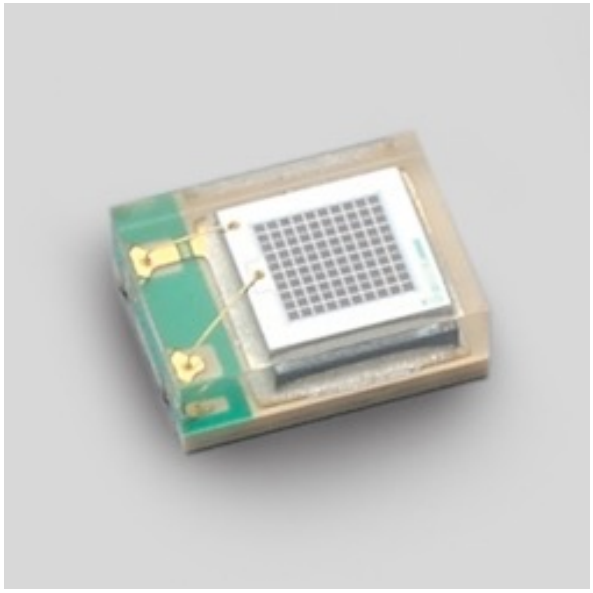
SiPM at Belle II

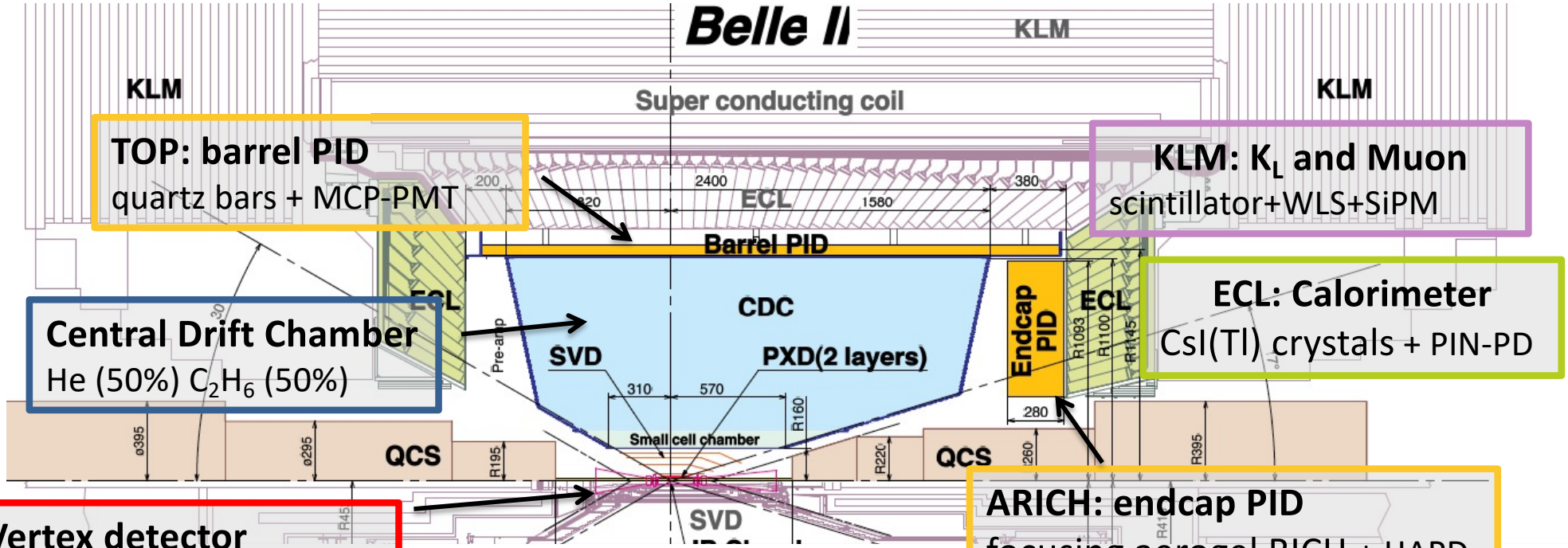


On behalf of Belle II Padova

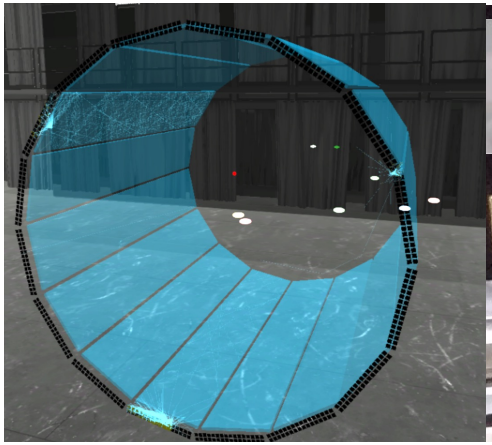
Belle II experiment

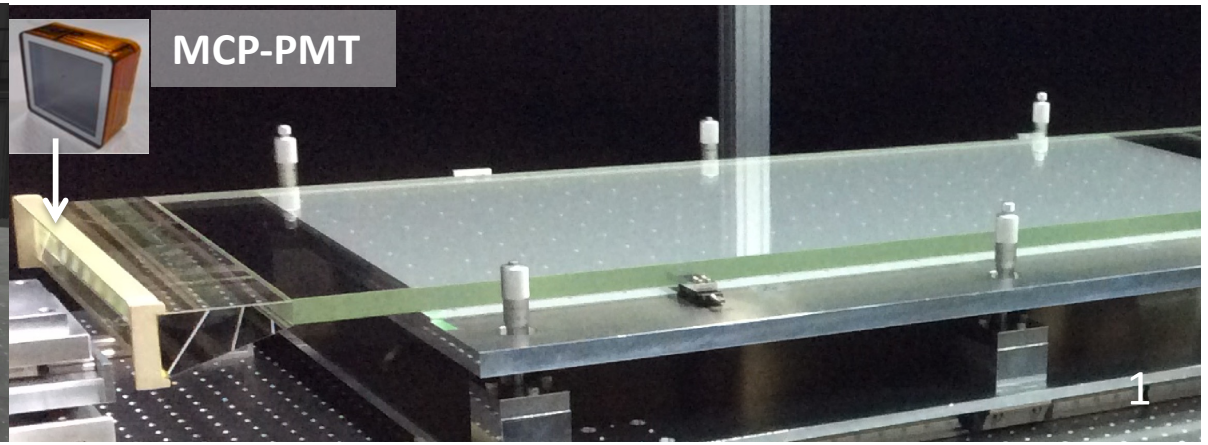
e^- (7GeV) Y(4S) e^+ (4GeV)

The TOP detector is the barrel PID system of the Belle II detector. Is made by 16 quartz bars readout by 512 MCP-PMT (micro channel plate photomutipliers).



TOP detector
16 quartz bars
512 MCP-PMT





TOP upgrade

According to the Roadmap2020 we can have 3 upgrade periods for TOP

2021	2022	2023	2024	2025	~2026	2027	2028	2029	2030	~2031

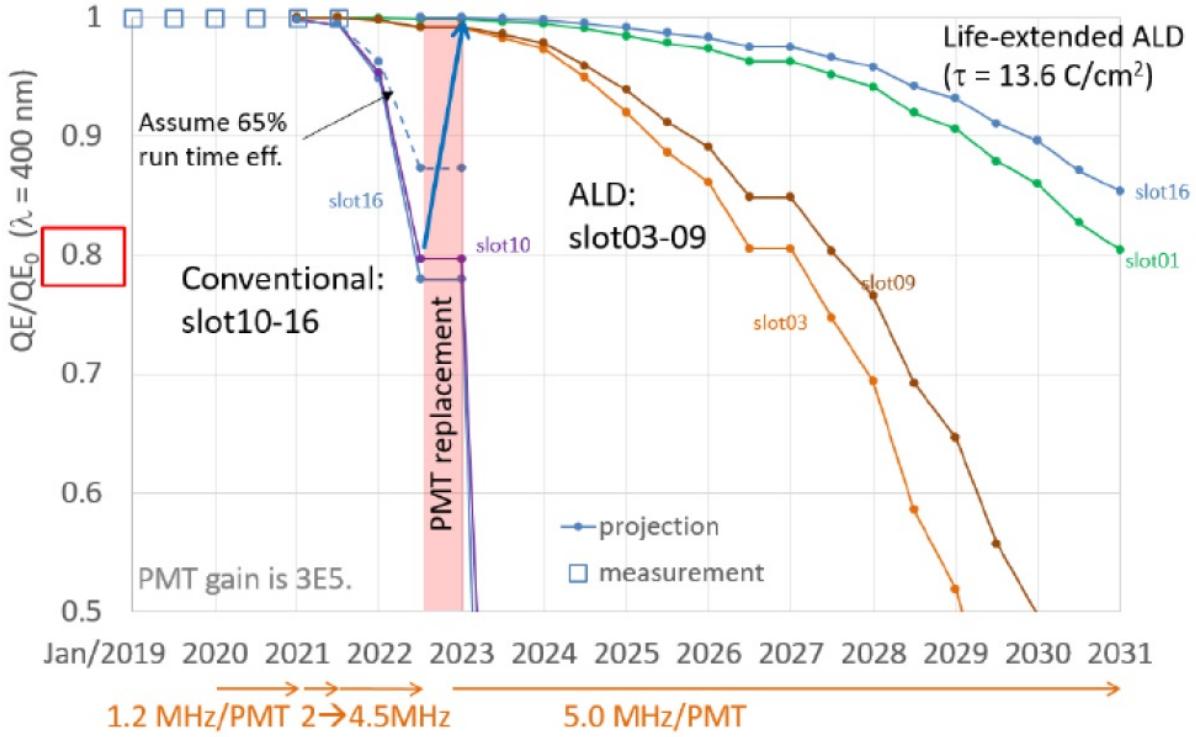
Replacement of conventional MCP-PMT

Replacement of no life-extended ALD MCP-PMT

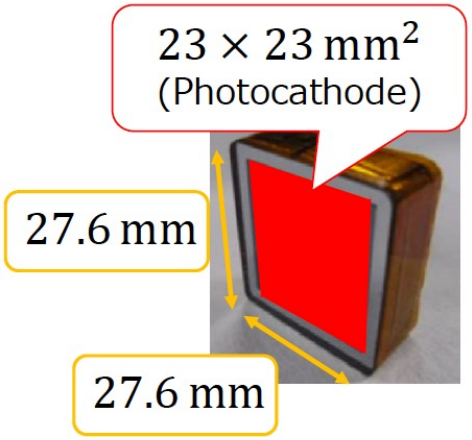
Replacement all ADL MCP-PMT

TOP readout upgrade

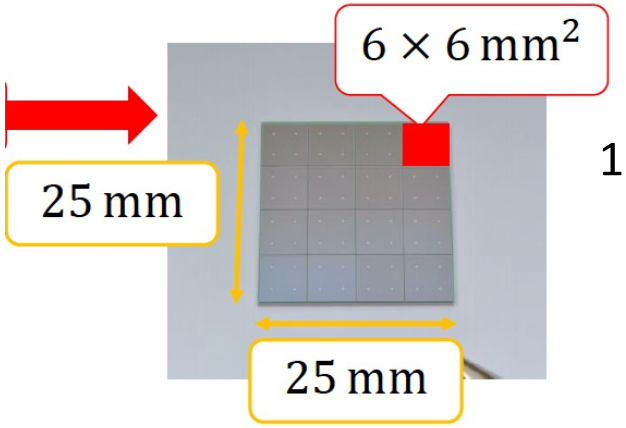
Projection of QE degradation



TOP upgrade



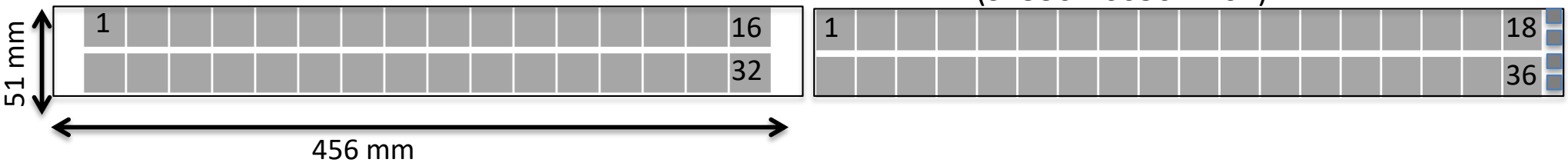
1 MCP-PMT
16 channes



1 MPPC
16 channels 6x6 mm²

Current detector: 32 MCP-PMT/module

Example: 36 SiPM 16 channels + 4 SiPM 4 channels
(S13361-6050AE-04)

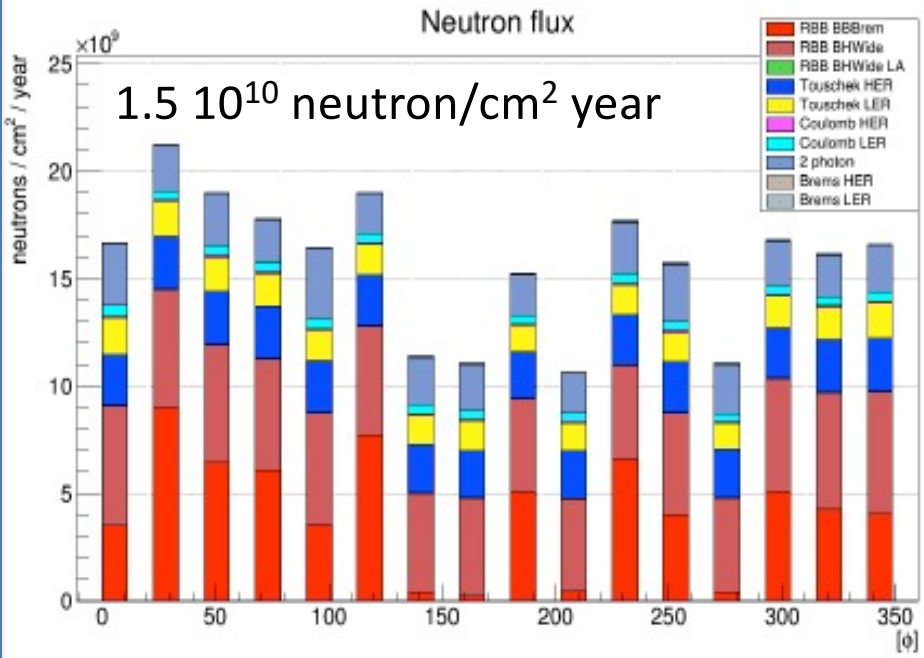


	MCP-PMT	SiPM
peak PDE	peak QE (30%) * CE (50%) = 15%	peak PDE = 40%
TTS	~ 50 ps	TTS < 100 ps
PMT/SiPM effective area	69% [$(23/27.6)^2$]	92% [$(24/25)^2$]
Global effective area	73%	90%

SiPM radiation damage

SiPM dark count ~ 50 kHz /mm^2 . Using 3 x 3 mm^2 SiPM:

- will reduce the dark count by a factor 4
- will require 4 times more electronic channels: 8192 -> 32768



Expected neutron radiation flux at the SuperKEKB nominal Luminosity of 6 x10^{35} cm^{-2} s^{-1} :

~ 1.5 10^{10} neutron/cm^2 year

Expected neutron radiation flux at the upgraded SuperKEKB

~ 10^{11} neutron/cm^2 year

The SiPM dark count

- increase a factor 4000
  from 0 to 10^{11} neutron/cm^2 year
- decrease a factor 2.5 every -10^{o}C

The TOP upgrade solution will require:

- Limited SiPM dimensions
- Rad. hard. SiPM (50 μm cells -> 10/15 μm cells)
- cold SiPM

The Belle II R&D working area

The Belle II R&D working area is inside the laser room of the 1st floor laboratory

The black box (100 x 85 x 65 cm^3)
is currently used to test the backup/upgrade of the laser stability monitor.

The laser stability monitor is made by two silicon photomultipliers (SiPMs) 1.3x1.3 mm^2
illuminated by the same laser source used for the laser calibration system of the TOP detector.
The laser stability monitor has been installed this summer inside the Belle II experiment.

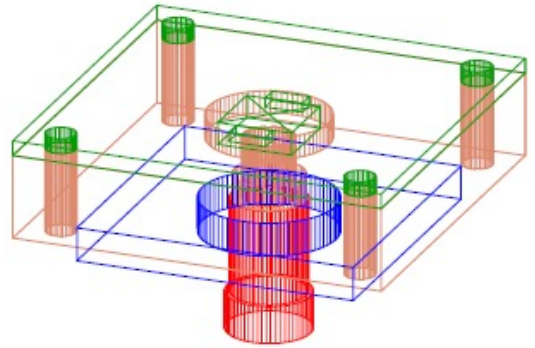
Chiller (28 x 42 x 50 cm^3) with a cooling plate to cool down SiPM

Huber Minichiller 600
Glycol water 0 ÷ -20°C
The Cooling system is under test.

SiPM test in Padova

Several SiPM from different producers are already in handle

SiPM code	Dim. (mm^2)	Pitch (µm)	Chips avail.
OnSemi 10035	1.0x1.0	35	6
OnSemi 30035	3.0x3.0	35	6
Hamamatsu S14160-3050HS	3.0x3.0	50	5
Hamamatsu S14160-3015PS	3.0x3.0	15	5
Hamamatsu S13360-1350PE	1.3x1.3	50	5
Hamamatsu S13360-3025PE	3.0x3.0	25	5
Hamamatsu S13360-3050PE	3.0x3.0	50	6
FBK-NUV-HD-RH-3015	3.0x3.0	15	3
FBK-NUV-HD-RH-1015	1.0x1.0	15	4
Ketek PM3315-WL	3.0x3.0	15	5
Ketek PM3335-WL	3.0x3.0	35	5

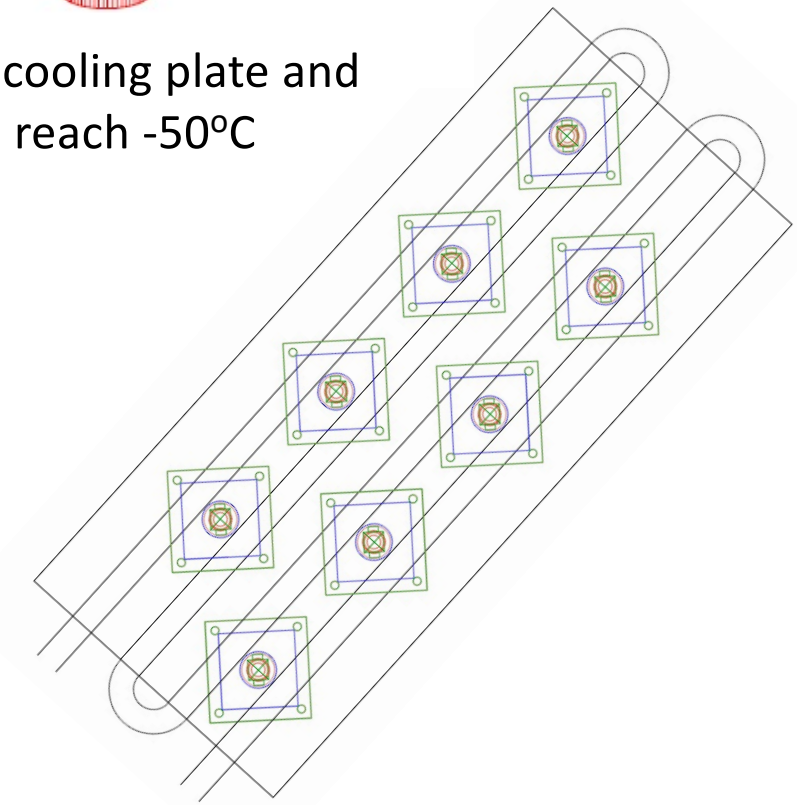


SiPM read-out block

PCB Amplifier
PCB SiPM with T sensor
PCB peltier

Amplifier TI THS4303

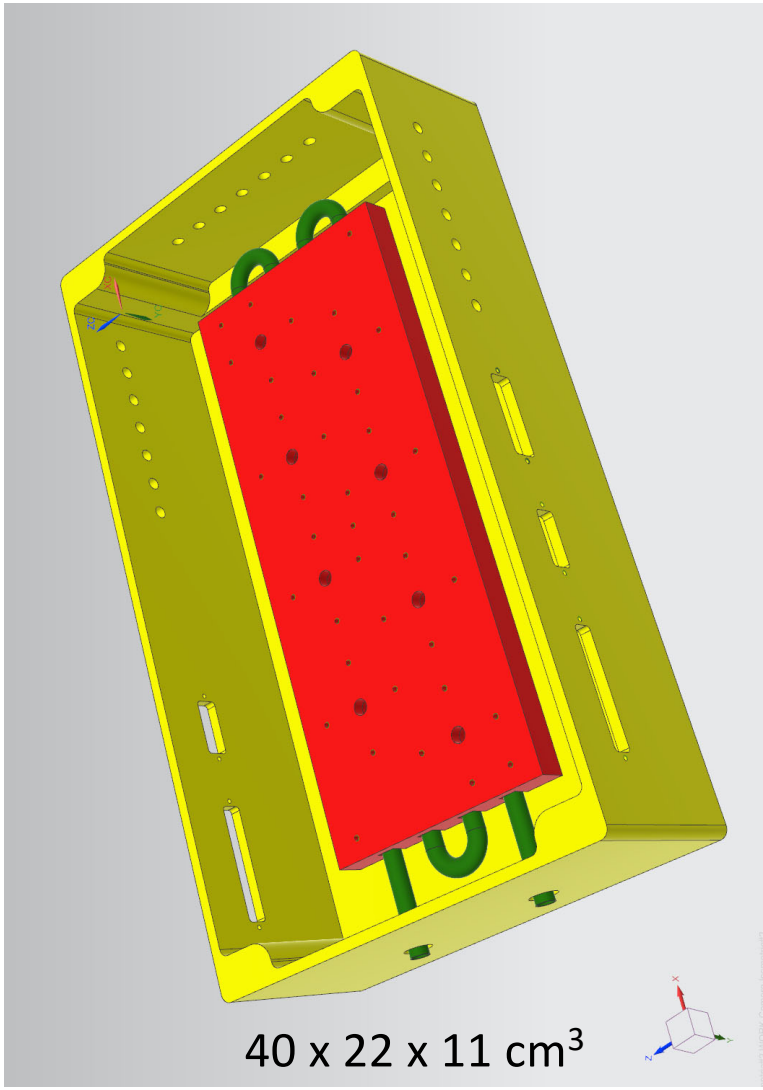
SiPM with cooling plate and peltier can reach -50°C



The read-out electronics is still under production.

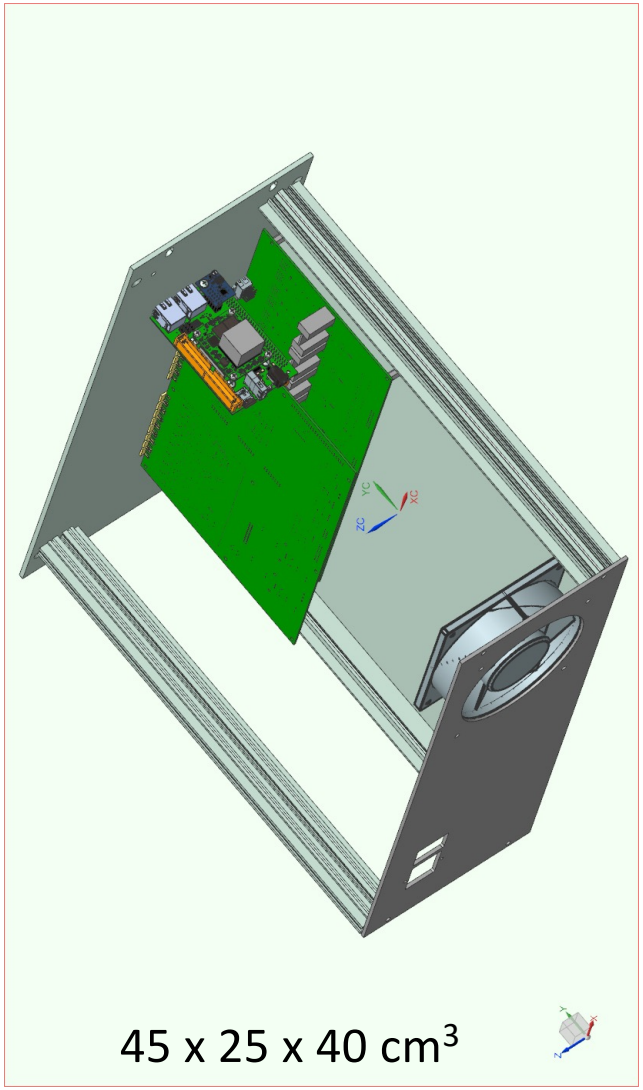
SiPM test in Padova

Box including SiPM with preamplifiers and cooling system (thermal insulation and dark box)



40 x 22 x 11 cm^3

Electronic DAQ for SiPM (crate CAMAC, rack is missing).

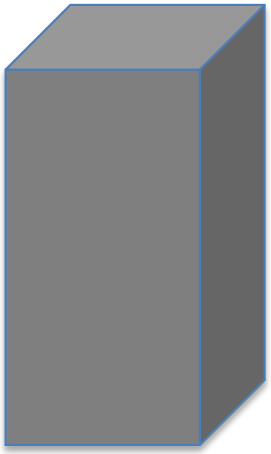


45 x 25 x 40 cm^3

Digitizer DT5743
8 channel 3.2 GS/s

15 x 5 x 16 cm^3

PC desktop



15 x 35 x 30 cm^3