SiPM upgrade for Belle II TOP

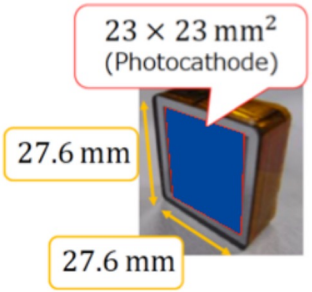
Baseline plan for LS2 (>2027) is replacement of ALD by life-extended ALD MCP-PMTs.

- Production plan is ongoing.
- First 90 MCP-PMTs was delivered
- The tests are ongoing
- Funding for the next years under discussion

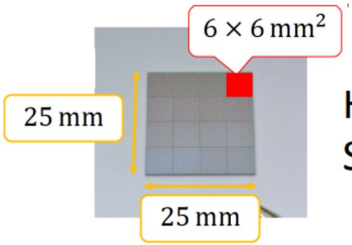
JFY	2021	2022	2023	2024	2025
Production	30	60	60	60	10

Another solution is replace MCP-PMTs by MPPC (SiPM)

1 MCP-PMT
27.6 x 27,6 mm²

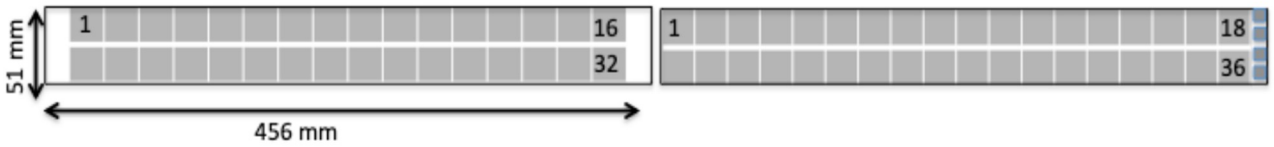


1 MPPC (SiPM)
4x4 channels
6 x 6 mm² / channel



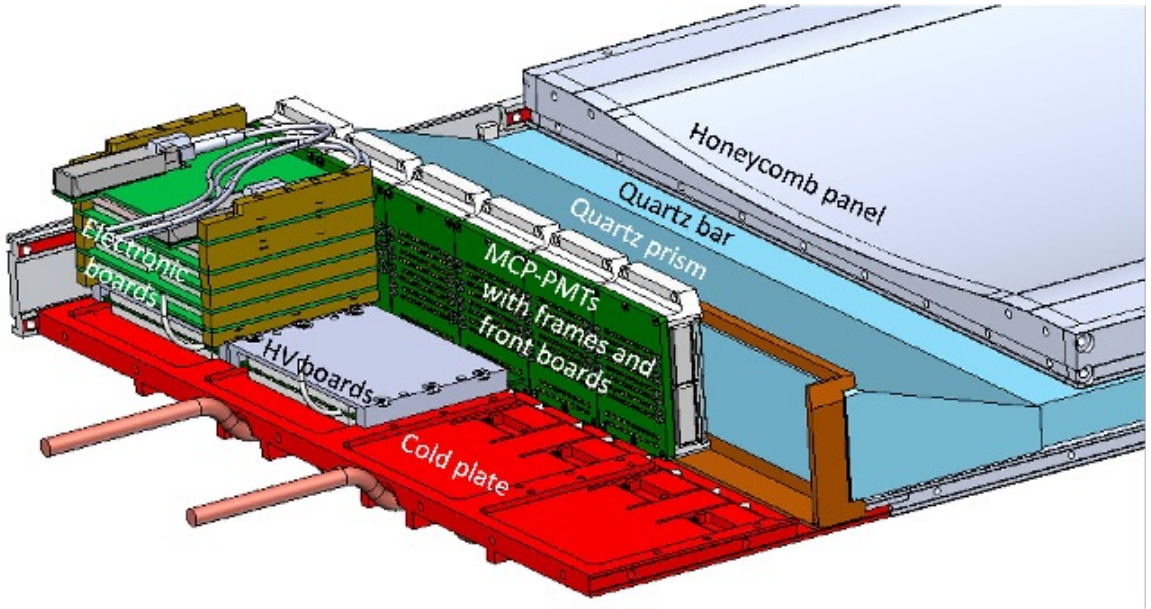
Hamamatsu
S13361-6050

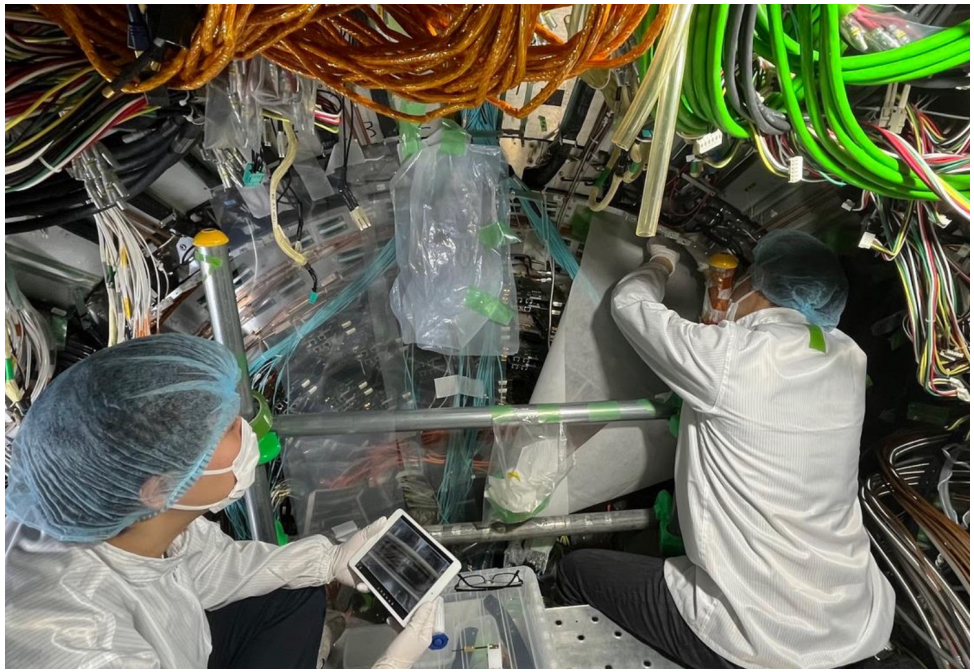
Global effective area **MCP-PMT** 73% **SiPM** 90%



- N_{ch} = 16 x 32 x 16 = 8192
- SiPM 6x6 mm² -> N_{ch}
- SiPM 3x3 mm² -> 4*N_{ch}
- SiPM 1x1 mm² -> 36*N_{ch}

Fig. 1 Upgrade CDR TOP





The back side of one TOP module where electronic boards and photodetectors are interfaced with the quartz prism and quartz bar.

Upgrade options must consider the limited space available in the back region.

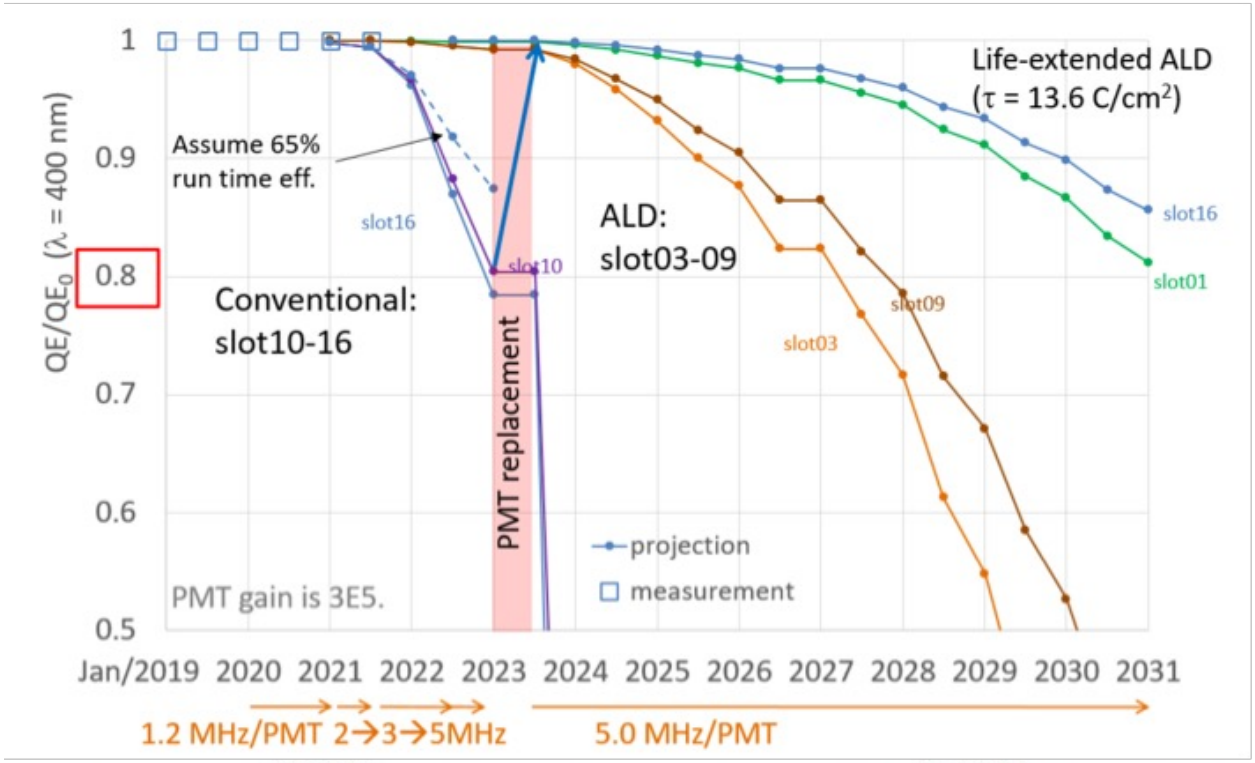


Fig. 2 Upgrade CDR TOP

Projection of QE degradation for three different generation of MCP-PMTs. MC expected background was considered for the components related to the luminosity and a maximum of 5 MHz/PMT for the other components (beam-gas, Touschek).

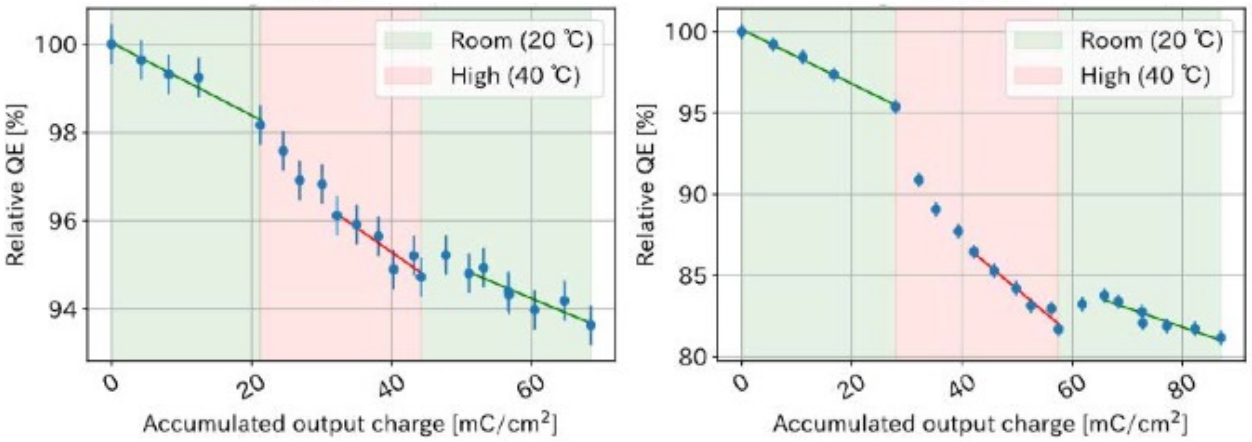
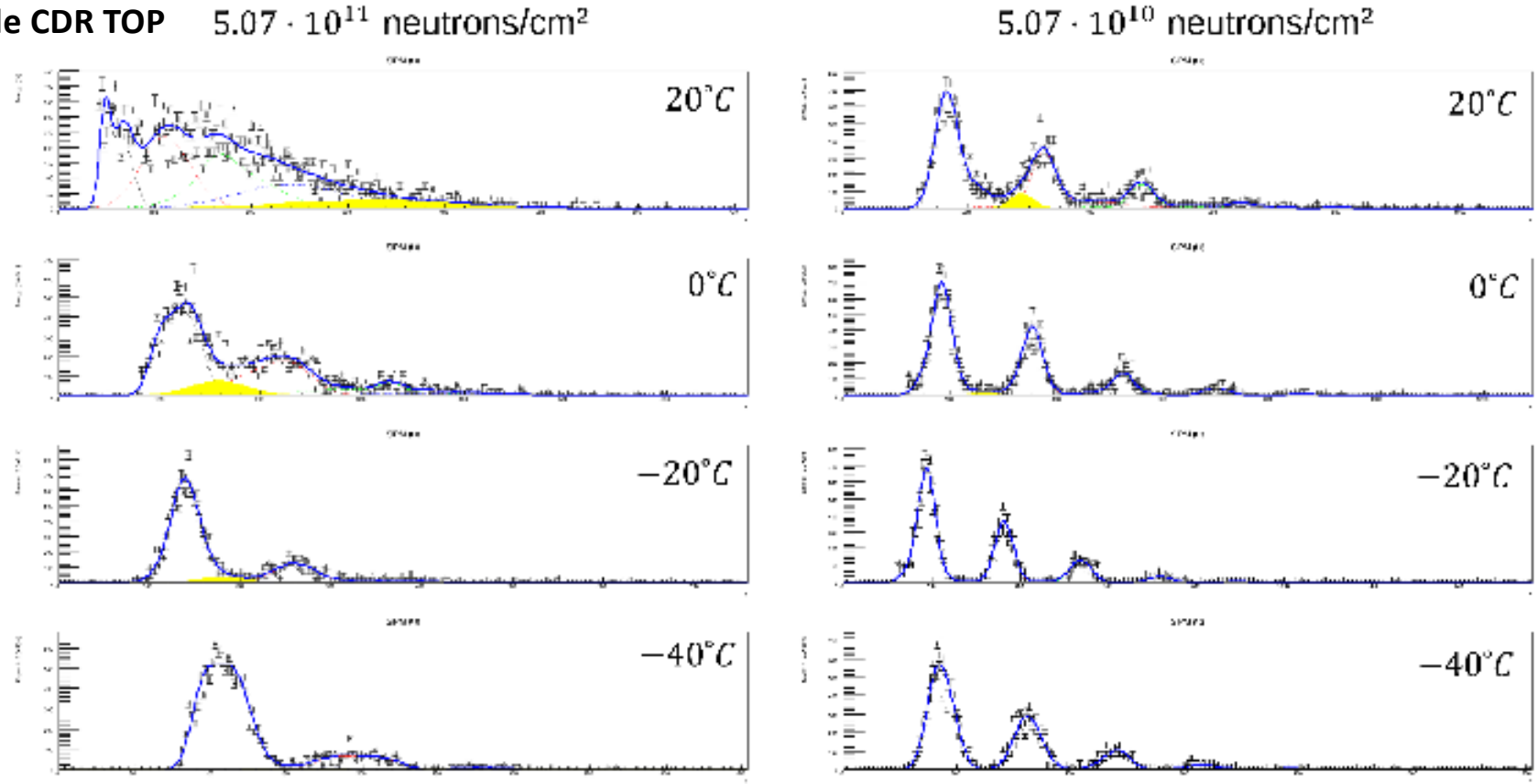


Fig. 3 Upgrade CDR TOP

Relative QE degradation as a function of the accumulated charge at 20 °C and 40 °C for two conventional MCP-PMTs

The expected neutron rate near the the photodetector region at the target instantaneous luminosity
Of 6 x 10^{35} cm^{-2} s^{-1} is about 2.0 x 10^{10} neutrons / (cm^2 year)

Fig. 4 Upgrade CDR TOP

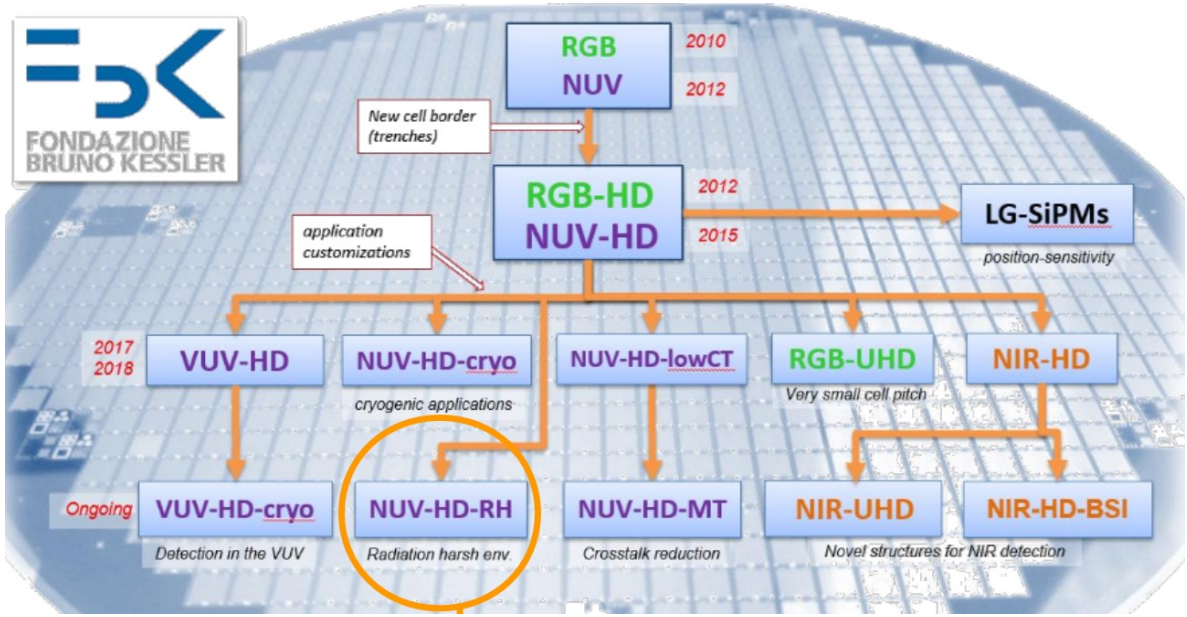


Single photon spectrum for Hamamatsu SiPM S13360-1350PE (1.3x1.3 mm^2 50 μm cells)
for an irradiation of 5.07 10^{10} neutrons/cm^2 and 5.07 10^{11} neutrons/cm^2 at different temperatures.

Test with different SiPM producers, cell sizes and dimensions are ongoing:

FBK (NUV-HD-RH-3015 , NUV-HD-RH-1015) KEKTEX (PM3315-WL , PM3335-WL)

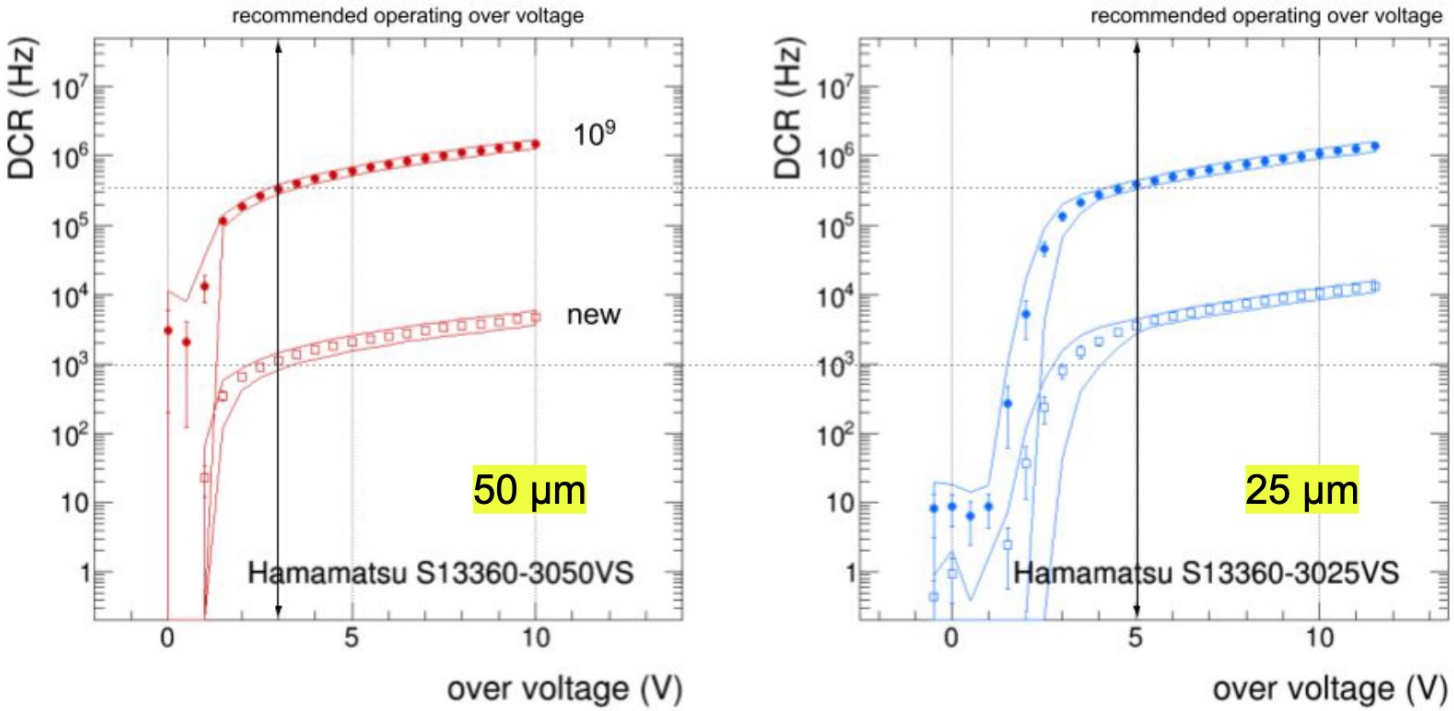
OnSemi (10035, 30035) Hamamtsu SiPM (S14160-3050HS)



FBK NUV-HD-RH have low field technology and small cell size

New SiPM development by FBK with AIDAinnova funds, will be ready for May 2024

R. Preghenella, INFN Bologna, Phose2023 workshop



Hamamatsu SiPM 3x3 mm^2 50 µm and 25 µm cells

Sensors with 50 µm sensors have lower DCR than 25 µm when new
Both sensors have similar DCR after 10^9 neutrons / cm^2 irradiation