Cylindrical detector.

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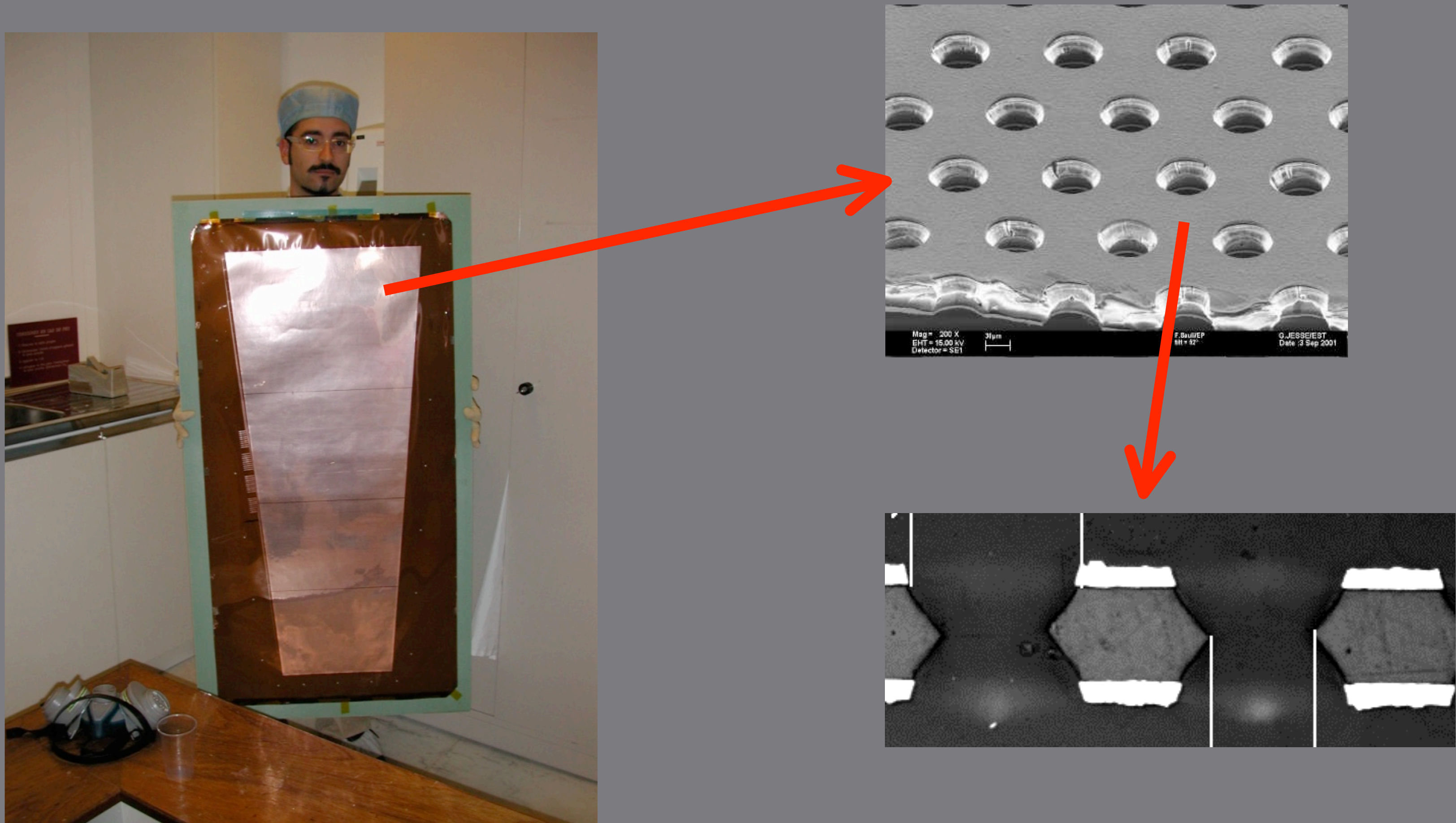
Frascati 10/2012

OUTLINE

- GEM
  - Large size process
  - Equipments
  - Production capabilities
- Read out boards
  - Different options and limitations
  - Kloe
- NS2

GEM Foil

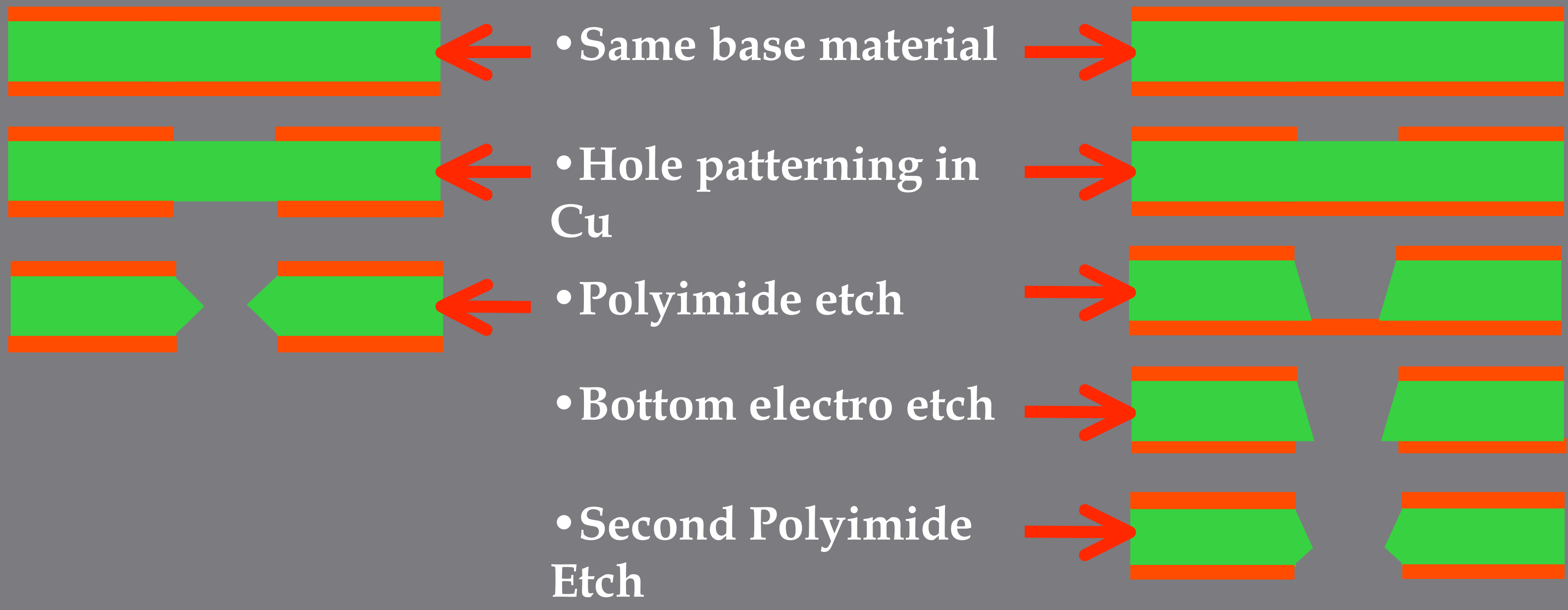
Present size 1.2m x 0.5m (active area)
Future max size 2m x 0.5m
Std pattern 140um pitch/70um holes



GEM double mask Vs GEM single Mask

- Base material : Polyimide 50um + 5um on both sides
- Polyimide : Apical NP from company Kaneka (Japan)
- Supplier of the copper clad material : Nippon Mining (Japan)

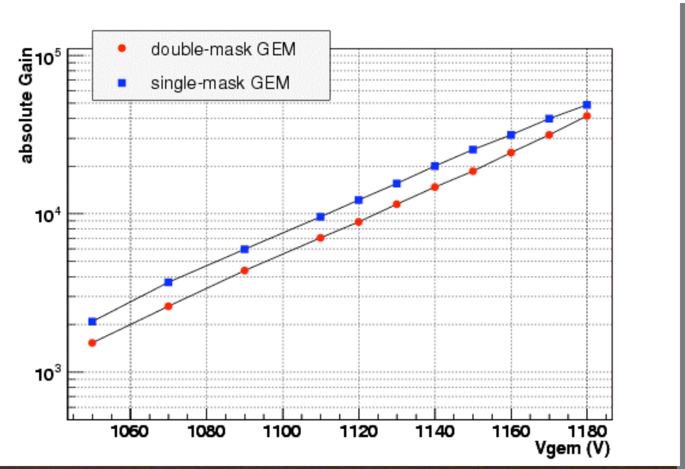
- Double mask
- Single mask

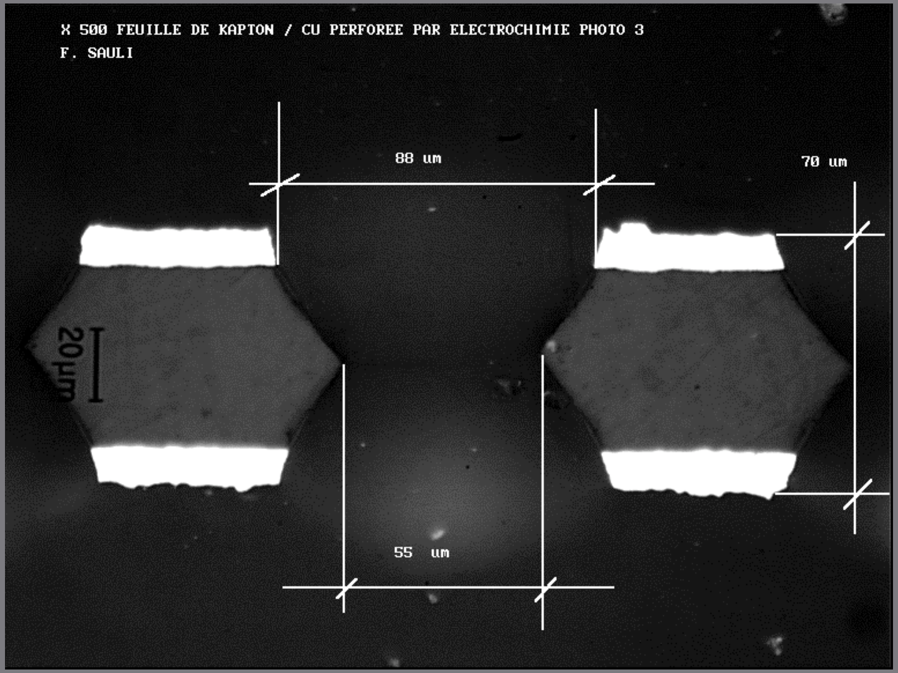


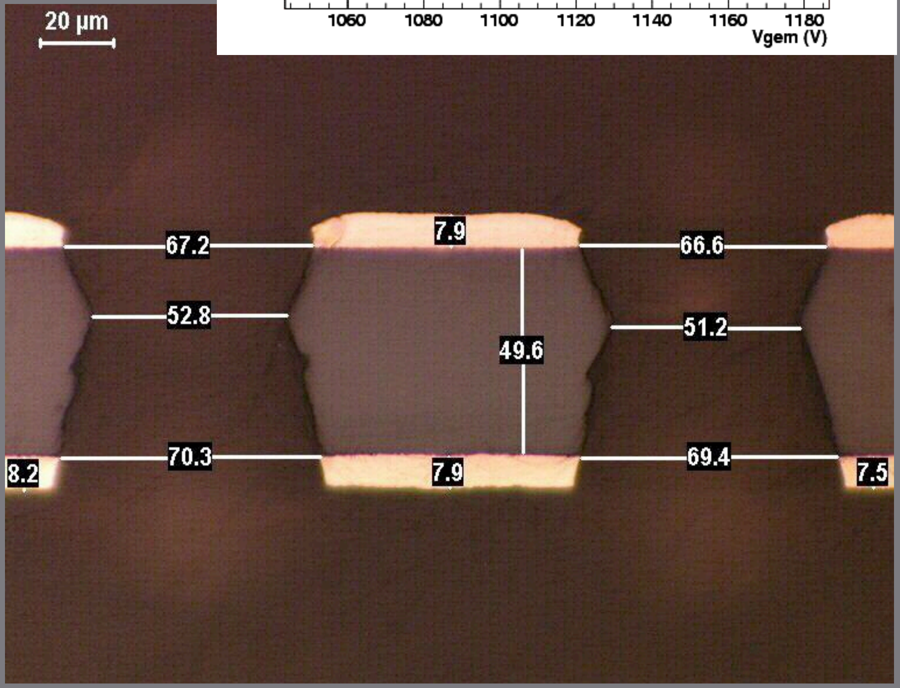
- Limited to 40cm x 40cm due to
  - Mask precision and alignment

- Limited to 2m x 60cm due to
  - Base material
  - Equipment

GEM Double mask Vs GEM single Mask



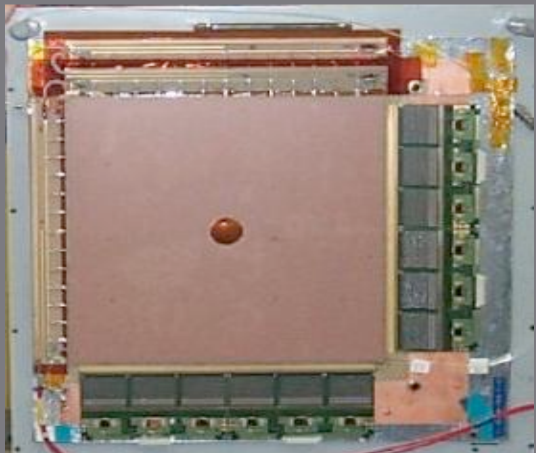




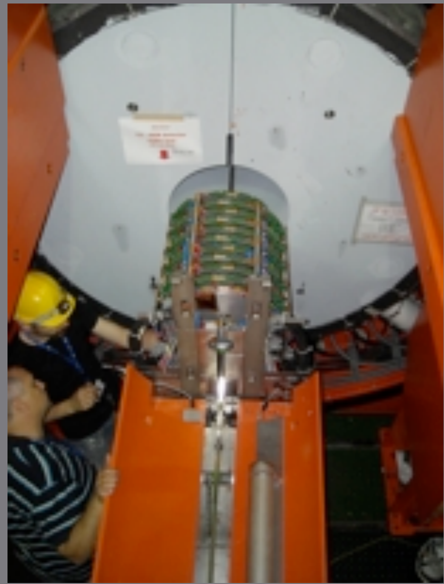
- Similar patterns , similar behavior, same material.
- Angles can be adjusted in both structure (Typ value : 70um copper hole , 50um polyimide hole)

Steeper angles gives lower gain but also lower charging up

GEM double mask examples

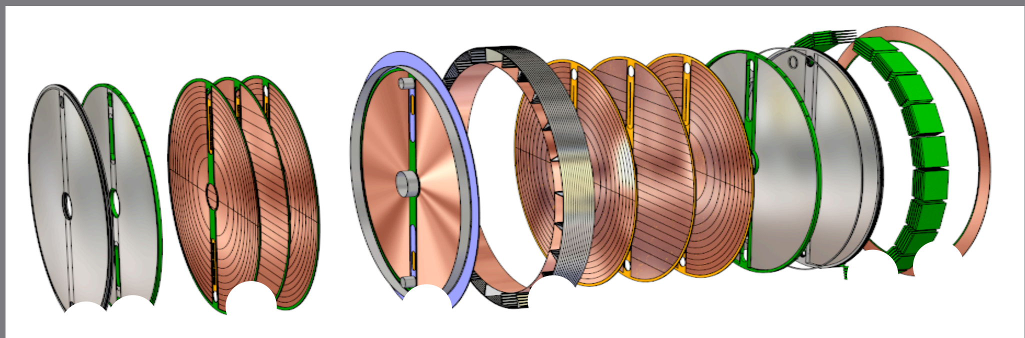


COMPASS (CERN)



TOTEM (CERN)

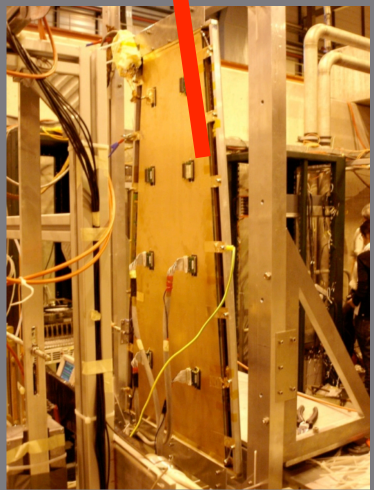
LHCb-Muon trigger (CERN

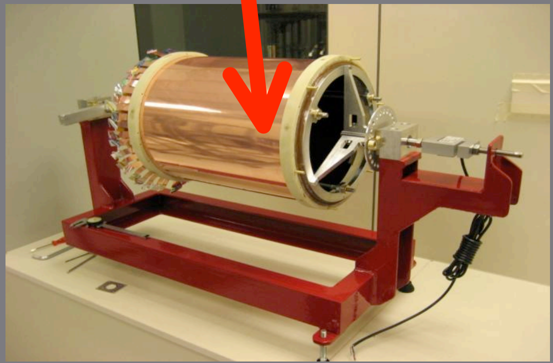


STAR experiment (US)

- Present double mask production quantities : around 500 GEMs/ year in average
- Max size: 40cm x 40cm

GEM Single mask examples





- CMS RPC possible upgrade
- GEM 1.1m x 500mm

- KLOE – Cylindrical 3 GEM Detector
- GEM 800mm x 500mm
- Read-out 2D : 800mmx 500mm

Kloe GEM

Foil : 1m x 0.6
Active area 800 x 500

Problems during production of Kloe GEMs

1/ cutting problem→ solved by chemical precutting around edges

2/ plated holes → solved by multiplying the number of holes

3/ Packing problems due to dust

- we will need a dedicated box for transportation

OUTLINE

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- Exposure machine 1.4m x 2.2m

- Laminator : 1.2m width

- Oven : 2.4m x 1.4m

- Continuous Kapton etching : 0.6m wide

- Electro chemical etching : 2m x 0.6

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Expected production rate

- Present production rate : 100 Gem /year (1.2mx0.6m)
- Expected rate for 2013 : 250 GEM/Year/technician
- Man power :
    - 2 technicians in 2012
    - 4 technicians in 2013 (training phase now)

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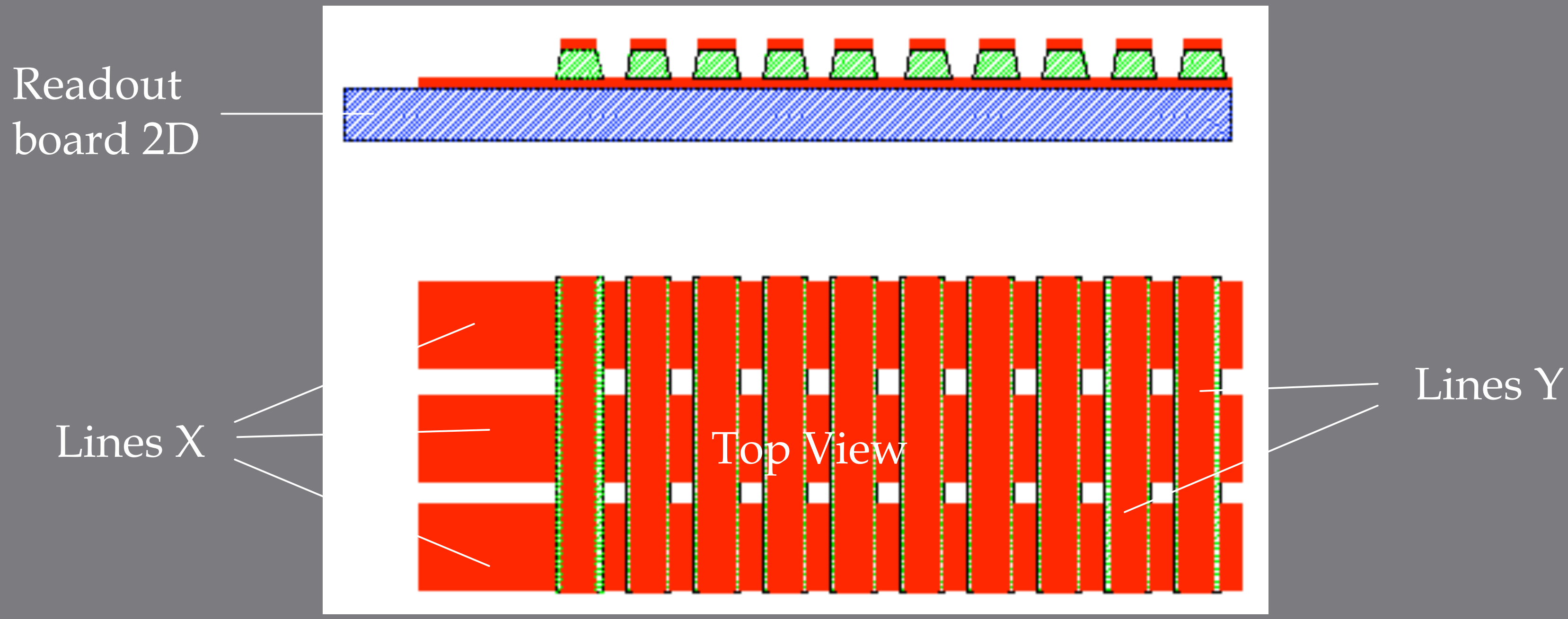
2D etched (Compass type)

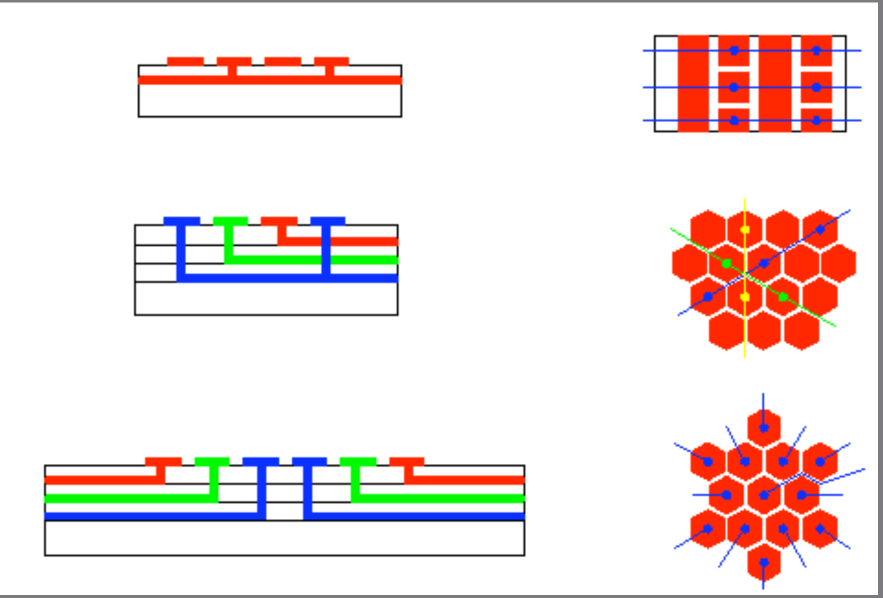


Pos:
Fine pitch
Easy control
Possibility to minimize errors
Lower mass ,less metal

Neg:
CERN single source

limited to 500mm x 700mm now → 2m x 500mm soon
Substrate gluing limited to 1.2m x0.6m

Read-out with Vias



2 Directions

3 Directions "3D"

Pixel

Pos:
3 D and Pixel possible
Flat electrode

Neg:
CERN single source for large size
Laser drilling 0.5m x0.6m, chemical 2m x 0.5m
High number of plated vias
Long electrical test
Lower pitch
More metal
More production steps

limited to 500mm x 700mm now → 1.6m x 500mm max
Substrate gluing limited to 1.2m x0.6m

2D process

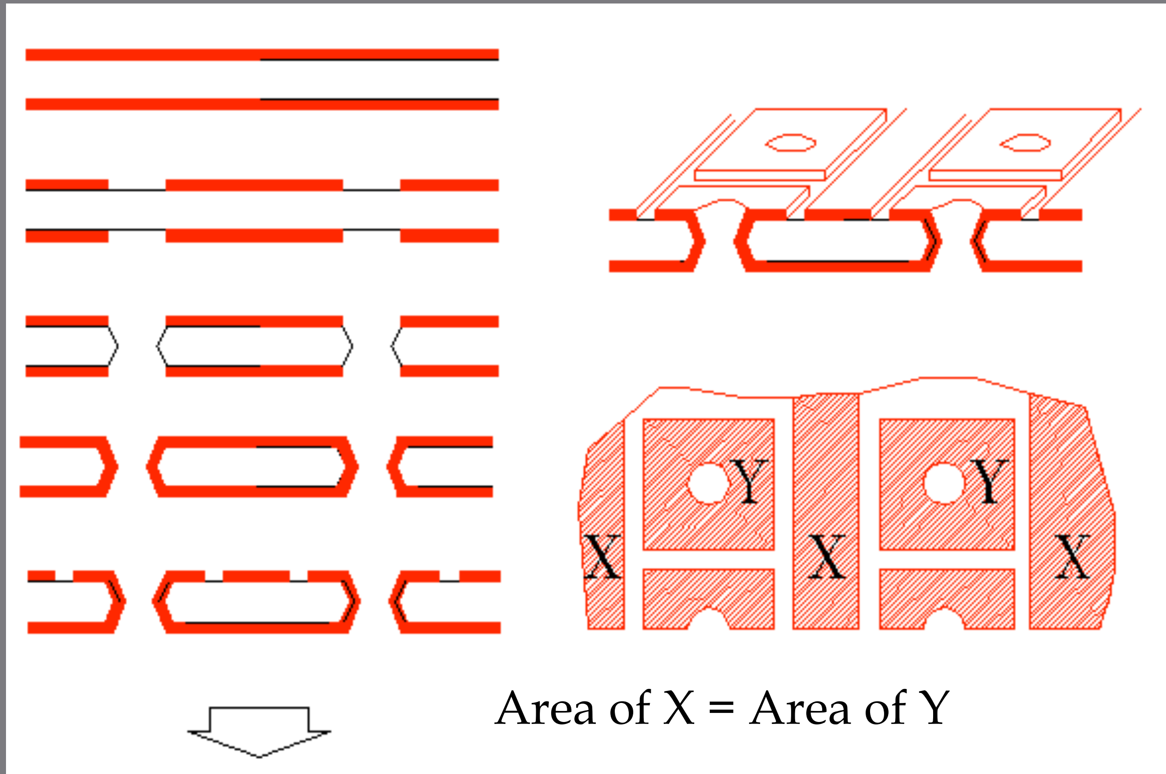
Polyimide 50 um

Image the micro-vias

Laser or Chemical drilling

Metallization

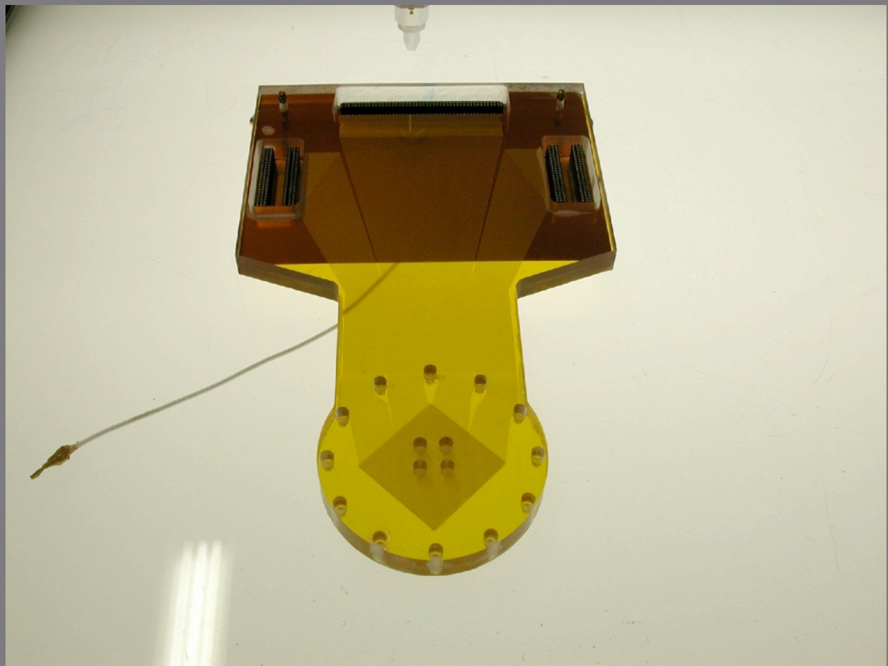
Photolithography

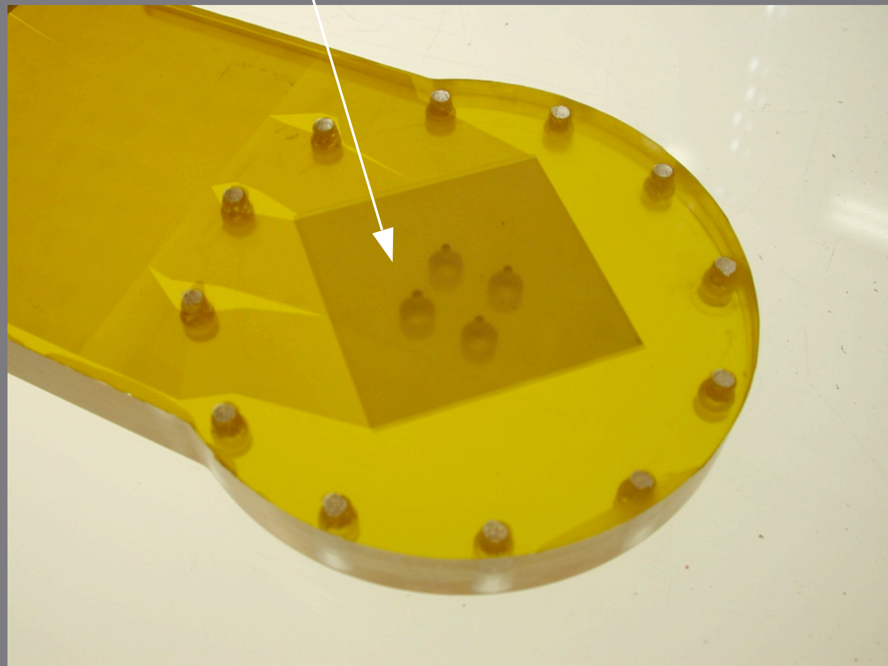


Glue to substrate

2D example

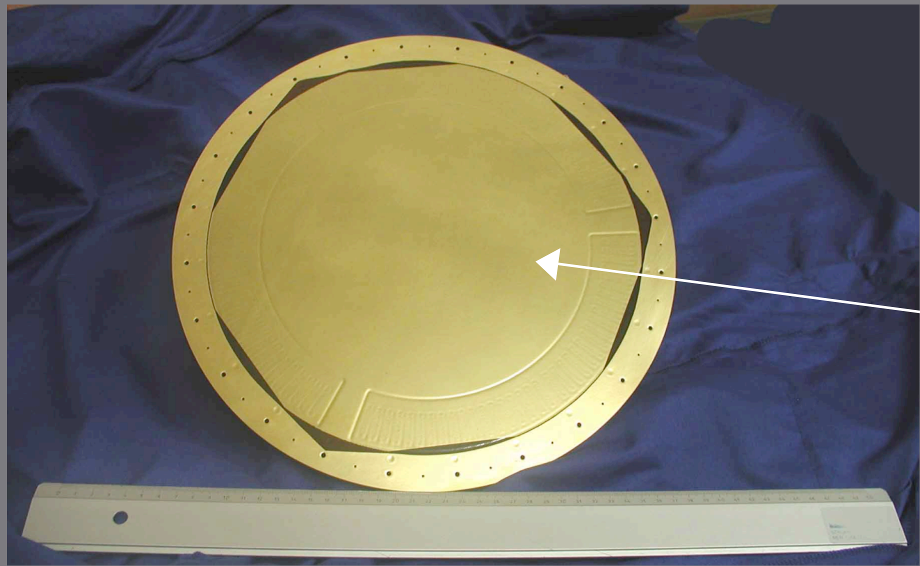
Readout active area





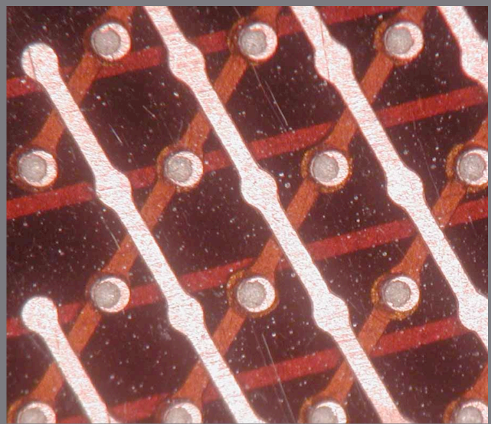
2D readout board glued on low intrinsic radiation Plexiglas substrate

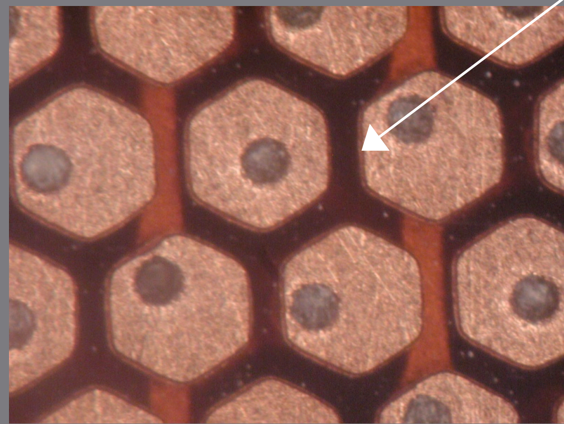
3D example



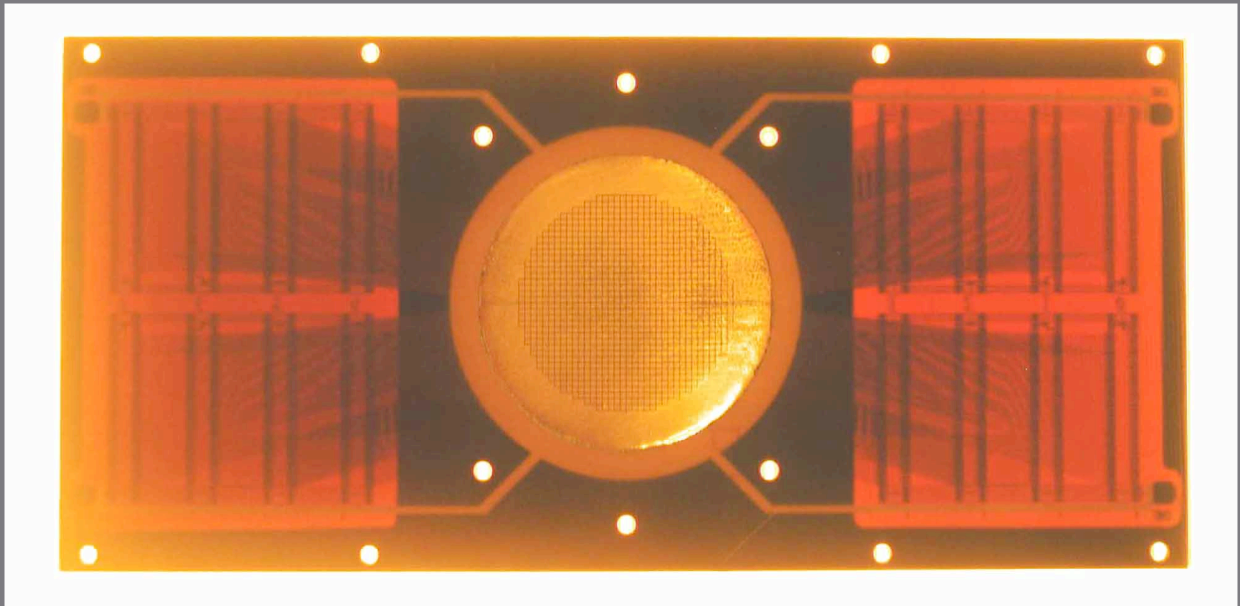
Readout for TPC with
backside connection
30cm diameter

18000 pads

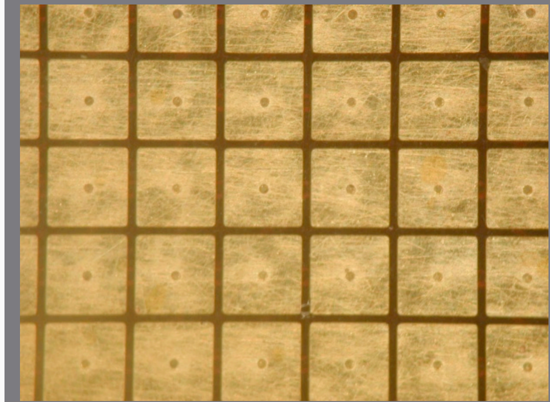




Pixel example



1024 pads on a diameter of 35mm



Close-up view
Pad : 1mm
Pitch : 1.05mm

Smallest pad produced : 250µm
Pitch: 300µm

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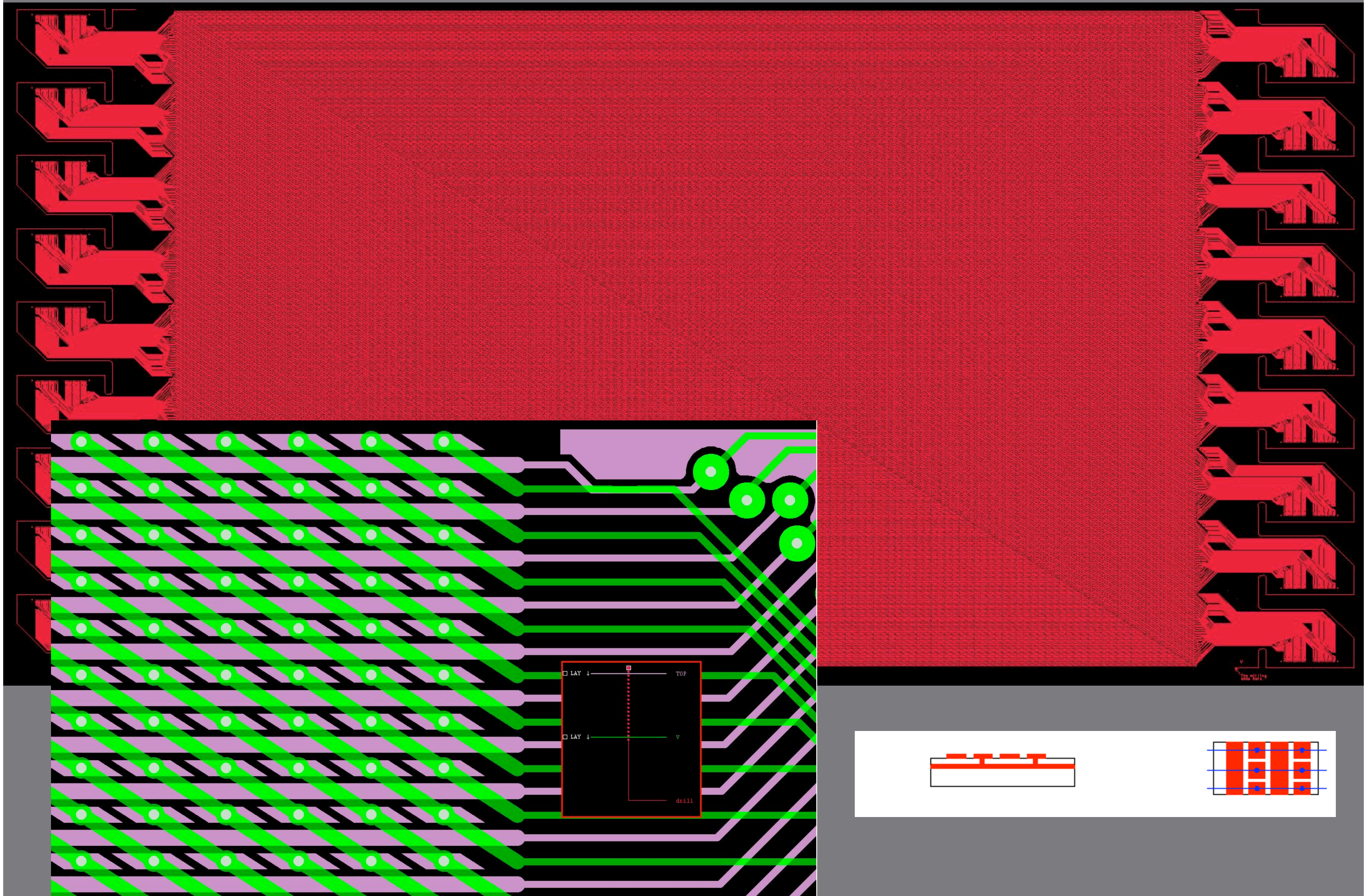
- *NS2*


LAY
TOP
LAY
drill

Problems during production

1/ Plating of large quantity micro via

2/ Dimensional accuracy

3/ Electrical test longer than expected

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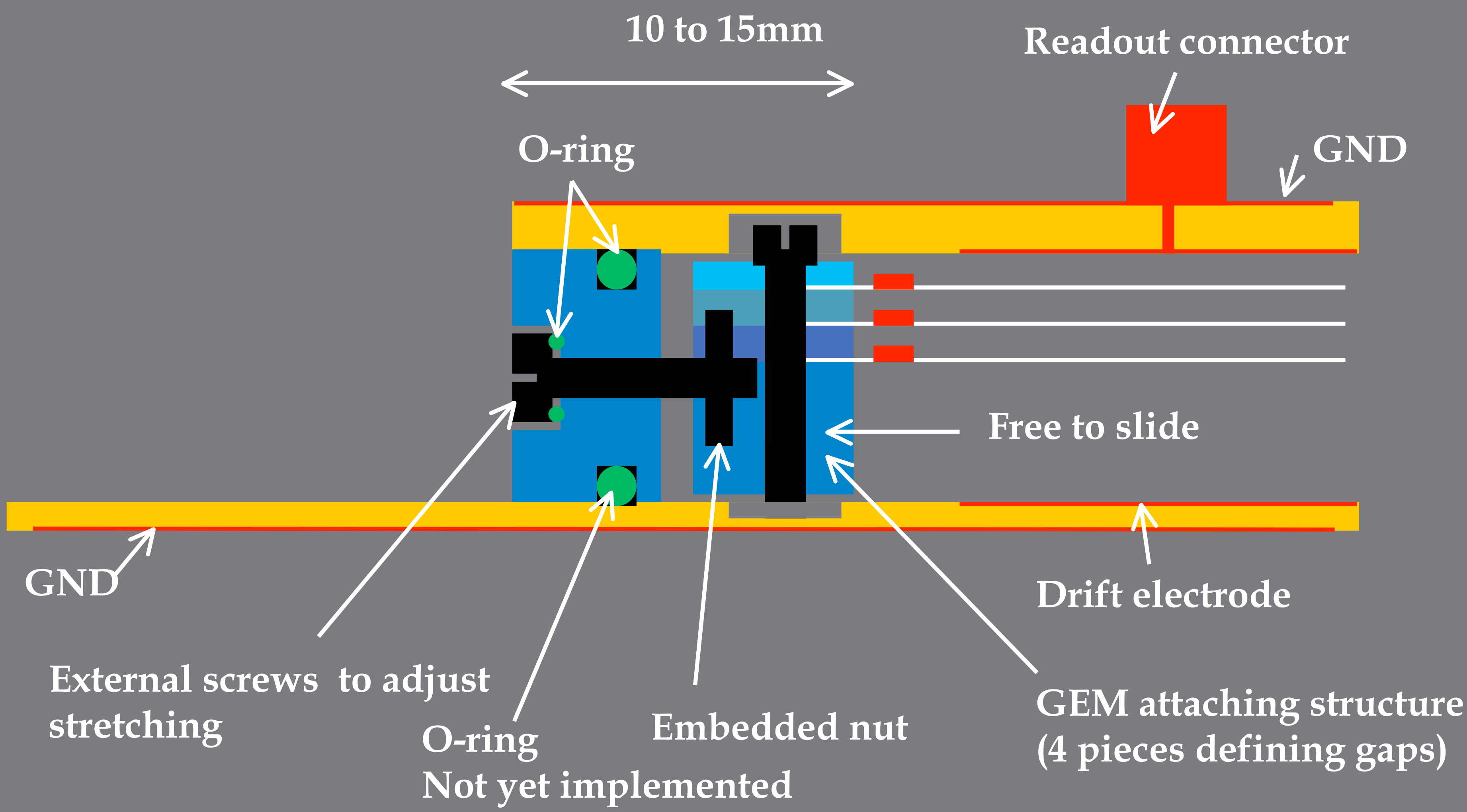
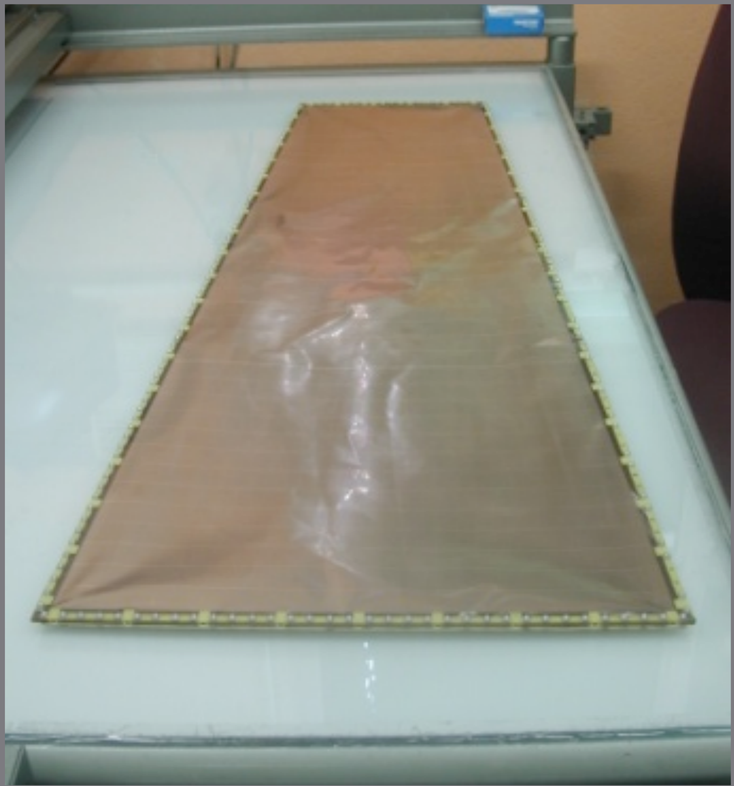
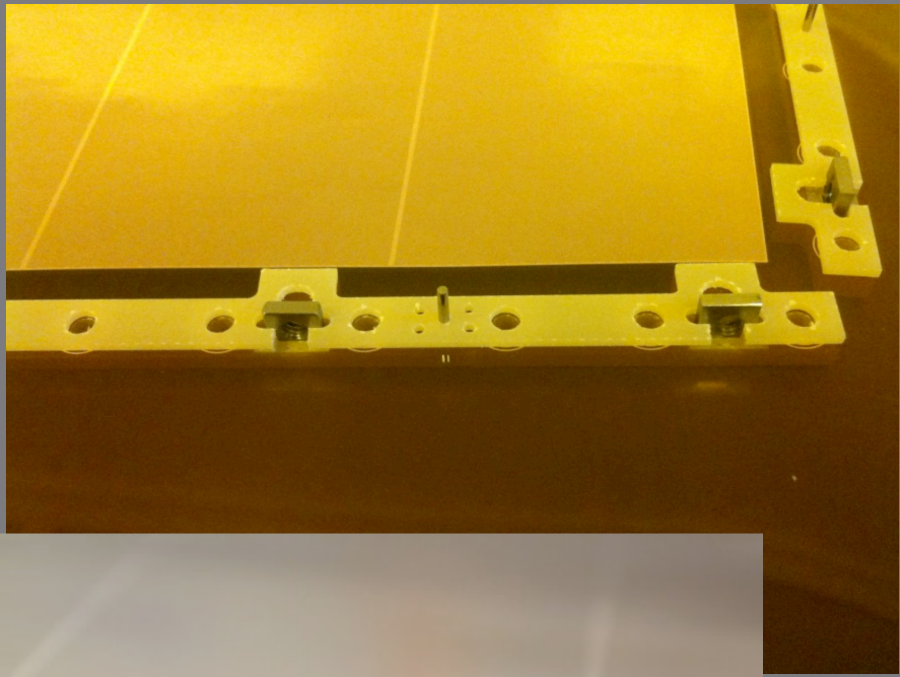
NS2

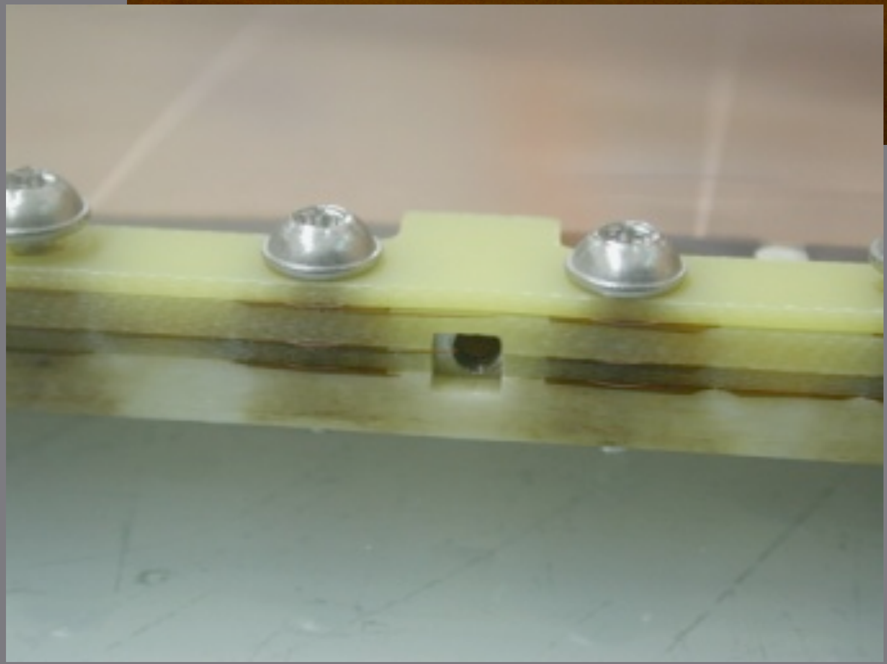

10 to 15mm
Readout connector
O-ring
GND
Free to slide
GND
Drift electrode
External screws to adjust
stretching
O-ring
Not yet implemented
Embedded nut
GEM attaching structure
(4 pieces defining gaps)

Gem Stack

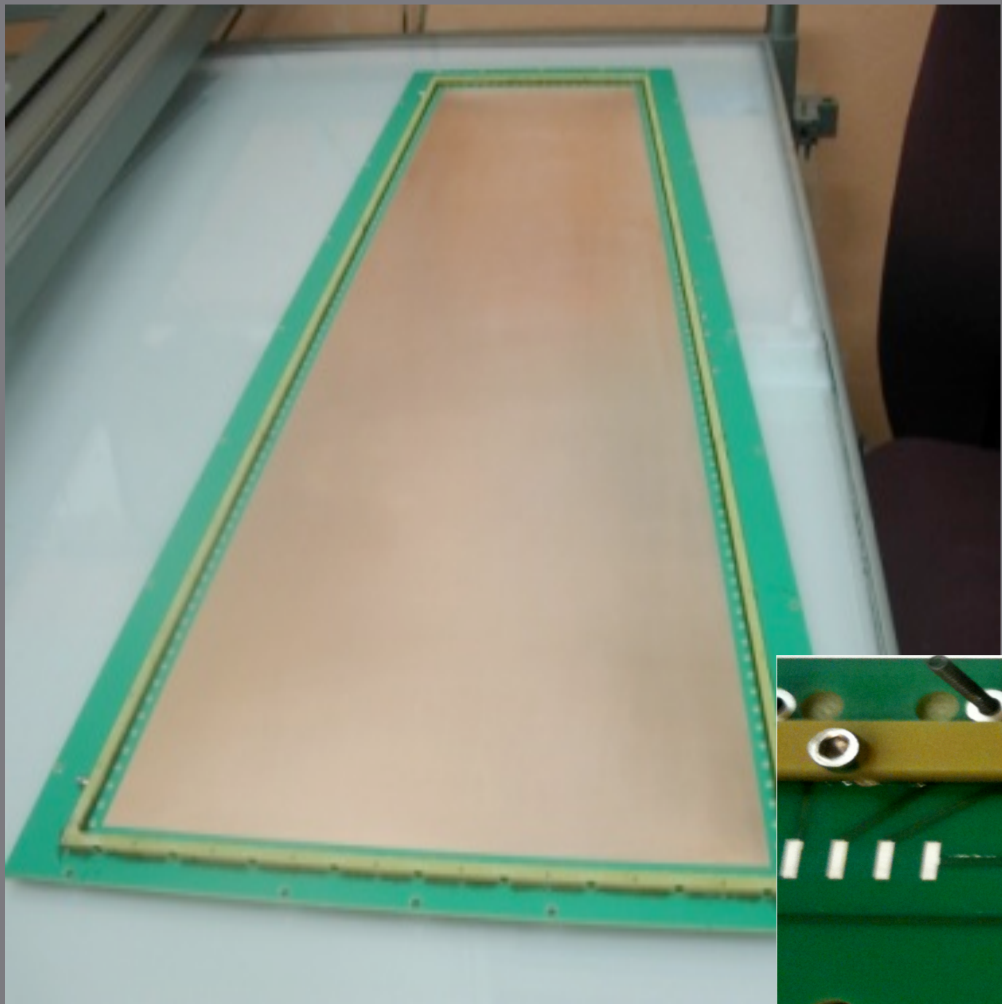


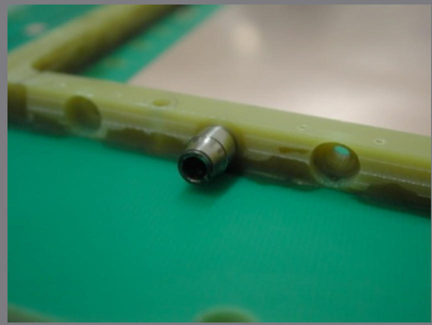
Resistor are directly soldered
On the GEM before final clean

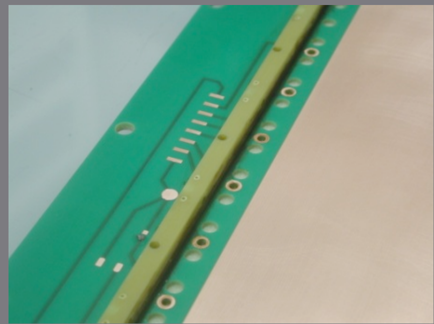


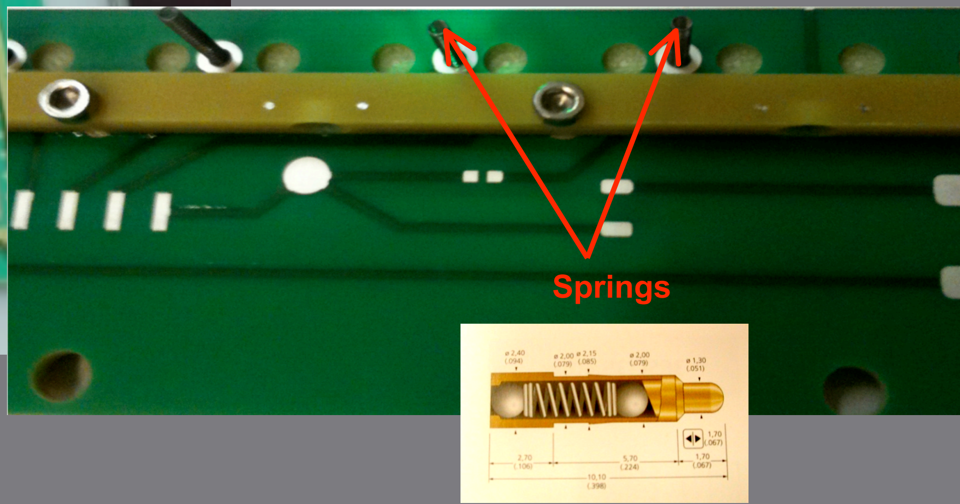


Drift board

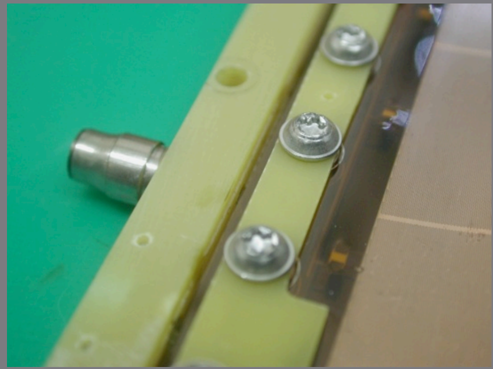


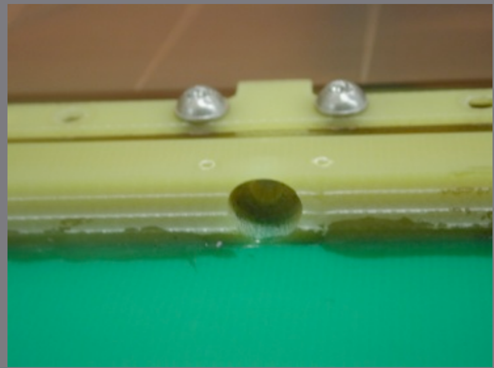




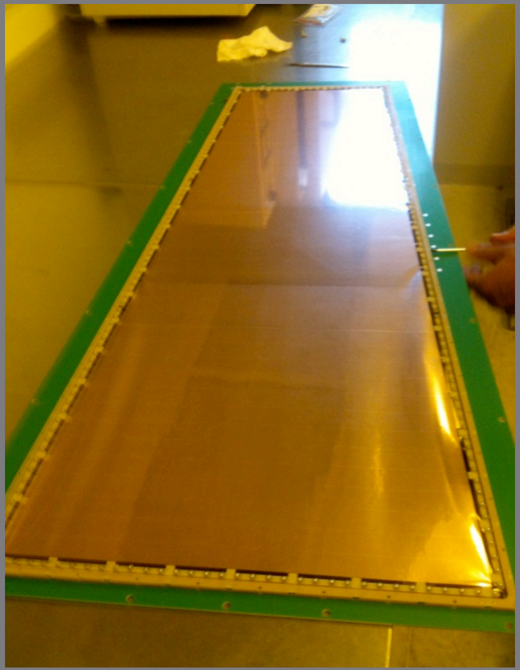


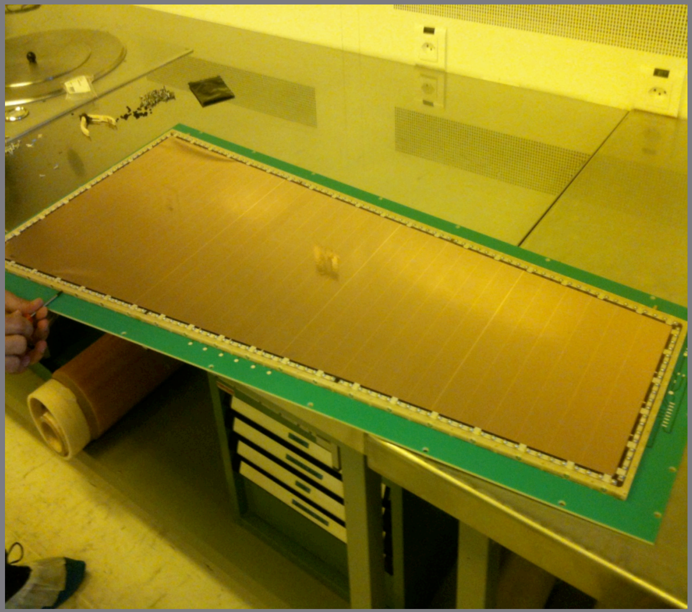
Gem stack introduction





Stretch



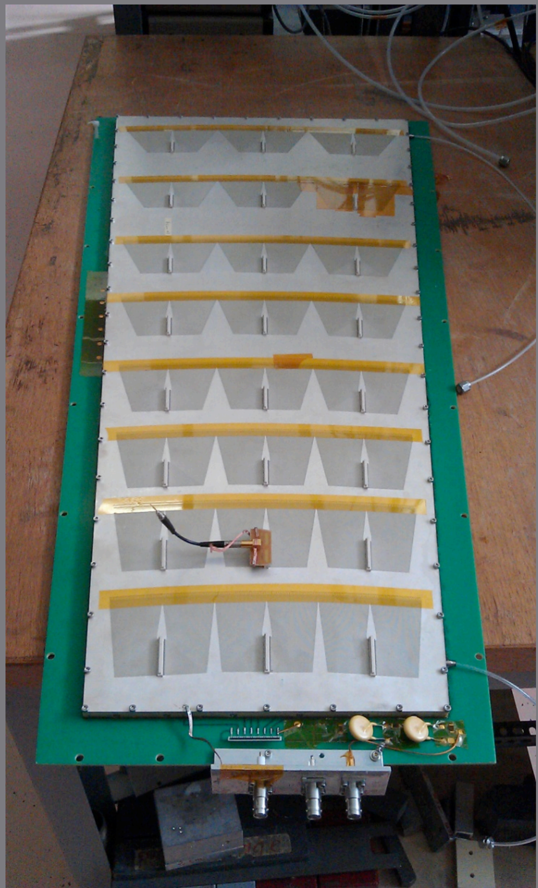


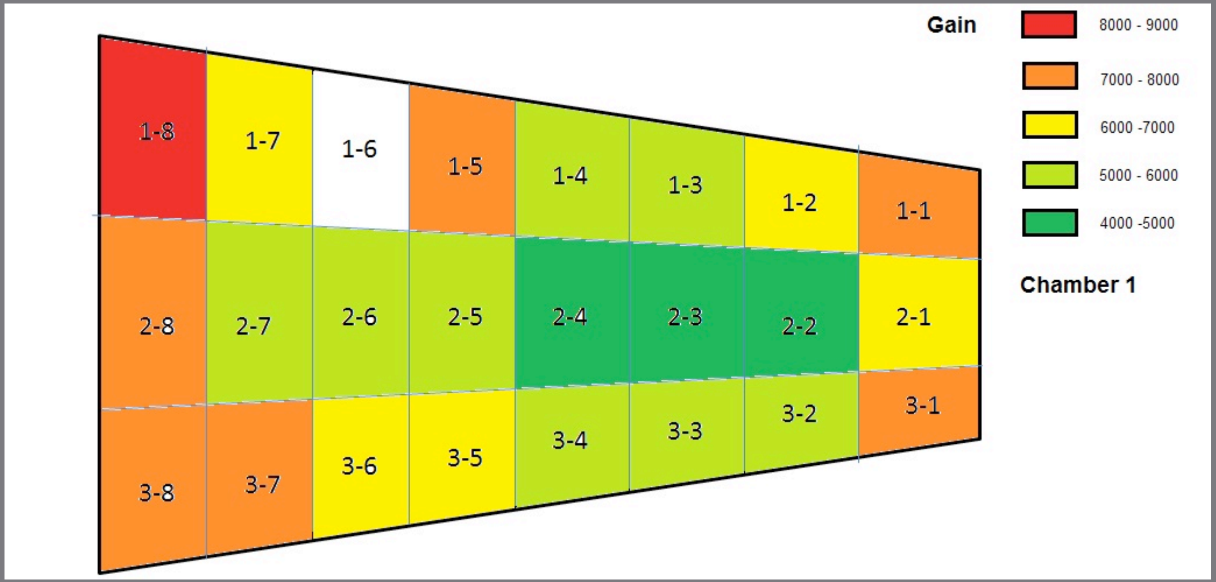
Visual stretching + Voltage breakdown measurement between GEMs

Cleaning

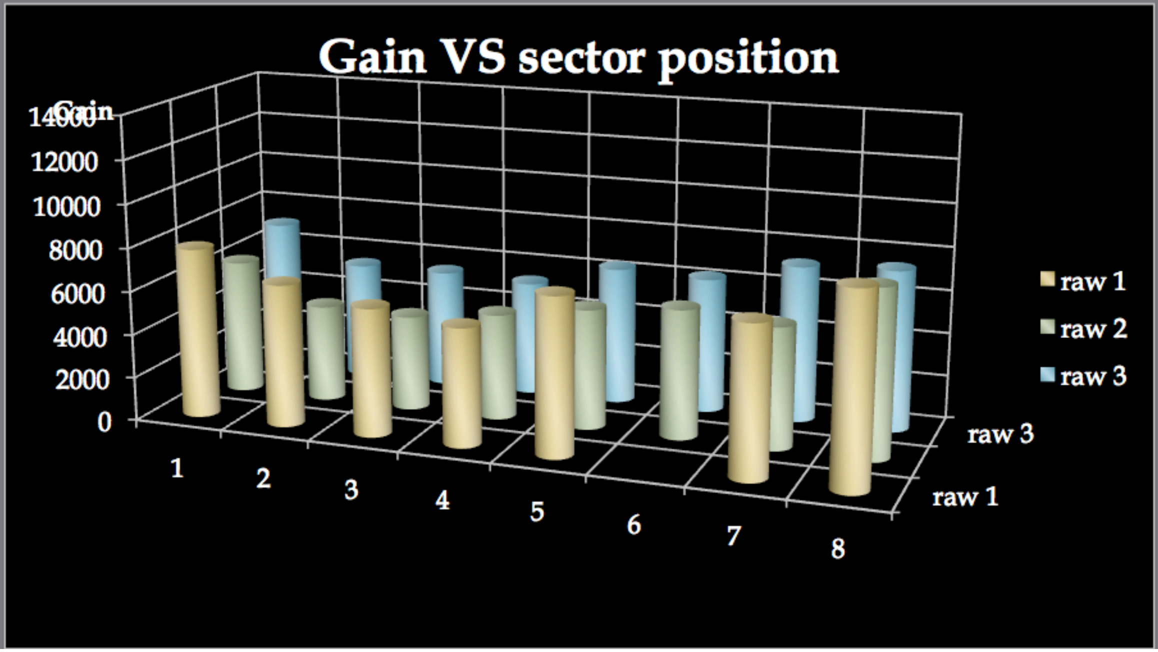
Cleaning if necessary

Closing with read-out





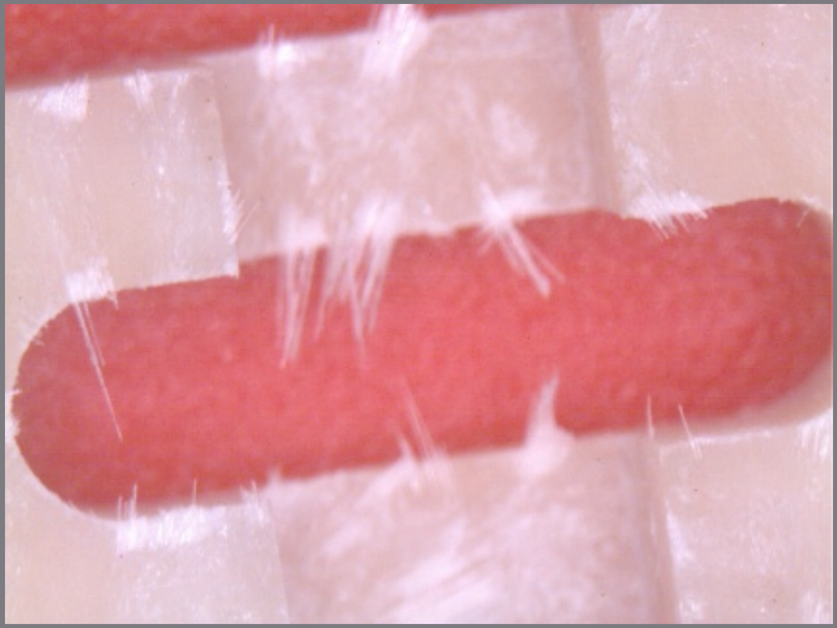
Gain
8000 - 9000
7000 - 8000
6000 -7000
5000 - 6000
4000 -5000
Chamber 1
1-8
1-7
1-6
1-5
1-4
1-3
1-2
1-1
2-8
2-7
2-6
2-5
2-4
2-3
2-2
2-1
3-8
3-7
3-6
3-5
3-4
3-3
3-2
3-1



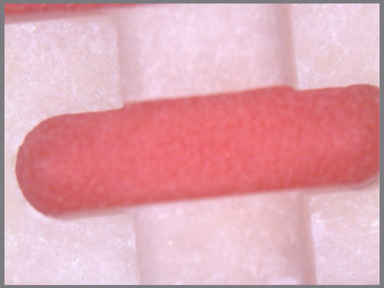
Gain VS sector position
Gain
14000
12000
10000
8000
6000
4000
2000
0
1
2
3
4
5
6
7
8
raw 1
raw 3
raw 1
raw 2
raw 3

Dust problem

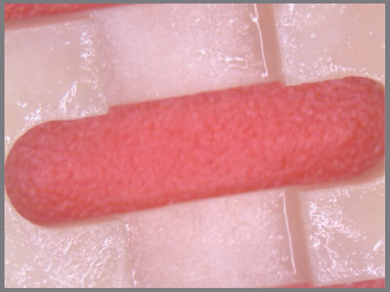
Frame after machining



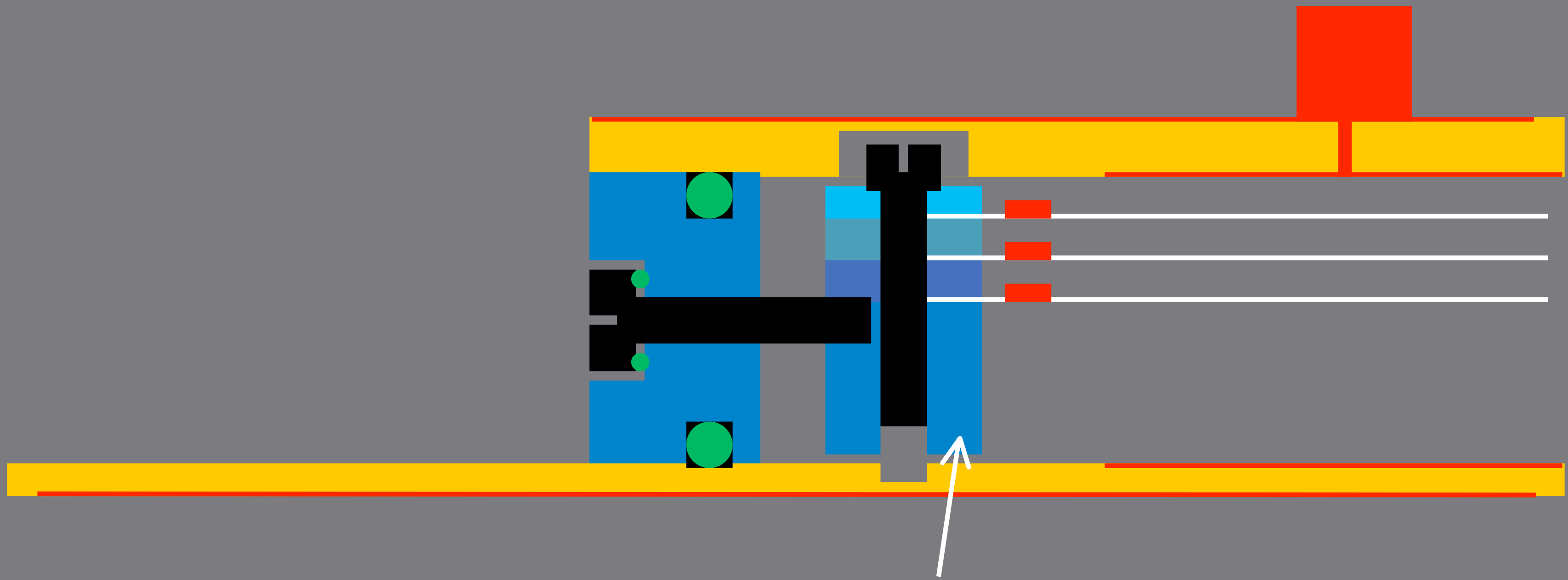
After sand blast



After PU coating



Dust problem



A lot of dust was released during the screwing in FR4 frame
We have replaced FR4 by PEEK

PEEK is one of the best polymer in tern of:
- radiation tolerance
- mechanical properties
- out gassing
- chemical resistance

Improvements for the next production:

- Outer Frame in one piece and screwed , the gluing needs too much care and time..

- Inner spacer in 4 pieces not 8 (even if they are longer).

- Replace the springs for GEM connection

- Modify the play in the fixing holes of the read-out board to avoid any stress in order to keep it flat. (the 2 last detectors are already modified in this way).

NS2 detector advantages:

- No dead zone in active area
- Assembly time
  - ½ hour for 10cm x 10cm detector (1 technician)
  - 2 hours for 1m x 0.6m detector (1 technician)
- No gluing , no soldering (still 1 gluing to be removed)
- Re opening possible
- GEM exchange possible→ tested OK
- Full detector Re-cleaning possible → tested OK
- No intermediate test needed
  - final test :High voltage test of GEMs and between GEMs
  - → send for calibration and endurance tests
- Upgradable.
  - The read-out board can be upgraded at any time
  - Production can start before final electronic design

Thank you