Resistive High Granularity Micromegas for Future Detectors

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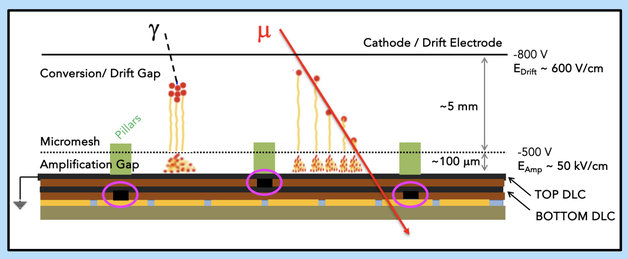
Introduction

- **Challenge**: Future particle physics experiments will require large-area detector systems capable of providing high spatial resolution and excellent time resolution while operating efficiently and reliably in extreme particle fluxes.
- **Our Approach**: The Resistive High granularity Micromegas (RHUM) group develops and characterizes novel, scalable detector prototypes specifically designed to meet these demanding criteria.
- **On This Poster**: We present an overview of our prototypes, which feature different design concepts to optimize performance for various applications. We highlight key results related to their design and performance.

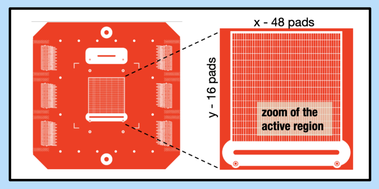
Don't blink: Micromegas at extreme rates

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



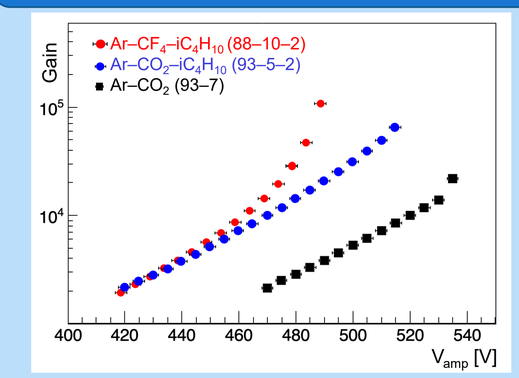
Resistive configuration concept from:
G. Bencivenni, et al., JINST 12 (2017) 06, C06027

To provide both spark protection and rapid charge evacuation, the readout pads are covered by a double layer of Kapton coated with a resistive diamond-like carbon (**DLC**) layer. These layers incorporate a grid of staggered vias that provide a direct path to ground for surface charge.

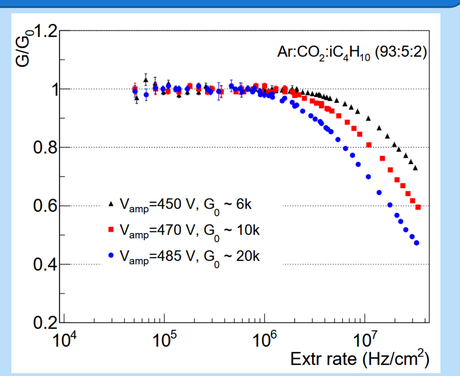


Readout layer of a Micromegas prototype.
Pad size: 1x3 mm²

Stability and rate capability at high rates



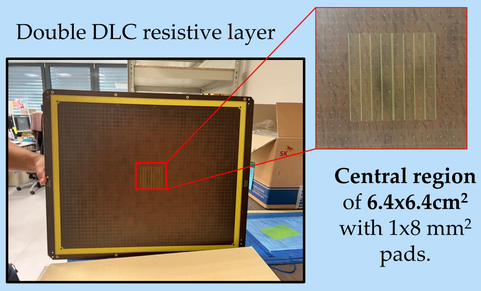
Gain as function of the amplification voltage. The chamber is stable for **gains up to 10^5** with the addition of 2% Isobutane.



Gain drop at 10 MHz/cm² limited to:
- 10% at G_0=6k;
- 20% at G_0=10k;
- 30% at G_0=20k

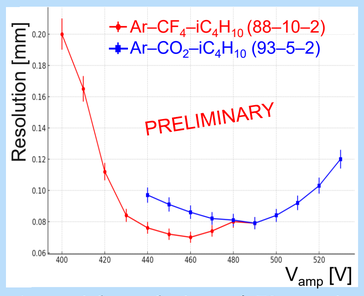
Thinking big: the large-area Micromegas

Double DLC resistive layer

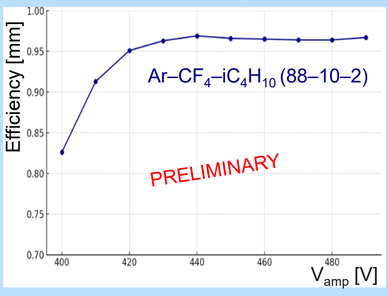


Central region of **6.4x6.4cm²** with 1x8 mm² pads.

"Paddy-2000" is a **large-area** prototype, measuring **50×40 cm²** designed with a segmented readout plane divided into two distinct regions. The high-granularity central area is surrounded by a coarser region where the pad area is 1 cm².



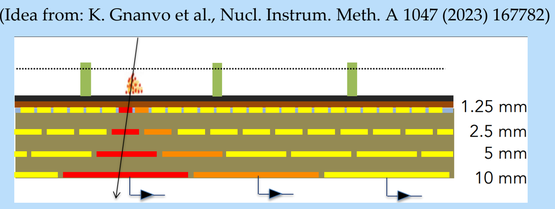
A spatial resolution of **70 μm** is achieved in the high-granularity central region, which features a **1 mm pad pitch**. This performance was evaluated using two different gas mixtures at a test beam.



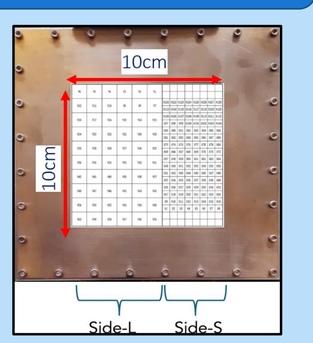
Based on test beam data with straight tracks, the detector achieves a stable detection efficiency of **97%** in the central, high-granularity region. Part of the efficiency is lost due to the pillars dead area.

Less is more: capacitive-sharing readout

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

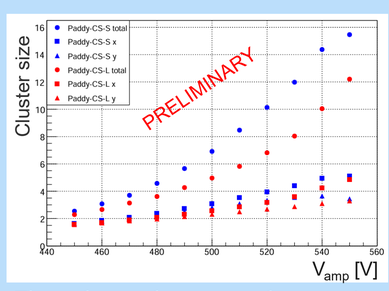


For applications at **low-medium rates**, a configuration with larger size readout elements has been developed. The capacitive-sharing layout enables the use of a coarser pad geometry, **reducing the readout electronic channels**, while **preserving spatial resolution**. This design is being implemented in resistive Micromegas detectors, targeting **muon system** applications at **FCC-ee.**

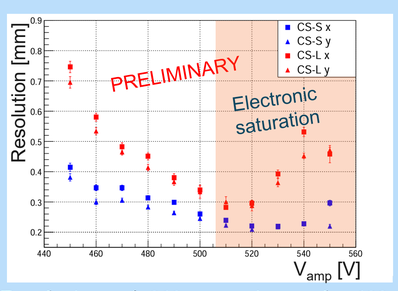


Side-L pad pitches:
1.25mm➔2.5mm➔5mm➔10mm
Side-S pad pitches:
1.25mm➔2.5mm➔5mm➔5mm

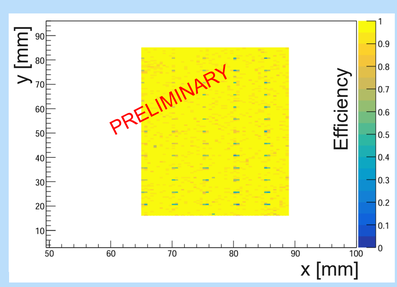
Capacitive-sharing with straight tracks



The observed mean cluster size provides evidence of charge-sharing being consistent with the capacitive-sharing layout.

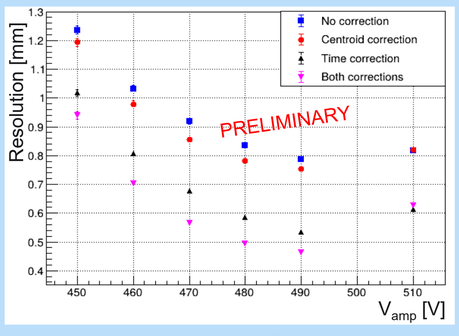


Resolution of **210 μm** using only **128 readout channels** on the **5x5mm²** side. While a resolution of **300μm** using only **60 readout channels** is achieved on the **10x10mm²**.

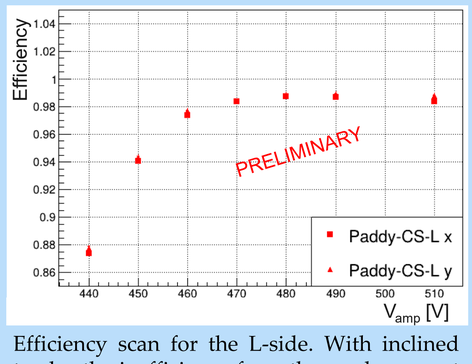


Side-S efficiency map. The overall efficiency is **98%**. The main inefficiency source are the pillars supporting the mesh, which are visible as regularly spaced spots.

Capacitive-sharing with inclined tracks



Spatial resolution for **~38° inclined tracks** before and after applying time and centroid corrections for the **L-Side**. Resolutions as good as **460 μm** are reached.



Efficiency scan for the L-side. With inclined tracks, the inefficiency from the mesh support pillars is mitigated, resulting in a measured detection efficiency of **99%**.

The best of both worlds: large-area capacitive-sharing

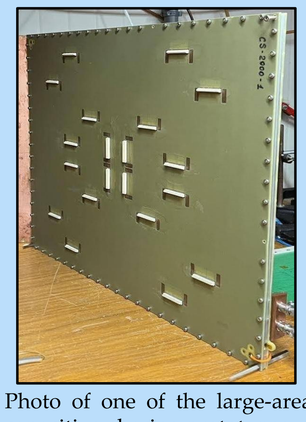
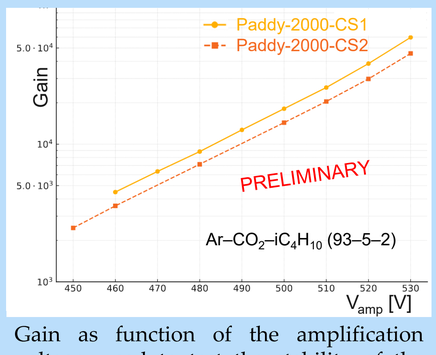


Photo of one of the large-area capacitive-sharing prototypes.

We have developed **two new prototypes**, the "Paddy-2000-CS-1" and "Paddy-2000-CS-2", which integrate our large-area Micromegas technology with capacitive charge-sharing and double DLC resistive layer. Both detectors were recently assembled and are now undergoing systematic characterization.



Gain as function of the amplification voltage, used to test the stability of the two detectors. Gains of over **$3x10^5$** are reached with no observed instability.

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