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Alignment of the ATLAS Inner Detector

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Atlas is a multipurpose experiment that records the LHC collisions. In order to reconstruct the trajectories of charged particles, ATLAS is equipped with a tracking system built using disticnt technologies: silicon planar sensors (both pixel and microstrips) and drift-tubes (the Inner Detector). The tracking system is embedded in a 2 T solenoidal field. In order to reach the track parameter accuracy requested by the physics goals of the experiment, the ATLAS tracking system requires to determine accurately its almost 700,000 degrees of freedom. The demanded precision for the alignment of the silicon sensors is below 10 micrometers.
The implementation of the track based alignment within the ATLAS software framework unifies different alignment approaches and allows the alignment of all tracking subsystems together. The alignment software counts of course on the tracking information (track-hit residuals) but also includes the capability to set constraints on the beam spot and primary vertex for the global positioning, plus constraints on the track parameters as the momentum measured by the Muon System or the E/p using the calorimetry information. The assembly survey data can be used as constraint to the alignment corrections.
The alignment chain starts at the trigger level where a stream of high pT and isolated tracks is selected online. Also a cosmic ray trigger is enabled while ATLAS is recording collision data, but only during those short intervals where there are no LHC beams inside ATLAS. Thus a stream of cosmic-ray tracks is recorded exactly with the same detector operating conditions as the normal collision tracks.
As the alignment algorithms are based on the minimization of the track-hit residuals, one needs to solve a linear system with large number of degrees of freedom. The solving involves the inversion or diagonalization of a large matrix that may be dense. The alignment jobs can be executed either at the CERN Analysis Facility or using the GRID infrastructure. The event processing is run in parallel in many jobs (for both collision data and cosmic ray tracks). Then all output matrices and vectors are added together before the linear algebra solving. The alignment procedure can also be run either offline (to reprocess old data) or quasi-online at the Tier0 in the calibration loop. With the latter alignment constants are computed before the bulk reconstruction of the ATLAS data.
We will present results of the alignment of the ATLAS tracker using the 2011 collision data. The validation of the alignment is performed first using its own observables (track-hit residuals) as well as using many other physics observables, notably the resonance invariant masses in a wide energy range (K0s, J/ψ and Z decays in to μ+μ-) and the effect of the detector systematic distortions on the reconstructed invariant mass and on the μ momentum. Also the electrons E/p has been studied mainly in the W⟶ eν channel. The results of the alignment with real data reveals that the attained precision for the alignment parameters is approximately 5 micrometers.

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