

Performance of DESY GEM Module in Testbeam Measurements •

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DESY

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- GEM Module Design
- Testbeam Setup
- Field Distortions
 - Simulation
 - Measurement
- Single Point Resolution
- Momentum Resolution

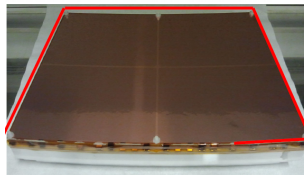
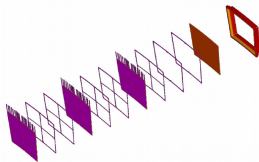
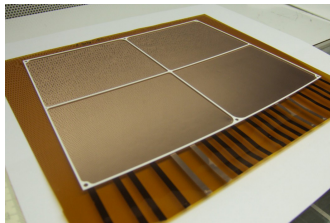
The DESY GEM Module

Goals:

- Minimal dead space
- Minimal material budget
- Smooth and even surface of GEM
- Stable HV operation

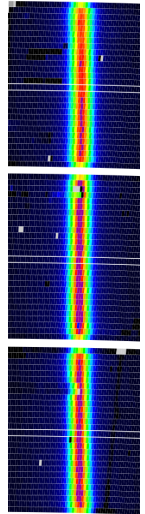
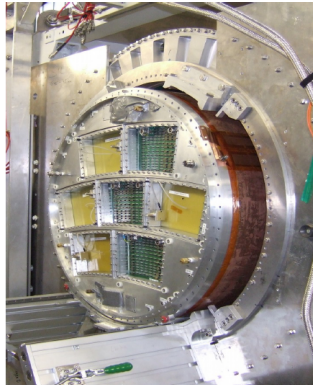
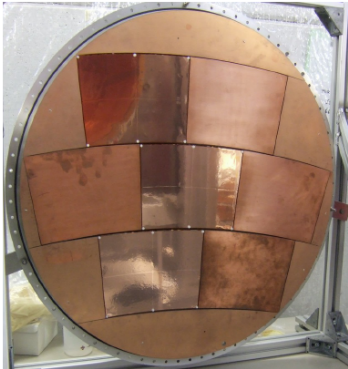
Solution:

- Divide anode side of GEM into 4 sectors $\Rightarrow$ HV stability
- No division on cathode side $\Rightarrow$ better field homogeneity
- Thin ceramic mounting grid $\Rightarrow$ good flatness of GEM
- Triple GEM stack
- Fully sensitive readout board $\rightarrow 4829$ pads ($1.26 \times 5.85 \text{ mm}^2$)
- Field shaping wire



DESY Testbeam Measurements

- Magnetic field of 0 or 1 T, electron beam up to 6 GeV
- 3 modules, half equipped
→ 7200 channels ALTRO readout electronics
- Lever arm of ~ 50 cm along the beam

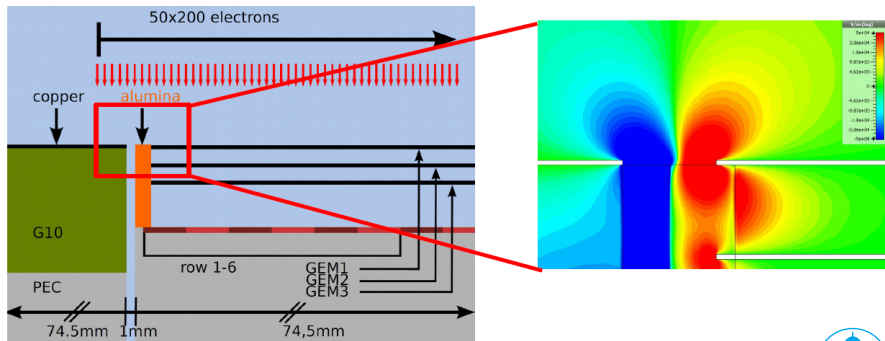


Simulation: GEM Module

Previous measurements showed field distortions at the border of the module.

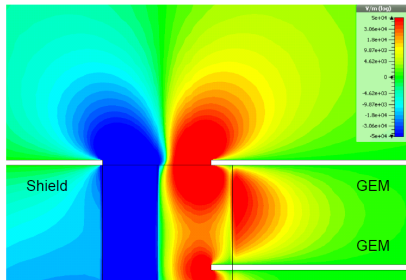
→ Simulation study to understand the observed behavior and optimize module design:

- Use finite element based software to simulate electrostatic fields (CSTTM)
- Use Garfield++ to drift electrons in that field and add constant B-field

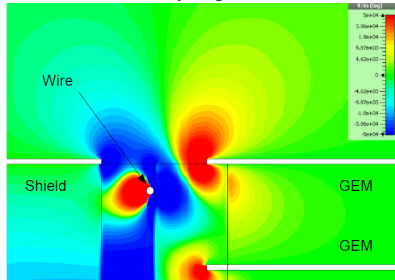


Simulation: Field Distortions

Module without modification



With field shaping wire



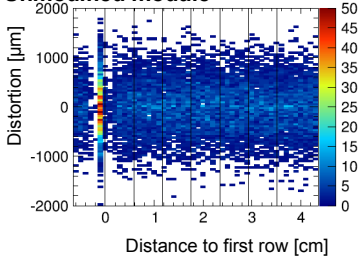
Study distortion of electron path:

- Start 200 electrons from start points which have a distance of 0.1mm and have the same distance to the module
- With 50 start positions you can cover the first 6 rows (first start point is 0.6 cm in front of the 1st row)
- Pad height: $h_{\text{Pad}} = 0.585 \text{ cm}$ (corresponds to the row height)

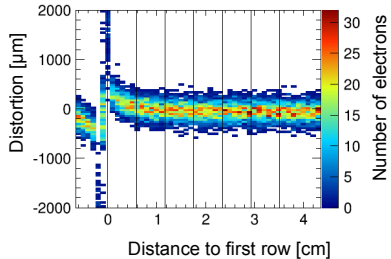
Field Distortions: Electron Position

$B=0T$

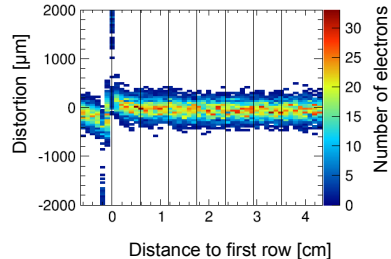
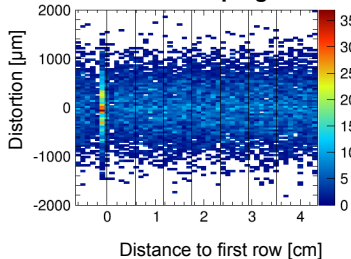
Unmodified module



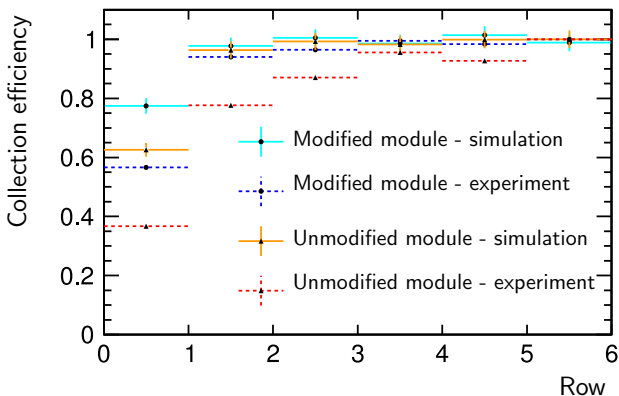
$B=1T$



Module with field shaping wire



Hit Efficiency: Comparison



- Good qualitative agreement: Improvement of charge collection of 30% both in simulation and measurement
- Absolute values different, both for charge efficiency and size of distortions, due to the simplifications in the simulation

- Data Quality
- Distortions
- Distortion Correction
- Single Point Resolution
- Track Angle

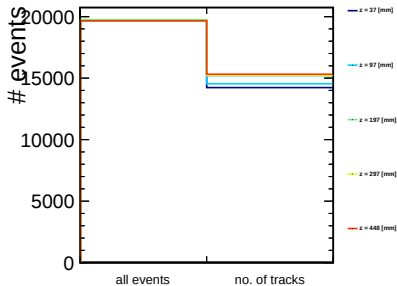
Disclaimer:

- First complete pass of data sets through improved reconstruction chain and new analysis tools
- Still some improvements in reconstruction planned
- Better tuned tracking still outstanding
- Some features appeared that we need to understand

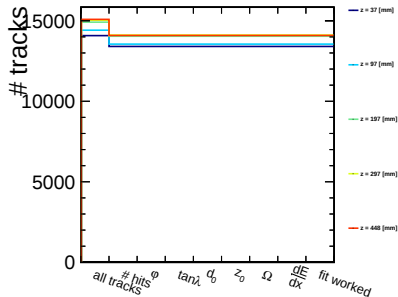


Data Quality I

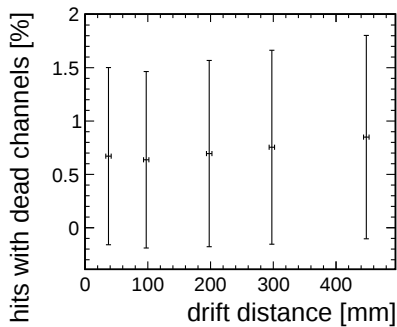
Event selection:
→ 1 track events



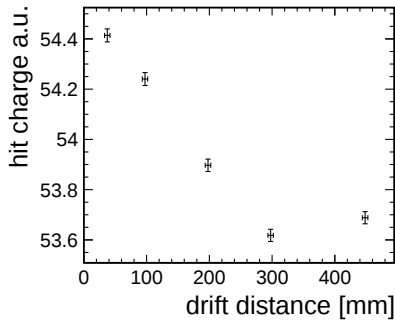
Track selection:
→ # track hits > 60 (out of 84)



Hit quality

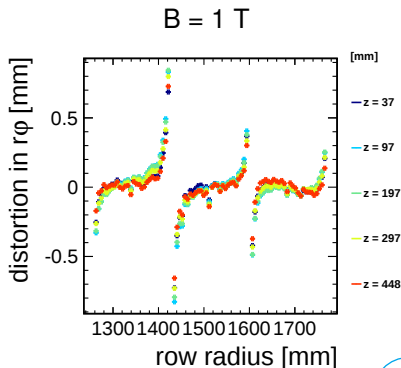
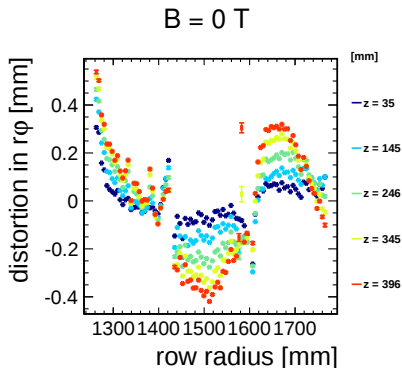


Charge stability



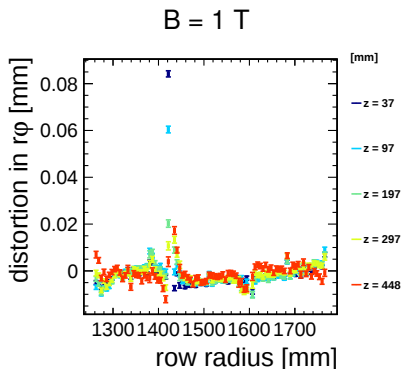
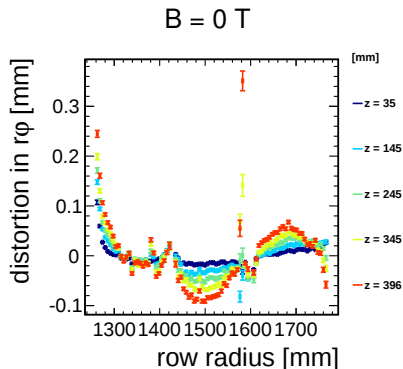
Measurement: Module Boundaries

- Field distortions are observed at the boundaries of the modules
- No or small z dependency is expected. Not the case for $B=0\text{T}$!
- $B=0\text{T}$ needs further study (dedicated tracking with straight tracks still pending)



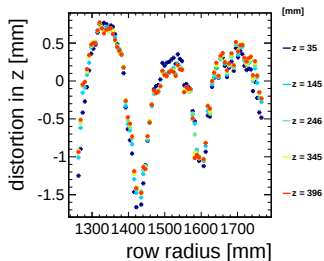
Distortion Correction

- Correction method is data driven
- Evaluate and correct on a run by run basis
- Correction works better for B=1T

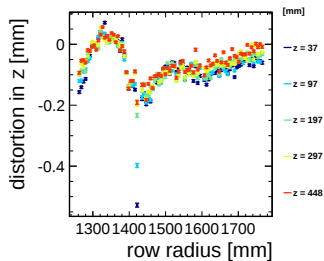
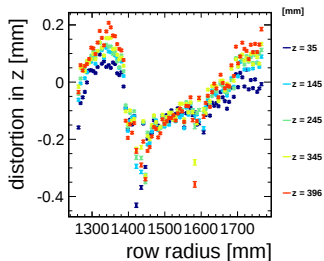
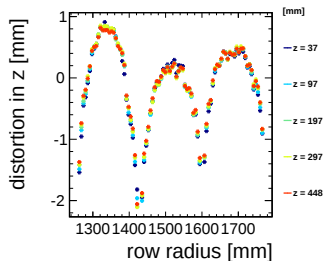


Distortions in z Direction

B = 0 T



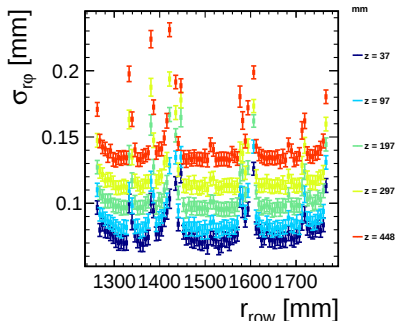
B = 1 T



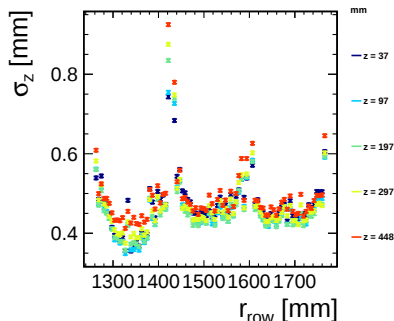
Single Point Resolution

- Distortions affect angle of track along row
- Outer rows with large distortion show worse resolution
- Distortions need to be corrected for proper estimation of resolution

along the row

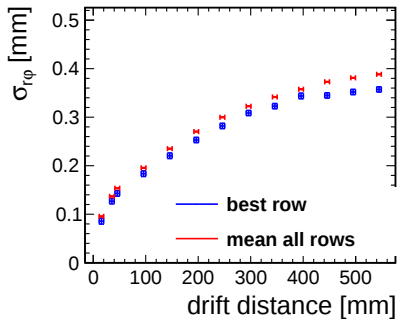


along drift direction

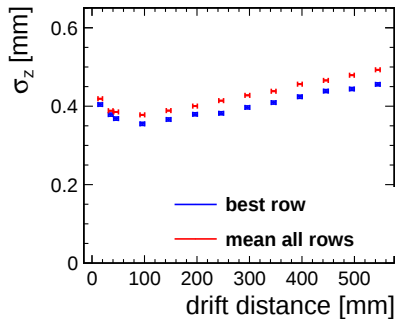


Measurement: Resolution @ 0 T

along the row

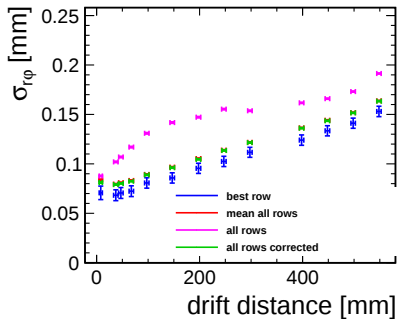


along drift direction

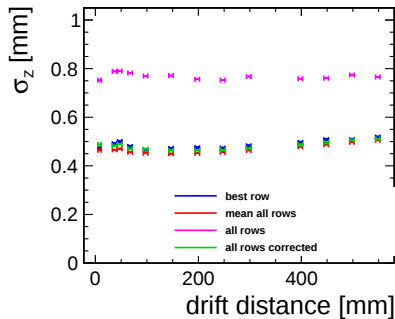


Measurement: Resolution @ 1 T

along the row

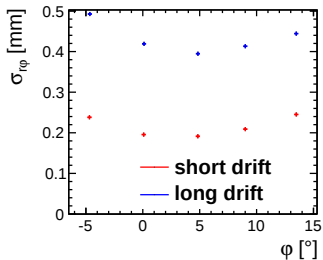


along drift direction

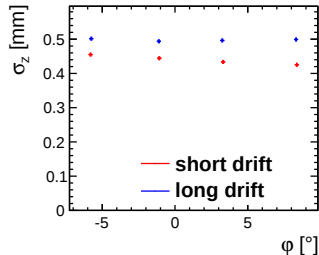
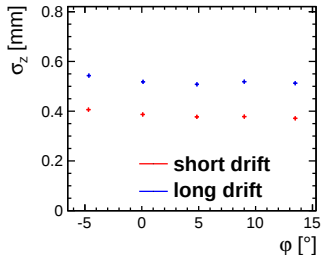
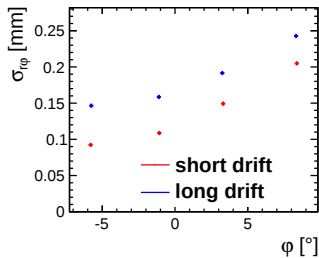


Resolution with Track Angle

B = 0 T



B = 1 T



Status:

- Successfull test beam campaign:
 - Very stable operation of GEM modules
 - A lot of data taken
- Improvements in the reconstruction and analysis have been made and are still ongoing

Outlook:

- Measuring momentum resolution: Ideally with external reference
- Study field distortions, find better correction procedure
- Further improve module designs to limit distortion at the borders
- Design and test gating schemes

Next: Laser System Measurements

- Simulation of laser calibration system
- Photodots on cathode
- Tool to measure field distortions
- Measurement starts next week

