A simulation study for designed triple GEM detector at IOP

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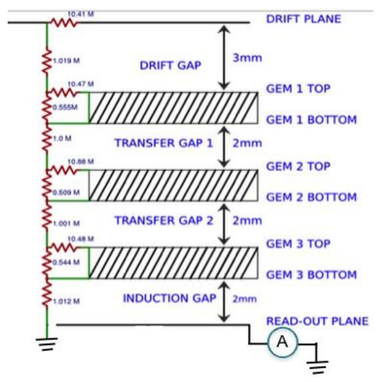
Introduction

The GEM is one of the Micro Pattern Gas Detector (MPGD) proposed to be used as a readout for ALICE TPC upgrade in LHC experiment, at CERN [1]. The existing Multiple Wire Proportional Chamber (MWPC) will be replaced by GEM based readout which provides intrinsic ion blocking capability without any gating grid system [2]. At IOP detector laboratory, we have build a 10 cm × 10 cm standard triple GEM based detector prototype and tested it with Ar/CO_2 70/30 gas mixture.

In order to study the properties of the detector, a full and detailed simulation have been performed with Garfield++ simulation package [3]. ANSYS is used to create the geometry of the detector and the meshing needed for the field calculations [4].



Simulation Tools

Building field map

↓

ANSYS

↓

ELIST.lis, NLIST.lis, MPLIST.lis, PRNSOL.lis
(loading the mesh, list of nodal solution, material properties)

↓

Garfield++
(particle tracking)

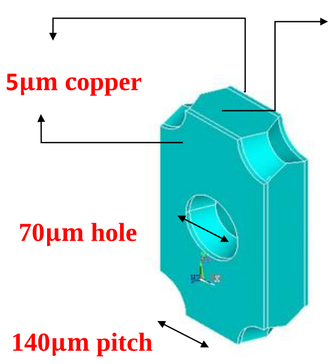
Magboltz (transport of electron in gas mixture) ↔ **Garfield++** ↔ **Heed** (interaction of particles with gases)

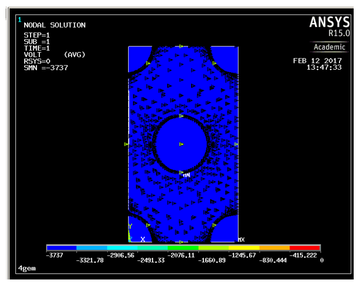
↓

Maxwell
(electric field and magnetic field map)

Building field map

- Triple GEM set up
- Drift : Transfer : Induction = 3 mm: 2 mm: 2 mm
- Hexagonal geometry
- Pitch 140µm (SP)
- Ar/CO_2 : 70/30
- Penning ratio r_p : 0.57
- Voltage range 3000 kV- 4600 kV





Field mapping with ANSYS

Numerical calculations and analysis

$$\epsilon_{coll} = \frac{N_{GEM'}}{N_{Drift}}, \quad \epsilon_{ext} = \frac{N_{anode}}{N_{GEM}}$$

$$\text{Transparency} = \epsilon_{coll} \times \epsilon_{ext}$$

$N_{GEM'}$ = No. of electrons getting inside the GEM hole
N_{Drift} = No. of electrons created above the GEM hole
N_{GEM} = No. of electrons created inside the GEM hole
N_{anode} = No. of electrons reaching anode plane

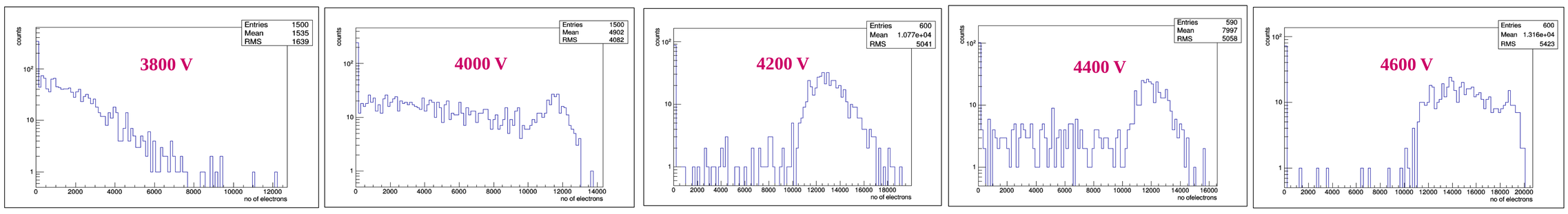
For triple gem setup

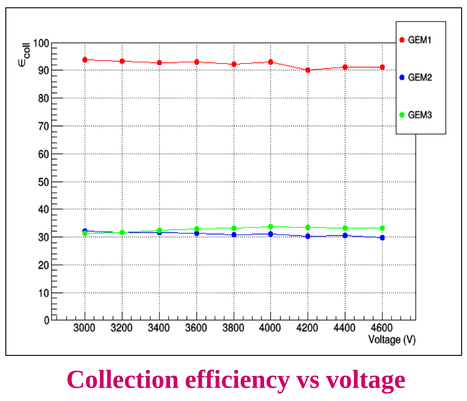
$$\text{Transparency} = \underbrace{\epsilon_{coll1} \times \epsilon_{ext1}}_{\text{GEM1}} \times \underbrace{\epsilon_{coll2} \times \epsilon_{ext2}}_{\text{GEM2}} \times \underbrace{\epsilon_{coll3} \times \epsilon_{ext3}}_{\text{GEM3}}$$

$$G_{eff} = G_{int} \times \text{Transparency}$$

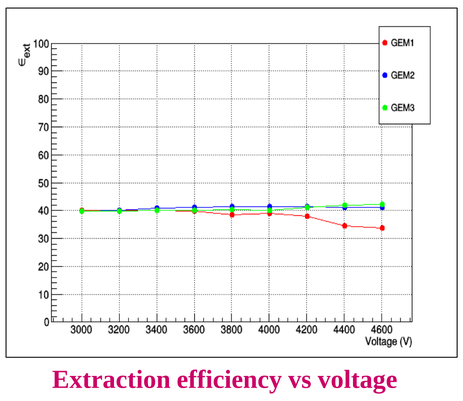
G_{int} = Intrinsic gain (mean no of e produced)
G_{eff} = Effective gain

Results

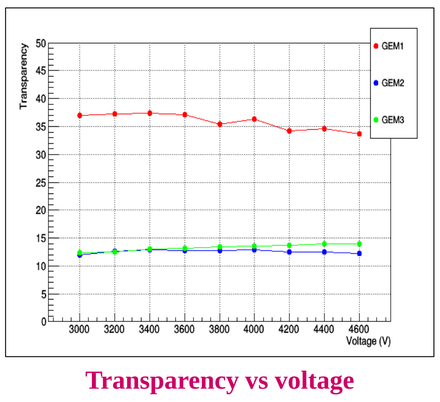




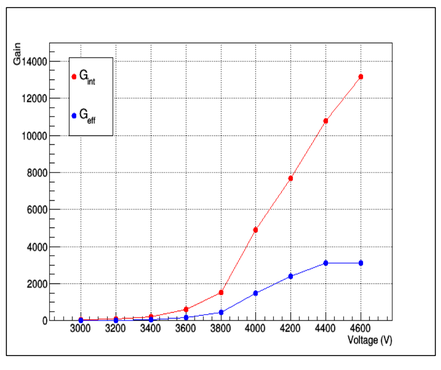
Collection efficiency vs voltage

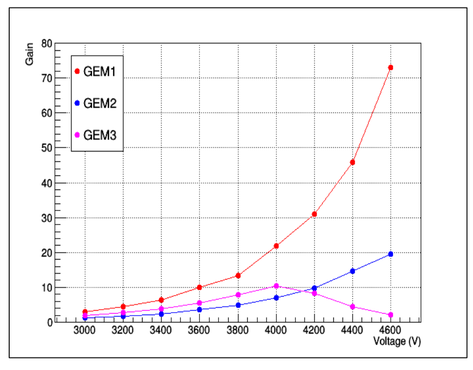


Extraction efficiency vs voltage



Transparency vs voltage





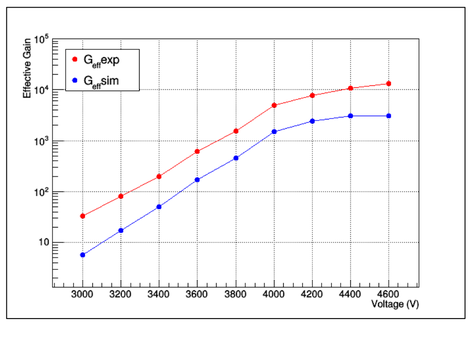
Gain vs voltage

Comparison with Experiment

- The gain was experimentally measured for this triple GEM detector setup with 5.9 keV Fe55 X-ray source
- But here we are getting a lower gain in simulation

Possible reasons!!!

- Penning transfer ratio is not optimized yet
- Initial position of electron is set at (0,0,0)
- Electron is used instead of X ray photons



Conclusion and Outlook

- Generous study have been performed for the triple GEM detector with Garfiled ++ for the existing setup at IOP.
- Efficiency and gain are calculated for different voltage setups.
- Full simulation for triple GEM detector with varying penning transfer ratios and with X-ray photon using Heed will need to be done for further analysis.

References

[1] F. Sauli, et al., Nuclear Instruments and Methods 805 (2016) 224
[2] G. Charpak, et al., Nuclear Instruments and Methods 62 (1968) 262
[3] https://gareldpp.web.cern.ch/gareldpp/
[4] http://www.ansys.com/