Searching for "Other" 5-quark States in Present and Future Experiments

Summary of Focus Group Discussion

Experiments: Reinhard Schumacher Theory Aspects: Carl Carlson

Experiments

- Experiments at COSY/Juelich
- Measurements at STAR/RHIC/BNL
- Cascades (Ξ^{--}_{5}) at CLAS/JLab
- Sigmas (Σ_5) at CLAS/JLab
- Other narrow baryons HallA/JLab
- Discussion Summary





Detectors at COSY:

- Internal:
- External:
- ANKE
- BIG KARL
- COSY-11 TOF
- NO electromagnetic calorimeter ("photon blind")
 - \rightarrow only charged particles

NO dedicated experiment yet !

 \rightarrow use existing data









Experimental result:

- Invariant mass distribution of (p K⁰) for events within [K⁰, Σ⁺] range:
 - covers proper inv. mass range
 - No signal; too much background !





 $pp \rightarrow \pi^+ \theta^+ \Lambda \rightarrow \pi^+ [p \ K^0][p \ \pi^-]$



→ 4-charged-particle events: a) Is there a <u>second</u> proton ? $p p \rightarrow p_1 p_2 \pi^+ \pi^- X$ <u>2c:</u> $M_{inv}(\pi^+\pi^-) = K^0$ & X = π & $M_{inv}(p_1 \pi) = \Sigma^+$ $M_{inv}(p_1 \pi^-) = \Lambda \quad \& \quad X = \mathbf{K}^0$ 2f: \rightarrow M_{inv}(p π^-) vs. MM (pp $\pi^+\pi^-$) Candidate events in [K⁰, Λ]







Hans Ströher









Pentaquark Search at $\sqrt{s_{NN}}$ =200 GeV with STAR at RHIC

- •Introduction to STAR
- •Techniques and Analysis
- •Simulation Studies
- •Conclusions and Future Plans

Sevil Salur Yale University STAR Collaboration



Available Data





	# of Events	dNch/dη
p+p	8 Million	3
d+Au	14 Million	15
Au+Au	1.5 Million	800



What pentaquarks are we looking for?

$\Theta^+ \rightarrow n + K^+$	No	No id for n
$\Theta^+ \rightarrow p + K^0$	Yes	
Ξ →Ξ ⁻ +π ⁻	Yes	
$\Xi^{} \rightarrow \Sigma^{-} + K^{-}$	No	No id for $\Sigma \rightarrow n + \pi^-$
$\Xi^+ \rightarrow \Xi^0 + \pi +$	No	No id for $\Xi^0 \rightarrow \Lambda + \pi^0$
$\Xi^+ \rightarrow \Sigma^+ + K^0$	No	No id for $\Sigma^+ \rightarrow p + \pi^0$
Θ ⁺⁺⁺ →p+π ⁺ +π ⁺	Yes	
Θ -→n+π-	No	No id for n or π^0
Θ ⁰ →p+K ⁻	Yes	
N₅ → Λ+K	Yes	
$\Sigma_5 \rightarrow \Lambda + \pi$	Yes	
$\Sigma_5 \rightarrow p + K^0$	Yes	

Good oportunity to observe anti pentaquarks ($p/p \sim 0.7$ at RHIC) First we need to identify the decay daughters K⁰, Ξ , Λ , π and p.







Efficiency X Acceptance $\sim 3\%$. This factor depends highly on cuts applied. Investigating!



Feasibility Studies with current Au+Au data

From AuAu to pp we have a slightly smaller efficiency with a much higher background!

~0.5-1.5 Θ per event for AuAu

- 0.5-1.5 X 1.5 Million \rightarrow 0.8-2.3 Million
- Efficiency $3\% \rightarrow 25-70 \text{ K}$
- Branching Ratio 50% \rightarrow 10-35 K

Background pairs per event in the mass range of Θ is 2.

• 2 X 1.5 Million \rightarrow 3 Million Significance $\sigma = \text{Signal}/\sqrt{2 \text{ X Background+Signal}}$

$$\sigma \rightarrow 4-14$$

But bin by bin fluctuations ...

We might be losing some of it via re-scattering of daughters.

And the STAR result is....

- Not officially released
- Ask the authors for a peek at preliminary data
- They see NO $\Theta(1540)$ peaks in pp pd or Au Au
- Their present statistics are too poor to conclude much

Searching for Cascade Pentaquarks with CLAS

John W. Price University of California, Los Angeles

Pentaquark 2003 Workshop



Detect everything but the Ξ_{z} ; infer by m_x

$K^-p \rightarrow K^+\pi^-\Xi^+$	(p _K > 2.7 GeV / <i>c</i>)
$K^-n \rightarrow K^+ \Xi^{}$	(p _K > 2.3 GeV/ <i>c</i>)
$\gamma p \rightarrow K^+ K^+ \pi^- \pi^- \Xi^+$	$(E_{\gamma} > 4.7 \text{GeV})$
$\gamma p \rightarrow K^+ K^0 \pi^- \Xi^+$	$(E_{\gamma} > 4.3 GeV)$
$\gamma n \to K^+ K^+ \Xi^{}$	$(E_{\gamma} > 3.9 \text{GeV})$

Good π/K separation needed



CLAS search for Ξ_{5}

Look at m_{χ} of K ⁺K ⁺ π^{+} system

 m_{χ} (max) ~ 2.3 GeV

No statement about Ξ_{z}

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 E nough 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_{ς} ?

What are the properties of the pentaquarks in general? A re there excited Ξ_{s} ?

New CLAS proposal for a large data set

Discussion session after workshop on Saturday



- Are they 'narrow'?
- Have they been hunted?
- CLAS g1c data set at 3.1 GeV may be a good place to look.

q ≯ q , q The Anti-decuplet in the Chiral Soliton Model D. Diakonov, V. Petrov, hep-ph/0310212 uudds (revised version) Can mix with $\Theta^{+}(1539)$ octet baryons How 'narrow' are they? N(1650-90) Σ(1760-1810) Ξ(1862) uussd ddssu

Other baryon states

Xiaodong Jiang, Rutgers

- Hall A search for narrow baryons between the nucleon and the πN threshold
- p(e,e'p⁺)X⁰
- Upper limit published; previous sightings not confirmed
- Science Lesson: If multiple experiments don't see a state, then the state is not real.

Discussion Summary

- Exotics searches will have biggest impact
- 27-plet exotics exist: look for them
 - But they may not be narrow...
- Try nuclear targets in photoproduction?
 - Neutrino data suggest production ~ A