CDF Silicon Alignment

based on an original idea by Volker Blobel (http://www.desy.de/~blobel)

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CDF note 5700

Various plots from CDF 5700 were included in this presentation and are indicated by reference

Standard Approach

Ignore Misalignments

Make Track Fits

OK, if residual calculated as difference to ‘truth’

Calculate Residuals

Iterate ??

Deduce Alignment Parameters

Blobel's scheme

- It is better if all free parameters are fitted simultaneously.
- One gigantic error matrix
- No iteration required

All = Track parameters (local)
+ Alignment parameters
(global)

Advantages

- Standard Method often uses different classes of tracks. How to combine?
- Blobel naturally combines them. Takes care of error propagation.

- For CDF *no* external information is required
- End result: One internally consistent detector.
- Systematics in COT or beam-line will not be mapped onto silicon.

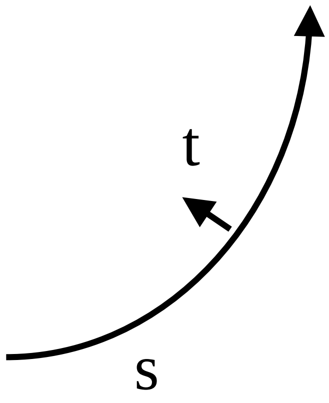
(in fact can be used to sort out pedestals, drift velocity etc.)

Brief Mathematical Prelude

Linearity

- Circle Fit is not linear
- Multiple scattering term is not linear

- Transform from (x,y)->(s,t)
- Take 1/p MS term from COT
- (second order effect)



Maths: P.6 of CDF5700

Tests

- Results presented for 5 SVX layers + L00
- Flat momentum spectrum 2-10 GeV pT
- Flat theta spectrum
- 5um precision in silicon

- Misalignments of 20um // to wafer (Rphi), 60um perp. to wafer (R), 0.2mrad twist.

Plots: P. 8,10,11,13,14,15,16,18 of CDF5700

Proof of Principle

- 100,000 tracks.

- Note correlation generated v reconstructed
- Note dependence on number of tracks
- Note Pull Distribution

- Must calculate chisquared correctly….
- Note chisquared probability distribution for 100 samples of 1000 tracks
- Note **Impact Parameter Distribution**

Conclude (in principle…)

- We find correct alignment
- We find correct error estimate (to 2%)
- Small number of tracks required

Stability

- As function of
  - Multiple Scattering Estimate
  - Mechanical Survey Precision
  - Size of Misalignments
  - Misassociation of hits to tracks

Plot: P20 of CDF5700

Stability (Multiple Scattering Estimate)

- Current estimate of material is incorrect
- Even if well modelled, can not say with certainty where particle went.

- Increase MS by 2 in generation (not in rec.)
- Plot
- Central value ok. Error underestimate 32%

[redacted] (40%)

Plots: P21,22 of CDF5700

Stability (Mechanical Alignment)

- Suppose our mechanical alignment is twice as bad as we think…(motion in transit…)
- Plot
- Bias. Error underestimate of 30%

- Suppose alignment twice as good
- No bias. Error overestimate of 9%

- [redacted]

Plot: P24 of CDF5700

Stability (Larger Misalignments)

- Suppose misalignments were factor of 5 larger.
- Errors fine (8% scale req'd); no bias.

- Caveat: If we fit 1/pT term, errors underestimated by 25%. Fit starts to depart from our linear assumptions.

Stability (Hit associations)

- If alignment incorrect, silicon hits will be incorrectly associated
- Choose isolated tracks (5% incorrect hits)
- Sizeable tails in alignment !!
- Iteration doesn't work.
- Identify good tracks (not by chisquared but by repeating after trial alignment.)
- Removes tracks with incorrect hits.

Plots: Pages 26,27 of CDF 5700

Conclusions

- Starting from mechanical survey, using 10,000 tracks, correct positions recovered with precision 6um in Rϕ, 12um in R.
- Local Alignment more precise
- Impact Parameter 1.5um > perfect

- Stable to changes in scattering, survey, & hit misassociations.

- Alignment code ready for data.