Alignment of the ATLAS Muon Spectrometer with Muon Tracks

B. Bittner[1], S. Kaiser[1], O. Kortner[1], H. Kroha[1], S. Kotov[1], I. Potrap[1]
R.Harrington[2], J. Love[2], N. Nation[2]

[1] Max-Planck-Institut für Physik, Munich, Germany
[2] Boston University, Boston, USA

The muon spectrometer [1] of the ATLAS experiment is equipped with three layers of muon detectors in a toroidal magnetic field of $3 - 6\,\mathrm{Tm}$ bending power generated by a superconducting air-core magnet system. The spectrometer is designed to provide muon momentum resolution of better than 10% for transverse momenta up to 1 TeV over a pseudo-rapidity range of $|\eta| \leq 2.7$. This requires very accurate track sagitta measurement with three layers of drift-tube chambers which have to be aligned relative to each other with an accuracy of about 30 μm in the bending direction. The relative positions of the chambers are continuously measured with optical alignment monitoring systems [1][2].

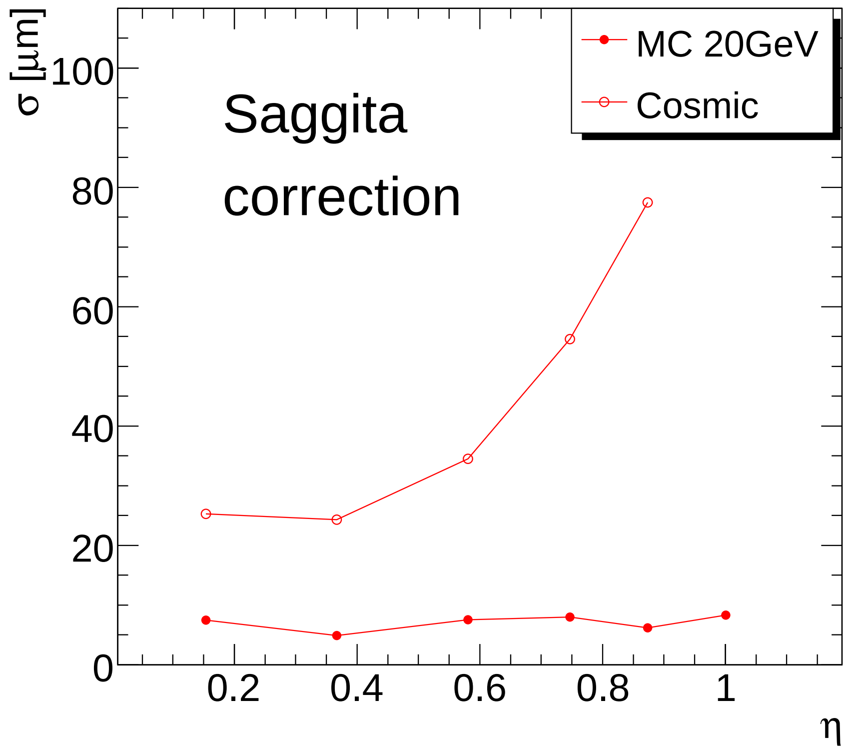

Figure 1: Accuracy σ in the determination of the muon track sagitta corrections due to chamber misalignment as a function of pseudo-rapidity $\eta = -\ln\tan(\theta/2)$ (with the polar angle θ of the track defined with respect to the beam axis) in the barrel part of the muon spectrometer using in each azimuthal sector 100000 simulated straight muon tracks of 20 GeV momentum originating at the interaction point (full circles) and 400000 straight cosmic muon tracks from the detector commissioning data (open circles).

In the barrel part of the spectrometer, only the large chamber sectors mounted in between the magnet coils can be fully aligned with optical sensor measurements. The small chamber sectors mounted on the coils have to be aligned with respect to the large sectors using muon tracks passing through the overlap regions between the small and the large sectors. The alignment corrections will be calculated in intervals of a few hours at dedicated computing centers for the calibration and alignment of the muon chambers [2].

Straight muon tracks from proton-proton collisions, measured while the toroid magnets are turned off, are needed for the precise determination the initial chamber positions after installation as a starting point for the monitoring of further chamber movements by optical sensors mounted on the chambers. An efficient algorithm has been developed for this purpose [3] and successfully tested with cosmic ray data taken with the installed ATLAS detector (see Fig. 1). The chamber displacements from nominal positions determined this way agree well with mechanical and optical measurements. Tests with simulated data show that the relative chamber positions in each barrel sector can be determined with the required accuracy on the track sagitta corrections [3] (see Fig. 1).

The method has being extended to the alignment of the muon chambers with curved muon tracks in the magnetic field during normal operation of the experiment in order to verify the optical alignment corrections. This requires an independent measurement of the muon momentum which is insensitive to misalignment of the MDT chambers along the muon track. The MDT chambers with their two triple or quadruple layers of precisely positioned drift tubes measure not only track coordinates with high accuracy but also the local track direction. This feature can be utilized for independent momentum determination from measurement of the track deflection angles between the inner and the outer chamber layer and between the two multilayers of the chambers in the middle layer located inside the magnetic field. Studies with simulated data show that the required alignment accuracy can be achieved within two days of data taking at the nominal LHC luminosity of $10^{33}\,\mathrm{cm}^{-2}\mathrm{s}^{-1}$.

References

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