

Study of bulk and surface resistivity of carbon-loaded PTFE material for RPC

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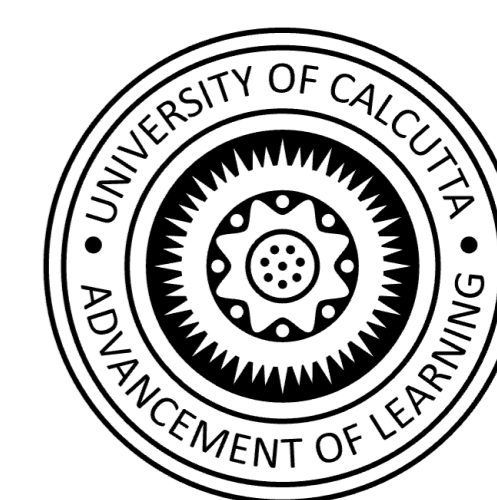
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Introduction

- Exploration of the possibility of using RPCs for the 4th station of CBM-Muon Chamber (MuCh) (Expected particle flux at the 4th station for central Au + Au collision ~ 10 kHz/cm² for 12 A GeV/c beam momentum)
- Highlights of the new RPC

Material: carbon-loaded Polytetrafluoroethylene (PTFE) commonly known as Teflon.

This particular sample is 25% carbon-filled

Bulk resistivity of $10^5 \Omega\text{-cm}$ (2018 result)

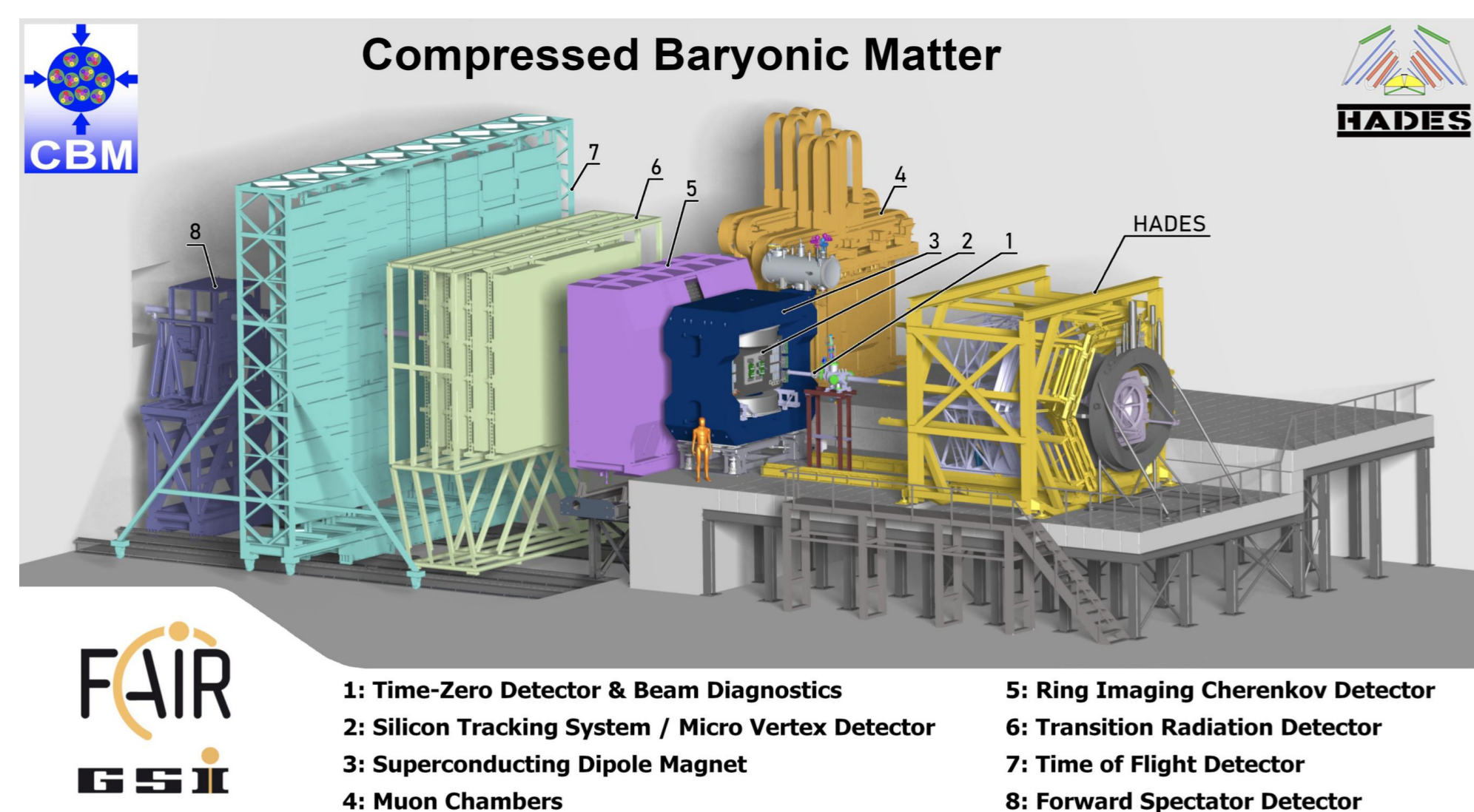
Plate dimension: 150 mm x 150 mm x 1 mm

Gas gap: 2 mm

Surface resistivity of bakelite: 20 k Ω /□

No graphite coating

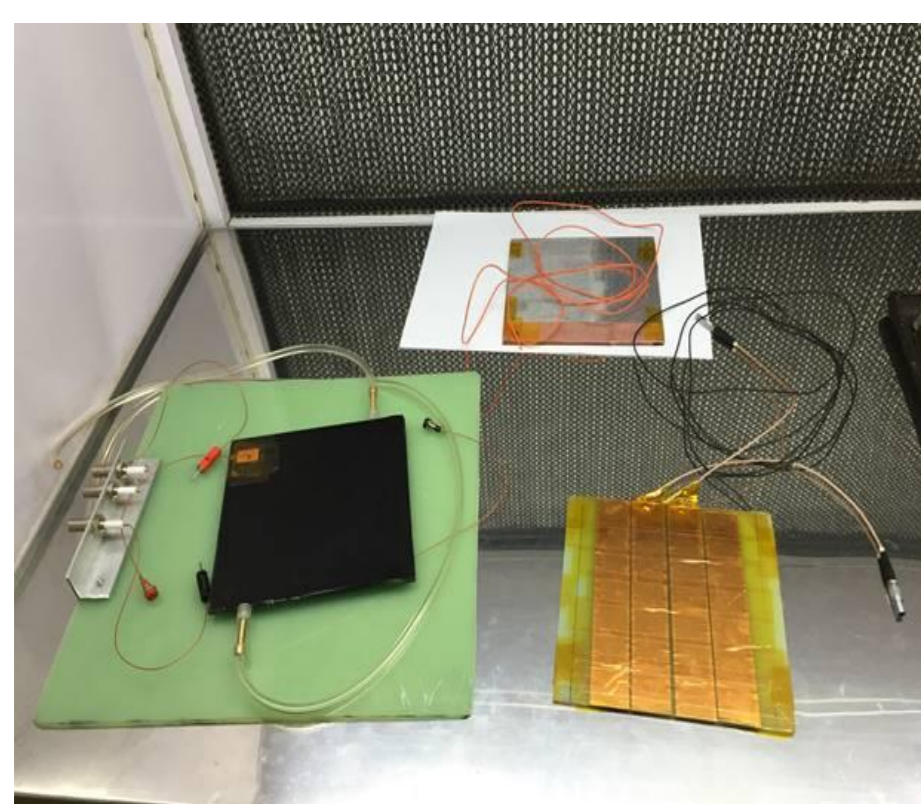
- At a voltage of 4 kV an efficiency $\sim 60\%$ is achieved. Afterwards Discharge observed.



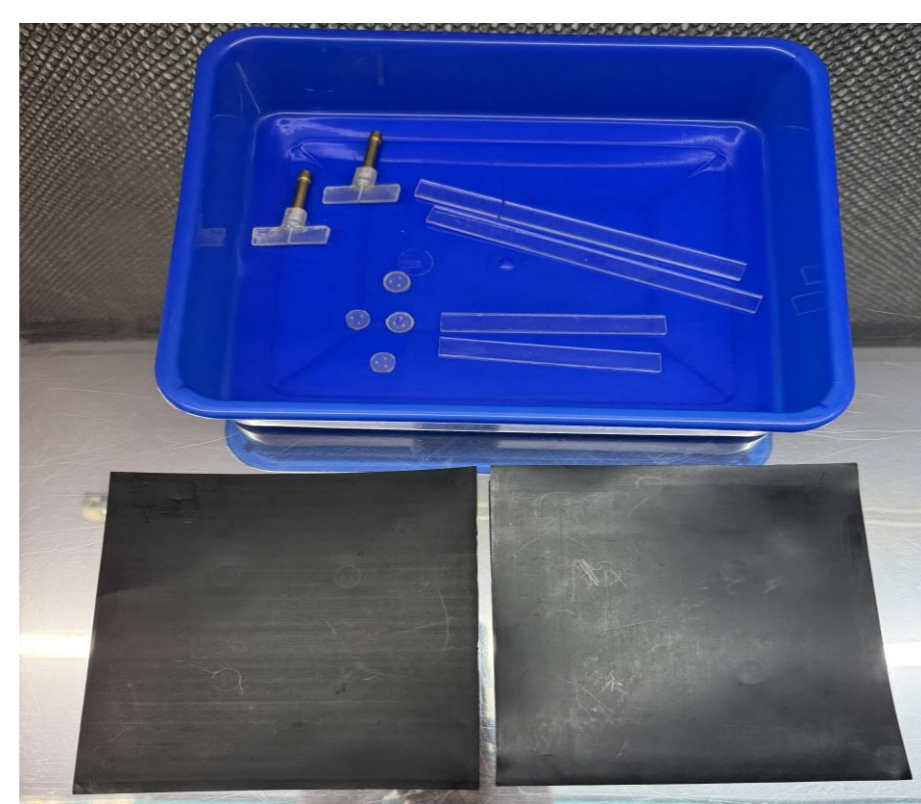
CBM experimental set-up @ FAIR

Motivation for the Present Study

- Re-measurement of bulk and surface resistivity of the PTFE electrode
- Comparison with 2018 data
- Re-fabrication of RPC prototype using the same electrode and to investigate the detector performance after 7 years.



Detector Prototype in 2018



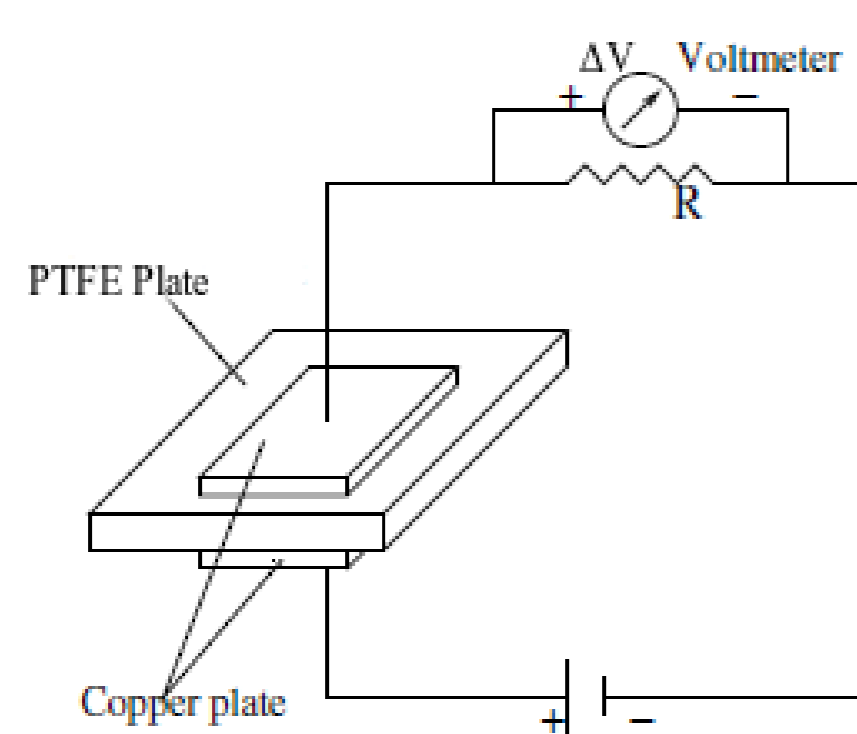
Components after reopened in 2025

Experimental Setup for Resistivity Measurement

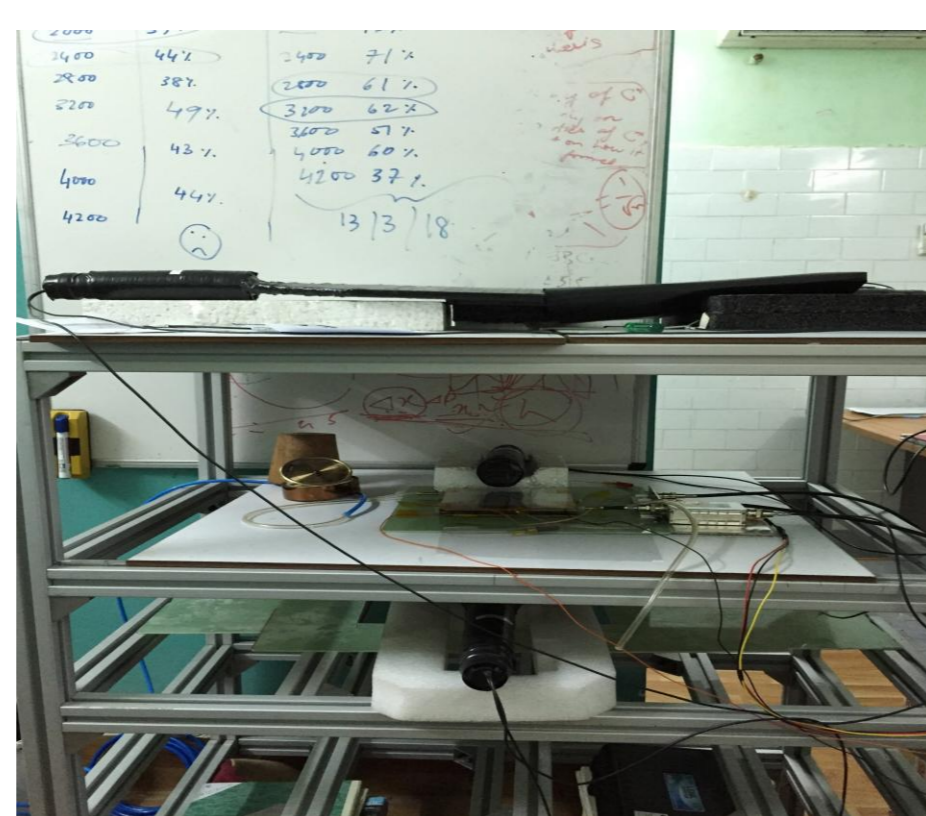
Bulk resistivity was measured by applying a DC voltage across the sample using 2.5 cm \times 2.5 cm copper electrodes and a 22 M Ω series resistor. The resistivity was calculated using:

$$R_v = (AV - \Delta V)R / \Delta V$$

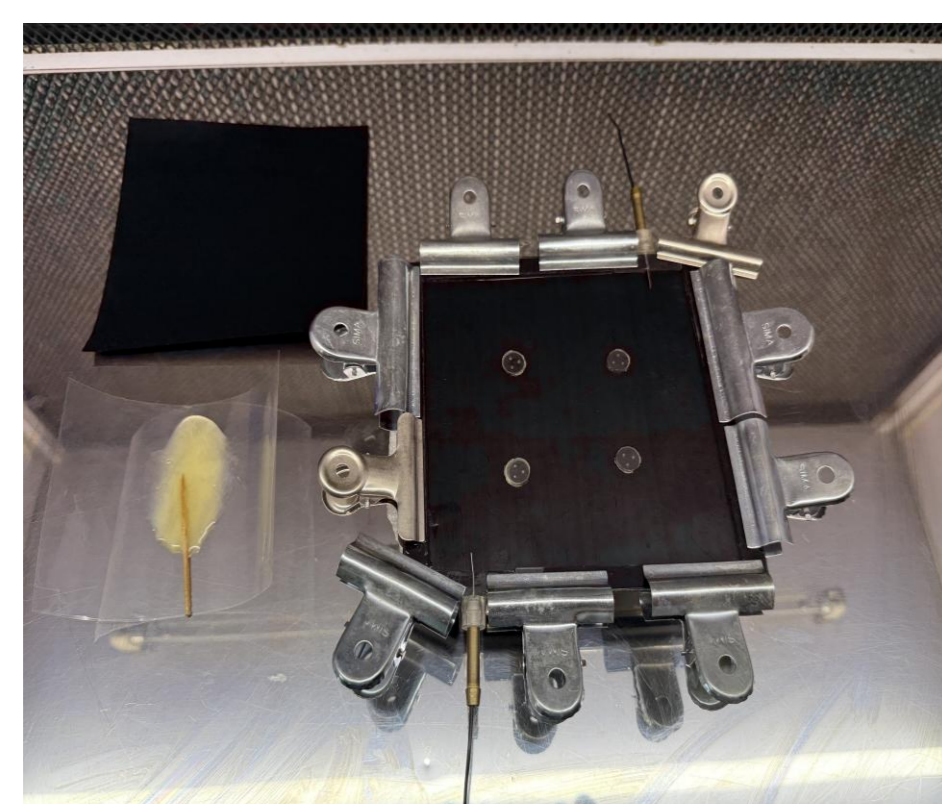
Measurements were performed at an average temperature of 21.5 $^\circ$ C and relative humidity of 75%.



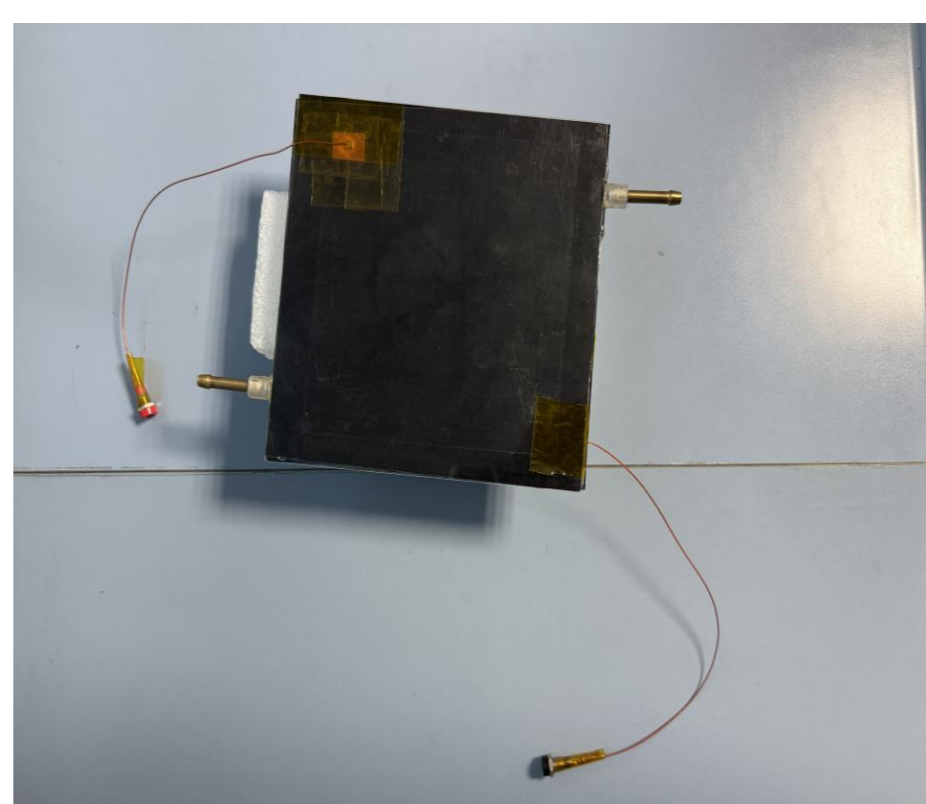
Circuit for bulk resistivity measurement



Experimental Set-up



Fabrication of the prototype in 2025

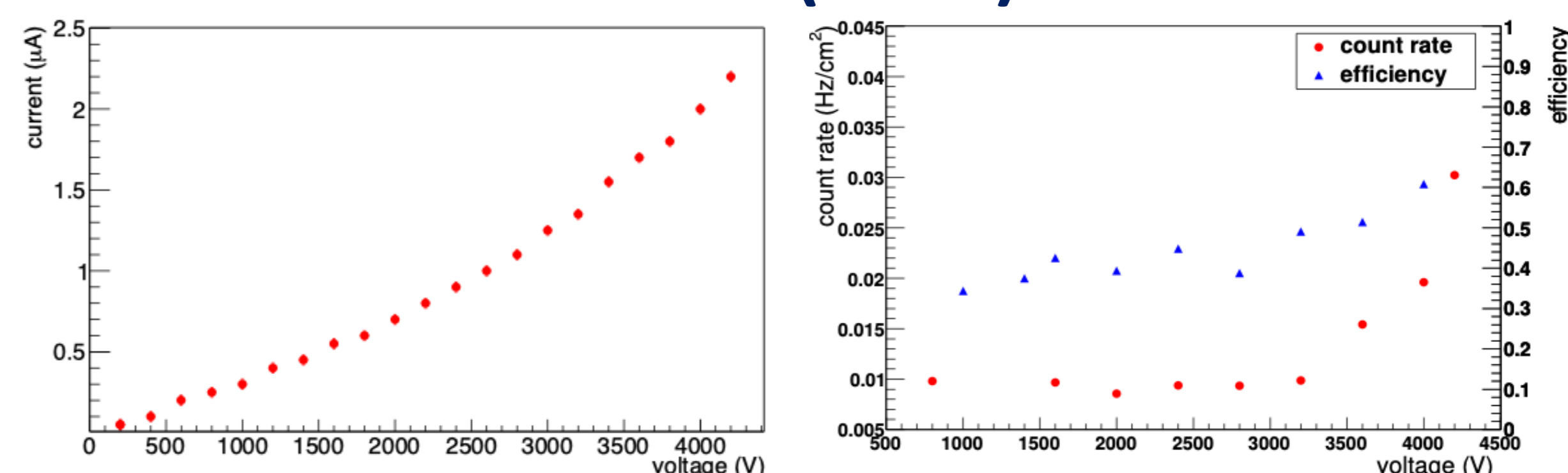


Complete RPC in 2025

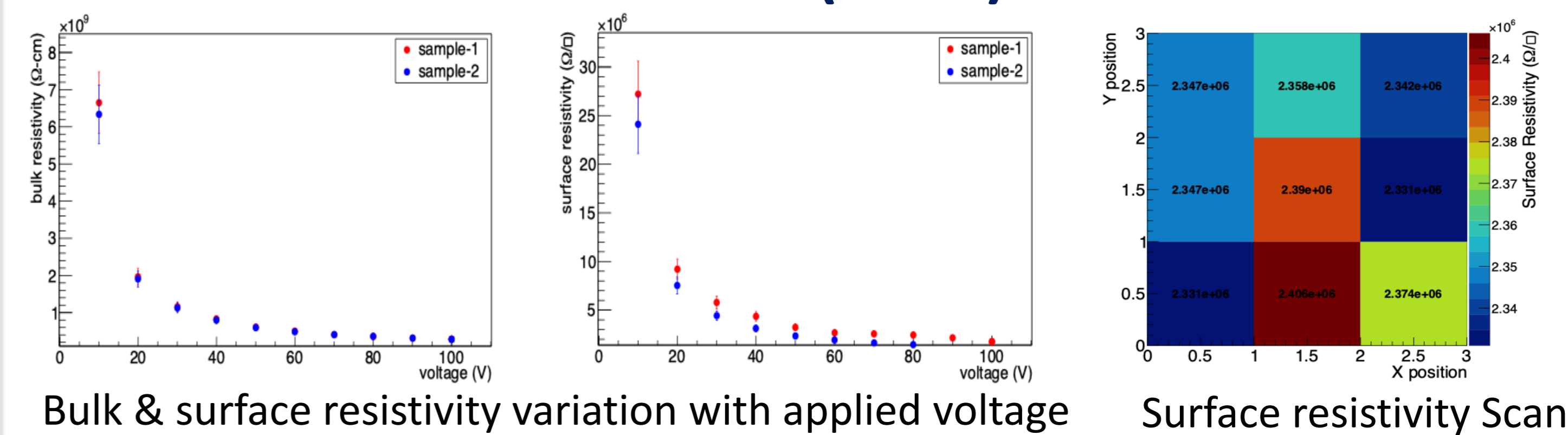
Summary and outlook

- A significant increase in bulk resistivity and efficiency $>80\%$ at 2700 V
- Future work will include stability and rate handling capability studies to assess the suitability of PTFE electrode for RPC detectors

Result (2018)

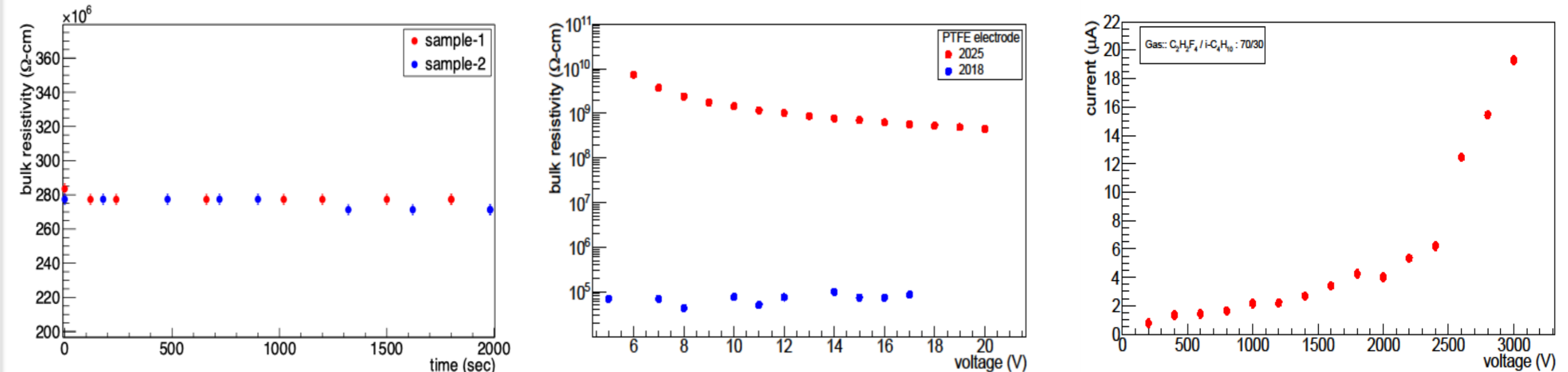


Result(2025)



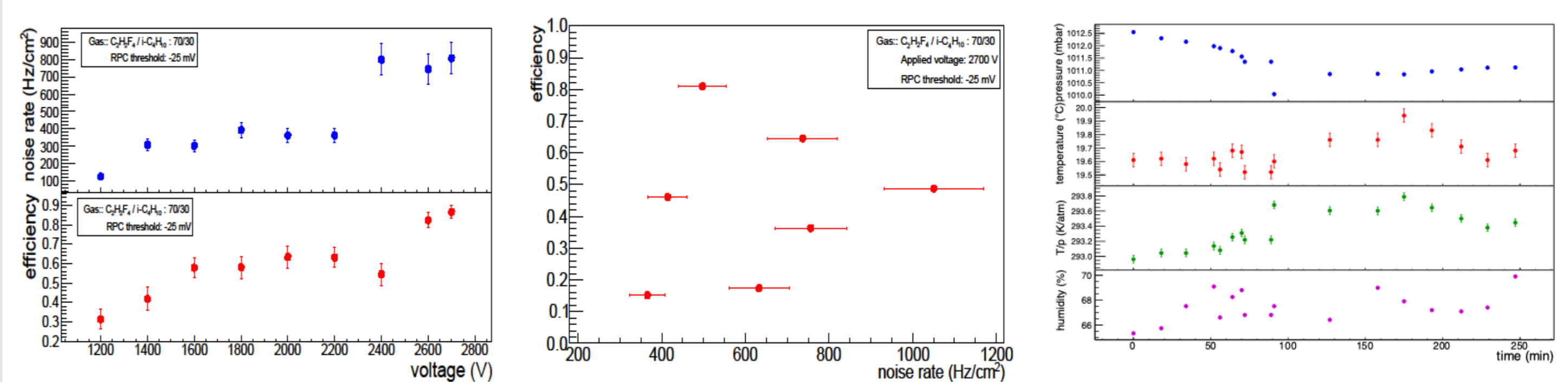
Bulk & surface resistivity variation with applied voltage

Surface resistivity Scan



Bulk resistivity variation of PTFE electrode with time

Leakage current with voltage



Efficiency, noise rate and voltage correlation

t, p and RH with time

Discussion

- The bulk resistivity has increased from $\sim 10^5 \Omega\text{-cm}$ (2018) to $\sim 10^9 \Omega\text{-cm}$ (2025): may be due to material aging, carbon migration, or changes in the microstructure after the discharge events observed earlier
- The detector prototype reaches an efficiency of $>80\%$ at an operating voltage of ~ 2700 V, compared to $\sim 60\%$ reported earlier
- The current-voltage characteristics indicate stable operation. These results show that increases in resistivity in the PTFE electrodes have shifted the detector behaviour towards a more favourable operating regime

Reference

- S. Chakraborty *et al.*, A new type of RPC with very low resistive material, Nucl. Instrum. Meth. A, A 936 (2019) 424.
- S. Chakraborty *et al.*, Development of RPC with low resistive material for CBM-MUCH. CBM Progress Report 2018, 67. ISBN 978-3-9815227-6-1.