# Commissioning and Calibration of ATLAS Drift Tube Chambers at the LMU Cosmic Ray Test Facility

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At the Cosmic Ray Test Facility of Munich university [1], 88 Monitored Drift Tube (MDT) chambers of the ATLAS muon spectrometer [2], built by the Max-Planck-Institut für Physik in collaboration with the JINR at Dubna and the LMU, are commissioned and calibrated at a rate of 1-2 chambers per week. These so-called BOS (Barrel Outer Small) chambers are the second largest type of precision chambers employed in the barrel region of the ATLAS detector—each measuring 3.8 m $\times$ 2.2 m $\times$ 0.5 m and consisting of 432 drift tubes arranged in 2 $\times$ 3 layers of 72 tubes mounted on a support frame. The individual wire positions and geometrical parameters of the MDTs are measured using 10-20 million events per chamber; it is further planned to measure the positions of the on-chamber alignment platforms [3]. Two MDT chambers certified by the X-ray tomograph [4] at CERN provide reference tracking for the enclosed third chamber, which is to be tested and calibrated. The relative chamber positions are monitored by optical and capacitive alignment systems with a precision of better than 5 $\mu$m. The trigger setup fully covers the chambers and selects only energetic muons ($E_\mu > 600$ MeV).

Before their installation in the cosmic ray facility, the chambers have to pass several tests and are completed at the LMU site: A measurement of the tube wire resistances detects broken anode wires and bad contacts. A leak test [5] ensures that the chambers meet the stringent requirements of an average leak rate smaller than $2 \times 10^{-8}$ bar l/s per tube (see fig. 1). The front-end electronics and Faraday cages are mounted and checked, and a high voltage test is performed to measure the dark current and to locate discharges.

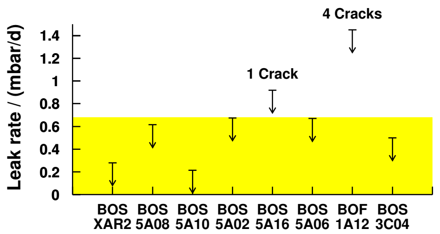


Fig. 1: Measured leak rate of BOS type MDT chambers, the shaded area marks the allowed range. The higher leak rates of the BOS1A16 and BOF1A12 are caused by known cracks in a few of the tube end-plugs.

After installation in the test facility, measurements with cosmic muons are used to further commission the chamber and determine its geometry. The homogeneity of the chamber response is important for the operation of the MDTs and the auto-calibration of the entire muon spectrometer. It can be studied by measuring the drift time spectra of the individual tubes. A set of parameters is obtained from fits with analytic functions to the rising and falling edge of each drift time spectrum and allows their comparison. The homogeneity of the response can be tested along each tube, for all tubes in a layer and for all layers of the chamber, separately. As an example, fig. 2 shows the distribution of the maximum drift times averaged over the tubes in the multilayers of each chamber.

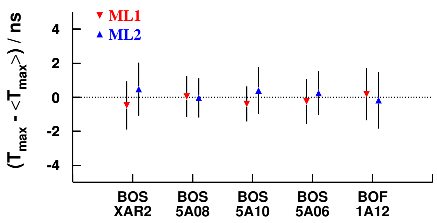


Fig. 2: Measured maximum drift times of BOS type MDT chambers. The points denote the mean maximum drift time in the multilayer, the error bars the RMS of the single tube measurements.

The positions of the individual anode wires are determined by comparing the measured drift times of tubes of the tested chamber with the predictions derived from the extrapolated tracks of the reference chambers [6]. A displaced wire leads to systematic deviations from these predictions. The LMU Cosmic Ray facility allows the measurement of the wire positions with a precision of approx. 8 $\mu$m in the chamber plane and 25 $\mu$m perpendicular to it. The chamber geometry, i.e. layer displacements (cf. fig. 3), layer tilt angles and grid constants, can be determined from the individual wire positions with even higher precision. The data sets obtained will be available in the ATLAS MDT calibration database.

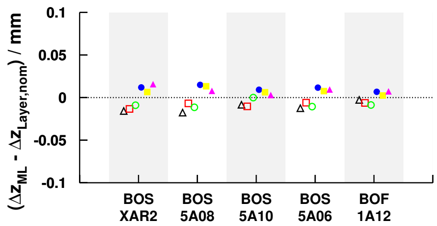


Fig. 3: Horizontal layer shifts of BOS type MDT chambers. For each chamber, the 6 points from left to right denote the layers from bottom to top.

The MDT chambers tested so far meet the ATLAS leak rate requirements, show a homogeneous response and are built well within the allowed geometrical tolerances.

## References

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