AIDA 2ND ANNUAL MEETING
WP13 TASK 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)

Gaseous detectors Task 13.4.2

Resistive anode Micromegas

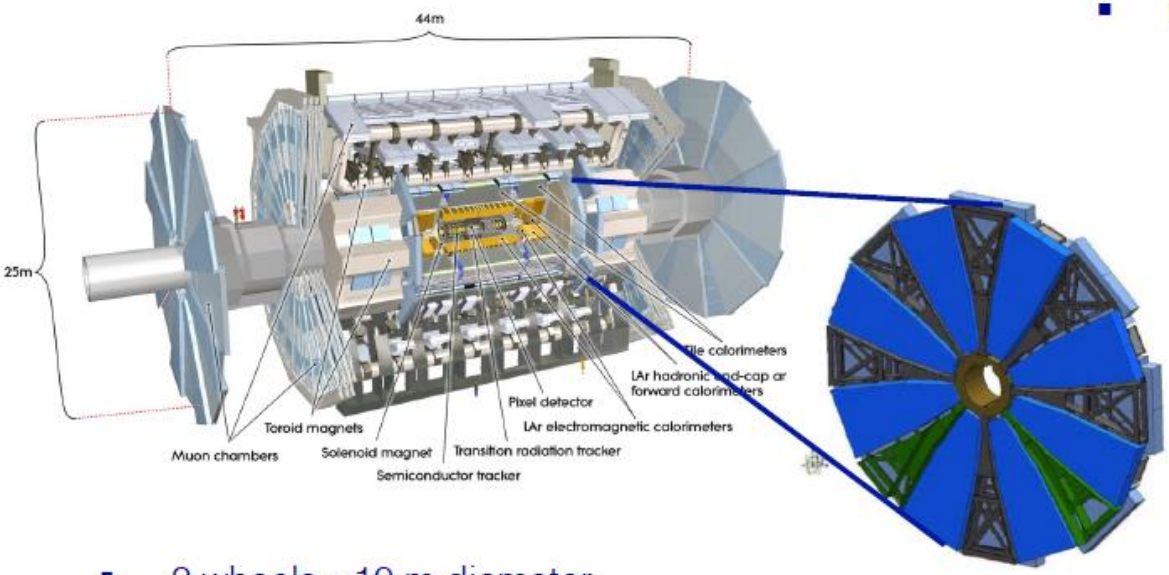
Preparation for large series production: procedures and tools for large series resistive micromegas anodes

(project leader : Stephan Aune)

These two tasks are very interrelated. The Resistive Anode task has a deliverable now (D13.7 for M24)

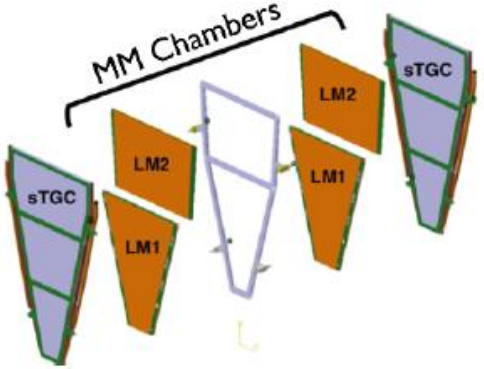
The ATLAS New Small Wheel project

- Upgrade of the innermost forward detector wheels of the ATLAS muon system during LHC Long Shutdown 2 (2019/2020)



- NSW requirements
  - Spatial resolution up to 32° track inclination
    100 um in precision coordinate (η)
    ~mm in azimuthal coordinate (φ)
  - 1 mrad angular resolution (from HL-LHC L1 trigger requirement)
  - Bunch crossing identification
  - Efficiency > 98%
  - Rate capability > 15 kHz/cm2

- 2 wheels ~10 m diameter
- 2 detector technologies both with triggering and tracking capabilities:
  - Micromegas: primary tracking detector
  - sTGC: primary trigger detector
- High redundancy: 8 sTGC and 8 MM layers arranged in quadruplets

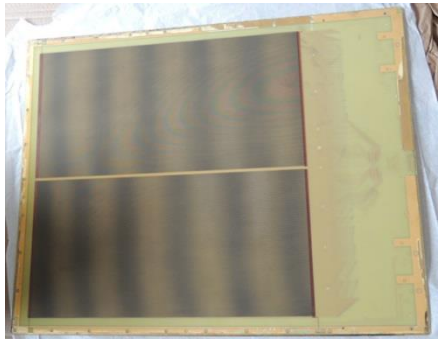


R&D – KNOW HOW TRANSFER

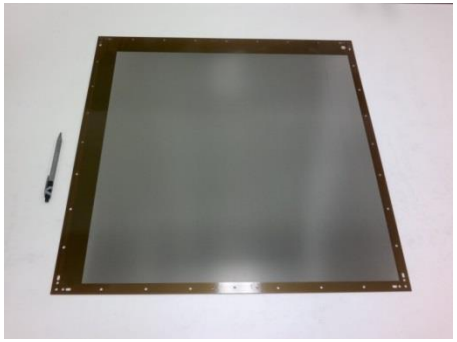
⟶ Know-how transfer to ELVIA-PCB since several years

LARGE MICROMEGAS FOR NSW (ATLAS MUON CHAMBERS)

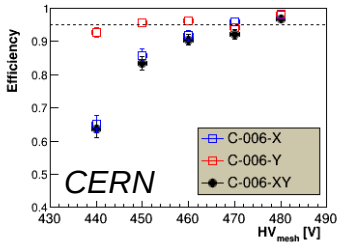
2013

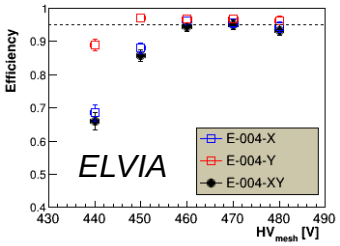


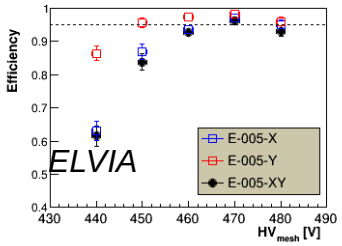
End 2015

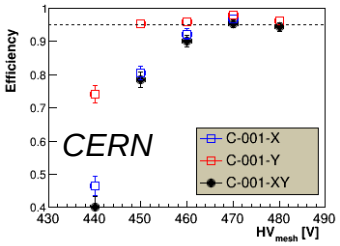


March 2016





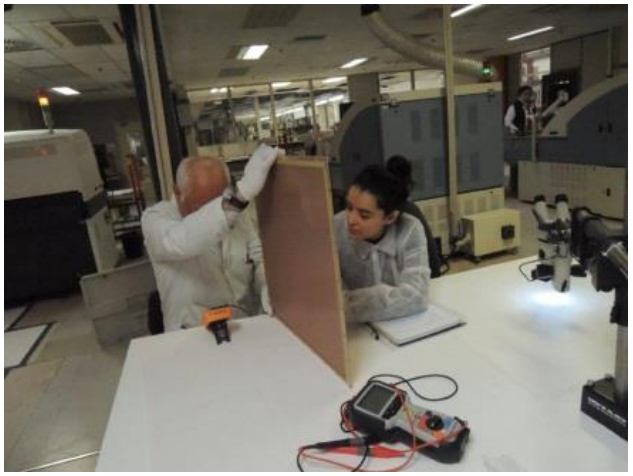




First operational prototypes in 2015
Now NSW under construction

Compatible performance between Cern and Elvia prototypes

Transfer in progress

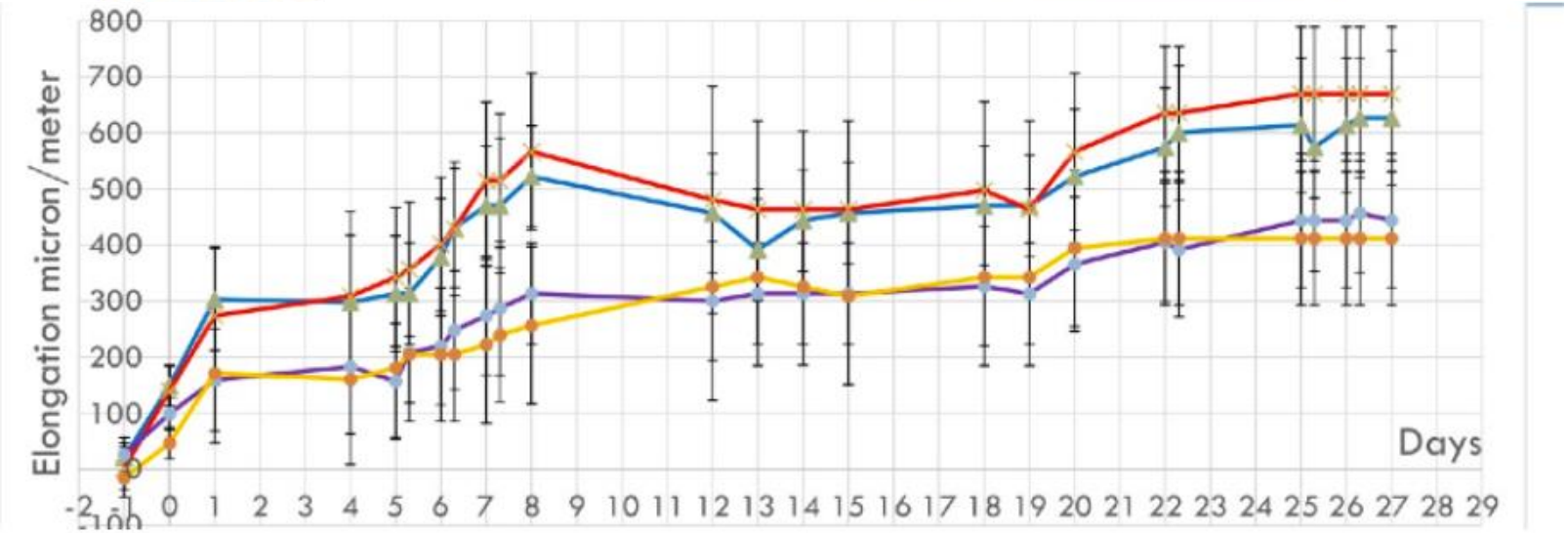


IMPROVEMENT OF THE QUALITY

- Enclosures and bubbles

Module0 boards: 2015

Great improvement:
- Technological transfer
- Procedure and work-flow optimization
- Cleanliness during gluing

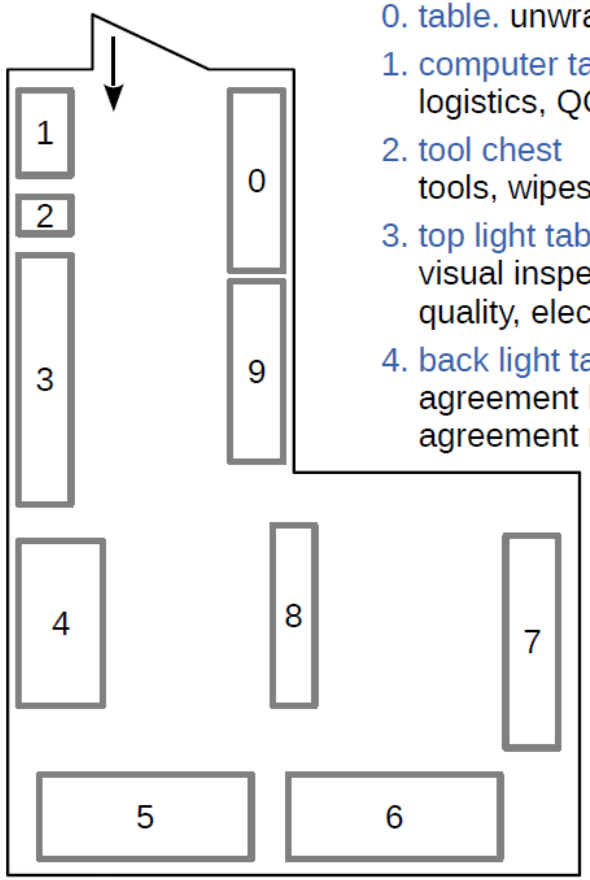


- Confirmed expansion as mostly related to humidity level (small effect of T)
- Saturation at ~+450µm/m

PRODUCTION – QUALITY CONTROL

→ Now ELTOS and ELVIA are doing the production and CERN is doing the QC

Quality Control Workflow – QC Lab in 188



0. table. unwrapping
1. computer table
   logistics, QC form setup, check of supplier report, coffee machine
2. tool chest
   tools, wipes, gloves & chemicals
3. top light table
   visual inspection, pairing of res. foil and board (log db), etching quality, electrical tests
4. back light table
   agreement holes & Cu pattern, edge precision & straightness, agreement resistive & Cu pattern, pillar pattern
5. rasmask granite table
   absolute dimensions & shape O(30µm)
6. granite table
   pillar height measurement
7. table
   resistivity mapping
8. shelf
   final storage
9. table
   strip capacitance measurement

Logistics of Readout PCBs

material stored at CERN and distributed as needed (FR4, resistive foils, coverlay, silver paste)

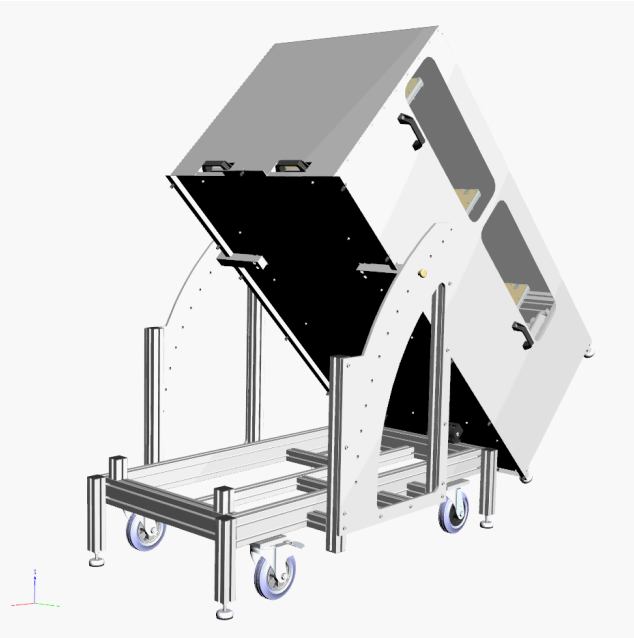
Elvia 1296 boards (LM1, LM2, SM2 Eta) — *produced Dec. 2016 to Feb. 2018*
Eltos 884 boards (SM1, SM2 Stereo) — telephone calls every second day
→ regular shipping to CERN O(50) boards — visits every four weeks

- counting & registration of all boards — *central logistics database*
- **in depth quality control of all boards** — up to 2h per board
  - dimensions & mechanical accuracy
  - electric integrity & HV stability
  - long-term stability
- acceptance/rejection decision
- board quality summary for each individual board — *CERN RO PCB QC database*
- drilling of precision holes

aggregation & packaging
ship to constructions sites or prepare for pick-up

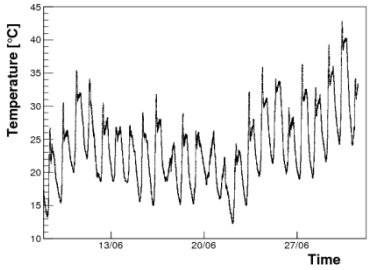
A SYSTEM FOR MUON TOMOGRAPHY

1st muon telescope with multiplexed Micromegas



⟶ 1st use of MM tracker outside

- *Temperatures fluctuations from 11 to 43 °C*
- *Online feedback on T (P)*



⟶ FEU from Clas12

⟶ Self-trigger mode

⟶ Miniaturized CAEN HV modules

⟶ Nano-PC (Hummingboard)

- *Set & monitor HV*
- *Acquisition & storage*

⟶ Compact electronic system

⟶ 30 W of consumption

⟶ 3.5 months of data taking

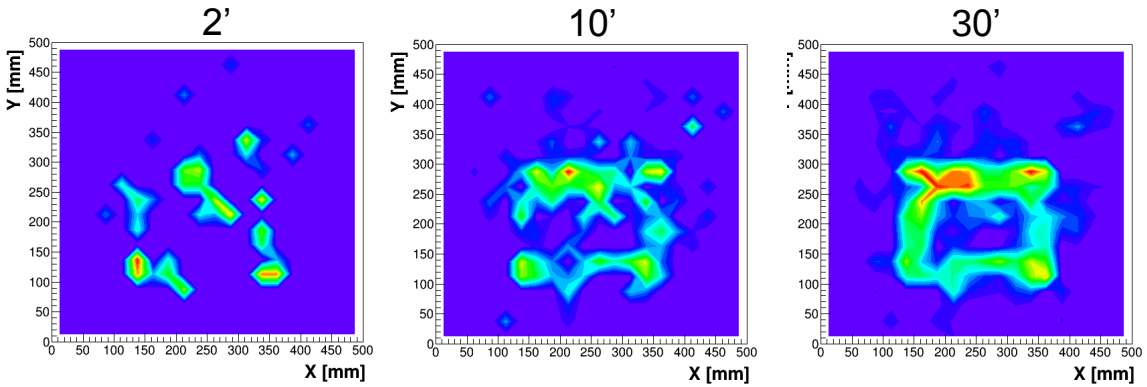
- *Including 1.5 on battery + solar boards*

S. Bouteille, S. Procureur et al. Large resisitve 2D Micromegas with genetic multiplexing …

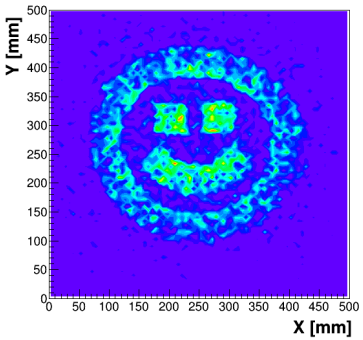
MUON TOMOGRAPY PROJECTS: TOMOMU, MCUBE, MIMOSA

Small setup for communication purpose (*La Diagonale Paris-Saclay*)

⟶ 4 MG2D-v2 detectors



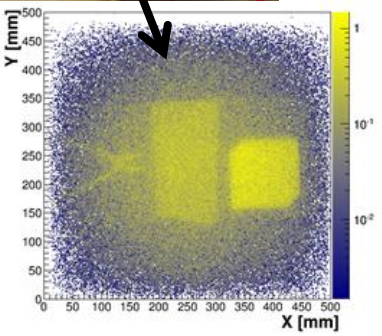
Lead Square



« Muona Lisa »

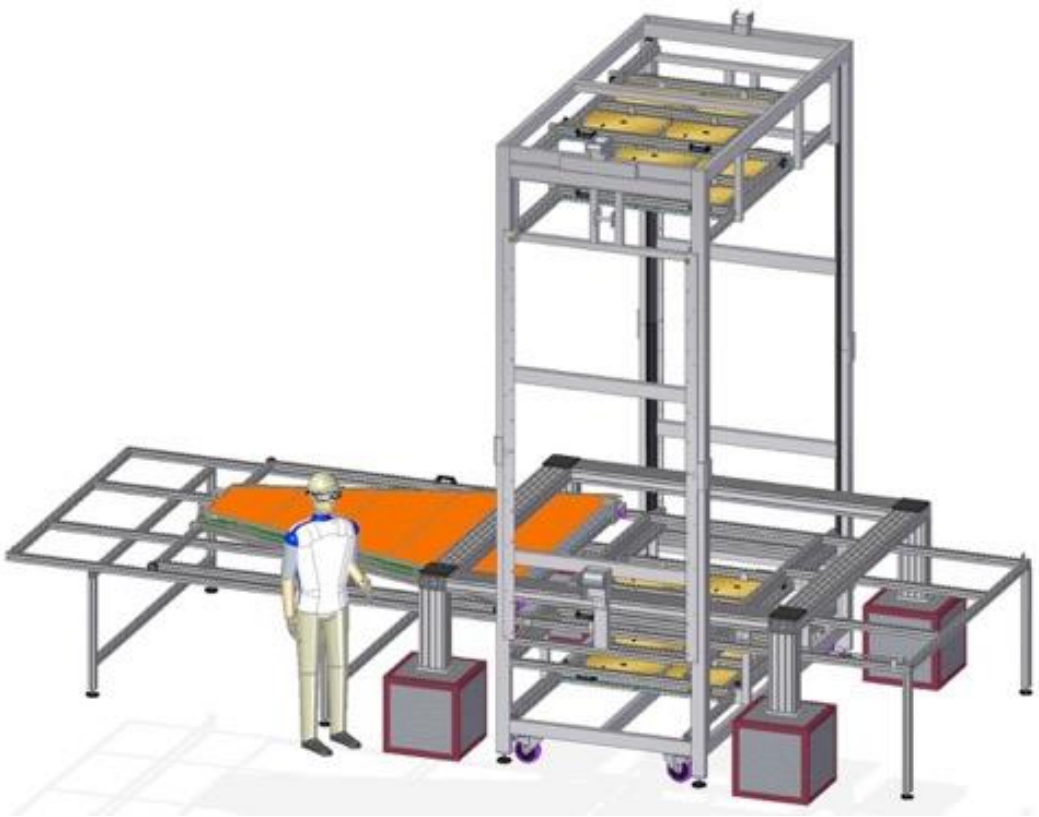
⟶ Can be used as a transportable scanner for in situ imaging:

⇒ ***Instrument unique in the word, benefit from excellent resolution of MM***



S. Bouteille, S. Procureur et al. A Micromegas-based telescope for muon tomography: the WatTo experiment

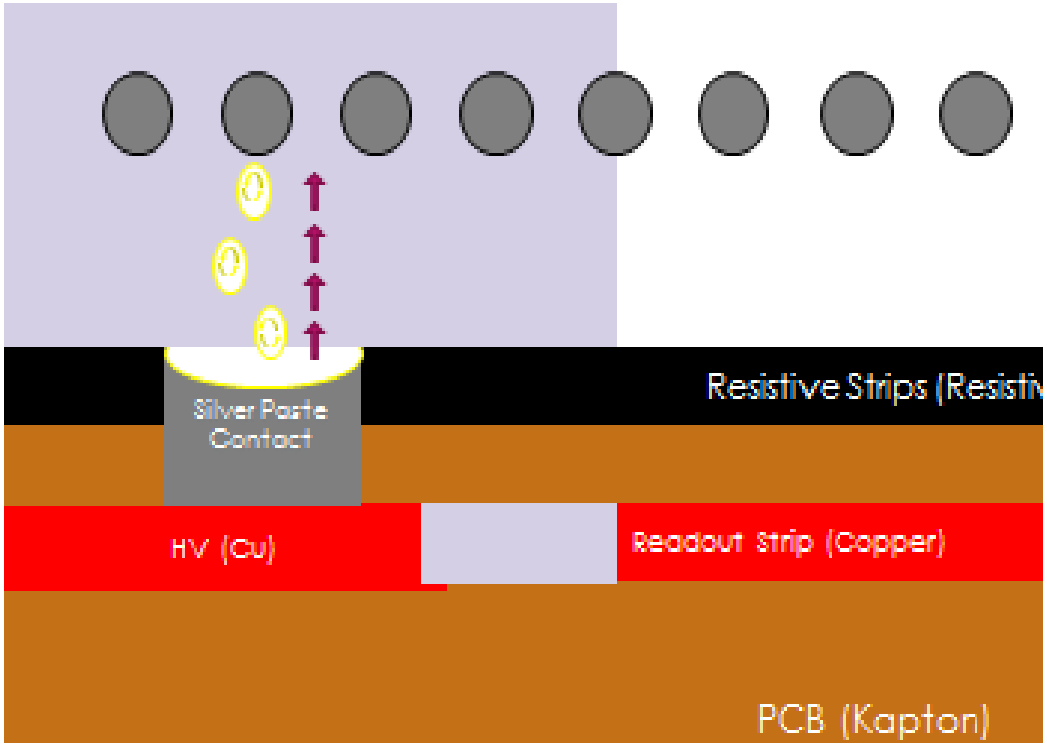
COSMIC TEST BENCH FOR ATLAS/NSW MODULES



- full test to obtain a gain homogeneity and efficiency map, identify dead channels and noisy channels
- Use of cosmic bench made out of Micromegas multiplexed detectors for the M3 projet at Saclay
- 12 Micromegas detectors (0.5 x 0.5 m2) with DREAM electronics
- Scan LM1 module in 5 steps with DREAM electronics

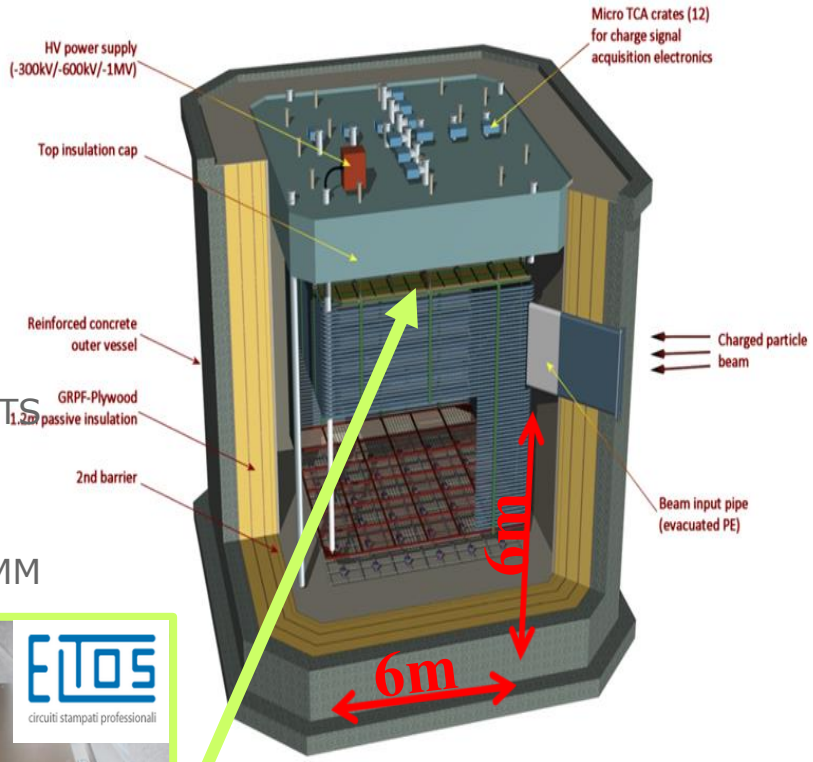
Why the bubbles ?

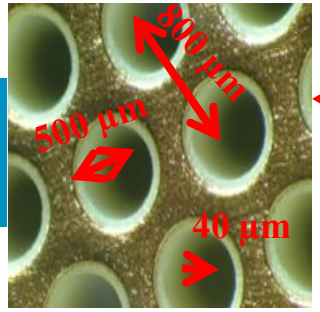
- Rui's explanation :
  - The Silver paste hole is not fully filled
  - Outgassing of the silver paste filled the hole
  - With HV, a corona effect starts in the hole
  - Bubbles starts migrating through the photoresist
  - This creates the short between mesh (ground) and the resistive layer (HV)



THE WA105 PROJECT AT CERN

- 300t fiducial mass ($6\times6\times6$m^3) TPC operating in Dual phase Liquid Argon (DLAr)
- Aim to demonstrate the scalability of the DLAr technique to ~10kt detectors for the future neutrino programme DUνE in U.S.A. (~2025)
- WA105 : 36m^2 readout plane instrumented with 144 MPGDs of LEM (Large Electron Multiplier) type
- LEM :
  - 1mm thick FR4 substrate with thin copper sheets on both sides
  - 50×50cm^2 active area
  - amplification through ϕ =500 mm holes (800 mm pitch)
  - 40 mm rim
  - read out by charge collection with a 2D anode



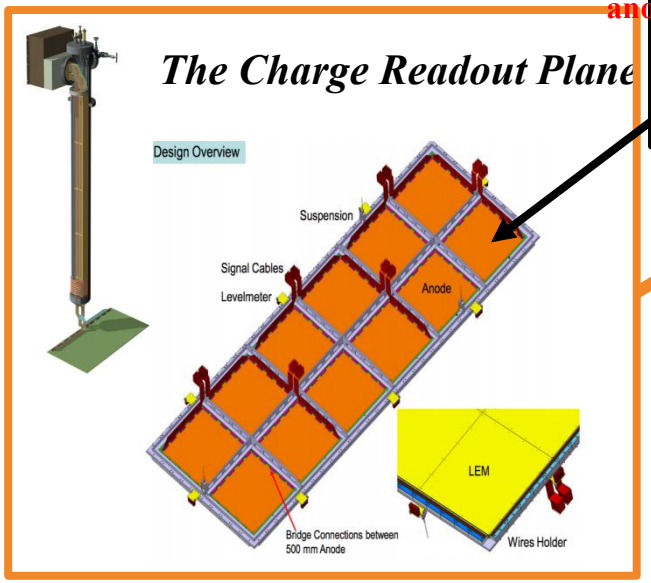


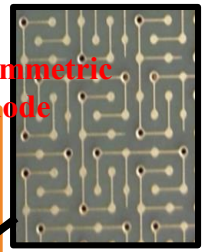
$E_{LEM} > 30$ kV/cm in pure Ar @ 87°K

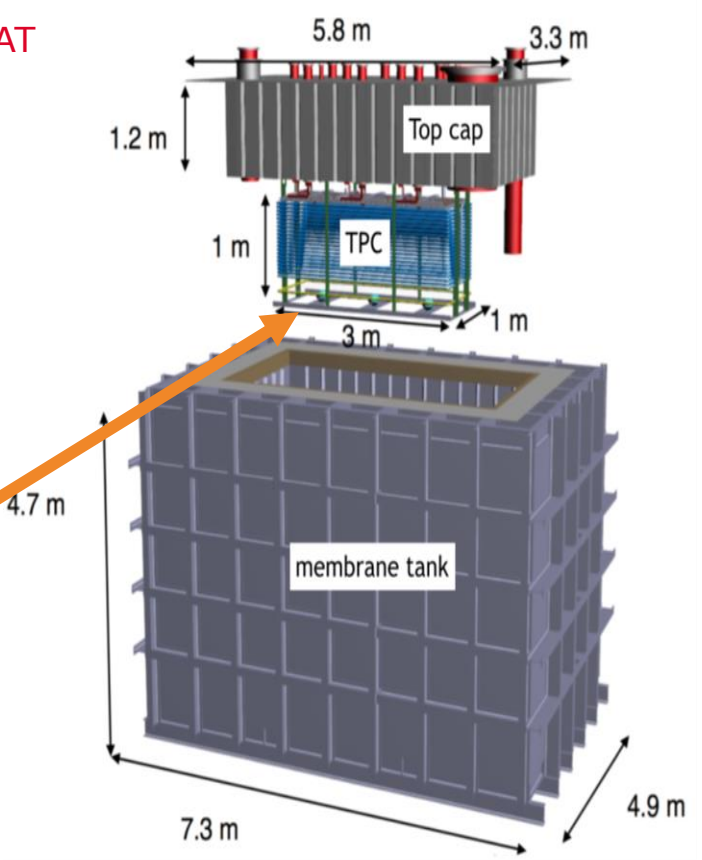
The WA105 DLAr demonstrator

THE 3×1×1M^3 DLAR PROTOTYPE

- THE 3M^3 PROTOTYPE IS BEING ASSEMBLED IN BLDG. 182 AT CERN
- AIM TO VALIDATE THE TECHNICAL SOLUTIONS FOR THE 300T WA105 DEMONSTRATOR (UNDER CONSTRUCTION AT PREVESSIN)
- COMMISSIONNING DELAYED BY INSULATION DEFECT
- NOW ELTOS AND ELVIA INVOLVED IN A PRE-PRODUCTION. BOTH ARE SATISFACTORY.





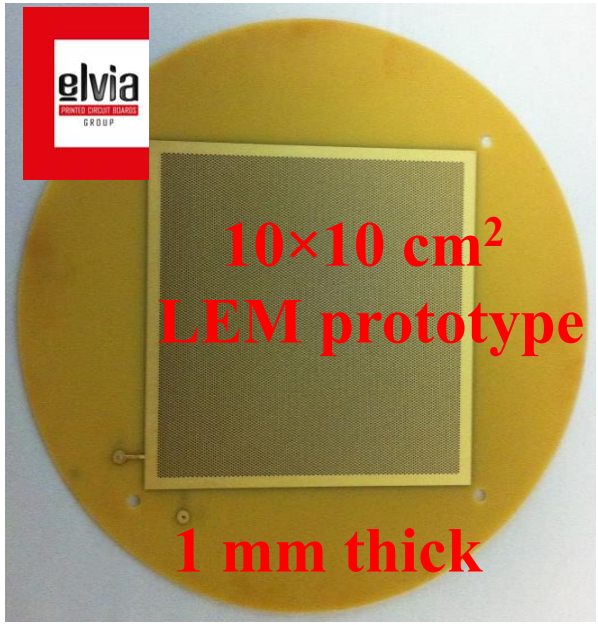


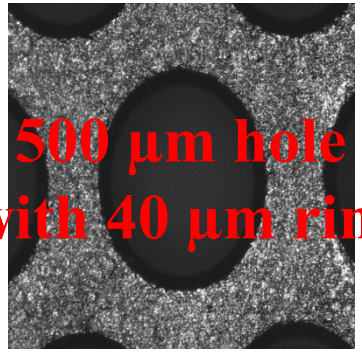
PARTNERSHIP WITH ELVIA

- Started in February 2016 a partnership with ELVIA (France) in view of the future LEM production for the WA105 demonstrator :
  - LEM specifications, tolerances and construction process (drilling, desmearing, polishing, …)
  - Visit by Irfu of the production site in Coutances (May 2016)

- First production of small (10×10cm^2) LEM prototypes (April 2016):
  - Geometry quality (PCB thickness, size of holes and rims, …) is OK
  - HV tests in air OK (up to 3.5 - 4.0kV)
  - Gain measurements with α source in argon @NTP

- Then 50×50cm^2 LEM samples have been produced by ELVIA





RESISTIVE ANODE TECHNIQUES

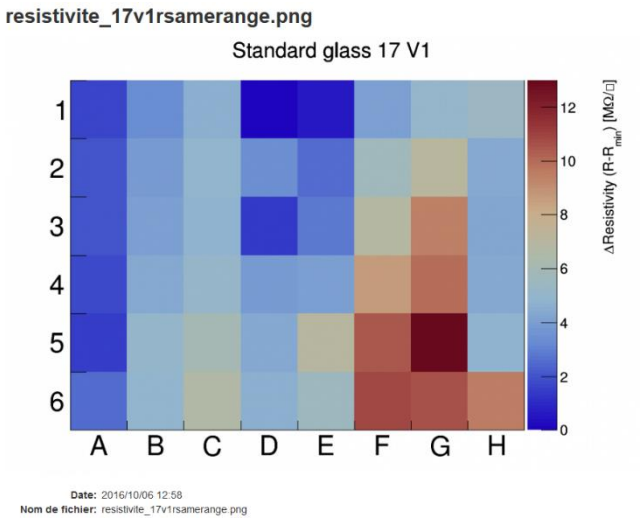
- Resistive anode stabilizes Micromegas and allows a charge spreading necessary to improve resolution of Micromegas
- Can be applied to other MPGDs but necessary for Micromegas
- Many open ways to be explored to apply the resistive material: screen printing, sputtering, painting, film lamination, etc...
- Several techniques are used and developed to measure surface resistivity of a coverlay.

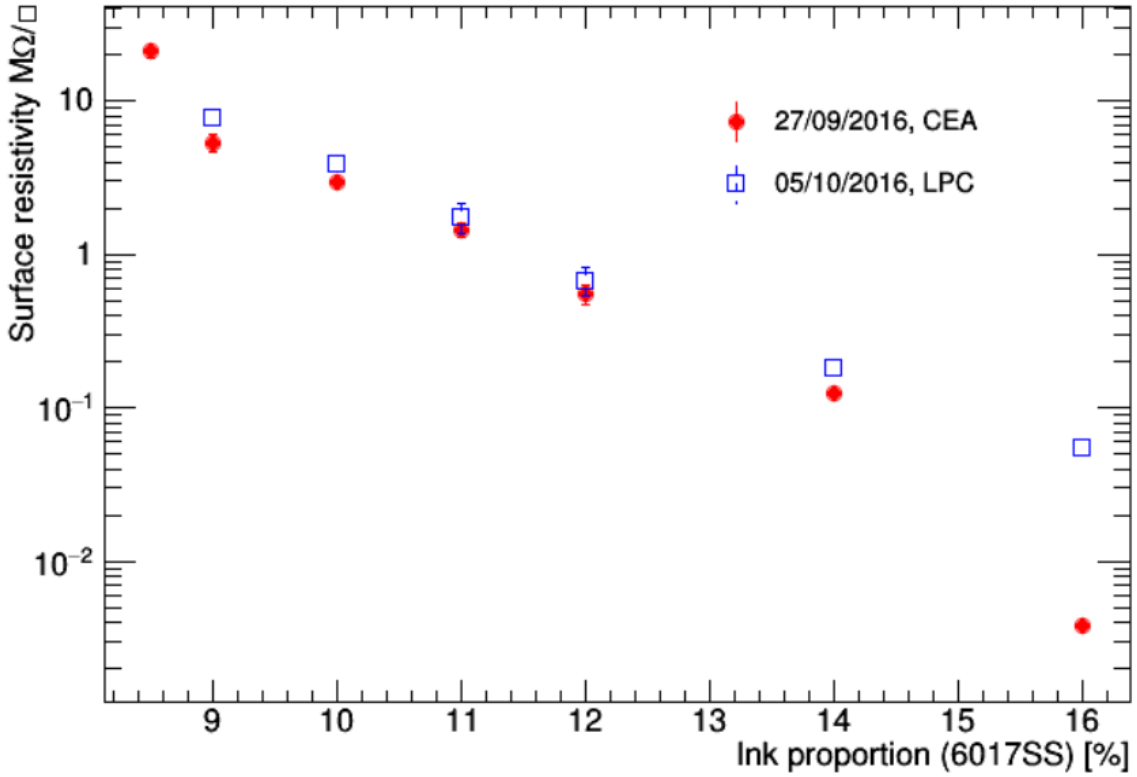
RESISTIVE MICROMEGAS AND RPC

- SCREEN PRINTING MACHINE USED ON VARIOUS MATERIALS (GLASS, KAPTON,…) WITH VARIOUS INKS AND VARIOUS PATTERNS (UNIFORM, STRIPS)
- PROTOCOLS HAVE BEEN DEVELOPPED (CURING TEMPERATURE, CURING TIME, UNIFORMITY TEST,…)
- TOOLS HAVE BEEN DESIGNED OR ACQUIRED (RESISTIVITY MEASUREMENT, ALIGNMENT)

THE BI COMPONENT PASTE (ELECTRODAG 6017SS + PM-404TM) RESISTIVITY CAN BE ADJUSTED.

UNIFORMITY TEST





DELIVERABLE D13.7 BEING COMPLETED

S. AUNE AND C. CARLOGENU MEASURING THE RESISTIVITY WITH A CIRCULAR PROBE IN THE BULK LAB AT SACLAY

STATUS SUMMARY (AFTER 2 YEARS)

Total Spending after 24 months : 32600 euro out of 95000 and 8.3 person.months out of 15.

Several techniques being developped, experience of transfer to industry gained and monitored, very positive results:full large resistive and standard detectors under construction IN INDUSTRY

ELVIA and ELTOS are involved in Micromegas (NSW) and LEMs/THGEMs (WA105). Other large Micromegas for Muography. Resistive techniques are developped for muography (volcanos, pyramids)

Thanks to S. Aune, D. Attié, A. Delbart, F.Jeanneau, M. Kebbiri, E. Mazzucato and Nathalie Laurion

BACKUP

PROJECT CHARACTERISTICS

Project leader : Stephan Aune

Beneficiary : CEA

Net EU contribution : 65 k€

Milestones (internal) : Purchase of material, screen design, Screen printing tests (M12), resistivity measurement techniques, tool design and purchase (M24); redaction of the protocol. Reports in RD51.

Deliverable : Resistive anode manufacturing *(protocols and tools for the large-size and large-scale production of resistive anodes for MICROMEGAS)*

PROJECT CHARACTERISTICS

Project leader : Fabien Jeanneau

Beneficiary : CEA

Other contributors : CERN, …

Net EU contribution : 35 k€

Milestones: Protocol and specifications for MPGD production and quality control (M36)

Internal Milestones: orders of detector series to at least two PCB companies (M8) characterization and tests and iterations.

Deliverable. Report on working detectors.