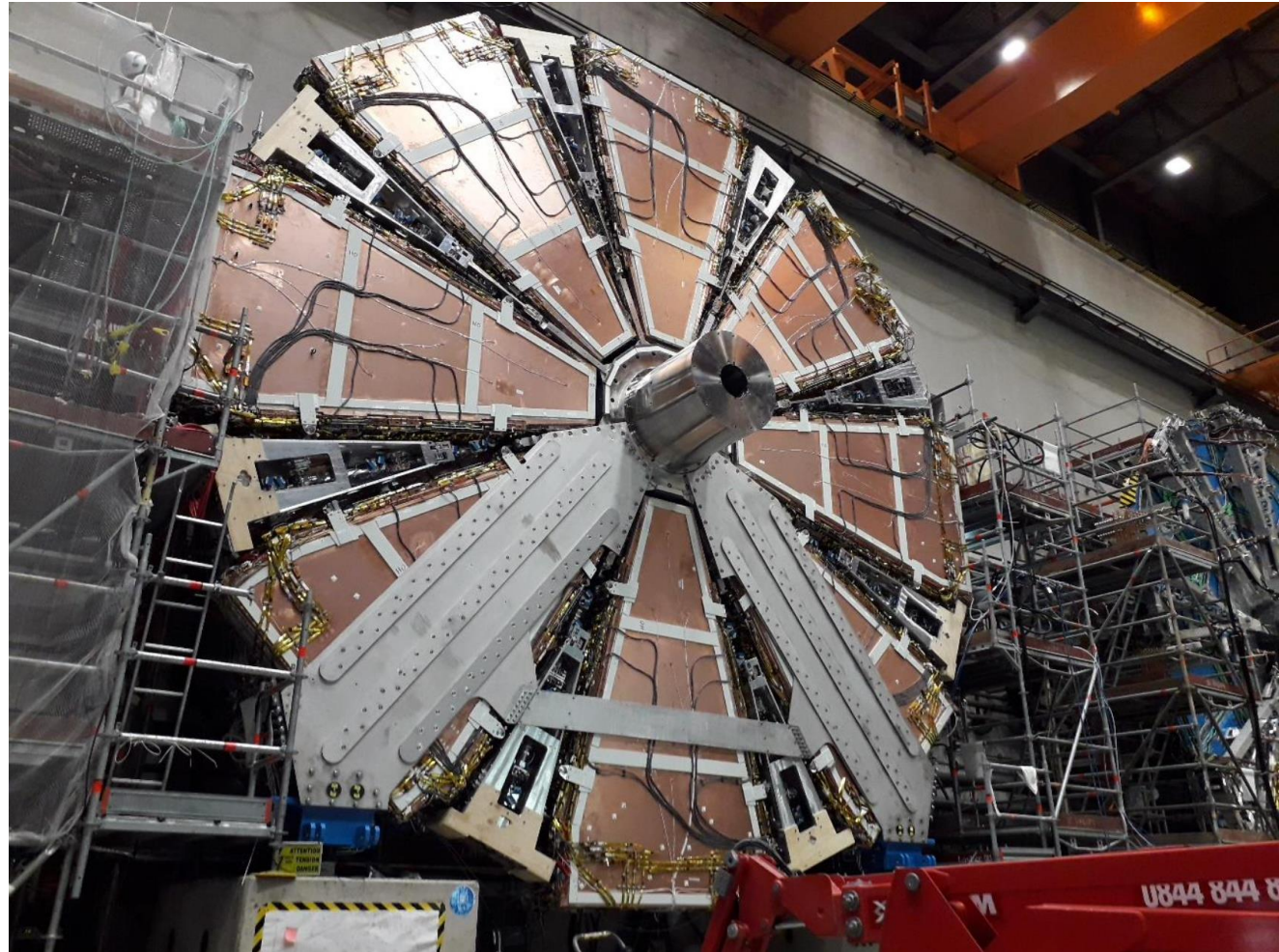


DE LA RECHERCHE À L'INDUSTRIE



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LM1 production report – RD51 Meeting – 06/21

M Vandenbroucke on behalf of F. Jeanneau for the Saclay team

STATUS OF LM1 PRODUCTION TODAY



- 1 mechanical module (2018)
- 32 standard production modules already at Cern
- First spare module shipped last week

Still to be produced:

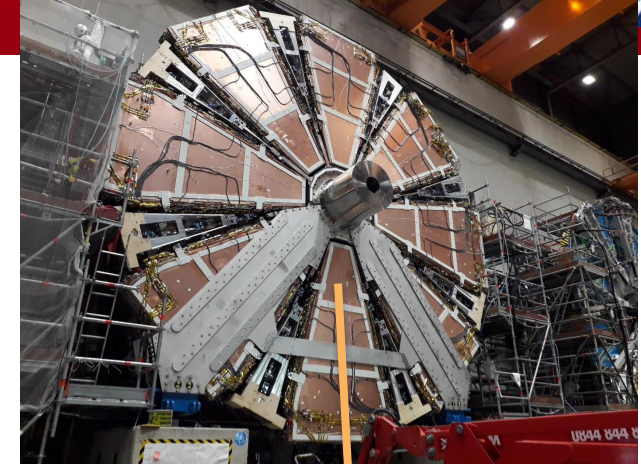
- Second spare module (additional PCB needed to build Eta panel)
- 1 stereo doublet for aging studies.

- 177 panels built and measured

→ 108 drift panels (36 central, 72 external)

→ 144 mesh stretched and transferred

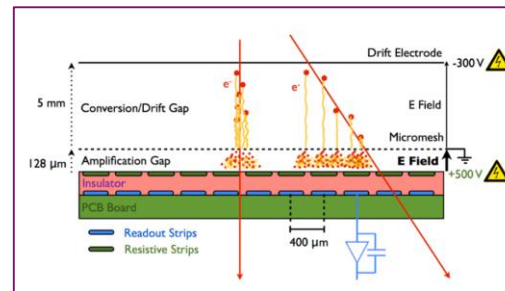
→ 69 RO panels (35 Stereo and 34 Eta)



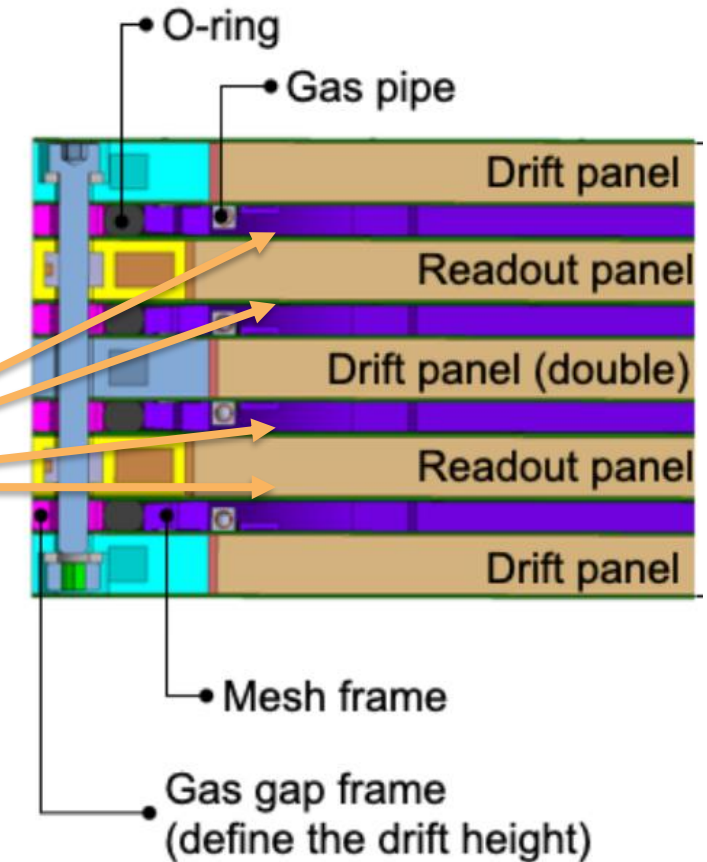
STEPS FOR MODULE CONSTRUCTION AND VALIDATION

- Panel building and planarity measurements of panels
- Readout Panels Passivation
- Washing and Drying
- Drift Panels Preparation
- Module Assembly
- HV Tests

- Gas Tightness
- Alignment (Rasfork) Meas.
- Module Planarity
- Conditioning/Drying of Module
- Test in Cosmic rays



1 Module = 5 Pannels
= 3 Drifts +2 Readout
= 4 MM gaps



LM1 Modules Cross-Section

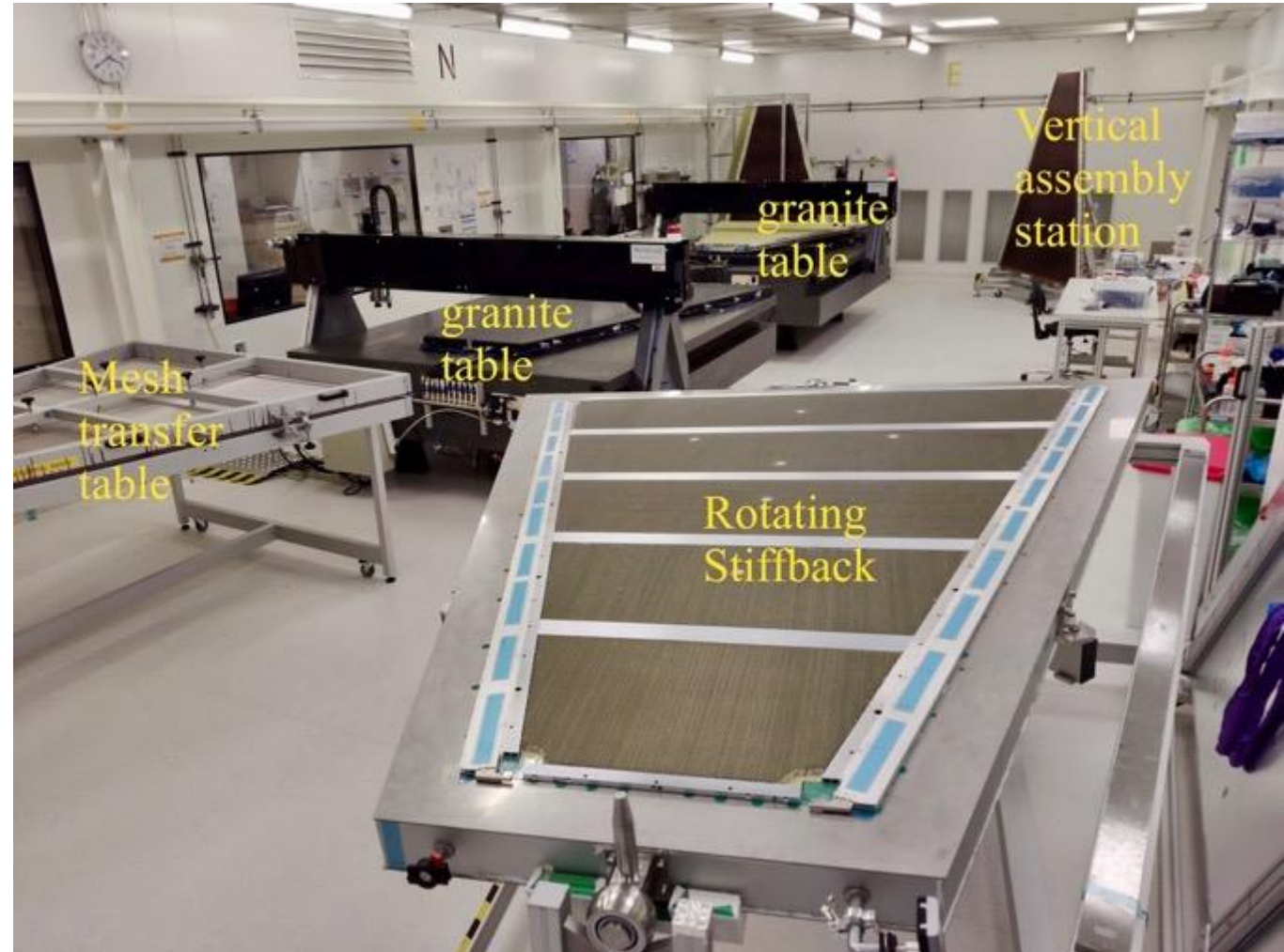
From : “The large inner Micromegas modules for the Atlas MuonSpectrometer Upgrade: construction, quality control and characterization”

<https://arxiv.org/pdf/2105.13709.pdf>

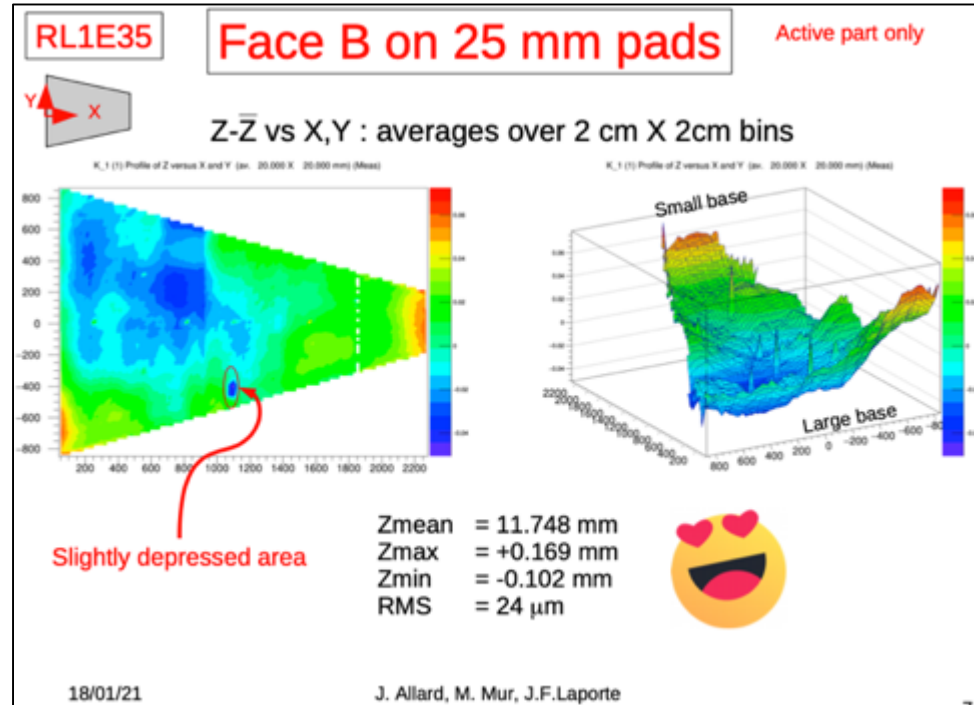
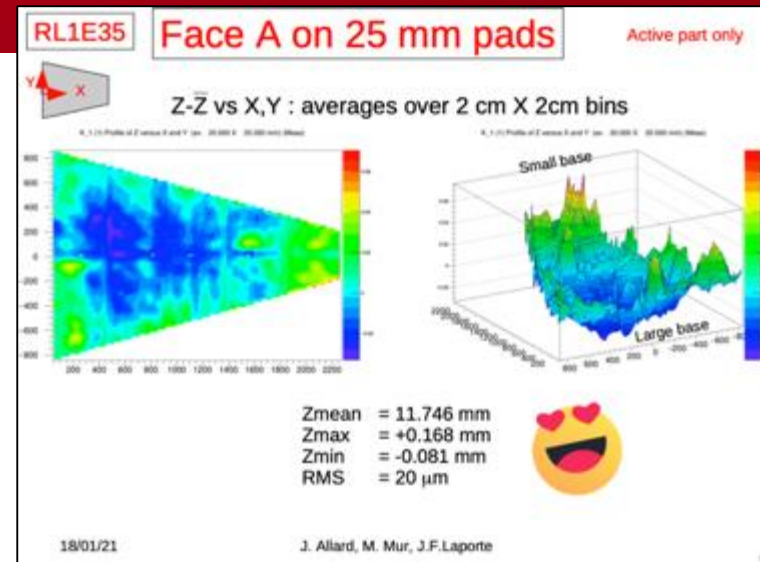
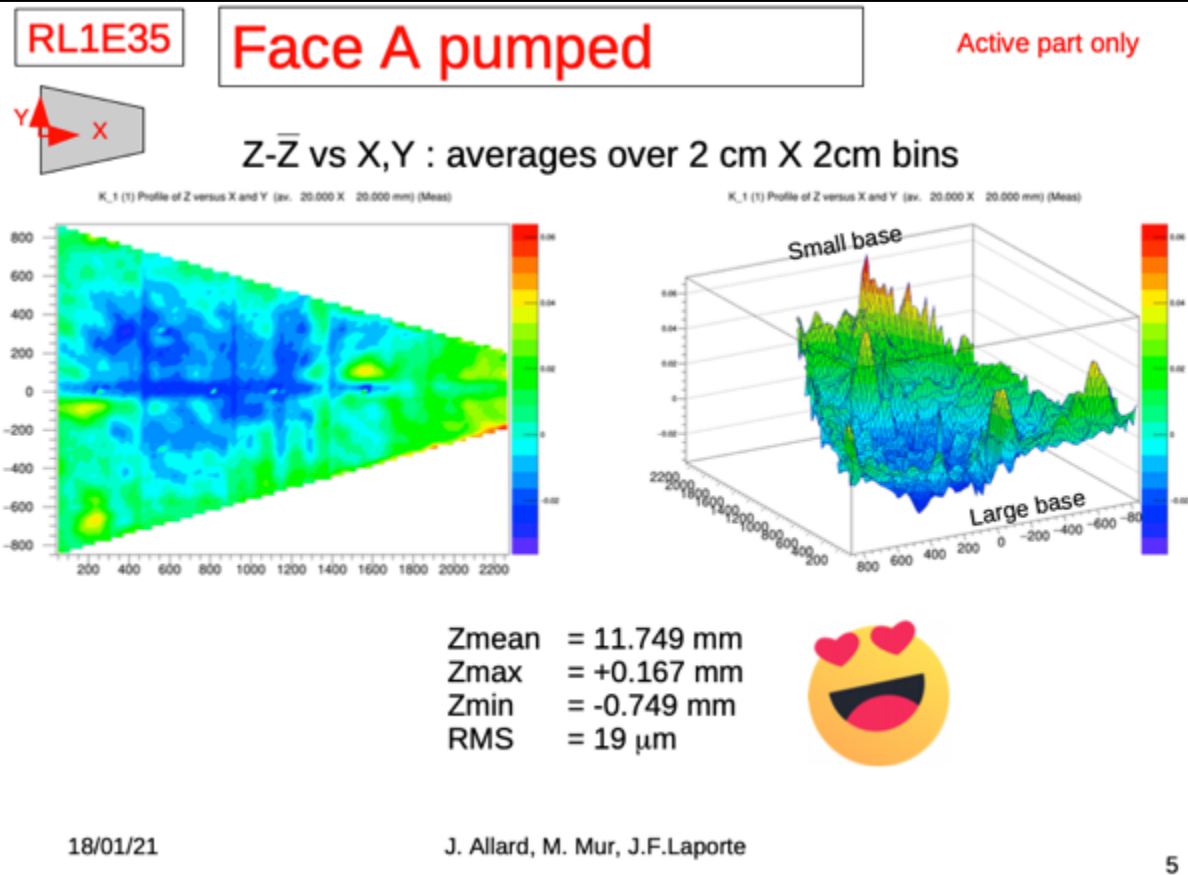
Panel building is glueing PCB on honey comb + bars

Planarity of each panel is measured in 3 steps:

- Face A – vacuum ON
- Face A – on shimes
- Face B – on shimes

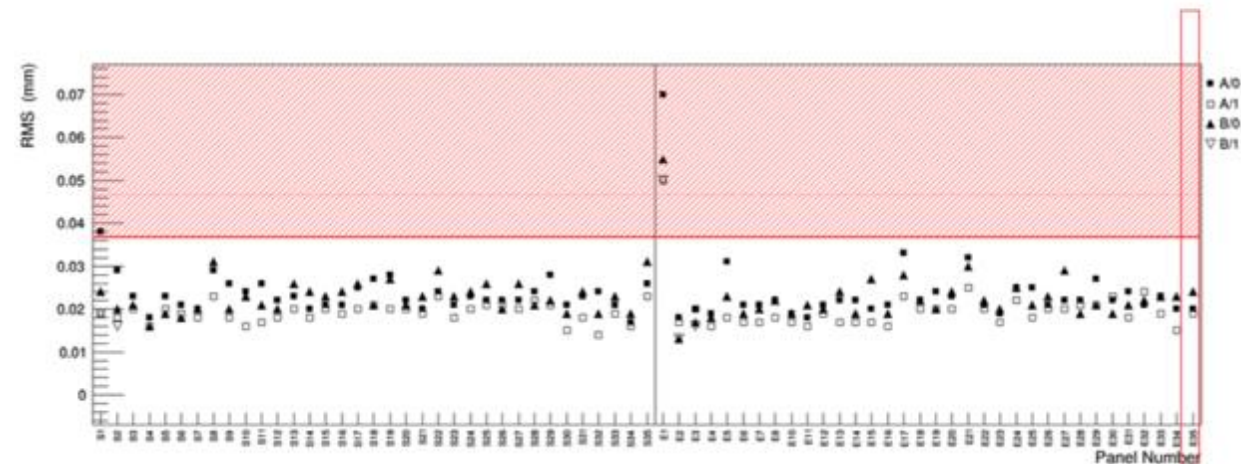
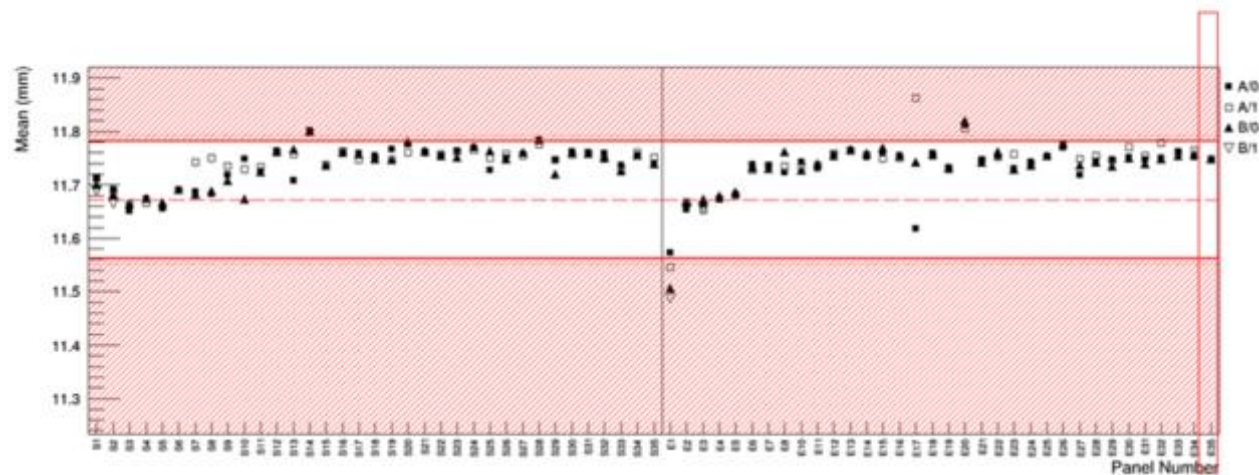


PANEL PLANARITY: MEASUREMENT SET

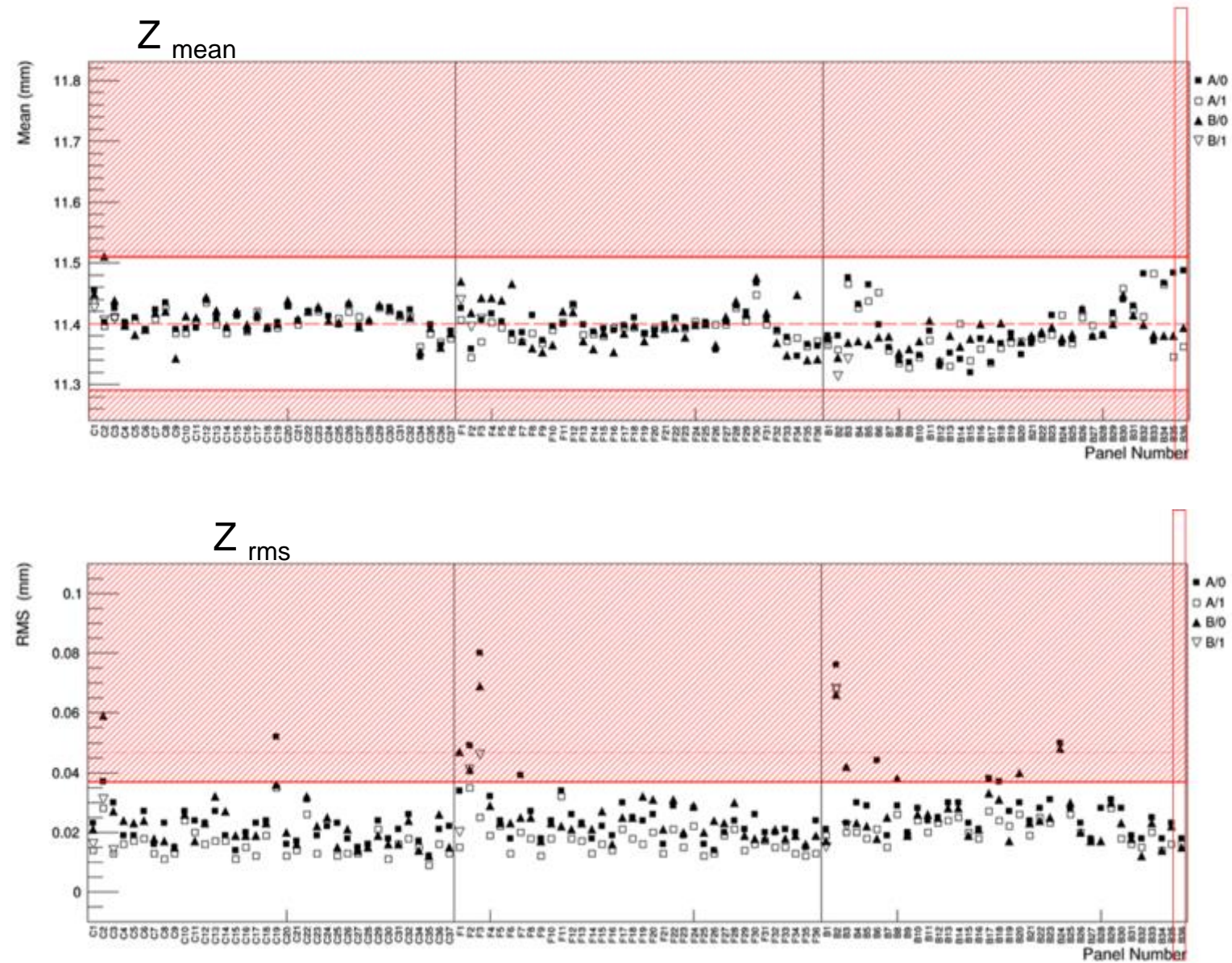


$$Z_{\text{Nominal}} - Z_{\text{Tol}} < \mathbf{Z_{Mean}} < Z_{\text{Nominal}} + Z_{\text{Tol}}$$

$$\mathbf{RMS} < Z_{\text{Tol}}/3$$



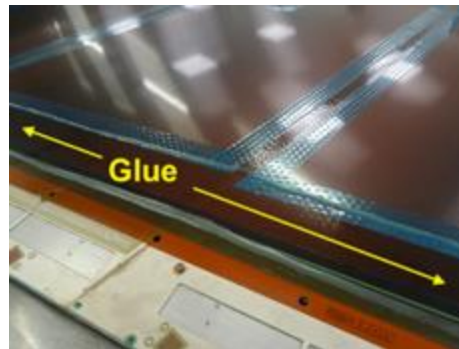
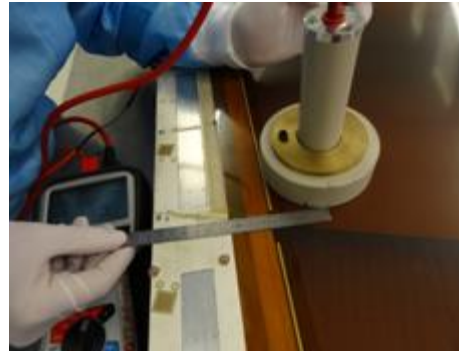
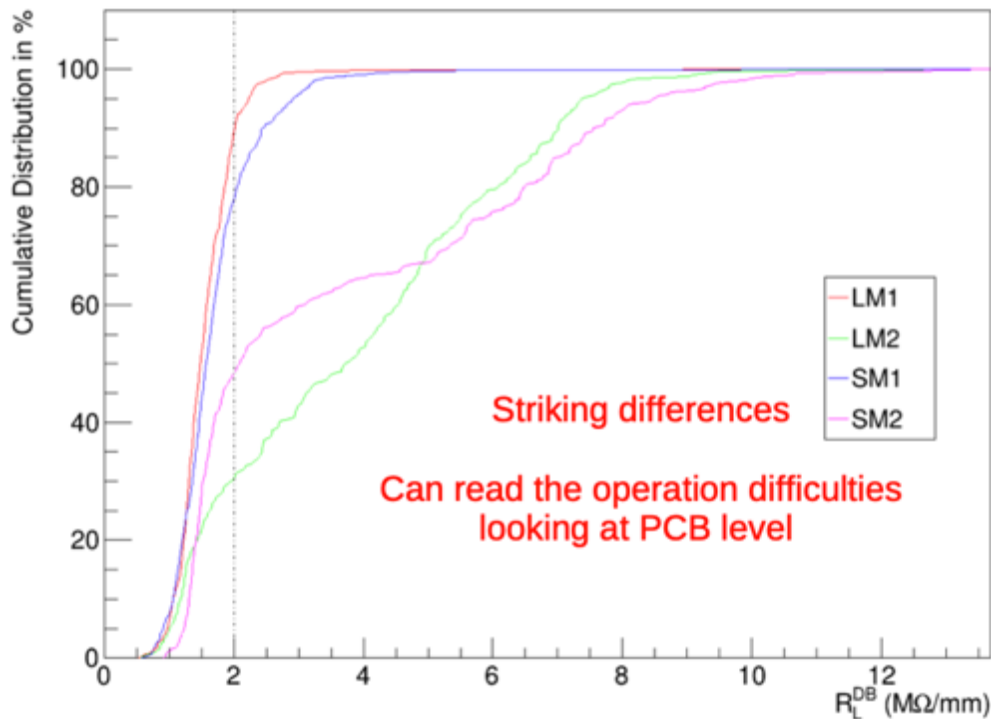
DRIFT PANEL PLANARITY



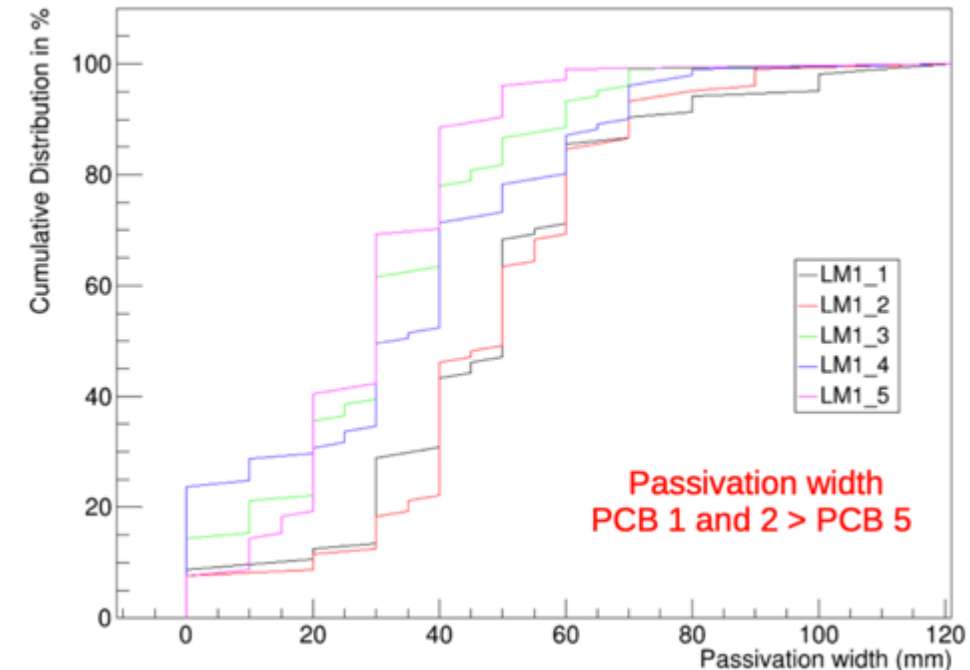
RO PANEL PREPARATION - PASSIVATION

- Panel finalization → FEB pin and alignment pin gluing
- Panel passivation: due to a lack of resistivity of resistive anodes and flaws in the layout of resistive strips, the edge of the panels, where resistance values are lower, must be passivated by applying a thin layer of glue.

Cumulative distribution of R_L^{DB} for all modules types



Cumulative distribution of passivation widths



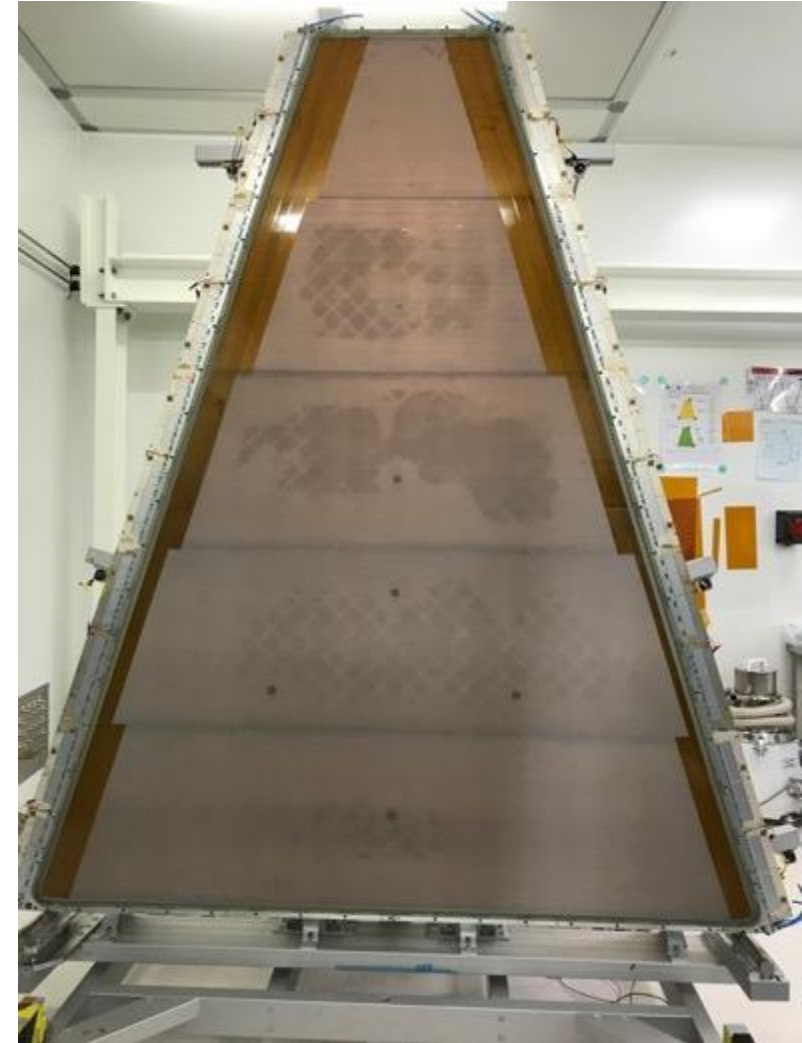
From JF Laporte

WASHING AND DRYING

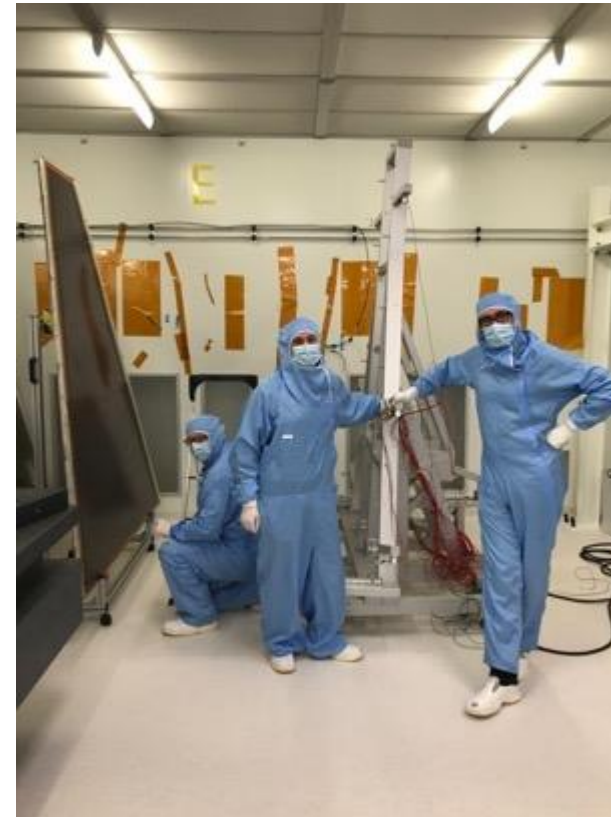
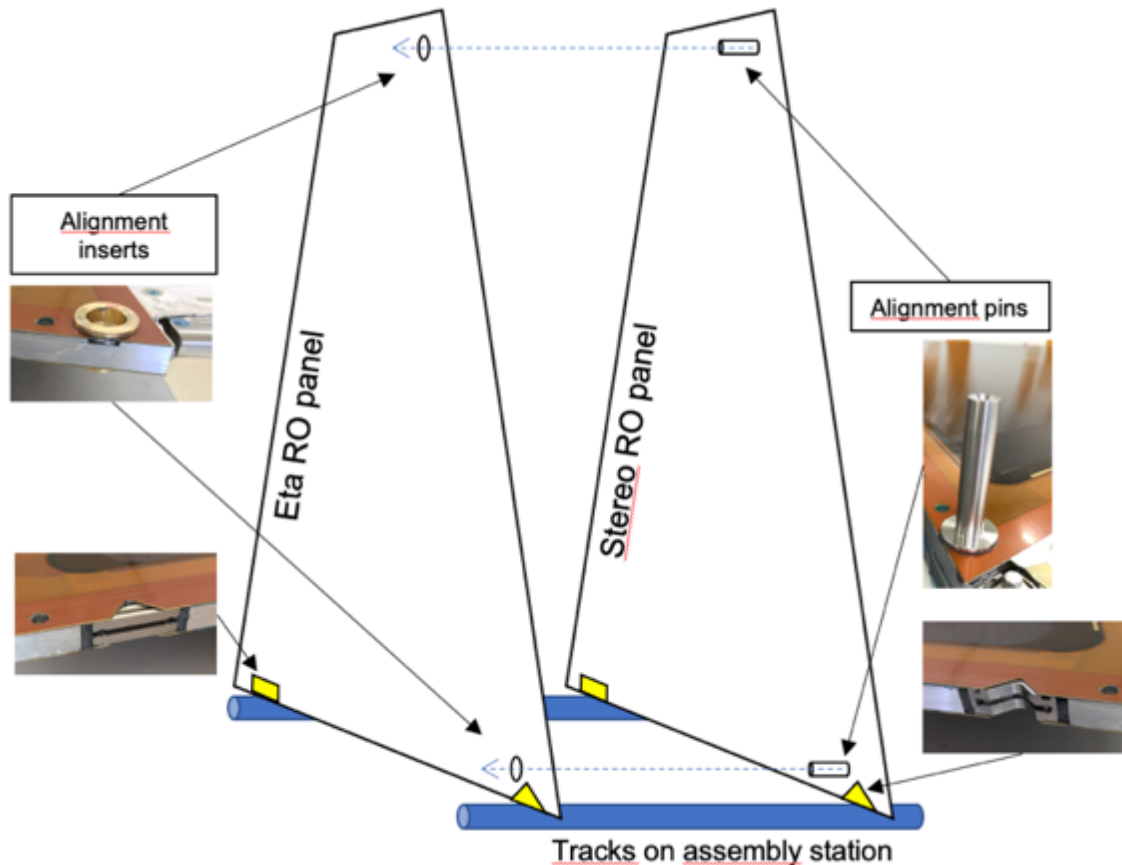
All panels are washed (sometimes several times) and dried



- Mesh tension is checked and must stay between 7 and 10 N.m
- Kapton tape is applied on the mesh to match the glue passivation on the corresponding RO panel.
- Electrical insulation between mesh and drift electrode is checked.



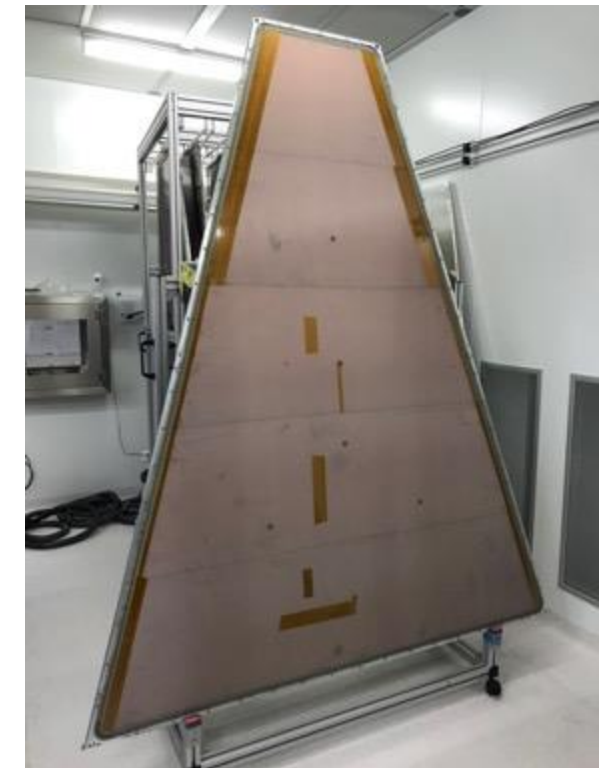
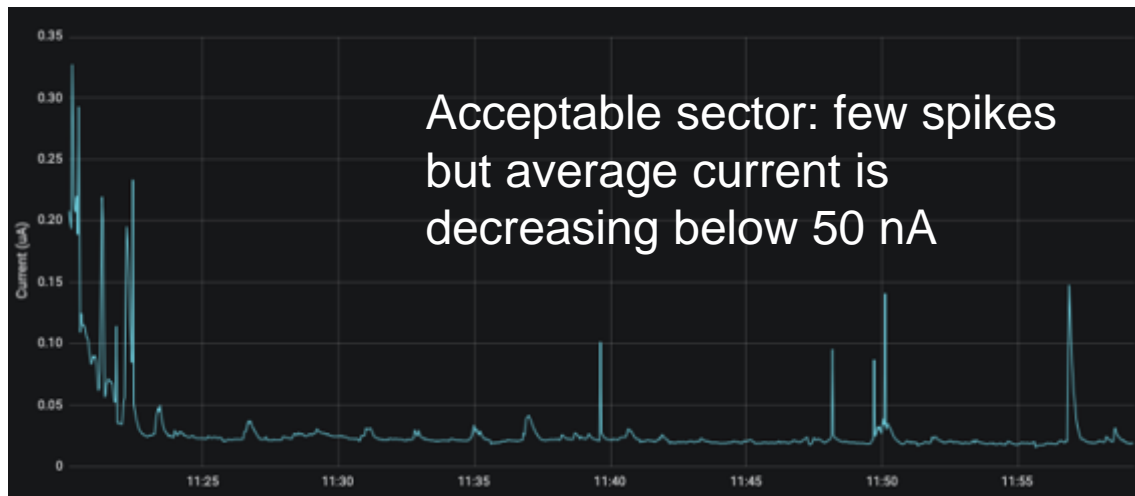
- Modules are assembled by stacking 5 panels (2 RO and 3 drift) onto the assembly station.
- In our case the alignment is done by construction, using the mechanical inserts precisely glued during the panel construction on the marble table.
- Each panel is carefully checked and cleaned: vacuum-cleaned, antistatic roller and a lot of isopropanol (especially for the RO panels)



- Each module is assembled gap by gap
- Each gap is validated if it sustains 850V in air with low dark current ($< 50\text{nA}$)



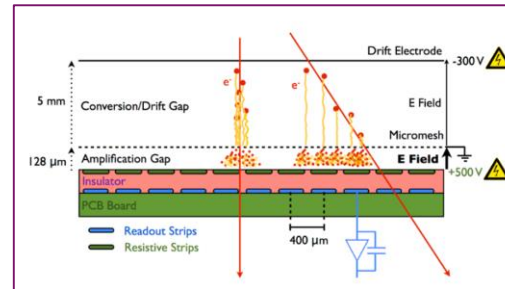
- If too much current \rightarrow new dry cleaning
- If short \rightarrow kapton method (use of large kapton foils to neutralize sector and localize the weak area by dichotomy)



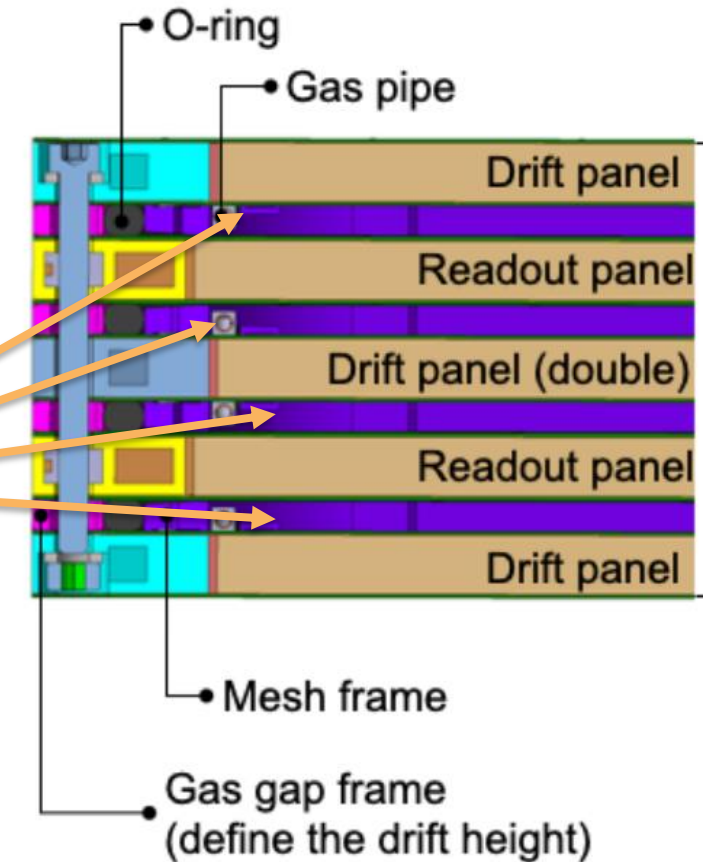
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- HV Tests

- Gas Tightness
- Alignment Rasfork Measurements
- Module Planarity
- Conditioning/Drying of Module
- Test in Cosmic rays



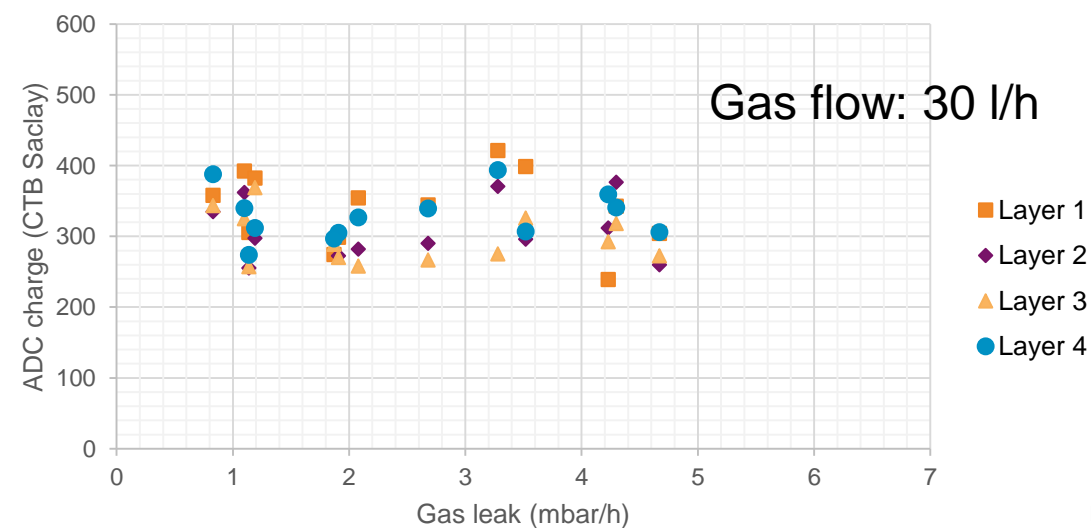
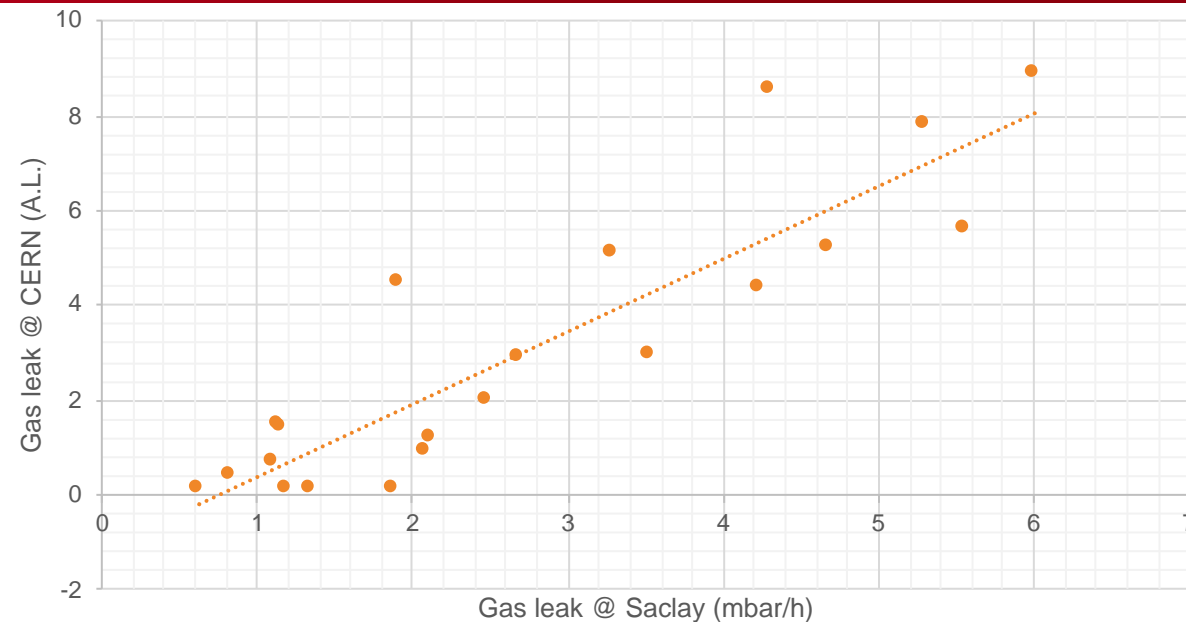
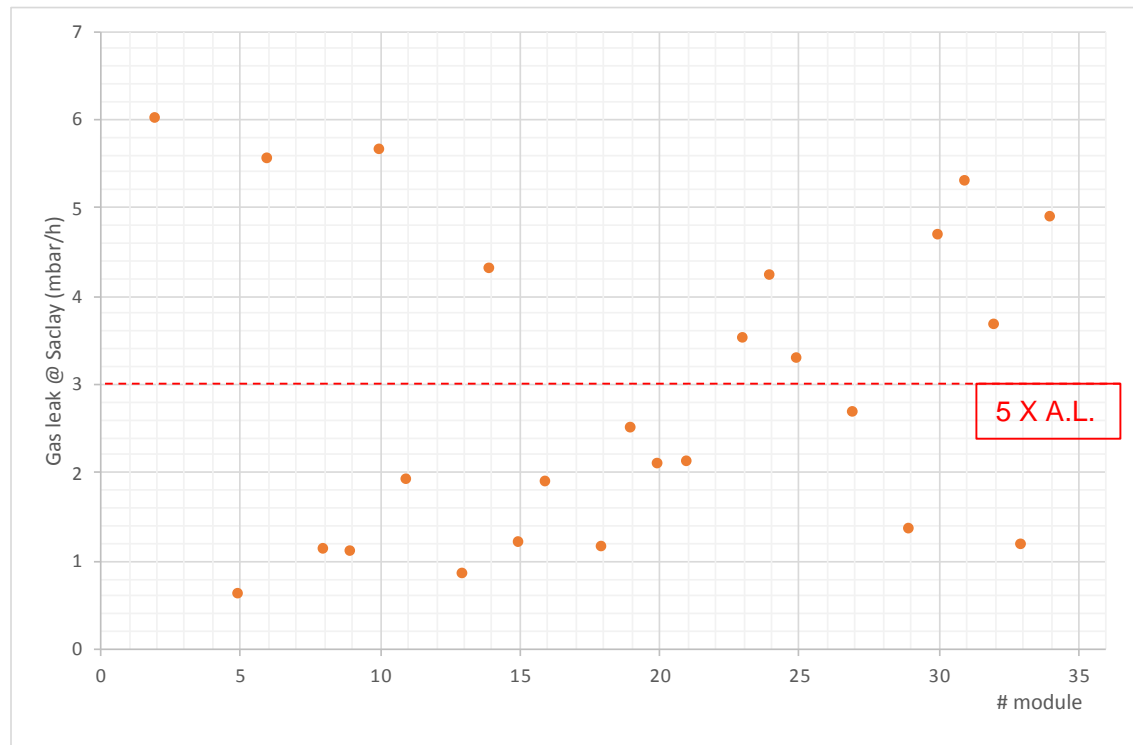
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LM1 Modules Cross-Section

From : "The large inner Micromegas modules for the Atlas MuonSpectrometer Upgrade: construction, quality control and characterization"

<https://arxiv.org/pdf/2105.13709.pdf>



- Rasfork has been developed at Saclay for doublet and quadruplet alignment checks.

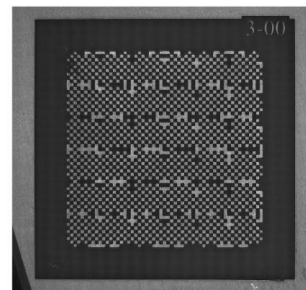
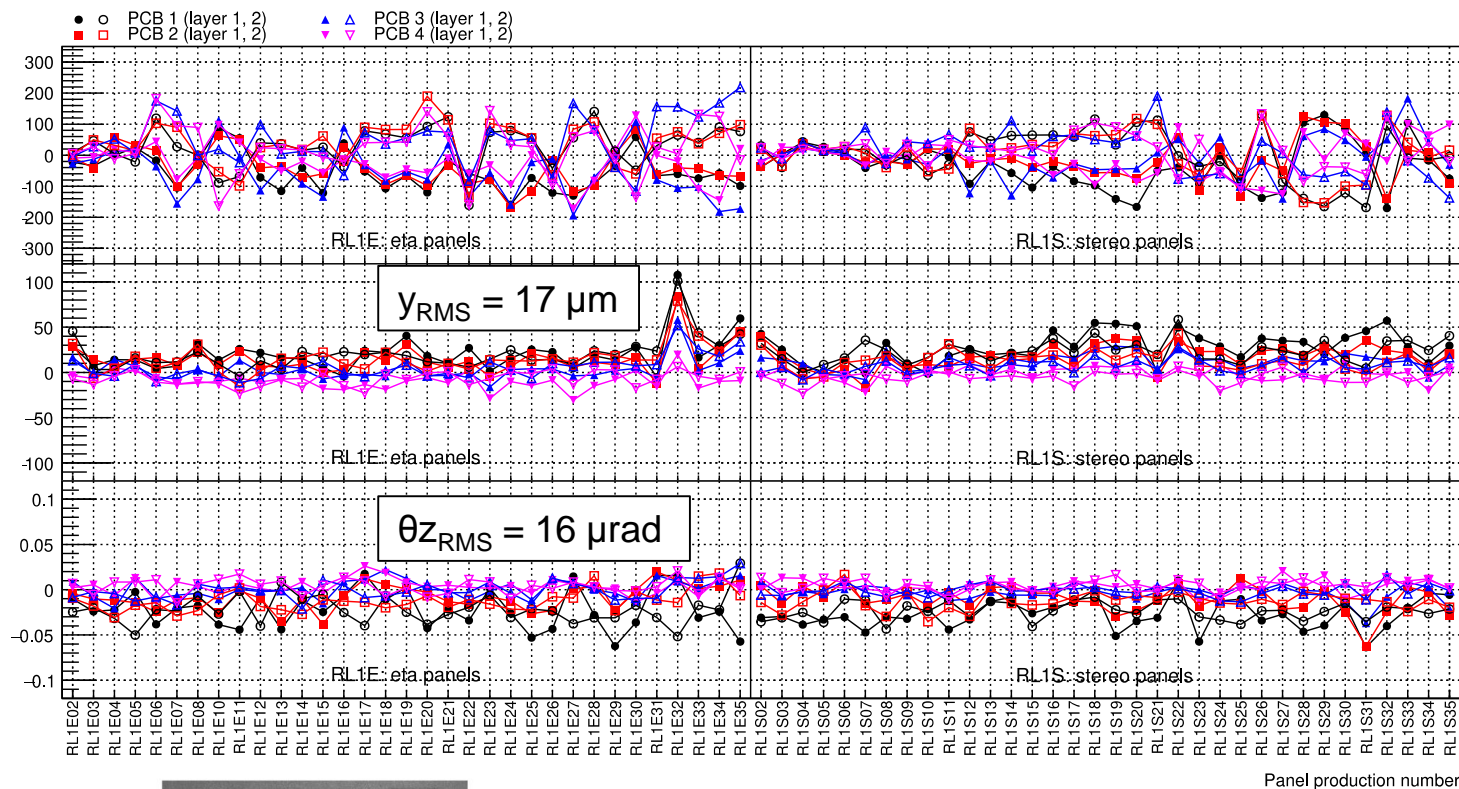
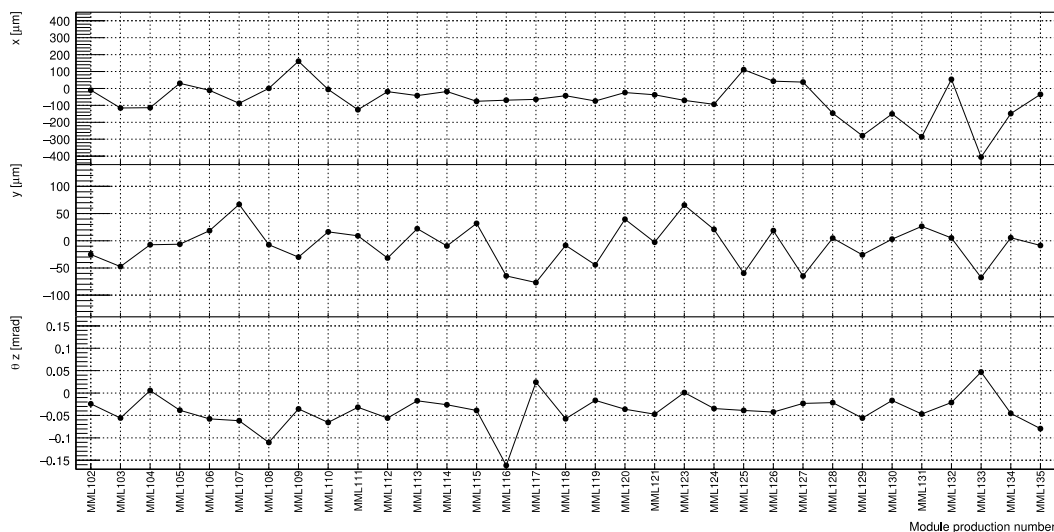
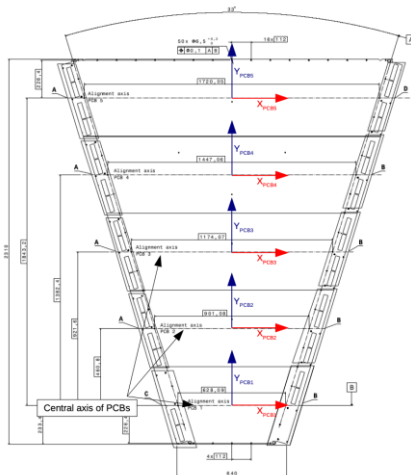
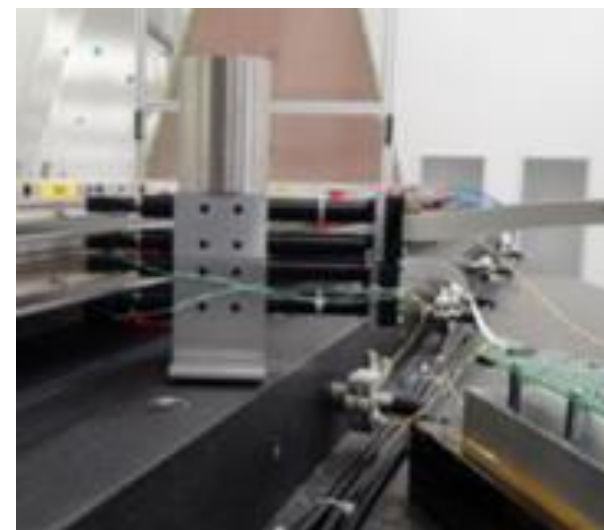
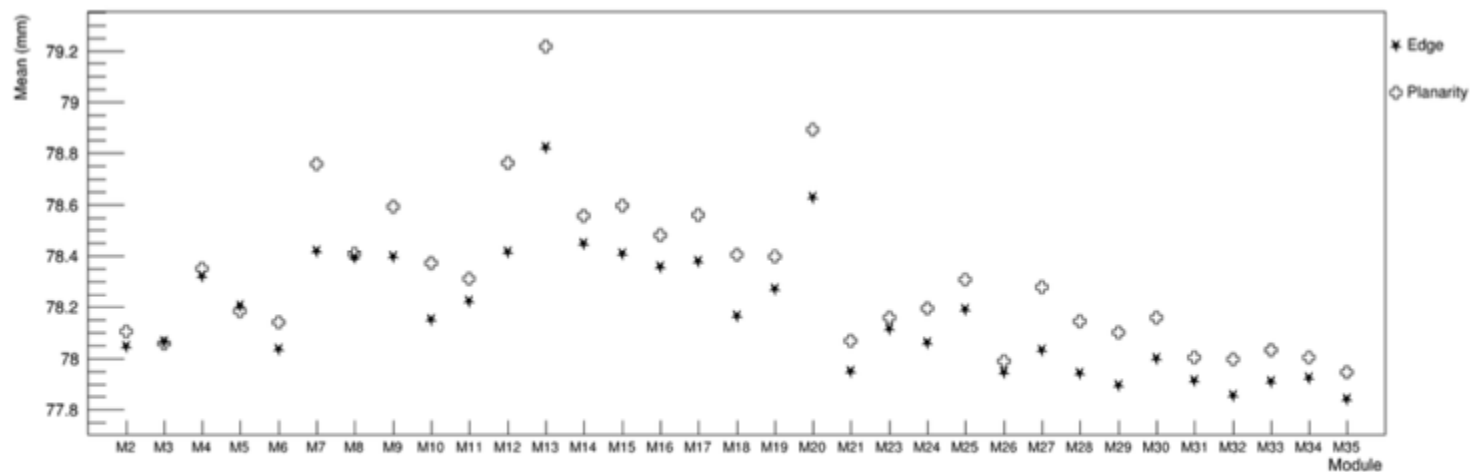


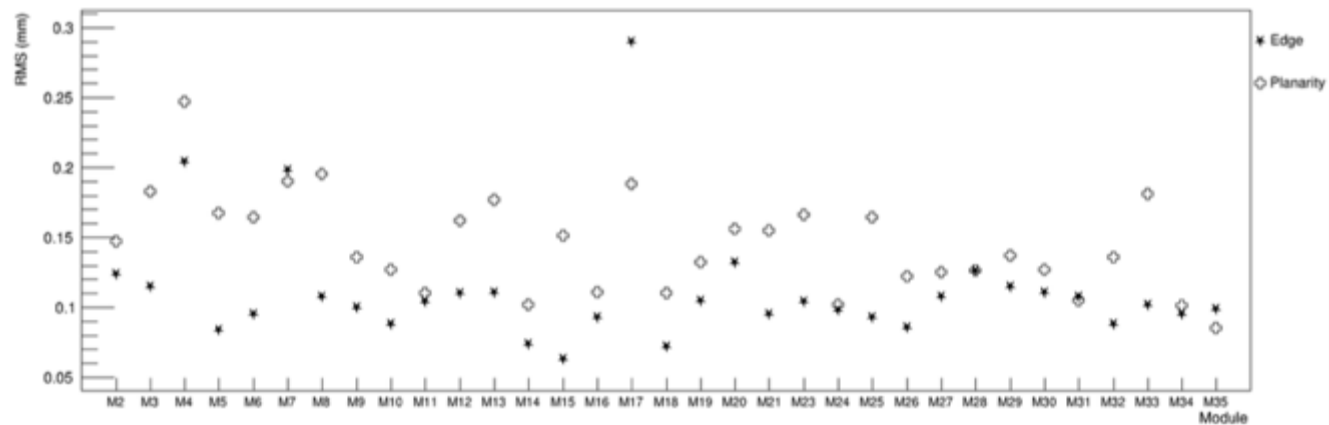
Figure 23: A Rasnik mask etched on PCB.

From PF Giraud

MODULE PLANARITY

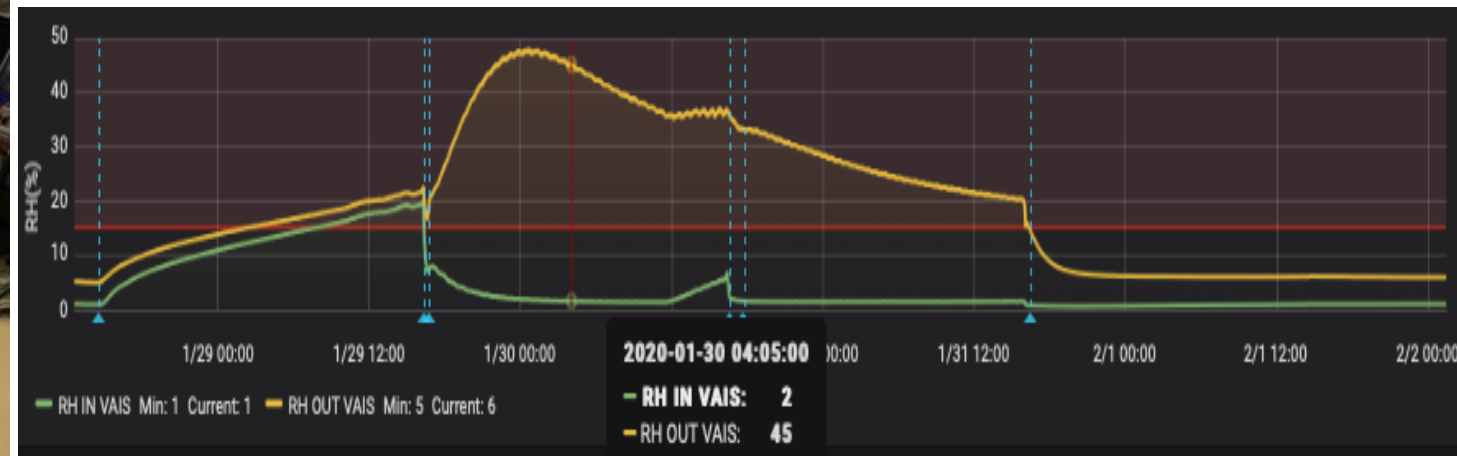


Edge : from 78.173 - 0.333 to 78.173 + 0.649
Core : from 78.318 - 0.373 to 78.318 + 0.899



Edge : ≤ 0.290
Core : ≤ 0.247

- After module closure, conditioning is needed before applying HV in Ar CO₂ mixture.
- Few days at 45°C under gas flow to remove humidity trapped in the material (essentially FR4 and kapton)
- Transfer on the cosmic bench then HV ramping-up for one day (controlled by software)



↑
Heaters on

↑
Changing
bottle of Ar

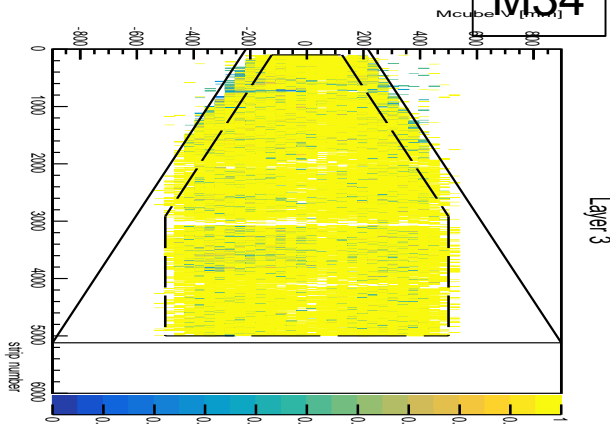
↑
Heaters off

M34:

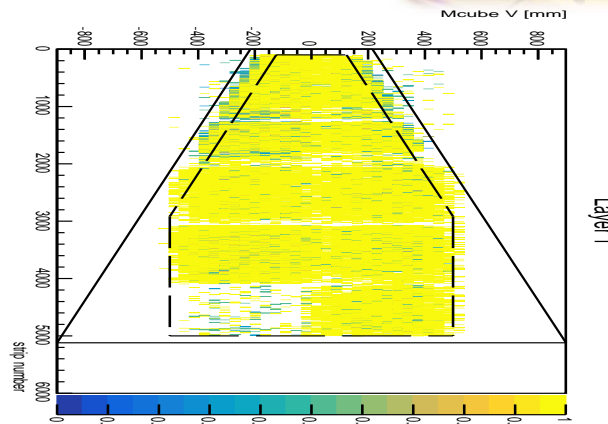
- Trip of L1R5 and L2R5 during test
- All sectors good at BB5



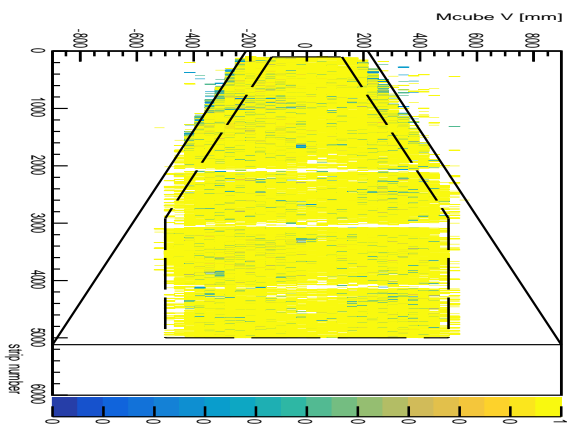
M34



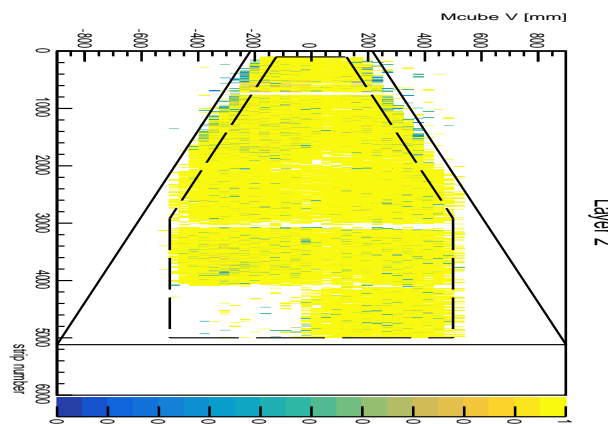
Layer 3



Layer 1

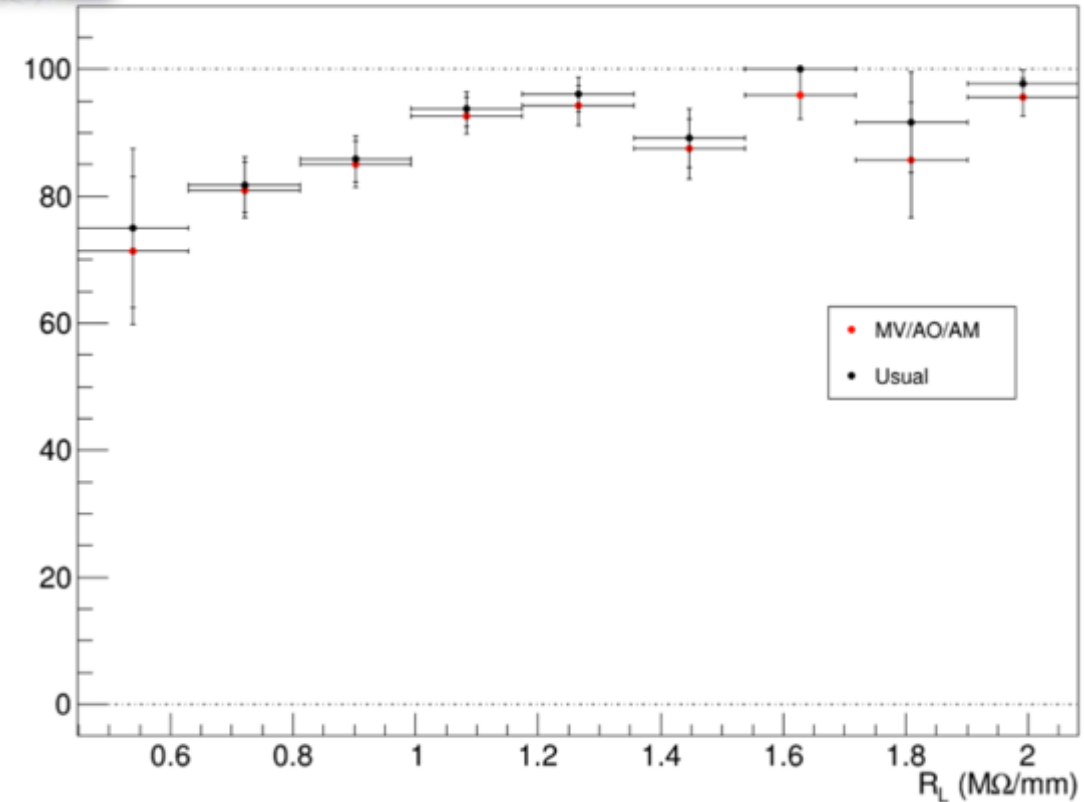


Layer 4



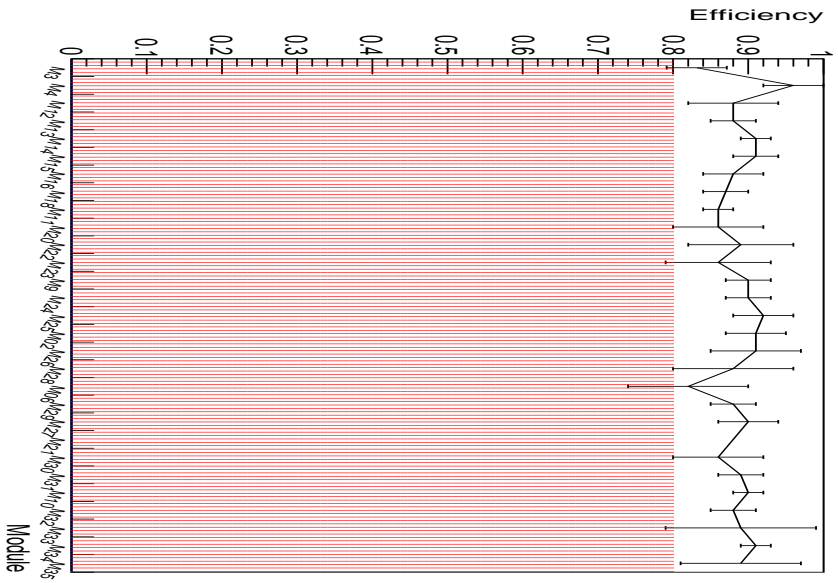
Layer 2

Fraction of good sectors - R_L^{Probe} - Both Sides

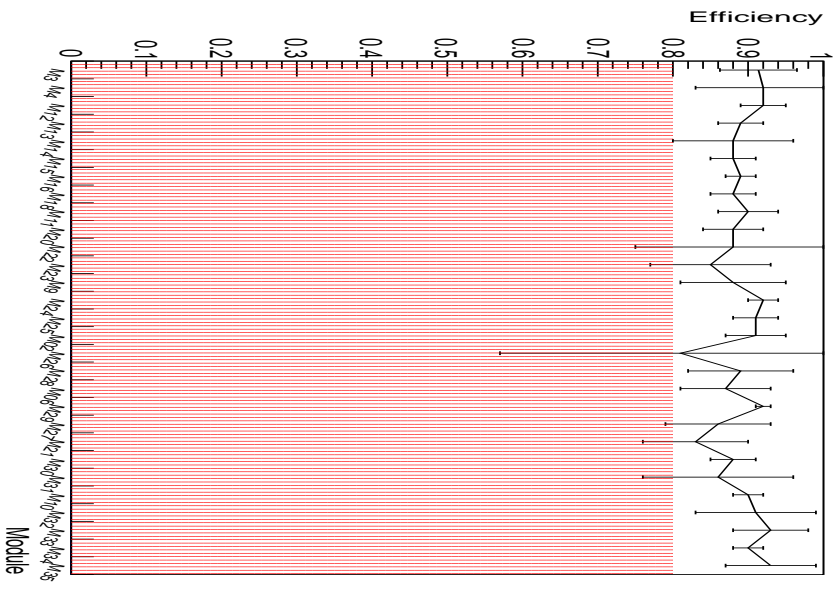


MODULE EFFICIENCIES

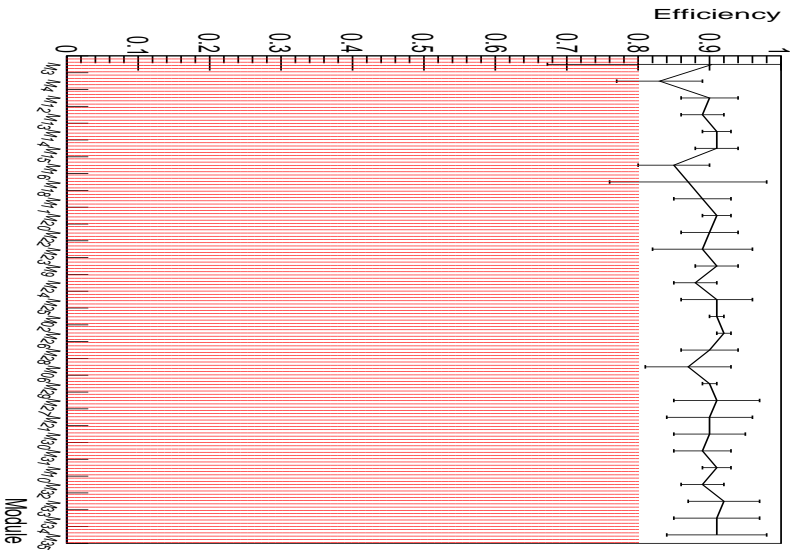
Efficiency: Layer 2



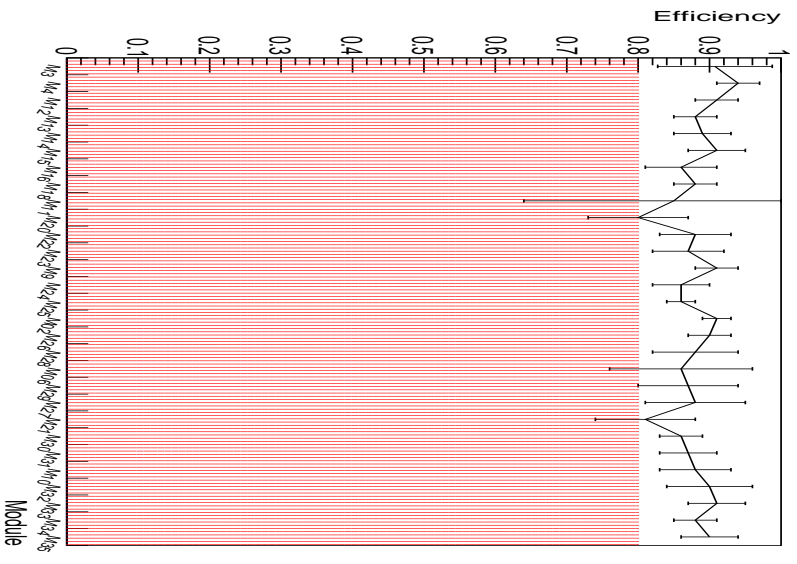
Efficiency: Layer 4



Efficiency: Layer 1



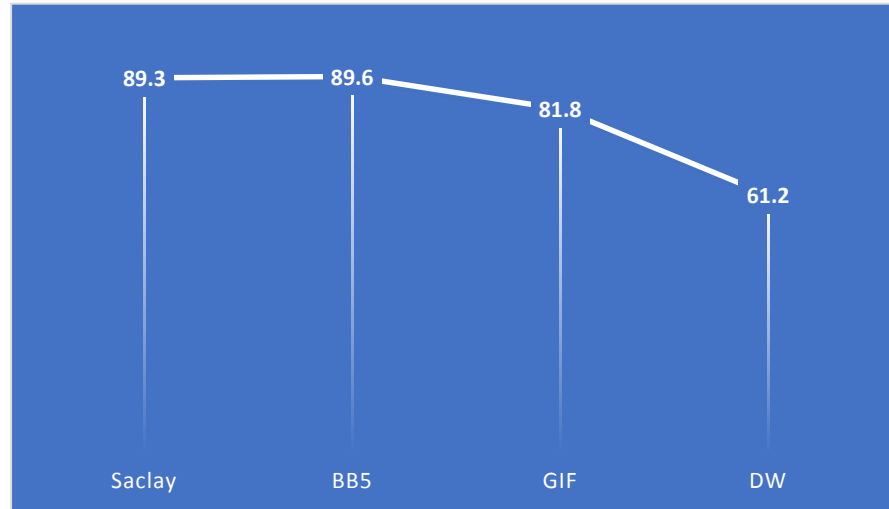
Efficiency: Layer 3



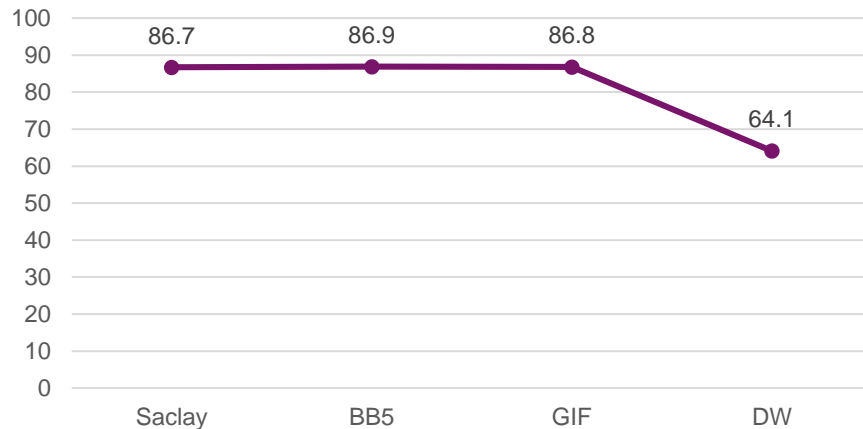
IMPORTANT DECONDITIONING WITH TIME



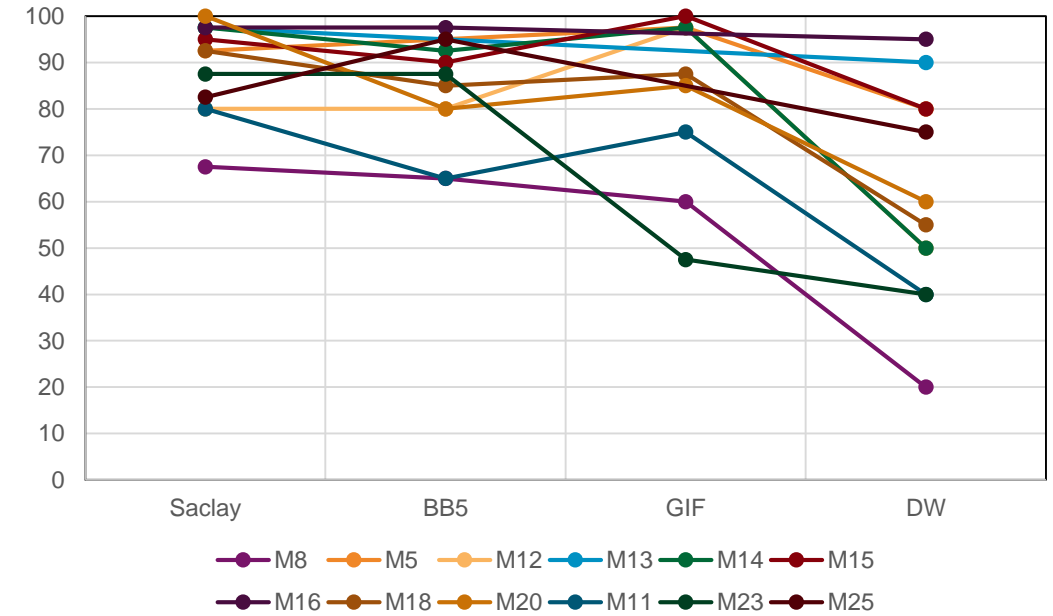
Proportion of good sections (HV > 550 V)



Average HV Efficiency LM1



LM1 evolution



- Main difference between Saclay and Cern is the time used for conditioning (drying and HV ramp-up)
- Gas flow without heating is not enough to remove humidity
- No storage under gas flow at Cern (humidity!)
- Continuous gas flow on the wheel → margin for improvement

- 32 LM1 modules + 1 spare have been produced and delivered at Cern
- Still one spare to produce and one Stereo doublet for studies
- This is (almost) the end of a very complicated production
- Despite the technical problems (mainly due to low resistivity) this technology is well adapted for large area. For future, a stronger prototype policy should be considered and avoid success-oriented planning.
- The work of the Isobutane group carries a large hope to operate these detectors in a more secure mode
- Special thanks to our Frascati colleagues who came several times at Saclay to help us during production



Thank you!