Optical Alignment of ATLAS Muon Chambers in the Cosmic Ray Test Facility

J. Elmsheuser, W. Stiller, M. Binder, J. Dubbert, R. Hertenberger, O. Kortner, F. Rauscher, M. Rykaczewski, O. Sahr, D. Schaile, A. Staude, V. Zhuravlov, and C. Zupancic

The cosmic ray test facility at the LMU Munich allows efficiency tests and calibration studies of 88 drift tube chambers built for the ATLAS muon spectrometer at CERN [1]. Every chamber is tested for operativeness, noise and their single tube drift-time spectra. The positions of the single tube wires are determined and measured with respect to an external reference platform. The physical requirements of the ATLAS muon spectrometer are fulfilled by the very precise chamber geometry and internal and external alignment procedures and control systems.

The cosmic ray test facility is in its final setup [2]. Three chambers are mounted on top of each other with a spatial distance of 80 mm between each of them. The top and the bottom chamber are the so called “reference” chambers. The wire positions of these two chambers have been determined at the CERN X-ray tomograph with a precision of about 4 μm. In between these two chambers a “test” chamber is placed and measured with respect to the two other chambers. During the planned operation time of about 10 hours the relative position of the three muon chambers with respect to each other must be known. These positions may vary in the order of a few μm because of mechanic tensions or thermal movements. To determine the precision coordinate of the single drift tube with a precision of about 15 μm, the relative position of the chambers should be know in a range of 5 μm to 10 μm.

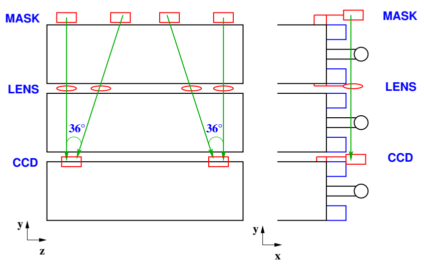

Fig. 1: The figure shows the front view (left) and side view (right) of the sensor mounting scheme on the MDT chambers in the test stand. The arrow lines sketch the infrared light rays from the mask through the lens to the sensor.

Two different systems are used to monitor the positions. The position change of the test chamber is monitored by a capacitive system with respect to the upper reference chamber [3]. The second system measures the movements of the two outer reference chambers relative to each other. It consists of several optical alignment systems, the so called RasNiK (Red alignment system NIKHEF) system [4]. The basic idea of the RasNiK system is to create an image of a coded mask on a CCD sensor by means of a lens. The analysis of the mask image position allows the determination of relative movements transverse to the optical axis with an accuracy of about 1 μm while movements along the optical axis are measured from the image size with about one order of magnitude less precision.

The RasNiK system is used for monitoring internal and external chamber movements. The inplane alignment system is mounted during chamber production and controls changes of the chamber geometry. The external monitoring system is needed for the cosmic ray test stand. The main task of the external monitoring system is the control of coordinates transverse to the tube wire, namely the y- and z-component (Fig. 1). The reference chamber monitoring system consists of four RasNiK systems on every corner of the chambers. These systems are capable of measuring the x- and z-coordinate with high precision. Two components, the mask and lens, are mounted on the top chamber and one component, the CCD, is mounted on the bottom chamber. In order to monitor the y-component with a similar accuracy, four additional RasNiK systems are mounted in diagonal setups. The stereo angle measurement is about three times less precise.

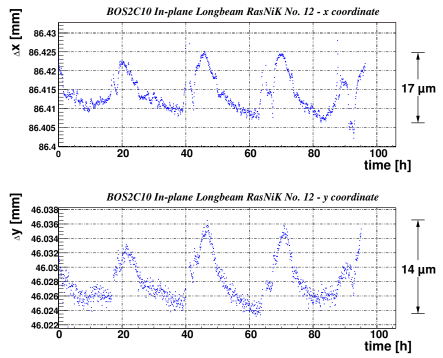

Fig. 2: The figure shows the movements of the x- (top) and y-coordinate (bottom) of the chamber inplane RasNiK system due to day and night temperature changes. The movement range is good agreement with the temperature variations.

The alignment monitoring system is in its final setup and shows stable operational behaviour. First tests of the system show that it is working within its specifications. The test stand is operated in an air-conditioned hall with a temperature stabilization at $(19.5 \pm 0.5)^\circ$C [2]. Aluminum as main component of the chambers has an linear extension coefficient of about 23 μm for one meter of material at a temperature change of 1°K. In Fig. 2 one sees the variation of the chamber geometry due to the hall temperature changes during several day and night cycles. Further work with the alignment system will concentrate on the offline data analysis and the optimization of the tube wire position determination with the whole system at hand.

References

[1] T. Trefzger *et al.*, Annual report 1999, p. 106
[2] O. Kortner etal, this report, p.89
[3] A. Kraus *et al.*, Annual report 2000, p. 66
[4] The ATLAS Muon Collaboration, ATLAS Muon Spectrometer Technical Design Report, CERN/LHCC/97-22, 1997.