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An automated QC station for the characterization of the Mu2e Calorimeter Readout Units

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The Mu2e experiment at Fermilab will search for the Standard Model forbidden conversion, within the field of a nucleus, of a negative muon into an electron. A clean discovery signature is provided by the observation of mono-energetic conversion electrons with energy of 104.967 MeV. If the conversion is not observed, Mu2e can set a limit of the ratio between the conversion and the capture rate below $8 \cdot 10^{-17}$ with a 90% confidence level, improving by 5 orders of magnitude the current limit.
Mu2e is made by a very large solenoidal system for the production and transport of the muon beam, two detectors (a tracker and a calorimeter) for the analysis of the produced particles and a cosmic ray veto.

The Mu2e calorimeter complements the tracking information, providing track seeding and particle identification to help reconstructing the mono-energetic electron candidates.
In order to do this, the calorimeter is required to achieve an energy resolution $< 10\%$ and a time resolution of the order of 500 ps for 100 MeV electrons, all while operating in vacuum, in a 1T magnetic field and in a strong radiation environment.

The calorimeter is made of two annular disks, each one filled with 674 pure CsI crystals. Each crystal is read by two custom made arrays of UV-extended Silicon Photomultipliers (SiPMs). Two SiPMs glued on a copper holder and two independent Front End Electronics (FEE) boards form a Readout Unit (ROU). To ensure consistency and reliability of the ROUs, we have designed, assembled and put in operation an automated Quality Control (QC) station to test the O(1500) units to be assembled.

The QC station is located at LNF (Laboratori Nazionali di Frascati) and can test two ROUs at the same time.
The SiPMs see the light of a 420 nm pulsed LED, attenuated by means of an automated nine position filter wheel. The transmitted light is diffused uniformly on the SiPMs surface thanks to a box with sanded glass that also provides light tightness and allows to work in a controlled environment, thus ensuring good reproducibility of the measurements. The ROUs are held in place by an aluminum plate that serves also as a conductive medium for temperature stabilization at 25 ℃, obtained with an external chiller.
The ROUs are powered by a low voltage and a high voltage power supply which are controlled remotely. The data acquisition of the FEE signals is handled by a Mezzanine Board and a Master Board (Dirac), controlled via USB with Python and C++ programs. The data acquisition has been parallelized and 10000 events per wheel position can be acquired in around one minute.

A scan at different light intensities is performed for each of the selected supply voltages, V_i, around the SiPM operational voltage, V_{op}, thus allowing to reconstruct the response, the gain, the photon detection efficiency and their dependence on V_i-V_{op}.
We will present the first results obtained on a large sample of production ROUs and the achieved reproducibility.

In-person participation

Yes

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