VXDBasedReco TRACK RECONSTRUCTION PERFORMANCE STUDIES

Bruce Schumm University of California at Santa Cruz ALCPG Workshop, Snowmass Colorado August 14-28, 2005

Tracking Performance of an All-Silicon Tracker

Thanks to **Michael Young** (UCSC Master's student), and SLAC for support and advice

Original Goals:

- Verify tracking efficiency for all-silicon tracking
- Verify track parameter resolution
- Compare performance with 5- and 8-layer tracker, based on SD-Jan-03 design

Many slides stolen directly from Michael Young

TRACKING CODE

Available track reconstruction/fitting is VXDBasedReco, due to **Nick Sinev** (Oregon).

- Start with segment from VXD
- Attach tracker hits (at least one hit needed to reduce bckgd)
- Can be run with no hit smearing, gaussian smearing, or realistic CCD hit smearing (realistic μ strip smearing still under development).
- **NOTE:** These studies have led to some iteration of Nick's code. Presented here are only the results from his latest working versions.
- Also: we use **Wolfgang Walkowiak's** TrackEfficiencyDriver for the core of the tracking efficiency calculation.

EVENT/TRACK SELECTION

Choose qqbar events at E_{cm} = 500 GeV (dense jet cores); Pan/Pythia and GEANT4 generation

Choose events/tracks that should be easily reconstructed (tracks curl up below p_{\perp} = 1 GeV):

Event Selection

- $|\cos\theta_{thrust}| < 0.5$
- Thrust Mag > 0.94

Track Selection

- $|\cos\theta_{\text{track}}| < 0.5$
- p_⊥ > 5 GeV/c

SOME PRELIMINARIES

1. Gaussian variable related to momentum resolution is curvature ω , inversely related to p_{\perp} and radius of curvature R according to

$$\omega = 1/R = 0.003 * B(T) * (1/p_{\perp})$$

- 2. Define α as angle between track and jet core, where jet core angle is taken to be the thrust axis.
- 3. All fitting studies done without beam constraint

Caveat: No "realistic" hit smearing in central tracker; no cut on goodness of fit (take efficiency numbers with a grain of salt).

EFFICIENCIES FOR QQBAR EVENTS



Doesn't look that spectacular; what might be going on here?

Of course! The requirement of a VXD stub means that you miss anything that originates beyond r ~ 3cm. This is about 5% of all tracks.



With VXDBasedReco, we won't see a difference between 5 and 8 layer tracking.

So – what is the efficiency for tracks that originate within the beampipe?

All-Gaussian Smearing

Realistic CCD Smearing



By the way: µµ efficiency looks good

All-Gaussian Smearing

Realistic CCD Smearing



Efficiency Versus Transverse Momentum



TRACK PARAMETER PERFORMANCE

- 1. Compare width of Gaussian fit to residuals with two different estimates:
 - Error from square root of appropriate diagonal error matrix element
 - Error from Billior calculation (LCDTRK program)
- 2. Only tracks with all DOF (5 VTX and 5 CT layers) are considered.
- 3. Only gaussian smearing is used, since this is what is assumed for the two estimators.

Qqbar sample extends out to ~100 GeV; use $\mu^+\mu^-$ sample to get higher energy (200-250 GeV) bin.

CURVATURE ERROR vs. CURVATURE



CURVATURE ERROR vs. CURVATURE



"NEW" CODE WITH MODIFIED FITTER

QQBAR EFFICIENCY vs. CURVATURE



"NEW" CODE WITH MODIFIED FITTER

RESULTS FOR μμ (LOWEST ω BIN)

Residuals (Gaussian smear):	$\delta\omega = 3.40 \mathrm{x} 10^{-7}$
Error Matrix:	$\delta\omega = 3.12 \mathrm{x} 10^{-7}$
LCDTRK:	$\delta\omega = 3.26 \mathrm{x} 10^{-7}$
Actual momentum resolution is about 9% worse than LCDTRK expectation	
Residuals (realistic CCD):	$\delta\omega = 3.29 \mathrm{x} 10^{-7}$
Apparently, "realistic" CCD resolution is better than assumed value of 5um	

TOWARDS A MORE REALISTIC ESTIMATE OF EFFICIENCY

Are there a lot of fake tracks?



What about bad fits?

→ A number of tracks have no entries in the fit covariance matrix.

FAKE TRACKS

A "fake track" is one for which there is no MC particle associated (we have yet to look into "confused tracks").

There are only 17 out of 30,000 (high Pt, central)



BAD TRACK FITS

- About 1,000 out of 30K tracks have no error matrix.
- Their momentum errors are large (MC Truth). Assume for now they're bad fits.
- Tracks with all ten layers never show this problem



BAD TRACK FITS AND EFFICIENCY





CONCLUSIONS I

VXDBasedReco achieves ~96% efficiency in dense jets; we must still simulate central tracker hits.

The ~5% of tracks that originate outside the VXD will be missed. Outside-in (GARFIELD) and/or stand-alone tracking will get some of this (study!).

Without these, we will not be able to explore difference between 5 and 8 layer trackers.

CONCLUSIONS II

Curvature (p_{\perp}) performance is within 10% of expectation at high momentum. Fitter does not treat material correctly. More work needed here.

The current version of VXDBasedReco pattern recognition has some additional problems (fixed?).

We'd love to extend our studies into the Forward region.

Personpower: Michael Young is graduating. A promising undergraduate thesis student (Eric Wallace) is tentatively interested.