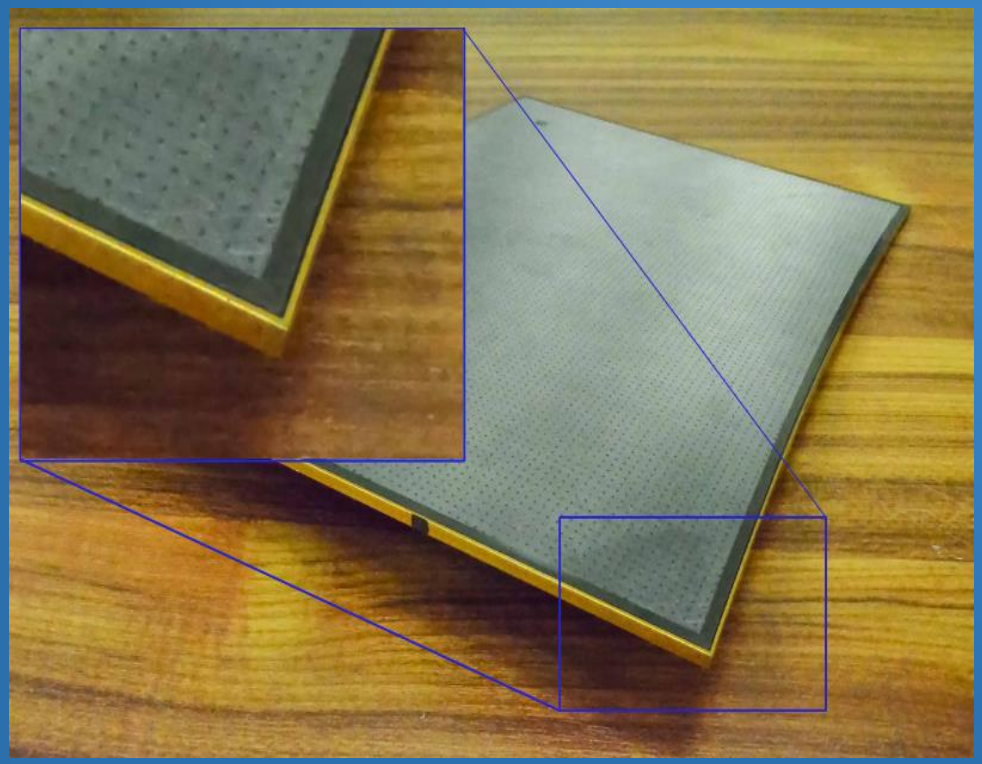
Calculation of expected distortions near the module edges

Supratik Mukhopadhyay on behalf of the CEFIPRA 4304-1 group

Two challenges in track reconstruction

- Misalignment between the modules.
- Electric field distortion near the edges of the modules.

Misalignment occurs during the installation of the modules at the LPTPC end-plate.

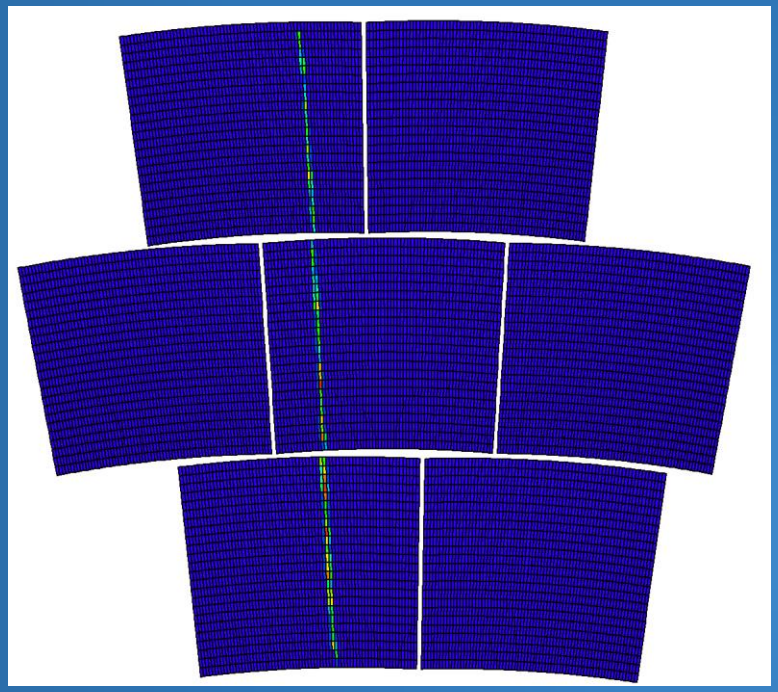


A copper frame supports the readout and rests very close to the micro-mesh.

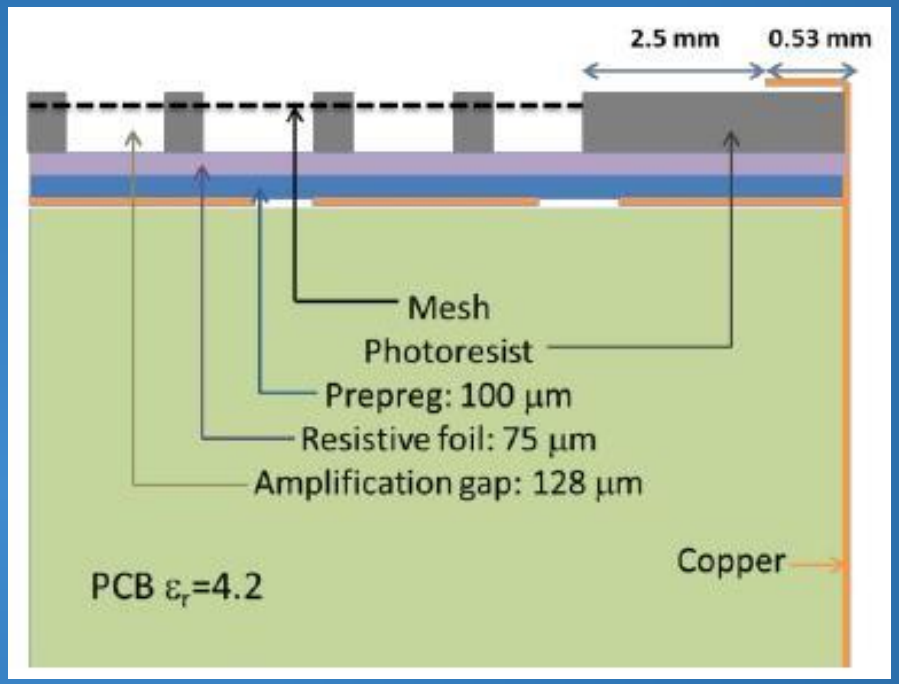
Since the frame is kept at ground potential, it introduces non-uniformity in the electric field near the edges of the modules at the vicinity of the anode plane.

The non-uniform electric field influences pad-hits.

Investigation of Track distortion by Numerical Methods



Micromegas modules on the LPTPC endplate.

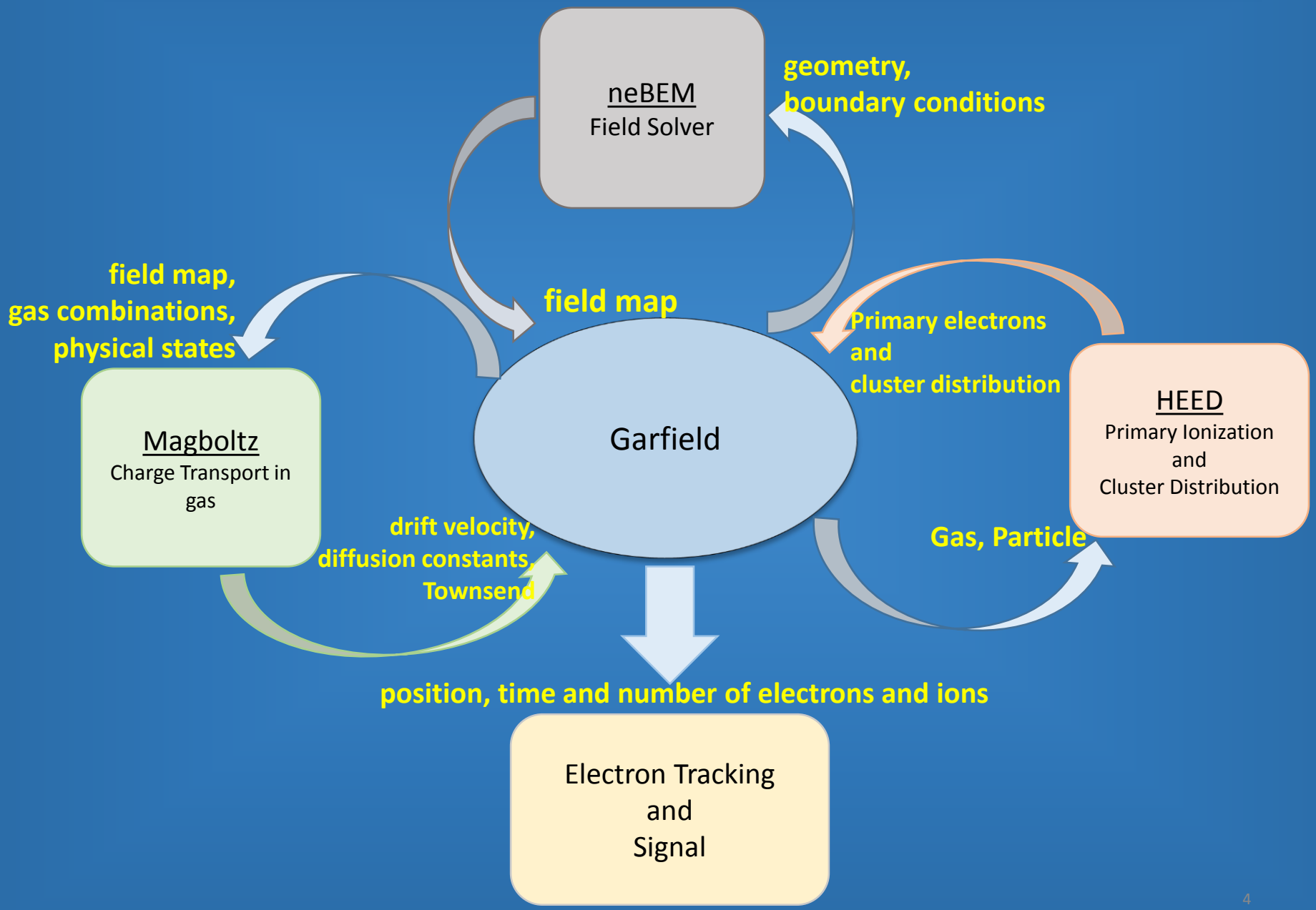


A close up of the module edge

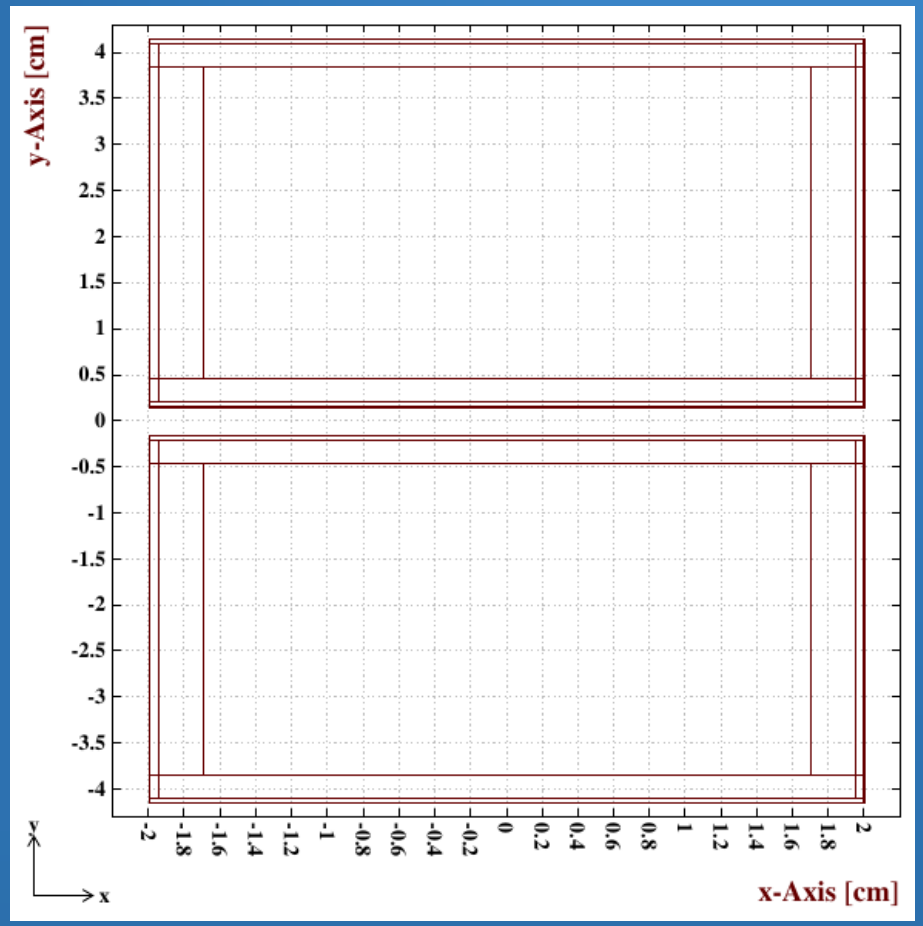
Module size: 17 cm × 22 cm.
Reference frame is in r-phi system.

Earlier work by Klaus Zenker on multi-module GEM TPC using Garfield+CST

Simulation Framework



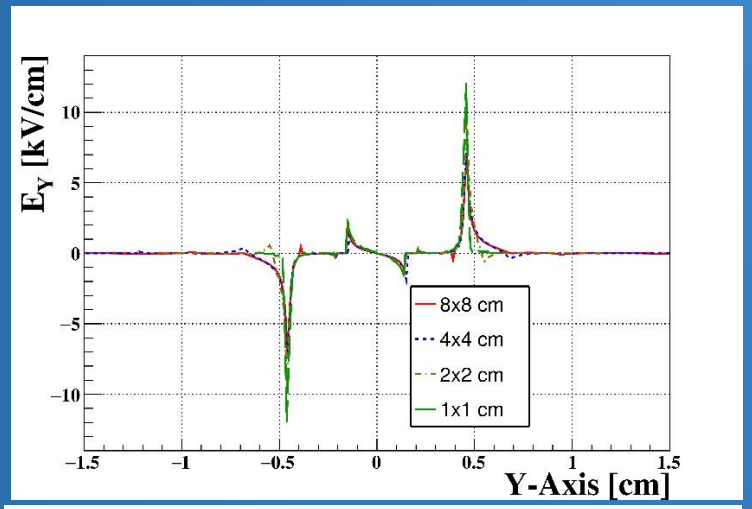
Optimization of Computational Efforts (1)

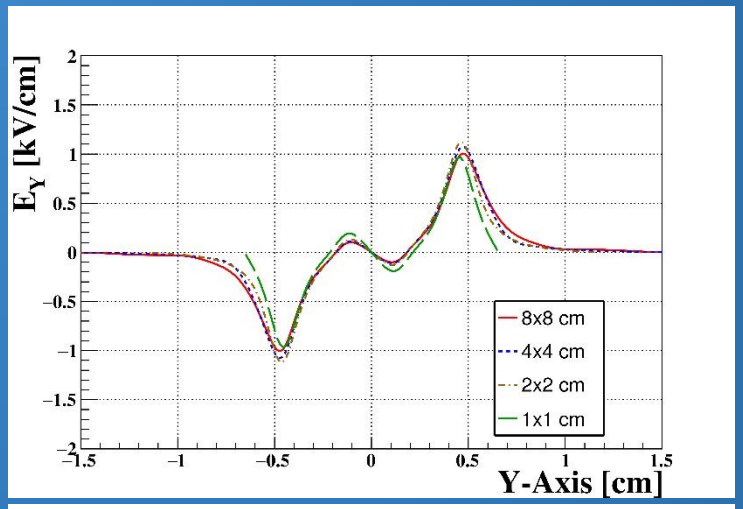


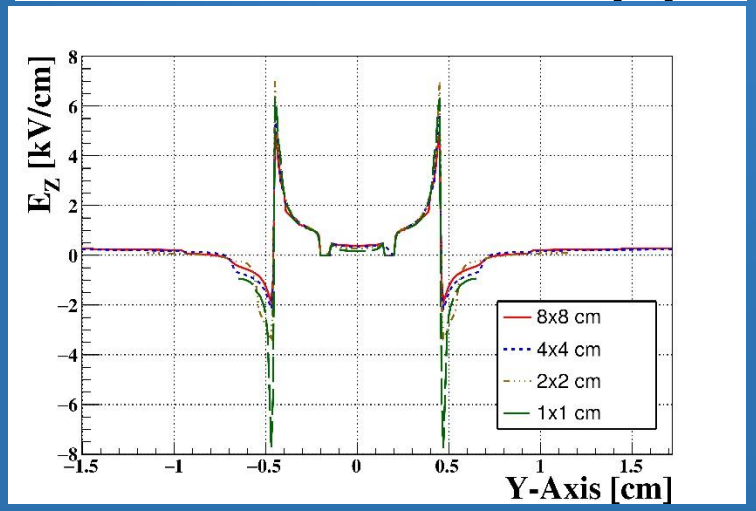
For computation, the real geometry is not convenient. The longest side of one module is 22cm whereas the smaller dimensions are of the order of 10s of μm. In fact, if we consider just two modules (a reasonable study of this distortion must necessarily have more than one module), we have a larger length of at least 34cm. So, the ratio of length scales is ~ 30000:1.

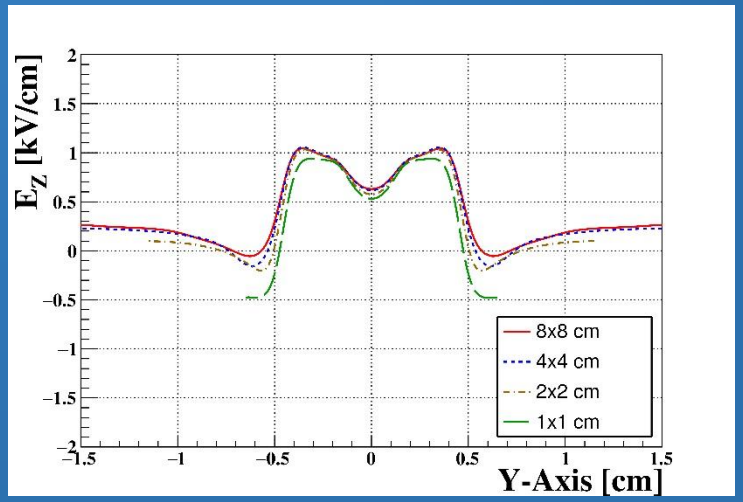
So, initially, we study how computational modules of smaller size affect the field configuration.

Optimization of Computational Efforts (2)





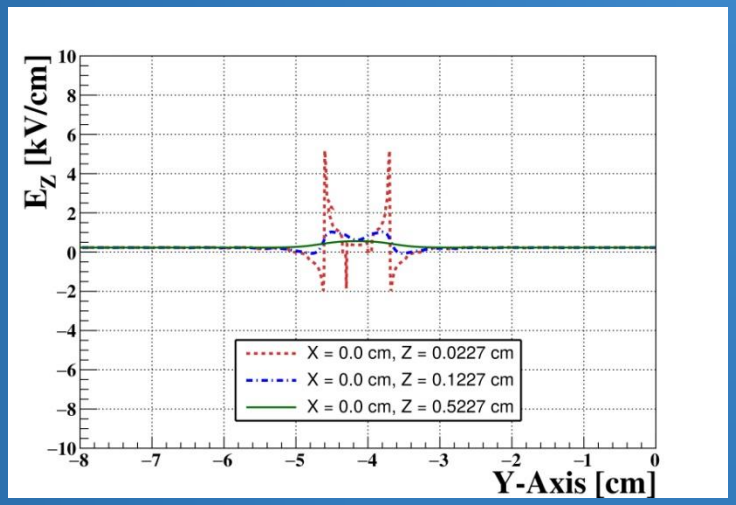


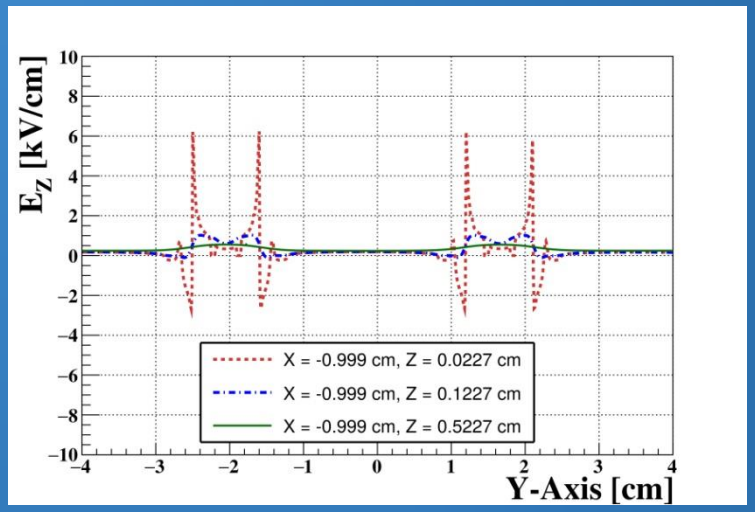


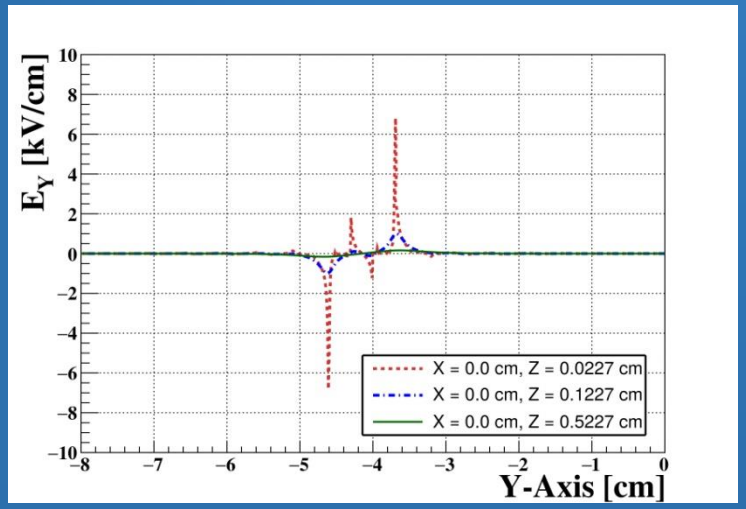
Field along a line Z = 227 μm

Field along a line at Z = 1.227 mm

Optimization of computational efforts (3)

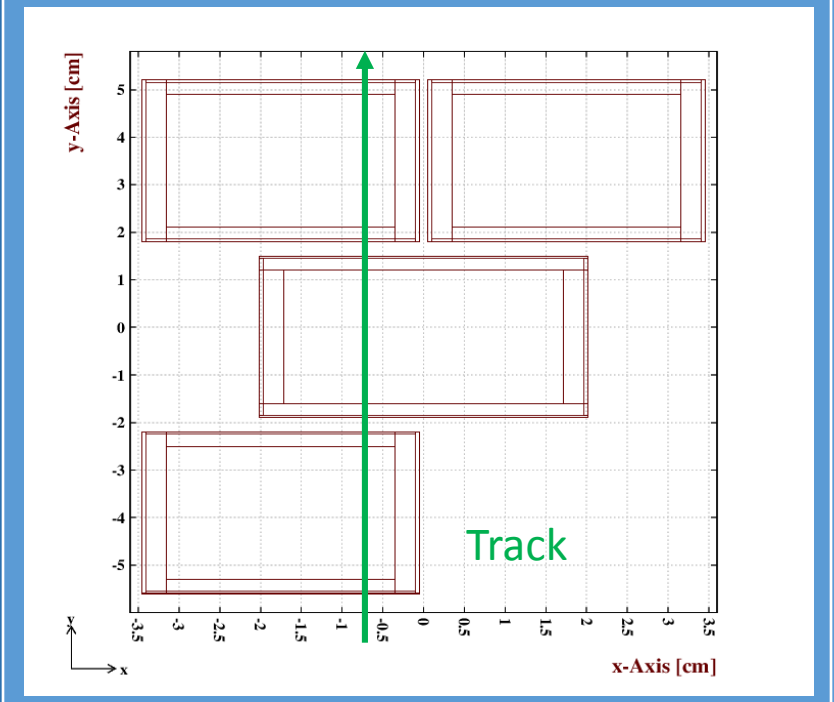




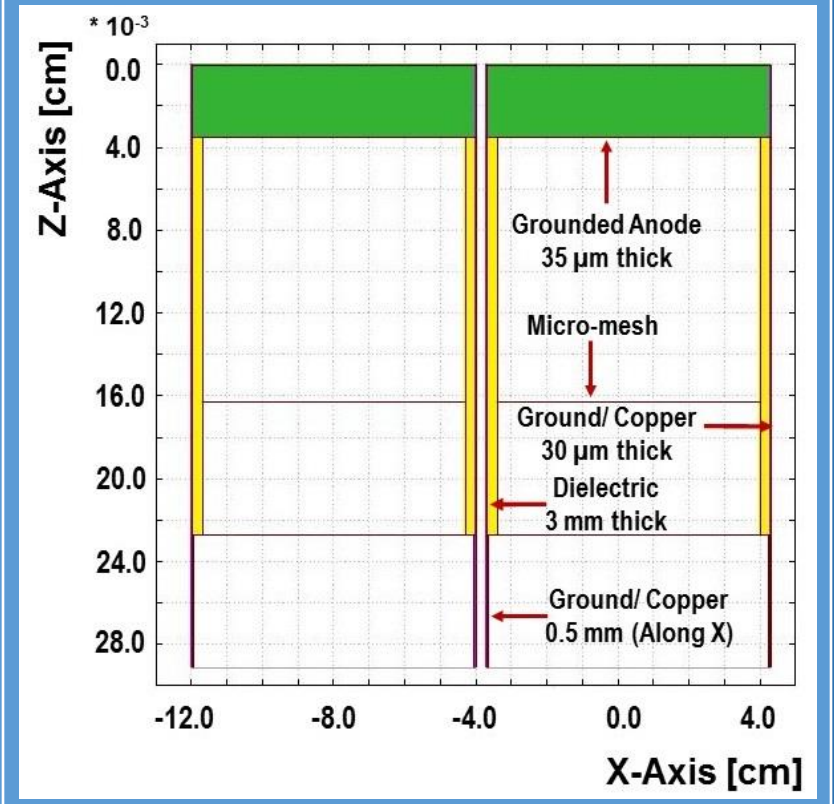


From these studies, we concluded that a module having size 3.4cm X 3.4cm could be a starting point.
More detailed studies now indicate that the size needs to be slightly increased to ensure good precision, although that does not change the nature of the results.

Numerical model

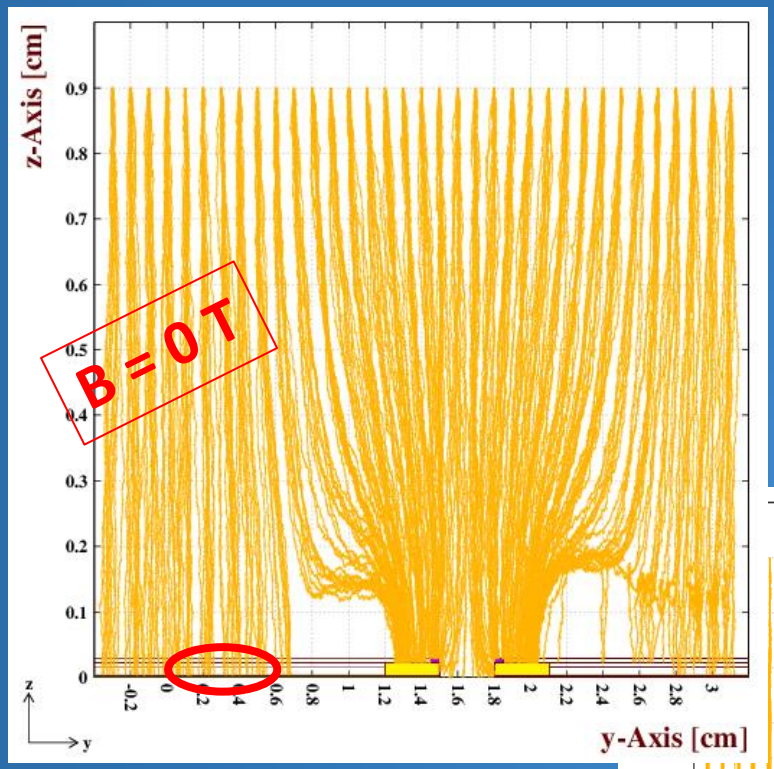


Module size: 3.4 cm × 3.4 cm.
Reference frame is in Cartesian.



Mid points: -2.05cm and 1.65cm; Gap: 3mm; Module outer edges: (-2.2cm, -1.9cm) and (1.5cm, 1.8cm); Module inner edges: -2.5cm, (-1.6cm, 1.2cm), 2.1cm

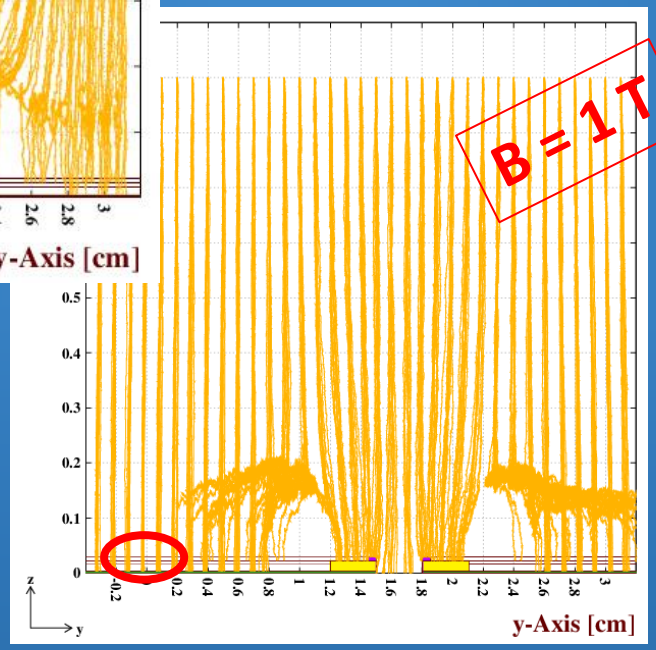
Electron drift lines



One electron is released from each of the 456 equidistant points that constitute a track. Monte-Carlo method is used to track the electrons.

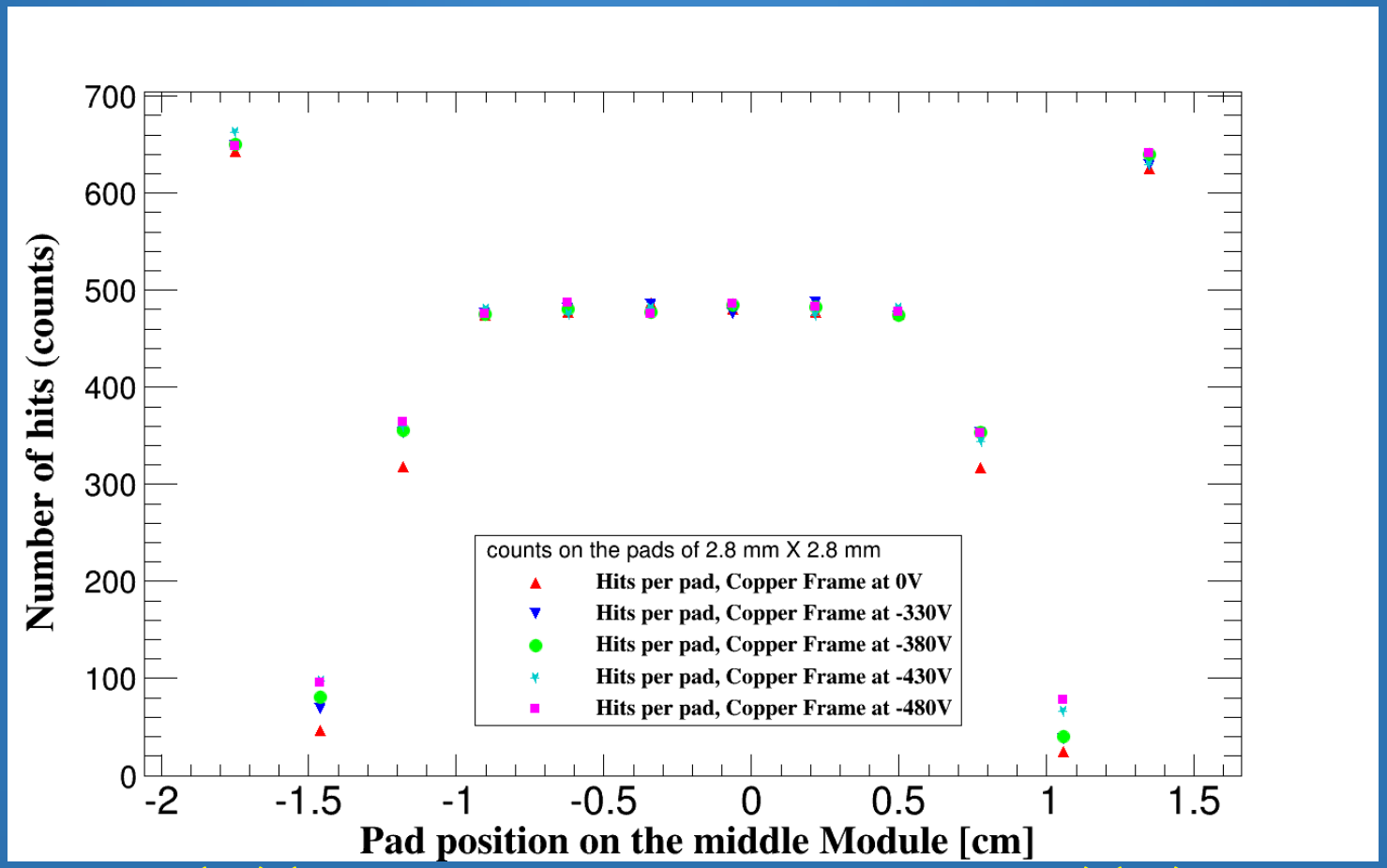
The track is repeated over 50 times to gather enough statistics.

Diffusion in gas is reduced by by applying Magnetic field.



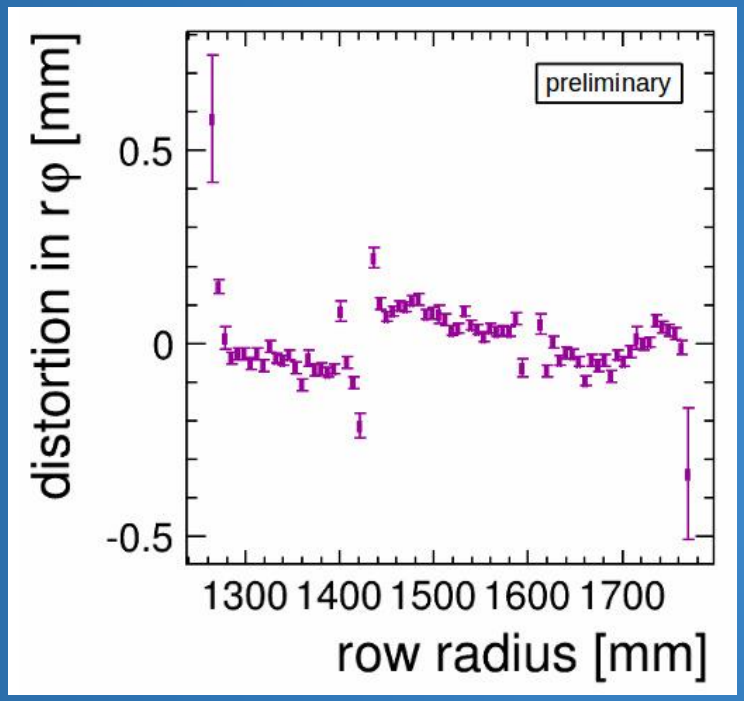
On the edges of the detectors, significant signal loss may be noticed as they hit the dielectric pillar because of the grounded frame.

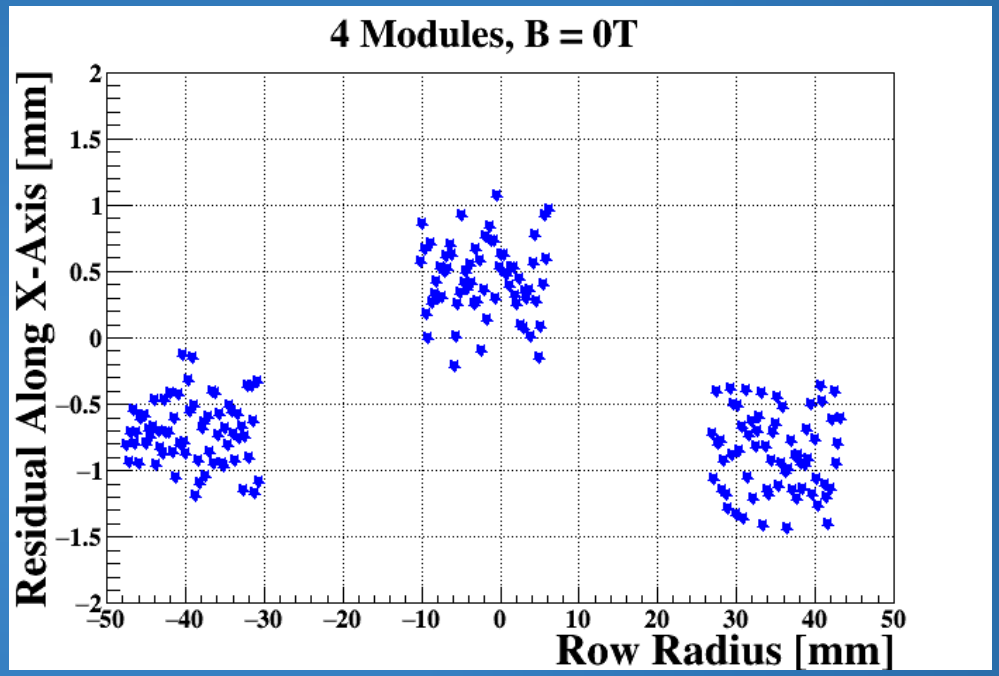
Loss of efficiency close to module edge



Inner edges of Module1

Comparison of distortion between experiment and simulation





For the Micromegas modules on the **LPTPC endplate.**

B=0T

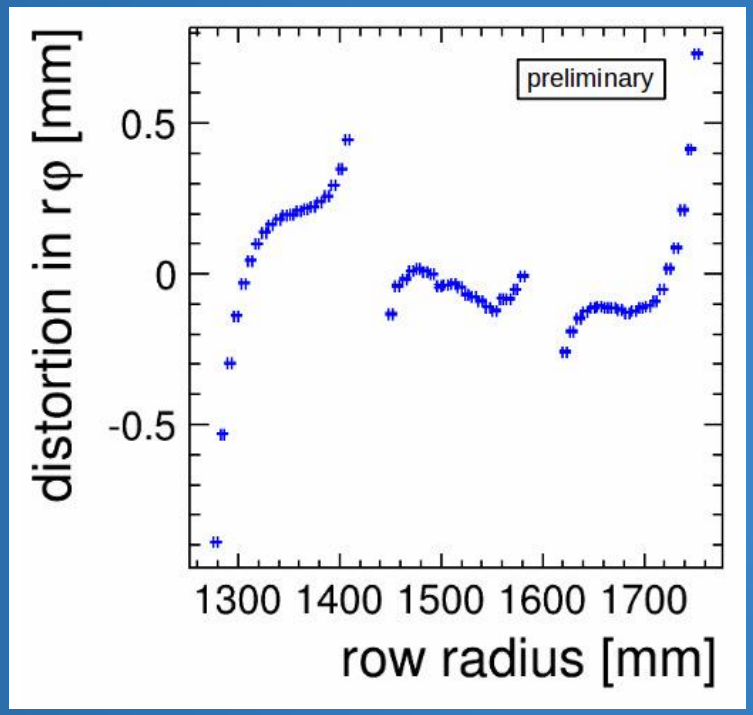
Distribution of the residuals as obtained in **Experiment** *after* alignment correction.

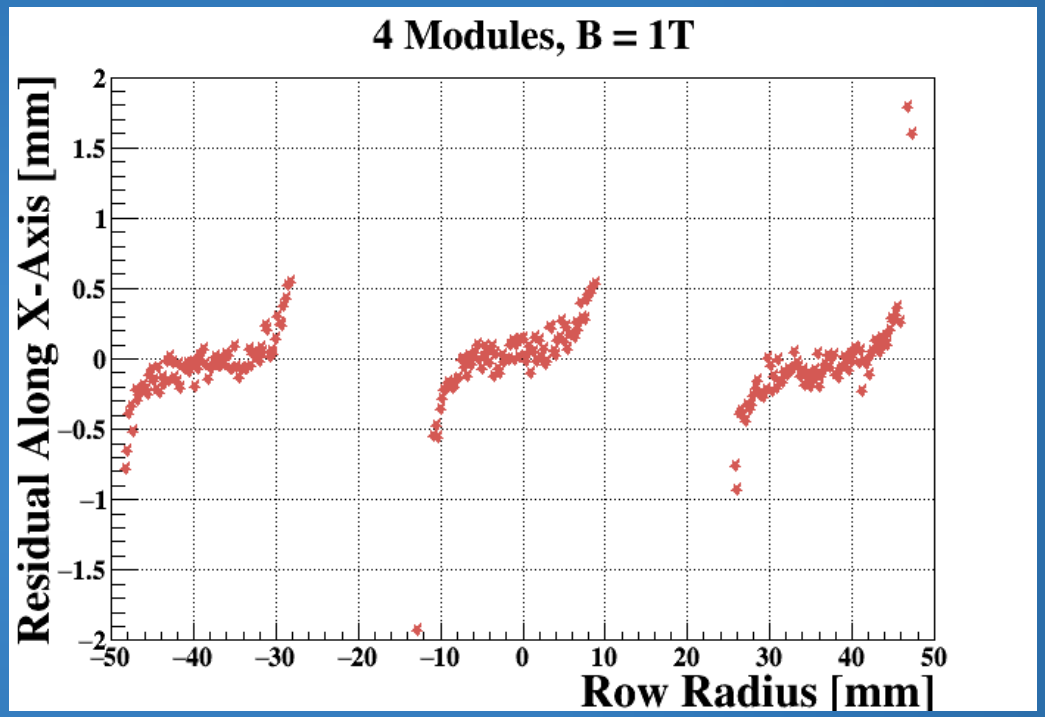
For the **simulated** Micromegas modules

B=0T

Distribution of the residuals as obtained in **Simulation**

Comparison of distortion between experiment and simulation





For the Micromegas modules on the **LPTPC endplate.**

B=1T

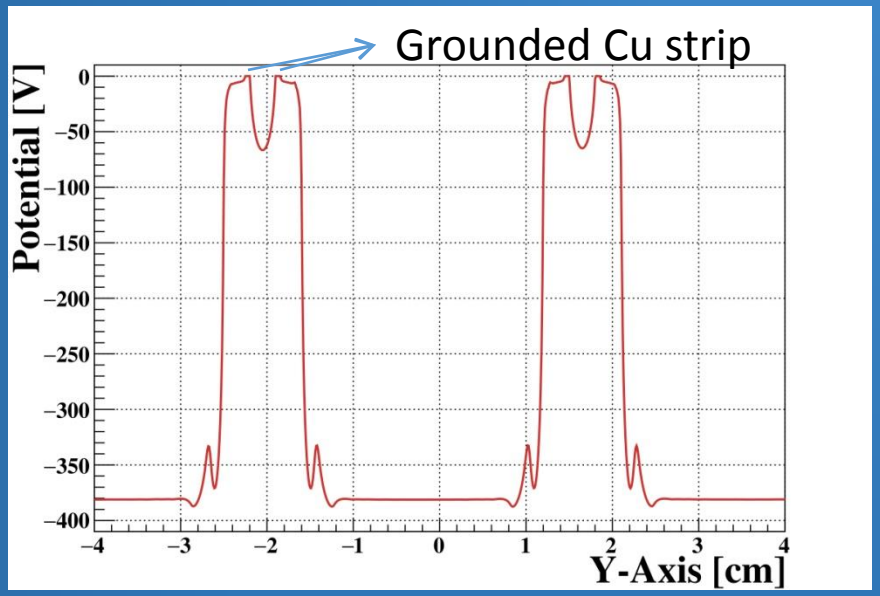
Distribution of the residuals as obtained in **Experiment** *without* alignment correction.

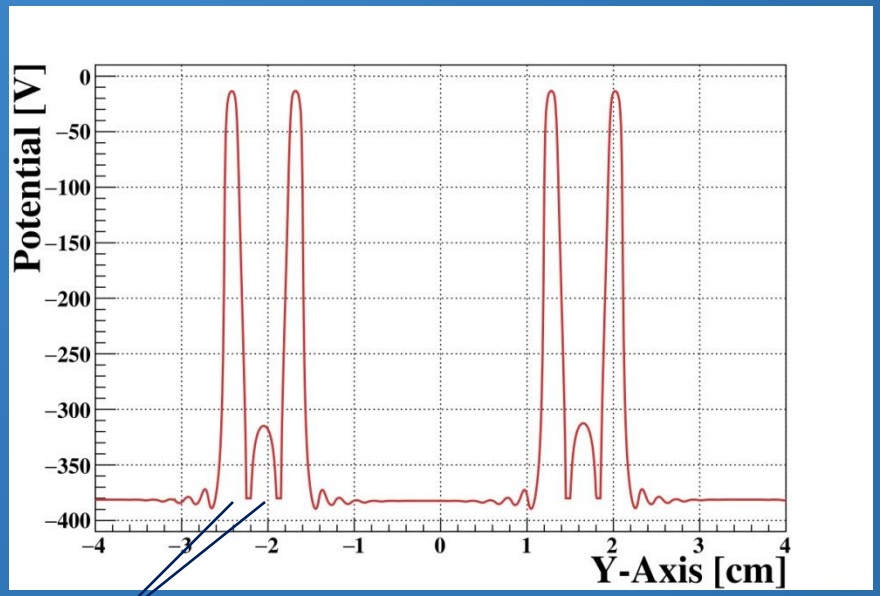
For the **simulated** Micromegas modules

B=1T

Distribution of the residuals as obtained in **Simulation**

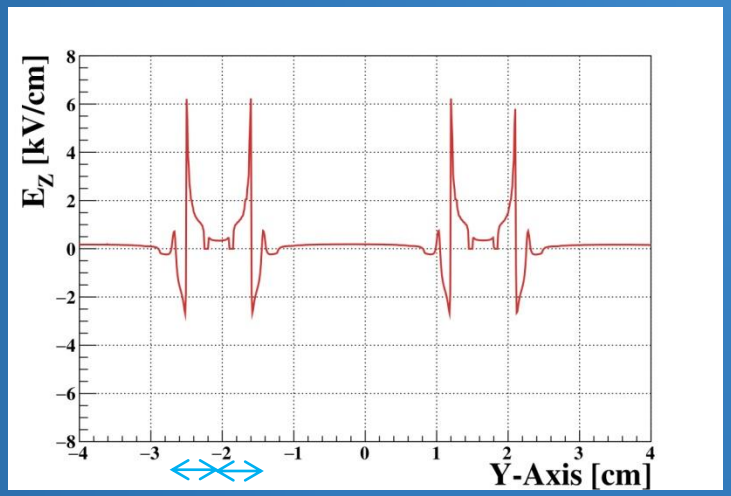
Alleviation of the electrostatic distortion

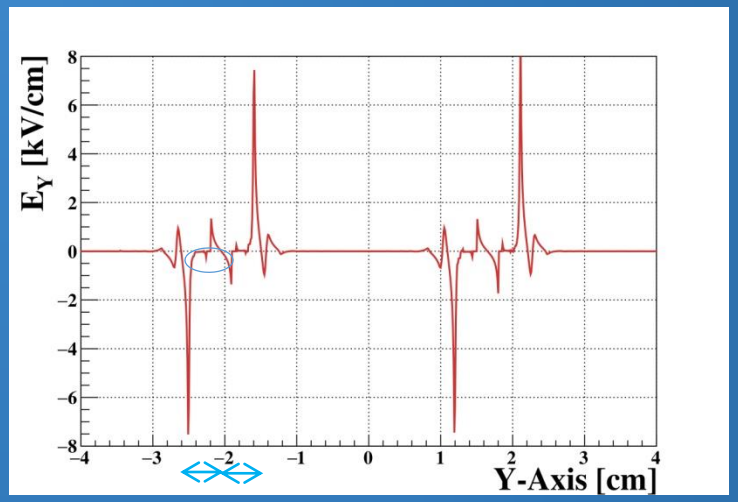


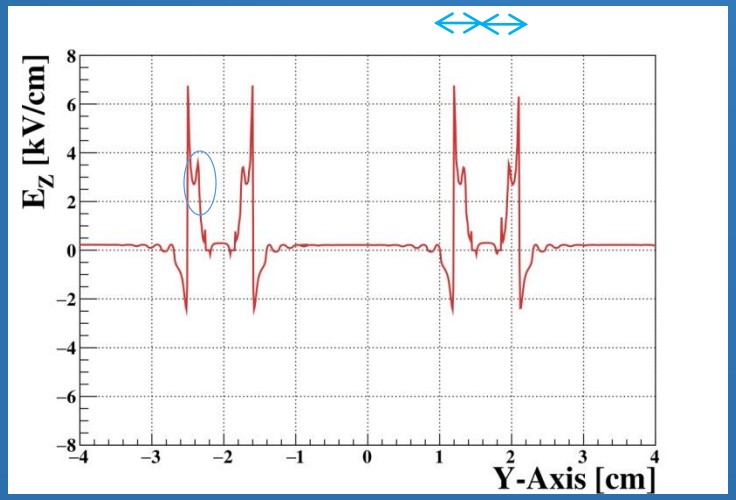


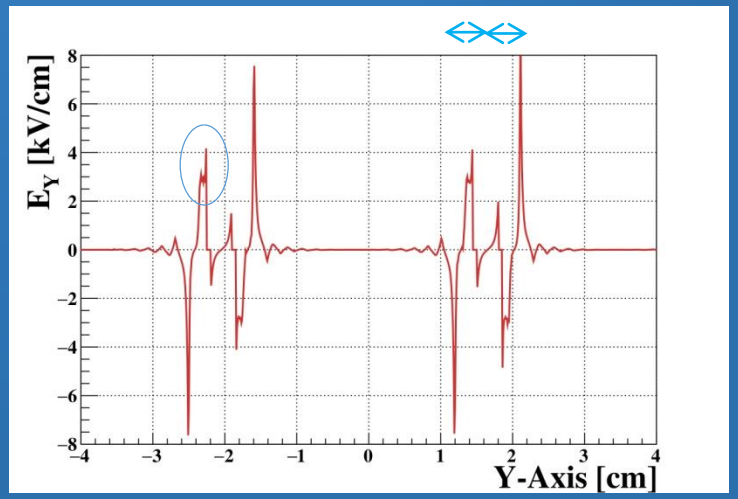
Cu strip at a given potential

Alleviation of the electrostatic distortion

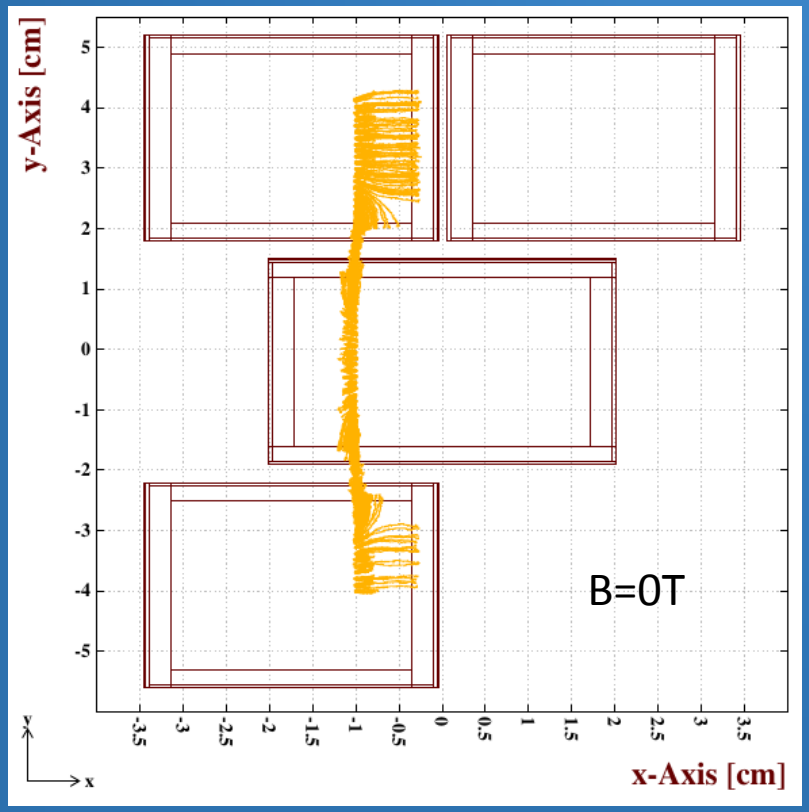


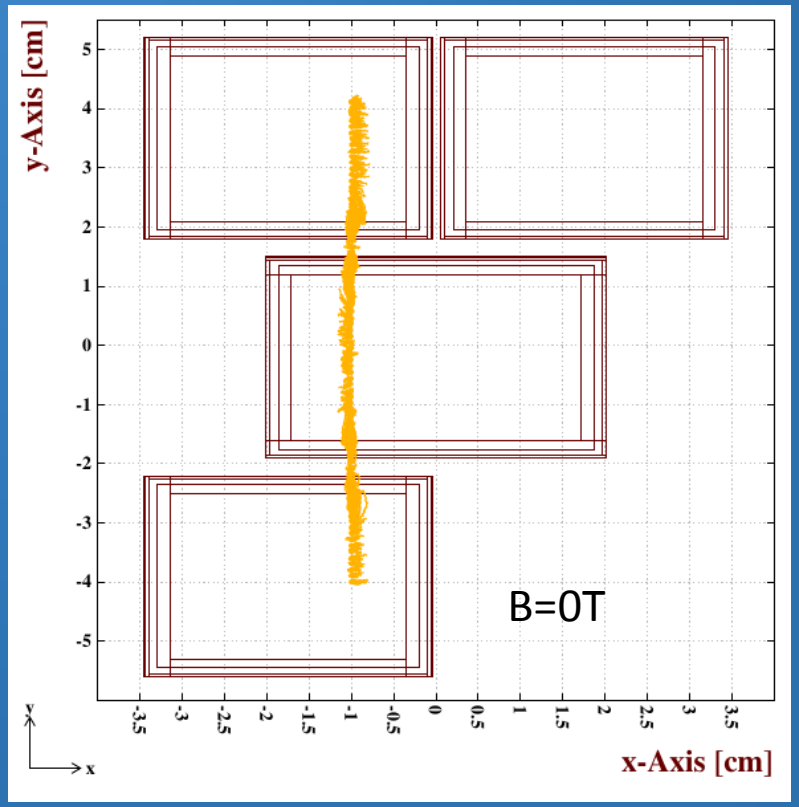




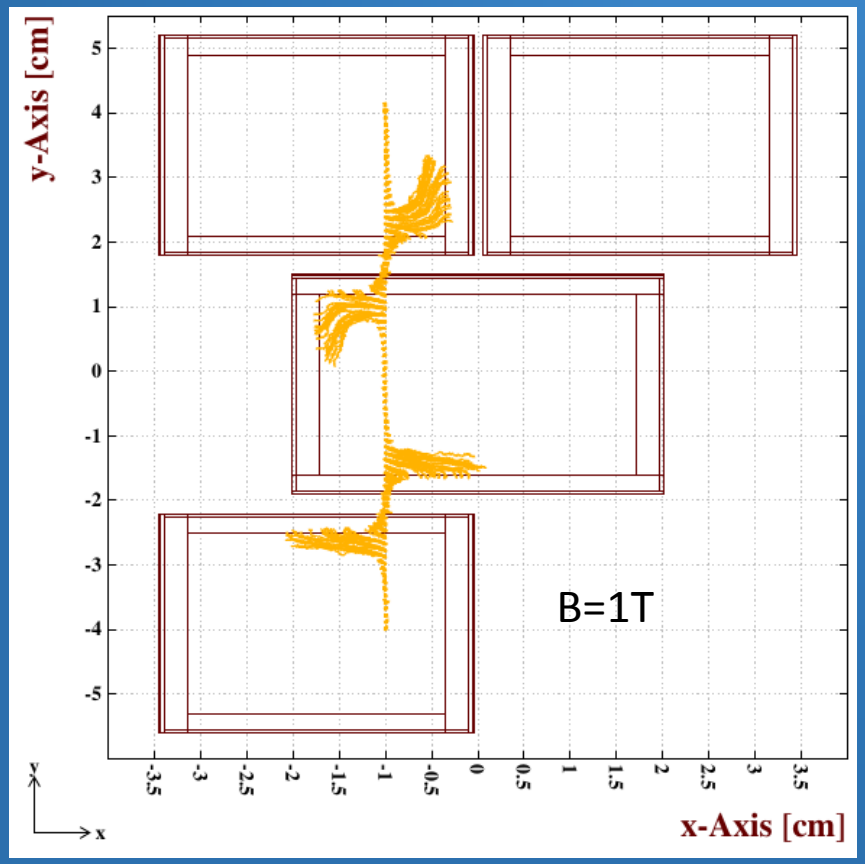


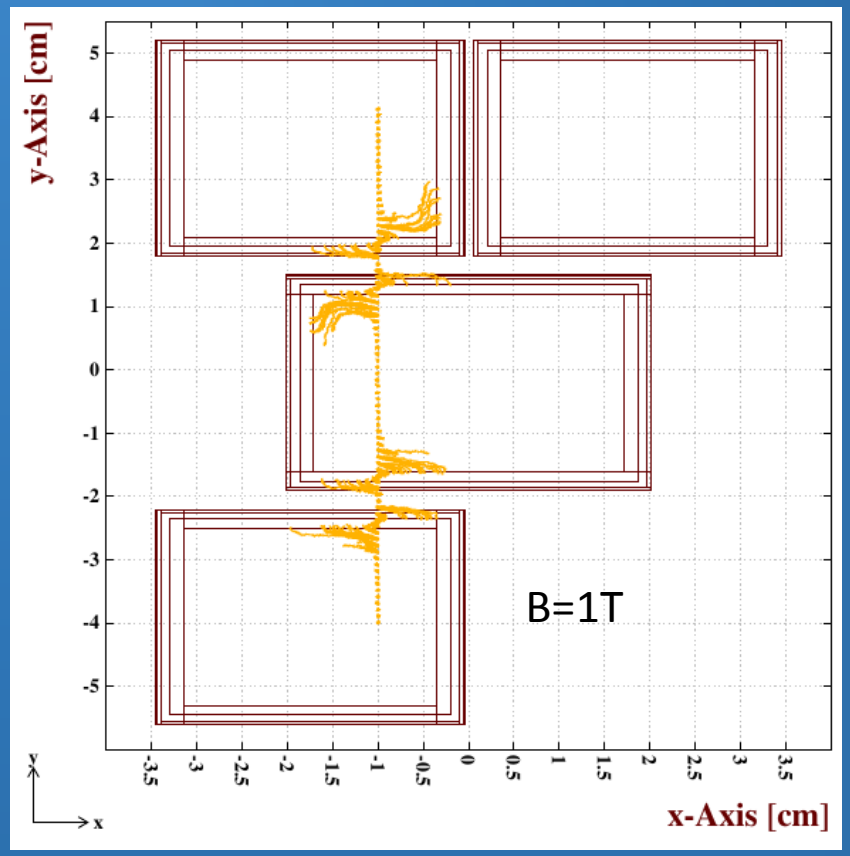
Alleviation of the electrostatic distortion



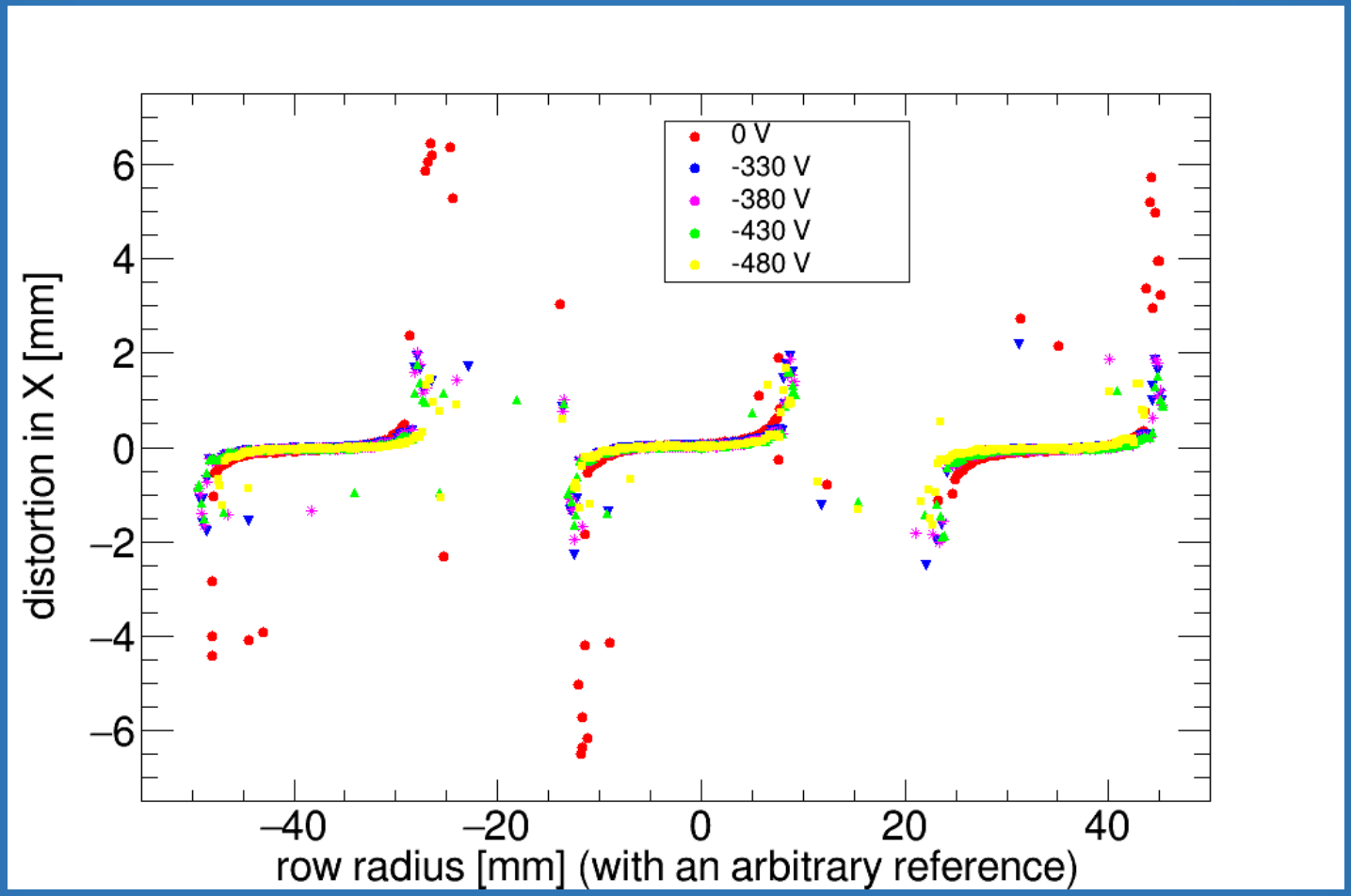


Alleviation of the electrostatic distortion





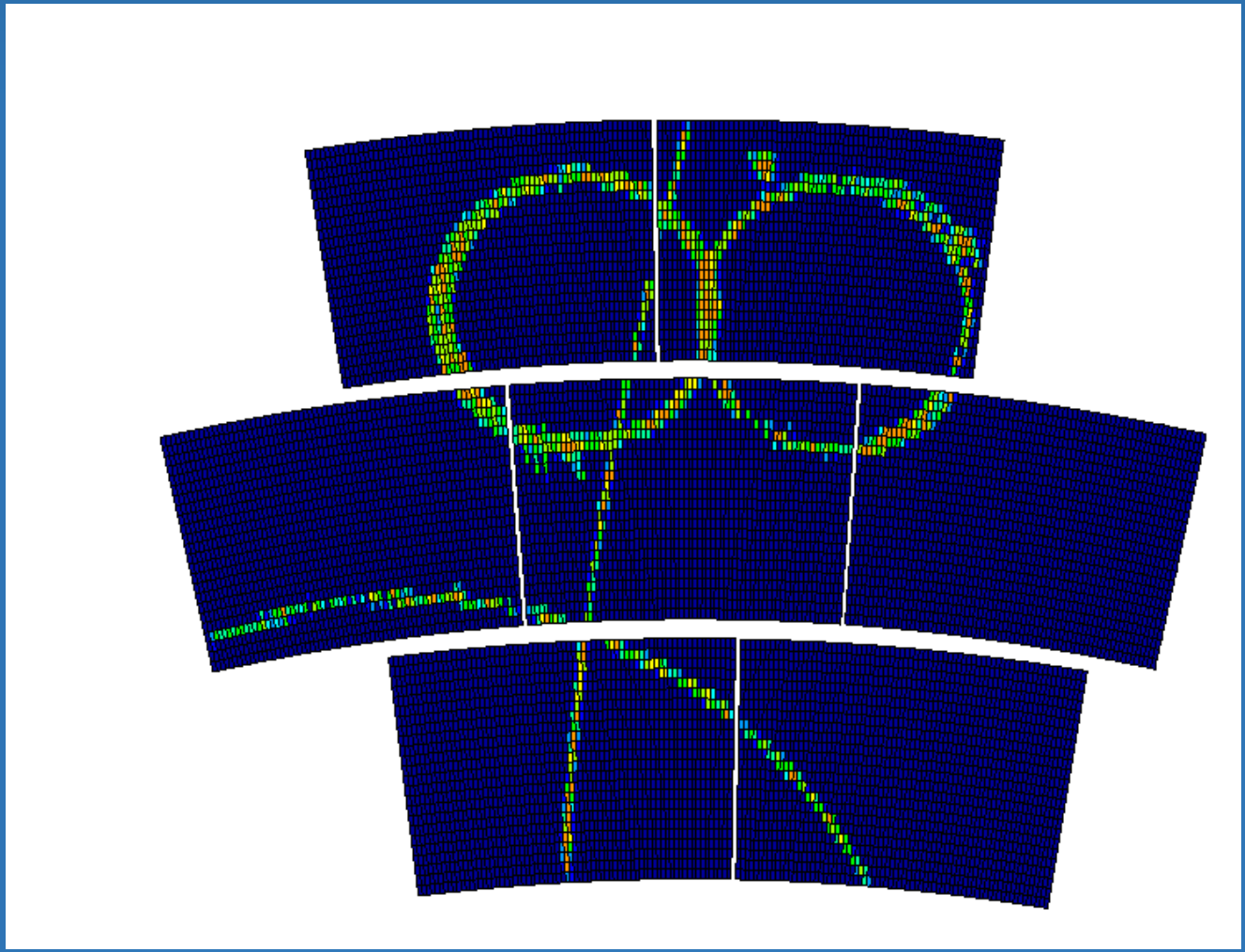
Effect potential of the peripheral frame on residue



Changing the potential of the copper frame has reduced the residuals of the pads near the edges.

Summary

- Track distortion has impact on the overall performance of a TPC.
- Distortion has been studied during analysis. Here we have tried to simulate distortion using numerical methods.
- The numerical study is done with a number of simplifications in geometry of the detector. Hence a direct comparison with experiment may not be applicable.
- The intrinsic detector parameters are, however, taken true to the experimental setup.
- Simulation matches the experimental trends and explains the behavior of distortion.
- The possibilities to mitigate distortion by biasing the peripheral frame has been tested in simulation.
- Further studies are in progress to improve the performance of the modules.



THANK YOU