A High Eta Forward Muon Trigger & Tracking detector for CMS

PROTO GE1/1 – With The Largest GEM Foils

UPDATE AT RD51 COLLABORATION MEETING BARI

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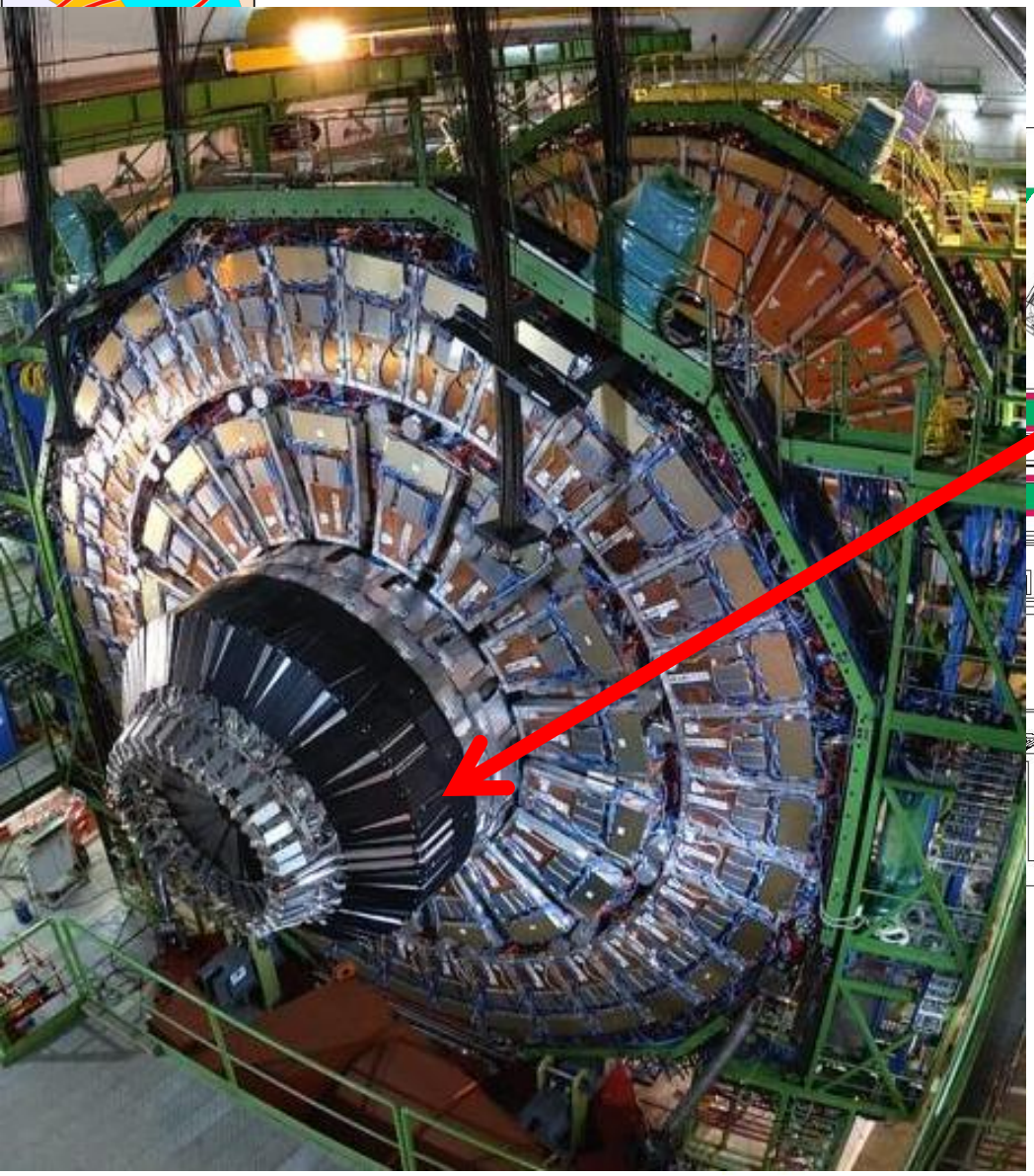
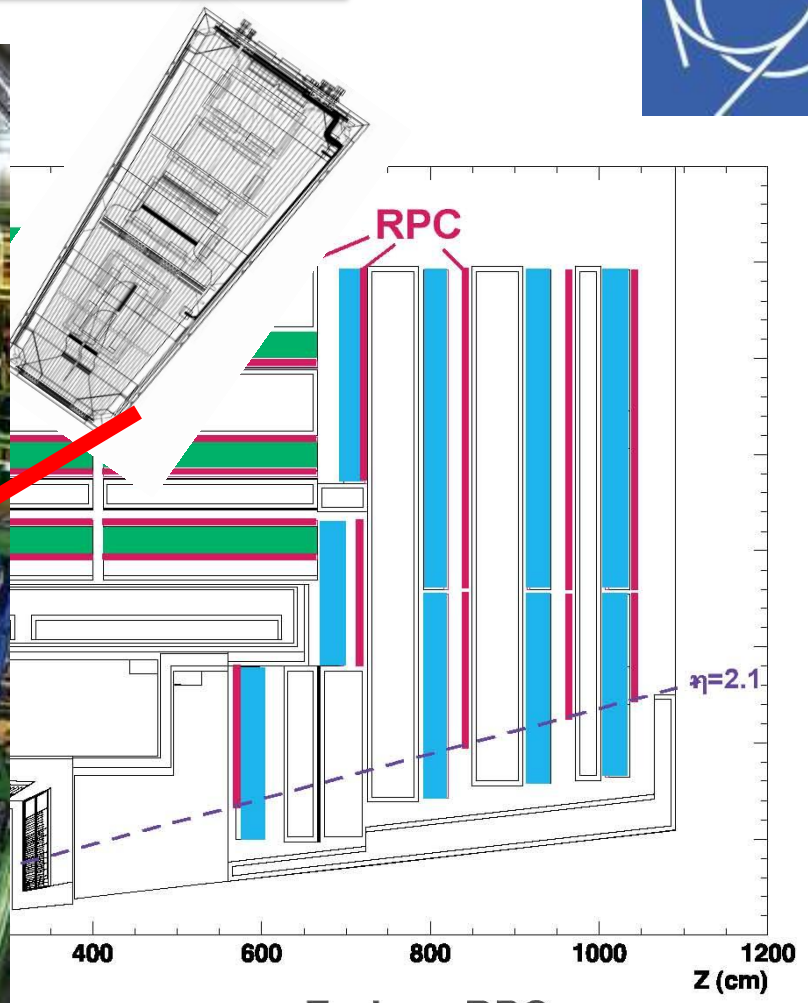
For CMS High Eta Upgrade Team
CMS GDD RD51

Oct 8-11, 2010

CMS - Redundant Muon System

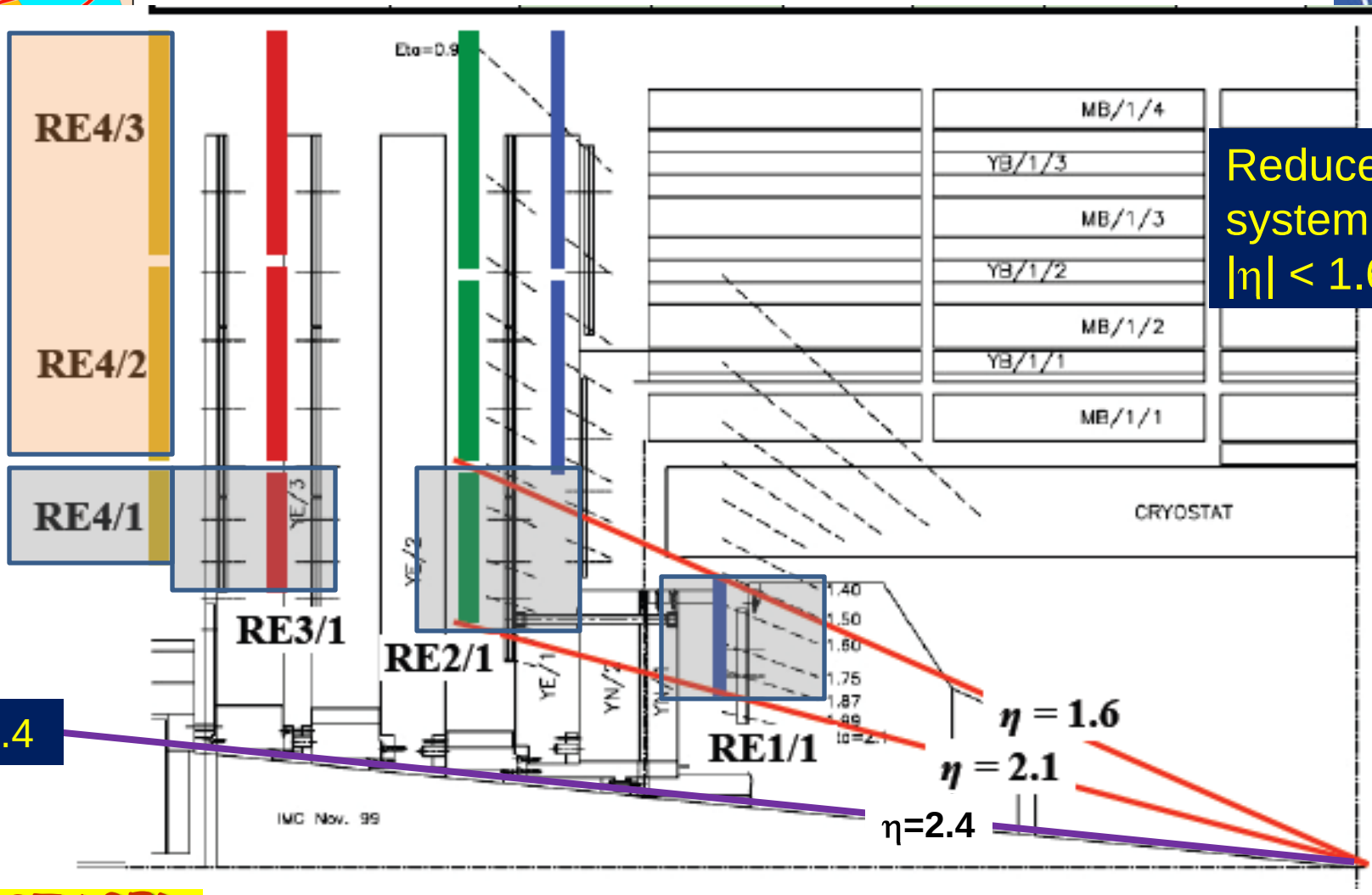




Endcap RPC:

- RE 1,2,3,4 = 1 layers
- 540 trapezoidal chambers
- 80 000 radial strips

Initial RE system –tailored to budget



Reduced RE system
|η| < 1.6

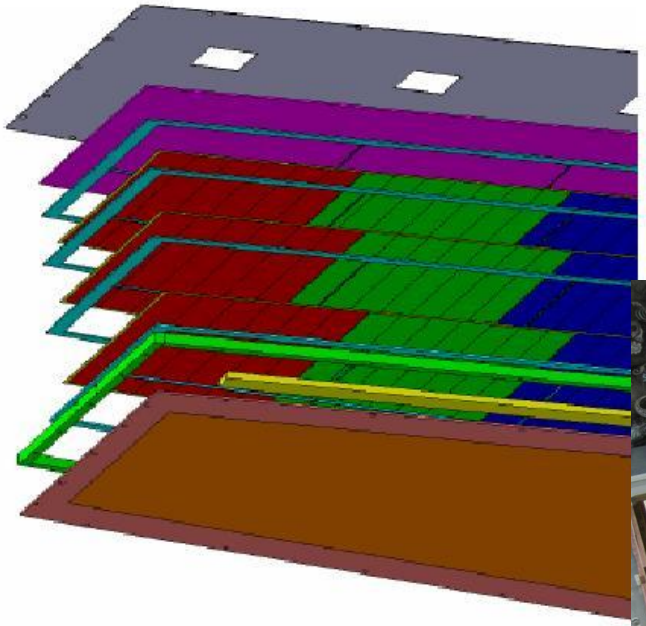
STAGED

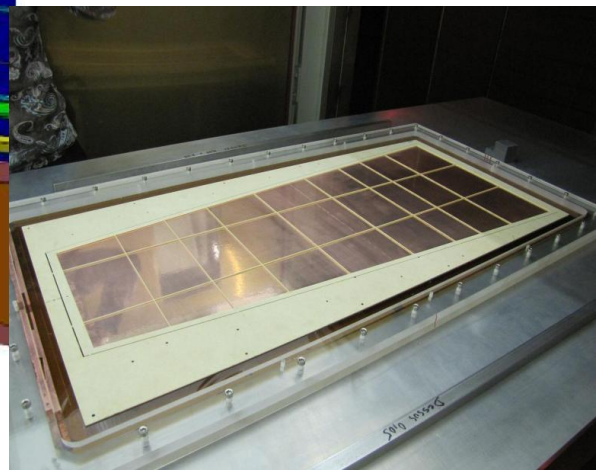
	RE 1/1	RE 1/2	RE 1/3	RE 2/1	RE 2/2	RE 2/3	RE 3/1	RE 3/2	RE 3/3	RE 4/1	RE 4/2	RE 4/3
No. of chambers	36*2	36*2	36*2	18*2	36*2	36*2	18*2	36*2	36*2	18*2	36*2	36*2

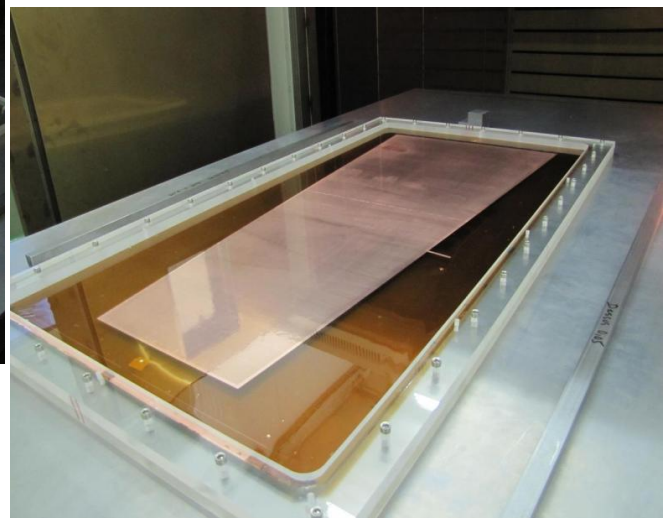
Estimated Particle rates in Forward CMS

RPC Region	Rates Hz/cm^2 LHC (10^{34} cm^2/s)	High Luminosity LHC 2.3 x LHC	(10^{35}cm^2/s) Phase II SLHC ??
RB	**30**	**Few 100**	**500 Hz - kHz (tbc)**
RE 1, 2, 3,4 $\eta < 1.6$	**30**	**Few 100**	**kHz (tbc)**
Expected Charge in 10 years	0.05 C/cm^2	0.15 C/cm^2	~ C/cm^2
RE 1,2,3,4 $\eta > 1.6$	**500Hz ~ kHz**	**Few kHz**	**Few 10s kHz**
Total Expected Charge in 10 years	(0.05-**1**) C/cm^2	few C/cm^2	Few 10s C/cm^2

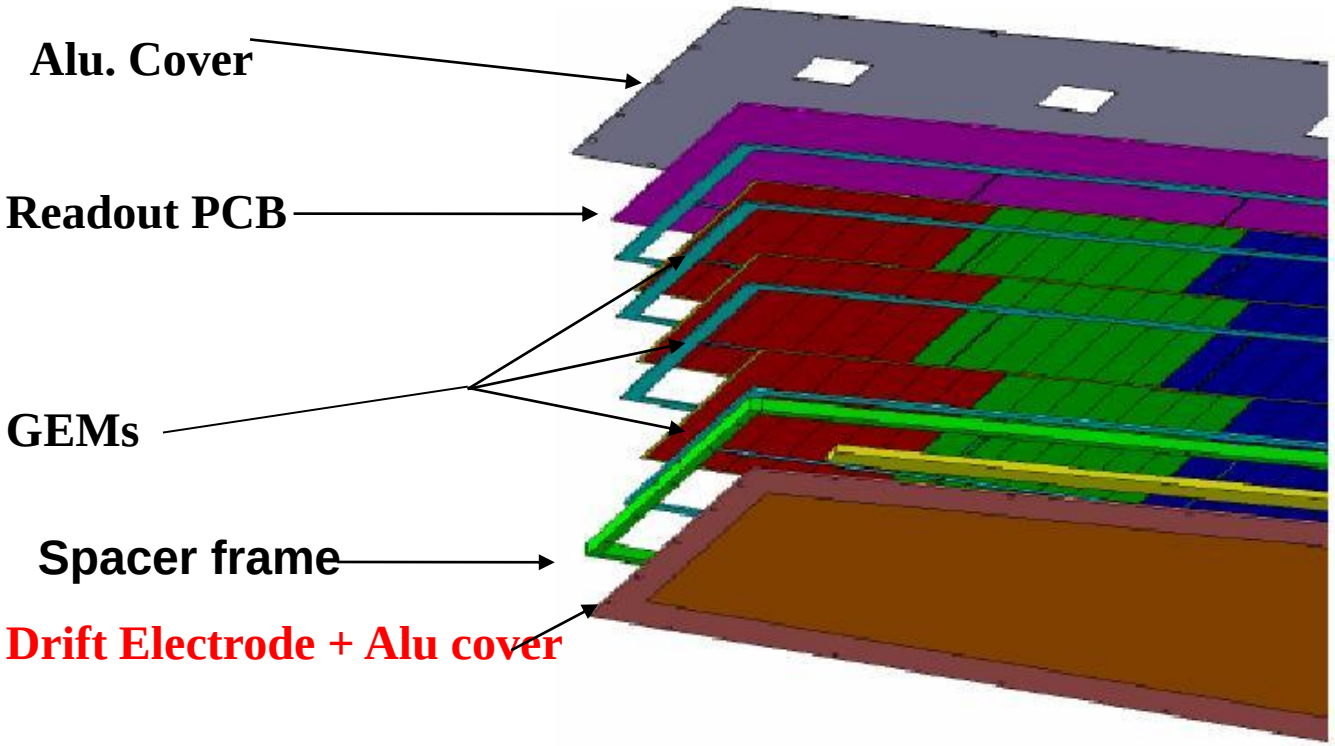
CONSTRUCTION OF THE LARGE PROTOTYPE CMS GE1/1



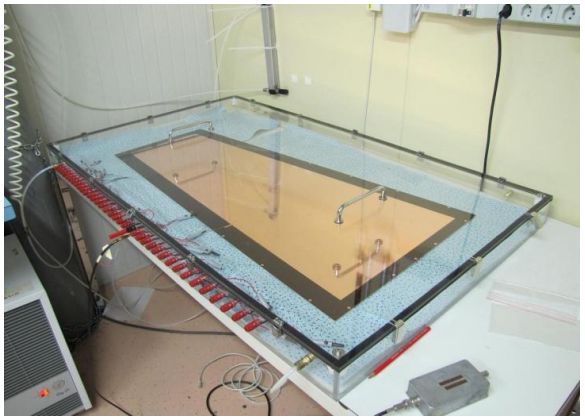


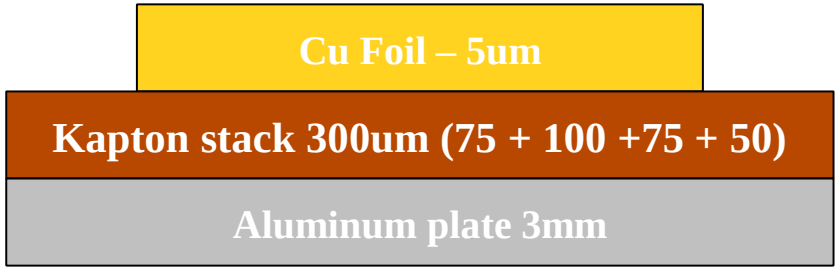


GE1/1 3D Model

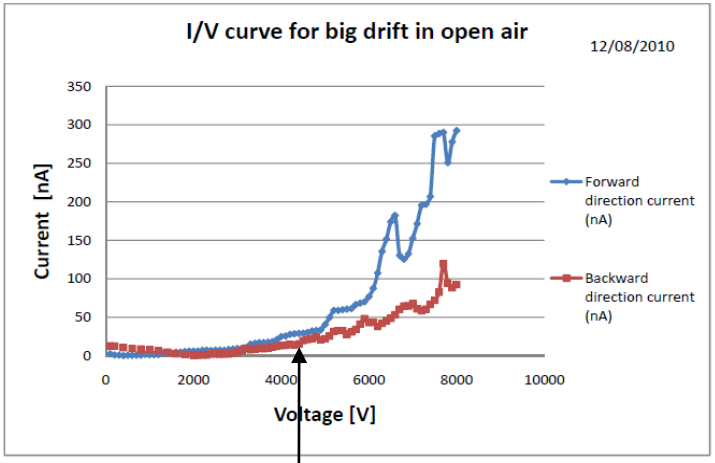


GE1/1 Drift Electrode

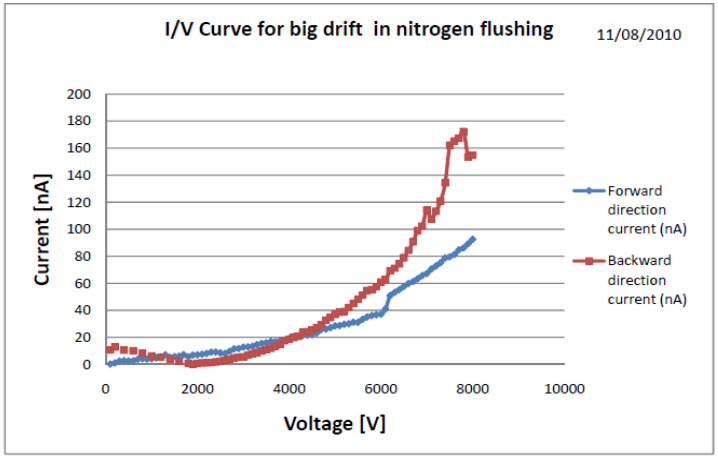




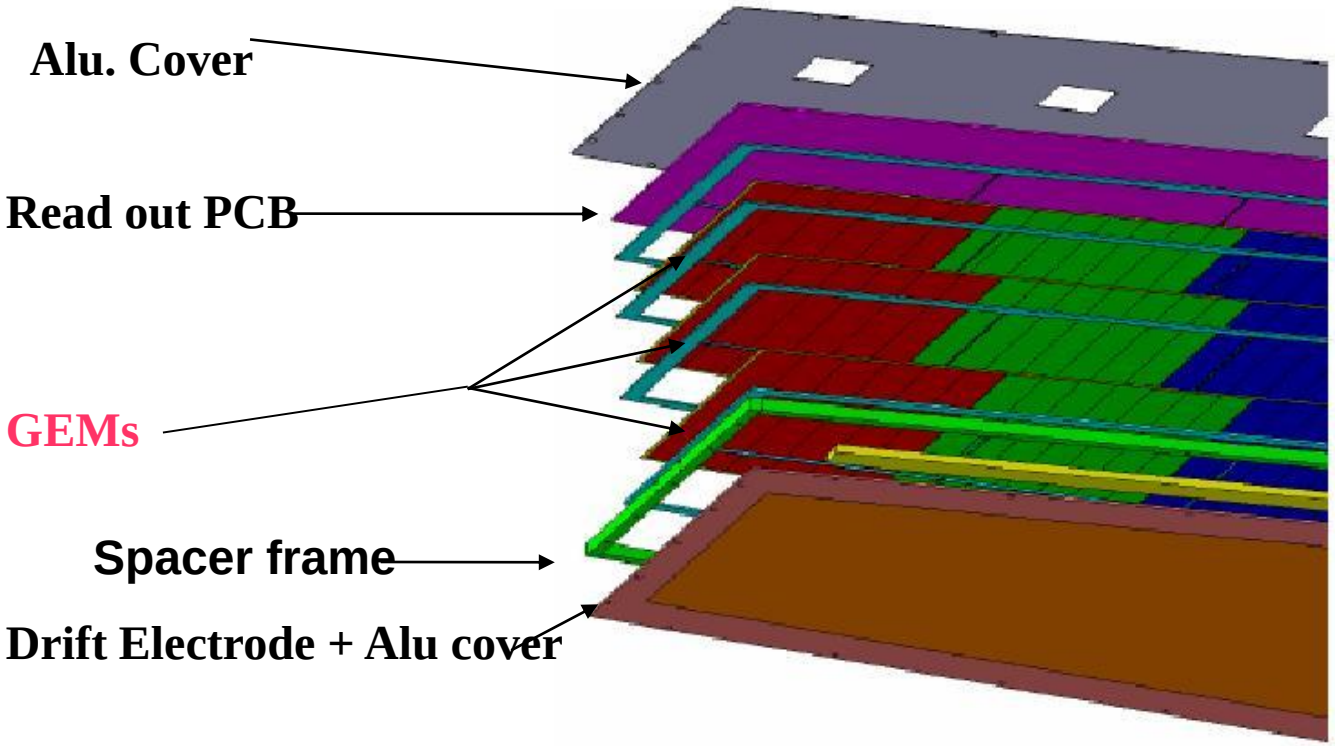
The operation voltage is 4.5kV
The leakage current is 20nA in open Air



Working point



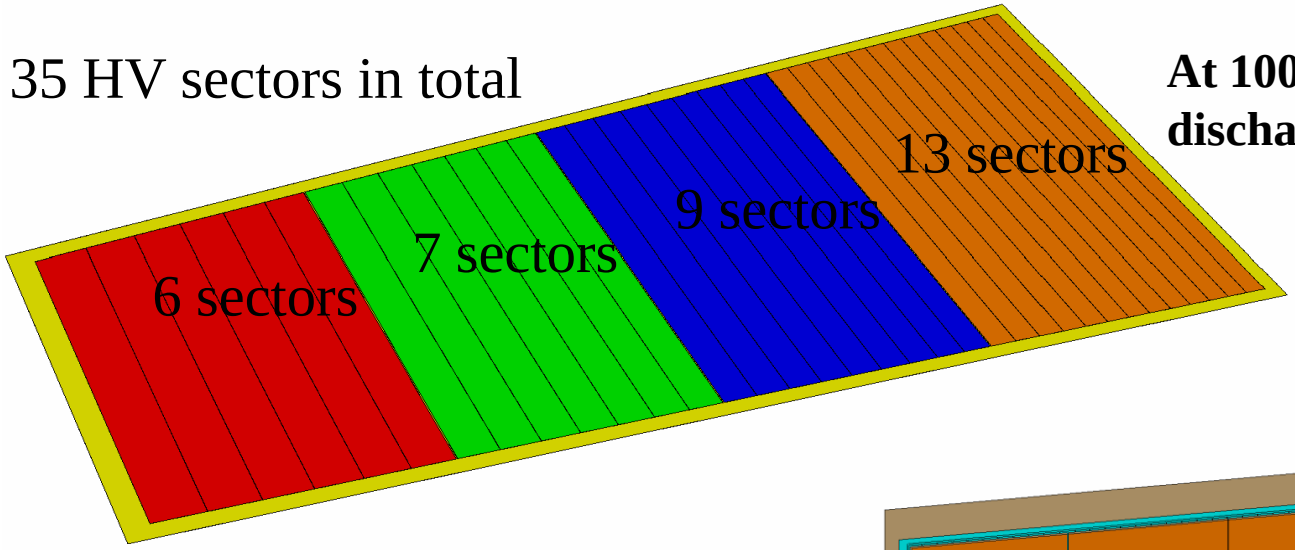
GE1/1 3D Model



GE1/1 – GEM Foils Sectorization

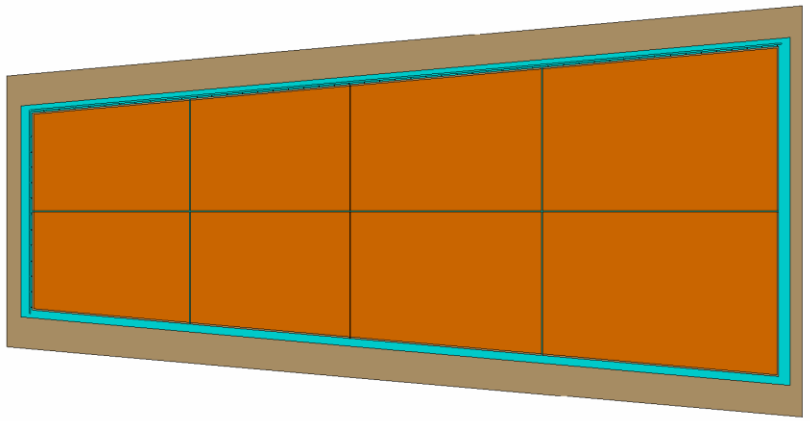
1 HV GEM sector = 100cm^2

35 HV sectors in total



At 100cm2 the probability of discharge is negligible

4 Eta sectors

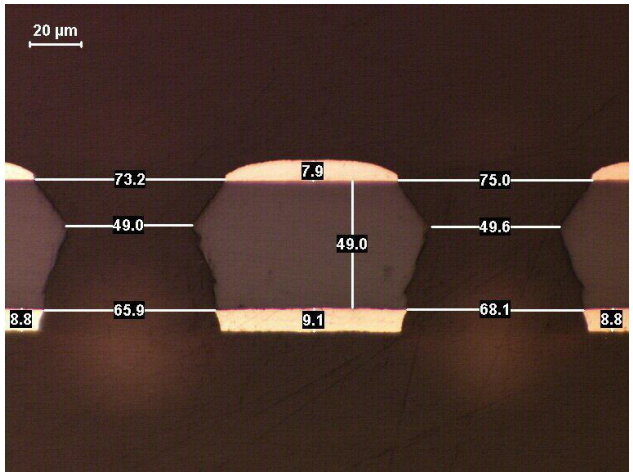


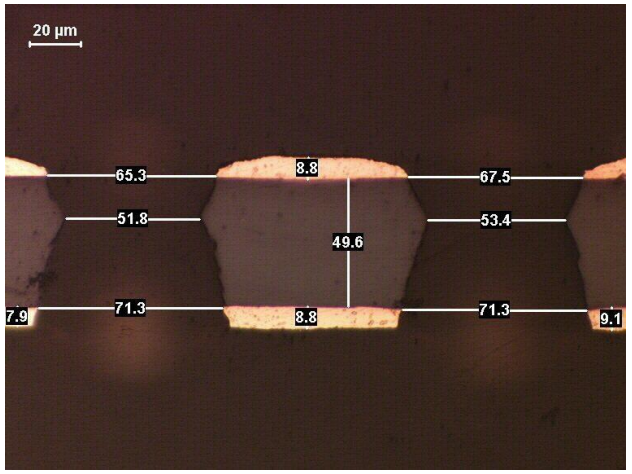
Using Single Mask(SM) production technology

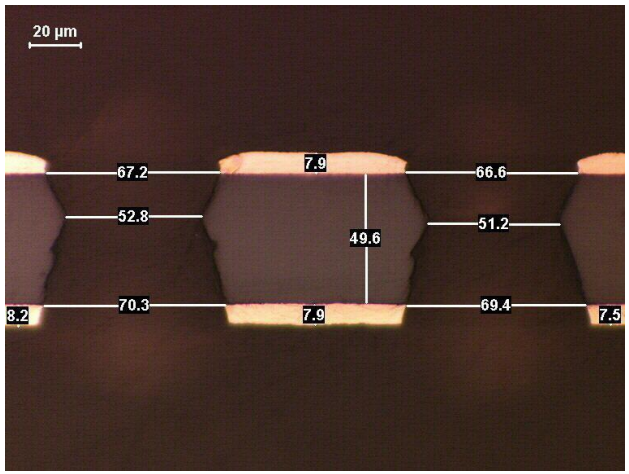
Rui's Workshop builds Largest Sized Single Mask GEMs

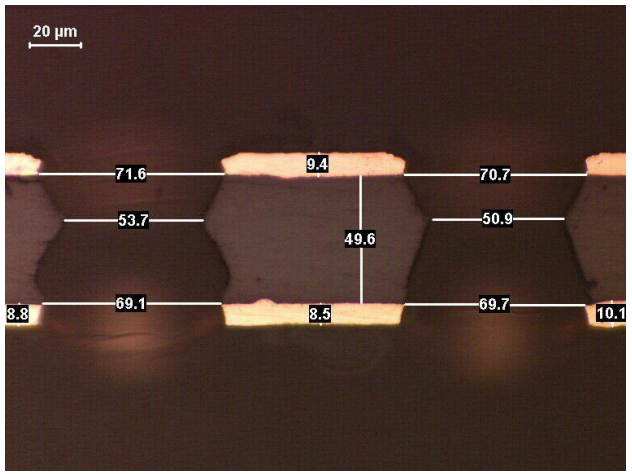
CMS: 1m x 45cm (6 pieces)

cross section pictures

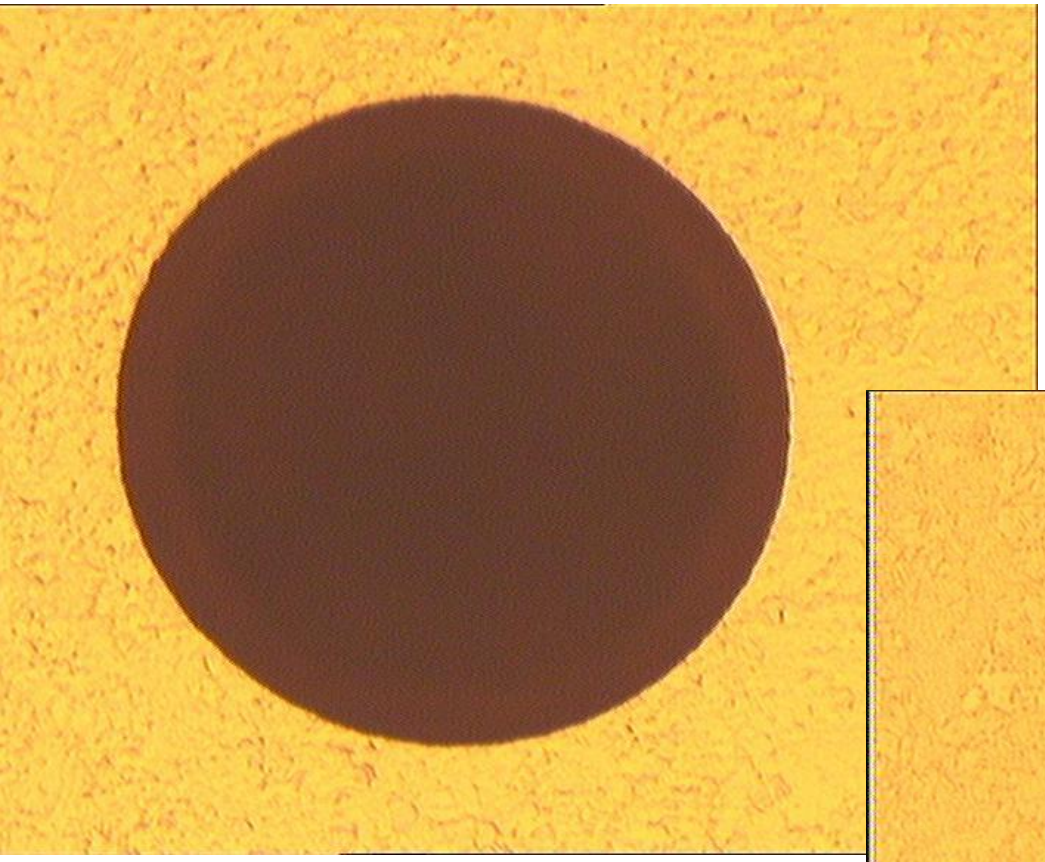


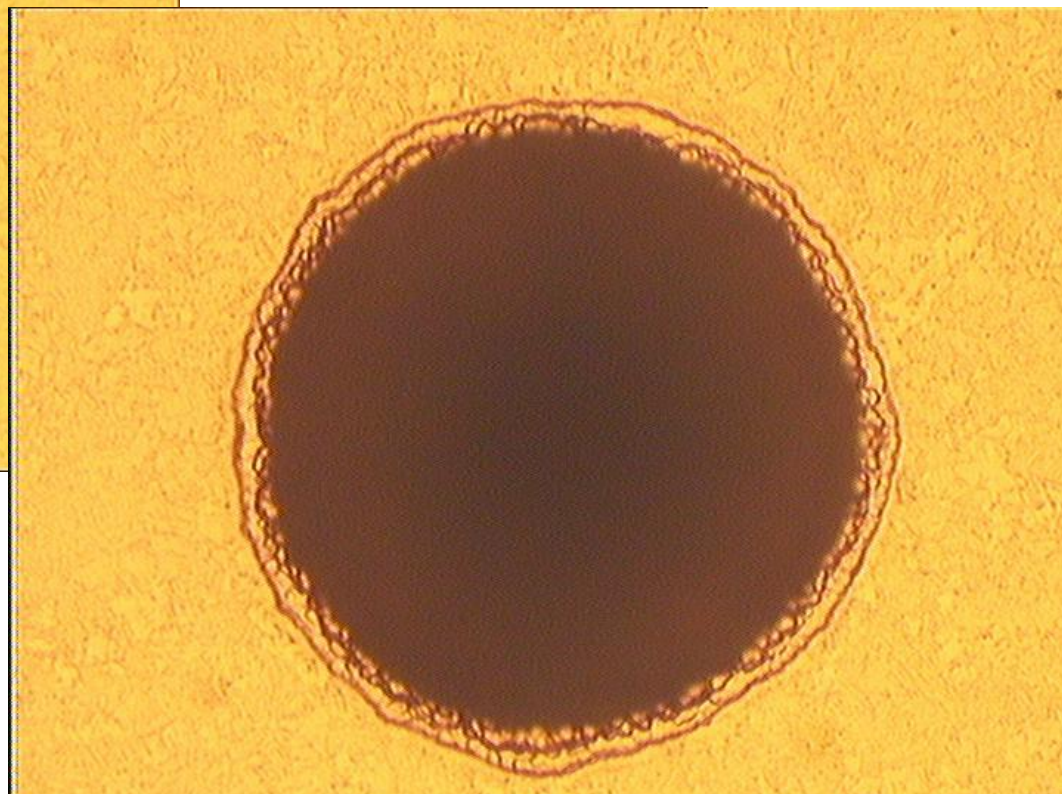




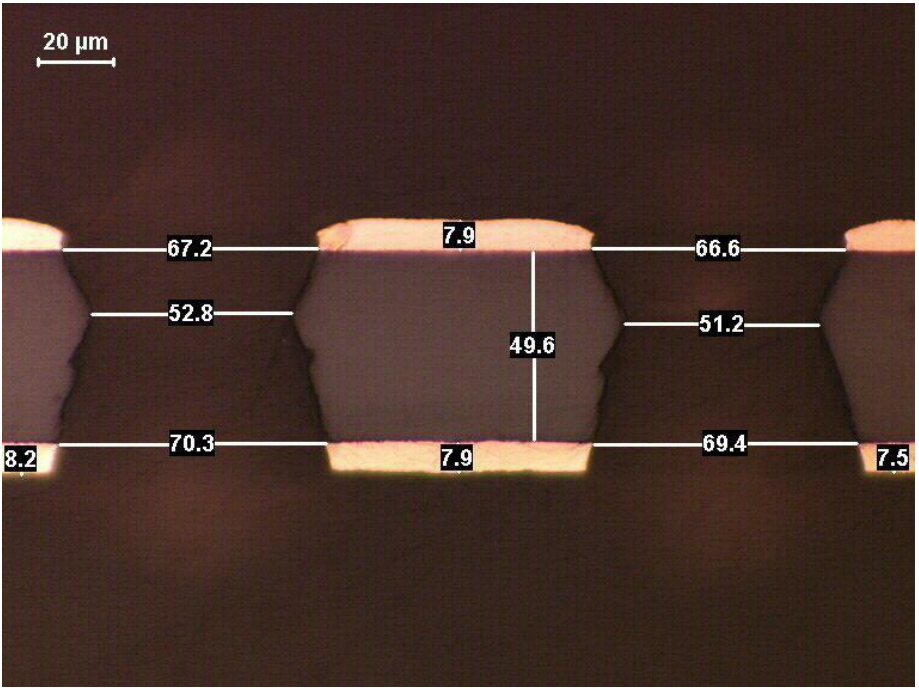


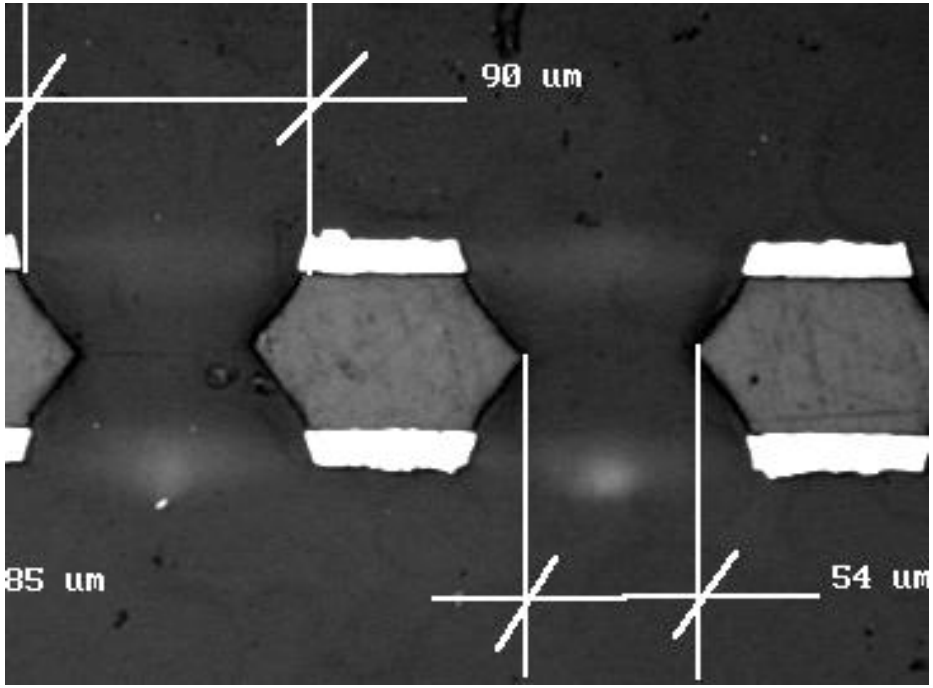
Introducing GEM #3 – electrodes…



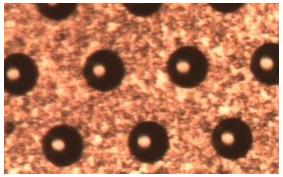


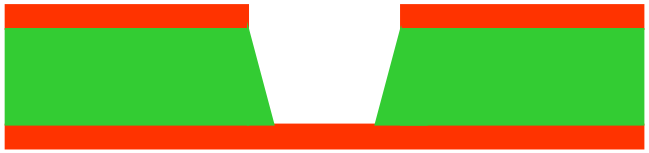
Comparison with *standard GEM * from external supplier



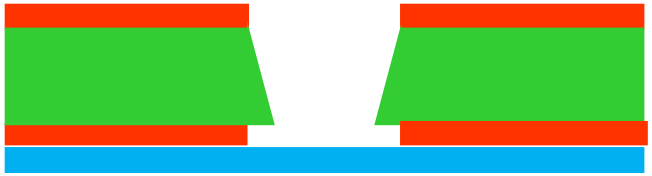


GEM single mask process

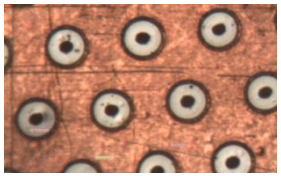


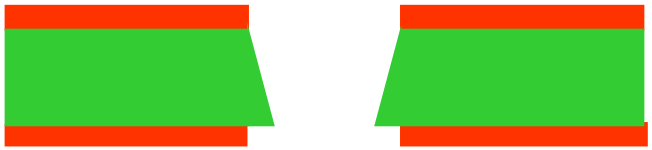


Chemical Polyimide etching

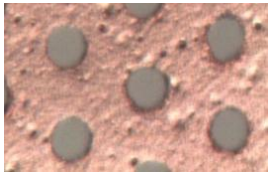


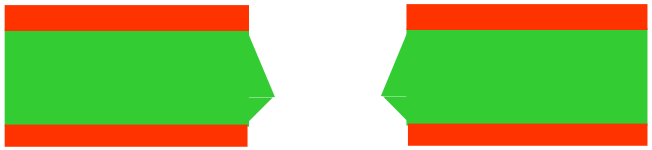
Copper electro etching



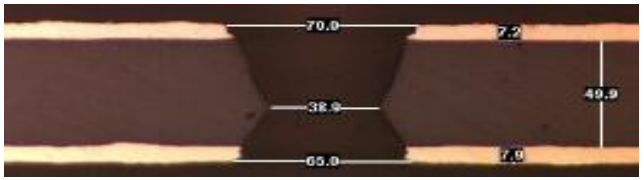


Stripping



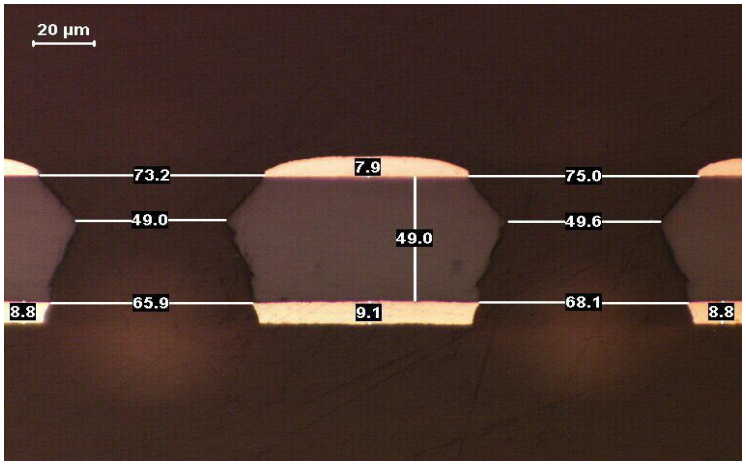


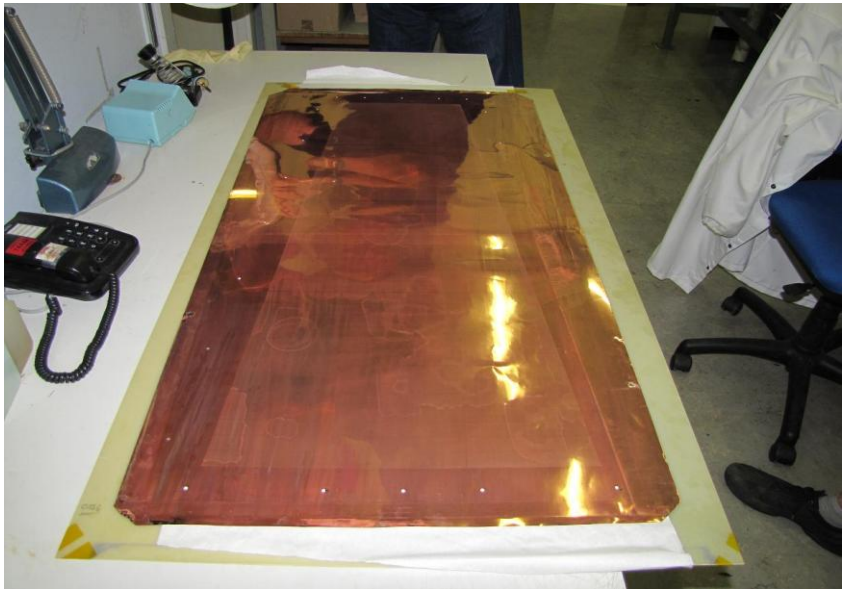
Second Polyimide etching

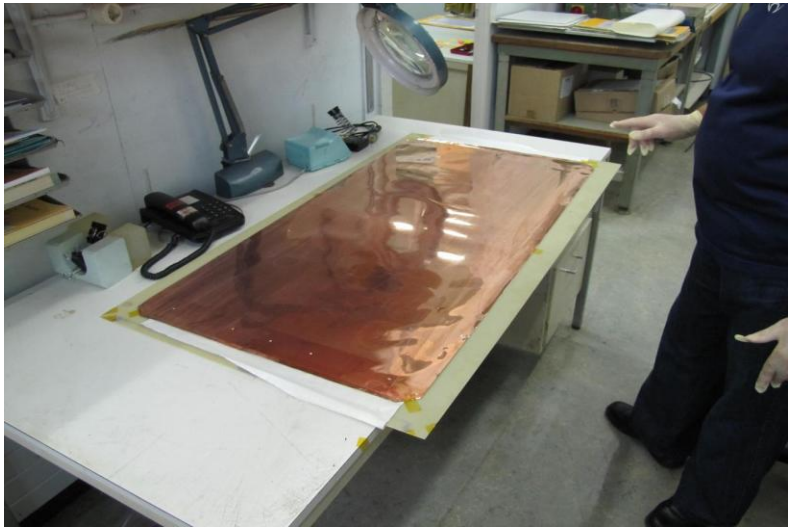


Reality

Production of CMS Single Mask (SM) GEMs



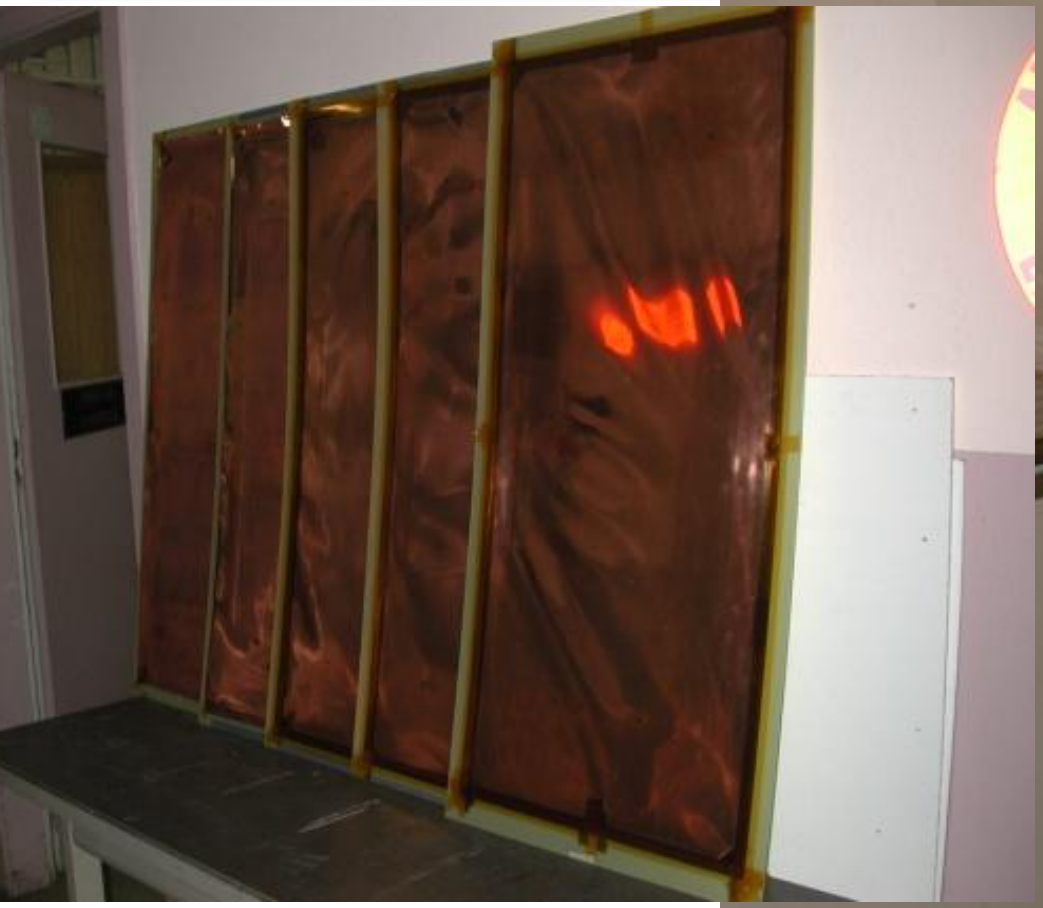




Single Mask technology
Elimintaes
alignment of the holes issue

Size 990/45.5/22 mm

Rui's Workshop
Single Mask GEMs



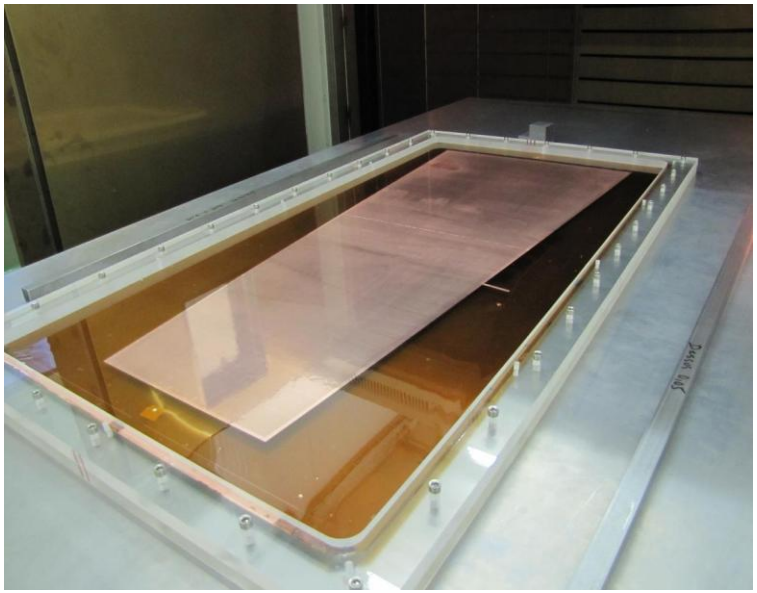
CMS: 1m x 45cm (6 pieces)

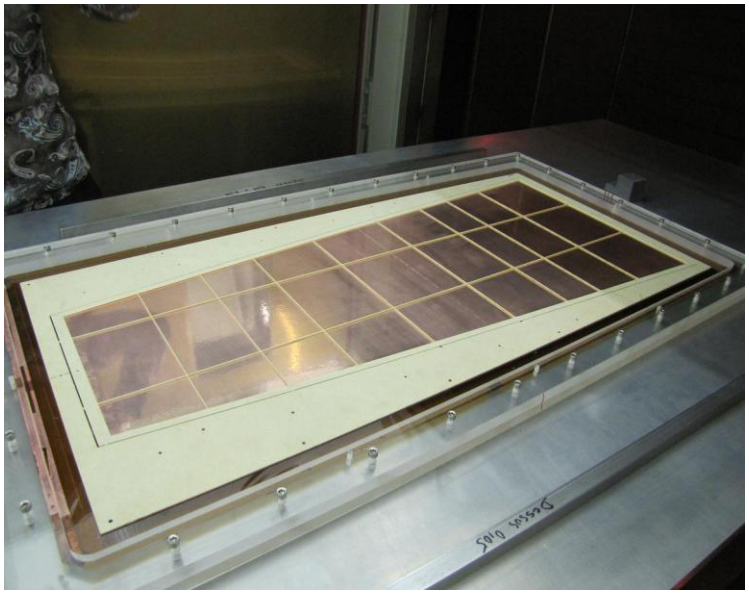
Stretching and Framing Procedure for GE1/1 GEMs

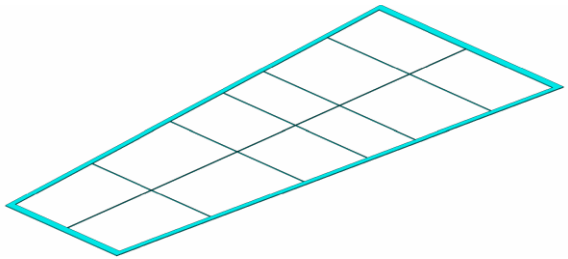
- GEM foil goes in a special oven for heating up to 37degree

Stretching and Framing Procedure for GE1/1 GEMs

- Gluing the spacer frame on the GEM foil.







Stretching and Framing Procedure for GE1/1 GEMs

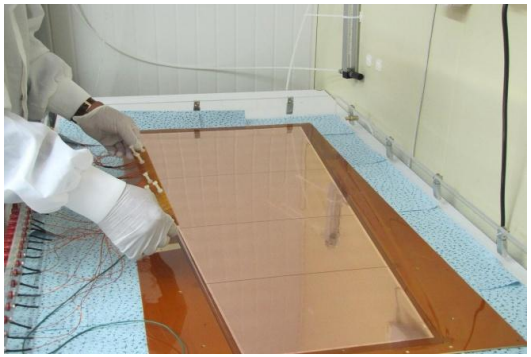
- The GEM foil, with glued frame, stays in the oven heated up to 37°C over 24 hours.

HV test of the GE1/1 GEMs

Before and after stretching and framing, the GEMs are passing QT of the GE1/1

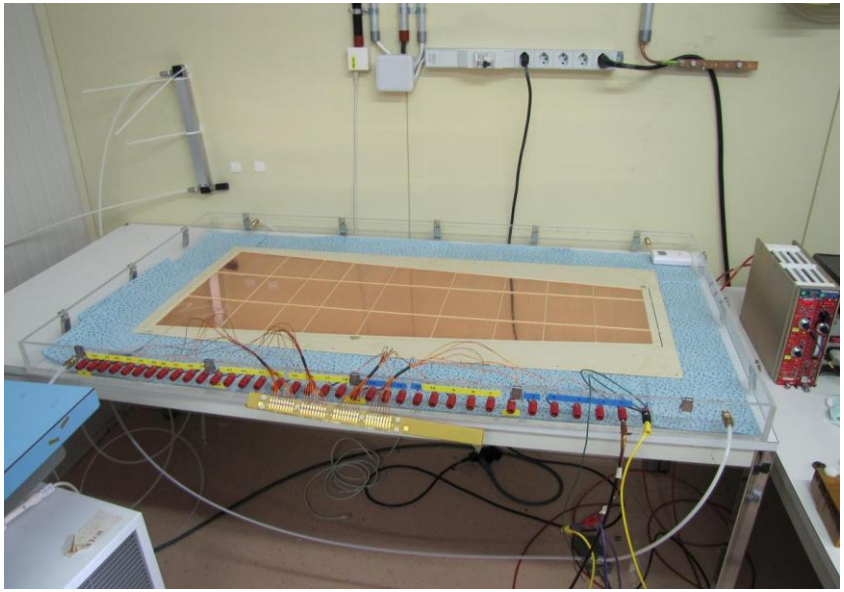
1. Optical inspection
2. HV test before stretching
3. HV test after stretching

→ Applying up to 500V between the top sector and the bottom layer plus the 2 neighbor sectors as well.

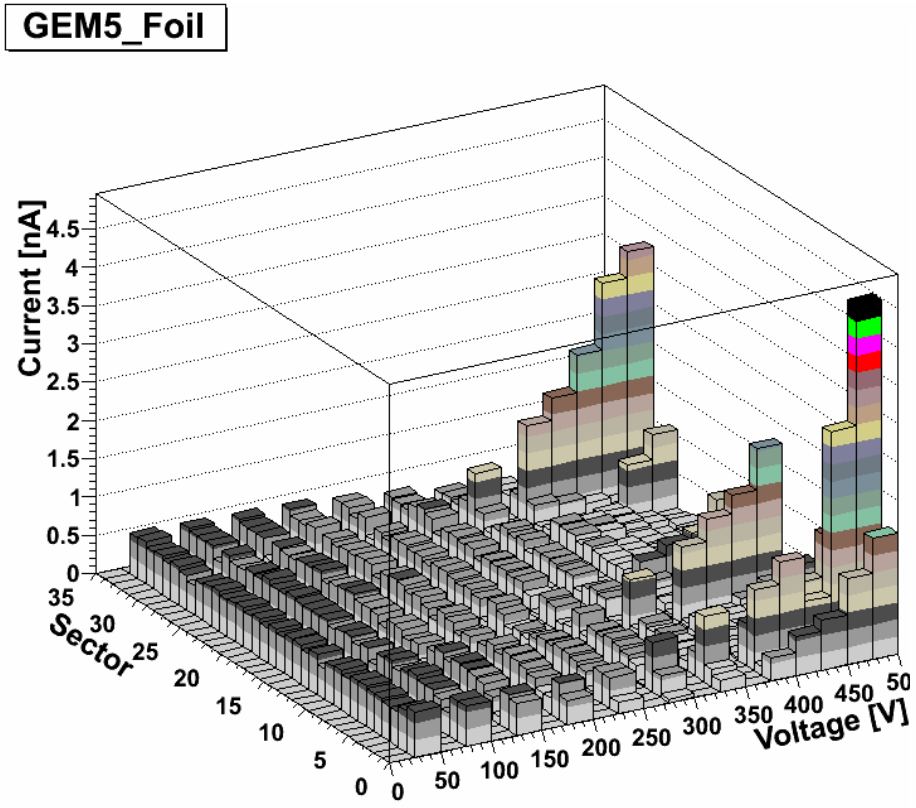


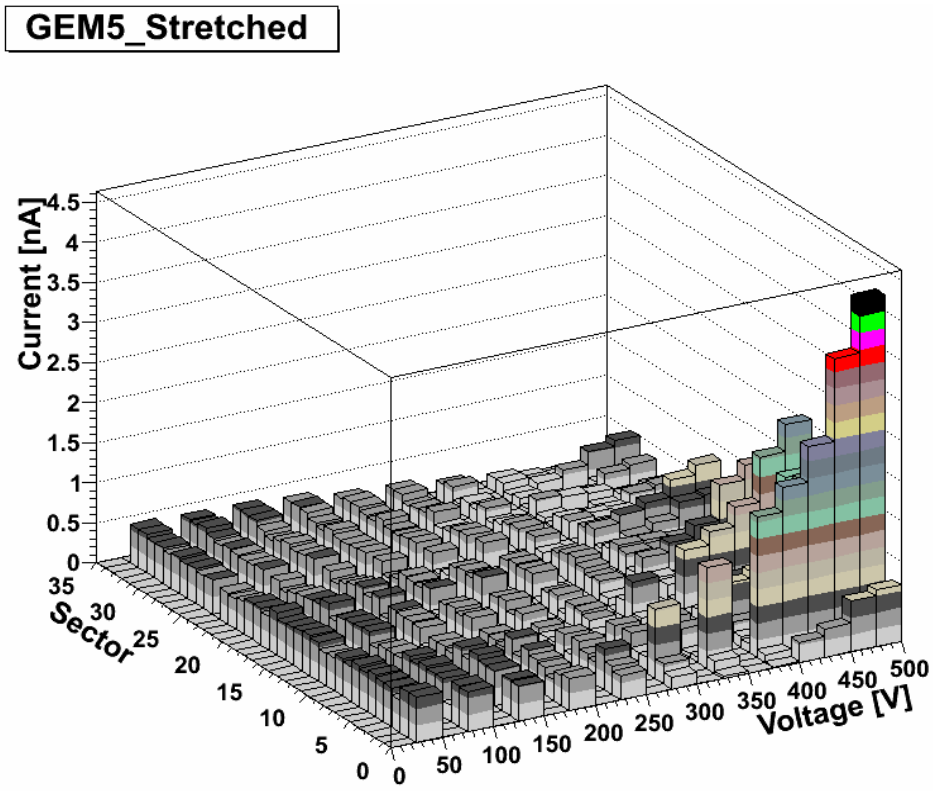
Testing sector by sector

Criteria - Current less 10nA



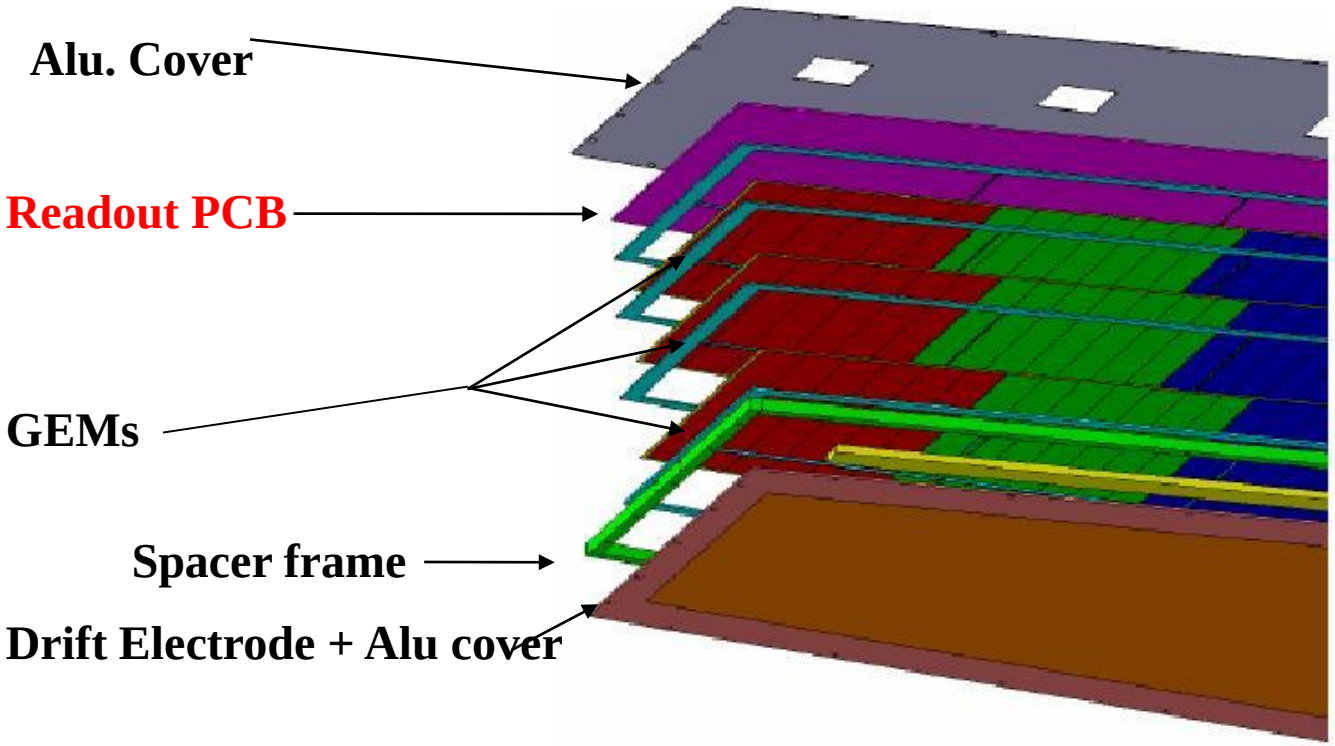
HV test of the GE1/1 GEMs





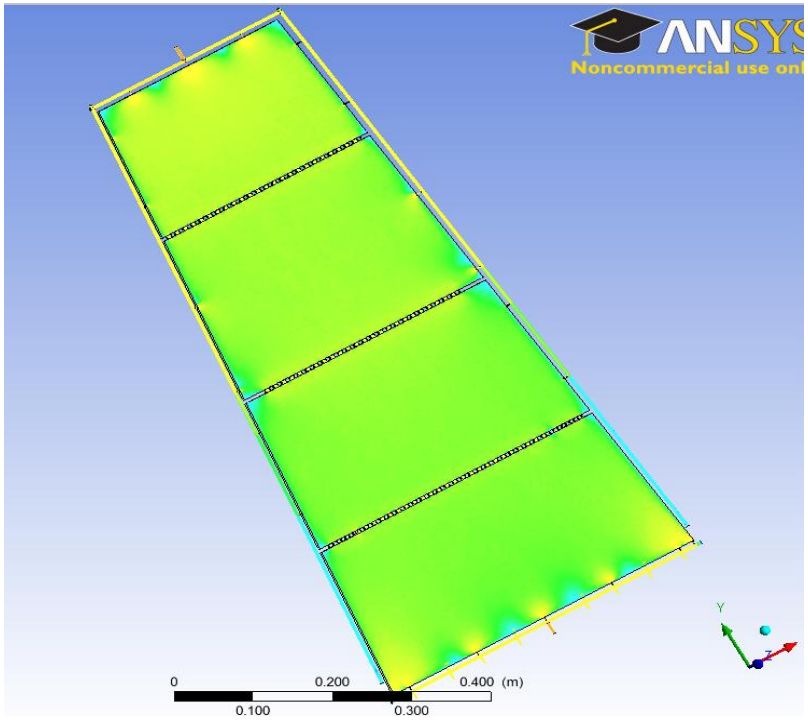
Results of the HV test. Sectors/Voltage/Current

3D Model of GE1/1



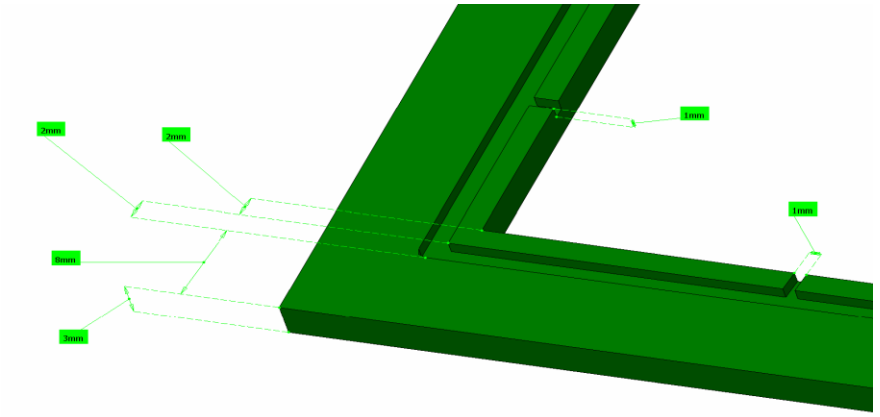
GAS FLOW SIMULATION

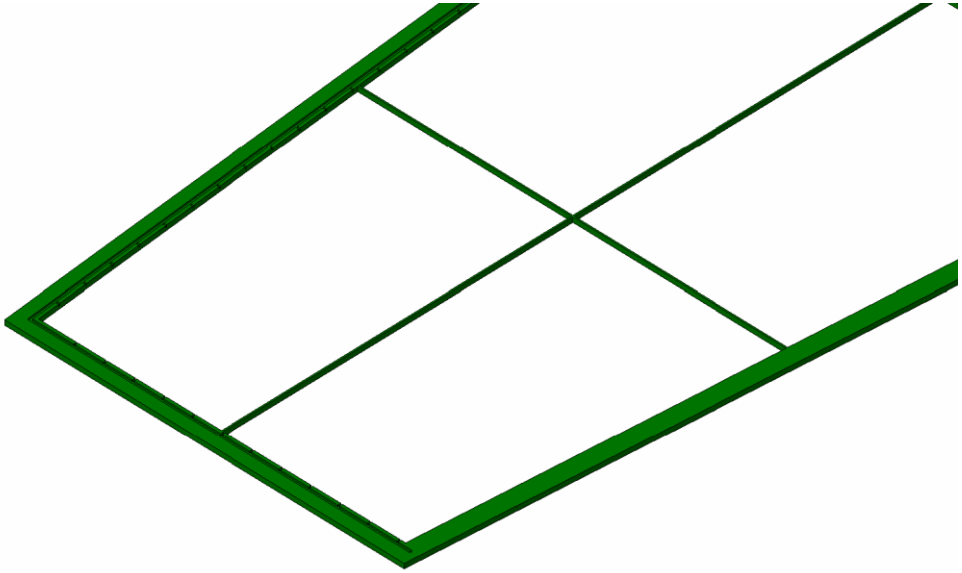
- Gas flow studies and simulation with ANSYS
- Taking in to account all the environmental conditions – gravity, different gas mixtures,temperature, atmospheric pressure
- Gas Mixtures studied
  - Ar-CO2 70-30%
  - Ar-CO2-CF4 45-15-40%



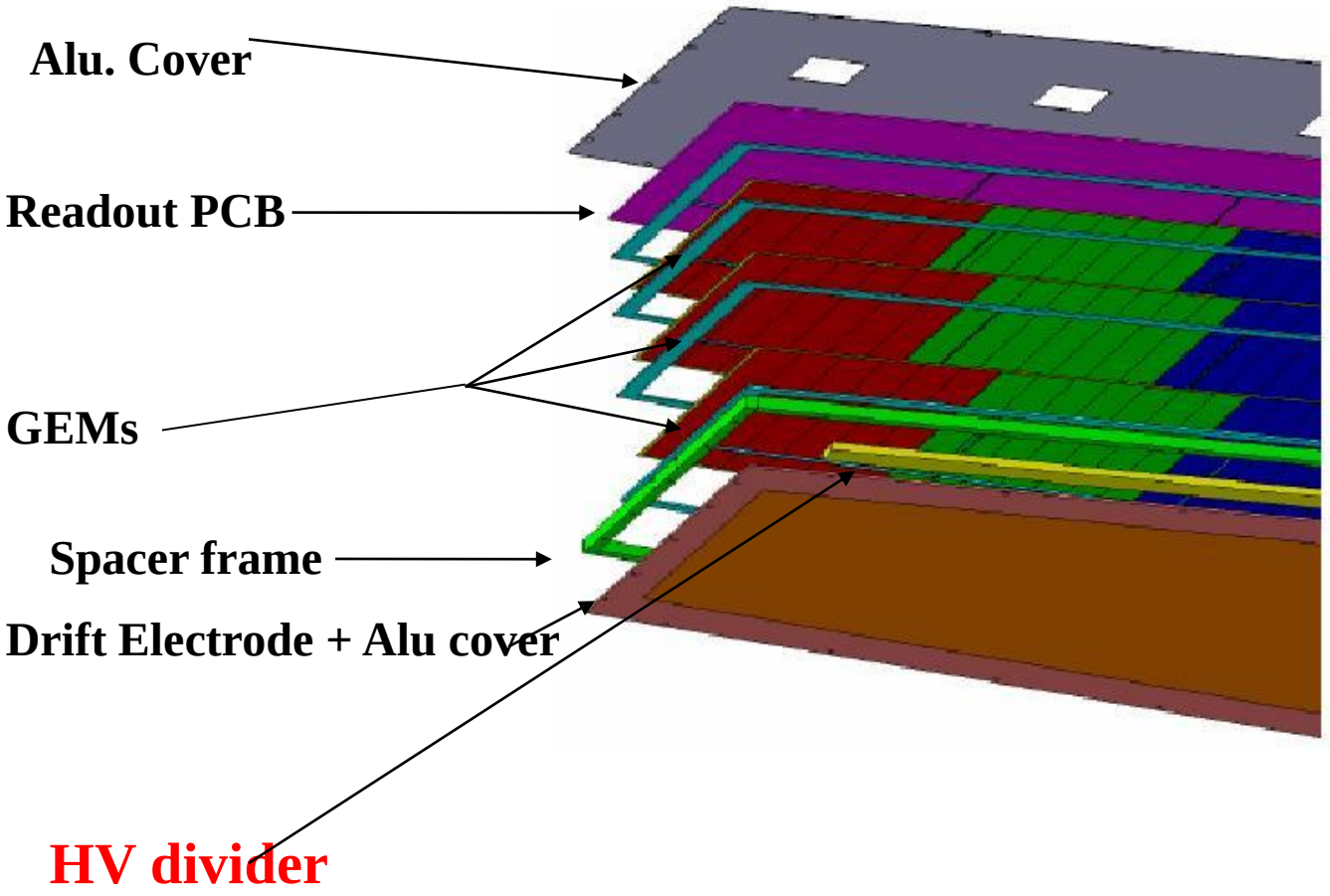
Gas I/O Design

- Based on the simulations we have the optimal gas flow I/O design.
- Minimizing the number and size of the gas pockets



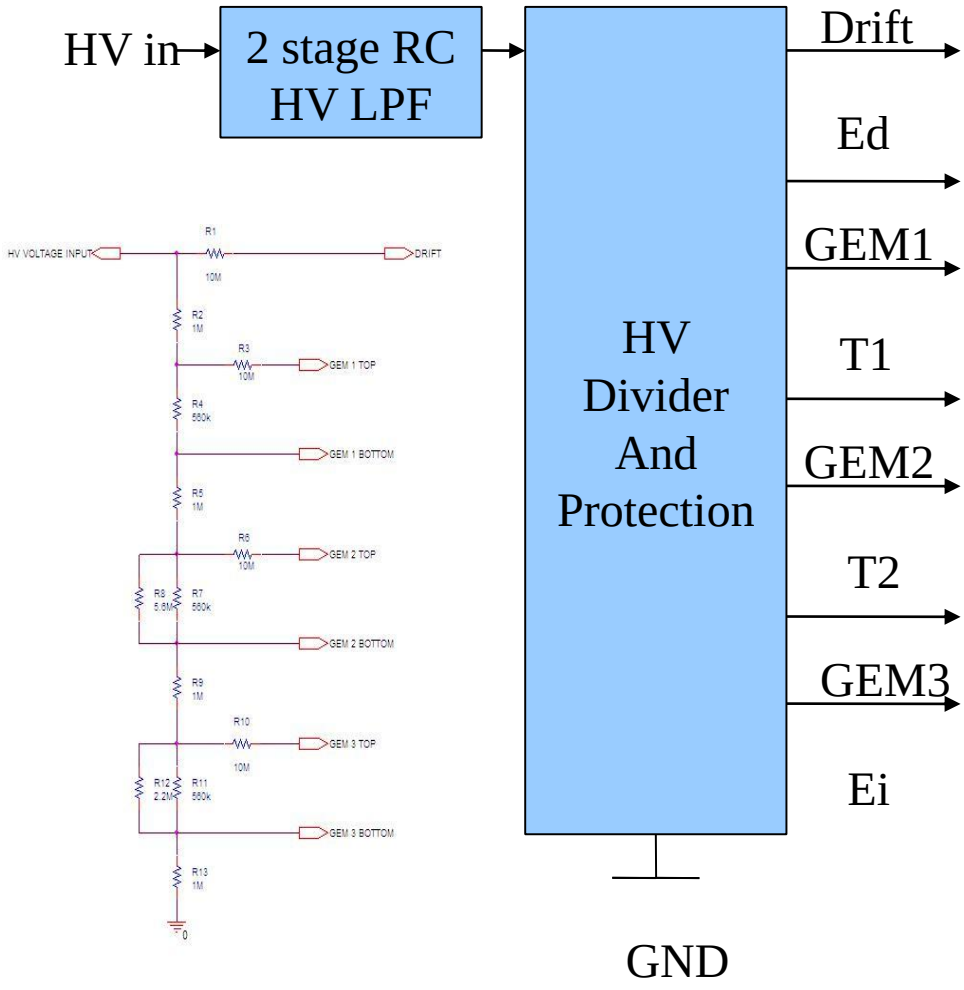


GE1/1 3D Model



GE1/1 - HV Divider

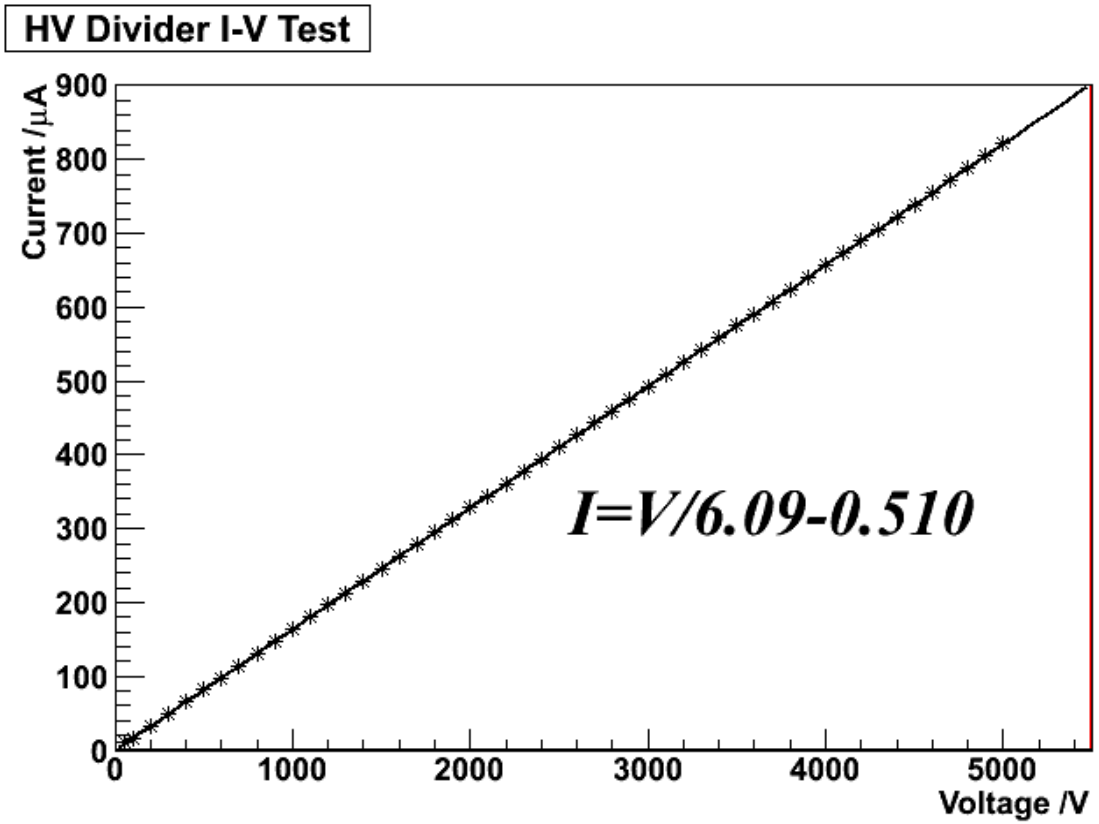
- GE1/1 – HV Divider has built in RC Filter
- The divider is made by HV SMD Resistors.



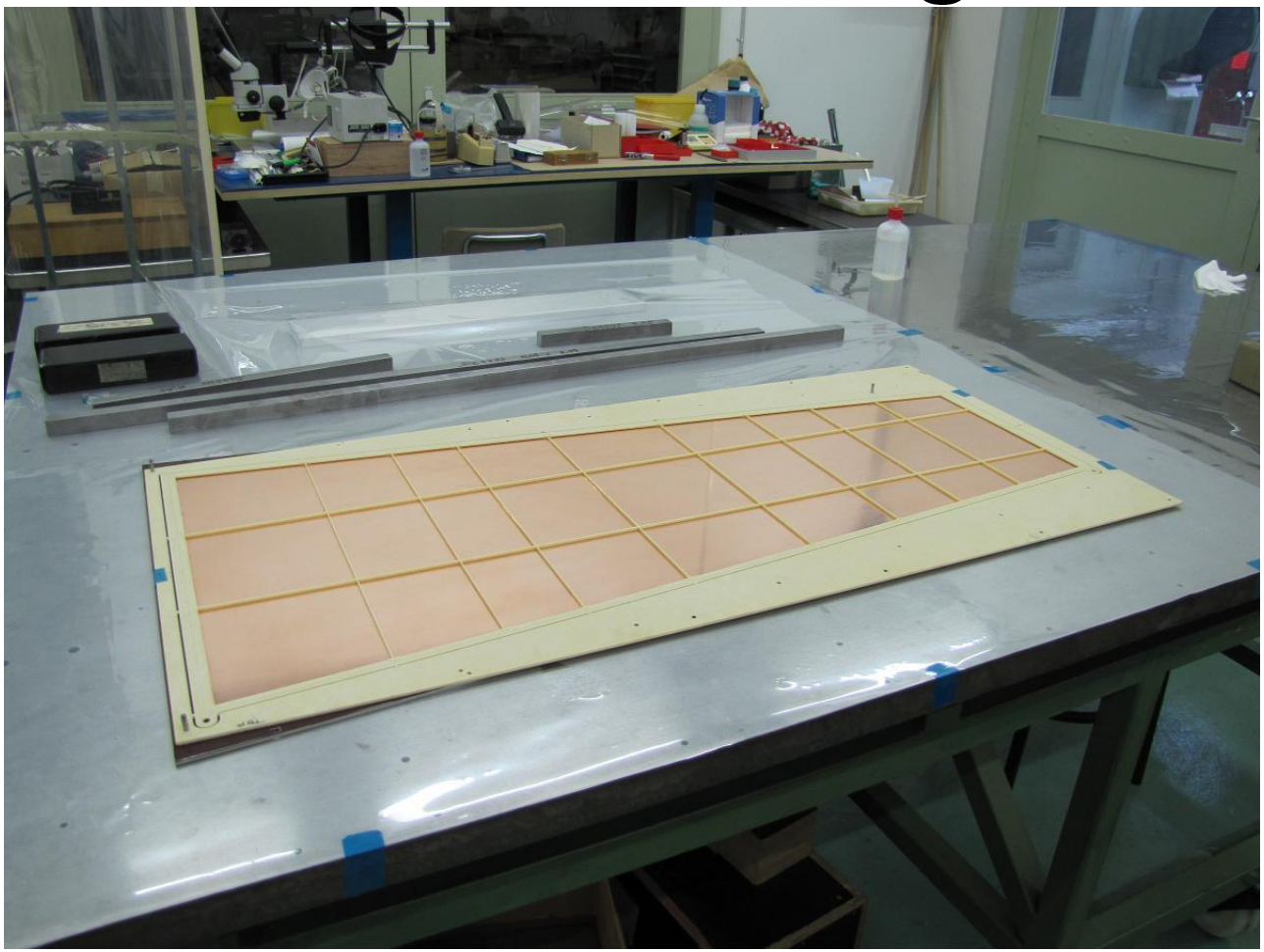
HV divider Production steps

- PCB layout design is made with “Altium Designer” software
- 2 Layers PCB
- Deep cleaning after soldering the SMD components
- HV silicon protection layer for keeping the PCB fiberglass away from humidity

I/V measured plot



Glued drift and 3 gems



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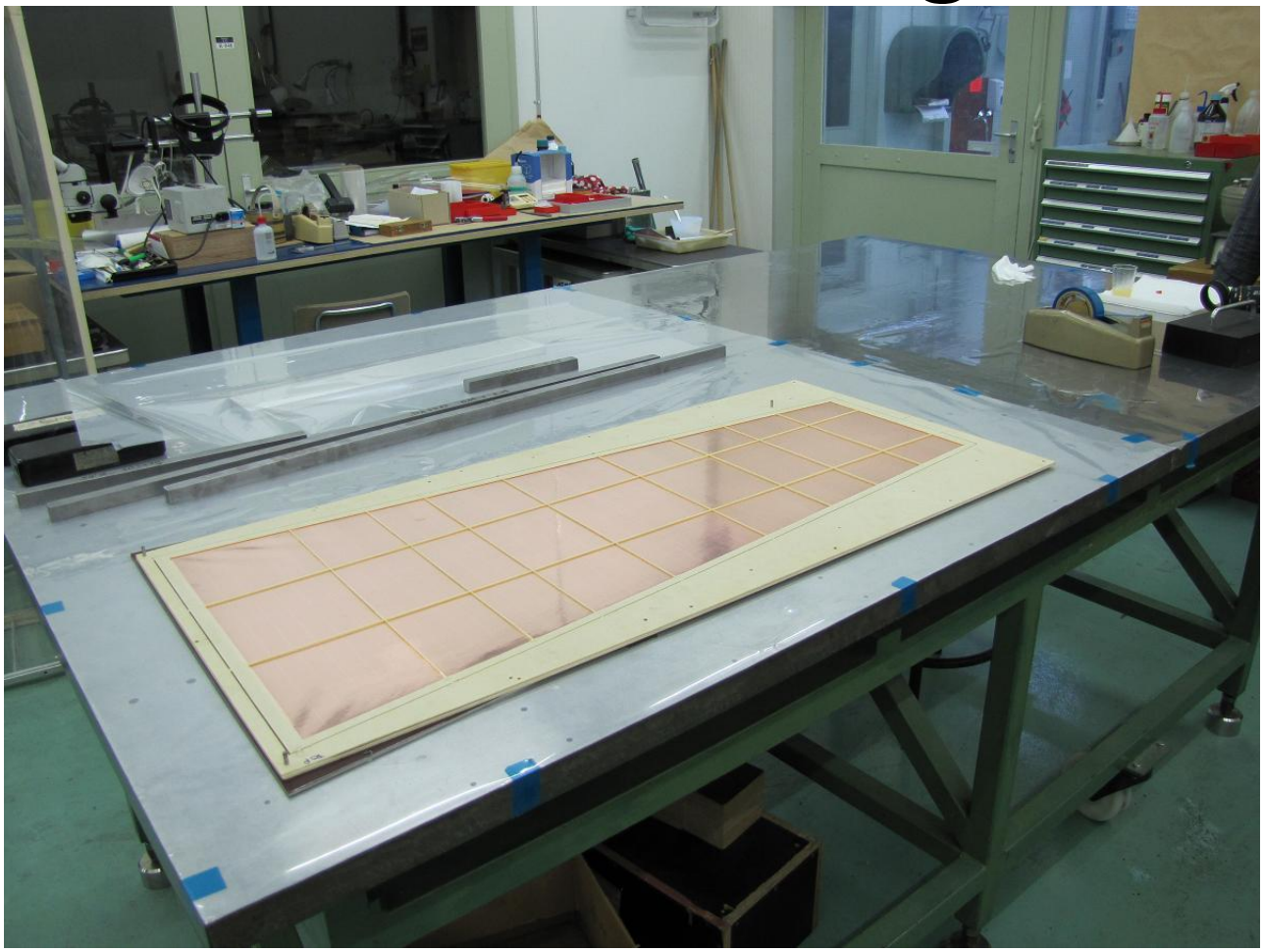
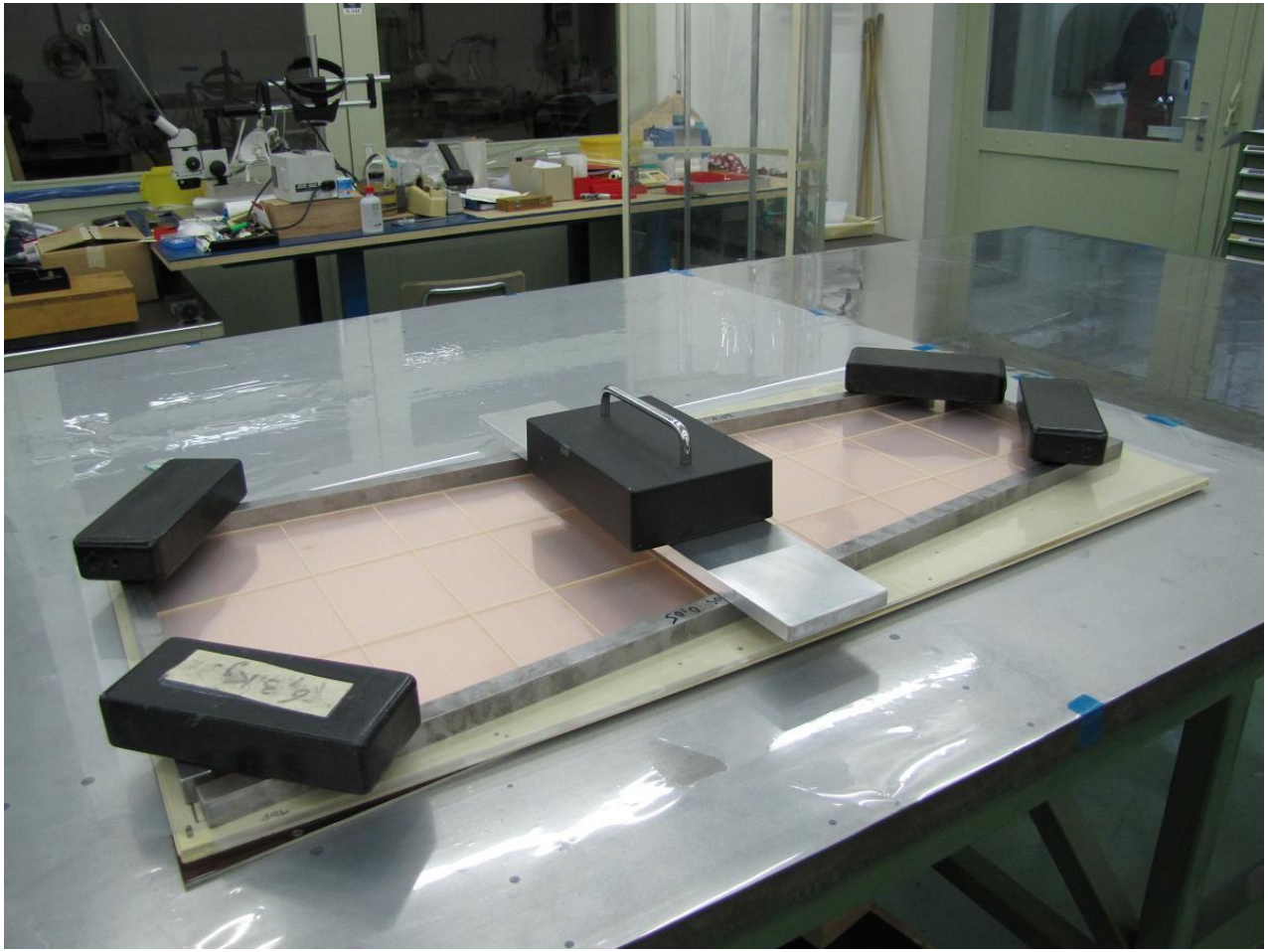
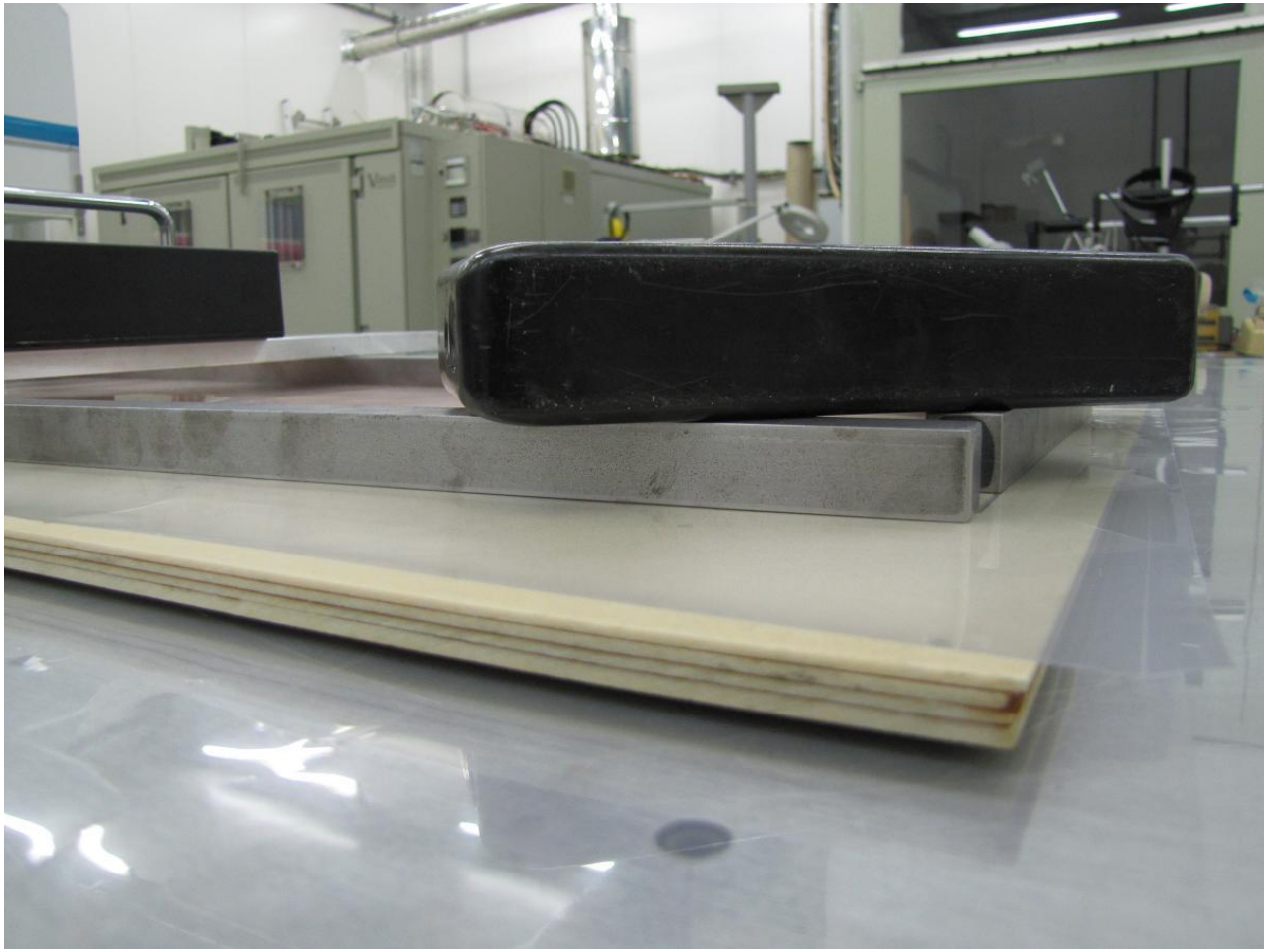


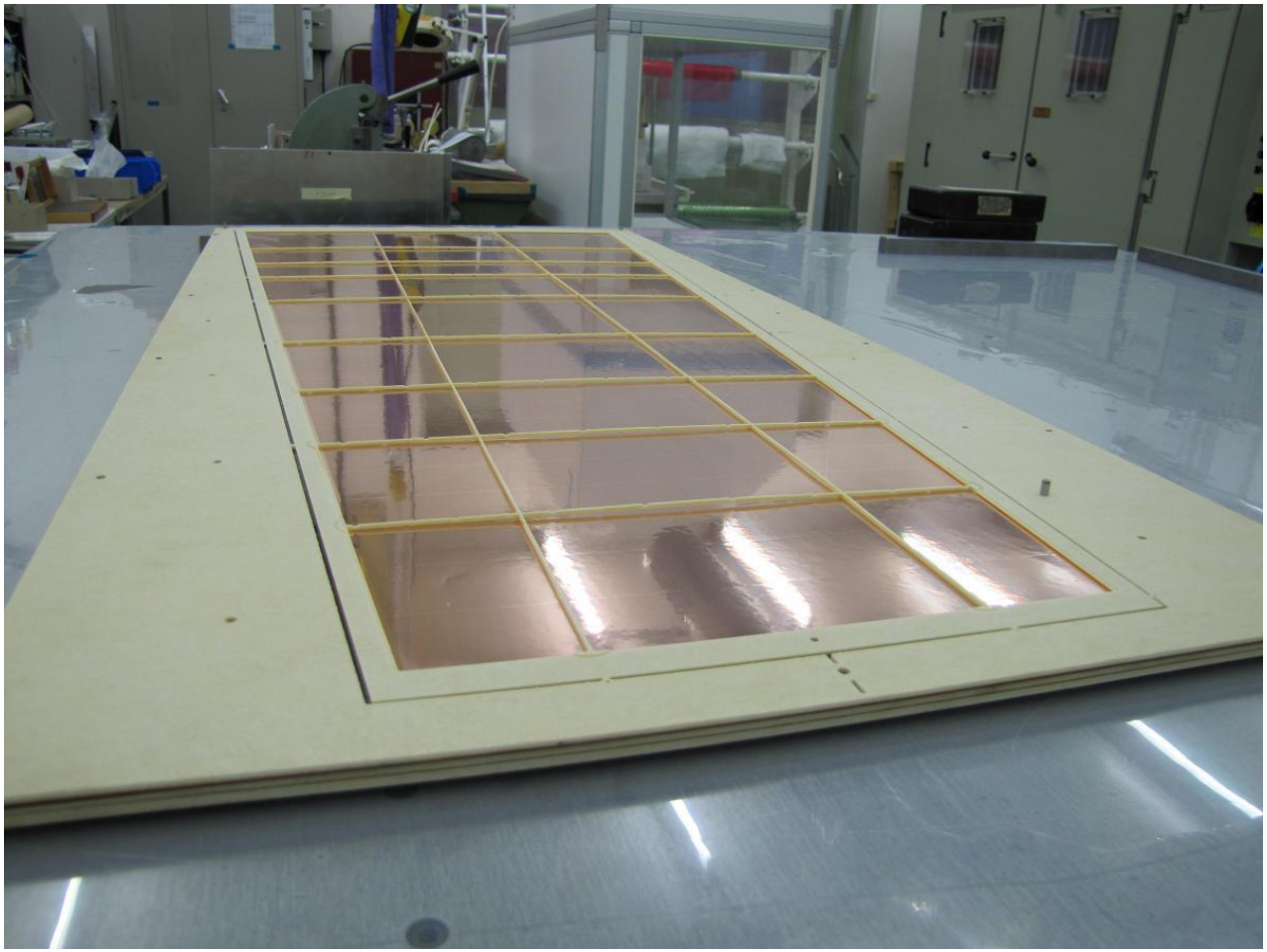
Weights on top



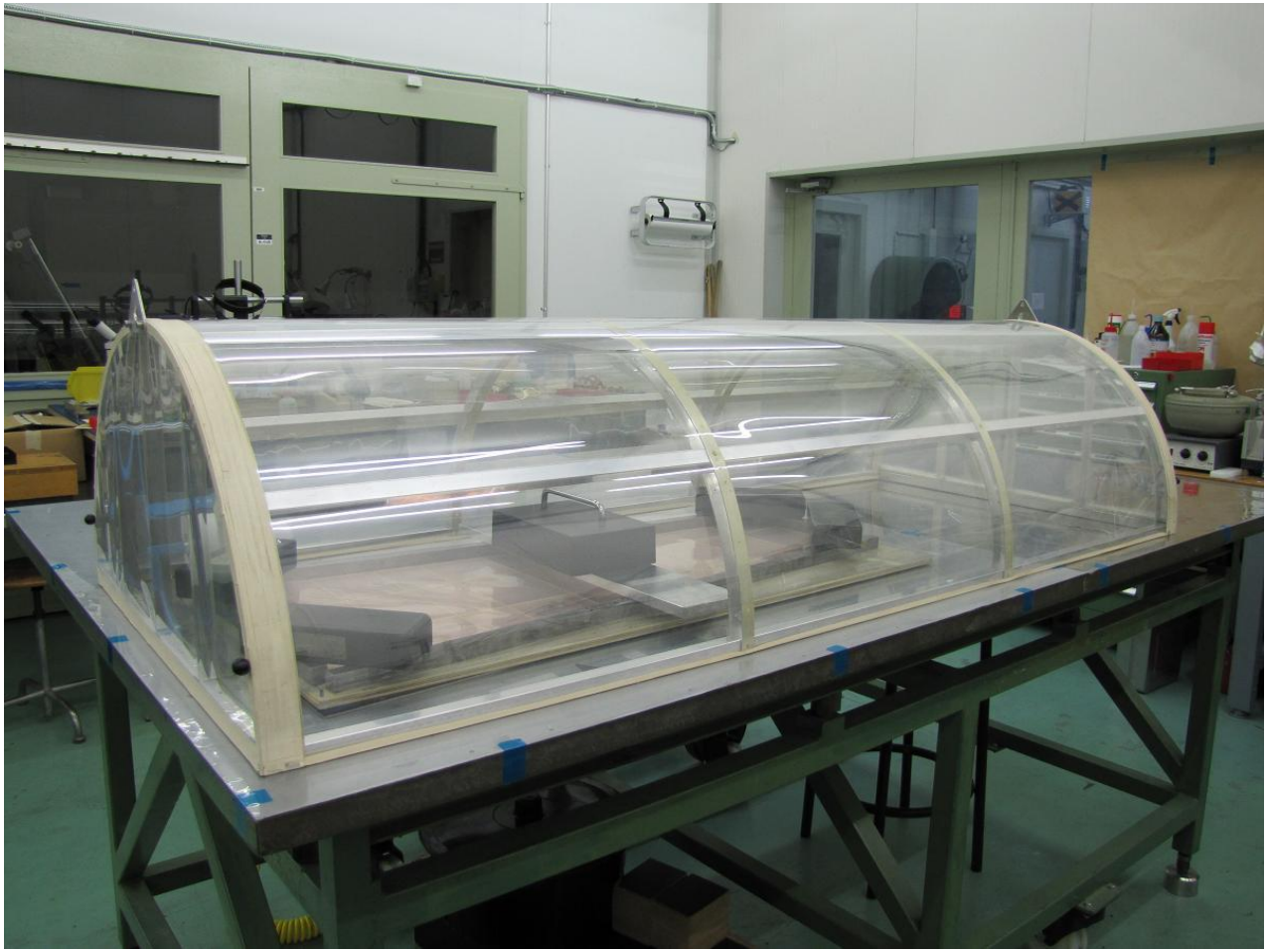
Corners



Without weights



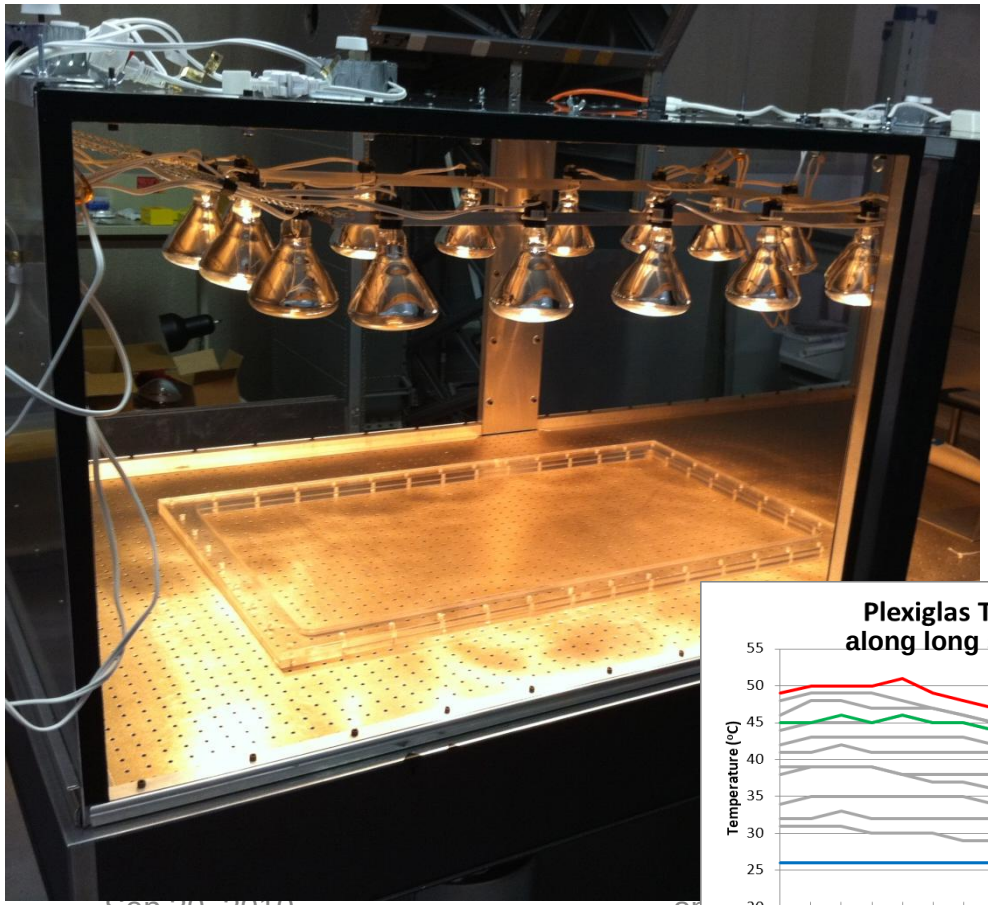
Waiting the readout in safe

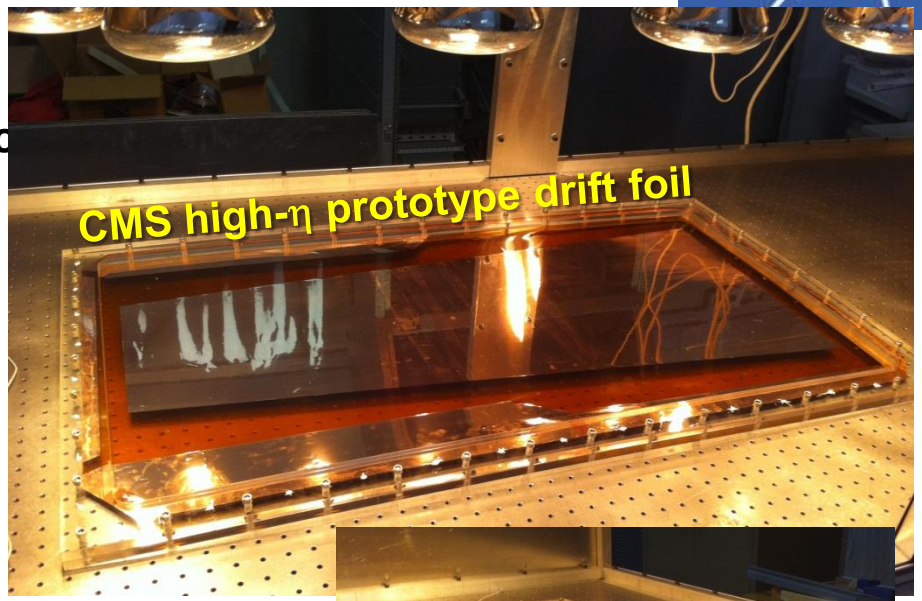


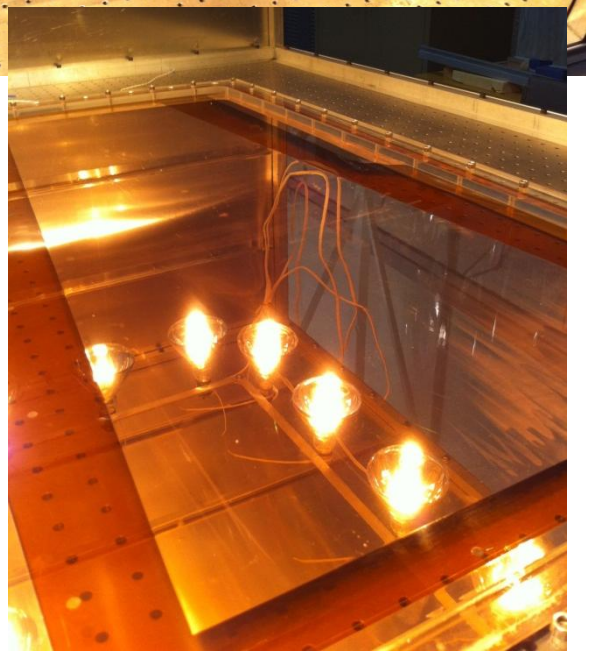
R&D at FIT FLORIDA

- CMS High-η upgrade

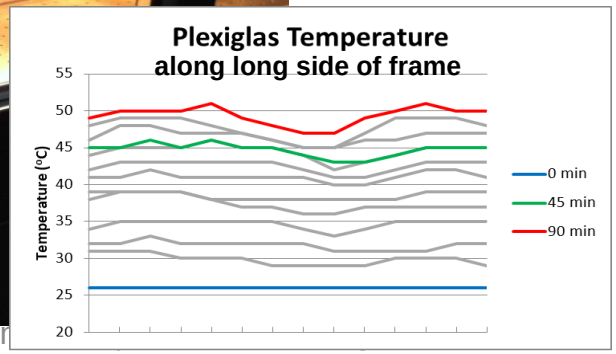
New, cost-effective GEM foil thermal stretching technique via infrared heating under clean room conditions in our high- bay lab (RD51 Technical No in prep.)



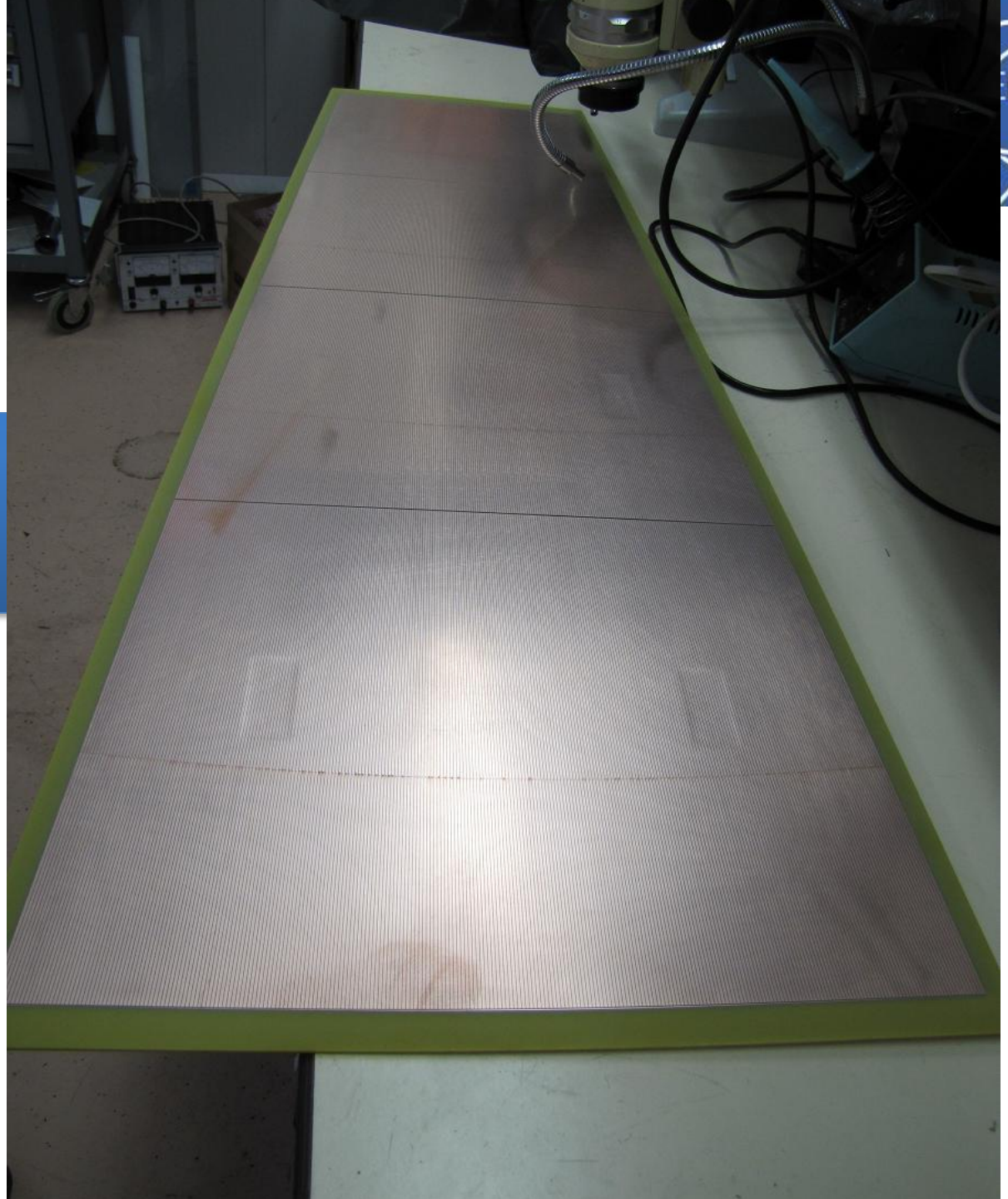




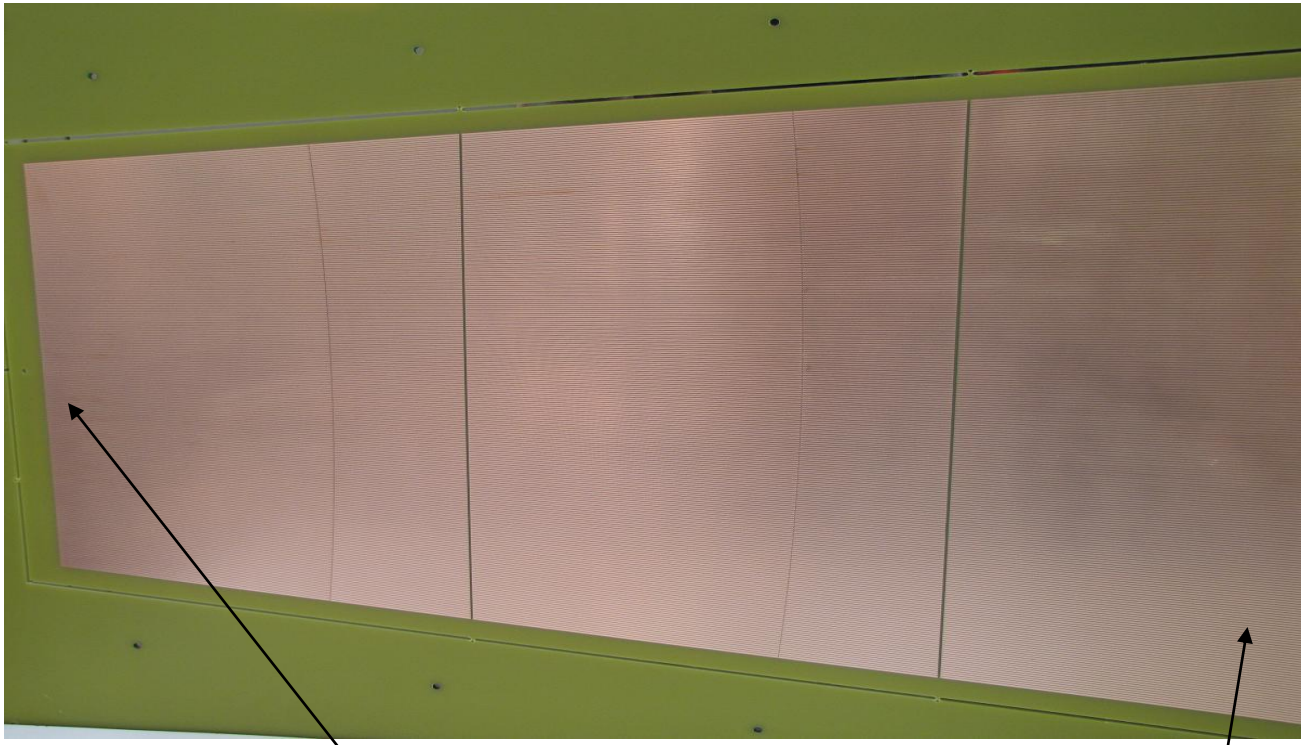
Works well !



READOUT STUDIES



Readout PCB



128 channels per connector

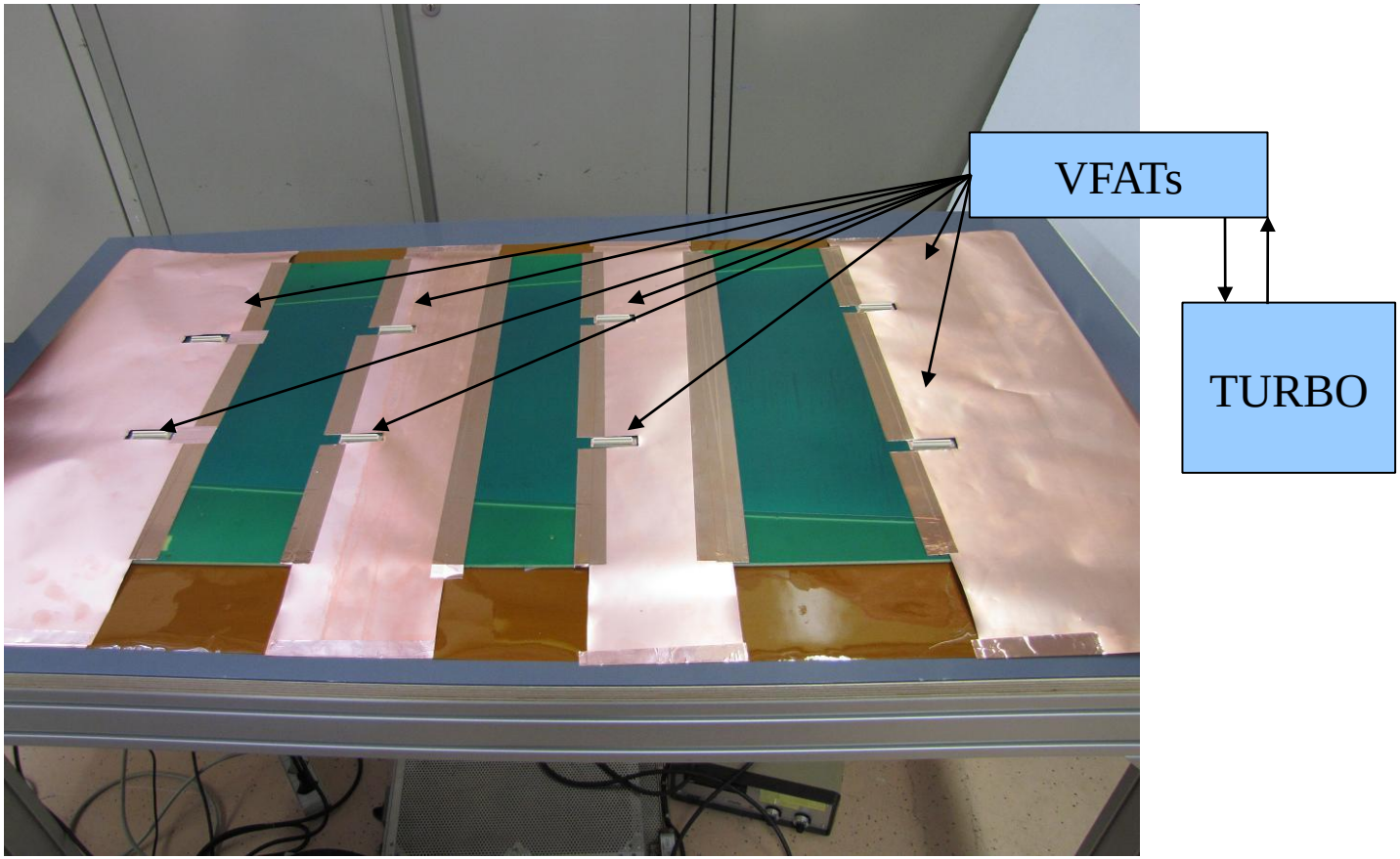
256 strips for each eta partition

0.8mm pitch

1.6mm pitch

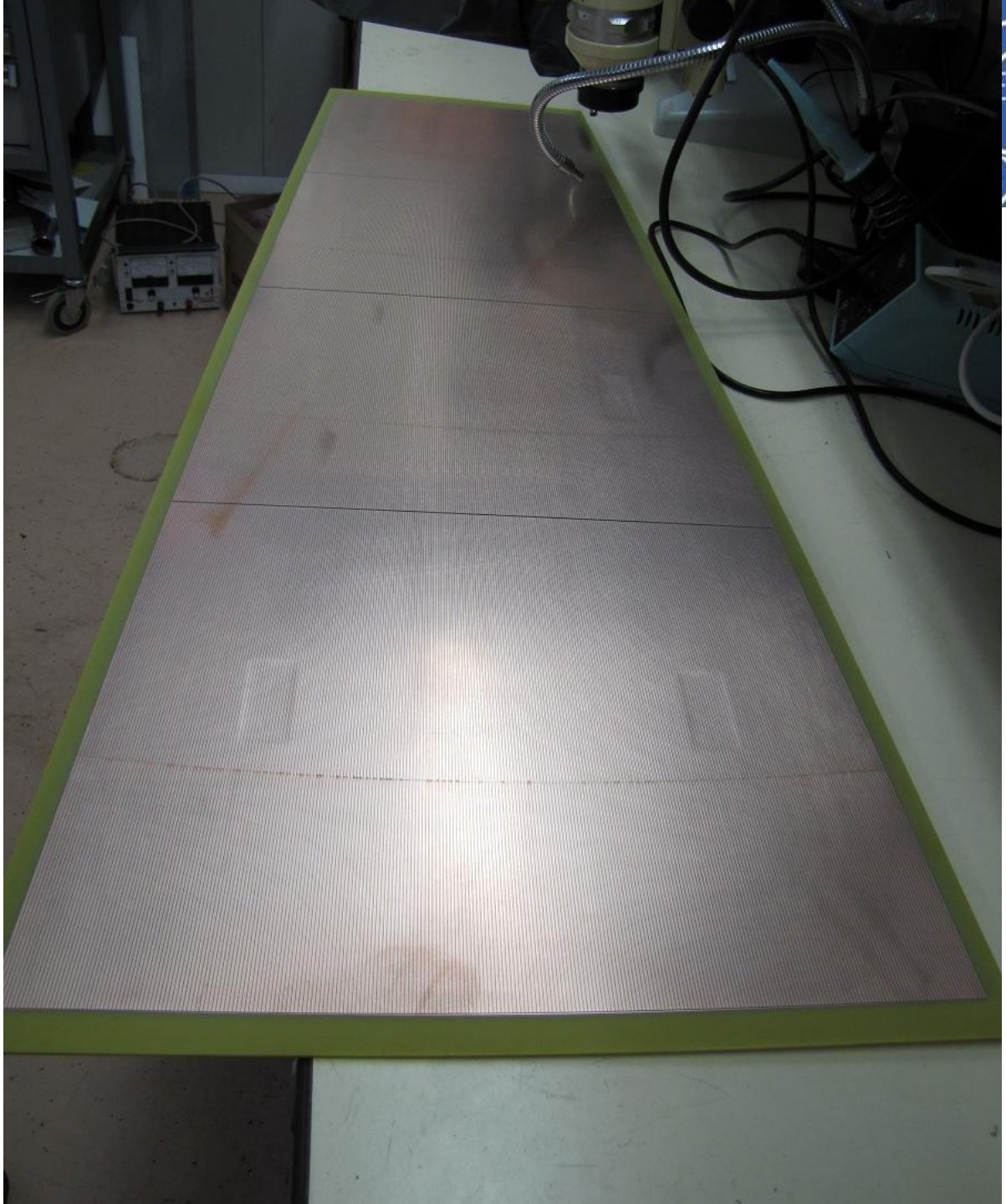
PCB thickenss = 3mm

Readout Board Noise Test



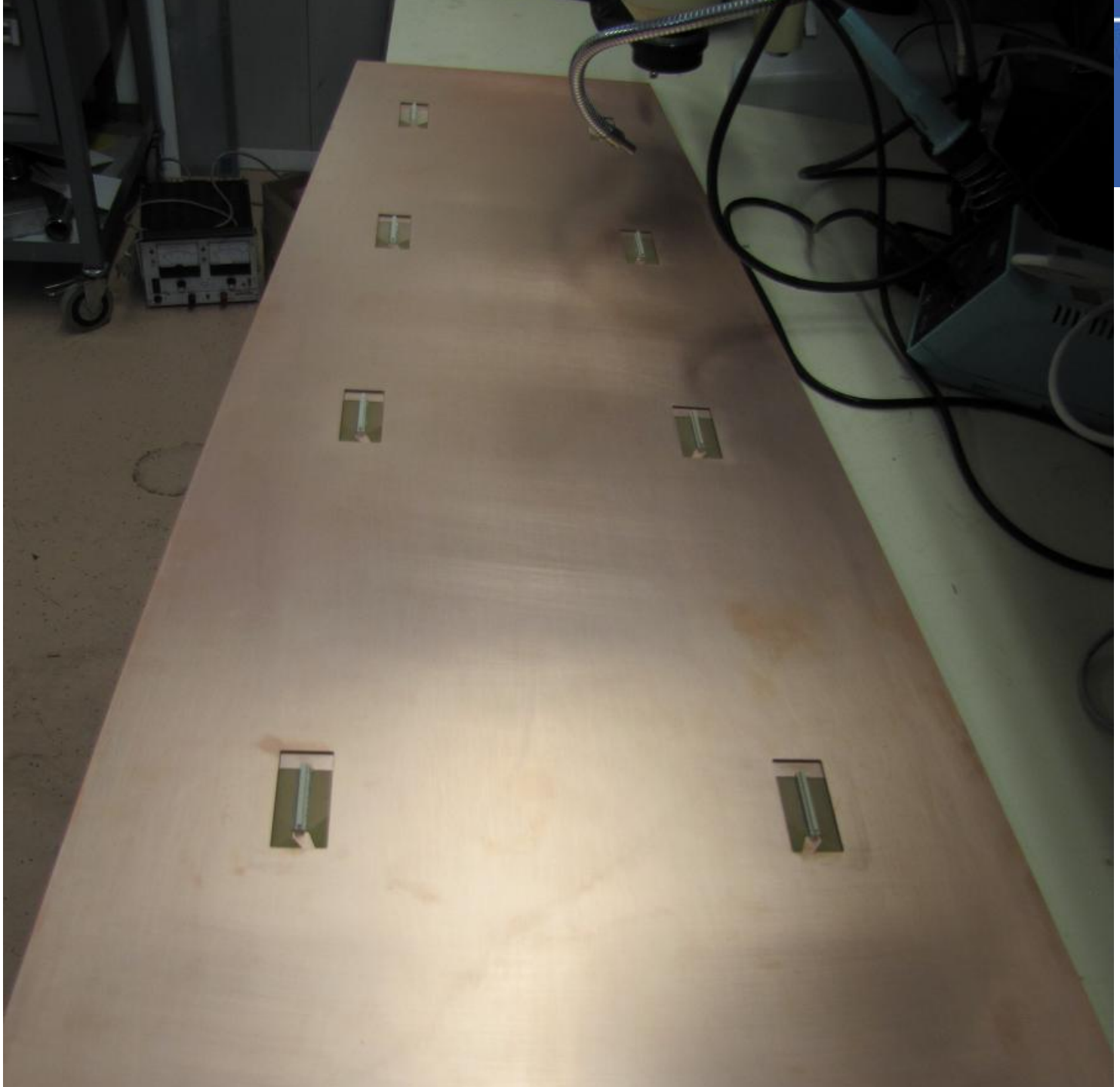
Noise test is ongoing with the VFAT electronics.

2 READOU T s tested
OLD No ground plane
NEW - Ground Plane layer integrated between strip plane and electronics



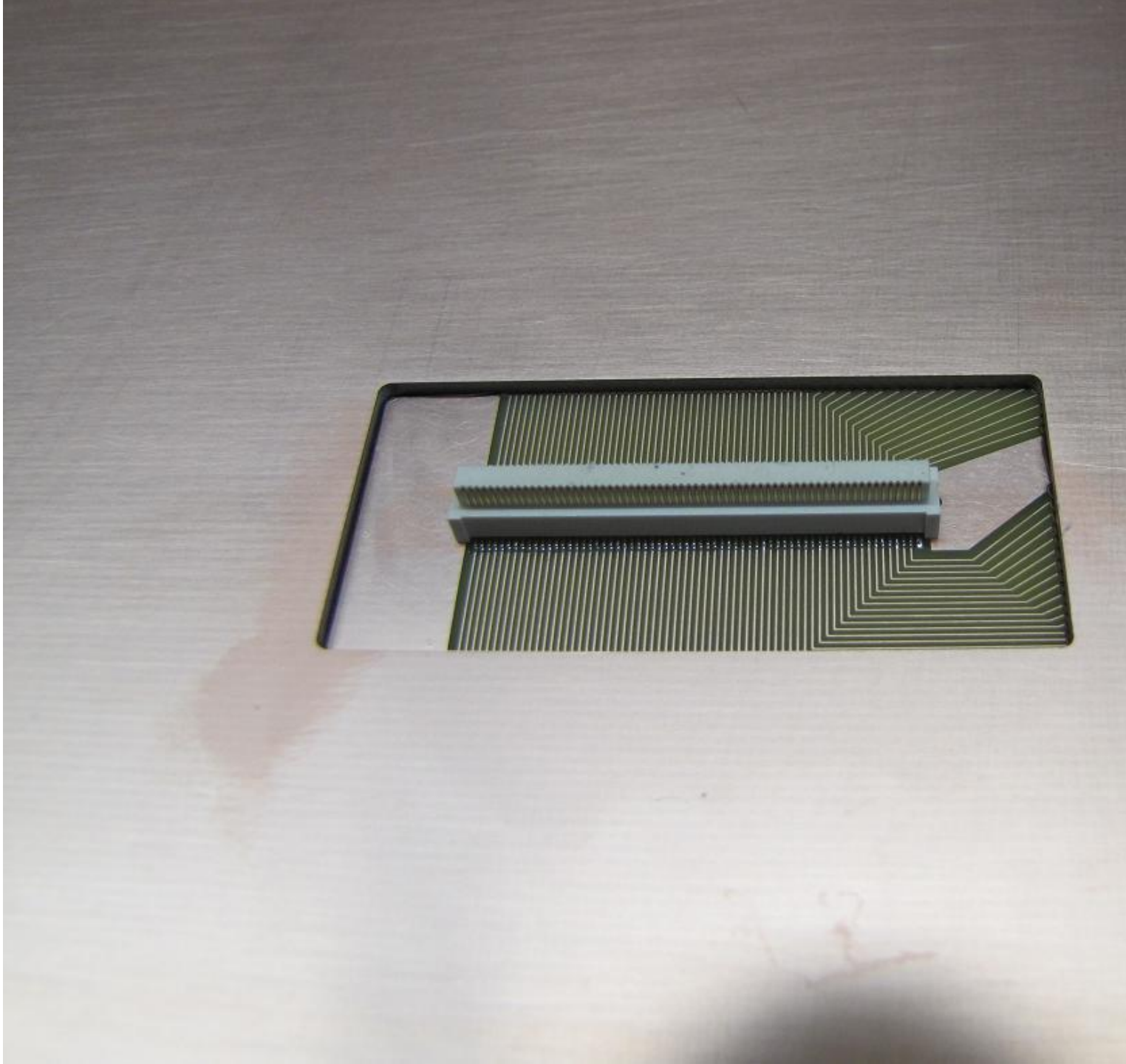
The new readout

VFAT side



The new readout

VFAT slot

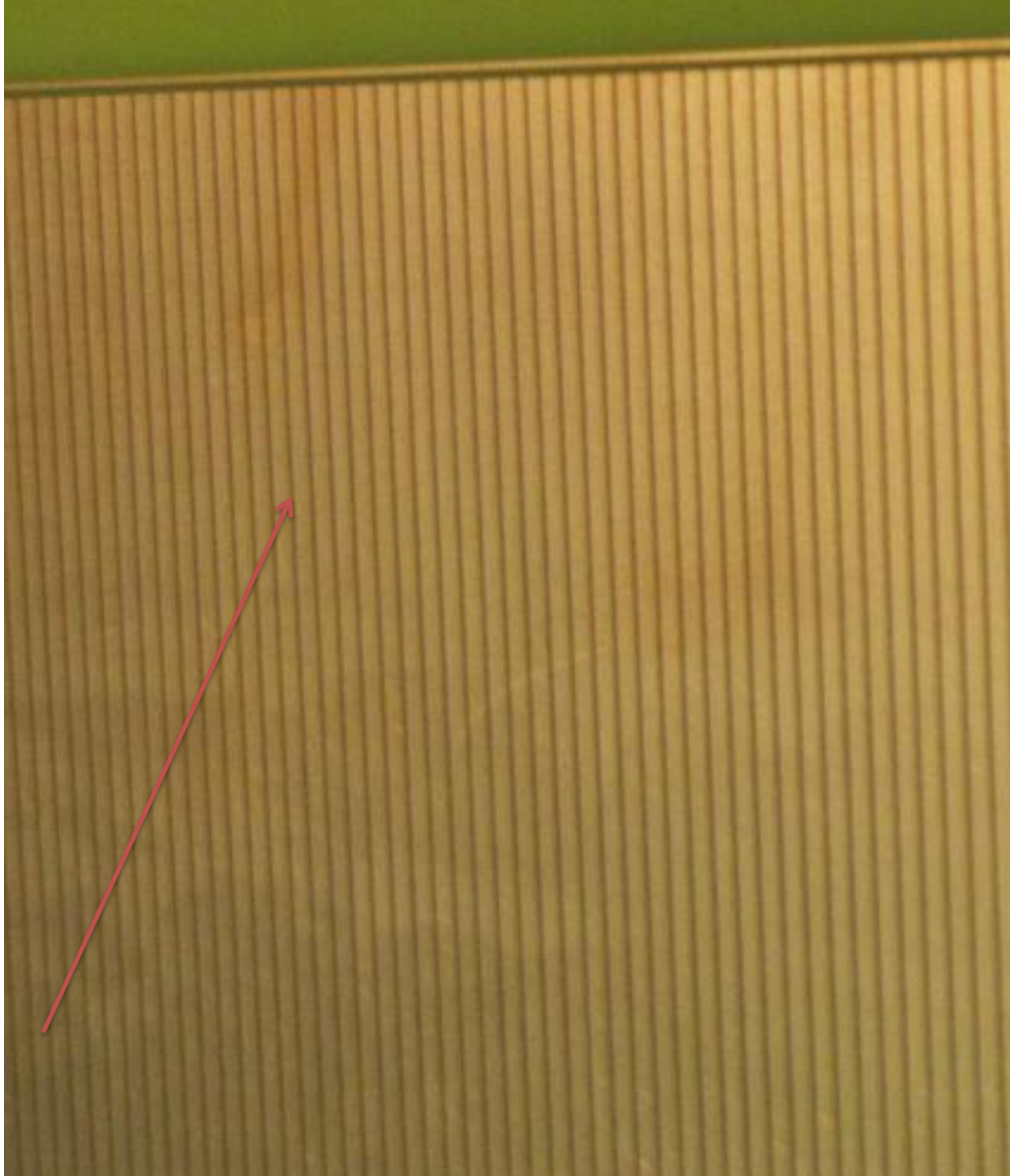


The new readout

1 defect is found

There is non etched copper in the low eta partition end. Due to this we have a floating copper area very close to our strips. It is source of noise.

Non etched copper.
– Source of noise

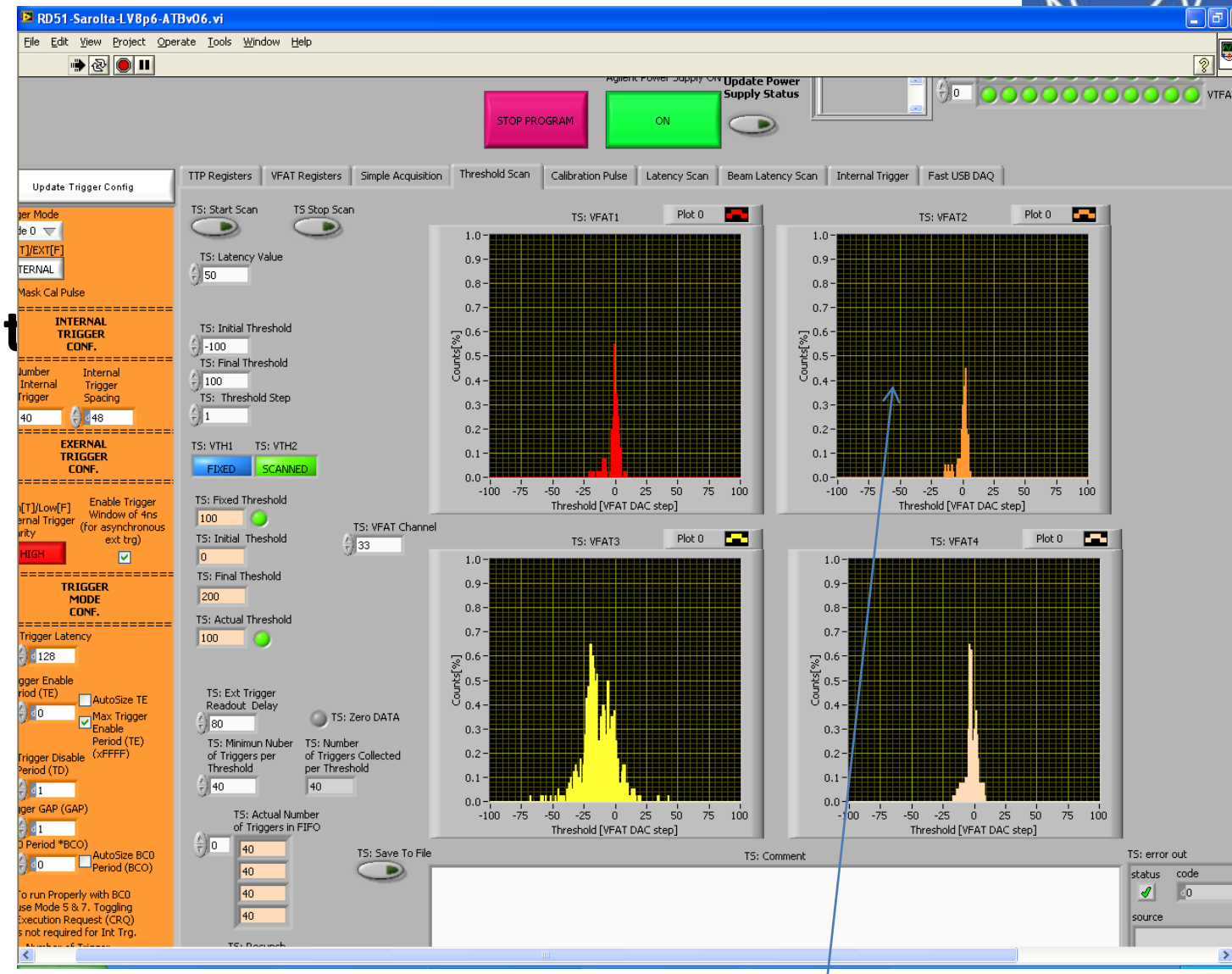


The old readout

We found

2 disconnected strips.

The noise level

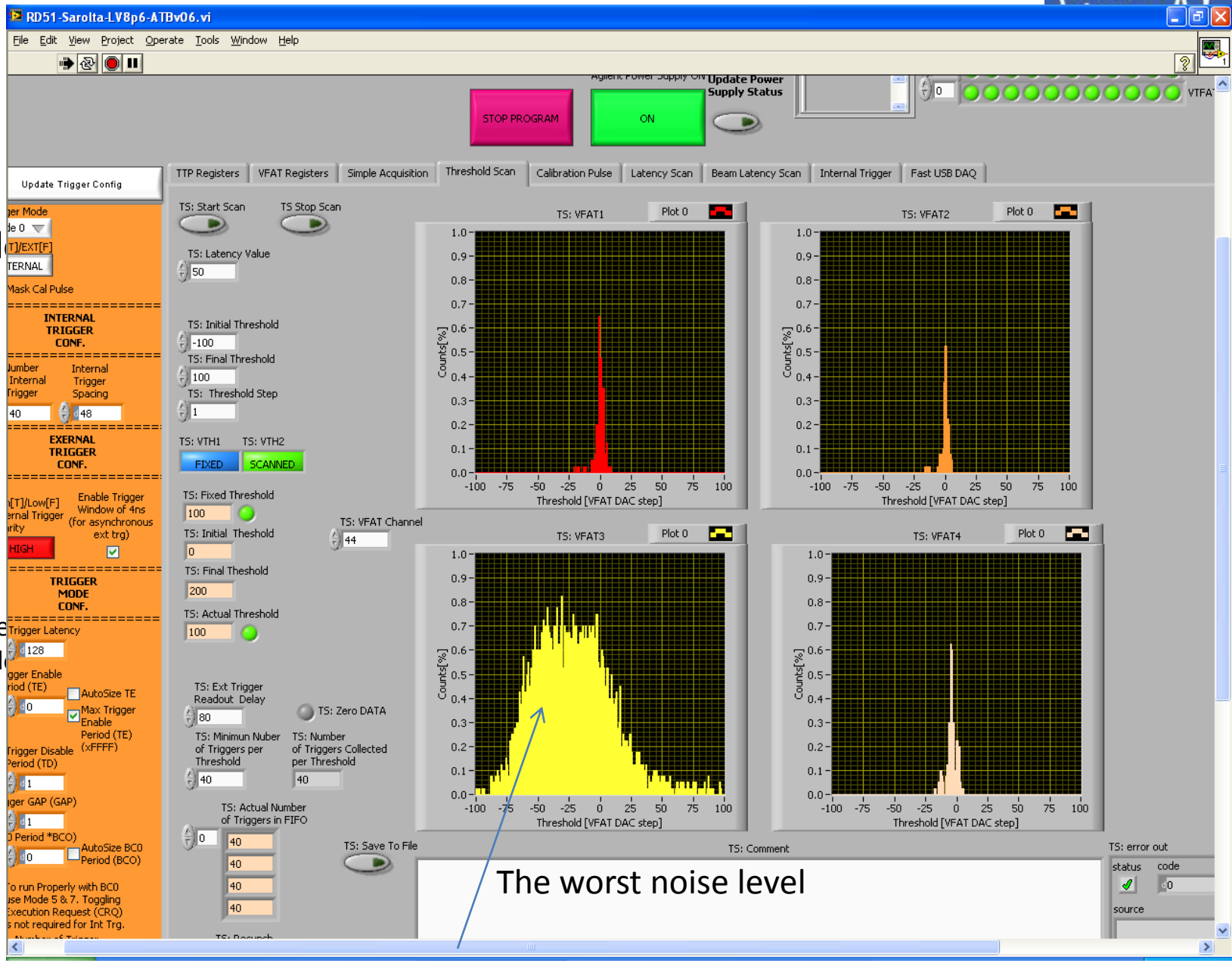


The best noise level

The old read

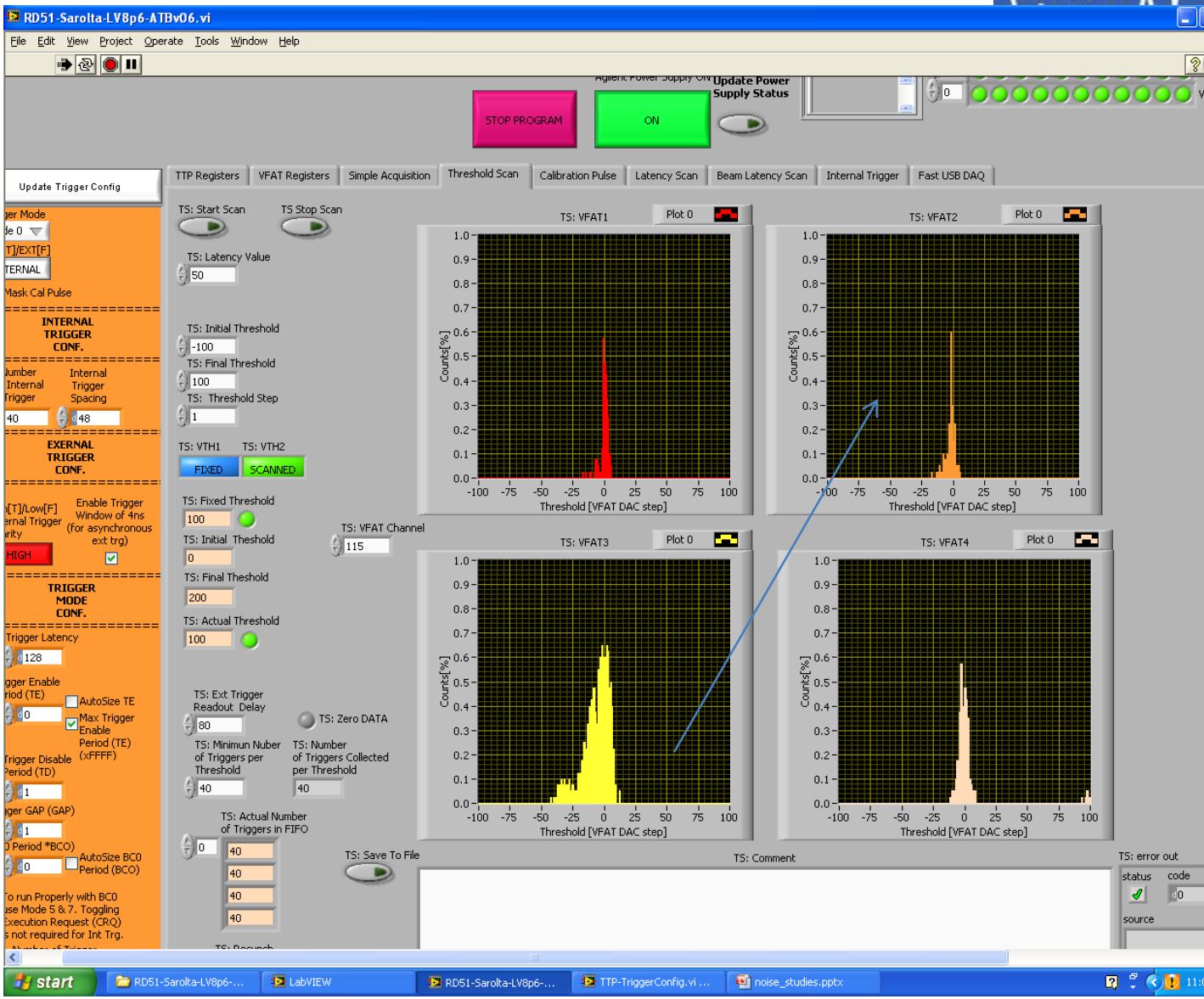
We put inside
the grounding
envelope
one dummy gem
to simulate
conditions
in the detector.

Now preparing the
with the new read



New readout Noise level

Looks better then the old one.



The best noise level

GE1/1 Status and Plans

Item	Present Status
GEM foils production	Done
GEMs HV test	90% finished
Stretching and Framing procedure	90% finished
Drift Electrode	Done
HV divider production	In progress
HV divider test	Pending
Readout PCB production	Done
Readout PCB testing	In progress
Ready with prototype for 18.Oct.2010	OK