RD51 MPGD School
Lab 1: Detector Assembly

Group 4

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RD51 Collaboration Meeting: W8 Training and Dissemination
04th - 08th Dec 2023 @CERN

Daily Laboratory Exercises

Lab 1: Detector Assembly

Lab 2: Detector Operation

Lab 3: Detector Characterization

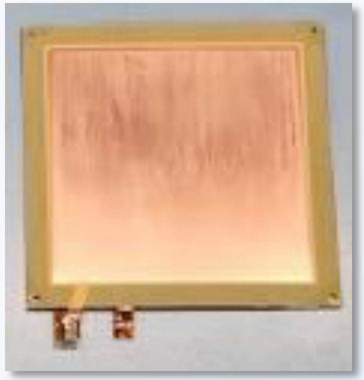
Lab 4: Readout Techniques

Lab 5: Simulation

Aims

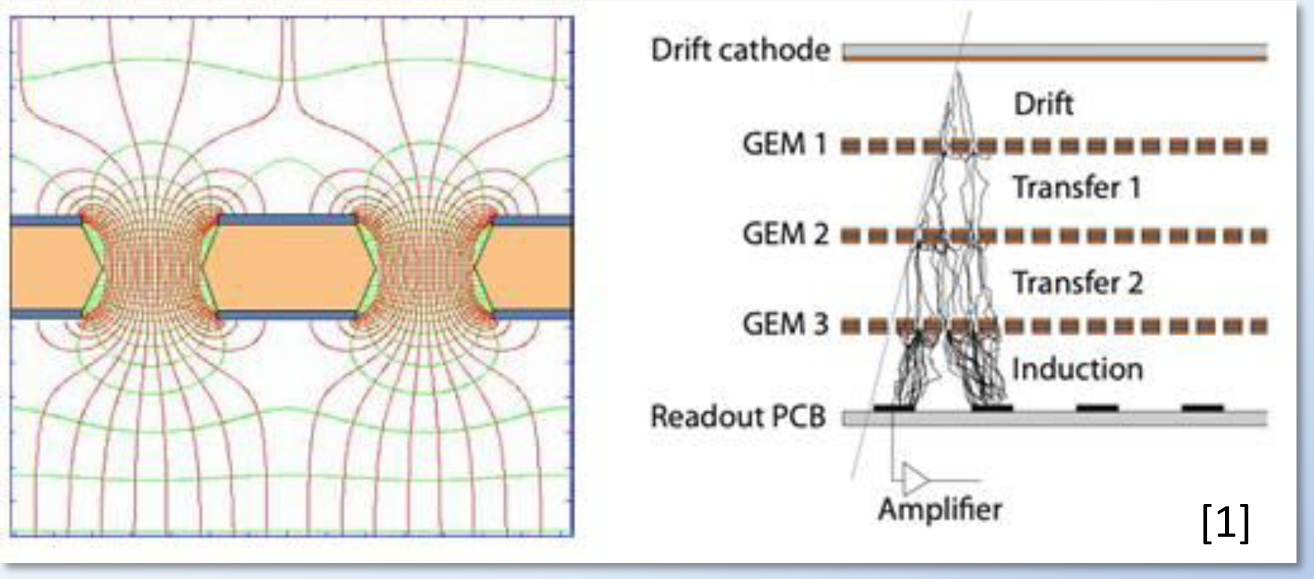
- Familiarisation with cleanroom code of conduct.
- Assembly of triple-GEM structure.
- Quality control measures.
- Functionality testing of structures.

Triple – GEM Detector



Standard GEM foils.
50 µm thick insulating polyimide dielectric.
Clad on both sides with 5 µm copper.
A matrix of holes with high density are etched into the dielectric using photolithography.
Biconical with 50 µm inner diameter /70 µm outer diameter/pitch 140 µm.

A high voltage is applied across copper electrodes to produce regions of high electric field strength where field lines are focused in the holes.



Electrons from primary ionization produced in the drift region undergo multiplication from avalanche processes in the holes, which produces a signal readout from the anode.

Triple GEM structures are used to provide higher overall gain with a reduced probability of discharges, as the multiplication is divided across stages.

[1] F. Sauli, *GEM: A new concept for electron amplification in gas detectors.* NIM A 386 (1997) 531

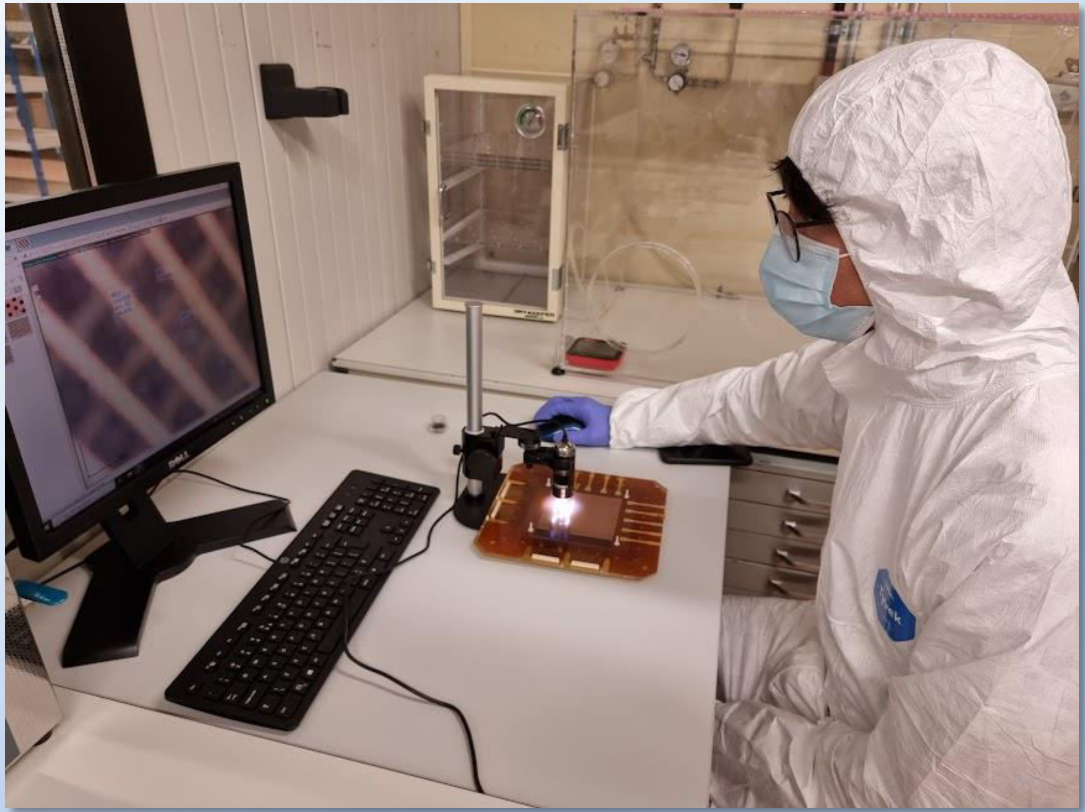
Emphasis on Cleanroom Practices

- Wiping objects with ethanol before introducing them to the cleanroom environment.
- Cleaning detector components in an ultrasonic bath
- Wearing protective clothing including masks, overalls and gloves.
- Using a tacky roller to pick up dust collected on surfaces.
- Viewing MPGD surfaces under a UV lamp to locate contaminants.
- Dislodging contaminants with a nitrogen gun.

These procedures can prevent damage caused by contaminants inside the detector, which necessitate time-consuming repairs!

Quality Checks – Optical Inspection

A microscope was used to measure hole sizes and pitches and search for defects such as over-etching, under-etching, scratches and damage from sparks.

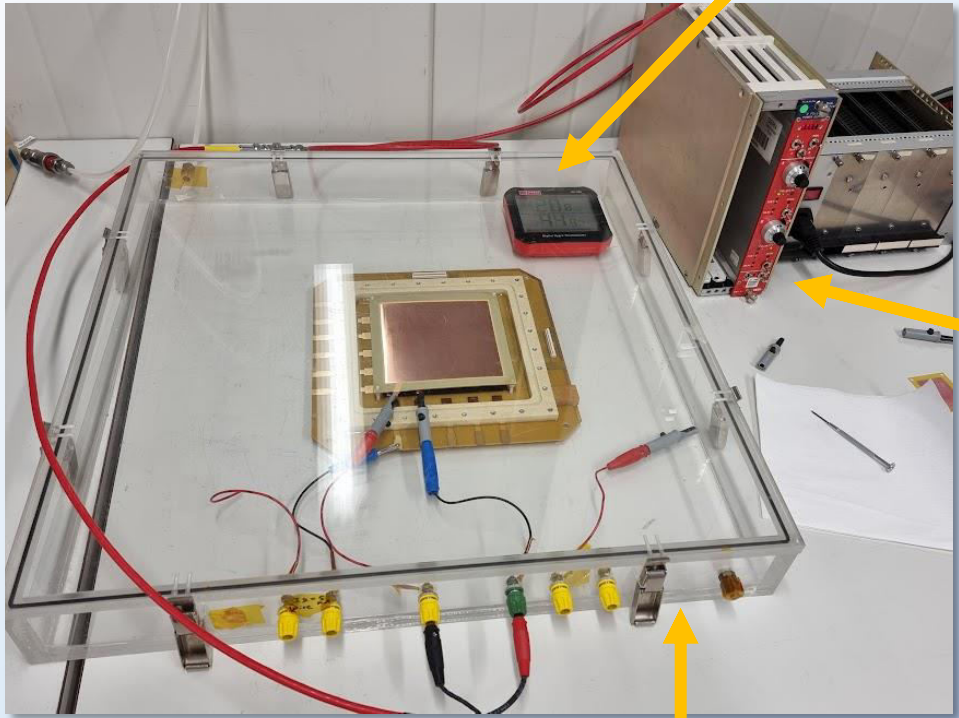


Quality Checks – Leakage Current

Temperature and humidity can be monitored with a sensor in a flow box.

Principle

- The leakage current observed when applying high voltage is determined by the surface conductivity of the dielectric.
- The conductivity depends on the quality of the foil and also it's cleanliness.
- Foil defects and dust particles form an electrical bridge, increasing the current flow through the foil.
- Measuring the current thus provides information on the foil quality and cleanliness.

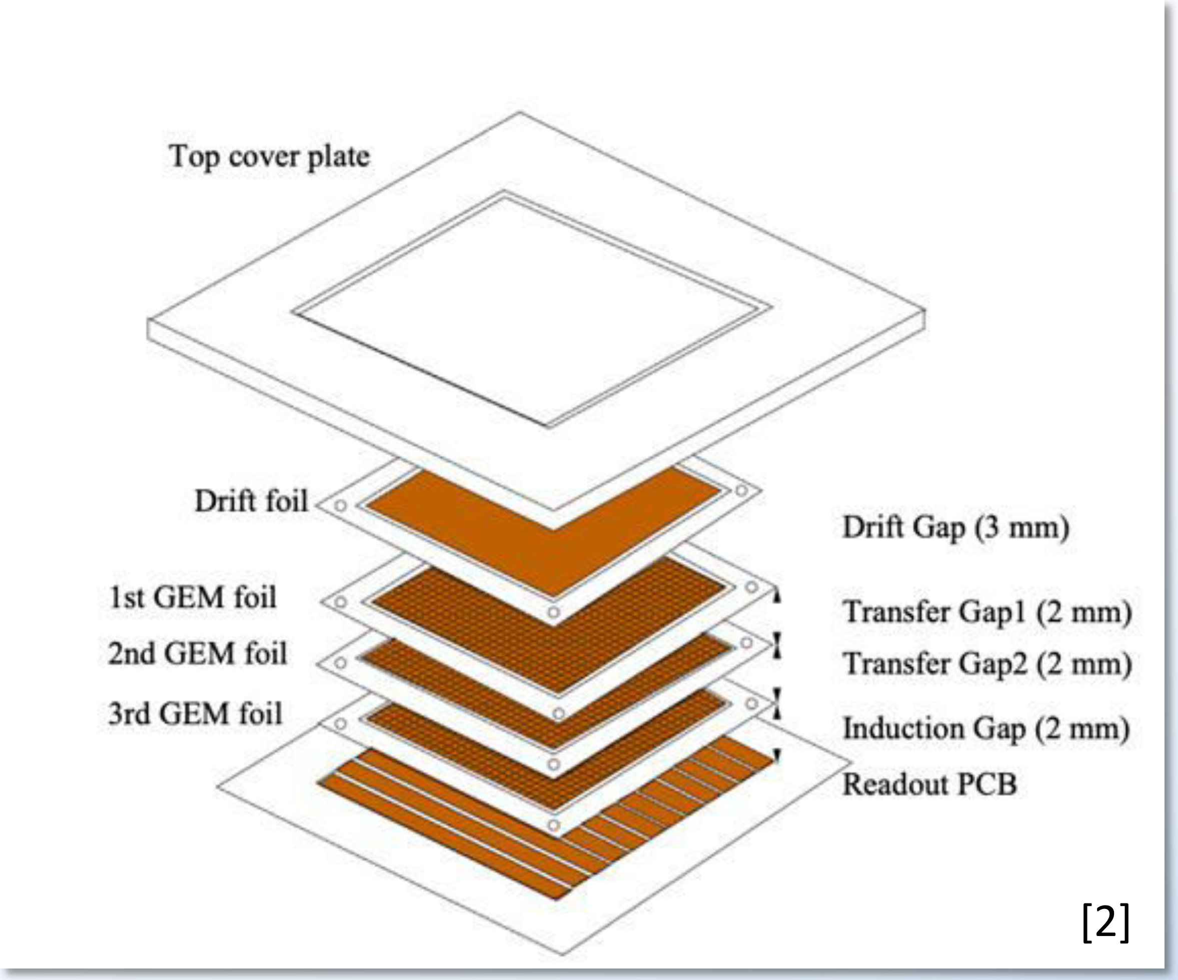


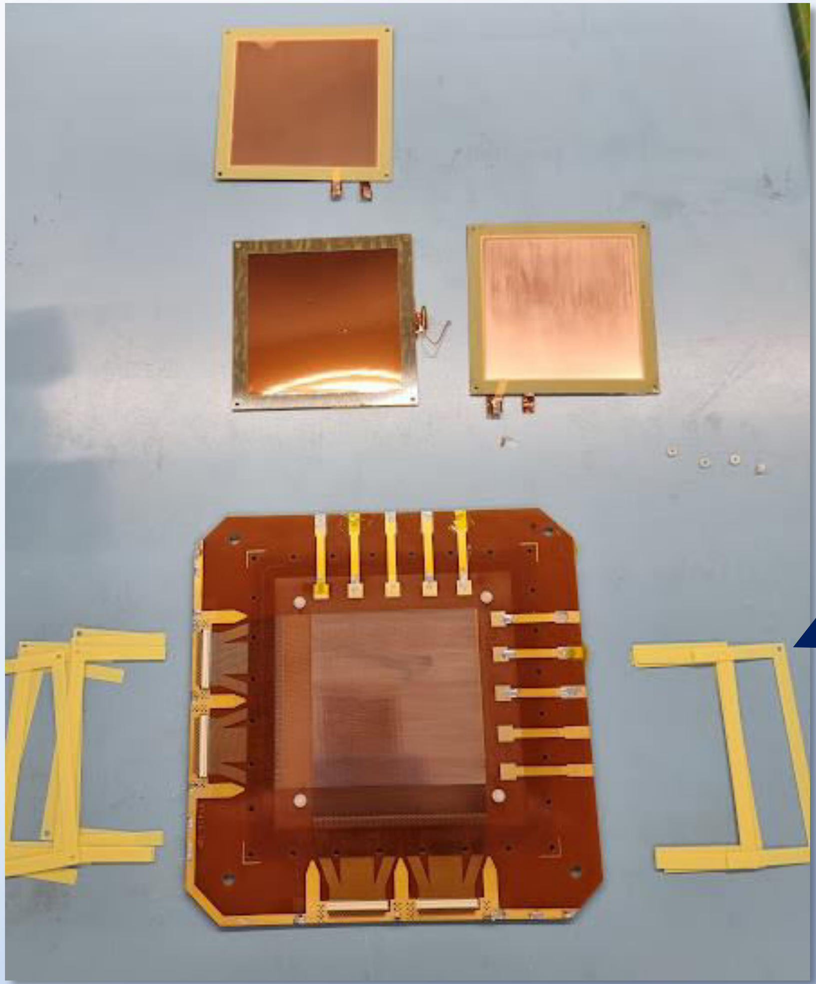
The structures can be tested in a flow box flushed with dry nitrogen, to control humidity.

Conditioning

A CAEN HV power supply is used to directly apply ~550V across the GEM, with ramp-up time of a few seconds. This burns away dust and conditions the GEM.

Assembly of Triple-GEM Structure

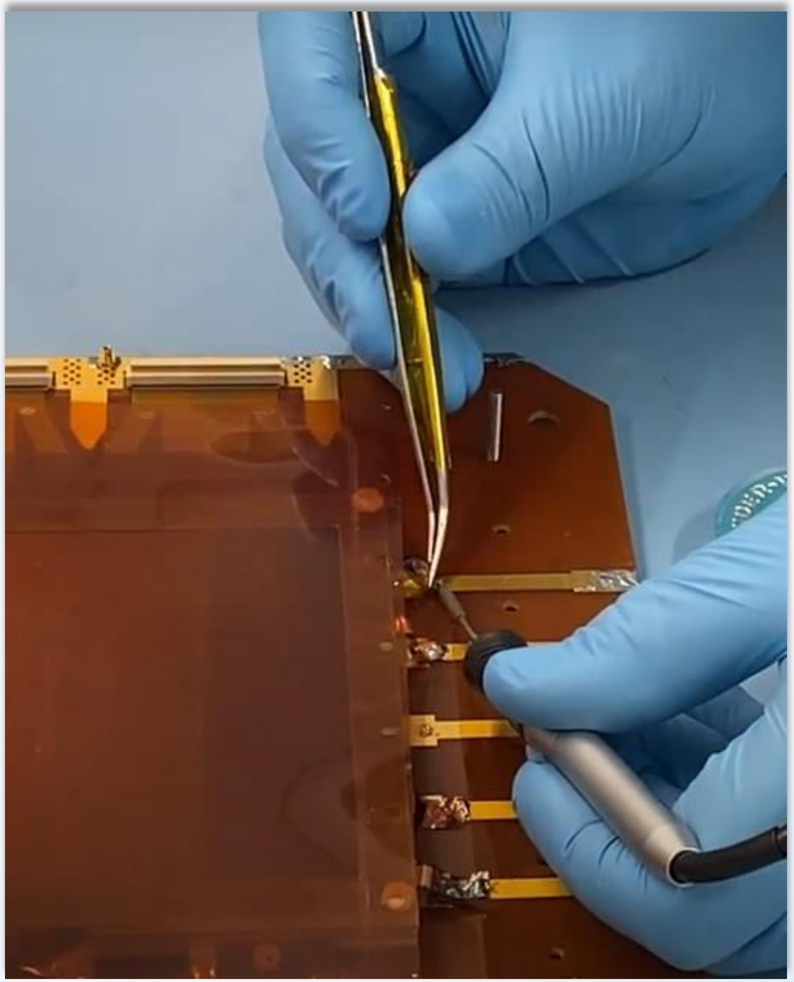




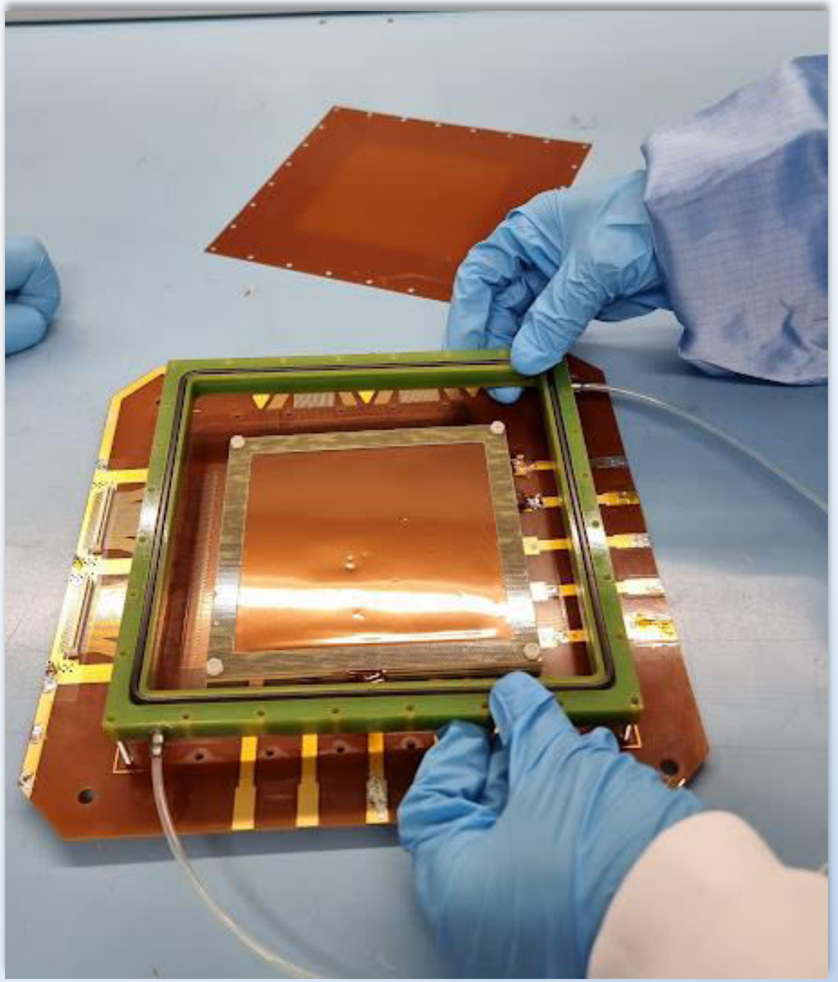
Spacers used to create a transfer gap of 2mm between GEMs.

[2] S. Chatterjee et al., *Study of uniformity of characteristics over the surface for triple GEM detector,* NIM A 862 (2017) 25

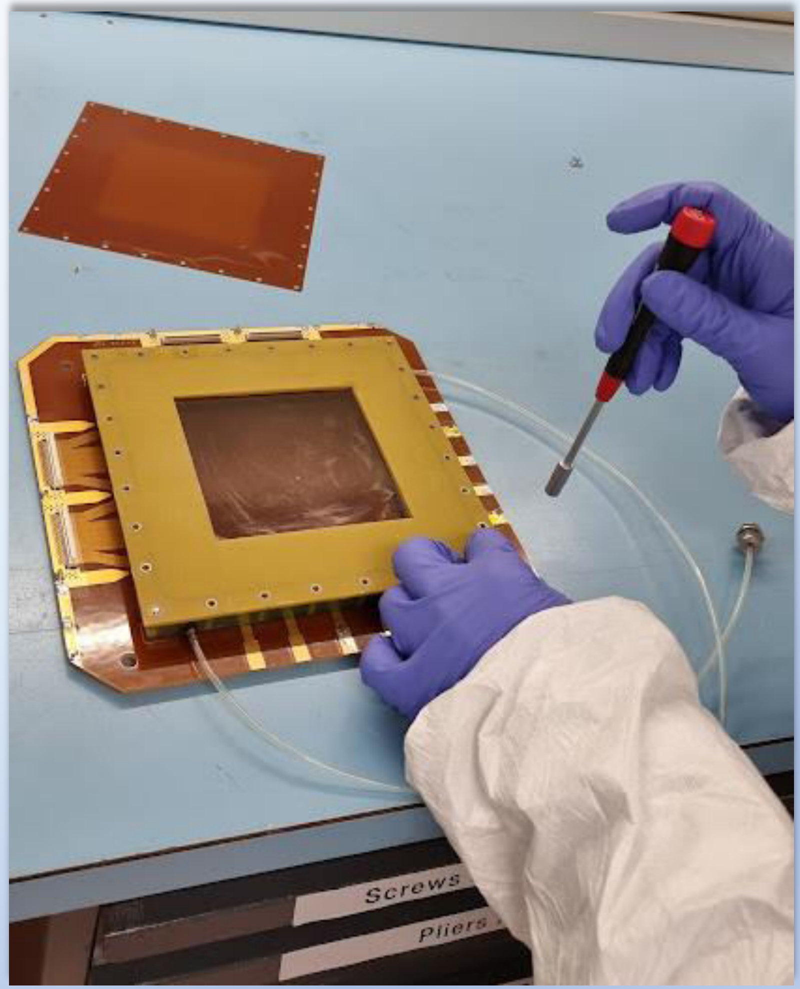
Assembly of Triple-GEM Structure



The GEM surfaces were protected with a Kapton sheet whilst soldering the electrical connections.



A gas-tight structure was created with an O-ring embedded in a frame.



A top cover plate with a Kapton window was used to close the volume.

Summary of Lab 1

- Good practices for cleanroom procedures were discussed.

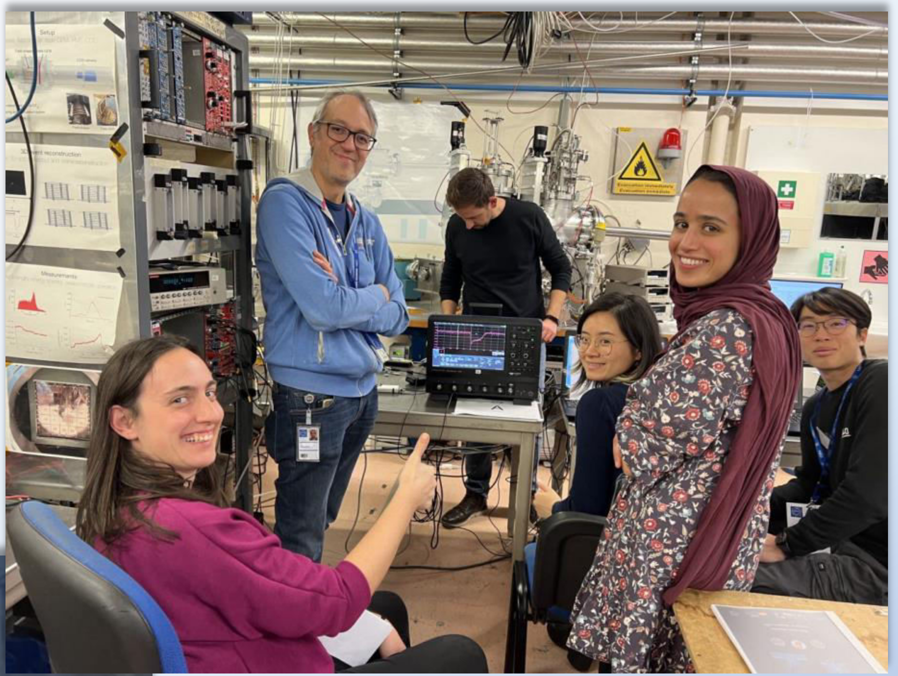
- Quality control was carried out via optical inspection and measurements of leakage current.

- Accepted GEM foils were mounted in a triple-GEM layout.

A final note:

THANK YOU
MPGD School organisers

…and lecturers and tutors!



Group 4 enjoying another lab exercise, operating resistive Micromegas.