Charge sharing in Gas Electron Multipliers

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Introduction

Gas Electron Multiplier (GEM)[1] is one of the Micro Pattern Gaseous Detectors (MPGDs) which is characterized by reasonably good position resolution and high rate capability. These are high granularity gas detectors with very small gap between cathode and anode electrodes. High granularity of these detectors offers good position resolution and small gap between the electrodes offers high rate capability, thus they are being widely used for tracking and timing purposes in various high energy physics experiments. GEM detectors have a very thin dielectric foil coated with copper on both sides, placed in between cathode and anode. This foil has numerous holes, across which very high voltage is applied to make them a multiplication region for electrons. Thus GEM has a separate drift gap, multiplication gap and an induction gap. This motivates us to explore the dependence of various figures of merits such as pad multiplicity, spatial resolution, timing resolution on different electromagnetic and geometric configurations.

Simulation tool

We have used Garfield and Garfield++, as simulation tools for the detailed simulation of gaseous detectors where we have used methods like Runge-Kutta-Fehlberg method and Monte Carlo method for simulating the charge transport. The 3D electrostatic field calculation has been done by using a model neBEM (nearly exact Boundary Element Method). Apart from these, HEED and MAGBOLTZ[2] have been used for simulating primary ionization and transport properties respectively.

Results

We have used two geometric models, one with cylindrical and non-staggered holes and another with bi-conical and staggered holes. We simulated the electron and ion drift lines in both the geometric models for various combination of drift and induction fields. The field across GEM foil is kept unchanged at 100KV/cm.

TABLE I: First electromagnetic configuration for staggered and biconical GEM

Drift field (KV/cm)	Induction field (KV/cm)
1	4.5

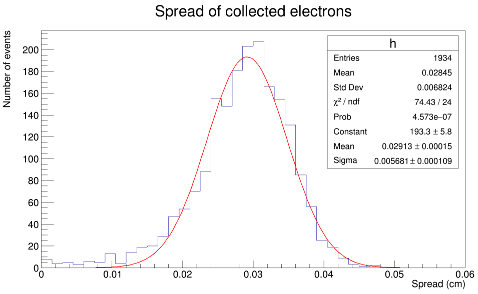

FIG. 1: Spread for a single electron

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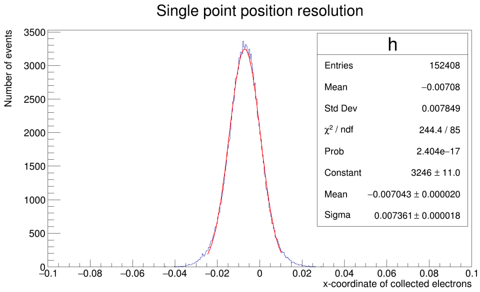

FIG. 2: Single electron position resolution

TABLE II: Second electromagnetic configuration for non-staggered and cylindrical GEM

Drift field (KV/cm)	Induction field (KV/cm)
0.33	2.0

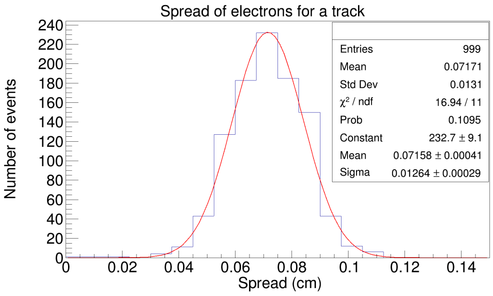

FIG. 3: Spread of electrons for muon tracks

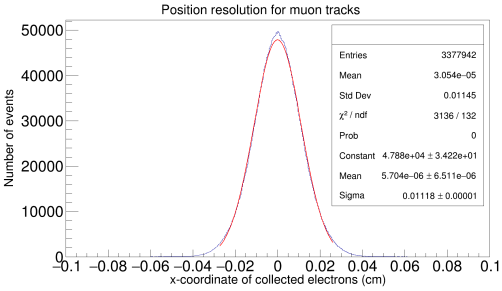

FIG. 4: Position resolution for muon tracks

Discussion

From the above figures, it is clear that mean spread of collected electrons (Fig:1) for a single starting electron is approximately 291.3 ± 56.81 μm which is around 2 strips(each strip is 200 μm and pitch is 200μm) whereas for a track (Fig:3),we see, mean spread of collected electrons is around $715 \pm 12.64 \mu m$ i.e. on an average 2 or 3 strips are getting fired each time a muon track passes. Also single point position resolution(Fig:2);measured in terms of Sigma, is approximately 73.61μm which is quite good for our experimental point of view. Finally, the position resolution for a muon track(Fig:4) is found to be 111μm, not as good as that for a single electron which can attributed to the different position of primary electrons created along a track.

References

[1] F. Sauli, Nucl. Instr. Meth. A 386 (1997) 531.
[2] S.F. Biagi, Nucl. Instr. Meth. A 421 (1999) 234.