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Updates on long-term alignment monitoring and diagnostics for ATLAS ID misalignments

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Summary. — This work deals with the alignment of ID tracker modules of the ATLAS experiment at the LHC.

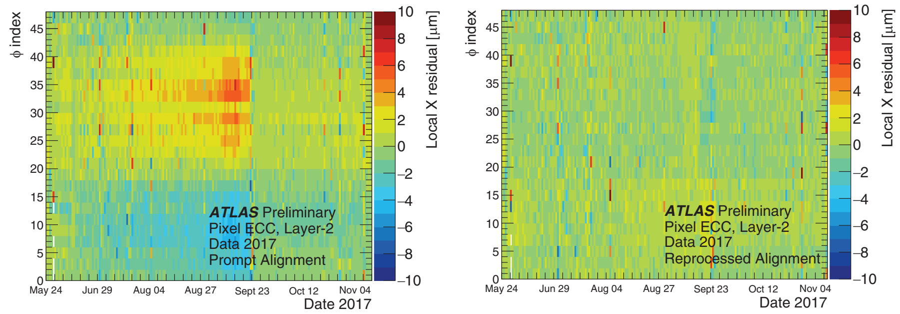
The ATLAS Inner Detector (ID) [1] has been designed to perform efficiently pattern recognition and to provide excellent momentum resolution and good vertex measurements for charged particle tracks. Misalignments are the differences between the real ID geometry and the nominal one. Detecting and correcting for these differences is crucial to correctly reconstruct the event kinematics. Details on alignment-related systematic effects for the ATLAS ID can be found in [2].

1. – ID alignment calibration loop and the residual time evolution monitoring

Misalignments affect the sensitivity to all track observables, making it possible to use them for an off-line correction. To this purpose, χ^2 is used, an explicit function of track observables being minimum for the ID geometry description closest to reality. To reduce the complexity of the problem the alignment is performed in levels, gradually increasing the degrees of freedom under consideration (alignment calibration loop). Alignment is known to change even during a single run, making it essential to accurately monitor its stability, *i.e.*, estimating residuals in local coordinates in different time intervals. The time evolution of residuals calculated by the alignment loop can be displayed *vs.* run number, showing misalignment patterns as a function of time. As an example, diagnostics reported in fig. 1(a) shows unusual misalignment in ϕ sectors 23–43 of pixel End Cap C during the first part of 2017. Once detected, the effect can be taken as baseline for the alignment loop and then corrected for in a later data reprocessing campaign (fig. 1(b)).

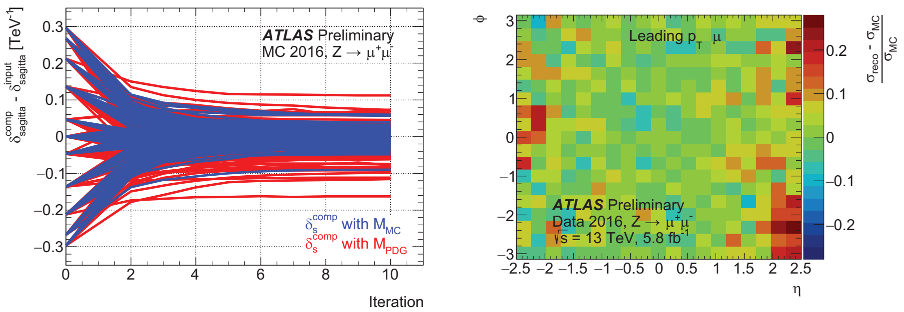
2. – Weak modes and sagitta bias calculation

Weak modes are misalignments due to geometry distortions that do not increase χ^2, because they preserve the helical shape of the track. Nonetheless, particle momentum and



(a) (b)

Fig. 1. – Pixel End Cap C alignment residuals before (a) and after (b) 2017 reprocessing.



(a) (b)

Fig. 2. – (a) δ_s estimate convergence rates comparison. (b) Further sagitta bias as a function of η and ϕ of the p_T leading muon.

impact parameters are systematically biased. Particles like Z, J/ψ and K_s are very good probes to detect and correct for weak modes, as they affect the mass distribution around the resonance. The *curl* is the weak mode resulting from layers curling increasingly with the distance from the beam line, producing a $\Delta\phi$ between modules and biasing the measurements of track sagitta s and momentum p. The Z mass bias is analytically defined as a function of the muon transverse momenta and the sagitta bias δ_s. Such relation can be inverted and used to compute δ_s iteratively for each direction (η, ϕ). After correction, further undetected sagitta biases can be revealed by still comparing expected and reconstructed mass distributions. To do that, two markers were introduced, namely $\frac{m_{reco}-m_{MC}}{m_{MC}}$ and $\frac{\sigma_{reco}-\sigma_{MC}}{\sigma_{MC}}$. The use of m_{MC} in place of m_0 is an original device of this work, accounting for reconstruction effects that are correctly predicted by Monte Carlo and sensibly improving the convergence of the algorithm (fig. 2(a)). Although cancellation effects due to opposite distortions of positive and negative muons may not shift the mass distribution, sagitta biases always make it wider, making the second marker a very efficient diagnostic tool for residual sagitta biases (fig. 2(b)).

REFERENCES

[1] ATLAS Collaboration, *JINST*, **3** (2008) S08003.
[2] ATLAS Collaboration, ATLAS-CONF-2012-141 (2012).