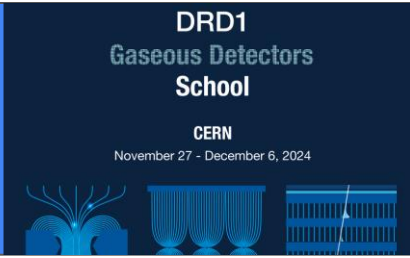

Characterization of THGEM Detector: A Member of the MPGD Family

DRD1 school 2024 - CERN

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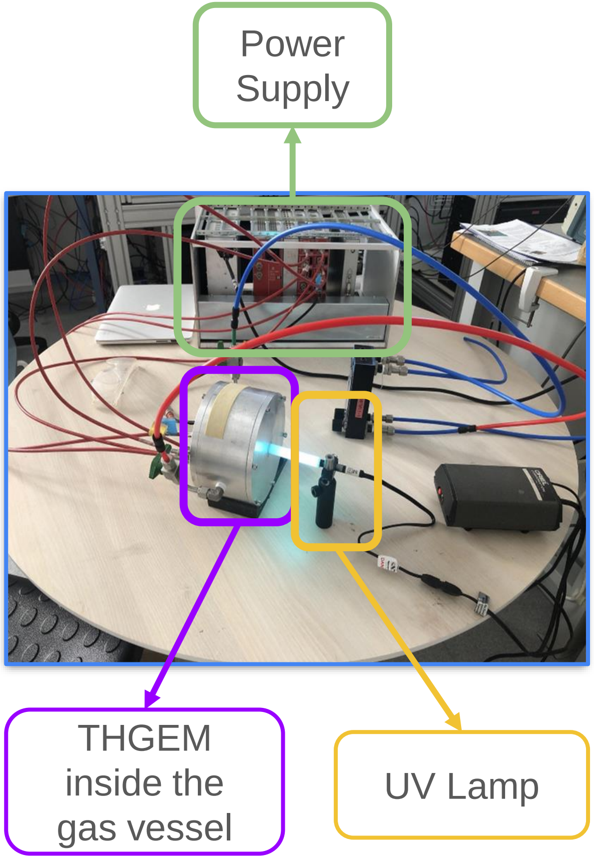
Outline

- Experimental setup
- Gain measurement and results
  - HV scan of the gem field with drift and induction field = 0
    - Gain Scan
  - scan of induction field with fixed gem field and drift field = 0
    - Best collection
  - scan of the drift field with fixed gem field and induction field = 0
    - Best Extraction
  - scan of the gem field with fixed drift (maximum extraction) and induction field (maximum collection at anode)
    - Optimal operation

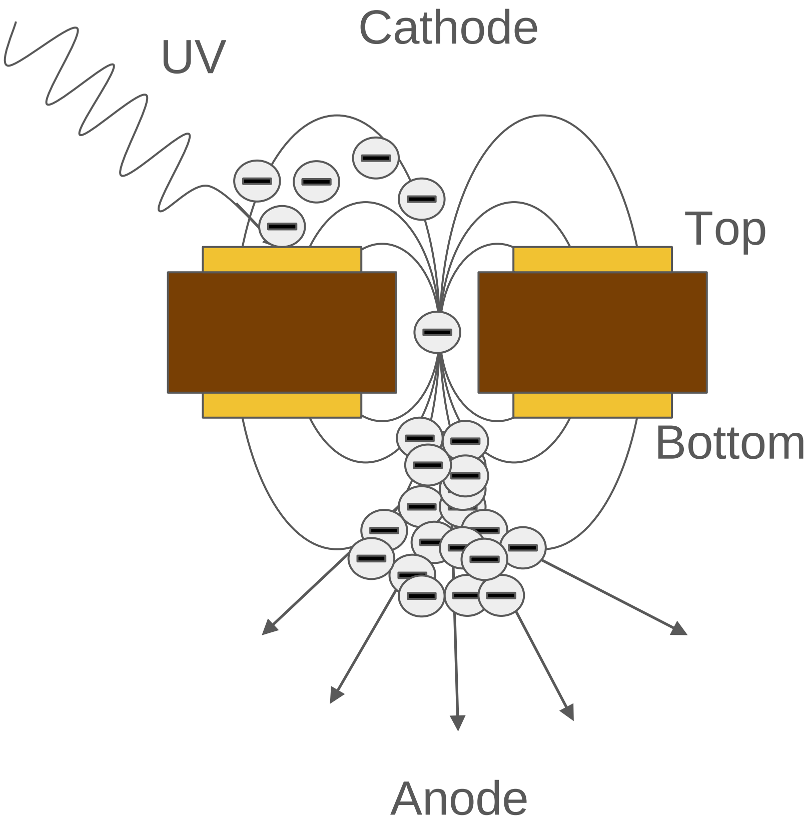
Experimental Setup

- Drift region ~ 5 mm
- Insulator ~ 0.8 mm
  a. 1 mm pitch hexagonal pattern of 0.5 mm diameter holes (obtained by drilling and etching)
- Induction region ~ 1 mm
- 10 x 10 cm2 Thick GEM
- Gas Mixture: Ar/CO2/iC4H10 (93:5:2%) flushing
- Sources: UV lamp (Hg) with lines in 200 to 600 nm range
- Keithely 6517A (1pA resolution)
- HV power supply : 4 ch. CAEN HV Module
- A computer for HV control and automated measurements (Labview interface)



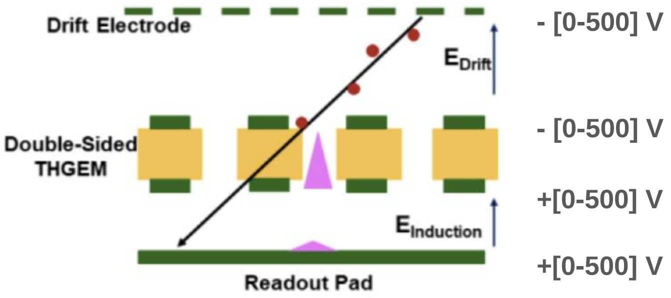
Experimental Setup - Photoelectric effect in GEM foils

- Photons from the UV lamp
  - λ ~ 200 to 600 nm
- Electrons extracted from the copper surface
  - work function ~ 4.5 to 5.1 eV
- The drift lines extracts the electrons and then the multiplication lines drags the electrons into the hole
- The electric currents generated in the cathode, top GEM, bottom GEM and anode are monitored to understand the phenomena



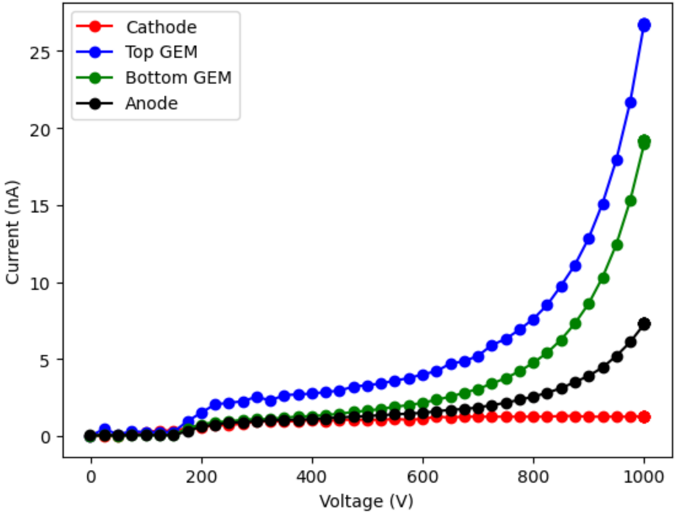
1) HV scan of the gem field

- ΔV(drift) = ΔV(induction) = 0V
- V(GEM) scanned from 0 to 1000V
  → ΔV GEM scanned from 0V to 1000V
  → opposite polarity tested



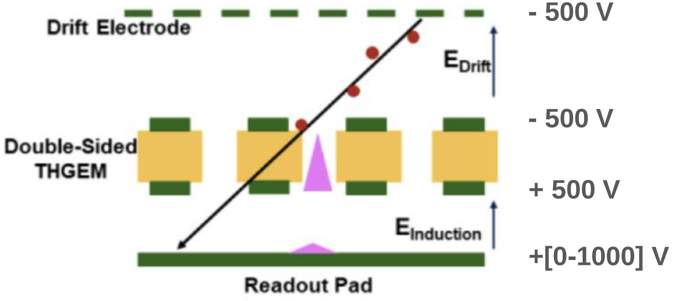
ΔV scan from 0 to 500 V → electric field ↓

- electrons from the avalanche are pushed towards the bottom electrode of the gem: all the electrons are collected at the bottom electrode of the gem
- most of the ions are collected at the top electrode of the gem
  - cathode and anode currents ~ 0



2) Scan of the induction field

- ΔV(drift) = 0V, ΔV(gem) = 1000V
- V(anode) scanned from 0 to 1000V
  → ΔV anode scanned from -500V to 500V
  → opposite polarity tested



1) ΔV scan from 0 to 500 V → electric field ↓
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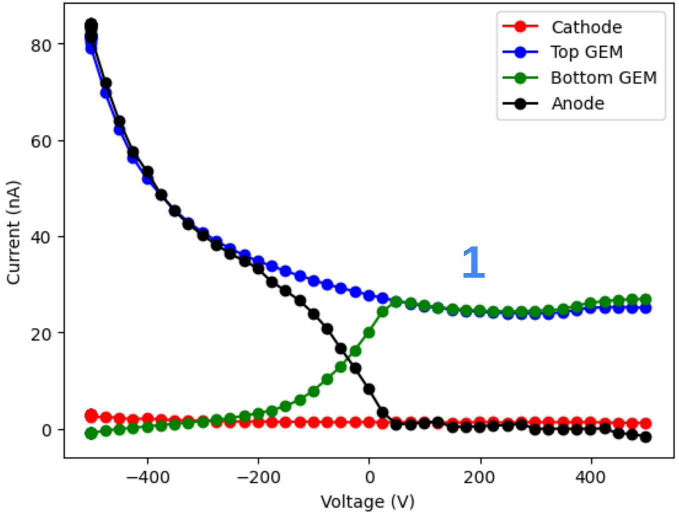
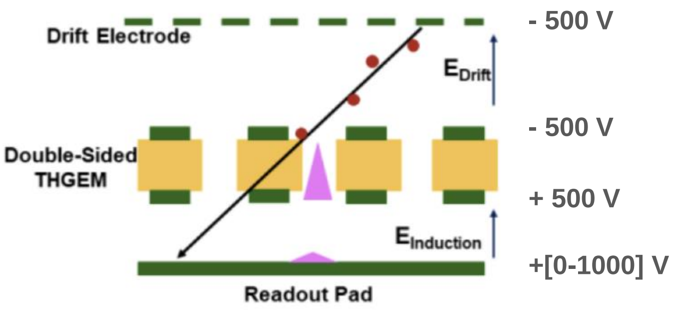
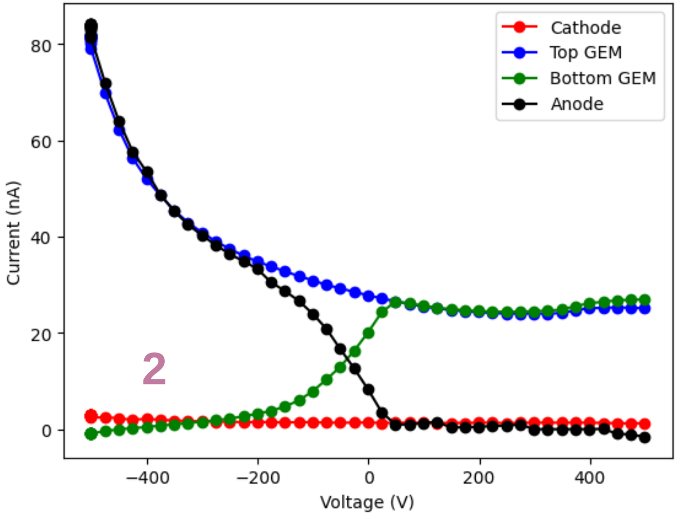


2) Scan of the induction field

- ΔV(drift) = 0V, ΔV(gem) = 1000V
- V(anode) scanned from 0 to 1000V
  → ΔV anode scanned from -500V to 500V
  → opposite polarity tested

2) ΔV scan from 0 to -500 V → electric field ↑ nominal direction of the electric field
   - as the electric field increases the electrons from the avalanche are directed towards the anode → the anode current increases and the gem bottom current decreases
     - from ~-200 V all the electrons are collected at the anode
     - from ~-350 V we start to observe the multiplication process in the induction gap

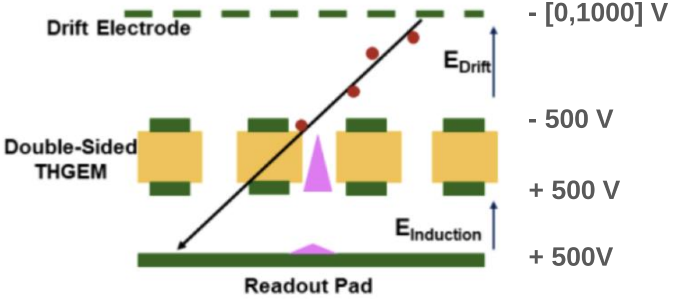


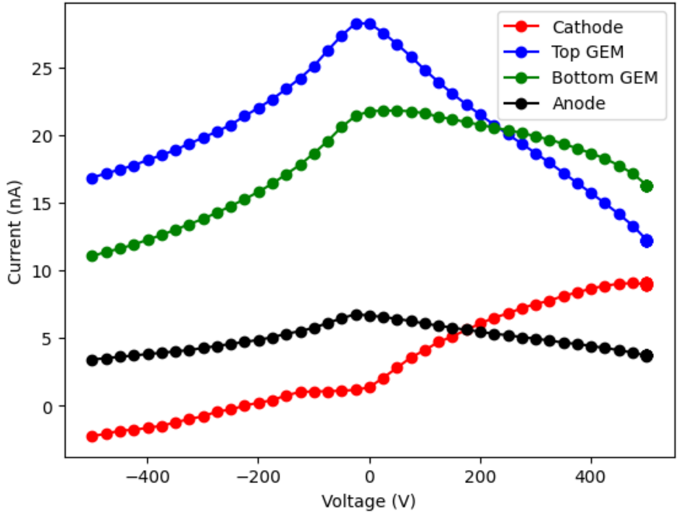


3) Scan of the drift field

- ΔV(induction) = 0V, ΔV(gem) = 1000V
- V(cathode) scanned from 0 to -1000V
  → ΔV cathode scanned from -500V to 500V
  → nominal and opposite polarity tested

1) ΔV scan from 0 to 500 V → electric field ↓
   - some of the electrons extracted from the top gem are drifted towards the cathode → the cathode current increases with ΔV
   - less electrons start an avalanche → less ions and secondary electrons produced
     → top and bottom gem currents and anode current decrease with ΔV

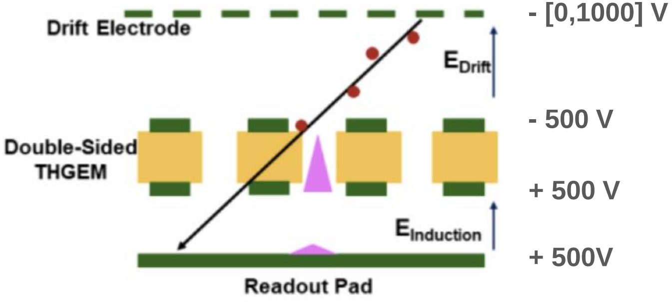


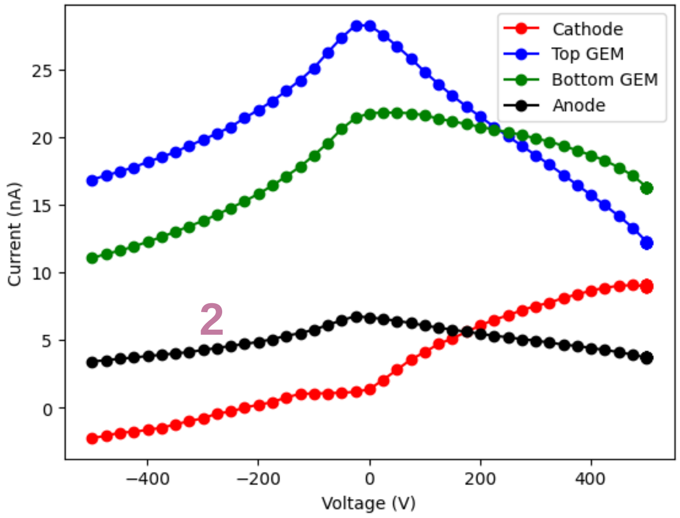


3) Scan of the drift field

- ΔV(induction) = 0V, ΔV(gem) = 1000V
- V(cathode) scanned from 0 to -1000V
  → ΔV cathode scanned from -500V to 500V
  → nominal and opposite polarity tested

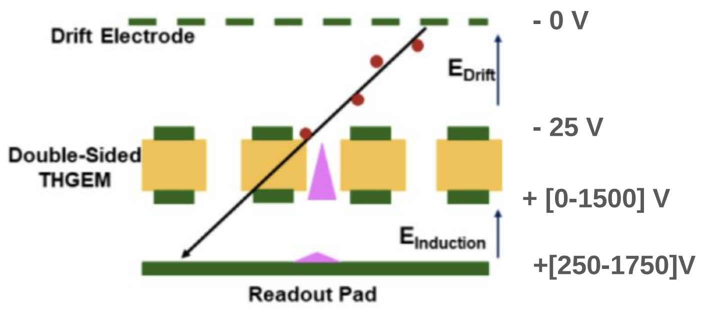
2) ΔV scan from 0 to - 500 V → electric field ↑
   - the electrons extracted are pushed towards the top gem electrode and some of the ions towards the cathode → small negative cathode current
   - the drift field reduces the number of electrons extracted from the top gem → less electrons start avalanches → top and bottom gem currents and anode current decrease with ΔV





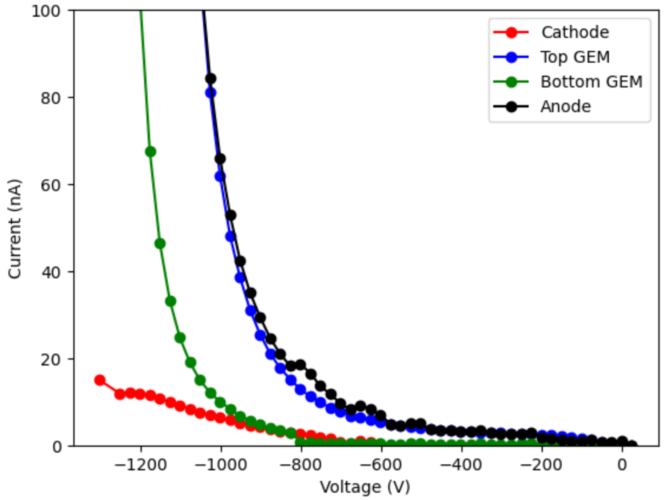
4) Gain in maximum extraction and induction

- ΔV(drift) = -25V
- ΔV(GEM) scanned from 0 to -1500V
- ΔV(Induction) scanned from
  → ΔV cathode scanned from -500V to 500V
  → nominal and opposite polarity tested



ΔV scan from 0 to +1500 V → gain ↑ (around 10^2)

- the electrons extracted are dragged by the electric field inside the hole where multiplication takes place
- the current in the top gem and the anode are very similar and much higher than the current in the bottom and the cathode
- Could not reach a maximum gain due to overcurrent



Conclusion

- Multiplication:
  - Almost no multiplication in ΔV below - 600V
  - Exponential growth in the gain in ΔV above - 600V
- Inverted Polarity:
  - Reversed induction field: higher current measured in the bottom
  - Matching induction field: higher current measured in the anode
  - top GEM measured the same current as the bottom/anode
- Voltage setup:
  - application of a GEM-based detector for photoelectric effect
  - optimal operation: best extraction and best collection of the electrons
  - Could reach higher gains