# SiPM development for the TOP detector upgrade of the Belle II experiment

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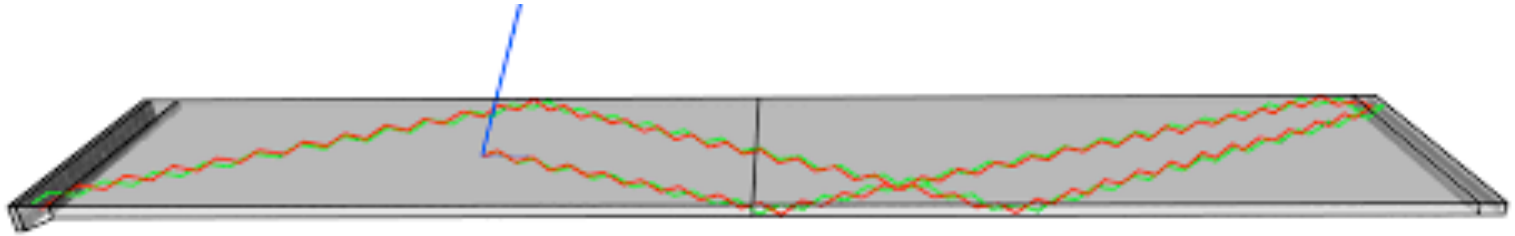
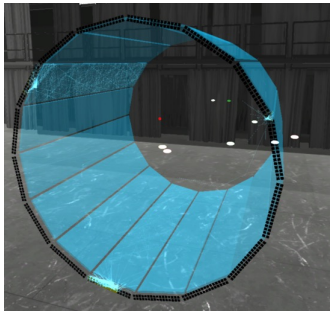
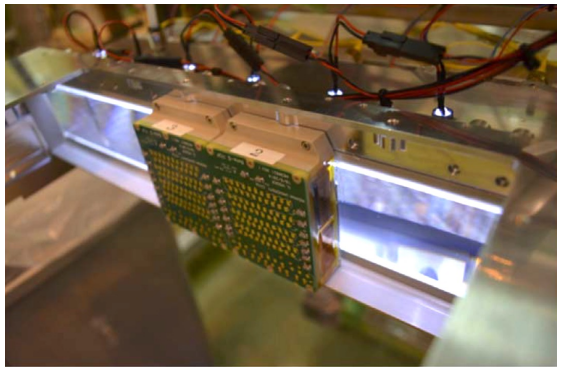
The **T**ime **O**f **P**ropagation is the particle identification detector in the barrel region of the Belle II experiment
The detector uses quartz bars acting as Cherenkov radiators and MCP-PMTs as photodetectos.



**Quartz Prism** **Quartz radiator** **Mirror**



For every TOP module 32 MCP-PMTs 16ch
1 in$^2$ are optically coupled to the prism

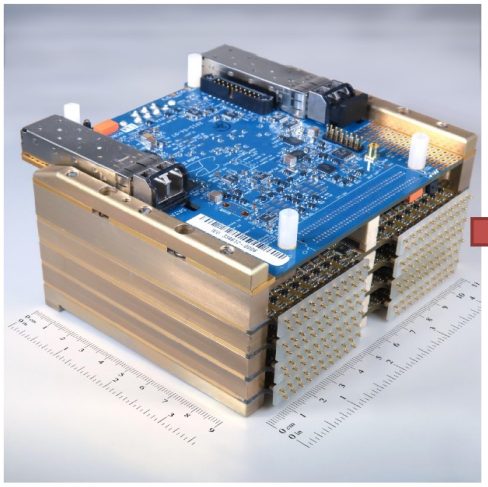


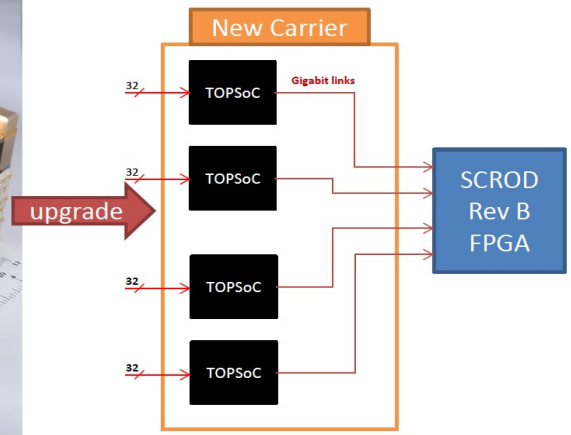
Three generations of MCP-PMT are currently installed in the TOP detector. Long shutdowns of the SuperKEKB accelerator in 2023 and 2027 will be used to upgrade the detector with the last generation of MCP-PMT.

Many improvements in SiPM production technology have been achieved in the last years. Using SiPM as a photodetector is the backup plan for the 2027 upgrade and the primary option for following upgrades with higher luminosity and higher background.

# Electronics upgrade

Replacement of MCP-PMT with SiPM will require to upgrade the electronics.



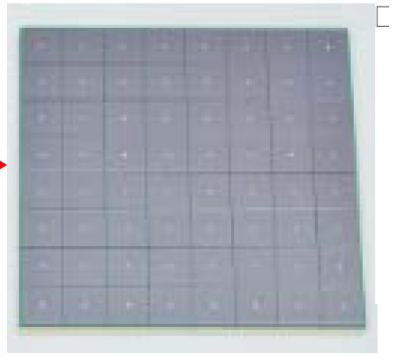



IRSX **ASIC 8-channel** 250 nm CMOS will be replaced with TOPSoC **ASIC 32-channel** 130 nm CMOS.

The total number of channels will be increased from 8192 to 32768. Developments of new boards are ongoing at the University of Hawaii

MCP-PMT
16 ch, 1 in$^2$

MPPC (SiPM array)
64 ch 3x3 mm$^2$



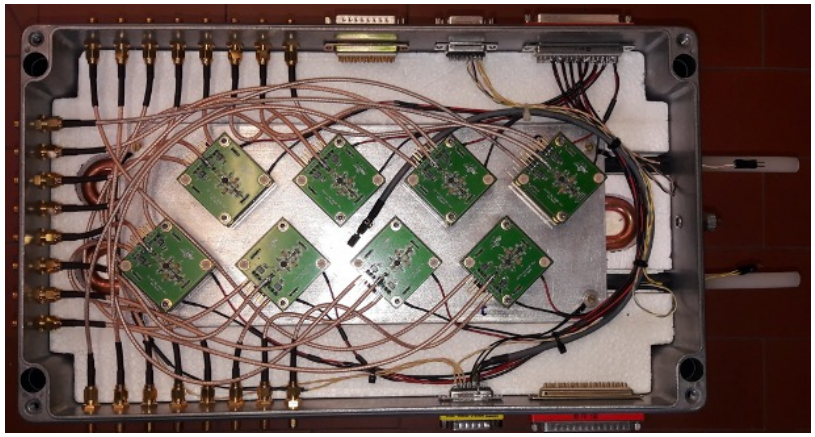
SiPMs compared to MCP-PMTs have higher dark count rate (DCR).

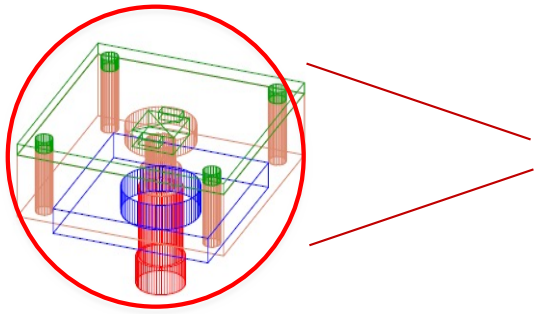
Radiation damages will increase DCR, the effect can be mitigated by lowering the temperature.

# SiPM test in Padova: setup

Tests are ongoing in Padova to measure the characteristics of the SiPMs in the market
1) for different temperatures 2) before and after irradiation.

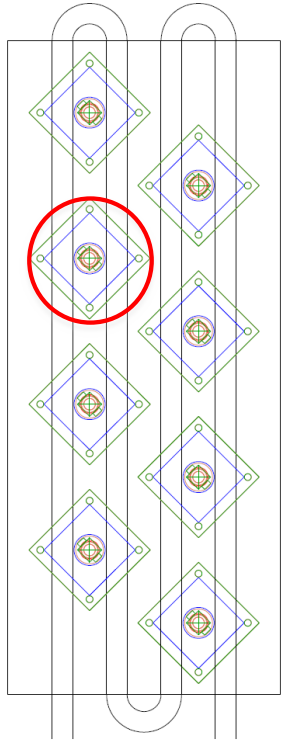
Dark box with SiPM blocks





PCB Amplifier
PCB SiPM with T sensor
PCB peltier

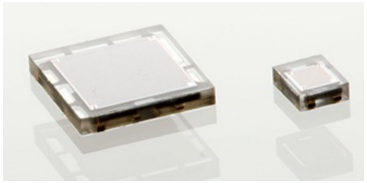
SiPMs illuminated with picosecond laser
T from +20 °C to -50 °C



Cooling plate
(glycolate water)

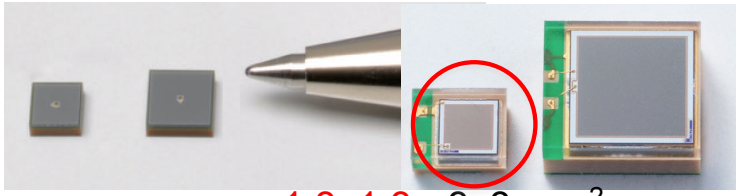
Available SiPMs to be tested

OnSemi (35μm)



1x1 - 3x3 mm$^2$

Hamamatsu (15-25-50 μm)

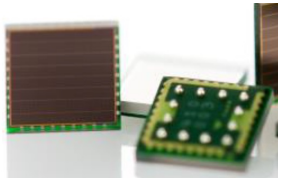


1.3x1.3 - 3x3 mm$^2$

FBK (15μm)

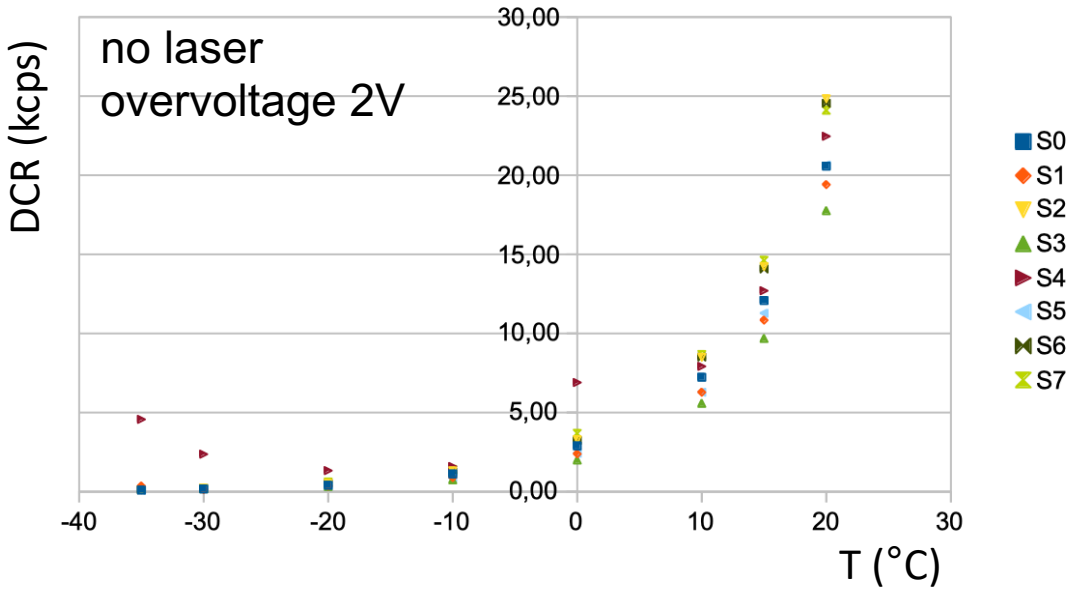
1x1 - 3x3 mm$^2$

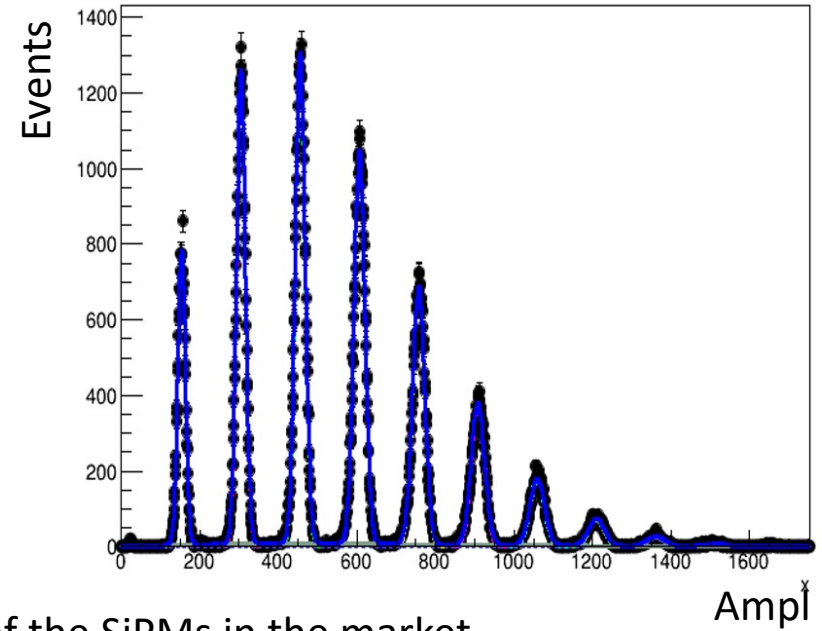
Ketek (15-35 μm)



3x3 mm$^2$

# SiPM test in Padova: first results

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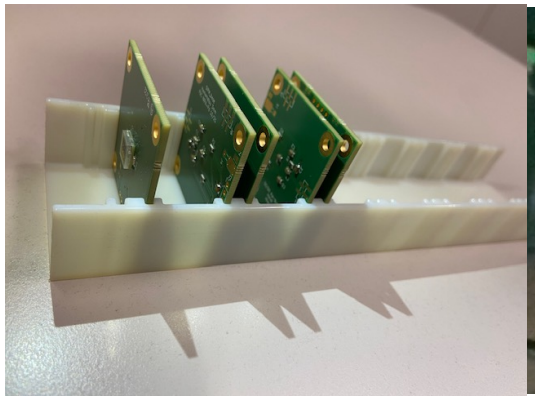

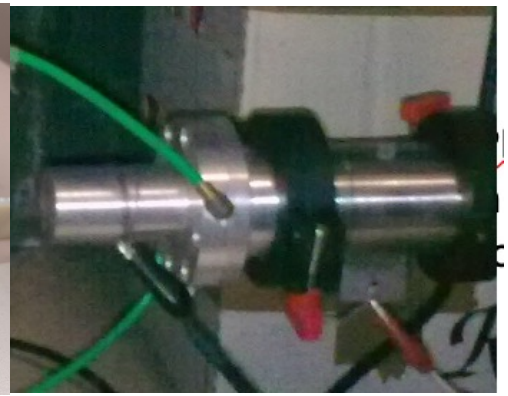

In November 2022 SiPMs will be irradiated at the LNL CN neutron beam facility with neutron fluxes from $1x10^{+09}$ to $5x10^{+11}$ neutrons/cm$^2$

SiPM development in collaboration with FBK is inside the AIDAinnova project in the framework of WP 8 task 8.4.1.