1. The Mu2e Experiment: a Search for $\mu + N \rightarrow e + N$

The Mu2e Experiment at Fermilab will search for charged lepton flavor violation looking for a coherent, neutrinoless conversion of muons into electrons in the field of an Al nucleus. Mu2e aims to improve by a factor $10^4$ the current best world sensitivity, 8 GeV protons entering from right in the production solenoid (PS) interact with a tungsten target producing pions and kaons. Muons produced in their decays are guided by a magnetic field gradient to the transport solenoid (TS) where they are selected in momentum and charge. Muons arriving in the detector solenoid (DS) are stopped in an Al target and the eventual monochromatic electrons produced in the muon conversions are identified by tracker and calorimeter. A cosmic ray veto system surrounds DS and half of TS.

4.6 T PS

2.5 T TS

2.0 T DS

Stopping target

Schematic view of Mu2e beamline

The Mu2e calorimeter: QA of production crystals and SiPMs and results from Module-0 beam test

S. Di Falco*

*On the behalf of the Mu2e calorimeter group

INFIN – Pisa (stefano.difalco@pi.infn.it)

2. The Electromagnetic Calorimeter

Calorimeter tasks:
- Particle identification $\mu/e$
- Seed for track pattern recognition
- Tracking independent trigger

Calorimeter requirements:
- $\Delta E/E < 10\%$
- $\Delta \phi = 500$ ps
- $\Delta \eta = 1$ cm

Each disk contains 674 undoped CsI crystals, 3.4x3.4x20 cm$^3$ each. Each crystal is coupled to two 14x20 mm$^2$ large area UV-extended SiPM arrays. Each array consists of a parallel arrangement of two groups of three cells biased in series.

Front end electronics (EE) is located just on the back of SiPMs; 20 digital and control electronics crates servicing a total of 2694 channels are located around the disks. Everything is inside the DS cryostat in a 10 Torr vacuum and a 1 T magnetic field.

3. CsI crystals characterization

Crystal quality controls:
- Mechanical parameters
- Light yield=100 p.e./MeV (with reference PMTs)
- Longitudinal Response Uniformity (LRU) < 5%
- Fast emission to Total Ratio > 75%
- Average Radiation induced noise (RIN), <0.6 MeV@1.8 rad/yr
- Radiation Hardness: normalized light output after 10(100) krad < 85(60)%

Crystal homogeneity:
- 52 (SIC) and 100 (SIC) delivered as of May 2018

SIPM quality assurance test station

An automated test station is used to measure breakdown voltage, dark current and PDE/Gain at different temperatures (20°C, -10°C, 50°C) in a 10 Torr vacuum for the 6 cells of each SiPM array. Custom electronics is used to control a set of relays to power and readout each single cell (via a Keithley multimeter) and to switch on and off a UV led. Data acquisition is managed using Labview.

4. SiPMs Characterization

- One cell characterization/1.2 min
- 25 sensors/time (20 tested + 5 as reference)
- 5x performed as of May 2018

5. The Module-0 prototype

Module 0 with preliminary electronics was tested in May 2017 at INFN Beam Test Facility (BTF) in Frascati. Electrons produced by muon conversions in Mu2e will reach the calorimeter with an energy of ~100 MeV and an average impact angle of ~50°.

6. Beam Test results

Beam impact on crystal.

Calorimeter time and energy resolutions well satisfy the requirements.

Radiation hardness for each batch. 5 SiPMs are irradiated at HZDR, Dresden with a neutron integrated flux of $3.7 \times 10^{10}$ n$_{eq}$/cm$^2$.