Measurement of Lorentz angle for Silicon Strip Detector

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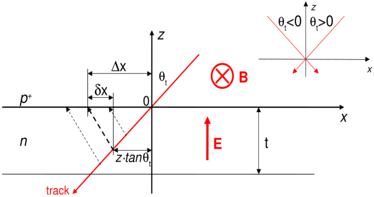
- Motivation and Definition
- Tracker Detector
- Method for Lorentz Angle(LA) Calculation
- Correction Factors
- Results
- Drawbacks and Remedy
- Future Plan

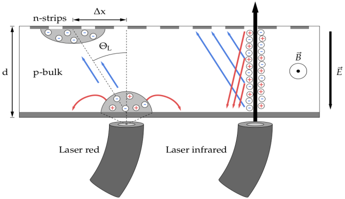
- The harsh radiation environment to be met at LHC changes some important parameter of the silicon sensors among which LA is one of them[1].
- A magnetic field not parallel to electric field will cause a Lorentz force [$\mathbf{F}$=q($\mathbf{E}+\mathbf{v}\times\mathbf{B}$)] effect distributes the charge carriers to several stips.
- The charge sharing can be used to calculate the centre of gravity of the charge distribution which improves the traversing particles track information.
- if $\mathbf{B}\perp\mathbf{E}$ the carriers drift at an angle Θ_L(LA) wrt the direction of $\mathbf{E}$, then,

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

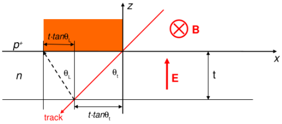
where μ_H(=$r_H\mu$, r_H=0.7(h),1.15(e))is the drift mobility.

- The x coordinate of the hole path endpoints at the junction side of the detector, expressed not in terms of strips but as the actual distance (micron) from the origin of the reference frame, is then calculated.
- The angle θ_t with respect to the z axis , the x coordinate of the path endpoint at the junction side for a hole formed at depth z (≤ 0) is given by, $\Delta x(z, \theta_t) = z \tan\theta_t + \delta x(z)$ where $z \tan\theta_t$ is the horizontal projection of the track and $\delta x(z)$ is the endpoint displacement due to the Lorentz force.

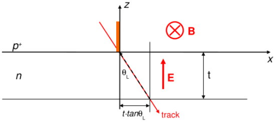




- Measurment-cluster width versus θ_t.
- **B** absent- hole drift follows the electric field lines$\perp$strips, tracks orthogonal to the detector achieve a minimum cluster width.
- **B** present-minimal cluster size is found for particles traversing the detectors with the same inclination as the drift lines.
- 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.



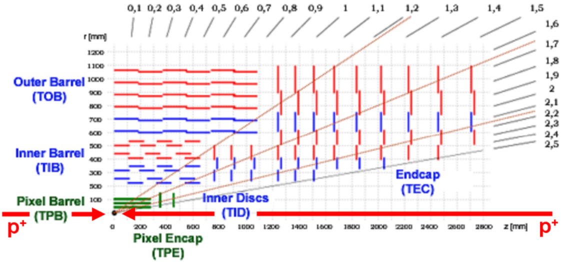
(a)



(b)

- **TIB:** 4L, $|z|$ <65cm, t=320μm, sp-(80-120)μm, F2L-stereo(r-ϕ,r-z), N2L-Mono, SPR-(23-34) μm.
- **TOB:** 6L, $|z|$ <110cm, t=500μm, sp-(120-180)μm, F2L-stereo(r-ϕ, r-z),N4L-Mono, SPR-(35-52) μm.
- **TEC:** 9D, modules arranged in Rings, 120cm< $|z|$ <280cm, 2IM+5th R-stereo(r-ϕ, r-z), t=3IMR 320μm;rest 500μm.
- **TID:** 3D, F2R-stereo, t=320μm, fill the gap between TIB and TEC.

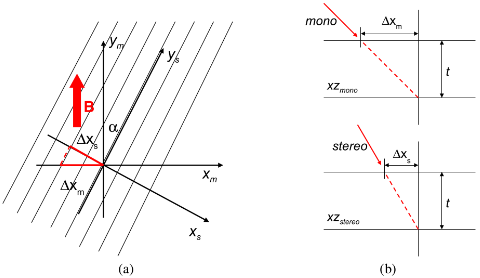
Total 15400 Detectors(TIB:TOB:TID:TEC⇔2724:5208:816:6400)

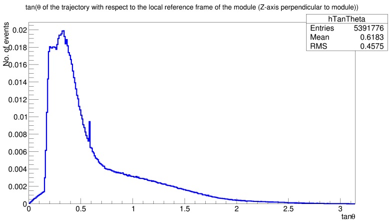


CMS technical design report, 2006, vol1

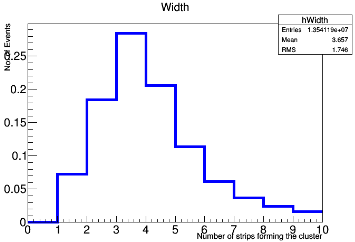
- The measurement has been performed on the aggregate data coming from all modules assembled on each layer.
- Different layer orientations of modules are different. In local reference frame some modules have y axis parallel to the $\mathbf{B}$ while other antiparallel. this causes different signs in LA. For $\hat{y}.\mathbf{B} > 0$ LA is ve^{+} and ve^{-} otherwise.
- Only the cluster centroid displacement orthogonal to the module strip is measurable by the detector.
- Stereo detectors are tilted wrt. to mono detector by 100mrad which cuases smaller cluster centroid displacement in stereo's than mono's for same incident angle.
- For TIB: $0.9 < |\eta| < 1.4$, TOB: $1.4 < |\eta| < 2.5$

$\Delta x_m = \frac{\Delta x_s}{\cos\alpha}$; $\angle\alpha := [\mathrm{y},\mathbf{B}]$ where, $\cos\alpha = \frac{\hat{y}.\mathbf{B}}{|\mathbf{B}|}$ and $\frac{1}{\cos\alpha}$ has to be multiplied to trackangle $\tan\theta_t$ for stereo's and for mono's $\cos\alpha = \pm 1$.
(**a**)JSV:α is the angle between the stereo strips and the magnetic field (supposed parallel to the mono strips);
(**b**) xz-mono and xz-stereo plane view: dashed lines represent the projection of the drift direction in the xz module plane, while the arrows represent the projection of the tracks which minimizes the cluster size.

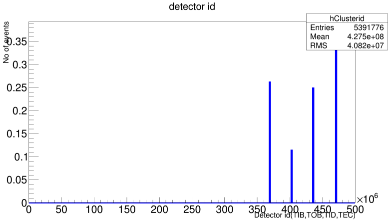




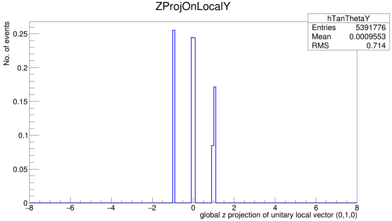
(a) tan(θ in LRF)



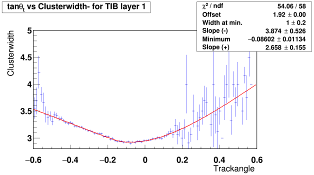
(b) Number of strips forming the custer

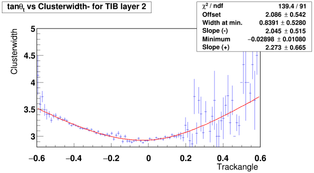


(a) Detector id(TIB, TOB,TID,TEC)

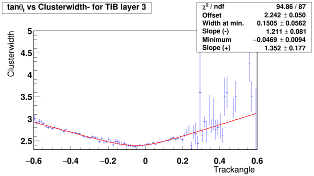


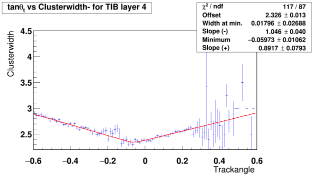
(b) Porj. of GL Z on Lcl Y





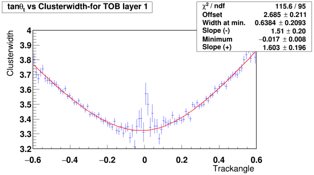
L1 -0.08602$\pm$0.01134 LA: $\sim$ -4.91^0 , L2 -0.02898$\pm$0.01080 LA: $\sim$ -1.66^0, expected LA for L1 $\sim$ -5.8^0

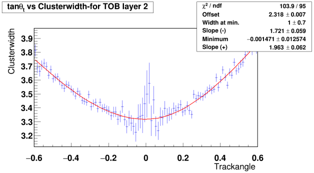




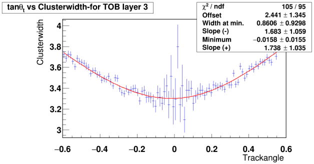
L3 -0.0469$\pm$0.0094 **LA:** $\sim$ -2.68^0, L4 -0.05973$\pm$0.01062 **LA:** $\sim$ -3.4182^0

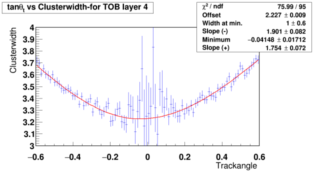
TOB





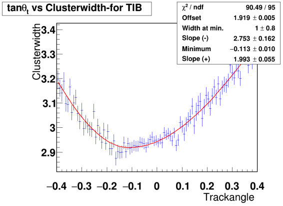
L1 -0.017$\pm$0.01134 LA: $\sim$ -0.97^0, L2 -0.001417$\pm$0.012574 LA: $\sim$ -0.084^0, expected LA for L1 $\sim$ -6.4^0



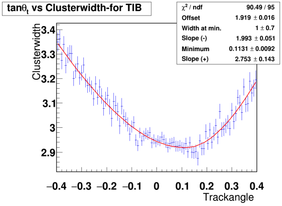


L3 -0.0158$\pm$0.0155 **LA:** $\sim$ -0.905^0, L4 -0.04148$\pm$0.01062 **LA:** $\sim$ -2.37^0

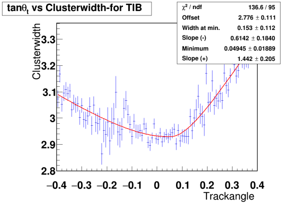
Separation of statistics based upon E, η, Z Proj., DetID



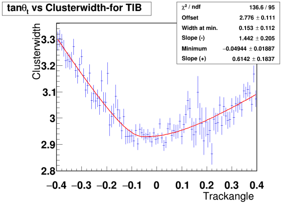
(a) ve$^+$ z and **E** for TIBL1,-6.44^0



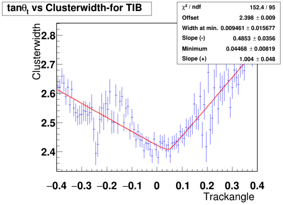
(b) ve$^-$ z and -**E** for TIBL1, 6.45^0



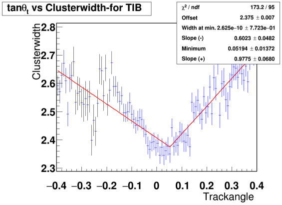
(a) ve$^+$ z and **E** for TIBL2, 2.83^0



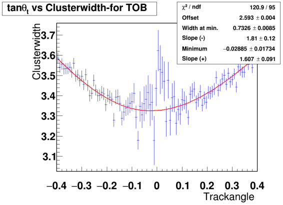
(b) ve$^-$ z and -**E** for TIBL2, -2.83^0



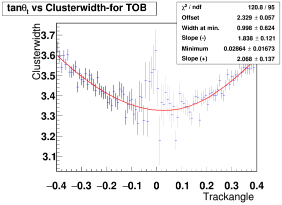
(a) ve$^+$ z and **E** for TIBL3, 2.55^0



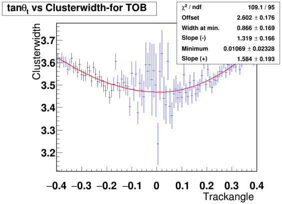
(b) ve$^+$ z and **E** for TIBL4, 2.97^0



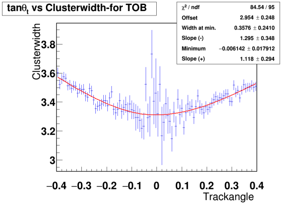
(a) ve$^+$ z and **E** for TOBL1, -1.65^0



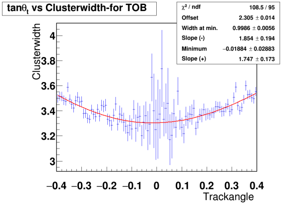
(b) ve$^-$ z and -**E** for TOBL1, 1.64^0



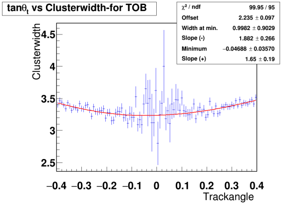
(a) ve$^+$ z and **E** for TOBL2, 0.61^0



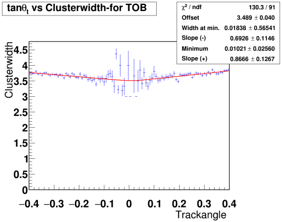
(b) ve$^-$ z and -**E** for TOBL2, -0.35^0



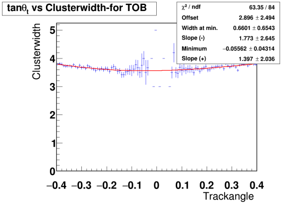
(a) ve$^+$ z and **E** for TOBL3, -1.07^0



(b) ve$^+$ z and **E** for TOBL4, -2.68^0



(a) ve$^+$ z and **E** for TOBL5, 0.58^0



(b) ve$^+$ z and **E** for TOBL6, -3.1835^0

Couple of comments: So far about bumps near zero for TOB there is no proper explanation, a possible one is mixup of **B** directed statistics. For the separation of statistics along the orientation of **B** we are working.

Future Plan

- We need to develop the code for calculating LA's for TEC,TID in the old data (2010).
- Data needs to be classified along the orientation of moduleid$\Leftrightarrow$**E** and **B**.

Plan for 2017 data and for future detector

- We are developing analysis package that will be used for calculating LA for silicon strip detector and monitoring LA in DQM. (work in progress)
- We are also proposing to have dedicated ntuple for LA studies (Work in progress). Proposal is in discussion with tracker DPG group.
- same package will be used for old data as well.

Thank you