New Capabilities in KWFIT

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Acknowledgment

Thanks to all the people who have found bugs and made suggestions for how to improve KWFIT. It would be impossible for me alone to explore the full phase space of possible situations.
**Definition**

Kinematic fitting is a mathematical procedure in which one uses the physical laws governing a particle interaction or decay to improve the measurements describing the process.

Example:

\[ D^0 \rightarrow K_s \pi^+ \pi^- \]
\[ K_s \rightarrow \pi^+ \pi^- \]

Hypothesis is that decay happens at the beam spot

Constraints:

1. \( \pi^+ \pi^- \) vertex for \( K_s \) (2*2–3 = 1)
2. \( K_s \) mass (1)
3. \( D^0 \rightarrow K_s \pi^+ \pi^- \) vertex (3*2 = 6)

So a total of 1 + 1 + 6 = 8 degrees of freedom
Overview of Capabilities

Independent of CLEO

- Dependence only in track filling routines
- Allows one to interface it to fast MC routines

Single track list

- Charged particles, $\gamma, \pi^0, K_s, \Lambda$
- “Virtual” particles, e.g. $D^0, B$, anything you define
- Tracks have 7 indep. quantities and $7 \times 7$ cov. matrix
  $p_x, p_y, p_z, E, x, y, z$

Non-vertex constraints

- Mass (1)
- Energy (1)
- Total momentum (1)
- 3-mom (3)
- 4-mom (4)
- Back-to-back (for $\mu^+ \mu^-$) (5)
**Vertex constraints**

- Unknown 3-D \((2N-3)\)
- Known 3-D (initial cov. matrix) \((2N)\)
- Fixed 3-D \((2N)\)
- Beam spot (calls “known” case) \((2N)\)
- Unknown 2-D \((2N-3)\)
- Known 2-D (initial cov. matrix) \((2N)\)
- Fixed 2-D \((2N)\)
- “Double vertex” \((2N-3)\)

Double vertex case is useful to find decay vertex for decays of type

\[
D^0 \rightarrow K_s \pi^0
\]

\[
K_s \rightarrow \pi^+\pi^-
\]

\[
\pi^0 \rightarrow \gamma\gamma
\]
Lifetime fitting ⇒ NEW!

- Fit for $c\tau$ directly ⇒ no multi-step procedure
- Correct accounting of all errors
- Uses all the information about the track, not just $y$
- You can smear $x, z$ errors to reproduce “$y$ only” method
- Keeps track of correlations of $c\tau$ with other parameters

\[ D^0 \]

- kvtx_known_lifetime
- kvtx_beam_lifetime
- kvtx_fixed_lifetime
- kvtx_two_vertex_life
Building virtual particles

- Idea: apply vertex constraint to a set of particles to build a new particle with the correct 4-momentum at the fitted position. Full $7\times 7$ covariance matrix computed.
- Compute track behaves like any other track, i.e., it can be moved, used in fits, etc.

Several ways of building virtual particles

- Unknown vertex
- Known vertex (covariance matrix)
- Beam vertex (calls “known vertex” case)
- Fixed vertex
Track quantities

- You can get info on almost any track quantity

  \texttt{kget\_track\_param}
  \texttt{kget\_track\_covar}
  \texttt{kget\_track\_mass}
  \texttt{kget\_track\_energy}
  \texttt{kget\_track\_momentum}
  \texttt{kget\_track\_p4}
  \texttt{kget\_track\_pperp}
  \texttt{kget\_track\_phi}
  \texttt{kget\_track\_theta}
  \texttt{kget\_track\_dca\_bend}

Errors of track quantities

- You can get error of almost any track quantity in KWFIT
- Quick understanding of error behavior
  Plot errors without fitting lots of distributions

  \texttt{kget\_track\_err\_mass}
  \texttt{kget\_track\_err\_energy}
  \texttt{kget\_track\_err\_momentum}
  \texttt{kget\_track\_err\_pperp}
  \texttt{kget\_track\_err\_phi}
  \texttt{kget\_track\_err\_theta}
  \texttt{kget\_track\_err\_dca\_bend}
Working on CLEO 3 version

Replace energy by mass in internal representation ⇒ wait for CLEO 3

- Energy is too correlated with other momentum variables
- Mass shifts when constraints applied after mass constraint
- No fundamental problems