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Alignment of the ATLAS Inner Detector tracking system

ATLAS is a multipurpose experiment that records the products of the LHC collisions. To reconstruct trajectories of charged particles produced in these collisions, ATLAS is equipped with a tracking system built of silicon planar sensors and drift-tube based detectors. They constitute the ATLAS Inner Detector.
In order to achieve its scientific goals, the alignment of the ATLAS tracking system requires the determination of its almost 36000 degrees of freedom (DoF) with high accuracy. Thus the demanded precision for the alignment of the silicon sensors is below 10 micrometers. This implies to use a large sample of high momentum and isolated charge particle tracks. The high level trigger selects those tracks online. Then the raw data with the hits information of the triggered tracks is stored in a calibration stream. Tracks from cosmic trigger during empty LHC bunches are also used as input for the alignment.
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. Primary vertexing and beam spot constraints have also been implemented, as well as constraints on survey measurements. As alignment algorithms are based on minimization of the track-hit residuals, one needs to solve a linear system with large number of DoF. The solving involves the inversion or diagonalization of a large matrix that may be dense. The alignment jobs are executed at the CERN Analysis Facility. The event processing is run in parallel in many jobs. The output matrices from all jobs are added before solving.
We will present the results of the alignment of the ATLAS detector using real data recorded during the LHC start up run in 2009 plus the recent 7 TeV data collected during 2010 run. Validation of the alignment was performed by measuring the alignment observables as well as many other physics observables, notably resonance invariant masses. The results of the alignment with real data reveal that the precision of the alignment constants is just below 10 microns.

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