Uniformity of Drift Properties in ATLAS MDT Chambers

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The precision tracking system of the muon spectrometer [1] of the ATLAS experiment at the LHC accelerator at CERN will be build mainly of Monitored Drift Tube (MDT) chambers. In collaboration, the Max Planck Institute for Physics and the Ludwig-Maximilians University of Munich are producing 88 of the second largest type of these chambers. Each such MDT chamber consists of 432 drift tubes arranged into two triple layers which are glued to a support frame (see fig. 1), the chamber dimensions are 3.8 m $\times$ 2.2 m $\times$ 0.5 m. The individual drift tubes have a diameter of 3 cm and a centered anode wire of 50 μm thickness. The tubes will be operated at a gas gain of 2×10^4 with a gas mixture of $Ar{:}CO_2$ = 93:7 at a pressure of 3 bar absolute and are connected in parallel to the gas distribution system. The average resolution of the measurement of the impact radius of a crossing muon in a tube—which is calculated from the drift time of the liberated ionisation via the *space-drift time (r-t) relation*—will be about 80 μm.

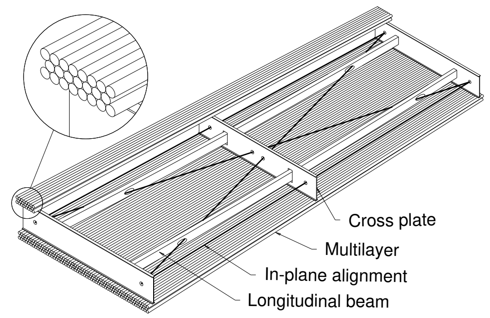

Fig. 1: Schematic view of a MDT chamber.

As the knowledge of the r-t relation in the drift tubes is crucial to the proper track reconstruction it is foreseen to determine it every 24 h from high energy events during normal LHC operation with the so-called autocalibration procedure [1,2]. Thus, longterm changes which can influence the drift properties and the r-t relation—e.g. slight changes in the gas composition—can be taken into account; otherwise they would deteriorate the measurement precision of the drift tubes and weaken the performance of the muon spectrometer. The size of the different autocalibration zones, for which a common space-drift time relation is assumed, usually corresponds to a MDT multilayer [2]. The uniformity of the drift properties in the individual tubes within a multilayer of a chamber is therefore an important prerequisite for the operation of the MDT chambers in the ATLAS experiment.

To investigate the uniformity of the drift properties we used three MDT chambers which were operated under the same conditions in the cosmic-ray test facility [3]. The chambers were connected in parallel to a gas system using premixed gas, the pressure was stabilized to 3.000 $\pm$ 0.002 bar and the temperature in the experimental hall was constant to within 0.5 degrees. Due to a lack of available electronics only the middle third of 5 multilayers could be read out. The data obtained in 72 hours of measurement time—about 20 million events—were divided into 3 samples of 24 hours each to also allow a study of the time stability.

The uniformity of the drift properties can be easily tested by analyzing the *drift time spectra* of the tubes. The drift time spectrum is the distribution of the measured drift times of a homogeneously illuminated tube, see fig. 2—small times correspond to tracks crossing the tube near the anode wire, large times to tracks near the tube walls.

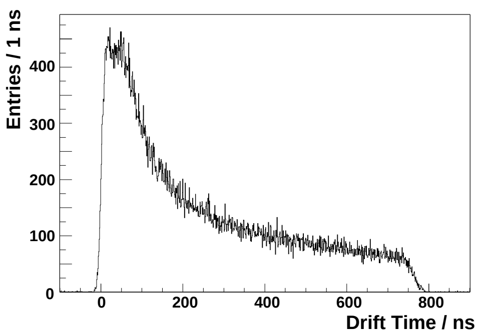

Fig. 2: Measured drift time spectrum of a drift tube in an ATLAS MDT chamber.

By fitting analytic functions—the sum of a Fermi function and a constant to the rising edge, the sum of a Fermi function multiplied by a first order polynomial and a constant to the falling edge—the length of the drift time spectrum can be extracted from the fit parameters with a precision of about 1.5 ns. The average maximum drift time is around 762 ns. In all multilayers the RMS spread of the length of the drift time spectra of the individual tubes was less than 2.2 ns and the change within the 72 hours of measurement time was less than 1 ns.

As a further step, the approximate space-drift time relations derived from the integration of the drift time spectra can be compared. Thus, not only global changes like the maximum drift time, but also local changes of the drift properties as a function of the impact radius can be investigated. Within the statistical errors, the space-drift time relations of all tubes in a multilayer were consistent with the average r-t relation and the average space-drift time relations showed no time dependency.

The results obtained—the uniformity and time stability of the drift properties in the MDT chambers—increase the confidence that the foreseen autocalibration procedure can be successfully applied to the ATLAS muon spectrometer.

References

[1] ATLAS Muon Spectrometer Technical Design Report, CERN/LHCC/97-22, CERN, 1997
[2] See e.g. M. Deile, Optimization and Calibration of the Drift-Tube Chambers for the ATLAS Muon Spectrometer, PhD Thesis, Munich 2000
[3] O. Kortner *et al.*, this report, p.89