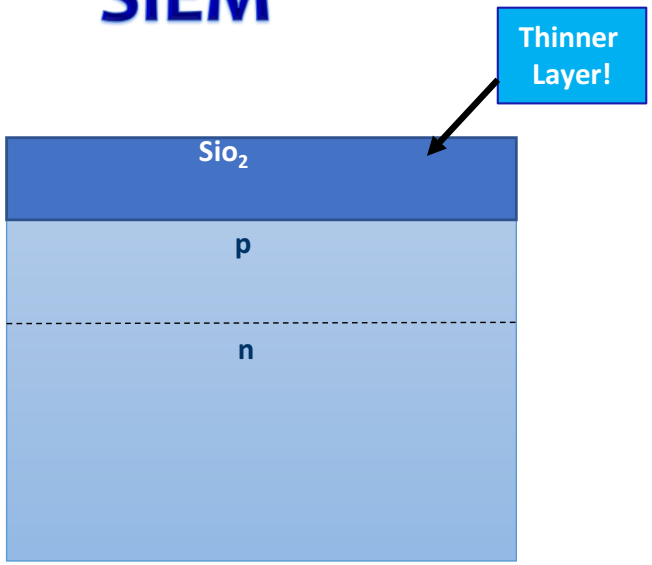
The SiEM

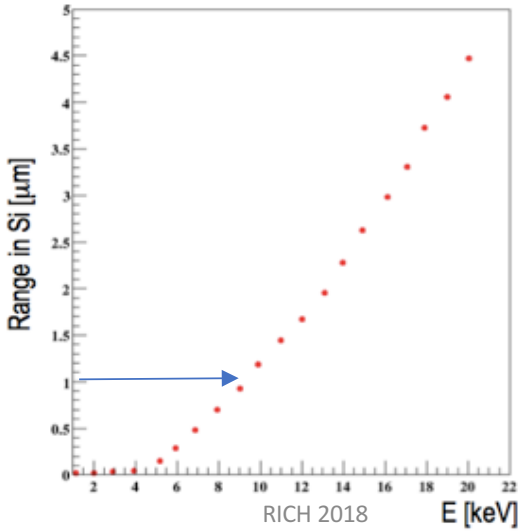
SIPM





SIEM





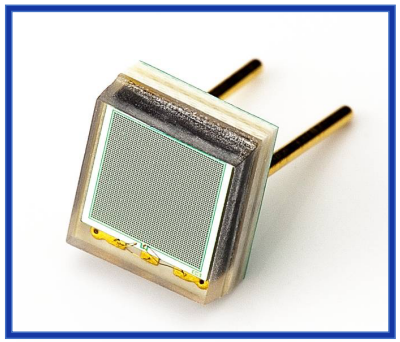
SiEM (Silicon Electron Multiplier)

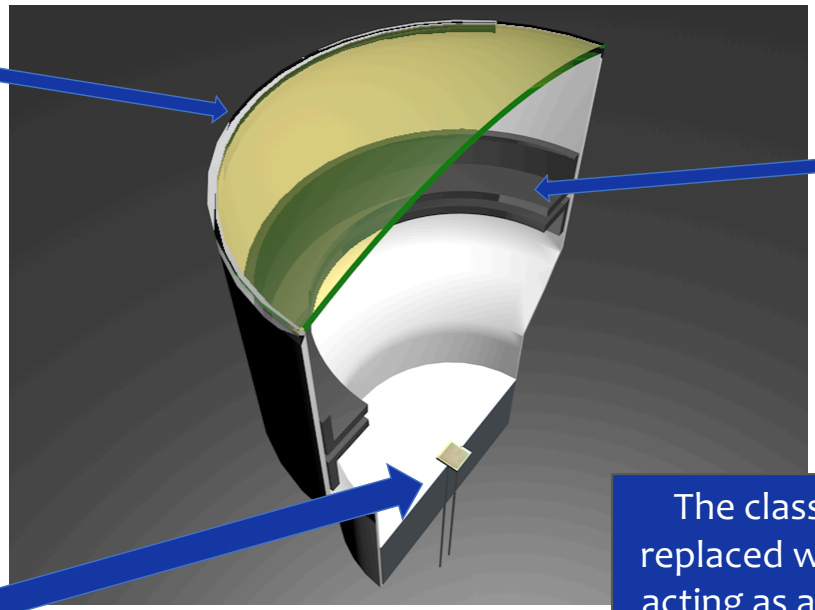
- No epoxy resin
- Thinner SiO_2 layer
- P over n junction

The goal: increase the SiPM surface

Photocathode

SiEM



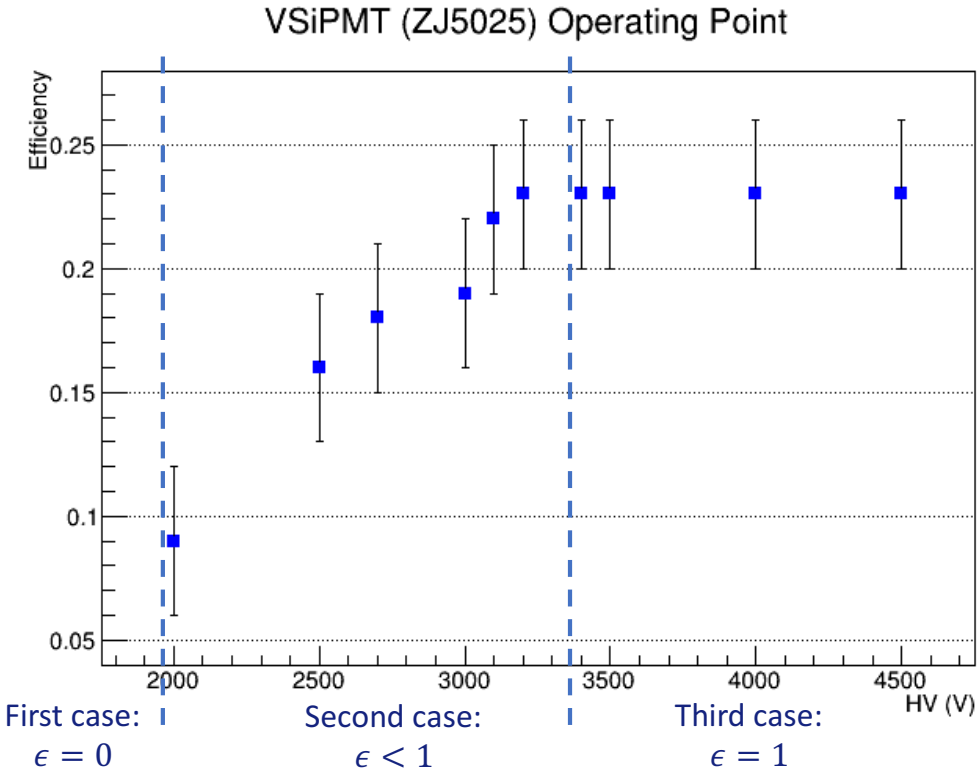


Focusing Ring

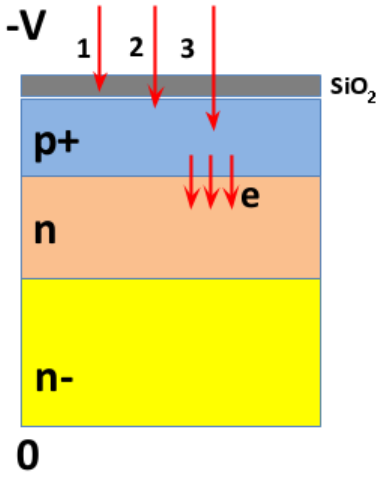
The classical dynode chain of a PMT is replaced with a special windowless SiPM, acting as an electron multiplying detector (SiEM).

An innovative design for a modern hybrid photodetector based on the combination of a Silicon PhotoMultiplier (SiPM) with a hemispherical vacuum glass PMT standard envelope

Work function

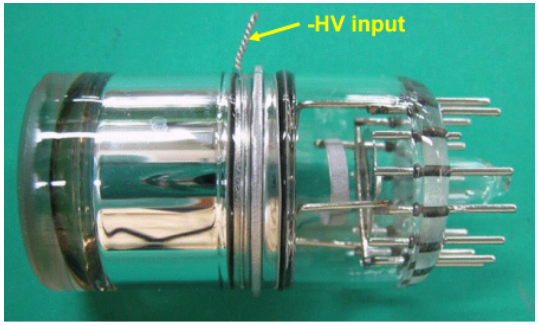


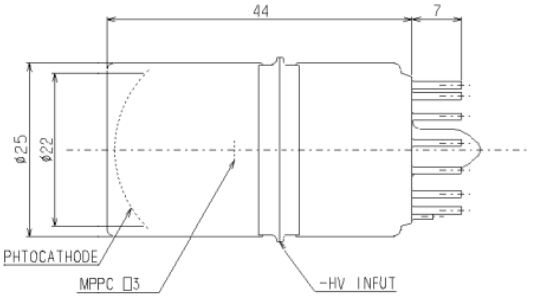
Efficiency is highly stable over 3200 V.
No need for high voltage stabilization.

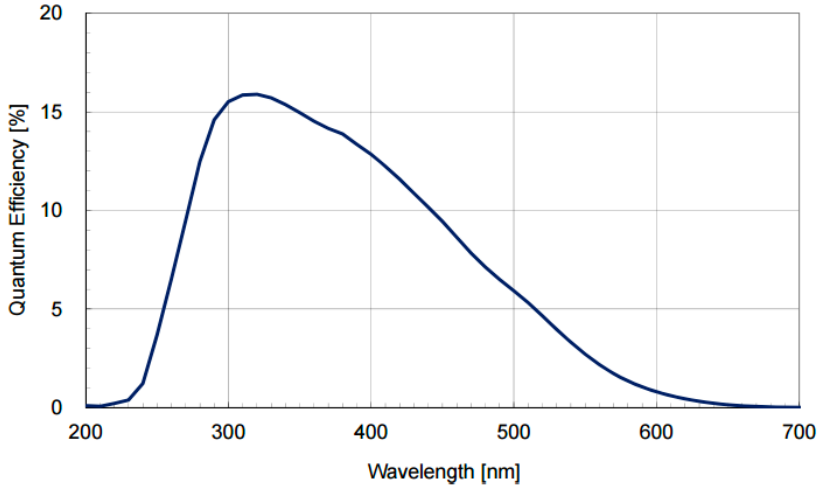


- HV: photoelectron transfer ➡ NO power consumption (NULL current)
- LV-based gain ➡ EASY STABILIZATION
- Reducing the SiO_2 coating layer it will be possible to reach the plateau region at even lower voltages.

The 1-inch prototype







Specifications

Parameter		Value	Unit
Spectral Response		200 to 650	nm
Photocathode	Material	Bialkali	-
	Effective Area	Φ22	mm
Window Material		Borosilicate Glass	-
Target		MPPC 3x3 mm	-

Maximum Ratings (Absolute Maximum Values)

Parameter	Value	Unit
Photocathode Voltage	**-2000**	V dc
MPPC Reverse Bias Voltage at 25℃	**+72.0**	V dc

To avoid trouble, please adjust incident light intensity as low as possible.

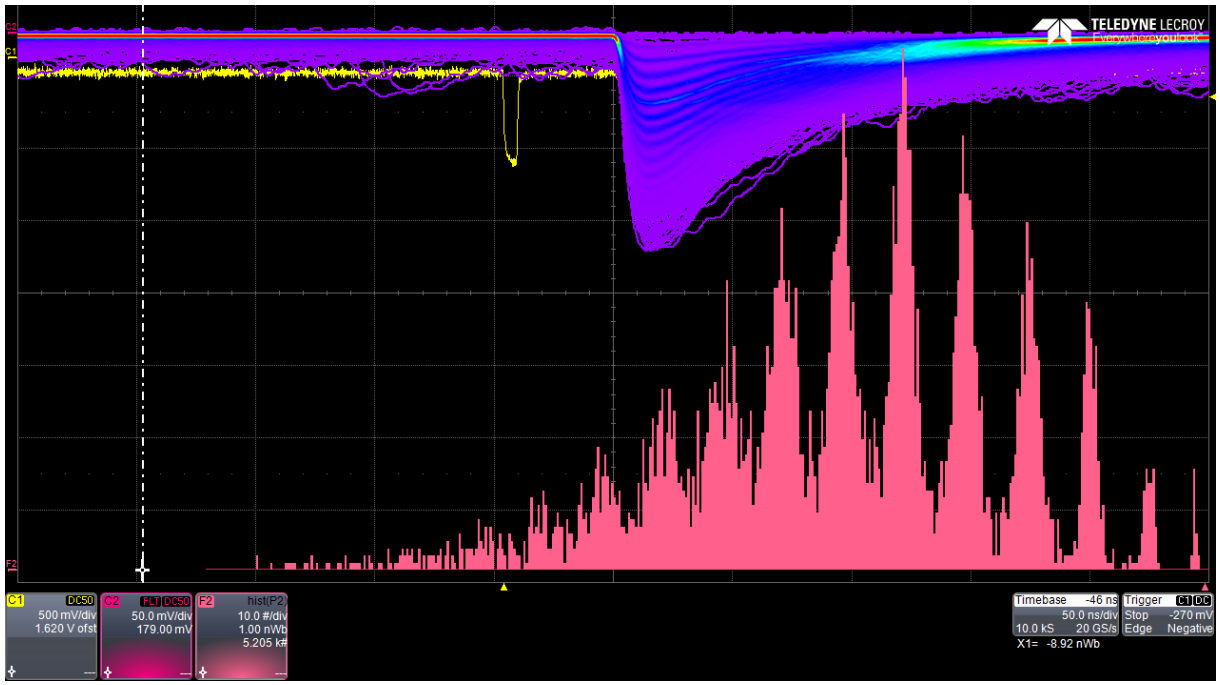
Characteristics (at room temperature)

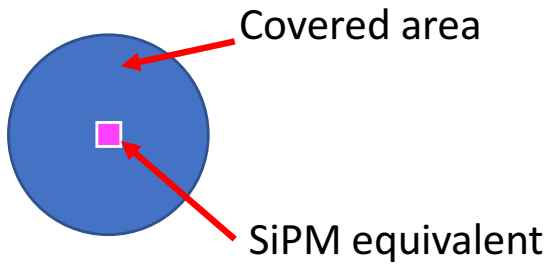
	Pixel Type (μm)	Photocathode Quantum Efficiency*1	MPPC Max. Reverse Bias Voltage	Max. Photocathode Voltage	**Recommended Voltage**
XE2597	100 x 100	15.0 %	+ 72.0 V	-2.0 kV	**-1.5 kV, +71.5 V**

*1 At 350 nm

The photon counting

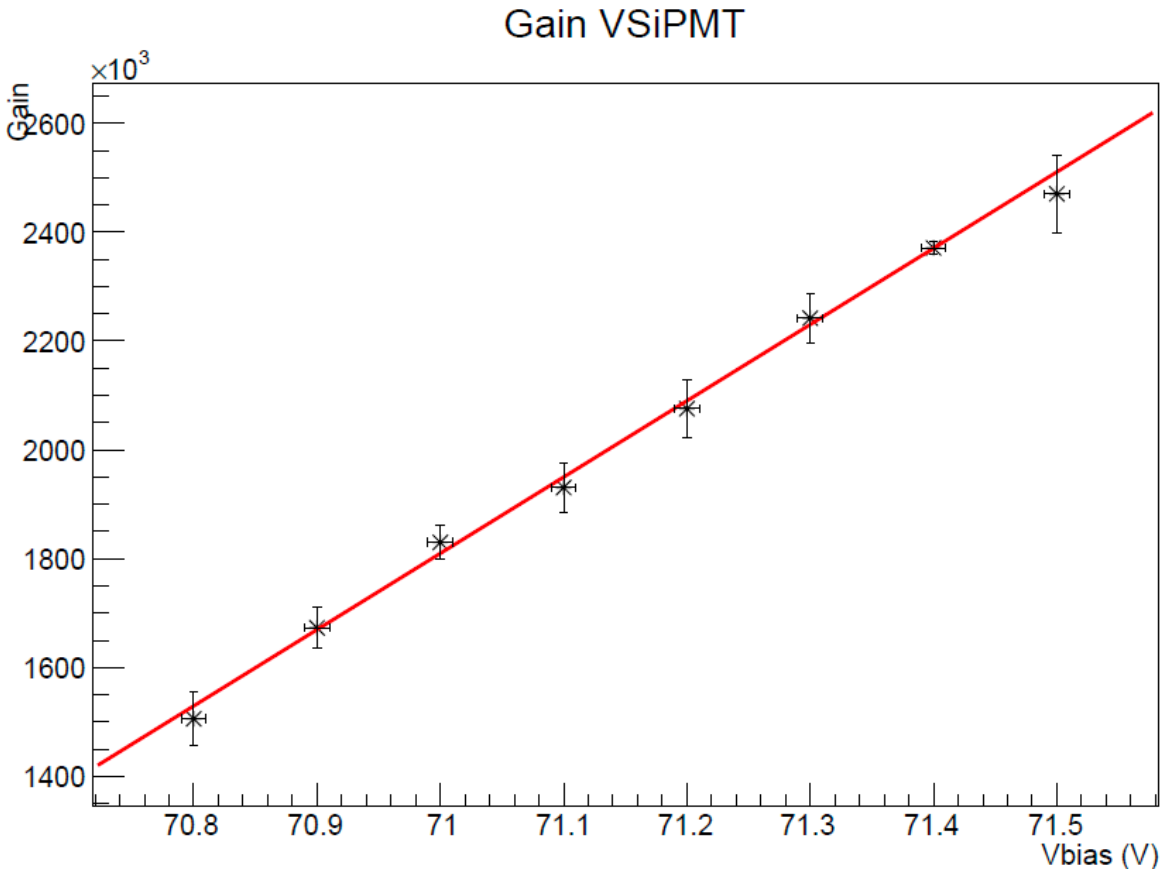
GREAT PHOTON COUNTING!





Another step towards photodetector innovation: the first 1-inch industrial VSiPMT, G Barbarino, FCT Barbato, CM Mollo, E. Nocerino, D. Vivolo, Fukasawa Astroparticle Physics (2018)

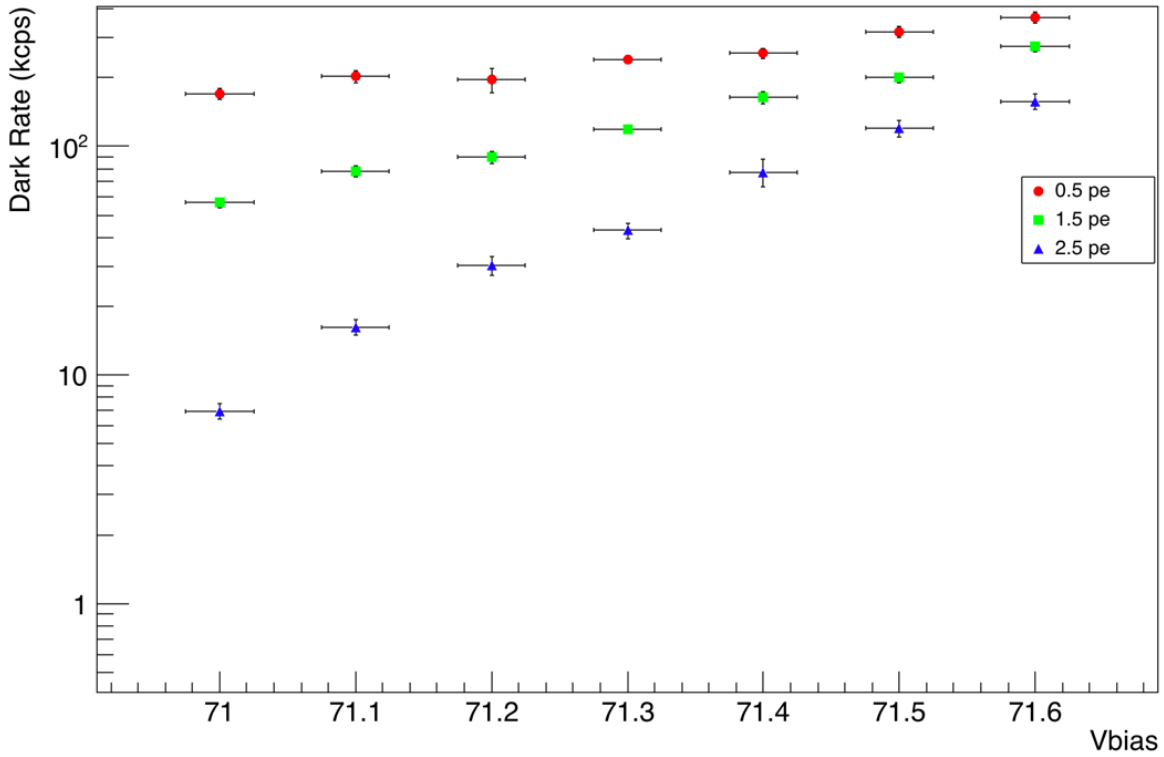
The gain



SAME GAIN OF THE SIEM!

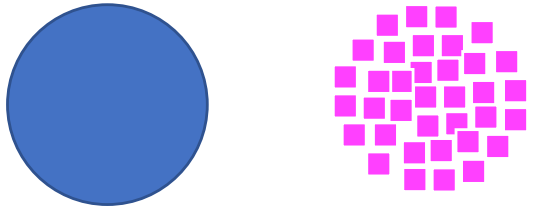
HV NEEDED ONLY FOR FOCUSING

The dark noise



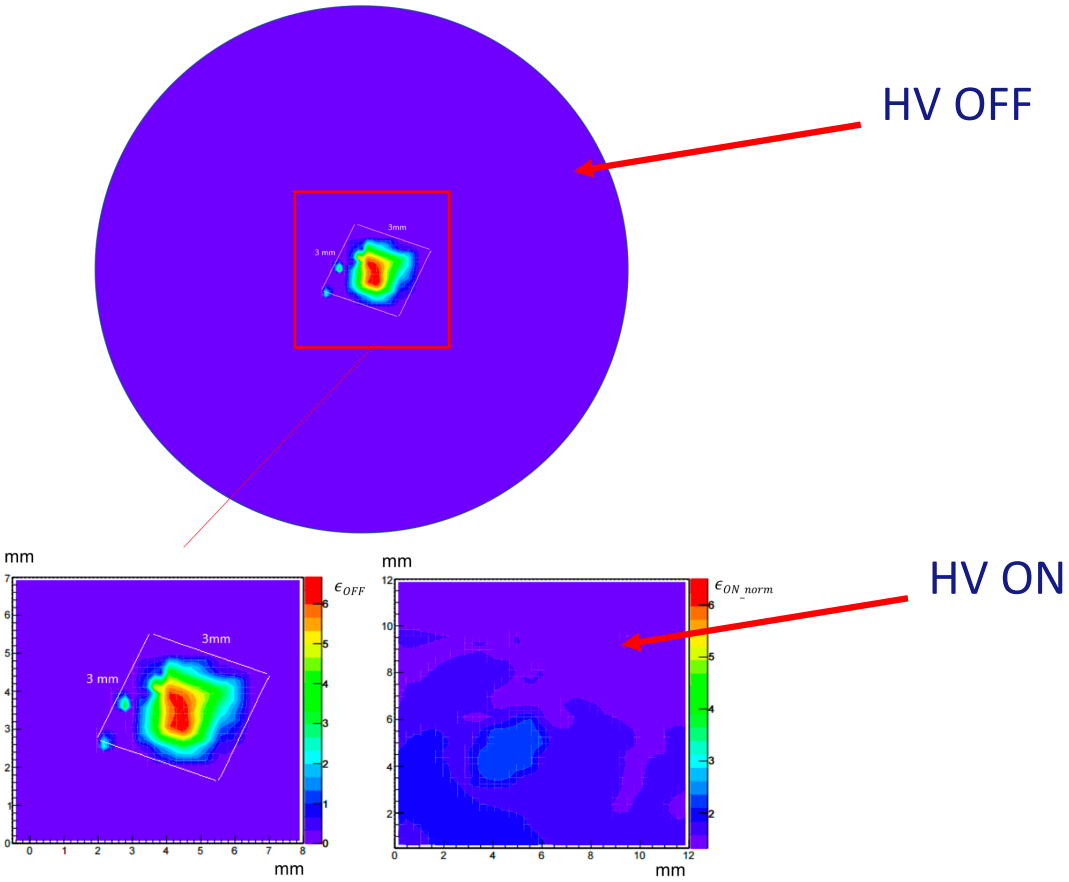
SAME NOISE OF THE SIEM!

COVERING LARGE AREA WITH THE SAME RESPONSE OF SIPMS BUT THE NOISE OF ONLY ONE!



REDUCTION OF THE EQUIVALENT NOISE

Photocathode scan



The SiEM is also sensitive to photons

We want to evaluate this over efficiency effect

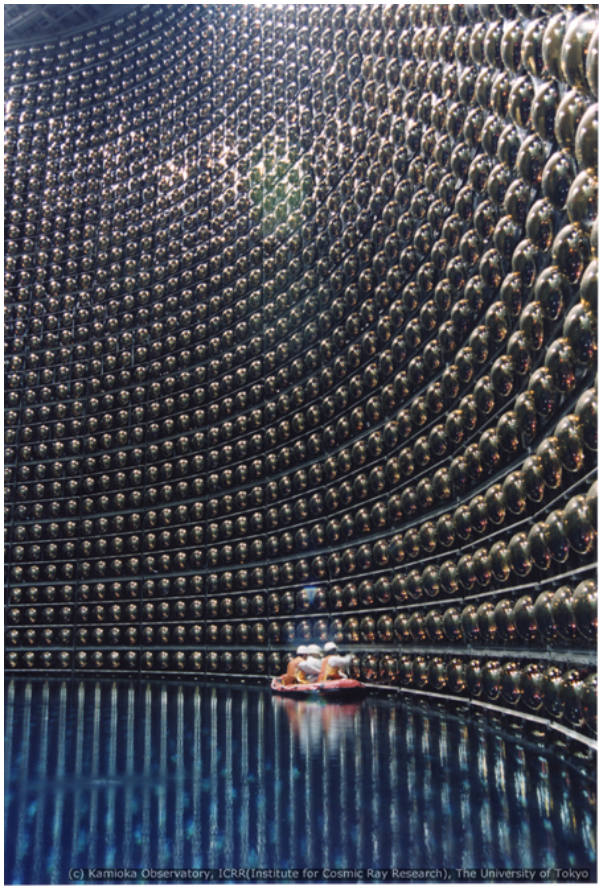
By turning on the HV the homogeneity of the photocathode is 90%

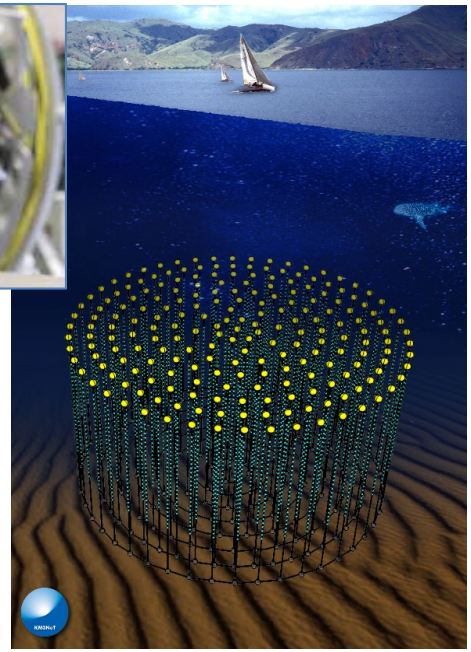
The new industrial prototype

2-INCHES BY HAMAMATSU CURRENTLY UNDER TEST IN NAPLES

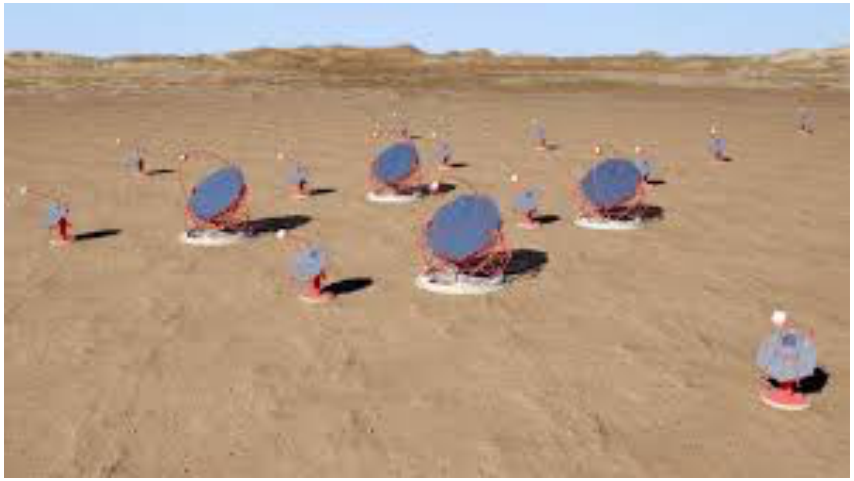
Development of a new 2-inch hybrid photo-detector using MPPC.
A.Fukasawa[a]Y.Hotta[a]T.Ishizu[a]Y.Negi[a]G.Nakano[a]S.Ichikawa[a]T.Nagasawa[a]Y.Egawa[a]A.Kageyama[a]I.Adachi[b]G.Barbarino[cd]F.C.T.Barbato[cd]L.Campajola[c]R.de Asmundis[d]F.Di Capua[cd]C.M.Mollo[d]E.Nocerino[c]D.Vivolo[d]…G.De Rosa[cd]
NIM-A (2017)

Applications





Next future Cherenkov photon counters



Applications

PMT

VSiPMT

Conclusion

The VSiPMT is an idea born in Naples in 2007 to fulfill the requirements of current and next future astroparticle experiments.

The first proof of concept of the device dates back to late 2012. It was made testing a special SiPM with an electron beam at the Physics Department of the University of Naples.

One year later the first industrial prototype has been realized by Hamamatsu Photonics and tested by our group.

Today the VSiPMT project is financially supported by the Italian Space Agency.
Within this panorama a 1-inch prototype acting in the VUV region has been realized by our group.

A 1-inch prototype manufactured by Hamamatsu Photonics has been tested and a 2-inch is currently under test.

We are confident that the VSiPMT will be a reality for the next future experiments!

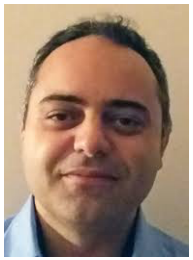
Thanks

Prof. G. Barbarino –
Inventor of VSiPMT

The VSiPMT research group

G. De Rosa

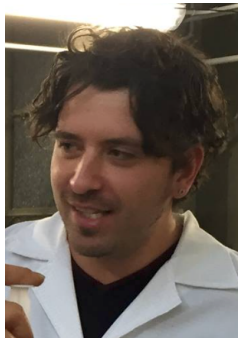
R. de Asmundis



F. Di Capua

L. Campajola

P. Migliozzi



D. Vivolo

C.M. Mollo

F.C.T. Barbato

SPECIAL THANKS TO HAMAMATSU FOR SUPPORTING OUR IDEA!