GEM Flatness Studies for the DESY GridGEM Module

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GEM Flatness Studies

LCTPC WP-Meeting, 12.05.16

HELMHOLTZ ASSOCIATION

Universität Hamburg

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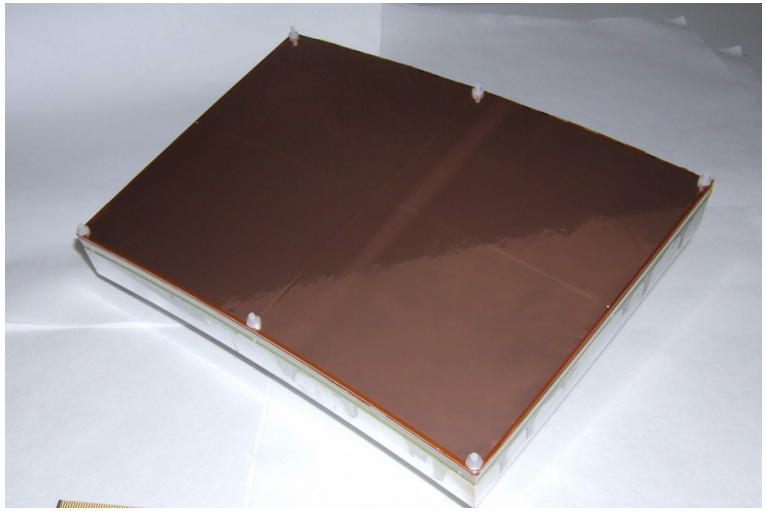
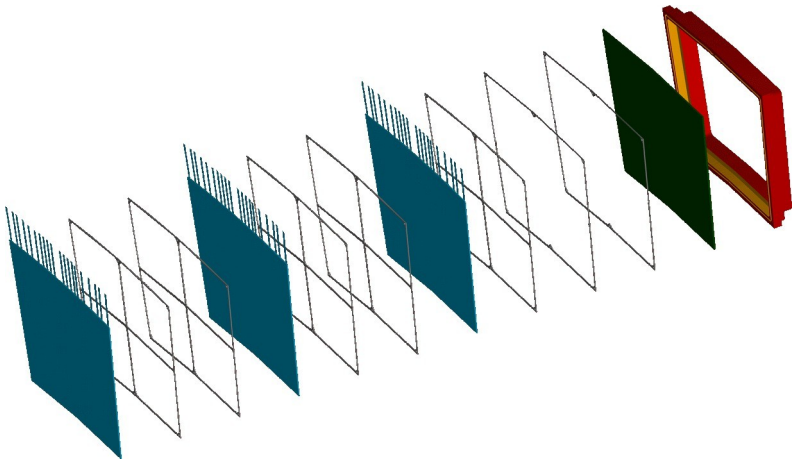
DESY GridGEM-Modules

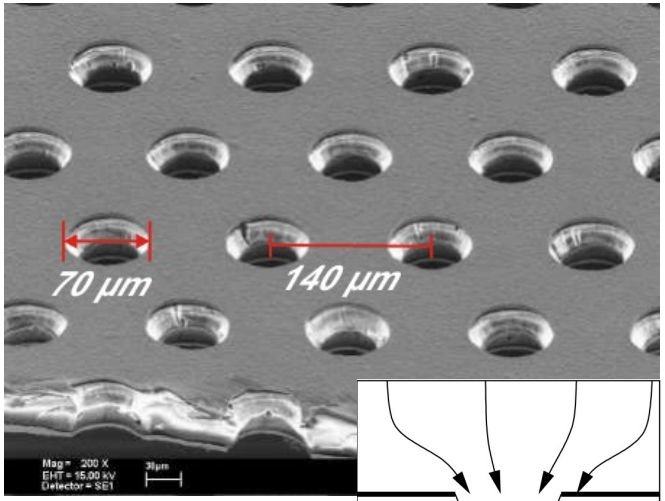
- feasibility was shown with 10x10cm² GEMs
- tests with two generations of full-size readout modules at the DESY test beam facility
  - reaching ILD requirements regarding point resolution is possible
- still some issues to address and performance parameters to test
  - e.g. ion gate, field shaping ring, field distortions, dE/dx performance, …
- new iteration of the module needed

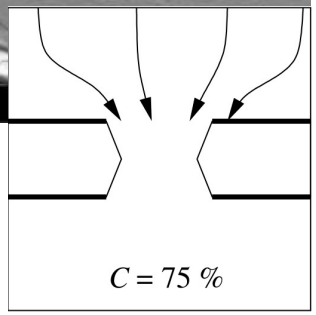


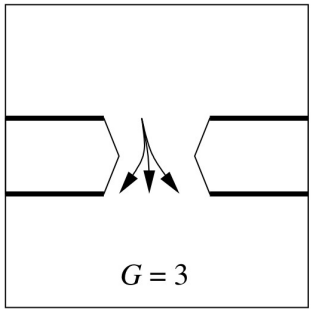


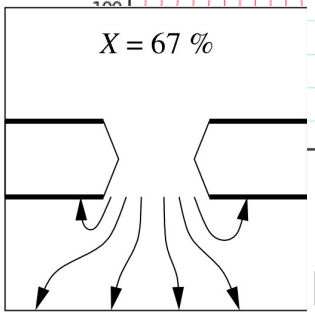
Effective GEM Gas-Gain

[http://gdd.web.cern.ch/GDD/]







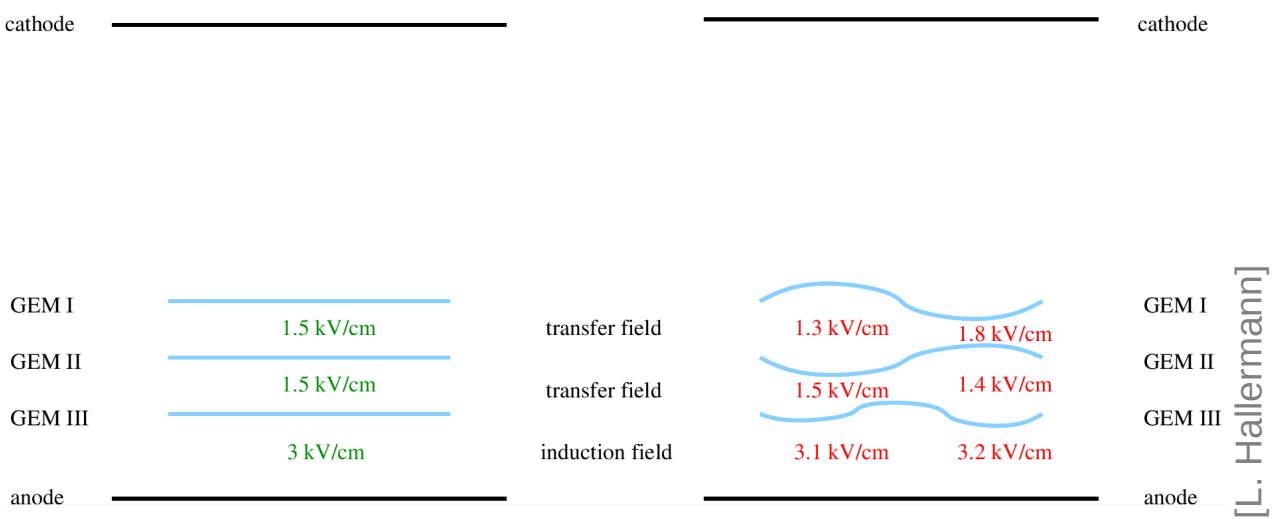


[B. Sobloher & O. Schäfer]

[A. Vogel]

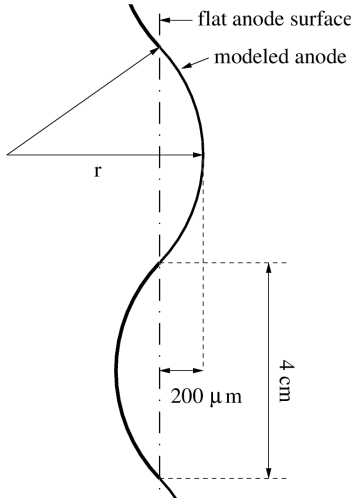
- strong fields inside GEM holes lead to gas amplification of electrons
- limited efficiencies of collecting / extracting electrons into / from the holes → modified effective gain
- efficiencies depend on the ratio of the external field strength to the field strength inside the GEM holes

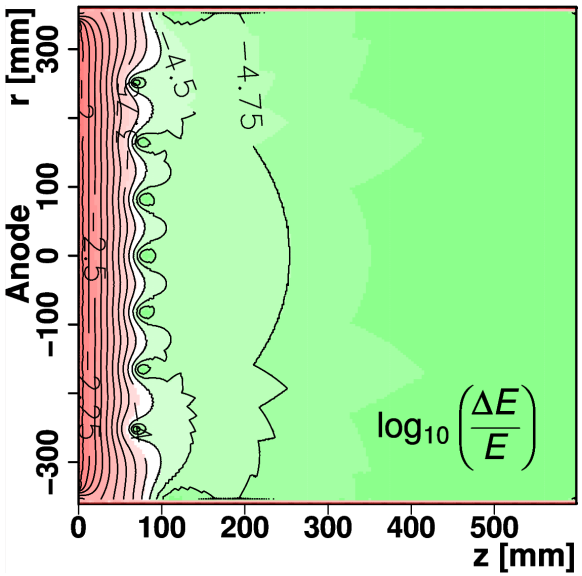
GEM Flatness – Impact on dE/dx



- deflection of GEMs → disturbance of electrical fields between GEMs
- gas gain independent of external fields
  → only linear changes of collection / extraction efficiencies
- deterioration of local energy resolution
  - $\sigma_E/E \approx 10\%$, $\sigma_G/G \approx 5\%$ → $\sigma_{E\text{-eff}}/E \approx 11\%$
  - can be calibrated (if stable over time)
  - dE/dx resolution still dominated by uncertainty on primary ionization

GEM Flatness – Impact on Point Resolution

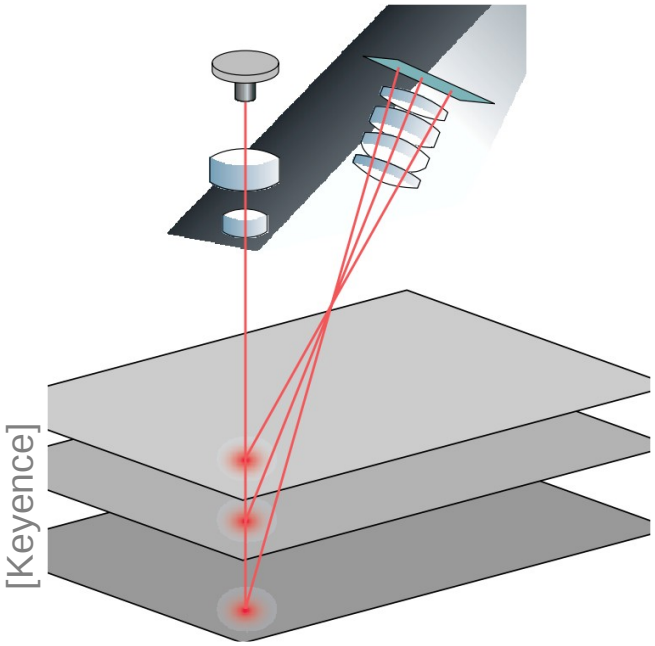


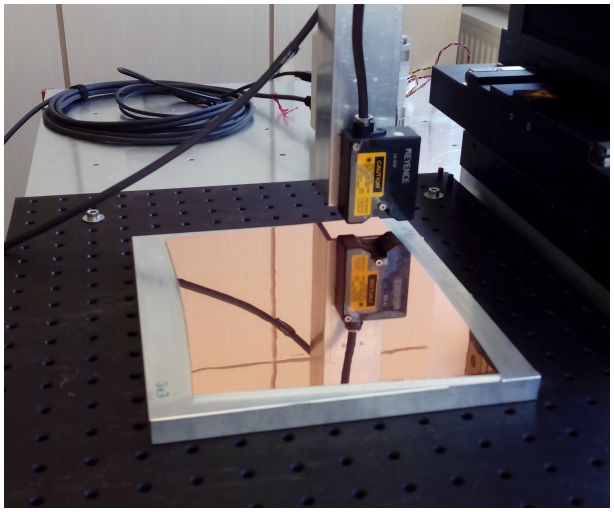


[P. Schade & L. Hallermann]

- deflection of GEMs → drift field inhomogeneities
  - ΔE/E > 10^{-4} over ~10 cm
- degradation of point resolution: ~3%
  - Residuals: 100µm ILD-TPC design + 25µm field distortions added quadratically
- also local gain changes can impact point resolution
  →was shown to be negligible (L. Hallermann)

GEM Flatness Measurements





- height profiles of GEMs on their support frames were measured
- setup:
  - precision xyz-table
  - laser-displacement sensor
- height distribution RMS: ~100 µm
  - similar for all measured GEMs
  - maximum height differences: 300-400 µm
- similar to 10x10cm² Grid-GEMs measured during Lea Hallermanns thesis

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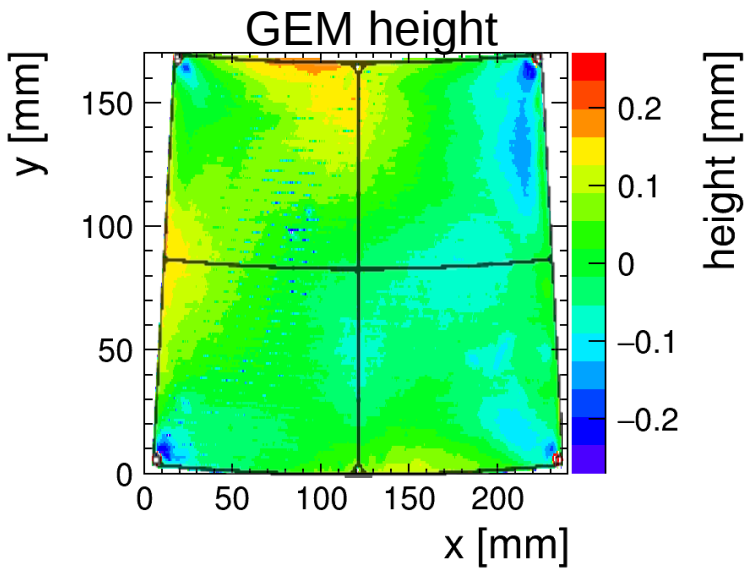

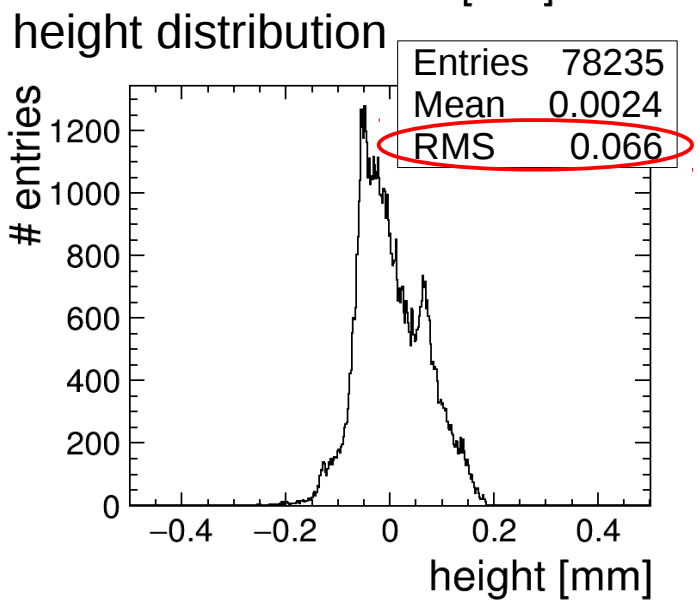

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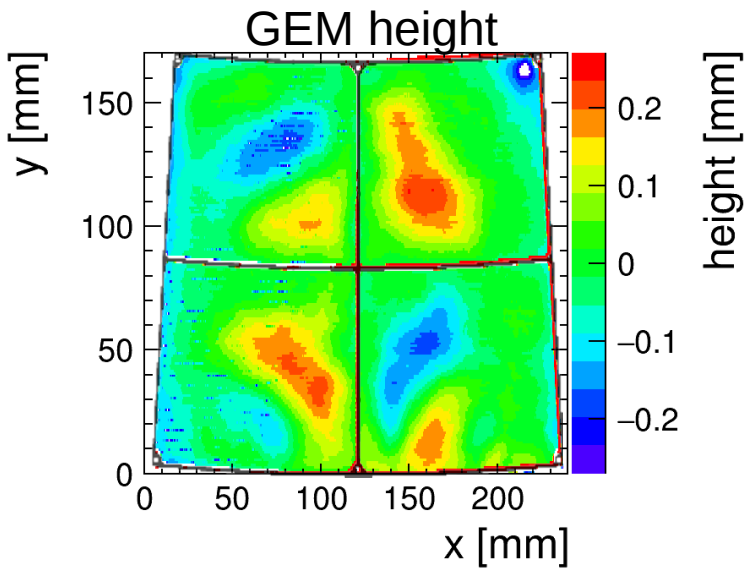

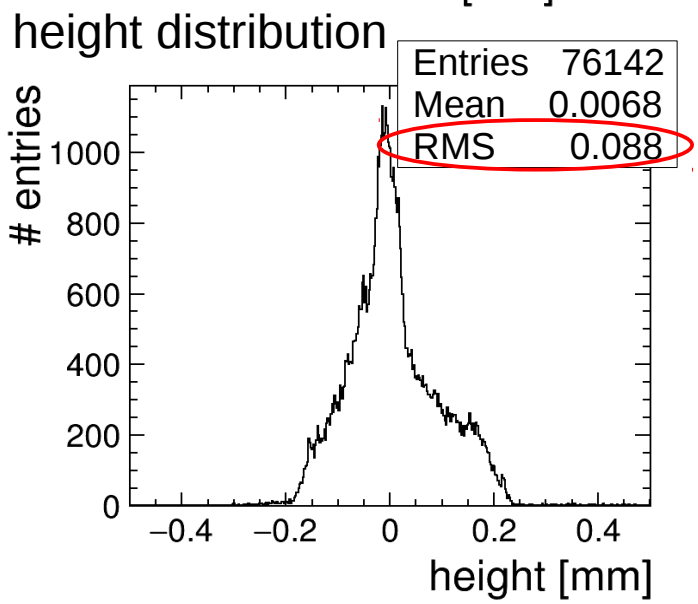

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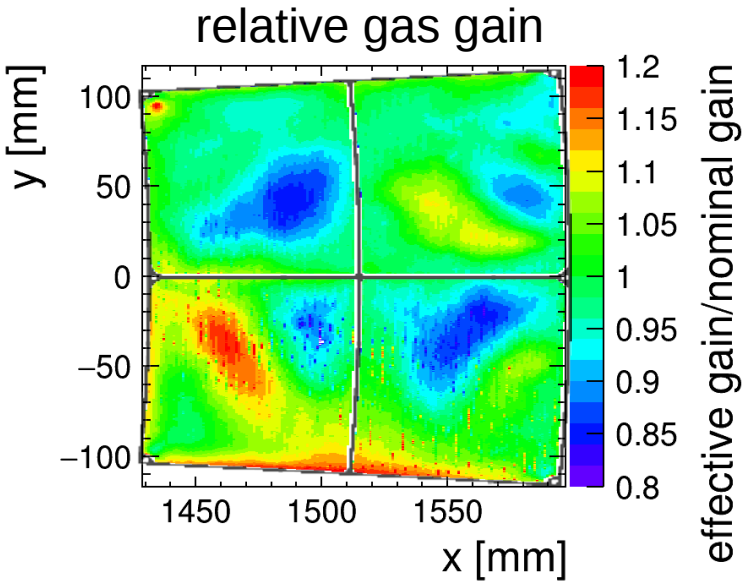
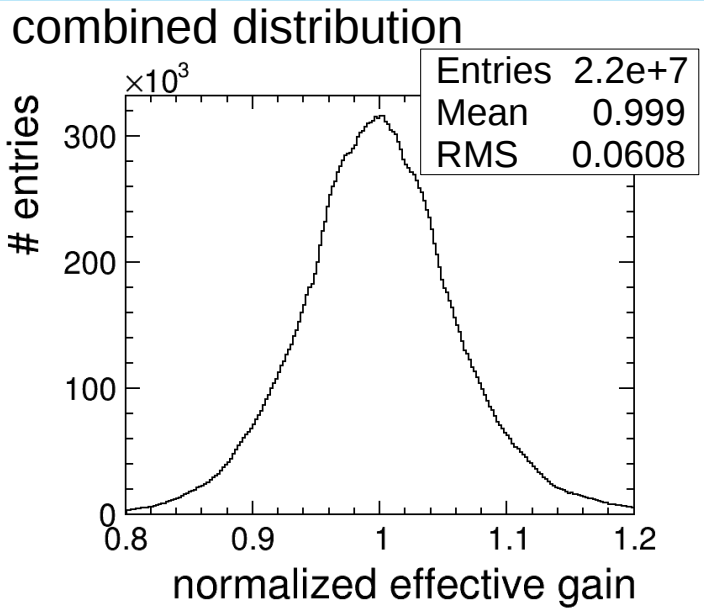
Calculated Gain Deviation





- calculated gain distribution for triple GEM stacks from measured GEMs
- gain RMS 5%-8% in T2K gas for different stacks
- RMS of combined distribution: 6.1%
- consistent with 10x10cm² GEMs with similar deflection
  - both show RMS of ~2% in P5 gas with 4T magnetic field
  - 10x10cm² Studies done by Lea Hallermann

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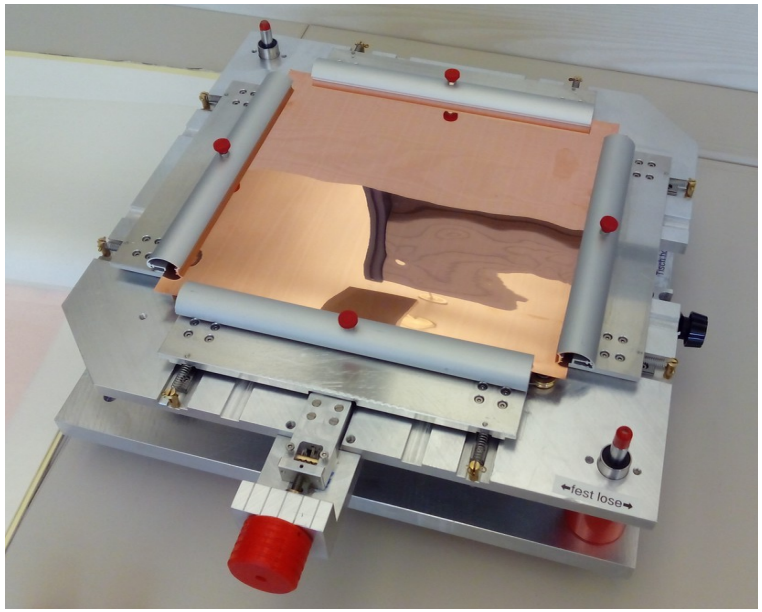
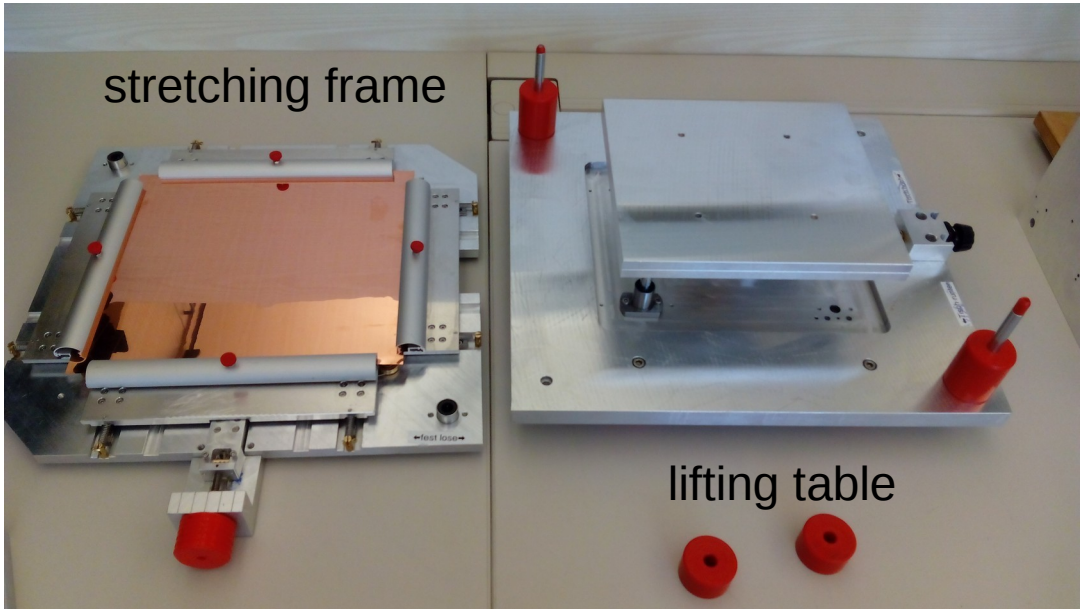
Improving GEM Flatness - Mounting

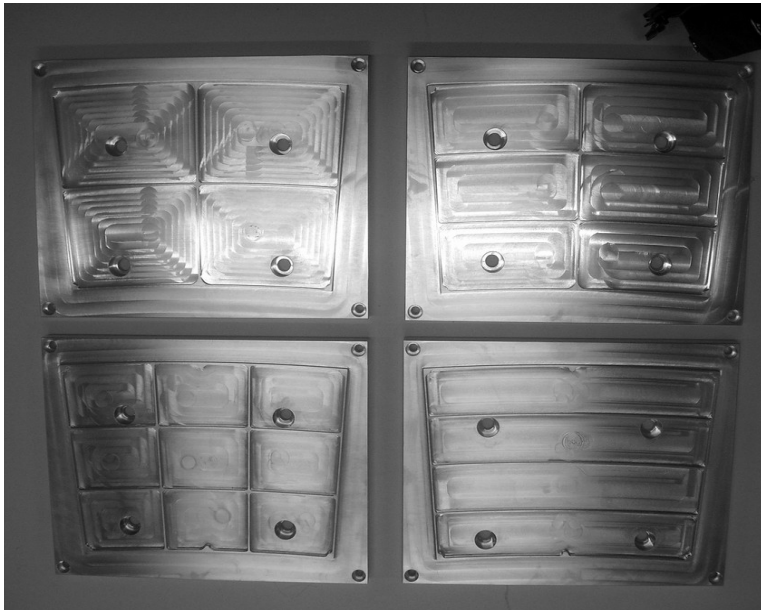


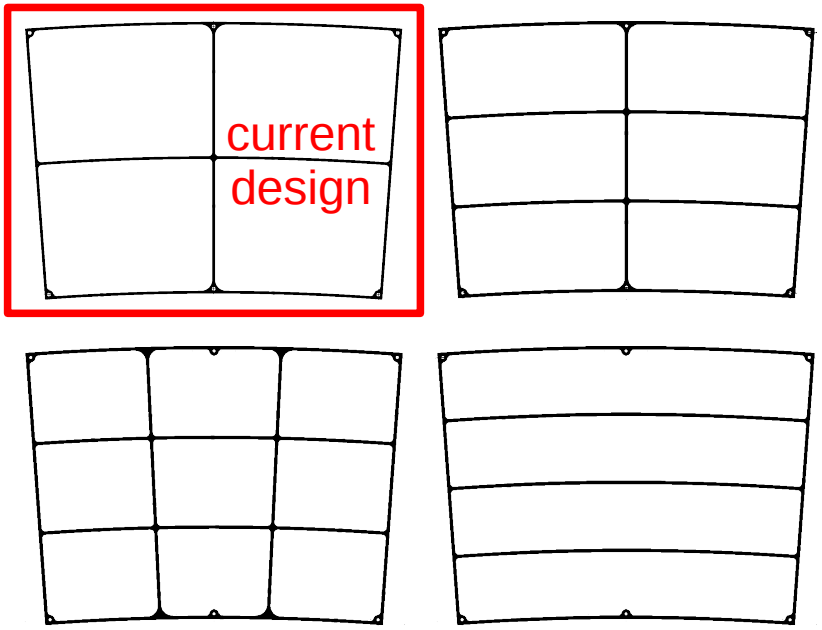


- optimization of GEM mounting on frames for improved reproducibility
- mechanical mounting tool
  - low force stretching of GEM foils during mounting
  - controlled merging of GEM and frame for gluing

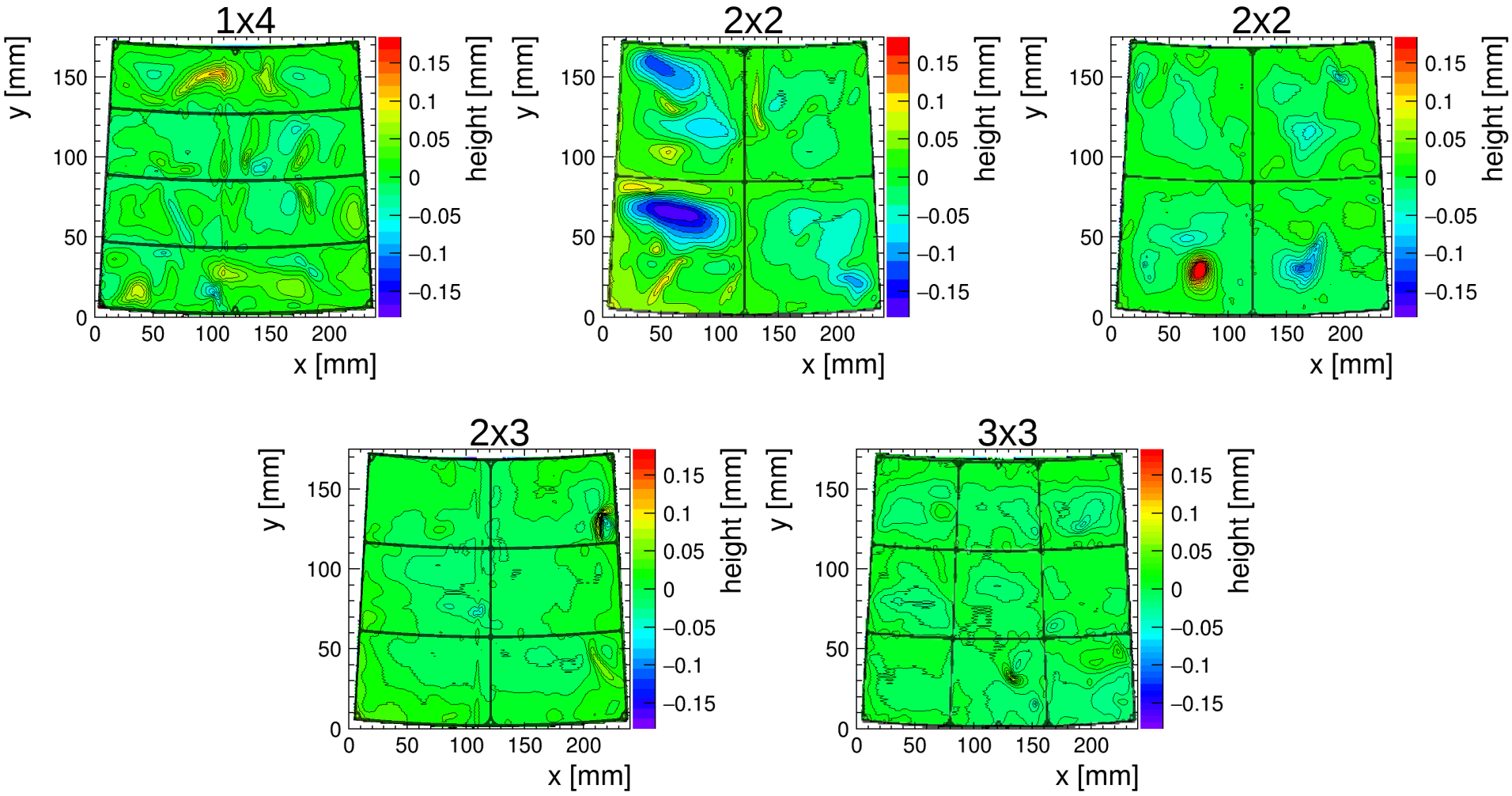
Improving GEM Flatness – Frame Geometry

- investigating the impact of the frame geometry on GEM flatness
- four designs have been proposed, including current one
- GEM behaviour on different geometries was tested
  - height profile measurement of GEM material on aluminium dummy frames

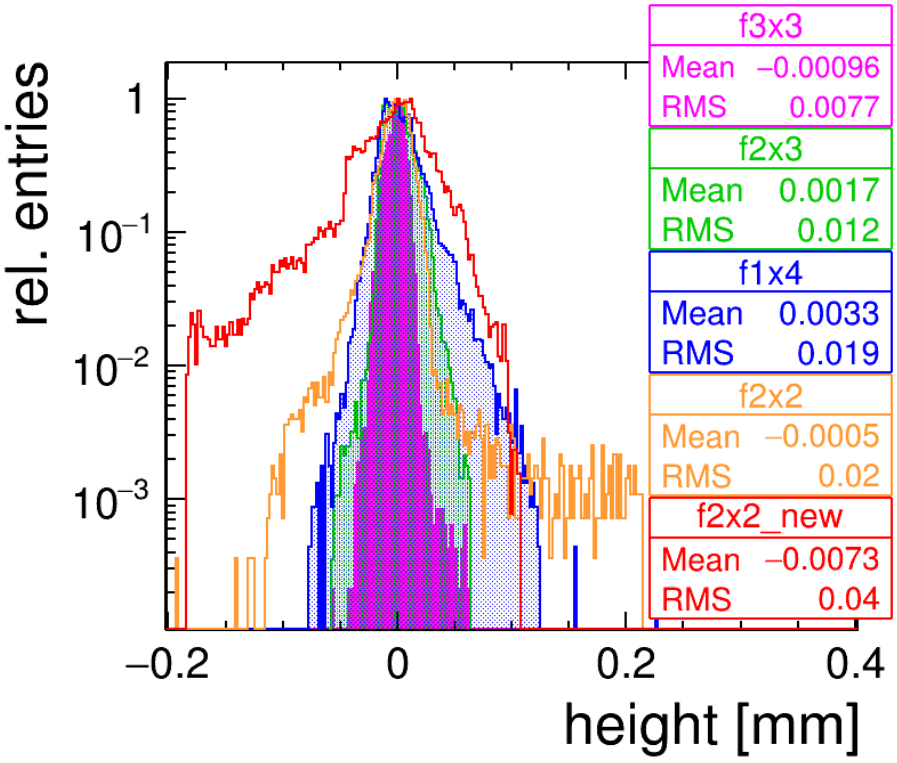




Dummy Frame Height Profiles

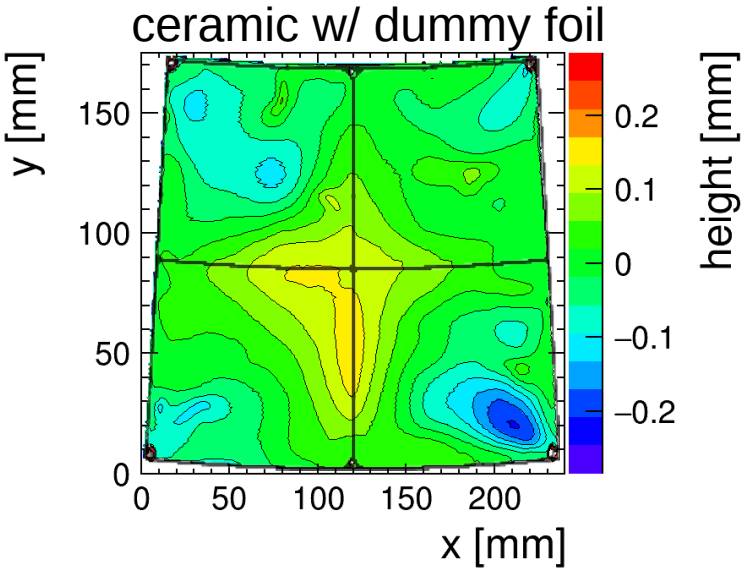


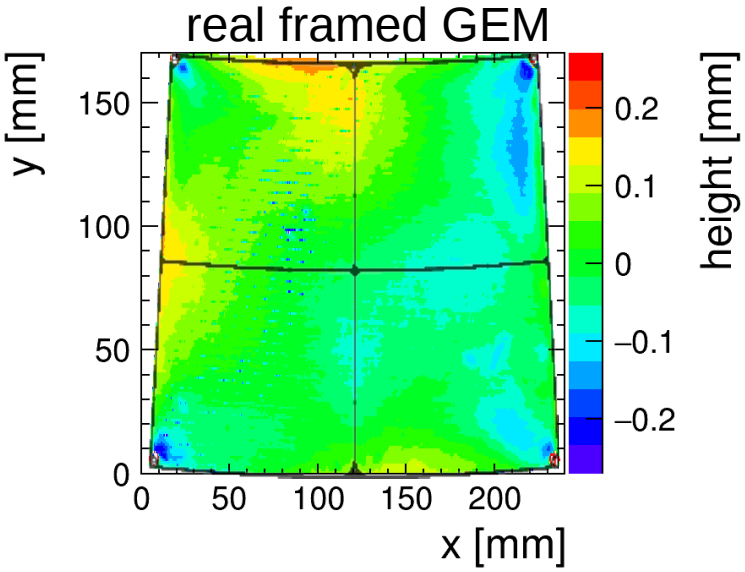
Comparison of Geometries

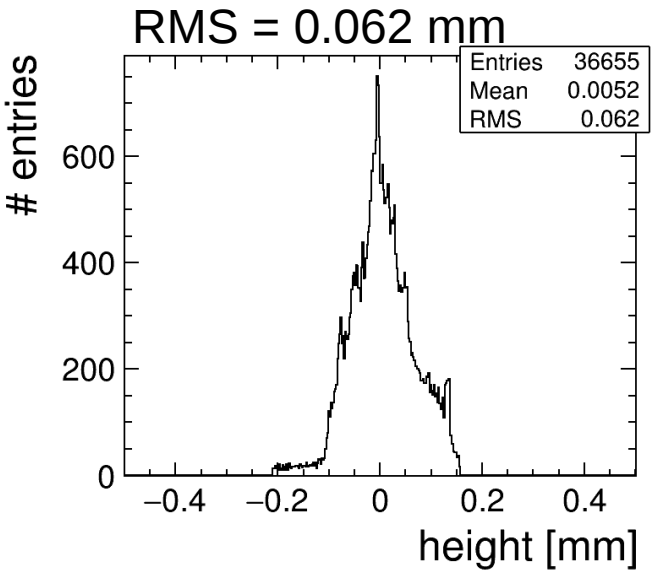


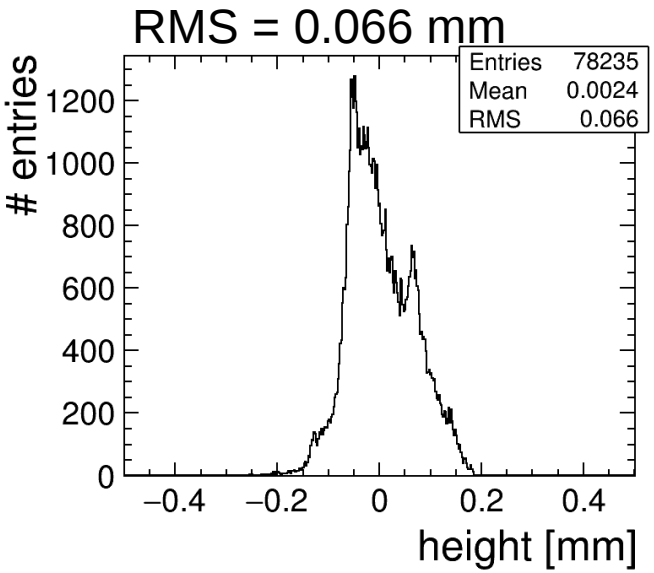
- variation for same geometry can be bigger than between different geometries
  - e.g. 2x2 old and new
- no clear preference for one frame geometry
- gathering more statistics by repeating takes too long for the current test beam preparations
- old 2x2 design will be used for upcoming test beam

Comparison: Stretching Tool



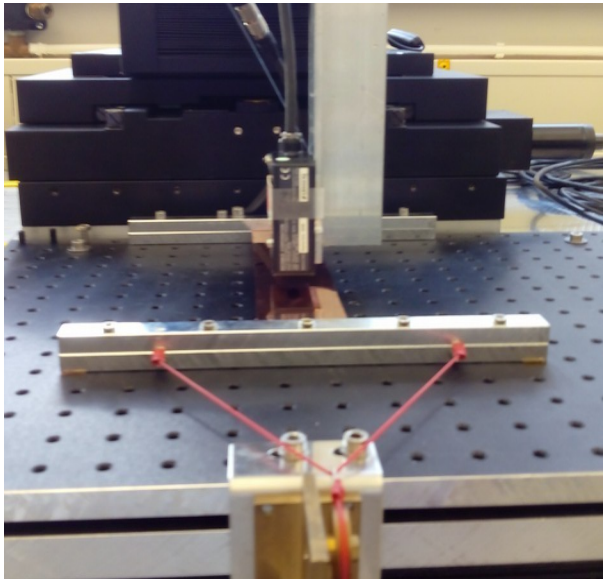


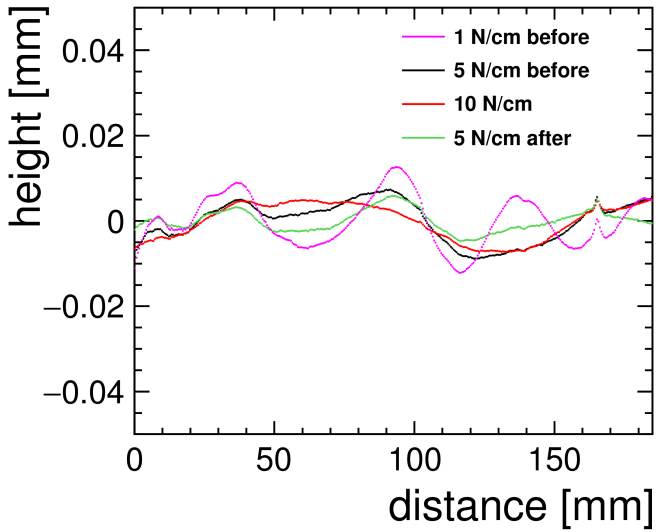




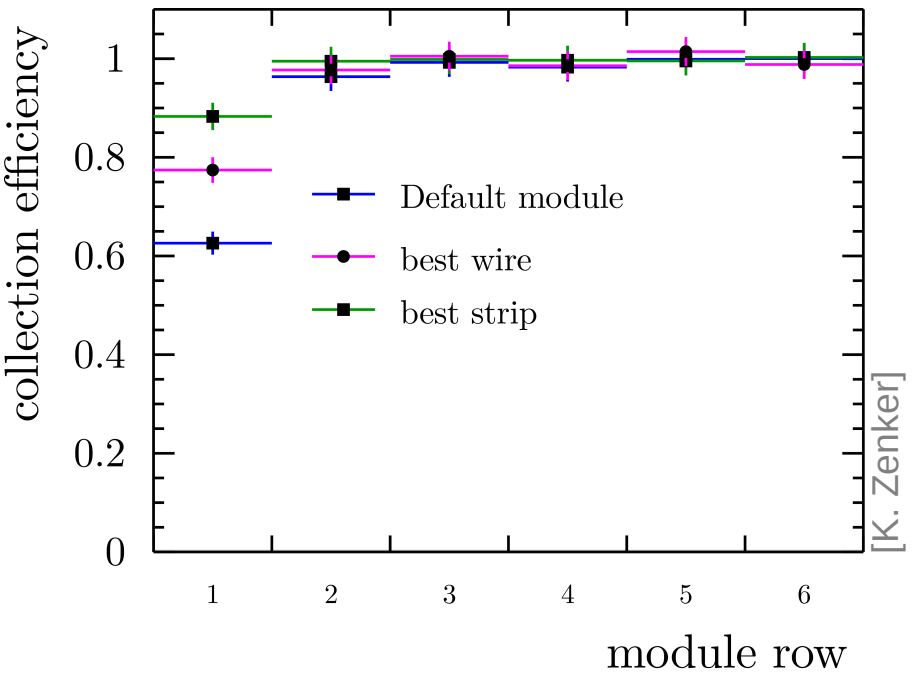
Improving GEM Flatness - Stretching

- lower strength of thin ceramic frames compared to big GRP frames
  → only low stretching forces possible during mounting
- How much force is needed?
- Idea: temporary application of higher force
  - “overstretching” to mitigate deflections in the material
- measurement results show changes but not yet conclusive



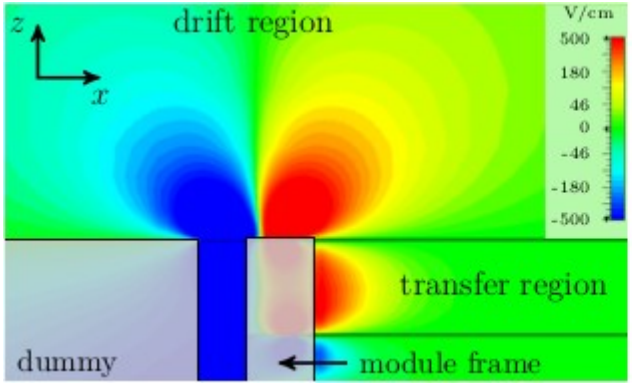


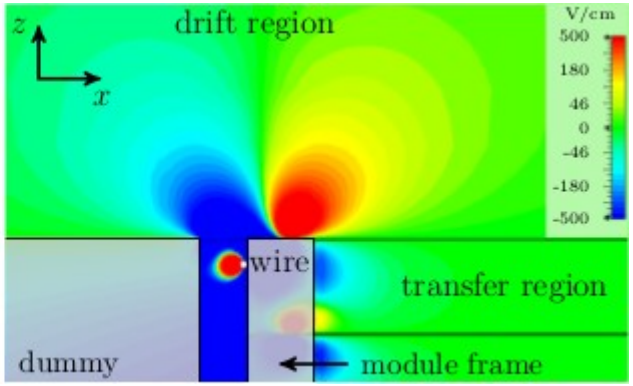
New Frame Supplier and Guard Ring



[K. Zenker]

- found a new supplier for ceramic frames
- no more need to buy plates ourselves and send to cutting
  - full production at one company
- possibility to metallize outer frame edge as guard ring
- full guard strip gives significant improvement over the wire used in last test beam





[K. Zenker]

Summary

- GEMs need to be flat as to not cause field distortions
  - avoid degradation of point- and energy-resolution
- GEMs are not flat enough in current modules
- better assembly procedure and different frame geometries have been tried out
- decided to keep 2x2 frame geometry for now
  - no conclusive improvement from different geometries
  - based on mechanical simulations and dummy frame measurements
- need to decide on stretching procedure and necessary forces
- found a new supplier for ceramic frames
  - guard ring possibly included in frame production