AIDA 2020
WP13 Tasks 4.2 and 4.7

Gaseous detectors Task 13.4.7 : **MPGD detectors to industry**

Preparation for large series production: standard production protocols of optimized MPGD components to ease technology dissemination

(project leader : Fabien Jeanneau)

MS84 (M36) PROTOCOLS AND SPECIFICATIONS FOR MPGD PRODUCTION AND QUALITY CONTROL

AIDA 2020

Grant Agreement No: 654168

AIDA-2020

Advanced European Infrastructures for Detectors at Accelerators

Horizon 2020 Research Infrastructures project AIDA-2020

MILESTONE REPORT

PROTOCOL AND SPECIFICATIONS FOR MPGD PRODUCTION AND QUALITY CONTROL

MILESTONE: MS84

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Abstract:

MPGDs are becoming the most common gaseous detectors used in High Energy Physics and Nuclear Physics. They have promising applications in Medicine, Security, Geology, Cultural Heritage Imaging, power generation, and many other domains of societal applications. Thus the question of manufacturing MPGDs in industry is becoming decisively needed. In the last 3-4 years, we ordered sets of various kinds of MPGD detectors to industrials equipped for various operations as hole drilling (for Thick GEMs), laminating coverlays or meshes (for Micromegas), photo-imaging and others, which are needed in the process of MPGD fabrication. We then tested the products, defining criteria for Quality Control. We report here on this experience.

Grant Agreement 654168 PUBLIC 1 / 10

Gaseous detectors Task 13.4.2 **Resistive anode Micromegas**

Preparation for large series production: procedures and tools for large series resistive micromegas anodes

(project leader : Stephan Aune)

These two tasks are very interrelated.

Thanks to D. Attié, S. Aune, A. Delbart, E.Dumas, F.Jeanneau, M. Kebbiri, E. Mazzucato, M. Mur

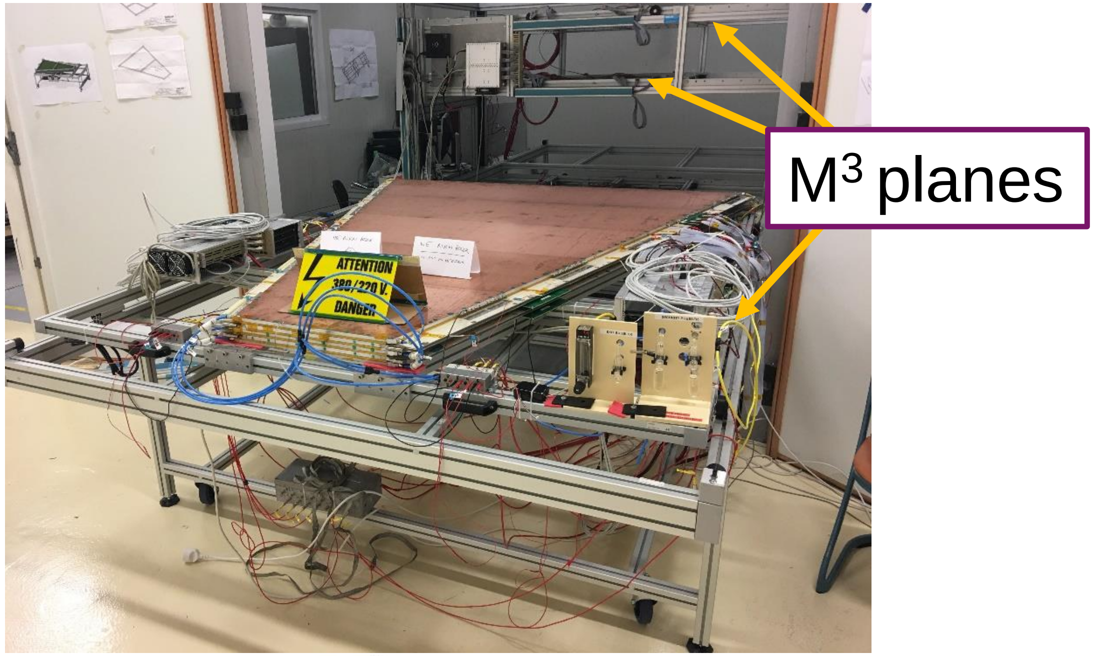
Initial motivation in 2014-2015 : Production of large Micromegas detectors for NSW (ATLAS muon chambers)

CERN workshop, though upgraded –for prototyping– in AIDA, is not sufficient to produce the 1200 m² of chambers needed for ATLAS New Small Wheel.

QC/QA of base elements from ELTOS and ELVIA done at CERN (bdg 188, see report in second annual meeting)

Assembly of the chambers in 4 labs in Germany, France and Italy.

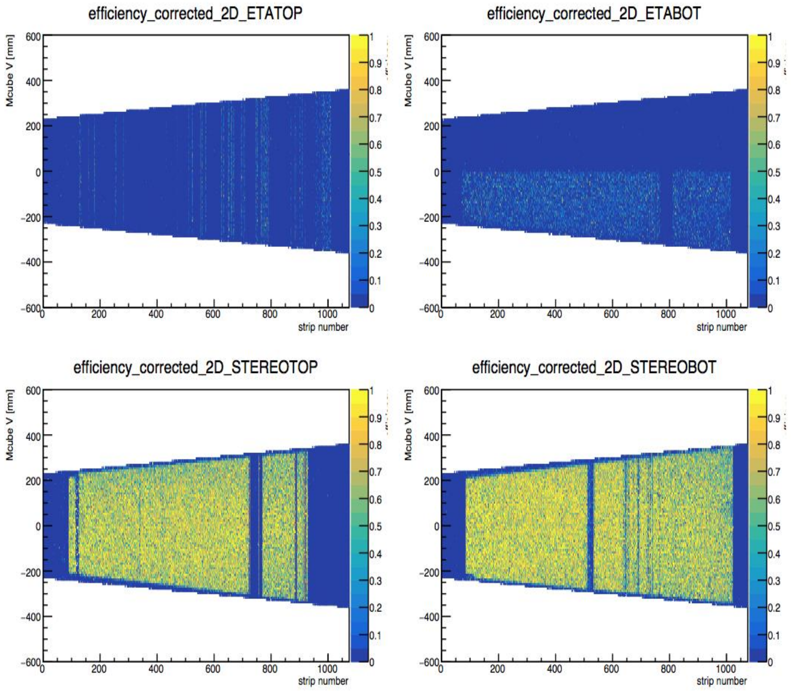
Cosmic Ray Setup at Saclay



The Cosmic ray test bench is a key part of the NSW on-site validation of the large modules

- 3 tracking planes of 1 m^2 from Mcube exp.
- Trigger provided by M^3 (1500 channels)
- DREAM-based DAQ (5000 multiplexed channels)

THE SETUP PLANNED AT THE BEGINNING OF AIDA 2020 IS NOW OPERATIONAL




NGL + warm water + brush

CIF application + more aggressive brushing (!)

Rinsing + brush at the same time (!)

No tape masking (!)

+ Drying


500x500 mm² resistive Micromegas produced for muon densitography (for Security, Cultural Heritage, and industrial applications). Screen-printing at a pitch of 500 µm on kapton now used at CEA to improve the resolution by charge sharing.

Bulking at CERN and Industry

In 2016-2017, 40 large bulk Micromegas have been built: 20 at CERN and 20 at ELVIA. Steady improvement of ELVIA quality.

PCB from ELVIA

+

Screen-printed Kapton at CEA

⇨ Pressed and bulked at ELVIA

In 2018, 40 more resistive bulks will being produced at ELVIA, 20 with screen printing and 20 with DLC. Issues on pressing dispersion and stability, now understood: high resistivity past tends to crack when pressed

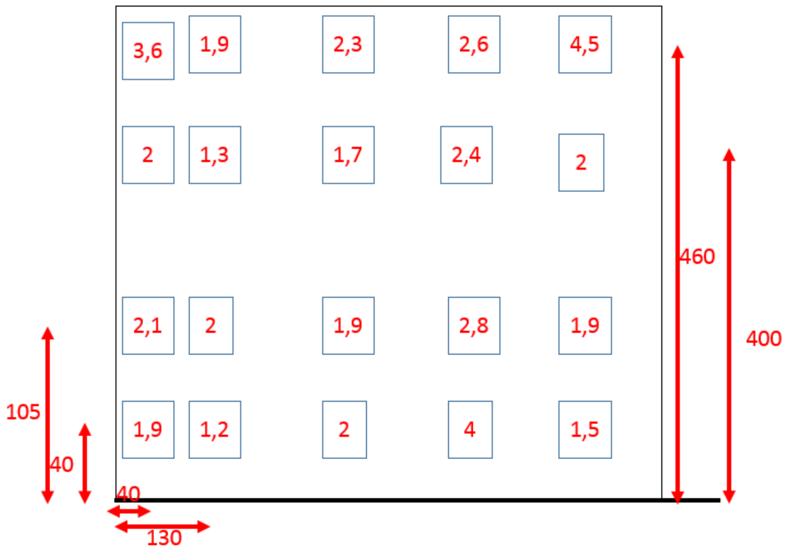
MUON DENSITOGRAPHY : PROSPECTS

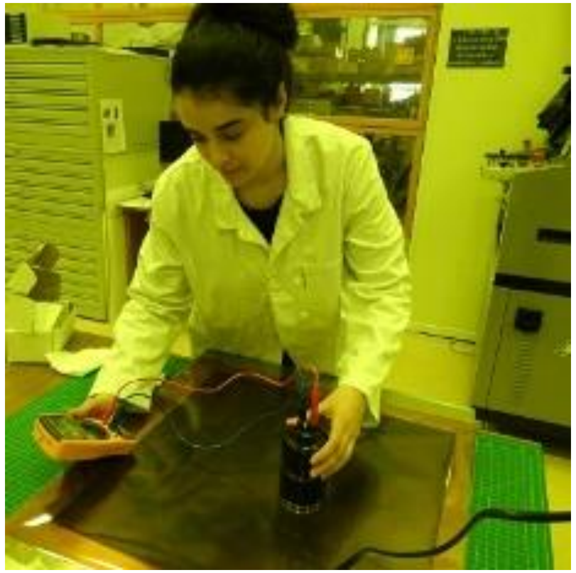
Many applications

- Homeland security
- Scan pyramids and other ancient graves
- Muo-graphy of stones
- Control of concrete buildings
- Mining
- …

But still a market has to be found to make industrial production cost-effective

Resistivity measurement protocole defined and reproducible, using circular probe and square ‘Ochi’ probe for plain coating



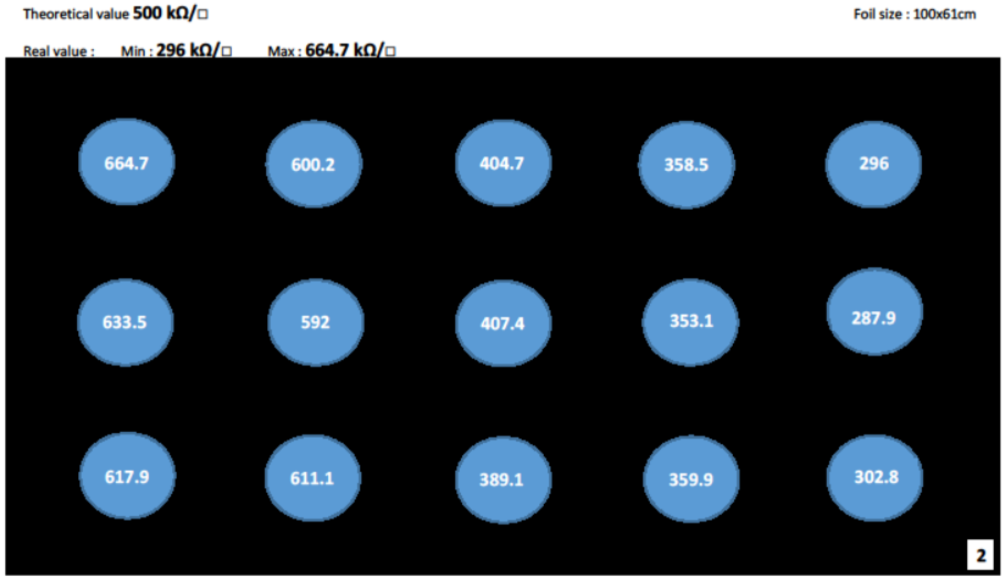


And ‘square counting’ for resistive strips

under Microscope

RESISTIVITY MEASUREMENTS

Resistivity measurement protocole defined and reproducible, using circular probe and square 'Ochi' probe for plain coating

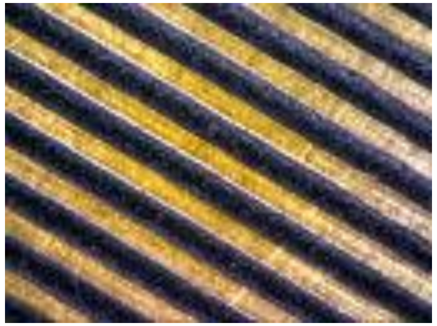


Lower resistivity DLC-coated foil for T2K TPC

And 'square counting' for resistive strips under Microscope

IMPROVEMENT OF STRIP QUALITY

Problem 1 : ink spreads so that strip width is larger than what is on the mask



Solution: adapt the mask to fine enough pitch to compensate

Problem 2 : Static electricity and dust degrade the stips

Solution : Discharge the base foil and work in a dust-free environment

Problem 3 : unstable high resistivity (pressing at 12 bar at ELVIA for NSW takes the 400 kOhm/sq made in Japan to 800 kOhm/sq).

Solution : after 11 trial productions spread from Feb. 2018 to October 2018, a process to make homogeneous production was determined:

- Humidity control
- Improvement of the clean room
- 1 Mohm paste + 10 to 30% of 100 kOhm + 5% of neutral paste (insulating) + a few drops of solvant, careful mix and immediate screen-printing.
- Pressing at 7 bar at ELVIA.
- The result is more uniform than DLC, at 3.4+-0.2 Mohm/sq

LEM PROCUREMENT

LEMs / THGEMs are MPGDs using PCB drilling technology : holes are drilled in a FR4 panel between 2 coper layers.

The most delicate feature is a rim around each hole, which has to be wide enough to prevent discharge triggering, and narrow enough no to affect too much the amplification field in the hole.

A careful sanding down is necessary to trim any point triggering discharges

72 THGEMs have been produced in 2018 to equip half of the protodune DP detection plane.

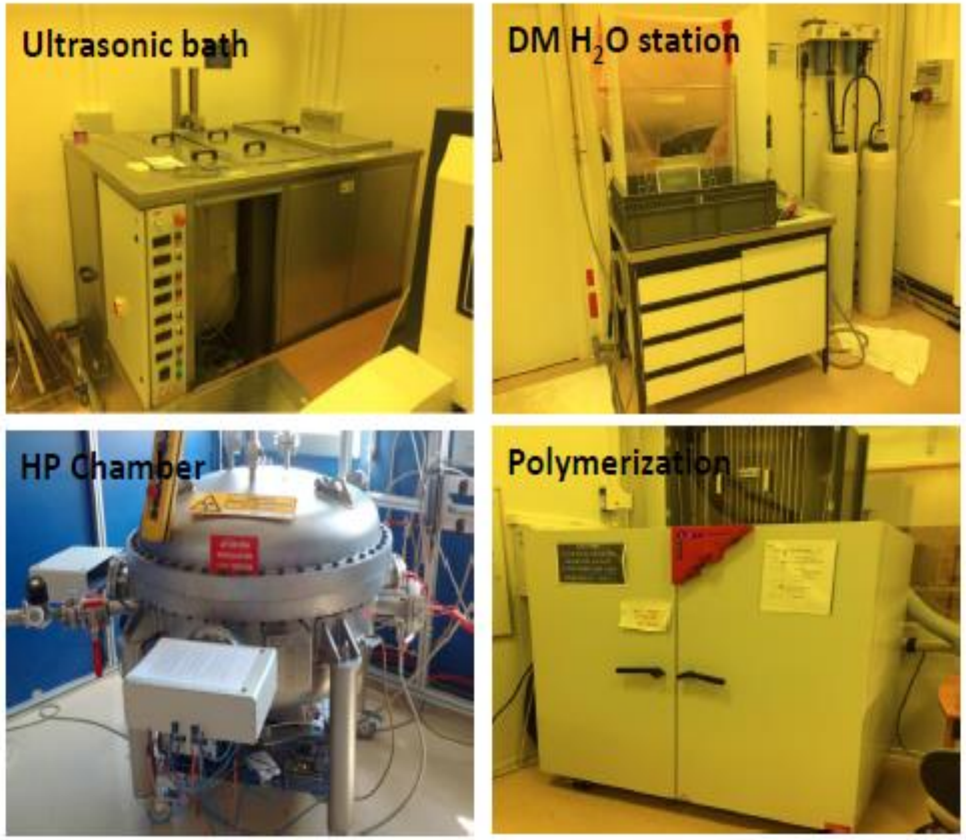
LEM PROCUREMENT AND QC/QA

80 50x50 cm² LEMs are to be produced for the demonstrator for DUνE (neutrino long baseline experiment) and tested at Saclay under pressure

CEA/ Irfu is in charge of procurement and validation of half of the 144 LEMs necessary for the 6x6x6 m3 prototype of Dune. All the infrastructures necessary for the preparation and tests are available at Saclay (cleaning, baking, polymerization, metrology, etc…)

A high-pressure chamber has been built to perform LEM tests in argon at the same gas density as in the experiment (3300 hPa at room temperature).

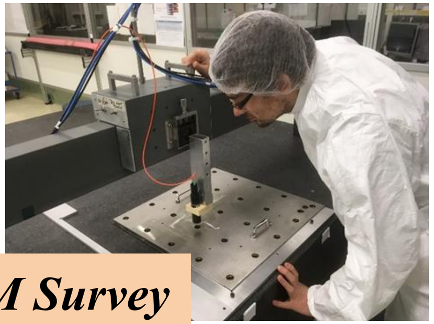
LEM production started in July 2017 (contract with ELTOS for 78 LEMs)



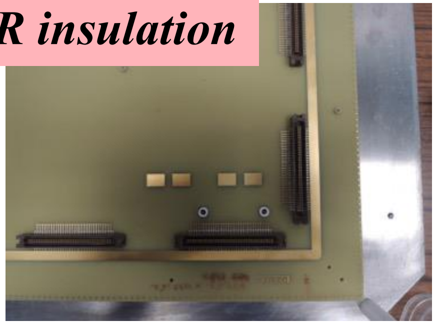
LEM production

(Jan. – Oct. 2018)

- LEM manufacturing by ELTOS (Italy) – requested specifications met (FR4 and copper thicknesses, hole, rim and LEM size)
- Characterization and tests @ CEA/Irfu
- 74 LEMs produced and validated for 2 CRPs

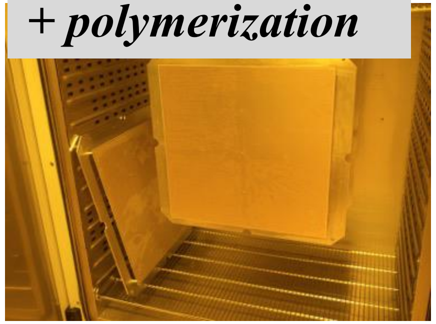


LEM Survey



Soldering HV pins + glueing MACOR insulation

Ultrasonic bath



Cleaning + drying + polymerization

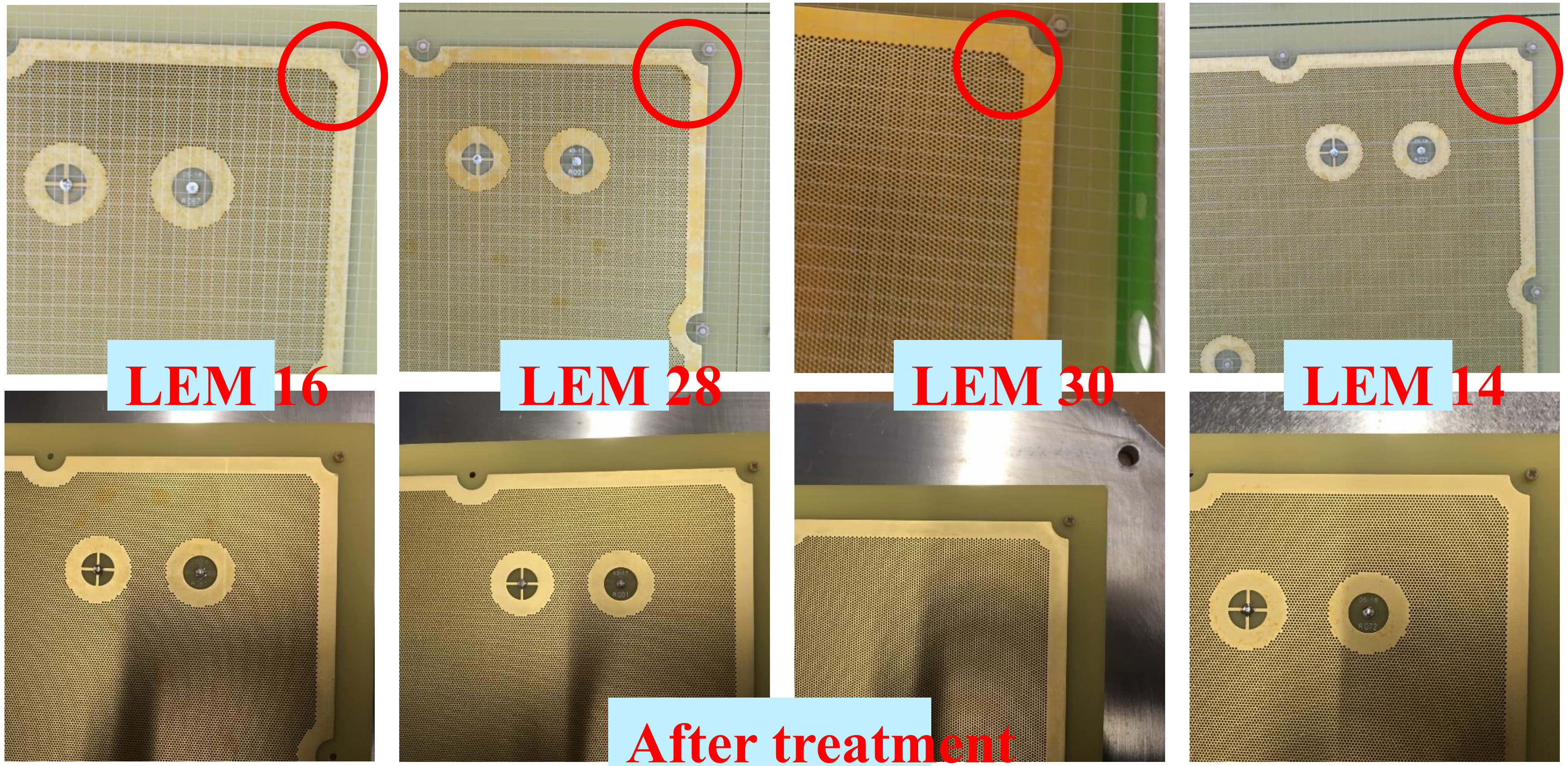
ISSUES WITH A FEW LEMS (5/72)

INSPECTION OF DISCHARGING LEMS AFTER TESTS IN COLD BOX REVEALED DARK SPOTS IN THE CORNERS

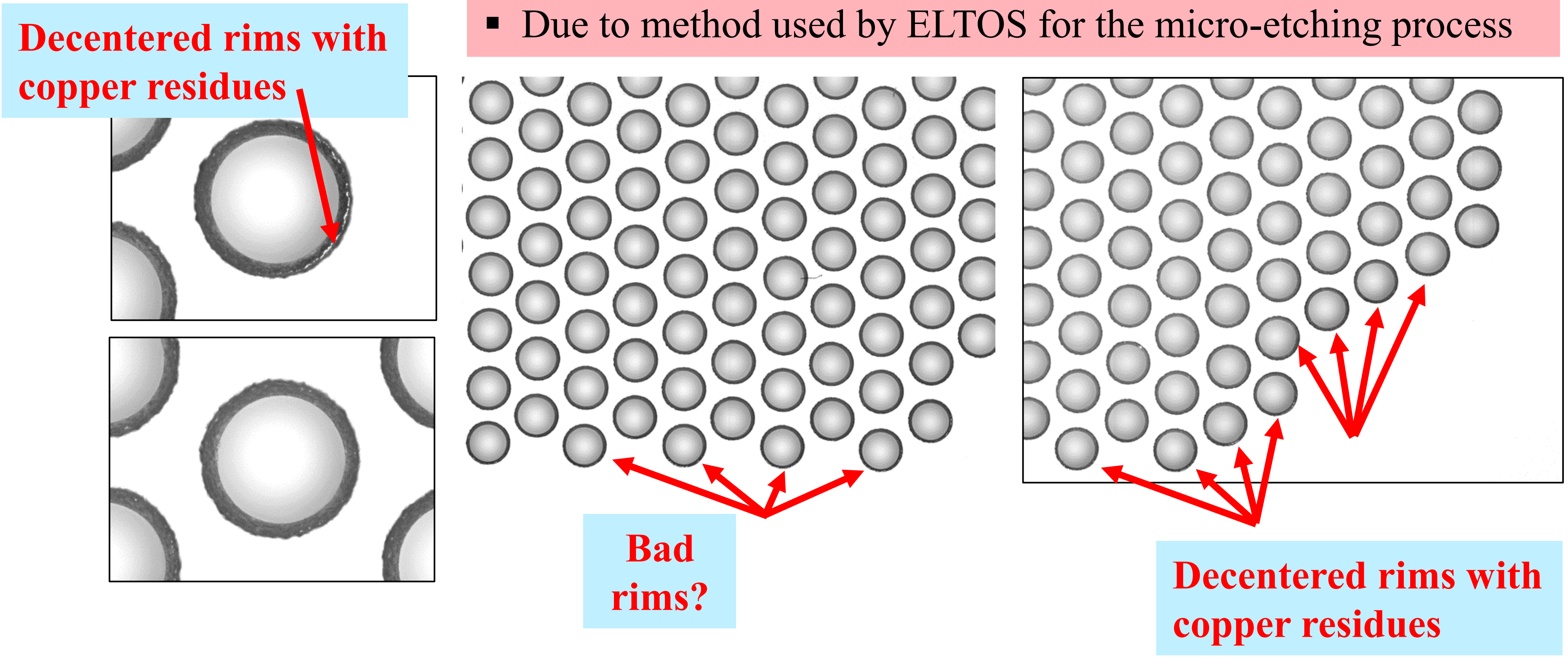
- Points to a weaker region of the LEM

- Treated with potassium permanganate @ CERN to remove carbonized FR4 inside holes.
- Copper surface unaffected.
- LEMs operational again

- Work in progress with CERN EP-DT-DI

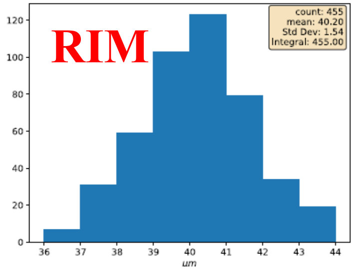


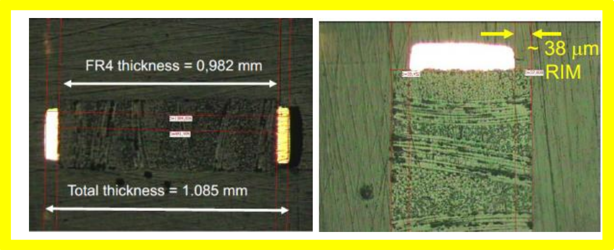
- Rims around holes near the LEM edges/corners appear to be decentered and containing copper residues
- Problem known by Rui de Oliveira (CERN EP-DT-EF)
- Due to method used by ELTOS for the micro-etching process

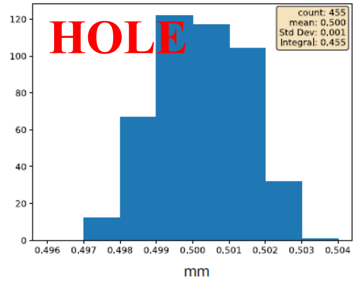


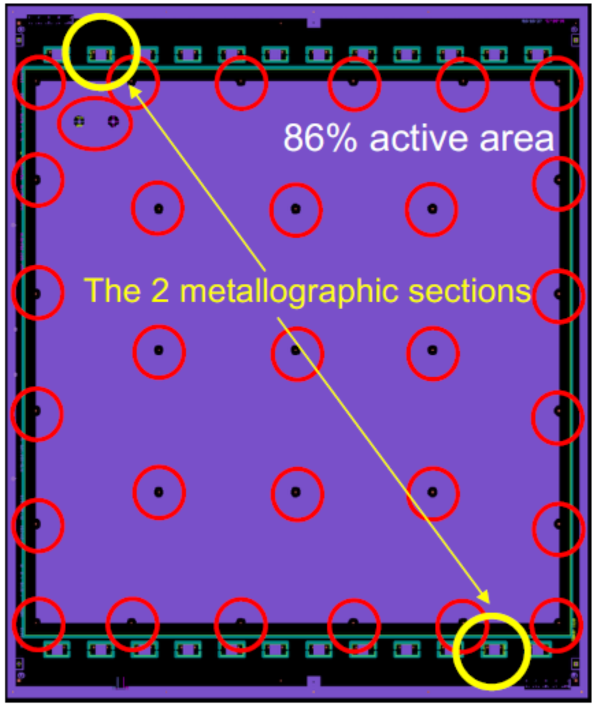
LEM Specifications

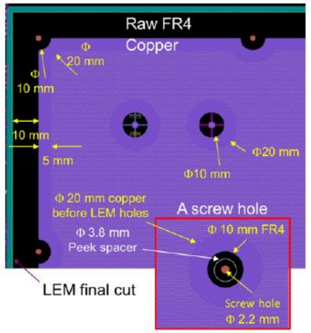
Laminate specifications	
Laminate	FR4 epoxy PANASONIC R-1566W
Dimensions	530 mm x 540 mm
Bare FR4 epoxy thickness	1 mm (-0.05 /+0 mm)
Copper thickness	105 μm
Mean thickness	1,20 (-0.06/+0) mm
Thickness uniformity	+/- 0.04 mm
final LEM specifications	
Dimensions	499.5 mm x 499.5 mm +0/-0.3 mm
Ni/Au	5 μm Ni + 0.1 μm Au
Final thickness	1.10 (-0.05/+0.02) mm
LEM holes	≈ 400 000 non-plated Φ=0.5 mm -0/+0.01 mm
RIM (with Ni/Au)	40 μm +/- 4 μm

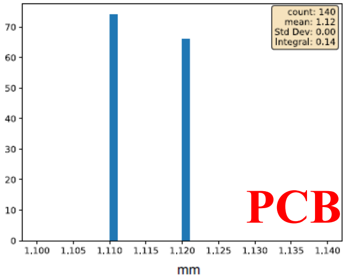


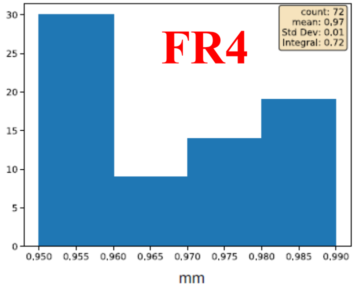






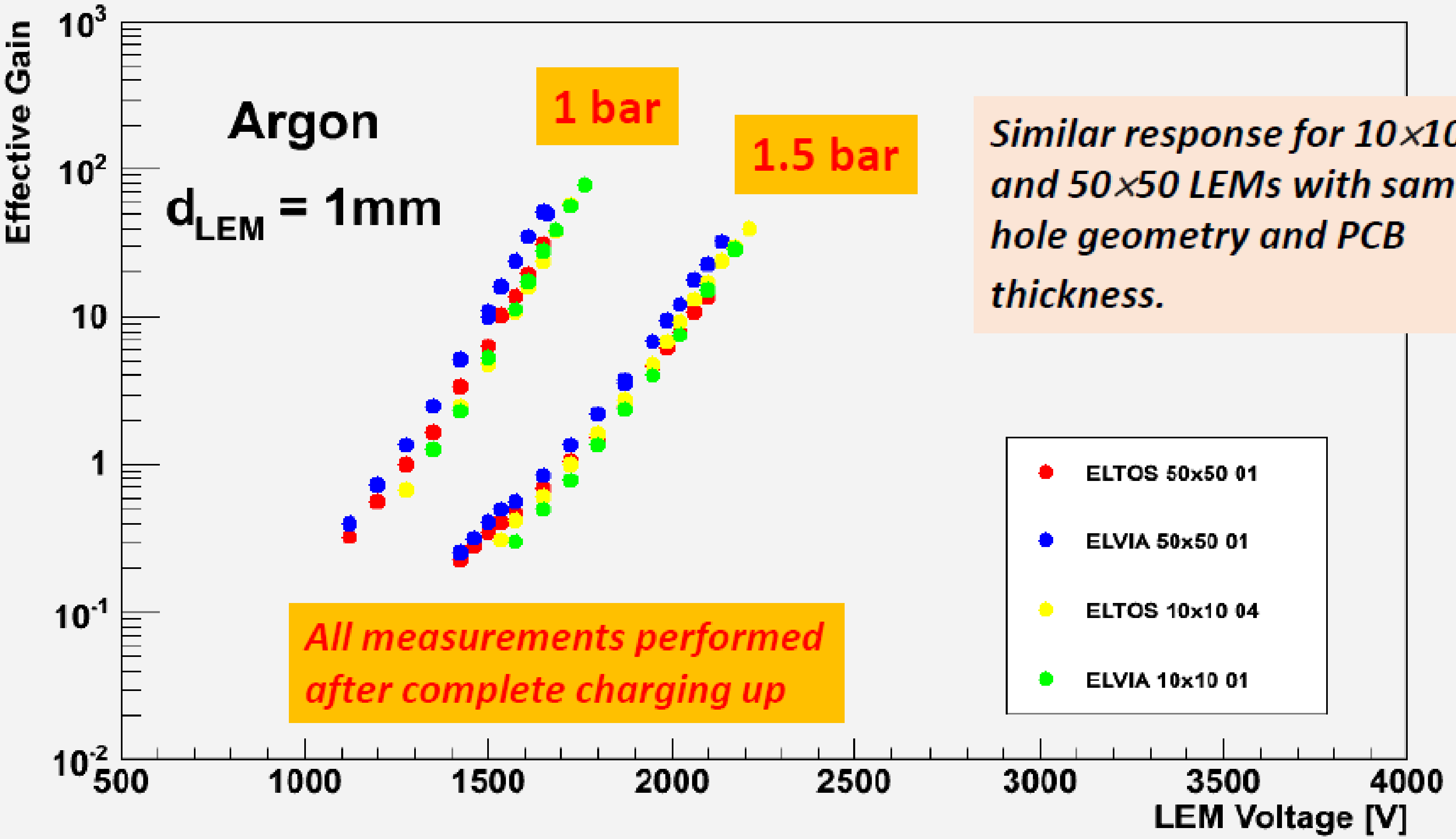






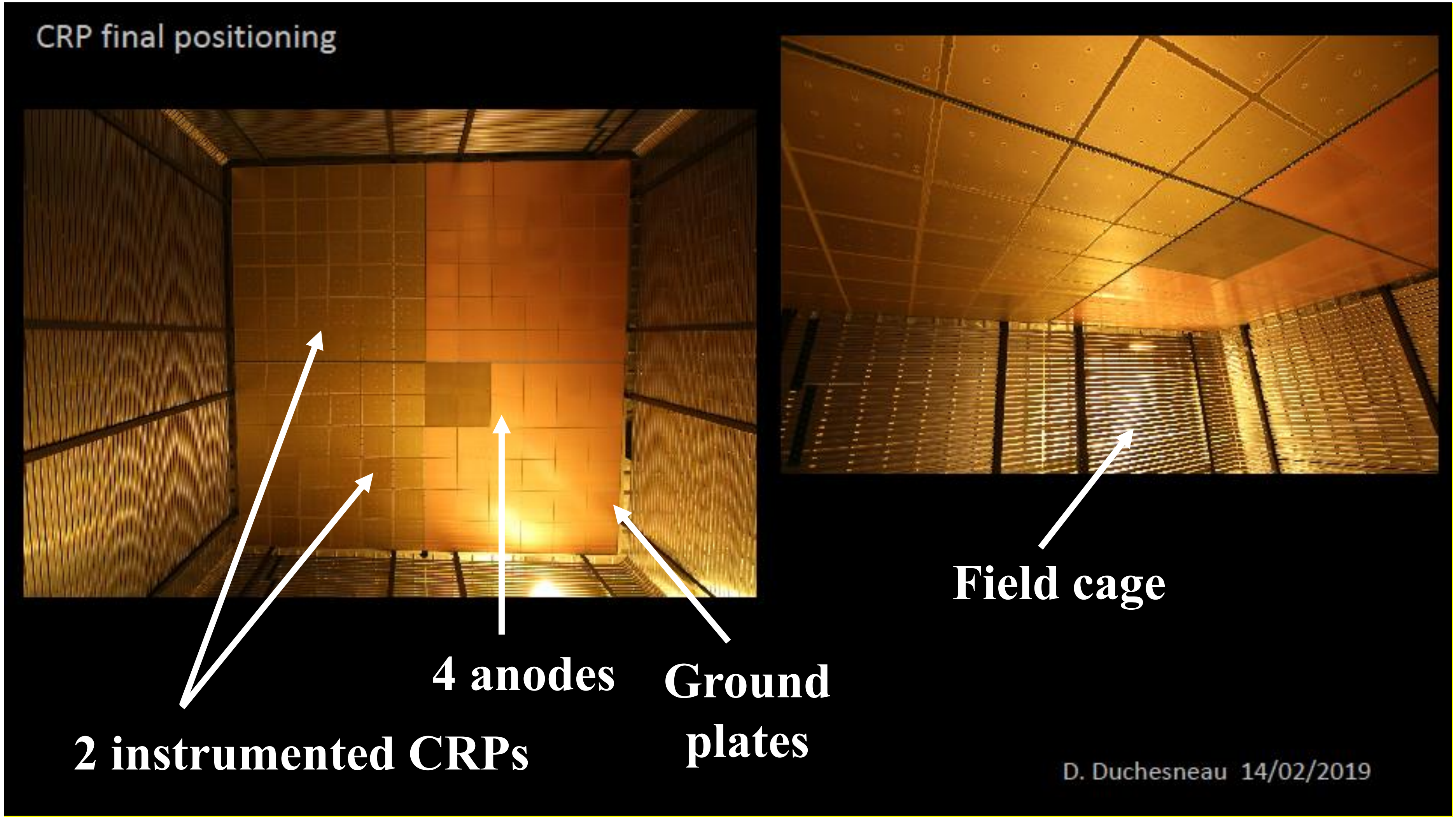
LEM GAIN MEASUREMENT AND BREAKDOWN TESTS

(Spring 2017)



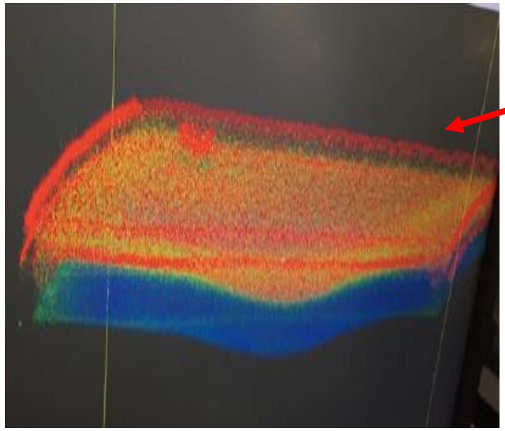
Similar response for 10×10 and 50×50 LEMs with same hole geometry and PCB thickness.

CHARGE READOUT PLANE OF DP-DUNE NOW INSTRUMENTED



E. Mazzucato

The xy table for flatness measurement of NSW (ATLAS muon) Modules was used to characterize TPC panels



The Aluminum frame is not deformed

Maximal deformation of the PCB : 130µm

Owing to remaining 8000 euro and good stocks of base material (resistive paste, substrates, test detector), the studies of 13.4.2 and 13.4.7 WP will be continued until the end of the AIDA2 project in 2020 and published.