

Recent results from Test Beam of **Hybrid THGEM – Micromegas** Photon Detector

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INFN Trieste and Trieste University

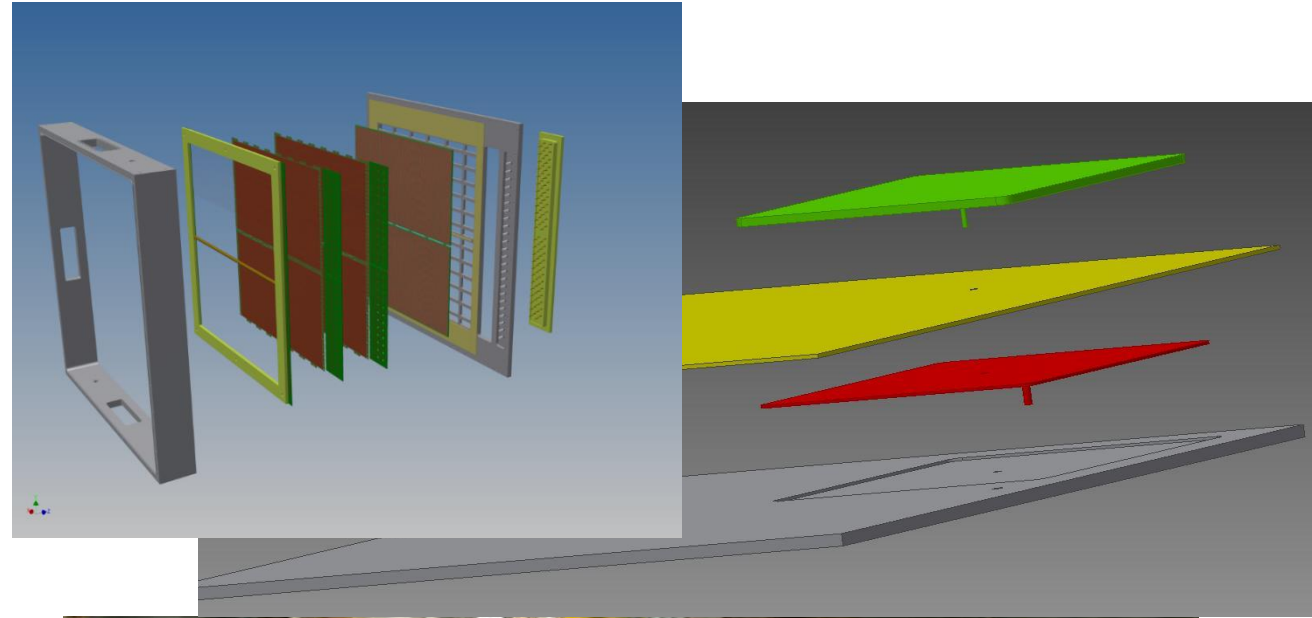
On behalf of:

Alessandria, Aveiro, Budapest, Calcutta,
Freiburg, Liberec, Prague, Torino, Trieste

collaboration

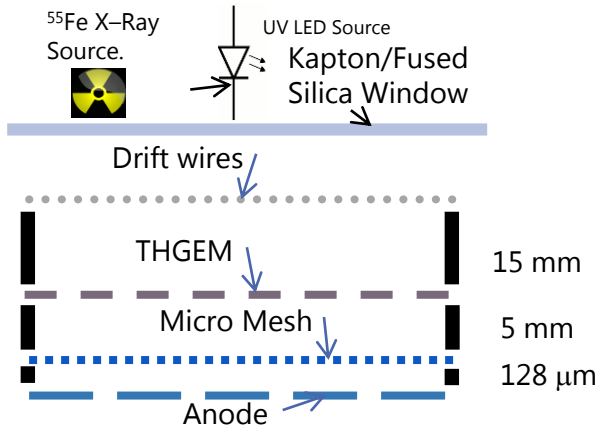
Outline

- Hybrid THGEM + MM PD.
- The new Hybrid PD equipped with **capacitive anode**.
- Test Beam at CERN PS T10.
- Results from analogue readout.
- Results from digital readout.
- Conclusion

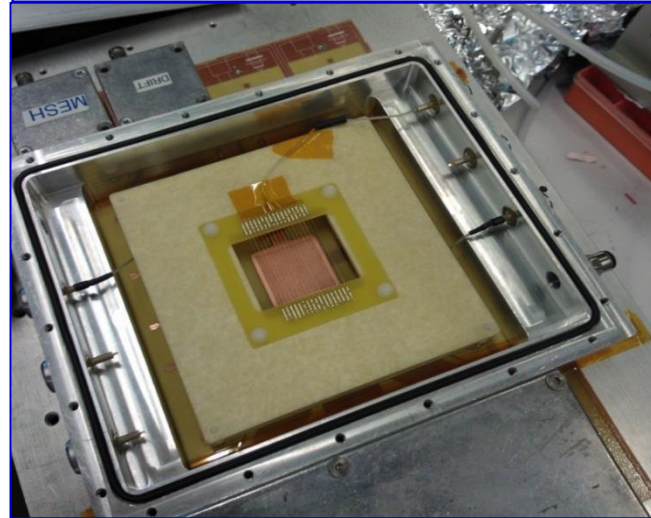


First Hybrid Photon Detector prototype: working principle and results

Hybrid detector

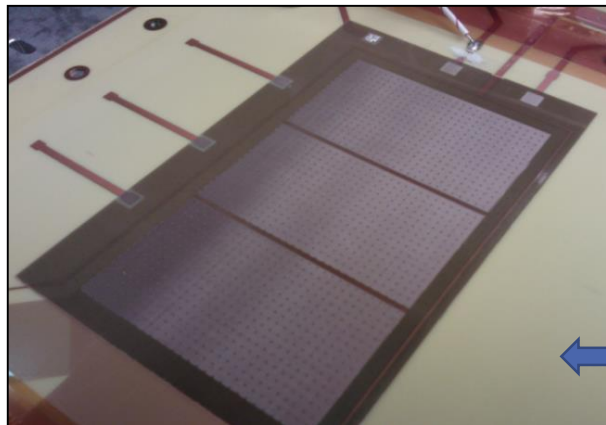


FIRST SMALL SIZE PROTOTYPE



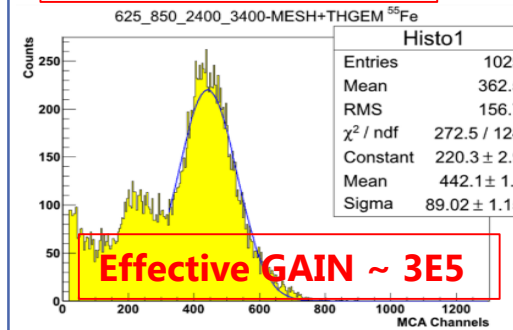
CAEN N471A High Voltage PSU
 Charge Sensitive Pre amplifier
 CREMAT CR – 110/111
 Normal Readout Chain

Bulk Micromegas: courtesy of Saclay COMPASS colleagues

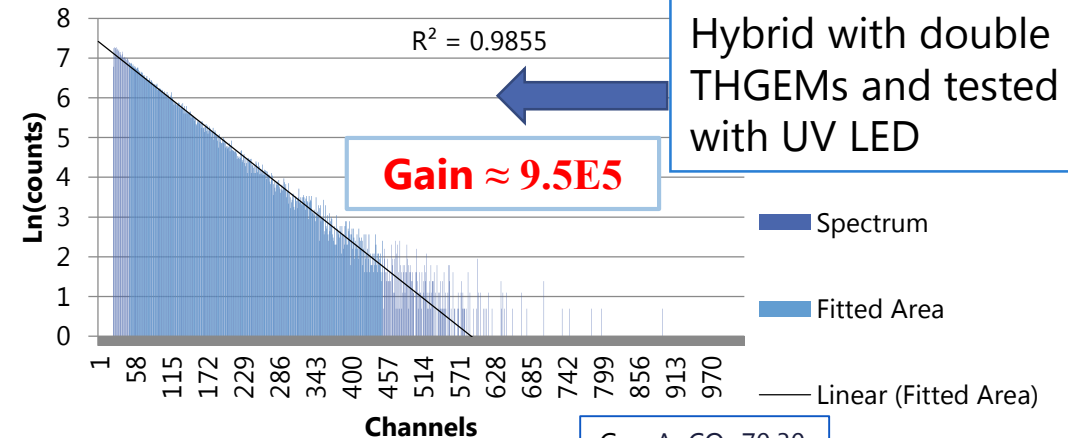
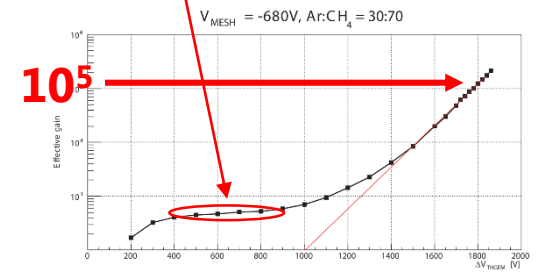


Preliminary test

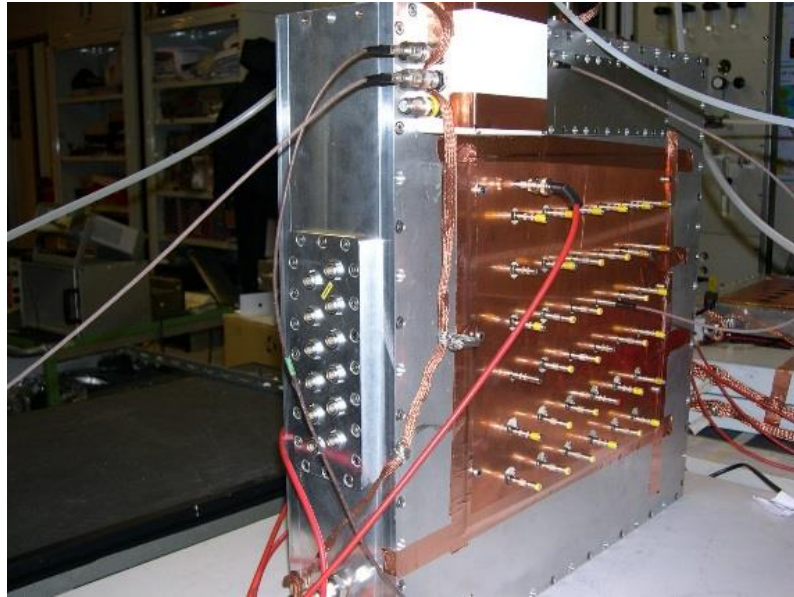
55Fe source,
 Gas used: Ar:CO₂ 70:30.



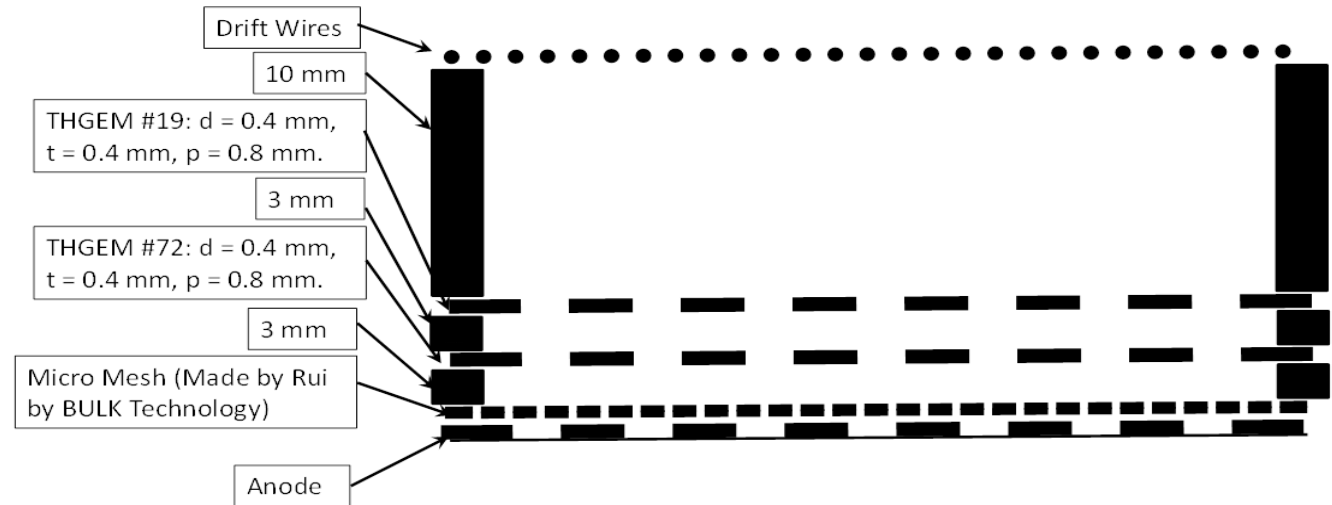
Double THGEM ΔV scan. Plateau represents the unitary THGEM gain, corresponding MM GAIN ~ 500.
 Gas: Ar:CH₄ 30:70



300X300mm² Hybrid prototype with THGEM



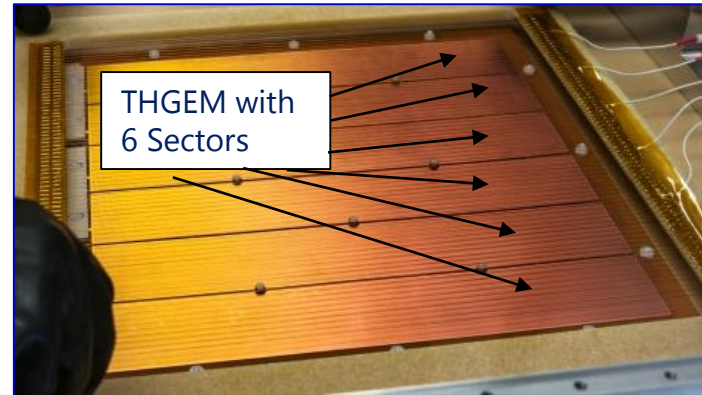
Setup Hybrid (300 X 300 mm²) with double THGEM



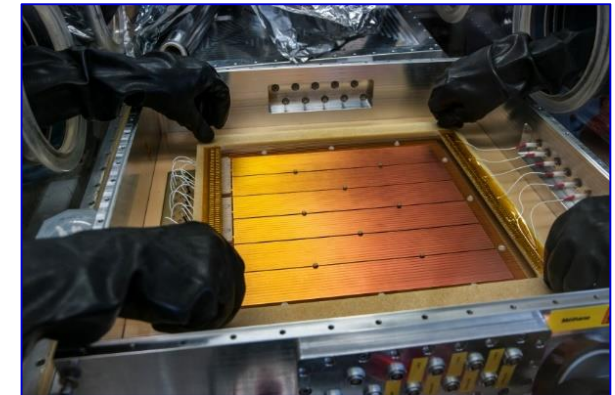
Anode Pads (12mm X 12mm)



Micromegas produced by Rui at CERN by Bulk technology

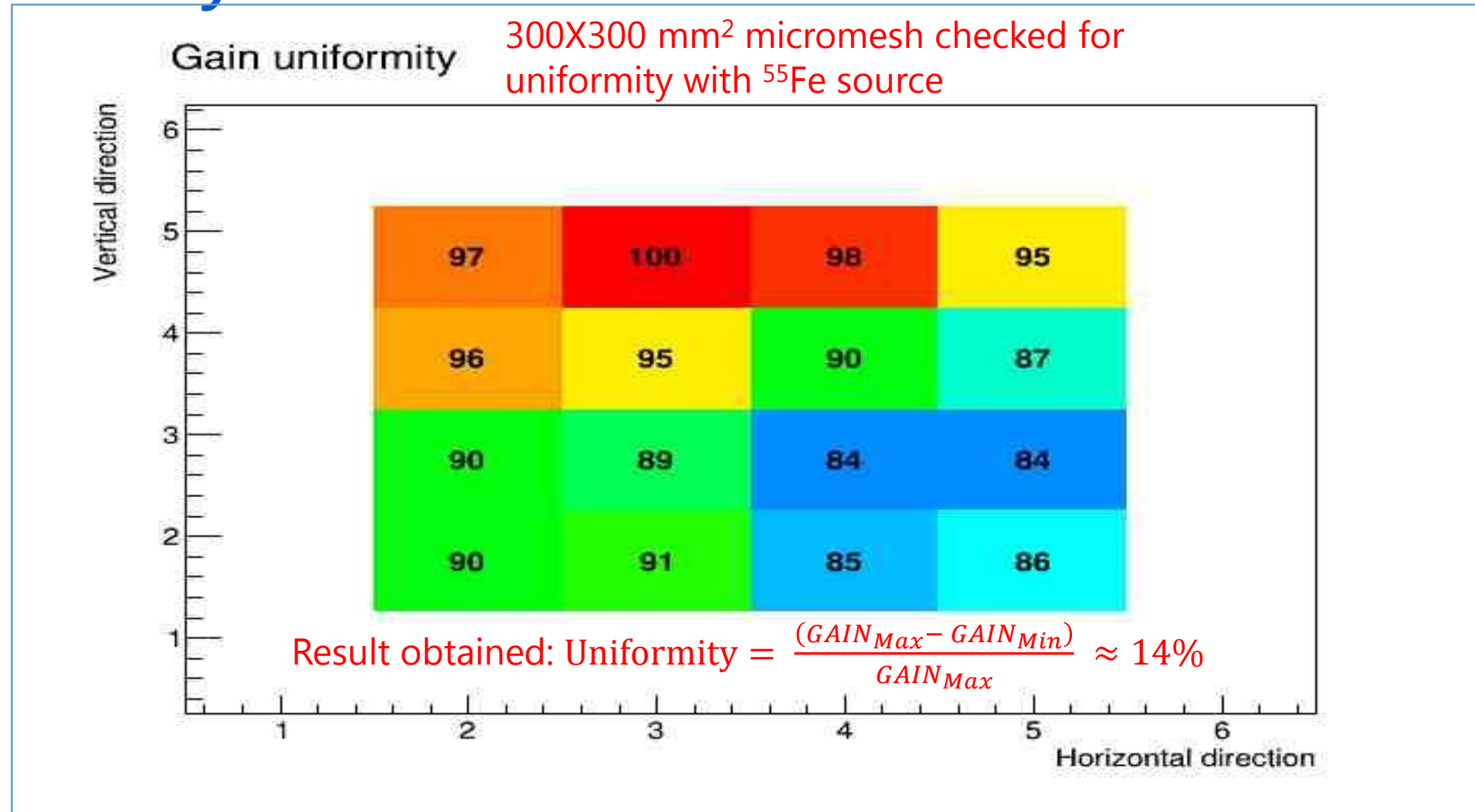


THGEM with 6 Sectors



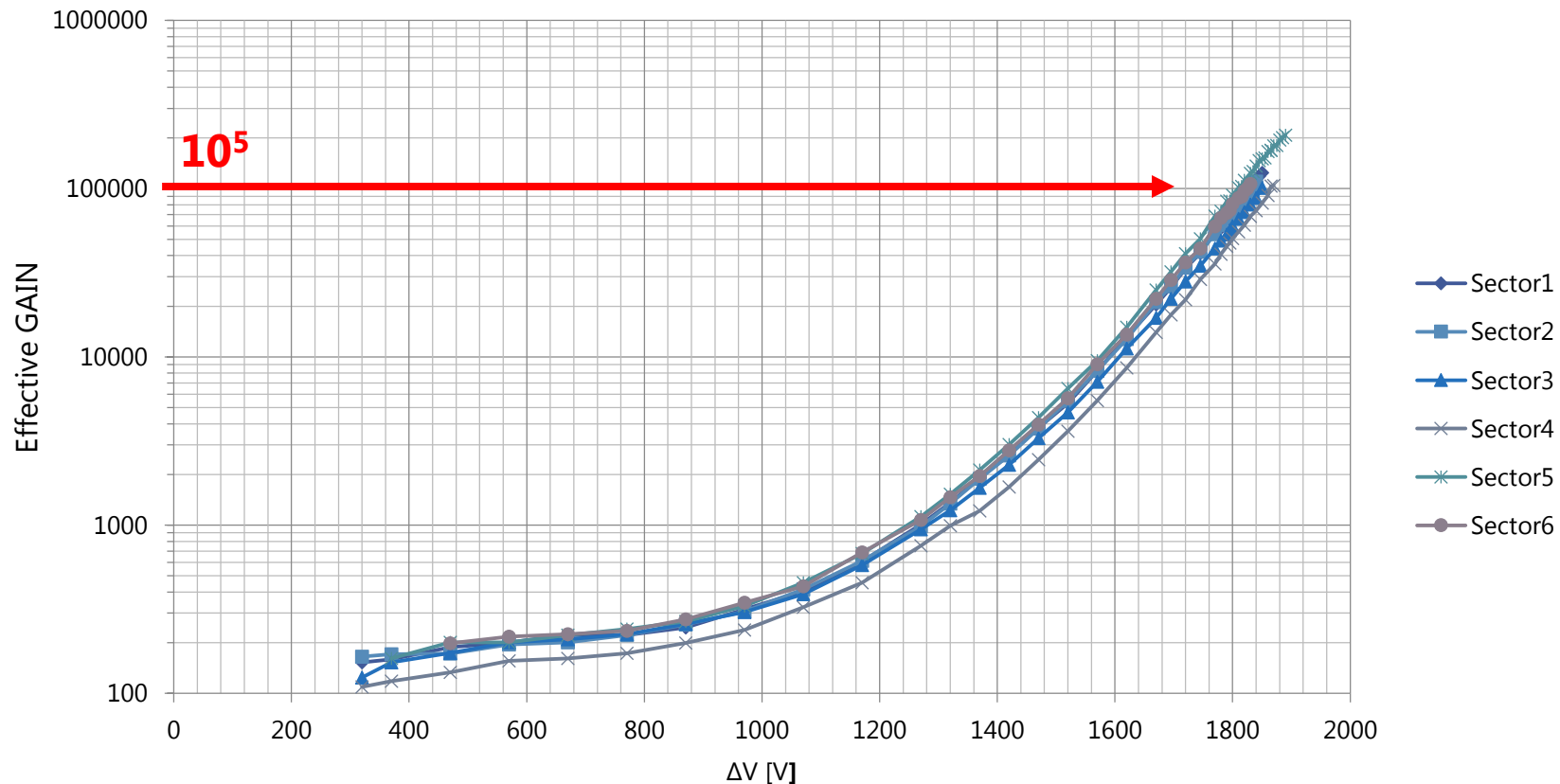
300 X 300 mm² Hybrid prototype: Micromegas only

- The Micro Mesh was produced by Rui de Olivera in CERN with BULK Technology.
- Checked with Ar:CO₂ 70:30, CAEN N471A HV PS, CREMAT CR – 110/111 and Normal Readout chain.



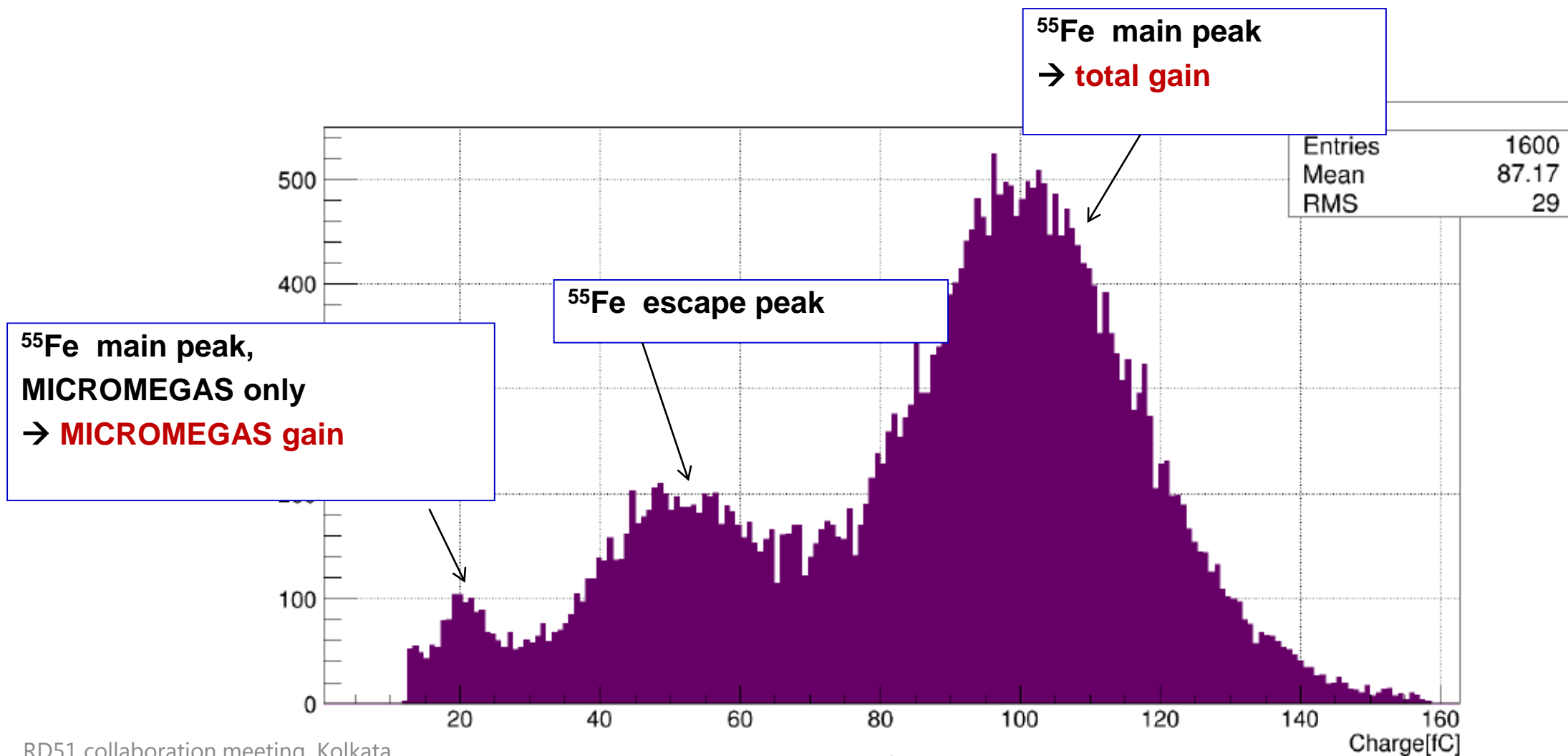
300 X 300 mm² Hybrid prototype: Micromegas + THGEM

ΔV Scan of Sectors of a 300X 300 mm² THGEM. $V_{\text{MESH}} = 640\text{V}$.
Source used: ⁵⁵Fe X – Ray source; Gas used Ar:CH₄ 30:70.



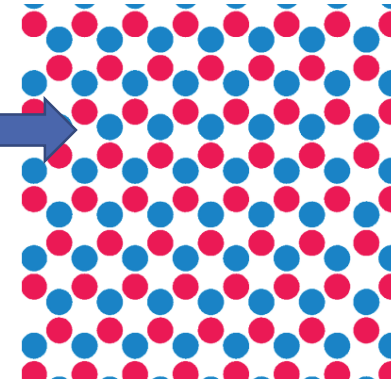
- 300 X 300mm² THGEM + Micromegas provide the same response as the 30 X 30 mm² prototype.
- All the 6 sectors of the THGEM have been checked with different bias voltages.
- Maximum effective gain achieved: **10⁵** or larger with ⁵⁵Fe X – Ray source.
- **Ar:CH₄ 30:70 is the reference gas mixture for compass THGEM photon detector.**

Hybrid Micromegas + THGEM



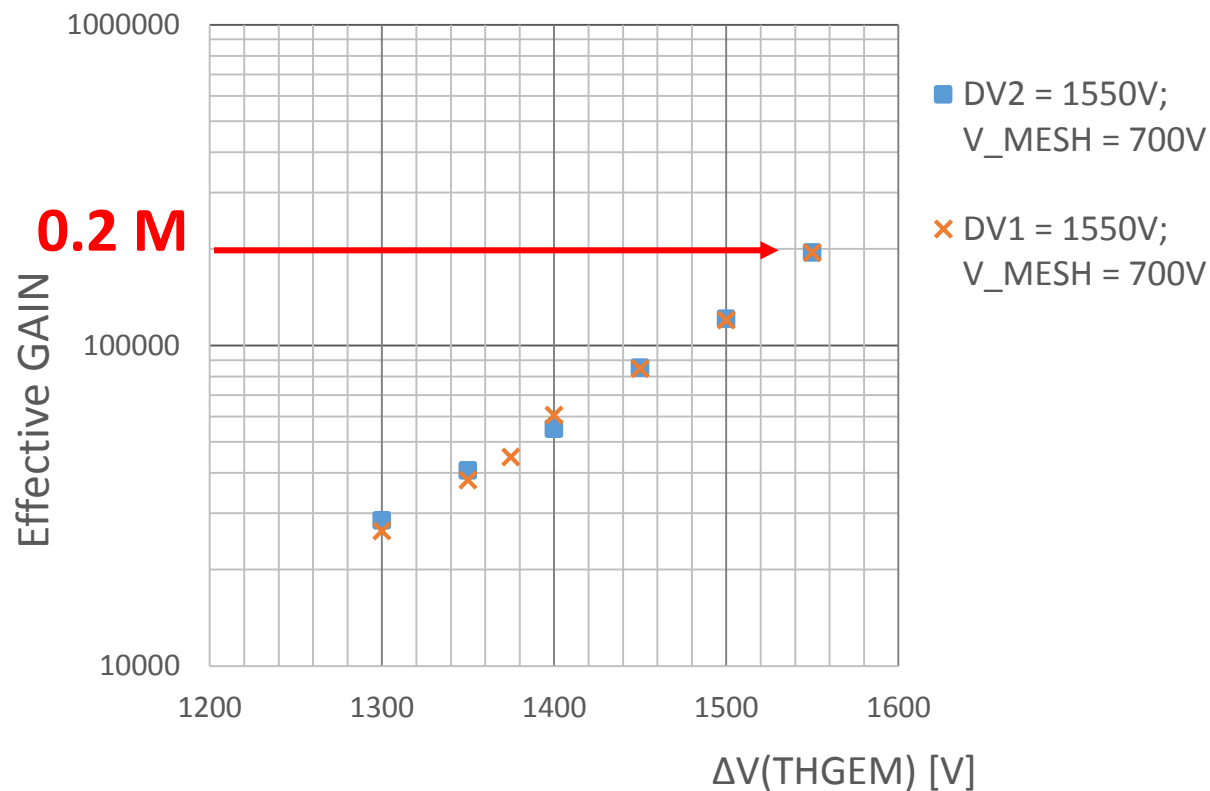
Hybrid with double THGEMs

Staggered configuration

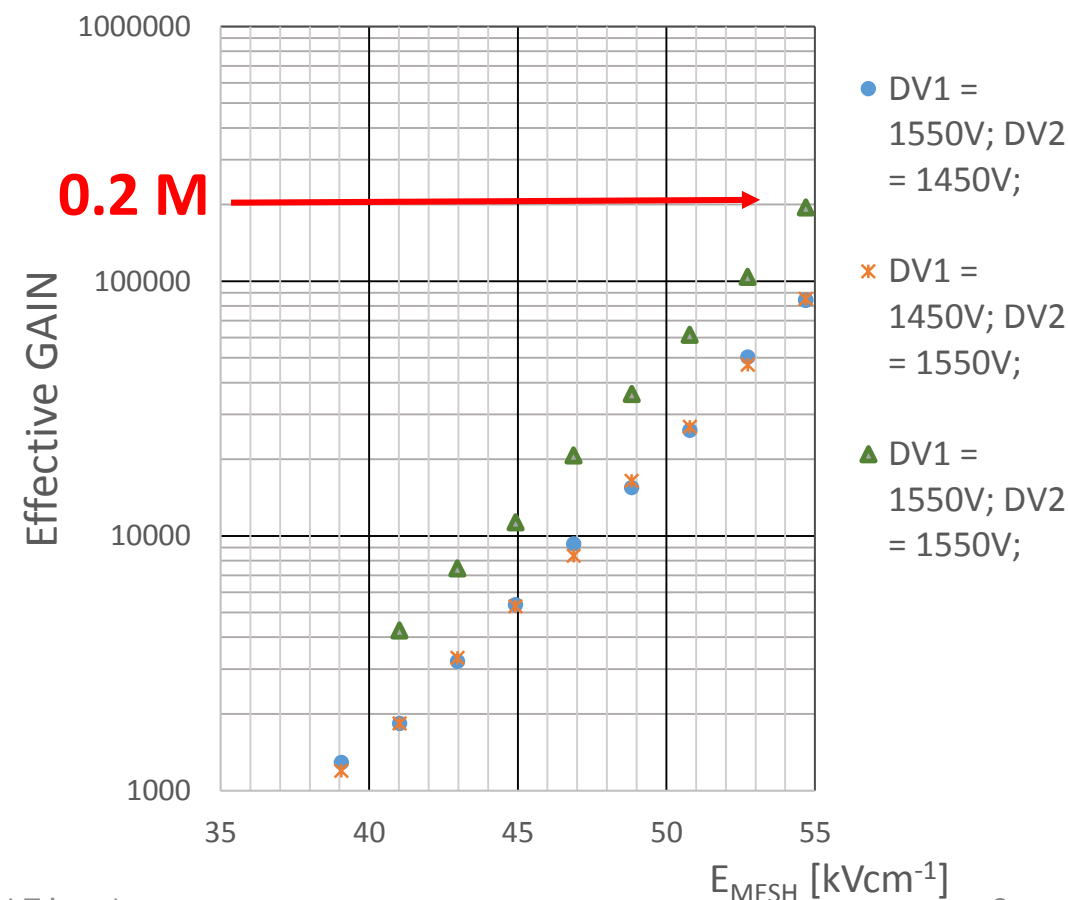


Source used: ^{55}Fe , Gas used: Ar:CH₄ 30:70

Effective GAIN vs. one of the ΔV Scan, keeping V_{MESH} and other ΔV constant



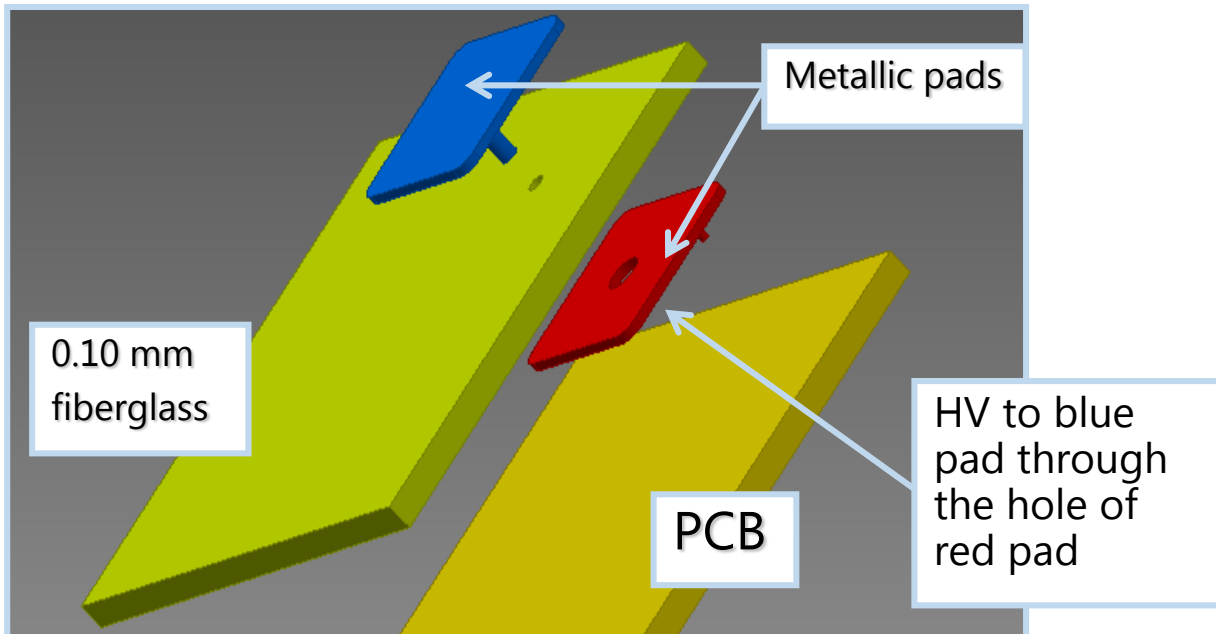
Effective GAIN vs. V_{MESH} Scan



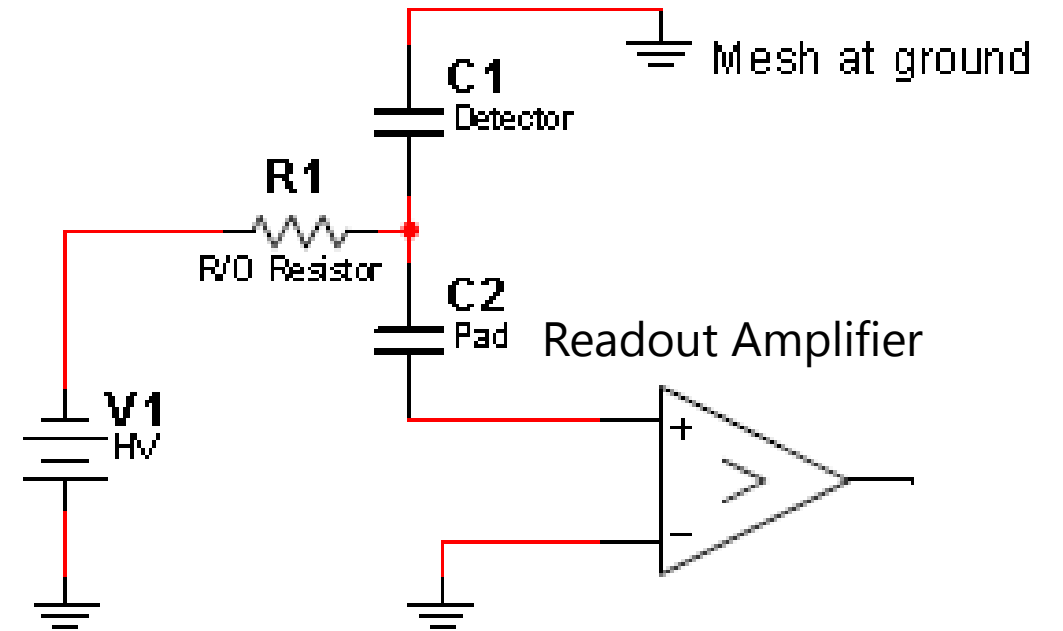
Improving the detector concept

- At the test beam two hybrid detectors have been tested.
- The first one has been described so far.
- The second is identical but equipped with a capacitive anode architecture.
 - Inspired by ATLAS MAMMA principle already presented by J. Wotschack.
 - Positive voltage bias on anodic pads via external resistors.
 - Mesh at ground (only not segmented electrode).
 - Signal readout via capacitively coupled pads.

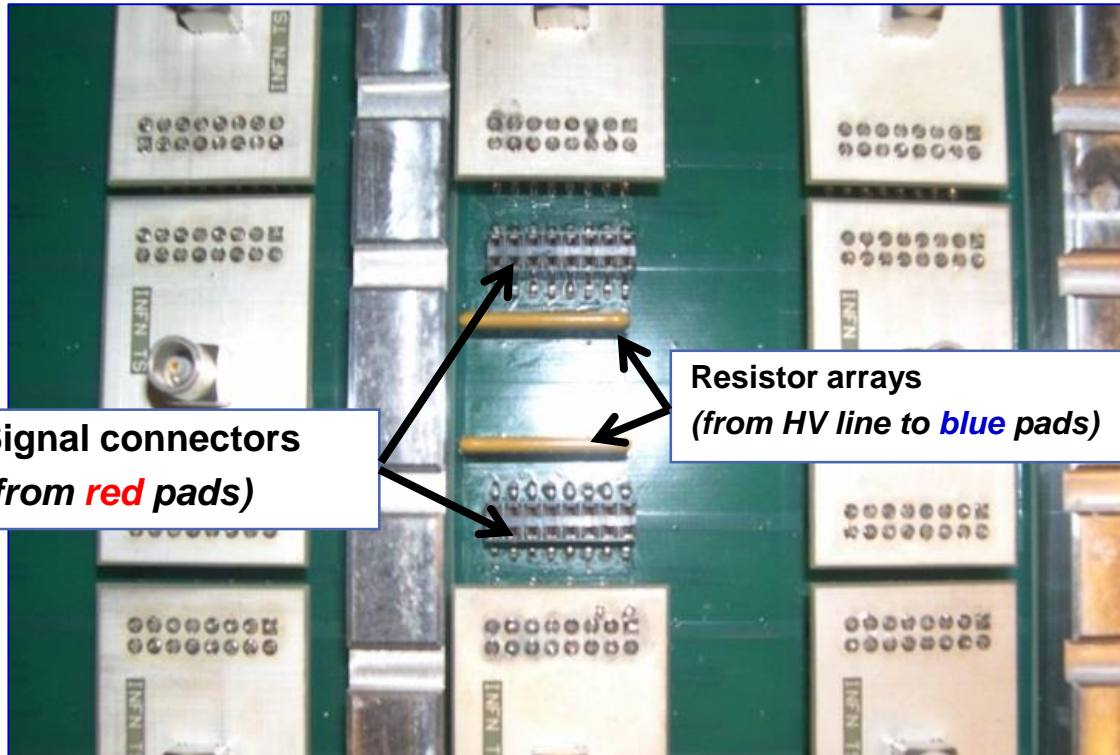
Readout via capacitive anode



- Scheme (not to scale)
 - Only 1 single pad shown
- Principle
 - Blue pad at HV via internal connection
 - Resistive (individual pad resistor at the PCB rear surface)
 - Red pad: signal induced by RC coupling



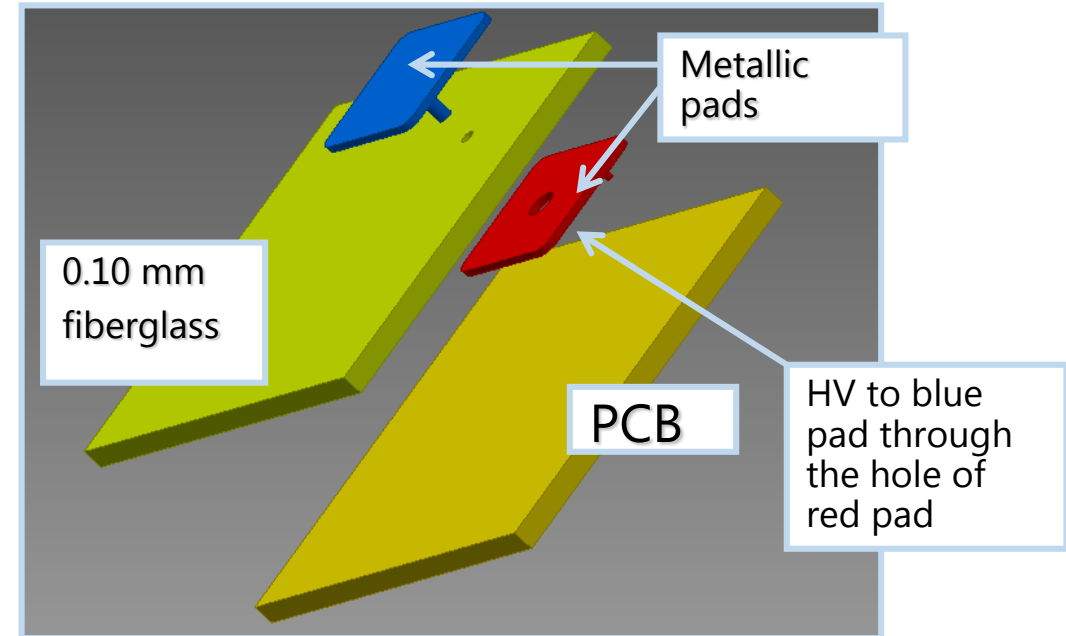
Layout of the capacitive anode PCB



Signal connectors
(from red pads)

Resistor arrays
(from HV line to blue pads)

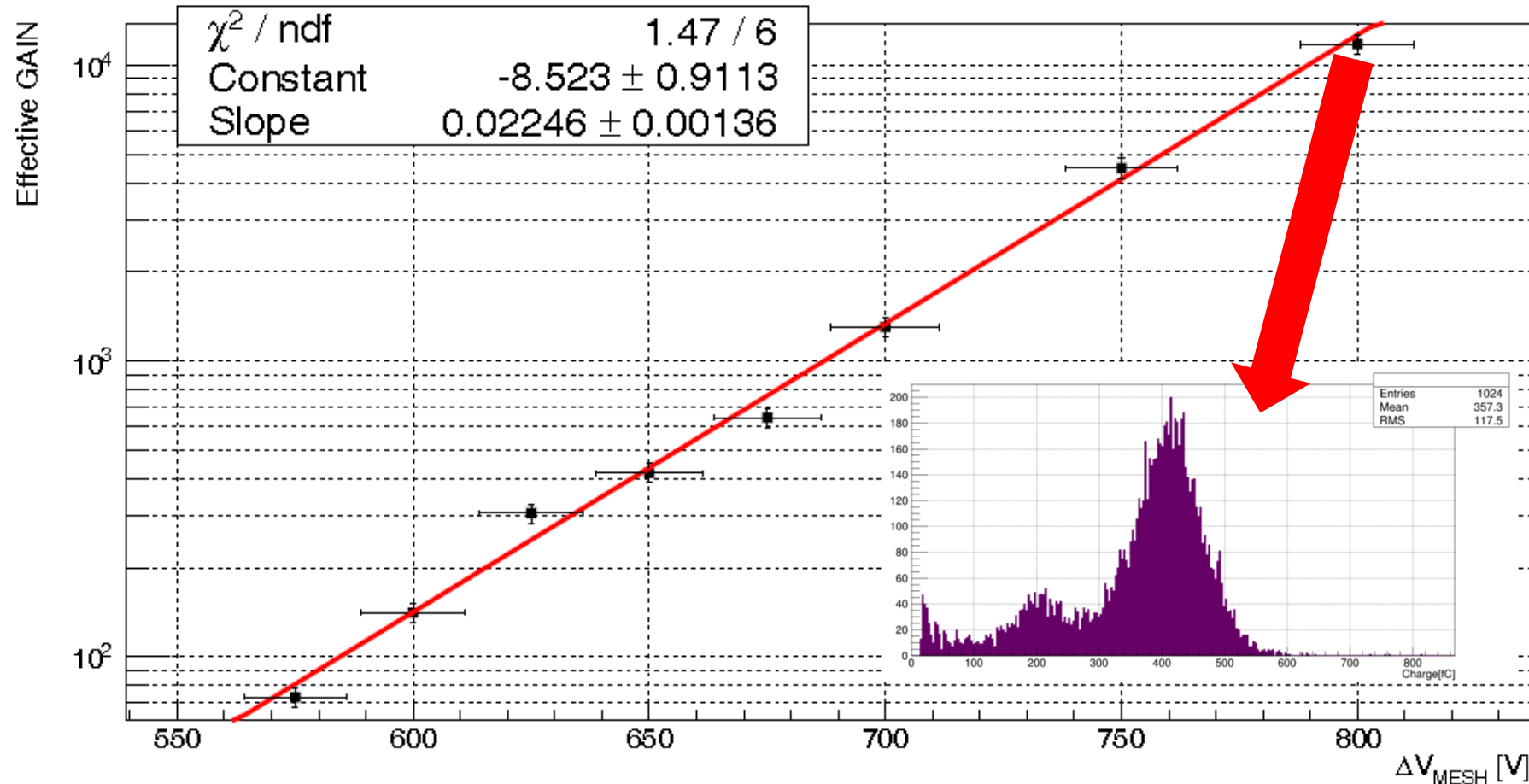
Section of the back part of the 300 X 300 mm² anode PCB. It has 24 X 24 = 576 (12 X 12mm) pads. For each 16 pads we have this readout board which is used to read all of these 16 pads together through the LEMO female connector.



- We already did extensive study with a small prototype to find out the optimal resistance.
- The optimal resistance for <10% signal loss has been found = 1M Ω .
- We use a resistor array for each 8 pads.

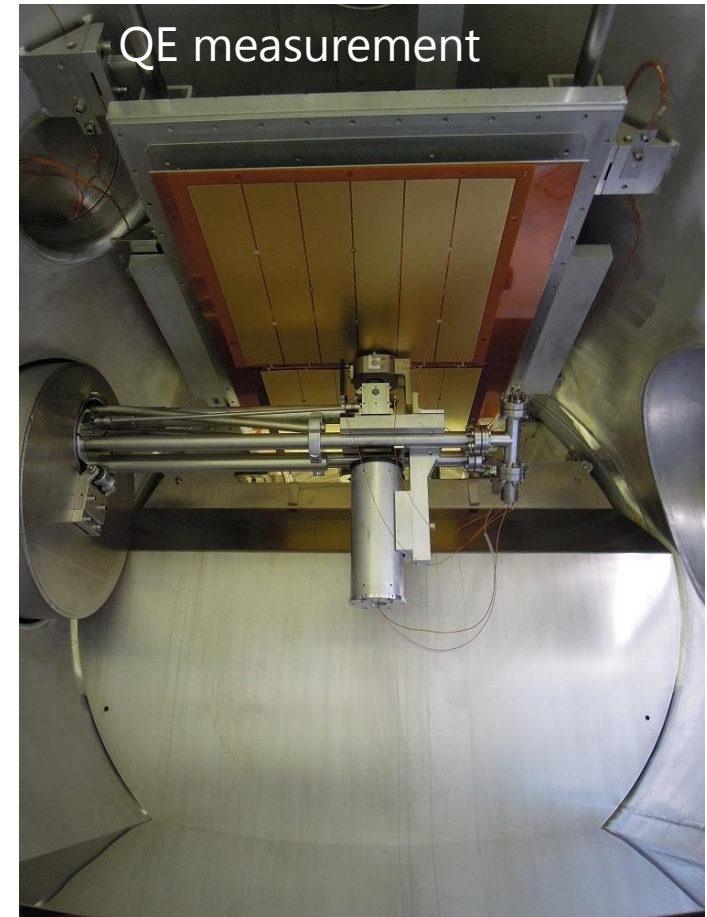
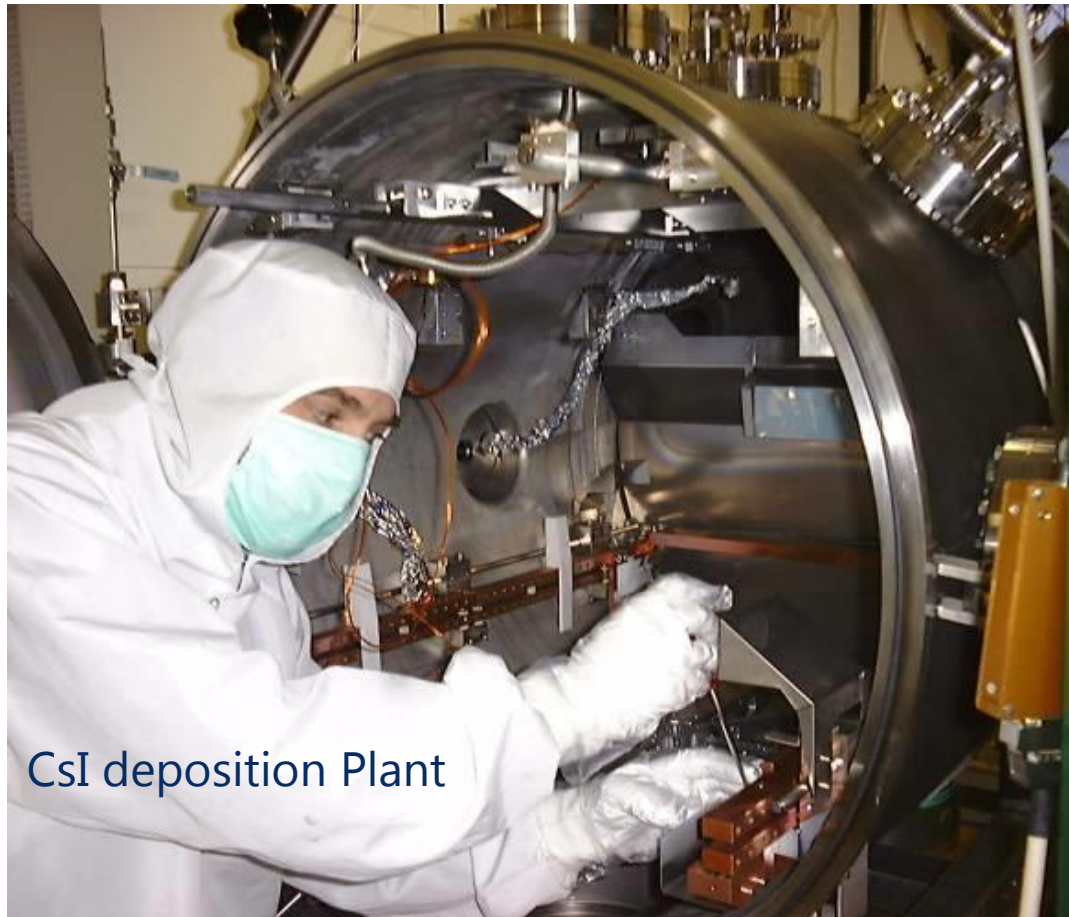
Micromegas with capacitive anode

ΔV_{MESH} vs. Effective GAIN scan



From now on all results refer to the capacitive Micromegas chamber.

CsI Deposit at CERN



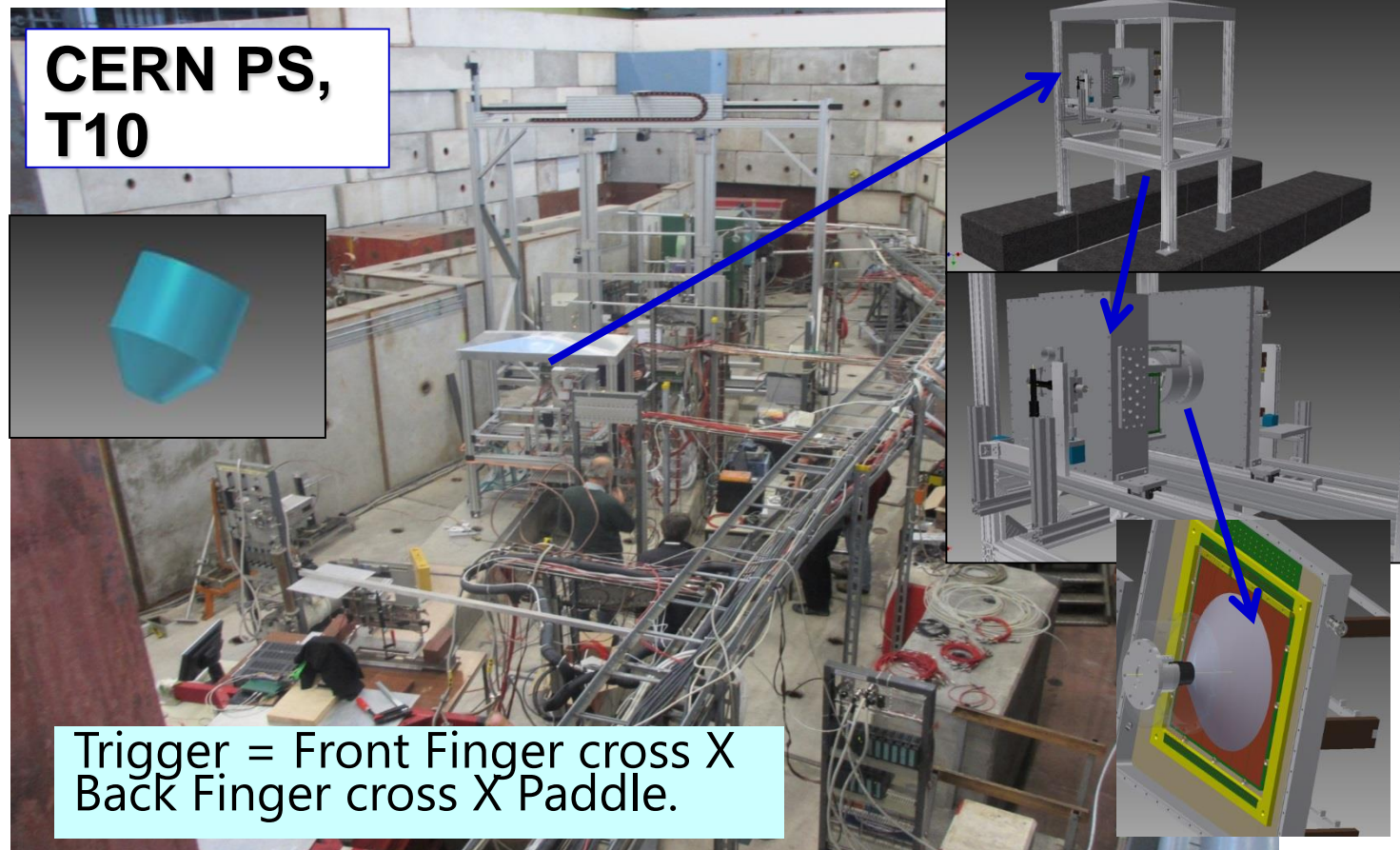
Assembling the Photon Detector



- Here this picture shows the delicate operation carried out in CERN in a controlled environment to assemble the CsI coated THGEM to the chamber.

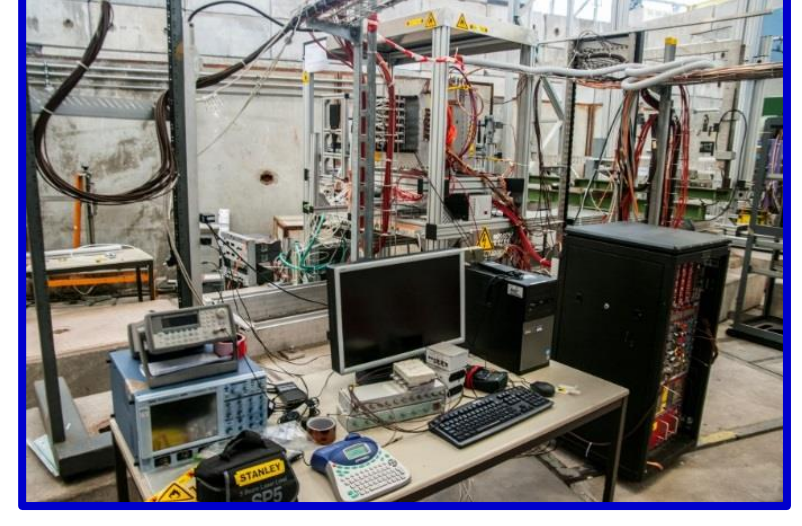
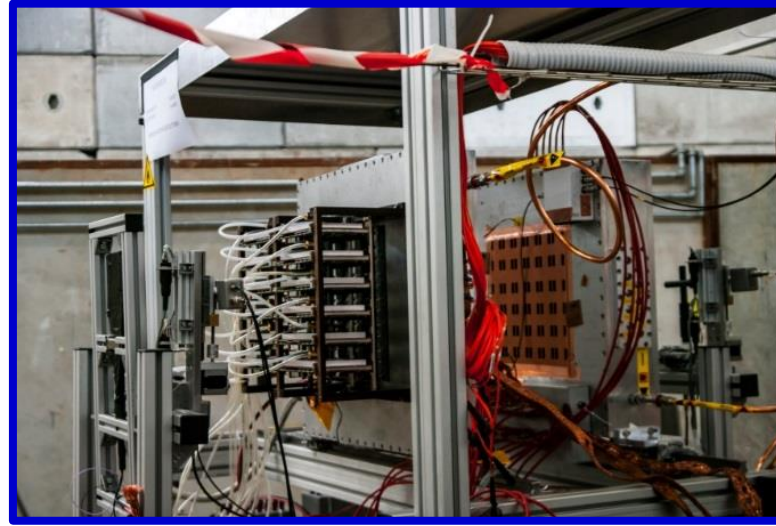
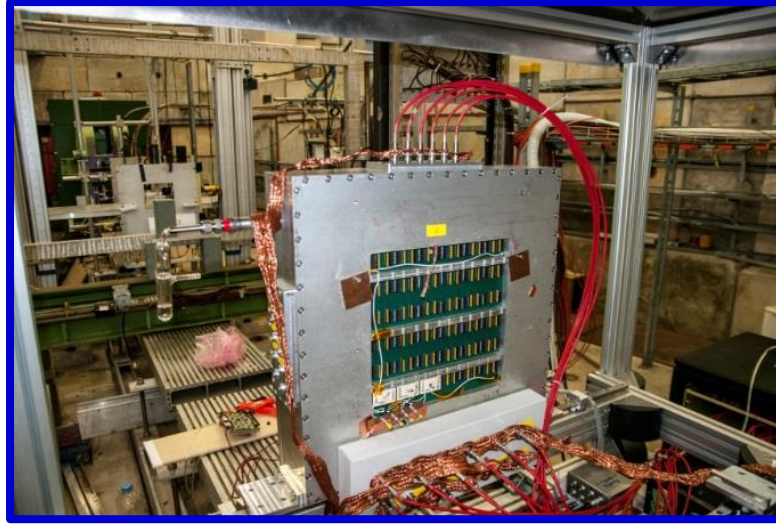
setup for Test Beam

Beam area setup



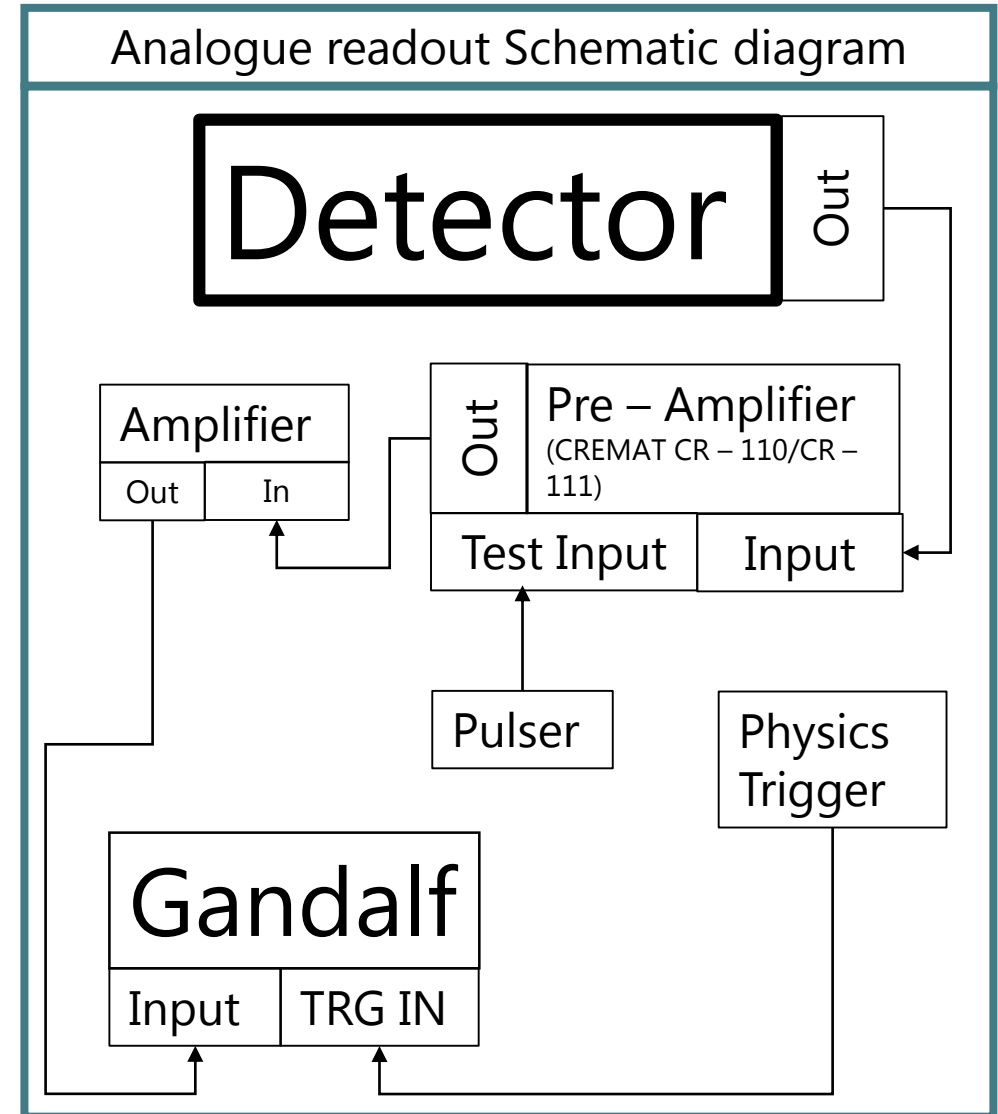
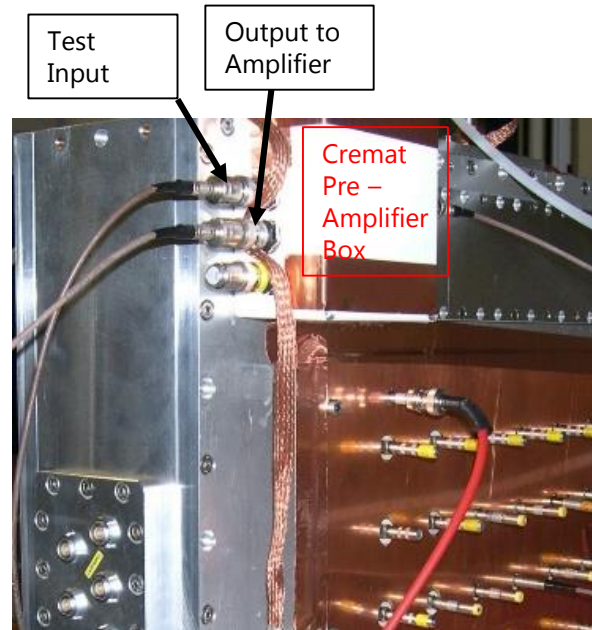
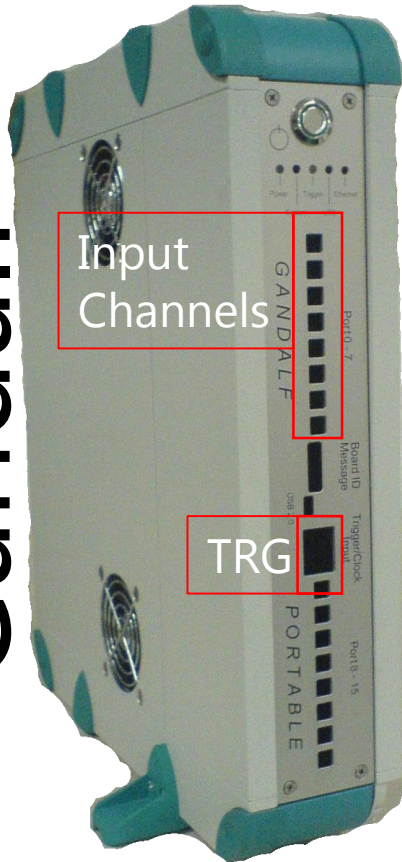
- We set up our prototype in CERN PS T10 beam line.
- We used a truncate cone fused silica radiator for Cerenkov photons.
- For trigger we use 2 finger cross in front + 2 finger cross in back+ a Paddle.

Beam area installation

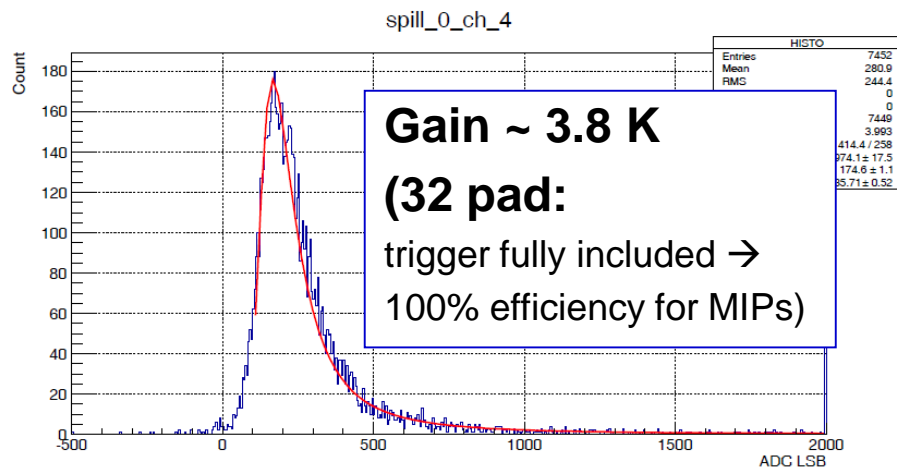
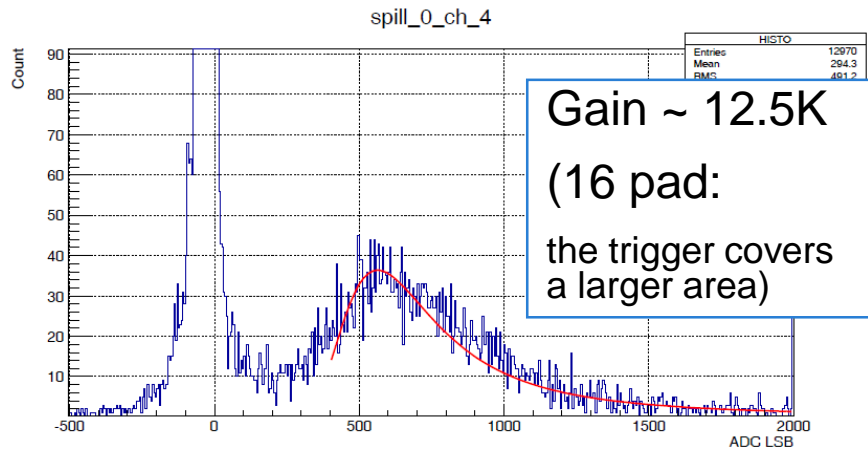


Analog Read – Out

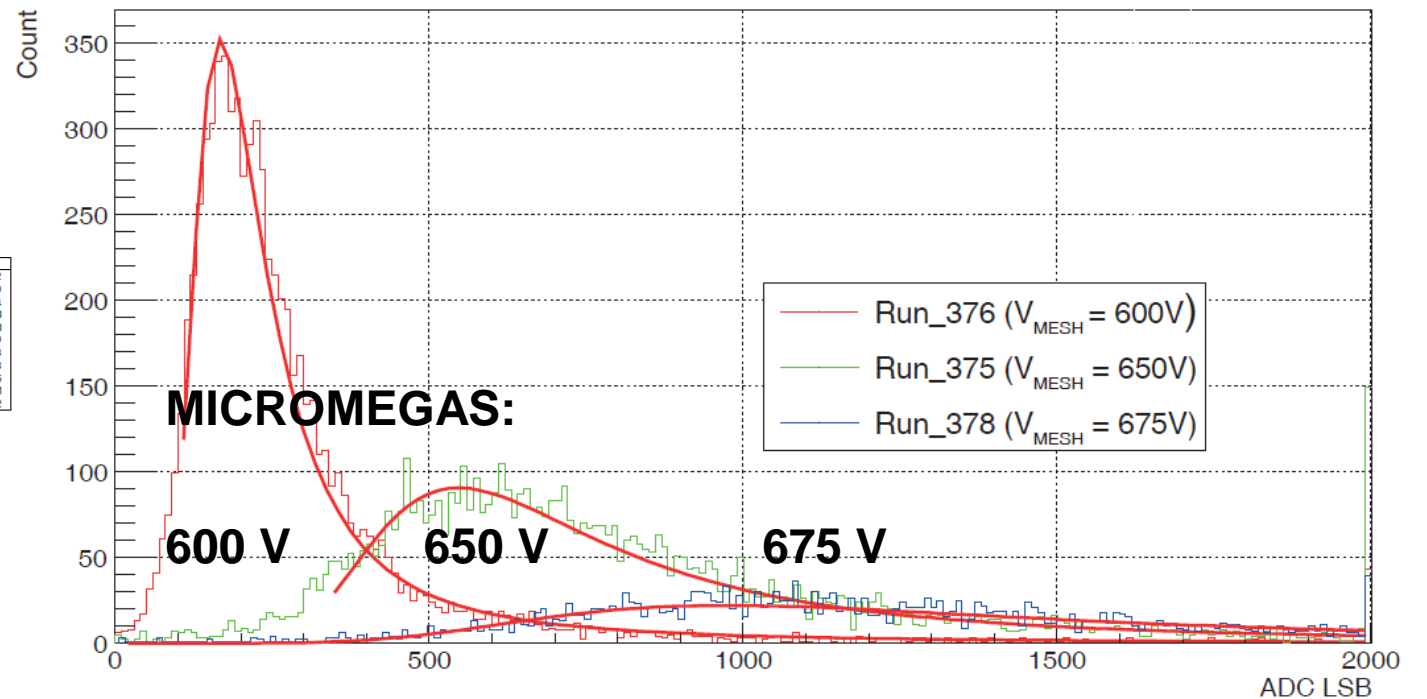
Gandalf



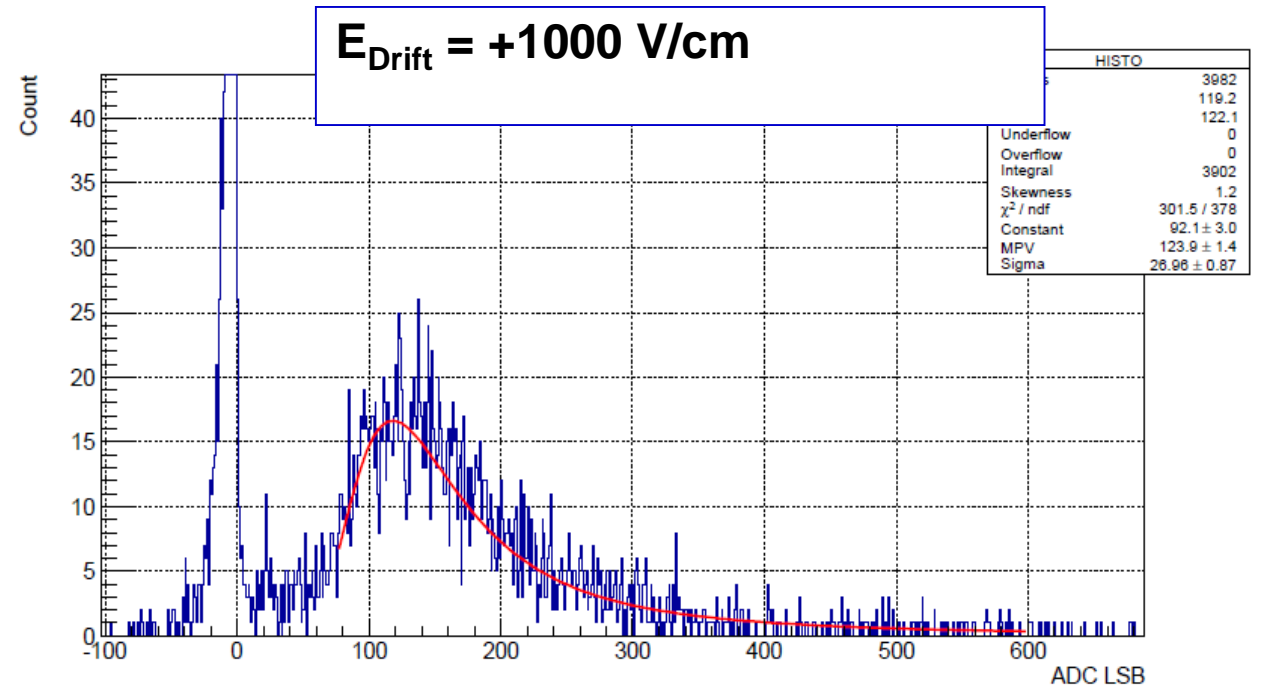
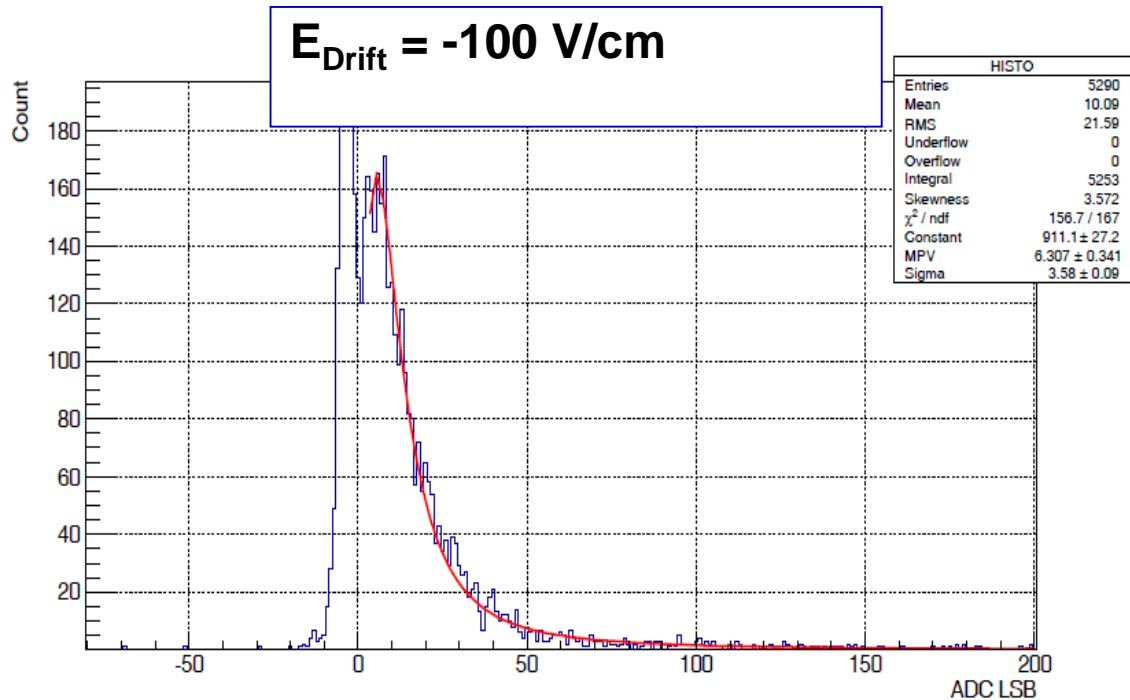
Amplitude distribution of beam particles signals



Evaluation of the landau due to the charged particles with Mesh voltage



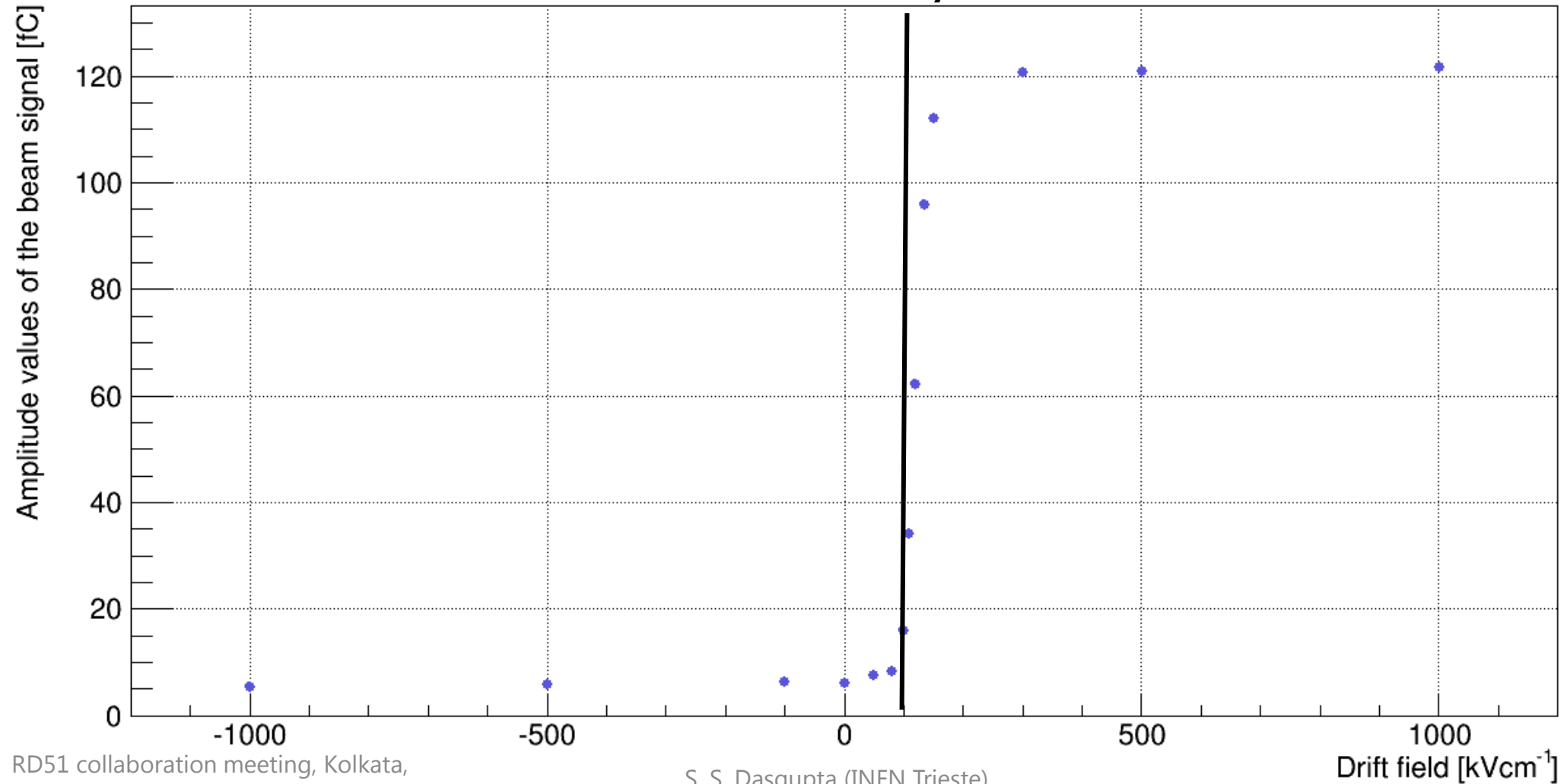
Amplitude distribution of beam particles signals for different Drift field values



Charged particle signals vs. drift field

Amplitude for beam particle signals variation with drift field

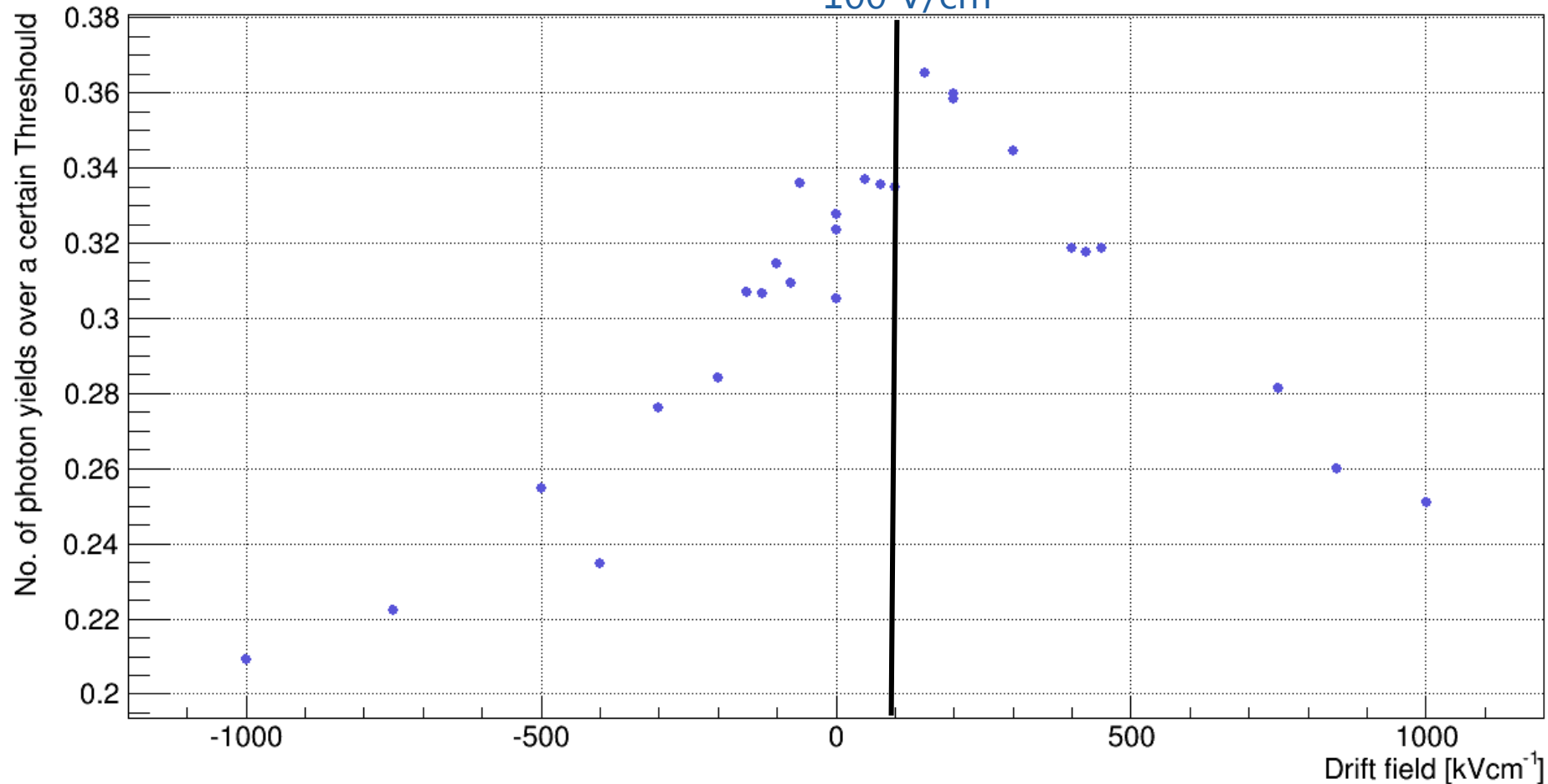
100 V/cm



Photon signal vs. drift field

No. of Photon yields variation with drift field

100 V/cm



X – Axis of the plot is

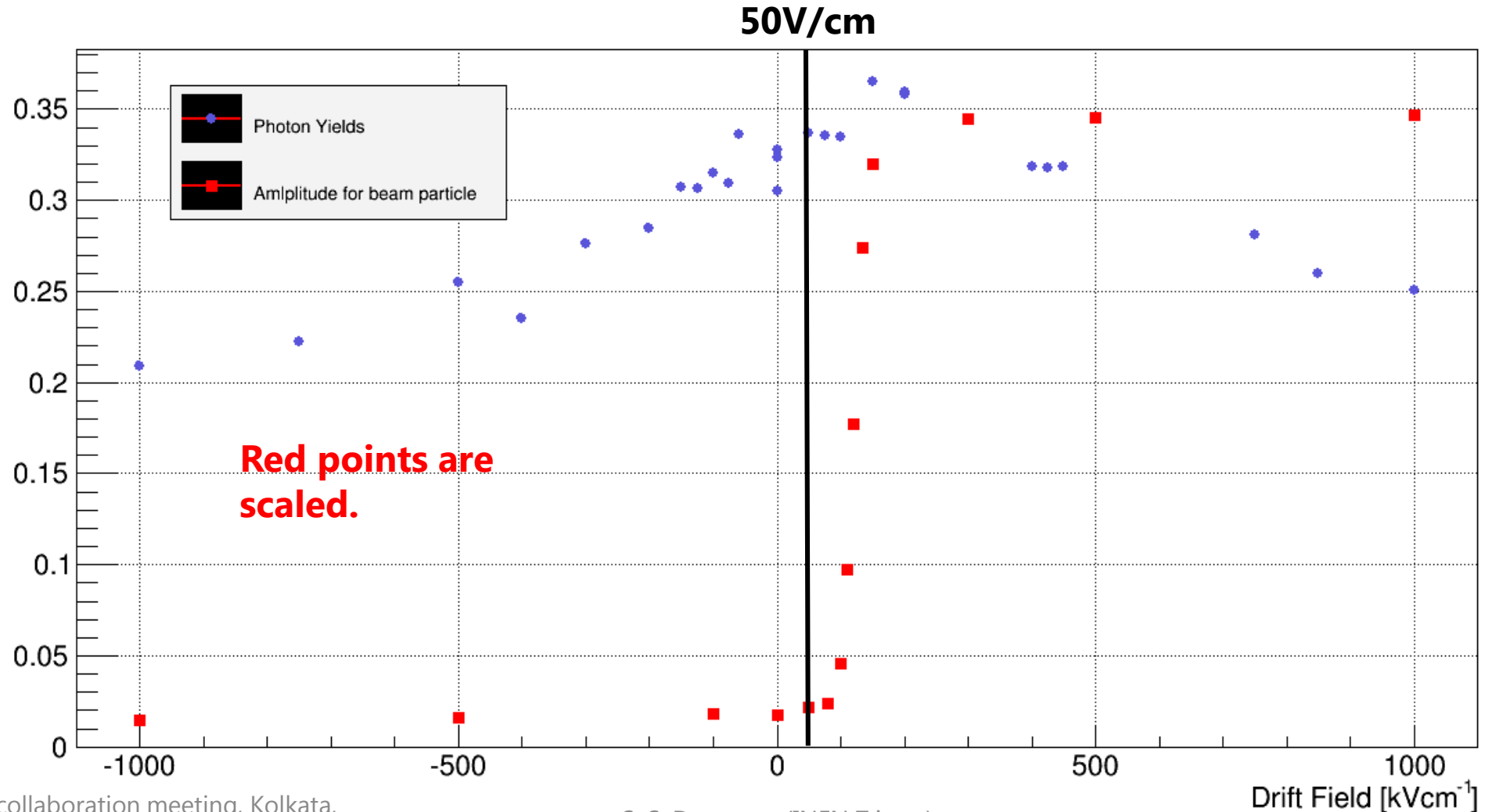
$$\frac{N_{Photons}}{\text{No. of events over threshold}} \\ \text{No. of Trigger}$$

Y – Axis is the drift field applied.

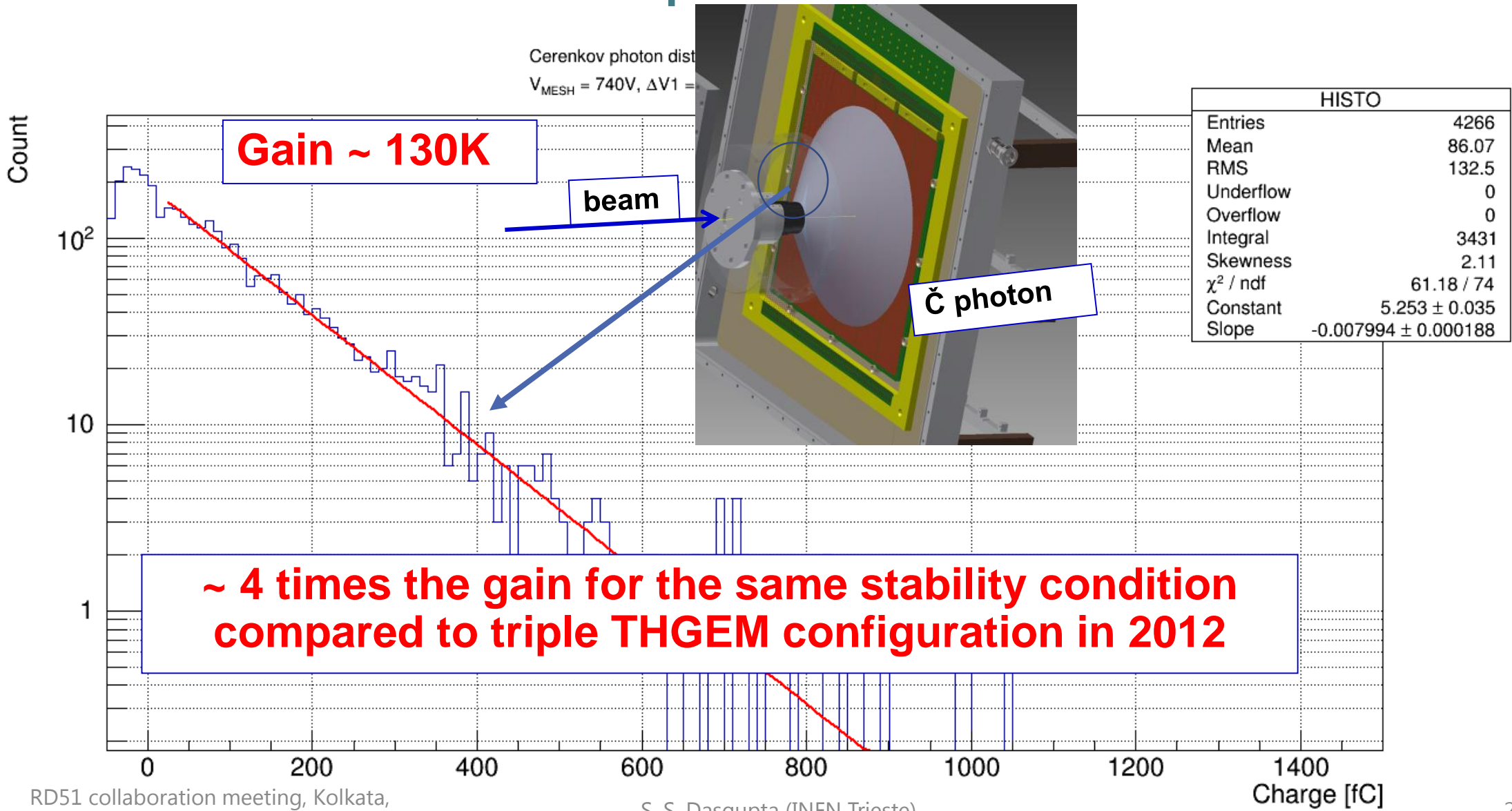
The number of detected photoelectrons depends on the drift field:

photoelectron detection efficiency to be maximized

Photon signal and Charged particle signal vs. drift field

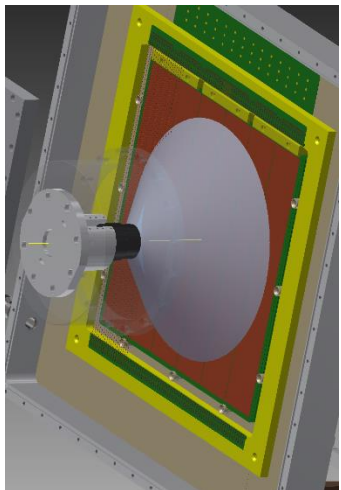
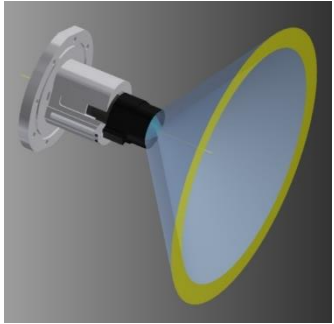


Cerenkov Photon amplitude Distribution



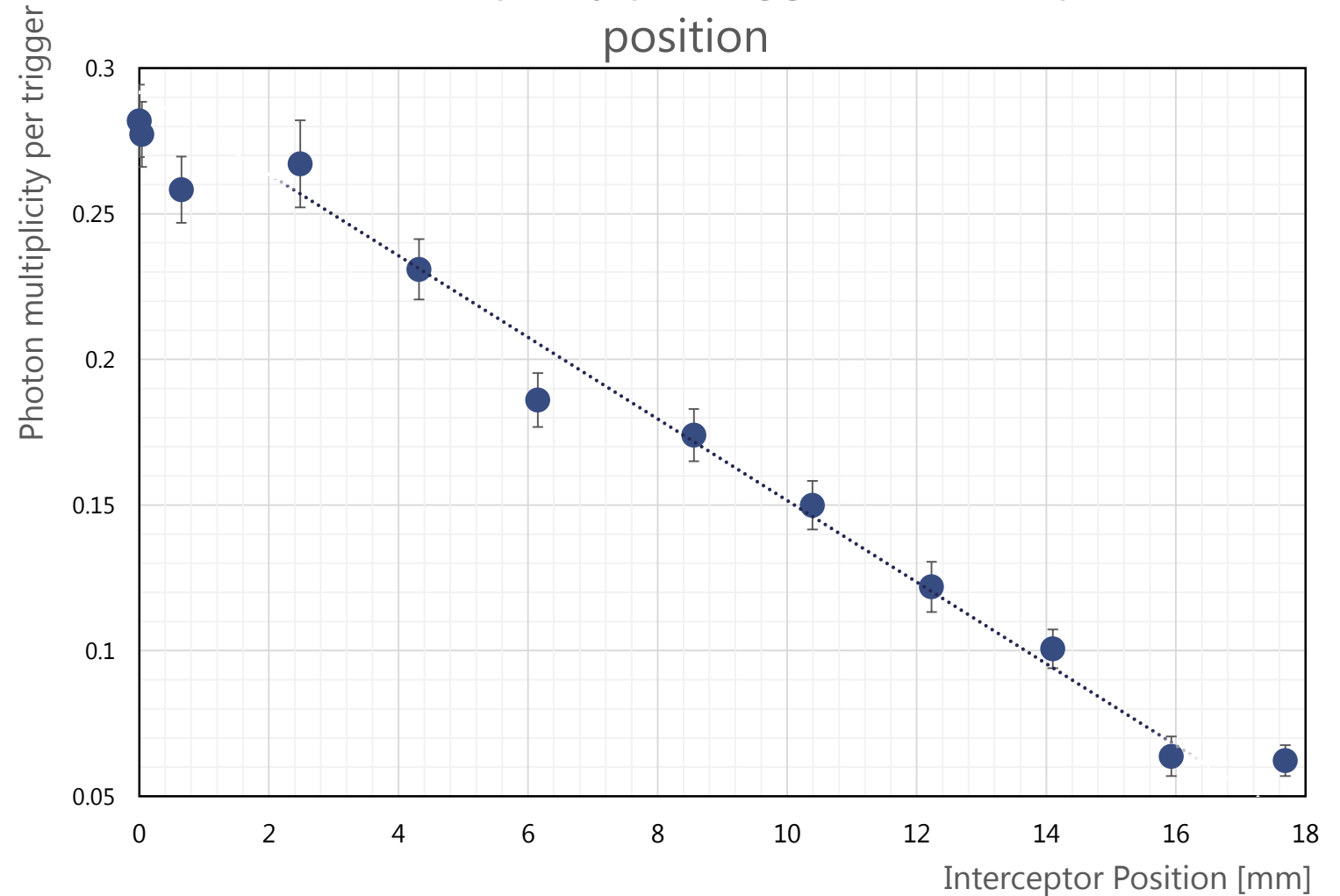
Interceptor position scan

Interceptor Scan



The remotely controlled movable interceptor allows for changing the number of photons in the corona

Photon multiplicity per trigger vs interceptor position



Digital Readout

Digital Readout Setup

- Readout chain: same as RICH-1 – MAPMT
 - C-MAD
 - Roof
 - DREISAM card
- No need for FE protection boards – 2012:
- Fighting against noise during the entire Test
 - Impossible to run with all channels together
 - Very high thresholds (from 6 to 15 fC) (**~3 fC in 2012 Test Beam**)

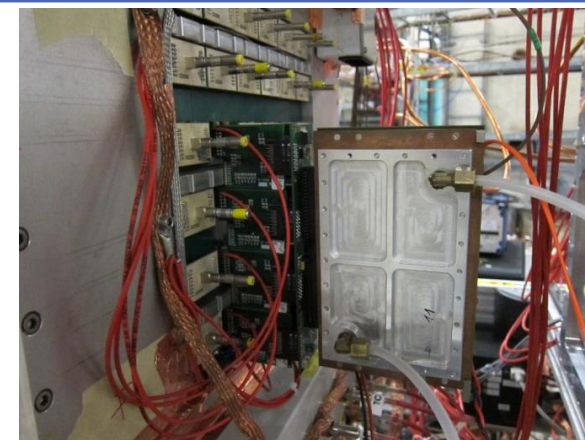
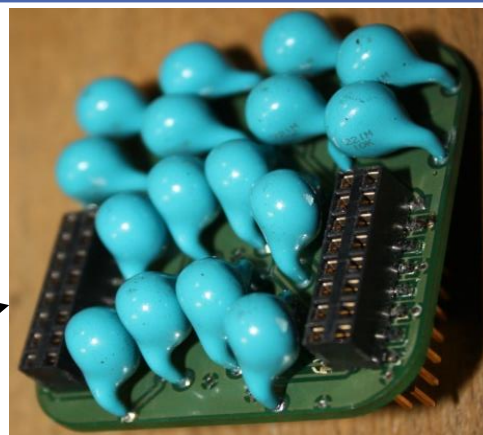


DREISAM
CARD

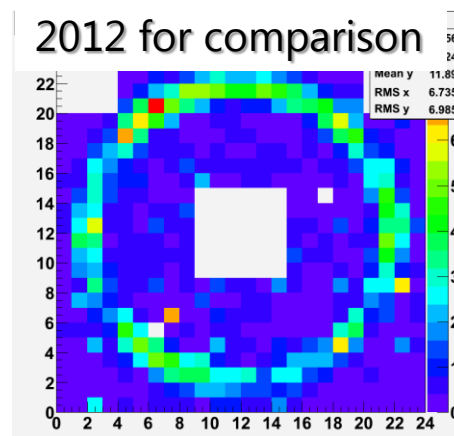
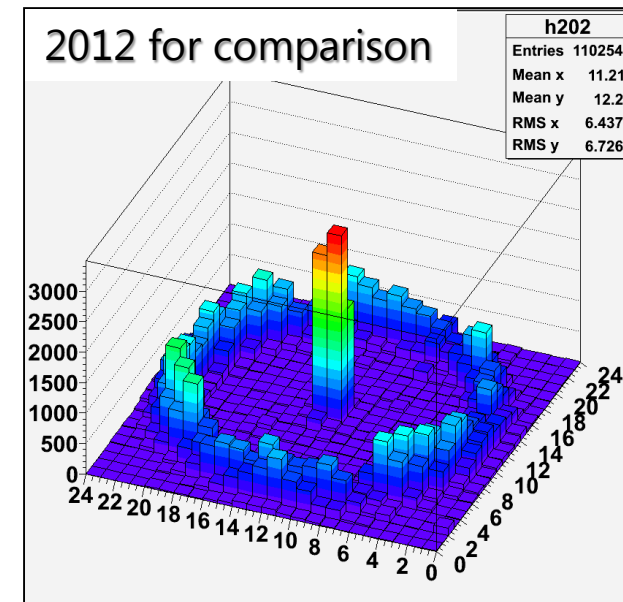
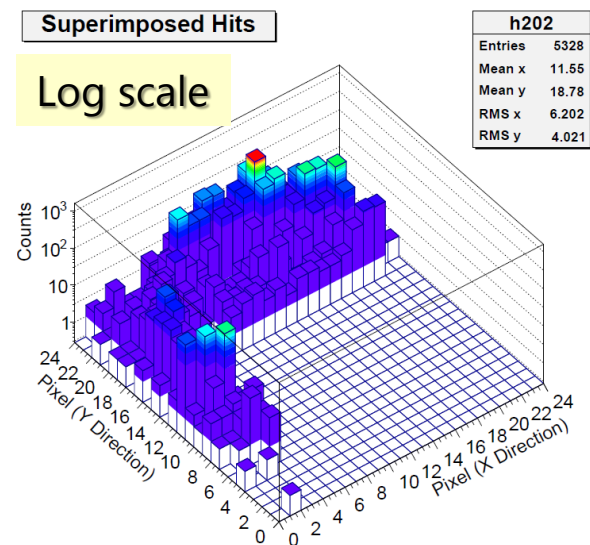
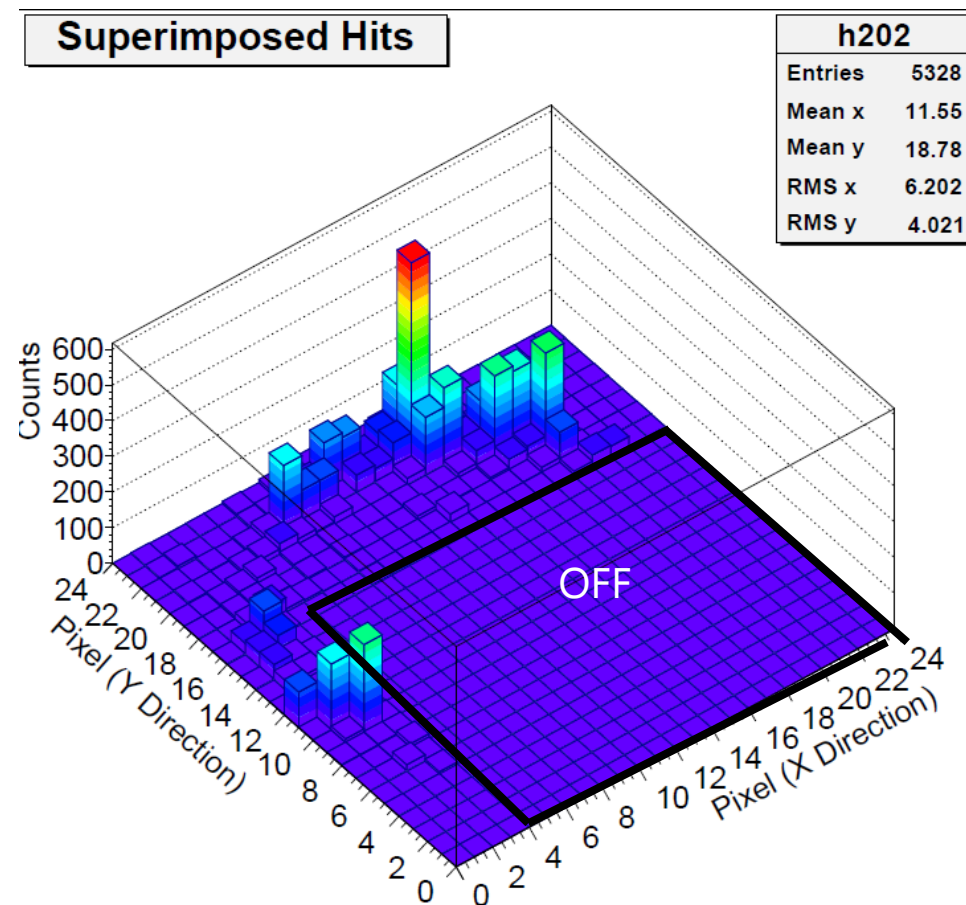
ROOF Board

CMAD Boards

Protection
Boards



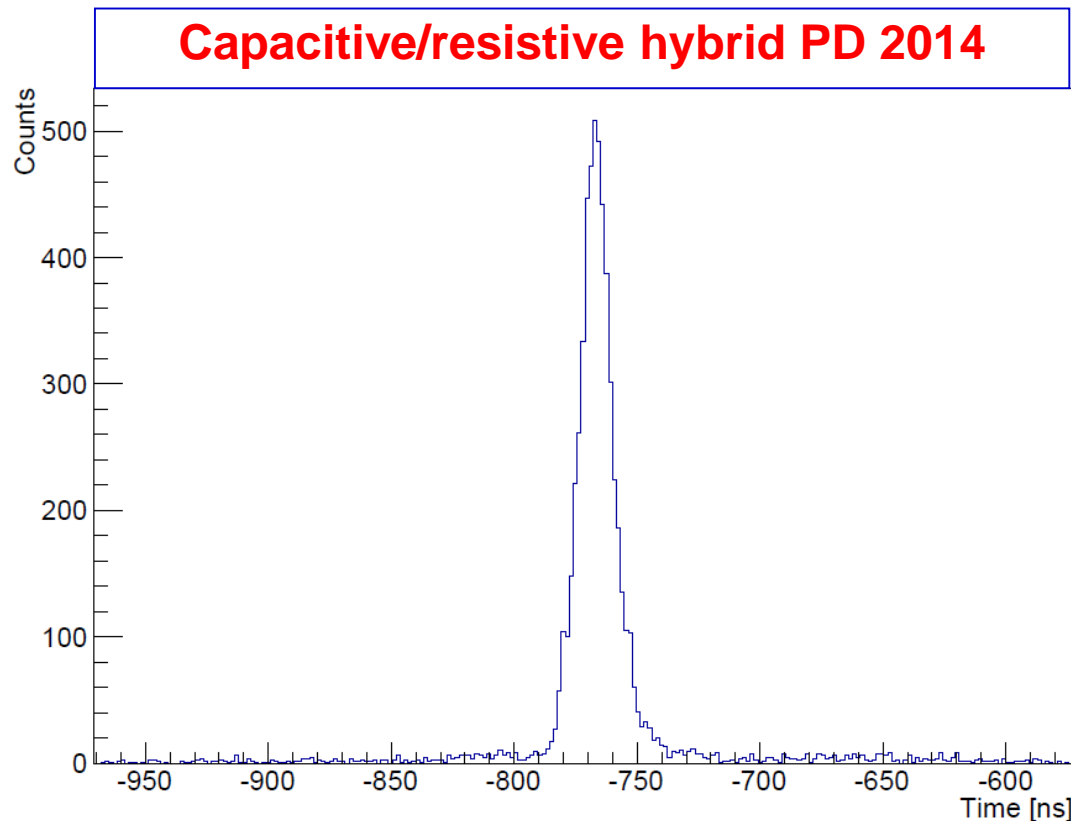
Cerenkov Ring Image



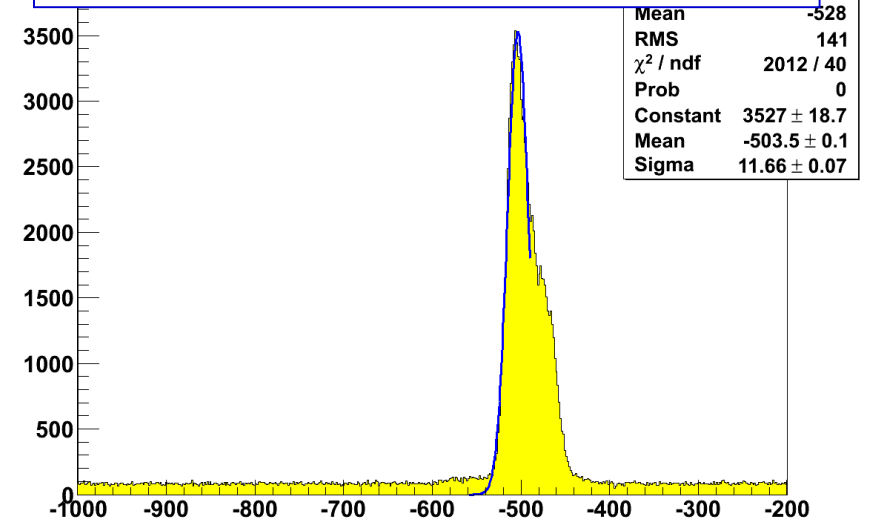
Digital Images

Time response

- The time distribution response is improved and affected by a lower noise level if compared to the 2012 data

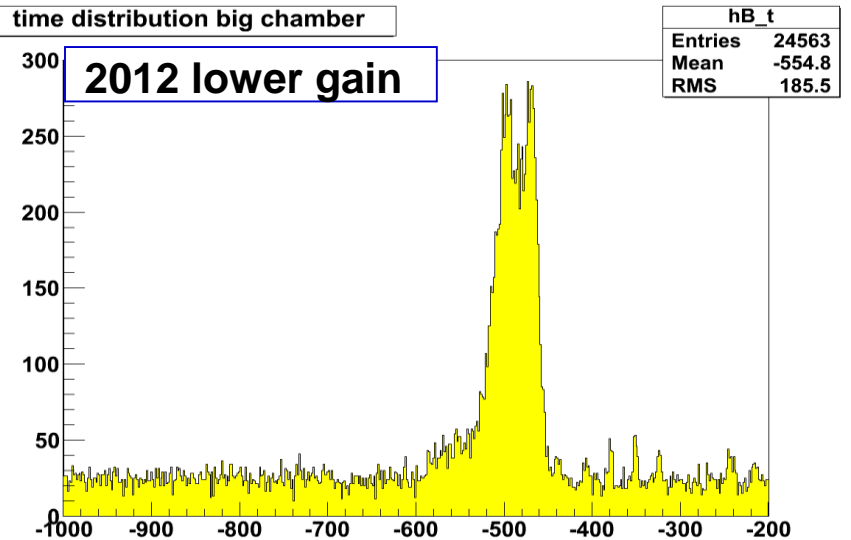


For comparison: triple THGEM time spectra from 2012 test beam



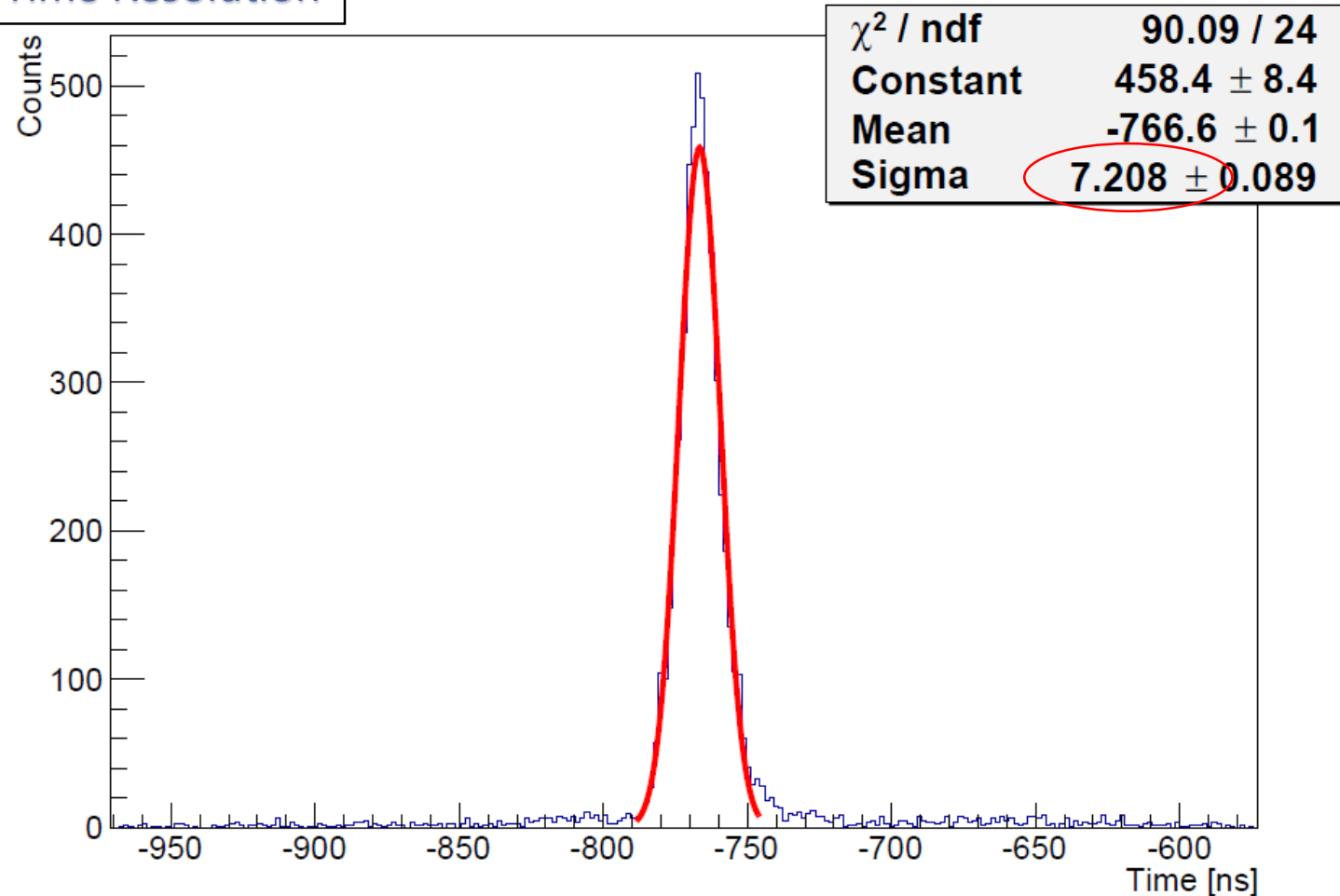
time distribution big chamber

2012 lower gain



Digital results

Time Resolution



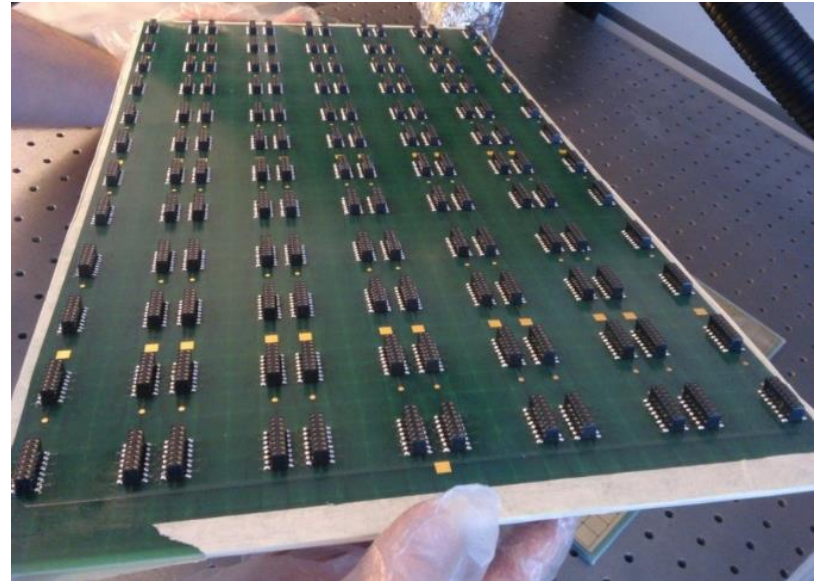
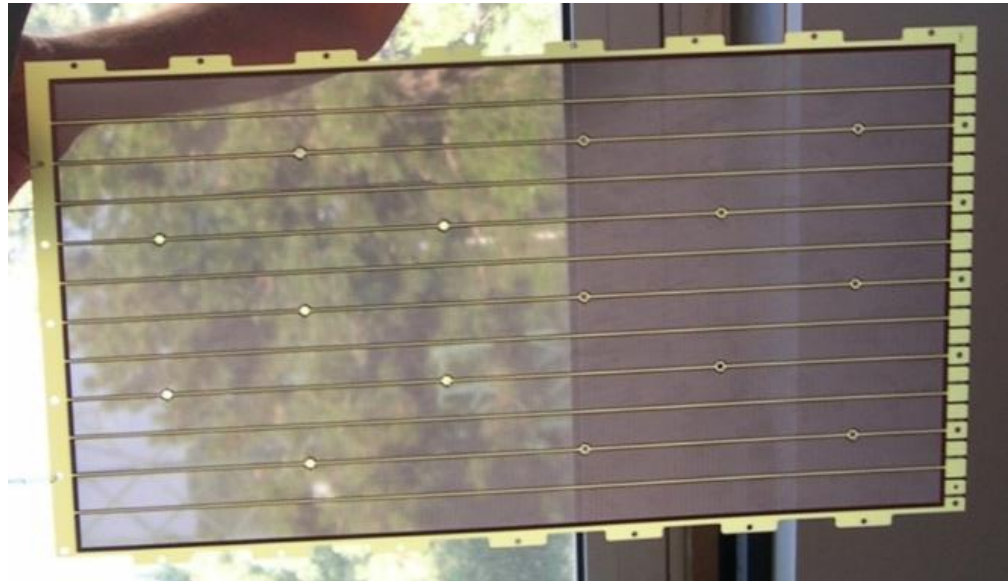
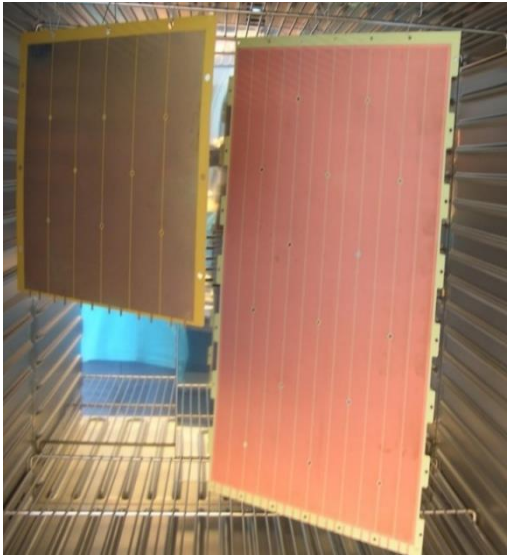
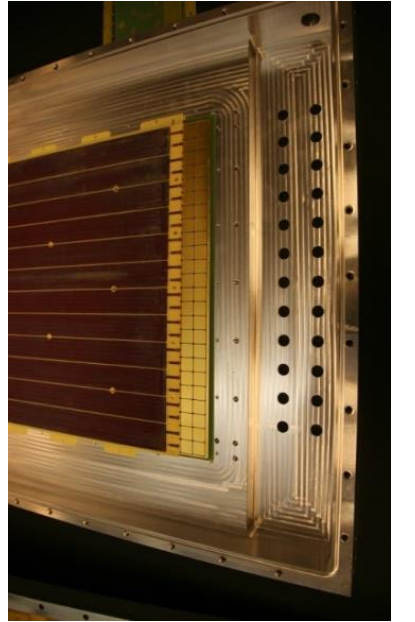
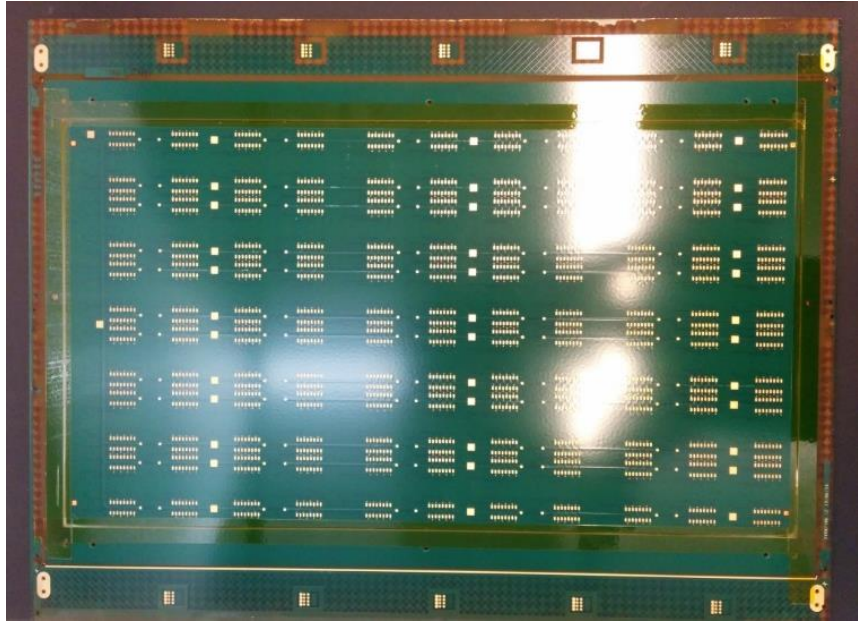
Conclusion

- The hybrid with capacitive anode performed at the Test Beam as they did in the Lab.
- The hybrid PD with capacitive micromegas allows to operate the MICROMEGAS at voltage bias which are 100 V larger than for the standard one →
 - Larger gain with less THGEM voltage and higher stability
 - No other large MPGD has ever been operated with a beam at 10^5 gain
 - Excellent time response
 - Nice device suitable for single Cherenkov photon detection
- Future GOAL:
 - Read-out & noise need to be fine tuned
 - HV powering system can be upgraded.
 - 600 X 600mm² prototype is in the preparation to be tested at our INFN Trieste LAB.

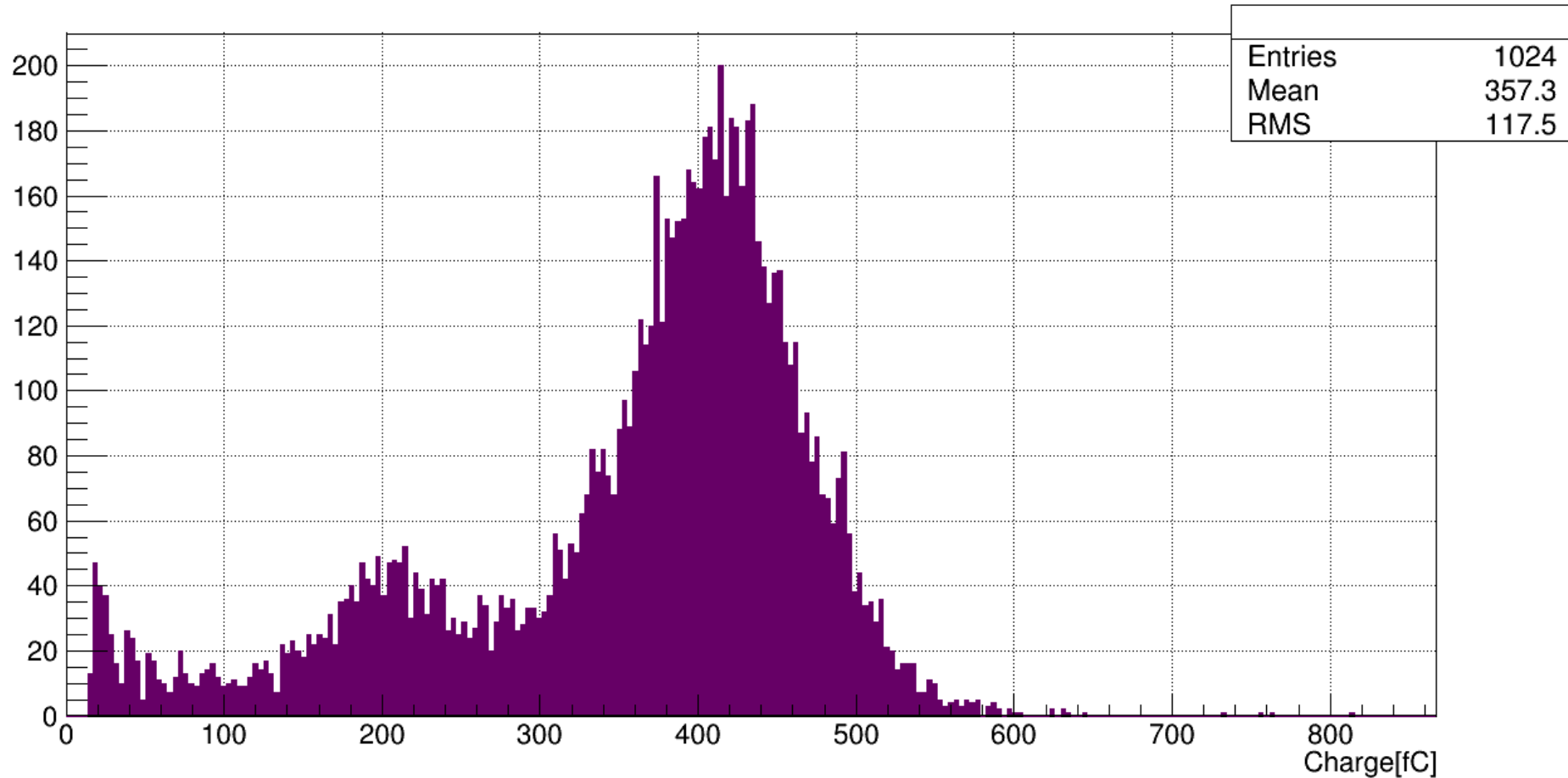


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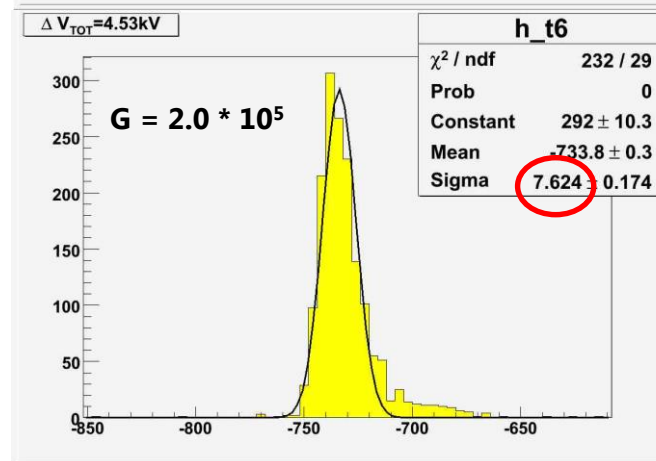
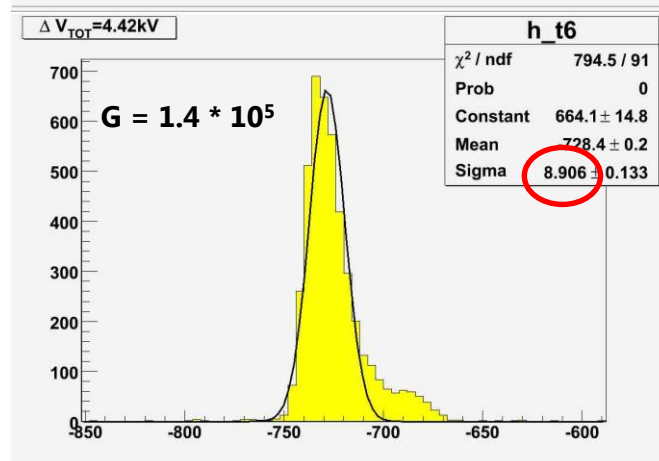
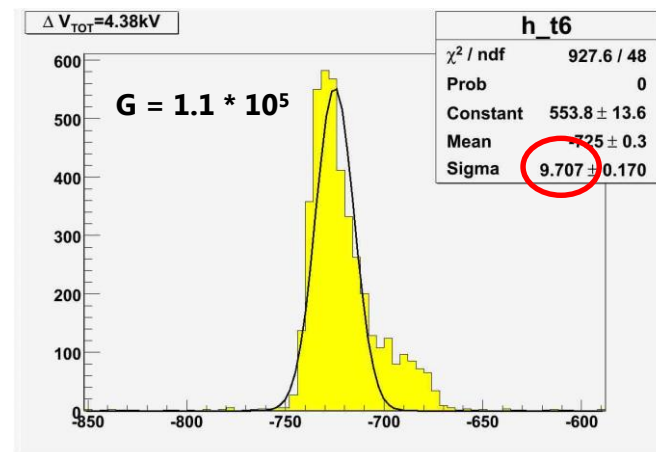
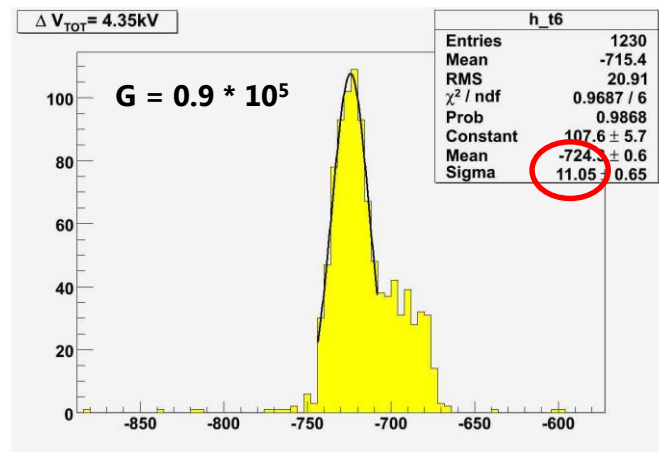


^{55}Fe Spectra for 11780 gain of the capacitive Micromegas



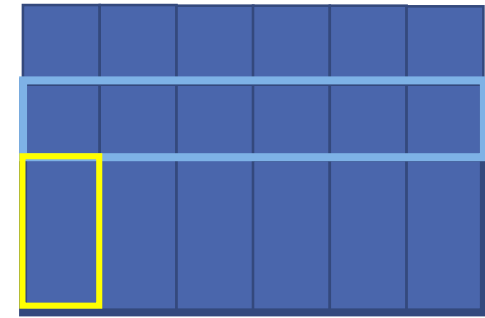
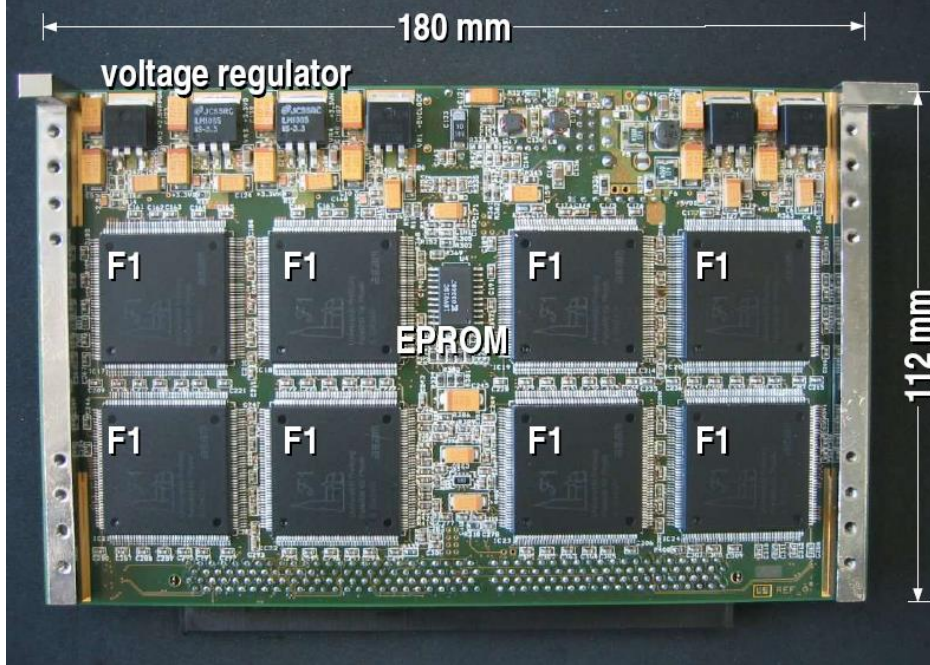
Time response from 2011

Small prototype: time response study (2011)



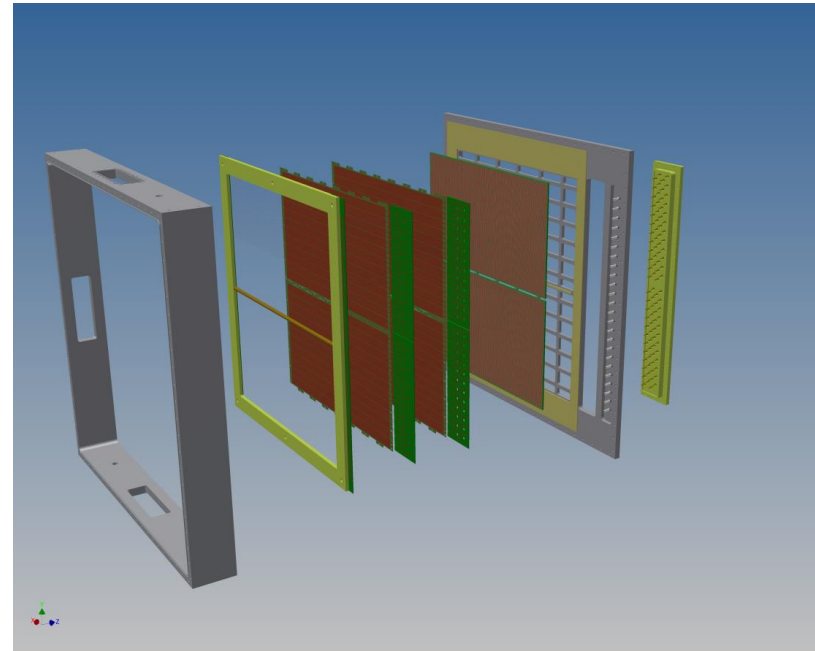
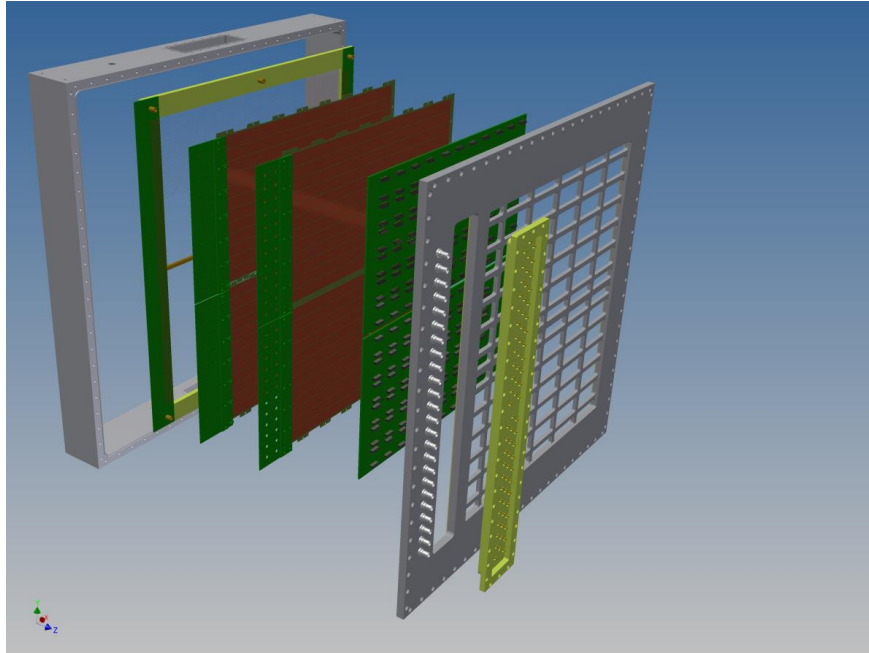
BACK UP

- 64 channels per card, compact solution
- **optical** data transfer (40 MByte/s)
- **high** rates per channel **10 MHz @ 100 kHz** trigger rate
- time resolution **< 100 ps**
- based on dead time free **F1-TDC**



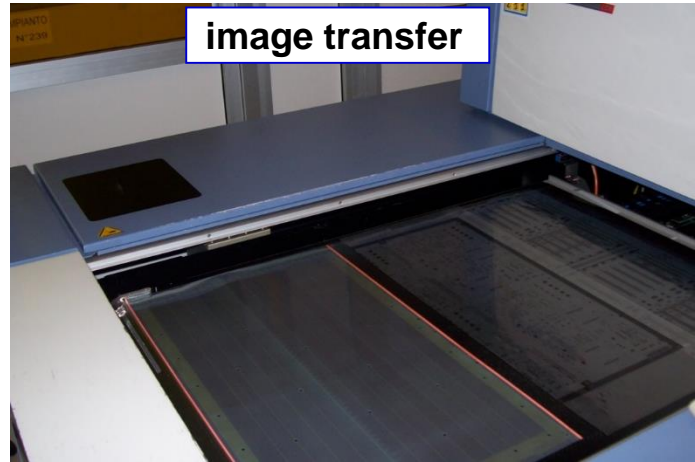
- Each CMAD readout board read 8 pads.
- Each ROOF board connects 8 CMAD card (means: 64 pads)
- Each DREISAM connected to each roof boards (Means each DRIESAM read 64 Pads)
- So we need 12 DREISAM boards where 6 of the roofs are half empty.

Progress of 600 X 600mm² prototype

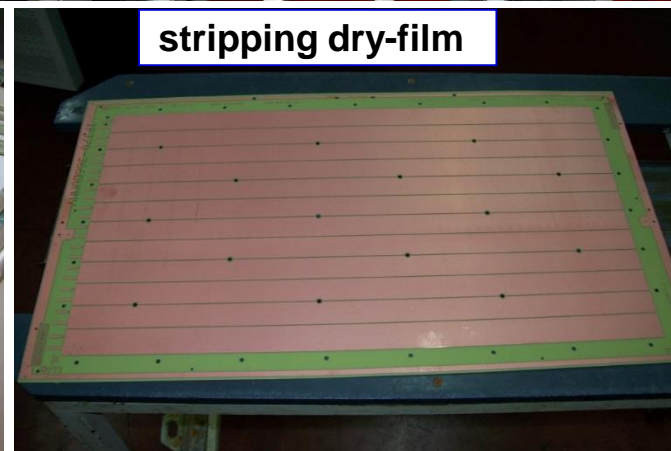
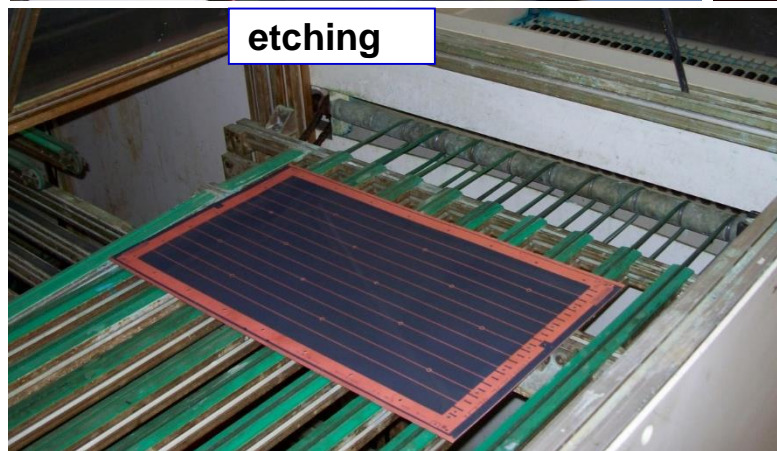


- Now the goal is to build a 600X600mm² Prototype to be build and to test it in lab.
- The pieces are already produced and ready to be commissioned in our Trieste Lab.

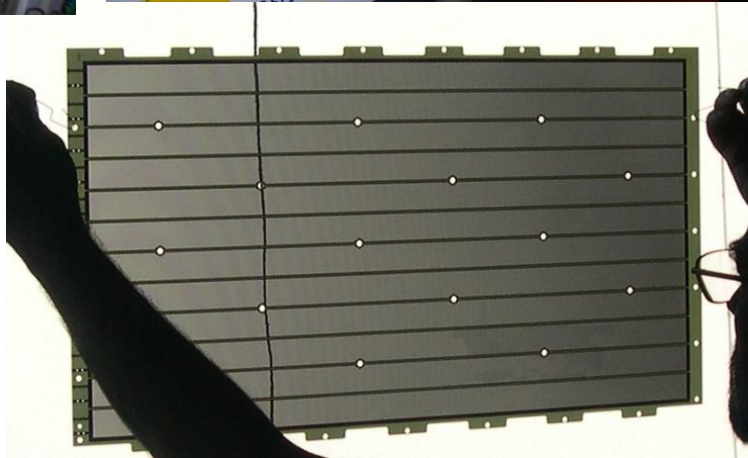
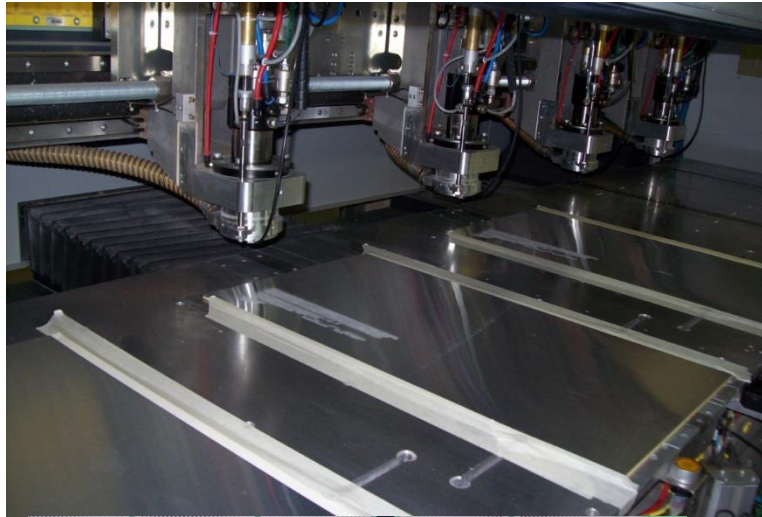
Progress of 600 X 600mm² prototype



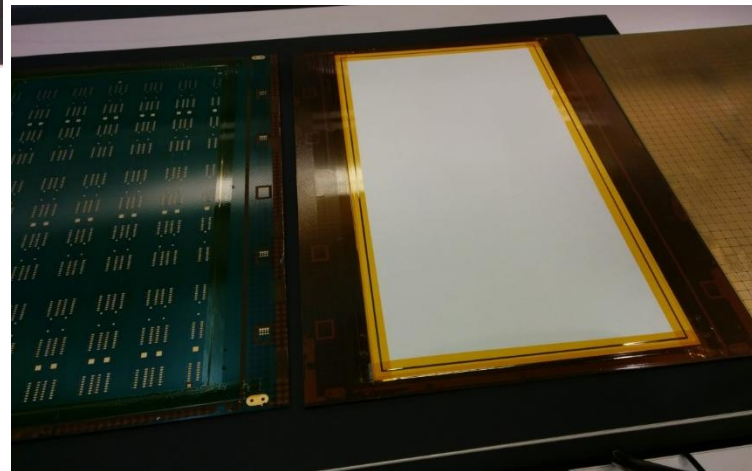
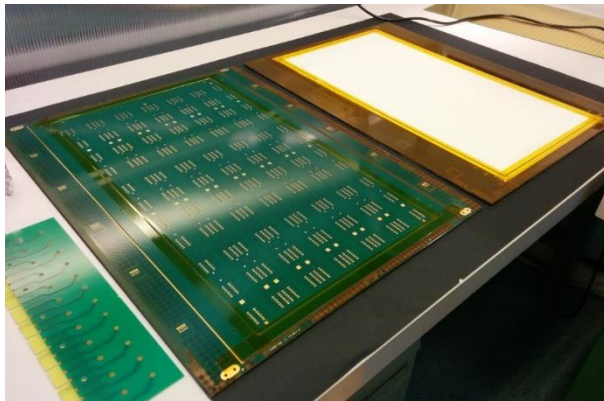
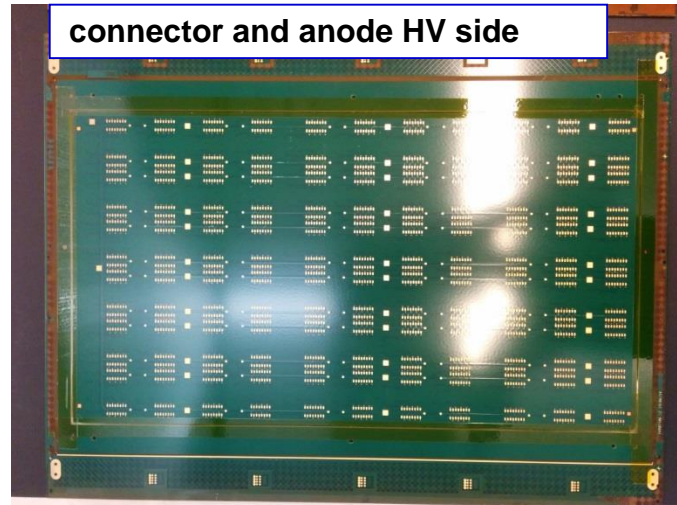
- Production procedures for 300X600mm² THGEMs



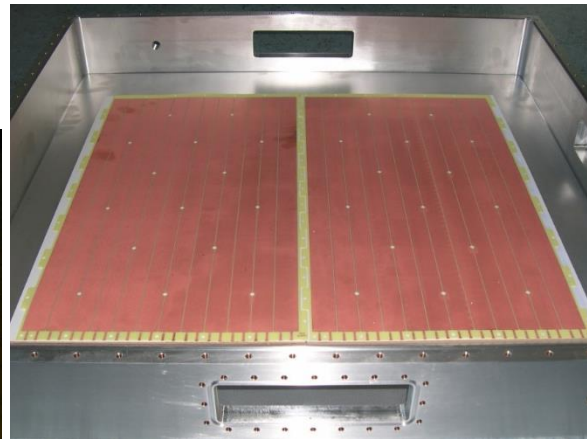
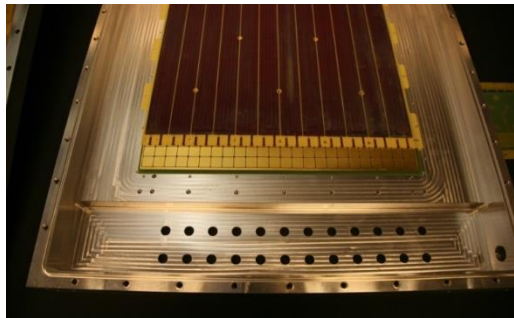
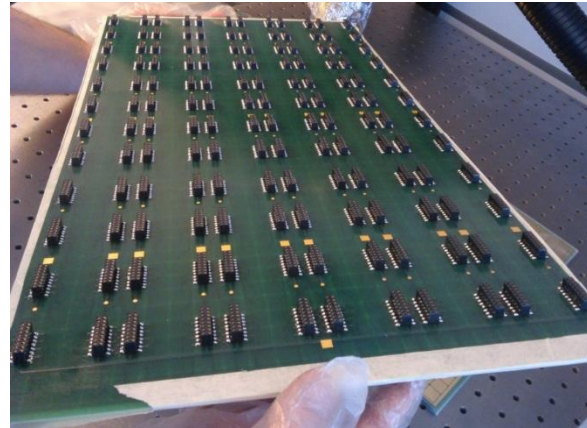
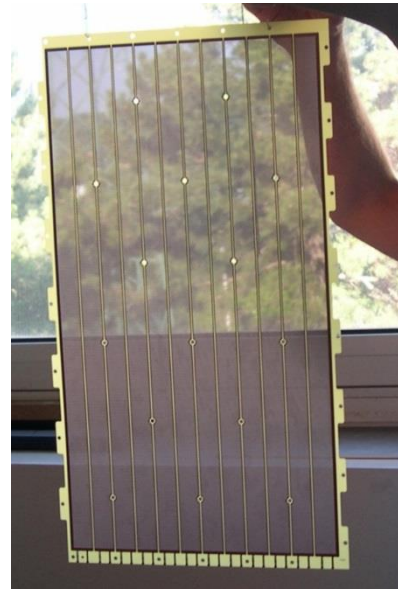
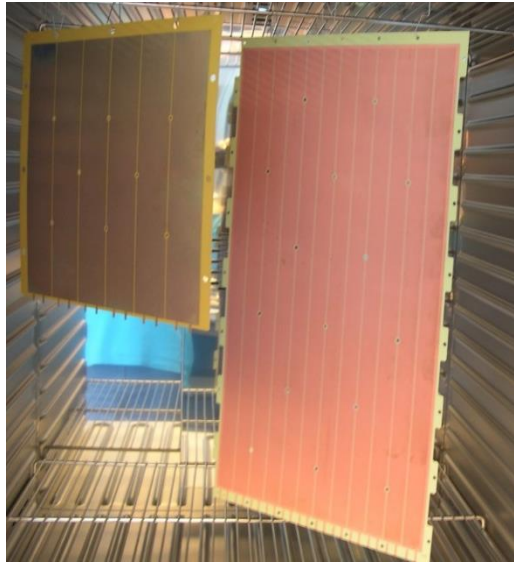
Progress of 600 X 600mm² prototype



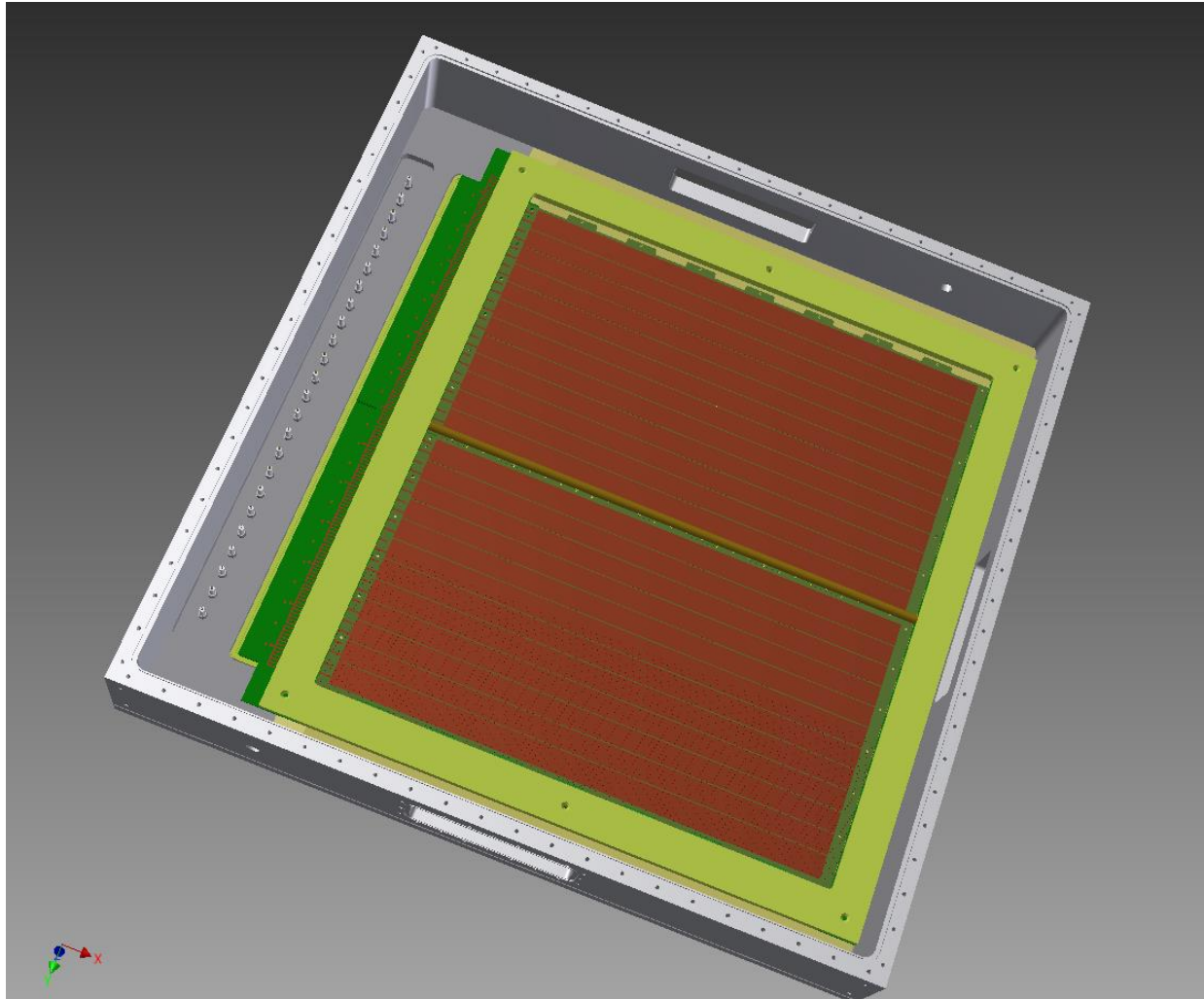
Progress of 600 X 600mm² prototype



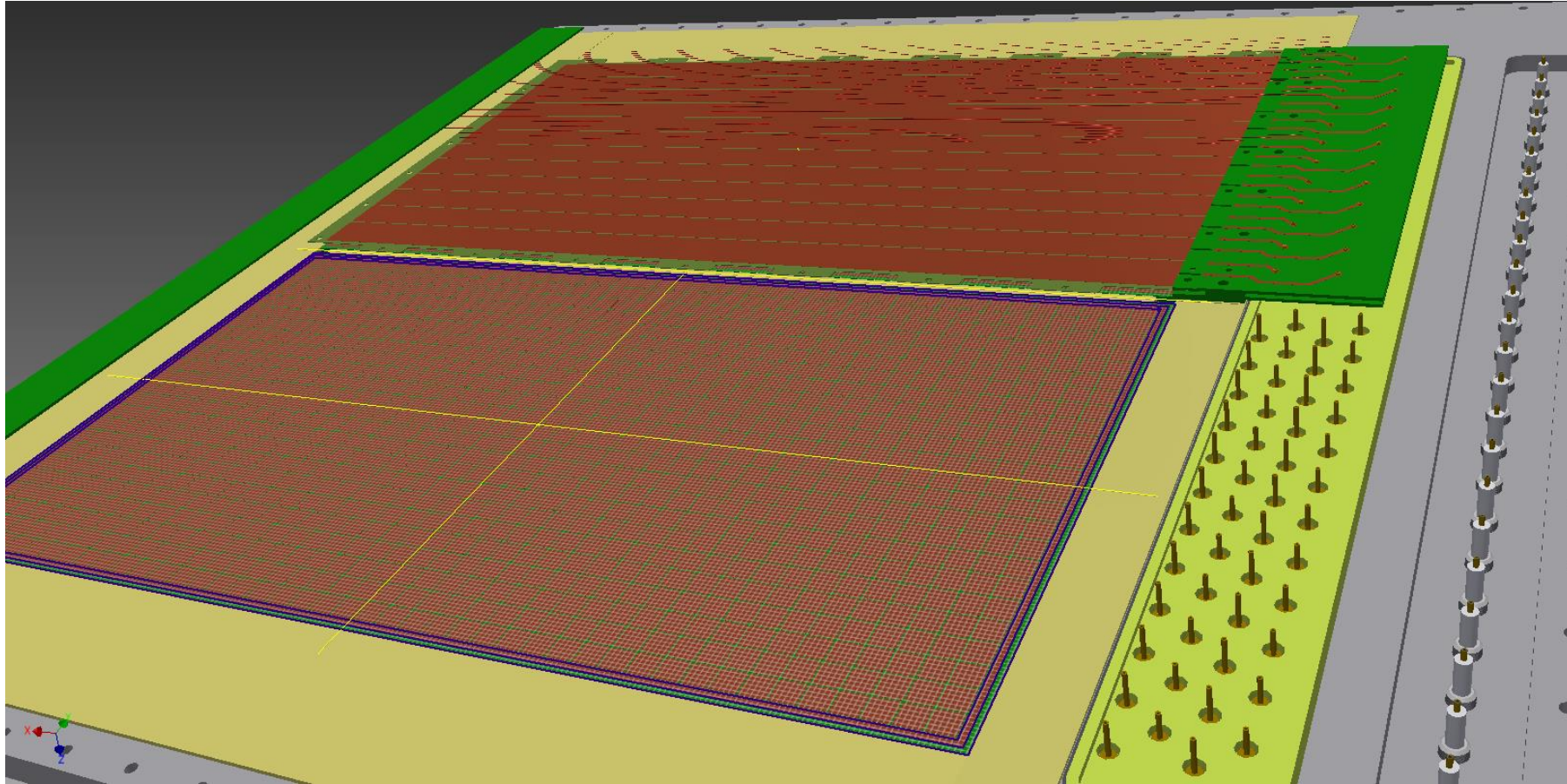
Progress of 600 X 600mm² prototype



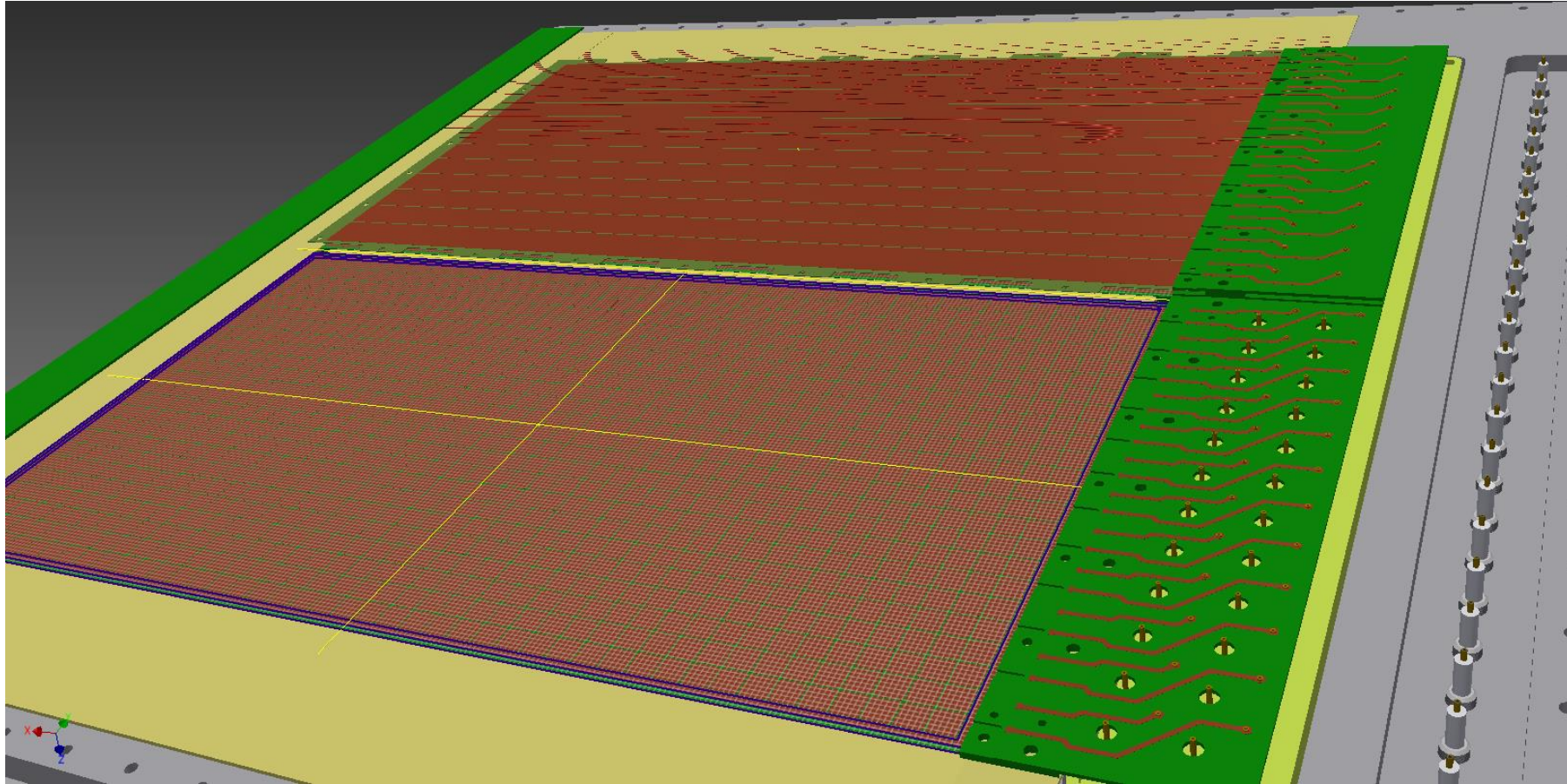
Progress of 600 X 600mm² prototype



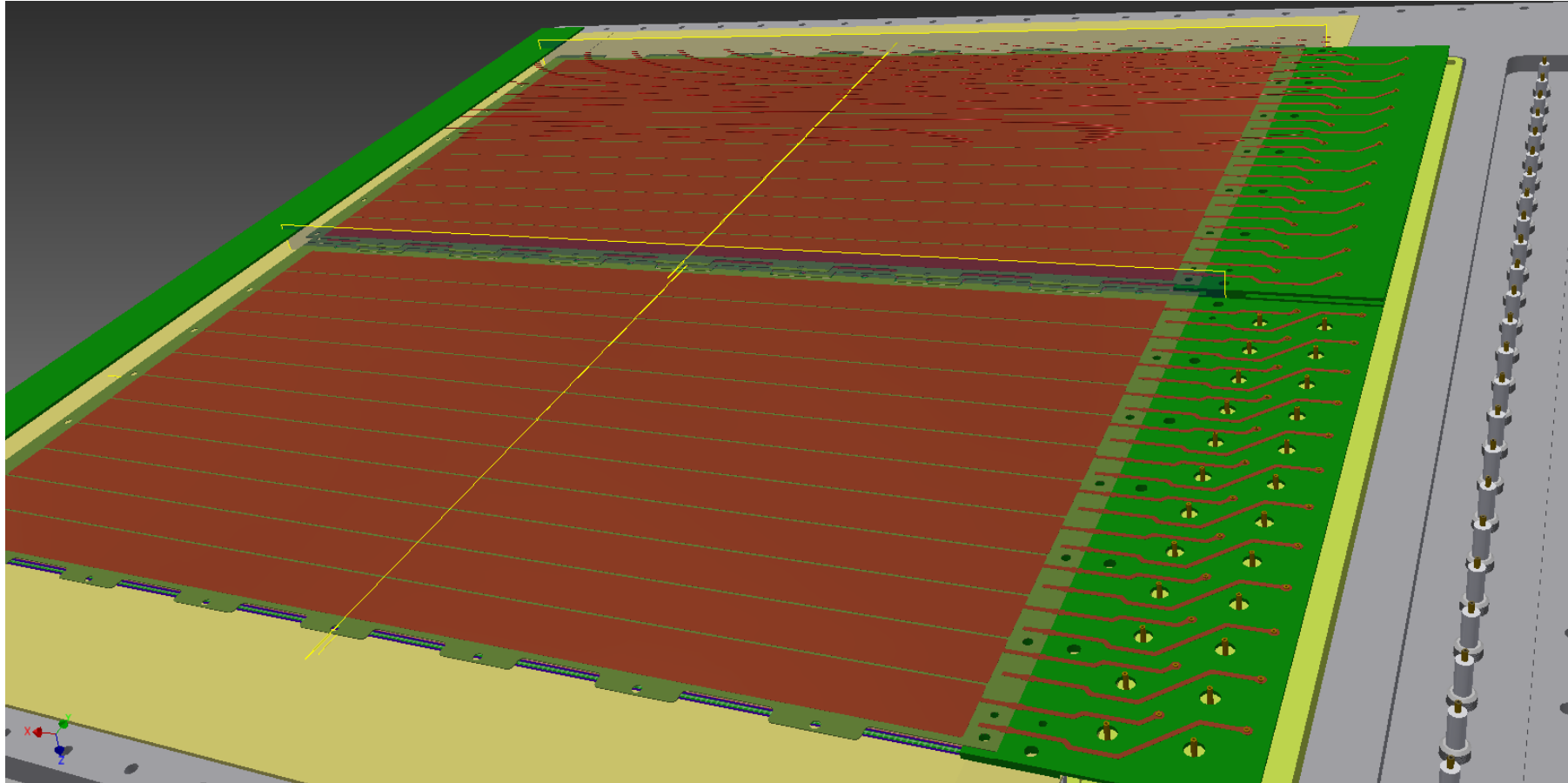
Progress of 600 X 600mm² prototype



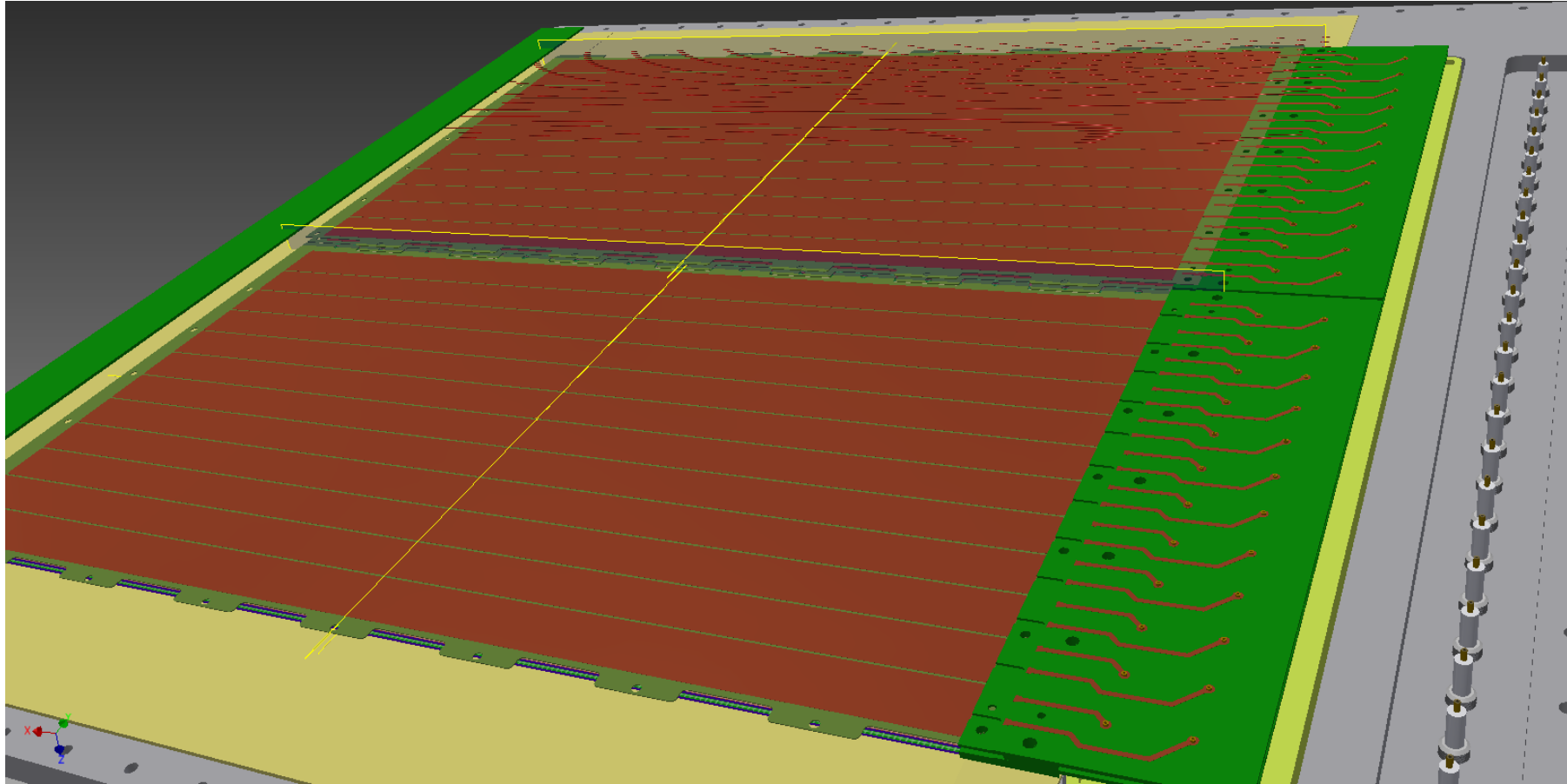
Progress of 600 X 600mm² prototype



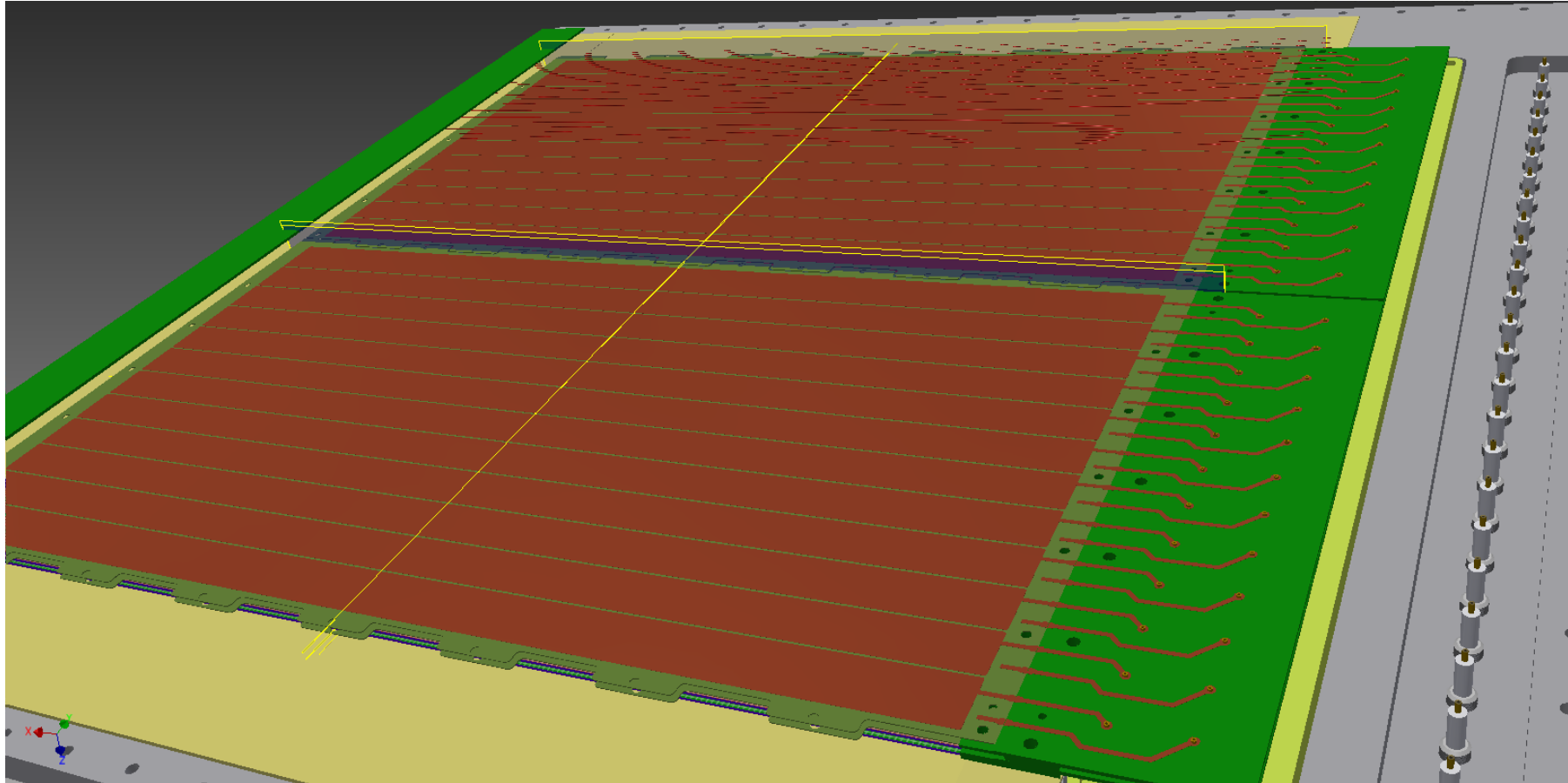
Progress of 600 X 600mm² prototype



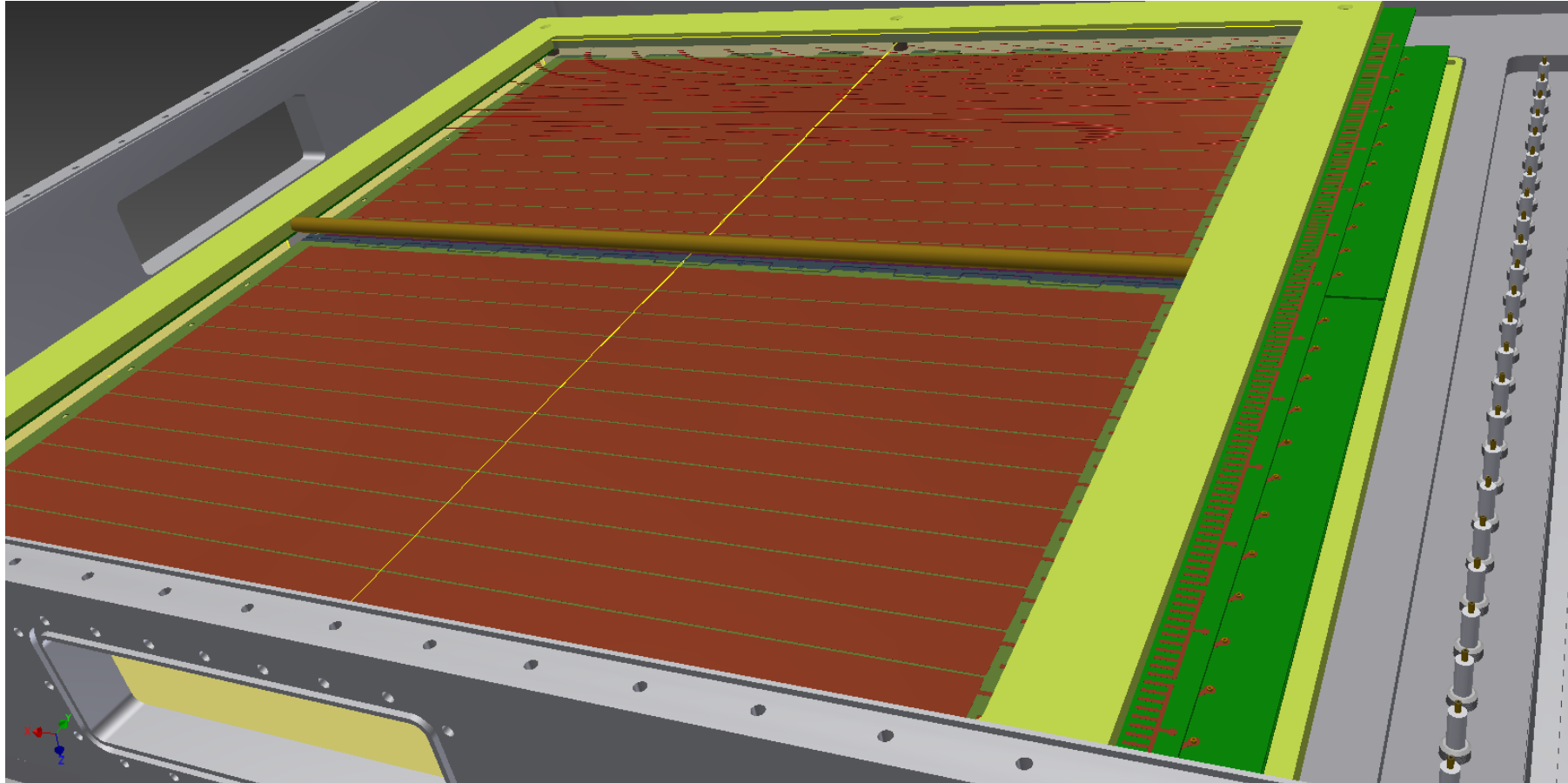
Progress of 600 X 600mm² prototype



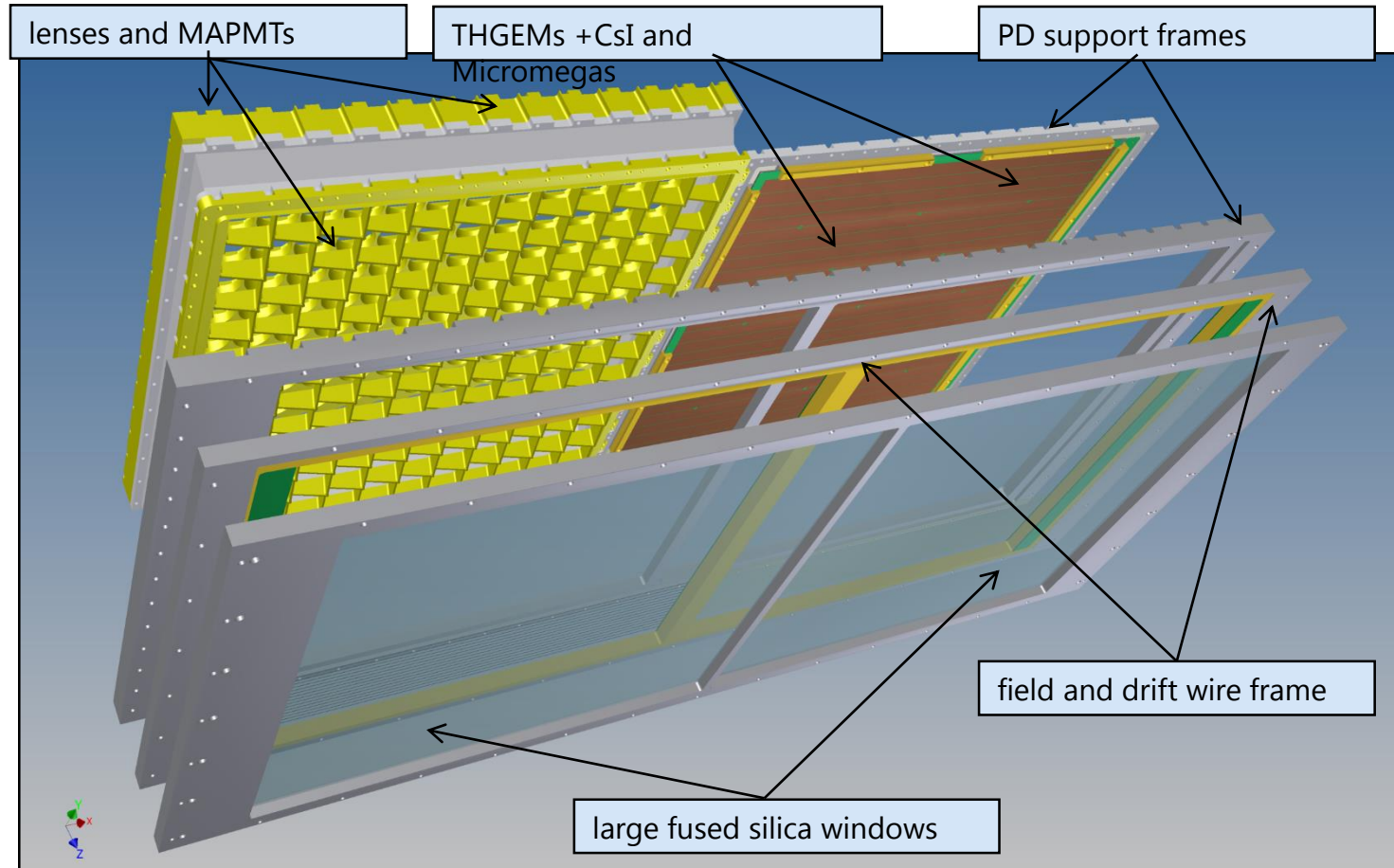
Progress of 600 X 600mm² prototype



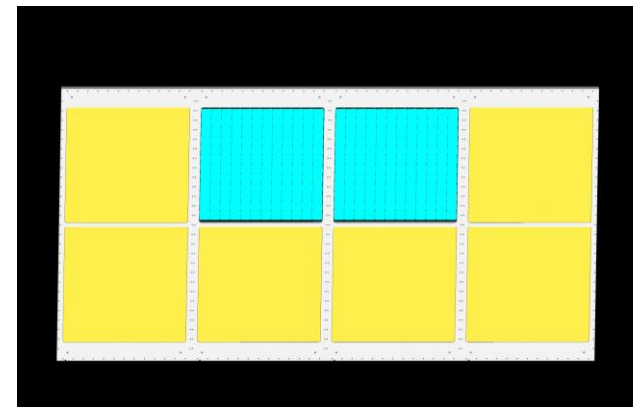
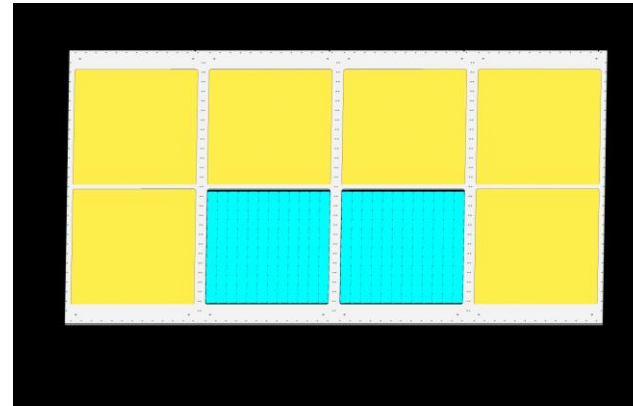
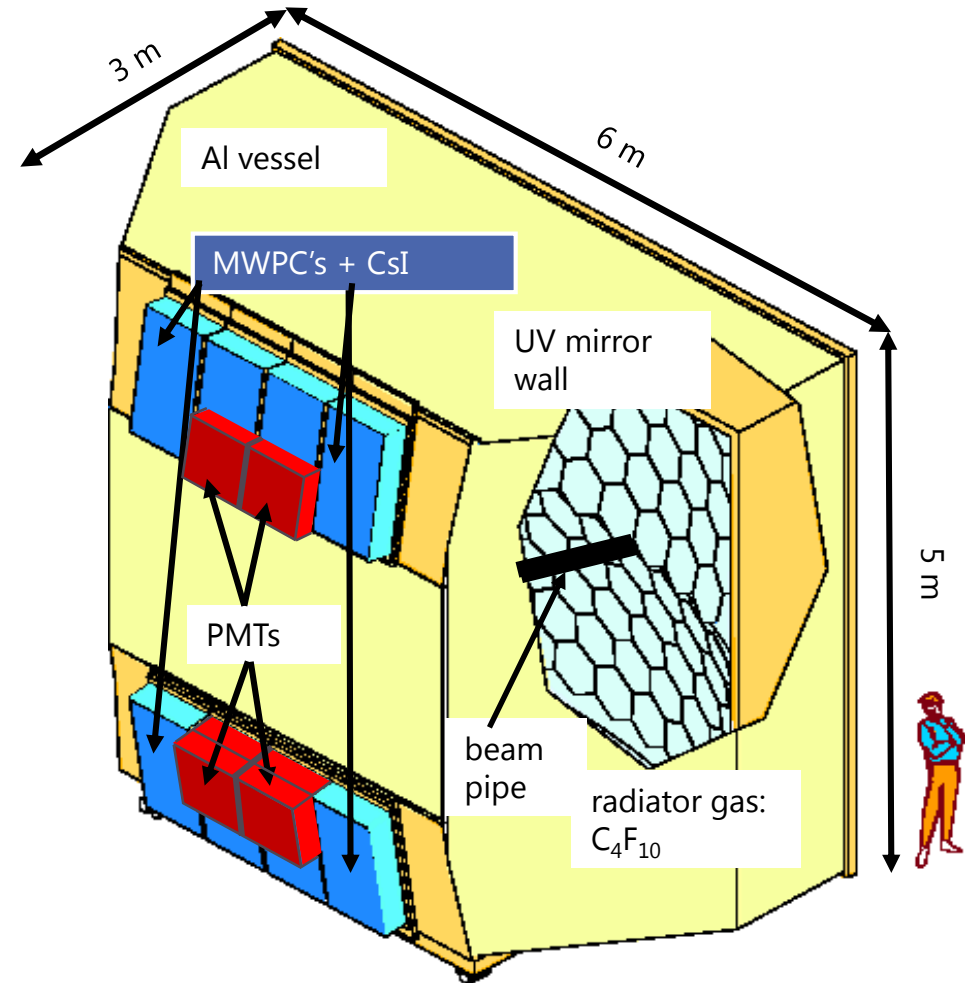
Progress of 600 X 600mm² prototype



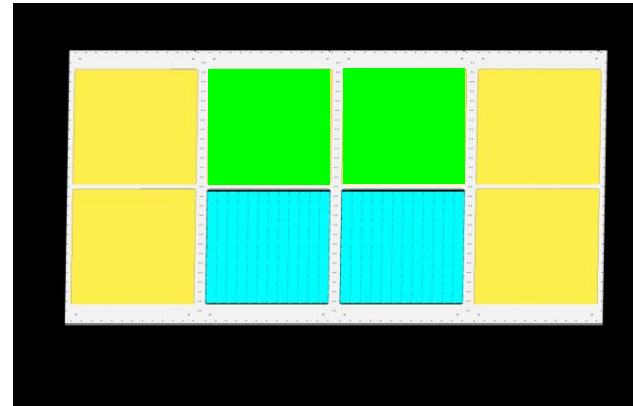
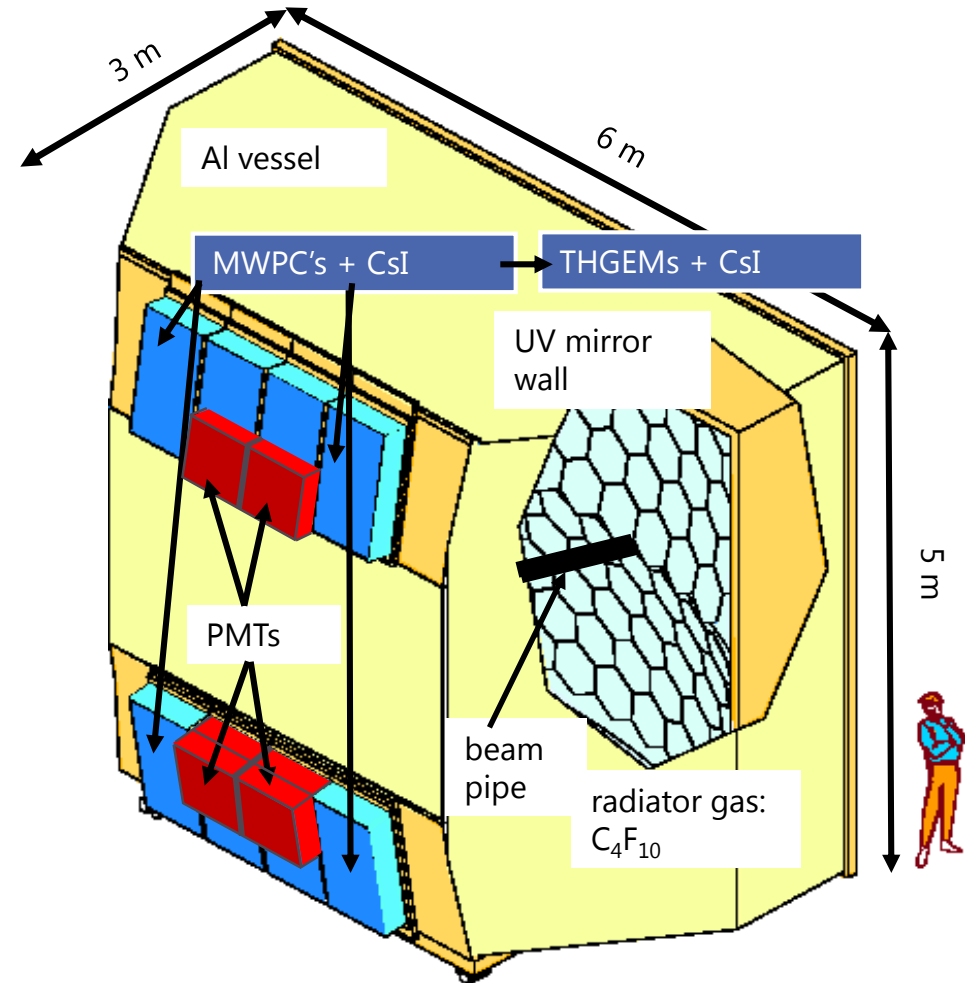
Progress of 600 X 600mm² prototype



Progress of 600 X 600mm² prototype



Progress of 600 X 600mm² prototype



Foreseen for 2016

