# Perfomance of DESY GEM Module in Testbeam

# Measurements .

A. Münnich
DESY
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HELMHOLTZ GEMEINSCHAFT

DESY

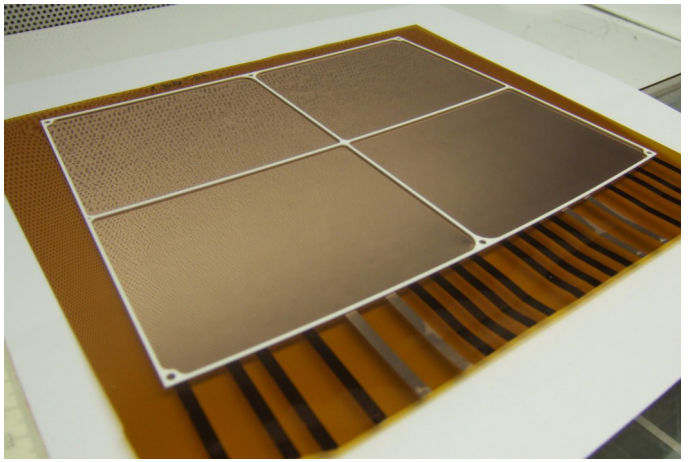
# Overview

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

# The DESY GEM Module

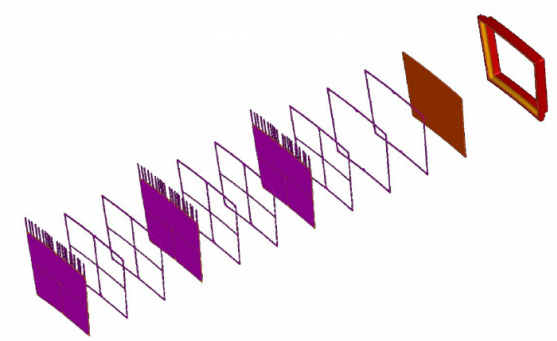
## Goals:

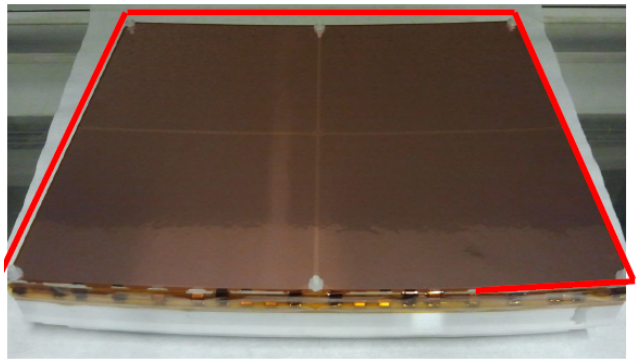
- Minimal dead space
- Minimal material budget
- Smooth and even surface of GEM
- Stable HV operation



## Solution:

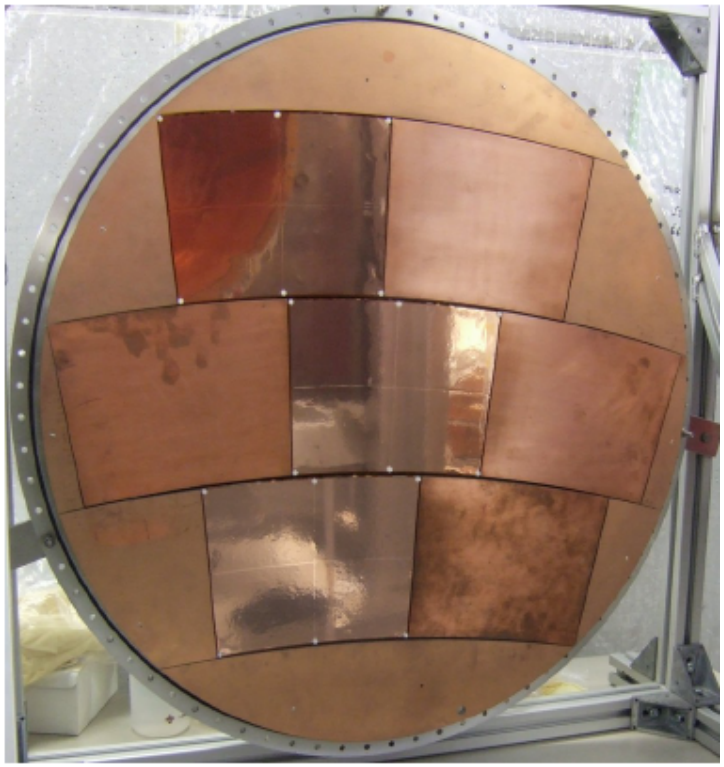
- Divide anode side of GEM into 4 sectors $\Rightarrow$ HV stability
- No division on cathode side $\Rightarrow$ better field homogeneity
- Thin ceramic mounting grid $\Rightarrow$ good flatness of GEM
- Triple GEM stack
- Fully sensitive readout board $\rightarrow$ 4829 pads ($1.26 \times 5.85$ mm$^2$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

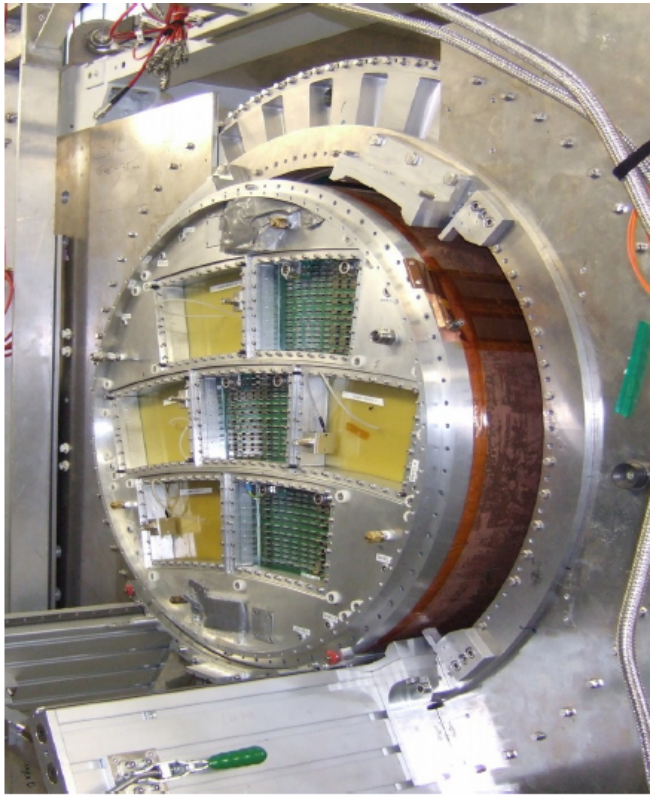


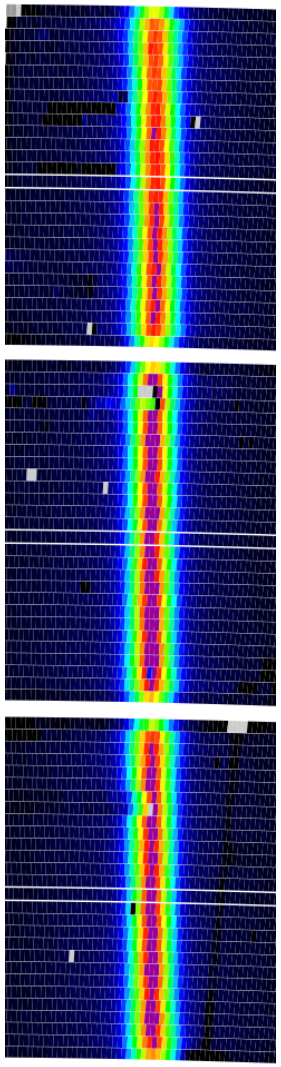


# DESY Testbeam Measurements

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



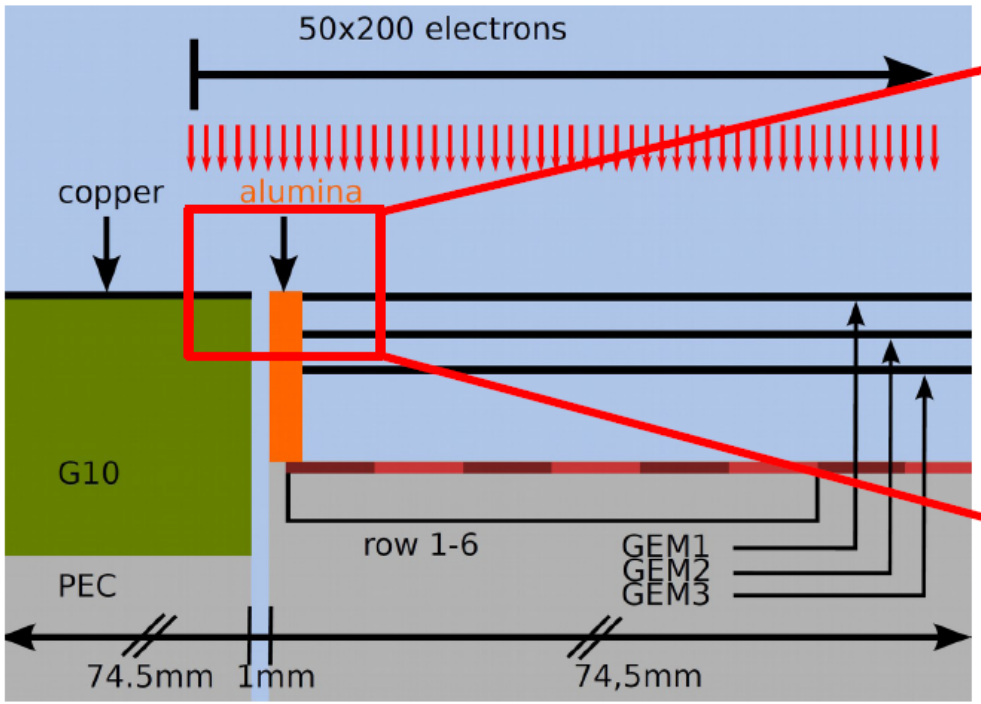


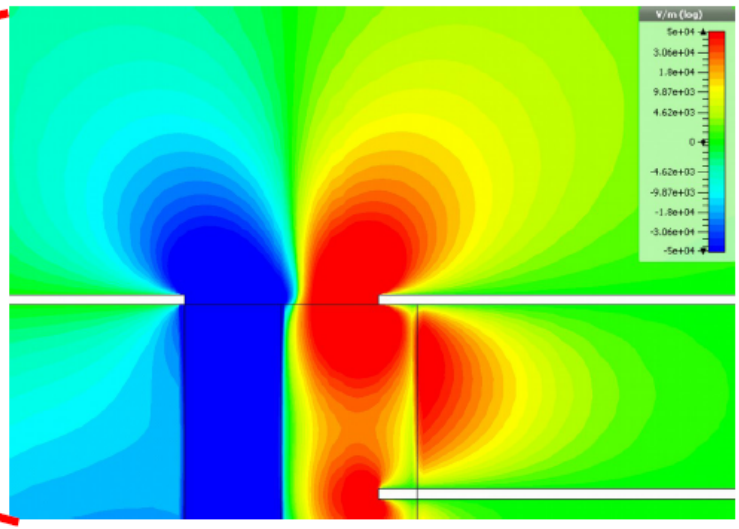


# Simulation: GEM Module

Previous measurements showed field distortions at the border of the module.
→ Simulation study to understand the observed behavior and optimize module design:

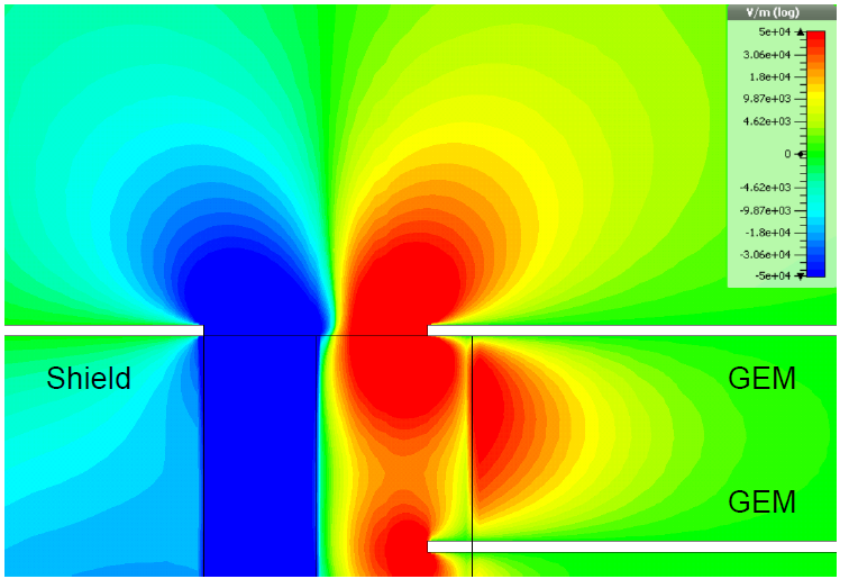
- Use finite element based software to simulate electrostatic fields (CST$^{\mathrm{TM}}$)
- Use Garfield++ to drift electrons in that field and add constant B-field



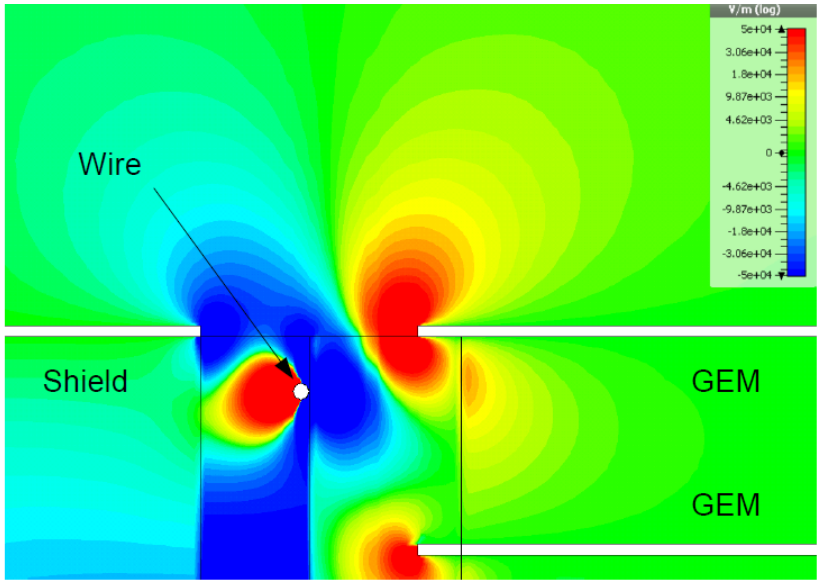



# Simulation: Field Distortions

Module without modification




With field shaping wire




Study distortion of electron path:

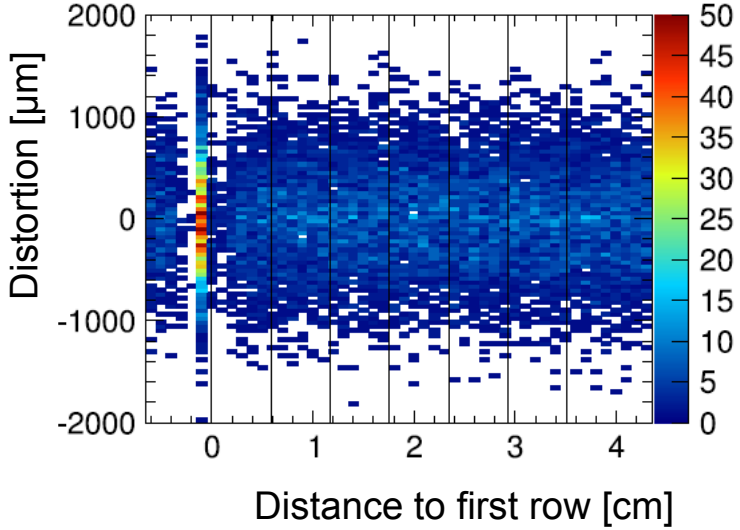
- Start 200 electrons from start points which have a distance of 0.1mm and have the same distance to the module
- With 50 start positions you can cover the first 6 rows (first start point is 0.6 cm in front of the 1st row)
- Pad height: hPad = 0.585 cm (corresponds to the row height)

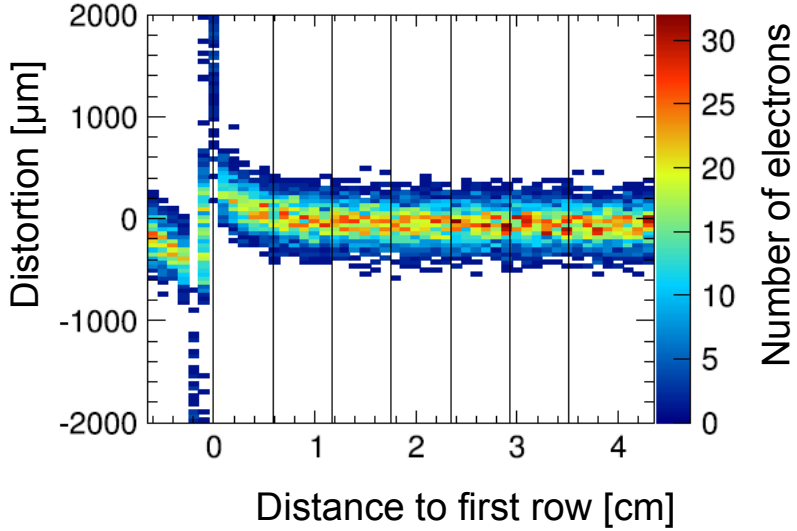
# Field Distortions: Electron Position

*B=0T*

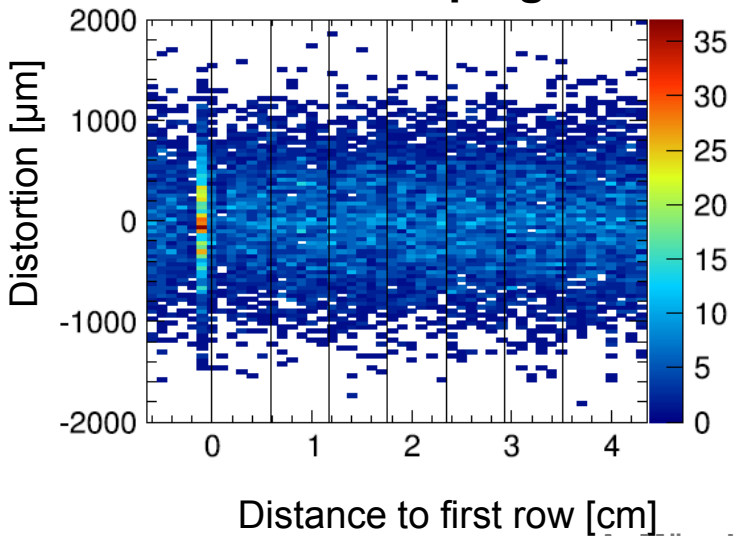
*B=1T*

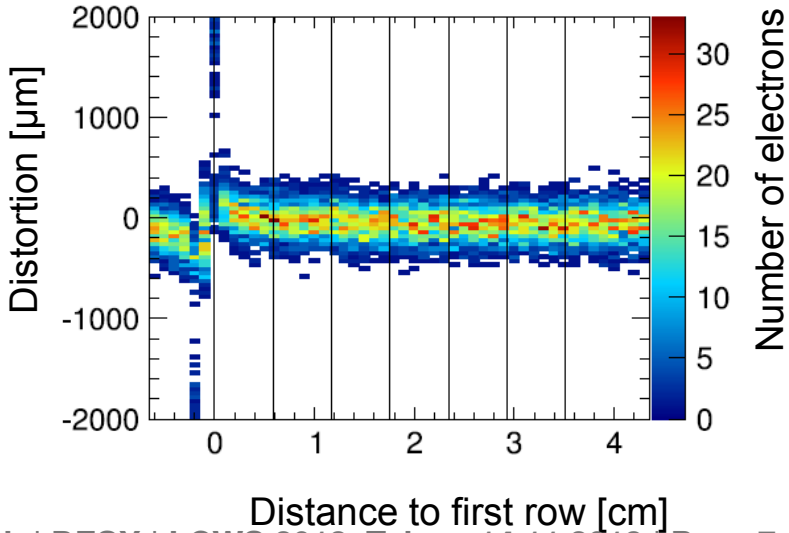
**Unmodified module**



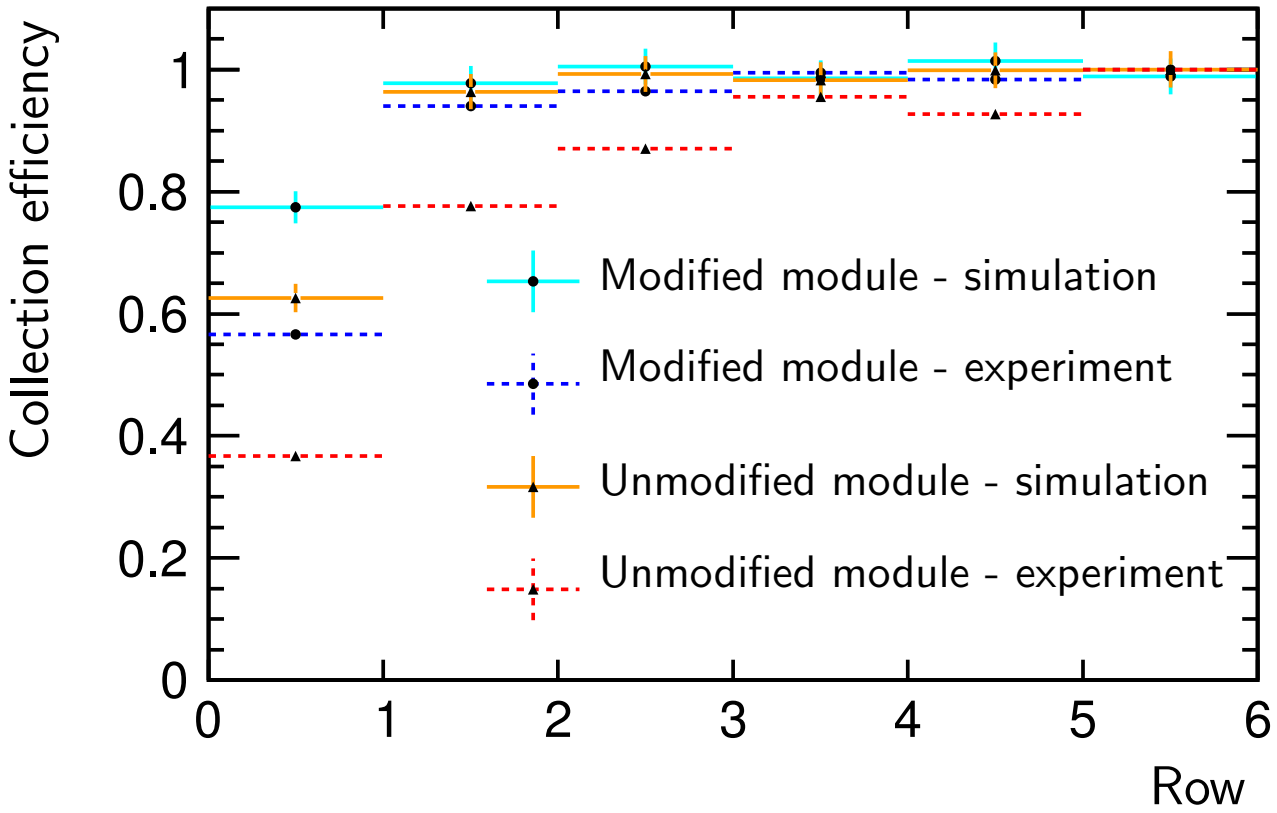




**Module with field shaping wire**



# Hit Efficiency: Comparison




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

# Analysis Results

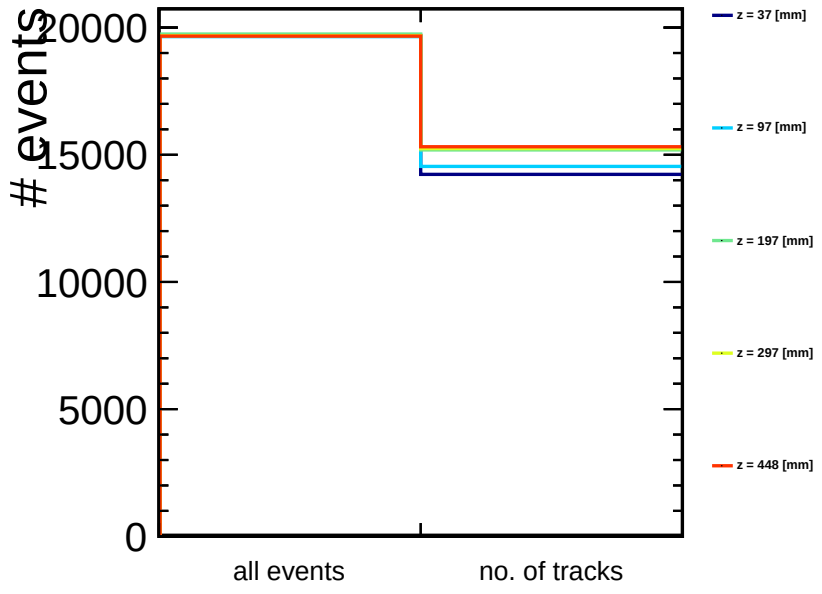
- Data Quality
- Distortions
- Distortion Correction
- Single Point Resolution
- Track Angle

**Disclaimer**:

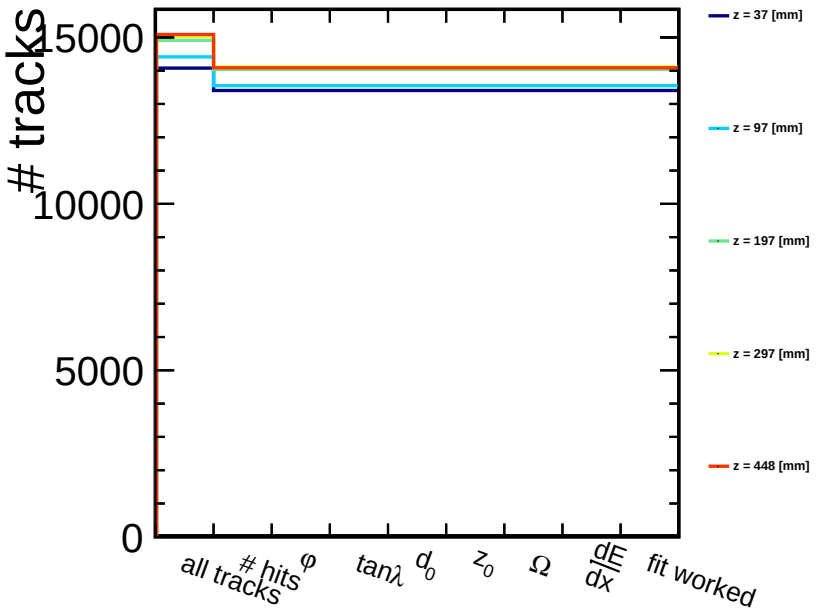
- First complete pass of data sets through improved reconstruction chain and new analysis tools
- Still some improvements in reconstruction planned
- Better tuned tracking still outstanding
- Some features appeared that we need to understand

# Data Quality I

Event selection:
→ 1 track events

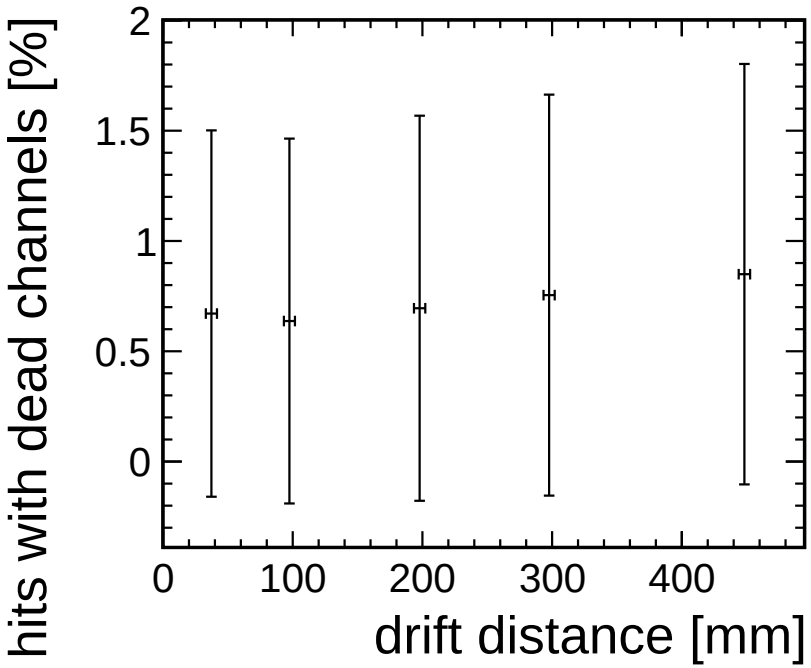



Track selection:
→ # track hits > 60 (out of 84)

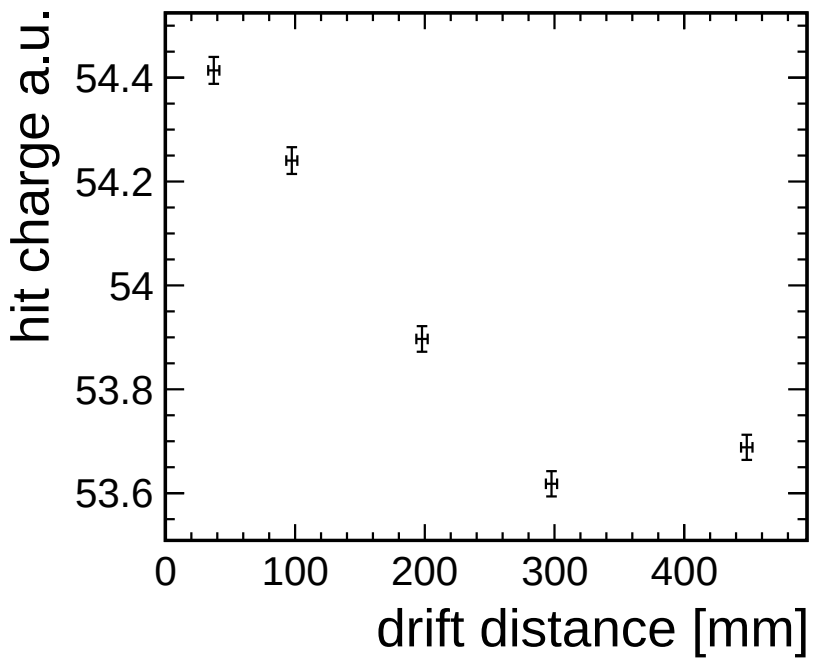


# Data Quality II

Hit quality

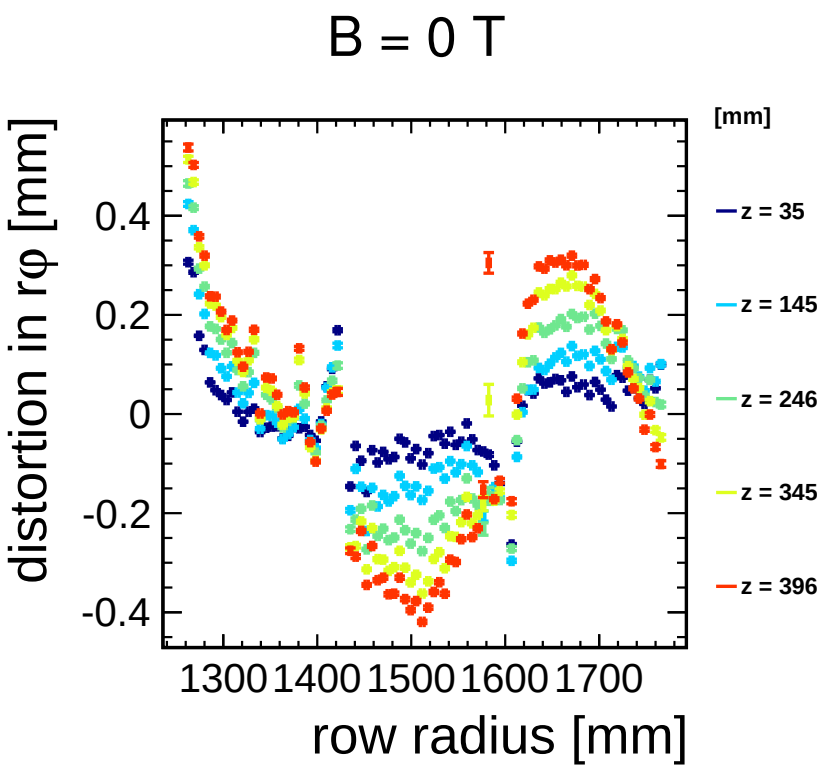


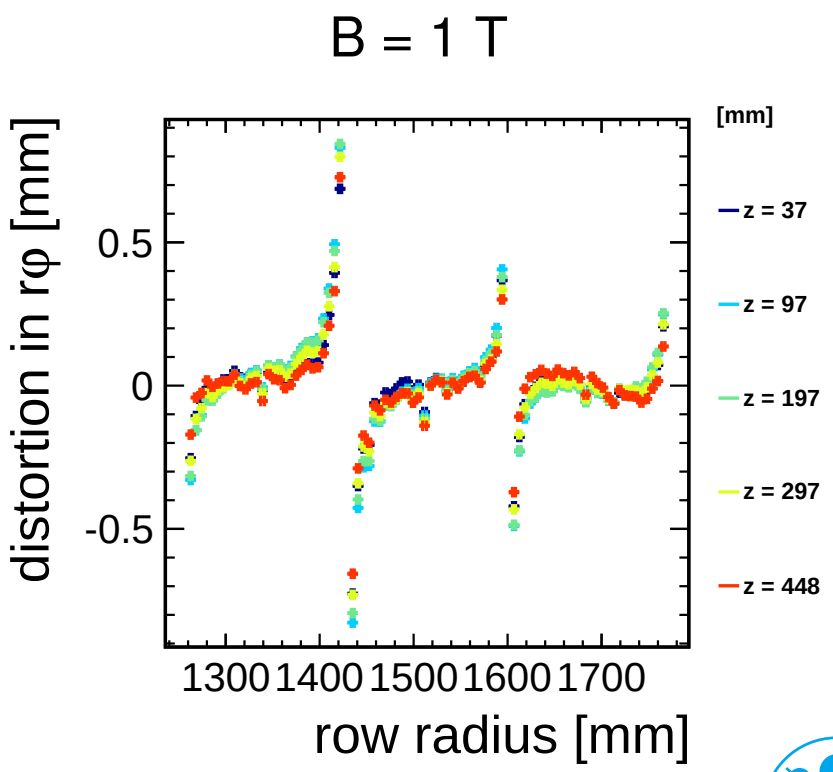

Charge stability



# Measurement: Module Boundaries

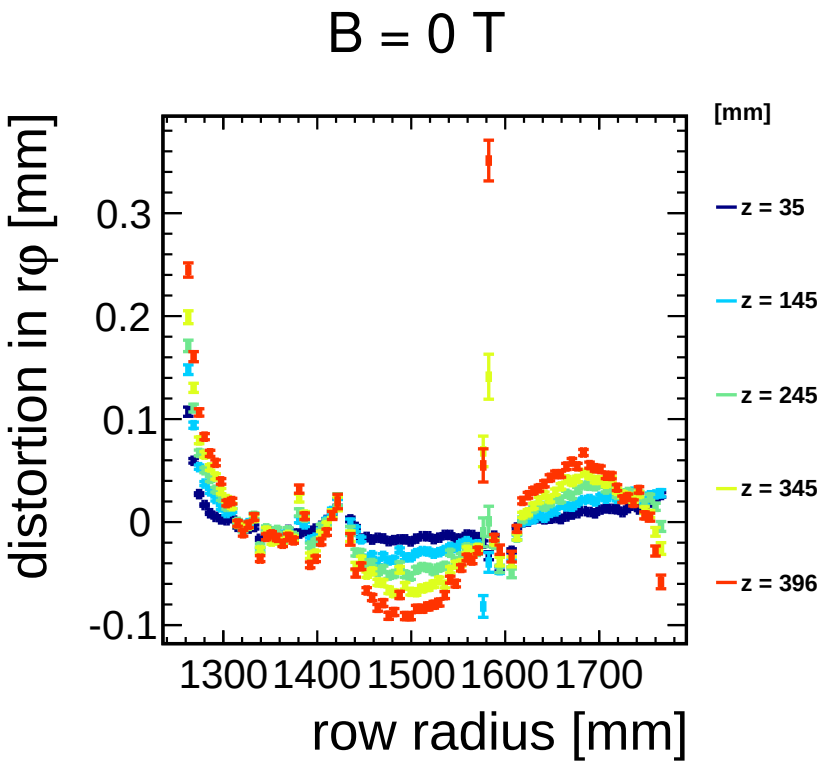
- Field distortions are observed at the boundaries of the modules
- No or small z dependency is expected. Not the case for B=0T!
- B=0T needs further study (dedicated tracking with straight tracks still pending)

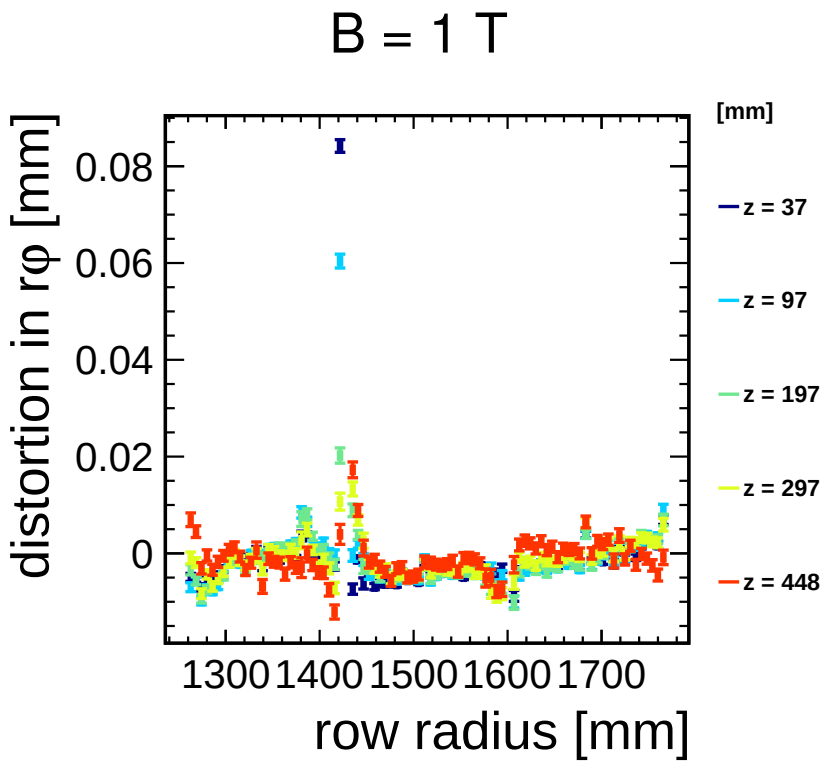


# Distortion Correction

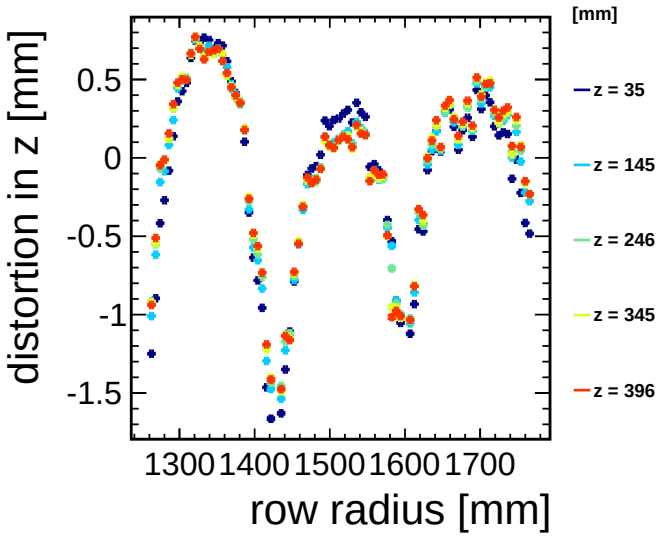
- Correction method is data driven
- Evaluate and correct on a run by run basis
- Correction works better for B=1T



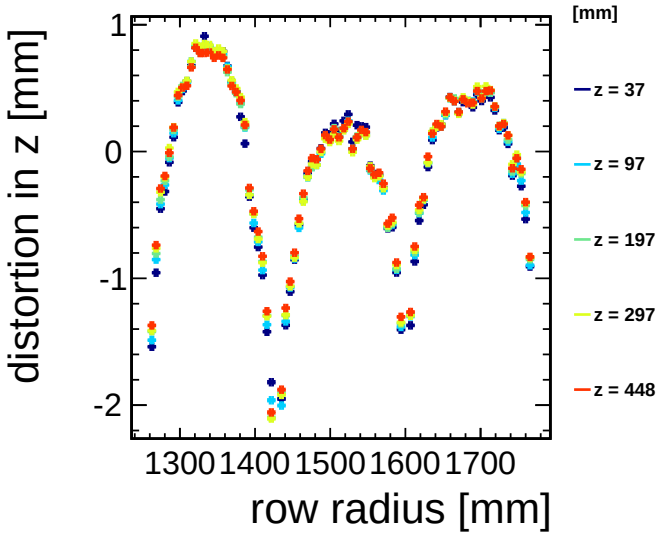



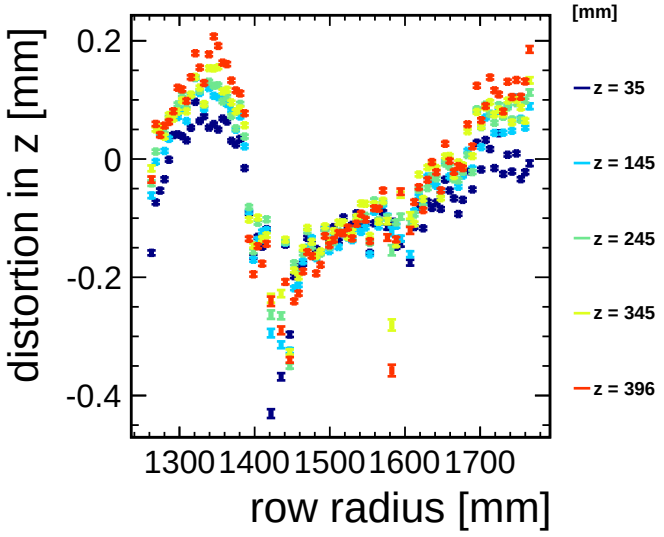
# Distortions in z Direction

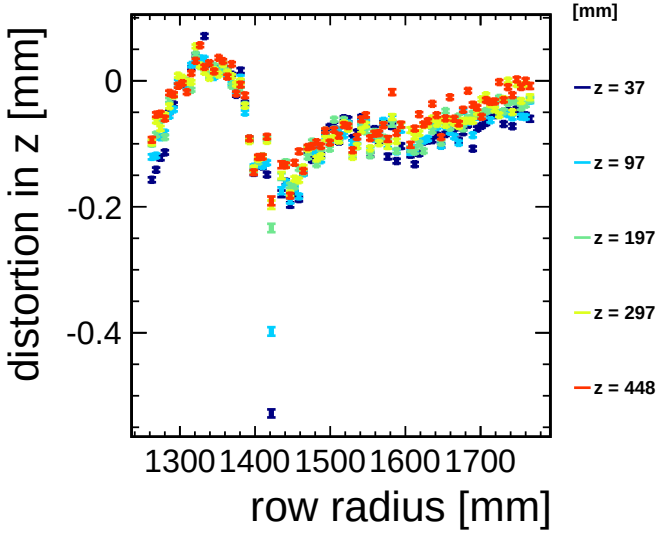
B = 0 T




B = 1 T



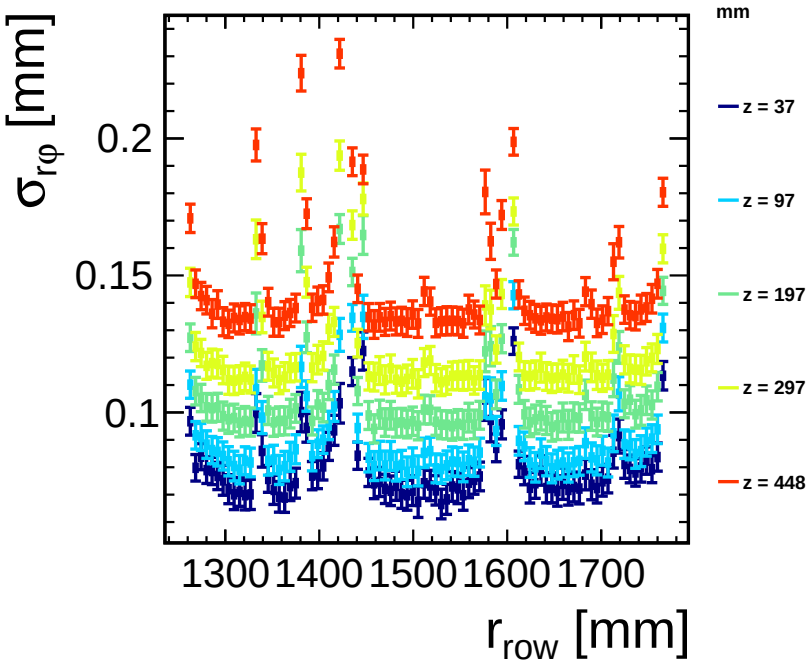



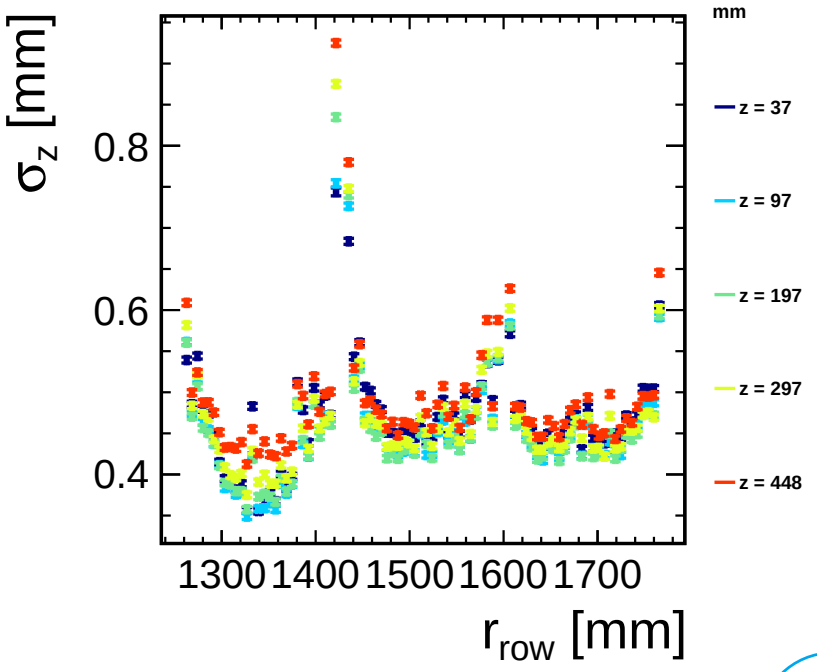
# Single Point Resolution

- 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

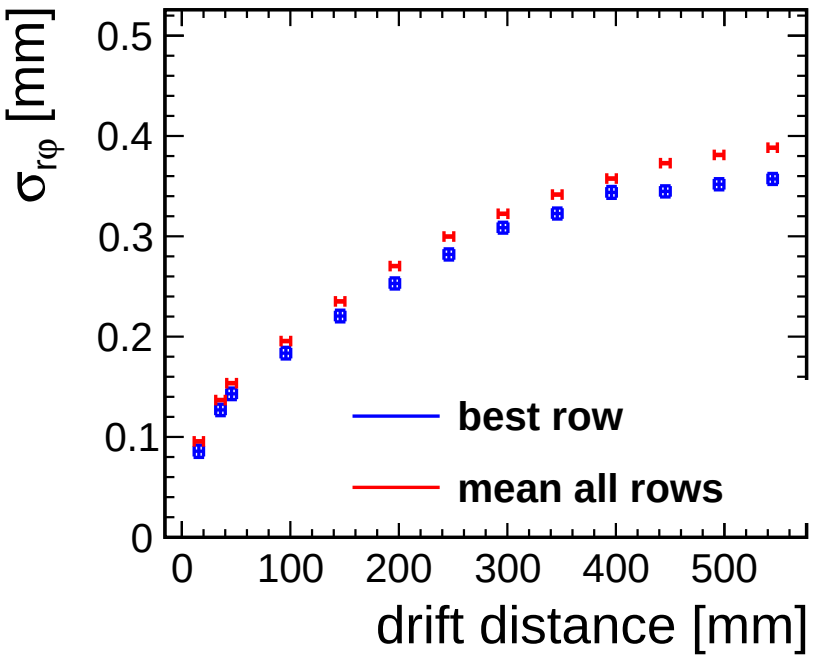



along drift direction

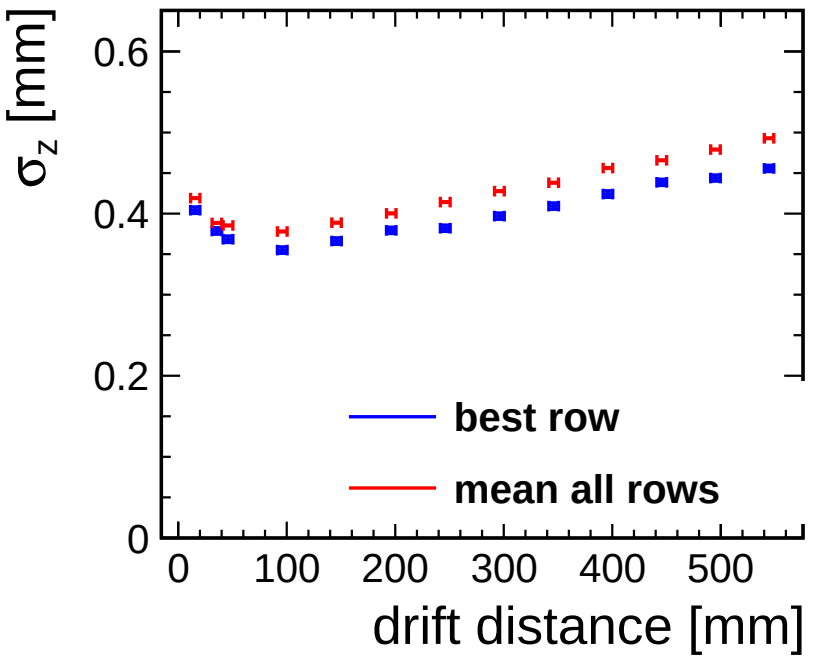


# Measurement: Resolution @ 0 T

along the row

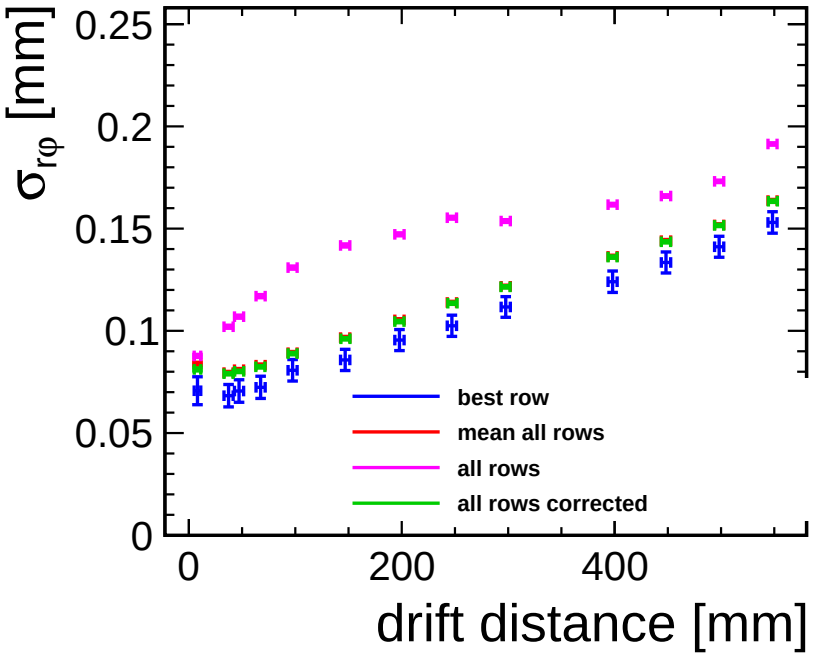



along drift direction

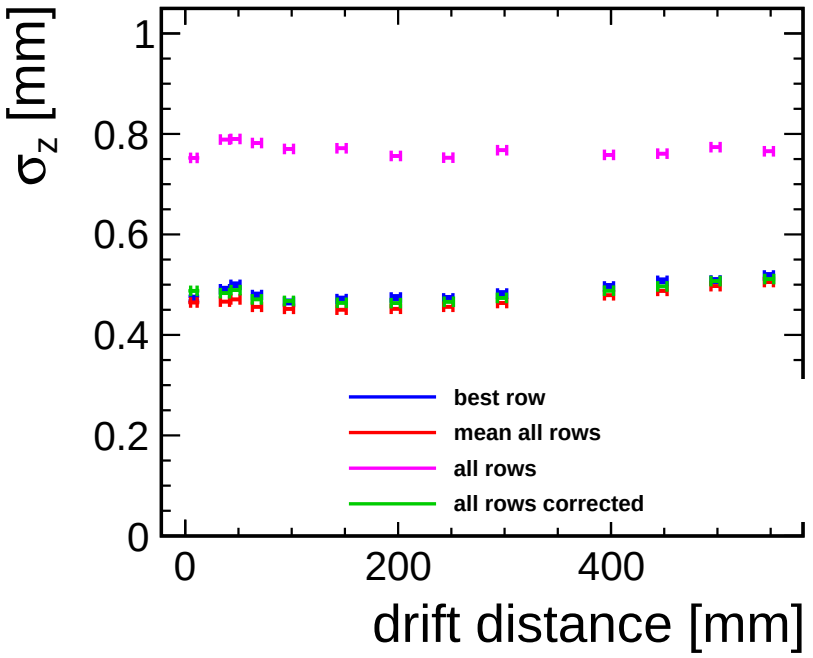


# Measurement: Resolution @ 1 T

along the row

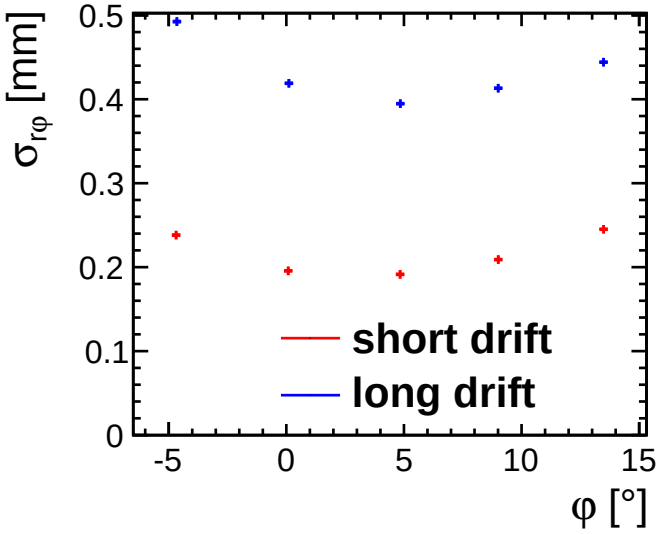



along drift direction

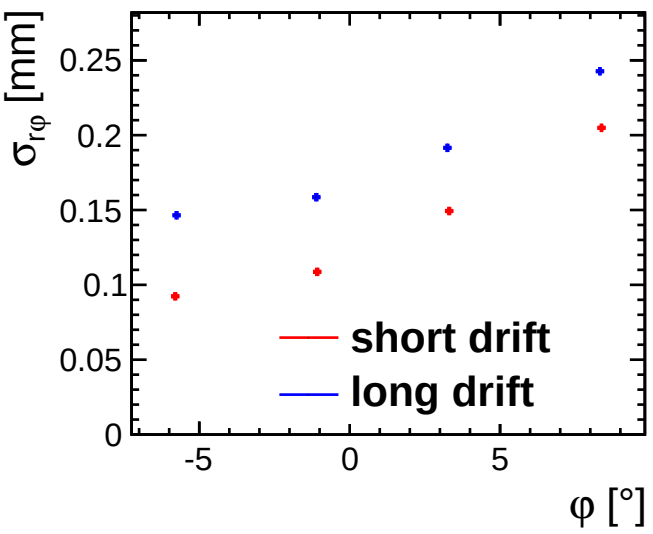


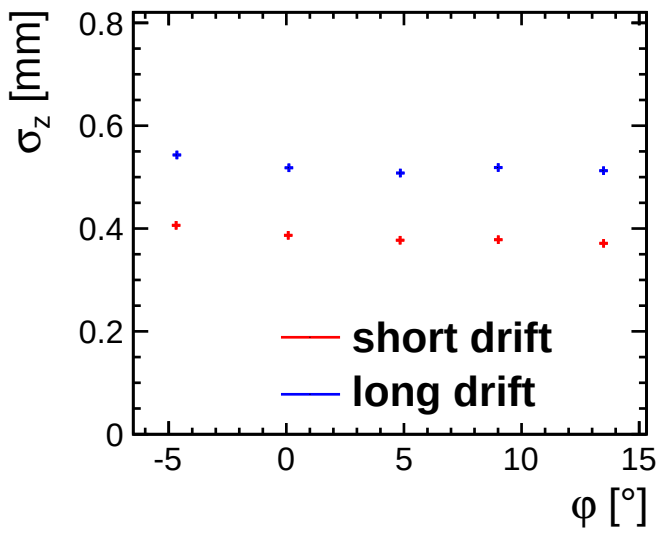
# Resolution with Track Angle

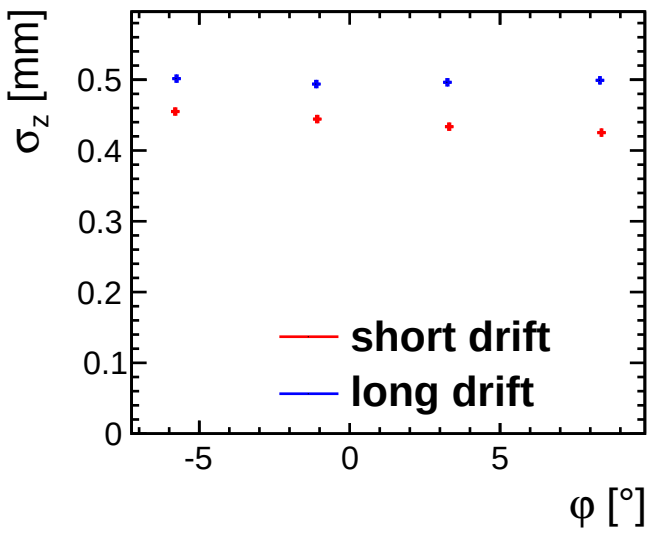
B = 0 T




B = 1 T



# Summary

## 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 proceedure
- 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