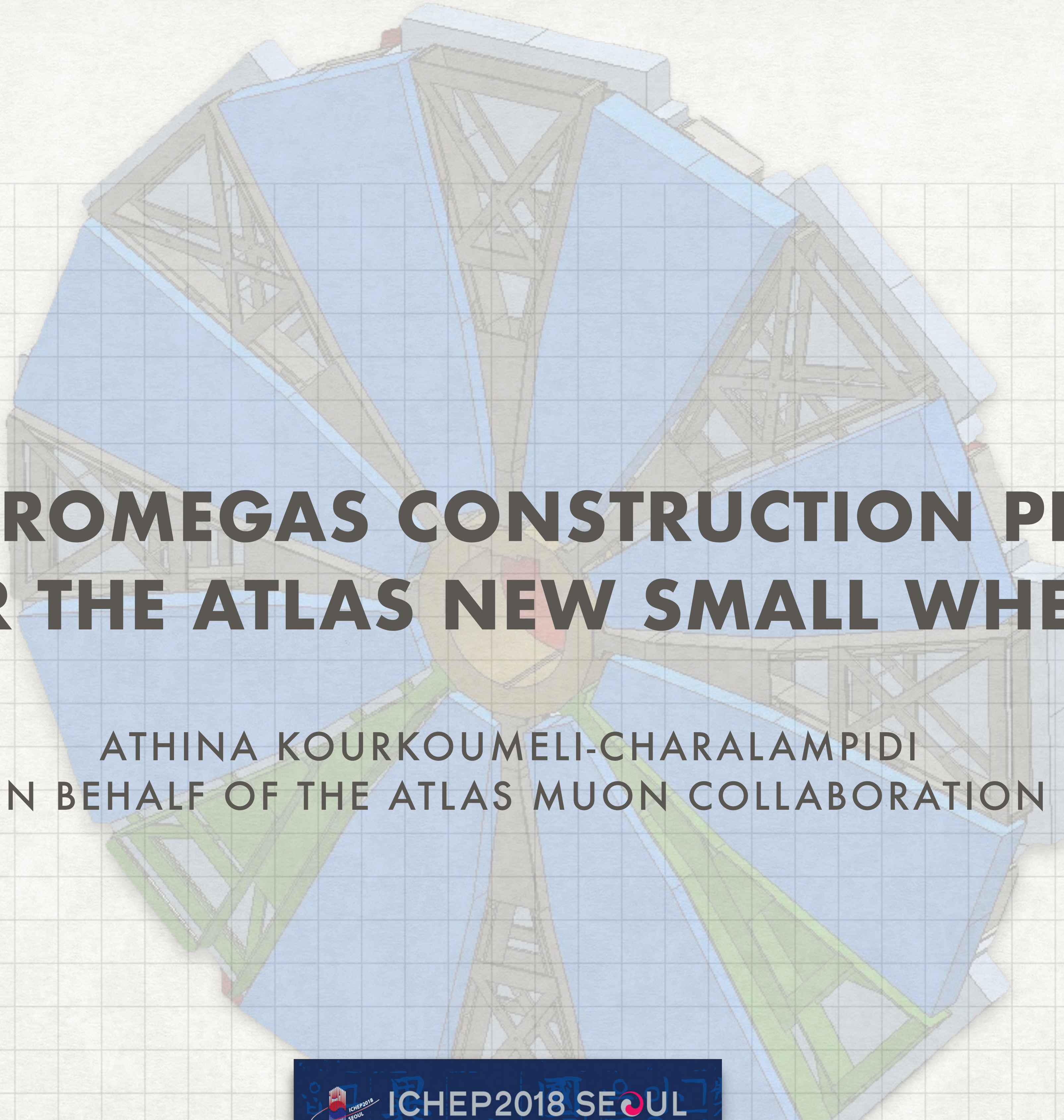

THE MICROMEGAS CONSTRUCTION PROJECT FOR THE ATLAS NEW SMALL WHEEL

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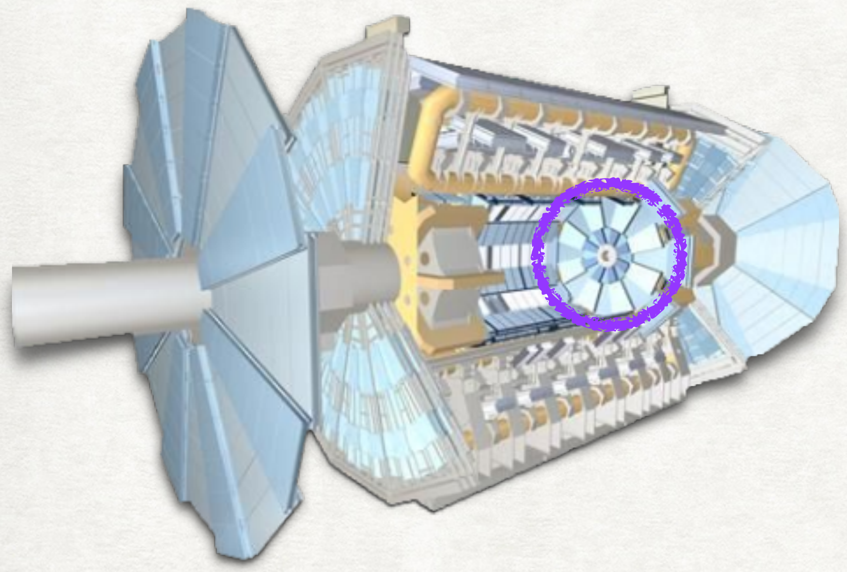
ON BEHALF OF THE ATLAS MUON COLLABORATION

ICHEP2018 SEOUL
XXXIX INTERNATIONAL CONFERENCE ON high energy PHYSICS

THE ATLAS NEW SMALL WHEEL

Upgrade of the innermost end-cap region of the Muon Spectrometer



Upgrade required to operate the Muon Spectrometer at higher rates

Run III (starting 2021): 2 x design Luminosity

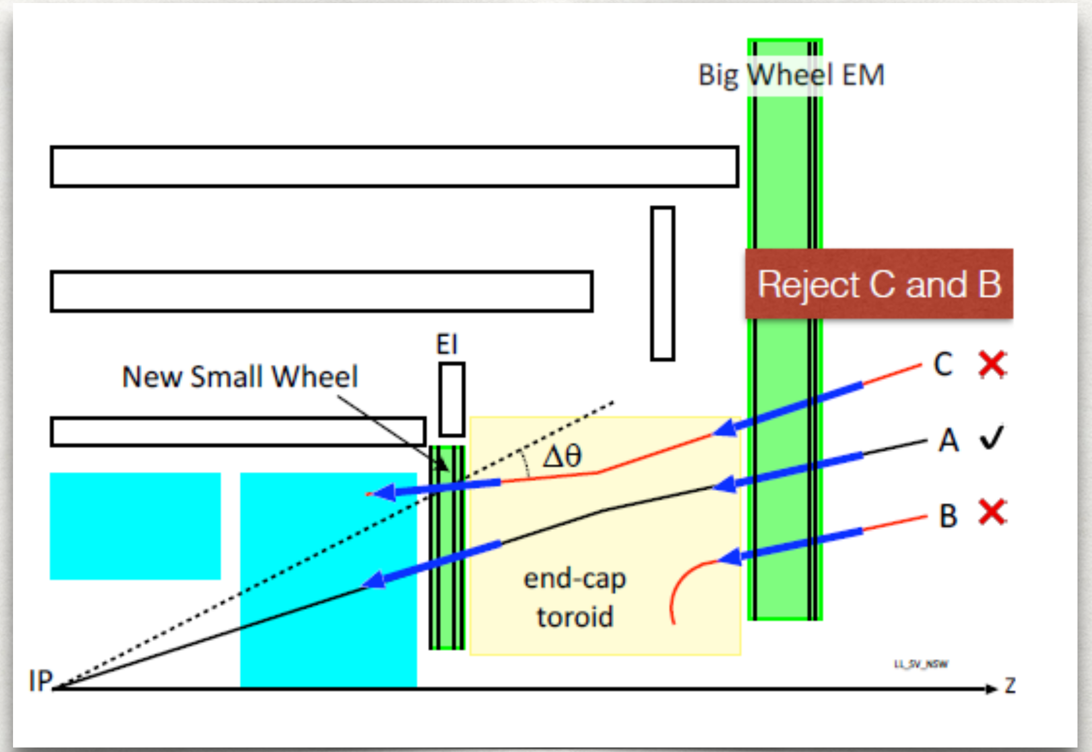
HL-LHC (starting 2026): 5-7 x design Luminosity

Motivations:

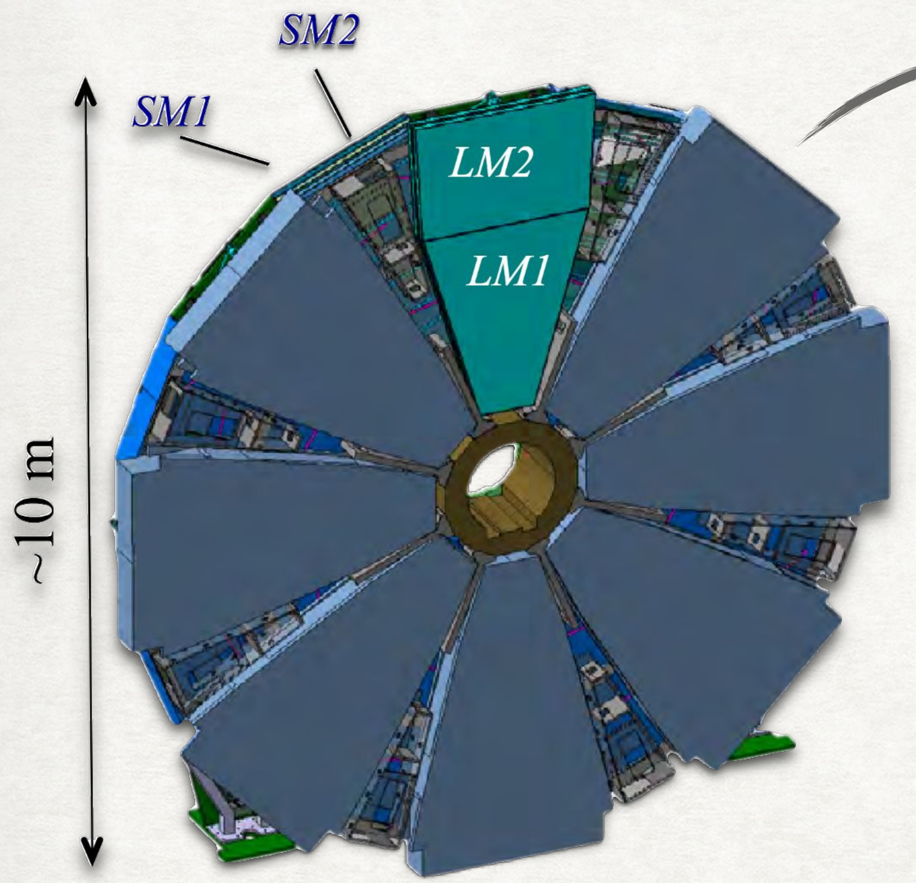
- Tracking:
  MDT/CSC performance will drop significantly at HL-LHC rates (expected: up to 15 kHz/cm^2)
  → Install detectors which can withstand the rates

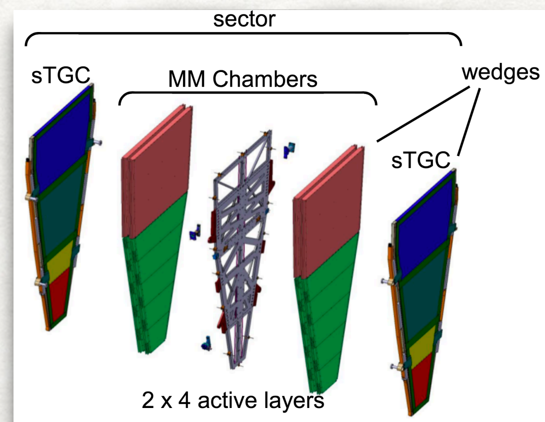
- Triggering:
  Current L1 Muon trigger relies mostly on Big Wheel:
  High fake rates on end-cap regions
  → Extend trigger coverage up of $|\eta|=2.7$
  → More robust trigger to reduce the fake rates

Above 90% trigger fake rates!



THE NEW SMALL WHEEL CONFIGURATION





128 MM q-plets

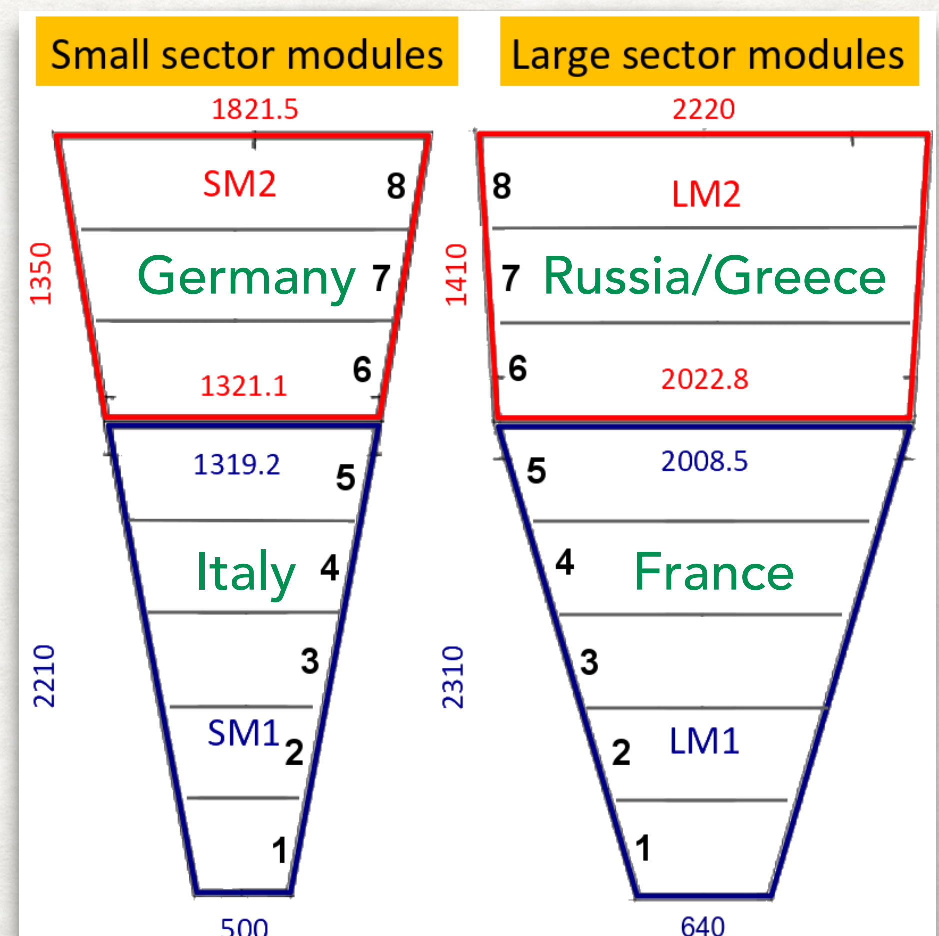
NSW:

16 sectors per wheel

- 8 small, 8 large

Sectors:

- Sandwich of 2 sTGC and 2 MM quadruplets



__Two detector types:__

Micromegas (MM): primary tracking

Strip TGC (sTGC): primary triggering

4 Micromegas (MM) q-plet types

SM1/LM1 types: 5 PCBs

SM2/LM2 types: 3 PCBs

32 q-lets per type

MICROMEGAS DETECTOR

MM detector characteristics:

- Good spatial resolution ~100 um independent of incident angle
- Good track separation: 0.4 mm RO granularity
- Rate capability above 15 kHz/cm²

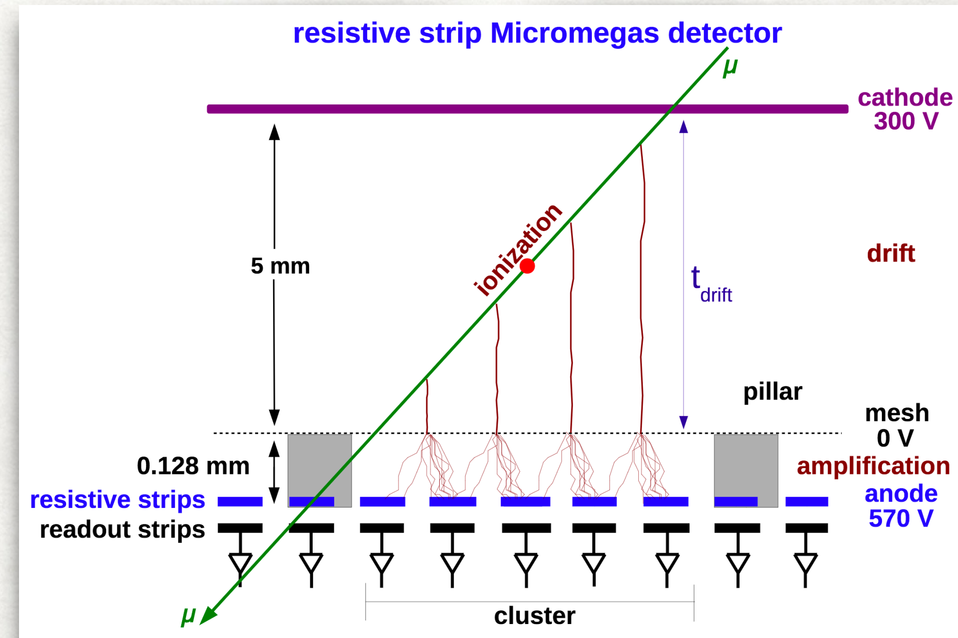
MM detector requirements:

- Provide online segments for triggering (1 mrad angular resolution)
- 15% resolution at 1 TeV

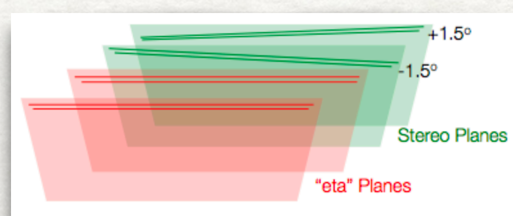
Gas used: Ar/CO_2 (93/7)

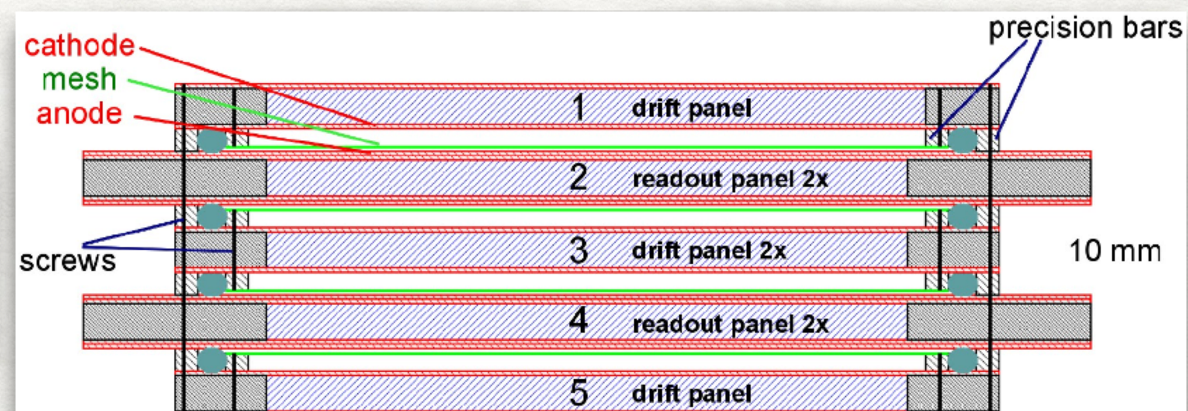
0.6 kV/cm

~50 kV/cm



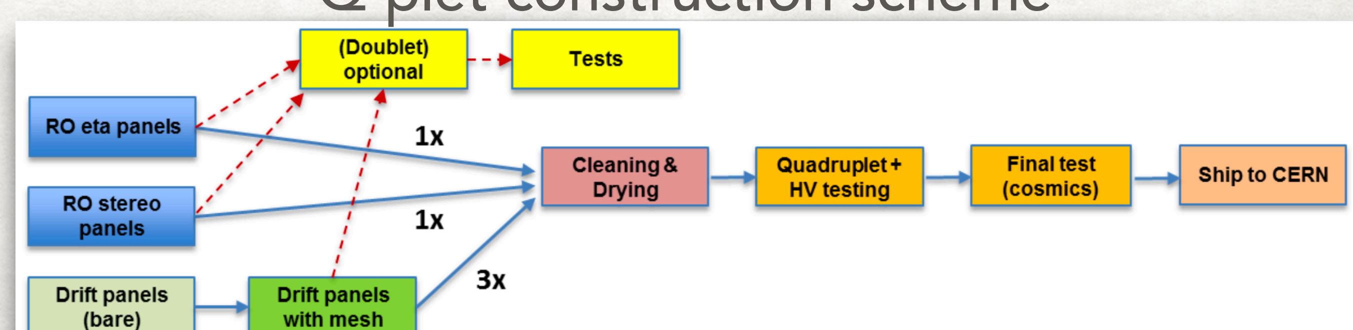
Quadruplet Structure:





- Two drift panel types
  - Single, Double
- Two readout panel types (back-back configuration)
  - Eta (strips perpendicular to η coord.)
  - Stereo (strips inclined by 1.5°)

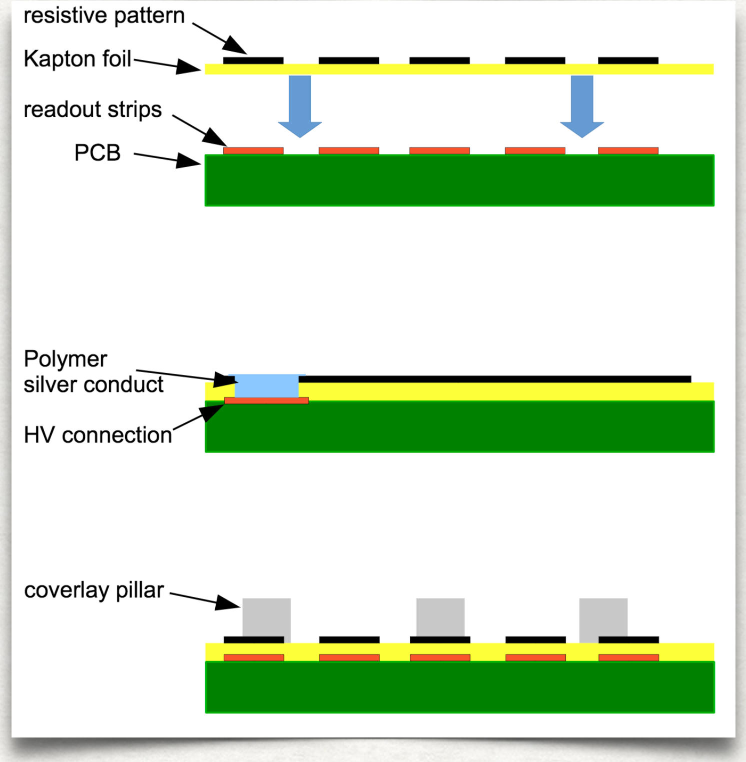
Q-plet construction scheme



READOUT PCB PRODUCTION AND PANEL CONSTRUCTION

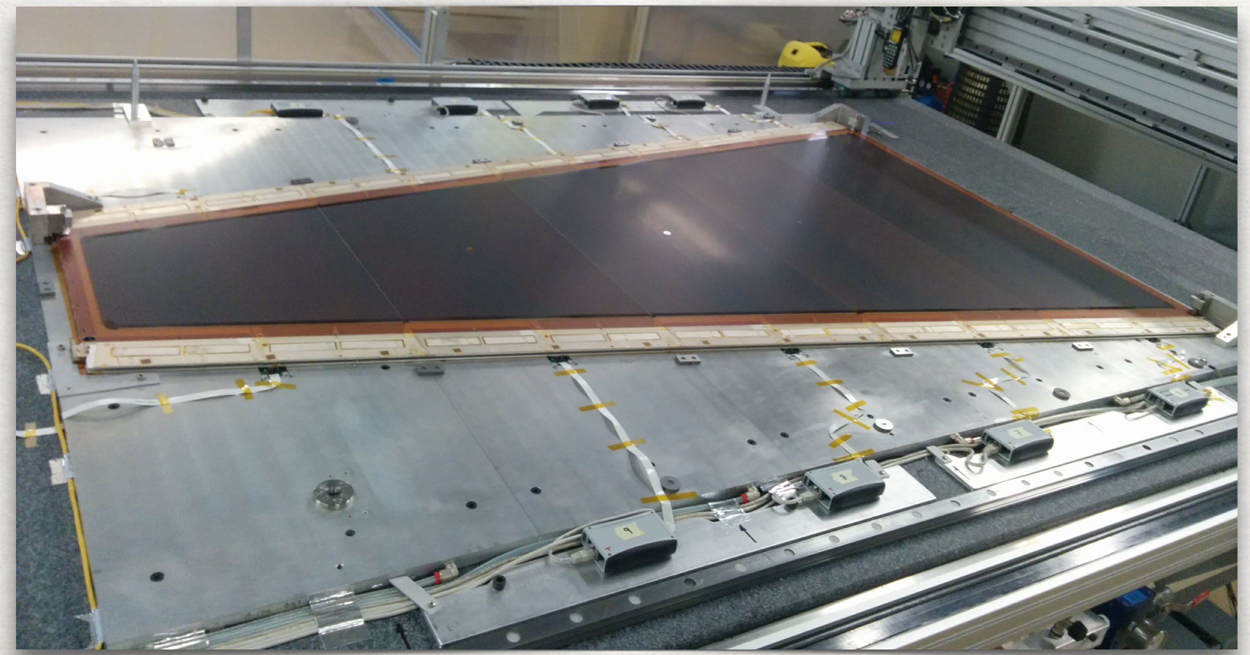
What is a readout panel made of?

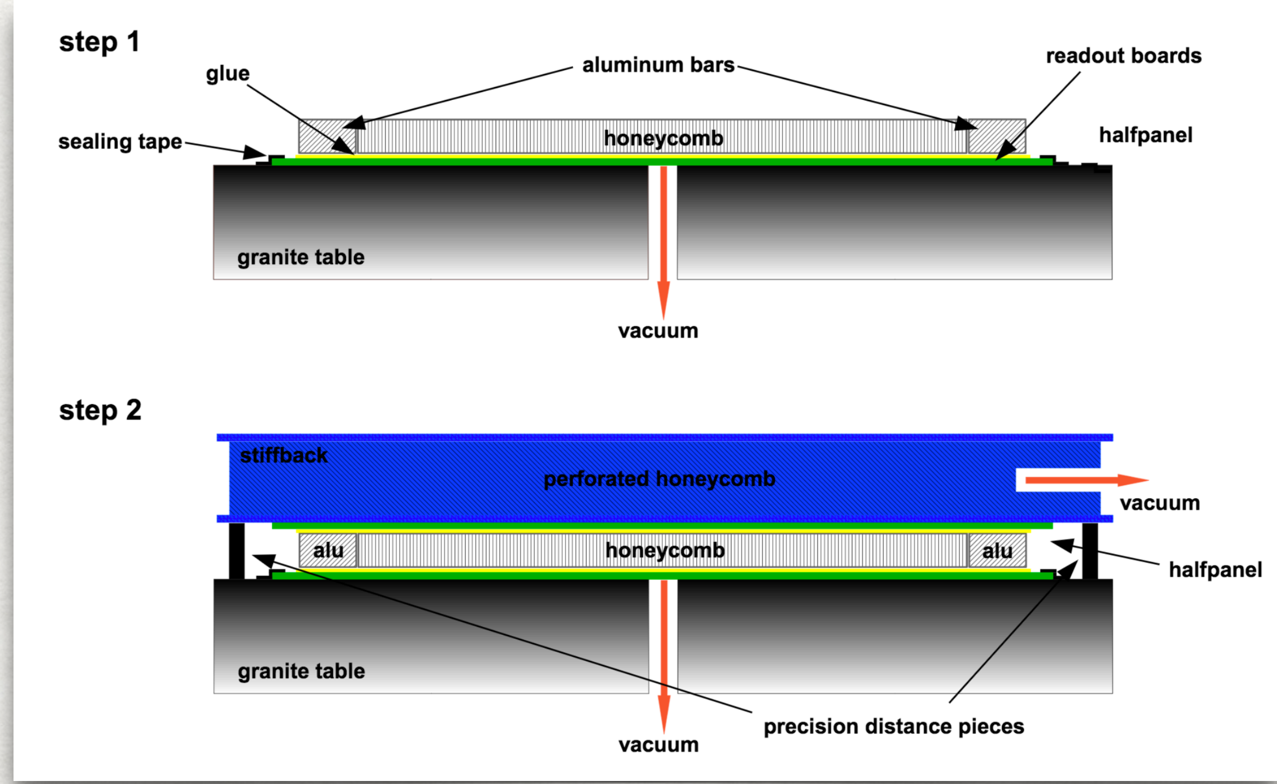
- Readout PCBs on both panel sides
  - Etched Cu strips on 0.5 mm glass fiber (FR4) sheets
  - Resistive foils (produced in Japan) for spark reduction
  - Pyralux® pillars to maintain the amplification region height
- Internal structure: Honeycomb, Frames, Cooling bars



Readout panel construction procedure

- PCBs placed on granite table under vacuum
- Internal structure glued on PCBs
  - Stiffback/Vacuum bag method





DRIFT PANEL CONSTRUCTION AND Q-PLET ASSEMBLY

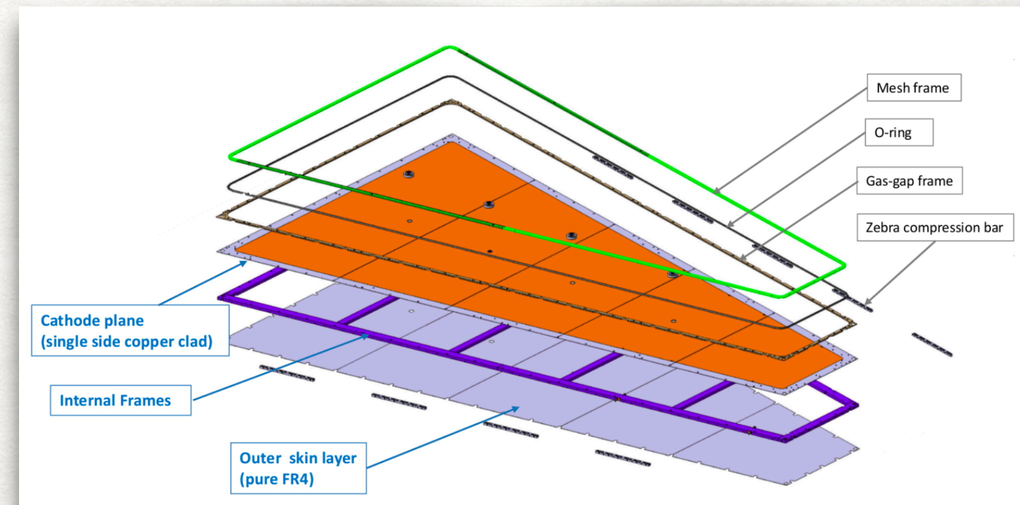
Assembled drift panel (Floating mesh):

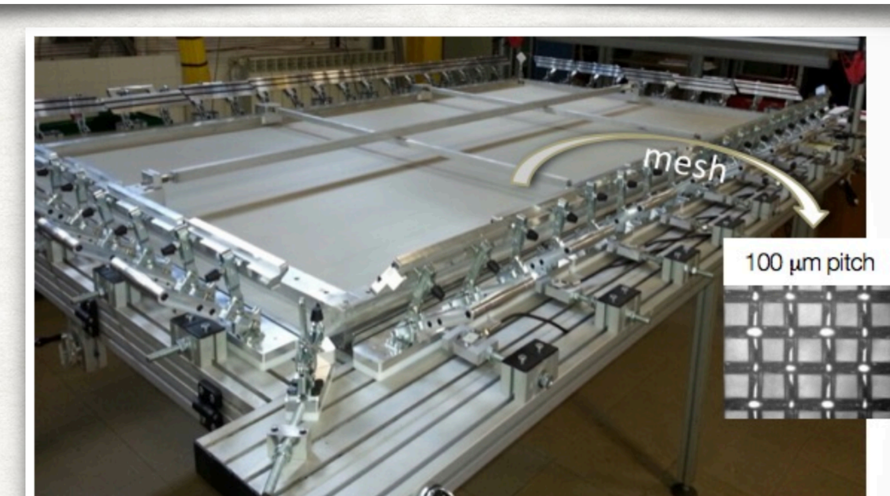
- Stretched mesh

- Mesh positioned on transfer frame
- Stretch until reaching 9 N/cm tension (clamps)
- Mesh glued on transfer frame

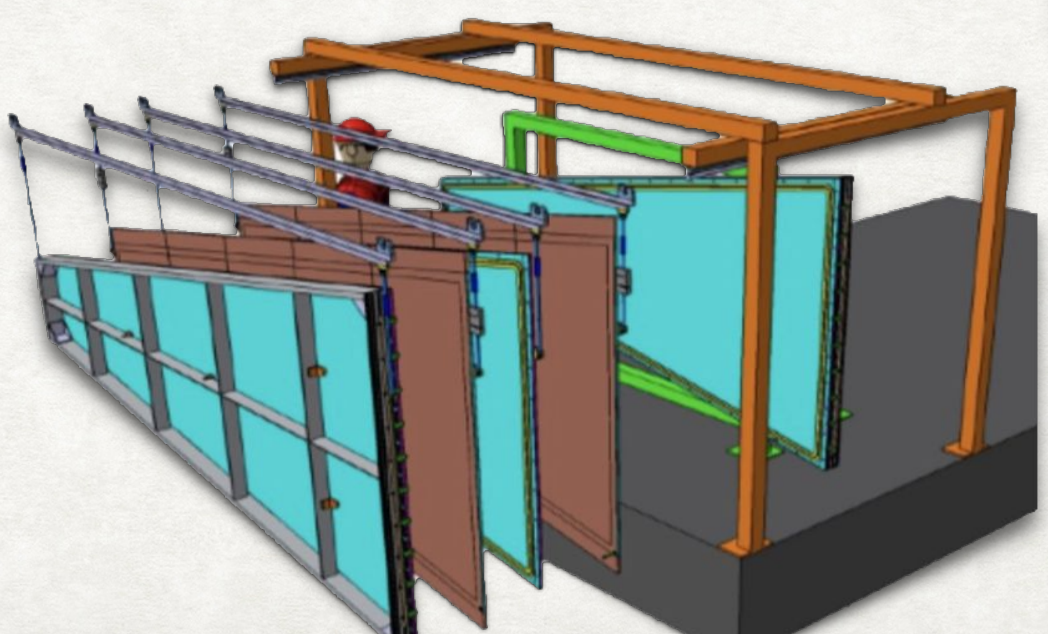
- Bare drift panel

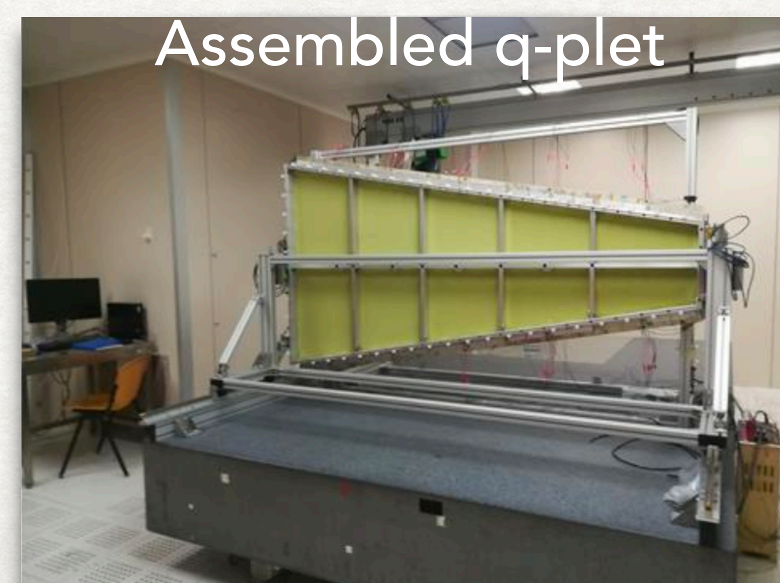
- PCBs: Outer skin (FR4-only), Cathode plane (Cu clad)
- Internal structure: Honeycomb Sheets, Frames





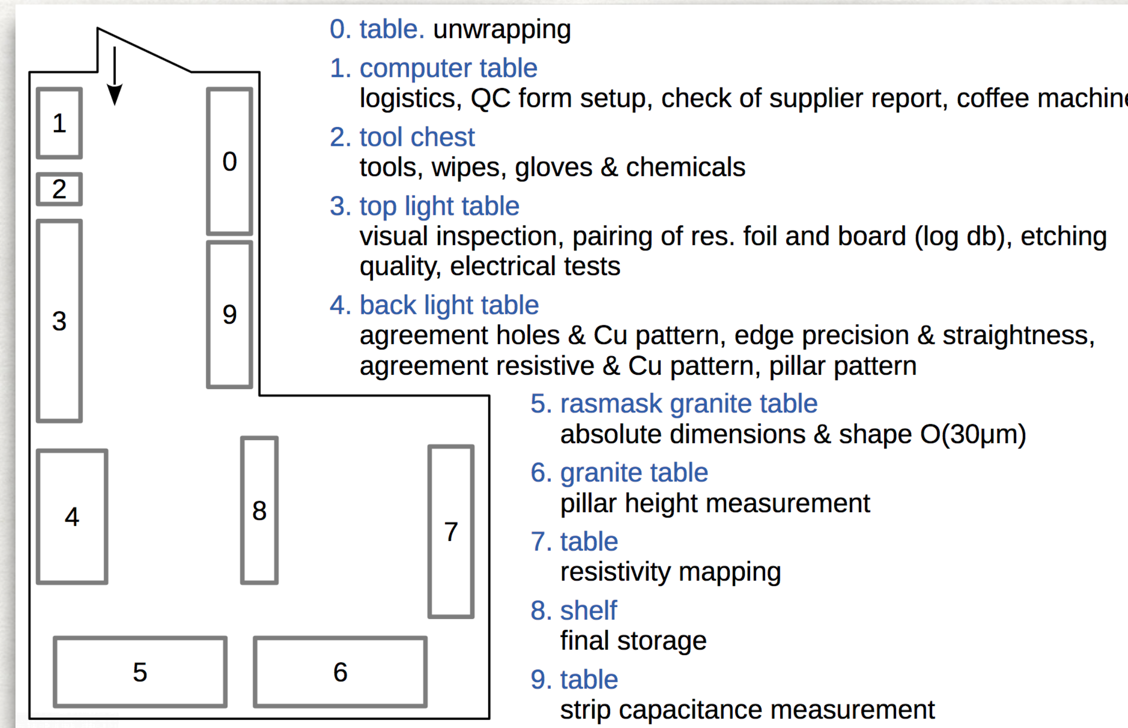
Q-plet assembly





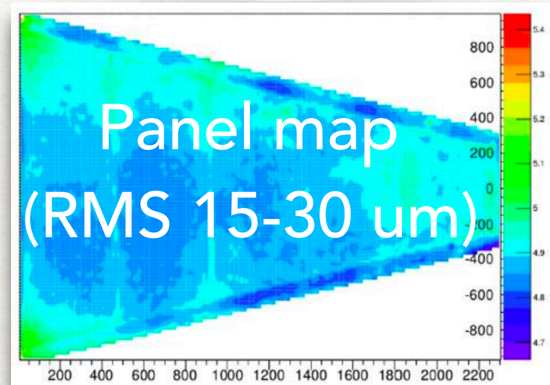
QA/QC AND TESTING

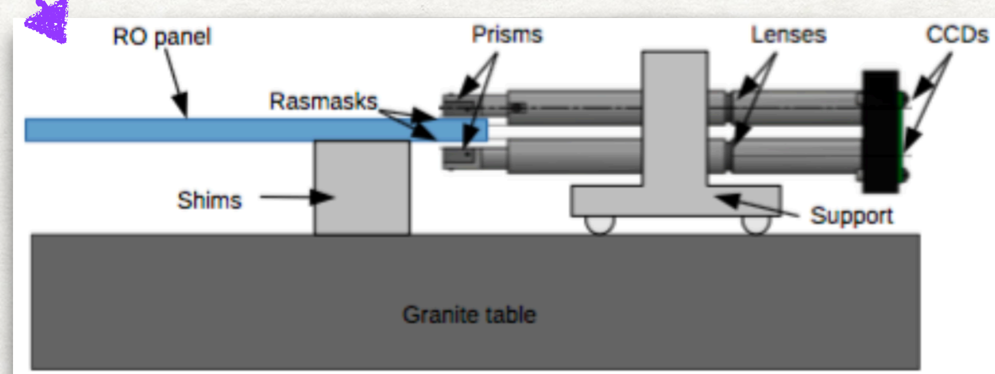
PCB QA/QC @ CERN



PCB/RO panel:

- Visual inspection
- Electrical tests
- Planarity mapping
- PCB/Layer Alignment (C-CCD/2-prong Rasfork)
- Gas leak





Mesh:

- Mesh tension

Drift:

- Planarity
- Electrical insulation
- Gas leak

HV instability issues

Q-Plet:

- HV tests (air+Ar/CO_2)
- Gas tests
- Planarity
- Panel-panel alignment (4-prong Rasfork)
- Cosmic ray tests

CLEANING PROCEDURES

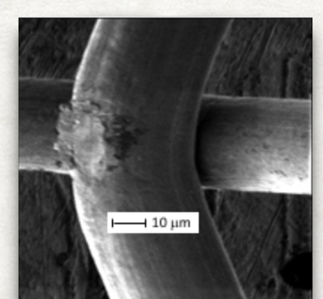
Upon panel inspection under microscope residues of "ionic contamination" were observed

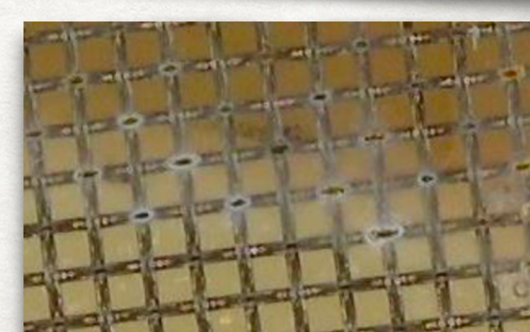
Cleaning procedure:

- Wash panel with tap water
- Brush with NGL/CIF (Drift&RO)
- Rinse with tap water & brush
- Spray with high pressure DI water
- Also spray inside drift gap pipes
- Dry panels in drying box
  - Warm air (up to 45°C)
  - Low filtered air flow
  - Dry panels for 2-3 days

Mesh polishing:

Can correct mesh imperfections: sandpaper polishing





After cleaning procedures were adopted by all sites, the HV levels greatly improved

"Ionic contamination" removed

HV STABILITY TESTS

HV test goal: Draw up to O(10 nA) currents in operating voltages

MM Operating Point

Vmax:

- 1000V in dry air (RH<10%)
- 590-610V in Ar+7%CO_2

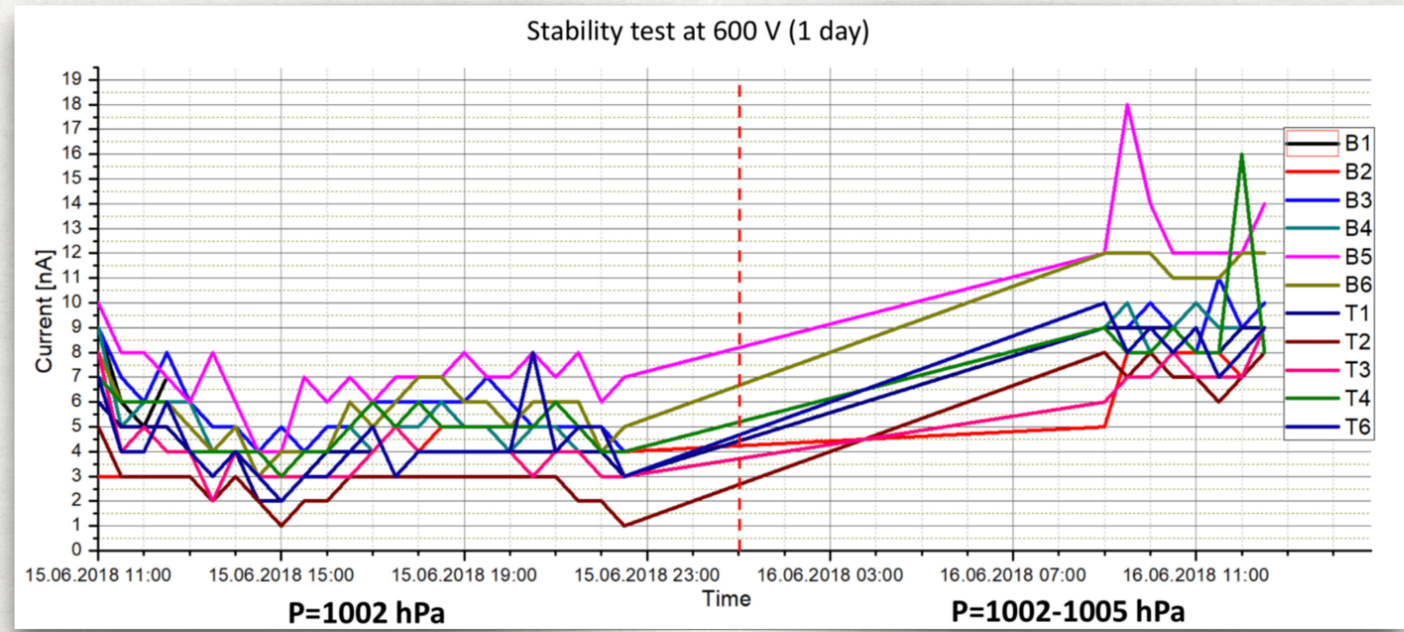
Requirements:

- Low current ramp up
- Not long "conditioning"

Stable HV levels above operating point reached

LM2 preliminary results - Voltage vs. Current (nA)

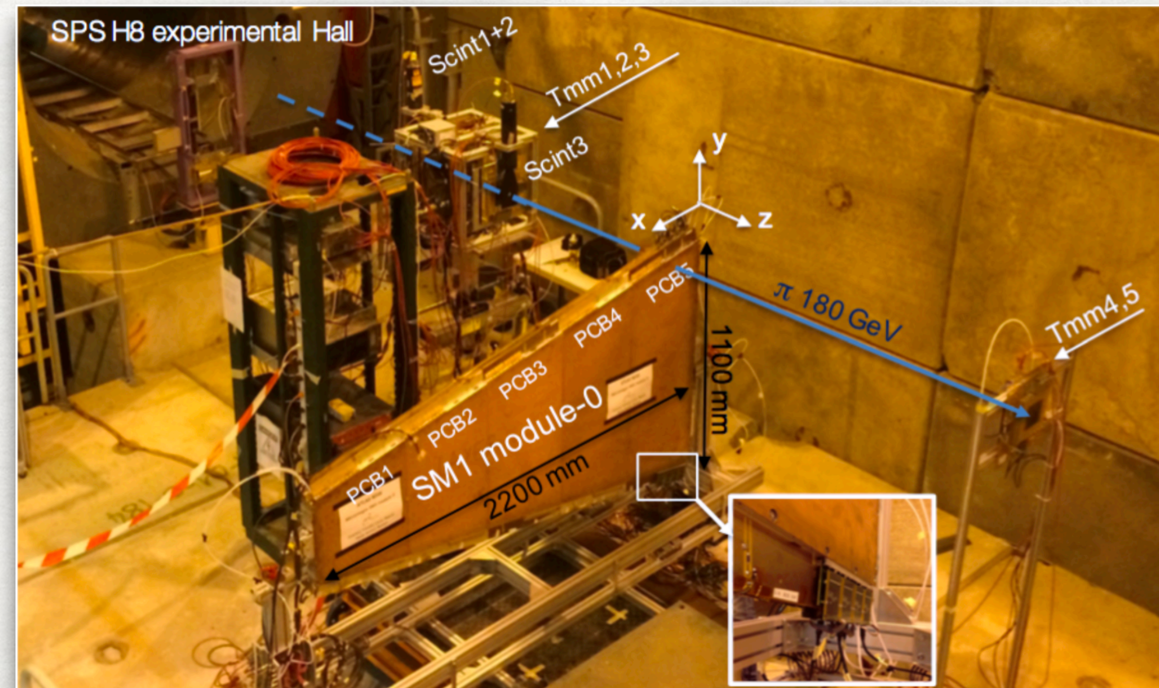
		570V	580V	590V	600V	605V	610V	
Bottom layer	CH#1	4 nA	4	2	7	7	6	
	2	3	3	Tripped --> 540 (stable voltage)				
	3	2	3	2	9	3	7	
	4	2	2	3	6	5	5	
	5	4	4	4	7	7	7	
	6	4	4	5	9	6	6	
Top layer	CH#1	3	3	3	4	4	Tripped after 2 min	
	2	3	3	4	5	4	Tripped after 2 min	
	3	3	3	4	7	5	6	
	4	3	3	3	6	4	6	
	6	4	4	4	6	5	7	



TEST BEAM RESULTS M0

Test Beams:

- SM1 M0 : June 2016
- SM2 M0 : August 2017 (Next Talk!)
- SM2 M1 : June/July 2018
- Cosmic ray tests
- Aging tests in GIF++ @CERN
  - No aging after 10y HL-LHC equivalent dose



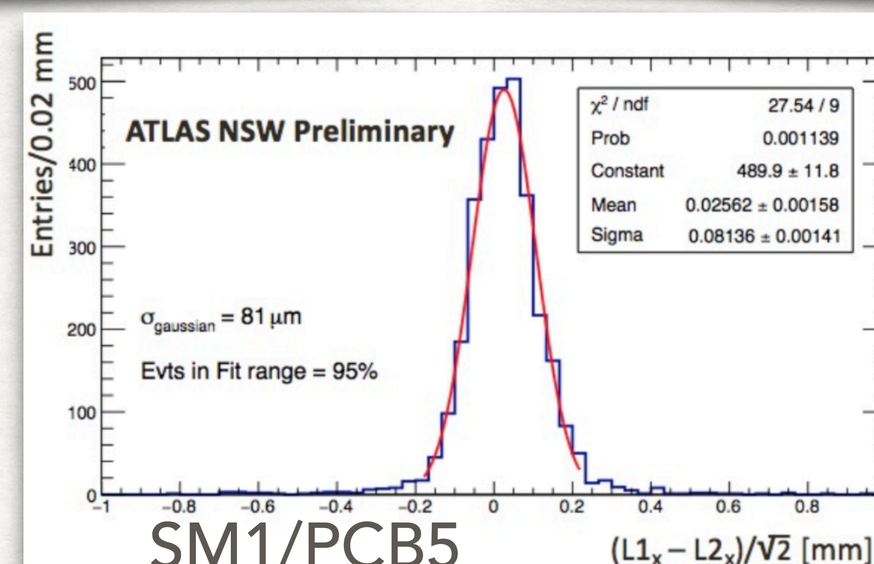
Perpendicular track performance @570-580V

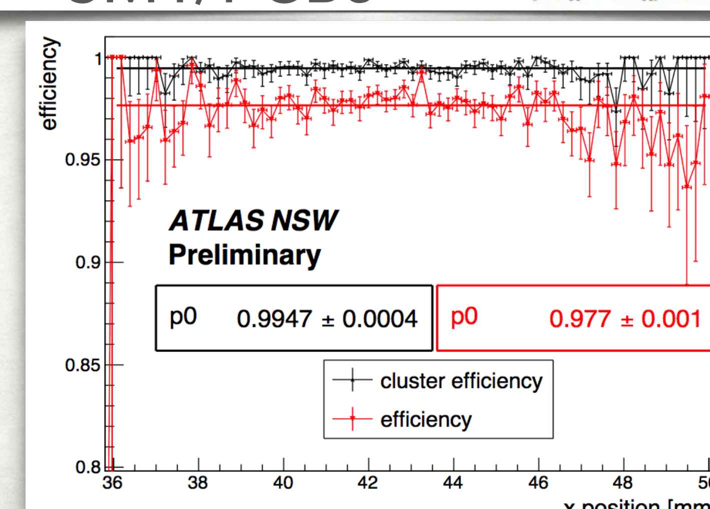
Precision coordinate resolution: 81 um

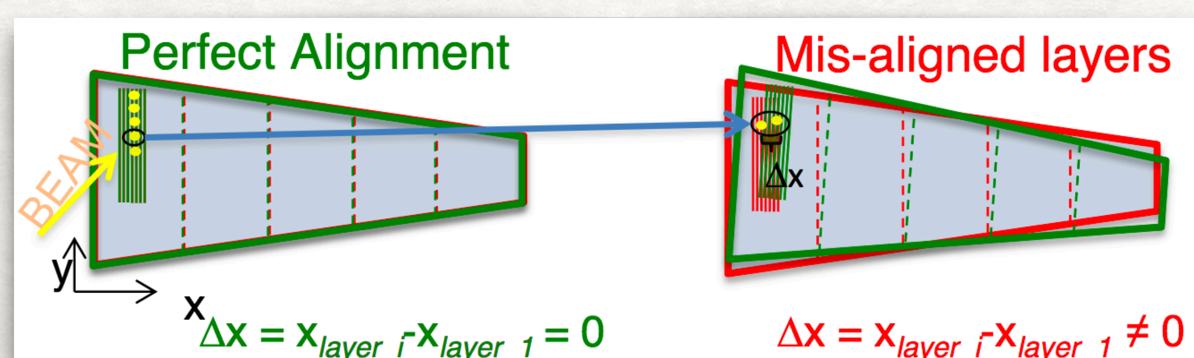
2nd coordinate resolution: 2.4 mm

Efficiency: ~99%

Alignment: Within max deviation 80um







CONCLUSIONS

The NSW is going to replace the current wheels (MDT+CSC detectors) in order to run at higher rates

- Micromegas detectors: Primary Tracking

  <u>Try to install both wheels during Phase I</u>

During q-plet testing, HV instabilities were noticed

- Linked to cleaning standards -> Cleaning procedure defined
- HV results showed great improvement after cleaning

Q-plets were tested in test beams/cosmic stands

- Results within specifications
- New test beam will show the results after applying the cleaning procedure

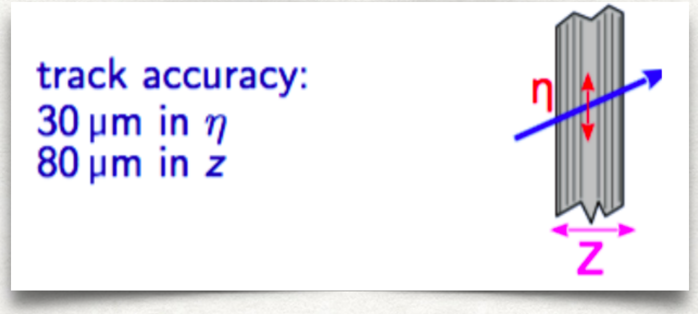
- More details on Maximilian's talk

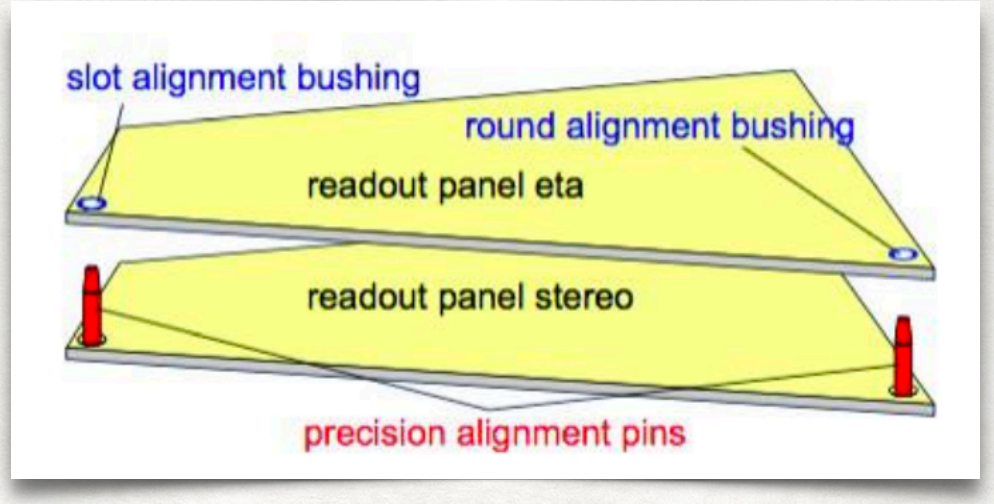
BACK UP

MICROMEGAS REQUIREMENTS

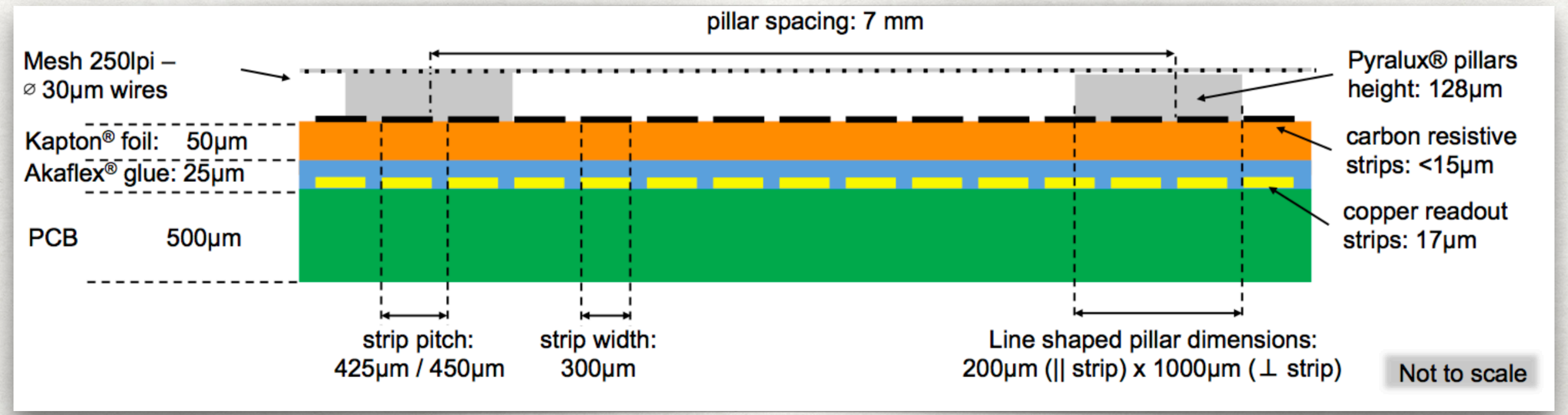
Mechanical accuracies:

- Track accuracy:
  - η coordinate: 30 um RMS
  - Z coordinate: 80 um RMS
- Precision coordinate:
  - Strip alignment: 40 um
  - Layer-layer alignment: 60 um
  - Panel-panel alignment: 60 um
- Panel planarity:
  - Max. deviation ±100 um
  - Max. RMS 37 um



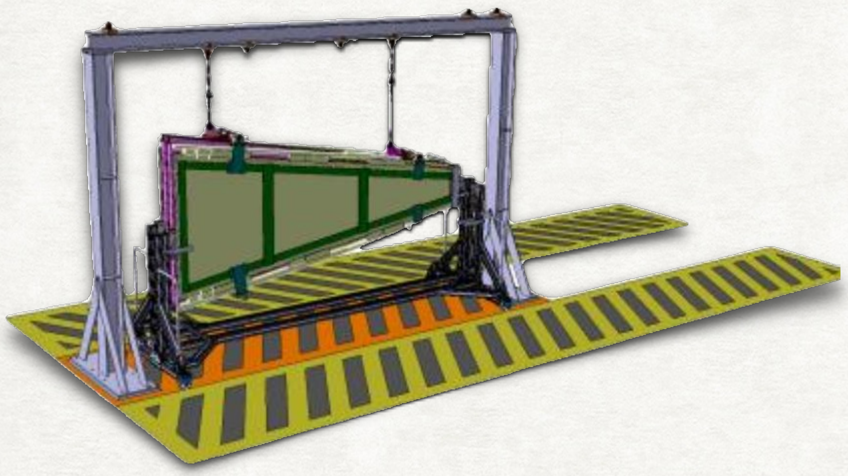


	Q-plet assembly
SM1	M1, M2, M3 done, M4 to do
SM2	M1, M2, M3 done, M4 to do
LM1	M1, M2 done
LM2	M1, M2 done



MICROMEGAS ASSEMBLY

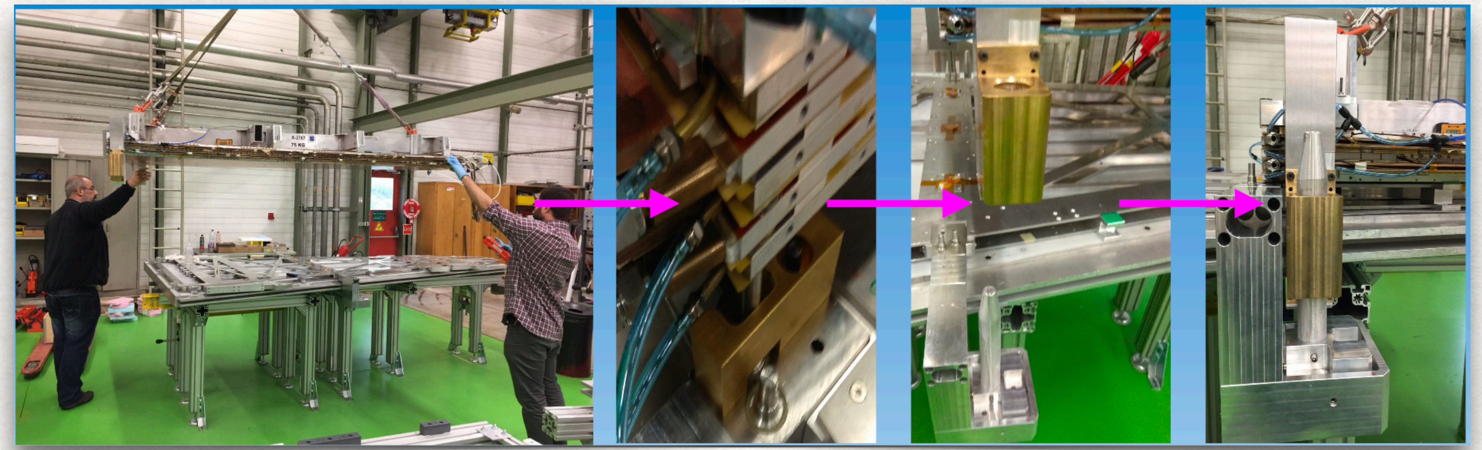
Sector assembly



The assembly will take place above surface

- Sectors will be mounted on NJD wheel

The wheel will then be transported to ATLAS point 1 and moved down to the shaft



Wheel transportation