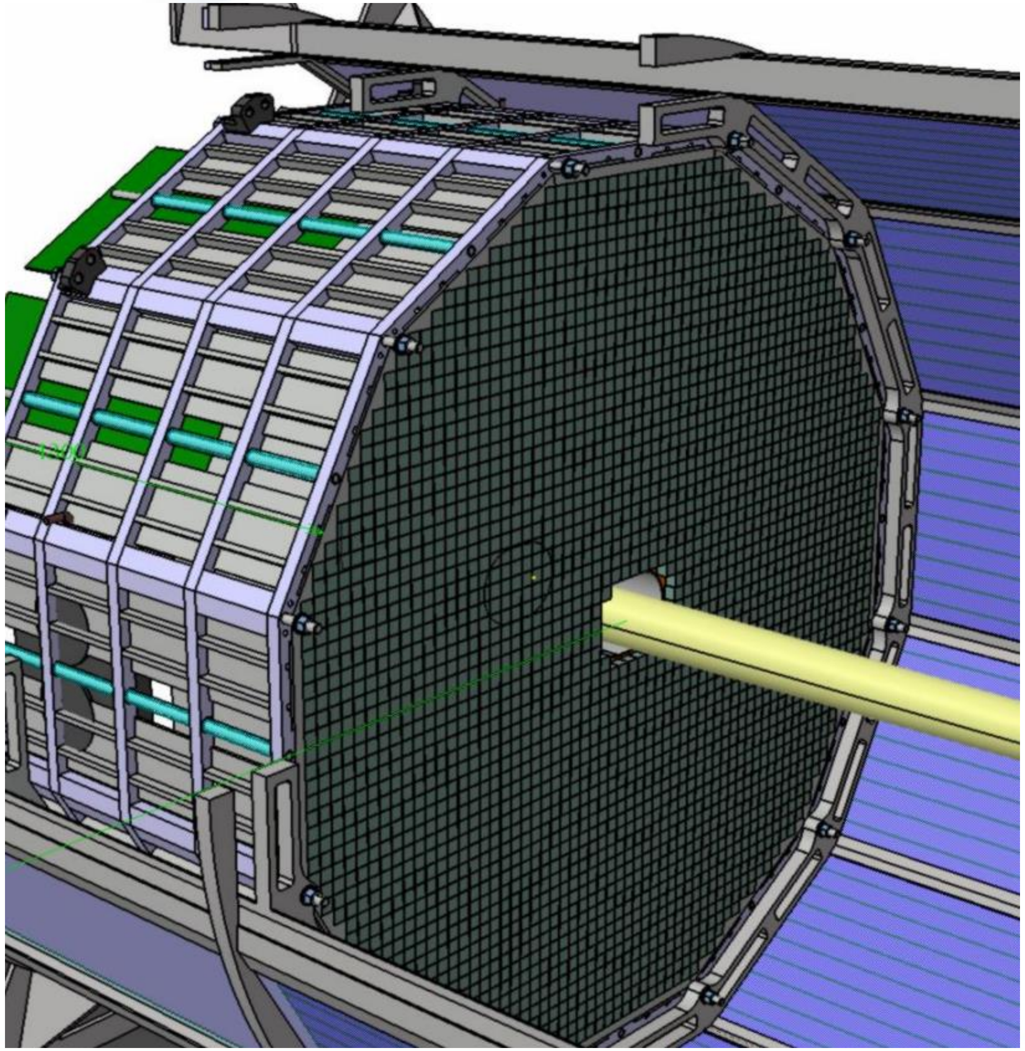


Backward ECal DSC

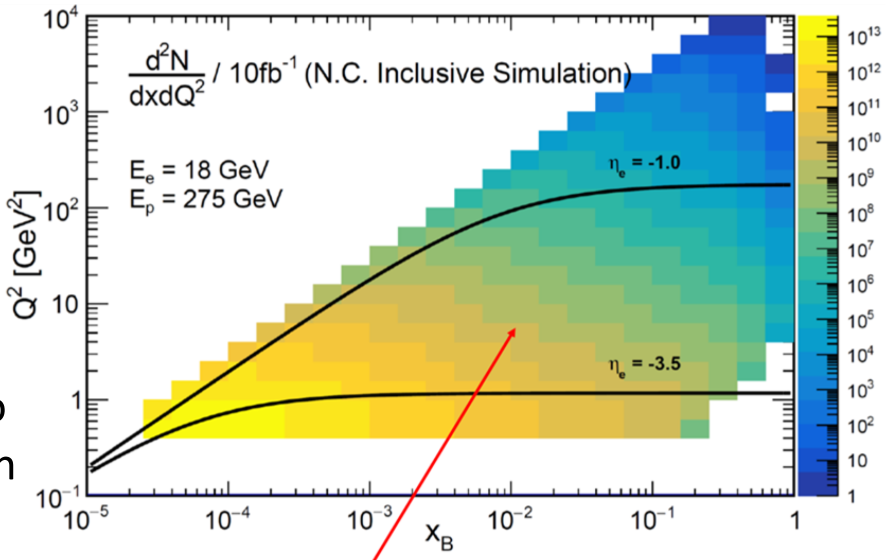
Carlos Muñoz Camacho
IJCLab (Orsay, CNRS/IN2P3)

on behalf of the backward ECal DSC
and the EEEMCAL consortium

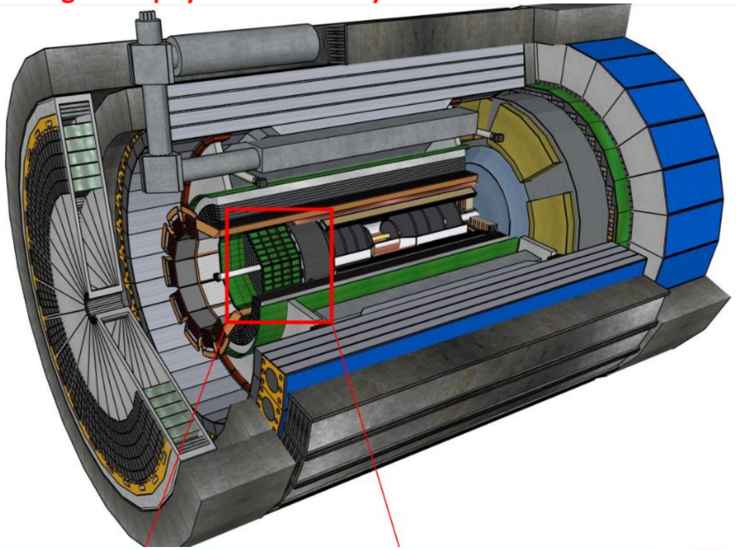
ePIC Collaboration Meeting
July 28, 2023

Electromagnetic (EM) calorimetry is key to any EIC detector concept

- Almost every channel needs to measured the scattered electron
- EM e-endcap calorimeter : $-3.5 < \eta < -1$



Region of physics enabled by the EEEMCal



High resolution in the forward region (endcap) can only be achieved with homogeneous materials, such as crystals and glass

Goals and requirements

Goals:

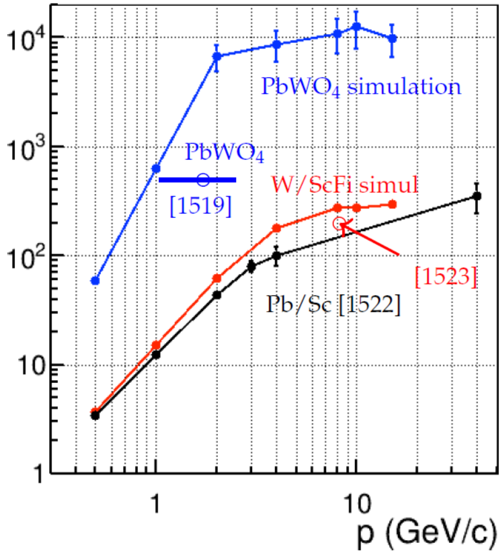
- Electron/pion separation
- Improve electron resolution at large |η|
- Measure photons with good resolution
- Separate 2-γ from π^0 at high energy

Requirements:

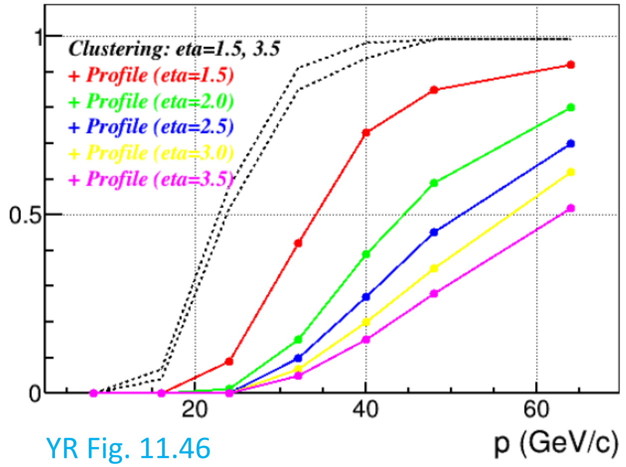
- Energy resolution: $2\%/\sqrt{E} + (1\text{-}3)\%$
- Pion suppression: $1{:}10^4$
- Minimum detection energy: > 50 MeV

Yellow Report recommended PWO as technology choice for backward endcap.

π± rejection YR Fig. 11.48



Pi0 merging prob vs p

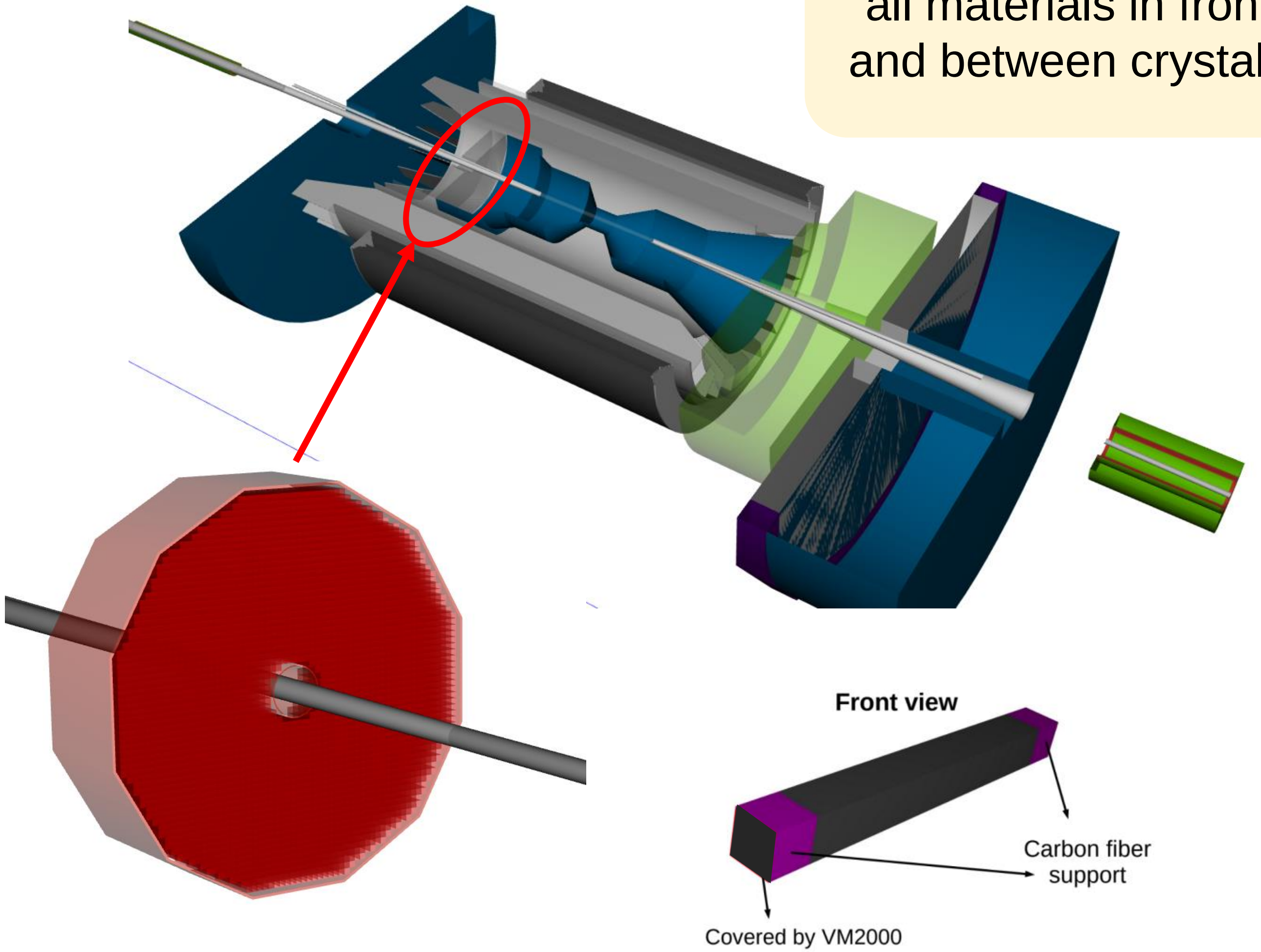


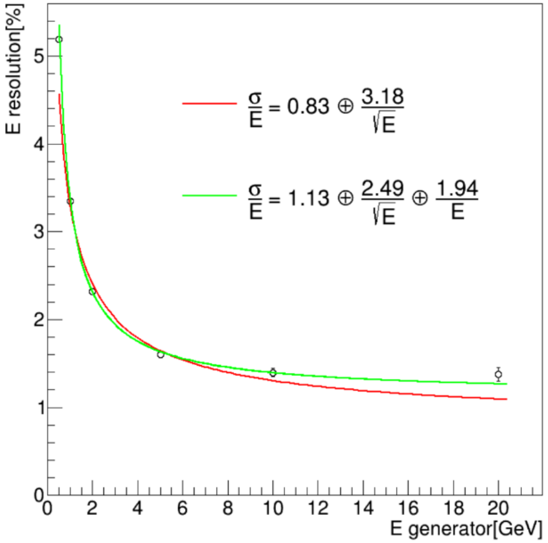
YR Fig. 11.46

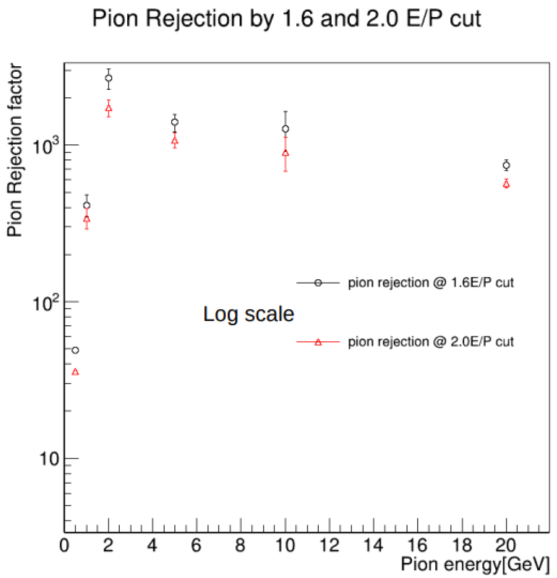
Anticipate readout: high density SiPM (16 3x3 mm^2 or 4 6x6 mm^2 per crystal)

Simulation implementation

Realistic geometry with all materials in front and between crystals







The EEEMCal consortium

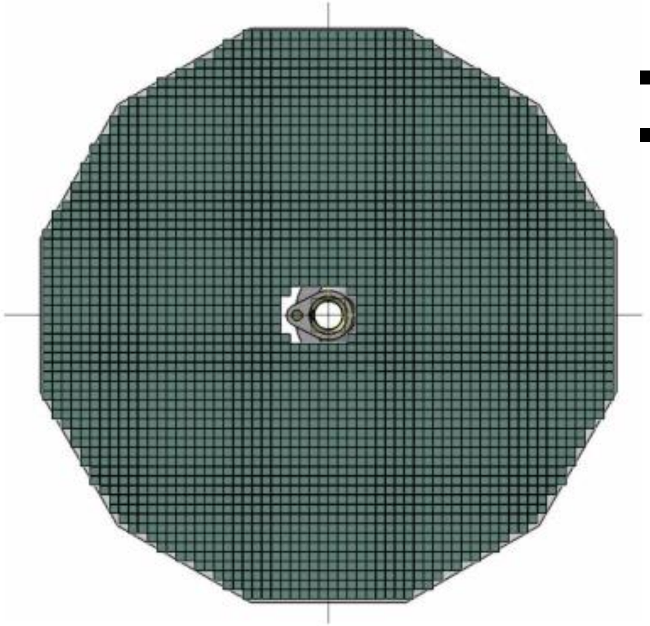
US

- The Catholic University of America (contact: Tanja Horn, hornt@cua.edu)
- Lehigh University (contact: Rosi Reed, rosijreed@lehigh.edu)
- University of Kentucky (contact: Renee Fatemi, renee.fatemi@uky.edu)
- MIT and MIT-Bates Research and Engineering Center (contact: Richard Milner, milner@mit.edu)
- Florida International University (contact: Lei Guo, leguo@fiu.edu)
- James Madison U. (contact: Gabriel Niculescu, gabriel@jlab.org)
- Abilene Christian University (contact: Larry Isenhower, ldi00a@acu.edu)
- Ohio University (contact: Justin Frantz, frantz@ohio.edu)
- College of William & Mary (contact: Cristiano Fanelli, cfanelli@wm.edu)

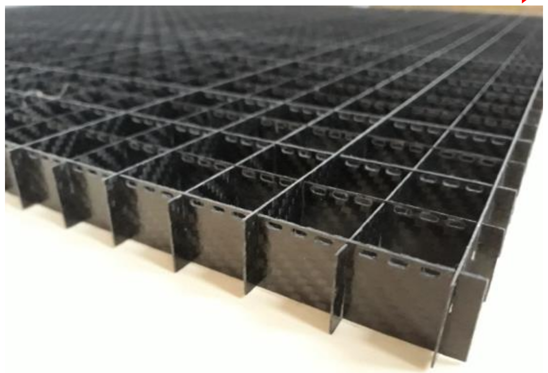
International

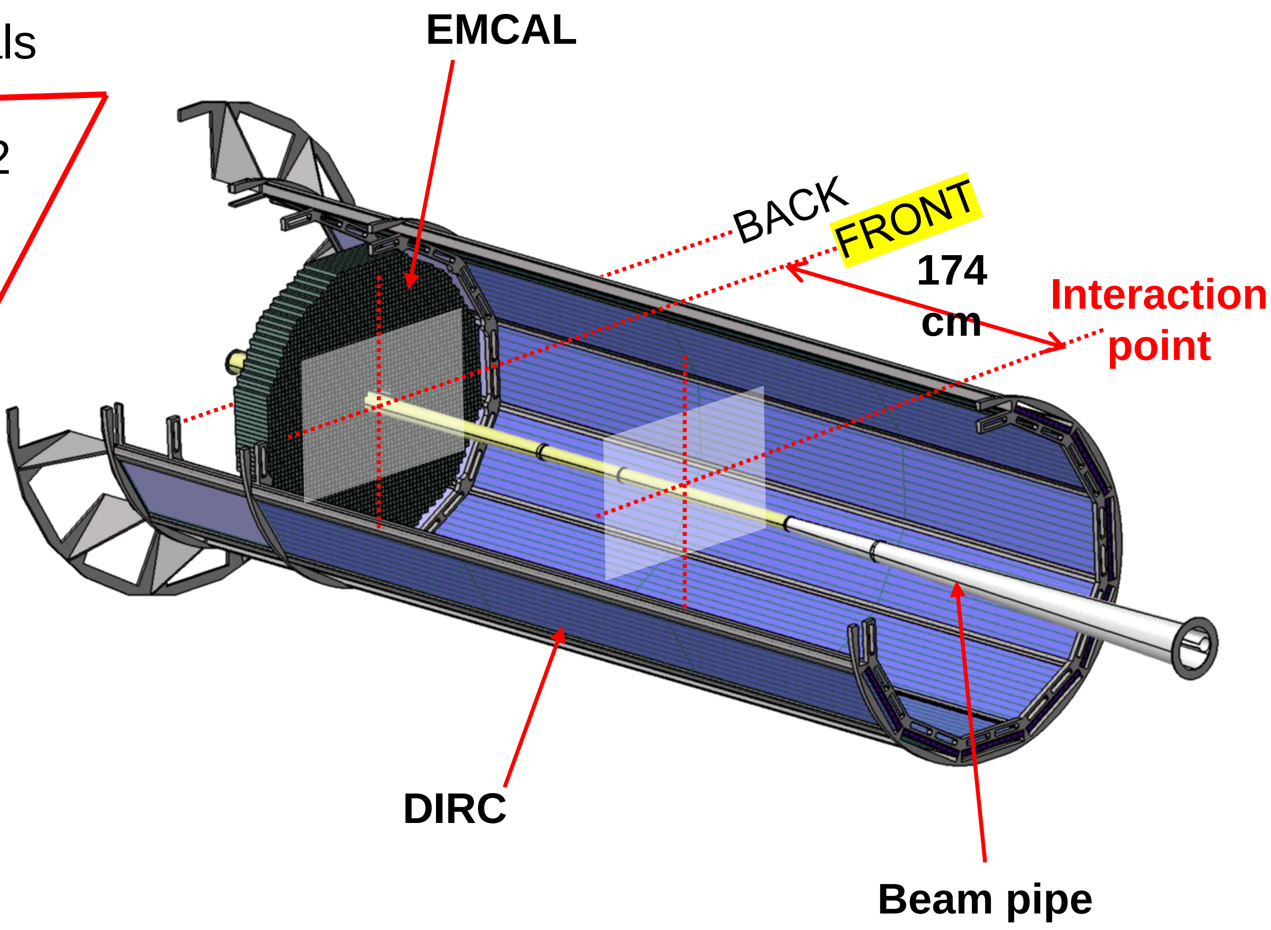
- AANL, Armenia (contact: Ani Aprahamian, aapraham@nd.edu)
- Charles University Prague, Czech Republic (contact: Miroslav Finger, Miroslav.finger@cern.ch)
- IJCLab-Orsay, France (contact: Carlos Munoz-Camacho, munoz@jlab.org)

Mechanical design



- 2x2x20 cm^3 PWO crystals
- 0.5-mm-thick C-fiber between crystals along 2 cm in the front & back; 0.5 mm of air elsewhere





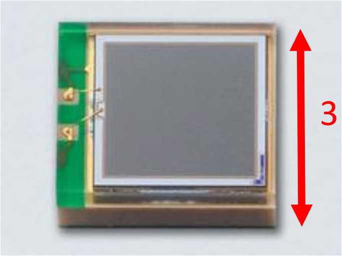
Specifications:

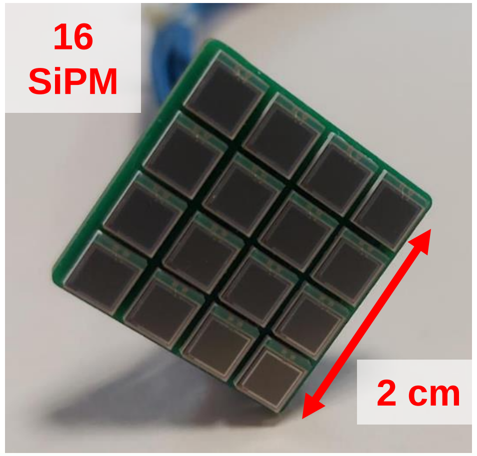
PWO:	8,28g/cm3
Dimension:	20x20x200 mm
Mass:	0,662 Kg
Nb:	≈ 2850 crystals
Total mass:	≈ 1900 Kg
External diameter:	≈ 123 cm
Space max:	0,5 mm (carbon plate)

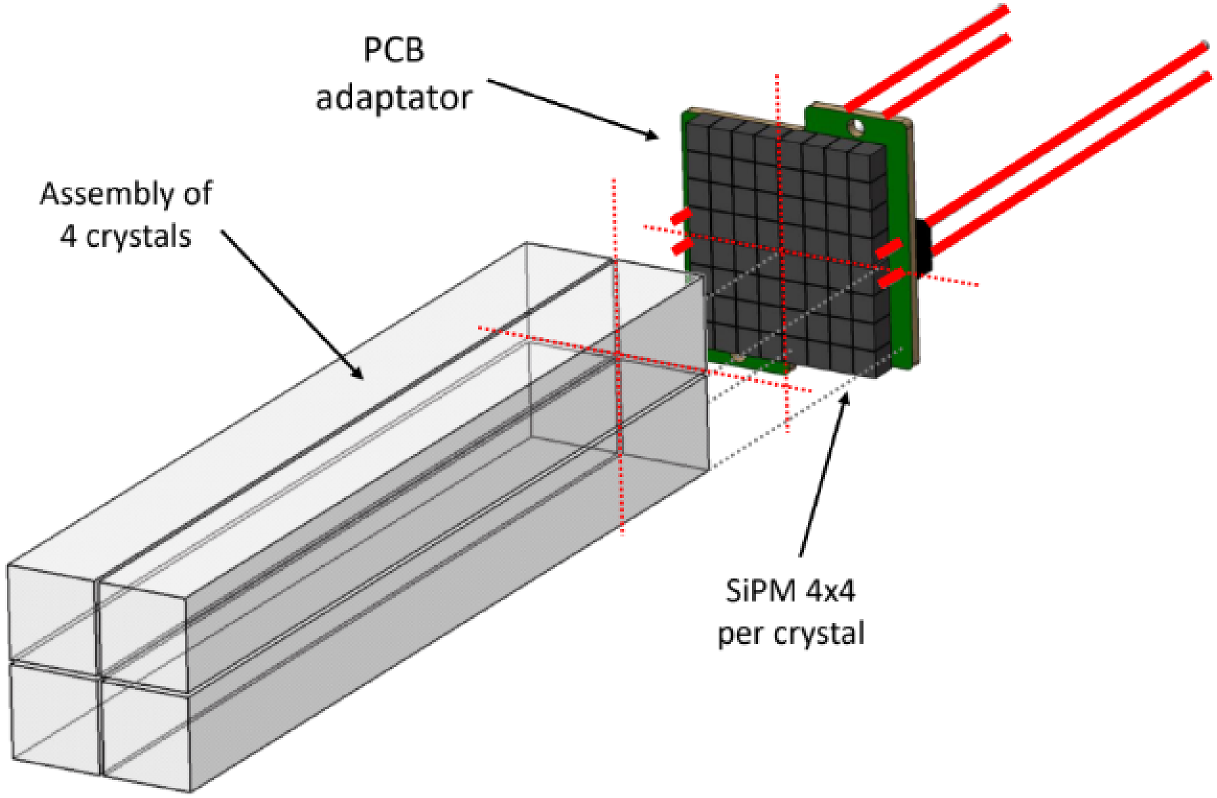
SiPM readout and monitoring system

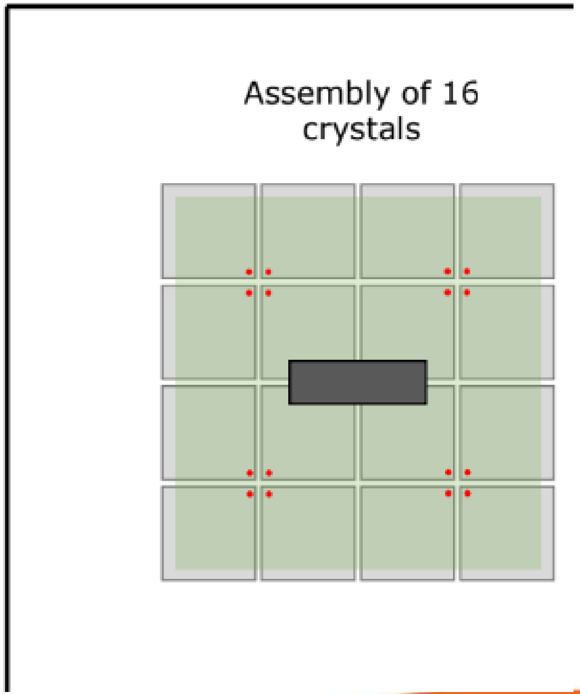
HAMAMATSU
PHOTON IS OUR BUSINESS

MPPC
S14160-3010PS



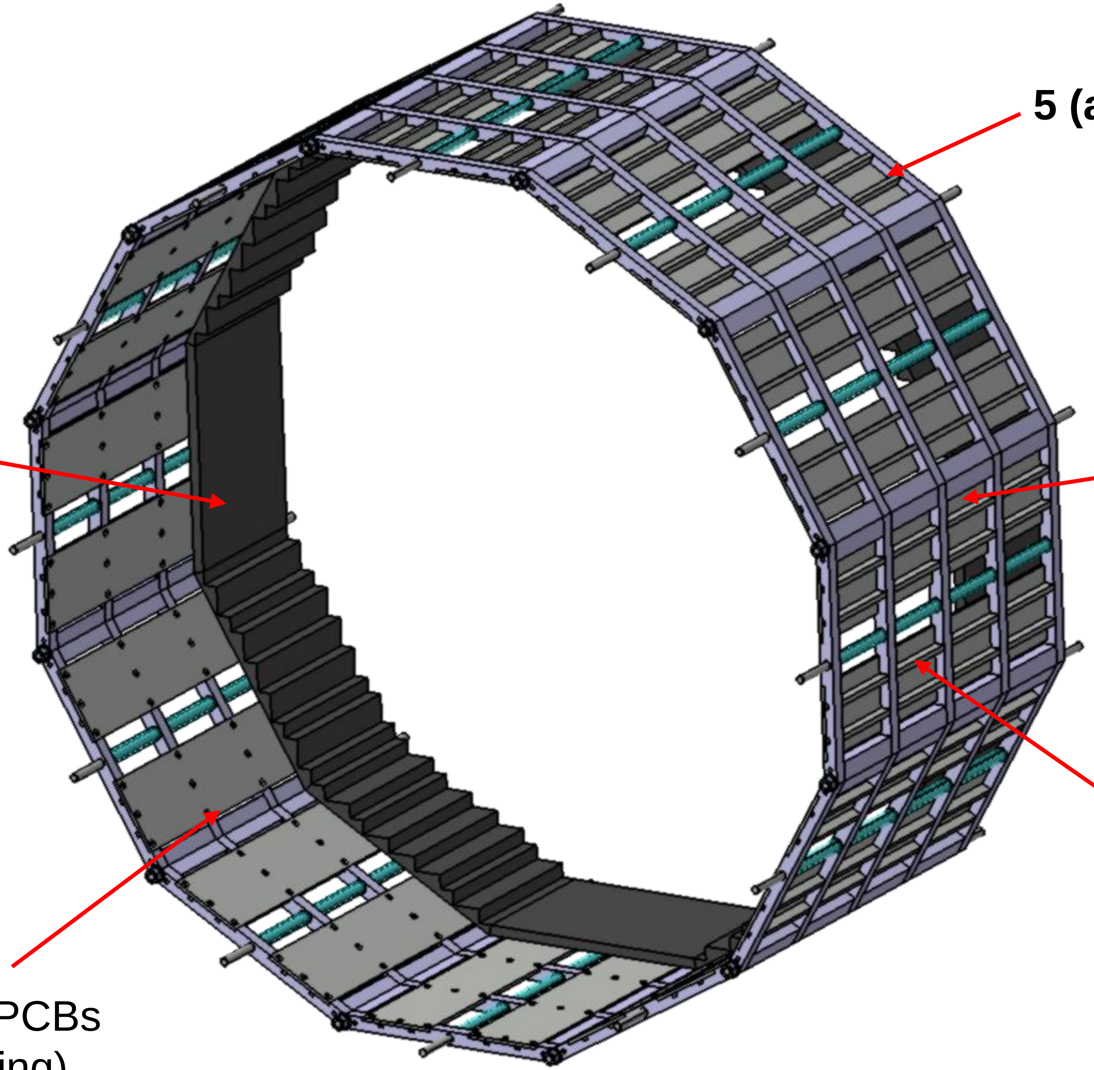






One fiber per crystal to monitor gain variations

Support structure



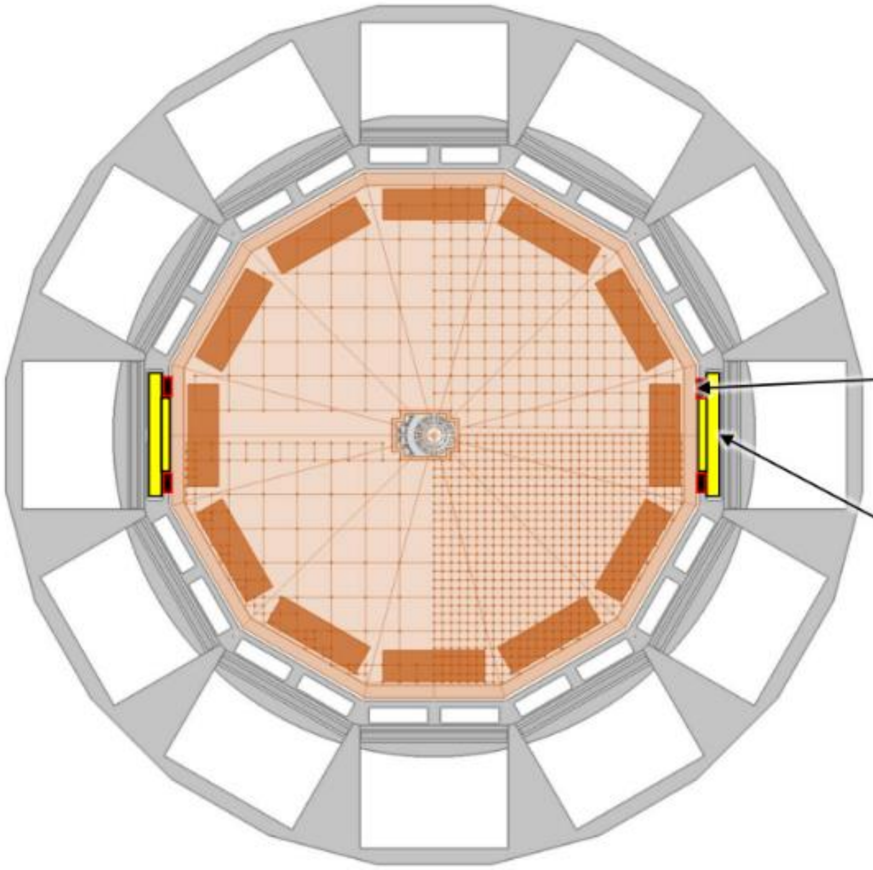
5 (at least) strong dodecagon frames
(to make the assembly easier)

Support structure for crystals
(can be used for cooling)

Mechanical pieces
(to reinforce the structure at the angles)

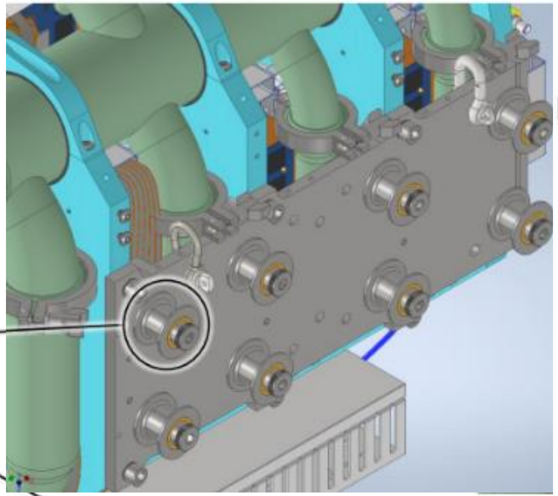
Plate
(to fasten the PCBs and the cooling)

Threaded rods and struts
(to ensure a good assembly and reinforce the structure)

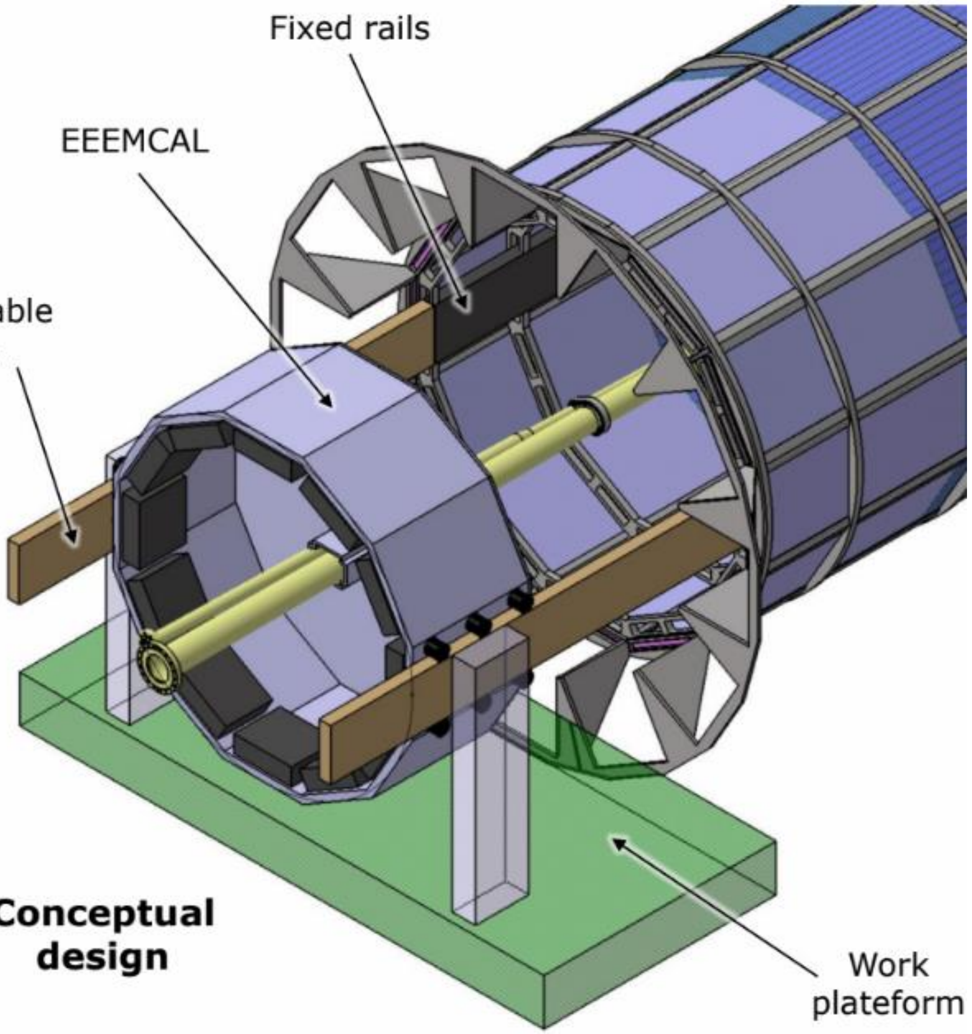


Positioning of the rails

Mechanical plate with roller **STAR**
(from Rahul Sharma)

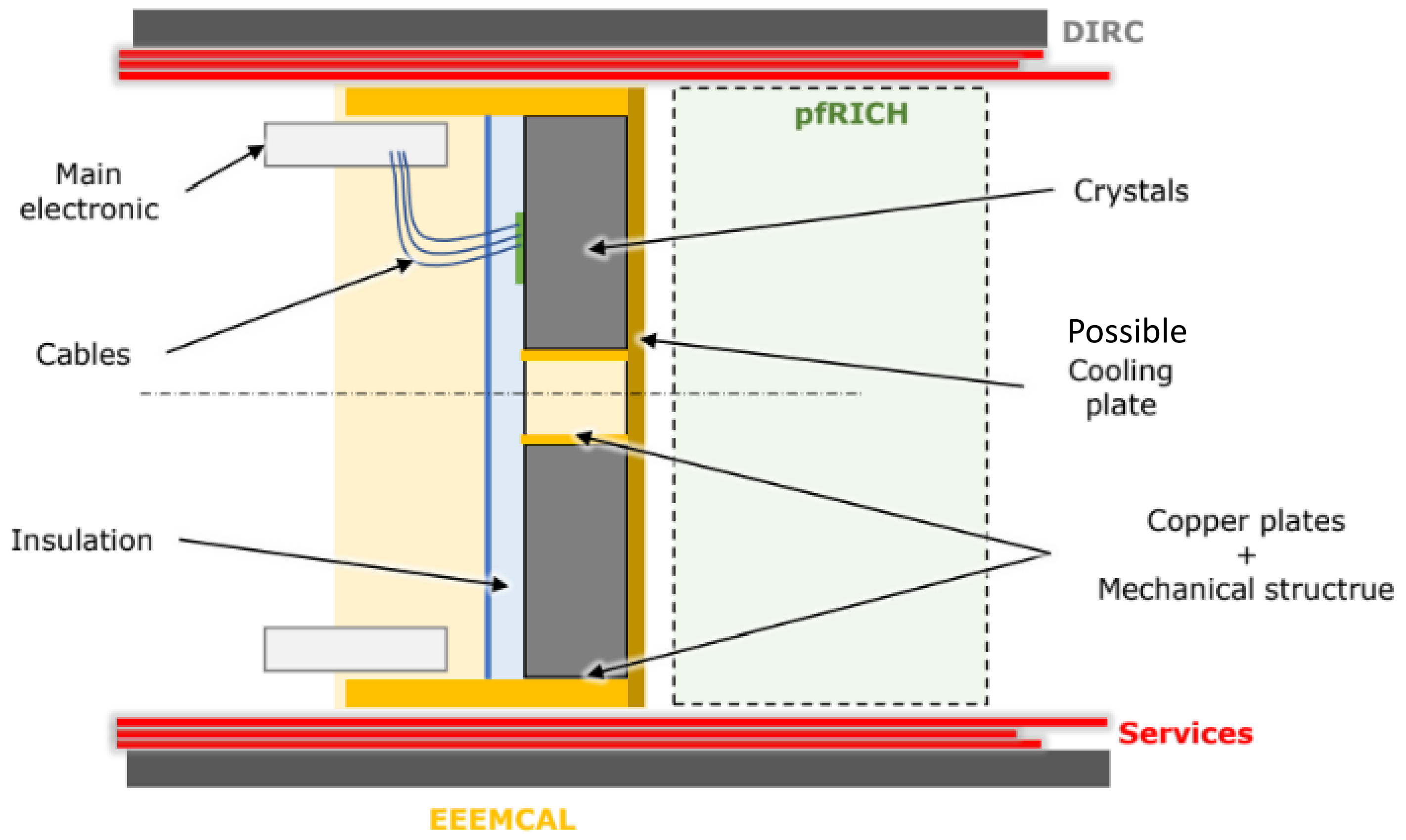


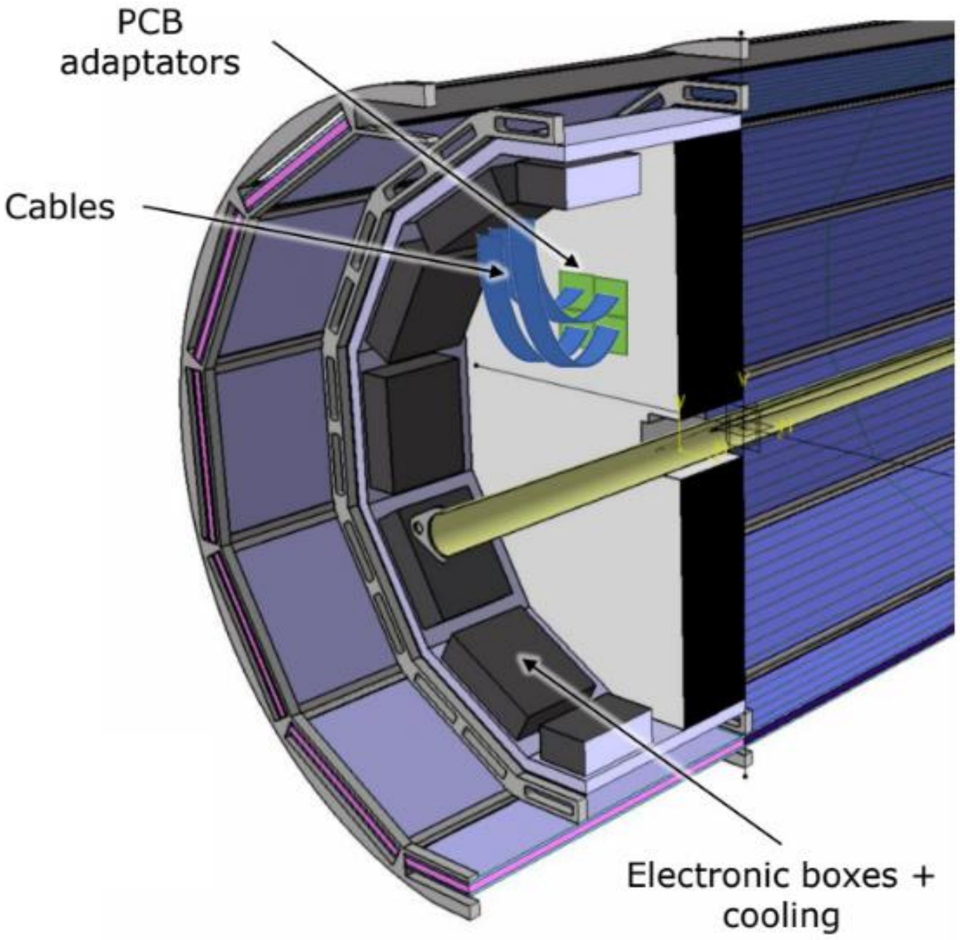
M



Conceptual design

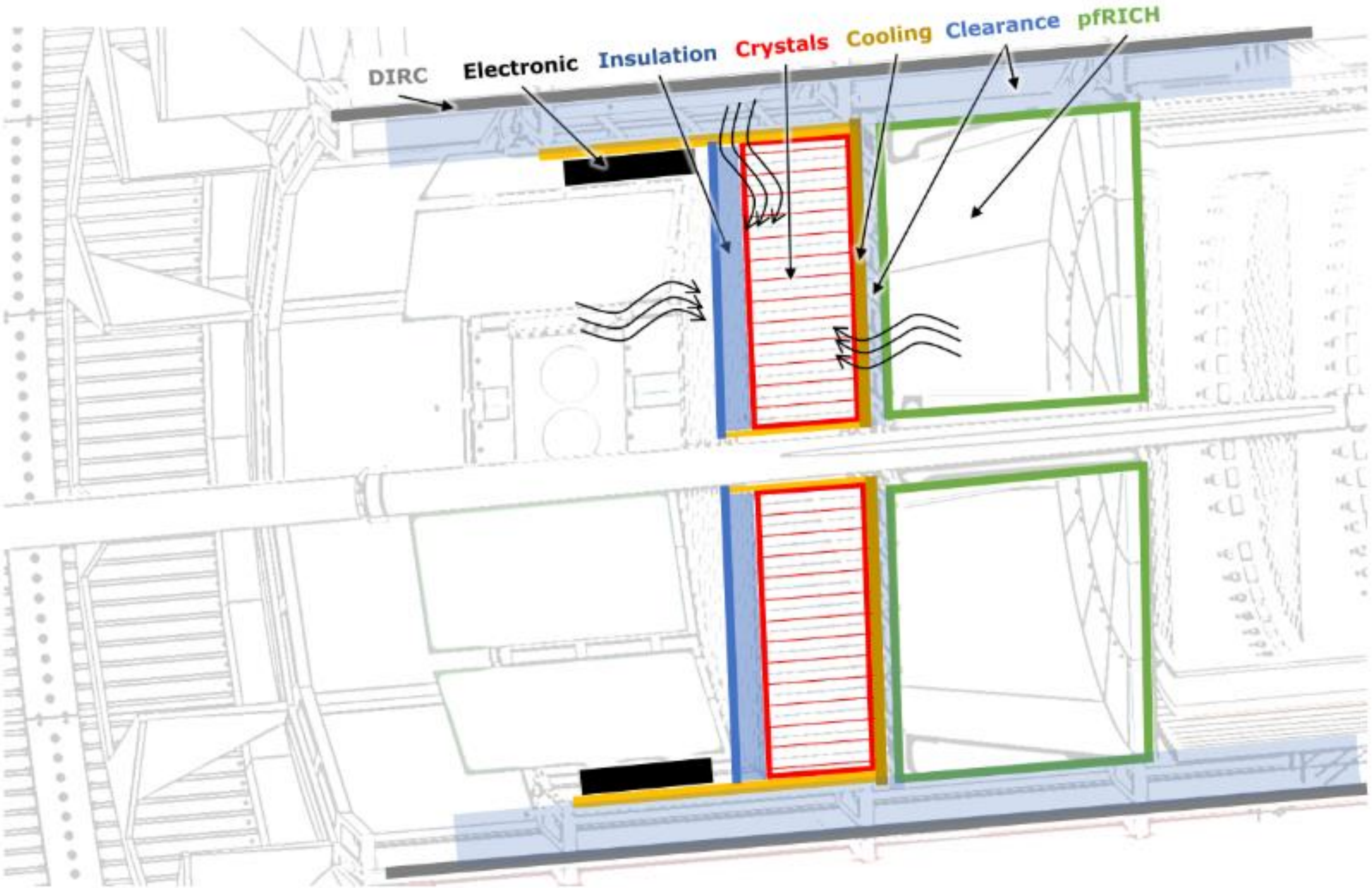
Front-end electronics and cooling





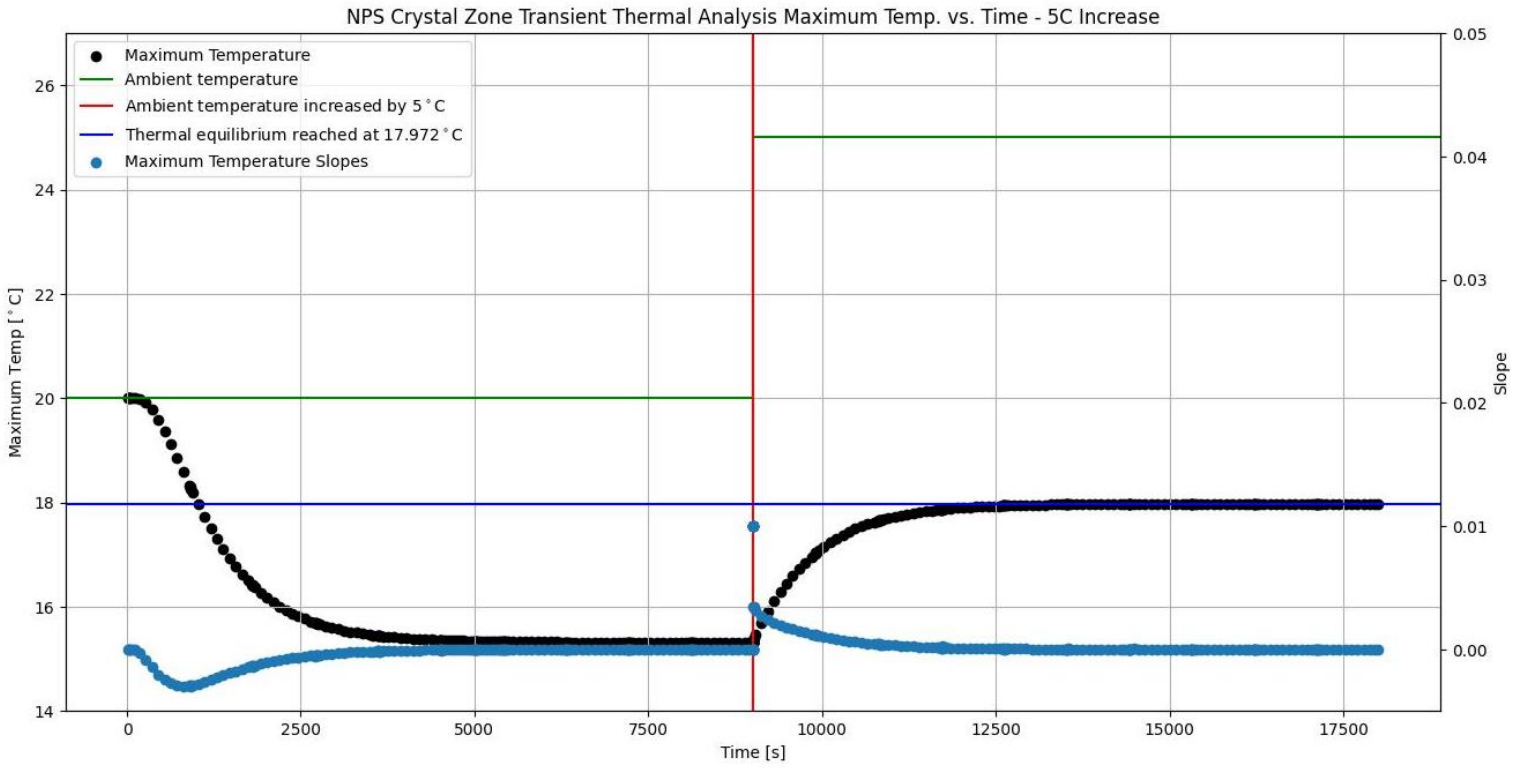
Ongoing work: thermal studies

- One of the main challenges of the design
- Simulations ongoing to quantify the effect of ambient temperature fluctuations on crystal temperature
- Also, measurements ongoing on a prototype

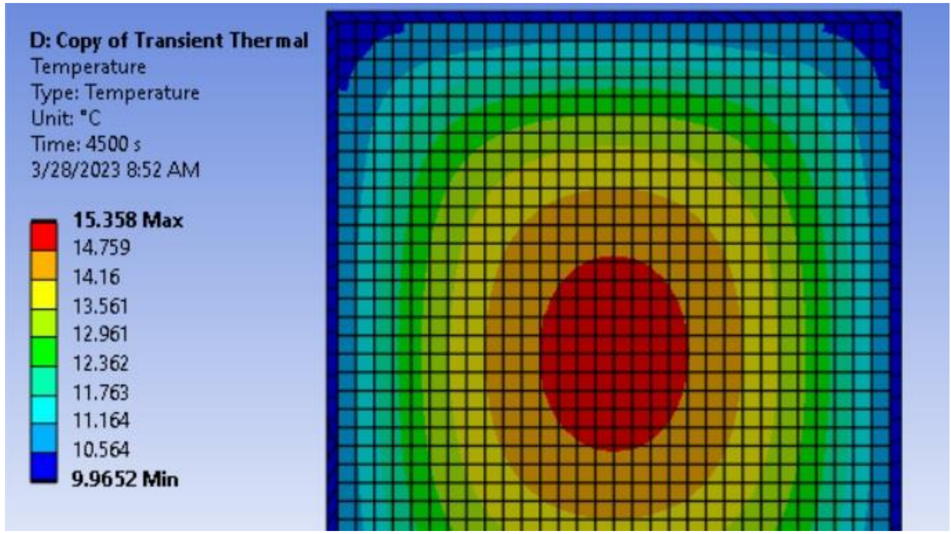


Ansys Transient Thermal Analysis

Studies by the JLab DSG for the NPS setup

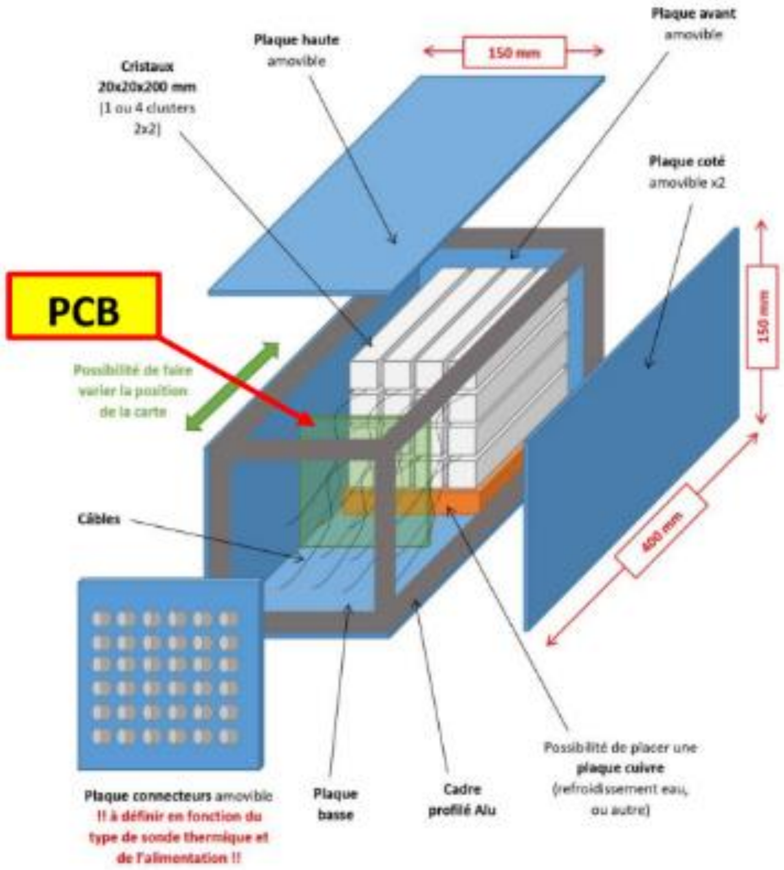


- Copper shell temp: 10°C (constant)
- Q = 0.3 W per crystal
- Ambient temp: 20°C

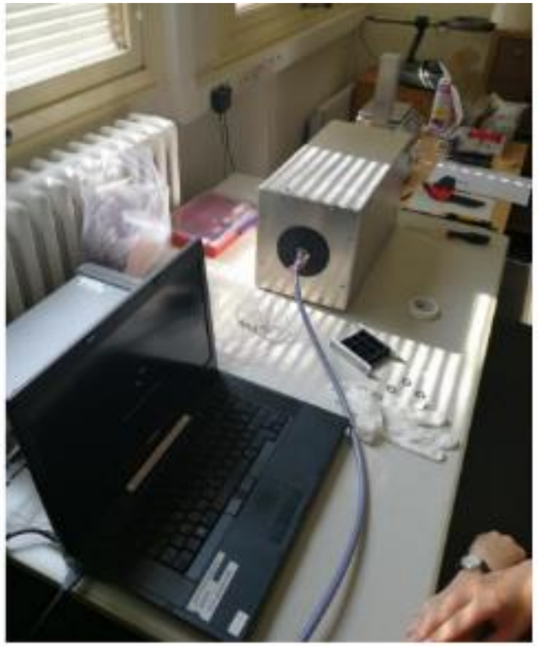


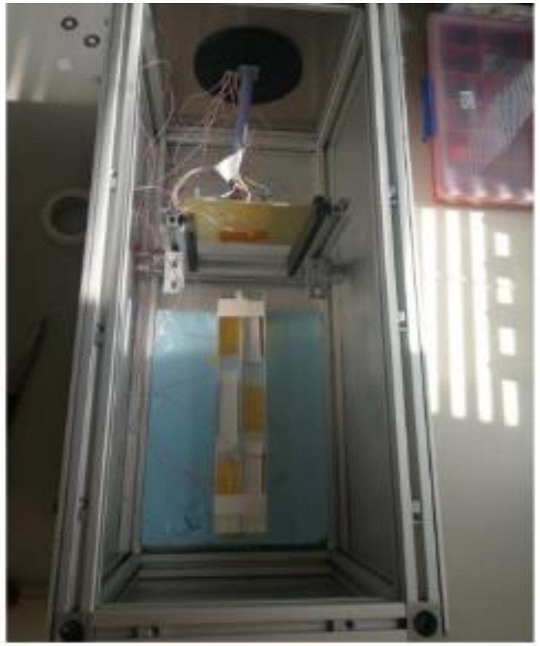
- ➢ Temperature stabilization has a **long time constant:** it takes >1h to reach equilibrium after a change
- ➢ Working with Ansys to understand the stabilization temperature (disagreement with previous steady-state simulations)

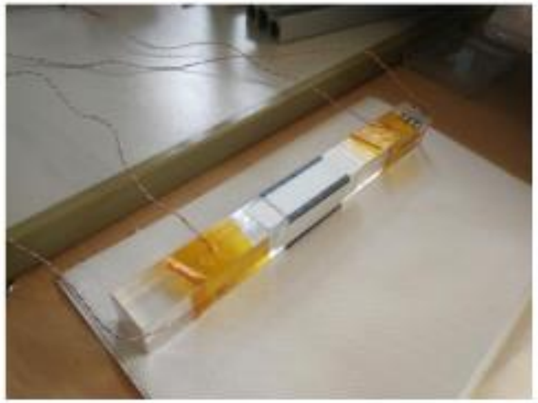
Thermal prototype

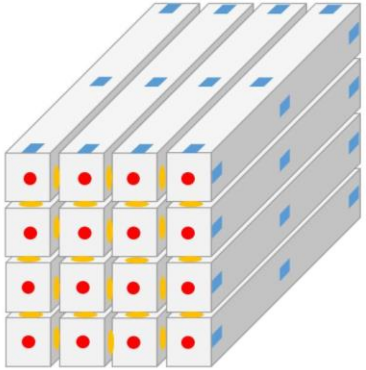


Setup of the tests





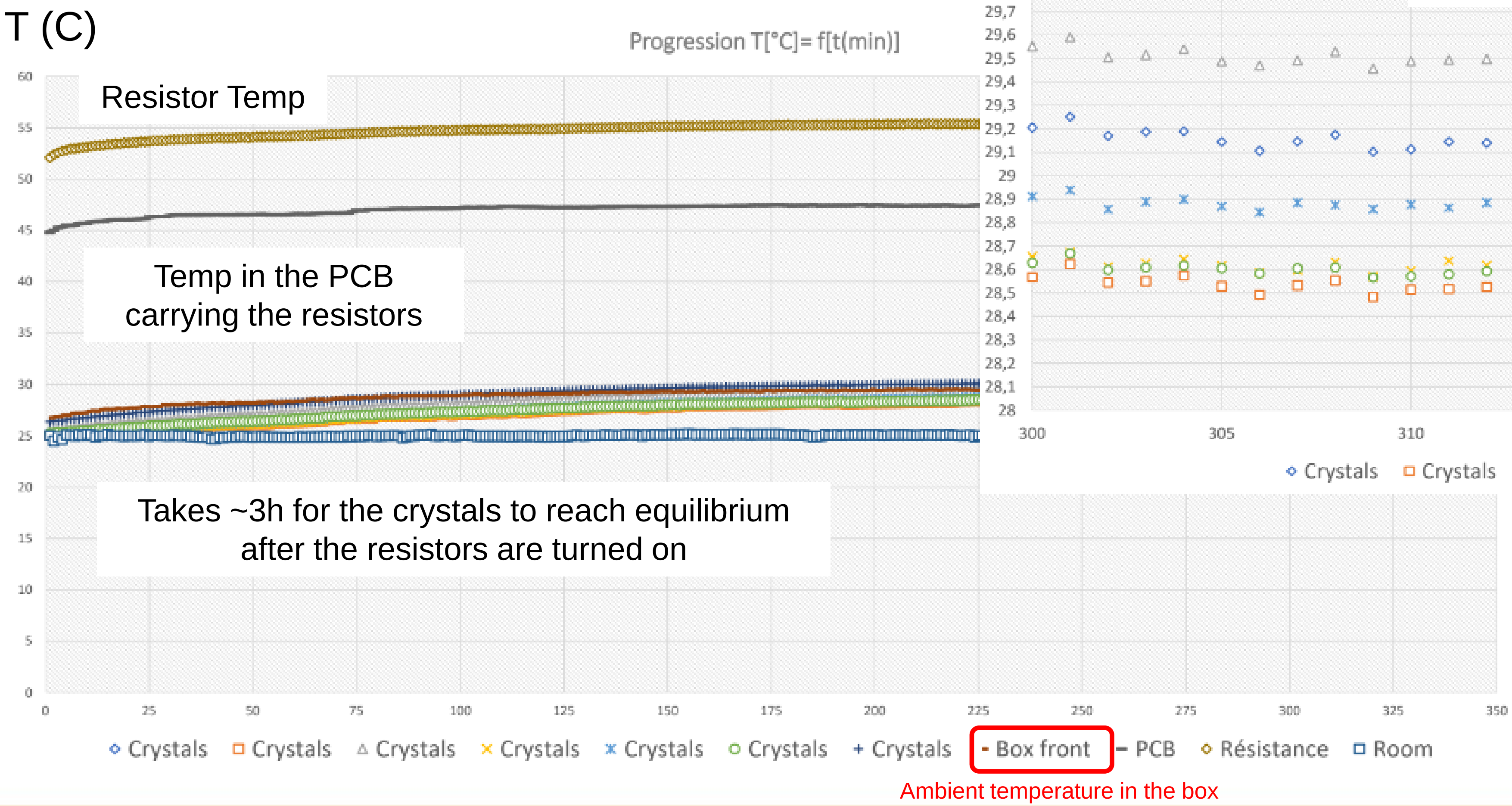


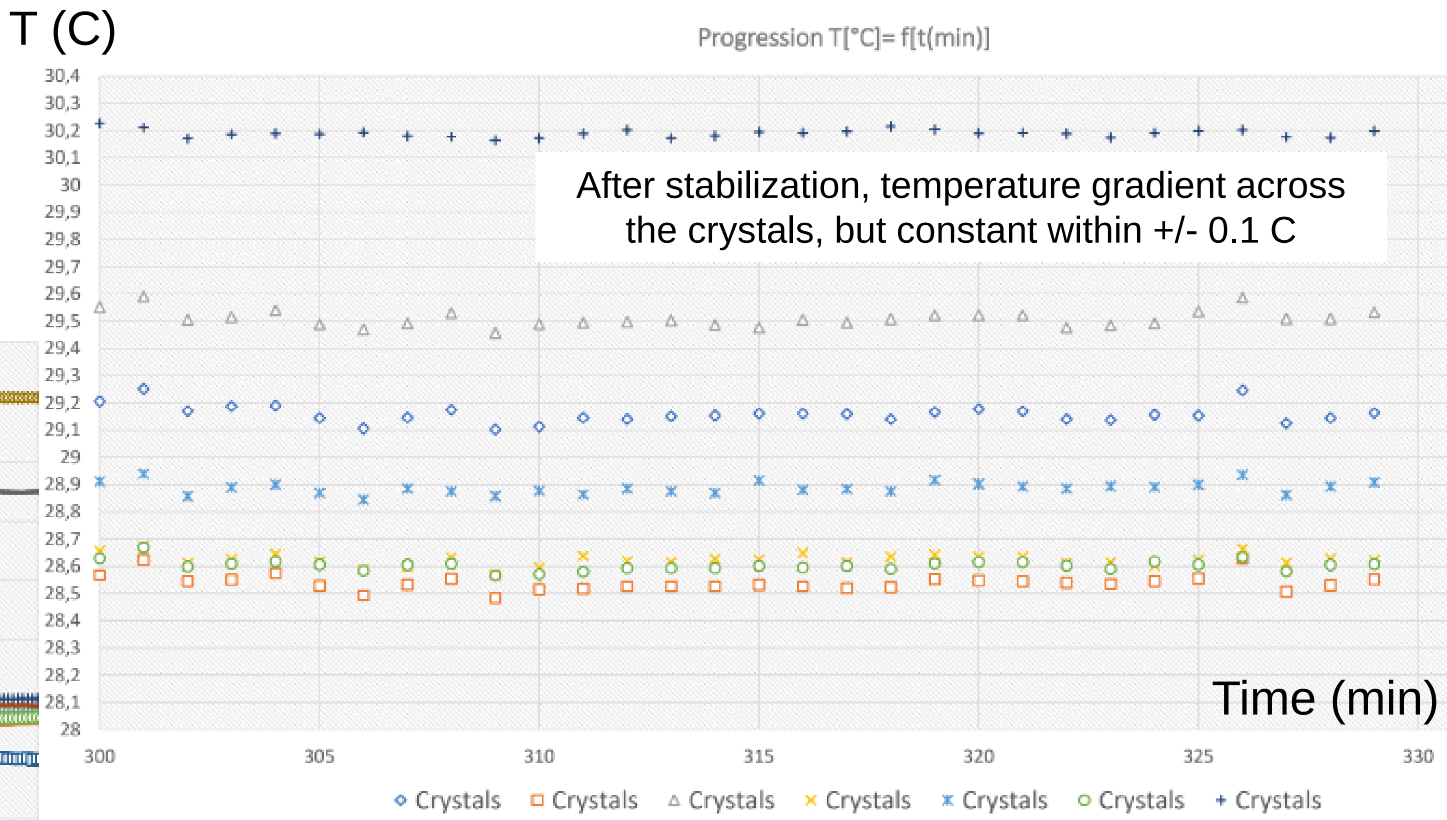


Positioning of the thermal sensors on & between the crystals

Initial measurements with prototype

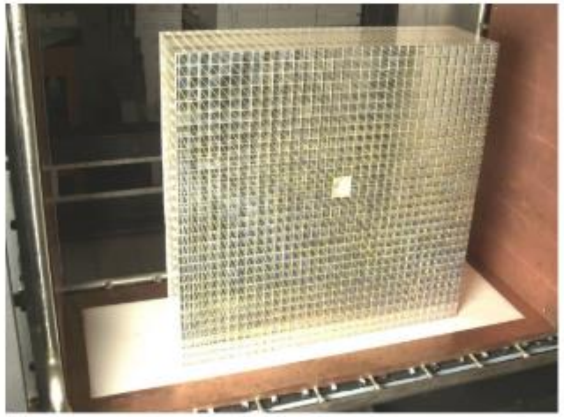
250 mW at 4 cm from crystals

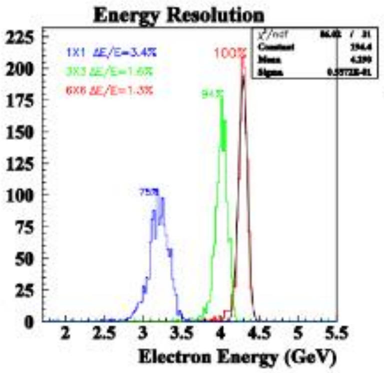


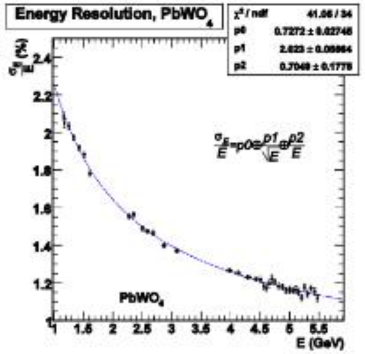


Prototype Beam Test Campaigns

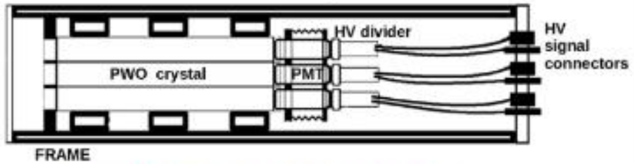
HyCal (pre-2014)
1152 $PbWO_4$ crystals (PWO-I)
SICCAS/China

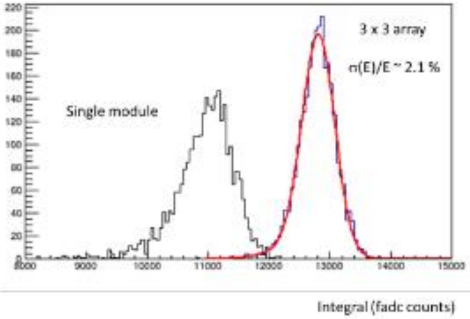






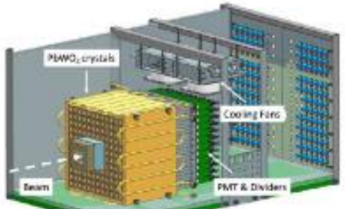
3x3 prototypes (2018/19)
9 $PbWO_4$ (PWO-II) crystals
CRYTUR/Czech Rep.

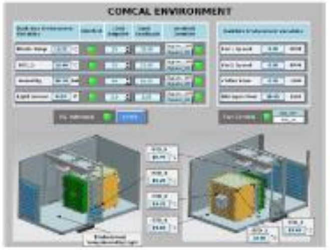


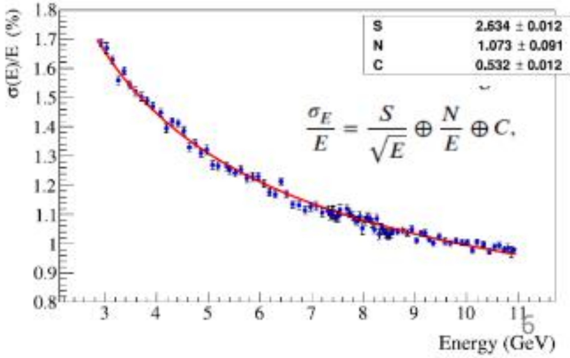


12x12 prototypes (2019)
144 $PbWO_4$ (PWO-II) crystals
CRYTUR/Czech Rep/

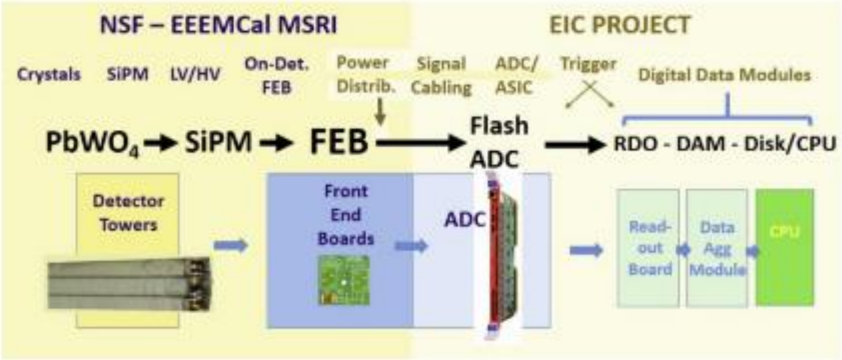
ComCal/
FCAL







Work Breakdown Structure



If ASICs will be used this would basically be "FEE" with contributors: OMEGA, Laboratoire Leprince-Ringuet (LLR)

WBS Title	EIC WBS	WBS Dictionary Description	
EEEMCAL Project	6.10.05.01	Construction of the EEEMCAL. The EEEMCAL is an electromagnetic calorimeter for measurement of the inclusive processes physics in the electron-going direction at the EIC	
Radiator	6.10.05.01.01	Radiation detectors consisting of scintillating crystals (PWO) and thin reflector sheets. These provide the detection of energetic electrons	CUA, Kentucky, JMU, AANL, Charles U.
Photosensors	6.10.05.01.02	Photosensors consisting of multi-pixel photon counters (MPPC) grouped into an array to maximize surface coverage of the PWO blocks, along with printed circuit boards to which the MPPC are also attached for analog readout.	OU, Lehigh, ACU
Mechanical Structure	6.10.05.01.03	Mechanical structure including installation fixtures and a cooling system providing thermal stabilization, which is important for crystal performance.	IJCLab, MIT
Signal Processing/DAQ	6.10.05.01.04	Signal Processing/DAQ providing the electronics to transmit the signals to the data analysis modules.	FIU
Simulations/Software	6.10.05.01.05	Software libraries and infrastructure foundation for analyzing the EEEMCAL detector data and simulating it.	W&M

Irène Joliot-Curie
Laboratoire de Physique des 2 Infinis

Summary

- DSC for backward ECAL draws from and collaborates with the EEEMCAL consortium
- Advanced preliminary design available
- Work in progress:
  - Electronics readout → Cooling
  - Thermal studies
  - Monitoring system

- NSF MSRI proposal submitted: May 4, 2023
- Project Final Design Review for PWO crystals: July 21, 2023

(overall very positive, final report expected in about a month)