The CMS Silicon Tracker alignment

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Abstract

At the Compact Muon Solenoid (CMS) experiment the alignment of the Strip and Pixel Tracker, with their large number of independent silicon sensors and their excellent spatial resolution, is one of the most complex and challenging tasks.

High precision mounting combined with survey measurements and the Laser Alignment System (LAS) are the initial inputs used in the alignment procedure, but only with the track based alignment it is possible to reach the envisaged precision.

The Tracker survey measurements can be used both as a starting point for first reconstruction as well as in the track based alignment procedure where computed alignment parameters are not allowed to move far away from their surveyed position, improving convergence and allowing to align modules which are crossed only by a low number of tracks.

The LAS provides a number of independent infrared laser beams that penetrate through modules in both Tracker endcaps. Additional laser beams are deflected on the innermost layer of the outer barrel structure and the outermost layer of the inner barrel, generating signals on the silicon detectors. By using straight-line constraints for the laser rays, the relative position of endcaps and barrel detectors as well as the internal disk positions of the endcaps can be determined with better than 80 $\mu$m precision. The system allows to monitor relative movements over time with 10 $\mu$m precision.

Ultimate precision can be reached only by alignment with tracks which cross the silicon detectors. The most useful are tracks from cosmic muons, beam-halo muons and charged pions occurring in minimum bias events at start-up, but with the increase of LHC luminosity, also isolated muon tracks and tracks from $Z$ and $W$ boson decays are selected as input to the alignment procedure. Many simulation studies were carried out during last years in order to define an initial strategy to align the CMS Tracker with those different kinds of track.

Furthermore, during the CMS Tracker commissioning in 2007, three different algorithms for track based alignment were successfully tested on a sample of 5 million cosmics tracks collected at the Tracker Integration Facility, where 15% of the Tracker was tested. New data taken from cosmic muon tracks with the full Tracker during summer will provide, together with data from first $p-p$ collisions, the basis for the full scale Tracker alignment.