

Design, construction and qualification tests of the Mu2e crystal calorimeter

The Mu2e experiment at Fermilab will search for the charged-lepton flavour violating conversion of negative muons into electrons in the coulomb field of an Al nucleus, planning to reach a single event sensitivity of about 3×10^{-17} , four orders of magnitude beyond the current best limit.

The conversion electron has a clear monoenergetic signature at 104.967 MeV, slightly below the muon rest mass, and will be identified by a complementary measurement carried out by a high-resolution tracker and an electromagnetic calorimeter (EMC). The calorimeter is composed of 1348 pure CsI crystals, each read by two custom UV-extended SiPMs, that are arranged in two annular disks. The EMC should achieve better than 10% energy resolution and 500 ps timing resolution for 100 MeV electrons and maintain extremely high levels of reliability and stability and in a harsh operating environment with high vacuum, 1 T B-field and radiation exposures up to 100 krad and $10^{12} \text{ n}_{1\text{MeVeq}}/\text{cm}^2$.

The calorimeter technological choice, along with the design of the custom front-end electronics, cooling and mechanical systems were validated through an electron beam test on a large-scale 51-crystals prototype (Module-0) and extensive test campaigns that characterised and verified the performance of crystals, photodetectors, analogue and digital electronics. This included hardware stress tests and irradiation campaigns with neutrons, protons, and photons.

The production and QC phases of all calorimeter components is completed apart for the digital electronics that has been revised for improving its resilience to SEU and SEL. A series of vertical slice tests with the final electronics is being carried out on the Module-0 at LNF along with the implementation and validation of the calibration procedures. The first disk has been assembled in 2022 while the second disk is under assembly at the moment of writing. Status of construction will be summarised, along with plans for commissioning and first calibration of the fully assembled disks.

[max 1000 words]