CHARGE SHARING IN SINGLE AND DOUBLE GEMS

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Motivation

- Radiation hardness, ageing resistance and stability against discharges are the main criteria for the long-term operation of detectors in high rate experiments.
- A discharge may create a permanent short between two sides of the GEM foil, and several such shorts may even render the whole of GEM stack non-operational.
- It has been proposed that charge density inside the amplification region could be one of the limiting factors of detector stability against discharges.
- Using multi-GEM structures, electron multiplication can be shared between different levels and maximum sustainable gain can be attained, thus reducing the probability of discharges in any one of the GEM foils. However, this has not been verified yet.

Parameters under study

- Charge dynamics study
- Study of spread of electrons at the anode and on the GEM foils
- Study of average charge within the holes of GEM foils
- Intrinsic position resolution study

CHARGE DYNAMICS

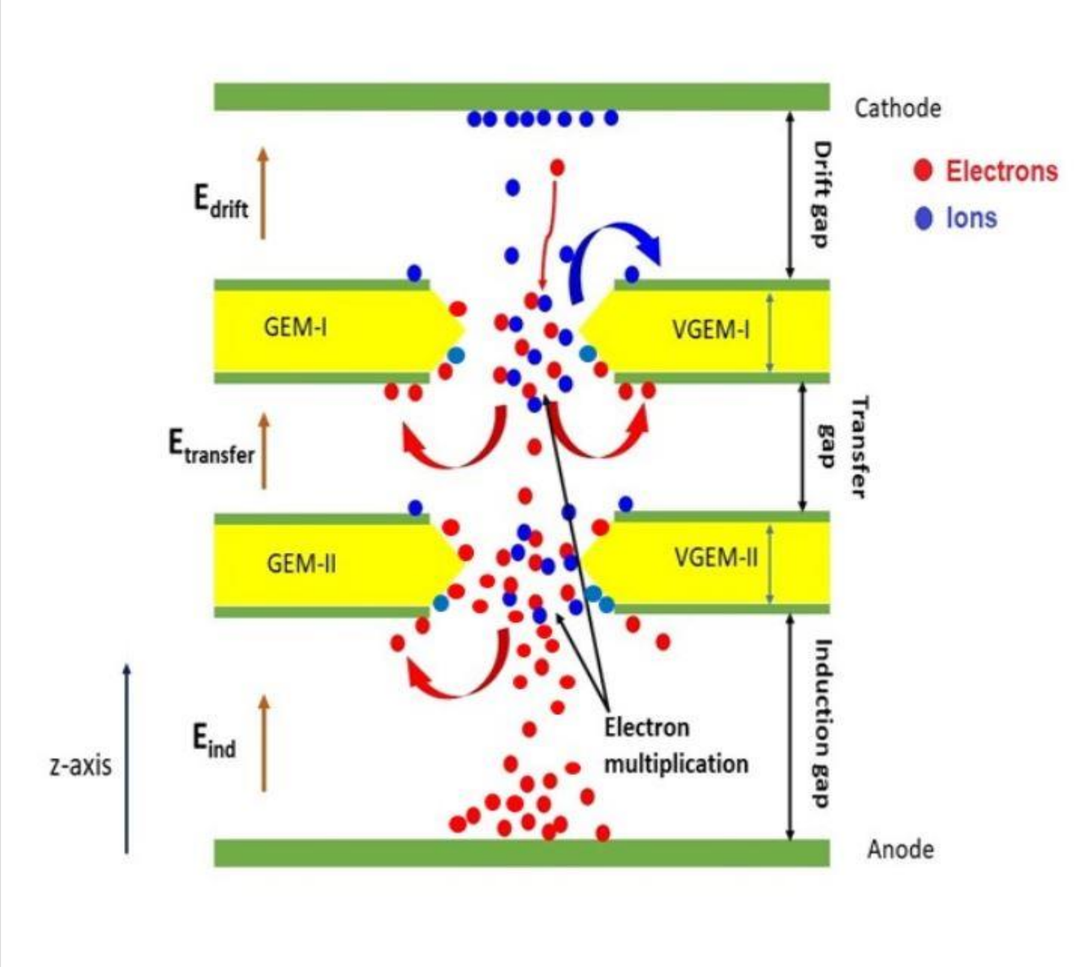
Charge sharing depends on 3 primary factors:

- **Resultant field**
- **GEM geometry**
- **Gas mixture**

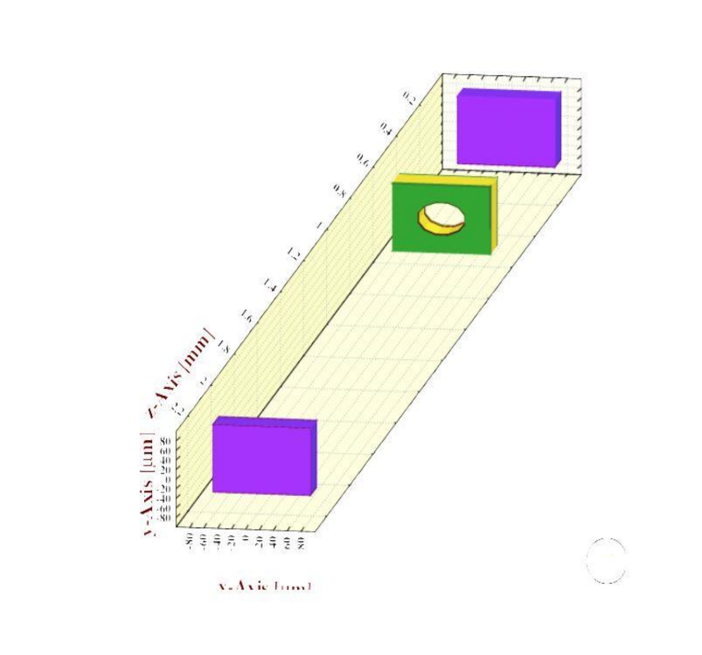
❑ Back drifting ions: most of the ions drift back to the cathode, some of them may get attached to the top copper coating and other relatively positive areas as well.

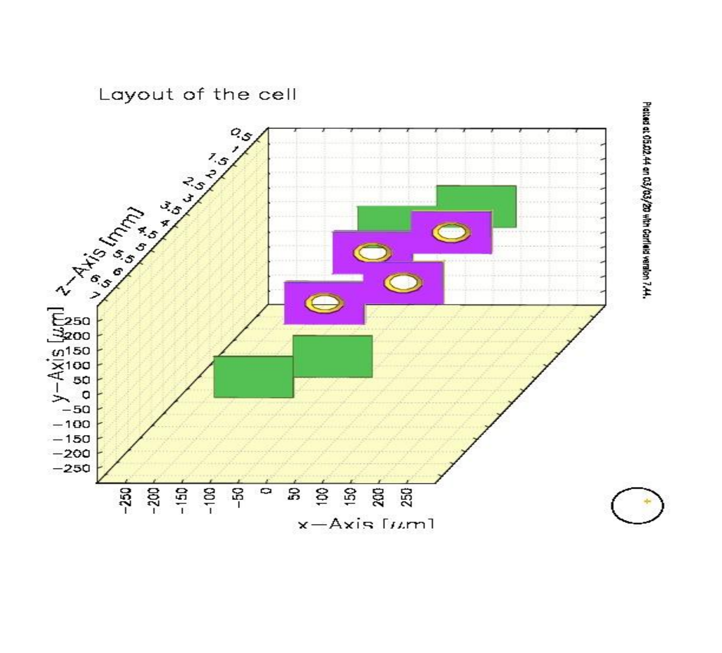
❑ Electrons: a significant amount of electrons may be lost at the bottom of the GEM foils, on the Kapton, some can even be lost on the top copper coating and remaining of them are collected at the anode.

Schematic of a double GEM



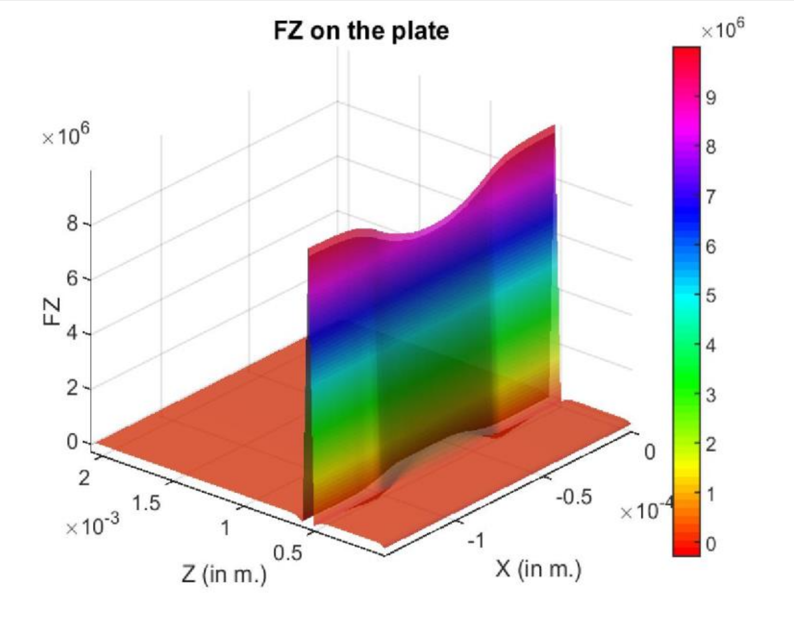
GEOMETRY AND FIELD CONFIGURATION

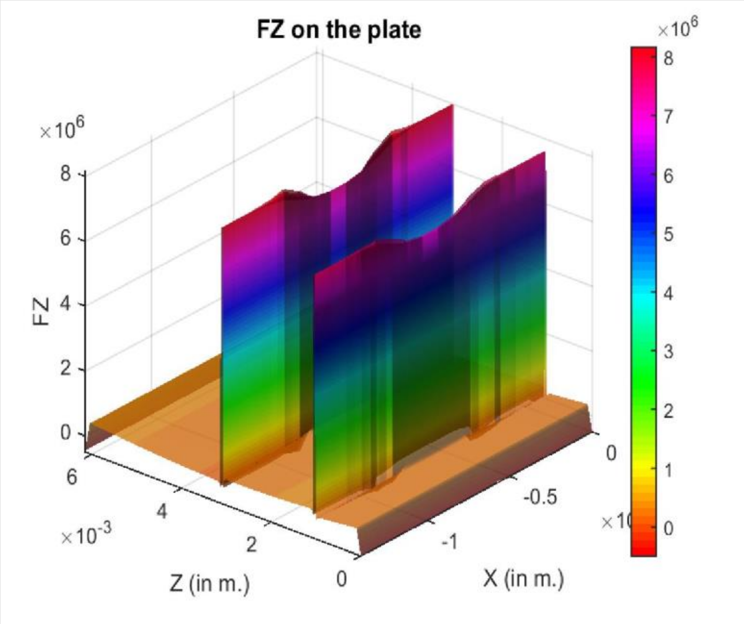




Single GEM

Drift gap : 1.5mm
Induction gap : 0.5mm
ΔVGEM = 500V





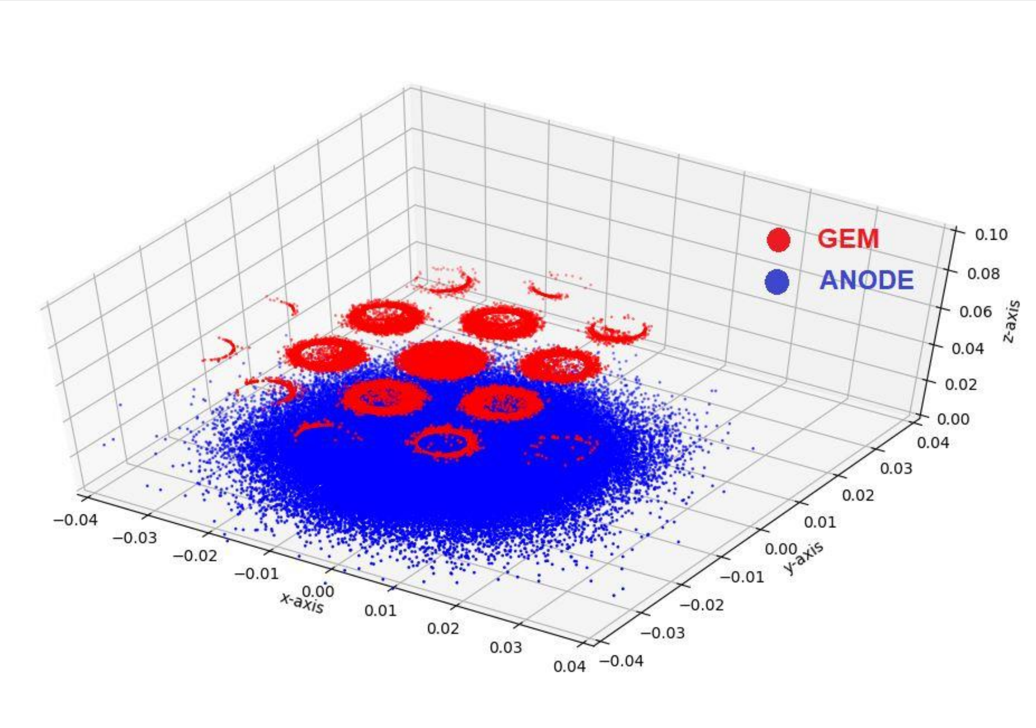
Double GEM

Drift gap : 3mm
Transfer gap : 2mm
Induction gap : 1mm
ΔVGEM-I = 400V
ΔVGEM-II = 380V

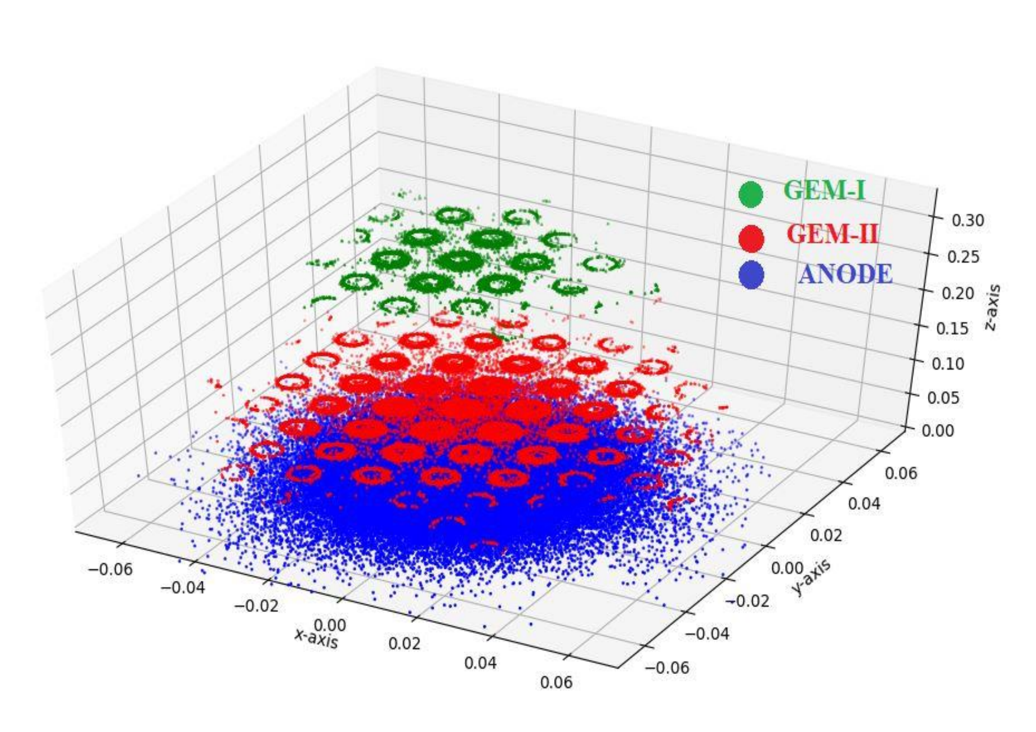
ELECTRON ENDPOINTS

- Electron endpoints show the spread of electrons on the top of GEM foils as well as anode.
- The number of holes covered in double GEM foils is more than that covered in single GEM.

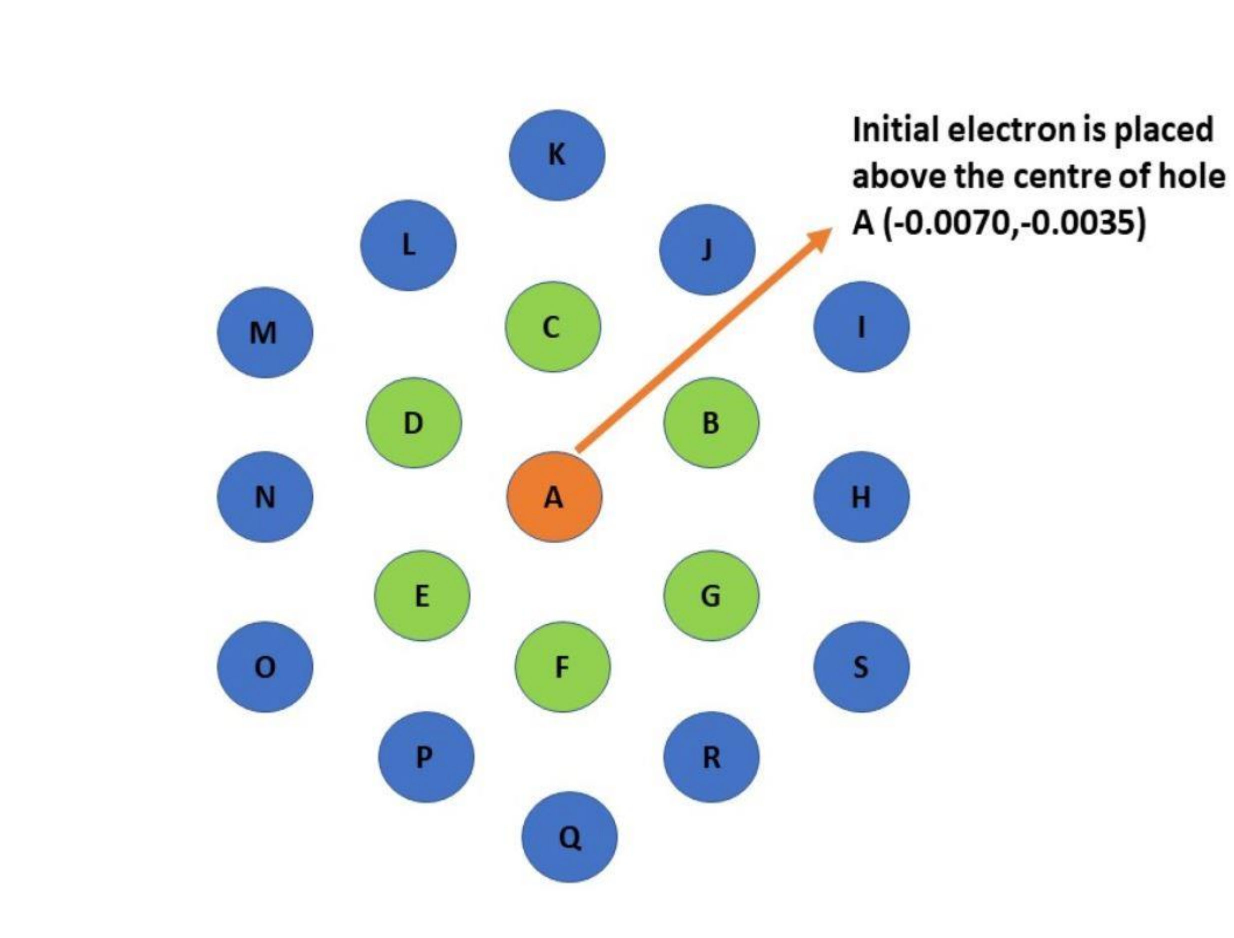
Single GEM



Double GEM



SCHEMATIC MODEL OF A GEM



- An initial electron is placed above the centre of the hole **A** at a particular height.
- Spread of electron is calculated at anode and on the top of GEM foils.
- For a given number of single electron events, number of charge per hole and corresponding percentage charge in each hole calculated.

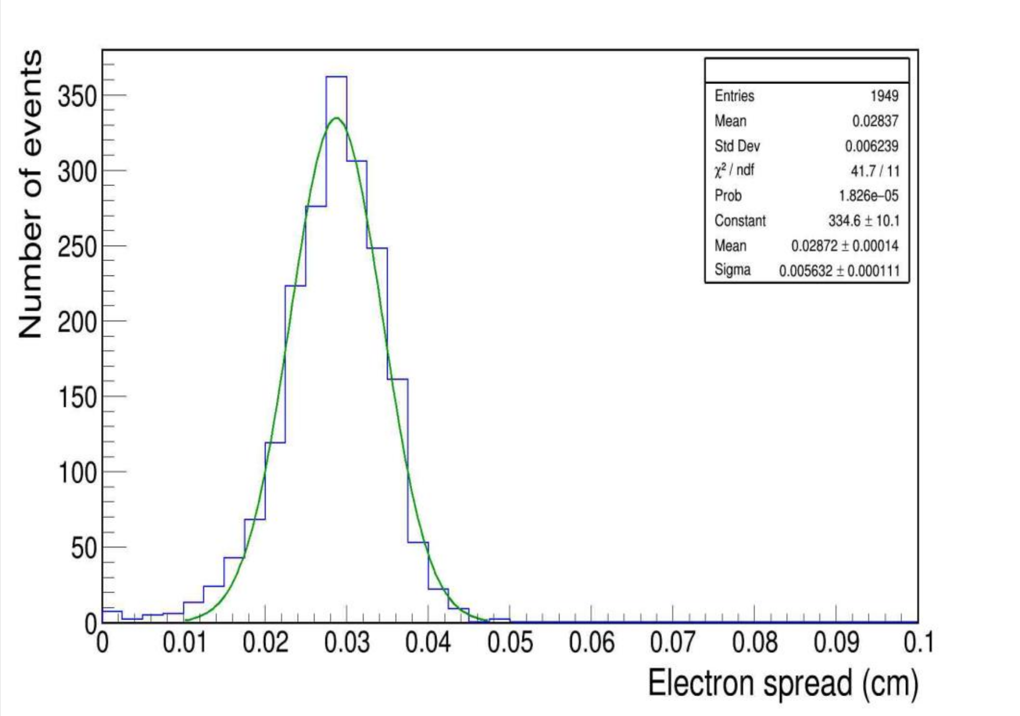
SPREAD OF ELECTRONS

For a given surface, spread of electrons is defined to be

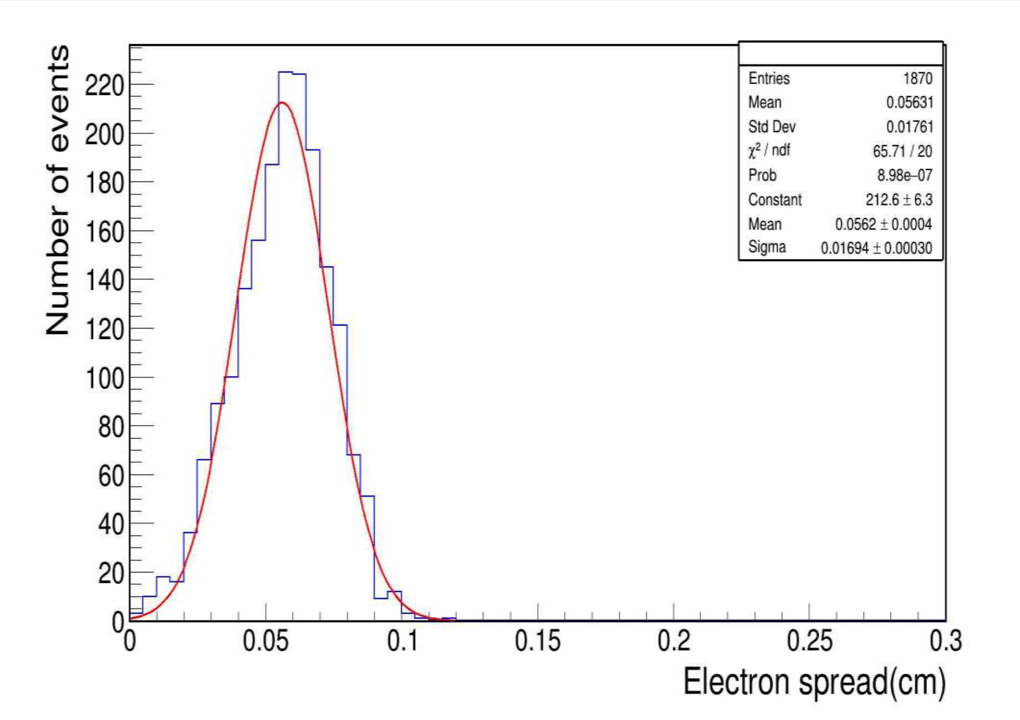
$$\Delta x = x_{max} - x_{min}$$

where x_{max} and x_{min} are the maximum and minimum x-coordinates of electrons for a particular event.

Single GEM



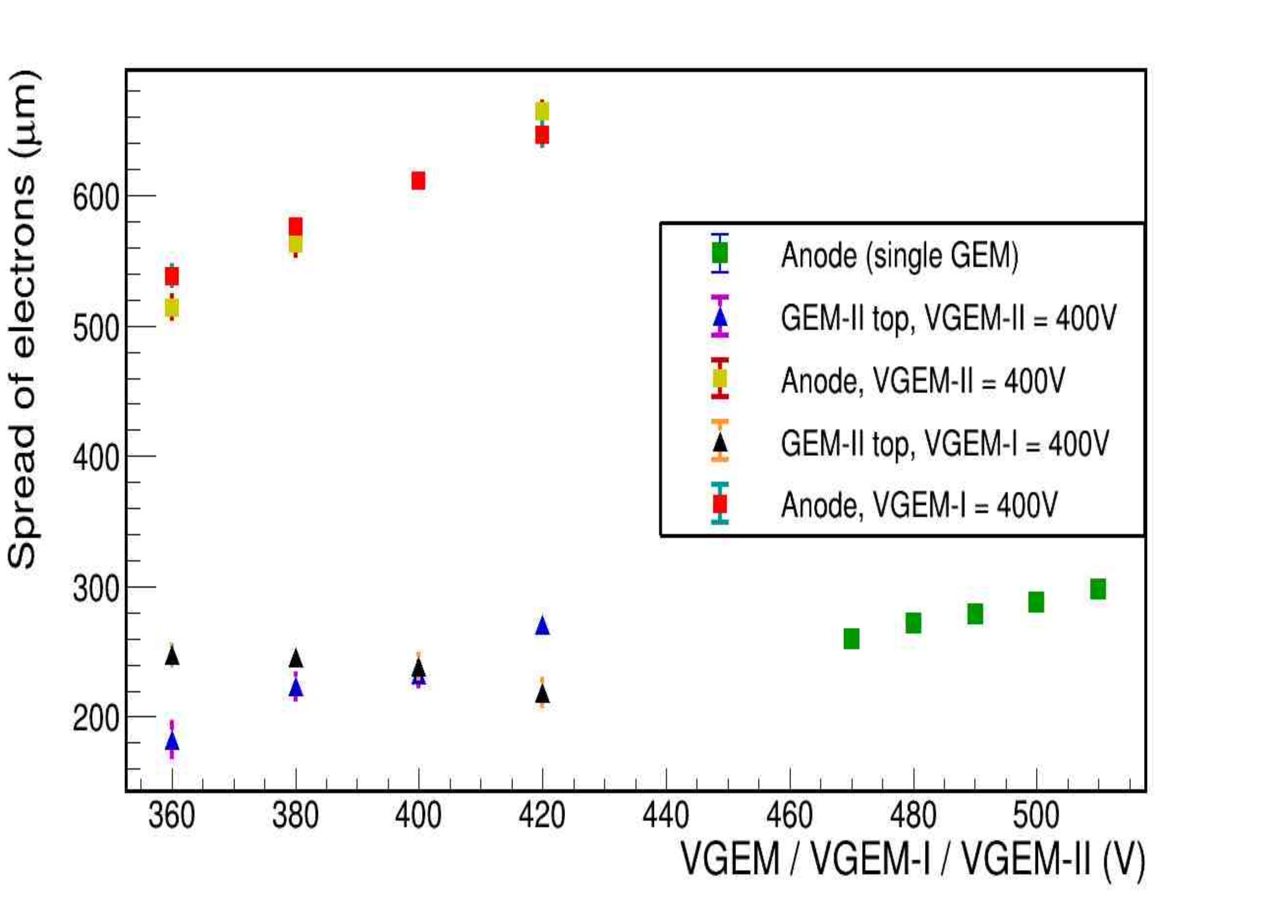
Double GEM



For this particular field configuration, the electron spread at anode for single GEM is 287μm and that in double GEM is 562μm.

SPREAD OF ELECTRONS WITH GEM VOLTAGES

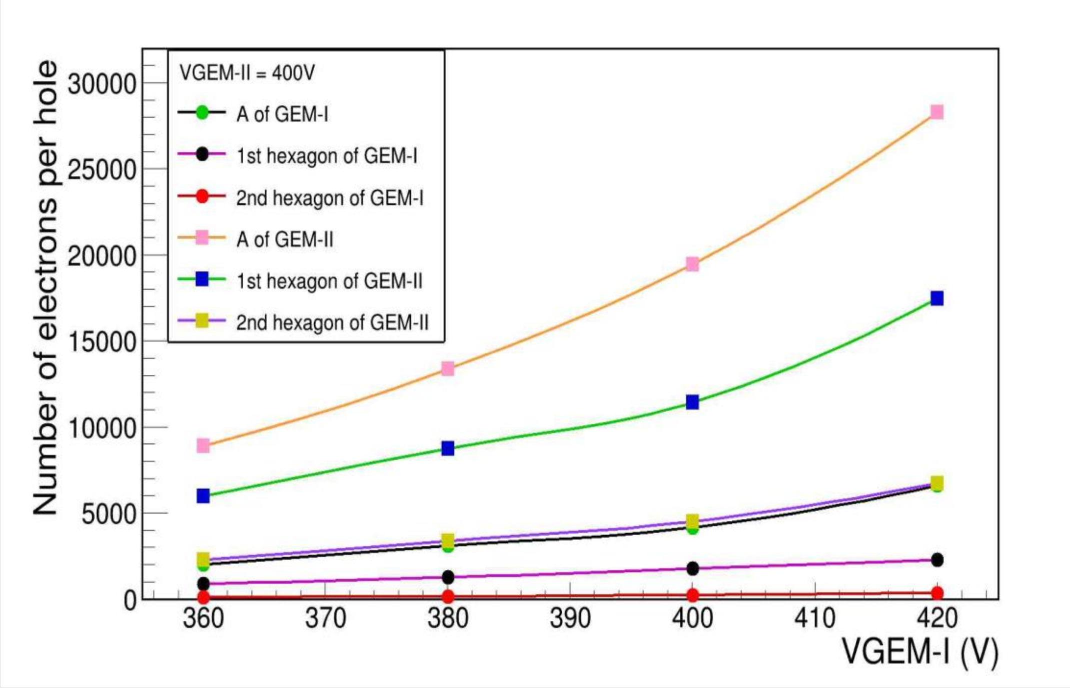
- Electron spread at anode is seen to have an increasing trend with increase in GEM voltage in Single GEM.
- The same trend is observed in double GEM both for electron spread at GEM-II top and anode when ΔVGEM-I is increased.
- Spread on GEM-II slightly decreases when ΔVGEM-II is increased.
- Magnitude of spread on top of GEM-II is similar to that of anode spread in single GEM.

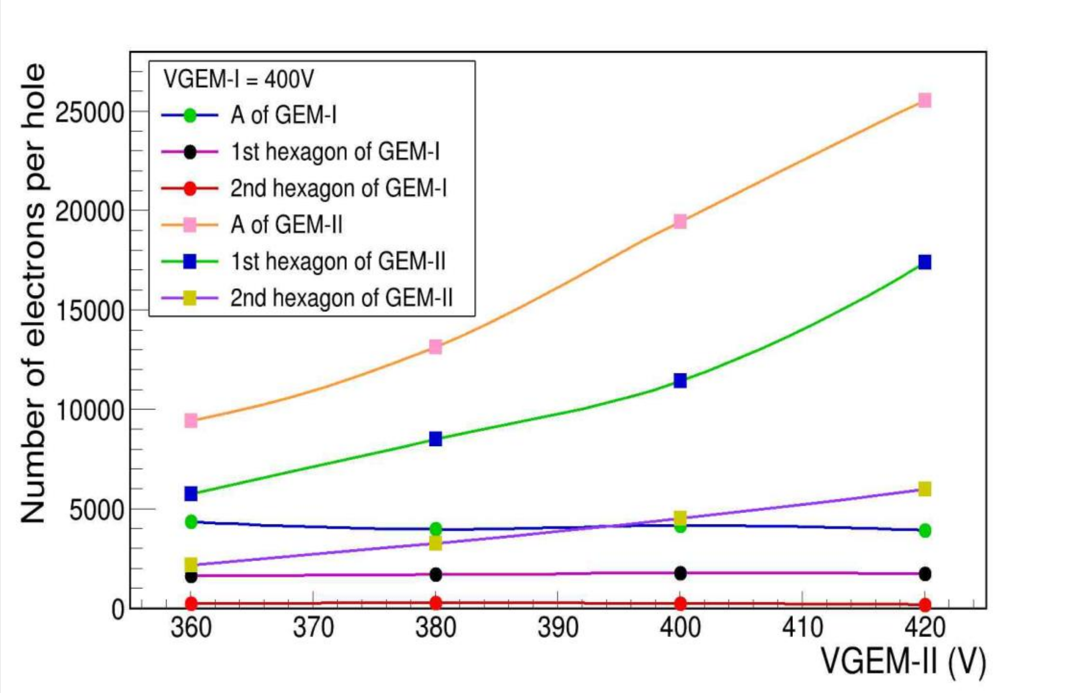


CHARGE PER HOLE

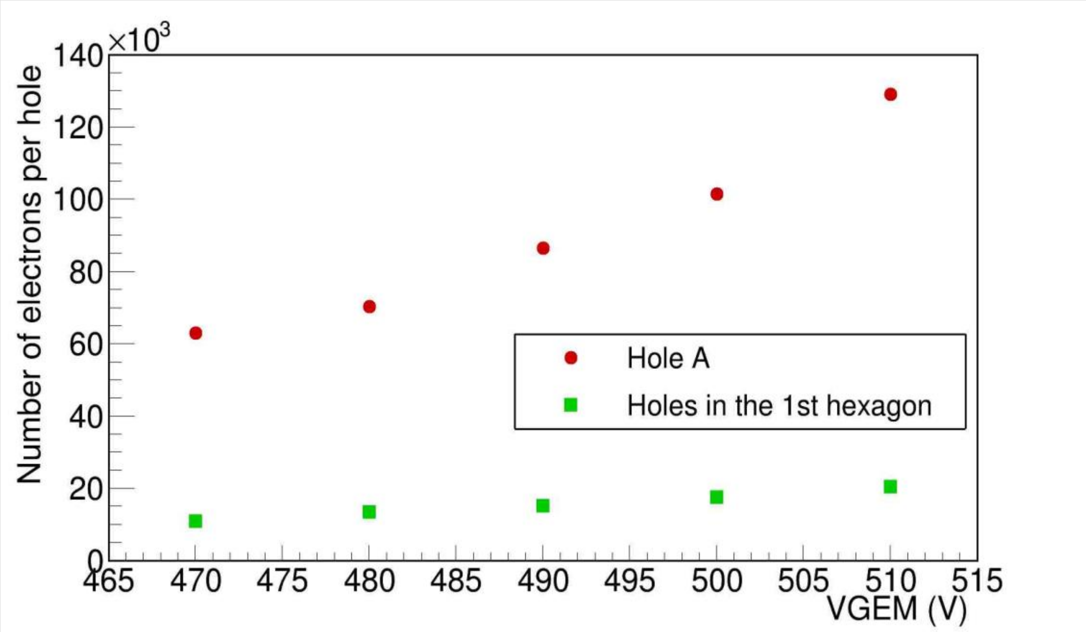
At constant drift, transfer and induction fields.

Double GEM



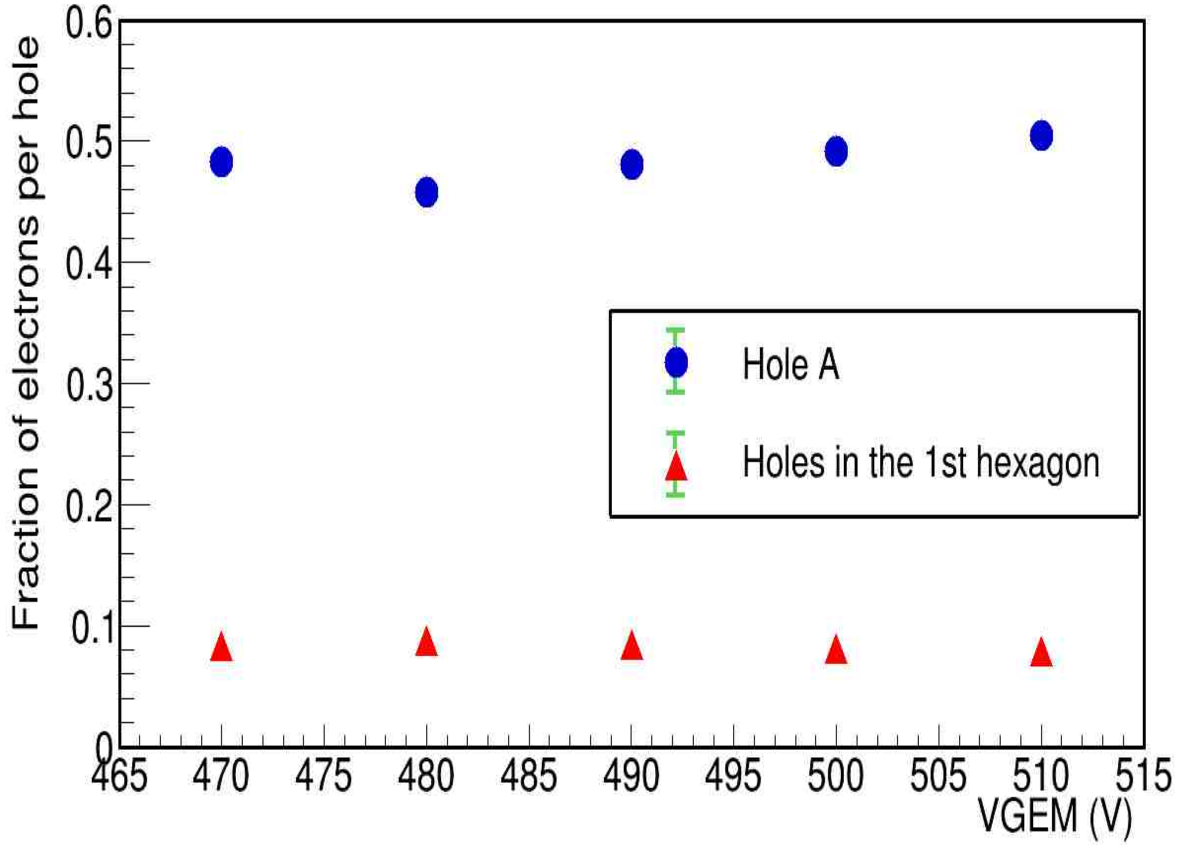


Single GEM



FRACTION OF ELECTRONS PER HOLE

Single GEM



<u>Variation with ΔVGEM</u>:

Around 48-50 % of total charge is present in central hole A, whereas on an average 8-9% of charge is present in each hole of first hexagon.

At constant drift and induction field

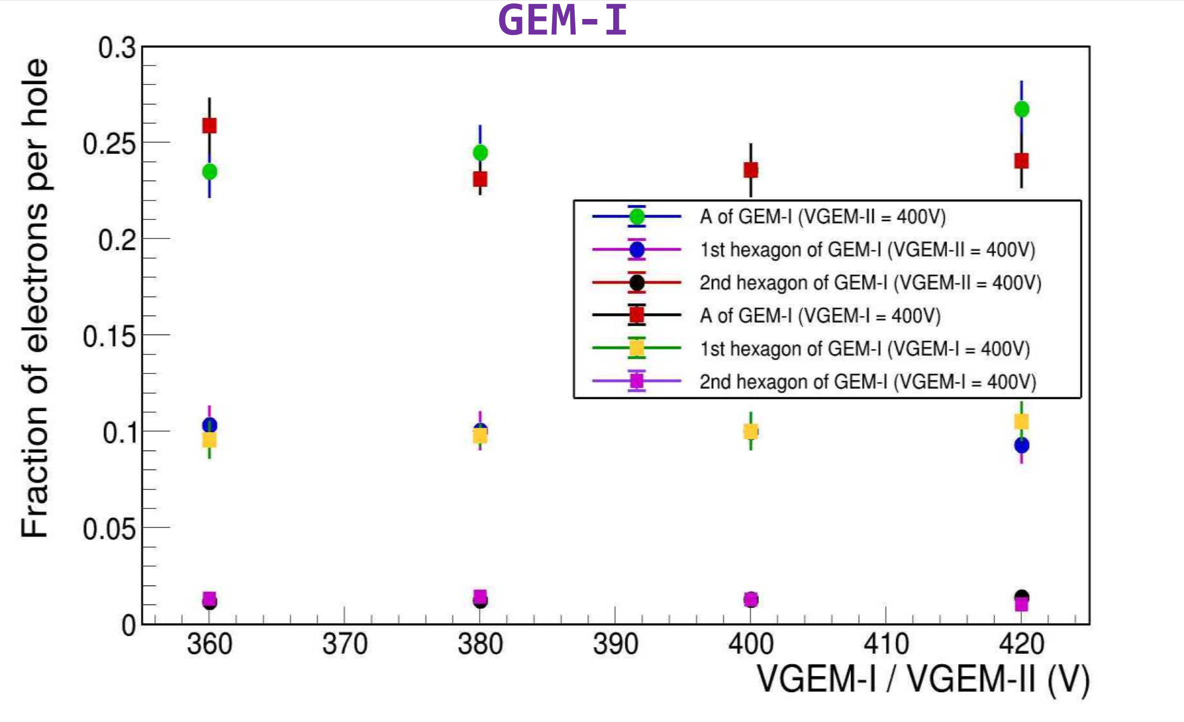
FRACTION OF ELECTRONS PER HOLE CONTINUES….

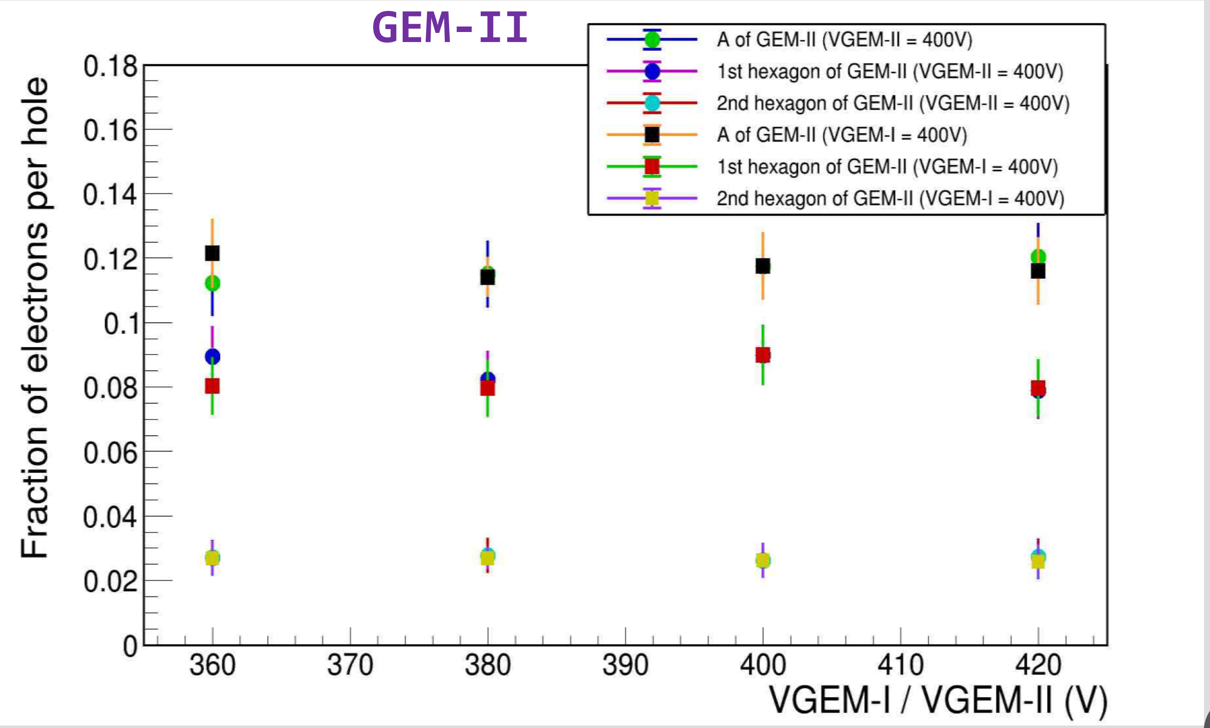
Double GEM

At constant drift, transfer and induction field.

- Around 25% of total charge is present in the central hole **A** of top GEM (GEM-I), 10% in each holes of first hexagon and around 1% in each holes of second hexagon.
- The distribution is more uniform in bottom GEM (GEM-II).
- The contribution of hole **A** reduces to approximately 12% whereas each hole of first and second hexagon shares around 8-9% and 3% of total charge respectively.

Variation with ΔVGEM-I and ΔVGEM-II…….



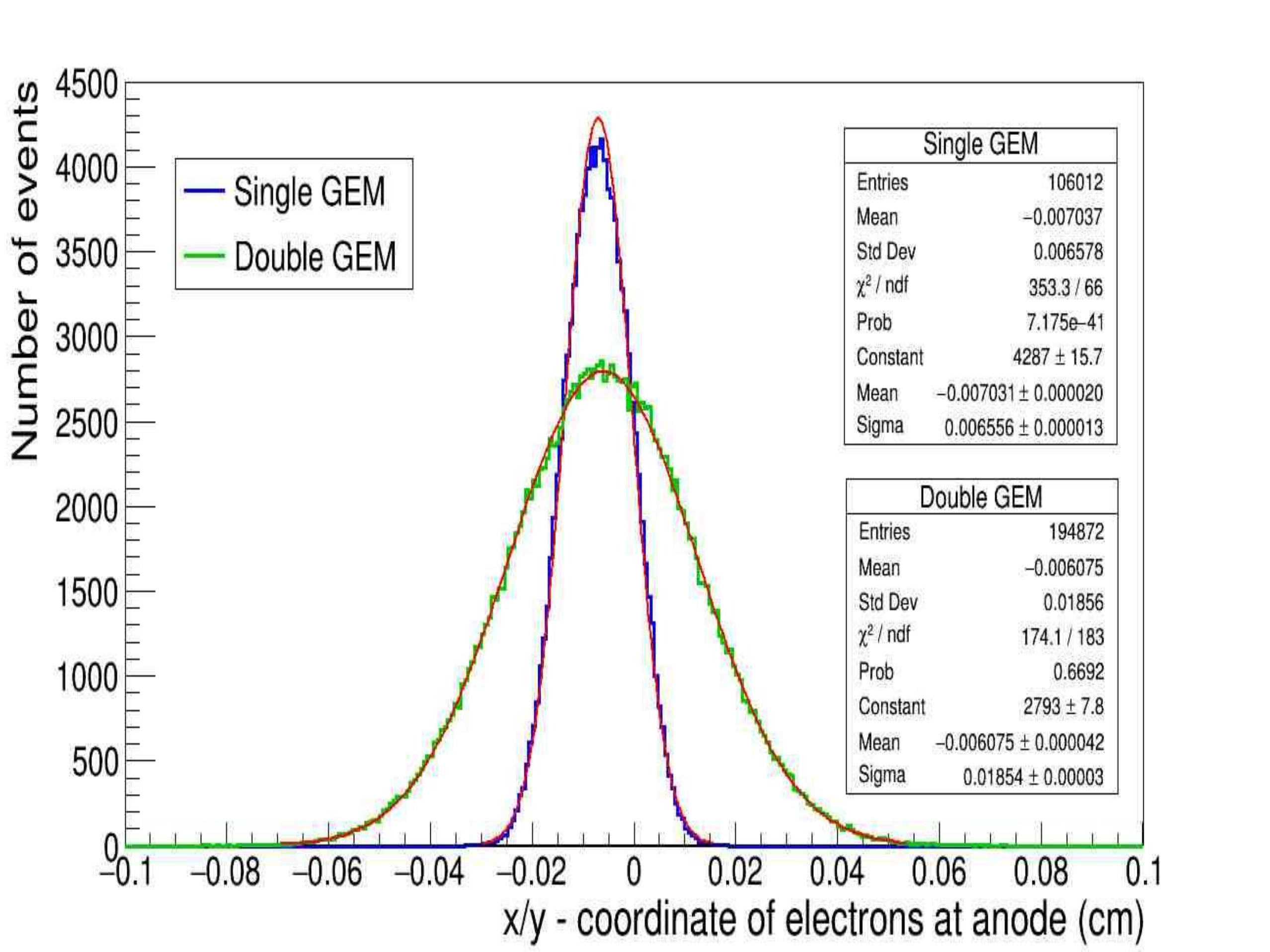


DISTRIBUTION OF END-POINTS OF ELECTRONS

- An intrinsic single point position resolution is defined to be the **sigma** of the distribution of the end-points at the anode.
- **Sigma** for single GEM endpoint distribution is around 70µm and that in double GEM is 185µm.
- These **sigma** values obviously depend on the ratio of electric fields within the GEMs.

ΔVGEM = 500 V (Single GEM)

ΔVGEM-I = ΔVGEM-II = 400V (double GEM)



SUMMARY

- Spread of electrons is found to depend on GEM voltages as well as intermediate field strengths.
- Around 50% of total charge is present in central hole for a single GEM, whereas this percentage reduces to almost half (~25%) in GEM-I of double GEM.
- The average charge distribution reduces further in the central hole of GEM-II (~12%) and thus, adding a second layer gives a more uniform distribution of charges within the foil.
- Drift and transfer fields are also seen to alter the charge distribution in GEM foils of single and double GEMs.
- Intrinsic position resolution is found to worsen on addition of a second GEM foil.

FUTURE PLAN

- Study the variation of charge density with evolution of time within the hole.
- Repeat the studies for other multi-GEM structures like triple-GEM.
- Check whether charge density can be related to discharge probability and if yes, then optimize various working parameters for triple GEM to have minimum discharge.

Collaborators

- **Prof. Supratik Mukhopadhyay, SINP, India.**
- **Prof. Nayana Majumdar, SINP, India.**
- **Prof. Sandip Sarkar, SINP, India.**
- **Dr. Purba Bhattacharya, INFN, Monserrato CA, Italy.**

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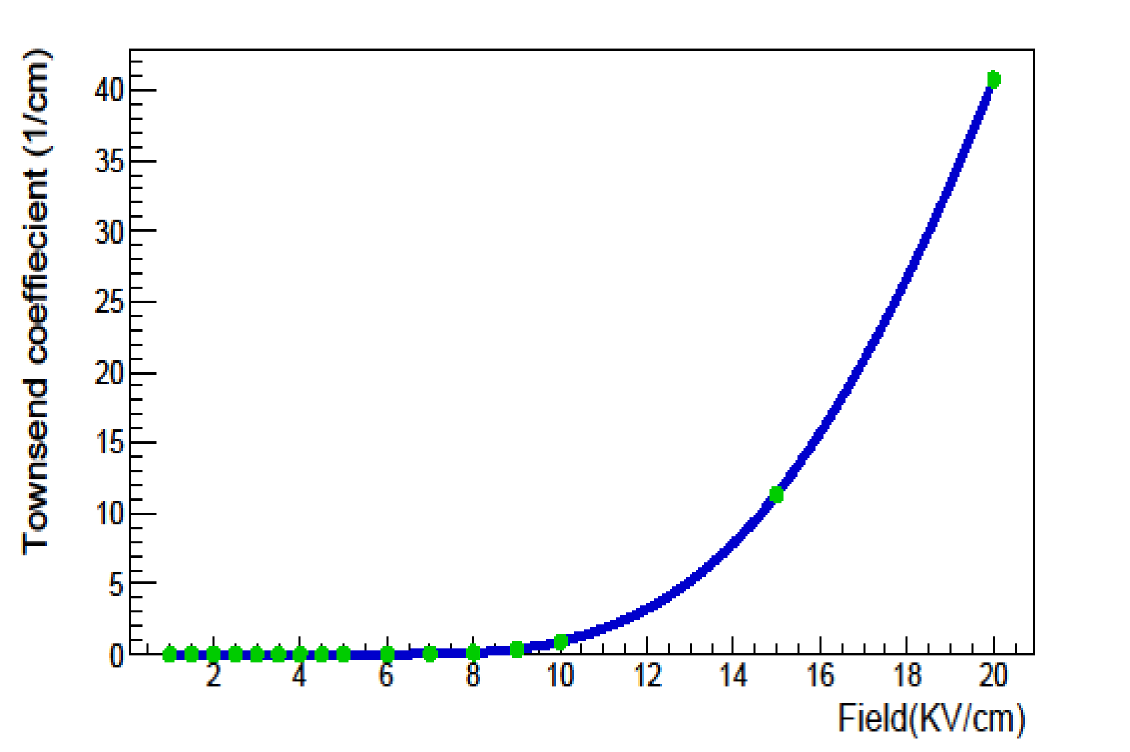
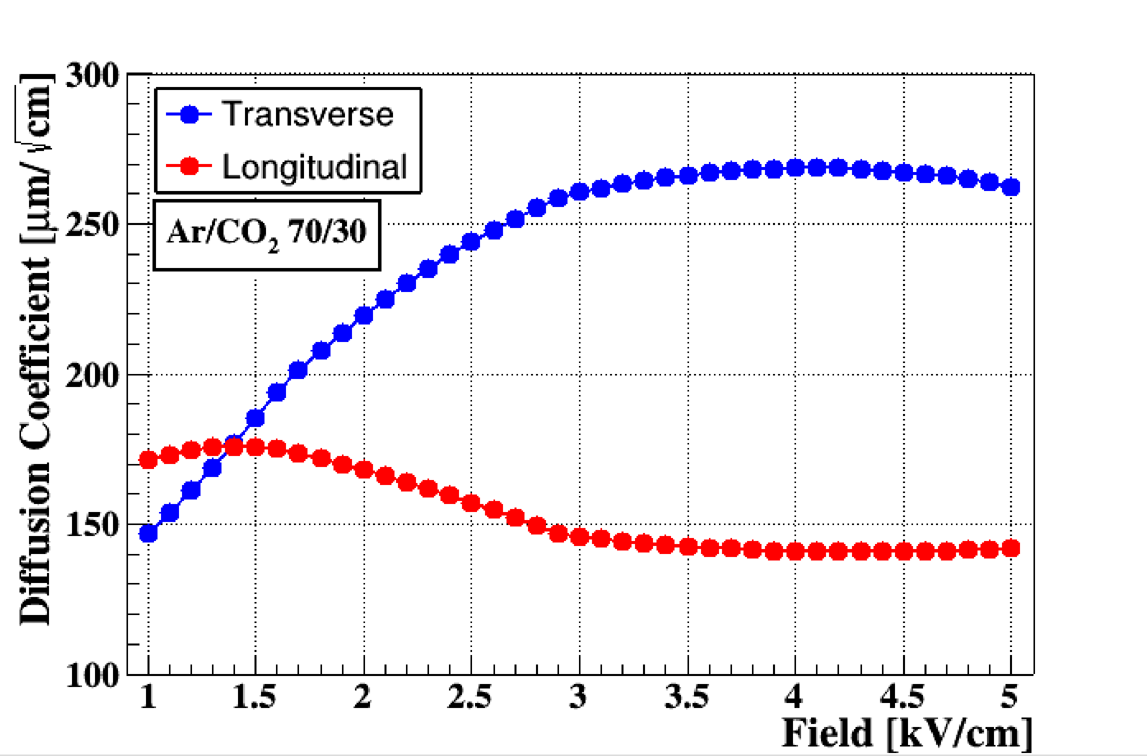
Thank You

Back up slides

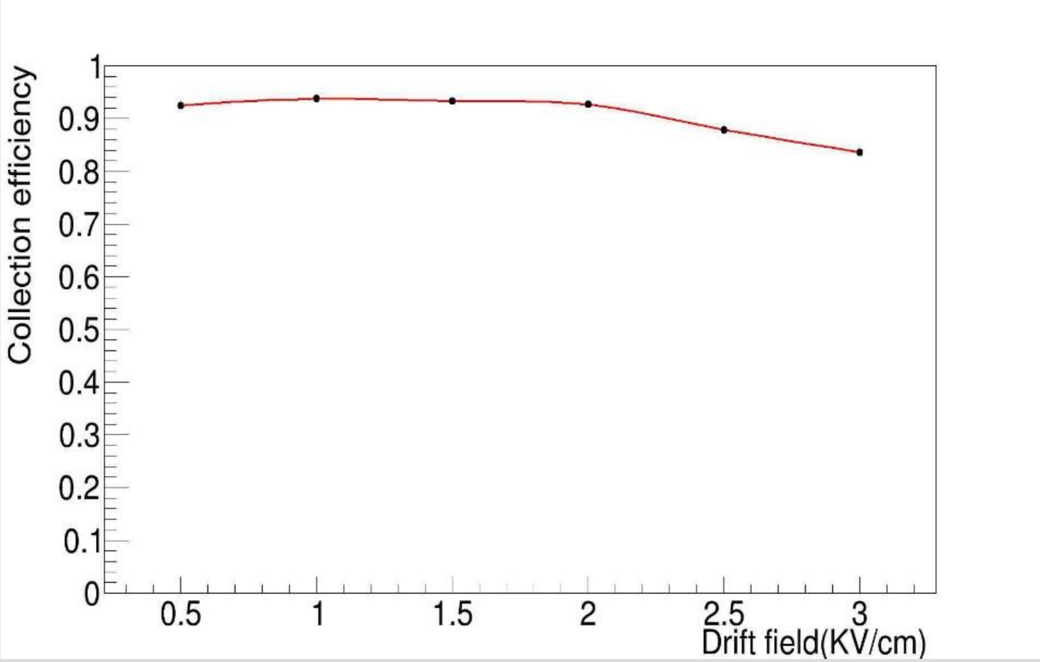
Transport properties

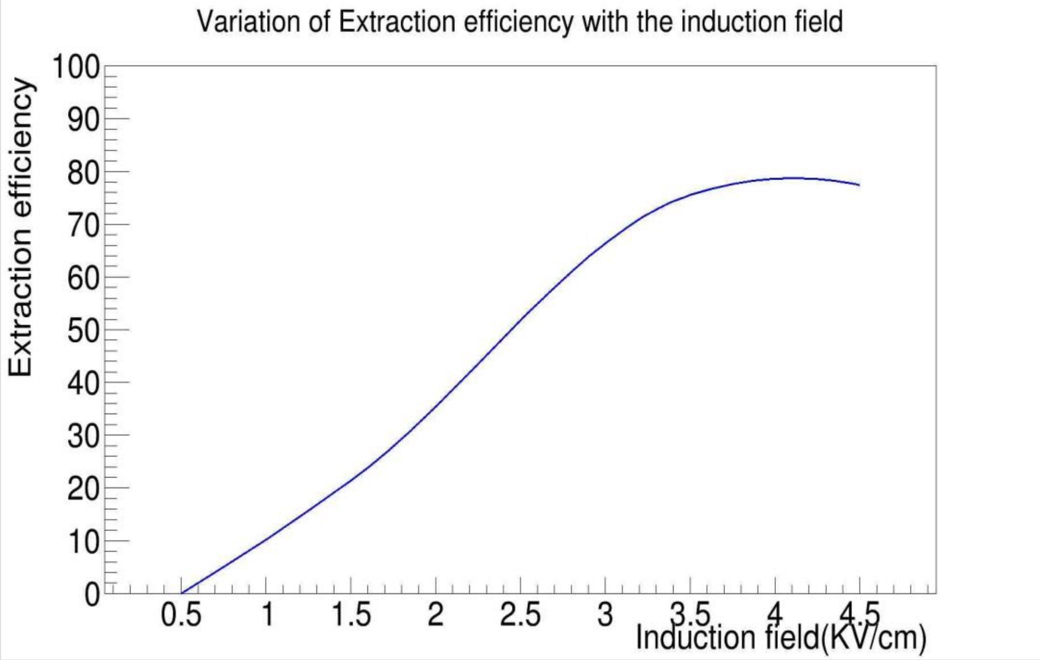




Efficiencies

Single GEM





Efficiencies (Double GEM)