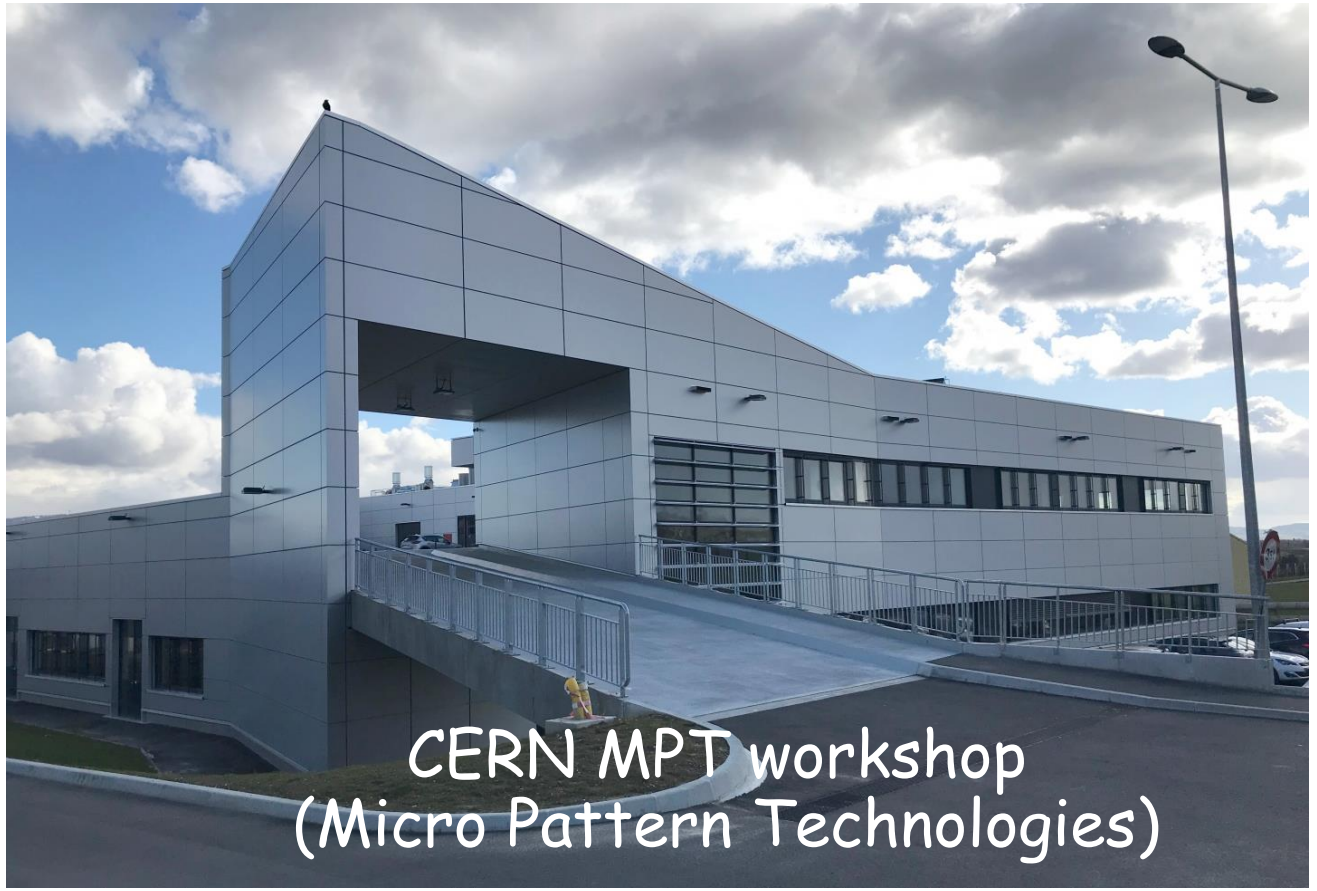


Rui De Oliveira December/11/2022

-20 persons

-13 persons from a contracting company → only productions using well established technologies.

-7 CERN staff → 3 administration and 4 dedicated to R&D prototypes.

-1400 square meters (new building finished in 2018).

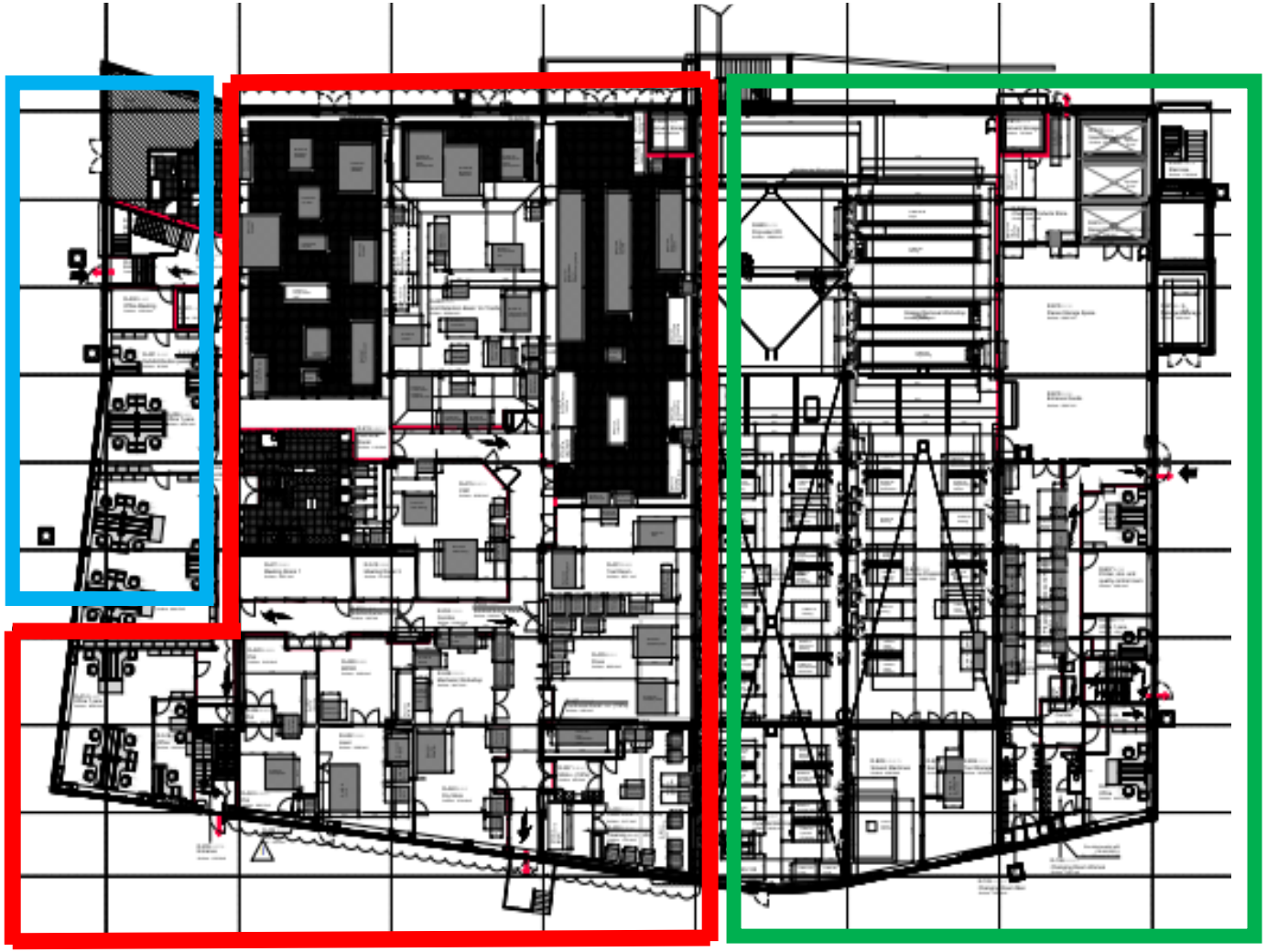
-Making PCBs since 1965

-Mandate:

- -Produce parts difficult to find in industry.
- -Provide to CERN users expertise in interconnections technologies.
- -Make sometime mass production.

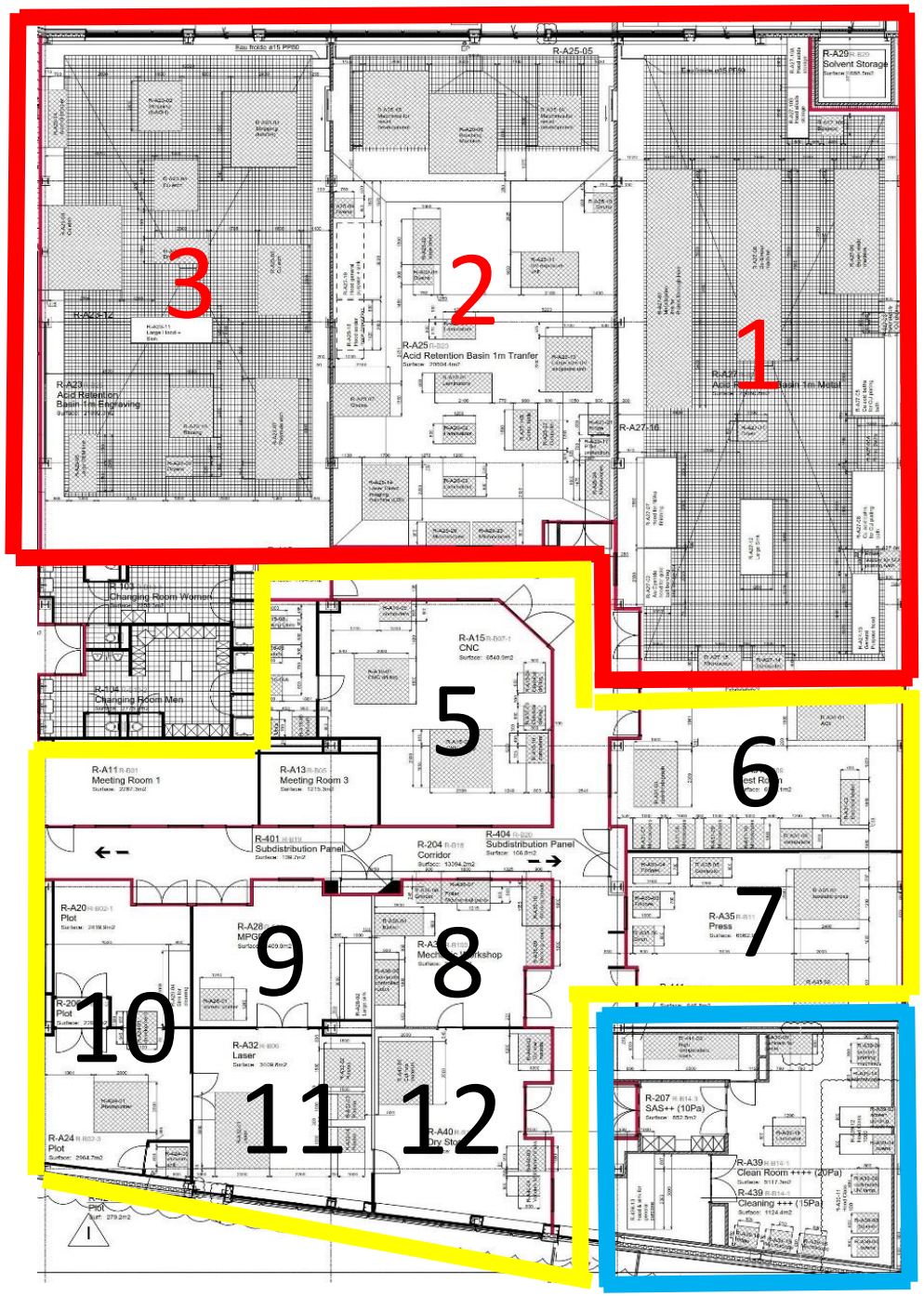
Building 107

PCB Assembly Lab
PCB design office



MPT workshop (EP Dept. -20persons)

Surface treatment workshop



Wet processing Area
1/Plating facility
2/Photo processes
3/Chemical Etching

Dry processing Area
5/Drilling/milling
6/Test
7/Pressing
8/MPGD
9/Chemical analysis
10/Photo mask lab
11/Vacuum deposition
12/Dry store

Clean room

Wet area

Plating facility

-Cu : bath
-Ni : bath
-Au Bath
-Carbon Horizontal
-desmear Horizontal
-Cu oxide Horizontal

Chemical etching facility

-Cu,SS,Al,Ni Horizontal
-Ti ,W, in hood
-Stripping horizontal line
-Cu/Ni horizontal plating line

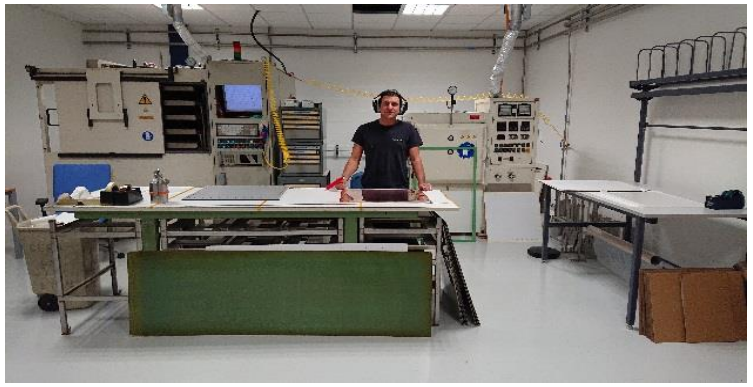
Photo processes

UV exposure : std and large size
Laser Direct imaging
Lamination : std and large
Soldermask spray deposition
Horizontal development:
-Solid resists
-Coverlays
-Solder masks
-Liquid resists

Dry area

CNC processes

-Drilling
-Milling



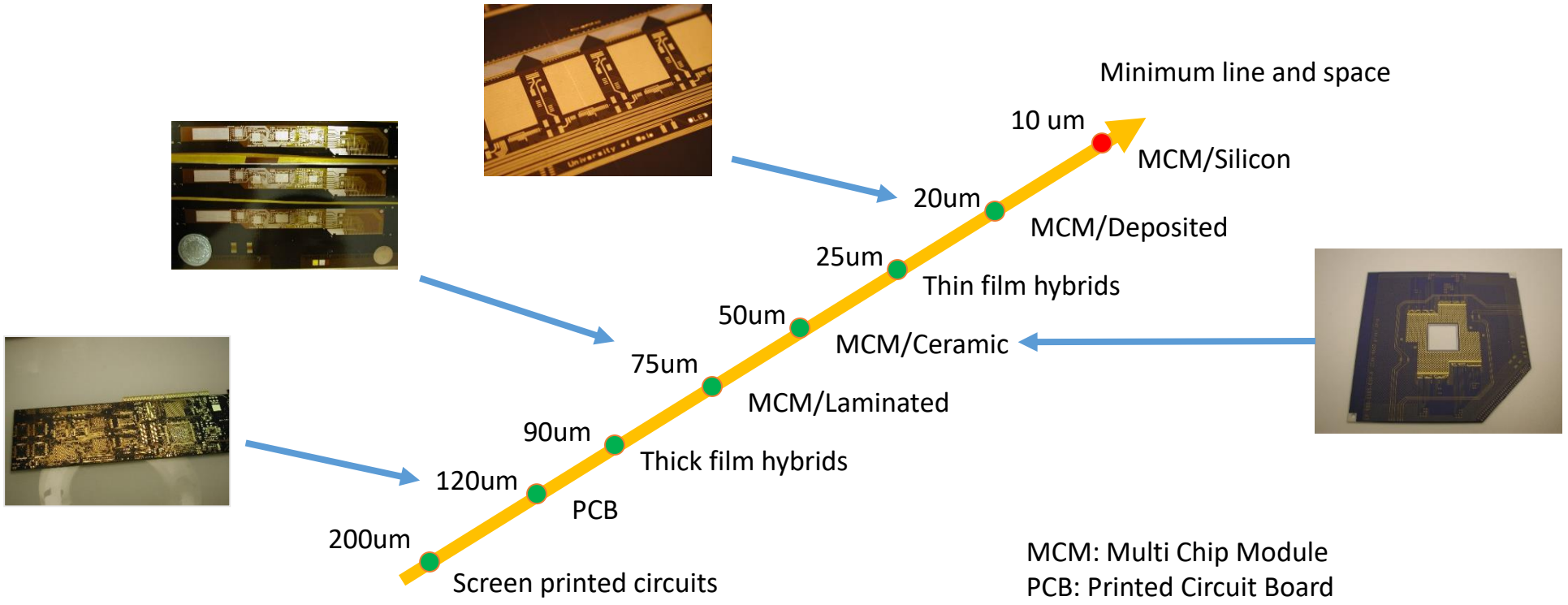
Press facility

-Multilayer gluing
-2 isostatic presses

Test facility

-Automatic Optical Inspection
-Electrical , flying probe tester
-microscopes

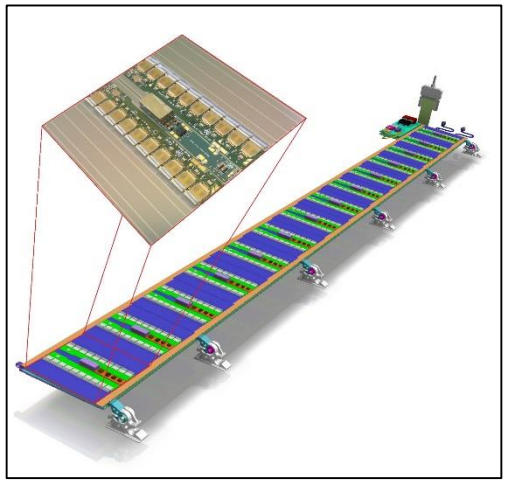
Core interconnections technologies available at MPT



MPT activities

Component for LHC machine

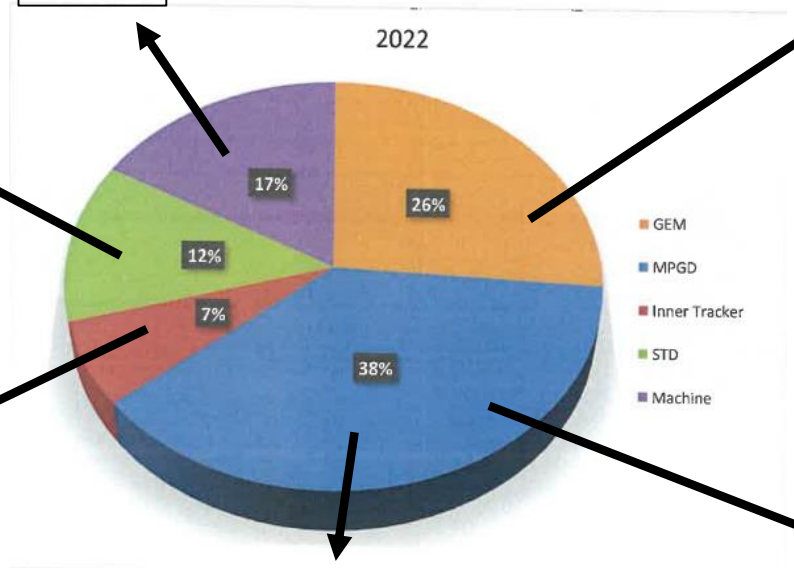
Ex: Quench heater flexes
-Different flavors , up to 14m long
-More than 40 planned for 2023



Inner trackers components

Ex: ATLAS ITK inner tracker long buses
-1.4m x 15cm
-900 pieces to be produced in 2023/24

STD PCB



Other detectors types
Ex: T2K upgrade
-Resistive Micromegas detectors
-40 pieces requested ,
-20 pieces still to be produced in 2023

GEM
Ex: CMS GE2.1
-Around 1000 GEM in total
-350 still to be produced in 2023
4 technicians dedicated to GEM productions

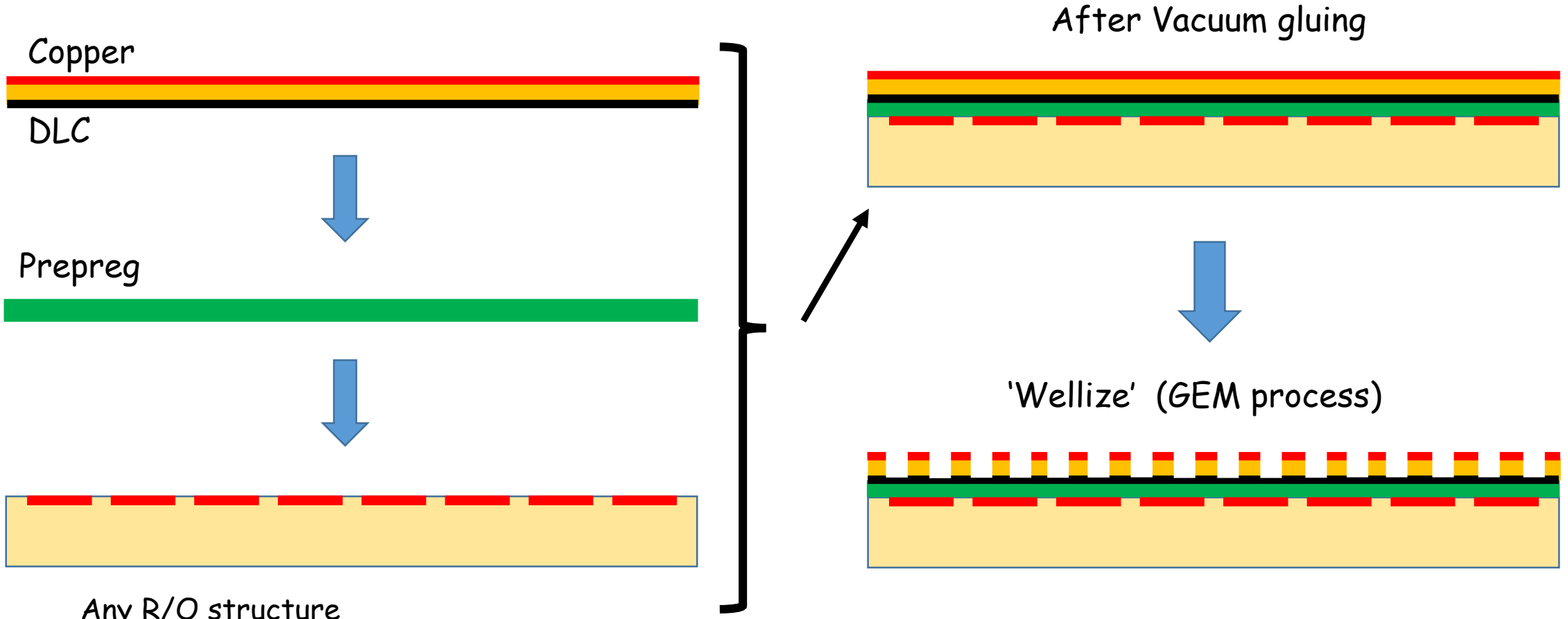
Heavy R&D program
-PEP uRwell large size detectors
-Capacitive sharing detectors
-High rate detectors (MM & uRwell)
-Resistive GEMs
-Low IBF detectors
-High dynamic range detectors
-Fast timing detectors
-Low mass

We are working on many projects, but I want to highlight today 2 of them:

1/News on uRwell detectors production

2/New vacuum depositing machine

uRwell structure (reminder)

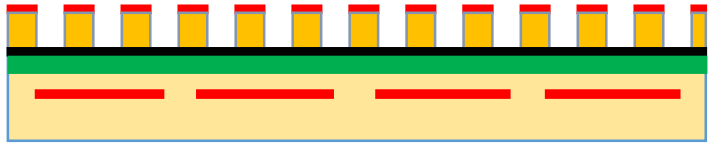


Any R/O structure
- -X/Y , UVW , Pads, Capacitive sharing
- -Rigid , flex, ultra thin flex
- -Copper, Chromium, Aluminum etc..

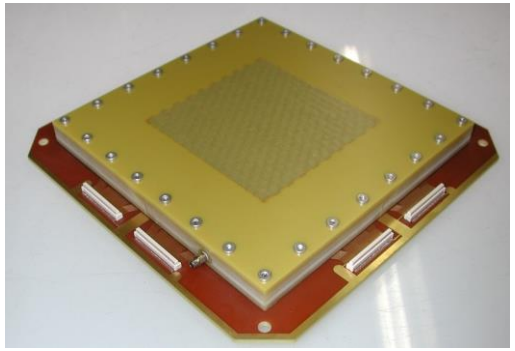
Many different ways to improve the rate capability

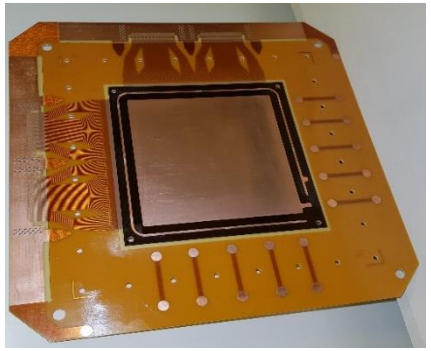
STD μRwell

DLC connected outside the active area



- Medium rate capability





10cm x 10cm
μRwell detector
"study kit"

High rate μRwell

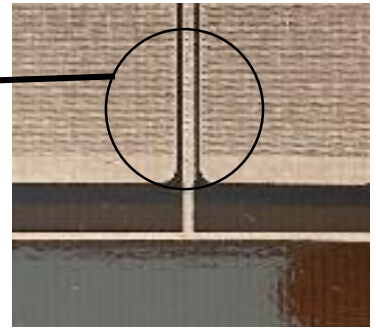
DLC connected in the active area

SG

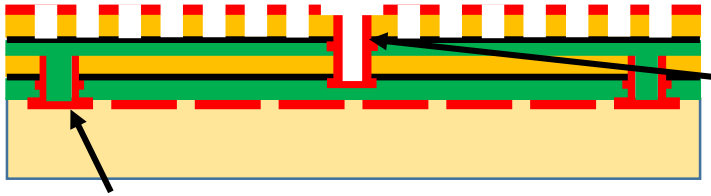
- DLC connected with Cu strips on the DLC

PEP

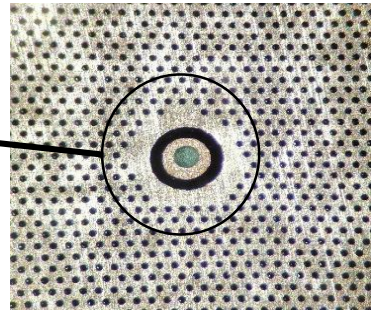
- DLC connected by plated strips



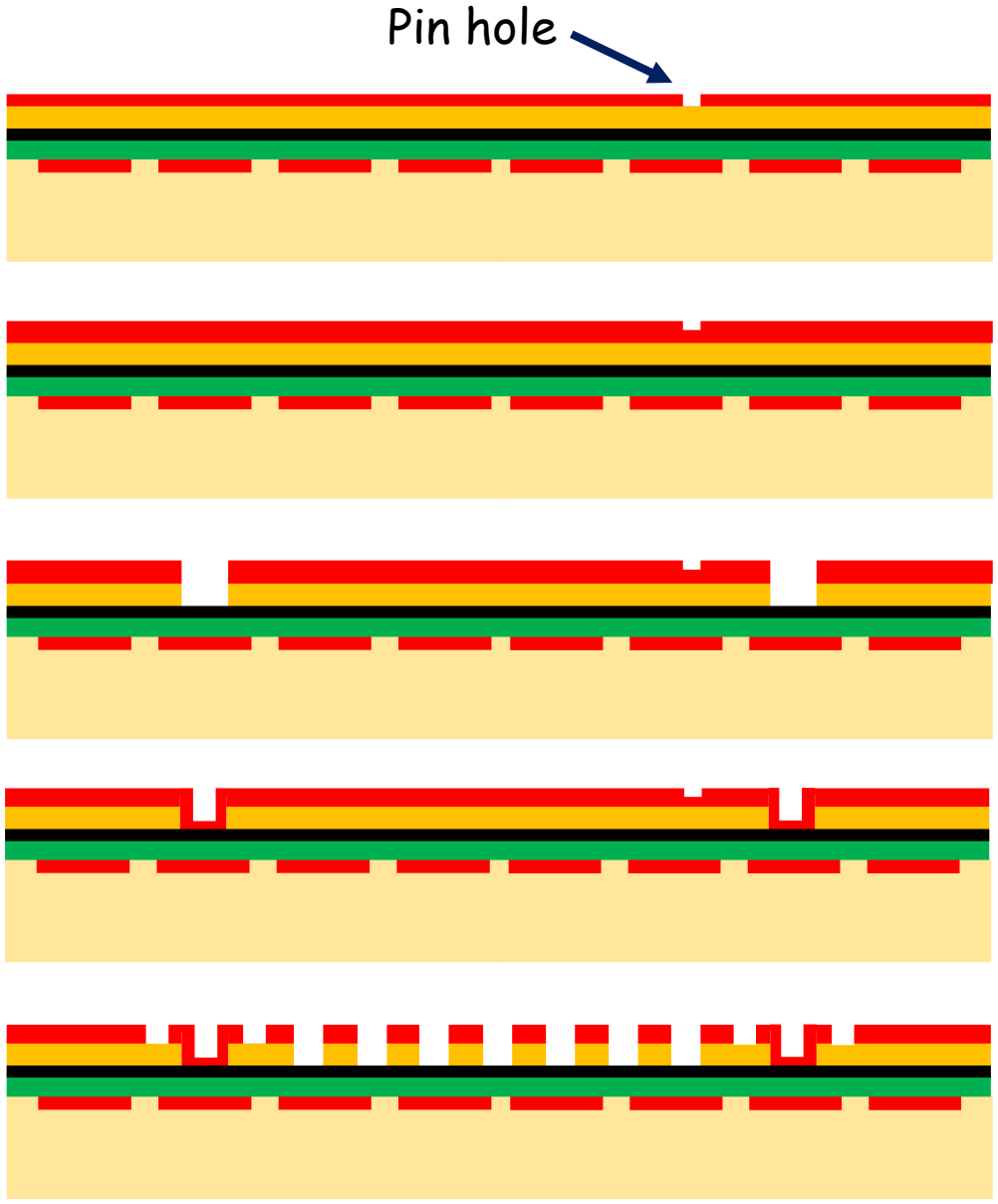
SBU



- 2 DLC layers connected by plated vias



PEP uRwell is for the time being our target



Around 95% yield

Basic structure

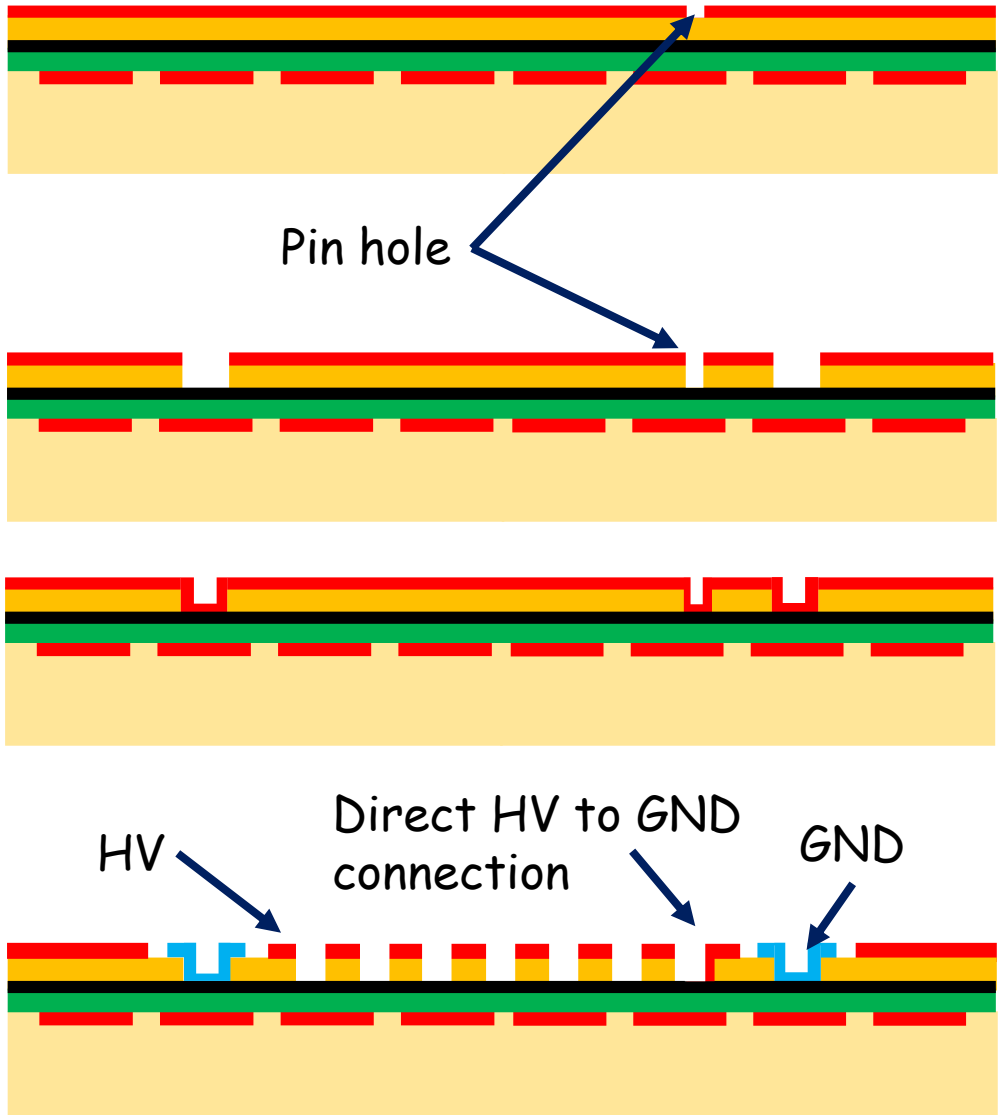
P → copper Plating
To hide the pin holes

E → Etch copper and APICAL
No need for precise alignment

P → Plate the holes or grooves
For DLC charge evacuation

Wellization , easy alignment on visible patterns

PEP uRwell without pin hole protection



Around 60% yield

Basic structure

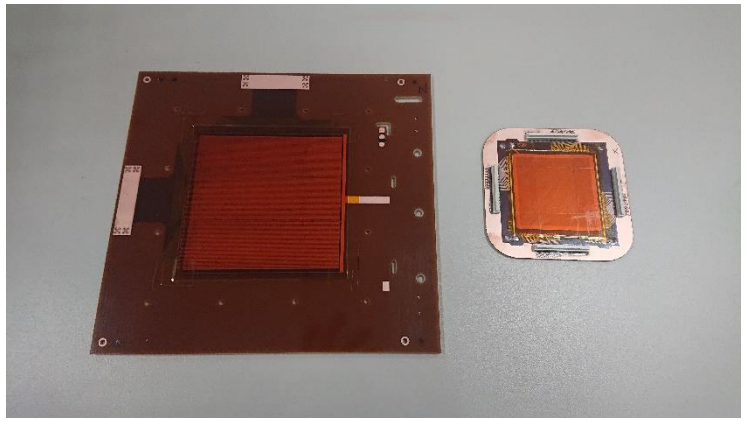
E → Etch copper and APICAL

P → Plate the holes or grooves

Wellization

E-cleaning

Oven et at 100 deg



Detector with Kapton protection
HV connections

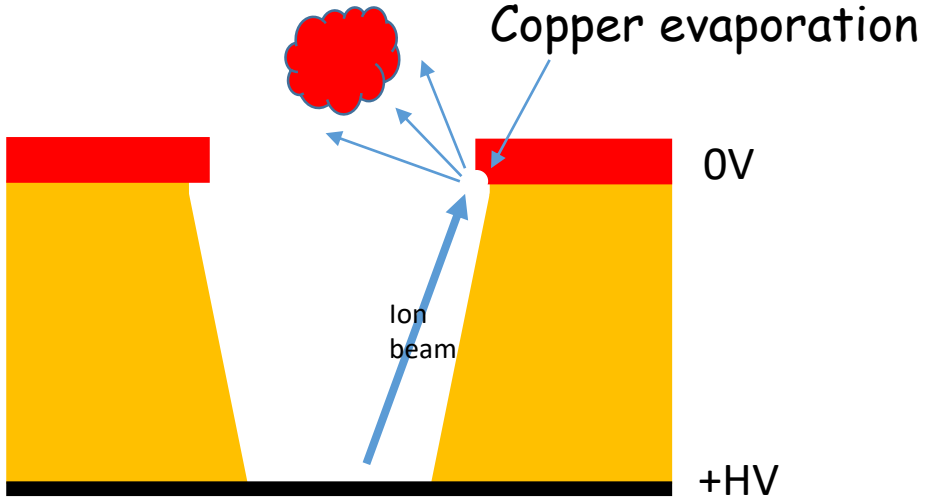
HV Power supply
10 to 20uA limitation

1/Minimum requirement → the detector should hold 250V in open air, leakage current <5nA.
2/We put a kapton protection on the detector.
3/We then put the detector in oven @100 deg for 8 hours.
4/We apply 250V , 10 to 20uA limitation
5/We wait to reach a leakage current <1 to 2nA and stay 2 hours with this current.
6/We then raise the voltage by 50V steps below 550V and then 20V steps.
7/We repeat step 3 and 4 till we reach 640V.

Depending on the detector size and the type of defect the E-cleaning can take a full week

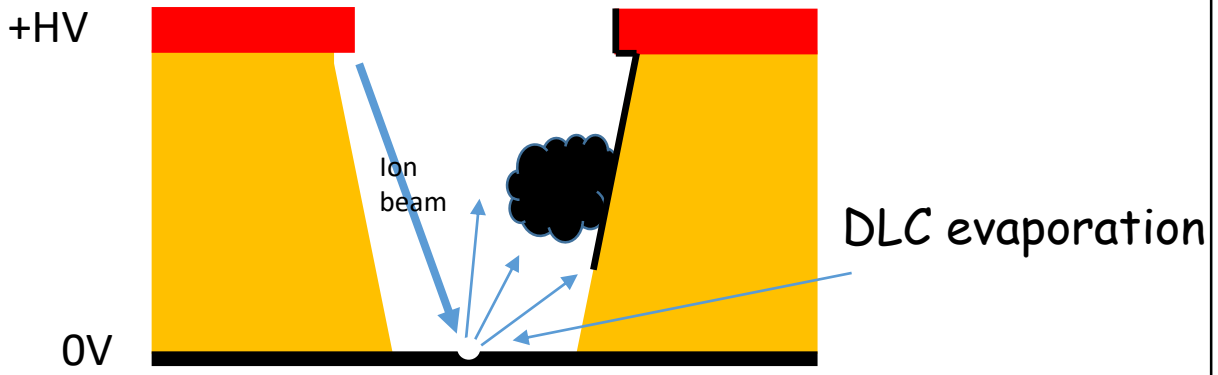
Explanation tentative presented at RD51 February/09/2022

Correct polarization → improvement



Evaporated Cu + Pi compounds
are pulled out from the hole

Wrong polarization → degradation

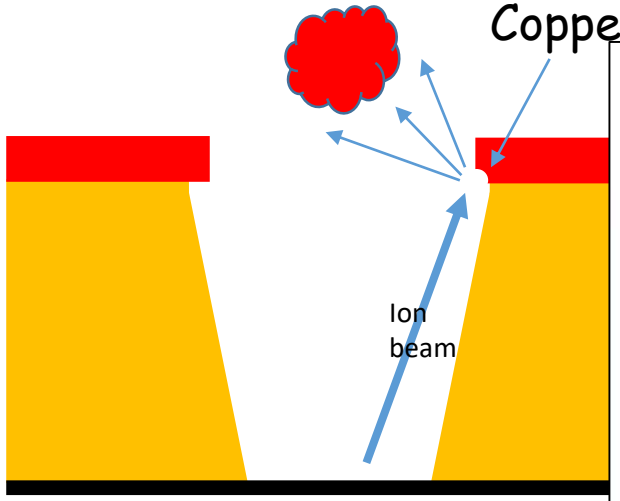


Evaporated DLC + PI compounds
can condense on the walls

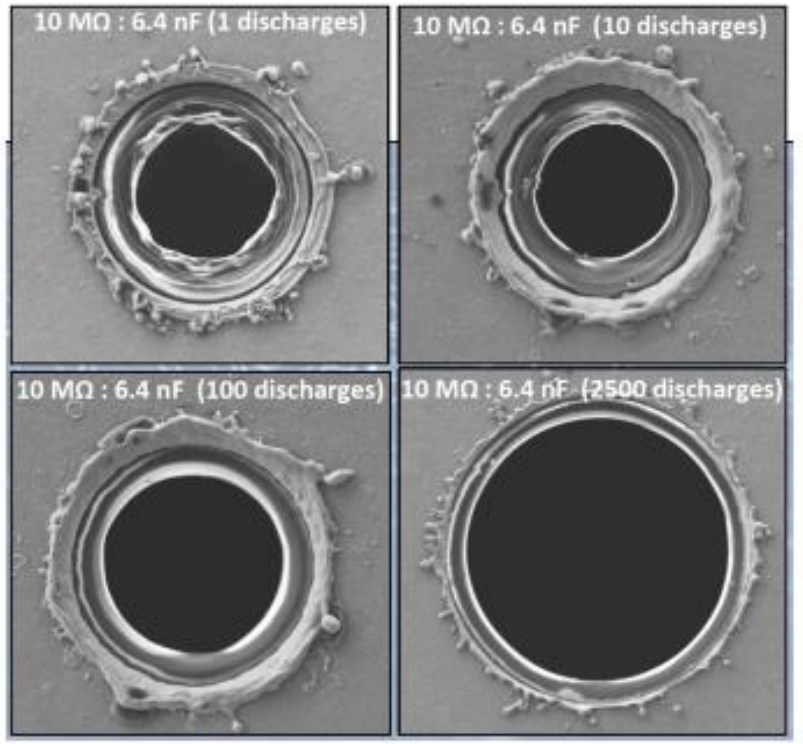
Explanation tentative presented at RD51 February/09/2022

Correct polarization → improvement

Copper evaporation



Evaporated Cu + Pi compoun
are pulled out from the ho



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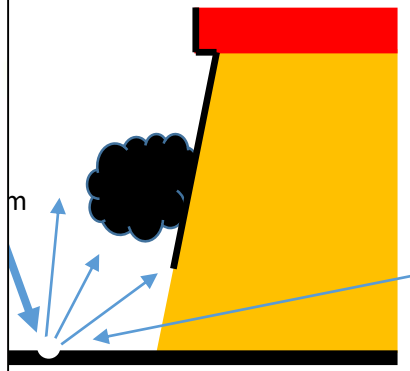
https://indico.cern.ch/event/709670/contributions/3008626/

Wrong polarization → degradation



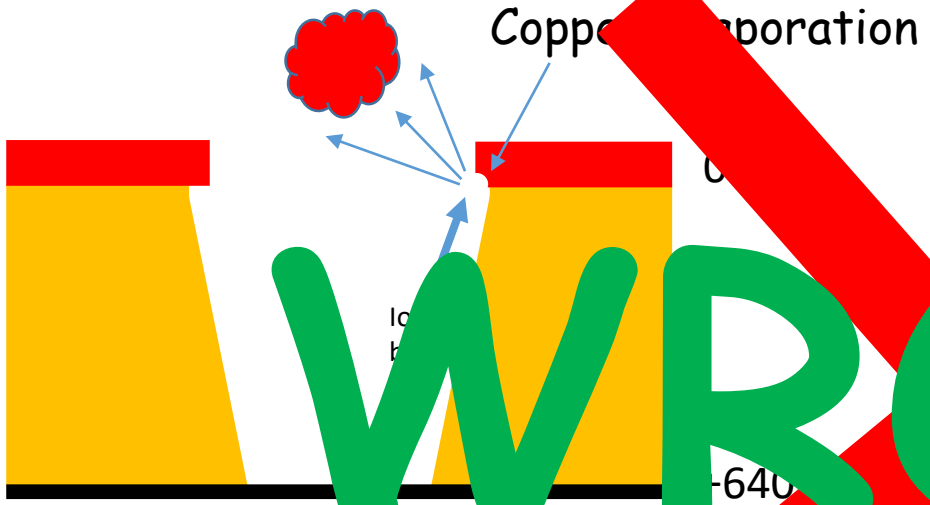
DLC evaporation

DLC + PI compounds
ense on the walls

In the GEM case we can clearly see material pulled out from holes after repetitive sparks
We do not see this with uRwell, but I do not see why the principle should be different

Explanation tentative presented at RD51 February/09/2022

Correct polarization → improvement



Evaporated Cu + Pi compounds
are pulled out from the hole

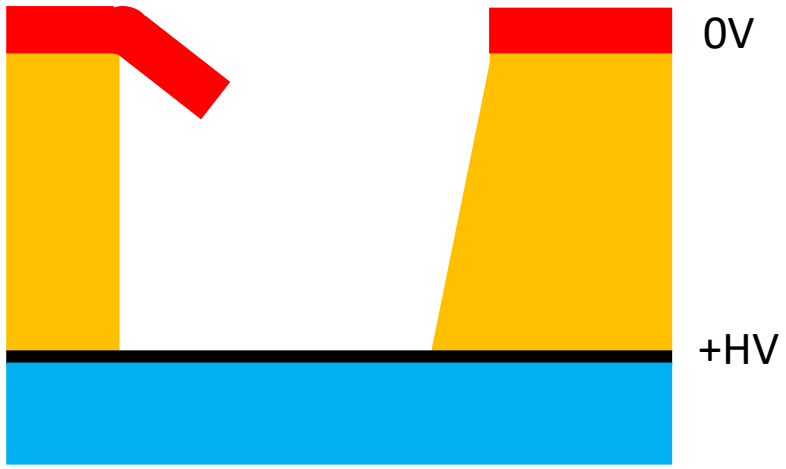
Wrong polarization → degradation

Evaporated DLC + PI compounds
can condense on the walls

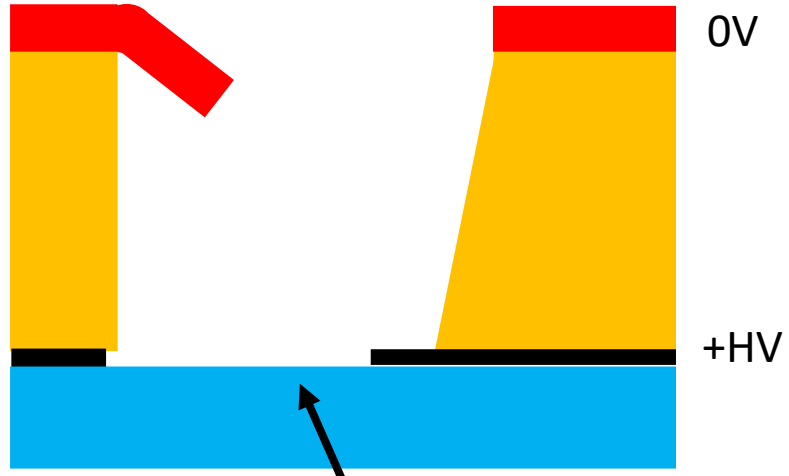
WRONG

Second tentative , first type of defect

Structural defect on the copper
Max Voltage 250V in Air @ 100deg



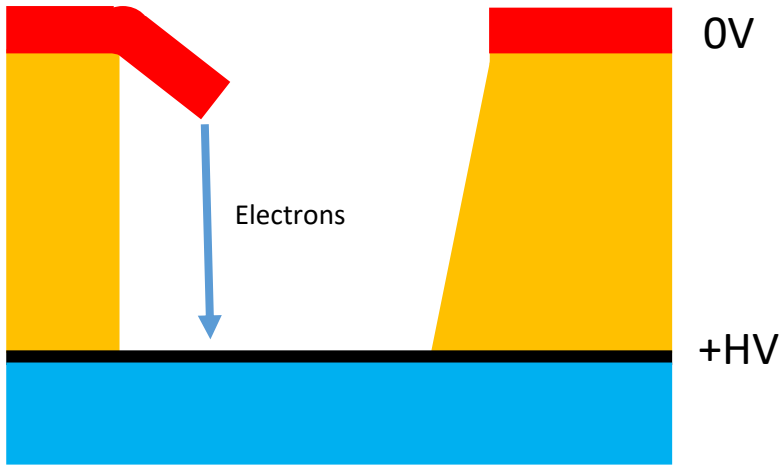
After cleaning
640 V @ 100deg with 1nA



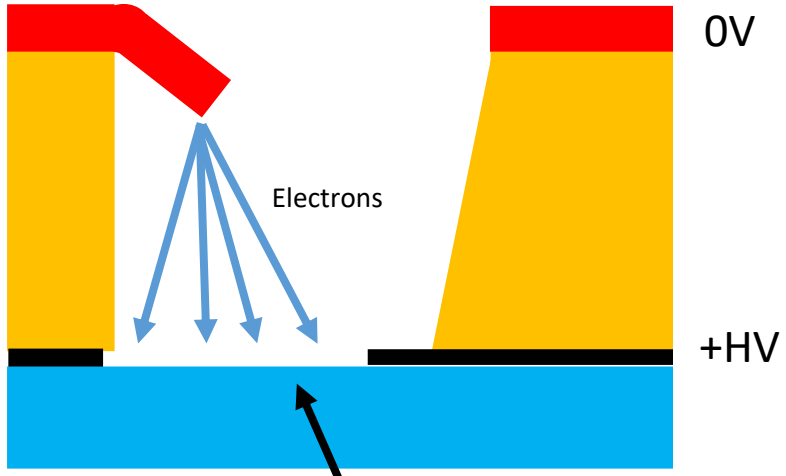
DLC is evaporated
near the defect

Second tentative , first type of defect

Structural defect on the copper
Max Voltage 250V in Air @ 100deg

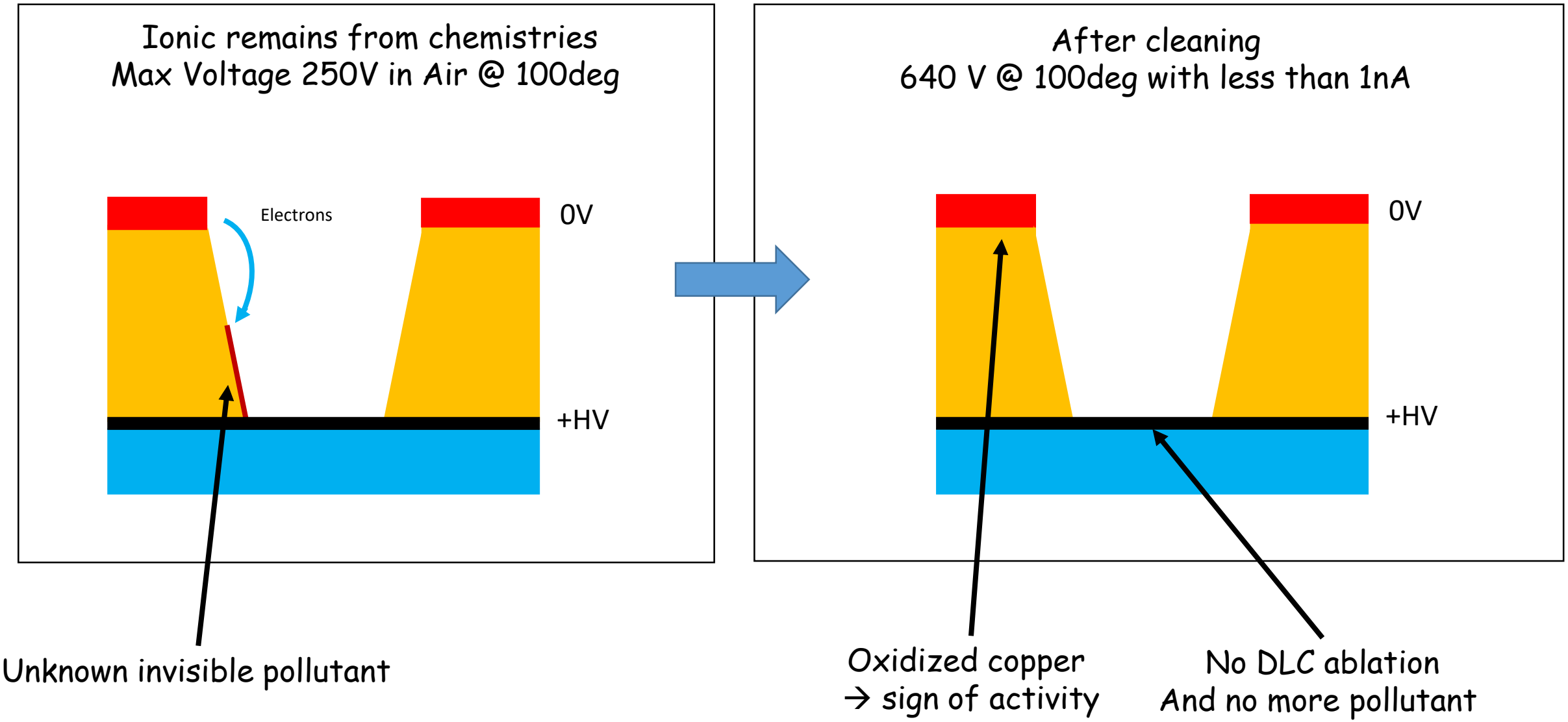


After cleaning
640 V @ 100deg with 1nA

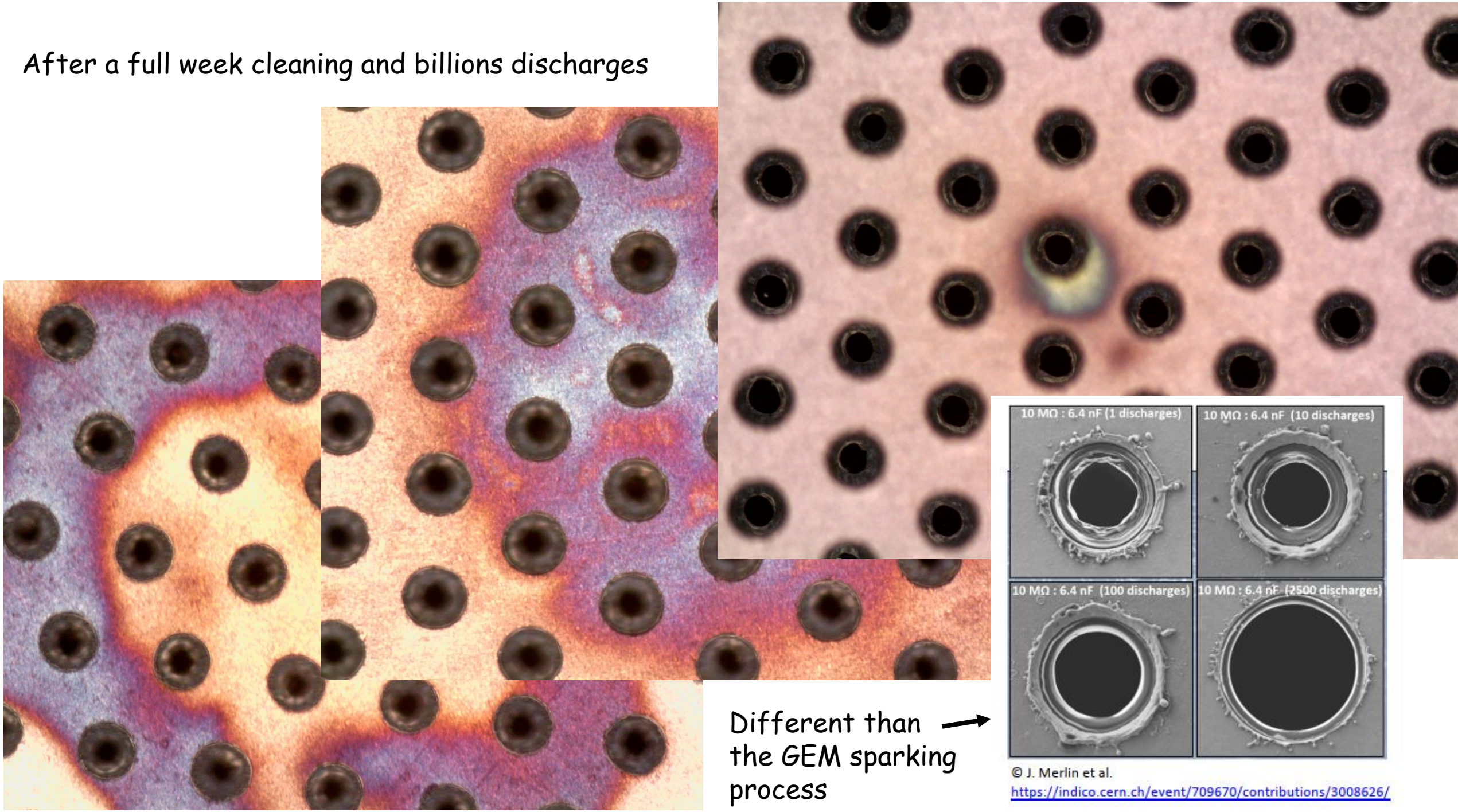


DLC is evaporated
near the defect

second type of defect (invisible)



After a full week cleaning and billions discharges



Different than the GEM sparking process

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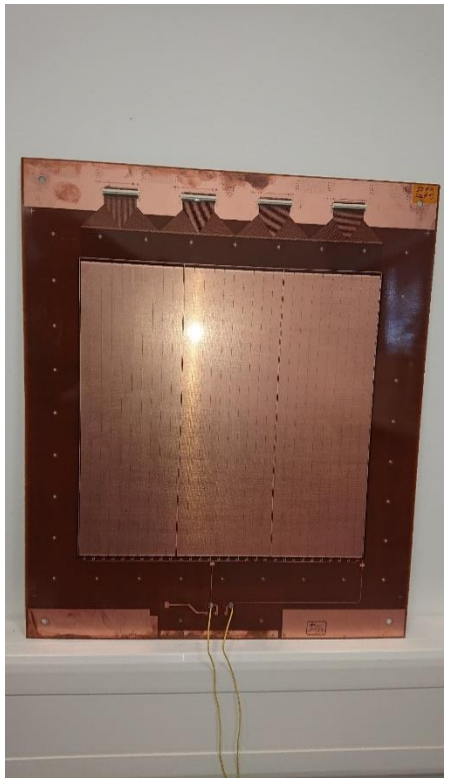
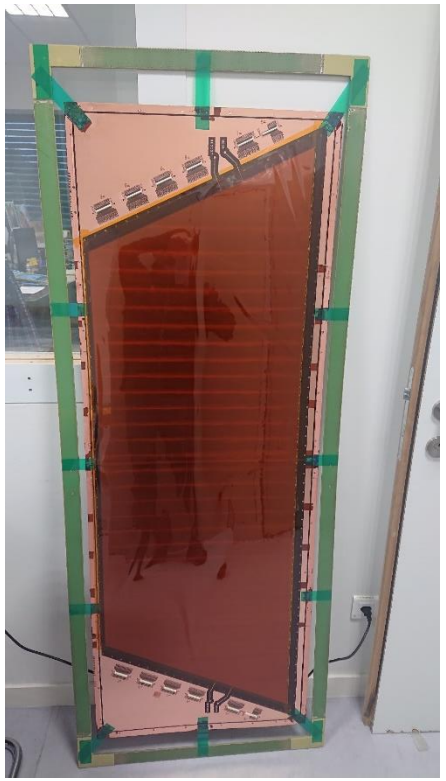
https://indico.cern.ch/event/709670/contributions/3008626/

PEP examples

Frascati R&D
1D PEP uRwell
Active area:
40cm x 5cm



Frascati R&D
1D PEP uRwell
Active area:
30cm x 30cm



CLAS12 uRwell
2D PEP with 3 CS layers
Active area:
150cm x 50cm

CLAS12 uRwell
rolled in the oven
for E-cleaning

Whatever is the size, we can always reach a few nA @ 640V/100deg !

New machine

Pulsed DC magnetron reactive PVD

- Max foil size:
  -1.7m x 0.6m.

- Resistive layers:
  -DLC, semiconductors.
- Photocathodes:
  -Metallic, DLC, B4C, GaN, mix?
- Metals:
  -AL, Cu, Ni, etc..

- 5 targets.
- 3 simultaneous deposition.
- 3 gas inputs for reactive deposits:
  - H2,N2,02,C2H2,Ar etc..
- 300 deg max built in heater.
- Plasma cleaning

- Fantastic help during from the DLC collaboration Team

- Machine cost (500kCHF) financed by:
  -25% INFN
  -25% CERN EP/DT group
  -50% MPT workshop
- Services cost (150kCHF) financed by:
  -100% MPT workshop

- Market survey → 04/21
- Invitation to tender → 05/21
- Purchase order → 08/21
- Delivery →10/22
- Operation →11/22

- Inner trackers
  - Low mass flexes, Al conductors.
  - Solid state detectors embedded in flex.
- MPGD
  - Resistive protection layers.
  - High rate in difficult background.
  - High granularity low channel count.
  - Ps timing resolution robust cathodes.
  - Layers for neutron detection.
- Other
  - TPC field shapers with continuous distribution.
  - High rate RPCs.

DLC collaboration

Title of project: *DLC based electrodes for future resistive MPGDs*

Contact person:
name: Yi Zhou
address: Jinzhai Road No.96, Hefei, Anhui, P.R.China, 23
telephone number: +86-551-63607940
e-mail: zhouyi@mail.ustc.edu.cn

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   University of Science and Technology of China,
   contact person: Yi Zhou
   e-mail: zhouyi@mail.ustc.edu.cn

2. *Kobe University,*
   contact person: Atsuhiko Ochi
   e-mail: ochi@kobe-u.ac.jp

3. *CERN*
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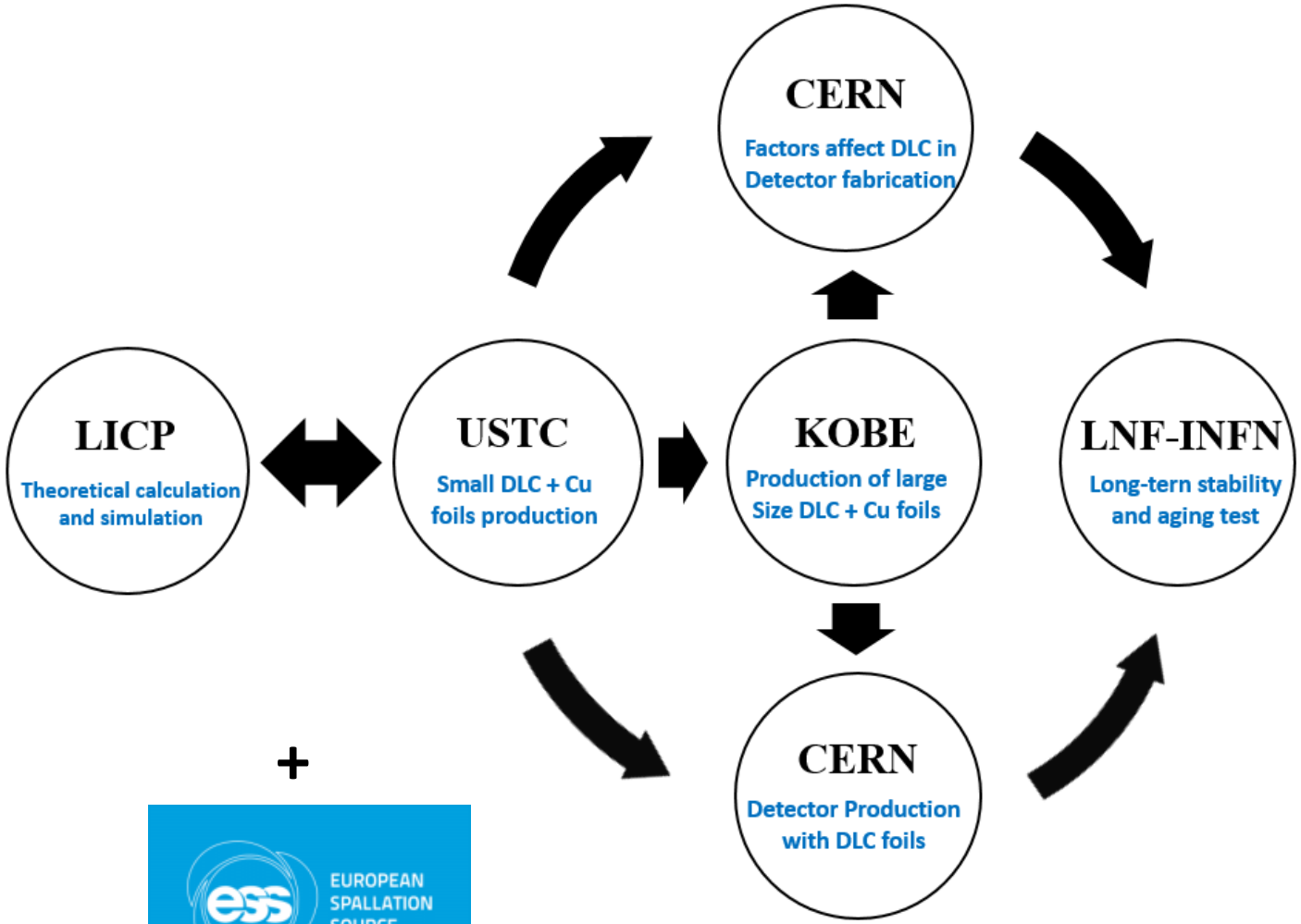
   e-mail: Rui.de.Oliveira@cern.ch

4. *Laboratori Nazionali di Frascati dell'INFN*
   contact person: Giovanni Bencivenni
   e-mail: Giovanni.Bencivenni@lnf.infn.it

Ext. Collaborators:

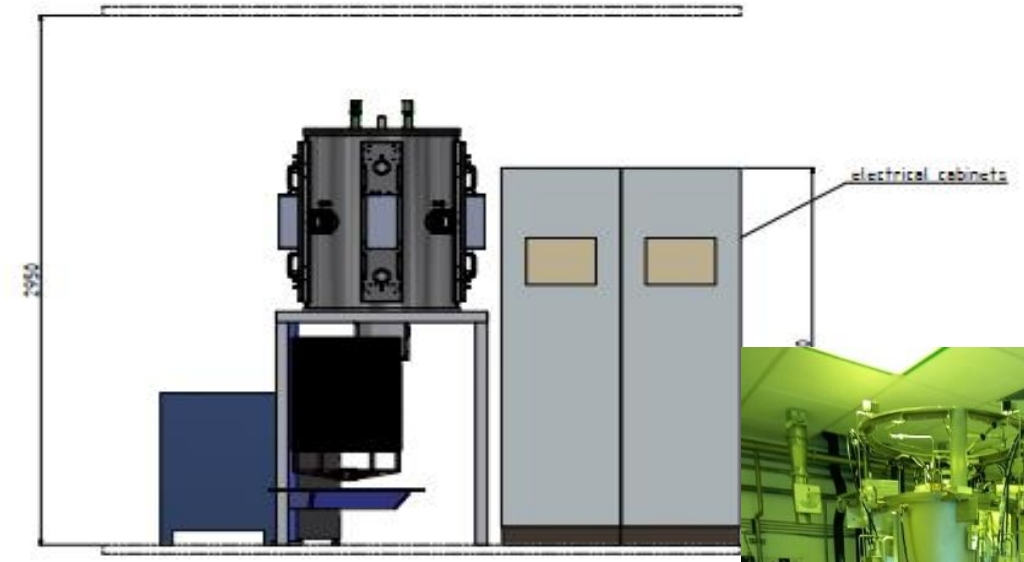
1. *State Key Laboratory of Solid Lubrication,*
   Lanzhou Institute of Chemical Physics, Chinese Academy
   contact person: Lunlin Shang
   e-mail: shangll@licp.cas.cn

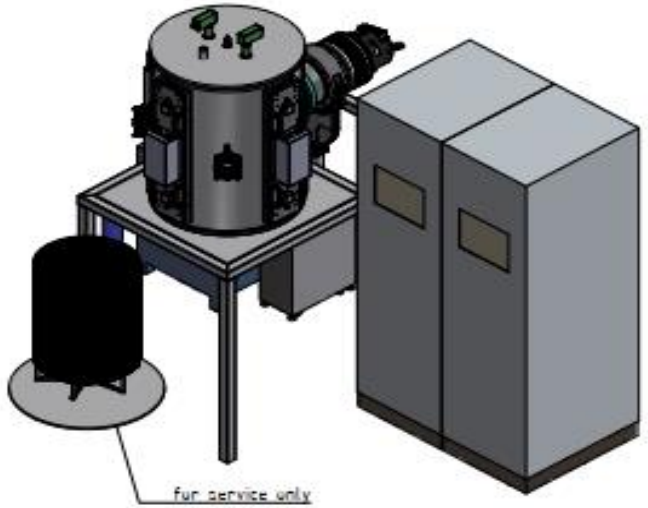


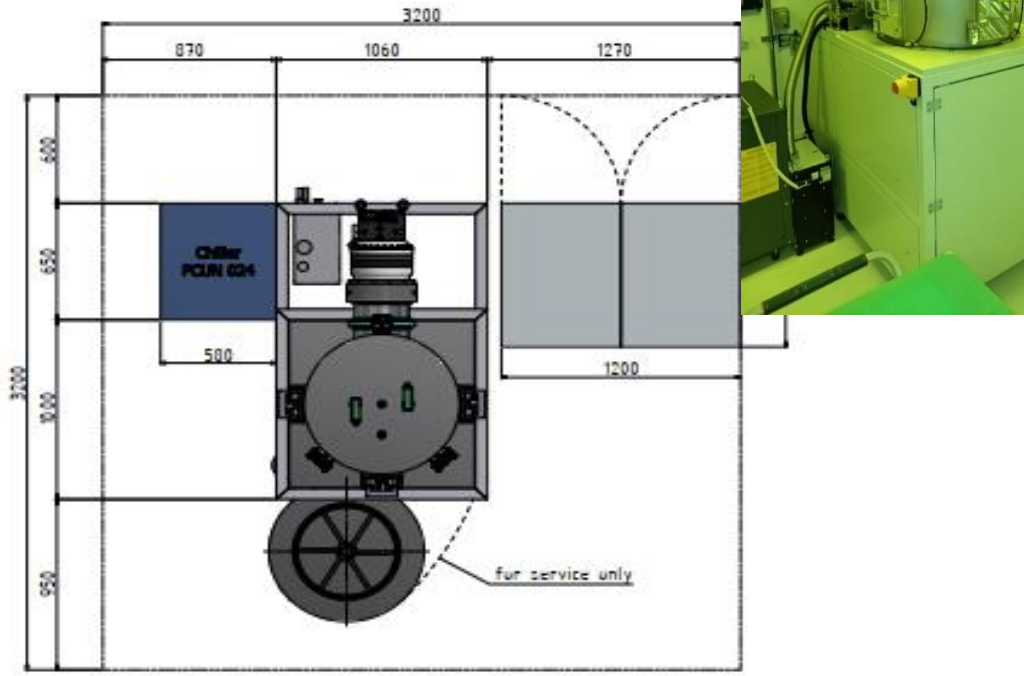
Kobe Japan
B-sputter
4 m x 1m real

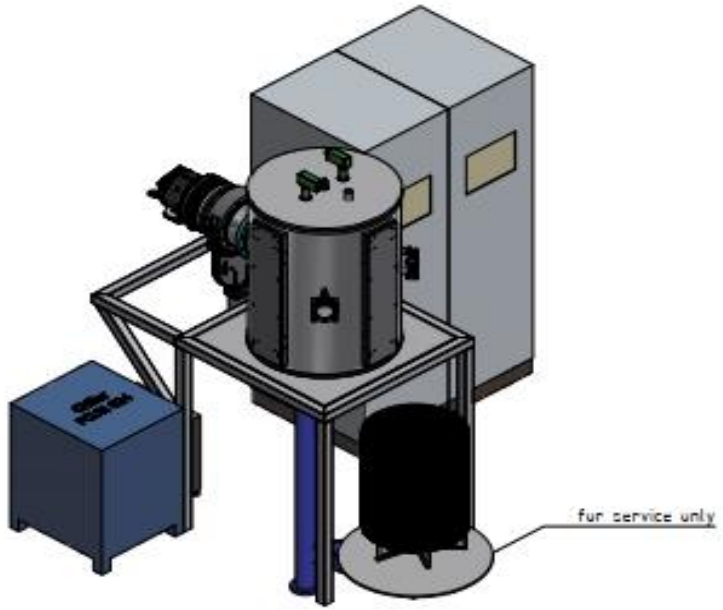
ESS
2.1 m x 400mm

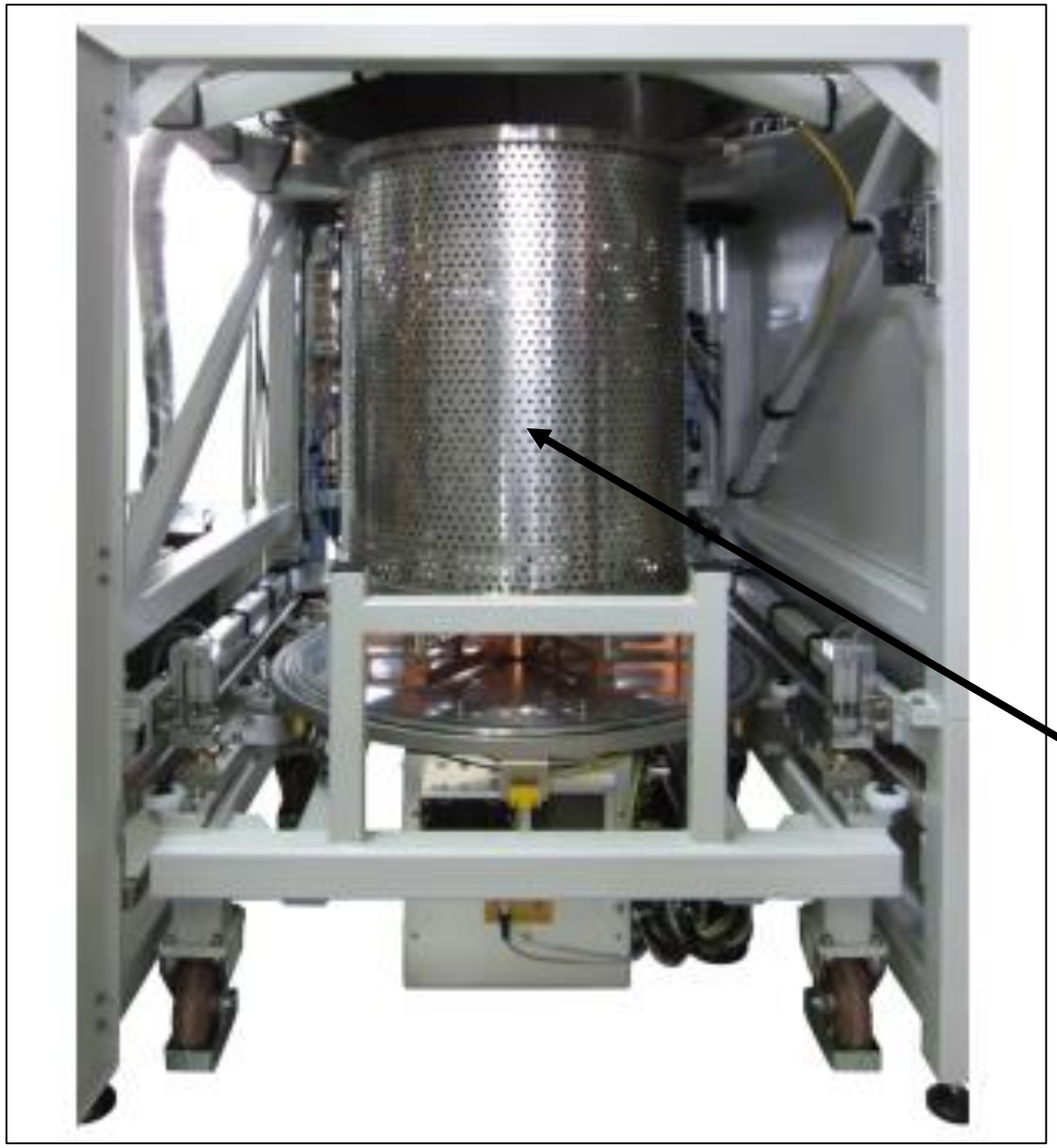
China USTC
1.2 m x 500mm


electrical cabinets


fur service only


3200
870
1060
1270
600
650
1000
950
3000
Chiller
PCUN 024
500
1200
fur service only


fur service only



Drum holding the samples

Possibility to prepare several drums
to increase the throughput

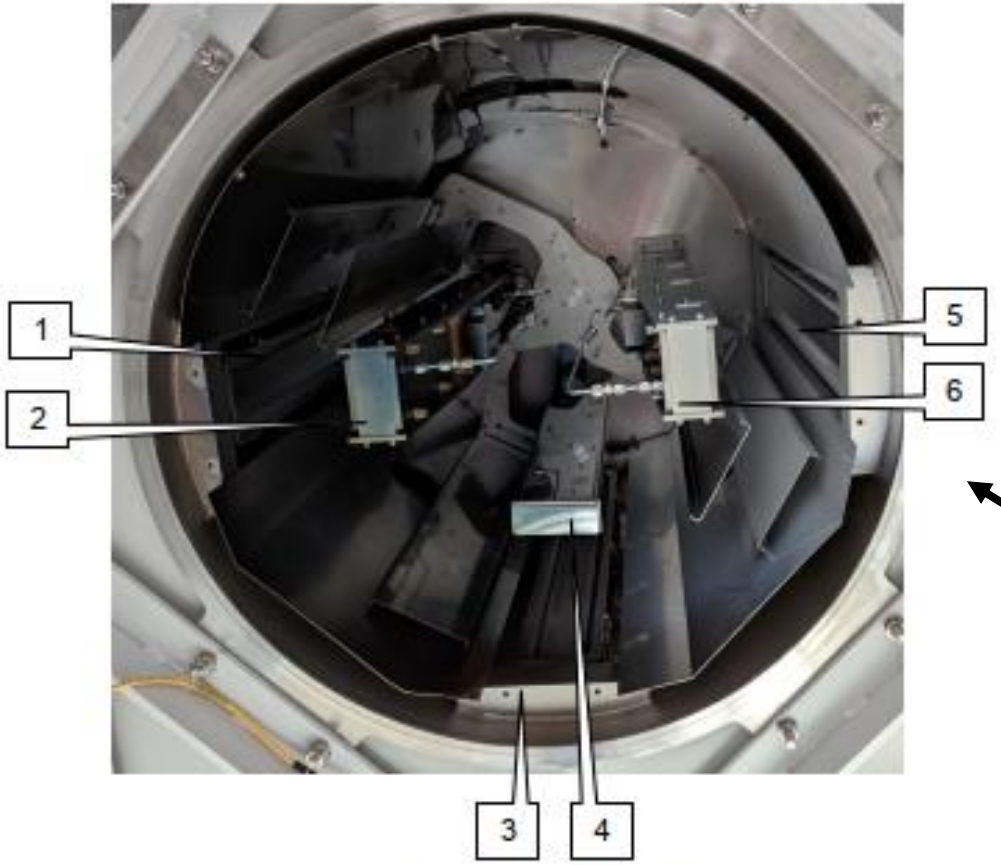
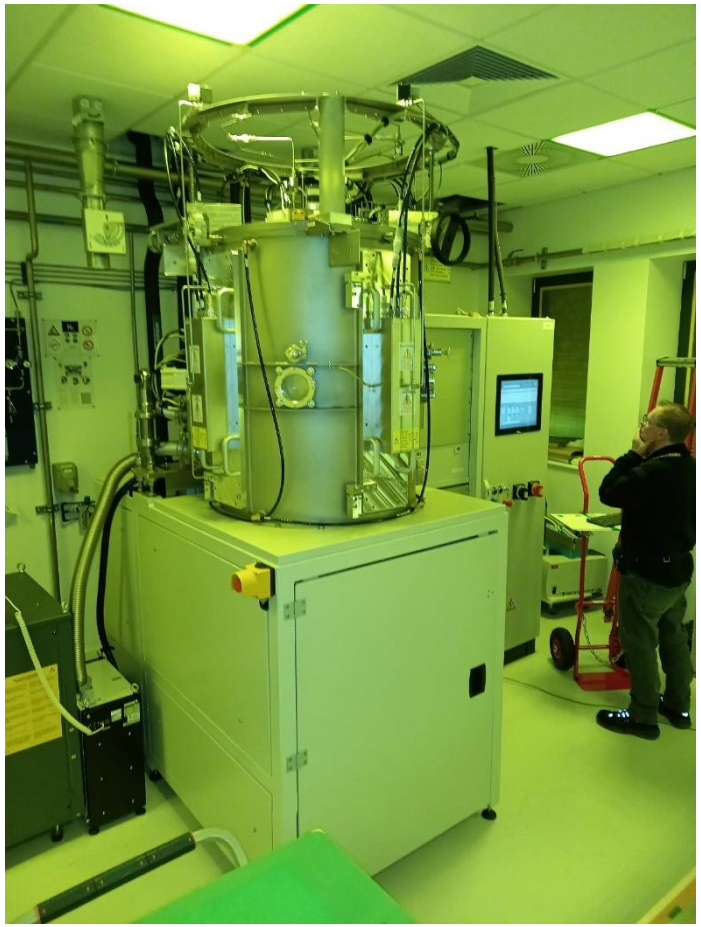


Fig. 6: Recipient – interior

	Function	*Item designation*	*Remark*
1	Cathode 1	+P01-2HT1	Details see circuit diagram
2	Cathode 2	+P01-2HT2	Details see circuit diagram
3	Cathode 3	+P01-2HT3	Details see circuit diagram
4	Heater	+P01-1E1	Details see circuit diagram
5	Cathode 5	+P01-2HT5	Details see vacuum scheme
6	Cathode 4	+P01-2HT4	Details see vacuum scheme

Bottom view of the Vacuum chamber

pictures



Machine in operation

70cm copper target installation

Drum unloading
after processing

Preliminary results obtained after few weeks

- Al , Cr and Cu (Ar)
  - Done : excellent results → this was the commissioning test
- DLC (Ar)
  - Done : from 30K to 300K →just playing on the kapton roughness
- DLC-Cr-Cu (Ar)
  - Done : good adhesion, still need a little tuning to be perfect
- DLC (Ar/N2)
  - Done : from 30K to some Gohms/square
  - Playing on deposit thickness, kapton roughness , N2 concentration.
- DLC (Ar/C2H2) , DLC (Ar/CH4) , DLC (Ar/H2)
  - Not Done
- B4C , GaN , Si ,Sio2
  - Not Done
- Uniformity test
  - Done : really encouraging →few % over 50cm

The team

- Serge Ferry (MPT)
  - Expert in the field
  - He co-designed the machine
  - He wrote all the specifications
  - He is now leading the preliminary test program
- Givi
  - He participated to the commissioning
  - Participation to preliminary test program
- Gianfranco Morello (Frascati)
  - He participated to the commissioning
  - Participation to preliminary test program

Better quantitative results will be given at the next RD51

Next

- PEP uRwell:
  - Produce 2 more 1.5m x 0.5m PEP uRwell
  - Fully automatize the electrical cleaning to reduce the uRwell cost.
  - Continue the uRwell technology transfer to industry
- Vacuum machine:
  - Improve our knowledge on N2 doped high resistive value DLC layers
  - Start some test with C2H2
  - B4C ?
  - We are ready to accept requests from the community for DLC layers.
- In next RD51 meeting I will give news on :
  - High rate SBU MM
  - High rate SBU uRwell
  - Capacitive sharing