Lorentz Angle slide notes

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First/Second Slide

Good afternoon/evening everybody. Today I am going to talk about *Calculation of Lorentz Angle for Tracker Strip Silicon Sensors as a part of calibration for CMS Tracker Detector*. Here is the outline of my talk. FIrst I will discuss the importance of LA calculation for SiStrip detector and the very definition of it. After that I will give a brief overview of detectors for which I am calculating LA as a part of calibration. Then I will describe the method we have been used for the calculation of LA for those corresponding detectors. As the discussion will goes on we will see to get correct trackangle we need to multiply some corrcetion factors to the trackangle to have proper tacks for charged particles, I have devoted one slide for that. Then we will have results. After that I will discuss the problems we have been faced in this work and how we are trying to solve it. I have also included one slide for the cross-check for this calculation that we are going in the proper direction. These things will come accordingly, let me start. Please move to next slide.

3rd Slide

As we know that our CMS detector there are harsh radiation environment submarged in high magnetic field $\sim$4T. That causes change in several important physical parameters in SiStrips(sensors) among which LA is one of them. The reason behind the shift in LA is following, when a charged particle is moving **E-B** field environment it tunrs out there exists a Lorentz force $\mathbf{F}$=q($\mathbf{E}+\mathbf{v}\times\mathbf{B}$) which leads the track to follow helical path or simply to say the charged particle track is bending due to this force. Also when the charged track bends then it distributes in several strips, to get a proper track we have to measure shift of the track by chossing the centre of gravity of the of charge distribution which I will discuss in the next slide. A definition for Lorentz angle related sensor parameter mobility is given by

$$\tan\Theta_L = \mu_H|\vec{B}|$$

where μ_H(=$r_H\mu$, r_H=0.7(h),1.15(e))is the drift mobility. The r_H is the Hall coefficient.

4th Slide

Among several methods of LA calculation we are using width method. Consider a local strip module where z is the perpendicular to the plane of the module, **E** is along positive z direction, **B** is perpendicular to the paper. The posive x direction is the actual distance from the origin shown in the figure 1. Here I would like to mension one thing which is very important for two sided module and that is to separate statistics depending upon the orientation of electric field by using the projection of z axis in the negative and positive direction. Now consider one track is coming in downward direction and hits the module at x,y,z(0,0,0). The size of the cluster is given by this formula and δx is the endpoint displace due to Lorentz force. Now how this path of the track bends inside the silicon detector? The 2nd cartoon describes this phenomenon. A laser is falling on a p/n sided detector and interacts with material which causes a polarization between charge and holes and both of them collected as electrical signals from n and p side respectively. The influence of magnetic field on polarization on charge shifts its position from the original one, we choose the centroid of these clusters as incident and emergent points of the corresponding track.

5th Slide

Lorentz angle can be obtained from the cluster width versus θ_t, the track incidence angle in the plane orthogonal to the strips. In the absence of a magnetic field the hole drift follows the electric field lines, which are normal to the strips. Hence tracks orthogonal to the detector achieve a minimum cluster width. If the track inci- dence angle increases, the cluster size increases accordingly. On the contrary, in the presence of a magnetic field, the drift direction is no longer along the electric field lines, as shown in fig. Therefore the minimal cluster size is found for particles traversing the detectors with the same inclination as the drift lines. Since the angle between electric field and drift direction is by definition the Lorentz angle, the measurement of the track incident angle for which minimum cluster size is achieved provides a direct measurement of the Lorentz angle itself.

6th Slide

The barrel tracker region is divided into 2 parts: a TIB (Tracker Inner Barrel) and a TOB (Tracker Outer Barrel). The TIB is made of 4 layers and covers up to $|z| < 65$ cm, using silicon sensors with a thickness of 320 μm and a strip pitch which varies from 80 to 120 μm. The first 2 layers are made with “stereo” modules in order to provide a measurement in both $r - \phi$ and r-z coordinates. A stereo angle of 100 mrad has been chosen. This leads to a single-point resolution of between 23–34 μm in the $r - \phi$ direction and 23 μm in z. The TOB comprises 6 layers with a half-length of $|z| <$110 cm. As the radiation levels are smaller in this region, thicker silicon sensors (500 μm) can be used to maintain a good S/N ratio for longer strip length and wider pitch. The strip pitch varies from 120 to 180 μm. Also for the TOB the first 2 layers provide a “stereo” measurement in both $r - \phi$ and $r - z$ coordinates. The stereo angle is again 100 mrad and the single-point resolution varies from 35–52 μm in the $r - \phi$ direction and 52 μm in z. The endcaps are divided into the TEC (Tracker End Cap) and TID (Tracker Inner Disks). Each TEC comprises 9 disks that extend into the region 120 cm$< |z| <$ 280 cm, and each TID comprises 3 small disks that fill the gap between the TIB and the TEC. The TEC and TID modules are arranged in rings, centred on the beam line, and have strips that point towards the beam line, therefore having a variable pitch. The first 2 rings of the TID and the innermost 2 rings and the fifth ring of the TEC have ”stereo” modules. The thickness of the sensors is 320 μm for the TID and the 3 innermost rings of the TEC and 500 μm for the rest of the TEC. The entire silicon strip detector consists of almost 15400 modules, which will be mounted on carbon-fibre structures and housed inside a temperature controlled outer support tube. The operating temperature will be around -20^{o}C.

7th Slide

Due to the fact that the Lorentz angle measurement is performed on the aggregate data coming from all the modules assembled on each layer, a correction which takes into account the different orientation of the modules is necessary. In fact some modules had the y axis of the local reference frame parallel to the magnetic field while the others anti- parallel. This engenders two different signs of Θ_L . Following the adopted reference frame, if $\hat{y}.\mathbf{B} > 0$ the sign of Θ_L is negative, positive otherwise. Moreover only the component of the cluster centroid displacement orthogonal to the module strips is measurable by the detector. Therefore the measurable displacement of the cluster centroid in the stereo detectors is less than the one observed in the mono detectors for the same angle of incidence, because of their 100 mrad inclination with respect to the mono detectors.

8th Slide

With reference to the figure:

$$\Delta x_m = \frac{\Delta x_s}{cos\alpha}$$

where α is the angle between the y axis and the magnetic field (assumed parallel to the strips of the mono detector) 8and $cos\alpha$ is given by

$$cos\alpha = \frac{\hat{y}.\mathbf{B}}{||B||}$$

Therefore, to correct the effect due to the inclination of the stereo module strips, the measured values of $tan\theta_t$ are multiplied by $\frac{1}{cos\alpha}$. This correction is also applied to mono detectors, for which $cos\alpha = \pm 1$. The expected sign of Θ_L thus is always negative.

Slide 9/10/11th

Here is the results of TIB and TOB, Some of then came up with expected values some of not.

Slide 12

P side of TOB in the negative z direction of tracker angle. Exactly matches with expected value.

Slide 13

Cross-Check that our results correct, we can have results from variance-trackangle method which can show the same result.

last Slide

We have performed this analysis taken may be in 2011 and we dont know the source of this data, previous than some has performed this analysis not in complete format. We have querried to DPG people and they also dont know but structure of this data file looks like first run calib tree, along with that it does not contain any information regarding to TEC, TID. Moduleid and electric field correpondence in not known properly for this data.

So we have moved to new data file, though the variables need to calculate LA does not come with general calibration tree we produced private ntuple. We already have started analysis for new data file. For the new data we are trying to extract LA for all layers and Disks with the application geometry helper classes.