R&D on a Novel Fast Timing Micropattern (FTM) Gaseous Detector

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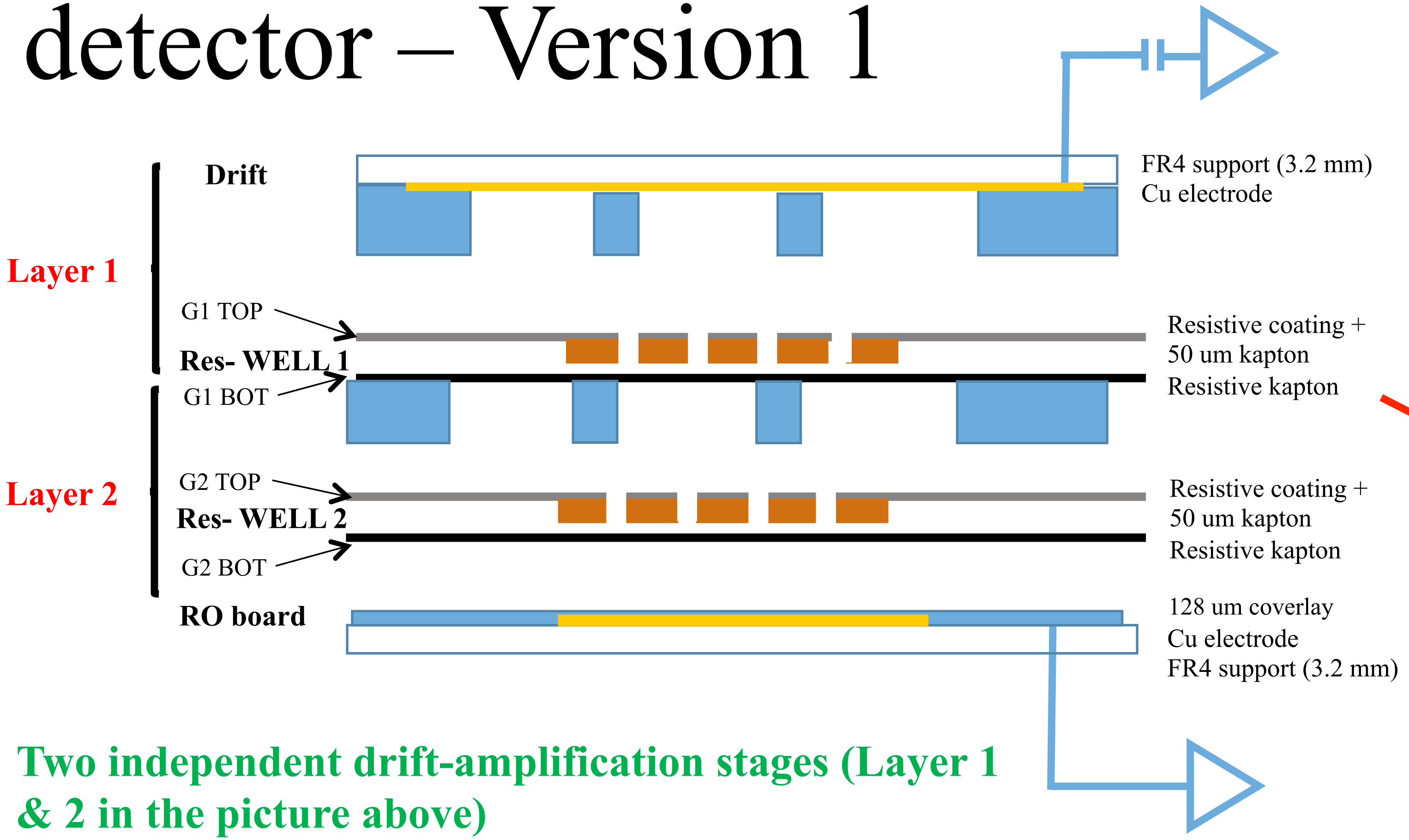
University of Pavia: F. Fallavollita
Gent University: S. Salva
INFN Bari: M. Maggi
CERN: S. Franchino, R. de Oliveira, A. Sharma, B. Dorney, J. Merlin

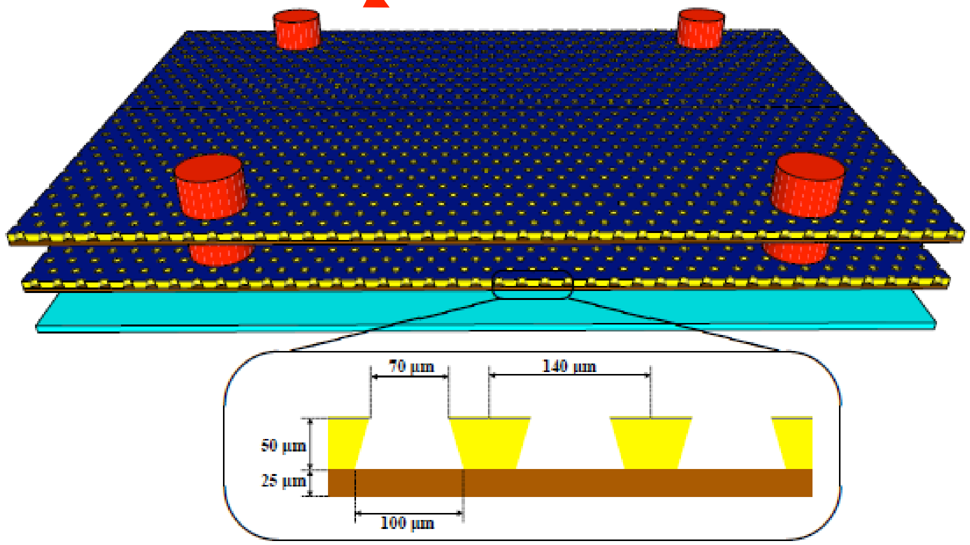
Fast Timing Micropattern Detector V1

Structure of the Fast Timing Micropattern (FTM) detector – Version 1



Two independent drift-amplification stages (Layer 1 & 2 in the picture above)

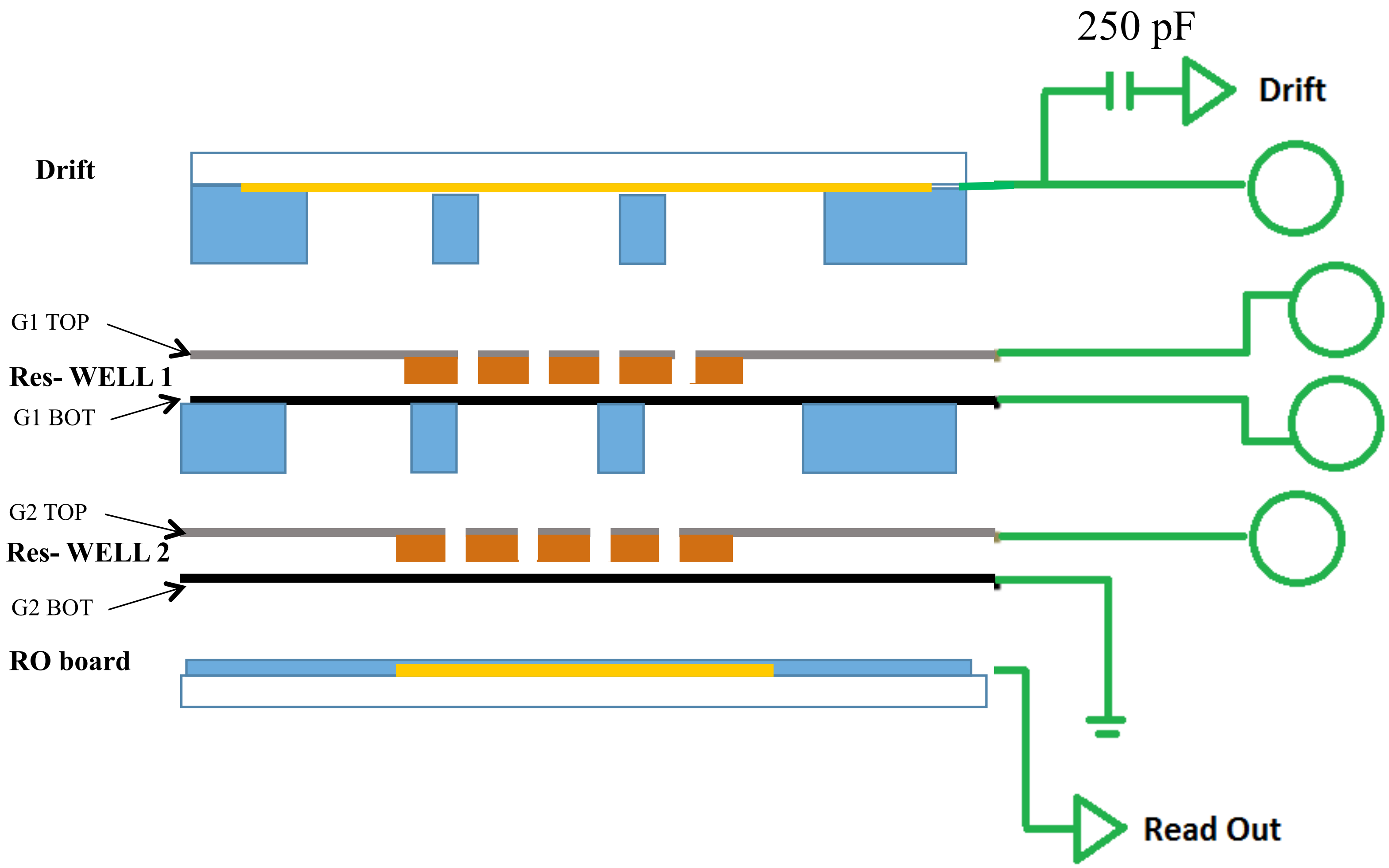
Reference:
R. De Oliveira, M. Maggi, A. Sharma, **arXiv:1503.05330v1**



- **DLC coating on the top**
- **Chemical etched foils**
- **Antistatic polymide foils**
- Two layers separated by **Pillars**
- **Pick-up electrode**

For similar studies see G. Bencivenni et al, 2015 JINST 10 P02008

Test with X-Ray – Diagram of the connections



Signal read at <u>the same time</u> from **ReadOut** and from **Drift** (through capacitive coupling) → important to check the *transparency* of the layers

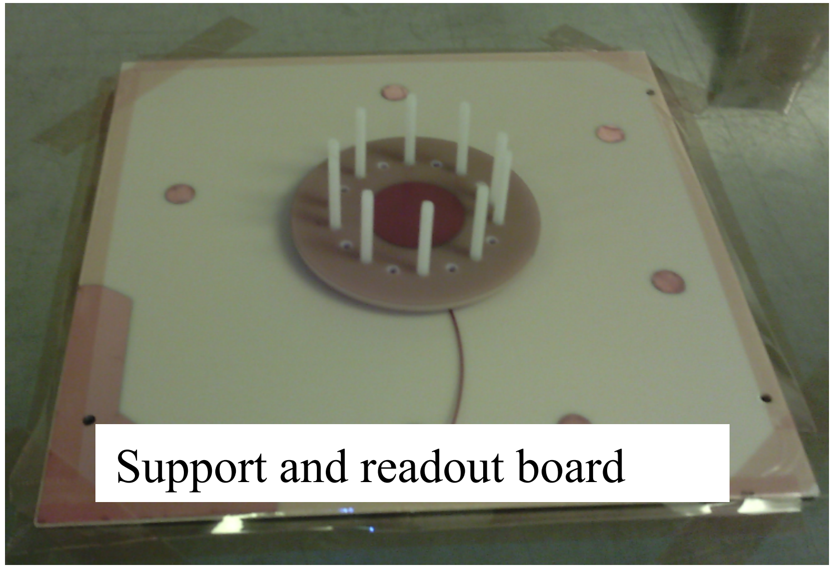
HV applied to:

- Drift
- G1 Top
- G1 Bottom
- G2 Top

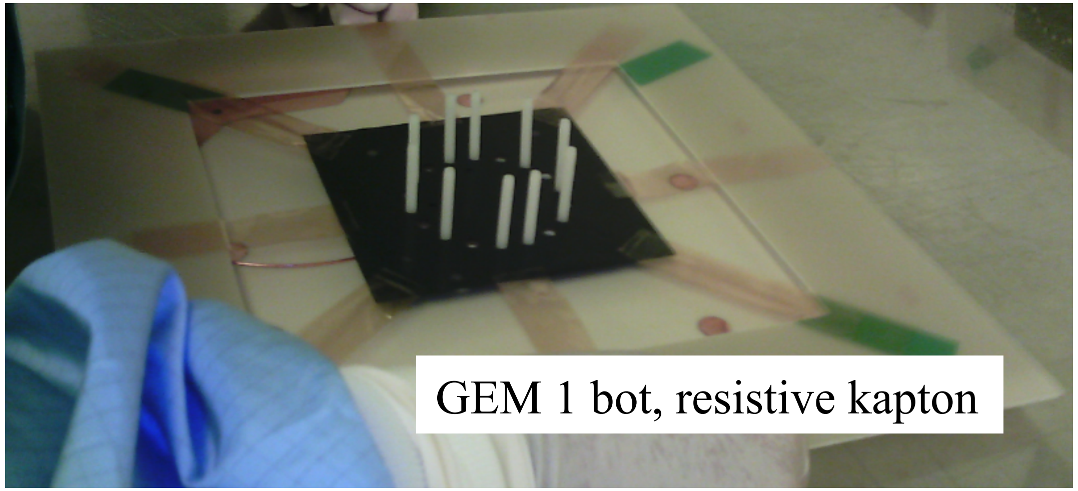
G2 Bottom always at Ground

→ <u>Different HV diagram depending on which Layer is on study</u> → dedicated diagrams in next slides

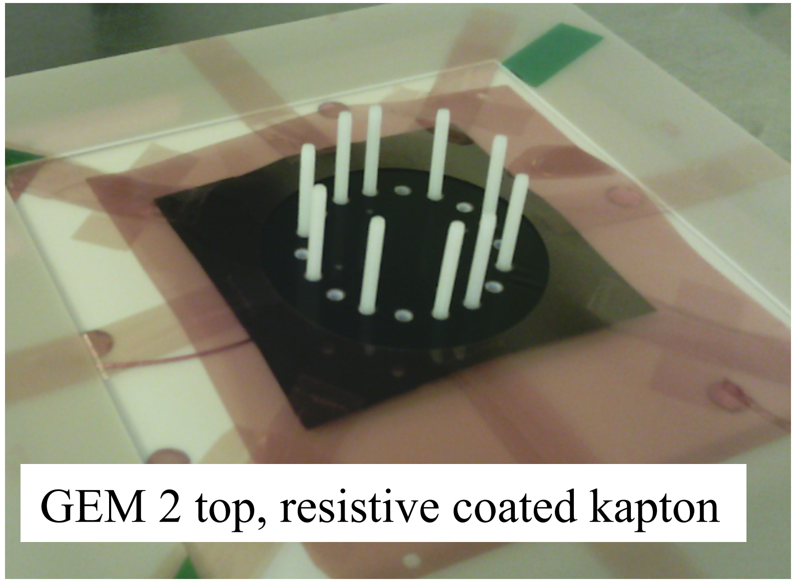
Some pictures of the assembly



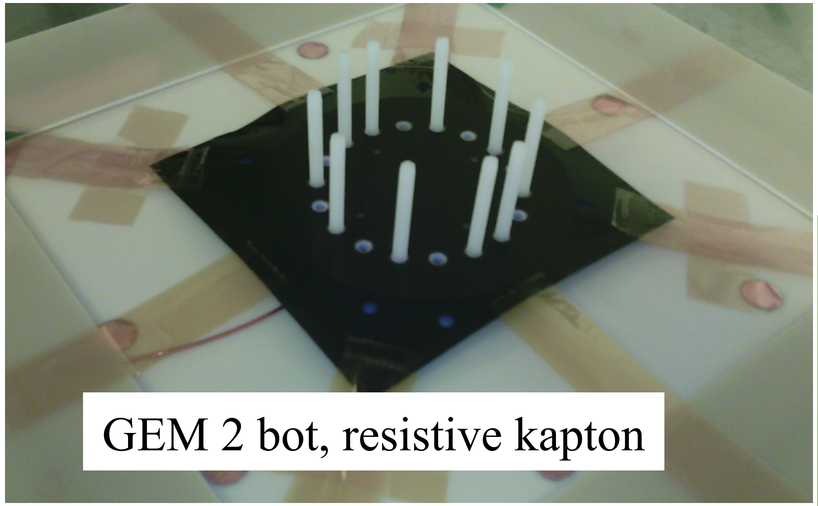
Support and readout board



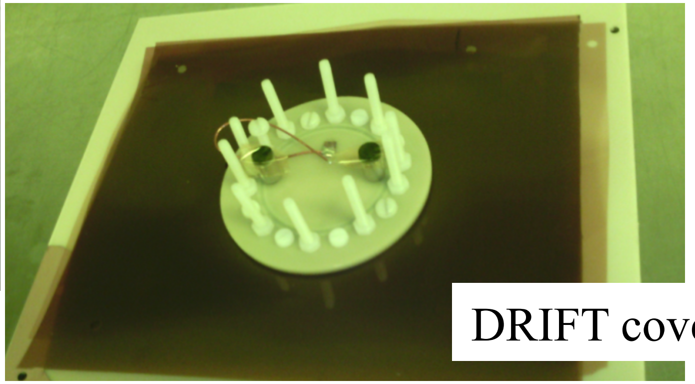
GEM 1 bot, resistive kapton



GEM 2 top, resistive coated kapton



GEM 2 bot, resistive kapton



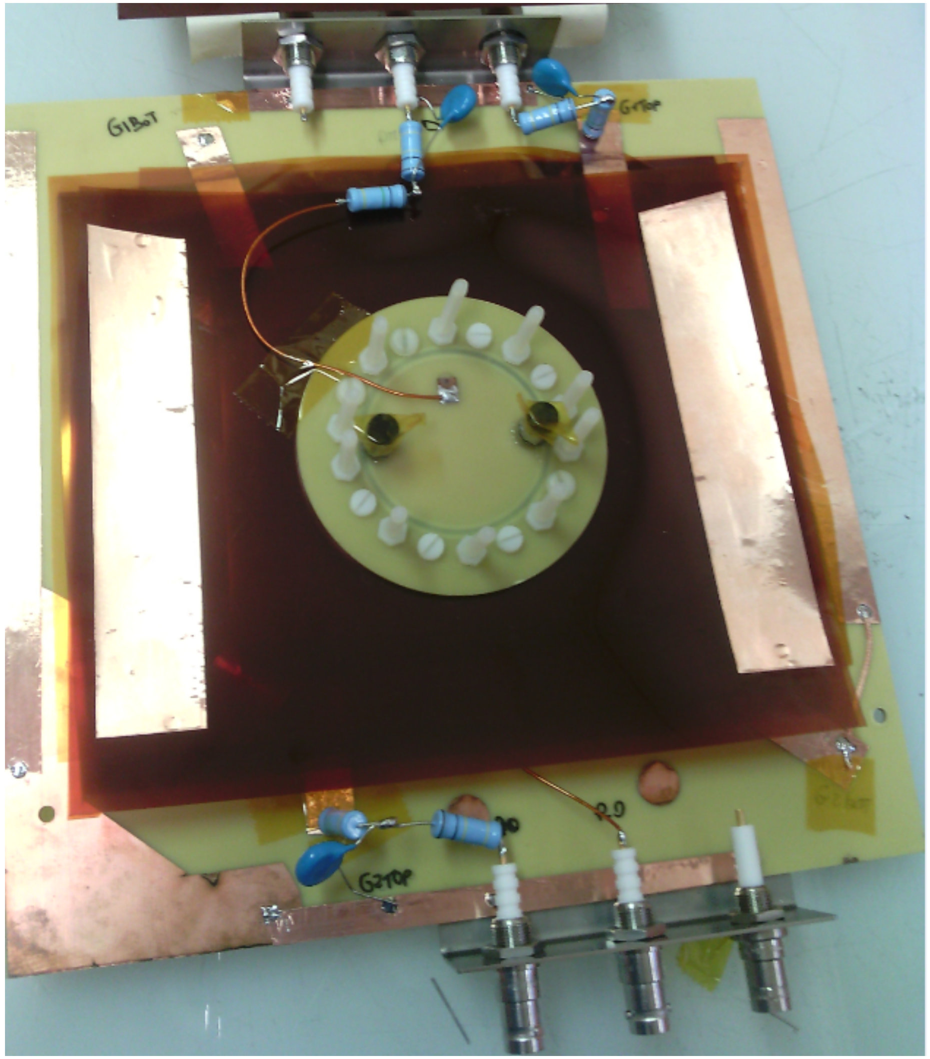
DRIFT cover and gas connectors

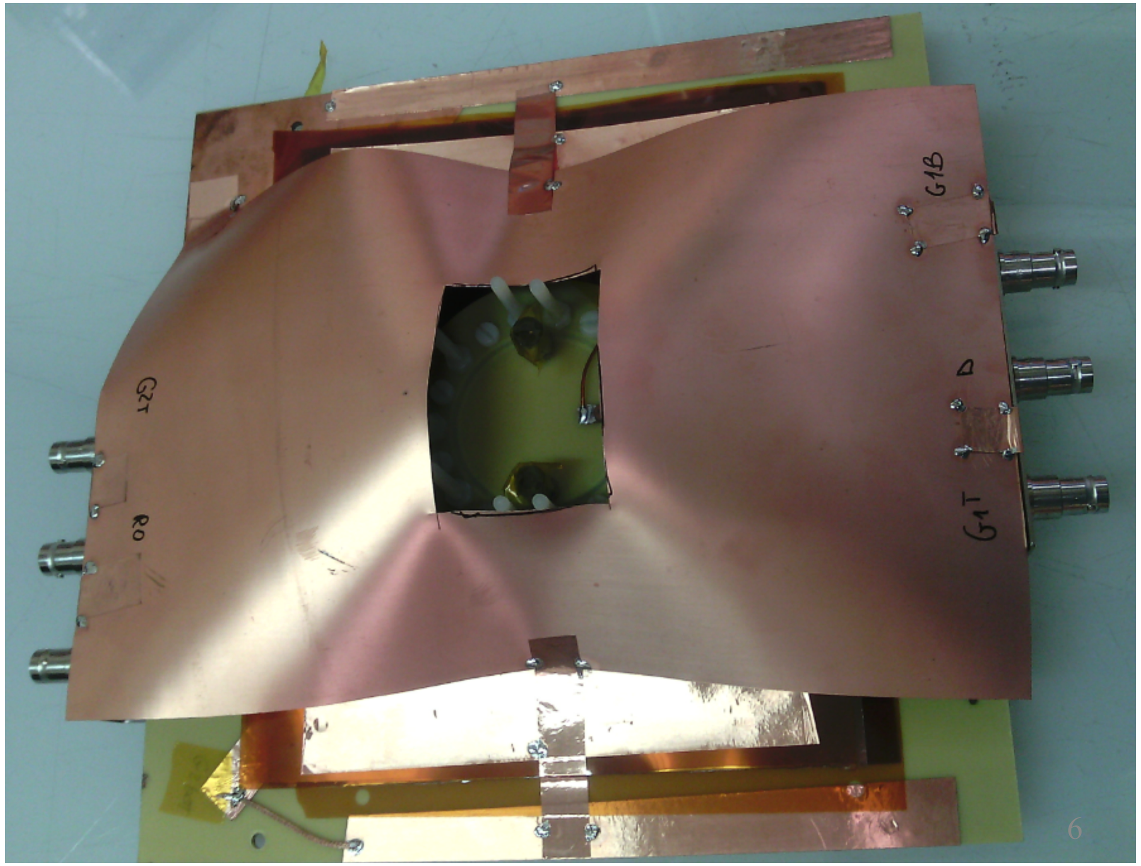
HV schema

HV filters on each channel:
G2BOT at ground

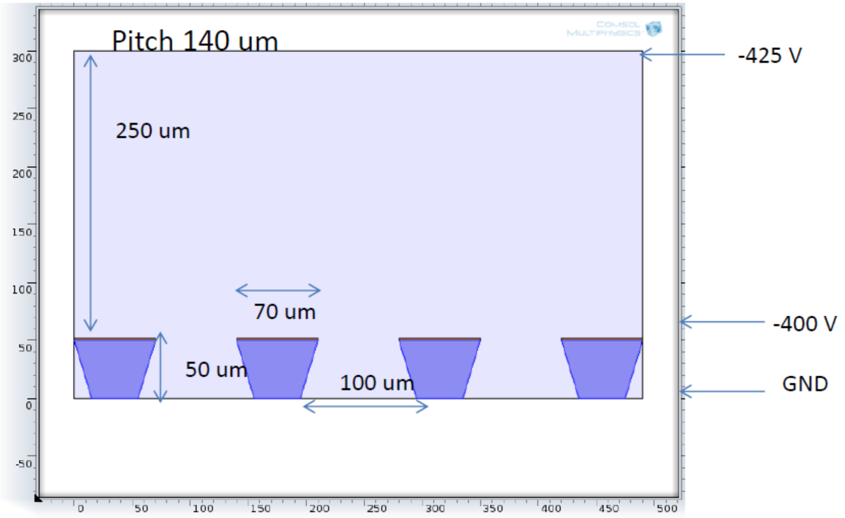
HV — 100kOhm — 1MOhm — layer

(between 100kOhm and 1MOhm) — 2nF — GND

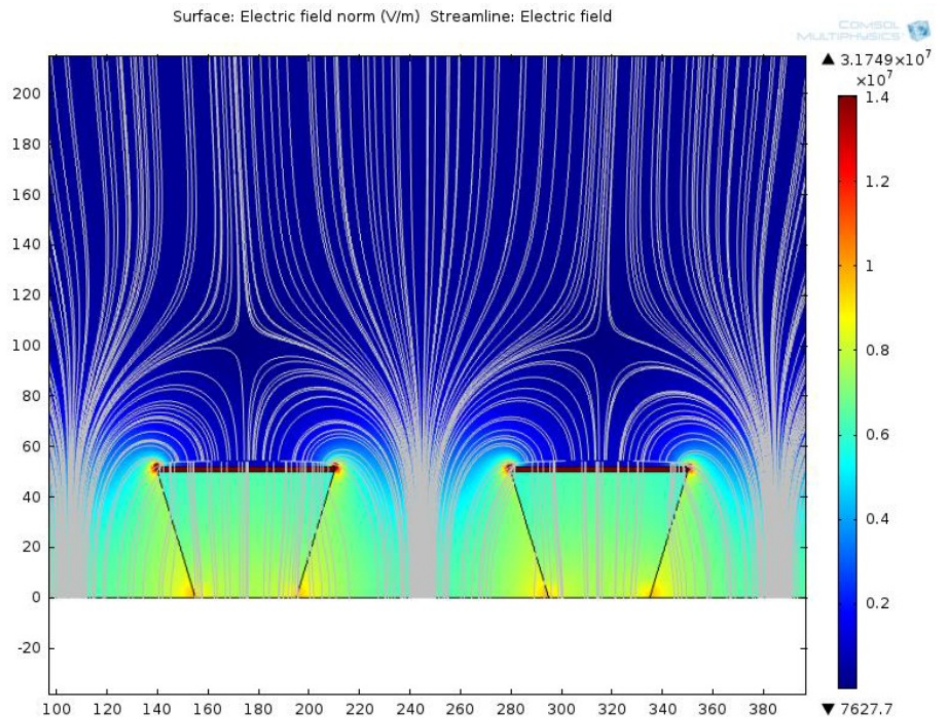




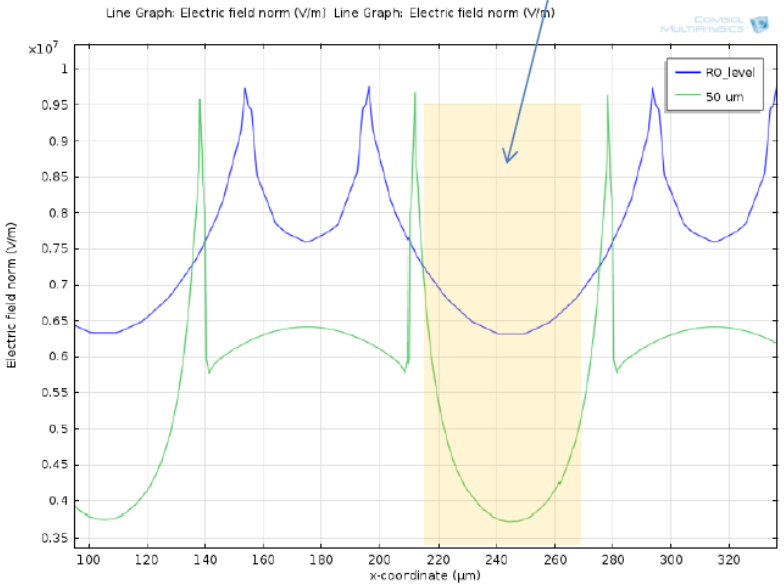
COMSOL simulations



Electric field (V/cm)



Amplification region



Electric field on horizontal lines

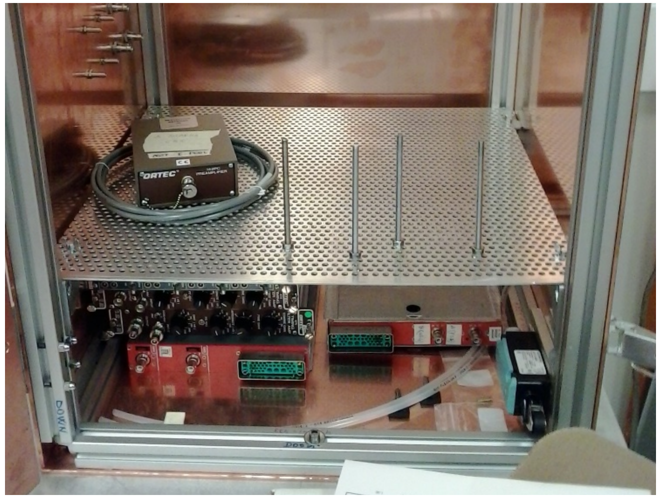
S. Franchino

New X-Ray box at TIF

X-Ray box completed and approved by RP on 22nd of June

Source: Ag - MiniX Amptek
- Flux: 10^6 s^{-1} mm^{-2} on the axis at a distance of 30 cm (50 keV/1 μA)
- Movement on X-Y-Z direction

Equipped with:
- 6 gas connectors (3 in + 3 out)
- 8 SHV connectors
- 8 LEMO connectors for signal
- 2 RS232 connectors for Preamp supply



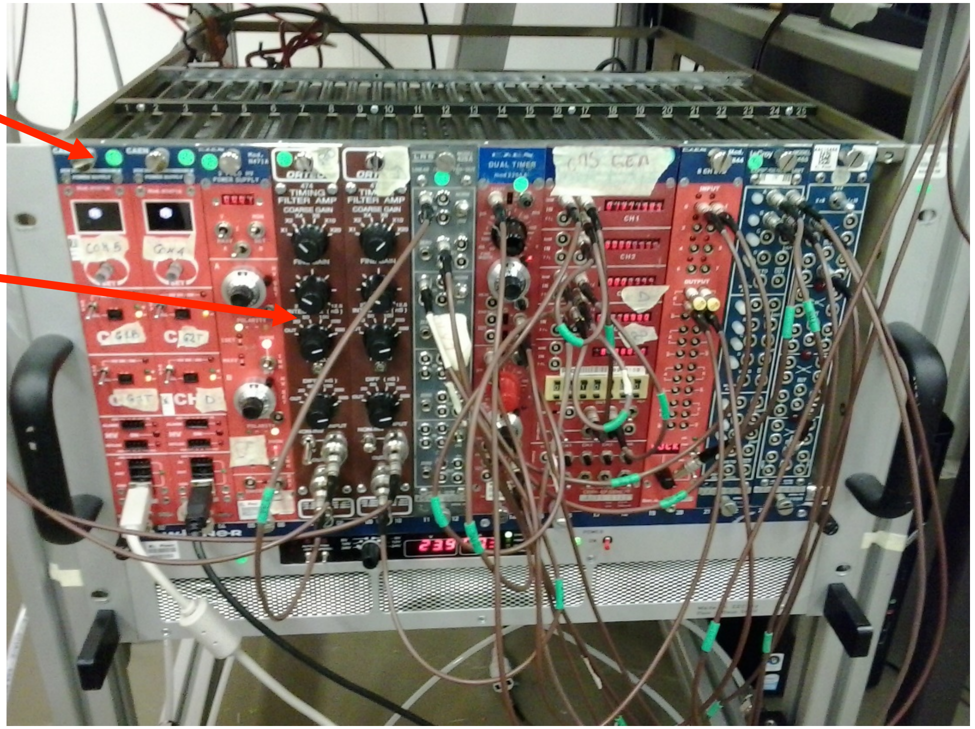
Shelf to place and fix the detector under the X-Ray

Setup available

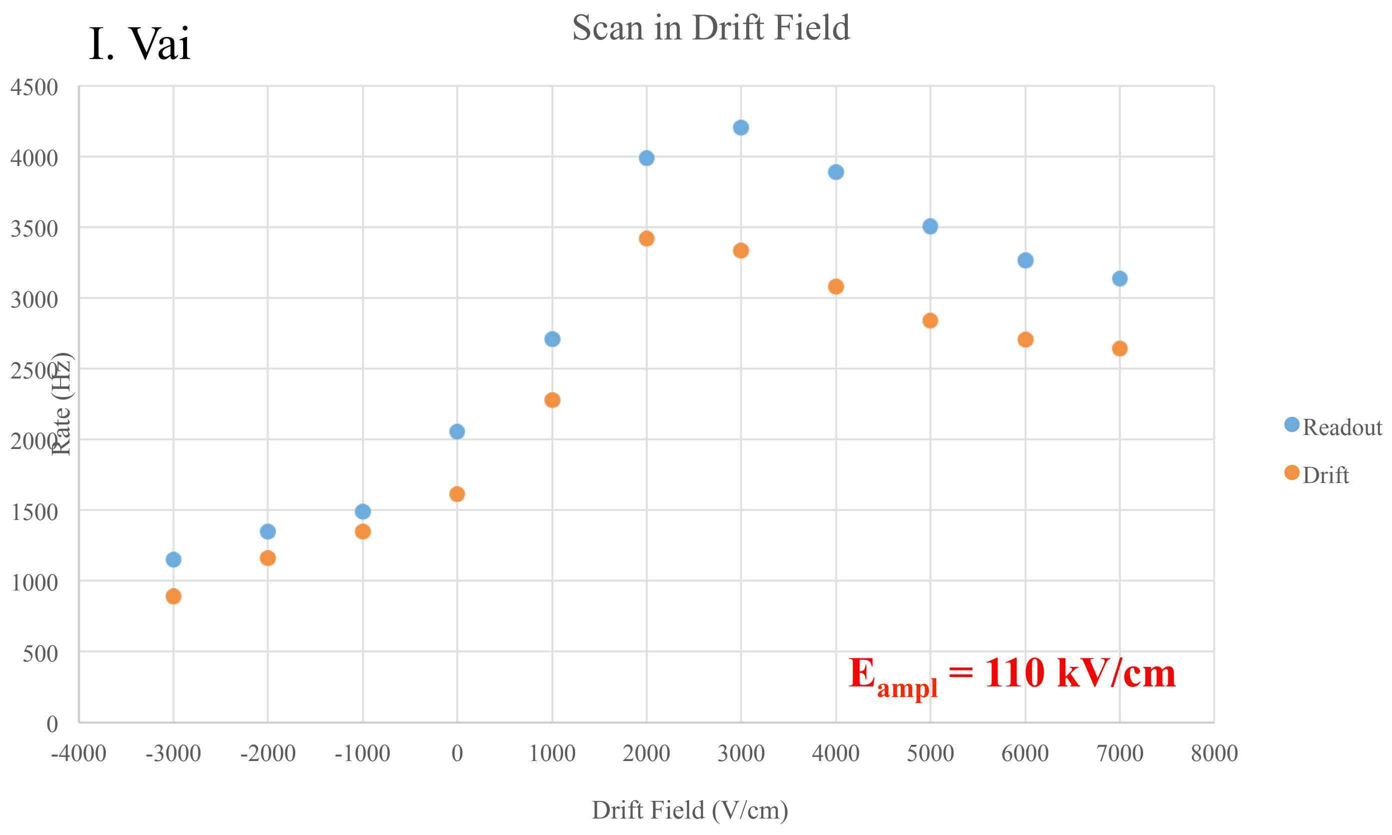
Gas System:
- In/Out Gas Line with Ar/CO2 70/30 from the TIF Gas System → **Flow**: 0,3 l/h
- Bottle Ar/CO2 97,5/2,5 + 2 Flowmeters + Pressure Regulator for independent Gas System

HV System:
- 2 Caen N1471A with 4 channels in total
- Caen GeCo software for the remote control of the modules

Readout chain:
- 2 Preamp ORTEC 142PC
- 2 Amplifiers ORTEC 474
- 1 Fan-IN-Fan-OUT
- 1 CAEN N844 discriminator with 1 mV – step threshold
- 1 Dual Timer
- 1 Coincidence unit
- 1 Logic Fan IN – Fan OUT
- 1 Scaler
- Scope



Some results



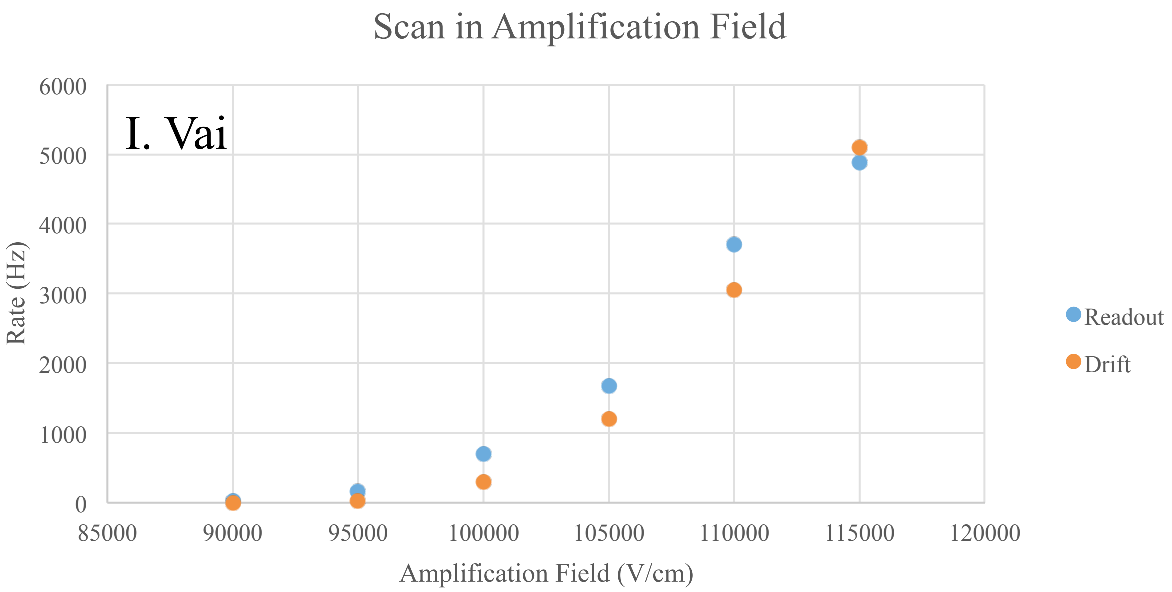
Error bars contained in the markers

As **the gap is really small (~ 250 μm), the amplification field penetrates in it** → even if the drift field is 0, particles in the gap feel the amplification field and move towards the amplification region

→ to compensate this effect and reduce the interaction rate to 0 we had to apply an **inverted Drift field**

This effect is confirmed also by COMSOL simulations

Result obtained with just one amplification stage ON



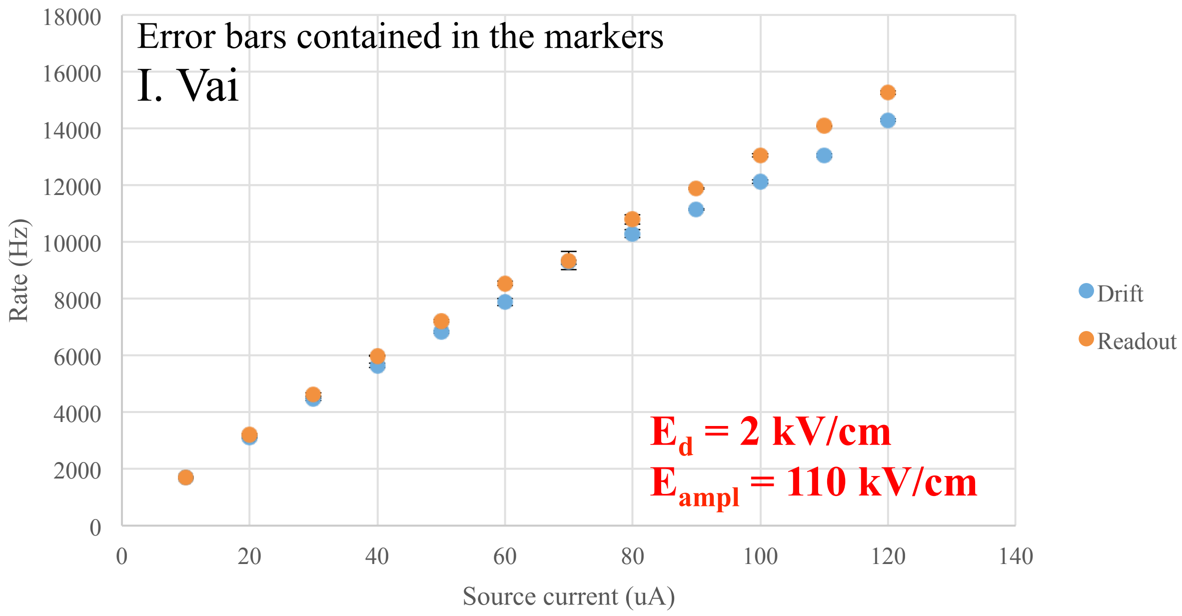
The scan in amplification field gives an <u>indication of the operational value</u> of the layer.

Over 120 kV/cm the layer starts to be **really noisy** (up to 500 Hz of noise)

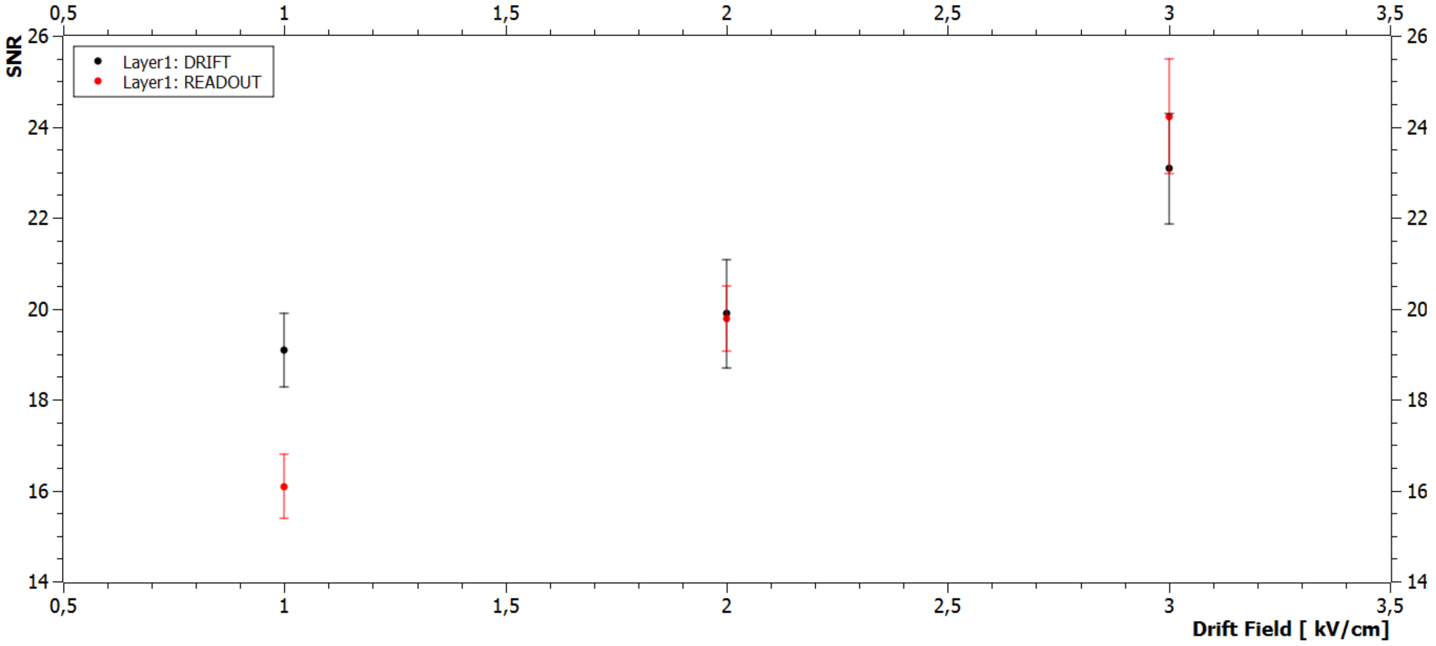
The **rate is linear** with the incident flux for both the series.

The differencies betwen the two series may be due to <u>not perfect settings of the discriminator thresholds</u>

Study of linearity of response



Result obtained with just one amplification stage ON



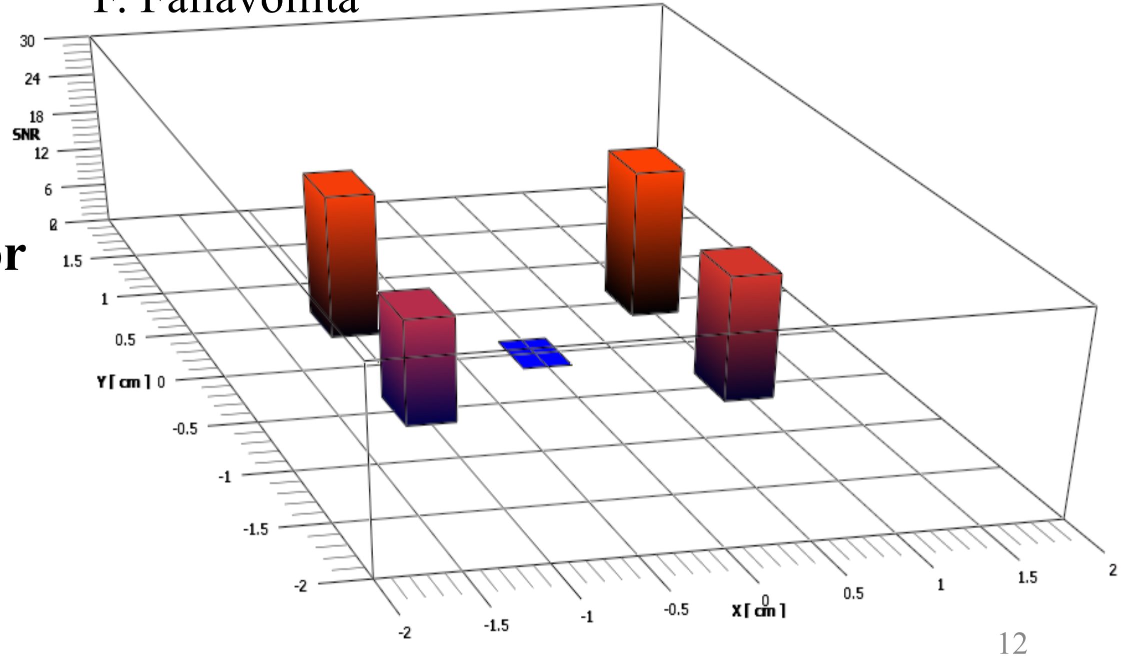
Signal/Noise for drift and readout signals

$E\downarrow Amp = 110\ kV/cm$

$E\downarrow Drift = (1 \div 3)\ kV/cm$

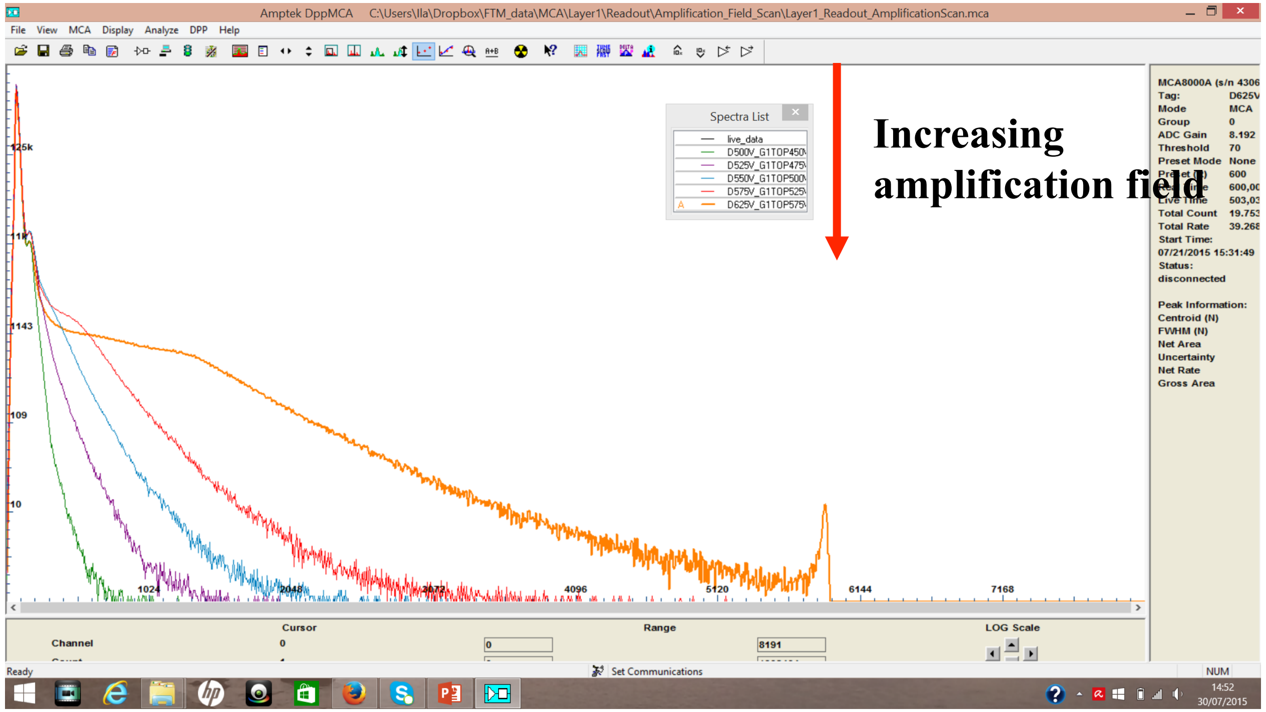
F. Fallavollita

Study of uniformity over the detector surface of Signal/Noise for readout signal



Result obtained with just one amplification stage ON

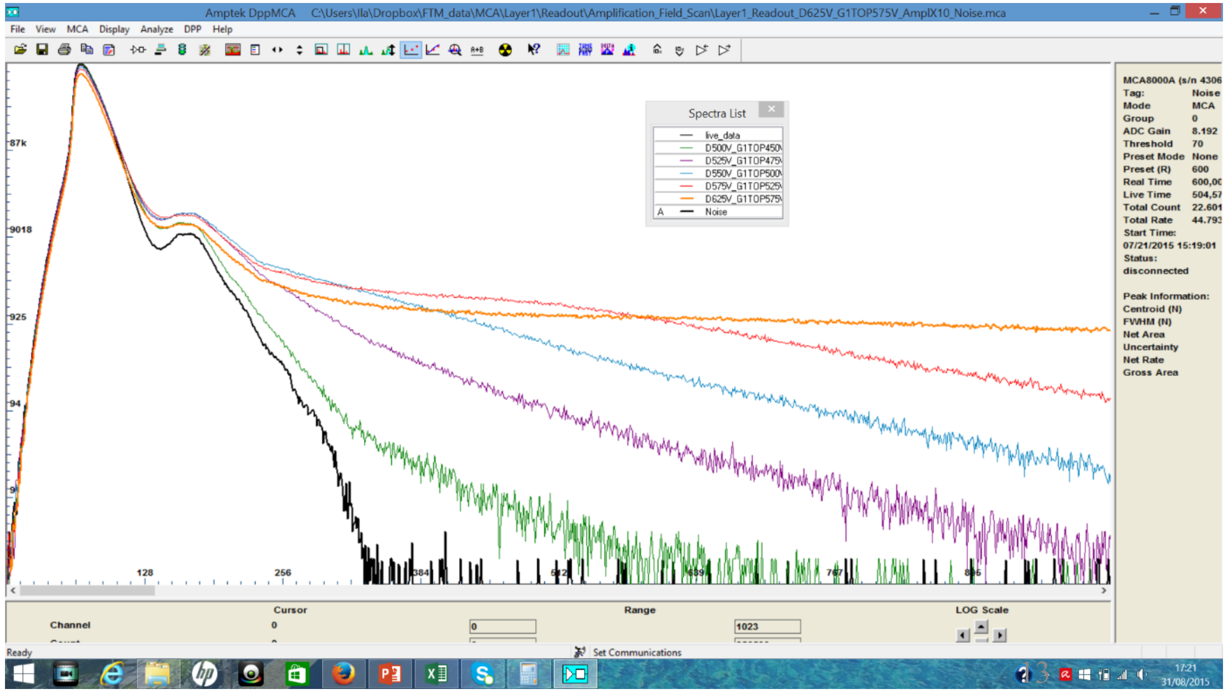
Some spectra



Increasing amplification field

I. Vai

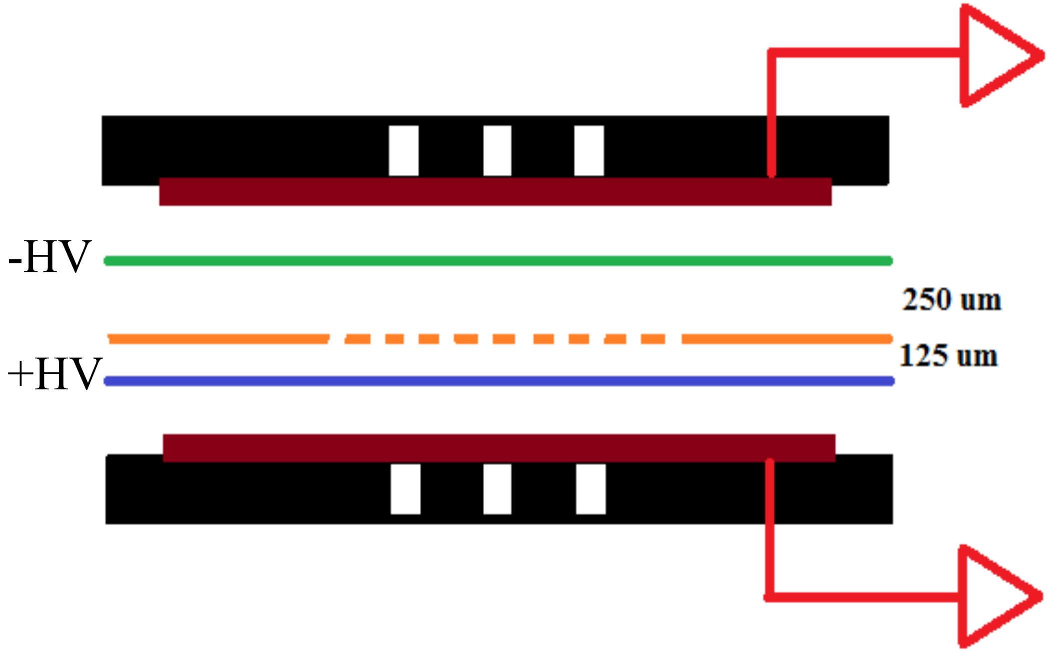
Zoom
With noise curve (in black)



Result obtained with just one amplification stage ON

Fast Timing Micropattern Detector V2

Fast Timing Micropattern 2 (FTM-V2) detector



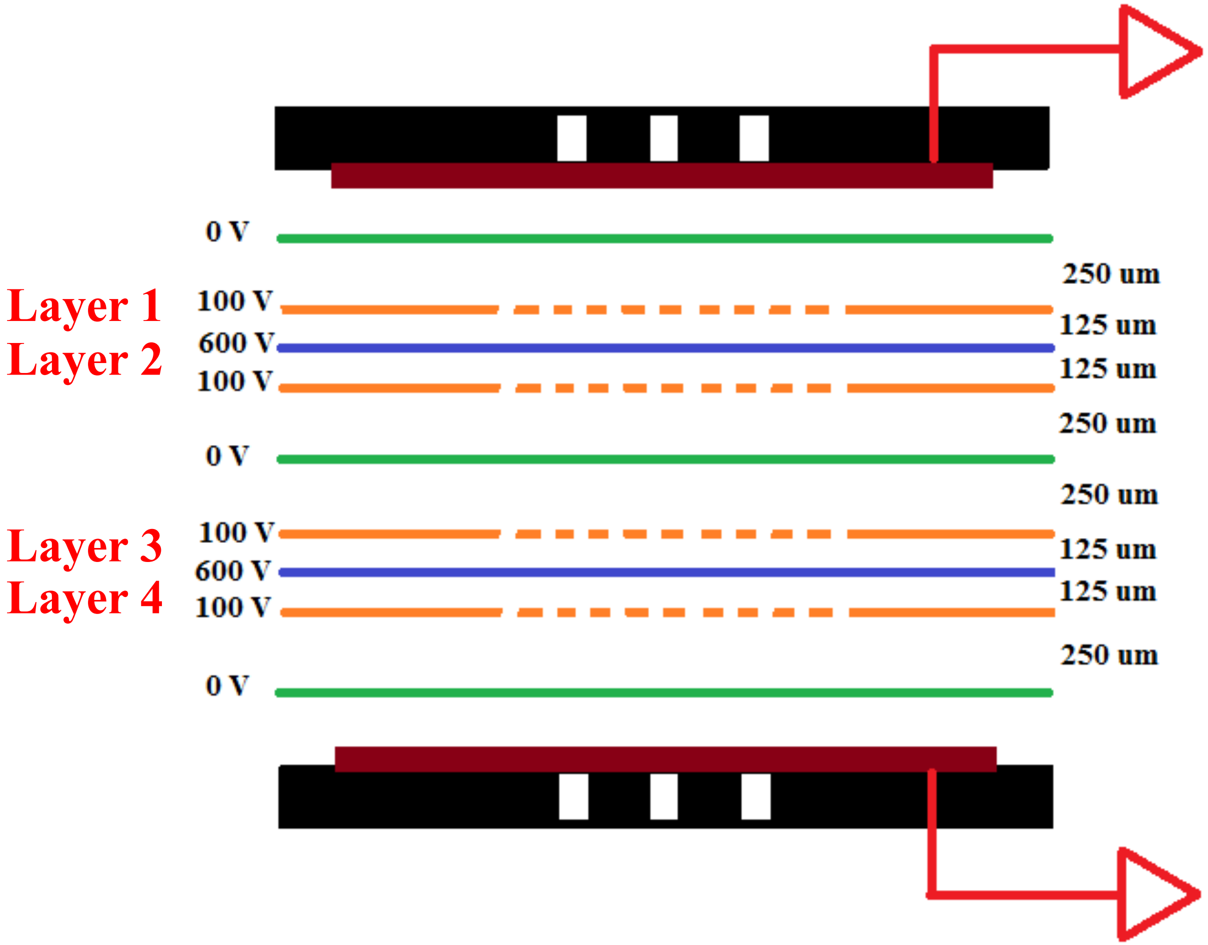
First prototype with just one amplification layer

Already assembled → test started at TIF

Resistive Micromegas-like structure

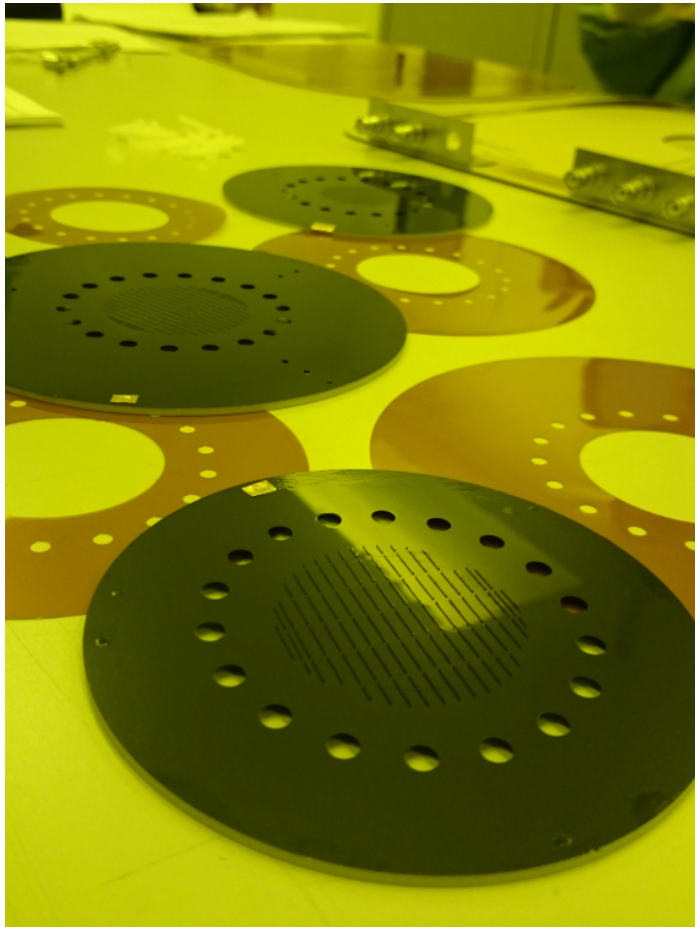
- All materials are flexible foils (drift, mesh, anode)
- Resistive foils are made by 25um XC Dupont Kapton
- The top and bottom PCBs are made by standard FR4 PCB material
- Pillar between each foil is 125 or 250um thick photosensitive coverlay

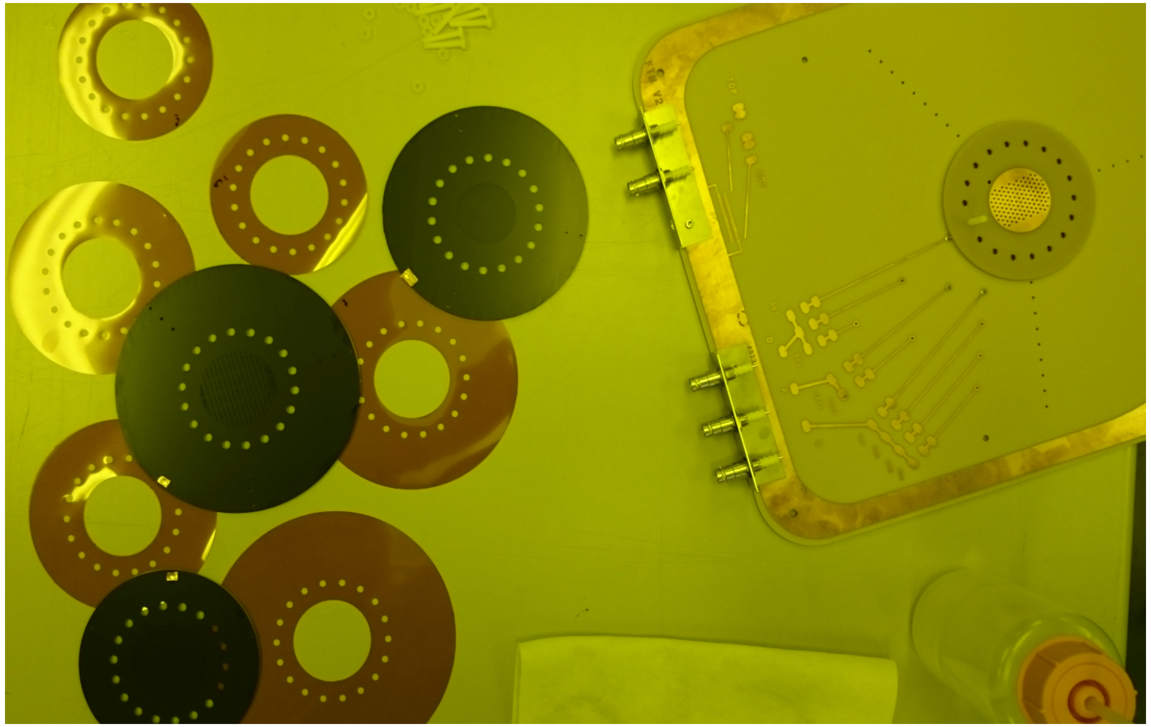
Fast Timing Micropattern 2 (FTM-V2) detector

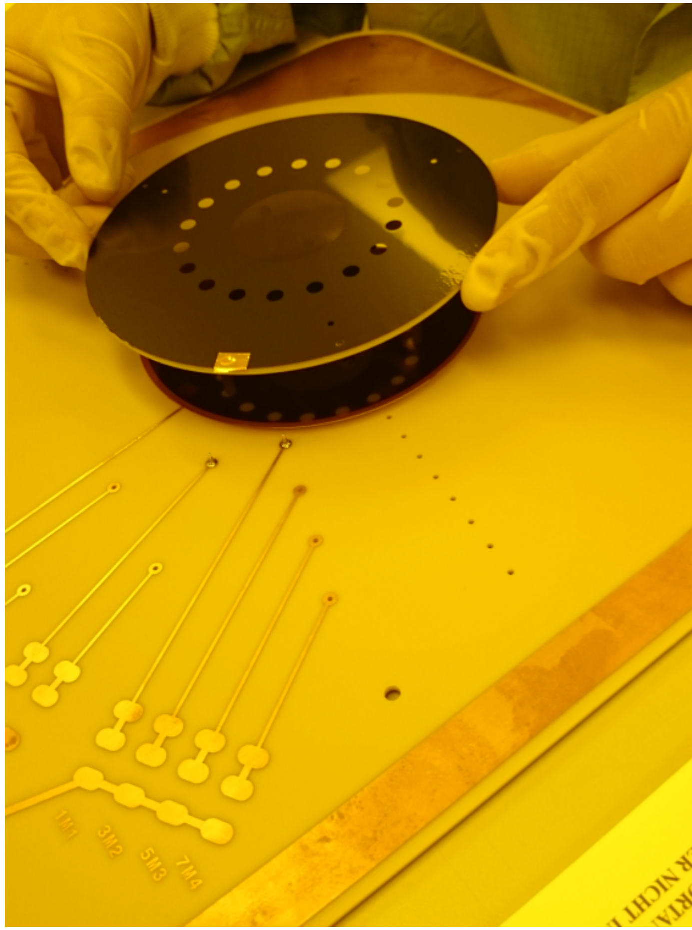


Final design with 4 amplification layers

Assembly of Fast Timing Micropattern 2 (FTM-V2)

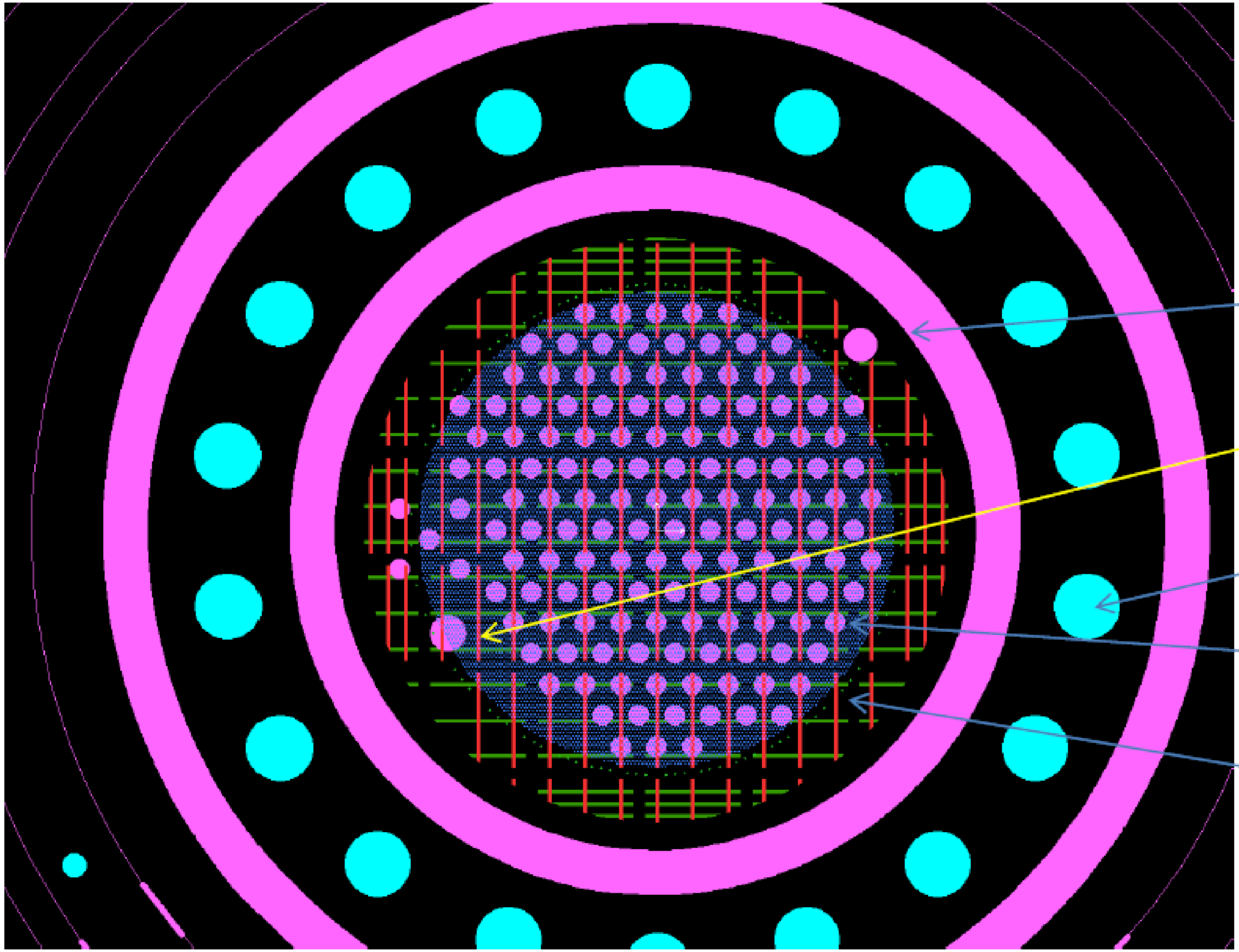






The design

Top view



Red: Pillar 250 um hight, 300um width
Green: pillar 125 um height, 300um width

Pink: Orings

Gas input

RO

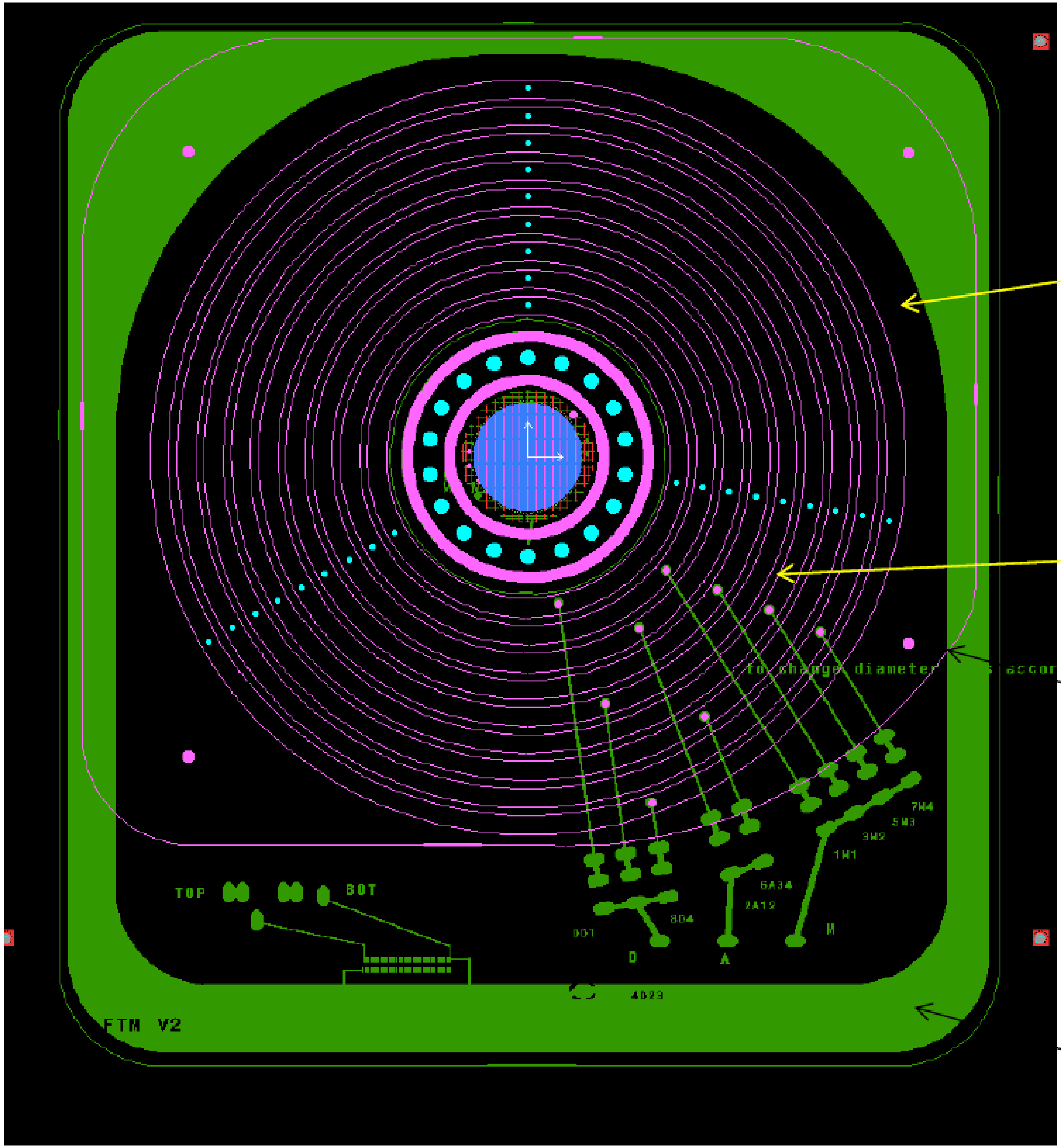
screws

1.5 mm holes in the PCB for allowing soft X rays to enter

Holes 250um in not drilled resistive kapton layers for gas circulation

S. Franchino

The design



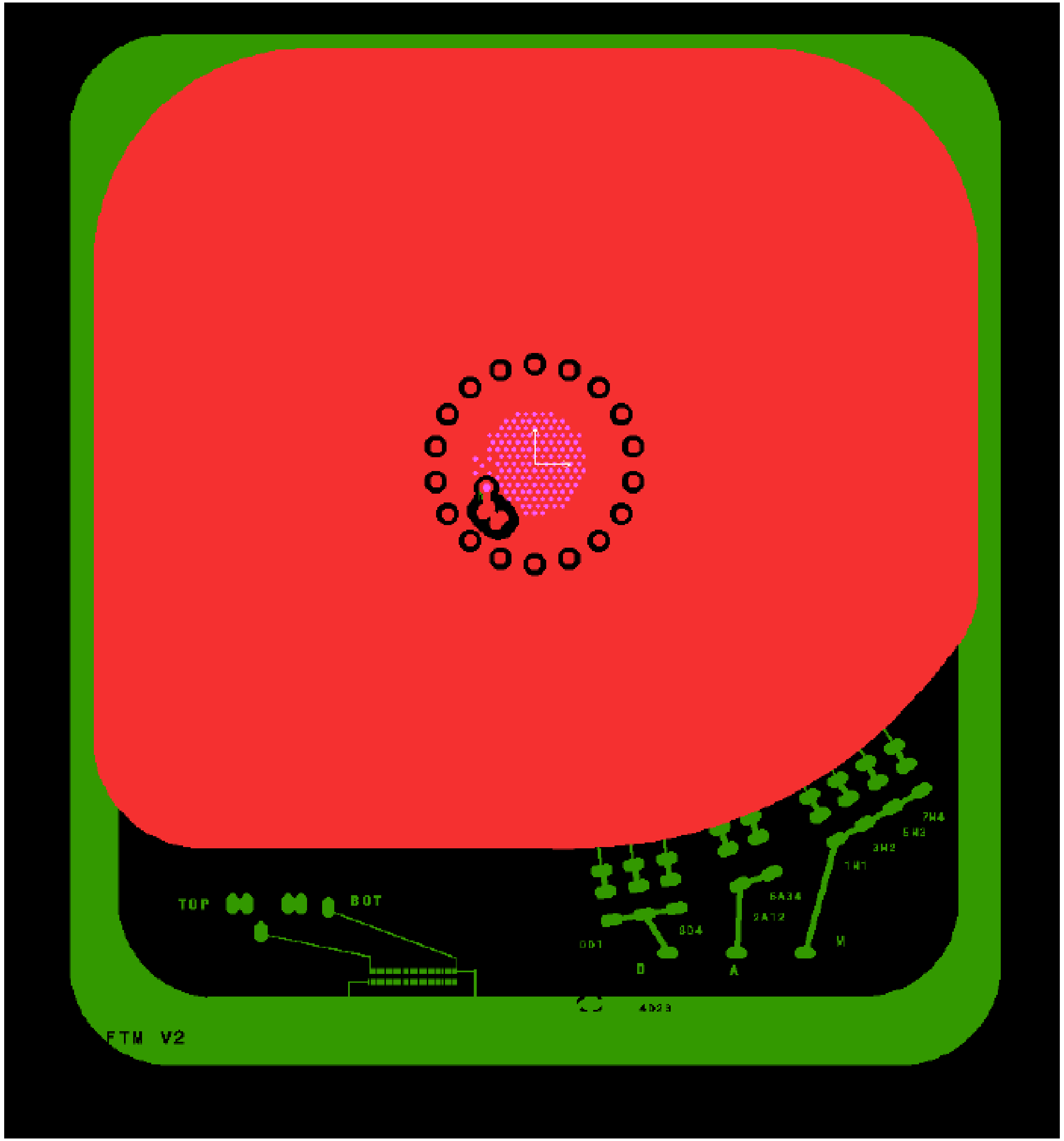
Frames with stretched resistive kapton foils

HV connections with pins with spring

PCB cover

Support PCb with HV and RO connectors (382 cm*350 cm)

The design



Overall view.

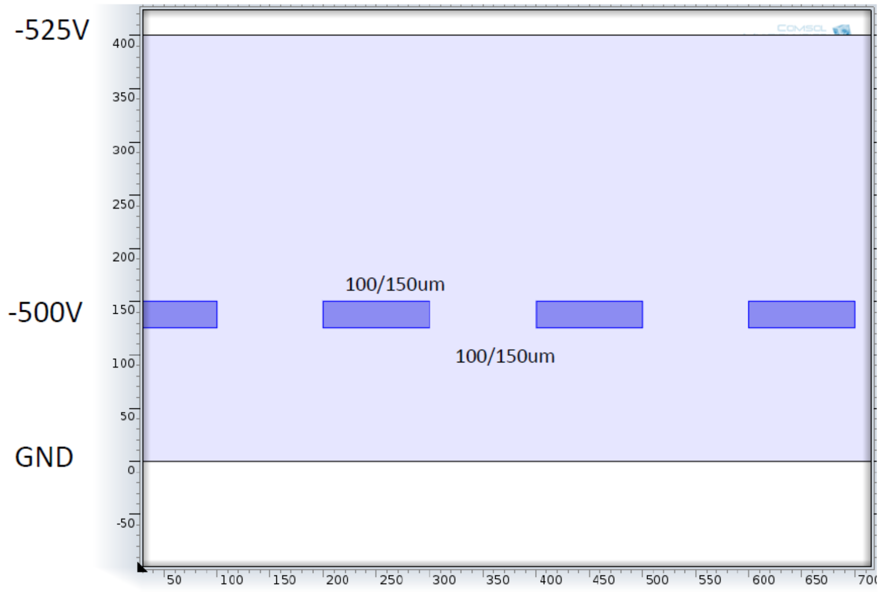
Red: Cu for top plane;

- RO pad
- GND

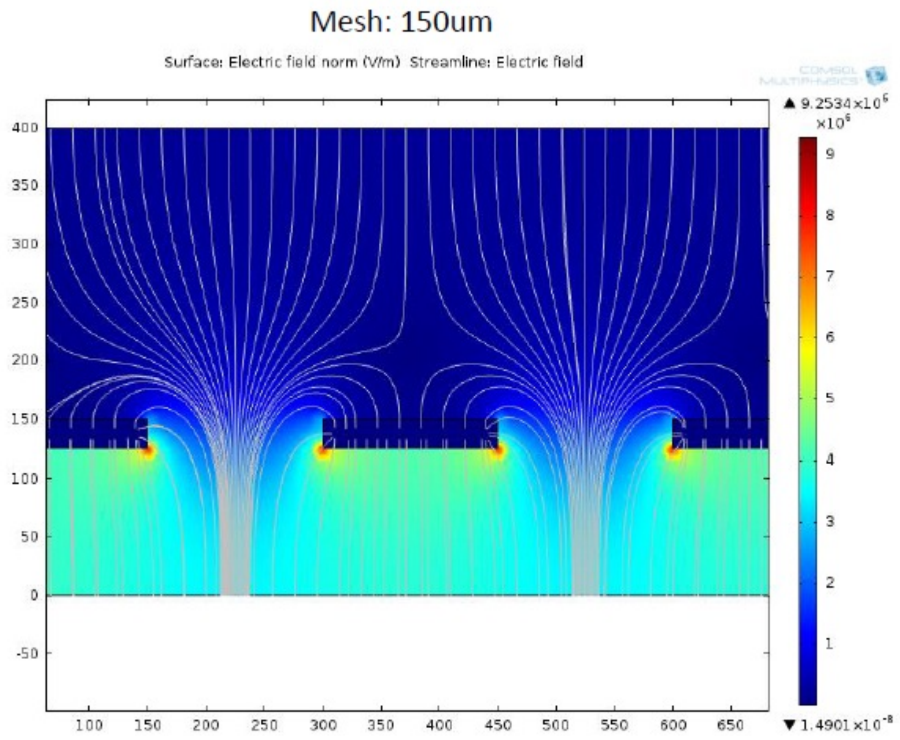
Green: Cu support plane

- GND
- HV connections
- RO pads
- RO panasonic connector

COMSOL Simulations

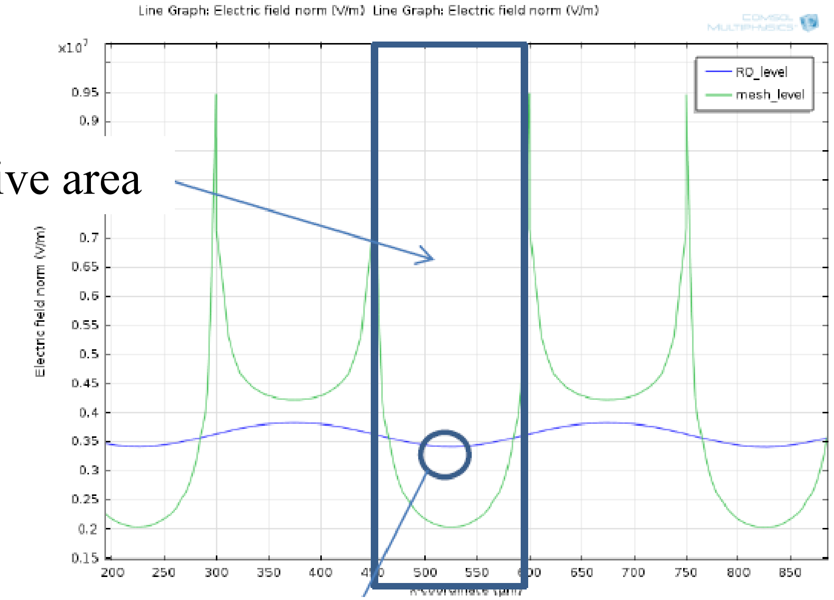


Electric field (V/cm)



Mesh: 150um

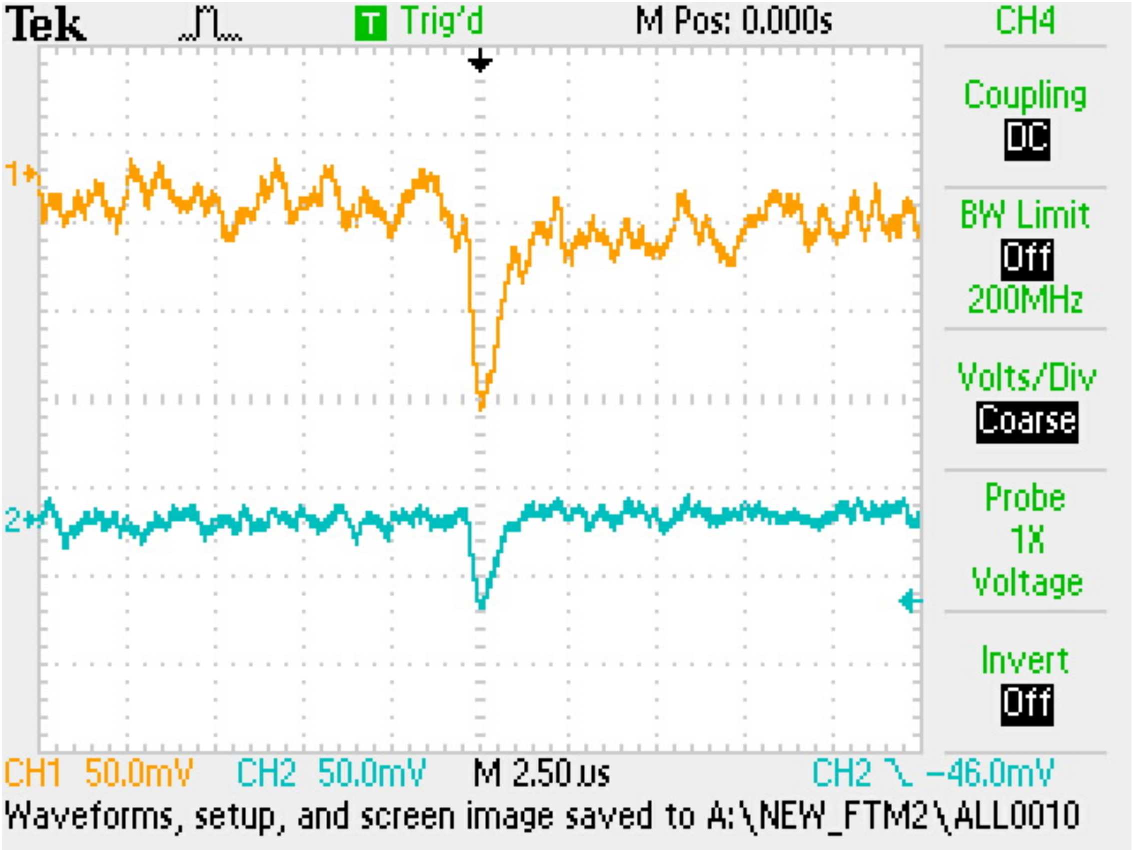
Active area



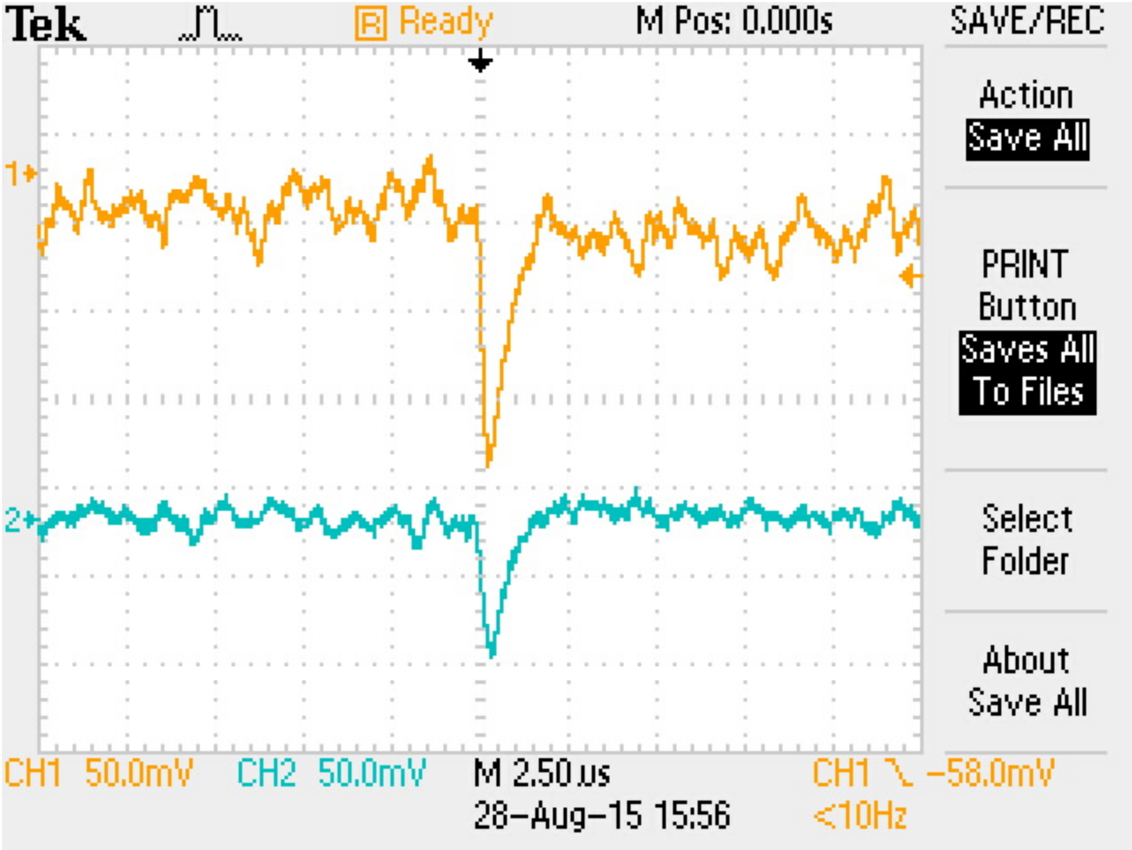
Electric field on horizontal lines

S. Franchino

Waveforms acquired with FTM-V2

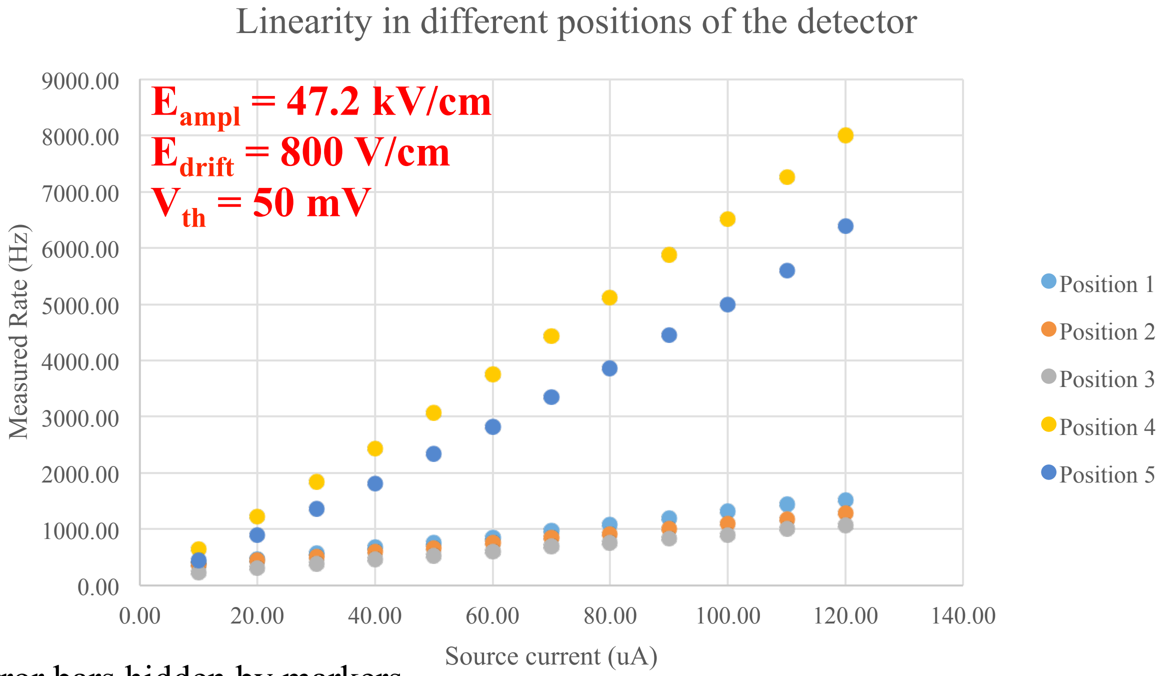


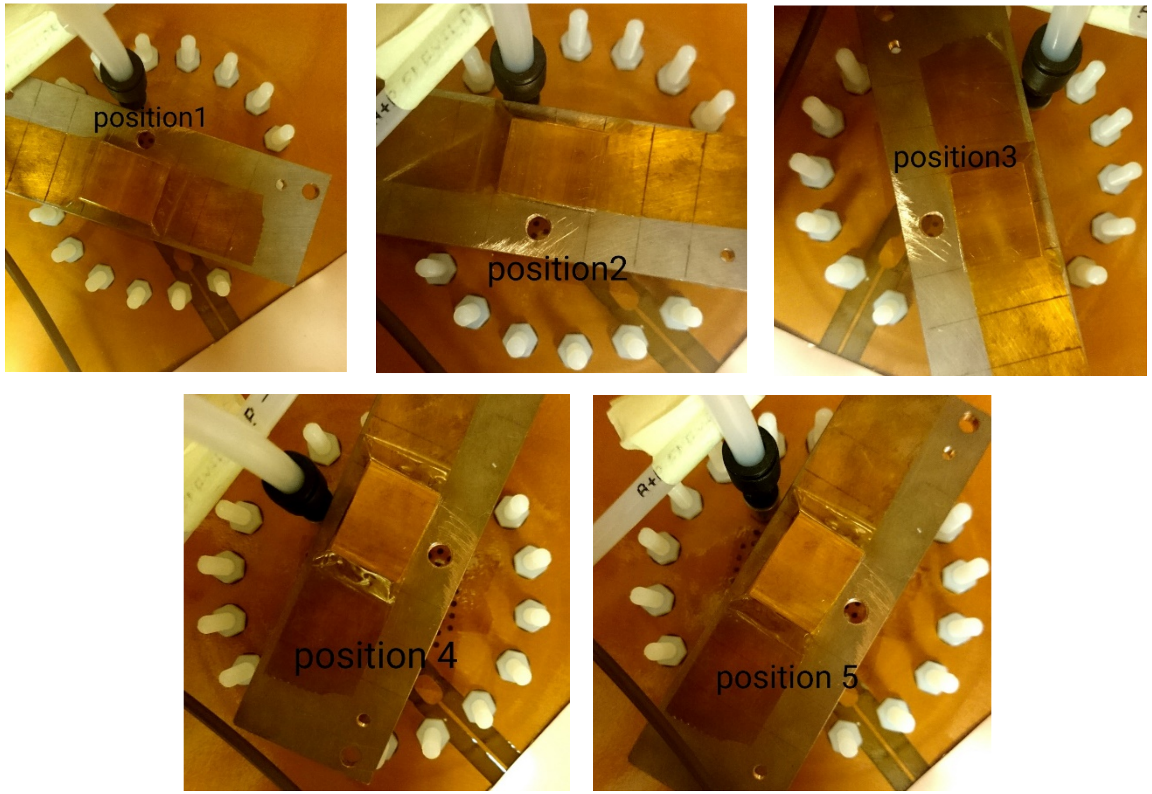
Ar/CO2 70/30
X-Ray source



Ar/CO2 70/30
109Cd source

One result…





Error bars hidden by markers.

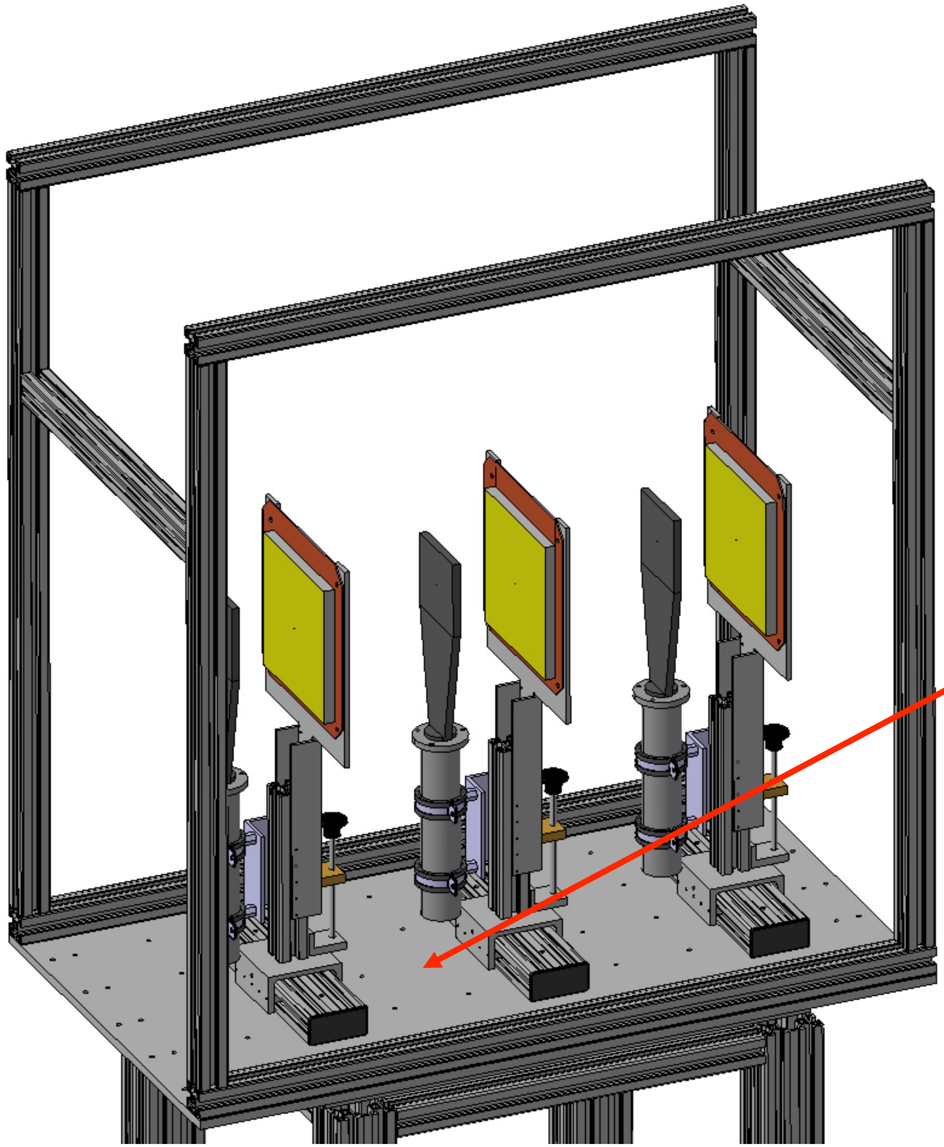
X-Ray source placed in **different positions** of the detector active area → rate measured at different value of the X-ray source currents, i.e. different fluxes.

The **response is linear** in each position analyzed.

S. Salva

The rate measured is not the same in every position, i.e. the detector response is **not uniform**.

Efficiency and Timing measurement → Cosmic stand



For measurements with cosmics, it has been placed on a table at TIF, turned by 90°.

In this picture the support for the FTM is still missing → it will be added **here**, together with an additional scintillator.

Cosmic stand will have dedicated gas panel and HV system → assembly on-going

Summary

- We have made a first characterization of FTMv1 with Ar/CO2 70/30
- We have seen the detector structure is transparent to the signal; and we have studied it's behavior in different operational conditions
- We will go to a test beam next week at CERN SPS H4; goal to measure efficiency and time resolution
- We have assembled the FTMv2 and its characterization is ongoing

Acknowledgements

- Special thanks and congratulations should go to:
  - I. Vai, S. Salva, F. Fallavollita, and S. Franchino

- Without their dedication and efforts spent understanding/ characterization the detector this talk would not be possible

- And to the rest of the team!!!