Calibration of the Wire Positions of the Atlas Muon Spectrometer

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The ATLAS Muon Spectrometer [1] will consist of about 1200 Monitored Drift Tubes(MDT) chambers. In order that the required momentum resolution at high momenta can be achieved in the ATLAS detector, the sense wires of the aluminum drift tubes which form the MDT chambers should be positioned to better than 10 μm inside a drift tube and better than 20 μm inside a chamber. A precise method for determining the wire positions of the chamber relative to each other using no external reference syste has been developed. This method was first tested using the data taken at a muon testbeam at CERN from a full scale prototype MDT chamber that was built in 1998 at the Max Planck Institute in Munich in collaboration with the LMU and Freiburg University. The results obtained for 50 tubes of the chamber and the corresponding results of the X-Ray Tomograph(a high precision device that by scanning the chamber determines the wire positions) were in agreement within 10 μm [2].

Simulation studies of the method along the whole length of the chamber (422 tubes in total) were performed. While the wires of a simulated chamber had displacements of 20 μm rms, muon tracks perpendicular to the chamber using a GEANT [3] based simulation program were produced. The two coordinates perpendicular to the wire are called y and z. The coordinate that is perpendicular to the tracks direction is called the y coordinate and the one parallel to the tracks is the z coordinate. In order to reconstruct the tracks of the muons passing through the chamber, straight lines have to be fitted to the impact circles defined by the drift times of those ionization electrons which arrive earliest at the drift tubes' anode wires. Then the difference between the fitted track and the radius of the impact circle of the tube is defined as 'residual'. Wh n the wire of a tube is displaced, the distribution of the residuals versus the drift distance for tracks which traverse the tube right from its wire is different from the distribution for tracks which traverse the tube left from its wire. For the determination of the relative wire positions, the positions of two tubes(one on each multilayer) are kept fixed, while the y coordinates of the twelve surrounding tubes are moved till the distributions of their residuals left and right from their wires become s mmetric. This procedure was followed for a total number of 70 overlapping groups of tubes, each group consisting of 14 tubes. The local displacements, that is the relative displacements of the wires within a group of tubes called 'a flower', were measured and subsequently they were compared with the generated ones (fig.1). This comparison revealed a local accuracy of the method in the order of 4 μm (fig.2).

This precision is by a factor two better than the one we obtained using the testbeam data. The reason is that the t0, which is a characteristic parameter of each tube and describes the relative shift between the drift time spectra of the tubes, was kept equal to zero in the simulation. In reality this is not the case. This parameter can be determined with an accuracy of 200-300ps for individual tubes. Therefore, we introduced to the drift time spectra of the tubes, gaussian distributed t0 offsets of an rms of 200 and 300ps. As a consequence the local uncertainty increased to 8 and 9 μm res ectively.

The next step was to combine the information of the 70 flowers acquiring the wire positions not within a flower but within the whole chamber. After correction for one global shift and scale the global accuracy is about 22 μm. If the shift and scale are determined separately for each tube using only 33 neighbouring tubes, the global accuracy improves to 10 μm. This local determination of the shift and scale parameter is justified if one wants to test wether individual tubes are at their nominal p sition with respect to the surrounding tubes.

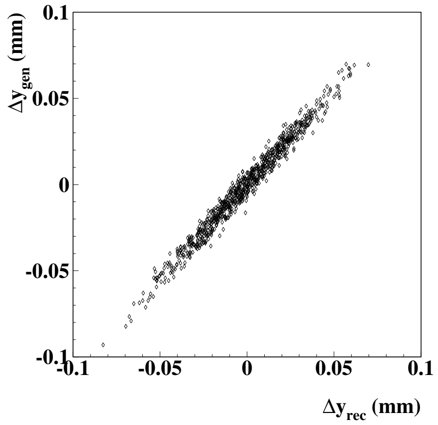

Fig. 1: The generated displacements of the y coordinates of the wire positions from their nominal positions for 422 tubes of a chamber(Δy_{gen}) versus the corresponding displacements(Δy_{rec}) found with the method discussed.

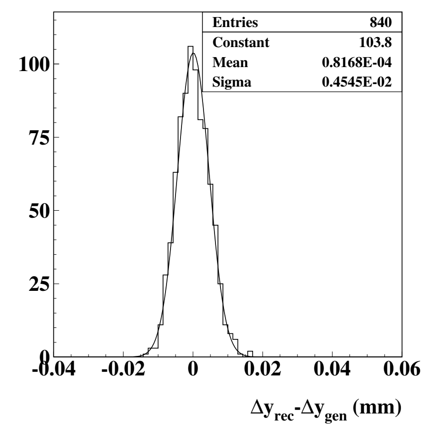

Fig. 2: Distribution of the difference Δy_{gen}-Δy_{rec} with an RMS of 5 μm for t0=0 ps.

References

[1] ATLAS Muon Spectrometer, Technical Design Report, CERN/LHCC/97-22, 1997.
[2] Jahresbericht 1999
[3] GEANT, CERN Program Library Long Writeup W5013, 1993.