# **Backward Ecal** / EEEMCal

Triple I **GST Workshop** (24/03/2025)

Julien Bettane

# Detector Views

## Positioning and clearance

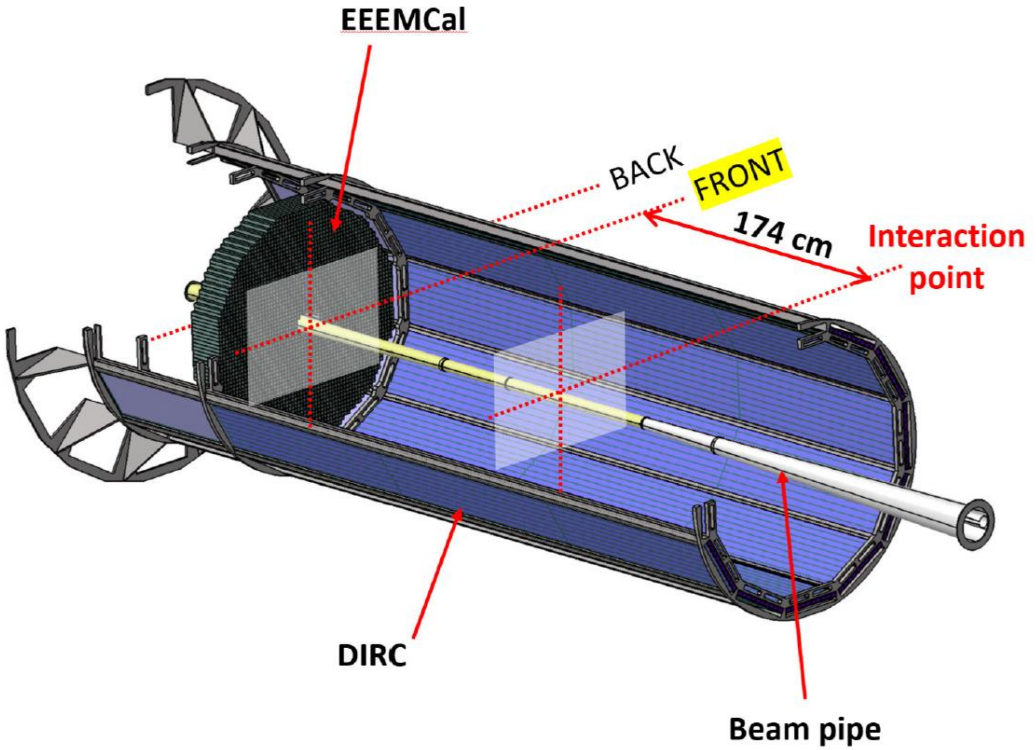
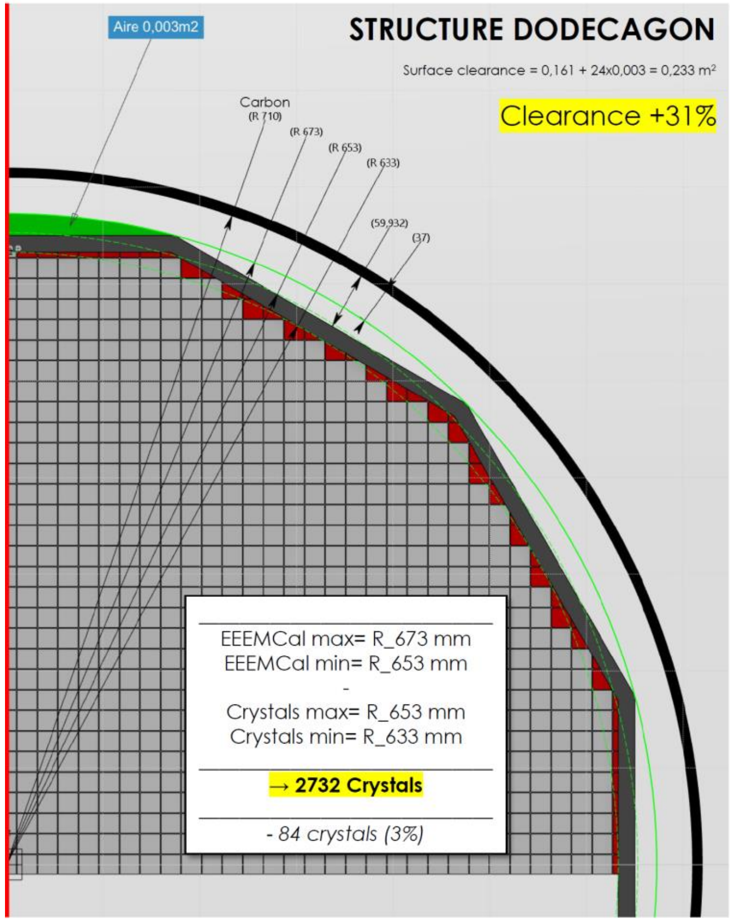
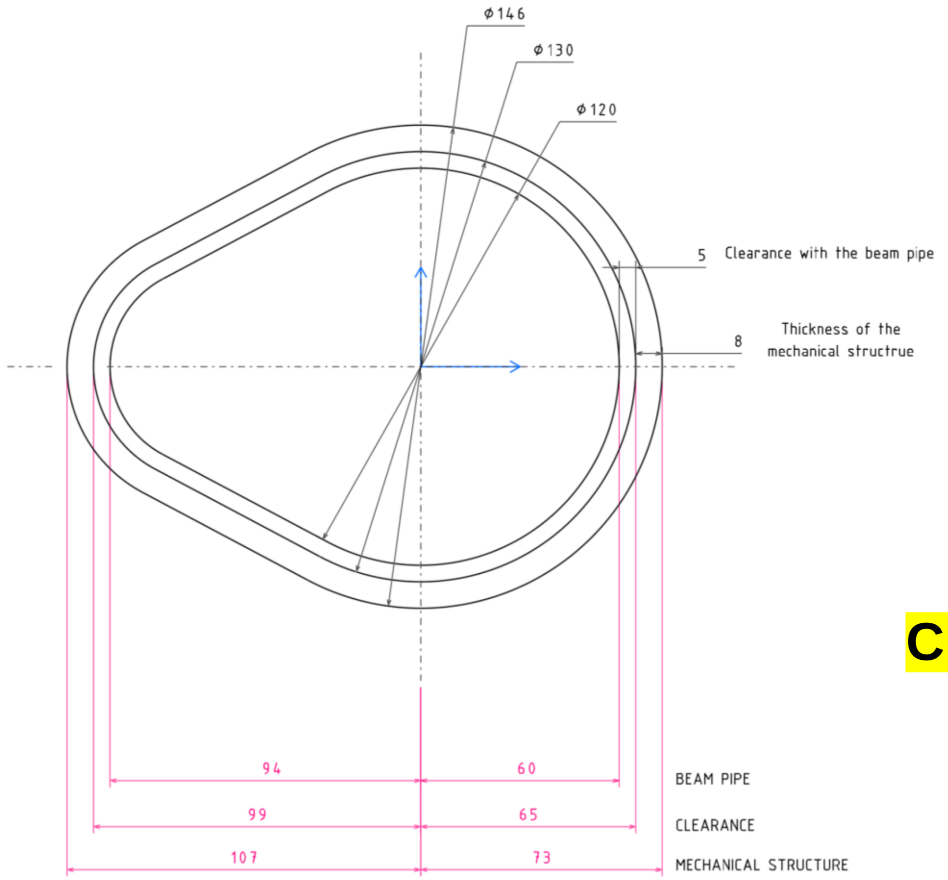
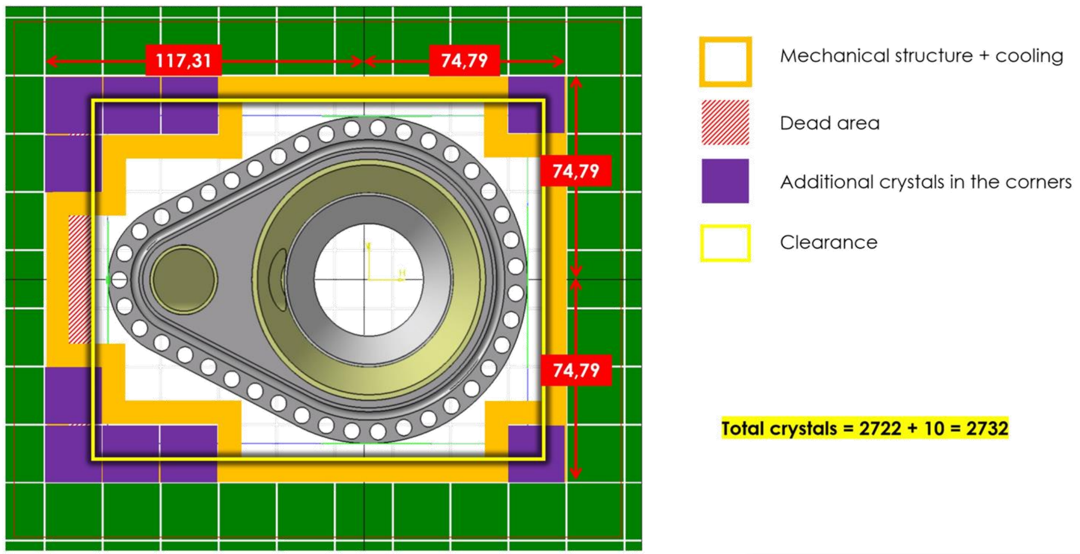



Figure 5: Positioning of the EEEMCal into the ePIC Detector, 176 cm < $d$ < 179 cm for the crystals (ideal position for physics: 174 cm)

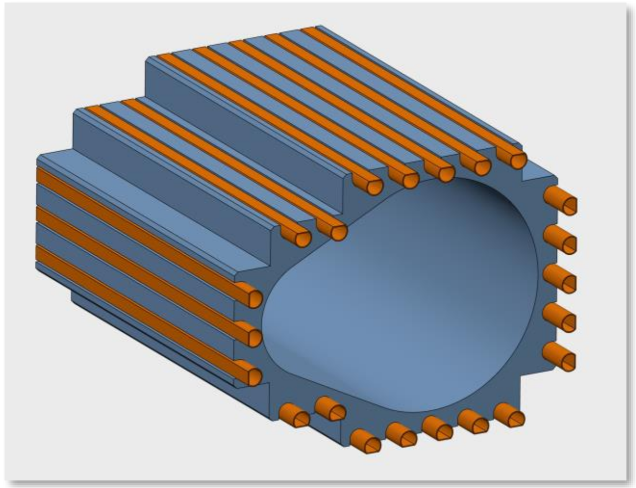


# Detector Views



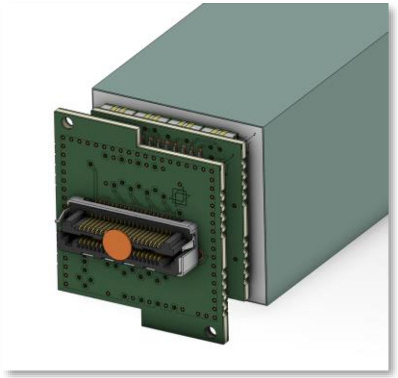

CENTERED

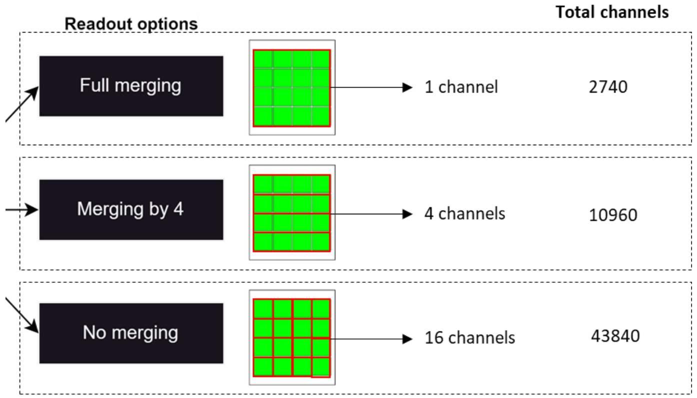


**Clearance with the beam pipe**

Diameter of the beam pipe recently reduced (clearance 5mm → 8mm)

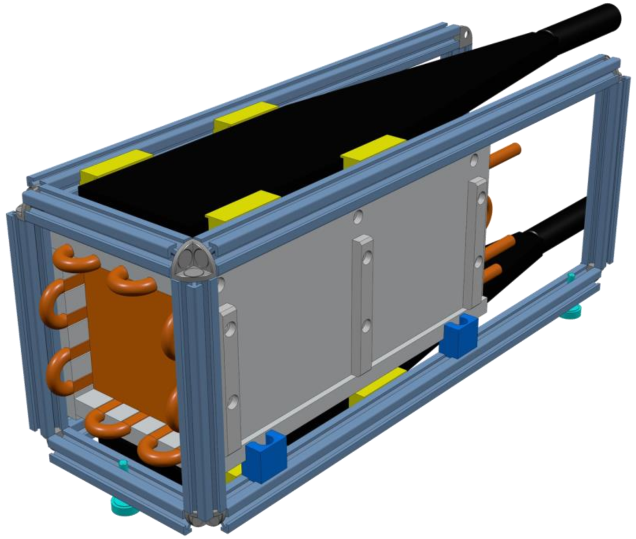
# Status / Updates | Beam test & Prototype






**Beam test:**

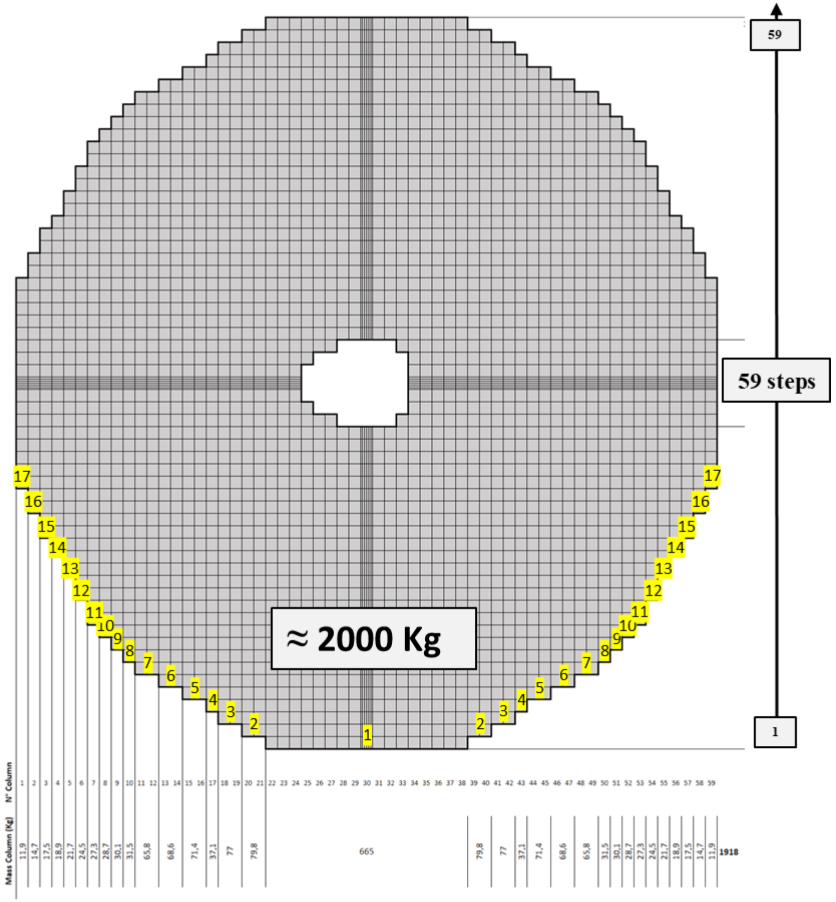
- @DESY : 16$^{th}$ Feb → 02$^{th}$ March 2025
- Test the SiPM readout (among others…)
- Ongoing results/Analysis

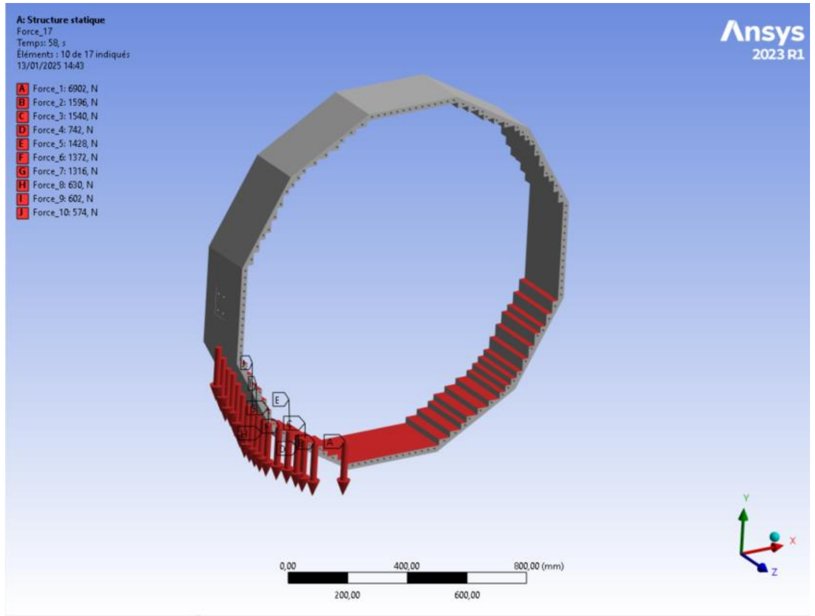


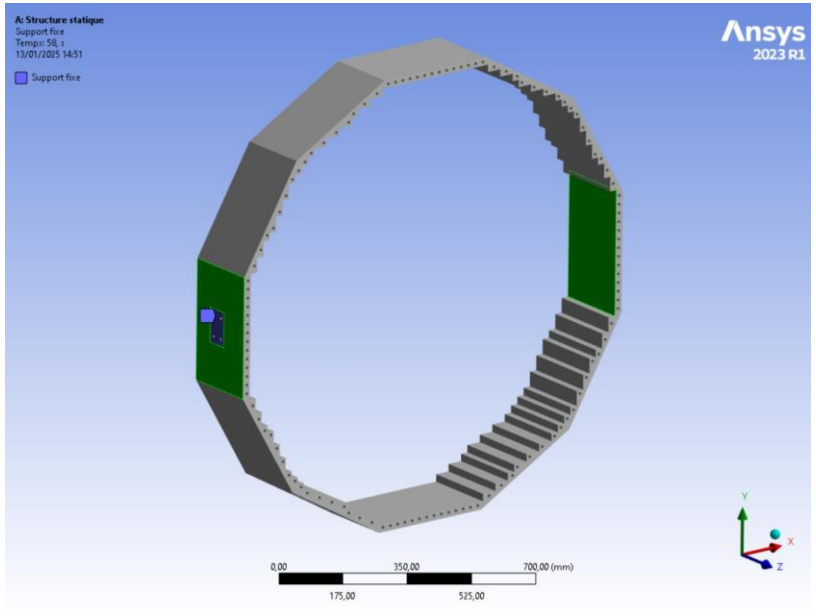
**Prototype upgrade:**

- Cosmic bench
- 2 scintillators + 2 PMTs
- 25 PWO crystals
- PCB SiPM with different readout
- Beam tests compatible

# Status / Updates | External structure



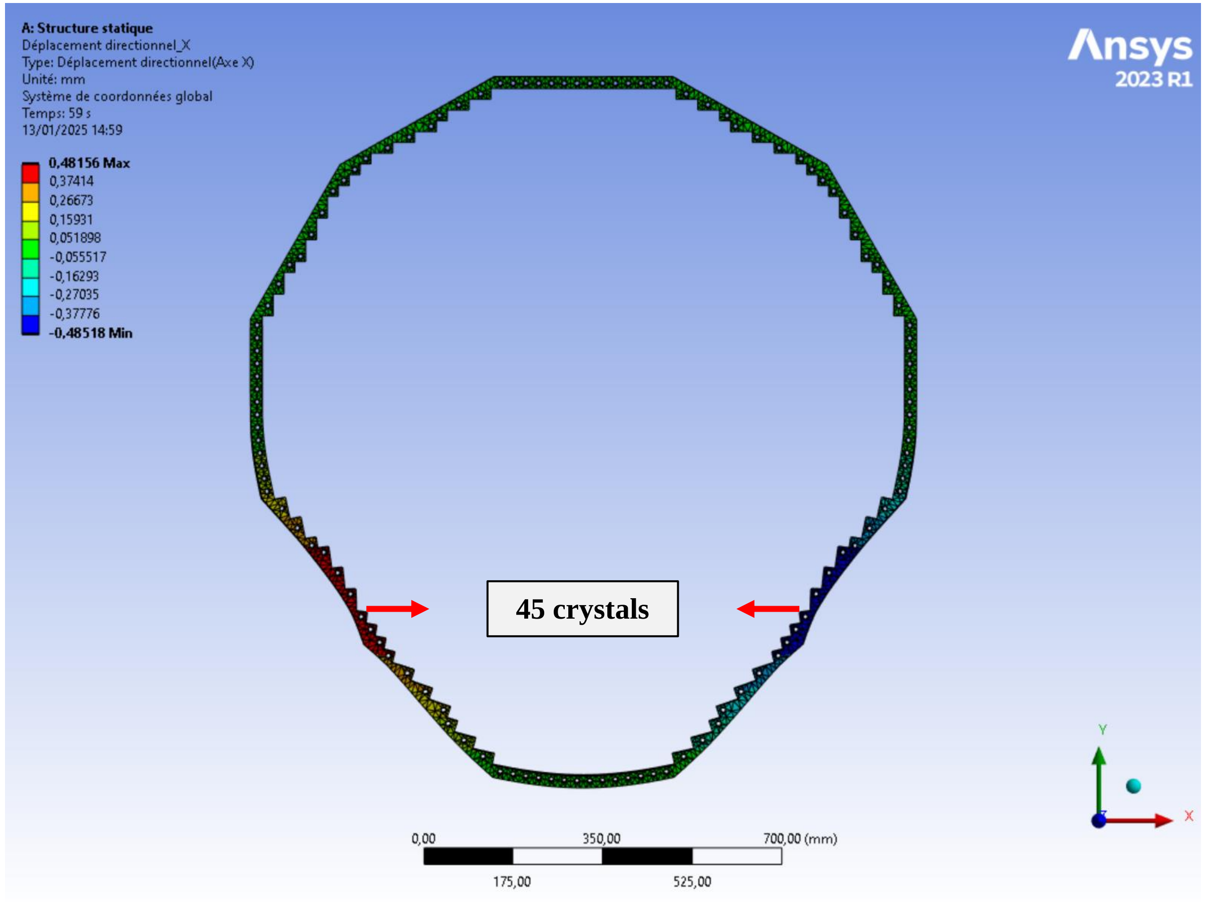

**FEA Model:**
- 1 face at the center

→ 665 Kg
- 16 other faces on both sides

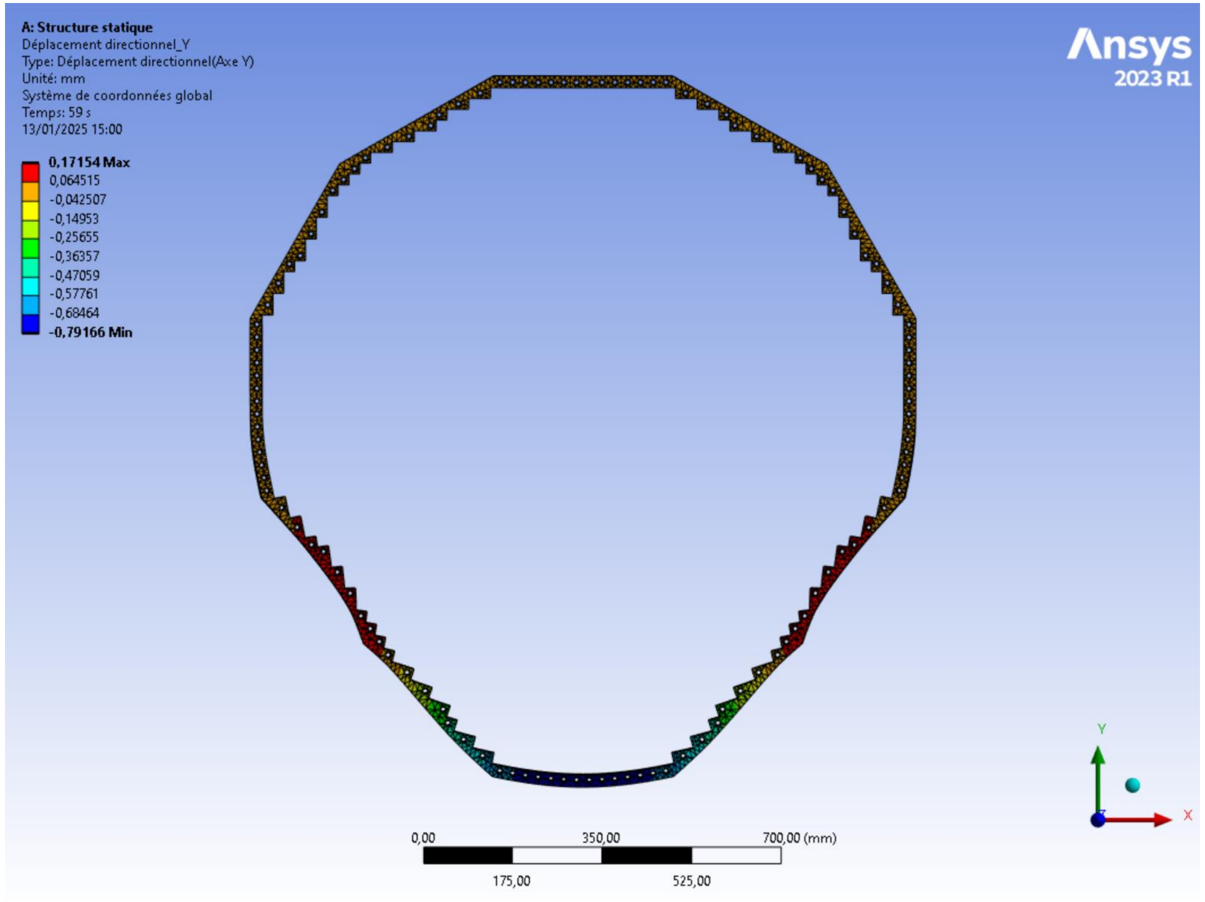
→ 626,5 Kg x2 (11,9 kg to 79,8 Kg)
- 59 steps to check the deflection during the assembly

**FEA Model:**
- Worst case: fastened at 3 and 9 o'clock
- The way to fasten the structure increase the results in terms of stress

# Status / Updates | External structure




**Displacement X < 0,5 mm**




**Displacement Y < 0,8 mm**

# Status / Updates | External structure

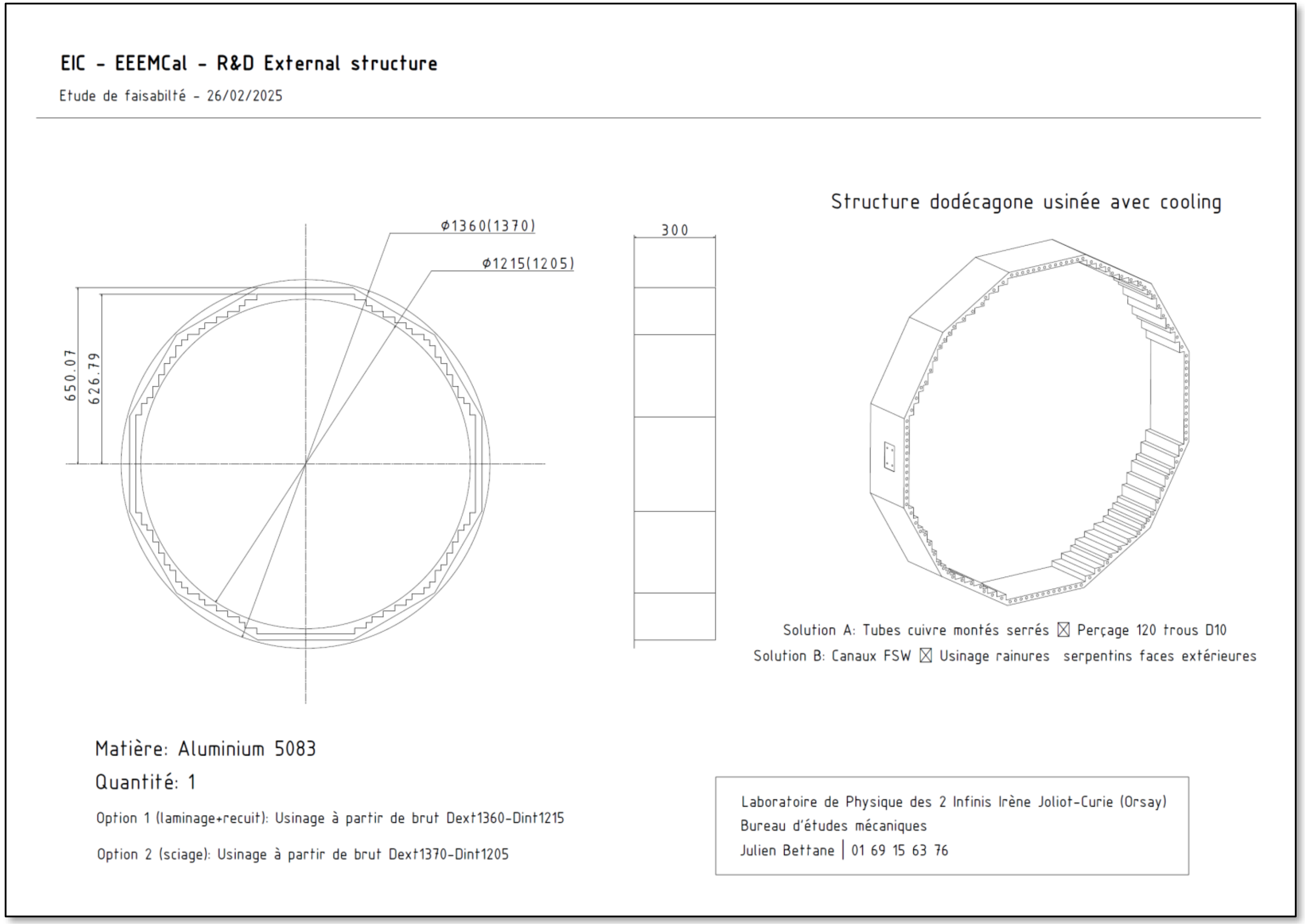
**Mechanical feasibility study**

- ❑ **How to cool ?**

→ Copper tubes insert in the aluminum
→ FSW + machined coil

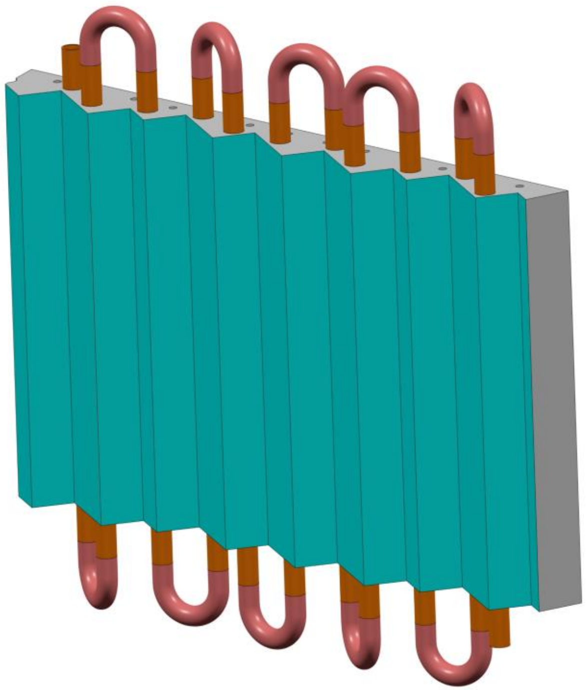
- ❑ **How to build the structure?**

→ Foundry (not selected)
→ Machining (bandsaw cutting)

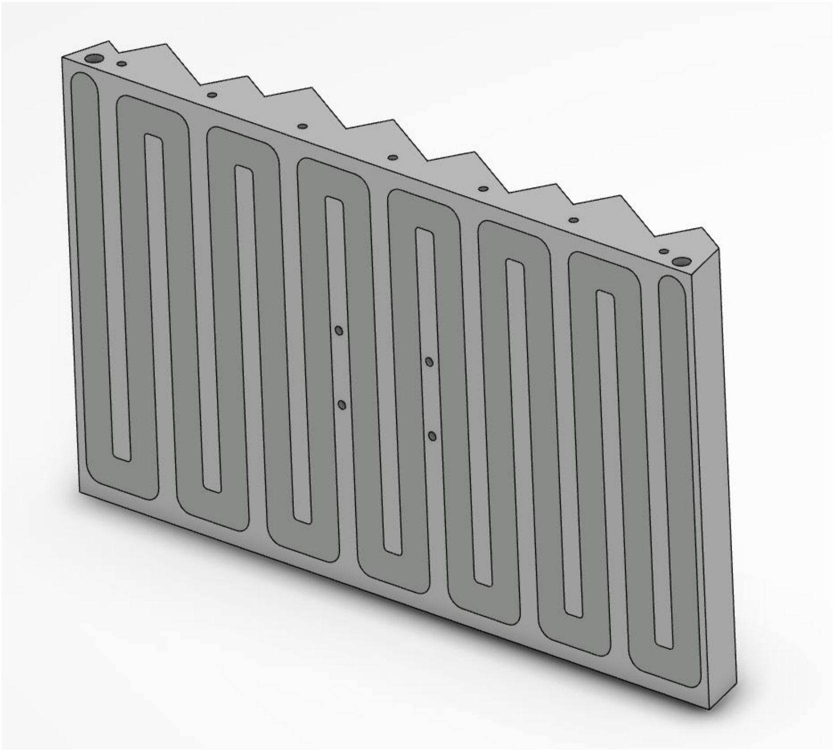


# Status / Updates | External structure

**Mechanical prototypes to compare the feasibilty and the efficiency of the cooling**



→ Copper tubes insert in the aluminum



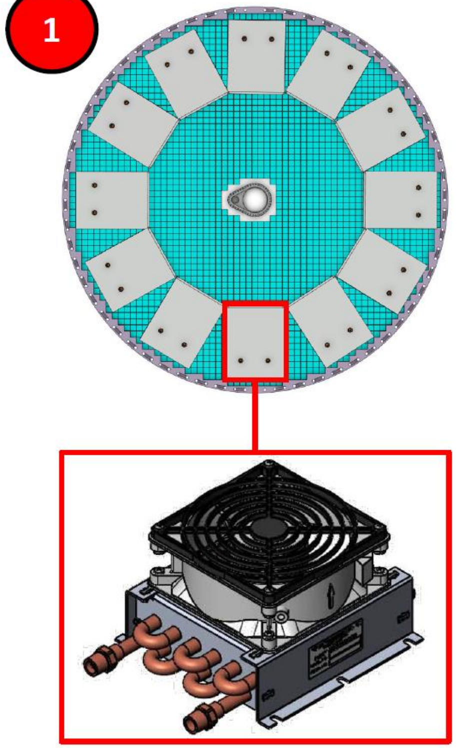
→ FSW + machined coil

**Quotation under preparation**

# Status / Updates | FEB        HEAT SOURCES

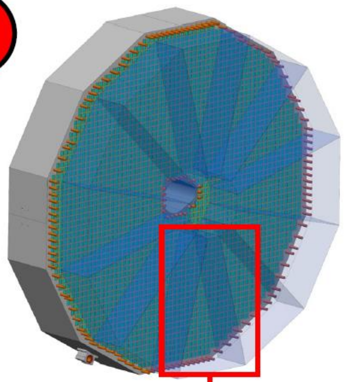
## 3 main options for the Front End Board

**1** Boxes all around

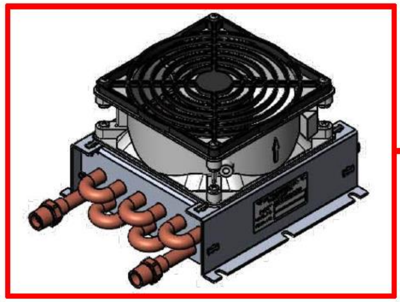


With cables → Fan + Exchanger

**2** Boxes in front of the SiPM

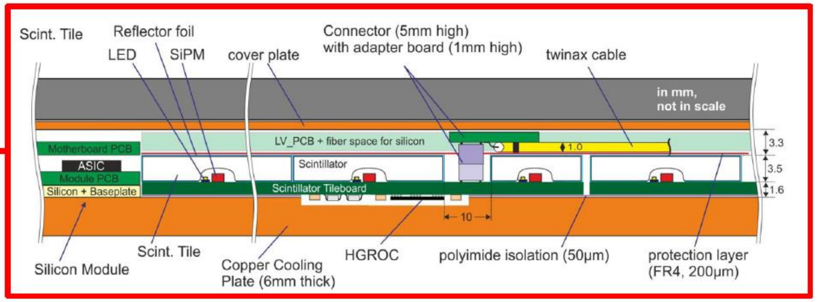


(A)



With cables → Fan + Exchanger

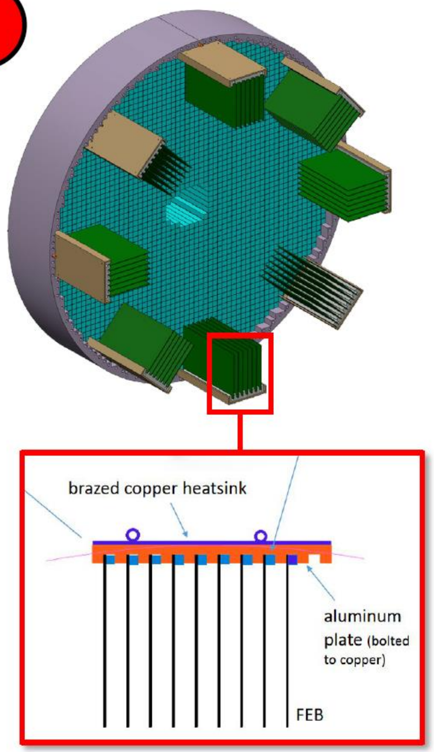
(B)




Without cables → Cold plate

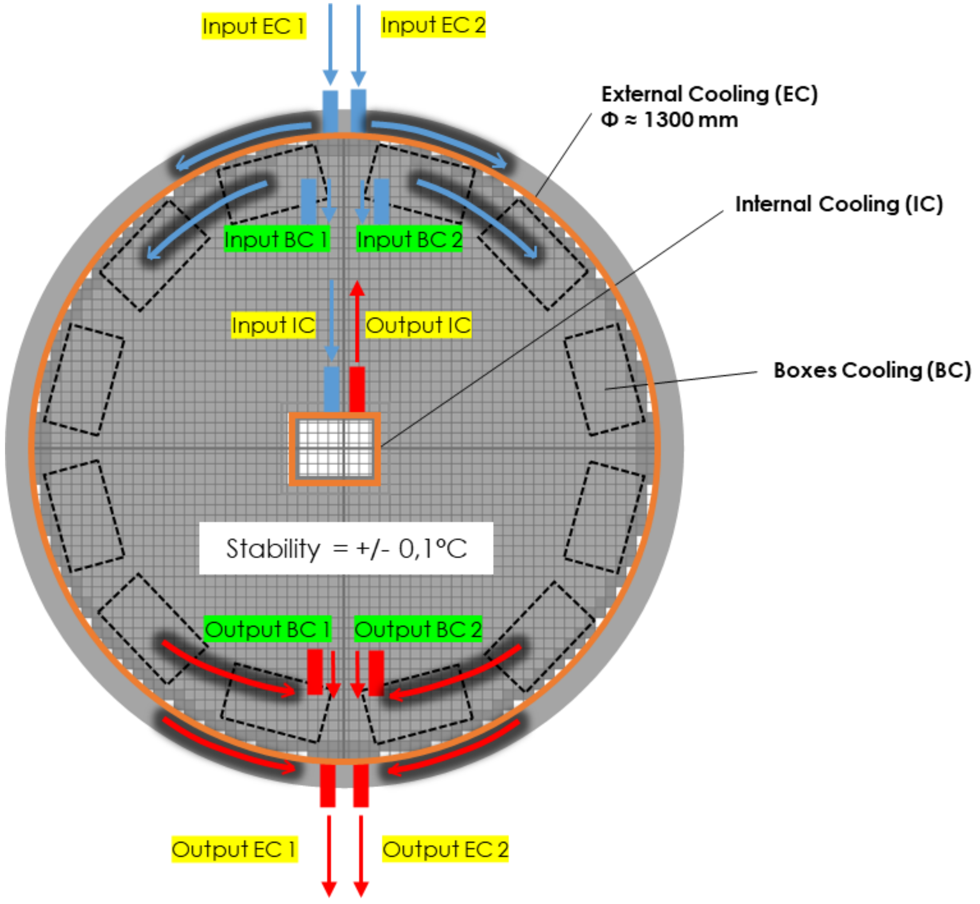
**= max 1500 W**
0,15 mW per channel
+0,15 mW for other components

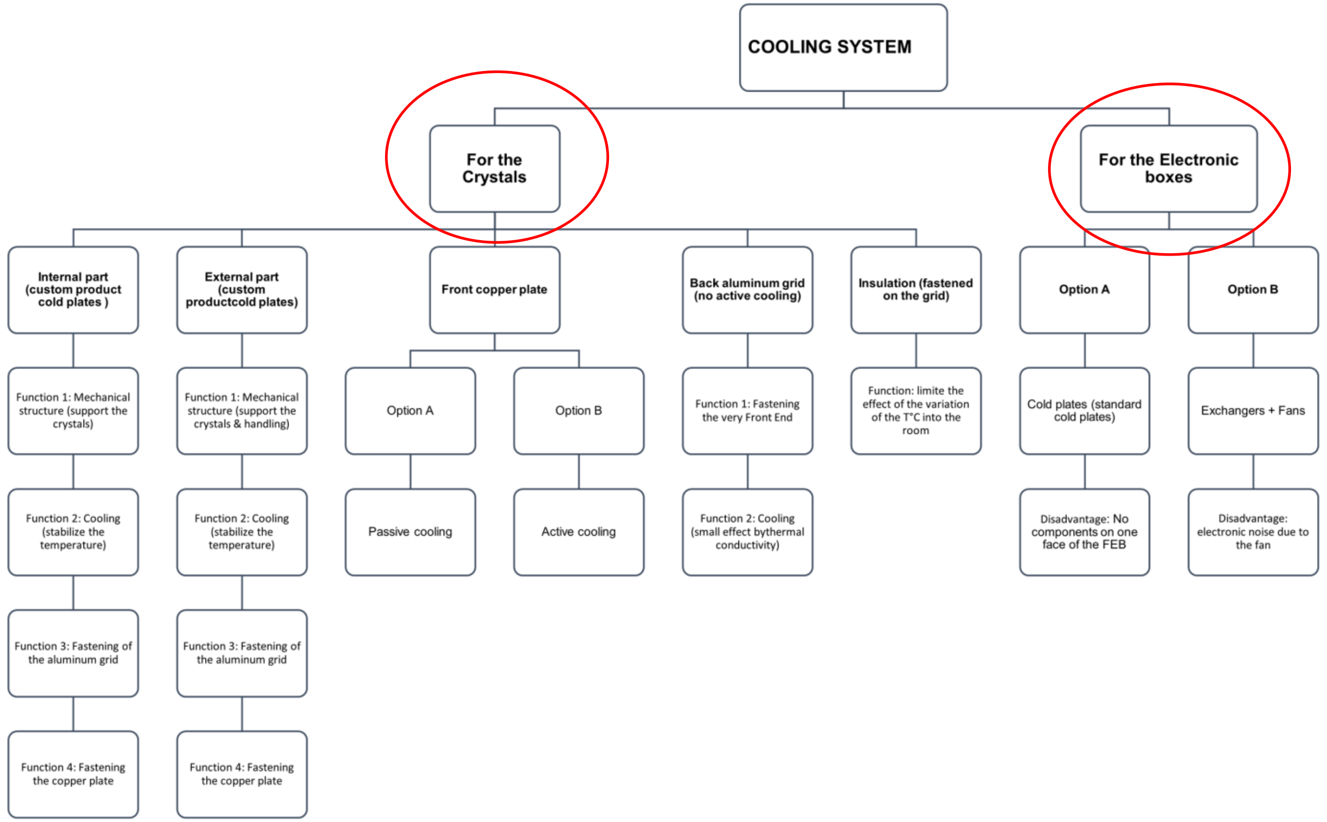
**3** Racks with cold plates




With cables → Rack + cold plate

# Cooling | Overview




## 2 main objectives:

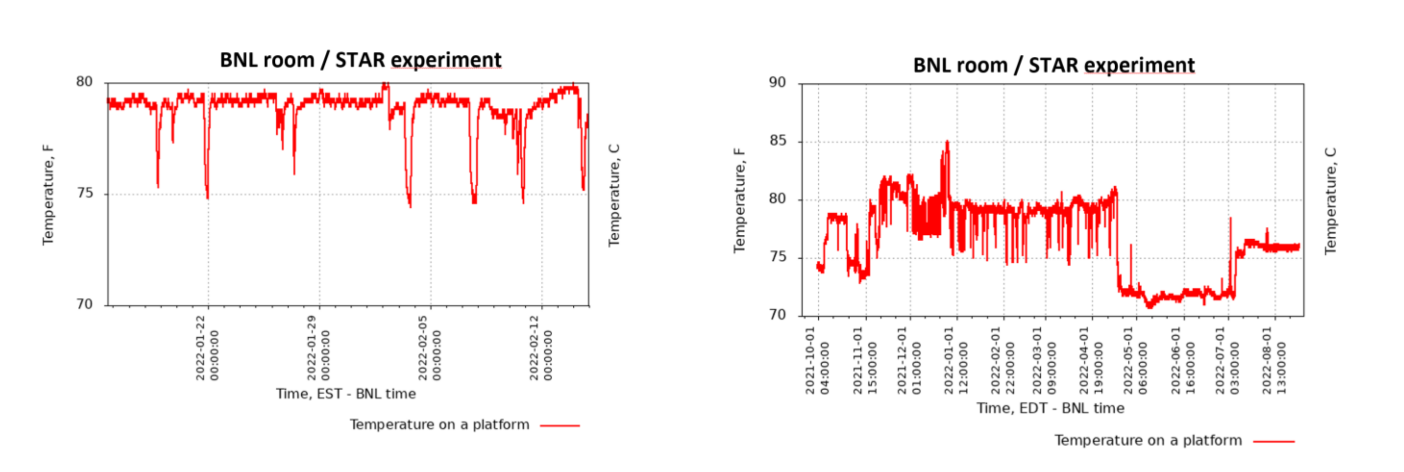
- Stabilize the temperature of the crystals to within 0,1°C
- Dissipate the power of the FEB (& RDO) ≈ 1500 W

# Cooling | Specifications

**3 main parameters for the sizing:**

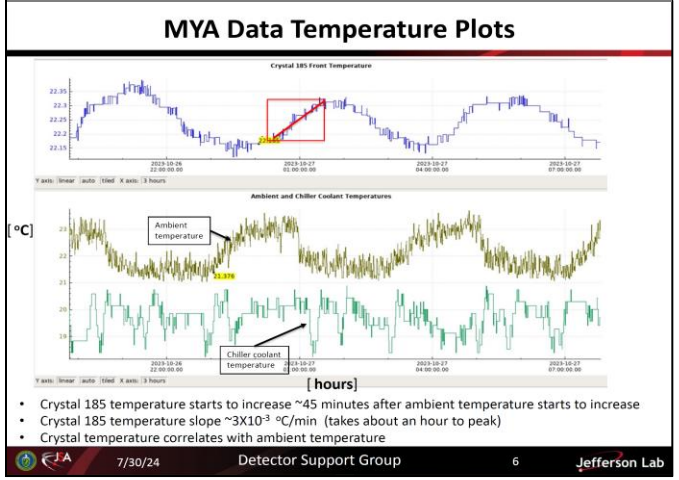
- The amplitude of the temperature variations in the experimental hall → ΔT= 3°C
- The frequency/period of the temperature variations in the experimental hall → 6 hours < T < 12 hours
- The location of the power to dissipate → Power on electronic boxes

**RHIC/ STAR experiment data**




*Temperature evolution | Long period*

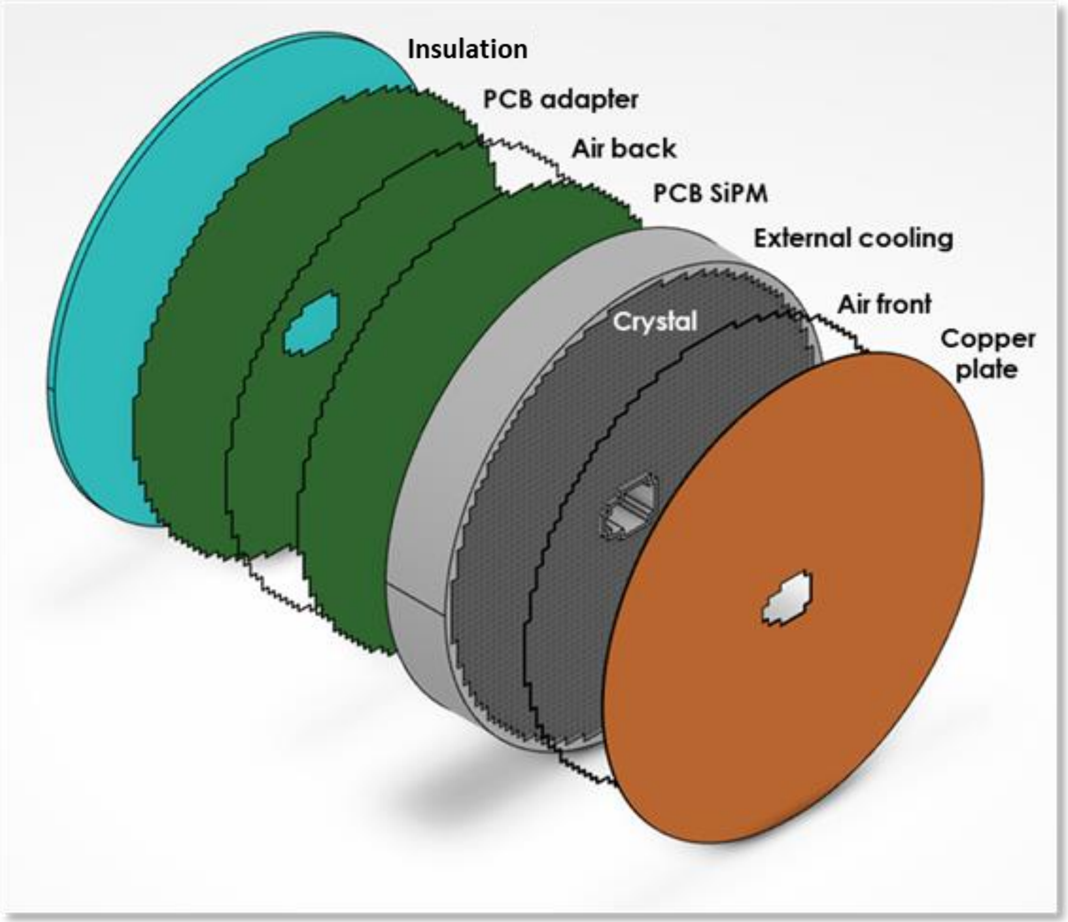
**NPS data**




*Temperature evolution | Short period*

# Cooling | Thermal simulation (1/4)

Simplified design for ANSYS thermal analysis

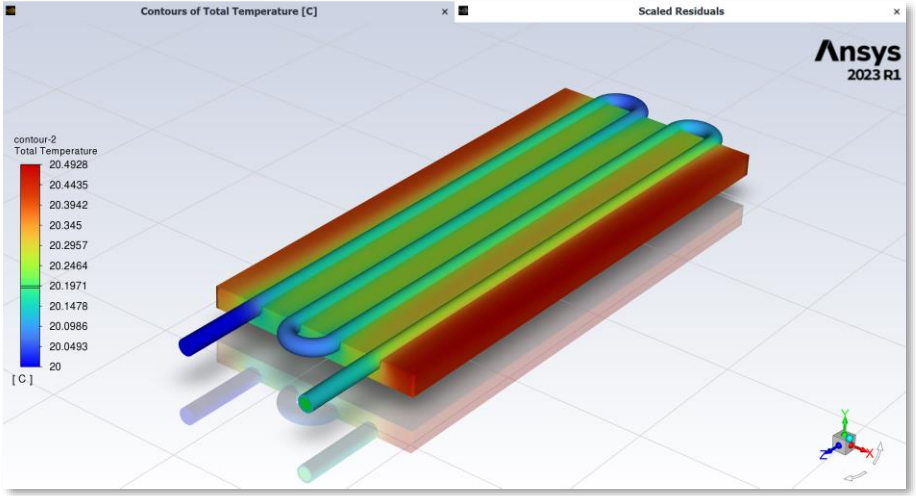



**Model:**

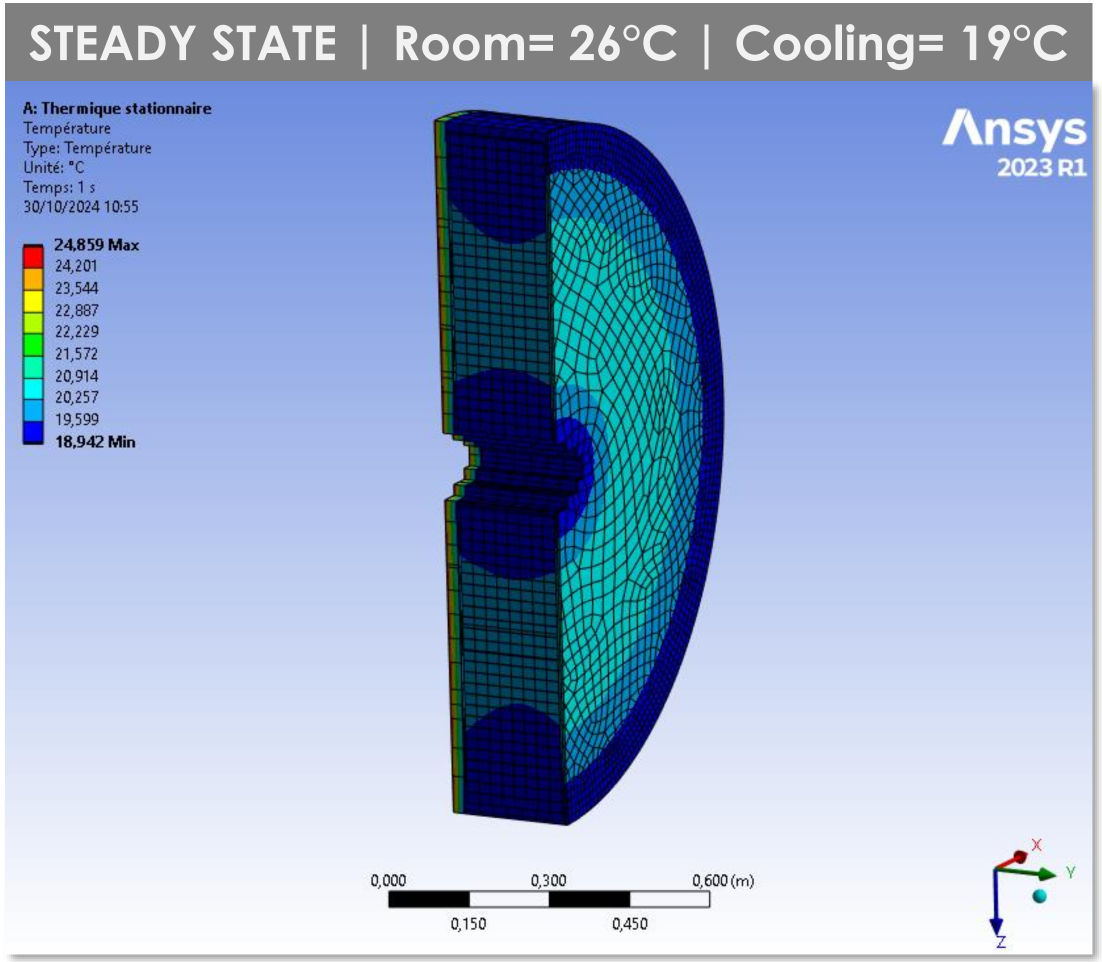
- To check the effect of the variation of the temperature in the room
- To check the efficiency of the insulation
- Several cases tested to see the efficiency of each parts
- No power near to the crystals

# Cooling | Thermal simulation (2/4)

STEADY STATE




*Fluent simulation of a cold plate to validate the homogeneity of the cooling*

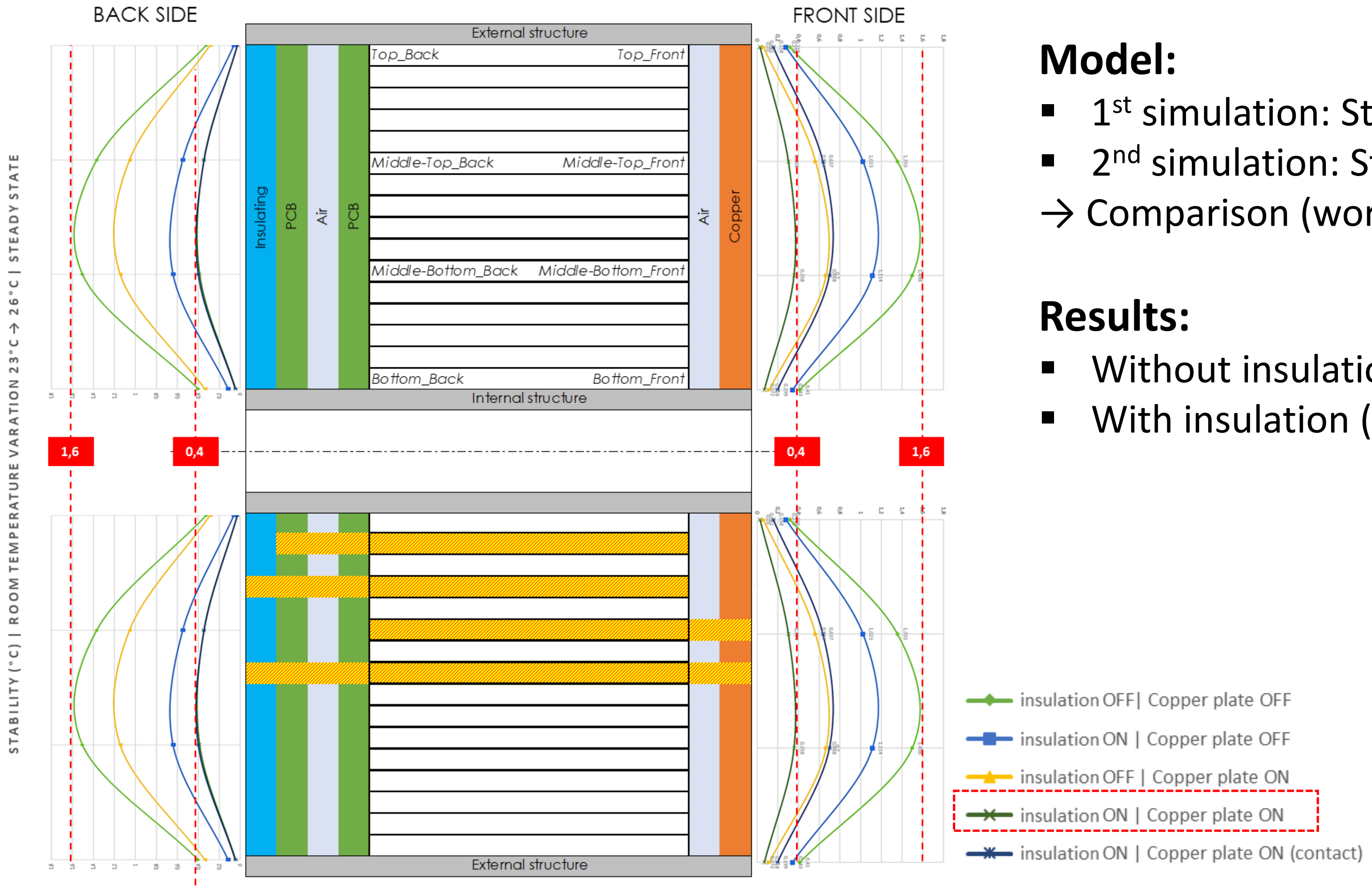



*Exemple of results at 26°C*
*Temperature distribution on the crystals*

**Model:**

- We consider the external & internal cooling are considered at the same temperature (19°C)
- Low gradient along the crystal ($\Delta T < 2°C$)

STEADY STATE




*Two steady states comparison*

## Model:

- 1st simulation: Steady state with temperature room= 23°C
- 2nd simulation: Steady state with temperature room= 26°C

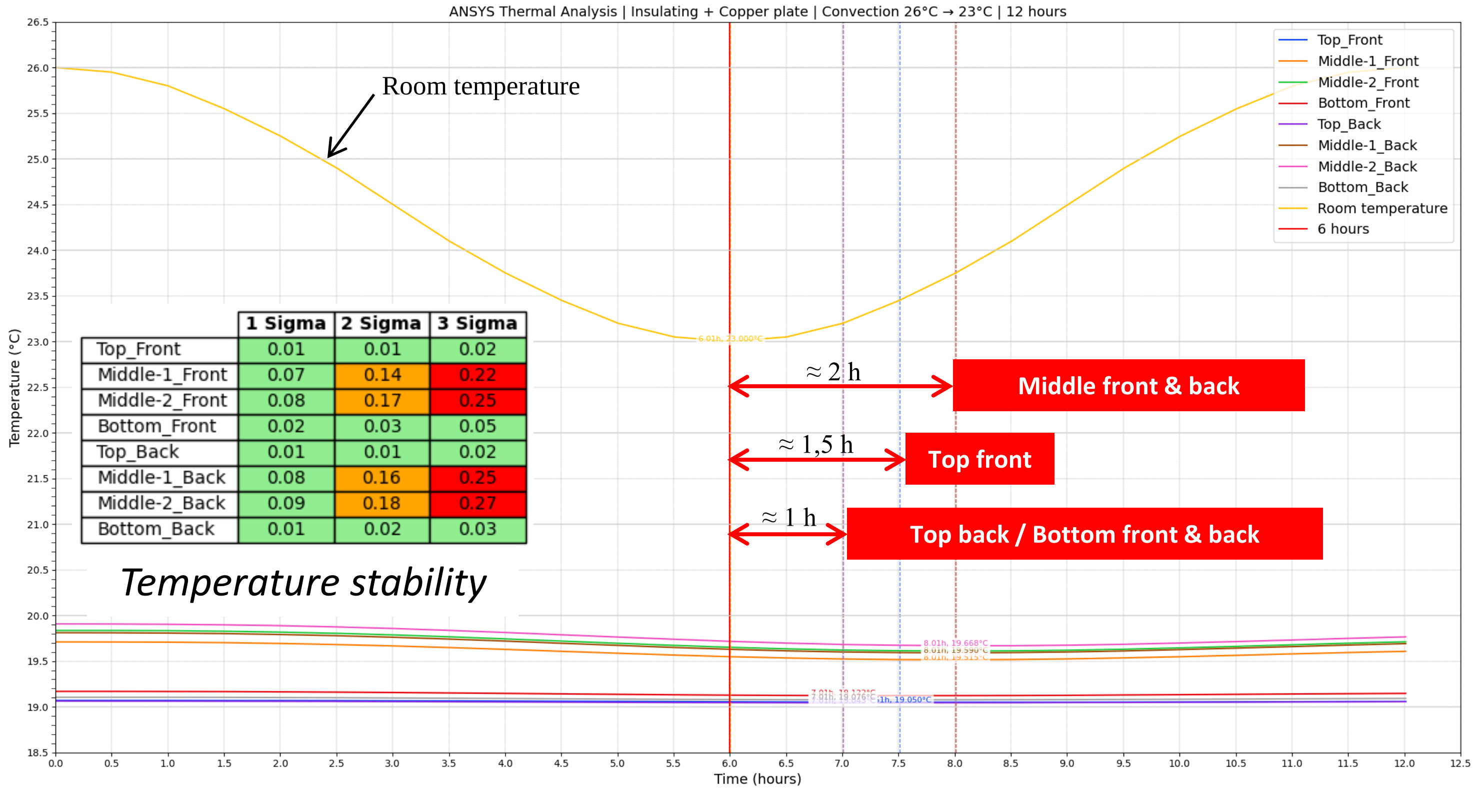
→ Comparison (worst case)

## Results:

- Without insulation: ΔT (stabilty) = **1,6°C**
- With insulation (foam, air and copper): ΔT (stability) = **0,4°C**

# Cooling | Thermal simulation (4/4)

**TRANSIENT STATE**




| | 1 Sigma | 2 Sigma | 3 Sigma |
|---|---|---|---|
| Top_Front | 0.01 | 0.01 | 0.02 |
| Middle-1_Front | 0.07 | 0.14 | 0.22 |
| Middle-2_Front | 0.08 | 0.17 | 0.25 |
| Bottom_Front | 0.02 | 0.03 | 0.05 |
| Top_Back | 0.01 | 0.01 | 0.02 |
| Middle-1_Back | 0.08 | 0.16 | 0.25 |
| Middle-2_Back | 0.09 | 0.18 | 0.27 |
| Bottom_Back | 0.01 | 0.02 | 0.03 |

*Temperature stability*

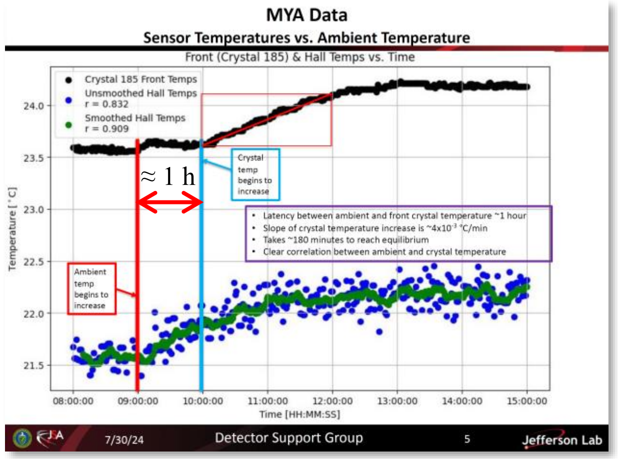
*Evolution of the temperature for a variation of the room temperature from 26°C to 23°C in 6 hours and 23°C to 26°C in 6 hours*

## Model:

- 26°C → 23°C in 6 hours
- T= 12 hours
- Start from the steady state at room= 26°C

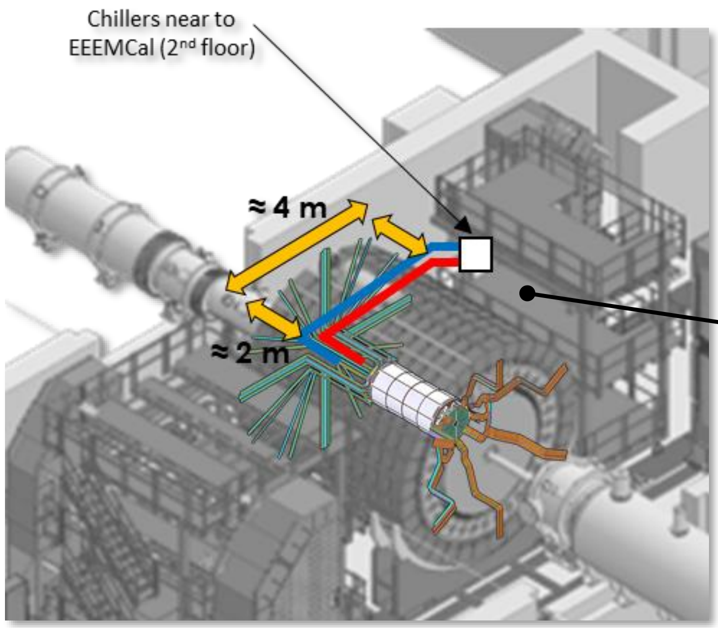
## Results:

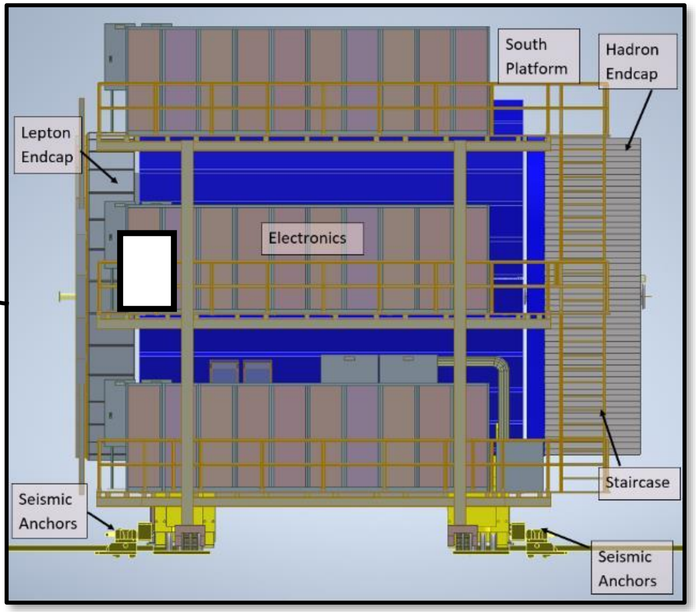
- ΔT (stabilty) < **0,1°C**
- 1 hour < Shift (inertia) < 2 hours
- In accordance with the NPS data

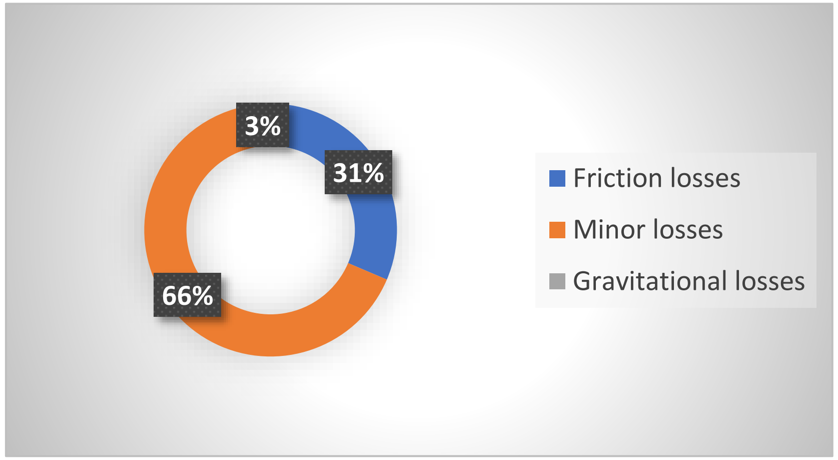


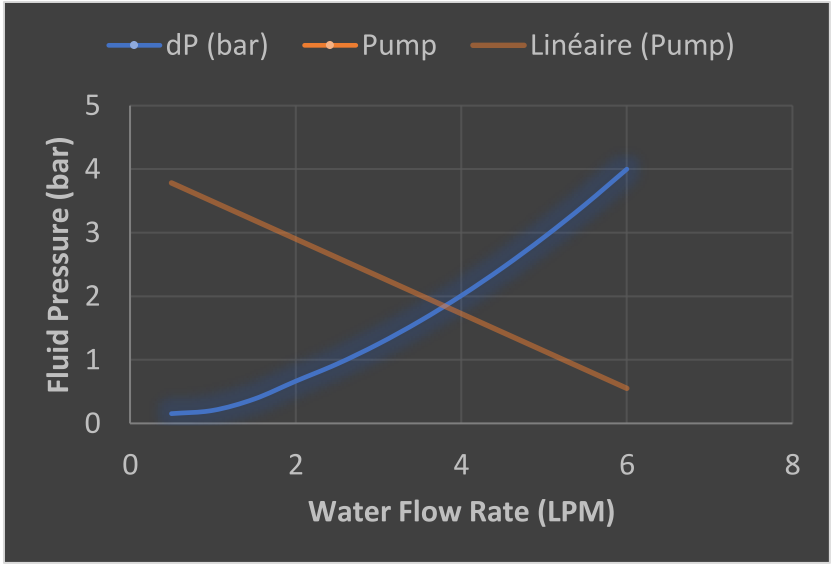

*NPS experiment, temperature data*

# Cooling | Chillers / Pressure drop



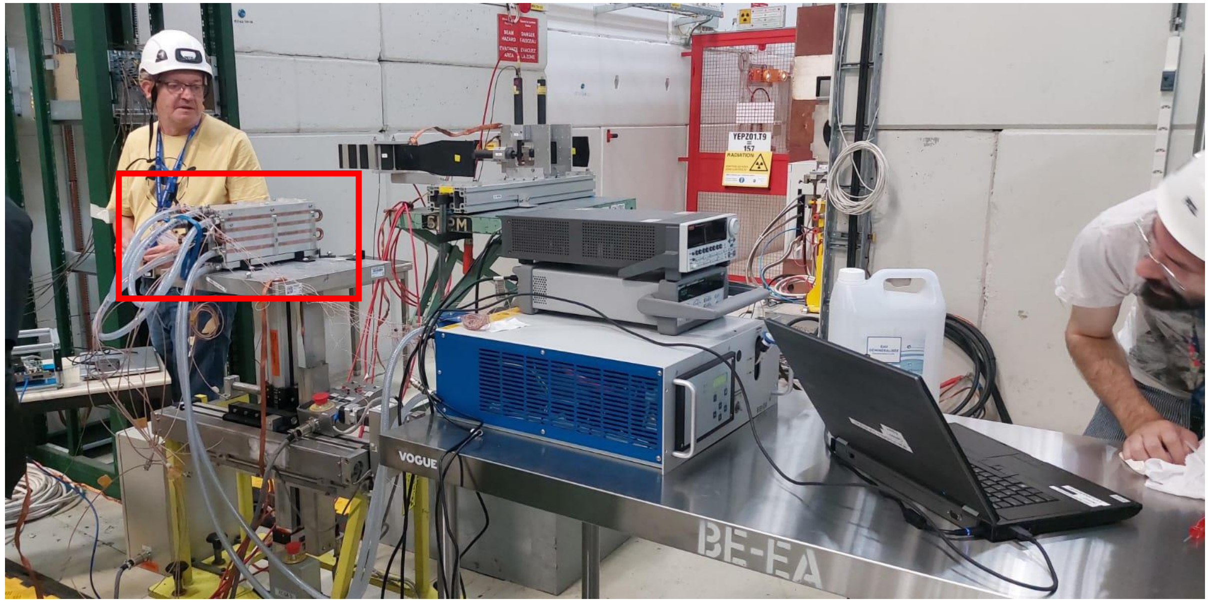



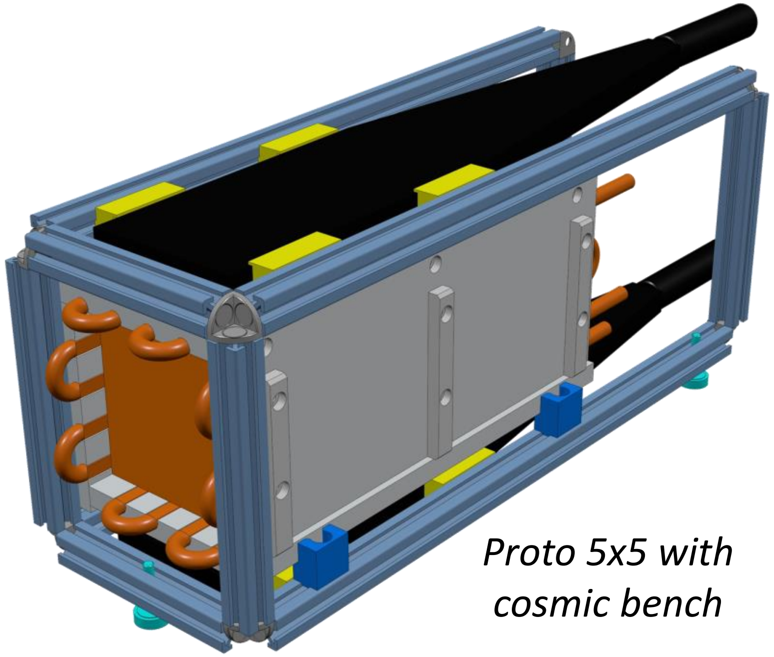




**To be considered:**

- The location of the chillers
- The entire network of tubes for the cooling
- The power of the pump of the chiller

# Prototype 5x5 | Beam test | Setup



*Proto 5x5 with cosmic bench*

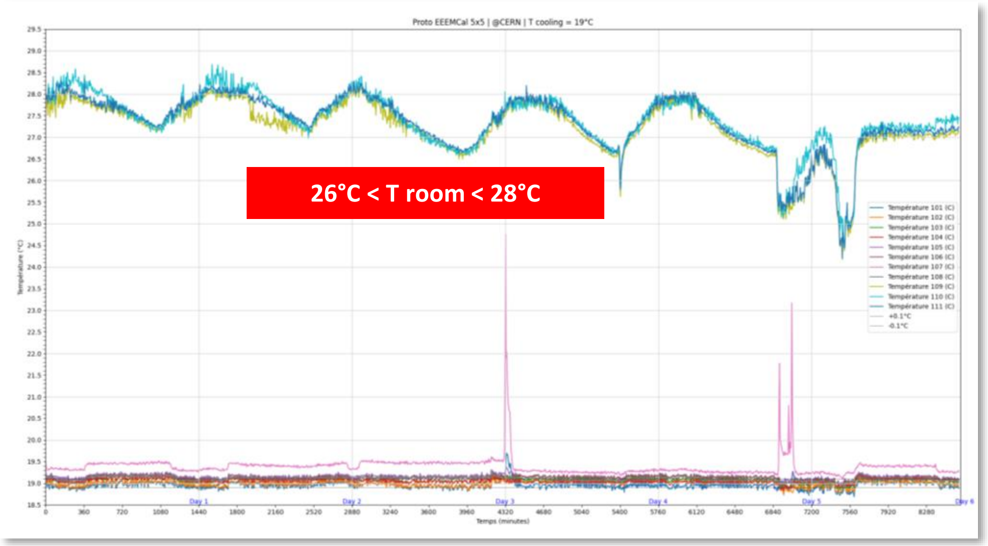
**Beam tests performed and planed:**

- @ CERN | August 2024
- @ DESY | November 2024 (problem, fire in the accelerator part)
- @ DESY | February 2024

**Main objectives:**

- Take physics data and validate reading by SiPM
- Tests several configurations of the daughter board

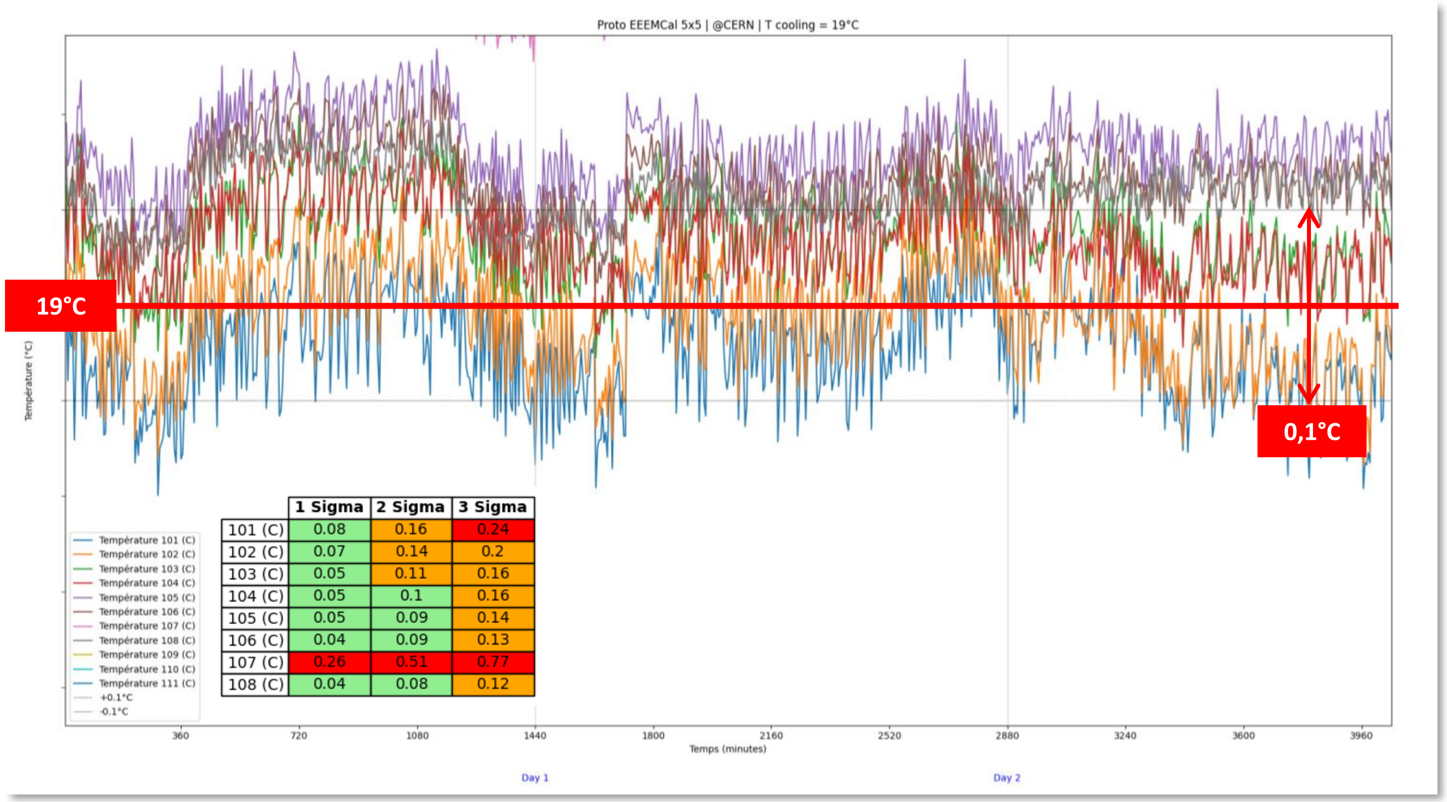
# Prototype 5x5 | Beam test | Thermal analysis




**Beam test @ CERN:**

- Temperature stability under +/- 0,1°C
- Problem on one sensor (107, out of use)

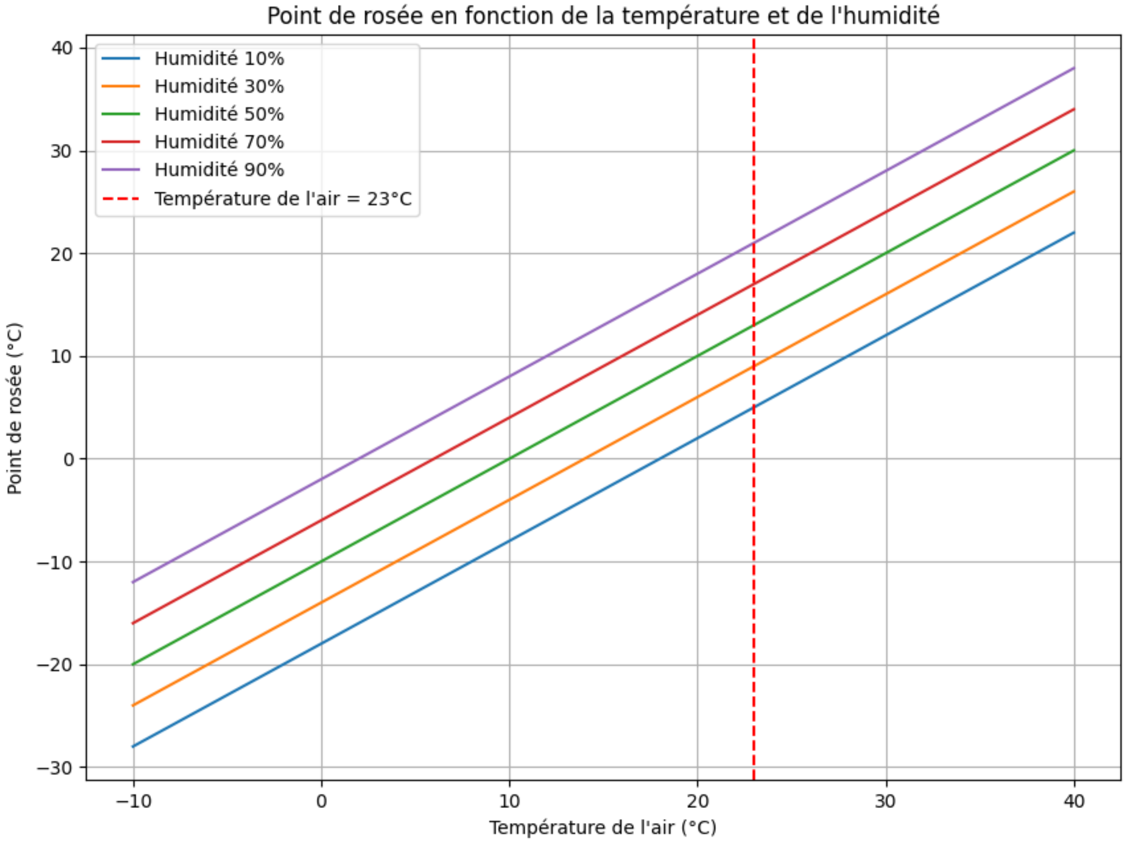
## Room= 26°C – 28°C | T= 3 days | Cooling= 19°C




| | 1 Sigma | 2 Sigma | 3 Sigma |
|---|---|---|---|
| 101 (C) | 0.08 | 0.16 | 0.24 |
| 102 (C) | 0.07 | 0.14 | 0.2 |
| 103 (C) | 0.05 | 0.11 | 0.16 |
| 104 (C) | 0.05 | 0.1 | 0.16 |
| 105 (C) | 0.05 | 0.09 | 0.14 |
| 106 (C) | 0.04 | 0.09 | 0.13 |
| 107 (C) | 0.26 | 0.51 | 0.77 |
| 108 (C) | 0.04 | 0.08 | 0.12 |

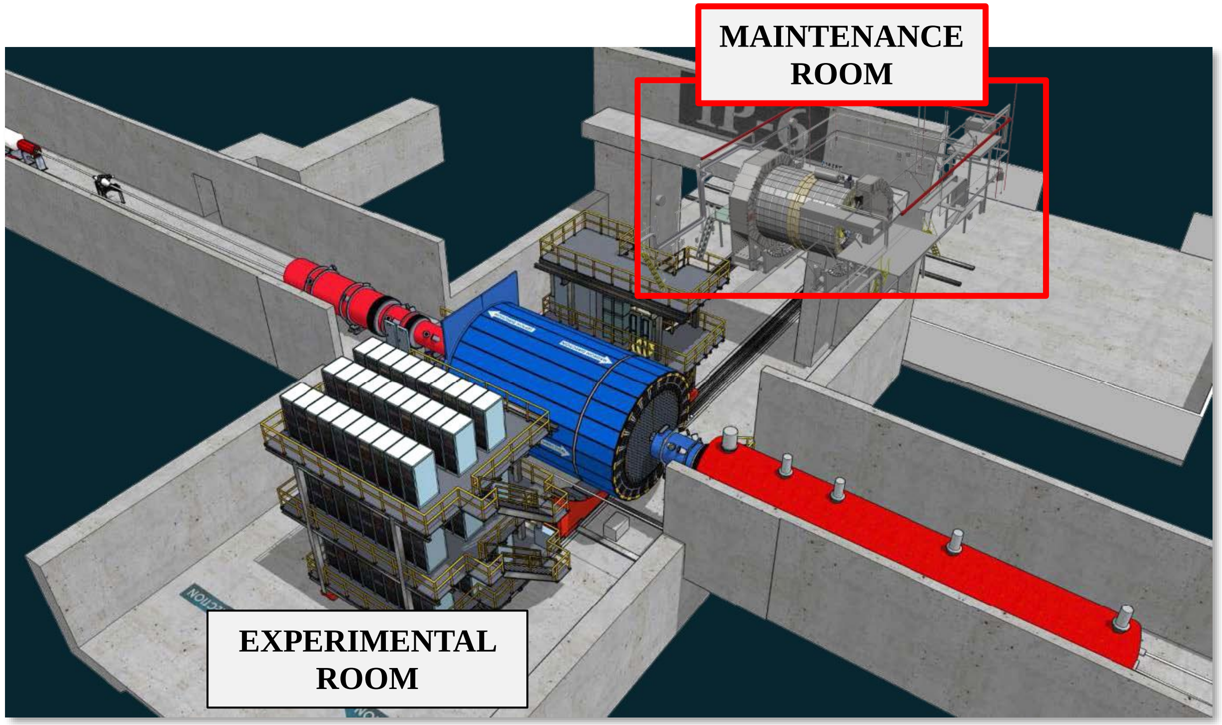
*Evolution of the temperature of the crystals during the beam test at CERN*

# QUESTION ABOUT DUE POINT




**Humidity in the room experiment ?**

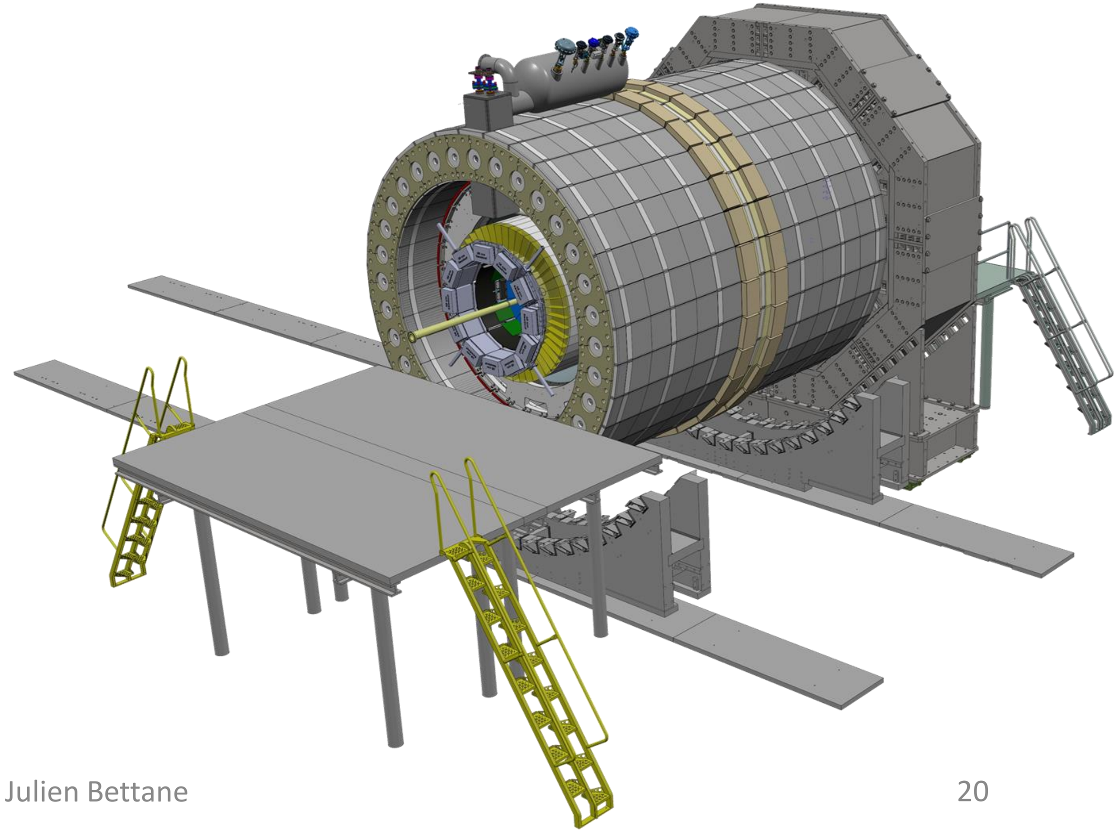
# Installation (1/2)




*Overview of the experimental and maintenance rooms*

**Requirements:**

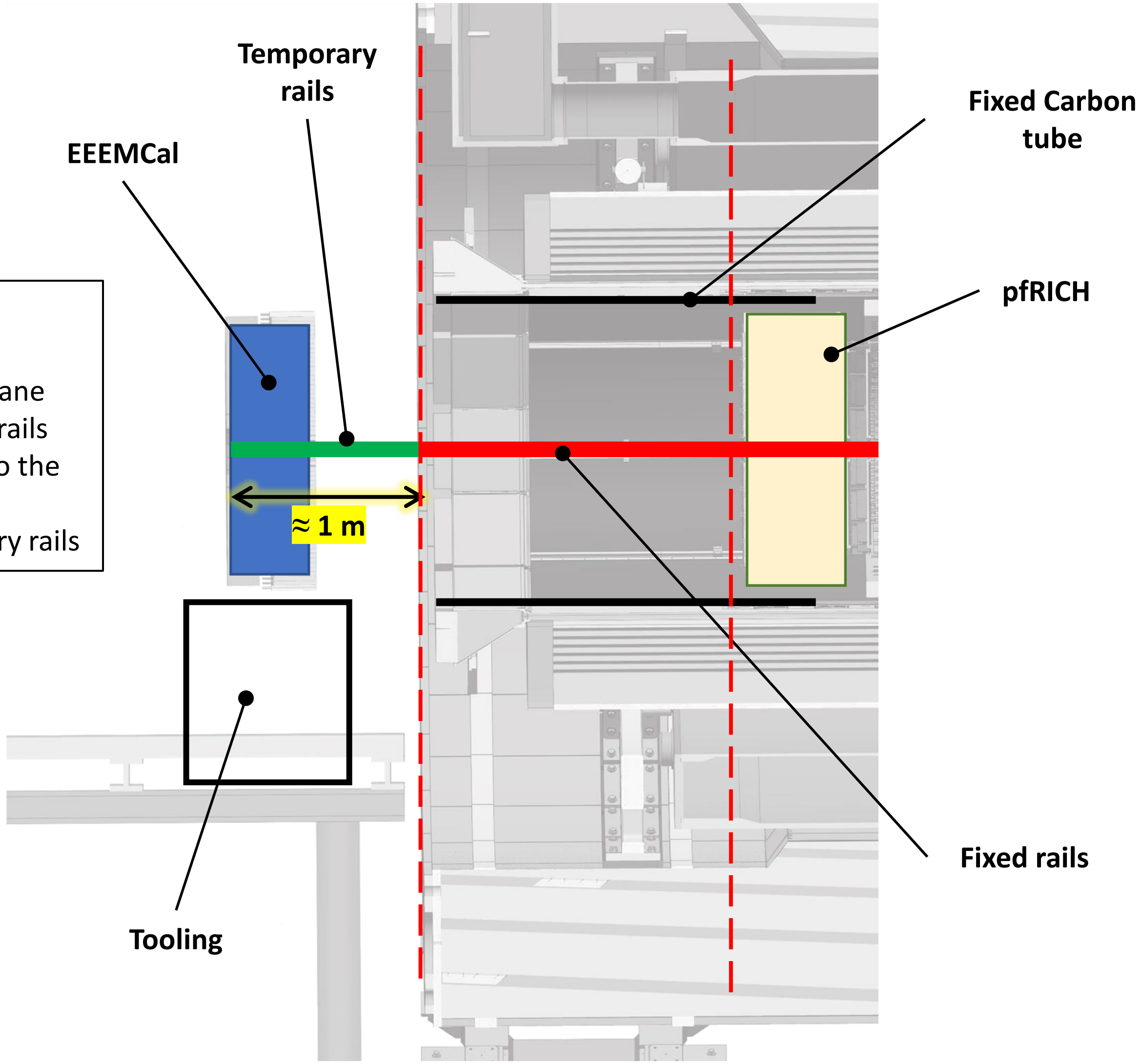
- Work in the maintenance room
- Disconnect the beam pipe
- Work plateform
- Special tooling assembly & Bridge crane

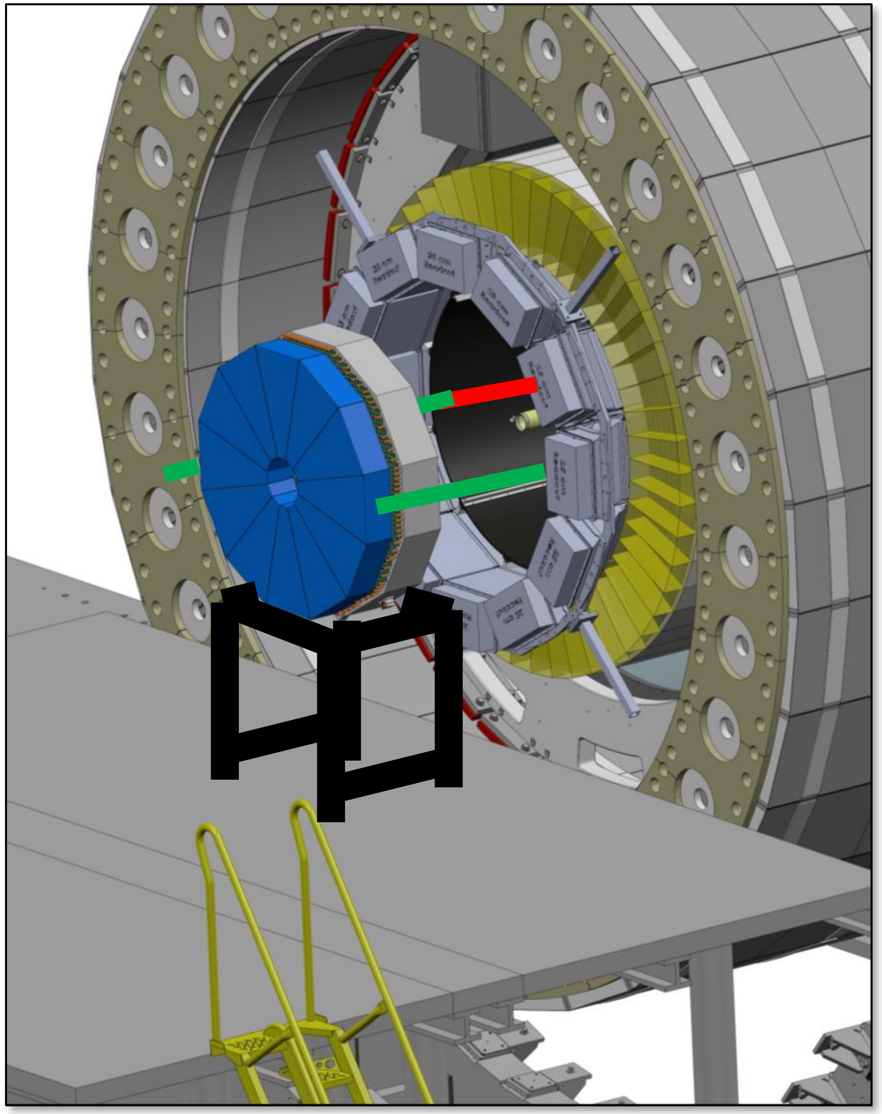


# Installation (2/2)

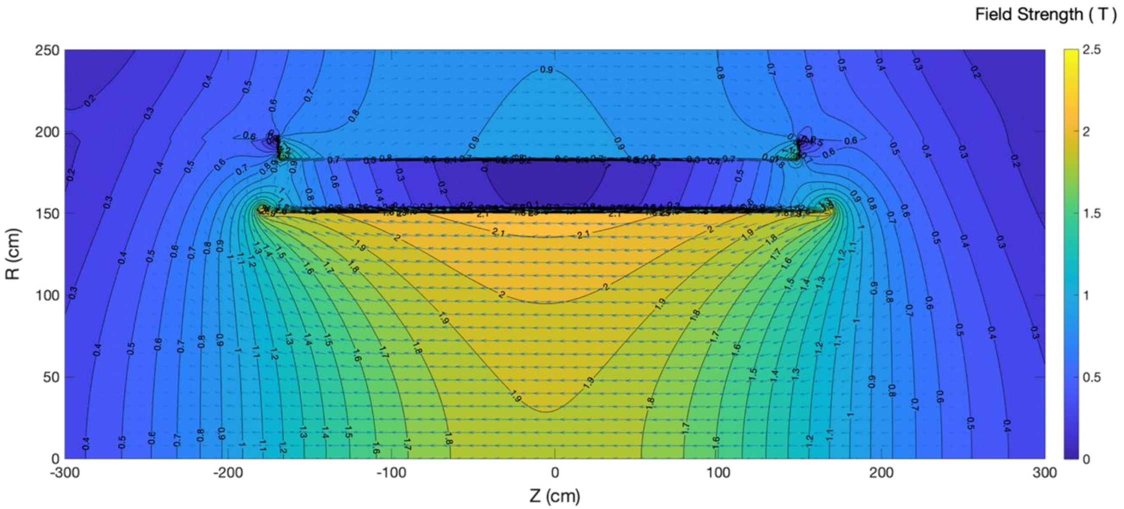
**Steps:**

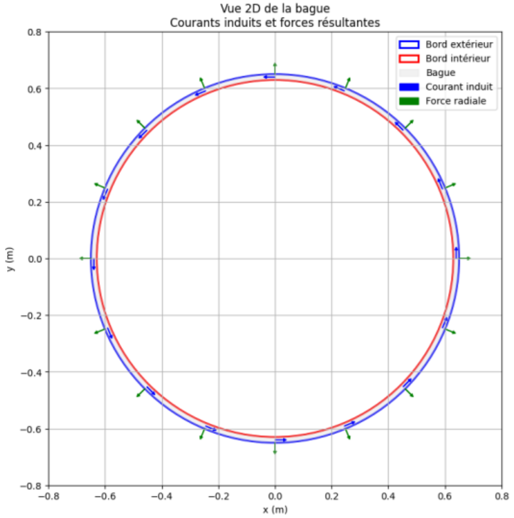
- Put the detector on a tooling with bridge crane
- Fasten the temporay rails
- Slide the detector into the carbon tube
- Remove the temporary rails

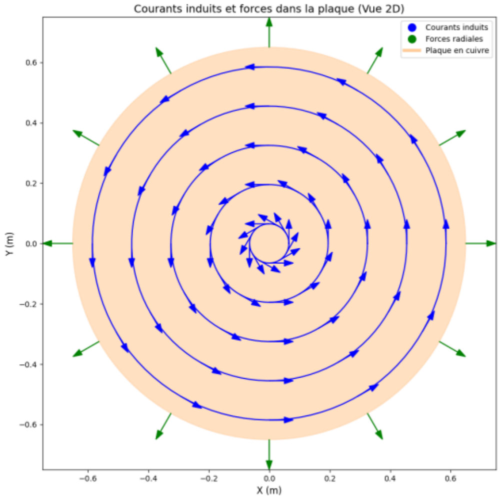


# QUESTION ABOUT MAGNETIC FIELD




**Calculation & simulation required**

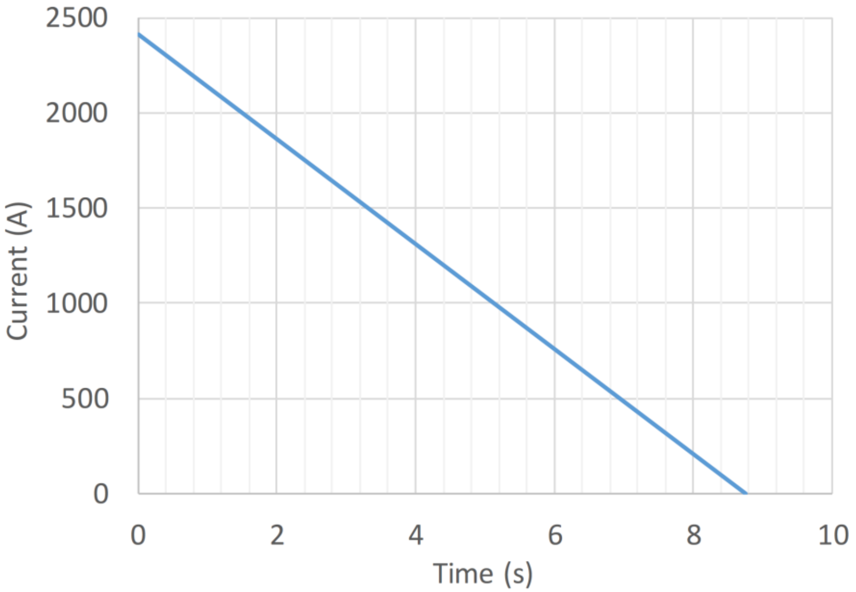



Fig. 5 The current decay assuming linear decay rate (281 A/s)

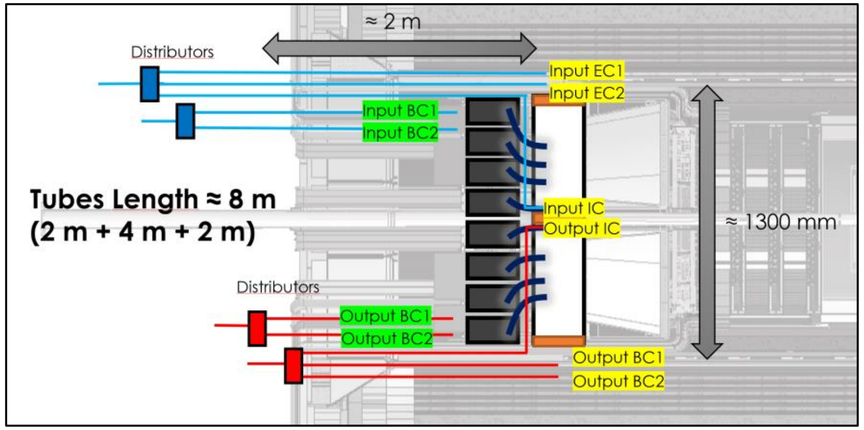
# QUESTION ABOUT VIBRATION

**Where/When:**

- During the transport
- During a quench
- During the handling into the hall
- …

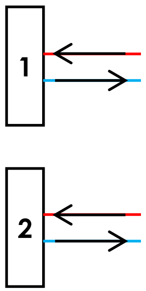
→ Need more studies and calculations

# Services Estimates



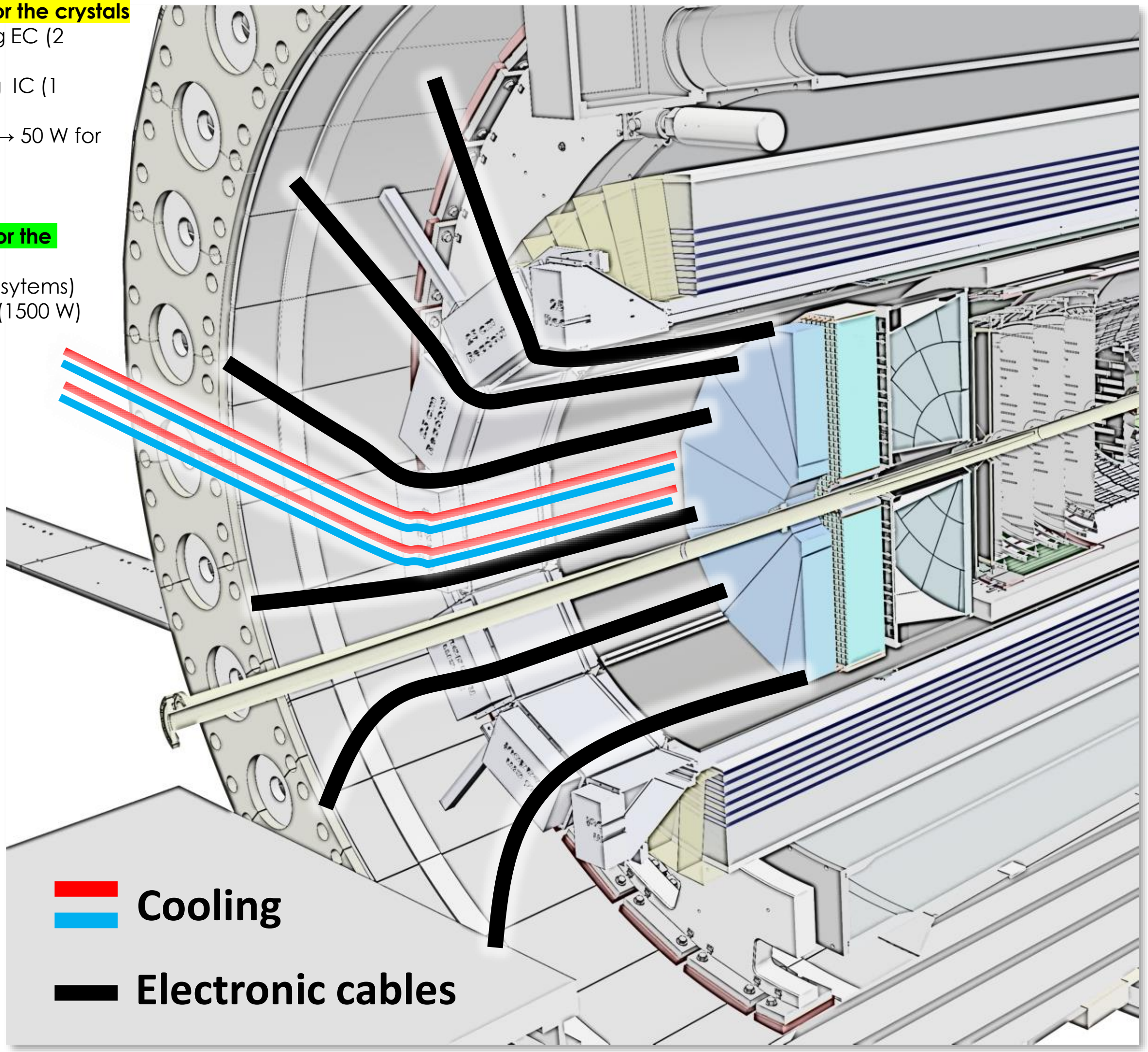

*Tubing drawing of the cooling*

**Chillers**




**Chiller 1: Cooling for the crystals**
- External cooling EC (2 systems)
- Internal cooling IC (1 sytem)
- ΔT room = 3°C → 50 W for the crystals

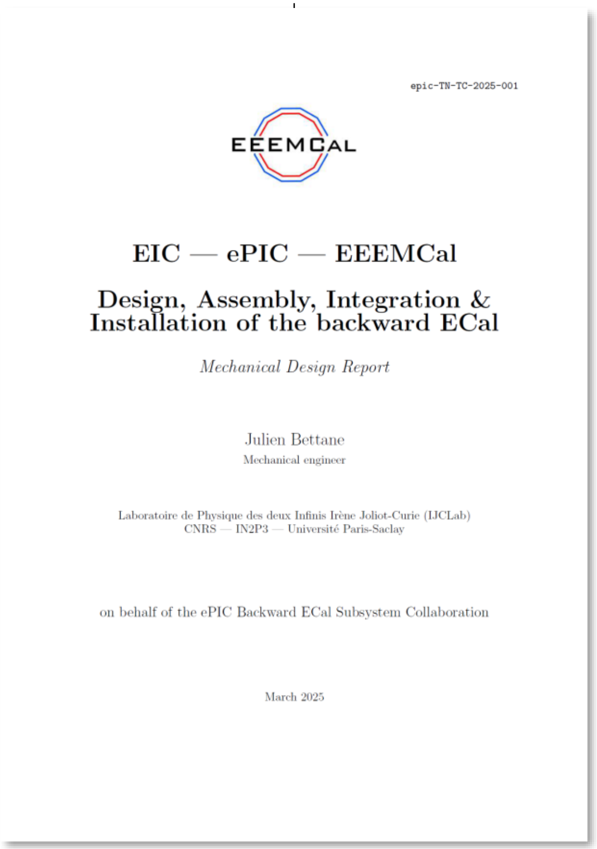
**Chiller 2: Cooling for the electronics**
- 12 boxes BC (2 sytems)
- 120 W per box (1500 W)




## Cables:
- LED (1 LED per crystal → controled by the FEB)
- Thermal sensors (10% of the crystals x2 → 600 cables)
- Signal cables (Depend on the regroupment, reading with 16 SiPM vs 4 SiPM)
- Power supply cables

**Work in progress**

# Plans Towards PDR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EEEMCAL

EIC — ePIC — EEEMCal

Design, Assembly, Integration & Installation of the backward ECal

*Mechanical Design Report*

Julien Bettane
Mechanical engineer

Laboratoire de Physique des deux Infinis Irène Joliot-Curie (IJCLab)
CNRS — IN2P3 — Université Paris-Saclay

on behalf of the ePIC Backward ECal Subsystem Collaboration

March 2025

*Mechanical Design Report*