

Construction and test of Micromegas detectors for the ATLAS NSW

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for the AUTH ATLAS group



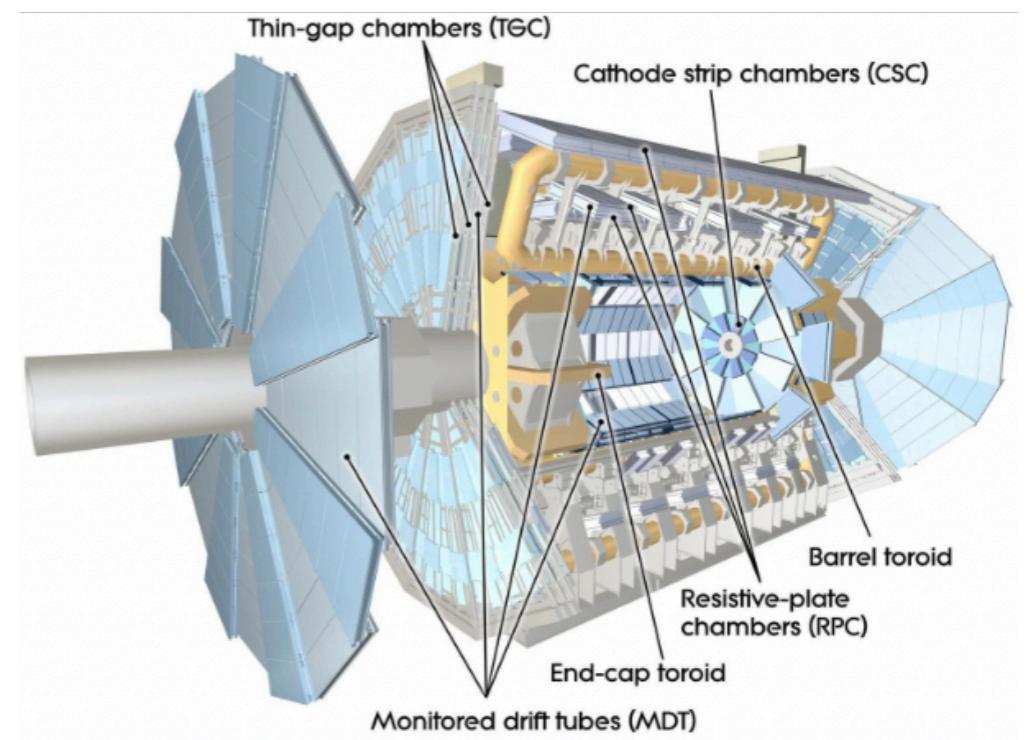
HEP 2018

Outline

- NSW
- Micromegas on NSW
- Production of drift panels
- QAQC

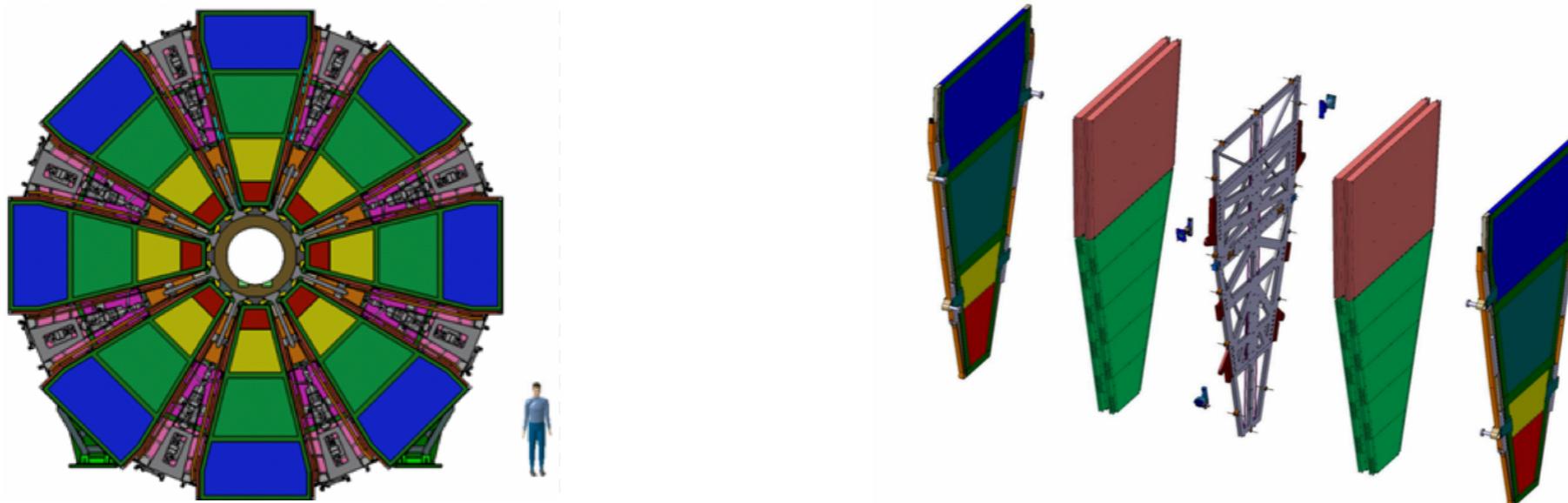
NSW - Requirements

- NSW will replace the innermost end-cap station of the muon Spectrometer
- Located between end-cap calorimeter and end-cap toroid
- Maintain momentum resolution and keep single muon trigger under control
- Requirements:
15% p_T resolution at 1 TeV—>~100 μm resolution per plane on a multilayer station
- Trigger:
1 mrad online angular resolution



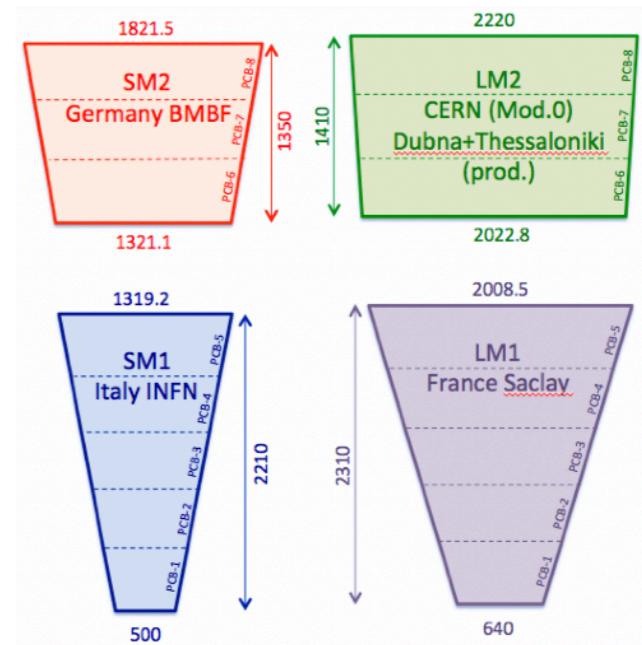
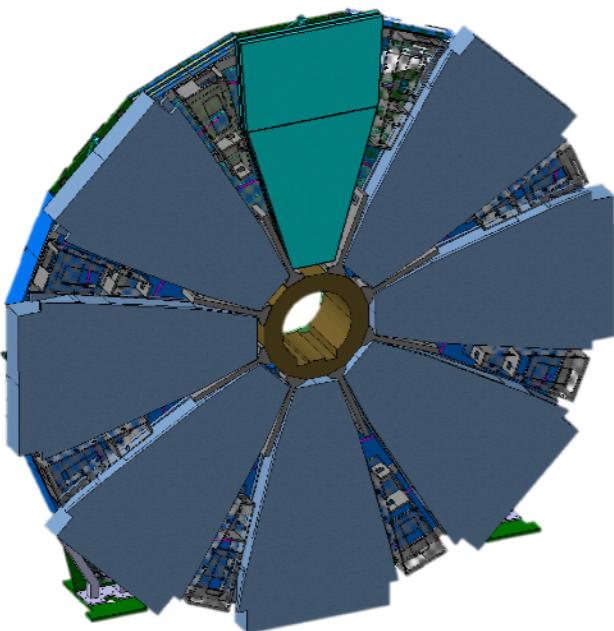
NSW layout

- Small-strip Thin Gap Chambers (sTGC) and Micromegas (MM)
 - sTGC: primary trigger detectors
 - MM: primary tracking detector
- Arranged in units (quadruplets) with 4 detector layers —>1 quad = 1 detector unit
- 8 sTGC and 8 MM detector layers
 - > high redundancy (limited accessibility, long lifetime)



Micromegas layout

- Trapezoidal shape quads, up to 3 m² surface
- 4 quad types; 32 detectors per type
- Each quad has 2 anode and 3 cathode panels
- Institutes from 5 Countries + CERN
- Thessaloniki in collaboration with JINR produces the LM2 type of MM quadruplets. (Drift panels – RO panels)
- Thessaloniki will provide 96 Dift panels, equipped with mesh.

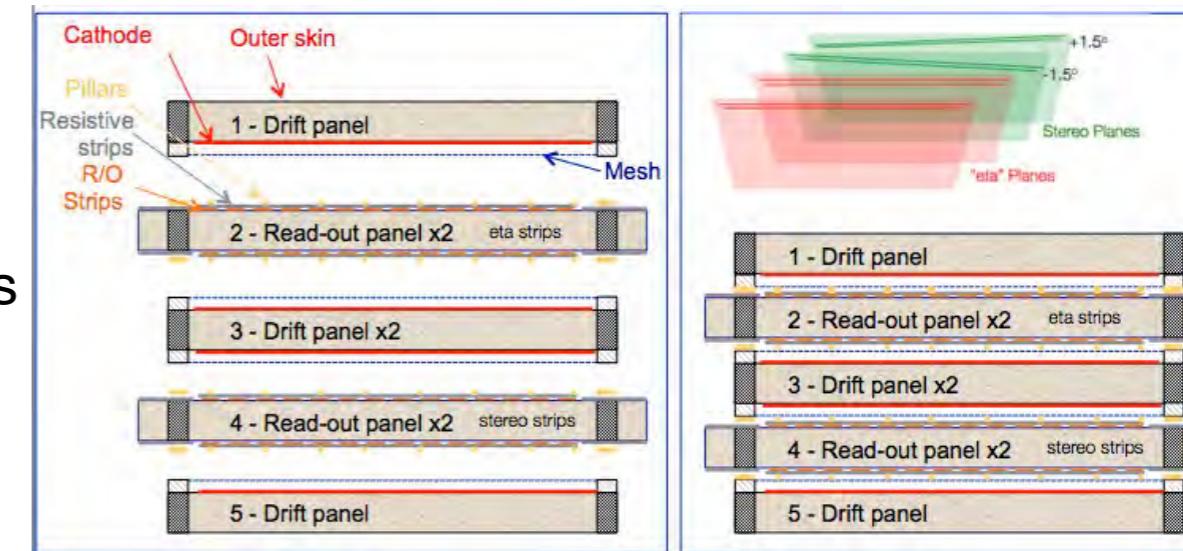


Micromegas quadruplet

- 1 Drift panel + 1 side of RO panel => 1 Micromegas chamber

- To make quad :

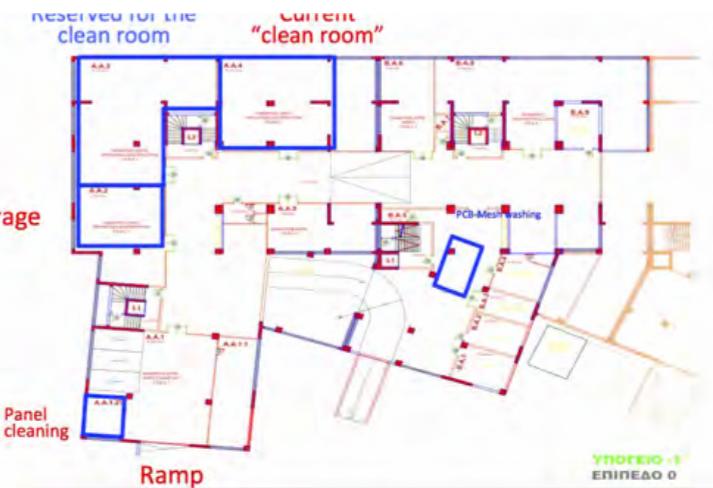
- 1 Central Drift panel, cathodes on both sides
- 2 external drift panels, cathode on one side
- 2 RO panels double-side
 - 1 → “eta” parallel strips
 - 1 → “stereo” strips $\pm 1.5^\circ$



- Total 4 micromegas gaps

The Lab

- Facilities @ Balkan Center



- Three rooms → **New Clean room**
- Three rooms → **2 Preparation rooms (1 vestibule of clean room)**

Workshop

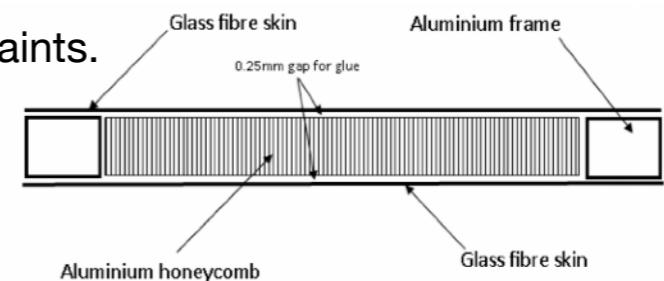
- Thanks to Aristotle University of Thessaloniki for funding the construction of the new laboratory.



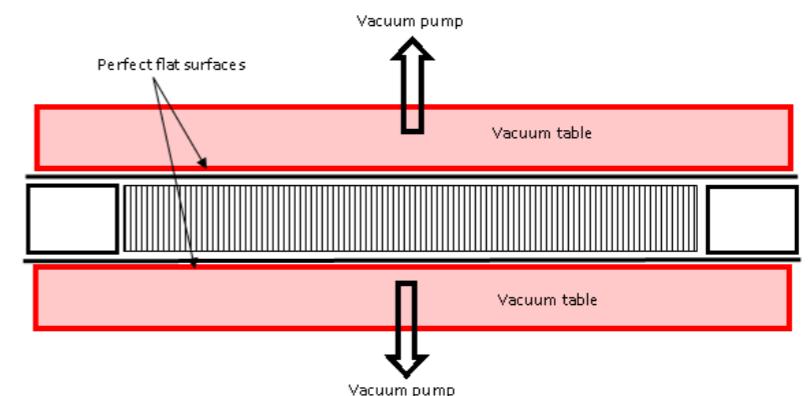
Construction of panel

Panel is:

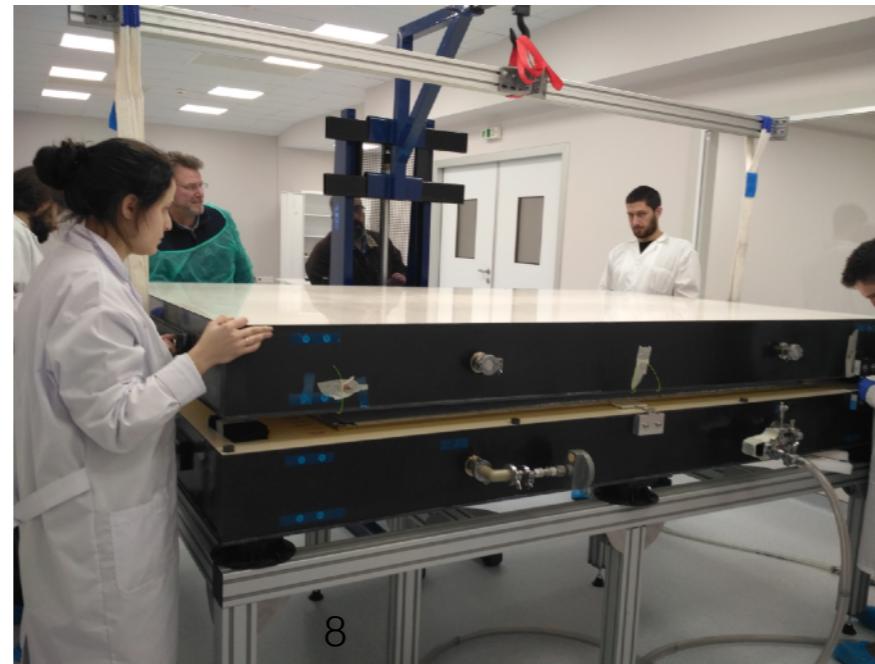
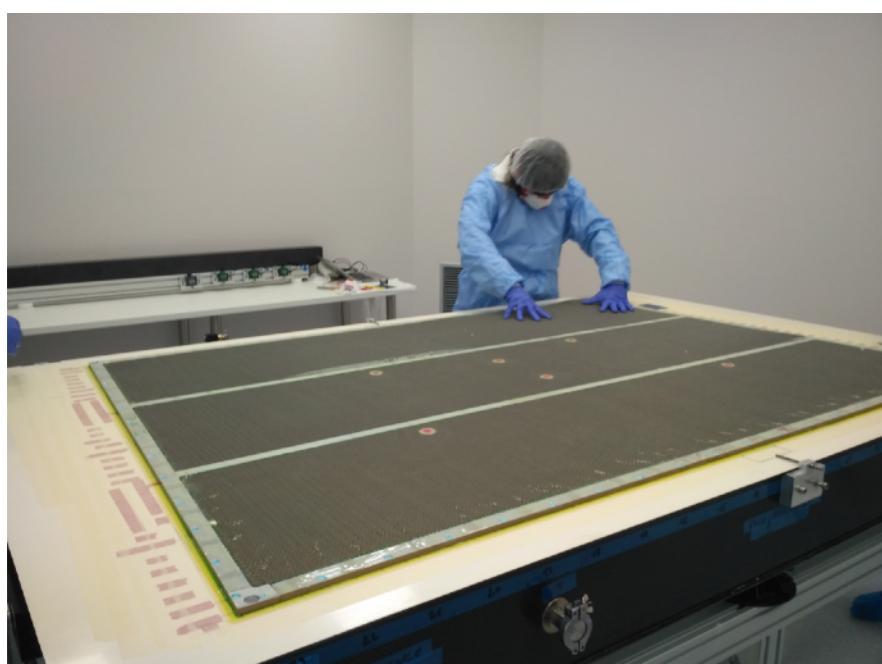
- A sandwich of two thin skins glued on a stiff plane without mechanical constraints.



- A sandwich consists of:
 - One PCB (glass fibre skin, 0.5mm)
 - Aluminium honeycomb surrounded with an aluminium frame
 - Second PCB (FR4 copper cladded, 0.5mm)



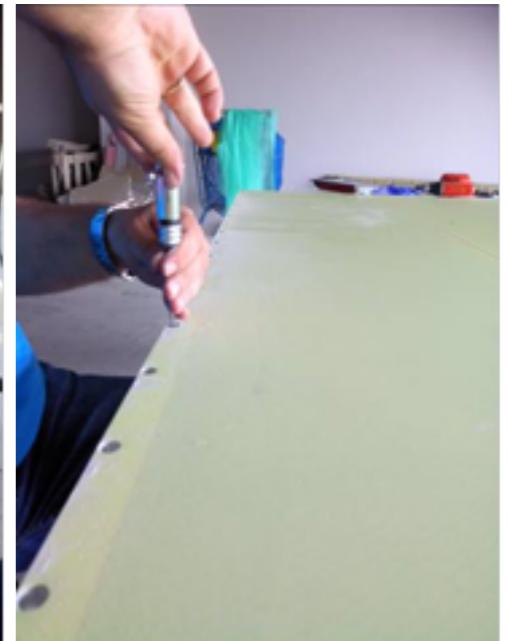
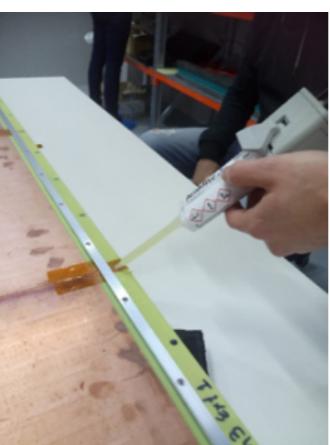
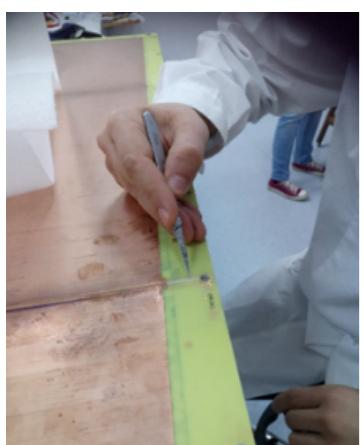
- Manufacturing concept:
 - The PCBs are sucked with two vacuum tables
 - The vacuum table surfaces are perfectly flat
 - The vacuum table surfaces are set in parallel position



Drift Panel completion

- A lot of work to proceed to the next step:

- Cutting and cleaning
- Sealing
- Mesh frame gluing
- Gas pipes - Soldering - Spacers gluing



Mesh stretching

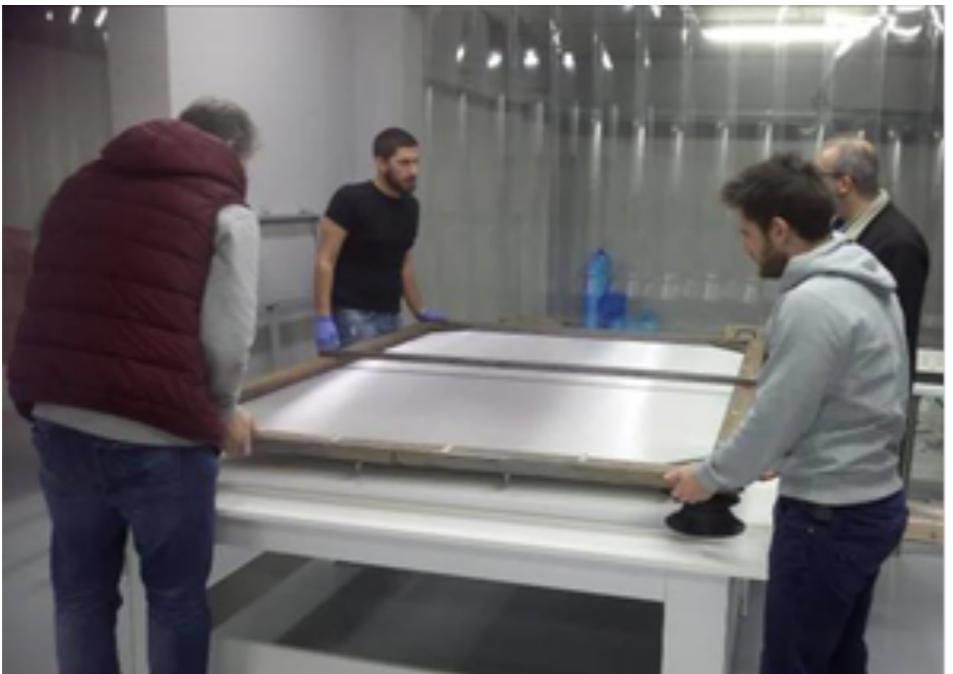
- Mesh sheet has to be stretched

—> stretching manually

—> meticulous measurement of tension (10 N/m)



- Glued on a transfer frame
- Glued on the drift panel



Mesh and panel cleaning

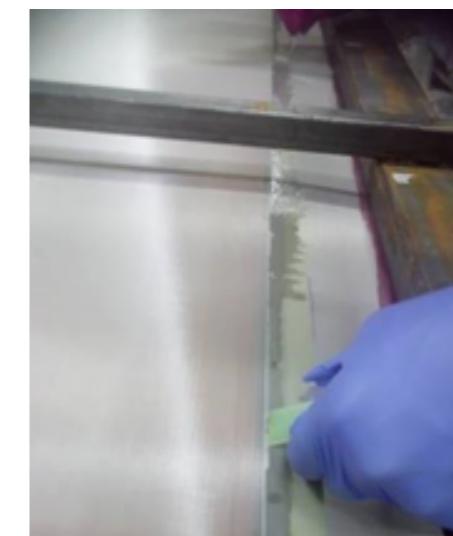
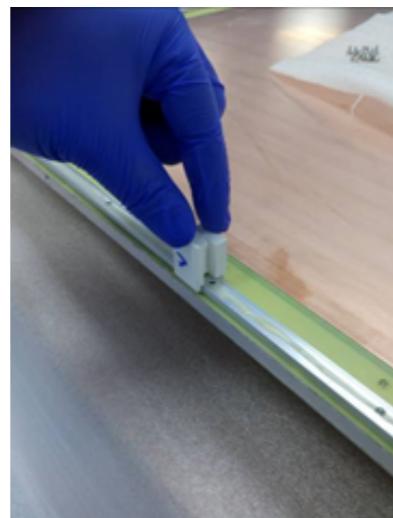
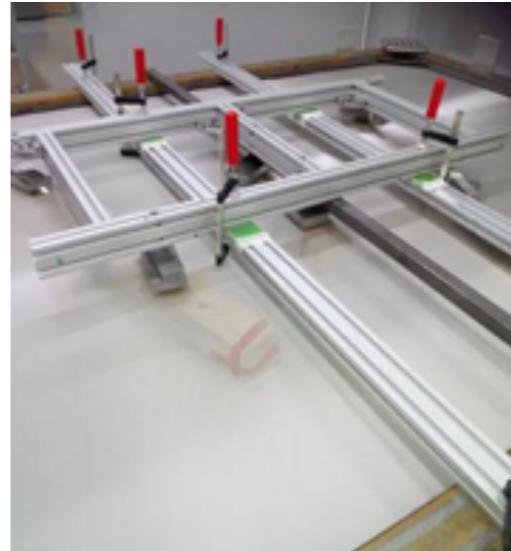
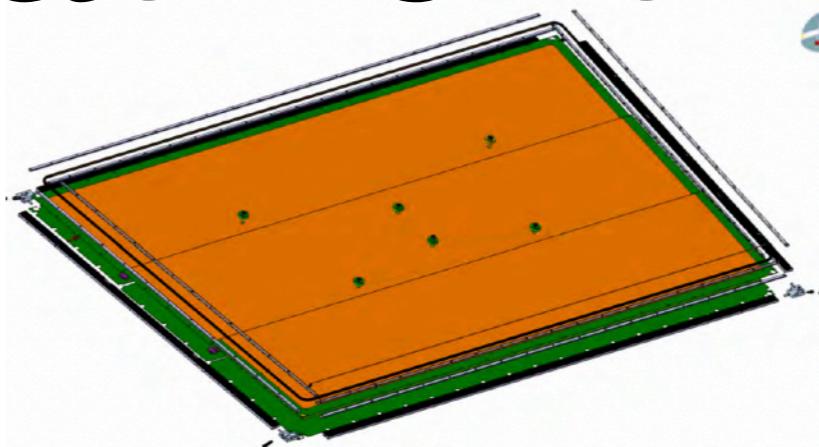
- Cleaning with tap water (40°C) and NGL detergent
- Rinsing with deionised water
- Careful cleaning is necessary
 - > Every possible fibre or residuals could affect the chamber operation (current leaks)



Mesh treatment

- 6 interconnection in LM2 module to minimise the volume expansion of the quadruplet

- Passivation (with a template)
- Punching (with standard weight)
- Transferred on the Drift panel and glued
- Cleaning mesh surplus from the mesh frame

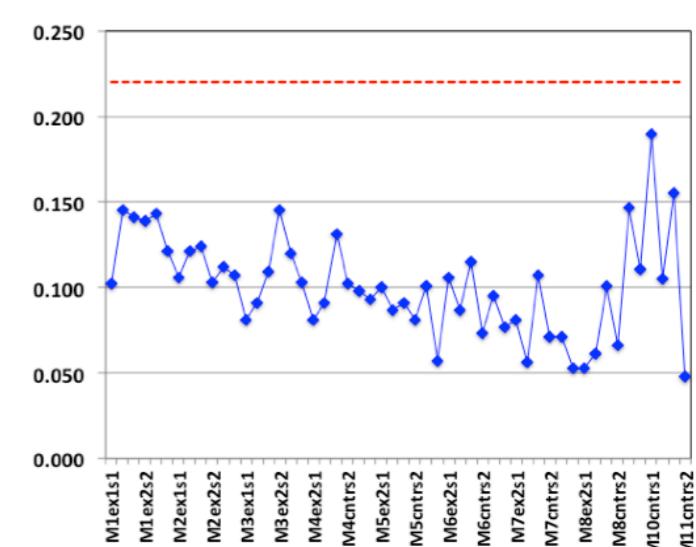
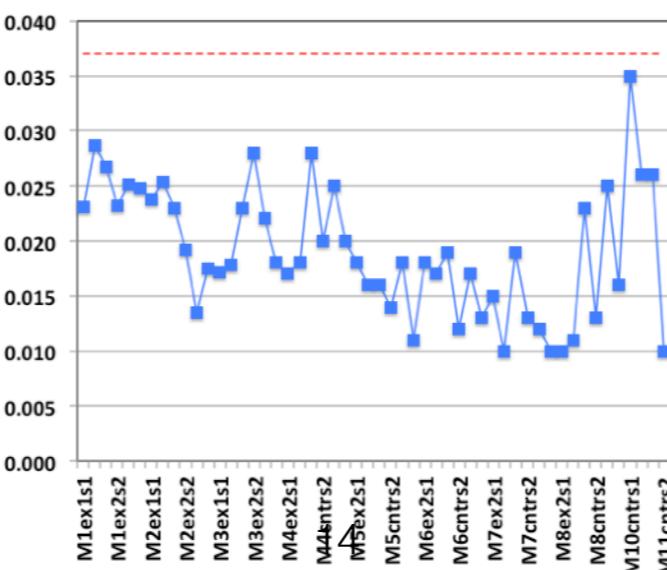
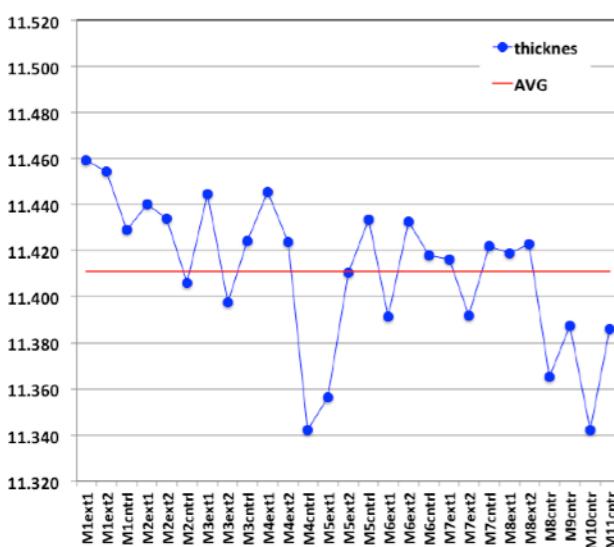
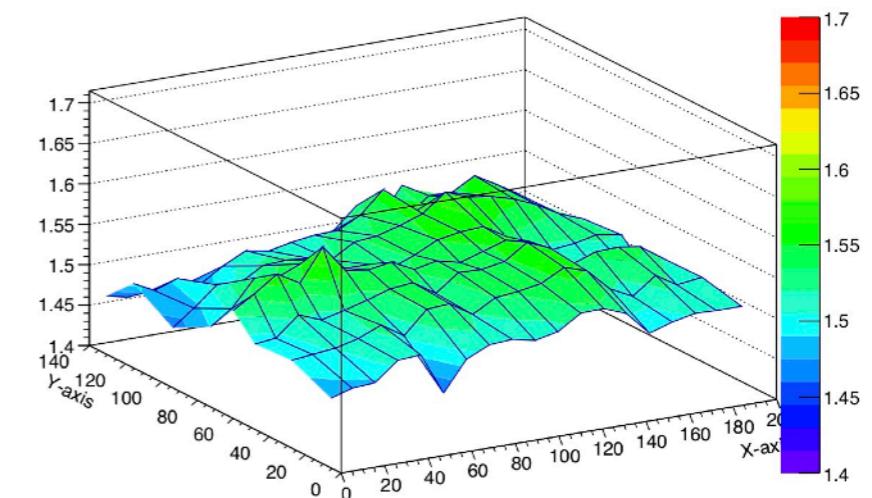
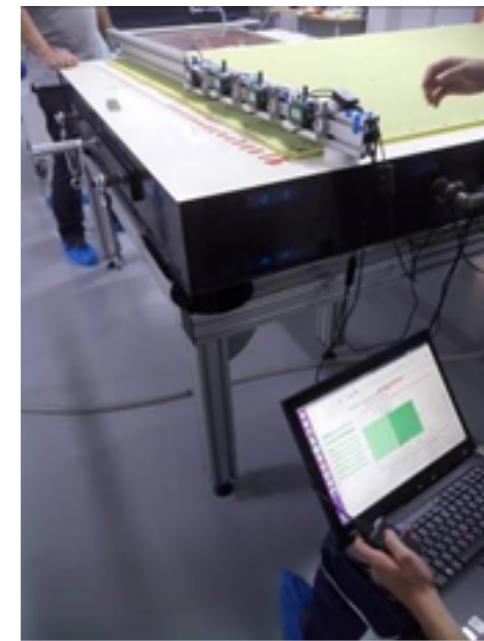


QA/QC

- Panels have to fulfil ATLAS specifications
- A lot of measurements are done on the produced panels
- Planarity and thickness
- Height of all parts added on the panel
- Gas tightness
- High Voltage test
- All measurements are stored in the ATLAS Database

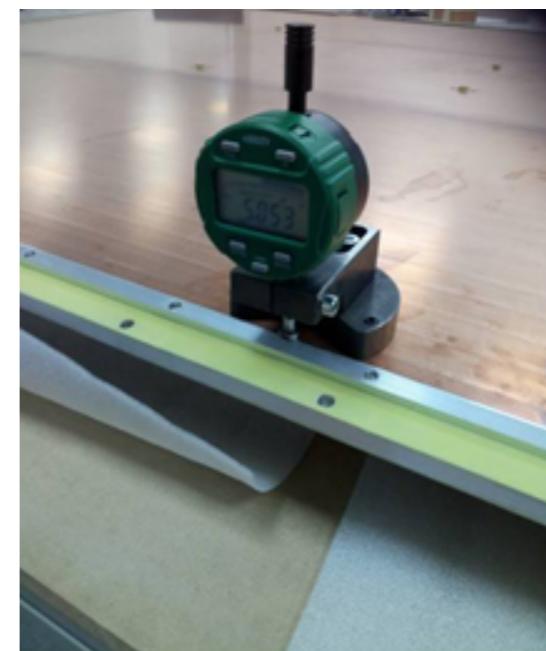
Planarity

- Measurements with vacuum on (thickness) and off
- Measurements using a limbo tool of thickness with digital indicators
- Nominal values $11.410 \text{ mm} \pm 0.037 \text{ mm}$
- RMS $< 37 \mu\text{m}$
- Crucial for the field uniformity

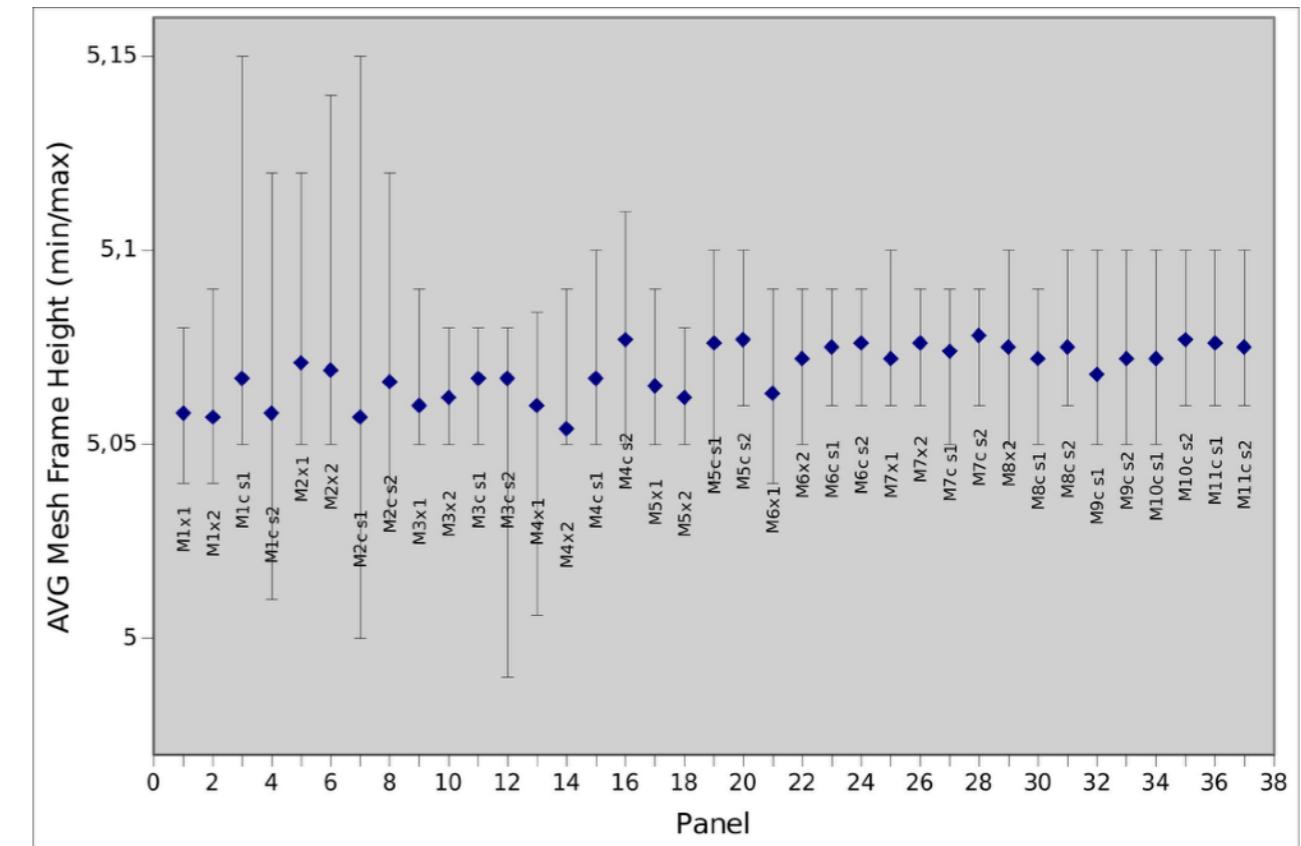
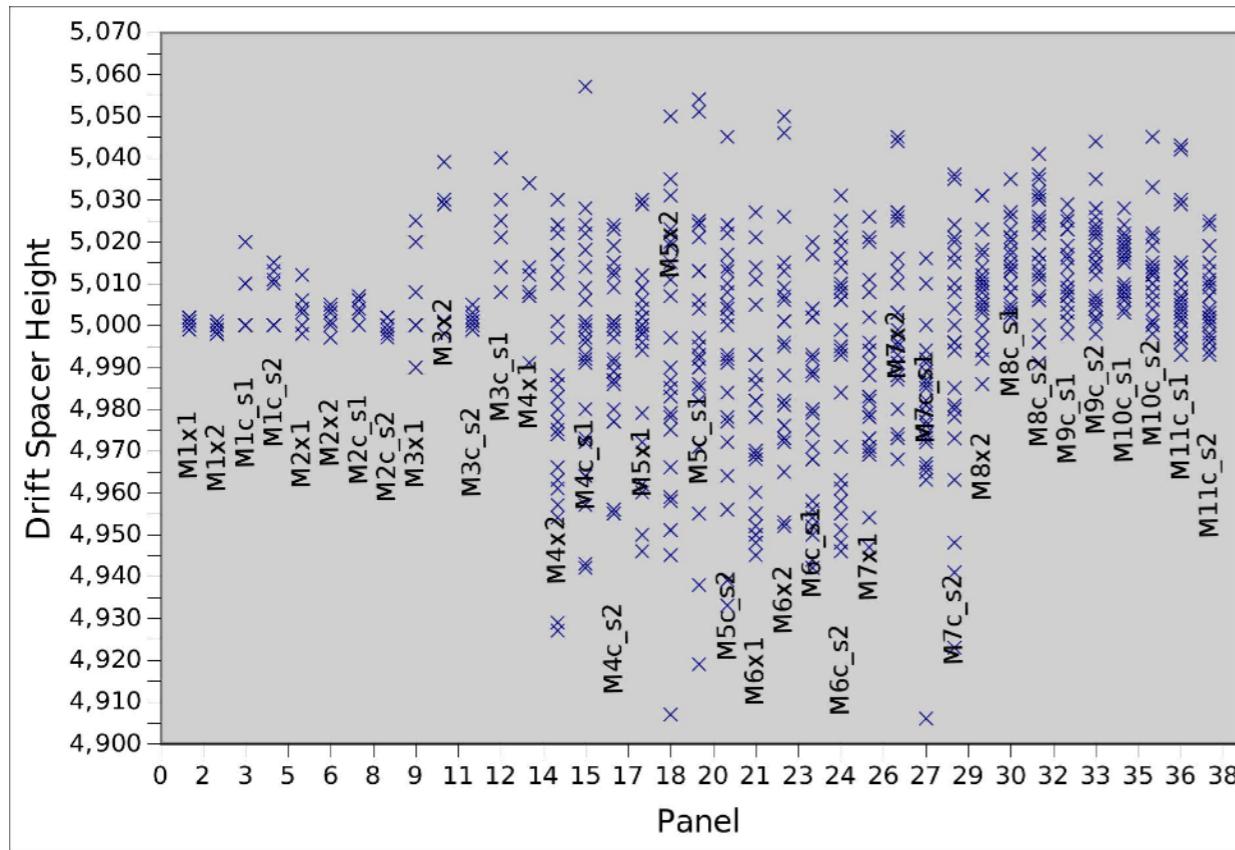


Height measurements

Measurement	Nominal Value(mm)	rms (mm)	Tolerance
Periphery thickness	< 11.5	-	
Spacers thickness	5	0. 045	[4.955,5.045]
Mesh frame hight	5.06	0.01	[5.03,5.09]

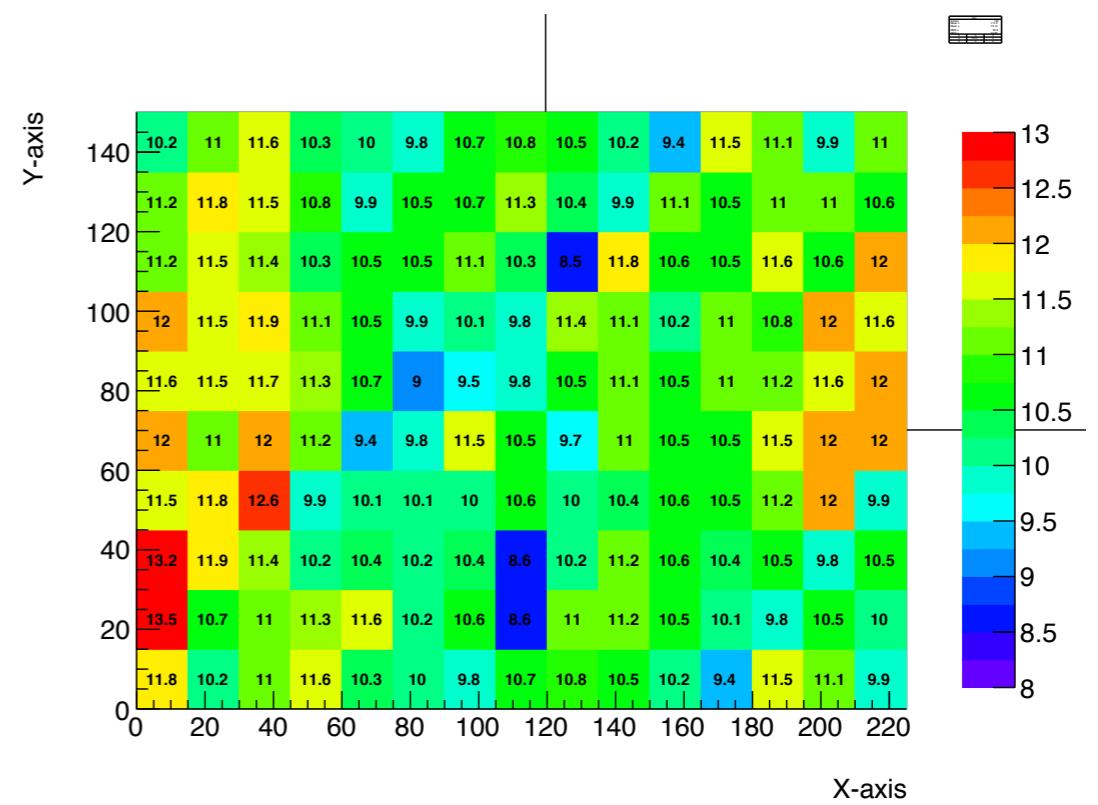
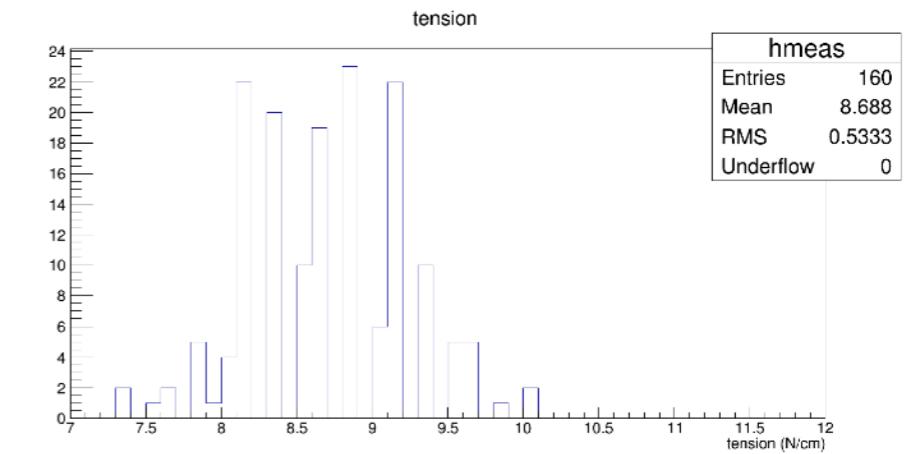


Hight measurements



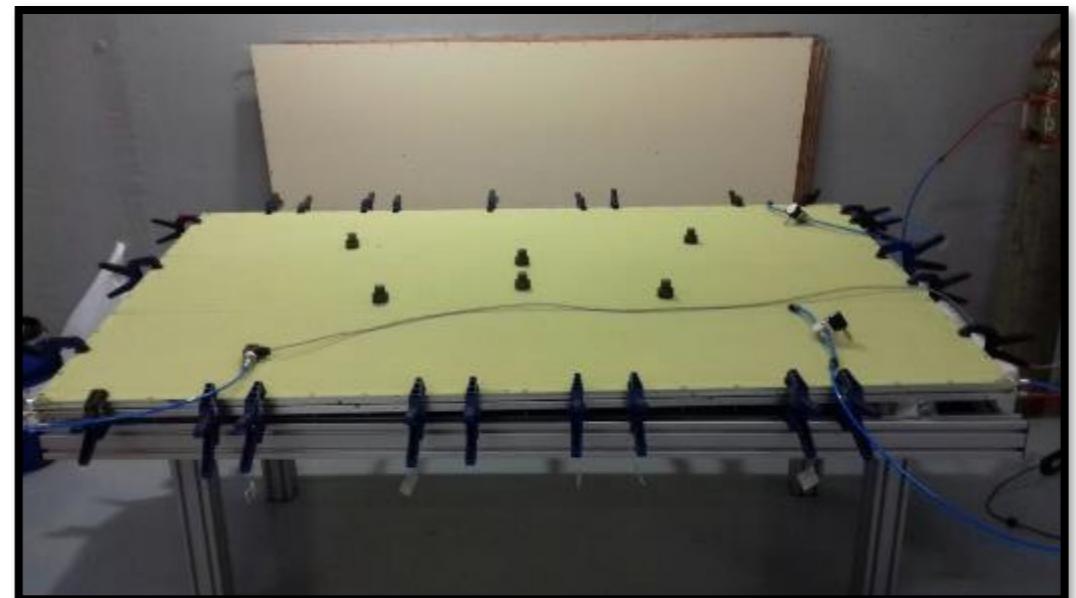
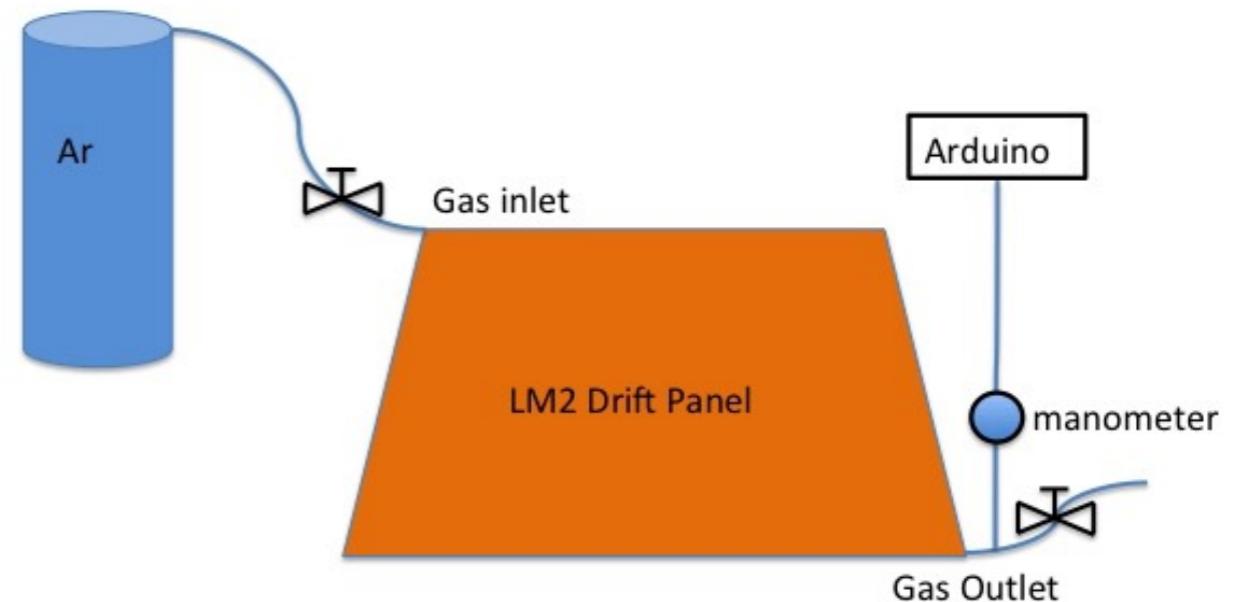
Mesh tension

- 2 dimension measurement of tension
- Average per measurement
- Range on drift panel [7,10]
- Uniformity < 10 N/m



Gas leak

- Pressure drop method
- 2 panels per measurement or 1 central
- Use of interconnection to limit the volume changes of the chamber
- Very crucial for the operation of the chamber —> velocity of electrons



Gas leak

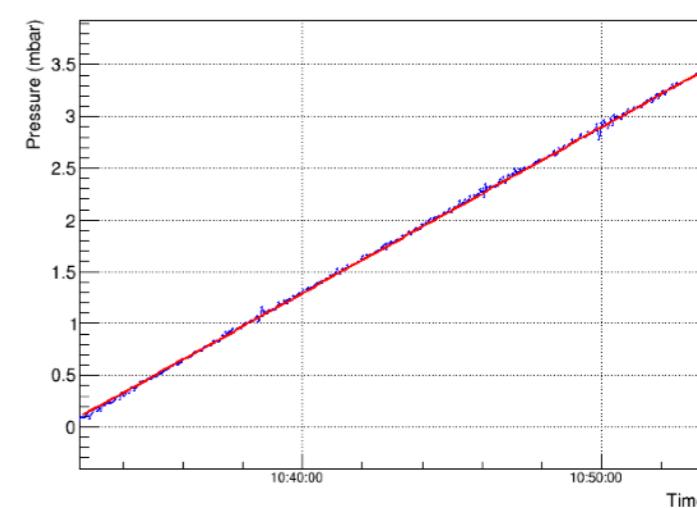
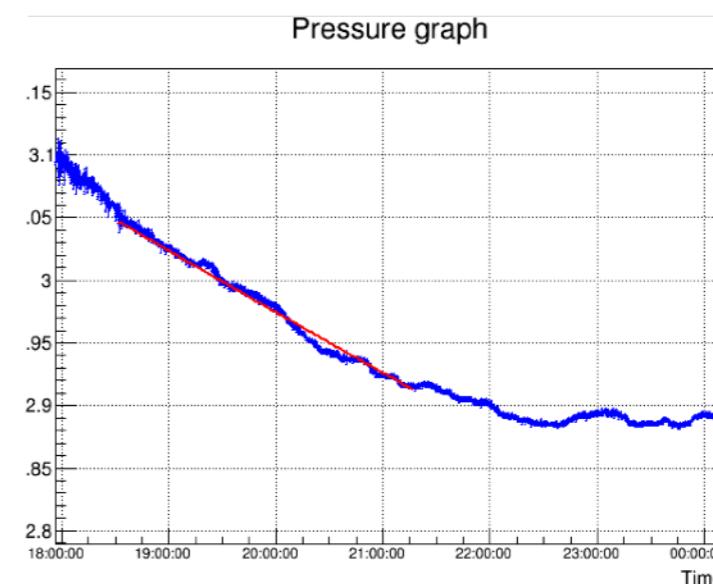
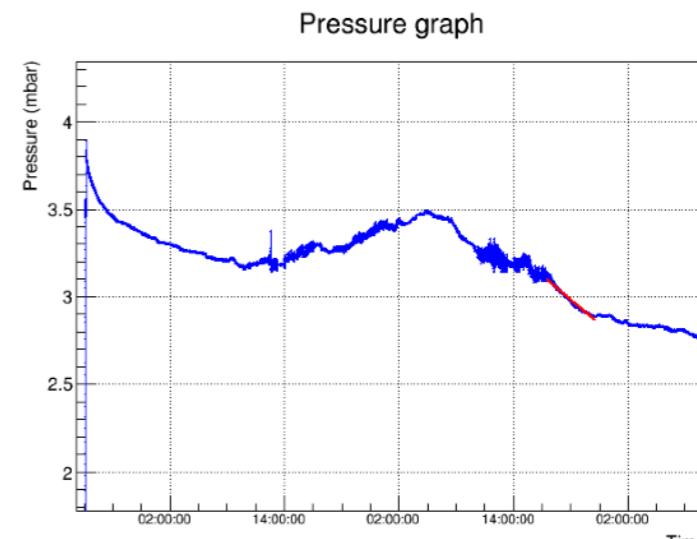
$$\begin{aligned}\text{Gas leak} &= \frac{\Delta p^{atm}}{p_0} + \frac{\Delta p^{over}}{p_0} + \frac{\Delta V}{V_0} + \frac{\Delta T}{T_0} \\ &= \frac{\Delta p^{atm}}{p_0} + \frac{\Delta p^{over}}{p_0} + k \frac{\Delta p^{over}}{p_0} \\ &= \frac{\Delta p^{atm}}{p_0} + (k+1) \frac{\Delta p^{over}}{p_0}\end{aligned}$$

- $\frac{\Delta p^{over}}{p_0}$ is the slope of the measurements (expo or P1)
- Improvement with deferential manometer to monitor the atmospheric pressure
- Upgrade by using mass flow method (S. Tzamarias)

Gas leak results

- Nominal value is 0.6 mbar/h
- Very demanding standards
 - > dependence on fluctuations of barometric pressure

Panel	mb/h
mod3_ex1	0.59
mod3_ex2	0.57
mod4_ex1	0.67
mod4_ex2	0.49
mod5_ex1	0.18
mod5_ex2	0.49
mod6_ex2	0.45
mod5_cntrl	0.41
mod6_cntrl	0.59

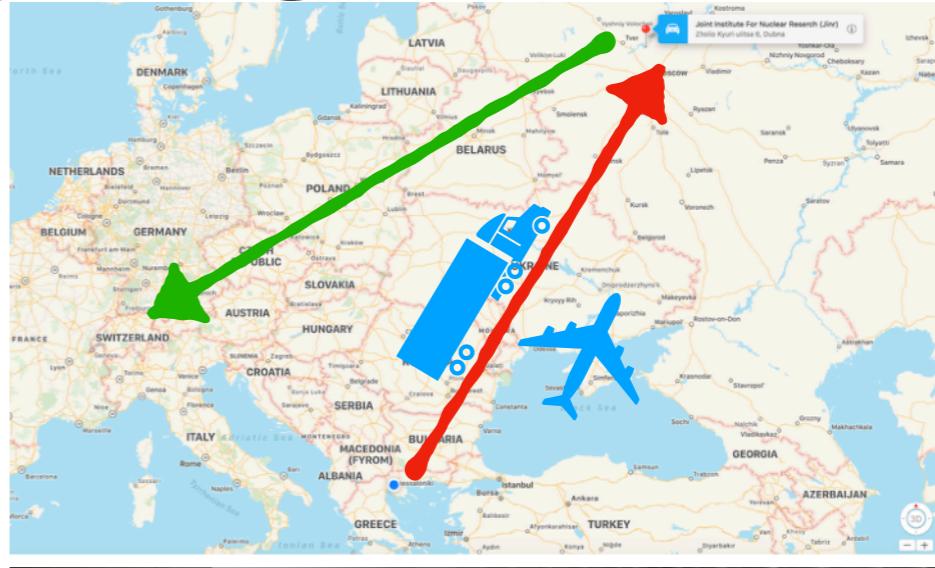


High voltage

- Panel must have resistance $\sim 100\text{GigaOhm}$
- Crucial for the quality of the panel. Possible leak current have to be eliminated
- Measurement of current \rightarrow at 500V current $< 10\text{nA}$

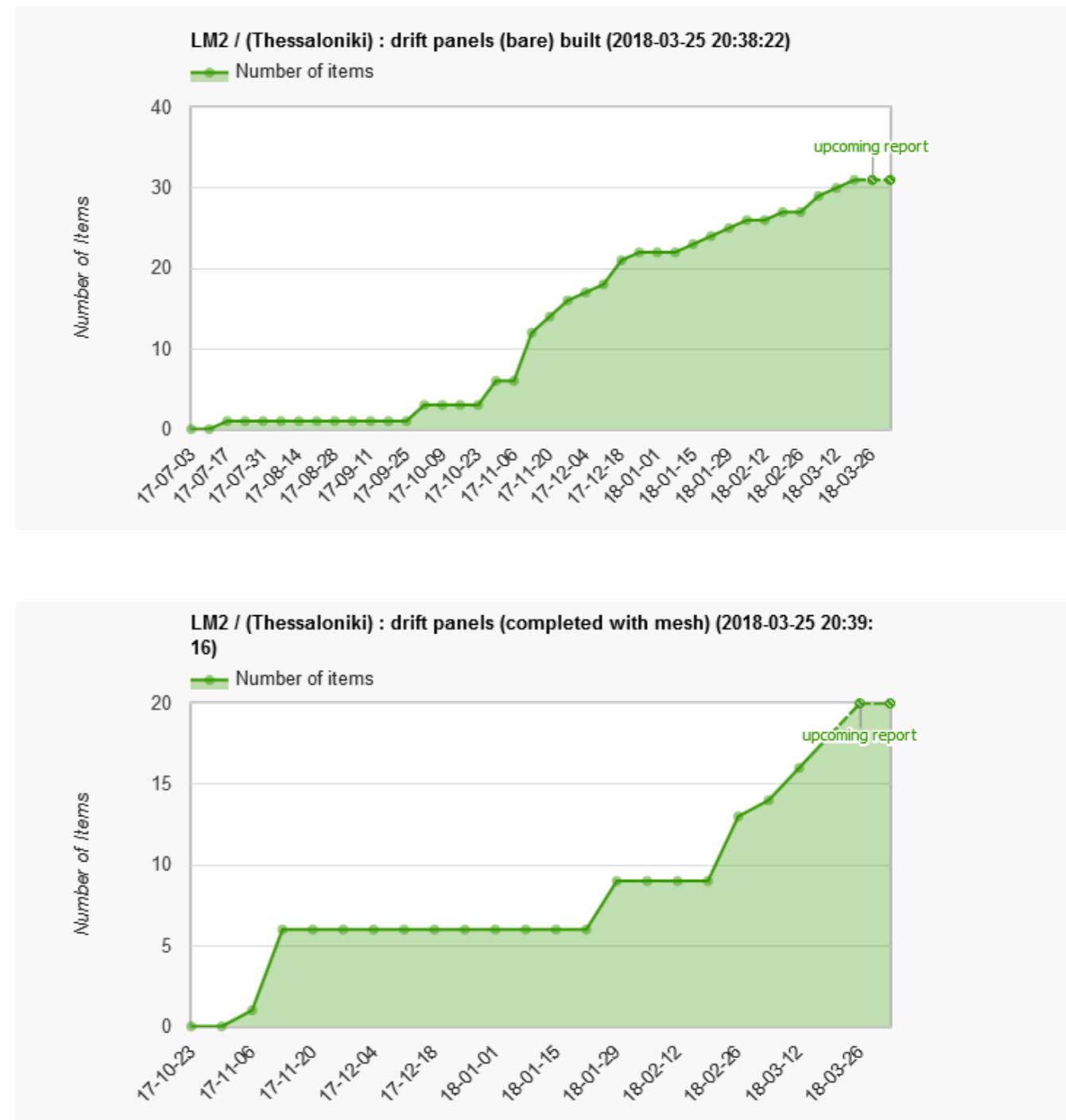
Packaging

- Read out panels are produced at JINR Dubna
- Panels are assembled in triplets (ready for later assembly together with RO panels in Quadruplets)
- Drift panels have to be sent there carefully
- A lot of parameters have to be considered:
 - Protection of the whole panels in case of movements
 - Protection of the mesh
 - Temperature variations



Time table

- Parallel working on 3 levels
- Estimated time/panel → 5 days
- Random delays from many reasons (lack of raw materials)
- Till now 32 bare panels have been produced (33% of production!)
- Estimated time of project's integration → 2Q 2019



Manpower

- Manpower of the lab: 8
 - 1 Post Doc
 - 1 Mechanical engineer
 - 3 PhD students physicists
 - 2 Physicists
 - 1 Technician



- 4 Qualification tasks for the ATLAS experiment
- A lot of experience is earned especially for the young members of the team

Conclusions

- Particle and Nuclear laboratory of AUTH is obtaining knowledge on the development of state of the art particle detectors on mass production
- Not only for prototype sizes but also for large scale detectors
- With the contribution of university, lab has acquired facilities (New Clean Room) and equipment sufficient to take over more projects on the future
- Staff of the laboratory is trained to fulfil projects with high standards

Thank you

Back up slides

Extremely high tightness of panels

