Search for Θ^+ in inclusive $\Lambda(1520)$ photoproduction on deuterium with CLAS

Tsutomu Mibe (Ohio University)
for the CLAS collaboration

Pentaquark 2005, Oct. 20-22
at Jefferson Lab.

Motivation

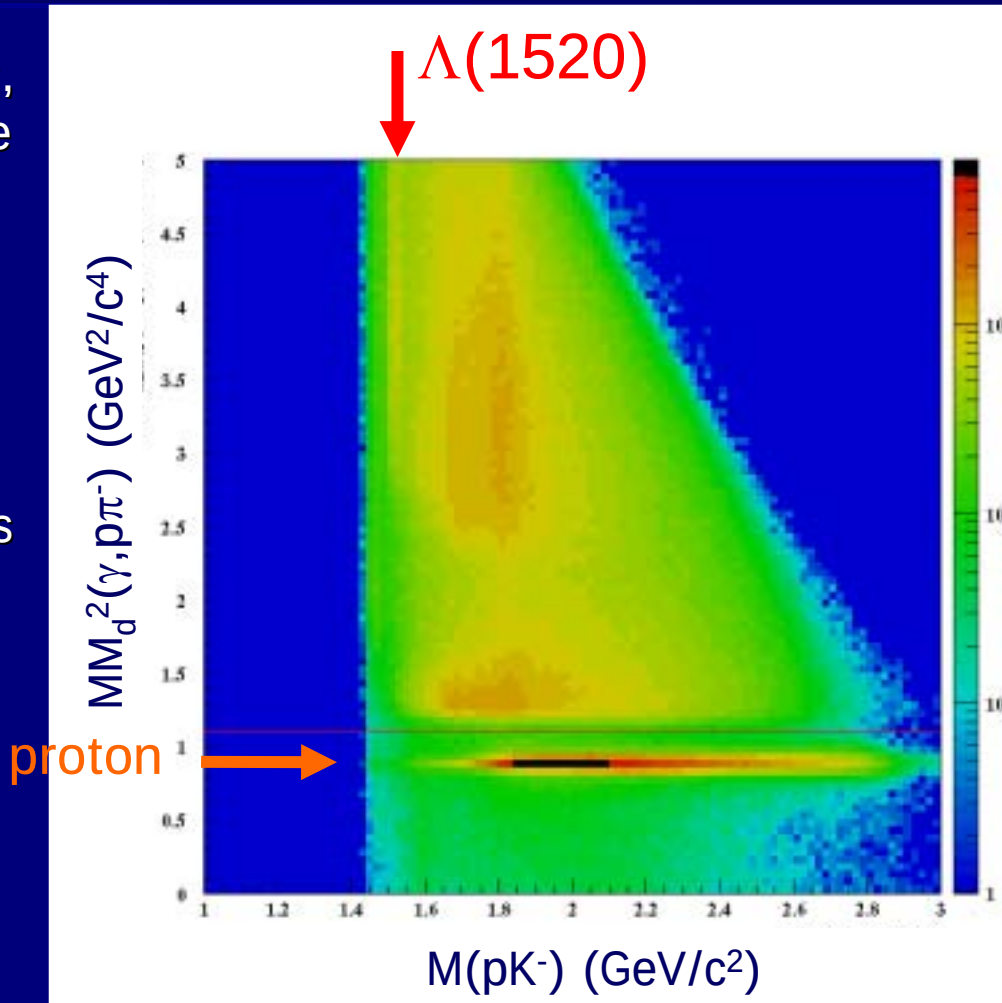
- Positive evidence of Θ^+ was reported by LEPS in $\gamma d \rightarrow \Lambda(1520)\Theta^+$ reaction by detecting pK^- (talk by Nakano).
- CLAS g10 experiment took high statistics data on photo-deuterium reaction (talk by Stepanyan)
- Can CLAS g10 check the LEPS Θ^+ evidence?

Data analysis

- Analysis requires …
  - p K- tracks reconstructed by CLAS
  - good tagged photon
  - track vertex originated from LD2 target
  - removal of mis-identified π^- track
  - K^- is not from quasi-free ϕ photoproduction
  - pK^- pairs from $\Lambda(1520)$ decay
- Search for Θ^+ signal in missing mass for $\gamma d \rightarrow pK^- X$ reaction
- All g10 data was analyzed. I will focus on results from the data with low torus field (larger pK^- acceptance).

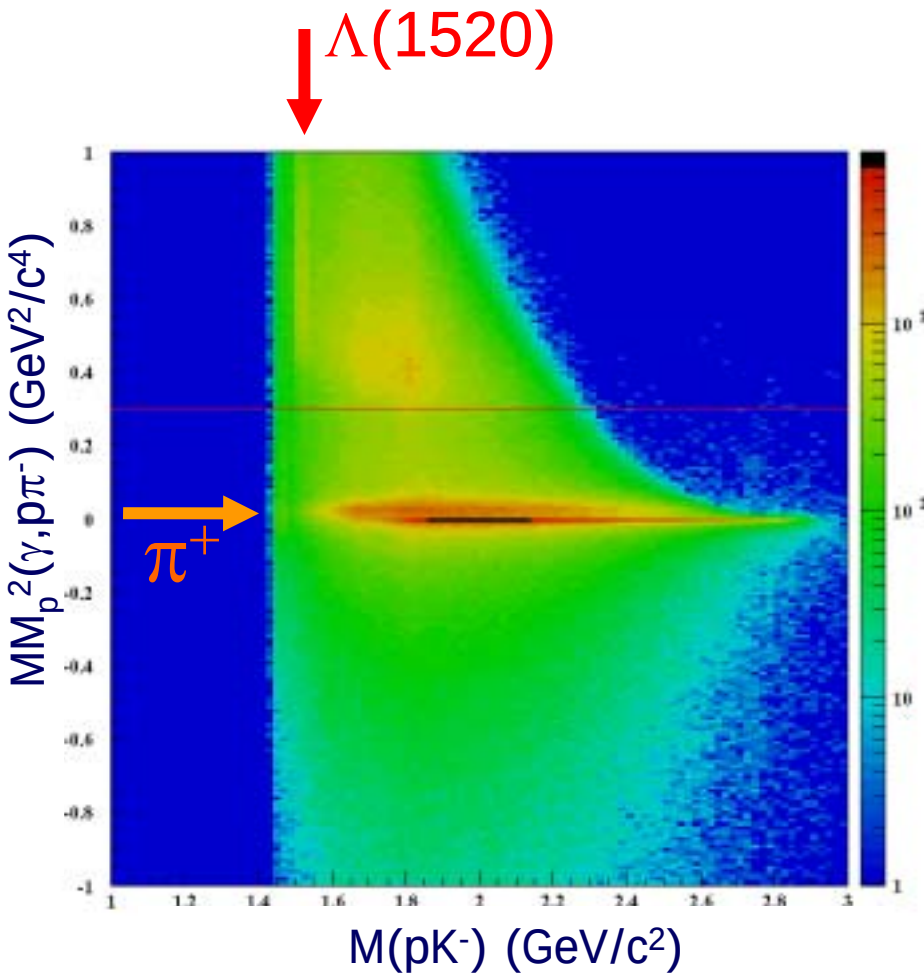
Background from mis-identified π^- track (I)

- If π^- is mis-identified as K^-, $\gamma d \rightarrow p\ \pi^-\ p$ reaction can be my background.
- $MM_d(\gamma,p\pi^-)$: missing mass assuming K^- track is π^-.
- $MM_d^2(\gamma,p\pi^-)>1.1\ GeV^2$ was required.



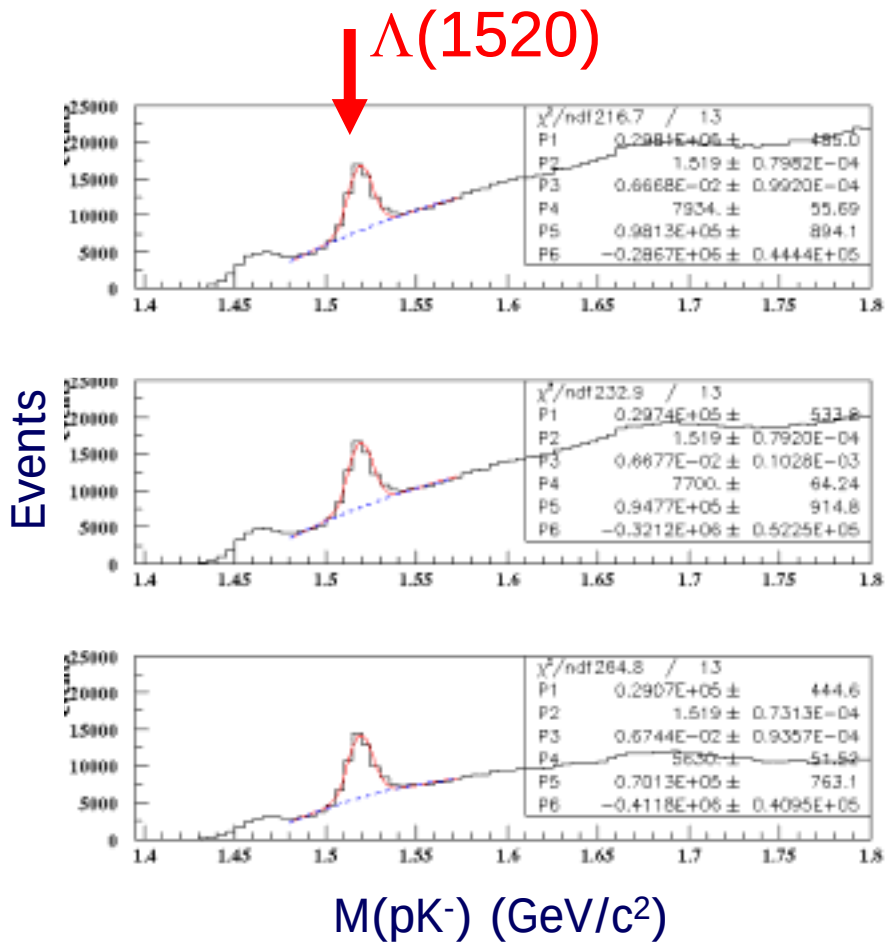
Background from mis-identified π^- track (II)

- Again, if π^- is mis-identified as K^-,quasi-free $\gamma p \rightarrow p\ \pi^-\pi^+$ reaction can be background.
- $MM_p(\gamma,p\pi^-)$: missing mass assuming K^- track is π^- in γp reaction
- $MM_p^2(\gamma,p\pi^-)>0.3\ GeV^2$ was required.



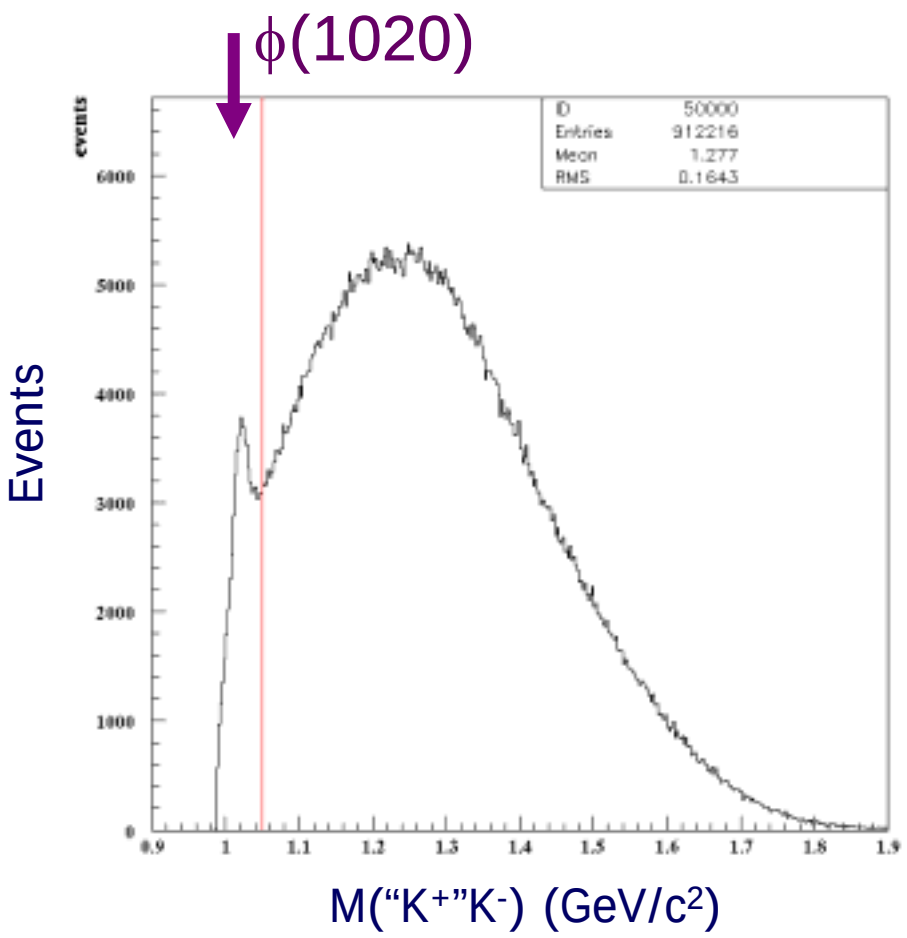
How much mis-identified π cuts affect $\Lambda(1520)$ yield?

- Number of $\Lambda(1520)$ events before the cuts
  - 29.8 +/- 0.5 k events
- after $MM_d(\gamma,p\pi^-)$ cut
  - 29.7 k events
- after $MM_d(\gamma,p\pi^-)$ and $MM_p(\gamma,p\pi^-)$ cuts
  - 29.1 k events
- Mis-identified π^- cuts removed 2.5% of $\Lambda(1520)$, while S/N ratio increased by ~30%.



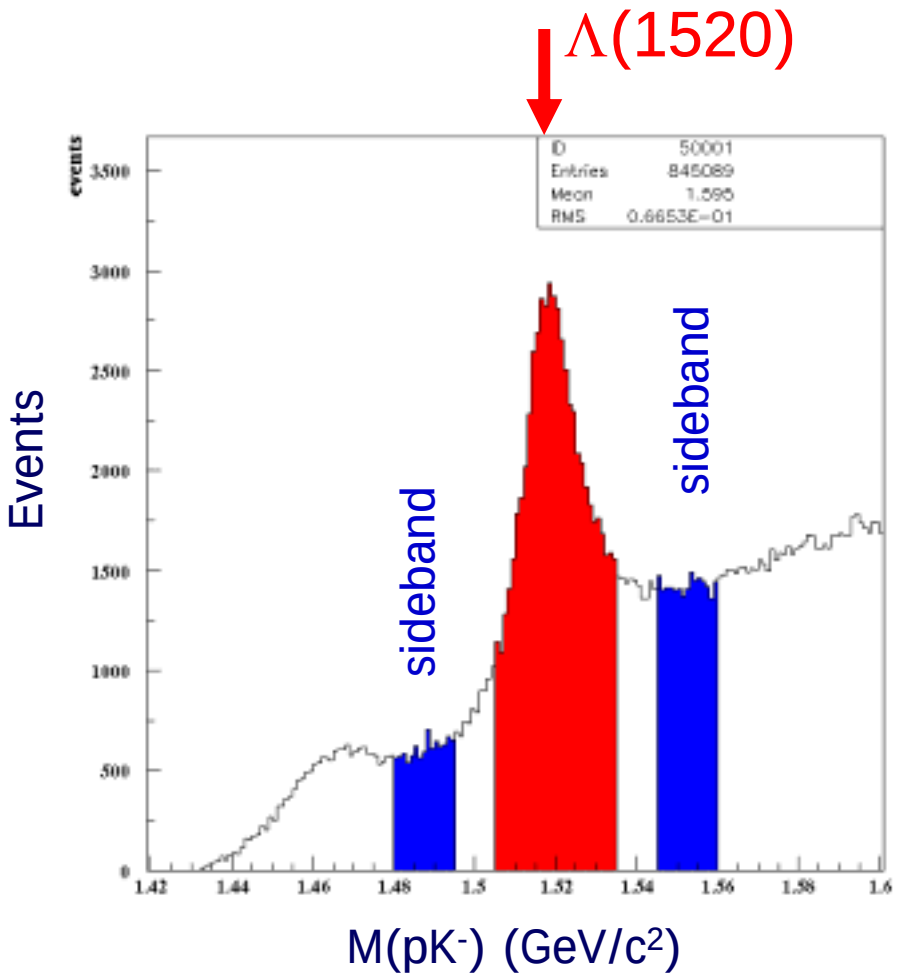
“K+”K- mass

- Background from quasi-free ϕ production was seen in M(“K^+”K^-) spectrum assuming $\gamma N \rightarrow K^+K^-N$ reaction.
- M(“K^+”K^-)>1.05 GeV/c^2 was required.



pK^- invariant mass

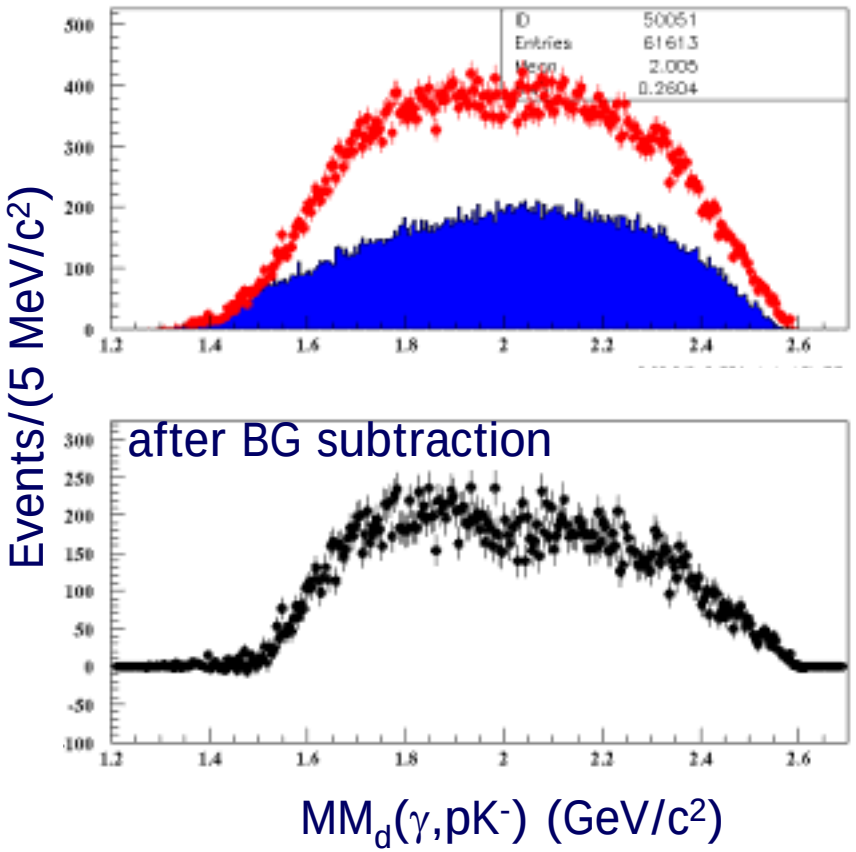
- $\Lambda(1520)$ selection : $1.505 < M(pK^-) < 1.535$ GeV/c^2
- Remaining BG
  - non-resonant pK^- pair from $\gamma d \rightarrow pK^- X (X = K^+ n, K^0 p, \ldots)$
  - $p\pi^-$ pair from 3 pion (or more) production ($\pi^+\pi^- \pi^0 pn$, $\pi^+\pi^-\pi^- pp$)
- BG was subtracted based on sidebands.



Missing mass

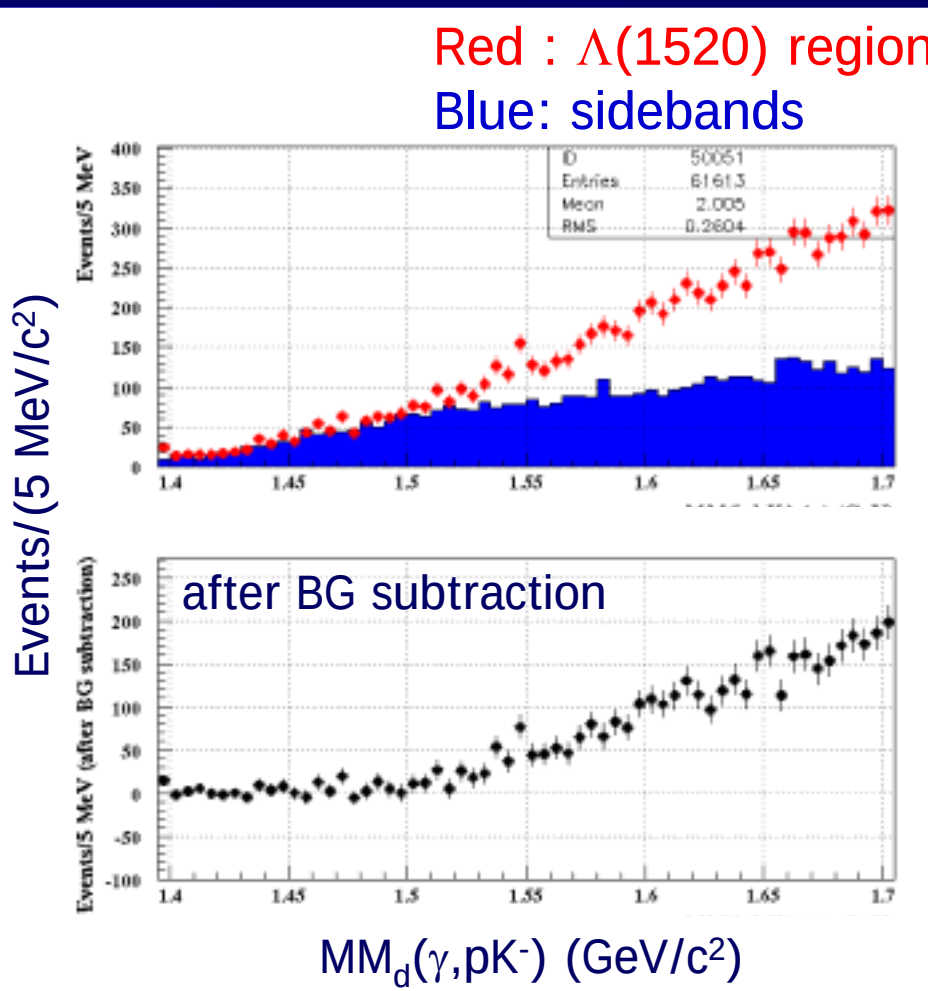
- Missing mass for $\gamma d \rightarrow pK^- X$ reaction, $MM_d(\gamma,pK^-)$
- Data mainly populates at high $MM_d(\gamma,pK^-)$ region.
- No statistically significant narrow structure is seen in entire spectrum.

Red : $\Lambda(1520)$ region
Blue: sidebands



Missing mass, Θ^+ mass region

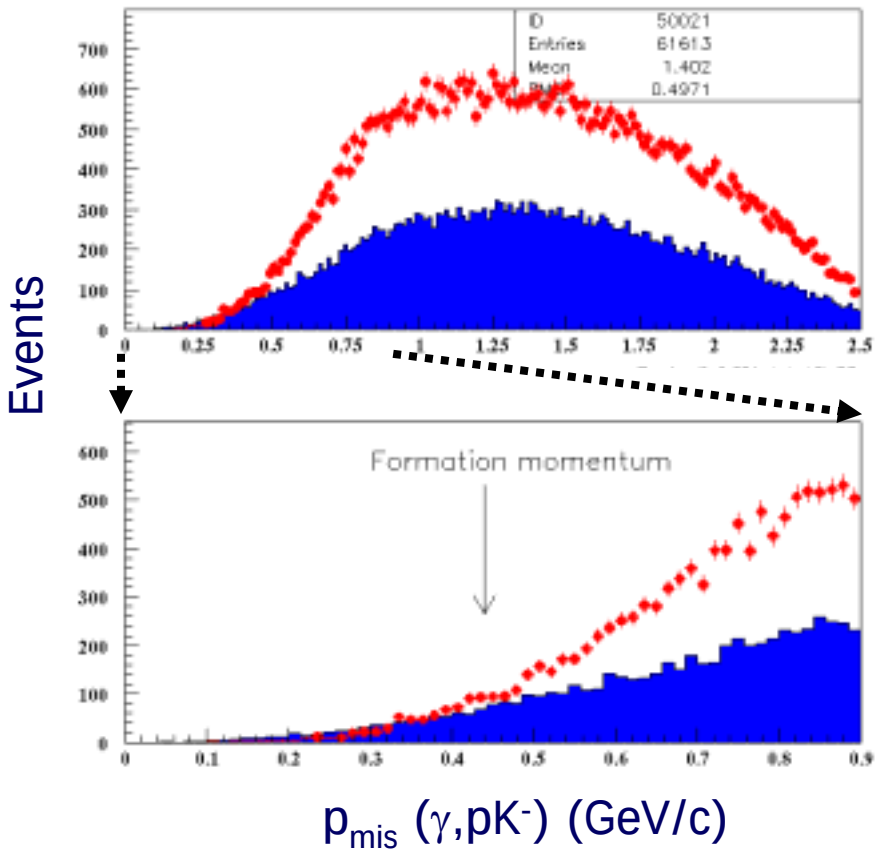
- Same as previous slide but zoomed in.
- No statistically significant peak was observed.
- However, statistics is poor at the Θ^+ mass region.



Missing momentum

- Suppose Θ^+ is formed by kaon exchange followed by the $\Lambda(1520)$ photo-production on nucleon, kaon momentum can be inferred from the missing momentum ($p_{mis}=p_\gamma-p_{\Lambda(1520)}$)
- Data poorly covers the region of the Θ^+ formation momentum.

Red : $\Lambda(1520)$ region
Blue: sidebands



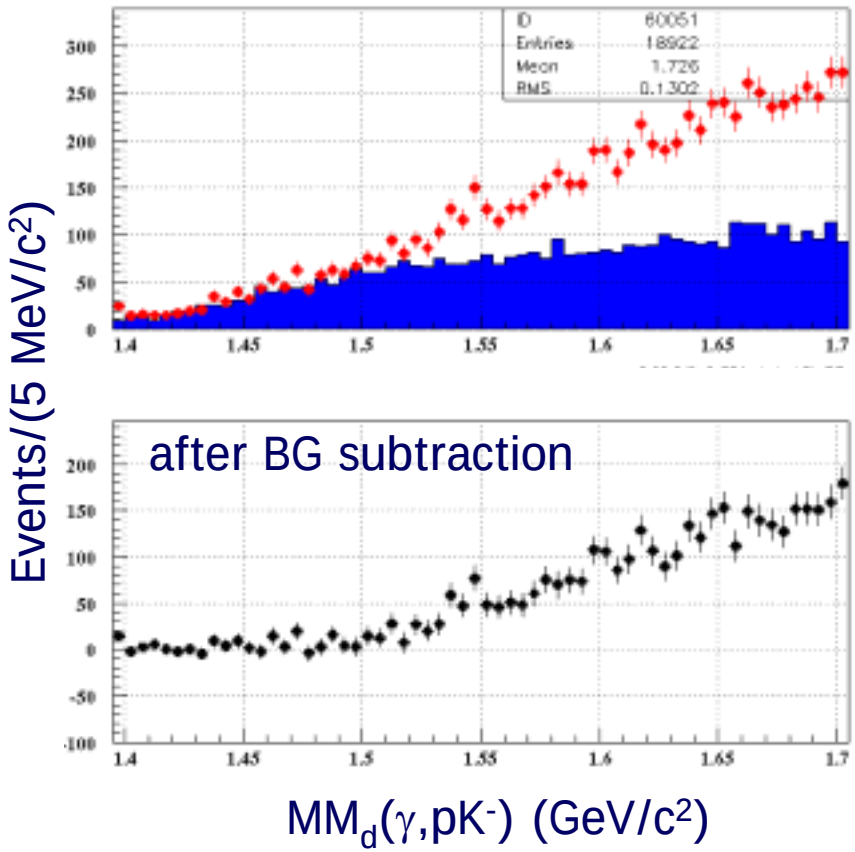
Comparison with LEPS data

- S/N ratio for the LEPS Θ^+ signal seems to be high.
  - Possible to see the signal in low statistics sample?
- This is a two-body reaction ($\gamma d \rightarrow \Lambda(1520)\Theta^+$)
  - Given photon energy and angle of $\Lambda(1520)$, reaction is completely determined.
- CLAS g10
  - tagged photon $0.8<E_\gamma<3.6$ GeV
  - High acceptance at mid- and large angles.
- LEPS
  - tagged photon $1.5<E_\gamma<2.4$ GeV
  - High acceptance at small angles.

Missing mass with photon energy cut

- E_γ<2.4 GeV was required to match the photon energy range in LEPS data.
- This cut mainly removes high MM events. Almost no change in the mass spectrum near the Θ^+ mass.

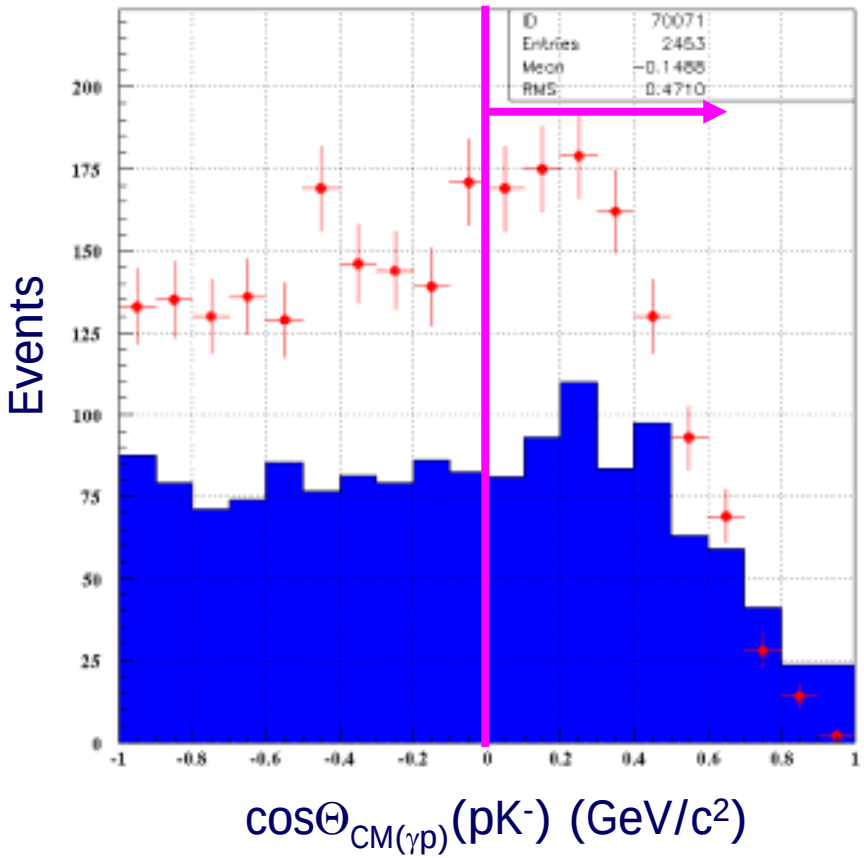
Red : $\Lambda(1520)$ region
Blue: sidebands



Angular distribution of $\Lambda(1520)$

- Polar angle of pK- pair in γp CM system is plotted for the events in Θ^+ mass region; $1.5<MM_d(\gamma,pK^-)<1.6$ GeV/c^2.
- CLAS acceptance drops rapidly in $\cos\Theta_{CM}>0.4$
- LEPS $\Lambda(1520)$ event is mainly from $\cos\Theta_{CM}>0$

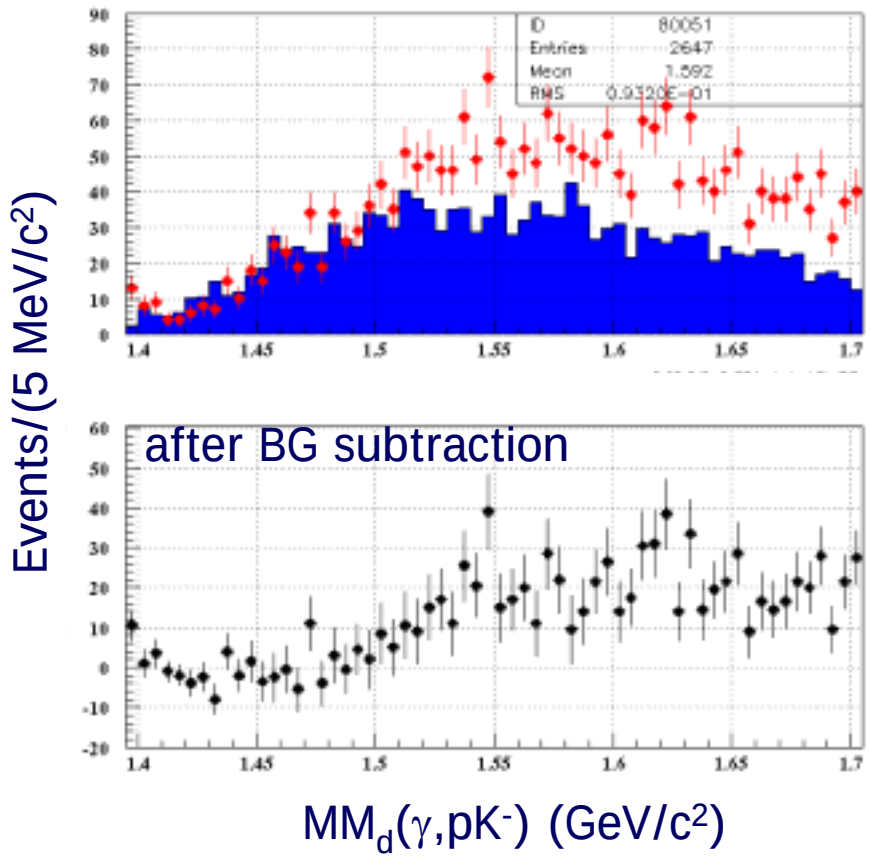
Red : $\Lambda(1520)$ region
Blue: sidebands



Missing mass with photon energy cut and $\cos\Theta_{CM}>0$

- $\cos\Theta_{CM}>0$ was required in addition to $E_\gamma>2.4$ GeV.
- Statistics is too poor to draw any statement on existence or non-existence of Θ^+.

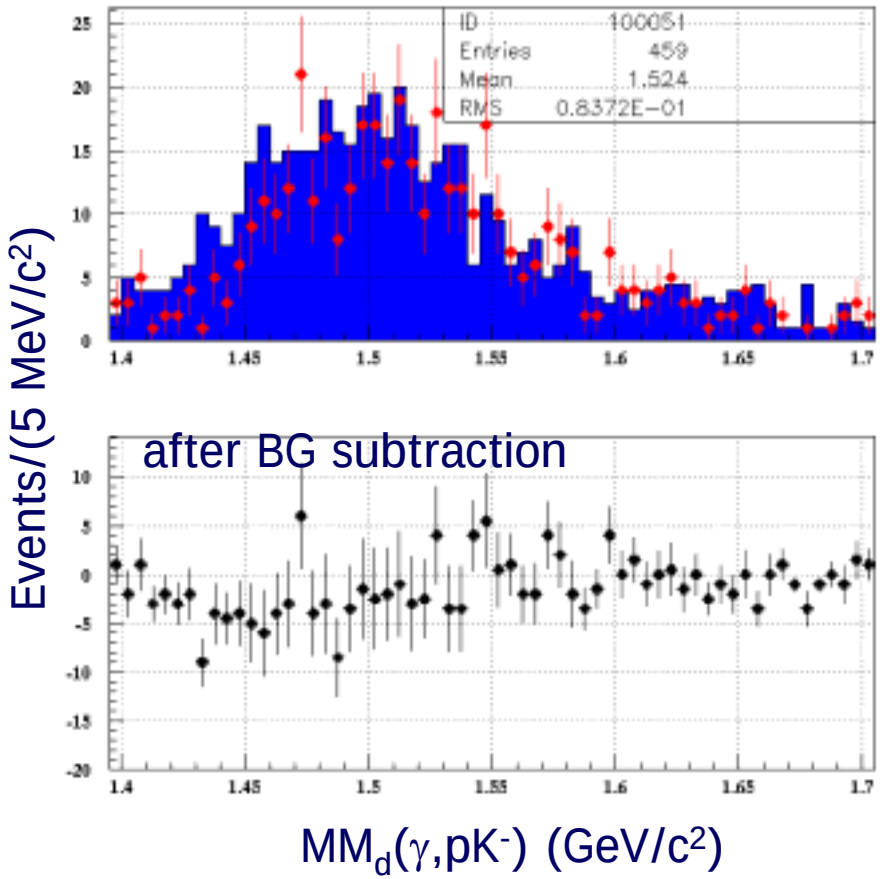
Red : $\Lambda(1520)$ region
Blue: sidebands



Missing mass with photon energy cut and $\cos\Theta_{CM}>0.5$

- $\cos\Theta_{CM}>0.5$ was required in addition to $E_\gamma>2.4$ GeV.
- There is no event left around the Θ^+ mass.

Red : $\Lambda(1520)$ region
Blue: sidebands



Summary

- Possible Θ^+ signal was searched in inclusive $\Lambda(1520)$ photoproduction on deuterium with CLAS.
- No statistically significant peak was found in MM(γ,pK^-) spectrum. However, statistics is poor near Θ^+ mass due to mismatch of kinematics.
- The LEPS positive Θ^+ signal could not be confirmed by CLAS g10 experiment.