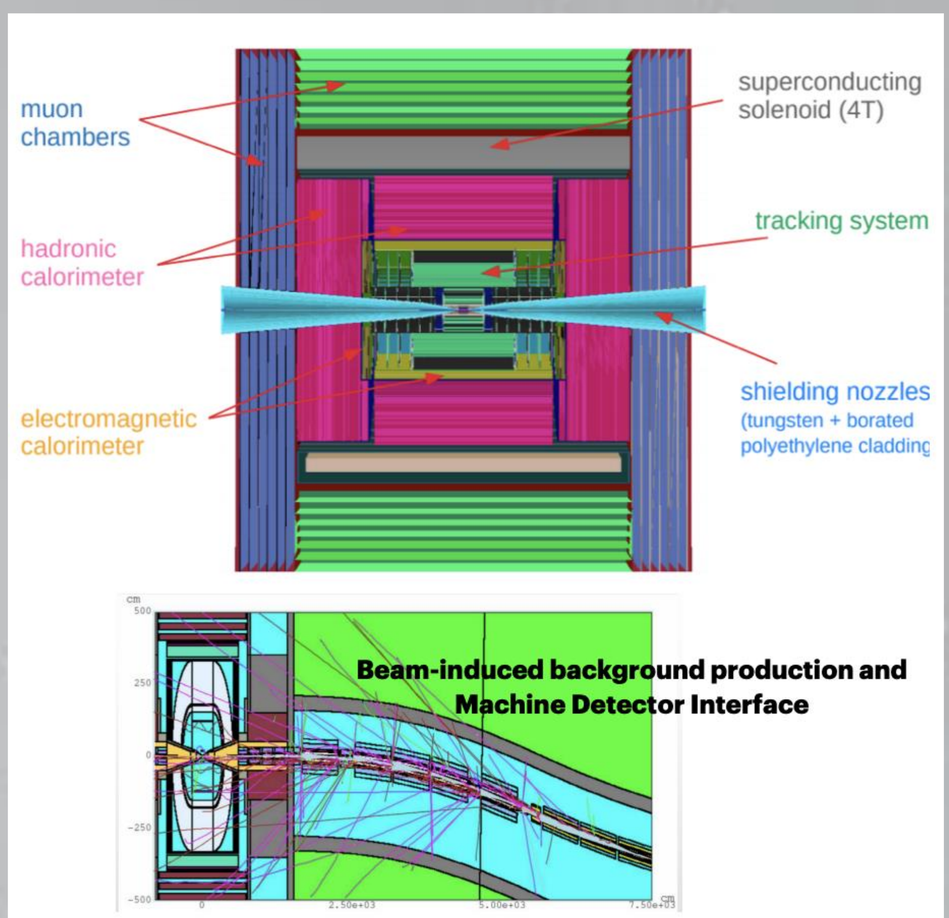
Mechanical Design of an Electromagnetic Calorimeter Prototype for a Future Muon Collider

CALOR 2020 – 19th International Conference on Calorimetry in Particle Physics
University of Sussex, UK, 16-20 May, 2022

A.Saputi[1], I. Sarra[2], D.Paesani[2], D.Tagnani[3]
1 INFN, Sezione di Ferrara, via Saragat 1 - 44122 Ferrara, Italy
2 INFN, Lab. Naz. Frascati, Via E. Fermi 40 - 00044 Frascati (Rm), Italy
3 INFN, Sezione di Roma 3, via della Vasca Navale 84, 00146 roma

The Muon Collider



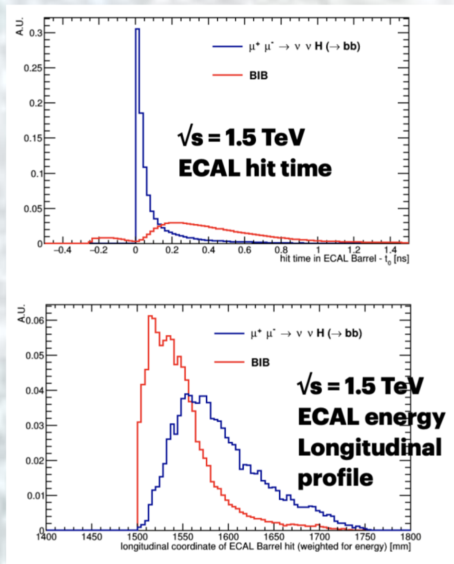
The Muon Collider is one of the most promising proposals for future accelerators.

- It puts together the advantages of lepton colliders (clean events) and hadron colliders (no bremsstrahlung, energy frontier).
- The **beam-induced background (BIB)** due to muon decays and subsequent interactions produces a challenging environment for detector design and event reconstruction.
- Although the BIB can be partially mitigated by shielding nozzles, **it poses requirements on the detector development**.

Ecal Requirements

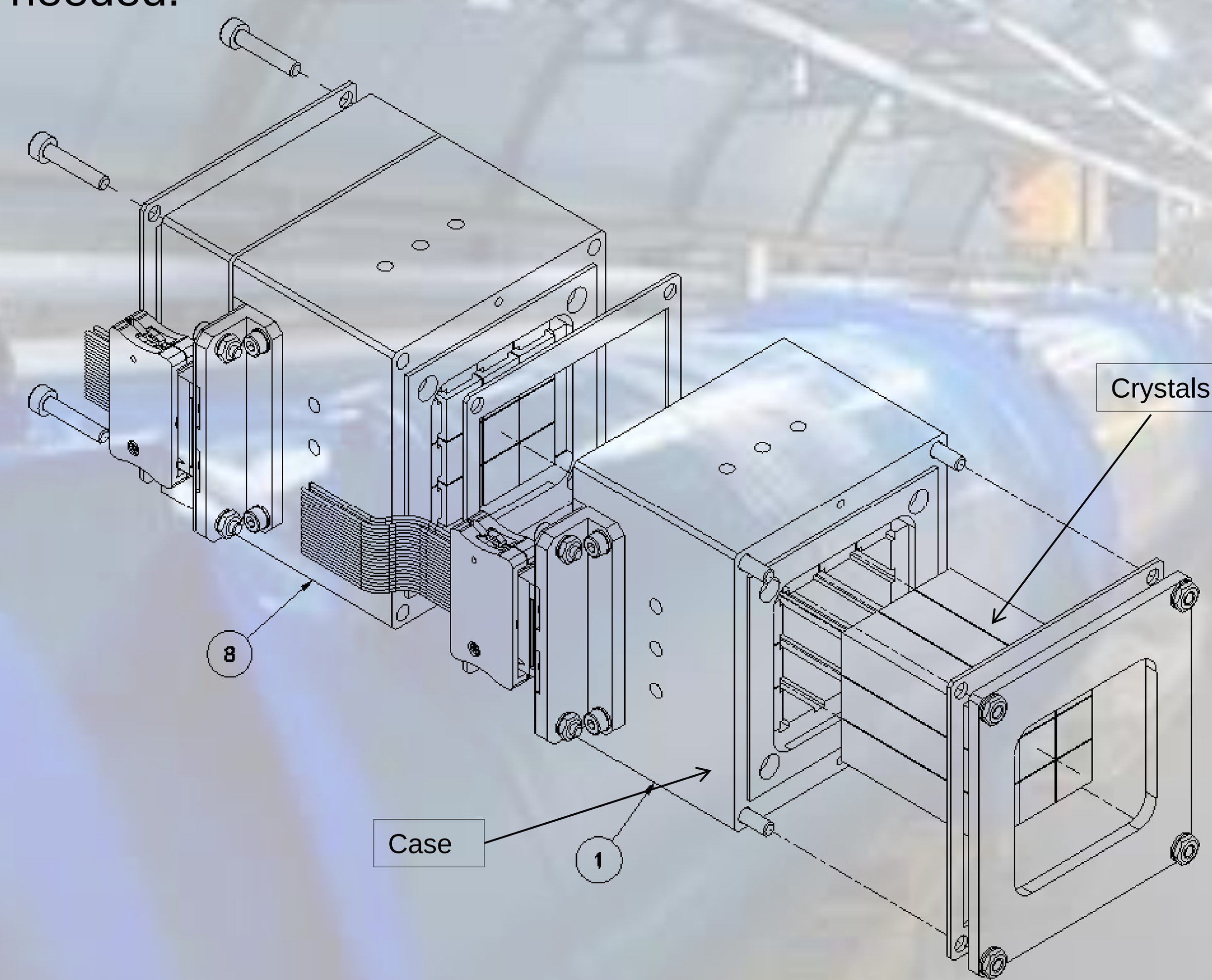
BIB simulation in the calorimeter is compared with a reference signal: Higgs boson decaying to two b-quarks.

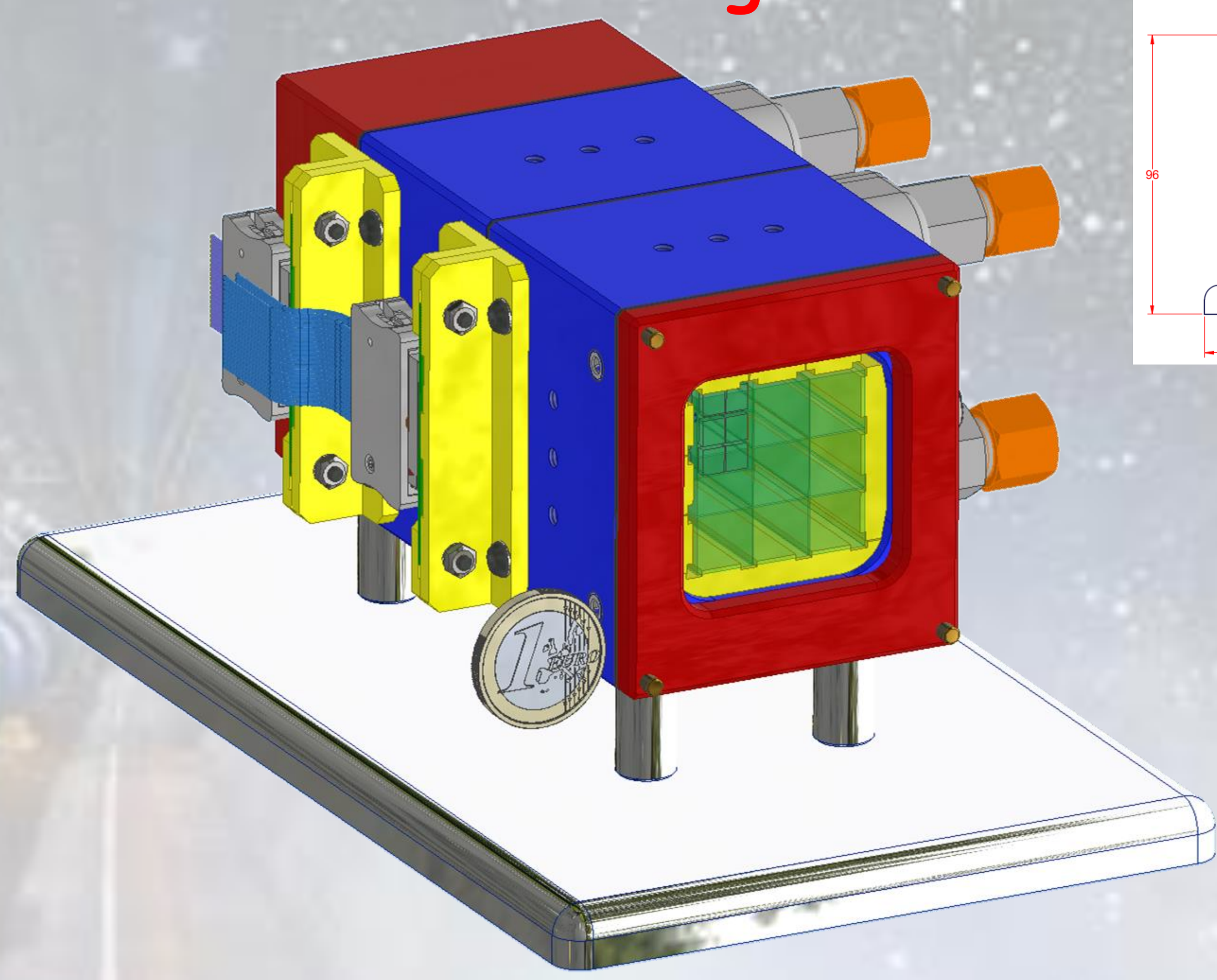
- BIB is out-of time with respect to bunch-crossing: **time measurement is crucial**.
- An acquisition time window of ±250 ps can get rid of most of the BIB, preserving the signal**. It can be achieved with a time measurement resolution of about 80 ps**.
- The longitudinal profile of the energy released by the BIB is different from the signal: **a longitudinal segmentation of the calorimeter can be useful**.

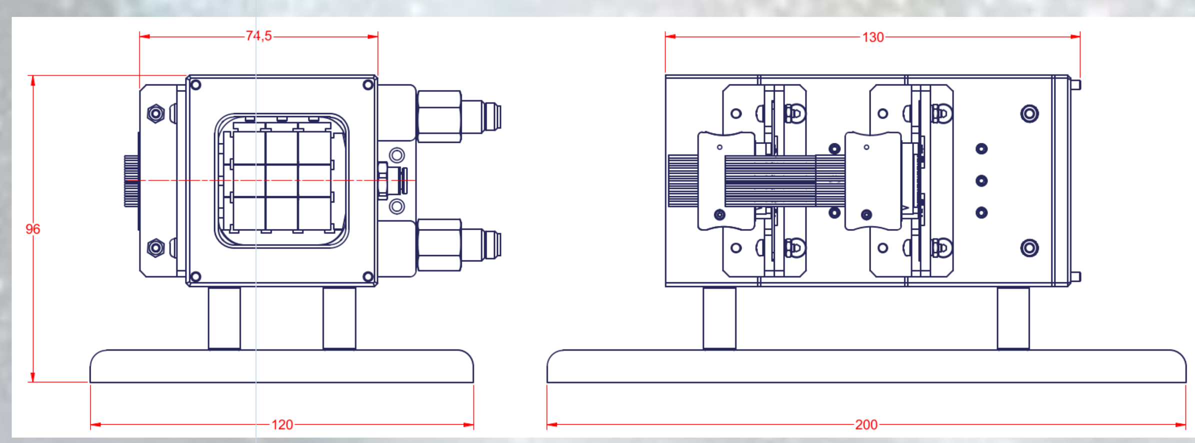


Detector Design

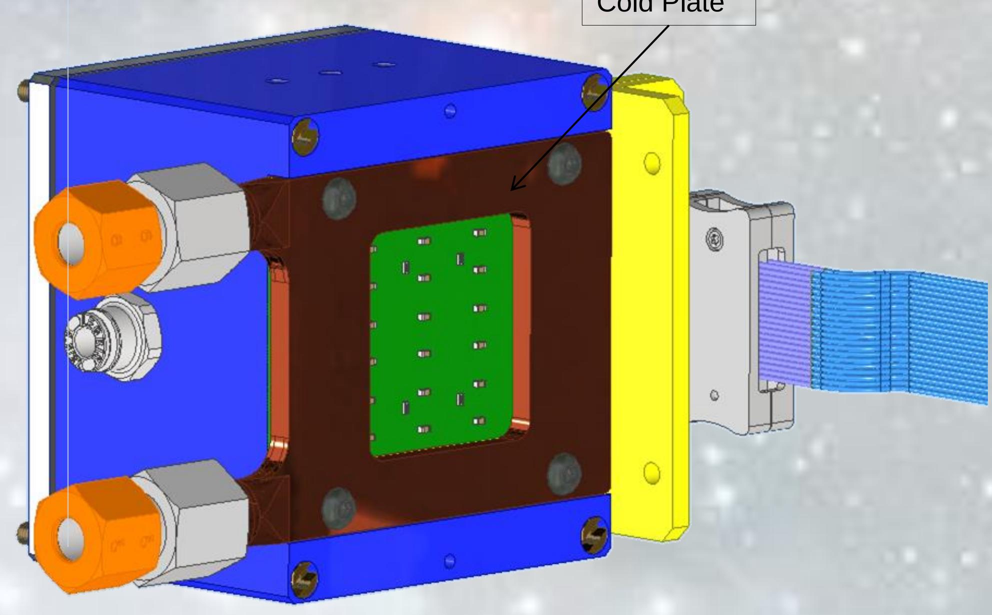
CRILIN prototype consists of two submodules, each composed of a 3-by-3 crystals matrix. The submodules are arranged in a series and assembled by bolting, thus obtaining a compact and small calorimeter.
This solution allows an easy assembly of the calorimeter and allows to assemble the calorimeter with submodules arranged in series and in parallel to obtain any configuration needed.







Detector – Overall Dimensions

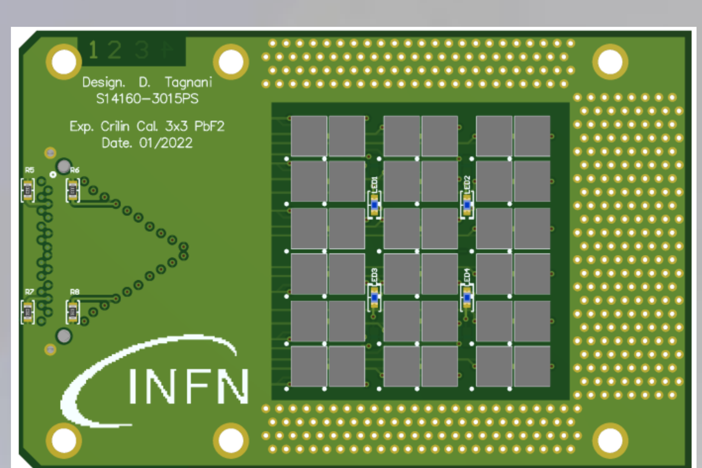


Detector – Cooling System

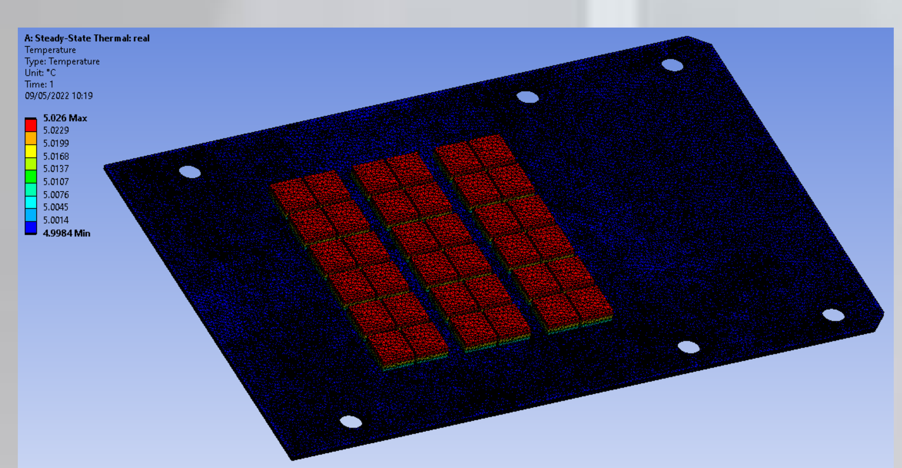
- -Total calorimeter length: 118 mm
- - Cross Section: 60 mm x 60 mm
- -Total weight: 200 g
- - PbF_2 crystals: 10mmx10mmx40 mm
- - Heat exchangers (Cu): 3.5 mm x 2

SiPM & FEE Cooling System

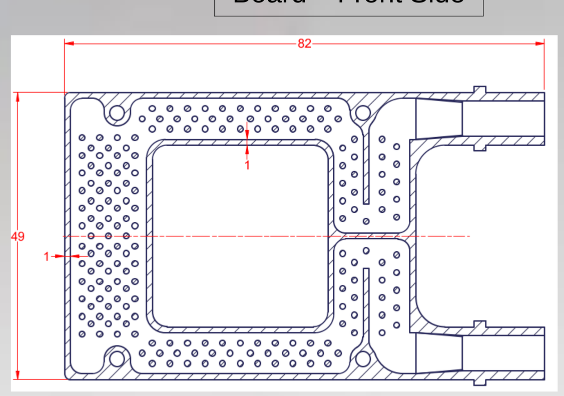
A cold plate heat exchanger , made of copper, is mounted over the electronic board and a glycol based water solution is passed through deep drilled channels to absorb the generated heat energy from SiPMs. As the cold plate needs to be performing well in the stringent environmental conditions of -20◦C to +50◦C, the glycol based water solution is mixed to avoid the freezing of the coolant in the low temperature environmental conditions.



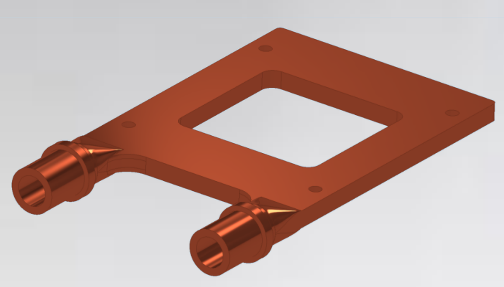
Board – Front Side



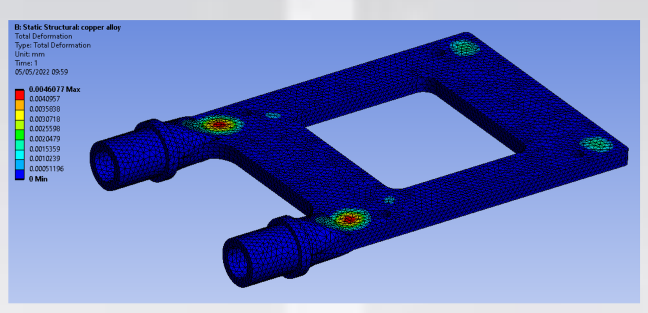
Board – FEM Thermal Simulation



Cold Plate - cross section



Cold Plate – 3D model

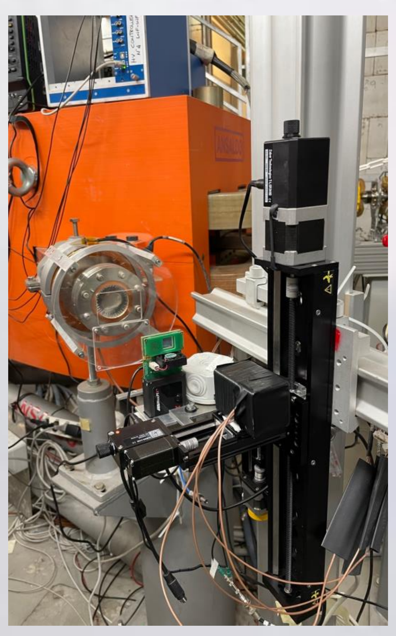


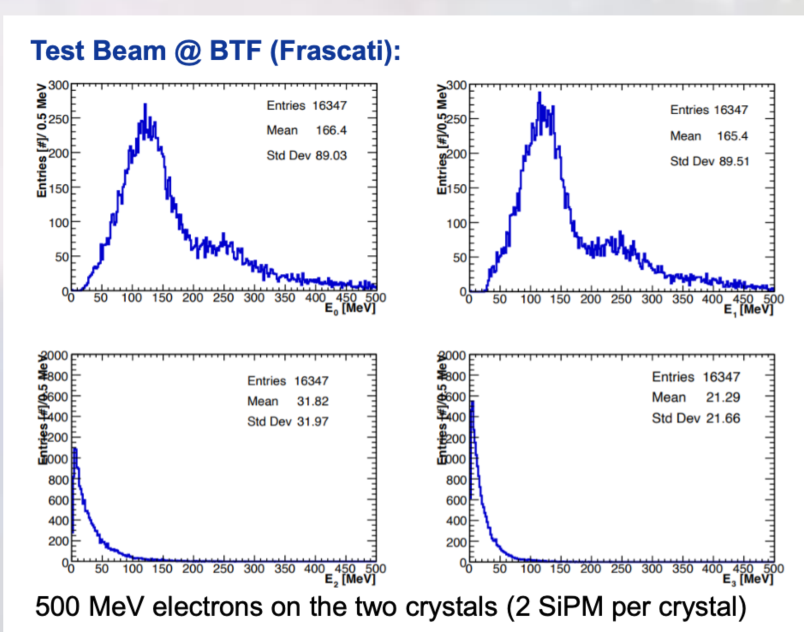
Cold Plate – FEM simulation

To improve the thermal performance of the cold plate, a micro-channel fin structure has been chosen to provide high thermal performance in a compact size.

Now in progress ....

In June 2021 a dedicated test beam was performed at the Beam Test Facility (BTF) of the National Laboratories of Frascati with 500 MeV electrons.





- A prototype made of one layer of 2x2 PbF_2 crystals has been realized and tested.
- A prototype made of two layers of 3x3 PbF_2 crystals is already in preparation.
- End of construction expected for June 2022.