Alignment Studies for the LMU Cosmic Ray Test Facility

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The LMU cosmic ray test facility allows precise calibration of ATLAS muon chambers by placing them between two reference chambers with well known wire positions. The setup and the operation of the ATLAS cosmic ray test facility are described in [1]. The relative alignment of the two MDT reference chambers to each other are monitored by an optical system of 8 so-called RasNik sensors [2]. Each consist of an illuminated mask which is projected by a lens onto a CCD camera. The horizontal movements of the chamber can be measured by the displacement of the image of the mask on the CCD using vertical light beams. In order to measure a vertical displacement of the chamber (e.g. to monitor whether the chambers move farther apart or closer together) the results of the vertical beams are combined with diagonal ones.

The movement of the test MDT chamber relative to the reference chambers is monitored by a capacitive system [3] of so-called Capacitec sensors. Eight sensors are arranged into two singlets and two triplets situated above steel steps. The vertical movements are monitored by the singlets and the central sensors of the triplet by the change of the capacity between the sensor and the steel plate. The outer sensors of the triplets are placed over the edges of the steel steps, and horizontal movements will therefore change the capacity measured by these sensors.

In the first setup of the test facility large day to day variations of both the RasNik and the Capacitec sensor readings were observed. In order to prove that these variations were indeed due to chamber movements the readings have been correlated with an internal alignment of the chambers which is based on reconstructed muon tracks in the three chambers.

Tracks are reconstructed in all 3 chambers separately. A comparison of the track coordinate (perpendicular to the wire) extrapolated to the middle of the test chamber can be used to align the chambers relative to each other. If two chambers are displaced horizontally to each other in the direction perpendicular to the wire, the track coordinates measured by the two chambers will on average differ by this displacement. This difference is independent of the incident angle of the track. If on the other hand the distance between the two chambers is changed from its nominal value the extrapolation to the middle of the test chamber will be shifted. This shift depends on the incident angle and vanishes for vertical tracks. The comparison of the track position and its dependence on the incidence angle of the track can therefore be used to align the chamber both vertically and horizontally.

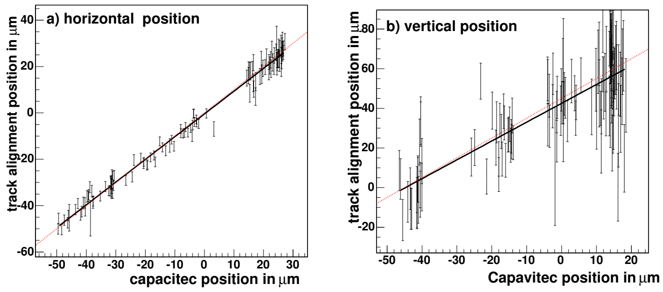

Fig. 1: Comparison of the Capacitec measurement with the track alignment for a) horizontal chamber and b) vertical chamber movements

Figure 1 shows the comparison of the position of the test chamber measured by the Capacitec system and measured by the track alignment. The uncertainties are due to the limited statistics of the track alignment. Each data point represents one hour of data taking. In order to improve the sensitivity the chamber was, in addition to the daily movements, moved mechanically into four different positions. These movements cause the clustering of measurement points. The measurements clearly confirm that the chamber movements can be monitored by the alignment systems.

For the current setup of the test facility the daily chamber movements have been nearly eliminated by mechanically decoupling the support structures from the walls of the hall. In order to test the current setup the test facility was operated for a weekend without temperature stabilization. The main effect was a vertical movement of the chamber which is, as shown in figure 2, clearly correlated with the temperature near the support structures and which can be explained by its thermal expansion.

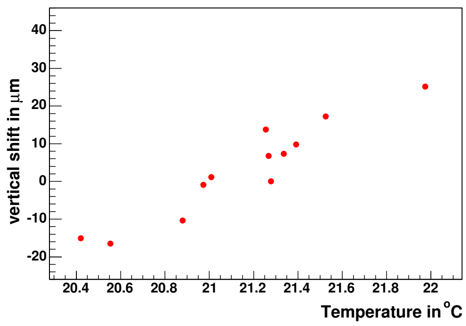

Fig. 2: Correlation between the vertical chamber movement and the temperature

References

[1] J. Dubbert *et al.*, this report, p. 88
[2] J. Elmsheuser *et al.*, Annual report 2001, p. 90
[3] A. Kraus *et al.*, Annual report 2000, p. 66