Small-pad resistive Micromegas for operation at very high rates

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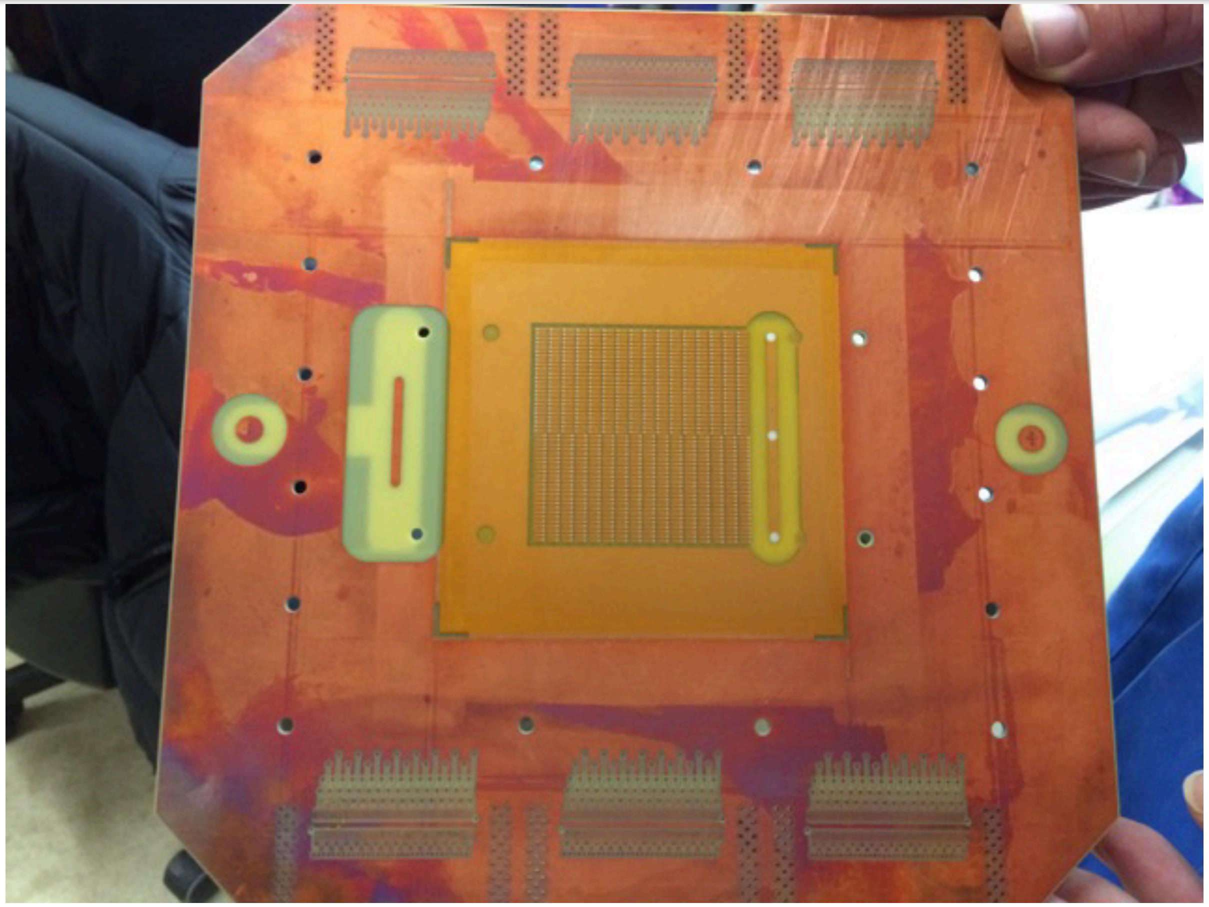
MPGD 2017 - Philadelphia, USA

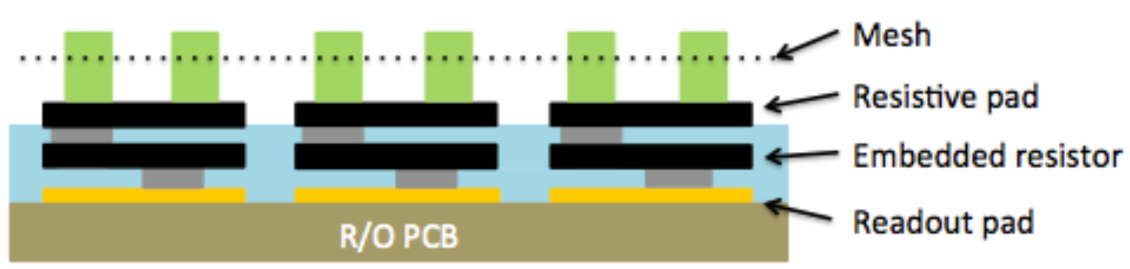
23 May 2017

Prototype construction

First design of a small size prototype:

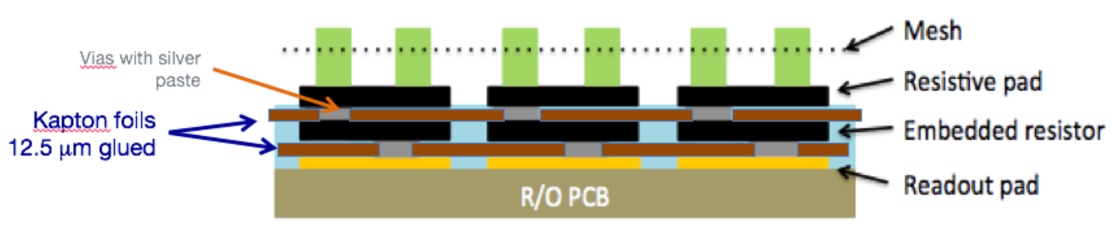
- Matrix of 48x16 pads.
- 0.8 x 2.8 mm^2 pads(pitch of 1 and 3 mm in the two coordinates).
- Active surface of 4.8x4.8 cm^2 for 768 total R/O channels.
- Drift gap 5 mm, amplification gap 128 um.
- Multilayer PCB.





Stack of all layers, including the insulator, all deposited by screen-printing -> interesting for large scale detectors

Pin-holes / weak points in the insulator.
Non flatness of the resistive pads.
Bumps and irregularities found.



Standard Kapton insulating foils.
Vias are filled with silver epoxy paste deposited by screen-printing followed by a planarization process.

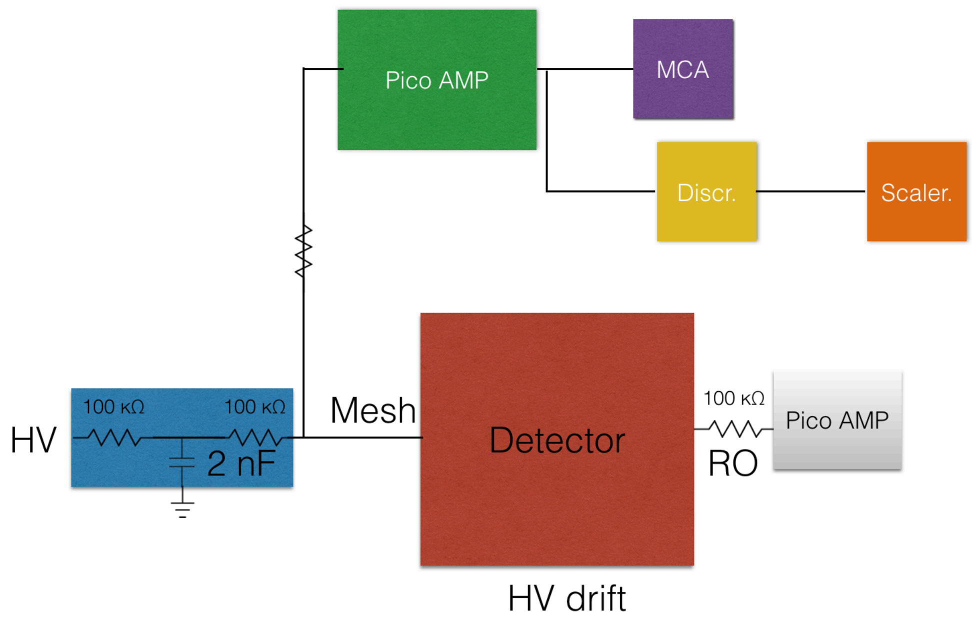
More info about construction ref: **M.Alviggi et al., 2017 JINST 12 C03077**

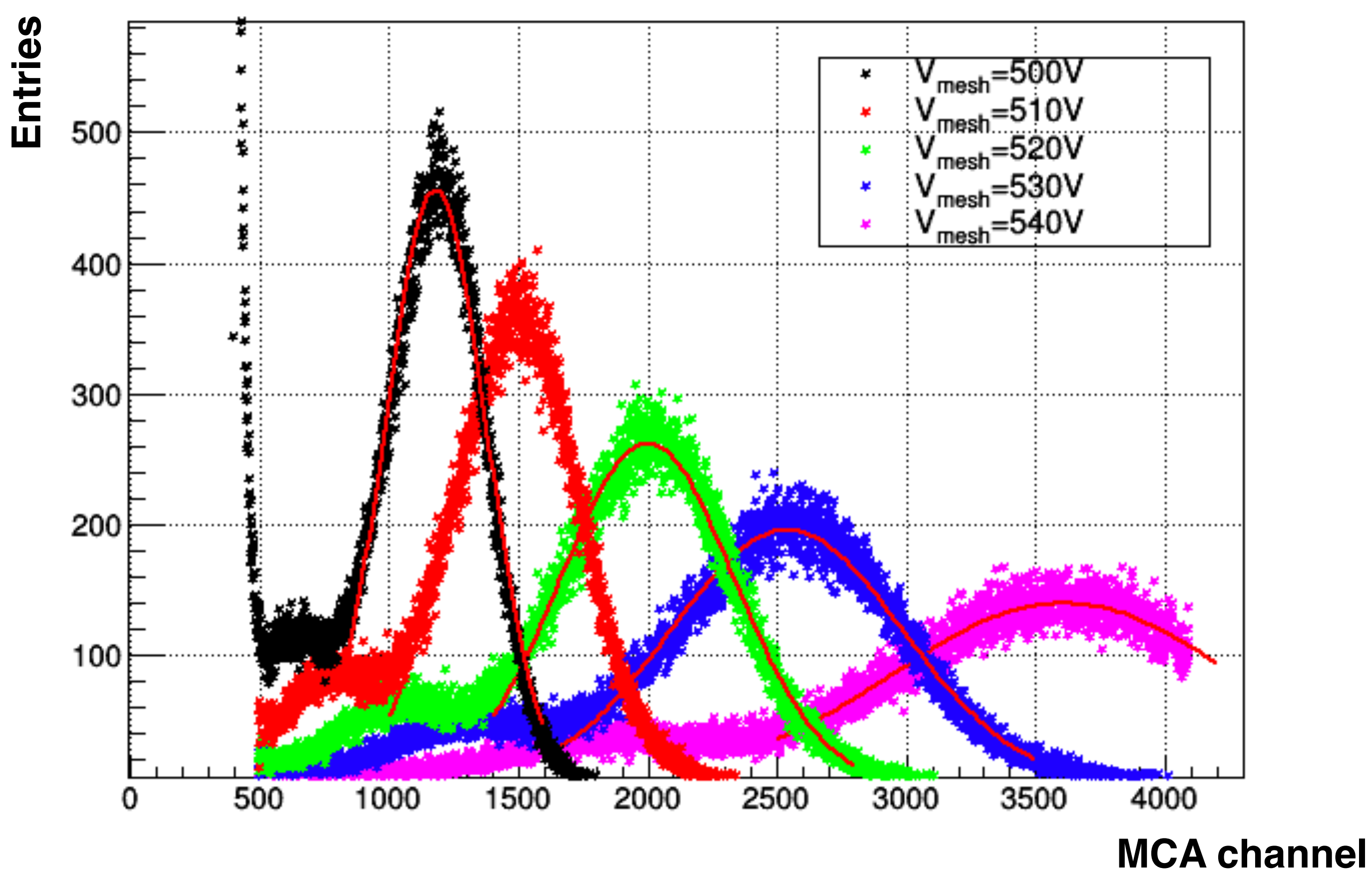
Characterisation with ^{55}Fe source

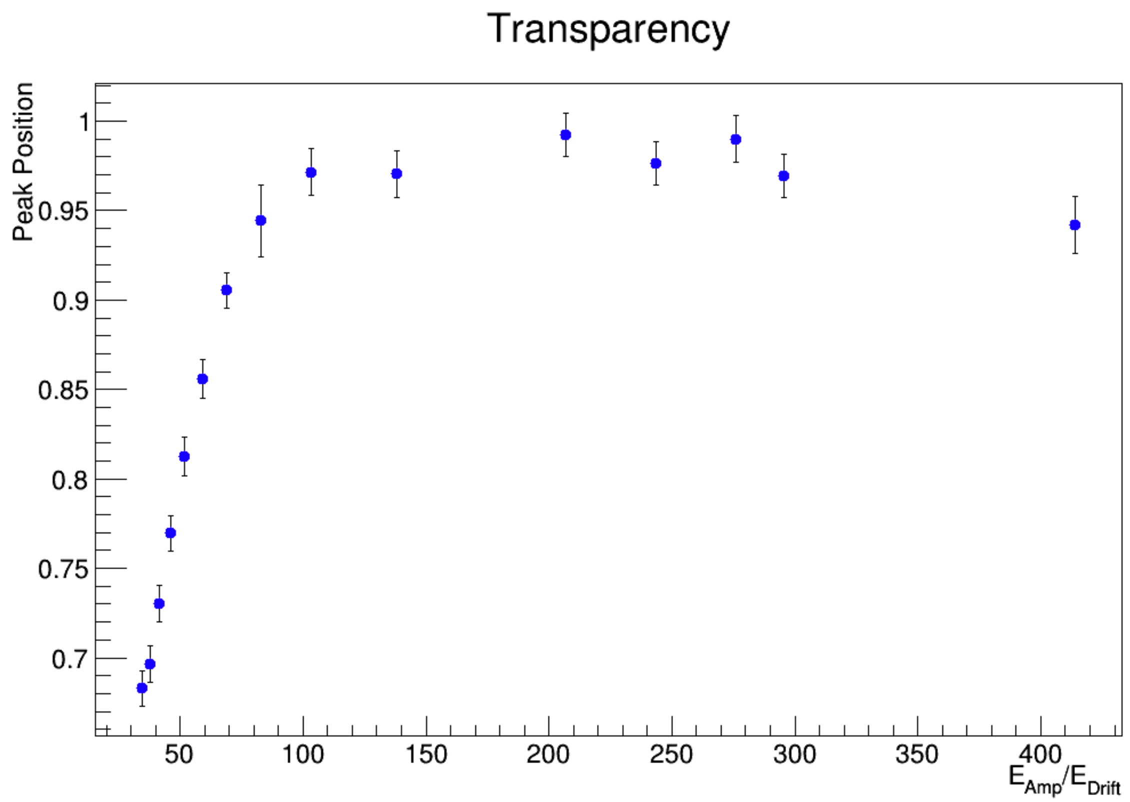
Preliminary characterisation carried out by means of ^{55}Fe sources:

- HV supplied to drift electrode and mesh.
- Current read from readout pads.
- Trigger rate obtained from mesh signals.

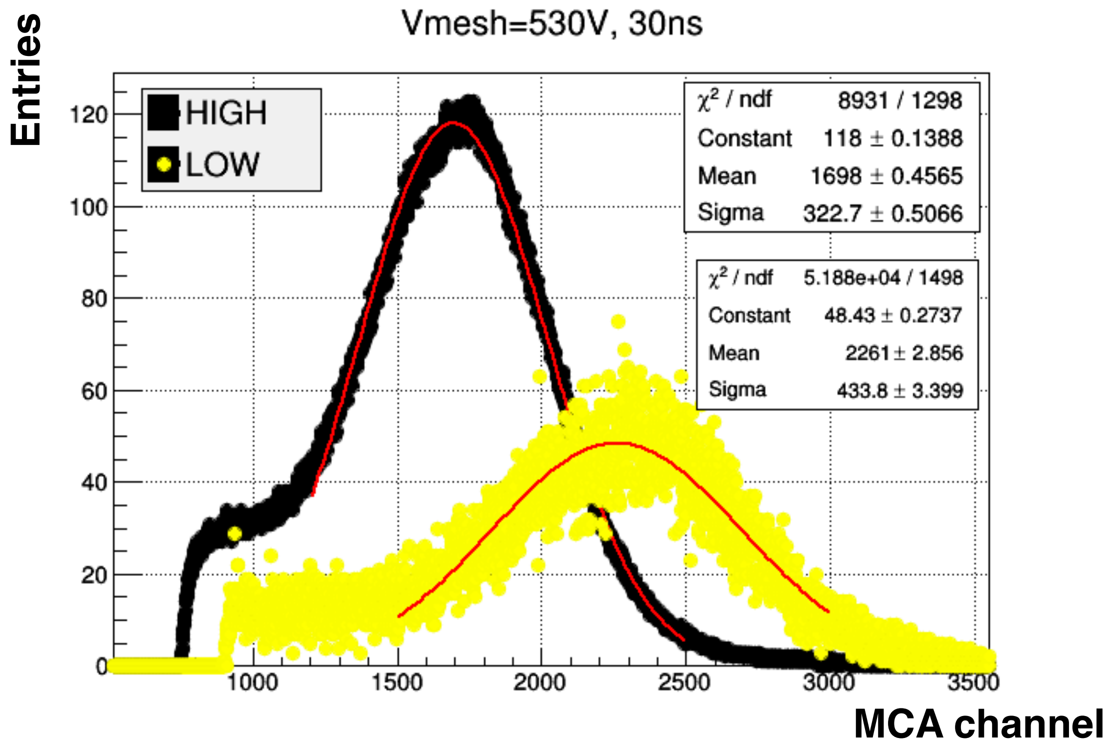
Energy resolution of about 40% has been obtained.
Not extremely relevant for the future applications.
Possible explanation: inhomogeneity of electrical field due to large border effect





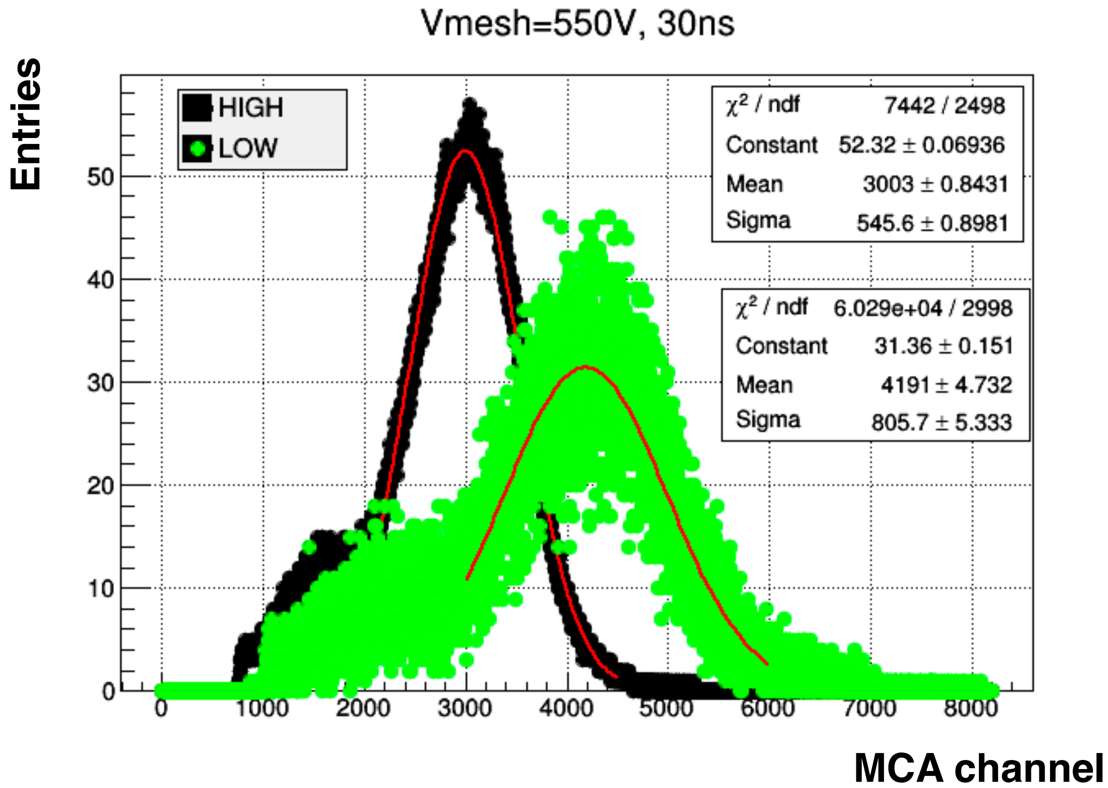


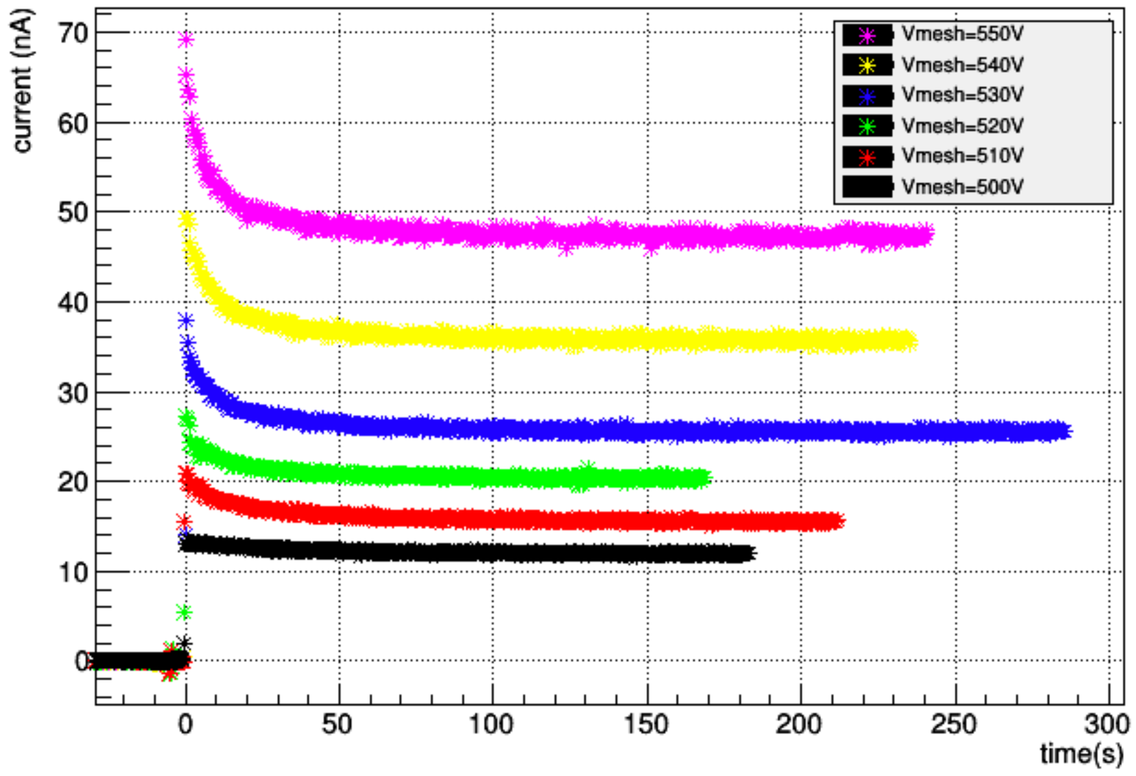
Characterisation with ^{55}Fe source



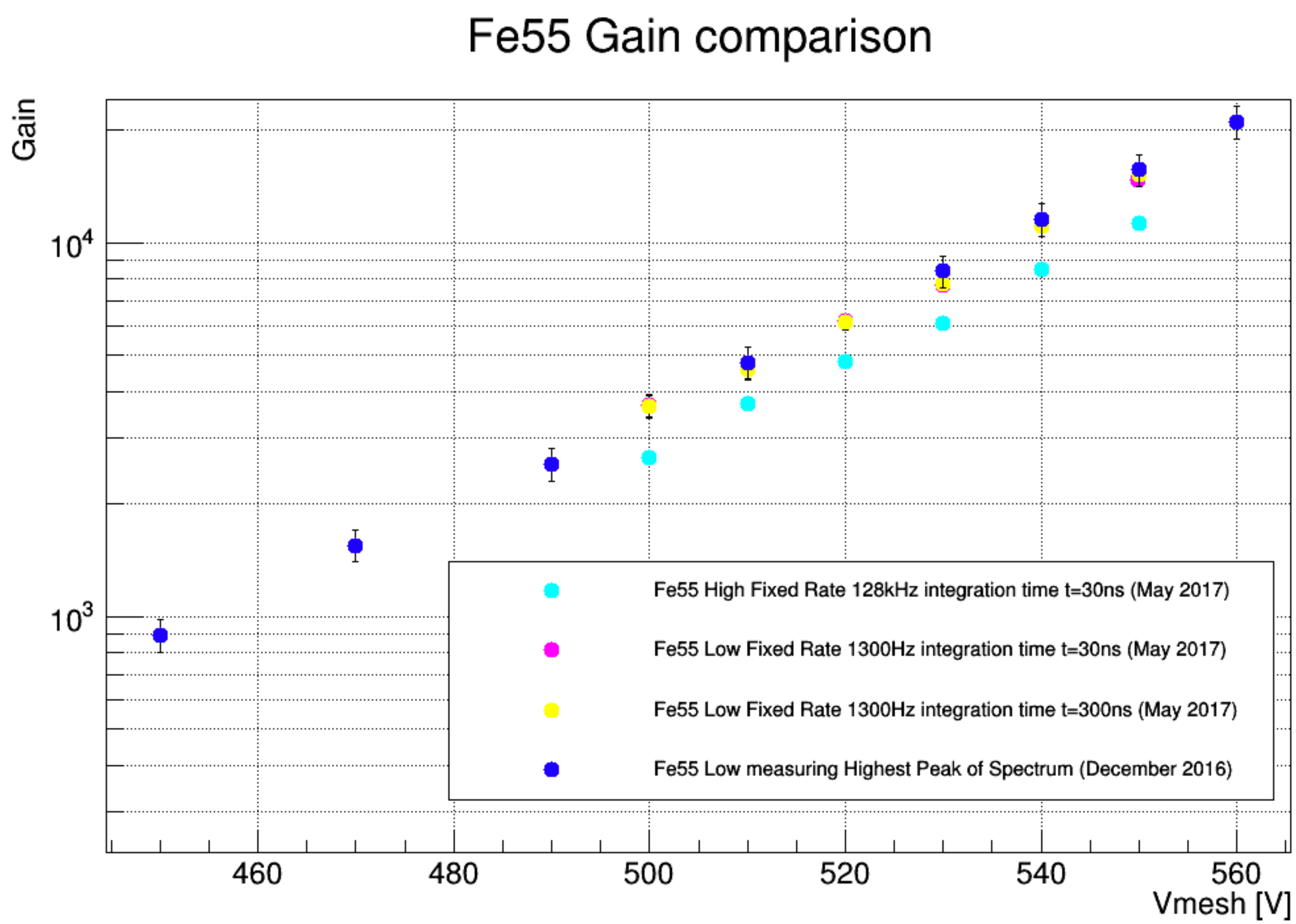
Different source intensities showed a current reduction of about 20%, compatible with the shift in the MCA spectrum position.

Possible explanation: dielectric charge-up effect





Characterisation with ^{55}Fe source



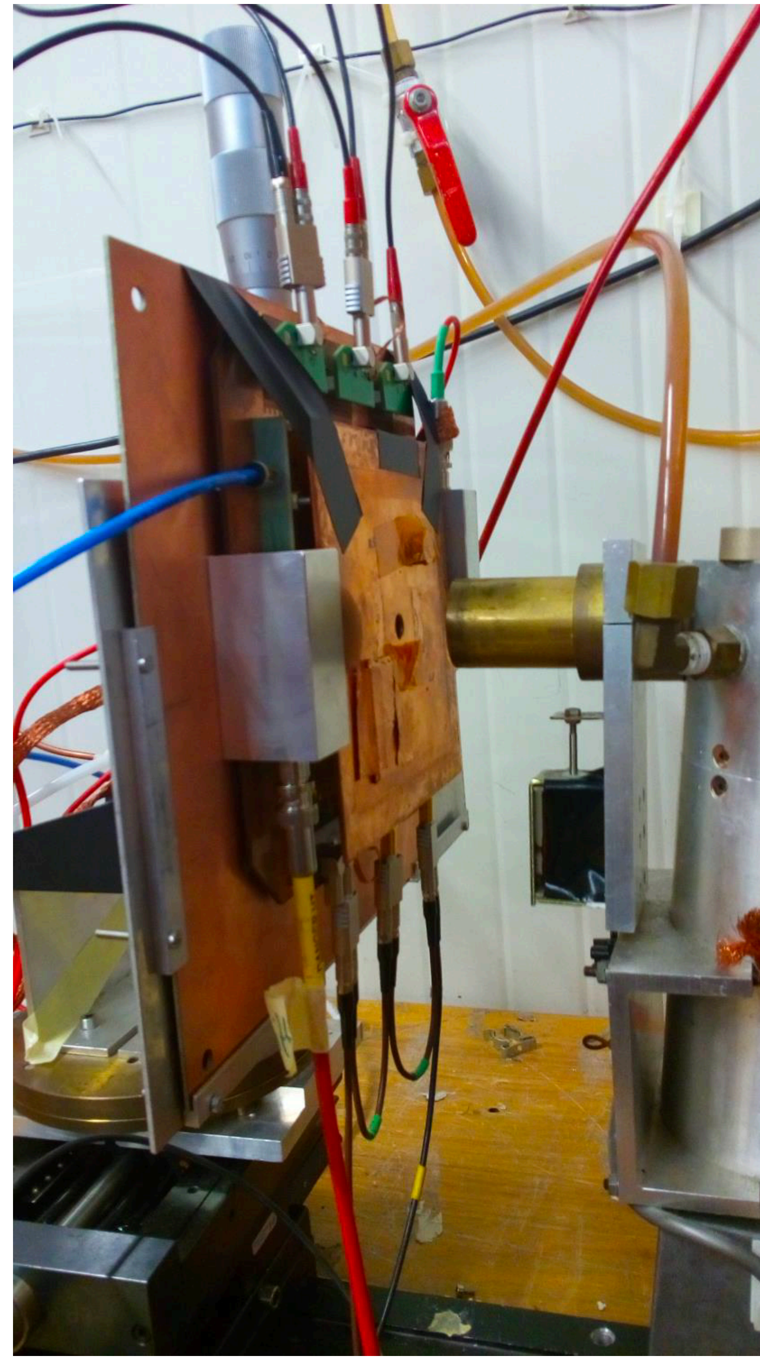
Gain difference of about 20% between high and low (1.3kHz, 128kHz) source intensity.

The detector response has been evaluated with X-rays.

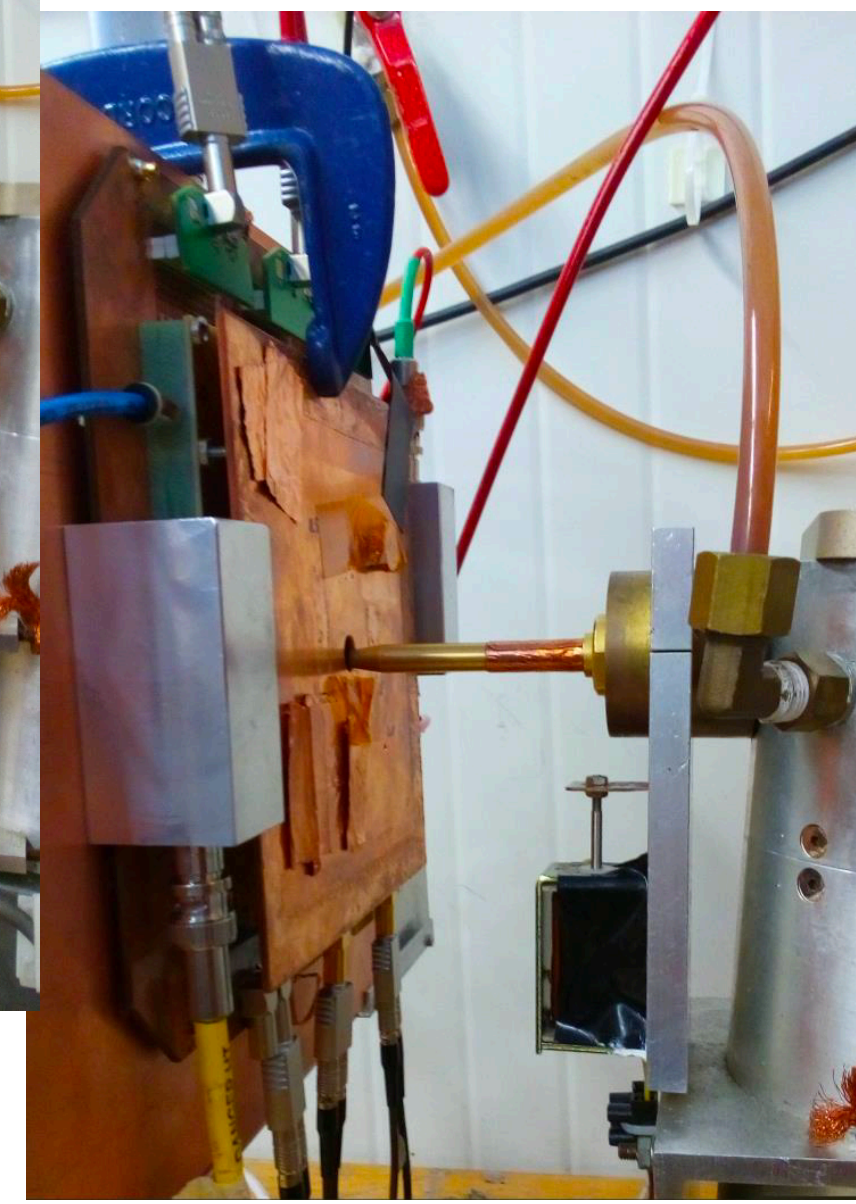
8 keV photons have been generated from Cu anode X-Ray gun at GDD Lab (Cern).

The same setup already used for radioactive source measurement has been used to monitor the gain.

Measurements performed with a 10mm hole on a Cu screen or with a 1 or 3mm collimator.



10 mm hole

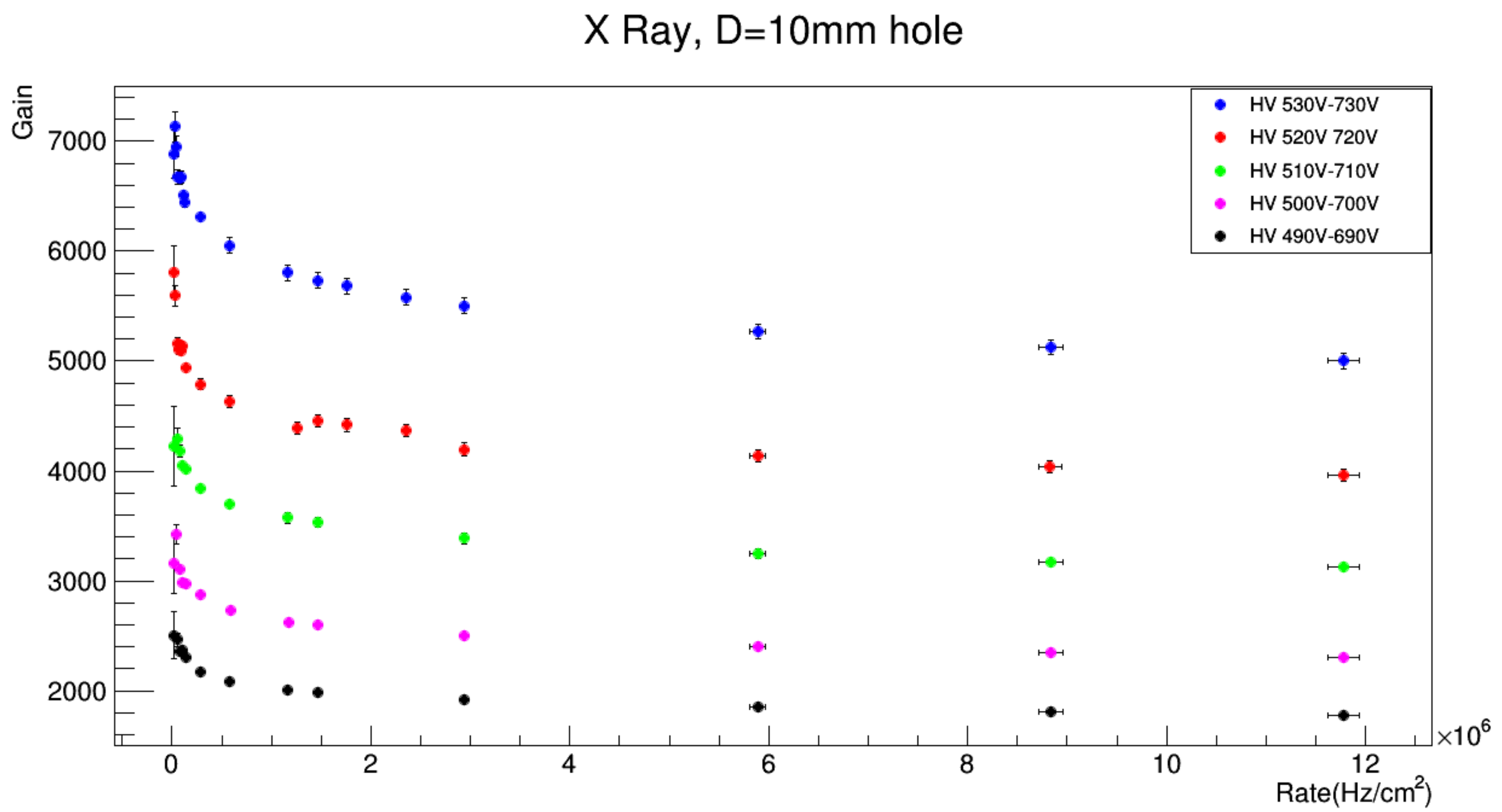


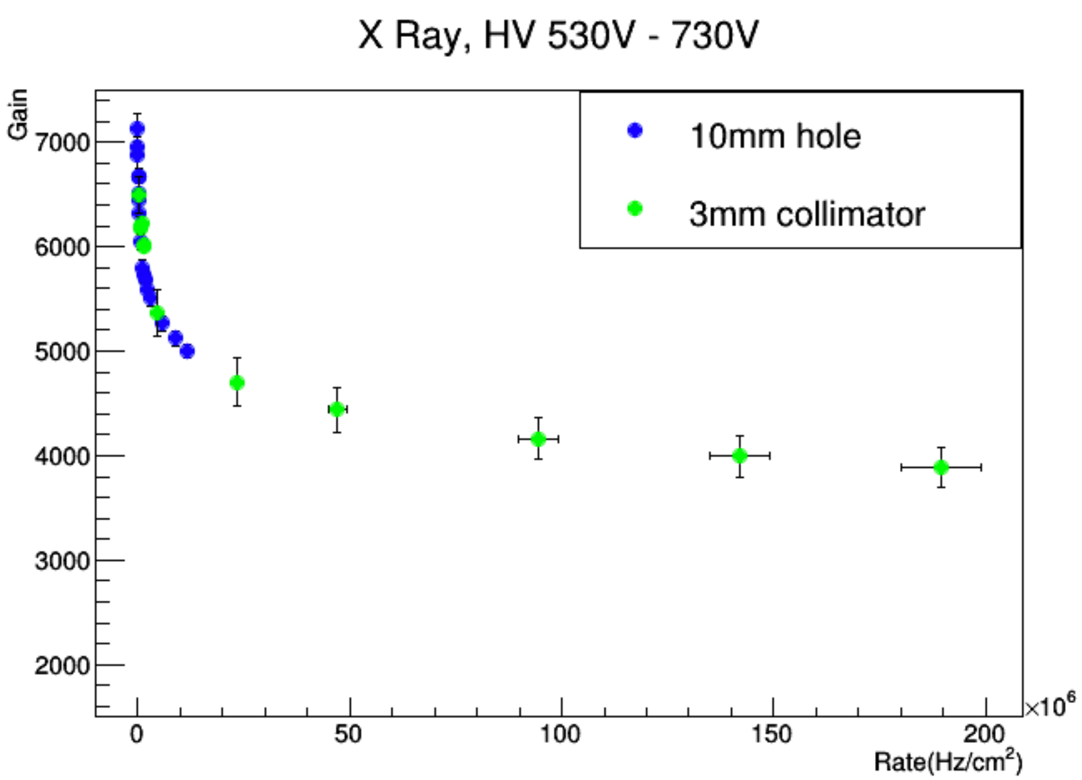
3 mm collimator

X-Ray measurements

Gain has been measured as a function of the rate and of the HV.

The same gain reduction already observed with the ^{55}Fe source has been obtained.

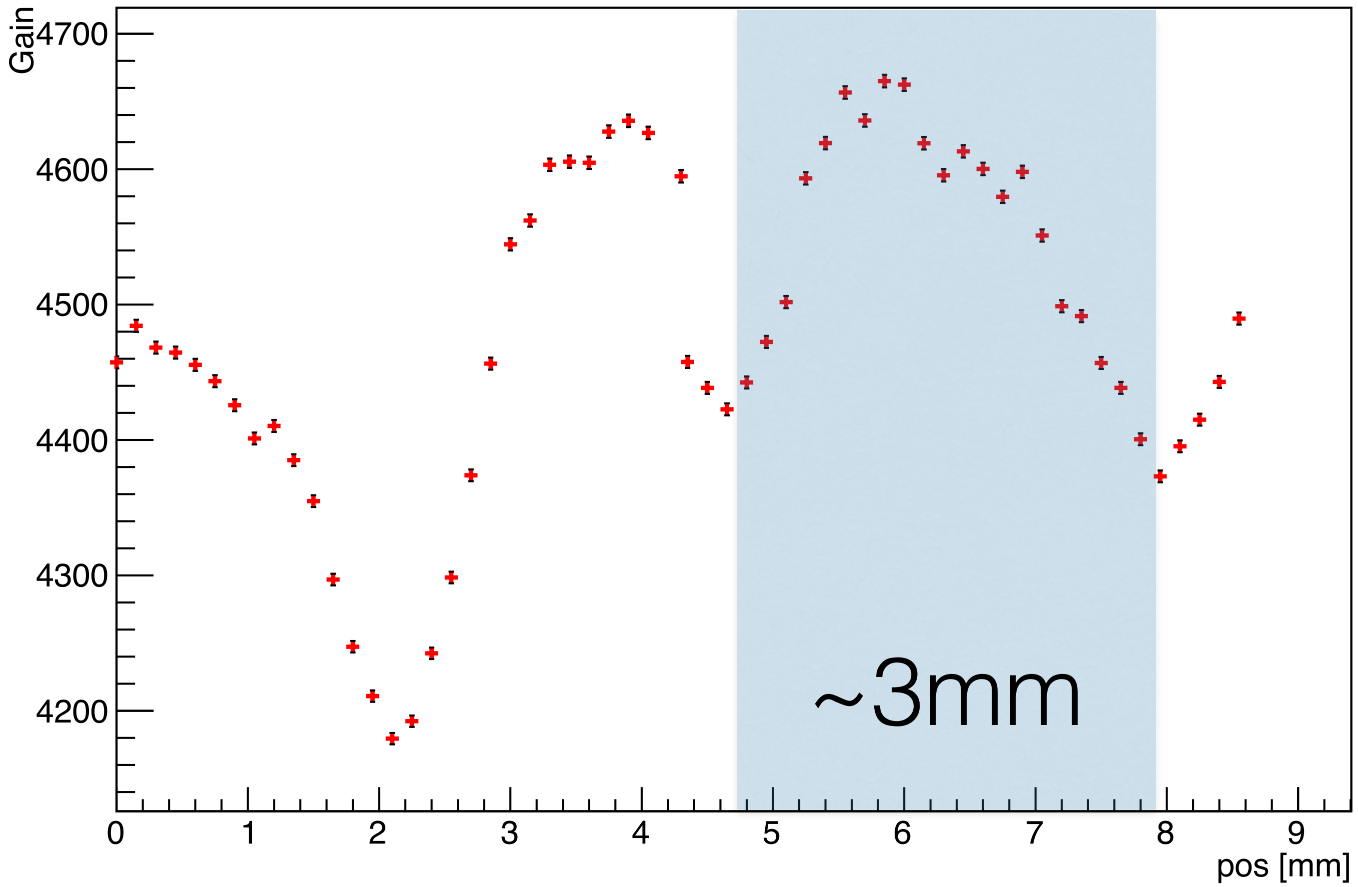


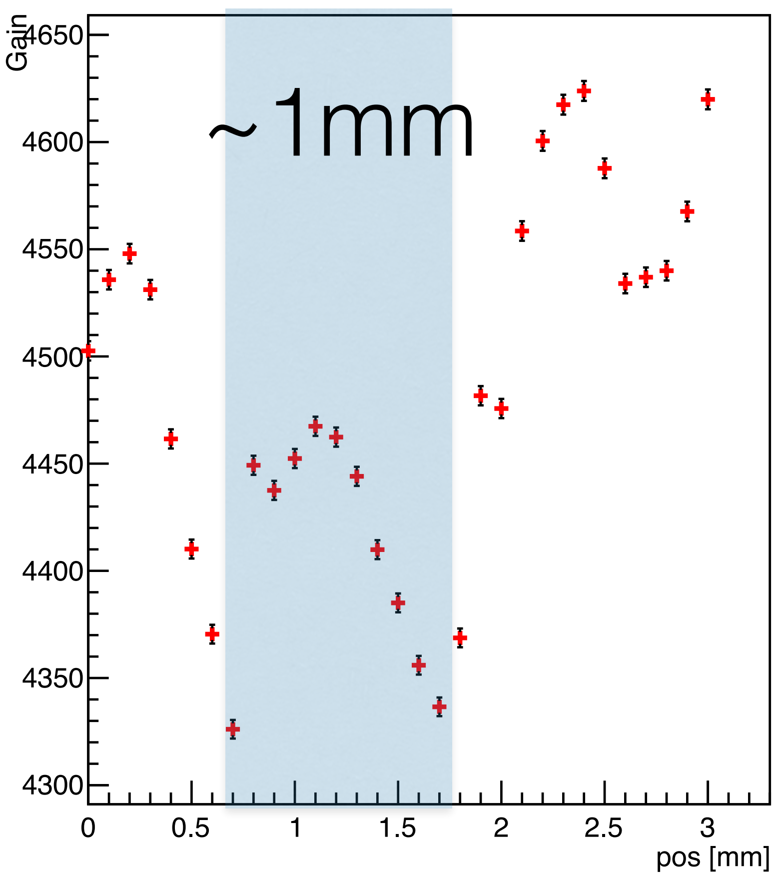


Behaviour with a 3 mm collimator has been measured, allowing to increase the rate up to ~100MHz/cm^2.

The detector shows a gain of **~4x10^3** at **150 MHz/cm^2.**

Steps every 150 um



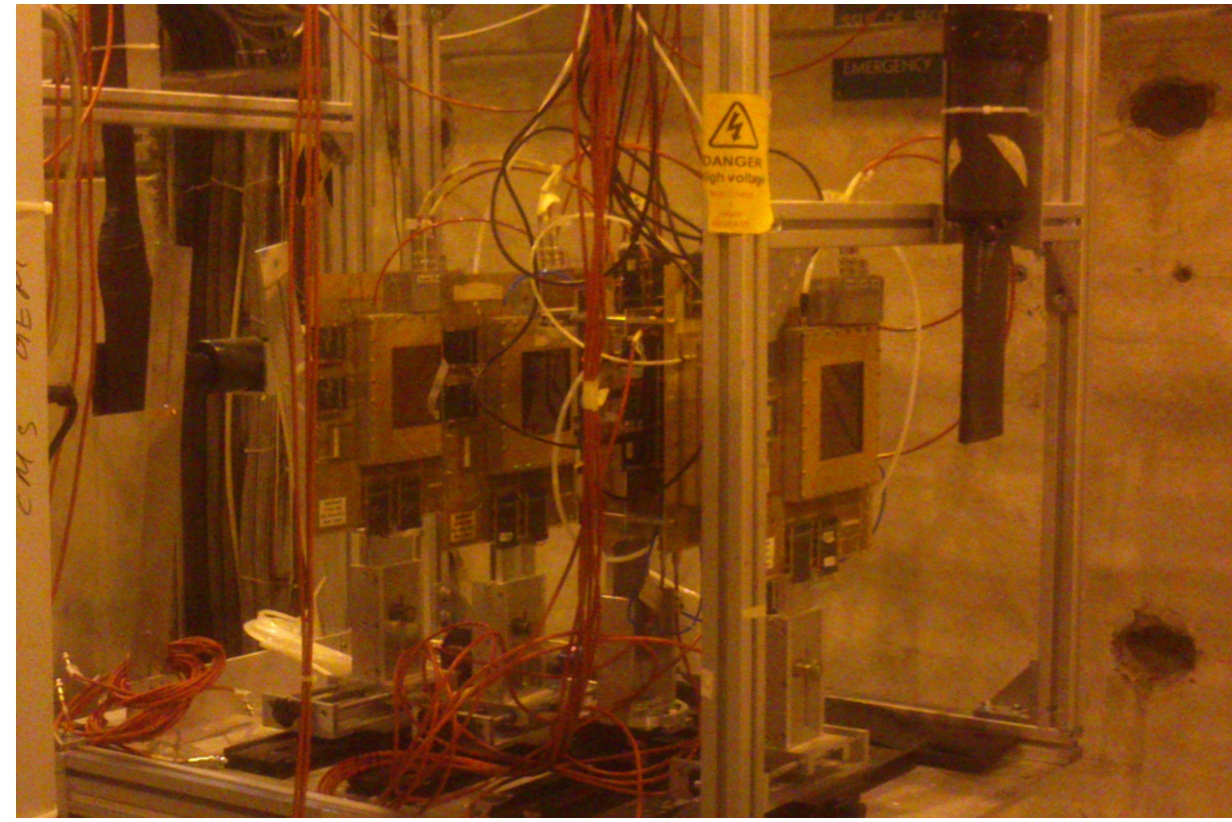


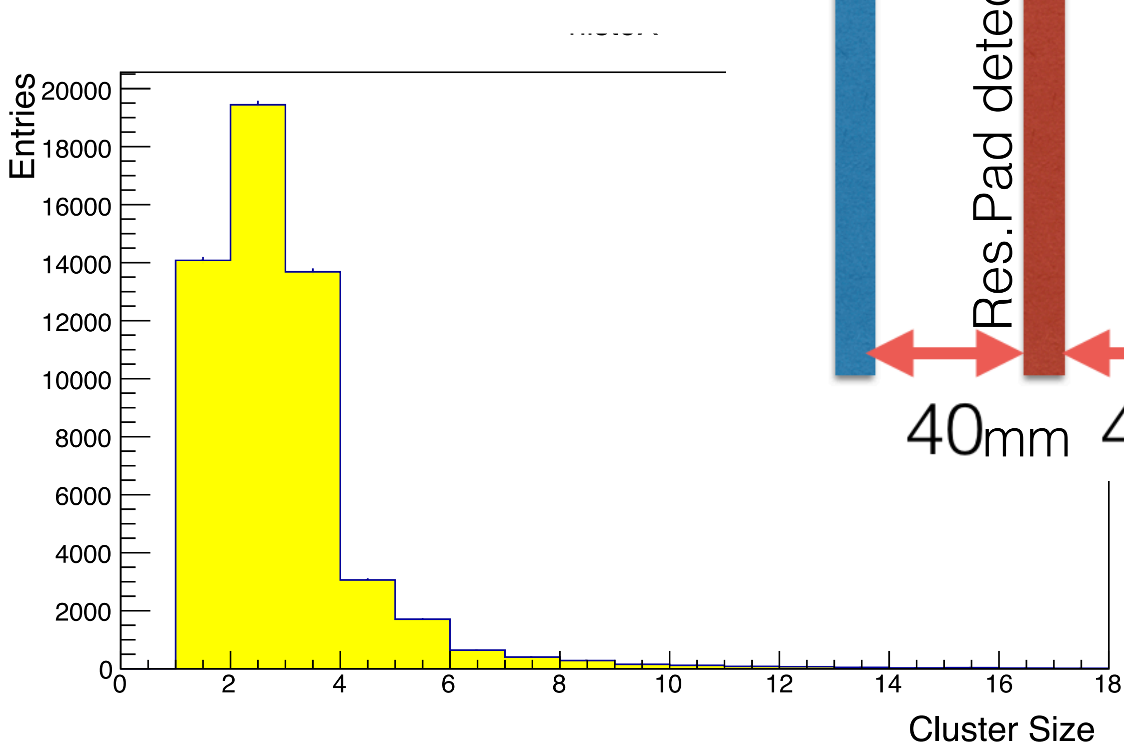
Modulation of the gain as a function of the position has been seen, compatible with the pad pattern.

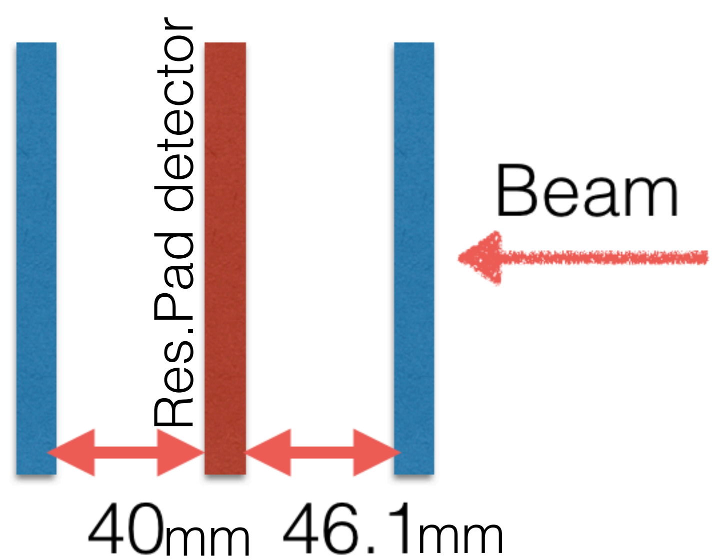
Test beam at CERN

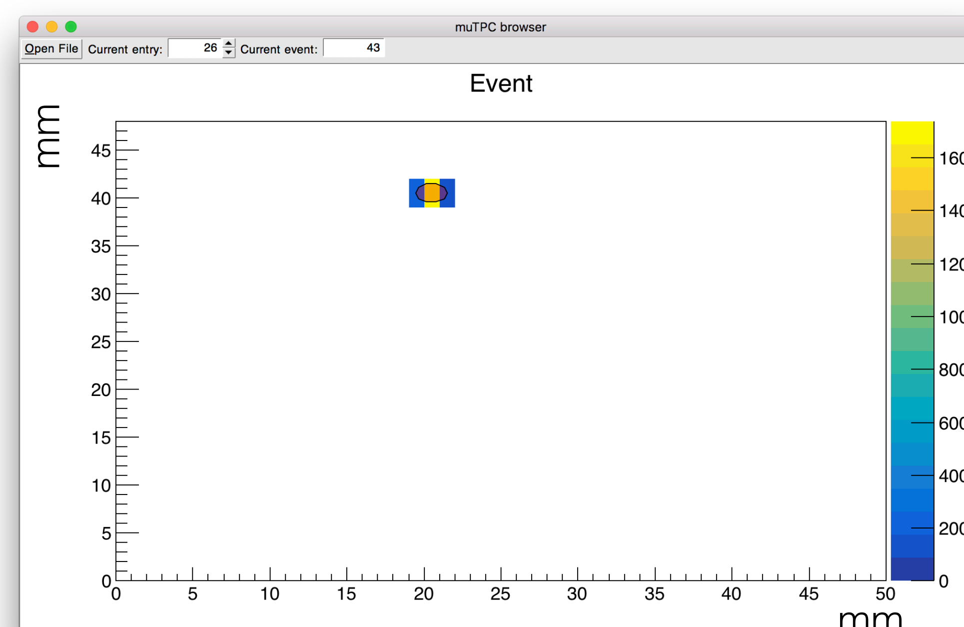
Performance assessed with muon beam at H4 beam line at CERN.

- Tracking performed with double view 10x10 cm2 Micromegas detectors.
- Data acquired with APV-25 hybrids and RD51 SRS system.
- Gas mixture: Ar/CO2 (93:7).
- Cluster reconstructed combining adjacent fired pads.





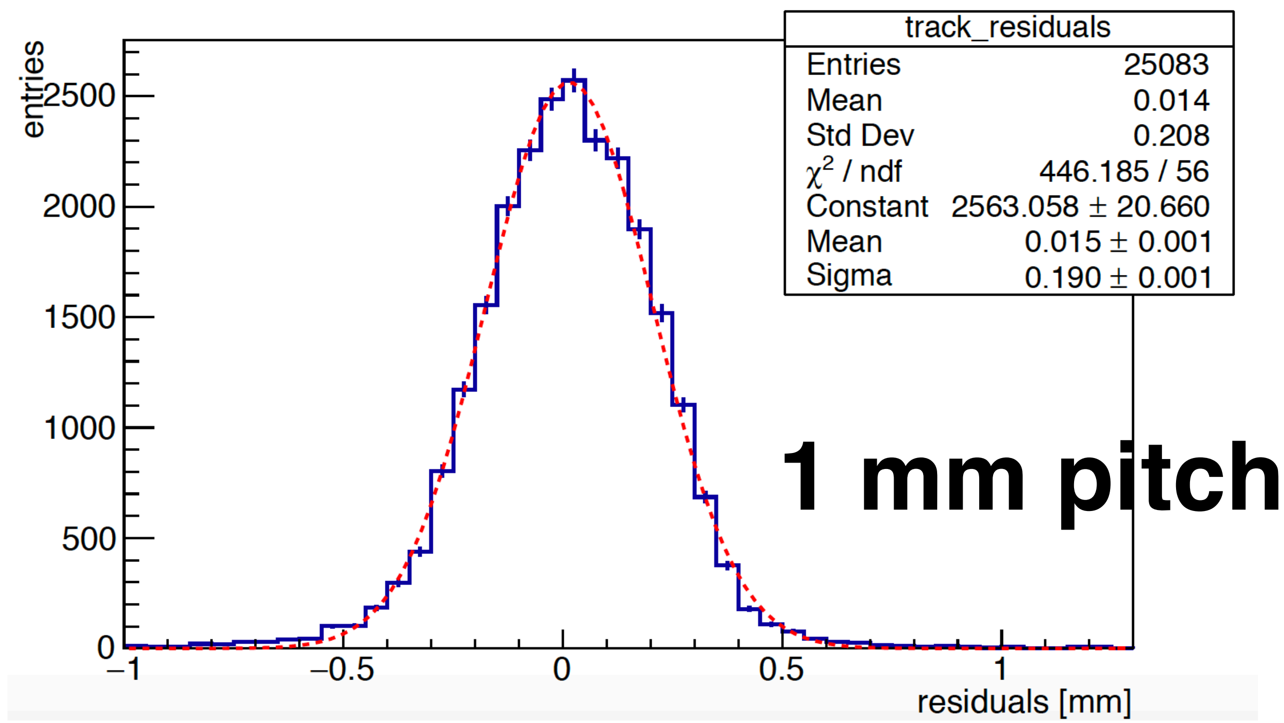




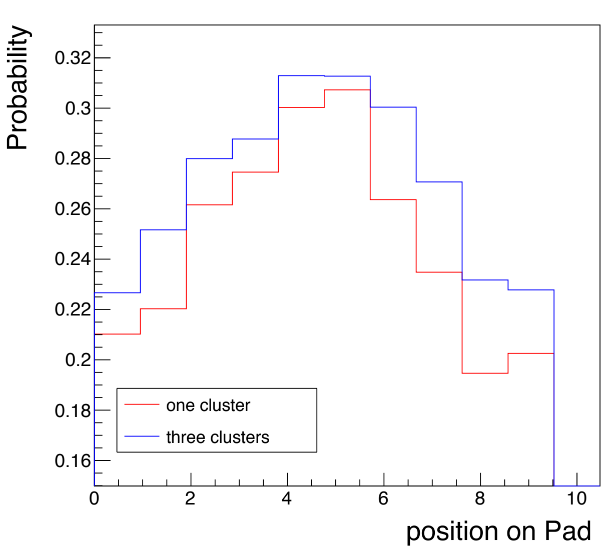
Test beam at CERN

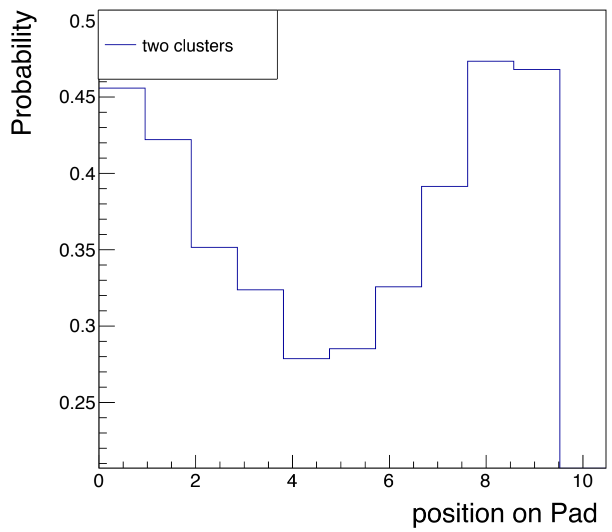
Resolution has been evaluated comparing cluster position and expected hit position obtained from tracking detectors.

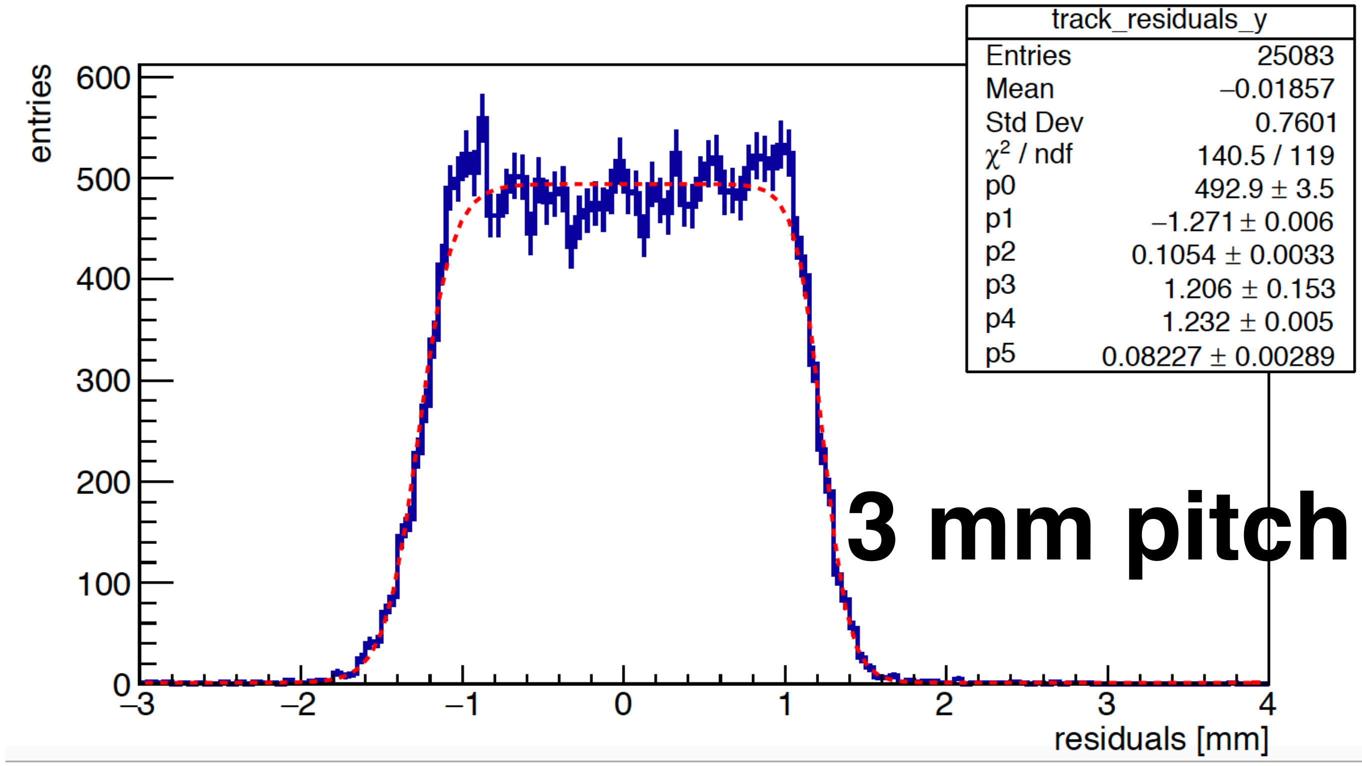
Resolution of **190 um** has been obtained on the precise coordinate.



Dependence of the **cluster size** (precision coordinate) on the expected muon position. Muons passing in the **center** of the pad have higher probability to fire an **odd** number of pads



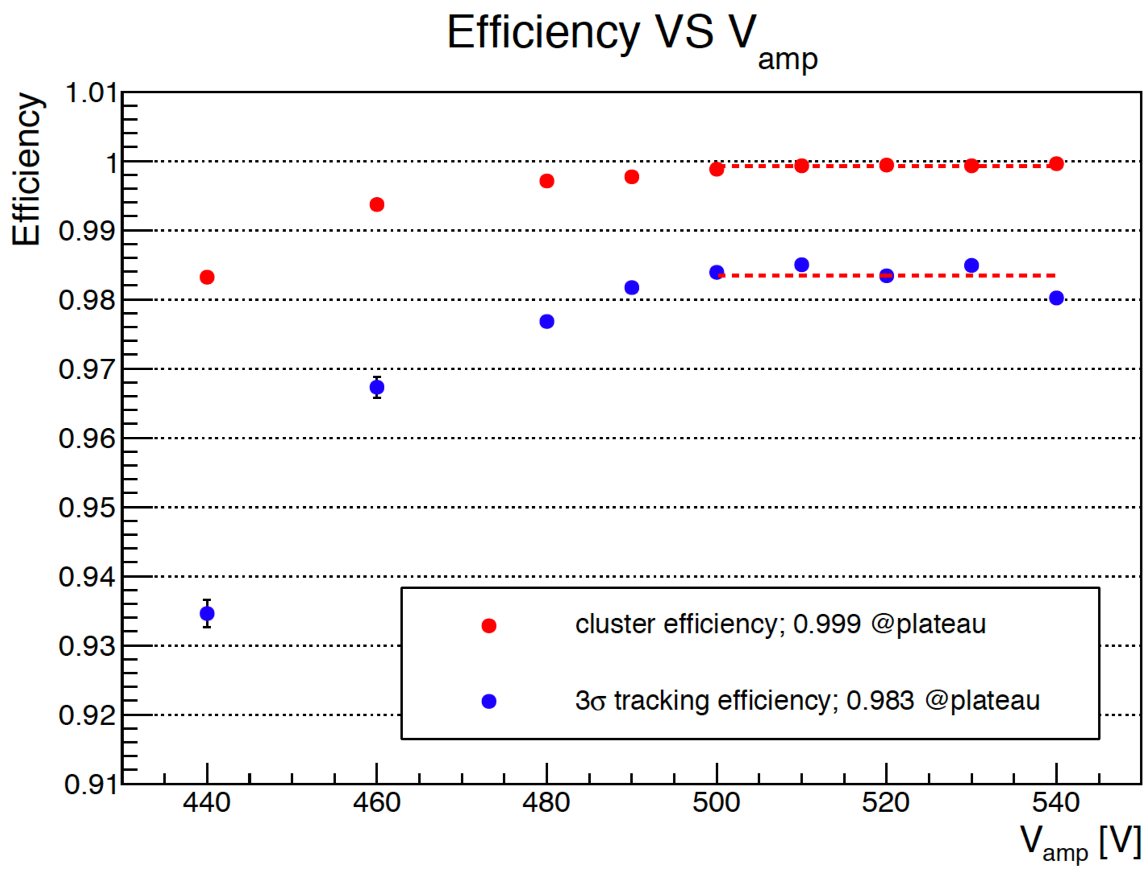




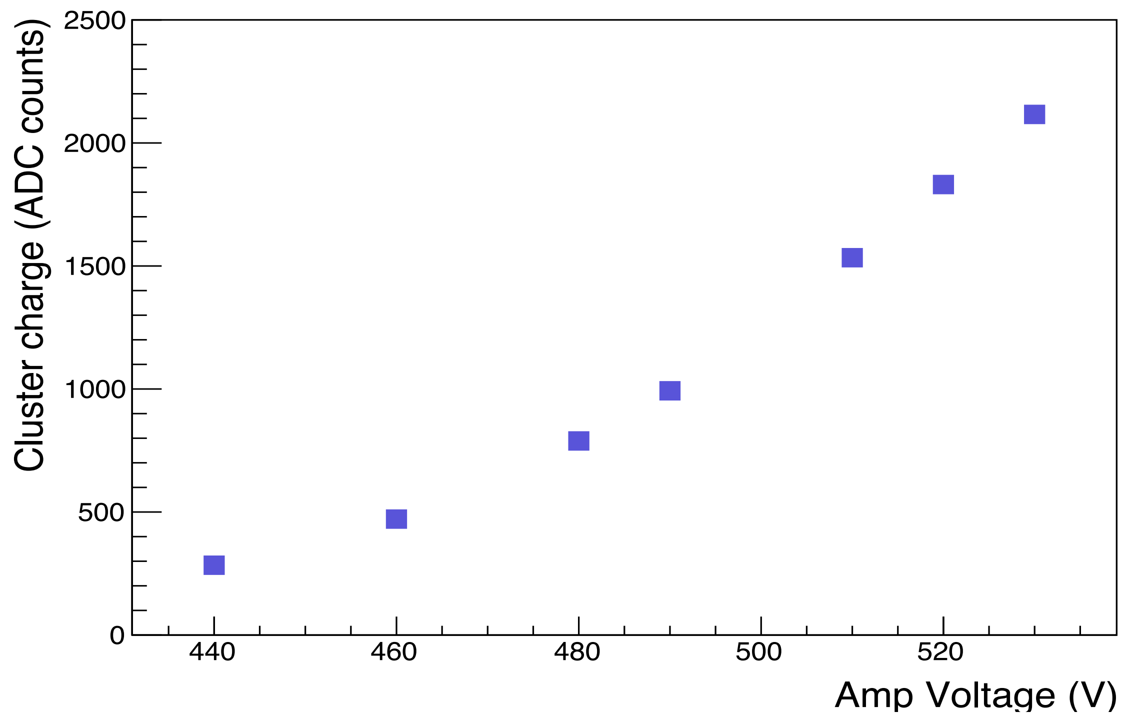
Test beam at CERN

Efficiency has been evaluated both considering an acceptance region around the expected hit and without.

Excellent performance has been measured, thanks to very low detector noise, allowing very loose offline cuts.



Cluster charge is defined as the sum of the maximum of the charge distribution of each pad belonging to the cluster.

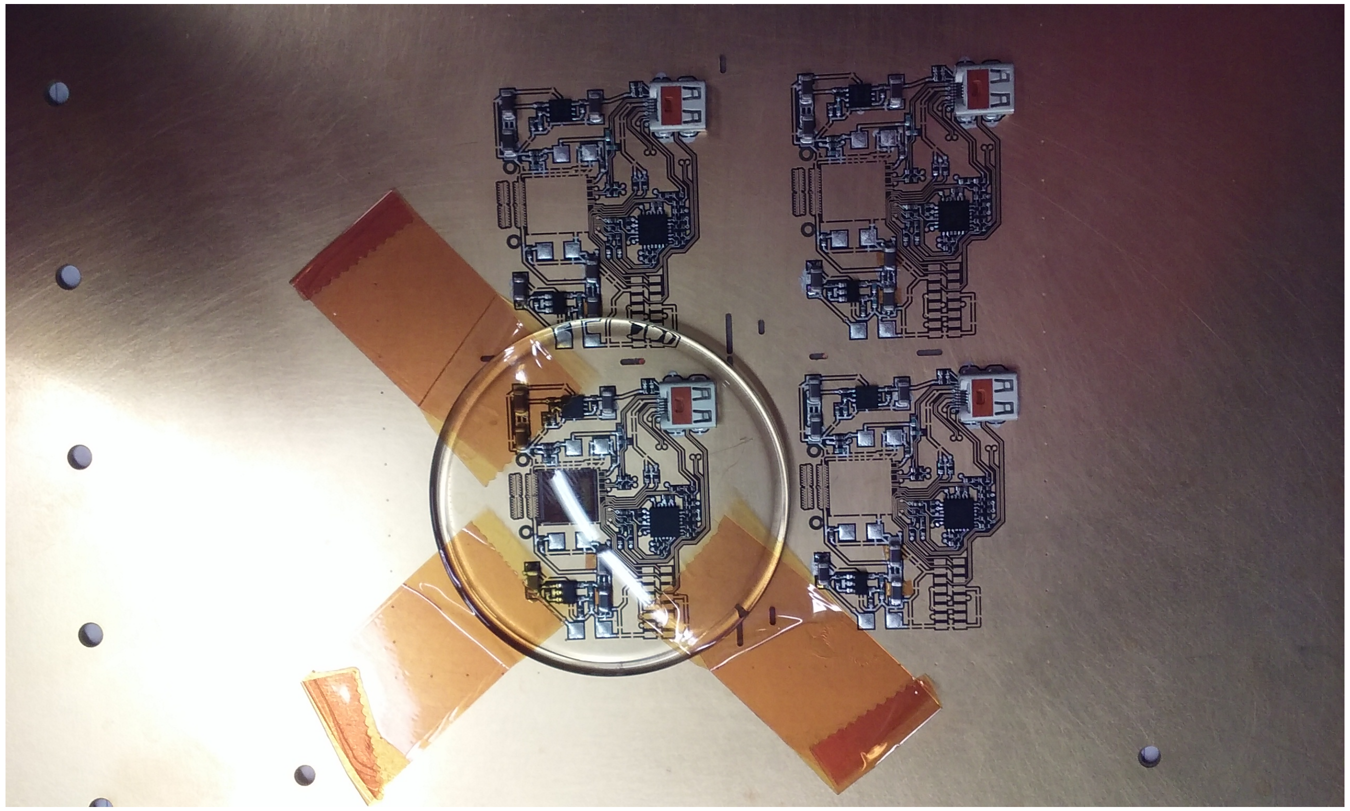


Conclusion and future development

- A resistive Micromegas prototype based on pads (1x3mm^2) has been built and characterised.
- Efficiency higher than **98%** and a resolution of **190 um** (most precise view) have been measured.
- Promising behaviour at very high rate has been obtained, maintaining a gain of ~4x10^3 at 150MHz/cm^2.
- Effects of charge-up and voltage drop from the pad resistors are under investigation.

Difficult to imagine scaling to large area detectors due to complex routing with present design.

A new prototype is under construction, with APV25 electronics directly embedded on the PCB.
Currently under debugging…



Acknowledgements

We would like to thank the CERN MPT Workshop, the R&D51 Collaboration for support with tests at the GDD Lab and at H4 SPS beam line.

References:

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