

Beam Test with the DESY GridGEM Module

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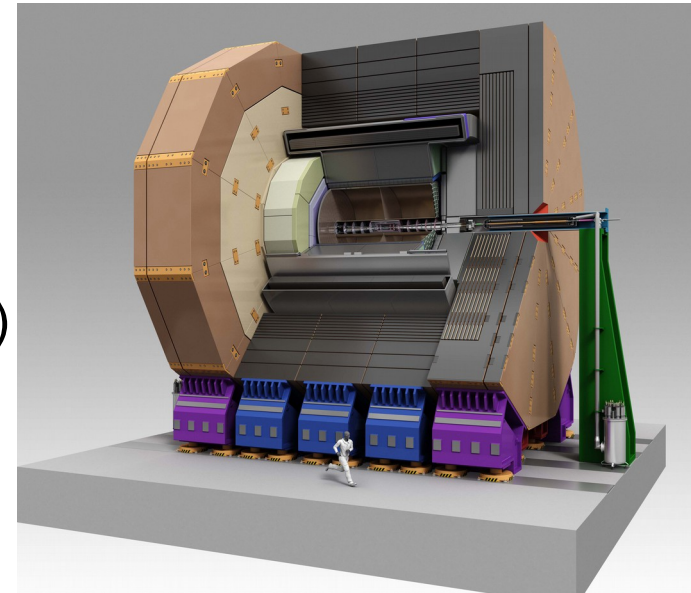
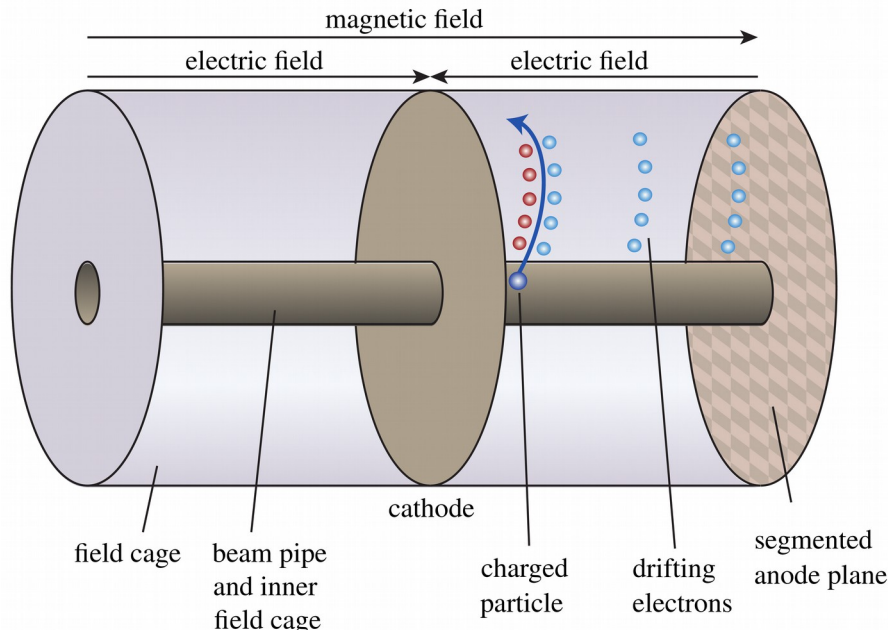


- Motivation
- DESY GridGEM Module
- Test Beam Setup
- Field Distortion Simulations
- Experimental Results
 - Hit efficiency
 - Distortion corrections
 - Transverse point resolution
- Conclusion and Outlook



Motivation

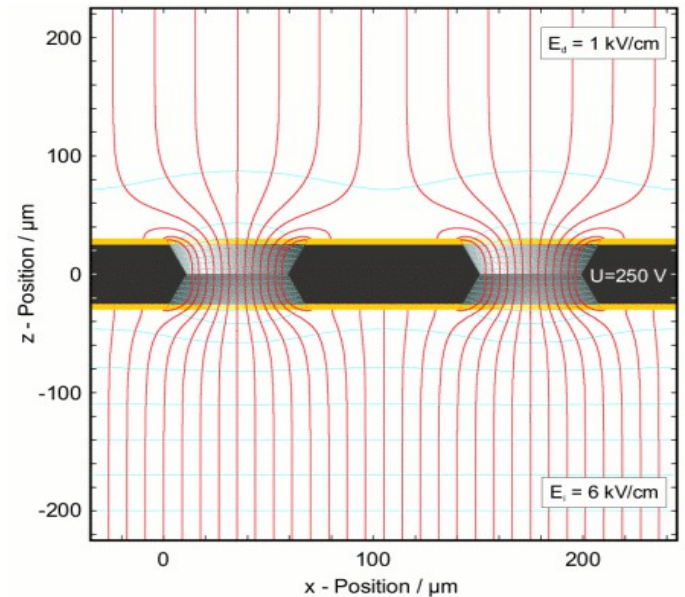
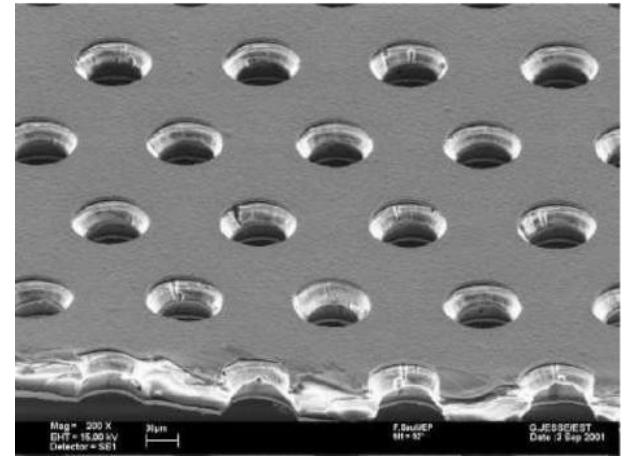
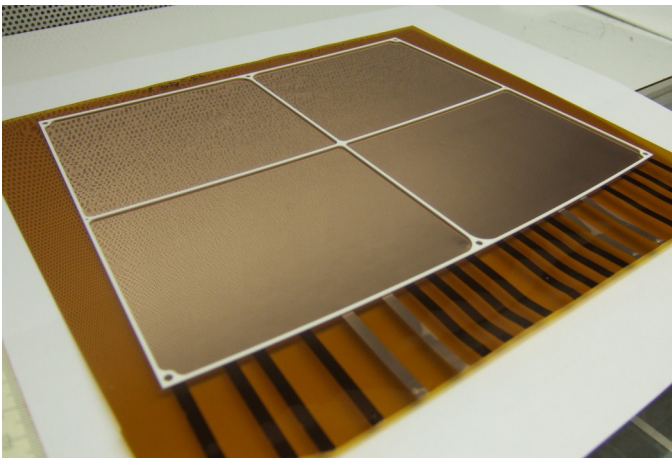
- The International Large Detector (ILD) foresees a Time Projection Chamber as the central tracking device
 - ~200 Track points per particle
 - Maximal drift length of 2.25 m
 - Momentum resolution $\delta(1/p_t) \approx 10^{-4} / \text{GeV}/c$
- Need micro pattern gaseous detectors (MPGD)
 - Gas Electron Multiplier (GEM)
 - Micro Meshed Gaseous Detectors (Micromegas)



<http://ilcild.org/>

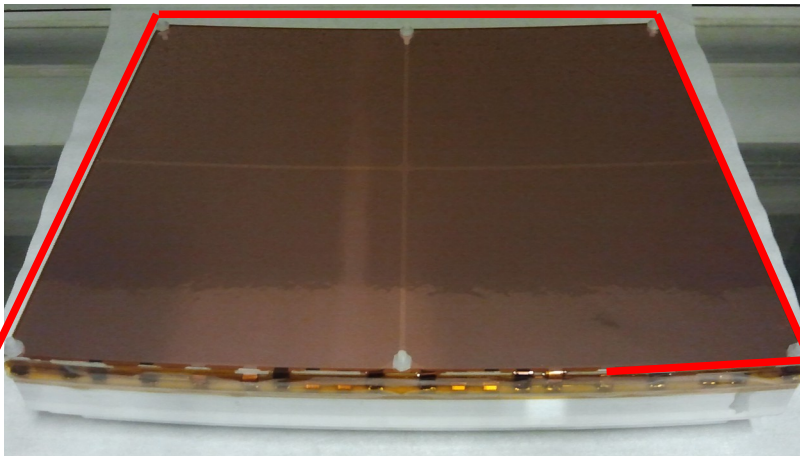
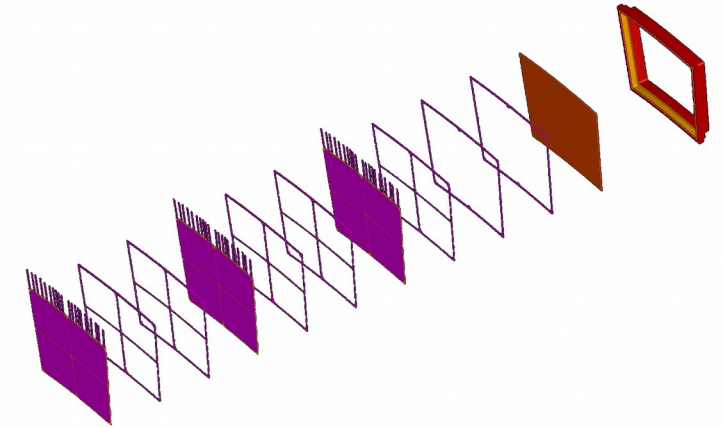
DESY GridGEM Module

- GEM module with integrated support structure
- Aluminum Oxide grid
 - Lightweight material
 - Minimal dead space
- Flatness of GEMs is an important issue
 - More homogenous electric field
 - Less gain variation → better dE/dx resolution
- Topologies of standard $10 \times 10 \text{ cm}^2$ CERN GEMs and GEMs with ceramic grid comparable



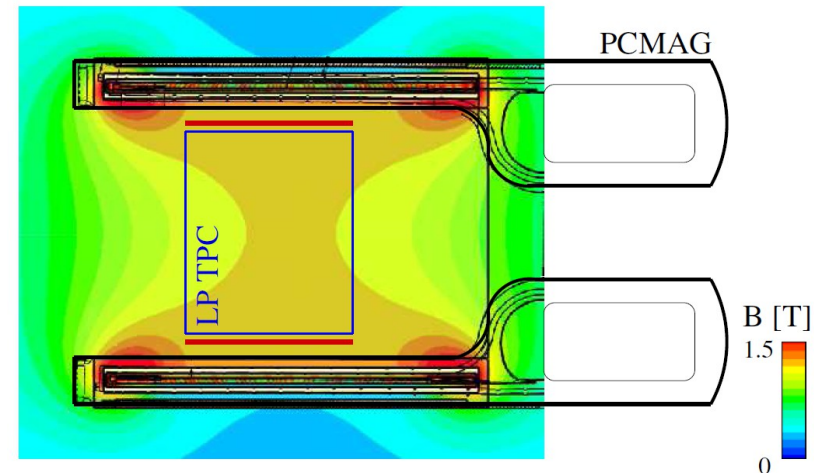
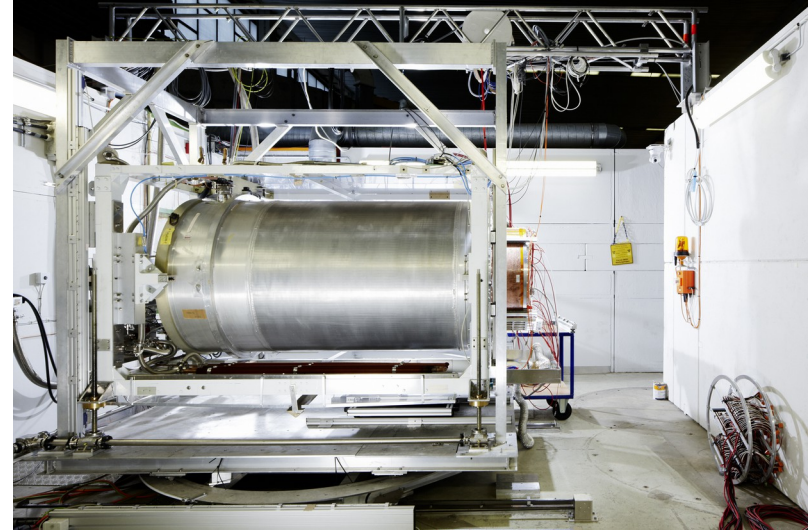
DESY GridGEM Module

- Triple GEM Module with pad readout
- Fully sensitive readout board $\sim 23 \times 17 \text{ cm}^2$
 - 4829 readout pads (size $1.26 \times 5.85 \text{ mm}^2$)
- Bottom side of the GEM divided in 4 sectors
 - Reduces energy stored in one sector to avoid destructive discharges
- Additional field shaping electrode around the module (wire) to reduce field distortions



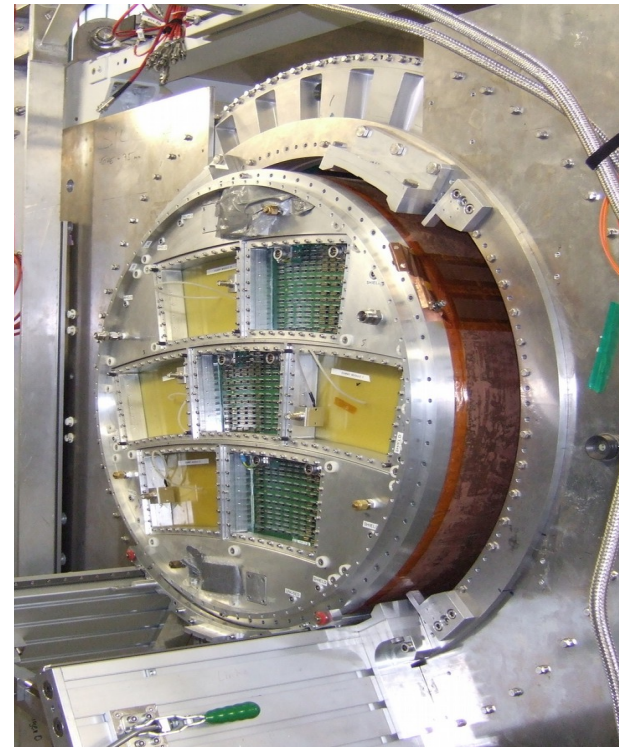
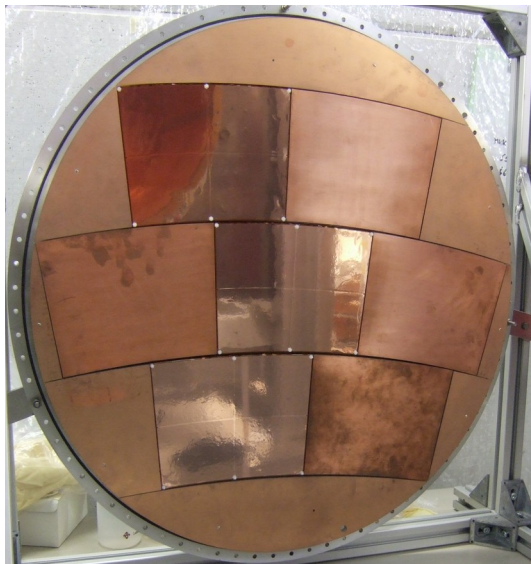
Testbeam Setup at DESY

- Setup at DESY II test beam, area T24/1
 - e^+/e^- from 1 GeV to 6 GeV
- PCMAG Magnet (1 T)
- Movable stage in three dimensions
- HV and gas system including slow control
- Cosmic and beam trigger
- TPC prototype (Large Prototype)
 - \varnothing 73 cm, max. drift length \sim 60 cm
- Work in progress
 - Photo electron laser calibration system
 - Silicon reference detector



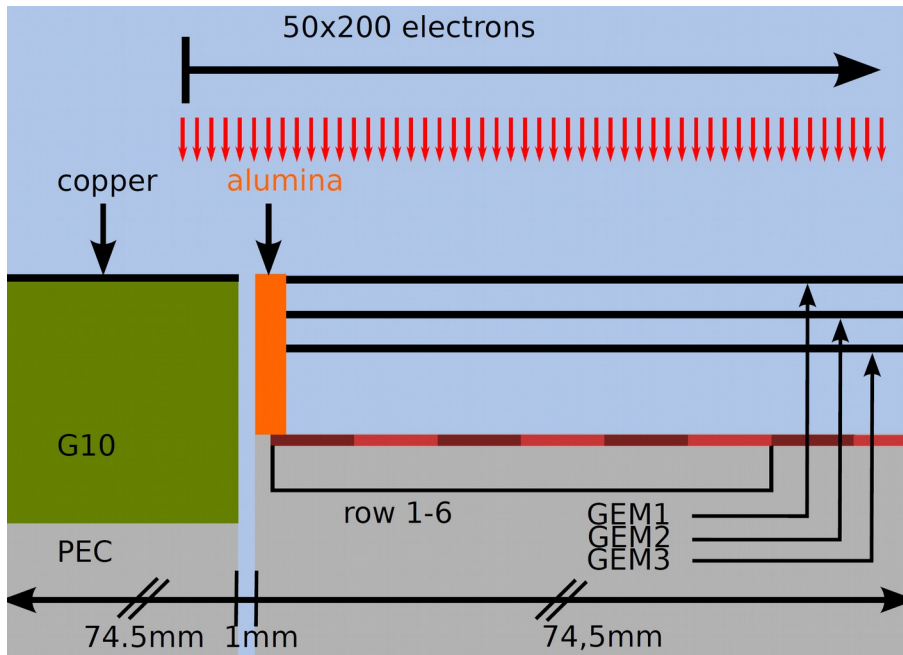
Test Beam Setup

- 3 DESY GridGEM modules
- ALTRO readout electronics
 - 120 ns shaping time
- Readout half of the three modules
- ~7200 channels along the beam profile
- Lever arm of ~50 cm



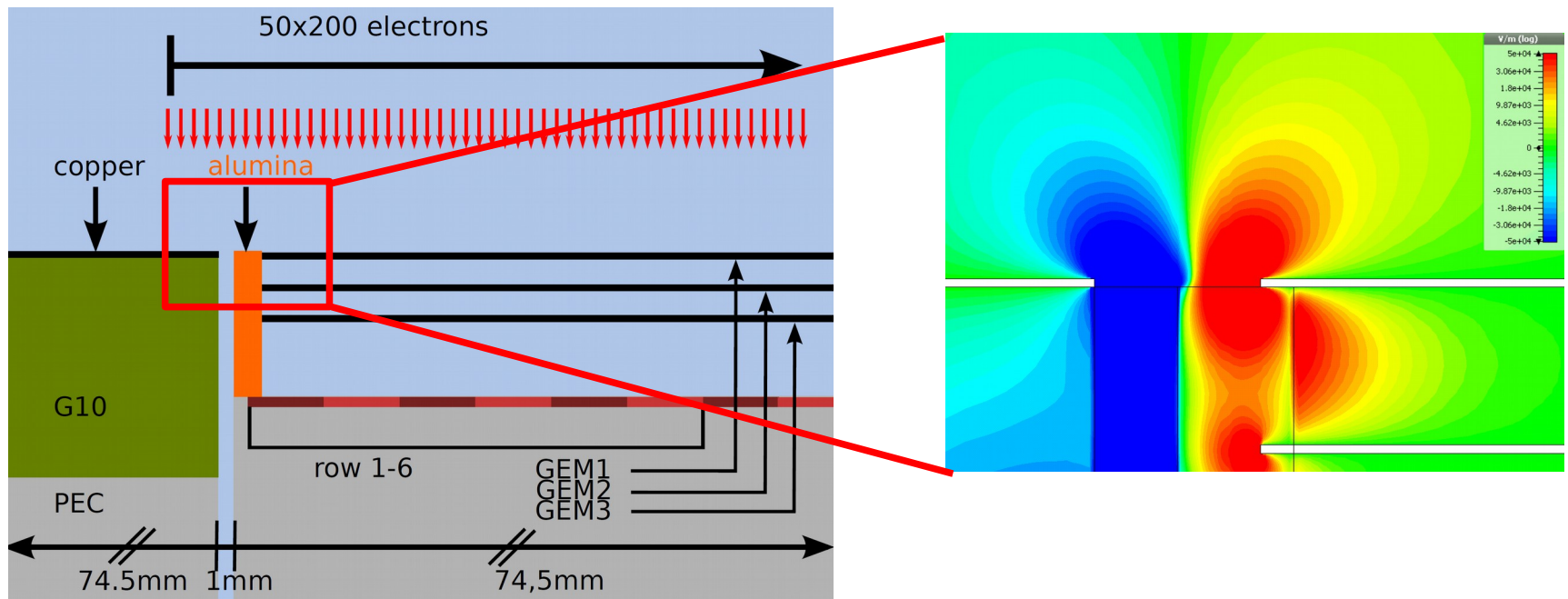
Field Distortions

- Previous measurements showed distortions at the border of the module
- Simulation study to understand the observed behavior (Klaus Zenker)
- Simulate the electric field at the border of a module
- Field distortions are visible due to the gap between the modules



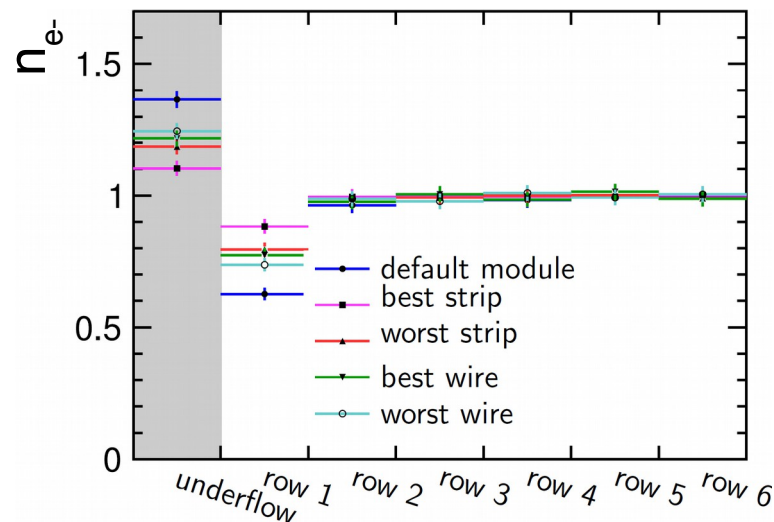
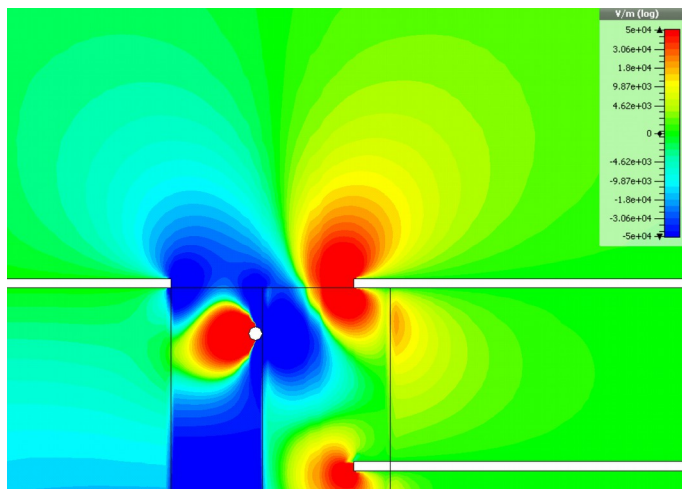
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Guard Ring

- Introduce a guard ring to suppress field distortions
 - Wire and strip solutions simulated
- Simulate the electron collection efficiency
- Retrieve up to 30 % collection efficiency on the first row with the guard ring



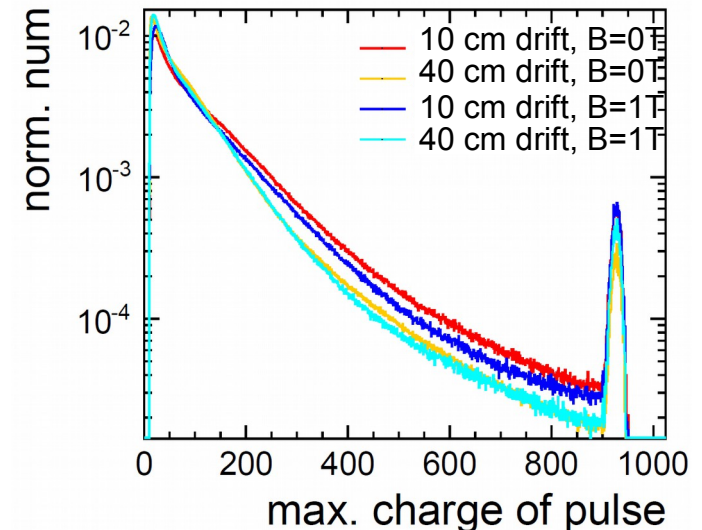
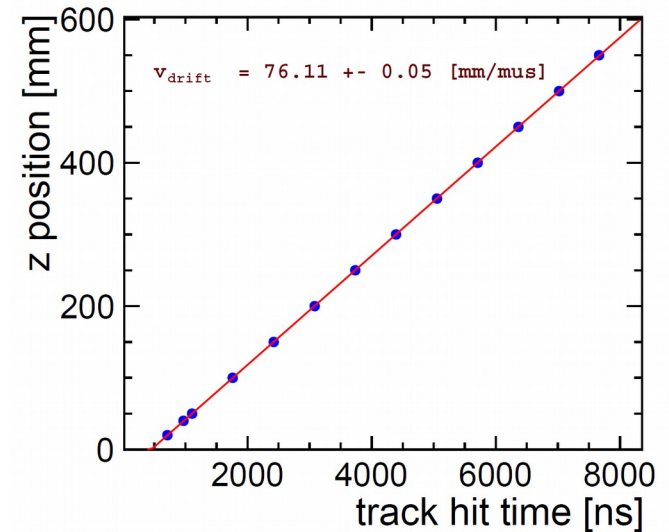
Test Beam Campaign March 2013

> Goal of the Measurements

- Validation of module design
- Understanding of field distortion
- First studies on momentum resolution

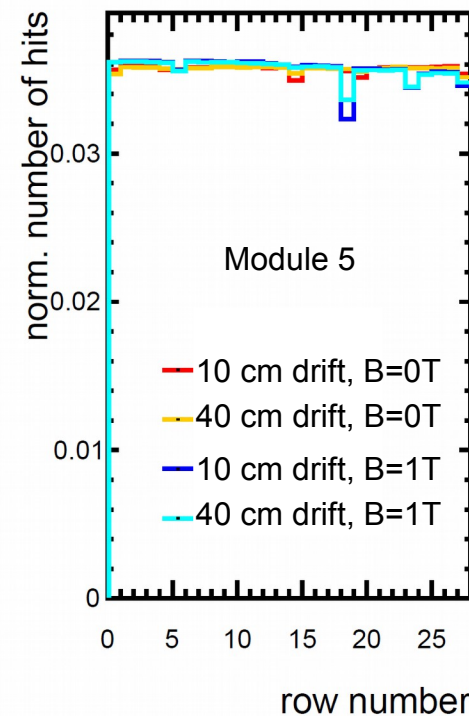
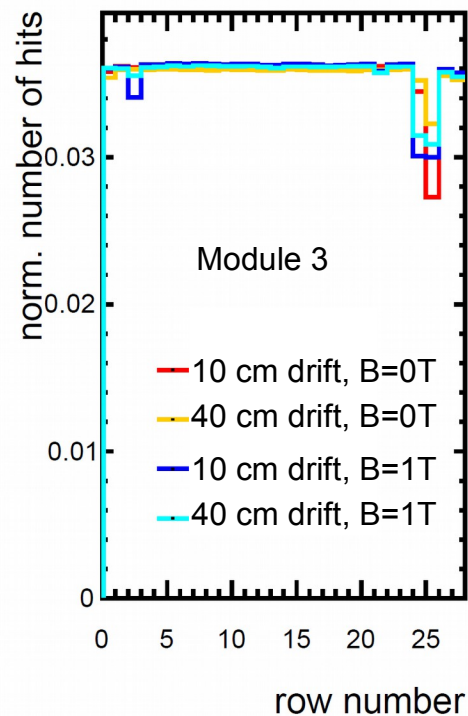
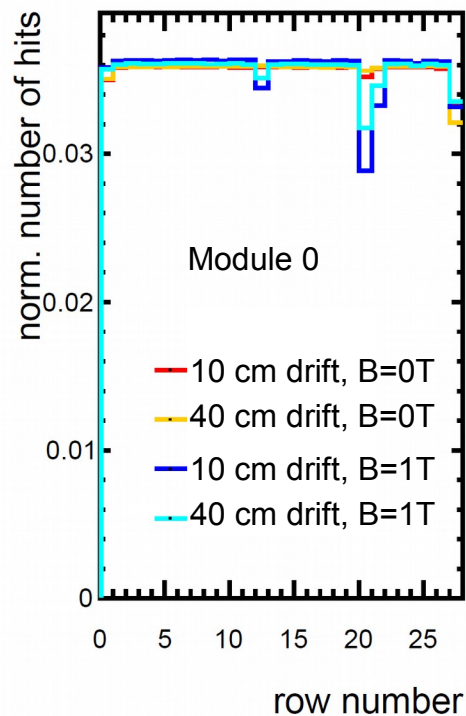
> Working point:

- ~240 V/cm drift field (maximal drift velocity in T2K gas (Ar:CF₄:iC₄H₁₀ 95:3:2))
- Voltage between the GEMs: 250 V
- Transfer field: 1500 V/cm
- Induction field: 3000 V/cm



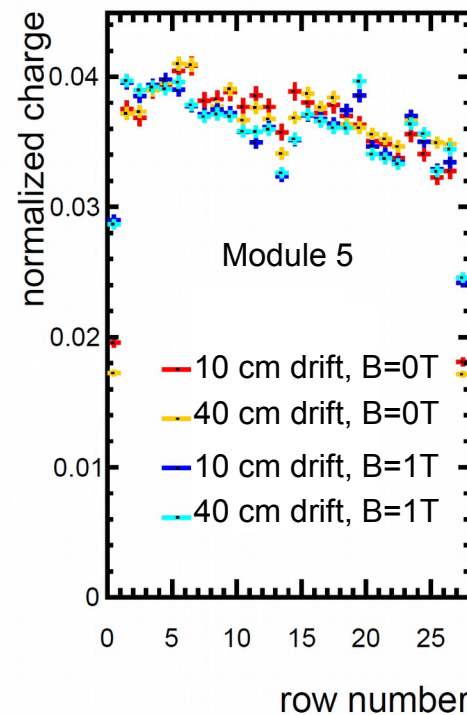
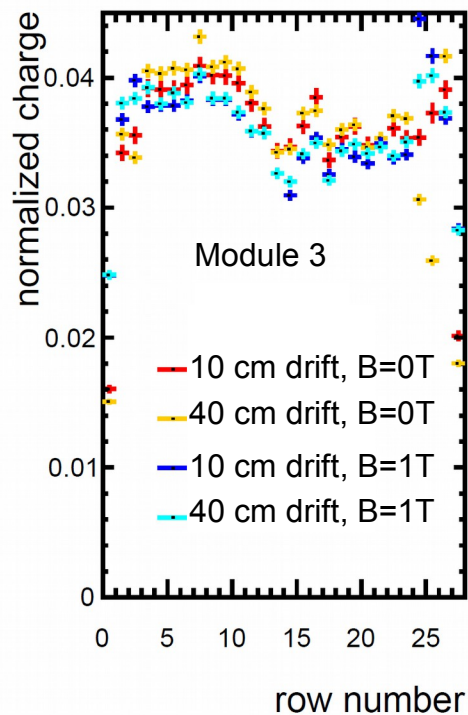
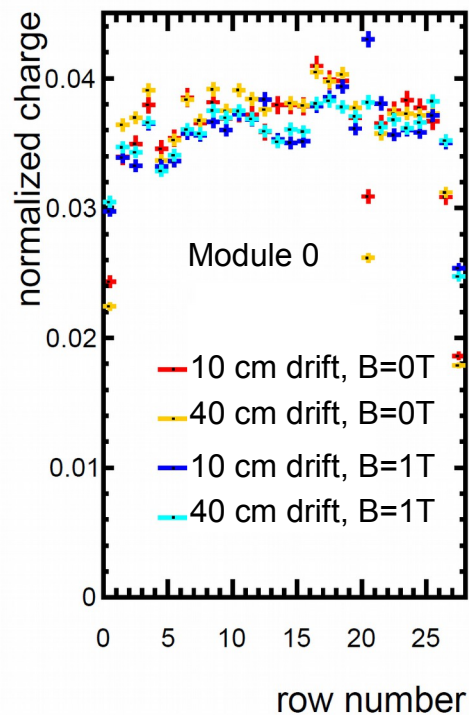
Measurement Results

- Hit efficiency proves to be close to >95%
- Independent on drift distance or guard ring potential
- Retrieved up to 30 % compared to measurements without a guard ring



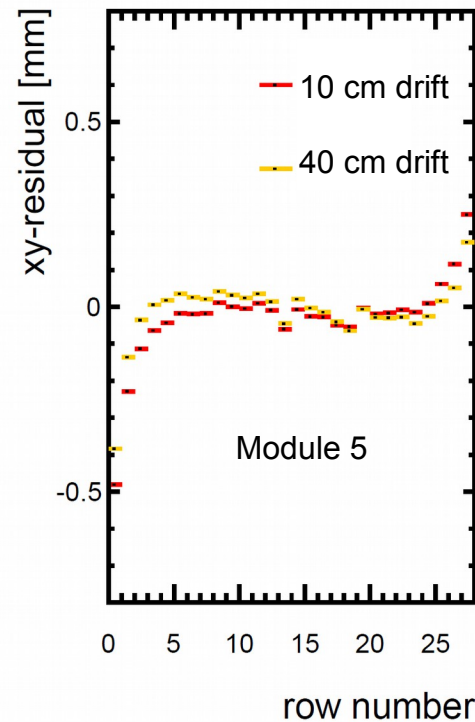
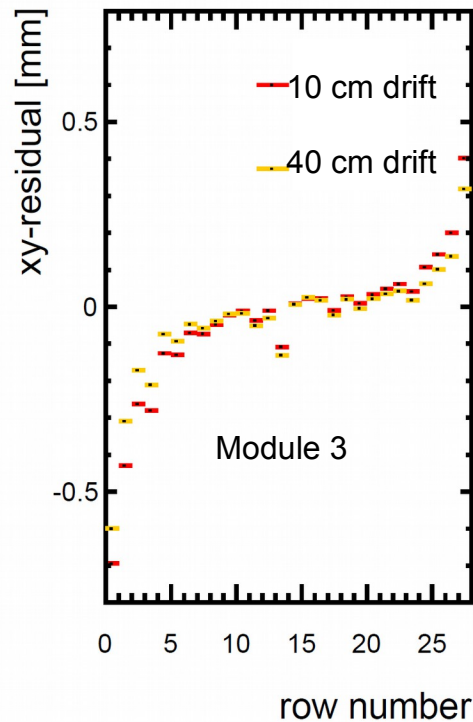
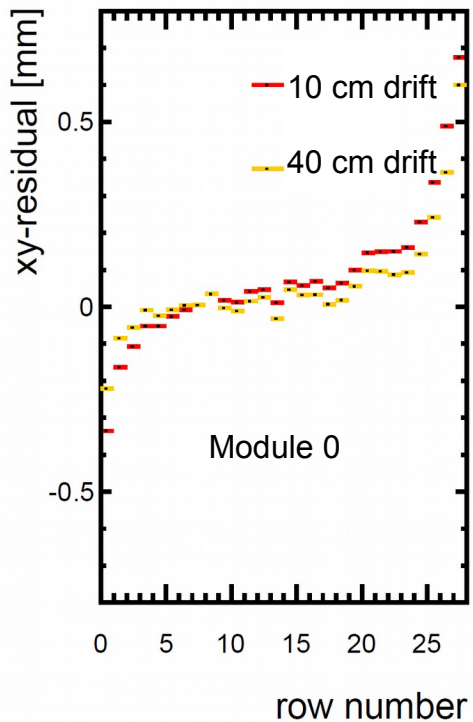
Beam Test Results

- Charge Efficiency still reduced at the border of the modules
 - Reduced electron collection efficiency or gas gain
- No charge calibration of the electronic channels possible
- Substructure proves that the GEM gluing and mounting needs more careful treatment



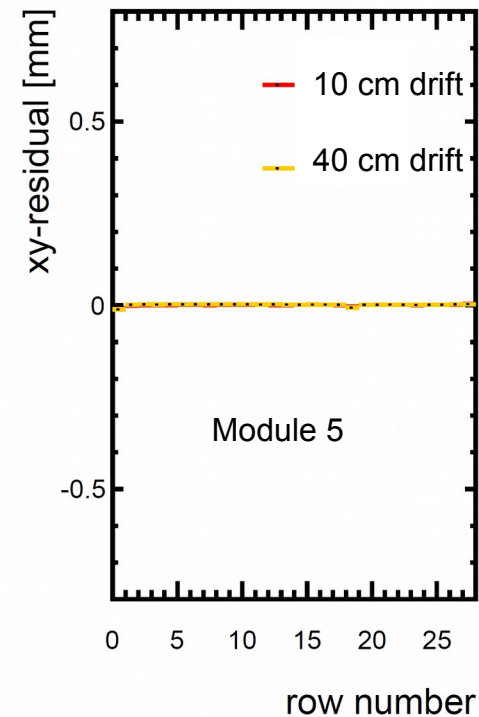
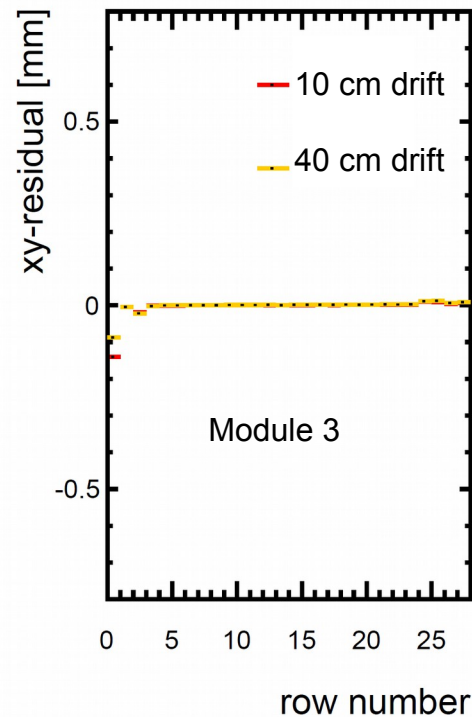
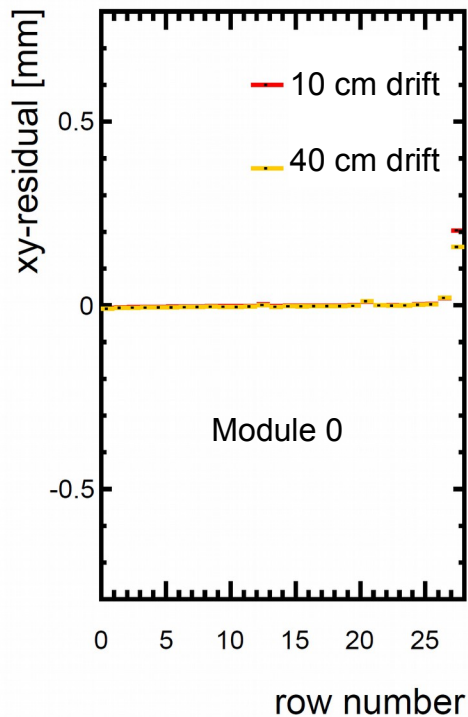
Track Distortions

- Measurements show s-shape of the residuals
- $E \times B$ effects cause the altering of the electron path
- Measurements shows similar behavior as simulation but with a larger amplitude



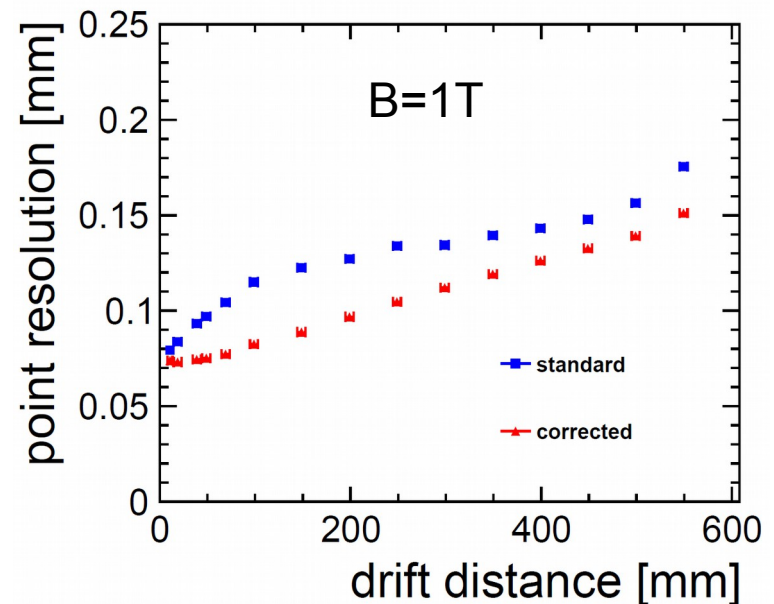
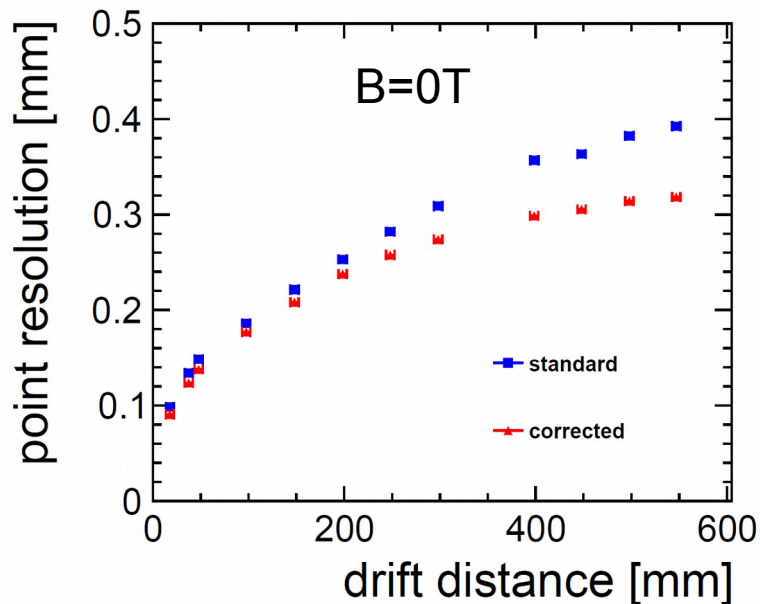
Distortion Corrections

- Shift all hits on a row by the mean of the residuals
- Redo track finding and fitting
- Might create a bias but data driven correction is the only option without an external reference



Transverse Point Resolution

- Finding and fitting the tracks with CLUPATRA
 - Same tool which is used in simulation studies for ILD
- Getting closer to the goal of $\sigma = 100 \mu\text{m}$ over the full drift distance



Conclusion & Outlook

- > A successful test beam with three DESY GridGEM modules was performed
- > The data shows promising results
 - Recover hit and charge efficiency due to the additional guard ring
 - Distortions at the border of the module still visible
- > Field simulations explains the observed behavior
- > Getting closer to the goal for the point resolution

- > Get an even better understanding of the field distortions
- > Further improve the analysis of the data

