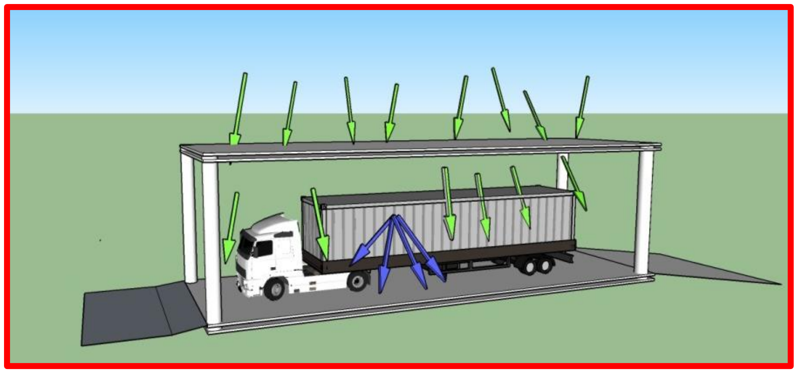
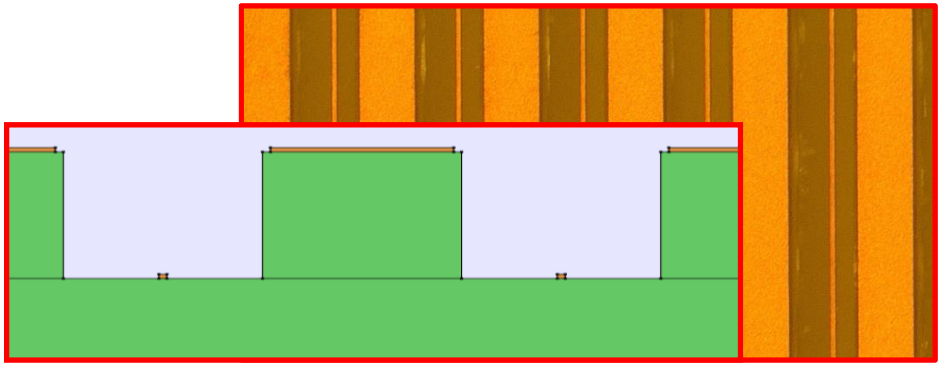
Status of Thick-groove detector





Silvia Franchino (on behalf of the Micro-Pattern Technology workshop)[2]
Michela Biglietti[1], Vincenzo Canale [3], Rui de Oliveira[2], Paolo Iengo[2,3], Mauro Iodice[1], Stefano Mastroianni[3], Fabrizio Petrucci[1,4]

[1] INFN Roma3, [2] CERN, [3] INFN Napoli, [4] Universitá Roma 3

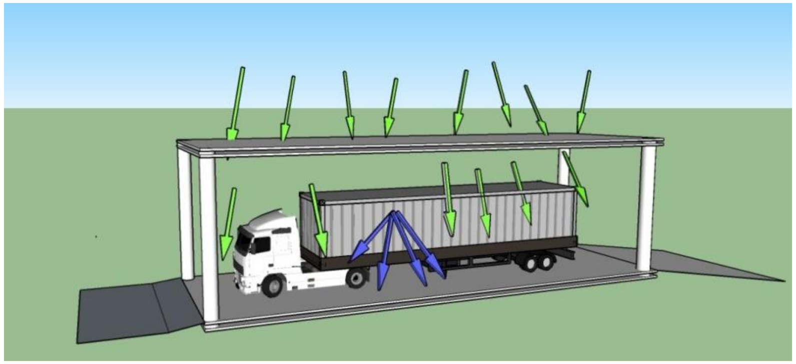
15th RD51 Collaboration Meeting
CERN, 18th March 2015

Outline

- Introduction
- Construction procedure
- First (very preliminary) results
- Future plans

The idea

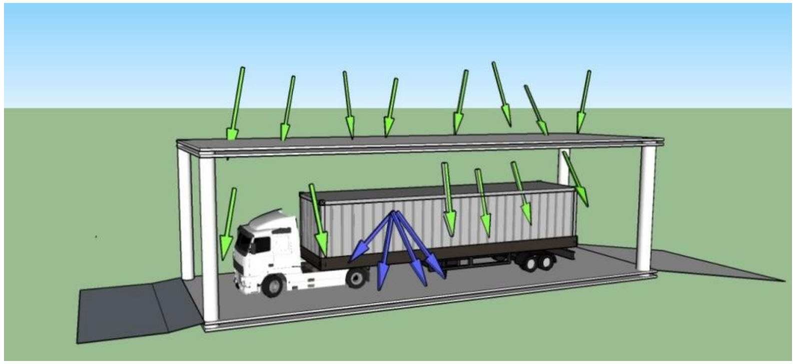
Application: Muon tomography, homeland security



- Simple construction (compatible with industrial mass production)
- Reduced operation costs
- Compact scanning station (even curved shape to increase angular coverage)
- Limited rate capability
- Single layer space resolution ~500 um

The idea

Application: Muon tomography, homeland security



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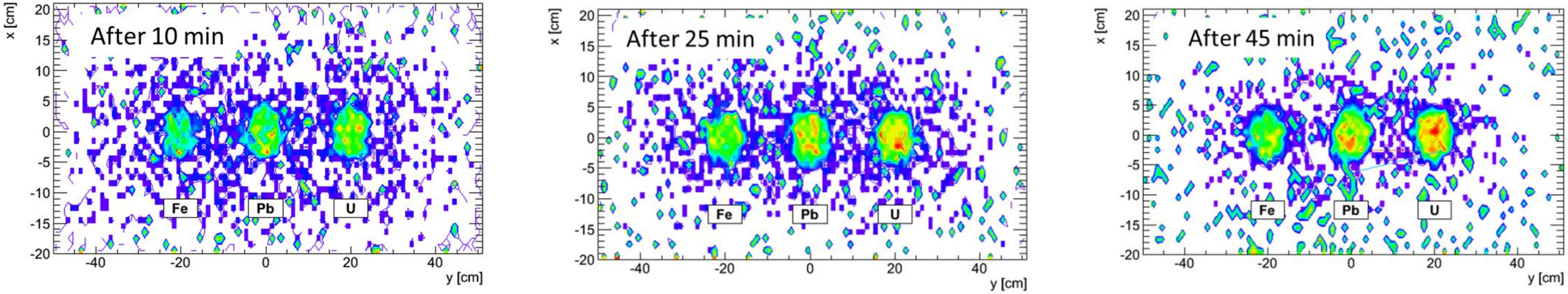
GEANT 4 simulation: Reconstruction of 4 cm-diameter spheres of Fe, Pb and U with the expected performance of a scanning station based on thick-Groove detector (500 µm spatial resolution, 3 mrad angular resolution).



This idea has been already used with other detectors, e.g. K. Gnanvo et al, "Detection and Imaging of High-Z Materials with a Muon Tomography Station Using GEM Detectors" RD51-Note-2010-004

The idea

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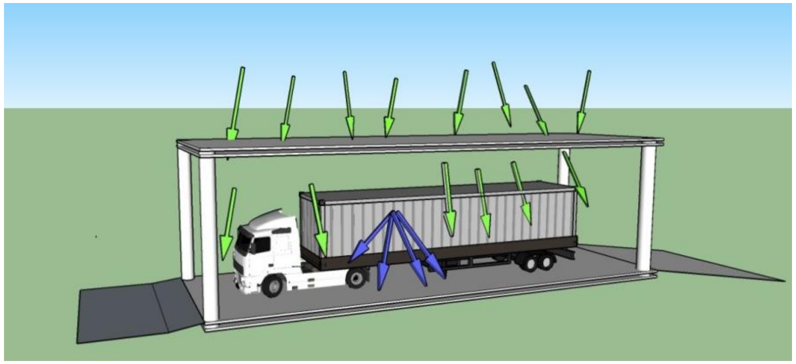

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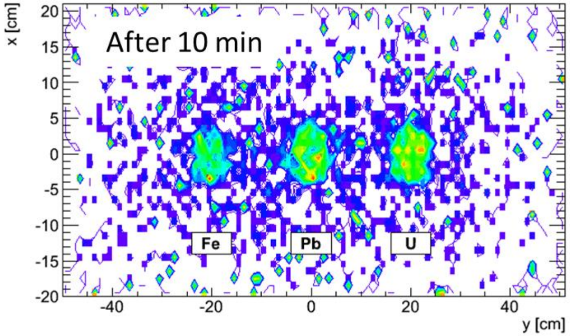

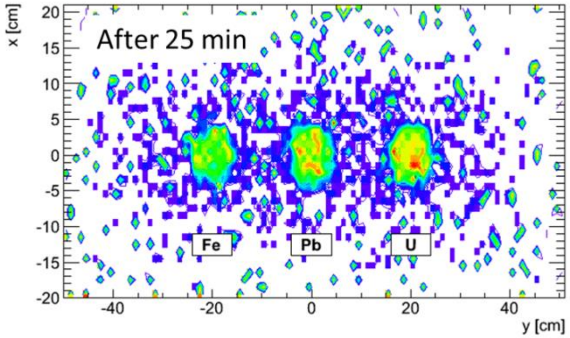

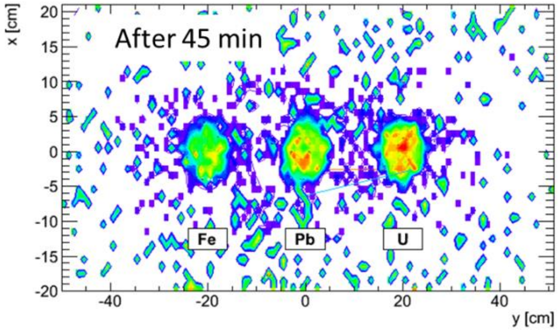

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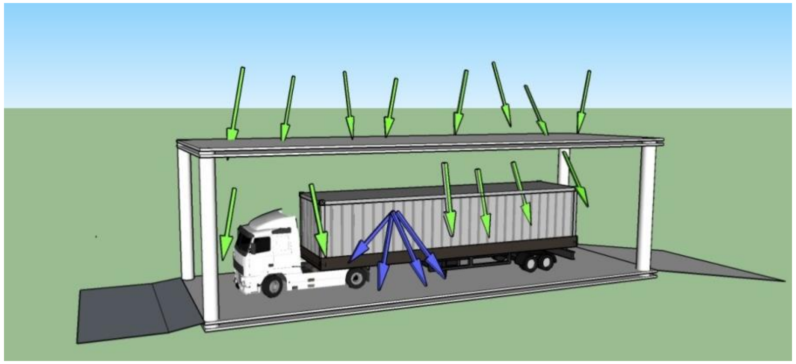
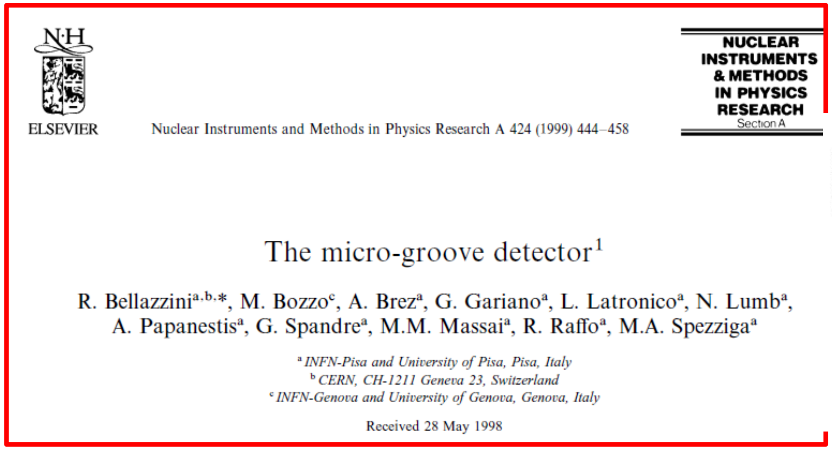
The idea

Application: Muon tomography, homeland security

- Simple construction
- Limited rate capability
- Single layer space resolution ~500 um
- Self-triggering capability



Structure like the Micro-groove detector but bigger scale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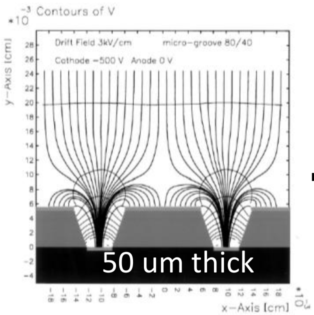
ELSEVIER
Nuclear Instruments and Methods in Physics Research A 424 (1999) 444–458
NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH
Section A

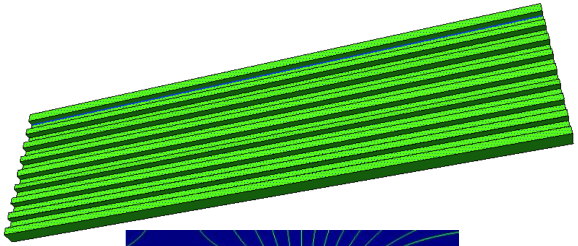
The micro-groove detector[1]

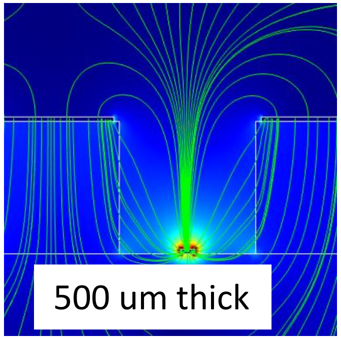
R. Bellazzini[a,b,*], M. Bozzo[c], A. Brez[a], G. Gariano[a], L. Latronico[a], N. Lumb[a], A. Papanestis[a], G. Spandre[a], M.M. Massai[a], R. Raffo[a], M.A. Spezziga[a]

[a] *INFN-Pisa and University of Pisa, Pisa, Italy*
[b] *CERN, CH-1211 Geneva 23, Switzerland*
[c] *INFN-Genova and University of Genova, Genova, Italy*

Received 28 May 1998



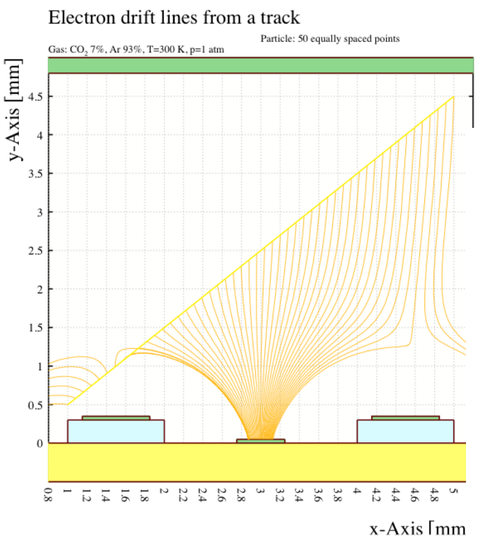


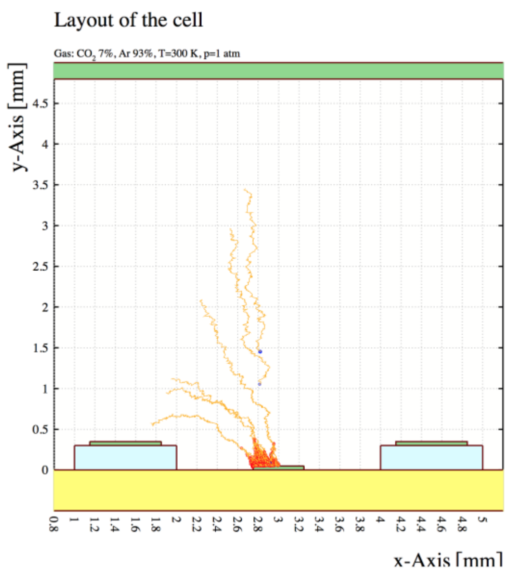


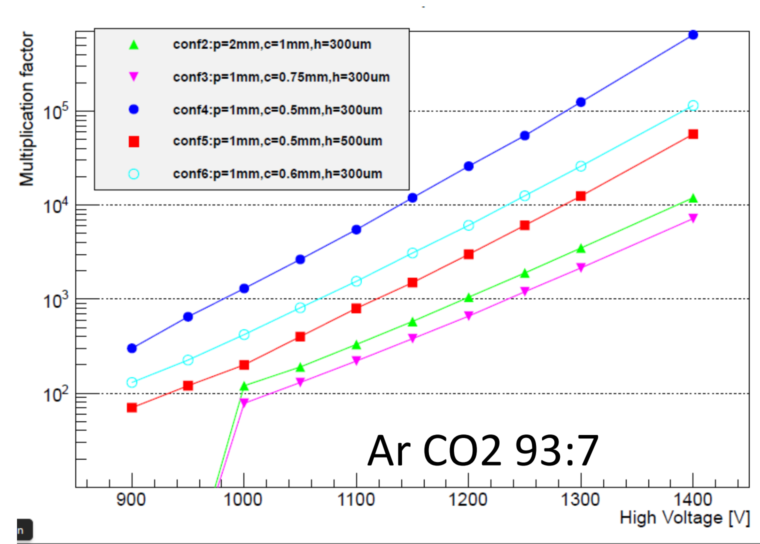
- Exactly like Thick GEM vs GEM, the thick groove should be feasible to be produced in PCB industries
- Thick groove vs MSGC: here we should have one more parameter to optimize (groove height) to fight against sparks for a given pitch

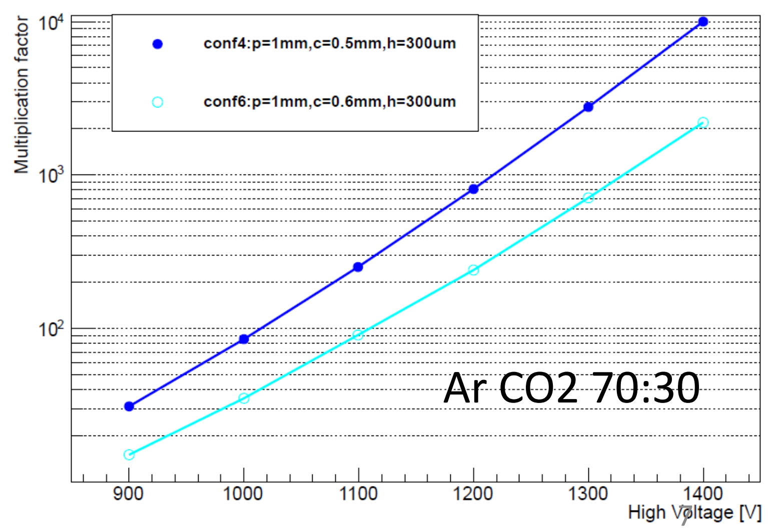
Geometry and simulation

Simulations performed with garfield and comsol in order to prove the principle and optimize the geometry before construction





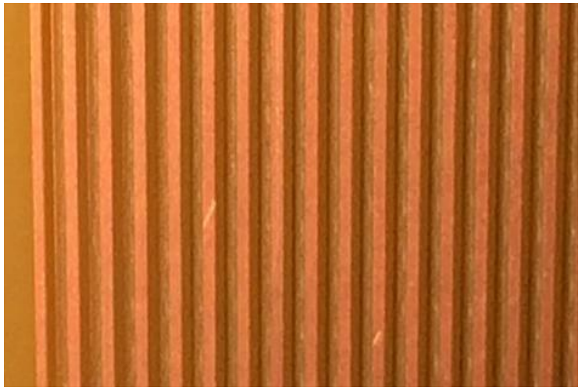


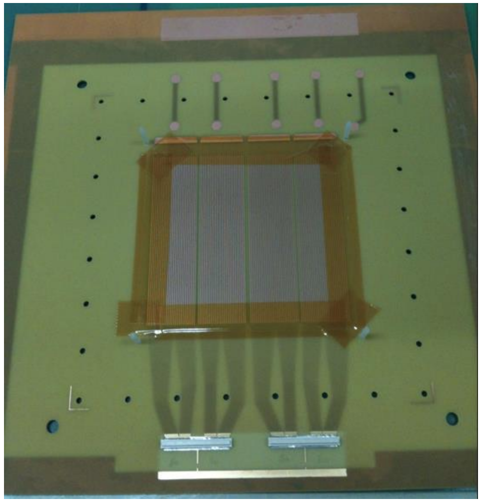


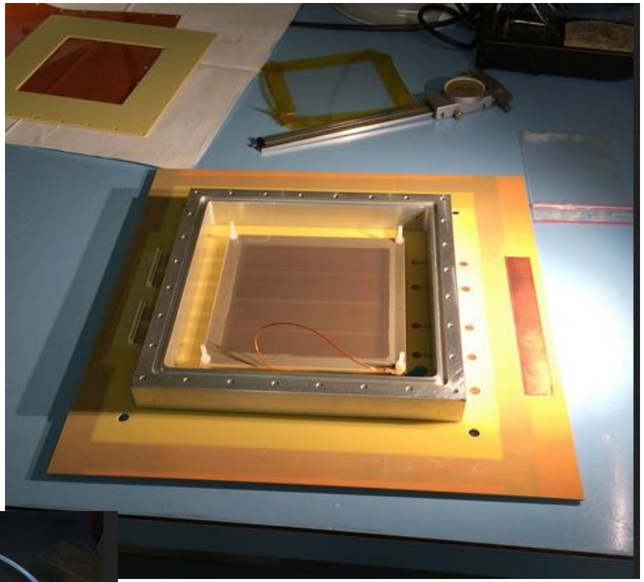
All simulations performed with thickness 0.3 mm,
First prototype thick 0.5 mm (easier to be produced)

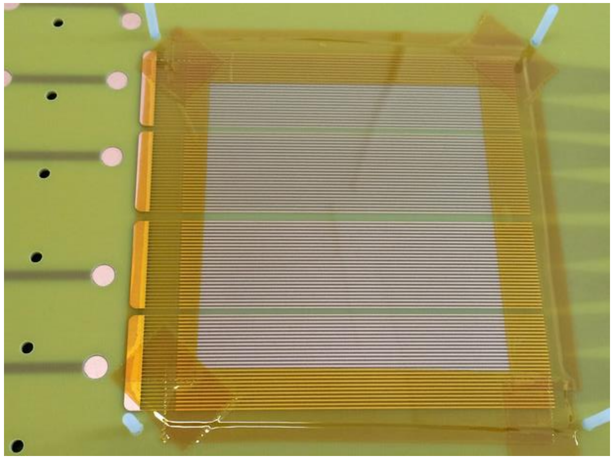
First prototype

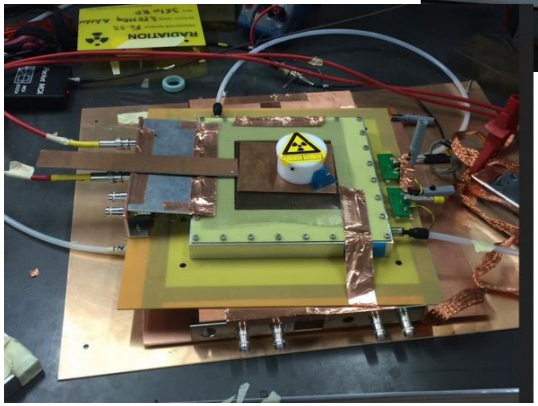
- First prototype designed and produced in the workshop (January 2015)
- 4 different detectors (active area 10 cm * 2.5 cm)
- All four detectors working (quickly tested in GDD lab) only preliminary results presented today
- We are evaluating critical points and possible improvements for next version



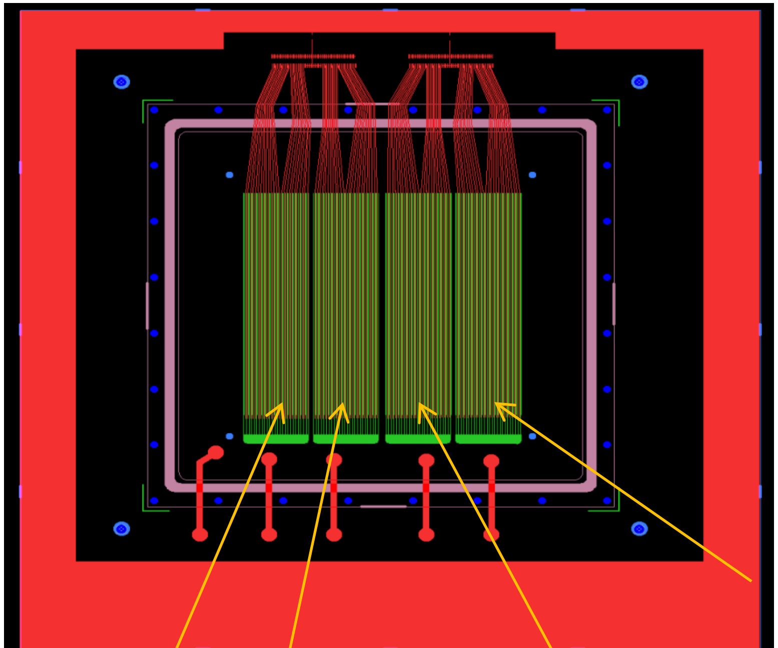






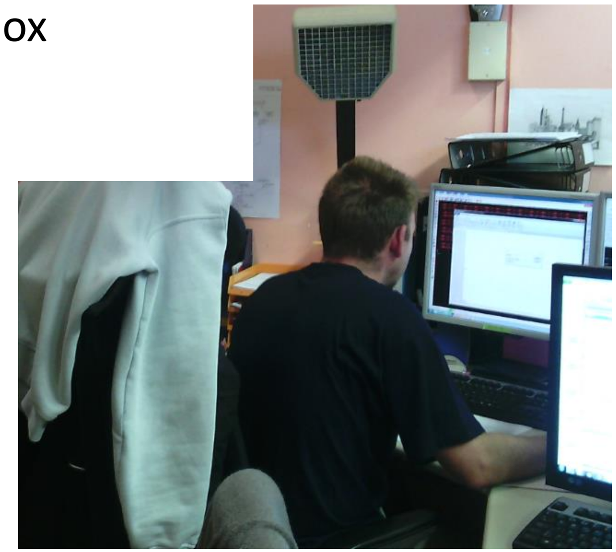


Design



4 independent detector in the same gas box

Pitch 1mm

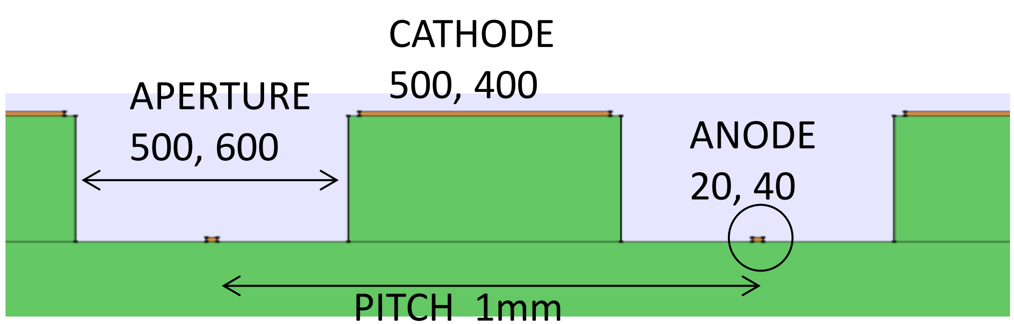


DETECTOR 4
Aperture 500 um
Cathode 500 um
Anode 40 um

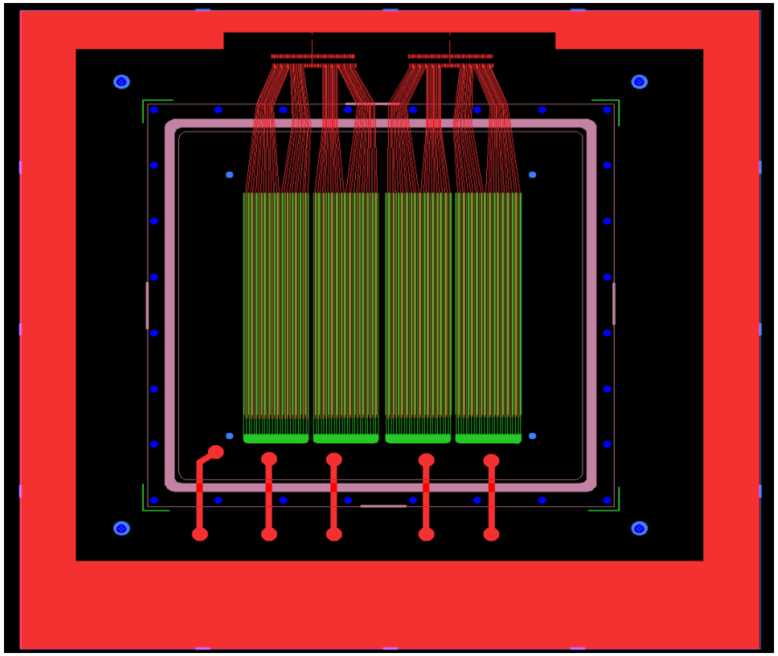
DETECTOR 1
Aperture 600 um
Cathode 400 um
Anode 20 um

DETECTOR 2
Aperture 600 um
Cathode 400 um
Anode 40 um

DETECTOR 3
Aperture 500 um
Cathode 500 um
Anode 20 um



Production technique

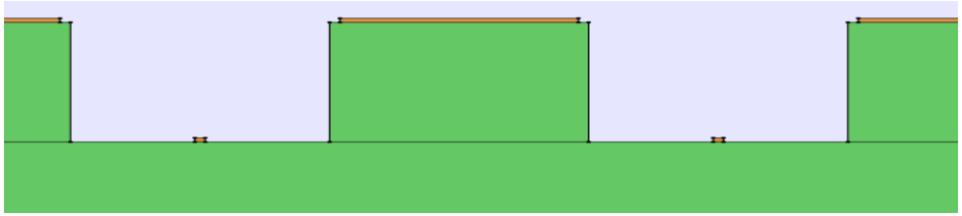


ANODE BOARD

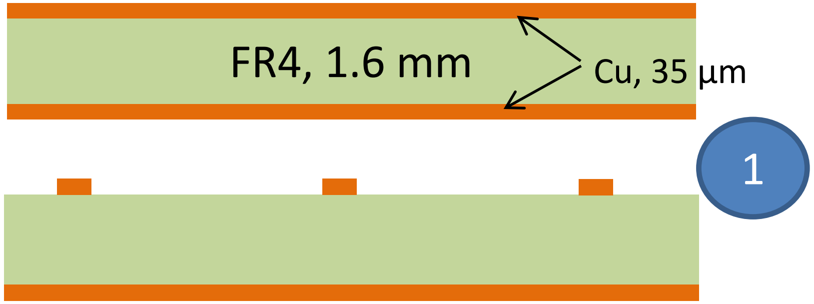
With four different designs, Two of them reaching 20 um anode width

CATHODE BOARD

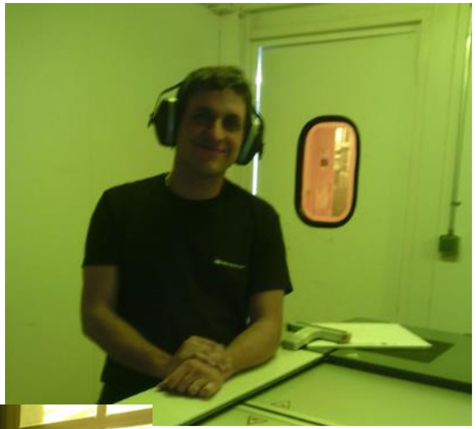
With four different designs and fiberglass machining

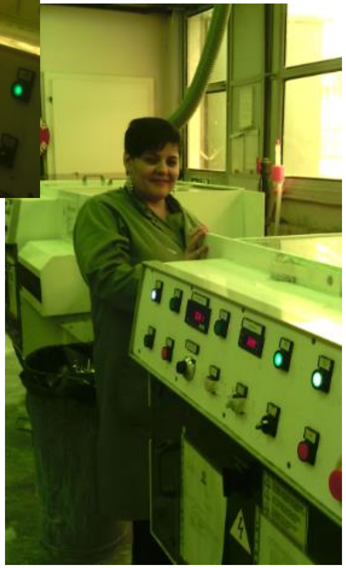


Anode board

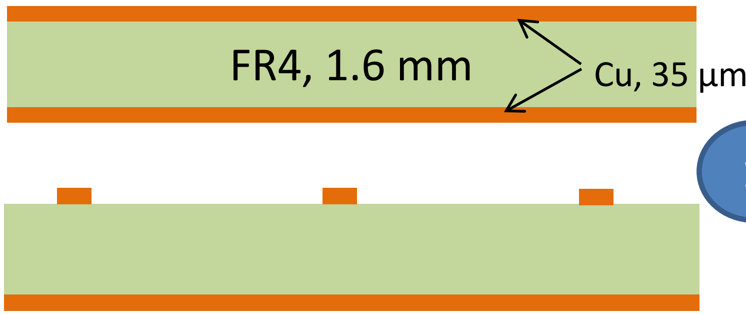


Top face:
Standard lithography
for anode lines up to 40 um width





Anode board



1

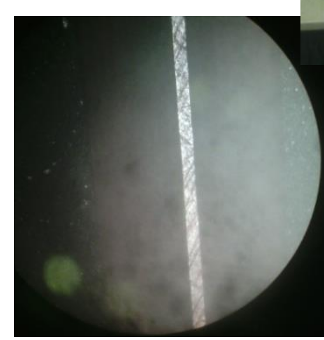
Top face:
Standard lithography
for anode lines up to 40
um width

2

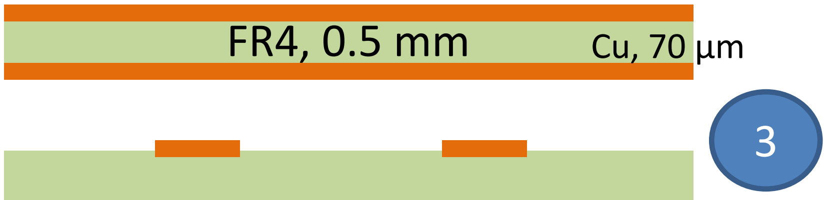
Micro-etching
To reach anode width 20 um
Protecting the two detectors
with 40 um anodes

Acid Chromic
Etching (~1 um/min)

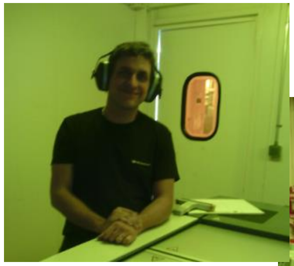
Optical control until
reaching 20 um width

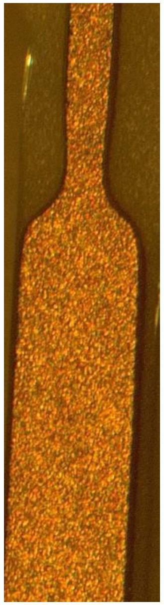


Cathode board

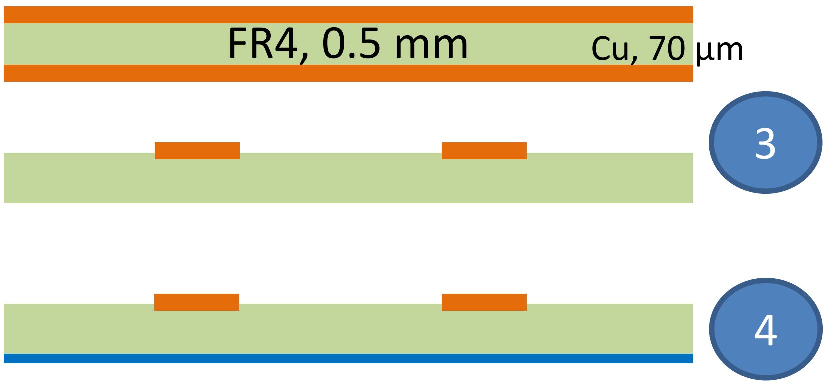


Top face: Standard lithography for cathode
Bot. face: full etching





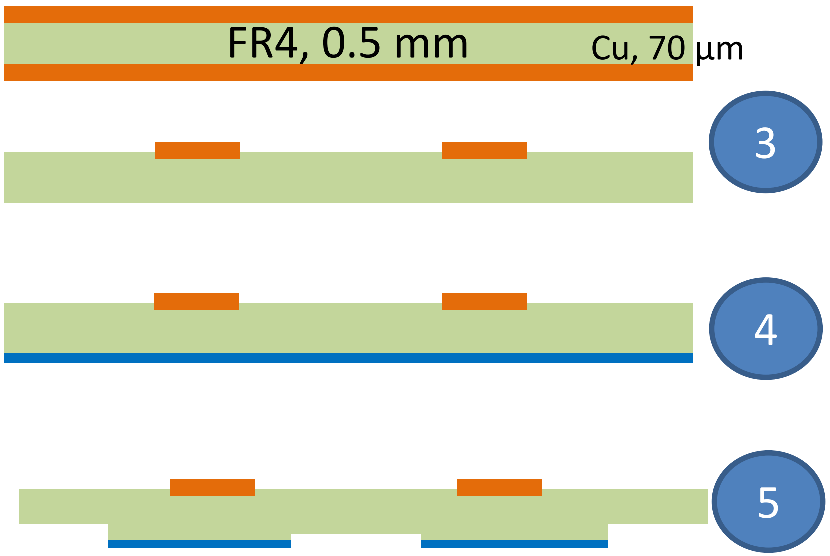
Cathode board



Top face: Standard lithography for cathode
Bot. face: full etching

Glue pressing
(krempel 2*25 um)

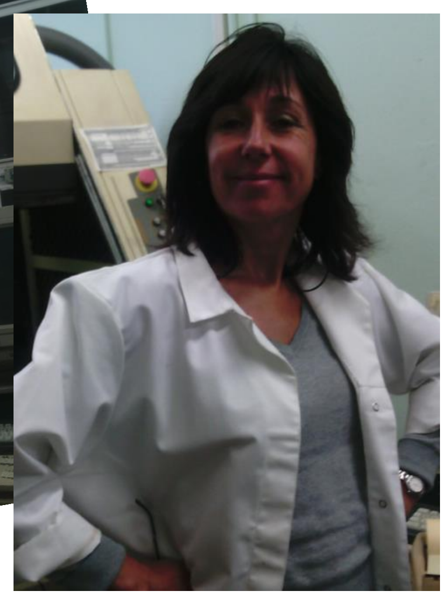
Cathode board



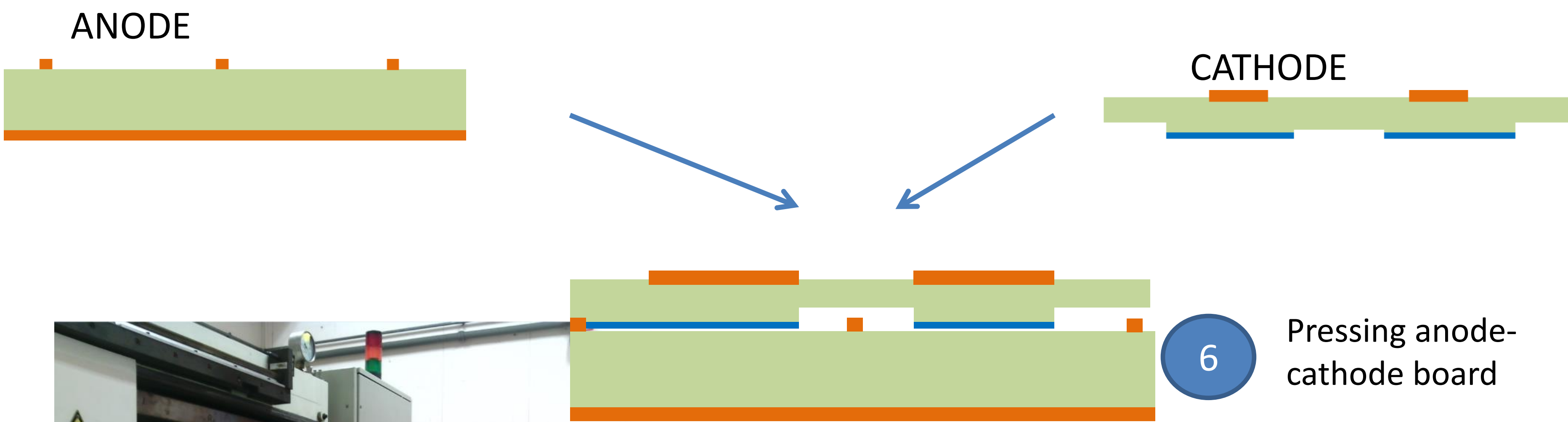
Top face: Standard lithography for cathode
Bot. face: full etching

Glue pressing
(krempel 2*25 um)

Milling of bot. face (CNC machine)



Detector completion

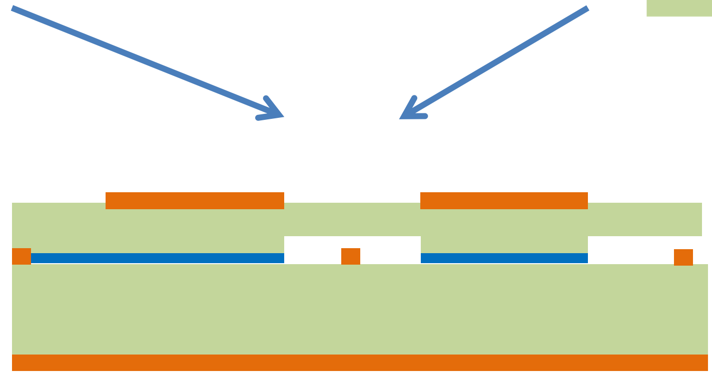


Pressing anode-cathode board

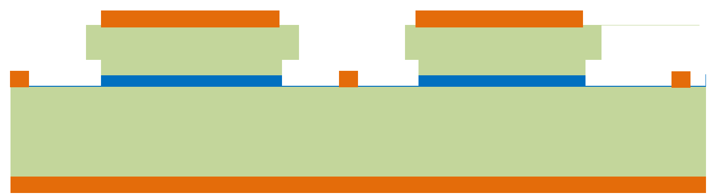
Detector completion

ANODE

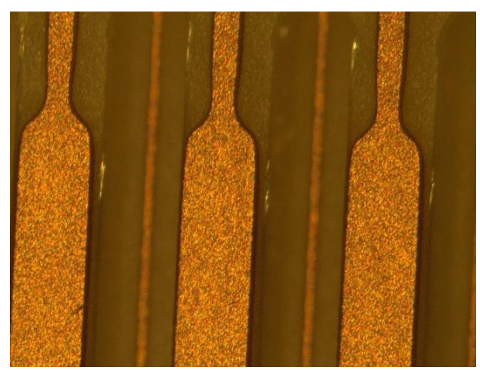
CATHODE

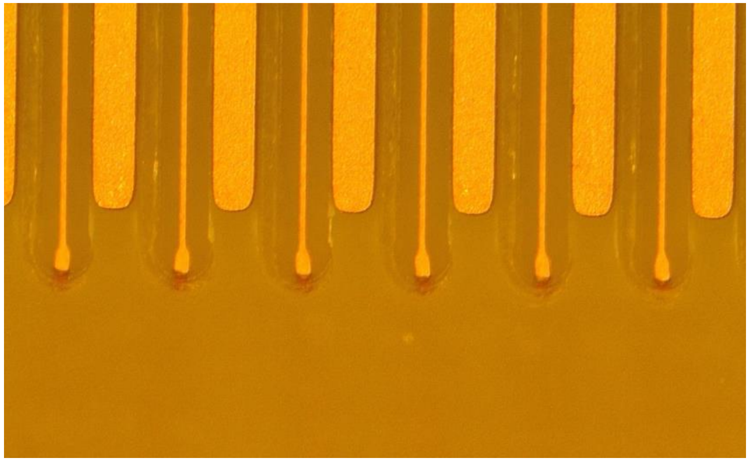
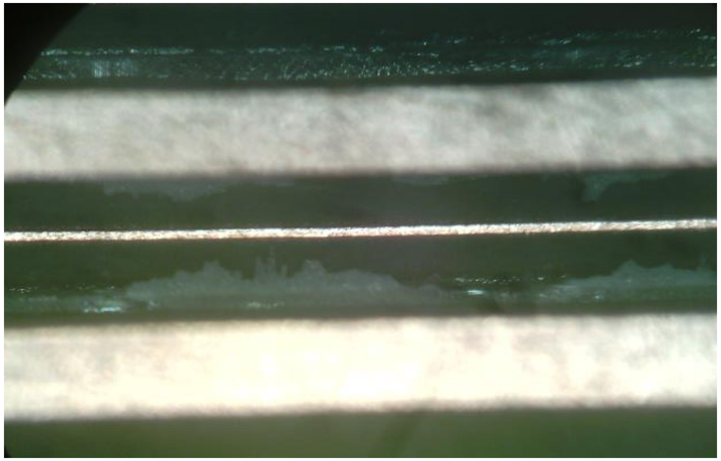
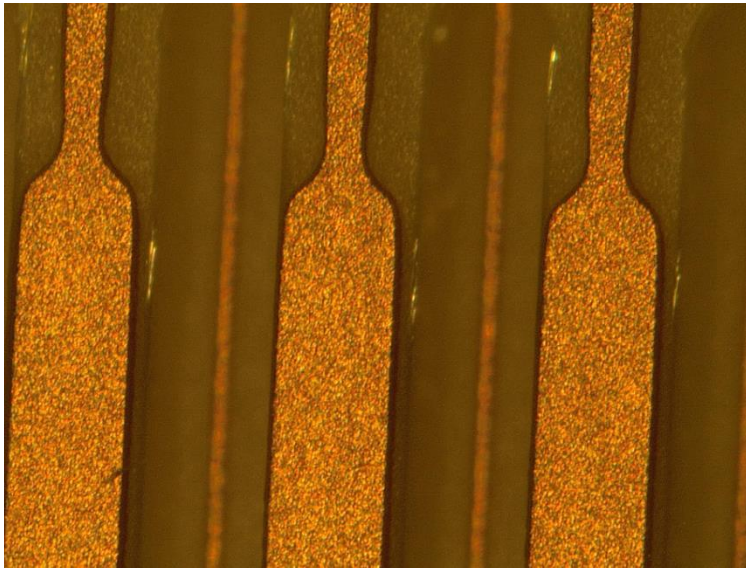


6 Pressing anode-cathode board



7 Milling of top face




Final cleaning and test in air

- Final cleaning with demineralized water high pressure
- Test in air. HV applied between anode and cathode

Far from Pashen curve (like Thick GEM without treatment)
probably due to machining of fiber glass
Theoretically should spark in air @ 3kV
Each of the four spark @ ~ 2.1 kV
Sparks not coming from the same spot

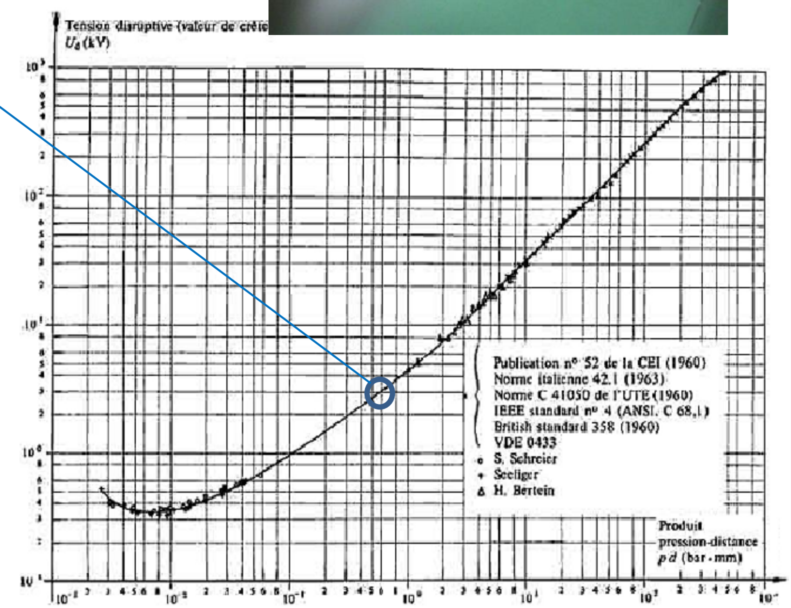


Fig. 9.11 Courbe de Paschen pour l'air en échelles logarithmiques. Température 20°C [262]

- Tried performance of detector in gas without additional treatment (easiest way compatible with industrial production)

We could improve it:

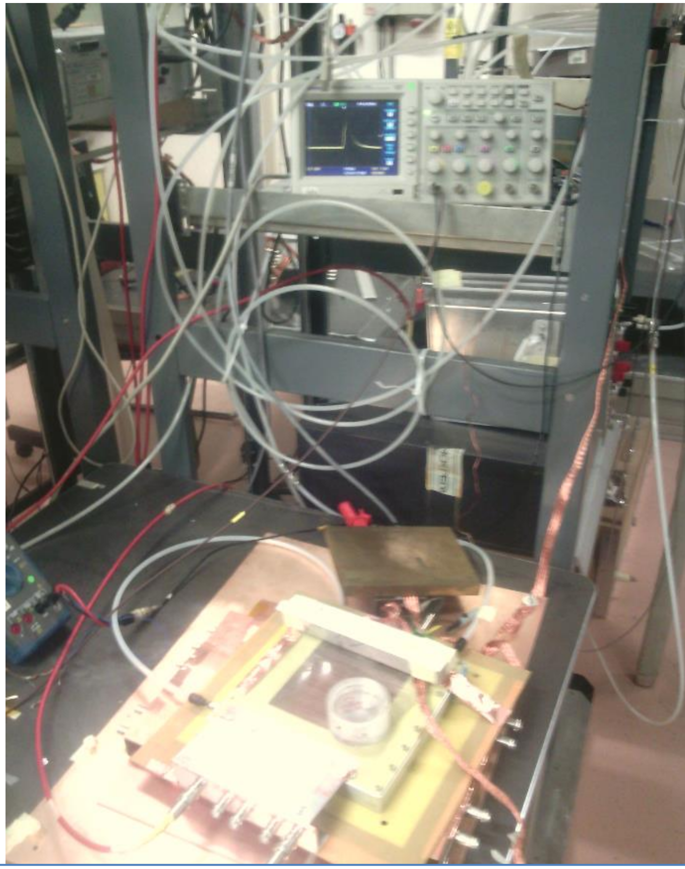
- rim on cathode electrodes
- Chemical treatment of machined fiber glass (e.g. permanganate, hydrofluoric acid)

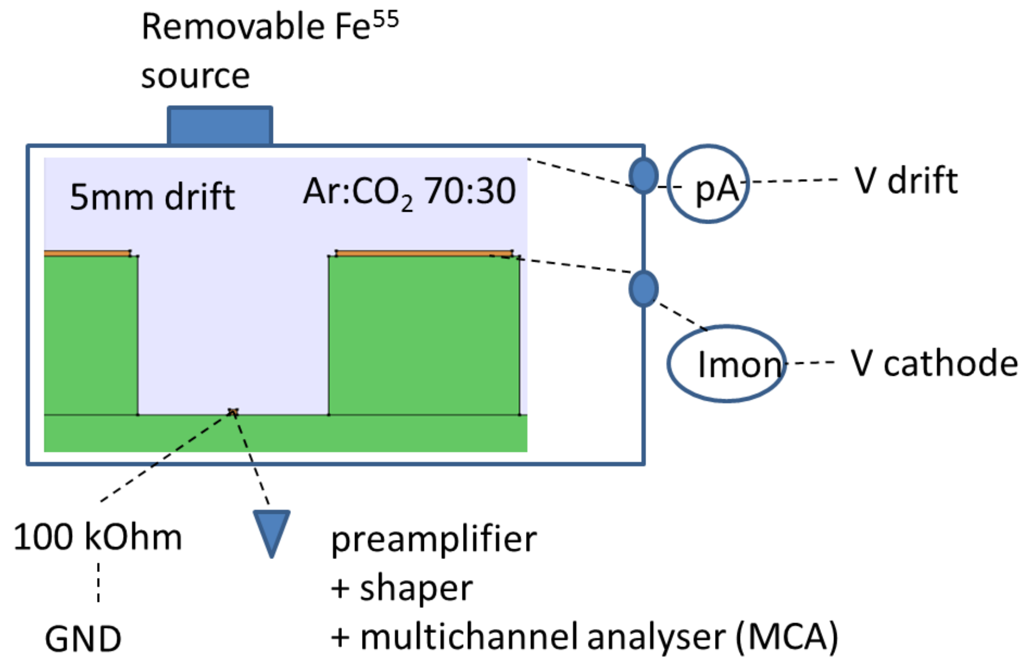
(not possible to put Polyurethane like thick GEMs(covering of anode…)

Detectors characterization
(Very preliminary results)

- Gain curves
- energy resolution
- uniformity

Experimental setup



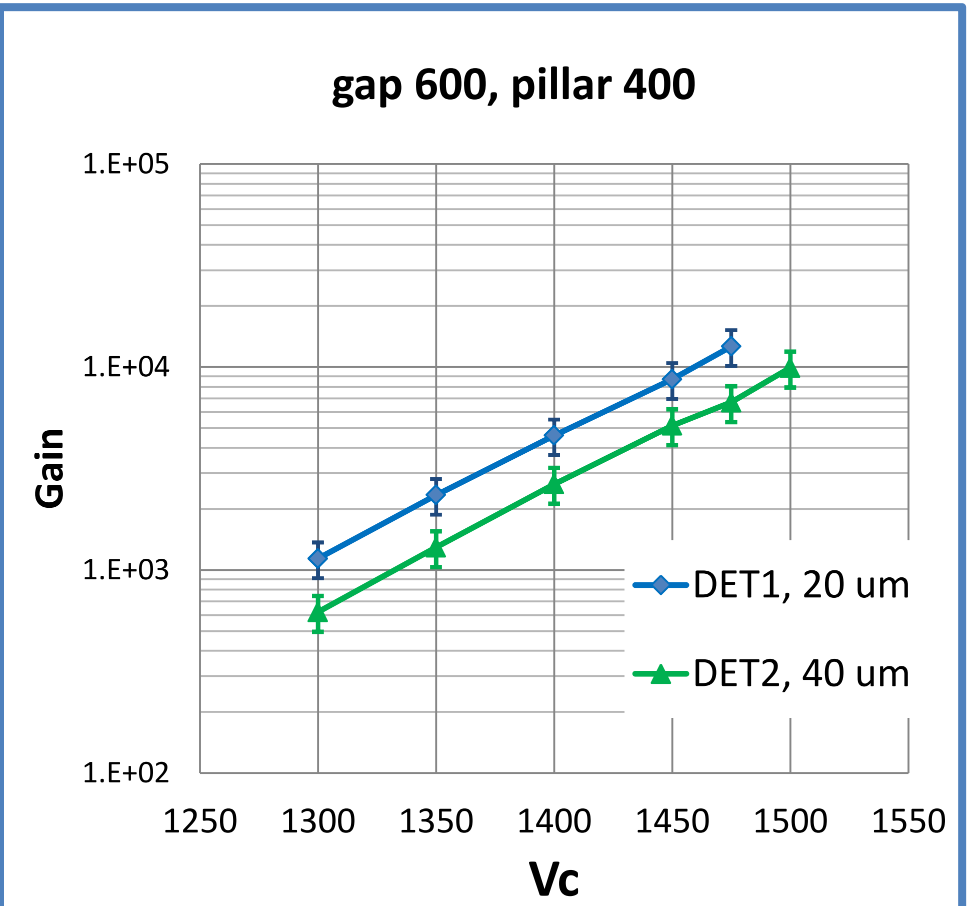


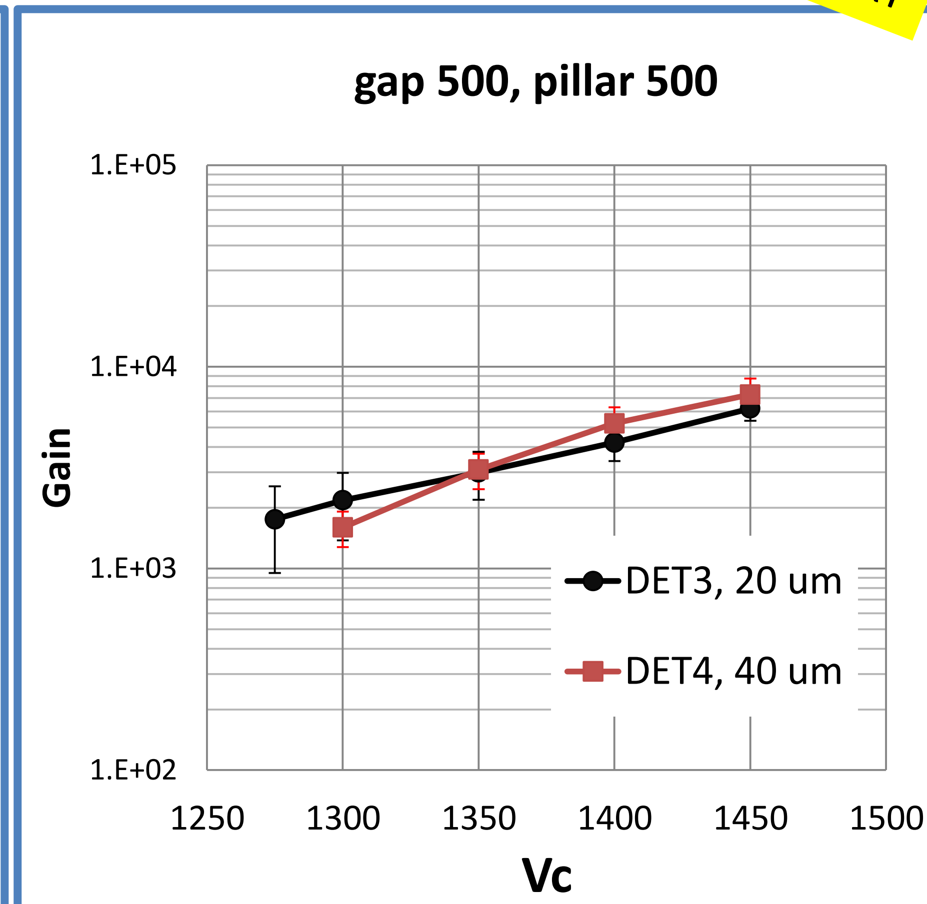
Many thanks to the CERN GDD lab support

- Reading all anodes of same detector together
- Applied voltage on cathodes
- GND anodes

Gain curves

PRELIMINARY

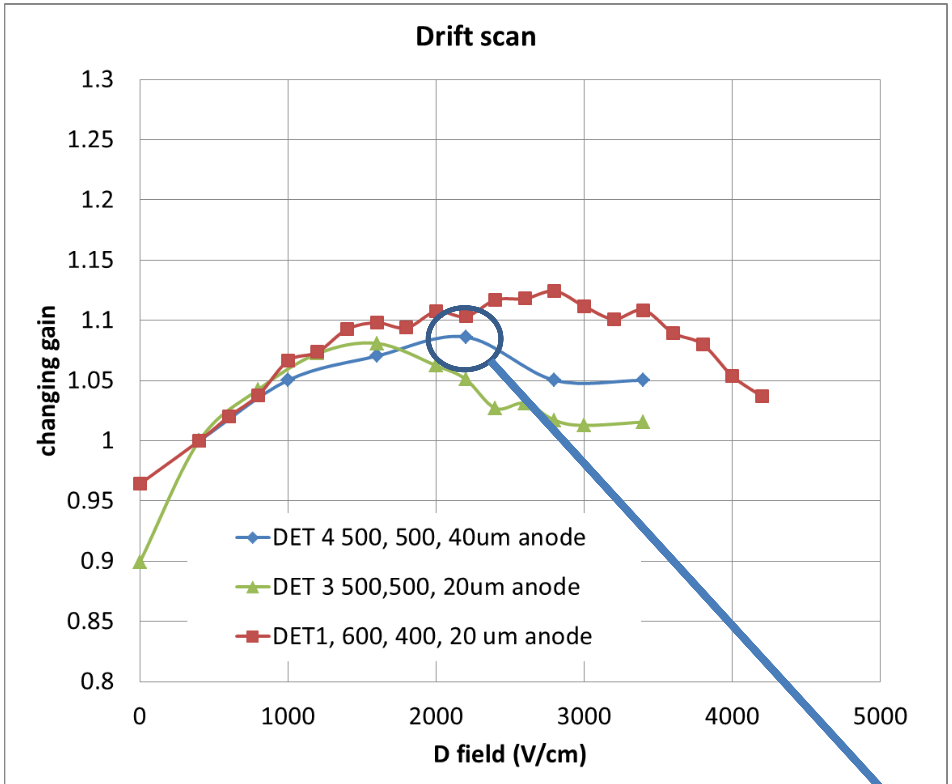


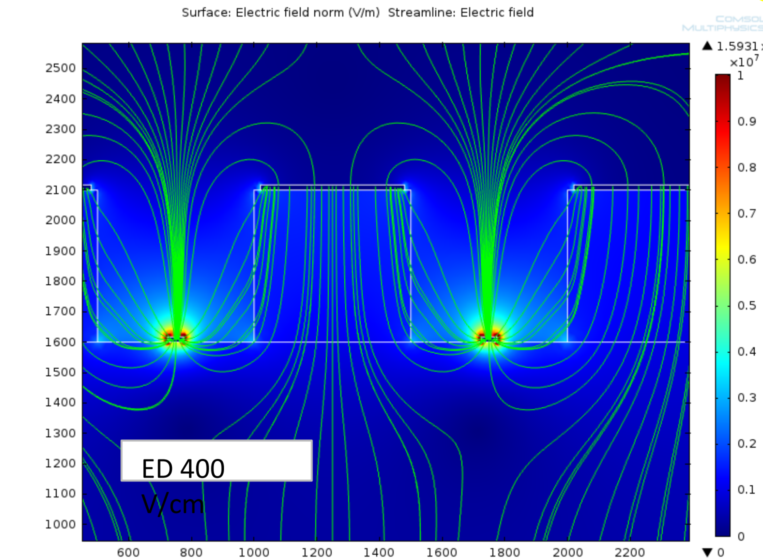


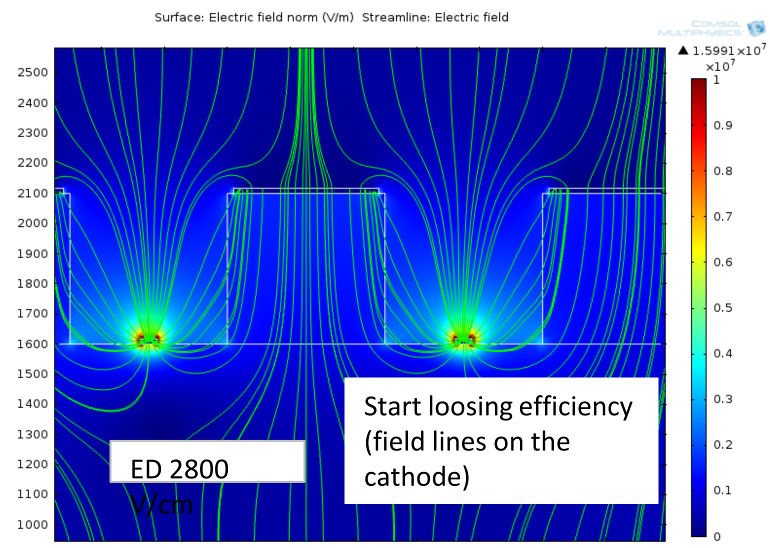
- From preliminary tests not possible to go higher than 10^4 with gain
- Frequent sparks (1 spark/min) on last points of gain curve
- Needed at least G~5000 for cosmic detection and stable operation (TO BE INVESTIGATED)

Drift scan

PRELIMINARY

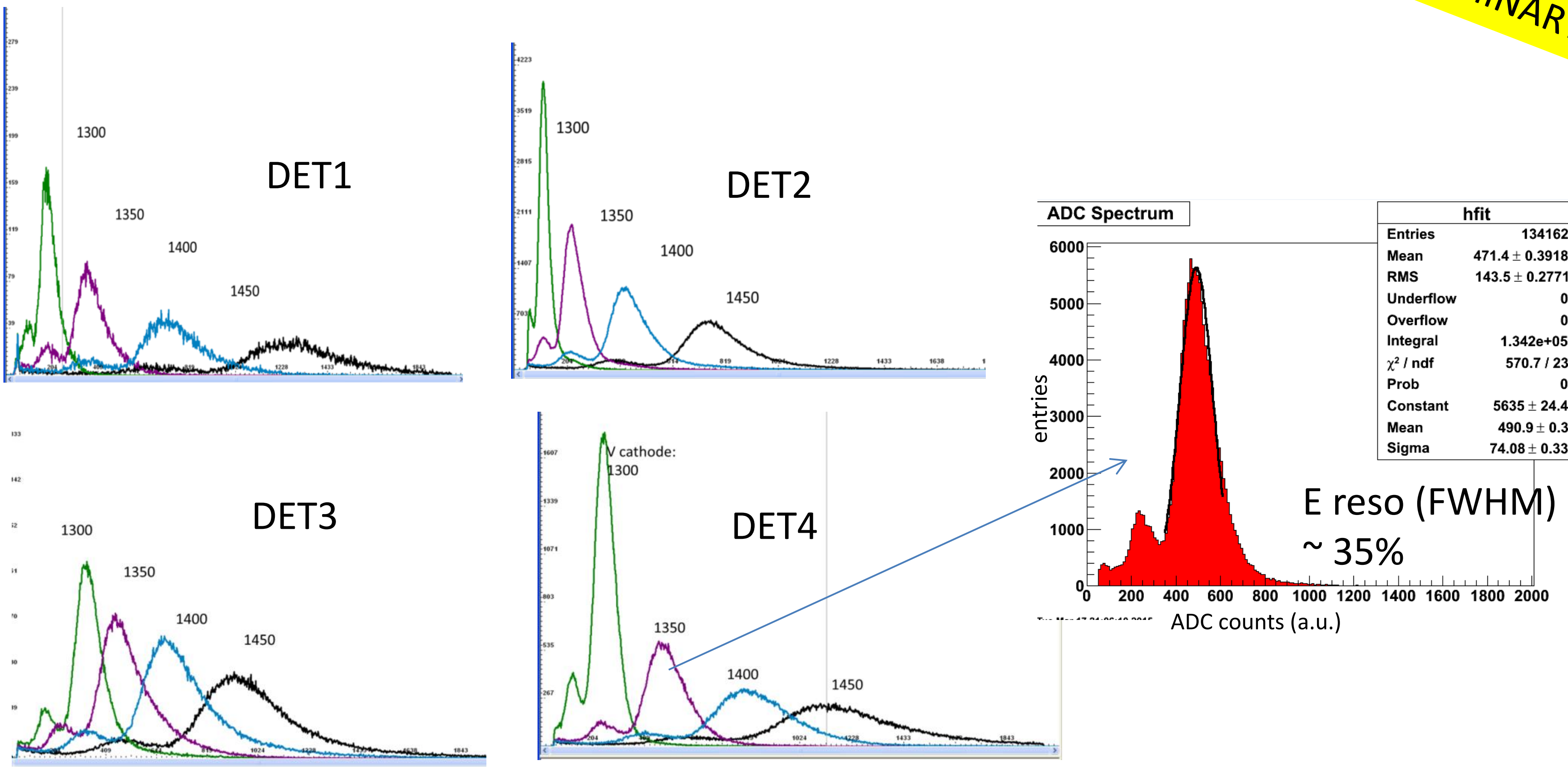






Energy spectra

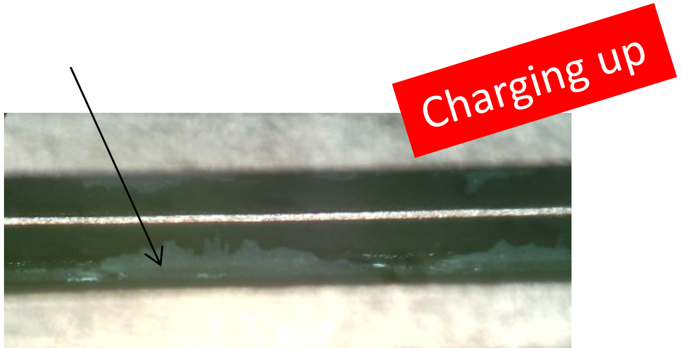
PRELIMINARY



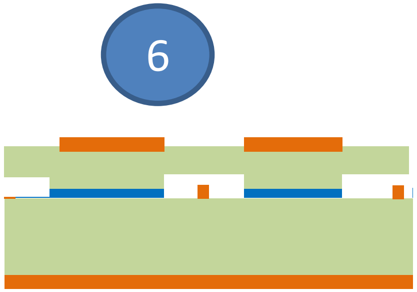
As a common problem of MSGC, seen changings of gain vs time (charging up).
We are studying more carefully in order to evaluate the amount of this effect (work in progress)

Construction critical points

- **Alignment** (for next prototype need to insert more pillars in order to be sure no misalignement durig pressing)
- **Glue flowing in amplification region**



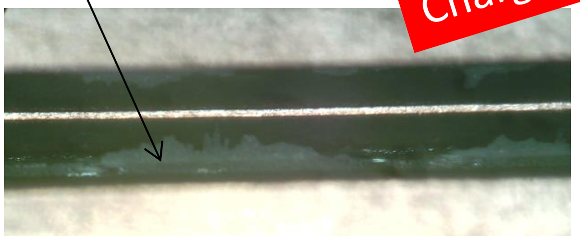
Pressing anode-cathode board



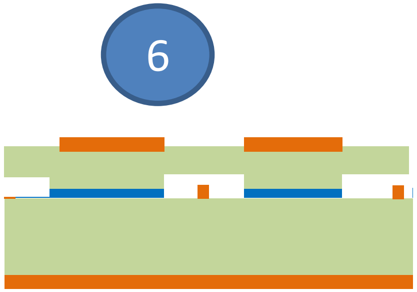
Construction critical points

- **Alignment** (for next prototype need to insert more pillars in order to be sure no misalignement durig pressing)
- **Glue flowing in amplification region**

Charging up



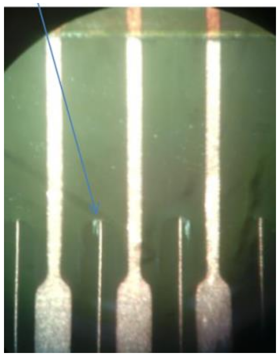
Pressing anode-cathode board



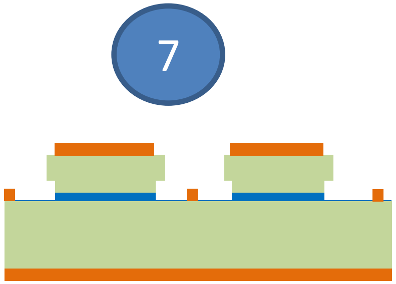
- **Machining of fiber glass**

Need to find a way of cleaning after milling (industry compatible)

Sparks



Milling of top face



Future plans

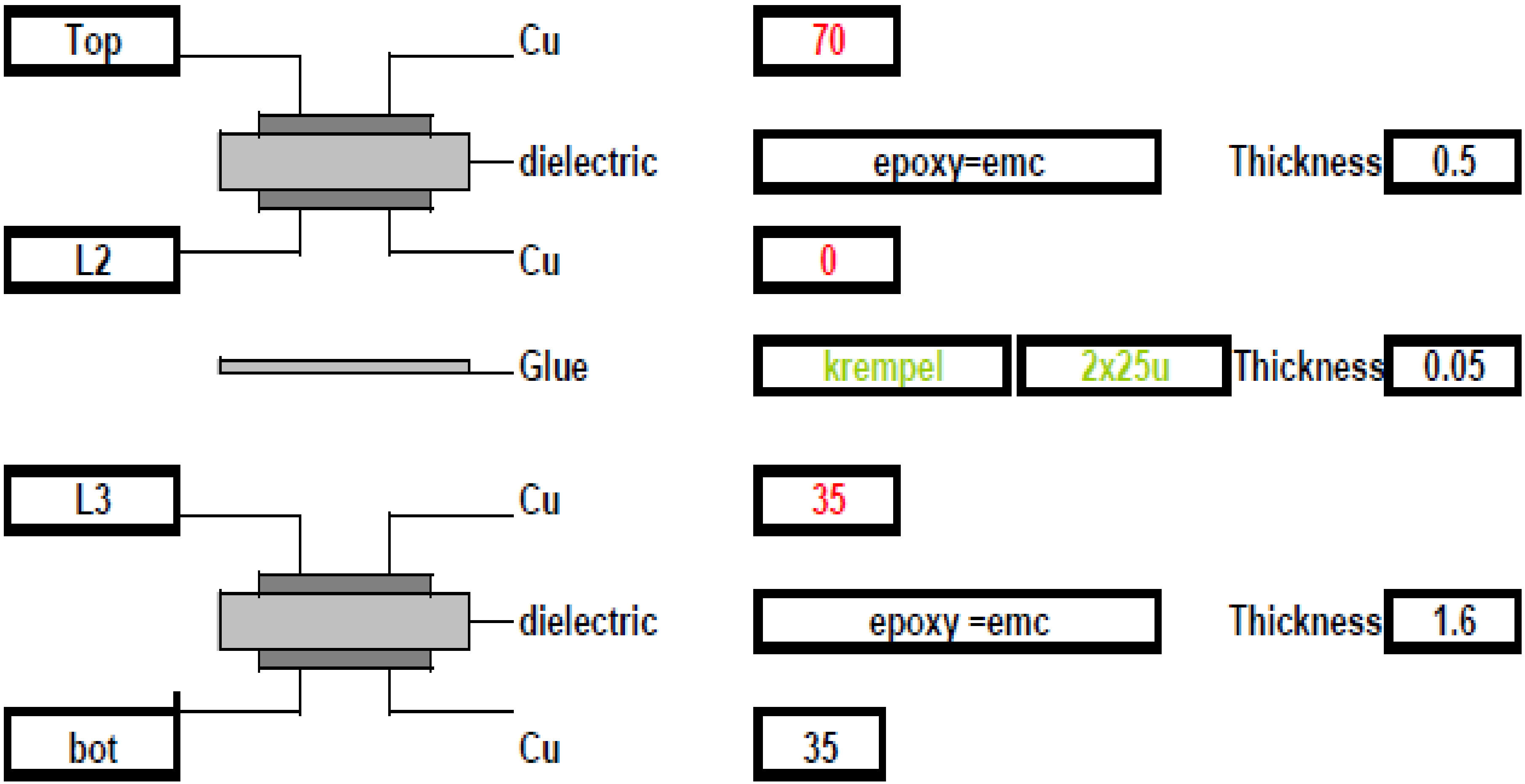
- Complete the first measurements
- Evaluate which of the four geometries is better in terms of sparks and gain stability
- Evaluate if detector is damaged by sparks (no resistive cathodes for first prototypes in order to be compatible with industrial production)

- Try other gas mixtures (e.g. Ar:CO2 93:7)
- Test in cosmic stand

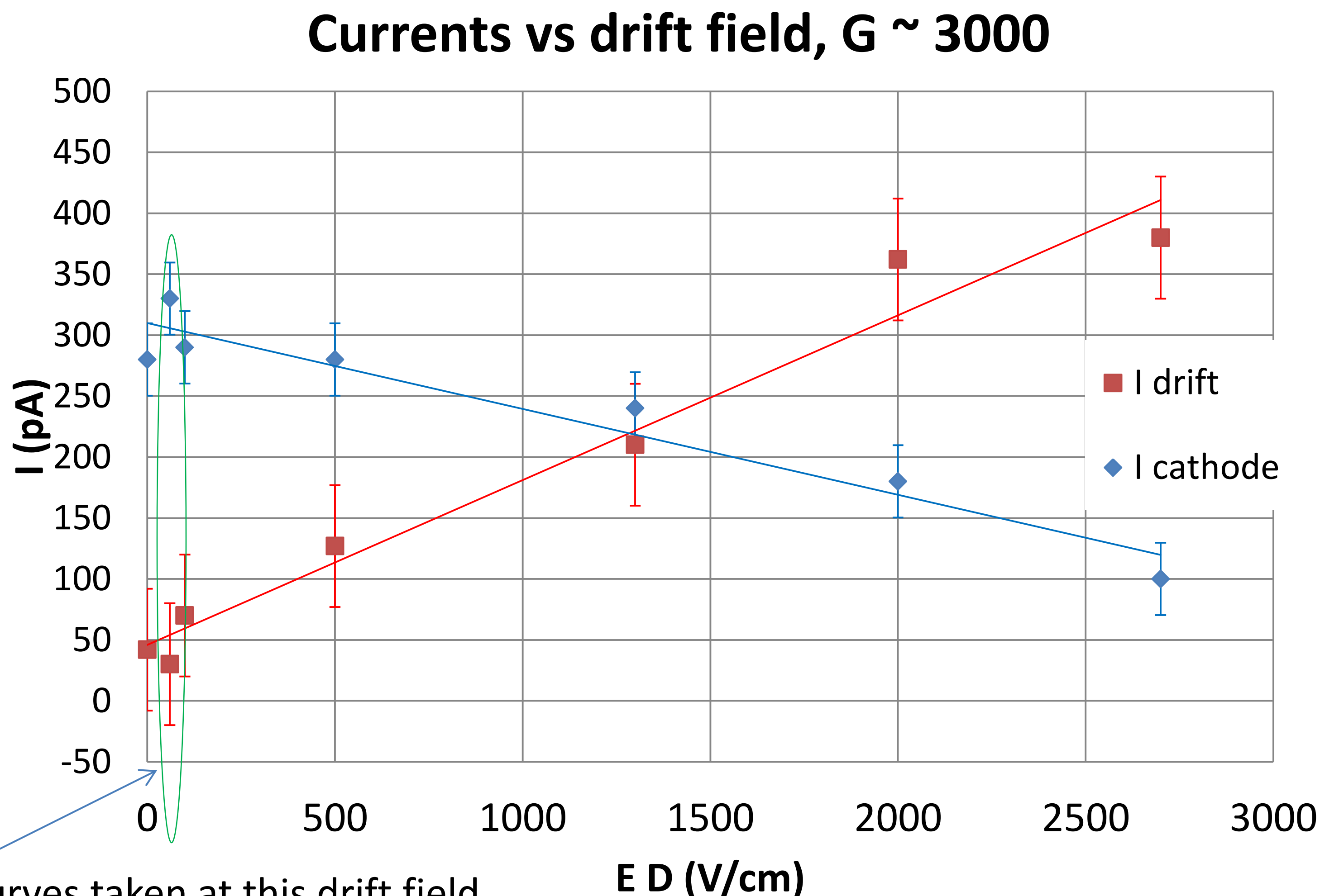
- Chemical cleaning and retest (evaluate best procedure for cleaning, compatible with industrial production)

- Construction of new prototype (improving alignment and flowing of glue)
- Optimization of groove thickness and width

Backup


Top
Cu
70
dielectric
epoxy=emc
Thickness
0.5
L2
Cu
0
Glue
krempel
2x25u
Thickness
0.05
L3
Cu
35
dielectric
epoxy =emc
Thickness
1.6
bot
Cu
35

Det 4, Vc 1350 (G ~ 3000).
Changing the drift field and monitoring currents on cathode and drift (ion movements)
Higher D field, more ions sucked to the drift



Gain curves taken at this drift field, error on estimation of gain through only I cathode ~ 10%

Chemical cleaning

Reduction of anode strips

Standard lithography process for anodes up to 40 um width

Protection of half of anodes

Micro etching for 20 um strips
Chromic acid bath
(etching time ~ 1um/min)

Gain uniformity