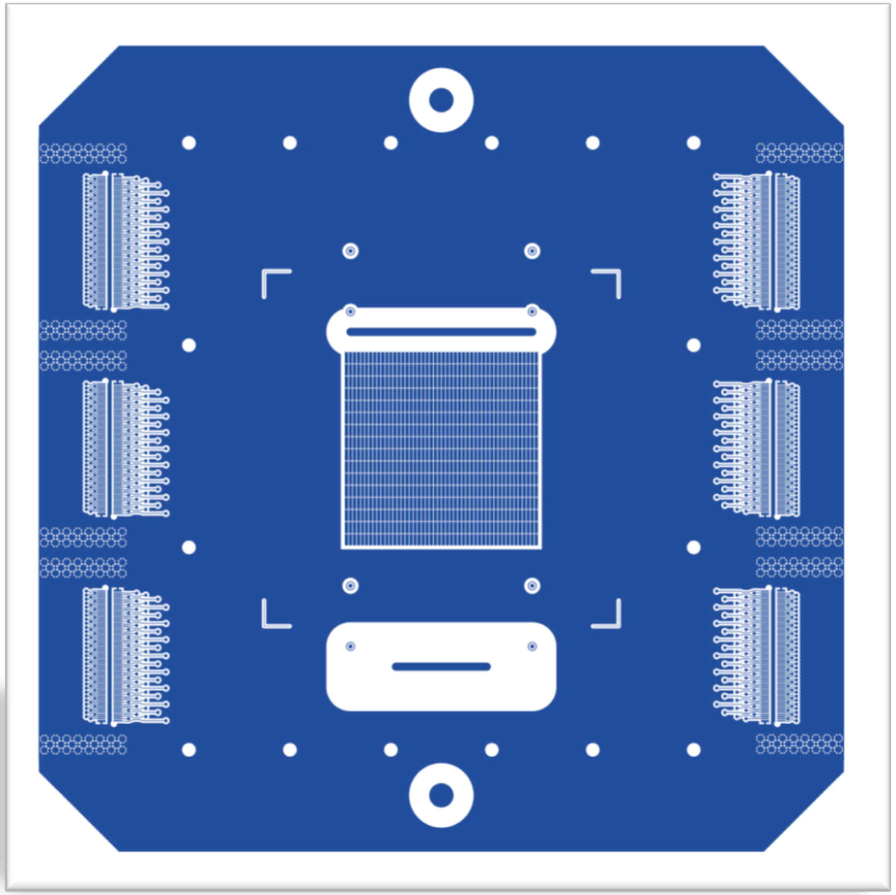
UPDATE ON SMALL-PAD RESISTIVE MICROMEGAS AKA **PADDY**

M. Iodice for the full GROWING team of Paddy enthusiasts

(INFN Lecce, Napoli, Roma Tre, and CERN)

M. Alviggi, M. Biglietti, M. T. Camerlingo, V. Canale, M. Della Pietra, C. Di Donato, E. Farina, S. Franchino, C. Grieco, P. Iengo, M. Iodice, L.Longo, F. Petrucci, A. Renardi, E. Rossi, G.Salamanna, G. Sekhniaidze, O. Sidiropoulou, V. Vecchio

RD51 Mini-week – December 15th, 2017



R&D based on previous developments of Pad micromegas for COMPASS and for sampling calorimetry :

- C. Adloff et al., Construction and test of a 1x1 m^2 Micromegas chamber for sampling hadron calorimetry at future lepton colliders, Nucl. Inst. Meth. A 729 (2013) 90–101.
- M. Chefdeville et al. Resistive Micromegas for sampling calorimetry, a study of charge-up effects, Nucl. Inst. Meth. A 824 (2016) 510.
- F. Thibaud at al., Performance of large pixelised Micromegas detectors in the COMPASS environment, JINST 9 (2014) C02005.

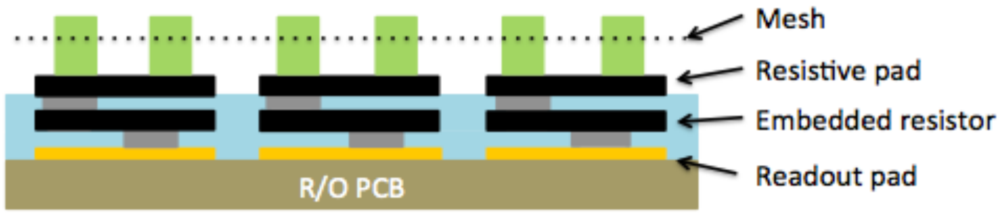
Reminder on Paddy Prototypes – Paddy Series 1 & Series 2

Two series of small pad resistive micromegas prototypes built so far with **pad dimension 3 mm²**.

The two series differ for the implementation of the resistive charge protection system :

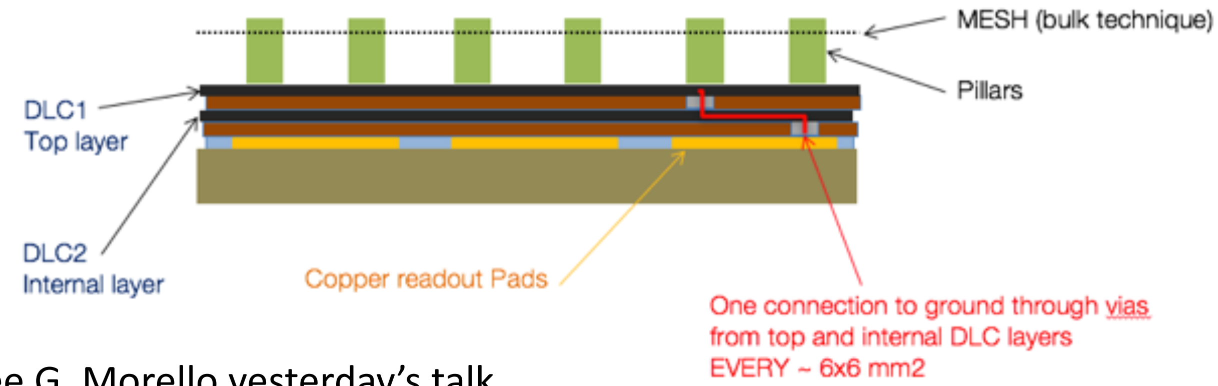
SERIES 1

- Small Pad pattern with EMBEDDED resistors.
- Screen printing technique
- Patterned resistive layer



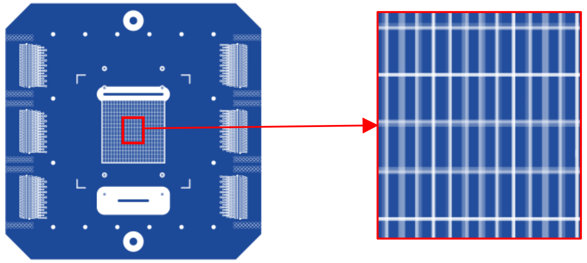
SERIES 2

- Double DLC resistive layer with a resistivity of ~50-70 MΩ/☐
- Connection to ground through resistive vias
- Design driven by recent developments of μ-RWell detector
- Uniform resistive layer

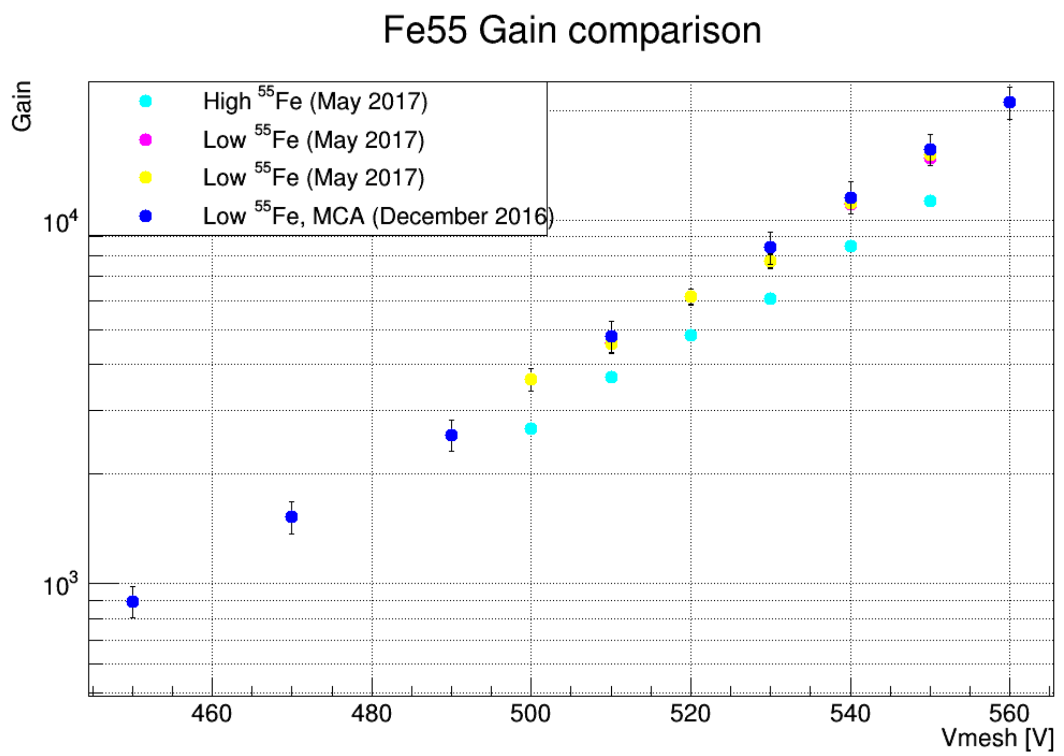


see G. Morello yesterday's talk

- All prototypes with same anode configuration: Matrix of 48x16 pads
- Pad size 0.8mm x 2.8mm (pitch of 1 and 3 mm in the two coordinates)
- Total # Channels: 768

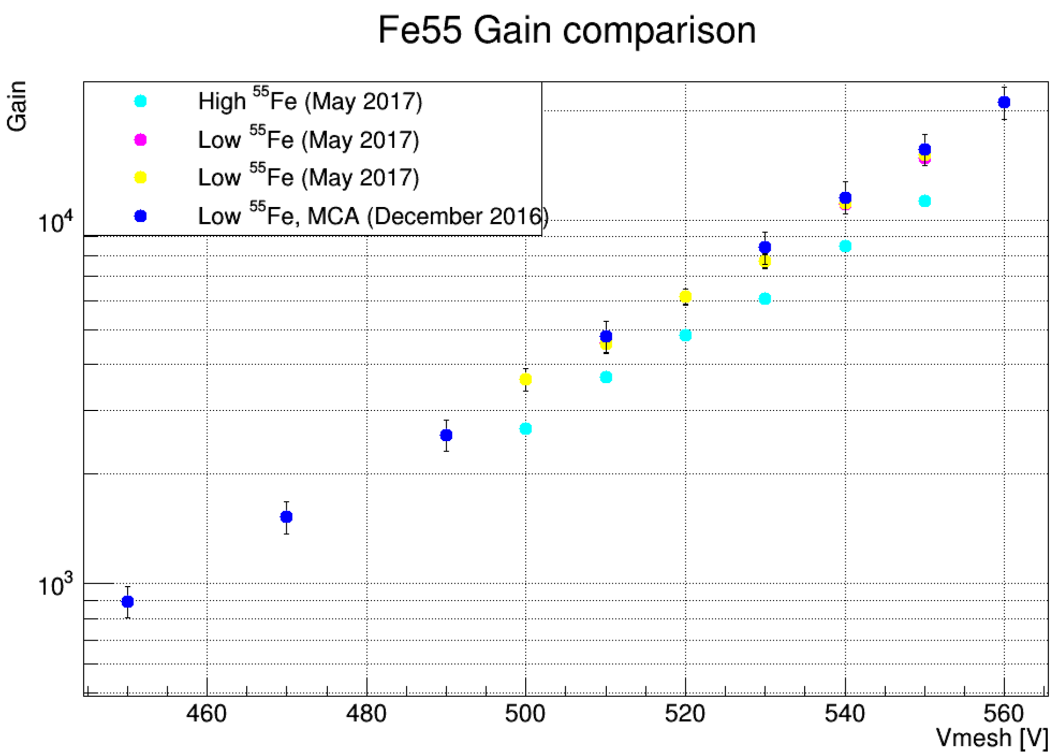


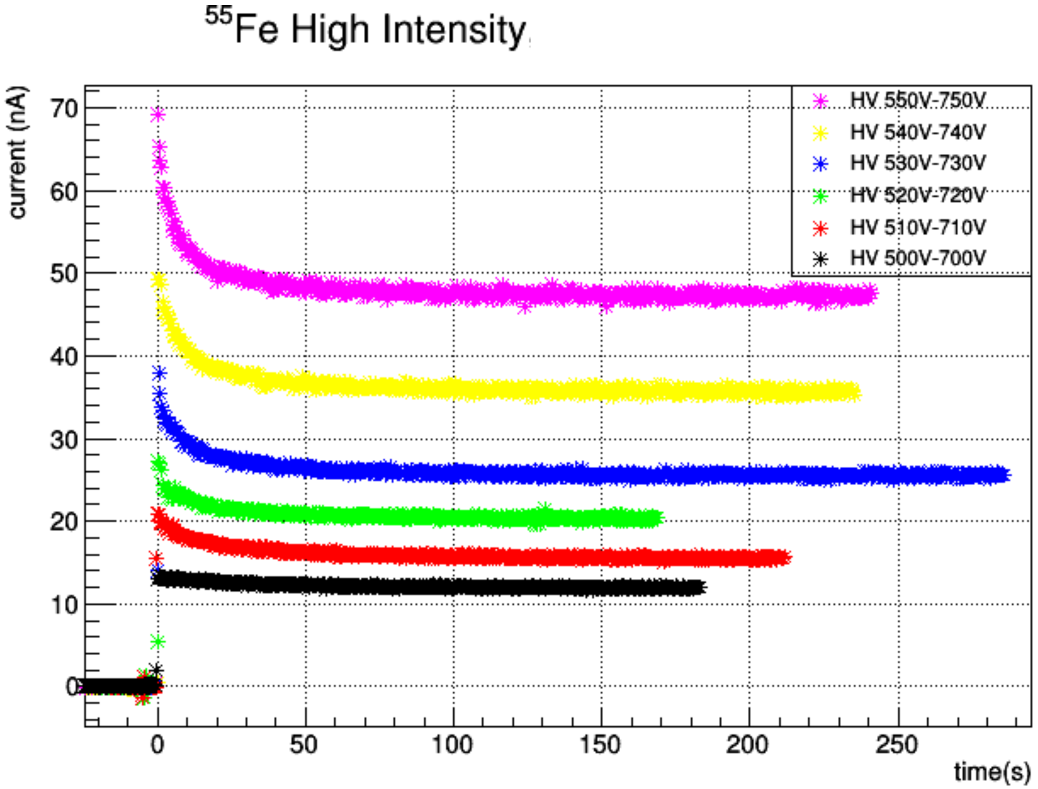
QUICK OVERVIEW OF PADDY SERIES-1 RESULTS – GAIN



- Gain compatible with resistive strip bulk micromegas
- ∼ 20% gain reduction from Low (1.3kHz) to High (128kHz) intensity ^{55}Fe source

Quick overview of Paddy series-1 Results – Gain & Charge-up





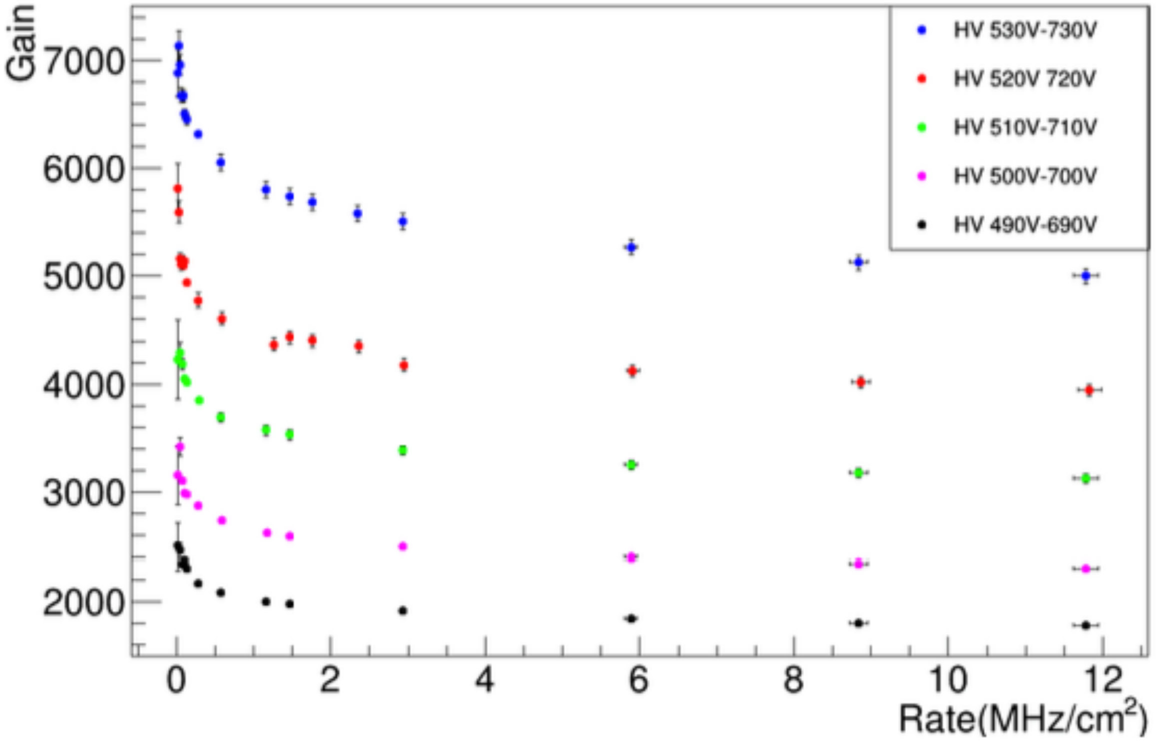
- Gain compatible with resistive strip bulk micromegas
- ∼ 20% gain reduction from Low (1.3kHz) to High (128kHz) intensity ^{55}Fe source

- observed a reduction vs time of the detector current with High intensity ^{55}Fe source
- ~20% gain reduction already observed with different intensities ^{55}Fe sources

- possible explanation for the 20% reduction: dielectric charge up

PADDY SERIES-1 X-RAYS TESTS: GAIN VS RATE

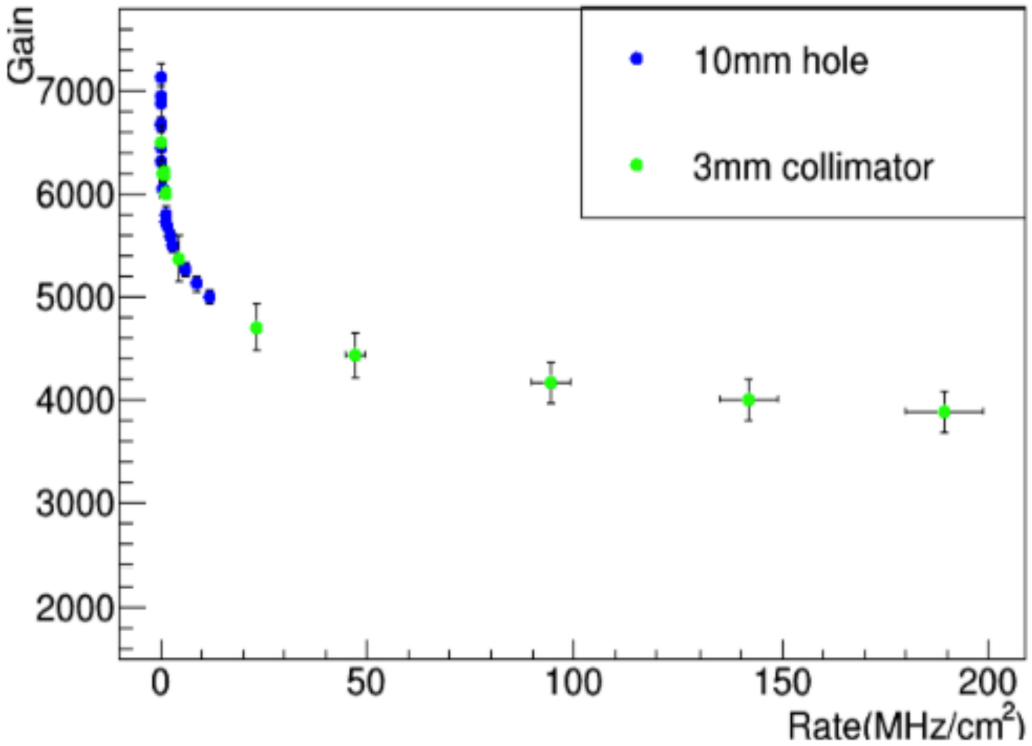
Gain as a function of rate for five different amplification voltages obtained with Cu plate with 10mm diameter hole.



Gain reduction ~20% up to 12 MHz/cm^2

same reduction as already observed with 55Fe intense source

Gain in an extended range of rates obtained with a collimator of 3 mm compared with data with a Cu plate with 10mm diameter hole



Gain drop increases as rate goes up.

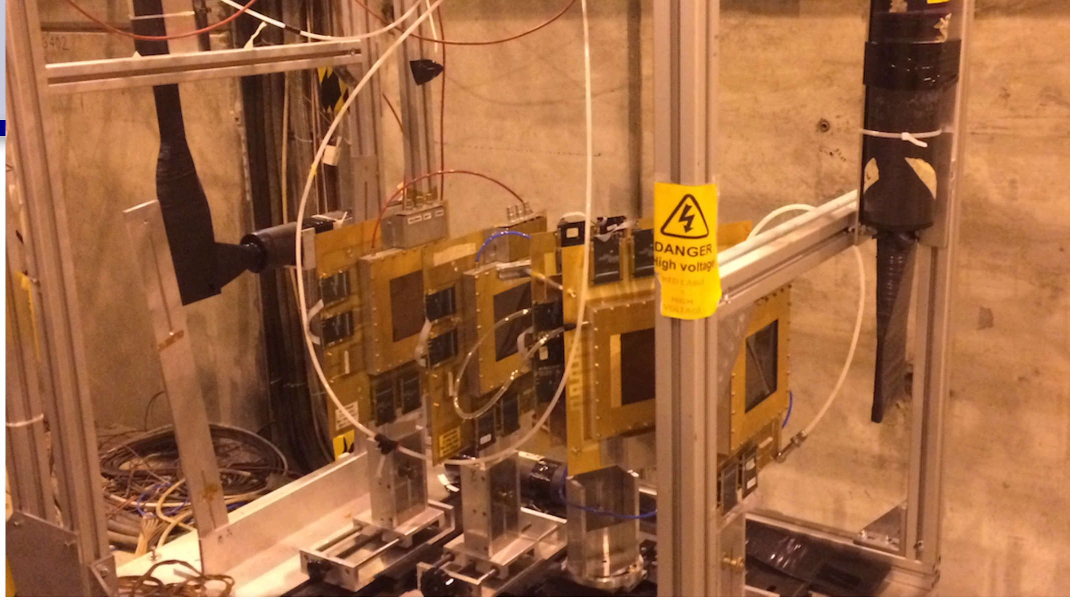
Still able to reach gain of 4x10^3 at a rate of 150 MHz/cm^2

PADDY SERIES-1 TEST BEAM 2016

SPS H4 CERN – OCTOBER 2016

Beam: high energy muons/pions

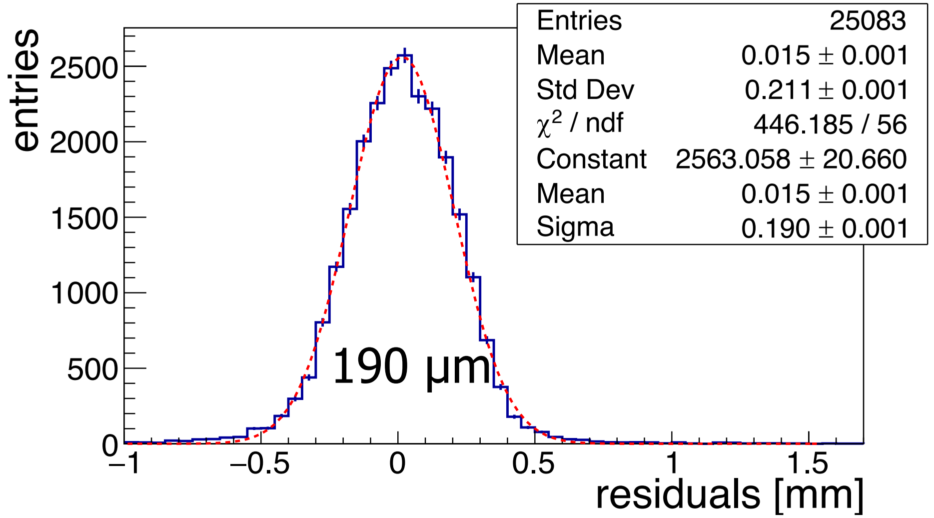
Setup:
- Gas: Ar:CO2 93:7
- Scintillators for triggering
- Two double coordinate micromegas for tracking
- DAQ: SRS + APV25 with custom DAQ



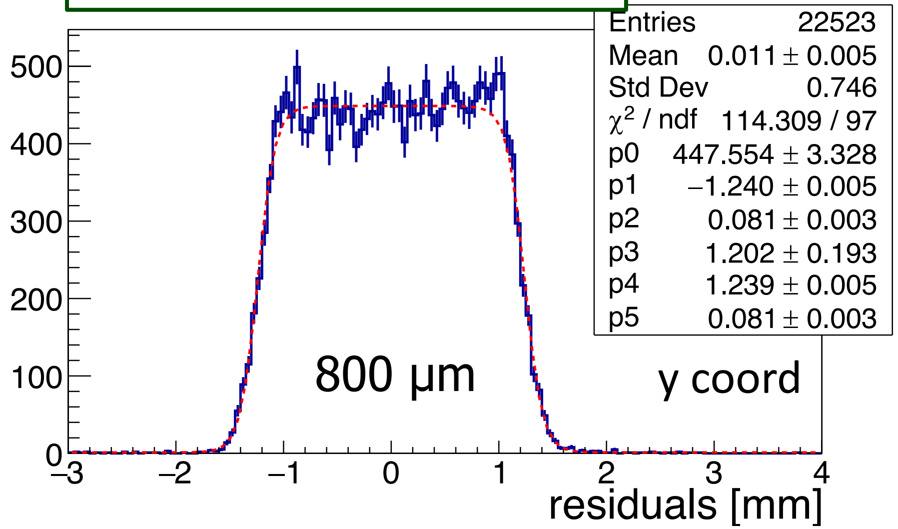
Position resolution: difference between the cluster position measured from the prototype and that interpolated by tracking chambers.

- alignment and rotation corrections have been applied;
- track extrapolation error (~50μm) has not been subtracted.

~190μm resolution on precision coordinate (pad pitch 1 mm)



~800μm resolution on second coordinate (pad pitch 3 mm)

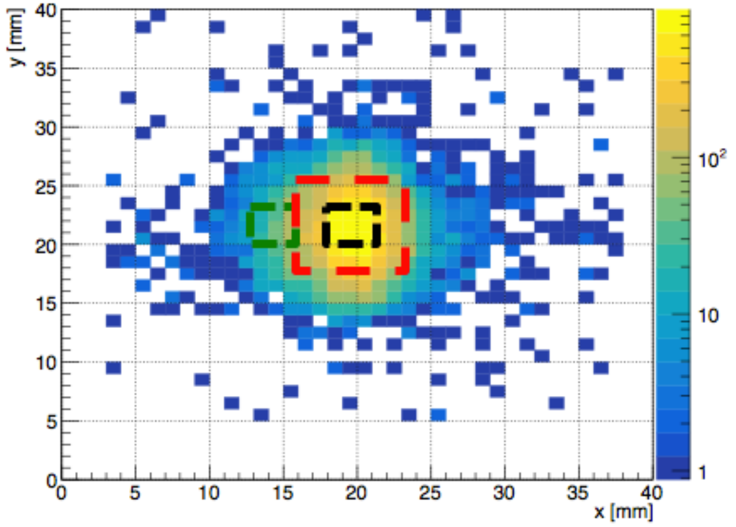


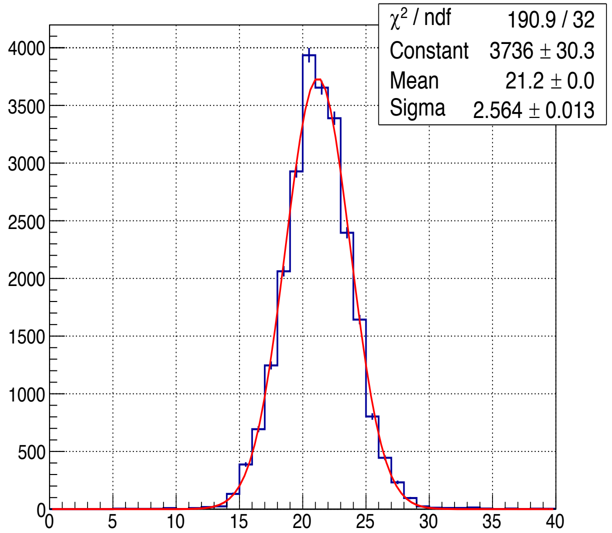
π Beam-spot profile from reference tracking chambers AT 400 kHz

SPS H4 CERN

OCTOBER 2016

HIGH RATE π BEAM

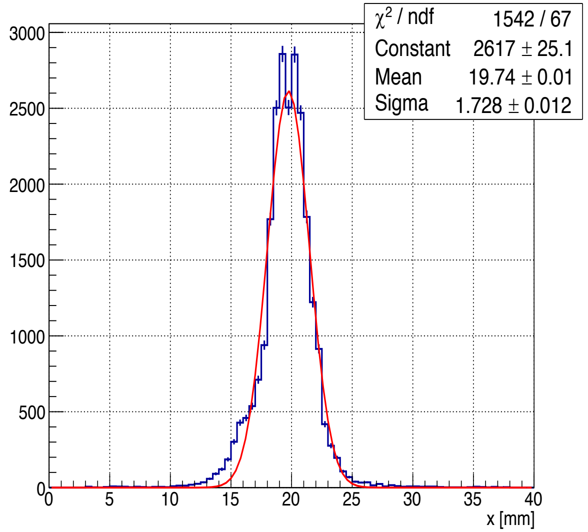




Data taken with

Trigger rate [kHz]:

35, 100, 200, 320, 400



Trigger rate: 400kHz

$49 mm^2$ with 80% of the events: $650 kHz/cm^2$

$6 mm^2$ with 20% of the events: **$1.3 MHz/cm^2$**

$6 mm^2$ with 1.5% of the events: $100 kHz/cm^2$

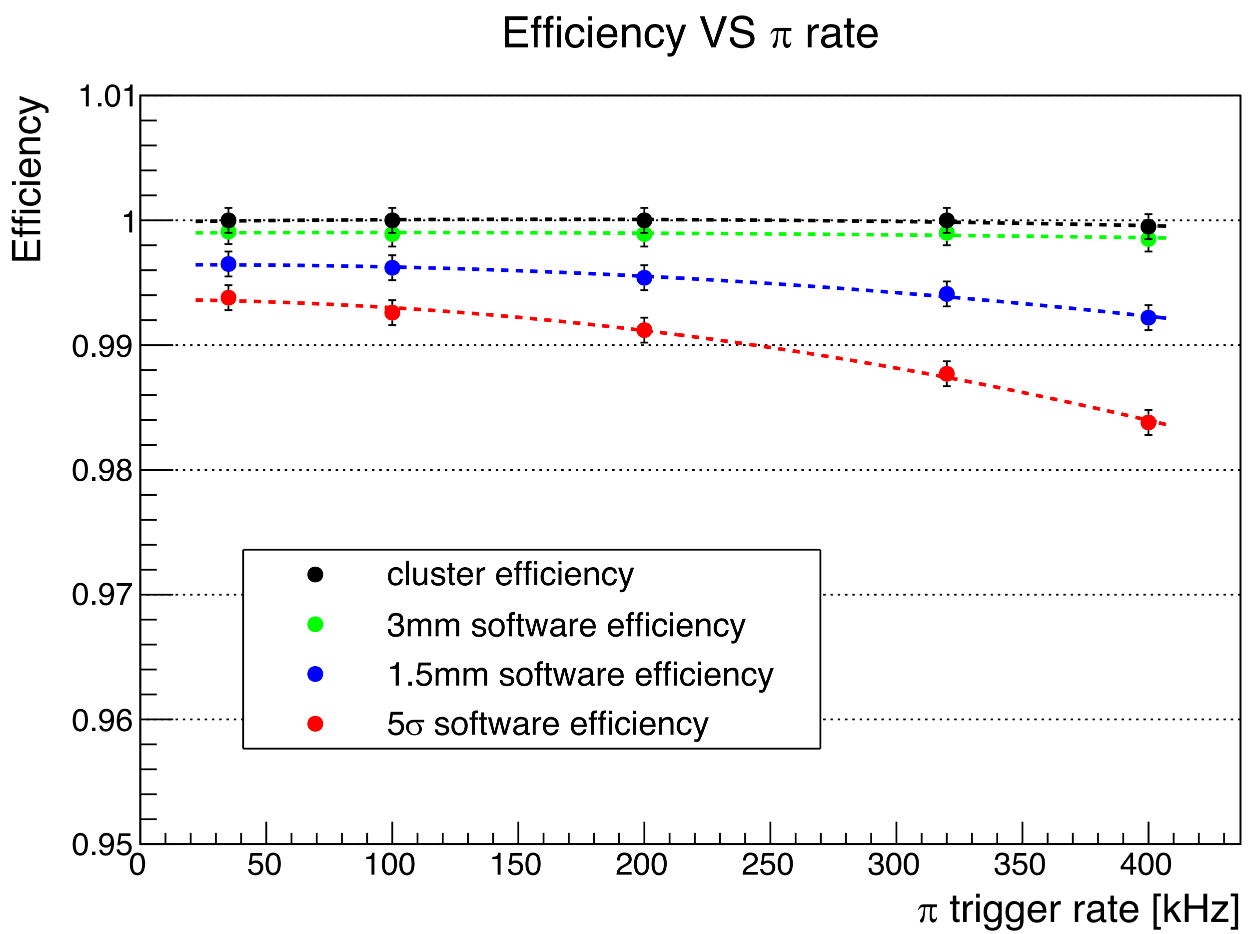
PADDY SERIES-1 TEST BEAM 2016 – NEW ANALYSIS (F.PETRUCCI IEEE 2017)

SPS H4 CERN

OCTOBER 2016

HIGH RATE π BEAM

Efficiency Vs Rate



- a small drop in the efficiency is observed at high rate; (possibly due to additional pads/cluster from secondary particles)
- efficiency remains >98%

Paddy series-2

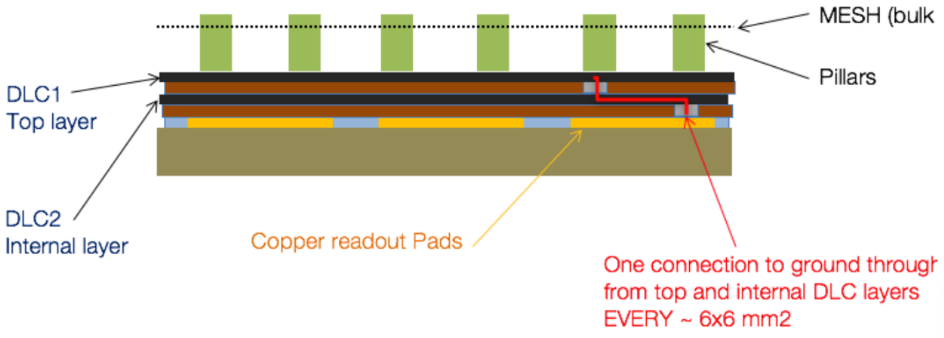
Series-2 Prototype → "Paddy-DLC"

:

- double DLC resistive layer as implemented in µRWell
- Resistivity of ~50-70 MΩ/☐
- connection to ground through resistive vias
- design derived by recent developments of µ-RWell

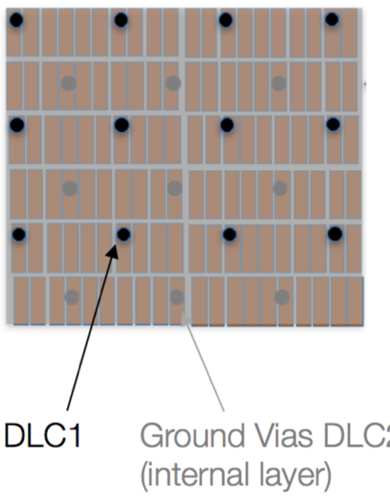
- Two regions with different pitch of the grounding vias
  - One region with vias on the two layers **every 6 mm**.
  - The other **every 12 mm**

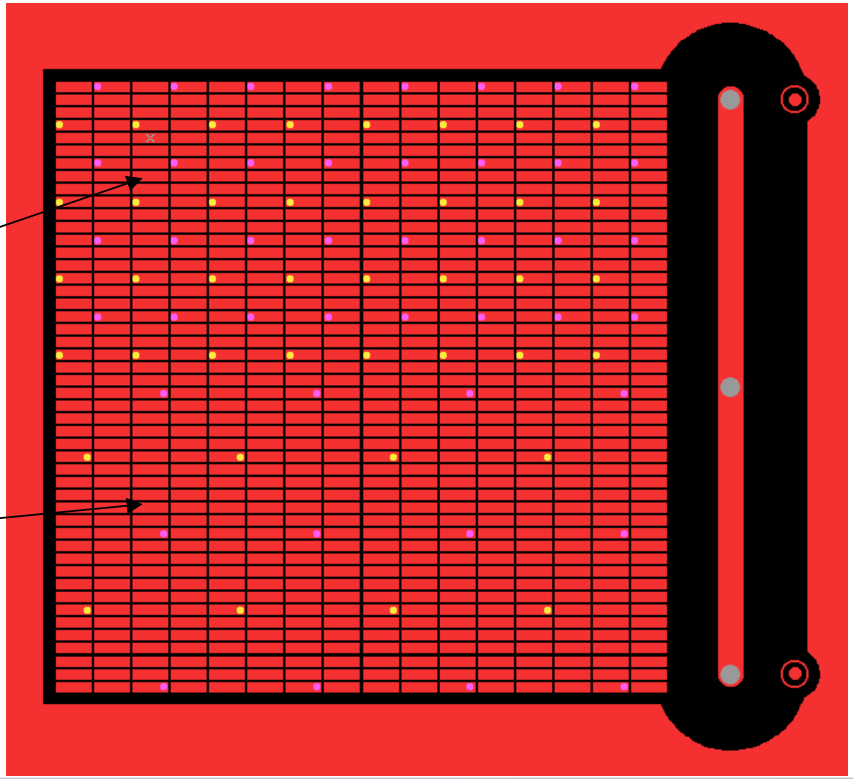
Side view



see G. Morello yesterday's talk

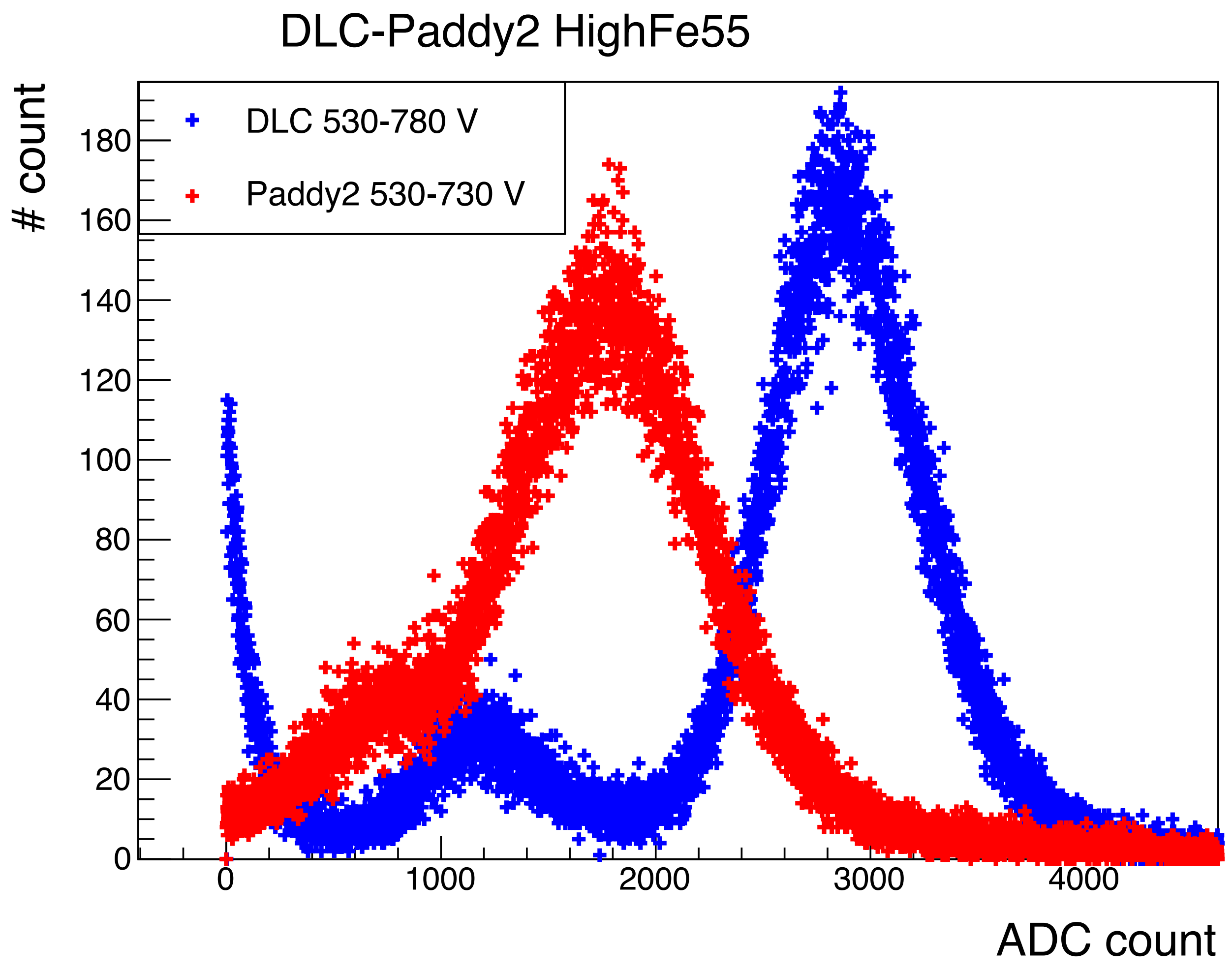
Top view

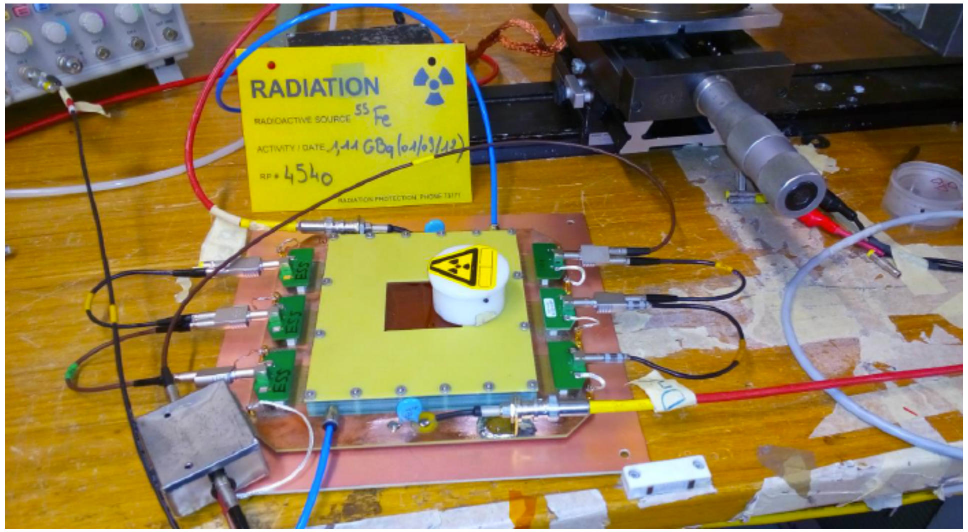




DLC1 pink
DLC2 yellow

PADDY_DLC (SERIES-2) – GDD LAB – OCTOBER/NOVEMBER 2017



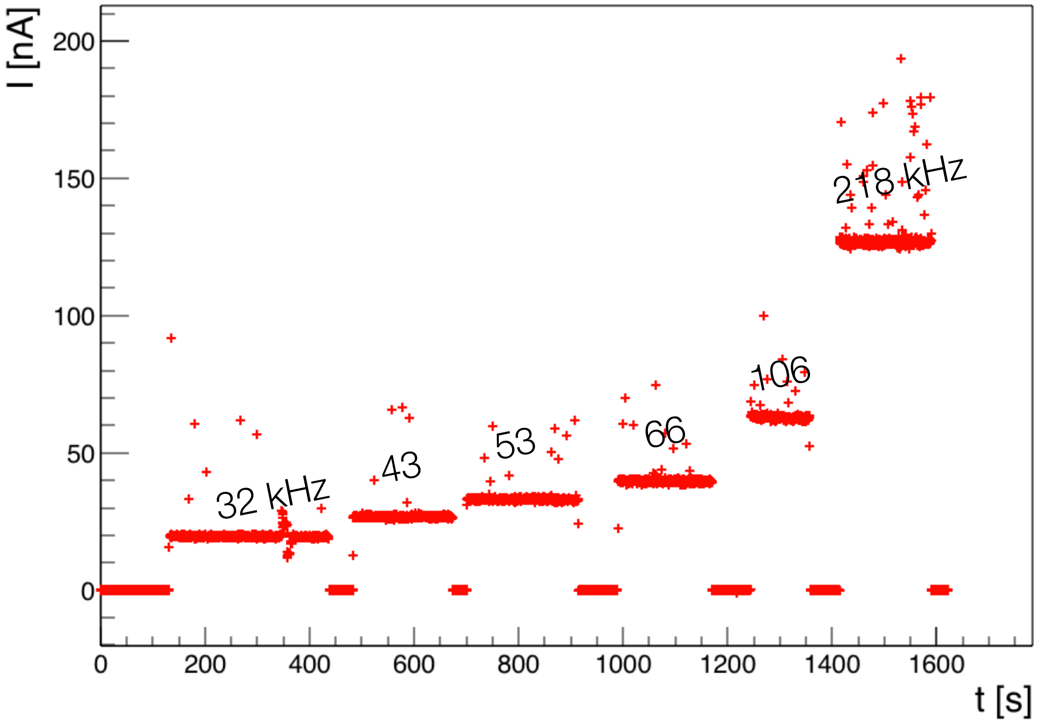


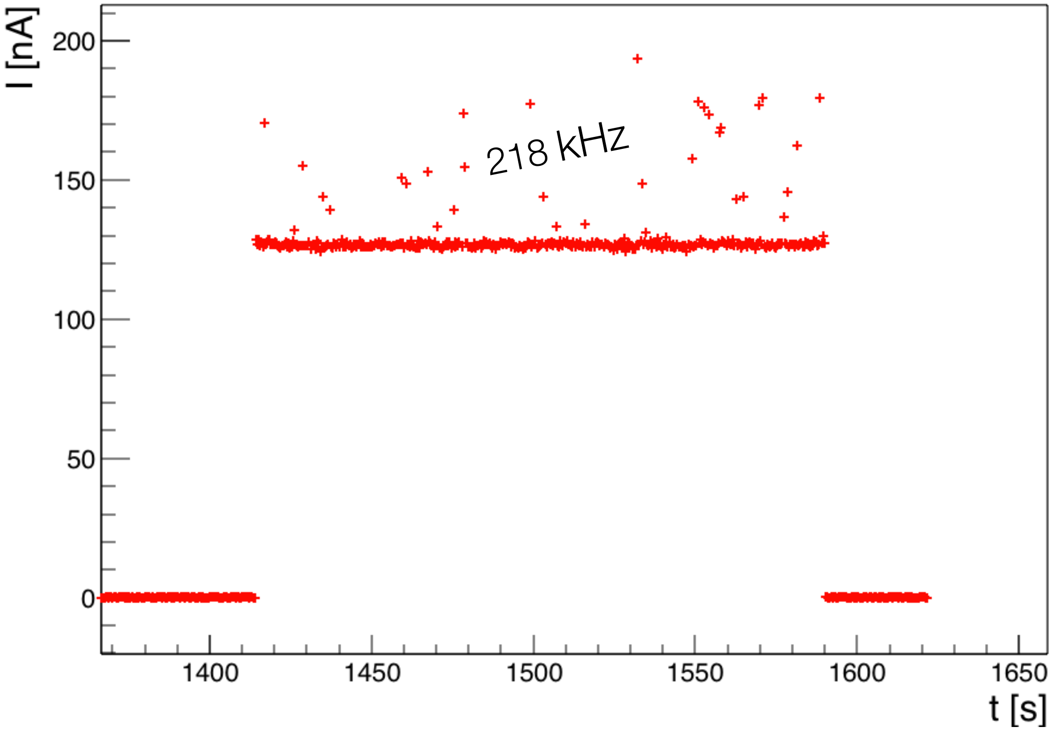
- Paddy_DLC (Series 2) has much better energy resolution (~10%)
- And also significantly higher gain (to be investigated further – different detector capacitance)
- Seems confirmed by other VERY preliminary measurements of currents with X-rays. But NEED further studies

PADDY_DLC STABILITY OF GAIN VS TIME WITH X-RAYS

- Paddy_DLC Current measurement Vs Time with X-Rays on/off and increasing rate (X-Ray current) at each step
  - no evidence of significant charge-up effects
  - Evidence of instabilities (discharges) to be further investigated (a single defect? more general issue?)

Paddy_DLC HV 530 – 780 / Copper plate with 10mm diameter hole

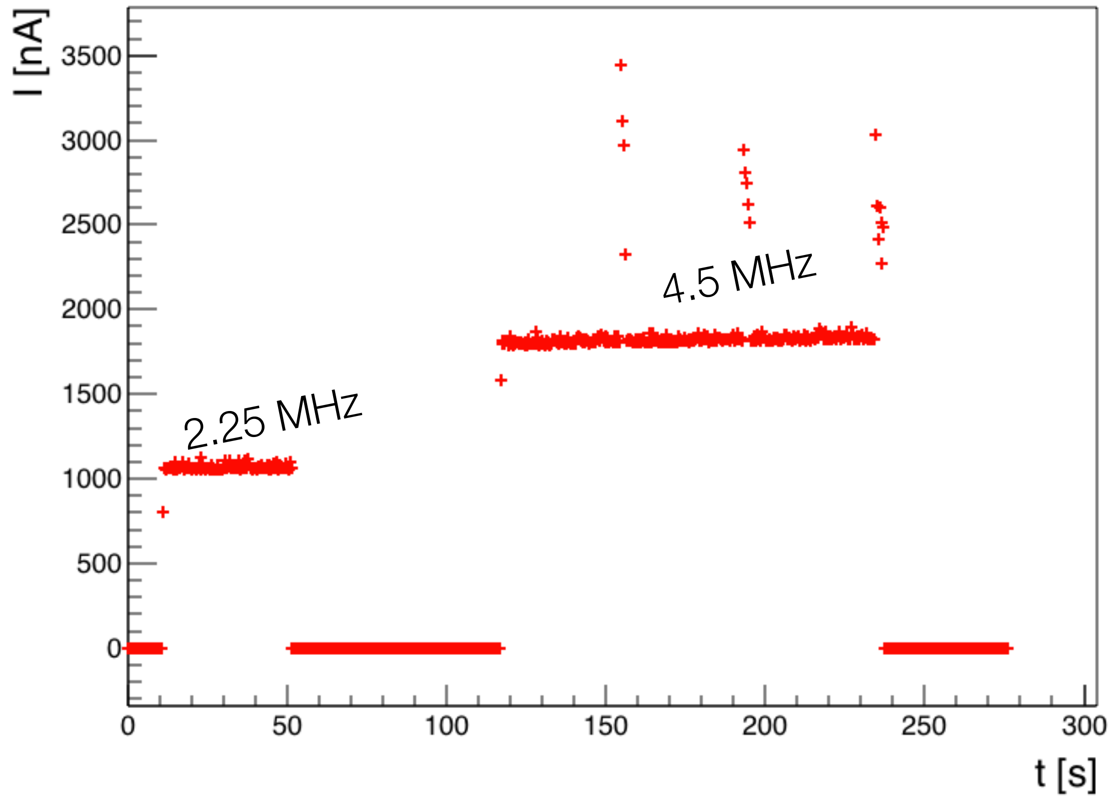




PADDY_DLC STABILITY OF GAIN VS TIME WITH X-RAYS

- Paddy_DLC Current measurement Vs Time with X-Rays on/off and increasing rate (X-Ray current) at each step
  - no evidence of significant charge-up effects
  - Evidence of instabilities (discharges) to be further investigated (a single defect? more general issue?)

Paddy_DLC HV 530 – 780 / Copper sheet collimator with 10 mm diam hole

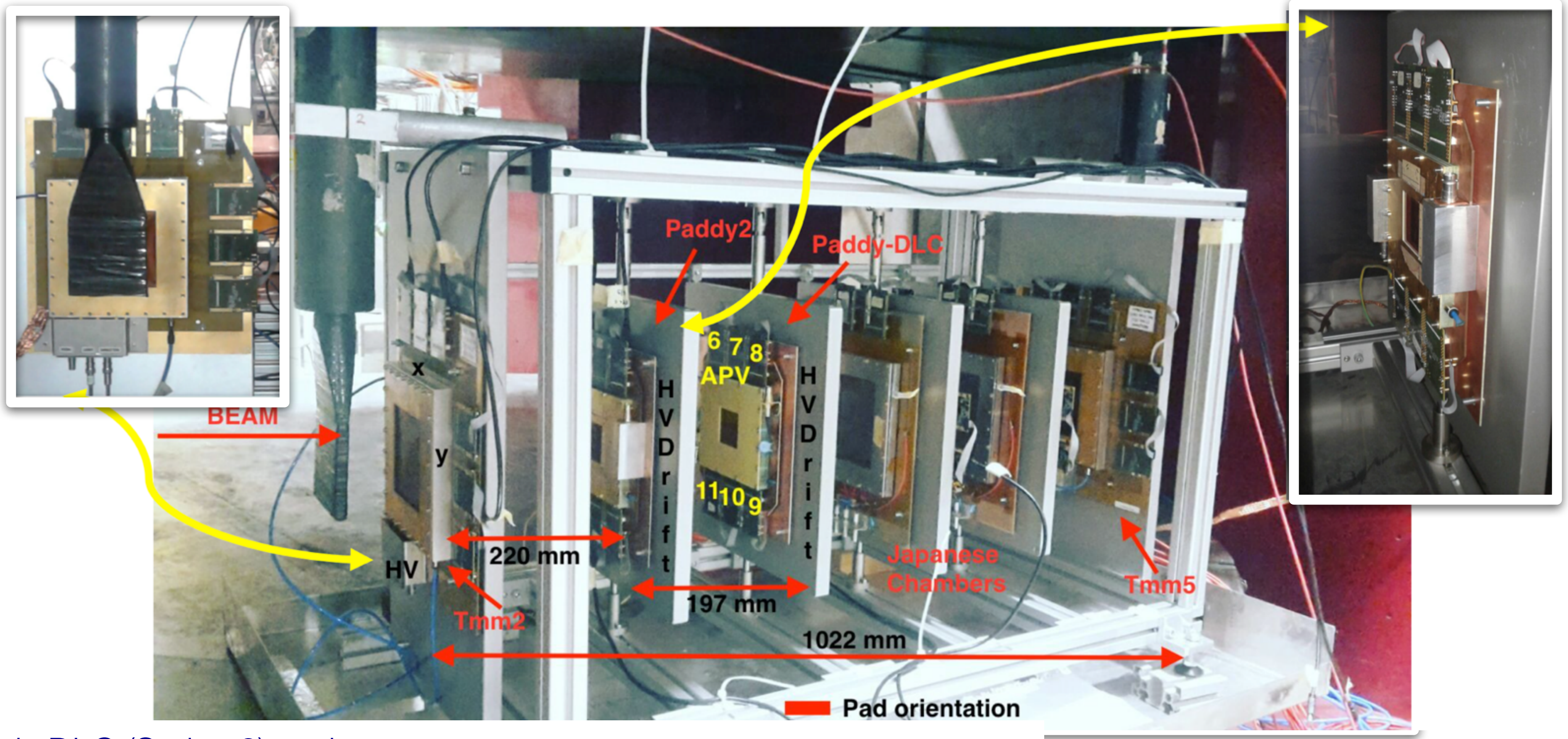


TEST BEAM – OCTOBER 2017

SPS H4 CERN
OCTOBER 2017

Beam:

high energy muons/pions



Setup:

- Paddy2 (series 1) and Paddy DLC (Series 2) under test
- 2 Tmm strips micromegas (x-y readout) for external tracking
- μPic and other micromegas by our Japanese colleagues in the same setup and same DAQ
- Gas: Ar:CO2 93:7
- Scintillators for triggering
- DAQ: SRS + APV25 with custom DAQ

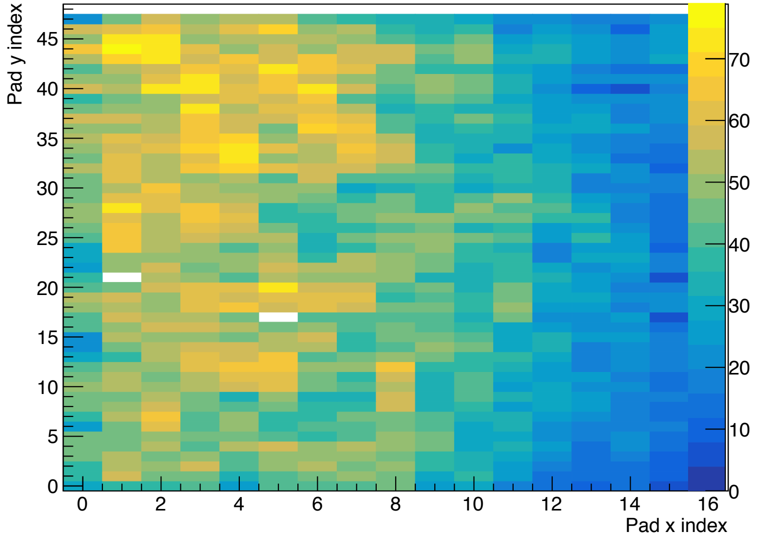
by the way ..many thanks to our Japaneese colleagues for the very effective and nice collaboration durng data taking !

TEST BEAM 2017 – BEAMS PROFILES

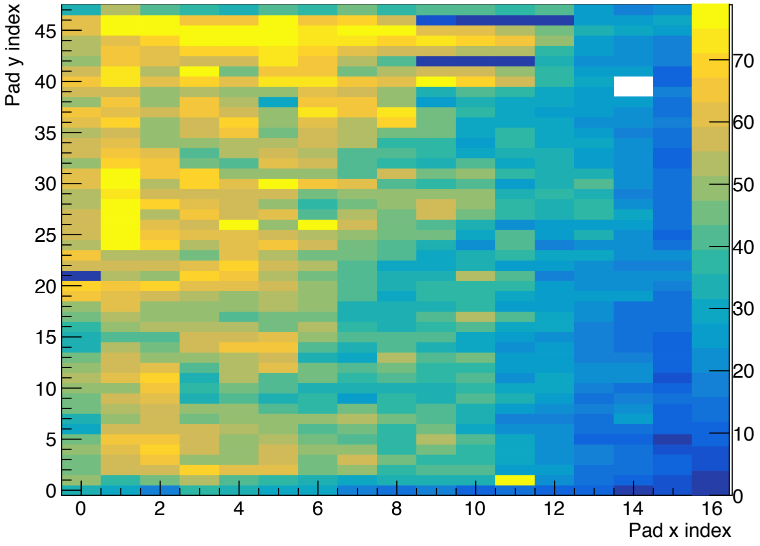
Data taken with muon beam

(preliminary data here reported)

μ-Beam Spot on Paddy2



μ-Beam Spot on Paddy_DLC

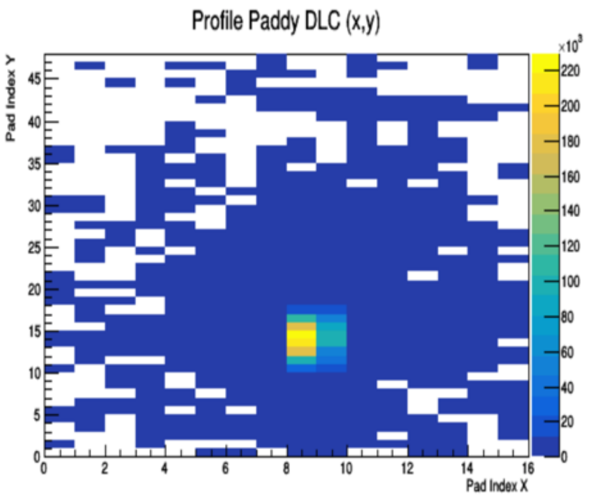


And with focused and dispersed pion beam

(max pion rate: **~450 kHz**)

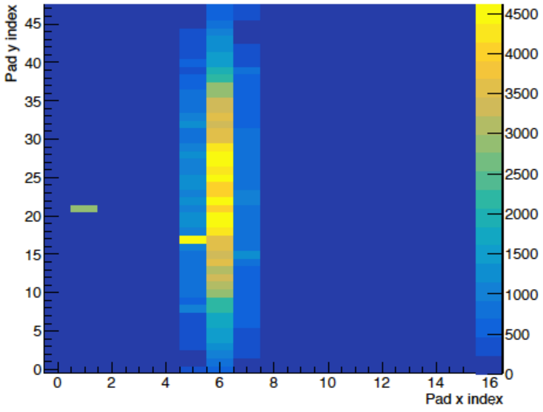
Analysis just started not reported here

π- Focused Beam Spot

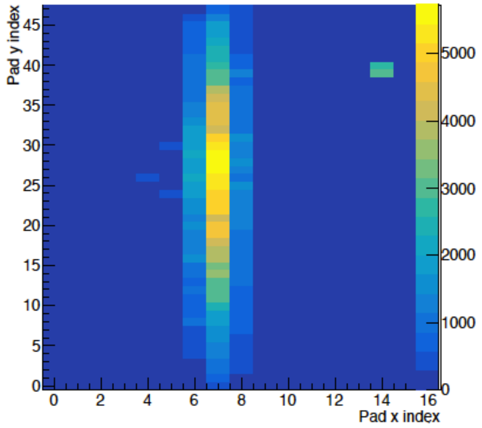


π- Dispersed Beam Spot

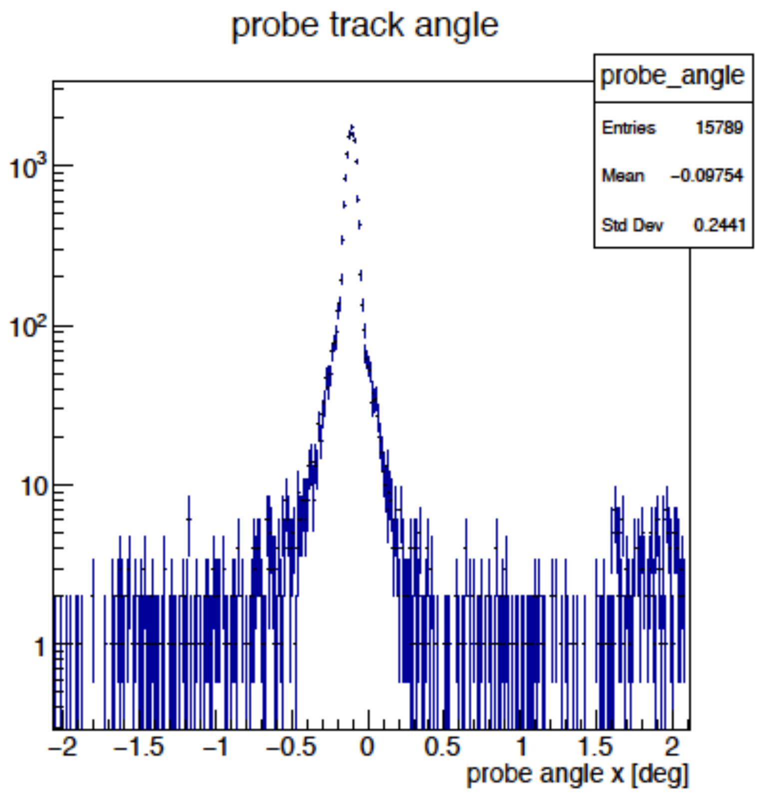
Paddy-2

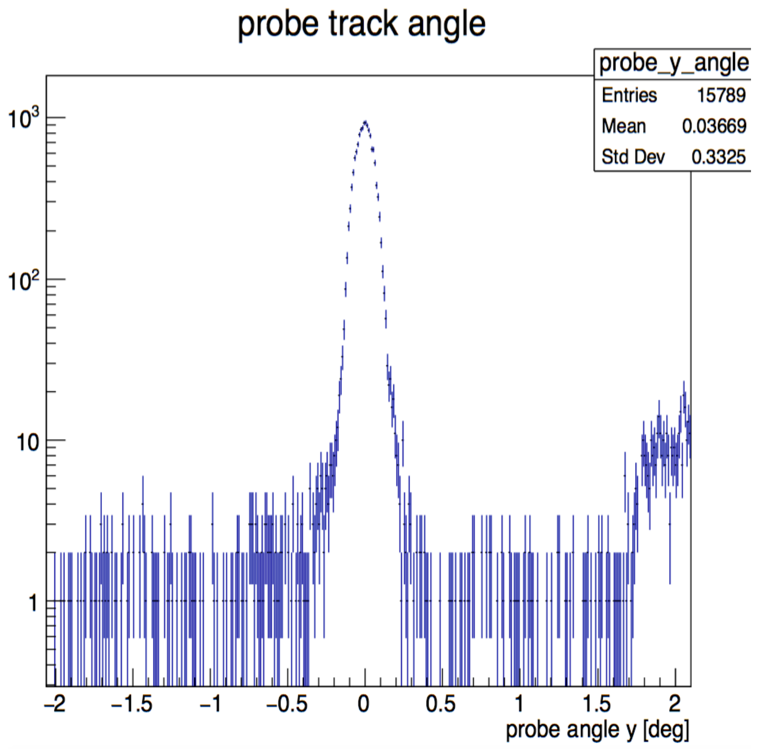


Paddy-DLC



TEST BEAM 2017 – TMM REFERENCE TRACKS



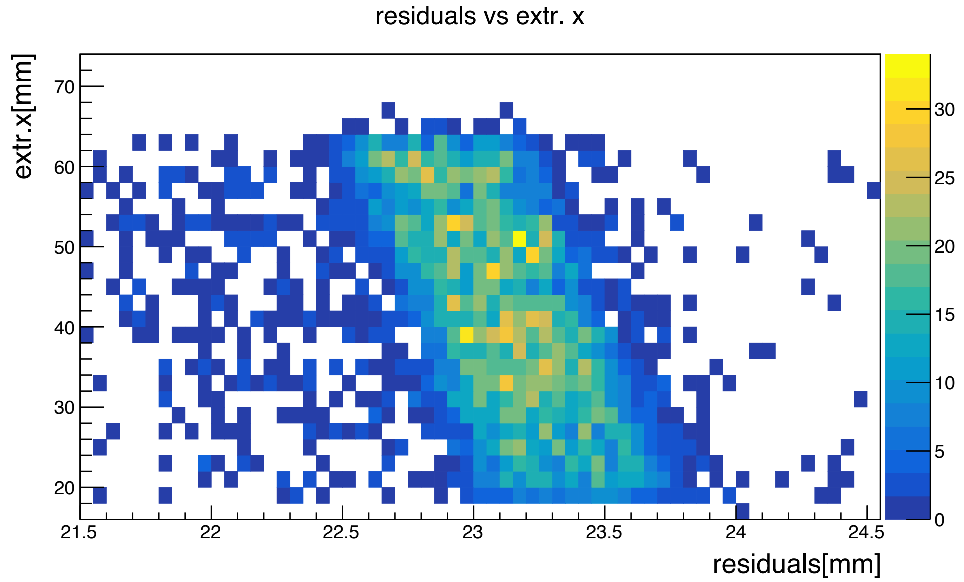


Selection on Reconstructed Reference track: both θ_x and $\theta_y \in [-1 : 1]^o$

Spatial resolutions of Chambers under tests (next slides) are derived by residuals distributions of the reconstructed cluster with respect to the impact position on the chamber of the reference track

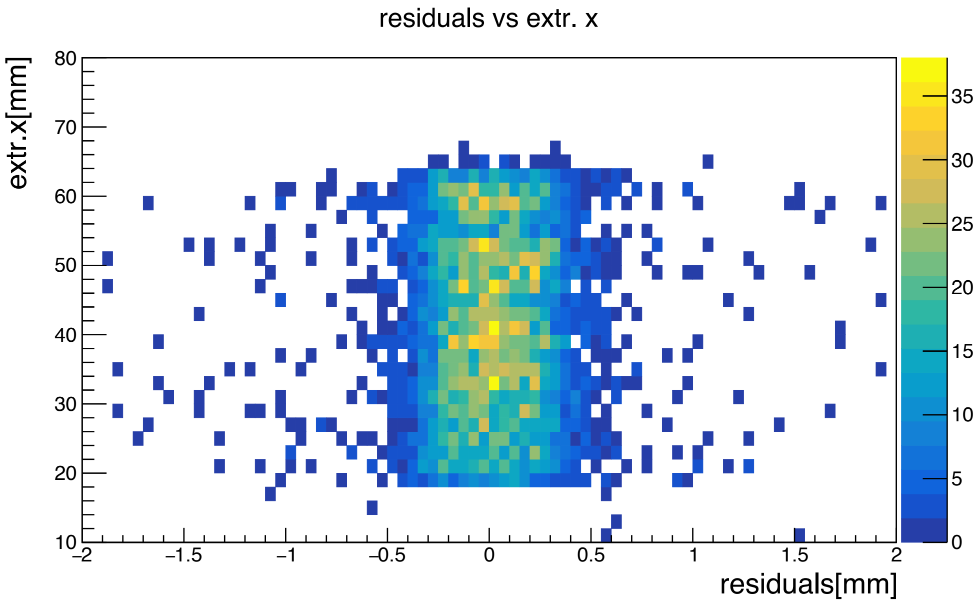
TEST BEAM – 2017 PADDY2 (SERIES-1) POSITION RESOLUTION

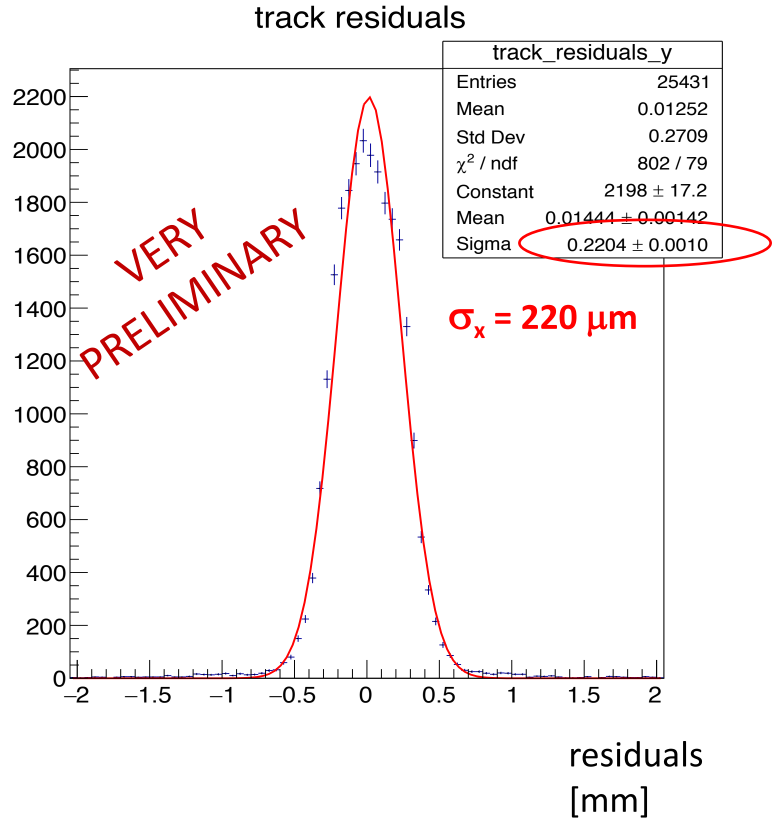
HV 530 V (gain ~ 8000)



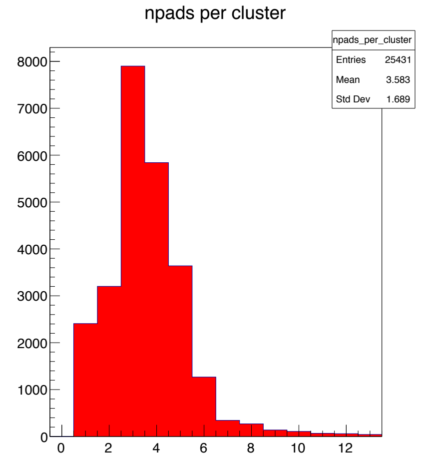
Before alignment

After alignment





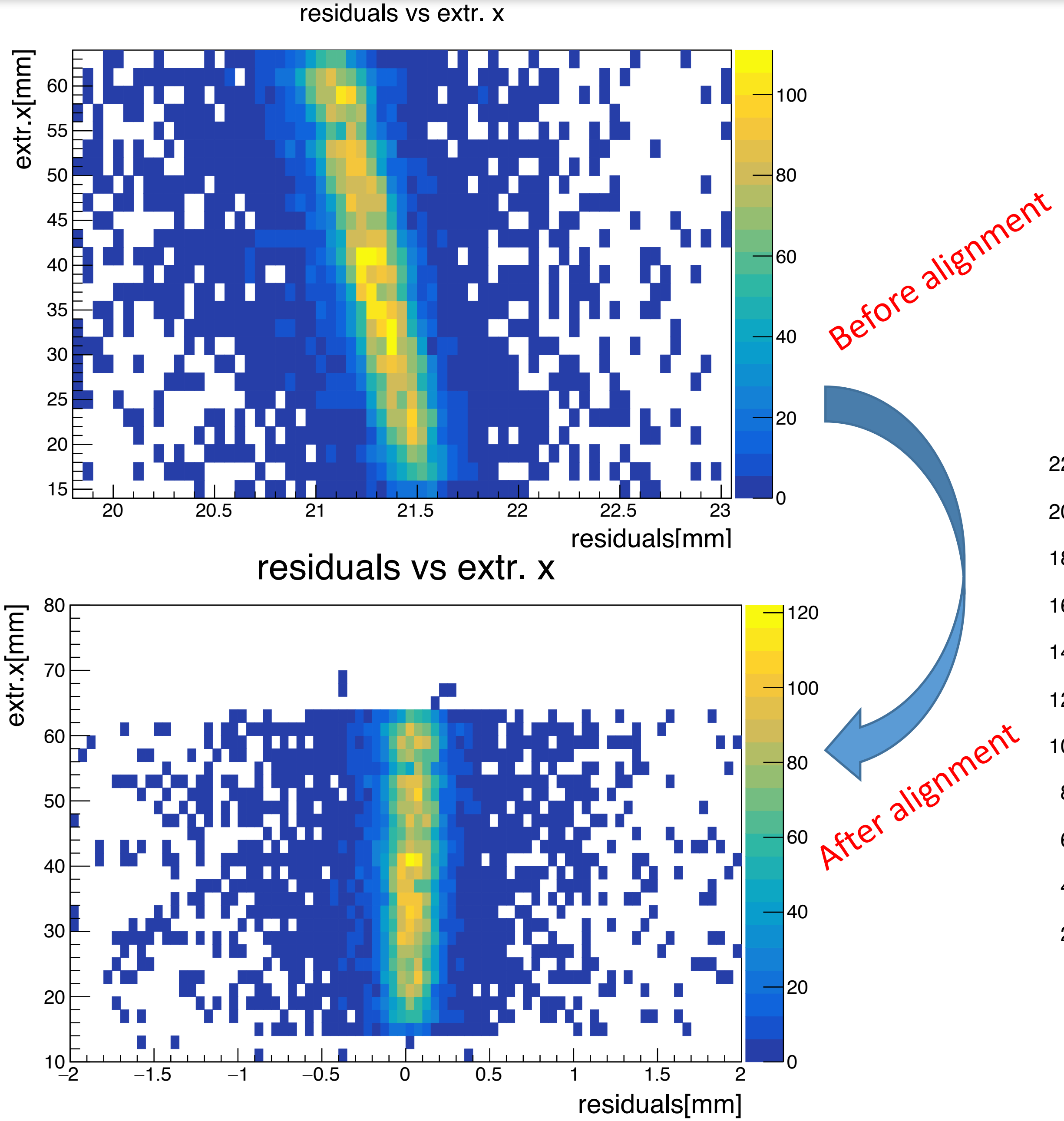
σ_x = 220 μm

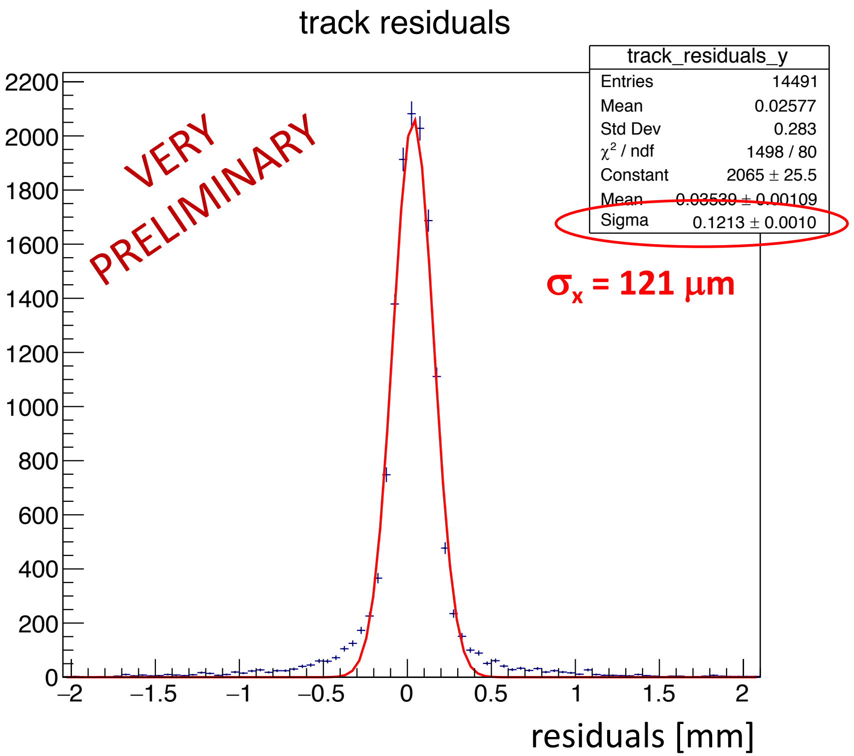


Number of pads per cluster

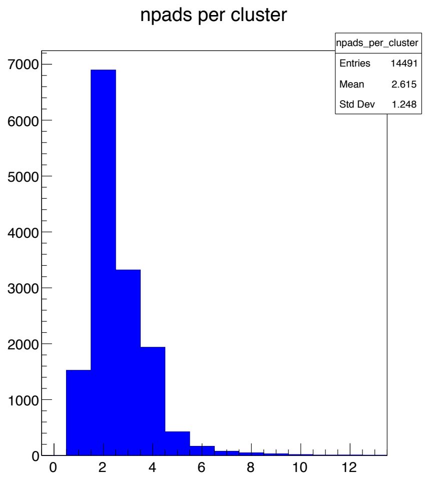
(to be compared with 190 μm obtained last year)

TEST BEAM – 2017 PADDY_DLC POSITION RESOLUTION





σ_x = 121 µm



Number of pads per cluster

Conclusions and Outlook

- Two small-pad resistive micromegas, with different concepts of the spark protection resistive system, have been tested and compared
  - Series-1 with patterned resistive layer (small pads 1x3 mm^2 same as anode pads) shows:
    - a very good performance under high rate (operate with a gain of 4000 at 150 MHz/cm^2 with X-rays)
    - moderate energy resolution (25-30%) (not critical for us)
    - good position resolution (~200 μm)
    - evidence of dielectric charge-up effects (reduction of ~20% in gain and then saturate)

  - Series-2 (Paddy_DLC) with uniform DLC resistive layer VERY PRELIMINARY results show :
    - Much better energy resolution (~10%) (expected – more uniform electric field – no pad border effects)
    - no evidence of significant charge-up effects
    - very good position resolution (~120 μm however with tails → under investigation)
    - MORE ANALYSIS ONGOING.
      IN PARTICULAR BEHAVIOUR UNDER HIGH RATES: X-Rays and PION BEAM

THANK YOU !

- A big thank to Eraldo, Yorgos and RD51 for their continuous support during the tests at the GDD Lab and at H4 SPS Test-Beam

- We would like also to thank Rui and the CERN MPT Workshop for all the useful discussions, ideas, input, …and construction !