LEM/Anodes and CRP Improvement Plan

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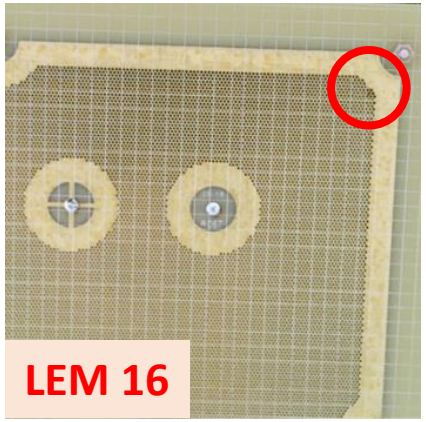
LEM Improvement Plan

Three issues being addressed:

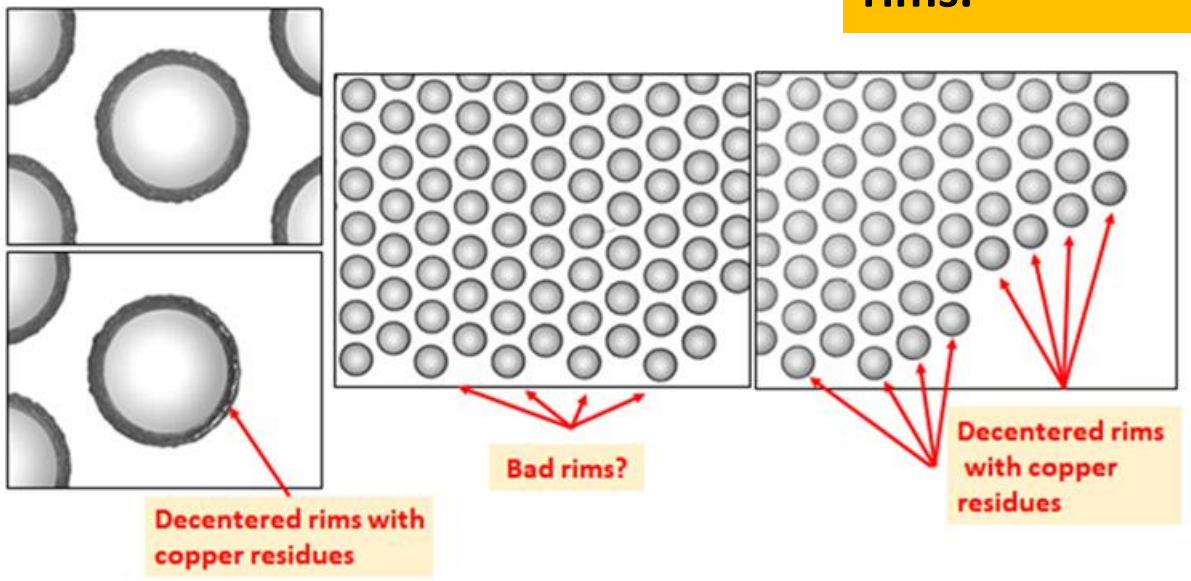
- LEM active area. In ProtoDUNE-DP, LEM active area reduced to 86% in order to mitigate spark rates in the boundary regions of the PCB. Would like to achieve > 95% for DUNE.
- LEM HV stability. Aim is to keep spark rates as low as possible for very long term operation in DUNE and avoid ageing effects. Spark rates < 1/h per CRP at gains ~ 20 in Cold Box tests at CERN in 2018.
- Rim defects. LEM carbonization issues found during Cold Box tests point to method used by ELTOS (Italy) for the micro-etching process of rims around amplification holes.

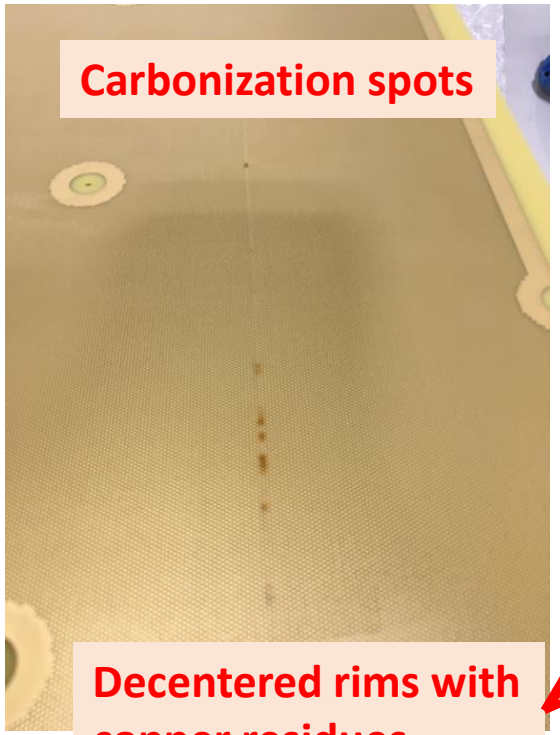
Reminder : carbonization issues during CB tests in 2018

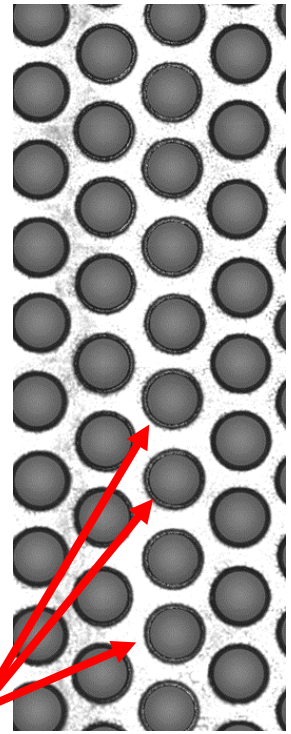


In total, 5/72 LEMs affected by such problems

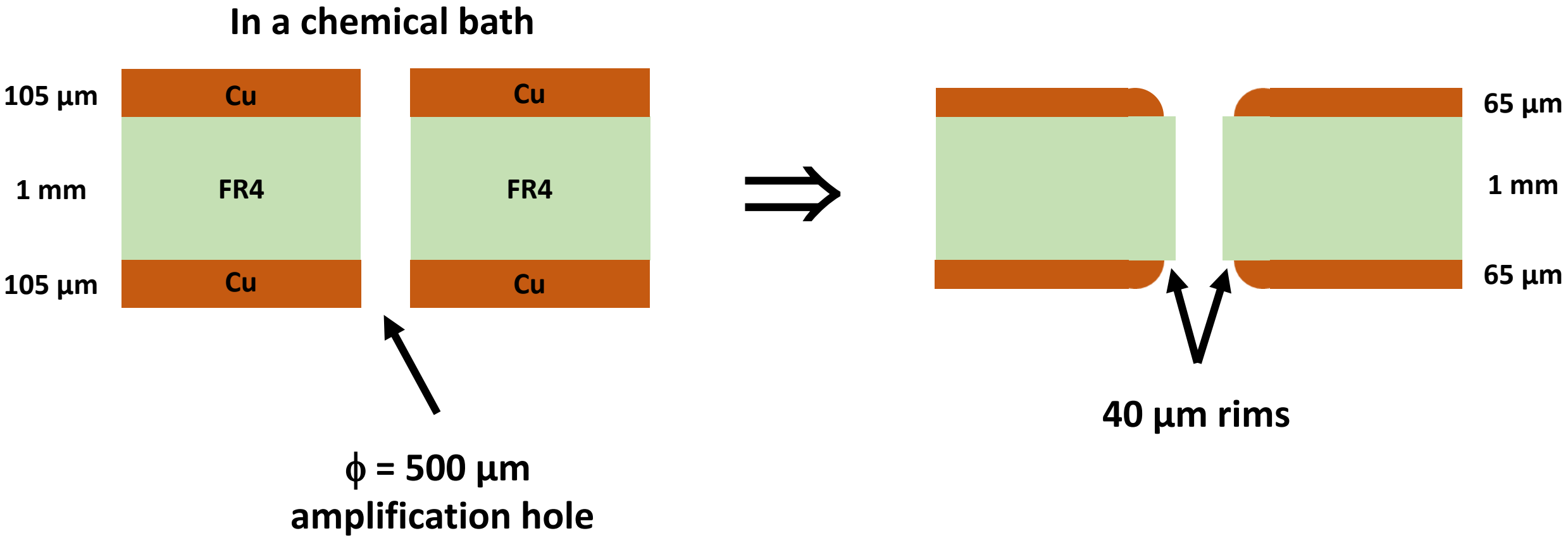
Issues point to standard micro-etching process used by ELTOS to make rims.





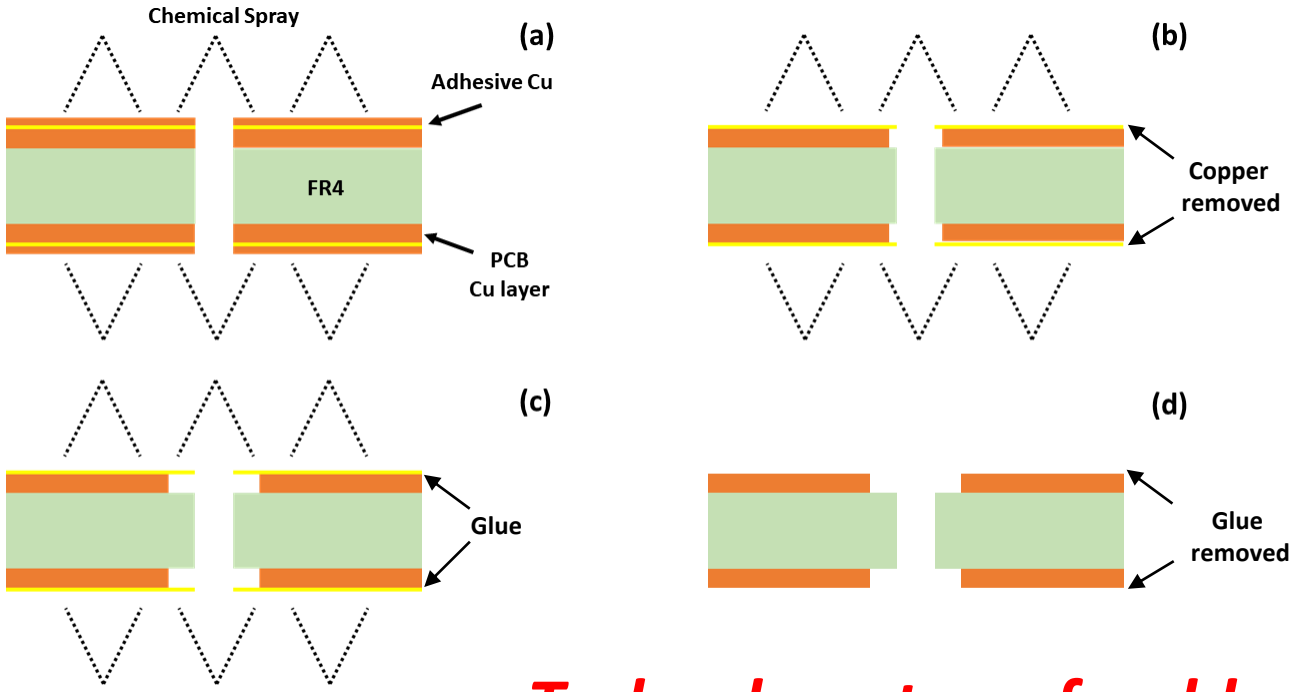


Standard micro-etching process by ELTOS

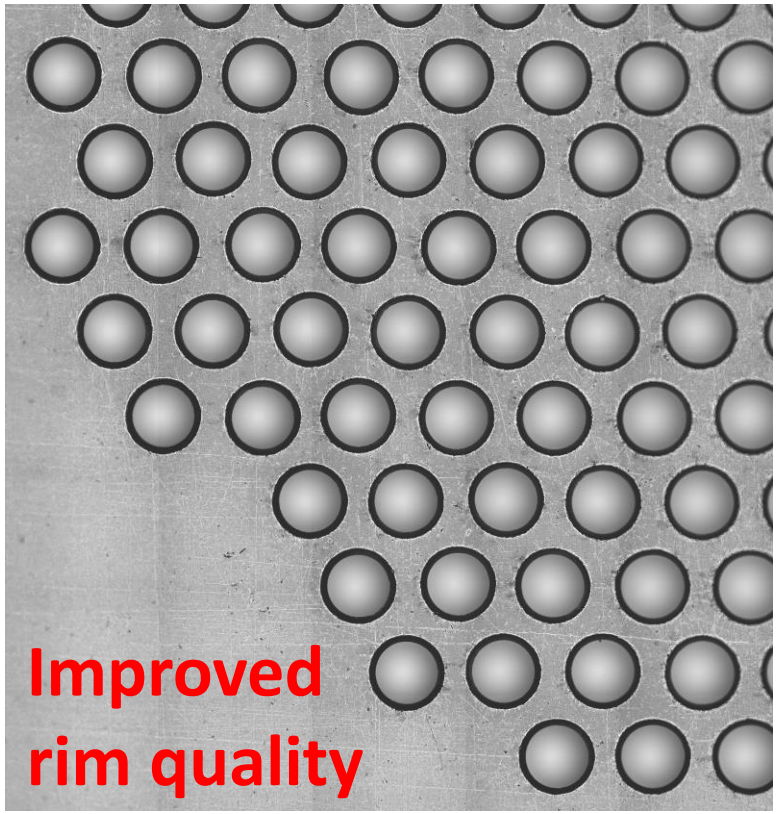


Improved micro-etching process for rims

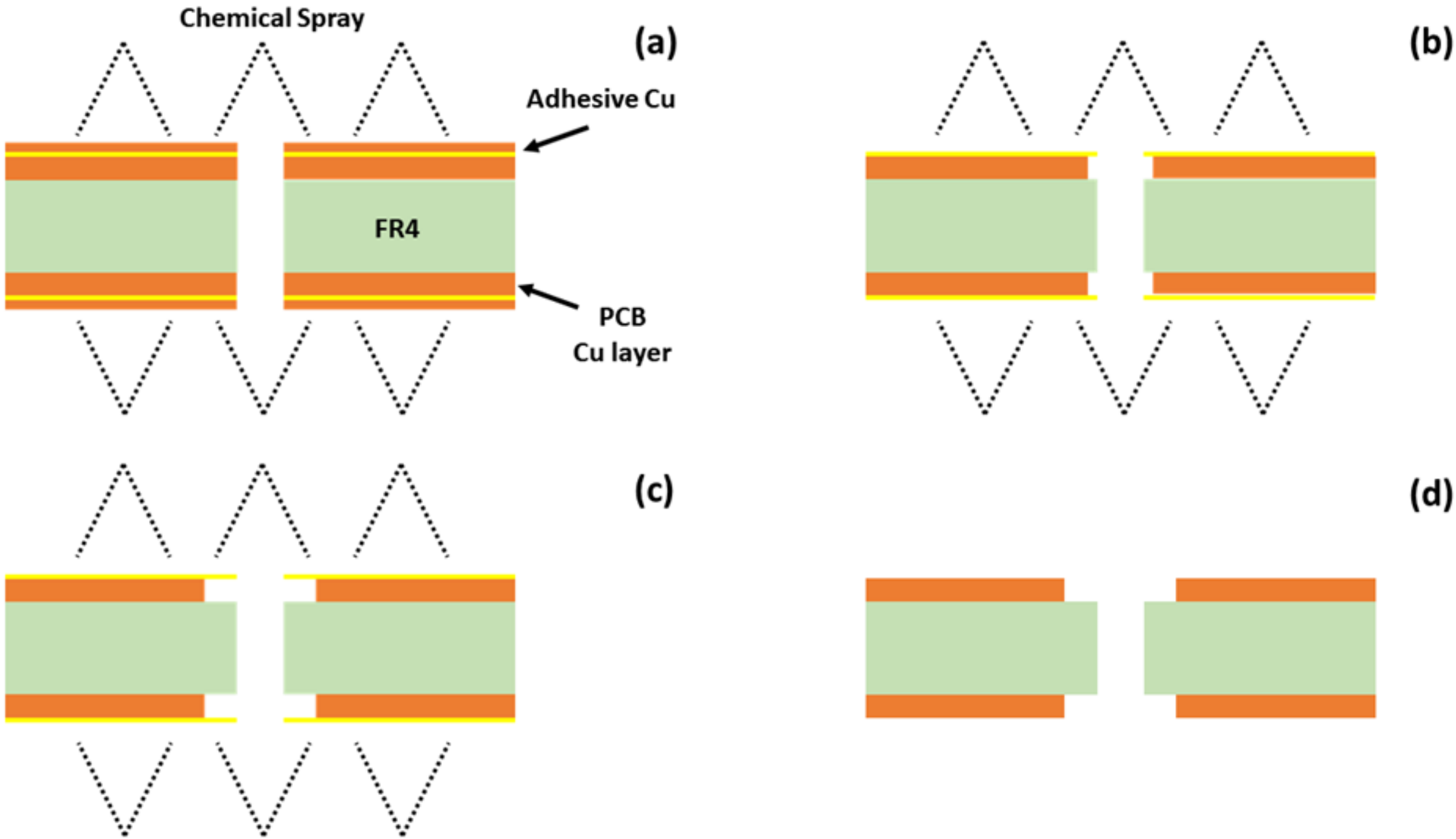
- Developed at CERN by EP-DT-EF.
- LEM copper surfaces protected with thin (15 µm) adhesive copper foils before drilling.
- Micro-etching only around holes, visible through transparent glue.



50×50 cm^2 LEM manufactured at CERN

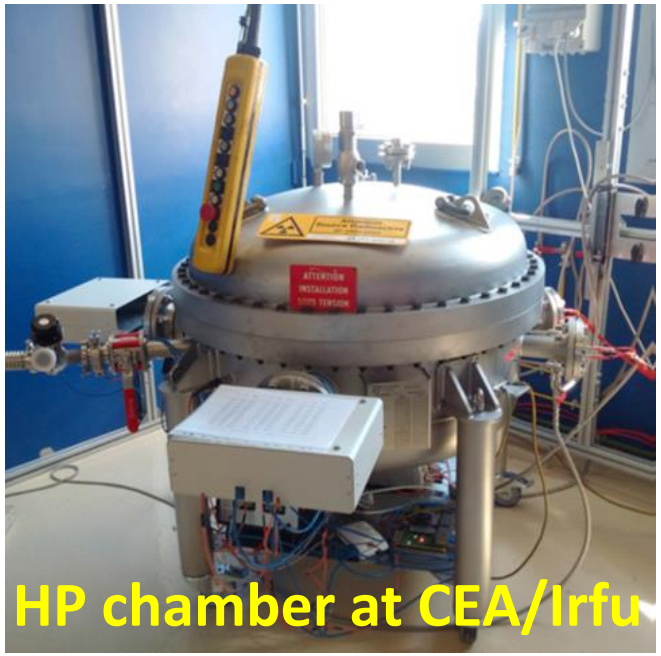


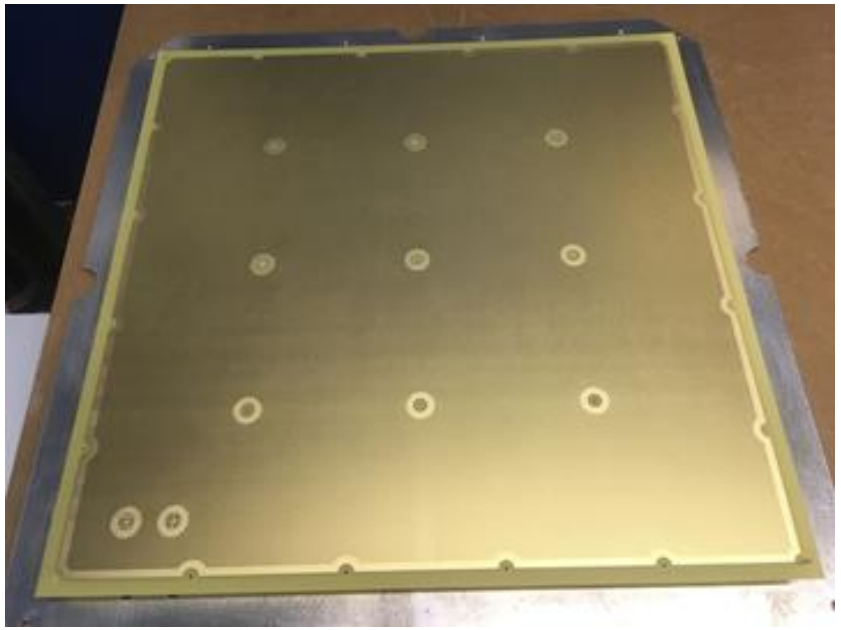
Technology transferable to PCB industry

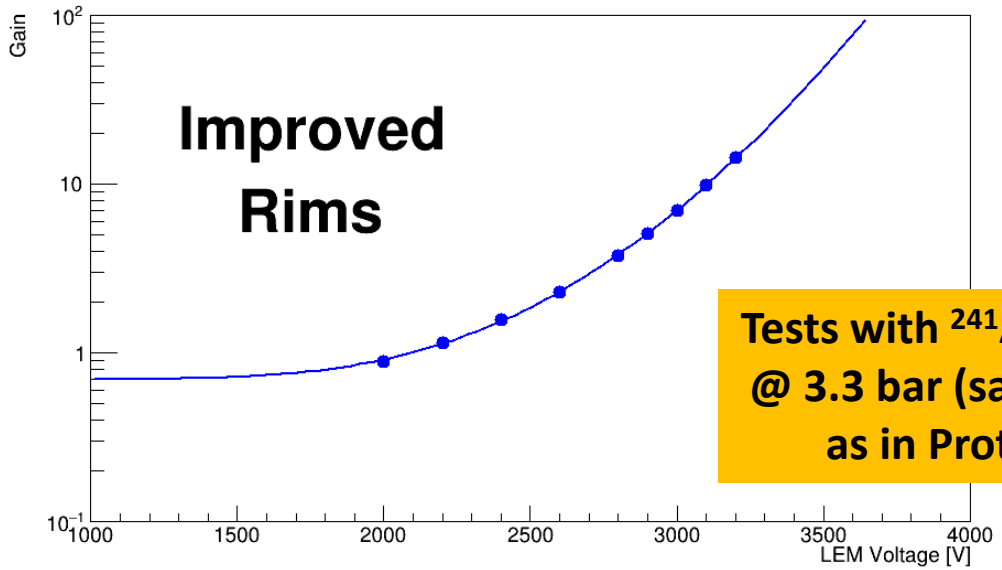

Chemical Spray
(a)
Adhesive Cu
FR4
PCB
Cu layer
(b)
(c)
(d)

LEM with improved rims

- Prototype built by CERN with same design as the one for ProtoDUNE-DP







Tests with ^{241}Am source in Ar @ 3.3 bar (same gas density as in ProtoDUNE-DP)

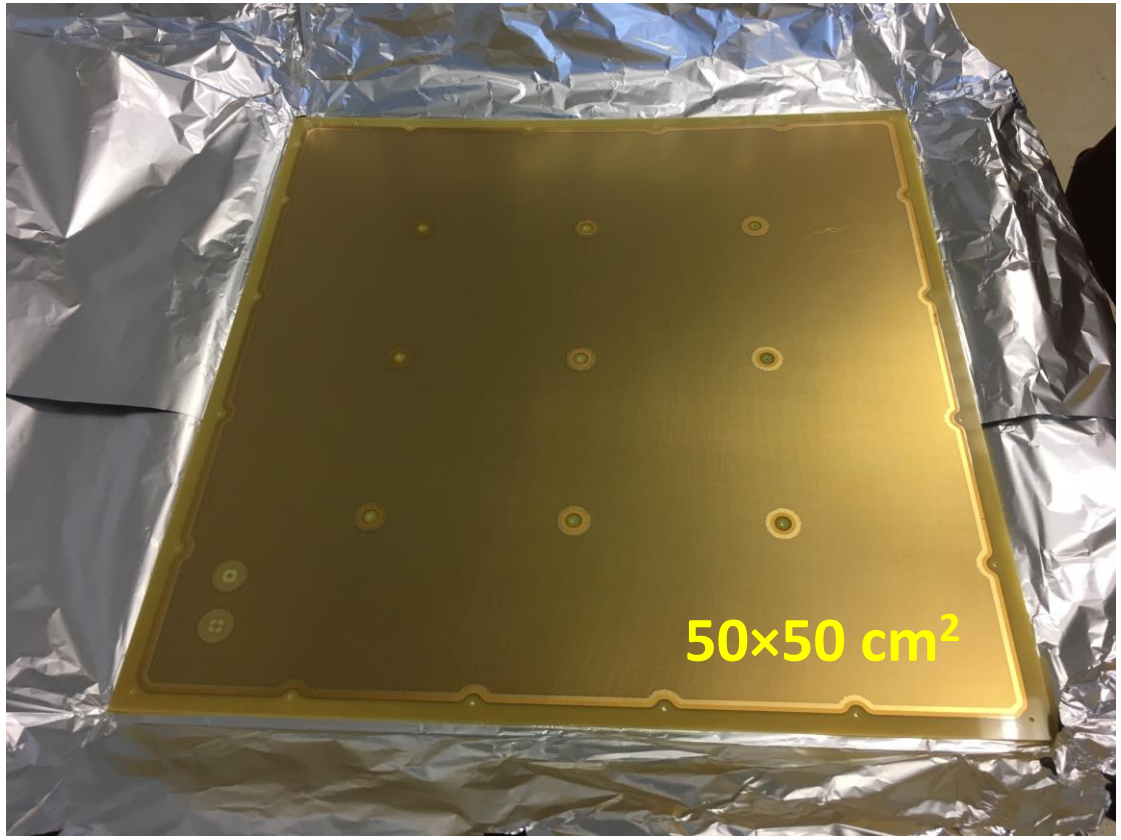
LEM with insulation

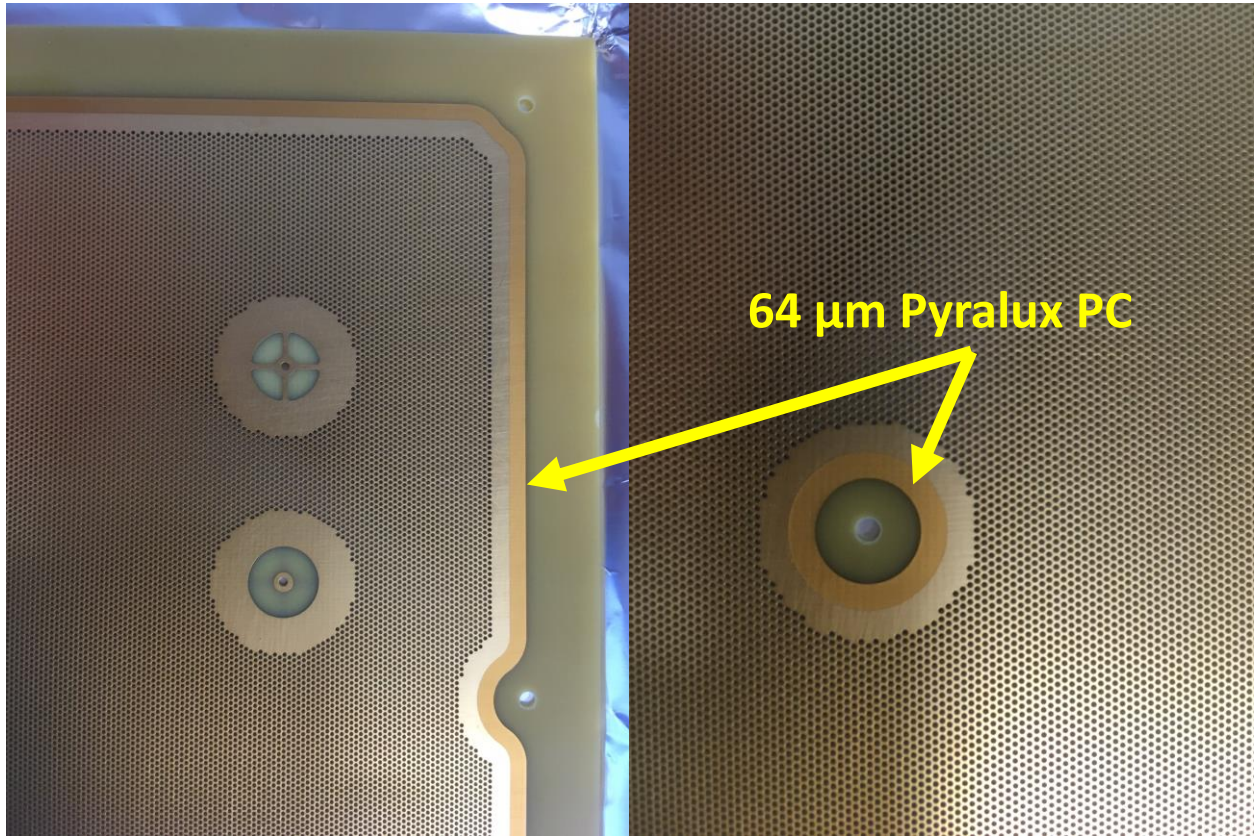
- Improve HV stability by insulating areas where E-field is high (edges, corners, boundary regions).
- Add 64 µm coverlay (Pyralux PC) on dead areas.
- Use improved rim micro-etching process.
- Prototypes built at CERN by EP-DT-EF.
- Technology transferable to industry.
- If successful, increase active area.

LEM prototypes being constructed at CERN

LEM with insulation

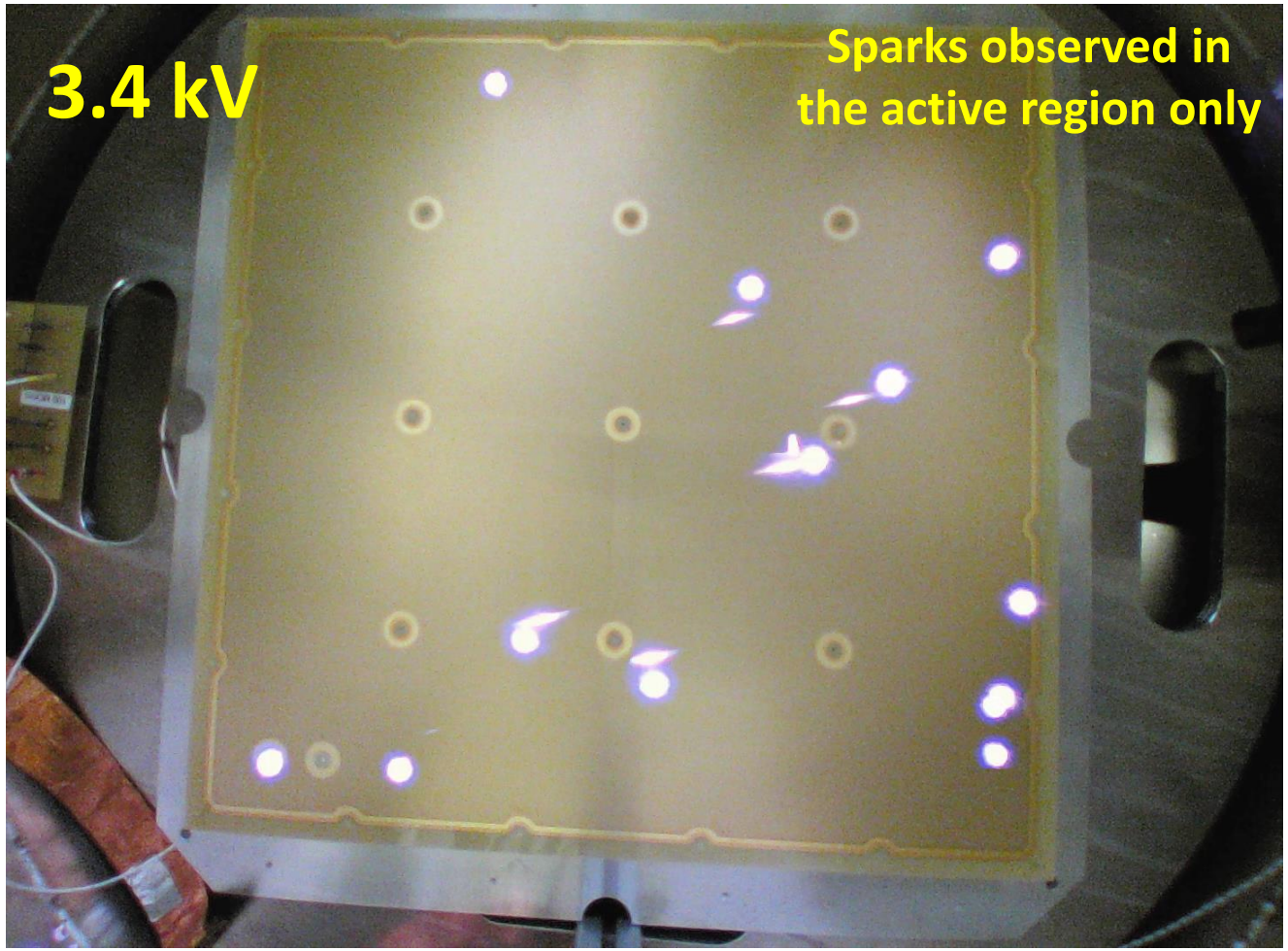
First prototype with insulation and improved rims arrived at CEA/Irfu on Nov. 25th 2019

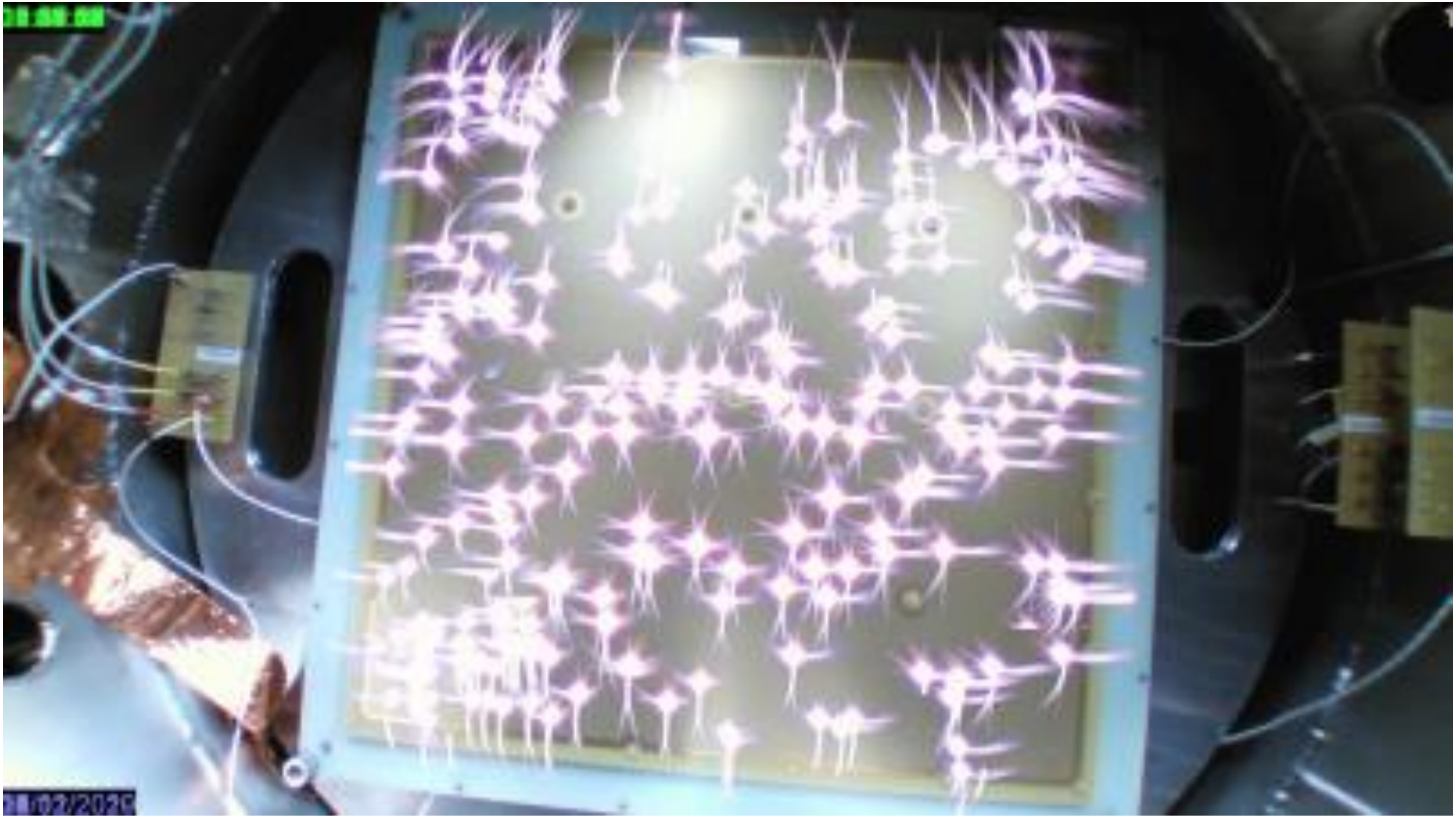




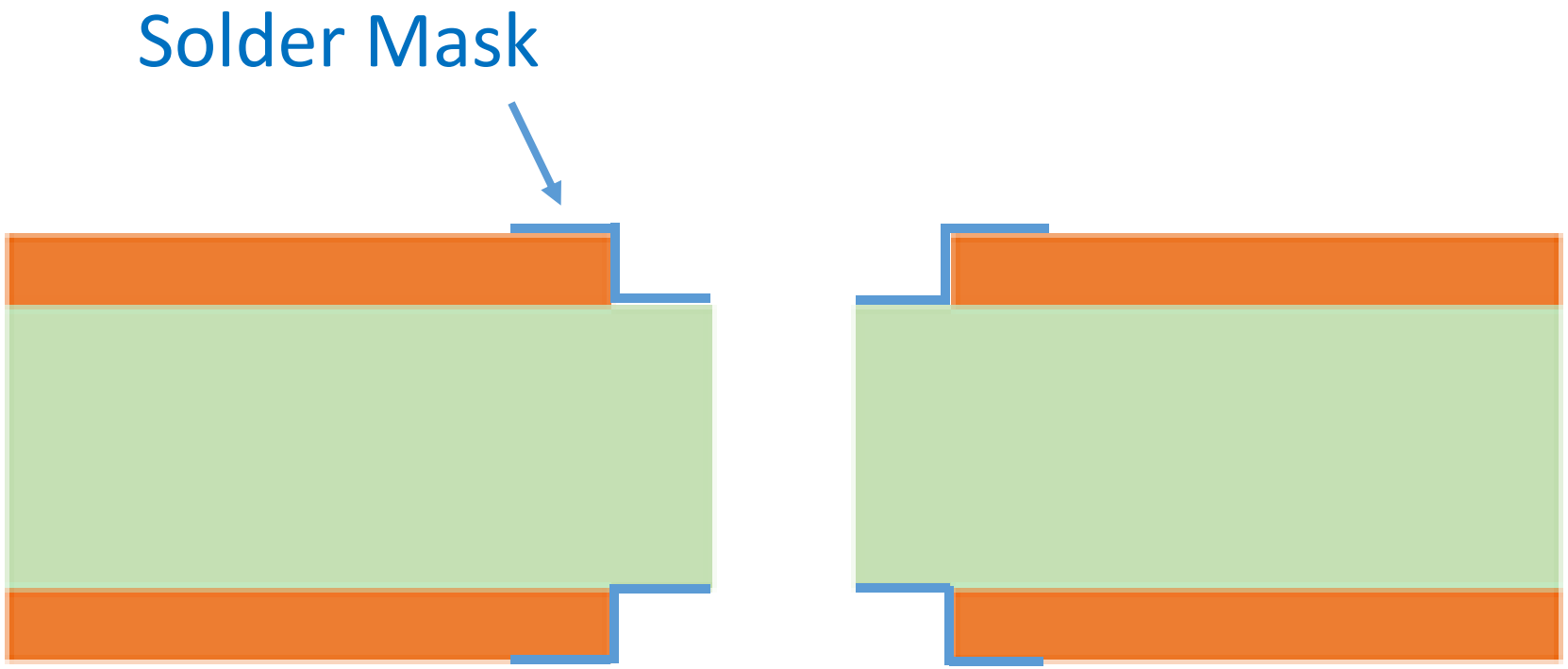
First tests in pure Ar @ 3.3 bar

- Tests in progress at CEA/Irfu.
- Spark rates and amplification gain measurements up to max. HV to be performed soon.



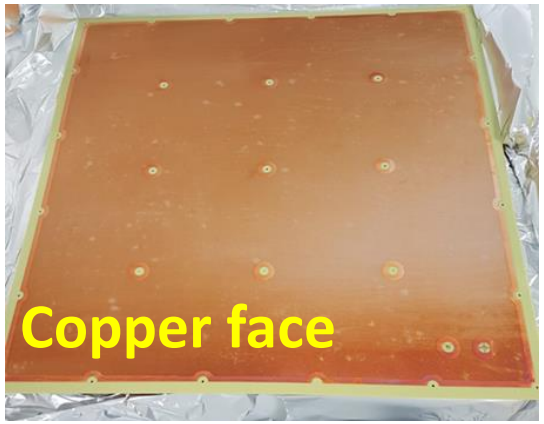


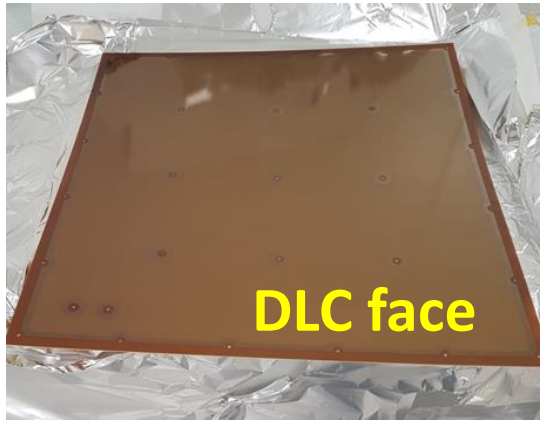
Next …



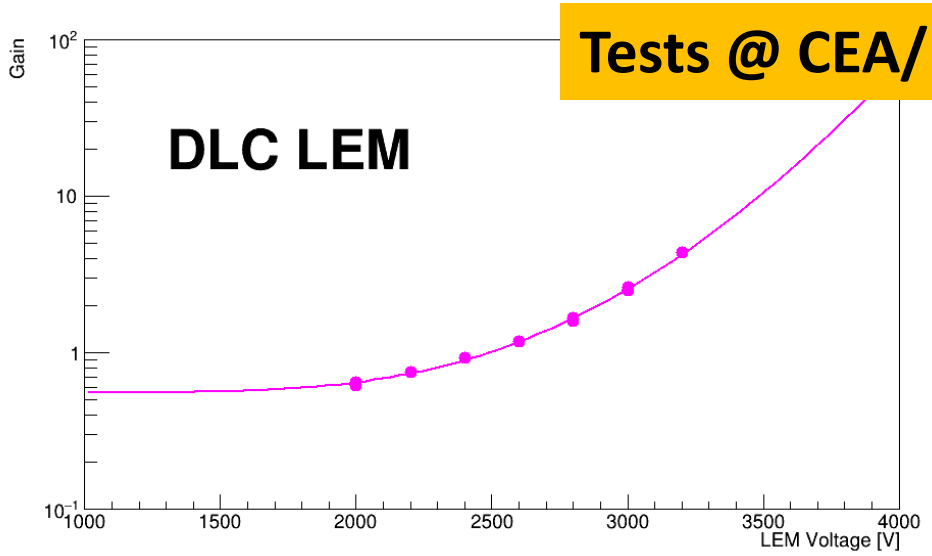
Resistive LEM

- Quenching of discharges with resistive 50×50 cm^2 LEM :
- Made at CERN EP-DT-EF :
  - copper side facing readout anode
  - DLC on 50 µm APICAL polyimide film (250 MΩ/□)
  - same geometry as CFR-35 (ProtoDUNE-DP)
  - no rims, no gold plating on copper face.
- Tests in progress at CEA/Irfu.
- R&D will continue in collaboration with CERN.

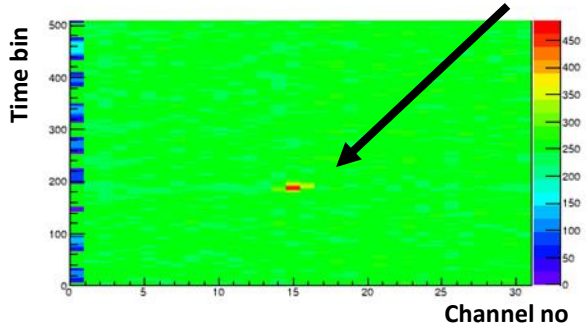


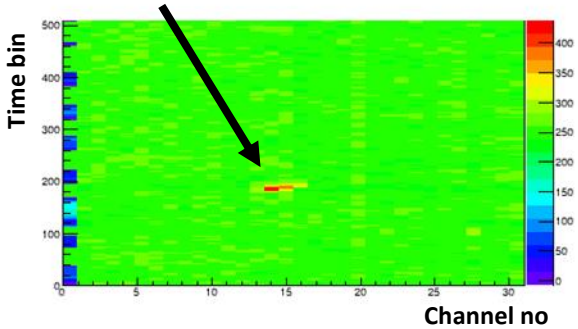


Tests @ CEA/Irfu



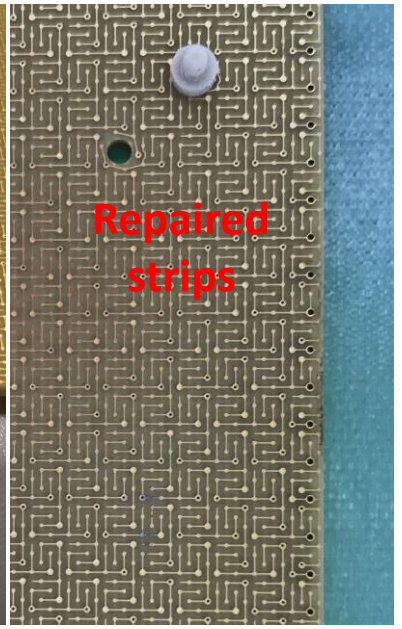
Signal from 5.5 MeV alpha

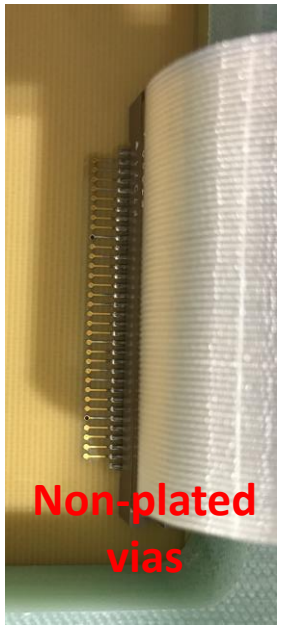




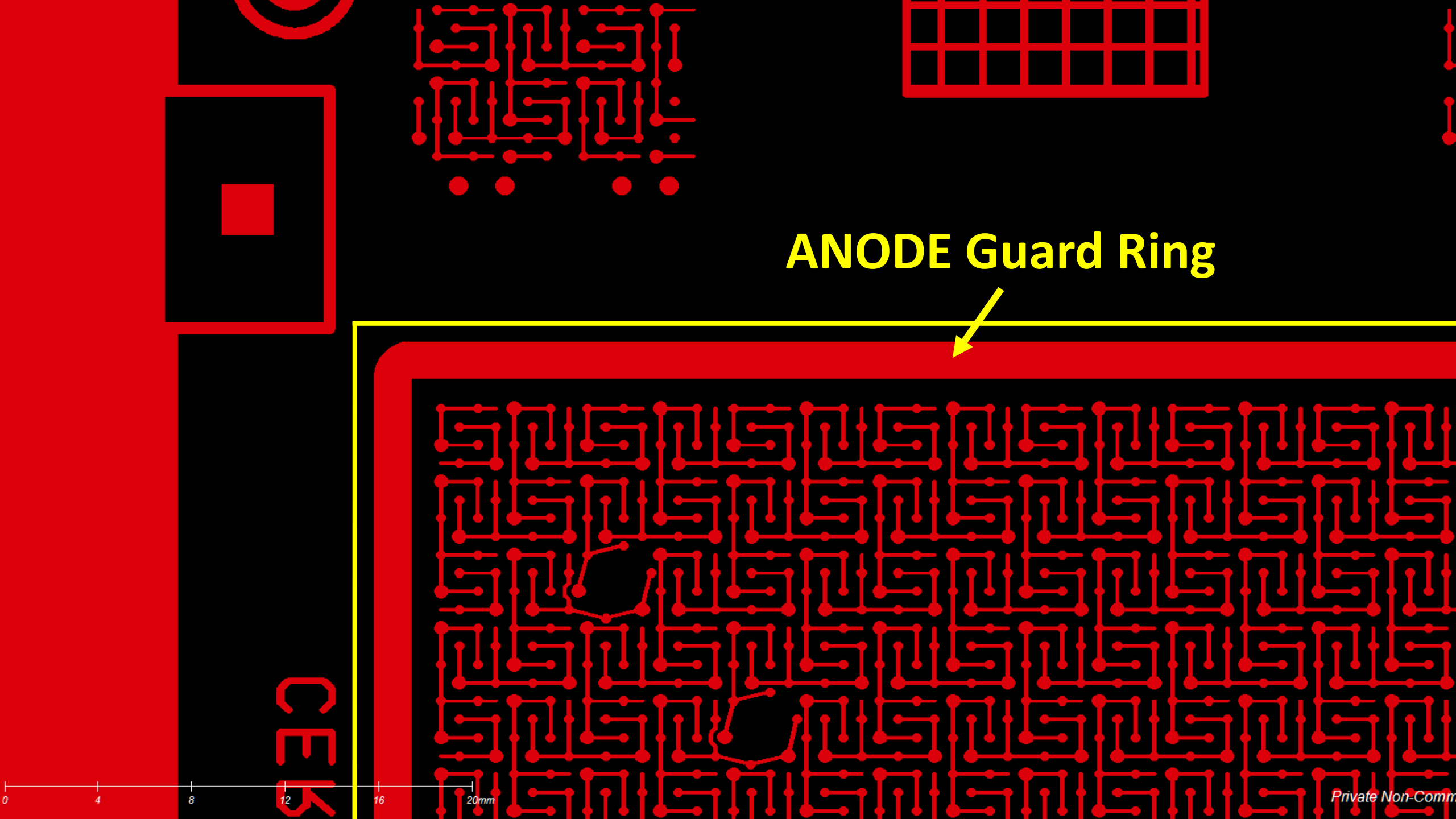
Anode

- No change needed in the anode concept.
- Facilitate manufacturing process with minor changes to fix observed defects (about 10% of anodes for ProtoDUNE-DP had their outer strips damaged ⇒ increase clearance).





- In discussion with ELTOS (Italy) and ELVIA (France) to improve QC/QA.


ANODE Guard Ring
0
4
8
12
16
20mm
Private Non-Comm

CRP

LAPP in Annecy is working on the following improvements:

- Stiffening of the Invar structure :
  - to guarantee a $\pm$ 1 mm planarity in cold
  - to make structure less sensitive to inhomogeneous distribution of mass like cables, instrumentation.
- Implementation of a guard ring around the CRP to avoid grid sparks to reach the anodes and thus potentially damage the FE electronics.
- Development of resistive combs for the Grid to collect ions remaining on the LAr surface (ion feedback). Needs more input from ProtoDUNE-DP
- Consider the possibility to increase LEM-Grid distance from 10 to 12 mm.

Possible schedule for a 2-CRP production
(to replace the current 2 dummy CRPs)

- 2020:
  - LEM prototyping and tests at CEA/Irfu, tests in CB at CERN.
  - LEM & anode final design.
  - CRP prototyping and tests: guard ring, resistive combs.
  - CRP final design.
- 2021:
  - Early 2021: start production of 1st CRP.
  - Mid-2021: tests in CB at CERN and start production of 2nd CRP.
- 2022:
  - Test of 2nd CRP in CB at CERN.
  - Integration in cryostat.