Tipp 2014 - Third International Conference on Technology and Instrumentation in Particle Physics

Contribution ID: **188** Type: **Poster**

Tracker alignment validation in CMS using electrons

The tracker of CMS experiment is composed at one hundred percent of silicon detectors. They are arranged in successive layers of concentric cylinders around the beam axis, in the central part of CMS detector, and in disks perpendicular to the beam axis, in the forward and backward part of the detector. The whole has the shape of a cylinder of 110 cm radius and 540 cm length. The silicon detectors are of two different types, pixel and micro-strip. The pixels, having a higher granularity, are placed closest to the collision point, while the micro-strip complete the outer parts of the tracker. The aim of the tracker is to reconstruct the trajectories of charged particles. Taking advantage of the 3.8 Tesla magnetic field delivered by CMS solenoid magnet, the tracker provides a measurement of the transverse momentum of these particle, which is directly related to the radius of curvature of their trajectory.

We know that the real positions of all the silicon sensors composing the tracker are not exactly the same as the designed ones. Some imperfections appear during the construction, and some other displacement of these sensors can also be progressively induced, with the effect of the magnetic field, the temperature, the weight of the detector… The disposition of all the sensors evolves with time. The goal of alignment in CMS is then to determine what are the real positions of all these sensors, to take them into account in tracks reconstruction, and improve the resolution of all tracker measurements. The precision of alignment constitutes therefore a very central issue of the CMS experiment.

The best precision for alignment is obtained using minimization algorithms (Millipede, HIP). These algorithms use the information from millions of different tracks to detect and quantify the possible misalignments. Though an alignment accuracy of a few micrometers can be reach with the help of these algorithms, there exists nevertheless some particular deformations, called "weak modes", that can not be fully retrieved with these algorithms.

In this poster, I will present a tool that I have been developing to detect momentum changing weak modes. These are misalignments consisting in global rotations of tracker modules with respect to the beam axis of CMS, by a certain $\Delta\varphi$ angle. This angle can depend either on the transverse or longitudinal position of the modules. Such deformations would impact the curvature of reconstructed tracks. And as the transverse momentum of tracks in CMS is estimated from their radius of curvature, a systematic bias would be introduced in the measurement of this quantity. For electrons, the transverse energy measured in the electromagnetic calorimeter can be used as a reference and be compared to measurement given by tracker, in order to estimate this bias. This is not made track by track, as the calorimeter energy resolution is greater than the typical expected bias. We instead use the shift eventually observed in the mean value of the E/p distributions for different energy bins. Finally, our tool uses this information to calculate an estimation of the deformation amplitude in term of the rotational angle $\Delta\varphi$.

A selection has been defined and optimized to select good electron tracks out of events where a Z boson decays into an electron and a positron. The selection and the method have been tested using Monte-Carlo sample reconstructed with a tracker geometry on which we have introduced momentum changing misalignments of various amplitudes. The tool has also been tested on 2012 data. A sensibility of about 1 µrad/cm can be reached by using 10 000 tracks. No momentum changing weak modes have been detected for 2012 data.

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Track Classification: Experiments: 2a) Experiments & Upgrades