

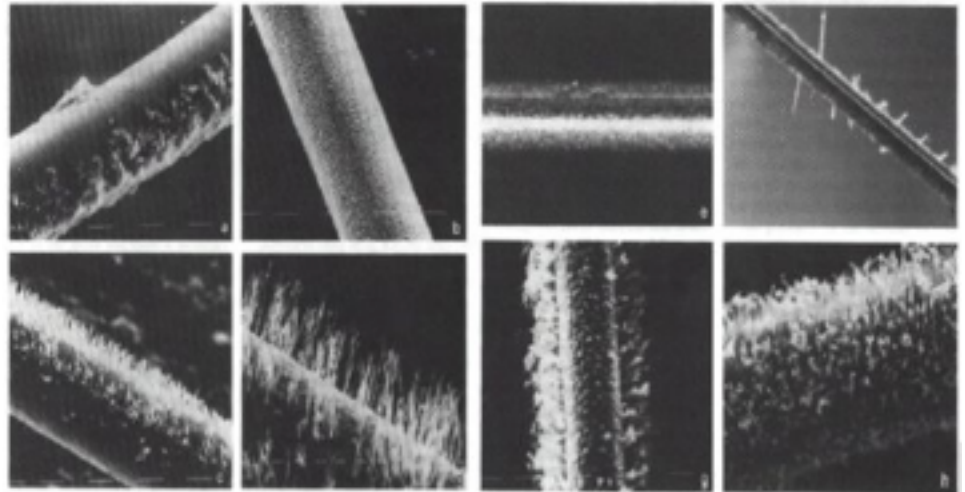
Ageing of GEMs in Ar-CH₄

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MPGD vs MWPC

- MPGD have higher rate capability
- MPGD provide better position resolution
- MPGD are faster
- MPGD allow to limit ion back flow
- **MPGD do not age – why not?**

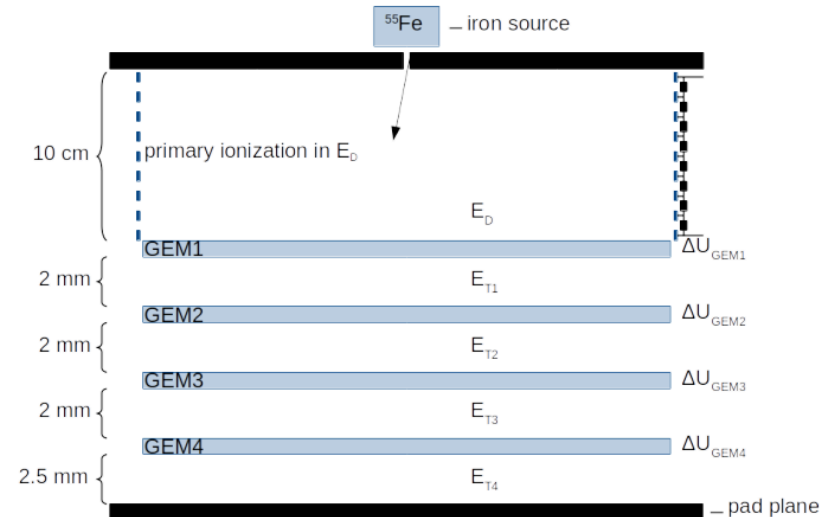
- In the avalanche plasma, conditions are met (energy density, density of ions and radicals, high electric fields) for CH₄ to polymerise.
- As hydrocarbon molecules grow, they 'fall' in the nearest place, e.g. the electrodes of the device
- Classical ageing results in gain drop, deterioration of energy resolution, and Malter currents



Reminder – Ageing test set-up for the ALICE TPC

- A quadruple GEM stack is irradiated with a ^{55}Fe source
 - X-rays converted in the 10 cm drift volume produce enough charge for accelerated tests
- GEM1 is periodically turned off to allow for the recording of the energy spectrum -> peak position and energy resolution
- Gain is corrected for ambient T, P
- An outgassing box allows for material testing
- Gas used: Ar-CO₂ and Ne-CO₂-N₂

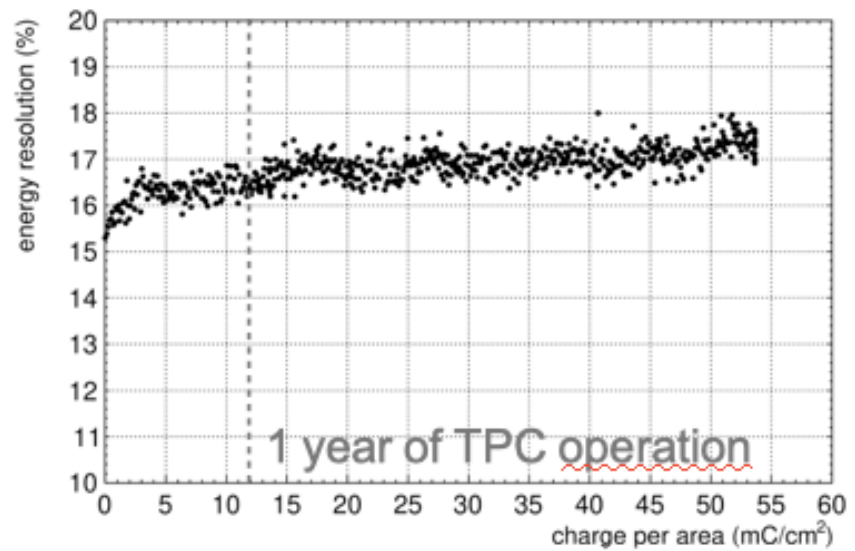
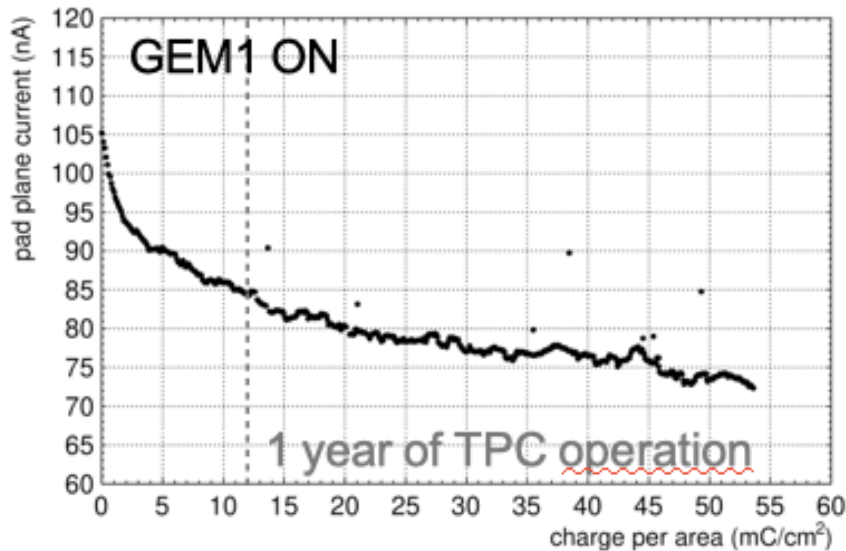
After finishing our outgassing campaign, we tested Ar-CH₄ (95-5)



Reminder – First test with Ar-CH₄

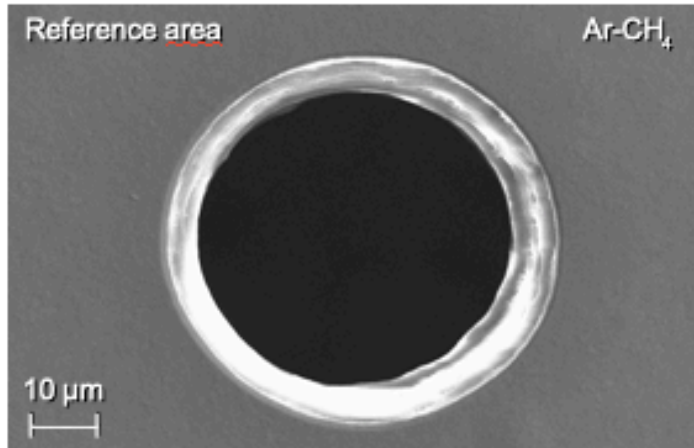
Gain = 4200

Current density = 21 nA/cm²



- Gain drops and energy resolution deteriorates – clear sign of ageing

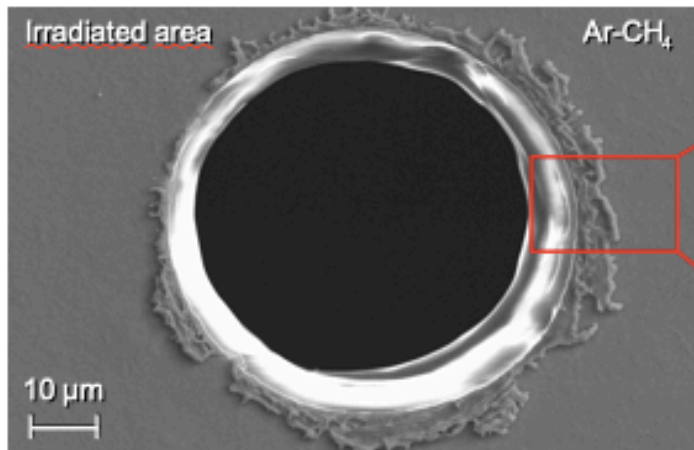
Reminder – Foil inspection 1/3



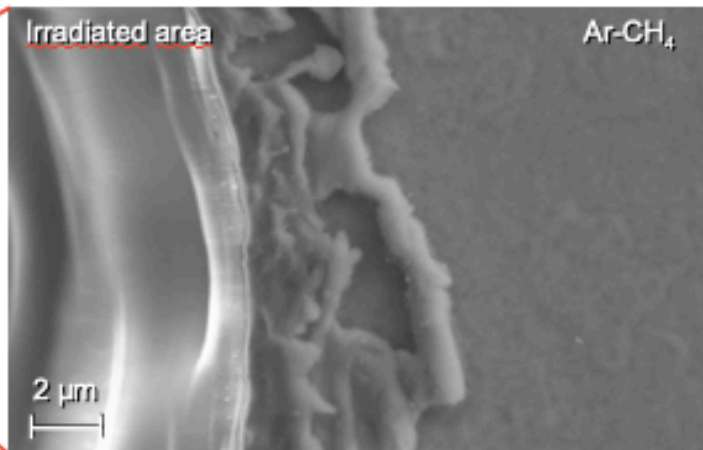
Magnification: 1000

Secondary Electron (SE) analysis of GEM4 Top

- Melted copper around the edges of the GEM hole



Magnification: 1000

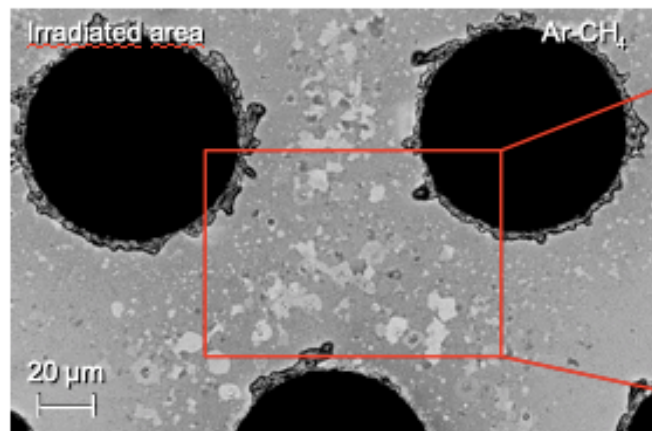


Magnification: 5000

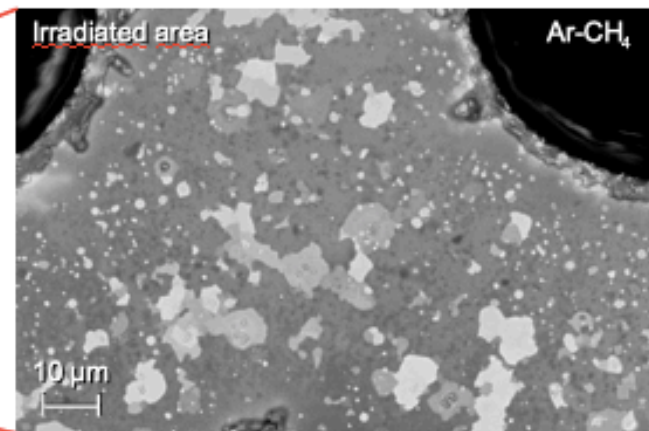
Reminder – Foil inspection 2/3

Analysis of Back-Scattered Electrons (BSE) of GEM4 Bottom

- BSE can be used to detect irregularities in the chemical composition since heavy elements backscatter electrons more strongly than light elements
- **Heavy elements** will appear brighter in the images, whereas **lighter elements** will appear darker



Magnification: 500



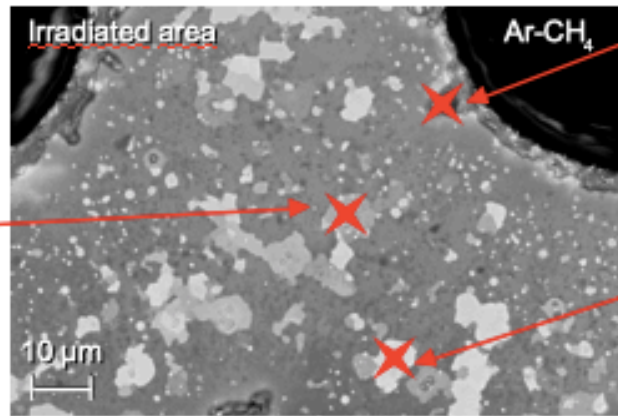
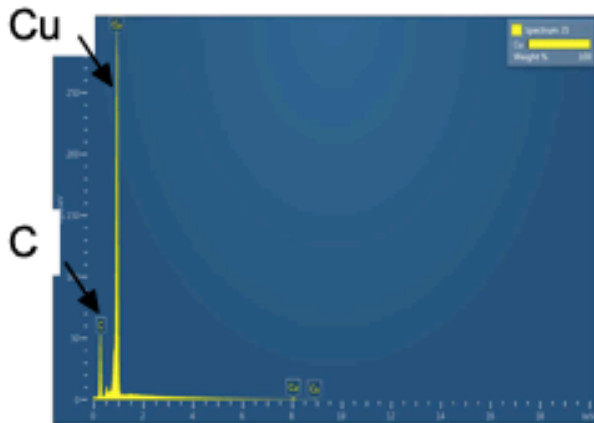
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Reminder – Foil inspection 3/3

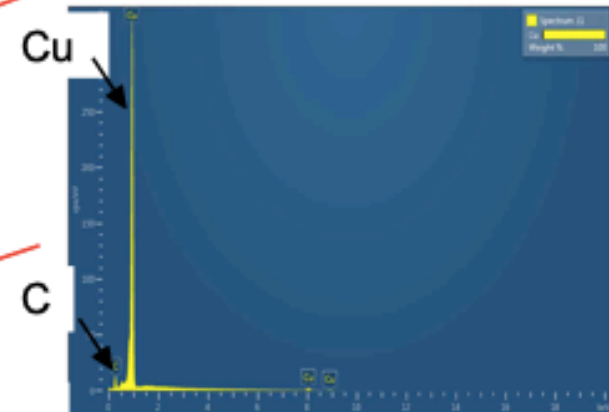
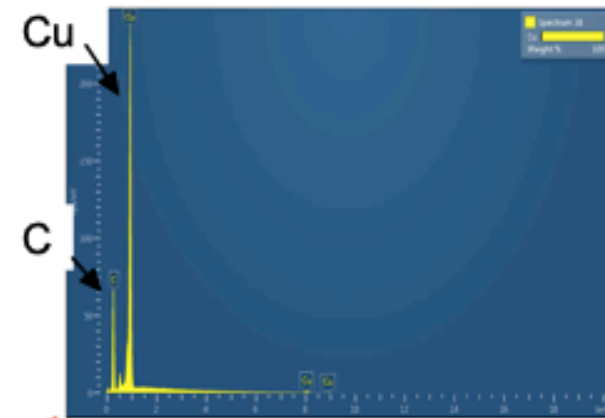
Energy-Dispersive X-ray spectroscopy (EDX) of GEM4 Bottom

- Traces of carbon were detected on the surface of the electrode (maybe hydrocarbon?)

Technique not sensitive to H_2



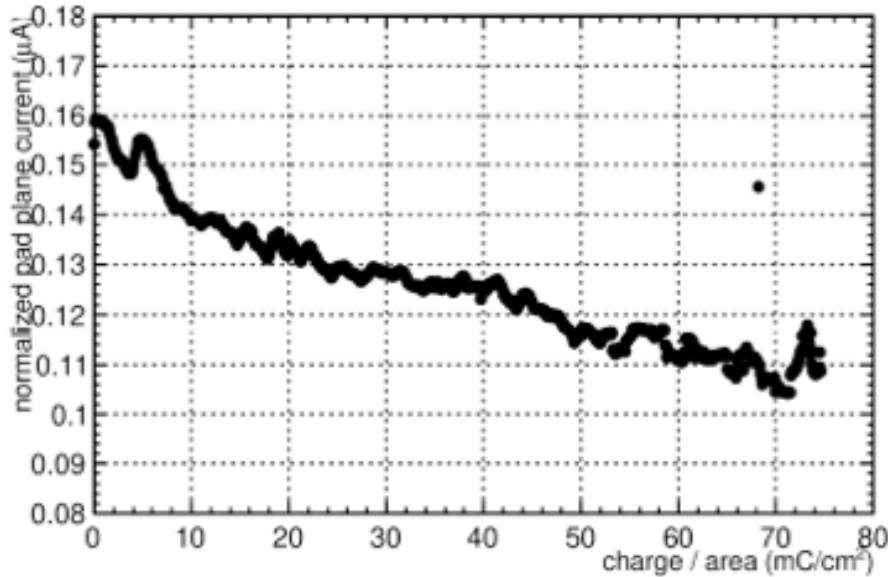
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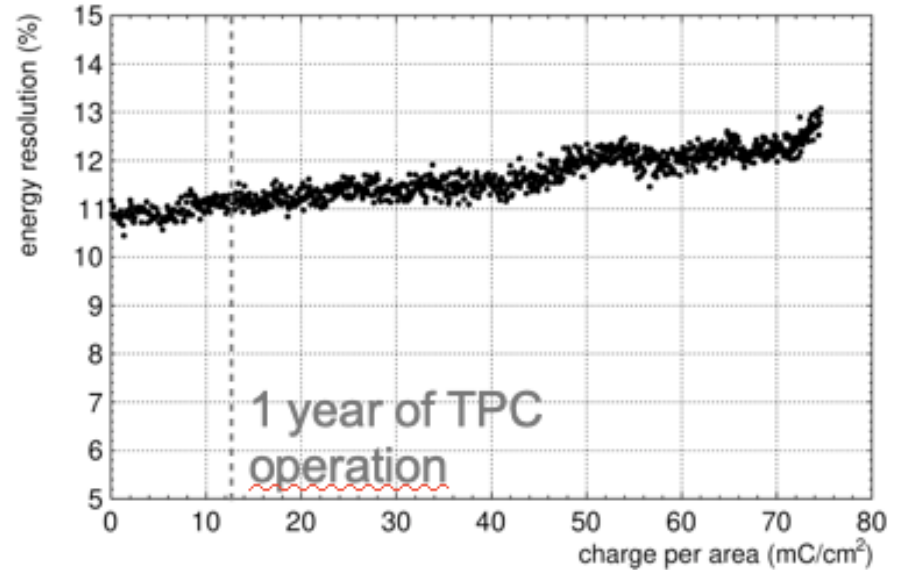
Second ageing tests with Ar-CH₄

Gain = 7200

Current density = 35 nA/cm²

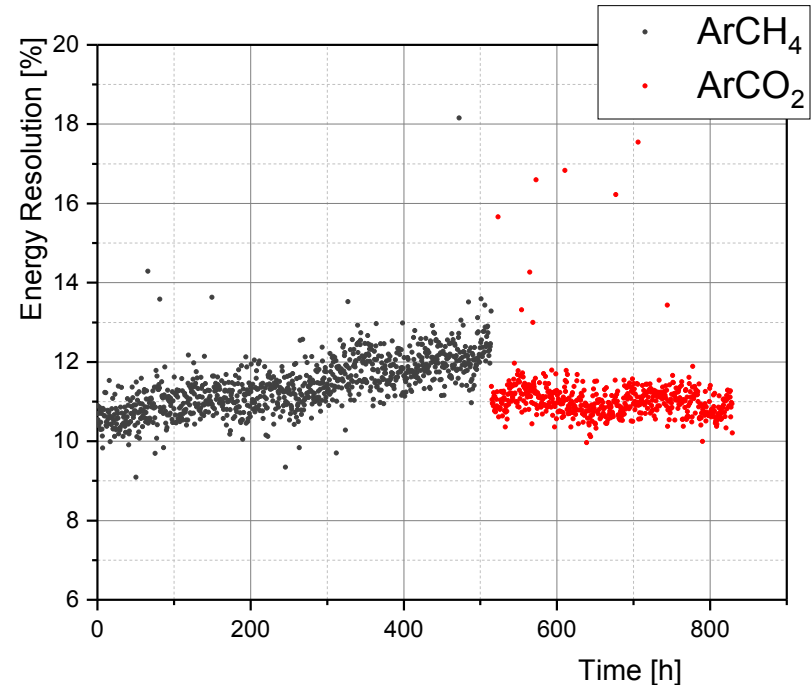
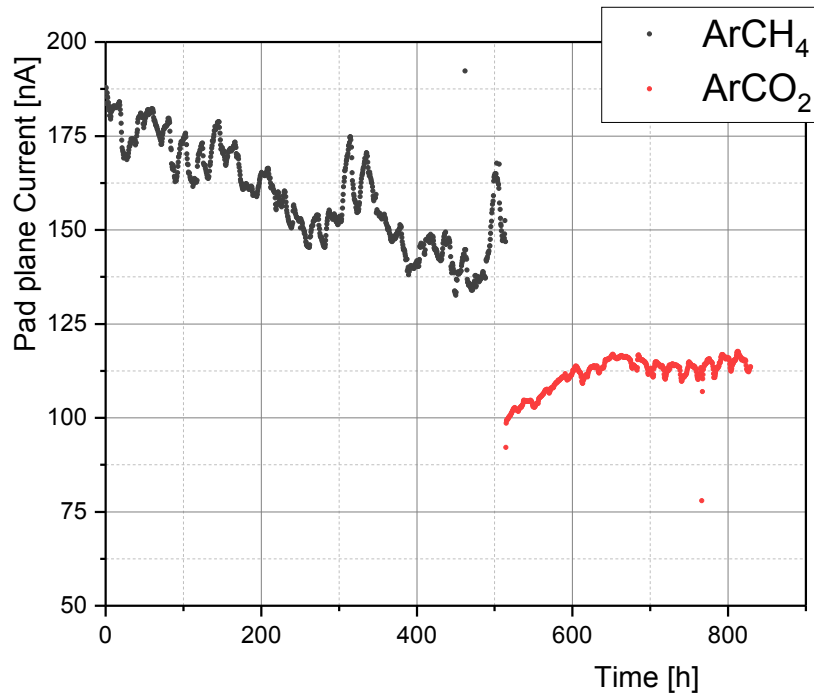


30 % gain drop after 75 mC/cm²



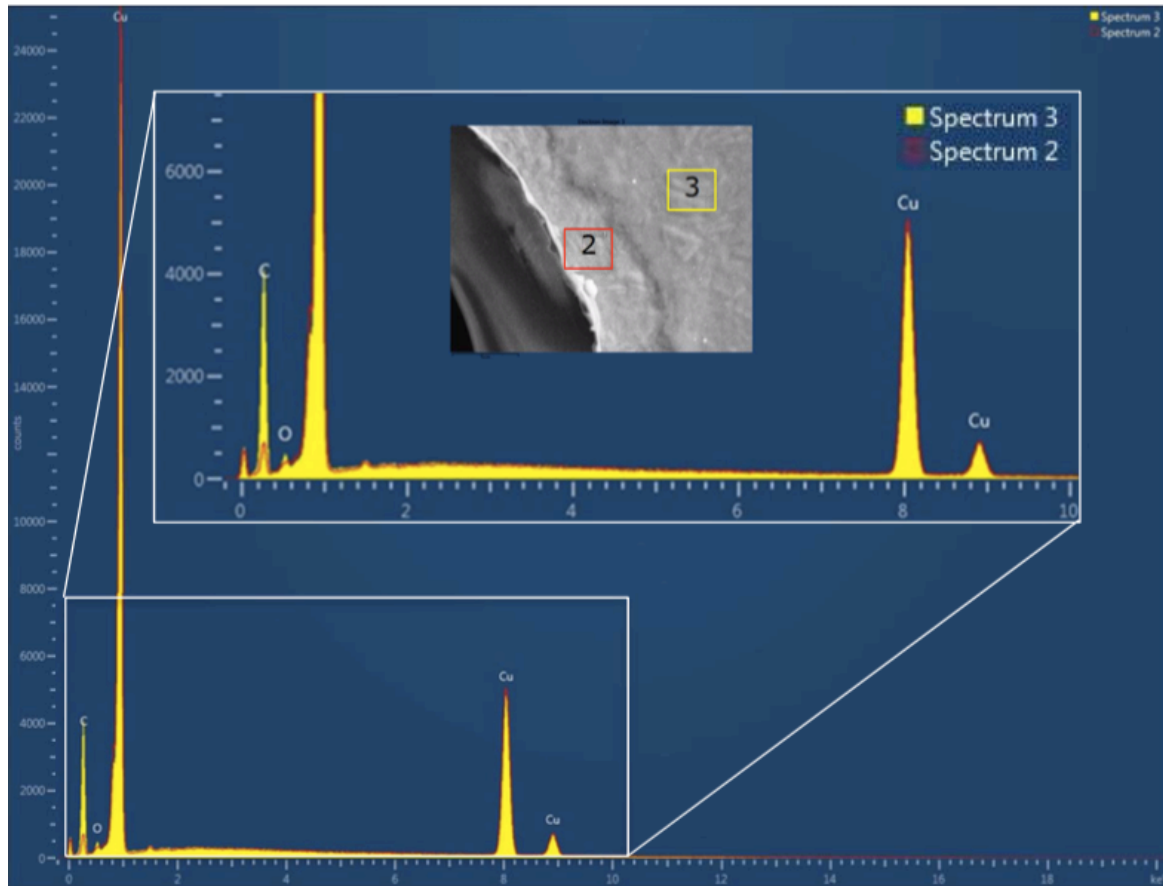
16 % energy resolution increase

Replace CH₄ by CO₂



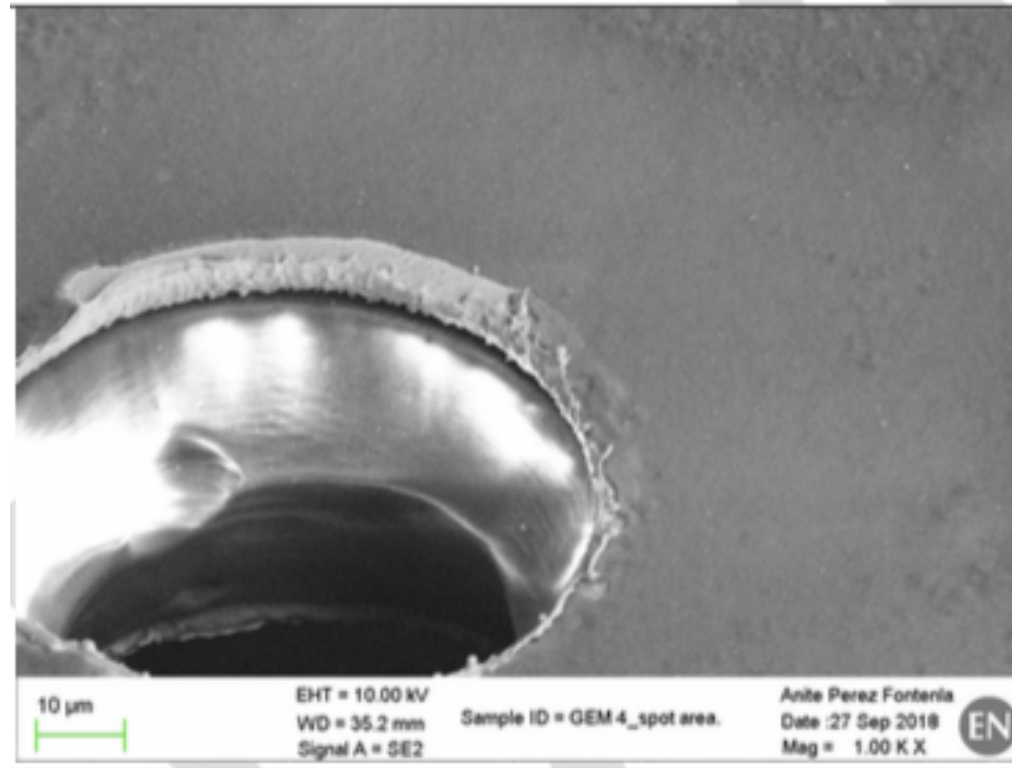
- Gain and energy resolution (raw data) flat
- Only change is the gas

Chemical analysis



- Clear evidence of hydrocarbon deposits on Cu
- Cu around holes seems to have melted and resolidified

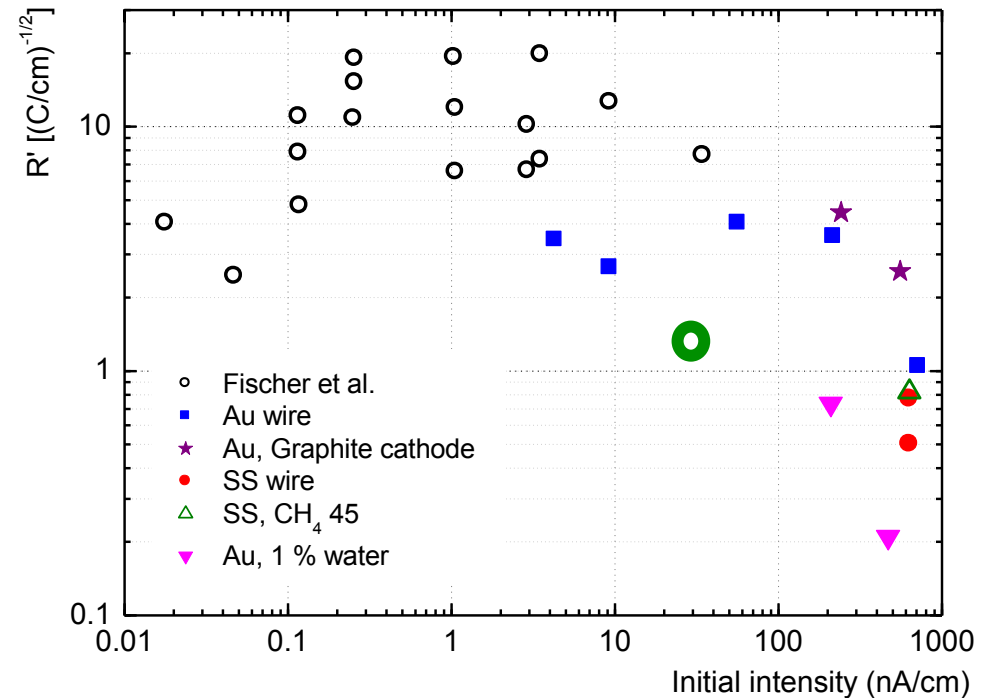
SEM image



- Cu affected around holes
- Insulator material OK

Rate of ageing

- Rate of ageing in CH_4 characterised, for wire chambers, by R' :
$$G = a \exp\{-R' \sqrt{Q}\}$$
- Rate of ageing in GEMs (green circle) is somewhat slower than in MWPC
 - note different charge density units



NIM A346 (1994) 114-119

Conclusions

- Polymerisation in CH₄ happens irrespectively the particular detector one irradiates
- GEMs do age in CH₄, probably not as fast as MWPC
 - CH₄ would not work for ALICE
- At some point, also Malter currents should ignite