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

The Mu2e Experiment will search for coherent, neutrinoless conversion of muons into electrons in the field of a nucleus. Such a charged lepton flavor-violating reaction allows to probe energy scales up to thousands TeV, far above the highest energy reachable at the most powerful colliders. If no event conversions are observed in three years of running, Mu2e will set a limit on the ratio between the conversion rate and the capture rate: $R_{\nu e} < 6 \times 10^{-15}$ (90% C.L.).

Production Solenoid (PS)
An 8 GeV proton beam hits a tungsten target. A graded magnetic field reflects muons to the TS

Cosmic-Ray Veto (CRV)
A layer of p-type silicon bars. Covers the entire PS and half of the TS

Straw Tracker (TRK)
20000 low mass straw drift tubes. Momentum resolution 180 mrad/

Electromagnetic Calorimeter (ECAL)
1368 undoped CsI crystals. Energy, Time and Position measurements

2. The Electromagnetic Calorimeter

The Electromagnetic Calorimeter is a high-granularity crystal calorimeter consisting of about 1348 undoped CsI crystals, 3.4x3.4x20 cm$^3$ each. The crystals are arranged in two disks, separated by 75 cm, with inner and outer radii of 37.4 cm and 66 cm.

Each crystal is coupled to two 14x20 mm$^2$ large area UV-extended SiPM, for a total of 2694 electronics channels. Photo-sensors are packed using a parallel arrangement of two groups of three crystals in series.

Calorimeter Requirements:
- Particle identification $\mu/e$
- Seed for track pattern recognition
- Tracking independent trigger
- $\Delta E/E < 10\%$ and $\Delta t < 500$ ps
- Position resolution of O(1 cm)

Electronics are located inside the crystal to limit the number of pass through connectors.

3. The Mu2e Custom SiPM

The Mu2e custom SiPM are made of a 3x3 array of 56x56 mm$^2$ UV-extended SiPM. The two series readout reduces the overall capacity and allows to reach a faster signals.

SiPM Requirements:
- A Gain greater than 10$^8$
- A PDE above 20% at 310 nm
- A fast rise and recovery time
- Total实习生 Energy from $710^{-4}$ to $1$ MeV (Si/Mu)

Hamamatsu devices have been selected after and international call: production is ongoing and about 1000 devices have been tested so far!
QA process will involve 24k cell characterizations!

4. SiPMs Characterization

Automated Test Station: 25 sensors/time (20 tested + 5 as reference), one cell characterization/1.2 min!

I-V Curve and Breakdown Voltage:
- $V$ is the bias voltage
- $I$ is the breakdown voltage
- $S$ is the current before the breakdown
- $C$ is proportional to the number of the free carriers (thermal + optical)

- Dark Current:
- Gain x PDE:

For each cell we measure:
1. Breakdown Voltage
2. Dark Current @ Vpp
3. Gain x PDE @ Vpp

The cell to bias is selected among the 150 inside the vessel by a custom electronic system that drives more than one hundred relays. The bias voltage is provided by a Keithley 6487 that also performs the current measurements.

5. Dimensional Test

Each SiPM has to respect a mechanical tolerance of 100 micrometers:
- Integrity and damages check
- Measurement of SiPM dimensions (transversal dimensions and thickness)
- Chinese Shadow technique with a laser
- Go, not go gauge test station

6. Radiation Hardness

For each batch, 5 SiPMs are irradiated @ EPOS (HZDR, Dresden) with a neutron integrated flux of $1.7 \times 10^{22}$ n$_{eqv}$/Si/cm$^2$

7. Mean Time To Failure

Each batch of SiPMs has to grant an MTTF of 1 million hours when operating at 0° C:

$AF = \exp \left( \frac{E_f}{k} \left( \frac{1}{T_{mean}} - \frac{1}{T_{ref}} \right) \right)

- 0.5 \times N_{mean} \times AF \times N_{pmp} = 10^4$ hours

- Stress temperature 65 °C
- 18 days of test for 15 SiPMs
- Dark current at the operational voltage acquired every 5 minutes
- No "deads" $\rightarrow$ MTTF > 10$^4$ hours

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