$K^0\Lambda$ and $K^+\Sigma^*$

PHOTOPRODUCTION ON THE DEUTERON

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Missing N* resonances
  - Coupling to Y and Y* decay channels to help find high mass states

\[ \gamma D \rightarrow K^*0 \Lambda (p) \text{ and } \gamma D \rightarrow K^+ \Sigma^{*-} (p) \] have same final state (pK^+π^-π^-)
  - Calculate Cross Sections & Asymmetries for both

g13a experiment data (circularly polarized photons)

Perform reaction-specific particle ID to obtain a relatively clean K^+ signal

Preliminary Signals with 2% of g13a data, cooking now underway
Missing $N^*$ resonances
- predicted by quark models
- hard to find (wide, overlapping resonances)

Most $N^*$ data comes from $\pi N$ analyses ($\pi$ beams or decays into final state $\pi$’s)

Coupled-channels analysis of $N^*$ decays
- Can be used to isolate the different $N^*$ signals
- $Y$ and $Y^*$ decay channels are new

Several $N^*$ predicted to decay non-negligibly to $Y^*$ channels:

- $K^*\Lambda$
  - $[N7/2-]_1(2090) = N(2190)G_{17}^{****}$
  - $[N1/2-]_3(1945) = N(2090)S_{11}^*$
  - $[N1/2-]_5(2070)$

- $\Sigma^*K^+$
  - $[N5/2+]_2(1980)$
  - $[N3/2-]_3(2095)$

* Capstick, Roberts; Phys Rev D, 58 074011 (1998)
Cross-sections predominantly t-channel process (red lines)

However, in the s-channel calculations only the Born term is included
- No resonant s-channel terms included because not enough information yet on couplings

**K⁺ Σ⁺⁻ Predictions and LEPS Data**

- γ P Prediction shown, γ N on the way
- γ N LEPS/CLAS data forward/large angles
- Haiyun Lu: eg3, High Energy

* Hicks, et al. (LEPS); arxiv:0812.0771v1 (2008)
g13 Experiment Overview

- Ran between October 2006 and June 2007

**g13a – Circularly Polarized Photons**
- $E_e$ 2.0 GeV, 84% $\gamma$ polarization
- $E_e$ 2.65 GeV, 78% $\gamma$ polarization
- Trigger = 2 Sectors, Up to 10 kHz
- Statistics
  - $2 \times 10^{10}$ Triggers
  - $> 2 \times 10^5$ Exclusive $K^0 \Lambda$ Events

**g13b – Linearly Polarized Photons**
- $E_e$ 3.3 – 5.2 GeV
- $E_\gamma$ 1.1 – 2.3 GeV
  - Six Settings
  - Polarization 70 – 90%
- Trigger = 1 Sector, 7 – 8 kHz
- Statistics
  - $3 \times 10^{10}$ Triggers
  - $> 10^5$ Exclusive $K^0 \Lambda$ Events
Pass 1 of g13b cooking completed
  - Problem found with dc-alignment
  - No trip files
Pass 1 of g13a cooking underway (7.5%)
Analysis Outline

- Pass0 g13a Data, ~2% of g13a Total
- Reaction-Specific Particle Identification
- Wide-cut Event Candidate Skim
- $p$ & $\pi^-$ Identification
- $\Lambda$ Event Selection
- $K^+$ Identification
- Missing Proton Event Selection
- $K^*0$, $\Sigma^*$ Interference Cut
Event Candidate Skim

- Require at least 2 $q^+$ and 2 $q^-$ tracks
- Test every possible track combination: all $q^-$ tracks as $\pi^-$, all $q^+$ tracks as $p$ and $K^+$
- The $\gamma$ with time closest to the $\pi^-$ at reaction vertex is selected
- Wide Timing Cuts
  - $p$, $\pi^-$ within 8 ns at $\Lambda$ decay vertex
  - $K^+$, $\pi^-$ within 5 ns at reaction vertex
  - $\gamma$, $\pi^-$ within 4 ns at reaction vertex
  - $\gamma$, $K^+$ within 6 ns at reaction vertex
- Wide Mass Cuts
  - $1.09 \text{ GeV} < \Lambda$ Invariant Mass $< 1.14 \text{ GeV}$
  - $0.7 \text{ GeV} < p$ Missing Mass $< 1.2 \text{ GeV}$
- 0.025% Data Remaining, Negligible Signal Loss
\( \pi^- \) Identification

- \( \Delta \beta \) Vs Momentum
  - Fit to Gaussians, 3\( \sigma \) Cut
Proton Identification

- $\Delta \beta$ Vs Momentum
  - Fit to Gaussians, 3 $\sigma$
  - Cut
Fit $t_p - t_{\pi^-}$ vs Proton momentum to Gaussians, Cut at $3\sigma$

Fit $p\pi^-$ Invariant Mass to Gaussian + Flat Background, Cut at $3\sigma$

Entries 34384
$\chi^2$/ndf 42.06/36
Gaussian Height 604.8
Gaussian Mean 1.116
Gaussian Sigma 0.001675
p3 140.2
K⁺ Identification

- Δ β Vs Momentum
  - Fit to Gaussians, 3 σ Cut
Missing Proton Selection

- Fit Proton Missing Mass to Gaussian + Flat Background, Cut at $3 \sigma$
- 1.4% of events have > 1 successful track combination: the one with the smallest $p$, $\pi^- \Delta t$ is chosen
A $\pi^+$ misidentified as a $K^+$ will most likely manifest in $K^0$.

$\pi^+$, $\pi^-$ invariant mass by forcing all $K^+$ as $\pi^+$.
Interference Cut

![Graph showing interference cut in a two-dimensional coordinate system withInvariant Mass (GeV/c^2) on the x-axis and K^+ Invariant Mass (GeV/c^2) on the y-axis. The graph is color-coded with a color bar indicating entries from 0 to 18.]
Signals, 2% g13a Data

- \[ \sum^{*-} \]
  - 1798 Events
  - 10.9 Sig/Back Ratio

- K^*0
  - 179 Events
  - 1.1 Sig/Back Ratio

CLAS Collaboration Hadron Spectroscopy Group Meeting

June 12, 2009
KC\(^*\)0 ∨ Signal Binning

- 2% of g13a Data
- 25 Bins In Either Variable (1D), ~350 Counts/Bin
K$^+ \Sigma^*$ Signal Binning

- 2% of g13a Data
- 25 Bins in Either Variable (1D), ~3600 Counts/Bin
Major Ongoing/Future Work

- Acceptance Corrections
  - Using fsgen with t-channel model from Oh, Kim
  - Working on Matching Monte Carlo & Data
- Beam Energy & Momentum Corrections
  - $\gamma D \rightarrow pp \pi^-$ Kinematic Fit, Track Momentum Treated As Unknown (eg3)
- Photon Flux Determination (gflux)
- Reproduce a Known Cross-Section
- Systematic Error Studies
- Calculate $K^0 \Lambda$ and $K^+ \Sigma^-$ Cross Sections & Asymmetries