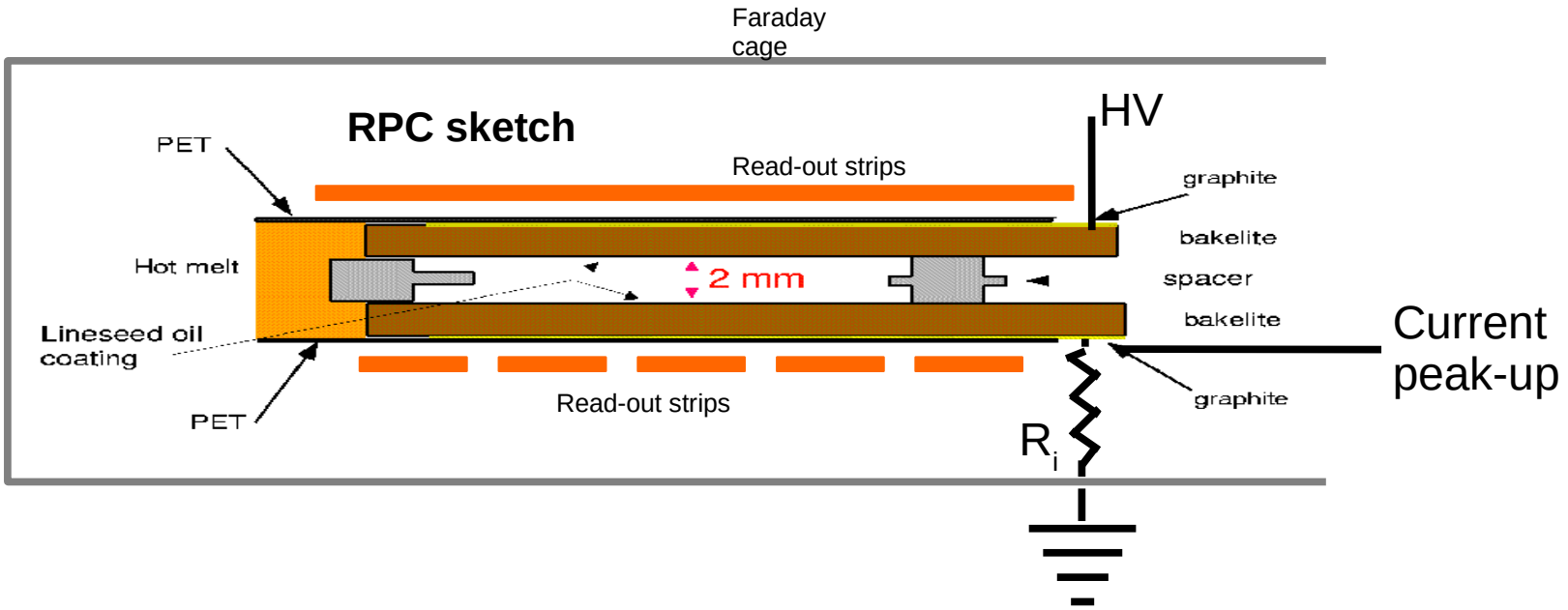
Study of ionic signal properties with different read-out methods

A. Paoloni on behalf of
Tor Vergata – LNF RPC collaboration

XVI Workshop on Resistive Plate Chambers and Related Detectors (RPC 2022)

CERN 26-30 September 2022

RPC ionic signal



In typical RPC detectors:
(Fast/prompt) signal induced by electrons movement on read-out strips, terminated on their characteristic impedance, and read out on one side.
Ionic (movement induced) signal read-out from ground electrode on high impedance.
Prompt charge (q) lower than Ionic charge (Q).
Ionic signal useful to study detector working principles and properties.

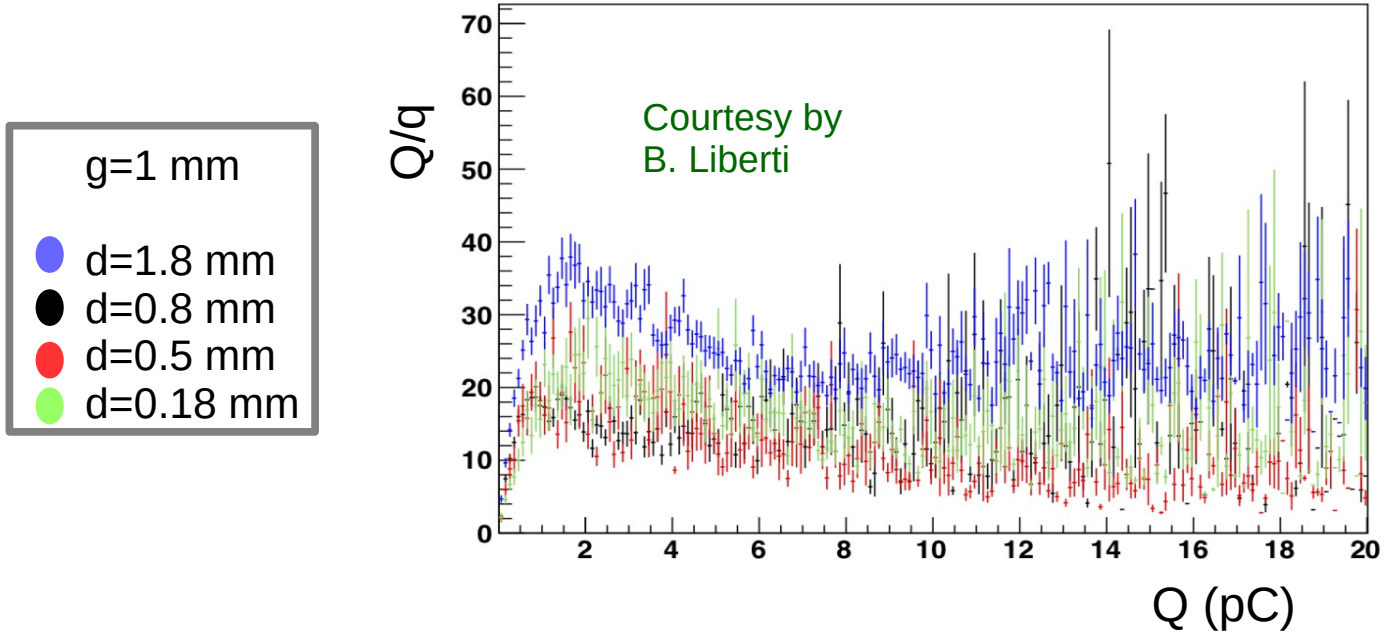
Ionic signal use

Read-out of ionic signal can be used for spatial measurement.
Graphite can be described as a distributed network of RC.
R. Cardarelli et al, "Improving trak resolution in the RPC chamber", Nuc.Phys.B proc. Suppl. 2006
"Development of new read-out technique for Resistive Plate Chamber"
E. Alunno Camelia PHD thesis (XXXIII Cycle, Tor Vergata University)

Q/q studied as a function of g/d (gap/electrode thickness)
Change detector geometry to increase q at fixed Q

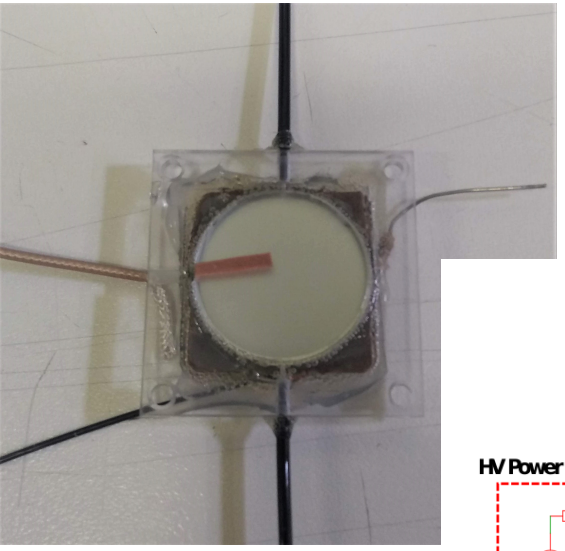
Q/q can be used to tag streamers. (G. Proto talk, this workshop)

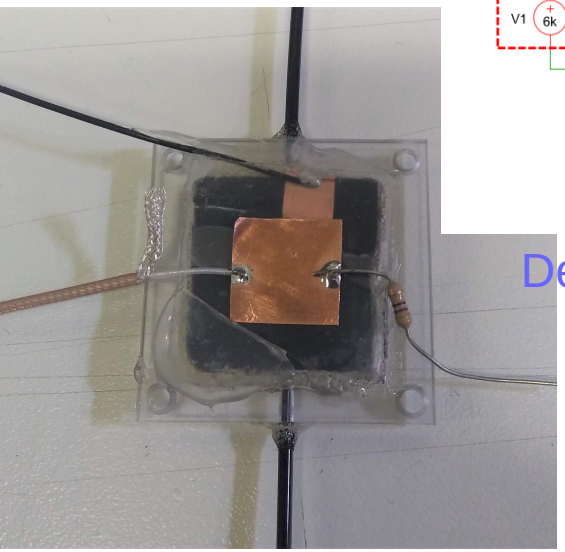
$Q_{ionic}/q_{prompt}(streamer) < Q_{ionic}/q_{prompt}(avalanche)$



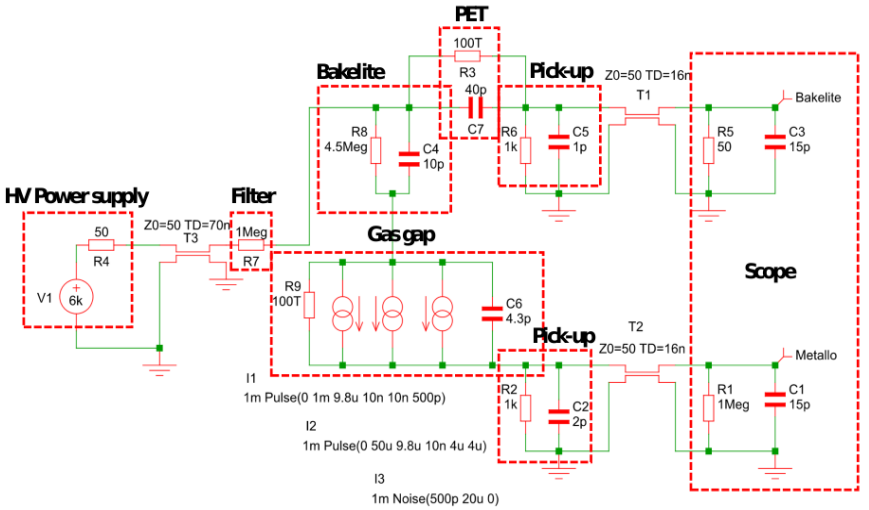
Caveats:
Signal shape depending on position.
Graphite coating surface resistivity control.

Former studies on Q_{ionic}

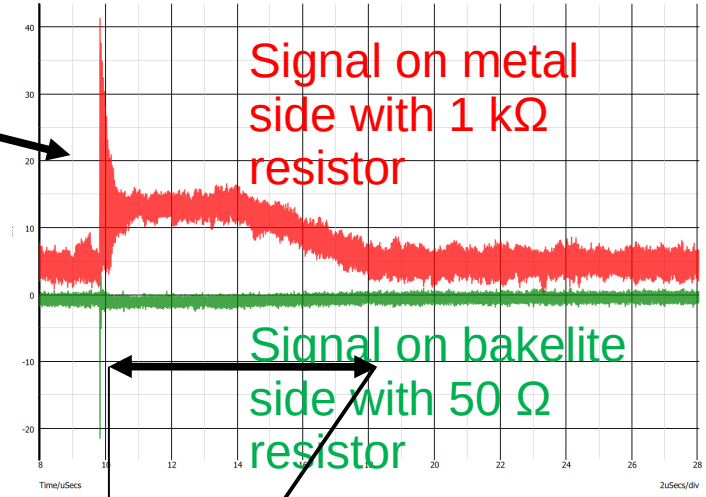


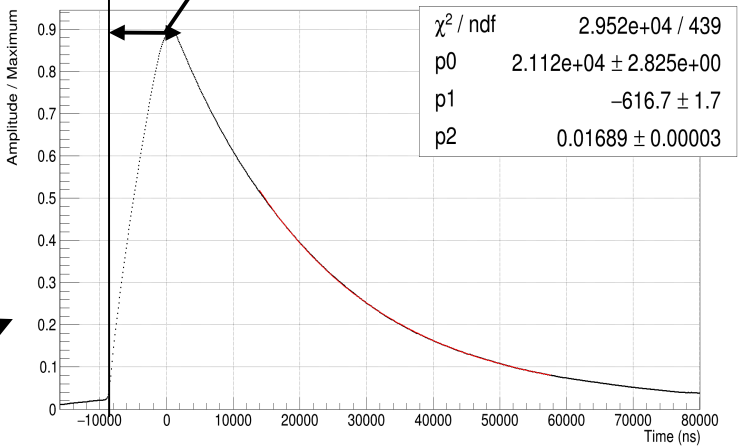


Special R&D detector designed with:
Bakelite HV electrode
Metallic ground electrode
(real shape of ionic signal)



Detector simulation for signal pick-up

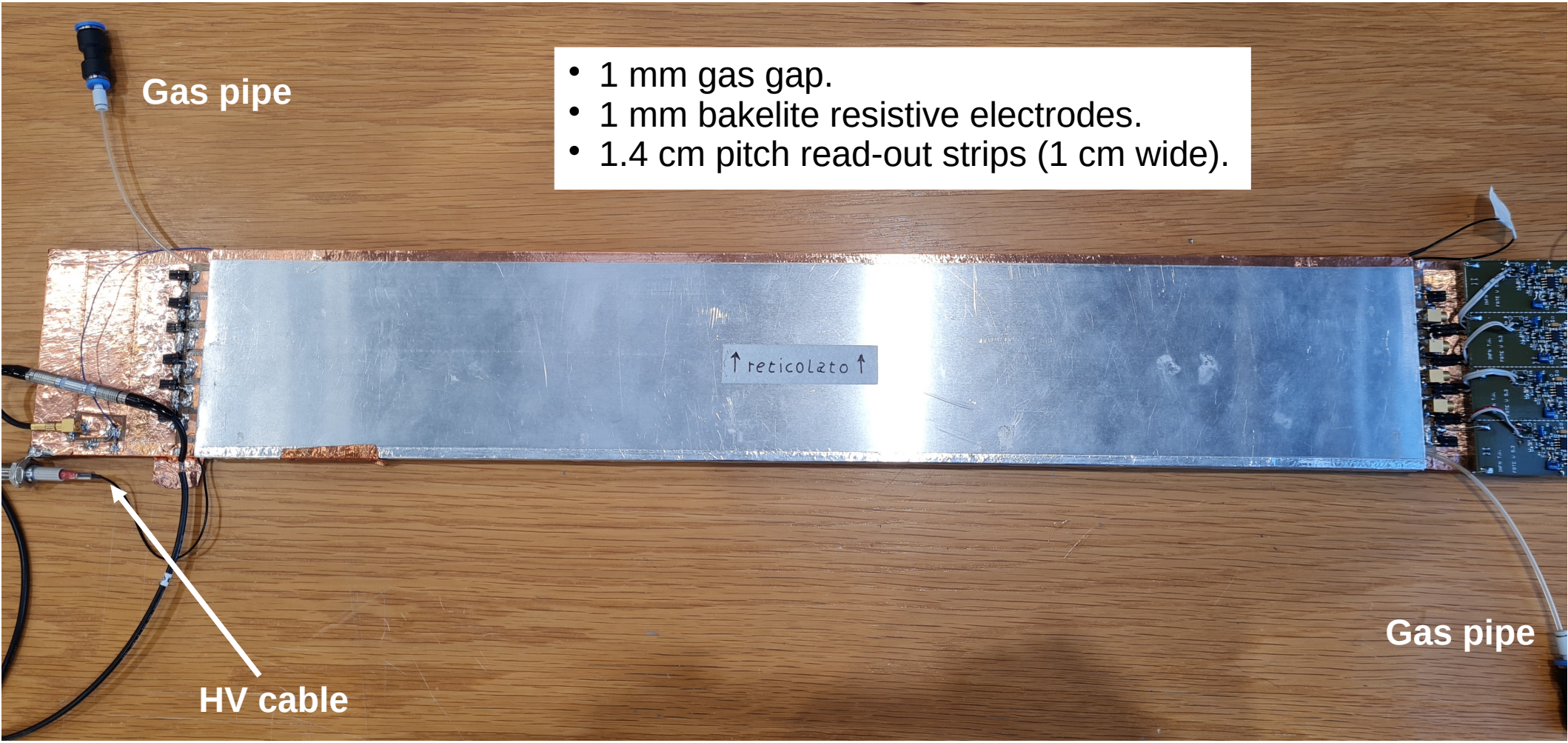




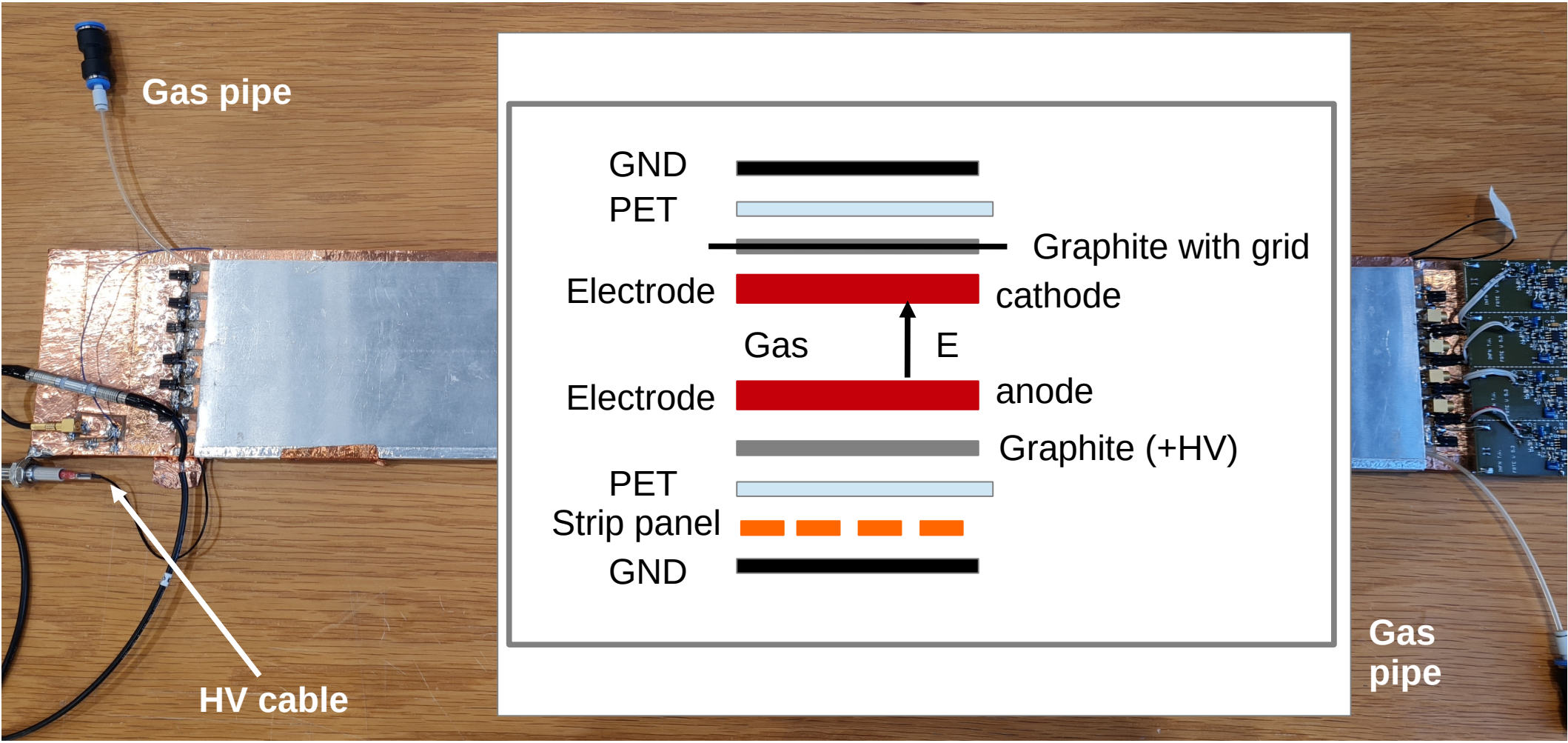
Effect of graphite electrode and high impedance read-out (integration + RC decay)

Courtesy of A. Rocchi, “Advances in Resistive Plate Chambers development”, PHD thesis (Tor Vergata University)

New test chamber



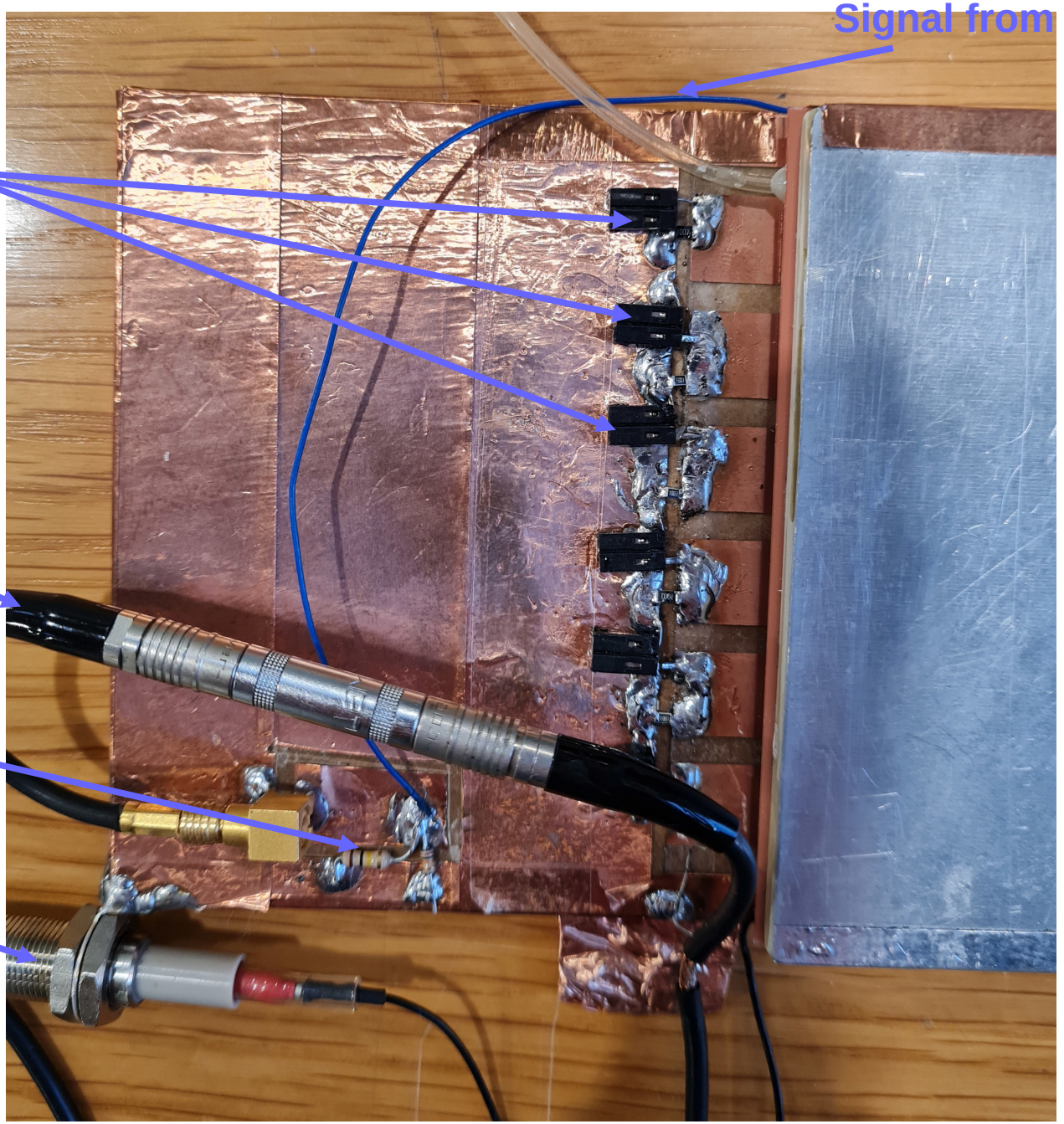
New test chamber



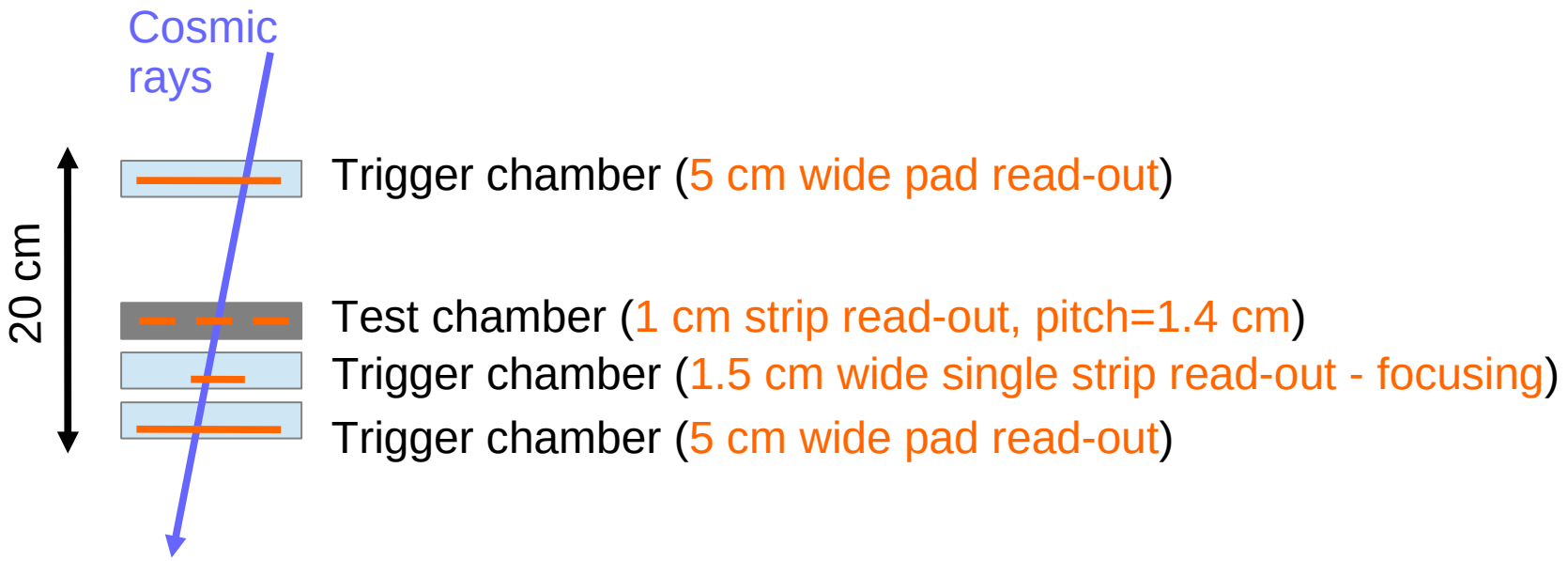
Metallic grid deployed in the cathode graphite layer (opposite to HV side):

- To avoid signal diffusion in the graphite
- Graphite not completely opaque to induced ionic signal

New test chamber

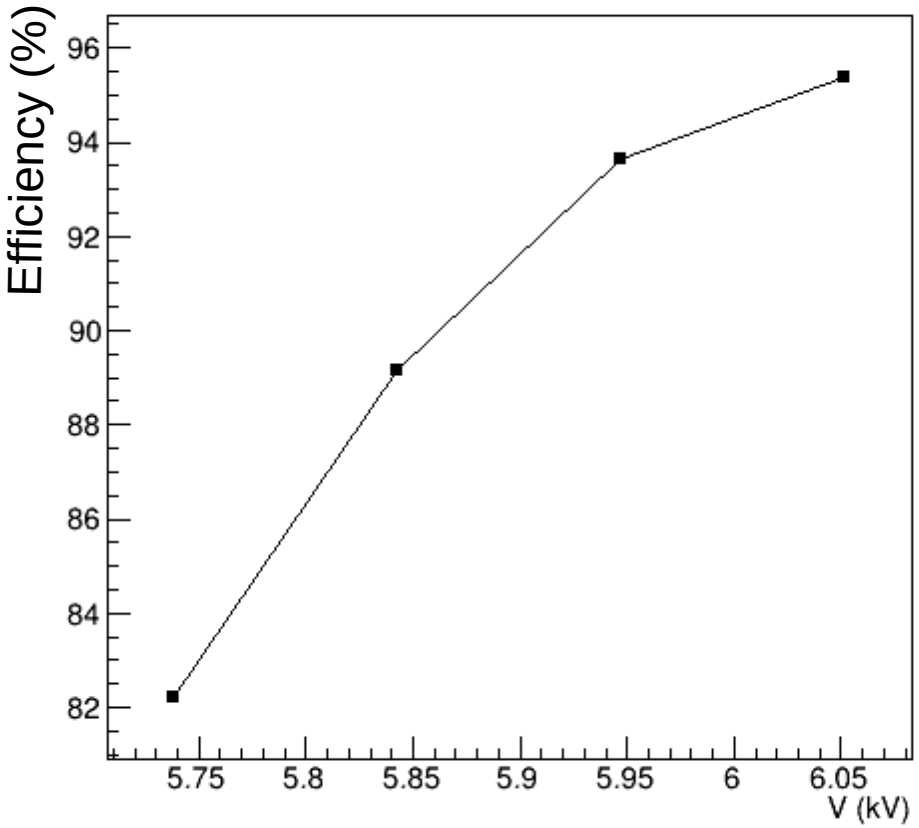


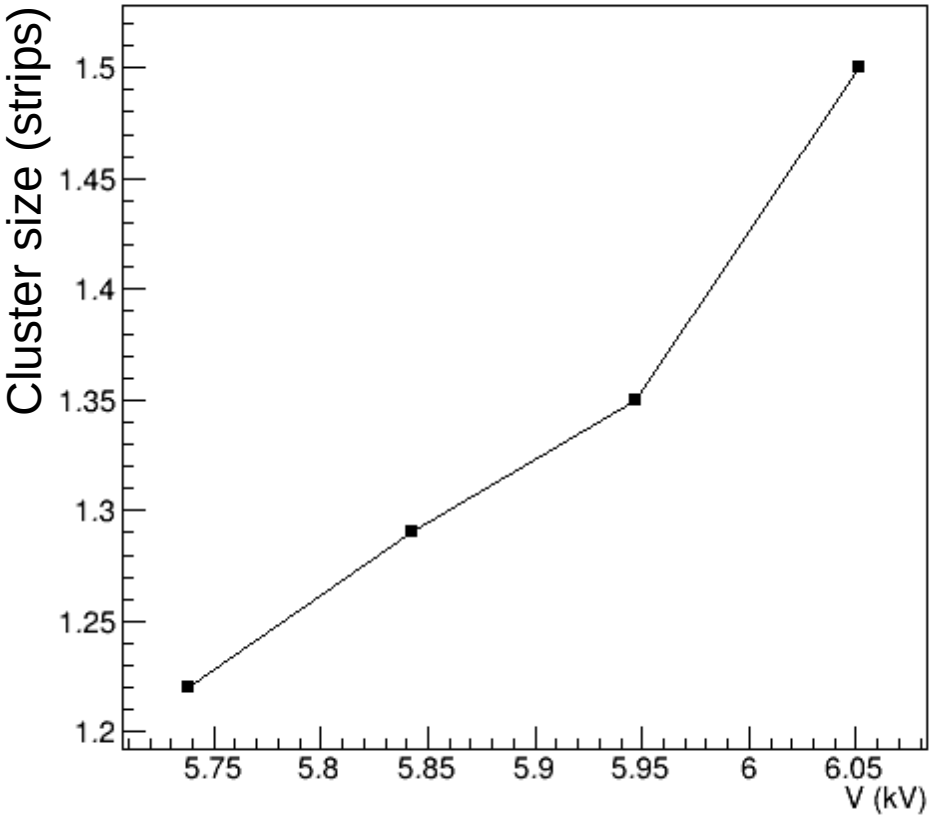
Experimental set-up



Gas mixture = Standard ATLAS gas mixture (avalanche mode)
Trigger chambers = 2 mm thick gap and bakelite electrodes
Digital scope acquisition (LeCroy HDO9404 4 GHz bandwidth 40 GS/s).
Ionic signal (Ri=9 kΩ) on high impedance.
Signals from 3 Strips (without amplification) acquired on 50 Ω.
Baseline subtraction for analysis.
Threshold on read-out strips: 2 mV (about 5*baseline noise).
Prompt signal corrected for strip/oscilloscope impedance mismatch.

Experimental set-up





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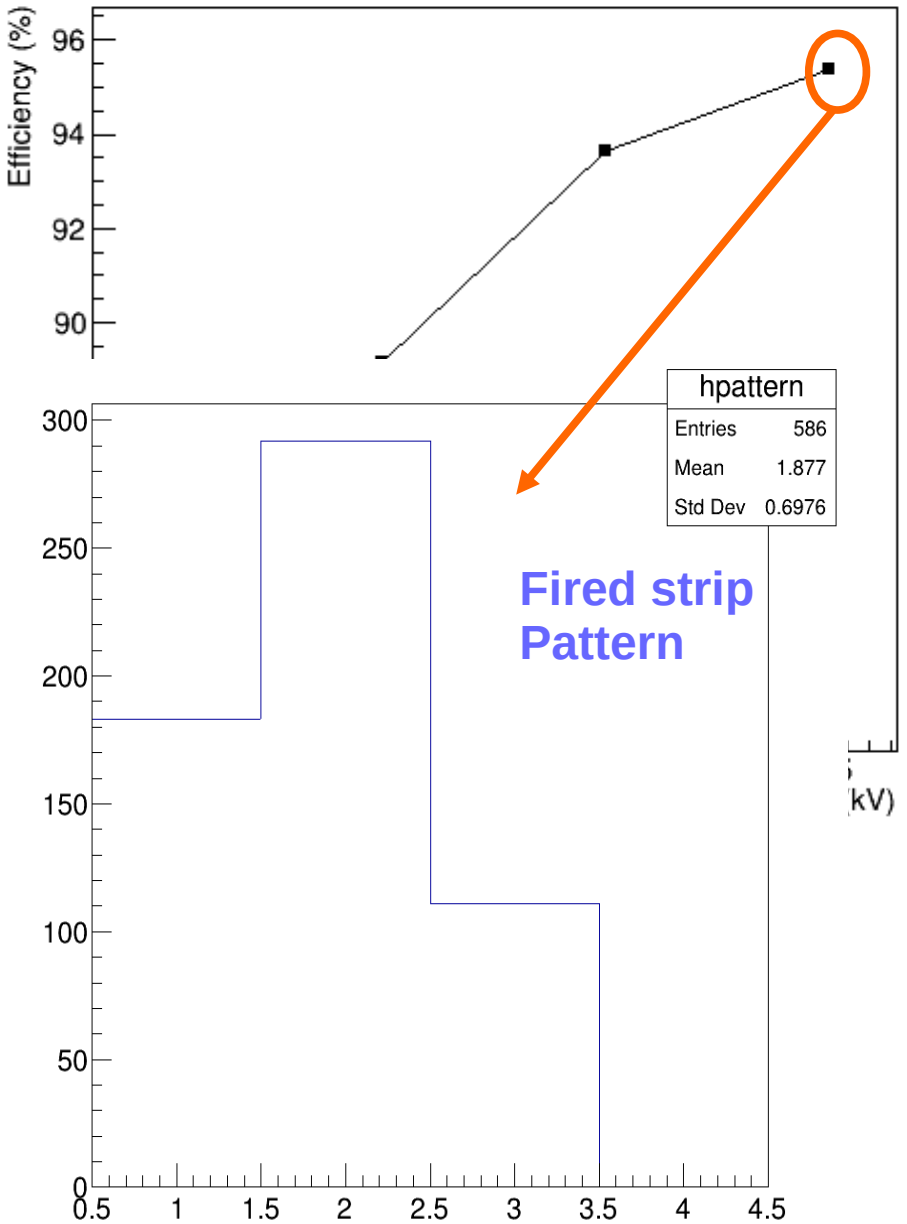
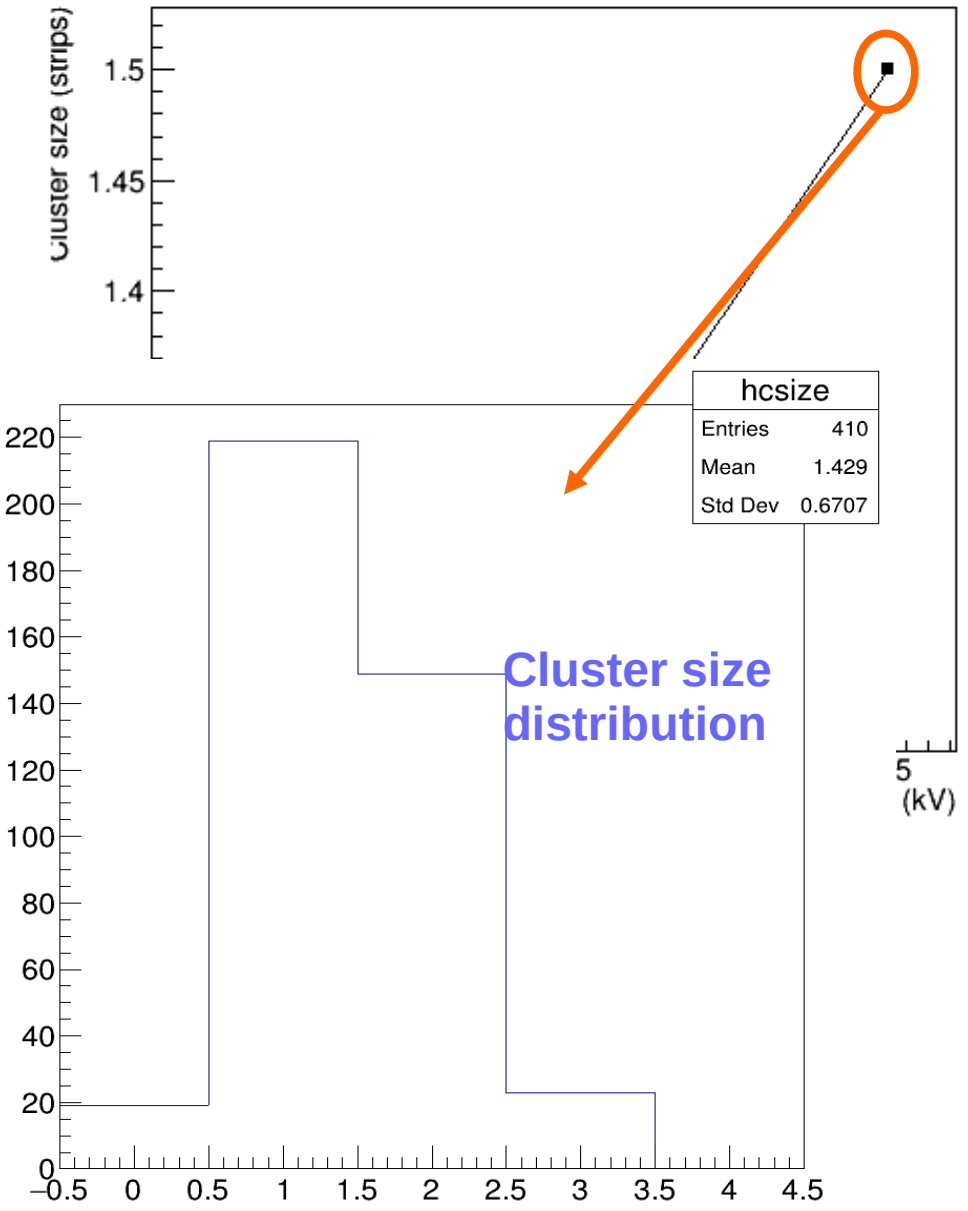


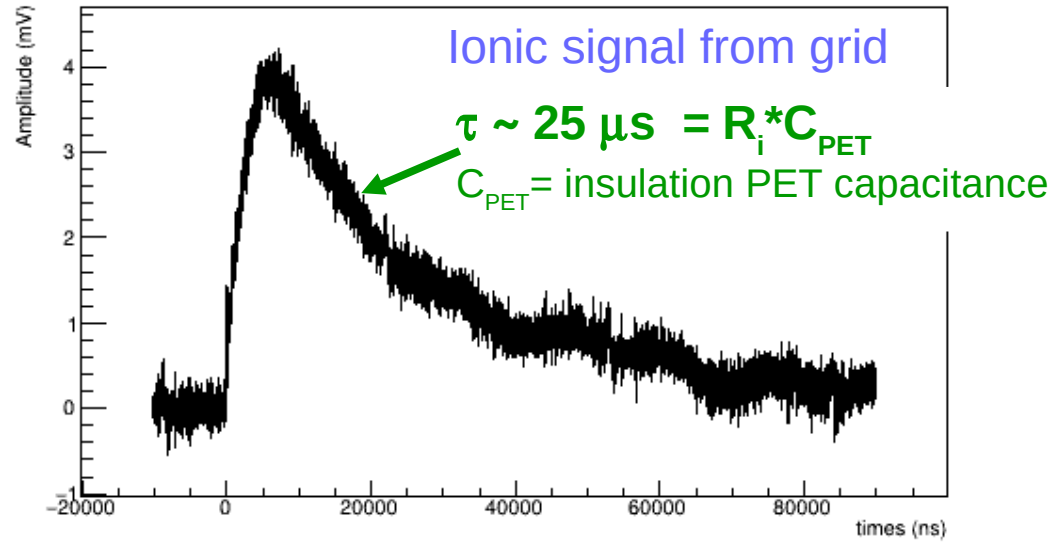
Fired strip Pattern

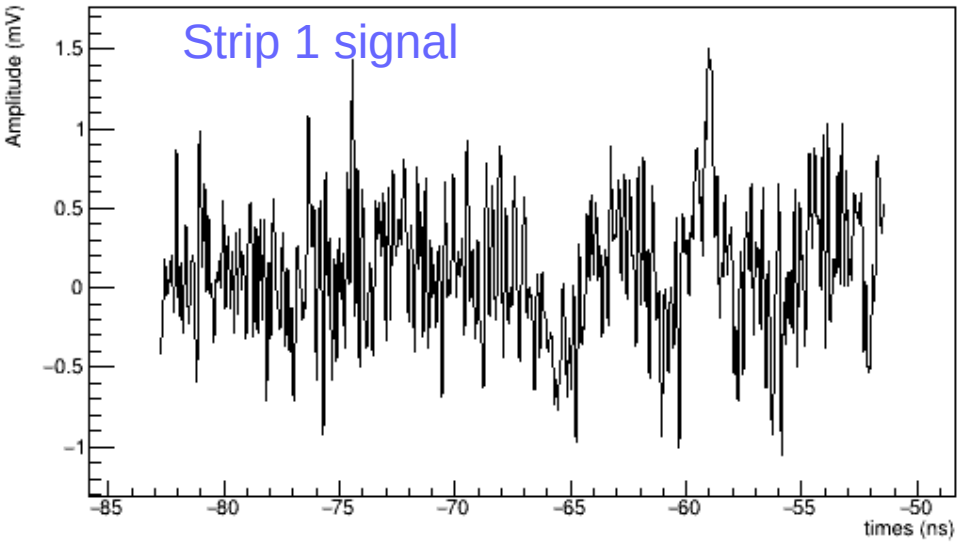


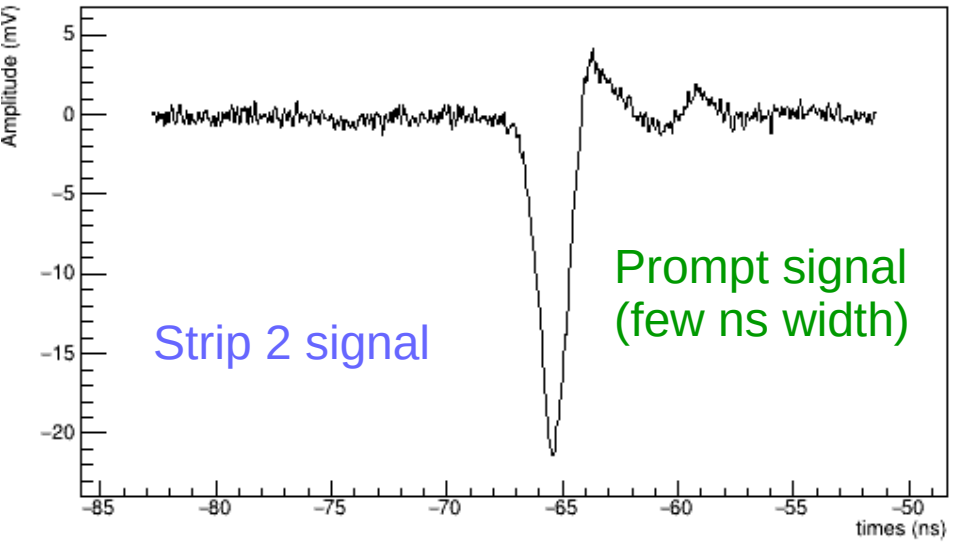
Cluster size distribution

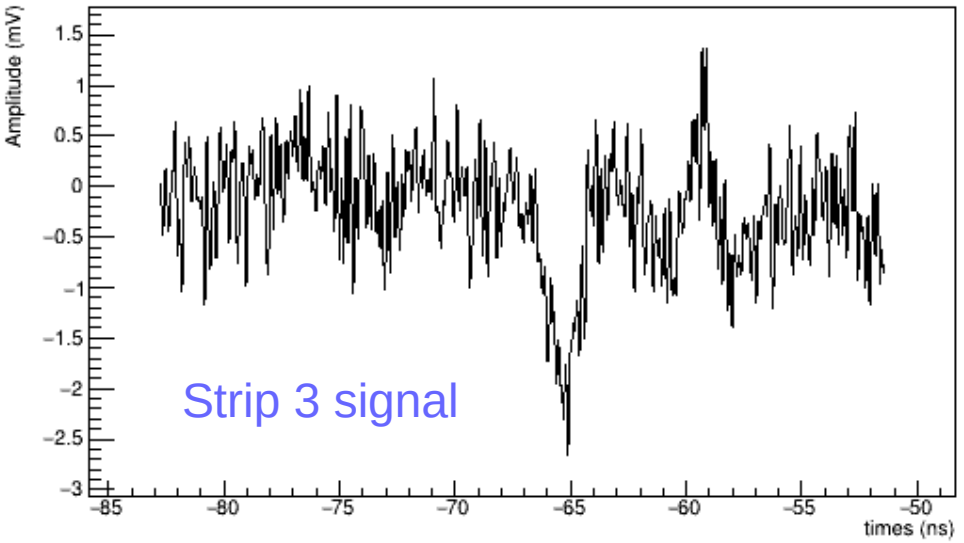
RPC centered and with low cross-talk between strips.

Experimental set-up



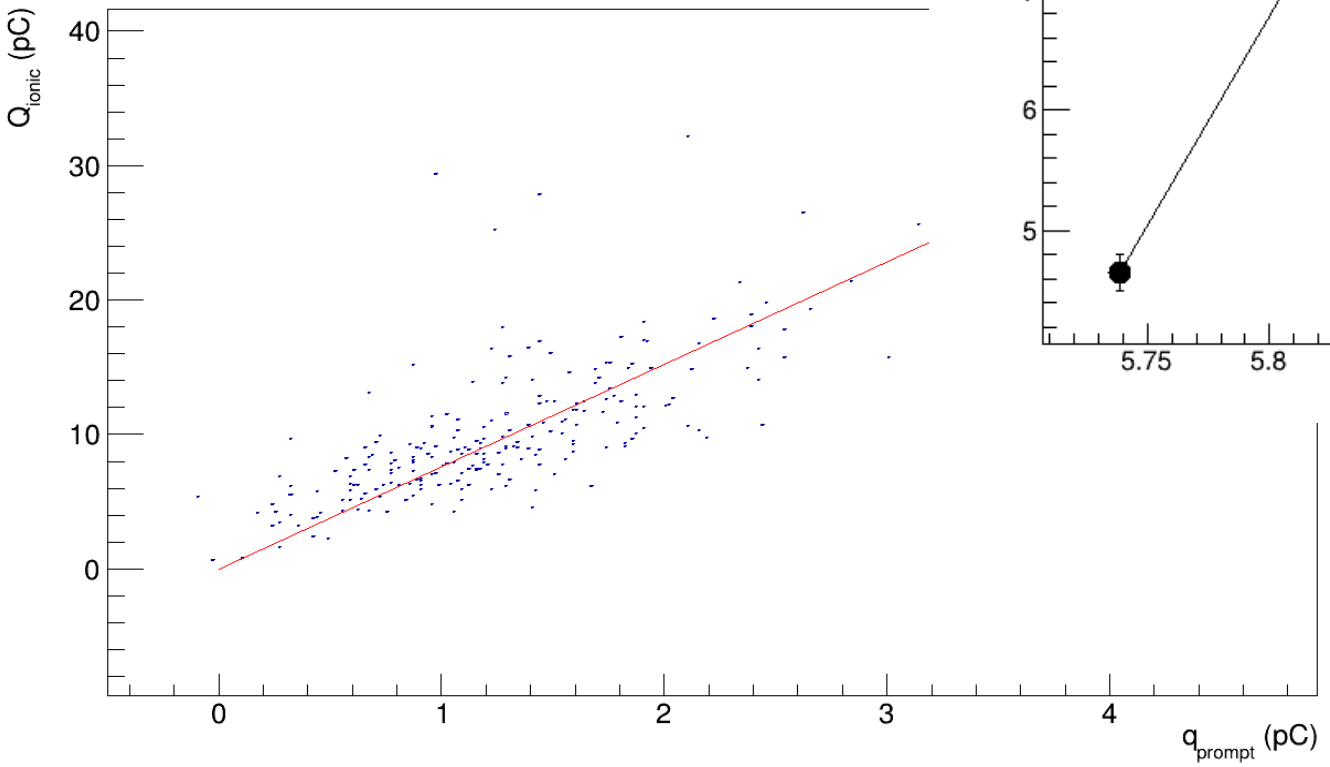


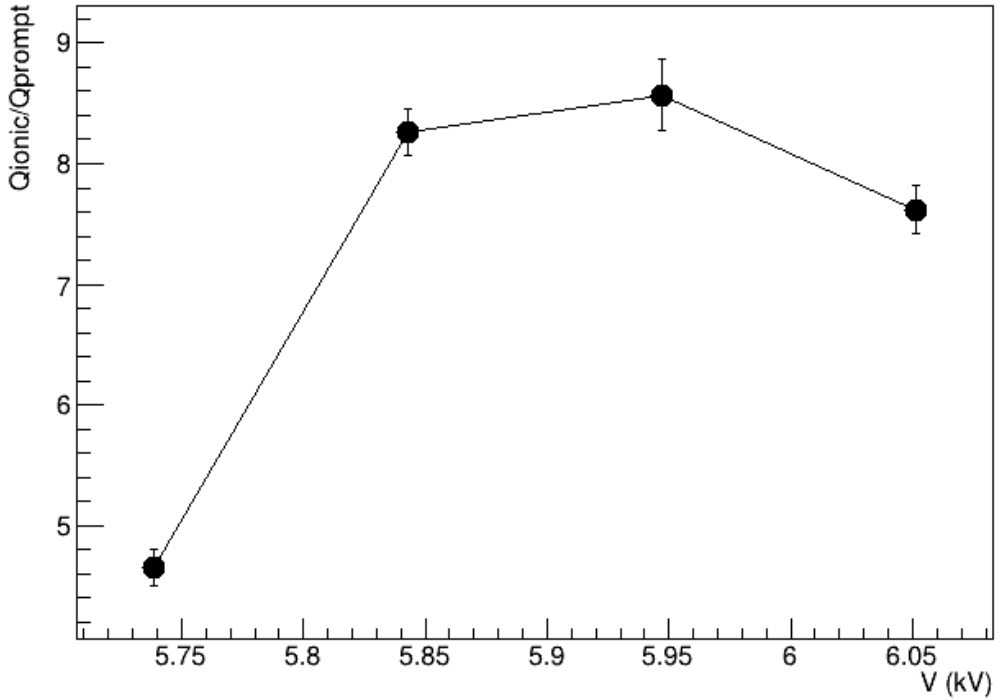




Q/q measurement

Ionic vs prompt charge:
Correlation observed.

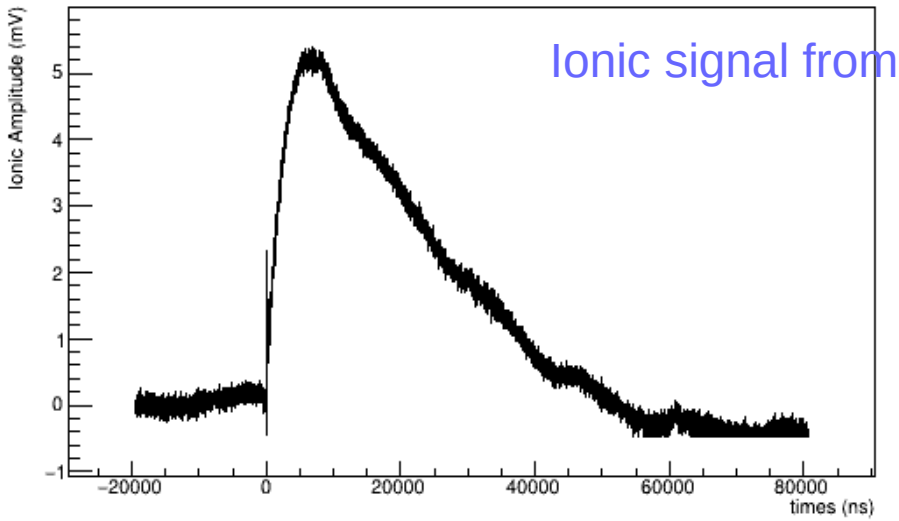


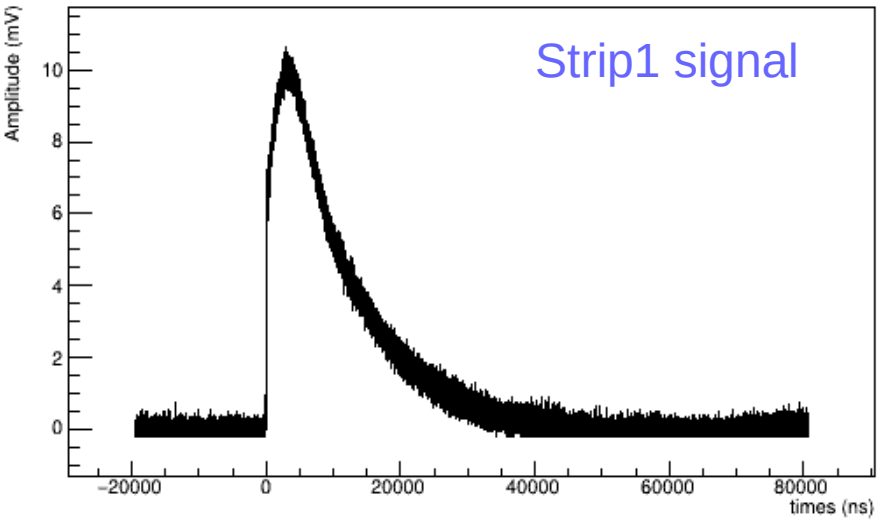


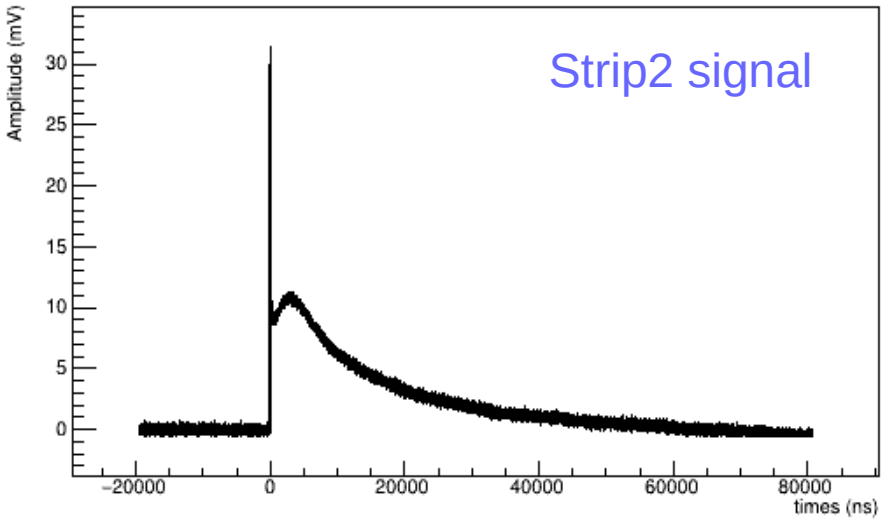
Q/q ~ 8.4, roughly consistent with previous results.

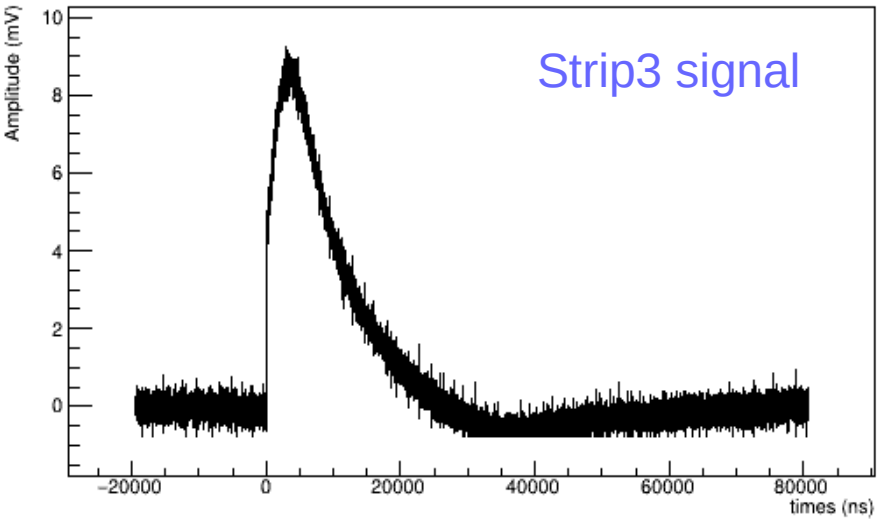
Q_{ionic} alternative read-out

Read-out strips (facing standard graphite HV electrode) terminated on both sides on 100 kΩ.









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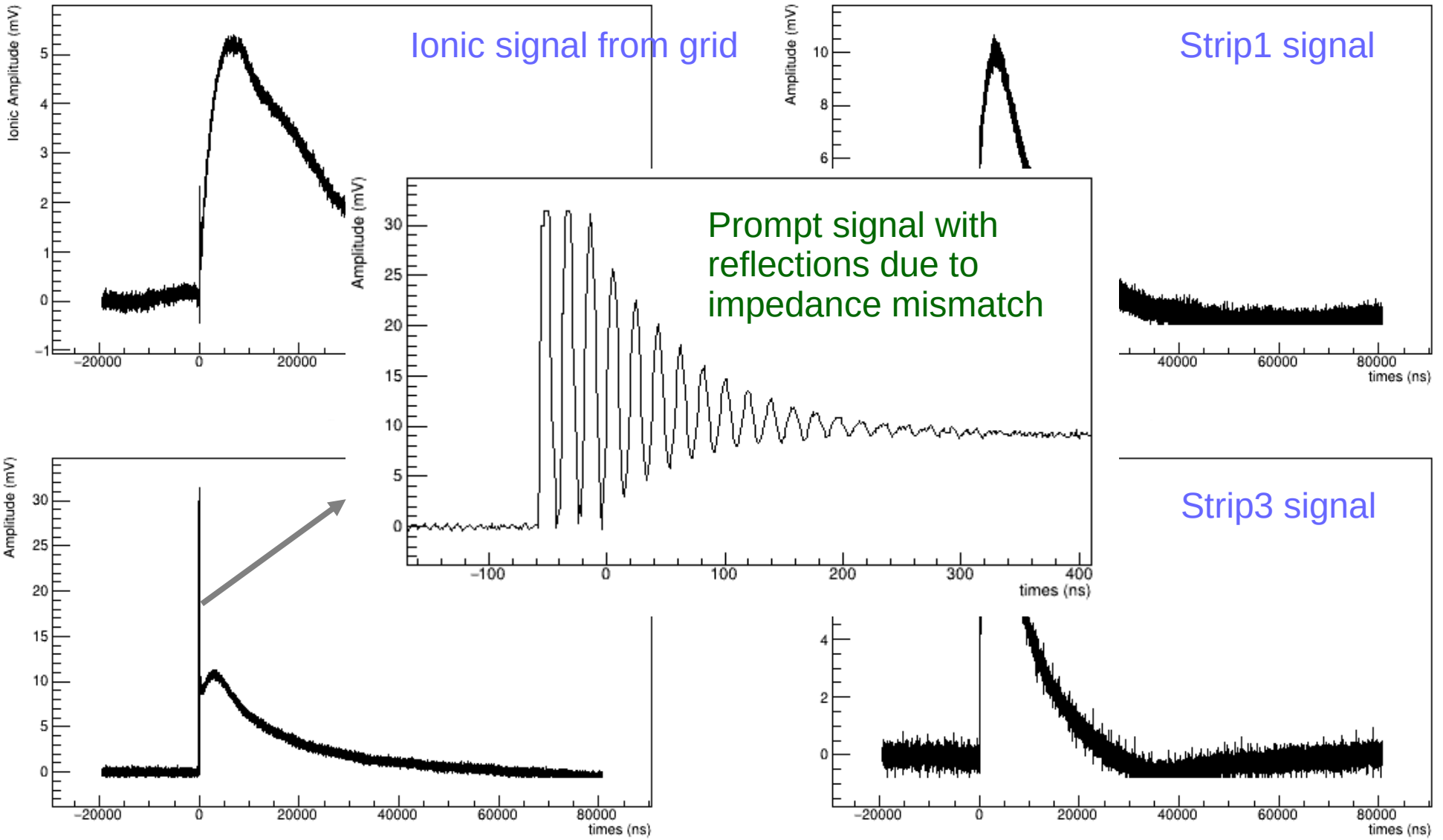


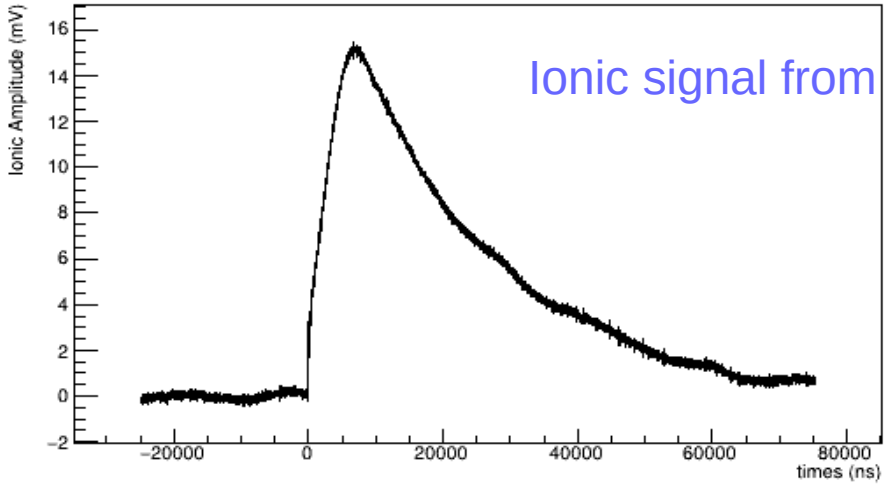
Time constant τ of strip signal ~10 μs, different from τ of metallic grid signal (lower capacitance).

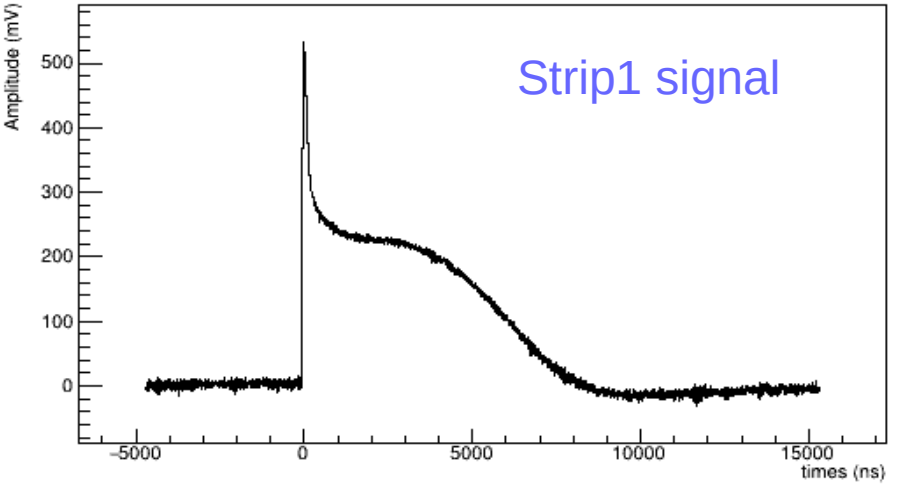
Q_{ionic} alternative read-out (2)

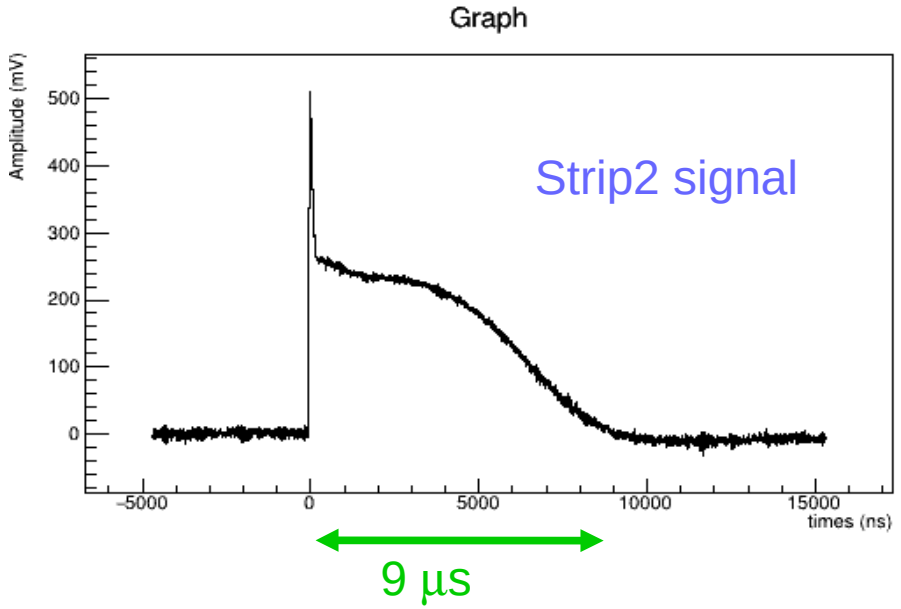
High impedance strip signals read-out by means of amplifier (R. Cardarelli et al., JINST 8 (2013) P01003).
Low input impedance + amplification:

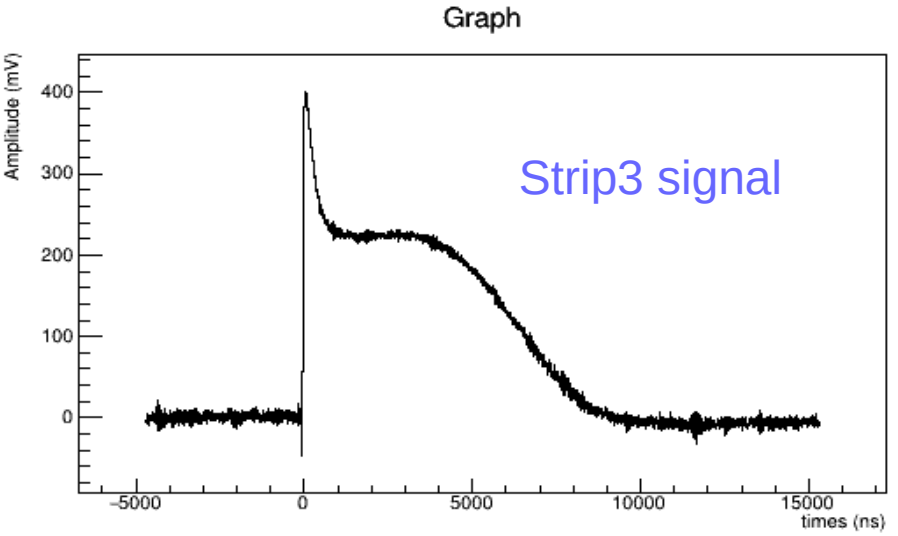
- Ionic signal visible and not integrated.
- Prompt signal reflections limited.

Q_{ionic} alternative read-out (2)









Conclusions

Signal induced by ions movement in the gas can be detected.

Both to study gas and detector properties, as well as for specific applications at low rate (spatial measurement).

A special detector has been built with a metallic grid buried in the graphite coating, to correct for signal distortions due to diffusion.

We have read both the signal in the newly designed electrode as well as on read-out strips, at high impedance and with amplification.

Outlook:

Study different electrode thicknesses and gas mixtures.

Improve the set-up.