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

Zhiwen Zhao
Hadron 2009/06/12

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

\[ \Lambda(1520) \ D_{03} \]

Mass \( m = 1519.5 \pm 1.0 \) MeV\(^{[a]}\) 

Full width \( \Gamma = 15.6 \pm 1.0 \) MeV\(^{[a]}\)

- \( \Lambda^*(1520) \) production mechanism is still poorly understood due to the lack of experimental data.
  1. a few photoproduction measurements on the Proton
     no published data on the Neutron
  2. a few electroproduction measurements on the Proton

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

- Several model predictions for total and differential cross sections are available.
  J. M. Laget, V. Yu. Grishina et al., L. Roca et al., S. Nam et al.

- 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.
Existing data

Photoproduction

- 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 $m_z=\pm 3/2$ spin projection.
  - Limited statistics.

- **No data on Neutron yet**
Theoretical result  Photoproduction

Comparing between data and theory (Proton)

• Electroproduction of Λ* 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
**Reaction Channels**

*two exclusive*

\[
\gamma p(n) \rightarrow K^+ \Lambda^* (n) \quad \text{Proton}
\]

\[
\gamma n(p) \rightarrow K^0 \Lambda^* (p) \quad \text{Neutron}
\]

\[(\Lambda^* \rightarrow p K^- , K^0 \rightarrow K^s \rightarrow \pi^+ \pi^-)\]

**eg3 run**

- **Photon beam**  
edlectron beam 5.77 GeV, photon energy Tagger 4.5 < E < 5.5 GeV, 30 nA
- **Target**  
40 cm upstream, LD2
- **Trigger**  
Tagger 4.5 < E < 5.5, STxTOF (mainly 3 sectors and prescaled 2 sectors)
- **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
Particle Identification

starttime by cooking code

starttime after photon selected with particle vertex timing

Cut Missidentified Pions

Proton

Positive

Negative

Mom (GeV)

MM2 \( p\pi^+\pi^- (\text{GeV}^2) \)
Particle Distribution data

Proton 

mom\_phi\_Lambda1520\_kaonm

theta\_phi\_Lambda1520\_kaonm

theta\_Lambda1520\_kaonp

mom\_Lambda1520\_kaonp

mom\_theta\_Lambda1520\_kaonp

mom\_phi\_Lambda1520\_proton

theta\_phi\_Lambda1520\_proton

theta\_Lambda1520\_proton

mom\_Lambda1520\_proton

mom\_theta\_Lambda1520\_proton

Mom (GeV)

Mom (GeV)
Particle Distribution data

Positive, Sector 1 - 6

Negative, Sector 1 - 6

Mom (GeV)
Particle Distribution

Proton

Negative, Sector 1 - 6

Positive, Sector 1 - 6

Mom (GeV)
Neutron Missing Mass

MM2 of Neutron

- Signal: 232722
- Background: 113143
- Ratio: 2.056883

MM2 of Neutron

- Signal: 52651
- Background: 29799
- Ratio: 1.766877

Proton
Yield Extraction (data)

- Data are binned by $E_\gamma$ and $t^* = -(t-t_0)$
- The $\Lambda^*$ yield is extracted as fitting the $P K^-$ invariant mass spectrum with BW function convoluted with a Gaussian + polynomial
- The width and peak of the BW are fixed to $\Lambda^*$ PDG value. the sigma of the Gaussian is a fitting parameter

$0 < t^* < 2 \text{ GeV}^2$
6 bins, binwidth = 0.33 GeV$^2$

$1.5 < E_\gamma < 5.5 \text{ GeV}$
16 bins, binwidth=250MeV

InvM pK- (GeV)
Proton

Yield and Acceptance

Data

Yield

Simulation

N of generated

Acceptance

$E_Y$, $t^*$ bin

$E_Y$, $t^*$ bin

$E_Y$, $t^*$ bin

$E_Y$, $t^*$ bin

$E_Y$, $t^*$ bin

$E_Y$, $t^*$ bin

$E_Y$, $t^*$ bin

$E_Y$, $t^*$ bin

$E_Y$, $t^*$ bin

$E_Y$, $t^*$ bin
Differential Cross Section

- $1.5 < E_{\gamma} < 5.5$ GeV
  - 16 bins, binwidth=250 MeV
- Extrapolating to low $t^*$ with an exponential function
- Integrating over $t^*$ to get total cross section.
Yield and Acceptance

Data

Yield

$E^*_\gamma$ bin

Acceptance

Simulation

N of generated

$0 < t^* < 2 \text{ GeV}^2$

4 bins, binwidth = 0.5 GeV$^2$

$1.5 < E^*_\gamma < 5.5 \text{ GeV}$

8 bins, binwidth = 500 MeV
Total Cross Section

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

Daresbary on proton
g11 on proton, preliminary result by R. De Vita
eg3 on proton, integrated over differential cross section
eg3 on proton, fit over $E_\gamma$ bin
eg3 on neutron, fit over $E_\gamma$ bin

Very Preliminary
t slope

Very Preliminary
Summary

• The Λ*(1520) total cross section on the Proton extracted by integrating over differential cross sections agrees with the result from the g11 run group and extends to higher energies up to 5.5 GeV.
• The Λ*(1520) total cross section on the Proton, extracted by fitting yields in $E_\gamma$ bins, depends on the $t$ slope input in the simulation. It can be tuned closer to the more accurate result based on differential cross sections.
• The total cross section on the Neutron is obtained by fitting yields in $E_\gamma$ bins and it’s much larger than what the theory expected.

Outlook

• Study other inclusive channels (eg. K not detected) with higher statistics to obtain differential cross section on the Neutron.
• Look for possible missing N* resonances.