Tracking Issues

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- Anomalous behavior observed by Kei Moriya
- Improvements to hit selection
- Reconstruction speed

Some strange behavior...

Kei Moriya observed problems with version of code dating from late last year...

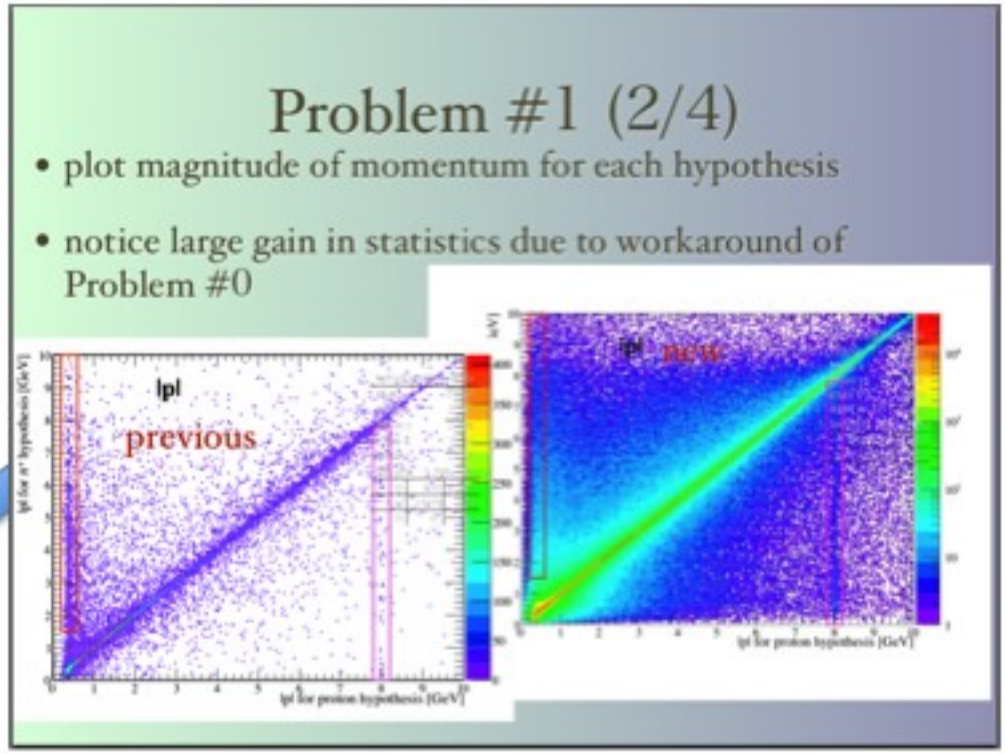
- High momentum pions reconstructed as low (~0.5 GeV/c) momentum protons
  - Recall that positive tracks are fit with two hypotheses (π^+ and proton)
  - Problem seen with Global Least Squares (ALT1) fitter
  - This symptom not seen with Kalman Filter, but proton fit often failed
  - ... problem seems to be associated with hit selection (next slide)
- Tracks pointing in wrong direction (thrown +z, reconstructed -z for one mass hypothesis)
  - Seems to be fixed in latest version of code
- For reconstructed ρ events, Kei observed a spike at ~8 GeV/c momentum not present in thrown events
  - ... I have not been able to duplicate this behavior using the latest version of the code ...

Reconstructed momentum varies (too) strongly as a function of mass hypothesis used

Problem:
When fitting positively charged tracks with different mass hypotheses, the total reconstructed momentum sometimes varies a lot. The proton hypothesis tends to p=0.5GeV/c even when the pi+ reconstructs to several GeV/c

History:

- 12/13/2010 - reported by Kei Moriya at ad hoc meeting with IU and JLab
- 1/12/2011 - reported again by Kei at offline software meeting
- 1/26/2011 - update from Kei comparing results from KalmanSIMD fitter



A potential cause was identified as the hits selected to fit the track. Kei provided an event sample and it was observed that the tracks in question contained hits not from the track. Work was started on an "ALT2" hit selector and on actively filtering hits while running the Kalman Filter.

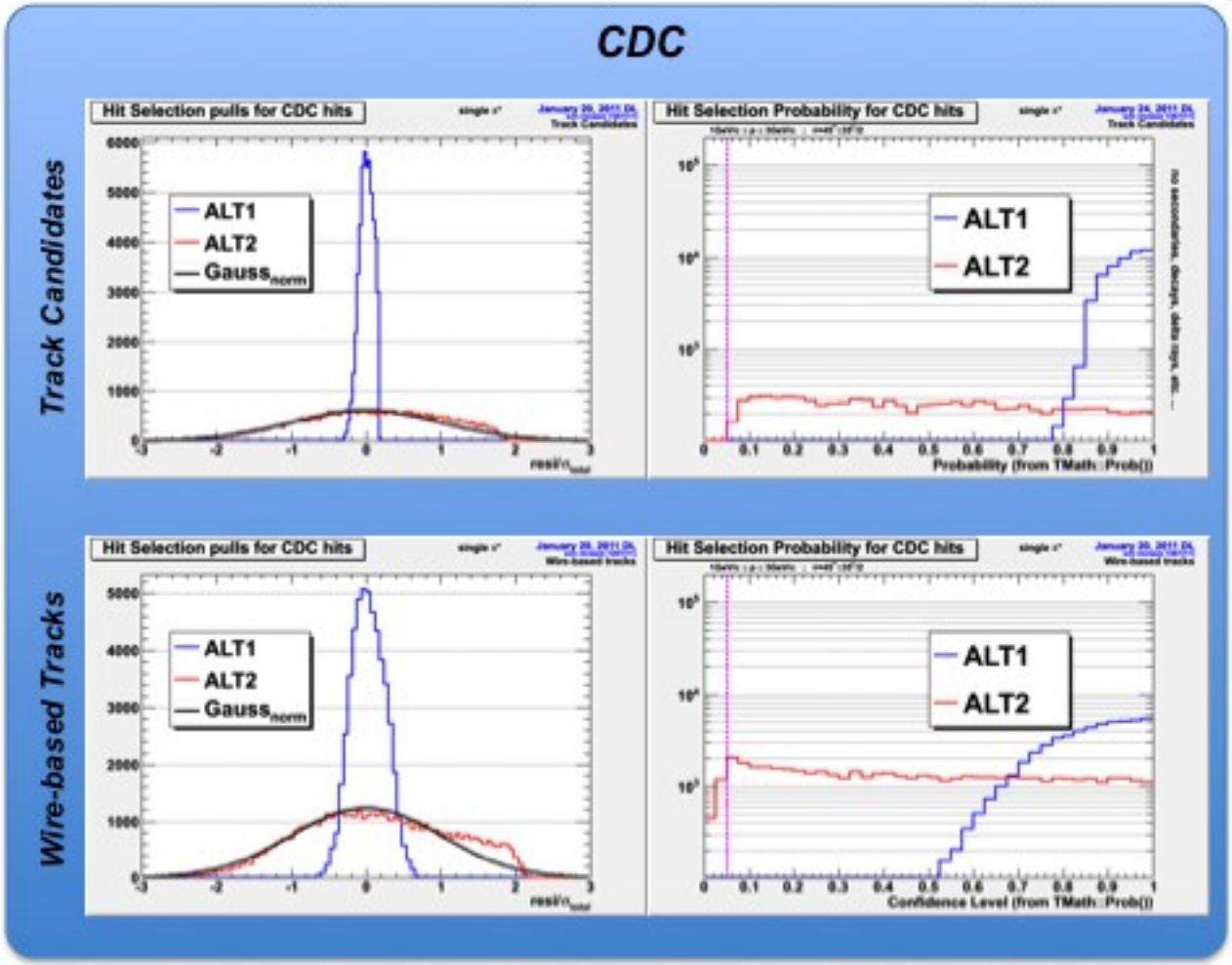
Hit Selection for Charged Particle Tracking

Hit selection is done using a probability function with normalized residuals as input. Residual normalization is calculated as a function of:

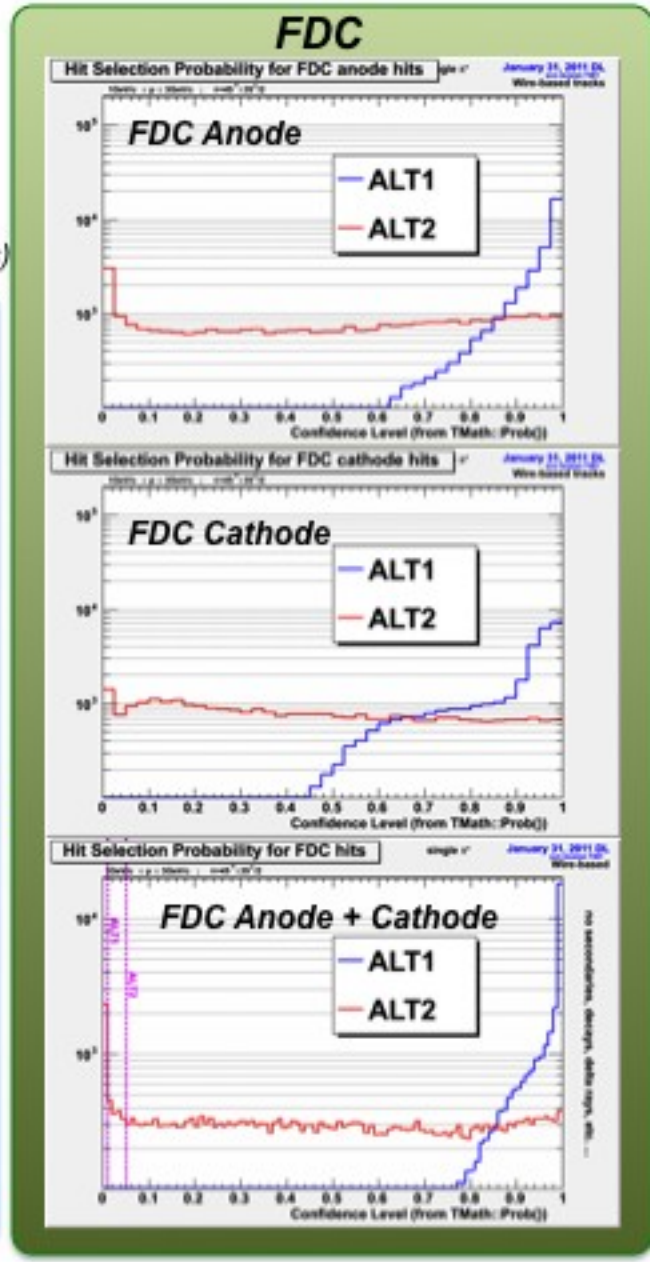
- integrated material seen by the track
- total momentum
- detector type

(these plots are all made from clean, single track events)

CDC



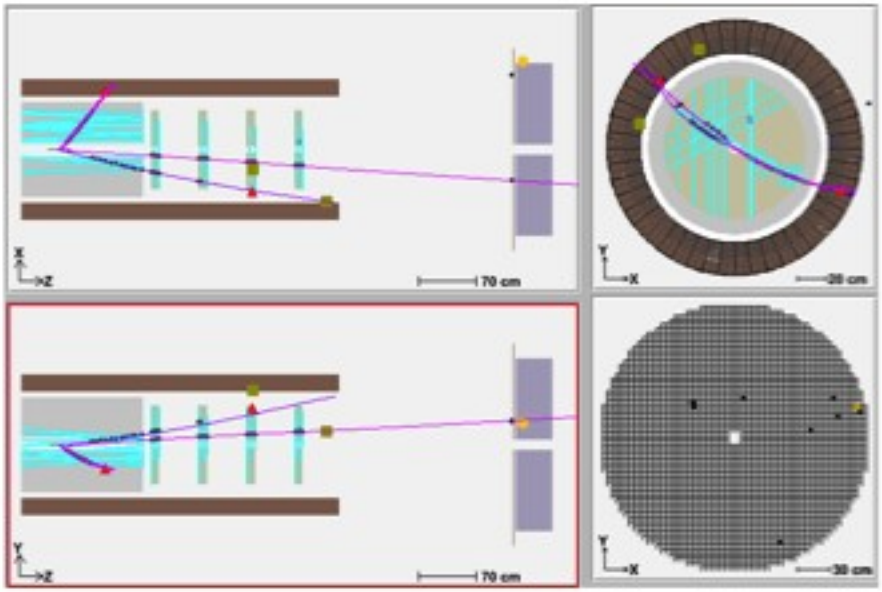
FDC

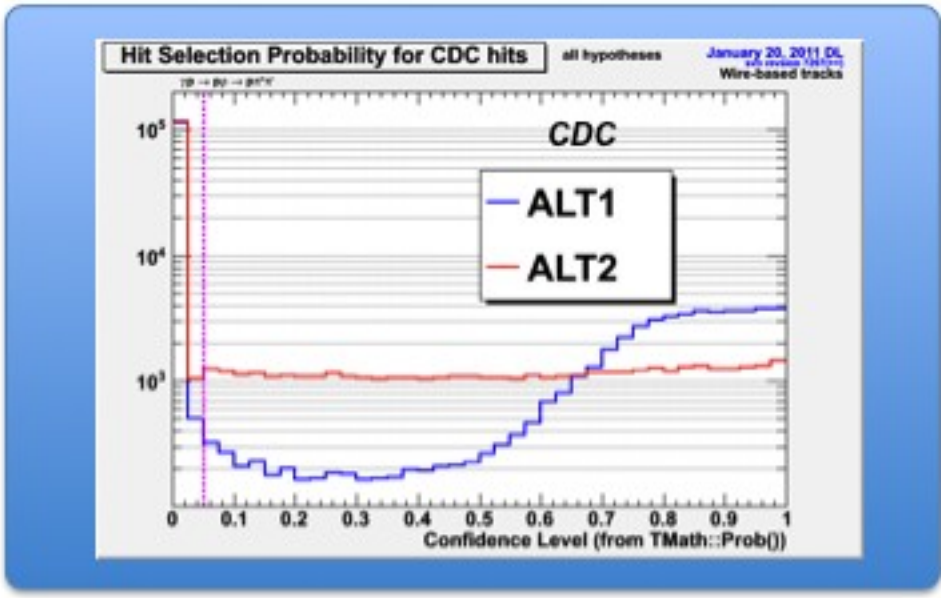


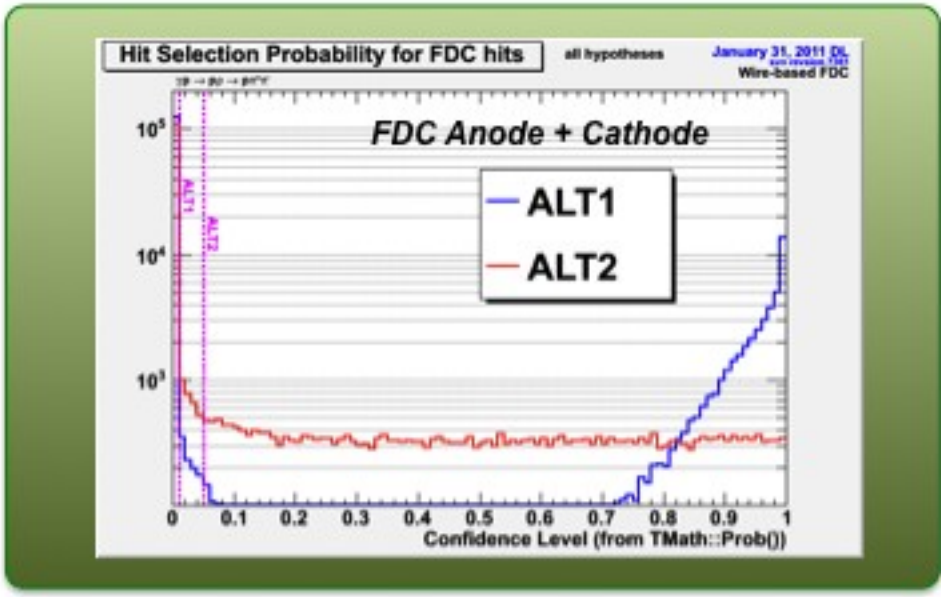
Hit Selection for $\gamma p \to p\rho \to p\,\pi^+\pi^-$

ALT2 hit selector was tuned using clean, single track events.

Here it is applied to 3 track events.



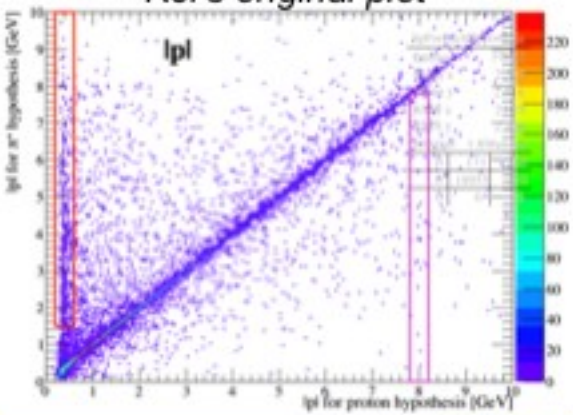




Hit Selection for Charged Particle Tracking

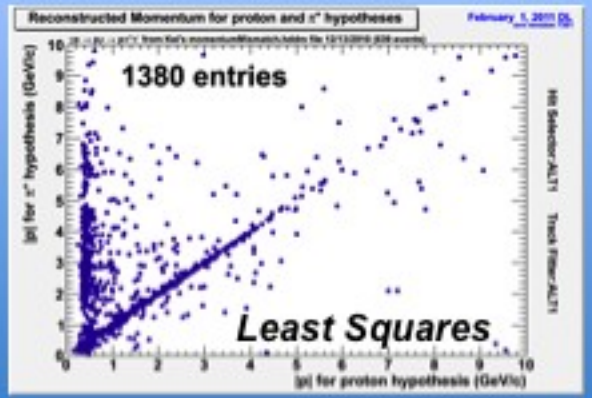
The old (ALT1) and new (ALT2) hit selectors were used with both the old (least squares) and new (Kalman) track fitters on the 639 event set Kei supplied to exhibit the problem.

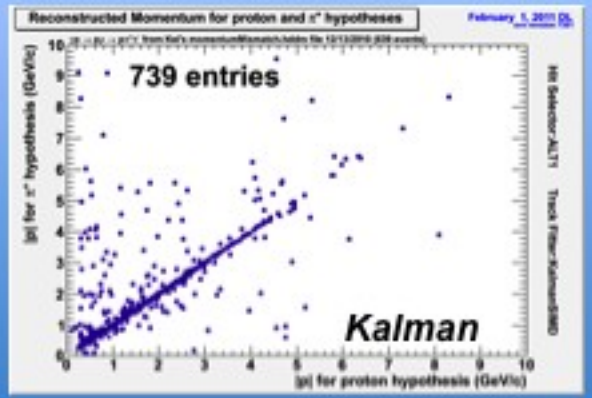
Kei's original plot



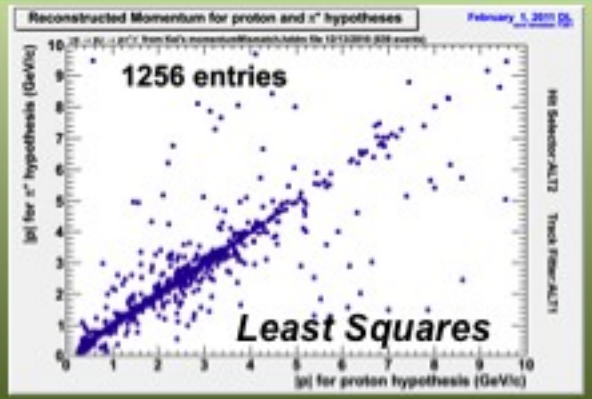
Full report will be in GlueX-doc-1668

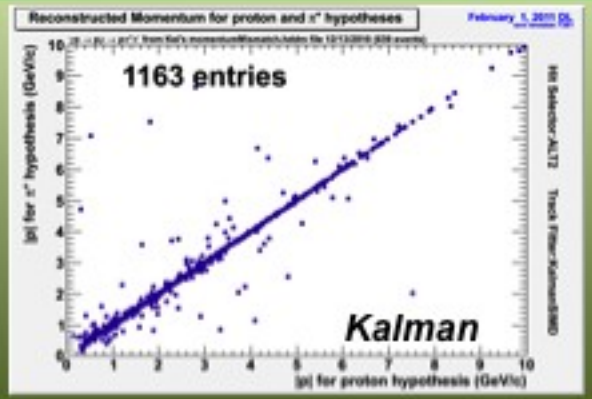
ALT1 Hit Selector





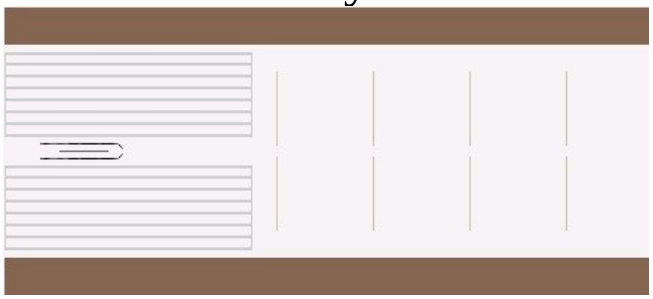
ALT2 Hit Selector



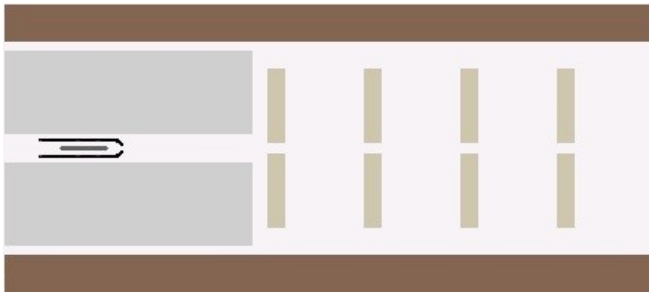


Suggestions for improving speed

- During the Parallelism Workshop we met with Dmitry Emeliyanov, a tracking expert involved with ATLAS
  - ATLAS offline reconstruction ~1 ms/fit vs GlueX ~20 ms/fit at the time of the workshop
  - Dmitry had several suggestions where to look for speed improvements:
    - Increase maximum step size
    - Reduce number of iterations
    - Simplify calculation of Jacobian matrices
    - Use parabolic approximation instead of 4th order Runge-Kutta for stepping through magnetic field for regions where small steps are needed
    - Clump material for energy loss/multiple scattering calculations into delta-function-like layers



vs.



Recent changes to tracking code

- The SIMD("Single Instruction, Multiple Data")-enabled Kalman Filter is the default fitter
  - SIMD instructions cause crashes on 32-bit Linux – a work-around is in place
- Some of the changes suggested by Dmitry have been implemented:
  - Increased maximum step size in non-active regions from 5 mm to 1 cm
  - Increased maximum energy loss in a step from 25 keV to 100 keV
  - Reduced the number of iterations in both the wire-based and time-based passes
  - No longer using the full Runge-Kutta algorithm to compute the Jacobian matrices, but still doing 4th order for state vector propagation
- Drift-time smearing for FDC anode hits is now position-dependent

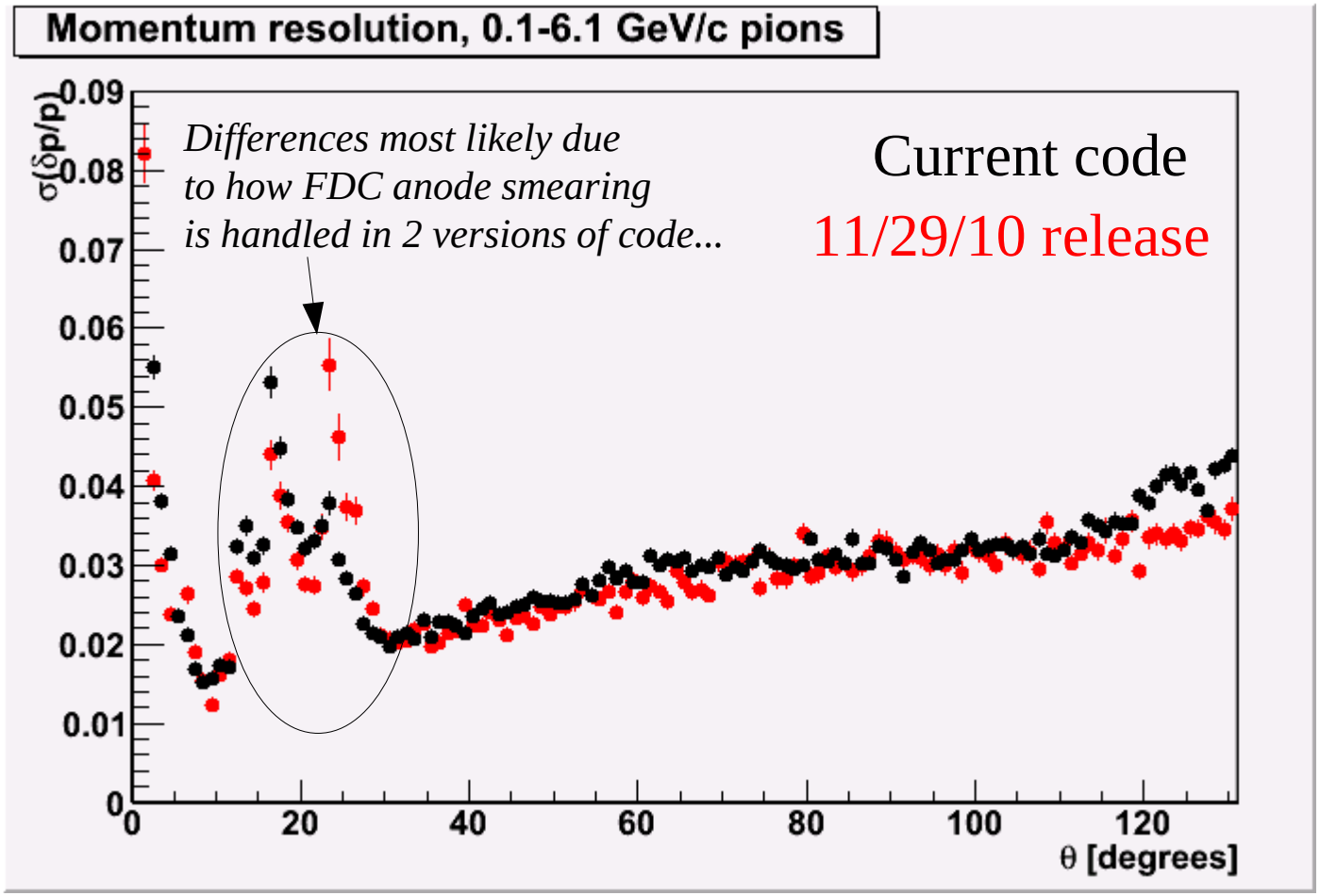
Reconstruction rates

- Events reconstructed on 2.8 GHz Nehalem machine with 4 threads
  - No background, but decays and secondaries on

Topology	11/29/10 Release (Hz)	Current code (Hz)
p (0.1-6.1 GeV/c)	92.4	172.5
π^+ (0.1-6.1 GeV/c)	86.9	171.5
π^- (0.1-6.1 GeV/c)	153.5	288.6
$n\pi^+\pi^+\pi^-$	26.9	44.5
$p\rho$	33.7	63.0
$pb_1^+\pi^-$	13.9	21.3

New version of code is ~1.5-1.9× faster than old version...

Momentum resolution



Summary

- Some of the problems observed by Kei appear to be associated with hit selection – Dave is working on a solution
- Speed of tracking has been improved without greatly worsening quality of reconstruction, but need to keep an eye on this...
    - Transition region between FDC and CDC (~20°) is tricky...