The Mu2e Calorimeter

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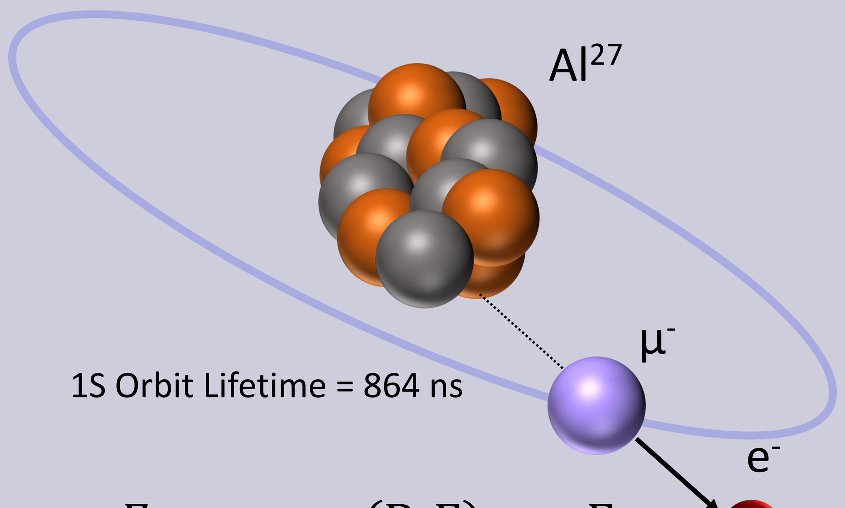
Searching for μ-e conversion

The **Mu2e Experiment** will search for neutrinoless conversion of muons into electrons in the field of an Al nucleus**.**

Such a **charged lepton flavor-violating (CLFV) process allows to probe energy scales up to thousands TeV.**

Mu2e will set a limit on the ratio between the conversion rate and the capture rate: **$R_{\mu e}$<3 x 10^{-17} (@ 90% C.L.)**, which is 4 orders of magnitude better than the current experimental limit**.**



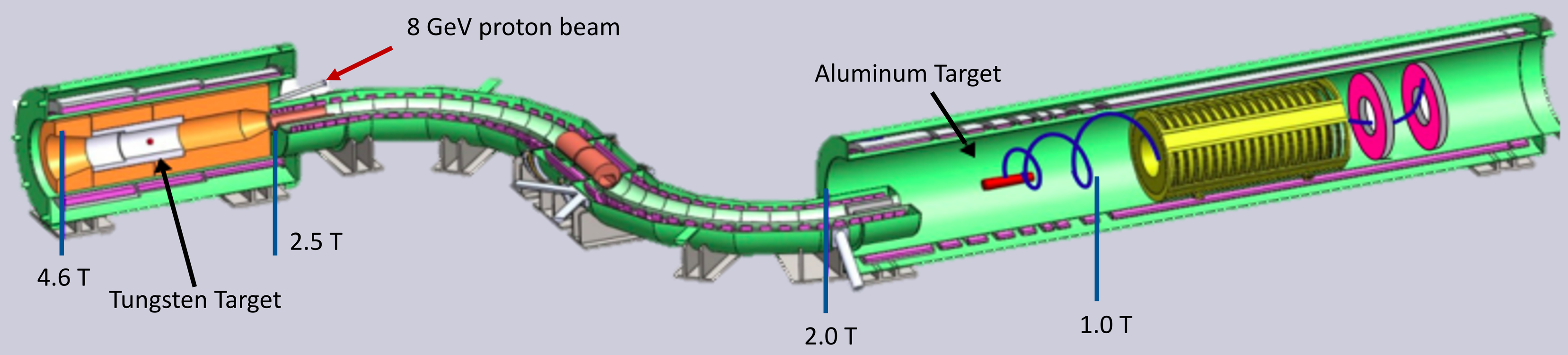
$$E_e = m_\mu - (B.E)_{1S} - E_{recoil} = 104.96\ \text{MeV}$$

The signature of the conversion is a mono-energetic electron with energy slightly below the muon rest mass

The experimental setup

Mu2e is composed of a system of three superconducting solenoids:

- The Production Solenoid: the 8 GeV proton beam hits the tungsten target producing mostly pions, thank to the graded B field charged particles are directed downstream
- The Transport Solenoid: filter the beam and select low momentum (40 MeV/C) μ^- beam
- The Detector Solenoid: muons are stopped in the Al Target, the Straw-tube tracker and the calorimeter optimized to detect conversion electron. The entire region is surrounded by a cosmic ray veto (CRV)

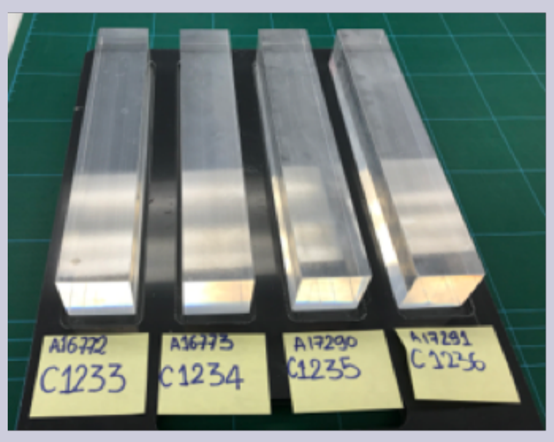


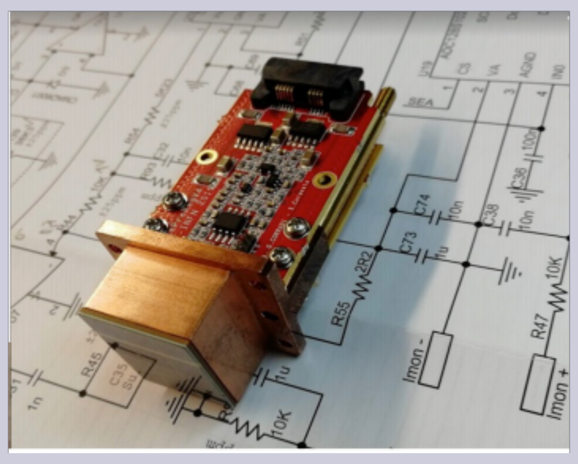
The Crystal Calorimeter

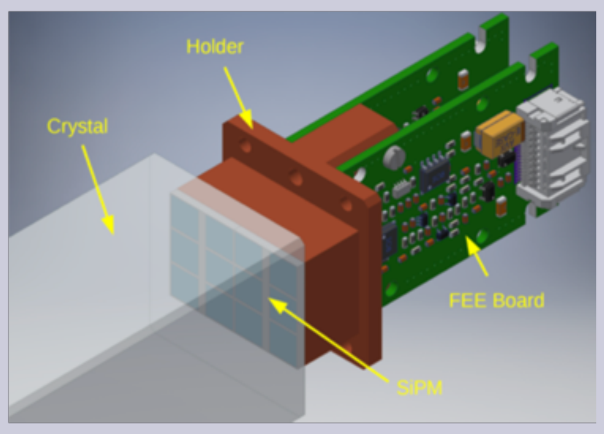
The Mu2e calorimeter is composed of two annular disks, each one filled with 674 pure CsI crystals. Each crystal is coupled to two custom 2x3 arrays of 6x6 mm² SiPMs.

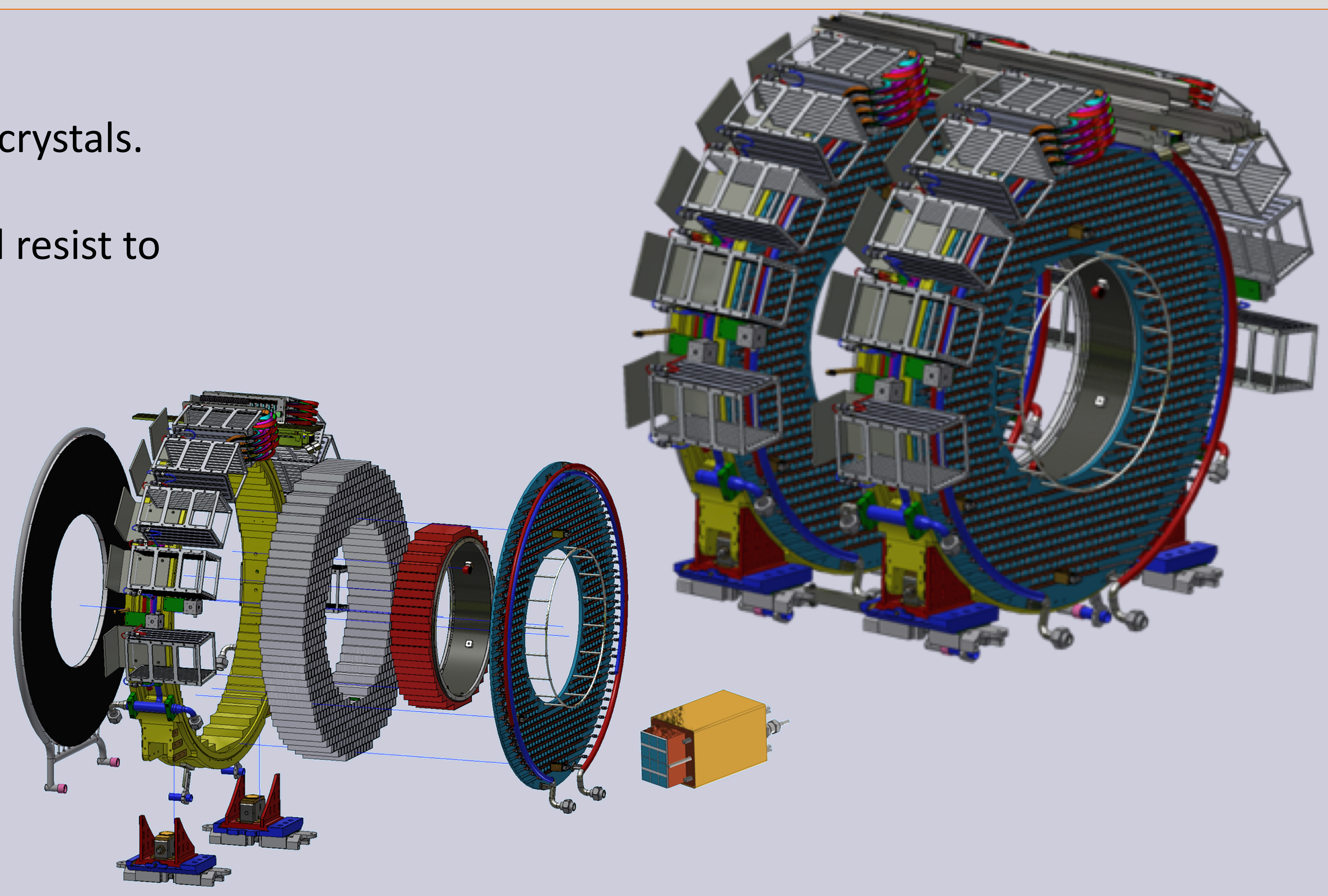
The calorimeter requirements are to provide a large acceptance for 100 MeV electrons and resist to the 1 T magnetic field and to a harsh radiation environment. The calorimeter must reach:

- **a time resolution better than 0.5 ns @ 100 MeV;**
- **an energy resolution *O(10%)* @ 100 MeV;**
- **a position resolution of 1 cm.**



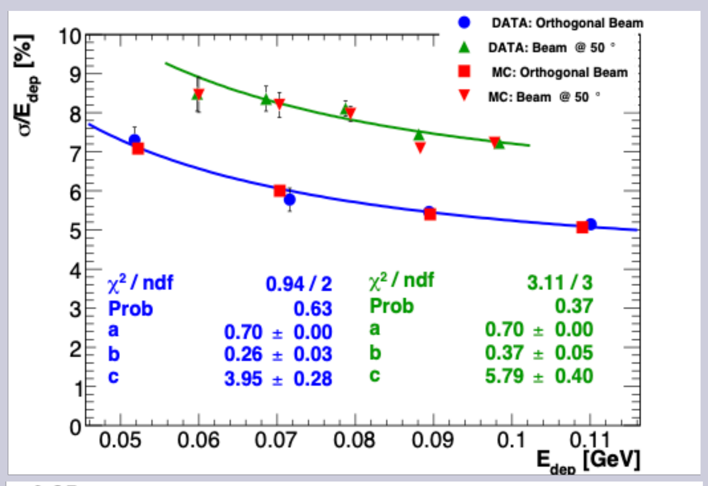


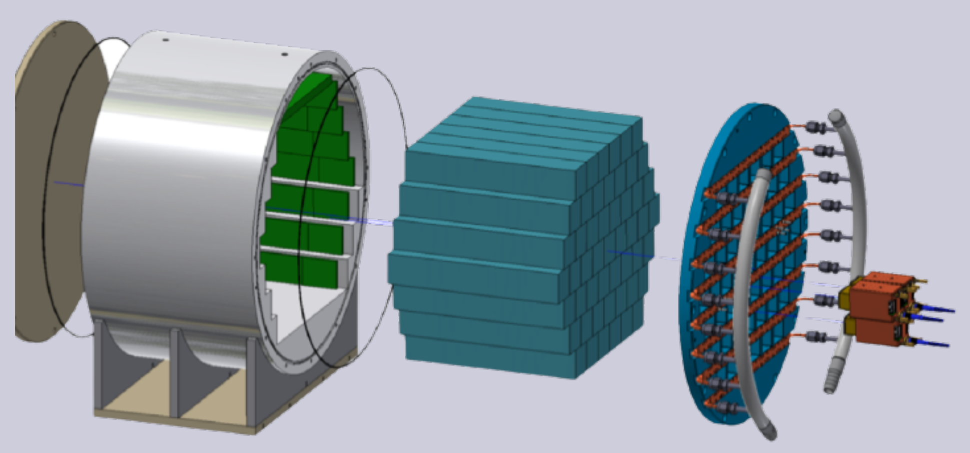


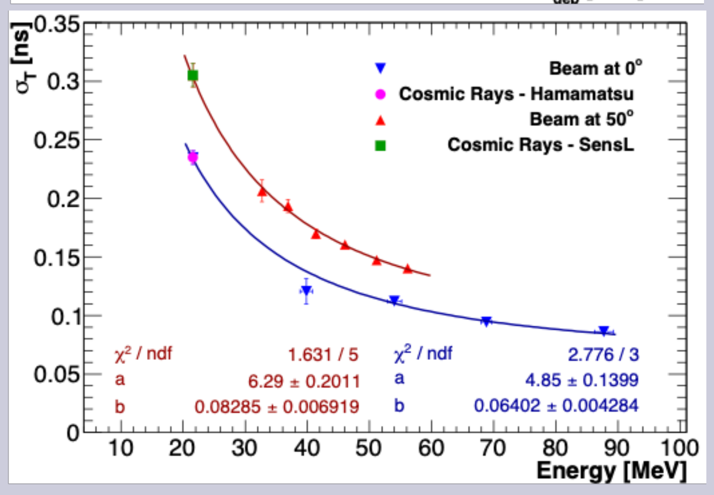


The Module-0 and the test beam

The Module-0 (51 crystals + 102 SiPMs + 102 FEE) is built to resemble as much as possible the final design of the Mu2e Calorimeter. The energy resolution and timing resolution obtained for 100 MeV electron is well in agreement with the Mu2e requirements







Crystals, SiPMs and FEEs QA

Crystals produced from Siccas and St Gobain

- 1430/1430 crystal delivered and tested
- Good optical properties (~4% rejection)
- Irradiation test up to 100 krad on random samples

Custom UV-extended SiPM from Hamamatsu

- 4000/4000 delivered and tested
- 1.2% SiPM rejected
- Passive n irradiation @ HZDR + MTTF>107 hours

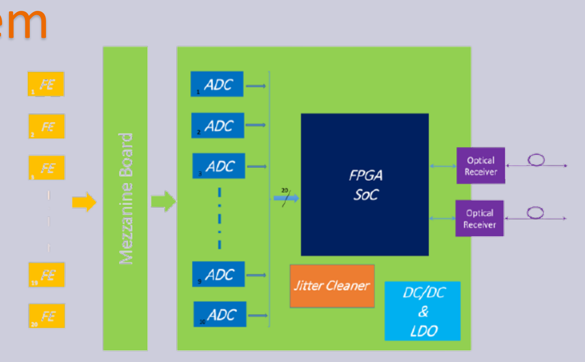
Front End Electronics board produced by Artel

- Test started in June 2021
- 65 ˚C burn-in a climate chamber
- Gain/linearity test
- ADC/DAC + temperature calibration

The Readout system

Mezzanine Boards (MB):

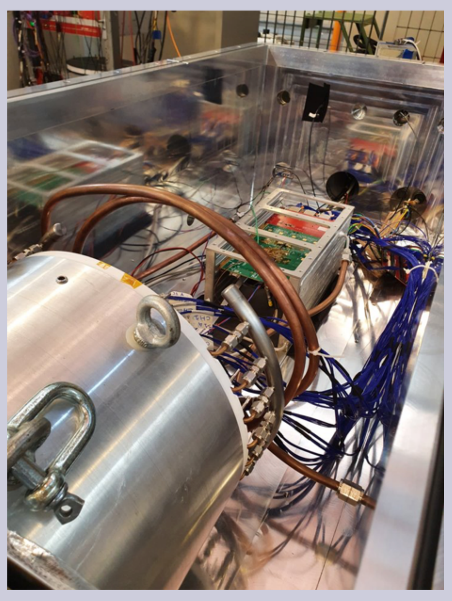
- Distribute low and high voltages reference values
- set and read back the locally regulated voltages
- SiPMs current and temperature readout



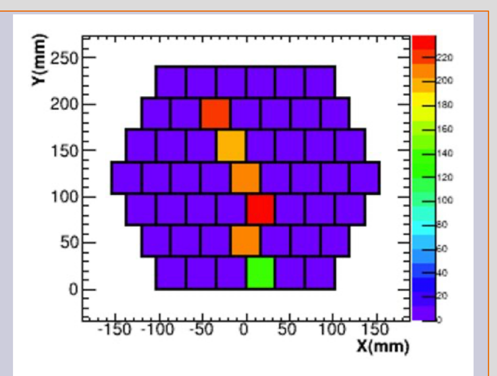
DIRAC board provides zero-suppression and digitization at 200 Msps, 12 bit ADC and transfer data to the TDAQ system via optical links

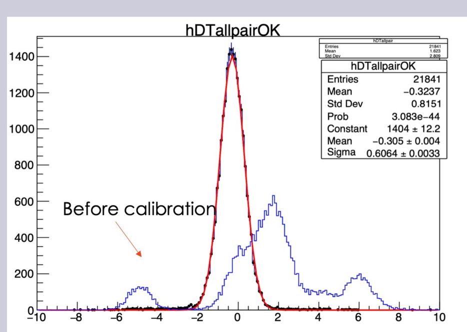
Slice Test

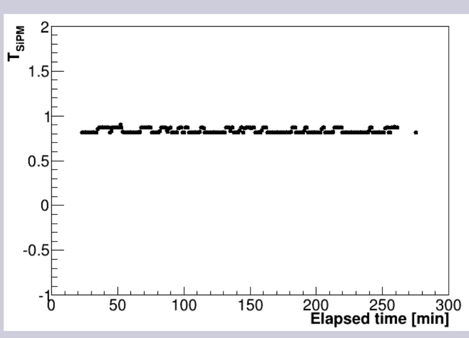
In May 2021, the Module-0 has been equipped with the final version of DAQ system (SiPMs+FEEs, cable, MZB+ DIRAC boards). CR events are collected in physical conditions similar to the ones required during the data taking (0 ˚C and 0.1 mbar)



- Define the algorithm to perform calorimeter calibration with CR events
- Improve timing calibration strategies
- Start implementing the Detector Control System







Status of the Mechanics

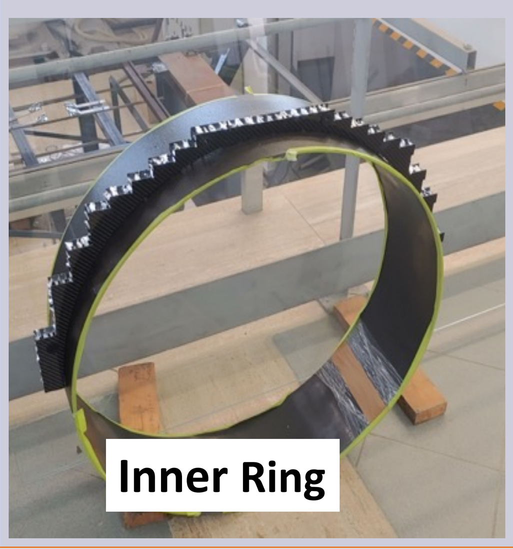
Design and integration of the components within the envelope ✅

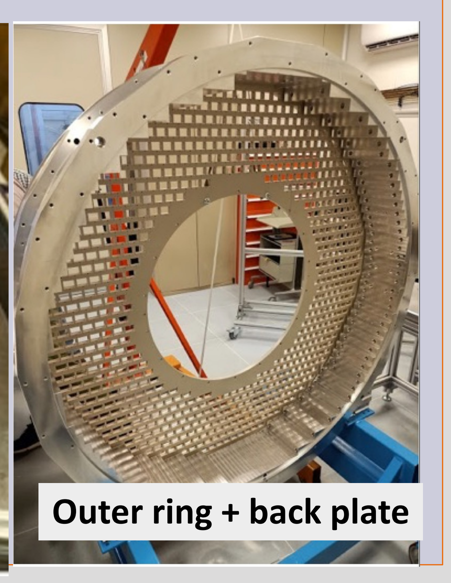
Outer ring construction ✅ → one disk is installed in FNAL clean room and one at LNF clean room for mechanics dry runs

Back FEE plate construction ✅

Front CF plate with source incorporated under assembly ⏳

Inner CF ring under assembly





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