Micromegas assembly and operation

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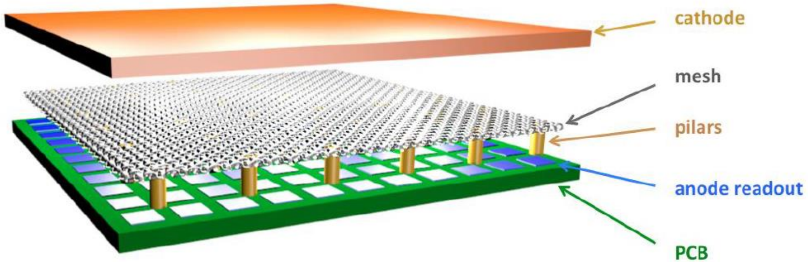
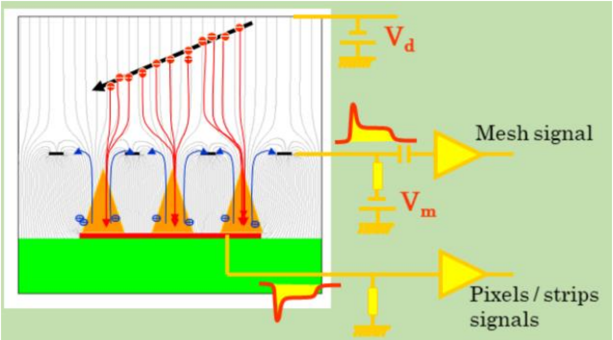
What are micromegas?

- Two-stage parallel-plate avalanche chamber
- Multiplication takes place in **high E field** (~ **40 kV/cm**) between the anode and the mesh
- Thin amplification gap **(50-150 µm)**
- **High gain** (up to **10^5** or more)
- **Single stage** of **amplification**
  - → **Fast signals** (< 1 ns)
  - → **Low ion backflow** to the drift region
  - → **Short recovery time** (~150 ns) → **High rate** capability (>MHz)
  - → **high spatial resolution** (<100 µm) → used for tracking
- **Signal** is **induced by both electron & ion movement** towards the anode / micromesh
- **Resistive layer** to limit damages from discharges



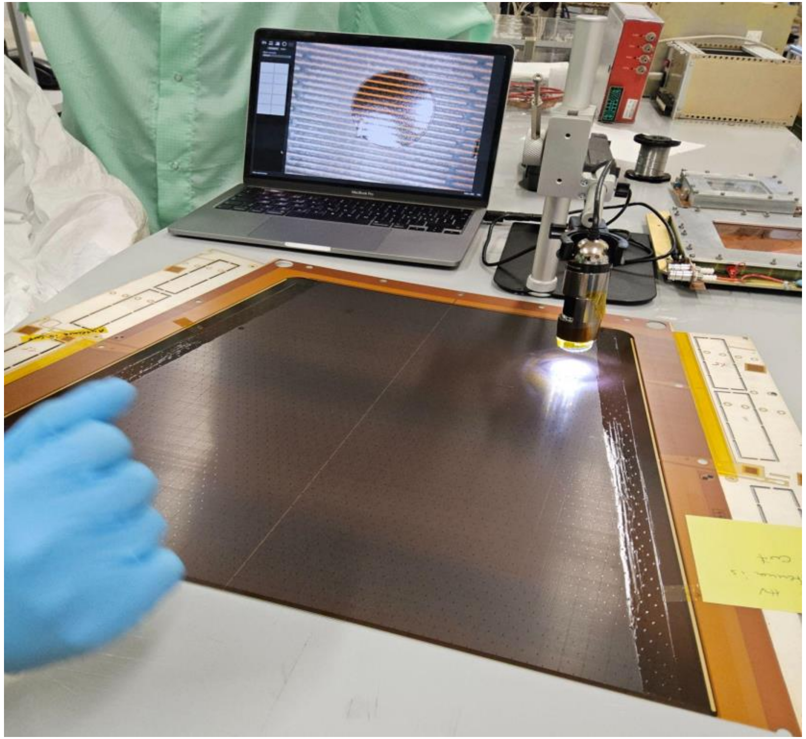


from Esther Ferrer Ribas slides

What are micromegas?

- **Large area** detectors
- Low cost detectors
  - ➞ **large scale** production
- Used in:
  - ALICE muon tracking chambers
  - CMS endcap muon system
  - ATLAS New Small Wheel

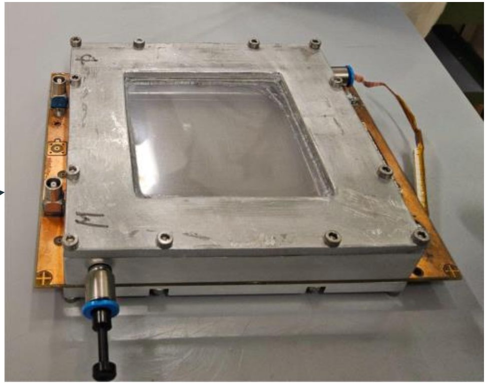
… and in many other experiments

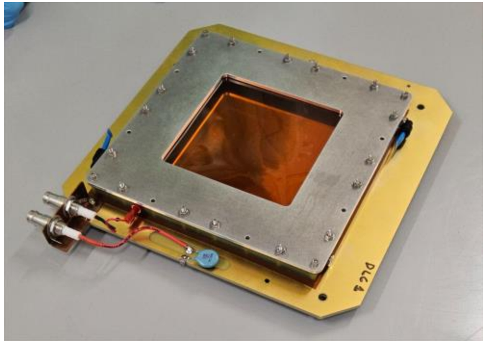


SM1 of the ATLAS NSW, produced in Italy

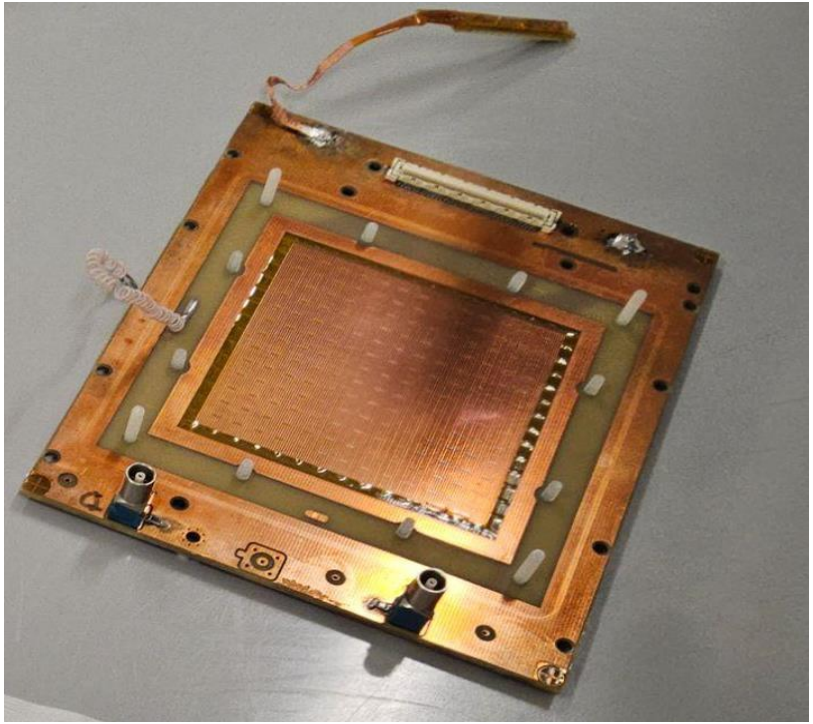
Lab activity outline

1. Two detectors
   a. **Non-resistive** Micromegas with **strip** readout, active area 8x8 cm^2 with 1 mm strip pitch
   b. **Resistive** Micromegas with **pad** readout active area 10x10 cm^2 with pad 1x3 mm^2.
2. **Disassembly & assembly** of both detectors.
3. Non-resistive Micromegas operated in discharge region.
4. Characterization of **Fe-55 energy spectrum.**



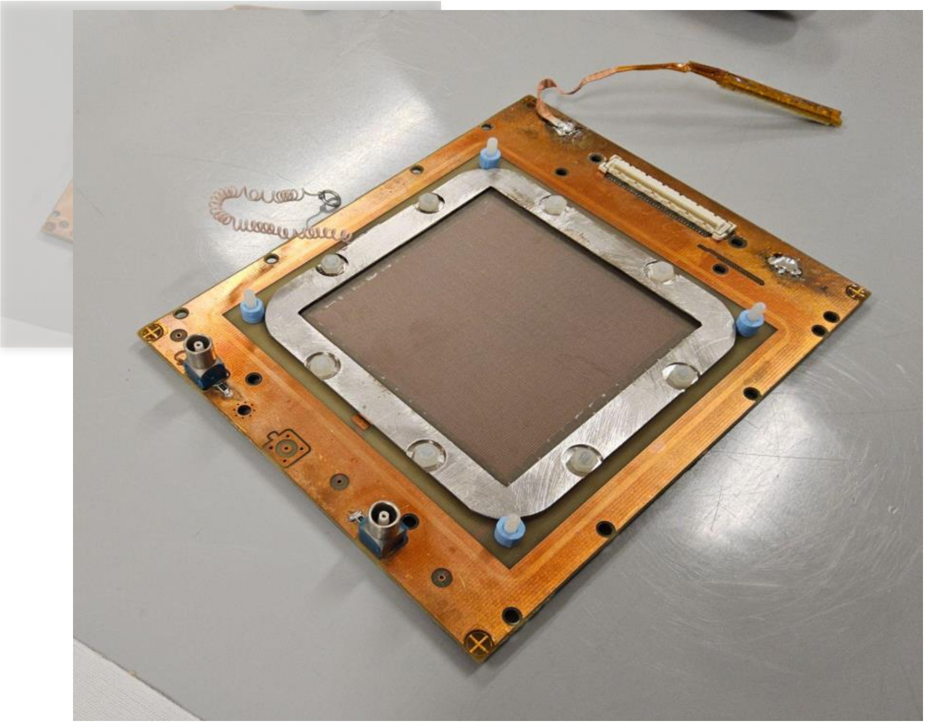


Assembly - Non-resistive Micromegas



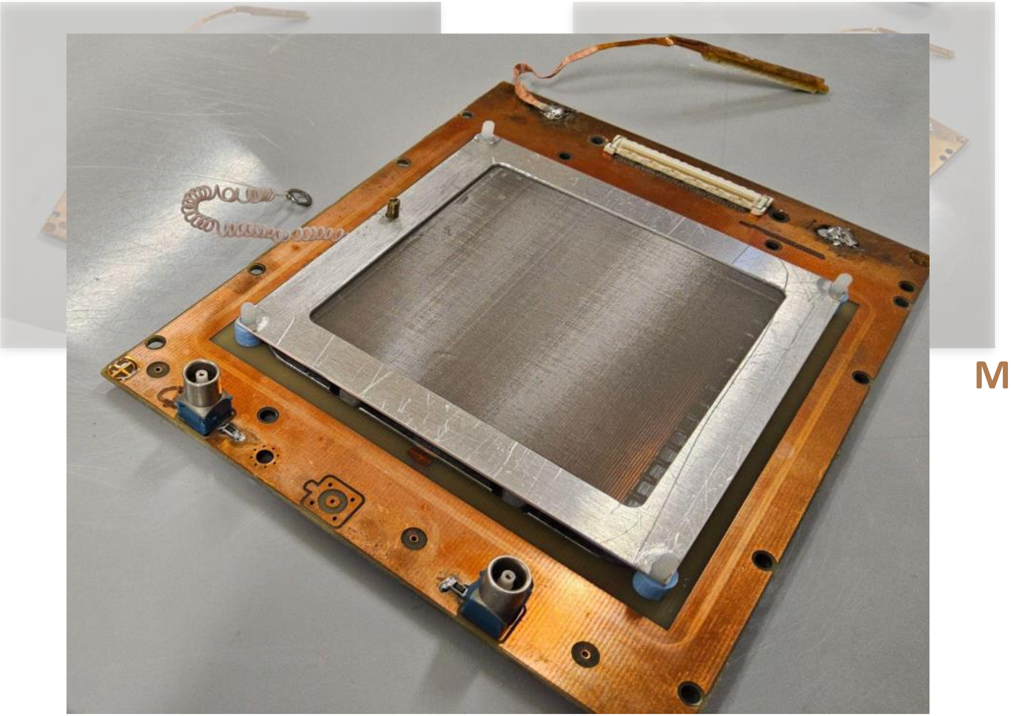
PCB board with strip anode readout

Assembly - Non-resistive Micromegas



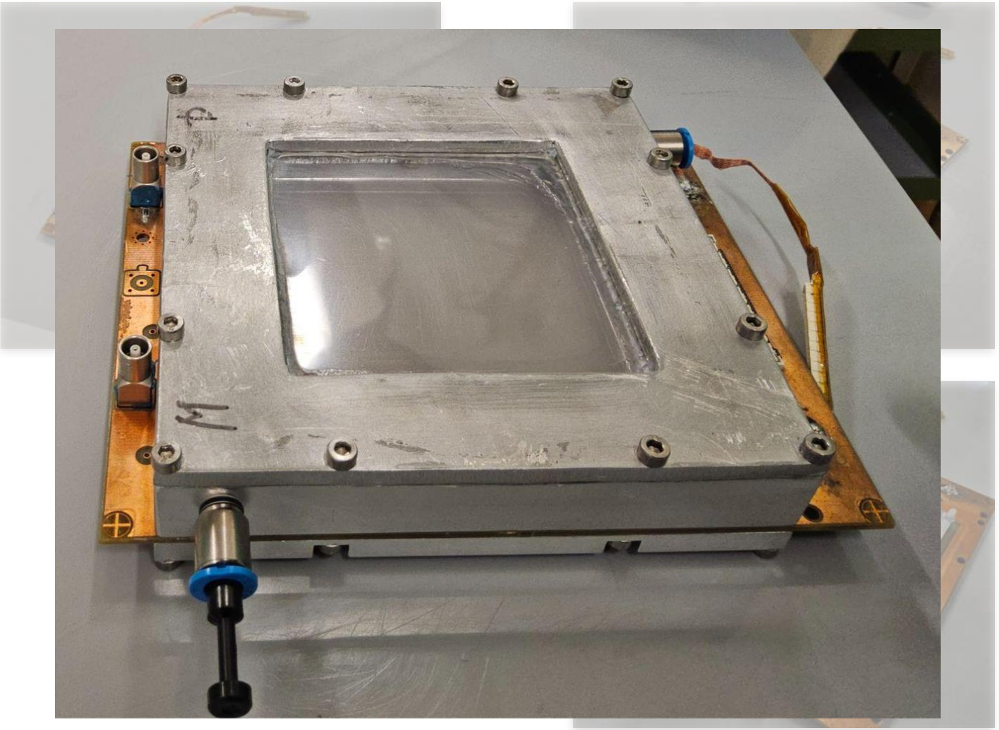
Floating Mesh

Assembly - Non-resistive Micromegas



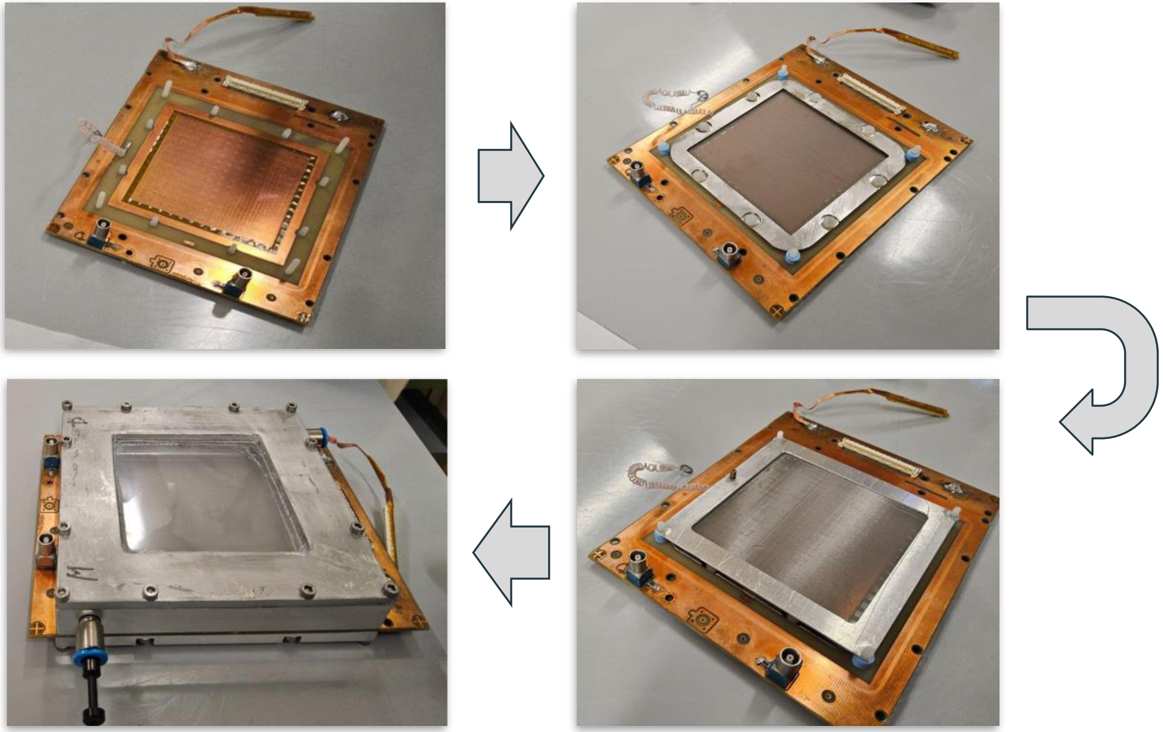
Mesh-like Cathode

Assembly - Non-resistive Micromegas

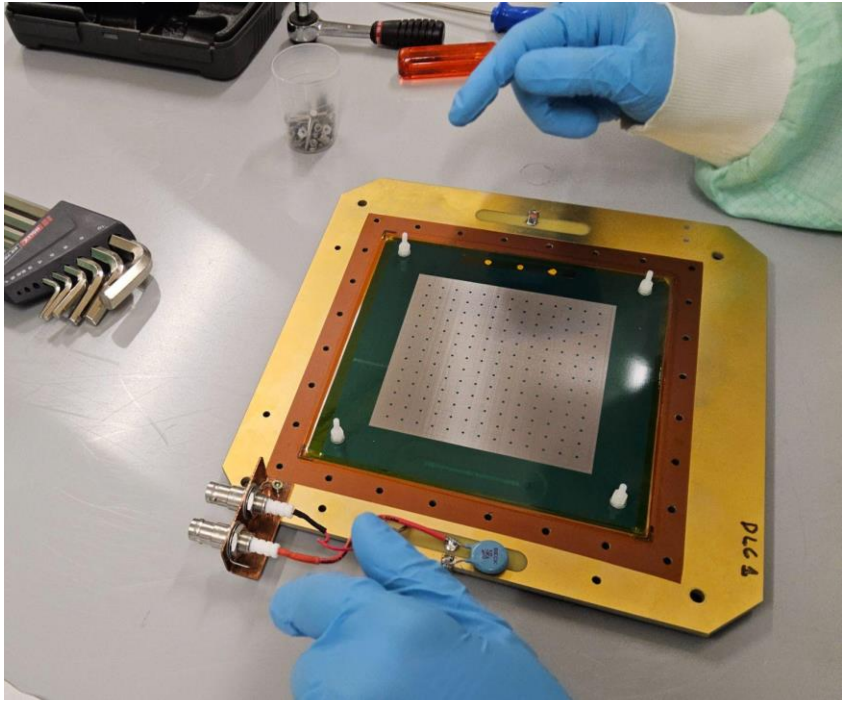


Aluminium frame with plastic window to complete the assembly

Assembly - Non-resistive Micromegas



Assembly - Resistive Micromegas



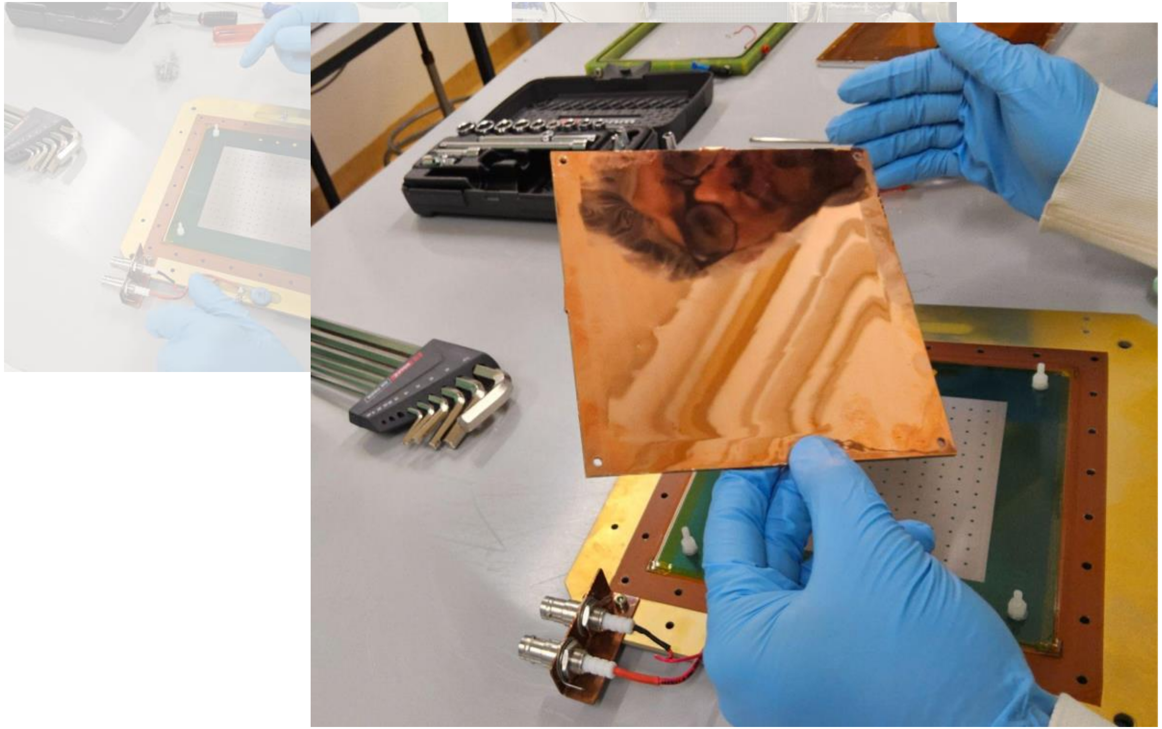
Anode plane with grounded bulk mesh

Assembly - Resistive Micromegas

mesh embedded in the pillar

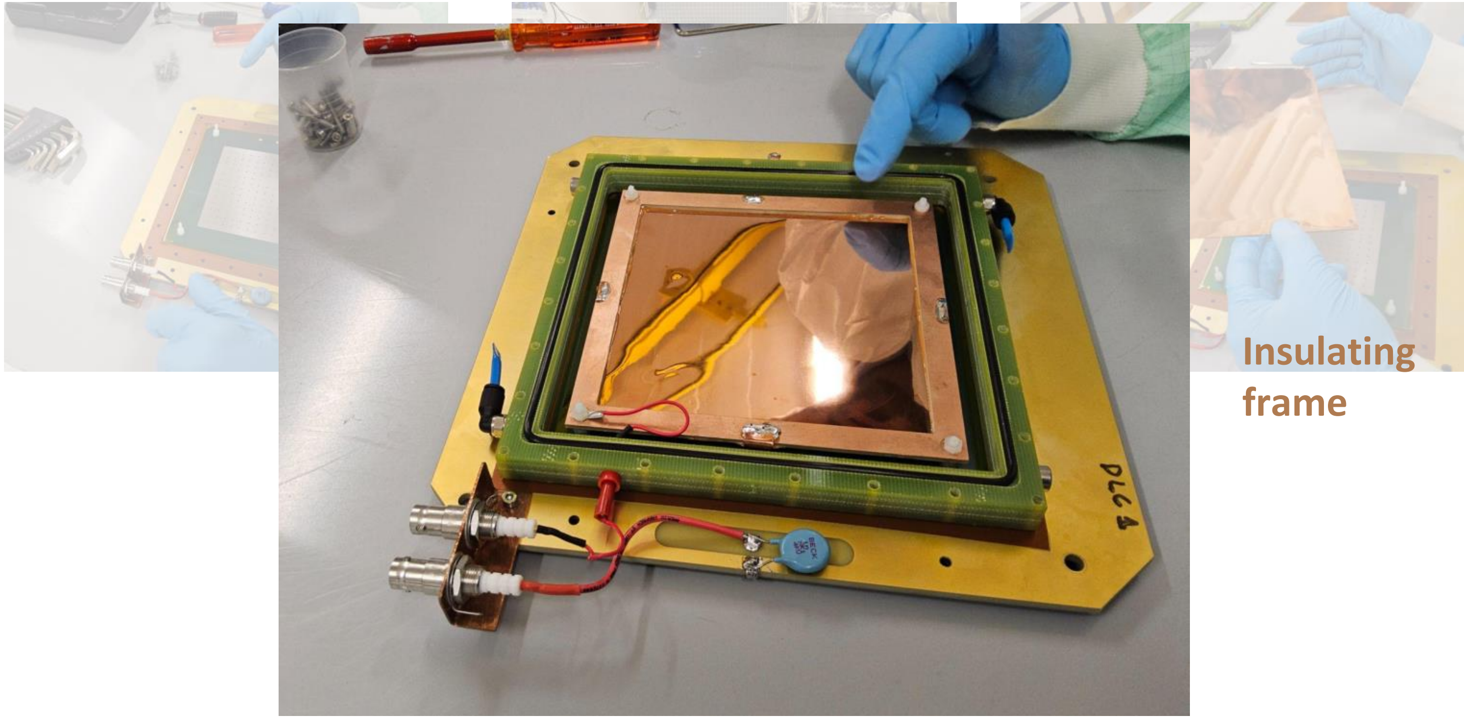
Observation of one pillar with the microscope

Assembly - Resistive Micromegas



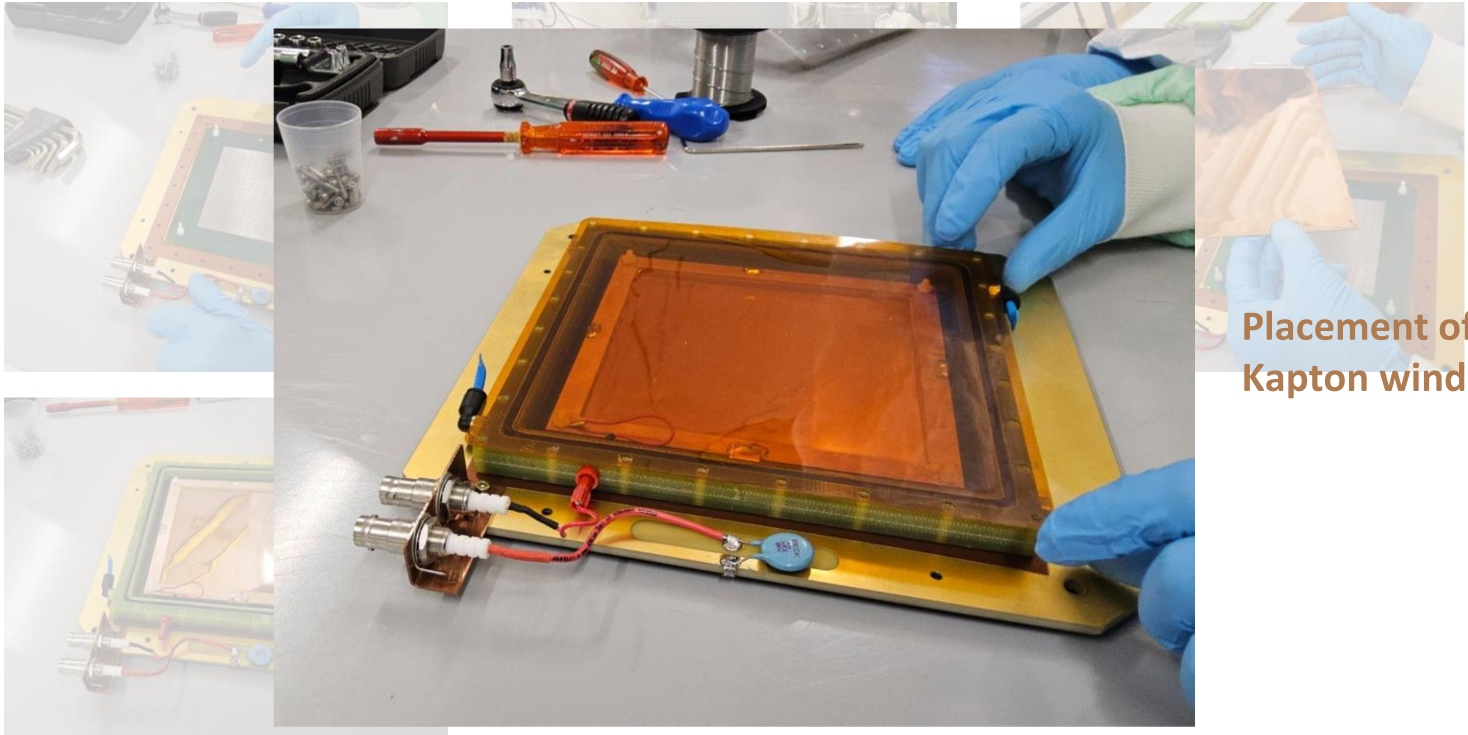
Copper cathode

Assembly - Resistive Micromegas



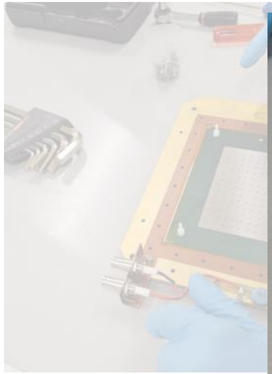
Insulating frame

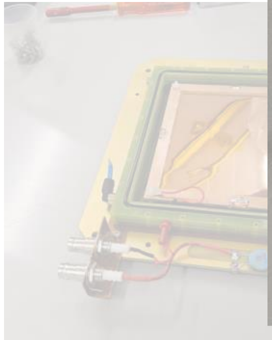
Assembly - Resistive Micromegas

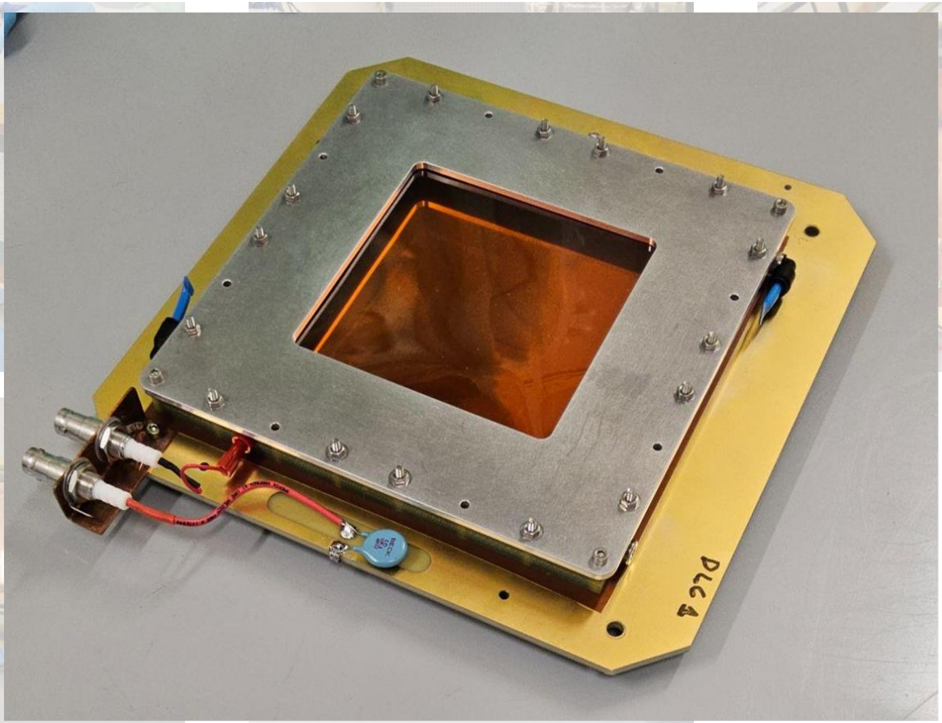


Placement of Kapton window.

Assembly - Resistive Micromegas

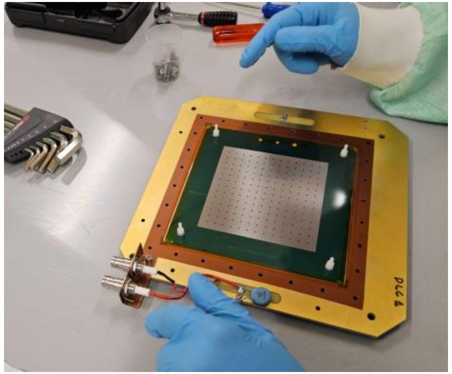


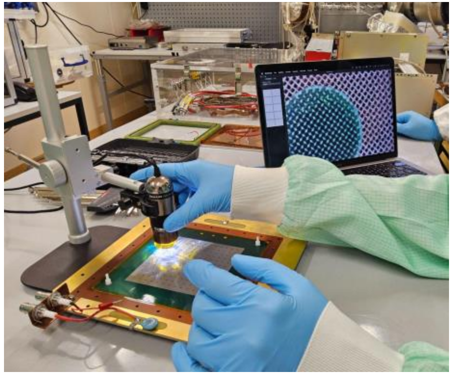


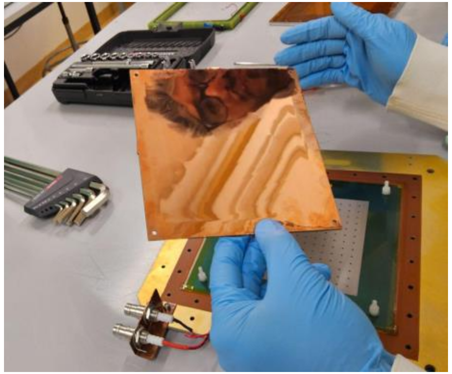


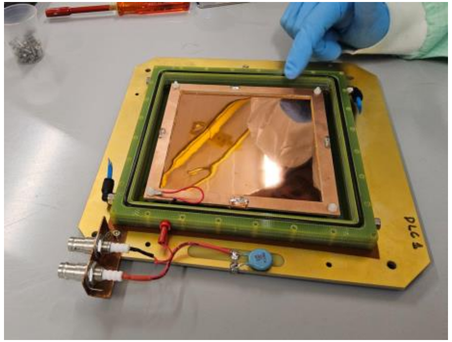
Placement of Aluminium frame on the top to complete the assembly.

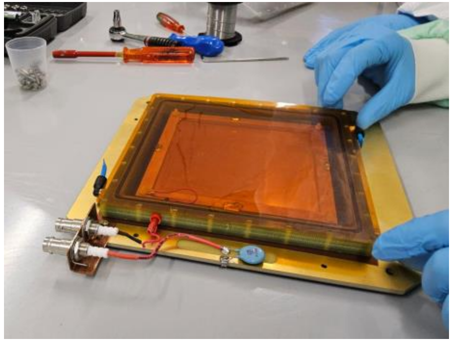
Assembly - Resistive Micromegas

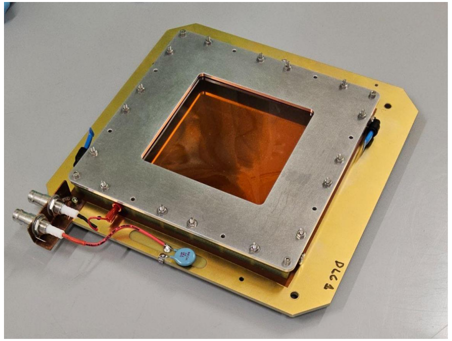












Operation in Discharge Region

- Non-resistive Micromegas tested under extremely high voltages to see discharges

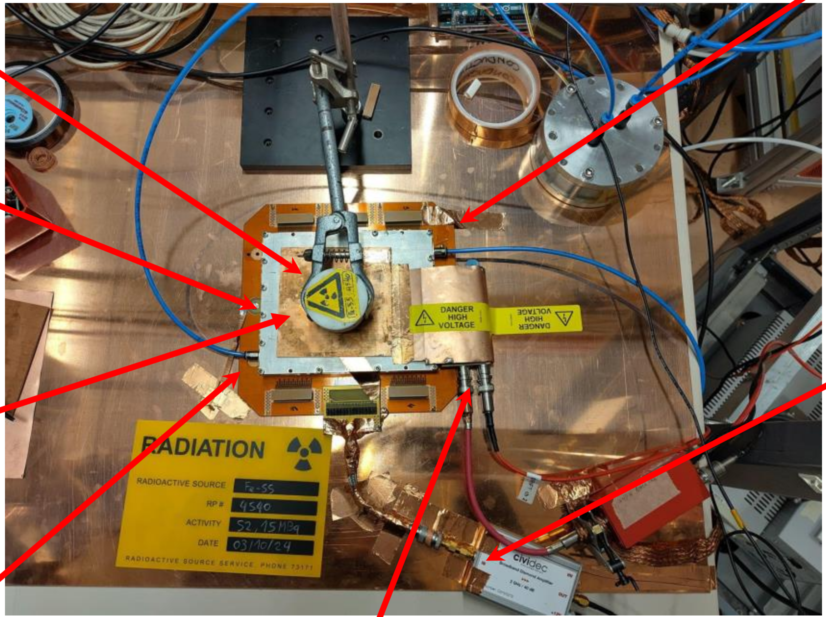
- Discharges can cause damages to the anode layer and can reduce the overall performance of the detector

Operation with Fe-55 source

Fe-55 source

The detector: active area **20x20 cm²**, with readout **pad** size 1x3 mm². **Only 8 pads** were actually connected

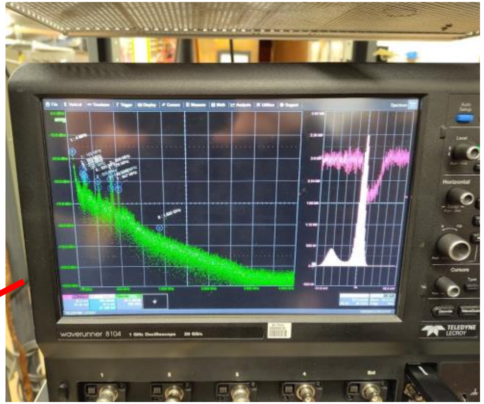
mask



Gas in: Ar:CO_2 (93:7)

Gas out

Amplification voltage 480-500 V
Drift voltage 780-800 V

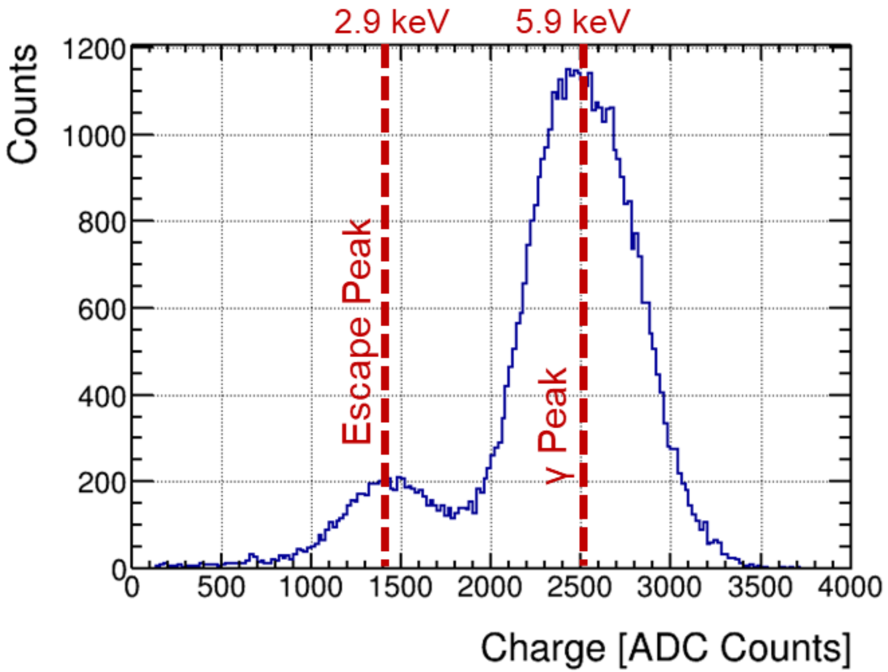


Acquisition of frequency and energy spectrum of Fe-55

Operation with Fe-55 source

- Two peaks:
  - 5.9 keV γ peak of Fe
  - 2.9 keV Argon escape peak
- Energy resolution:

$$\frac{\Delta E}{E} \approx 22\%$$



Conclusions

First of all… **amazing experience!**

- Assembly of Micromegas detectors
- observed the different detector structures like bulk and floating meshes, resistive and non-resistive anode structures, etc.
- Characterisation of the detector using an Fe-55 source was performed.
- Energy resolutions of up to 22% were achieved optimising the rate and the operating voltages

Thank you for the attention!

And many thanks to our tutors!
Chiara Alice & Valerio D’Amico

Backup

Fe-55 decay

55Fe → Mn* + νe
Mn* → Mn + γ

When the photon interacts with the Argon atoms, it can induce the emission of an electron from the shell k by **photoelectric effect**. It is possible that an electron of an outer shell occupies space in the k-shell, releasing photons of X-rays that, in turn, can interact with other electrons of outer shells, emitting them. This phenomenon is known as **Auger electron emission** occurs in **85% of cases.**