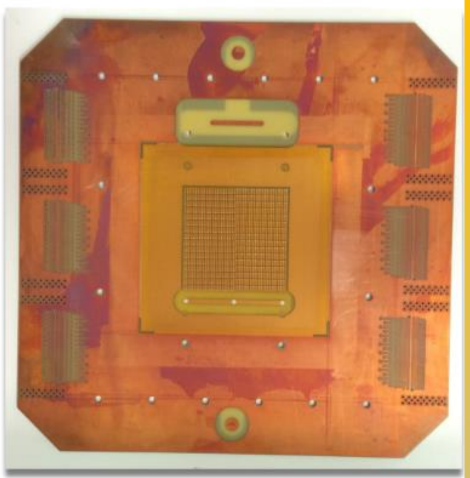
RHUM

Resistive High granUlarity Micromegas



Joint project of INFN Napoli and Roma Tre

Research activities on new Resistive Micromegas structures

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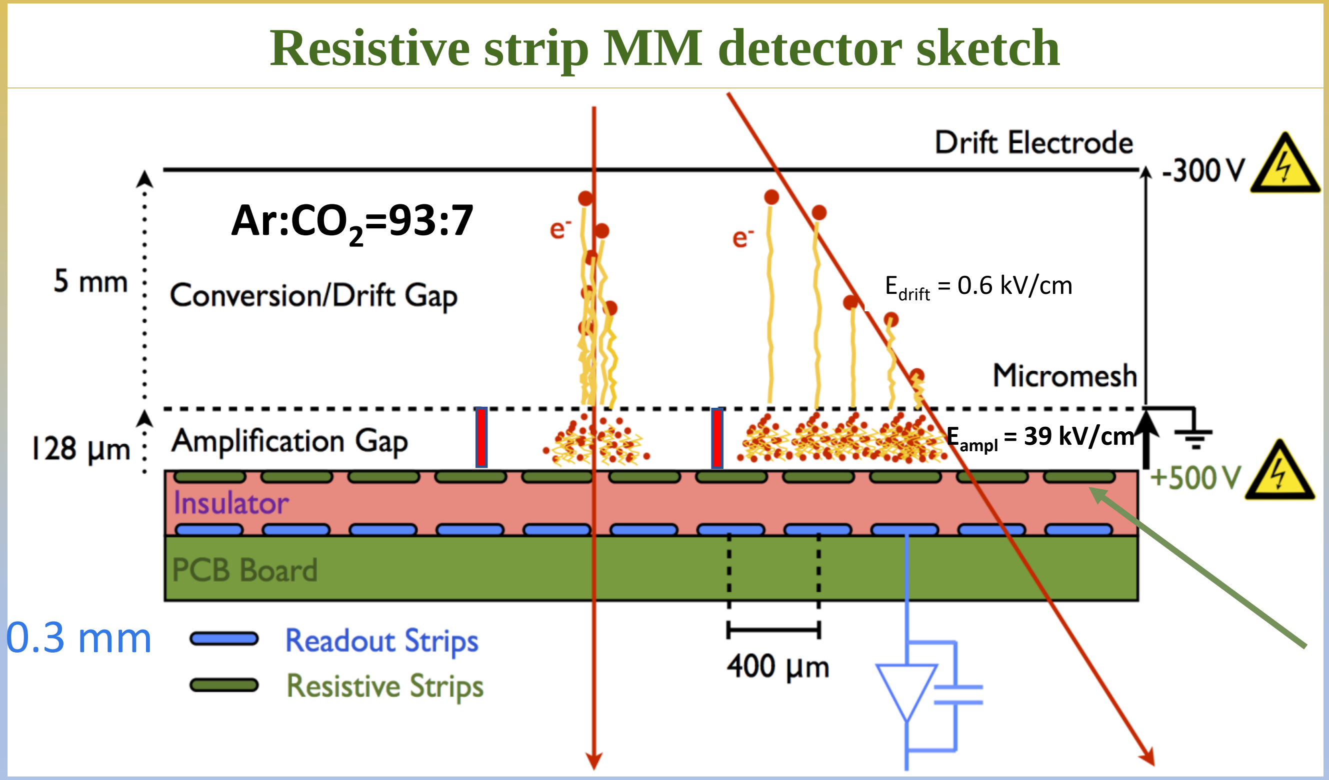
INFN GR1 meeting: 12th January 2023

(ATLAS-like) RESISTIVE MICROMEGAS technology

Planar proportional mode – Micro Pattern Gaseous Detector (MPGD)



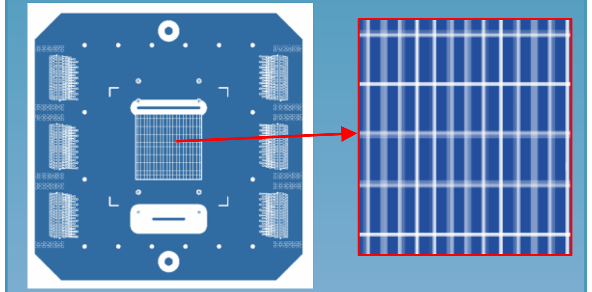
5 mm Drift Gap → e^- /ion pairs

~120 µm Amplification Gap →
Electron avalanche multiplication
Discharge vulnerability

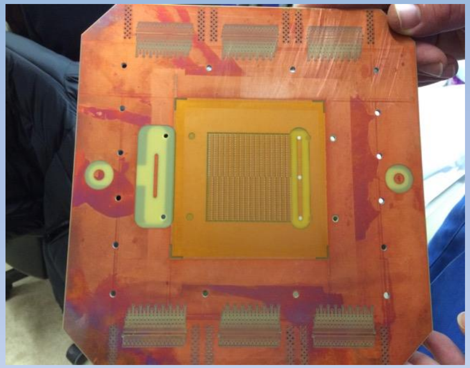
Resistive strips quench the possible discharges

Small-Pad resistive Micromegas detectors

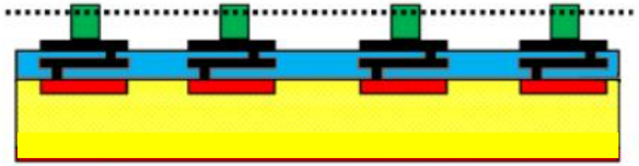
PIXELATED ANODIC PLANE



Pixelated readout:
5x5 cm^2 anodic plane,
pads of **0.8 x 2.8 mm^2**



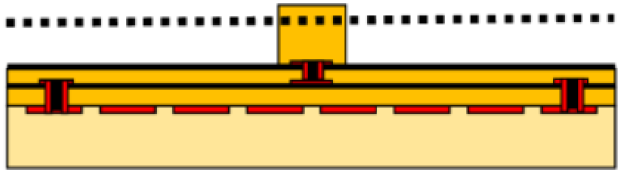
Resistive spark protection schemes



- **PAD-P**:

  micro-mesh (dot line) + pillars (green)
  Embedded pad resistors (black)
  Coverlay insulator (blue)
  Copper readout pads (red) on PCB (yellow)
  O(10) MΩ resistance btw top pad resistor and ground;

Ref [1] Construction and test of a small-pad resistive Micromegas prototype (https://iopscience.iop.org/article/10.1088/1748-0221/13/11/P11019)



- **DLC-like** (Diamond-Like-Carbon)

  micro-mesh (dot line) + pillars (orange)
  DLC foils with 20-50 MΩ/sq (black)
  Polymide insulator (orange);
  6-12 mm vias pitch side;
  Copper readout pads (red) on PCB (beige)

Ref. [2] Alviggi et al. - NIM Research Sec. A, Vol. 936, 21 Aug 2019, pp 408-411 (https://doi.org/10.1016/j.nima.2018.10.052)

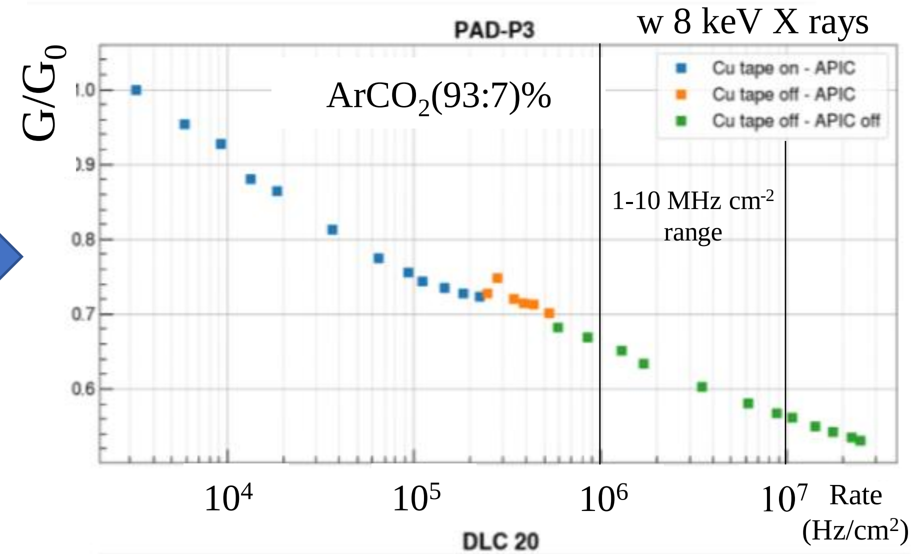
Studies of rate capability

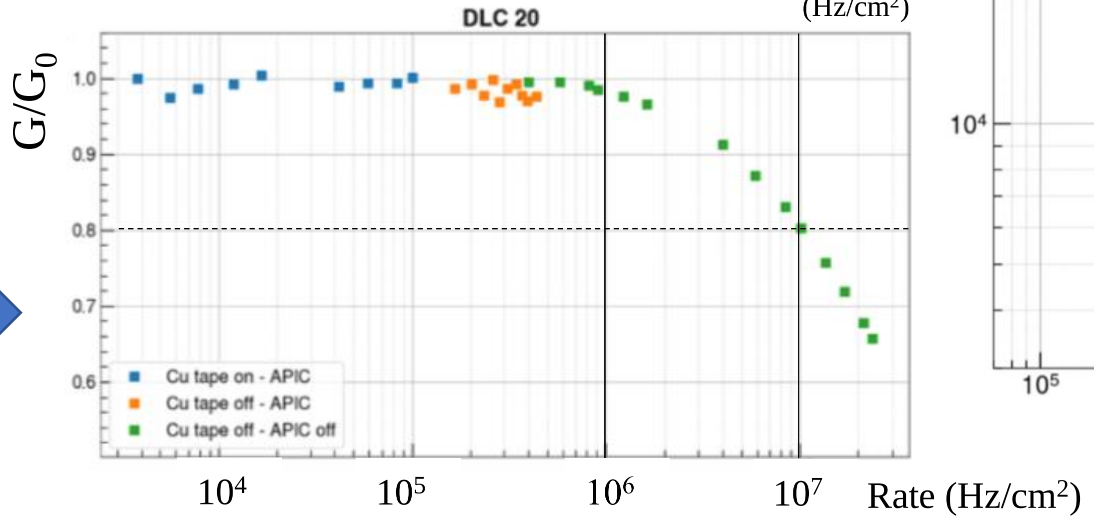
PAD-P scheme

- Relatively fast loss for rate < 0.1 MHz/cm^2 due to charging-up;
- Slower ohmic voltage drop through the individual pads at higher rates;

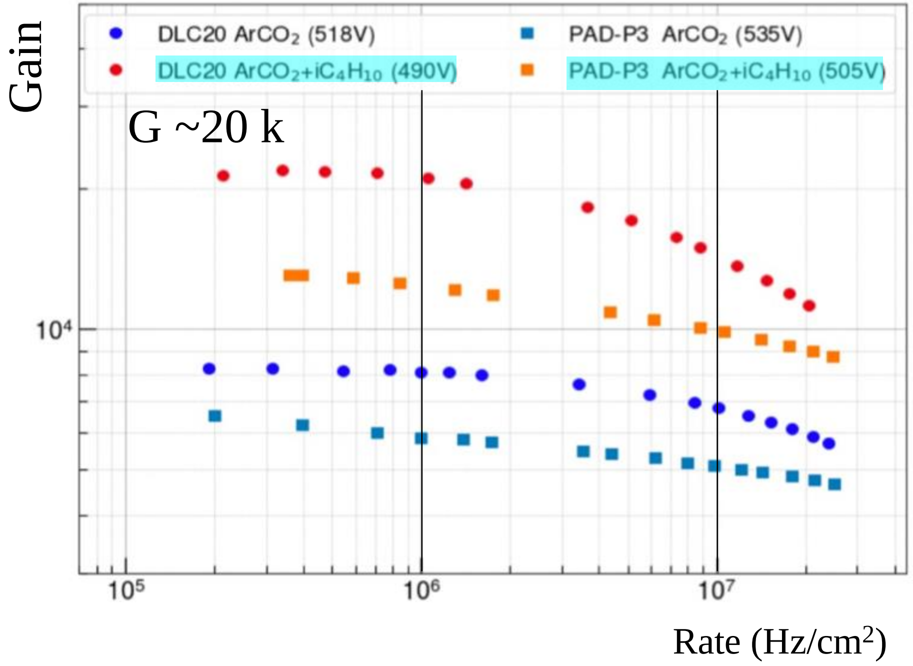
DLC-like scheme

- Negligible charging-up effects.
- Gain stable up to 1-2 MHz/cm^2, and at higher rates, gain drop due to ohmic contribution.
- At 10 MHz/cm^2, gain drop of ~20%





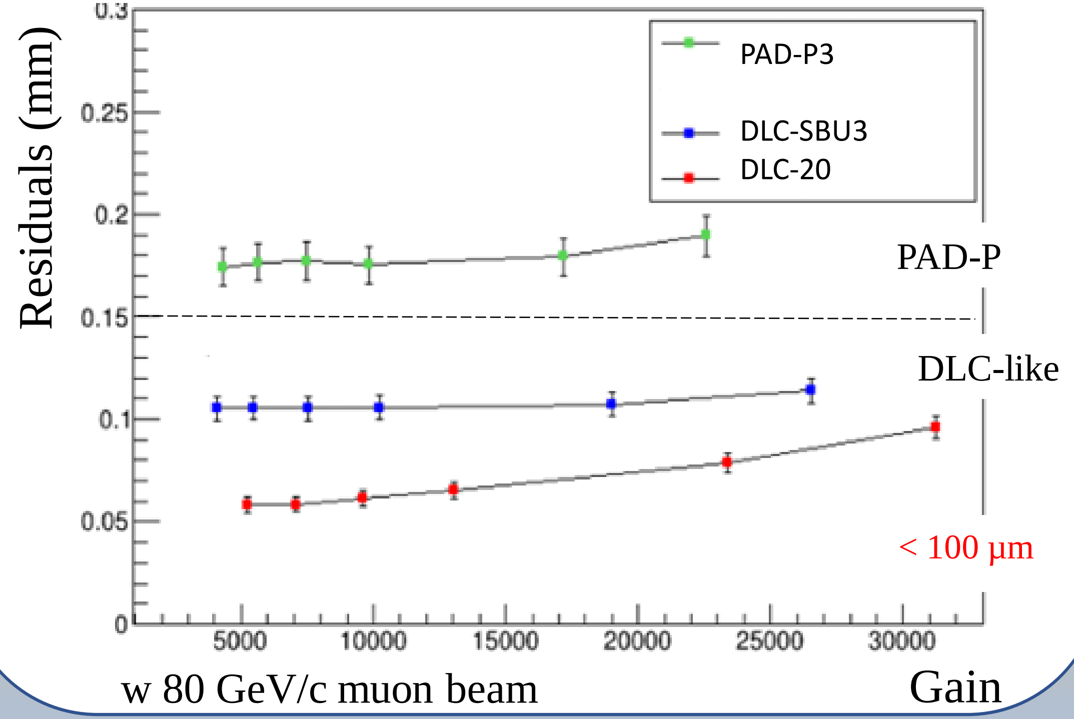
With the two mixtures, we observed compatible drops, **$ArCO_2iC_4H_{10}$(93:5:2)%** lets to work at a **higher gain** and to a **larger spark quenching.**



plots from Master thesis of S. Franchellucci (Univ. Roma Tre)

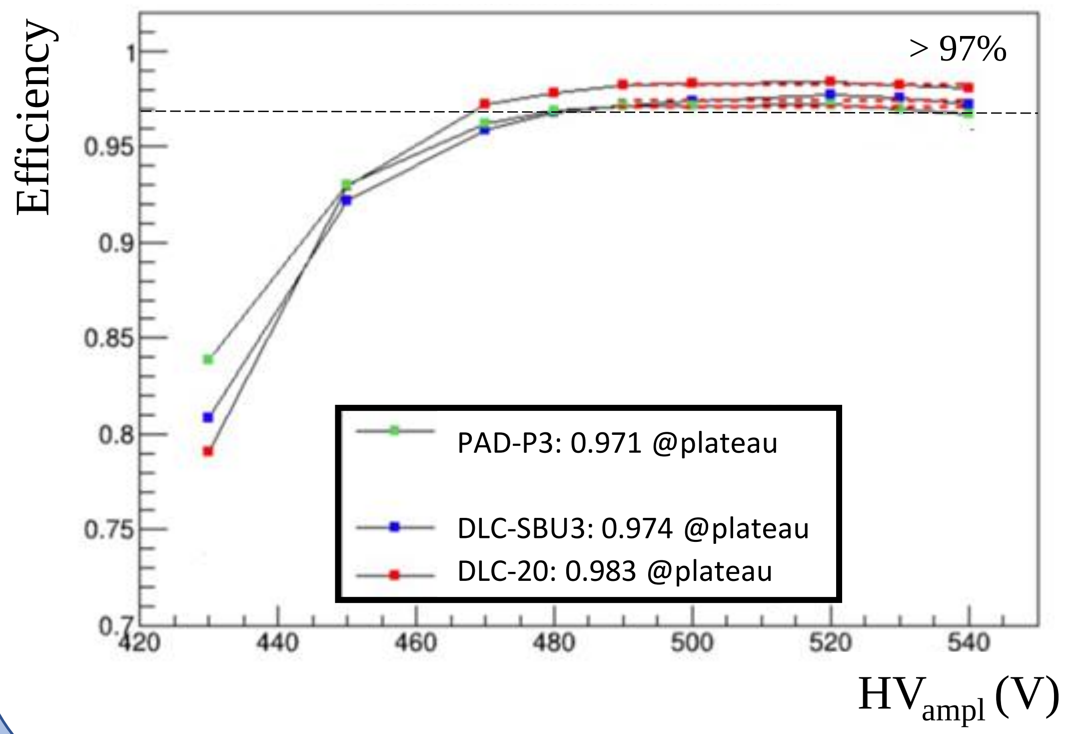
Studies of tracking performances ($ArCO_2iC_4H_{10}$(93:5:2)%)

Spatial resolution (along pad short side)



Tracking efficiency

based on cluster search within 1.5 mm fiducial range along the extropated track position in the pad short side



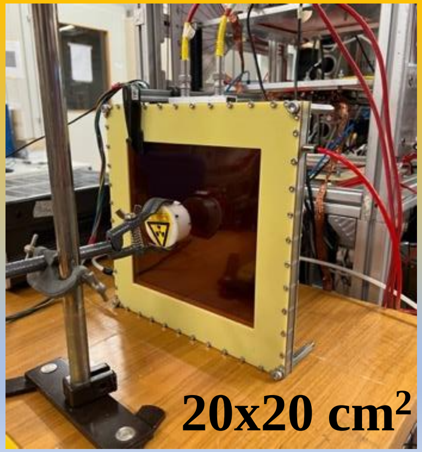
On going studies of **time resolution:**

with the investigated gas mixtures and APV25 FE chips, detectors have similar time performances (O(10 ns)). To improve

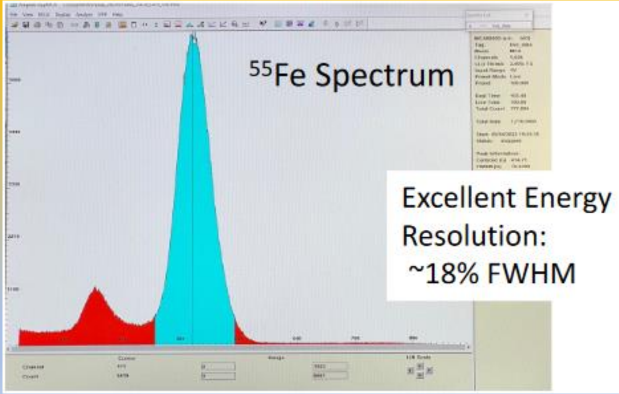
- «Faster» gas mixtures (with a small fraction of CF_4);
- New FE chips as VMM, tiger, fatic (in touch with the respective groups).

plots from Master thesis of C. Gimmillaro (Univ. Roma Tre)

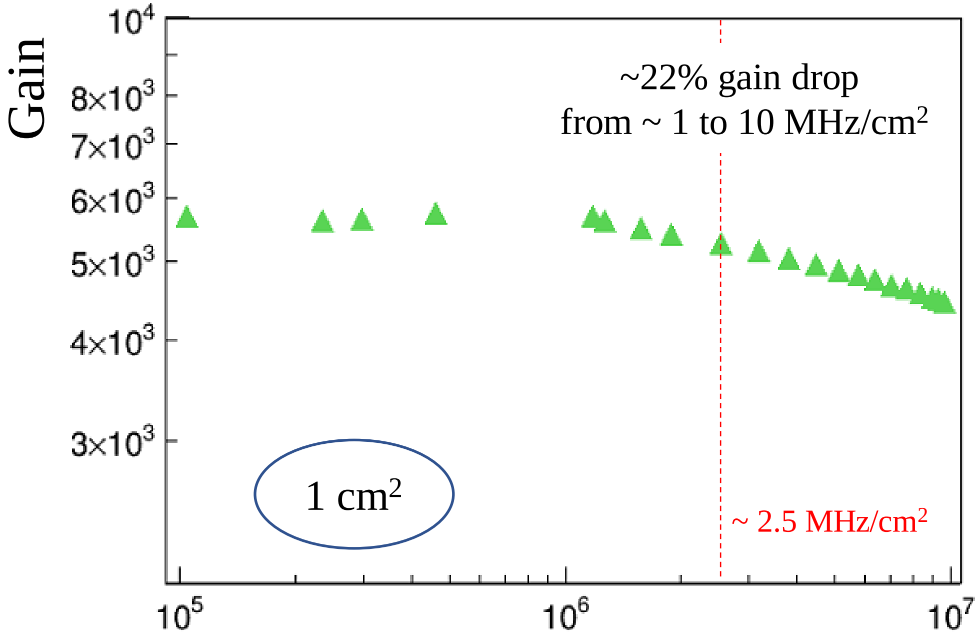
Towards large areas



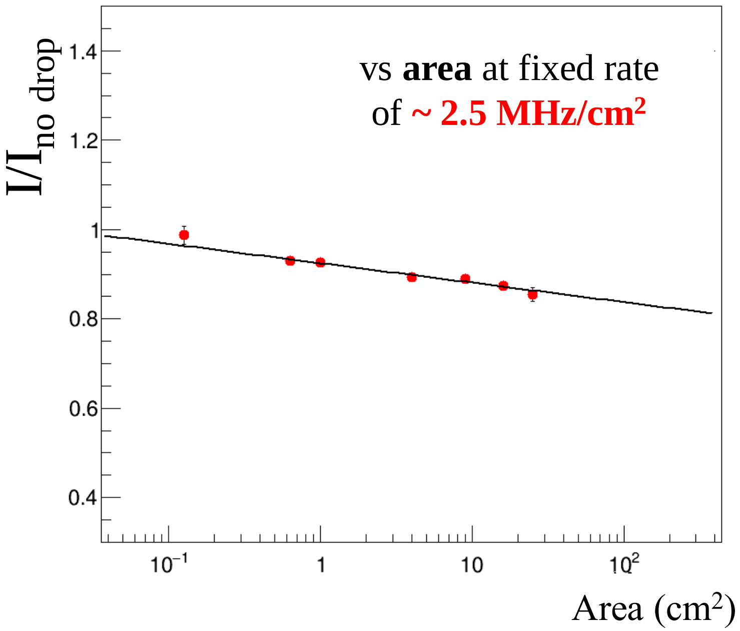
- **Pad size:** 1x8 mm^2
- **Number of Pads:** 4800
- **DLC-like layout** w 8 mm grounding vias pitch
- FE connectors on the back of the detector (partial readout)



Repeated gain/rate capability studies with $ArCO_2$(93:7)%, varying irradiated area up to 25 cm^2 max area until now.



Area dependence tends to saturate,



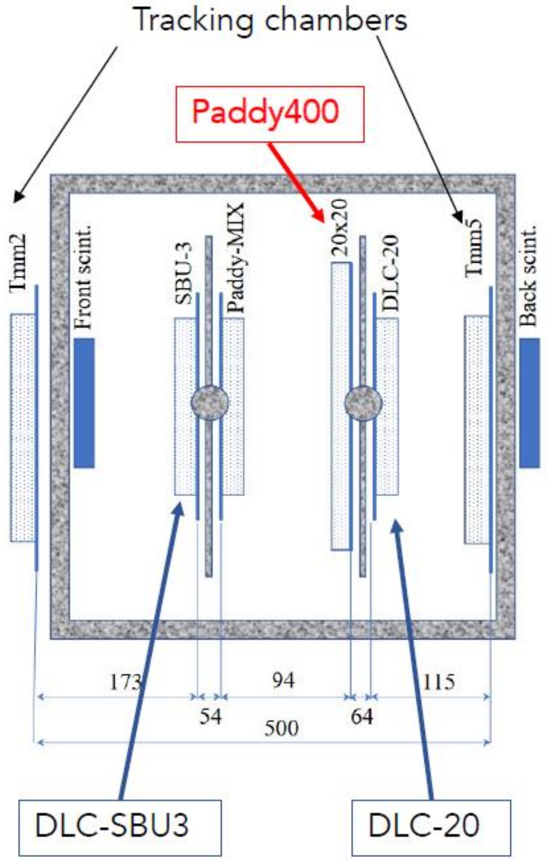
as already observed for smaller areas in previous study

https://indico.cern.ch/event/868940/contributions/3813865

Preliminary results from last CERN H4 TB

- Spatial resolution
- **Tracking efficiency**
- **Time resolution** (start of a dedicated study with «new» gaseous mixture Ar:CF_4:iC_4H_{10}(88:10:2))

150 GeV/c μ beam

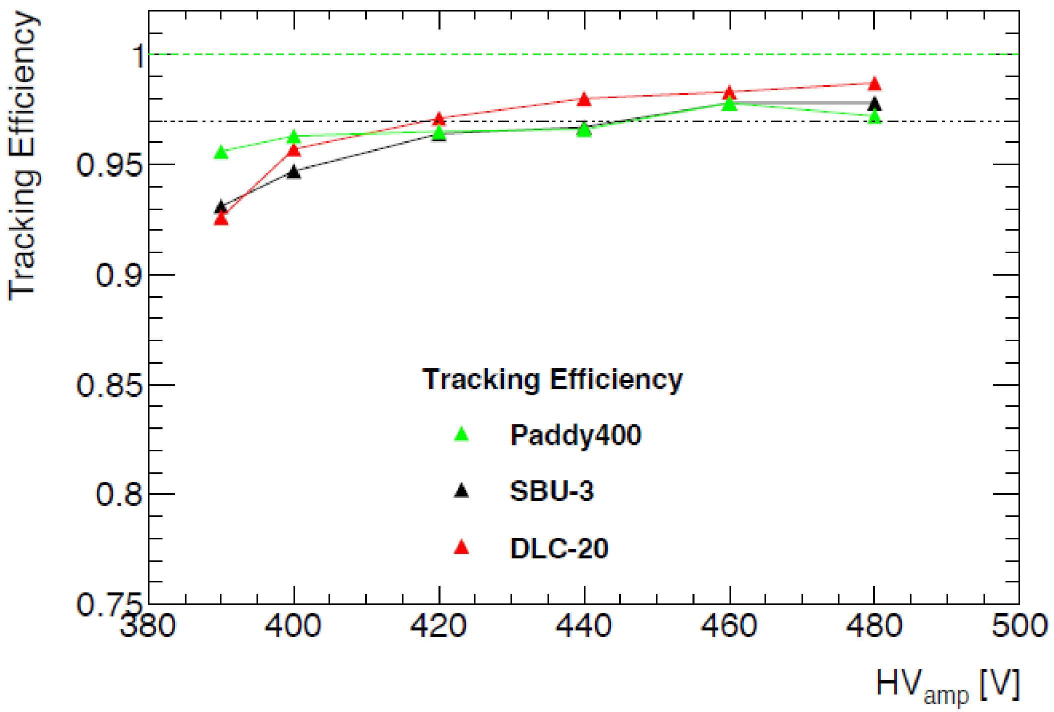


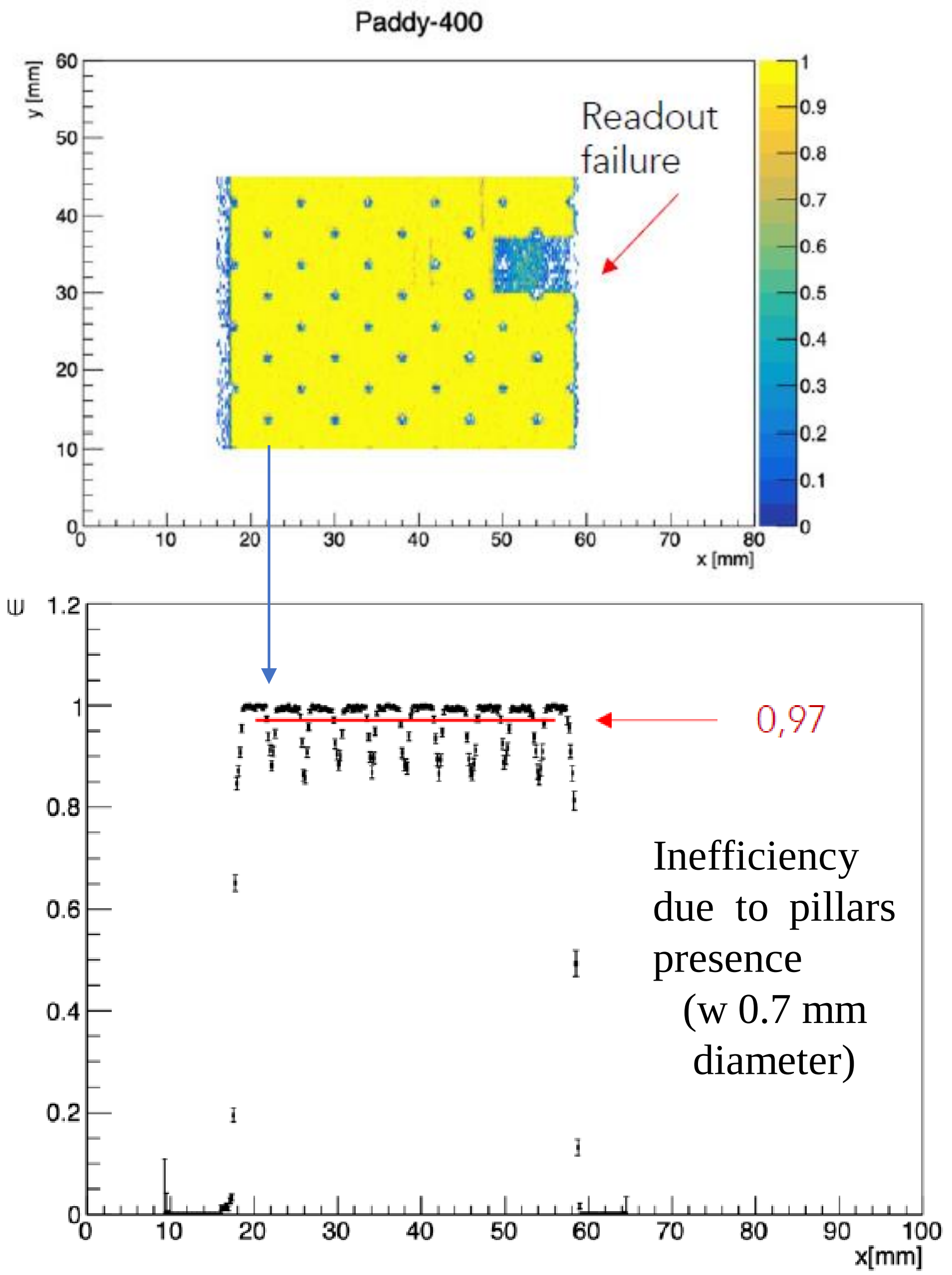
Tracking efficiency

Tracking efficiency:

1.5 mm fiducial range wrt extrapolated position from external tracking chambers

$Ar:CO_2:iC_4H_{10}$ (93:5:2) gaseous mixture

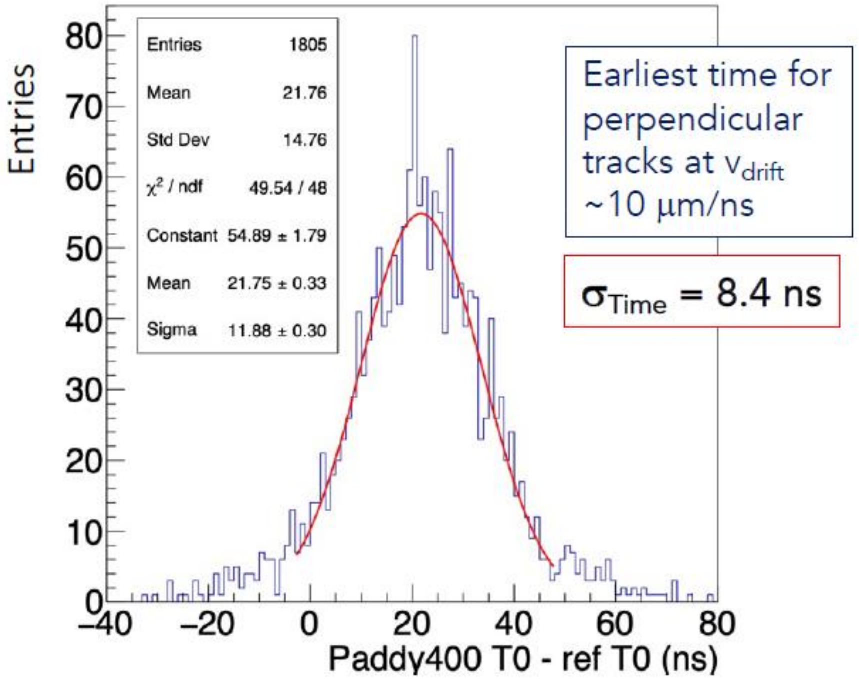




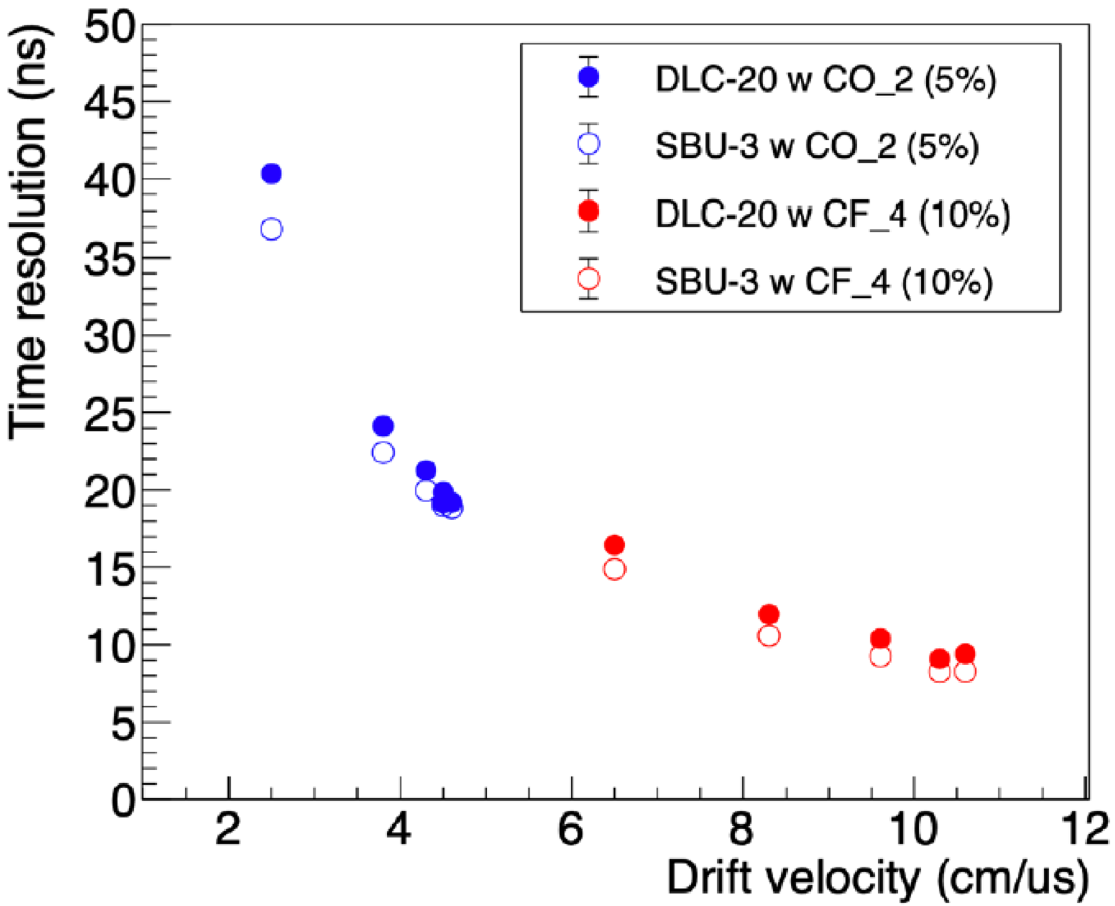
Time studies

Methodology

- Times from PADs extracted from Fermi-Dirac fit to the signal shape
- Different times computed for clusters:
  - **earliest time of a pad in the cluster (in slide)**
- Take two on-track clusters in each pair of chambers and compute the time difference;
- Gaussian fit performed to each time difference distribution;
- Time resolution evaluated as σ/sqrt(2)



Angle 0°, V_{ampl} 440 V



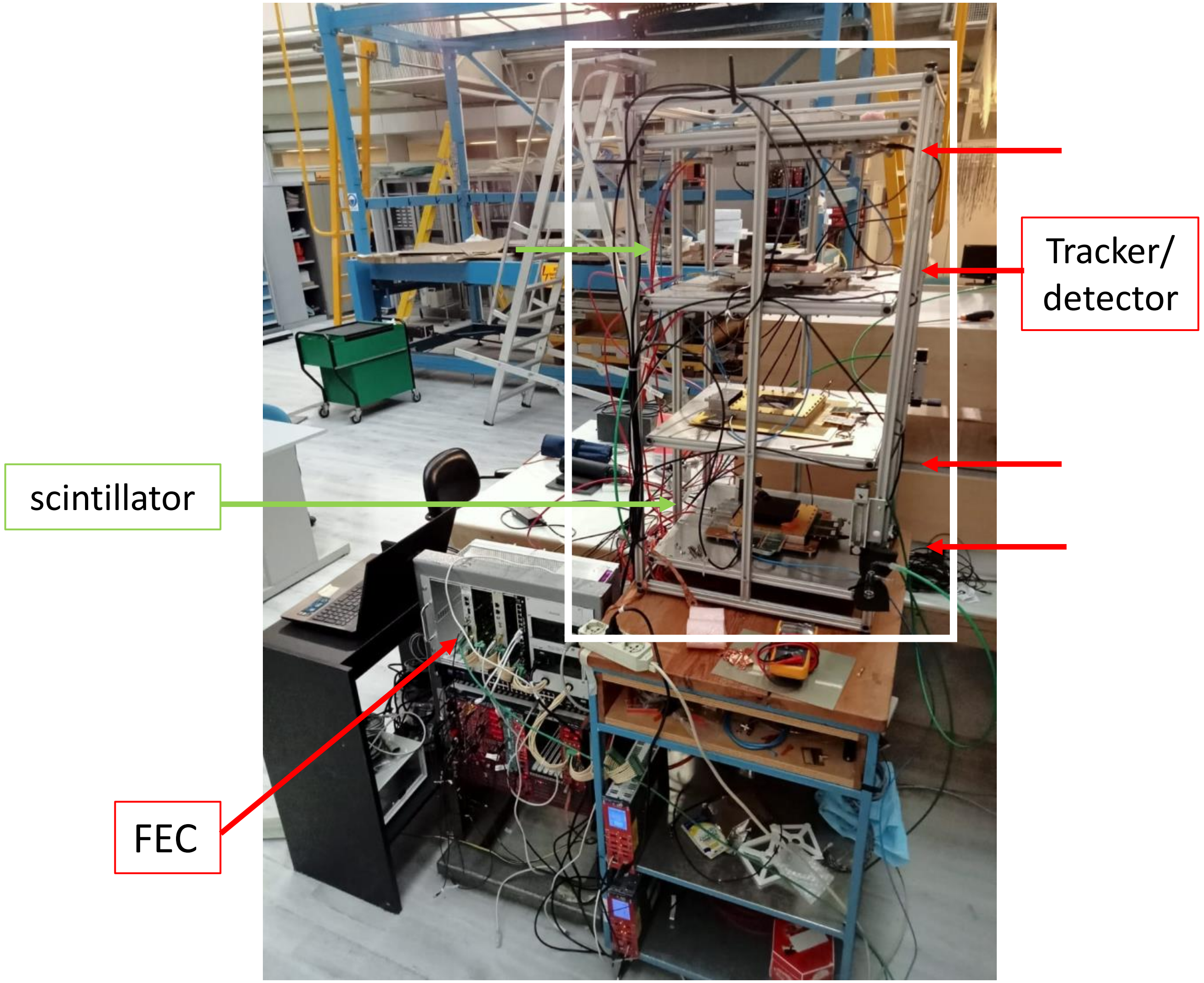
electronics and fit uncertainties not subtracted yet

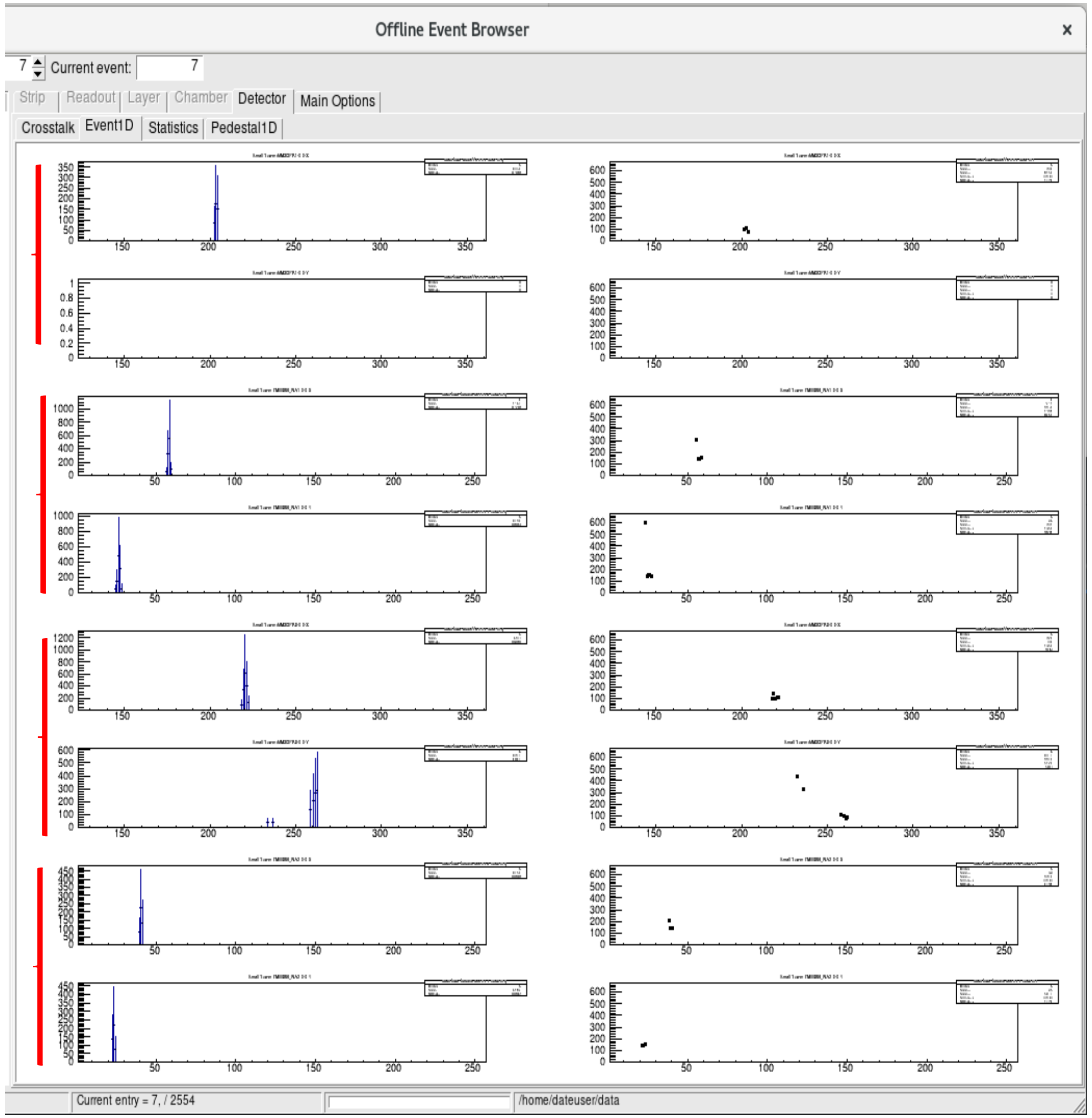
Applications

- RHUM project fot high rate application (like very forward muon detection at LHC, e.g. ATLAS Large Eta Muon tagger)
- Ongoing R&D for the sampling hadron calorimetry at muon collider (RD51 common project-contact person: P. Verwillingen)
- Currently under consideration:
  - Muon veto for SHADOWS (proposal for proton dump FIPs Physics at CERN)
  - Replacement of Muon detectors for AMBER (successive experiment of COMPASS)
- Small-pad resistive MM are among the MPGD candidates in experiments at future HEP accelerators (e.g. Snowmass21)
- Readout layer of Time Projection Chambers
- More «exotic» applications…detection of Energetic Neutral Atoms (ENA) in Space weather reaserch program

Naples site 1: Studies of tracking performance with cosmic rays

1. Studies of tracking performance with cosmic rays



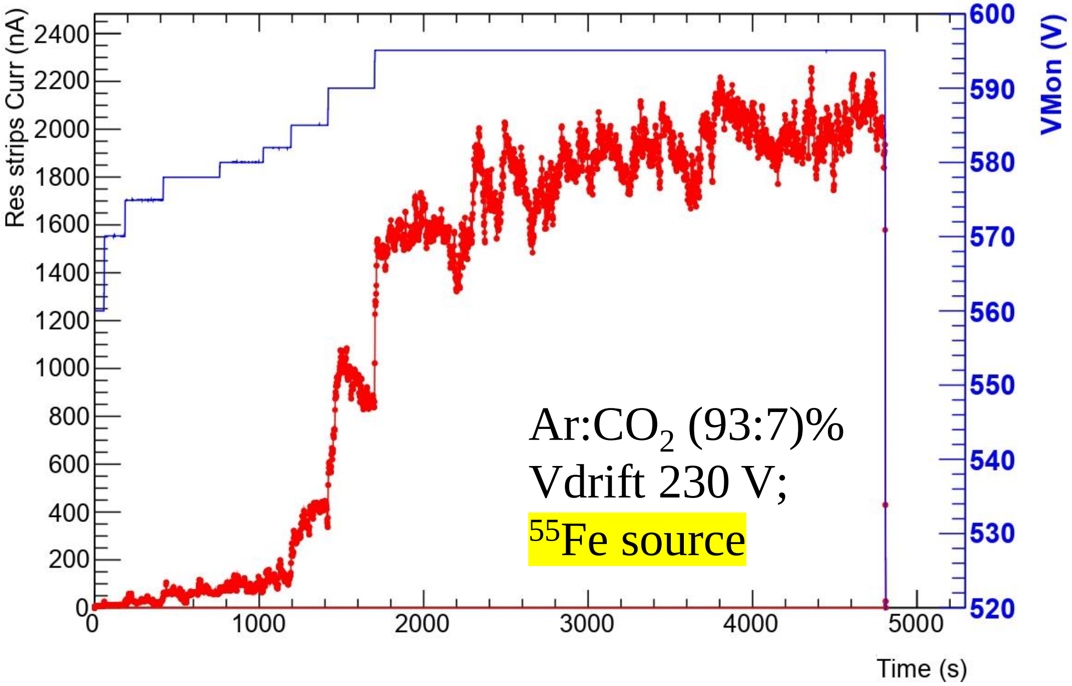


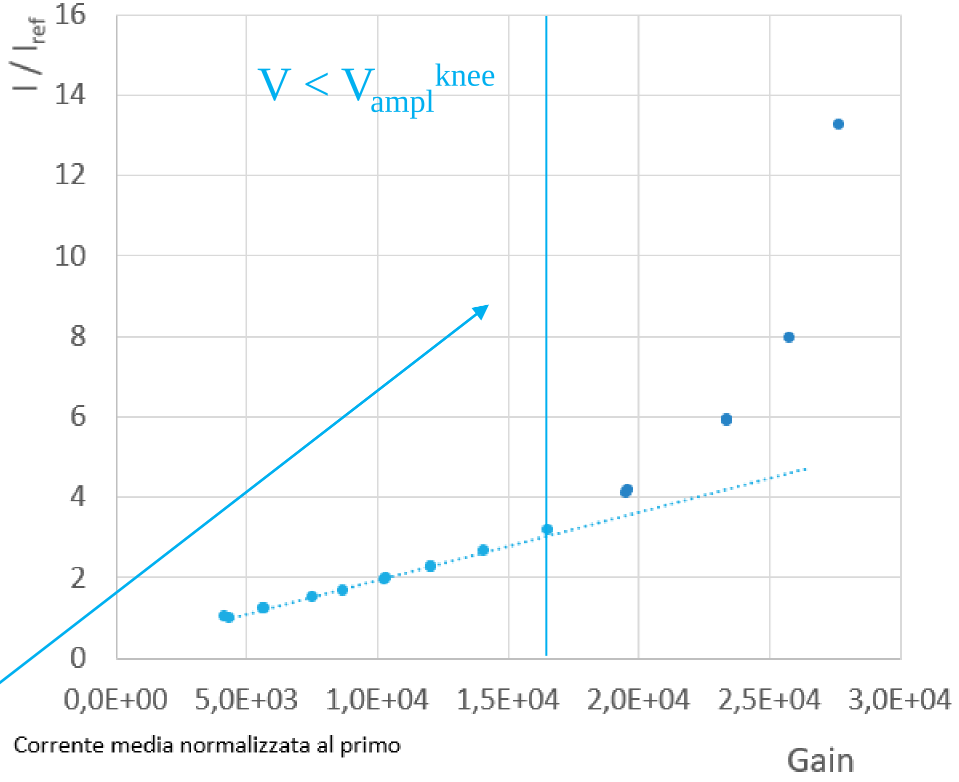
- External trigger system + 3 external trackers +1 detector to study (1 FEC);
- Next step: External trigger system + 4 external trackers +1 detector to study (2 FECs)

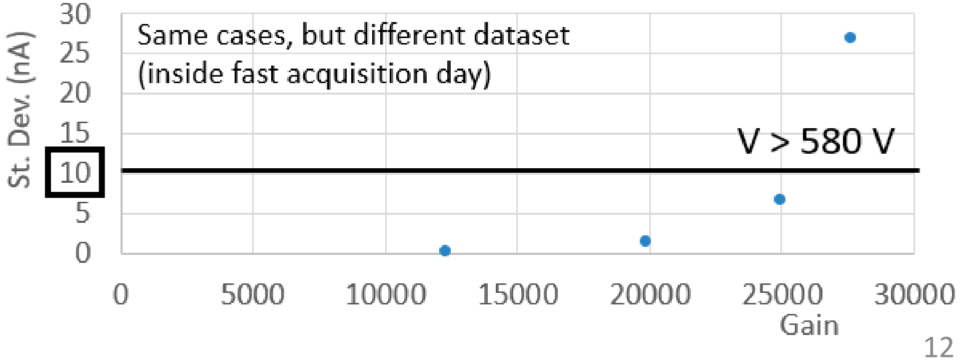
Naples site 2: Studies of G_{max} and detector robustness against discharges

R20 prototype: Current as a function of time and V_{ampl}

We stressed the detector to locate the amplification voltage V_{ampl}^{knee} (and $G_{max}(V_{ampl}^{knee})$).







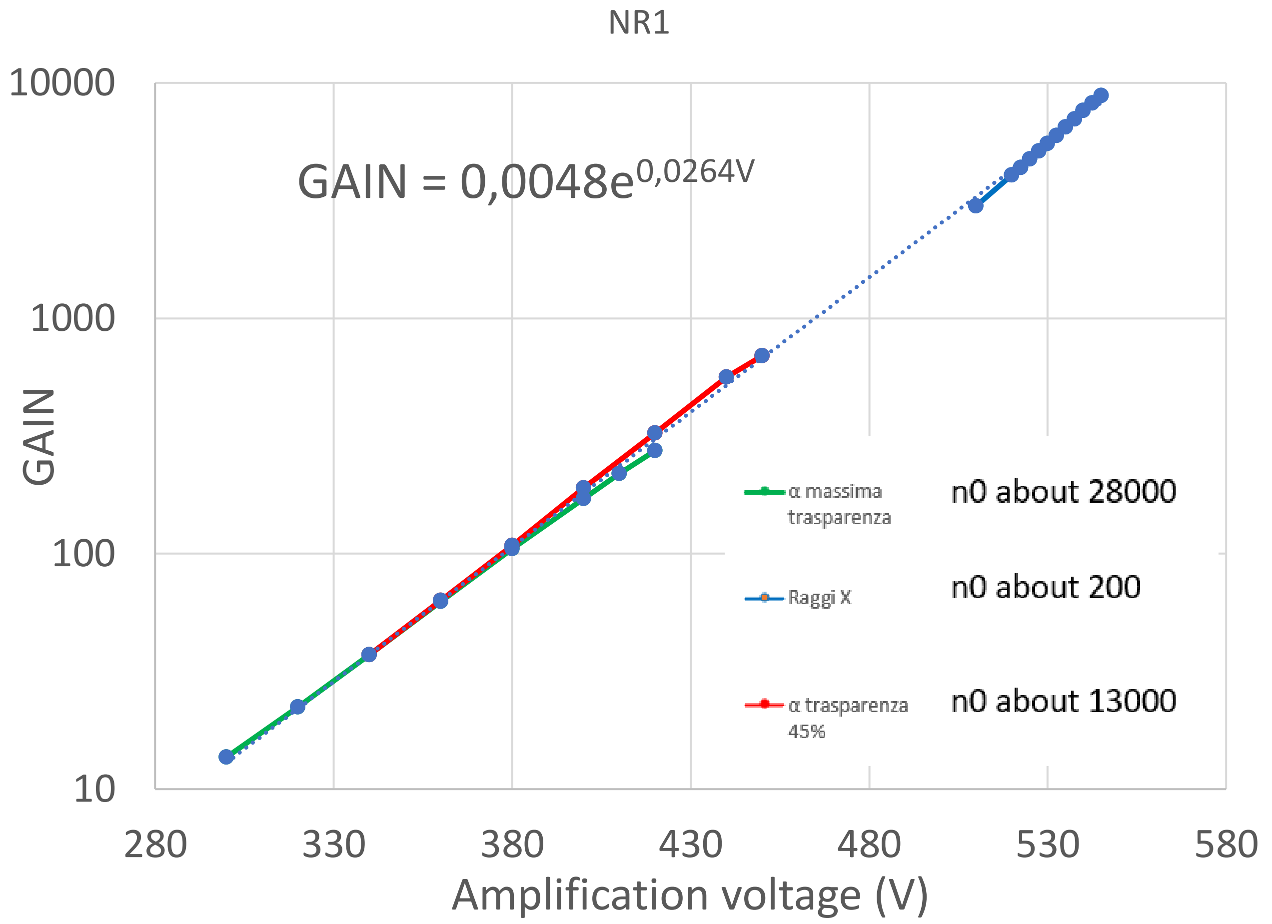
Criteria to estimate V_{ampl}^{knee} :

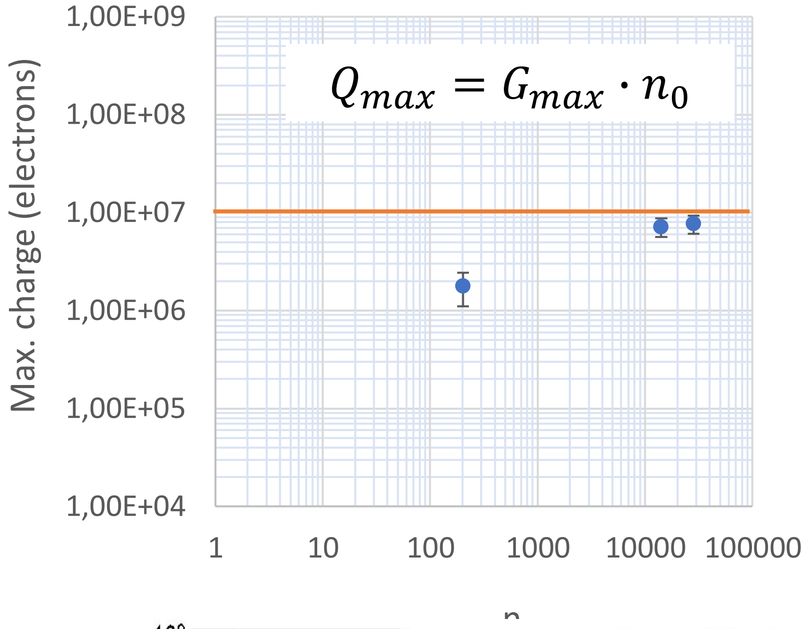
- I/I_{ref} vs G has linear trend for $V < V_{ampl}^{knee}$
- St.Dev = 10 nA
- Now we are optimising a different criterium based on I/I_{exp} with I. Osteria

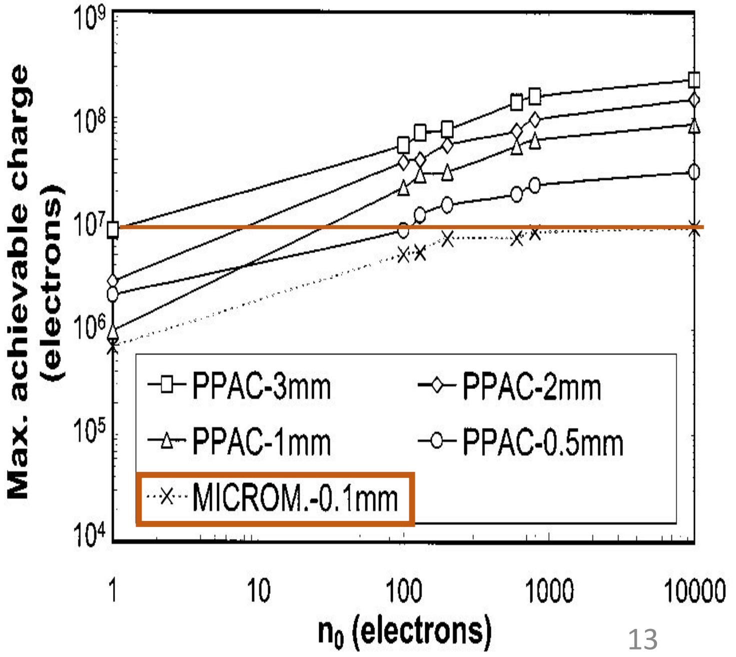
plots from from G. Boccia's thesis

Naples site 2: Studies of G_{max} with α particles and not-resistive NR1 prototype

α particles from ^{241}Am source







V. Peskov, P. Fonte, *Research on discharges in micropattern and small gap gaseous detectors*

Continuation of this study with I. Osteria on resistive R20 protoype

plots from from G. Boccia's thesis

Conclusions

The results show that small-Pad resistive Micromegas:

are <u>**excellent candidates for particle tracking and trigger operation**</u> up to rate O(1-10 MHz cm^{-2}) with

- **stable HV behaviour,**
- **O(100 um) spatial resolution;**
- **O(10 ns) time resolution**

reached a consolidated constructive techniques for large area detectors, in touch with ELTOS company for the technological transfer

Back-up

Drift velocity vs Drift electric field intensity