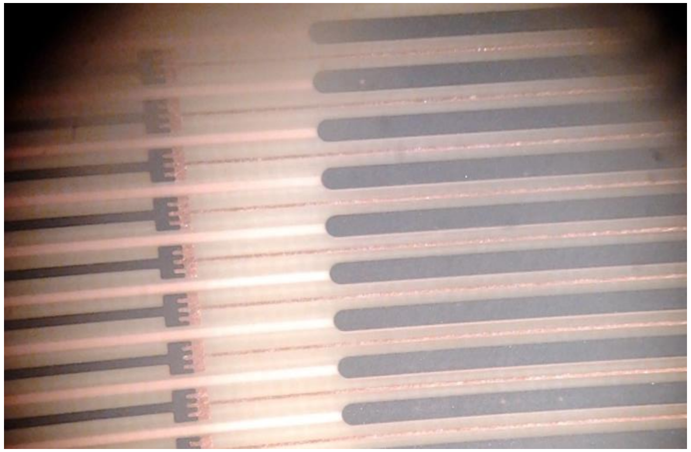
Simulations and first tests of double layer resistive Micro-Strip-Gas-Chambers (MSGC)



Rui de Oliveira, Silvia Franchino, Vladimir Peskov

13th RD51 Collaboration Meeting
6 February 2014

Outline

- Basic idea
- Electric field simulation
- First prototype production
- Preliminary measurements and results
- Future plans

Basic idea

use of pcb-embedded electrodes to modify electric field lines

First Test: Multilayer resistive MSGC

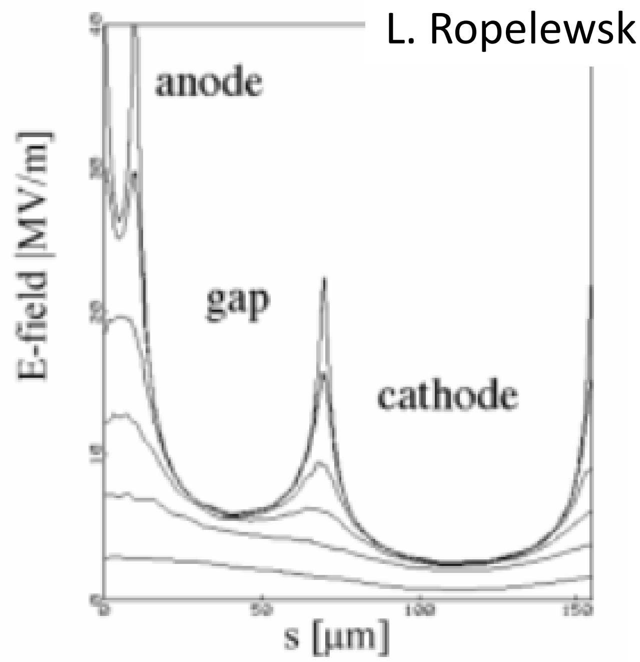
Why to try it in a resistive- MSGC?

Simple production and simulation

Spark-protected (studies of V. Peskov et al. , http://arxiv.org/abs/1107.5512)

The electrode's purpose in the resistive-MSGC:

lowering the E field on cathode's edges and increasing the electric field over the anode



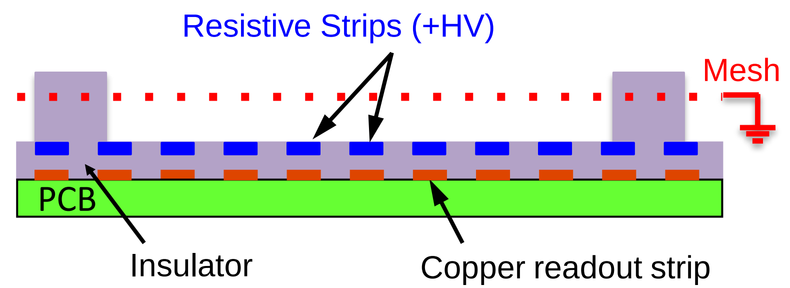
L. Ropelewski

Where does the idea of multilayer MSGC come from?

- Resistive MICROMEGAS have shown different behaviour between "grounded mesh" or "grounded resistive strips" configuration

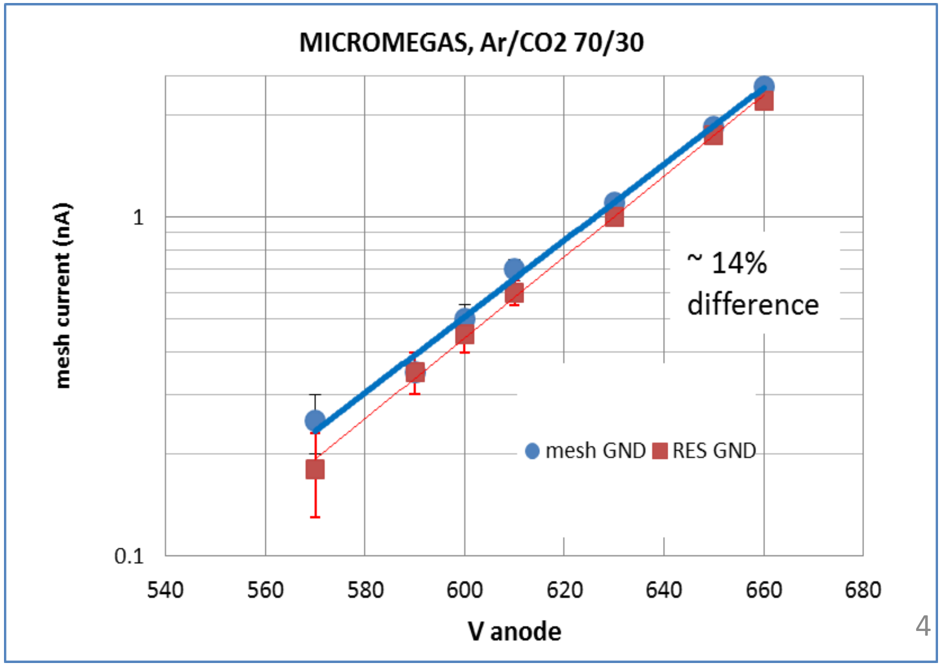
- With GND mesh:
  - Less charging up,
  - Capability to reach higher voltages
  - Less instabilities

  (J. Wotschack, RD51 meeting, 11-08-2011)

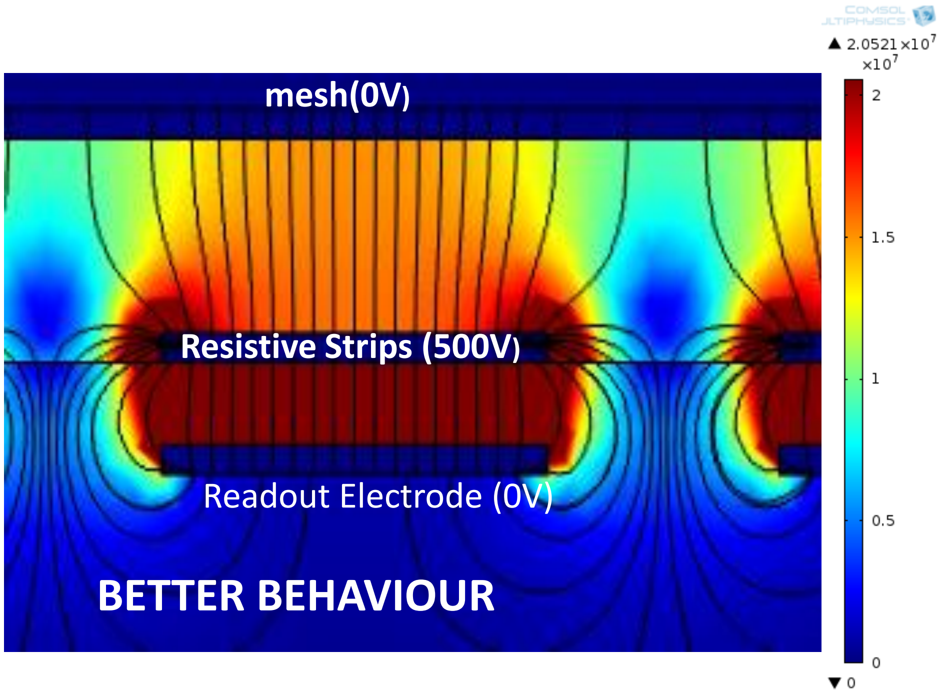


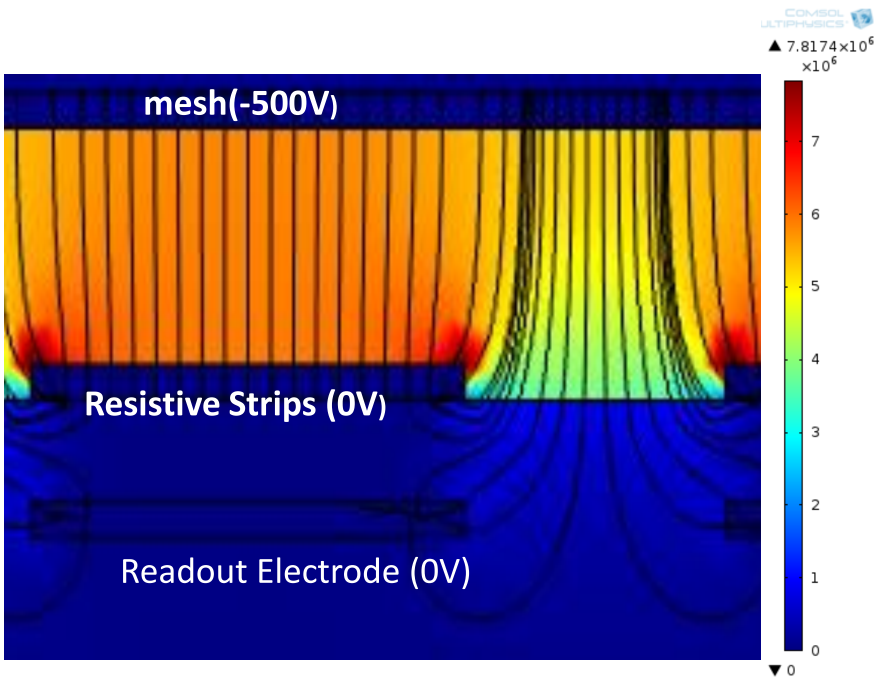
We measured the gain of a resistive micromegas with the two configurations.

Hypothesis: the readout electrodes are affecting the field in the active volume.



Field Lines Simulation with COMSOL



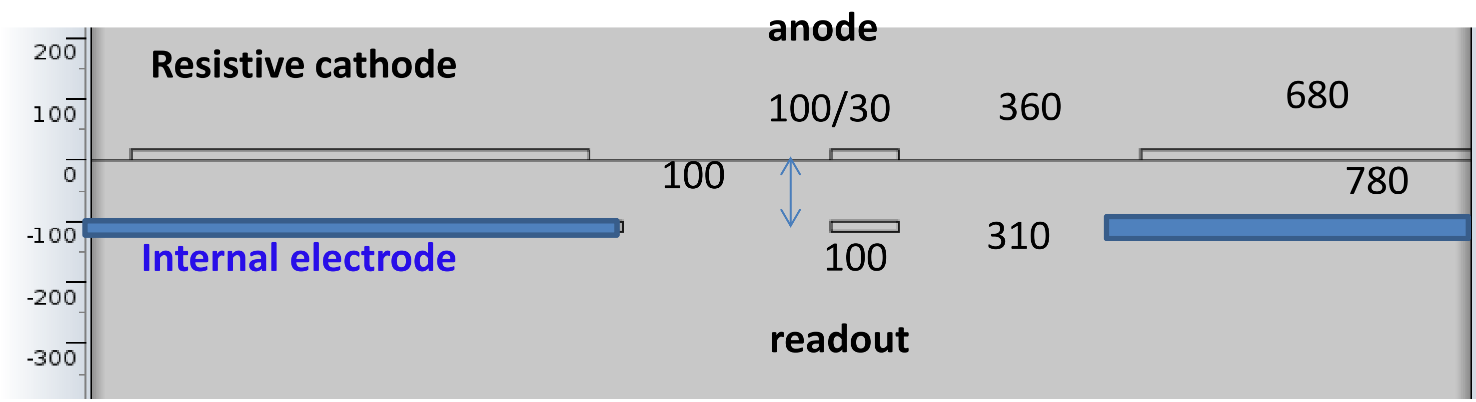


Triggered idea: use embedded electrodes to modify the field lines in different devices.

Geometry and HV

Geometry of the first prototype:

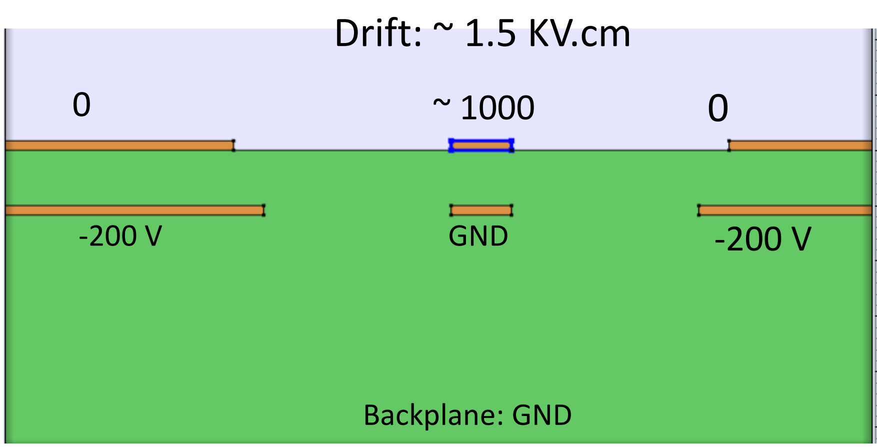
- Pitch (1.5mm) and strip width (30-100µm) bigger than std MSGC
- Strips edges not optimized
- FR4 Substrate (std PCB)



Pitch 1.5 mm

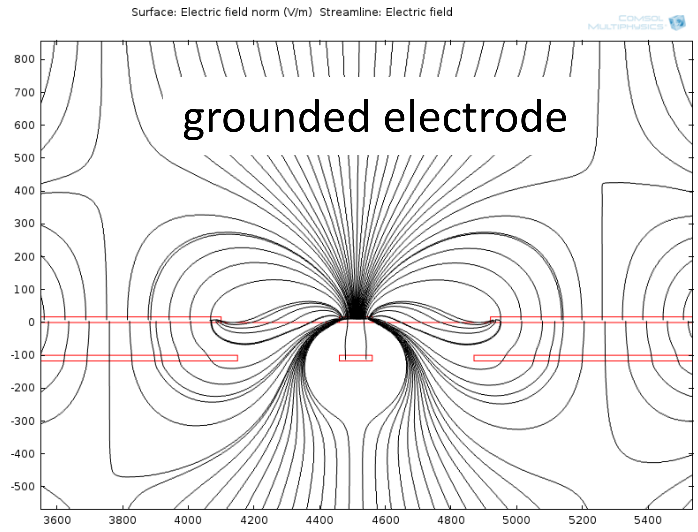
GEOMETRY

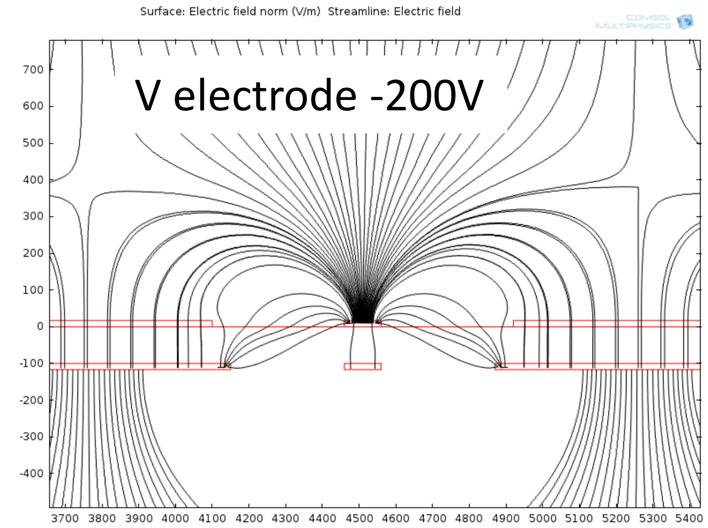
Geometry and High Voltage configuration defined using the simulation outputs



VOLTAGE SETTINGS

Field-lines



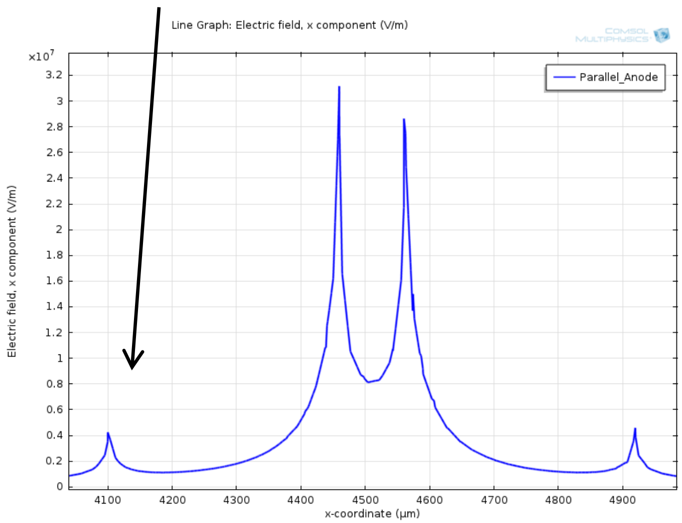


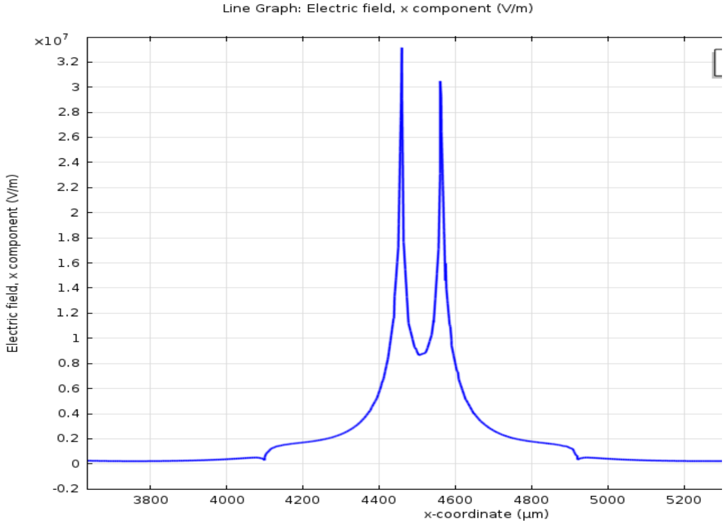
→ spikes on corners of cathode

→ Better field lines distribution

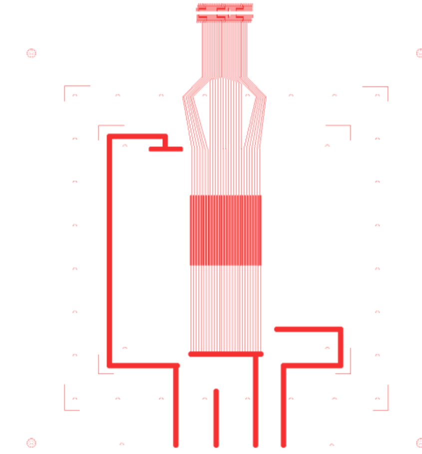
→ No field spikes on corners of cathode

Ex

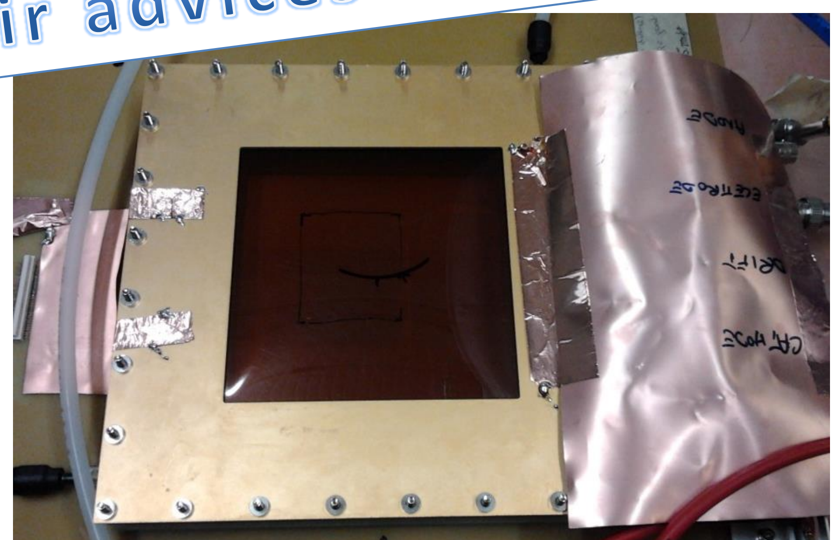




Production

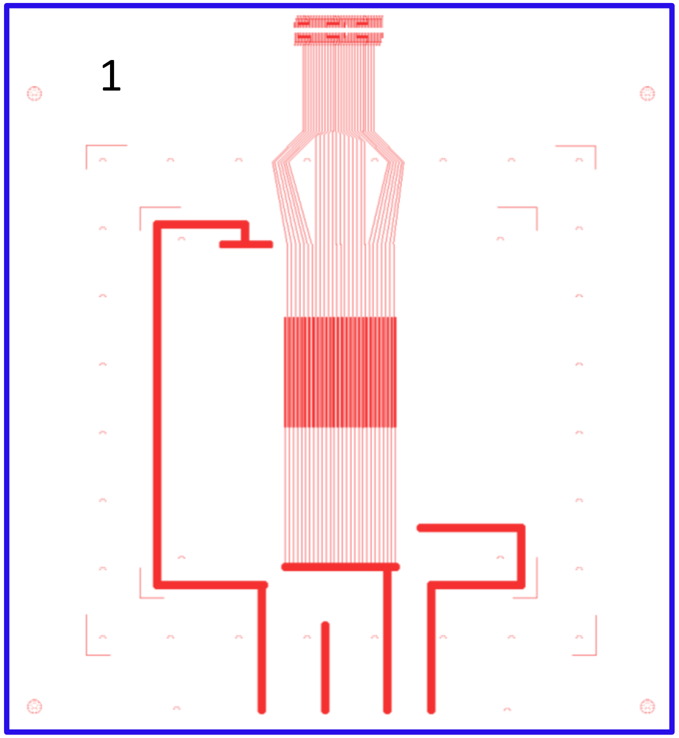


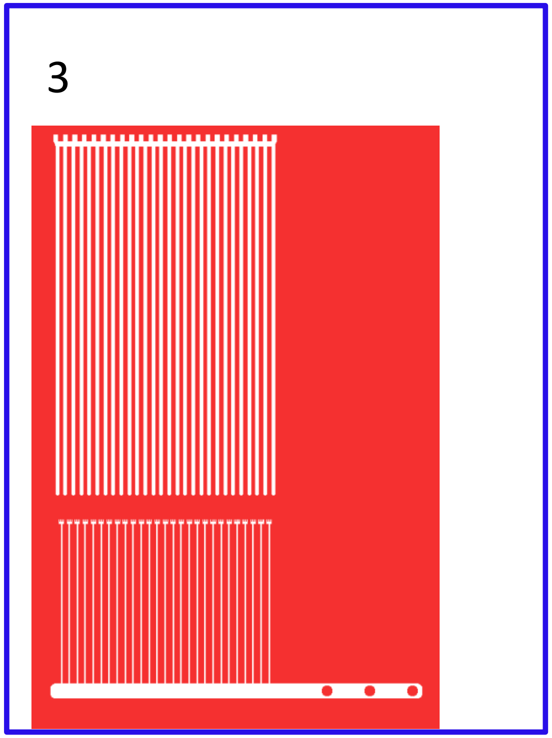
Many thanks to all my colleagues of PCB lab for their advices

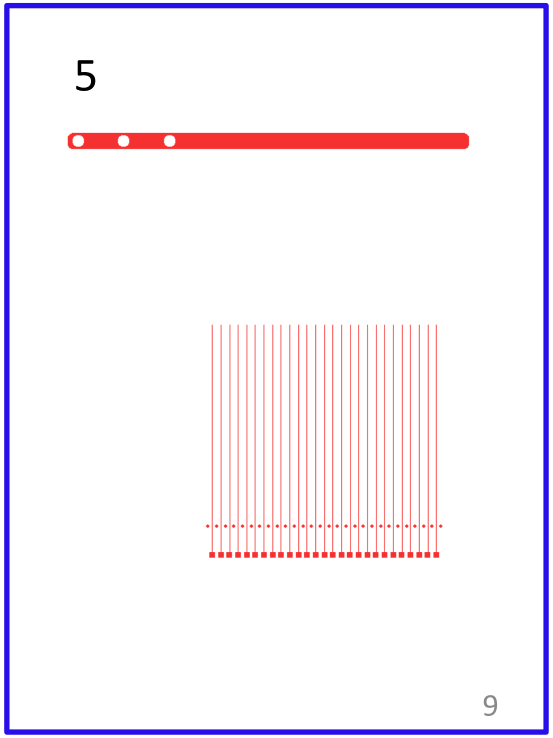


Production Steps

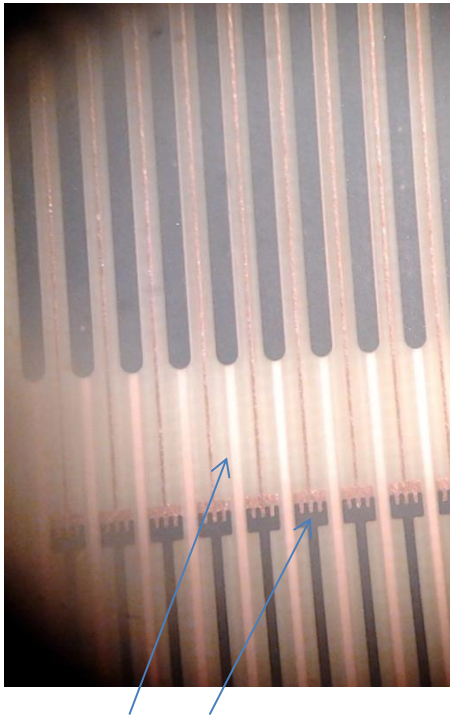
1. PCB with Cu readout and electrodes
2. 100 µm epoxy glue and 17 µm Cu (pressed)
3. Image of resistive cathodes and anode connections
4. Fill with resistive paste (1MΩ/sq)
5. Image of anode and etching all the remaining Cu





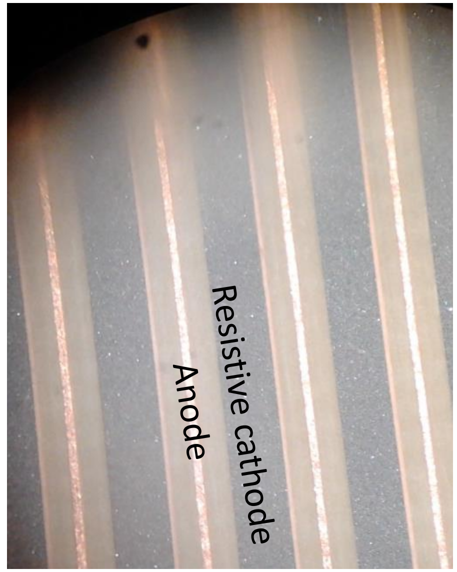


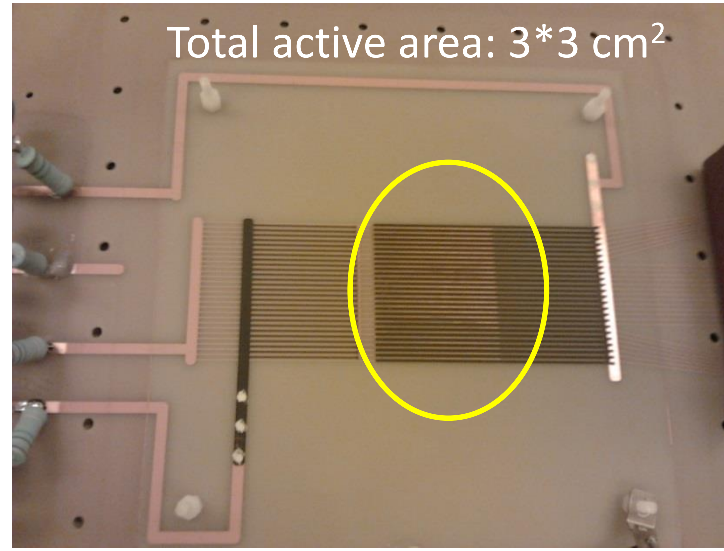
The first prototypes



Embedded electrode

Resistive connection of anodes

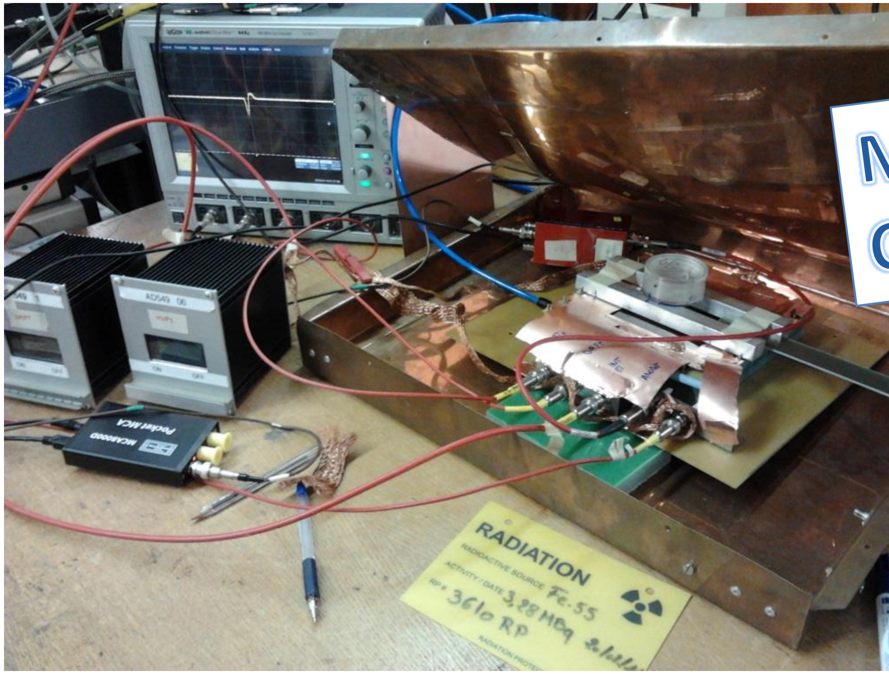




- Two detectors were produced: 30, 100 µm anode
- Measured resistivity:
  - 30 µm. Cathode: 1GΩ - 20 GΩ, anode: 2-20 GΩ
  - 100 µm. Cathode: 300 MΩ -10 GΩ, anode: ~1 GΩ

Big dis-uniformities in the R value , ok for first tests, we will redo better if results will be promising

Preliminary results



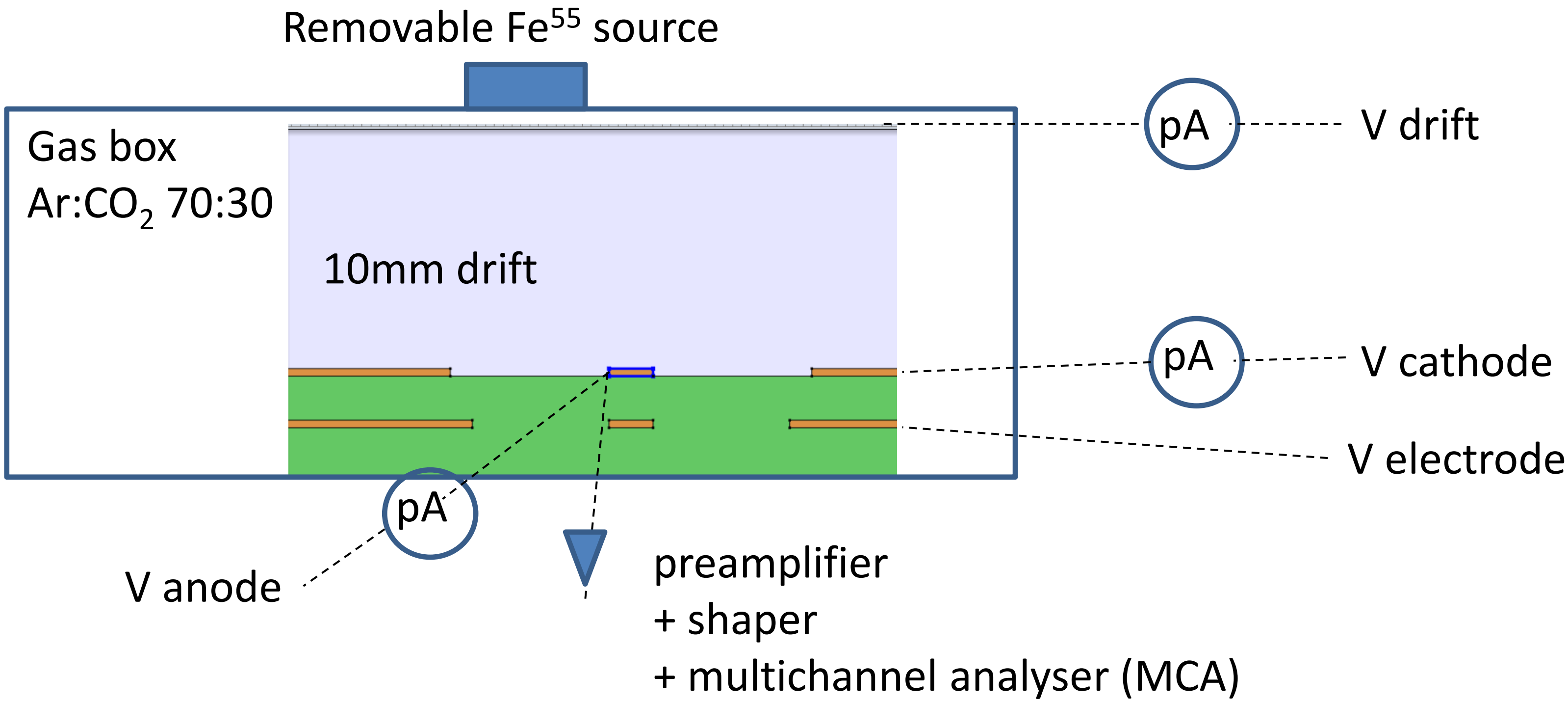
Many thanks to the CERN RD51 lab support

Characterization of the detector (gain, energy resolution).

Checked the behaviour of the internal electrode for:

- Gain measurements
- Breakdown voltage range

Experimental setup

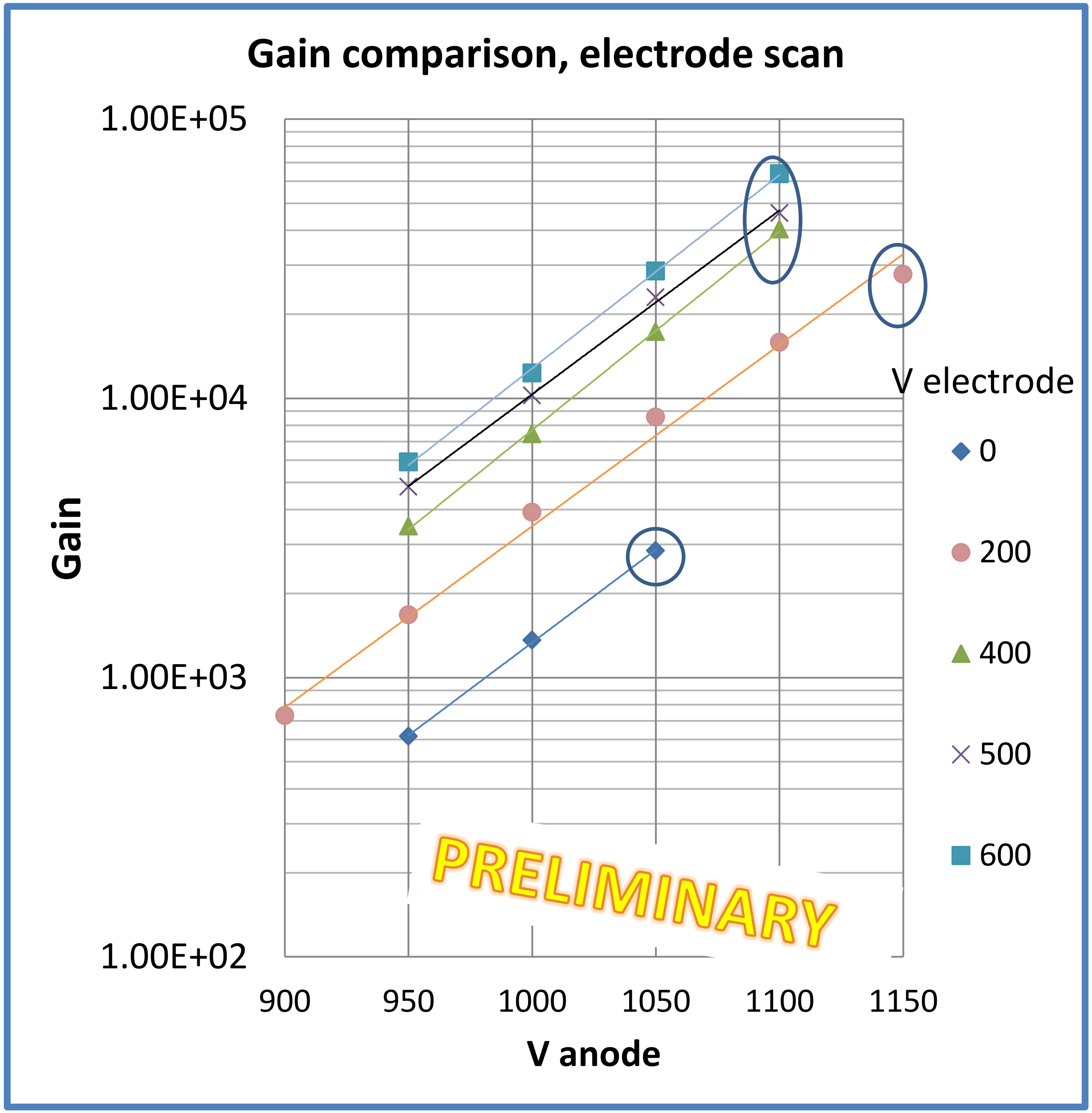


Preliminary measurements: signal read from the anode (bypass of the resistive connection)

Anode, cathode and drift current monitoring via the floating picoammeters of the Trieste's Group available in the rd51/gdd lab.

Next step: read from RO strips

Gain, electrode effect (30 µm strip)



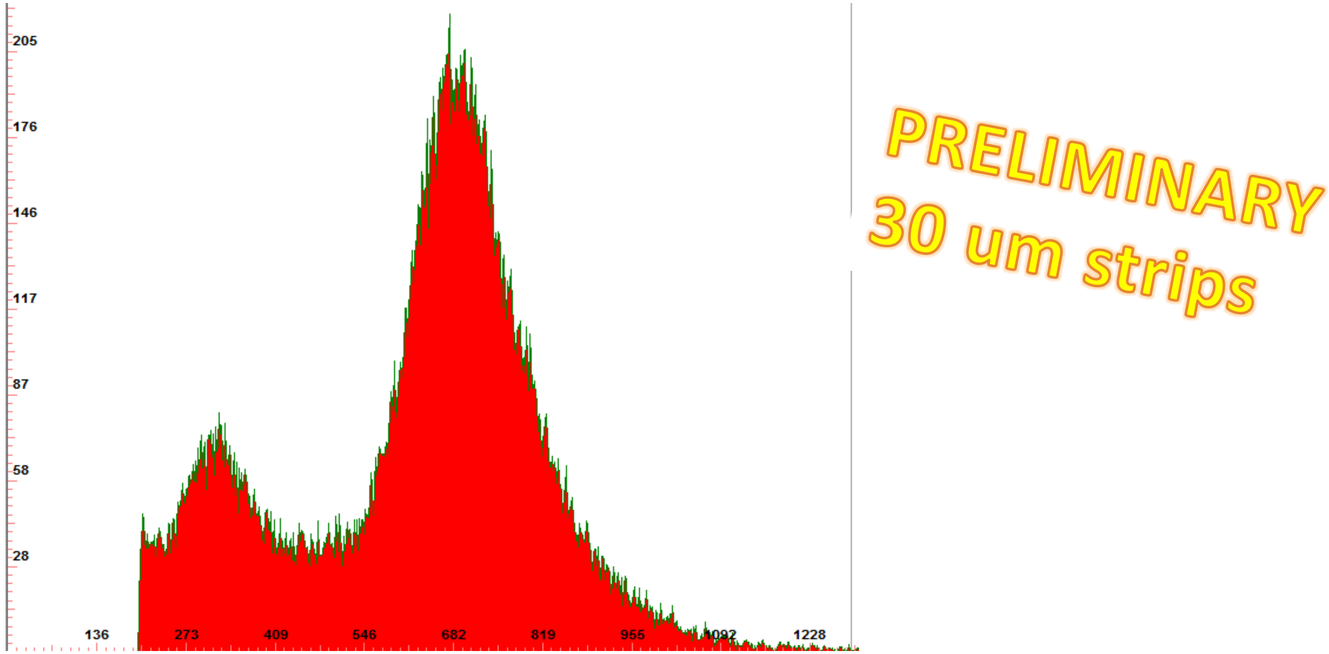
Embedded electrode effects:

- increased voltage (100V higher)
- increased gain (≈10 times)

Both effects are coherent with the simulation outputs.

- $G > 10^4$

Energy resolution



Energy resolution (FWHM) for 6 KeV X rays from Fe55 source:

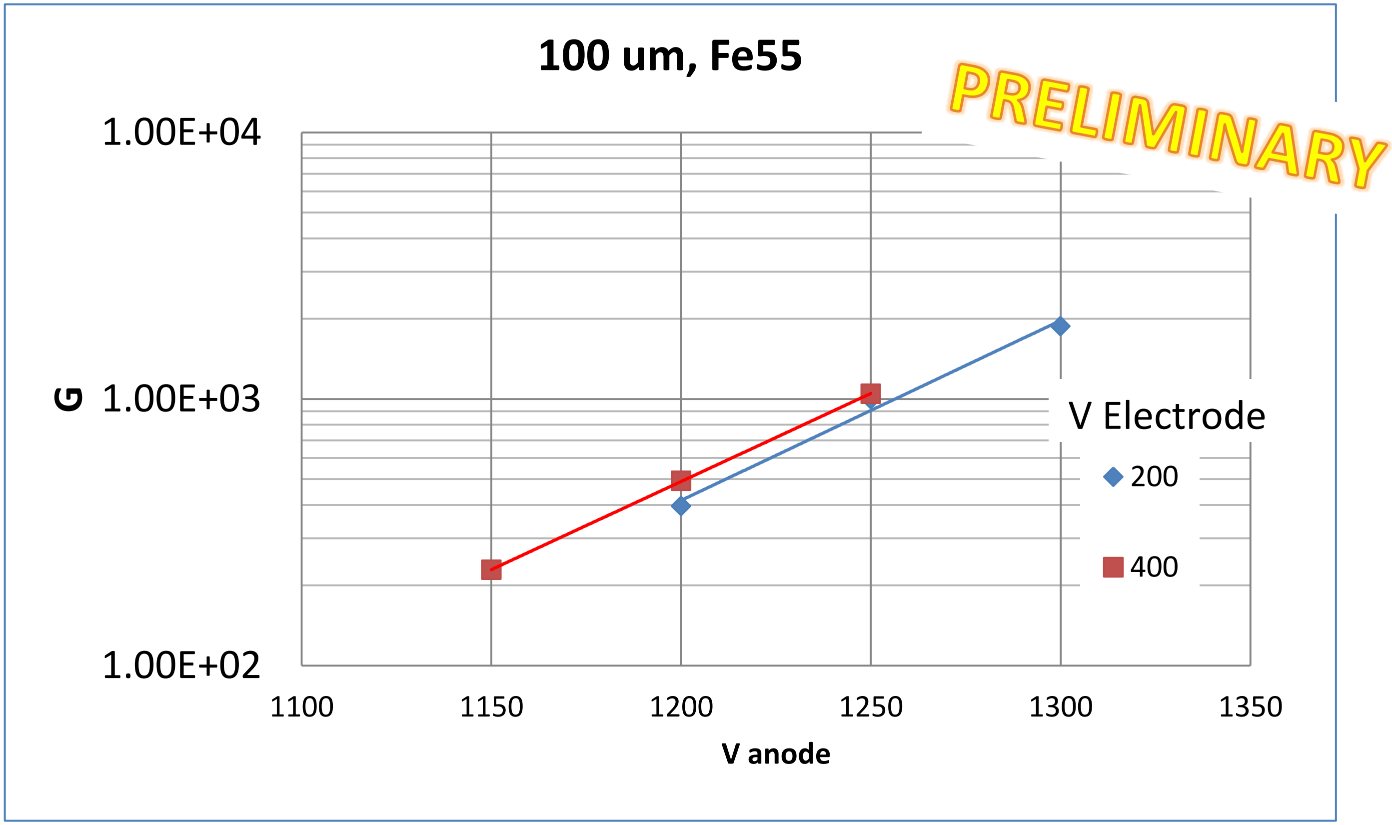
~**26%-28%** (depending from the electrode voltage),

Compatible with previous resistive MSGC prototypes

http://arxiv.org/abs/1107.5512

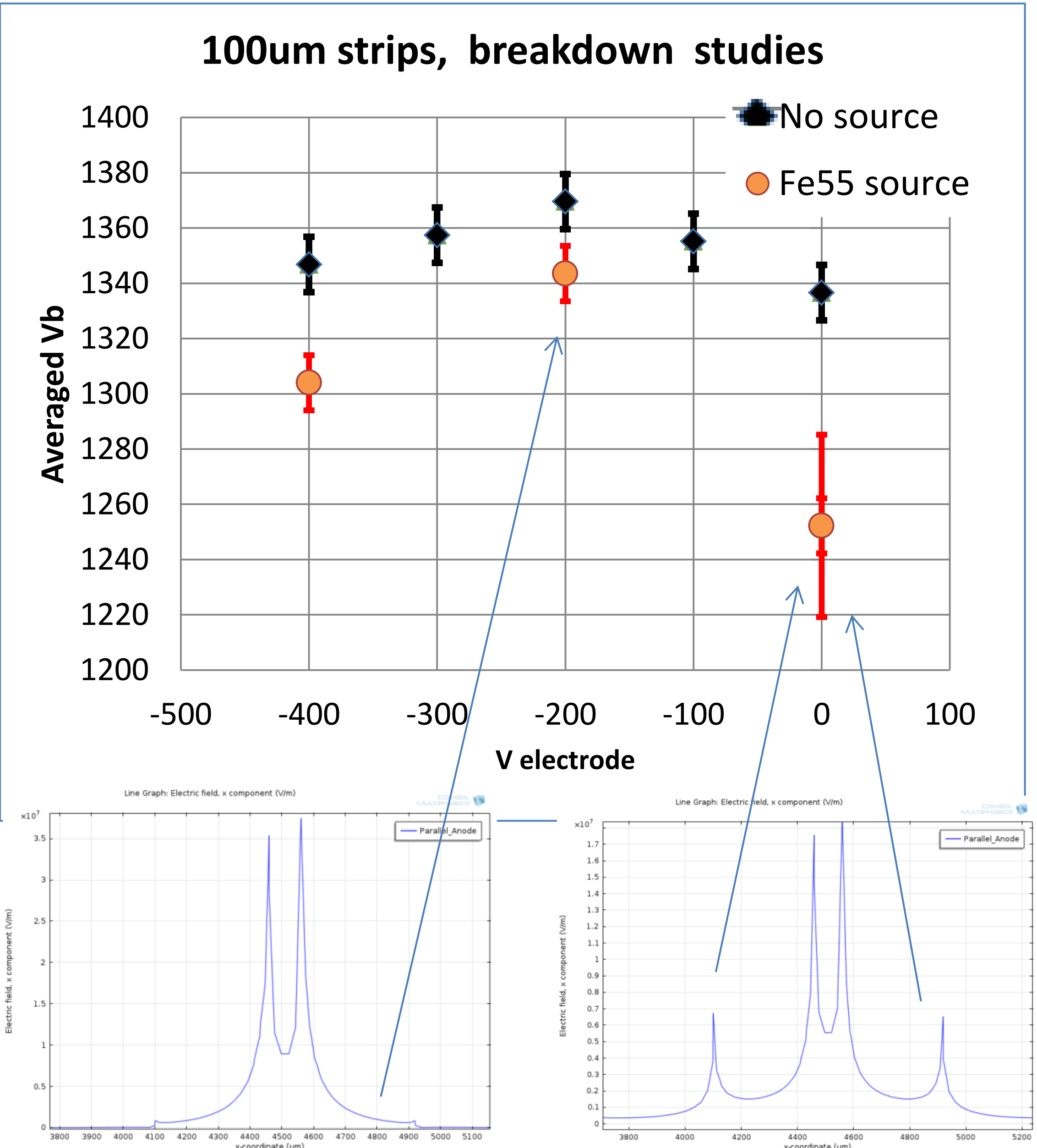
The measured energy resolution is affected by the poor gain uniformity of the prototypes.

Gain, electrode effect (100 µm strip)



Lower gain respect with the 30 µm anode strips prototype (as expected)
The embedded electrode performs as in the 30 µm anode case
The gain is smaller than 100 when the embedded electrode is grounded.
100 µm strips have been investigated because of their simpler production procedure

Breakdown voltage, electrode effects



- Spark defined as 50nA over-current in the power supply
- No visible damages after sparks (resistive protection)
- $V_{breakdown}$ averaged over 6 sparks
- Higher Breakdown voltage using the electrode
- optimal configuration at 200V, confirmed also with the 30 um strips
- Compatible with simulation (peaks of E field on the edges of cathode disappear at V=200V)

Conclusions

Advantages:

- **Embedded electrode:**
  - Adjust and increase the gain with internal electrode
  - Higher breakdown voltage
  - The idea can be applied to other detectors (ThickGEM)
- **Resistive MSGC**:
  - Very thin detector (only the PCB)
  - Very simple to produce and to clean

Work in progress on the resistive-MSGC:

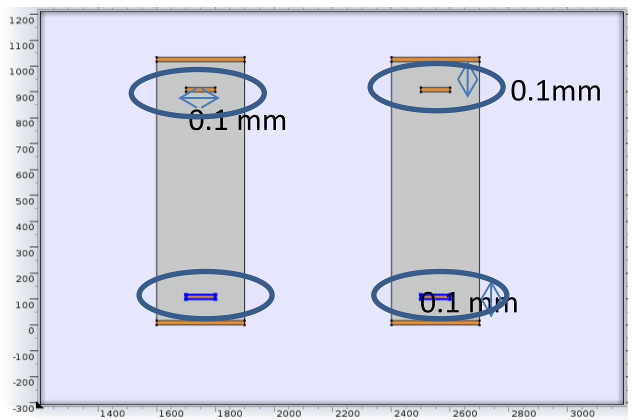
- Evaluate and improve the detector stability (charging up, polarization, recovery time after discharge)

Future plans

1. To optimize the current version of res-MSGC:
   - Optimizing uniformity and resistivity value of the cathode.
   - Improving the quality of the detector.
   - Adding resistive coating and/or using different substrates to face charging up issues.

2. Produce and test other detectors with multilayer embedded electrode technology
   - Thick GEM already simulated and produced (we will study them soon)
   - Thick GEM with many internal electrodes and conic holes to shape the electric field (work in progress)
   - Other detectors ??

Thick GEM with embedded electrodes, simulation

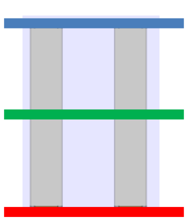


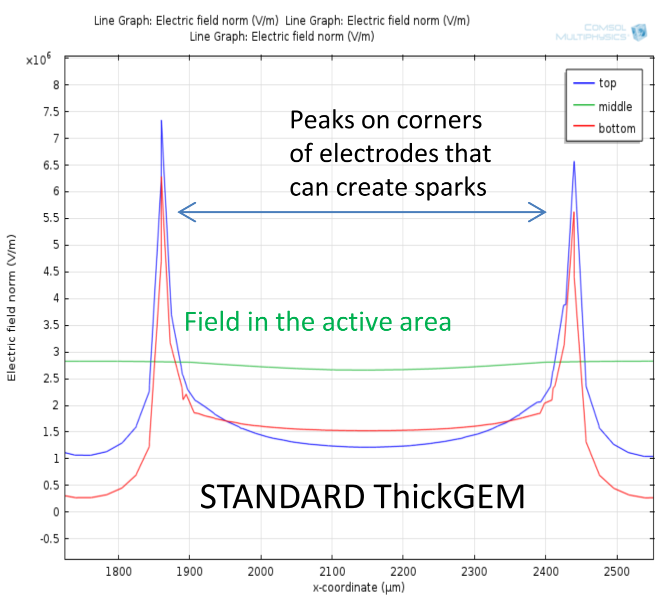
Simulated and produced a first prototype of thickGEM with embedded electrodes

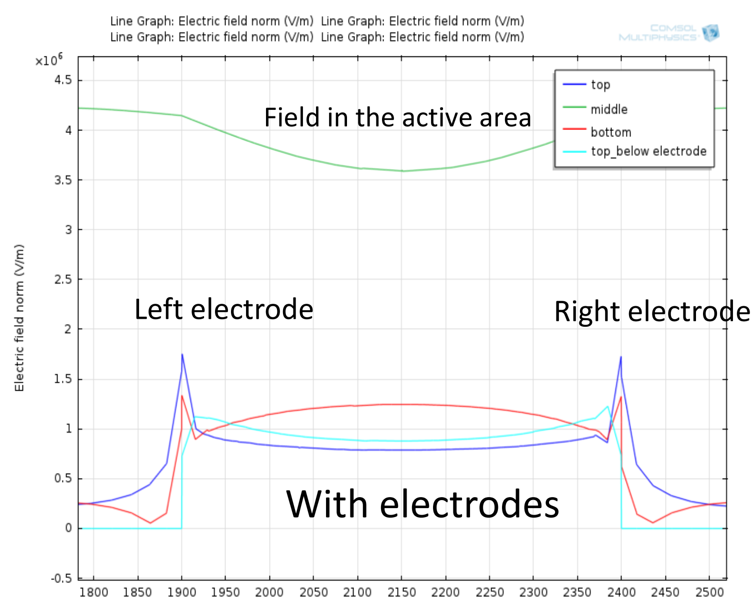
- no rim
- stack of three layers
- easy to produce for industries

Also in this case the electrode (properly tuned) allows to reduce peaks of E-field in the borders of the holes

- Reduction of spike probability
- Possible application for LAr experiments





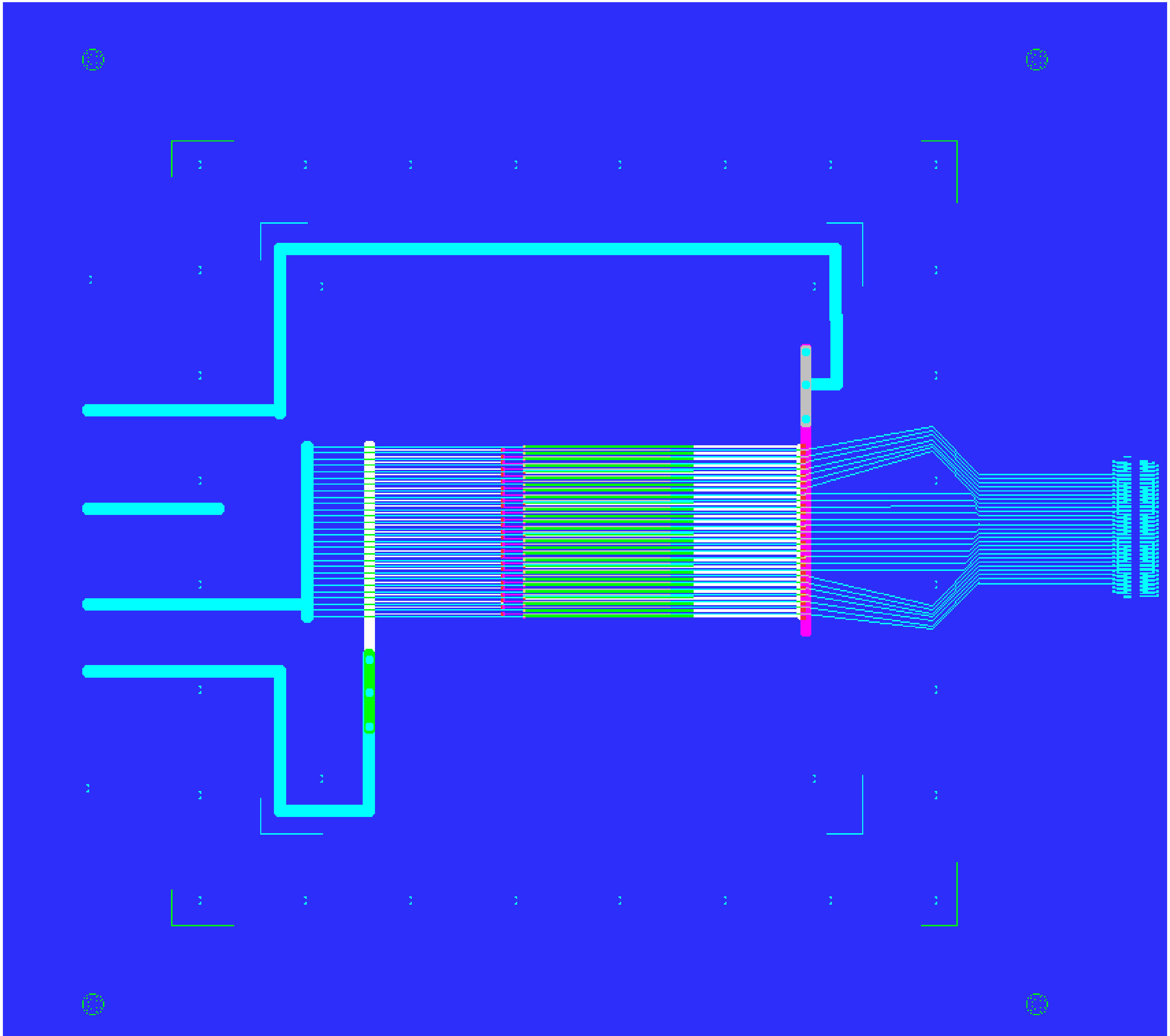


More readings

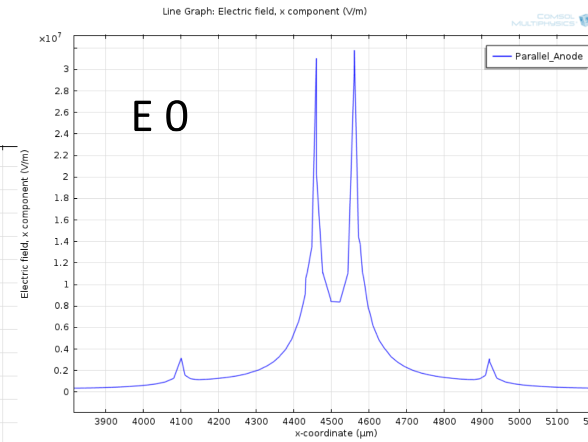
- http://arxiv.org/abs/1107.5512 An improved design of spark-protected microstrip gas counters (R-MSGC)
- http://arxiv.org/abs/1101.3727 Further developments and tests of microstrip gas counters with resistive electrodes
- NIM, A 400 (1997) Operation of microstrip gas chambers manufactured on glass coated with high resistivity diamond-like layers.
- A, Oed NIM A, 263 (1988)
- NIM, A 400 (1997) The virtual cathode chamber
- ….. And many others on MSGC…

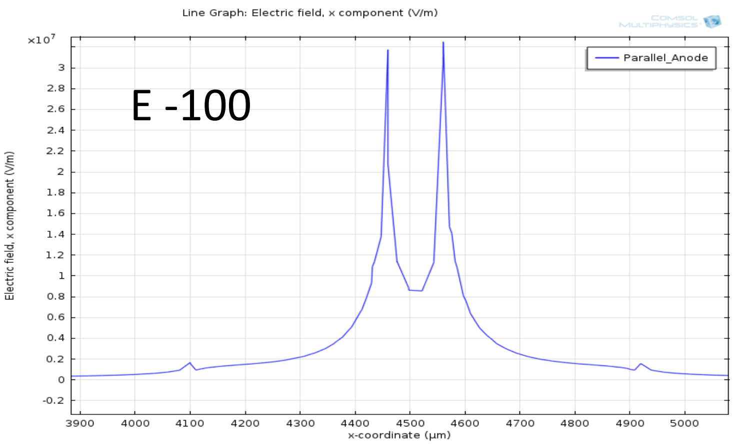
Work in progress,
more results soon…

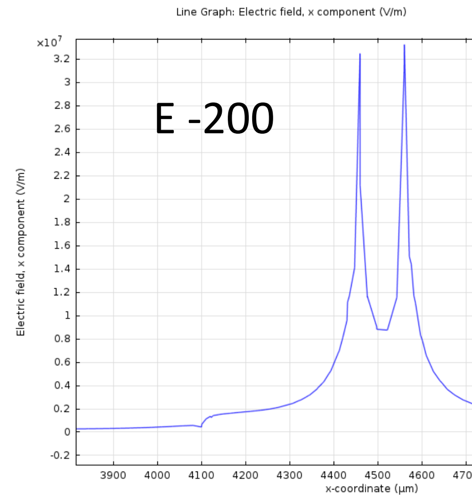
Backup slides

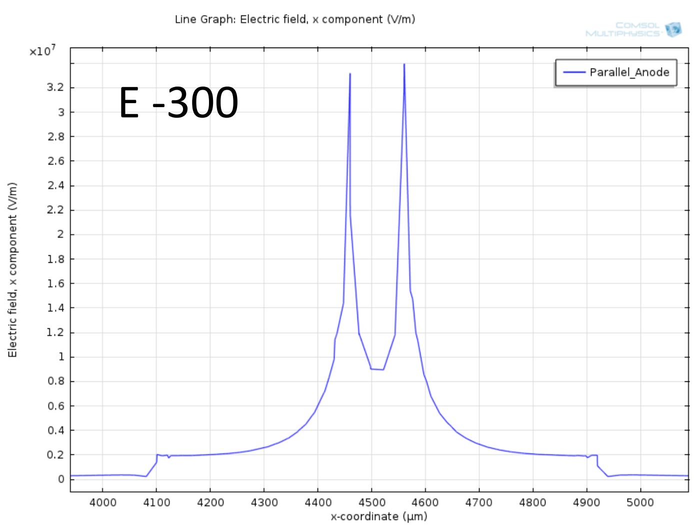


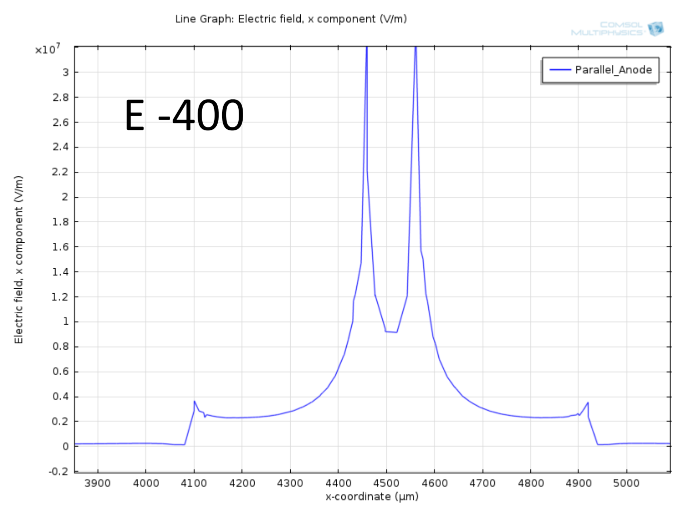
Breakdown voltages, values from simulation



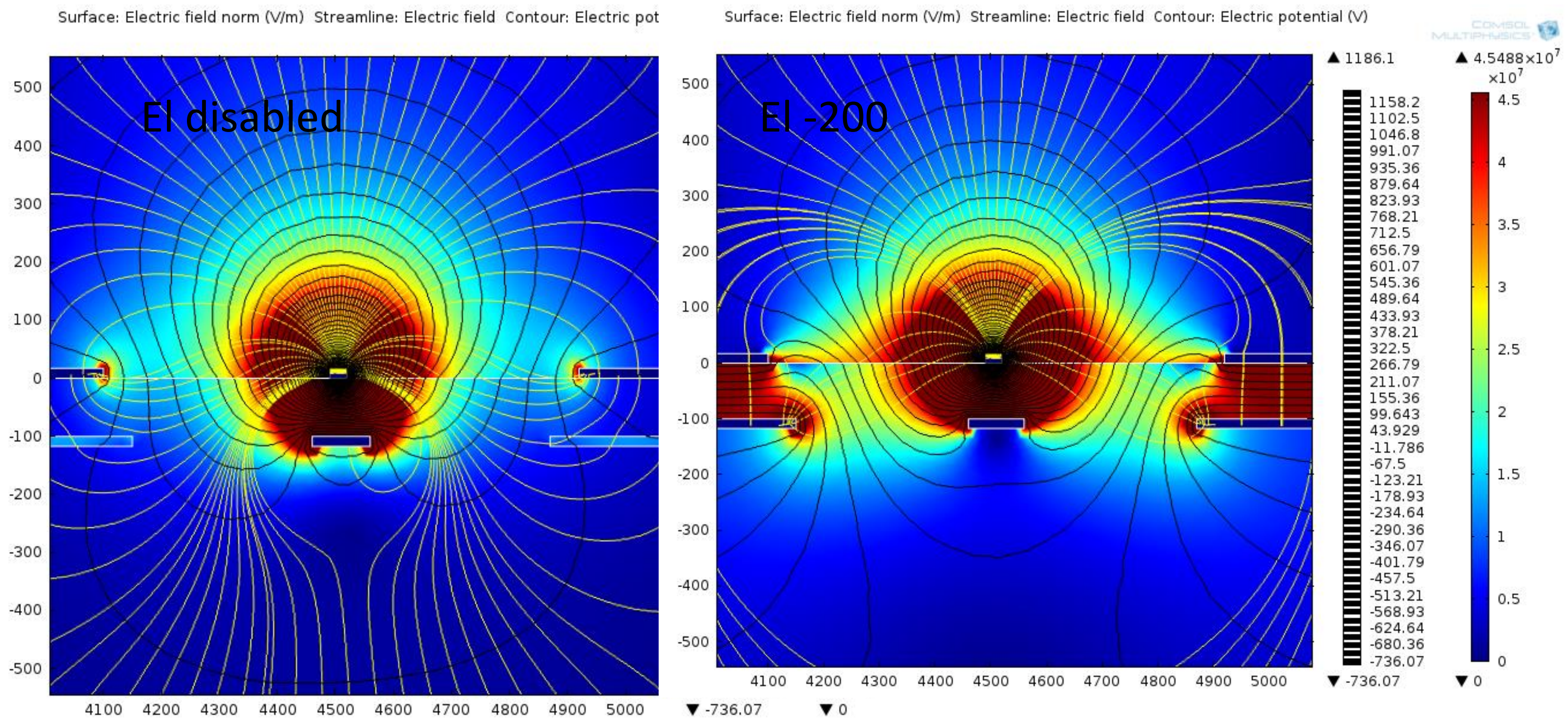


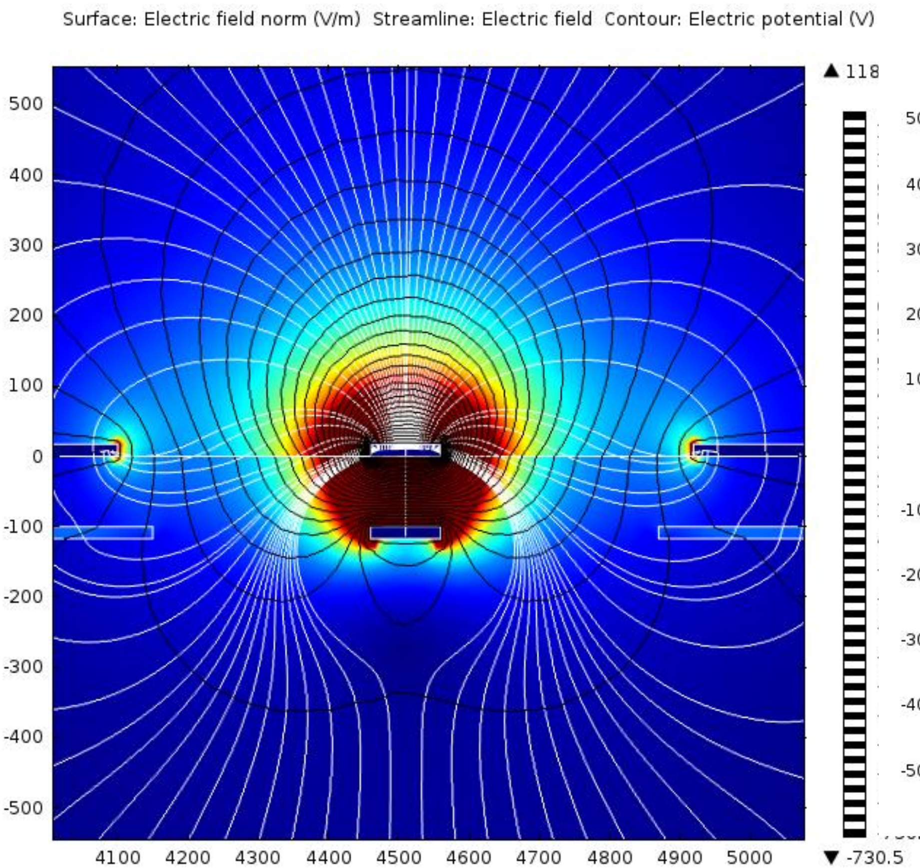


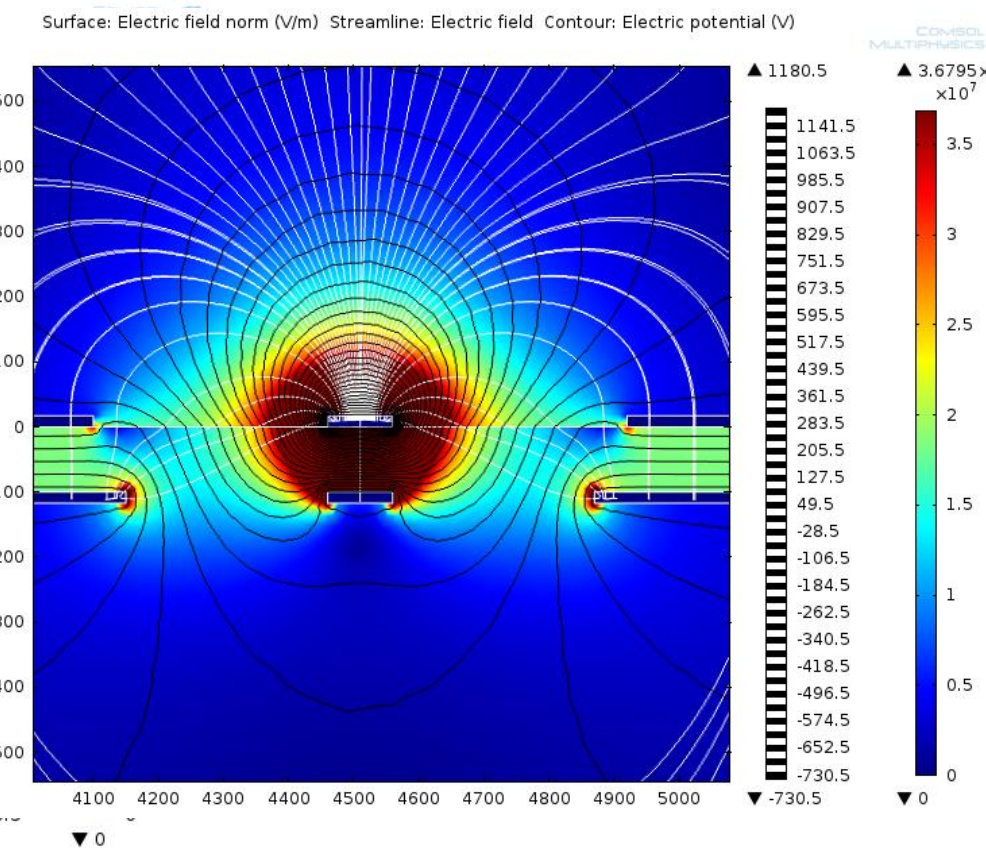




Powering anode, cathode GND




Surface: Electric field norm (V/m) Streamline: Electric field Contour: Electric potential (V)
500
400
300
200
100
0
-100
-200
-300
-400
-500
4100 4200 4300 4400 4500 4600 4700 4800 4900 5000
▲ 118
▼ -730.5


Surface: Electric field norm (V/m) Streamline: Electric field Contour: Electric potential (V)
500
400
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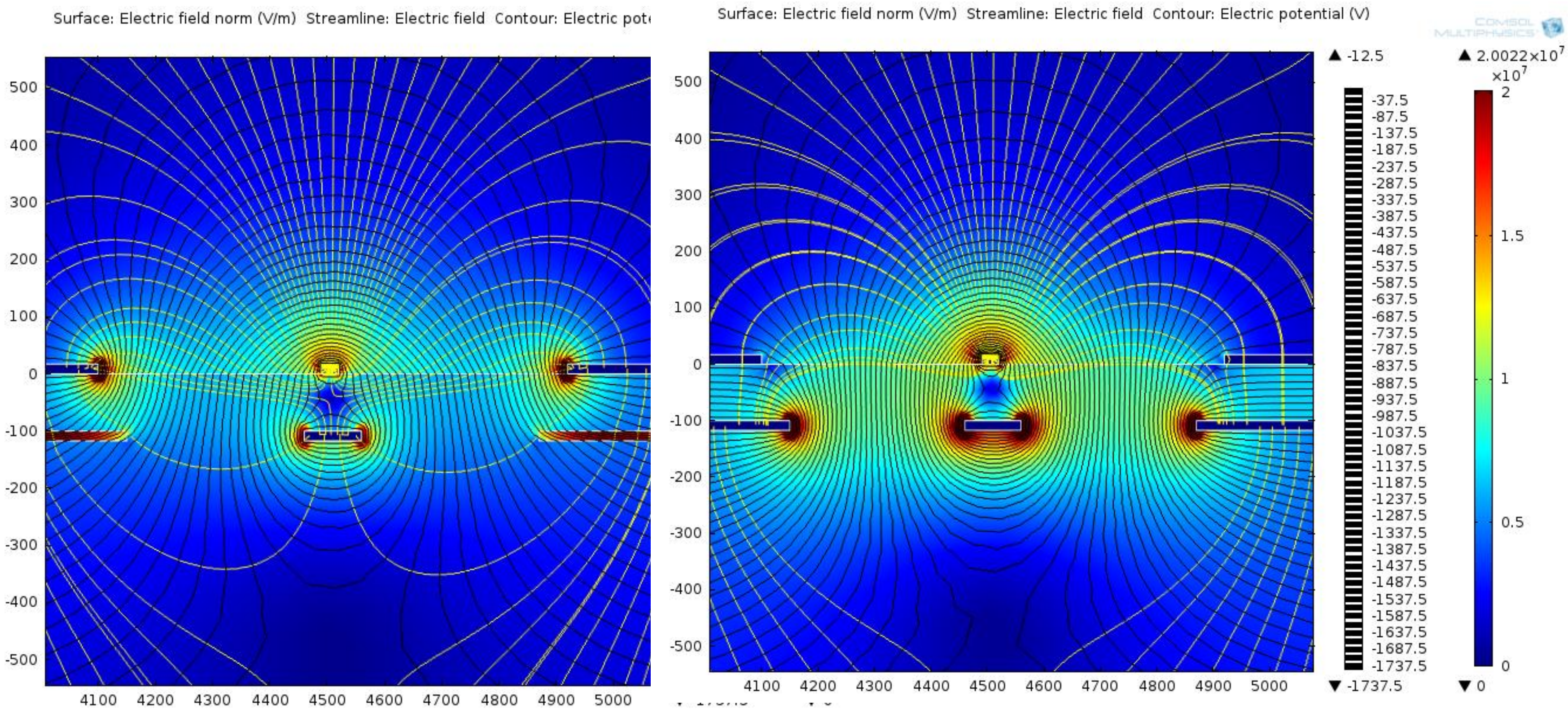
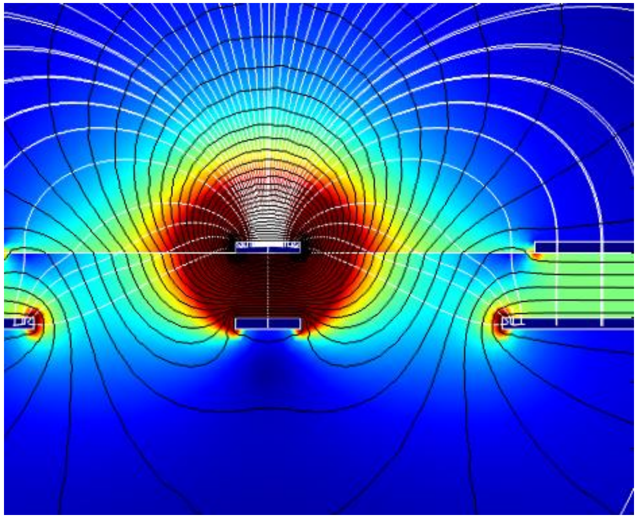
-100
-200
-300
-400
-500
4100 4200 4300 4400 4500 4600 4700 4800 4900 5000
▲ 1180.5
1141.5
1063.5
985.5
907.5
829.5
751.5
673.5
595.5
517.5
439.5
361.5
283.5
205.5
127.5
49.5
-28.5
-106.5
-184.5
-262.5
-340.5
-418.5
-496.5
-574.5
-652.5
-730.5
▼ -730.5
▲ 3.6795
×10⁷
3.5
3
2.5
2
1.5
1
0.5
0
▼ 0
▼ 0

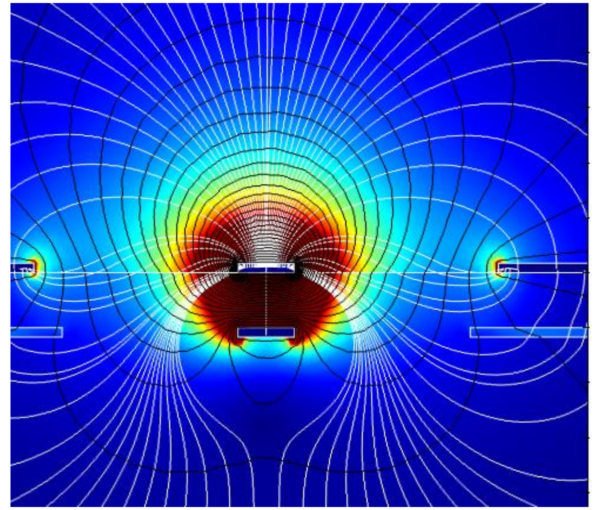
Powering cathode, anode GND

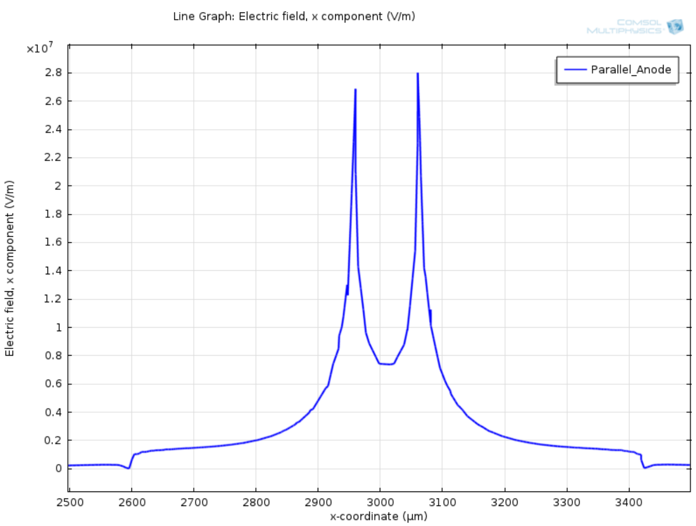
More visible the electrode effect on reduction of spike in E field at the edges of cathode

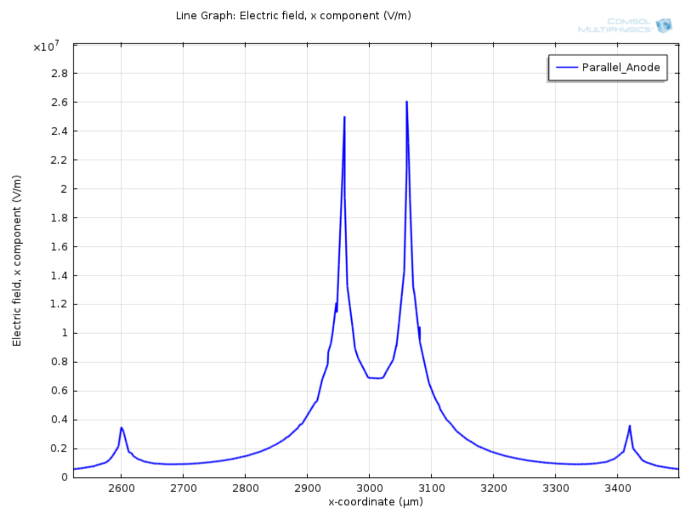


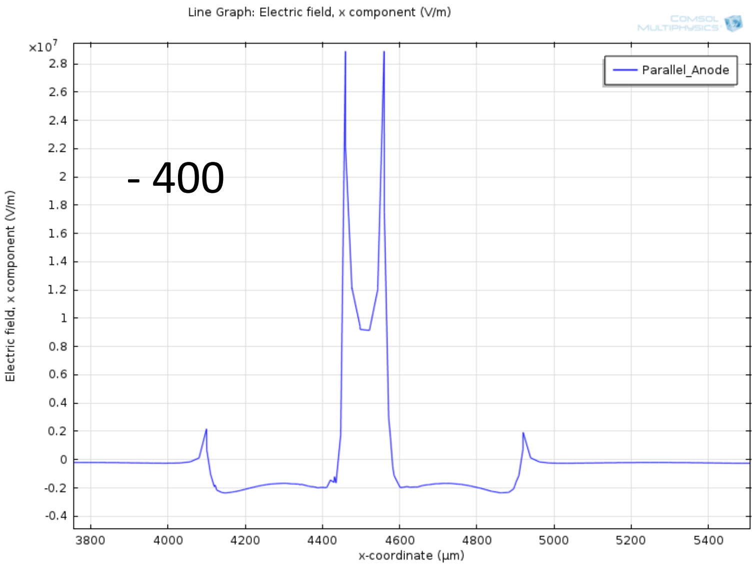
Field-lines studies

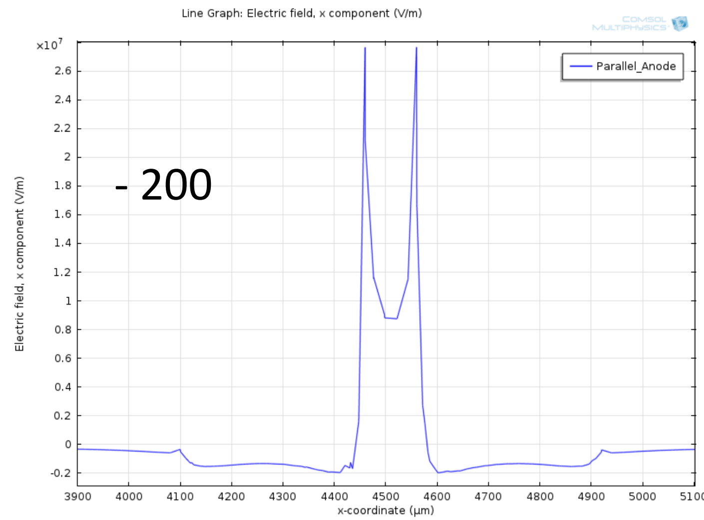


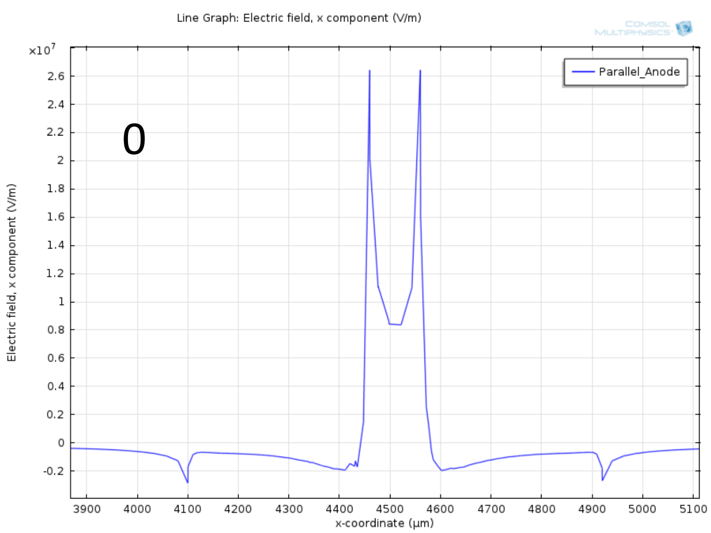


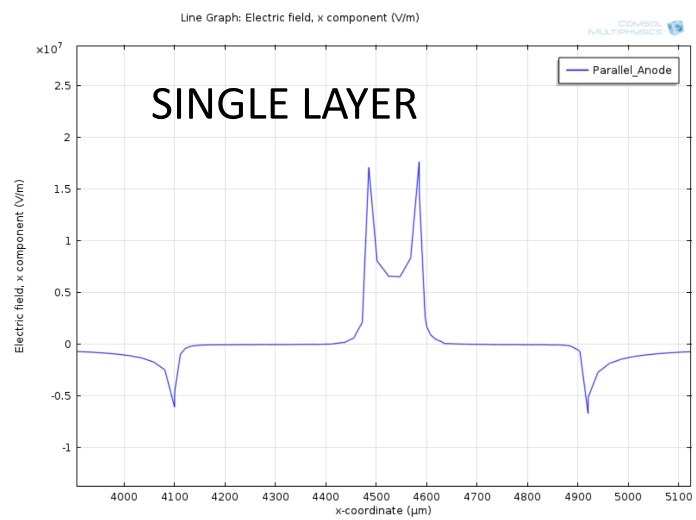




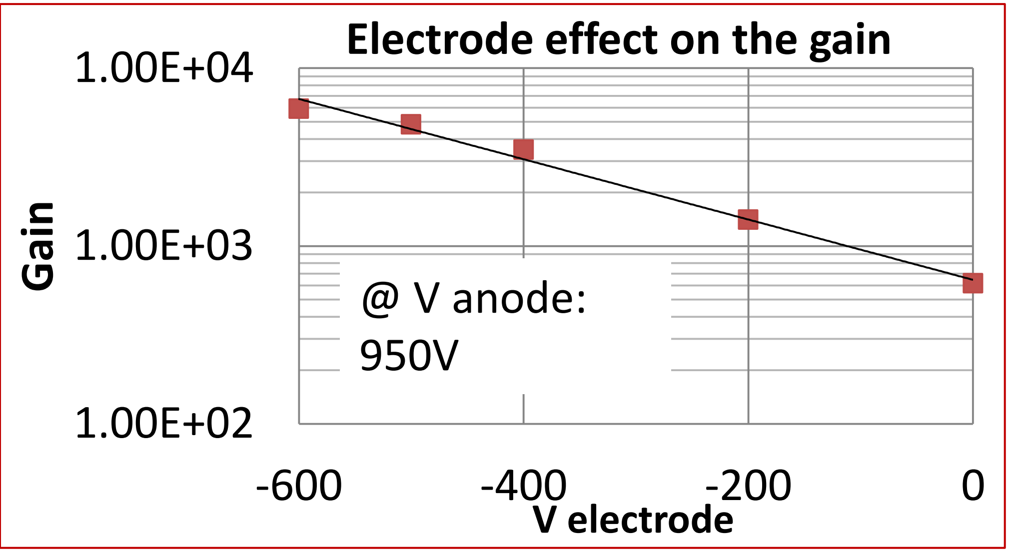

Line Graph: Electric field, x component (V/m)
- 400
Parallel_Anode
Electric field, x component (V/m)
x-coordinate (µm)


Line Graph: Electric field, x component (V/m)
- 200
Parallel_Anode
Electric field, x component (V/m)
x-coordinate (µm)


Line Graph: Electric field, x component (V/m)
0
Parallel_Anode
Electric field, x component (V/m)
x-coordinate (µm)

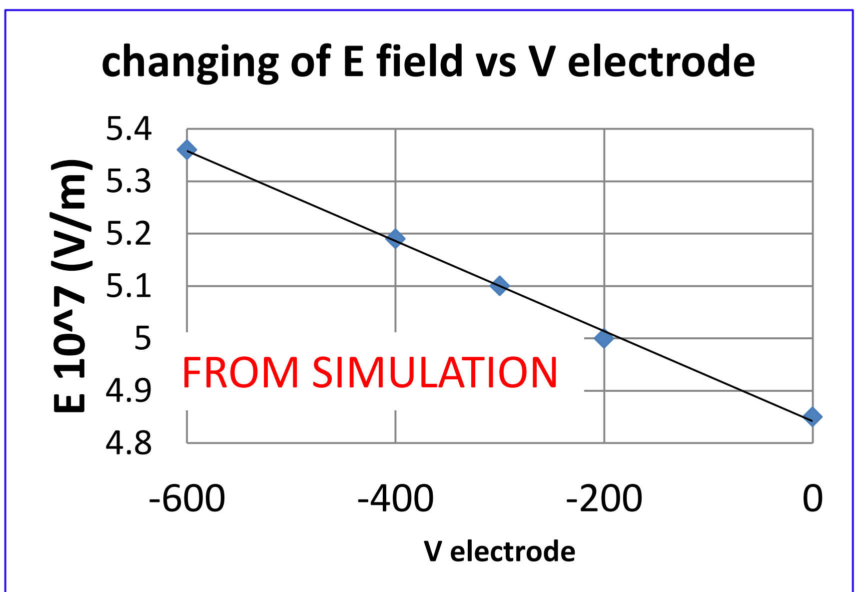

Line Graph: Electric field, x component (V/m)
SINGLE LAYER
Parallel_Anode
Electric field, x component (V/m)
x-coordinate (µm)

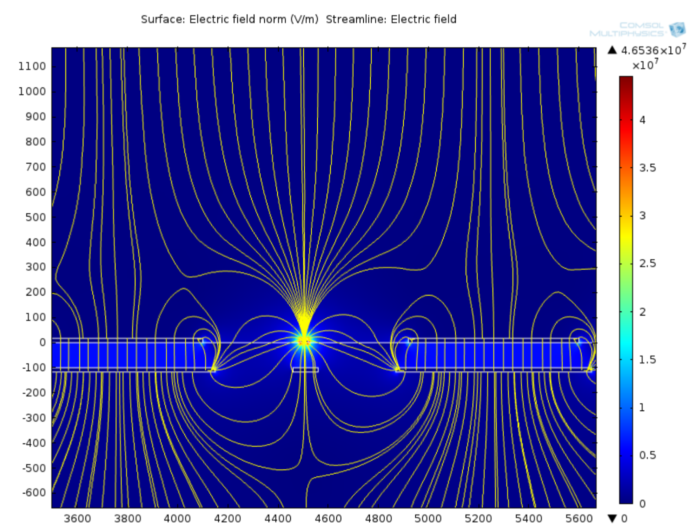
Gain, electrode effect (30 µm strip)



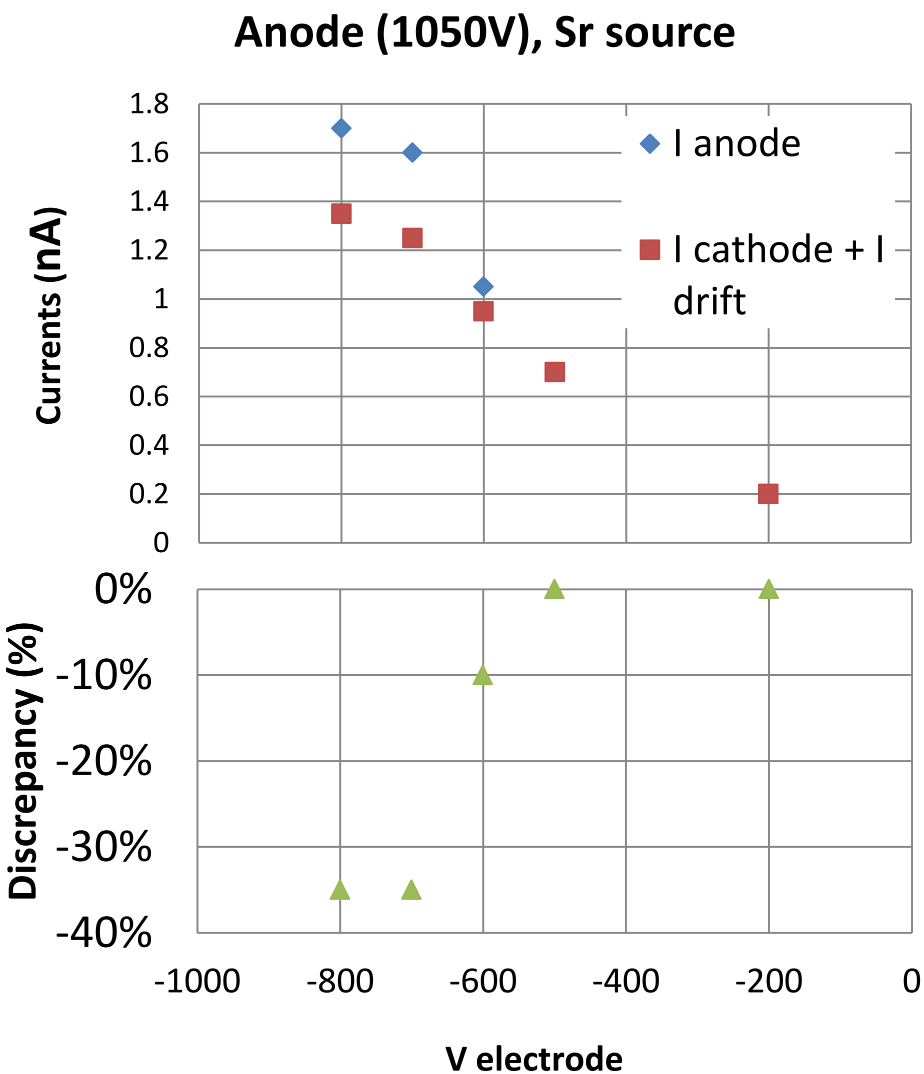
The effect of increasing of gain with increasing of voltage in the electrode is confirmed by the simulation

From simulation we see that for:
Vel>600V start to loose primaries





Monitoring of currents vs V electrode



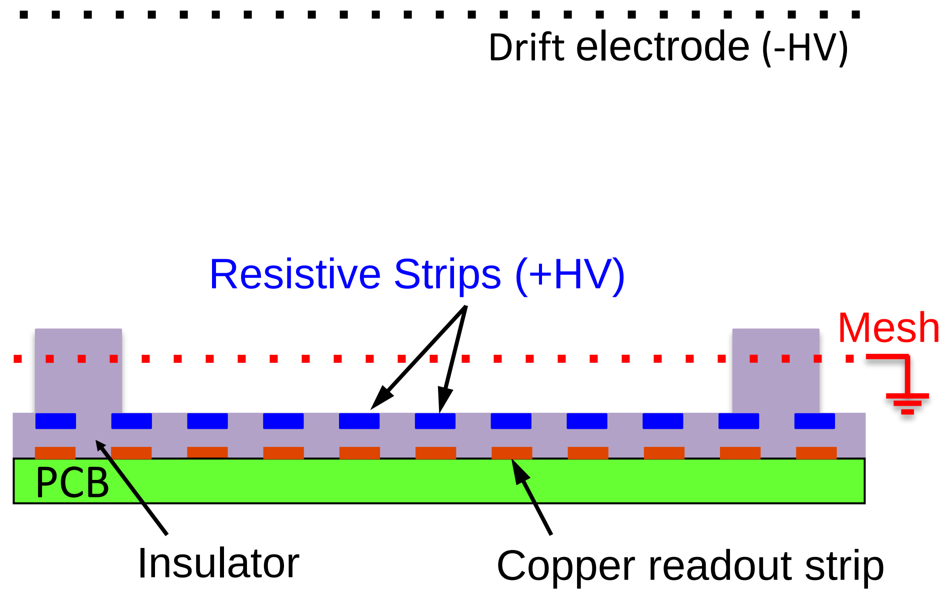
To check if we are loosing ions due to bad configuration of electric field

Ideal case: I anode = I cathode + I drift

If V electrode> 500V start to loose ions, bad collection.

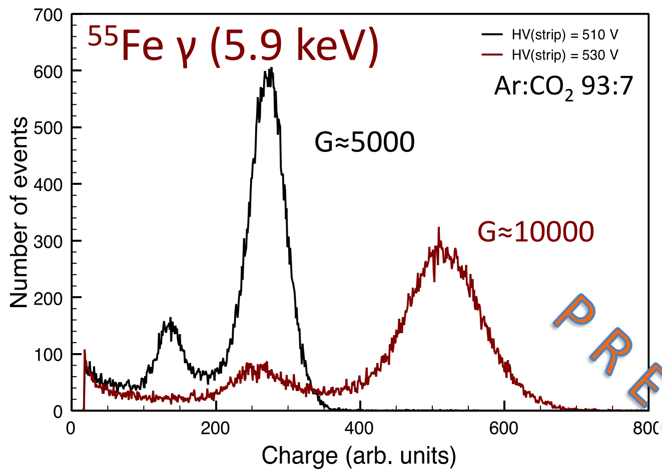
B. MM with mesh connected to GND

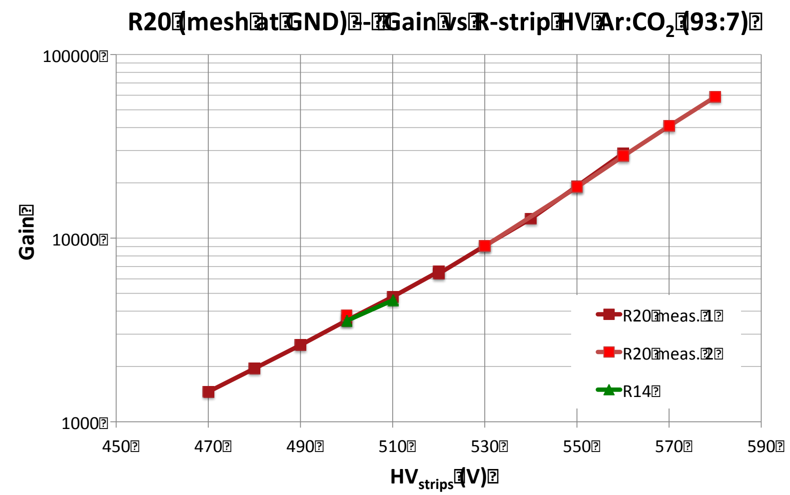
- Idea by A. Ochi 'Why not connect the R strips to HV and the mesh to ground ?'
- R. de Oliveira built one for us (10 x 10 cm^2) with x strips of 250 µm pitch
- Chamber was ready mid of last week, results are brand-new and preliminary
- First results: Clean signals, good energy resolution
  - High gain
  - Little charge-up
  - Good high-rate performance

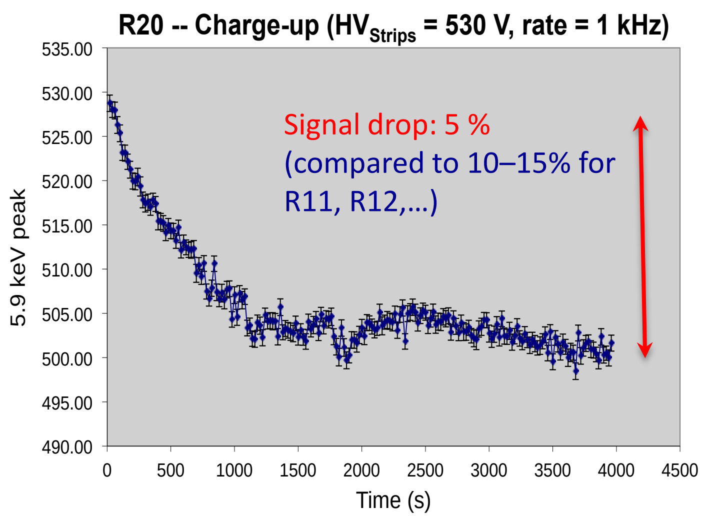


Looks very promising – may be the future

B. MM with mesh connected to GND II







PRELIMINARY