

Polyimide etching studies in GEMs under Cu X-Ray irradiation

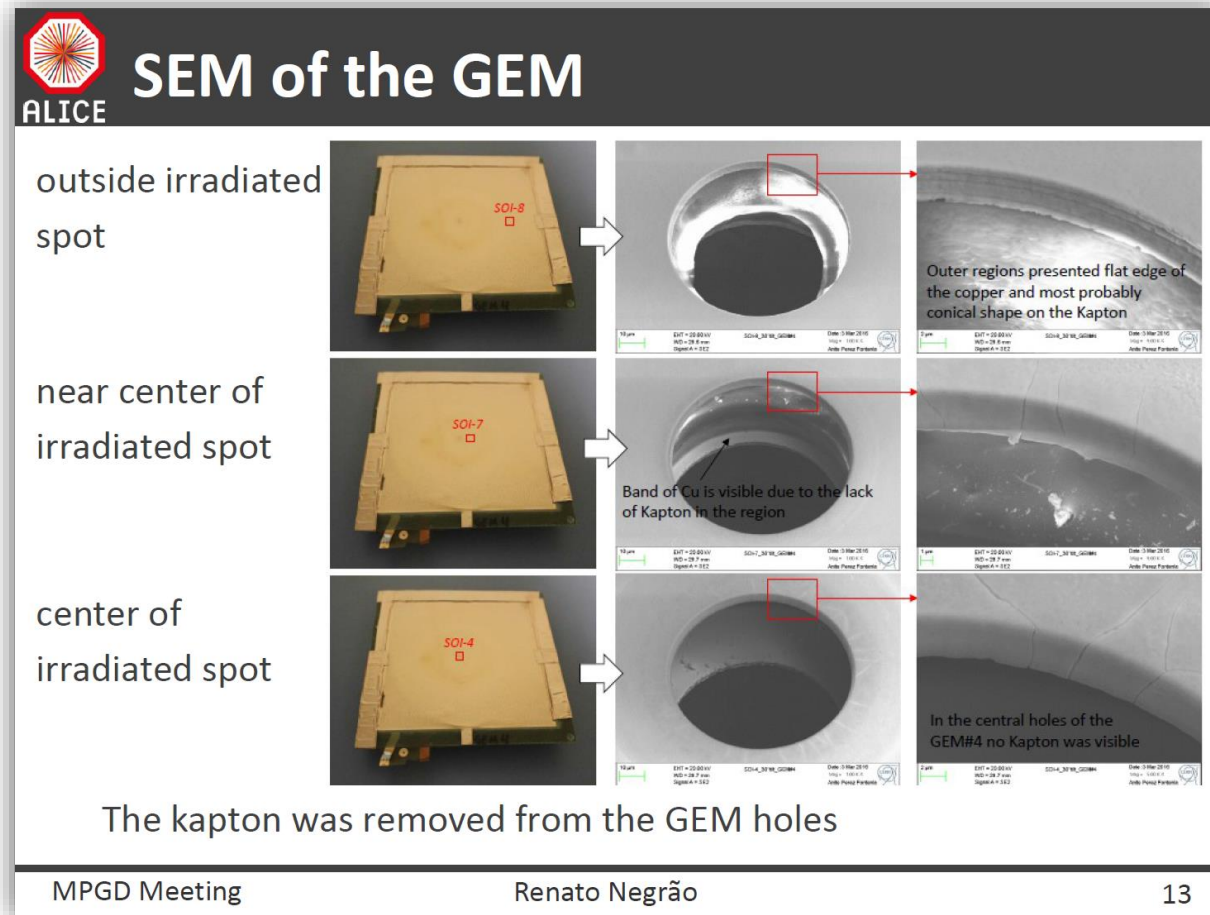
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4th year student of Tomsk polytechnic university)

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Motivation

Ageing studies with GEMs at relatively high gains* by Renato Negrão, Michael Jung and Chilo Garabatos presented at MPGD Applications Beyond Fundamental Science Workshop and the 18th RD51 Collaboration Meeting, Aveiro, Portugal



Idea:

Investigate more deeply the effects observed by the ALICE group during their aging studies.

← Total charge around $10\text{mC}/\text{mm}^2$
ArCO₂ 70/30 gas mixture

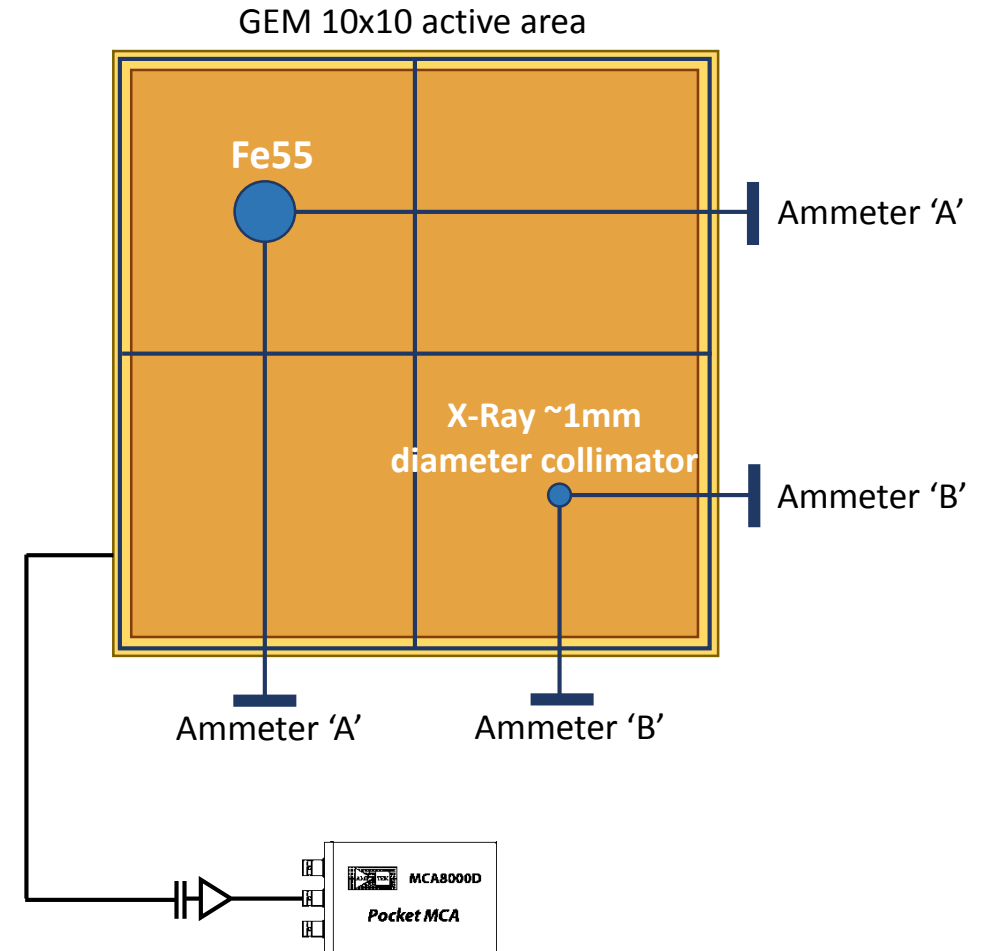
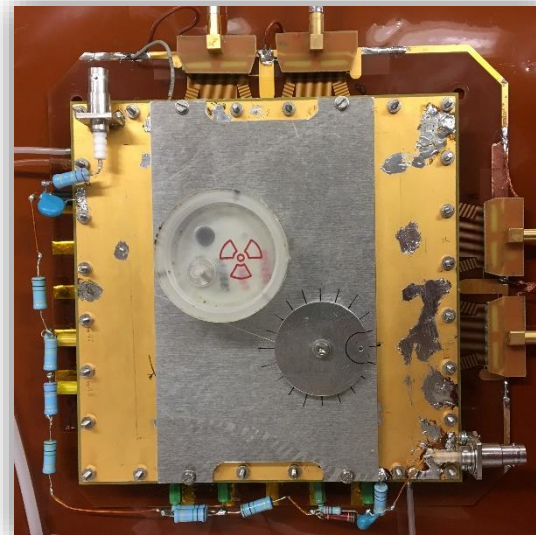
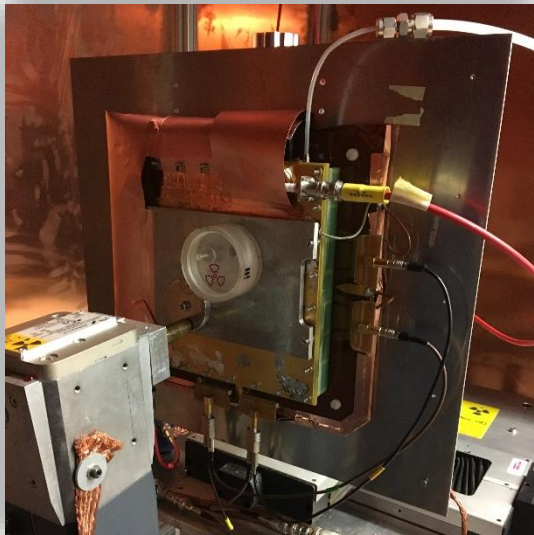
* https://indico.cern.ch/event/525268/contributions/2301380/attachments/1335653/2008900/Ageing_MPGD_Sept_2016_v2.pdf

Summer Measurements

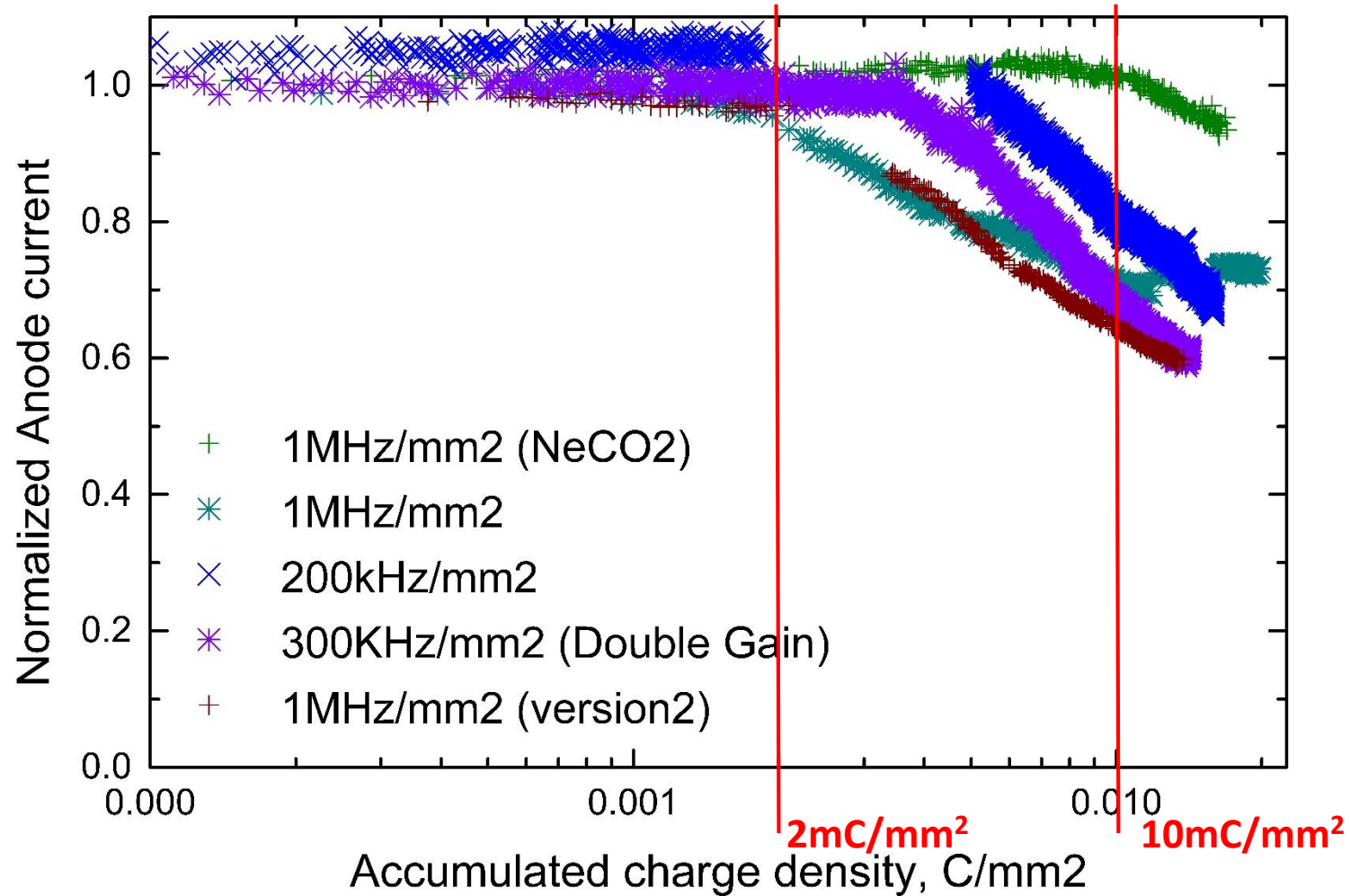
- Main goals:
 - to reproduce observed effect;
 - to estimate, can it be described as a function of total charge or does the process depend on a rate
- Setup requirements:
 - Being able of disentangle gain fluctuation coming from etching from other fluctuation like:
 - gas and ambient parameter (P, T) → continuously monitoring Fe55 source
 - stability of the X-Ray source → continuously monitoring low X-Ray density background from X-Ray gun

Setup

- Fe55 source to monitor global gain changes (gas, P, T)
 - Keithley A, Shutter OFF
 - Bottom GEM preamp, Shutter OFF
- X-Rays background to monitor source fluctuations
 - KeithleyA, Shutter ON
- High X-Ray flux
 - KeithleyB, Shutter ON
 - Bottom GEM preamp, Shutter ON (main component is given the rate)

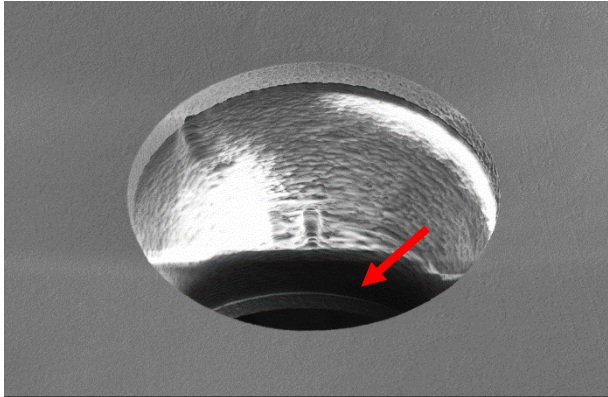


Summer results

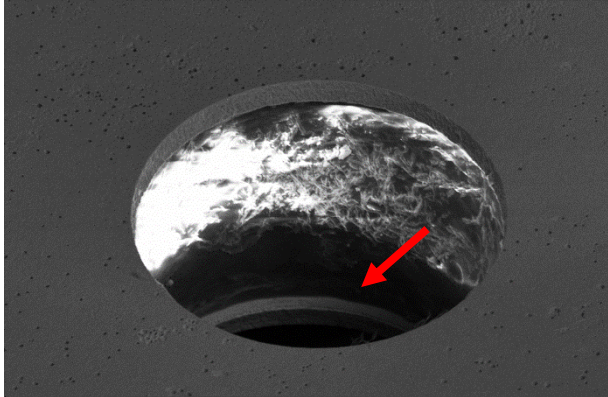


1. The effect has been reproduced and quantified in the terms of collected total charge.
2. It is not straightforward to claim if is total charge or rate dependent (different space charge condition at different rates plays certainly a role here. *Suggestion for the next measurements: monitoring Current at lower rate during the irradiation*)

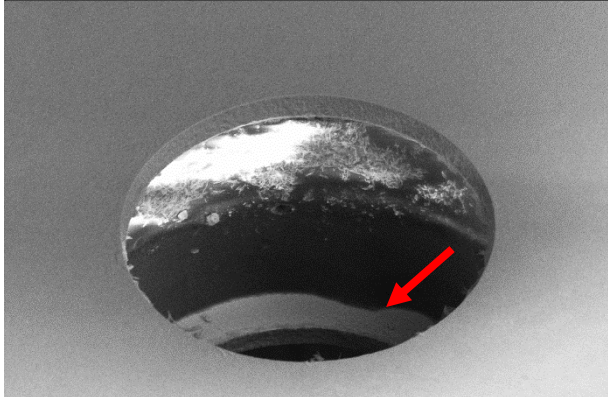
SEM analysis



The reference (not irradiated) hole on the top side of the 3rd GEM

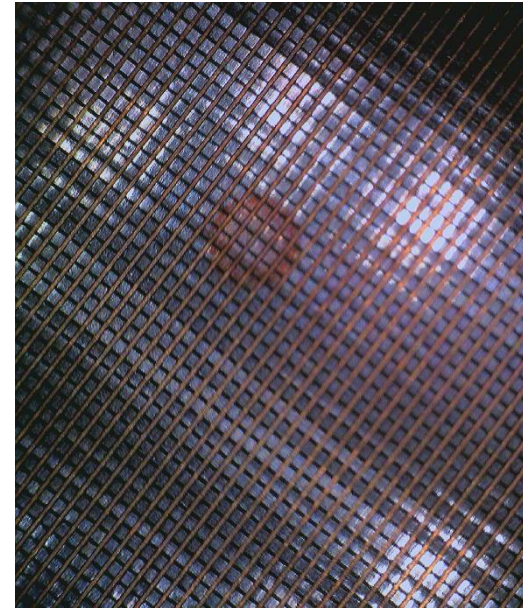


The hole irradiated at 1MHz/mm² (version 2) on the top side of the 3rd GEM



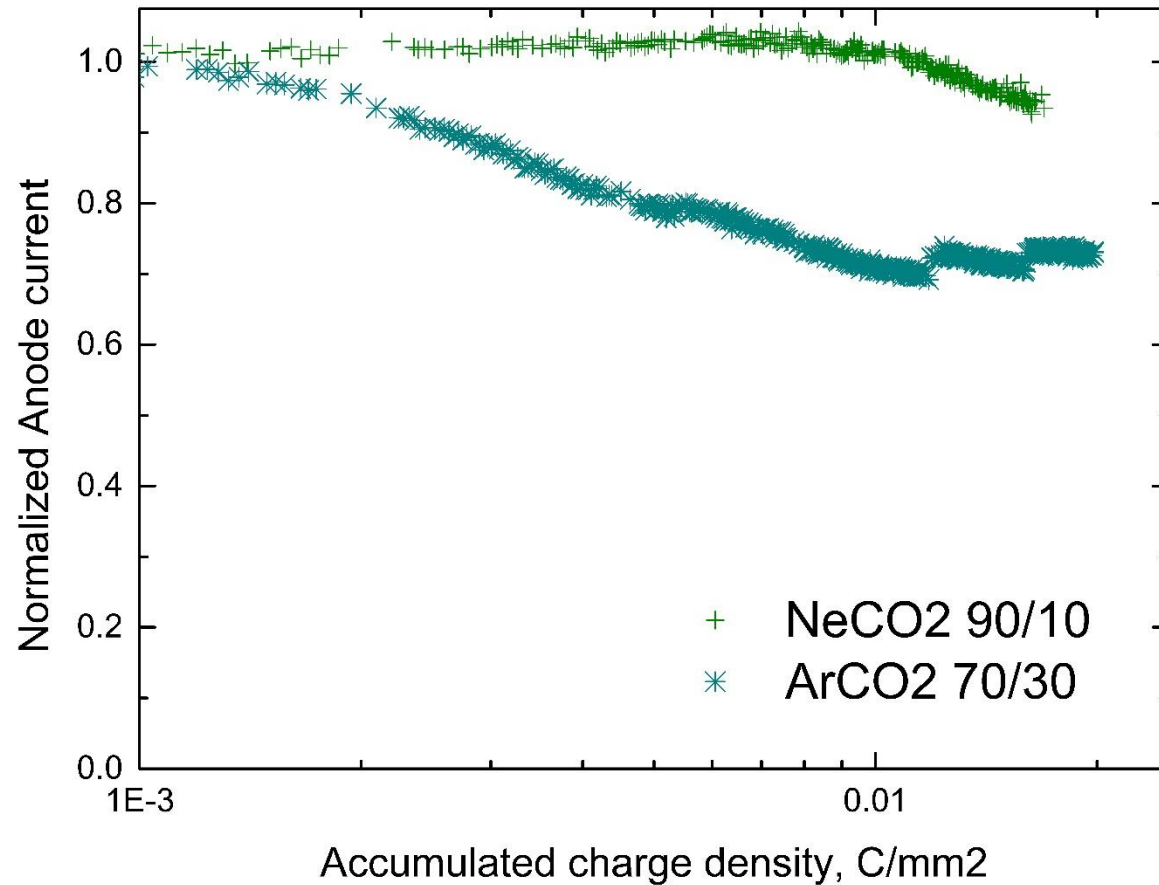
The hole irradiated at 1MHz/mm² on the top side of the 3rd GEM

10 μ m EHT = 10.00 kV Date: 15 Aug 2016
WD = 38.4 mm Sample ID = GEM#3_Darina_SOI-3/ Mag = 1.00 K X
Signal A = SE2 Stage at T = 45.0 ° Anite Perez Fontena



Shadows of the area irradiated at 200kHz/mm² on a readout plate

Among all the measurements performed, what triggered our attention was



CO₂?

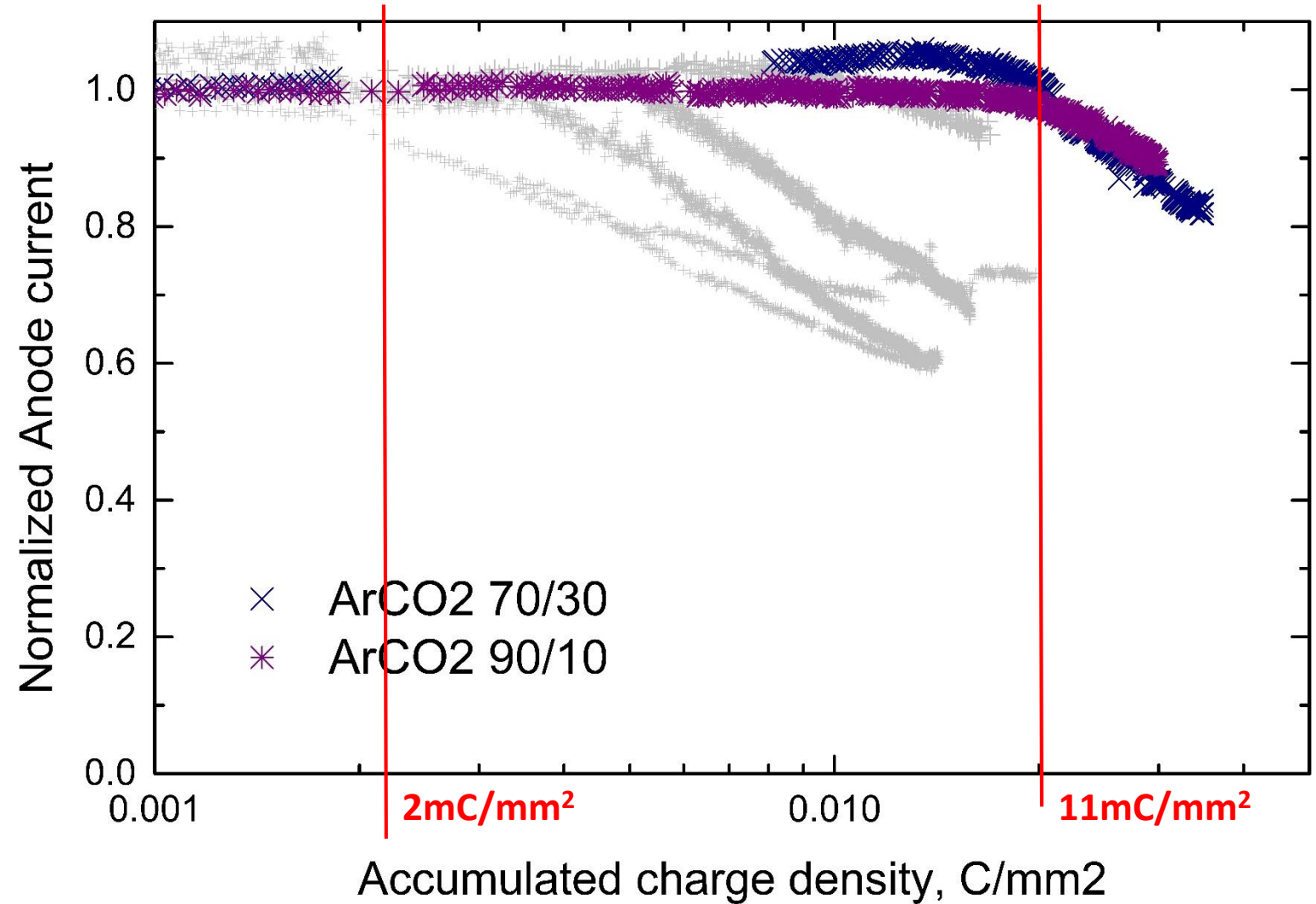
Winter Measurements

- Main goals:
 - To estimate the role of CO₂ in the process
 - Changing CO₂ percentage... limit the possible phenomena involved changing the quencher
 - Using other quencher.. Ar-CH₄, Ar-CF₄
- Setup Requirements:
 - Measurements at lower rate during the irradiating
 - Faster electronics on the bottom side of 3rd GEM

Preliminary results

Question:

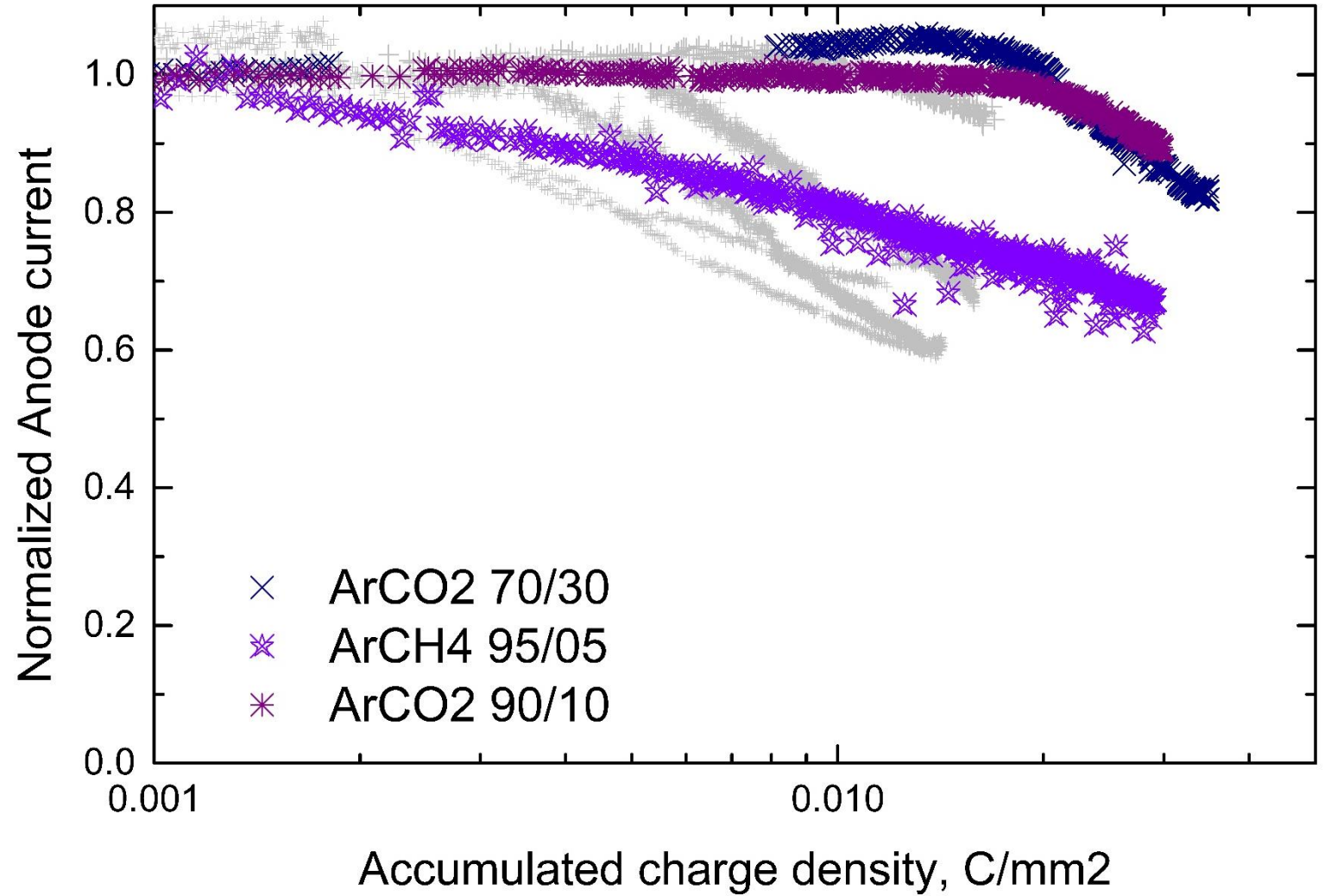
Is CO₂ playing a role in the process?



1. CO₂ is not playing any strong role dependent on its concentration
2. Measurements are not reproducible (It's understandable because we had different detector, different GEM foils, different gas system. This means that the effect can be limited or cancelled once understood)

Preliminary results

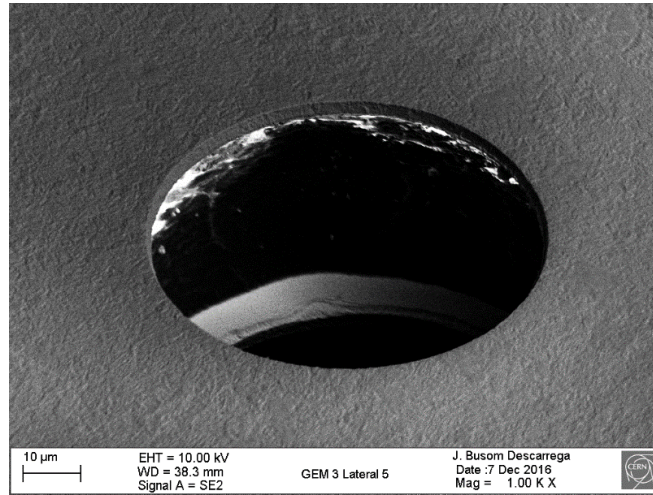
Idea:
Moving to CH₄ to be
free from CO₂



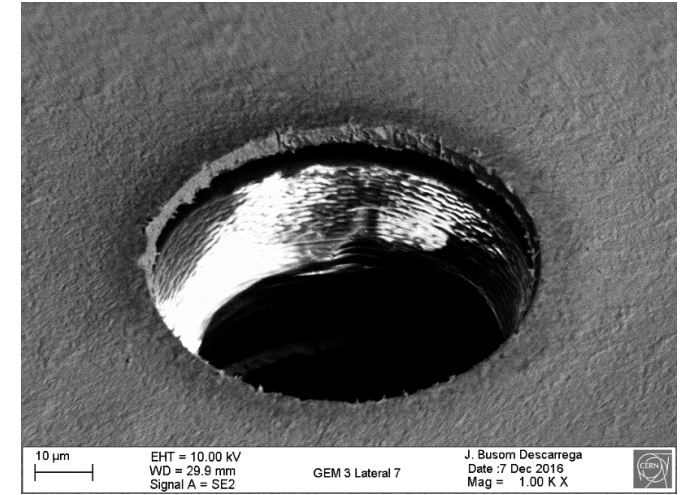
SEM analysis



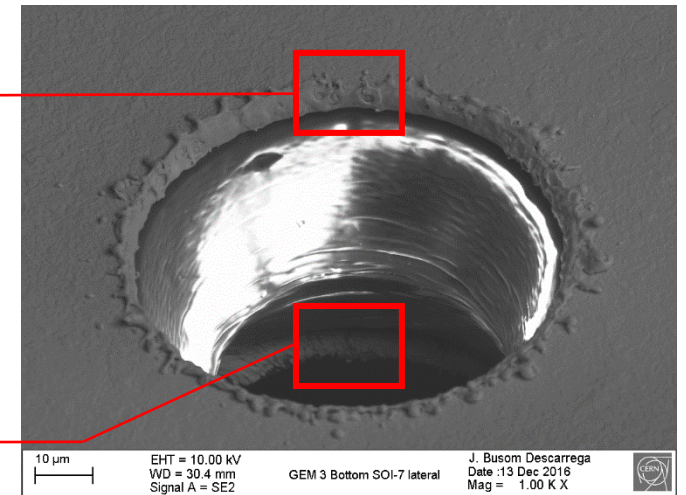
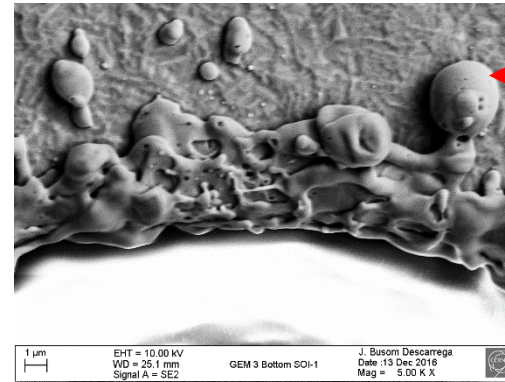
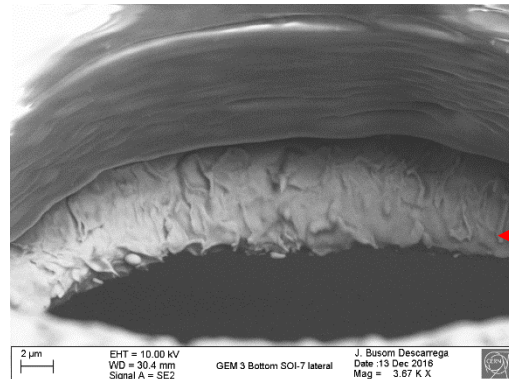
Non-irradiated area – TOP side



Area irradiated in ArCO₂ 90/10
gas mixture – TOP side



Area irradiated in ArCH₄ 95/5
gas mixture – TOP side



Area irradiated in ArCH₄ 95/5
gas mixture – BOTTOM side

Current activities

New detector with three brand new GEM foils (Techtra)

In a view of possible test with CF4 and generally to have a cleaner and more under control system plastic pipes were replaced with the copper pipes

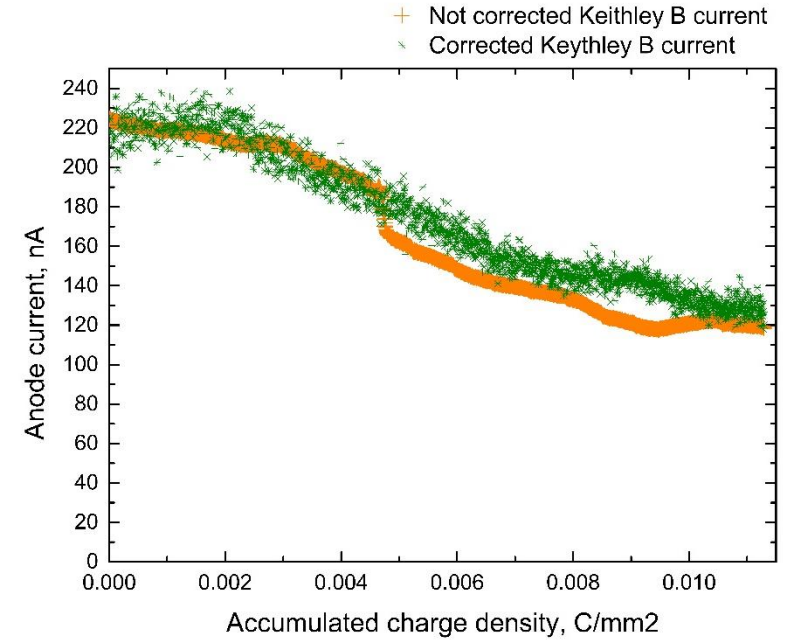
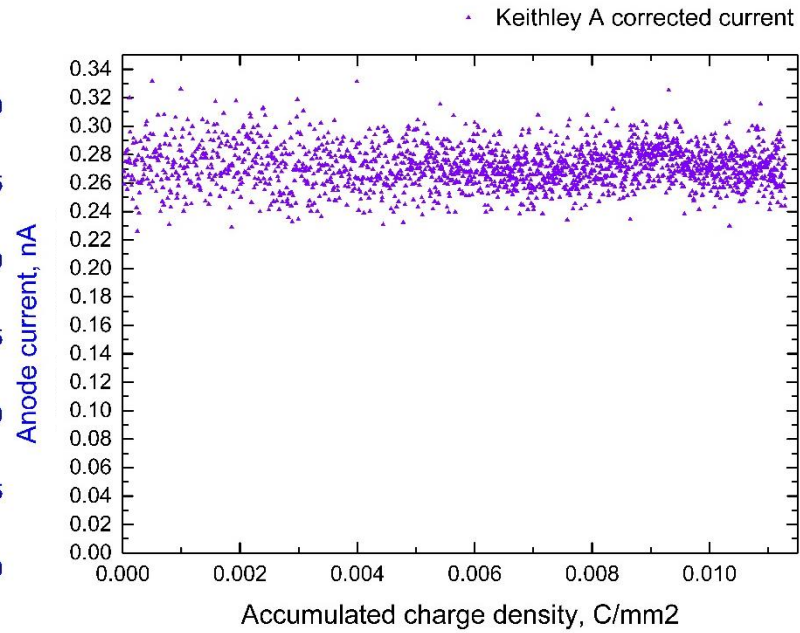
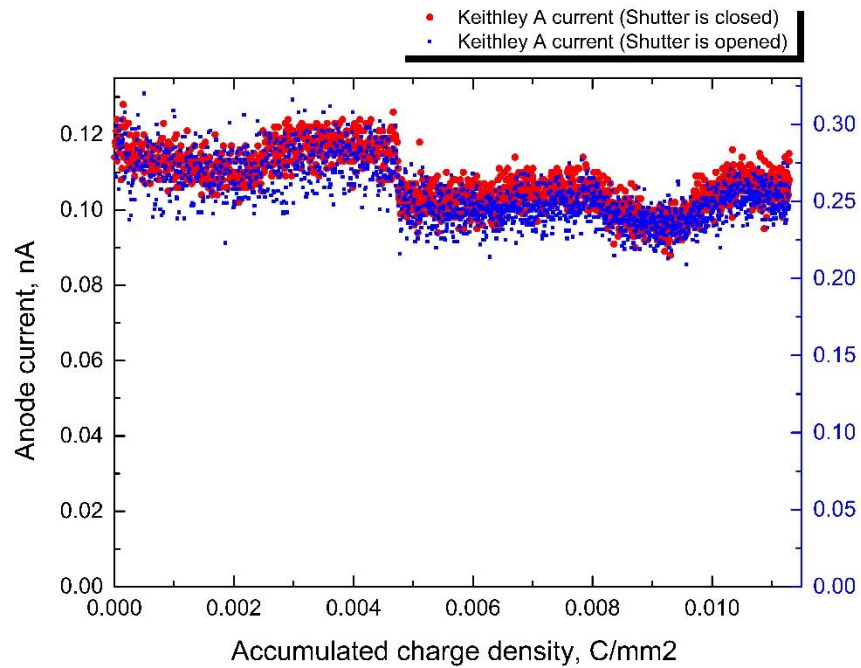
- Humidity level has been decreased (roughly 2 times less)
- We got one more parameter to monitor
- Data is in a process

Conclusion

- ✓ Effect of polyimide etching is reproduced and measured in terms of total anode charge collected
 - ✓ Etching with ArCO₂, NeCO₂ mixtures affecting the polyimide and not the copper
(with hydrocarbon (CH₄) different observation, but it is not a priority now the understanding of what observed)
 - ✓ Until now effect is observed at very large total amount of charge (tens of mC/mm²)
- We have observed different results (and not under control at the moment!) in different (foil, gas system, gas purity) but also similar (triple gem, same mixtures, same gain) conditions
- ... i.e. the etching process is not an intrinsic property of a GEM detector.
- Once the critical parameter will be spotted (impurity, humidity, Oxygen affecting, gem foil), it will be possible to limit or suppress the etching even at this very large amount of total charge

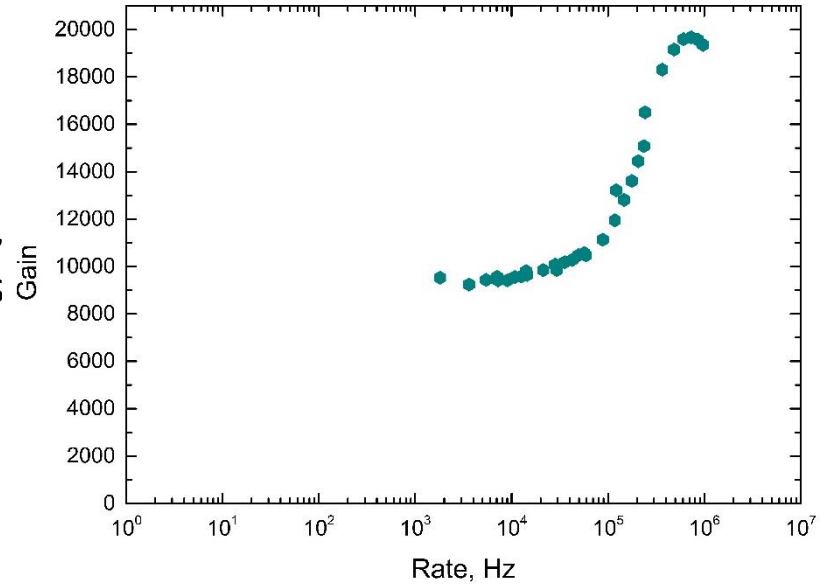
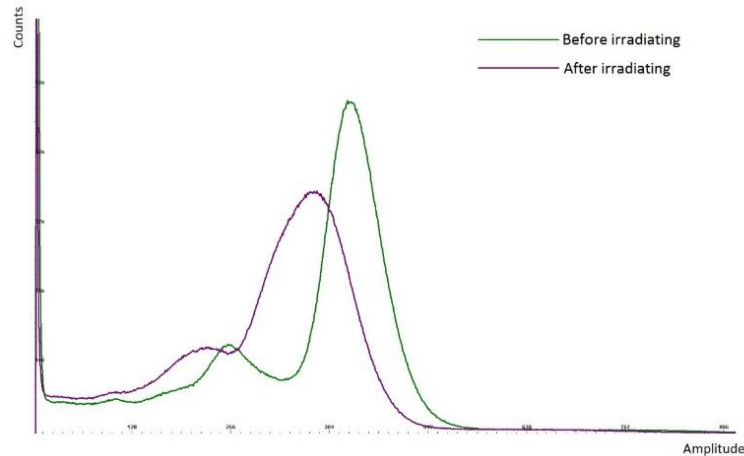
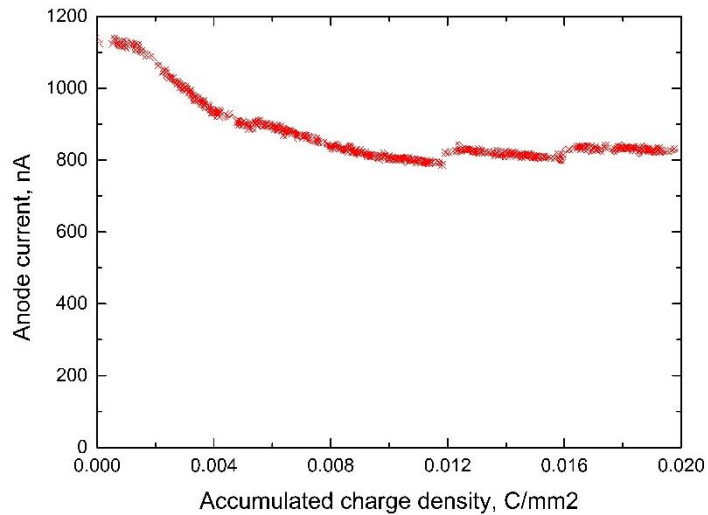
Thank you!

Applied correction



Space charge contribution

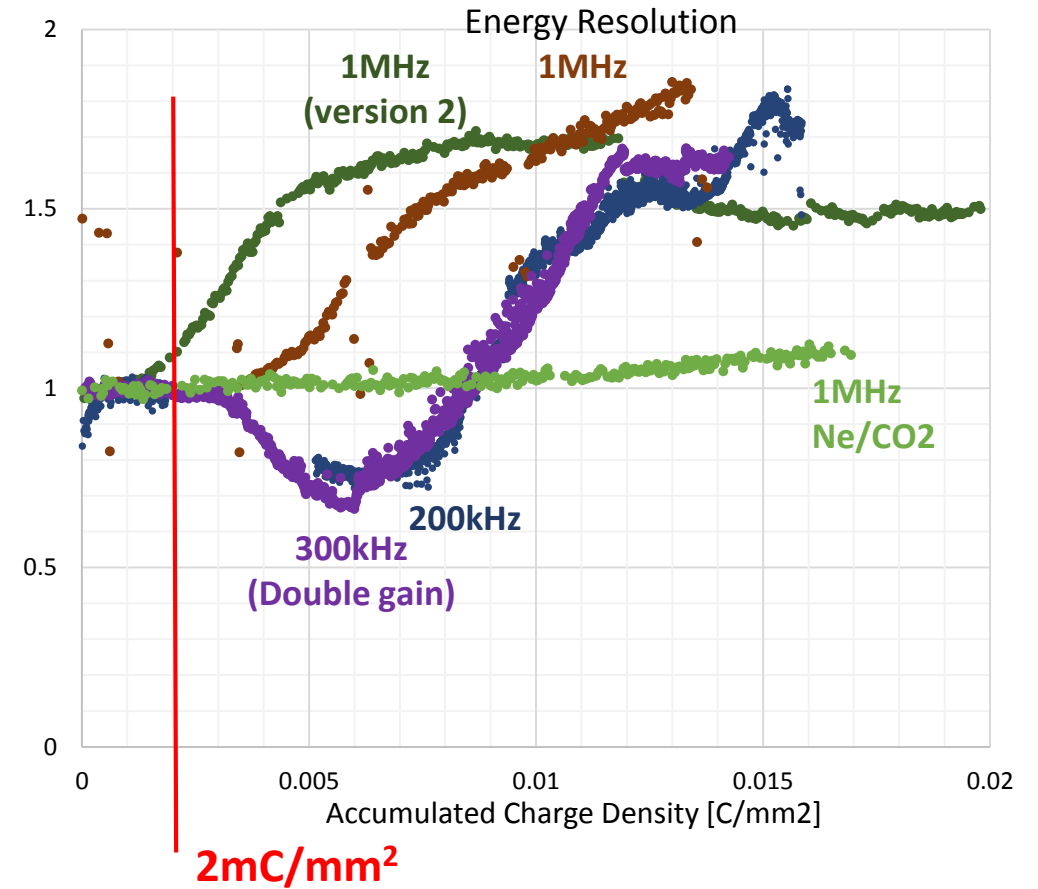
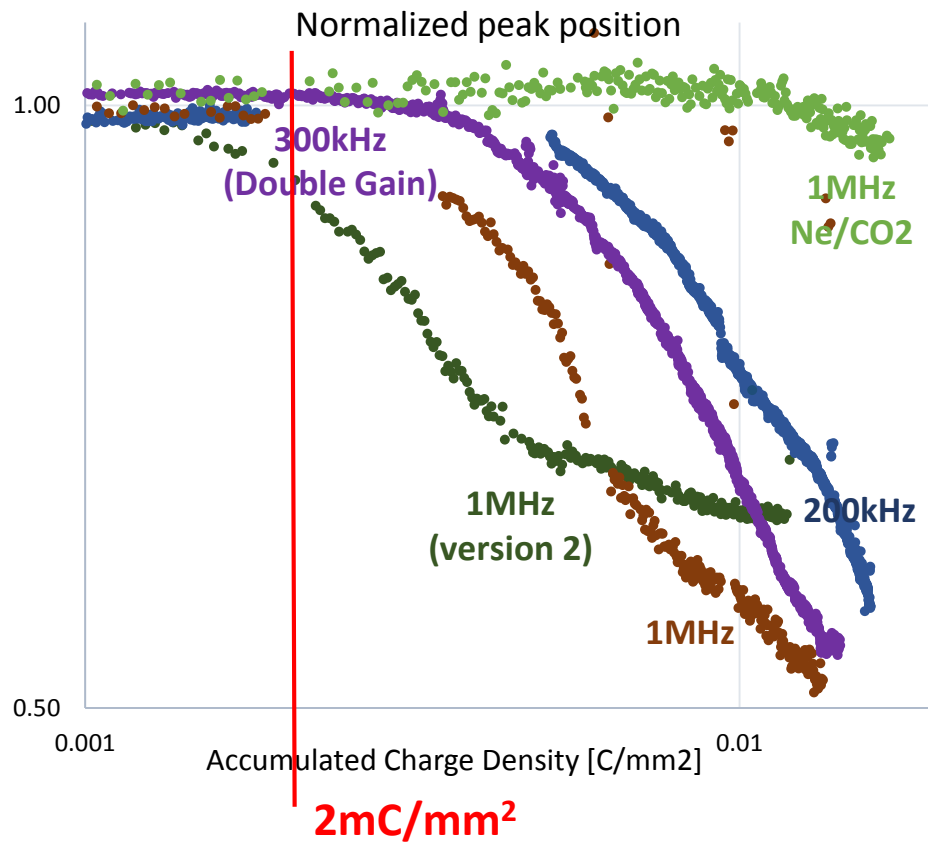
Measurements are performed in a region where space charge effect matters, i.e. any gain variation during the measurement is reflecting real gain changes driven by the hole modification plus effect in the space charge.



Spectrum acquired continuously and after/before irradiation.

Suggestion for the next measurements: monitoring Current at lower rate during the irradiation.

But nevertheless...



Given the slow response of the electronics and the high rate using, these measurements are quantitatively meaningless but they still represents a monitoring of changes in the detector performances.

Suggestion for the next measurements: faster electronics in the bottom of the 3rd GEM