Phase I and II Upgrades of the ATLAS Muon Spectrometer with Integrated Small Diameter Drift Tube Chambers and Thin-Gap Resistive Plate Chambers

The Sixth Annual Large Hadron Collider Physics Conference LHCP 2018

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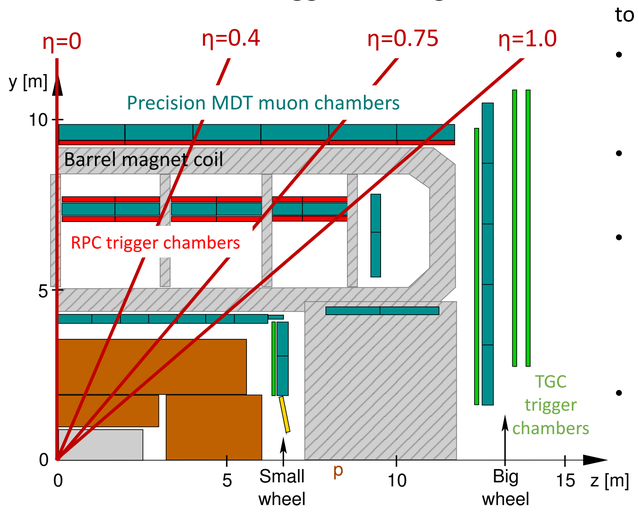
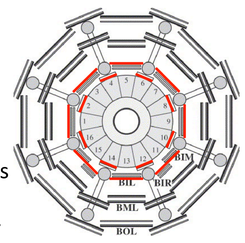
Motivation:

Limited barrel muon trigger coverage:



High p_T muon trigger acceptance is limited to ≈ 72% due to non-instrumented regions of the muon spectrometer:

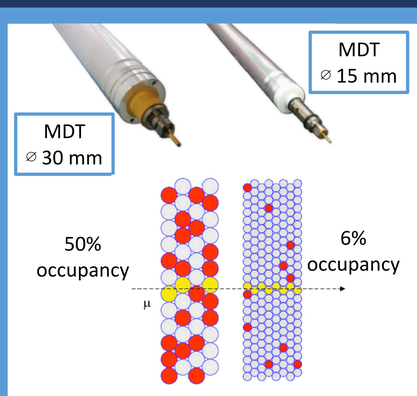
- η =0: Non-instrumented region of the spectrometer to provide space for services of the inner detector and the calorimeters
- η =0.4, 0.75, 1.0: Non-instrumented region due to toroid and rib structures
- Installation of additional RPCs with increased high-rate capability in the inner barrel layer → increase muon trigger acceptance
- Replacement of MDT chambers with sMDT chambers in small barrel sectors to free space for RPCs



→ Phase I (2017): 12 sMDT chambers

→ Phase II (2019/20): 16 sMDT+RPC chambers

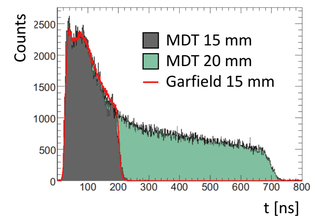
Small-Diameter Muon Drift Tube (sMDT):



Reducing the drift tube diameter by a factor of 2:

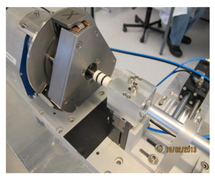
- 8 x lower background occupancy (4 x shorter maximum drift time, 2 x smaller tube cross section)
- Electronics dead time (≈max. drift time because of after pulses) can be reduced by a factor of 4
- Space for twice as many tube layers → additional increase of in muon tracking efficiency and resolution

Drift time spectrum:

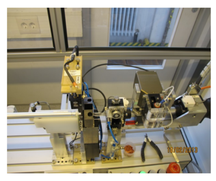


Automated drift tube production and test:

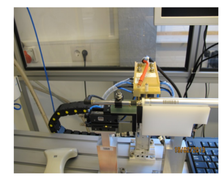
Wire insertion by air flow



Endplug and wire fixation

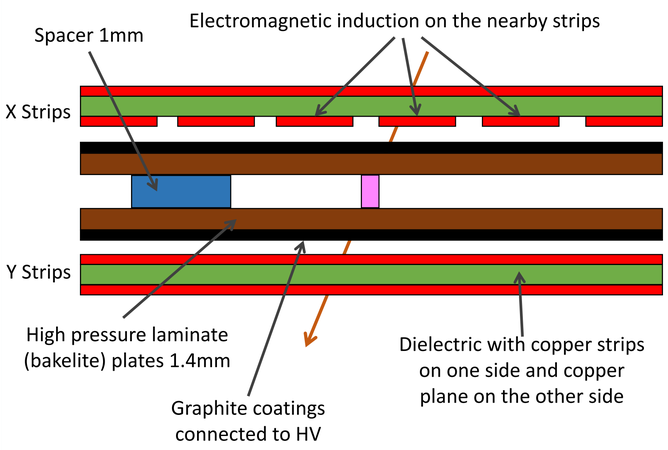


Wire tensioning



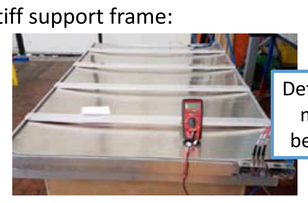
Wire tension measurement

Thin-Gap Resistive Plate Chambers:



→ Increase of lifetime well beyond 10 years at HL-LHC background rates

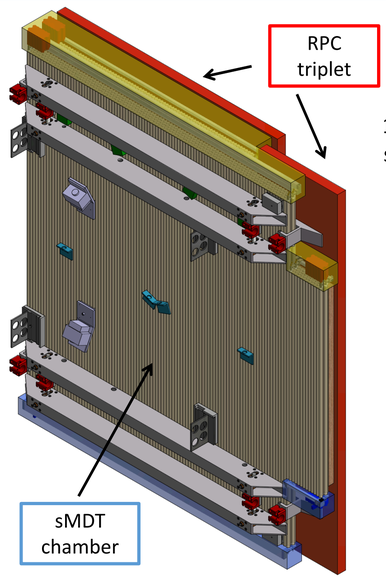
Prototype of a new RPC triplet in the light but stiff support frame:

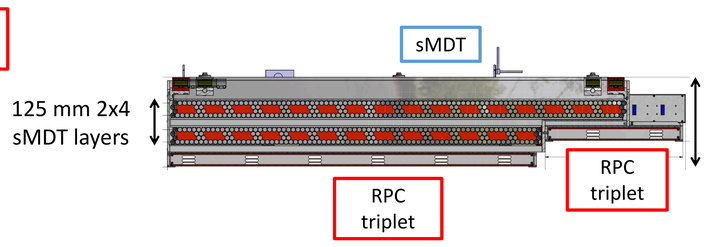


Twice thinner gas gaps (1mm) and thinner HLP electrodes and new highly sensitive amplifiers:

- Improvement of time resolution from 1 ns to 0.4 ns
- Allow for operation at substantially lower voltage, 5.4 kV instead of 9.6 kV, and ~15 x lower gas gain and avalanche charge

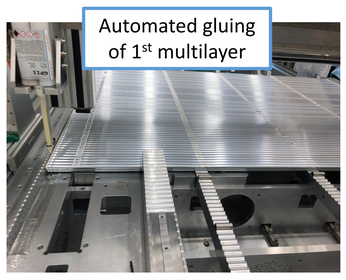
Integrated sMDT and Thin-Gap RPC Chambers :





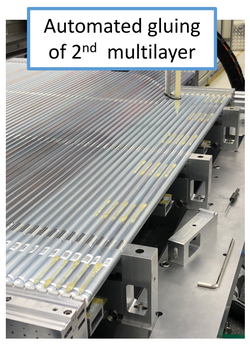
- New RPC chambers require replacement of existing MDT chambers by sMDT chambers → provide sufficient radial space
- Tight spatial constraints on new detectors
- Optical sensors for global alignment system on top and bottom of sMDT drift tube layers

sMDT Chamber Construction (2018):

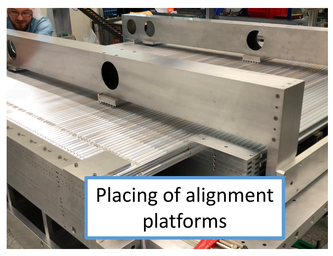


Automated gluing of 1st multilayer

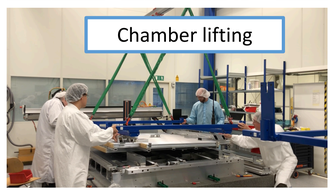
Gluing of spacer



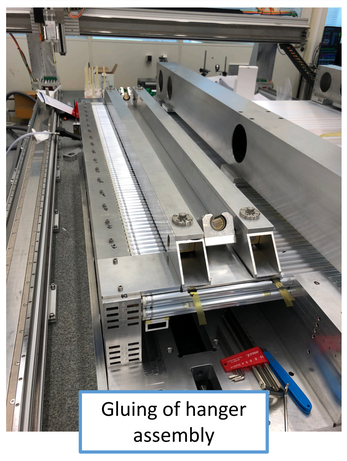
Automated gluing of 2nd multilayer



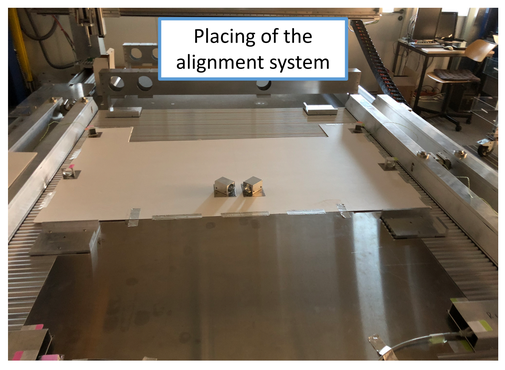
Placing of alignment platforms



Chamber lifting



Gluing of hanger assembly

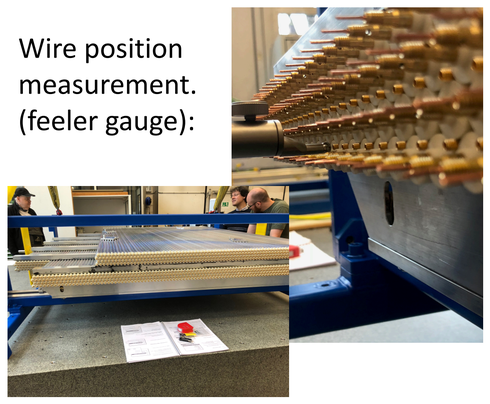


Placing of the alignment system

Installation of RPC's

Measuring of Chamber:

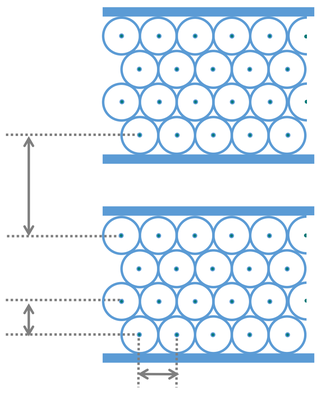
Wire position measurement. (feeler gauge):



nominal
measured

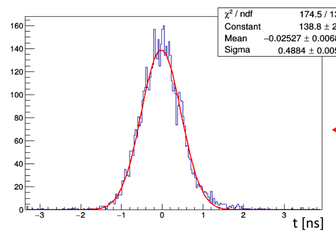
Δy multilayer= 45.6 mm
(45.5900 ± 0.0005) mm

y-pitch = 13.085 mm
(13.0888 ± 0.0001) mm

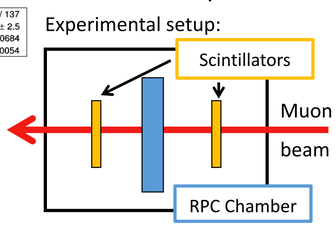


z-pitch = 15.099 mm (15.0992 ± 0.0001) mm

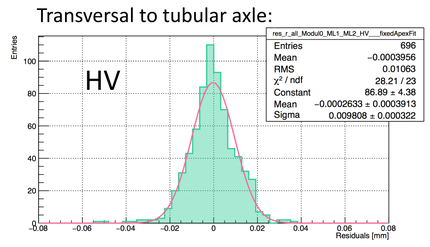
Measurement of time resolution of Thin-Gap RPC's:



Experimental setup:



Transversal to tubular axle:



→ Excellent time resolution: better than 0.4 ns on a single hit

→ Wire positioning accuracy of better than 15 μm