Λ*(1520) Photoproduction on Proton and Neutron from CLAS eg3 data set

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- Physics motivation
- Data analysis
- Preliminary results
- Summary and outlook
Physics Motivation

\( \Lambda(1520) \, D_{03} \quad I(J^P) = 0(3/2^-) \)

\[ \text{Mass } m = 1519.5 \pm 1.0 \text{ MeV} \quad \text{Full width } \Gamma = 15.6 \pm 1.0 \text{ MeV} \]

- \( \Lambda^*(1520) \) production mechanism is still poorly understood due to the lack of experimental data.
  
  on the Proton

1. two photoproduction measurements

2. two electroproduction measurements

  on the Neutron,

  *No published data*

- Existing Data suggest dominance of t-channel processes and \( K^* \) or \( K \) exchange.

- Several model predictions for total and differential cross sections are available.

- Measurement of cross section and decay angular distribution can provide constraints on model prediction and insights into the production mechanism.

- Possible missing \( N^* \) resonances decaying through strange channels.
• Photoproduction measurements on the Proton were performed at SLAC and Daresbury

• Daresbury measured differential and total cross section as well as decay angular distribution in the energy range of 2.8-4.8 GeV
  – First look at the decay angular distribution showed dominance of \( m_z = \pm \frac{3}{2} \) spin projection
  – Limited statistics

• **No data on Neutron yet**
Theoretical Result

Proton
Comparing between data and theory

Electroproduction of $\Lambda^*$ off Proton has been studied at DESY and CLAS

CLAS data (S. Barrow, e1c) showed:
- Dominance of t-channel process confirmed
- Decay angular distribution showed significant contribution from $m_z=\pm 1/2$ spin projection
CLAS Detector

Drift Chambers
35,000 wires
$\sigma_R = 350 \, \mu m$

Superconducting Toroidal Magnet
$\int Bdl = 1.7 \, T \cdot m$

Cerenkov Counters
216 channels
99.5% efficient
over 50 m$^2$ area

electron beam direction

Time of Flight Counters
500+ channels, 145 ps resolution

Electromagnetic Shower Calorimeters
1700+ channels
$\sigma/E = 10\% / E^{0.5}$
Relevance Channels

deacon target

\[ \gamma p(n) \rightarrow K^+ \Lambda^* (n) \quad \text{Proton} \]
\[ \gamma n(p) \rightarrow K^0 \Lambda^* (p) \quad \text{Neutron} \]
\[ (\Lambda^* \rightarrow p K^-, K^0 \rightarrow K^s \rightarrow \pi^+ \pi^-) \]

eg3 run

- Photon beam: electron beam 5.77 GeV, photon energy Tagger 1.15 < E < 5.5 GeV, 30 nA
- Target: 40 cm upstream, LD2
- Trigger: Tagger 4.5 < E < 5.5 GeV, STxTOF (3 sectors and prescaled 2 sectors), ST
- Torus field: optimized to -1980 A, negative outbending
- Run period: 12/06/2004 – 01/31/2005, 29 days of production on LD2 target
- Data: 4.2 billion physics events, 32 TB raw data, average 2.7 tracks/event
Event Selection

Particle timing after photon selected

Cut Missidentified Pions

Before misid $\pi^+ \pi^- \text{ cut}$

After misid $\pi^+ \pi^- \text{ cut}$
Event Selection

Positive

Negative

Particle timing after photon selected

InvM of $K^0$

Before $K^0$ cut

After $K^0$ cut

Before $K^0$ cut

After $K^0$ cut

MM($\rho\pi^+\pi^-\pi^-$) (GeV)

MM($\rho\pi^+\pi^-K^-$) (GeV)
InvM of $p\ K^-$

Proton

Neutron
Proton Kinematic Distribution

$1.5 < E_\gamma < 5.5$ GeV
16 bins, bin width = 250 MeV

$0.25 < t' < 3$ GeV²
6 bins, bin width varies
Kinematic Distribution

1.75 < $E_\gamma$ < 5.5 GeV
6 bins, bin width varies

0. < $t'$ < 3 GeV$^2$
6 bins, bin width varies

Data

Simulation

$t' = -(t - t_0)$ (GeV)$^2$

$E_\gamma$ (GeV)

$t' = -(t - t_0)$ (GeV)$^2$

$E_\gamma$ (GeV)
Yield Extraction (data)

1.5 < \( E_{\gamma} \) < 5.5 GeV
16 bins, bin width=250 MeV

0.25 < \( t' \) < 3 GeV^2
6 bins, bin width varies

\( M(pK^-) \) GeV
Yield Extraction (data)

0. < t' < 3 GeV²
6 bins, bin width varies

1.75 < E_γ < 5.5 GeV
6 bins, bin width varies
Yield and Acceptance

Yield

Data

Simulation

N of generated

Acceptance

Proton

\[ \text{Yield} = \frac{dN}{dE} \]

\[ \text{Acceptance} = \frac{dN}{dE} \]

\[ t' \text{ bin} \]

\[ E'_Y \text{ bin} \]

\[ t' \text{ bin} \]

\[ E'_Y, t' \text{ bin} \]
Proton

Differential Cross Section

\[ \frac{d\sigma}{dt} (\mu b) \]

1. 1.5 < $E_\gamma$ < 5.5 GeV
   16 bins, bin width=250 MeV

2. Extrapolating to low \( t' \) with an exponential function

3. Integrating over \( t' \) to get total cross section.

Preliminary, stat error only
Differential Cross Section

- $1.75 < E_\gamma < 5.5$ GeV
- 6 bins, bin width varies

- Extrapolating to low $t'$ with an exponential function

- Integrating over $t'$ to get total cross section.

Preliminary, stat error only
Total Cross Section

\( \Lambda^*(1520) \) total cross section

\[ \sigma_{\text{Tot}} (\mu b) \]

Preliminary, stat error only
t-slope

Preliminary, stat error only
Summary

• The $\Lambda^*(1520)$ differential and total cross sections up to 5.5 GeV on the *Proton* are extracted. The total cross section is in good agreement with the the CLAS g11 run and Daresbury results.

• The $\Lambda^*(1520)$ differential and total cross sections on the *Neutron* are obtained for the first time. The total cross section is much larger than what the theory expected.

Outlook

• Decay angle study

• systematics

• Look for possible missing N* resonances.
Back up
Phi and Lambda_{1520} interference
Decay angle