Upgrade of the ATLAS Muon Spectrometer with New Small-Diameter Drift Tube Chambers

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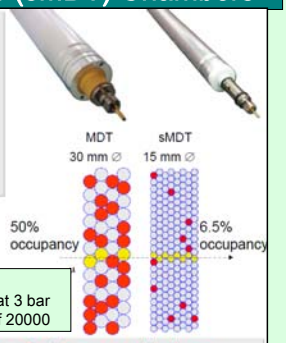
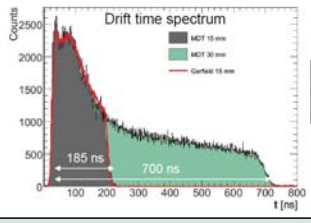
Small-Diameter Muon Drift Tube (sMDT) Chambers

By reducing the drift tube diameter from 30 mm (MDT) to 15 mm (sMDT) at otherwise the unchanged operating conditions and while keeping all advantages of the MDTs as well as their services:

- 8 x lower background occupancy (4 x shorter maximum drift time, 2 x smaller tube cross section).
- Electronics deadtime (≈ max.drift time because of afterpulses) can be reduced by a factor of 4, thus the masking of muon hits by preceeding background hits.



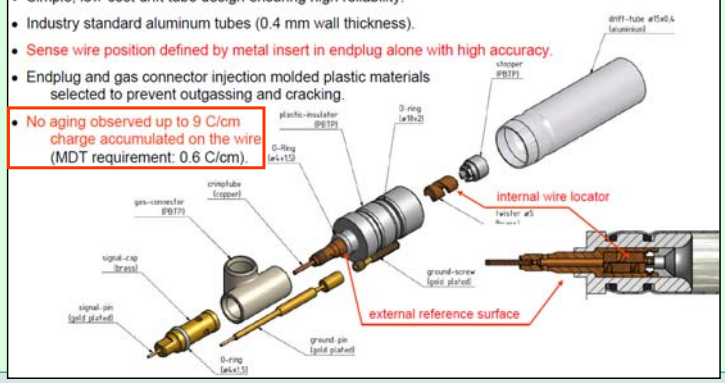


Operated with Ar:CO_2 (93:7) at 3 bar and gas gain of 20000

- Also, space for twice as many tube layers within the same available detector volume, allowing for additional increase in muon tracking efficiency and resolution.

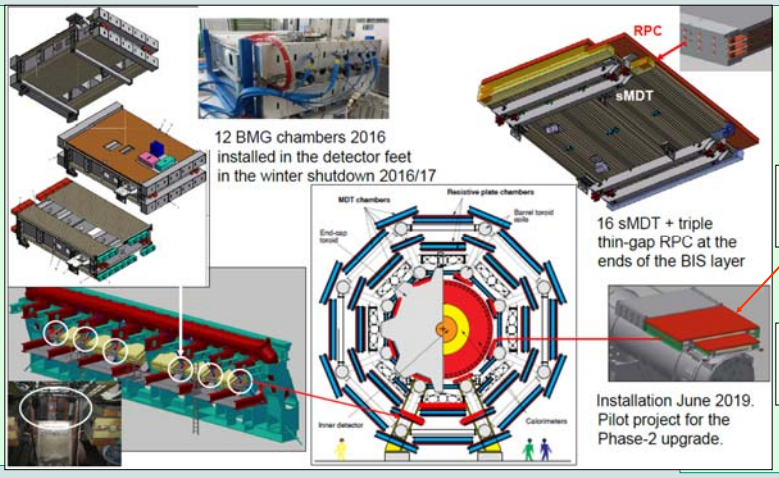
sMDT Drift Tube Design

- Design and assembly procedures optimized for mass production.
- Simple, low-cost drift tube design ensuring high reliability.
- Industry standard aluminum tubes (0.4 mm wall thickness).
- Sense wire position defined by metal insert in endplug alone with high accuracy.
- Endplug and gas connector injection molded plastic materials selected to prevent outgassing and cracking.
- No aging observed up to 9 C/cm charge accumulated on the wire (MDT requirement: 0.6 C/cm).



Assembly Method

Insertion of endplug reference surfaces into precision machined hole grid which directly defines the relative wire positions to **better than the required 20 µm rms**. Assembly procedure optimised for mass production. Use of automated glue dispenser (top). Complex chamber shapes feasible.



sMDT Chambers for ATLAS

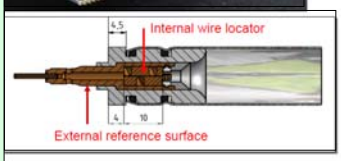
sMDT chambers: Precisiosn muon tracking detectors with **35 µm spatial resolution** and **10 x higher background rate capability** than current MDT chambers. Robust and cost effective technology for HL-LHC and FCC-hh.

BIS78 chamber type under construction

BMG chamber type in operation in ATLAS

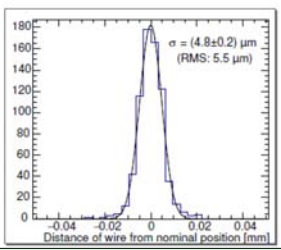
Automated Drift Tube Production and Test

Sense wire positioning measurement and accuracy

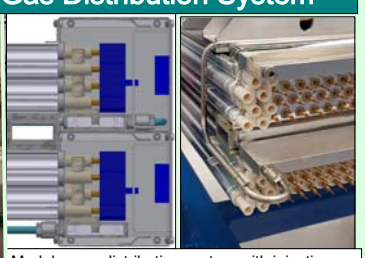


Measurement of individual sense wire and alignment sensor positions with **commercial 3D coordinate measuring machine** with 2 µm precision

⇒ Wire positioning accuracy of better than 5 µm (MDTs: 20 µm).



Alignment Sensors and Gas Distribution System



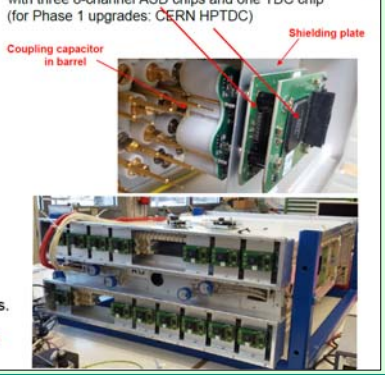
Modular gas distribution system with injection molded gas connectors to a gas distribution bar.

Measurement of alignment sensor platform positions relative to the wires grid

sMDT Electronics

High-voltage distribution boards (24 channels)

Signal distribution and readout boards (24 channels)
with three 8-channel ASD chips and one TDC chip (for Phase 1 upgrades: CERN HPTDC)



Dense hedgehog boards.
⇒ HV protection of termination resistors and coupling capacitors
⇒ Stacked passive and active boards.
Already tested on BMG chambers.

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