Analysis of Exclusive $\Sigma^*$ Production

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EG3 Collaboration, CLAS Collaboration
Physics Motivation

- Reaction channel: $\gamma D \rightarrow K + \Sigma^* (p)$
- Final Particles $K^+ p \pi^- \pi^-$
- $N^* \rightarrow KY$, search for "missing" states and KY coupling
- $Y^*$ spectrum, constraint on SU(3) of decuplet baryons
- $KN$ coupling, comparison with $\pi N$
- $YN$ final state interaction if possible
World Data

K. Hicks et al., PRL 102, 012501 (2009)

Polarized data by Paul Mattione

Hadron 2009, Tallahassee, FL
Jefferson Lab
Detector
Data Set

- EG3 run
  - Electron beam energy: 5.7 GeV
  - Beam intensity: 30nA
  - Tagged photon energy: 1.15 GeV – 5.5 GeV
  - Target: 40 cm Deuteron
  - Trigger:
    - photon energy 4.5 GeV – 5.5 GeV
    - three-sector triggering
Channel Specified PID

\[ \beta \text{ vs. Momentum of Positive Particles} \]

\[ \beta \text{ vs. Momentum of Negative Particles} \]
Event Selection

$K^+ p \pi^- \pi^-$ is required exclusively and $\Lambda$ is reconstructed, fitted and cut on 3 $\sigma$. The pair of $p \pi^-$, whose invariant mass is closer to $\Lambda$ is selected.

$\Lambda$ from experimental data

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Invariant vs. Missing Mass

Invariant Mass of $\Lambda\pi^-$ vs. Missing Mass of $K^+\Lambda\pi^-$
$\Sigma^*$ vs spectator proton should appear.

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Slices into Photon Energy

17 histograms

Photon energy: 1.25GeV – 5.5GeV

Side band appears and increases on the right hand side when photon energy increases

Cut is on $3\sigma$ around the peak

Missing Mass of $K^+\Lambda\pi^-$ is plotted and peak of spectator proton is fitted
Invariant Mass of $\Lambda\pi^-$ is plotted after MM cut and peak is fitted with Breit-Wigner function.

17 histograms

Photon energy: 1.25GeV – 5.5GeV

Red: overall fit
Green: B-W fit
Yellow: background

Integration ranges are same as the range of the green lines.
Non-exclusive Background Subtraction

Plotted after $3\sigma$ cut on the RHS of spectator peak

17 histograms

Photon energy: $1.25\text{GeV} - 5.5\text{GeV}$

Red: overall fit
Green: B-W fit
Yellow: background
Preliminary Yield

Preliminary yield obtained after side band subtraction and correction due to trigger on photon energy above 4.5 GeV

Immediate result after subtraction  Yield after correction applied
Preliminary Cross Section

Total Cross Section

Events Generated

GFlux Corrected Yield

Acceptance
Corrections and Cuts

- ELoss Correction – Done on both data and simulation
- Trigger Correction – Done only on data
- Trigger Efficiency – Done only on data
- Particle ID Cut – Done on both data and simulation
- Λ Mass Cut – Done on both data and simulation
- Missing Momentum Cut – Done on both data and simulation
K*Λ vs KΣ*
Comparison

Total Cross Section

- with $k^*$ (no cut applied)
- without $k^*$ (cut applied)

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Exchange Meson Study

\[ \Lambda (p) \rightarrow z \]

\[ K (K^*) \rightarrow \Sigma(1385) \]

\[ /\Lambda(1520) \]

\[ \pi^0(K^-) \]

t channel helicity frame
(Gottfried-Jackson frame)

D. P. Barber et al., Z. Phys.
C 7, 17 (1980)

\[ \sigma = a \left( \frac{1}{3} + \cos^2 \theta \pi_0^+ \right) + \beta \sin^2 \theta \pi_0^- + \gamma \cos \theta \pi_0^- \]

|\( m_z \)| = 1/2 \quad \text{or interference}

|\( m_z \)| = 3/2

J=1/2
$\Sigma^*(1385)\rightarrow \Lambda\pi$ Decay Angular Distributions

Preliminary results from L. Guo

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$\Sigma^*(1385)$ Exchange Meson Study

Preliminary results: $K^*/K = 4:1$
(J=1/2)/K = -0.1
Outlook

• Finalize the total cross section, $\sigma$
• $T$-dependent differential cross section, $d\sigma/dT$
• Angle-dependent differential cross section, $d\sigma/d\theta_k$
• Energy-dependent exchange meson study
References

- D. P. Barber et al., Z. Phys. C 7, 17 (1980)
- http://www.jlab.org/~lguo/talks/gwu/GWU_GUO.ppt
Trigger Correction

Graph showing data with values 67.636019, 14.872306, and R=4.547783. Table with entries, mean, and RMS values.
Missing Momentum

[Graph showing Missing Transverse Momentum VS Missing Pz]
GFlux Normalization

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Missing Momentum

![Graph showing the distribution of missing momentum with bins for particle energies in GeV.](#)
Trigger Efficiency

![Graph showing trigger efficiency data with entries, mean, and RMS values.]

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Initial Particle Identification

$\beta$ vs. Momentum of Negative Particles

$\beta$ vs. Momentum of Positive Particles

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Reaction-Specific PID Method

Final particles: $K^+\Sigma^*$ $\rightarrow K^+p\pi^-\pi^-$. Obtain photons coincident with two negative particles and plot time difference difference.

From the above, the mis identification is on the level of 1% and the loss of good events is another order small.
Simulation

Events generated with fsgen and simulated with GSIM

17 histograms

Photon energy: 1.25GeV – 5.5GeV

There is no side band appearing and no surprise about that

Cut is on 3σ around the peak
Ratio of difference over without $k^*$