First Results with 3 Chambers at the Cosmic-Ray Test-Facility

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The Ludwig-Maximilians University of Munich and the Max-Planck Institute for Physics are producing 88 drift-tube chambers for the muon spectrometer of the ATLAS experiment. In order to commission these chambers [1], measure the anode wire positions, and gain experience with calibration procedures which have to be applied during ATLAS data taking, a cosmic-ray test-facility has been built in Garching. The set-up is depicted in figure 1.

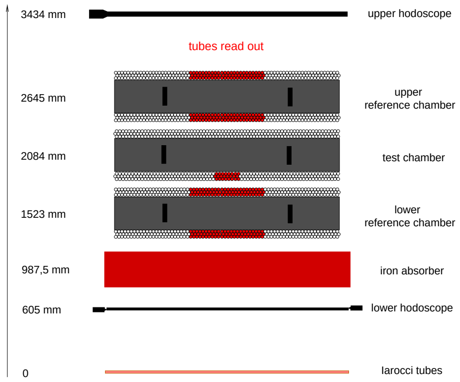

Fig. 1: Schematic of the cosmic-ray set-up during the measurement presented in this article. Only the coloured drift tubes were read out.

A coincidence of the upper and the lower scintillator hodoscopes triggers the data acquisition. With their segmentation of about 10 cm they also measure the muon path in the plane perpendicular to the plane of projection in figure 1. A 34 cm thick block of iron above the lower hodoscope absorbs the low-energy component of the cosmic spectrum ($E_\mu < 600$ MeV). The Iarocci tubes on the ground measure the muon position with an accuracy of 1 cm. This measurement allows the determination of the scattering angle of the muon in the iron block. Since low-energy muons show larger multiple scattering than highly energetic muons, this measurement contains information about the muon energy. Three muon chambers are mounted in the set-up. Two reference chambers whose geometry is known from x-ray tomograph measurements [2] enclose a third chamber. The third chamber is to be tested in the stand and will therefore be called test chamber from now on. The reference chambers provide a muon track which is used to inspect the geometry of the test chamber.

If a muon $y = mz + b$ passes a displaced wire, as illustrated in figure 2, the distance r_t of the track from the nominal (undisplaced) position differs from the drift radius r_d measured by the tube under investigation by

$$r_t - r_d = \pm\frac{m\delta_z - \delta_y}{\sqrt{1+m^2}} \approx \pm(m\delta_z - \delta_y);$$

the sign depends on whether the muon passes the wire on the left or on the right. The distribution of the slopes of the tracks which traverse the inner region of the test chamber is symmetric about 0. So the mean value of the their slope vanishes. Therefore, the mean value of $r_t - r_d$ equals

$$< r_t - r_d >= \pm\delta_y.$$

The average $< r_t - r_d >$ gives the horizontal displacement δ_y. The vertical displacement is obtained by plotting $r_t - r_d$ versus m. The points $(r_t - r_d, m)$ are scattered about a straight line with slope δ_z.

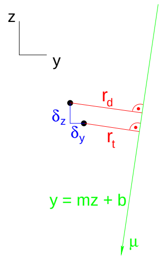

Fig. 2: Muon track hitting a tube with a displaced wire.

In the first cosmic run, the horizontal wire positions of all the 24 tubes read out in the test chamber were measured. In addition, the distance of the three layers each containing 8 tubes was determined. The accuracy of the measurements was found out by a comparison of the results obtained at the cosmic-ray stand and the results of x-ray tomography [2]. For the comparison of the horizontal displacement let D denote the horizontal distance of two neighbouring wires; let Δ be the deviation of D from its nominal value, i.e. $\Delta := D_{measured} - D_{nominal}$. In figure 3 the values of Δ measured with cosmic muons are plotted against the tomograph results. The points $(\Delta_{teststand}, \Delta_{tomograph})$ are scattered about the bisector of the coordinate system in the first and third quadrant. The cosmic-ray measurement is consistent with the tomograph measurement and agrees with it on the level of 10 μm. Hence horizontal displacements can be determined with an accuracy of 10 μm.

The distance of layer segments of eight tubes is measured with the same precision. Our results agree with the tomograph measurements within the errors and deviate from them by less than 10 μm.

We conclude that our cosmic-ray test-stand enables us to guarantee the knowledge of the coordinates of the anode wires in a test chamber with the required accuracy.

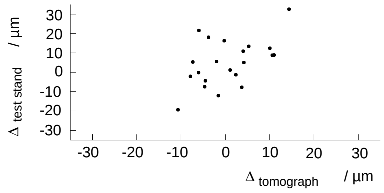

Fig. 3: Comparison of the measurement of the horizontal wire spacing by the cosmic-ray stand and the x-ray tomograph.

References

[1] J. Dubbert et al., this report, p.93.
[2] X-QC Muon group, ATLAS, October 2000, see http://x.home.cern.ch/x/xtomo/www/Results/Mun_2000_08/.