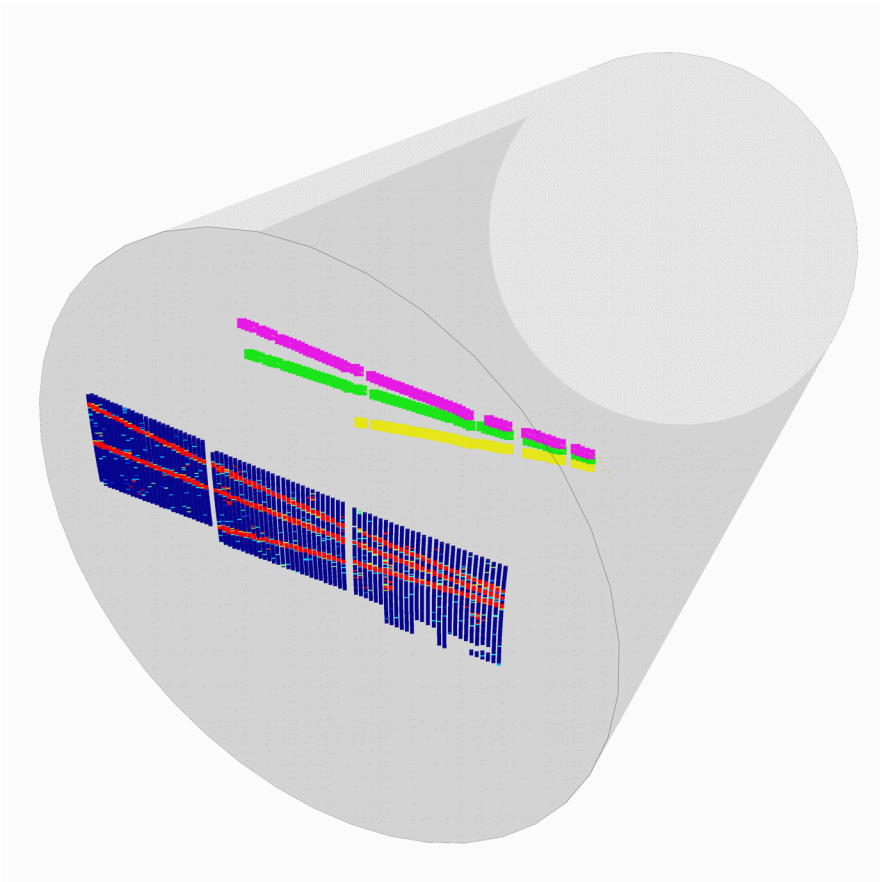
DESY GridGEM Module



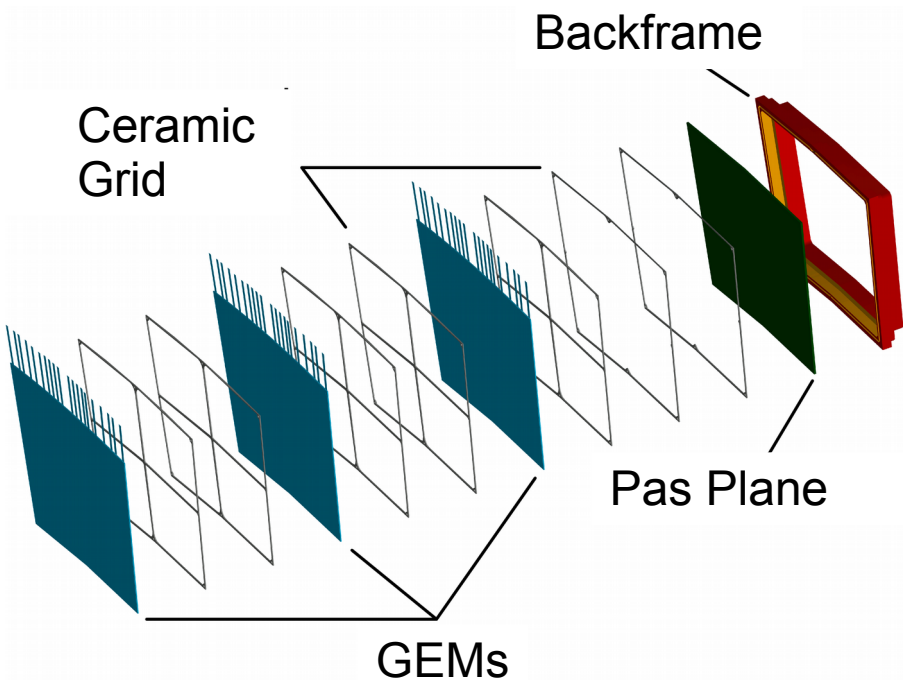
Ralf Diener
LCTPC Collaboration Meeting 2017

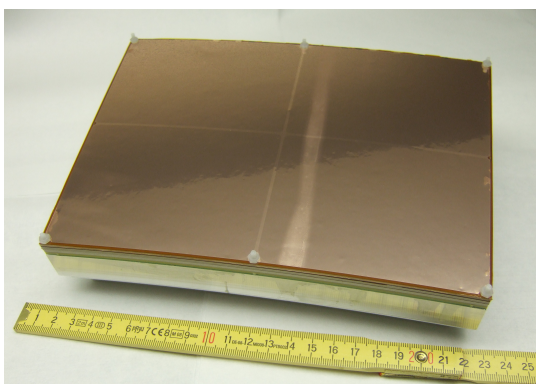
HELMHOLTZ ASSOCIATION

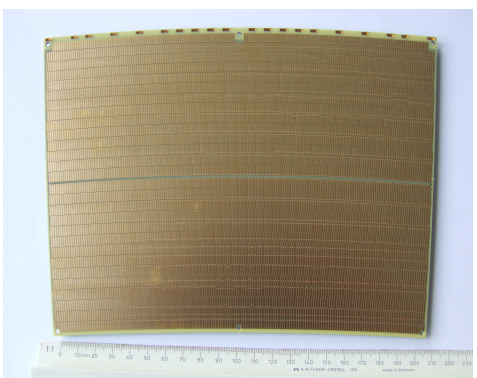
DESY

DESY GridGEM Module

- Goals:
  - Minimal material budget
  - Maximal sensitive area
  - Minimal gaps
- Integrated, self supporting GEM/ceramics structure
  - Stack of 3 GEMs on thin ceramic frames
- Size, shape as planned for ILD TPC endplate
  - Area ~ 17 x 23 cm²
- Padplane
  - 28 rows
  - Pad size: 1,26 x 5,85 mm²



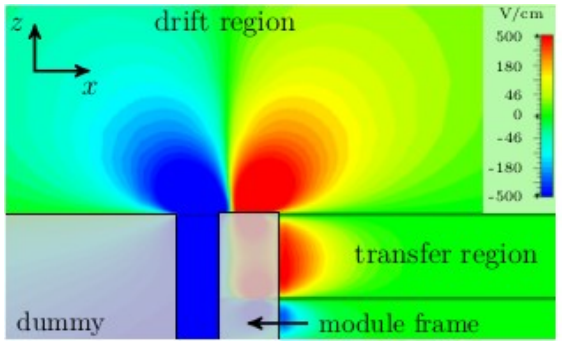


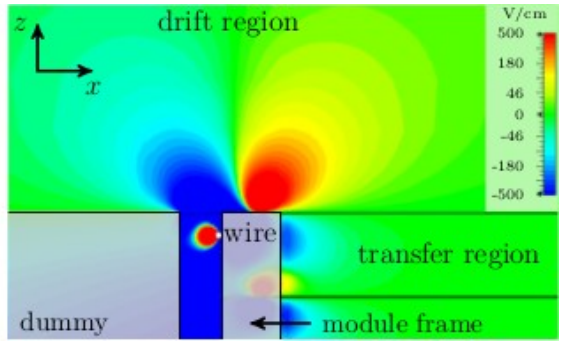


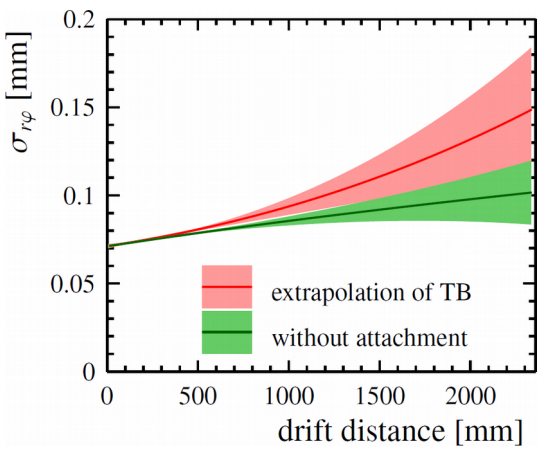
New Iteration

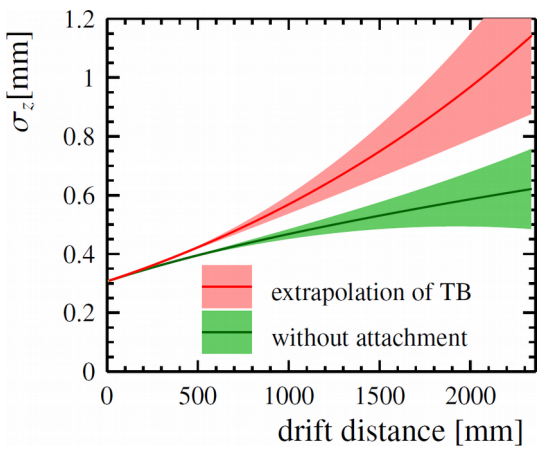
- Last module iteration worked well during testbeam effort in 2013
  - HV stable during testbeam
  - Guard ring reduced field distortions significantly
  - Alignment procedure established
  - Excellent hit efficiency > 99.5%
  - Point resolution requirements in z and rφ reached

- R&D and goals for latest iteration
  - Improved, reproducible production techniques
  - Controlled, improved GEM flatness
  - Optimized guard ring
  - Revised mechanics and drawings
  - Long term HV stability



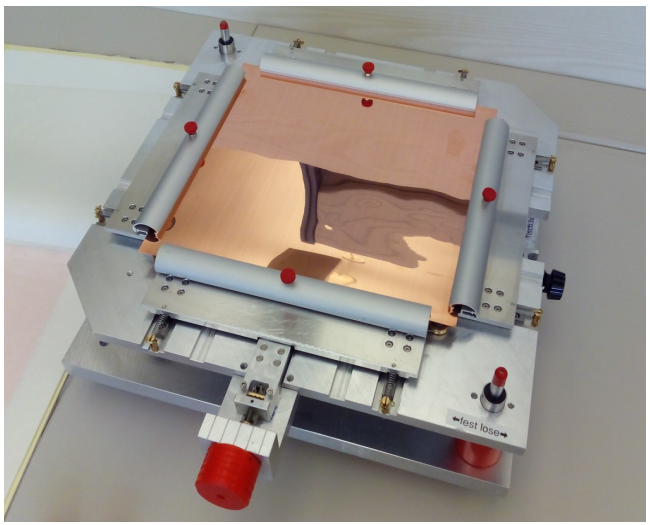


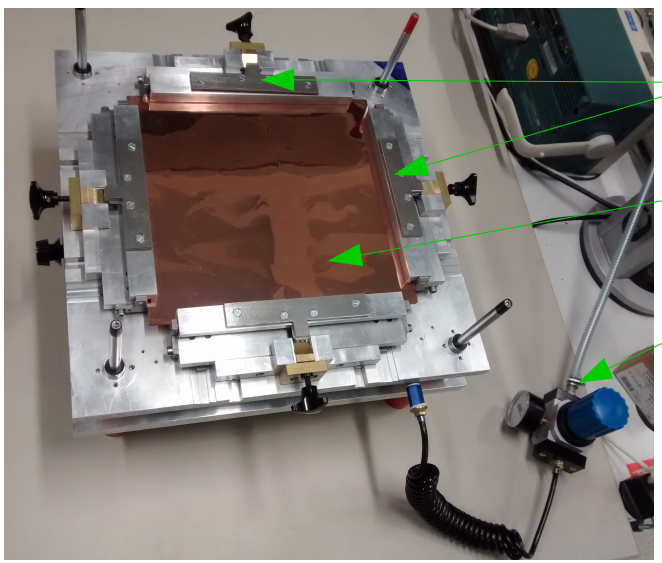


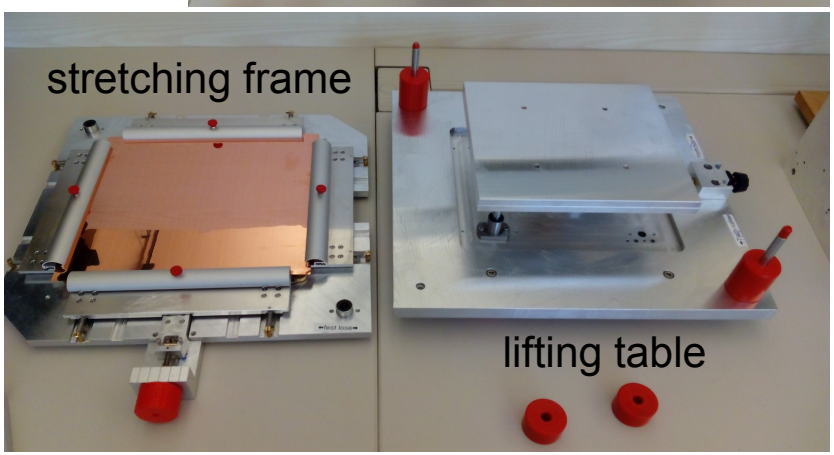


Improved, reproducible production techniques

- GEM mounting in ceramic frames
  - Before done by manual stretching on aluminum form and fixing by tape
  - New, flatter aluminum form for flatness measurements produced
  - New GEM mounting tool for controlled, reproducible construction







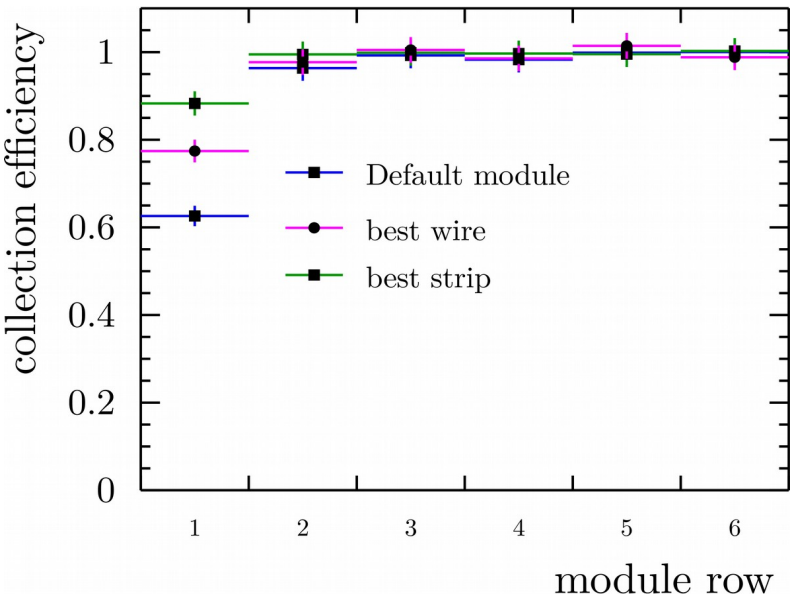
- Low force stretching of GEM foils during mounting, controlled merging of GEM and frame for gluing
- Still being improved (new clamps, stretching by air pressure instead of springs, ...)

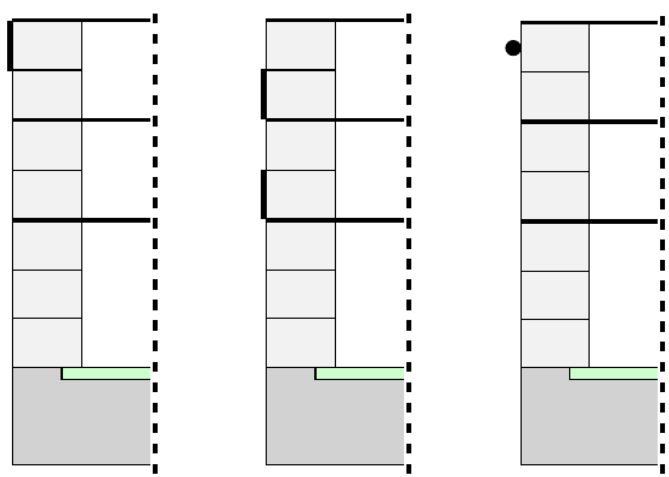
Ceramic frames and Field Shaping

- Planned:
  - New ceramics supplier
  - Plates and cutting from same company (guaranteed flatness: 0.3%)
  - Possibility to produce guard ring as a strip directly onto a frame

    Did not work out

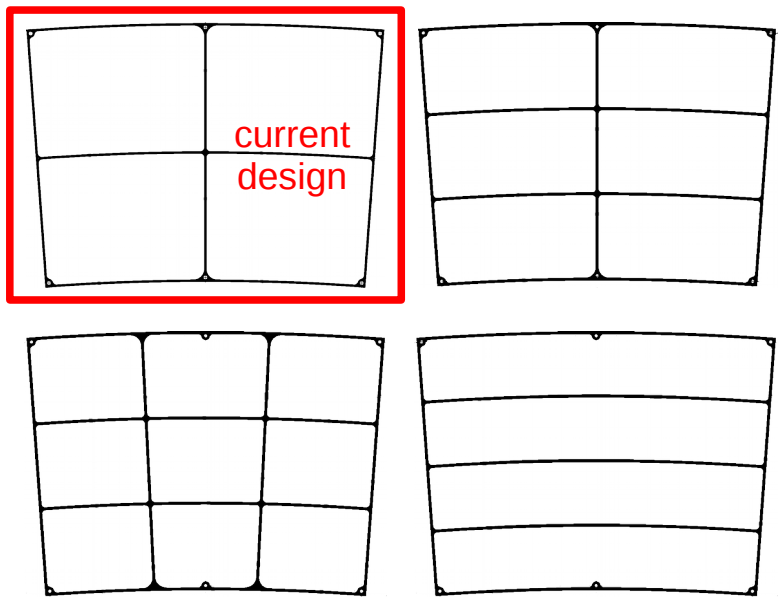
- Future steps
  - Repeat simulation of distortions
  - Find a possibility to produce strips on the ceramic frames
    - Fraunhofer-Institut IKTS?
    - In contact to DESY machine group (experience with ceramics metalization)





Ceramic Frame Geometry

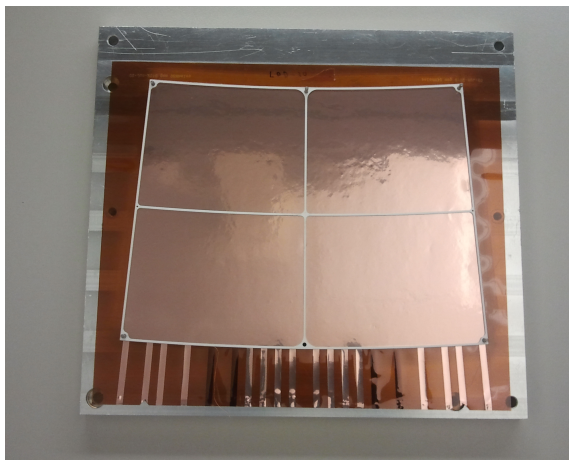
- Study of four different frame geometries regarding GEM flatness using aluminium frames

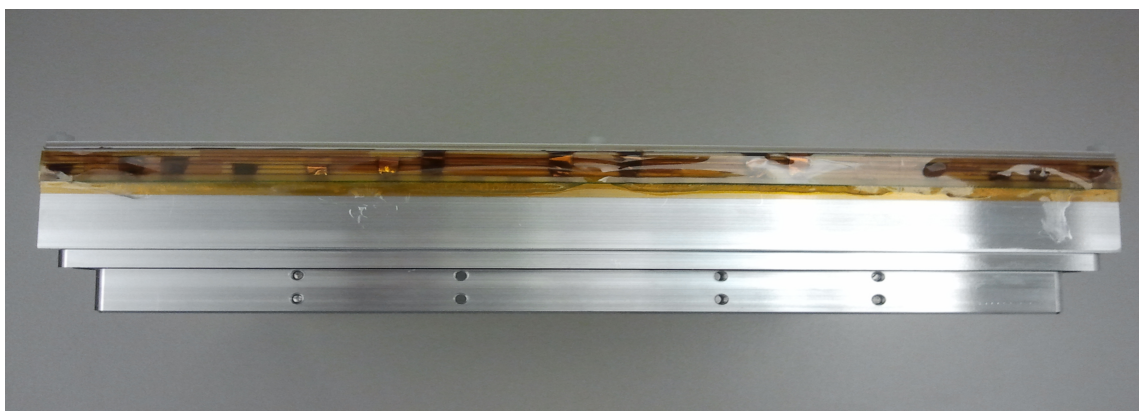


- Did some additional tests with an intern this fall using dummy foil
- No conclusive results yet, flatness difference between designs seems negligible

GEM foils

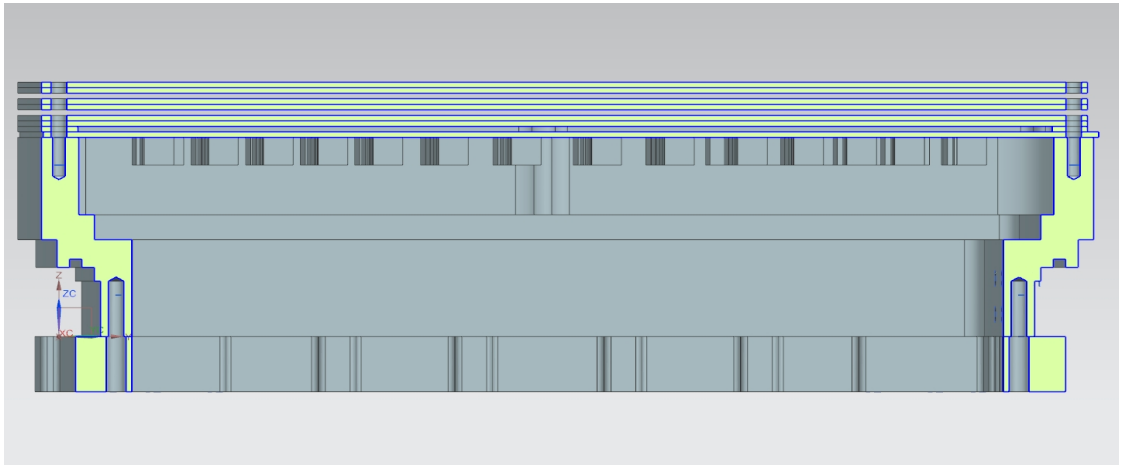
- Adjusted GEM foil design
  - Before, all 3 foils with the same layout
- Now HV supply lines separately for each foil
  - Avoids sharp edges from cut HV lines
  - Saves some insulation by Kapton tape
- Fixed mismatch in frame/foil drawings:
  perforation did go under the ceramic frame
  → adjusted according to gluing tests
- Topmost GEM:
  more area coverage of the copper coating
- Small additional improvements included
  in the drawings after the current module's
  construction



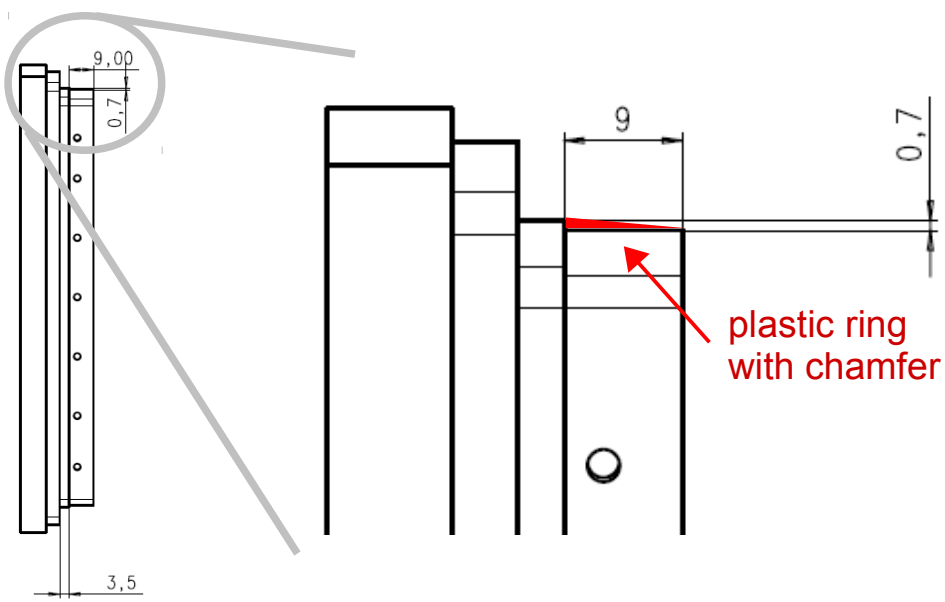


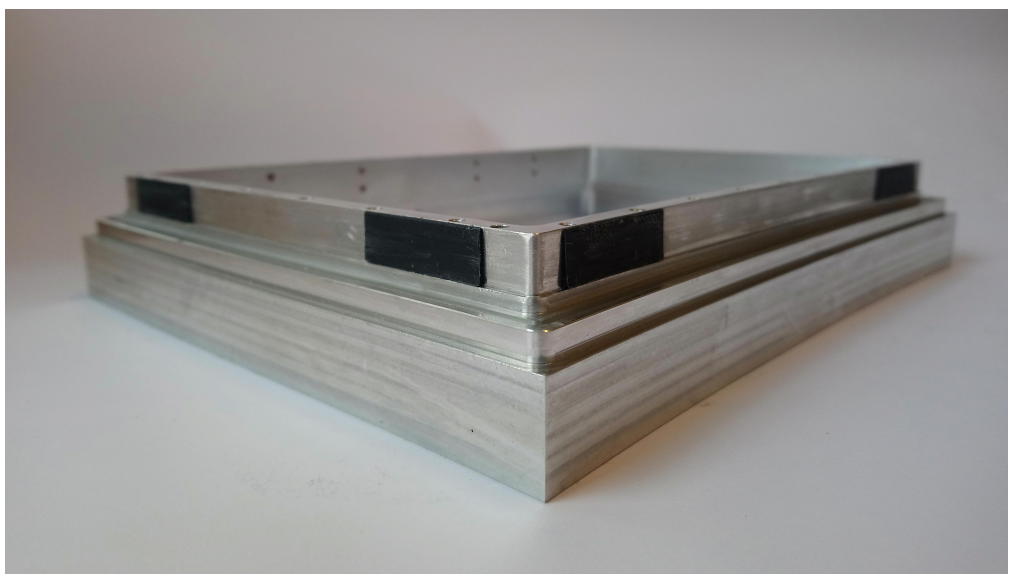
Mechanics

- Adjusted and reviewed design/drawings of all components (backframe, pad plane, frames, GEMs)
  - Detected small offsets of different parts in previous drawings which have been corrected



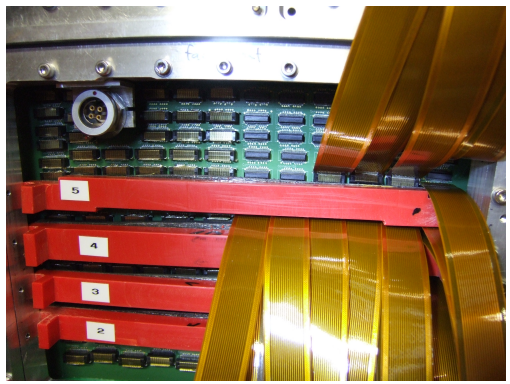
- Introduced plastic ring at backframe for easier insertion into endplate without aluminum abrasion

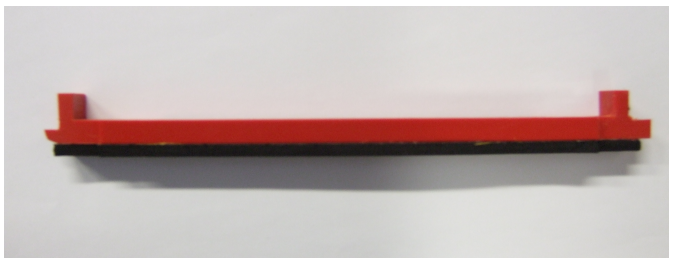


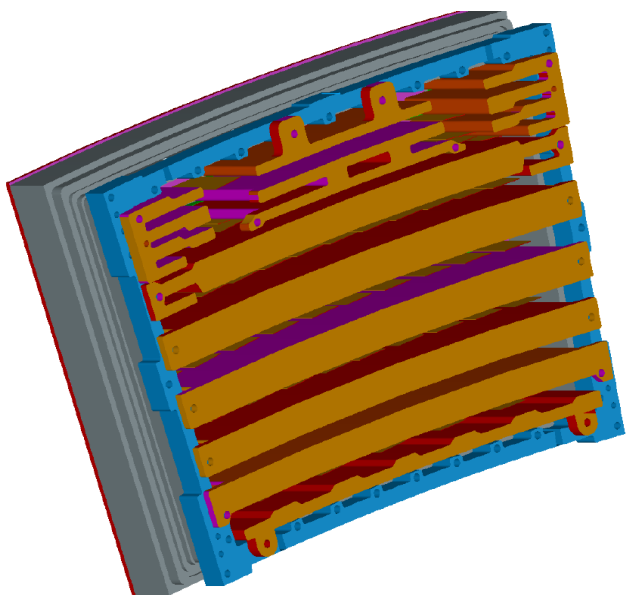


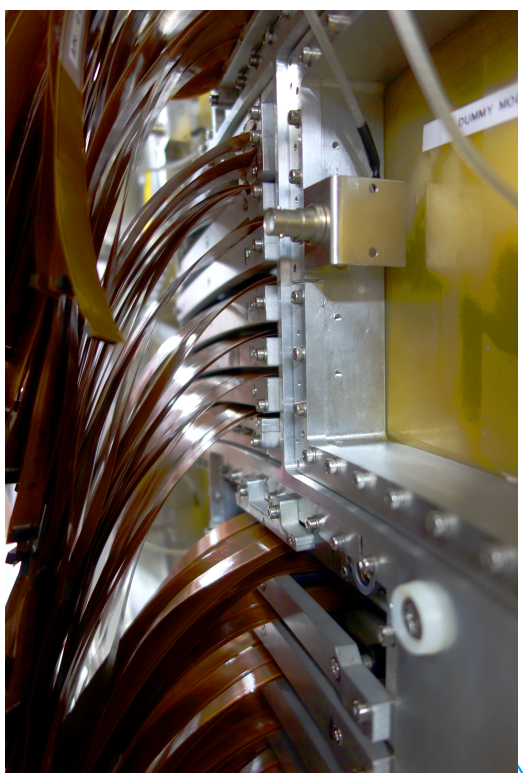
Mechanics

- ALTRO plug holding clamps
  - Old design did not perfectly fit
  - Did not hold plugs reliably in place
    → loss of readout channels
  - Applied pressure to pad plane
    → spoiled gas tightness at glue seal
    between pad board and backframe
- New design ready
  - Fastened by same screws as mounting bracket
  - Made with rapid prototyping printer (lightweight)
  - Nearly zero force on the pad board
  - Worked very well during 2016 testbeam period
  - Good gas quality



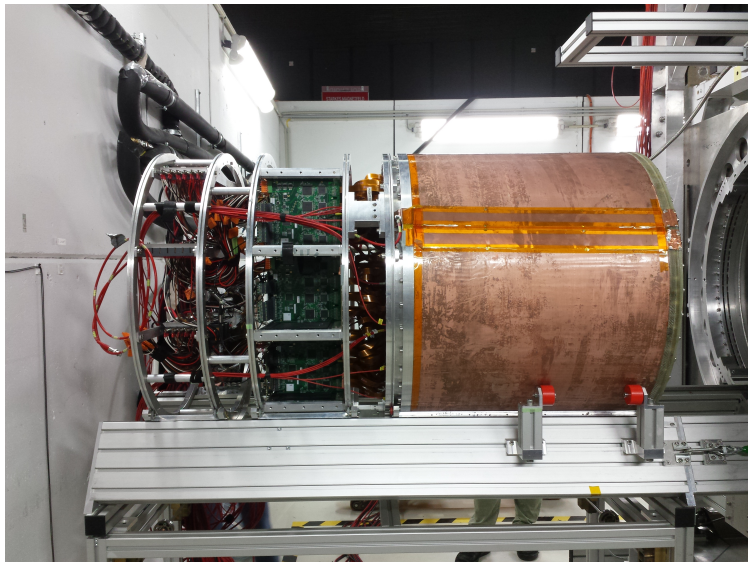




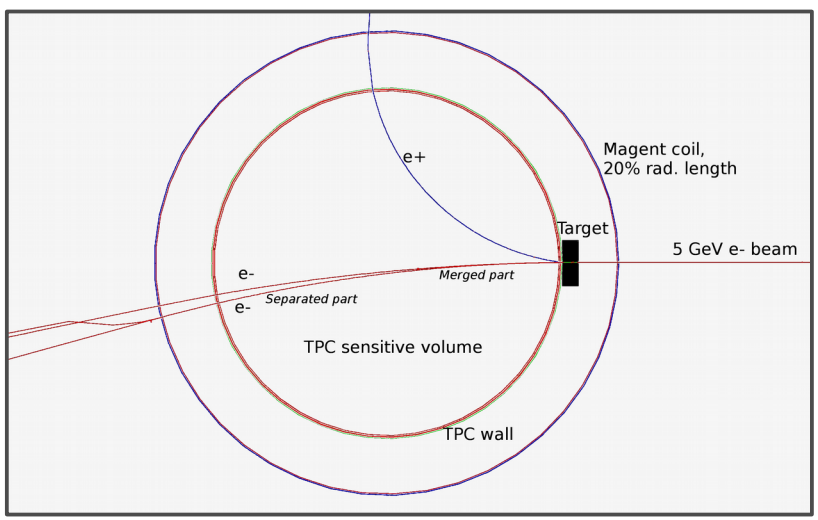


Testbeam

- Tested modules in November/December 2016
- Goals
  - Test module performance
  - Study double track resolution: Measurements with target (~ ½ X0):
  - dE/dx Studies
  - Calibration test



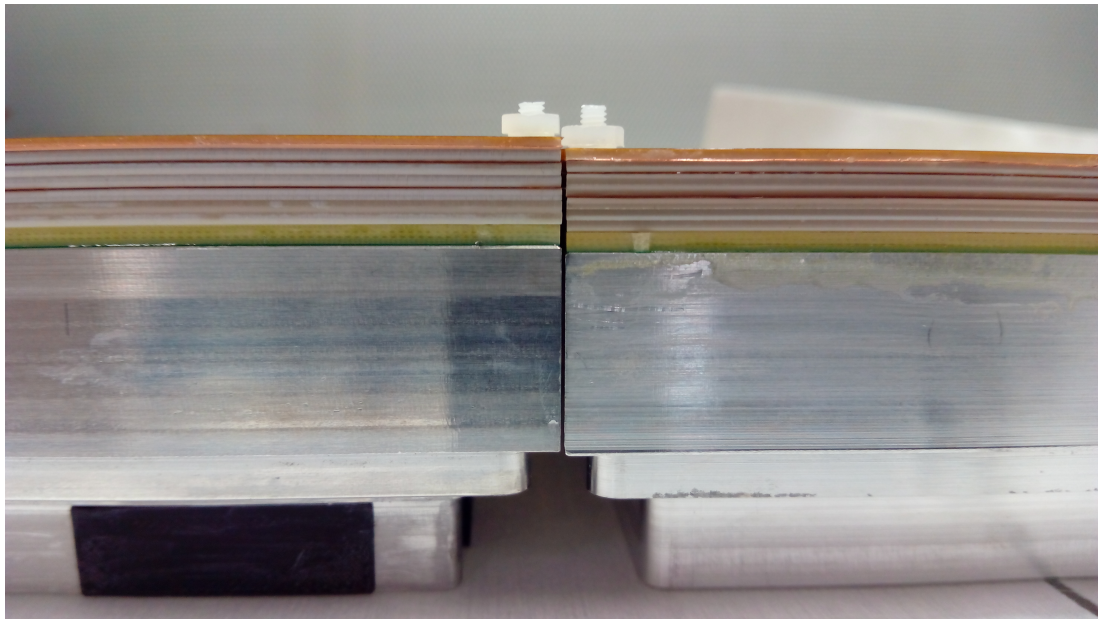
- 9.5 M events recorded in 400 runs separated into 34 scans
  - Runs at 0T, 0.5T, 1T magnetic field at different drift lengths and angles
  - Standard drift field: 240 V/cm
  - Runs with minimal diffusion drift field: 130 V/cm
  - Runs with minimal ion backflow GEM settings
  - Almost 6 million events of this were taken with the target
  - Rate of usable double track events ~6-7% for 1T magnetic field



Lessons Learned – Quality Control

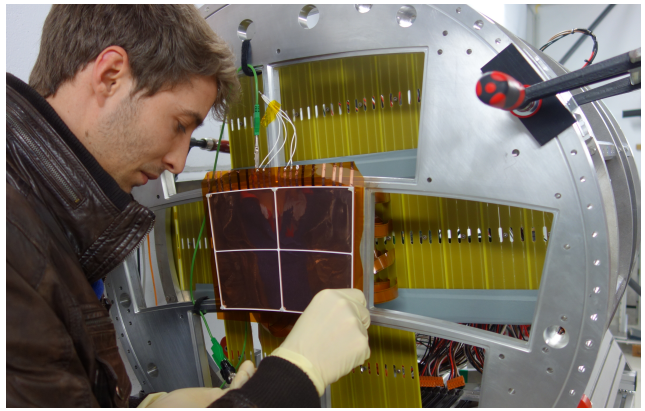
- Height comparison of new (left) and old (right) module
  - Stack of the new module is ~0.5mm higher Including PCB and aluminum back-frame
  - Could be compensated by guard ring settings
  - Material from same manufacturer, except ceramic grids

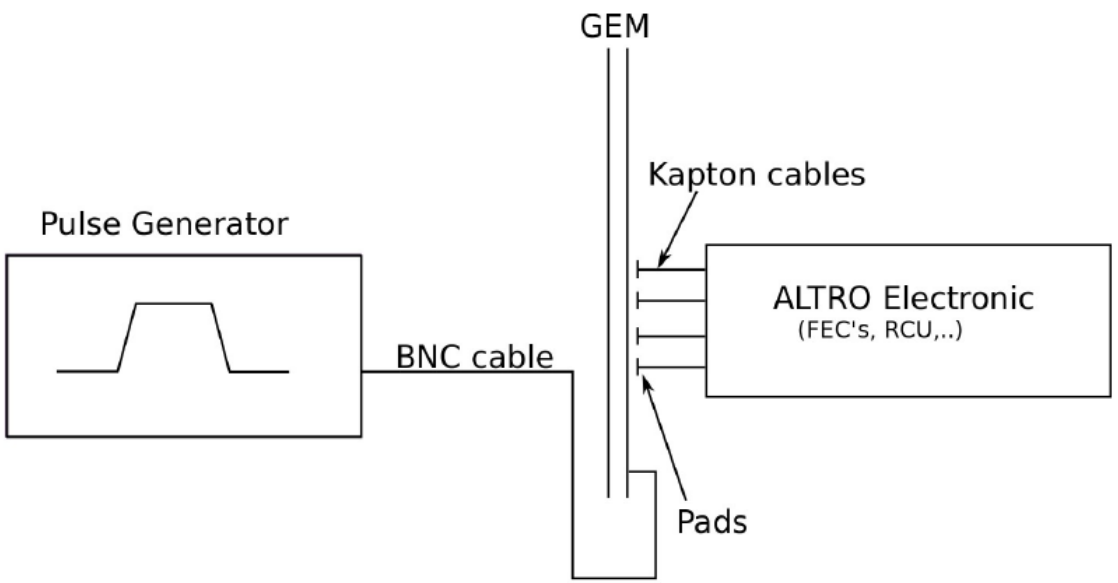
  → Better quality control before assembly



Lessons Learned - Calibration

- Charge and time calibration by pulsing the common electrode of the bottom-most GEM
  - Tested before testbeam period with mock setup
  - Measurements with testbeam setup tricky (for 3rd module not possible), since HV contacts had to be connected free-hand for pulsing the GEM ← ALTRO electronics and cables block easy access
  - Next module iteration should include easily accessible contact (over capacitor?) to bottom-most GEM layer





(Possible) Future Steps

- Integrate gating GEM
  - In principle already included in design
  - Several details to be designed/discussed:
    guard rings, HV schemes, height difference,
    design of gating GEM + mounting on ceramic grid
- Optimize field shaping
  - Strips instead of wire, layout
- GEM stability
  - Testing long term (months) stability
  - GEM oxidization (baking) results not conclusive yet
  - Trying different GEM base material?
    (glass GEMs, “Die Hard” PTFE insulator http://iopscience.iop.org/article/10.1088/1748-0221/9/03/C03043)
- Look further into alternative grid designs
- S-ALTRO version with higher integration
  - Solve occasional time shift between RCUs?