

Construction and Performance of the Precision Tracking Chambers for the ATLAS Muon Spectrometer Upgrade for High-Luminosity LHC



sMDT

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New ATLAS Muon Chambers for HL-LHC

Installation of **96 new sMDT** precision muon tracking detectors in combination with 96 new Resistive Plate (RPC) muon trigger chambers on the toroid magnet coils in the barrel inner layer in the Long Shutdown 3 of the LHC in 2026-2028.



Small-Diameter Drift Tube (sMDT) Chambers

By reducing the drift tube diameter from 30mm (MDT) to 15mm (sMDT) at otherwise unchanged operating conditions one achieves:

- 8x lower background occupancy (4x shorter maximum drift time, 2x smaller tube cross section)
- Space charge effects on resolution strongly suppressed

Wire locator (brass spiral)

Plastic insulator

Drift tube endplugs contain a brass insert

Goal: Improvement of the trigger acceptance, efficiency and selectivity under the conditions of the HL-LHC at > 5x the luminosity of the current LHC nominal.



(surrounded by an insulator) containing a spiral wire locator

MDT

This spiral locator ensures the **wire position is** known relative to the external reference **surface** with a precision of 1µm

sMDT Chamber Assembly Procedure



- Gluing of the tubes layer by layer – 7 work days
- Gluing and testing support structures and alignment platforms – 2 days
- Installation of gas distribution system -1 week
- Installation of electronics and final certification with cosmic muons

Wire Position Measurements

- Automated Coordinate Measurement Machine (CMM) used to measure position of each endplug external reference surface and therefore of each wire
- Derive wire position accuracy w.r.t. fitted sense wire grid $\Delta r (r^2 = y^2 + z^2)$







Wires positioned with around 5 µm precision relative to the wire sense array \rightarrow Corresponds to comb precision!

Auomated tube layer gluing

Gas Leakage Measurements

- Before a chamber can be certified, the gas system and electronics are installed and tested
- Gas system is mounted in temperature controlled clean room, involves around 4000 O-rings per chamber
- Filled at 3 bar absolute pressure
- Gas leak rates are measured after the gas system mounting, after the electronics are installed and again once the chambers have arrived at CERN
- Leak rates well below ATLAS limit (6.7 mbar pressure loss in 24 h) for all chambers





Chamber Performance

- Single tube resolution measured during chamber performance testing with cosmic muons, consistent across all chambers
- Apply systematic uncertainties (ca. 10 µm) due to multi-scattering of low-energy muons
- No time walk corrections applied before installation of final electronics (TDC)
 - \rightarrow Test beam measurements show single tube resolutions < 100 µm achievable with corrections



Quality Monitoring

Common quality control (QC) database with web-frontend for the two production sites

sMDT Chamber Construction 2020-2023

Series production at MPI finished Dec. 2022

--- Production Plan: 48 chambers / 2 years MPI chambers assembled

at MPI Munich and Michigan, hosted at CERN



- Series production in Michigan finished Sep. 2023
- All MPI chambers and half of Michigan chambers shipped to CERN, waiting for final electronics and certification at BB5





16th Pisa Meeting on Advanced Detectors, 26 May – 1 June 2024