

"TOWARDS BUILDING A MICRO PATTERN GAS DETECTOR (MPGD)"

B. MEHL, CERN EP-DT-EF

EXPERIMENTAL PHYSICS (EP) - DETECTOR TECHNOLOGY (DT) –
ENGINEERING FACILITIES (EF)

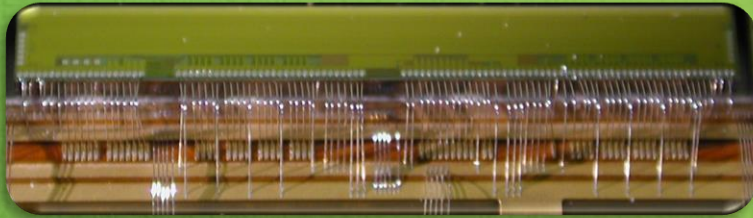


"TOWARDS BUILDING A MICRO PATTERN GAS DETECTOR (MPGD)"

- MICRO PATTERN LAB AT CERN
- MOST COMMON MPGD DETECTORS
 - WHAT IS NEW IN RECENT YEARS

MICRO-PATTERN LAB AT CERN

Triple levels of bonding on multilayer aluminium bus

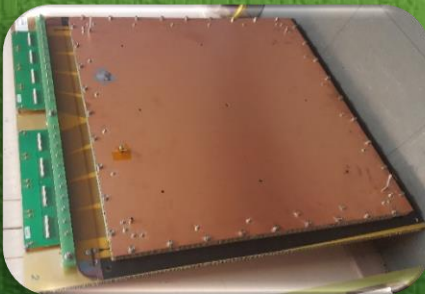


1.40m pcb coil to measure magnetic field



Embedded chip in low-mass aluminium flex

- PCB 30%
- MPGD 60%
- C-milling 5%
- Low-mass 4%
- embedded 1%



500x500 Micromegas KIT
(Atlas NSW type)



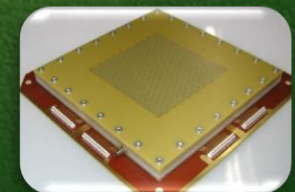
Large gem readout



Field cage



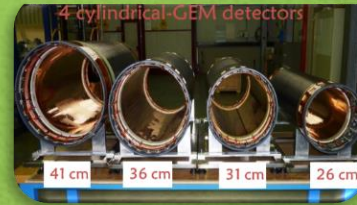
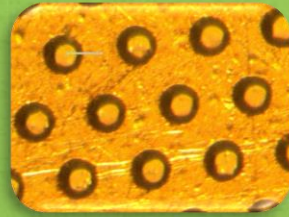
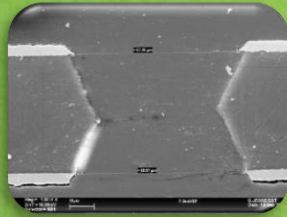
Long flex mixed
Copper & stainless steel



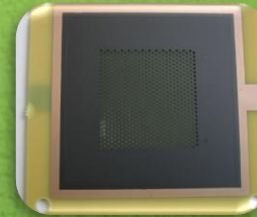
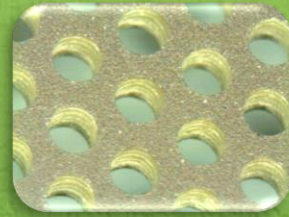
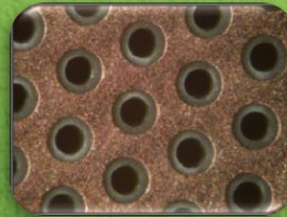
100x100 Study MGPD Kit

MOST COMMON MPGD DETECTORS BASED ON PRINTED CIRCUIT BOARD TECHNOLOGY

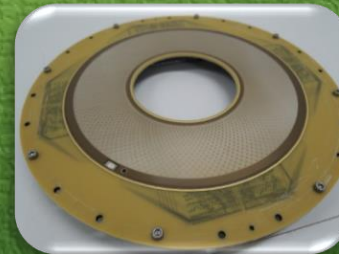
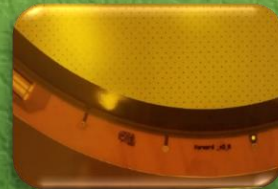
GEM



THGEM



MICROMEAS

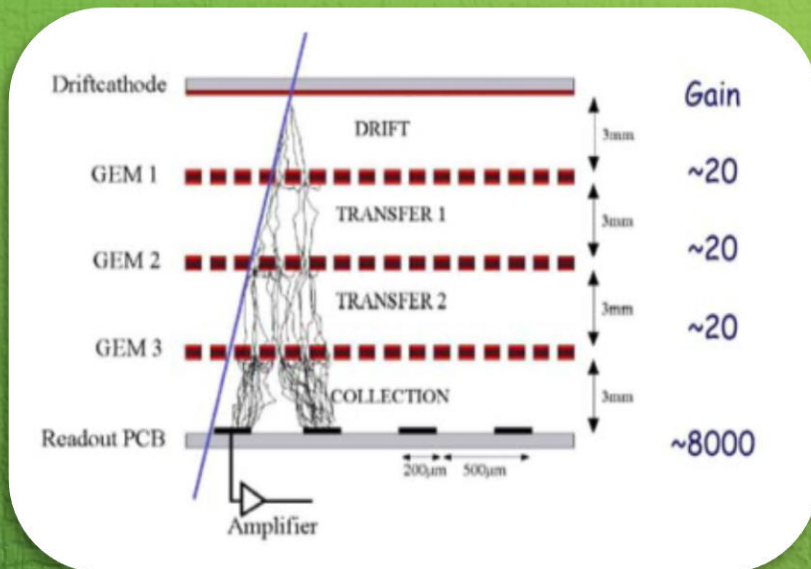


Used At CERN
for High
Energy
Physics

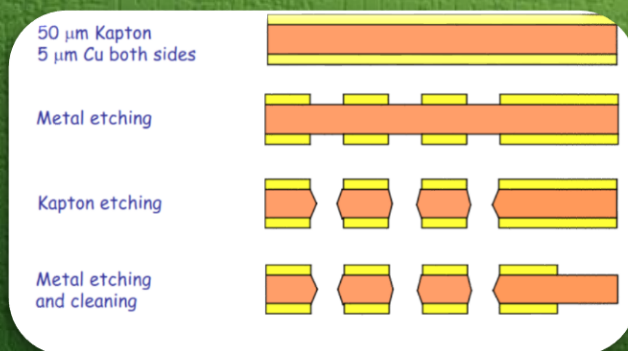
Used for Nuclear
Physics

MOST COMMON MPGD DETECTORS BASED ON PRINTED CIRCUIT BOARD TECHNOLOGY

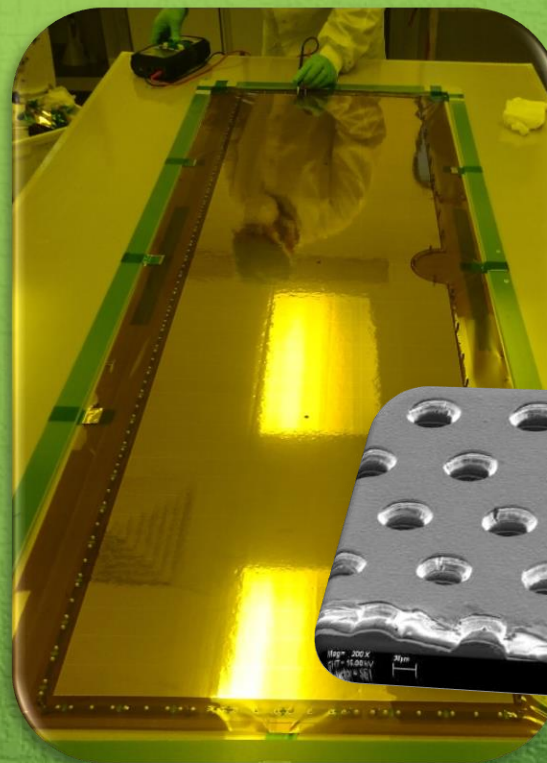
• Quick view of Gem



Global operating scheme



Production process



1.80m GEM for BM@N dubna

Thin polyimide layer with copper on both sides.
Holes Chemically etched.
Large production is now possible for reasonable cost.
Up to 550mm x 1800mm



Aluminium GEM in R&D process



ALICE mass production

MOST COMMON MPGD DETECTORS BASED ON PRINTED CIRCUIT BOARD TECHNOLOGY

• Quick view of THGEM

- Production possible with different values :
Thickness, pitch, holes sizes...
- different substrates and conductive layers :
FR4, Kapton, Plexiglas, Aluminium...
- mixed with standard pcb technology :
plated holes, multilayers, flex rigid...

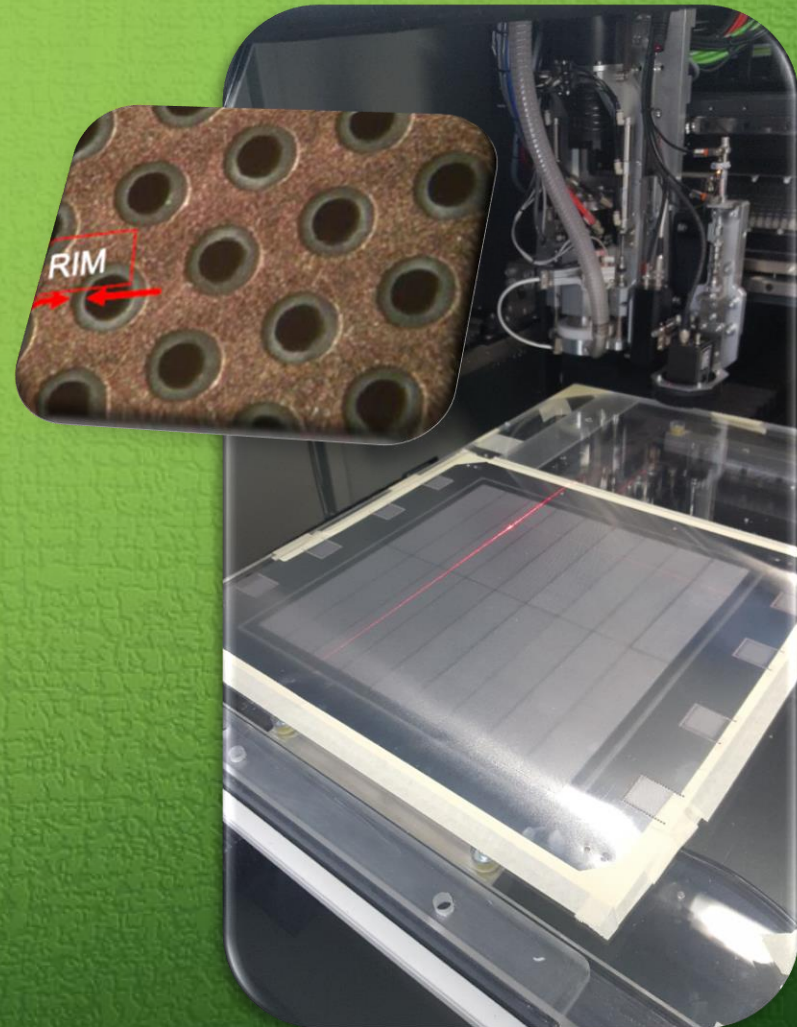
Thick substrate layer with copper
on both sides.
Holes mechanically drilled.

Anisotropic material compatible.

Production can be compatible
with standard pcb factory.



Thgem in cleaning step
LEM-TPC



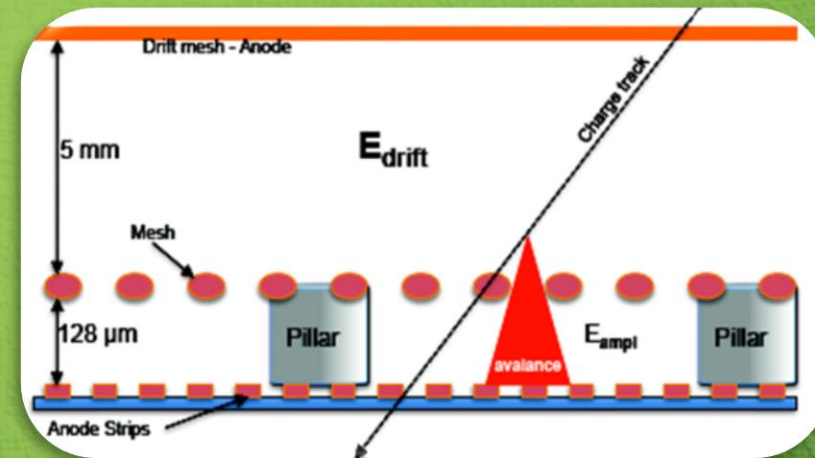
Thgem in drilling machine

MOST COMMON MPGD DETECTORS BASED ON PRINTED CIRCUIT BOARD TECHNOLOGY

- **Micromegas detectors :**

Composed by 3 electrical elements :

- One Drift electrode
- One metallic Mesh for amplification stage
- One Anode Electrode



Global operating scheme

HT1

$$E \approx 0.6 \text{ kV/cm}$$

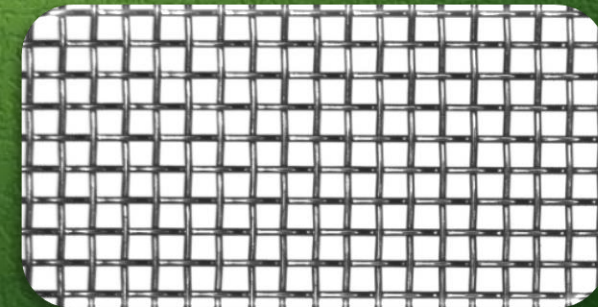
HT2

$$E \approx 42 \text{ kV/cm}$$

Then amplification takes place in a fine gap that can be controlled by polyimide pillars.

Many configurations are possible.

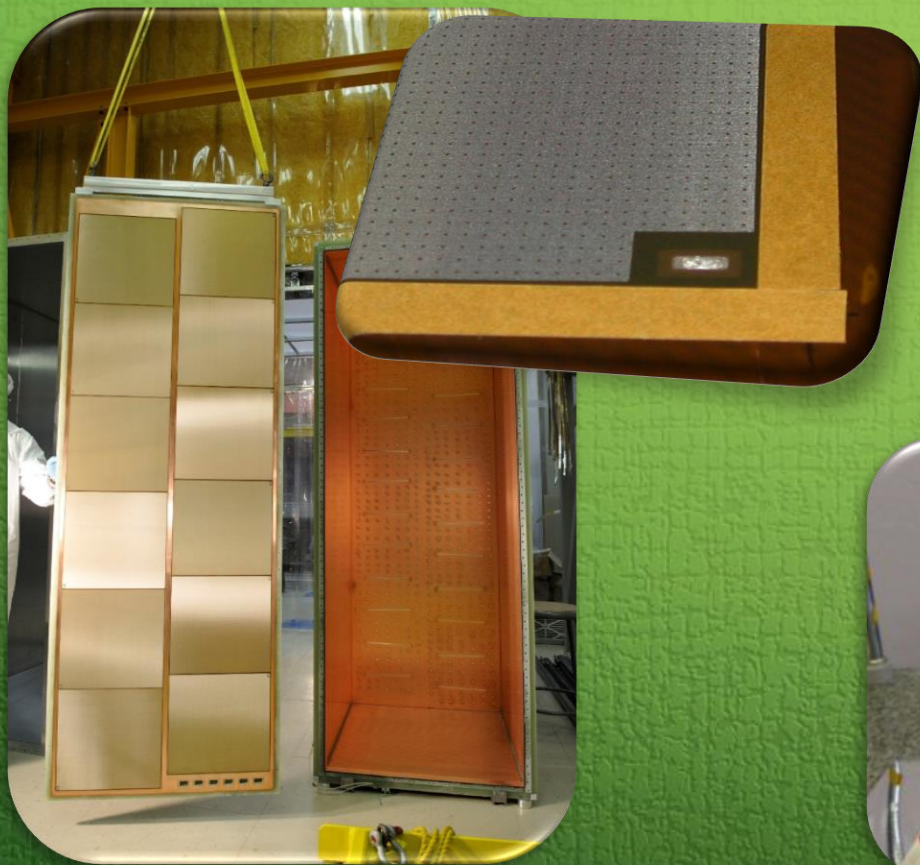
It can be also combined with Gem or Thgem.



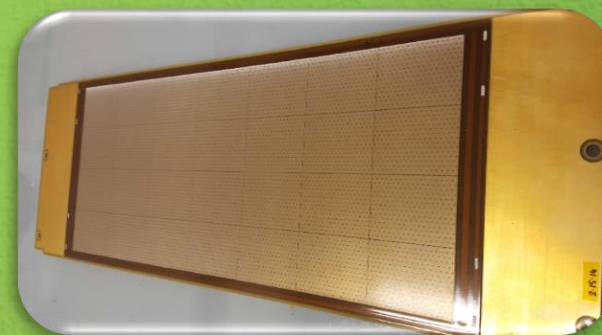
Example of meshes

MOST COMMON MPGD DETECTORS BASED ON PRINTED CIRCUIT BOARD TECHNOLOGY

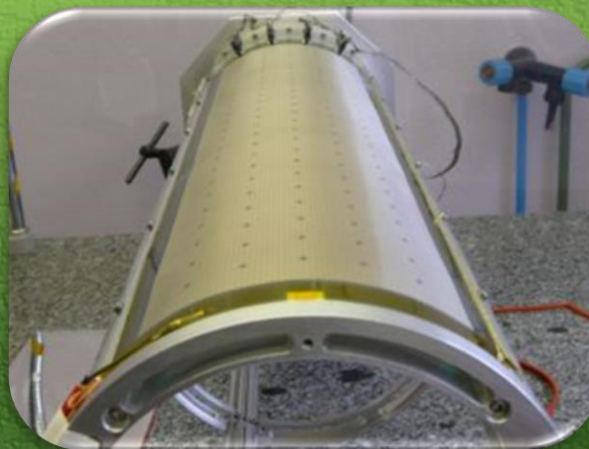
- Micromegas bulk “classical”



T2K Inner readout plane
(360x360 module)



Spectrometer



Jlab-Class12 (CEA/Irfu)



SLHC/ATLAS μ ch. (MAMMA)

MOST COMMON MPGD DETECTORS BASED ON PRINTED CIRCUIT BOARD TECHNOLOGY

- μ Bulk

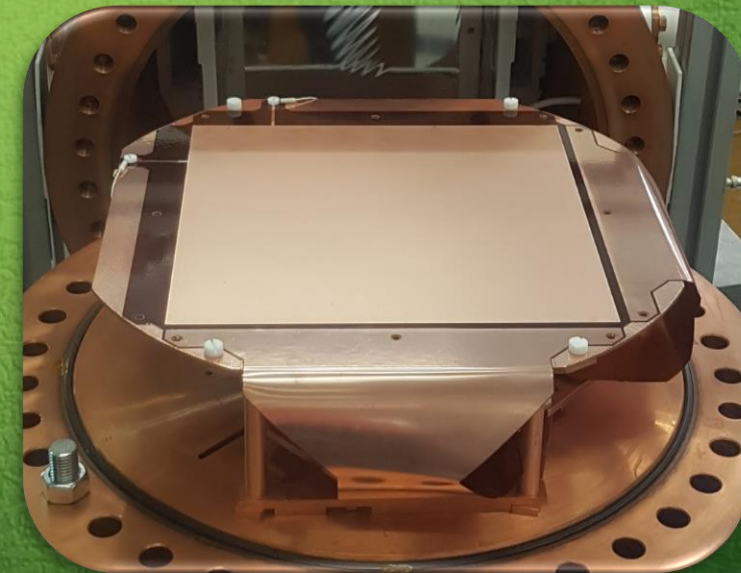
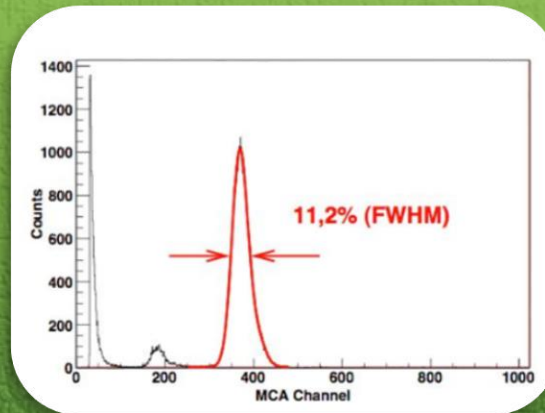
Holes are usually $30\mu\text{m}$ to $60\mu\text{m}$

With $50\mu\text{m}$ of kapton (the gap between HV and Anode) and holes like gems (140/70), The biggest Readout produced is $250\text{mm} \times 250\text{mm}$

The μ Bulk has the best energy resolution of the MPGD.

11.2% FWHM
(full width at half maximum)

But limited in size to 300×300



TREX-DM readouts
Rare Event Experiments @ UNIZAR

MOST COMMON MPGD DETECTORS BASED ON PRINTED CIRCUIT BOARD TECHNOLOGY

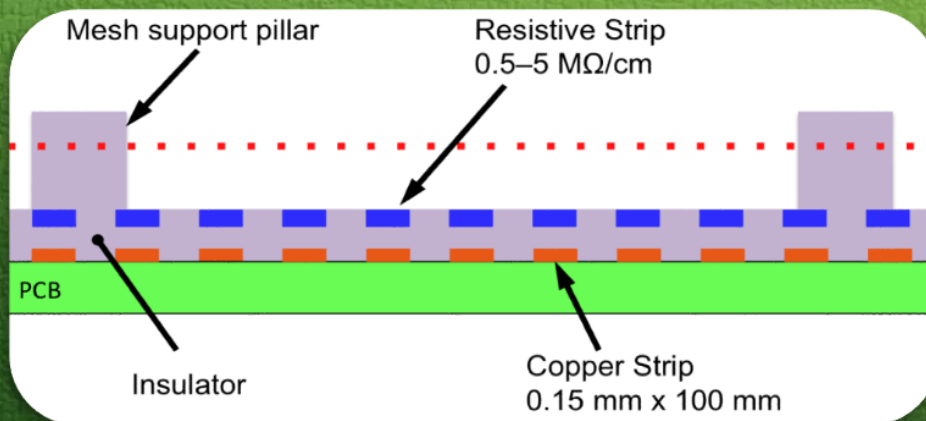
- Resistive micromegas

A resistive layer is added on top of the anode layer. This protects the electronics from sparks.

The anode layer is read in capacitive mode.

Works with multi-directions strips or pads

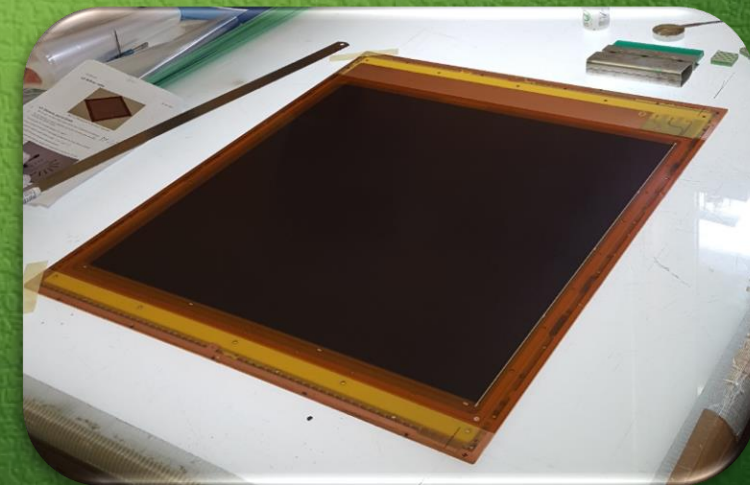
Many kind of resistive layers & structures...



Global operating scheme



First Micromegas module 1 m x 2 m



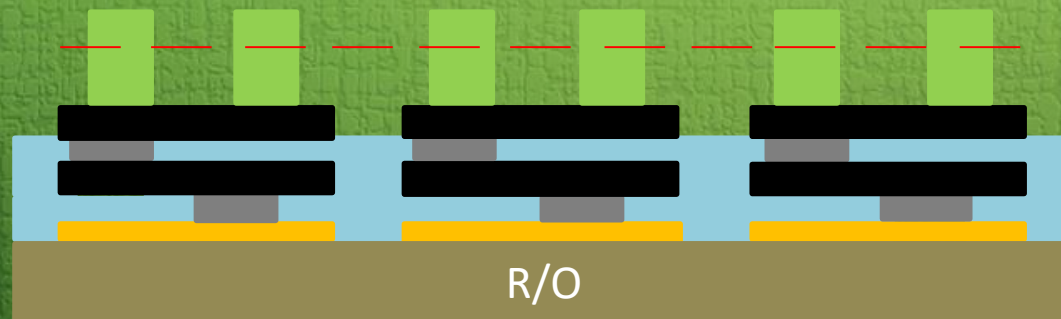
Production of MultiGen 2D (M-cube) / CEA
used in the scanPyramids project (Cheops discovery)

MOST COMMON MPGD DETECTORS BASED ON PRINTED CIRCUIT BOARD TECHNOLOGY

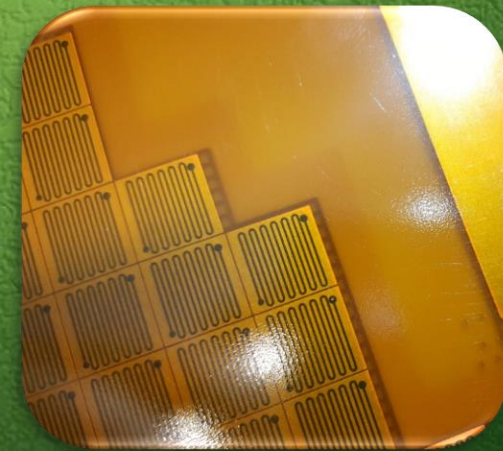
- **Embedded Resistive micromega**

A resistive layer is added between the top of the anode layer and the bulk.

This protects the electronics from sparks and can reach a higher readout rate than classical resistive structure.



Sample of pattern

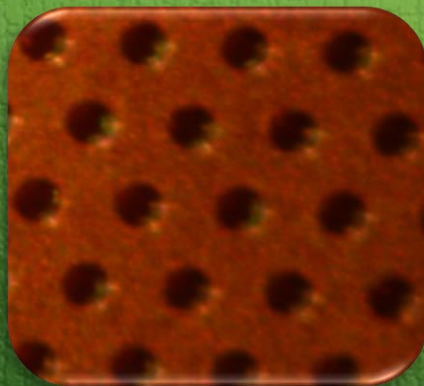


Sample of pattern

MOST COMMON MPGD DETECTORS BASED ON PRINTED CIRCUIT BOARD TECHNOLOGY

- μ Rwell

Mixed between gem and resistive bulk.



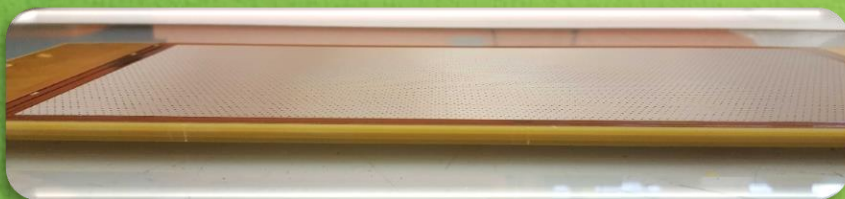
Microscope picture of μ Rwell



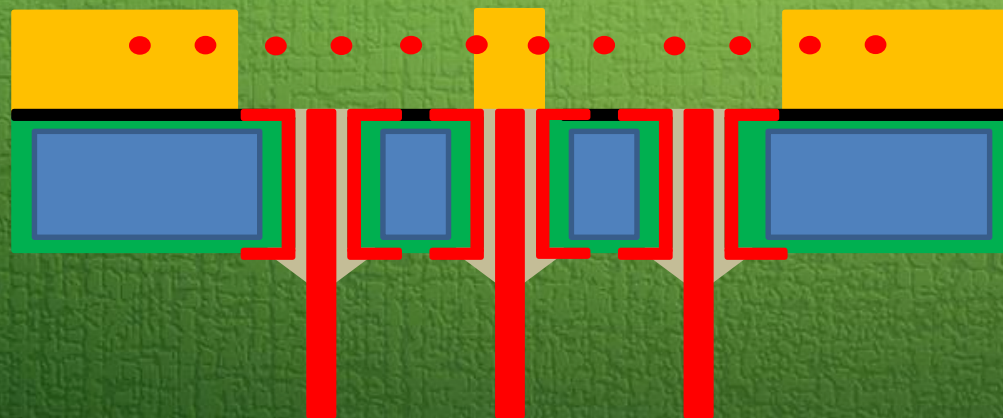
CMS GE21 large Module

WHAT'S NEW IN RECENT YEARS

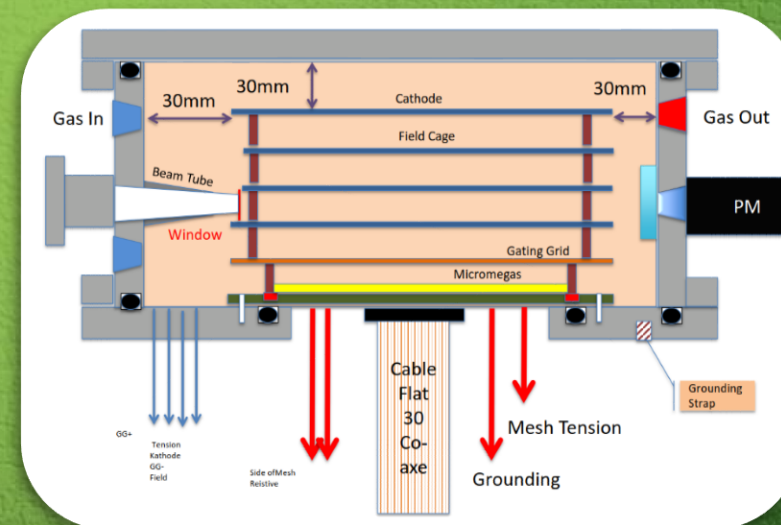
- Thick PCB readout (with mechanical insert, Airtight ...)



5 mm thick FR4 core
(Epoxy-Fiberglass)



ACTAR sectional scheme



ASTROBOX-II

PRODUCTION OF THICK DETECTOR :
can be used as empty chamber wall

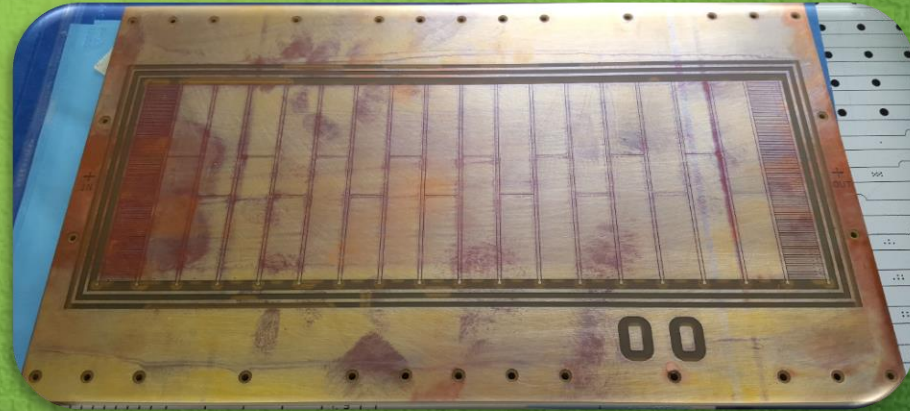
Possible with EPOXY or metallic core like
Aluminium, Stainless steel or copper.

WHAT'S NEW IN RECENT YEARS

- Pad Geometry optimized and multilayers structure with shielding to avoid X-talk

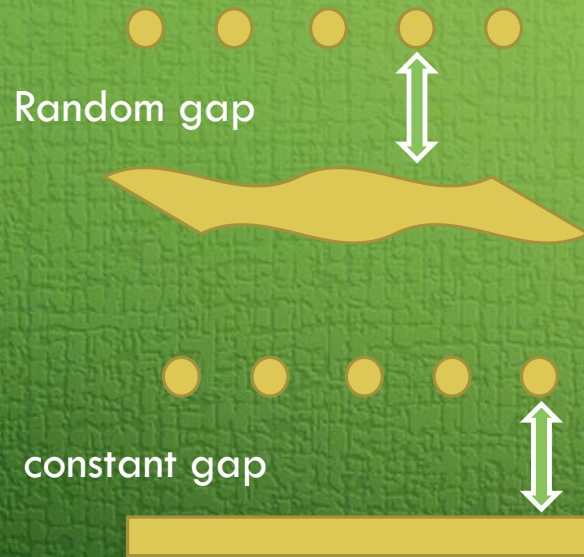


ZITIX Readout sample

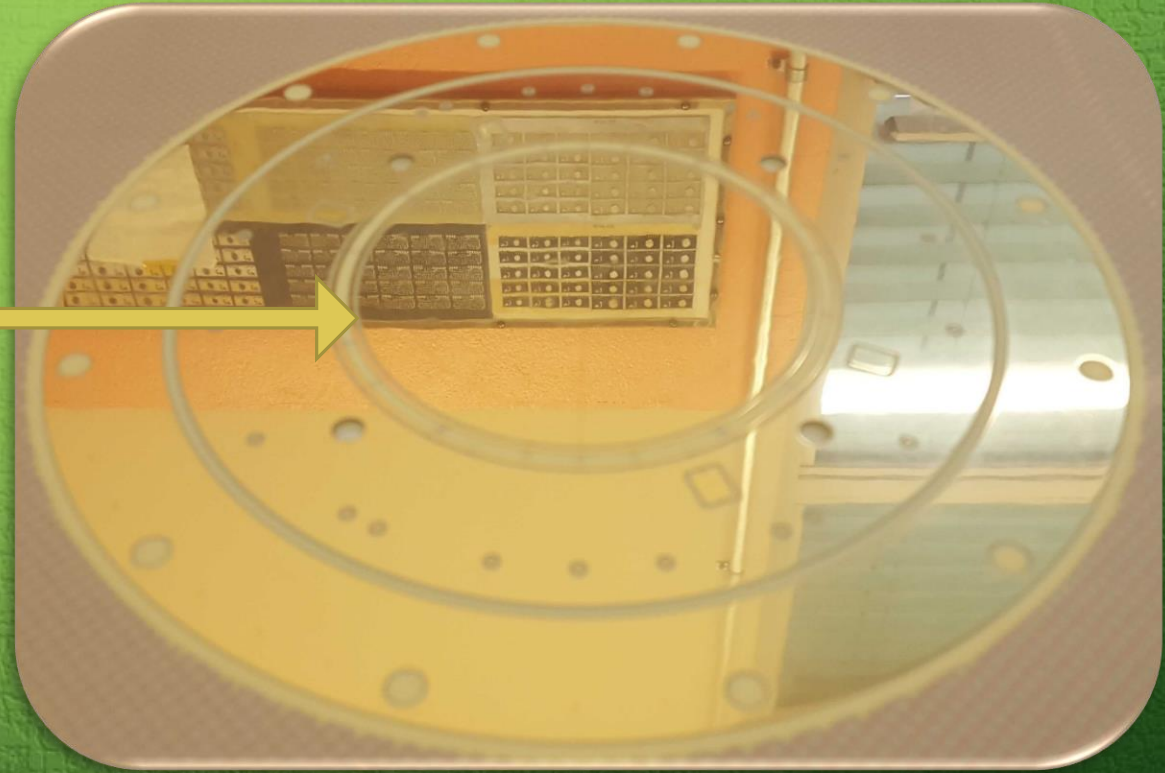


WHAT'S NEW IN RECENT YEARS

- Surface roughness optimization :
 - Pads Mirror polishing



Mirror finish



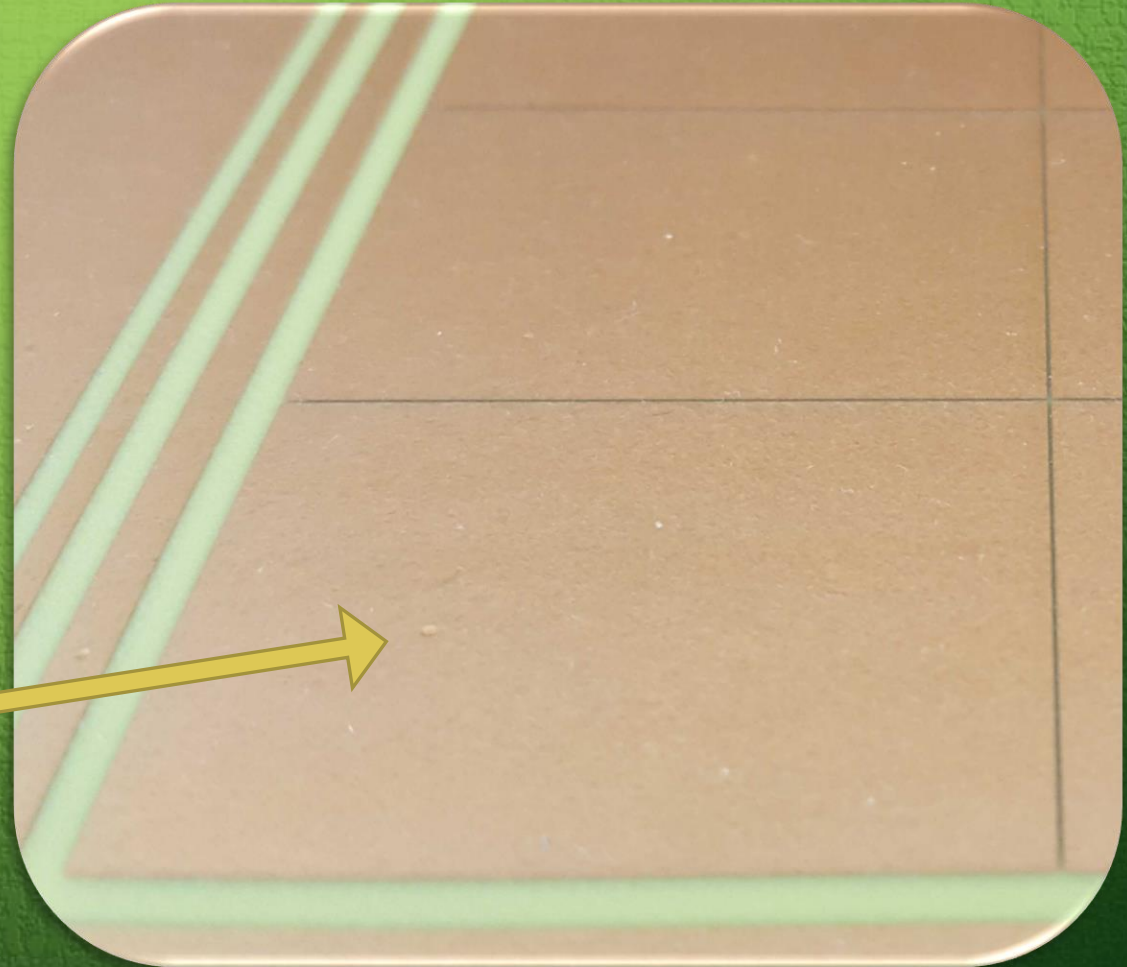
ASTROGAMMA

WHAT'S NEW IN RECENT YEARS

- Surface roughness optimization :
 - Vias filling



FILLED VIAS IN PADS

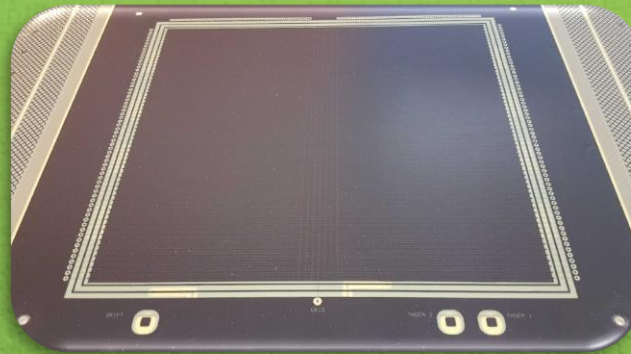


WHAT'S NEW IN RECENT YEARS

- Surface roughness optimization :
 - Inter-pads gap filling

1st step :

Pressing a Prepreg layer of epoxy on Top of pads.



2nd step :

Polishing the resin until the copper is exposed.



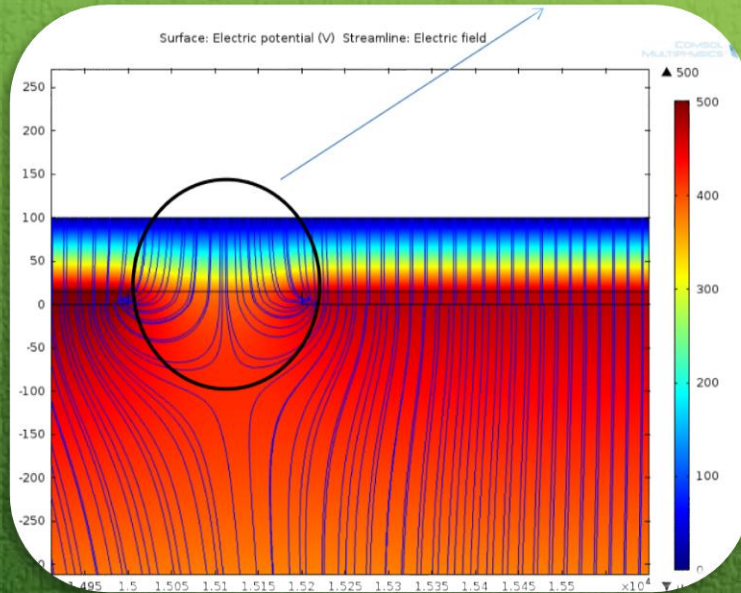
TEXAT-P after gold plating

WHAT'S NEW IN RECENT YEARS

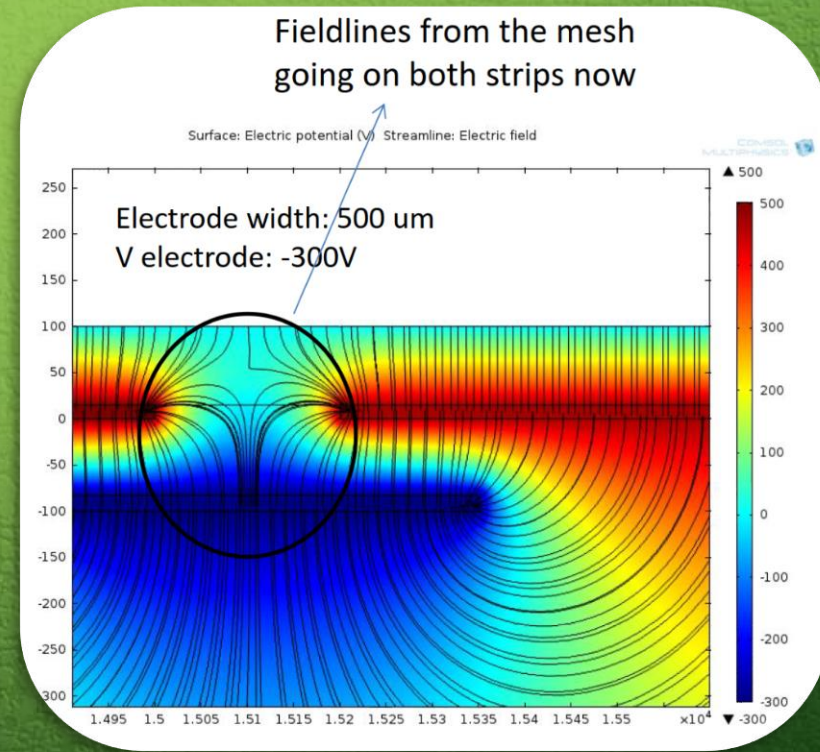
- Embedded Electrodes

To allow the customer to tune the field lines.

Need more results in practice...



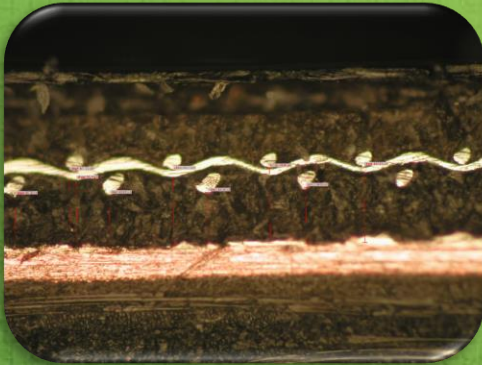
Without field correction



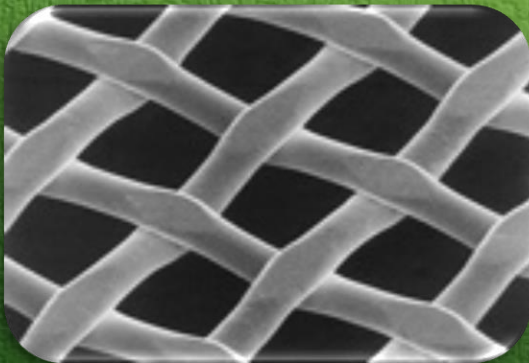
Embedded field correction electrode

WHAT'S NEW IN RECENT YEARS

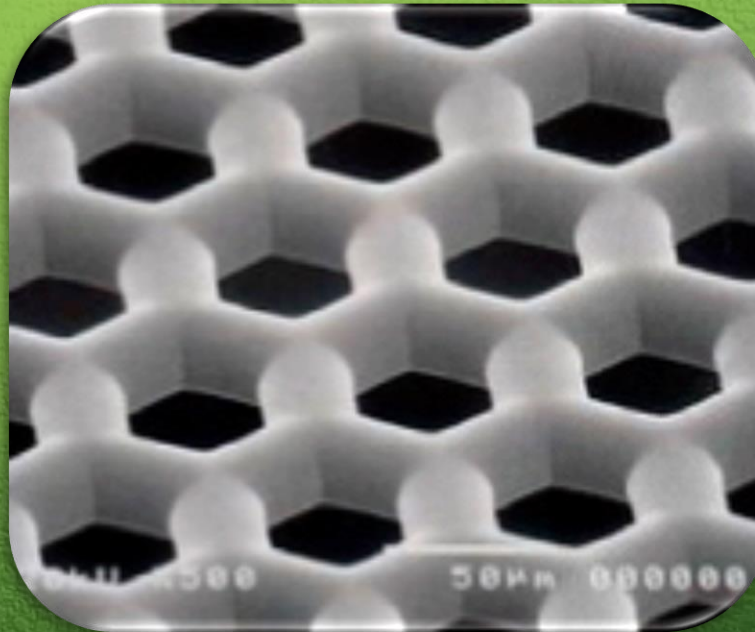
- New Kind of mesh : β mesh
 - Electro deposited mesh instead of woven mesh



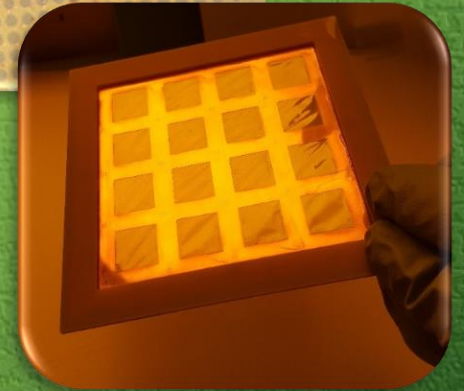
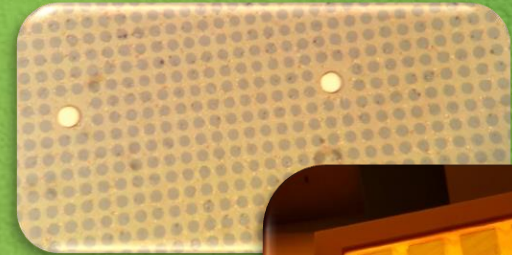
Sectional view of Classical mesh 45/18



Calendered mesh 45/18



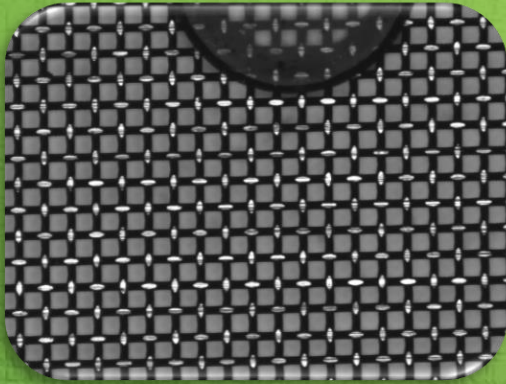
Electroformed mesh
(Limited in size)



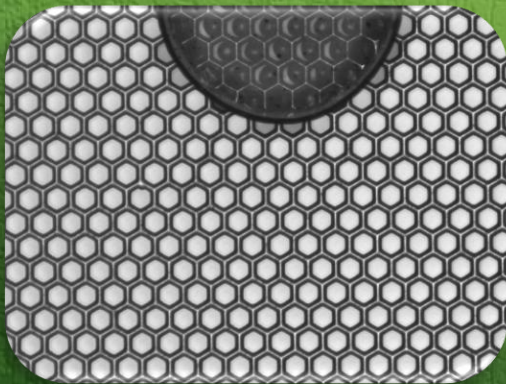
Etched mesh
5 μ m of copper with pillars

WHAT'S NEW IN RECENT YEARS

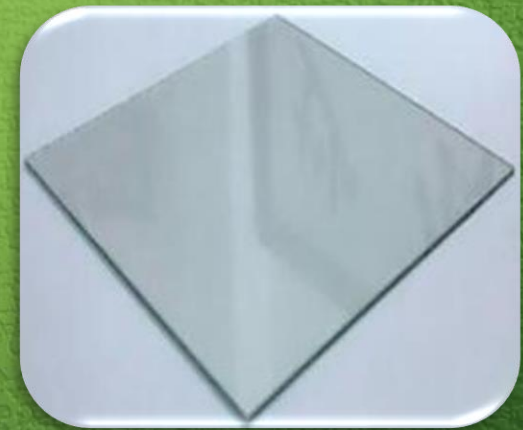
- Transparent Micromegas



Transparent Micromegas with
classical mesh



Transparent Micromegas with
 β mesh



Indium tin oxide (ITO)
or chromium electrodes

"TOWARDS BUILDING A MICRO PATTERN GAS DETECTOR (MPGD)"

- UPCOMING DEVELOPMENTS

some ways that can be explored to improve the detectors :

- Polyimide substrate for anode layer
- Ceramic or Glass substrate
- Rigid field cage
- Embedded resistor with Surface roughness optimization

TO SUMMERISE:

- Thick PCB readout (with mechanical insert, Airtight ...)
- Pads Geometry optimized and multilayers structure with shielding plane to avoid X-talk
- Surface roughness optimization :
 - Pads Mirror polishing
 - Vias filling
 - Inter-pads gap filling
- New Kind of mesh : β mesh
 - Electro deposited mesh instead of woven mesh
- Transparent Micromegas
- Embedded Electrodes
- Resistive Kapton, Embedded resistors, DLC...



SPARE SLIDES

MICRO-PATTERN LAB AT CERN

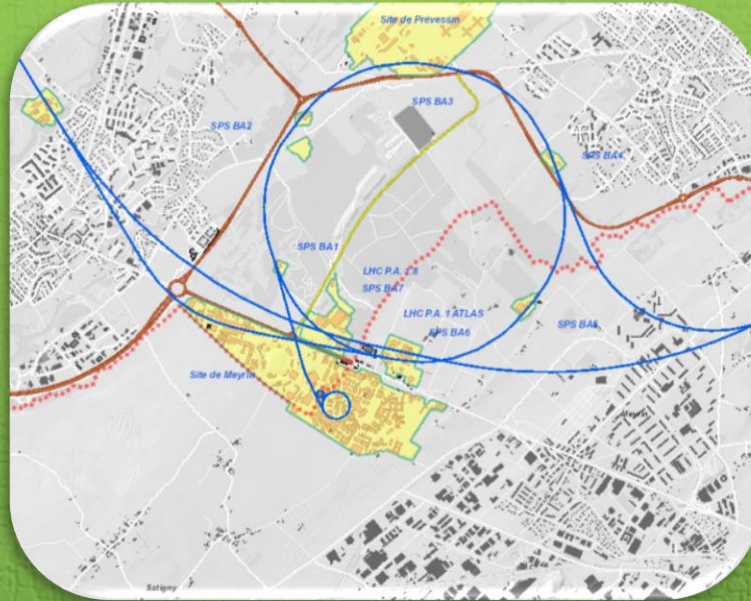
WHERE WE ARE ?

Department :
Experimental Physics (EP)
Group:
Detector Technologies (DT)
Section :
Engineering Facilities (EF)

At building 102 since 1965

The workshop will move to the new Building
107 current of this year !

At building 102 since 1965



The workshop will move to the new Building 107 current of this year !

THE TEAM

- Rui DE OLIVEIRA
- Antonio TEIXEIRA
- Olivier PIZZIRUSSO
- Alexis RODRIGUES
- David RANCHIN
- Serge FERRY
- Bertrand MEHL
- Alexandra GRIS
- Simon WILLIAMS
- Roch

9 CERN STAFF EXPERT

Lab Supervisor

μRwell, Ceramics, Staff management

Micromegas

GEM, GEM team management

Low Mass.

PVD

Design, CAM, std production management

Chemist (Maternity leave)

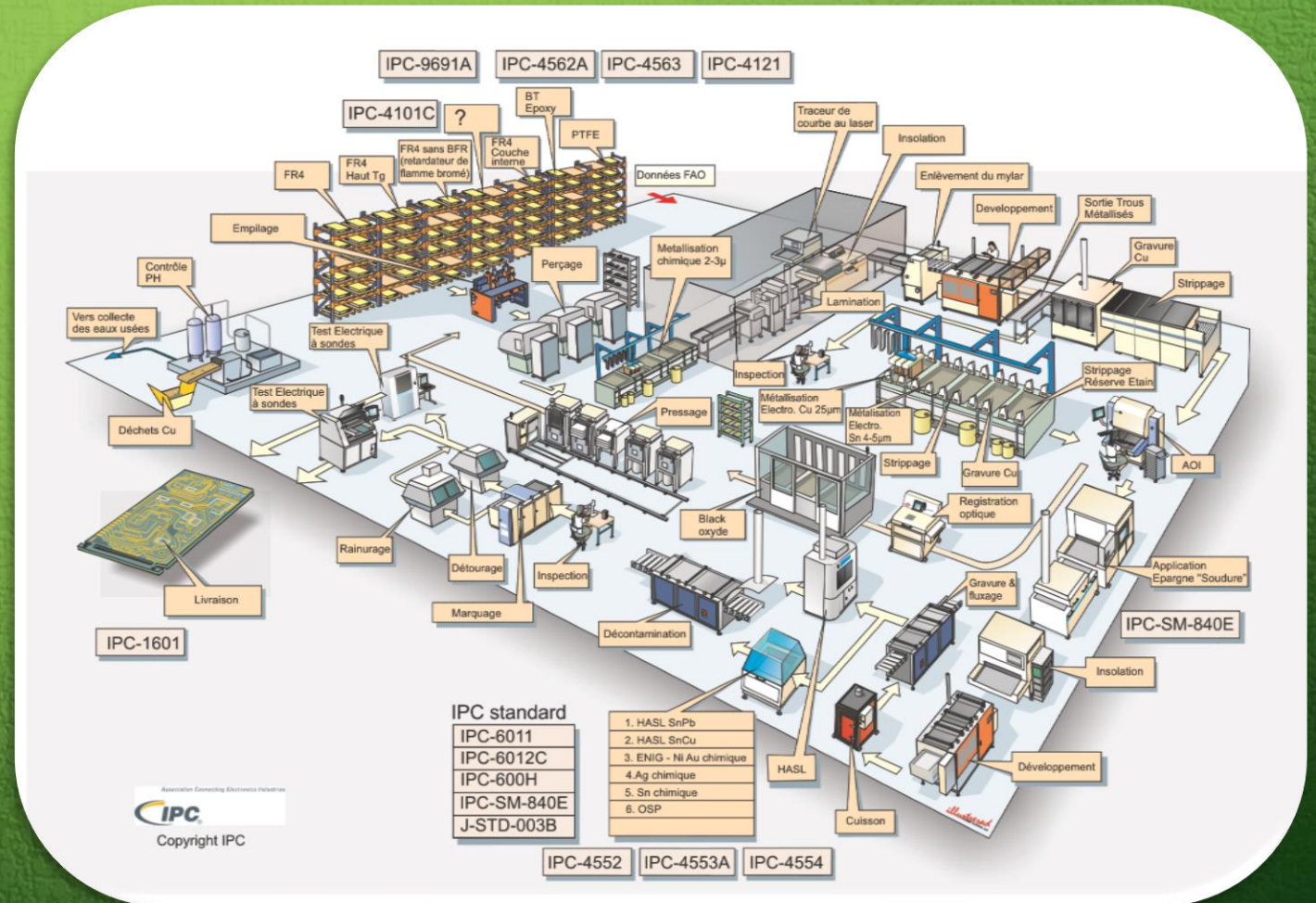
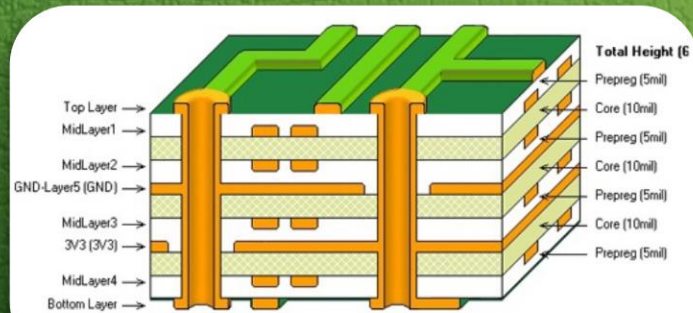
Electronics (in training)

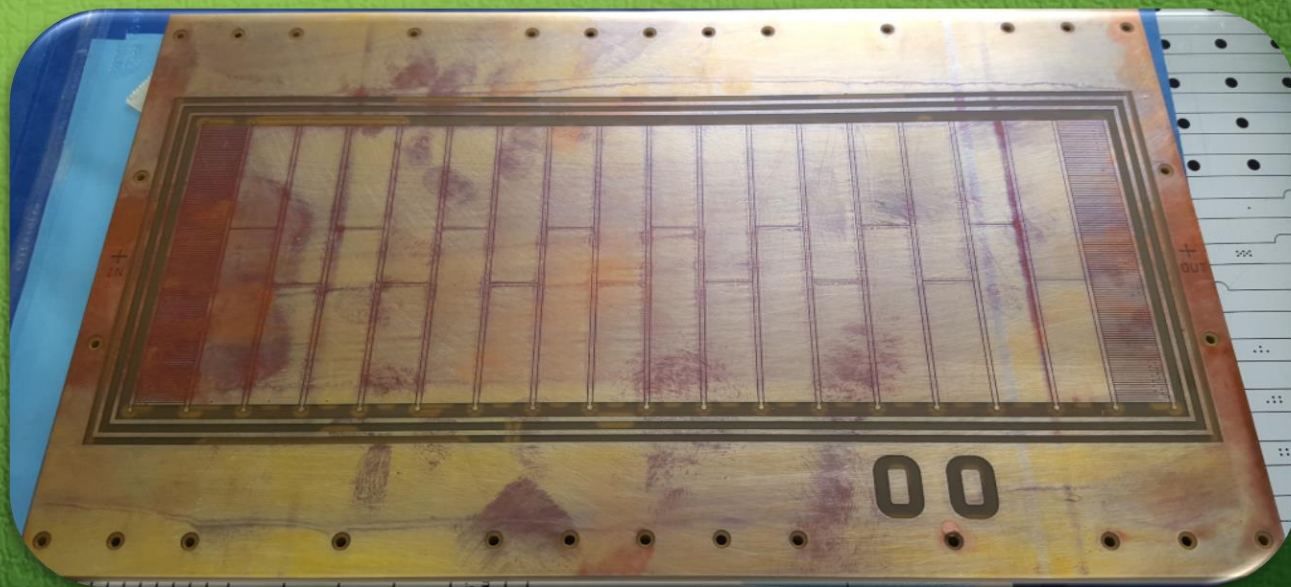
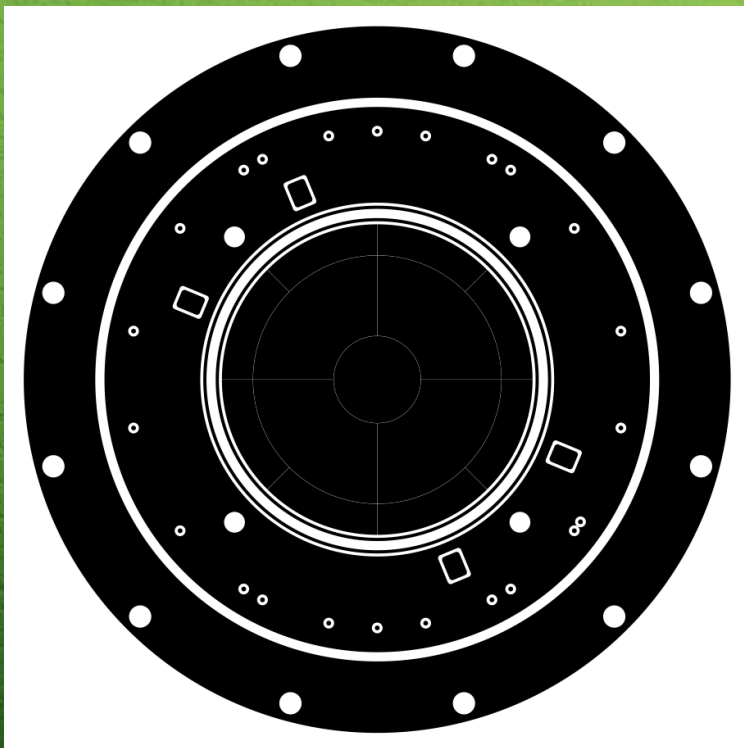
Chemist (in training)

to contact us : <https://phonebook.cern.ch/>

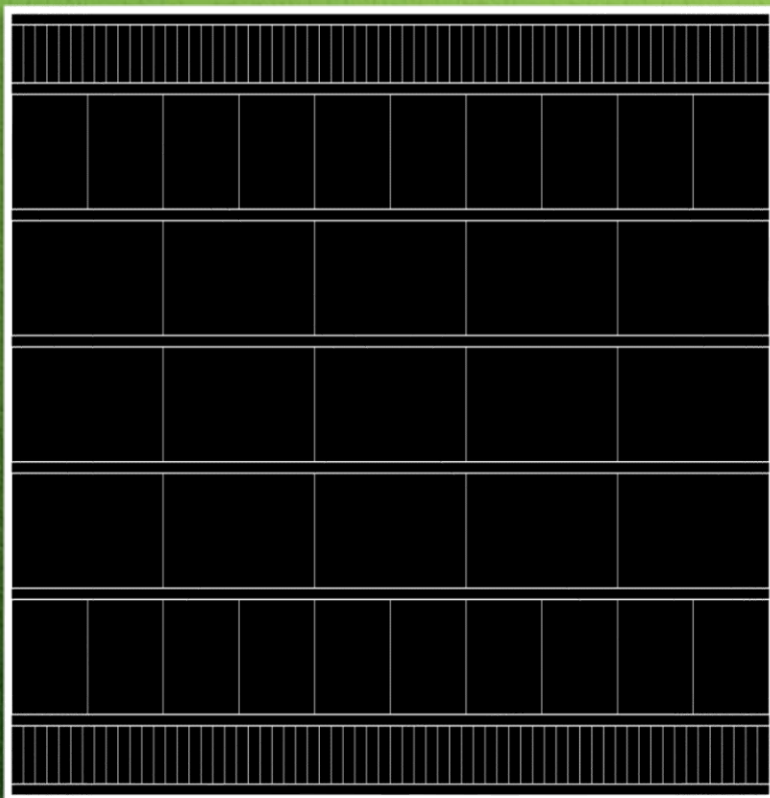
MICRO-PATTERN LAB AT CERN

PCB PRODUCTION (SPARE)





WHAT IS NEW SINCE THE LAST YEARS

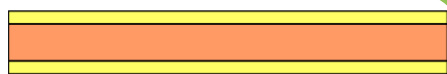


Field cage for AstroGamma

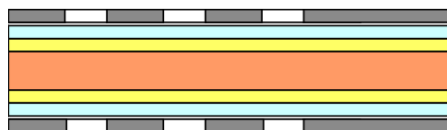
MOST COMMON MPGD DETECTORS BASED ON PRINTED CIRCUIT BOARD TECHNOLOGY

- Gem (spares)

50 μm Kapton
5 μm Cu both sides



Photoresist coating,
masking and exposure
to UV light



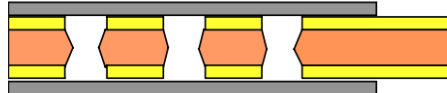
Metal etching



Kapton etching



Second masking



Metal etching
and cleaning

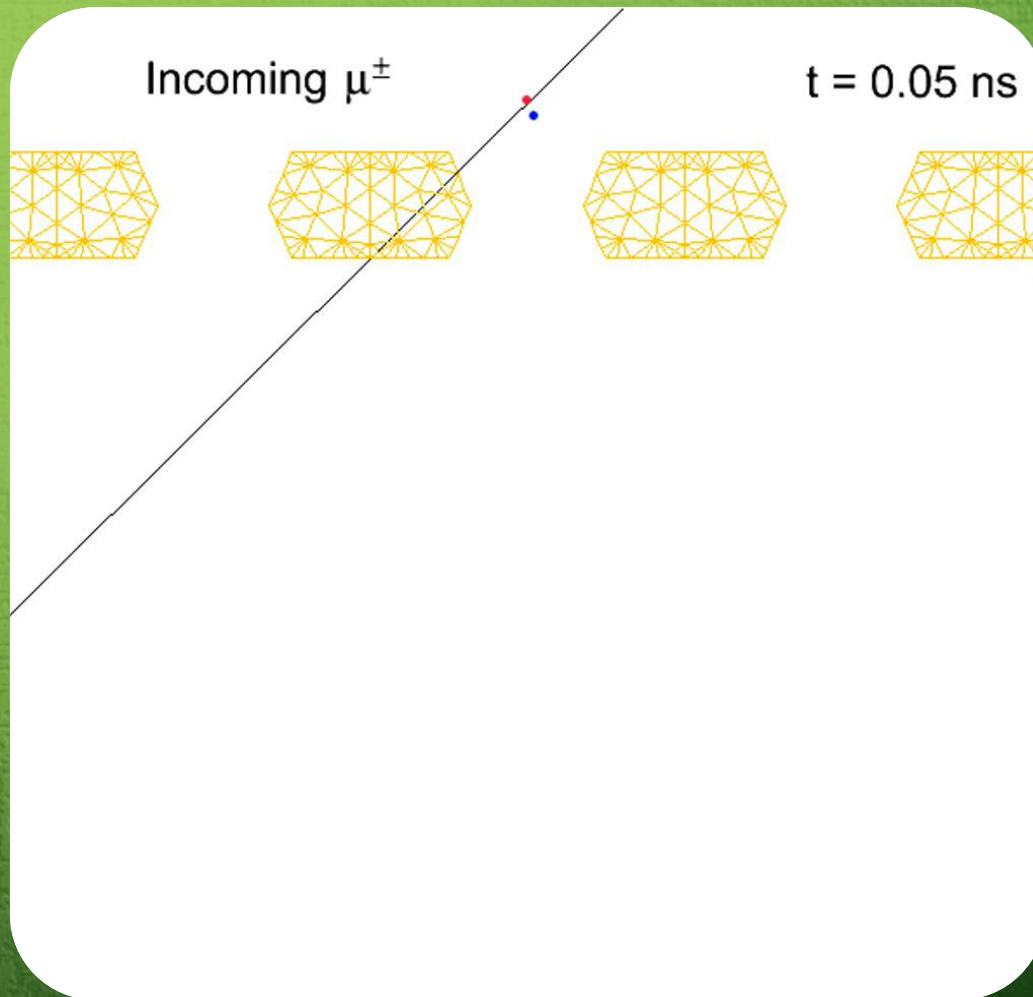


and cleaning
photoresist



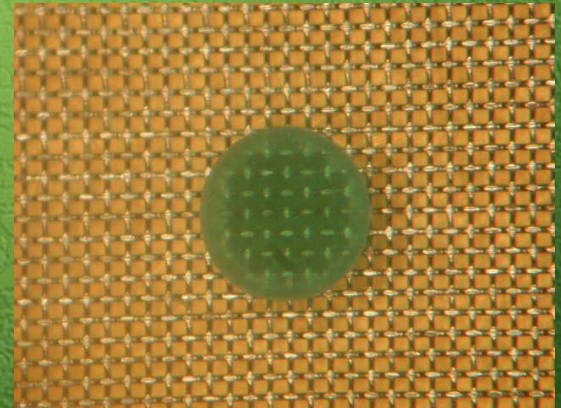
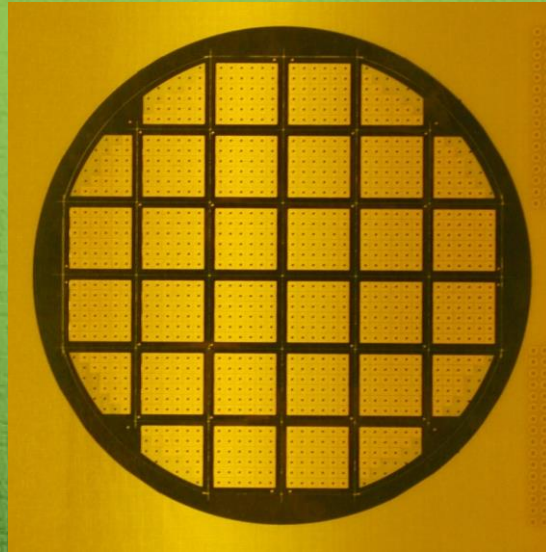
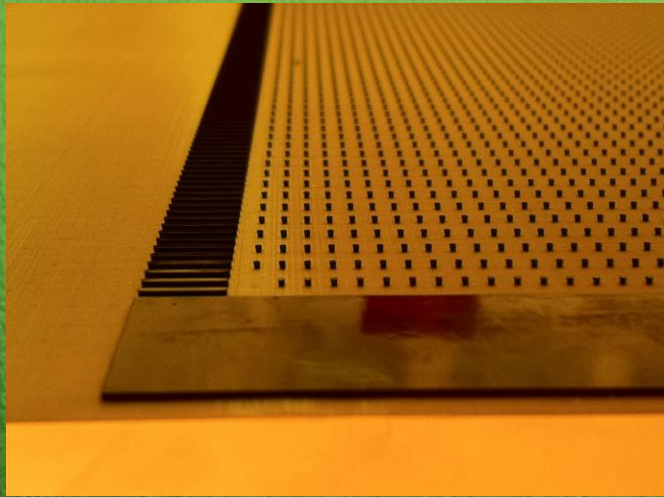
Incoming μ^\pm

$t = 0.05 \text{ ns}$



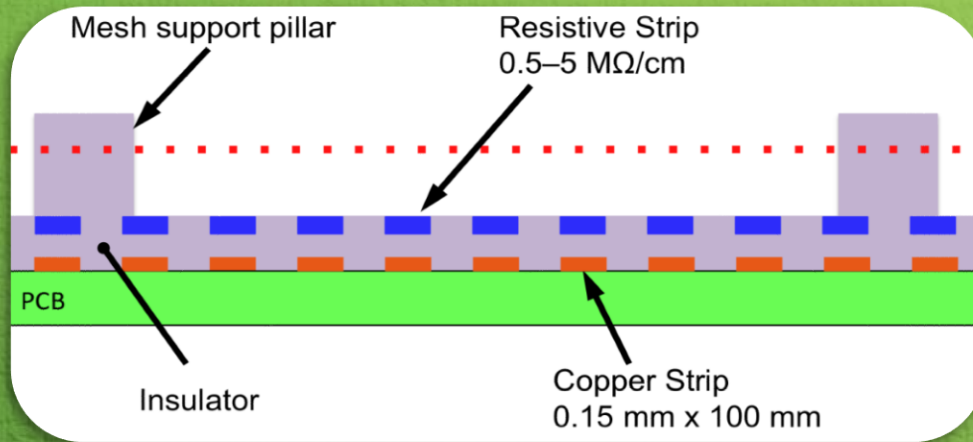
MOST COMMON MPGD DETECTORS BASED ON PRINTED CIRCUIT BOARD TECHNOLOGY

- Micromegas bulk “classical” (spares)



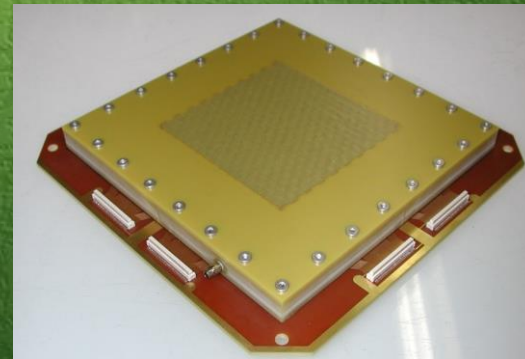
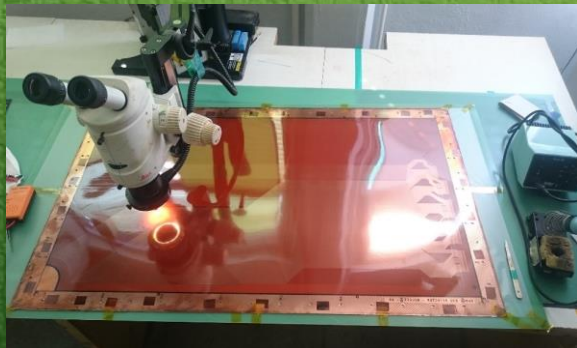
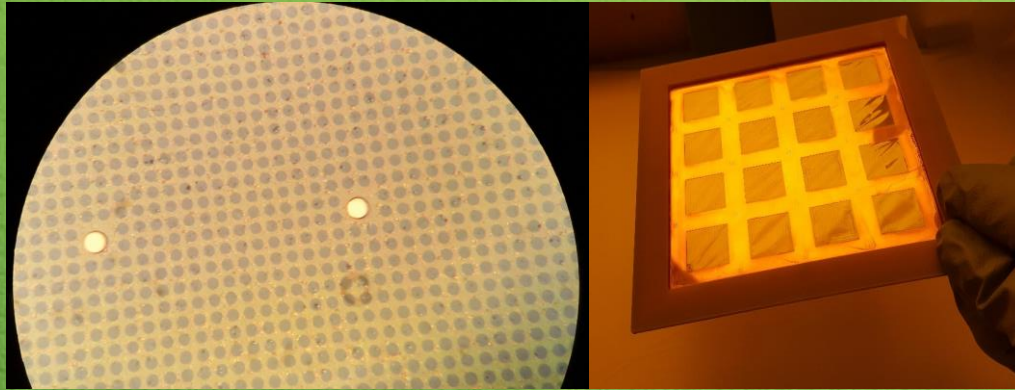
MOST COMMON MPGD DETECTORS BASED ON PRINTED CIRCUIT BOARD TECHNOLOGY

- Resistive Microbulk (spare)



MICRO-PATTERN LAB AT CERN

- 60% of the activity is R&D and production of MPGD.



THE TEAM

- 24 technicians work in the lab.
- Most tasks require the manual know-how of the operators like laminations, chemical etching but also for the step that seem easier : handling, cleaning, inspections...

