An overview of the ATLAS NSW Micromegas construction project at Aristotle University

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ARISTOTLE UNIVERSITY OF THESSALONIKI

Ευρωπαϊκή Ένωση
Ευρωπαϊκό Κοινωνικό Ταμείο

Επιχειρησιακό Πρόγραμμα
Ανάπτυξη Ανθρώπινου Δυναμικού,
Εκπαίδευση και Διά Βίου Μάθηση
Ειδική Υπηρεσία Διαχείρισης
Με τη συγχρηματοδότηση της Ελλάδας και της Ευρωπαϊκής Ένωσης

ΕΣΠΑ 2014-2020
ανάπτυξη - εργασία - αλληλεγγύη

Outline

Introduction

LHC, HL-LHC, ATLAS detector

ATLAS

detector’s overview and Muon Spectrometer

The New Small Wheel project

motivation

NSW basic description

Micromegas technology

Construction

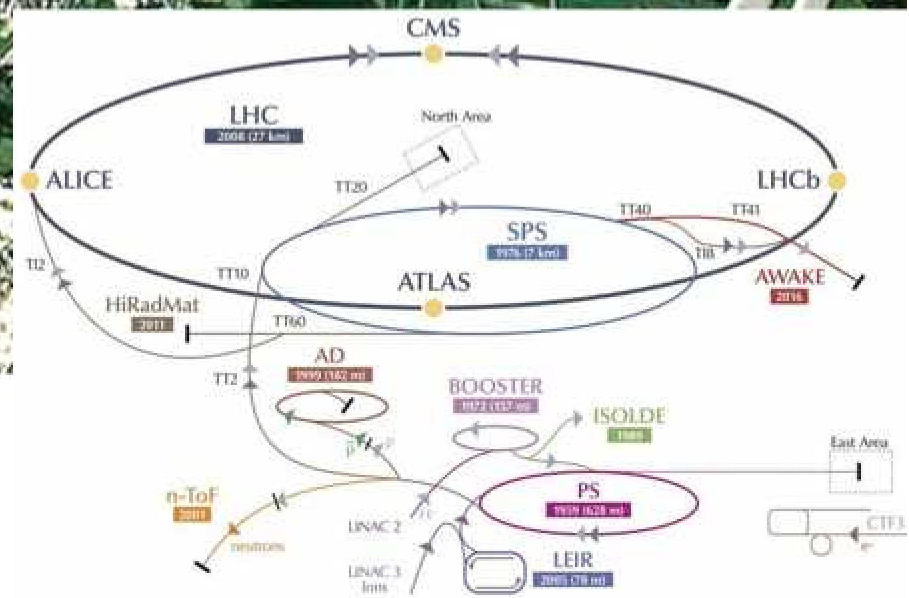
mechanical challenges

methods adopted

tooling and QA/QC

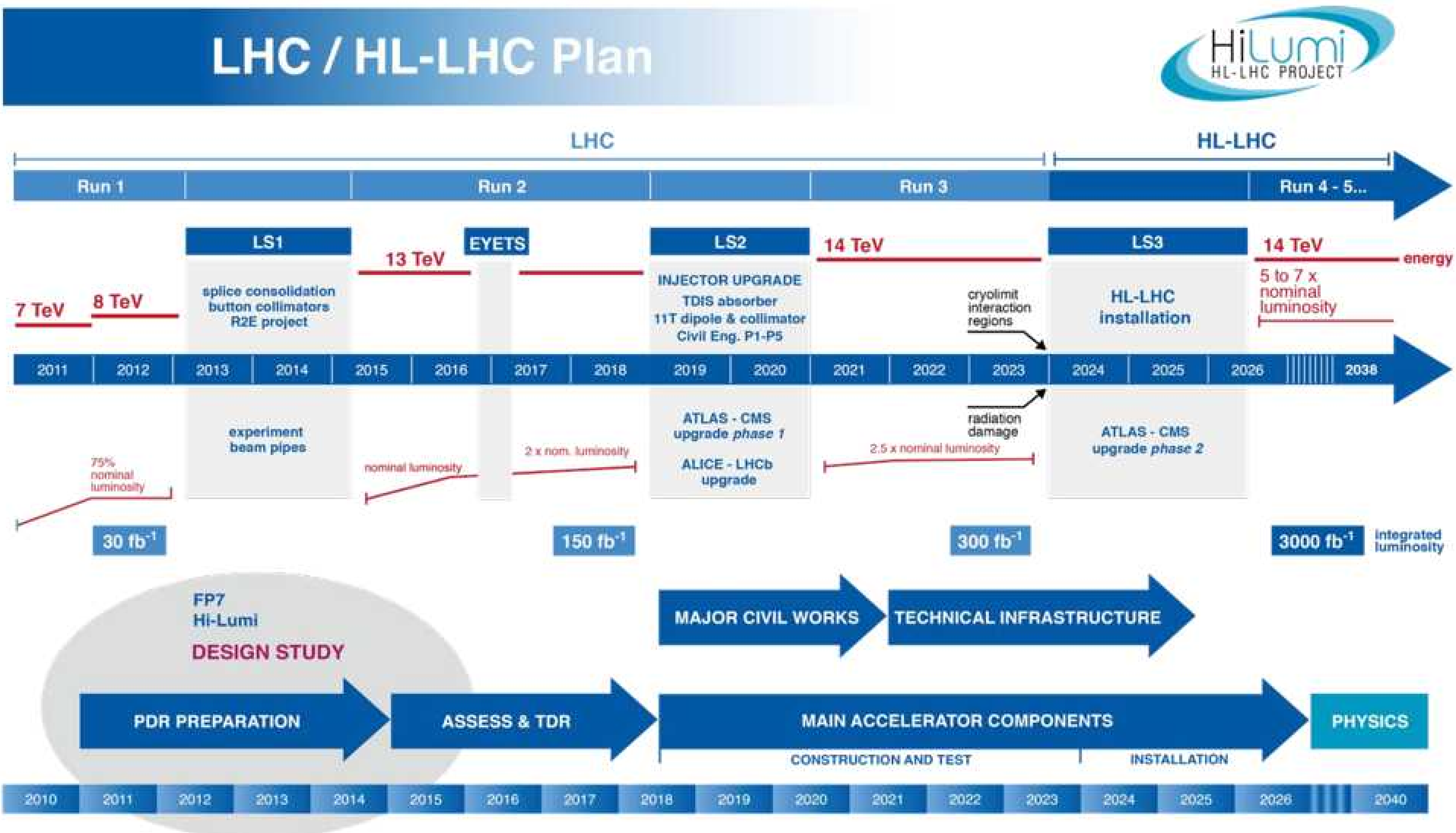
Summary

Motivation

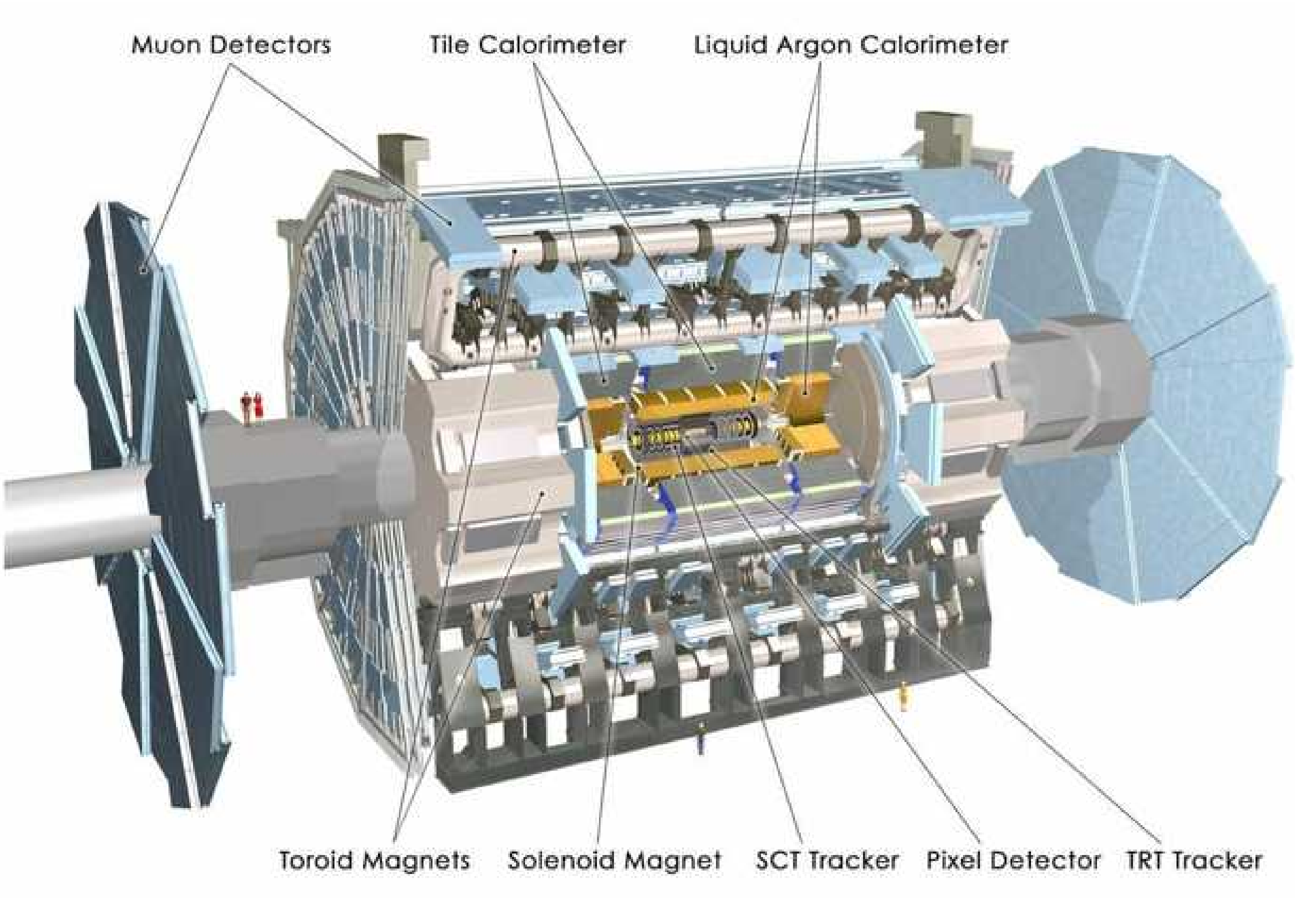


Several improvements since the beg. of LHC functioning, and the CERN accelerators chain.

LHC and HL-LHC planning



ATLAS detector



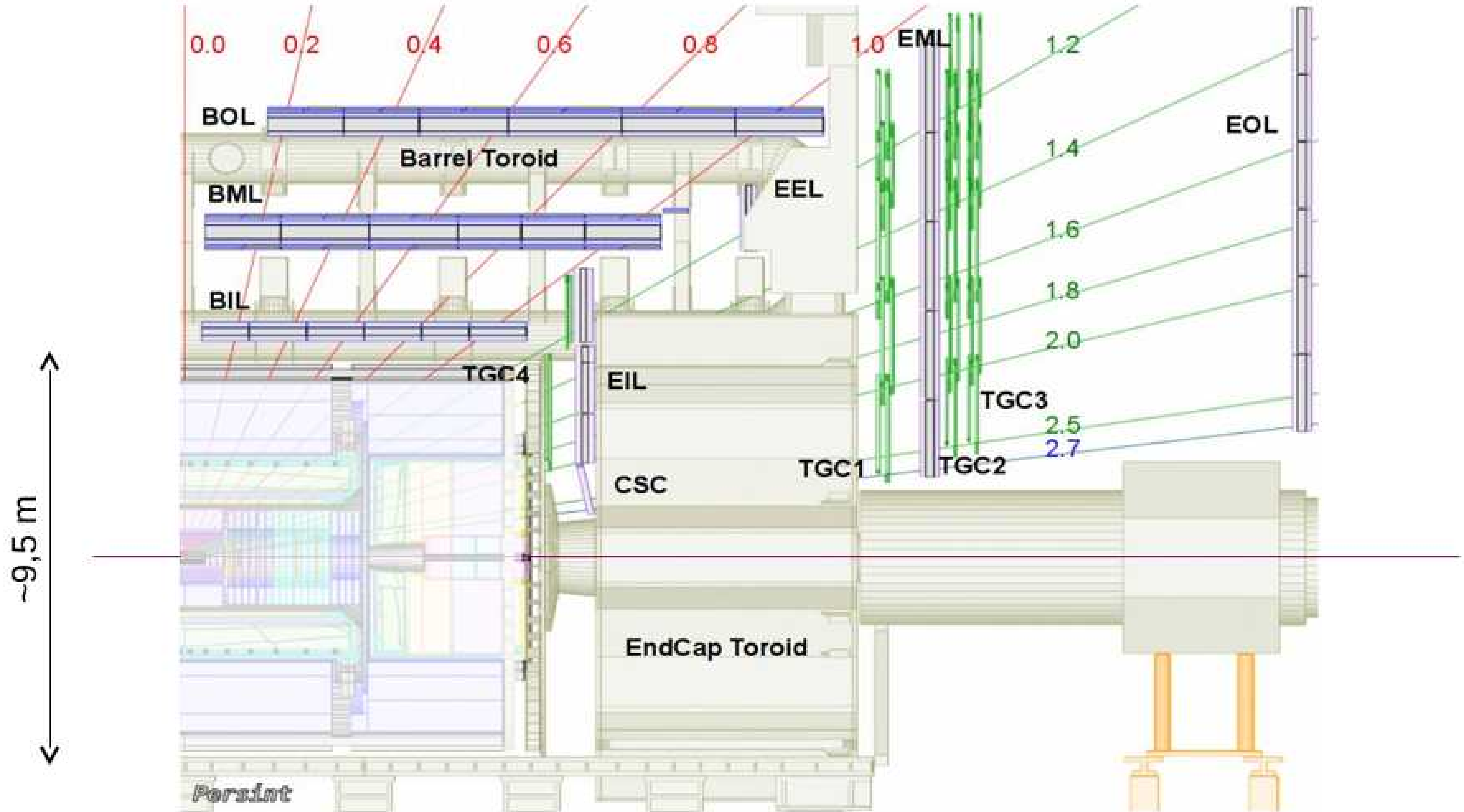
Three Parts

- Inner detector
- Calorimeter (e/m, h/d)
- Muon Spectrometer

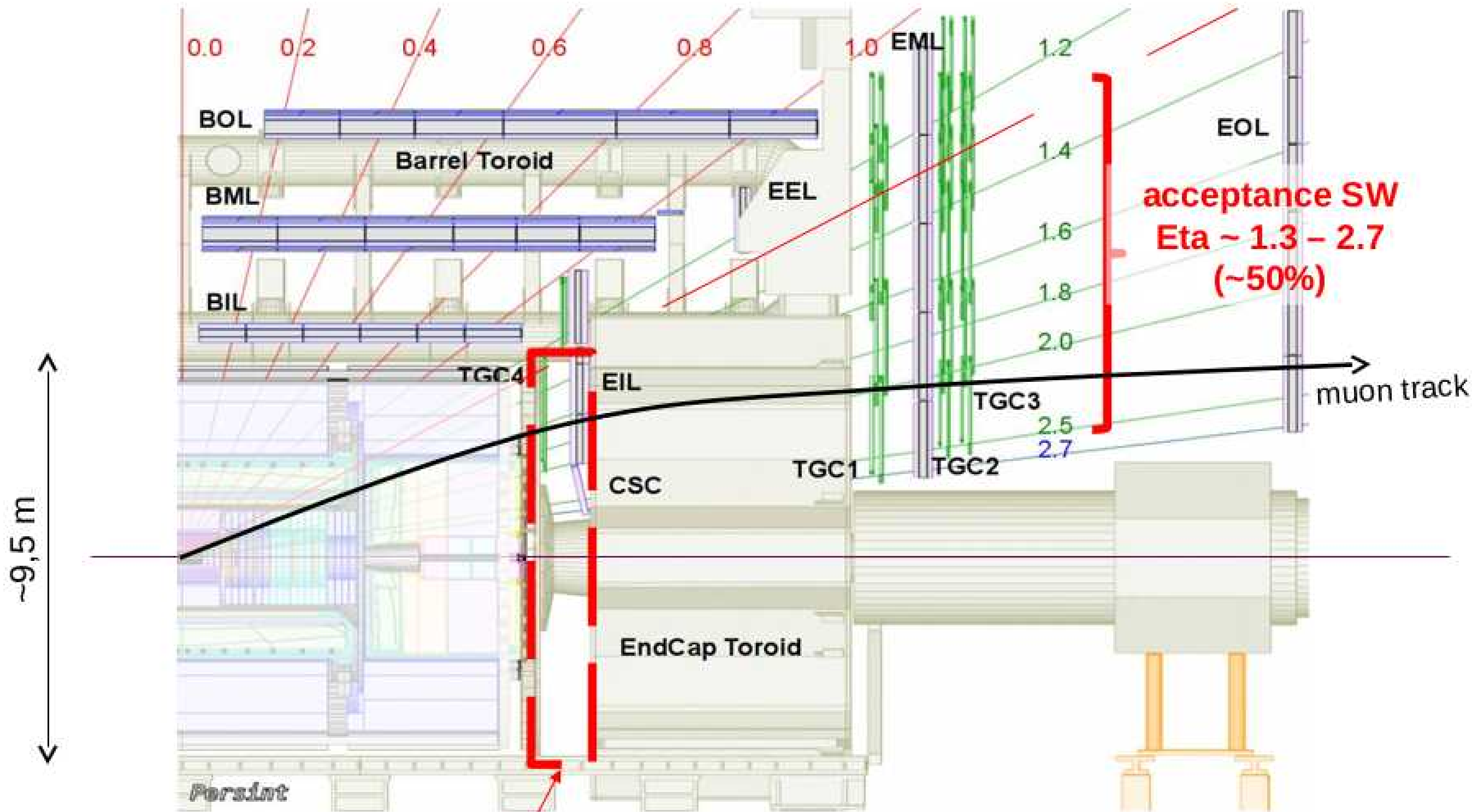
Magnet systems

- Toroid: 0.4T
- Solenoid: 2T

ATLAS Muon spectrometer



ATLAS Muon spectrometer

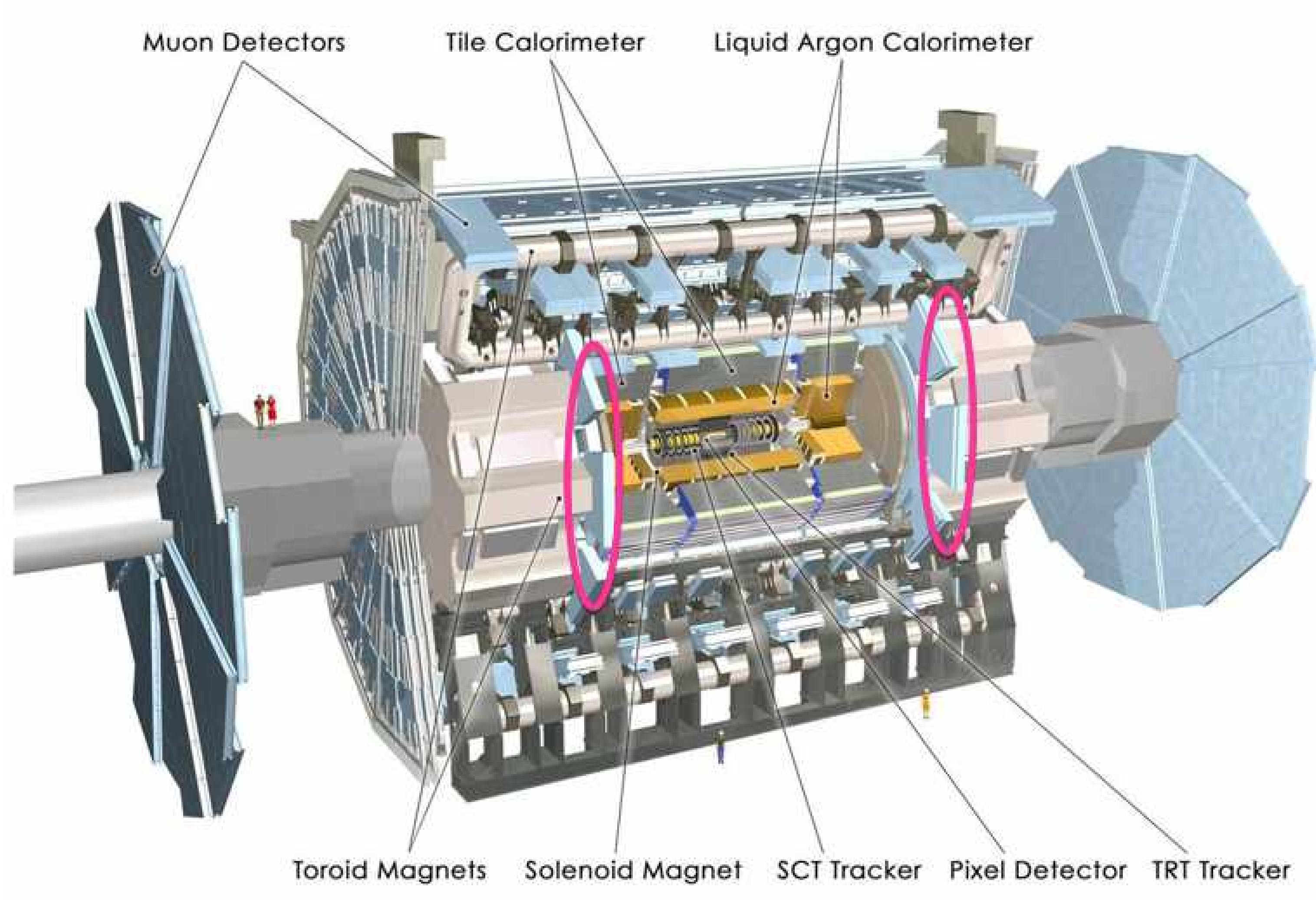


SW:1.3 < |η| < 2.7

SW position and future NSW

ATLAS detector

New Small Wheels will replace the present Innermost end-cap station of the Muon Spectrometer



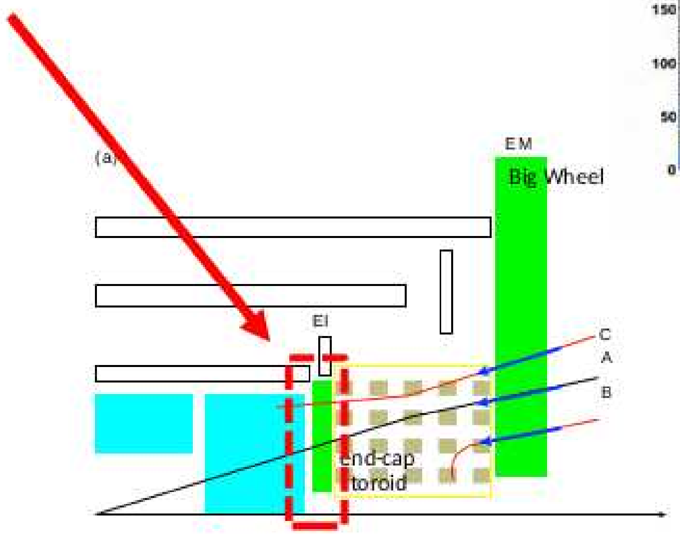
NSW Motivation I

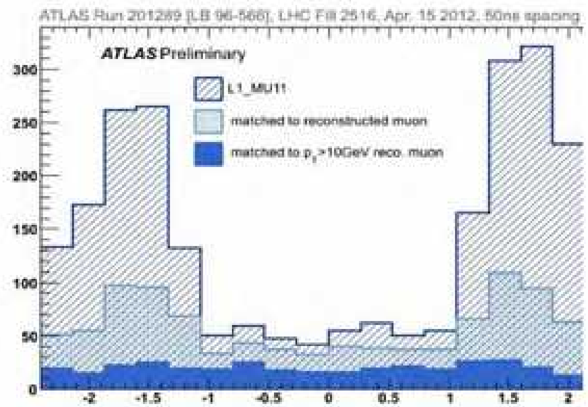
Present end-cap muon L1 trigger **saturated by fake muons** (~5% are real >20GeV muon).

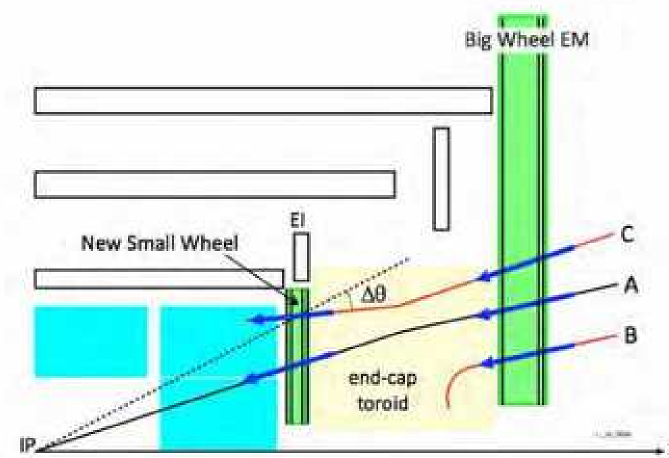
L1 trigger relies only on Big Wheel (fake triggers)
Cannot distinguish cases:
- A (real high-p_T track)
- B (low-p_T particle created in toroid)
- C (multiple scattering)

New Small Wheel allows fake tracks filtering by reconstruction of track direction

Extension of L1 trigger coverage to η=2.4 with angular resolution of 1 mrad





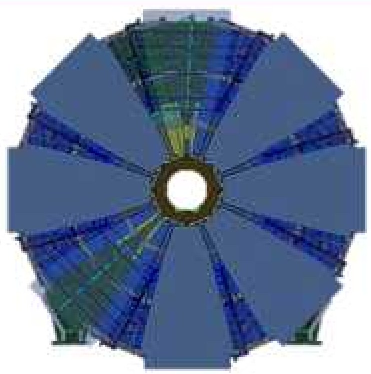


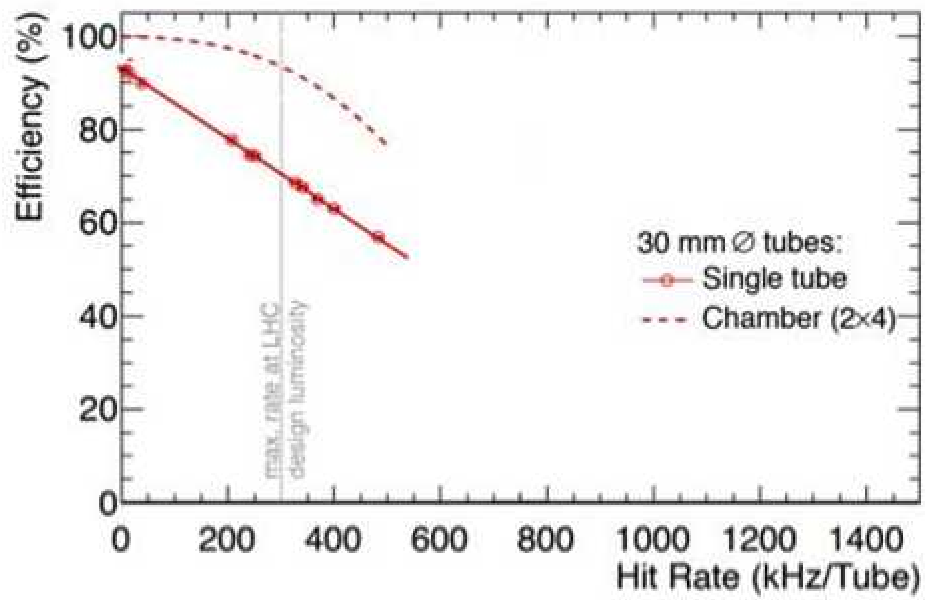
NSW should participate to the trigger decision.

NSW Motivation II

MDT: Efficiency drops significantly (dead time) and resolution is degraded (gain loss – space charge)

CSC: Limit reached even earlier (only 4 detection layers)

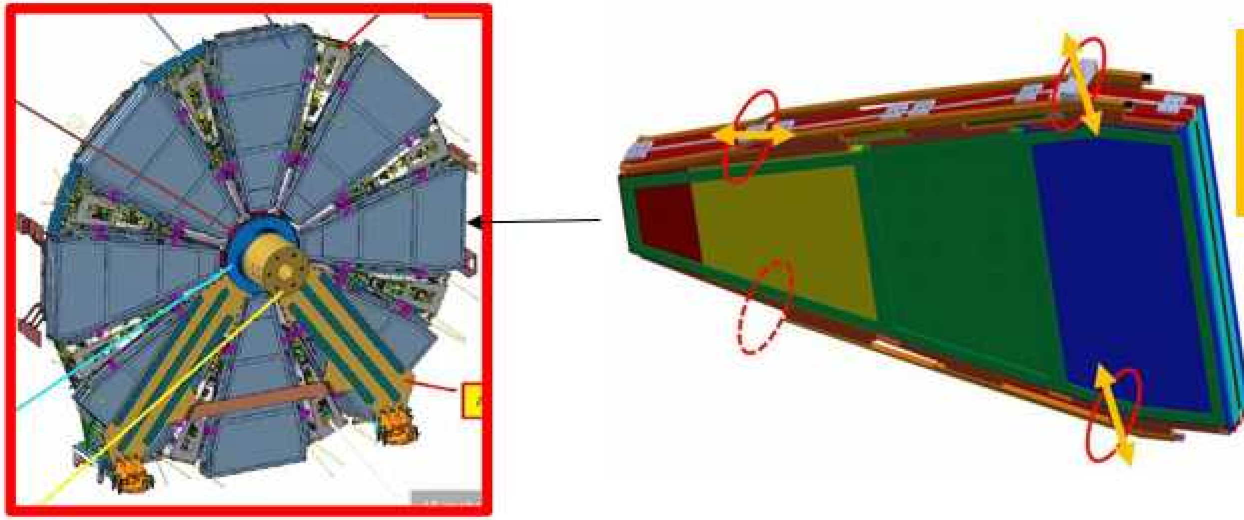




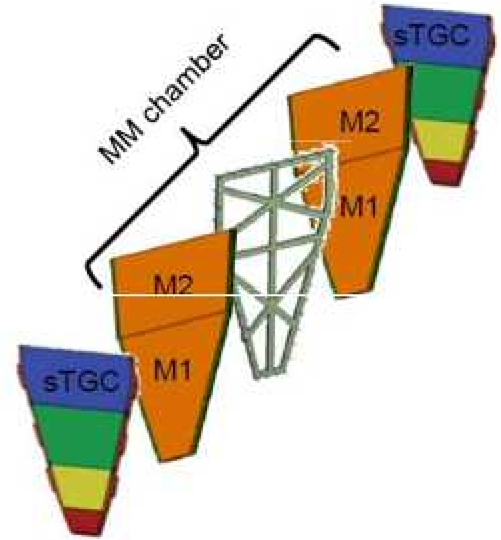
At $5x10^{34}$ cm^{-2} s^{-1} (luminosity of HL-LHC) the maximum expected rate in the NSW is about 15 kHz/cm^2 (>5 MHz/MDT_tube) (incl. Safety factor of 1.5)

NSW configuration I

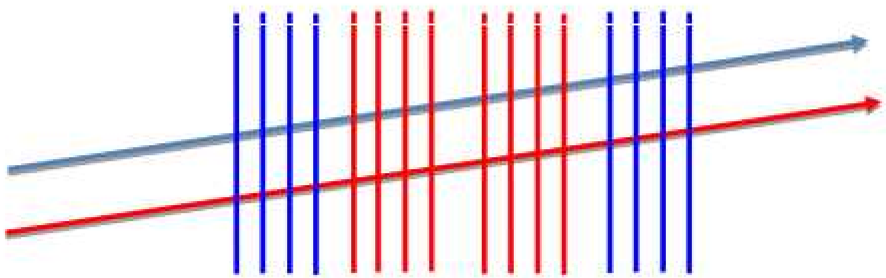
ATLAS

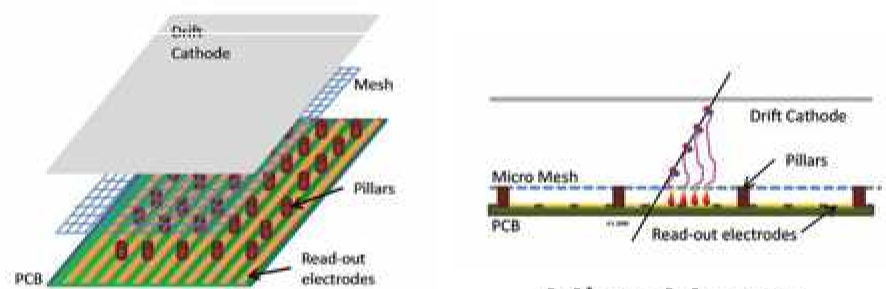


Sectors: Package of sTGC and MicroMegas "wedges" + central spacer frame



- 2 detector technologies for NSW chambers: small strip Thin Gap Chambers (sTGC) and MicroMegas (MM)
- 4 + 4 + 4 + 4 detection planes





MicroMegas

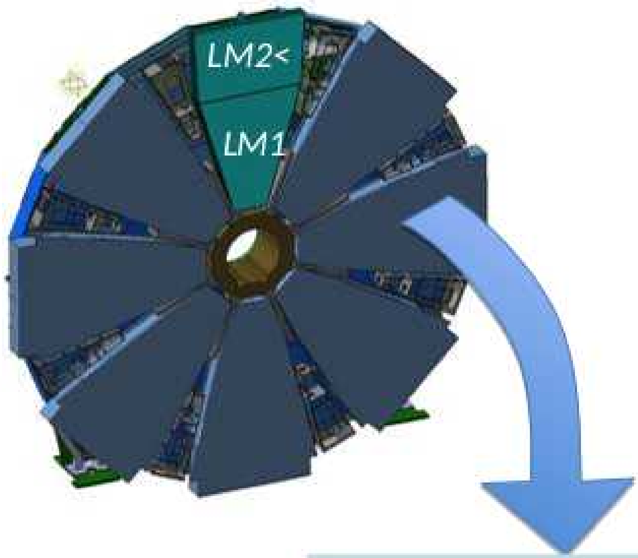
NSW configuration II

ATLAS

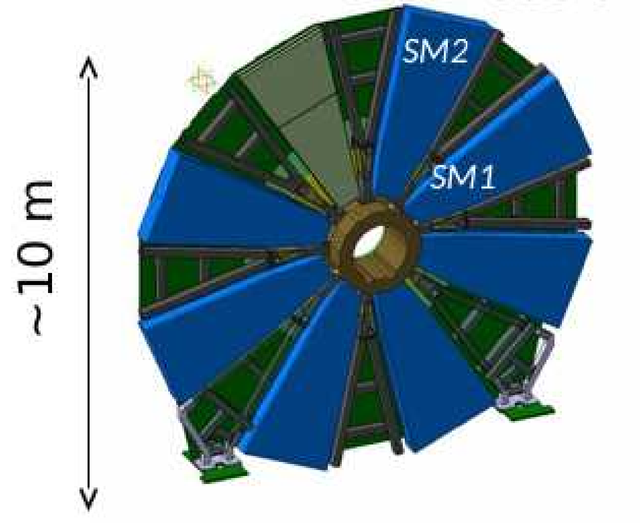
8 Small + 8 Large

Large sector

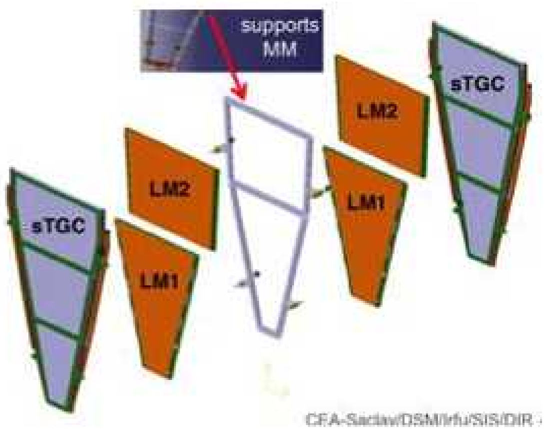
Non-IP side:
Large sectors, covering area from
r = 92 to 465 cm

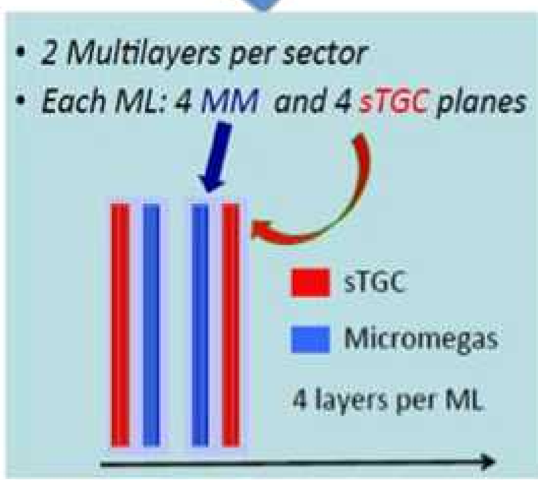


Small sector



IP side:
Small sectors, covering area from
r = 90 to 445 cm





Sectors:
sTGC and MM “wedges” + central spacer frame

NSW detector technologies

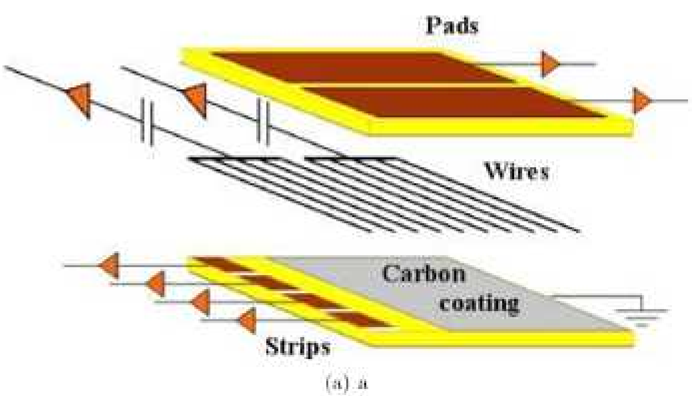
Combination of sTGC and Micromegas (MM) multiplets: 4+4+4+4 detector planes

sTGC (small strip TGC)
primary trigger detector

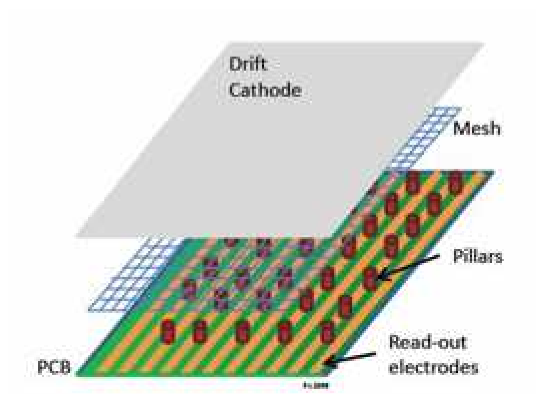
- Good timing resolution
- Good online space resolution for NSW with <1 mrad angle resolution

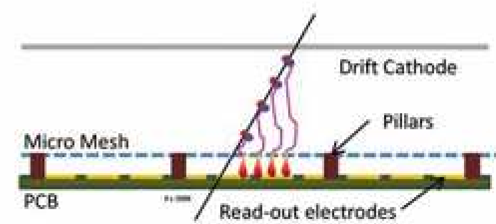
Micromegas (MM)
primary precision tracker

- Good Spatial resolution ~100 μm,
- Good track separation (0.4 mm readout granularity)
- Provide also online segments for trigger



sTGC



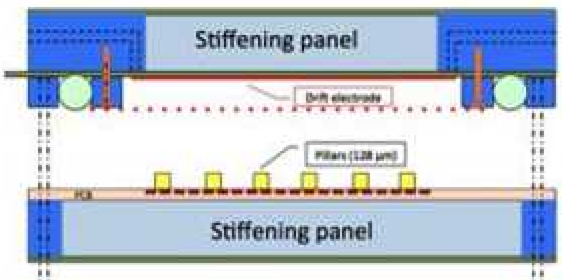


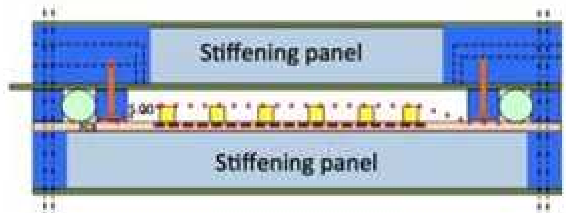
MicroMegas

Micromegas

Drift gap of ~5mm

NSW MM layout





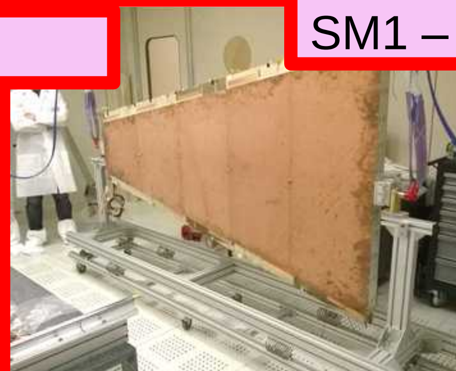
Strip pitch
450 µm

Total active area	1200 m^2
High rate capability	up to 15 kHz/cm^2 in ATLAS
Ageing	n, gammas, hadrons background
Tracking precision independant from incident angle	Position resolution ~100µm (+µTPC mode)
Trigger capability	Angular resolution (~1mrad for a multilayer) Time resolution ~ few ns

NSW modules construction: a shared effort

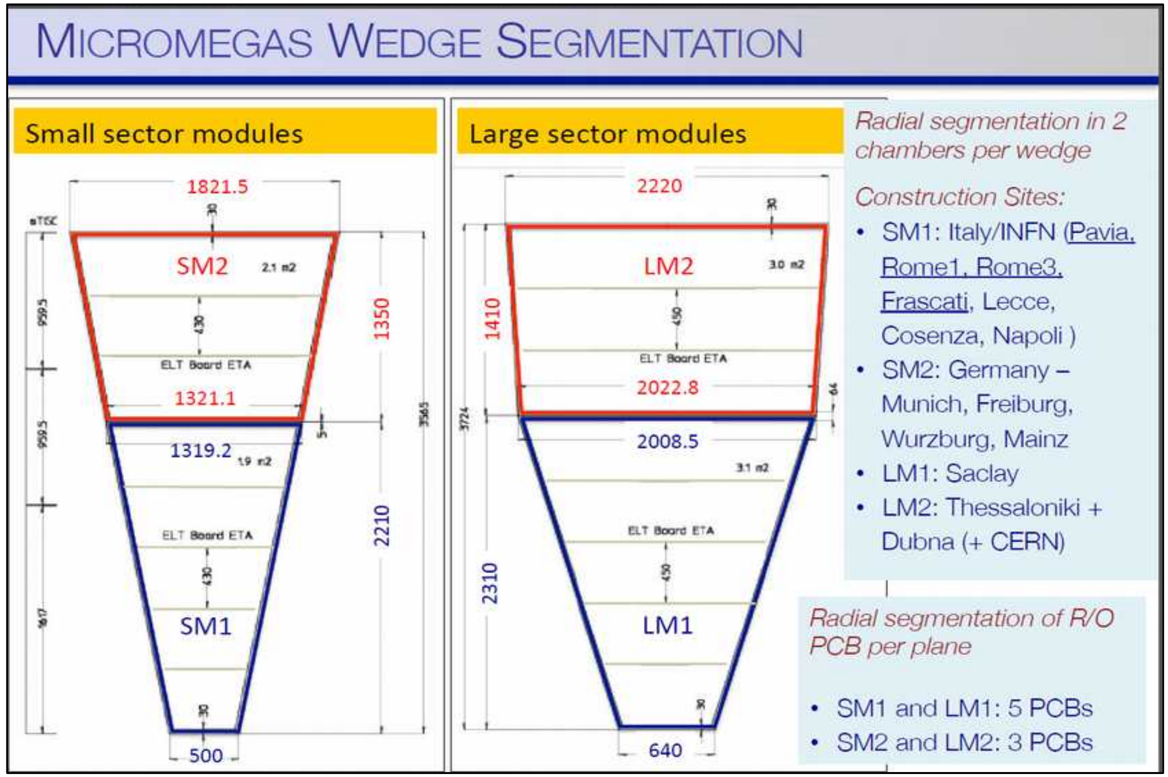
SM2 – Germany

SM1 – Italy



LM2 – Greece, Russia

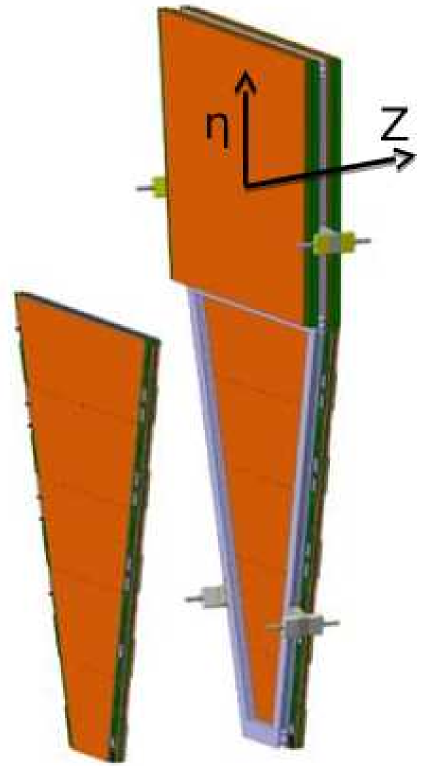
LM1 – France, **Saclay**



NSW mechanical precision requirements

Eta precision

- Board positioning
- RO panel: side/side alignment
- Modules on spacer frame

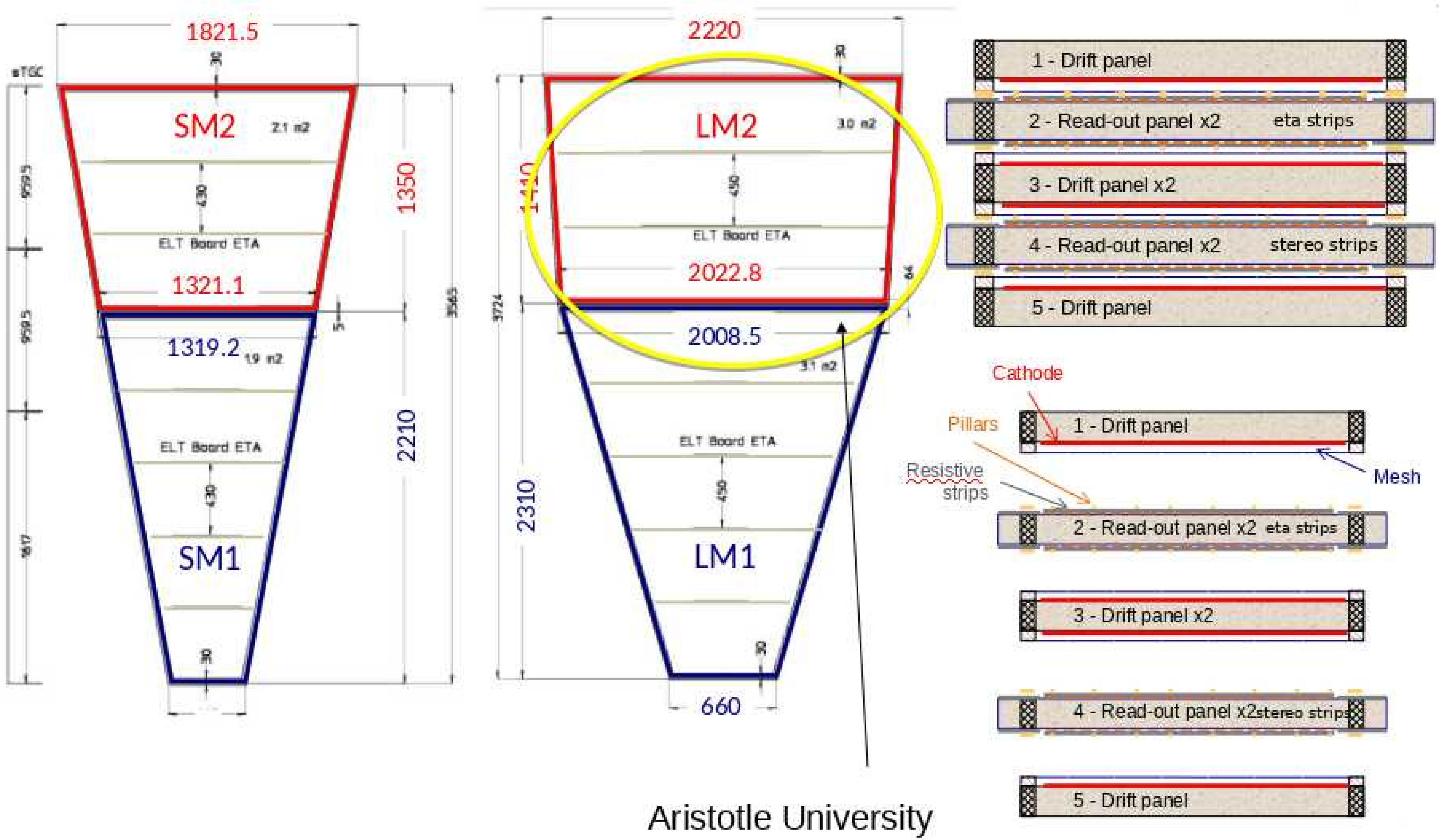


Z precision

- Panel thickness and planarity
- Precision of assembly frames
- Gas gap height

Requirements for a μ momentum resolution of 15% @ 1TeV in Atlas	
Precision of strip position in Eta (precision coordinate)	30 μm r.m.s.
Precision of strip position in Z (perpendicular to the detection plane)	80 μm r.m.s.

Micromegas wedge and module



NSW Micromegas construction reality

➔ The goals and requirements impose specific mechanical precision on the detectors

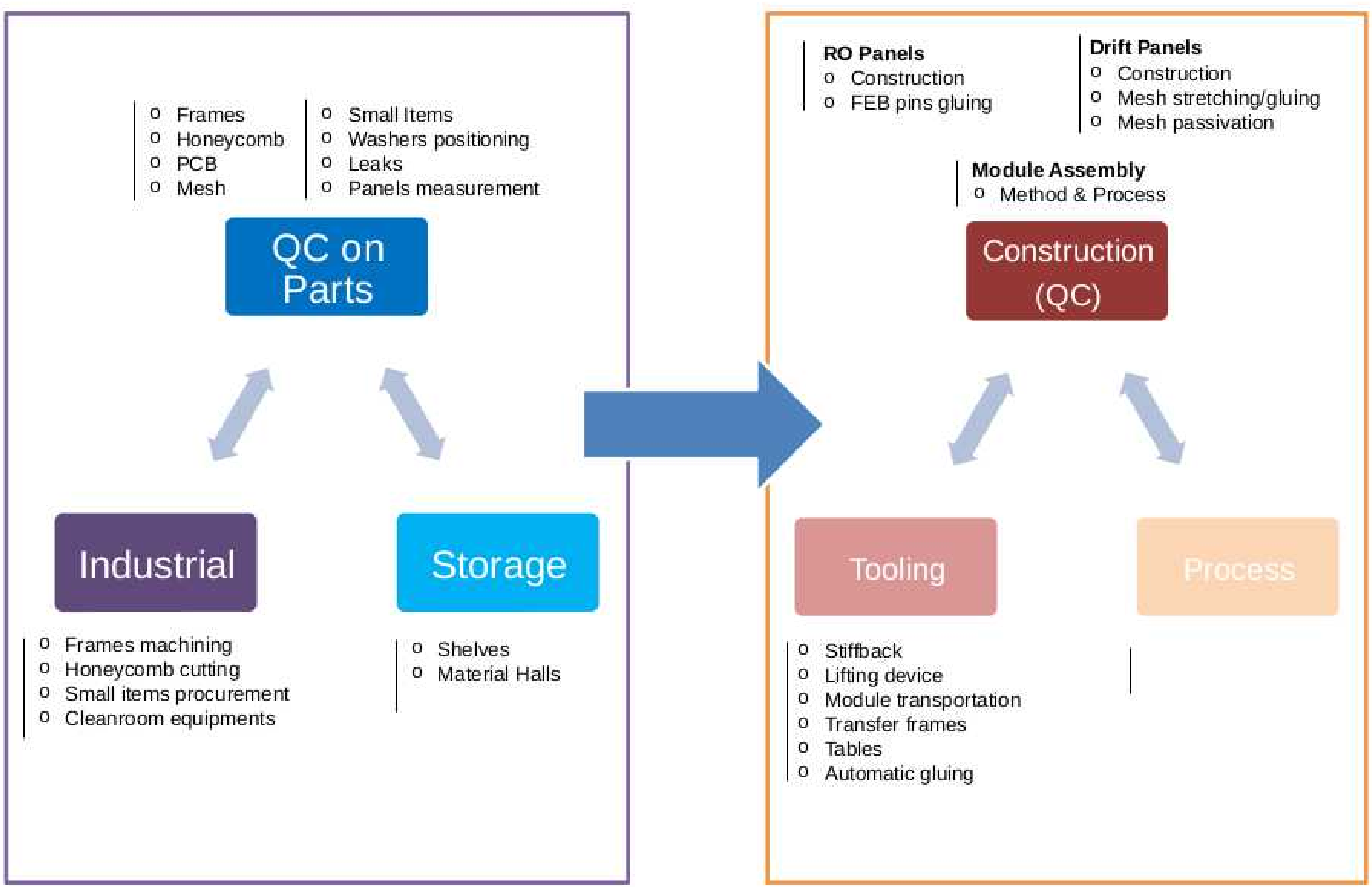
➔ NSW modules: very large surface detectors

➔ Challenging engineering solutions to be found and applied (integrate HV, elx connection, cooling, support, screwing, gas in and out etc.)

- How do we build the drift and readout "planes" ?
- How do we align the panels ?
- How do we restrict deformation due to gas pressure ?
- How the mesh is stretched and positioned ?
- HV related cleanliness issues ?
- Pillars height, diameter and spacing role on HV performance ?
- Is it robust enough ?
- Costs ?
- _
- _

long list of problems to tackle

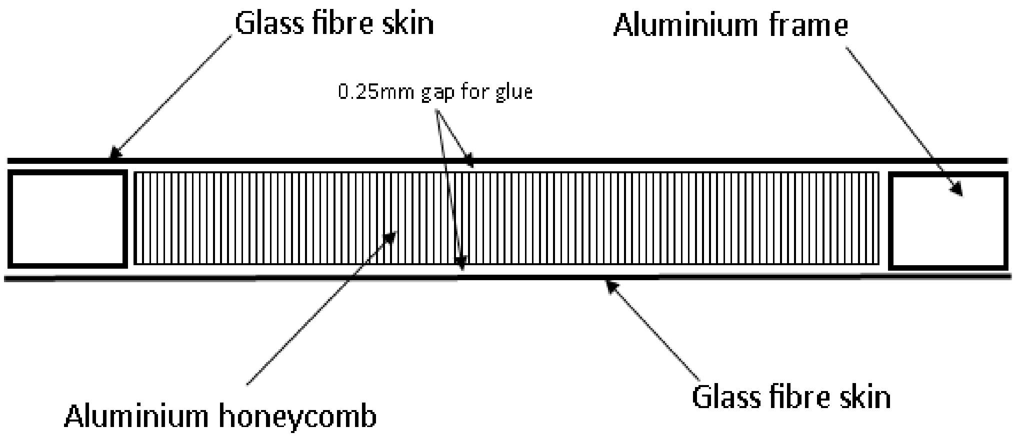
QC work-flow


Frames
Honeycomb
PCB
Mesh
Small Items
Washers positioning
Leaks
Panels measurement
QC on Parts
Industrial
Storage
Frames machining
Honeycomb cutting
Small items procurement
Cleanroom equipments
Shelves
Material Halls
RO Panels
Construction
FEB pins gluing
Drift Panels
Construction
Mesh stretching/gluing
Mesh passivation
Module Assembly
Method & Process
Construction (QC)
Tooling
Process
Stiffback
Lifting device
Module transportation
Transfer frames
Tables
Automatic gluing

NSW single panel construction basics

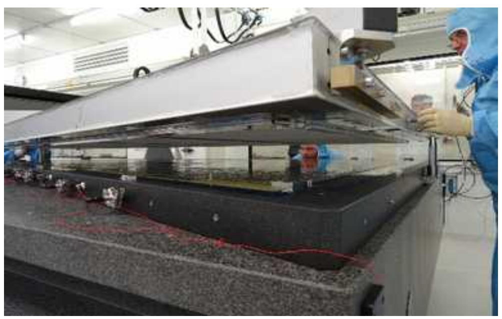
➔ Panel is a sandwich of two skins glued on a stiff plane without mechanical constraints

➔ It consists of two PCBs (500μm) with aluminum made honeycomb and frame in between



- <u>Super – flat surfaces are required as reference planes</u>
- <u>Granite + Stiff – back or Double Vacuum tables methods applied</u>
- <u>Single or dual step processes</u>

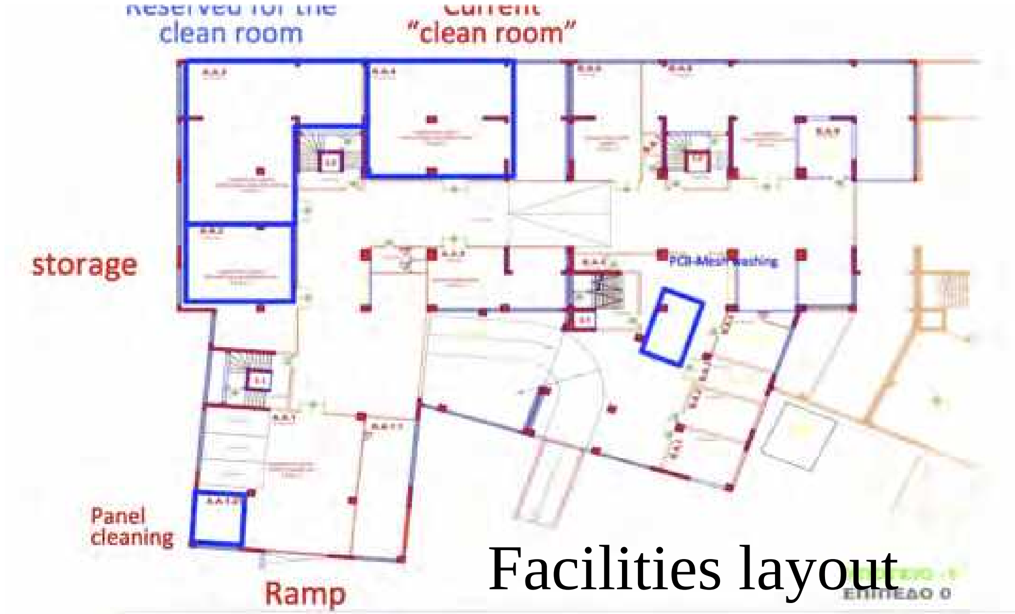
stiff – back



vacuum tables

NSW drift panels construction @ AUTh

KEDEK center



Facilities layout

Clean room & rooms for complementary works

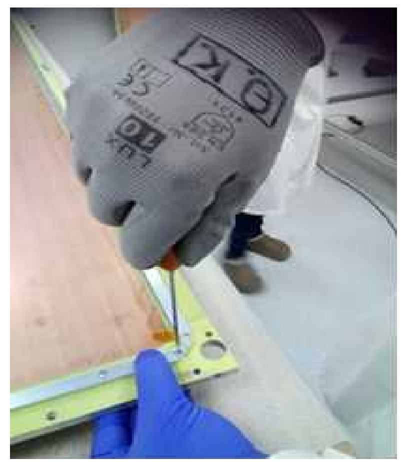
LM2 Drift panel construction clip

Drift panel completion actions

- Sealing
- Mesh frame gluing
- Gas distribution pipes - Soldering
- Cutting and cleaning
- Interconnection spacers gluing





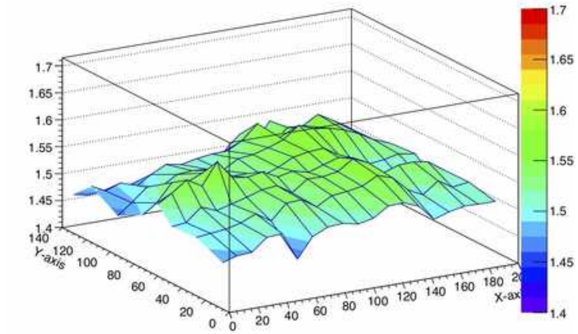



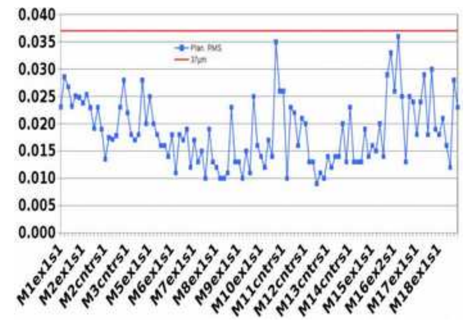

Mesh stretching and gluing

- Custom made stretching device
- Mesh transfer frames
- Passivation process and punchin
- Washing and cleaning
- Final gluing on drift panel

QA/QC measurements I

Panel thickness and planarity control

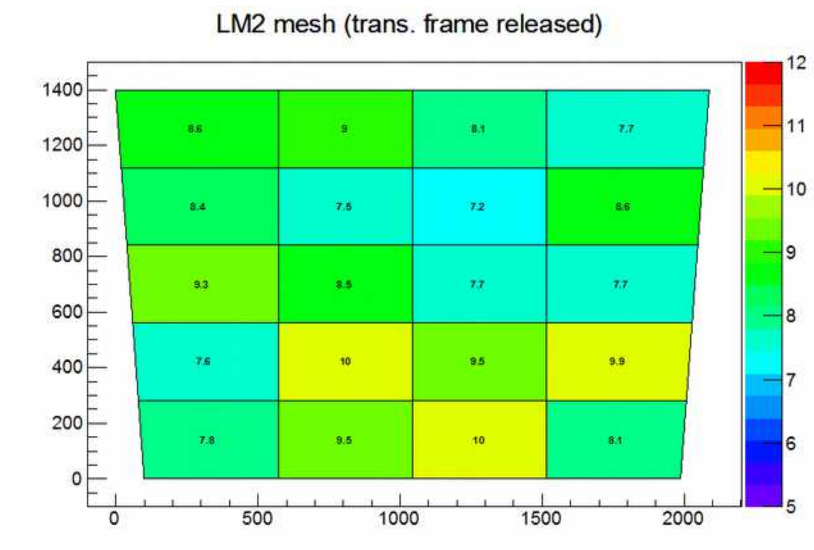


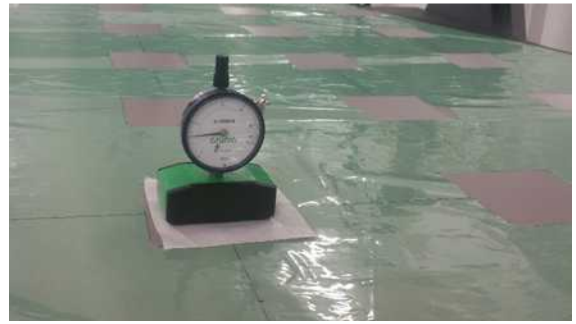


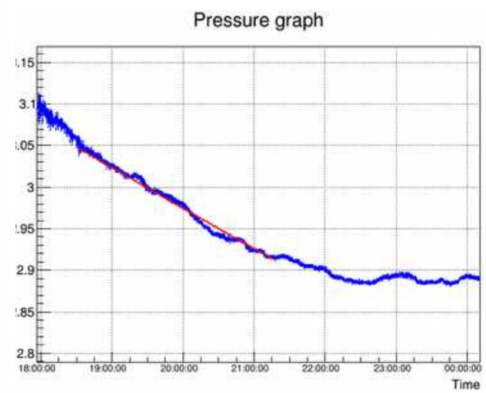
Mesh frame/interconnections height measurements and panel edge control

QA/QC measurements II

Mesh tension control (specs:7 - 10N/cm)







Gas leak measurement: pressure drop and/or mass flow

LM2 Drift panels final QC & logistics

B14 — Instructions: Please replicate "Check List" sheet according to total number of Drift panels under contr…

LM2 Quality Assessment Just Before Shipment

Dispatched Items

Number of Triplets in Transport Box	4
Number of Central Panels	4
Number of External Panels	8

Postage: Oct 2018

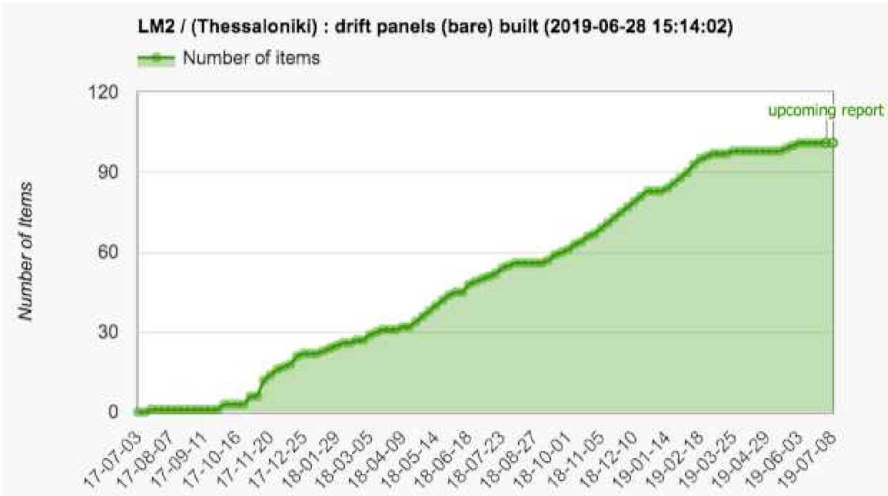
Instructions: Please replicate "Check List" sheet according to total number of Drift panels under control, upd… label.

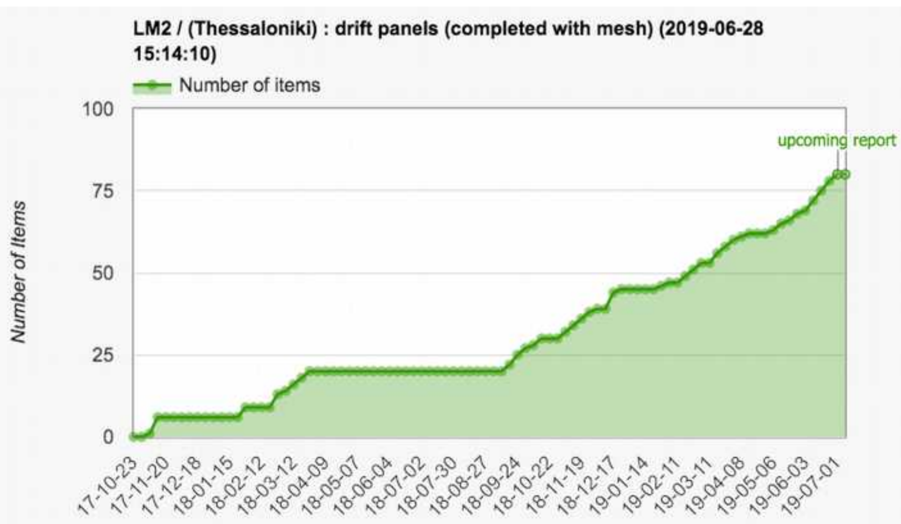
START | Information | Check List M4X1 | Check List M4X2 | Check List M4C1 | Check List M4C2 | Check List M…

Components Contributing to Global MM Quadruplet Quality	Side			
Drift Label:	External Side	Mesh Side	Mesh (Side 2)	Remarks/Treatment
1. Check Points				
Mesh Tension: measured flat on table (or on shims for		✓		AVG: 7.9 N/cm Uniformity: 0.06
Interconnections – Passivation: quality of hole alignment,		✓		OK
Mesh frame – O-ring groove: quick control of mesh frame		✓		Small scratch was sanded with 2500 sandpaper.
Mesh Quality: Thorough visual inspection to trace marks		✓		Small mark near interconnection #1 towards cathode (not sanded).
Delamination: Trace delamination spots/zones	✓	✓		OK
HV connectors: control placement and pin		✓		Checked mounting and HV pin orientation.
Gas Inlets: check and block using scotch tape		✓		Checked and scotched using red tape to protect.
Compression bars: proper mounting of all components		✓		#2 was hard to screw in, #4 #8 long pins were not used due to misalignment of the small holes.
Barcodes: mount stickers on side panel frames according		✓		Stickers glued on the side frames of panel.
2. DB stored information				
Thickness	✓			
Planarity	✓			
Mesh Frame/Interconnections Height	✓			
Gas Tightness	✓			
HV performance	✓			
3. Additional Information/Comments				
...if yes, place write below				

Check List M4X1 | Check List M4X2 | Check List M4C1 | Check List M4C2 | Check List M8X1 | Check List M8X2 | Check List M8C1 | Check List M8C2 | Check List M9X1 | Check List M9X2

LM2 drift panels production status





'Bare'

- External 70
- Central 35

total **105**

Completed

- External 56
- Central 24

total **80**

All panels constructed

Mesh gluing on few panels pending

TwinAX cables for NSW

Connection between FEC:

MMFE8-ADDC, MMFE8-L1DDC, ADDC-L1DC

Twinax, from 3M (ref.: SL8801/12) Thickness ~1.8 mm

Issue

Due to the way they are manufactured they can loose their insulation where they are bent.

Solution

wrap the TiwnAx cables in Kapton

5400 cables, 3m length delivered to AUTH for ‘kaptonization’

Work finished

Aristotle University ATLAS – NSW group

Team of more than 10: professor(s), postdoctoral, graduate and undergraduate students, engineer(s), technician(s)

NSW project @ AUTh: multiple benefits

- A new lab was established and equipped with dedicated tooling
- Proven ability to construct and technical competencies acquired for detectors R&D
- Six Qualification tasks fulfilled
- 11 persons trained and worked for ~ 2 years to this demanding project
  2 postDocs, 4 PhD students, 2 Physicists, 1 engineer, 2 technicians
  2 student internships (from Ioannina and Aegean Univ.)
- 3 Diploma thesis, 1 Master thesis
- Continuous collaboration with Greek industry/private sector
- Enhancement of collaborations within the NSW community
- AUTH/KEDEK public awareness and visibility

Summary

The New Small Wheel is the largest ATLAS upgrade project for LHC Long Shutdown 2

Challenging project:

- Unprecedented use of Micromegas detector
- Complex mechanics
- Tight schedule

Shared effort between all construction sites:

SM1: Italy/INFN

SM2: Germany

LM1: France/Saclay

LM2: Russia/Dubna – Greece/Thessaloniki (+CERN)

The construction of the LM2 drift panels is coming successfully to the end

Acknowledgements

We acknowledge support under the Operational Programme Human Resources Development, Education and Lifelong Learning, Co-financed by Greece and European Union

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ΕΣΠΑ
2014-2020
ανάπτυξη - εργασία - αλληλεγγύη

Thank you!