RECENT RESULTS FROM SMALL-PADS RESISTIVE MICROMEGAS

F. Petrucci on behalf of the Small-pads Micromegas Group:

M.Alviggi (1), M.Biglietti (2), M.Camerlingo (1), V.Canale (1), M.Della Pietra (1), C.Di Donato (1), E.Farina (3), S.Franchino (4), C.Grieco (1), P.Iengo (3), M.Iodice (2), F.Petrucci (2), E.Rossi (2), G.Sekhniaidze (1), O.Sidiropoulou (3,5), V.Vecchio (2)

(1) Napoli (INFN + Università Federico II + Università Parthenope)
(2) Roma Tre (INFN + Università)
(3) CERN
(4) Heidelberg Univesity
(5) Wurzburg University

RD51- Mini week

December 13th, 2016 - CERN

Introduction

Goal:

- Development of Resistive MicroMegas (MM) detectors with small pad read-out, aimed at improving the high rate capability;
- Aim at ~1 MHz/cm2.

Applications:

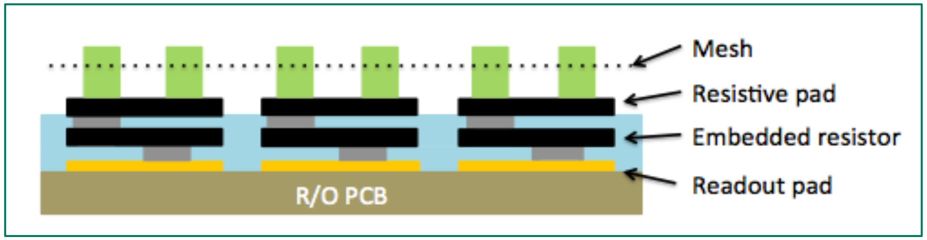
- Large area fine tracking and trigger with high rate capability;
- Sampling Hadron Calorimetry;
- ATLAS very forward extension of muon tracking (Phase2 Large eta Muon Tagger for the upgrade of the ATLAS Muon Spectrometer).

Contents:

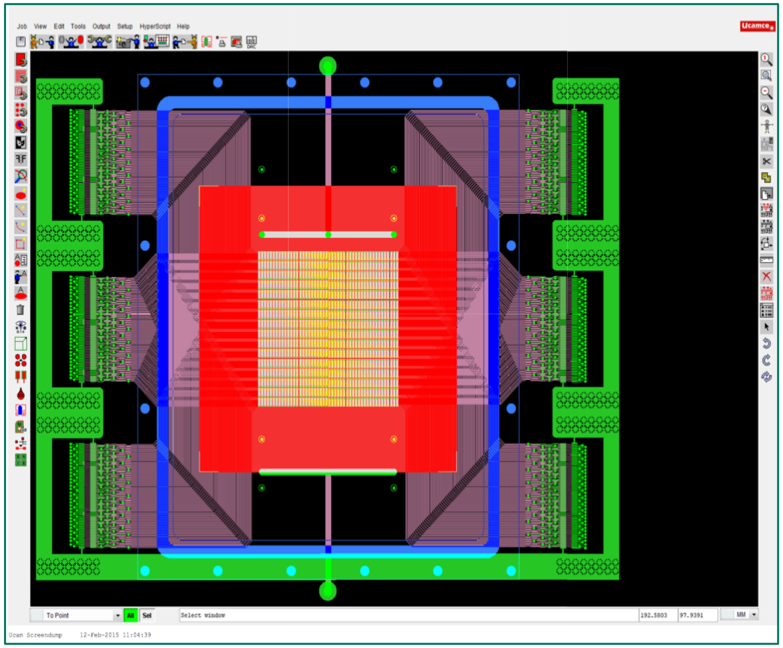
- Detector R&D
- Lab test with radioactive source
- Test Beam results
- Outlook

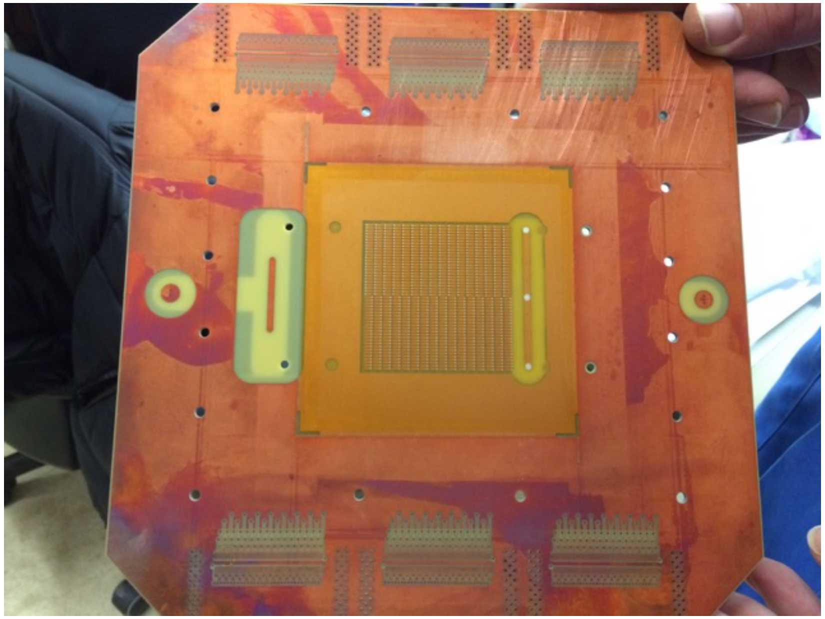
Detector R&D - Small Pad pattern with EMBEDDED resistors

- Technical solution inspired by a similar R&D by COMPASS and others within RD51;
- From existing R&D we aim at reducing the pad size to < 3mm^2.



- First design of a small size prototype;
- Matrix of 48x16 pads;
- Each pad: 0.8mm x 2.8mm (pitch of 1 and 3 mm in the two coordinates);
- Active surface of 4.8x4.8 cm2 with a total of 768 channels.



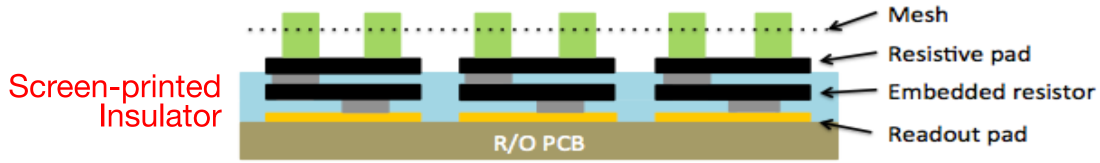


Detector R&D : Small Pads Resistive micromegas

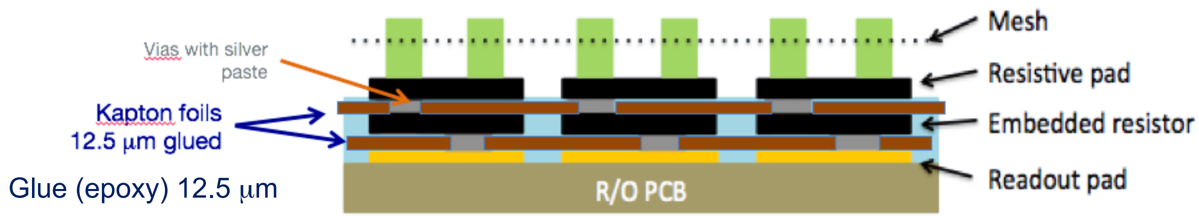
TWO Prototypes built so far (Paddy1 and Paddy2)

- Both with the same layout: Matrix 48x16 – 1x3 mm^2 pads – 768 channels
- The construction technique was different in the two cases:

1. Full screen printing: stack of all layers, including the insulator, all deposited by screen-printing.
   A simple, cost effective technique but subject to HV instabilities.



1. “standard kapton insulating foils”. Vias are filled with silver epoxy paste deposited by screen printing followed by a planarization step. Tested without any problem of HV instabilities.



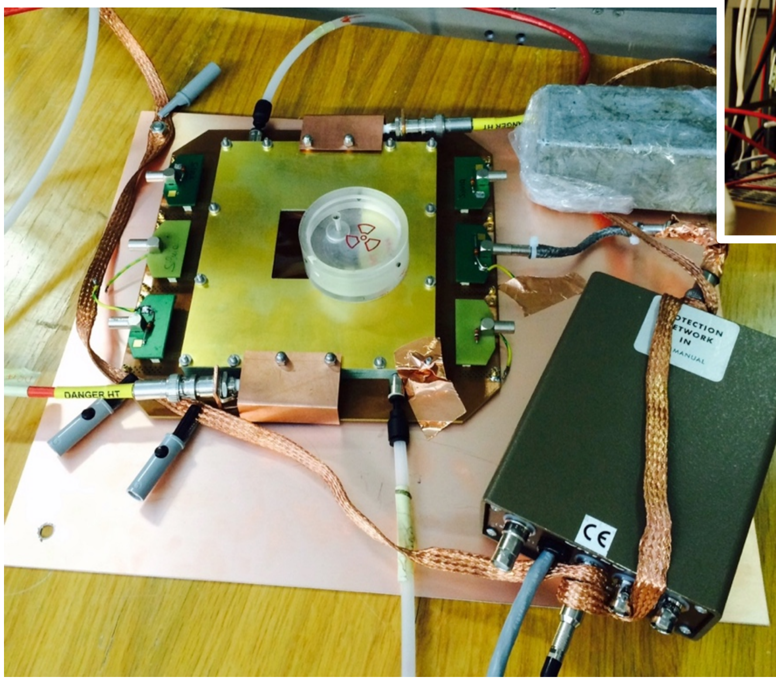
Each pad Resistors ~ 3 – 7 MOhm

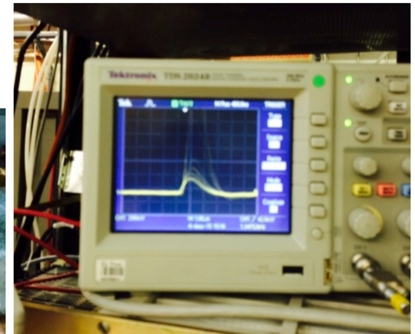
Before pressing the Kapton:

- Laminate the 12 μm glue on the back of the 12 μm Kapton
- Drill all the vias
- Then proceed with the gluing/press step

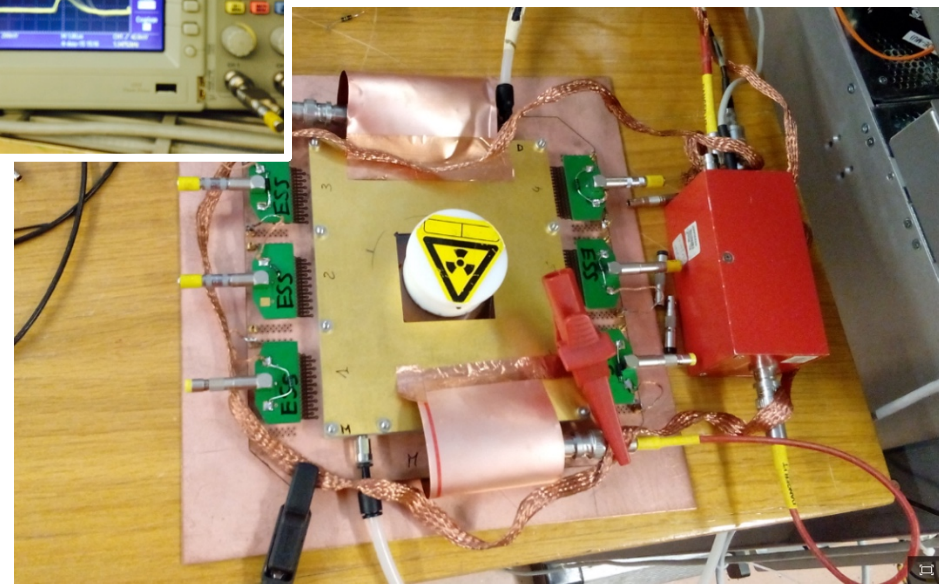
Lab Tests – Gain Curves, Spectrum analysis

Paddy1
Tests in September 2015





Paddy2
Tests in July 2016
and December 2016

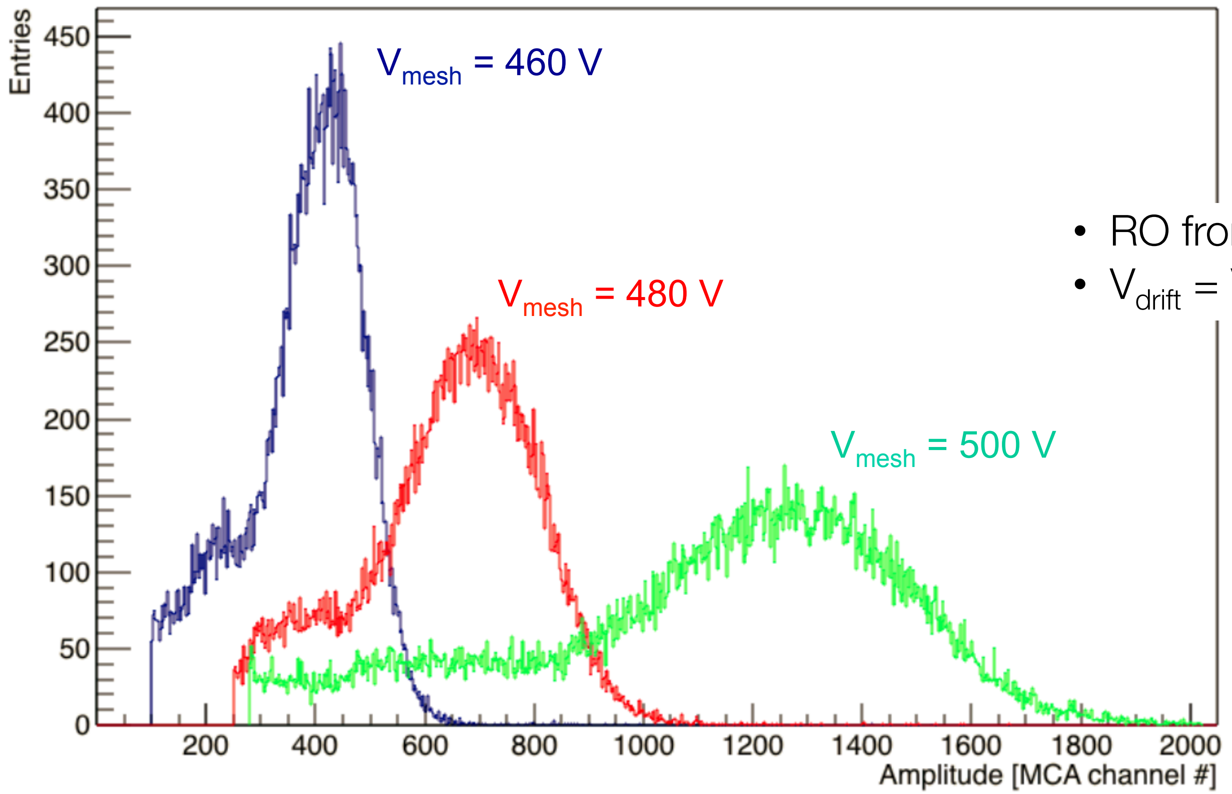


Source ^{55}Fe

- All Lab tests so far carried out at the *GDD Lab at CERN*
- Gas mixture Ar/CO_2 93/7 has been used for all tests

Paddy-1 problems - Vmesh 560: spark and then short between pads and mesh → Cleaned → Since then instable behaviour
→ DECIDED TO BUILD A NEW PROTOTYPE WITH Kapton as insulator → **Paddy-2**

Multi Channel Analyzer Spectrum analysis of ^{55}Fe source



- RO from the mesh
- $V_{drift} = V_{mesh} + 300$

Not great Energy resolution (not actually impacting of the foreseen applications)

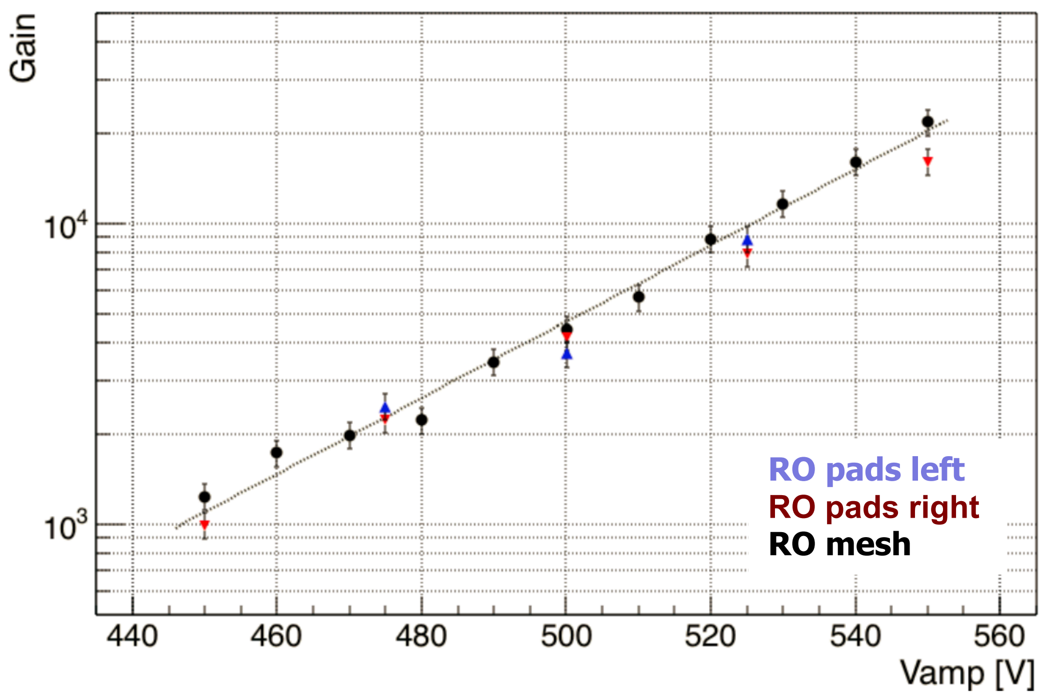
Possible causes:

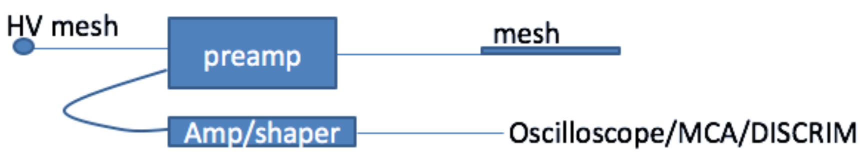
- non uniform pads → not uniform E field;
- Small pads → pronounced borders effects.

Gain Results - MM-pad Version 2 (Paddy2)

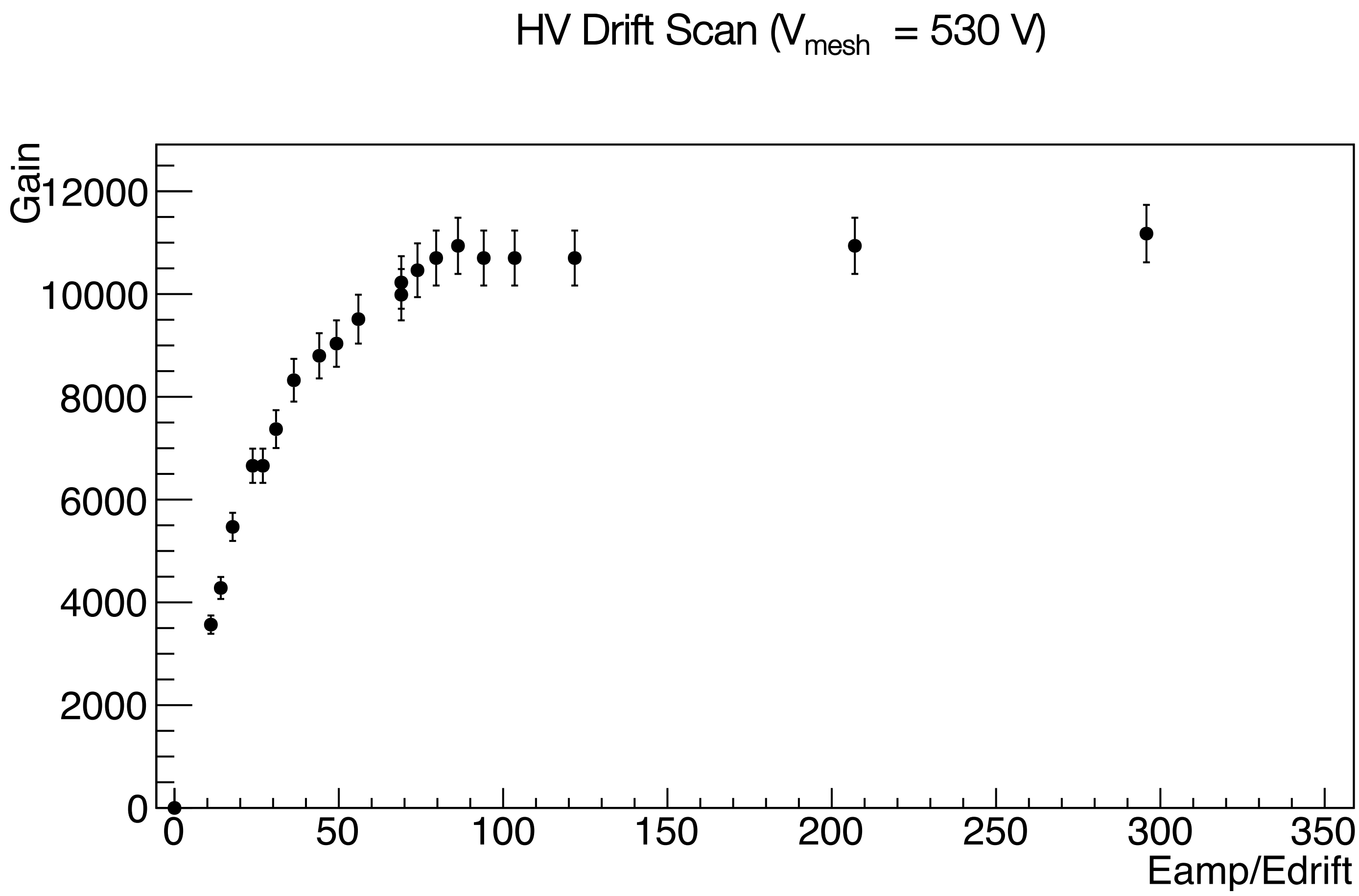
Paddy2 gain curve is compatible with bulk micromegas XY curves and with mm-pad-Version1.

- Signals from pads at ground with 12kHOhm resistor
- separate measurements for left pads and right pads
- Current from mesh
- Signals from mesh: give compatible results, better S/N ratio.
- Signals from mesh: remove the resistor of the HV filter, pads at ground without resistors.
- Signal from the mesh is used later as trigger of the DAQ



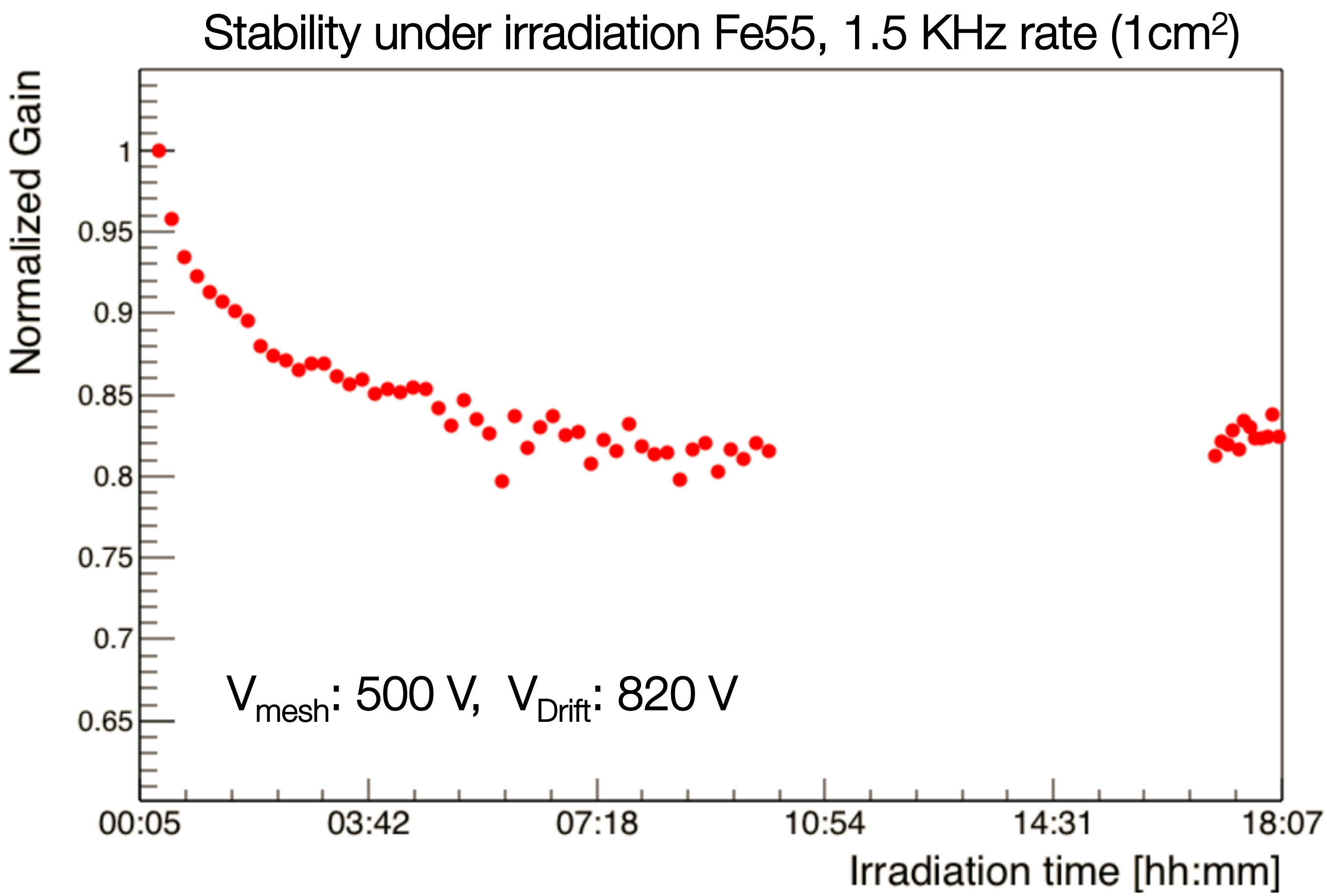


HV DRIFT Scan (measure the effect of the mesh transparency)



- The gain is measured from the current drawn by the detector measuring the counting rate.

Stability under irradiation – short term charging up



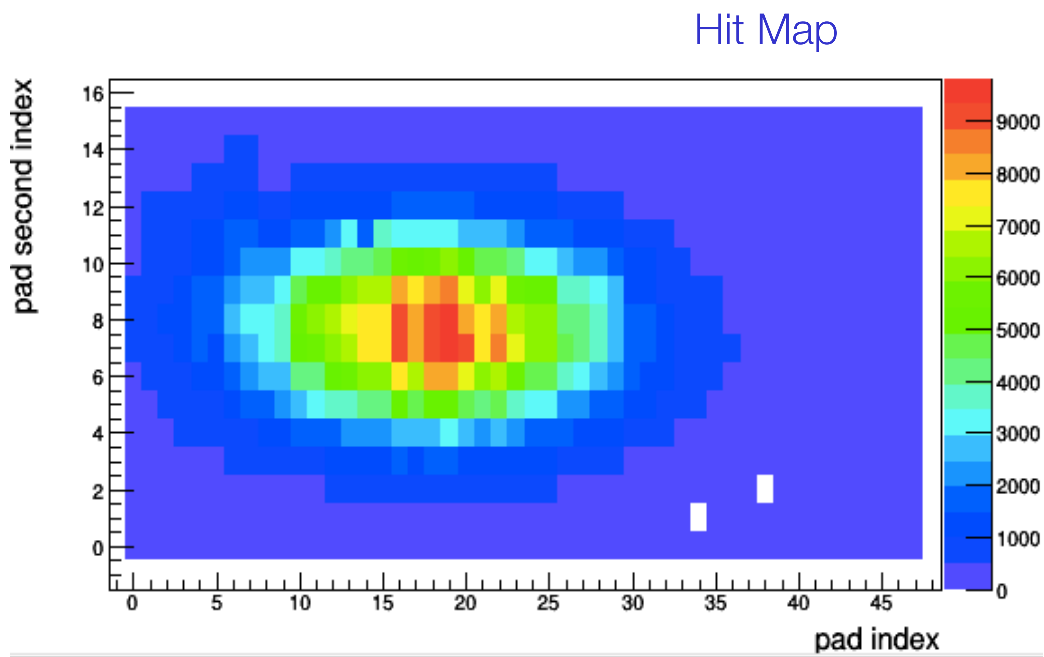
- Gain reduction estimated from mean value of MCA spectra acquired during the night;
- No temperature-pressure corrections;
- Measurement started after about 30 min HV ON without source.

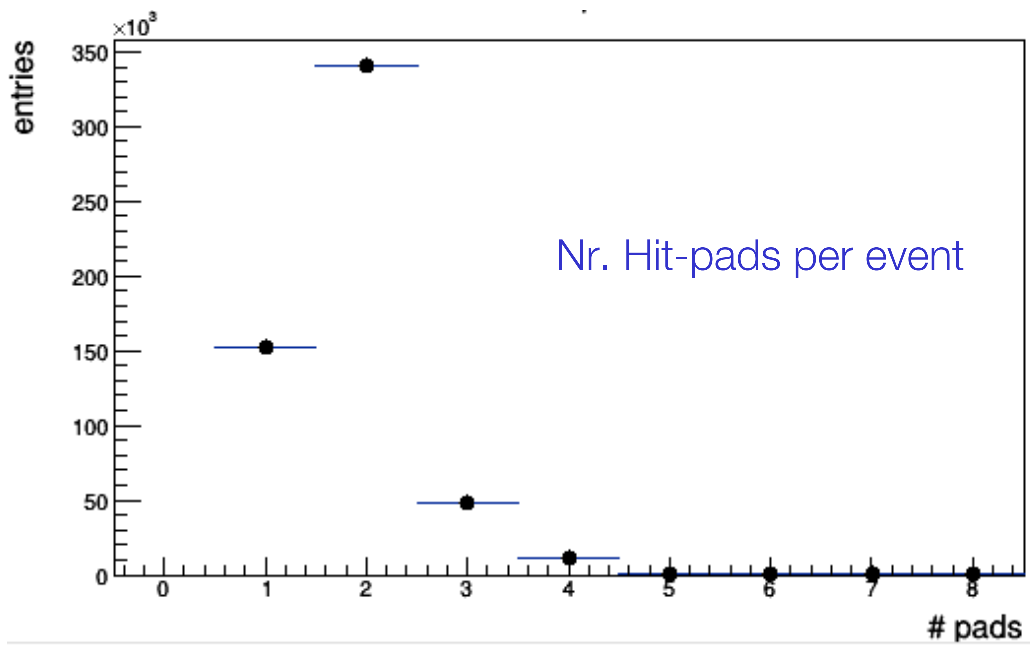
Pads readout under ^{55}Fe irradiation

- First tests of all 768 pads
  Readout done in August with ^{55}Fe source in auto-trigger mode (trigger from the mesh);

- Readout based on APV25 chips + Scalable Readout System (SRS by RD51);

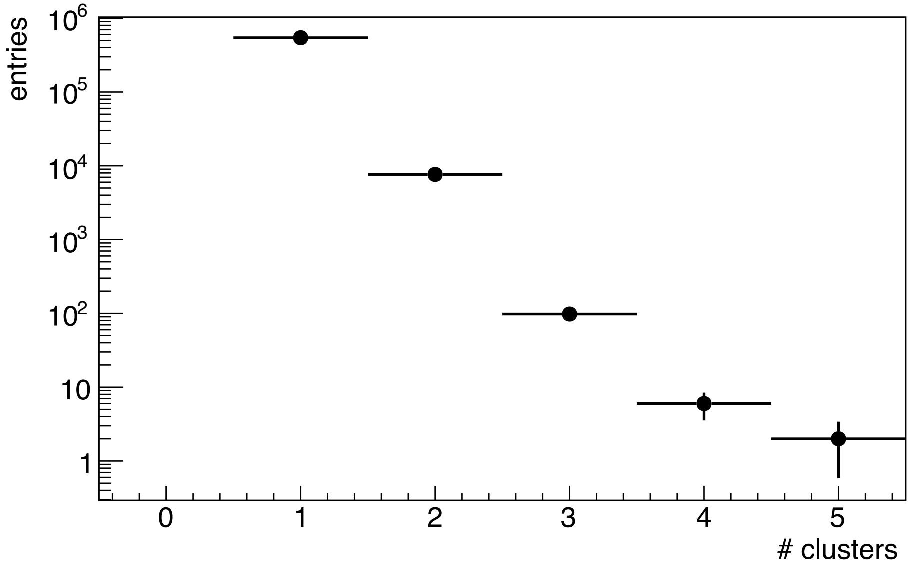
- Gas mixture: Ar/CO2 93/7.



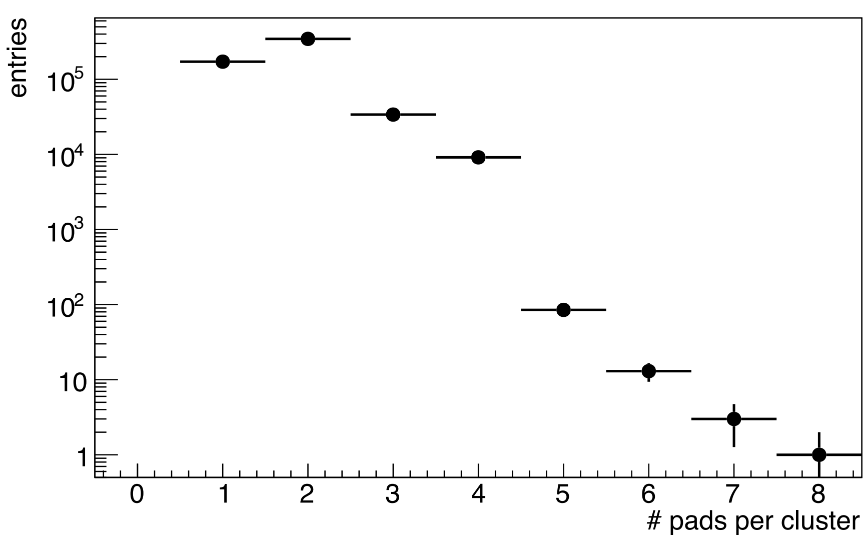


Pads readout under ^{55}Fe irradiation

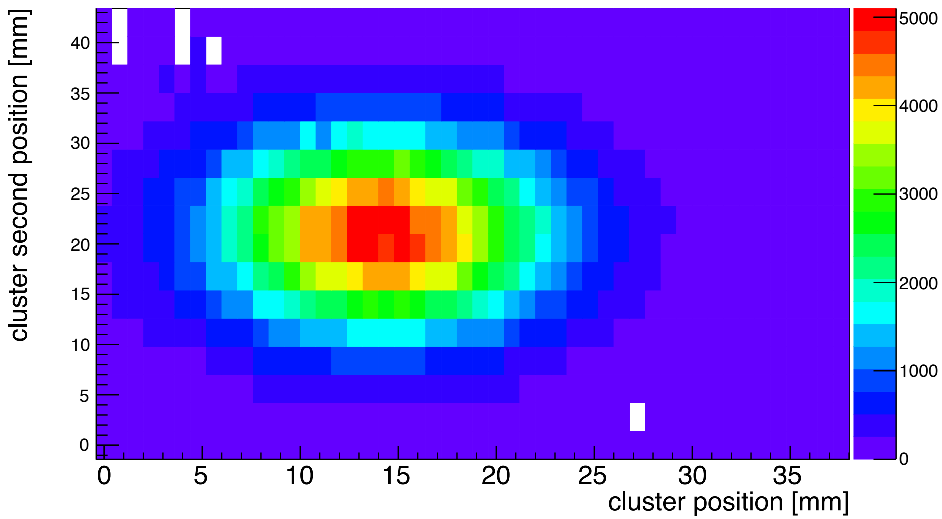
Nr. Clusters per Event



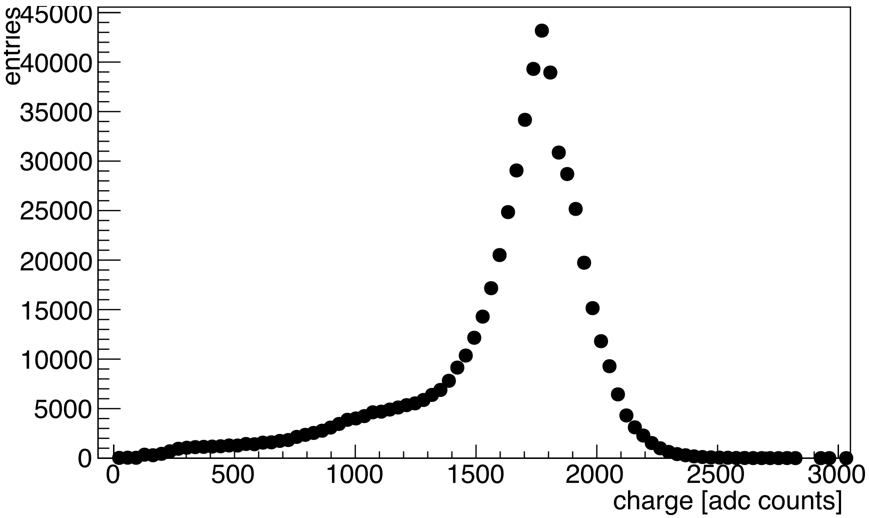
Cluster size



Cluster centroid position



Cluster Charge

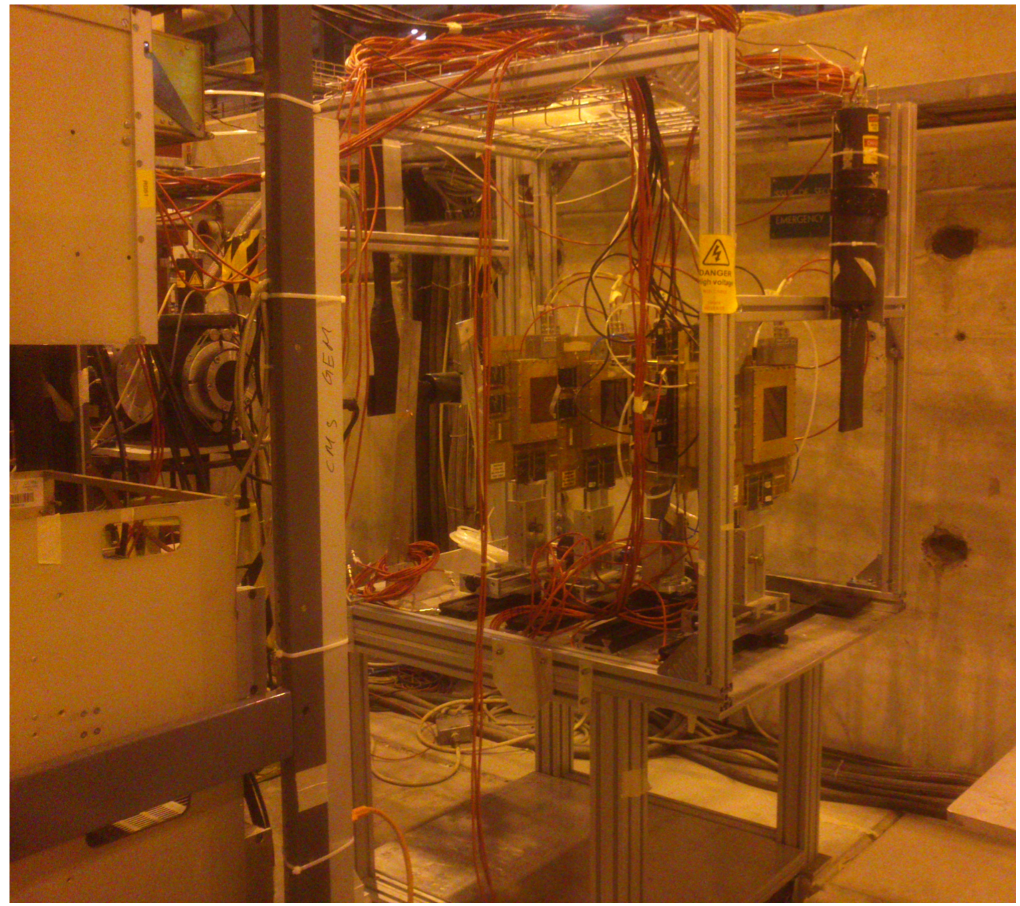


Test beam @ CERN

Test Beam at the SPS H4 CERN Experimental area in October with the RD51 beam period with high energy muons/pions beam.

Test Setup:

- Small-pads MM
- 2 double readout (xy) small size bulk micromegas as reference
- Ar/CO2 93/7 pre-mixed gas
- DAQ: SRS+APV25
- 2 scintillators for the trigger



Foreseen studies

- Efficiency Vs HV;
- Spatial resolution;
- Drift HV scan
- X-Y scan (limited, the detector is only ~50x50 mm^2)
- Inclined tracks
- Low/high intensity beam → rate capability

ONLY results with muons presented today

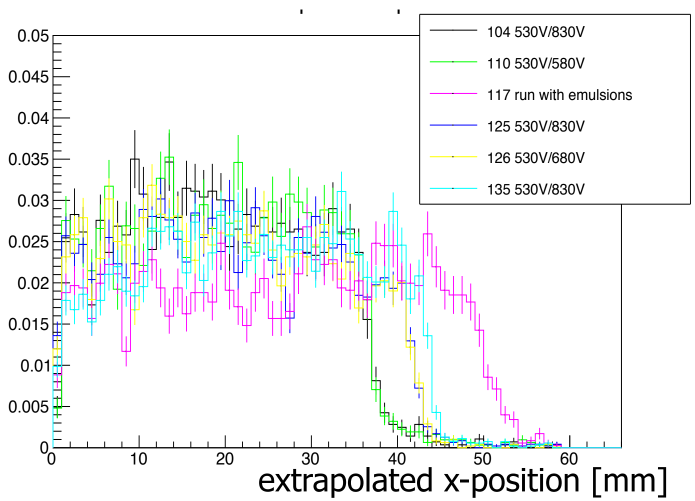
Micromegas reference tracks

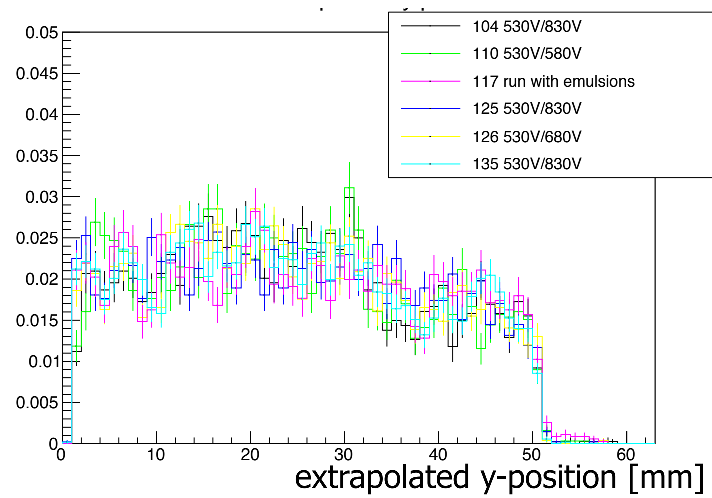
- x-y view (orthogonal to the beam direction) micromegas used as reference tracking
- Tracks are extrapolated at the position of the Pad-MM and used to measure efficiency and resolution.
- The extrapolation error of the track is of the order of 50μm in both coordinates.

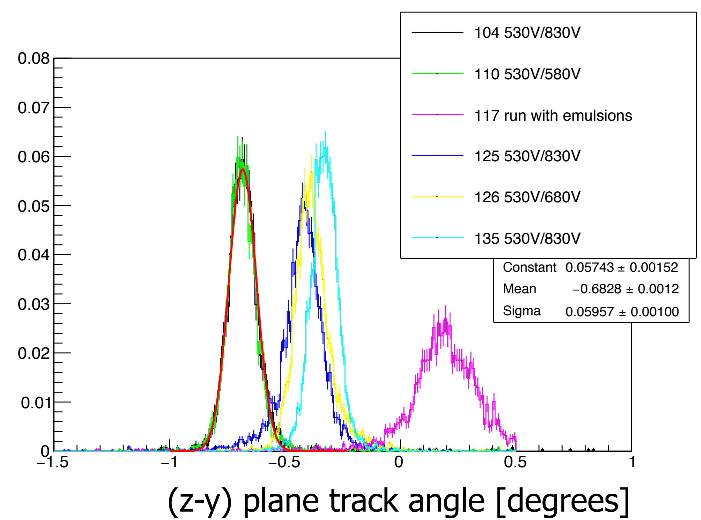
- The different positioning of the frame during data taking are clearly visible.
- In most of the runs **we cover ~40mm at the PAD MM position** (because of beam profile and trigger/detectors relative positioning)

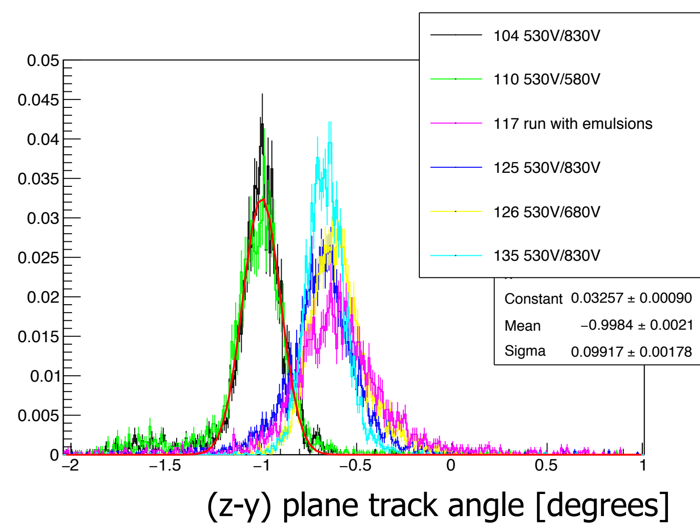
Tracks angle distributions have a width of:

- ~0.06 degrees in X
- ~0.1 degrees in Y

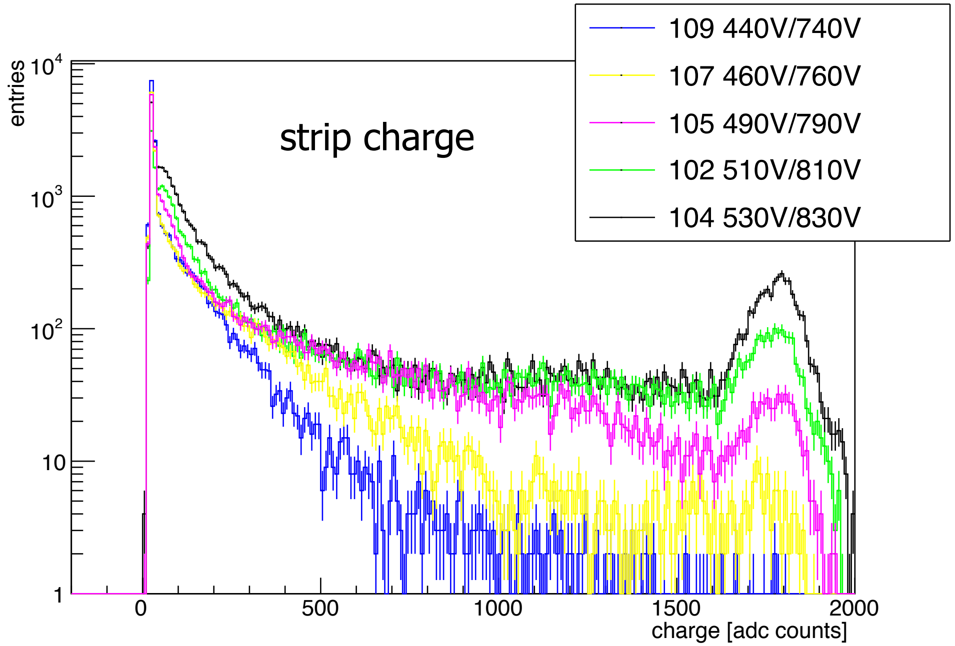






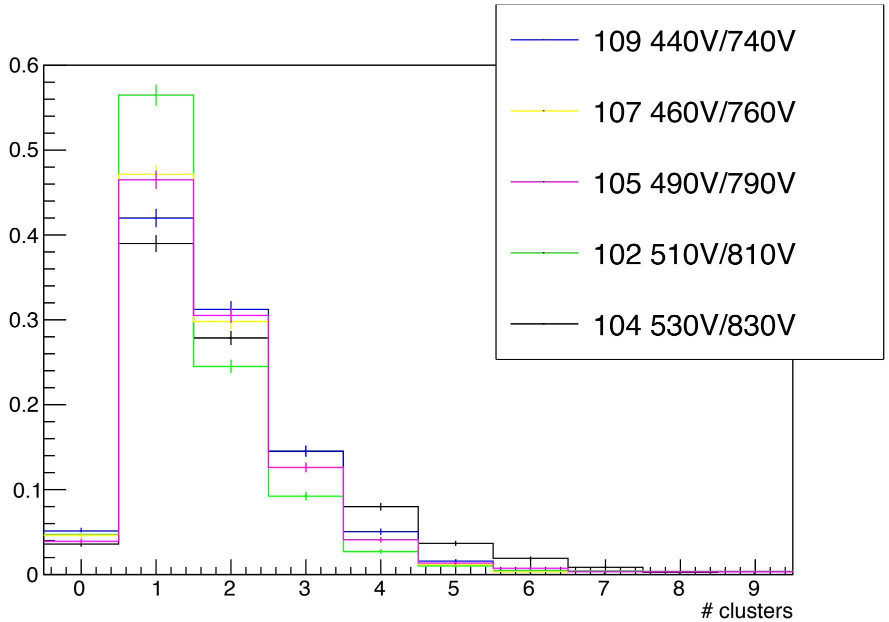


Strip charge and clusters



Strip charge for different runs of a V_{amp} scan (V_{drift} was fixed at V_{amp}+300V):

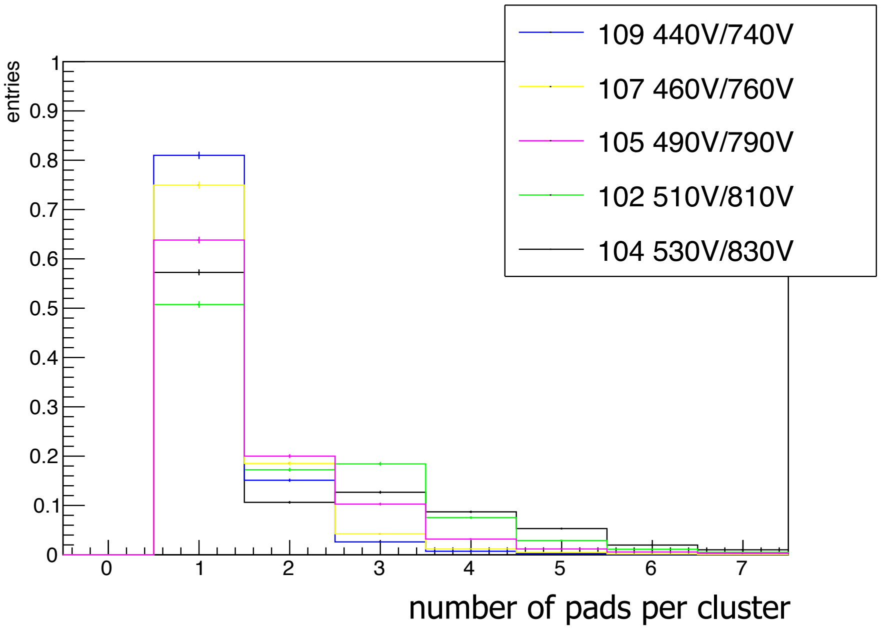
- with increasing V_{amp} strip charge increases;
- saturation peak increases as well.

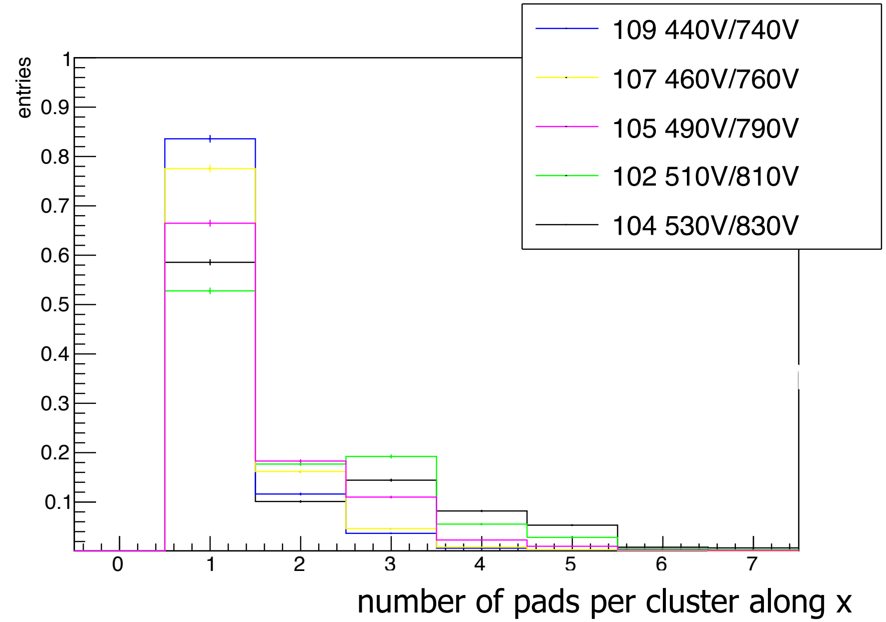


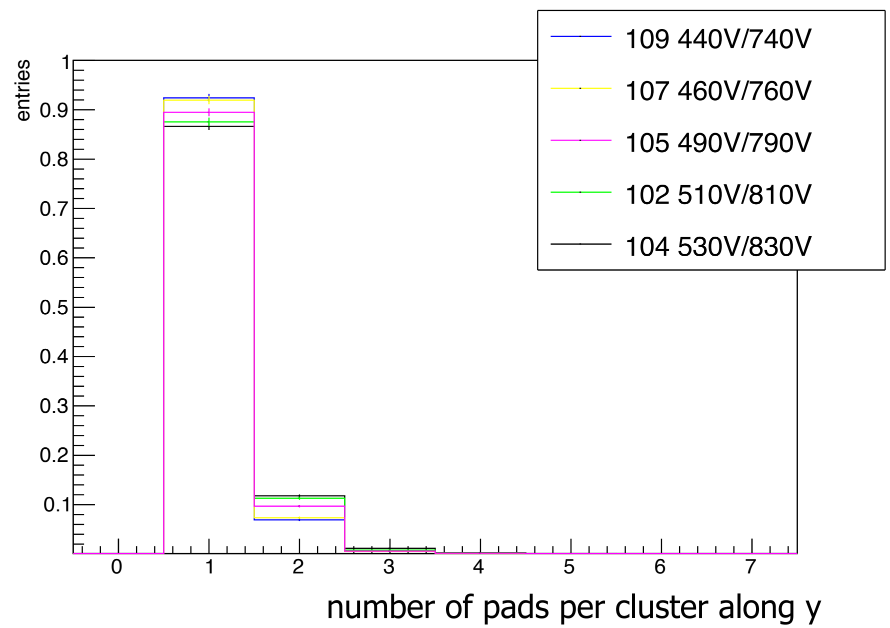
Number of clusters per event for different runs of a V_{amp} scan (V_{drift} was fixed at V_{amp}+300V):

- cluster are simply defined as neighboring strips in both direction (accurate noise reduction and refined algorithm are under study)

cluster size

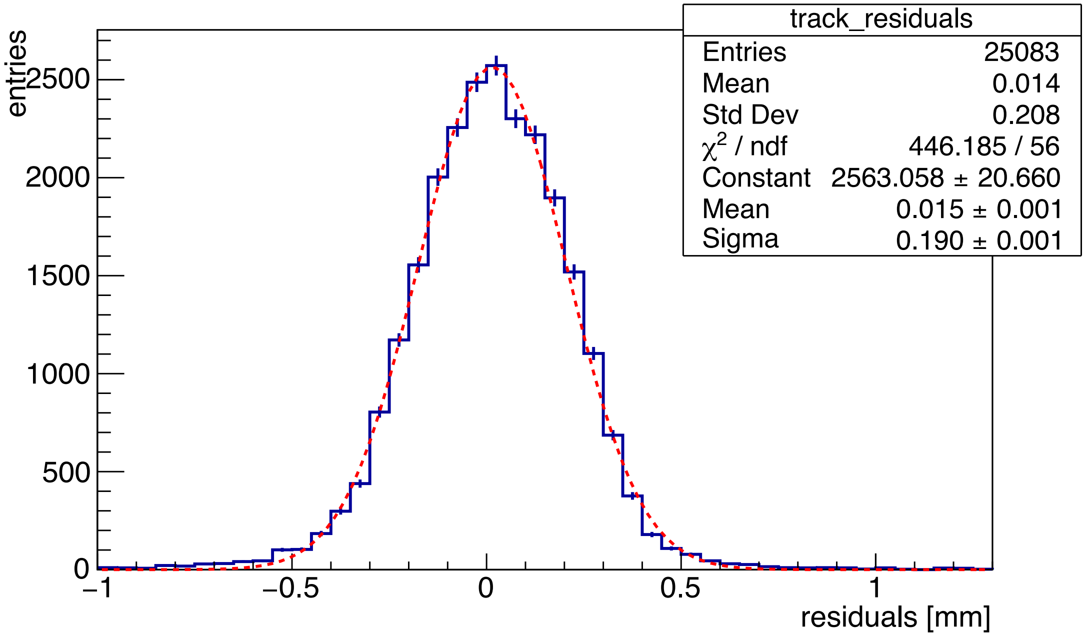


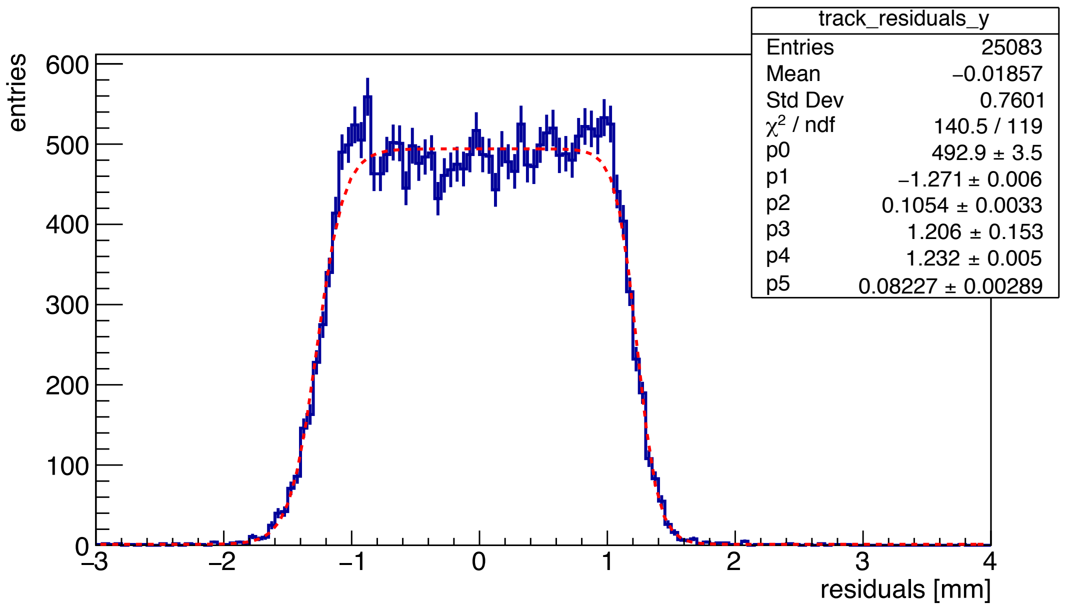




number of pads distribution divided in the two coordinates:
clusters are extended more in the small pitch direction (x) as expected.

position resolution





Position resolution is obtained by the difference btw the position measured from Paddy and that extrapolated by the Tmm tracks.

- Alignment and rotation correction were applied.

Residuals distribution:

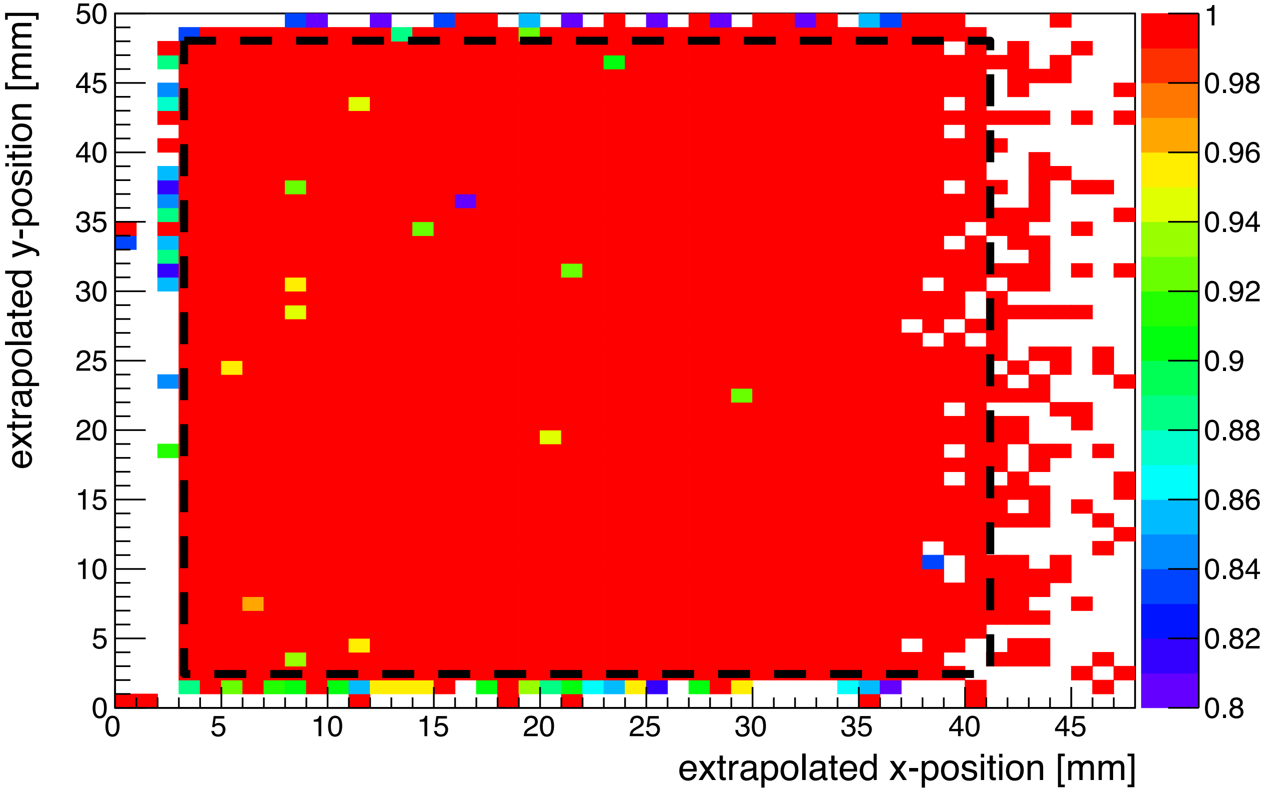
- track extrapolation error (~50μm) not subtracted

- **190 μm along x**
- **~800 μm along y**

Cluster efficiency

Cluster efficiency:

- for a Tmm track extrapolated in a given position we measure the fraction of events with at least 1 cluster in the event, regardless its distance from the track.



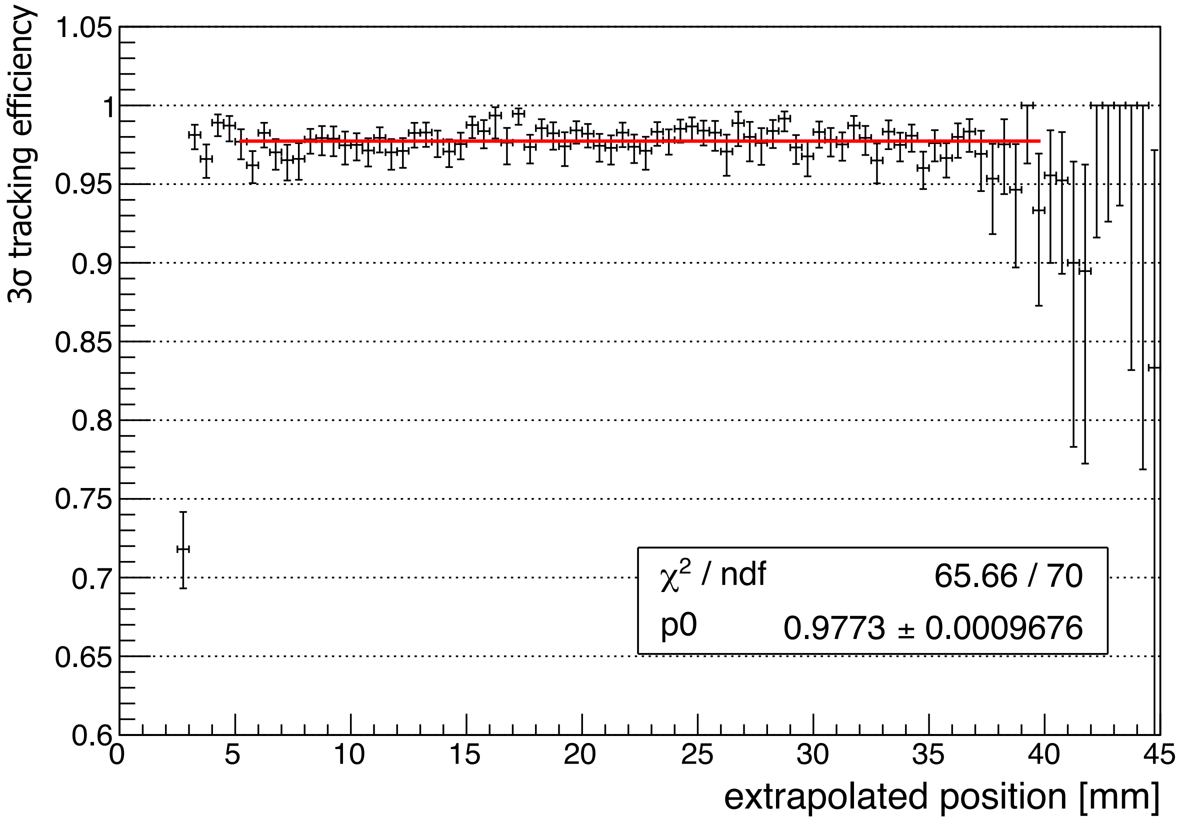
N.B.: the histogram is cut at 0.8

Because of the different active area of the detectors, the relative alignment and the beam profile, boundary regions suffers a low statistics → a **"fiducial area"** was defined to measure the efficiency.

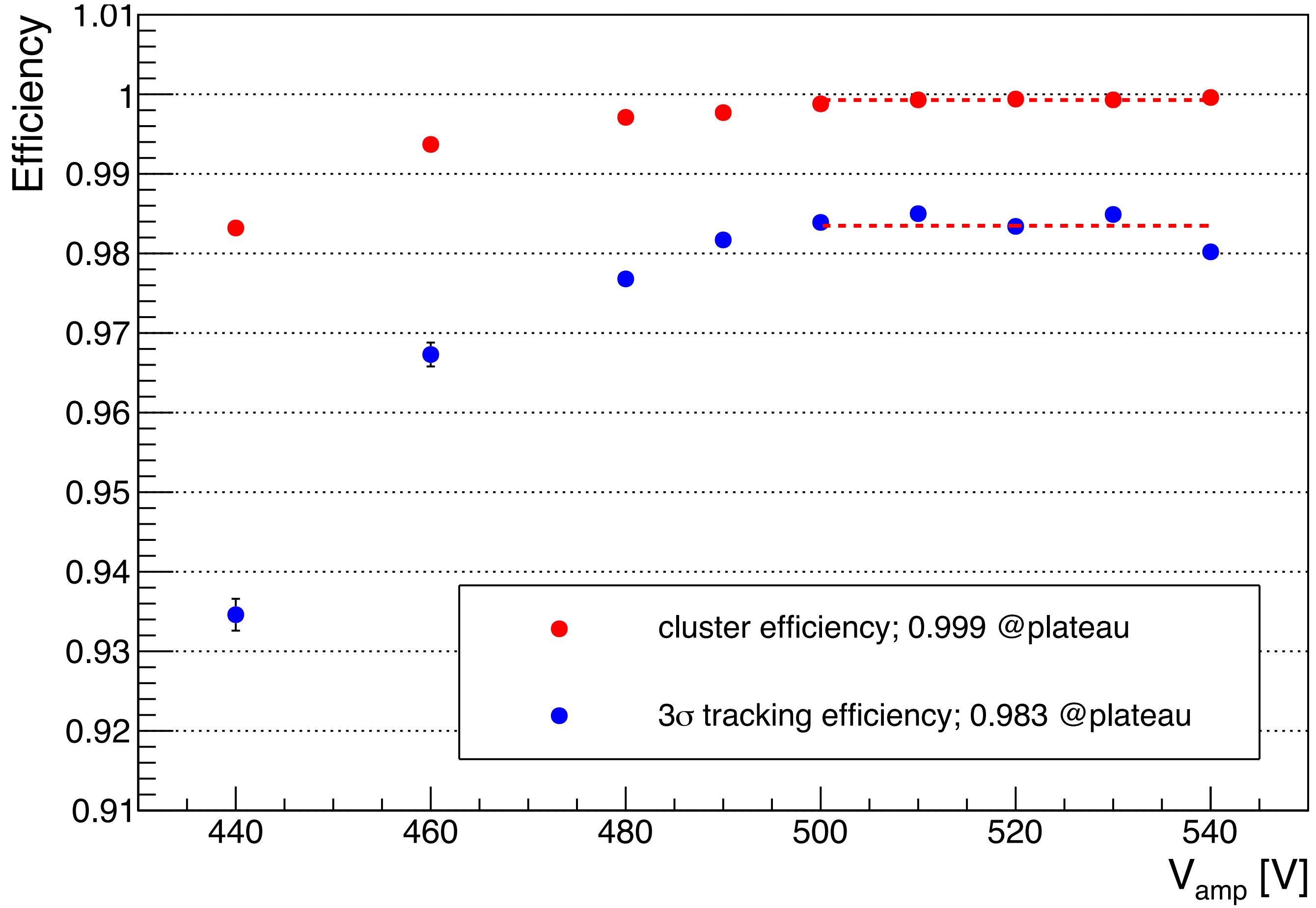
Tracking efficiency

Tracking efficiency:

- an event is considered efficient if a cluster is within 3σ (600μ) from the extrapolated Tmm track.

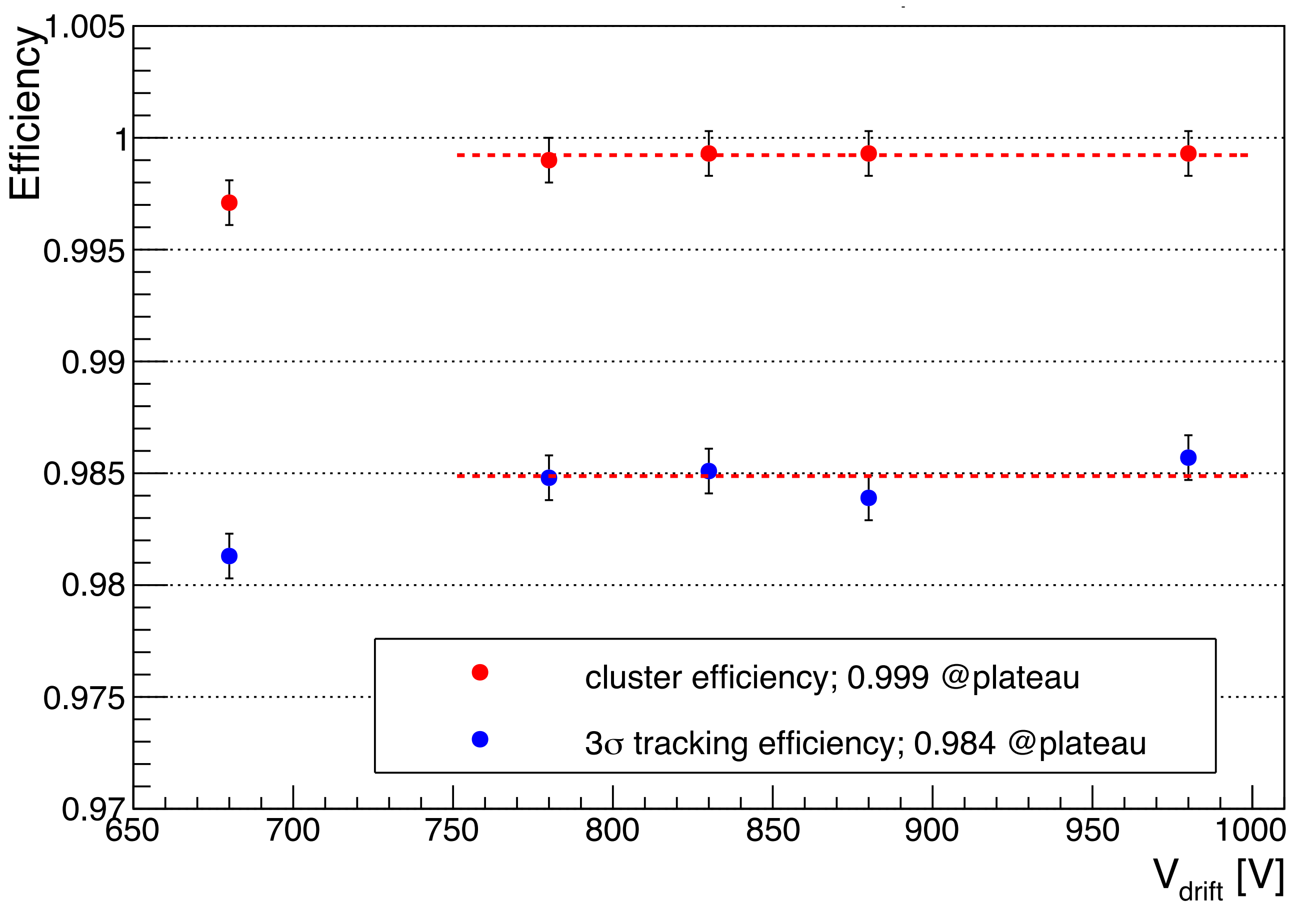


Efficiency dependence on amplification voltage



The plateau efficiency value for the tracking efficiency is ~1% lower than expected. This could be due to delta rays but we are still investigating both noise or reference track accuracy.

Efficiency dependence on drift voltage

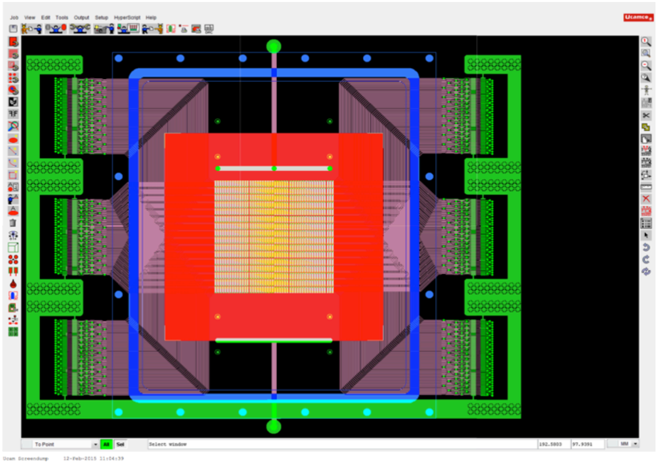


V_{amp}=530 V

The efficiency is rather constant.
The small drop at lower V_{drift} is under investigation.
We measured a gain decrease with increasing V_{drift} which would eventually result in the opposite behavior.

What's next: Large size Prototypes

Layout not scalable for large dimensions (very dense routing)



New R&D on MM mini-pad Detectors WITH EMBEDDED (back wire-bonded) electronics.

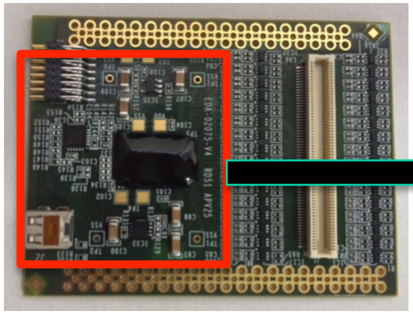
DESIGN OF A FIRST PROTOTYPE :

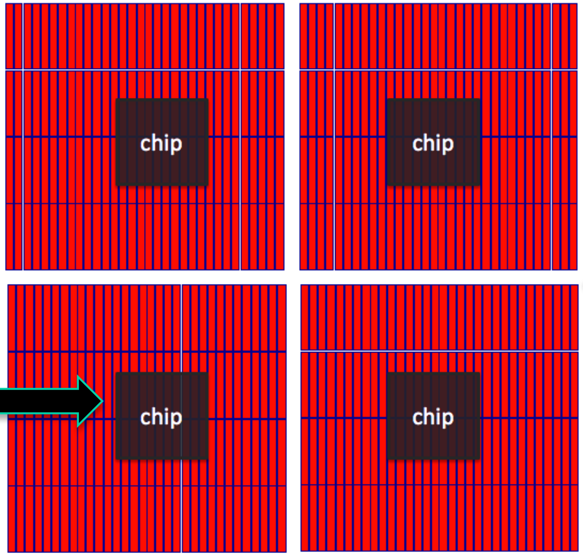
- 4 regions with 32x4 mini-pad
- Pitch 1x8 mm^2
- Each region can be readout by a back embedded APV25 chip with associated Front-end electronic reassembled on the detector board

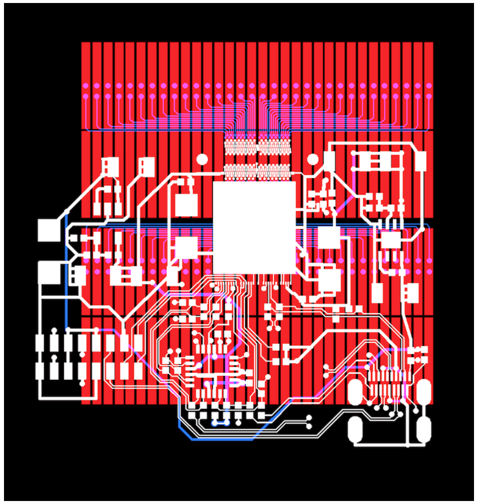
FIRST TIME EVER a MPGD with Embedded Electronics

- Pad readout
- Fully scalable

The RD51 front-end board with APV25







CONCLUSIONS

- We have started a R&D on small-pads resistive micromegas for operations under high rates;
- Two prototypes have been built;
- The construction technique has been optimized;
- Tests with both a ^{55}Fe source and a muon beam show that the second prototype looks promising;
- Several things should be addressed and the analysis is ongoing;

- Future R&D will include studies with different resistivities;

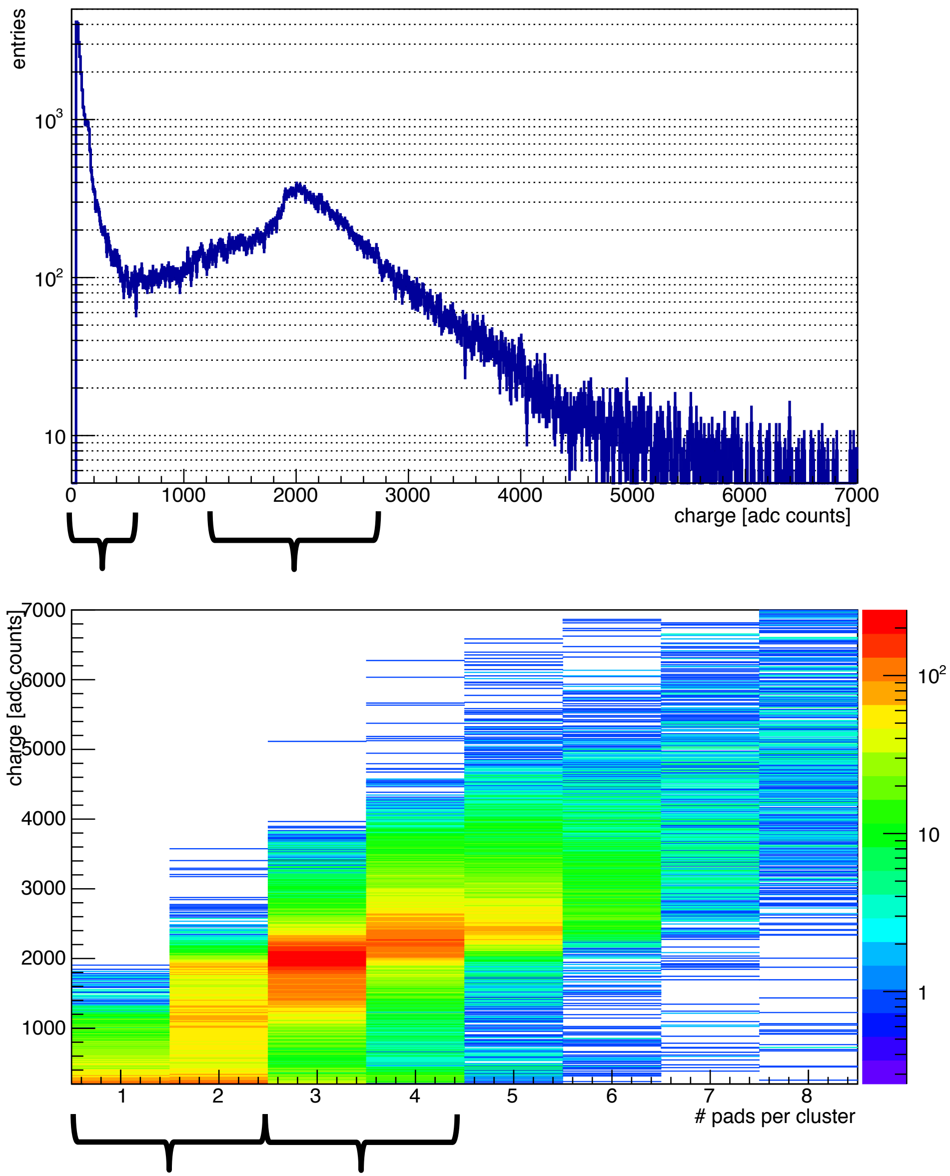
- At the same time a R&D phase has started on small-pads Micromegas WITH EMBEDDED electronics, in order to establish a full scalable configuration.

Acknowledgements:

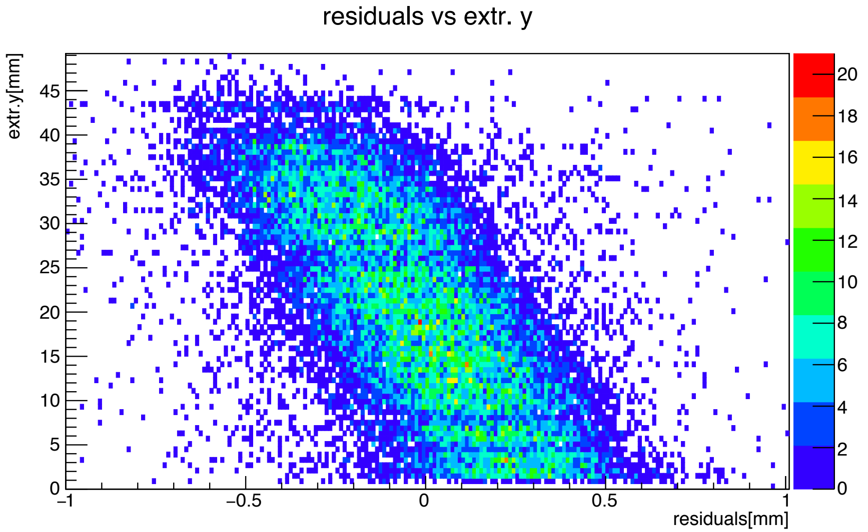
- Rui De Oliveira and Antonio Teixeira (CERN EP-DT) for: ideas, input, layout, construction,…
- The GDD lab at CERN and the RD51 collaboration for the valuable support for all the measurements both in the lab and during the test beam

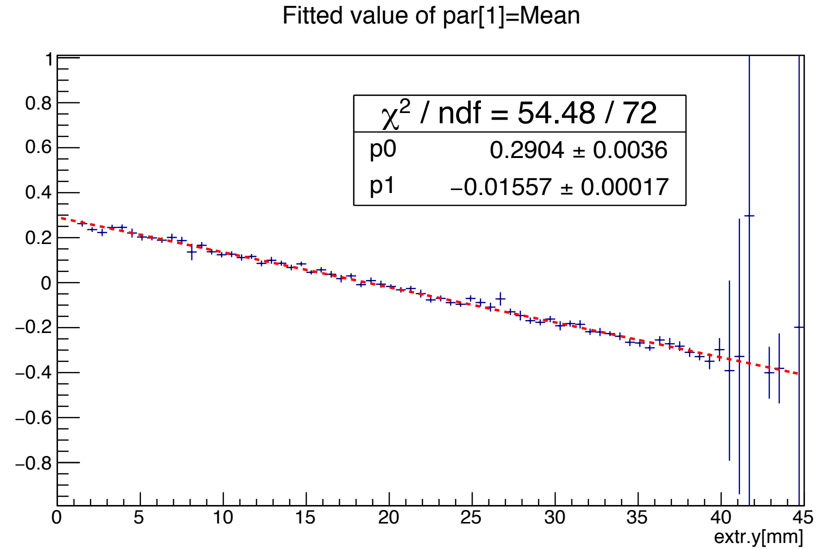
Backup slides

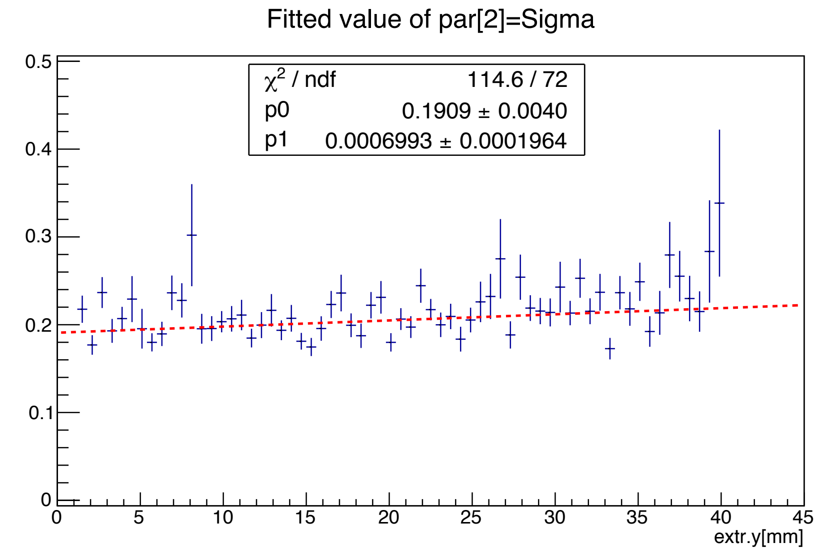
Cluster charge



Resolution X-coordinate







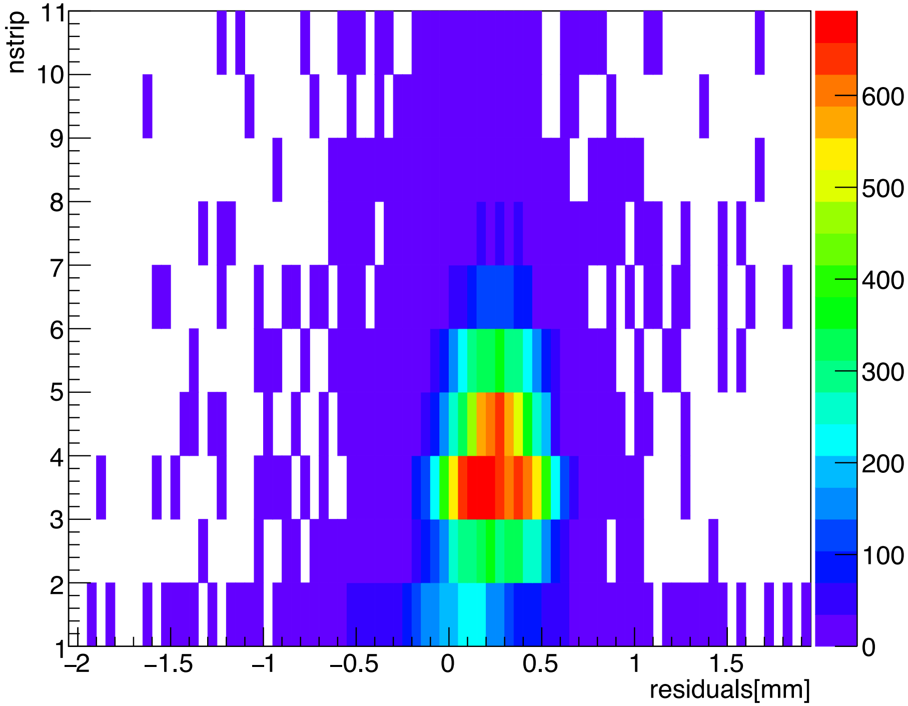
To correct for this y-dependence the x-coordinate from Paddy is:
x_{corr}=x+p1*y_extr
(p0 is just an overall shift...)

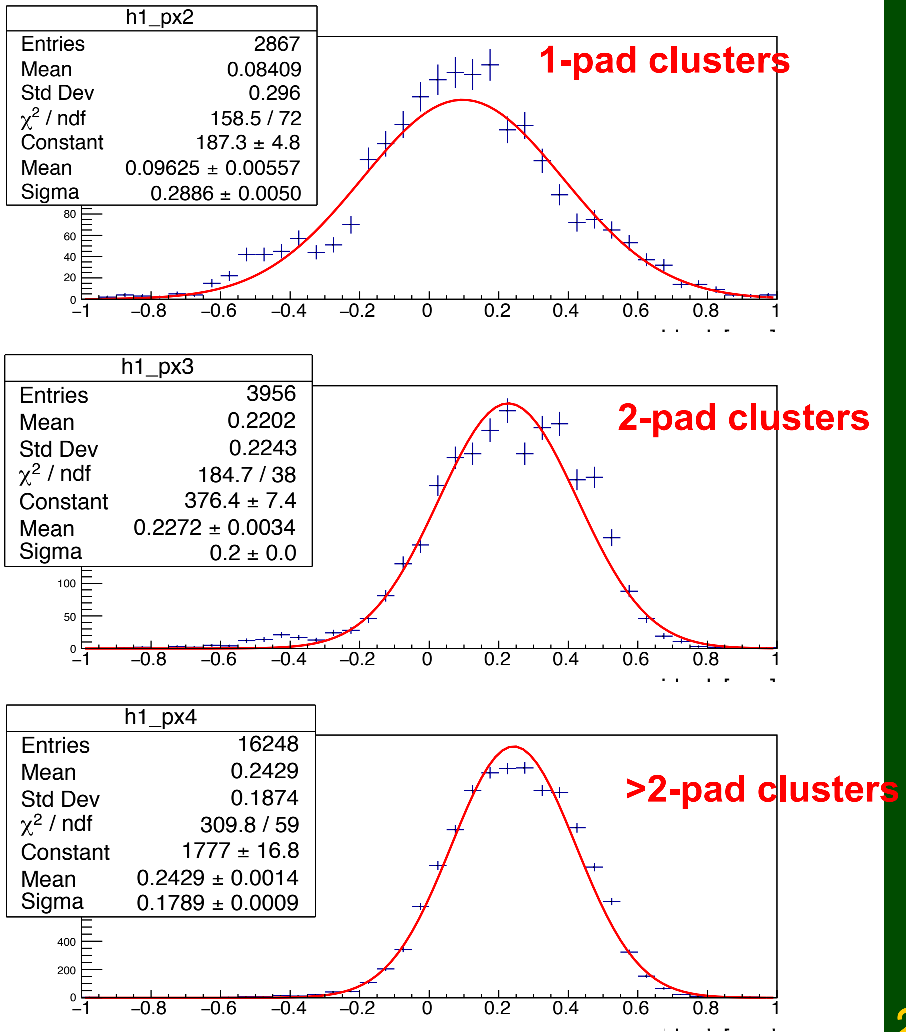
Using only info from paddy (do not rely on external tracker) → x_{corr}=x+p1*y

This is basically a rotation of tanϑ=-0.016 → ϑ~1°

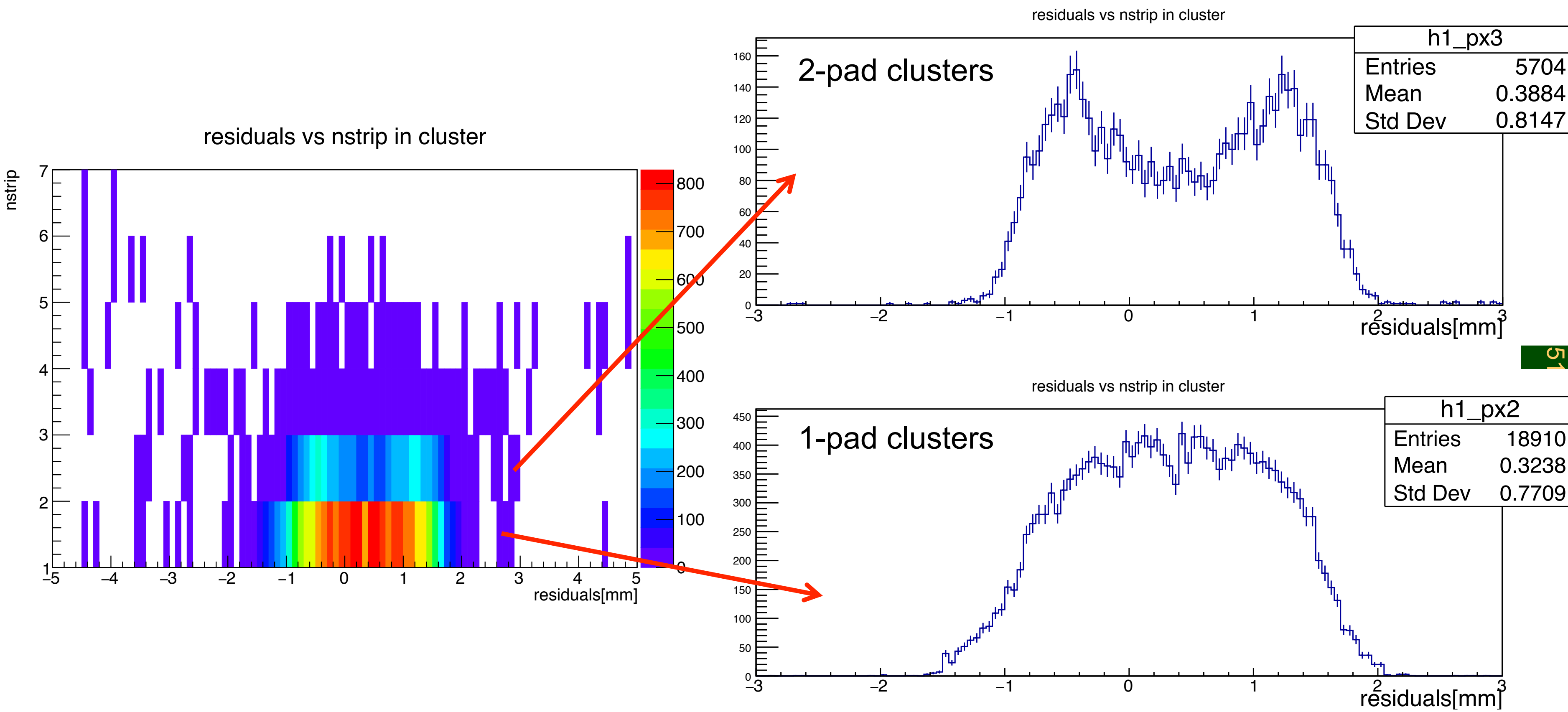
Resolution X-coordinate

residuals are computed wrt the extrapolated Tmm track
after the correction on the x-coordinate from paddy.

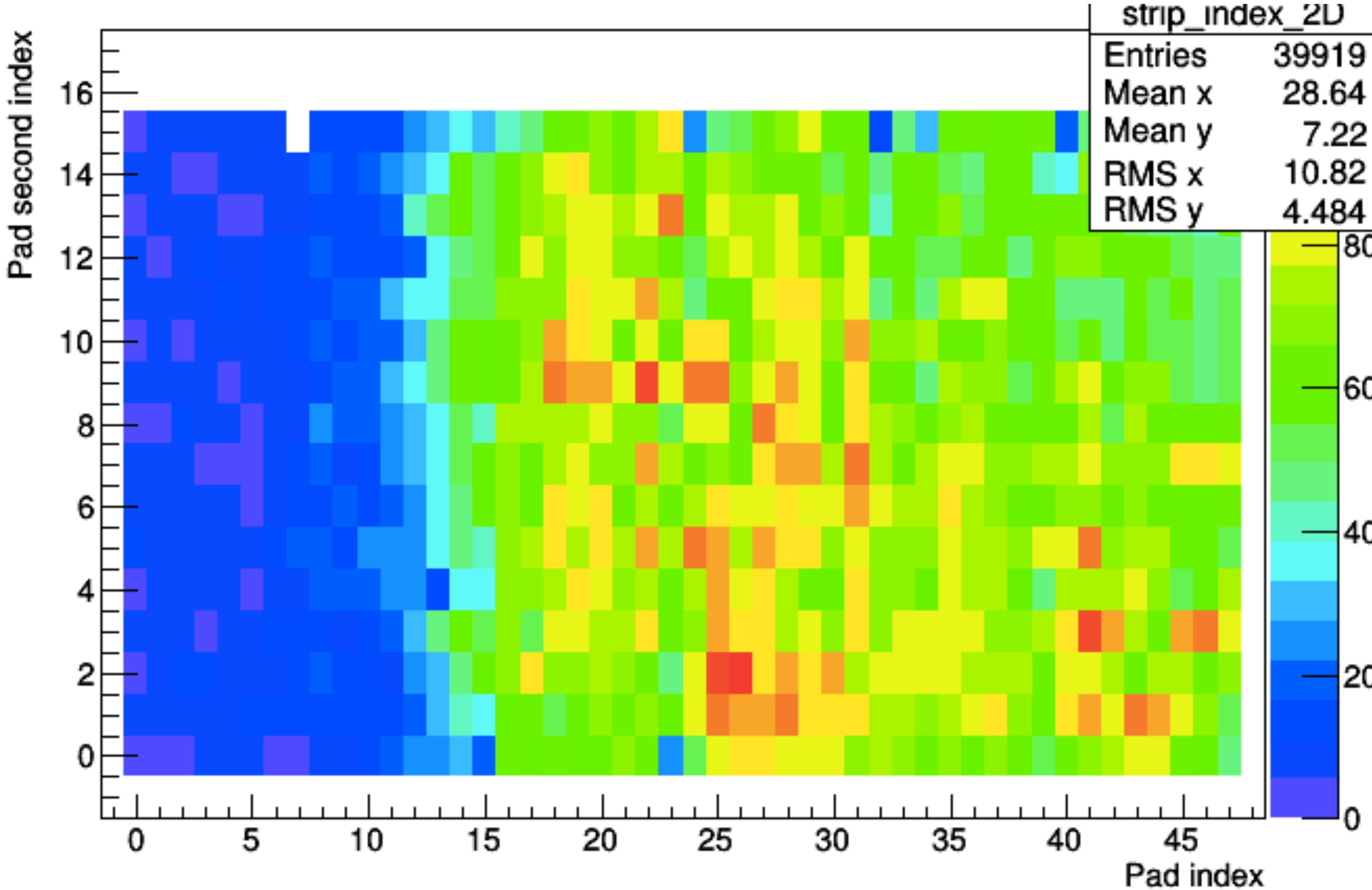




Resolution along Y



run111



strip_index_2D
Entries 39919
Mean x 28.64
Mean y 7.22
RMS x 10.82
RMS y 4.484
Pad second index
Pad index
0
2
4
6
8
10
12
14
16
0
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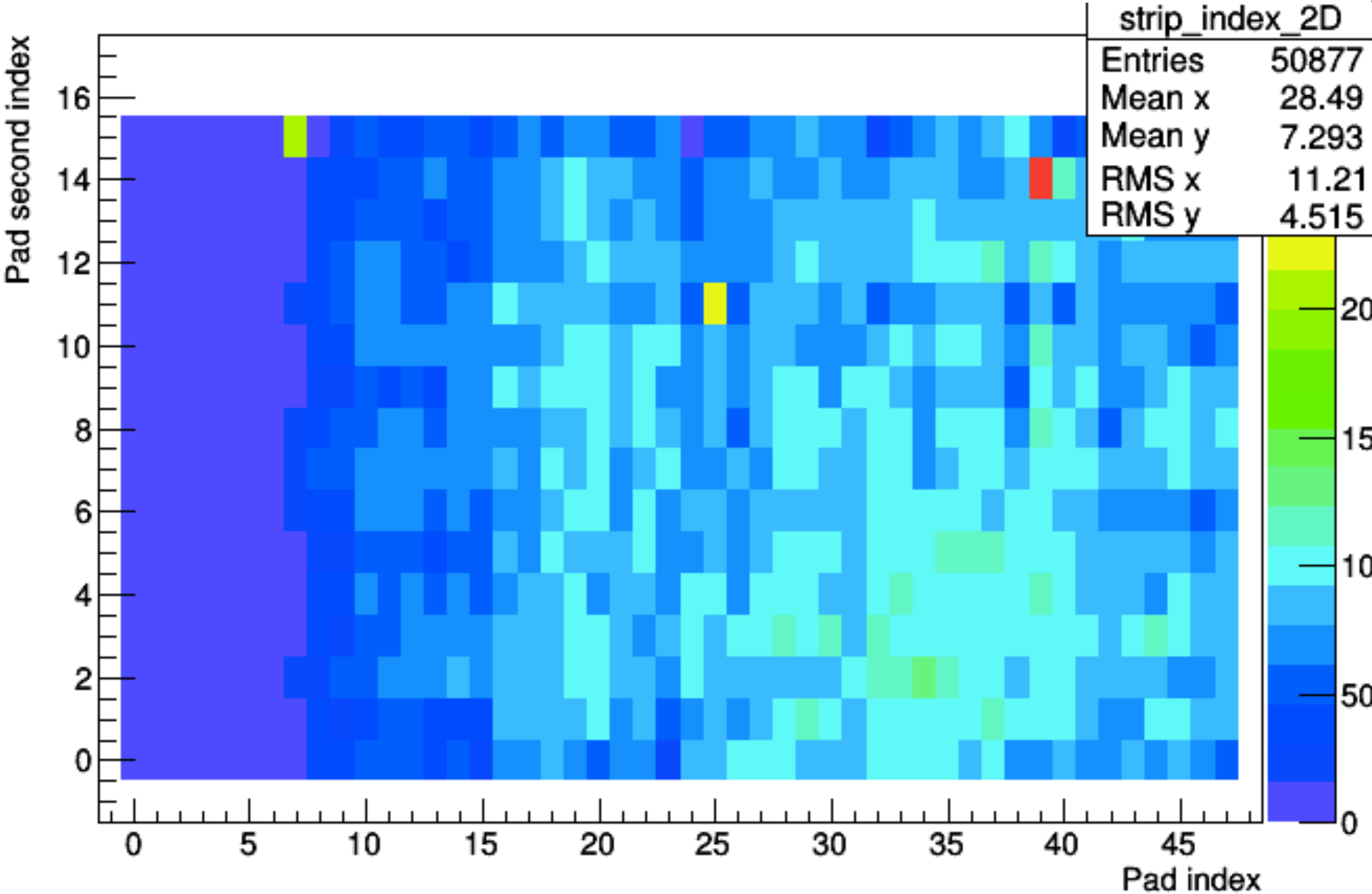
10
15
20
25
30
35
40
45
0
20
40
60
80

run 125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Entries 50877
Mean x 28.49
Mean y 7.293
RMS x 11.21
RMS y 4.515
Pad second index
Pad index
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2
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8
10
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20
25
30
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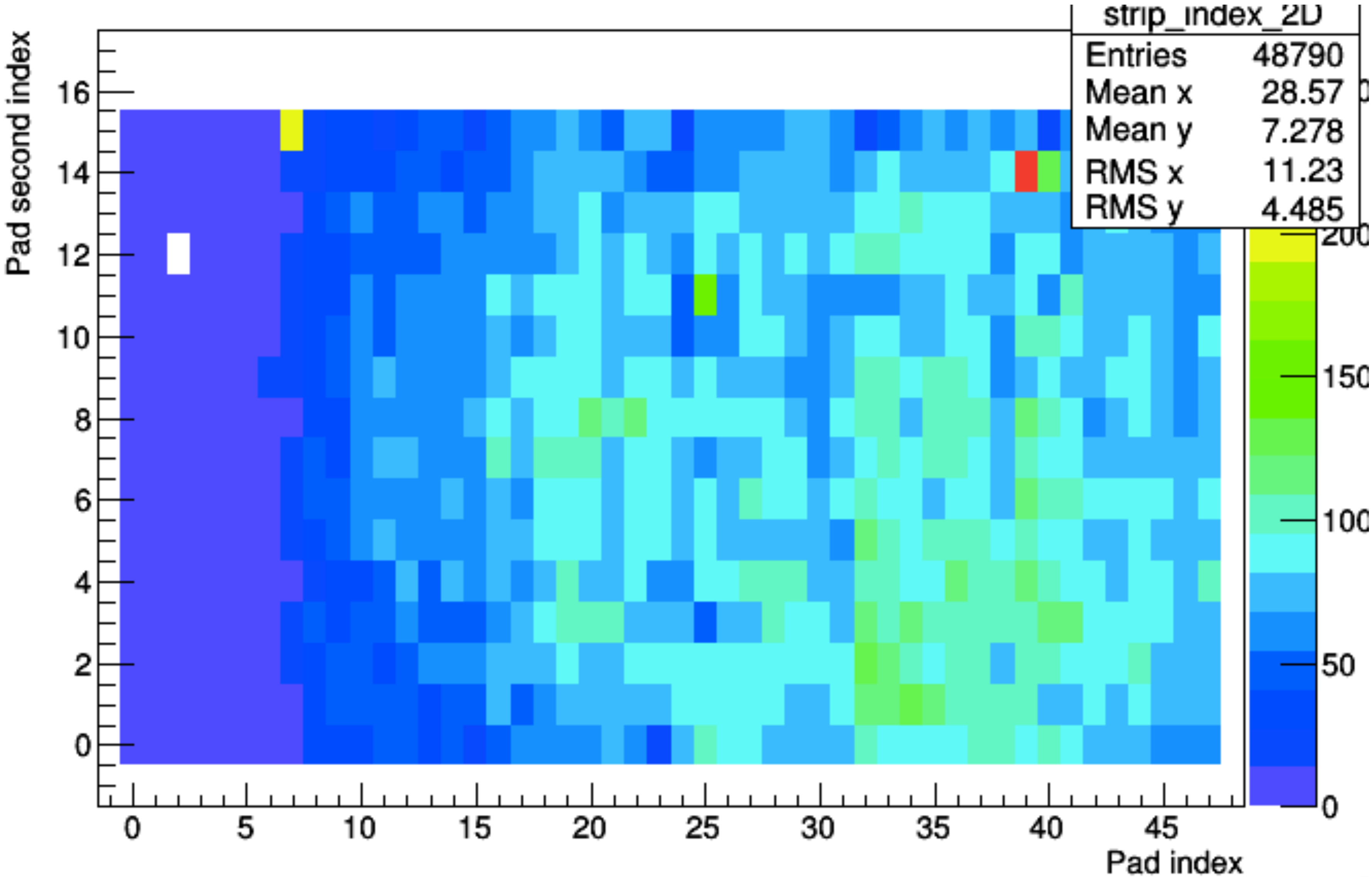
40
45
0
50
100
150
200

run 126


strip_index_2D
Entries 48790
Mean x 28.57
Mean y 7.278
RMS x 11.23
RMS y 4.485
Pad second index
Pad index
0
2
4
6
8
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