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Track based alignment of composite detector structures

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Modern tracking detectors are composed of a large number of modules assembled in a hierarchy of support structures. The sensor modules are assembled in ladders or petals. Ladders and petals in turn are assembled in cylindrical or disk-like layers and layers are assembled to make a complete tracking device. Sophisticated geometrical calibration is essential in these kind of detector systems in order to fully exploit the high resolution of sensors. The position and orientation of individual sensors in the detector have to be calibrated with an accuracy better than the intrinsic resolution, which in the CMS Silicon Tracker is ranging from about 10 um to 50 um. Especially if no hardware alignment system is available (which is the case for the CMS Pixel), the fine tuning of the sensors needs to be carried out with particle tracks.

There are about 20000 independent sensors in the CMS tracker and of the order 10ˆ5 calibration constants are needed for the alignment. The alignment algorithm needs to be computationally practical, especially if considered to provide almost on-line feedback. We present an effective algorithm to perform fine calibration of individual sensor positions as well as alignment of composite structures consisting of a number of pixel or strip sensors. The alignment correction of a composite structure moves the individual sensors like a rigid body under a rotation and translation of the structure. Up to six geometric parameters, three for location and three for orientation, can be computed for each sensor on a basis of particle trajectories traversing the detector system. The performance of the methods is demonstrated with both simulated tracks and tracks reconstructed from experimental data taken with a cosmic rack.

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