Testbeam Studies of Drift Tube Chambers for the ATLAS Muon Spectrometer ◇

M. Deile, S. Chouridou, N. P. Hessey, C. Perrot, T. Sammer, D. Schaile, A. Staude, R. Ströhmer, T. Trefzger, and P. Vannerem

1. The Muon Test Beam Experiments at CERN

Monitored drift tubes (MDT) arranged as multilayers in chambers will provide the precise tracking information of the ATLAS muon spectrometer [1,2]. In order to optimize their performance and to develop tracking techniques, test facilities were set up in the SPS Muon beam lines M2, H8 and X5 at CERN. Together with other institutes we study single drift tubes as well as complete MDT prototype chambers (fig. 1).

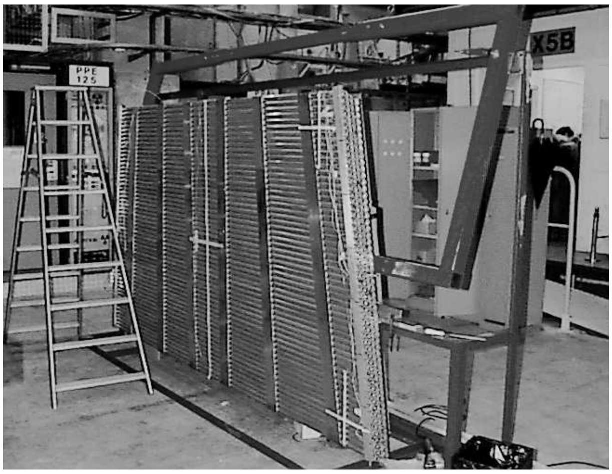

Fig. 1: An MDT prototype chamber before moving into the X5 zone

As an external reference system for determining the tubes' space to drift-time relationship, resolution and efficiency we built a hodoscope of 6 Silicon microstrip detectors with 7 μm resolution per plane (fig. 2).

The zones M2 and H8 were equipped with bipolar magnets allowing chamber tests in B-fields up to 1 T, which simulated the conditions in the toroidal field in ATLAS.

2. Optimisation of Drift Tube Operation Parameters

To meet the momentum resolution requirements for the muon spectrometer [1], the single drift tubes must measure the track distance from their anode wires with an accuracy of about 80 μm. As a compromise between minimum chamber ageing and optimum resolution ATLAS drift tubes run in proportional mode with a low ionisation amplification of $2 \cdot 10^4$ and a drift gas pressure of 3 bar. The low discriminator threshold of 25 primary electrons enhances both the resolution and the efficiency, which is at the level of 99.5 %. A very important aim of our test beam studies is the choice of an appropriate gas mixture which determines not only resolution and ageing, but also crucial parameters like detector occupancy (via the maximum drift time) and linearity of the space to drift-time relationship. The latter is desired for stability of the electron drift properties against fluctuations of operation conditions like temperature, pressure, anode voltage etc.

The comparison of tubes with different anode wire diameters has shown that the decision for 50 μm optimizes the performance in terms of spatial resolution and mechanical strength.

Fig. 2: The Silicon microstrip hodoscope in the H8 test beam zone

3. Autocalibration of the Space to Drift-Time (r-t) Relationship

Since no external reference system will be available at ATLAS, a self-consistent technique for calibrating the r-t relationship, called autocalibration, was developed. It is based on the fact that the drift times of a muon track in a multilayer of tubes are correlated with each other. Thus the problem is overdetermined and yields the particle tracks as well as the r-t relationship. In order to be sure that the algorithm converges to the correct solution, its results are compared with the data from the Silicon tracker. The accuracy of the calibrated r-t relationship was recently pushed below 15 μm.

4. Study of Drift Tube Chambers in Gamma Background

In ATLAS the MDT chambers will have to work with a gamma background of up to 100 Hz/cm^2. This leads to effects like baseline shift, space charge and pulse pile-up, all resulting in performance degradations. In order to examine these phenomena and to develop suitable read-out electronics, the Gamma Irradiation Facility GIF in the X5 beamline was created. In addition to a muon beam it offers a ^{137}Cs source producing 660 keV Photons with 750 GBq activity.

References

[1] The ATLAS Collaboration; ATLAS, technical proposal for a general purpose pp experiment at the Large Hadron Collider at CERN; CERN/LHCC/P2, 1994

[2] The ATLAS Muon Collaboration; ATLAS Muon Spectrometer Technical Design Report; CERN/LHCC/97-22; 1997

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