GEM gain mapping for QA purposes in framework of ALICE TPC UG

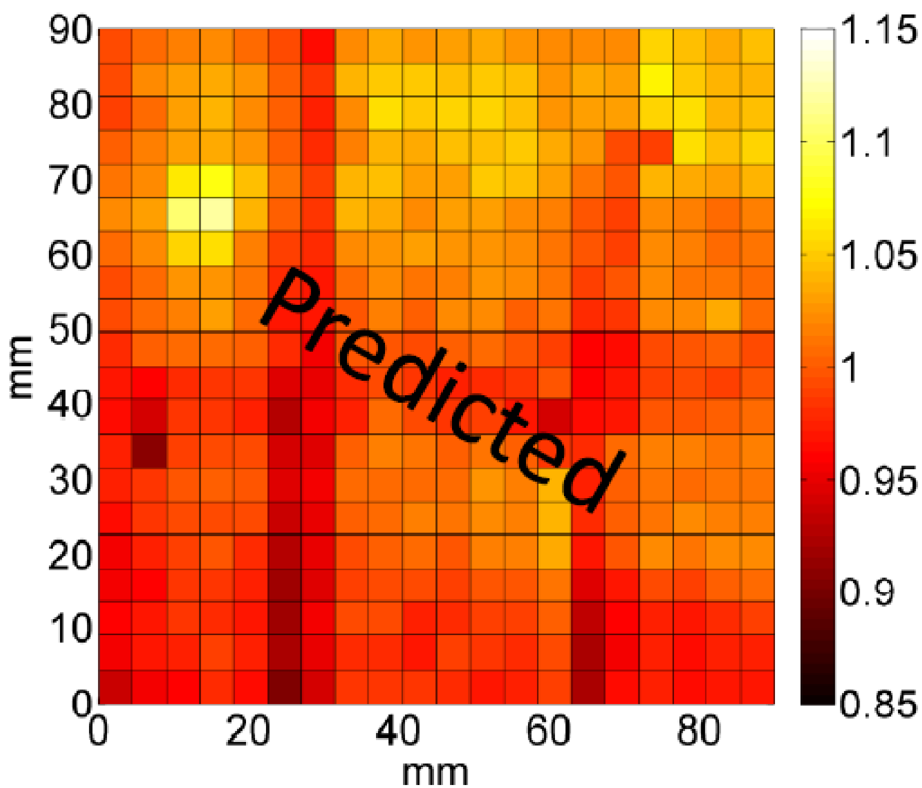
Dezső Varga for the Budapest group

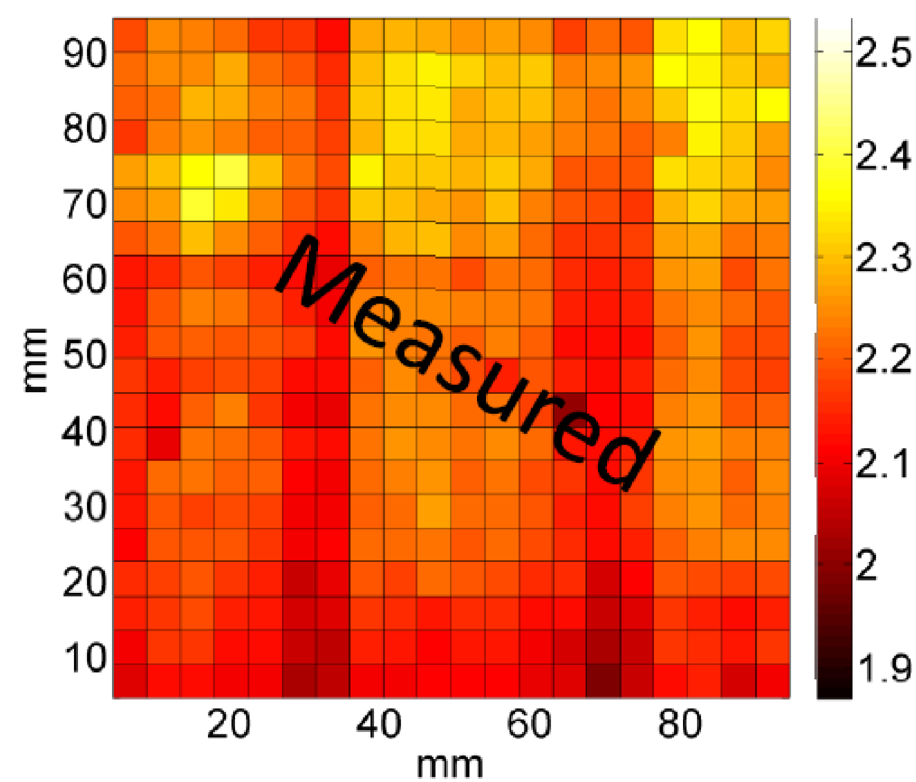
- GEM gain maps, 4mm by 4mm pixel size

  (4 min. time for 10cm by 10cm)
- Consistency checks (rotating, flipping)
- Maps at various gains: relation / predictivity
- Maps in different gases: relation / predictivity
- Hot spots?
- Scheme as a QA device

Prelude: demonstration of hole geometry and GEM gain relation

- Recent paper by the **Helsinki group**, demonstrating gain predictability by hole geometry!





NIM A 770 (2015)113

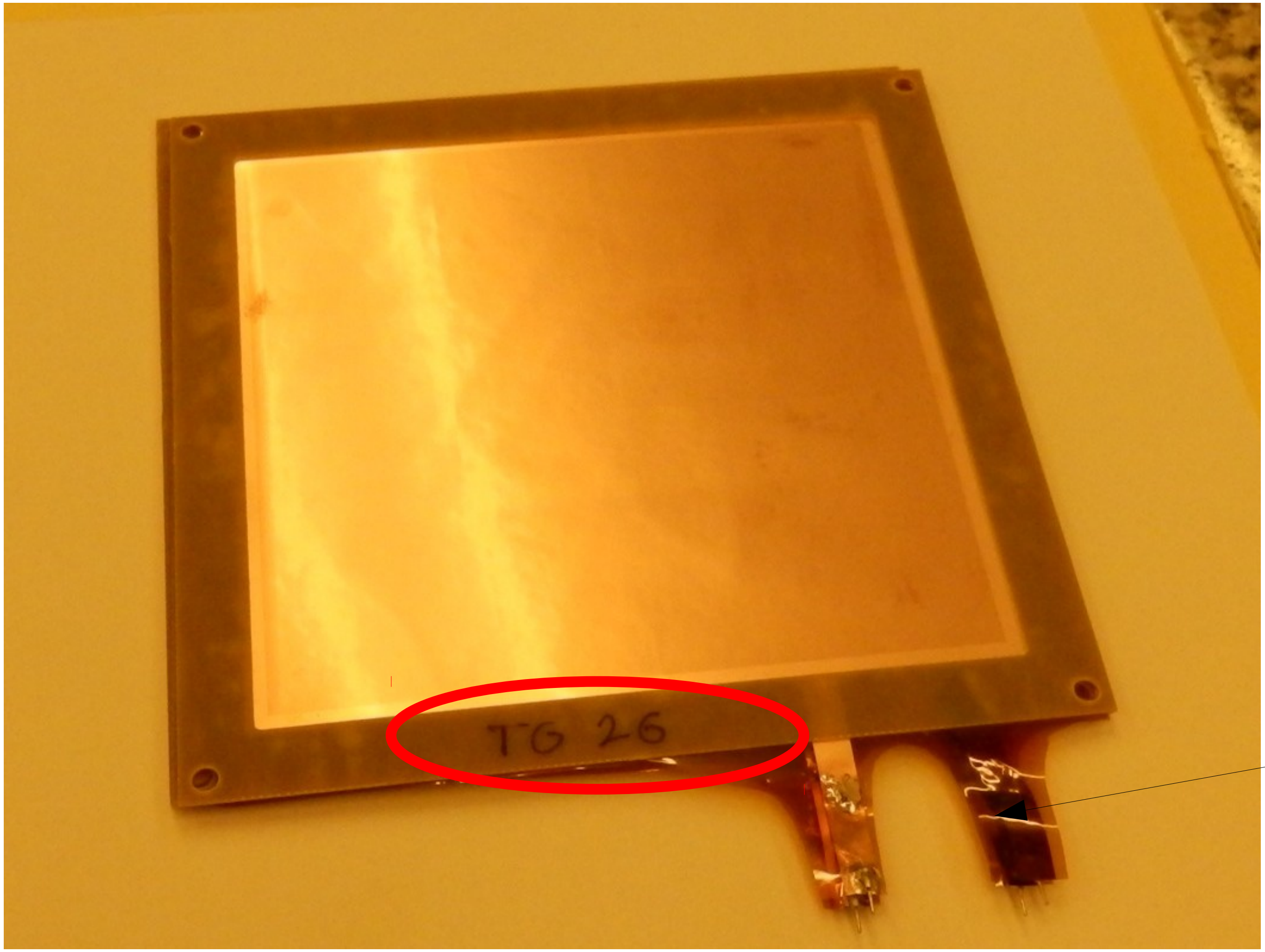
T. Hildén, E. Brücken et al, Optical quality assurance of GEM foils

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

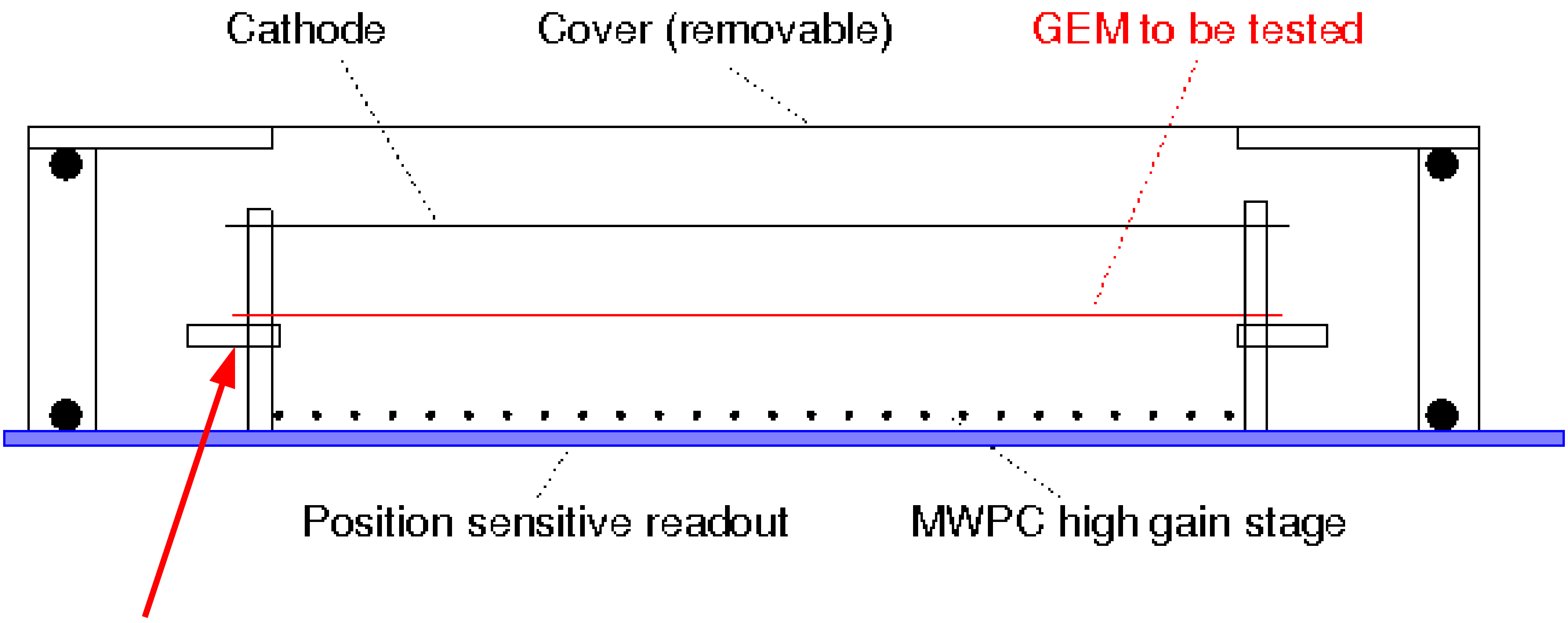
- **As an “R&D” issue:**
  - – how to obtain the best prediction of gain map from hole geometries
  - – how to relate different GEM voltages, working gases, transfer/drift fields etc.

GEM from the Helsinki group
– we are very grateful for the collaboration



GEM contacts

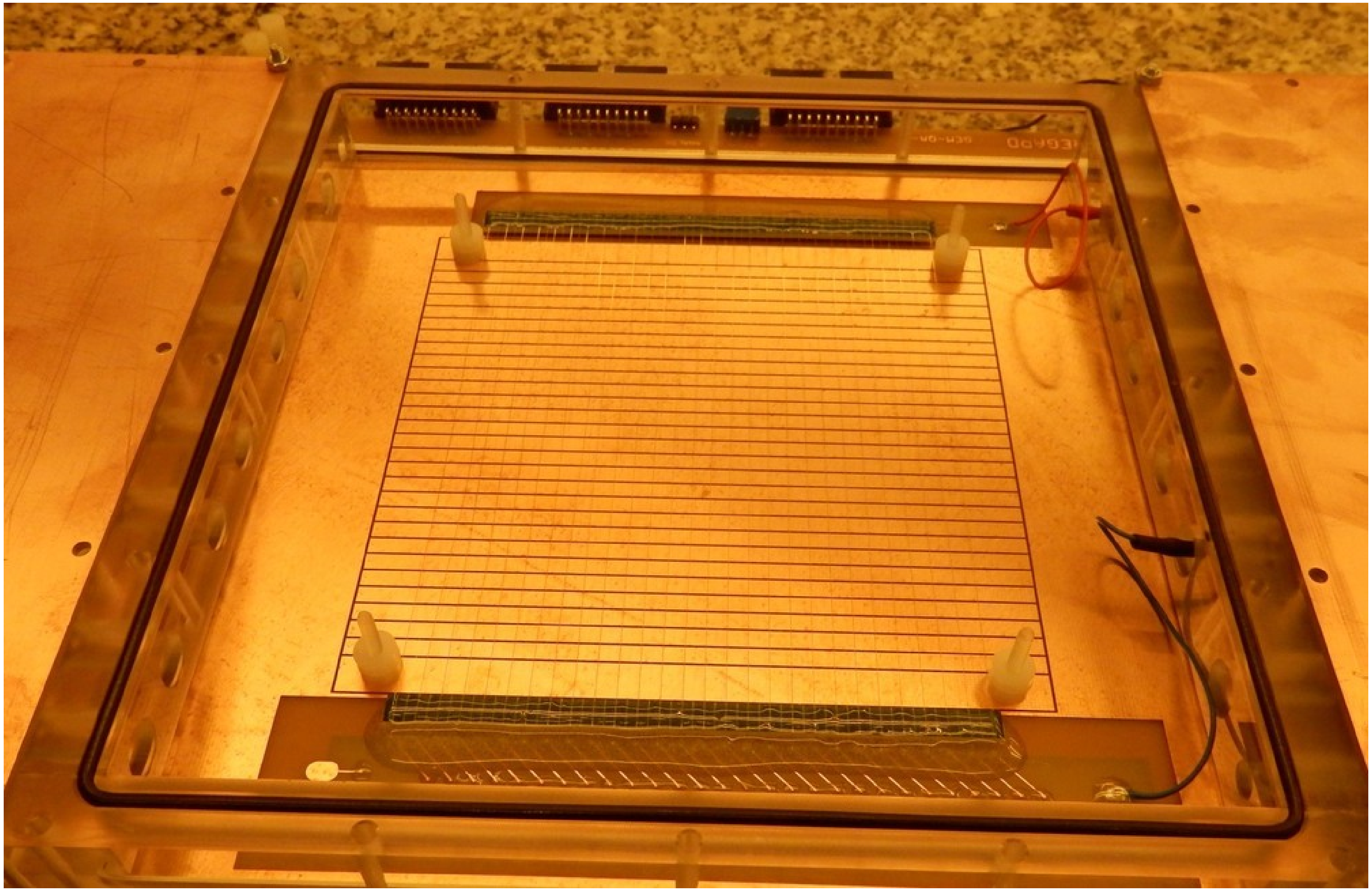
Chamber outline: GEM + high gain MWPC



Guard rim for well defined geometry and field

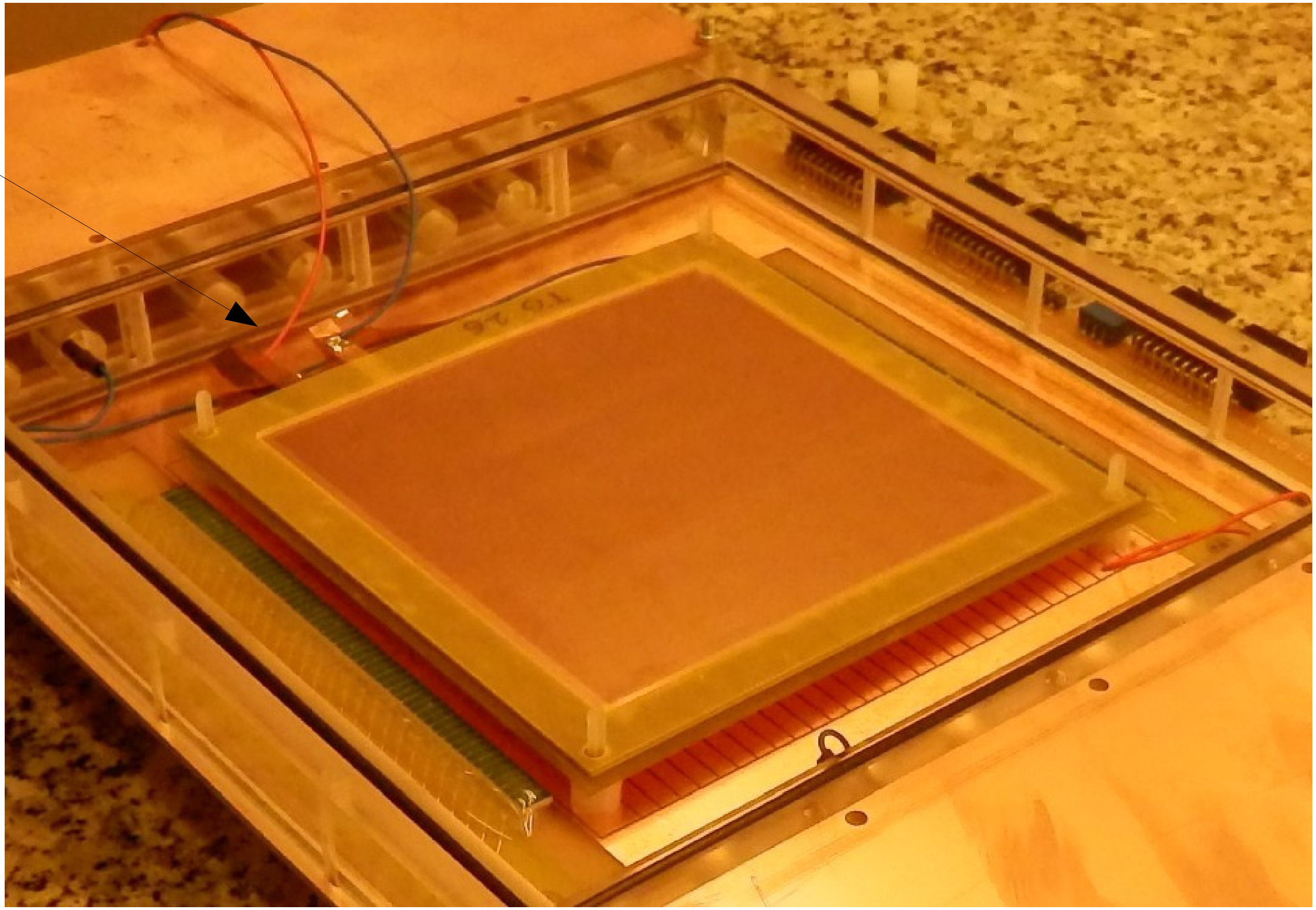
Detector assembly

- MWPC bare with GEM fixing screws

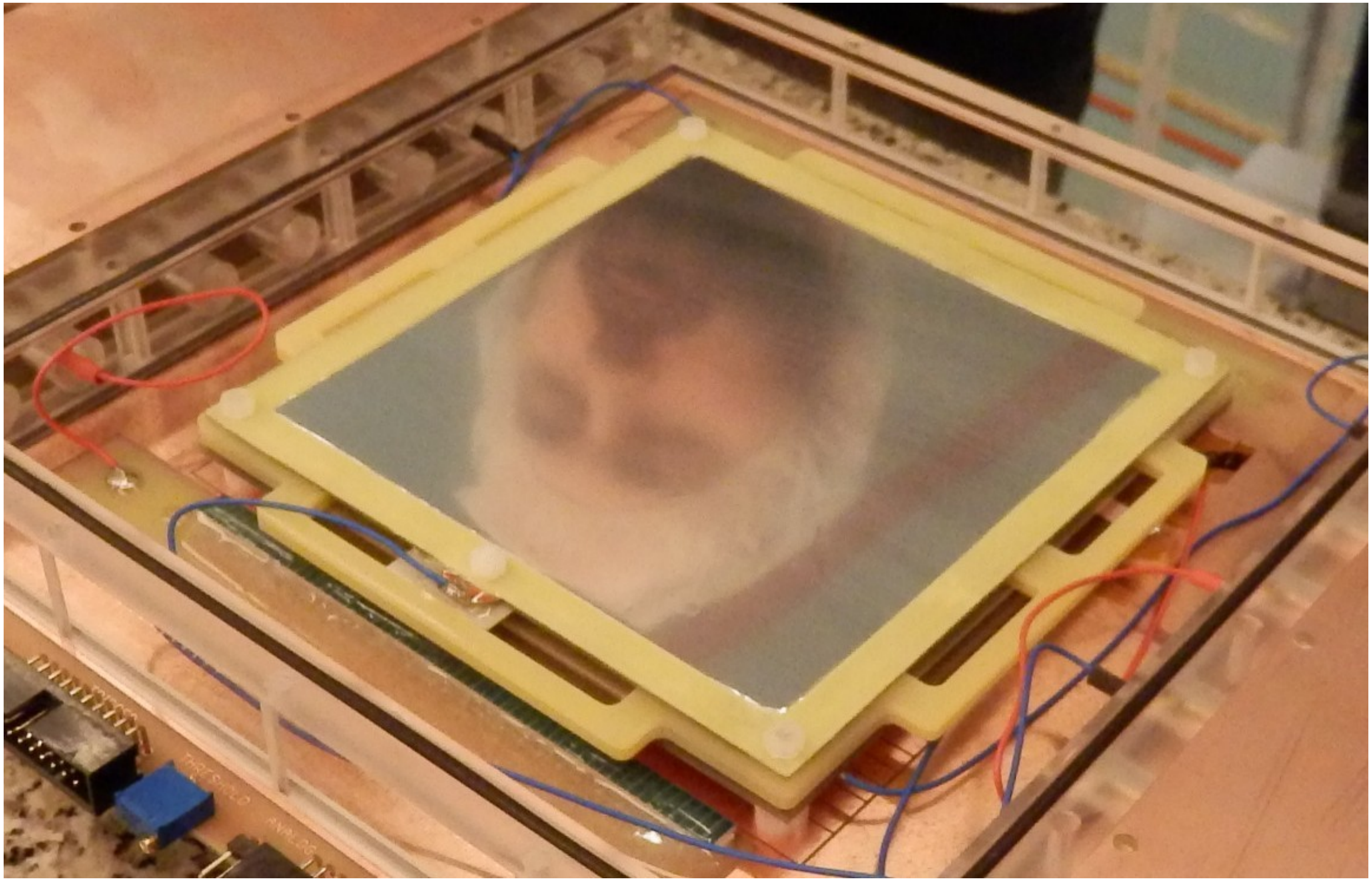


Installing GEM

GEM contacts

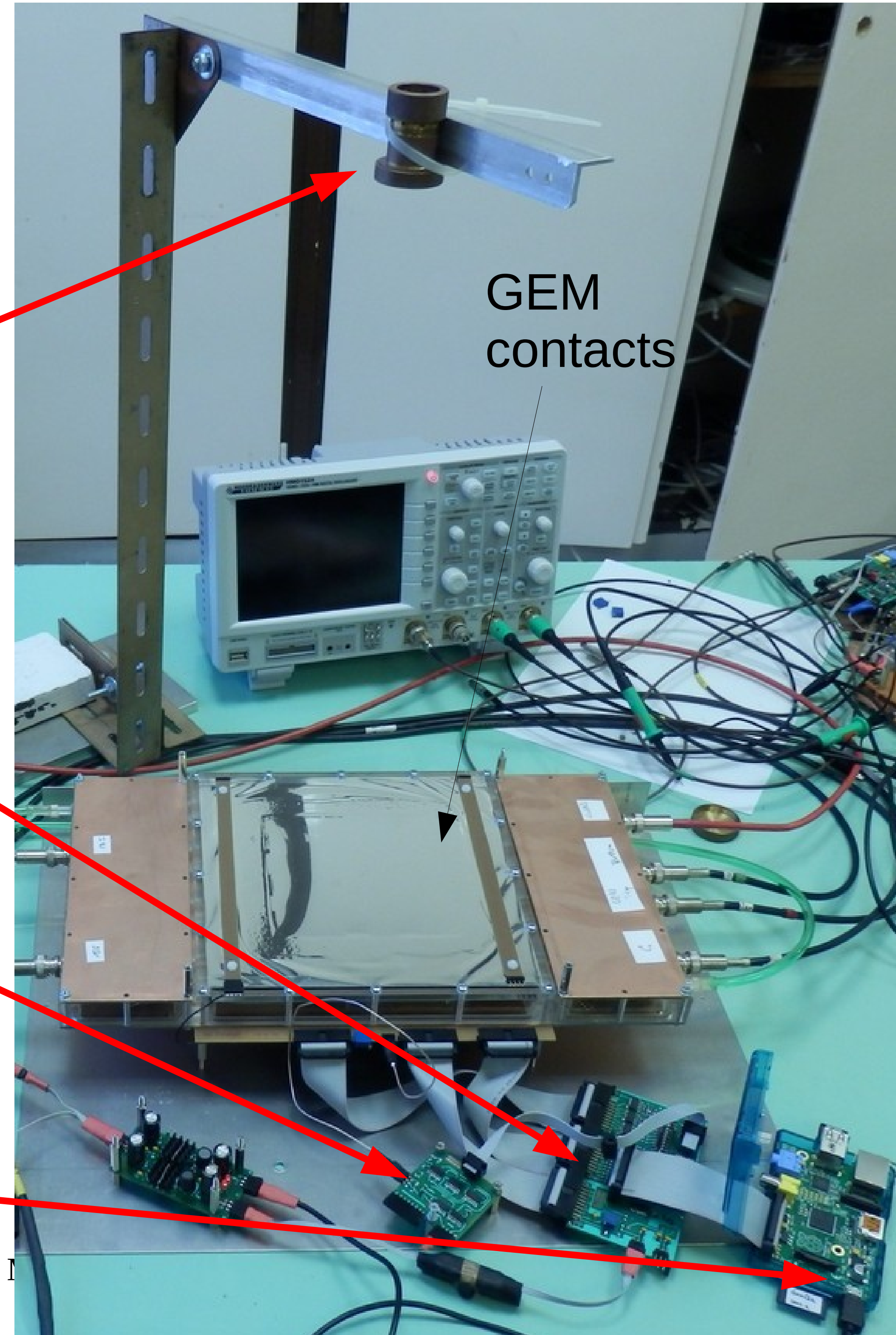


Installing cathode

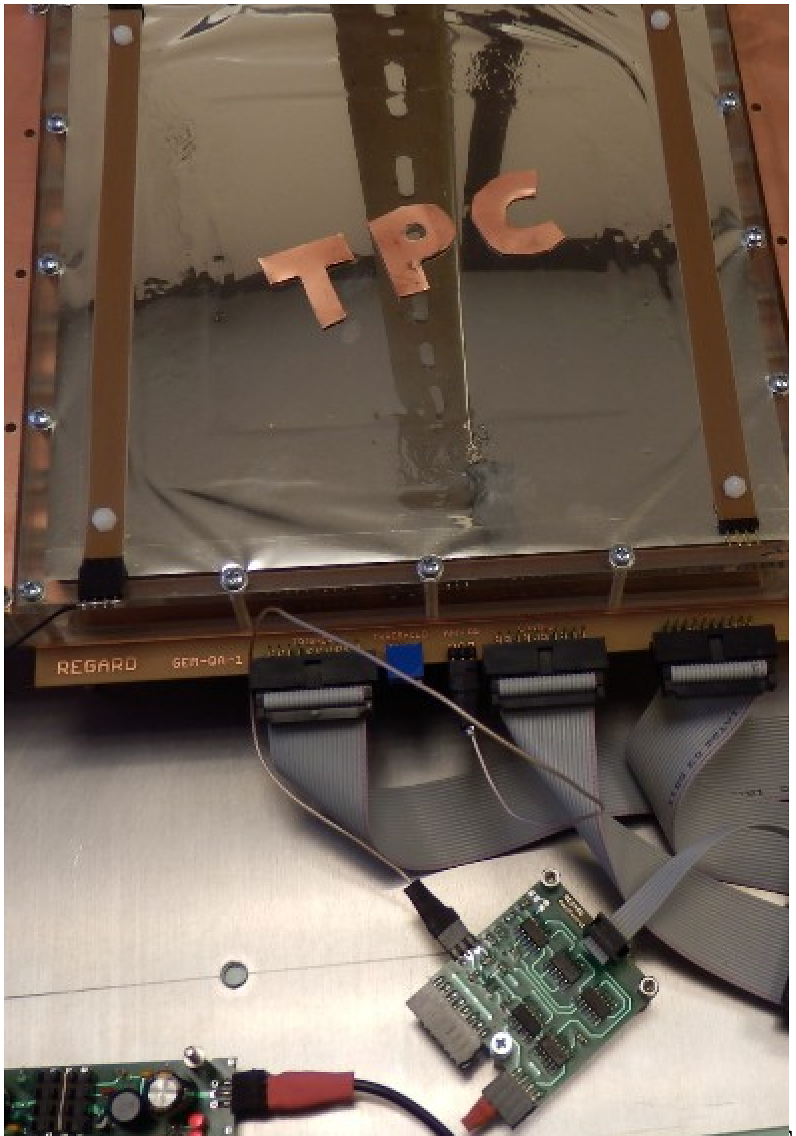


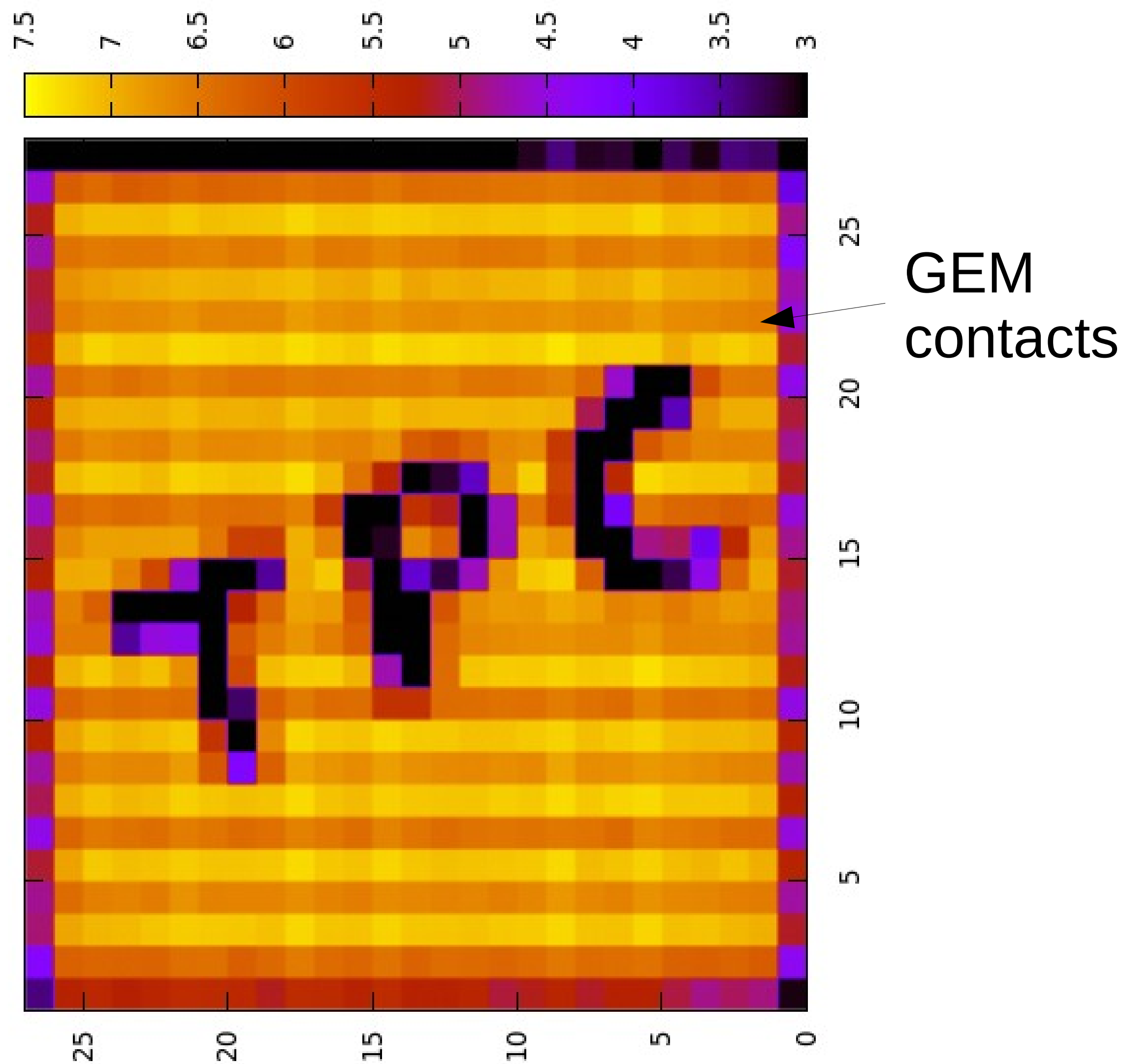
The complete setup

- Source 40cm above (Fe55)
- DAQ board
- ADC (12 bit)
- R-Pi computer (DAQ developed within RD51 CFP)



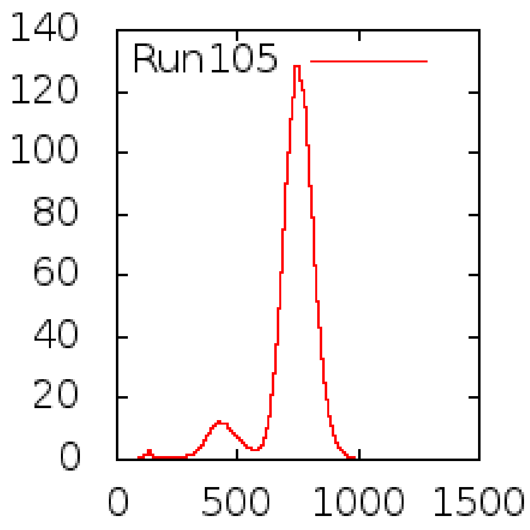
Check GEM / detector / readout orientation

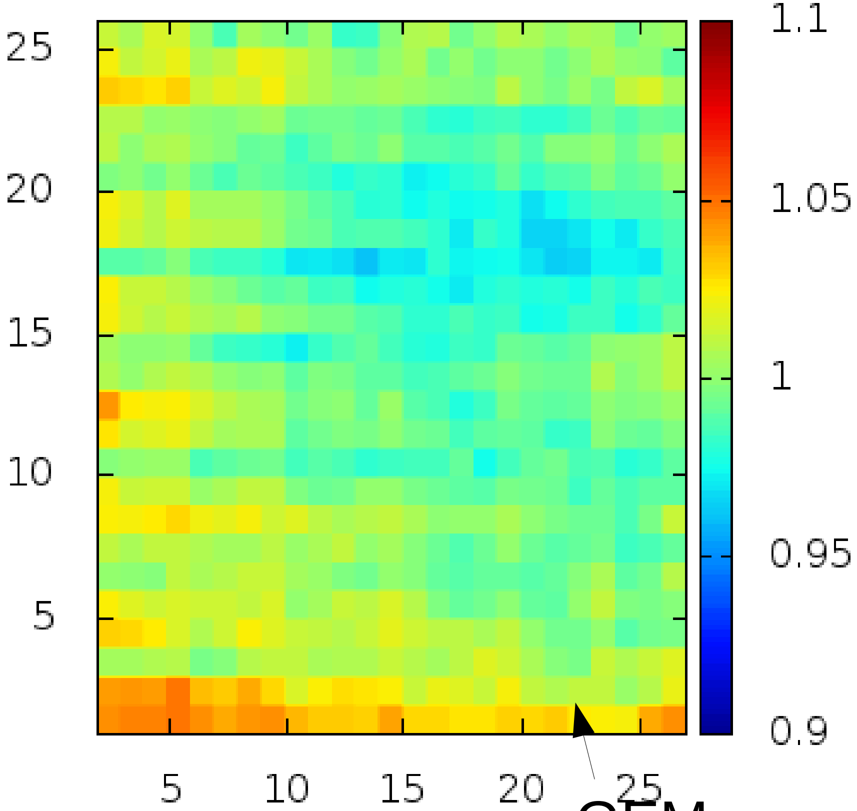




MWPC uniformity (GEM off)

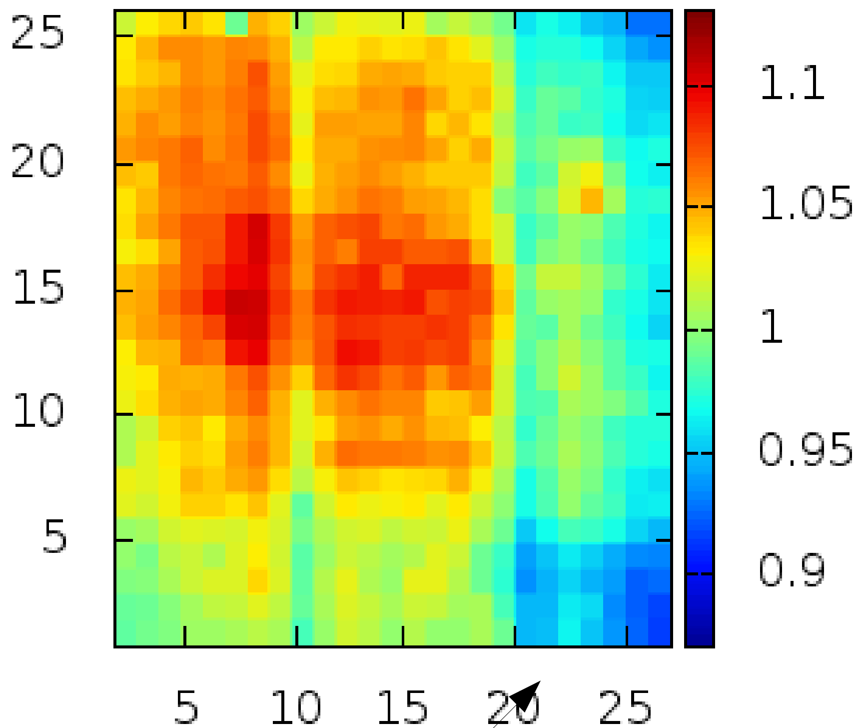
- Well equalized gain of the CCC – good **reference!**



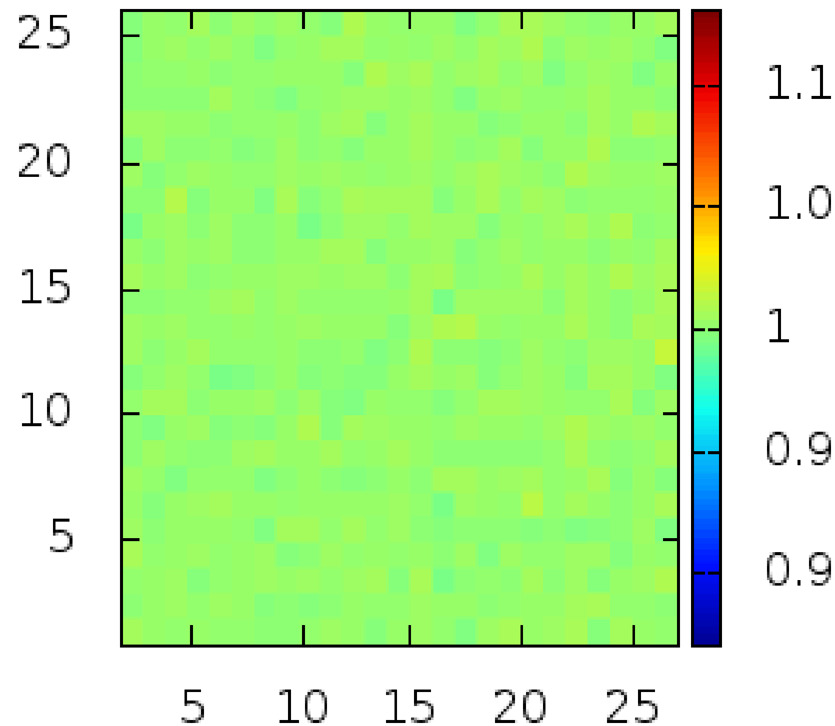


GEM gain map at gain of 6

U_{GEM}=300V U_{SW}=1000V



Re-done after 15 min, ratio



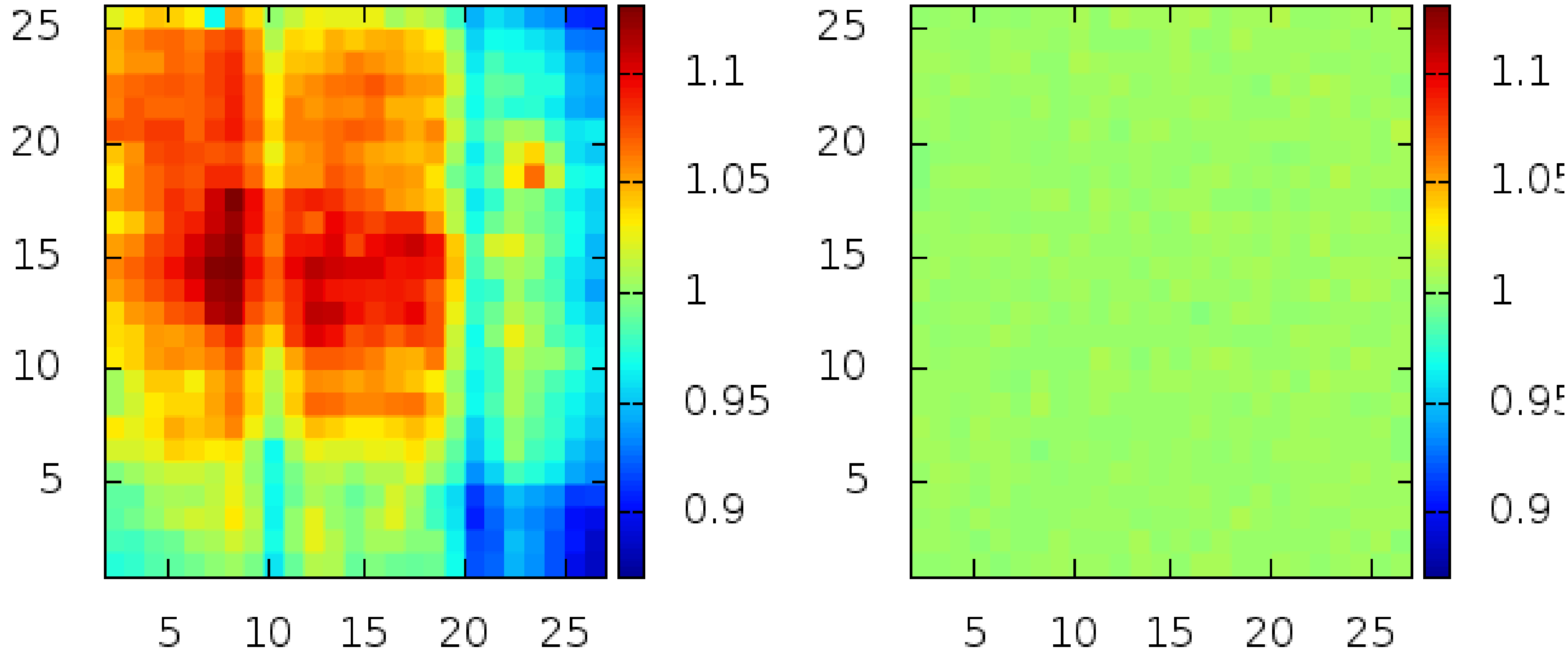
GEM contacts

GEM gain map at gain of 30

- High gain similar map as lower gain, non-uniformity increased

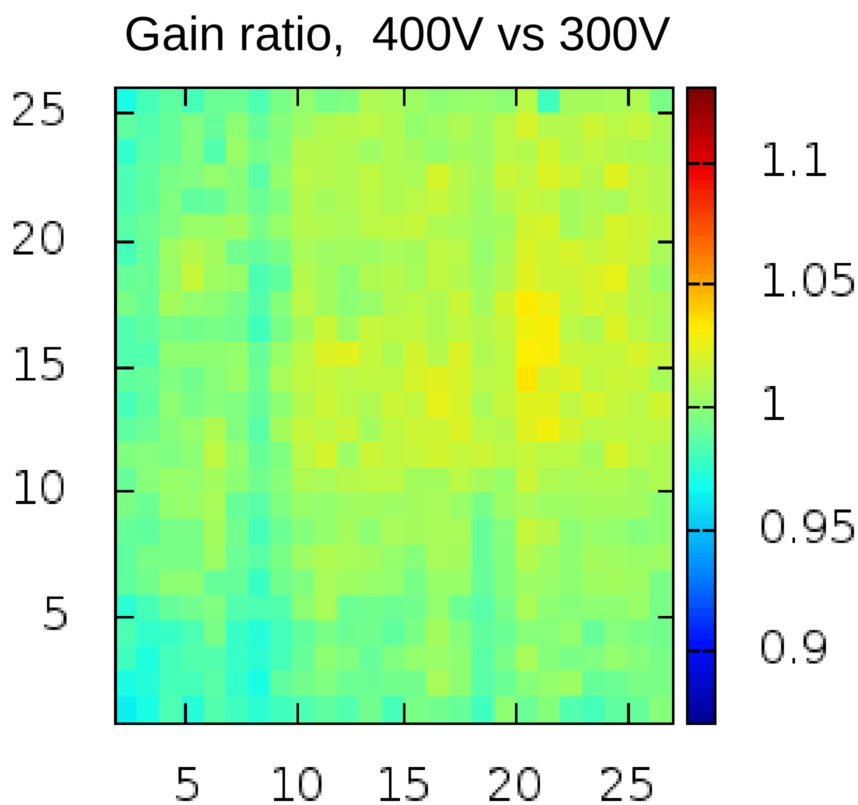
U_{GEM}=400V U_{SW}=800V

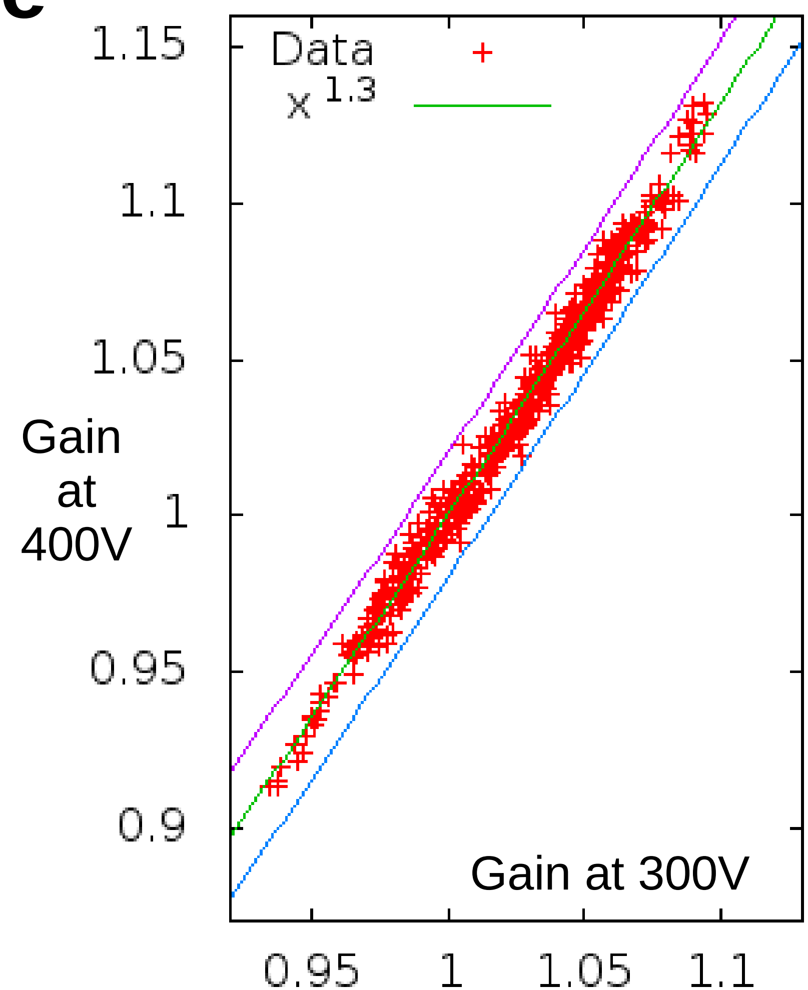
Re-done after 15 min, ratio



Relation between the different voltages: power law (linear)

- Non-uniformity goes with GEM gain slope!
  Predictable at any voltage





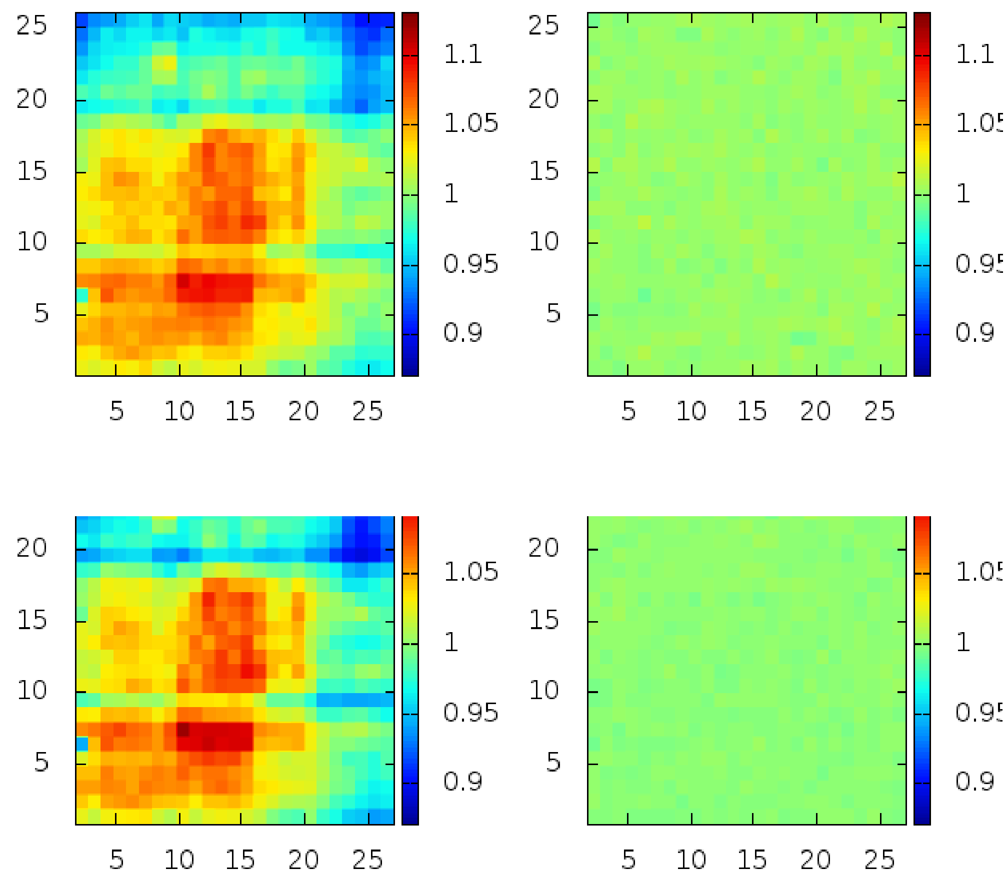
(Done in flipped configuration)

Rotation exercise
(shown in detector coordinate system)

- 300V GEM voltage

- 400V GEM voltage

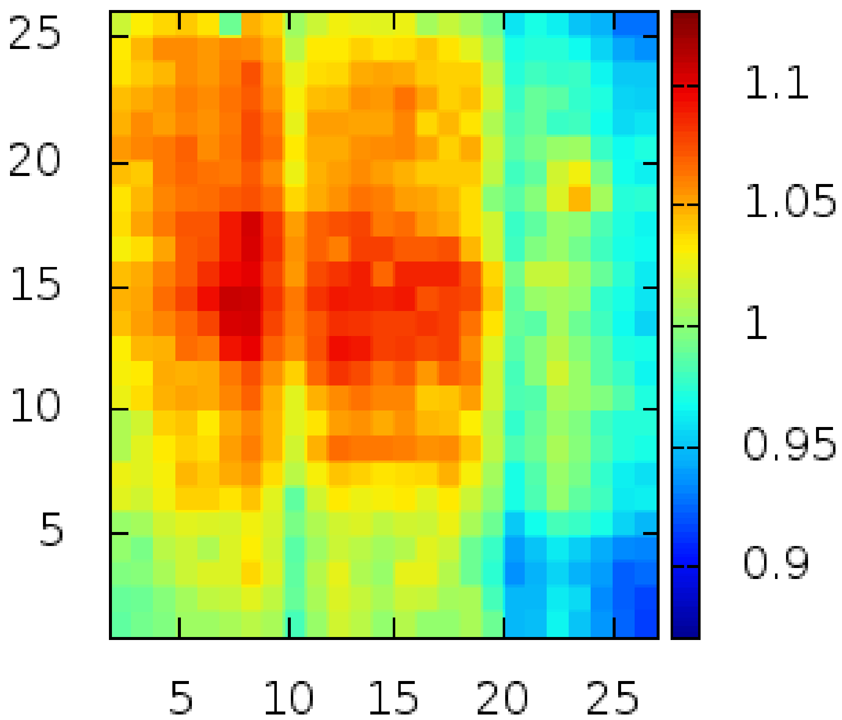
  (nicely rotates)



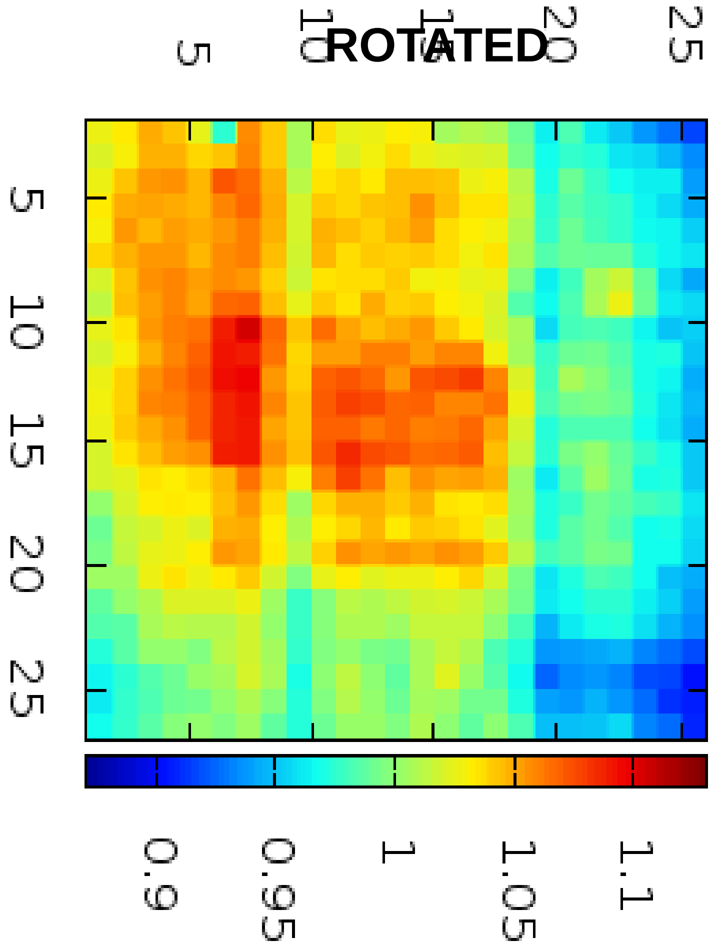
Comparing with non-rotated

- Apparent compatibility, needs to be quantified

ORIGINAL

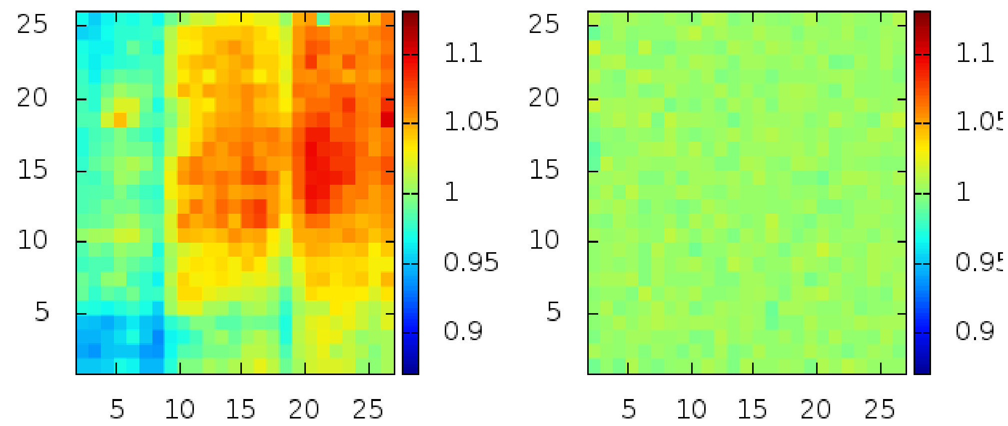


ROTATED

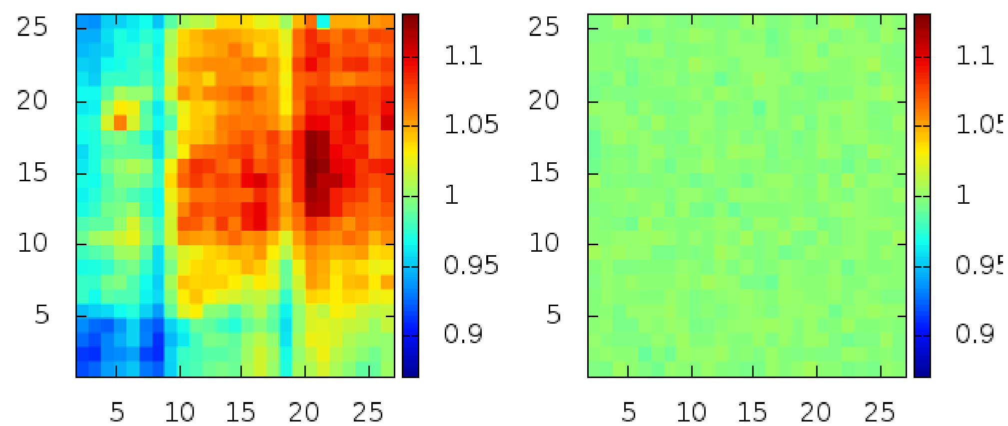


Flipping (upside down) exercise
(shown in detector coordinate system)

- 300V GEM voltage



- 400V GEM voltage

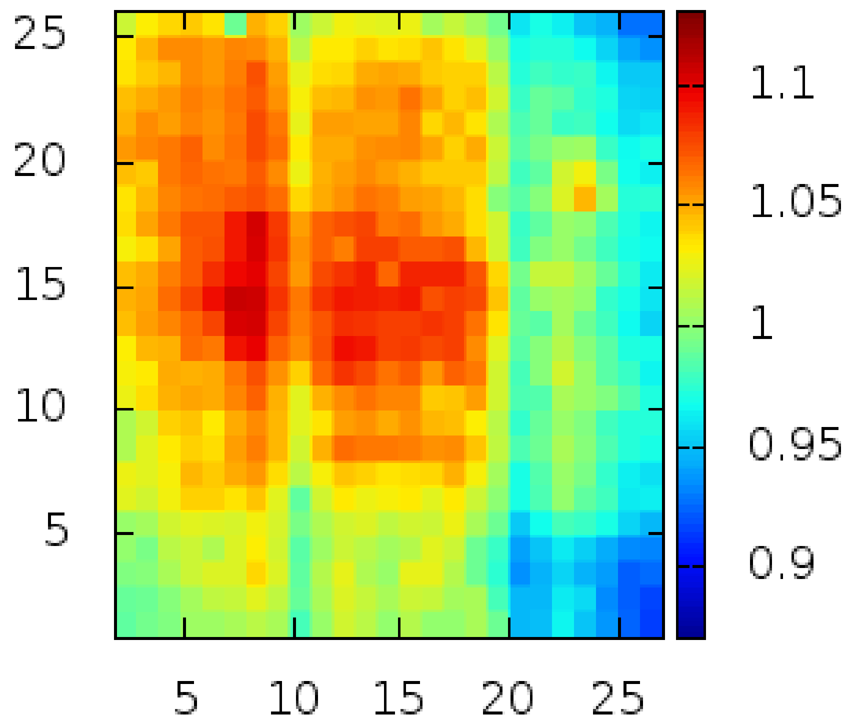


(nicely fips left/right)

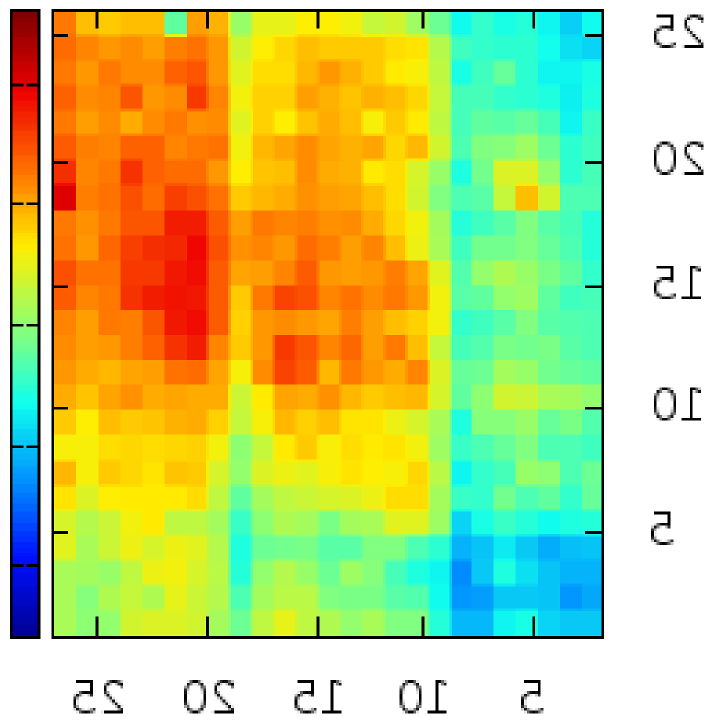
Comparing with non-flipped

- Apparent compatibility, needs to be quantified

ORIGINAL

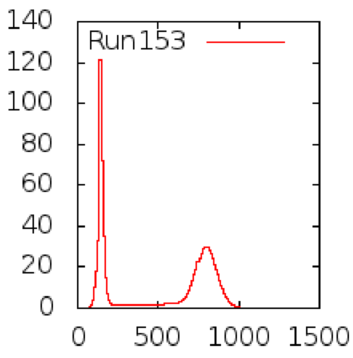


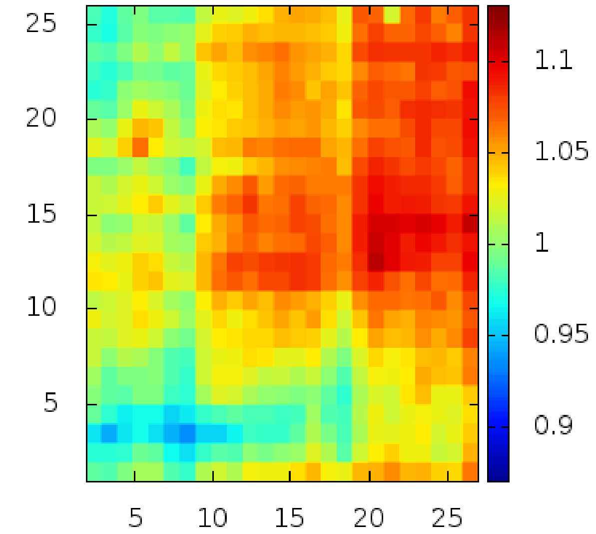
FLIPPED



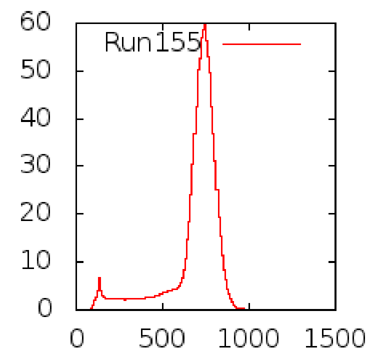
Going to TPC gas: $Ne:CO_2:N_2$ 90:10:5

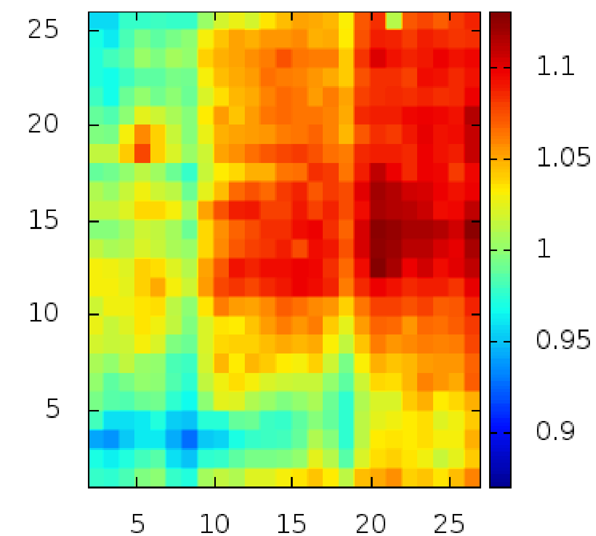
- 300V GEM voltage





- 400V GEM voltage



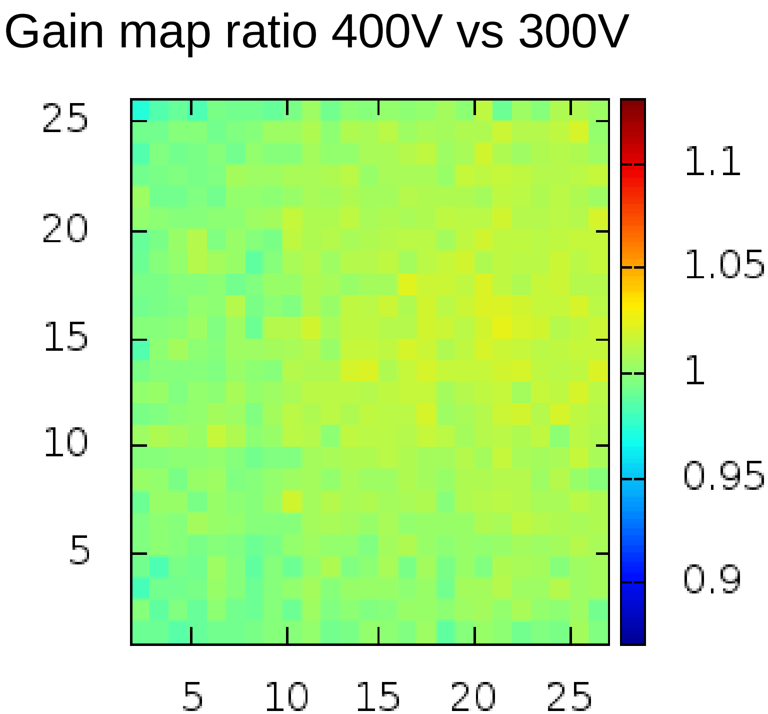


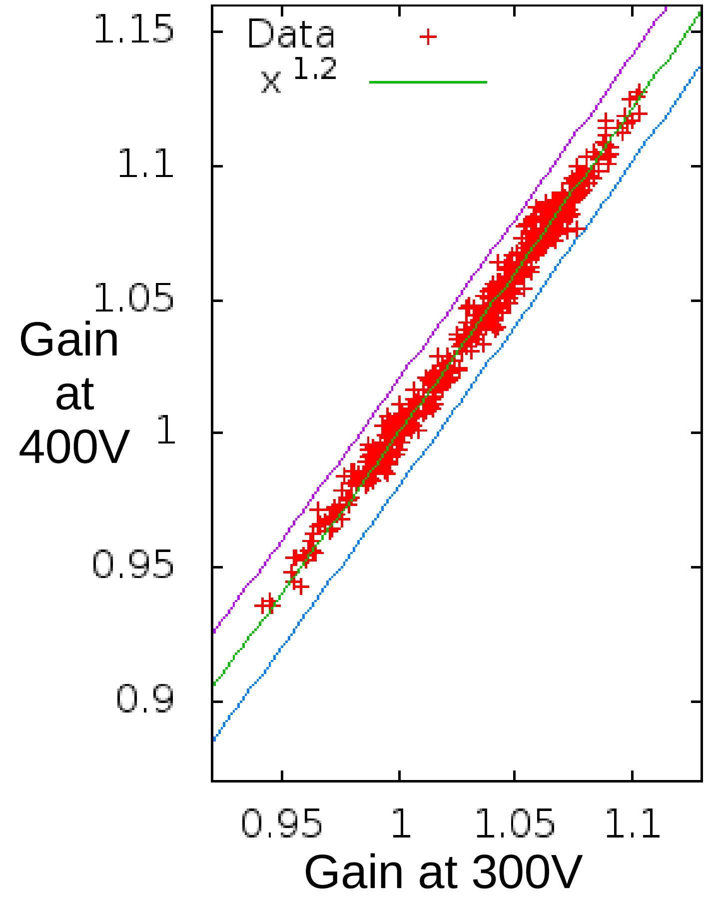
(similar as in $ArCO_2$)

GEM voltage dependence again established

- Again correlated, different slope

Predictable at any voltage



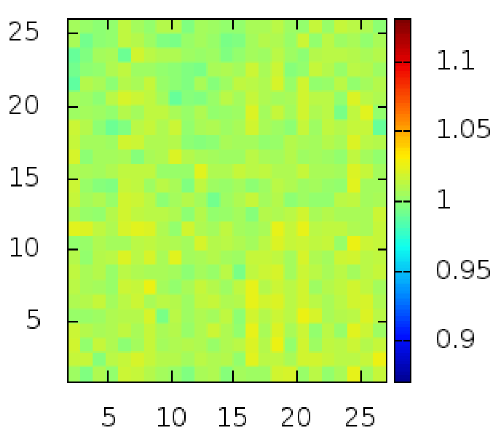


Difference between different gases: **power law / linear**

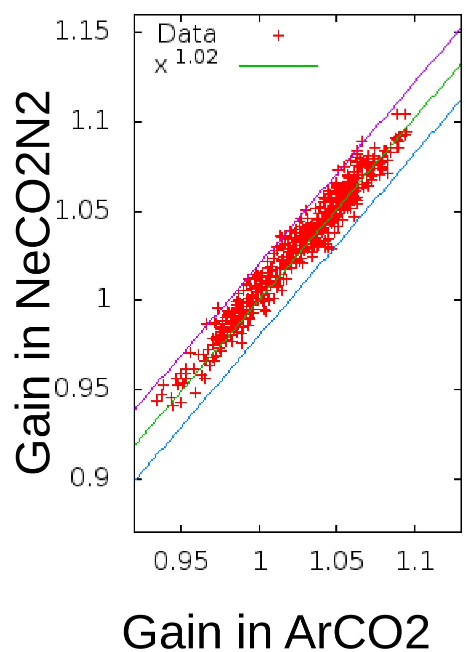
- Well established correlation at 300V and 400V

300V

Gain map ratio

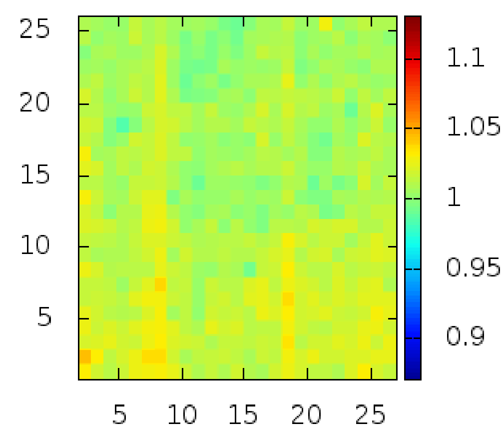


Correlation

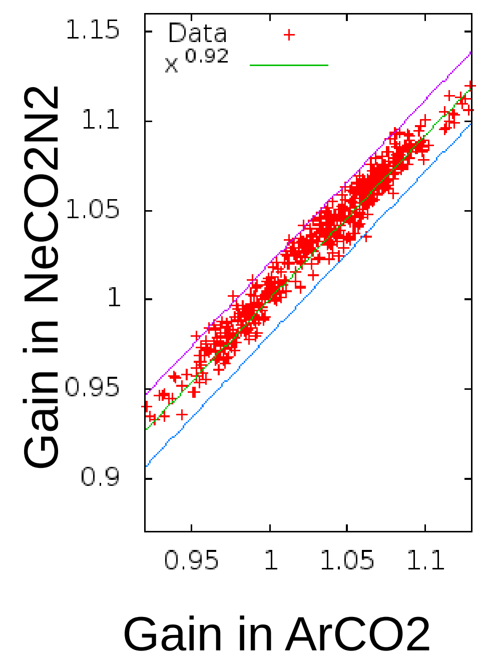


400V

Gain map ratio



Correlation

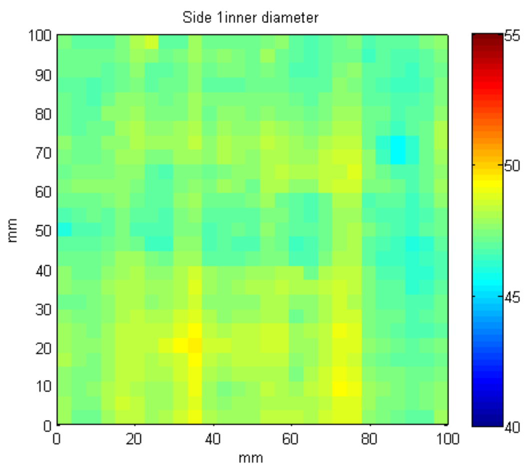


Predictable between $ArCO_2$ and $NeCO_2N_2$!

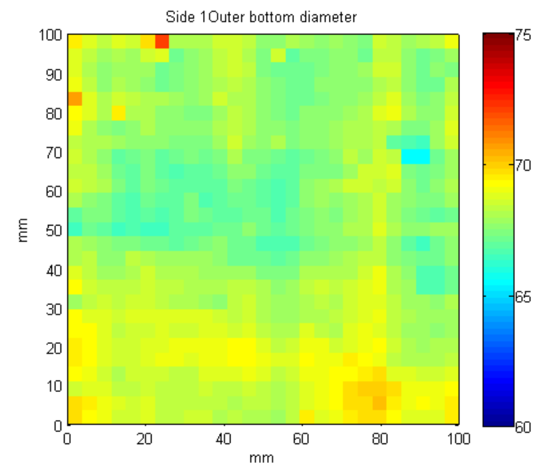
GEM scanning observables

- TG26 maps from Timo and Erik (thanks!)

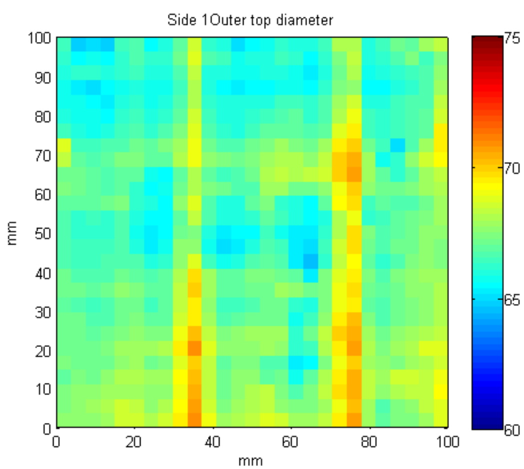
Inner



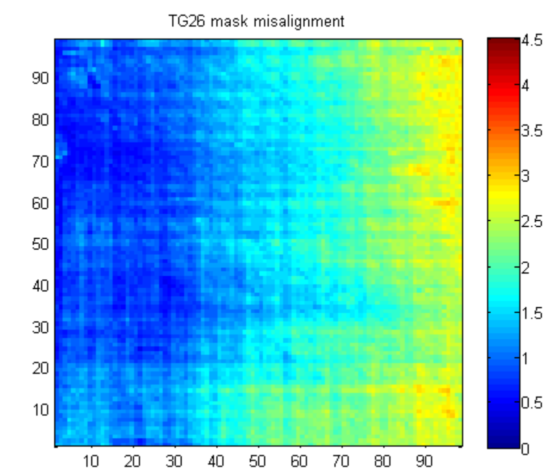
Outer BOTTOM



Outer TOP

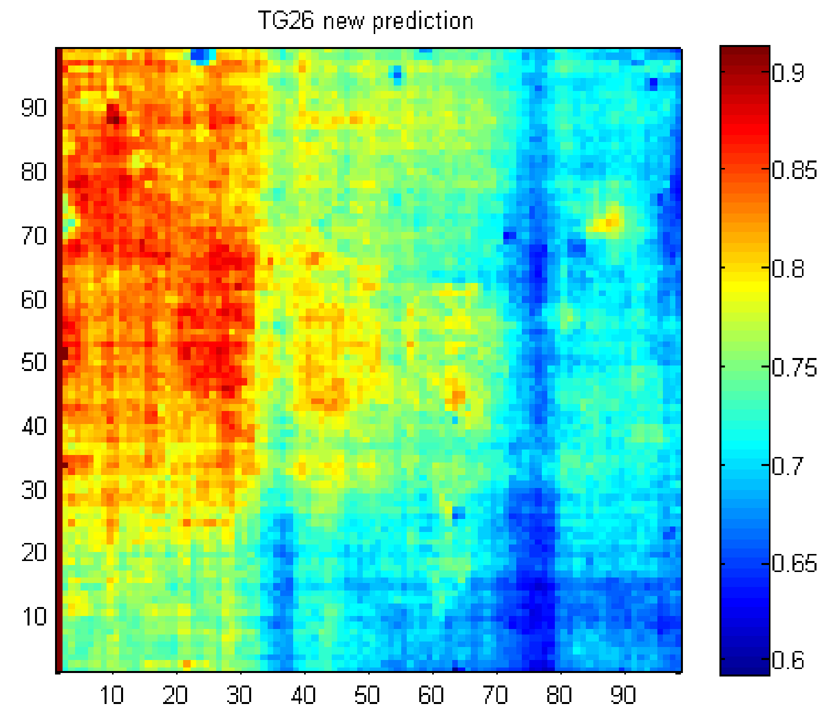


Misalignment

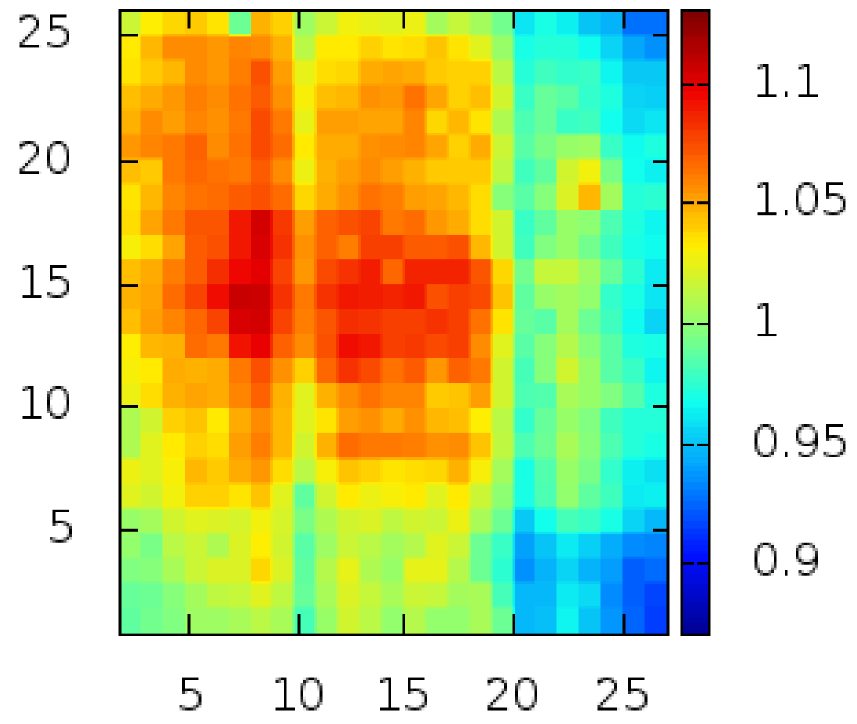


Comparing to present version of gain prediction (Helsinki results)

PREDICTION



MEASURED



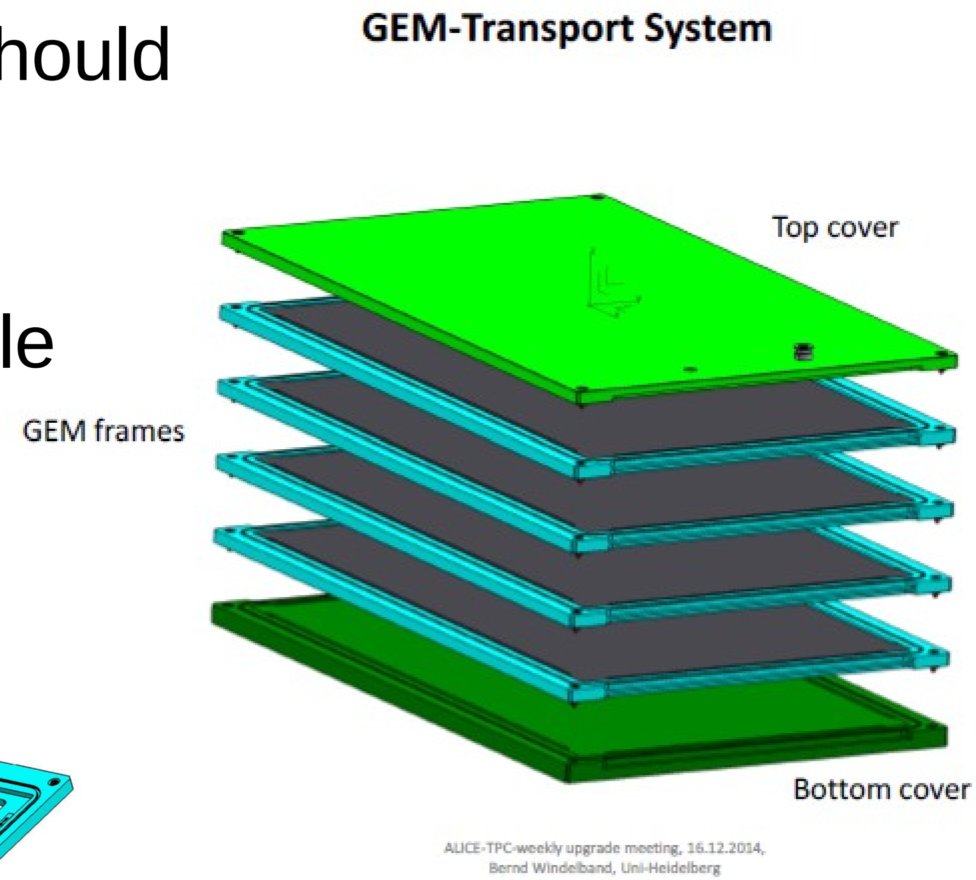
Prediction prescription is now **under work** and being improved by Helsinki colleagues!

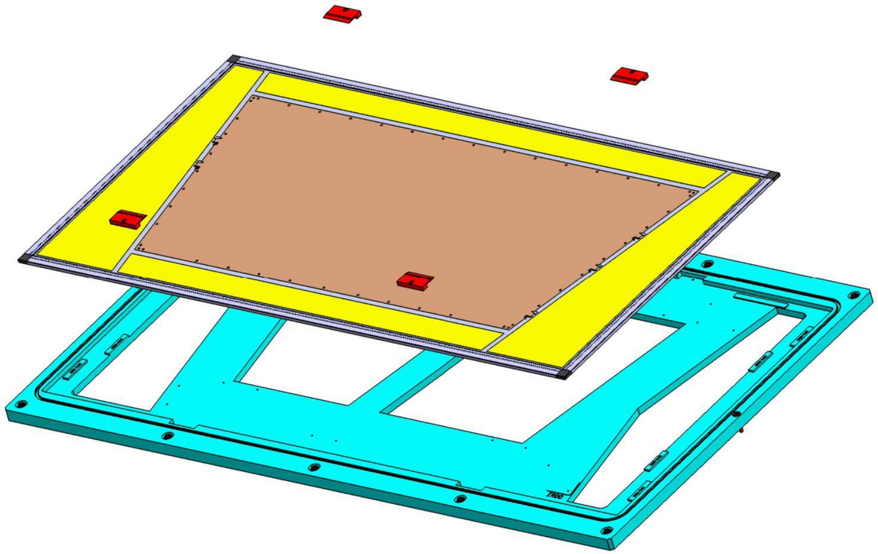
As a device: key parameters with the existing setup

- Now 4kHz data taking: 4min. for 1M events, that is: **1 hour for IROC (50cm) size**
- Point-by-point statistical error of 0.3%
- Above 90% “good” event efficiency

Next steps towards real size:
OROC and IROC foils for the ALICE TPC

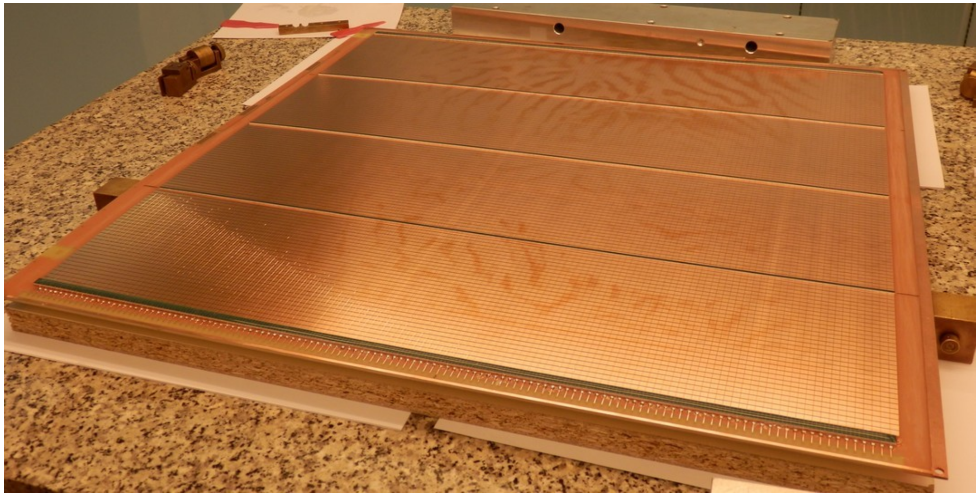
- Step 1: “50cm” version, should match an IROC
- Step 2: “OROC” version, matched with transportable GEM-s of full size

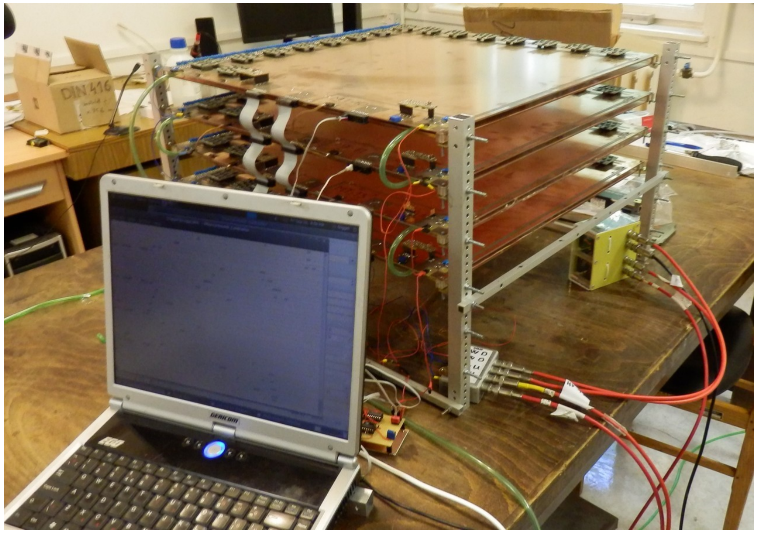




50cm version: based on existing design, existing components

- Will it work: **YES**, part of an existing cosmic detector showing 99% efficiency and 4mm position sensitivity





- Key details, such as GEM installation, gas box integrity, top cover is to be clarified

Can we find hot spots?

- Strategy:

  High GEM voltage/gain (e.g. 420V, 50)

  Go with SW from 750V to 950V (!)

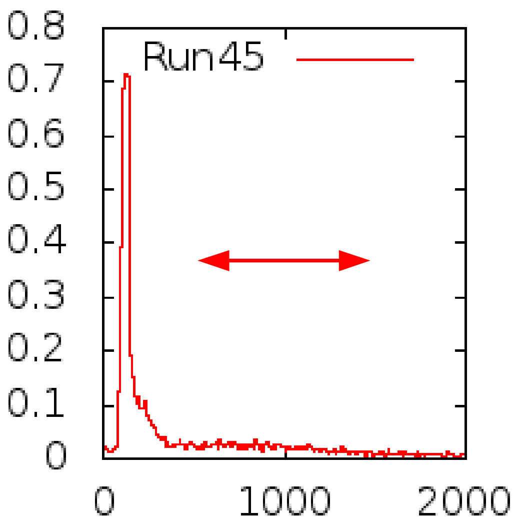
  No source (only cosmics)

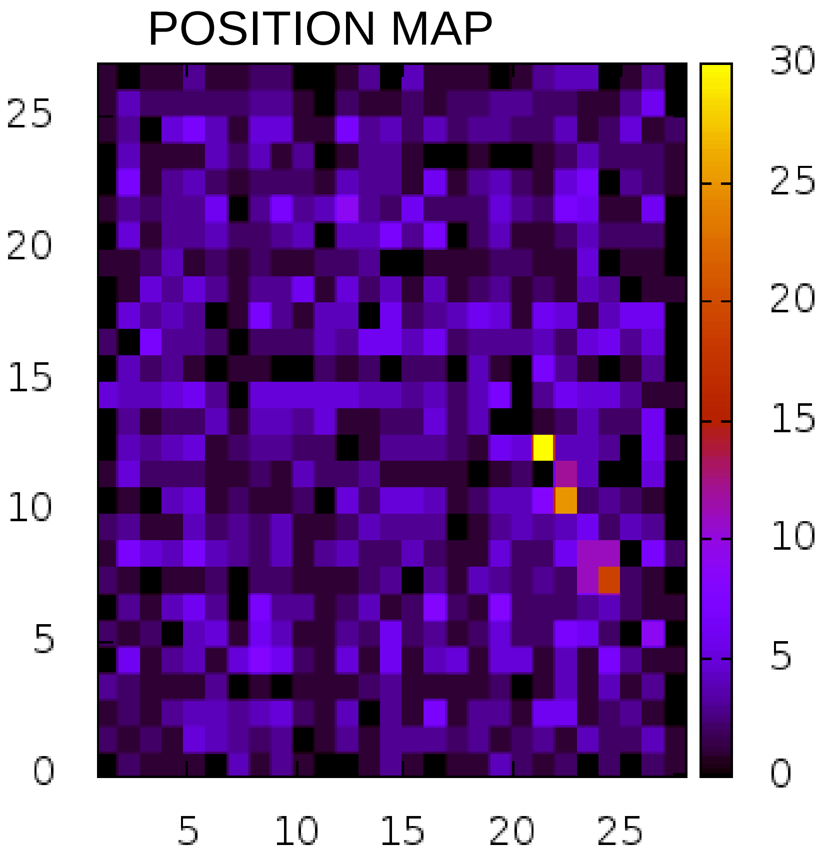
- Sensitivity to equivalent of a few electrons (to be checked). Local corona discharges should appear as low signal counts

No source, high signal (cosmic) map

- Uniform cosmic, local structures

U_{GEM}=400V
U_{SW} =950V





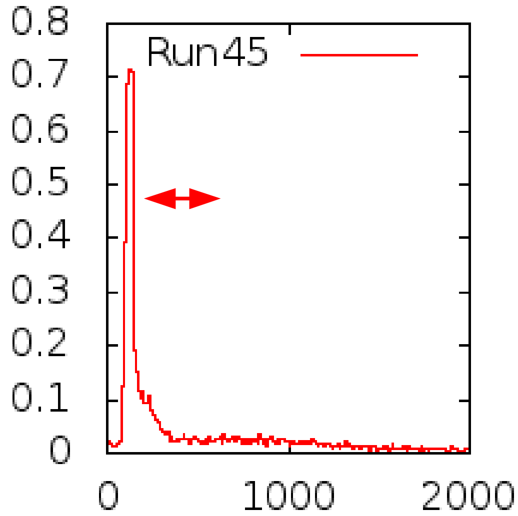
Signal region: 600 - 2000

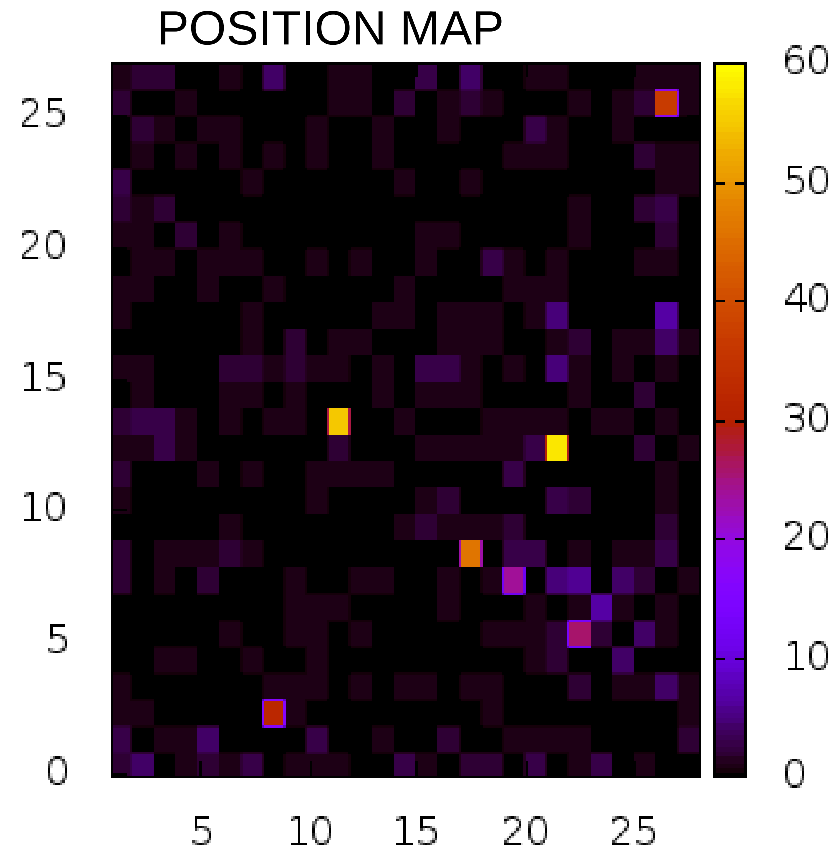
No source, low signal region

- Local “hot spots” clearly appear

U_{GEM}=400V

U_{SW} =950V





Signal region: 200 – 400

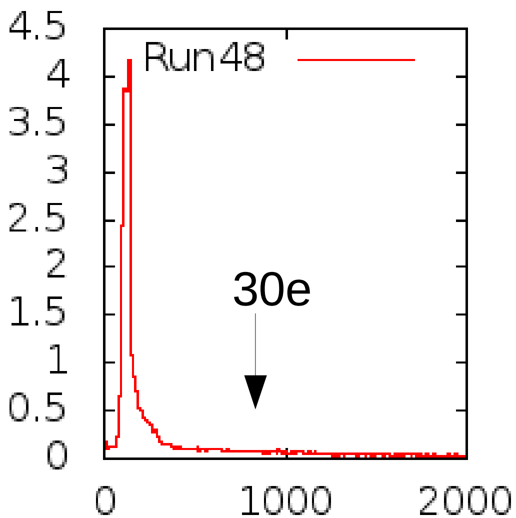
10 – 20e

Higher GEM voltage

- Hot spots persist (note 5 times data statistics!)

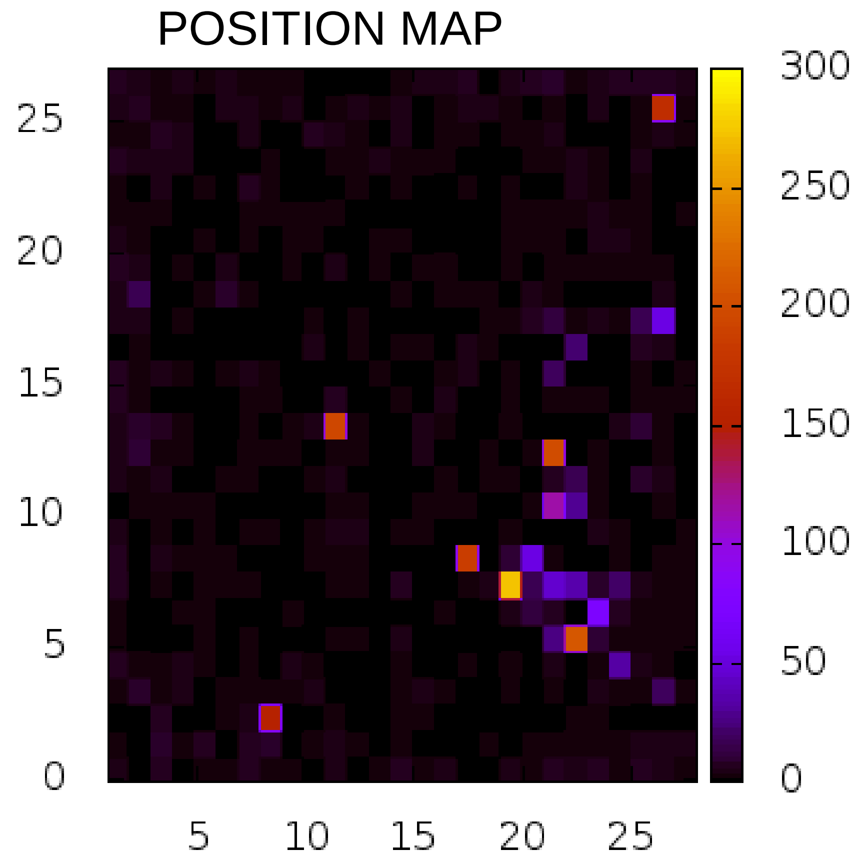
U_{GEM}=420V

U_{SW} =950V



Signal region: 200 – 400

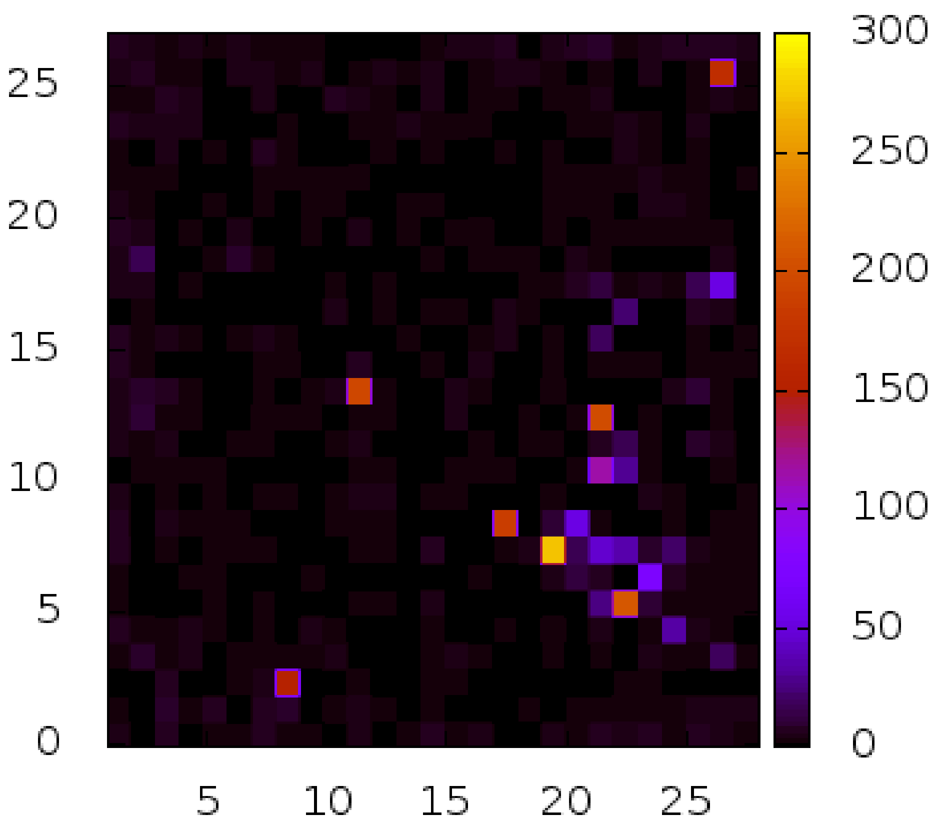
7 – 14 e



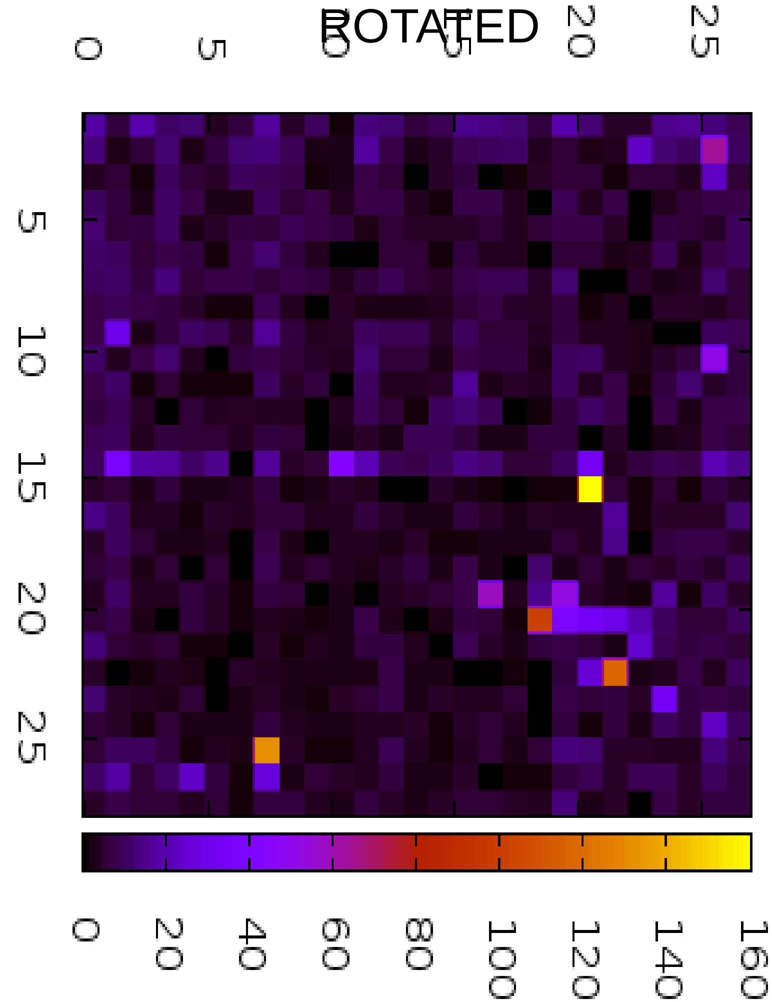
Hot spot appearance in rotated configuration

- Some (?) of the hot spots follow as expected

ORIGINAL



ROTATED



Observations

- Hot spots (few electron signals creating local noise at few Hz) **clearly observable**

- Does it have implication on QA:

  can such a hot spot trigger sparking?

  can one characterize GEM-s by "appearance voltage" of hot spots?

  may identified hot spots be correlated by optical?

Conclusions

- Detector proposed for fast GEM gain mapping
- Rotation, flipping exercise: detector performance OK
- Voltage dependence:

  seems predictable with power law / linear
- Gas filling ArCO2 vs NeCO2N2 dependence:
  seems predictable with power law / linear
- Full size versions for ALICE IROC/OROC foils are being designed as a QA device