Induction of GEM to GEM discharges by using a single hole THGEM

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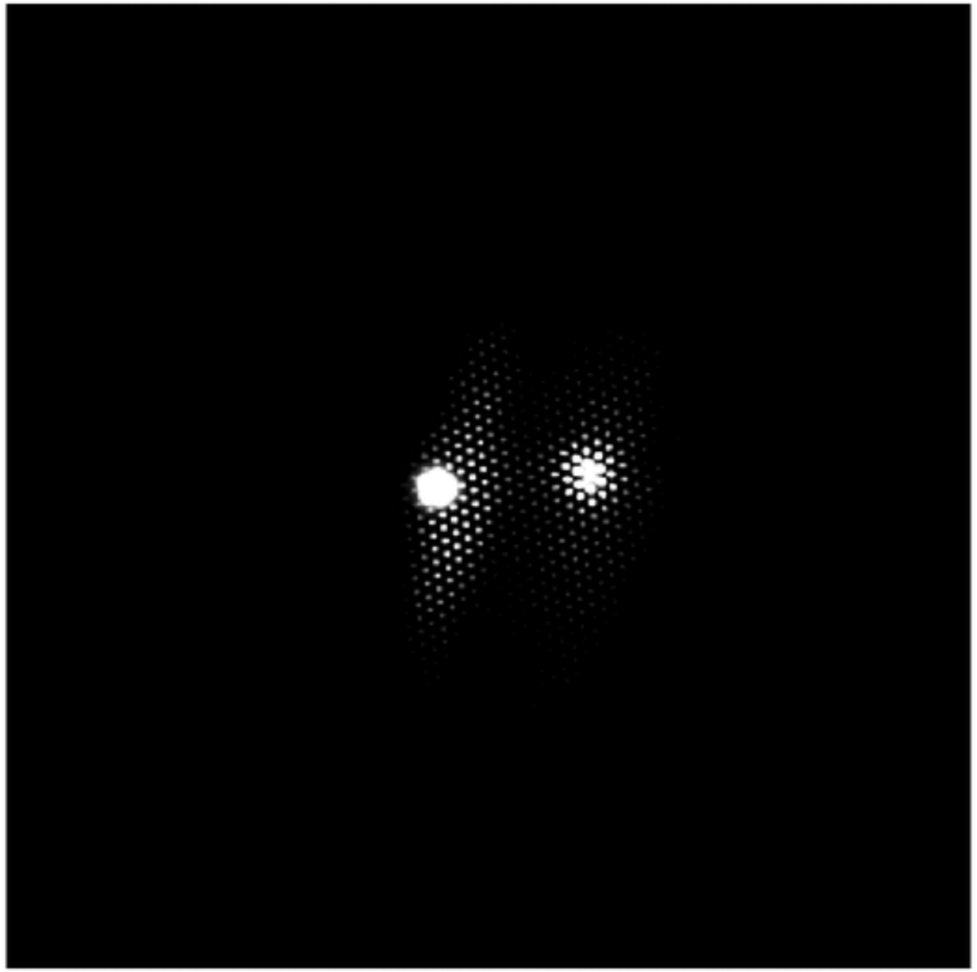
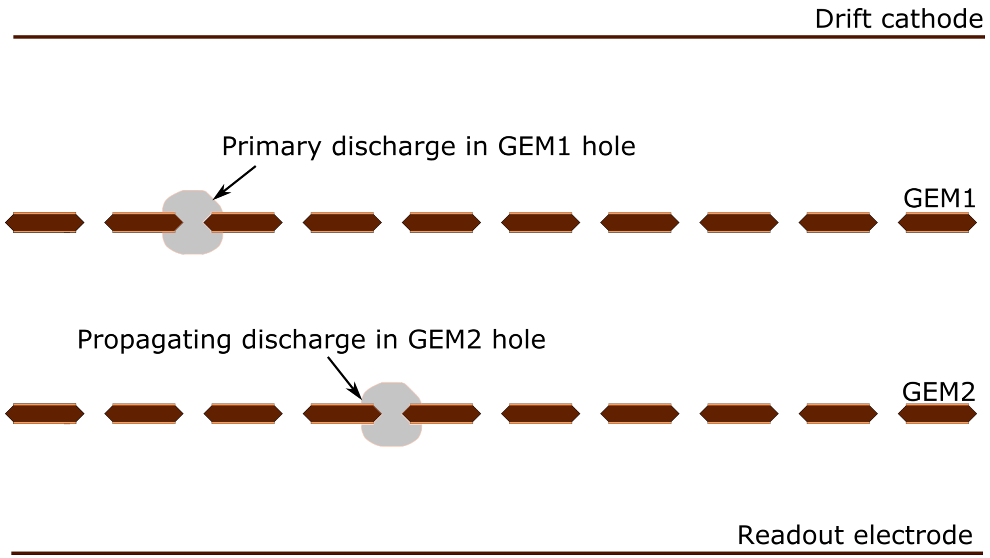
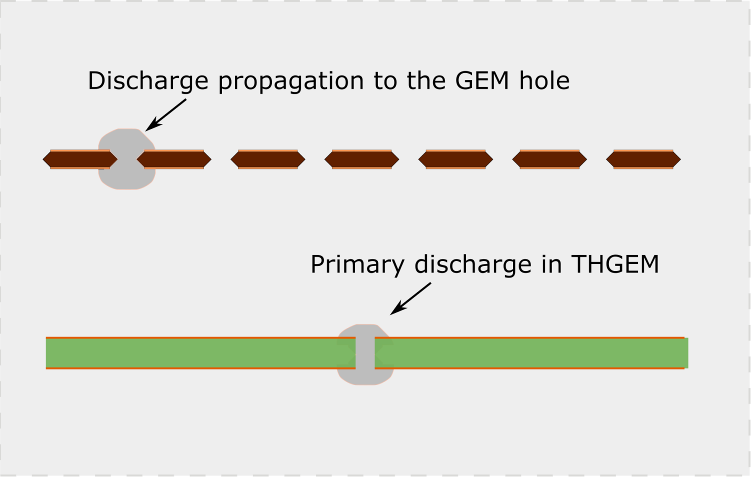


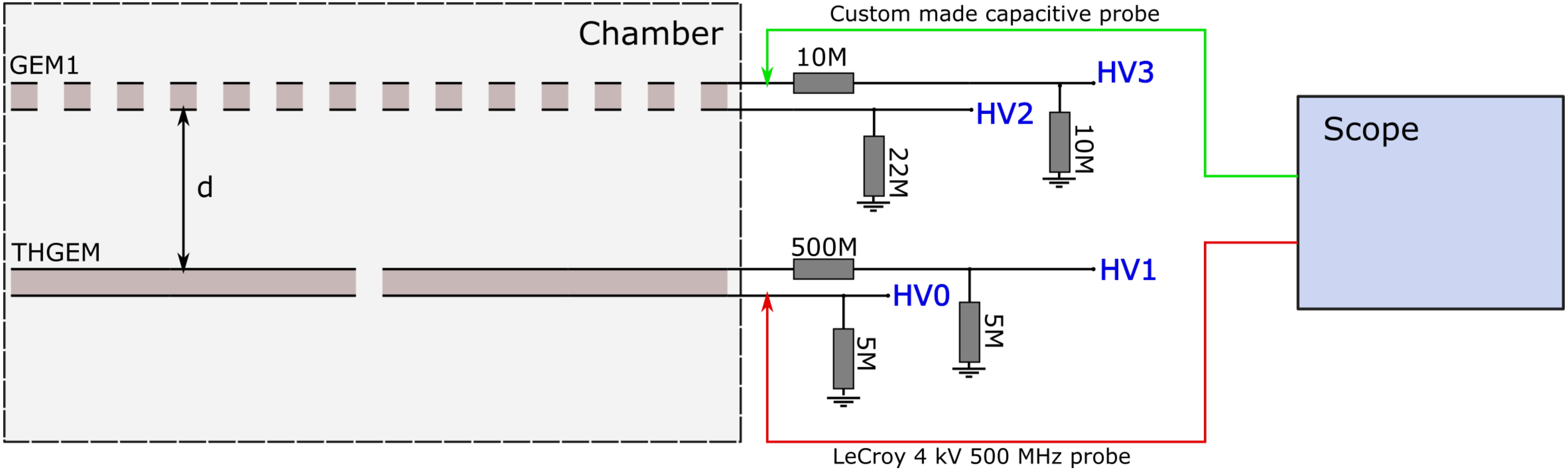
GEM to GEM discharges

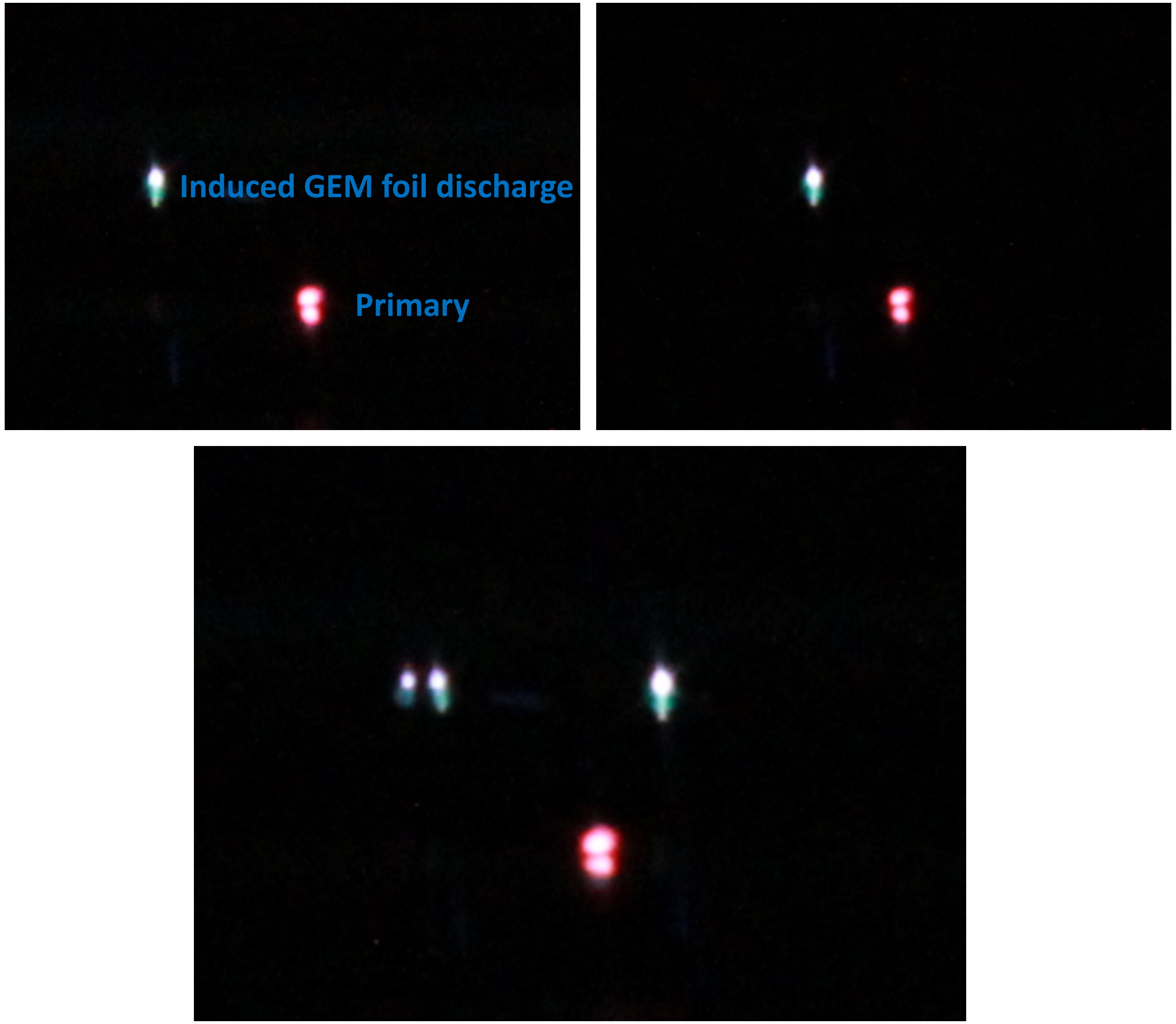
- Reffered to as a „GEM to GEM discharge propagation/fast propagation between GEMs” [Bachmann et al. NIM A 479.2-3, Peskov and Fonte, *arXiv 0911.0463* (2009), Wallmark NIM A 471.1-2]
- First measurements show no time delay with an accuracy of ~10ns between GEM discharges.
- Observed for „normal” and „inverted” field orientation between GEMs
- Photomechanism hypothesis
- How to avoid GEM2GEM DP?
  - Lower the voltage of the receiving GEM.
  - Increase the distance between the GEMs.



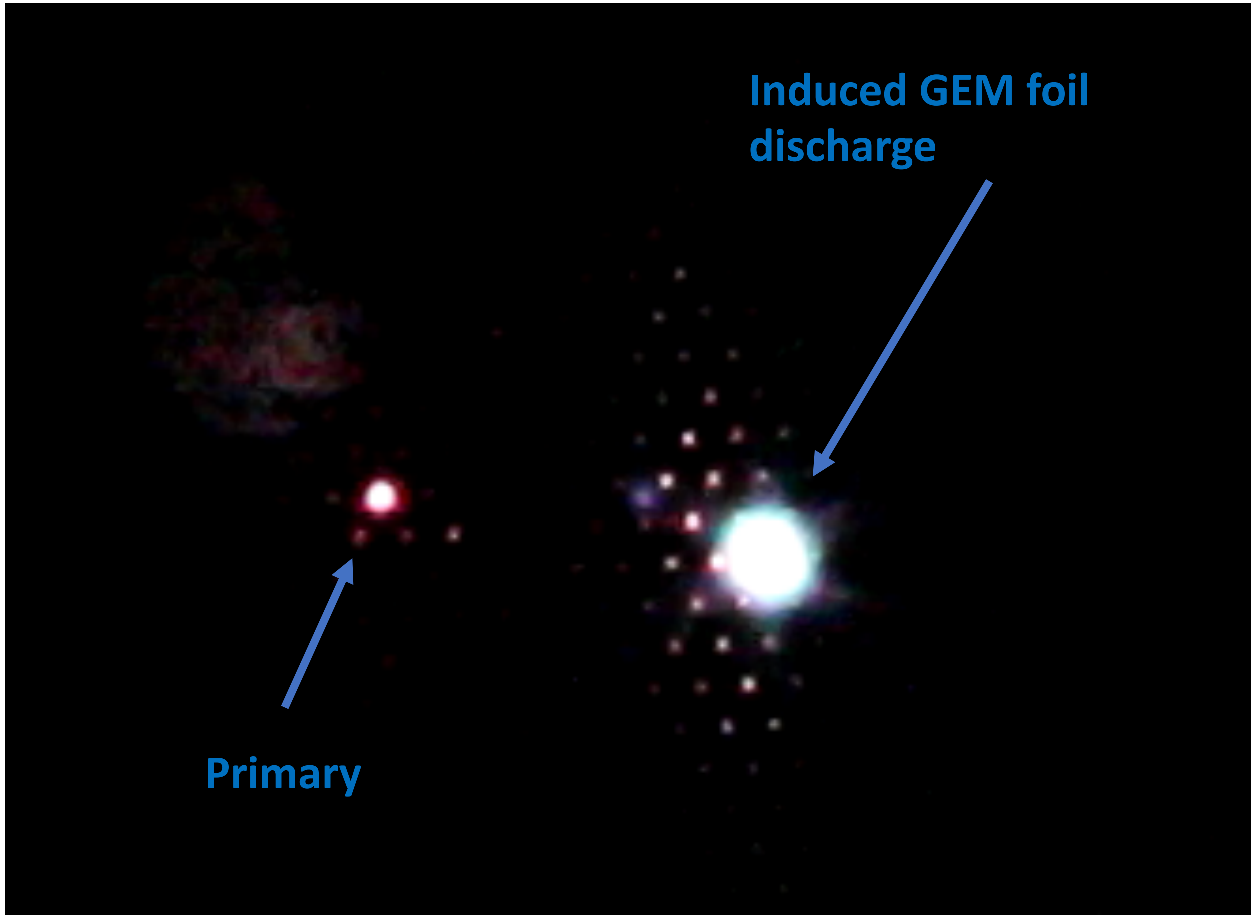
THGEM->GEM (upward)





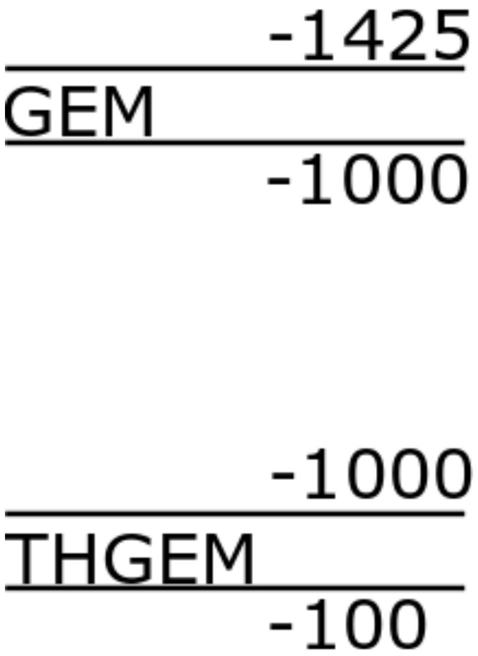


SIDE VIEW

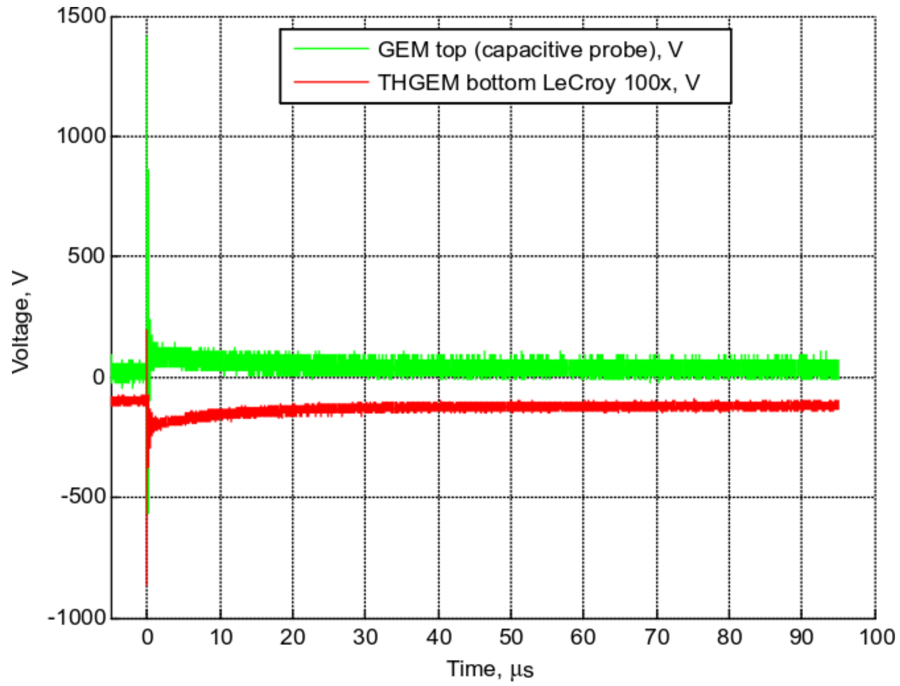


TOP VIEW

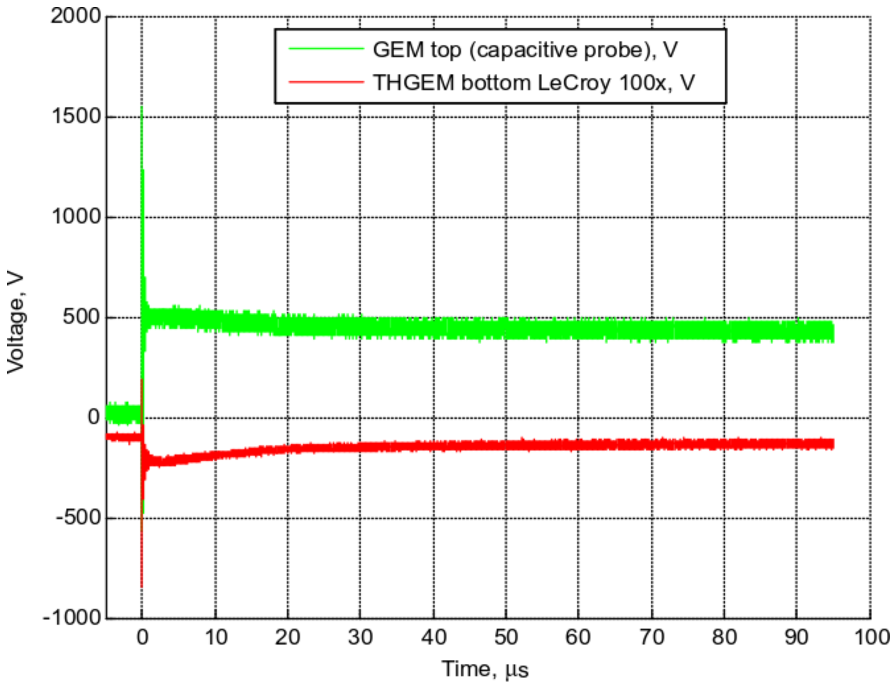
Electrical recordings



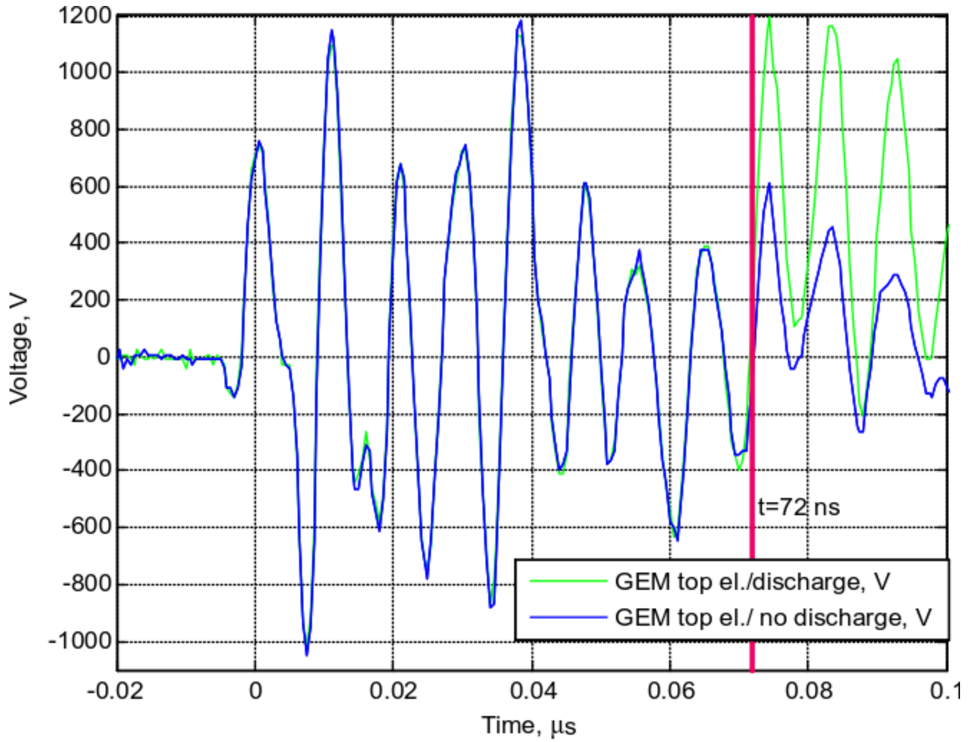
Event with NO discharge in GEM

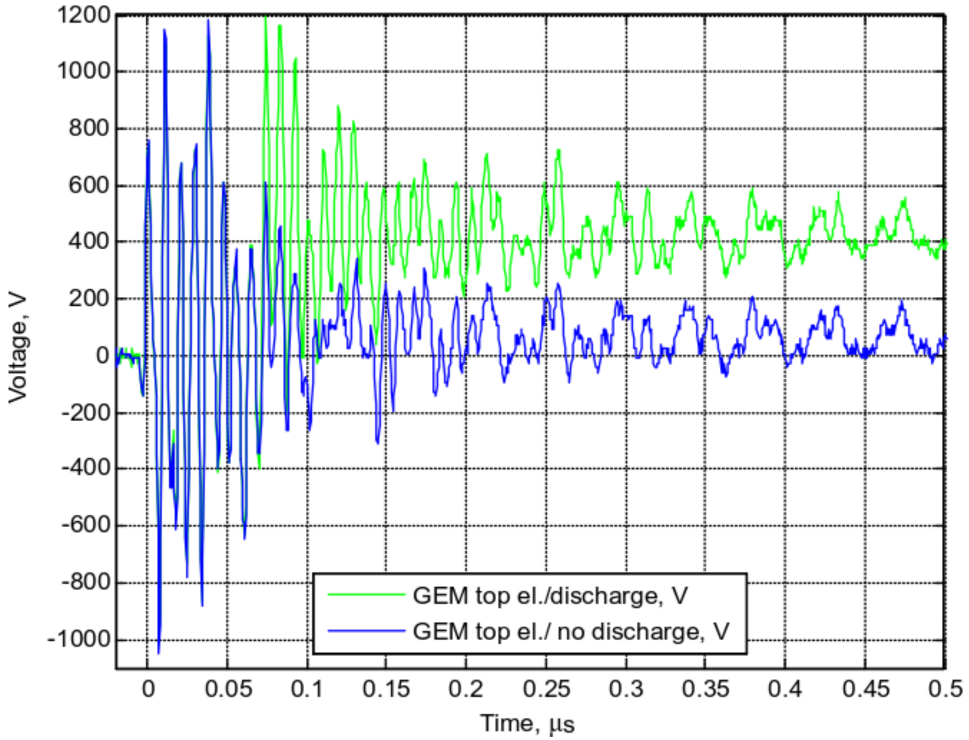


Event with discharge in GEM



- $\Delta V_T = 900\ V, \Delta V_G = 425\ V, E_{Ti} = 0\ kV/cm$

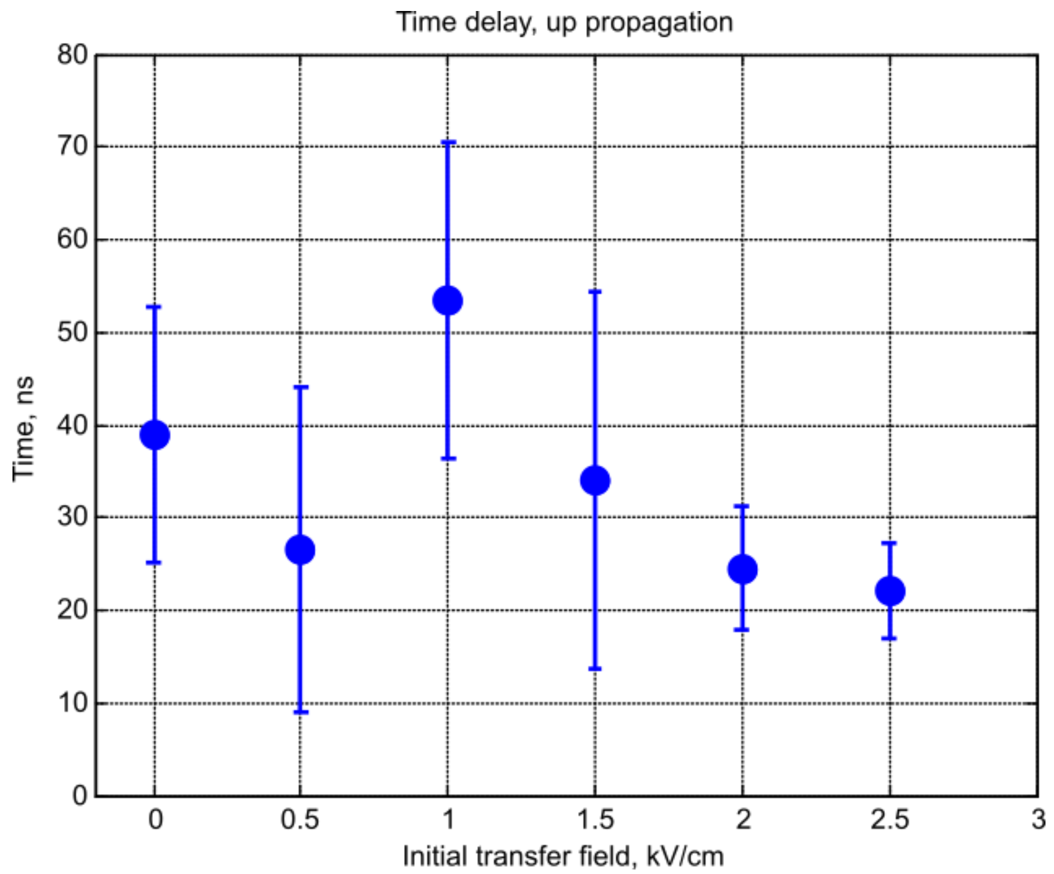


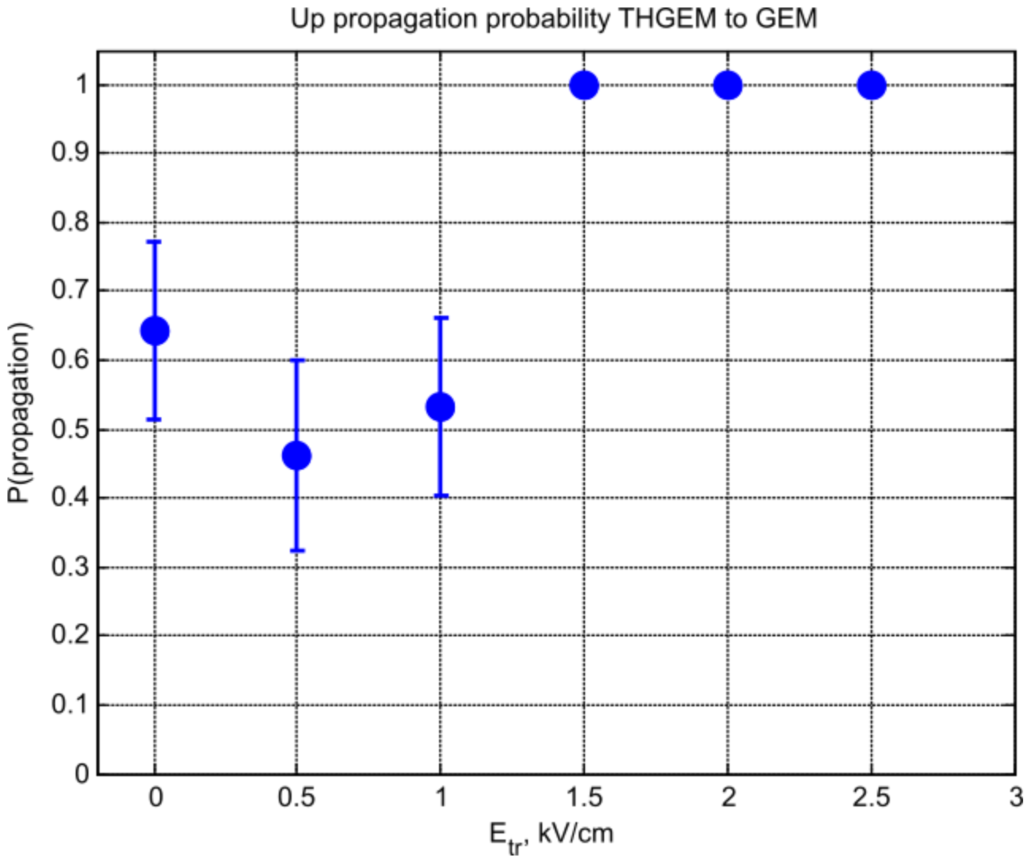


Comparison of the waveforms from the GEM top electrode in the event of discharge and no discharge in the GEM

- Large oscilattions at t= 0 s due to the primary in the THGEM foil
- Waveforms become identical in trend and amplitude at approx 70 ns after the primary in the THGEM foil
- After 72 ns there is a difference of a couple hundred volts in the recorded waveform amplitude, indicating the occurence of thedischarge in the GEM
- **There is a time delay** between the discharges

Time delay and propagation probability vs. the initial transfer field

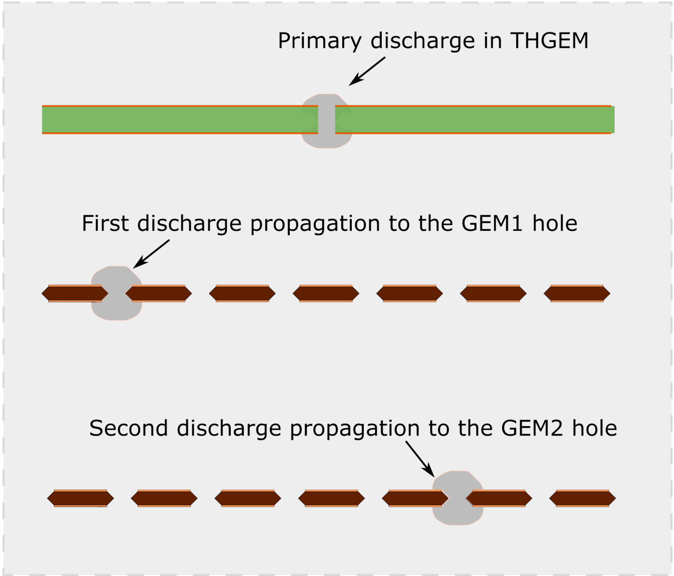




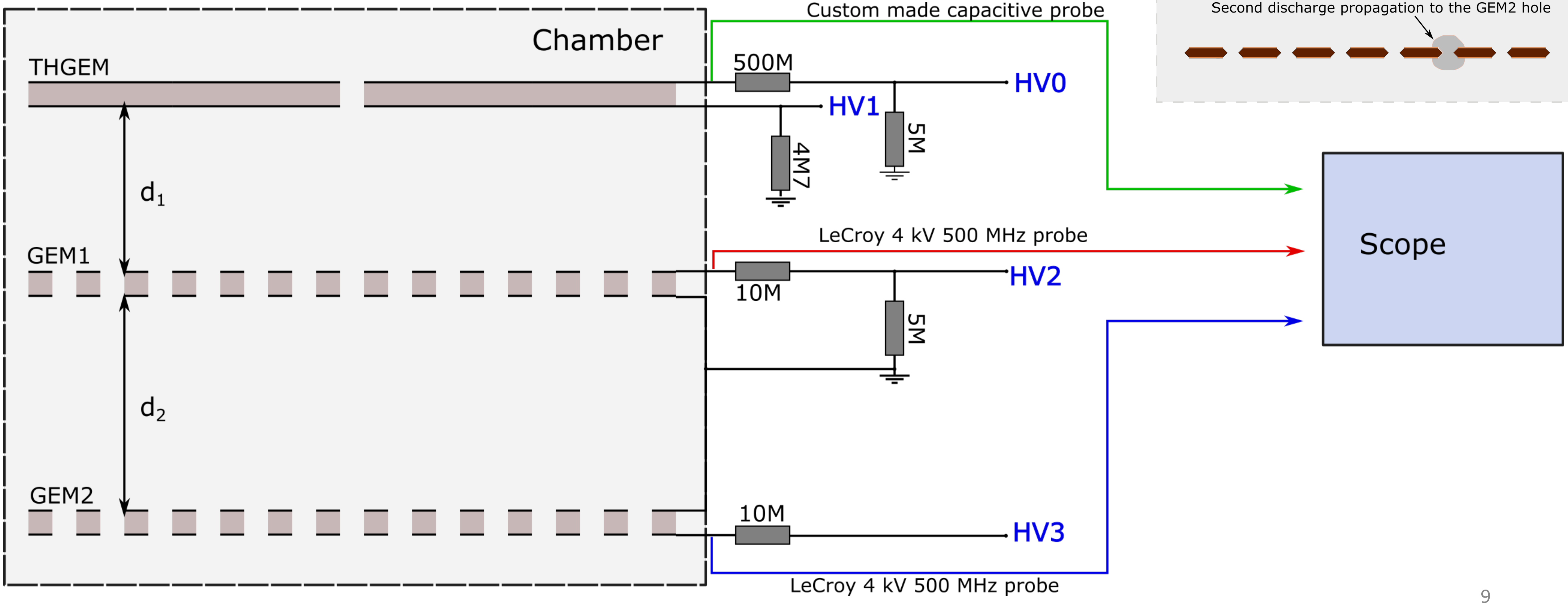
Observations

- There is a time delay between the primary discharge in THGEM and propagation discharge in GEM.
- Different time delayes (from 17ns up to the 70ns) have been observed.
- Optical measurement shows that this type of discharge propagation does not happen directly above the primary discharge.
- There is no clear dependency of initial transfer field on time delay and propagation probability.
- Is this same time delay observable in GEM-GEM measurements? If yes, how does it change with the increasing receiving GEM voltage?
- New configuration needed to be tested with fixed zero transfer fields between GEMs.

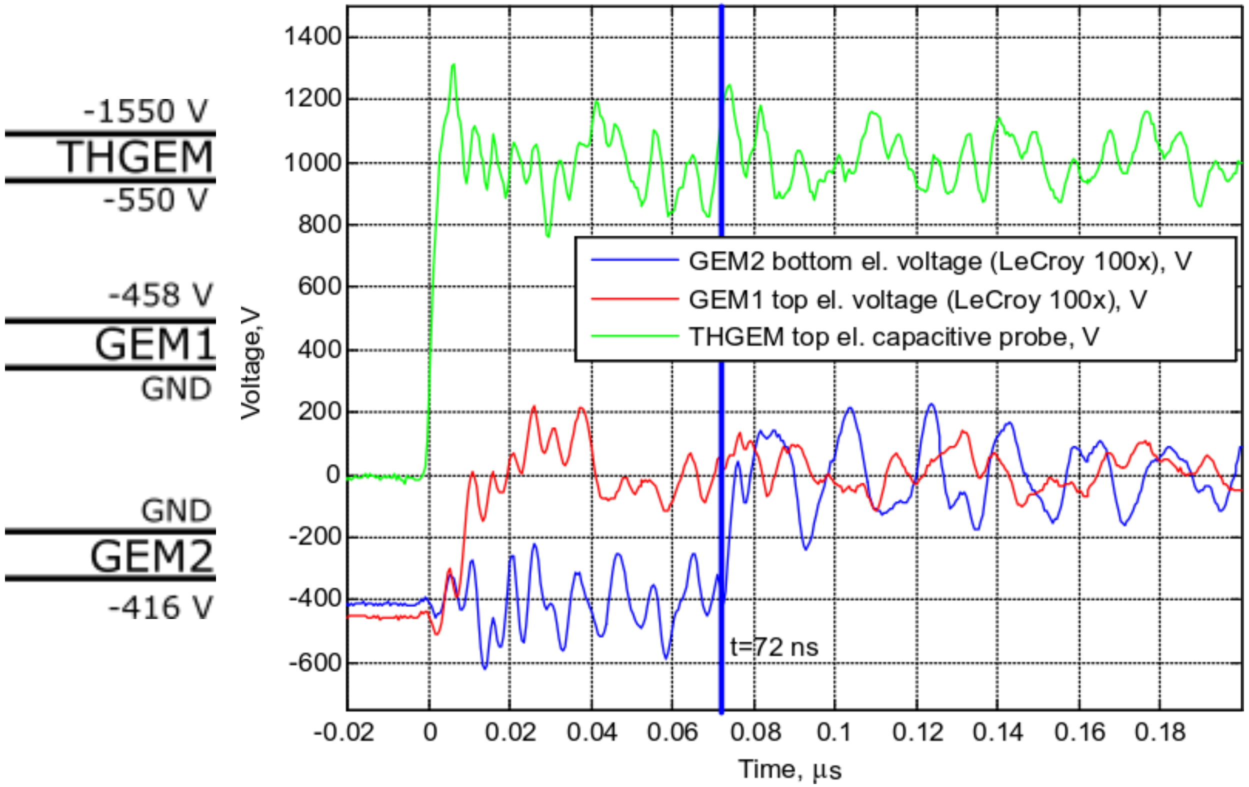
THGEM-GEM-GEM (downward)

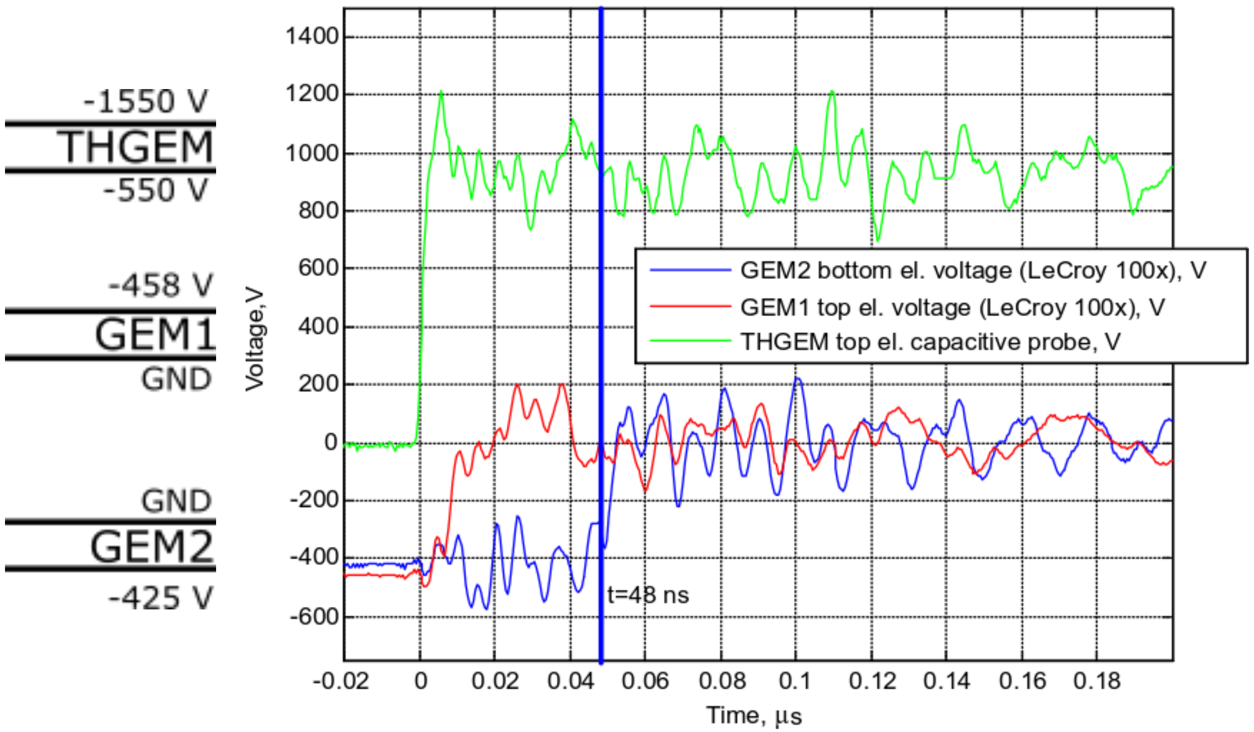


Power schamatics:

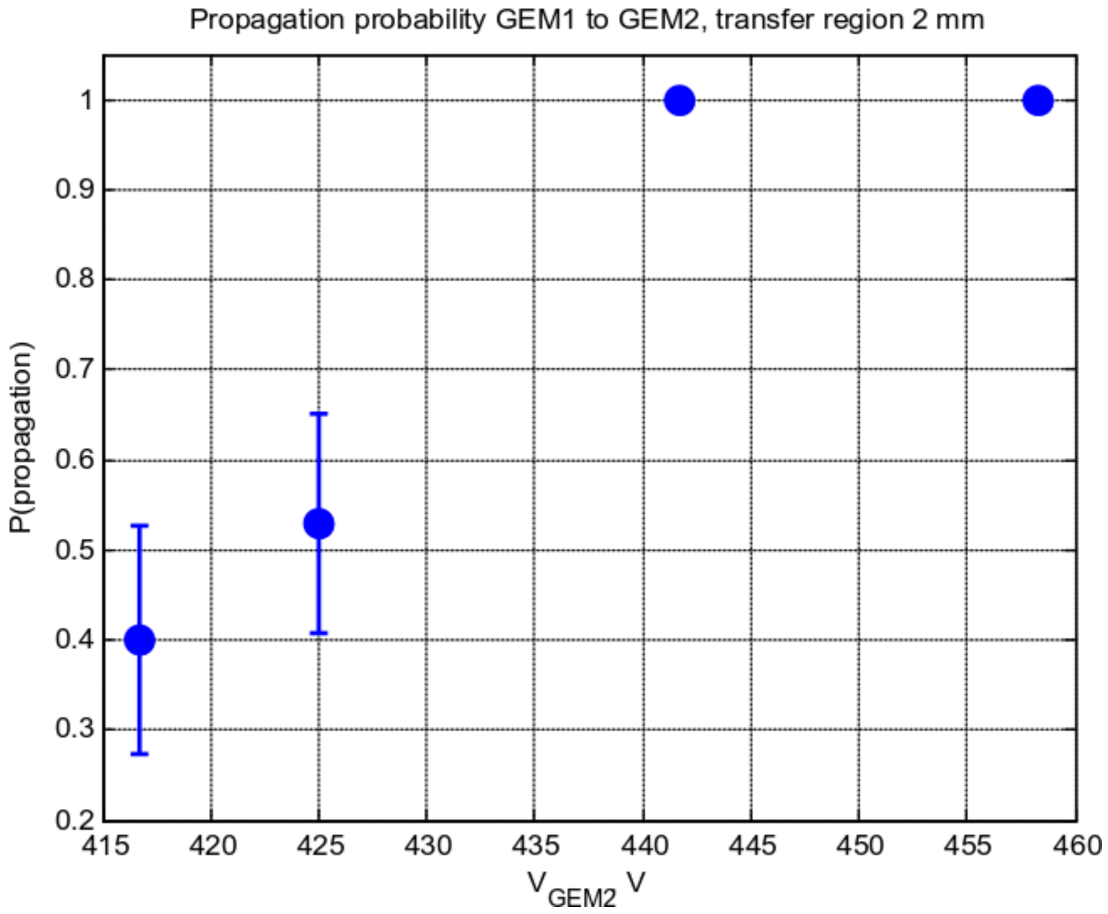


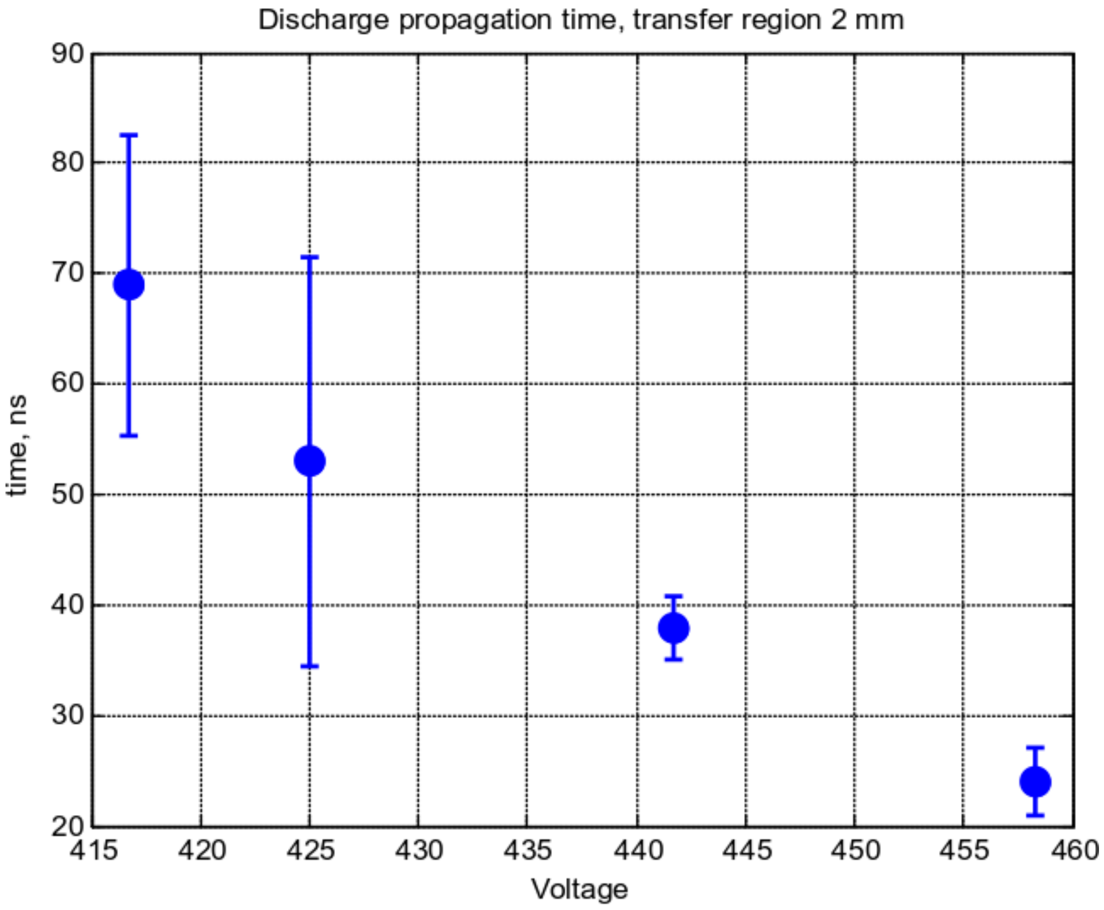
Measurements with zero transfer field between GEMs and **2 mm** gap lenght





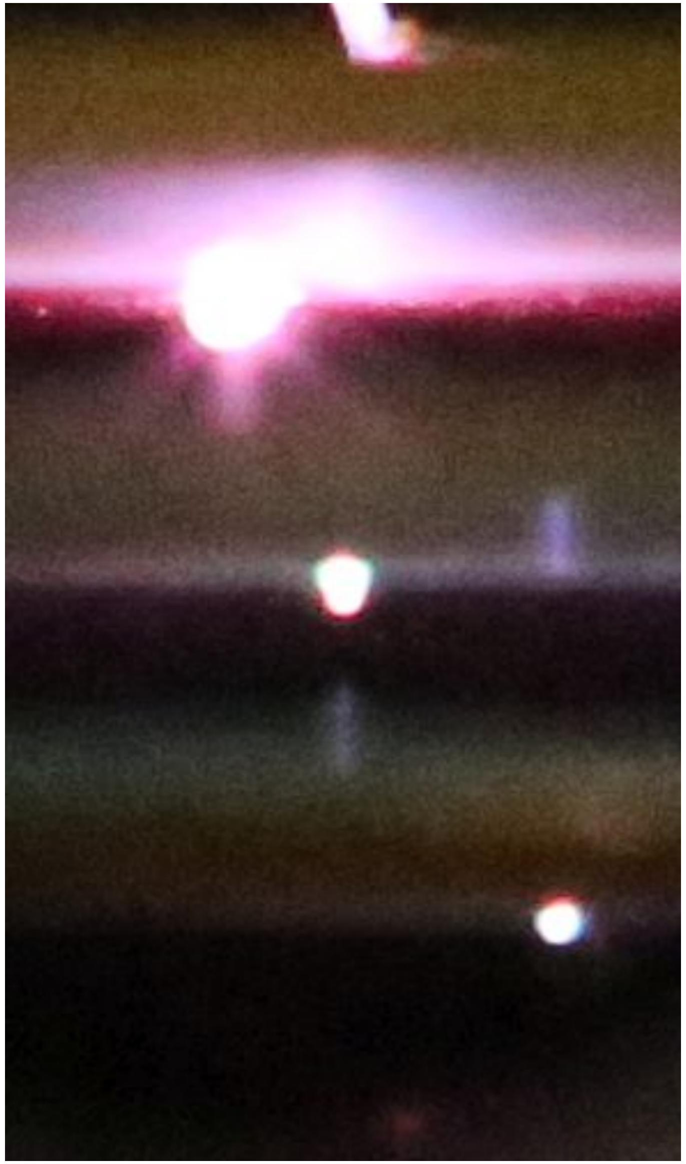
Propagation probability and delay times





Optical recordings

- A small circular borosilicate glass window was made to reduce the reflections from the plexiglass chamber walls
- Canon 6D + Canon EF 24-70 mm f/2.8
- The primary discharge in THGEM is followed by a displaced discharge in GEM1 that is again followed by a displaced discharge in GEM2
- The camera was focused on the primary discharge in the THGEM



Primary discharge in THGEM

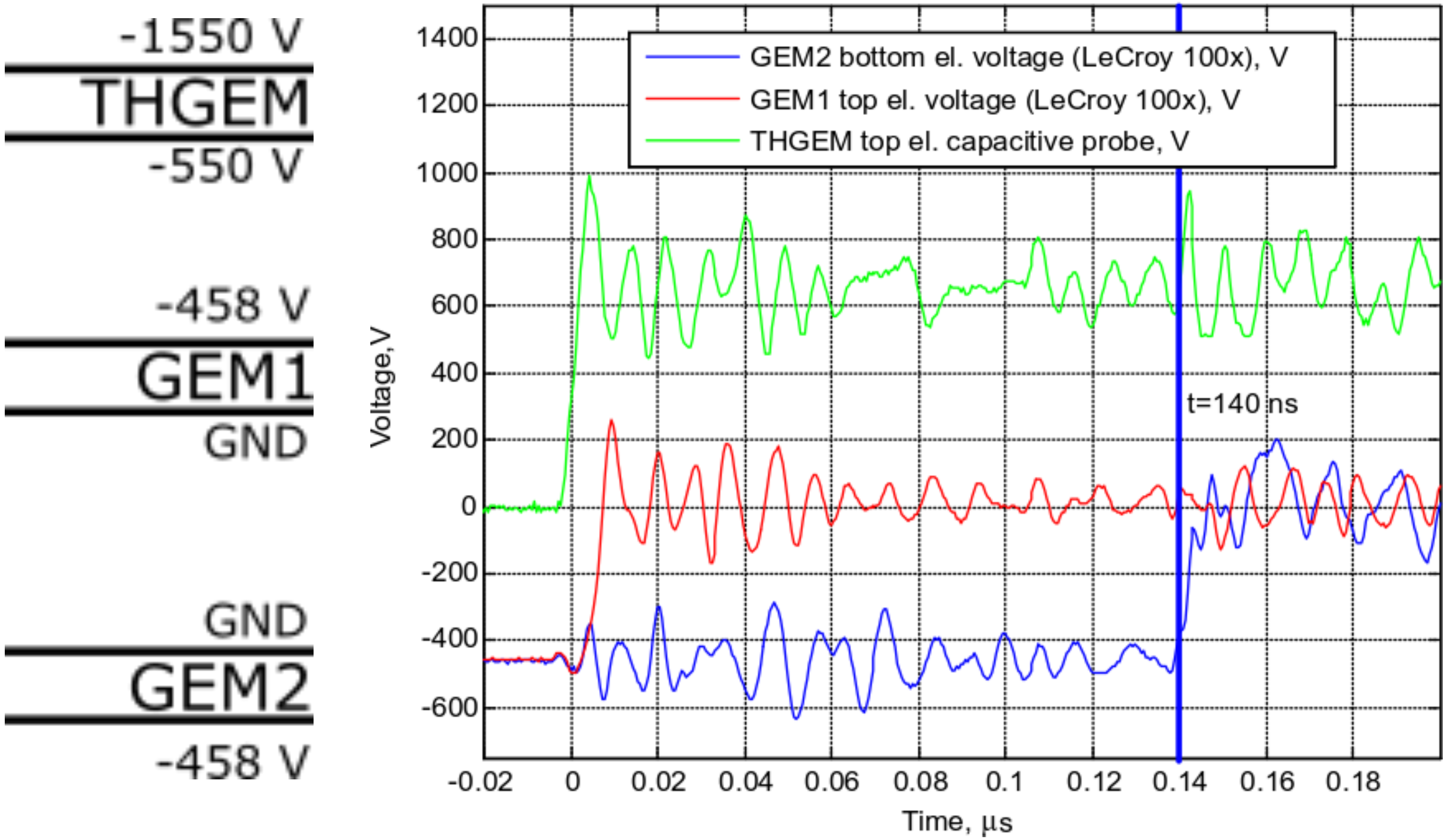
Discharge in GEM1

Discharge in GEM2

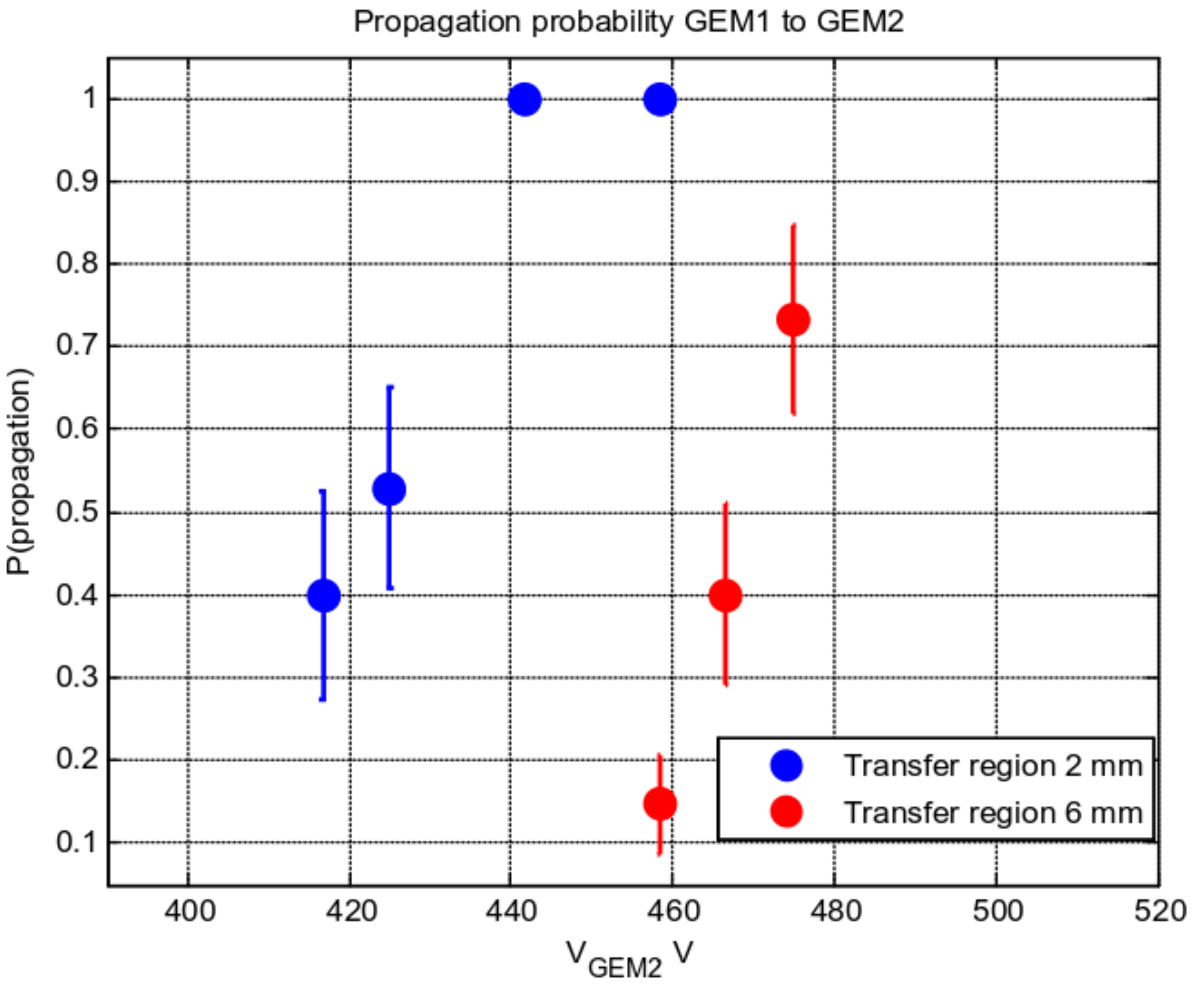
Observations

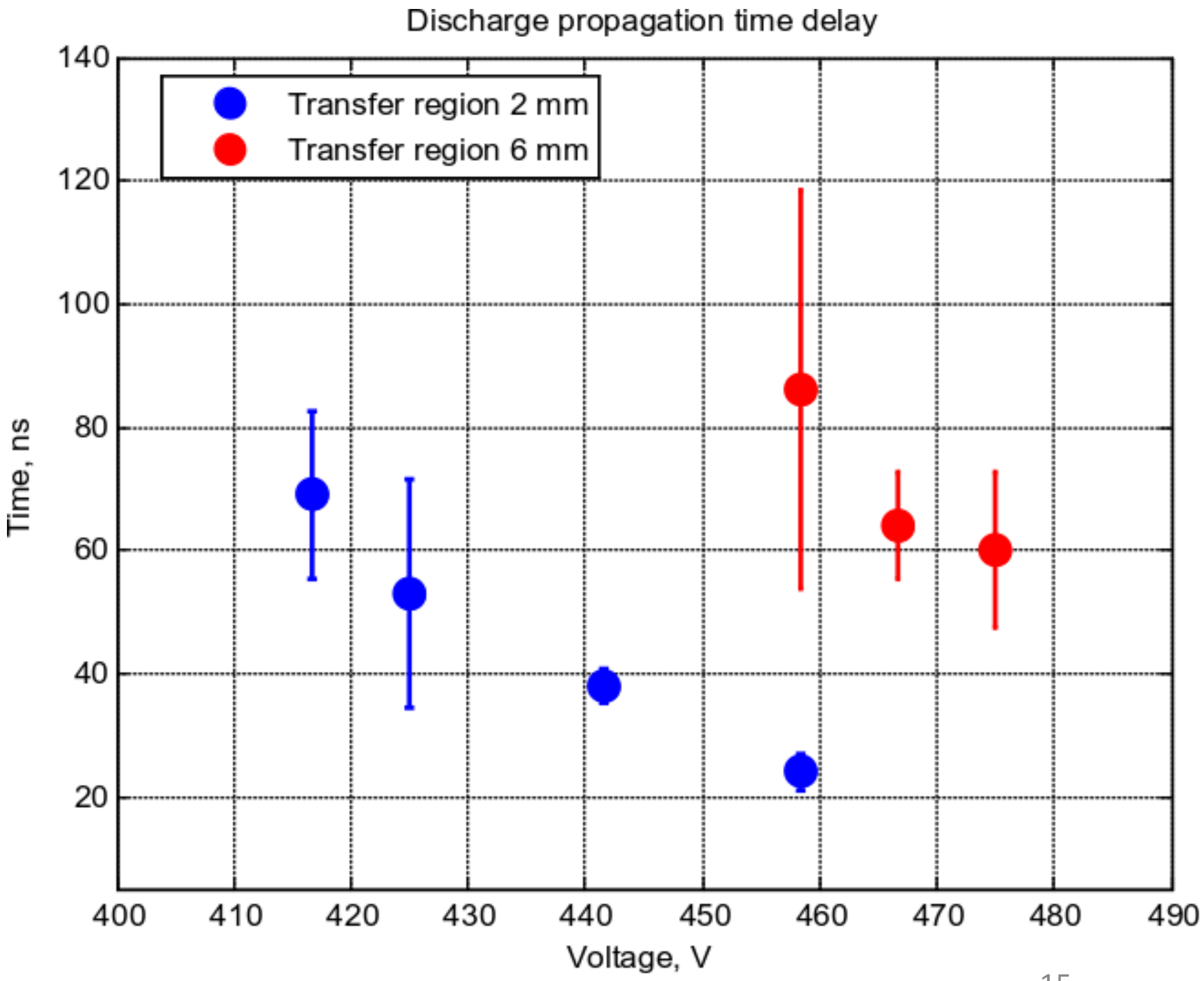
- The fixed zero transfer field toplogy shows that the discharge propagates from GEM1 to GEM2 with some time delay
- The discharge propagation probability increases with increasing GEM2 voltage
- The time delay between the discharges decreases with increasing voltage on the receiving GEM (GEM2).
- Optical measurements show a displacement in the discharge propagation position
- How does the increasing the distance between the GEMs infulence the discharge propagation probability and the time delay between the discharges?

Measurements with a zero transfer field between the GEMs and a **6 mm** gap lenght



Comparison of 2 and 6 mm transfer regions



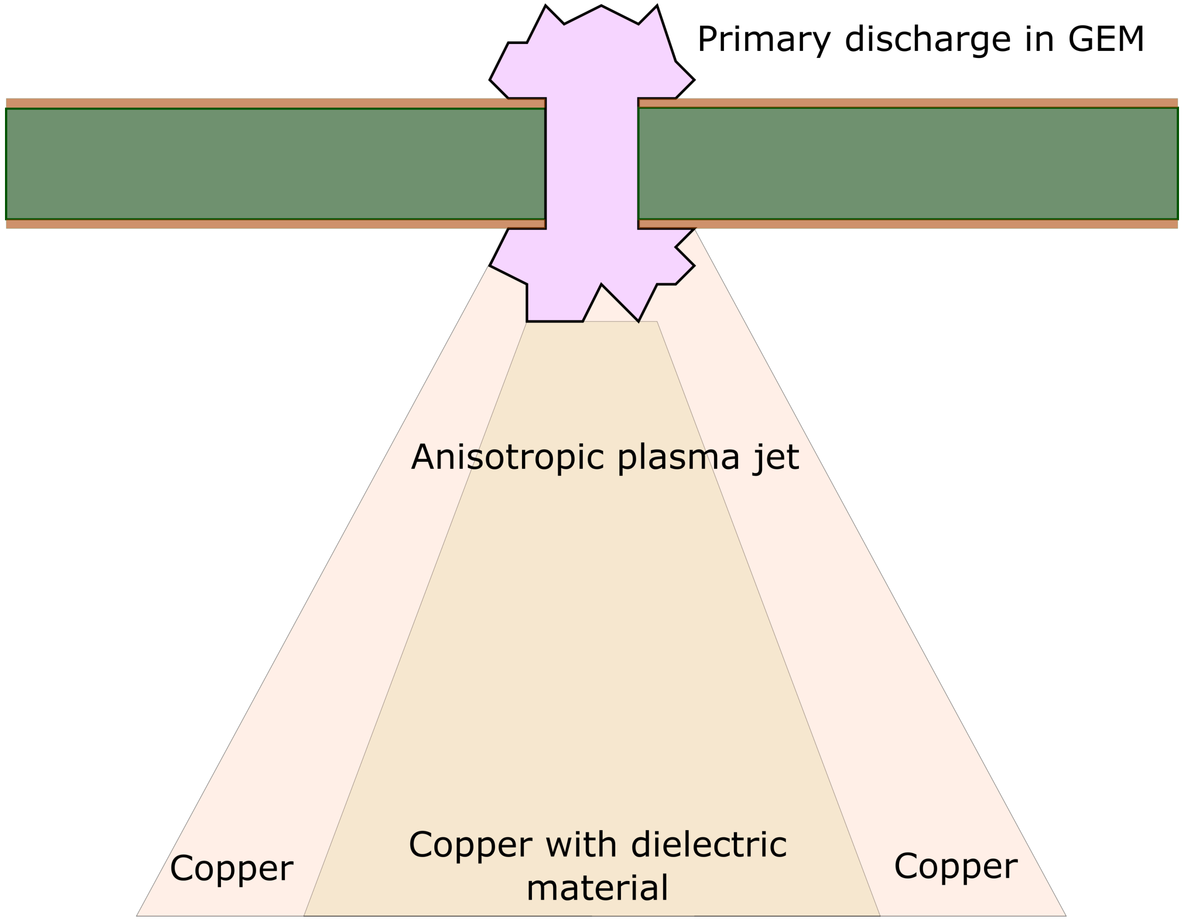


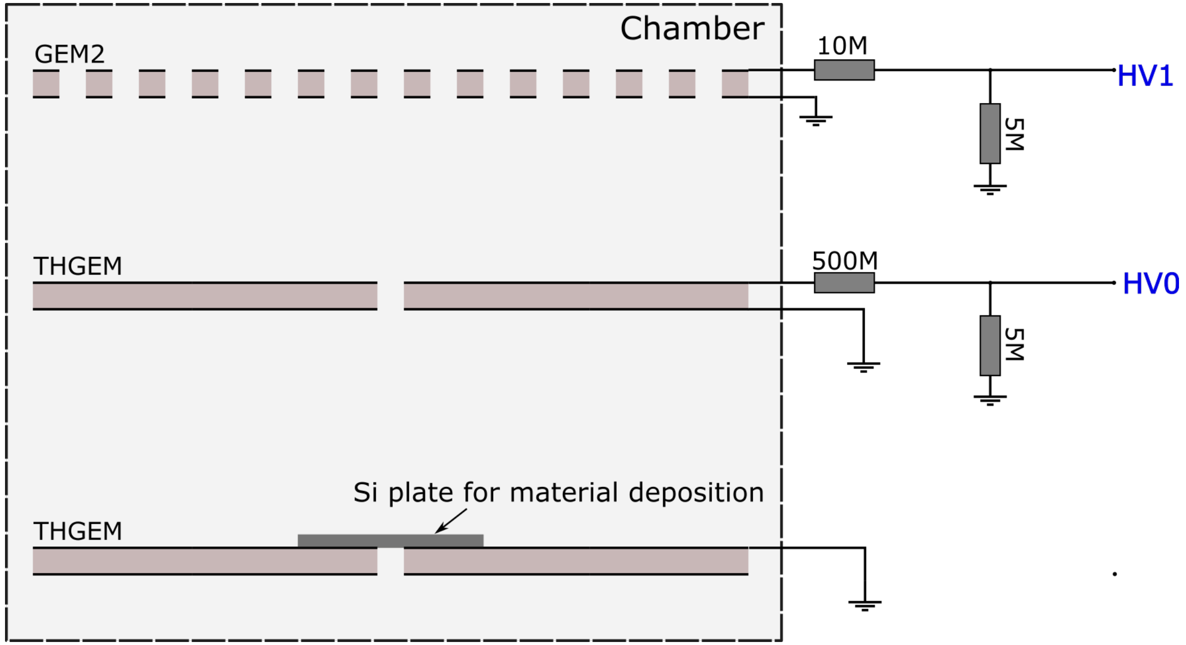
Observations

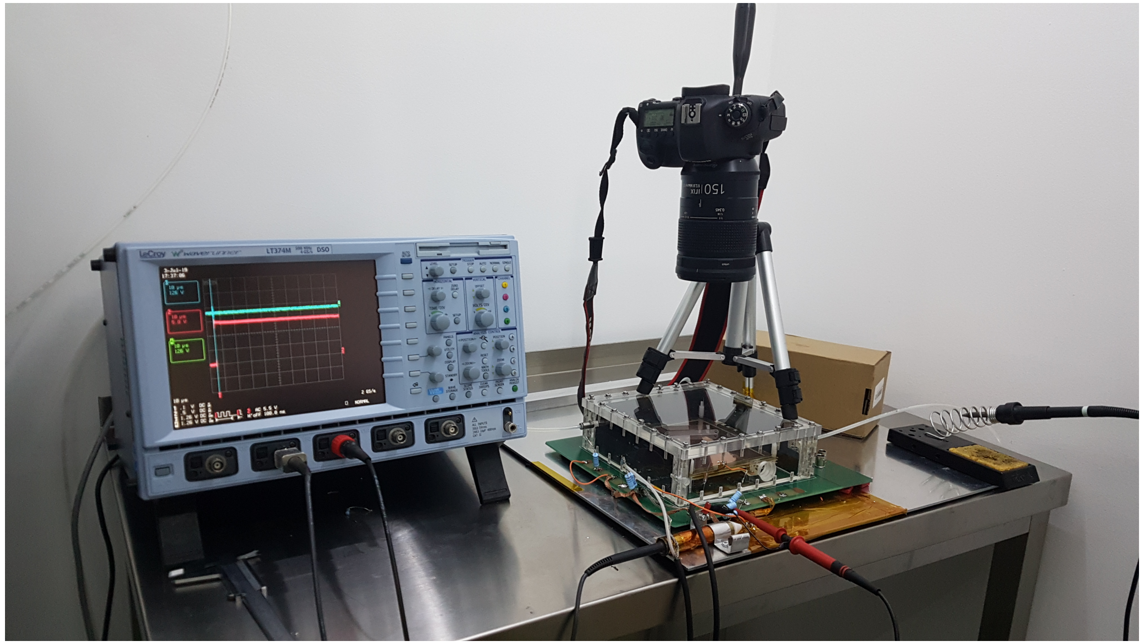
- The time delay in the discharge propagation was also observed for GEM1->GEM2 discharge propagation with a fixed zero transfer field
- The time delay increases with an increasing distance between the GEMs
- The discharge propagation probability increases with increasing GEM2 voltage
- The discharge propagation probability shifts to higher GEM2 voltage values with increasing distance between the GEMs.

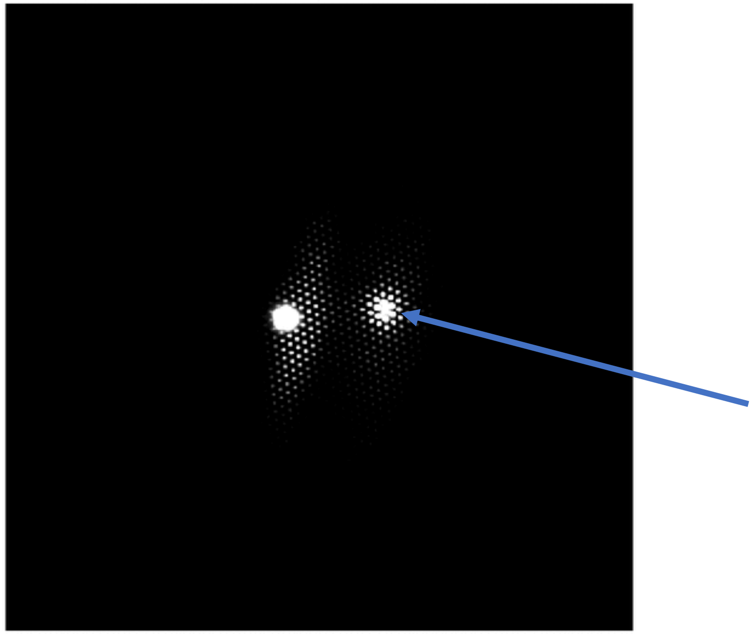
Hypothesis

- The plasma created during the primary discharge can cause the surrounding material to melt and detach from the (TH)GEM structure
- The material within the hole and surrounding the hole can be ejected above and below the hole during the primary discharge due to the high pressure inside the hole
- The jet of molten copper that was torn off the (TH)GEM hole rim forms a conical shape
- If the hot conductive material (copper) gets in close vicinity of the neighbouring GEM foil hole it can significantly alter the electrical field and cause a breakdown
- TEST: induce a large number of primary discharges in a single hole THGEM and see if there is any material deposition on the neighbouring structures
- Perform an SEM+EDS analysis of the material deposited below the THGEM foil hole

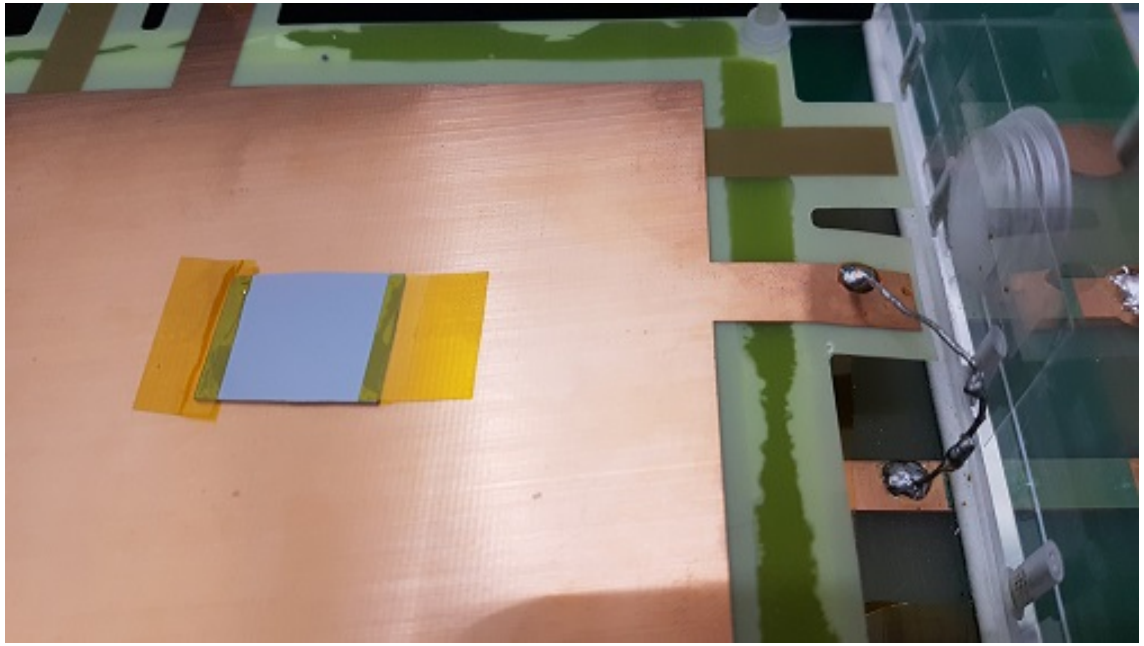




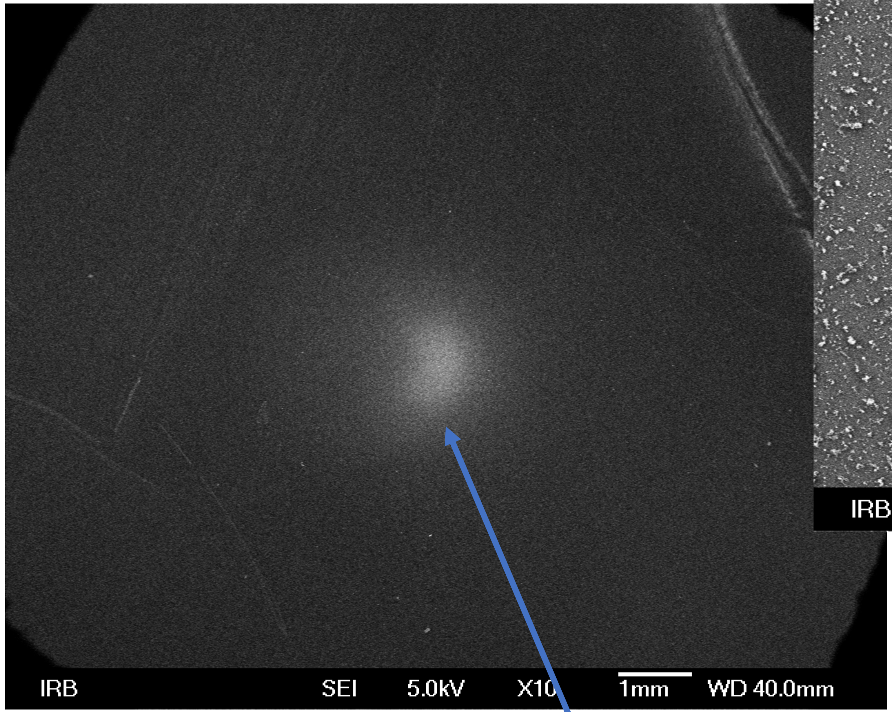


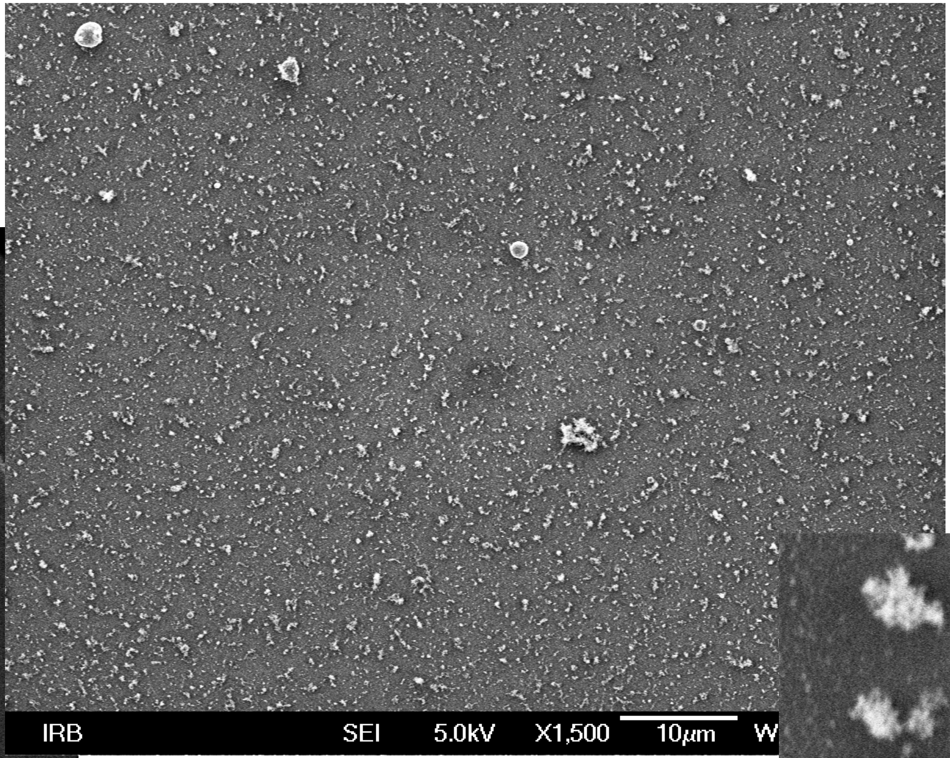


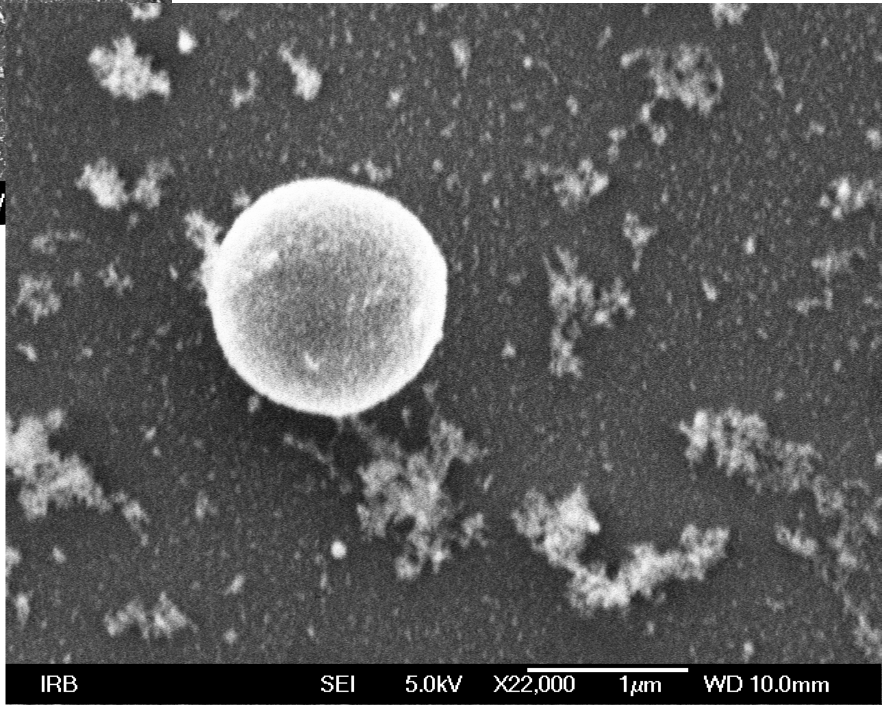
Primary discharge



SEM images

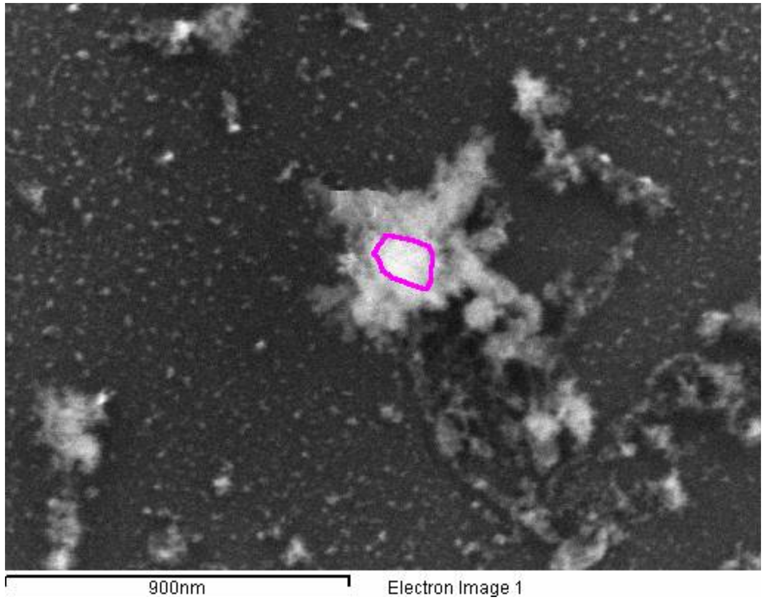




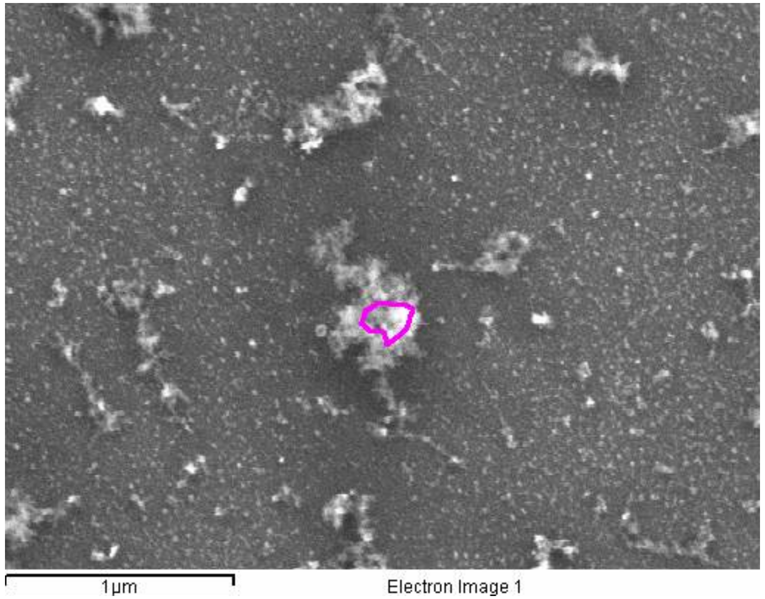


Primary location

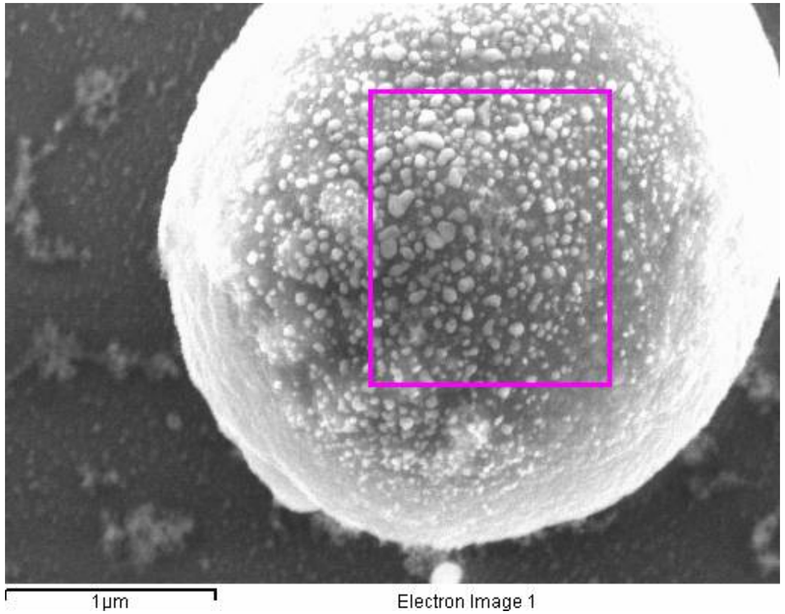
Chemical composition of the deposit



Element	Weight%	Atomic%
C K	2.96	6.51
O K	5.94	9.81
Si K	86.92	81.74
Ca K	1.18	0.78
Cu L	2.02	0.84
Br L	0.97	0.32
Totals	100.00	



Element	Weight%	Atomic%
C K	2.23	4.94
O K	4.68	7.81
Si K	90.40	85.91
Ca K	0.85	0.57
Cu L	1.84	0.77
Totals	100.00	



Element	Weight%	Atomic%
C K	1.34	6.69
O K	0.74	2.78
Si K	2.81	5.99
Cu L	69.63	65.49
Br L	25.47	19.05
Totals	100.00	

Conclusion

- GEM to GEM discharges were thoroughly studied using a setup with simultaneous optical and electrical recordings
- There is a time delay between the discharges in two GEMs that depends on the GEM distance and the receiving GEM voltage
- The optical recordings suggest that the discharges in the receiving GEM happen on the perimeter of the hole rather than in the center
- This strange location of the the discharge resulted in a new hypothesis for its occurence
- The primary discharge creates a large temperature in the hole, which melts the copper and the dielectric. Combined with a high pressure, the material is ejected in a jet. The outer part of the cone should contain most of the copper from the GEM hole rim.
- The initial SEM/EDS analysis shows promising results

BACKUP

Quartz glass measurements (no effect)