Study of gain variation as a function of physical parameters of GEM foil

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ALICE Time Projection Chamber (TPC) Upgrade

Limitation :

- ALICE TPC uses the Gating Grid to prevent the ions, resulting from avalanche at the detecting elements, from entering into the drift volume.
- This limits the operation of TPC to 3.5 kHz, whereas Pb-Pb event rate after LS2 is expected to be 50 kHz.

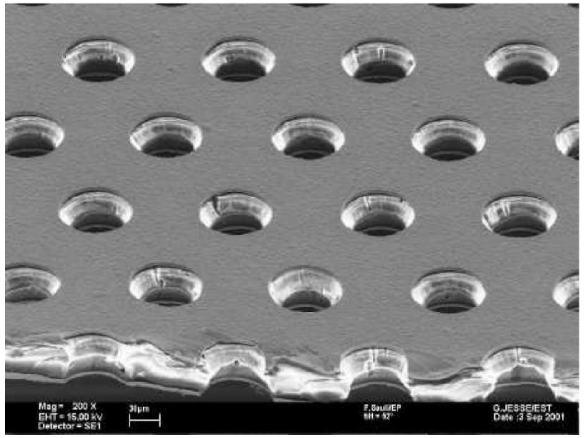
Solution :

- ✓ MWPC detecting elements will be replaced by those built with Gas Electron Multiplier (GEM) technology.
- ✓ All hits will be recorded continuously using trigger-less DAQ.

Implication :

- ✧ Pile up of ~ 5 events on an average

Gas Electron Multiplier (GEM)



A SEM image of GEM foil

- 50 μm thick polyimide foil, sandwiched between two 5 μm thick copper layers on both sides.
- Holes with ~ 70 μm diameter are made by etching. Pitch between two holes ~ 140 μm.
- When voltage is applied to the copper layers, very high electric field is generated inside the hole.
- Once this system is placed inside gas, electron multiplication occurs if field inside the hole reaches ~ 10 kV/cm (typical for most of the detector gases).

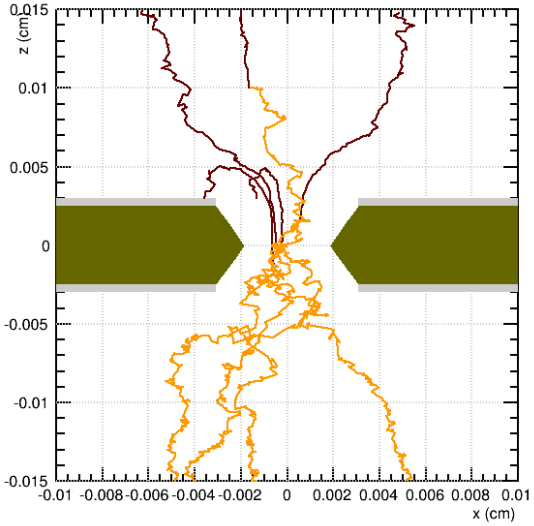
Field distribution in and around the hole strongly depends on the shape *i.e.* diameter of the hole. Consequently gain varies as a function of physical parameters *e.g*. hole diameter.

Garfield ++

- ROOT based simulation toolkit for gas filled detectors such as drift chambers, Time Projection Chambers (TPC), multiwire proportional chambers (MWPC) and Micropattern Gas Detectors (MPGD) such as GEM.
- Interfaced with finite element packages such as Ansys, Elmer, Maxwell *etc*.
- Heed is used to simulate the ionisation of gas molecules by particles traversing the gas volume.
- Electron transport properties and avalanche are calculated using Magboltz.

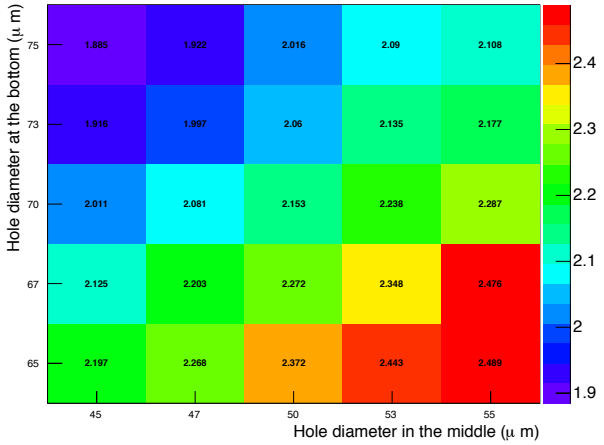
Parameters

- E_d = 400 V/cm
  E_i = 1 kV/cm
  ΔV_{GEM} = 267 V
- Gas mixture : Ar+CO_2 (70:30)
- Hole diameters varied around typical values of 70-50-70 μm (top/middle/bottom for double mask) and 70-60 μm (top/bottom for single mask)
- 100,000 avalanches simulated for each setting



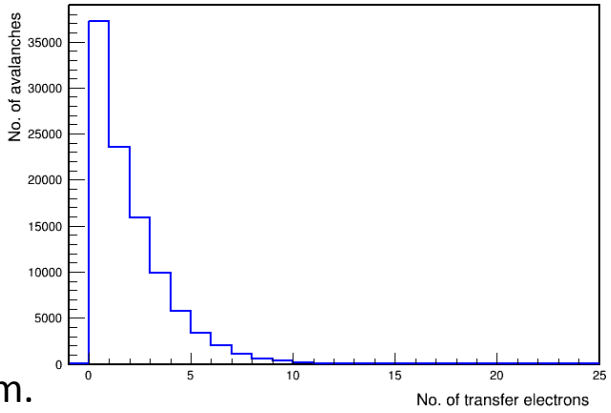
Avalanche through double mask GEM

Results

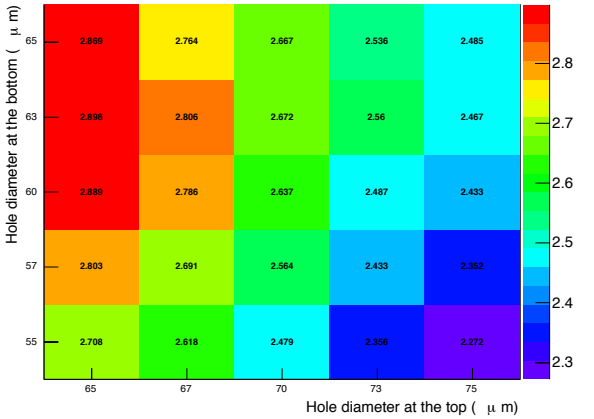


Gain map for double mask GEM (Top hole diameter = 70 μm)

- ✓ Gain is calculated as the mean of transfer electrons
- ✓ This has been plotted as a function of diameters of the holes at the top/middle/bottom.



Distribution of transfer electrons



Gain map for single mask GEM

Summary and outlook

- ✓ Garfield++ simulation toolkit has been used to study of variation in gain of GEM as a function of hole diameter.
- ✓ A correlation of gain with hole diameter is revealed from the results.
- ✓ These results need to be compared with those from measurements.
- ✓ This will help in the QA of the GEM foils where a large number of those are required to be used to fabricate large detector systems such as ALICE TPC.
- ✓ The variation in gain as a function of other parameters will also be studied as a continuation of this work.

References

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