AUM

American University Of The Middle East

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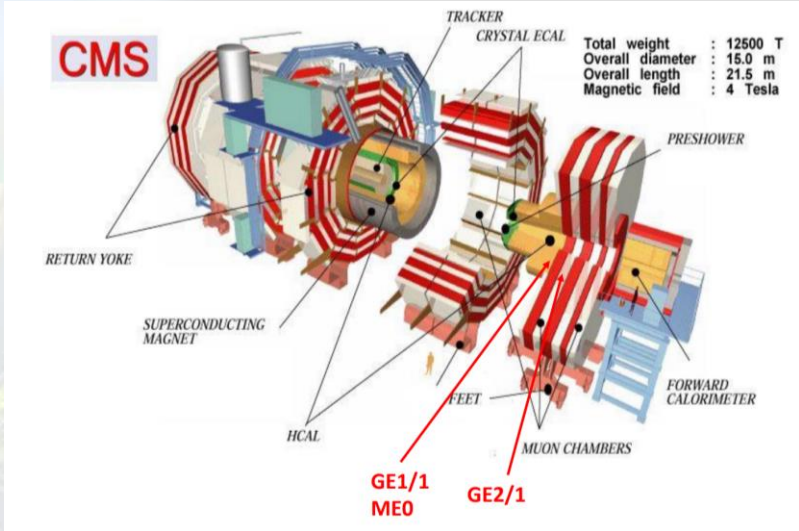
CERN Summer Student Presentation Session

GEM Detector Assembly and Quality Control (QC)

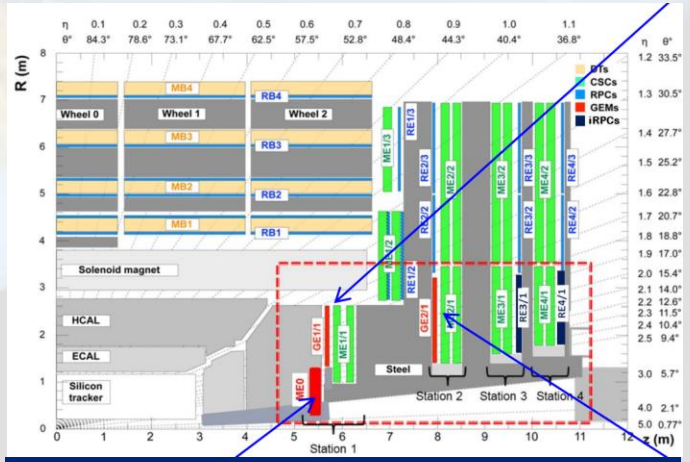
Monday 7th August 2024

ME0 Module

- The ME0 sits at the very front of the detector.
- It will be exposed to the highest radiation.
- Six ME0 modules will make a stack.
- Stacks are placed in the endcap of the CMS behind the HG Calorimeter.
- The ME0 works as a gas detector with Ag:CO2 70:30.



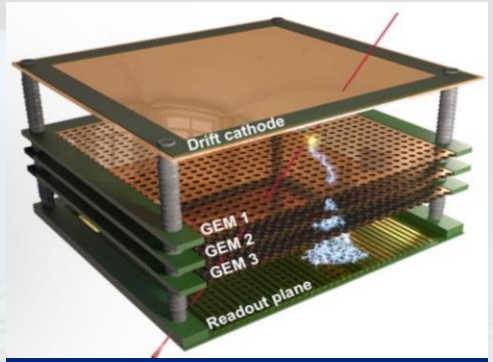
Compact Muon Solenoid



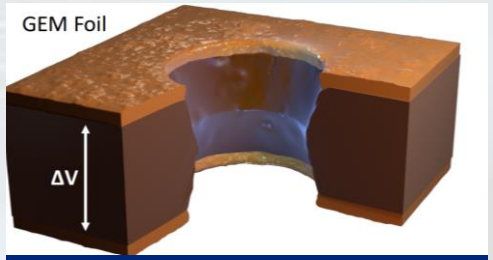
ME0 location

Gas Electron Multiplier (GEM)

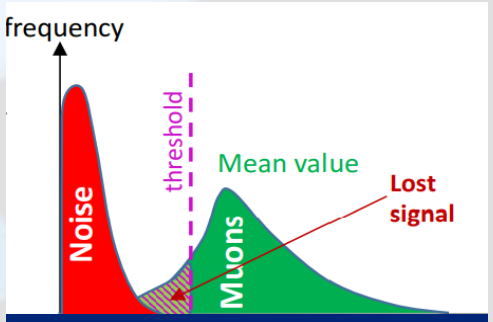
- Argon gas causes muon to ionize into positive ions and electrons.
- A voltage induced on the GEM foils induces an Electric field.
- The positive ions flow to the drift; the electrons flow to the readout.
- Moving charge induces current signals.
- The electrons are amplified with three GEM foils to eliminate noise from the induced signals.



3 GEM detector module

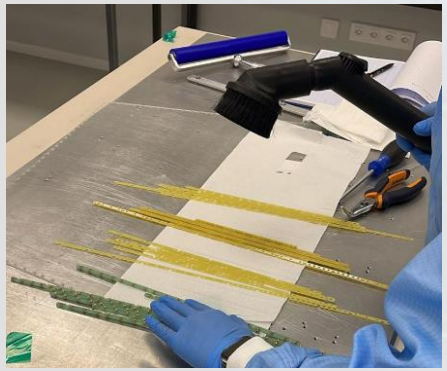


Micro GEM hole

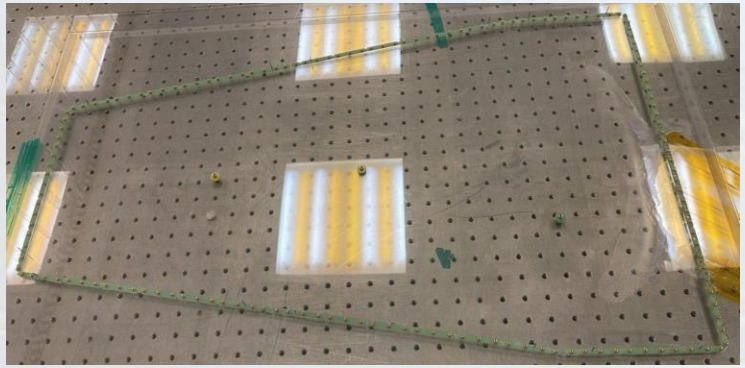


Poor Amplification

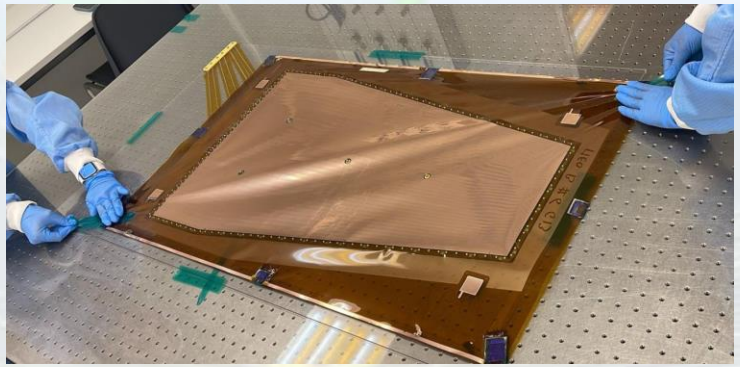
Assembly and QC of ME0 I



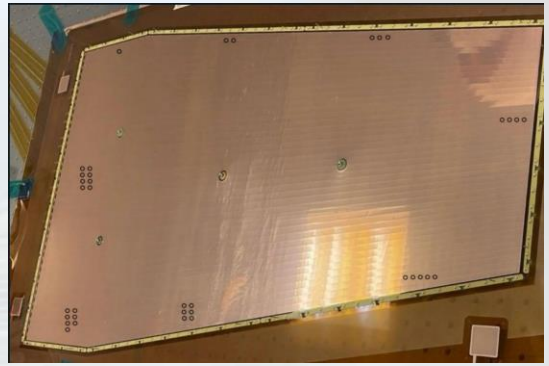
Removing dust from internal frames



Align the 3mm internal frames with the guiding pins

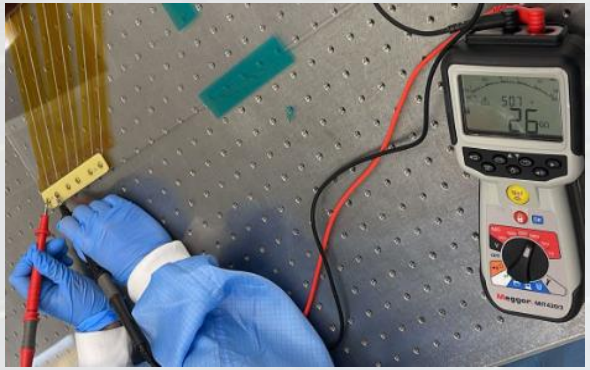


Add the GEM foil onto the internal frames

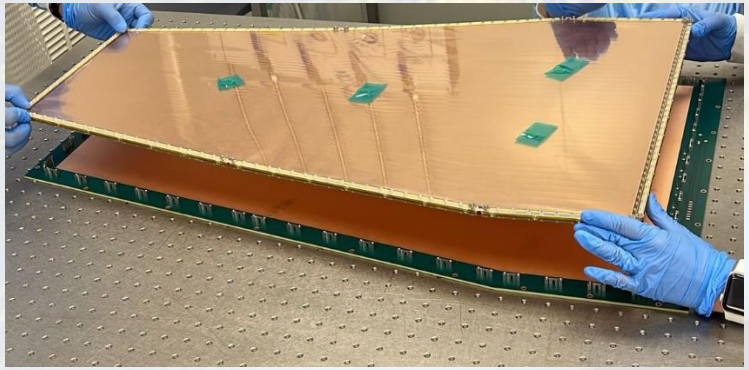


The 1mm frames demonstrate the order of installation

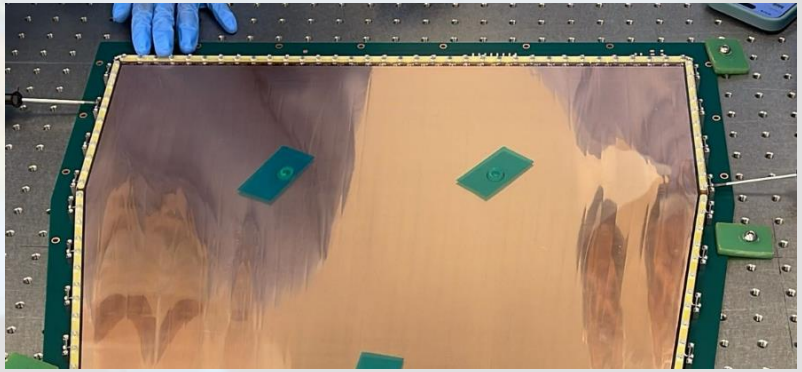
T-nuts are added to aid GEM stretching



Test health of GEM foils. Must not be less than 20 Giga Ohms.

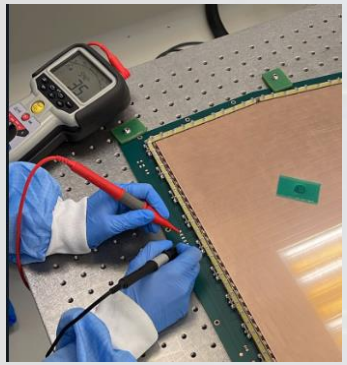


Place the GEM foils on the drift board.



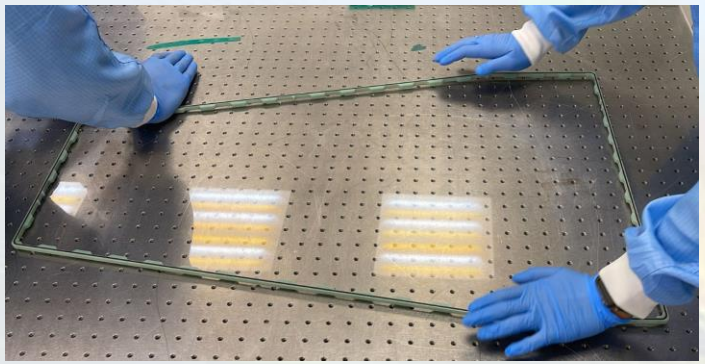
Stretching of the foils is done on opposing ends.

Assembly and QC of ME0 II

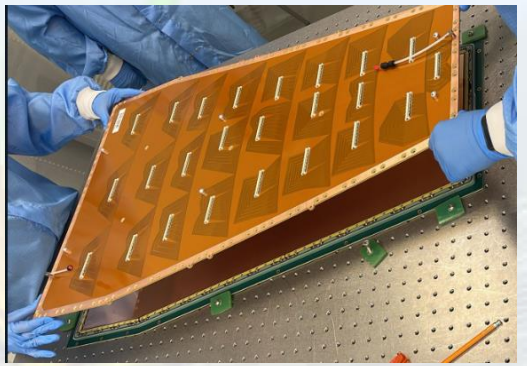


Check GEM foil health

Clean O-ring and external frame

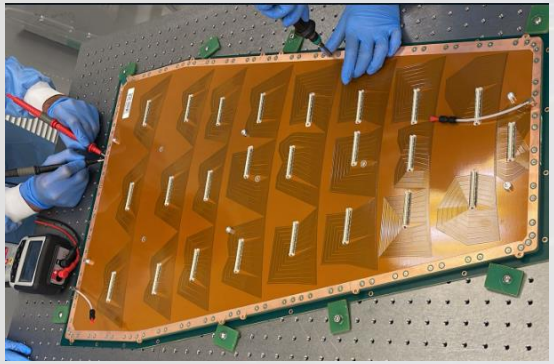


Attaching the O-ring to the external frame



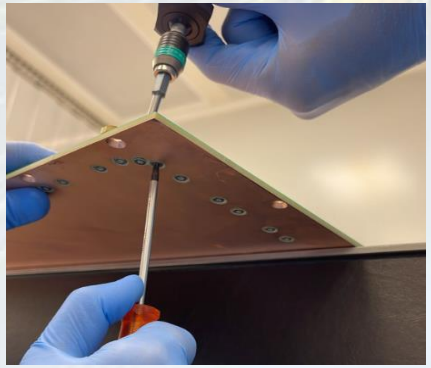
Attach readout board on the GEM foils

In the next step, GEM 3 will be monitored

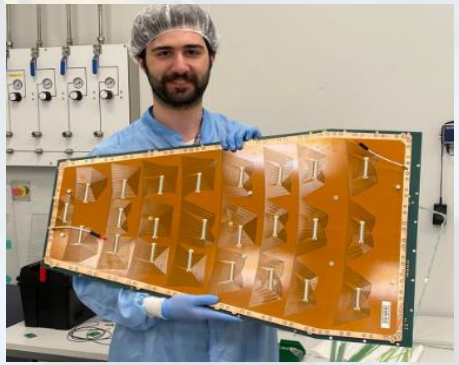


Screw the readout on to the GEM foils

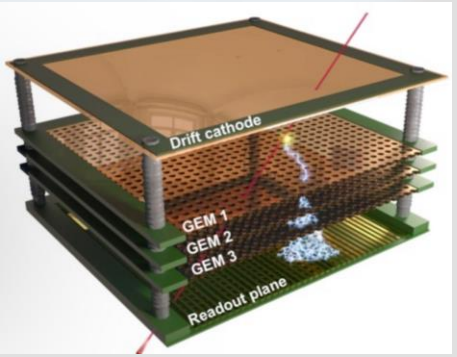
Make sure GEM 3 doesn't drop below MΩ



Tighten loose edges of the readout



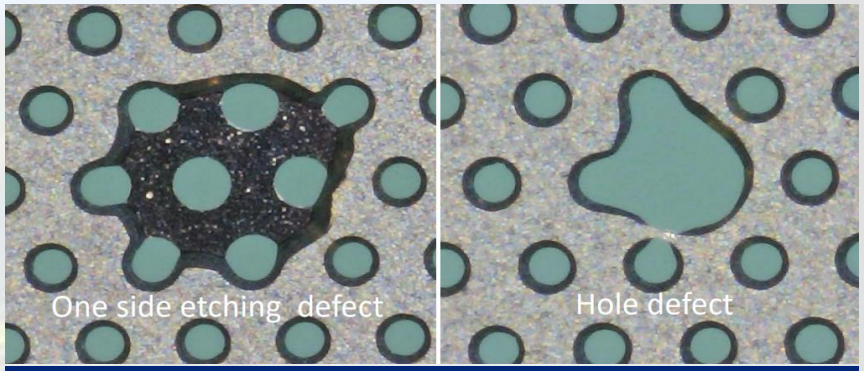
Me with my first ME0 module



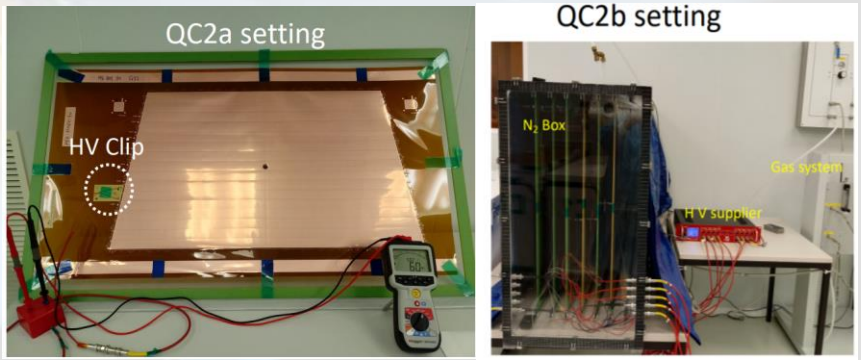
ME0 module is ready. Six ME0 per stack

QC 1 & 2 (GEM foils)

- QC1 sees the GEM foils inspected with an optical microscope.
- Less than 10 holes defect is acceptable
- QC2a checks the number of sparks after inducing 500V with a Giga-Ohm resistance.
- QC2b applies N2 gas until a humidity <7%
- 600V applied for 90min, leakage current <20uA
- 600V applied for 14h, leakage current <2uA, sparks<=3



QC1



QC2a & CQ2b

QC3 I (Module)

- The board is flushed with Ar:CO2 for one hour.
- After an hour, the output gas valve is closed.
- Internal pressure must reach 26.5mBar
- The input gas valve and the flow-meter are closed.

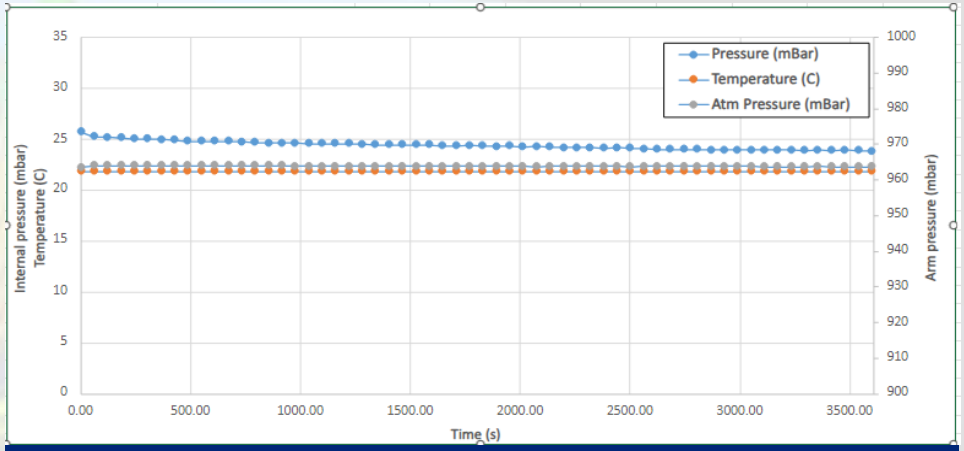
Opening the input and output valves for an hour.

Closing the input valve

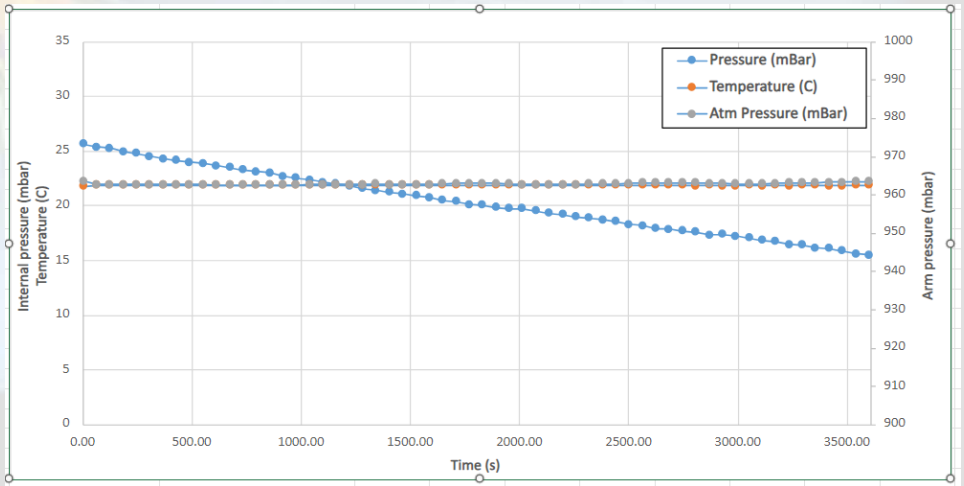
Closing the flow-meter

QC3 II (Module)

- Both tests start at 25.68mBar and end in 15983 seconds.
- The passed test ends at 23.86mBar.
- The failed test ends at -4.31mBar.
- The modules maybe tightened.
- Soap can be used to detect leaks.
- O-ring/External frame examined.



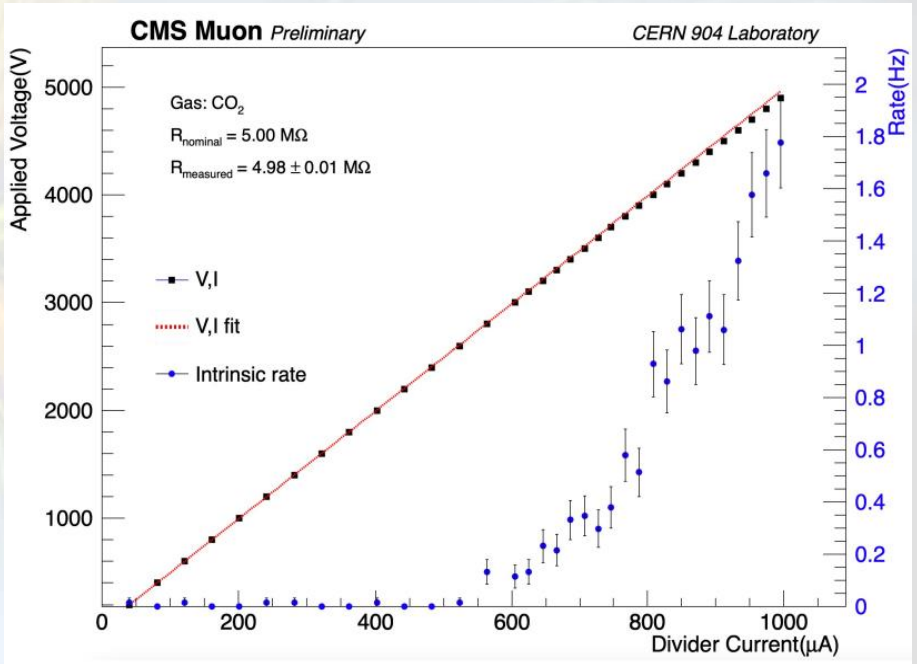
Passed test



Failed test

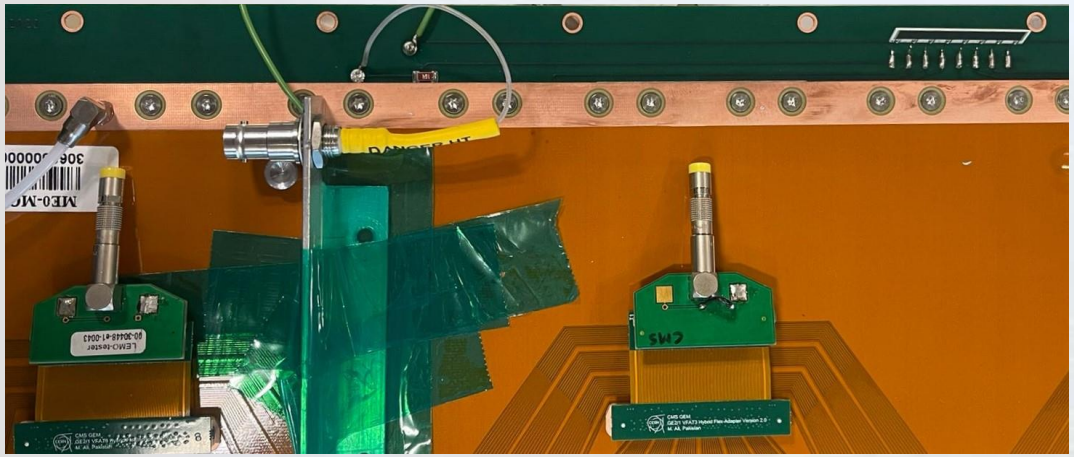
QC4 (Module)

- QC4 measures the linearity of high voltage against the divider current.
- To pass, the divider current increases linearly with high voltage.
- To fail, the divider current doesn't increase linearly.
- Nonlinearity can indicate that the GEM foils are contaminated with foreign impedance.
- Voltage is increased from 200V to 4900V.
- Acceptable intrinsic rate is at 100Hz.

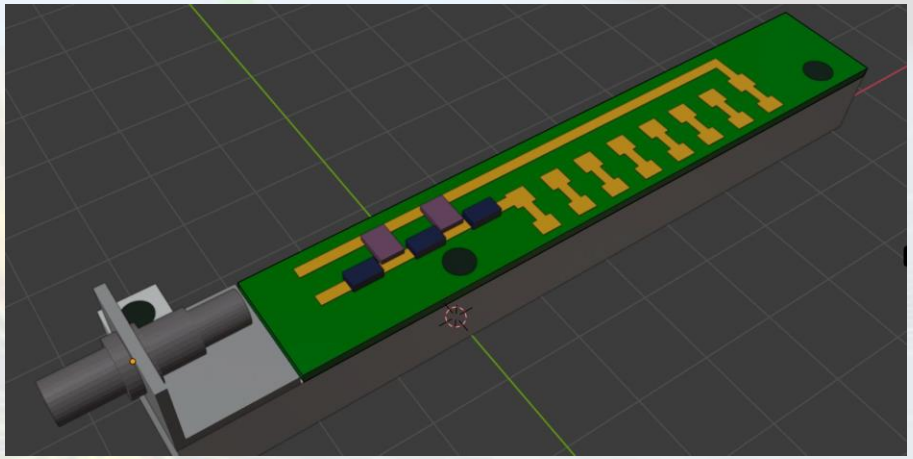


Linear Relationship

Voltage Divider I

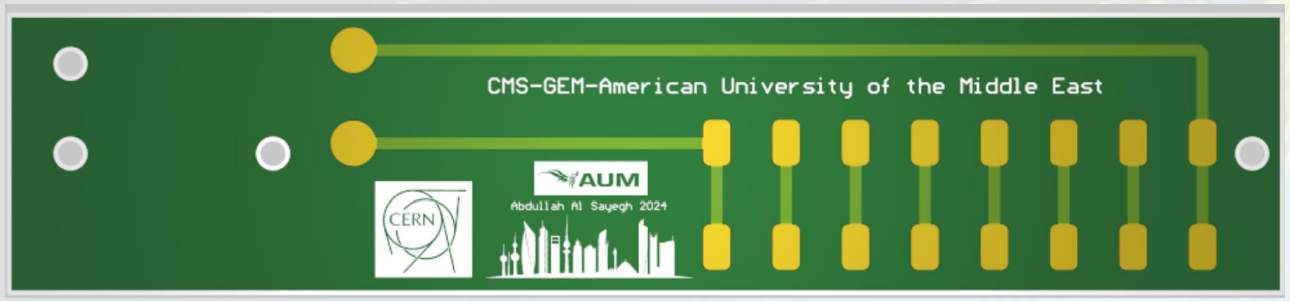


Original Design



Redeveloped Concept

Technical Drawing



PCB Design

Thank You!