Searching for Cascade Pentaquarks with CLAS

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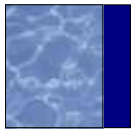
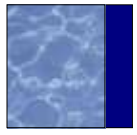
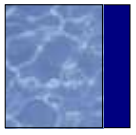
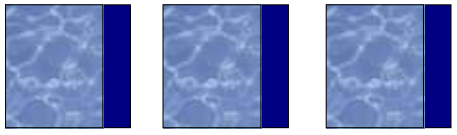
Pentaquark 2003 Workshop

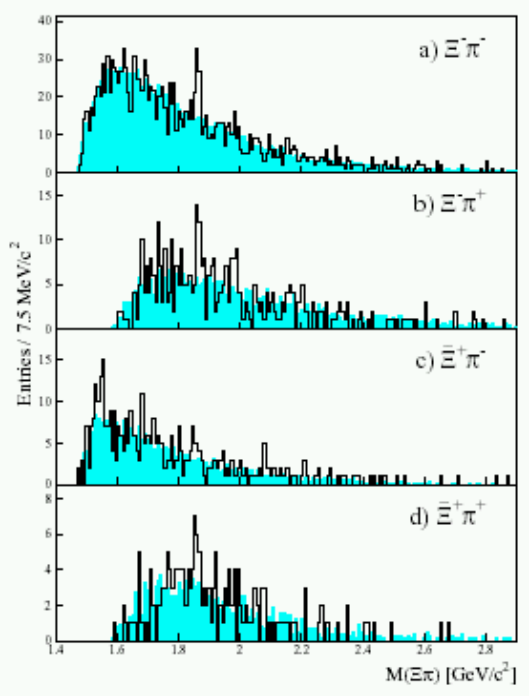
Introduction – Ξ Pentaquarks (Ξ_5)

- Needed to establish pentaquark antidecuplet
- Large range of mass, width predictions
  - Diakonov *et al.*: $m_{\Xi 5} = 2070$ MeV, $\Gamma_{\Xi 5} \sim 140$ MeV
  - Jaffe/Wilczek: $m_{\Xi 5} = 1750$ MeV, $\Gamma_{\Xi 5} \sim 15$ MeV
  - Many others...
- Finding Ξ_5 critical to understanding pentaquark nature



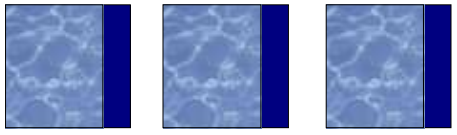
Ξ_5 Experimental Status

- NA49 sees a signal in *pp* at 17.2 GeV; strength similar to $\Xi(1530)$
- WA89 not so sure
- Confirmation needed by a third experiment
- ...but who can do it...?



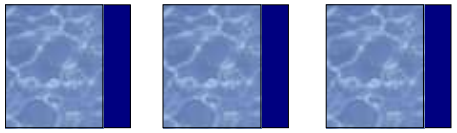
Detecting Ξ_5

- Decay measurements
  - Reconstruct the Ξ_5 via its decay to $\Xi\pi$ or ΣK
- Production measurements
  - Infer the Ξ_5 using a missing mass measurement
- Different techniques are complementary
  - Must obtain same mass for each technique



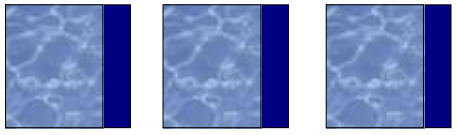
Ξ_5 Decay Measurements

- $\Xi^{--} \rightarrow \Xi^-\pi^- \rightarrow \Lambda\pi^-\pi^- \rightarrow p\pi^-\pi^-\pi^-$
  - Two secondary vertices (Ξ^-, Λ decays)
- $\Xi^{--} \rightarrow \Sigma^-K^- \rightarrow n\pi^-K^-$
  - One secondary vertex (Σ^- decay); need neutron ID
- $\Xi^+ \rightarrow \Xi^0\pi^+ \rightarrow \Lambda\pi^0\pi^+ \rightarrow p\pi^-\gamma\gamma\pi^+$
  - Two secondary vertices; need good photon ID
- $\Xi^+ \rightarrow \Sigma^+K^0 \rightarrow p\pi^0\pi^+\pi^- \rightarrow p\gamma\gamma\pi^+\pi^-$
  - One secondary vertex; need good photon ID



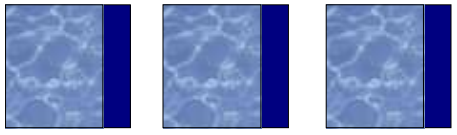
Ξ_5 Production Measurements

- Detect everything but the Ξ_5; infer by m_X
  - $K^- p \rightarrow K^+ \pi^- \Xi^+$ ($p_K > 2.7$ GeV/c)
  - $K^- n \rightarrow K^+ \Xi^{--}$ ($p_K > 2.3$ GeV/c)
  - $\gamma p \rightarrow K^+ K^+ \pi^- \pi^- \Xi^+$ ($E_\gamma > 4.7$ GeV)
  - $\gamma p \rightarrow K^+ K^0 \pi^- \Xi^+$ ($E_\gamma > 4.3$ GeV)
  - $\gamma n \rightarrow K^+ K^+ \Xi^{--}$ ($E_\gamma > 3.9$ GeV)
- Good π/K separation needed



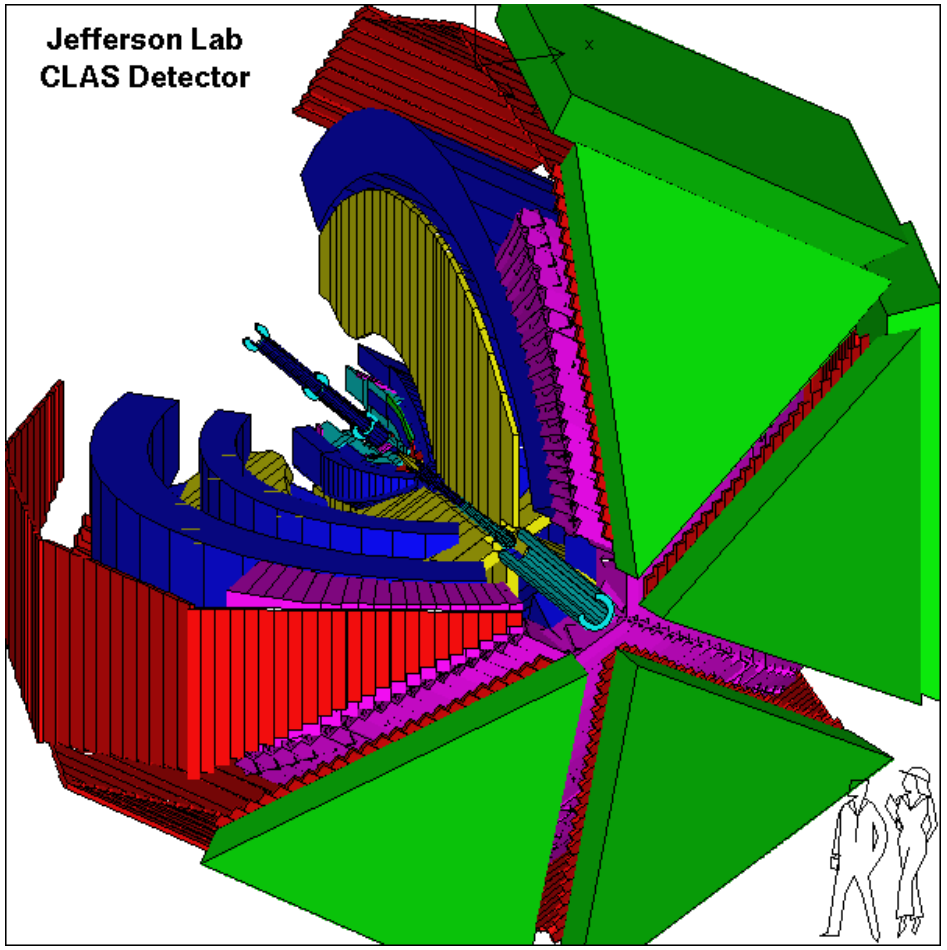
Where can we do it?

- CERN
  - WA89 no longer taking data
  - NA49 doing heavy ion work (for now)
- BNL
  - AGS doesn't have high enough K momentum
  - RHIC (STAR) looking, but no signal yet
- Japan
  - SPring-8 doesn't have enough γ energy
- SLAC, HERMES ... ?



The CLAS Detector

- Large acceptance
  - Holes in forward, backward directions, along coils
  - + bends in, – bends out (or vice versa)
- High energy
  - $E_\gamma < 6$ GeV
- Active, interested collaboration

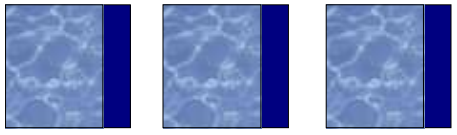


CLAS Data Summary

- Three data sets available

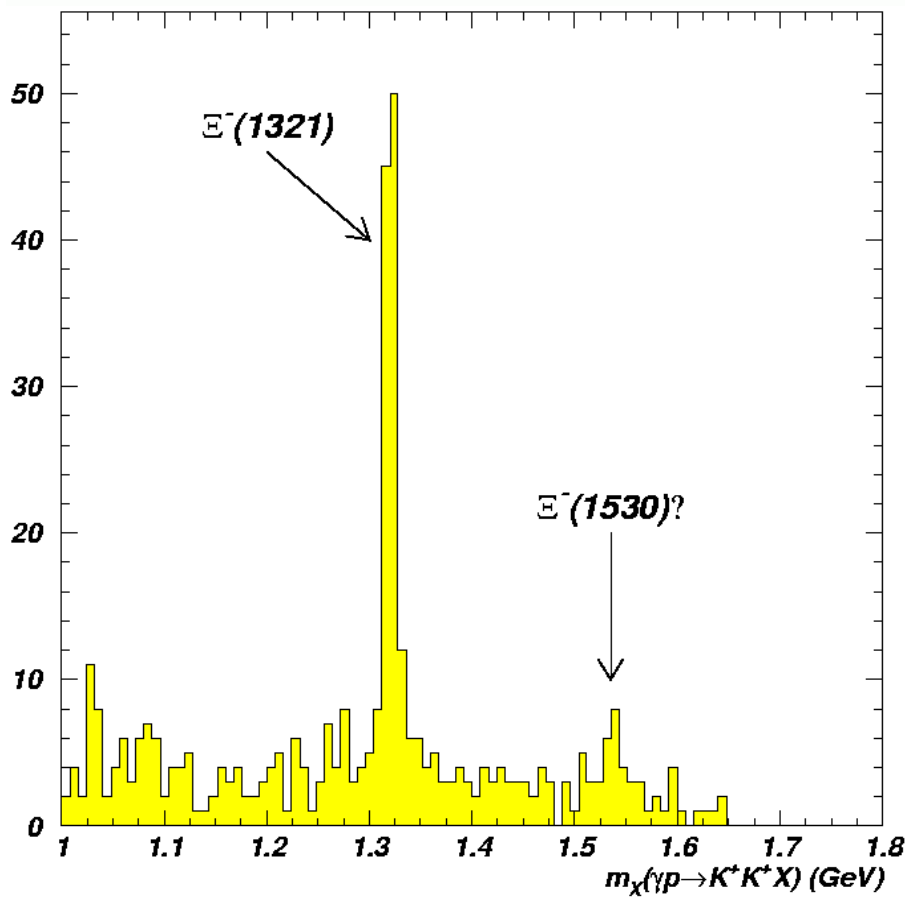
Run name	Energy (GeV)	Beam Flux	Target Position	Torus Current
g6a	3.2-3.9	Low	Center	I
g6b	3.0-5.2	Medium	Center	I
g6c	4.8-5.4	High	Upstream	I/2

- Existing Ξ program being extended to Ξ_5 search
- Only *g6b*, *g6c* viable for Ξ_5 search



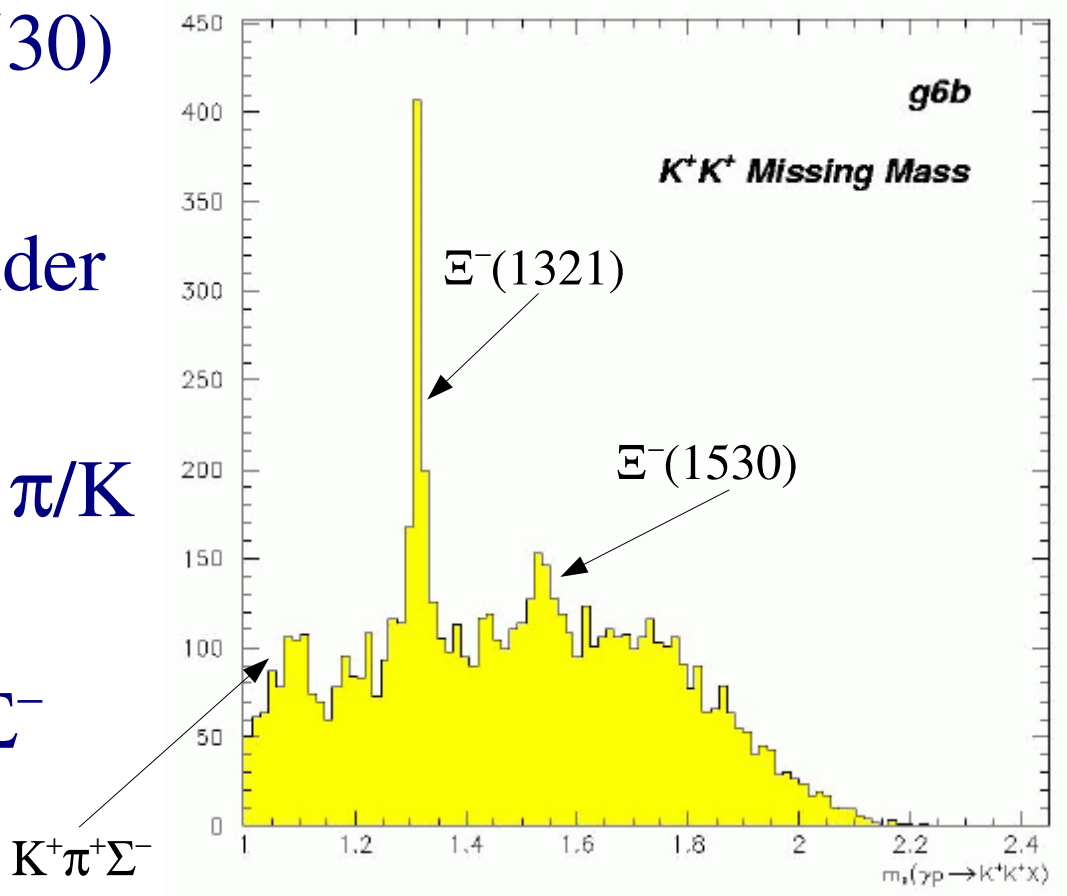
g6a Results – Mass sensitivity

- Clear ground state signal
- Highest attainable mass: 1880 MeV
- We lose ~150 MeV/K^+ in *g6a*
- Tighter PID ⇒ start to see $\Xi^-(1530)$
  - No chance to see Ξ_5



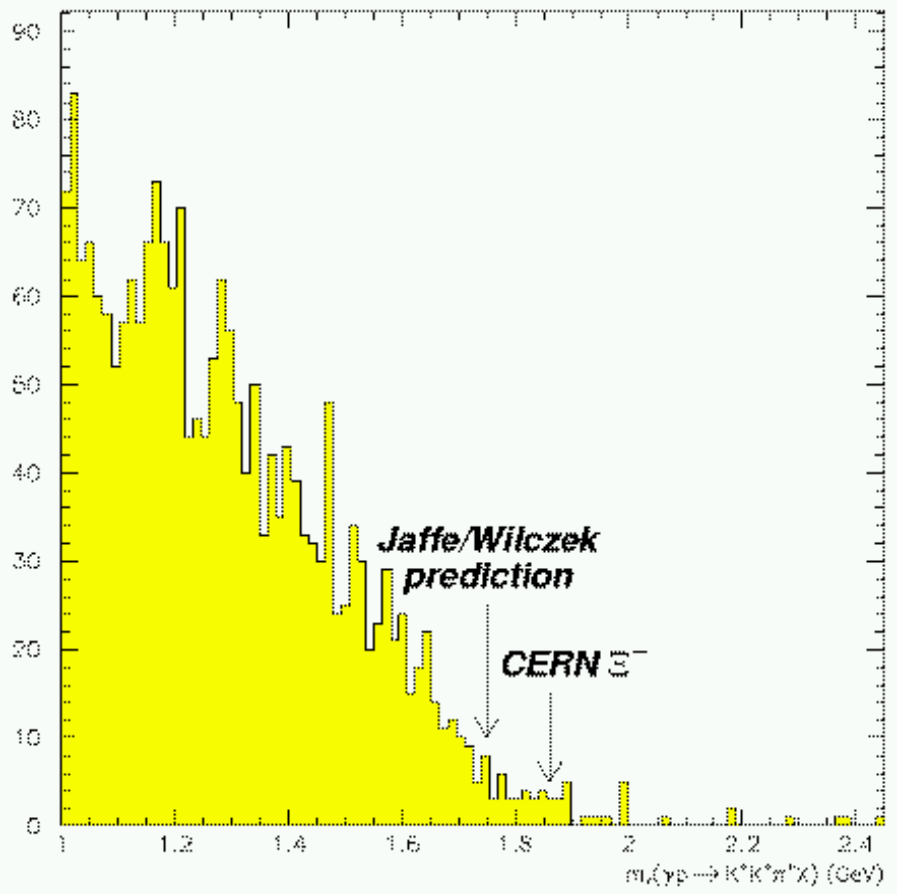
g6b Results – π/K misidentification

- $\Xi^-(1321)$ and $\Xi^-(1530)$ seen
- Tighter PID still under study
- Loose PID leads to π/K misidentification
- Reflection of $K^+\pi^+\Sigma^-$ seen at ~1.1 GeV



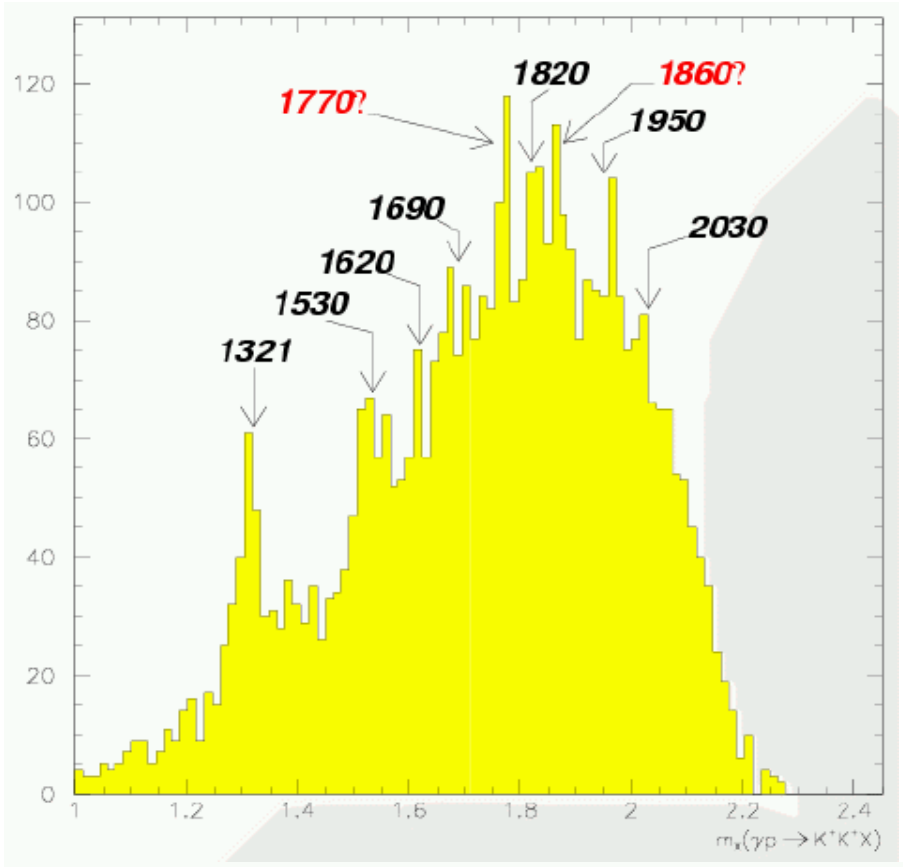
CLAS search for Ξ_5

- Look at m_X of $K^+K^+\pi^+$ system
  - m_X(max) ~ 2.3 GeV
  - No statement about Ξ_5 from *g6b* (except that we need more energy)
  - Would be easier on the neutron (higher mass sensitivity)



g6c Results – Final state cuts

- g6c has large bkgd
  - Suppress by requring proton in final state
- Every PDG Ξ state matches an enhancement
  - Persistent structure at 1770 and 1860 MeV
- Enough energy for strong statement on Ξ_5 w/small background



Short- and Long-Term Plans

- Short term issue: does the $\Xi^{--}(1862)$ exist?
  - New data are needed ASAP to answer
  - CLAS Proposals under consideration
- Long-term issues: too many to list
  - What are the properties of the Ξ_5?
  - What are the properties of the pentaquarks in general?
  - Are there excited Ξ_5?
- New CLAS proposal for a large data set
- Discussion session after workshop on Saturday

Conclusions

- The existence of the Ξ_5 is critically important to our understanding of the pentaquark sector
  - Understanding the Ξ_5 is just as important as understanding the Θ^+
- Searching for the Ξ_5 is beyond the capability (or not the main interest) of most facilities today
- The existing Ξ program at CLAS is in the unique position of being able to take new data to contribute to this search on both *p* and *d* targets