Progress on quality assurance of GEMs at the ALICE TPC Upgrade

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- Introduction
- QA scheme for TPC Upgrade construction
- Large size gain measurement
- Conclusions

ALICE TPC Upgrade project

- ALICE TPC:

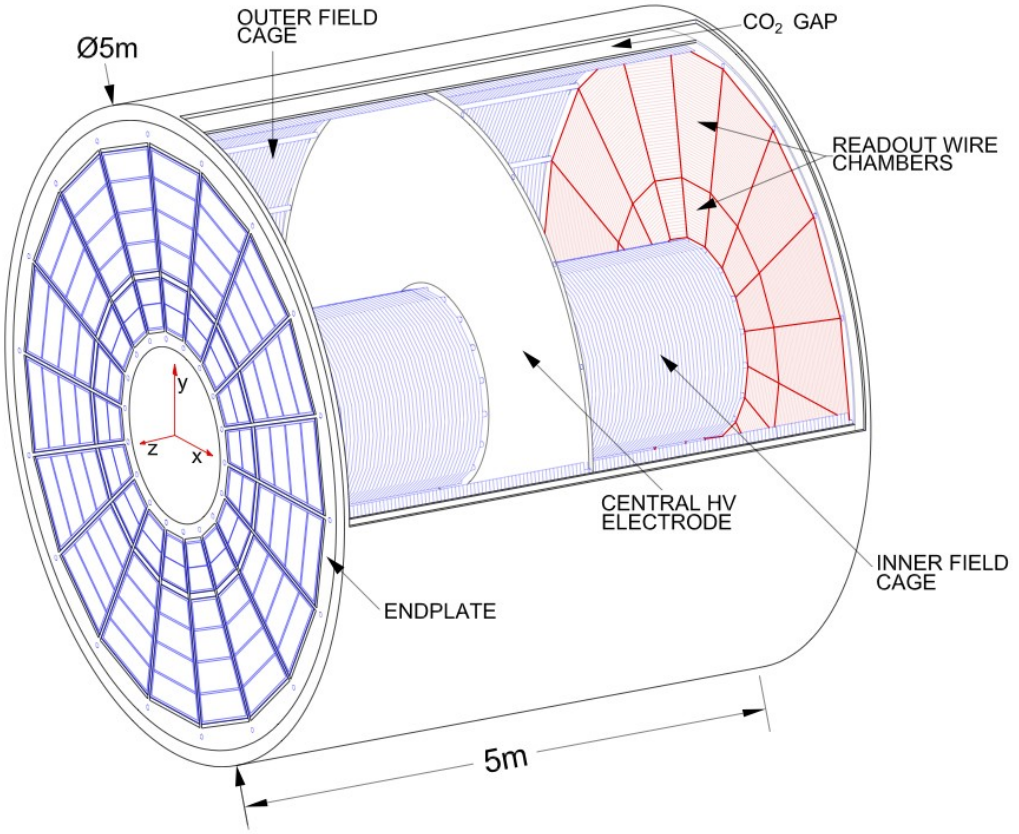
  88m^3 active volume

  32m^3 readout surface

- Upgrade goal:

  increased speed by

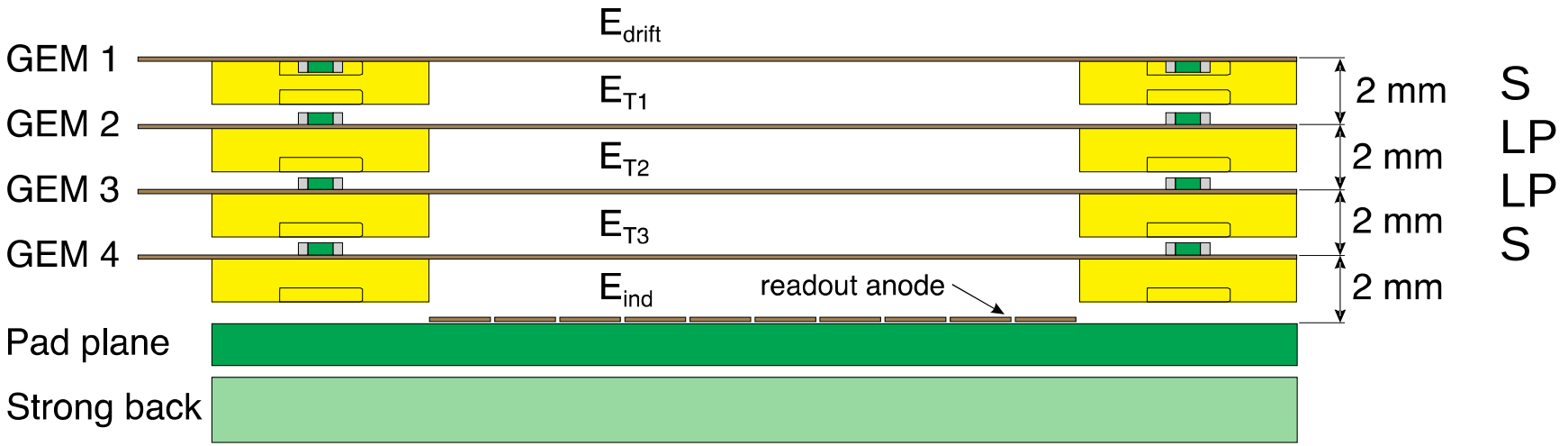
  continuous readout:



Main limitation: space charge by back-drifting ions

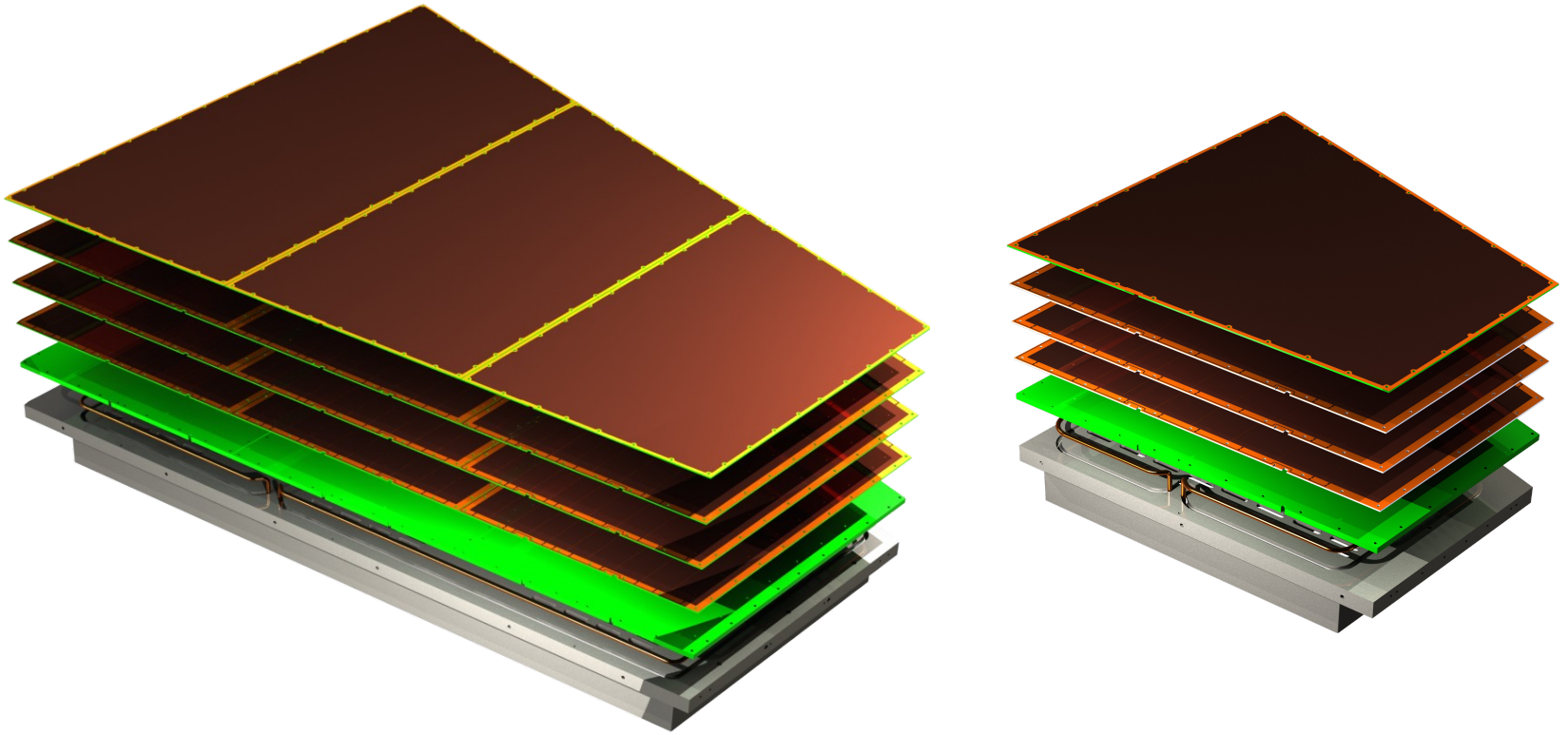
Solution: 4-GEM stack (TDR)

- Ion blocking inherent in GEM (high rate capability)
- Objective: (ions in drift) / (electrons on anode) <1%
- Energy resolution sufficient for dE/dx measurement



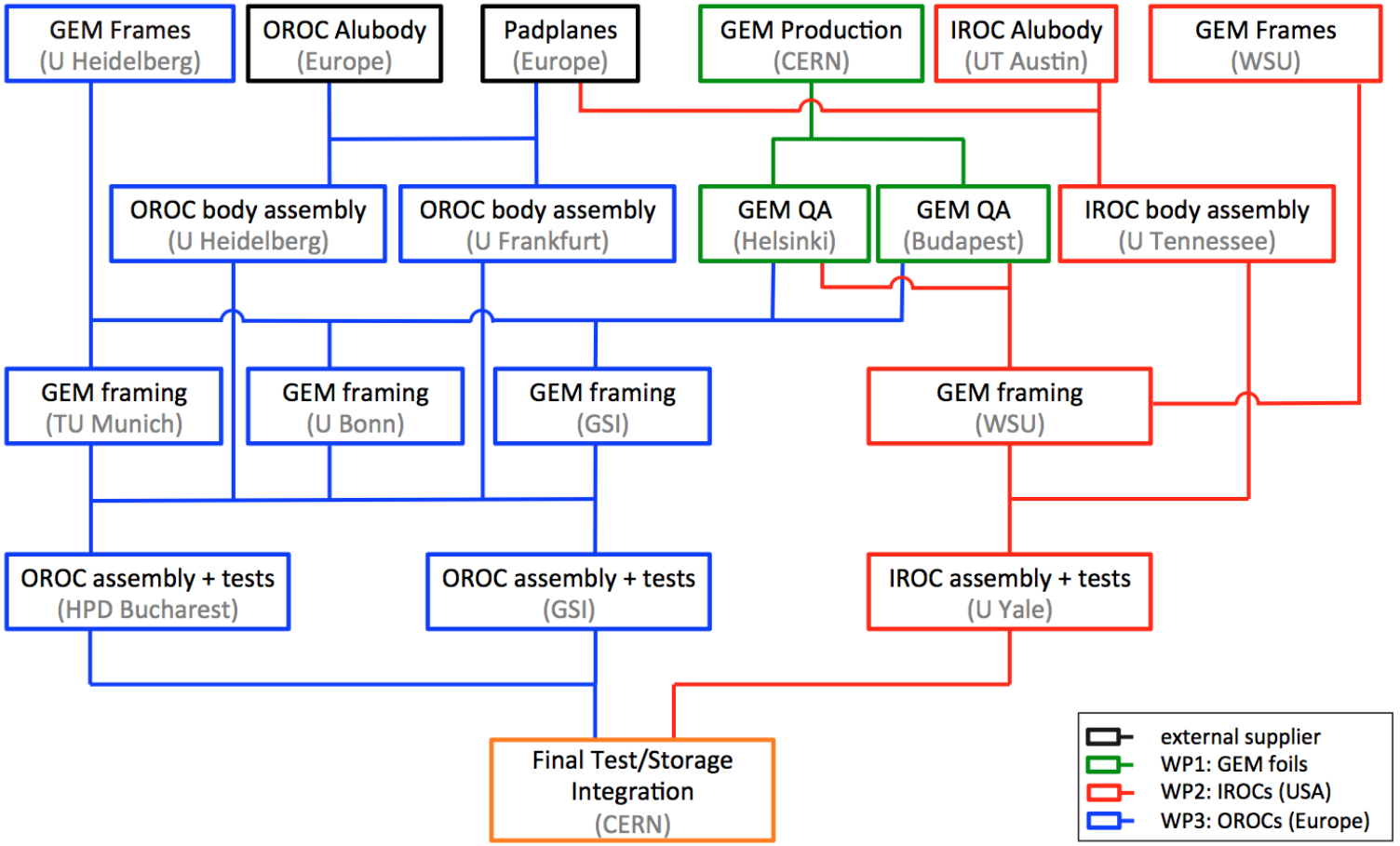
Readout chambers: Outer and Inner

- Large single mask GEM-s from CERN
- OROC: 3 x 4 foils IROC: 4 foils



- Quality assurance and recording is a key construction step

Participating Institutes and workflow



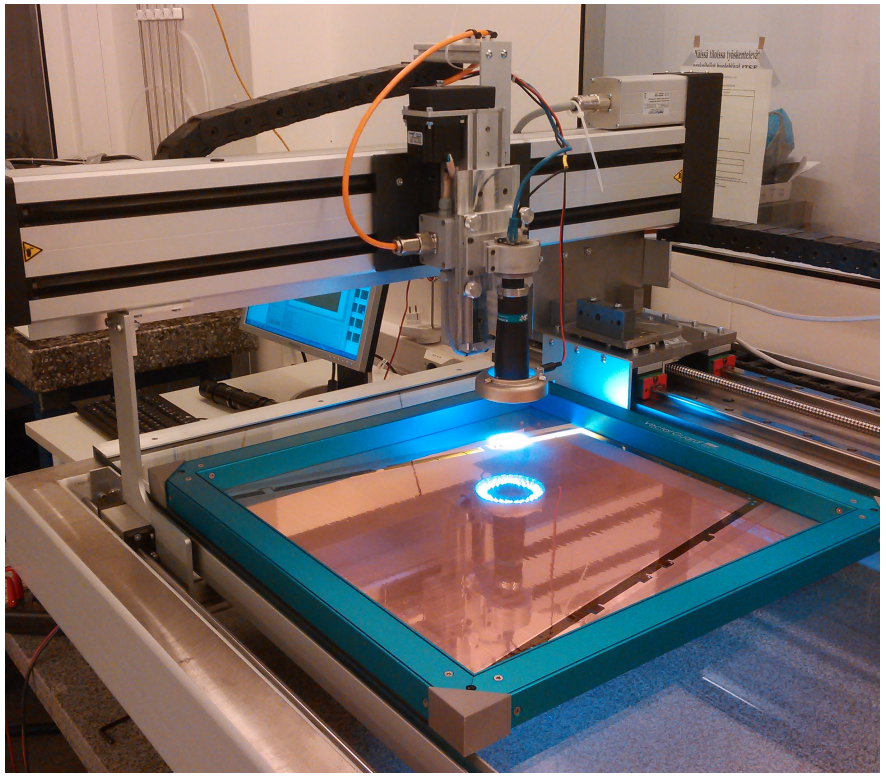
- QA scheme: “basic” and “advanced”

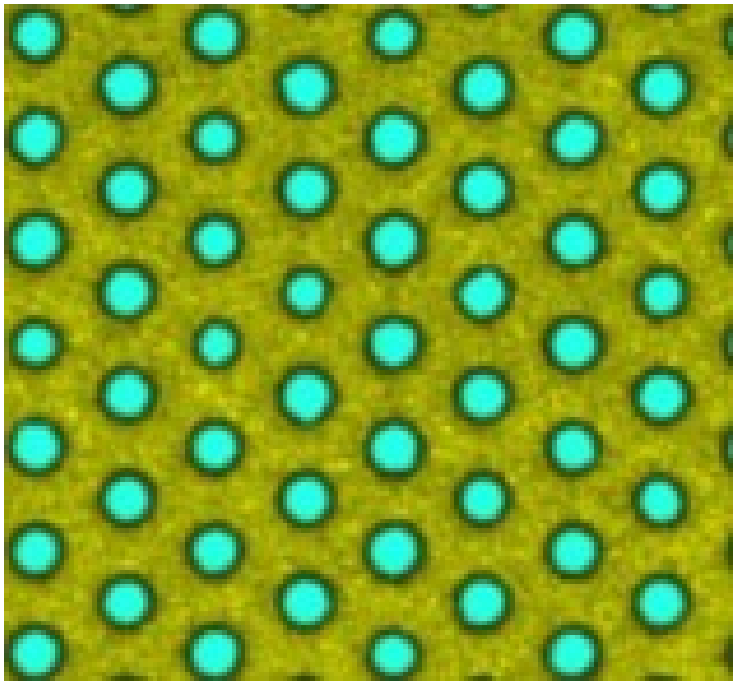
QA objectives, levels

- “Basic”
  - Coarse optical inspection to filter out major defects
  - Leakage current measurement sector by sector
- “Advanced”
  - High resolution optical scanning
  - Long term and HV stability tests
  - Gain uniformity measurement
- Traffic-light system based on criteria:
  - Red for reprocessing
  - Yellow for “non-fatal” but not coming up to quality
  - Green for fully conformal with quality criteria

High definition optical scanning

- Developed by Helsinki (E. Brücken, T. Hildén)

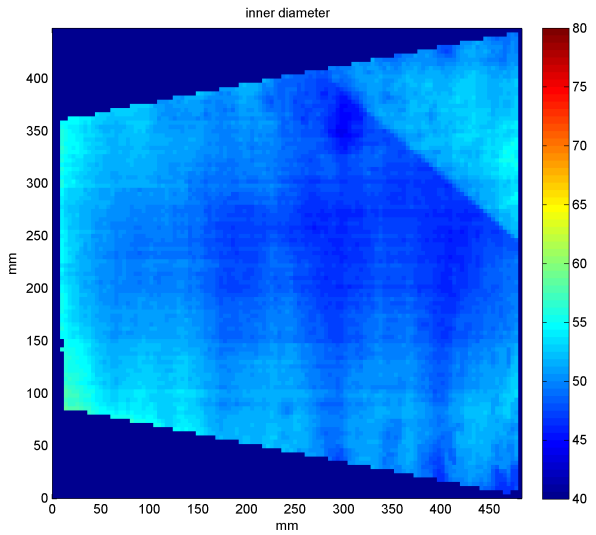




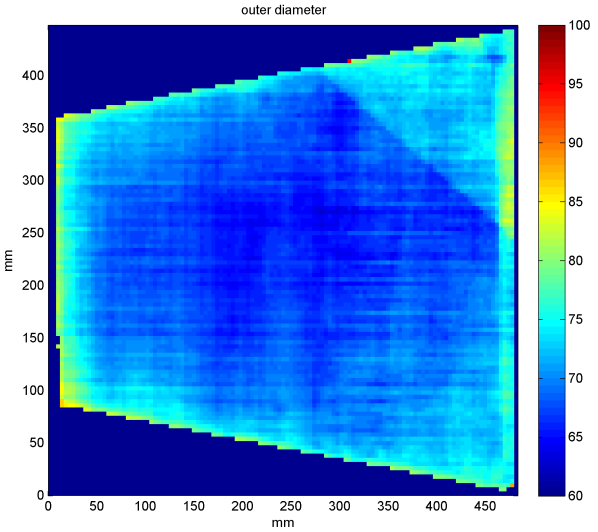
High definition optical scanning

- Result: detailed information on hole geometries
- Identification of the defective regions
- 15 IROC preproduction foils scanned, #5 as example

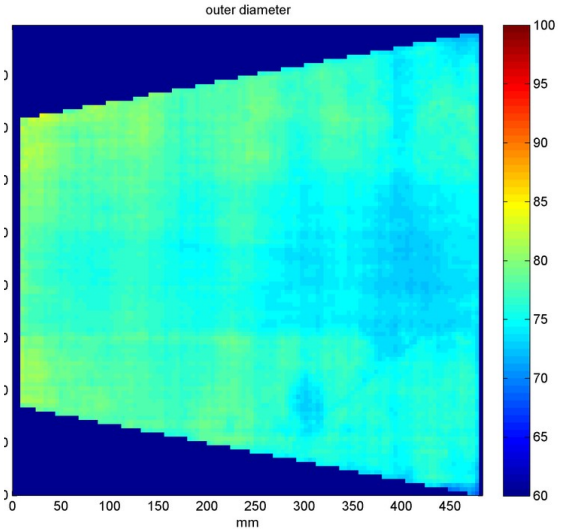
Inner



Outer top



Outer bottom

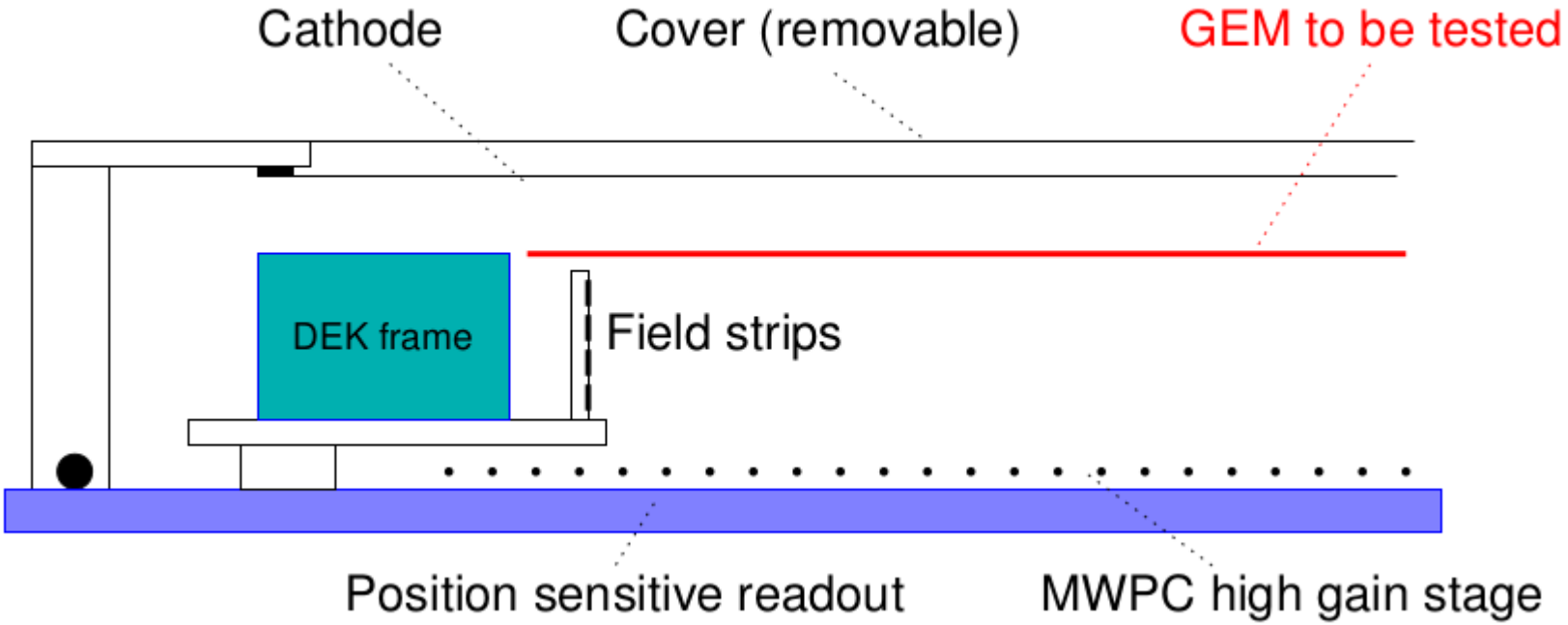


GEM gain mapping

- **As a “Quality Assurance” device:**
  - gain map for detector performance assessment
  - rejecting foils with excessive non-uniformity
  - cross-check the prediction from optical scanning

- **As an “R&D” issue:**
  - how to obtain the best prediction of gain map from hole geometries
  - how to relate different GEM voltages, working gases, transfer/drift fields etc.

Chamber outline: GEM + high gain MWPC

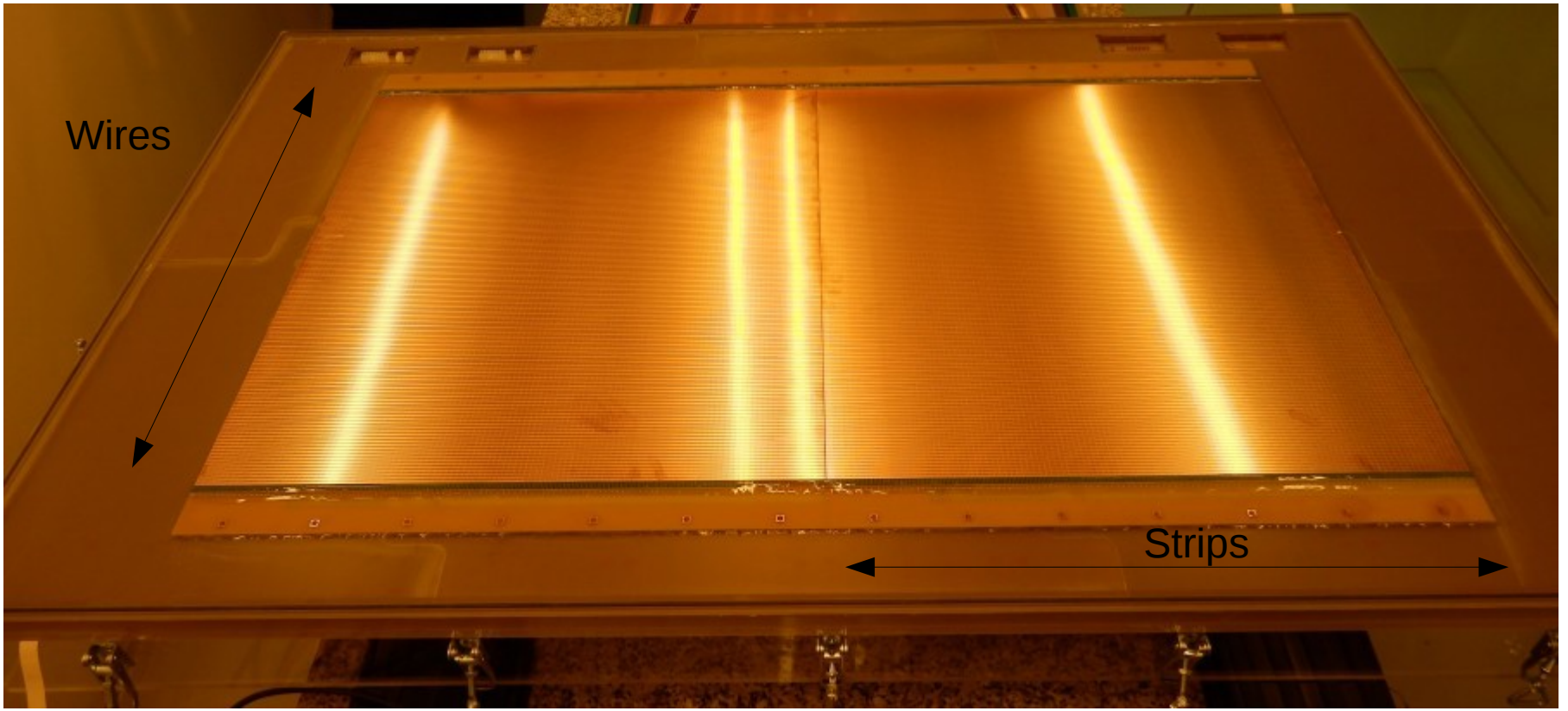


Why MWPC (CCC):

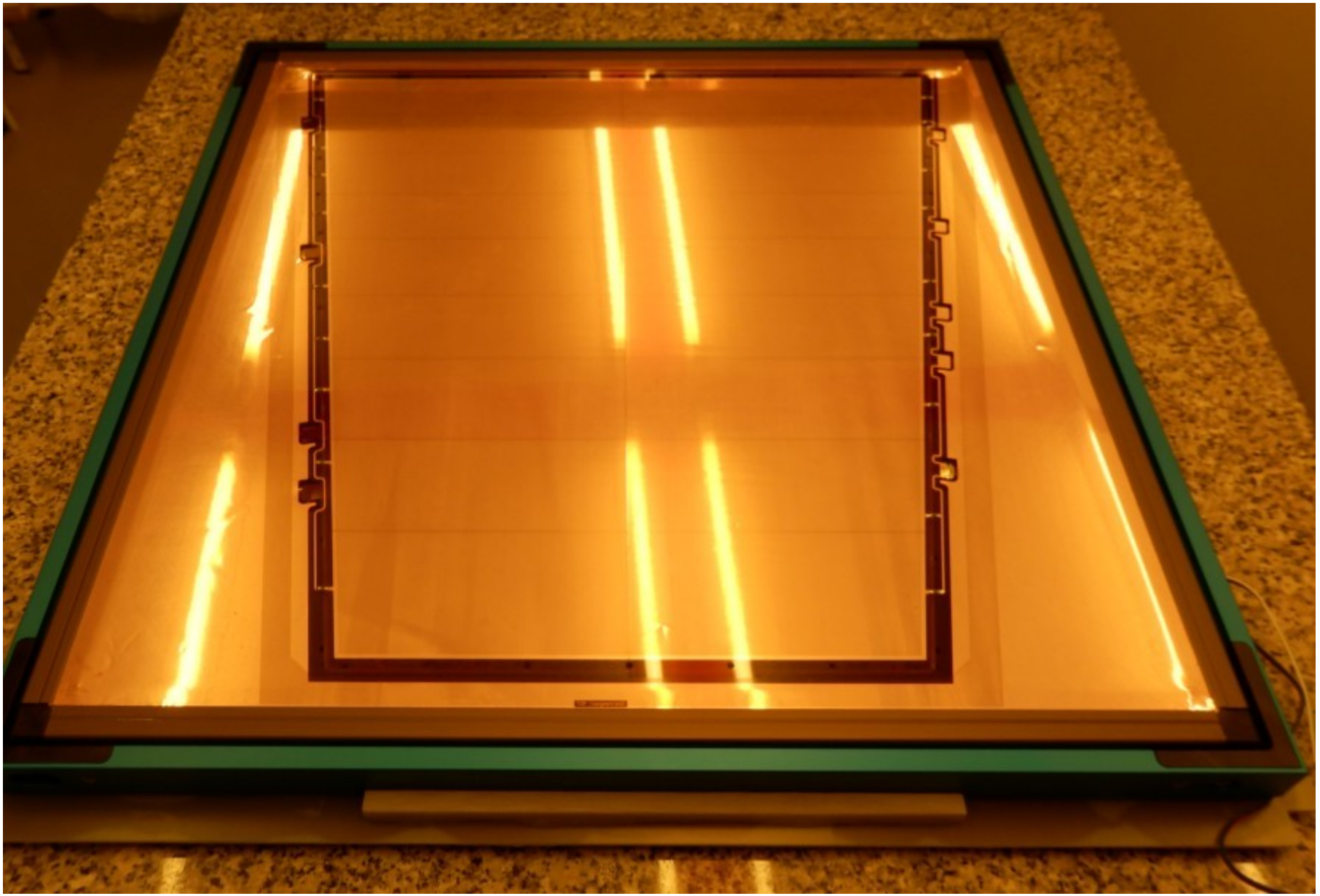
- Conservative approach, simple construction
- Recycling of existing DAQ for 2D readout

Detector assembly

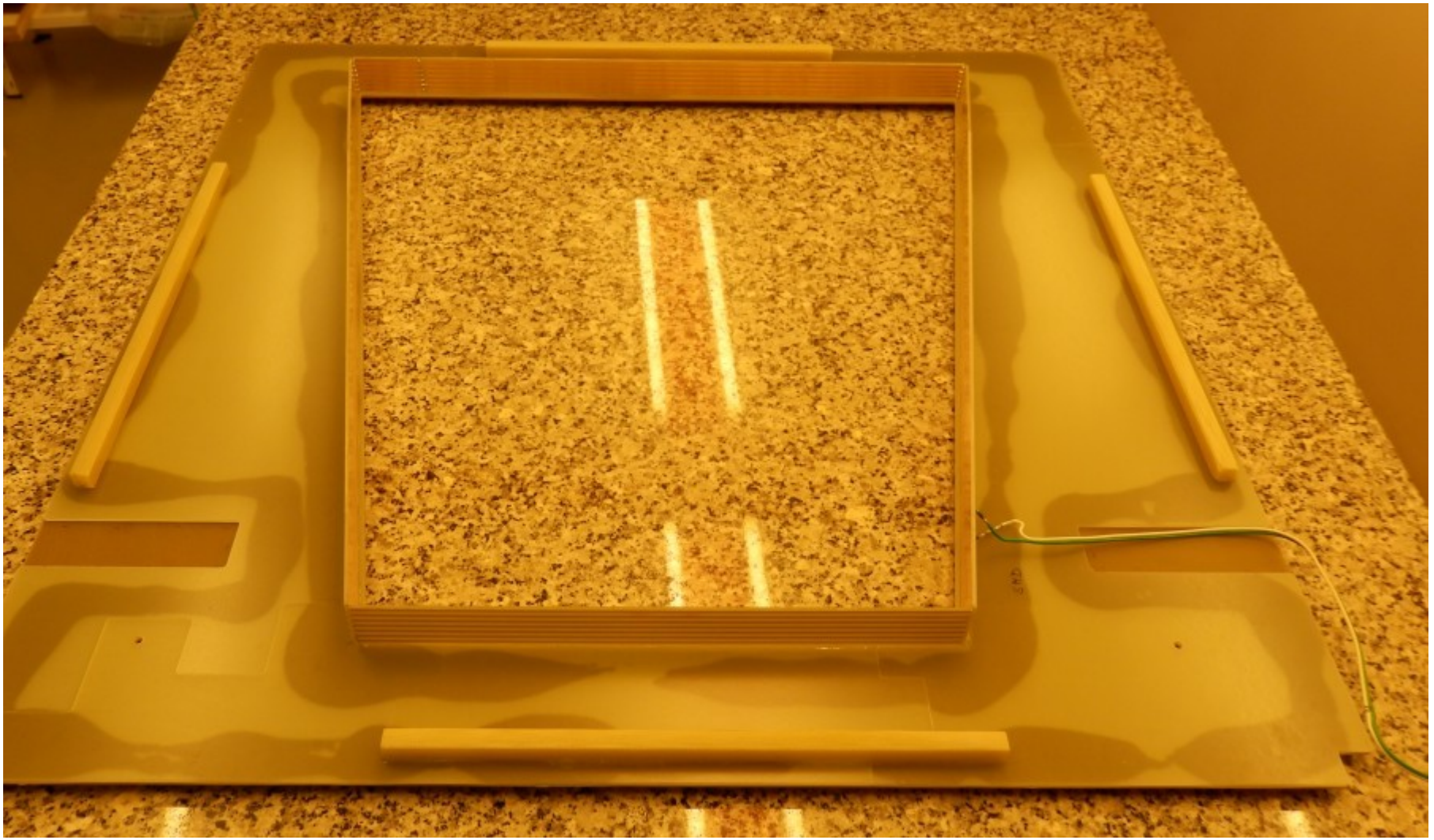
- Flat MWPC, 50cm by 90cm
- Wire spacing 4mm, strip spacing 3mm



Installing GEM: on support plate

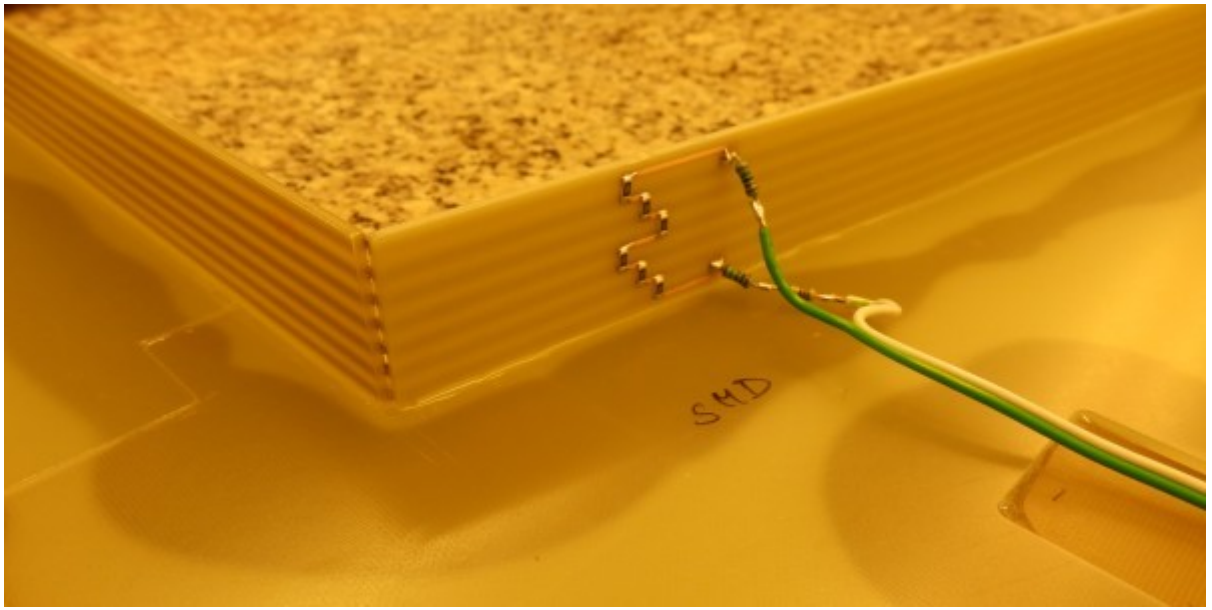


Support plate by itself: “field cage”



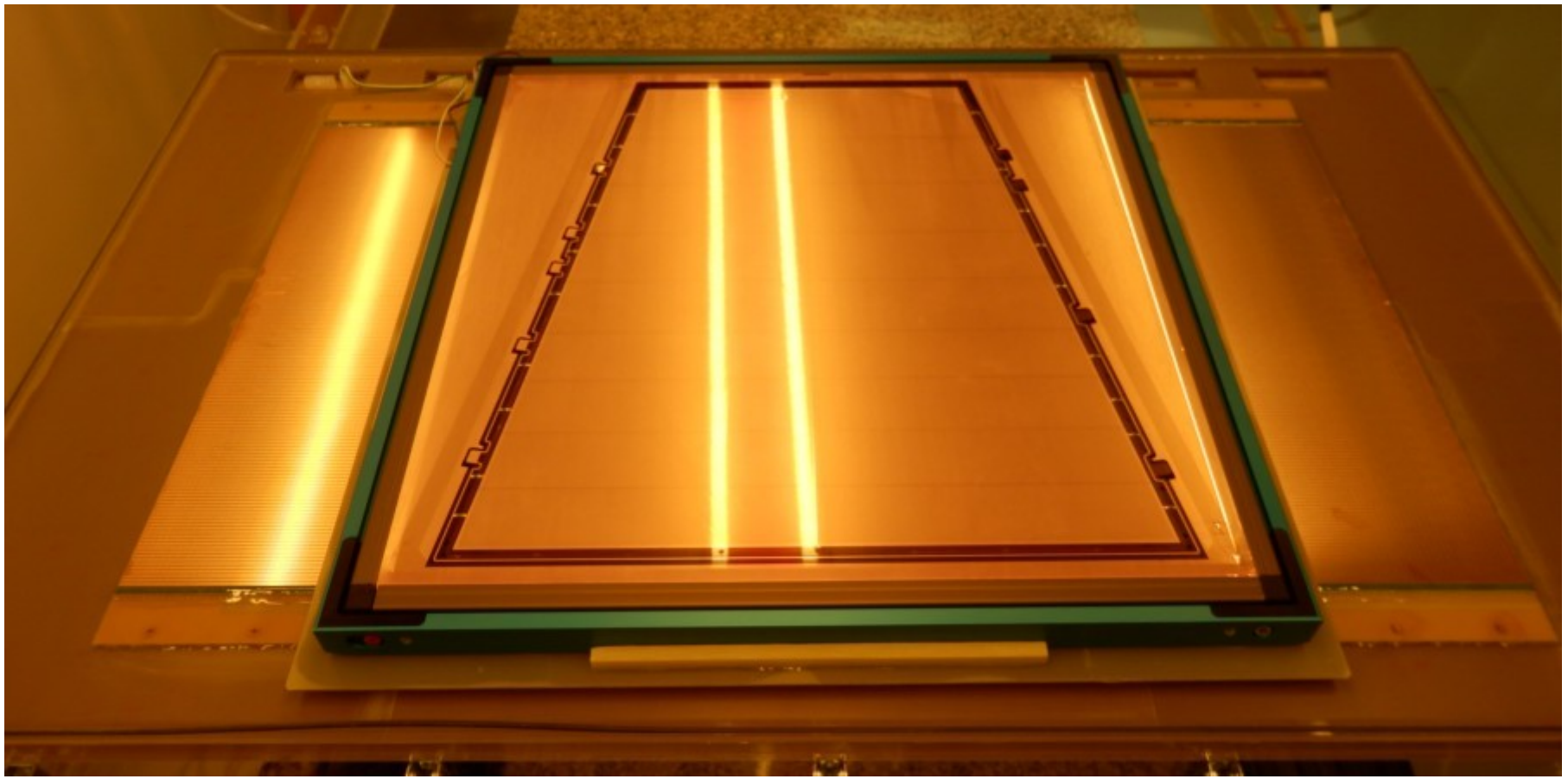
Divider chain for the support plate

- Ensures homogeneous field over 3cm
- SMD resistors for 7 field strips



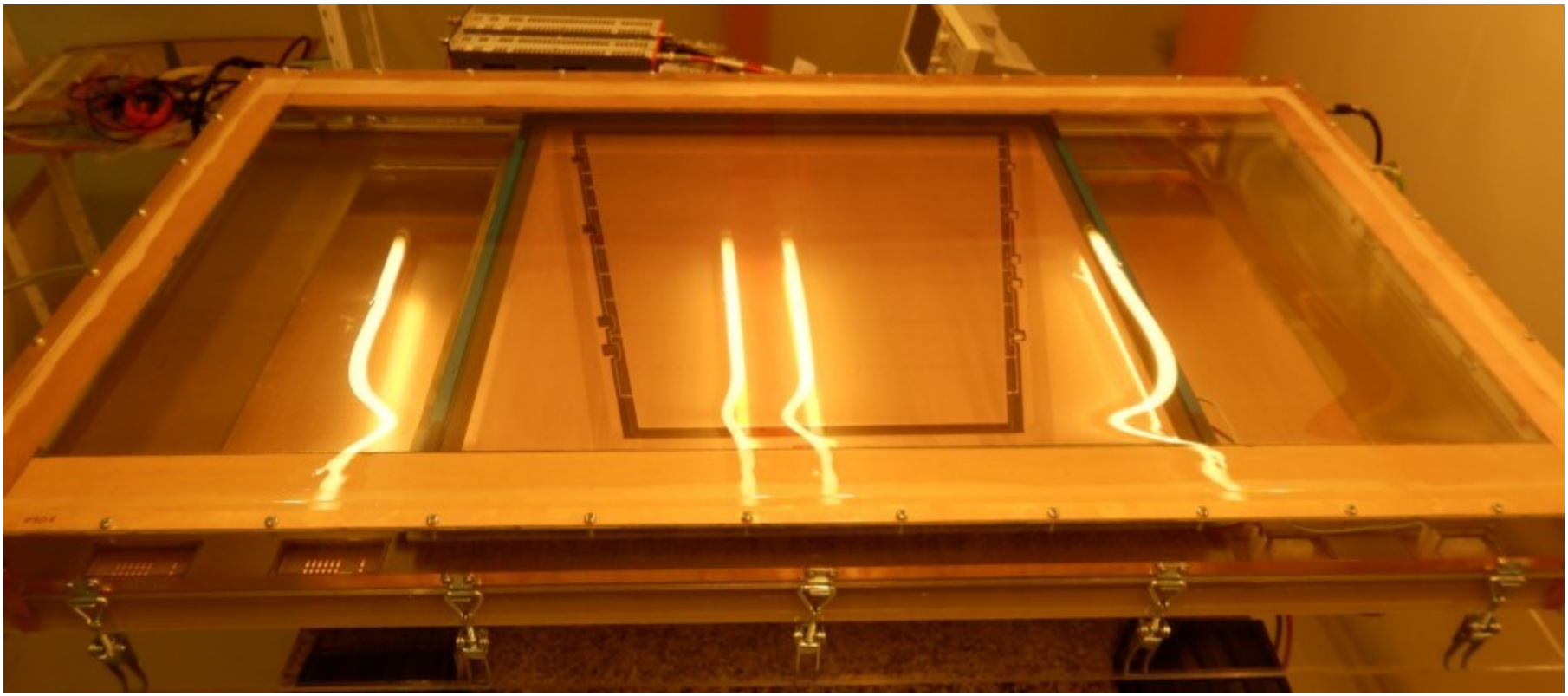
GEM inside the detector

- GEM with DEK stretching frame, placed into the detector directly



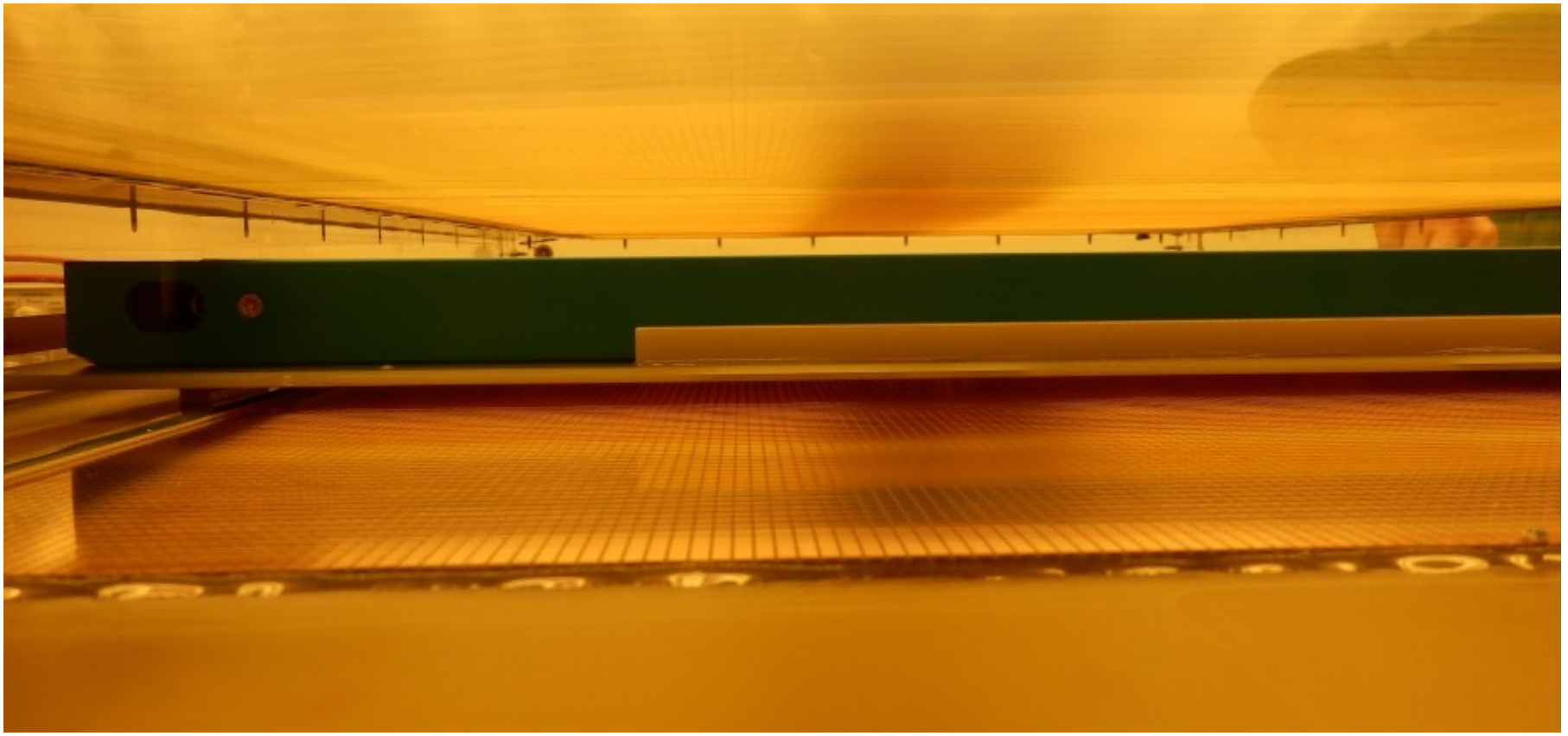
Installing cathode

- Wire grid for cathode, within the top cover box
- Quick fixing, gas seal with O-ring, Mylar top



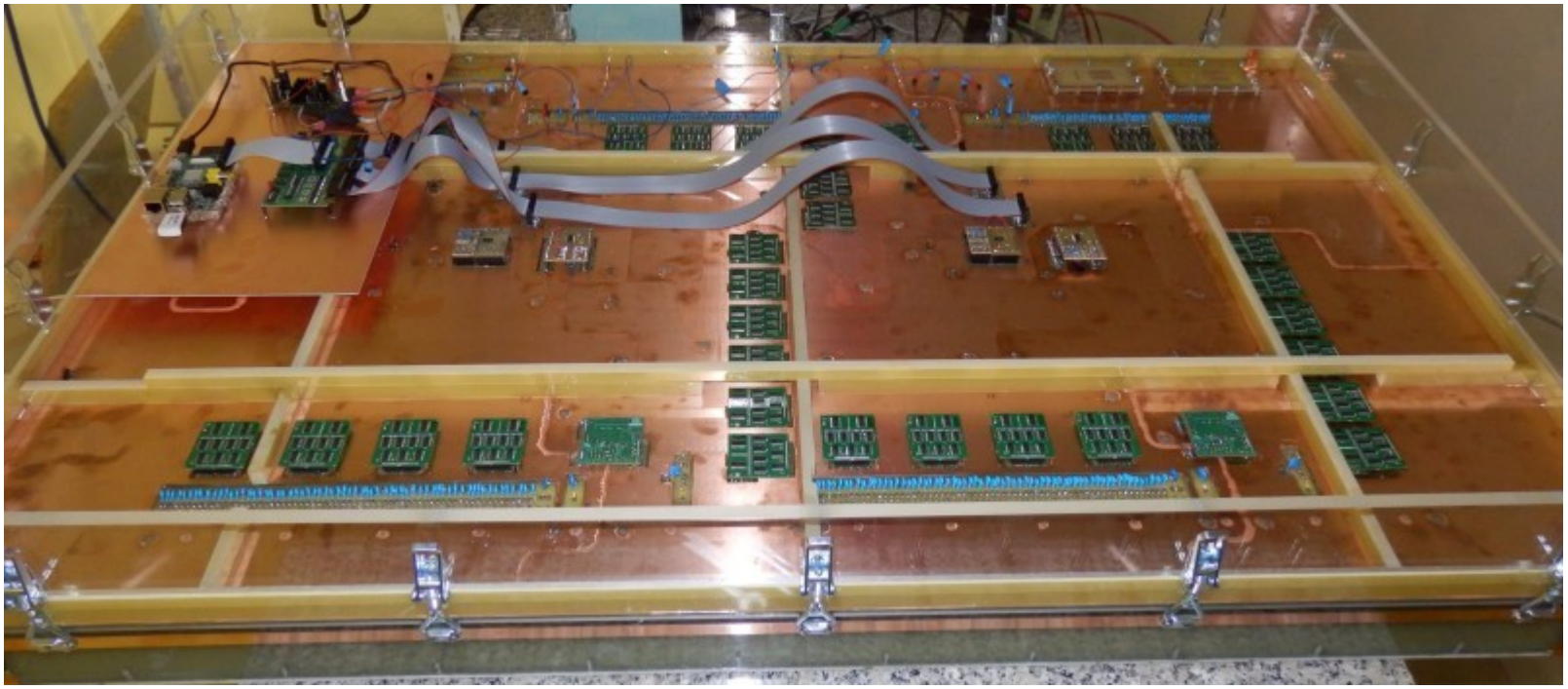
Looking inside: side view

- Drift gap above GEM around 2cm



The “bottom side story”: DAQ

- All electronics jammed below. This ensures clean environment during GEM installation



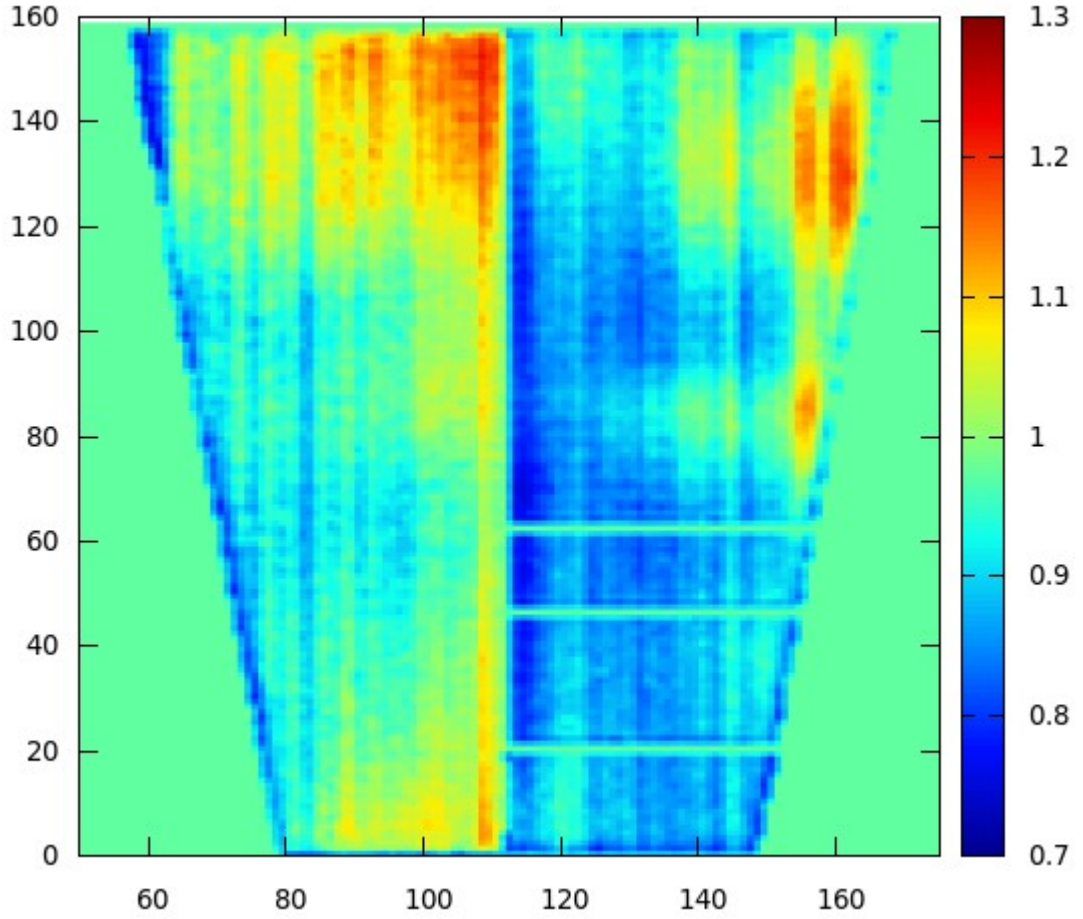
Data taking conditions

- Fe55 source placed about 70cm above detector, single irradiation position
- Charge from full surface ADC, position from wire and strip clusters
- Now running at 2kHz rate

- 50 litres total volume: 6-12 hours gas filling
- Industrial grade Ar+CO2 (82:18) gas mixture

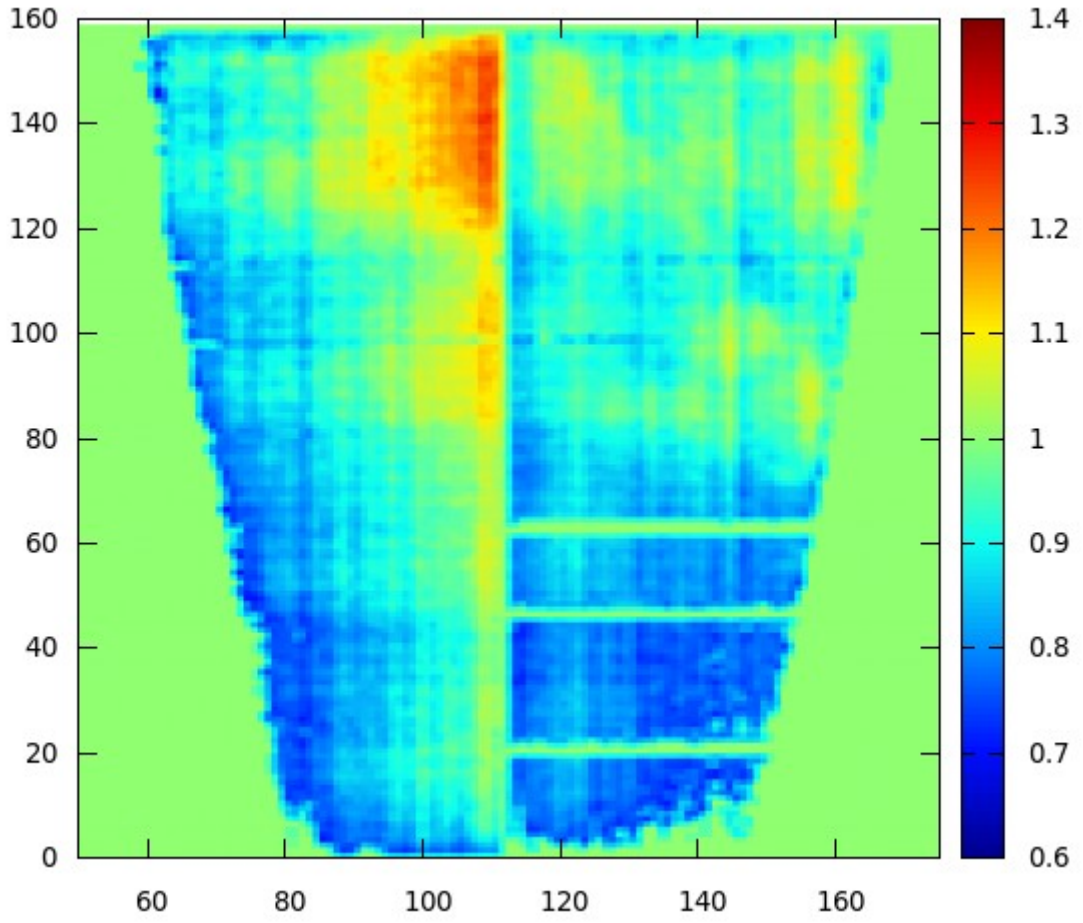
MWPC uniformity: measured gain (GEM off)

- Up to 20% systematic gain variation
- Further optimization might help
- (left – right different ADC-s)



Measured gain with 345V on GEM (gain 3-5)

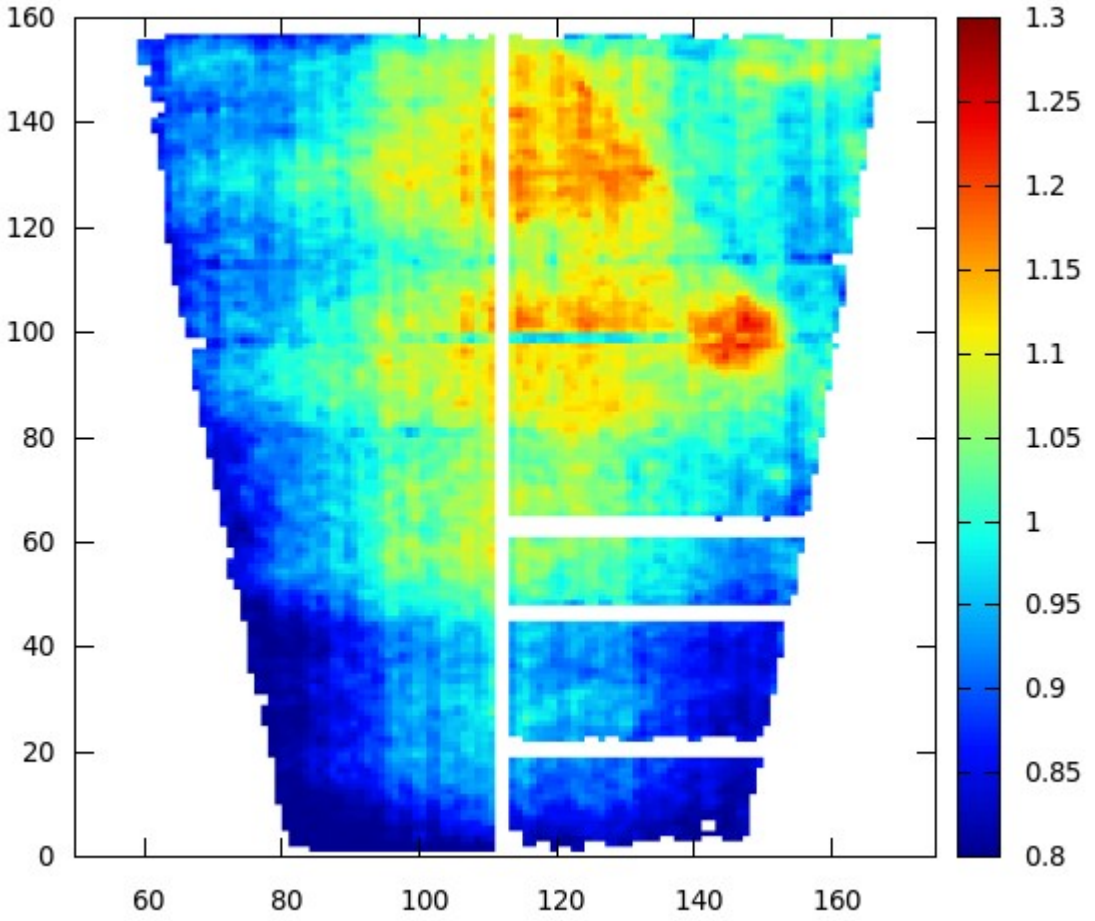
- Clear measurement over the whole surface
- MWPC sense wire voltage reduced



Ratio: GAIN MAP of an IROC foil

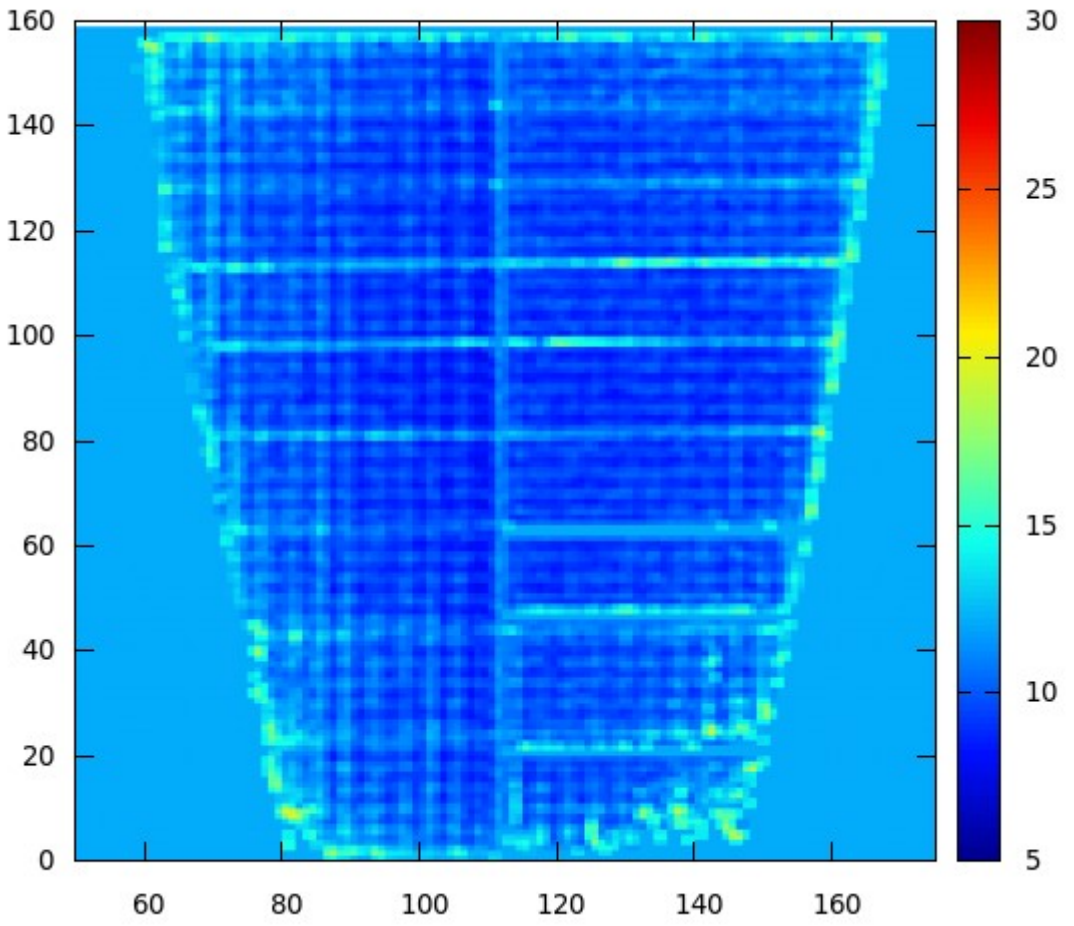
- Complete IROC foil gain measurement for the first time
- Data taking (4M evts):

32 minutes



Data quality

- Measured energy resolution map, around 10%
- Sector boundaries apparent

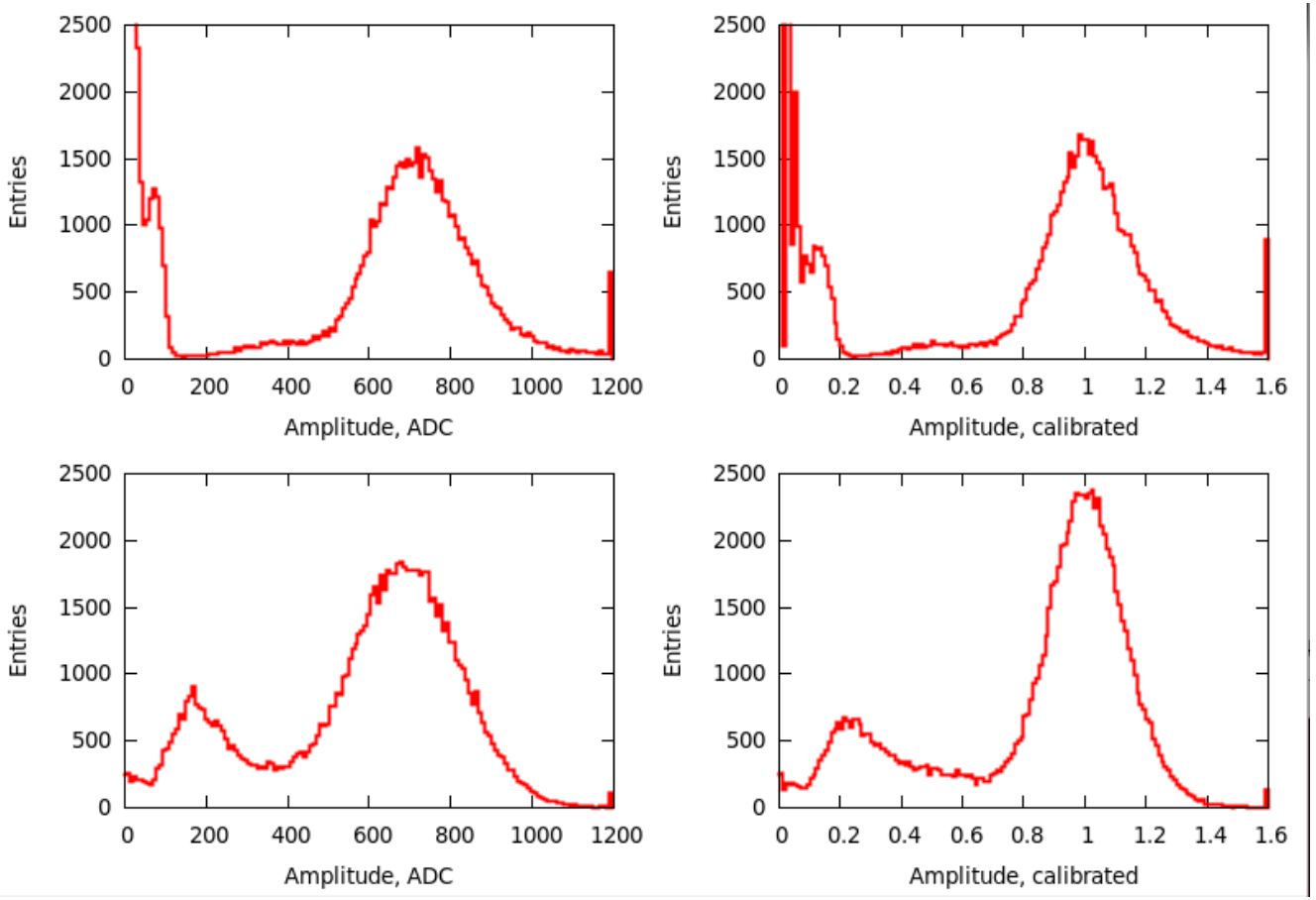


Data quality: whole surface spectra

- Raw ADC
- Calibrated

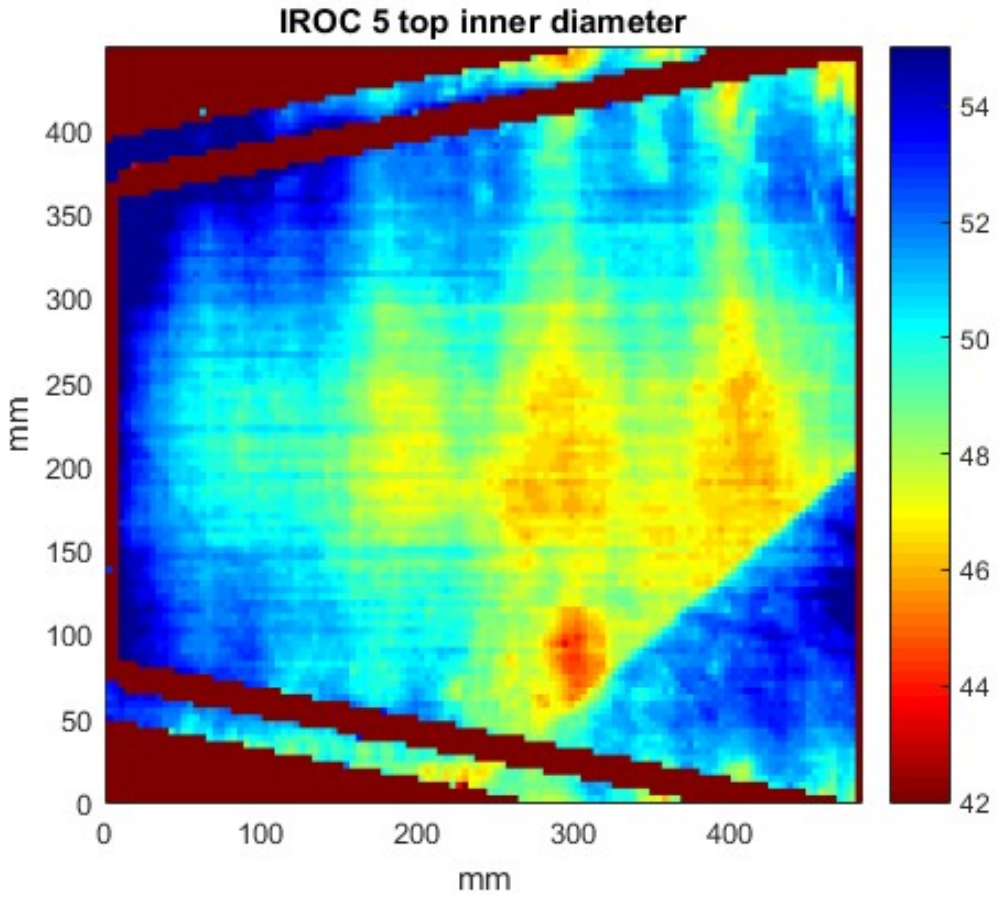
MWPC only

With GEM

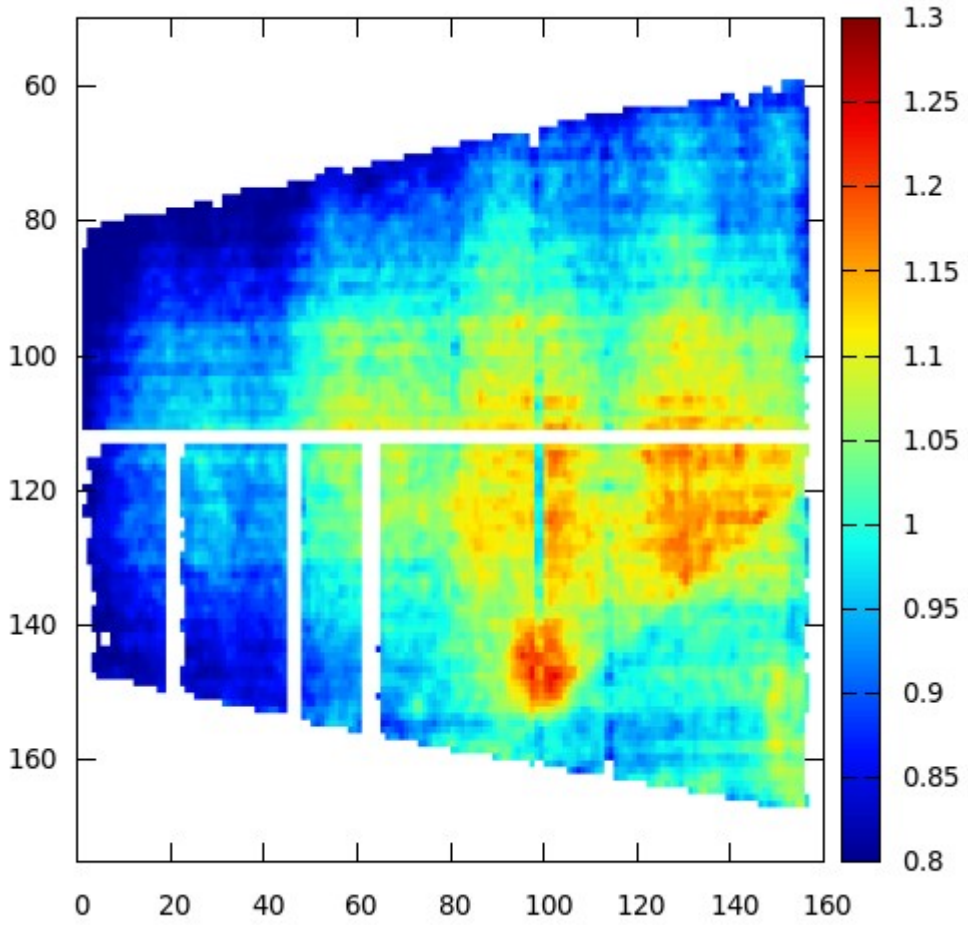


First qualitative comparison to optical scanning

- Optical (Helsinki) holes inner diameter



- Gain map measured



Conclusions

- QA for the ALICE TPC Upgrade: ensures full recording of details on the foil quality and selection criteria
- Optical scanning of pre-production IROC-s completed, conclusions being drawn
- Gain map measurement in IROC/OROC size functional, first map of an IROC foil
- Gain information needed for defining selection criteria and monitoring of foil production quality

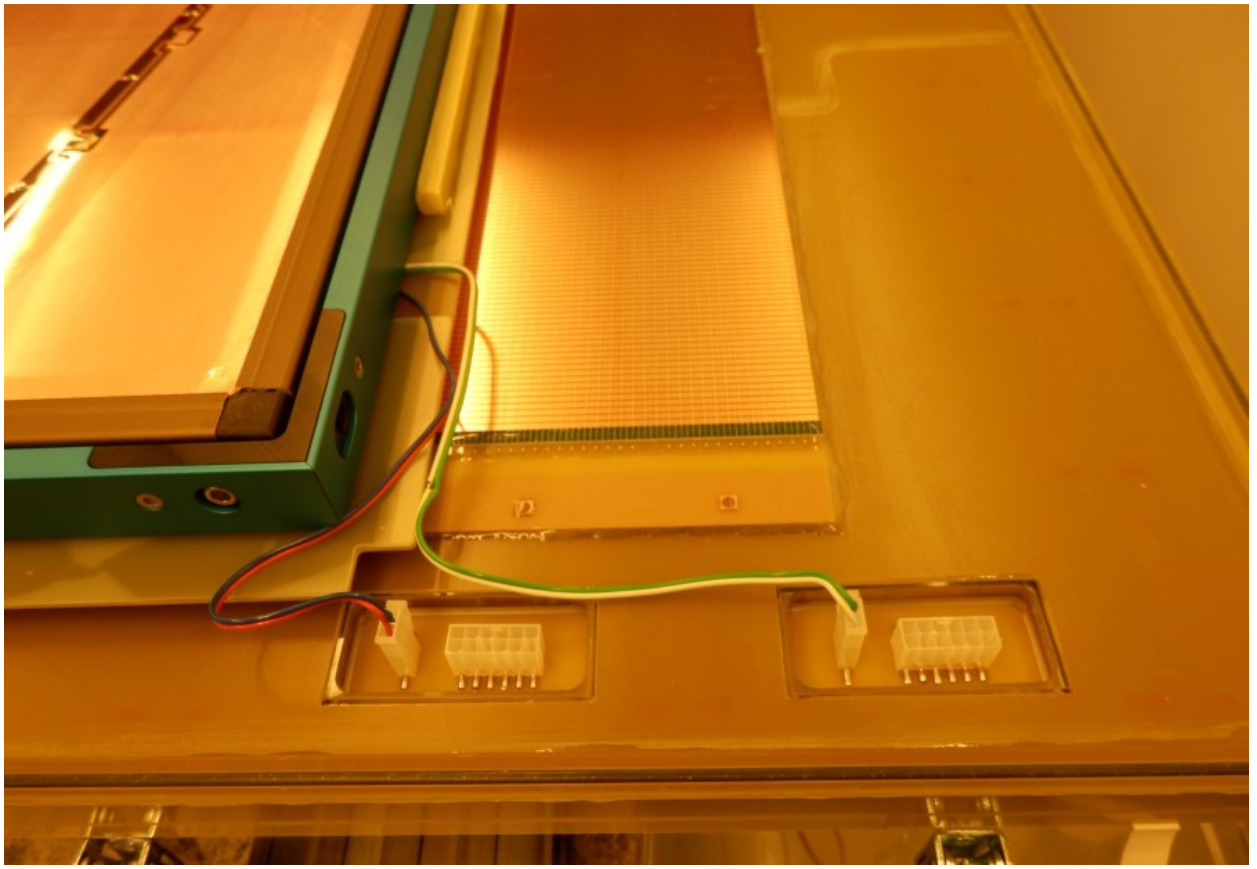
Acknowledgements

- We are grateful for Nikolai Smirnov having the method first proposed and encouraged the development from the beginning
- Helsinki colleagues Erik and Timo kindly provided the scanning information and various suggestions
- Budapest colleagues G. Hamar, J. Zentai, L. Oláh contributed to construction / design

Backups

HV contacts for the GEM + support

- All HV lines towards the bottom side



Data analysis and readout parameters

- Wire spacing 4mm
- Strip spacing 3mm
- ADC 10 bit on quarter of whole area (4 sectors)

- Point by point spectra
- PRELIMINARY gain maps can be extracted

- Clusters of 2-4 strips / wires firing due to charge sharing
- 50% “good” events: single cluster in both direction
- Data taking at 2kHz rate now