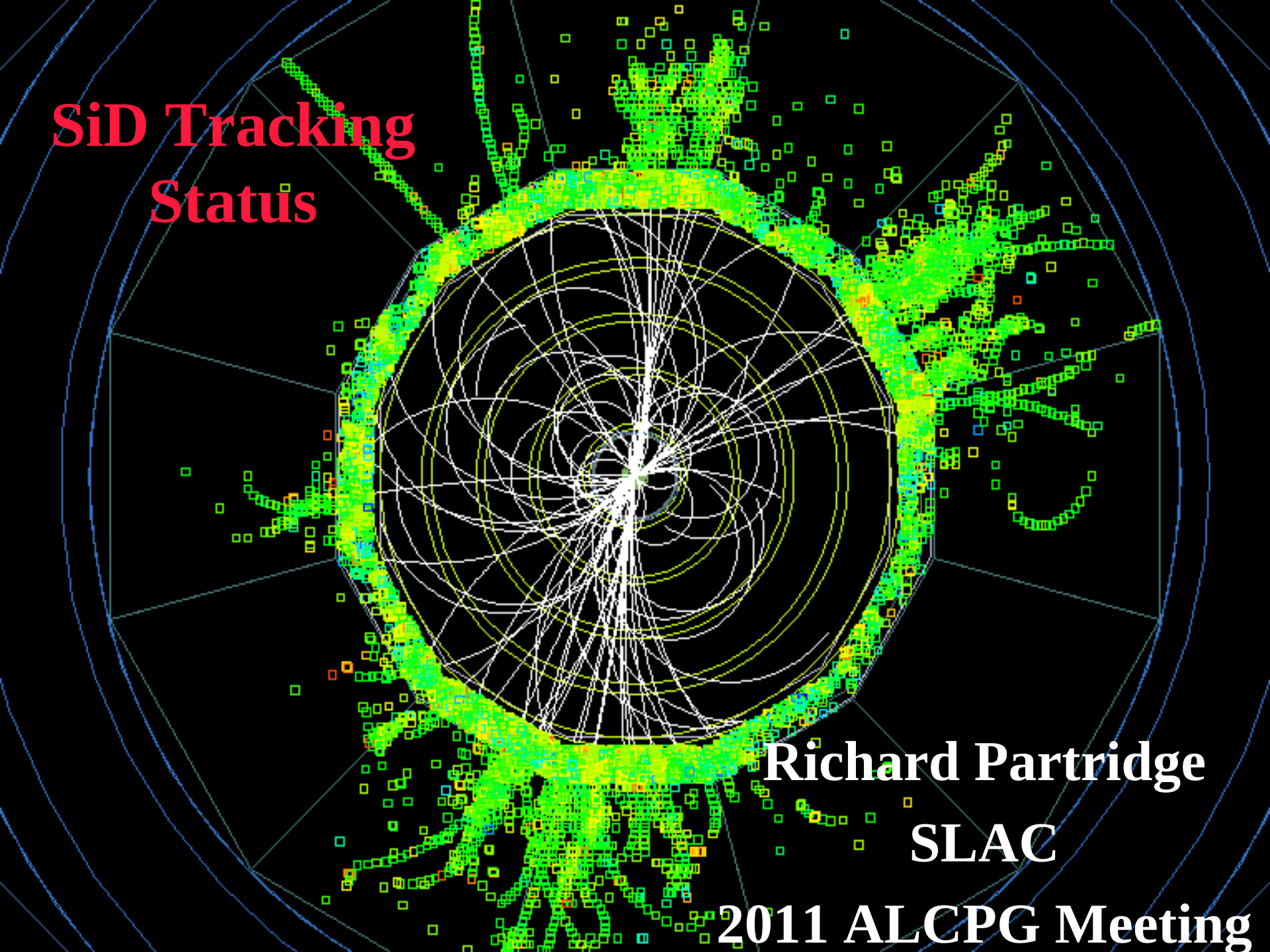
SiD Tracking Status



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2011 ALCPG Meeting

Tracking Performance Overview

LOI showed excellent performance for baseline SiD tracker

- >99% track finding efficiency over most of the solid angle
  - ~98% in core of 500 GeV light quark jets
- Momentum resolution typically ~0.2% for $|\cos(\theta)| < 0.65$
  - $\sigma(p_T) / p_T < 0.5\%$ over most of solid angle for 1 GeV $< p_T <$ 100 GeV
- DCA resolution typically ~15μm for $p_T = 1$ GeV, $|\cos(\theta)| < 0.65$
  - Most tracks multiple scattering limited – resolution approaches ~4μm at high p_T
- >99% of tracks have ≤1 mis-assigned hits
  - Fake track rate is 0.07% for tt events

Post-LOI Challenges:

- Increase detail/realism in modeling of the tracker
- Efficient tracking simulations with beam backgrounds, higher E_{cm}
- Address deficiencies in LOI tracking

Increasing Realism of Simulations

This goal is essentially complete

- Planar detector geometry with individual sensors simulated
  - Fully overlapping rectangular sensors in barrel detectors
  - Overlapping trapezoidal sensors on conical supports for endcap detectors
- Realistic charge deposition model for strips and pixels
  - For strips, track segment is divided into pieces and drifted/diffused to strips
  - For pixels, can either use strip model or Nick's PixSim package that provides detailed modeling of various types of pixel detectors
- Nearest neighbor clustering of hit strips/pixels
- Hits are formed with realistic hit position and uncertainties

However, there was some collateral damage

- "Ghost Tracks" are found when there are sufficient number of extra hits from overlapping sensors to form a second track
  - Code to add track hits from overlapping sensors also needed for Kalman fitter

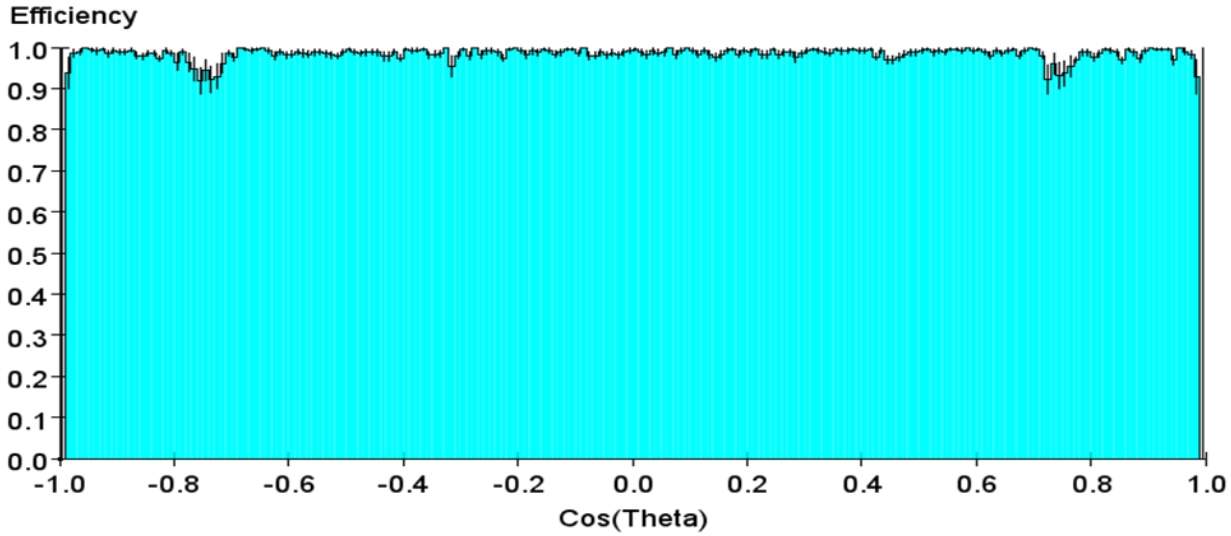
Efficient Tracking Simulations

Substantial work on making realistic simulations faster

- Fixed subtle bug in making HelicalTrackHits (used by tracking) from the strip digitization output
  - Showed up when we switched to trapezoidal endcap sensors with rotated strips
  - Strip rotation not accounted for giving large hit errors
  - With small number of layers, SiD relies on precise hit measurements to resolve ambiguities and keep number of viable hit combinations under control
  - Ron, Christian, and Norman all saw significant improvements in tracking speed
  - See slides posted in simulation sessions for details
- Improved FastCheck code that quickly checks a pair of hits for compatibility with the p_T and impact parameter cuts
- Aggregated endcap sensors into layers for multiple scattering
  - At some point, geometry infrastructure changes caused aggregation code to fail
- Make an early identification of track candidates that would eventually be discarded in favor of a better quality candidate

Address Deficiencies in LOI Tracking

- Working to eliminate dips in tracking efficiency
  - Problem traced to difficulty in calculating track path lengths for low momentum loopers in barrel tracker where axial strips make a poor measurement of the z coordinate (which was being used to order hits)
  - Have a fix – need to make sure there is no collateral damage



- Develop Kalman fitting code for final track fit
  - Work started last summer by Stanford student – needs more work to complete

Tracking Performance

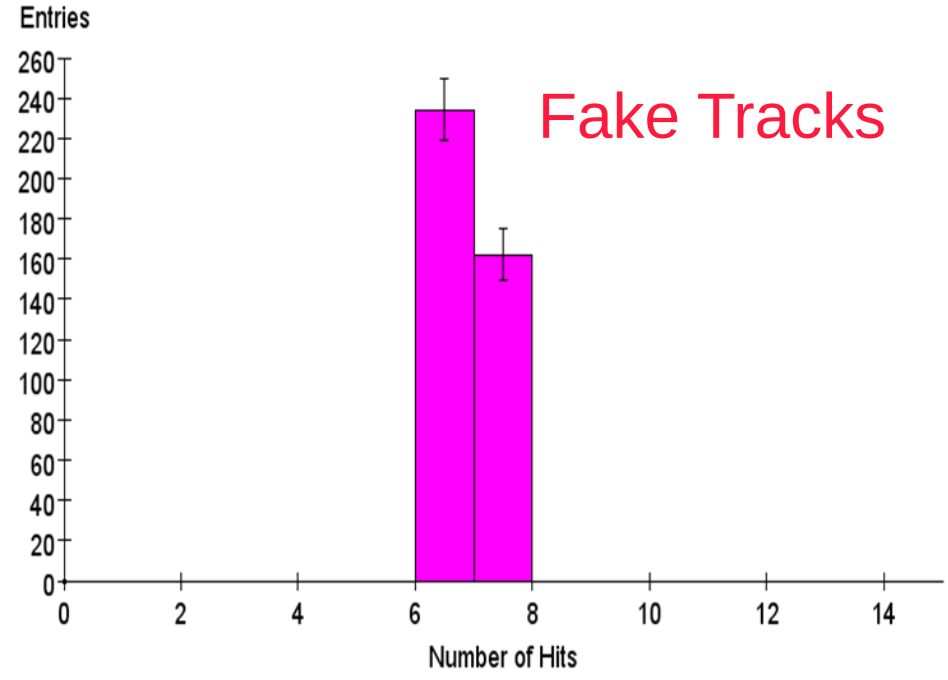
- Tracking performance for more realistic tracker is very similar to what we presented in the LOI

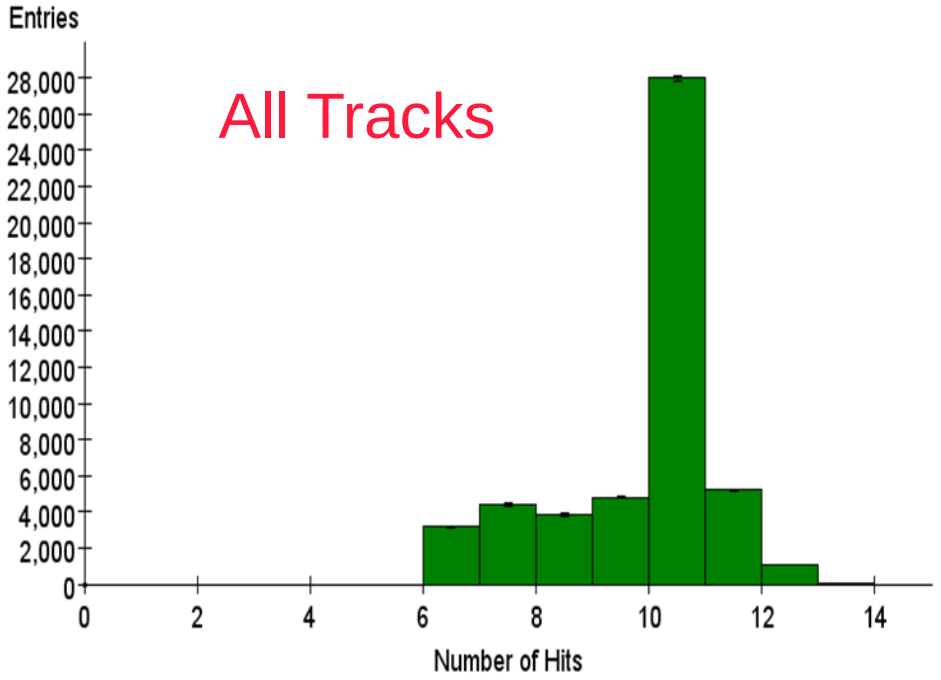
Breakdown of reasons a track isn't found

Selection	LOI: $t\bar{t}$ @ 500 GeV	New: $t\bar{t}H$ @ 1 TeV
$p_T \geq 0.2$ GeV	(93.45 ± 0.11)%	(94.02 ± 0.11)%
Nhit ≥ 6	(90.77 ± 0.13)%	(91.54 ± 0.12)%
Seed Hits Present	(99.77 ± 0.02)%	(99.76 ± 0.02)%
Confirm Hit Present	(99.96 ± 0.01)%	(99.97 ± 0.01)%
$\|d_0\| \leq 1$ cm	(99.83 ± 0.02)%	(99.80 ± 0.02)%
$\|z_0\| \leq 1$ cm	(99.72 ± 0.03)%	(99.81 ± 0.02)%
Track Reconstruction	(99.05 ± 0.05)%	(98.78 ± 0.05)%

Possible Concern: Fake Tracks

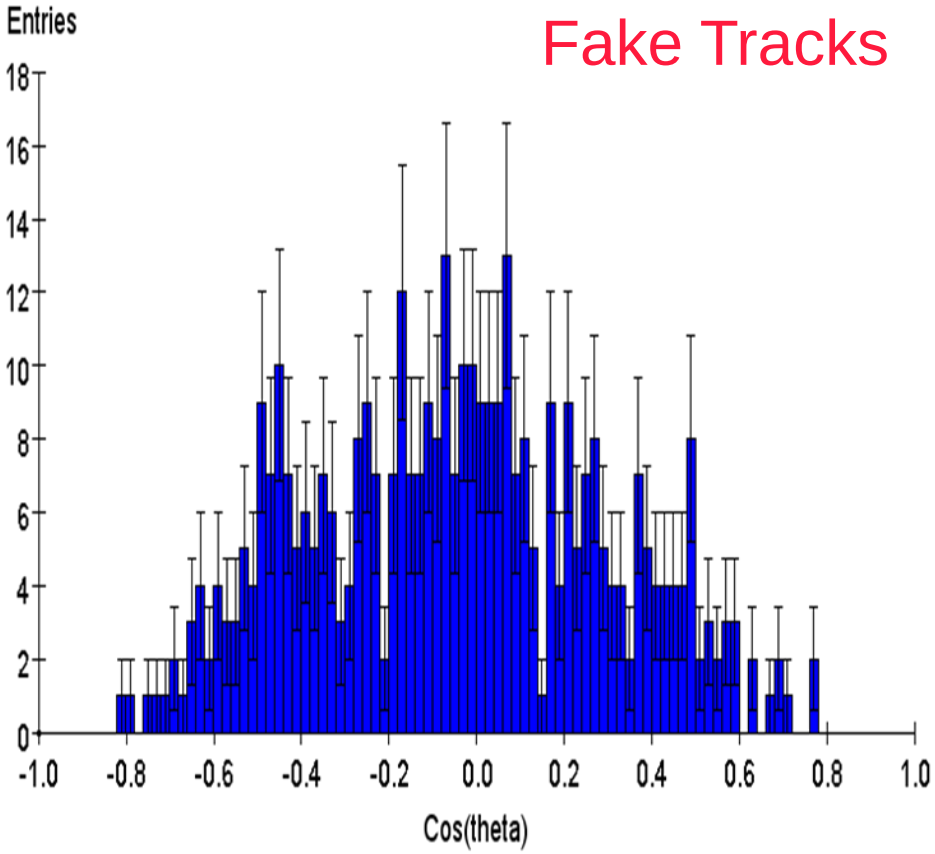
- Fake track rate in 1 TeV ttH sample (0.79%) is considerably higher than seen in the LOI for 500 GeV tt sample (0.07%)
- Preliminary look indicates they meet the track-finding criteria
  - Cases looked at appear to be combinatoric fakes with the minimum allowed hit multiplicity composed of hits from many different MC Particles

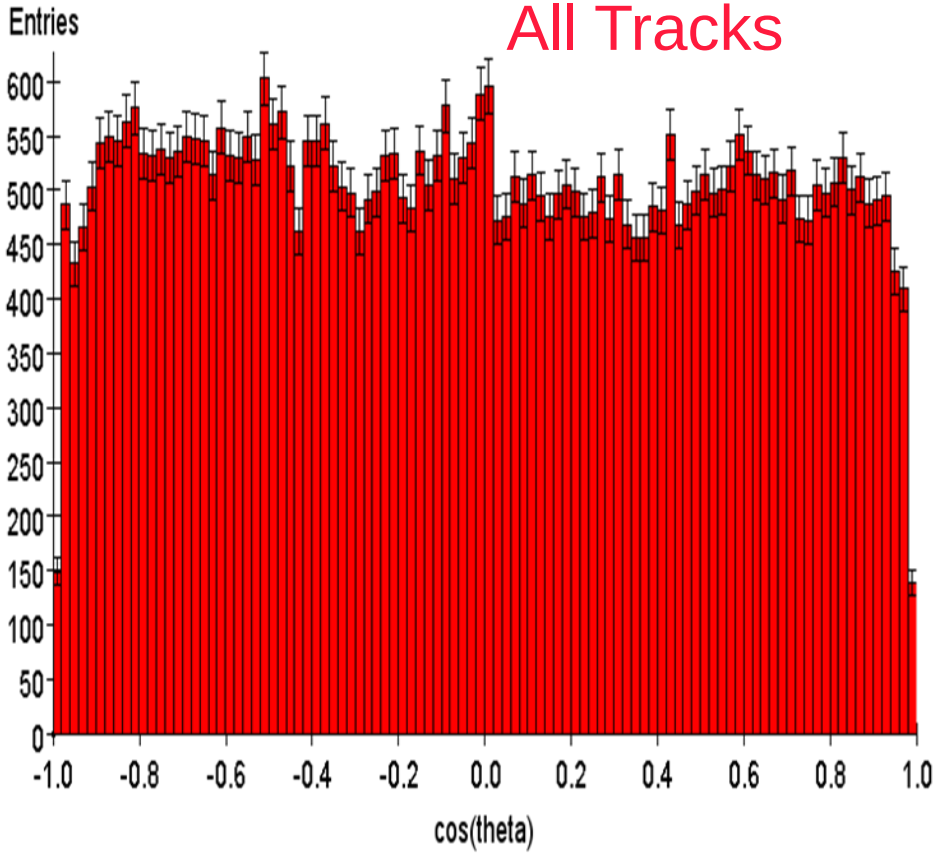




Where are Fake Tracks Located?

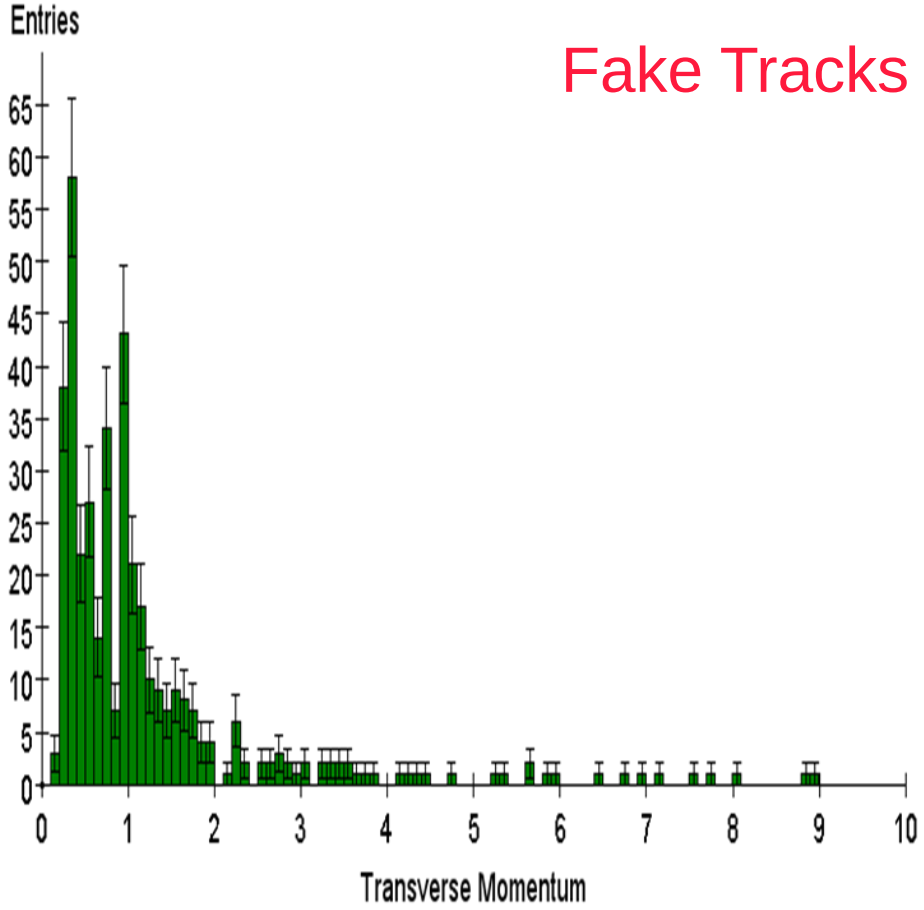
- Fake tracks are generally in the central region where the tracker has only axial strips – z coordinate is only constrained by ~92 mm length of strip

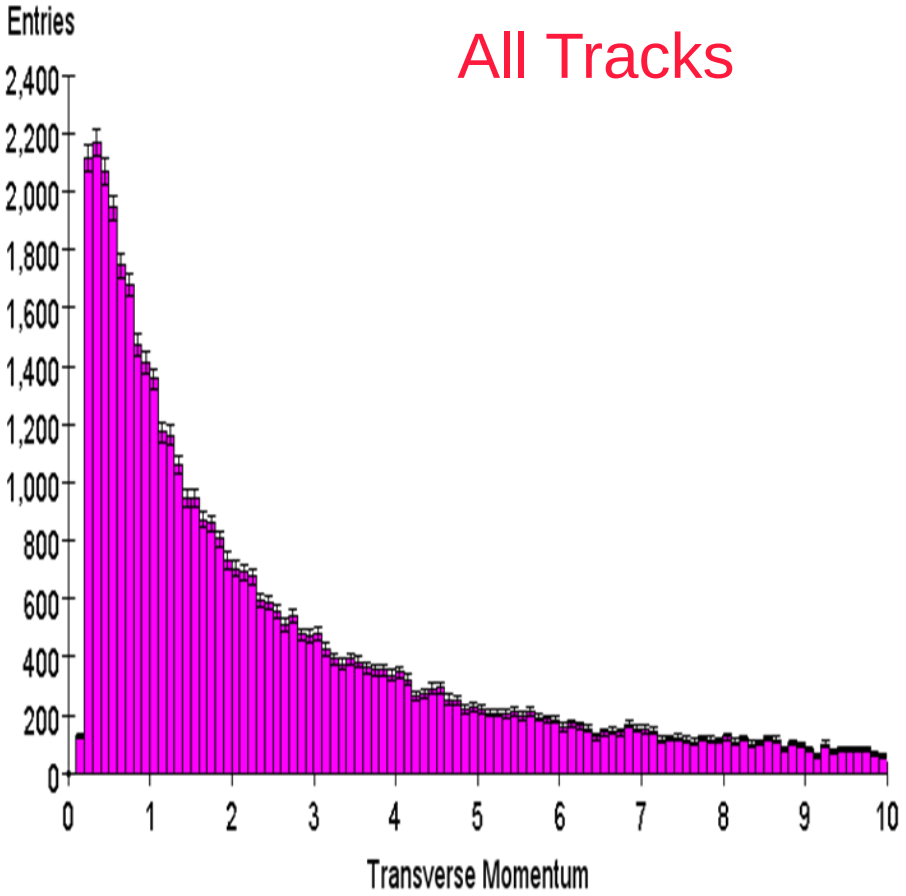




Fake Track Momentum

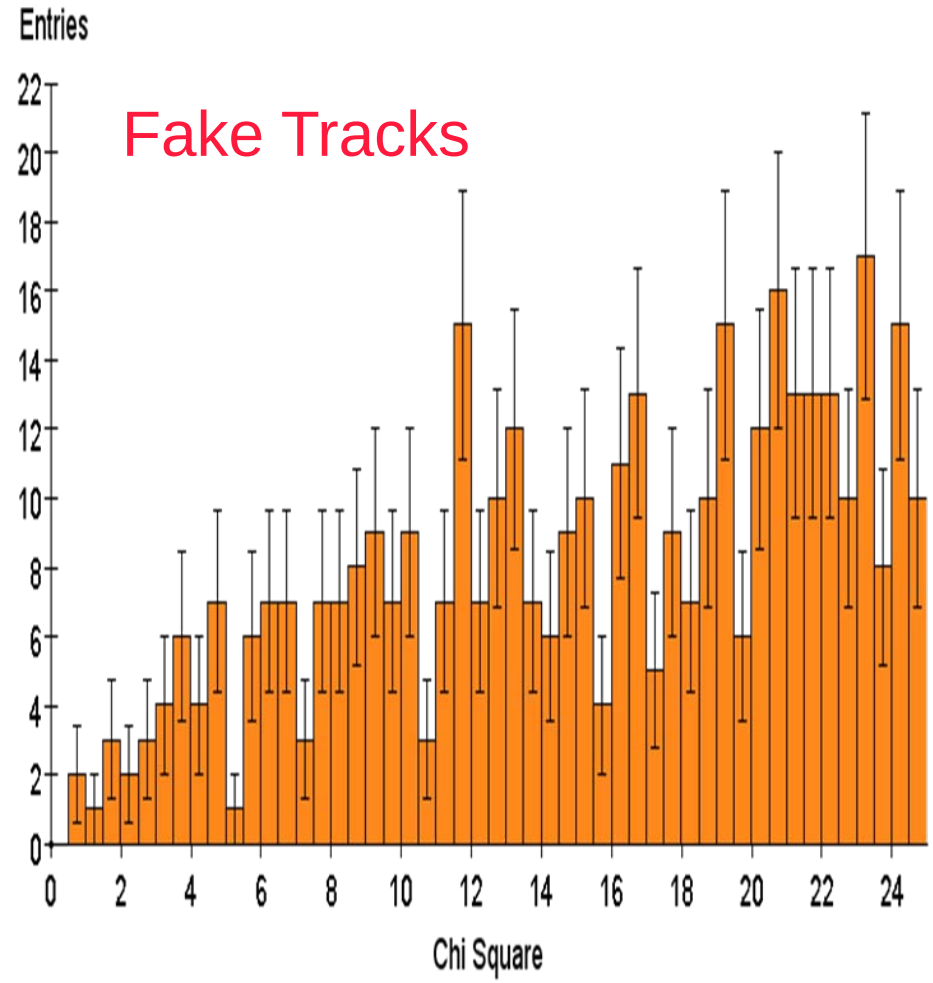
- Fake tracks tend to be low momentum, but there is a tail to high momentum

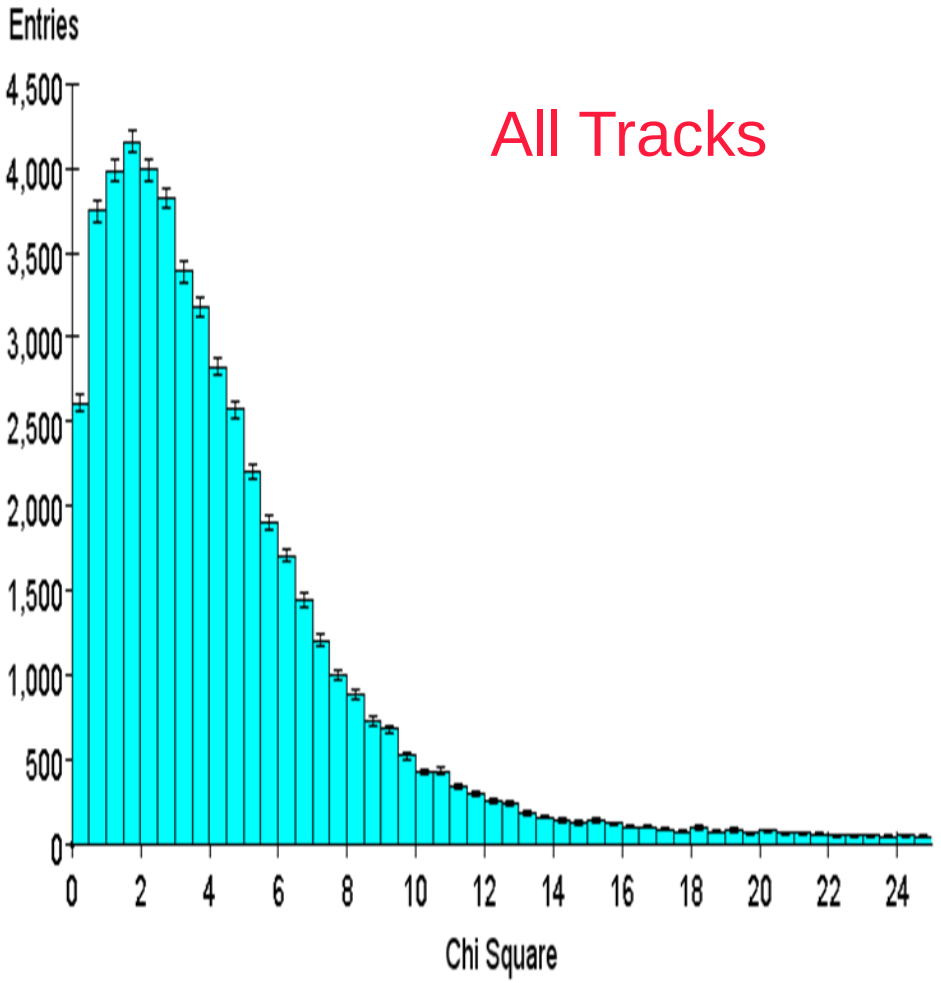




Goodness of Fit

- Fake tracks typically have larger χ^2 than non-fake tracks





Summary

- Lots of progress towards meeting post LOI goals
  - Increase detail/realism in modeling of the tracker is largely complete
  - Significant progress in making tracking code work efficiently for challenging environments with high hit density
  - Working to address deficiencies in LOI tracking
- Tracking performance advertised in LOI appears to be holding up rather well
- May be starting to see some indications of problems for complex events
  - Increased fake rate for ttH@1 TeV
  - Slow tracking performance for dense jets in central region
  - Perhaps need to think about some optimization studies (i.e., would four stereo layers in outer tracker be better than five axial only layers)
- A few items still need work
  - Development of a Kalman fitter for the final track fit
  - Elimination of ghost tracks due to hits in overlapping sensors