ZVTOP in org.lcsim

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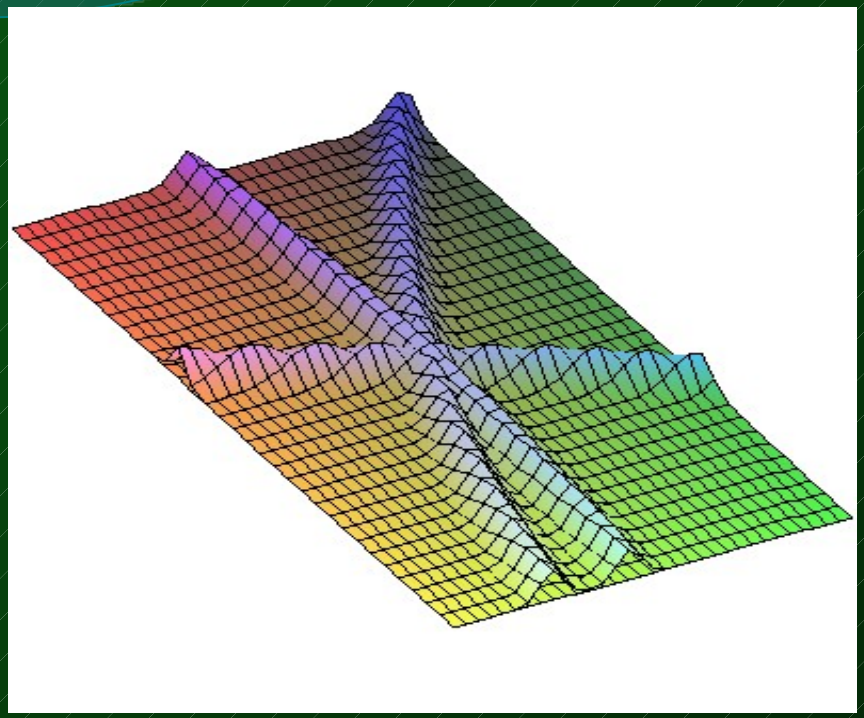
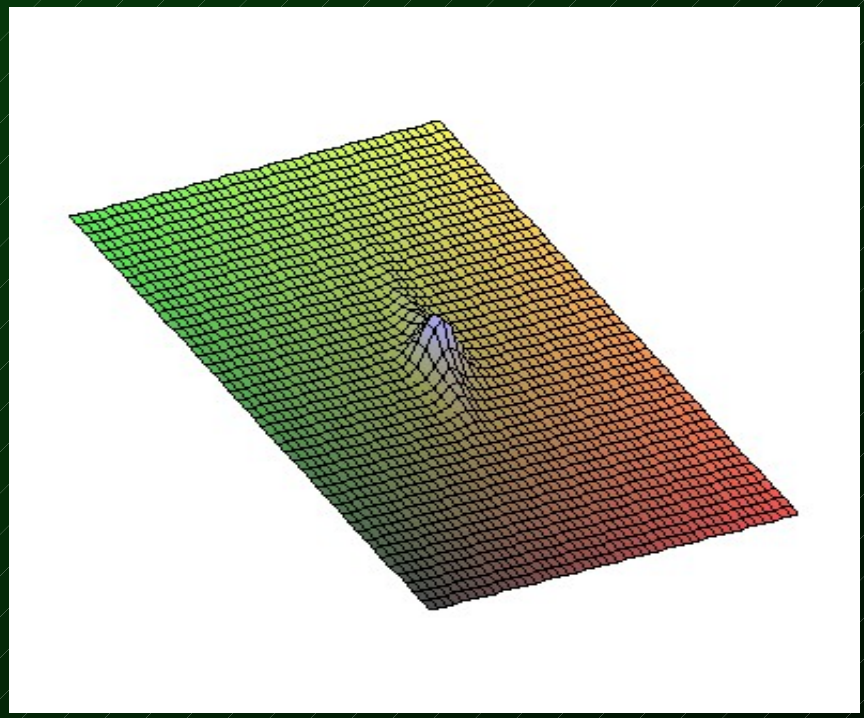
ZVTOP

- compute probability tubes for each track
- find two-track maxima
- cluster unresolved maxima
- disambiguate the clusters and uniquely assign the tracks to the clusters
- fit the tracks in a cluster to a common point
- prune tracks with large chi2
- find the seed vertex and compute pt-corrected mass

ZVTOP

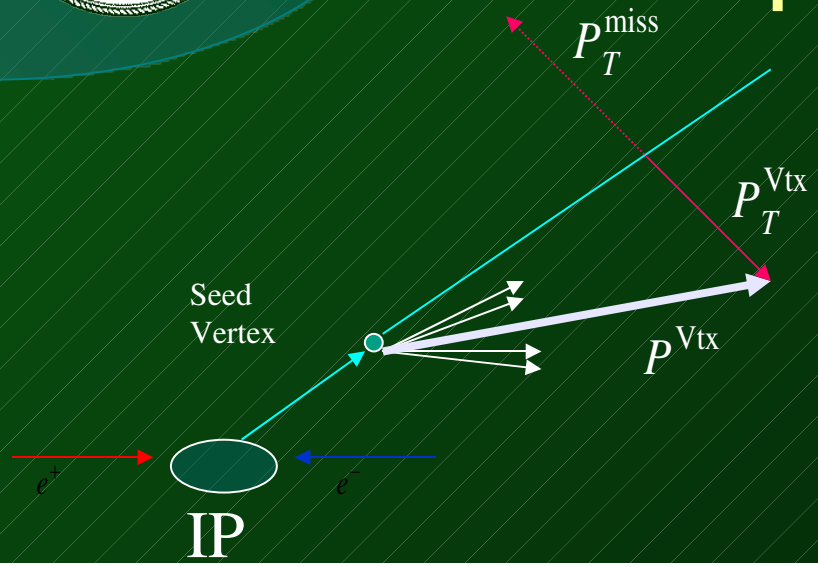




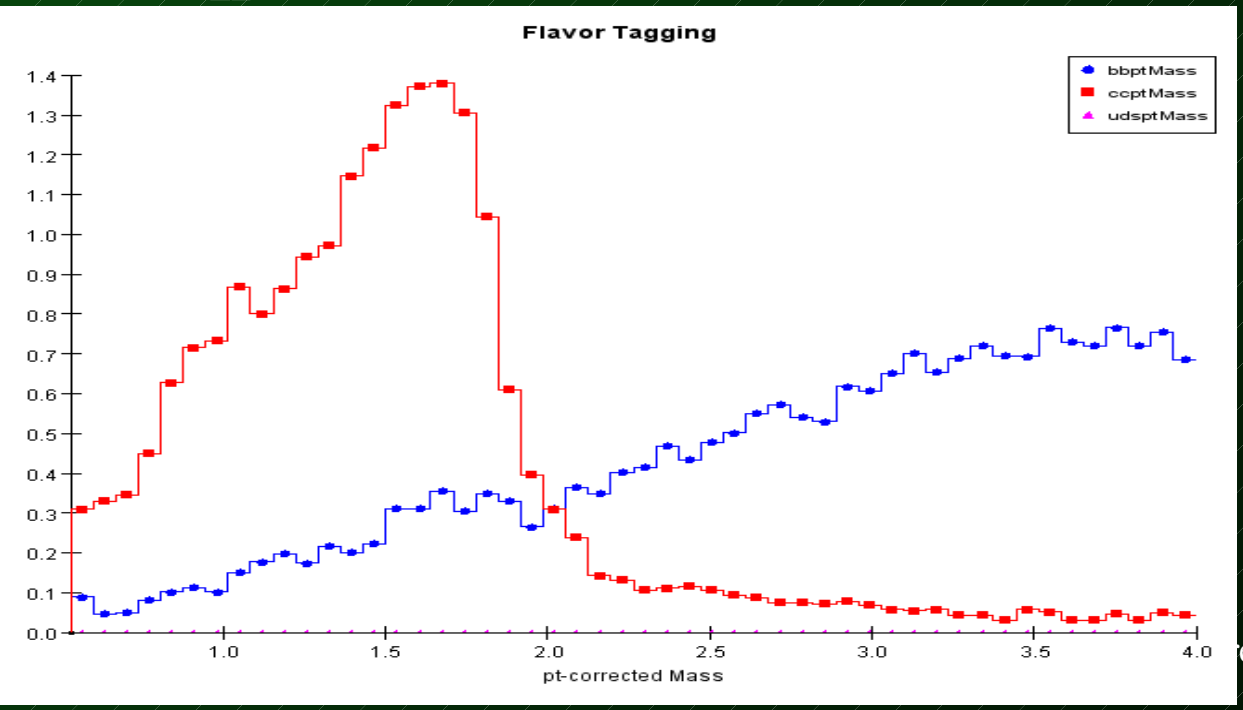
Tracks are assigned Gaussian probability tubes computed from the error matrix

The maximum overlap is calculated

P_T-corrected Mass for Flavor Tagging



$$m_{P_T} = \sqrt{\left(\sum_{\text{tracks}} m_{\pi^\pm}\right)^2 + \left|P_T^{Vtx}\right|^2} + \left|P_T^{Vtx}\right|$$



- The P_T-corrected mass already by itself gives quite reasonable results
- But you can see the contamination of B events in the D sample

ZVTOP @ SLD

- Developed by Dave Jackson
- Topological vertex finding, not a kinematic vertex reconstruction
- Written in a FORTRAN 77 dialect
- Evolved over the course of the experiment and resulted in a paper: NIM A388:247-253, 1997
  - The code has features that did not make it into the paper

hep.lcd

- Java analysis and reconstruction framework for the NLC
- ZVTOP was ported to hep.lcd by Wolfgang Walkowiak
  - Presentation of capabilities Snowmass 2001
- Direct translation of FORTRAN code to Java
- Various parts were working with different levels of reliability
  - ZVTOP seems to be working OK
  - GhostTrack was never finished
- Tied to specifics of hep.lcd, no unit tests

org.lcsim

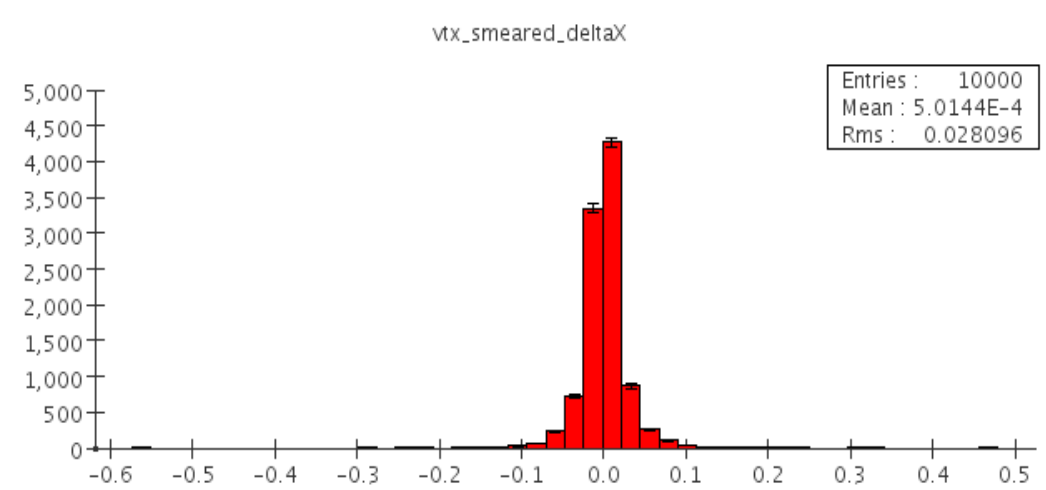
- ZVTOP did not survive transition from hep.lcd
  - The original author left, hardly any documentation
- New Approach:
  - Start afresh based on the paper
    - Make necessary adjustments to new environment
  - Implement the algorithm in the spirit of the new framework and the new language
    - Code re-use
      - HelixSwimmer
      - Kalman Fitter
    - Integration
      - Event Display
      - Fully reconstructed objects

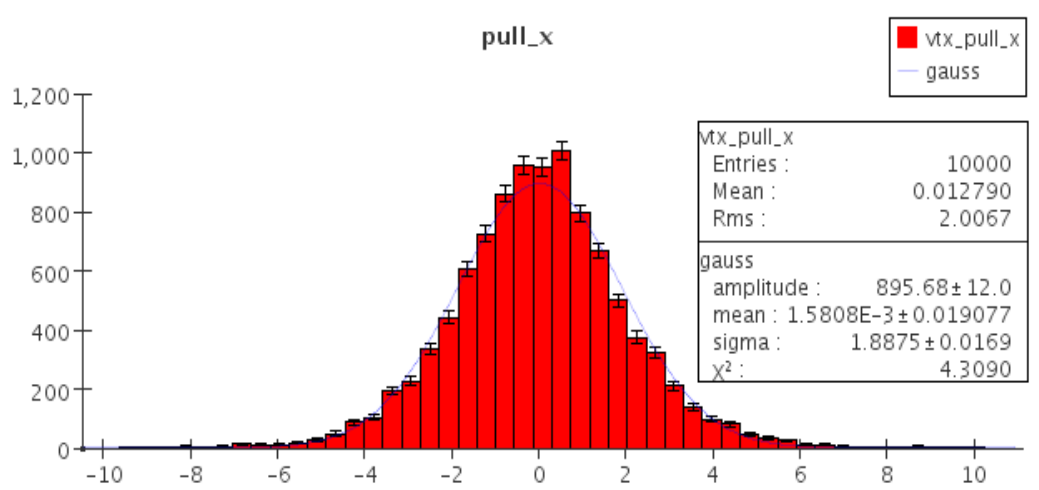
Code reuse

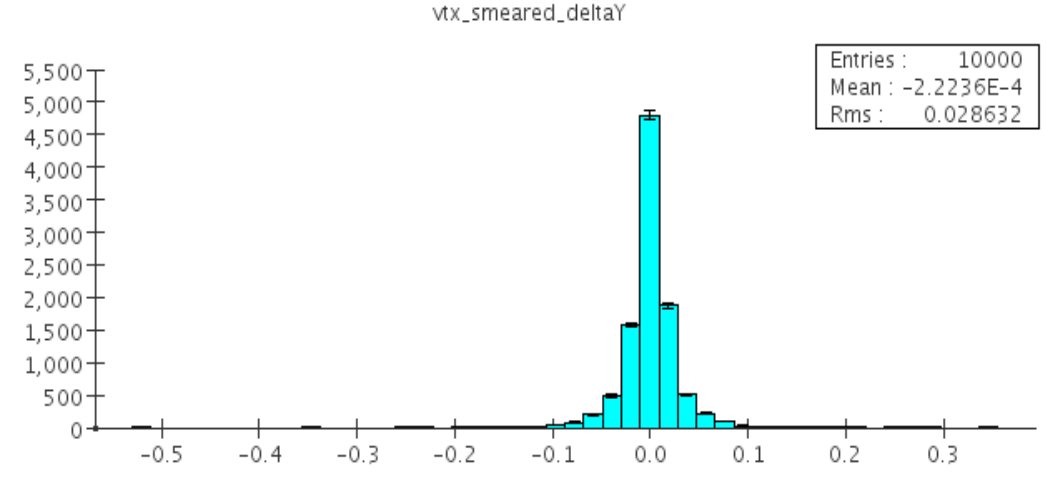
- HelixSwimmer
  - Paul Avery's algorithms
  - Implemented since Snowmass 2005
  - Today the default swimmer in org.lcsim
- Kalman Filter
  - Based on Grab and Luchsinger Comput.Phys.Commun.76:263-280,1993
  - Generic implementation, can be used for other analyses
  - Formalism suitable for incorporation of neutrals
    - Basis for extending ZVTOP and integrating into PFA

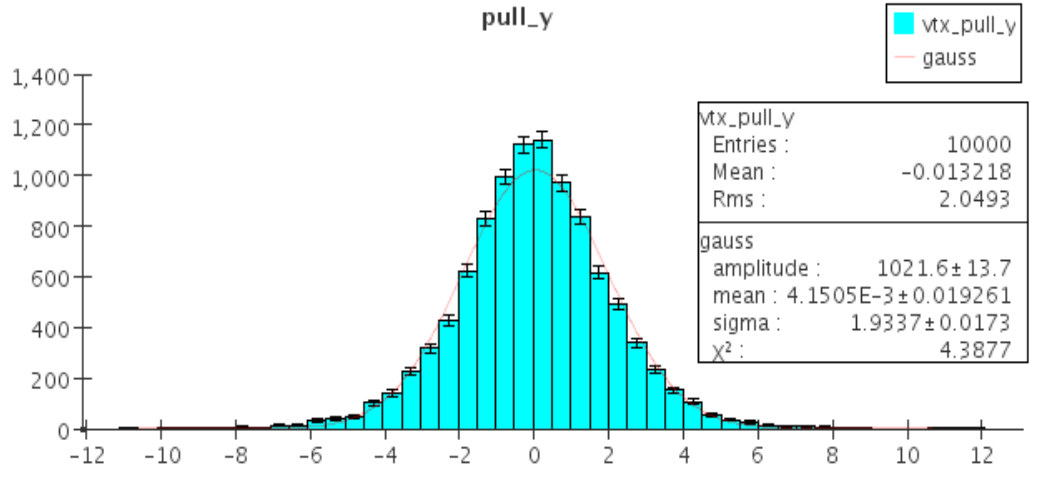
Kalman filter

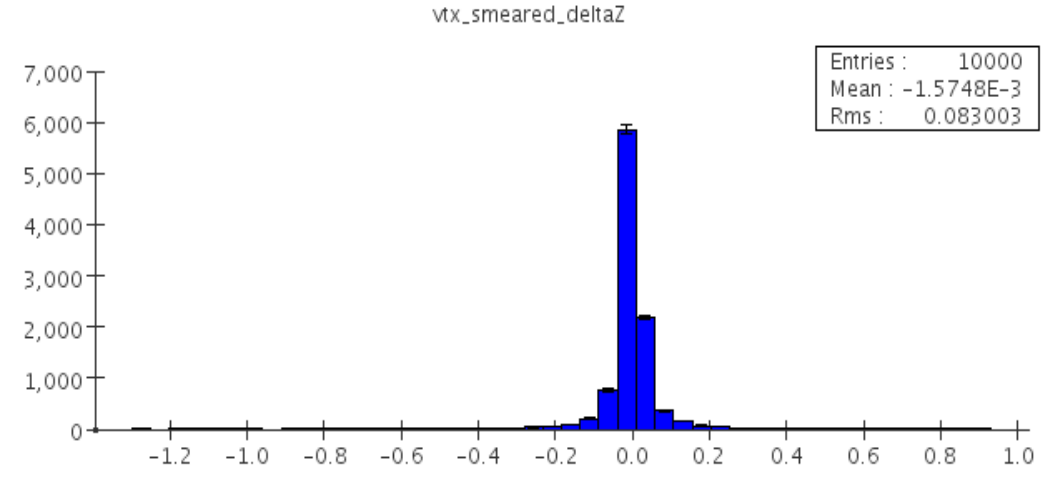
- Following is the resolution of the displaced vertex J/Psi --> mu mu
- Fast MC Tracks
- Results are without smoothing
- Possible Extensions: Adaptive Kalman filtering as implemented at the Tevatron
  - rather than having a chi2 cut, use chi2 weighting of all tracks

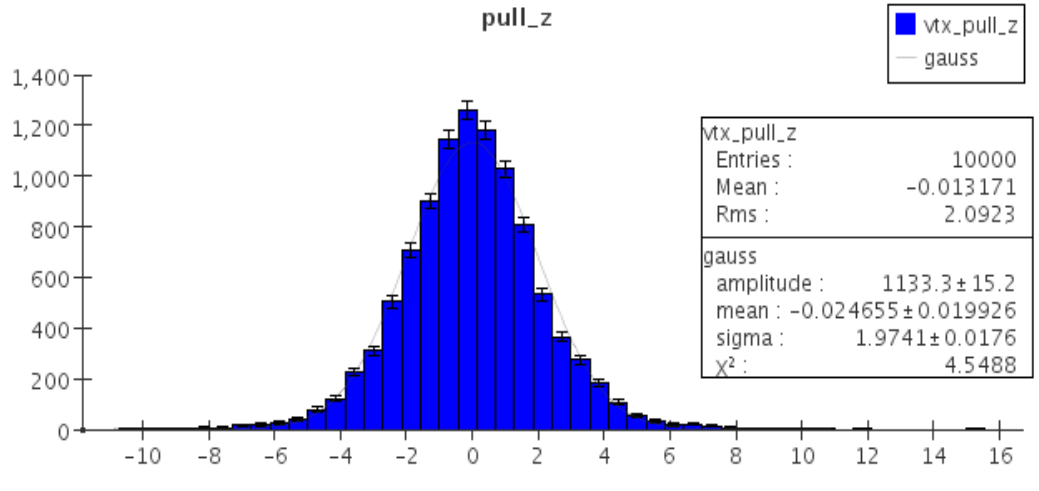

vtx_smeared_deltaX
Entries : 10000
Mean : 5.0144E-4
Rms : 0.028096


pull_x
vtx_pull_x
gauss
vtx_pull_x
Entries : 10000
Mean : 0.012790
Rms : 2.0067
gauss
amplitude : 895.68 ± 12.0
mean : 1.5808E-3 ± 0.019077
sigma : 1.8875 ± 0.0169
χ² : 4.3090


vtx_smeared_deltaY
Entries : 10000
Mean : -2.2236E-4
Rms : 0.028632


pull_y
vtx_pull_y
gauss
vtx_pull_y
Entries : 10000
Mean : -0.013218
Rms : 2.0493
gauss
amplitude : 1021.6 ± 13.7
mean : 4.1505E-3 ± 0.019261
sigma : 1.9337 ± 0.0173
χ² : 4.3877


vtx_smeared_deltaZ
Entries : 10000
Mean : -1.5748E-3
Rms : 0.083003


pull_z
vtx_pull_z
gauss
vtx_pull_z
Entries : 10000
Mean : -0.013171
Rms : 2.0923
gauss
amplitude : 1133.3 ± 15.2
mean : -0.024655 ± 0.019926
sigma : 1.9741 ± 0.0176
χ² : 4.5488

ZVTOP in org.lcsim

- The different components of ZVTOP work
- Many improvements over previous code
  - Full swimmer rather than parabolic approximation
  - Fitter algorithm to deal with neutrals
  - Fully reconstructed Tracks
  - Integration into event display
- Careful integration of all parts in order to maintain usability
- More users of each component
  → more stability

Competing implementations

- LCFI has a dedicated group working on ZVTOP
  - One full-time(?) grad student
  - Dave Jackson as advisor
- Sourceforge project
- Attempting a full implementation
  - ZVTOP
  - Ghost track algorithm
- Validation studies underway
  - Comparison with SLD code

Summary

- ZVTOP is an essential algorithm for physics studies at an ILC detector
- The implementation in org.lcsim was created with longevity and extensibility in mind
  - javadoc
  - high-level objects
  - PFA, Neutrals
- Testing, validation, documentation will be a lot of ~~work~~ fun

→ get involved now