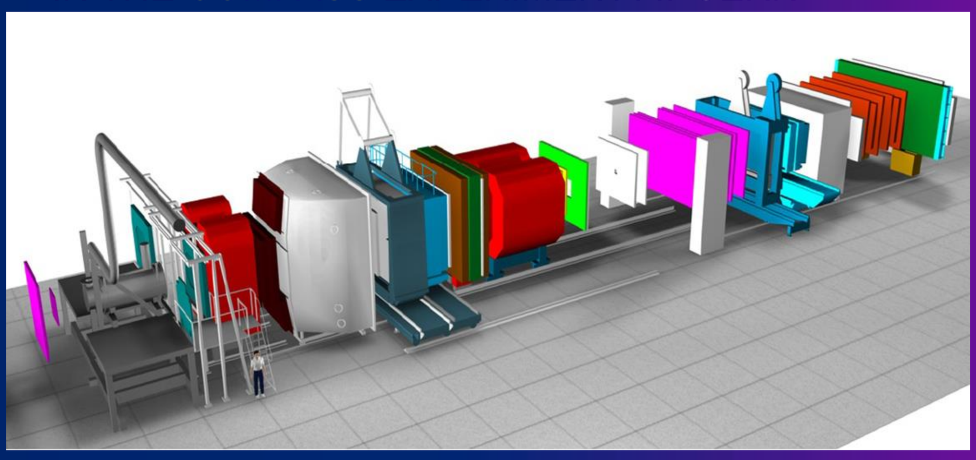
Progress in the production of large size THGEM boards

Stefano Levorato, INFN Trieste and Trieste University

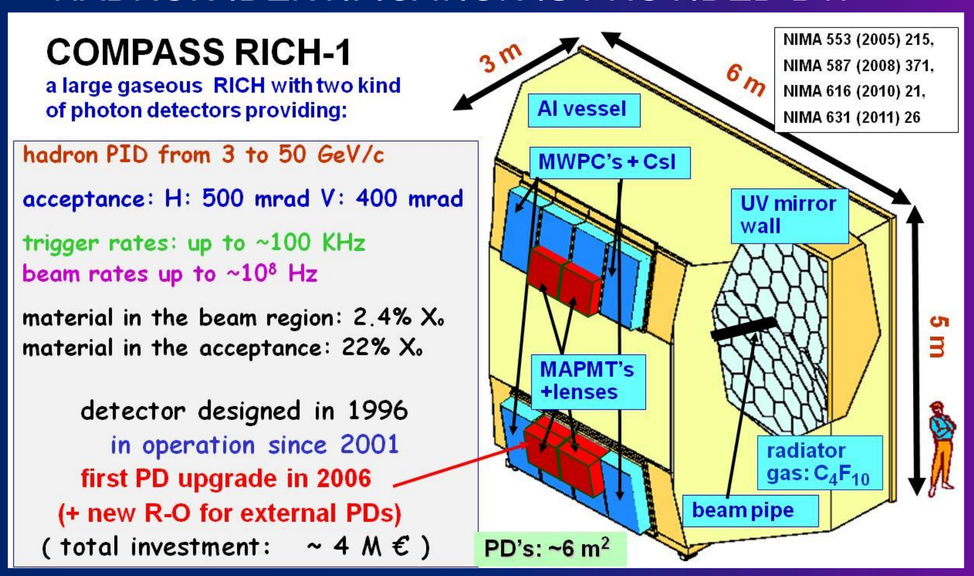
On behalf of an Alessandria-Aveiro-Freiburg-Liberec-Calcutta-Prague-Torino-Trieste Collaboration

COMPASS RICH-1

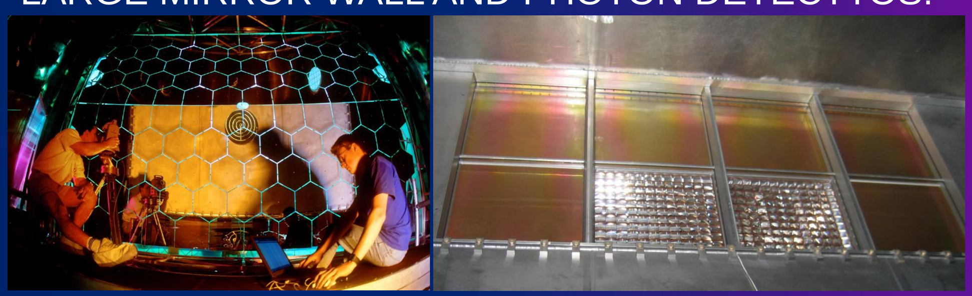
IN THE COMPASS EXPERIMENT AT CERN



HADRON IDENTIFICATION IS PROVIDED BY:



LARGE MIRROR WALL AND PHOTON DETECTTOS:

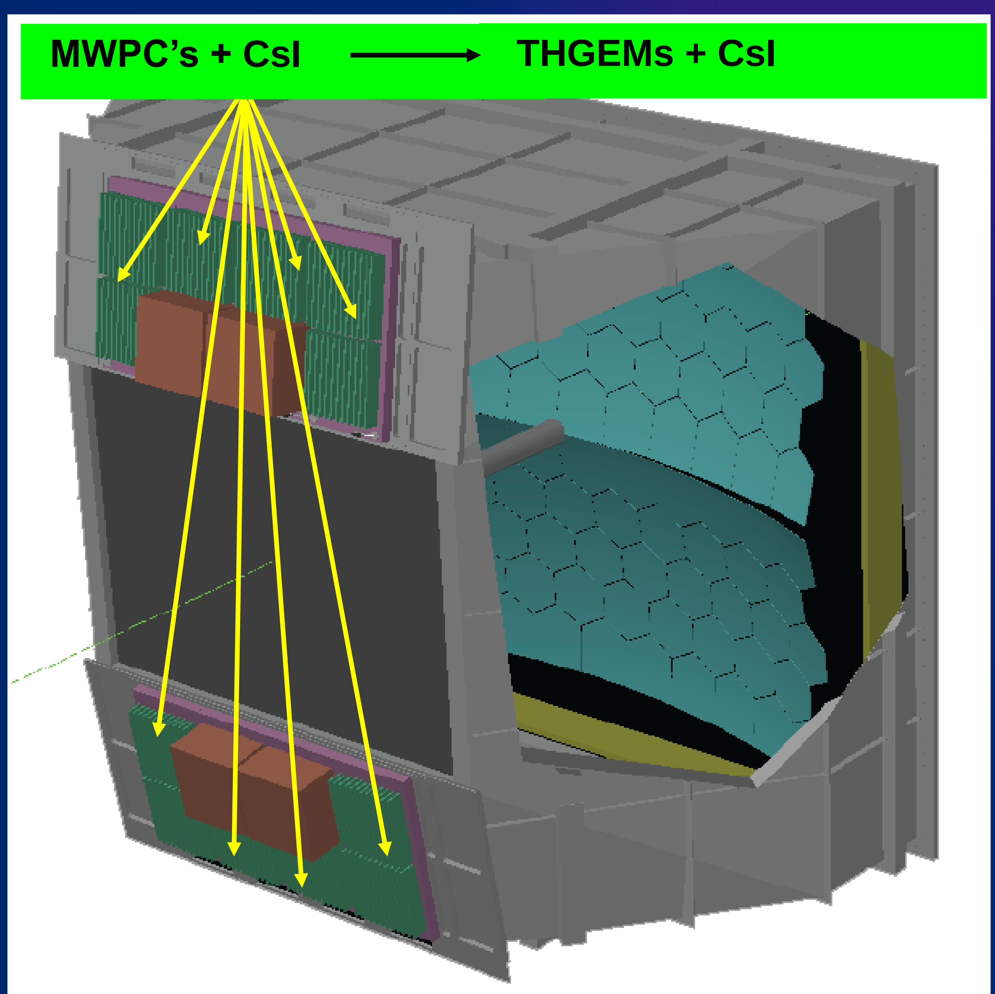


MWPC'S WITH CSI ARE NICELY WORKING, BUT:

- the effective gain is moderate (~10,000)
- Q.E. is challenged by aging (~1 mC/cm²)
- the signal is slow (~100 ns)
- for larger gains the electrical is limited and the recovery time after a detector trip is long (~1 d)

The THGEM-RICH upgrade

IN ORDER TO COPE WITH THE CHALLENGES OF THE MEASUREMENTS FORESEEN BY COMPASS AN UPGRADE OF THE GASEOUS PHOTON DETECTORS HAS BEEN DECIDED:



The new THGEM-based photon detectors will allow to:

- avoid photon feedback
- reduce the ion backflow to the CsI layer
- detect signals from electron drift (few ns)
- use simple and robust components

The THGEM – RICH team:

M.Alexeev[i,1], R.Birsa[i], F.Bradamante[h], A.Bressan[h], M.Chiosso[f], P.Ciliberti[h], S.Dalla Torre[i,*], S.Dasgupta[i,2], O.Denisov[g], V.Duic[h], M.Finger[e], M.Finger Jr[e], H.Fischer[c], M.Giorgi[h], B.Gobbo[i], M.Gregori[i], F.Herrmann[c], K.Königsmann[c], S.Levorato[h], A.Maggiora[g], A.Martin[h], G.Menon[i], F.Nerling[c], K.Novakova[i,d,4], J.Novy[e], D.Panzieri[a], F.A.Pereira[b], E.Rocco[f,3], C.A.Santos[b], G.Sbizzai[h], P.Schiavon[h], C.Schill[c], author[freiburg]S.Schopferer, M.Slunecka[e], F.Sozzi[h], L.Steiger[h,d,4], M.Sulc[d], S.Takekawa[f], F.Tessarotto[i] and J.F.C.A.Veloso[b]

[a] INFN, Sezione di Torino and University of East Piemonte, Alessandria, Italy
[b] Departmento de Física, Universidade de Aveiro, Aveiro, Portugal
[c] Universität Freiburg, Physikalisches Institut, Freiburg, Germany
[d] Technical University of Liberec, Liberec, Czech Republic
[e] Charles University, Prague, Czech Republic and JINR, Dubna, Russia
[f] INFN, Sezione di Torino and University of Torino, Torino, Italy
[g] INFN, Sezione di Torino, Torino, Italy
[h] INFN, Sezione di Trieste and University of Trieste, Trieste, Italy
[i] INFN, Sezione di Trieste, Trieste, Italy

THGEMs

THGEMS ARE ELECTRON MULTIPLIERS DERIVED FROM THE GEM CONCEPT CHANGING GEOMETRICAL DIMENSIONS AND PRODUCTION TECHNOLOGY

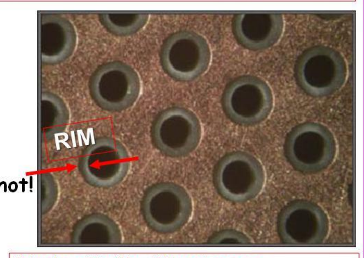
PCB technology, thus:
- robust
- mechanically self supporting
- industrial production of large size boards
- economic

Comparing to GEMs
- Geometrical dimensions X ~10
  - But e⁻ motion/multiplic. properties do not!
  - Larger holes: dipole fields and external fields are strongly coupled

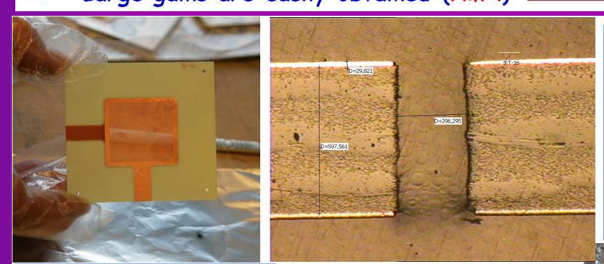
About gain:
- Large gains are easily obtained (rim !)

About PCB geometrical dimensions:

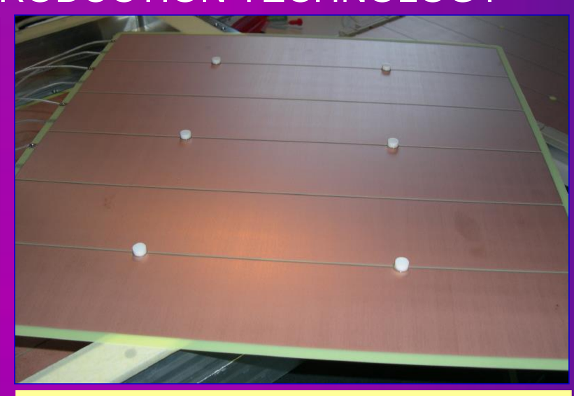
Hole diameter :	0.2 - 1 mm
Pitch :	0.5 - 5 mm
Thickness :	0.2 - 3 mm



introduced in // by different groups:
L. Periale et al., NIM A478 (2002) 377.
P. Jeanneret, PhD thesis, Neuchatel U., 2001.
P.S. Barbeau et al, IEEE NS50 (2003) 1285
R. Chechik et al, .NIMA 535 (2004) 303



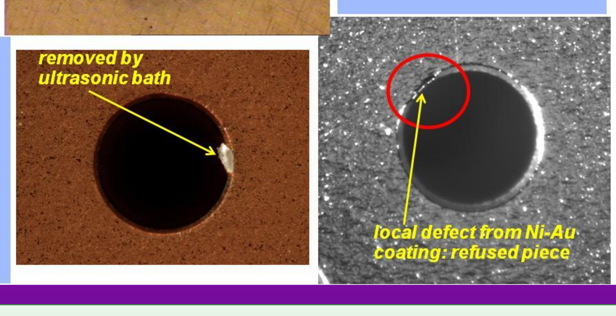
COMPASS THGEM pcb's are produced by an industrial pcb Company: ELTOS S.p.A. (Arezzo - Italy)



Pluritec Multistation Evolution (mechanical drilling at ELTOS)

Working area:630 mm x 765 mm
200,000 turns/min 20,000 holes/h
storage: 840 tools, controlled diameter depth, run-out

Defects are detected by a quality check procedure when THGEMs are received

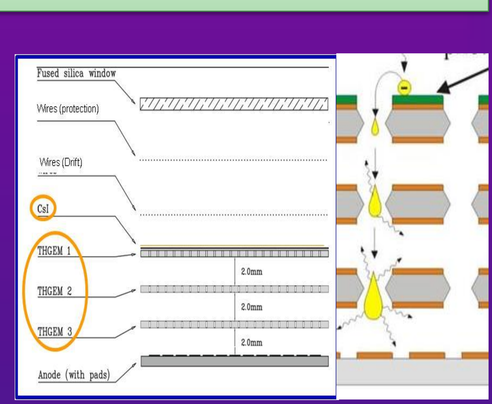


THGEM – based PD's

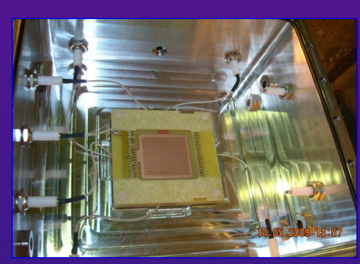
DURING 4 YEARS OF STUDIES WE PERFORMED:

Characterisation of small size THGEM prototypes
- Using X-ray sources
- Using UV light sources
- With Cherenkov light at the test beams
- Analog read-out, single channel
- Digital read-out, 1 channel per anode pad
- Read-out of the current on the various electrodes

More than 50 different THGEM samples characterized



Large size prototypes
- Construction and test of medium size (300 x 300 mm²) detectors
- Study of specific performances engineering aspects for very large prototypes (300 x 300 mm²)



→ F. Tessarotto talk for more details

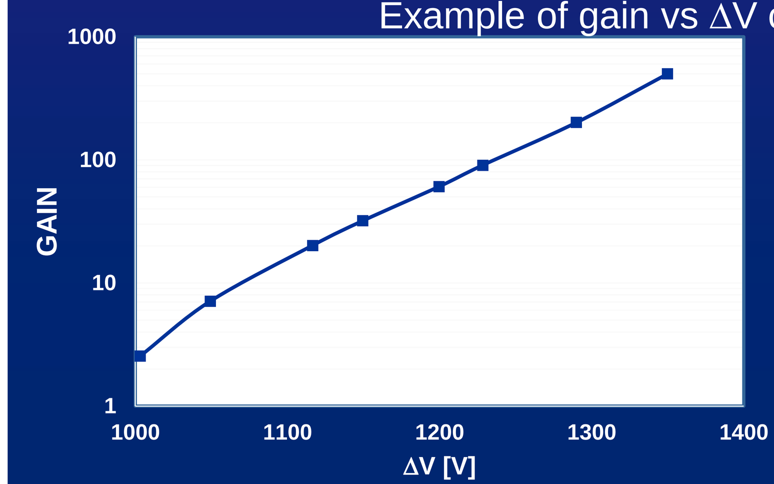
THGEM large size performance

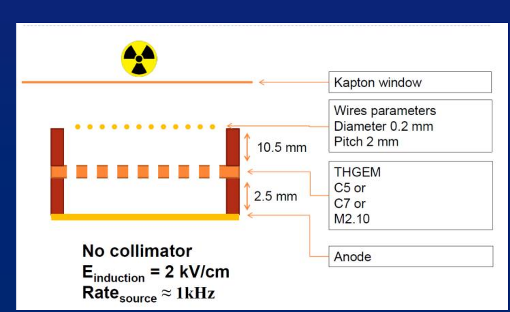
Small THGEM prototypes *30x30 mm²* have superior performances than our large prototypes: *stopping point to cover large surfaces ?*

Stick to one geometry 0.4 mm thickness 0.4 mm holes diameter 0.4 mm pitch

For small prototypes max stable gain achievable with ^{55}Fe source (single THGEM) Ar/CO2 70-30 mixture ~ 1K (Pieces received from Eltos) (no rim THGEMs)

Example of gain vs ΔV characterization





Same setup but with large prototypes : Gain ranging 30-50 (Pieces received from Eltos)

A factor up to 30 less than small prototypes.

Two sources of intrinsic performance limitations have been pointed out

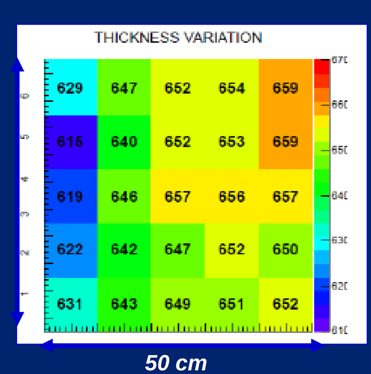
The thickness uniformity plays an essential role in defining the maximum gain achievable, we observed variation up to 50 μm for 400 μm THGEM thickness along one sector → the maximum gain is limited by the thinner area.

Irregular hole edges can trigger discharges due to the high local E field values

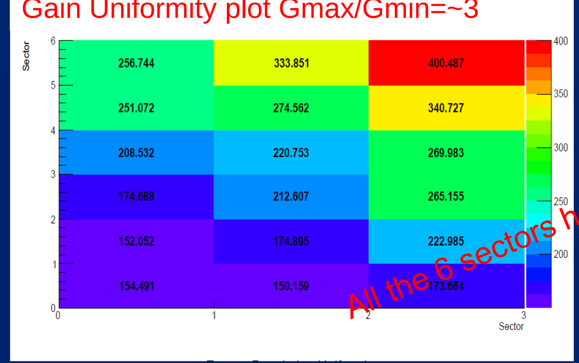
THICKNESS

We have implemented a pre selection chain for PCB thickness → tolerances reduced w.r.t. raw commercial pcb foils

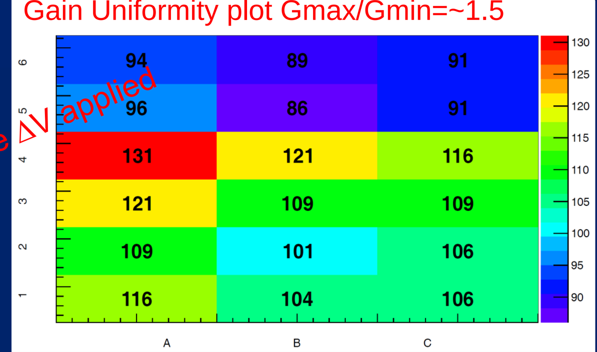
Starting from large PCB foils 1.2x1.6 m² 500mmx500mm pieces have been selected: the foil thickness is mapped, and the most uniform areas are selected and cut.



Gain Uniformity plot Gmax/Gmin=~3



Gain Uniformity plot Gmax/Gmin=~1.5

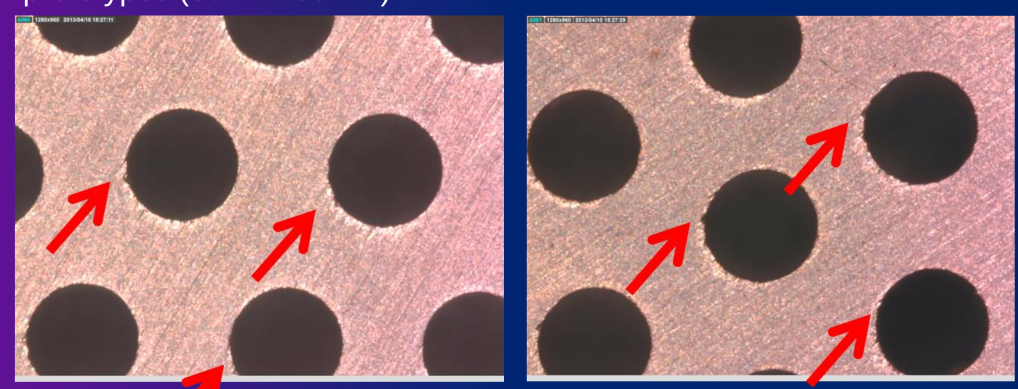


Before Selection

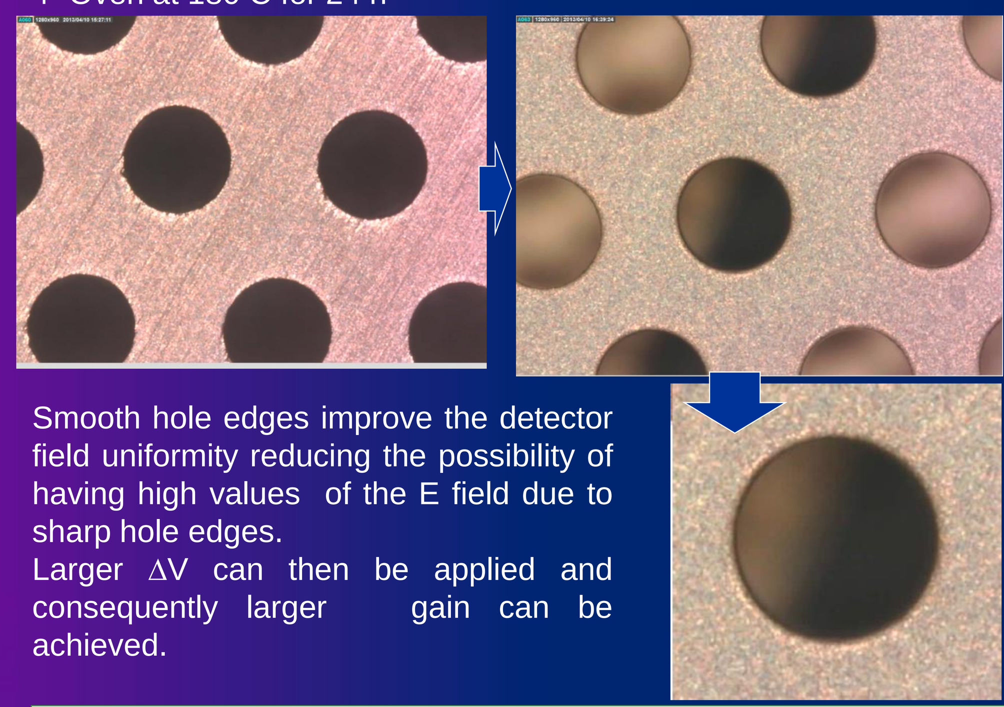
After Selection

SURFACE

Irregularities are located on one side of the hole and irregular hole edges are visible. These "problems" are not there for small prototypes (30mmx30mm)



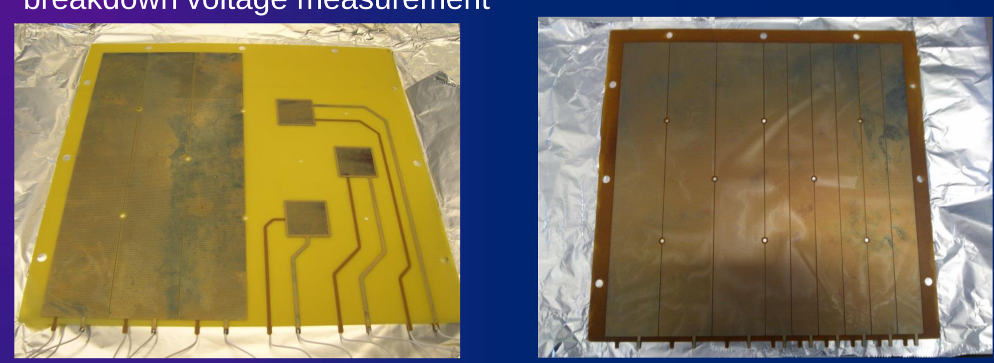
A procedure to improve the surface quality has been developed, it consists in:
1- Mechanical brushing using pumice stone plus water
2- Ultrasonic bath 50-60 C in Sonica pcb solution, ~1h mild chemical attack
3- Washing with demineralized water at high pressure
4- Oven at 180 C for 24 h

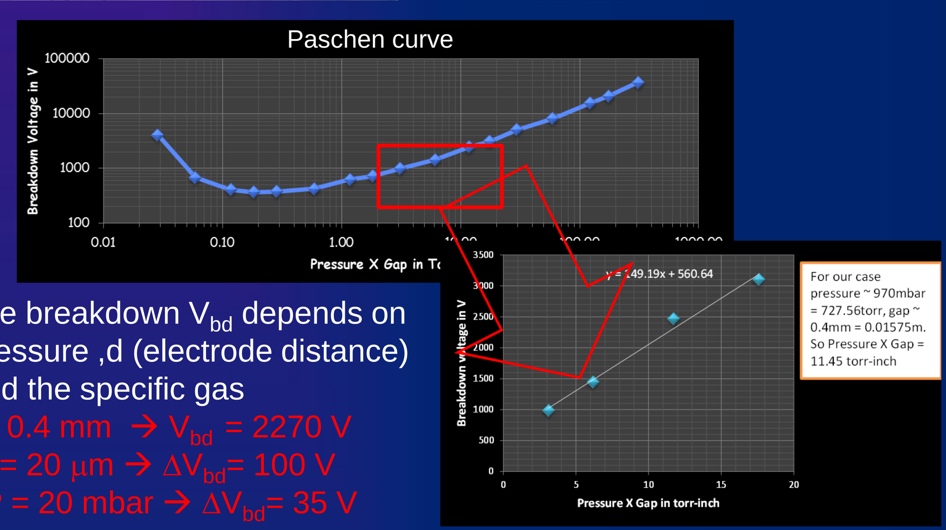


Smooth hole edges improve the detector field uniformity reducing the possibility of having high values of the E field due to sharp hole edges.
Larger ΔV can then be applied and consequently larger gain can be achieved.

Procedure test and results

Design and production of non-standard THGEMs dedicated to study the procedure effect, the active surface effect via Paschen breakdown voltage measurement



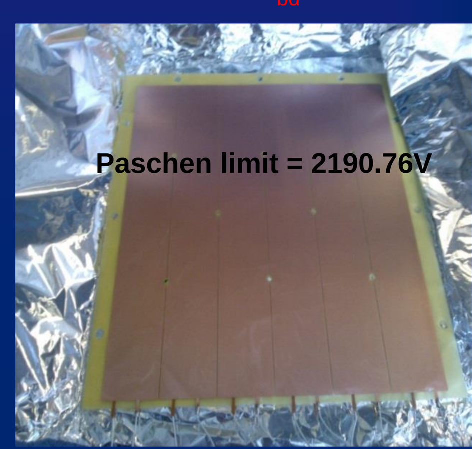


The breakdown V_{bd} depends on Pressure ,d (electrode distance) And the specific gas

$t = 0.4$ mm → $V_{bd} = 2270$ V

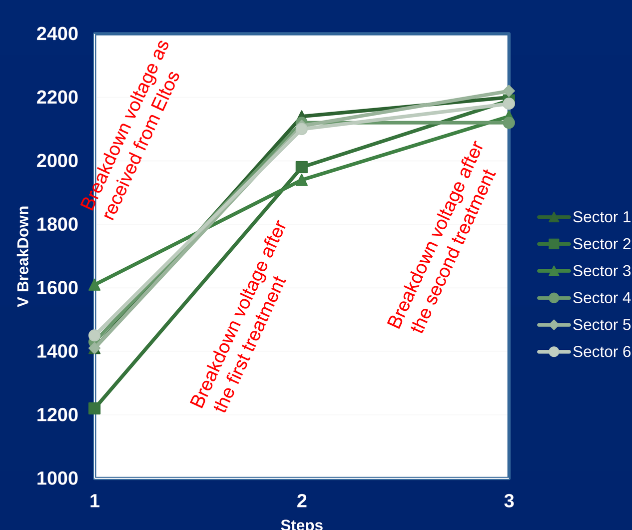
$\Delta t = 20$ μm → $\Delta V_{bd} = 100$ V

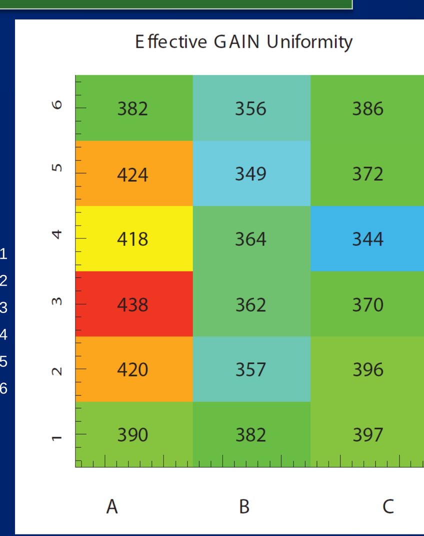
$\Delta P = 20$ mbar → $\Delta V_{bd} = 35$ V



The Paschen limit is used to check the breakdown voltage of the THGEM as received from the company and after the treatment (see table). For this piece the treatment was repeated twice. The 6 different sectors could reach breakdown voltages near the expected limit.

Out of the box	1410	1220	1610	1430	1410	1450
After treatment	2200	2190	2140	2120	2220	2180





For large prototypes the max gain achievable is only a factor 2 less compared to the small prototypes one. A large improvement has been reached.

CONCLUSIONS

The implemented quality checks and the procedure for the selection and the treatment of the large THGEMs has proven to be effective, in particular the performances of the large detector are nearly identical to the small prototypes: the gain difference between different areas of the same THGEM has been reduced to a factor 1.5, and there is still room for improvement.
The initial difference of maximum gain achievable, when compared with small prototypes has been reduced from a factor 30 to a factor 2.

Larger size prototypes (600mmx600mm) will be treated with the same procedure and their performance will be tested.