Towards Large Single-Stage THGEM detector

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Project supported by RD51

Outline

- Motivation & Final goal
- 300 x 300 mm^2 chamber
    - Detector design
    - Experimental setup
    - Results
    - Next steps
- Trying Argon again
- Summary

Motivation & Final goal

DHCAL

- Thin sampling element
- Large area coverage (~4000 m^2)
- 1 cm^2 pad readout
  - Low resolution
  - Medium rate
- Low multiplicity
- Relatively low gain ~ 2000

THGEM is a possibility: robust, simple to produce over large areas, etc

Motivation & Final goal

- Cost
  - THGEM detector cost is proportional to the number of holes
- Production
  - Drilling holes takes a long time (~50 hours for 1 m^2)
  - Hole quality determines the detector quality

Single-stage detector:

- Cheaper
- Produced faster
- Less potential problems

Motivation & Final goal

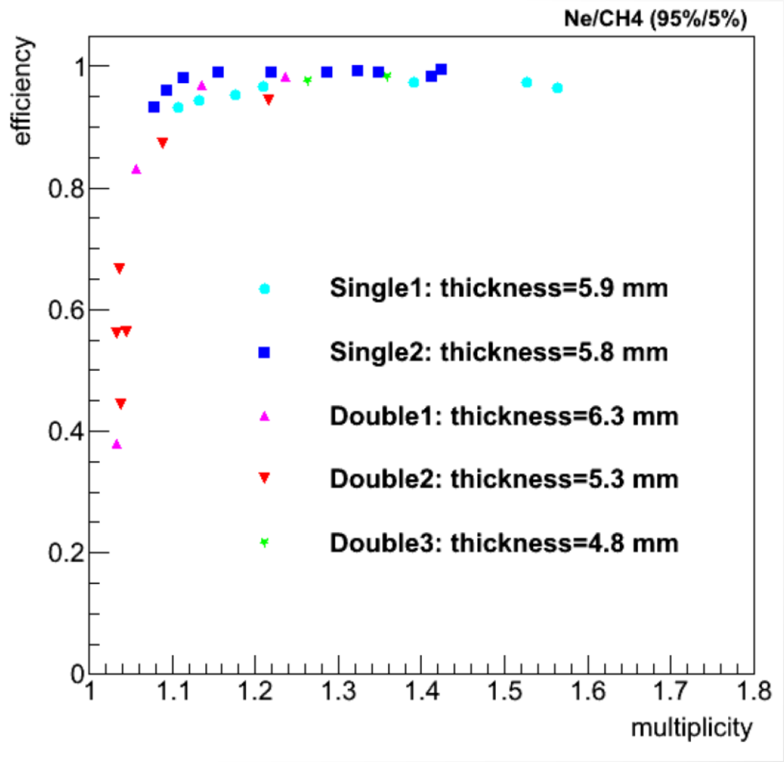
Large ~ 500 x 500 mm^2 single-stage THGEM detector

- Stable operation
- High efficiency
- Uniform (or controlled) response

DHCAL specific

- Thin: small drift and small (or no) induction gap
- Low pad multiplicity
- Stable in Hadronic environment

Feasible according to our last test beam result

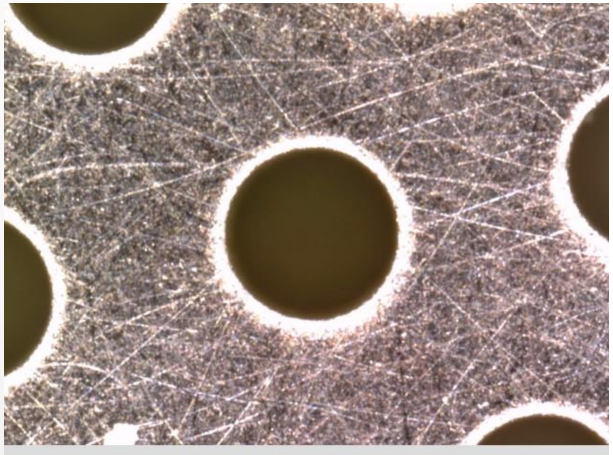


[arXiv:1305.4657]

Our first 300 x 300 mm^2 Detector

300x300 mm^2 – Trieste's experience

- Production quality
- Gain Vs. thickness
  - Will measure thickness carefully
- The lesson was learnt

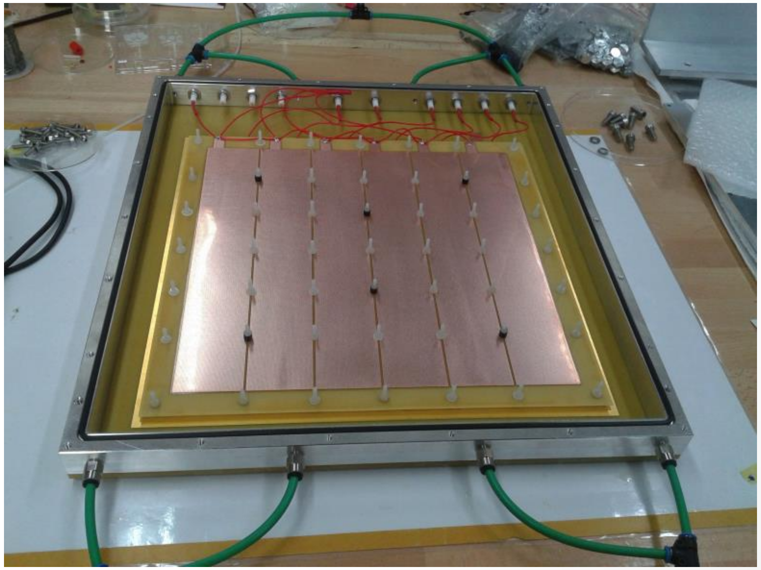


But many differences…

- Single stage Vs. Triple stage
- Higher gain in the individual layer
- Higher operation voltage
  - Less stable
  - Potential inter-segments discharges
- Use of resistive layers

300x300 mm^2 - Electrodes

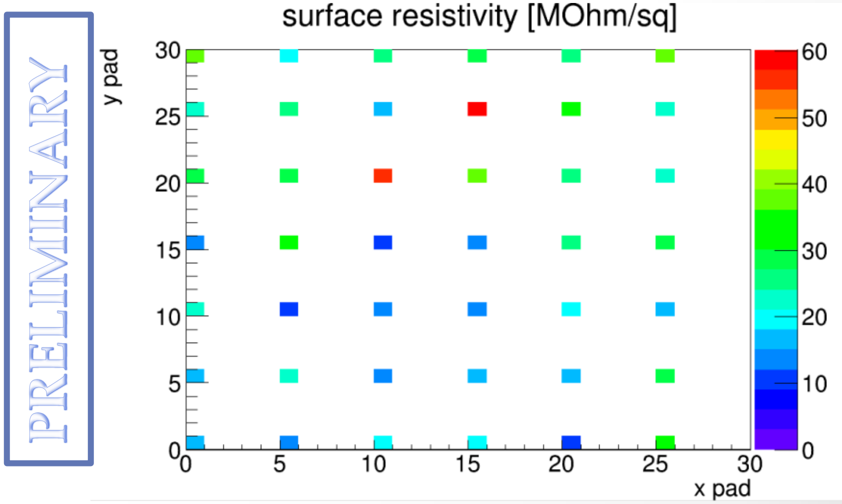
- Two structures
  - Double sided (induction)
  - Single sided (WELL)
- Geometry
  - a = 1 mm
  - d = 0.5 mm
  - t = 0.4 / 0.8 mm
  - h = 0.1 mm / 0
- Production:
  - Eltos followed by treatment with Polyurethane coating at Rui's
- Segmentation
  - 6 strips 300 x ~48 mm^2
  - Gap ~ 2 mm
- Support
  - Pins squared pattern 50 mm



Needs optimization

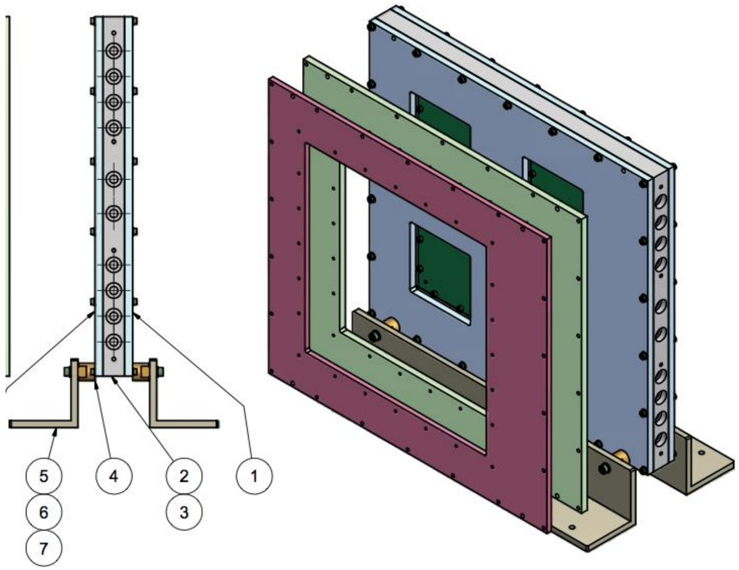
300x300 mm^2 – Resistive Layers

- Graphite epoxy mixture sprayed on copper-gridded FR4
- Nominal resistivity
  - 10 MΩ/sq
- Measured resistivity
  - Large variations
- Study the effect of resistivity variations
- Explore other types of resistive layers



300x300 mm² – Detector Design

- Flexible enough to test different configurations



- Next step: prototype #1:
    - Smaller spacers, glued to the anode / resistive layer

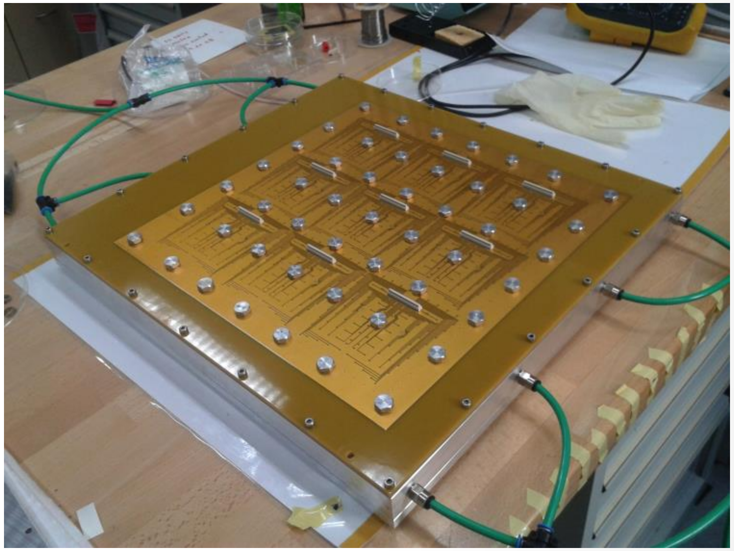
300x300 mm^2 – Detector Design

Power distribution

- So far each segment is powered with independent HV channel
- Needs optimization
  - Might affect the segmentation as well

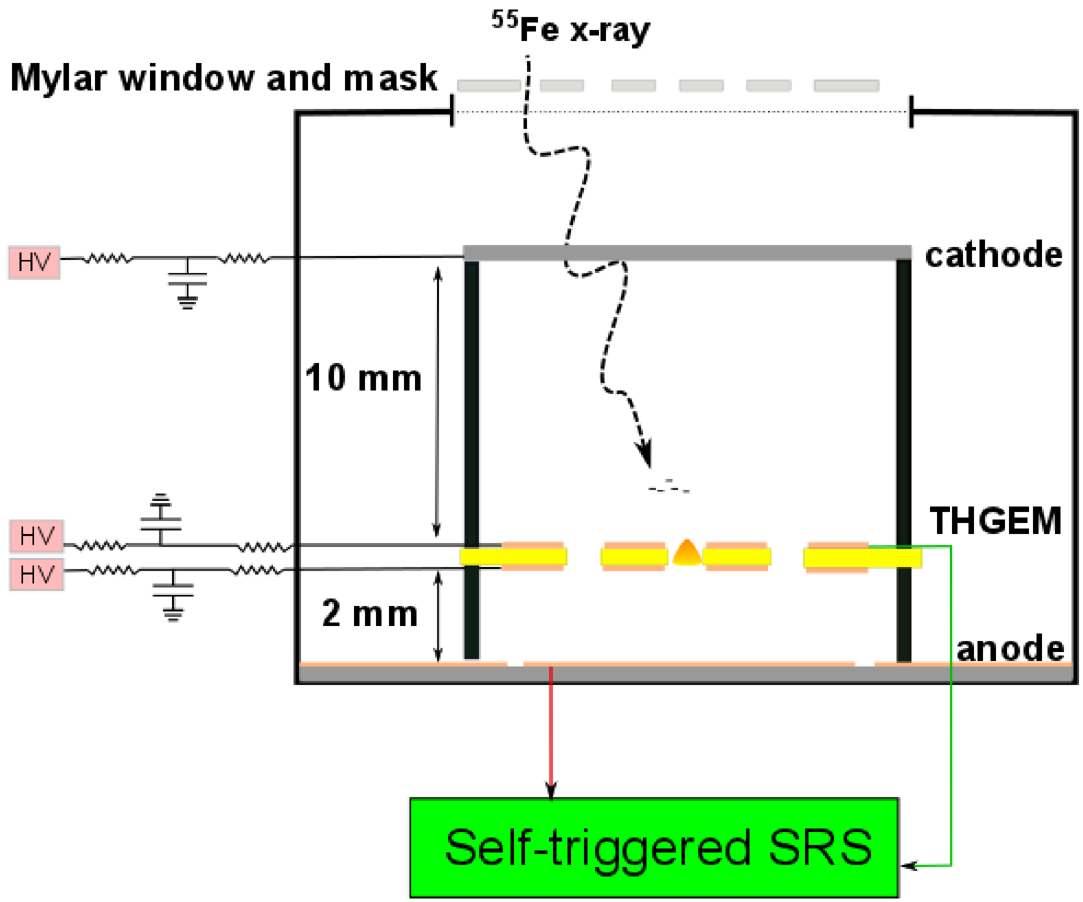
Readout

- SRS (9 APVs)

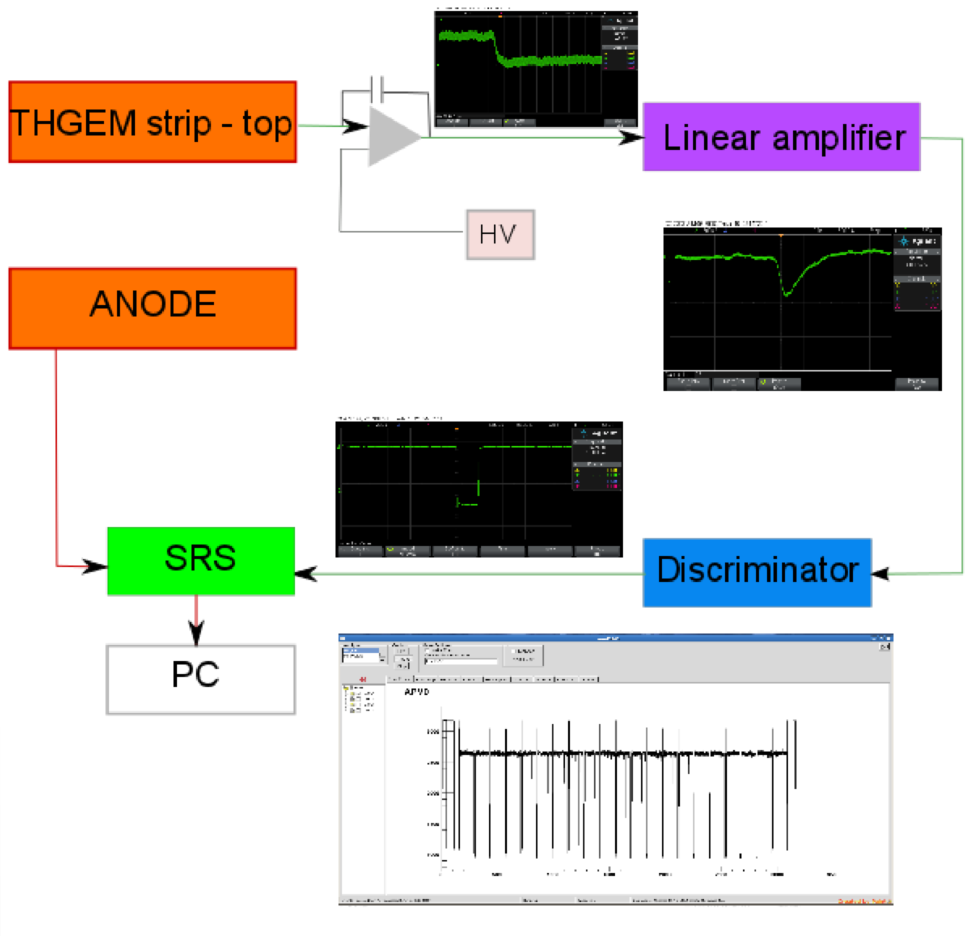


- Parallel setup - MICROROC

300x300 mm^2 - setup

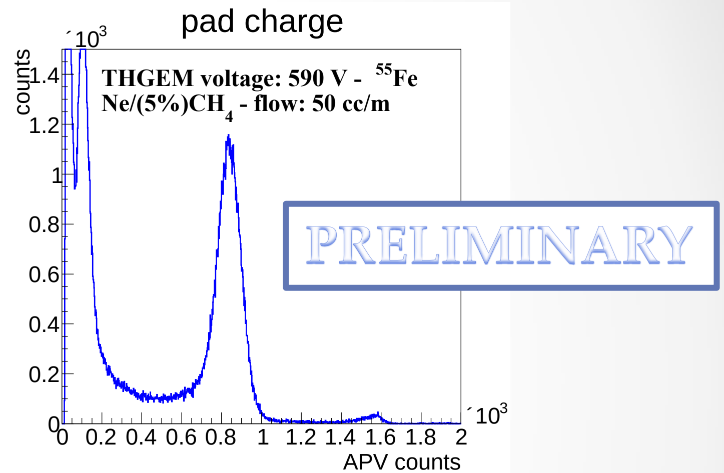


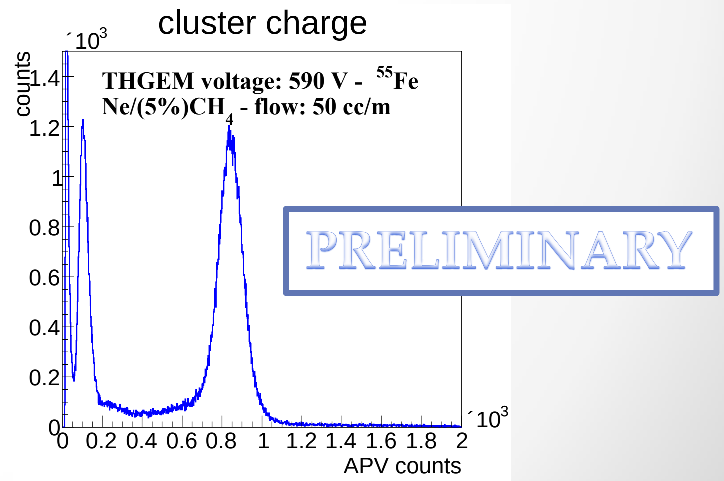
300x300 mm² - setup



300x300 mm² - DAQ & Offline SW

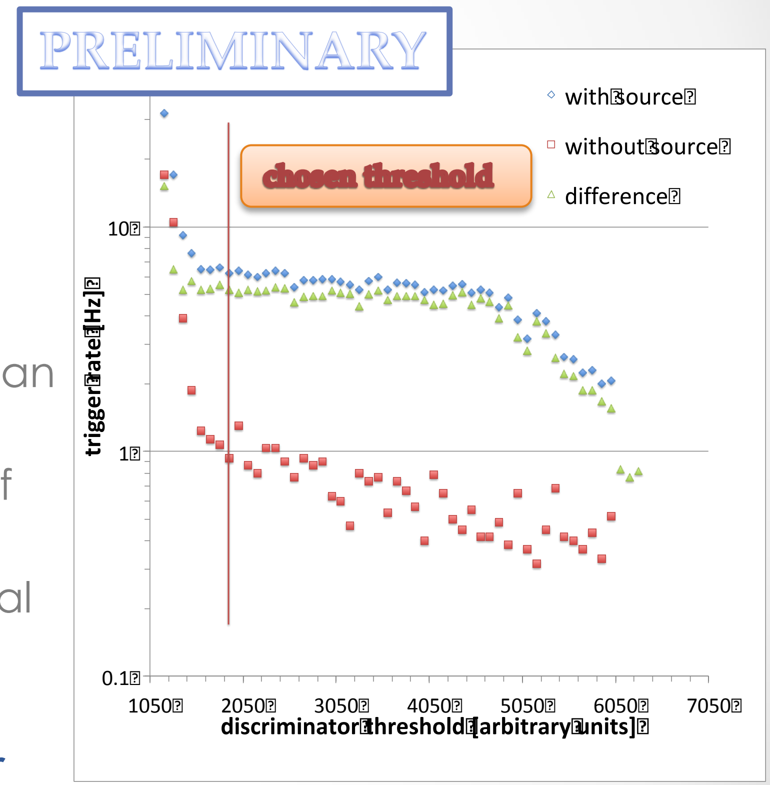
- DAQ: mmdaq
- Reconstruction I: Recomm
  - Offline zero order suppression based on dedicated pedestal measurement (threshold optimization)
  - Strips geometry
- Reconstruction II: RecoPad
  - Pad builder: Converts to pad geometry
  - Cluster builder: Merge neighboring pads
    - Charge: sum of pads in a cluster
    - Position: weighted average
- Analysis: root based





$300\times300\ mm^2$ - Self Trigger

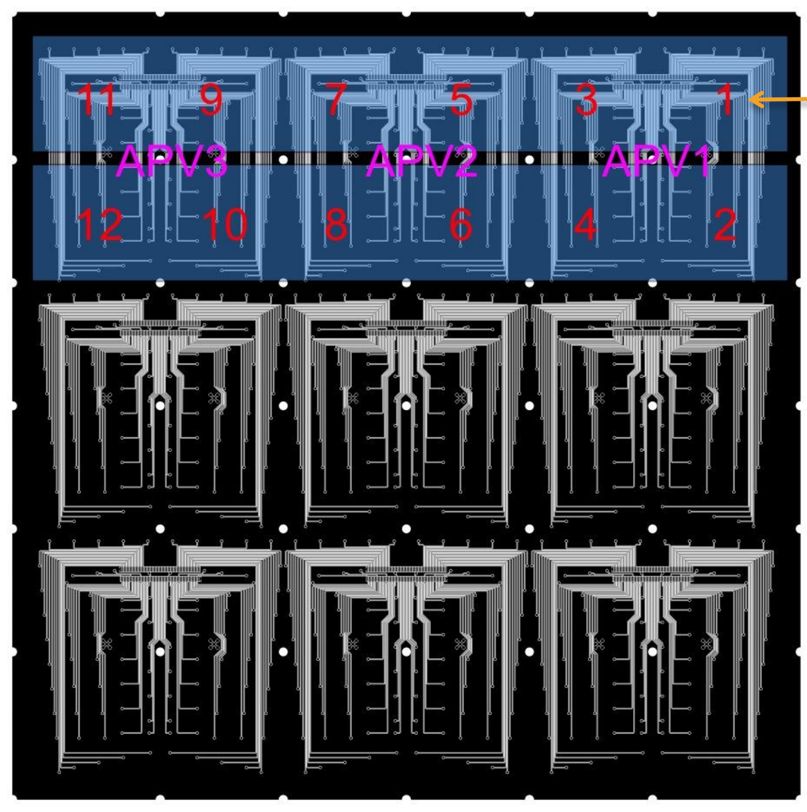
- Allows working with an x-ray source
- Correlates the trigger and the signal
  - Impossible to measure efficiency
  - To get clean trigger needs higher gain than to have good signal/noise separation
    - Might exceeds the dynamic range of the APV
  - High discriminator threshold cuts the signal

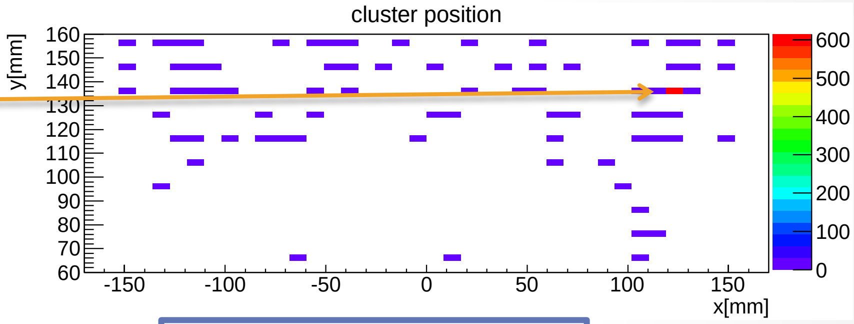


Choose the gain and the trigger threshold with care

300x300 mm² - Sanity check

- Identify the source position

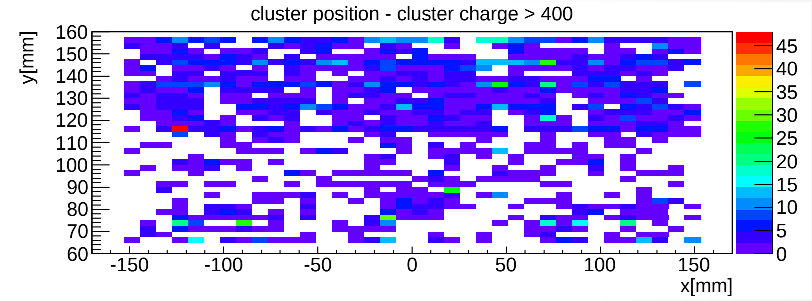


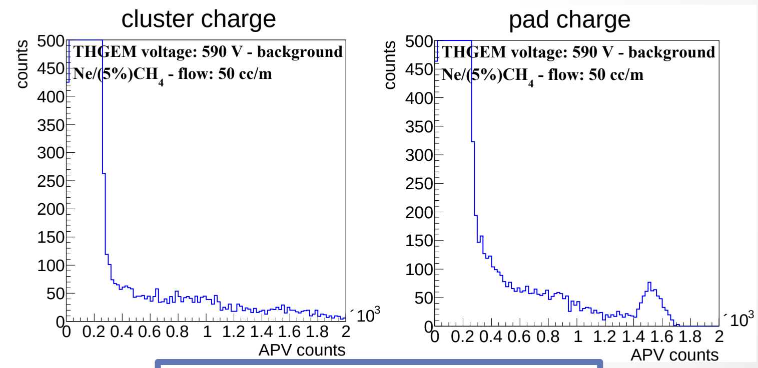


PRELIMINARY

300x300 mm² - Offline analysis

- Identify noisy pads
    - Remove the source and look for firing pads
    - The charge is not necessarily low
- Will study the origin of this pulses





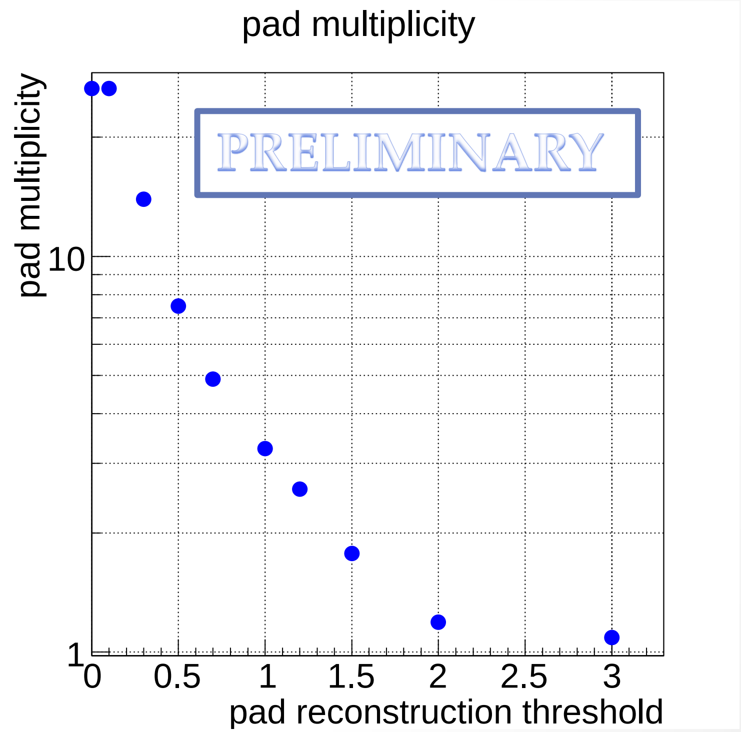
PRELIMINARY

For now these pads can be excluded from the offline analysis

300x300 mm^2 - Offline analysis

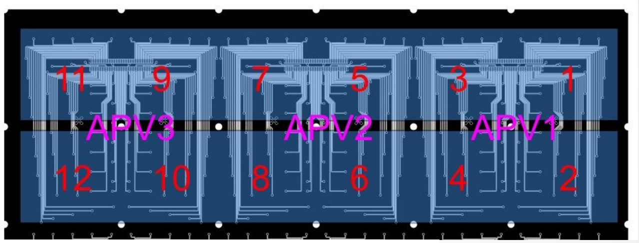
Set the parameter for the zero order suppression

- The source is located in the center of the pad
- Typical photo-electron track length in Ne/5%CH4 ~1 mm
- Expect pad multiplicity slightly higher than 1
  - Supported by test beam results

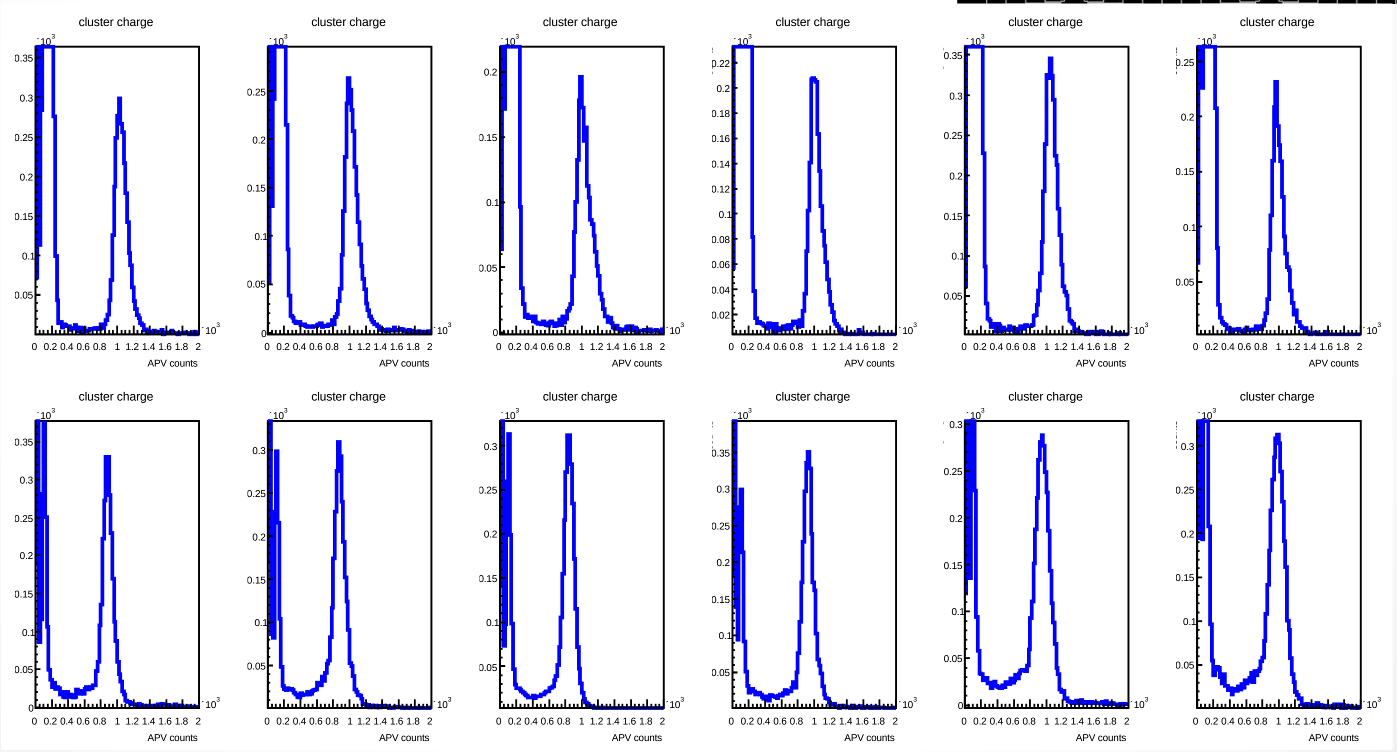


Results: Uniformity

Ne/(5%CH_4)- flow 50cc/m
THGEM voltage 590V – ^{55}Fe source
Zero order suppression parameter 1



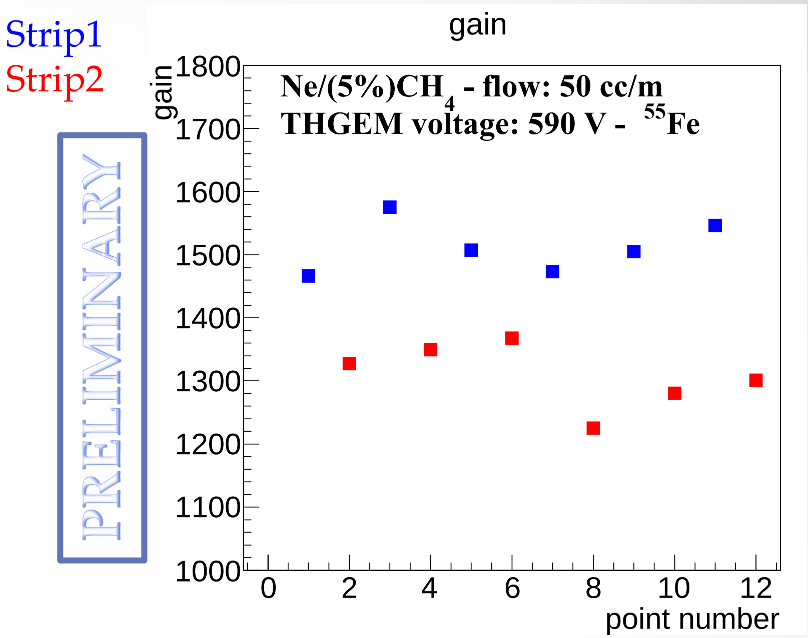
PRELIMINARY

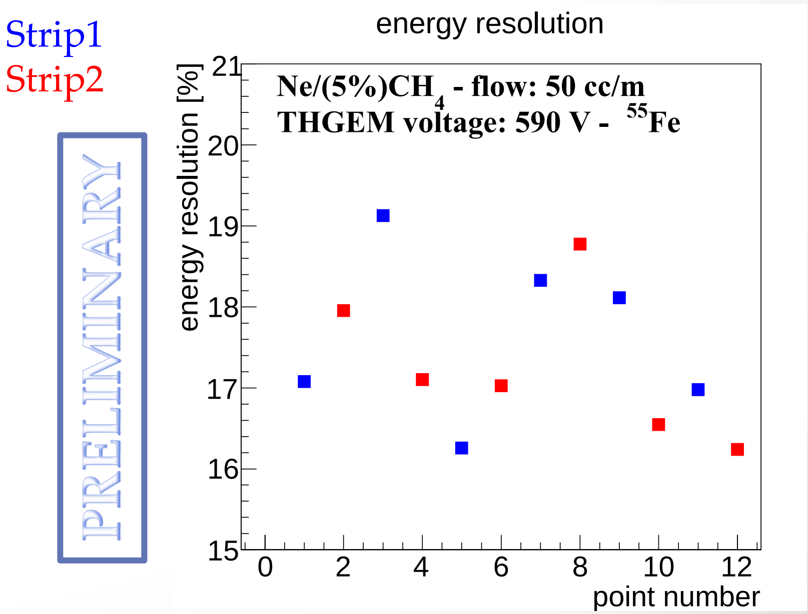


Results: Uniformity

- Small ~10% gain variations
- Small ~10% energy resolution variations

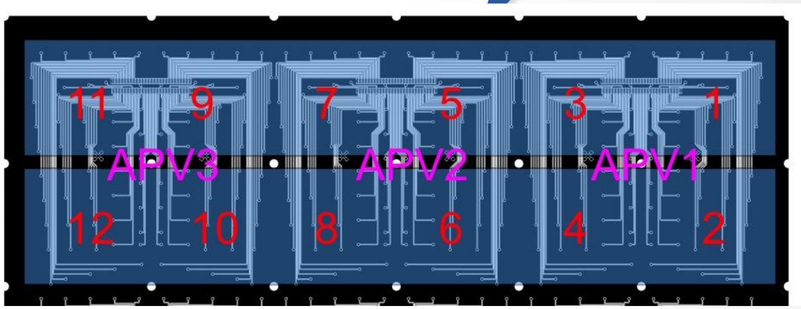
- Small gain difference between the two strips
  - Slightly different operation voltage?
  - Gain shift with time ?
  - To be understood
- Can be corrected

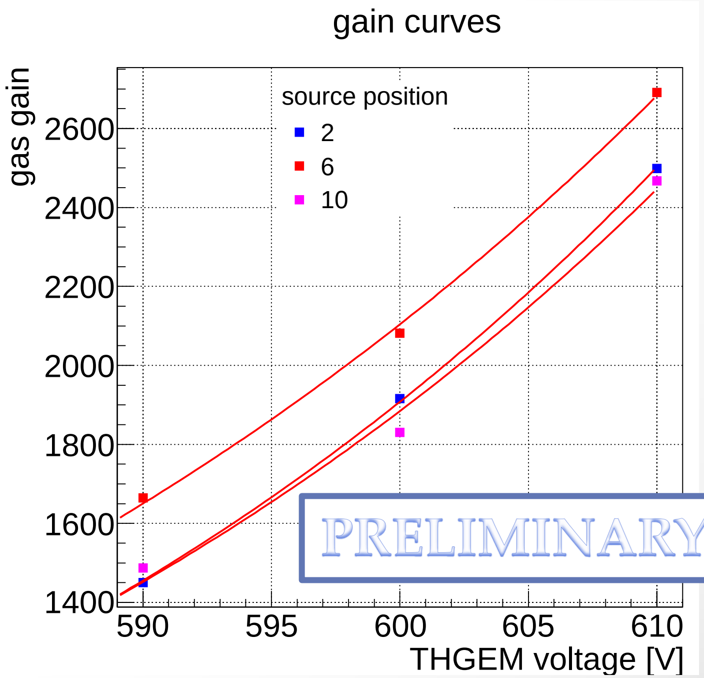




Results: Uniformity

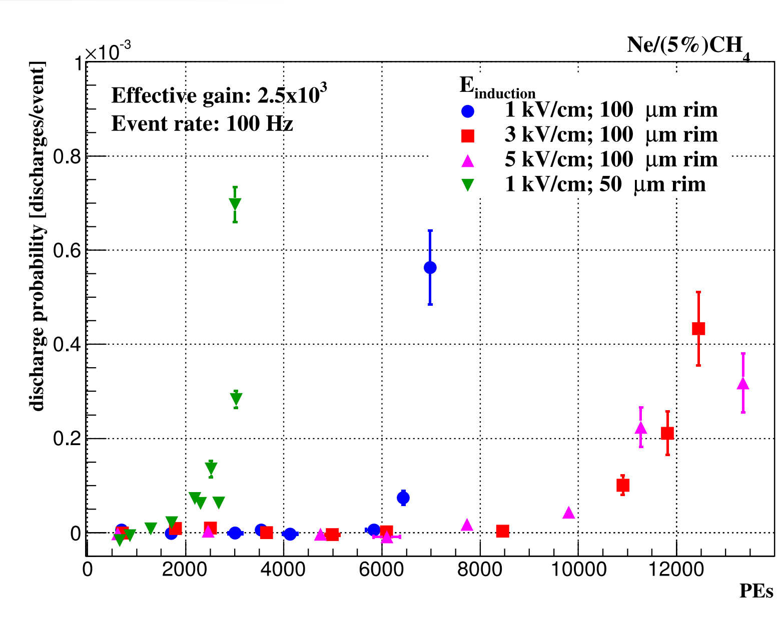
- The gas gain as a function of the THGEM operation voltage was measured in different points
- The different points shows similar response





300x300 mm² - Next steps

- Change configuration
  - 1 mm induction gap
  - Multiplication in the induction
  - Resistive layer

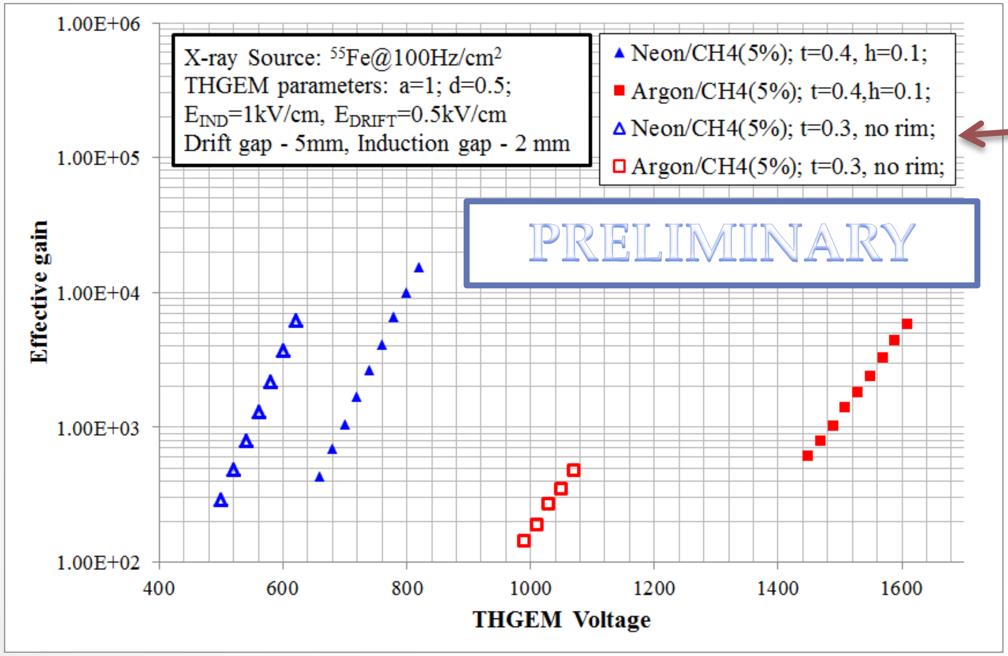


[arXiv:1311.0340]

- Re-do uniformity measurement
- Long term stability
- Discharge probability
- Argon based gas mixtures
- Efficiency with cosmic rays
- Test beam …

Trying Argon again

- As expected, much higher voltages are needed for the same gain in Ar/5%CH4 compared to Ne/5%CH4
- Gain of order 1000 seems to be the limit of the ~0.3 mm THGEM electrode with no rims



Non-standard thin t= 0.3 THGEM foils

Summary

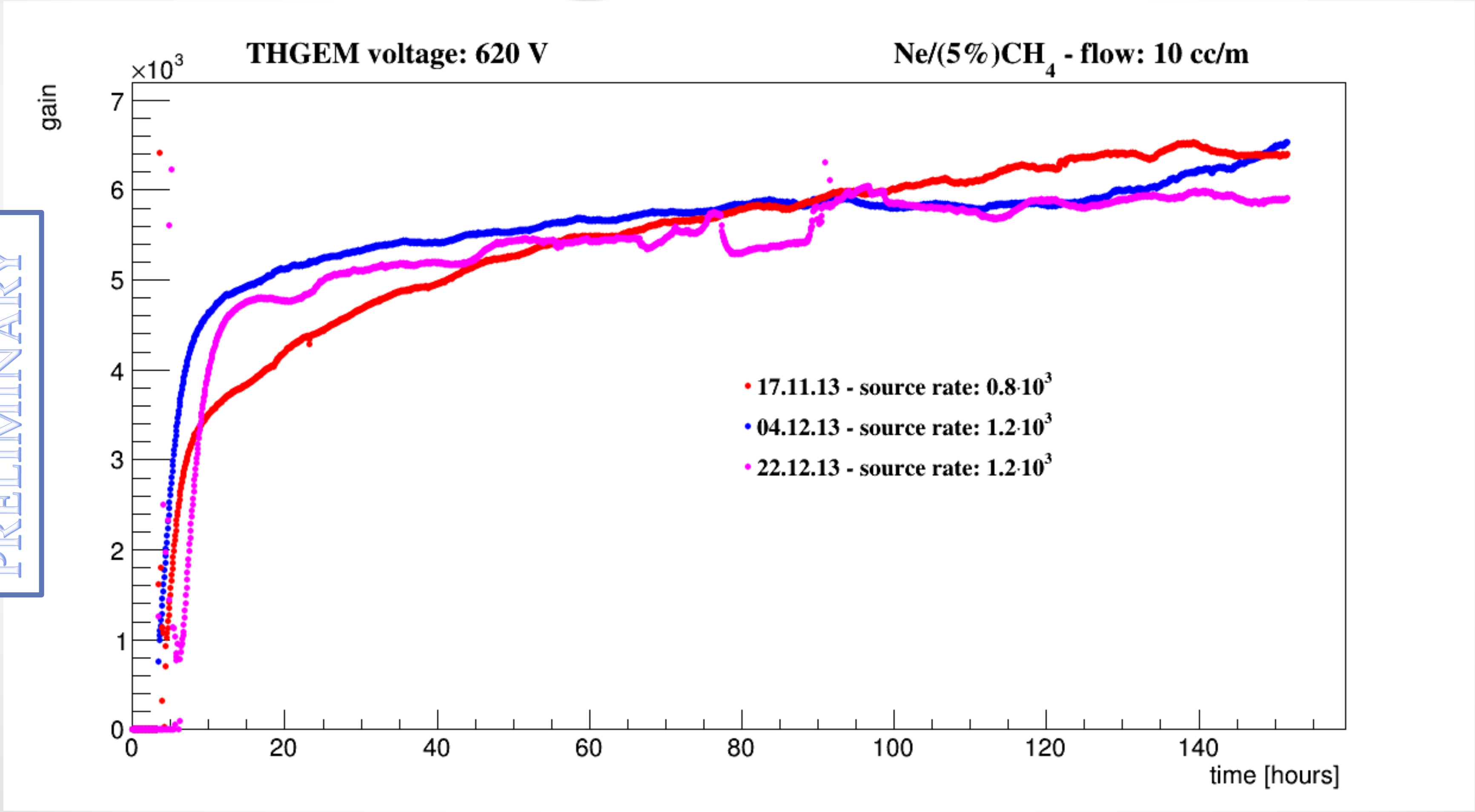
- First single-stage 300x300 mm^2 THGEM detector is assembled and working properly
- Fe55 x-ray signal are recorded with the SRS in self-trigger mode
- The spectra in different points of the detector is well separated from the noise at a gas-gain of ~2000
- Gain uniformity and energy resolution uniformity of order 10% are recorded
- Tests of the response to highly ionizing particles is on course
- Second setup is being built in Coimbra
- Many things to do…

Backup

From comparative to quantitative study

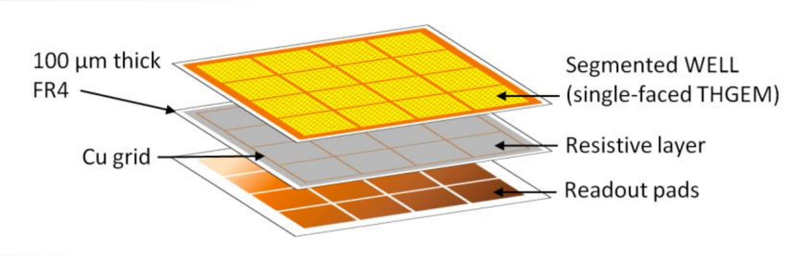
- So far tested many different structures and configurations
  - Double sided:
    - With & without multiplication in the induction gap
  - WELL, RWELL, SRWELL, RPWELL
  - Rim & no rim
- Choose 1 or 2 promising configurations
  - Quantify response
  - Define tolerances
  - Find parameters of impact

From comparative to quantitative study – Long term behavior

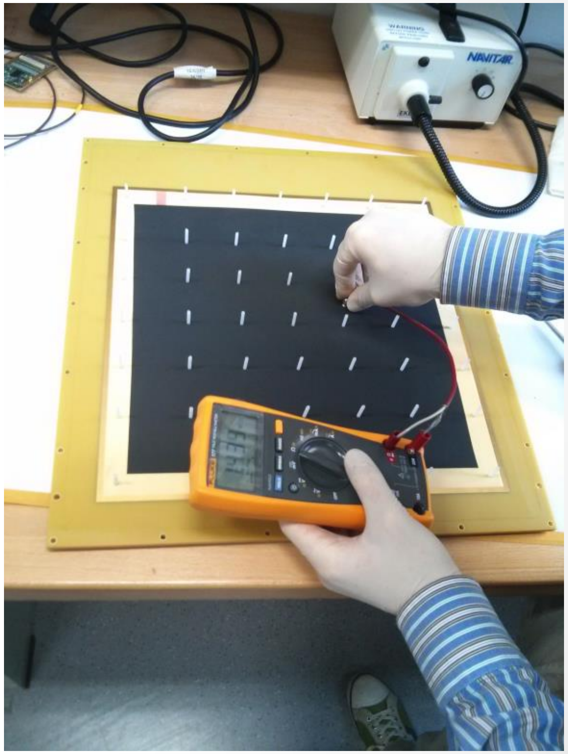


PRELIMINARY

Surface resistance measurement



The surface resistivity is measured within each $1cm^2$ pad



From comparative to quantitative study – Next steps

- Correlate and correct gain measurement with respect to external parameters
  - Temperature, pressure, humidity