Resistive High granUlarity Micromegas for Future Detectors

M. Iodice* on behalf of the RHUM group:

M. Alviggi[1,2], M. Biglietti[3], M. T. Camerlingo[5], K. Chmiel[3,4], M. Della Pietra[1,2], C. Di Donato[1,6], R. Di Nardo[3,4], P. Iengo[2], M. Iodice[3], R. Orlandini[3,4], S. Perna[1,2], F. Petrucci[3,4], G. Sekhniaidze[2], M. Sessa[7]

[1]INFN Napoli, [2]Università di Napoli "Federico II", [3]INFN Roma Tre, [4]Università di Roma Tre, [5]INFN Bari, [6]Università di Napoli "Parthenope", [7]INFN Roma 2

Frontier Detectors for Frontier Physics
16th Pisa Meeting on Advanced Detectors
La Biodola • Isola d'Elba • Italy
26 May - 1 June, 2024

GOALS

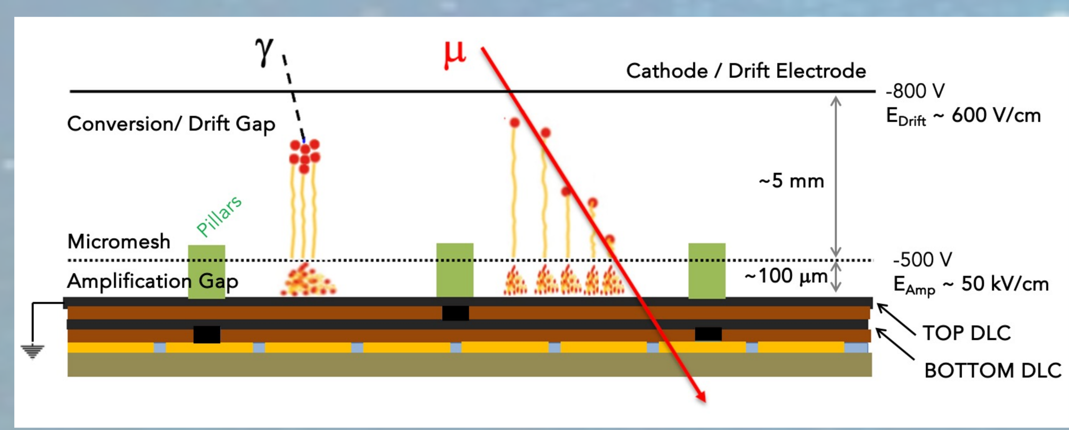
- Consolidation of resistive Micromegas, for measurements at rates of the order of 10 MHz/cm²
- High-granularity low occupancy readout on pads of the order of mm², capable of withstanding high radiation.
- Demonstration of the scalability of detectors on large surfaces
- High efficiency (close to 100%). Spatial resolution (depending on the application) of the order of 100 µm
- Robustness, stability of operation at high gains, working point with large margin before breakdown and instabilities onsets

Double DLC layer Micromegas Concept

Readout pads are covered by a **double layer of DLC** with a grid of staggered interconnecting vias for rapid charge evacuation.

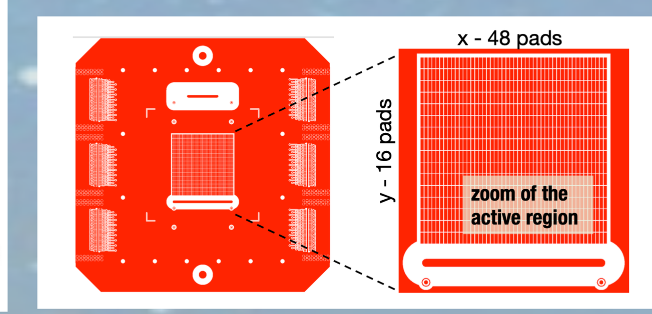
(Concept from: G. Bencivenni, et al., JINST 12 (2017) 06, C06027)

Typical (optimal) DLC resistivity: 20 – 40 MΩ/sq

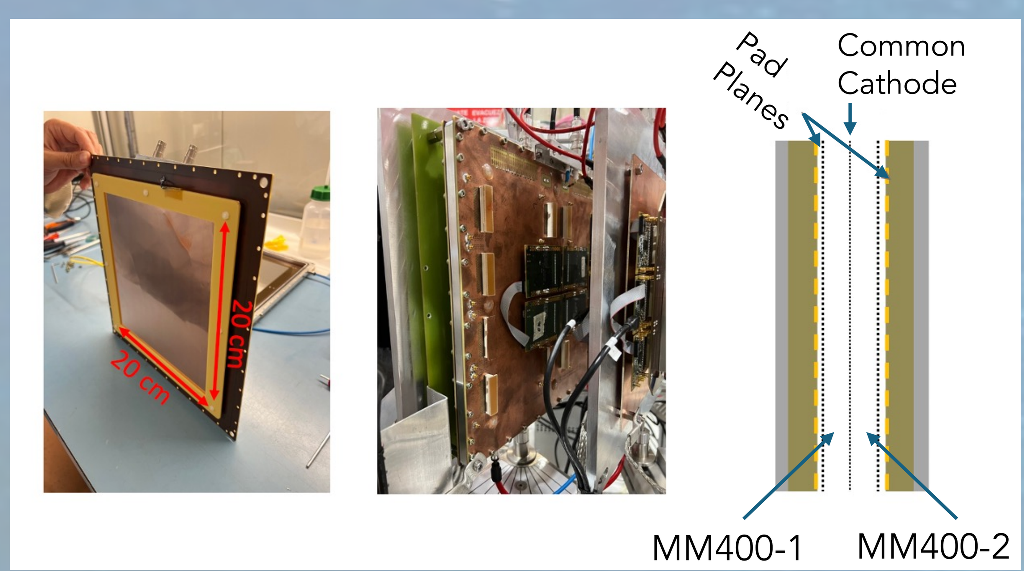


All small size Micromegas presented here consist of a similar anode plane, segmented in 48 x16 readout pads.

PAD SIZE: 1 x 3 mm²

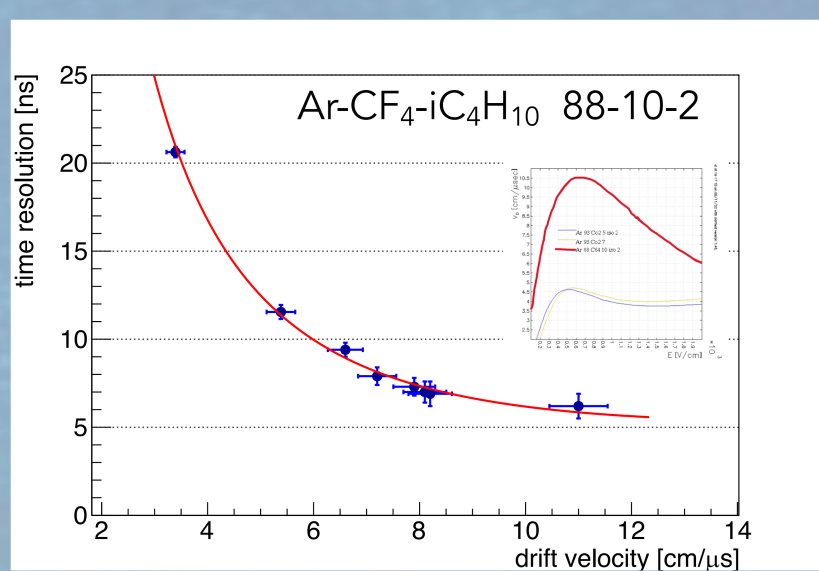


Medium-Size Double DLC layer Micromegas



Two detectors MM400-1 and MM400-2 designed to operate in sandwich config sharing the same cathode

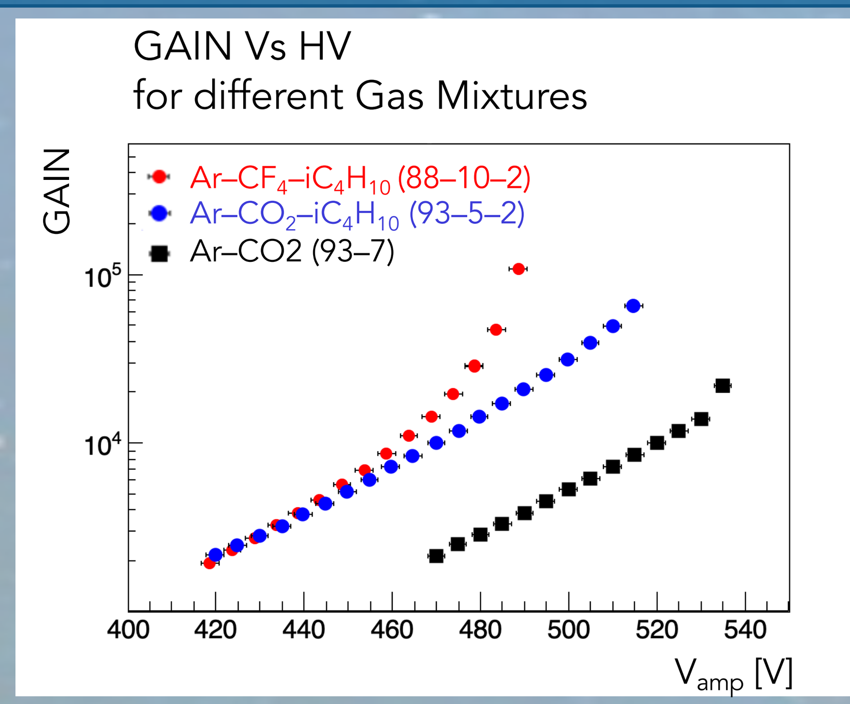
Anode plane pad size: 1x8 mm2



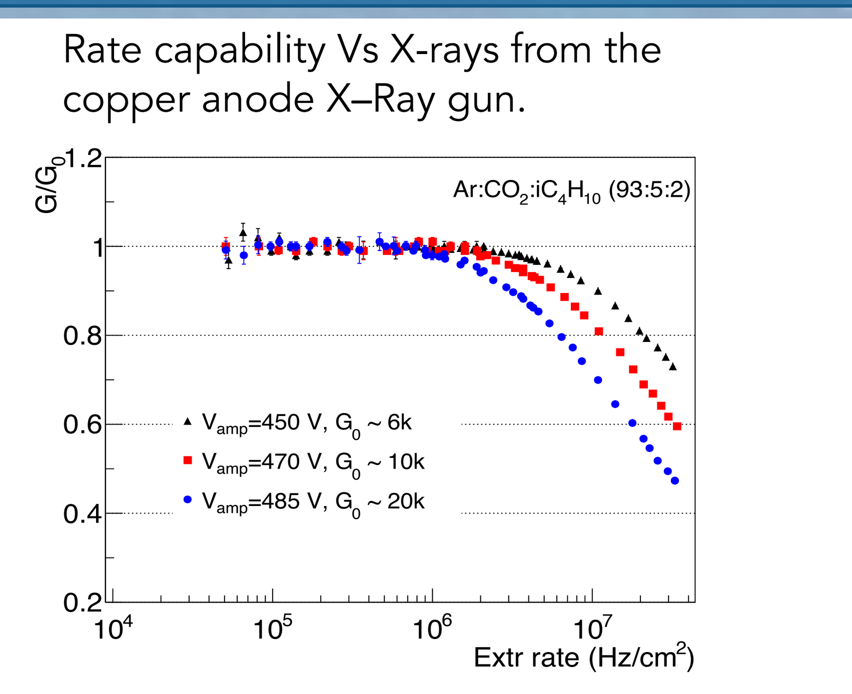
Test-Beam: Time resolution from cluster time arrival difference between MM400-1 and 400-2:

σ_{time}~6 ns at v_{drift} ~ 11 cm/µs

Gain and Rate Capability

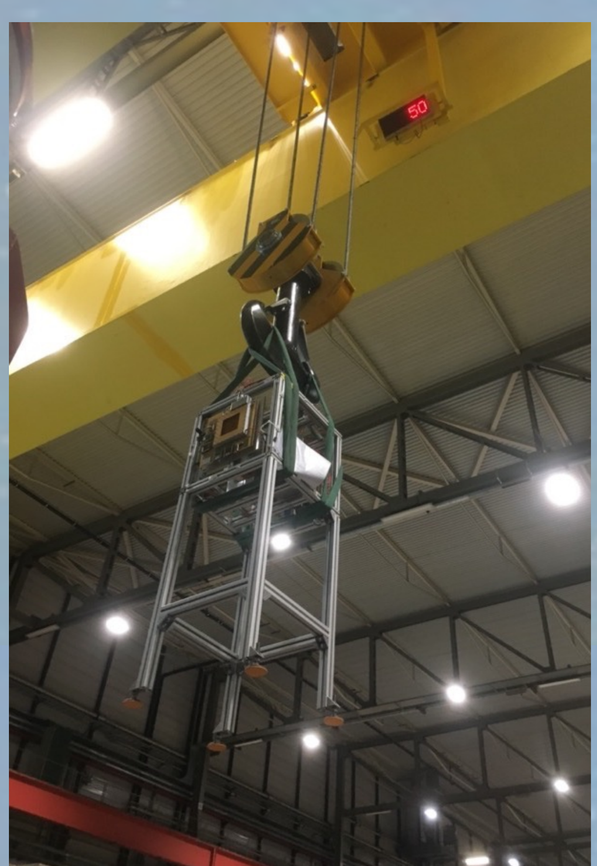


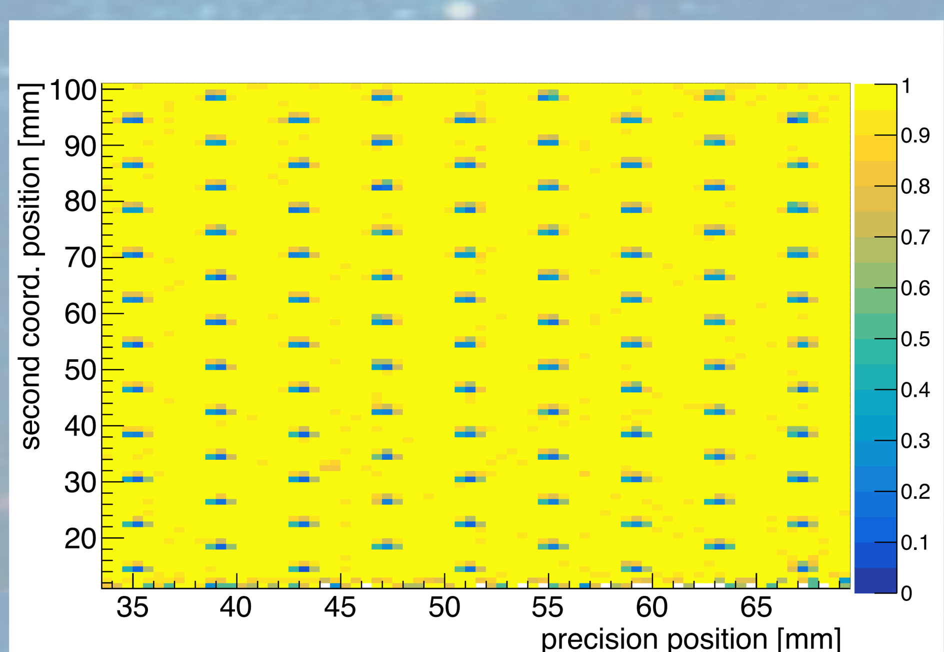
Addition of 2% of isobutane can significantly extend the stability range up to 7x10⁴ and 10⁵ with $Ar–CO_2–iC_4H_{10}$ (93–5–2) and $Ar–CF_4–iC_4H_{10}$ (88–10–2)



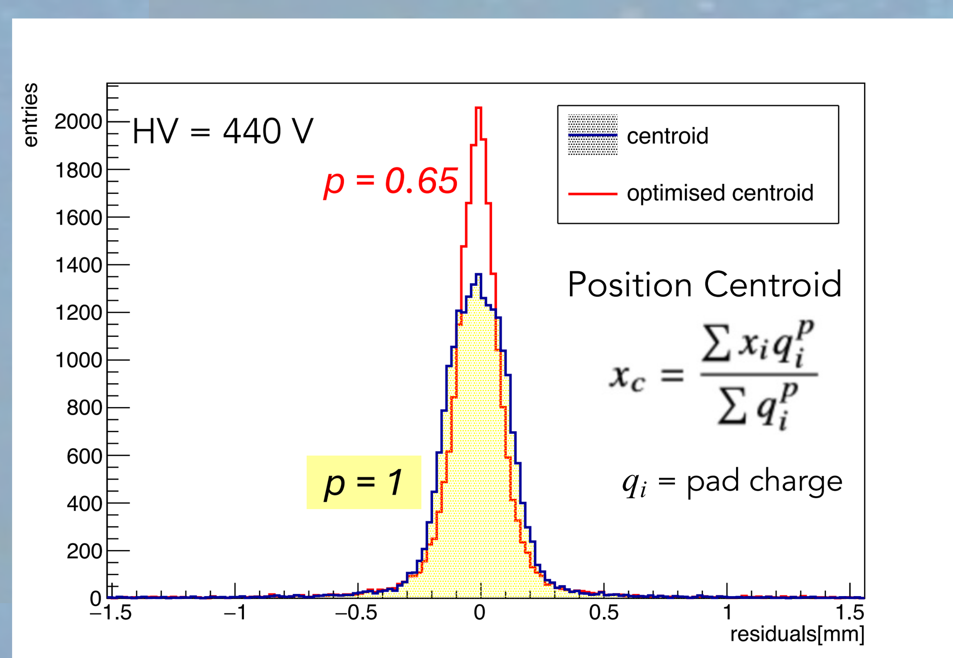
Gain drops at **10 MHz/cm²** are limited to 10% at G_0 = 6000, and to 20% and 30% at gains of 10k and 20k, respectively.

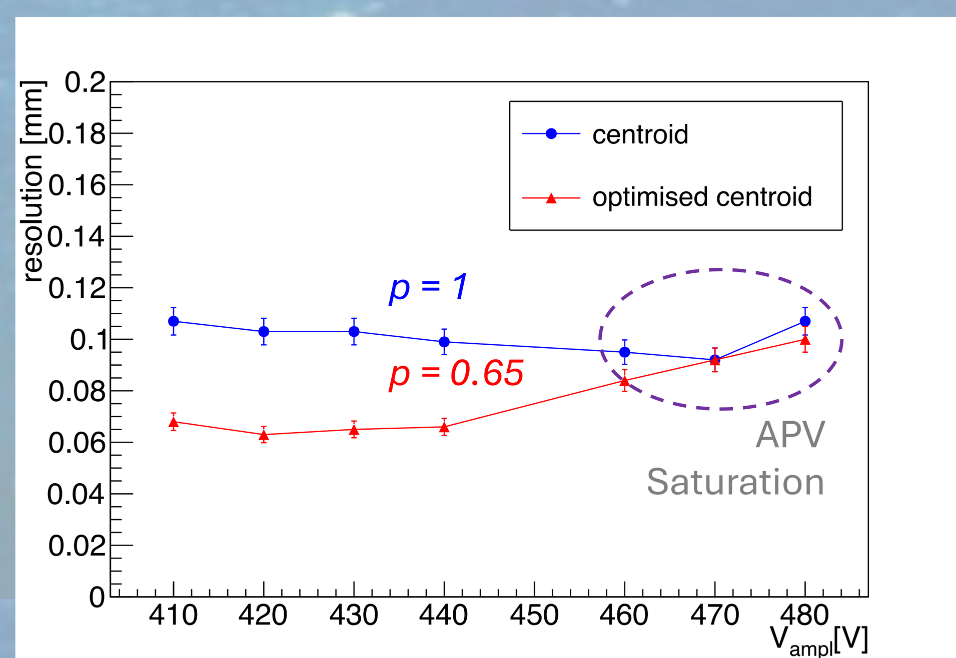
Test-Beam Results: Efficiency and Spatial Resolution for the Medium-Size Detector





Efficiency for perpendicular tracks is nearly 100% except at pillar positions.



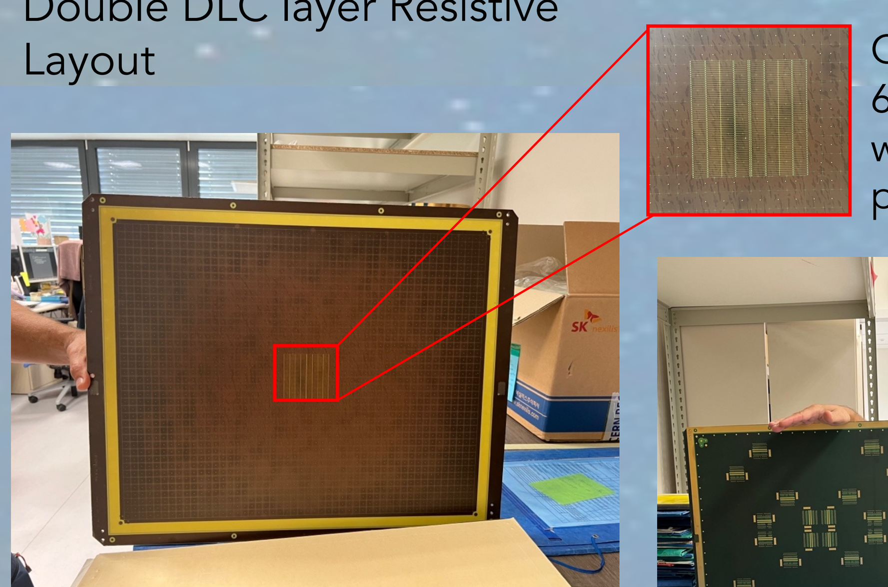


Spatial resolutions measured for perpendicular tracks (from residuals clusters vs track)

Optimised resolution: **~65 µm** with charge weighted centroid using p = 0.65

Towards Large Area: 50 x 40 cm²

Double DLC layer Resistive Layout

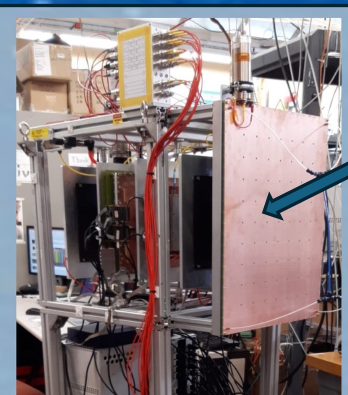


Central region 6.4x6.4 cm² with1x8 mm² pads

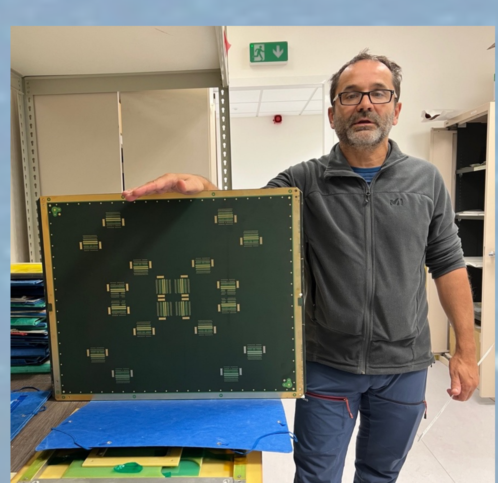
50x40 cm² construction completed

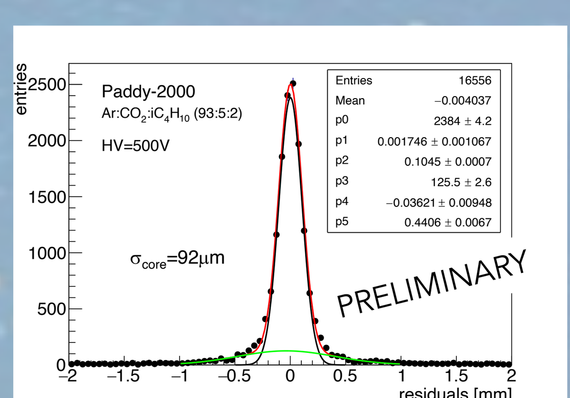
Fine granularity in the centre

1 cm² pads elsewhere



BigOne SPATIAL RESOLUTION



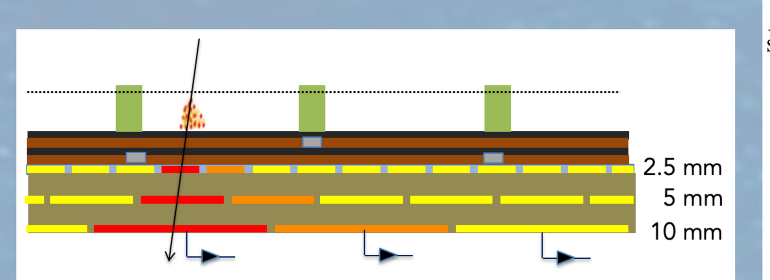


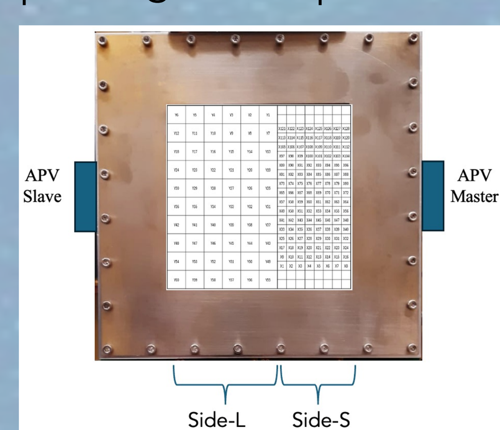
Many thanks for all aspects of our R&D to: Rui De Oliveira, B. Mehl, O. Pizzirusso, and all the MPT CERN Workshop

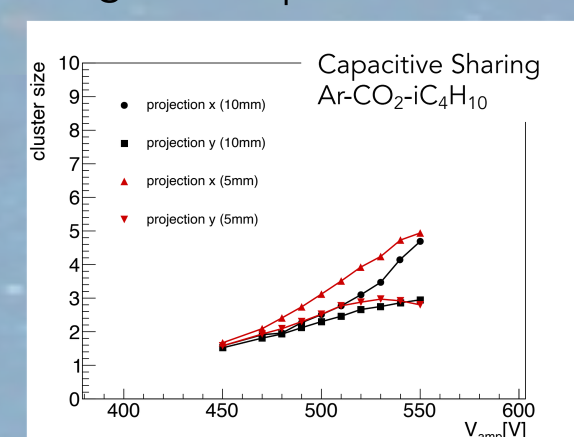
Medium/Low-rate Version – Capacitive Sharing

Reduction of the Readout Channels Exploiting the Capacitive Sharing Technique

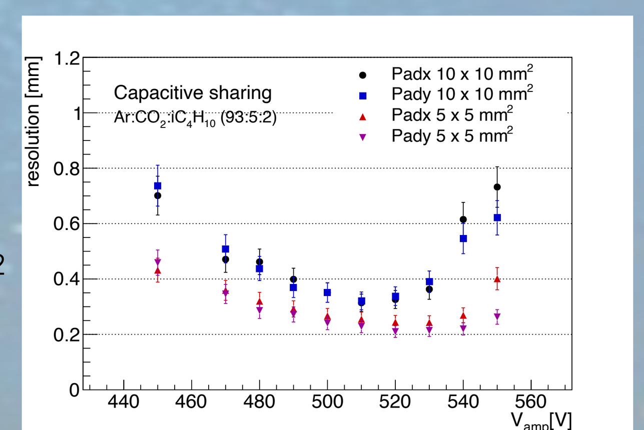
(K. Gnanvo et al., Nucl. Instrum. Meth. A 1047 (2023) 167782)







- Pad size of "top-layer" (signal induction): 2.5x2.5 mm2
- **Side-L**: three layers capacitive sharing: 2.5x2.5 mm² → 5x5 mm² → 10x10 mm²
- **Side-S**: two layers capacitive sharing: pad-size: 2.5x2.5 mm² → 5x5 mm²



Dependence on HV (Cluster-size)

REACH ~350 µm

→ A factor 1/30 of the pad size

(~200 µm with 5x5 cm² pads)

(*) M. Iodice INFN Roma Tre (Italy) mauro.iodice@roma3.infn.it