Lorentz angle determination in CMS Pixel detector

Jelena Luetić
Ruđer Bošković Institute
Zagreb, Croatia
CMS Pixel detector

Detection of charged particles through ionization

- Built from modules
- Each barrel module – 16 ROCs
- Each ROC – 52*80 pixels
- Each pixel – 100*150 μm
CMS Pixel detector

- Detector in magnetic field 3.8 T
- Charged particles moving in electric and magnetic field
- Particles experience Lorentz force and drift under combined fields
Lorentz angle in Pixel detector

- Lorentz angle - angle by which charge carriers are deflected in magnetic field perpendicular to electric field

Motivation:
- Improved charge sharing
- Improved spatial resolution through charge interpolation – 10 μm
- Effects of radiation damage: charge trapping, increasing bias voltage...
Grazing angle method

- Single pixel hits combined into clusters
- Fits to determine tracks passing through clusters in different layers
- Muon tracks used – hits in muon chambers
- Tracks with shallow impact angle – maximum cluster size in local y
Grazing angle method

- Extracting drift length as a function of depth in silicon bulk
- Procedure done for every pixel in cluster
- Without magnetic field - clusters largest extension parallel to track projection on (x,y) plane

Drift:
\[ d = \Delta x - \Delta y \tan \gamma \]

Depth:
\[ z = \Delta y \tan \beta \]

Lorentz angle:
\[ \tan \theta = \frac{d}{z} \]
Grazing angle method

- Charge carriers production depth and displacement determined from track parameters
- Use well reconstructed tracks – path through detector well known

- Drift distance of the electrons created at certain depth
- Averaged over many tracks – drift distance over production depth
Lorentz angle calculation

- Dataset: /MuOnia/Run2011*-PromptReco – v*/RECO
- /MuOnia/Run2012*-PromptReco - v*/RECO
- Used certified datasets to assure good runs

Selection:
- Cluster size in $y > 3$
- Track $p_t > 3$ GeV/c
- $\chi^2/ndof < 2$
- Hit residuals < 50 $\mu$m
- Cluster charge < 120000 e
- Exclude hits with edge pixels
- High purity tracks
Lorentz angle 2011

Operation conditions: $V_{\text{bias}} = 150\text{V}$

- Lorentz angle determined per layer
- Observed increase in Lorentz angle of about 2%
Lorentz angle 2012

Operation conditions: $V_{\text{bias}} = 150\text{V}$

- Observed increase in Lorentz angle depending on the layer
- Observed increase in Lorentz angle for L1 about 3.5%
- Observed increase in Lorentz angle for L3 about 1%
Lorentz angle 2012

Special run with bias voltage on Layer 1 changed to 140V

- Increase in Lorentz angle due to lower bias voltage in Layer 1 about 2.2%
Lorentz angle per ring

- 3 layers, 8 modules
- 8 rings per layer
- Rings 1-4 +Z
- Rings 5-8 -Z

- Lorentz angle measured for each of 8 rings in 3 layers
- Nonuniform irradiation along the beam-pipe direction, depends on the distance from the interaction point
Lorentz angle per ring

- Rings not irradiated equally
- More statistics needed for monitoring central rings
Summary

- Method for calculating Lorentz angle in CMS Pixel detector
- Increase of Lorentz angle with integrated luminosity

Thank you for your attention