Calibration of 88 BOS Muon Drift Chambers for Atlas at LHC/Cern

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In the last three years 102 BOS Monitored Drift Tube (MDT) chambers have been commissioned, quality controlled and calibrated at the Cosmic Ray Measurement Facility (CMF) at LMU. All 88 chambers foreseen for the ATLAS experiment at CERN have been shipped in 2005 and are already, or will be soon, installed in the ATLAS detector at the Large Hadron Collider. No problems occured after transport. 14 chambers are kept in Munich as spare and for further investigations.

The ATLAS MDT detectors are designed to provide standalone measurement of muon momentum. The large magnetic rigidity of the high energetic muons created in p-p collisions at LHC demands good spatial resolution, high mechanical accuracy, high quality of on-chamber electronics and gas tightness.

A standard BOS (barrel outer small) MDT chamber consists of 432 single drift tubes that are grouped into two multilayers of 3 planes with 72 tubes, each [1]. Each drift tube is 3.77 m long and has a diameter of 30 mm. In its center a 50 μm thick gold plated tungsten wire is charged to a potential of +3080 V. Throughgoing muons hit in most cases 6 tubes and ionize along their path through the Ar-CO_2 gas mixture (93% : 7%). The reconstructed muon track is then obtained by fitting a tangent to the 6 drift radii that are determined from the measured drift time using the so-called r-t relation. Due to the uniformity of the drift properties among the 432 tubes, confirmed by analyzing the drift time spectra, a single r-t relation per chamber could be used. The r-t relation is sensitive to temperature fluctuations or changes in the composition of the counting gas and has to be monitored and corrected, if needed. Herefore, autocalibration was used successfully, also during the nonequilibrium phase at startup when the composition of the permanetly flushed gas and the temperature still vary.

In the Cosmic Ray Measurement Facility three layers of scintillation counters trigger a throughgoing muon with a time resolution of 0.8 nsec. 12 Mio triggers, accumulated within 48 hours, are sufficient to calibrate individual wire positions of a chamber with an accuracy of 8 μm within a layer of tubes and 27 μm perpendicular to it. The vertical resolution of 27 μm was limited by the azimuthal range of accepted muon angles of about 30 degrees. An iron absorber between the lower reference chamber and the lower scintillator hodoscope enables a hardware and software cut on muon energies of about 1 GeV using absorption and the information from small angle scattering of the muons in the iron.

Two reference chambers with known wire positions, mapped in a computer tomograph at CERN with a precision of 5 μm, allow to reconstruct the track of a muon. The reference chambers are carefully aligned to each other and their mutual position is monitored using an optical system with an accuracy of a few μm. Correction for thermal movement is hereby enabled. The chamber to be calibrated sits in the middle of the two reference chambers. Its alignment in respect to the upper reference chamber is surveyed with a capacitive monitoring system. The deviation of drift radii from predictions by the reconstructed tracks of muons allows to determine the real position of the respective wire. Global parameters like distance and shift between the two multilayers or rotation against each other can be extracted by averaging over all wire positions of a multilayer. Wire positions and multilayer parameters are recorded in a database and will be available for muon reconstruction at CERN. This feature is beyond the ATLAS standard requirements for MDT chambers and was performed to this extent only in Munich. It will ease the alignment and calibration of the chambers at ATLAS considerably. Figures 1 and 2 show the distributions of multilayer distance and multilayer shift for the 102 tested chambers. Figure 1 shows the deviation Δ from the nominal multilayer distance of 346.898 mm. The mean value und the standard deviation of both distributions is well within ATLAS specification. The 8 outliers are correlated with failures during production and belong to the chambers kept in Munich.

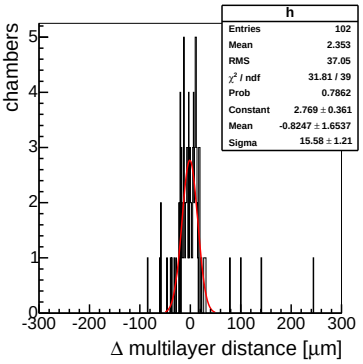

Fig. 1: Distribution of the vertical shift between the two mutilayers. mean=0.825μm σ=15.6μm

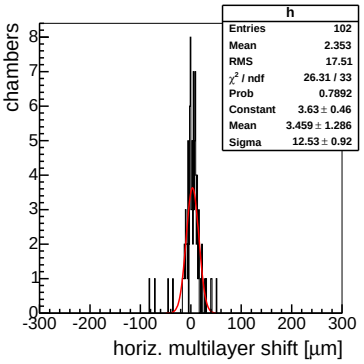

Fig. 2: Distribution of the horizontal shift between the two mutilayers: mean=3.46μm σ=12.5μm

The reconstruction of cosmic tracks proofed as a very sensitive tool to measure the mechanical properties of the MDT chambers. More details particularly on the monitoring of the agreement between the sag of the wires and the adjustable sag of the drift tubes are given in [2].

The 14 chambers kept in Munich will be used for future investigations as studies of background, long term stability, behaviour under temperatures above 30^0C or drift time investigations with different gas mixtures, also in view of the 10 times higher luminosity expected after the upgrade of LHC.

References

[1] O. Biebel *et al.*, physics/0307147,LMU-ETP-01(2003)

[2] F. Rauscher *et al.*, this report, p. 79