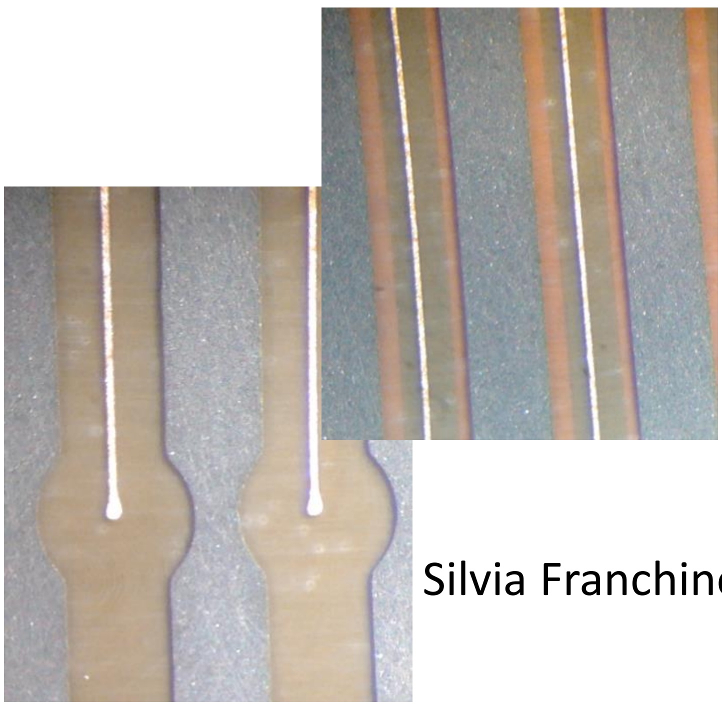
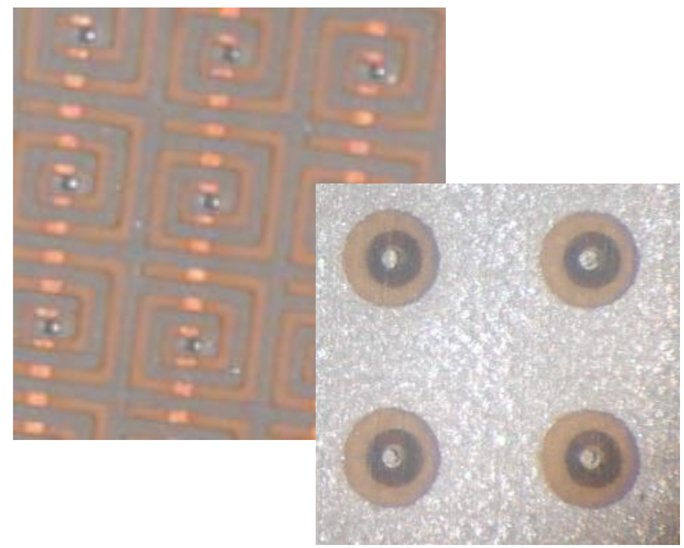
Update on new structures from the CERN workshop



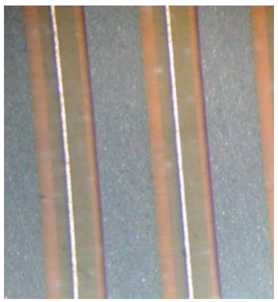


Silvia Franchino, Rui de Oliveira, Vladimir Peskov
CERN

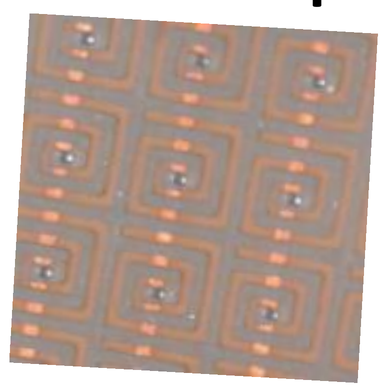
RD51 Mini Week
17/06/2014

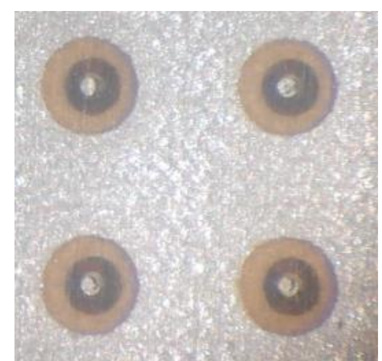
Outline

- Double layer, resistive MSGC



- Double layer, resistive-spiral micro pic detector

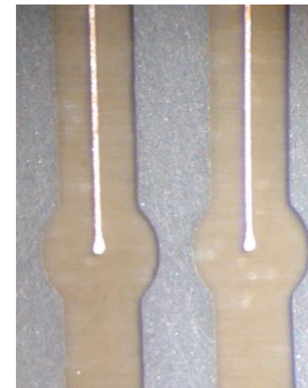


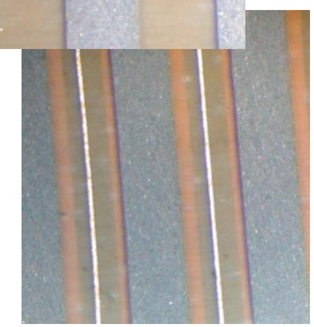


Double layer, resistive Micro-Strip-Gas-Chamber (MSGC)

Motivation:

- Monolithic detector
  - No floating structures (wire, foil, mesh)
  - Very thin, only the PCB and drift gap.
- Very simple to produce and to handle
  - The production can be easily industrialized
  - Cheap detector
  - Not needed special frames or mechanical structures
  - Easy to clean





Improvements with respect to standard MSGC:

- Spark protected
  - Resistive cathodes
  - Internal electrode
- Standard PCB substrate material (FR4, Polyimide)
  - Glass very fragile to be produced in big scales

First version presented at RD51, February 2014

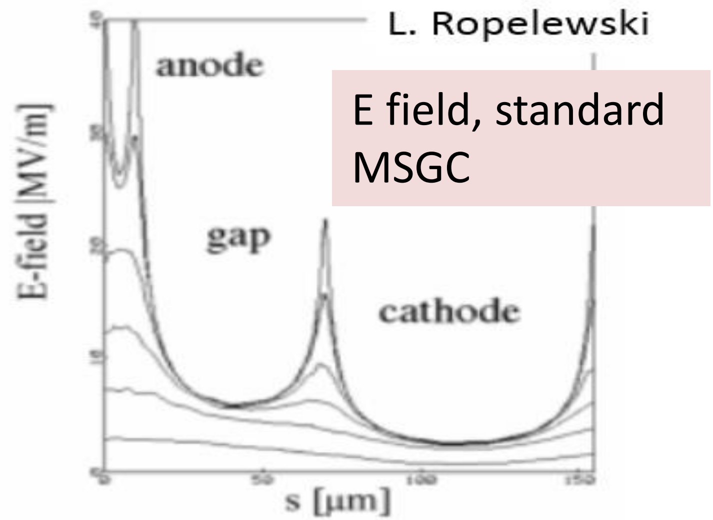
https://indico.cern.ch/event/283108/session/7/contribution/22/material/slides/0.pdf

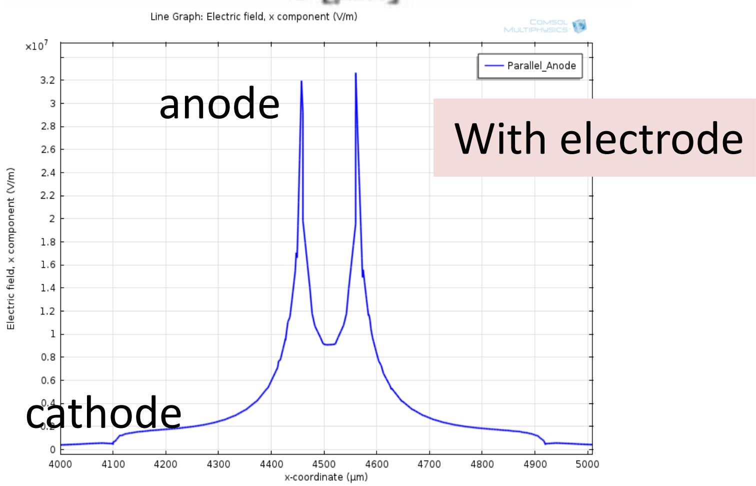
http://arxiv.org/ftp/arxiv/papers/1403/1403.7904.pdf

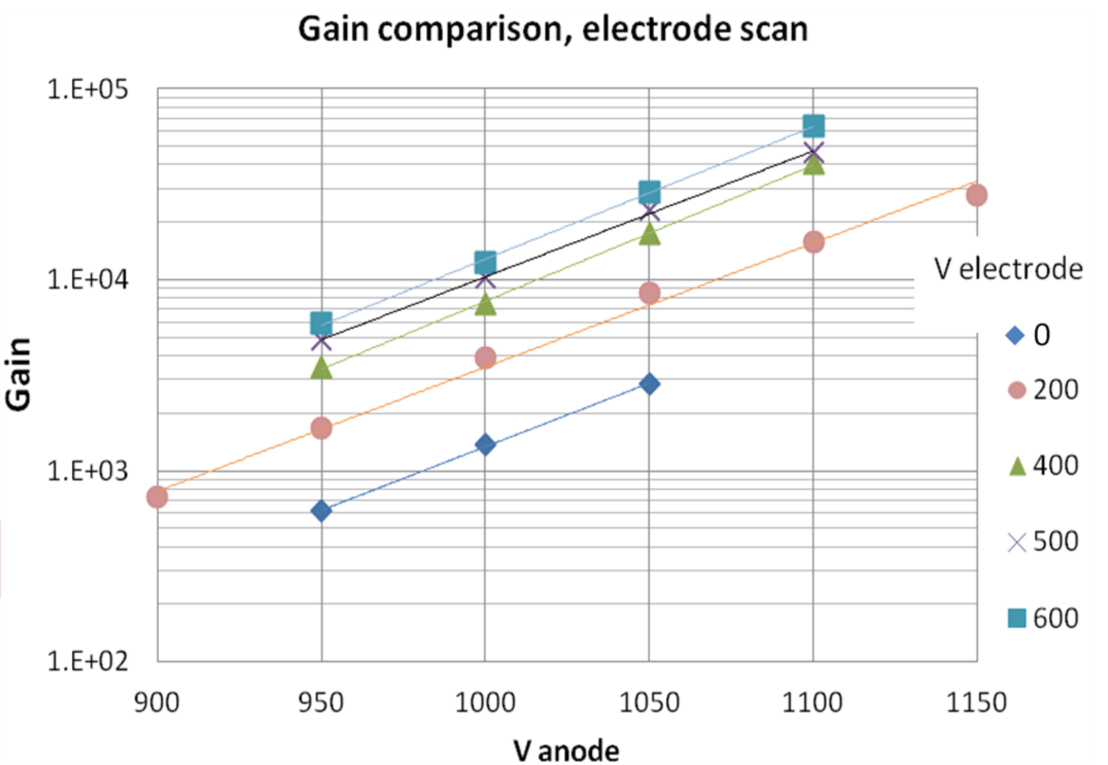
Summary of V1

First version: resistive cathodes, internal electrodes, FR4 material.

Goal of internal electrode: to lower the E field on cathode's edges and to increase the electric field over the anode → more stable operation





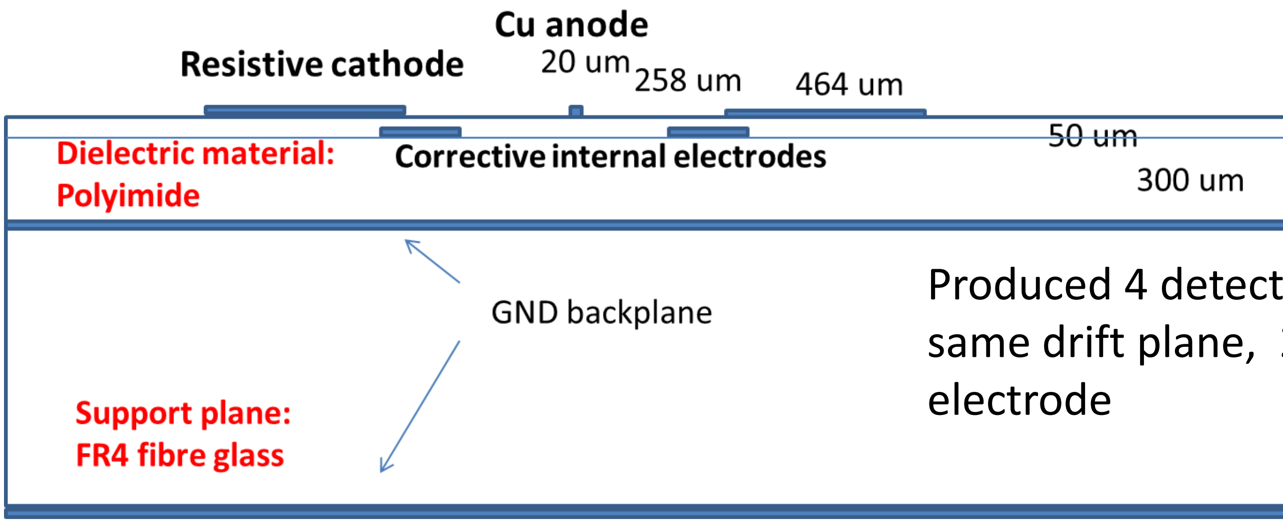


Problem: gain vs time: HV effect very slow, 4 days to reach plateau due to fiber-glass material

Double layer, resistive Micro-Strip-Gas-Chamber (MSGC)

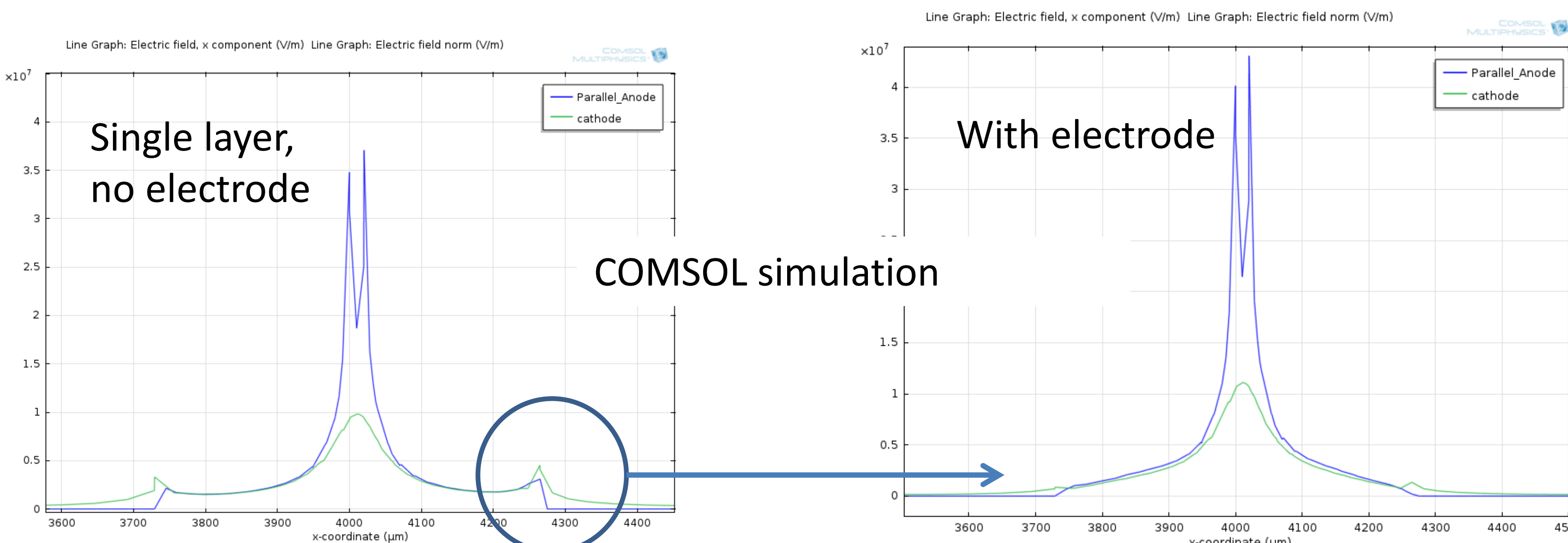
- First version presented at RD51, February 2014
  https://indico.cern.ch/event/283108/session/7/contribution/22/material/slides/0.pdf
  http://arxiv.org/ftp/arxiv/papers/1403/1403.7904.pdf
- New version with different materials
  - First version: standard PCB material: FR4 (EMC 370)
  - New version: Polyimide (pyralux AP9121)
- Allows direct comparison with and without internal electrode
  - 2 detectors with internal electrodes
  - 2 detectors single layer
- Tests ongoing

Geometry and simulation



Pitch 1mm

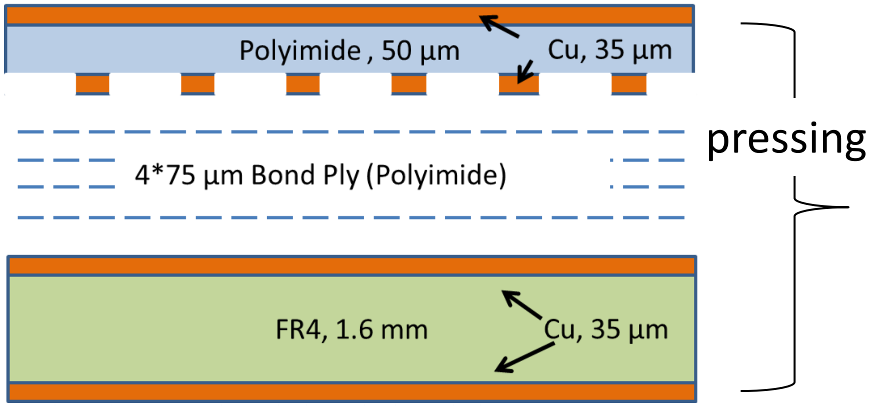
Produced 4 detectors in the same gas box, same drift plane, 2 with, 2 without internal electrode

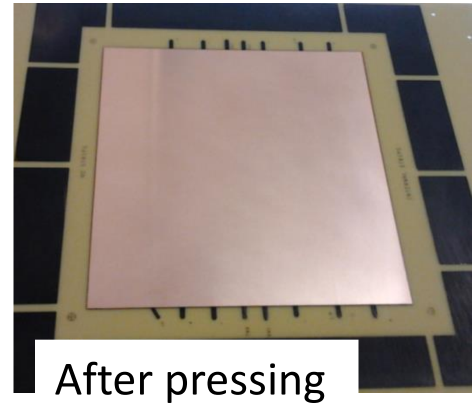


Production Steps

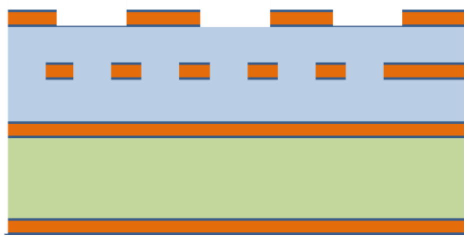
Internal electrodes

Support and backplanes

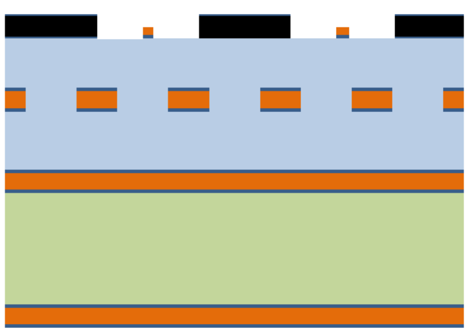


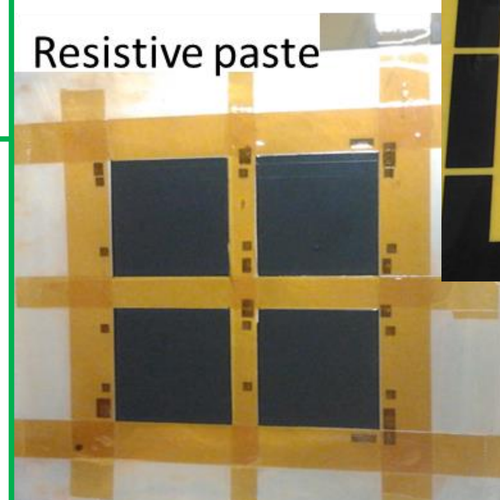


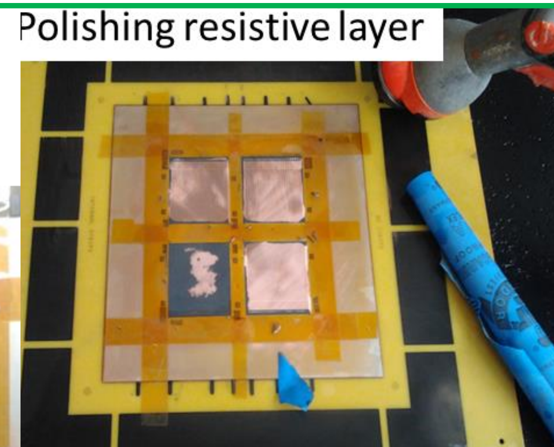
Grooves for resistive cathode strips



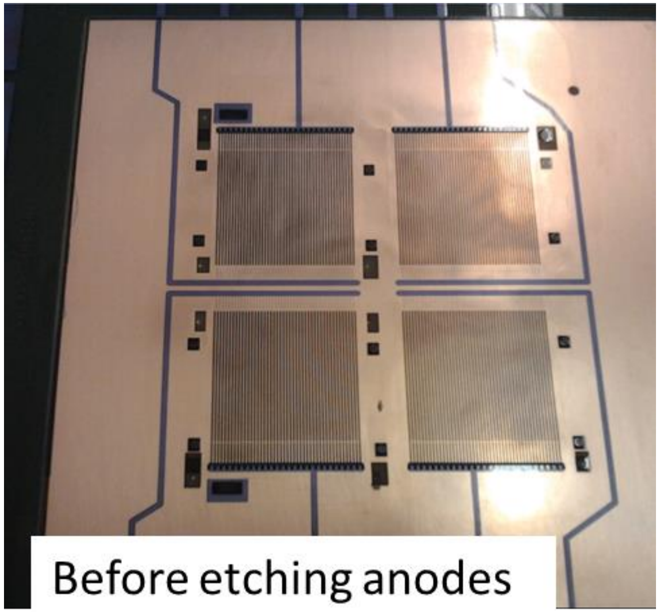
- Resistive cathodes (1MΩ/sq)
- Etching remaining Cu, leaving only ~20µm anodes



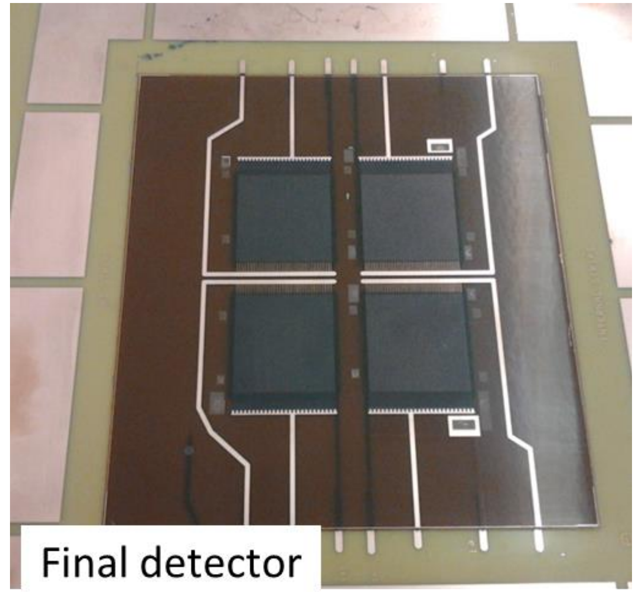




Production steps

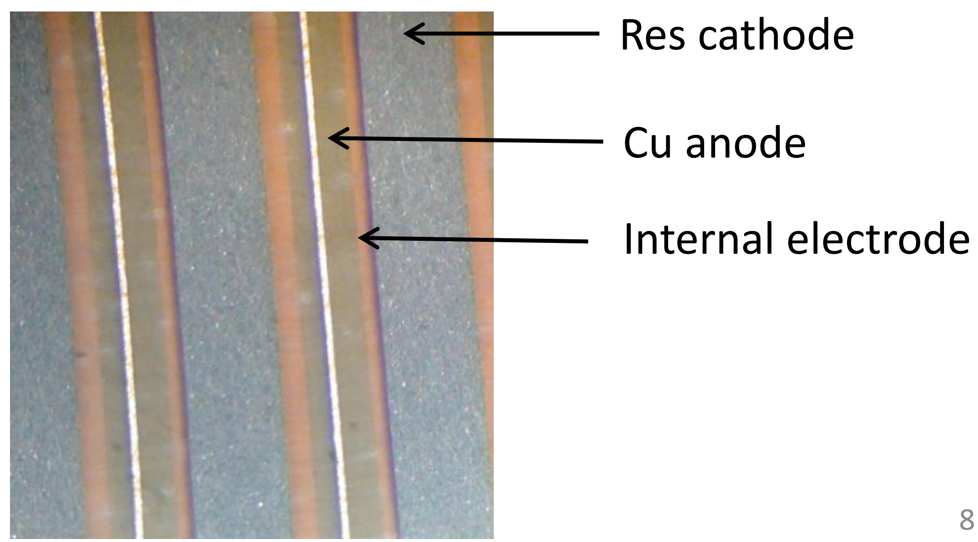


Before etching anodes

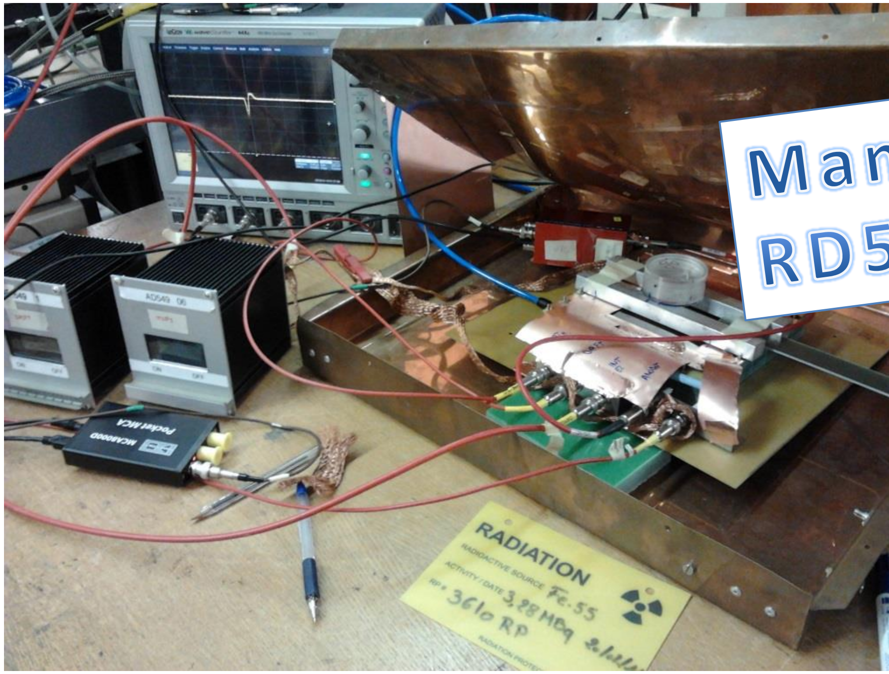


Final detector

Rounded anode ends



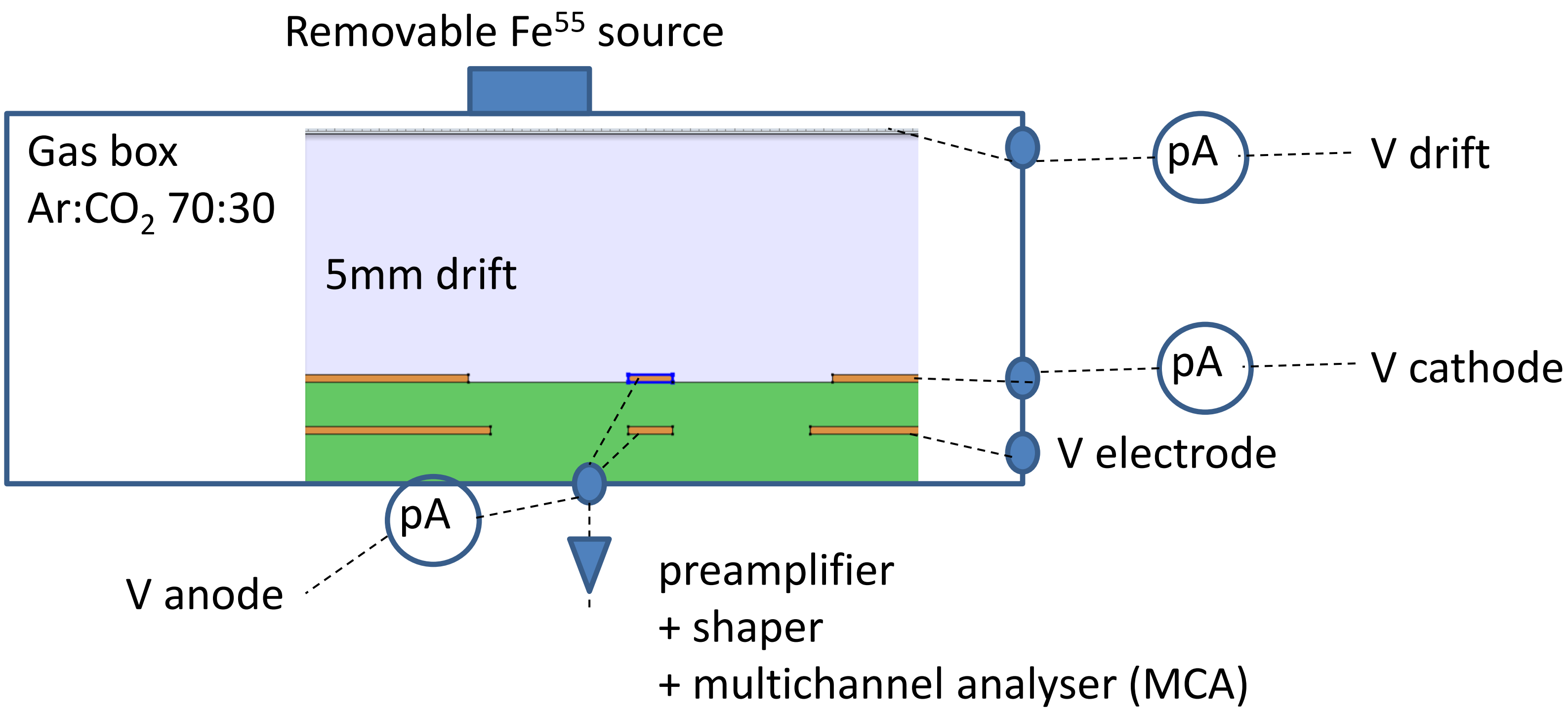
Preliminary results



Many thanks to the CERN RD51-GDD lab support

- Characterization of the detector (gain, energy resolution)
- Checked the effects of the internal electrode
- Stability of gain versus time
  - high voltage effects “polarization”
  - source effects “charging up”

Experimental setup

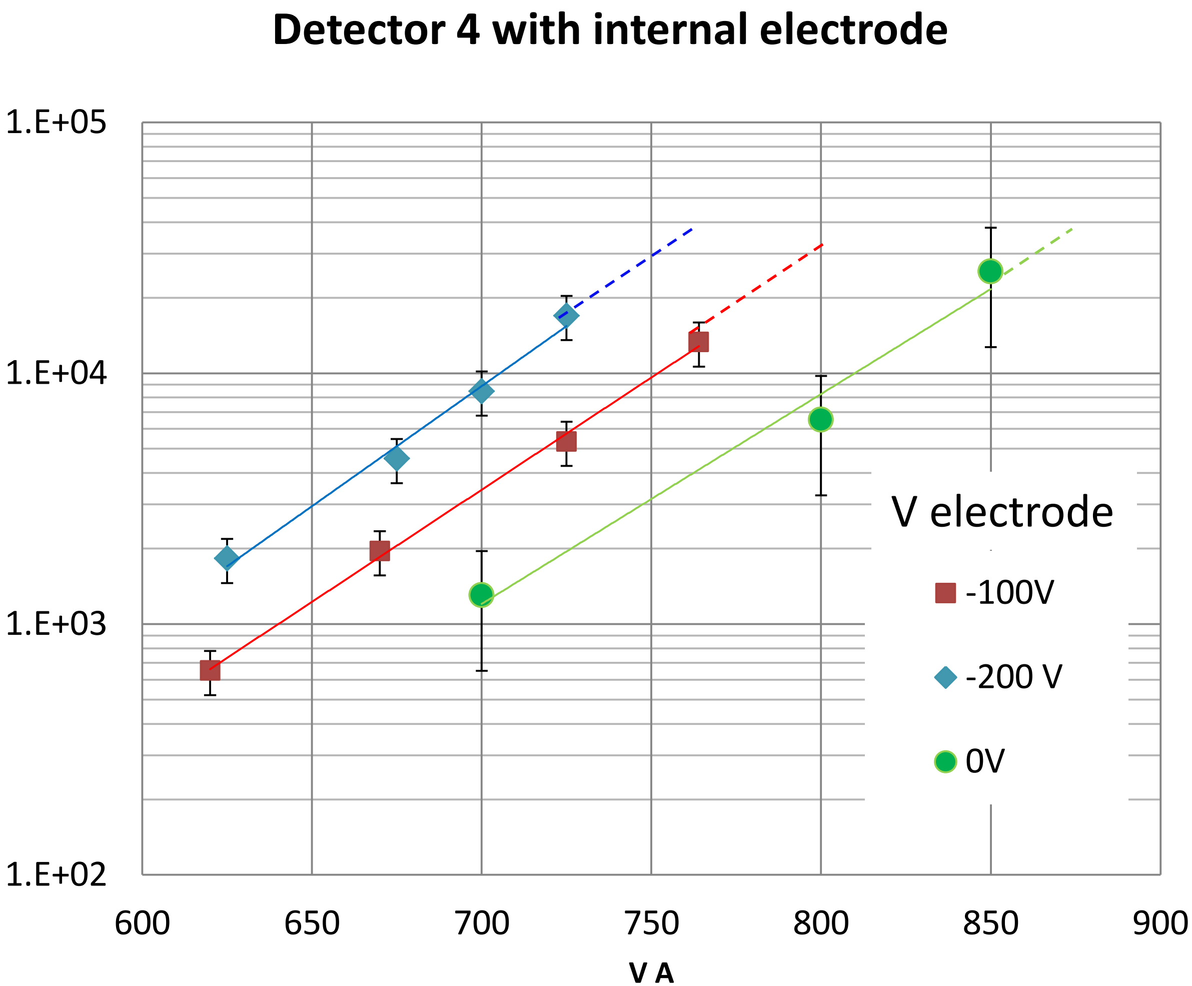


Common setup for res-MSGC and resistive spiral anode microdots.

- MSGC: read the signal from the anode
- SPIRAL: read pick-up strips

Monitor current through anode, cathode, drift with (Trieste's) floating picoammeters

Gain

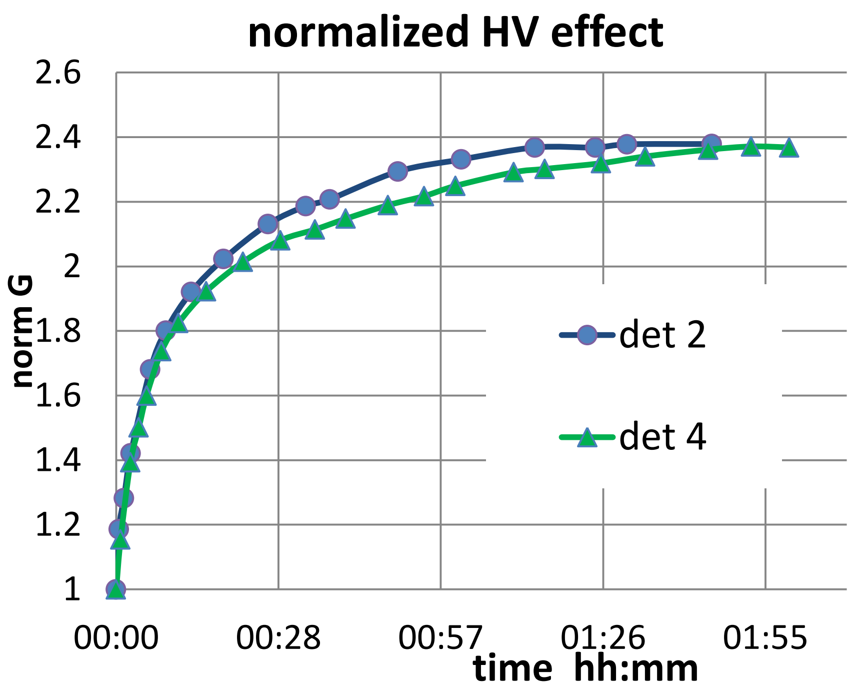


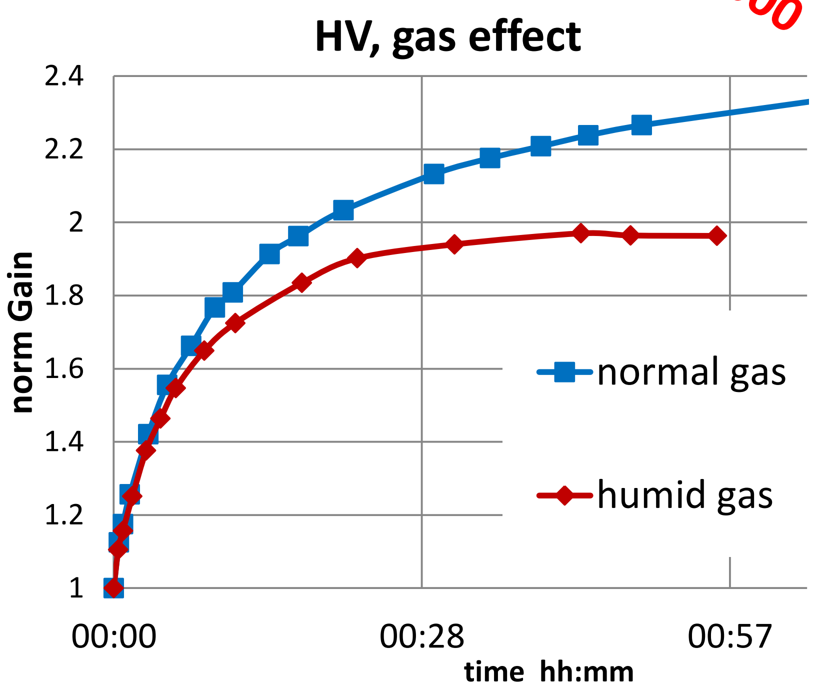
- Results with V el=0V compatible with detector without electrode
- Verified electrode effects seen in first version (increase of gain with V electrode)
- For this plot, not pushed gain up to spark level

As a common problem of MSGC, seen changings of gain vs time.
Studied more carefully (work in progress)

Gain stability vs time

HV effect @ G~2000





- Good repeatability of the measurement between two different detectors
- Known effect, due to charges movements inside dielectric material
- The amount and the time constant depend on the humidity (changing the resistivity of the kapton substrate)
- Better than first version (FR4, plateau after ~ 4 days also for recovering)
- As in standard MSGC, seen also effects of charging up

Conclusion and future plans

- This kind of detector is working
- We reached the point and the same problems of standard MSGCs but having solved spark problems and large size production:

  - **Production technique**: **OK**
    - Not specialized industries needed
    - Standard PCB technique
    - Glass substrate very expensive and fragile: replaced by standard PCB materials

  - **Spark problem**: **OK**
    - Resistive cathodes
    - Internal electrode

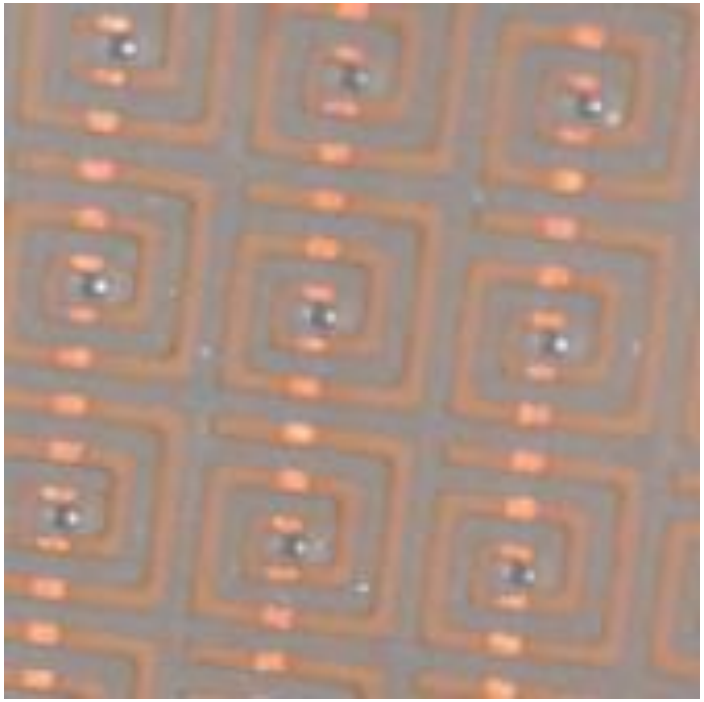
  - **Gain stability** **WORK IN PROGRESS**
    - Measured effects due to HV and radiations
    - Working for the solution, as people found in the past, the solution could be the resistive coating

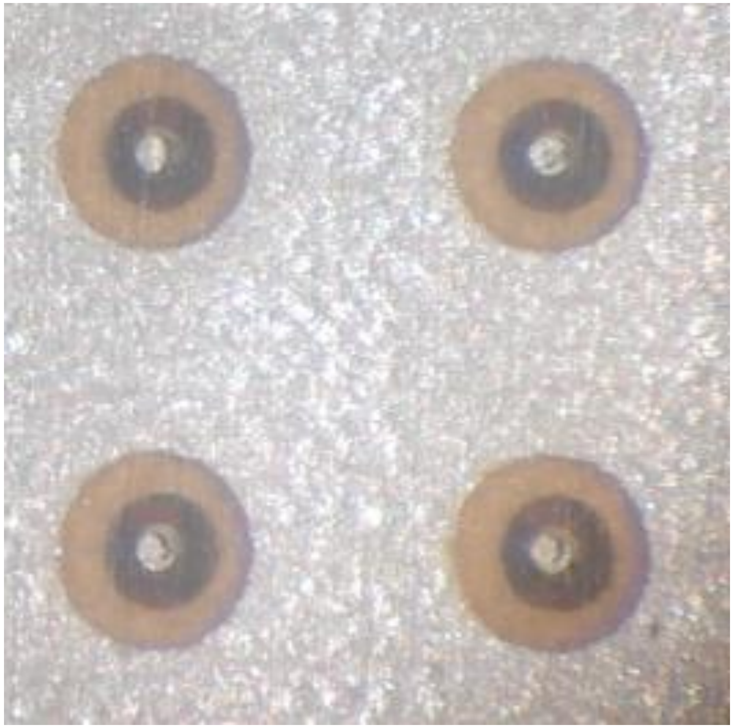
Diamond-like Carbon over-coating (Physical Vapour Deposition)

- Contacted an external company
- Two different resistive values, one for each detector
- Foreseen for next weeks

Thanks Serge Ferry

Microdot detector with resistive spiral anode and internal corrective electrode





Microdot detector with resistive spiral anode and internal corrective electrode

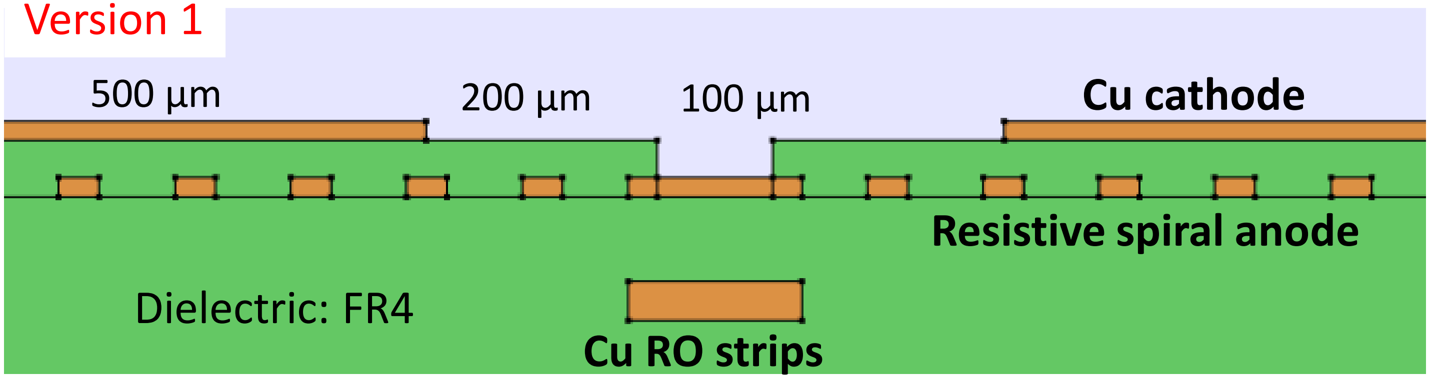
- **Motivation:**
  - Possible application in dual-phase liquid dark matter searches
  - Need high gain (in cryogenic environment) in order to see single photoelectron
  - All MPGD up to now perform good in gas, but have very low gain in cryogenic environment
  - Microdot detectors: possible to reach very high gain
  - Spark protected (anode spiral)

- **First version**: see Vladimir's talk at RD51, Oct. 2013
  https://indico.cern.ch/event/267513/session/6/contribution/2/material/slides/1.pdf

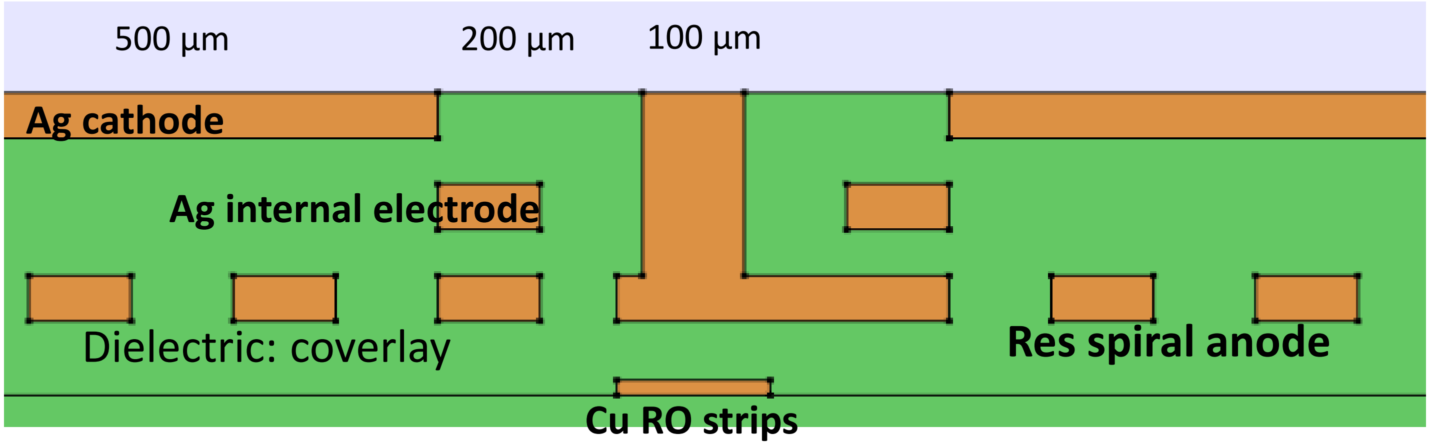
- **Second version**: improved version proposed by the workshop.
  - different production technique
  - Internal electrodes: from previous res-MSGC studies, can increase the gain and reduce instabilities

Geometry

Version 1



Version 2



Applied voltages:

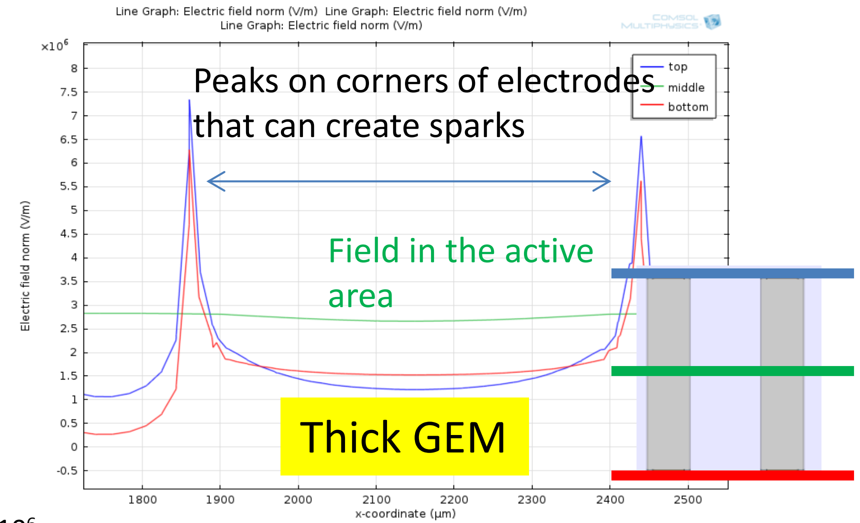
- Cathode, RO strips, backplane: 0V
- Anode: 600 V
- Internal electrode: -300V

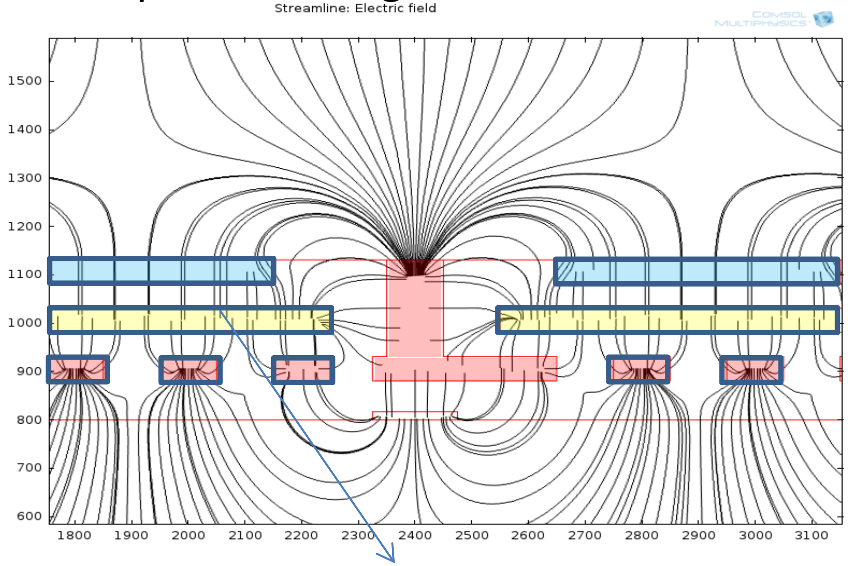
Same pitch, 1mm
Same anode: diameter 100 μm

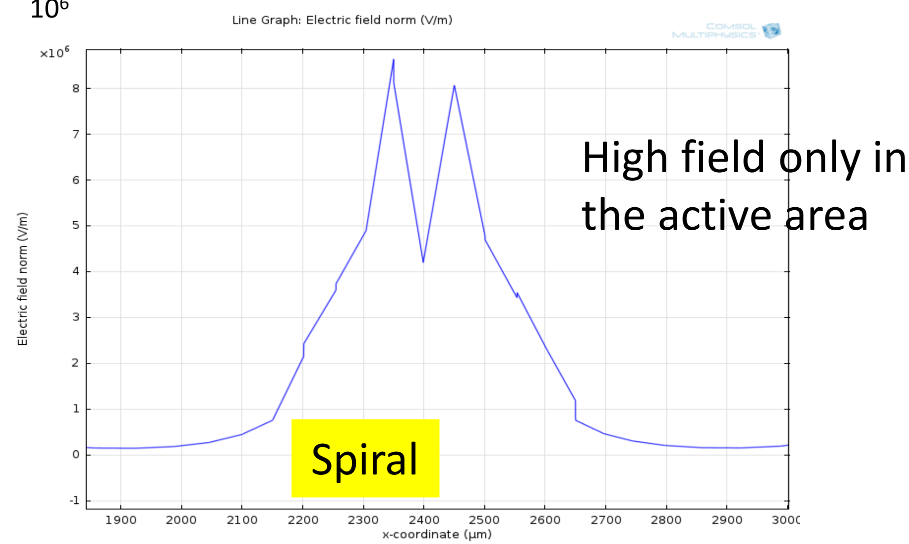
E-field simulation

Static E-field simulation with COMSOL
Comparison between horizontal field between:

- standard Thick GEM (with rim). Very high fields outside the amplification region can cause instabilities reduction of gain
- spiral detector: no high field outside amplification region





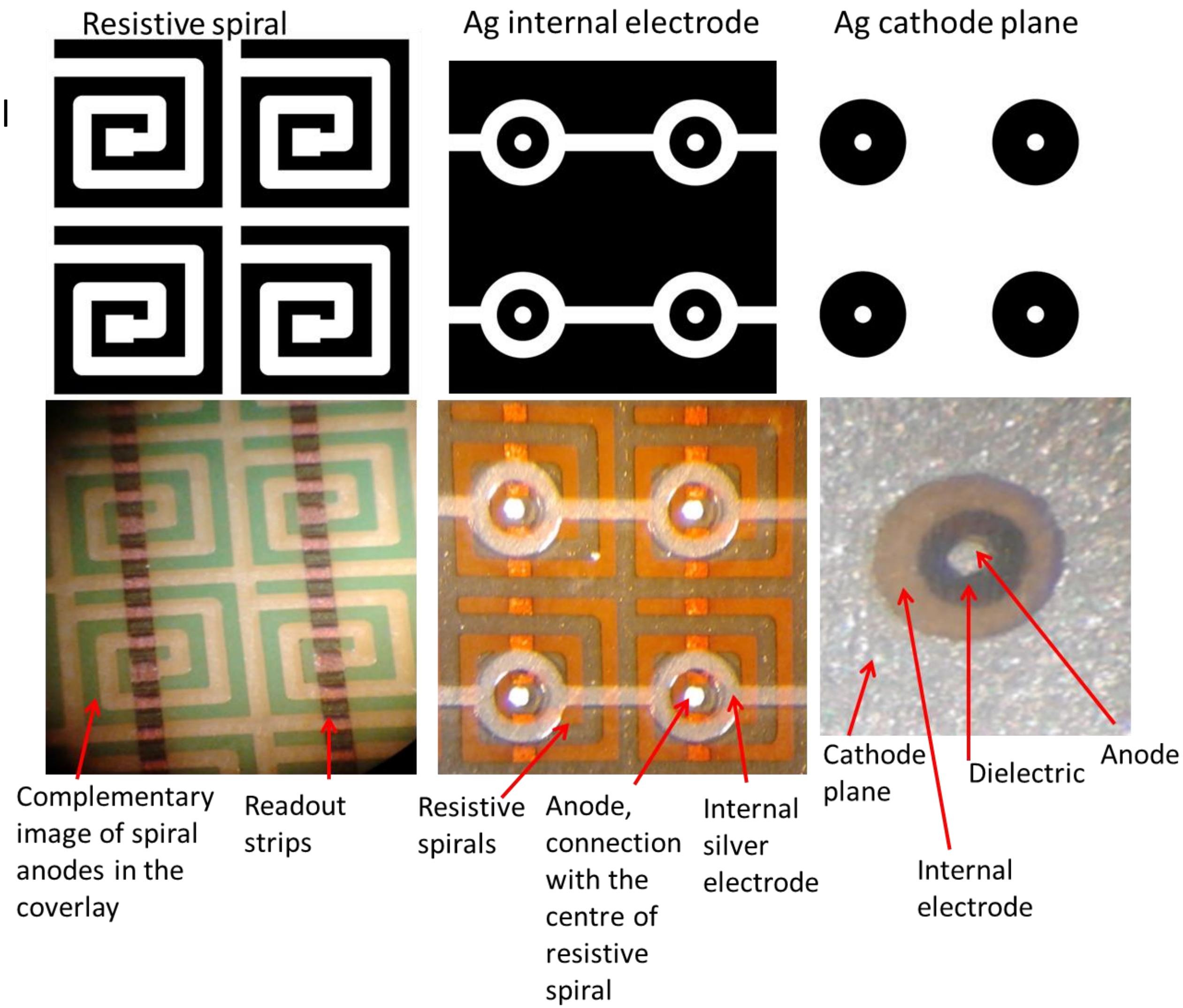


Similar results also with an internal ring instead of full electrode plane (Used the ring in the production, to minimize probability of defects and connections between cathode and electrode)

Thanks to V. Cairo for help on simulations

Production

1. Standard PCB readout plane
2. Photoimageable coverlay as dielectric and as a mask for all electrode planes .
3. **Anode**: resistive paste (1MΩ/sq) filling grooves in the coverlay
4. **Internal electrode** and **cathode**: silver glue filling grooves in the coverlay



Advantages of this technique:

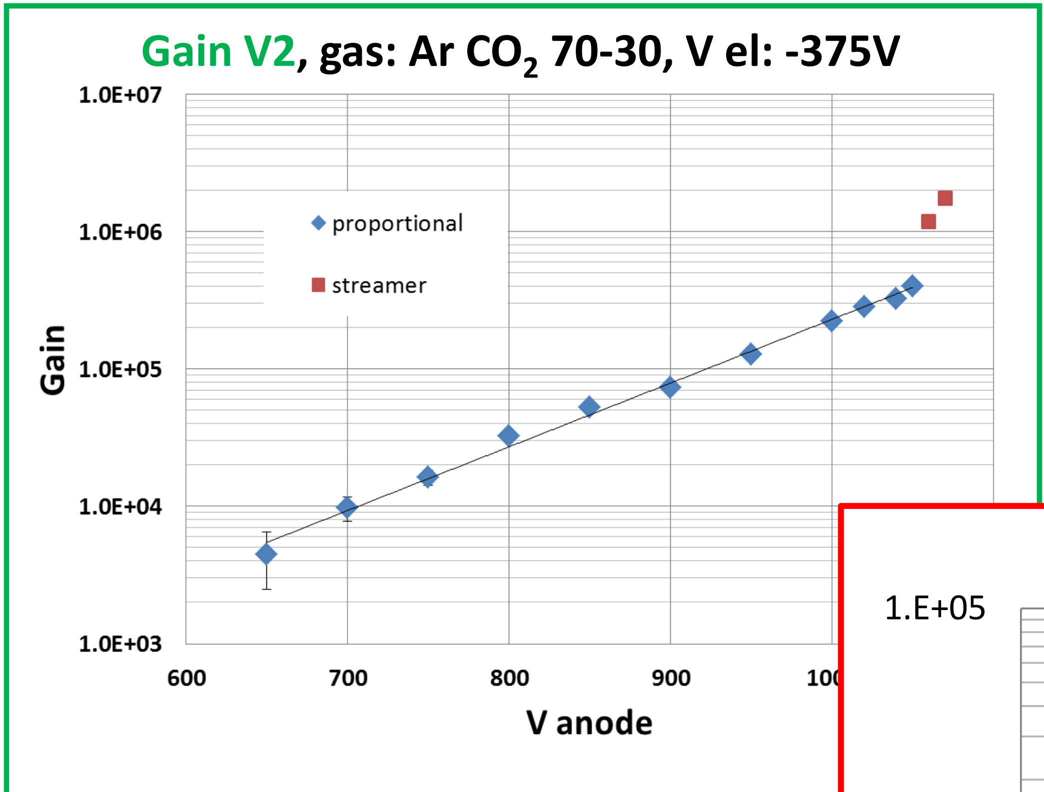
- Completely flat surface
  no dust problems
- Not used the press
  no alignment problems; checked alignment before passing to the next steps, if needed one can redo the layer before cooking it

Thanks to Antonio Teixeira and Valentina Cairo for help during production

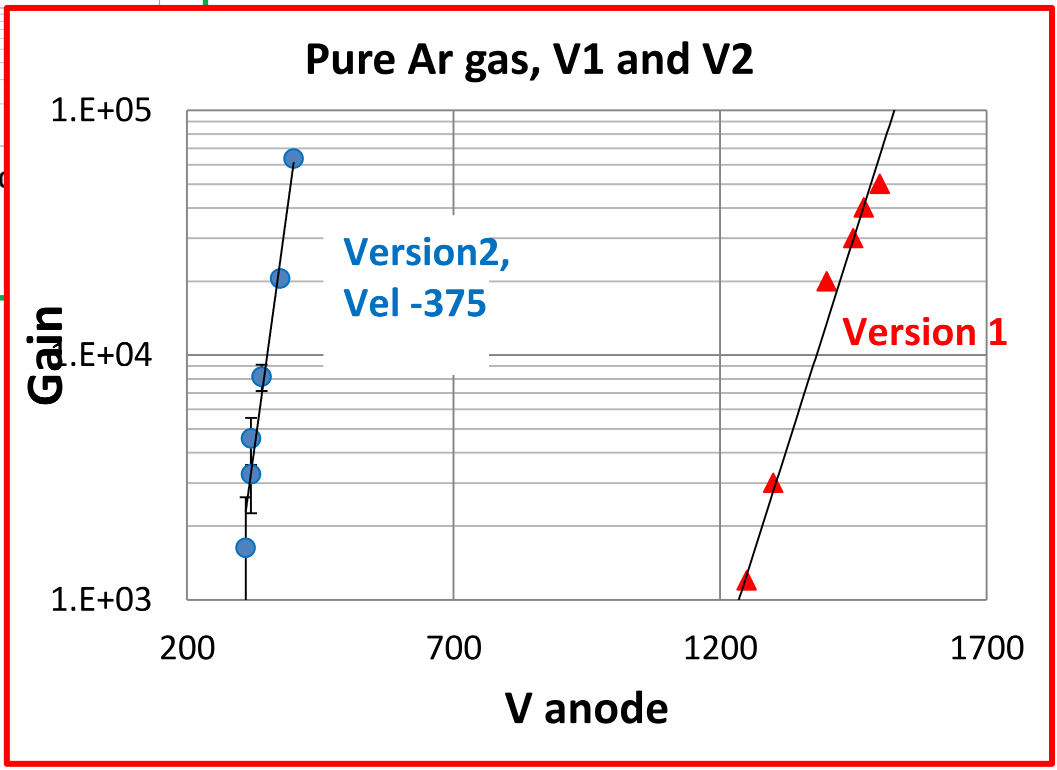
Preliminary results

- Gain
- Internal electrode effects
- Energy resolution
- Gain versus time stability

Gain



Very high gains (G >10^5) reached without instabilities

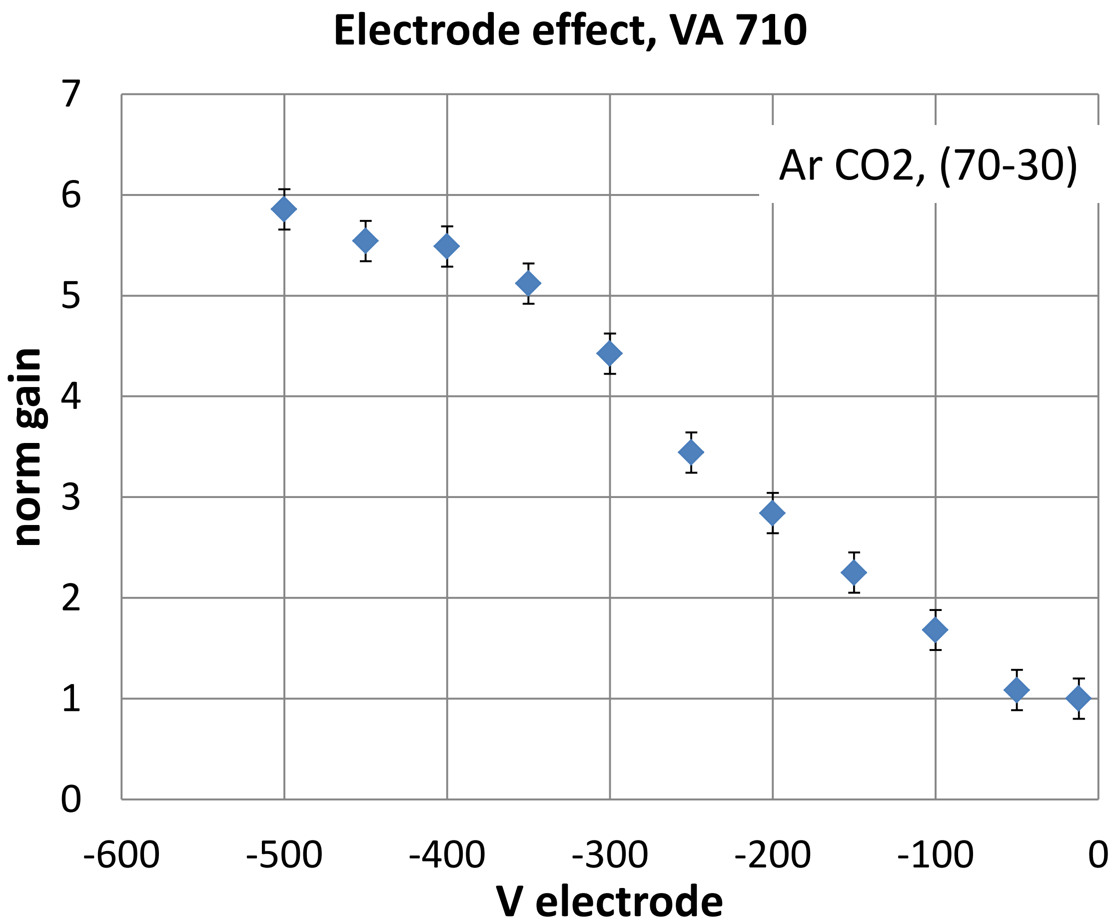


Tested in pure Ar to compare with Version 1

- Same performances, but
- Reduced a lot anode voltage (probably due to better anode collection)

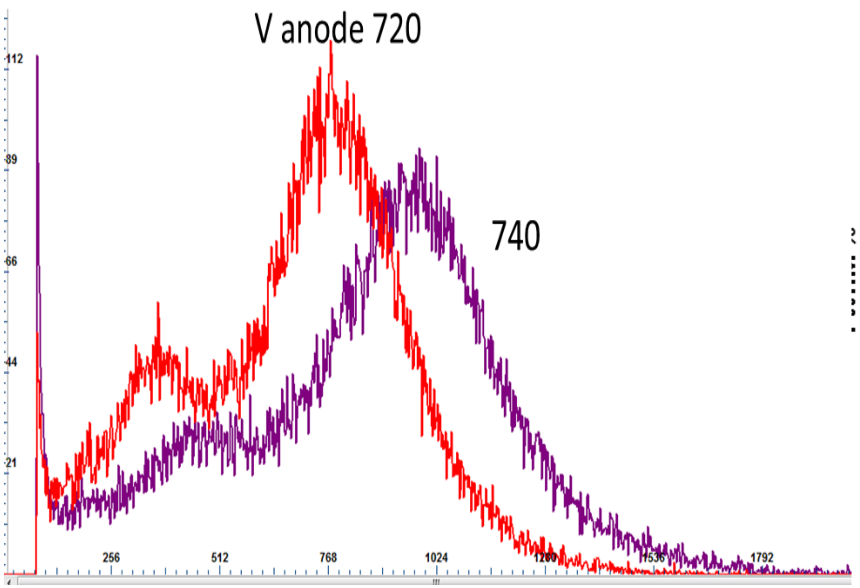
Internal electrode effect

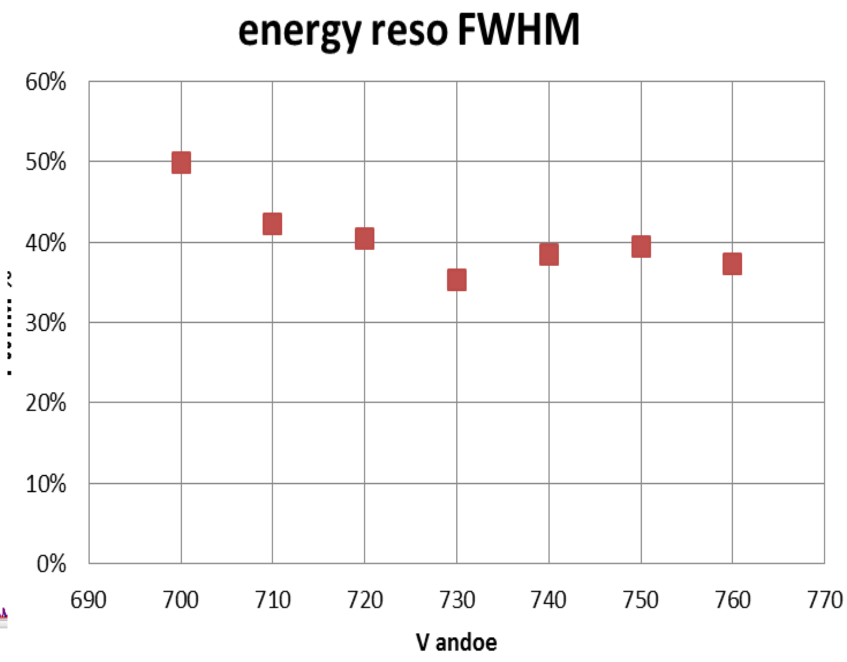
As in the MSGC case, we can increase the gain (~ 5 times) using the internal electrode



Energy resolution

- At G>10^4 E reso V1: > 55%, E reso V2: ~ 40% (Vel=-300V)



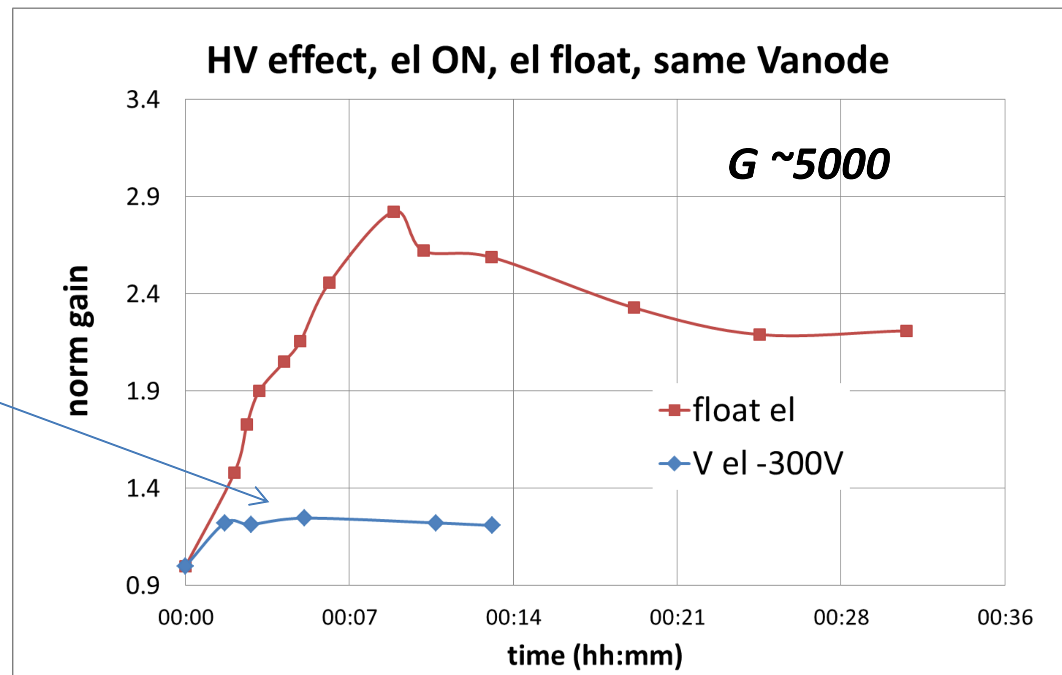


Gain stability vs time

- Also here we checked the gain stability vs time
  - High voltage effect
  - Charging up effect (Fe55 source)
- Encouraging results with electrode ON

(~ +30% HV effect, -25% charging up effect)

Very fast (~ 3 min) stabilization time



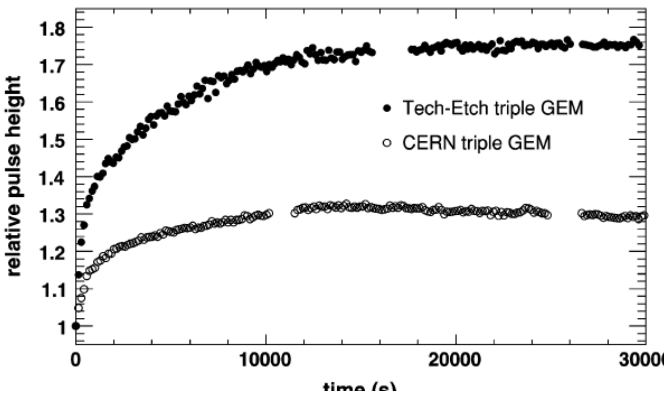
Future plans and conclusion

- The detector is working well (in gas)
- Ready to be tested at cryogenic temperatures

Backup

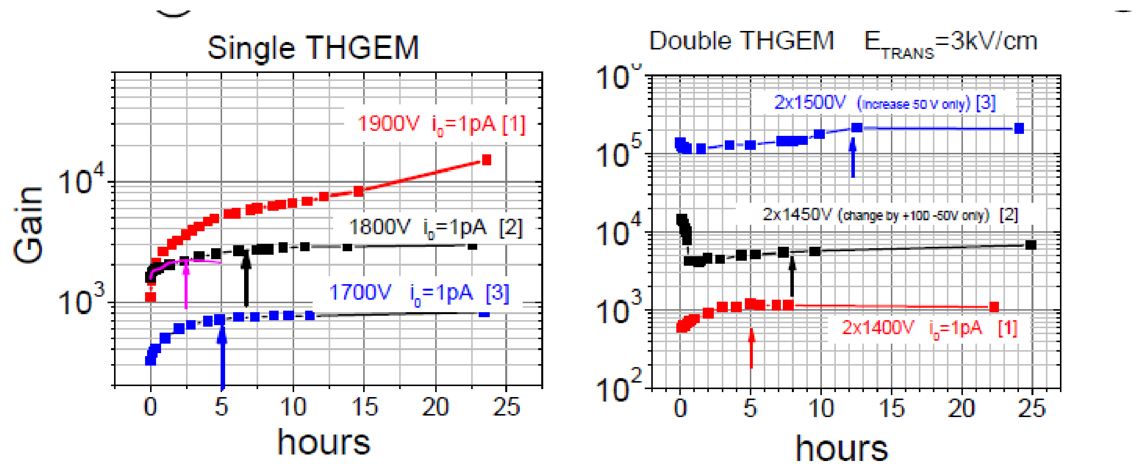
Gain time stability, a common problem

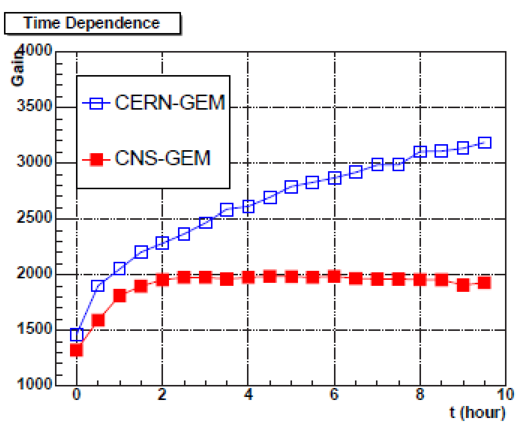
IEEE TRANSACTIONS ON NUCLEAR SCIENCE, VOL. 54, NO. 6, DECEMBER 2007



Measurements of Stability of Gas Electron Multiplier (G

Y. L. Yamaguchi, H. Hamagaki, K. Ozawa, S. X. Oda and M. Inuzul

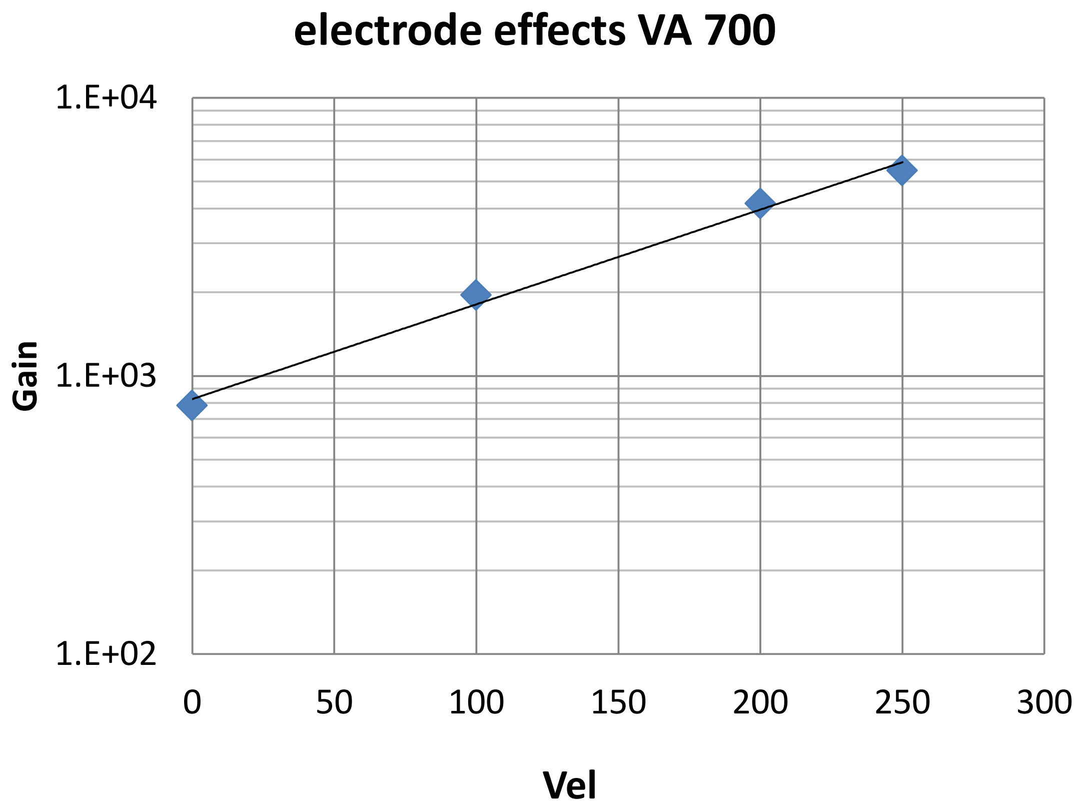




Progress in Thick GEM-like (THGEM)-based Detectors

R. Chechik, A. Breskin, C. Shalem, M. Cortesi & G. Guedes
Weizmann institute of science, Rehovot, Israel
V. Dangendorf
Physikalisch Technische Bundesanstalt, Braunschweig, Germany
D. Vartsky & D. Bar
SOREQ NRC, Yavne, Israel

MSGC_Internal electrode effects

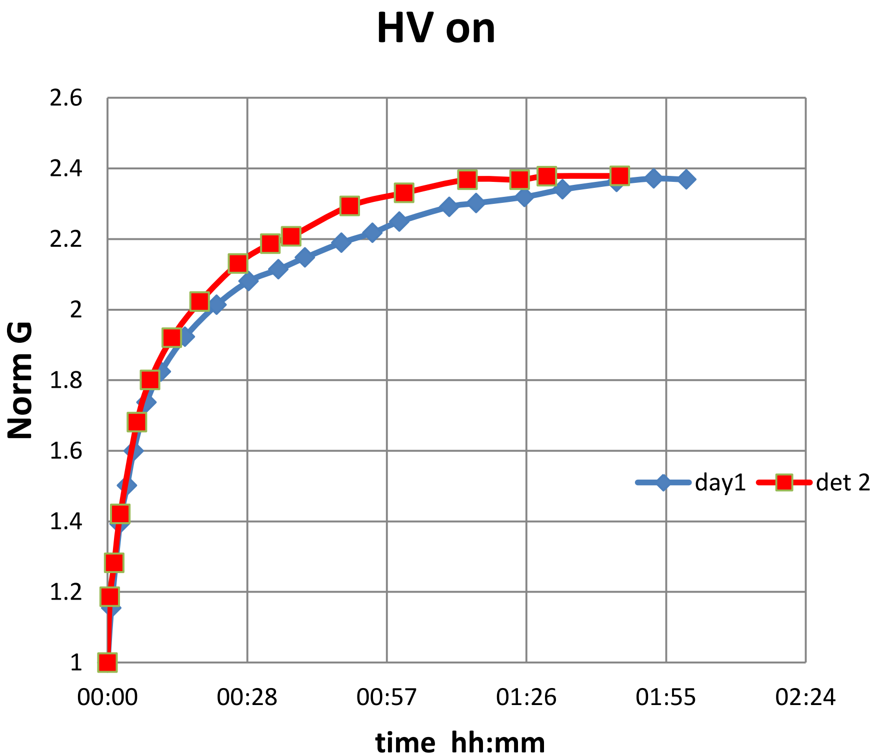


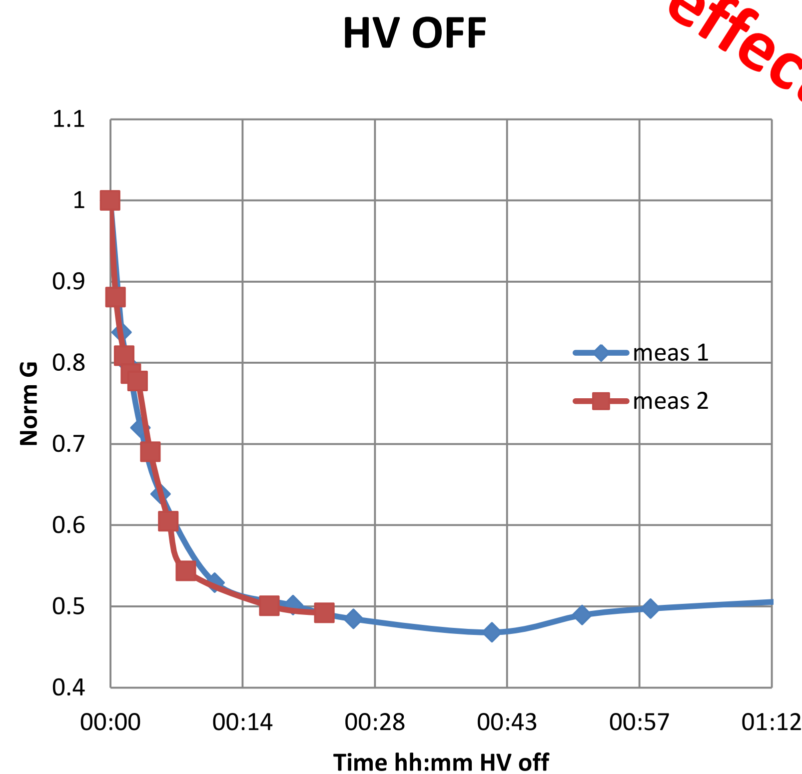
As in V1, seen electrode effects on the gain

(~ 10 times)

MSGC Gain stability vs time

HV effect



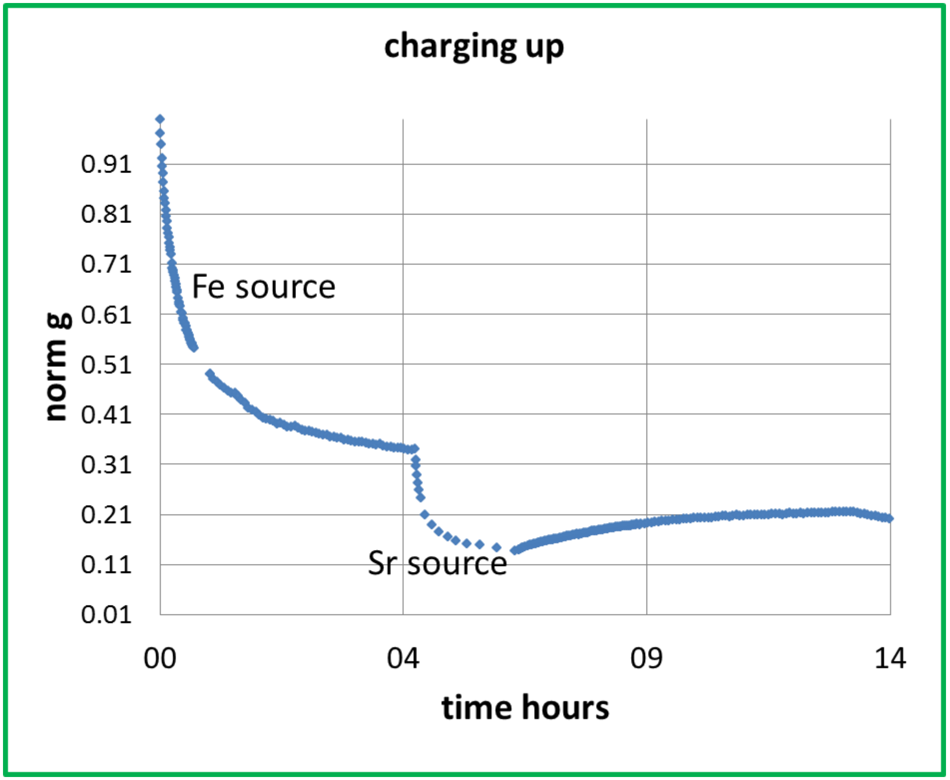


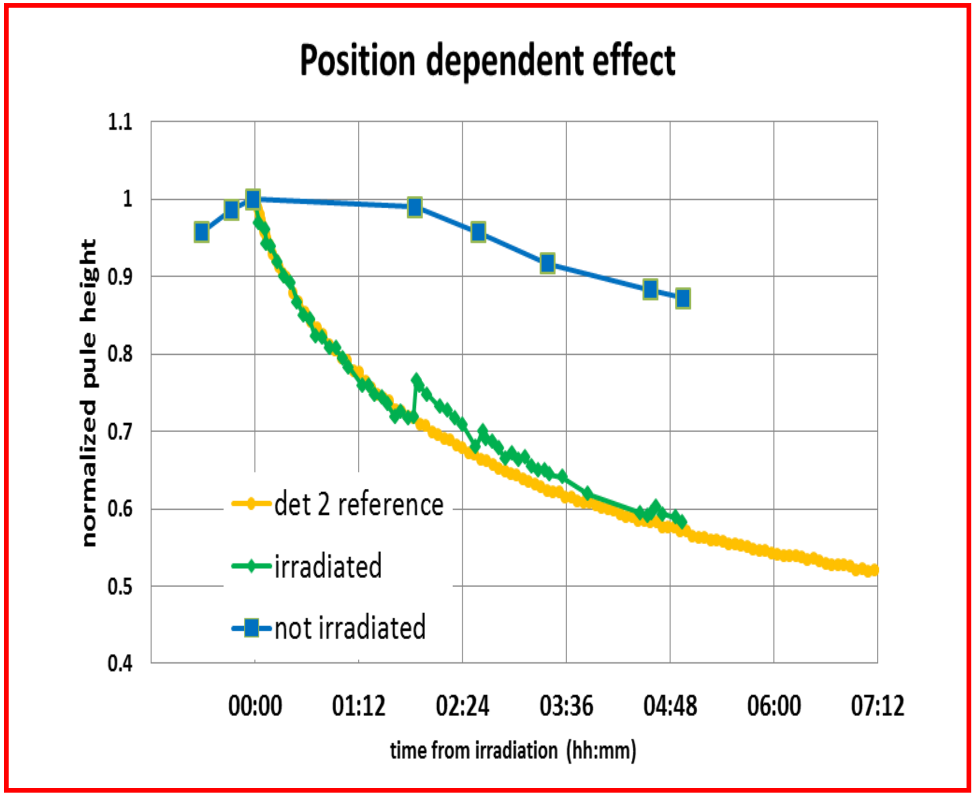
- Known effect, due to charges movements inside dielectric material
- Plateau reached after ~ 1.5h
- Good repeatability of the measurement.
- Better than first version (FR4, plateau after ~ 4 days also for recovering)
- Seen also effects of charging up

MSGC_Gain stability vs time

radiation effect

Once HV plateau is reached, start irradiation with Fe55 source (rate ~ 1500 Hz/cm2)





- Charging up effect (local effect)
- Also here good repeatability
- Rate dependent

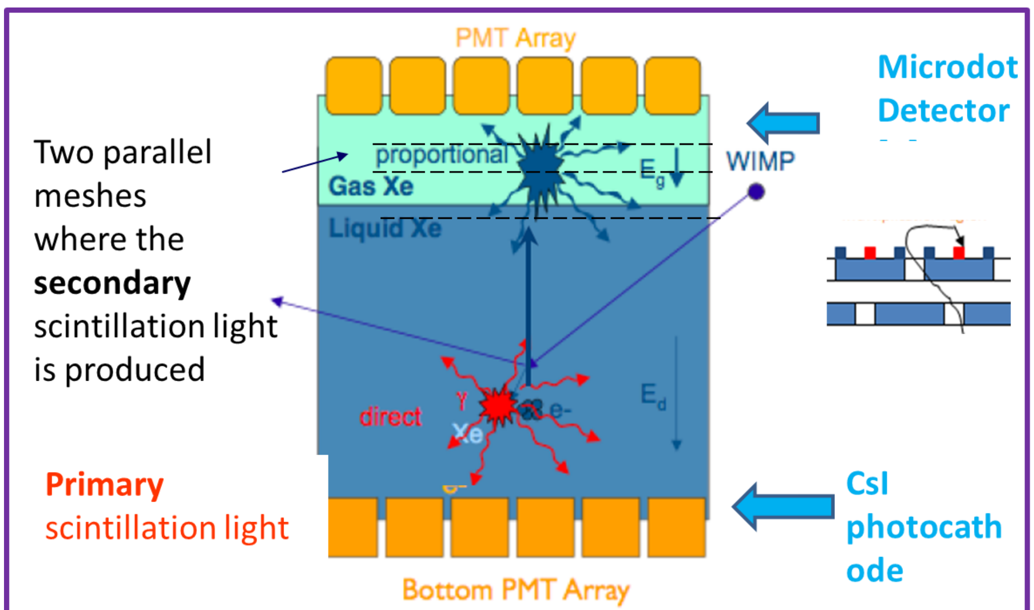
Spiral microdots, application

Possible application: dual phase **liquid dark matter detectors**.

From the ratio of **primary/secondary** lights one can conclude about the nature of the interaction and discriminate the background.

In order to lower the cost of the device: need to reduce the number of PMTs.

- Replacement of bottom PMTs by CsI photocathode, but problem of photon feedback.
- Replace the meshes with a MPGD.



Characteristics of MPGD:

- amplification region geometrically shielded from CsI
- Very high gain, need to measure single electrode

Resistive micro-dot detector

Goal of this work: to improve performances of microdot detectors.

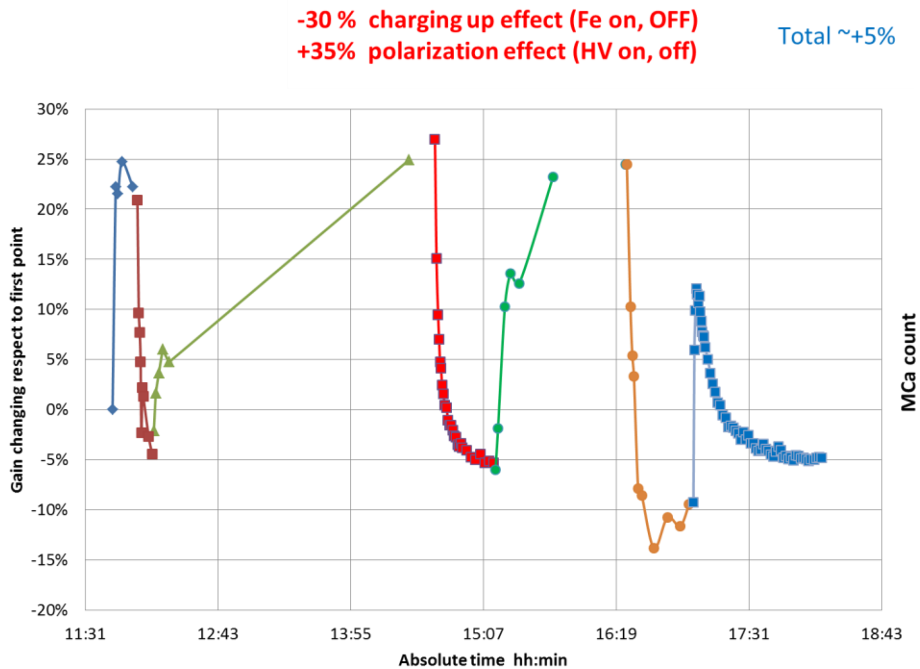
Geometry: Resistive spiral anode, readout strips below anodes.
Signal recorder by capacitive coupling.

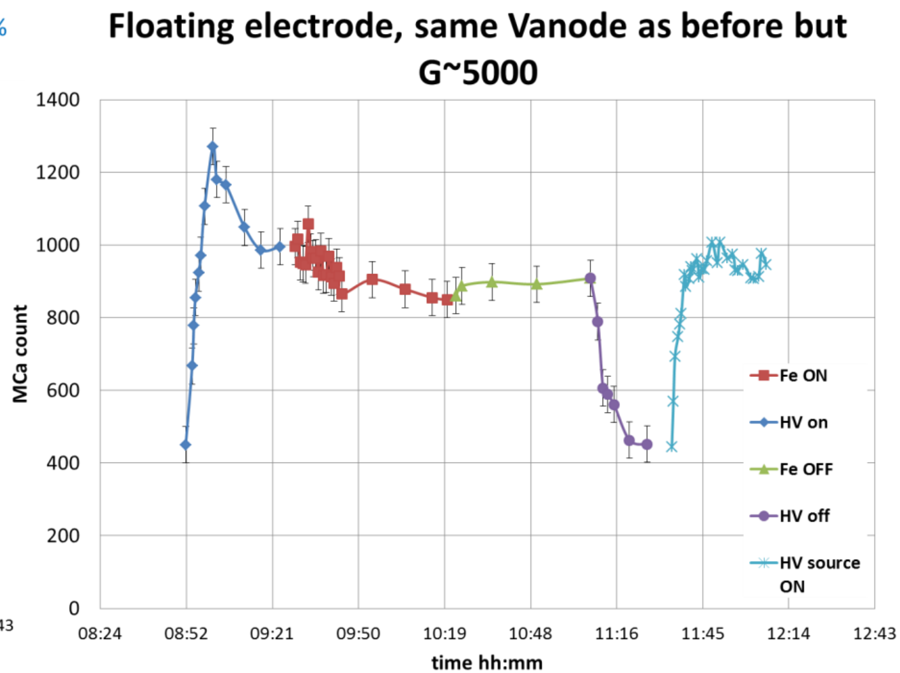
Advantages of this geometry:

- electric field more azimuthally symmetric
- spark protection due to the high resistance values in the anodes (GΩ). No problems of rate in this case
- decoupling of anodes from readout: possibility to do 2D readout

G 20 000, Va: 710V, Vel -300V

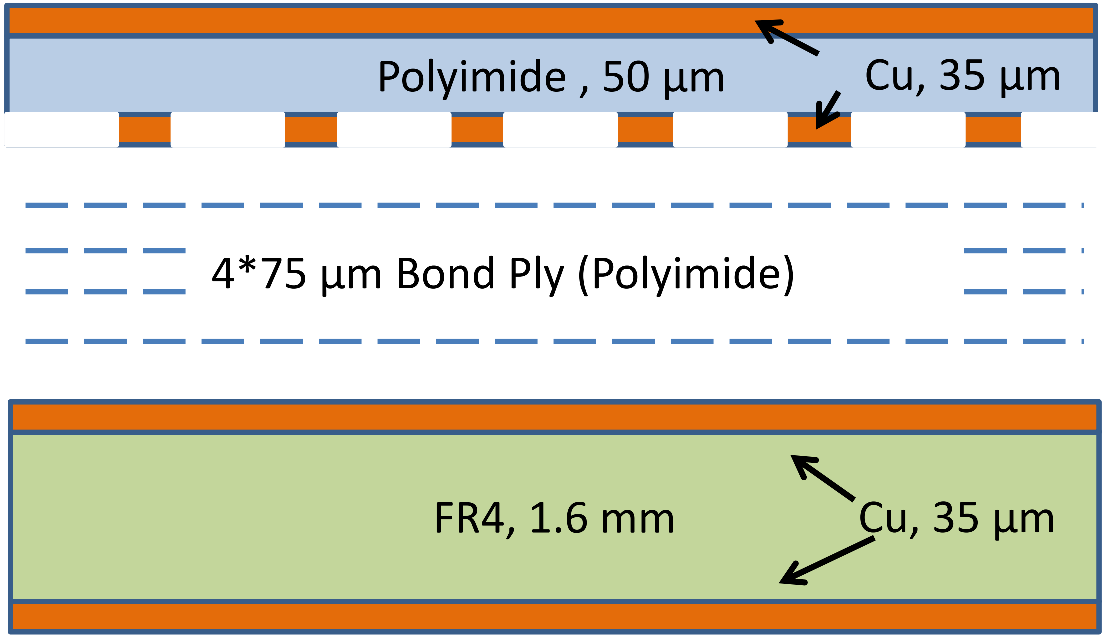
Not corrected for P-T variations



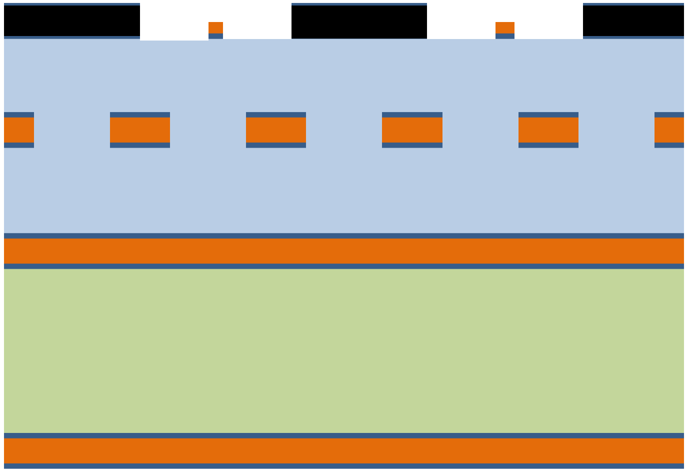


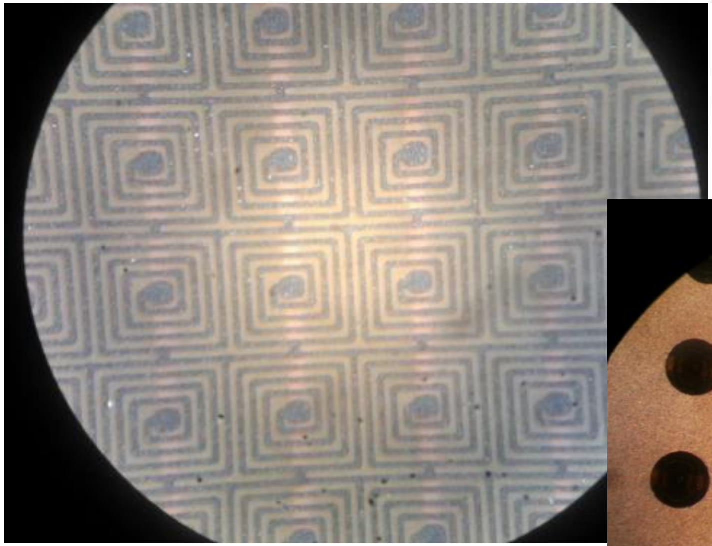
To redo with dt, not absolute time, same vertical scale (same plot?)

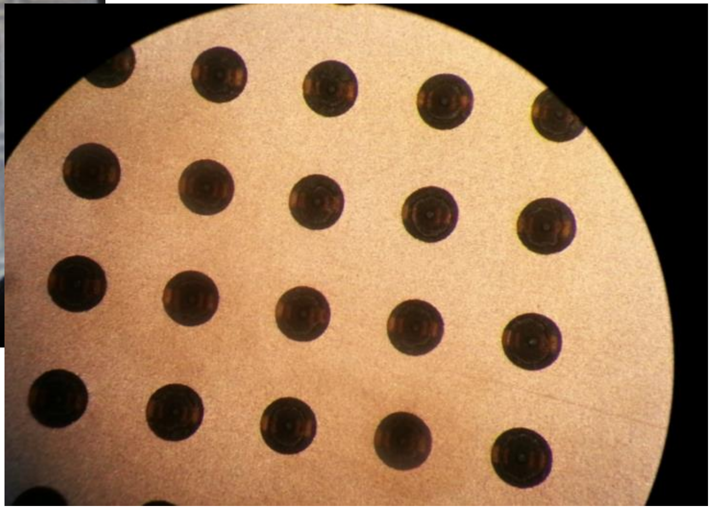
Production Steps



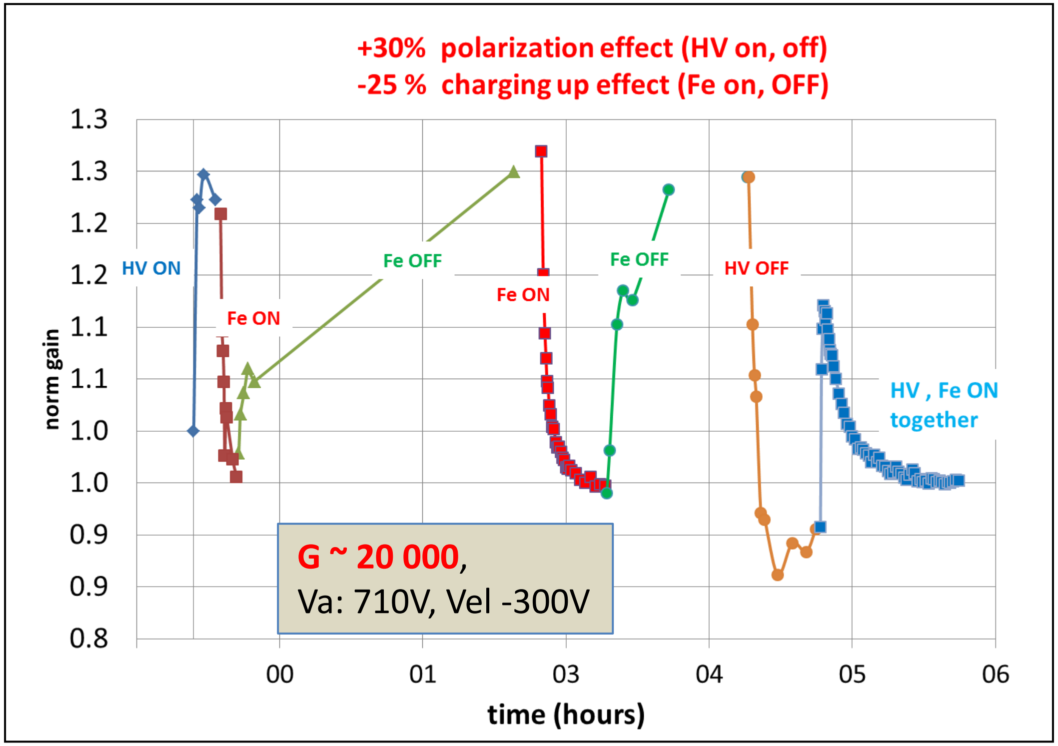
Production Steps

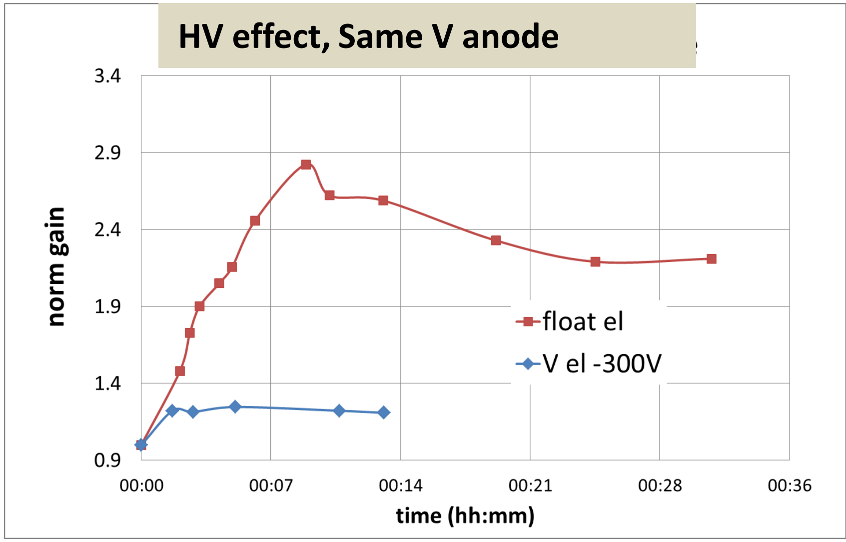






Spiral_Gain stability vs time





From preliminary measurements the use of electrode seems better also for G vs time:

With electrode faster stabilization time

- Much less HV effect (25% vs ~ 2 times)
- Less and faster charging up