Robustness test of a Micromegas detector with resistive DLC anode

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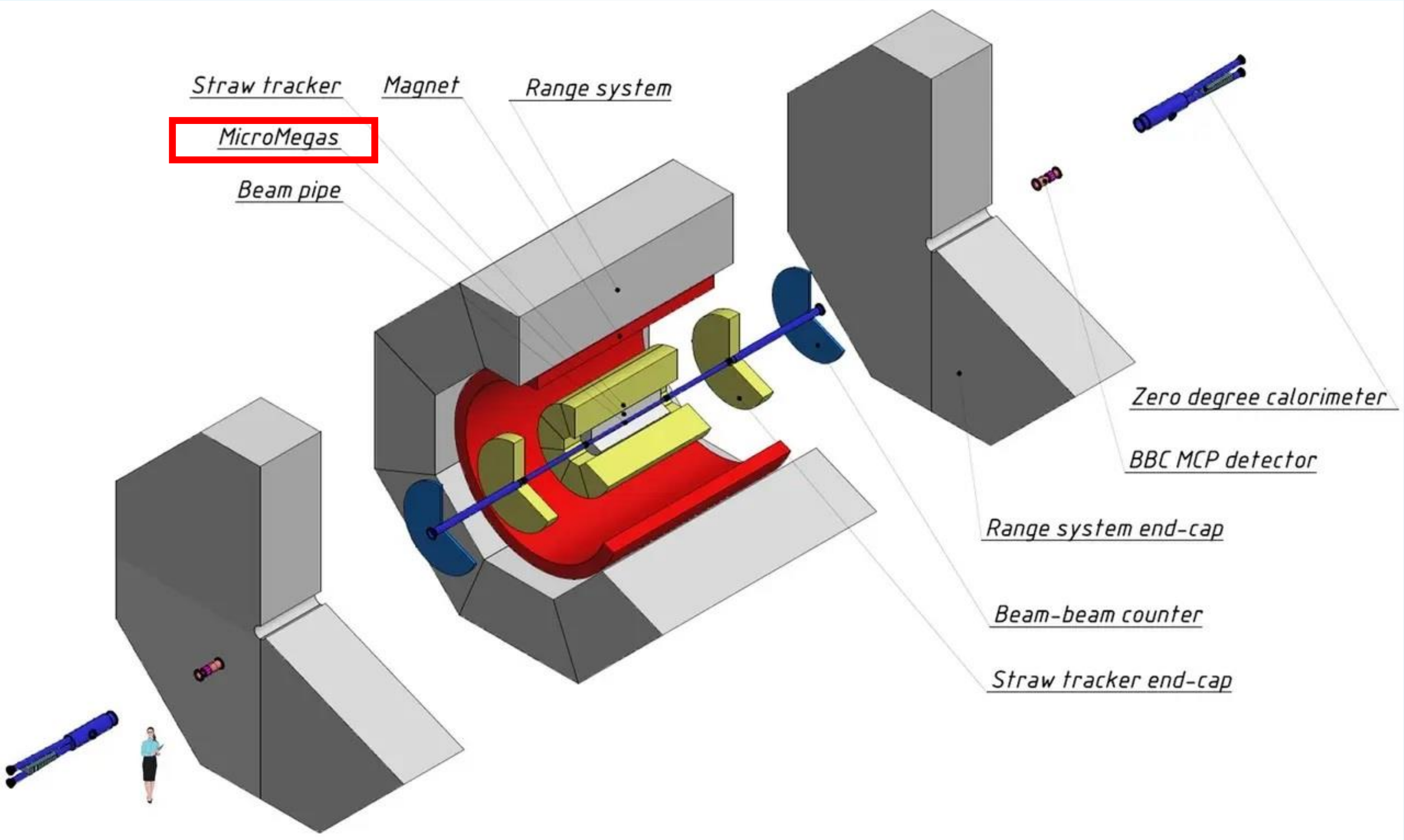
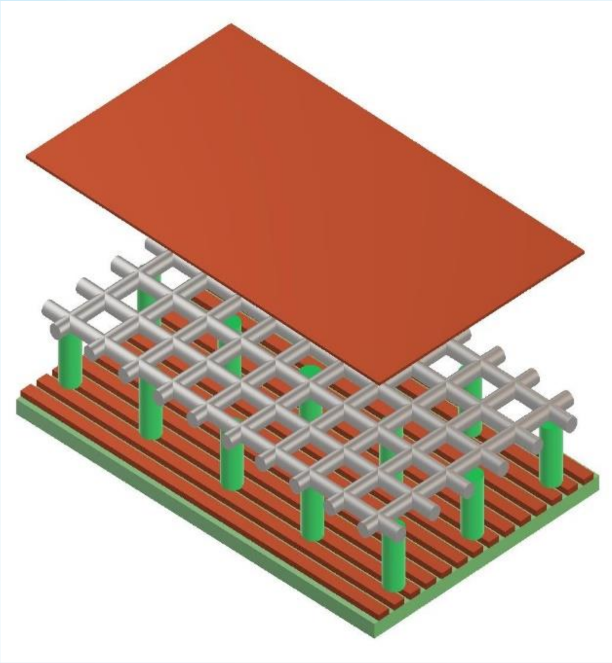
Experimental setup of SPD: Phase 1

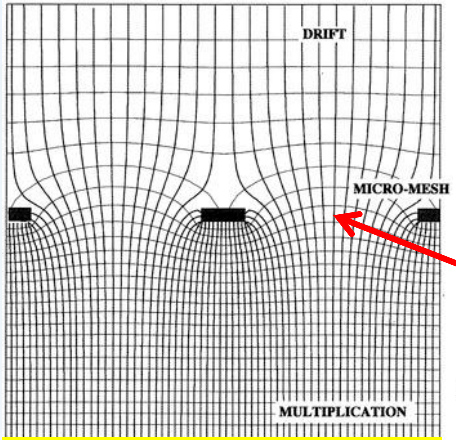


Micromegas Central Tracker (MCT) is a simple and low cost detector designed to improve impulse resolution and track finding efficiency in the early years of SPD operation.

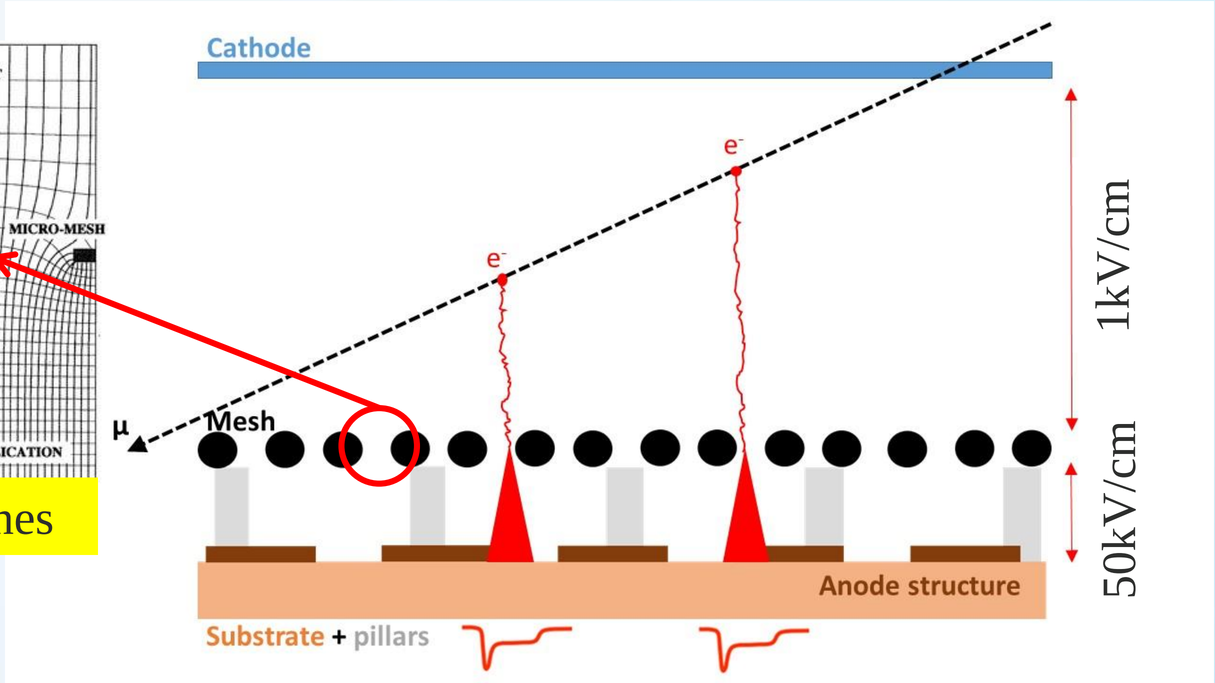
Micro Mesh Gaseous Structure

Micromegas is a flat counter with dedicated ionization and amplification gaps separated by a thin mesh. The detector consists of a cathode, mesh and anode. The anode is usually segmented.





Electric field lines

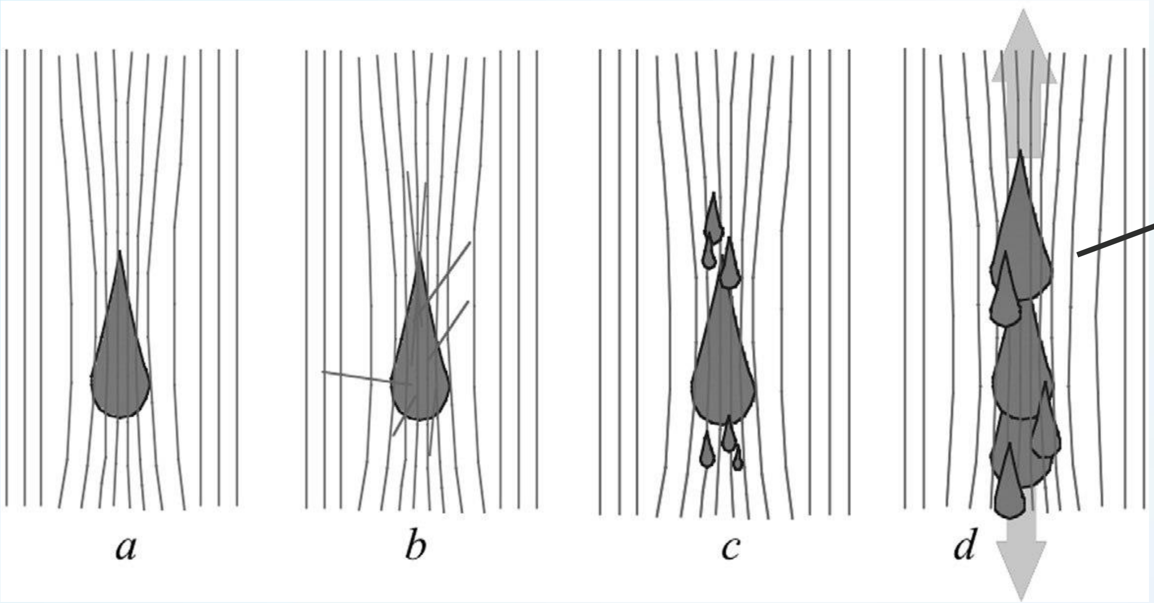


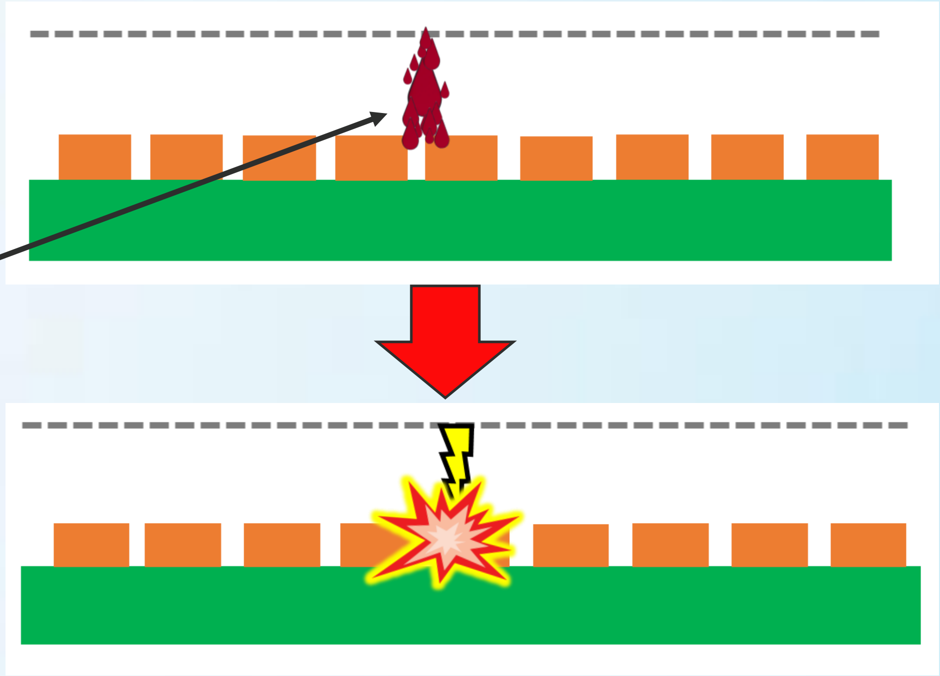
Advantages:
High loading capacity (10 MHz/cm^2)
Good dual-track resolution (on the order of 1 mm)
Coordinate resolution 100-150 μm

- Ionization gap: 3-5 mm (Electric field 1kV/cm)
- Amplification gap: ~120 μm (Electric field ~50kV/cm)

Discharge protection in the micromegas detector

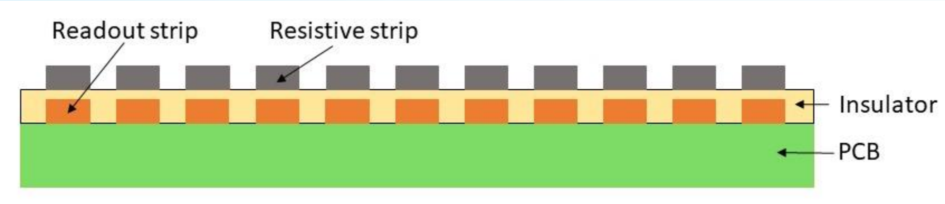
Avalanche evolution in the detector



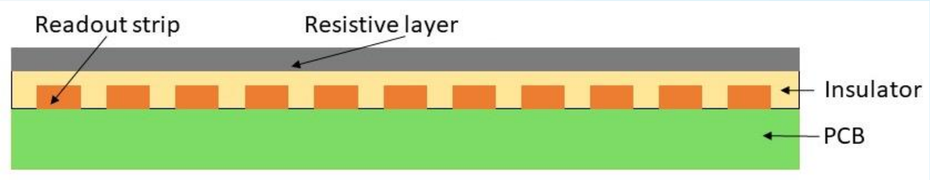


- In parallel plate detectors, an avalanche becomes a discharge if its charge exceeds the Raether limit of ~ 10^8 electrons.
- In Micromegas detectors, discharge is possible when strongly ionizing particles (e.g., slow protons) pass through them.
- In hadron collider environments such as the NICA the operation of classical MM detectors is not possible.
- To minimize the effect of discharge, detectors with resistive anode are used.

Resistive coating methods



On top of each reading strip, a resistive strip is applied to the insulator.



The resistive layer is applied to the entire surface.

Screen printing method

Pros: Cheaper for mass production.
Allows large detectors to be manufactured.

Cons: Surface irregularity.
(Height variation of resistive strips 15-20μm)

Experiments: ATLAS, CLAS12

Magnetron sputtering method

Pros: Smoother and more stable DLC (Dimond-Like Carbon) type coating quality

Cons: Cost and impossibility to make large area detectors (in our case leveled by the size of the detector).

Experiments: T2K

To be used in SPD.
DLC is applied at the Physical-Technical Institute of the National Academy of Sciences of Belarus.

Motivation for DLC degradation research

- Micromegas are prone to discharges when strongly ionizing particles pass through them.
  Under SPD operating conditions such events are typical (e.g., slow protons)

- The thickness of the DLC layer is 100 nm. It is sensitive to damage both mechanical during MM production and from discharges.

- The DLC coating is very recent and has never been used in a proton booster environment.

Methodology of DLC degradation research

It is necessary to make the detector work in a mode where almost continuous discharge is induced.
How to make it work? Expose our detector to α-particles, as they cause strong ionization.

Before α-particles exposure

Dial the control spectrum of ^{55}Fe

Resistance control during statistical acquisition

Set of statistics for α source exposure

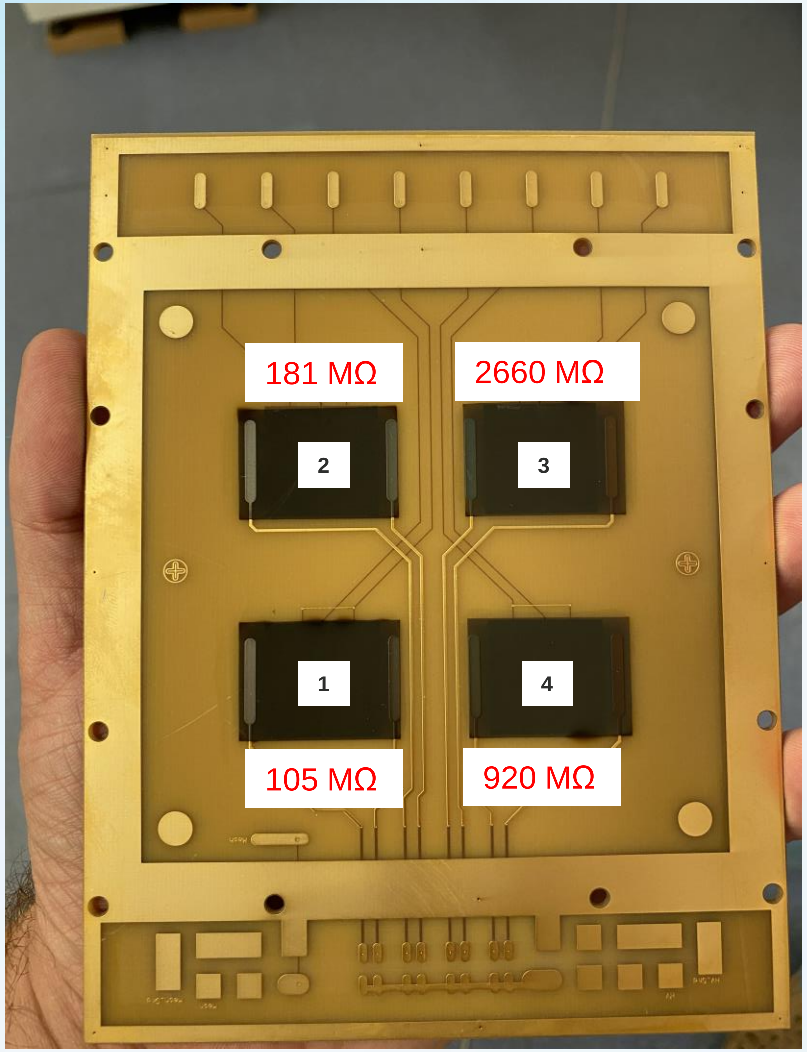
After exposure

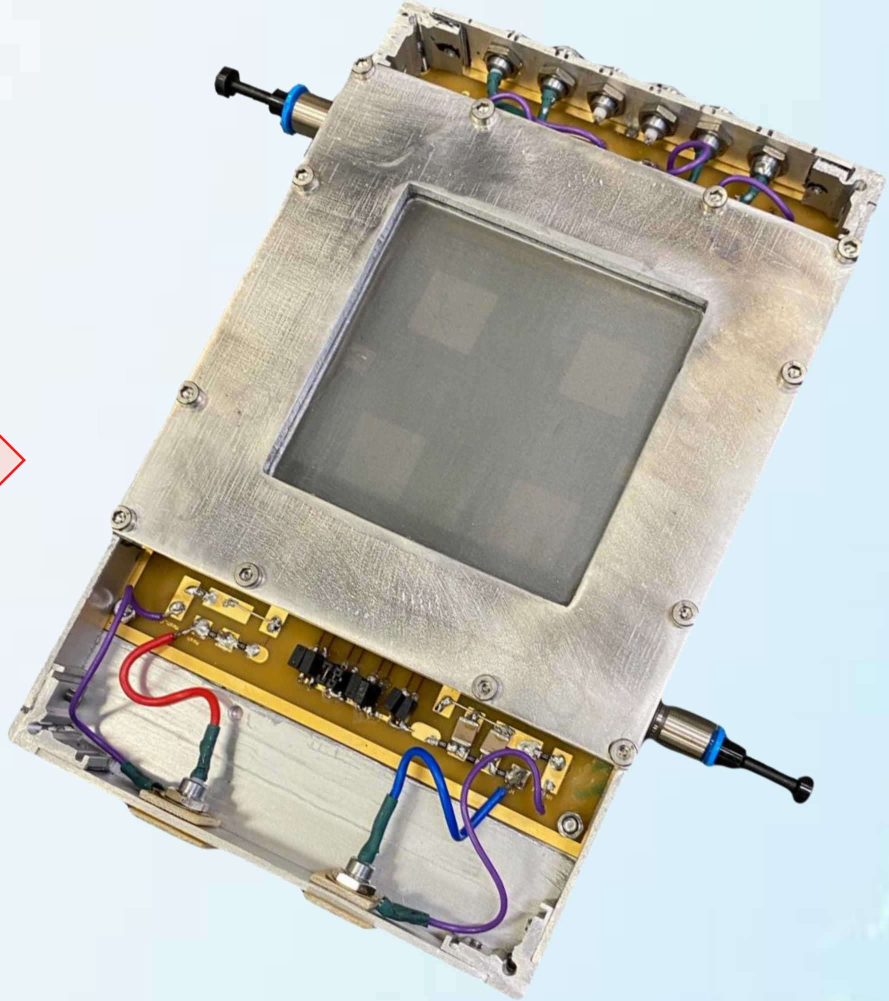
Dial the control spectrum of ^{55}Fe

How can degradation be manifested?

- ❑ Increase in coating resistance;
- ❑ Deterioration of energy resolution;
- ❑ Significant change in amplitude.

A prototype for a DLC degradation study

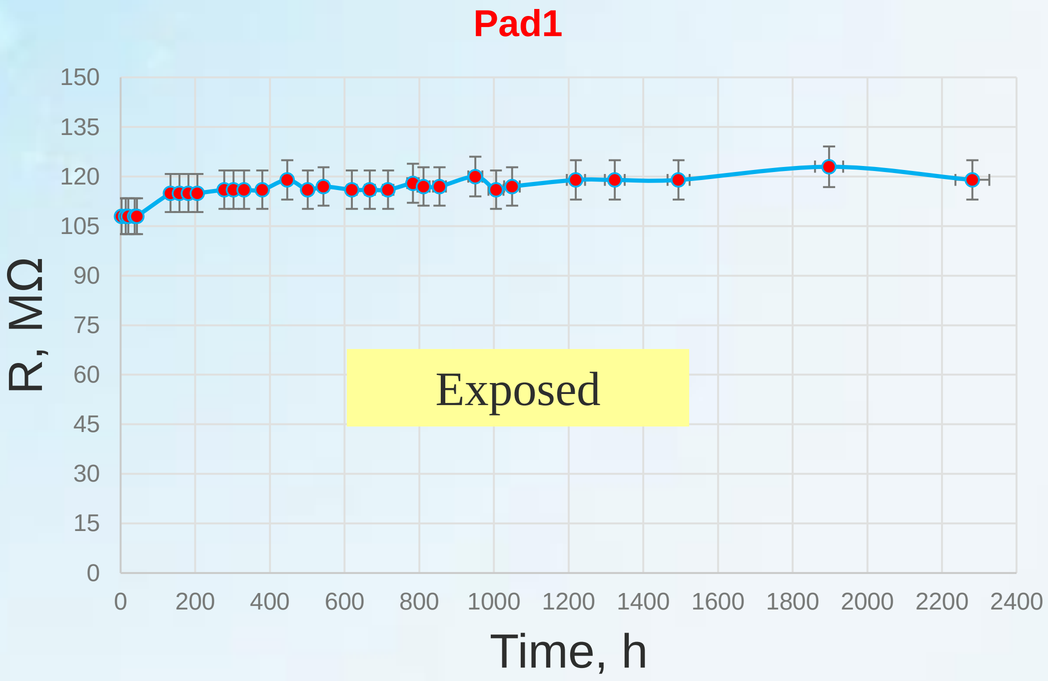


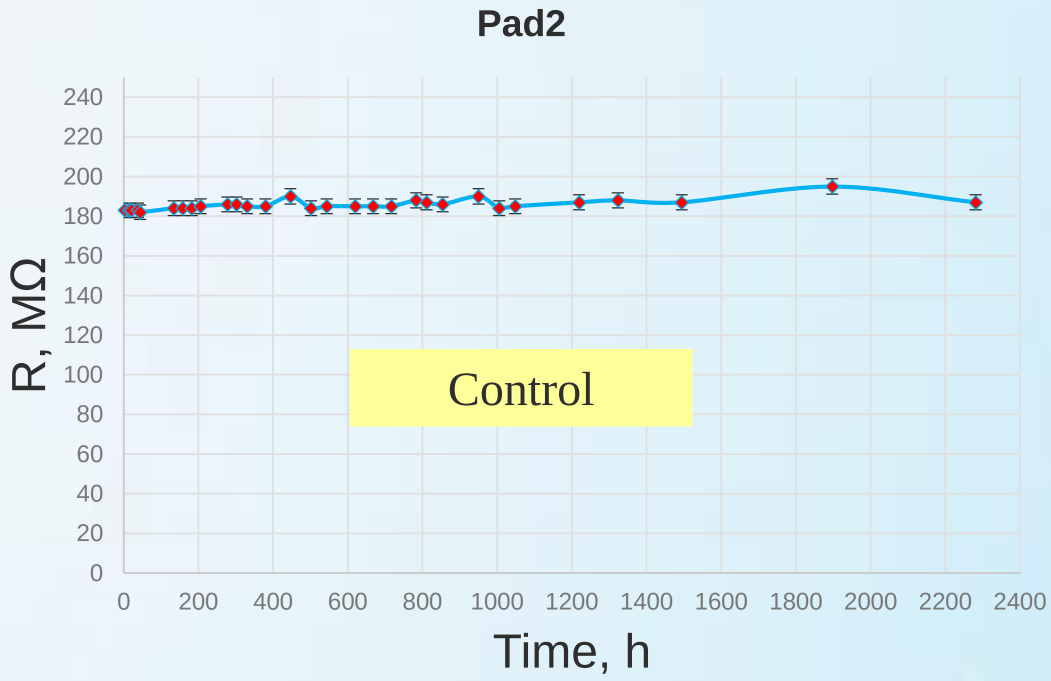


A prototype has been created with 4 working pads (1,5x1,5 cm^2) that are coated with DLC with different resistances. Pads 1 and 4 were exposed with α-source (^{238}Pu and ^{239}Pu), while 2 and 3 remained as control pads.

Set of statistics of resistance change under α - radiation

<u>Surface resistance of DLC coating</u>

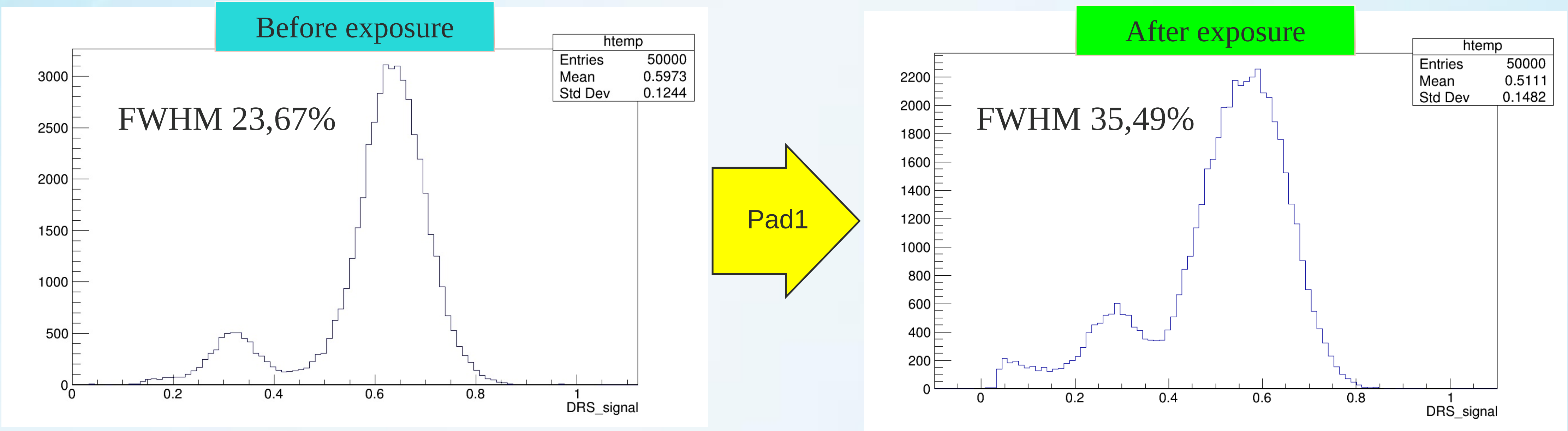




No significant signs of degradation observed

Total number of discharges ~ 9×10^8, which is equivalent $7\ Hz/cm^2$ over two years of detector operation.
In this case, according to the results of modeling in SPD for two years, the frequency of events in $1\ Hz/cm^2$ is expected

Control spectrum from ^{55}Fe



No significant signs of degradation observed

Therefore, we conclude that the DLC technology satisfies our requirements.

Conclusion and future plans

During reliability testing of the Micromegas detector with resistive DLC anode for the SPD project:

- A special prototype Micromegas detector was designed and fabricated for the study of DLC-type resistive layers.
- Resistance tests of DLC-type resistive layer have been conducted.

❖ Creation of a cylindrical prototype with strips and DLC-type resistive layer and testing it.

Thank you for your attention!