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Design, assembly and operation of a scintillator based Cosmic ray tagger with SiPM readout

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The Mu2e experiment at Fermilab aims to search for the SM forbidden process of muon to electron conversion in the Coulomb field of Al nuclei. The signal signature consists of 104.96 MeV monoenergetic conversion electrons, identified by a complementary measurement carried out by a very precise straw-tube tracker and an electromagnetic calorimeter.

The calorimeter is composed of $3.4 \times 3.4 \times 20 \text{ cm}^3$ undoped CsI crystals, each one coupled to two custom UV-extended Mu2e-SiPMs, arranged in two annular disks for a total of 1348 elements, to achieve high granularity and high resolution in energy ($< 10\%$) and timing ($< 500 \text{ ps}$) for 100 MeV electrons. In order to calibrate the calorimeter with cosmic ray muons in the assembly area, we have designed and realized a Cosmic Ray Tagger (CRT) at Laboratori Nazionali di Frascati (LNF) of INFN.

The CRT consists of two planes of eight $2.5 \times 1.5 \times 160 \text{ cm}^3$ plastic scintillator (EJ-200) bars, each one coupled to Mu2e-SiPMs on both edges to reconstruct the hit position by their time difference. A template fit algorithm is used for timing reconstruction of both sensors of each bar, achieving position measurements in the longitudinal direction, with a resolution $\sigma_Z < 1.5 \text{ cm}$, as measured with dedicated runs where a $1 \times 1 \text{ cm}^2$ scintillator is used as external trigger. The 2D reconstruction of the hits in the two modules, placed one above and one below the calorimeter disk, allows to track muons in 3D.

The selected tracks are finally used to equalise and calibrate the energy response of all calorimeter channels to a level below 1% using the MIP energy deposition. The CRT will also be employed to estimate the dependence of energy and time response and resolution along the crystal longitudinal coordinate. A first test will be carried out at LNF on the 51 crystals arranged in the large size calorimeter prototype named Module-0.

Collaboration

Mu2e

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