Thick GEM charging up simulation.

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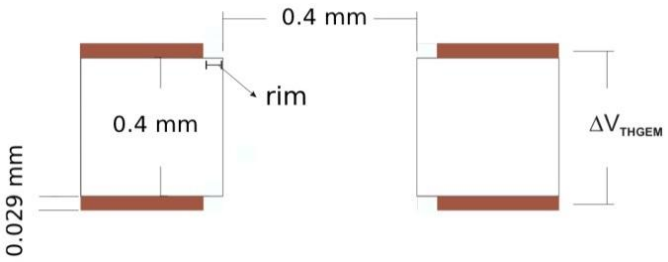
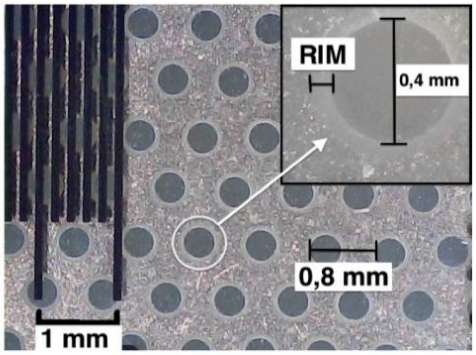
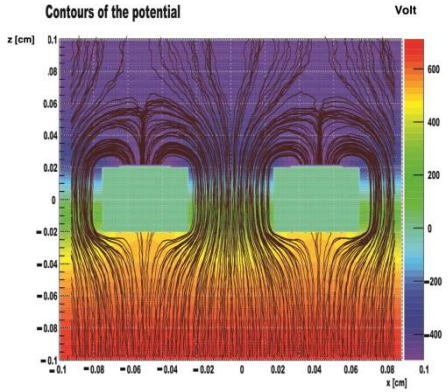
CHARGING UP IN MPGD

MPGDs, like GEM and Thick-GEM, are made of insulator foils.

Almost all the electric field line ends in the electrods, but some ends in the insulator, leading to charge accumulation during the detector operation.







Works reporting this effect:

- B. Azmoun, et al,"A Study of Gain Stability and Charging Effects in GEM Foils" IEEE NUCL SCI CONF R , http://dx.doi.org/10.1109/NSSMIC.2006.353830

- A Bressan, et al, “High gain operation of GEM in pure argon”, NIMA, http://dx.doi.org/10.1016/S0168-9002(98)01197-8

- M. Alfonsi, et al, “Simulation of the dielectric charging-up effect in a GEM detector” NIMA, http://dx.doi.org/10.1016/j.nima.2011.12.059

- S. Biswas, et al, “Development of a GEM based detector for the CBM Muon Chamber (MUCH)”, JINST, http://dx.doi.org/10.1088/1748-0221/8/12/C12002

- Among others...

CHARGING UP IN MPGD (Thick-GEM charging)

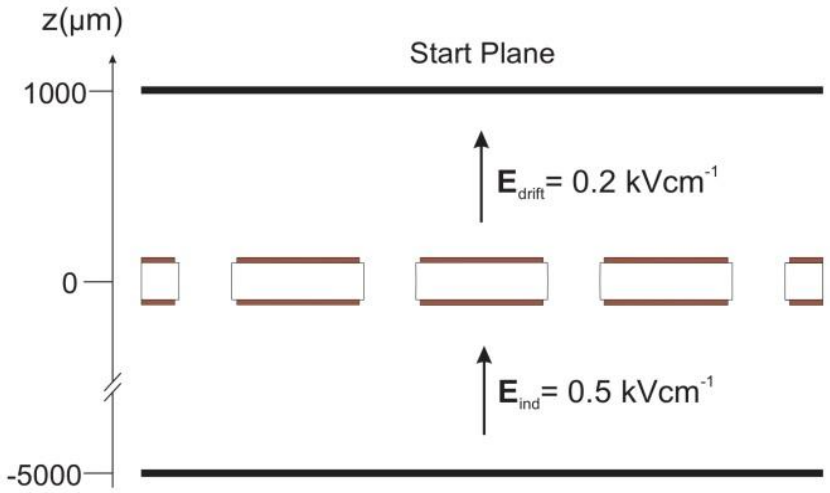
- GEM-type structure, with milimetric dimensions, cilindrical holes and etched RIMs;

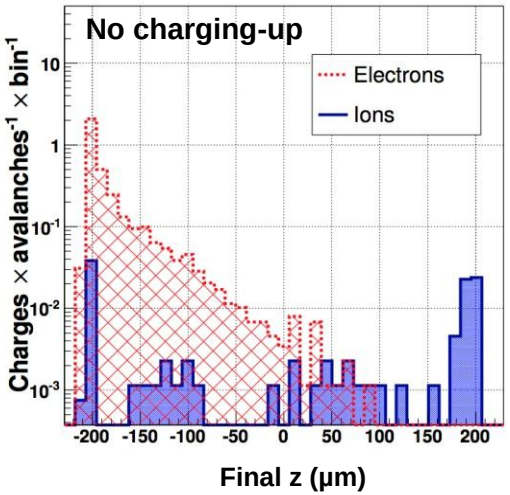
- During avalanches, ions and electrons may accumulate in the insulator surfaces;

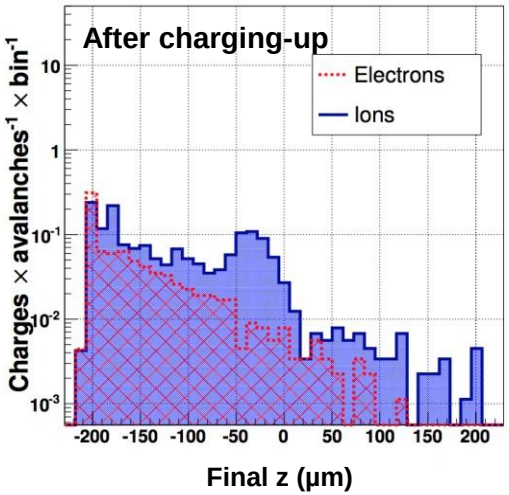
- Distribuction of deposited electrons and ions is not equal, originating changes in the local electric field;

- An iterative simulation was developed to study charging-up

- Initial simulations are shown at right.







$V_{thick\text{-}GEM}$=600 V

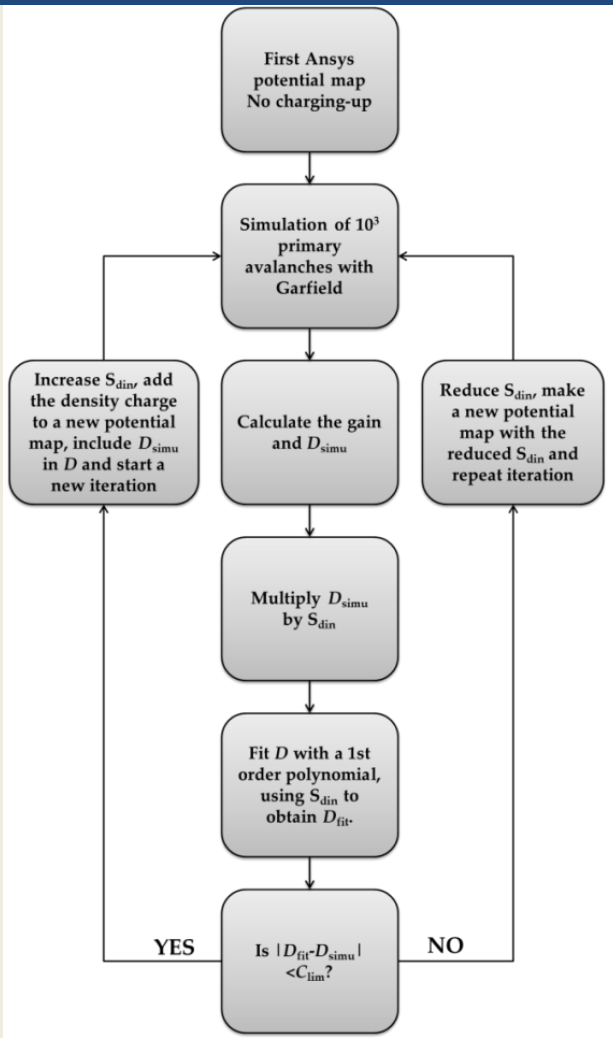
SIMULATIONS (Algorithm: dynamic step-method)

Two softwares are needed:
- FEM solver (like Ansys)
- Avalanche calculator (Garfield++)

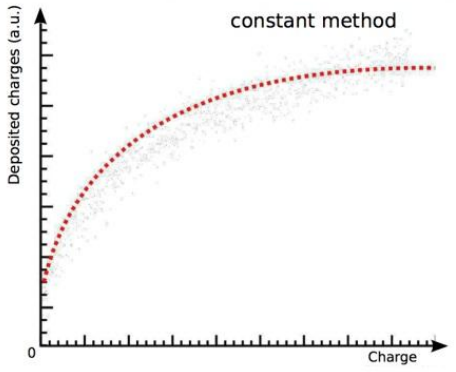
A 3rd software, like Python, may be used to write the algorithm.

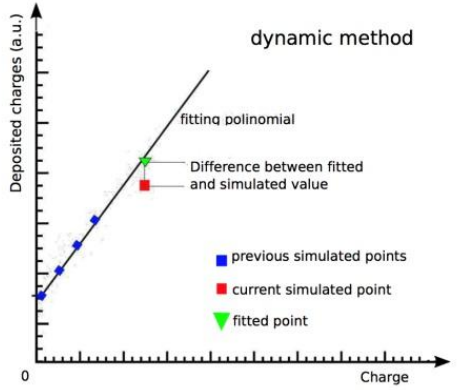
The dynamic step method accelerate the simulations.

For a more detailed description, see the paper under submission: http://arxiv.org/abs/1401.4009



D, D_{simu}, D_{fit}, S_{din}, C_{lim} are constants defined in the algorithm,





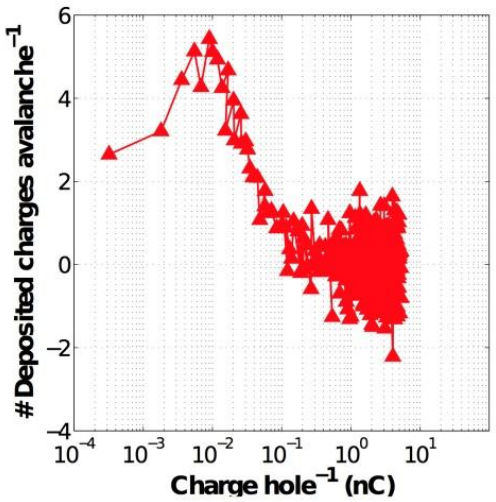
SIMULATIONS (Gain variation)

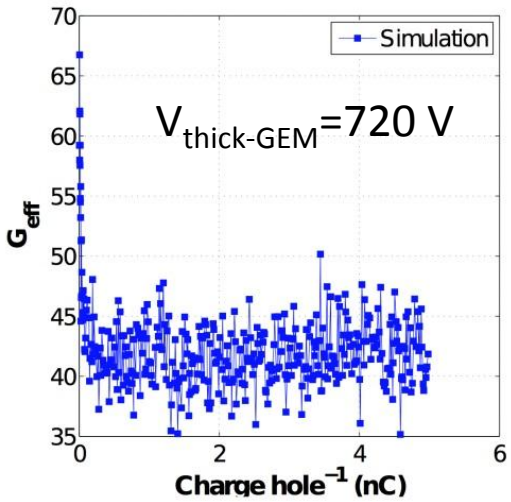
- More ions are deposited initially, but the charge deposition tends to zero, annihilating the electric field changing;

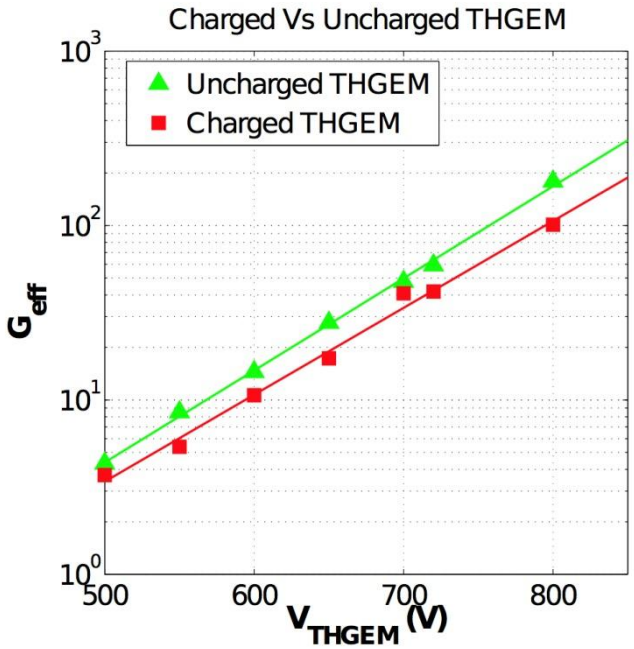
- The effective gain simulated decrease in the initial iterations and reach stabilization after.

For different applied voltages, the decrease (~30%) in effective gain is always observed.

- Ne 95% CH4 5% was used, at standard pressure and room temperature.





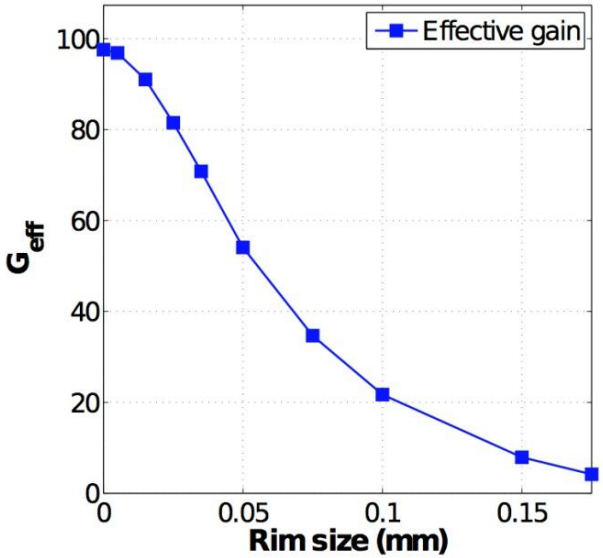


SIMULATIONS (RIM and thickness influence for gain)

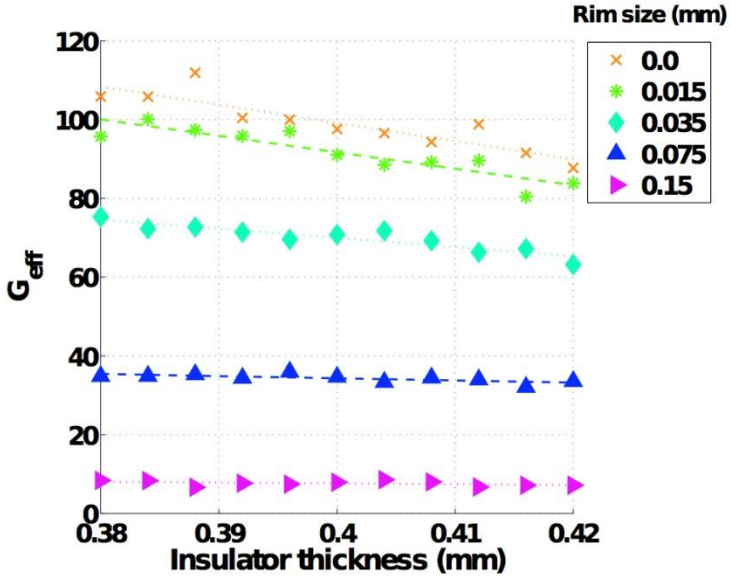
- The size of the rim and the insulator thickness affect the gain of the Thick-GEM.

- Larger RIMS and insulator foils decreases the gain, but no studies were made with charging-up yet.

- Investigate the influence of the RIM for charging-up (related with spark probabilities)



$V_{thick\text{-}GEM}$=720 V



EXPERIMENTAL SETUP (Detector and basic electrons)

Experimental conditions:

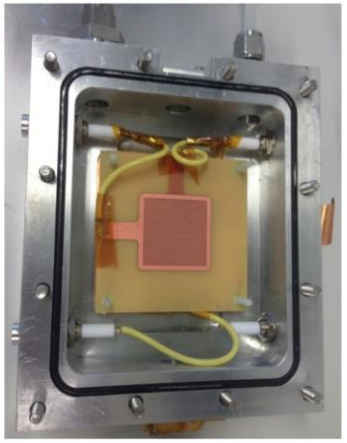
- single THGEM with 30 x 30 mm^2 was used, courtesy of Trieste group;

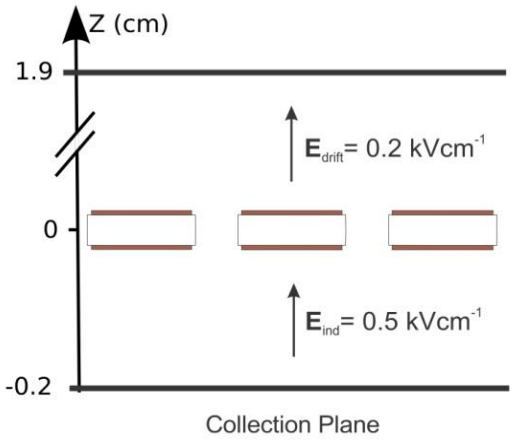
- 95% Ne-5%CH4, constant gas flux 0.2 mL/min;

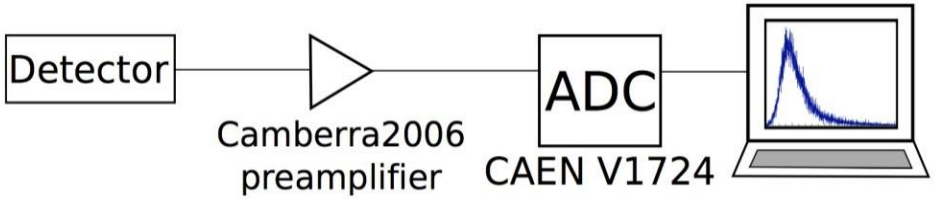
- The detector was heated at 70º and left for cool down at room temperature before the measurements, to remove humidity;

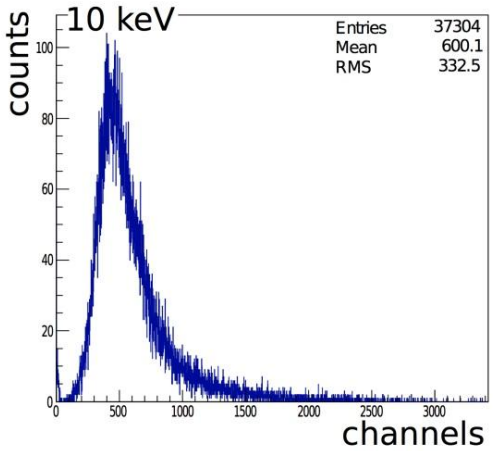
- molybdenum X-rays tube, collimated by a 2 mm diameter hole, was used as radiation source;

- for energy calibration of the channels, we used a ^{55}Fe X-ray source of 5.9 keV.





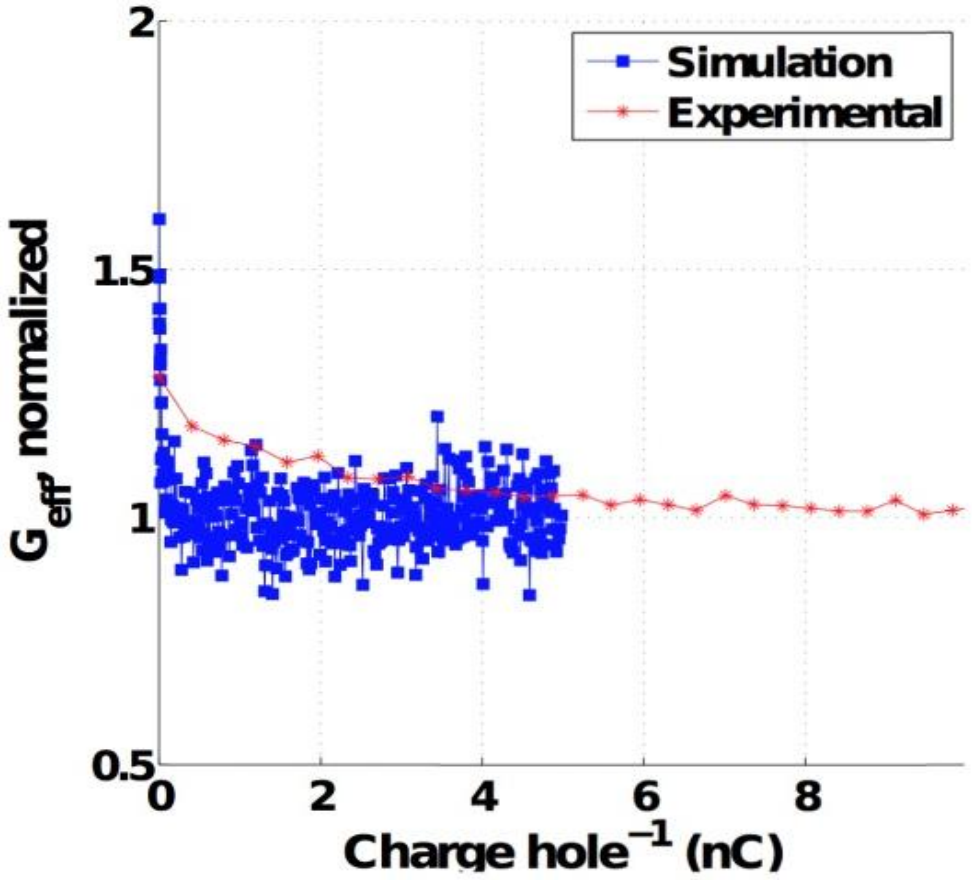




EXPERIMENTAL SETUP (Results and physical issues)

- Experimental gain was calculated using the peak position of the energy histogram

- The first decrease in gain is observed for both the simulation and the experimental measurements.



EXPERIMENTAL SETUP (Results and physical issues)

- We left the detector irradiated during some hours, at a constant rate of 20 kHz/mm^2

- Initial gain decreases, followed by an increase, discharge and new increase

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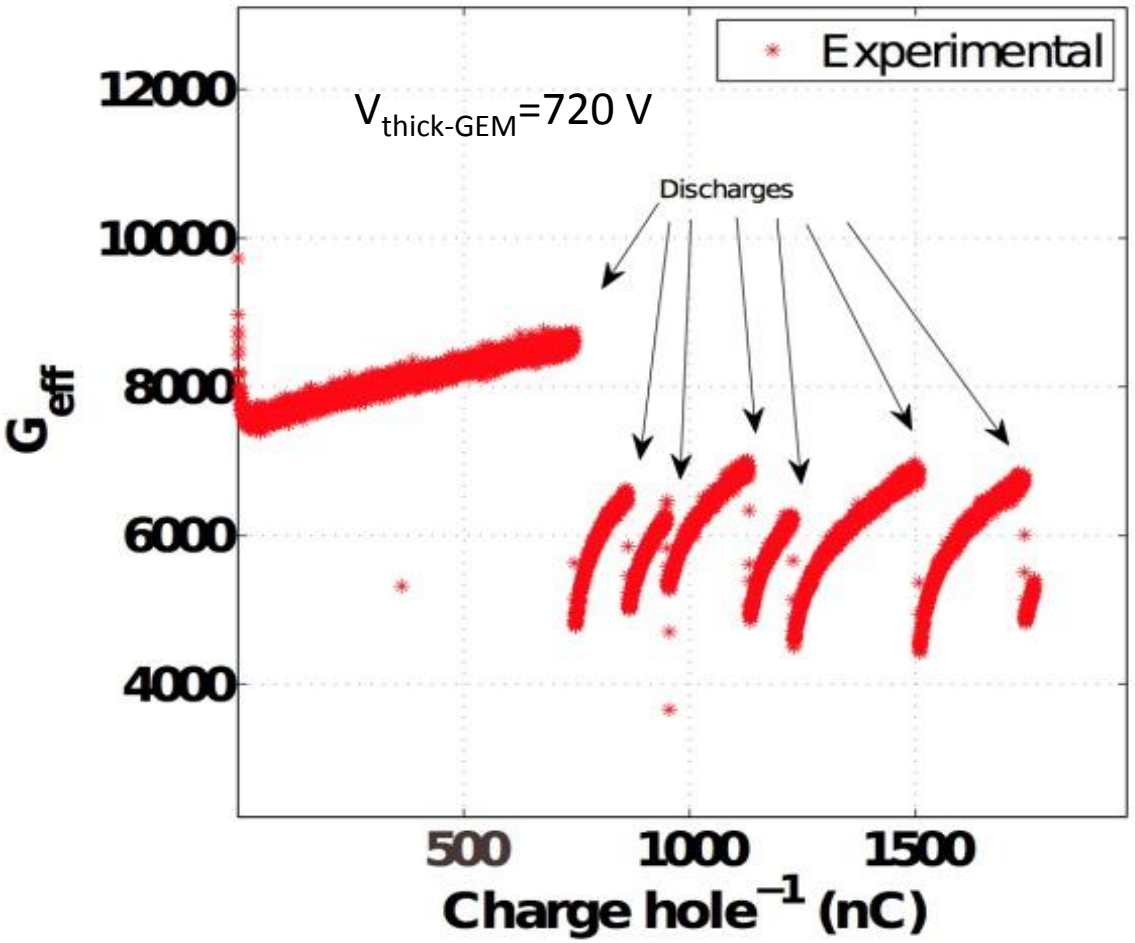
- There is no increase in the simulated gain (need more iterations?)

- Explanation: mobility of the deposited charges in the insulator not included in simulations?

- The magnitude of experimental and simulated gain still differs from a factor of 10^2.



CONCLUSIONS

- The algorithm presented for charging-up calculations explains the initial decrease in the gain, but not the following increase;

- Experimental part should be made with special care, since the simple irradiation for measurement affect the charging-up;

- When a spark occurs in the detector, the distribution of charges is affected, and a concise measurement of the charging-up is no longer possible.

FUTURE WORK

- Include the movement of the deposited charges in the simulation method may help to explain the increase of the experimental gain;

- More systematic and controlled measurements are being planned, to study the charging-up in:
  - Other Thick-GEM configurations (various RIM, thickness, etc);
  - More controlled irradiation rates and radiation sources (Copper fluorescence instead of direct X-ray tube);
  - Influence of the gas temperature , humidity and flow rate;

- Study other MPGDs and design new configurations to use/reduce charging-up effect.

- And??

ACKNOWLEDGMENT

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- ***Trieste group***, for the courtesy of the Thick-GEMs;

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