Construction and Test of New Precision Drift-Tube Chambers for Upgrades of the ATLAS Muon Spectrometer in 2016/17

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***Abstract*—The Monitored Drift Tube (MDT) chambers of the ATLAS muon spectrometer demonstrated that they provide very precise and robust tracking over large areas. Goals of ATLAS muon detector upgrades are to increase the acceptance for precision muon momentum measurement and triggering and to improve the rate capability of the muon chambers in the high-background regions when the LHC luminosity increases. Small-diameter Muon Drift Tube (sMDT) chambers have been developed for these purposes. With half the drift-tube diameter of the MDT chambers and otherwise unchanged operating parameters, sMDT chambers share the advantages with the MDTs, but have an order of magnitude higher rate capability and can be installed in detector regions where MDT chambers do not fit in. The chamber assembly methods have been optimized for mass production, reducing cost and construction time considerably and improving the the sense wire positioning accuracy to better than ten microns. The construction of twelve chambers for the feet regions of the ATLAS detector is currently ongoing with the goal to install them in the winter shutdown 2016/17 of the LHC. Design and construction of the new sMDT chambers for ATLAS are discussed as well as measurements of their mechanical precision.**

The Monitored Drift Tube (MDT) chambers of the ATLAS muon spectrometer [1] have demonstrated that they provide very precise and robust tracking over large areas. Goals of ATLAS muon detector upgrades are to increase the acceptance for precision muon momentum measurement and triggering and to improve the rate capability of the muon chambers in the high-background regions when the LHC luminosity increases. Small-diameter Muon Drift Tube (sMDT) chambers have been developed for these purposes [2]. With half the drift-tube diameter of the MDT chambers and otherwise unchanged operating parameters, sMDT chambers share the advantages with the MDTs, but have an order of magnitude higher rate capability [2] and can be installed in detector regions where MDT chambers do not fit in. The construction of twelve chambers for the feet regions (see Fig. 1) of the ATLAS detector is currently ongoing with the goal to install them in the winter shutdown 2016/17 of the LHC. The purpose is to extend the acceptance for three-point measurement of muon tracks which will substantially improve the muon momentum resolution in theese regions.

We report here about the construction of these chambers which started in the fall of 2014. The chamber design and construction procedures have been optimized for mass production while providing high mechanical accuracy of better than 10 μm in the sense wire positioning. The sMDT drift tubes are standard industrial aluminium tubes with a diameter of 15 mm and a wall thickness of 0.4 mm.

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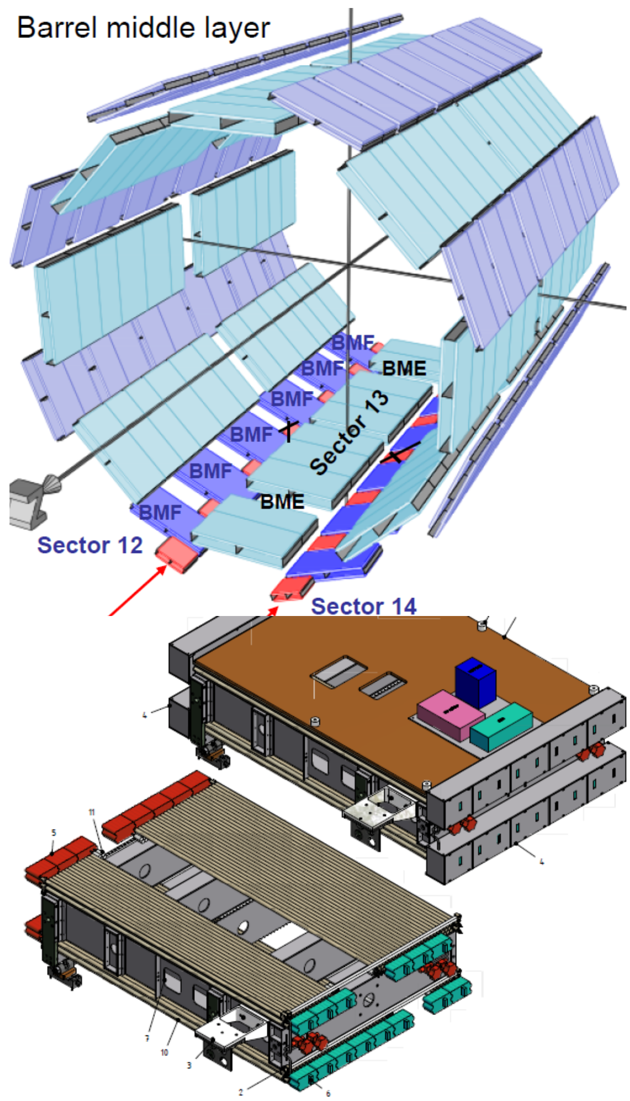

Fig. 1: Illustration of the location (top) of the new sMDT chambers (bottom) in the middle layer of the barrel part of the ATLAS muon spectrometer.

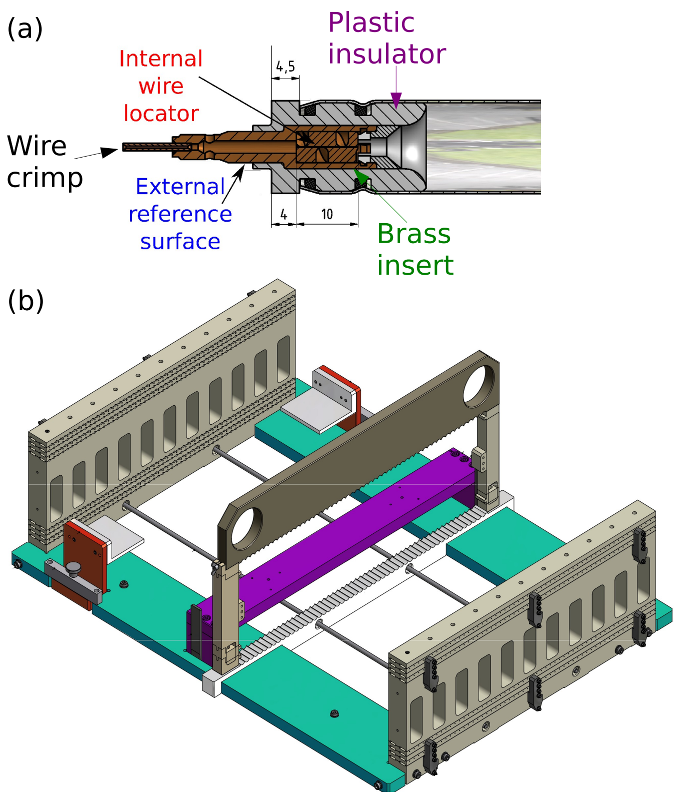

Fig. 2: (a) The endplugs of the drift tubes consist of a plastic insulator (grey) and a brass insert (brown) which positions the sense wire with better than 5 μm accuracy with respect to a cylindrical reference surface on the outside of the tube. (b) The reference surfaces are used during chamber assembly to position the tubes at each end in fitting holes in a precisely machined jig.

First, the drift tubes are assembled using a semi-automated wiring machine (see Fig. 3a). The wire tension, the gas leak rate and the leakage current under high voltage are measured for every tube before it is assembled in a chamber. The failure rate is only about 1%. About 100 tubes per day are produced and tested with this setup. The chambers are assembled by inserting the tubes with the reference surfaces on the endplugs into the jigs at each chamber end which define the wire grid as described in Fig. 2 and glueing them together and to a spacer and support frame (see Fig. 1 and Fig. 3b). A complete chamber can be assembled within one working day. Before mounting the modular gas distribution system and the readout and high-voltage distribution boards [2], the wire grid and the geometry of the assembled chamber is reconstructed with a few micron precision by measuring the positions of the reference surfaces of the endplugs at both chamber ends with a coordinate measuring machine with few micrometer precision). An overall sense wire positioning accuracy in a chamber of better than 10 μm has been achieved (see Fig. 4). At the same time, the positions of the optical alignment sensors on the chambers with respect to the wire grid are measured with high accuracy.

References

[1] ATLAS Collaboration, G. Aad et al., The ATLAS Experiment at the CERN Large Hadron Collider, *JINST 3* (2008) S08003.

[2] H. Kroha et al., Construction and test of a full-scale prototype drift-tube chamber for the upgrade of the ATLAS muon spectrometer at high LHC luminosities, Nucl. Instr. and Meth. A718 (2013) 427.

(a) (b) (c)

Fig. 3: (a)Semi-automated drift tube assembly in a climatized clean room. In the same room the quality control tests of the drift-tubes, wire tension, gas leakage, and leakage current tests, are performed (see text). (b) Assembly of a sMDT chamber with the precise jigging installed on a flat granite table in a climatized clean room as described in the text and in Fig. 2. (c) Assembled chamber, still on the assembly table, with two multilayers, each consisting of four drift-tube layers.

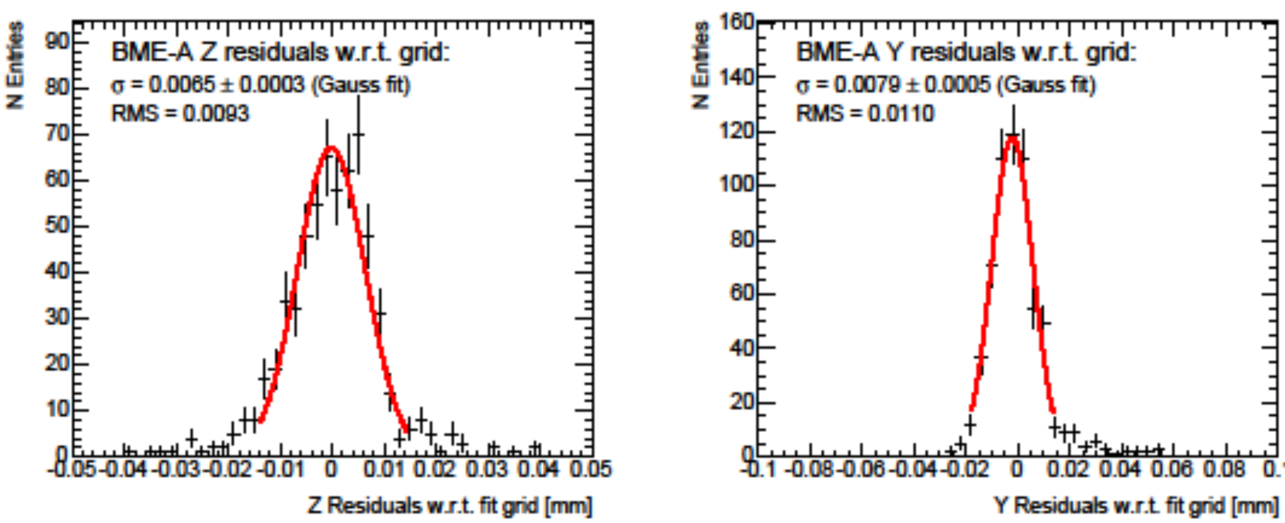

Fig. 4: Residual distributions of the transverse sense wire coordinates y and z, perpedicular and parallel to the chamber plane, respectively, measured with micrometer accuracy on a coordinate measuring machine using the external reference surfaces of the endplugs. A wire positioning accuracy of better than 10 μm with respect to the ideal grid has been achieved in both coordinates.