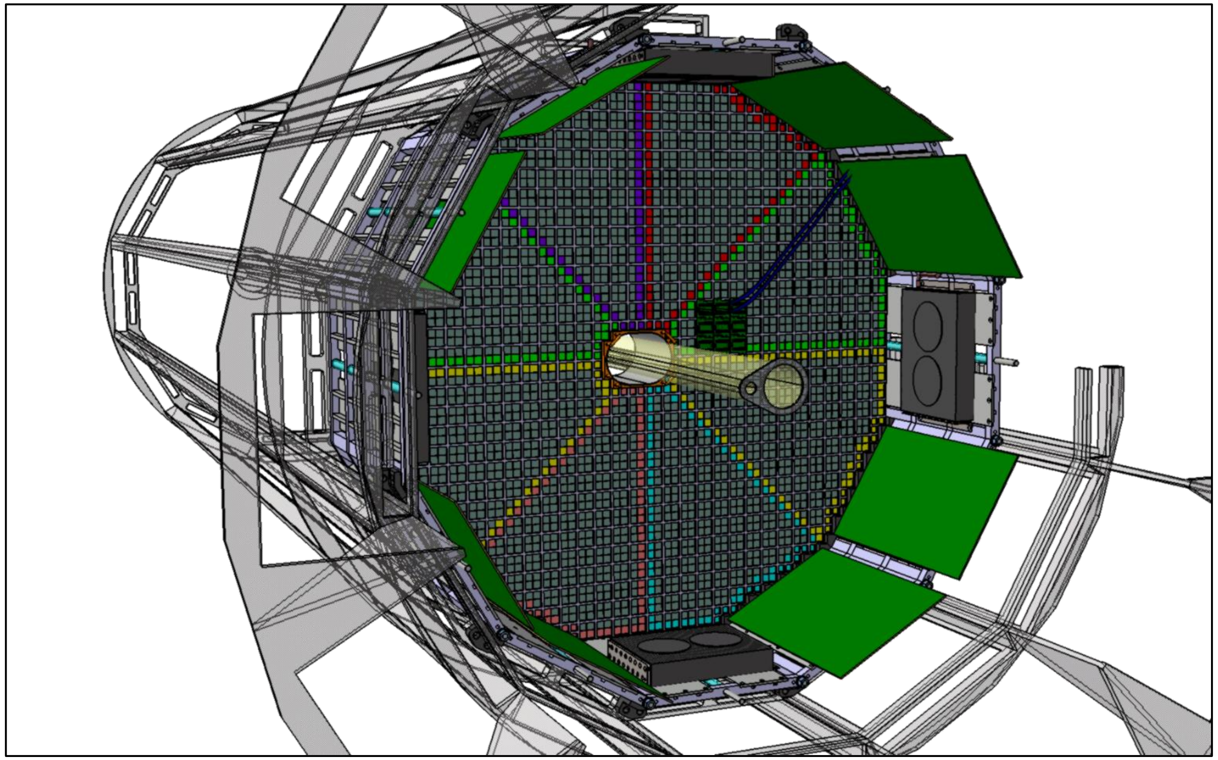


Backward Electromagnetic Calorimetry detector and integration

Julien Bettane, Carlos Muñoz Camacho IJCLab
(Orsay, CNRS/IN2P3)

Meeting on engineering progress of backward ECal

Requirements

❑ **Physics:**

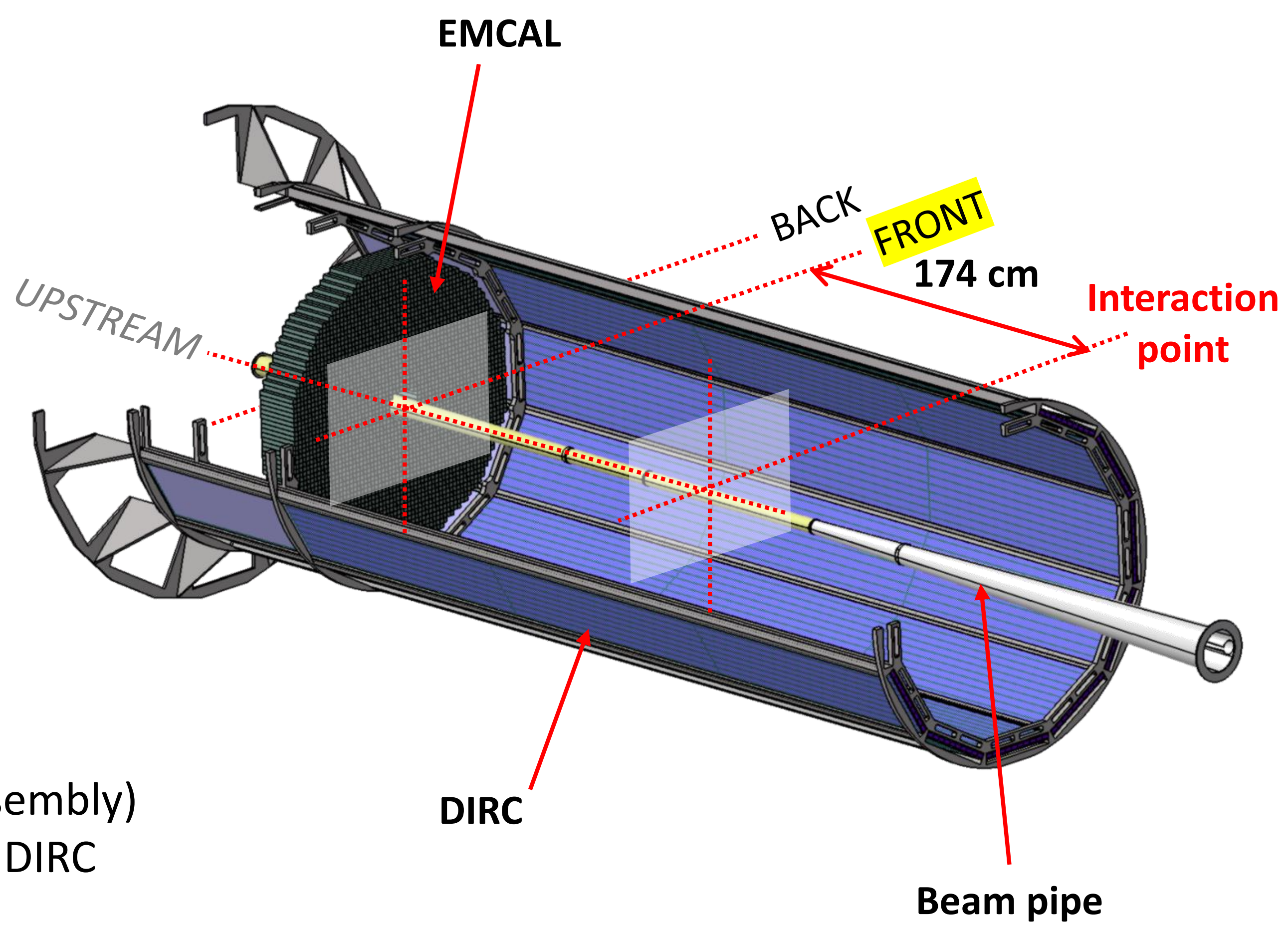
- Distance interaction point/EMCAL = 174 cm
- Minimize the material/space between crystals
- To be as close as possible to the beampipe
- Gain monitoring required (1 fiber/crystal)
- No material in front of the detector

❑ **Thermal:**

- Stability of the temperature at 20°C (room temp)
- Tolerance +/- 0,1°C
- Stability for the crystals and the SiPM

❑ **Installation:**

- Removing the detector in one block (without disassembly)
- Respect clearance between the beam pipe and the DIRC



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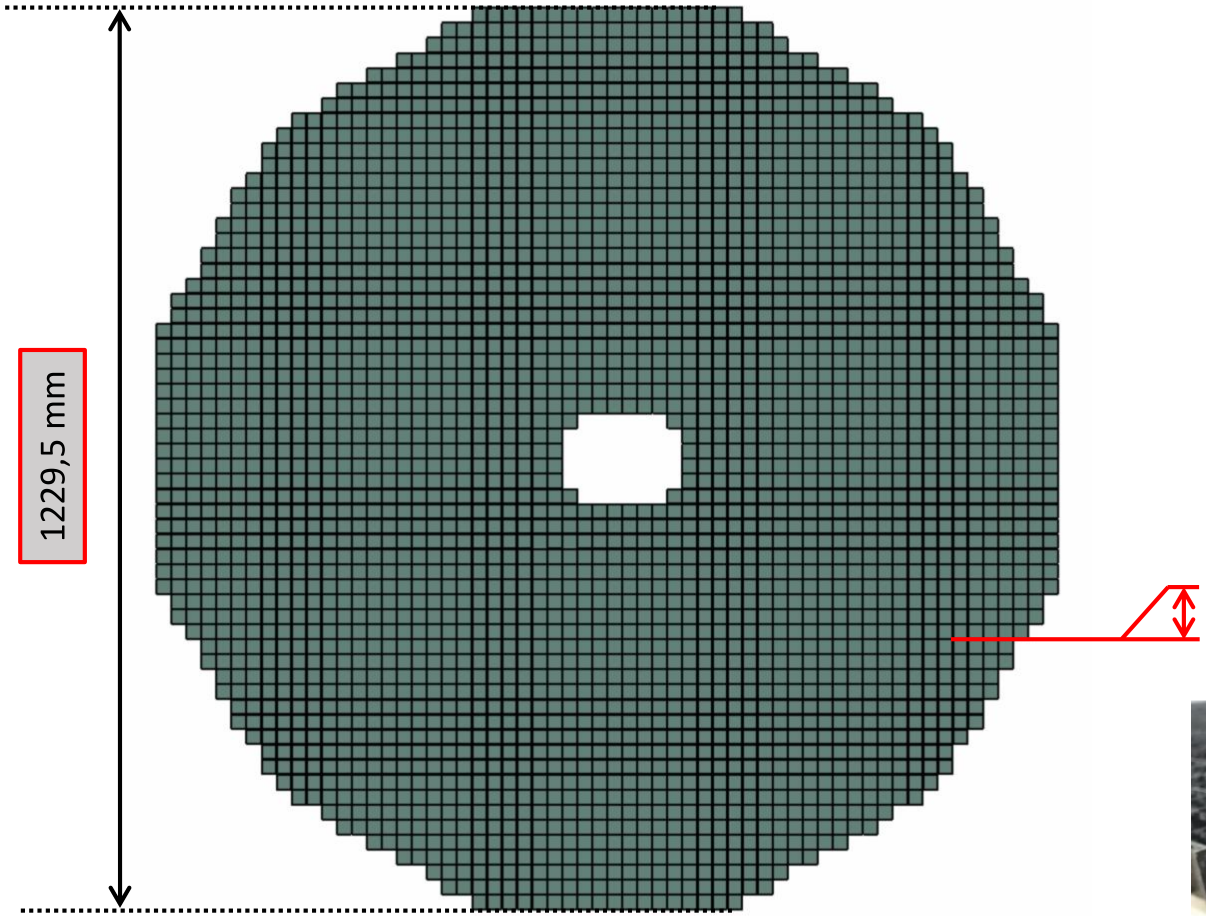
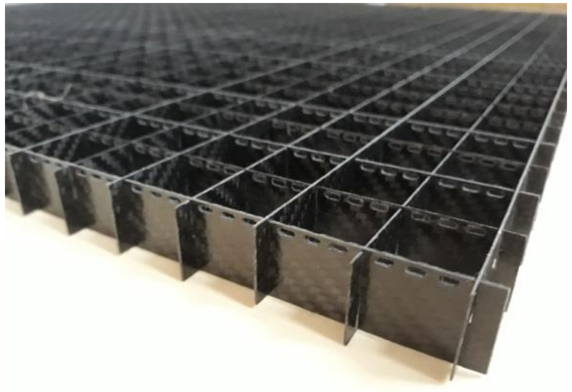
Overview / Crystals



Specifications:

PWO:	8,28g/cm3
Dimension:	20x20x200 mm
Mass:	0,662 Kg
Nb:	2852 crystals
Total mass:	1889,2 Kg
External size:	1229,5 mm
Internal size:	164,5x123,5 mm
Space max:	0,5 mm (thickness carbon plate)

0,5 mm the crystals are stacked with a 0,5mm carbon plates



NPS calorimeter design

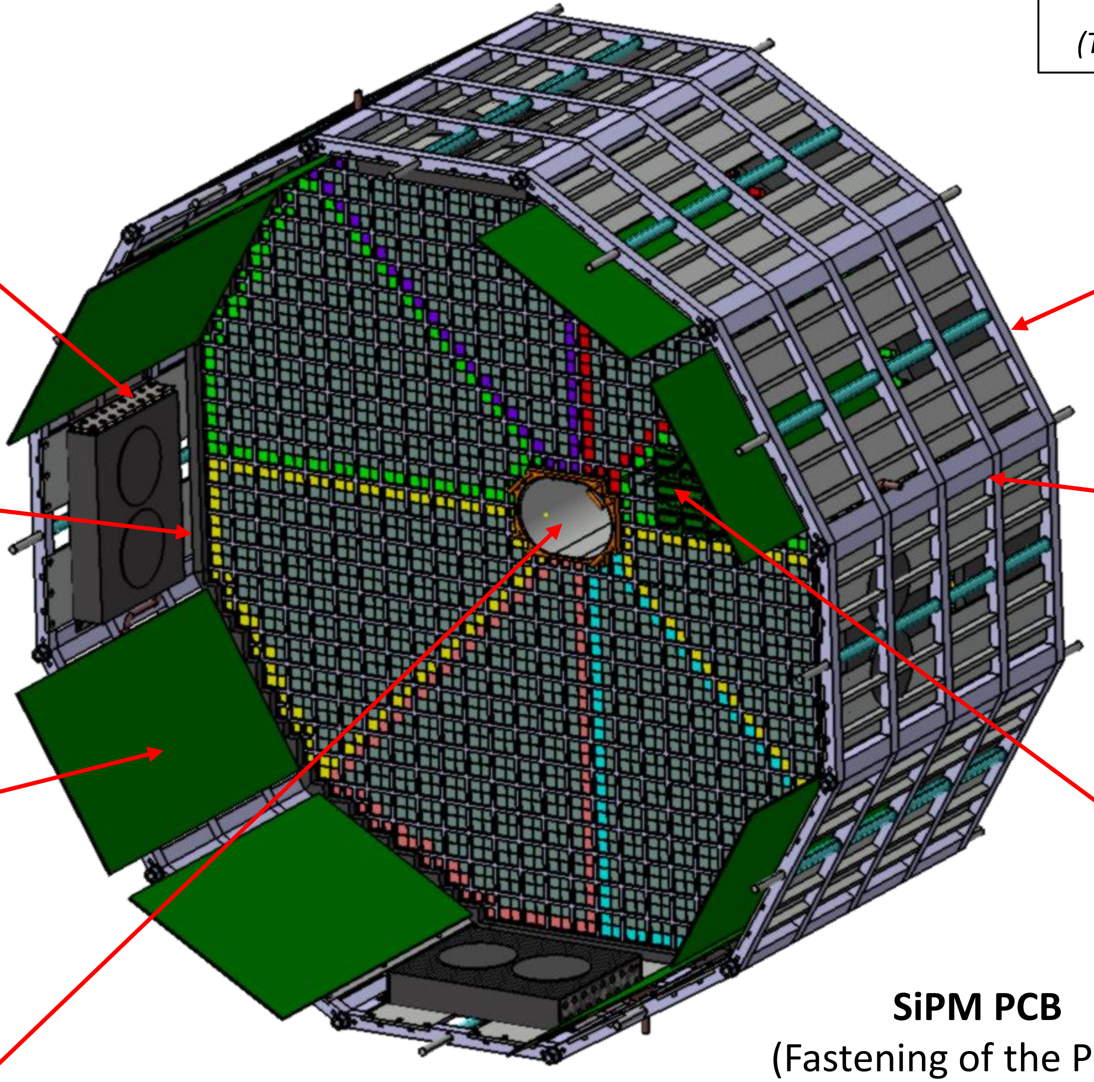
Overview / Mechanical design

EMCAL detector:
Mass max of the structure: 0,5T
Mass of the crystals: 2T
(To be consolidated by calculation)

Cooling (4 modules)
(to be validated by thermal studies)

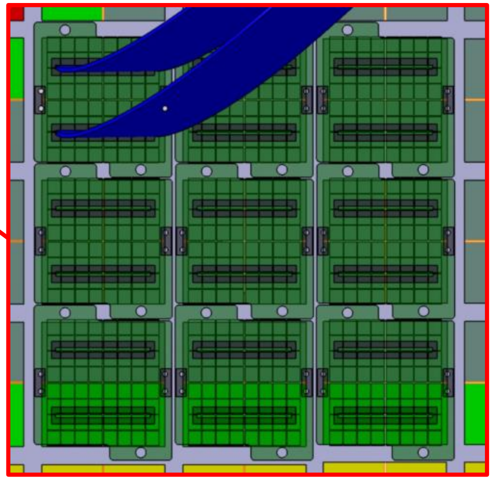
Support structure for the crystals
(can be used for the external cooling, with copper)

PCBs (8 boards)
(8 boards instead of 12 because of the cooling)



5 (at least) strong dodecagon frames
(to make the assembly easier)

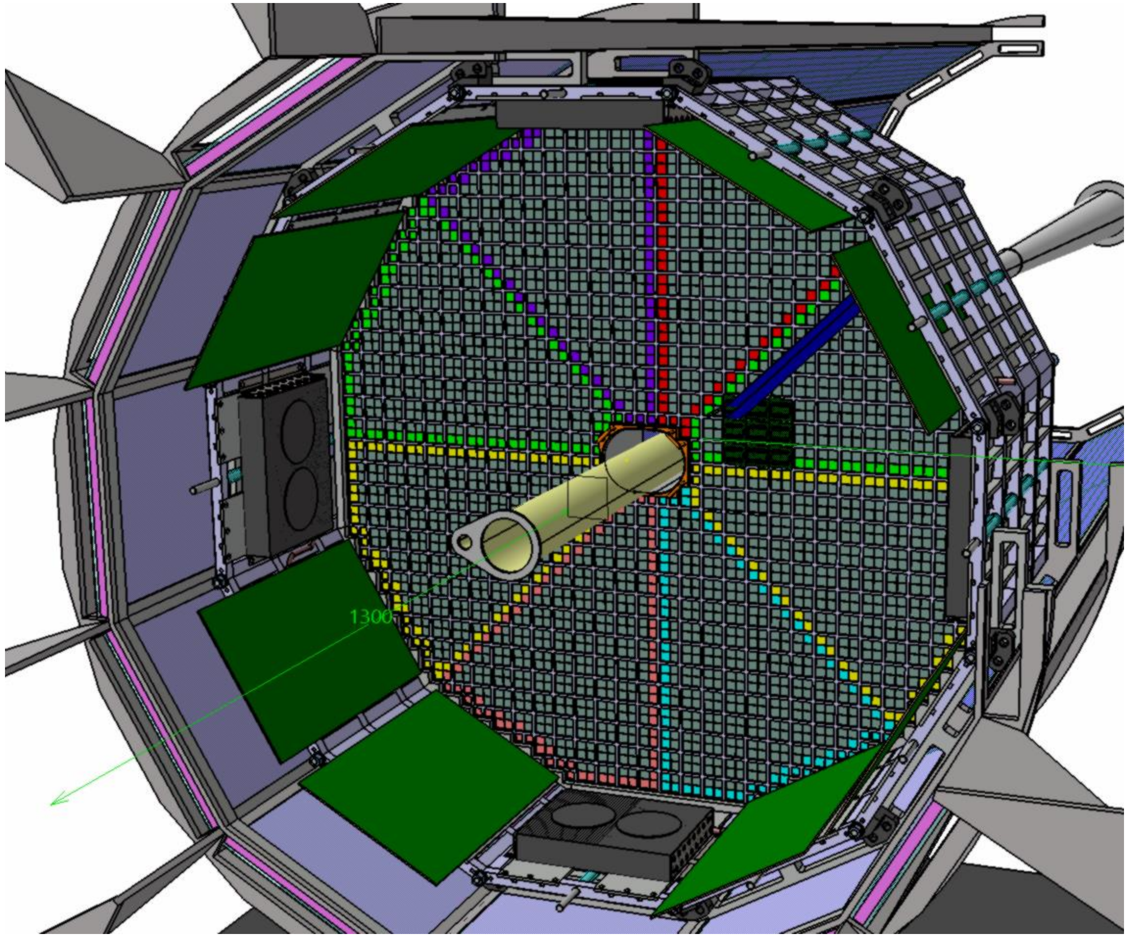
External mechanical structure
(+cooling)



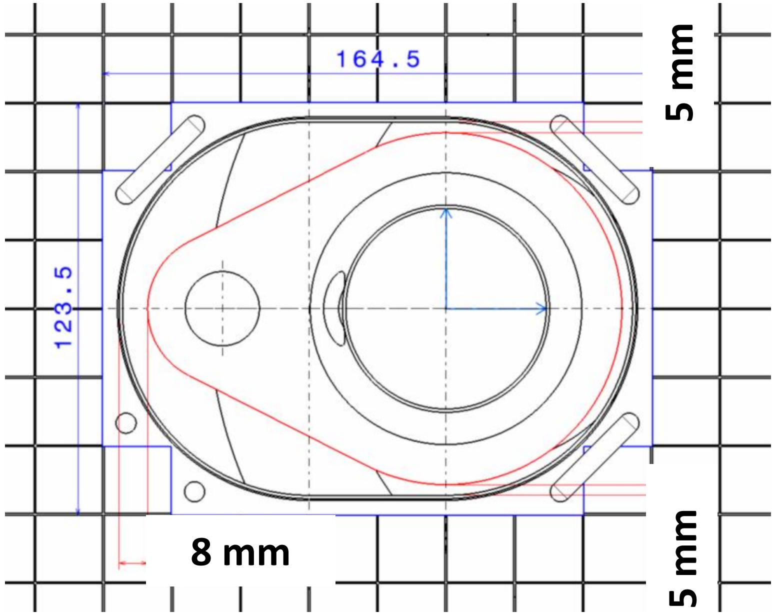
SiPM PCB
(Fastening of the PCB of the SiPM on the grating)

Internal mechanical structure
(+cooling)

Overview / Clearance with the beam pipe

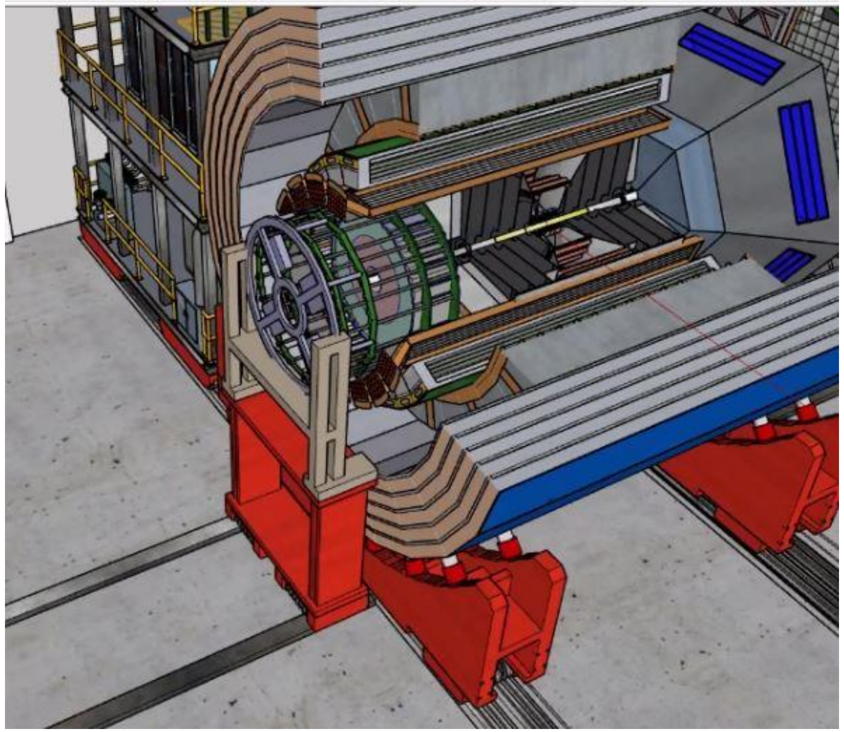


Requirement for the design of the calorimeter:
Crystals must be as close as possible to the beam pipe and allow the removal of the detector in one block



Clearance between the internal structure and the beam pipe: 5 mm

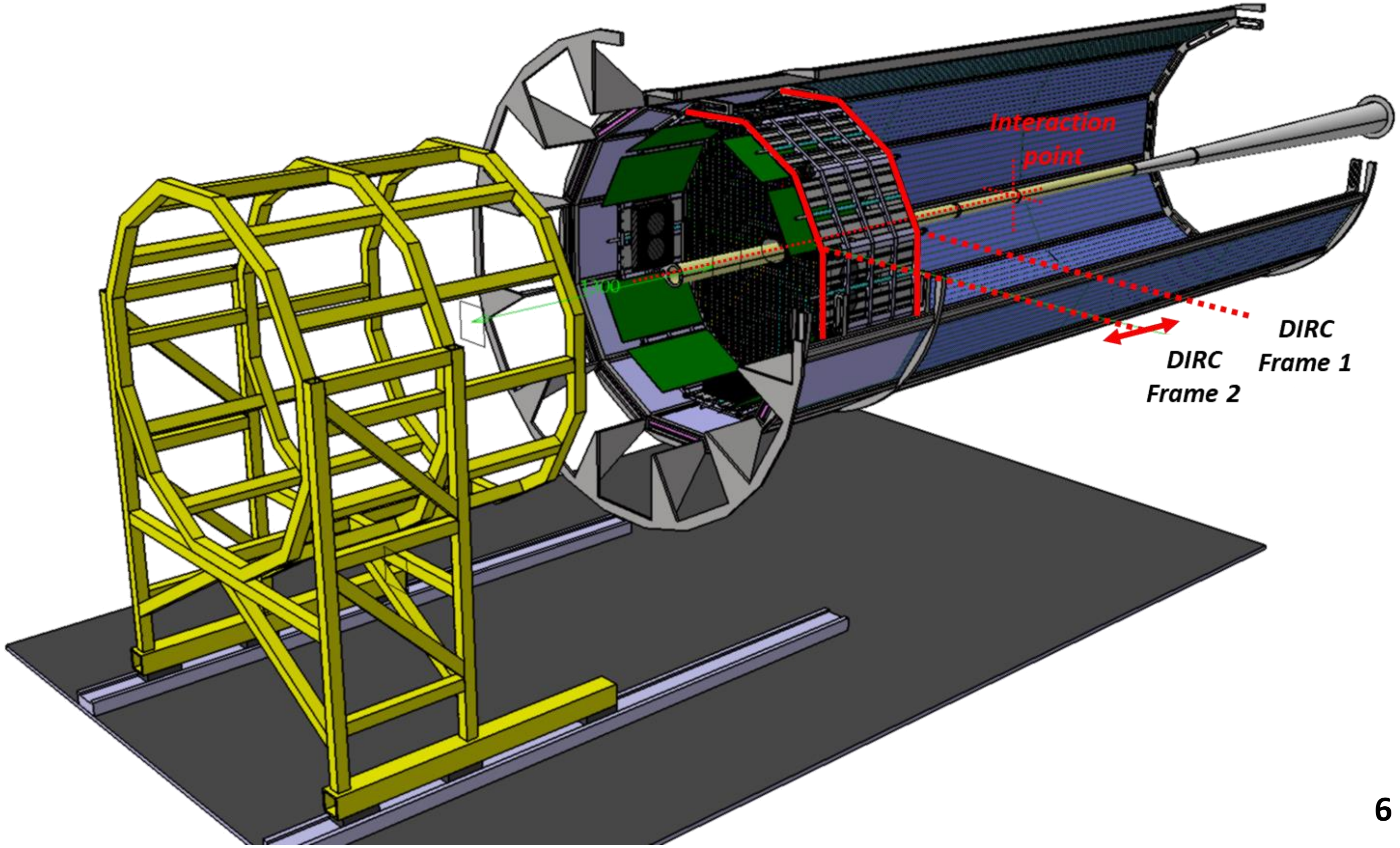
Overview / Installation



Experimental hall

Comments:

- The length of the EMCAL mechanical structure depends on the positioning of the DIRC frame 2
- The positioning of the DIRC frame 1 is imposed by the distance required to the interaction point



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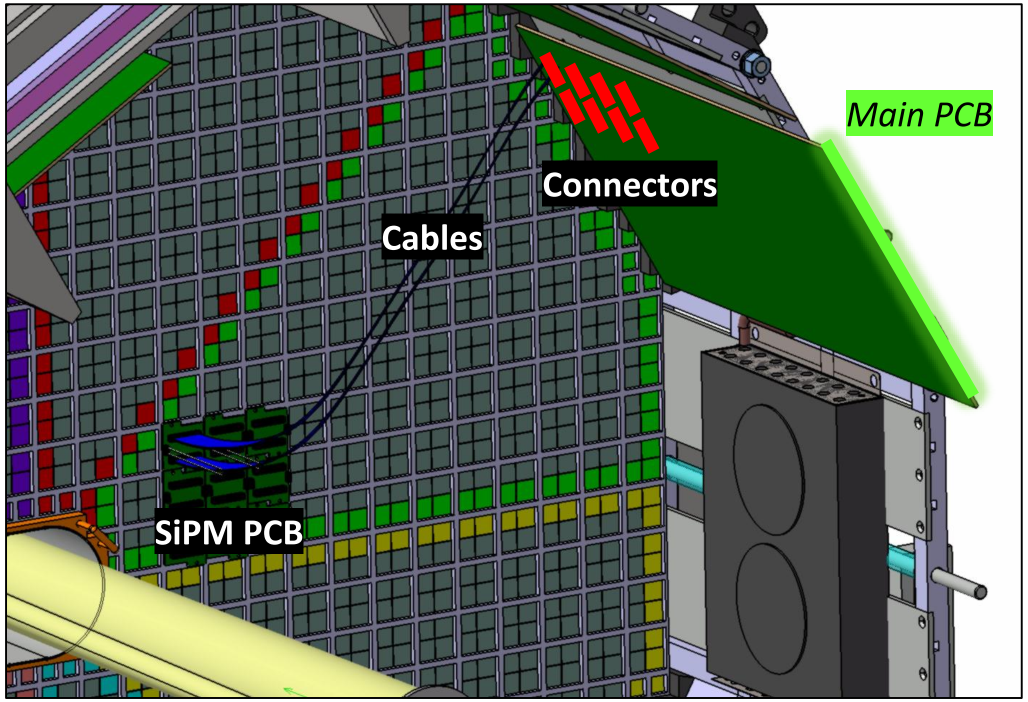
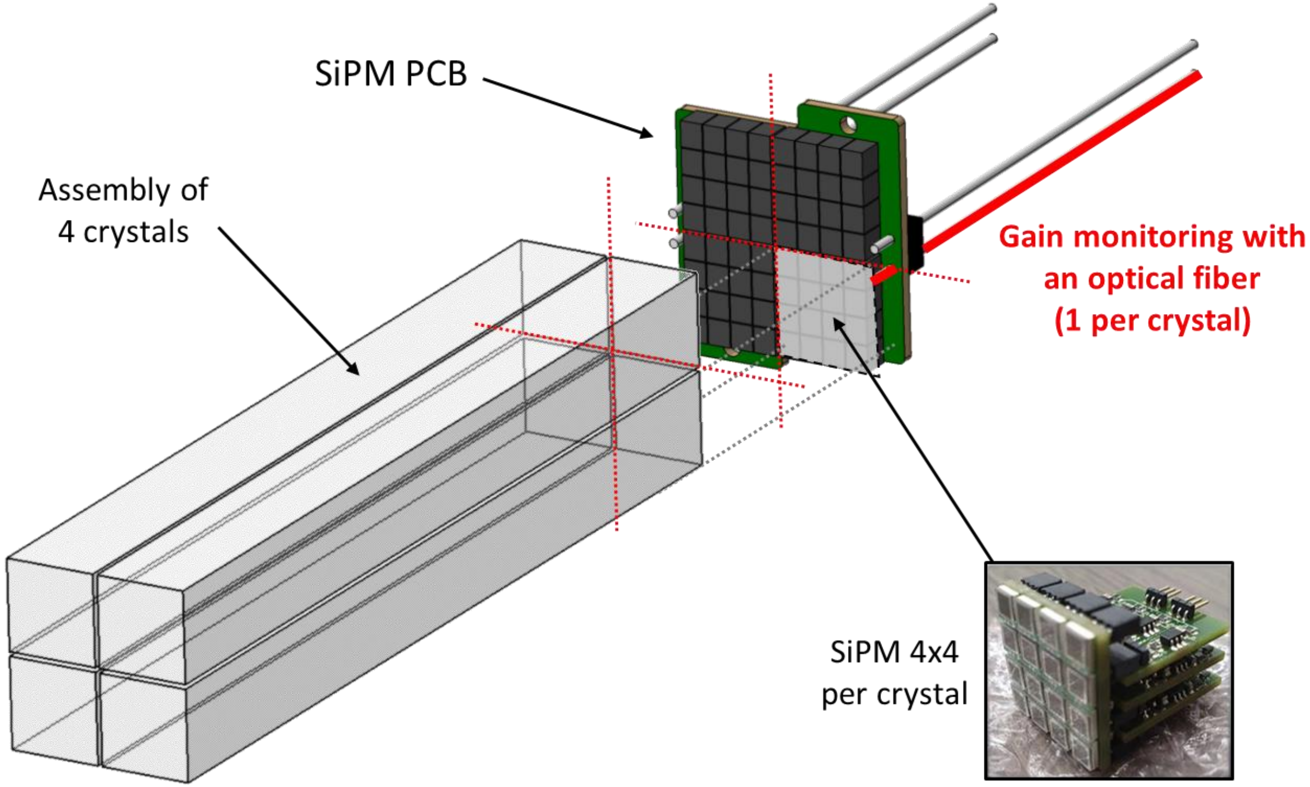
Overview / Electronic & SiPM configuration





Current design:

- Division on 8 sectors to perform the cabling of the SiPM PCBs
- Use of two cables (per SiPM PCB) to the main PCB
- Size of the main PCB depends on the size of the connectors

Comments received after the review (December 2022)

Comments/Concerns

Temperature stability is very crucial for long-term operation and must be verified. One should avoid direct heating of crystals due to front-end electronics. The effect might in addition be sensitive to the variation of the event rates or beam interruptions. Good thermal insulation has to be considered since a variance of 0.5°C already constitutes a change of light yield of 1.2% adding directly to the constant term of the energy resolution. The front-end electronics is still to be decided which is necessary for a full evaluation of the system.

Regarding mechanical integration one should avoid fixations with nuts in the forward part, as they would be inaccessible, and use fixed conical bolts that position the system when inserting it from the rear. Fixations can then be done solely at the rear. The availability of PWO can be a major risk as currently there is only a single supplier of high-quality material with a limited production capability.

Recommendations

R1. Prepare a system test with close-to-final electronics to verify the achievable resolution and the level of the threshold of minimum detectable energy.

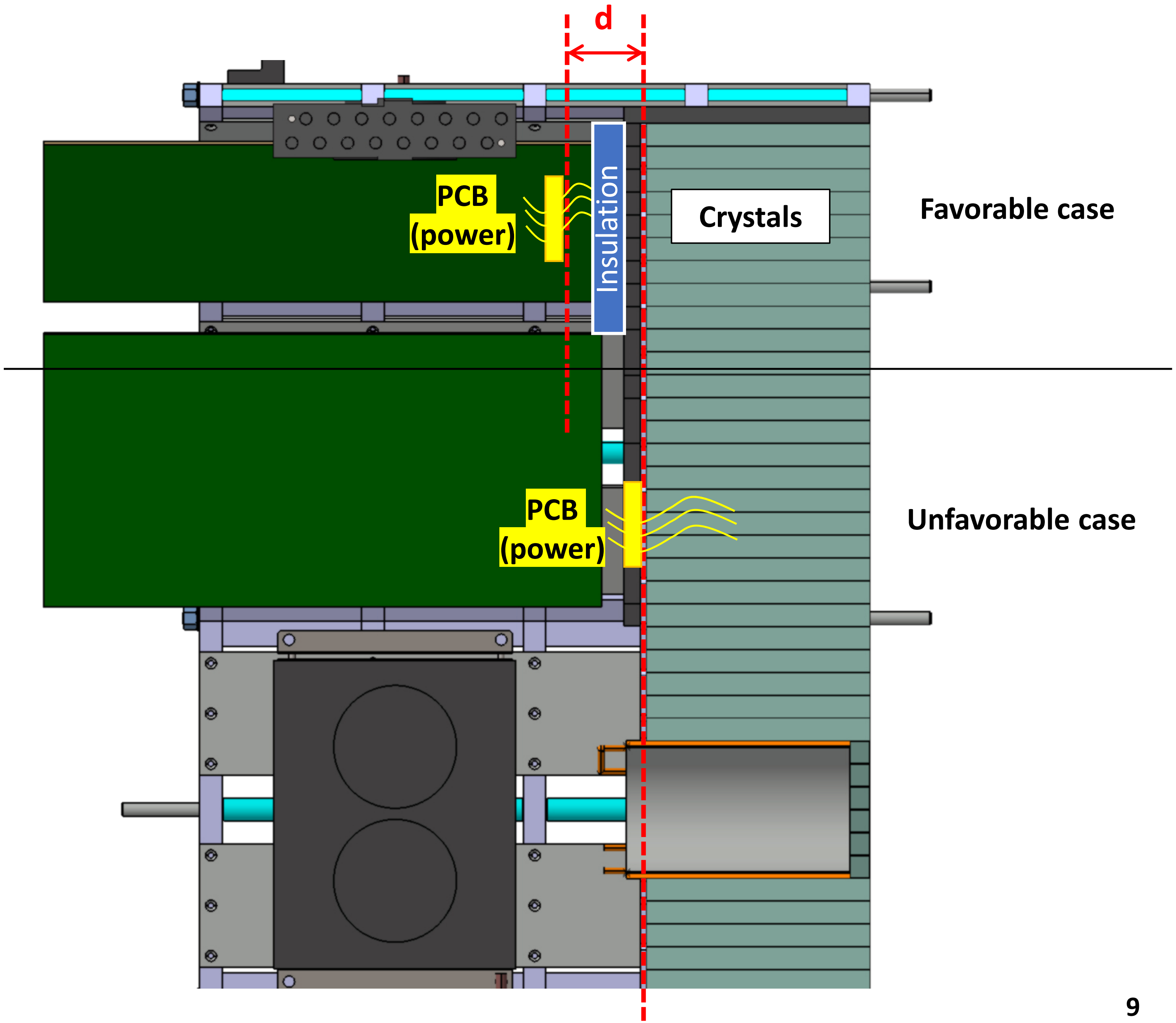
R2. Assess impact on physics output due to temperature instabilities.

R3. Procure PWO crystals as soon as possible as it is a long lead item. The supplier currently can provide approx. 700 crystals per year.

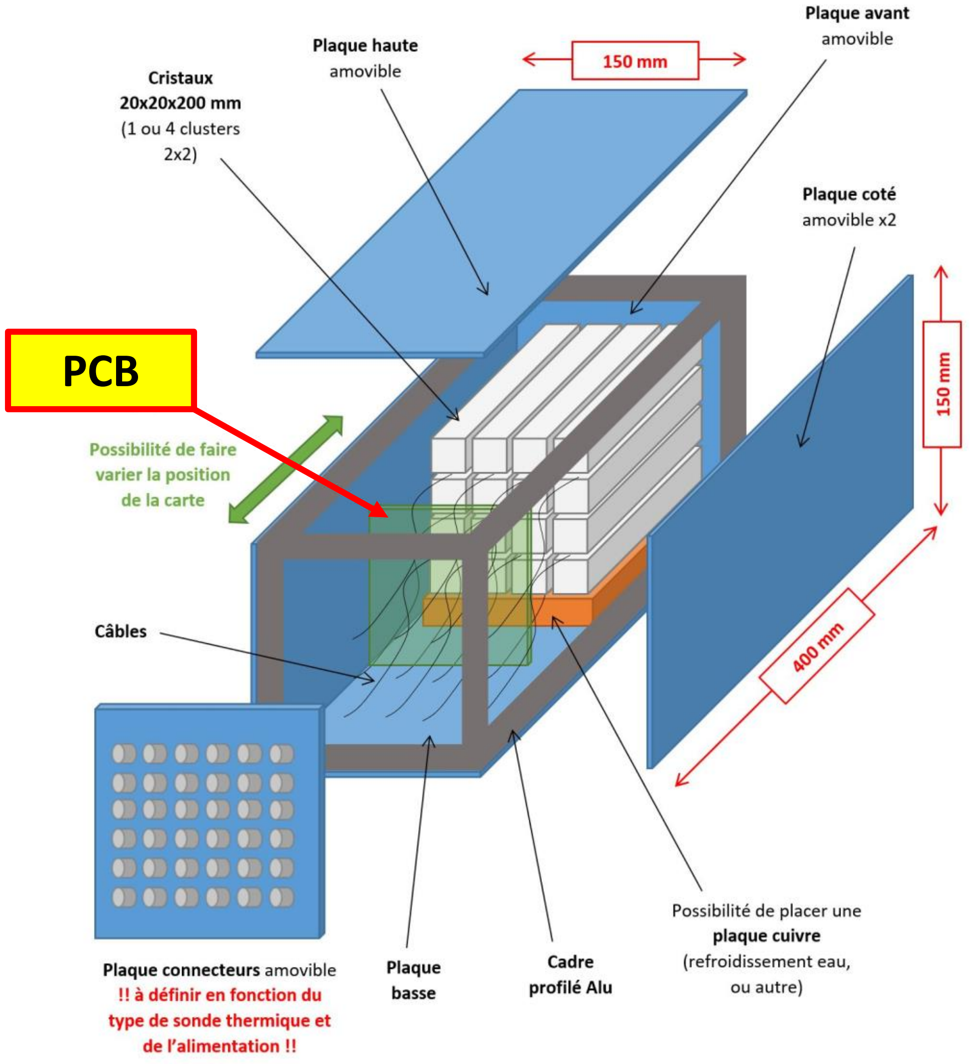
Thermal / Problem

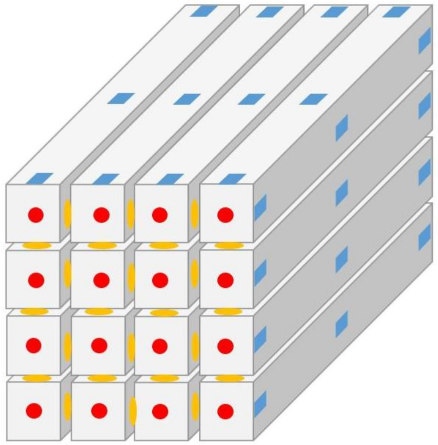
Comments:

- The distance beetween the crystals and the PCB must be optimized
- The thermal dissipation (w) to the crystals must be reduced with insulation
- The heat (Cal) must be evacuated with cooling (plates with water + air cooling)

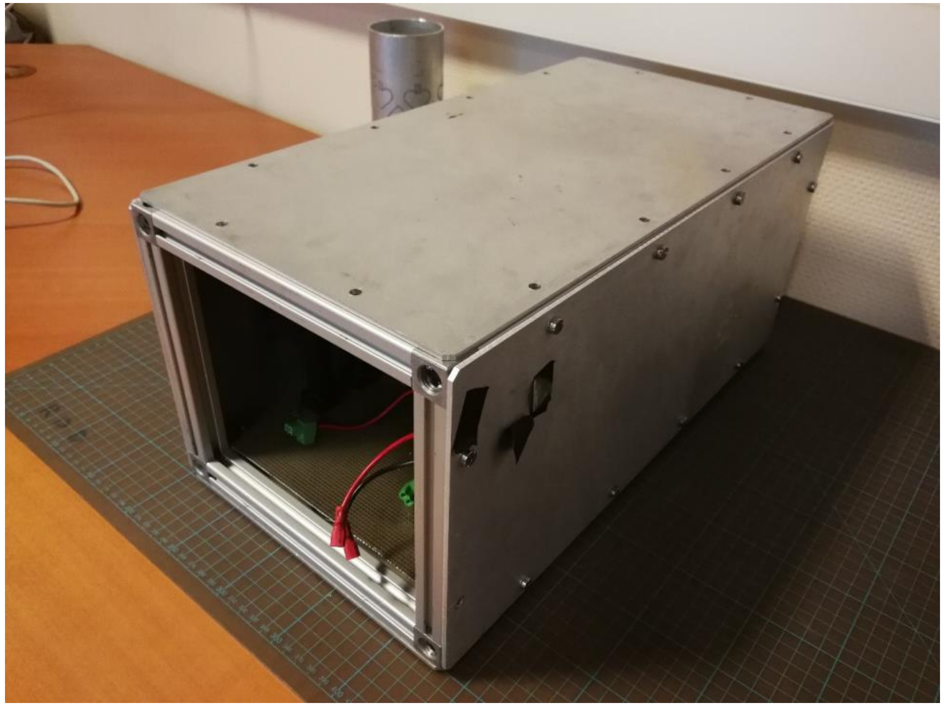


Modular Thermal prototype





Positionning of the thermal sensors on and between the crystals



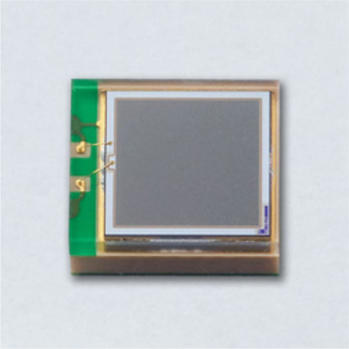
Prototype machined and assembled

Anticipated SiPM readout

Dynamic range for backward ECAL: 0.05 – 18 GeV (1:360)

MPPC

S14160-3010PS



Contact us >

Low breakdown voltage, wide dynamic range type MPPC with small pixels

The S14160 series is a small-pixel MPPC that features wide dynamic range. Even with an extremely narrow pixel pitch of 10 μm, it features high fill factor ,reduced crosstalk, and dark count.

Features

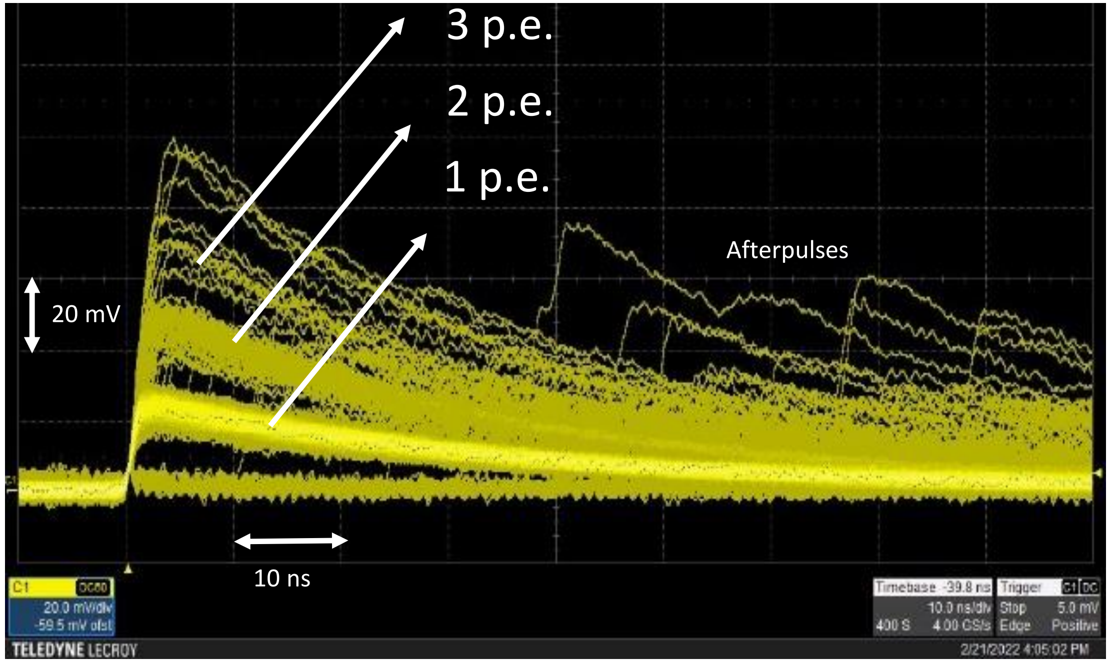
-Small pixel pitch (10 μm)
-High fill factor
-Wide dynamic range
-Low voltage operation (VBR=38 V typ.)
-Low crosstalk and after pulses
-high gain: 10^5 order

Specifications

Package type	Surface mount type
Number of channels	1 ch
Effective photosensitive area / ch	3 × 3 mm
Number of pixels /ch	89984
Pixel size	10 μm
Spectral response range	290 to 900 nm
Peak sensitivity wavelength (typ.)	460 nm
Dark count/ch (typ.)	700 kcps
Terminal capacitance/ch (typ.)	530 pF
Gain (typ.)	1.8×10^5

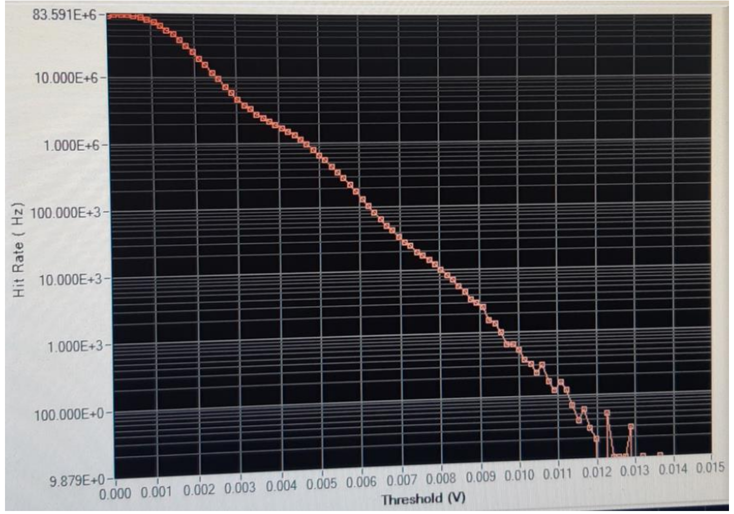
Initial tests at IJCLab

Calibration:

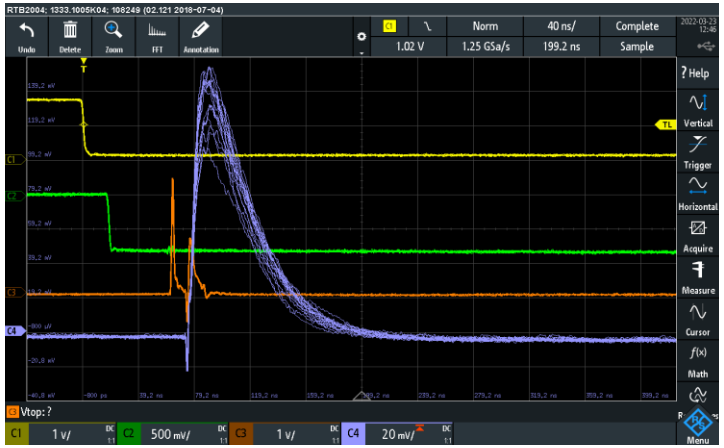


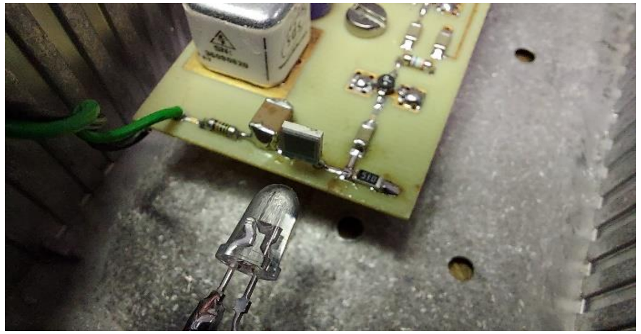
«Staircase»:
Dark count rate as a function of threshold

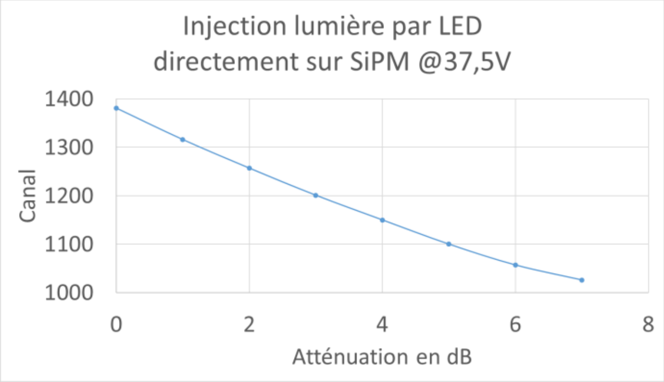
Rough estimate:
~3 mV per p.e



Tests with LEDs:







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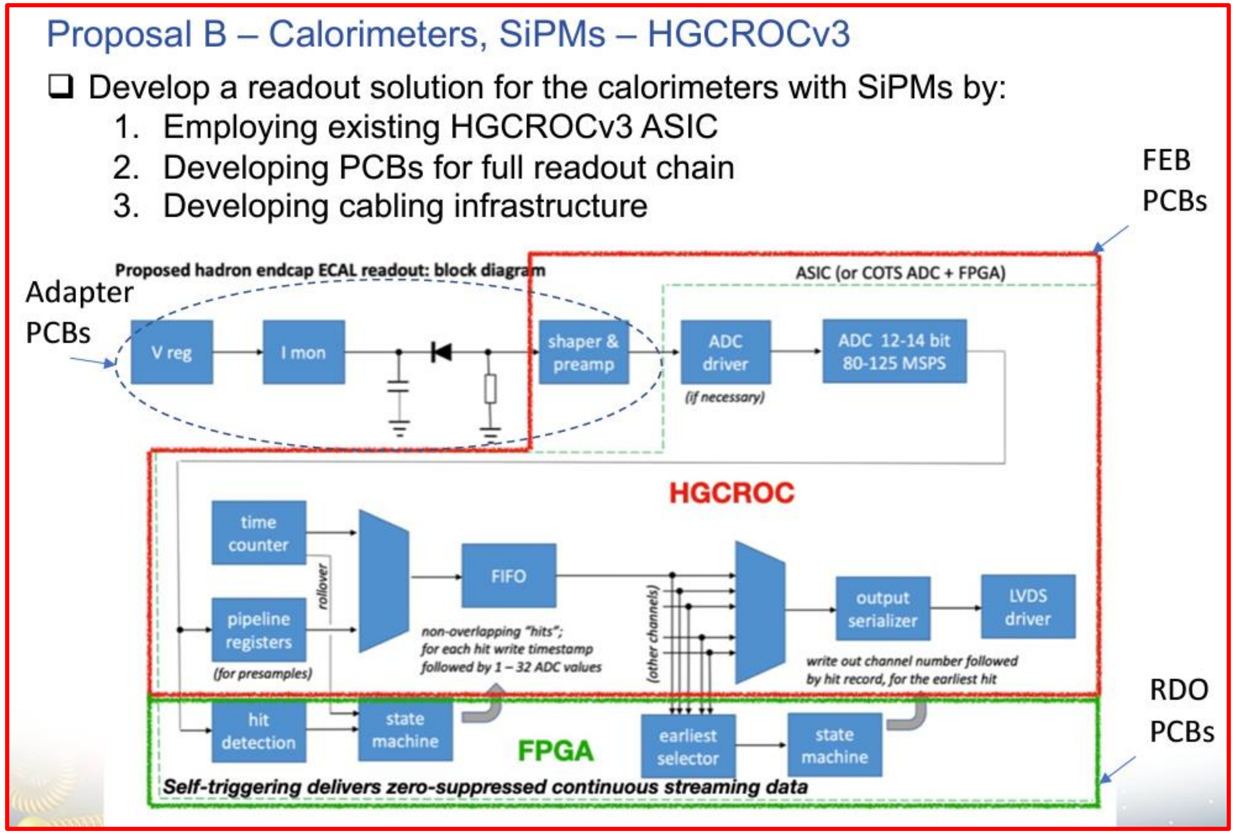
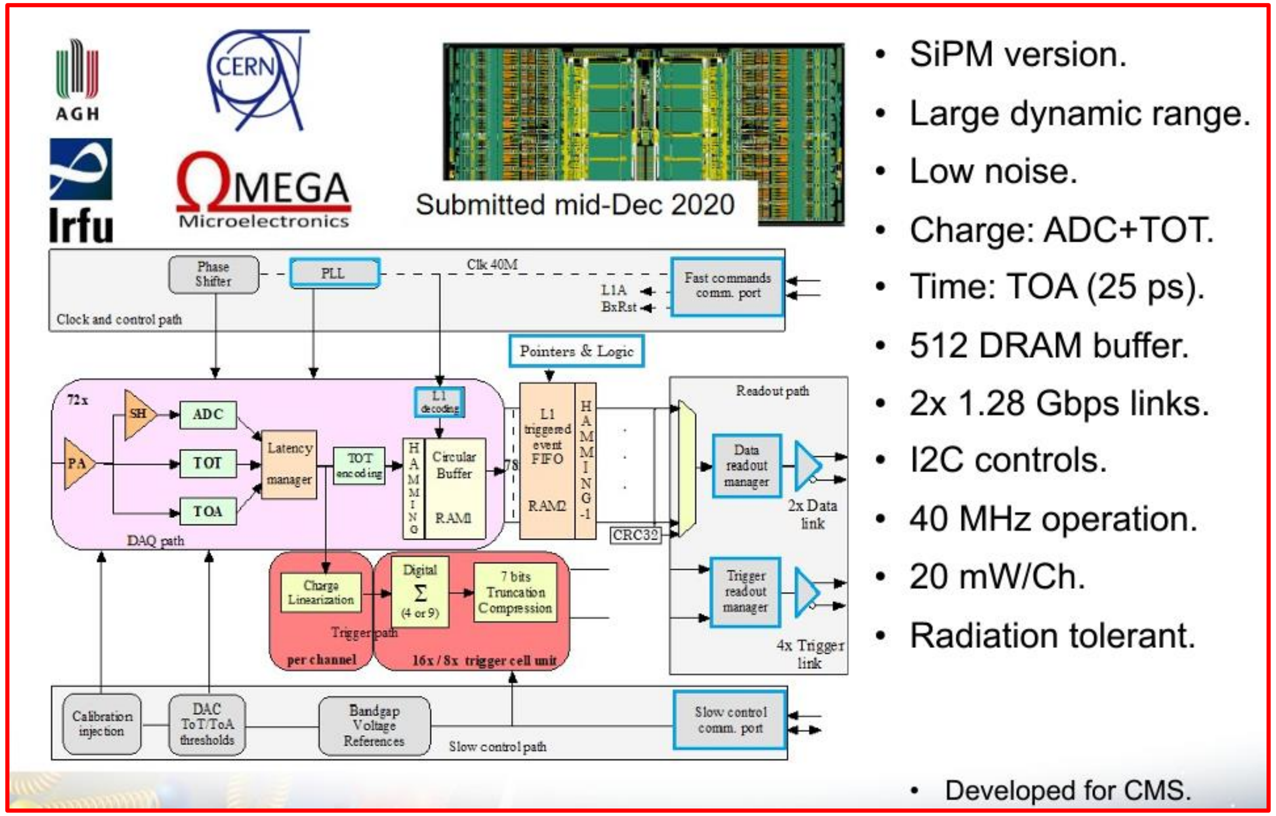
Front end electronics - plans

Slides by F. Barbosa (project calorimetry review Dec ’22)





We’d like to pursue this option with the local support of OMEGA, and the newly interested group at LLR (Palaiseau) who has ample experience in characterizing HGCROC for CMS

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List of technical points to discuss

- **Validate (priorities):**
  - Clearance with the beam pipe (tolerances of the positioning for the beam pipe, for the installation…): 5 mm?
  - Fastening with the structure of the DIRC (for the installation and the removal)
  - Positioning of the DIRC frame 2 (has an impact on the length of the structure of the DIRC)
  - Space available in the staging area in order to design the tooling

- **To do list for engineering:**
  - Validate the pressure on the bottom crystals
  - Calculation to size the internal and external structures (with thermal aspects)
  - Calculation to size the tooling for the installation
  - R&D on the cooling integrated into the mechanical grating, the internal and external structures
  - Thermal simulation with several configurations / To compare with the experimental measures
  - Production of a prototype and mockup