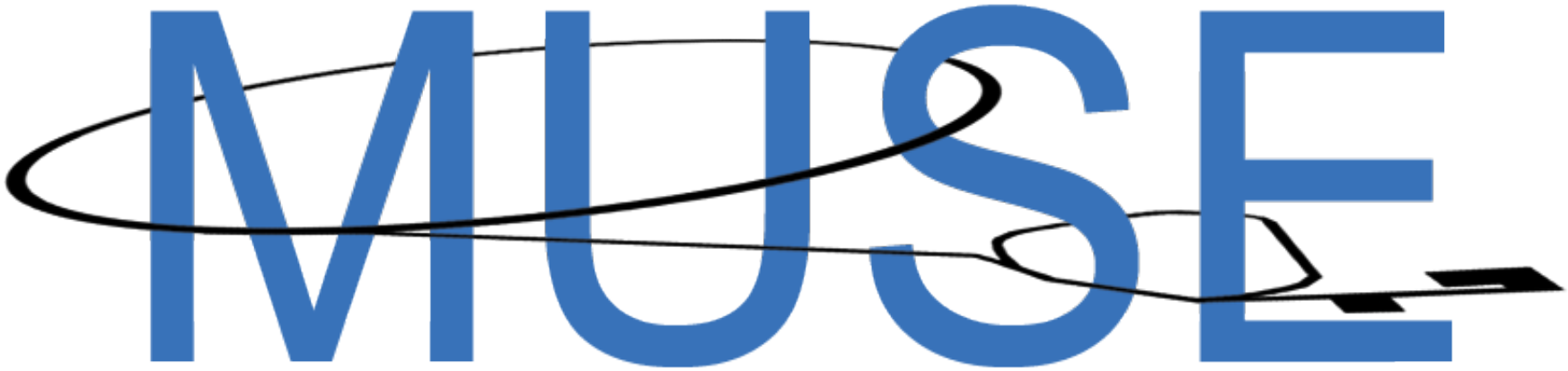


Plans for Module-0

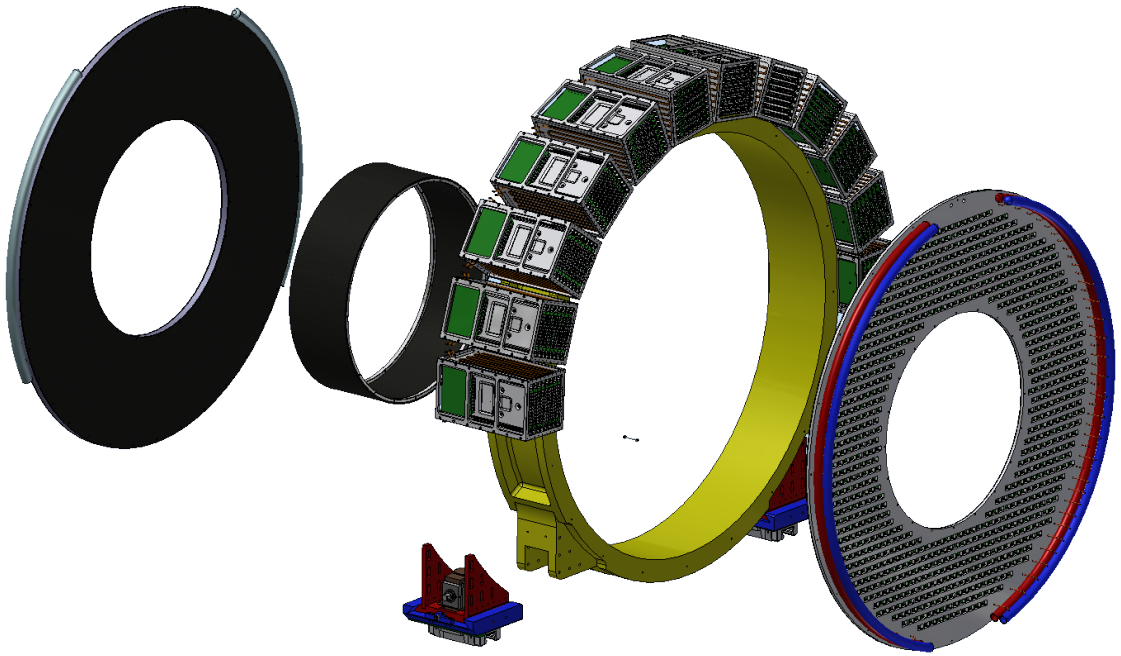
Matteo Martini

MUSE General Meeting
Pisa, 28 September 2016

Calorimeter design stuff

The mechanical design of the calorimeter has some important aspects to be carefully tested :

- Structure stability and deformation
- Adjustment system for motion and fine position regulation
- Total tolerances on crystals positioning and wrapping
- Cooling system
- Calibration source and front panel
- FEE+SiPM holder
- Cable routing
- Crate positioning and cooling
- ….

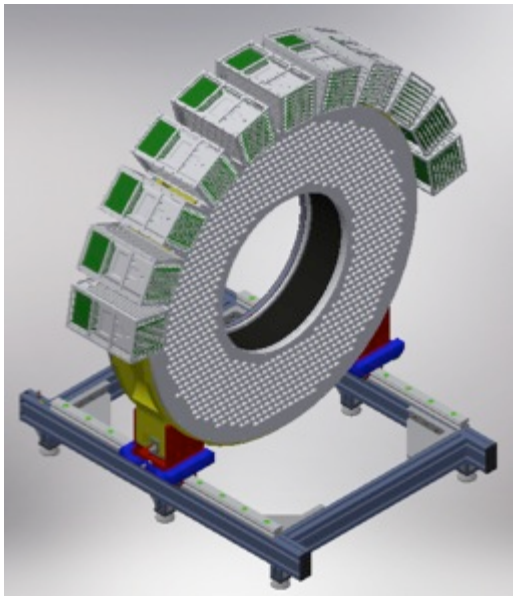


…. and some other problems that require to be tested with dedicated prototypes driven by Monte Carlo physics simulations, Mechanical finite element analysis, Ansys/Fluent simulations of the cooling, etc.

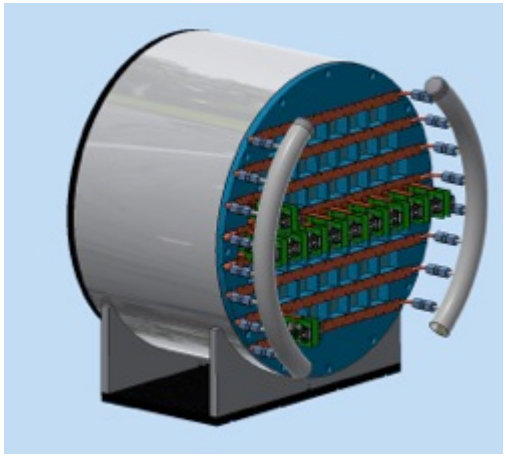
Calorimeter Prototyping

Two different steps of prototyping are scheduled for the calorimeter:

Mock-up



Module-0



Both are mandatory to experimentally test different aspects of the detector and provide information to finalize the project.

Very good collaboration and synergy between LNF, Pisa and Lecce.

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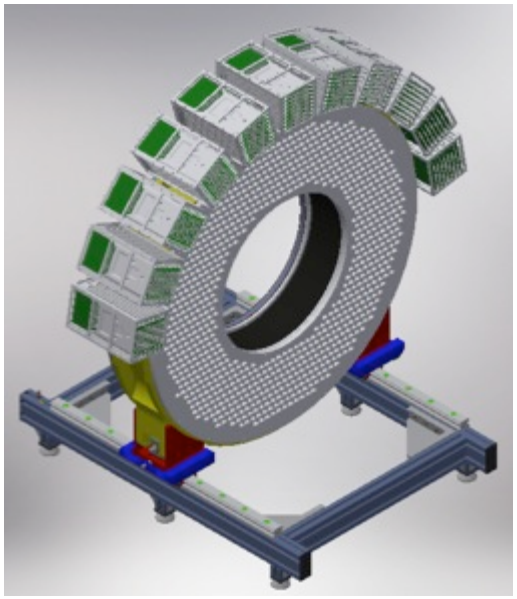
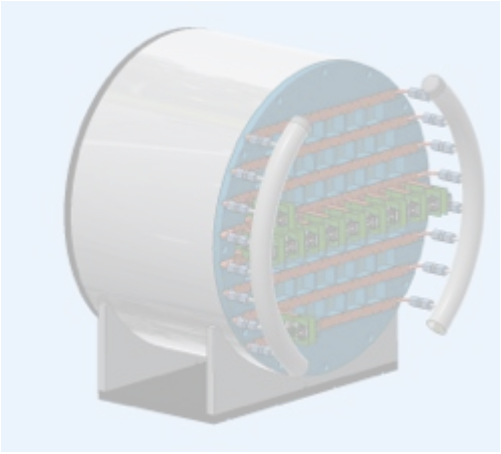


Module-0



Both these are mandatory to experimentally test different aspects of the detector and provide information to finalize the project.

Very good collaboration and synergy between LNF, Pisa and Lecce.

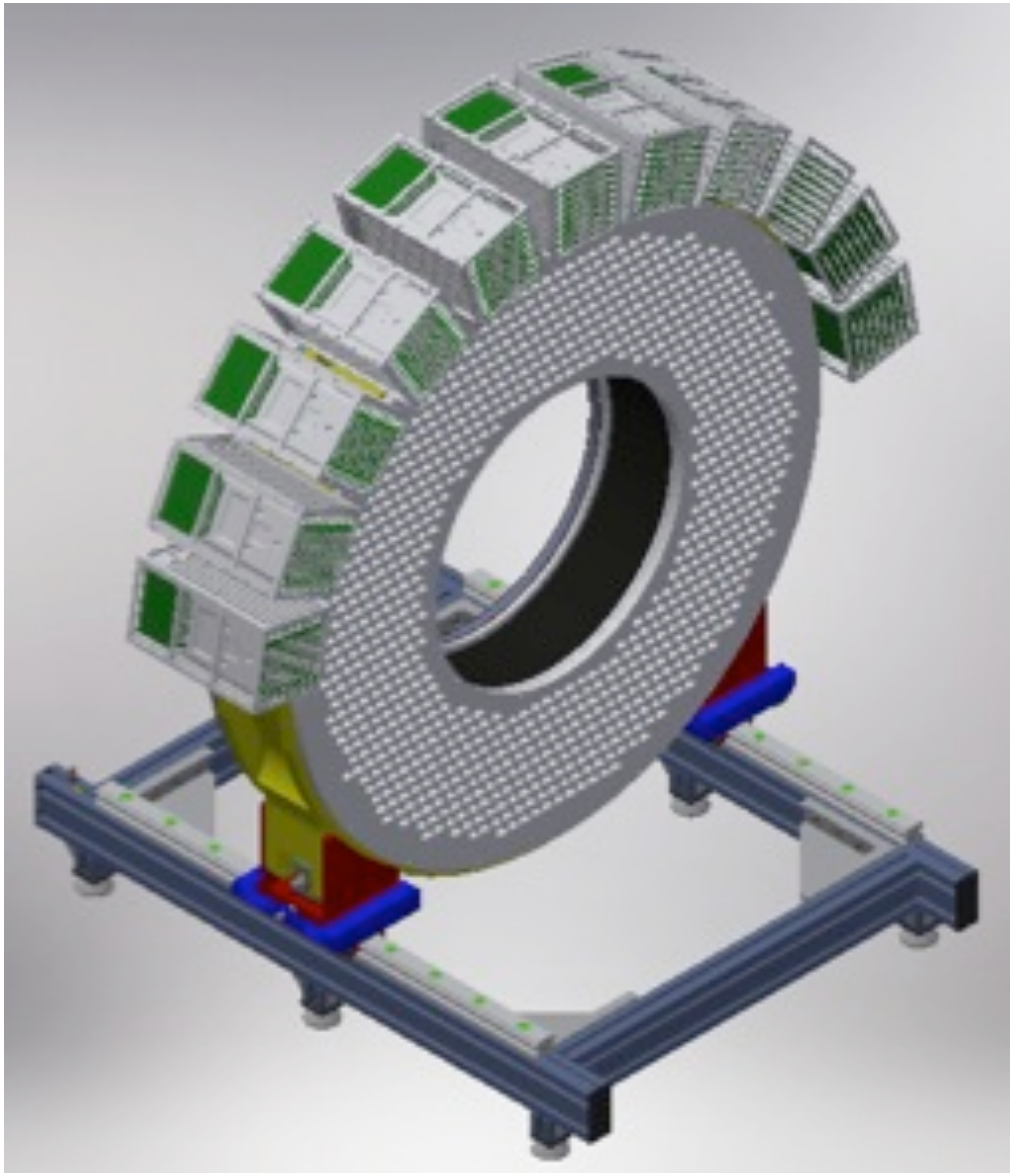
Mock-up philosophy

The mock-up is a 1:1 scale prototype of the mechanical structure and it will be useful to check:

- Mechanical stability
- Mechanical tolerances
- Crystals positioning
- Wrapping tolerances
- Position adjustment
- Cabling

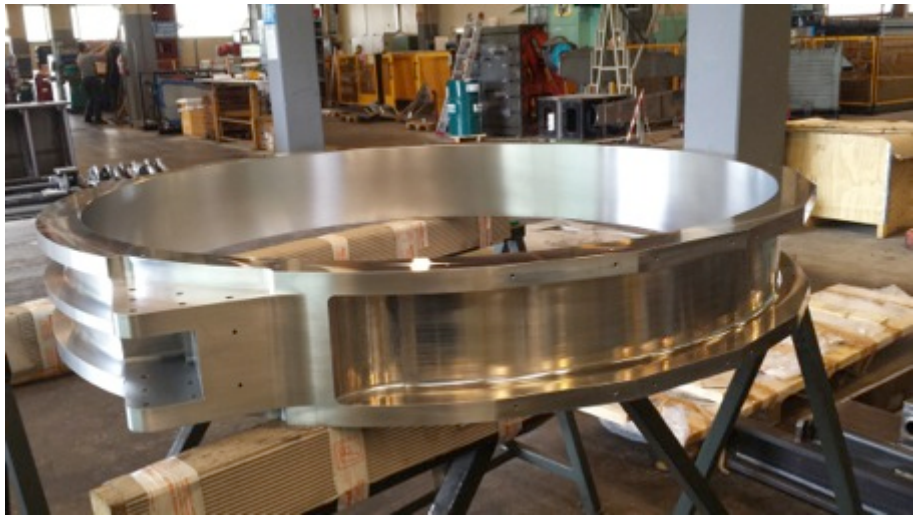
The realization of the mock-up is in progress with different responsibilities between LNF, Lecce and Pisa.

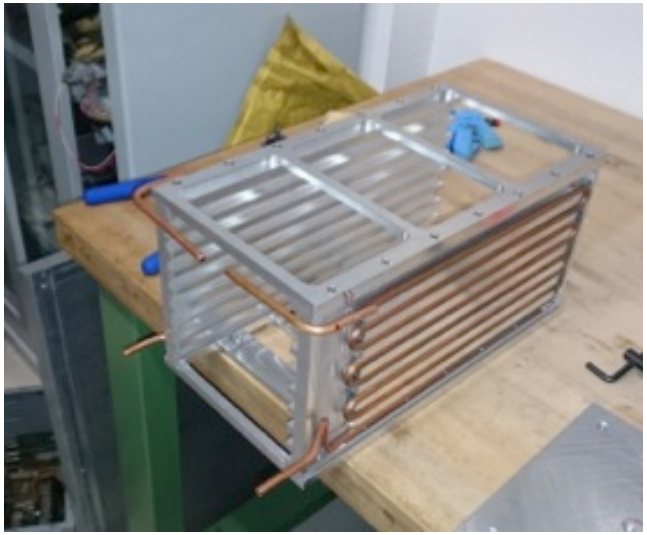
We are also building a dedicated mock-up of the cooling plate to test assembly and fluid dynamics properties.



Mock-up parts

- Proto Outer cylinder “full-size” – LNF -
- Feet+rails+adj mechanism - LNF -
- Inner cylinder - Lecce -
- Front plate - Lecce –
- Back Cooling plate - Pisa -
- SiPM+FEE holders – LNF -
- Crate prototype – Pisa -
- Cabling Mockup in preparation

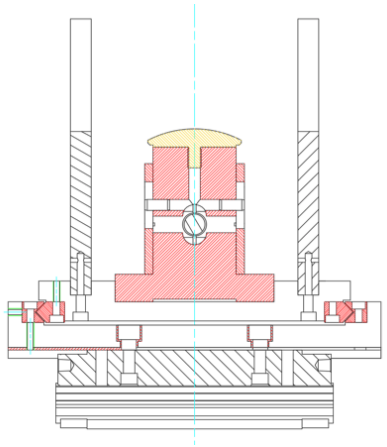


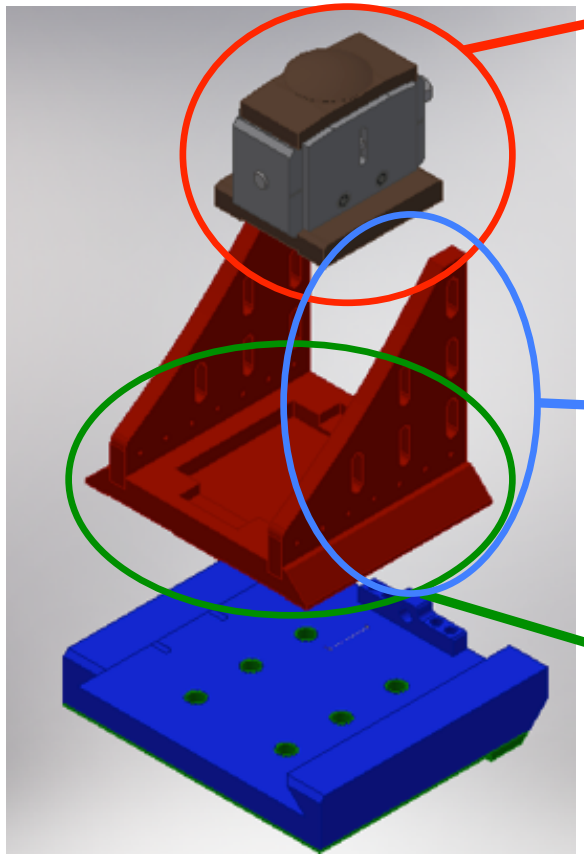


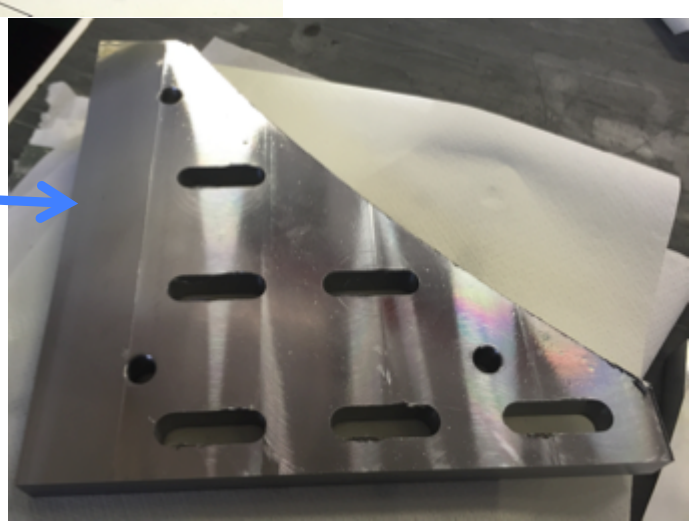
Mock-up: Leg details and adjustment

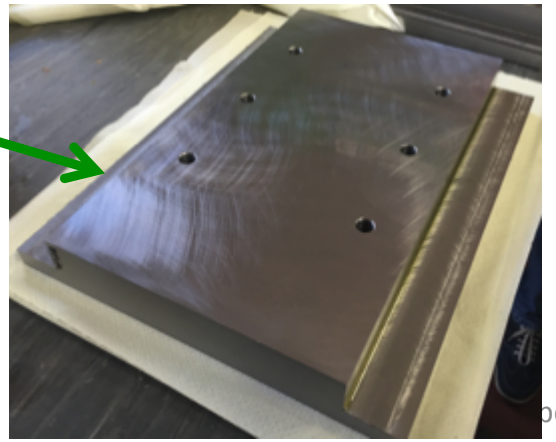
Leg details:

Status of the mechanical assembly @LNF





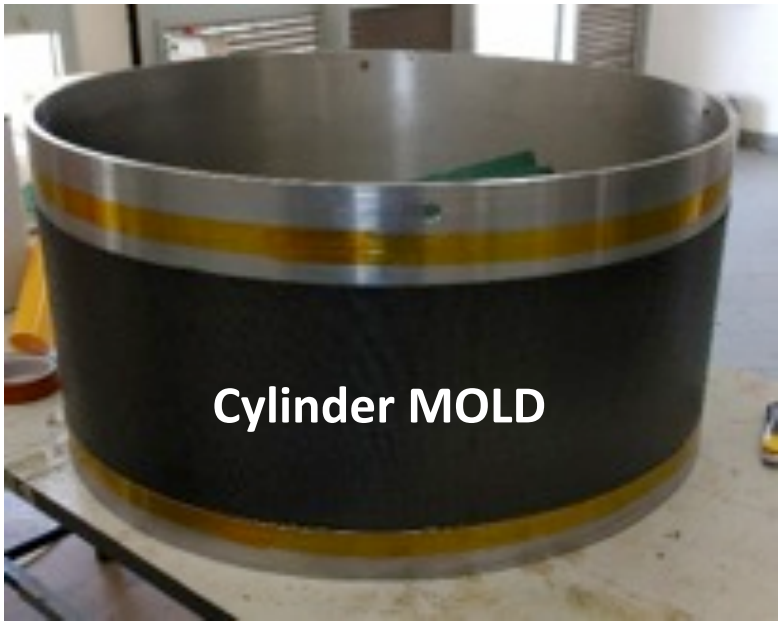


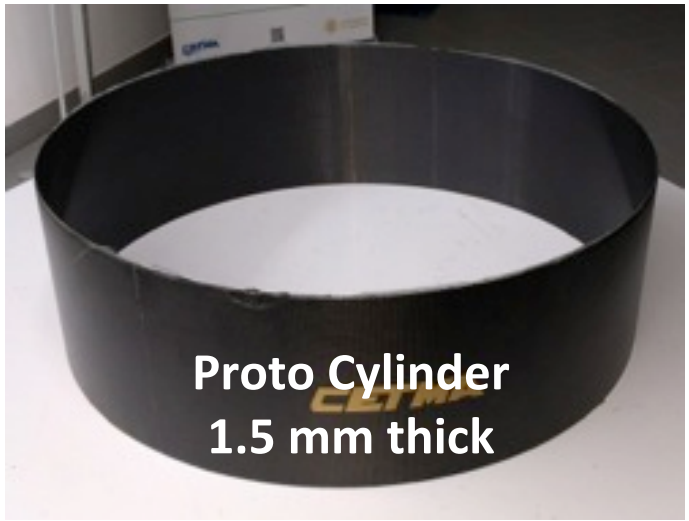


Mock-up: Inner cylinder

Inner cylinder is made of low density carbon fiber sandwich to minimize secondary interactions.

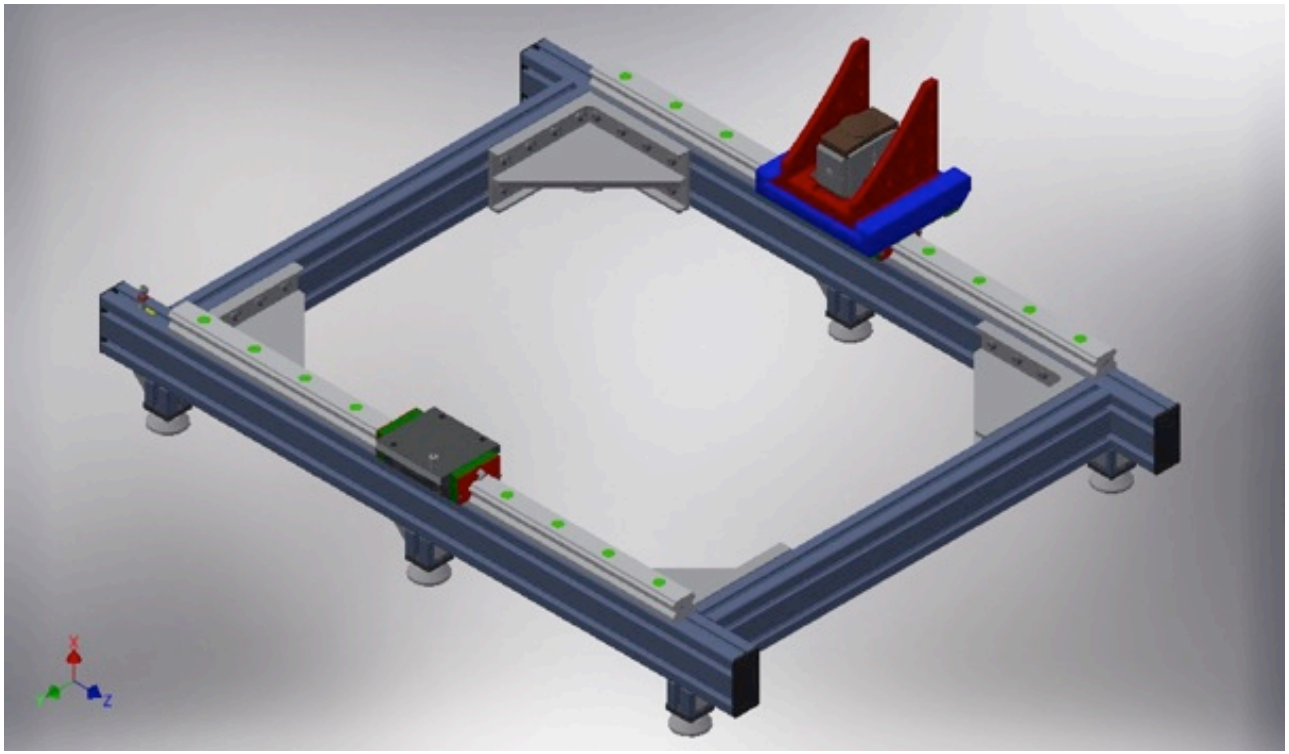
These parts are the outcome of many iterations of a Finite Element Method Analysis to guarantee that the maximum transverse deformation/displacement of the crystals and the structure be the level of ~tens of μm.





Mock-up: housing

- The mock-up will be housed on a dedicated aluminum structure to check positioning and stability.
- The fine regulation system will be tested.
- The mechanical structure will be filled with a sample of fake crystals miming size and weight to test wrapping and assembly.



Calorimeter Prototyping

Two different steps of prototyping are scheduled for the calorimeter:

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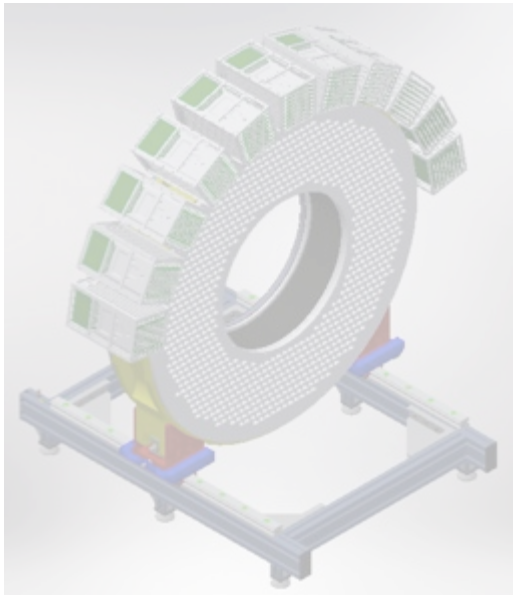
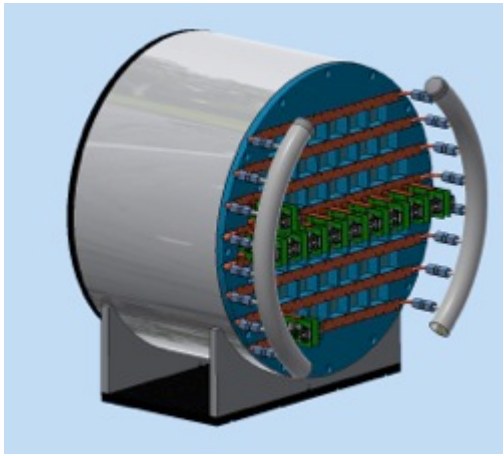


Module-0



Both these are mandatory to experimentally test different aspects of the detector and provide information to finalize the project.

Very good collaboration and synergy between LNF, Pisa and Lecce.

Module-0 philosophy

Build a module 0 using the final chosen technology

Module 0 definition summary:

→ 51 final size, kind of crystals, each one connected to 2 final package sensors, SiPMs

→ SiPMs inserted in a rear-disk for cooling

→ 1 final (pre-final) AMP-HV/SiPM

→ **51 Crystals, 102 SiPM, 102 AMP-HV FEE chips**

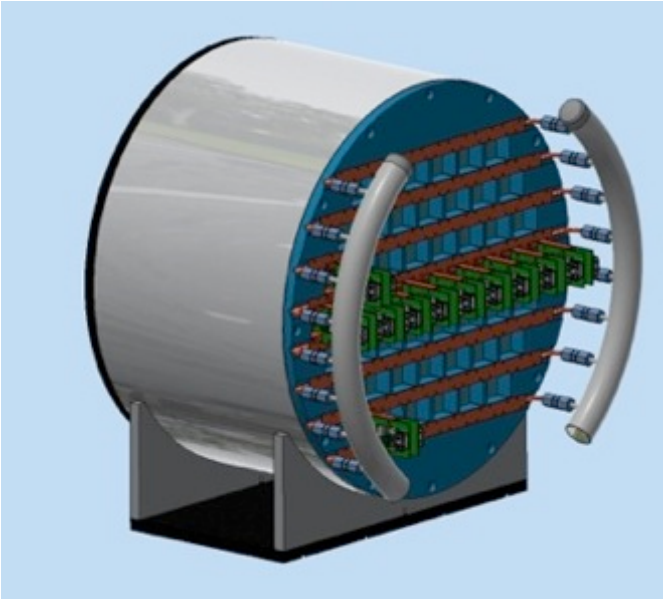
→ pre-final FEE differential cables to MB

- 4 adapted NIM Mezzanine boards (differential in input, coax cables output)

→ 48 (+16) Coax cables from MB to:

- CAEN DAQ standalone system 1 Gsps sampling
- first proto WFD, 200 Msps @ 1 Gbps ethernet

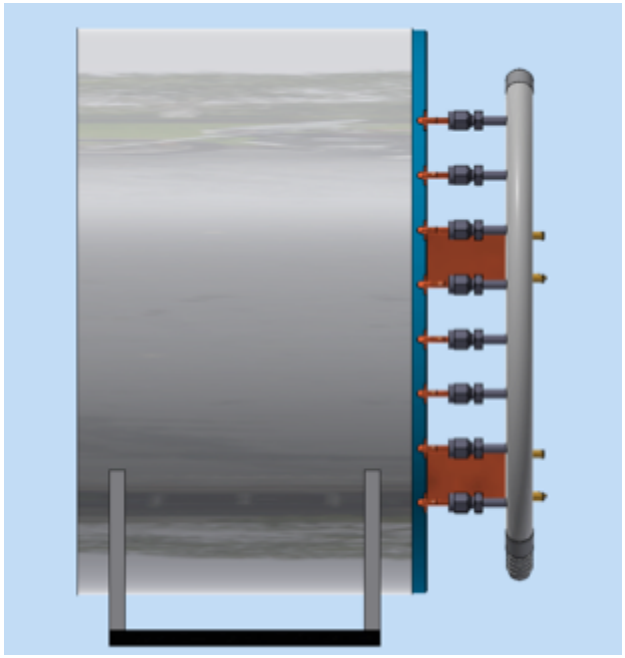
→ Test beam with e- beam at < 50 Hz

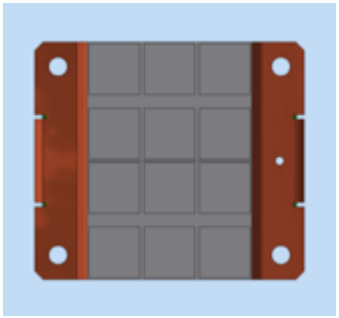


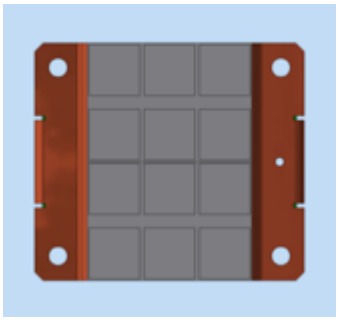
- Crystal QA/wrapping @ LNF
- SIPM QA at Pisa
- SIPM MTTF/Rad @LNF/Caltech
- FEE AMP-HV test @LNF
- LASER: blue Hamamatsu Laser
- WD @ Pisa

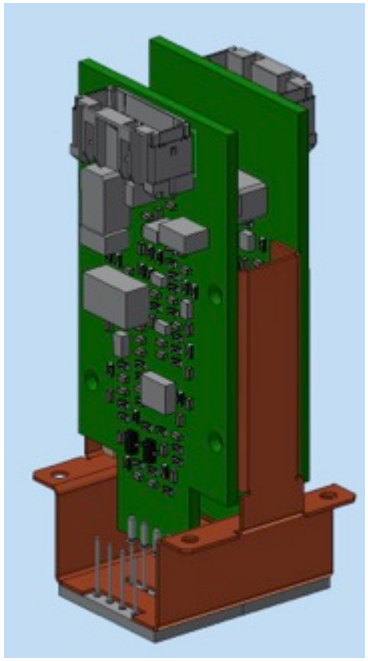
Drawings: executive
Procurement:
Crystals, Sensors OK, 50 from JINR
Tyvek (L-4173D, 155 mum) OK, FEE OK

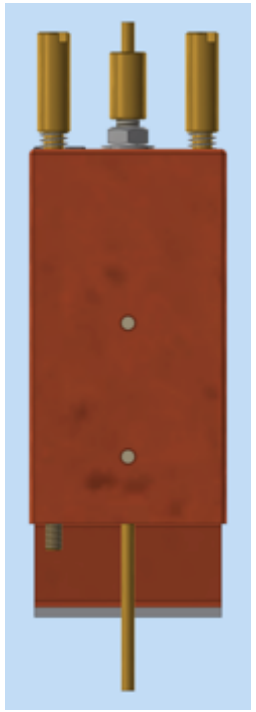
Module-0: details and work assignments



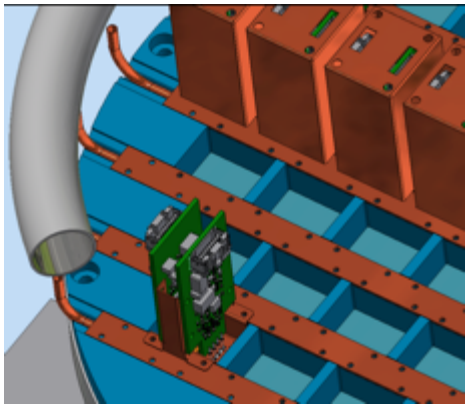








- Mechanical shell + cradle → Lecce
- Front Face in composite material → Lecce
- Additional material for proto source piping → Caltech
- Back disk and cooling lines: Pisa
- Connection of cooling lines to Chiller: Pisa.
- Moving table @ angle: Lecce
- 50 SiPM holder+ Glue for SiPM → LNF.

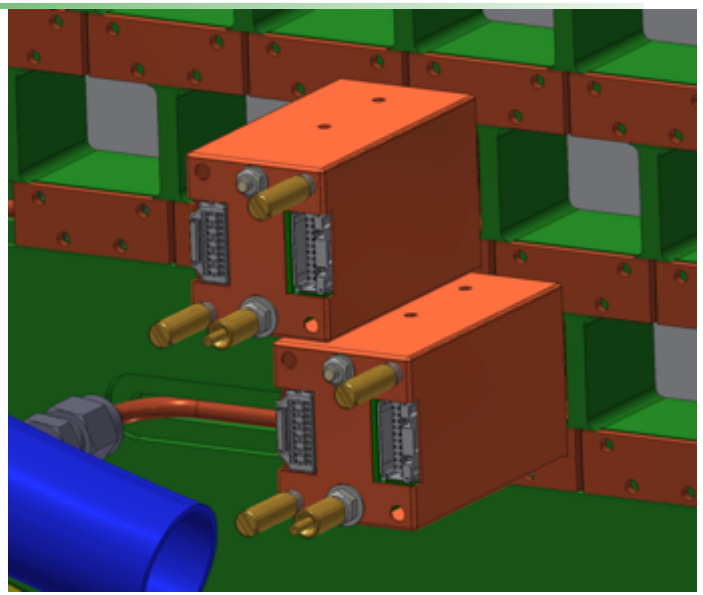


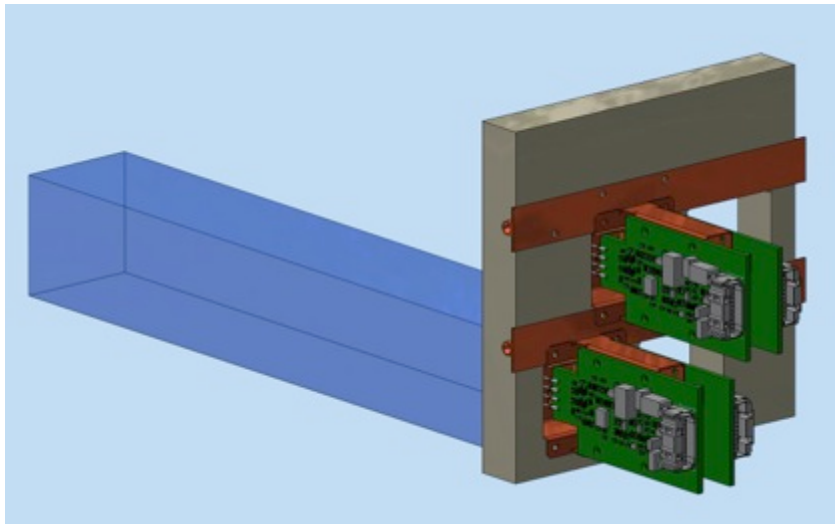
Module-0: Cooling line and FEE holder

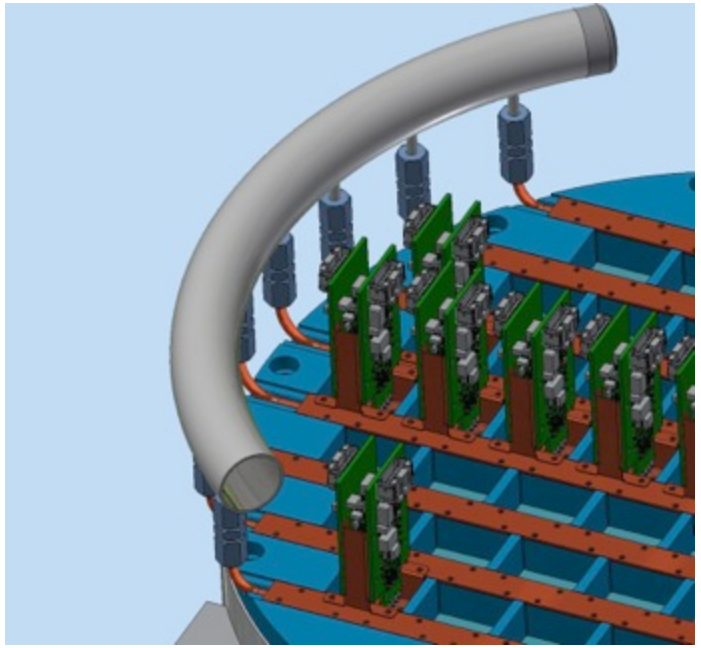
We are now finalizing FEE box to ensure:

- SiPM positioning
- Light-tight structure
- Thermal connection with cooling line

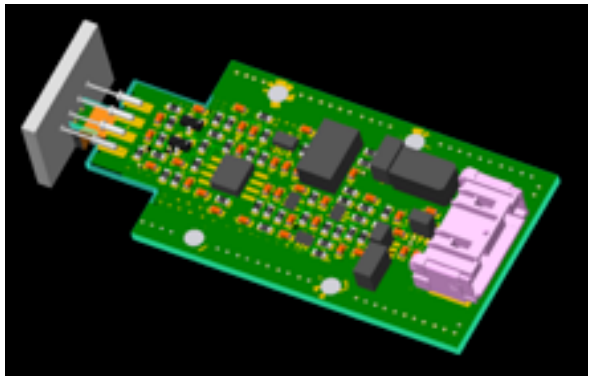
Final solution for cooling still under discussion between Pisa and LNF to maximize efficiency while maintaining mechanical simplicity.

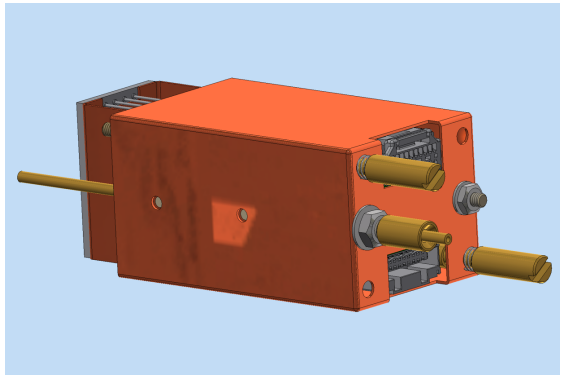


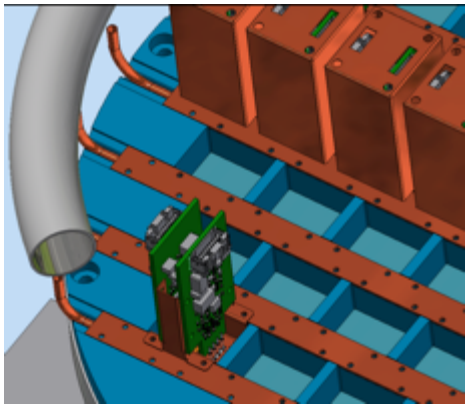


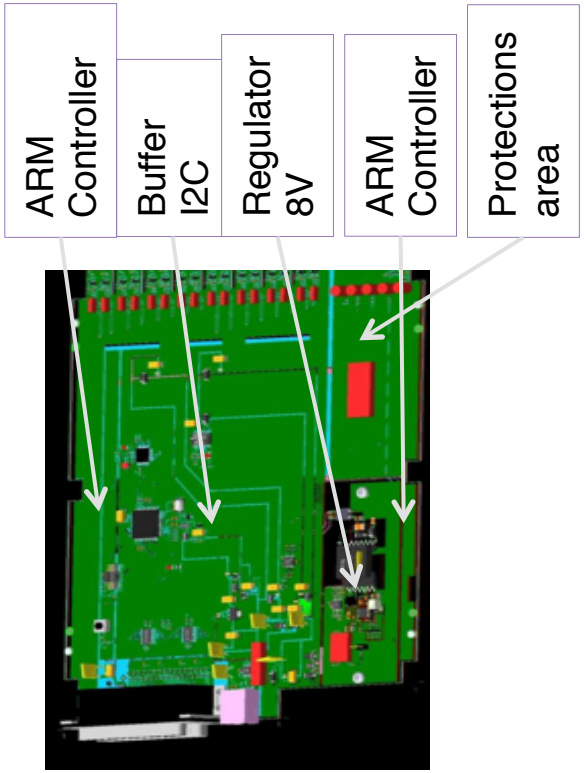


Module-0: FEE

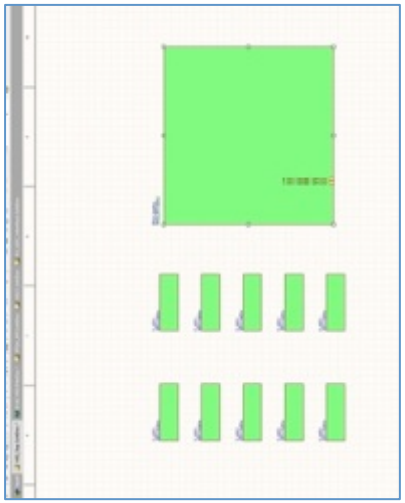








TDAQ from Mu2e PC server



- 20 channels/board (Mezzanine and Waveform Digitizer)
- 4-5 Input connectors to MB with final cables
- Final MB and WD interface.
- WD with Optical Fiber readout
- I2C from MB to WD for slow control (DCS)
- Total of 6 MB and 6 WD needed

WFD and crate → See E.Pedreschi talk

Module-0: FEE

Production of version-0 FEE is underway

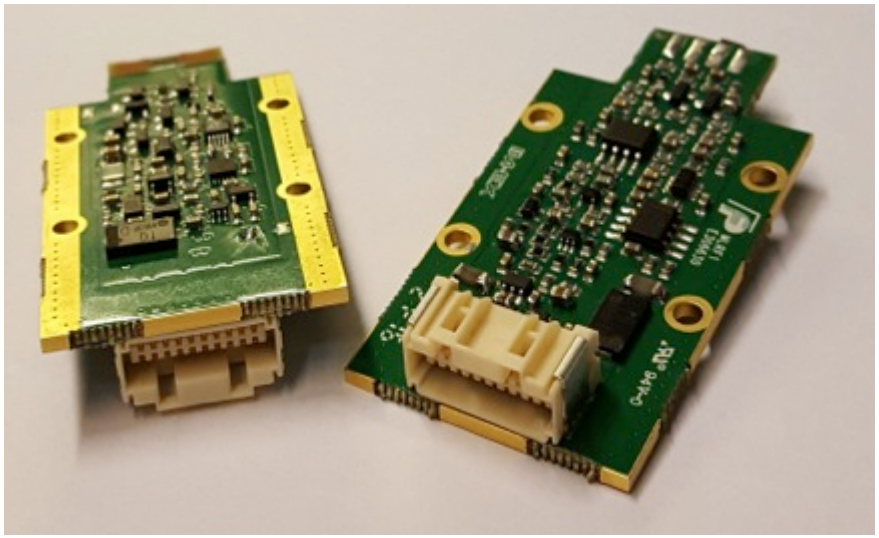
- 3 PRE-amps produced and tested.
  All functionality OK: noise, amplification, temperature sensor, current readout and pulse generator, HV regulator.

- Firmware for “proto”-mezzanine board almost completed.

- Cable from PRE to Mezzanine board selected. Connector for final MB is still under discussion.

- BID for 130 PRE-amps for Module-0 and 5 NIM proto MBs started.

- PO expected for 15 October;
  Production completed @ 20 November.



Module-0: planned tests

- **Step-1: rate test with LED/Laser flasher**
  Instrument at least one channel of CsI+SiPM +FEE
  Pulse it with fast LED/Laser system for High rate test (10 to 200 kHz)

  → Readout of 1 single channel first
  → Fanout to 20 channels, readout of 20 channel with TDAQ pilot system at high rate;

- **Step-2:** repeat test beam, CR data taking with full readout and TDAQ pilot system (Spring 2017)

- **Step-3:** repeat test beam under vacuum with cooled SiPM in large dewar with Mylar window in front of calorimeter face;

- **Step-4:** Irradiate at 3 x flux module-0 for 1 month @ FNG neutron area and study response with CRs.

- **Step-5 (SJ):** If all other steps work → transport module-0 @ FNAL for test with pion beam at high rate.

Conclusions

- We are now finalizing the mechanical design of the mu2e calorimeter.

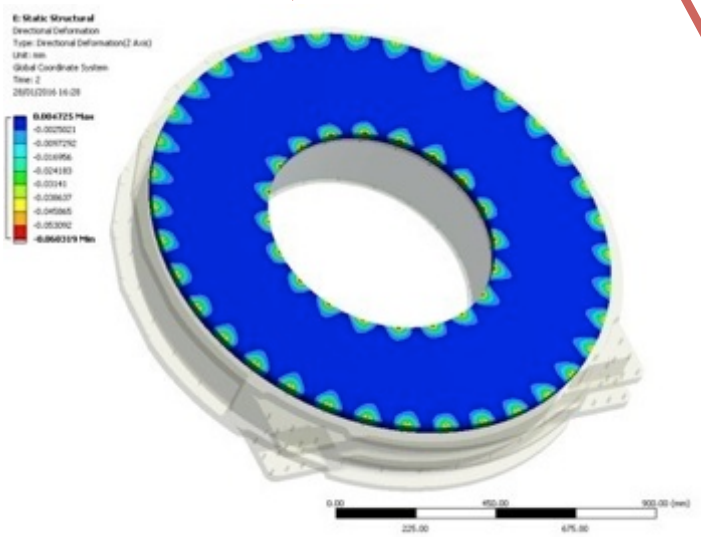
- The project is carried out by LNF, Pisa and Lecce with different competencies and synergies.

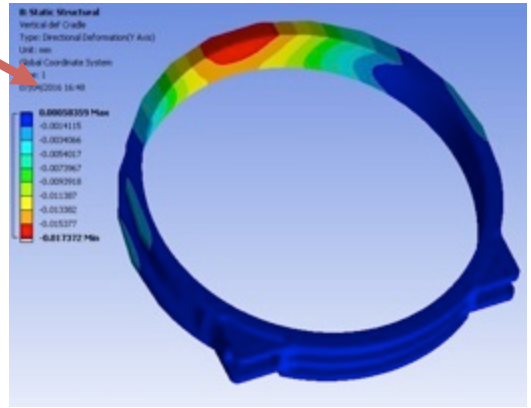
- Two prototypes will be ready by the end of the year:
  - Mock-Up: full scale structure to test mechanical stresses, tolerances, assembly and position adjustment.
  - Module-0: a fully instrumented small scale crystal matrix realized using the final chosen technologies to test: detector response, readout, cooling and vacuum.

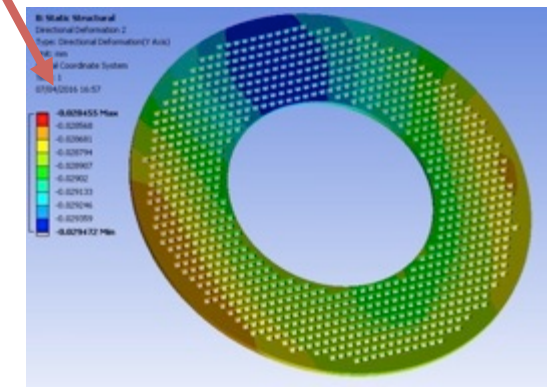
- Test and information from these prototypes will be fundamental to finalize the project and the integration inside mu2e cryostat.

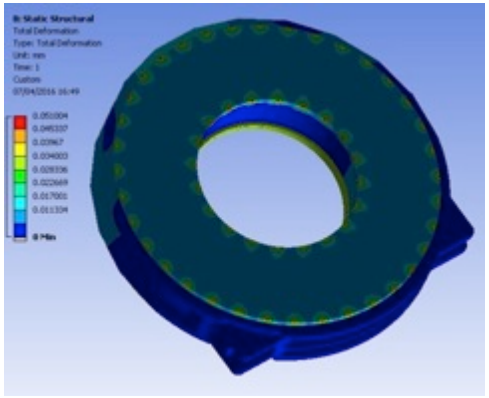
Mechanical stresses (FEA)

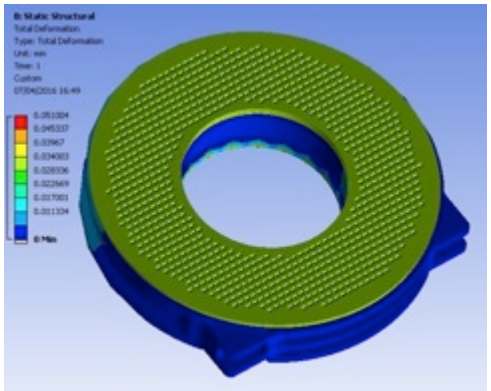
- Total deformation of the entire structure front and rear side
- Deformation of outer ring
- Deformation of back plate
- front plate











Everything within ~ tens of μm: max 50 μm on bolts preloads – 17 μm on outer ring