

Kinematic Fitter Updates

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April 10, 2014

Kinematic Fitting: Major Improvements

- ▶ Can now disable individual mass constraints: Useful for studying background underneath the peaks.
- ▶ Can now perform inclusive fits: e.g. $\gamma p \rightarrow K^+ \Lambda(X)$
 - ▶ Kinematic fit won't apply p^4 constraint but will still apply m_Λ and vertex constraints.
- ▶ Improved invalid-constraint detection & recovery.
 - ▶ E.g. $\gamma p \rightarrow (K^+) \Lambda$ was not working before:
 - ▶ Tried to constrain both p^4 and m_Λ : non-invertible matrix.
 - ▶ Library now detects these cases and removes the m_Λ constraint.
- ▶ Confidence level histogram now shows details on the constraints & unknowns.

Kinematic Fitting: Minor Improvements

- ▶ Slightly-improved ($\sim 1 - 4\%$) convergence in detached-vertex fits: better initial guesses for vertex positions. E.g. for $\gamma p \rightarrow K^+ \Lambda$, $\Lambda \rightarrow p \pi^-$:
 1. Gets crude Λ decay vertex guess using $p \pi^-$ DOCA.
 2. Performs fit to $p \pi^-$ vertex to improve guess.
 3. **NEW:** Performs vertex- p^4 fit to $\Lambda \rightarrow p \pi^-$ to reconstruct Λ .
 4. Gets crude production vertex guess using ΛK^+ DOCA.
 5. **NEW:** Performs fit to ΛK^+ vertex to improve guess.
- ▶ Now returns full covariance matrix of reconstructed decaying particles (useful for above).
- ▶ Introduced mechanism for recovering fits that oscillate closely around the minimum χ^2 without converging:
 - ▶ If fit reaches max # of iterations (20) without converging ($\Delta\chi^2 < 0.001$) will mark as converged if ($\Delta\chi^2 < 0.005$)
- ▶ Fixed various minor bugs.

Tests of Kinematic Fitter

- ▶ 1M events generated with genr8 for the following reactions
 - ▶ $\gamma p \rightarrow K^+ \Lambda$
 - ▶ $\gamma p \rightarrow \pi^+ \pi^- \pi^0 p$
 - ▶ $\gamma p \rightarrow K^+ K^+ \Xi^-$
 - ▶ $\gamma p \rightarrow K^+ \Lambda \eta'$
- ▶ Simulated events analyzed with new and old kinematic fitter

General comments

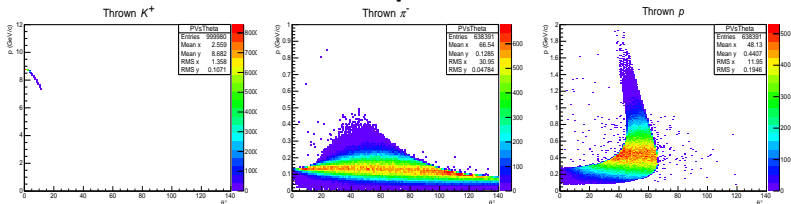
- ▶ Two t-slope values used for generation (1.5, 5)
- ▶ Most of the decays handled by HDGeant
- ▶ Cut on combined tracking FOM (0.1%)
- ▶ Cut on combined PID FOM (0.1%)
- ▶ Final cut is on Kinematic Fitter FOM (1%)

$$\gamma p \rightarrow K^+ \Lambda \rightarrow K^+ \pi^- p$$

Simulation details

- ▶ Λ decayed by HDGEANT
- ▶ Branching ratio $\Lambda \rightarrow p\pi^- \sim 64\%$

t-slope 5

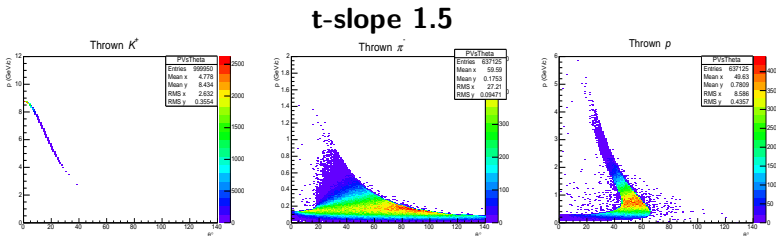


Note the different scales on the axes

$$\gamma p \rightarrow K^+ \Lambda \rightarrow K^+ \pi^- p$$

Simulation details

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- ▶ Branching ratio $\Lambda \rightarrow p\pi^- \sim 64\%$



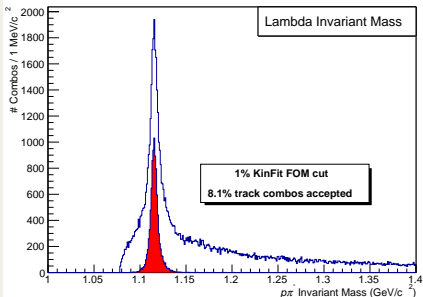
Note the different scales on the axes

$$\gamma p \rightarrow K^+ \Lambda \rightarrow K^+ \pi^- p$$

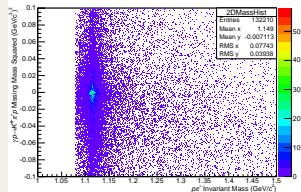
All particles detected

- ▶ 3% of simulated events accepted (t-slope 1.5)

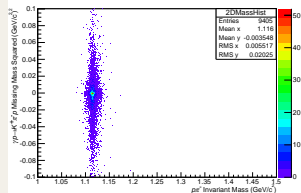
Λ invariant mass



Before KinFit Cut



After KinFit Cut

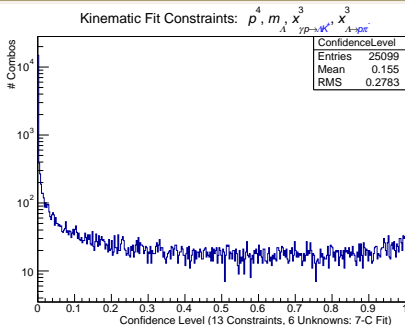


$$\gamma p \rightarrow K^+ \Lambda \rightarrow K^+ \pi^- p$$

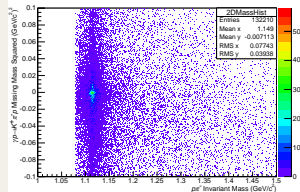
All particles detected

- ▶ 3% of simulated events accepted (t-slope 1.5)

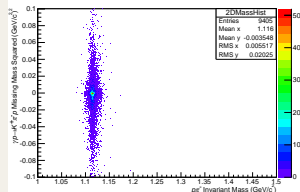
Kinematic Fit FOM



Before KinFit Cut



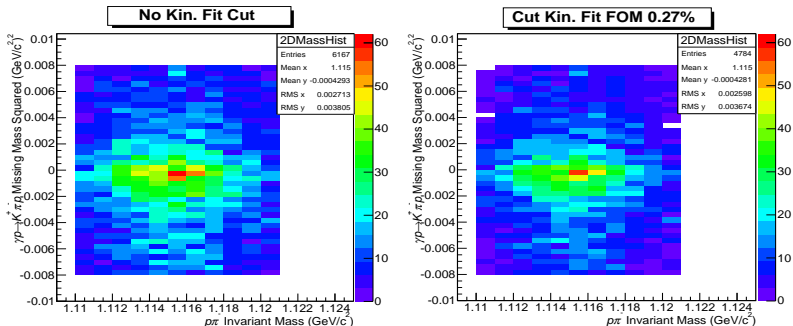
After KinFit Cut



$$\gamma p \rightarrow K^+ \Lambda \rightarrow K^+ \pi^- p$$

Comparison with cuts based analysis

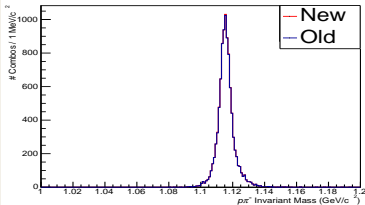
- ▶ Is the kinematic fitter converging as often as it should?
- ▶ How many events selected near our signal peak pass our kinematic fit cut:



- ▶ 77% of selected events pass our cut
- ▶ Background not accounted for - seems reasonable.

$$\gamma p \rightarrow K^+ \Lambda \rightarrow K^+ \pi^- p$$

Λ Inv. Mass (exclusive)



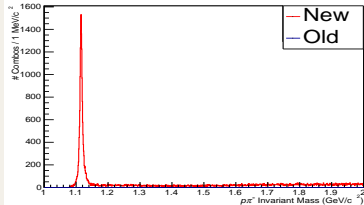
0.3% more accepted combos

Acceptance (passed all cuts):

t-slope 1.5: 3.0%

t-slope 5.0: 1.5%

Λ Inv. Mass (K^+ Missing)



Analysis was not working

Acceptance with missing K^+ :

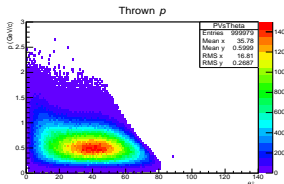
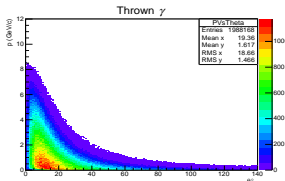
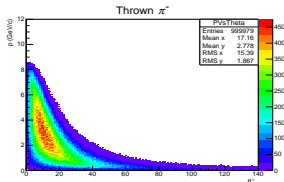
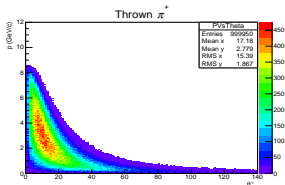
t-slope 1.5: 10.4%

t-slope 5: 8.6%

$$\gamma p \rightarrow \pi^+ \pi^- \pi^0 p$$

All particles detected

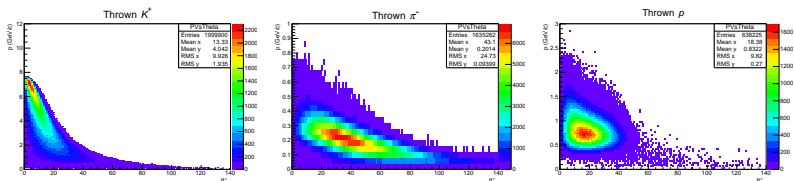
- ▶ Both new and old code perform roughly the same.
- ▶ 7.2% simulated events accepted (t-slope 5)



$$\gamma p \rightarrow K^+ K^+ \Xi^- \rightarrow K^+ K^+ \pi^- \Lambda \rightarrow K^+ K^+ \pi^- \pi^- p$$

Simulation details

- ▶ Ξ^- decayed by HDGEANT
- ▶ Branching ratio $\Xi^- \rightarrow \pi^- \Lambda \sim 100\%$
- ▶ Branching ratio $\Lambda \rightarrow p \pi^- \sim 64\%$

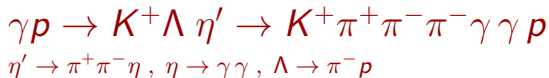


$$\gamma p \rightarrow K^+ K^+ \Xi^- \rightarrow K^+ K^+ \pi^- \Lambda \rightarrow K^+ K^+ \pi^- \pi^- p$$

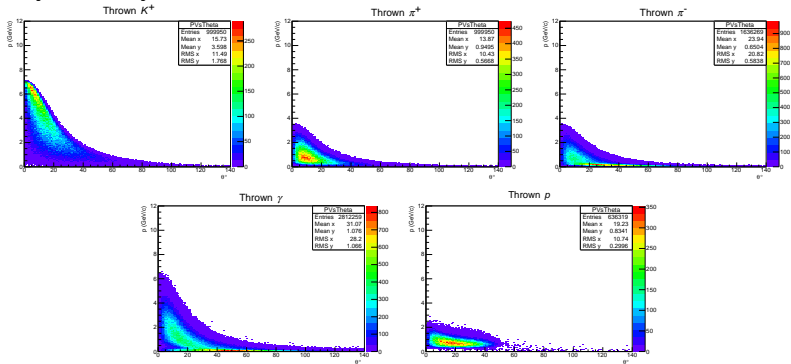
Overview of Results

638k events with correct topology
t-slope 5

	# Passed Cuts		Change
	Old	New	
Exclusive	242	243	+0.4%
Missing K^+	980	1011	+3.2%
Missing p	721	740	+2.6%
Missing π^- (Λ decay)	151	180	+19.3%



Only Λ decay in HDGEANT, others forced



	# Passed Cuts		Change
	Old	New	
Exclusive	382	396	+3.6%

- ▶ Latest update fixes several bugs and improves performance of the kinematic fitter.
- ▶ Overall a more robust package for the user without having to write custom code.
- ▶ Some other simulated channels checked:
 1. $\gamma p \rightarrow K^0 \eta \Sigma^+$
 2. $\gamma p \rightarrow \pi^+ \pi^- p$
 3. $\gamma p \rightarrow K^+ \Sigma^0$
 4. $\gamma p \rightarrow K^{*+} \Lambda$
- ▶ Code is available on Hall-D SVN.