Using the MMSA in a Search for the Θ^+ at CLAS

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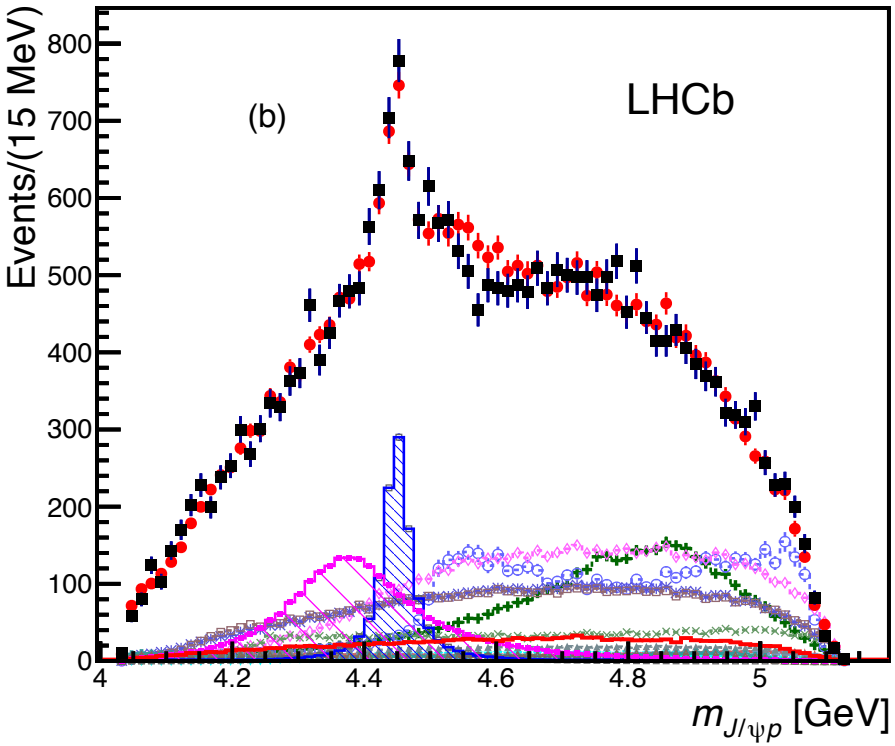
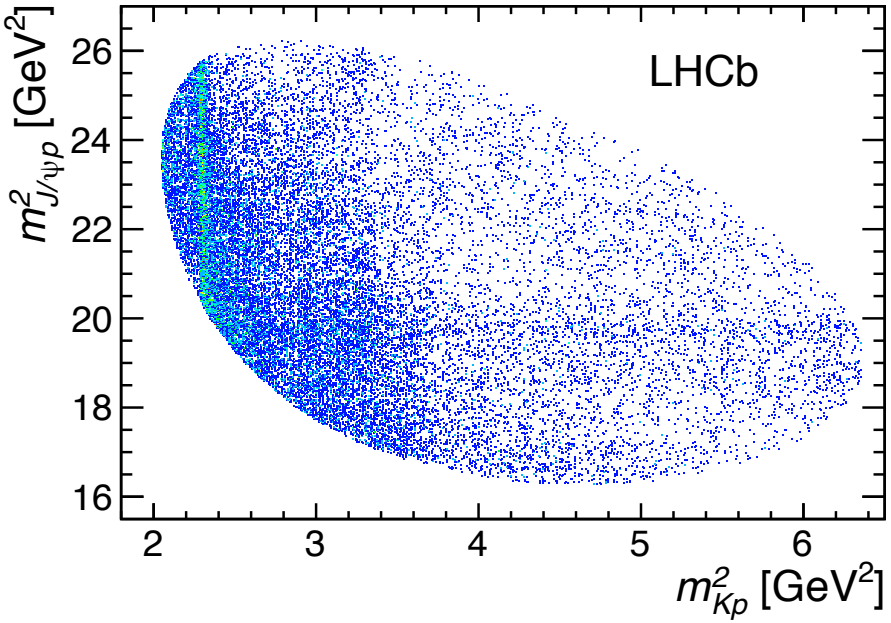
Some History

- 2003: LEPS publishes evidence for the Θ^+.
- 2004: Many publications seeing the Θ^+.
- 2005: Null evidence from high-energy expts.
- 2006: Earlier CLAS results were fluctuations.
- 2007-8: Many people skeptical of Θ^+.
- 2009: LEPS sees Θ^+ with higher statistics.
- 2015: LHCb sees “charm” pentaquark.

The “charm” pentaquark from LHCb

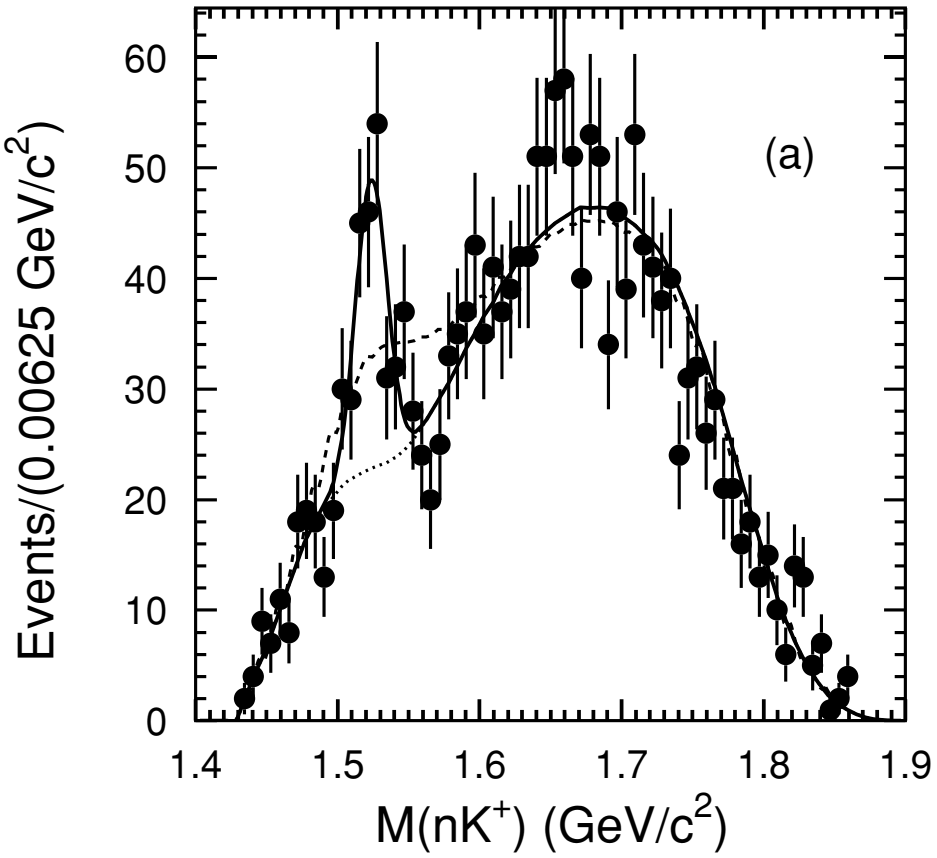


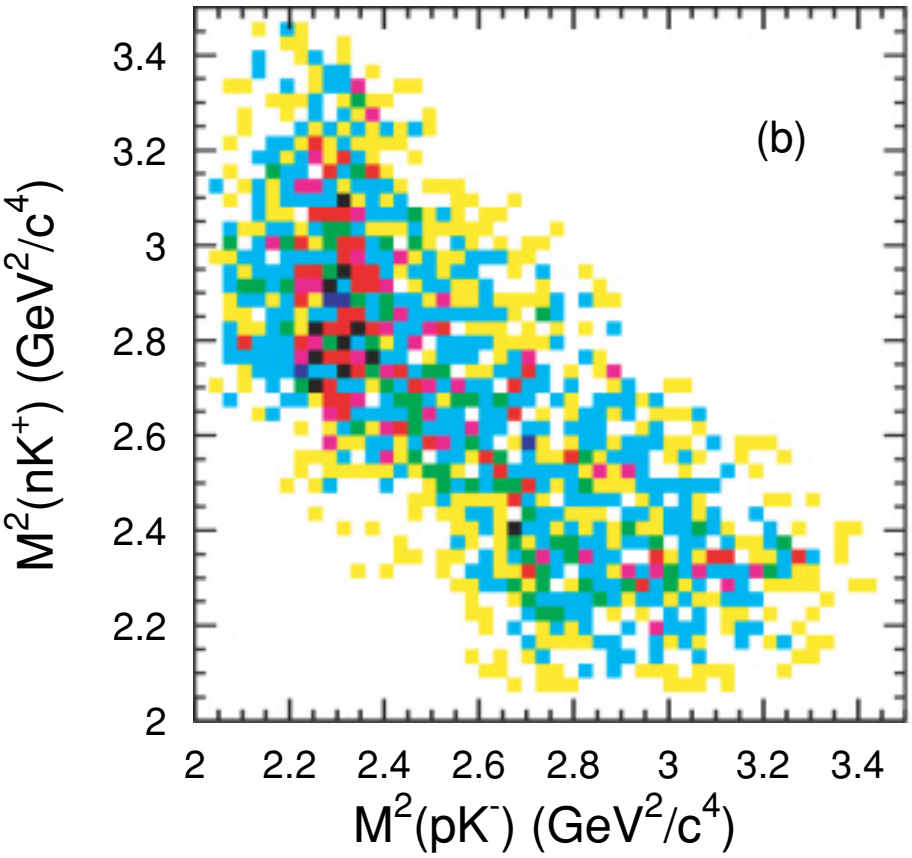
Quark structure:
(c-bar c u u d)
“non-exotic” pentaquark
Is it a molecule or a spherical 5-quark bag?



The 2009 LEPS result using MMSA

Quark structure: (s-bar u d u d): “exotic” pentaquark



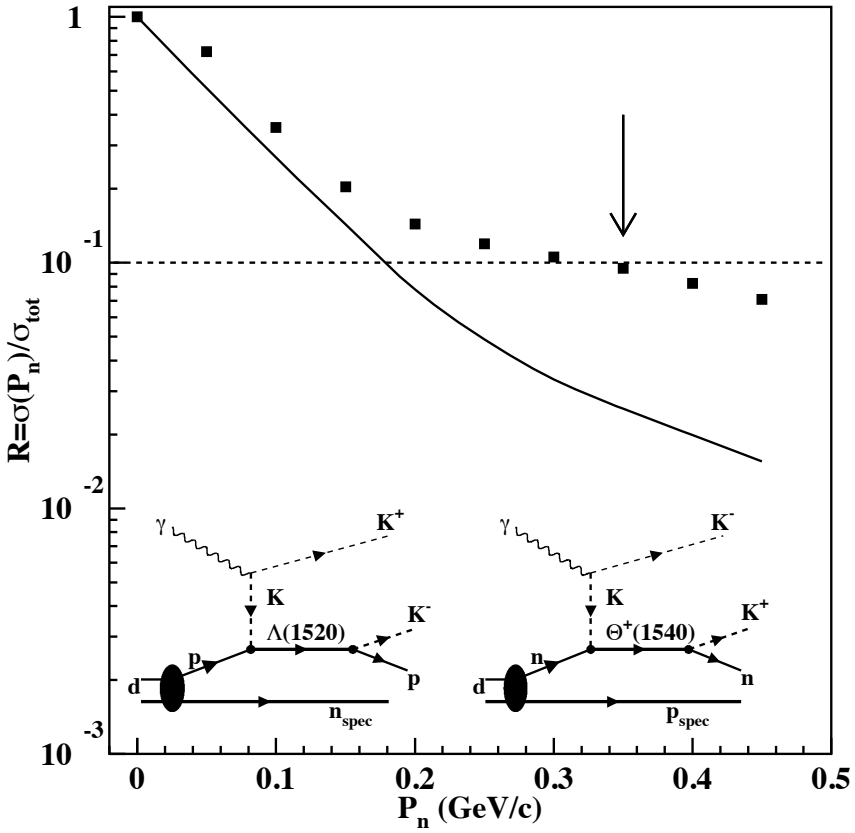


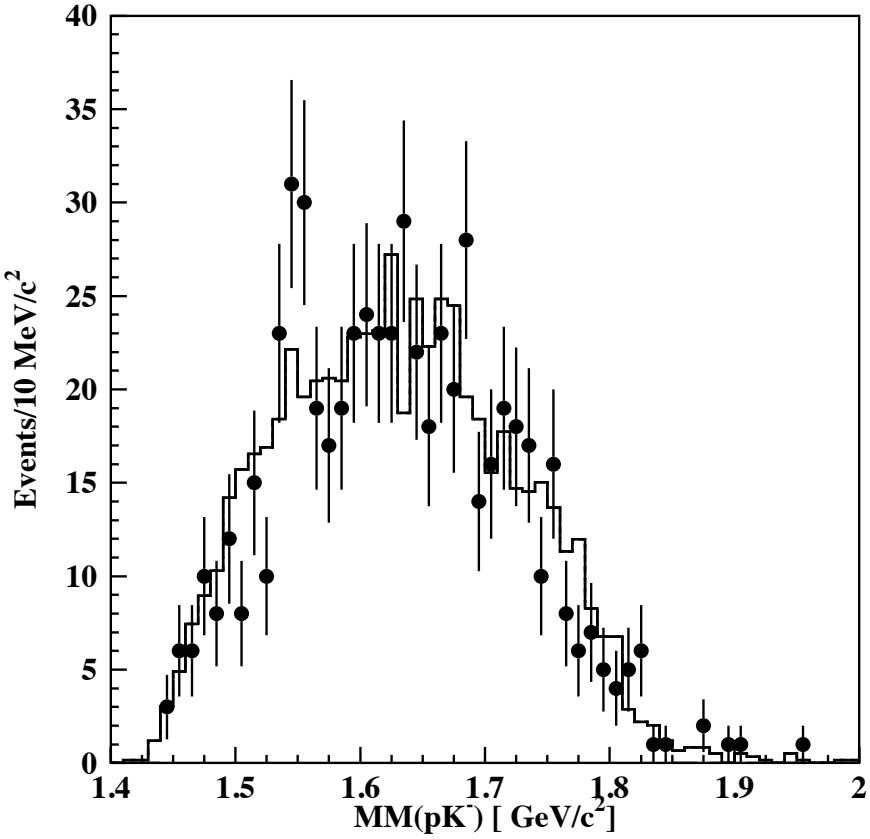
But could it be a statistical fluctuation?

The 2006 CLAS result

B. McKinnon et al., PRL 96, 212001 (2006).

Reaction: γ d → K^+ K^- p (n) exclusive. Requires proton knock-out.





This is not exactly the same as LEPS measured. Can we do better?

Re-analysis of CLAS data using MMSA

- Reaction: γ d $\rightarrow$ K^+ K^- (p n). Same as LEPS.
- Problem: Fermi momentum smears resolution
  - Use the MMSA technique to correct for it.
- Summer project (2014) for Max Camp.
  - Refined analysis summer 2015.
  - Now under analysis review by CLAS.
- Goal: as best possible, same analysis as LEPS.
  - Exception: detection angles are not the same.

Data selection cuts

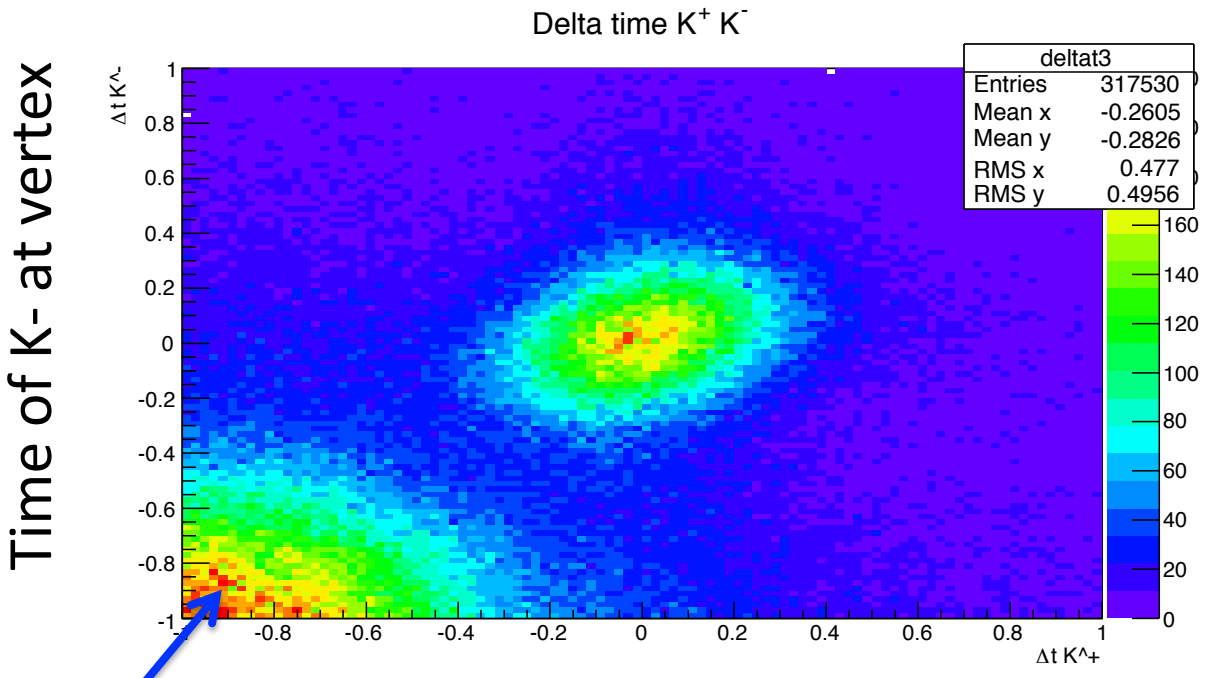
Number	Cut Type	Cut Made
Cut1	Beam Energy	$2.0GeV < E_{\gamma}^{eff} < 2.5GeV$
Cut2	Vertex	$-36 < z - vertex < -16$
Cut3	Timing	$\Delta t_{radius} < 0.54$ns
Cut4	Missing Mass	$\mathrm{MM}(\gamma, \pi^+, \pi^-) > 1.0GeV/c^2$
Cut5	Fiducial	Half maximum of $\phi(\theta)$
Cut6	ϕ meson	$1.01 < M(K^+, K^-) < 1.03$ GeV/c^2
Cut7	p_{min}	$\lvert p_{min} \rvert < 0.1$

Cuts 1, 6 & 7 are the same as for LEPS.

Cuts 3 & 4 are for Particle ID.

Cuts 2 & 5 are standard for CLAS.

Particle Identification

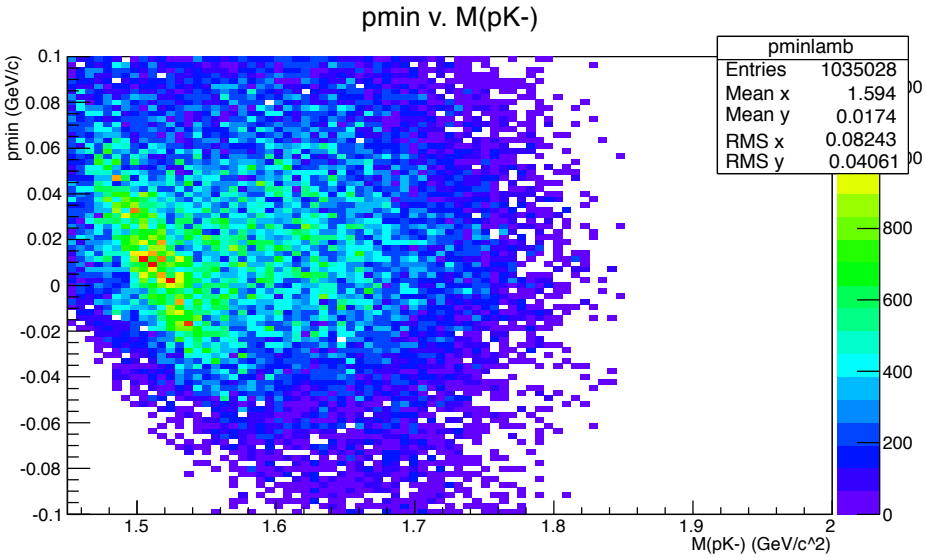


Pion Background

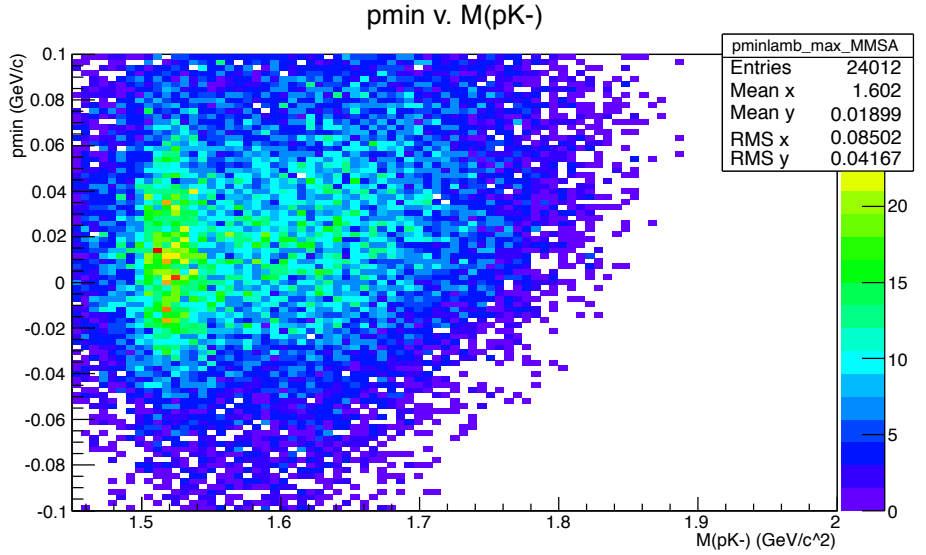
Correcting for Fermi Smearing

Reaction: γ d → K^+ X

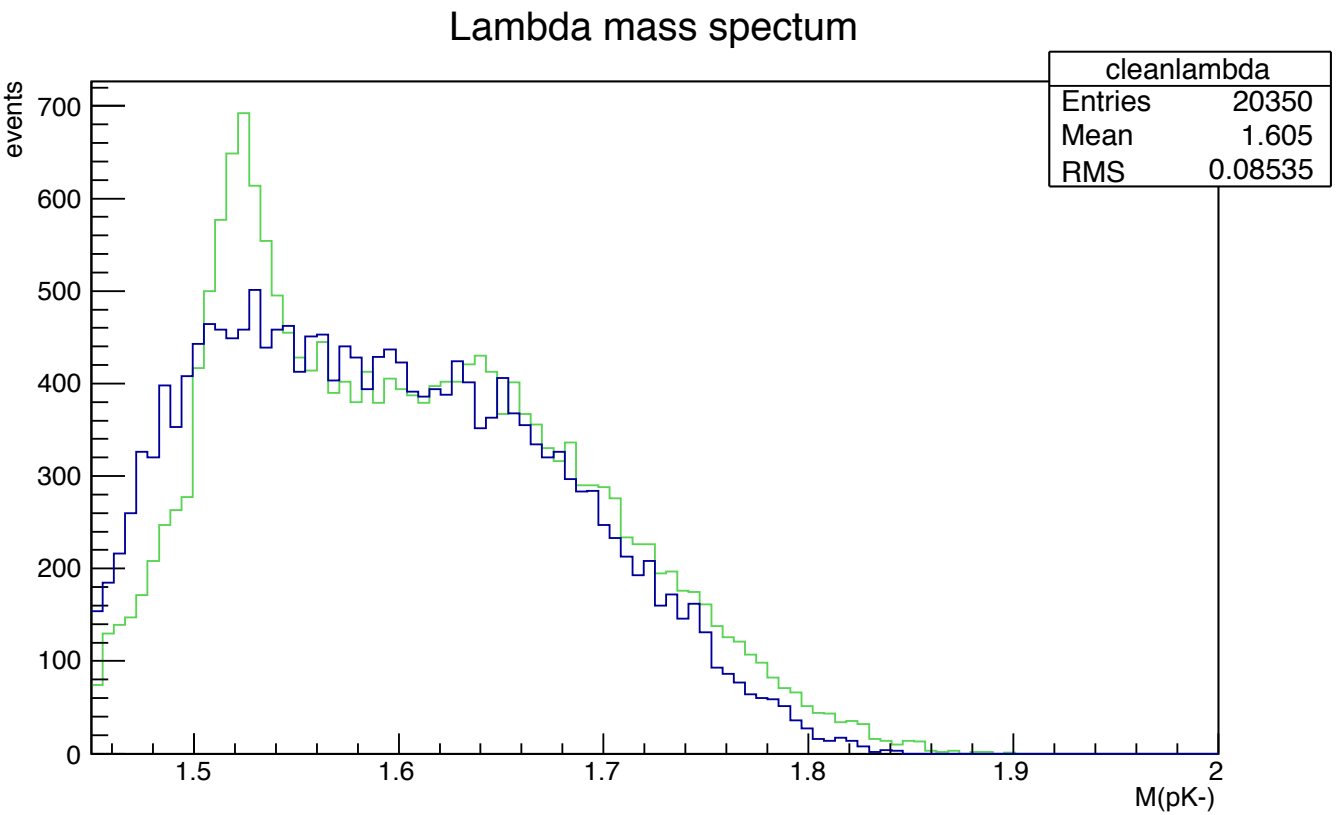
$MM(K^+)$ before the MMSA correction (vertical axis is the Minimum Momentum)



$MM(K^+)$ after the MMSA correction



MMSA for the $\Lambda(1520)$



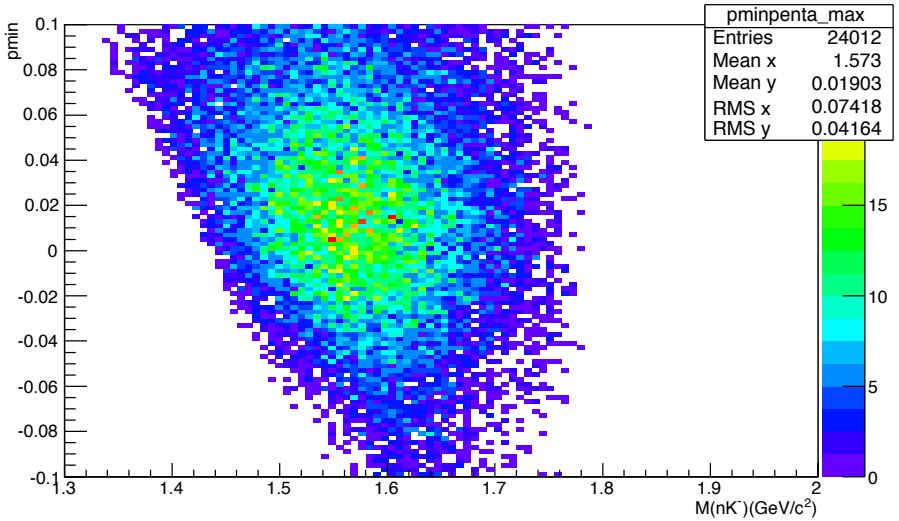
Mass of the (pK-) System

The $\Lambda(1520)$ peak only becomes clear after the MMSA correction.

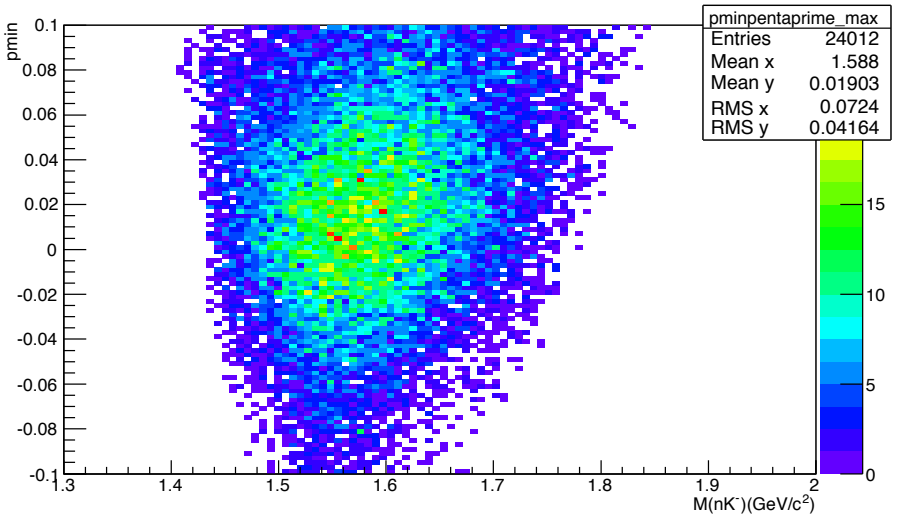
MMSA for the MM(K^-)

Reaction: γ d → K^- X

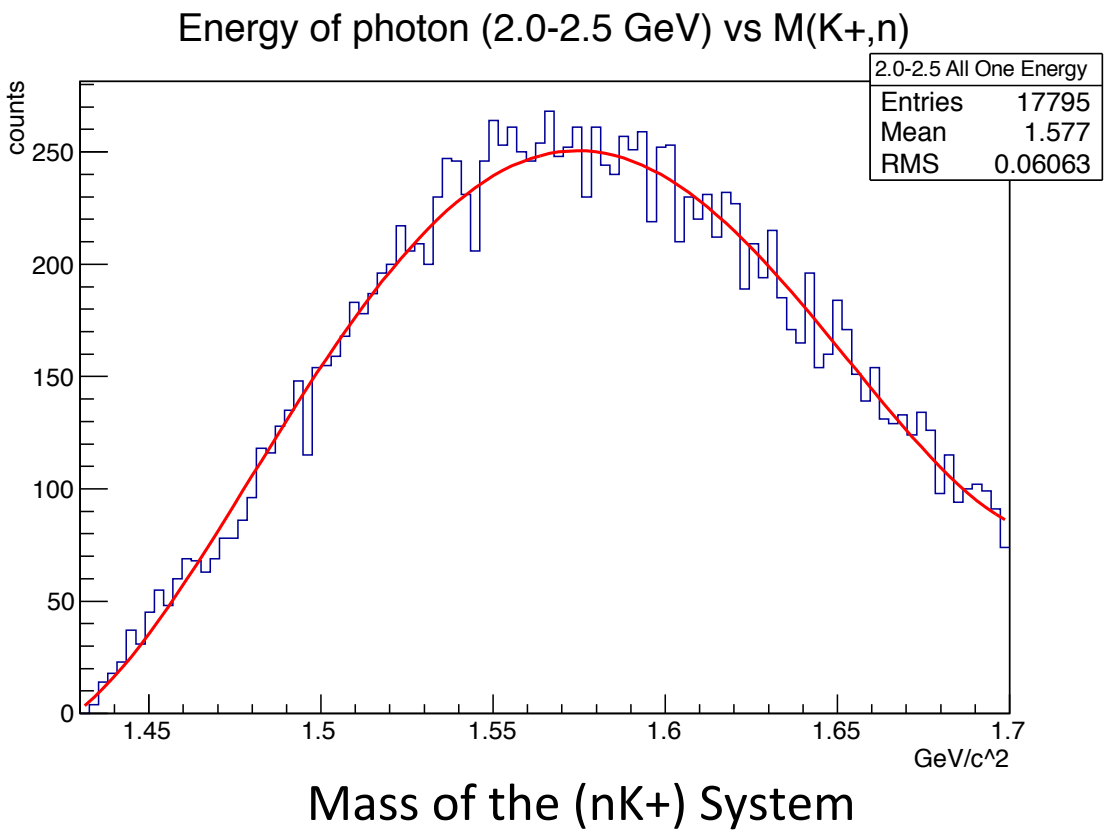
$MM(K^-)$ before the MMSA correction (vertical axis is the Minimum Momentum)



$MM(K^-)$ after the MMSA correction

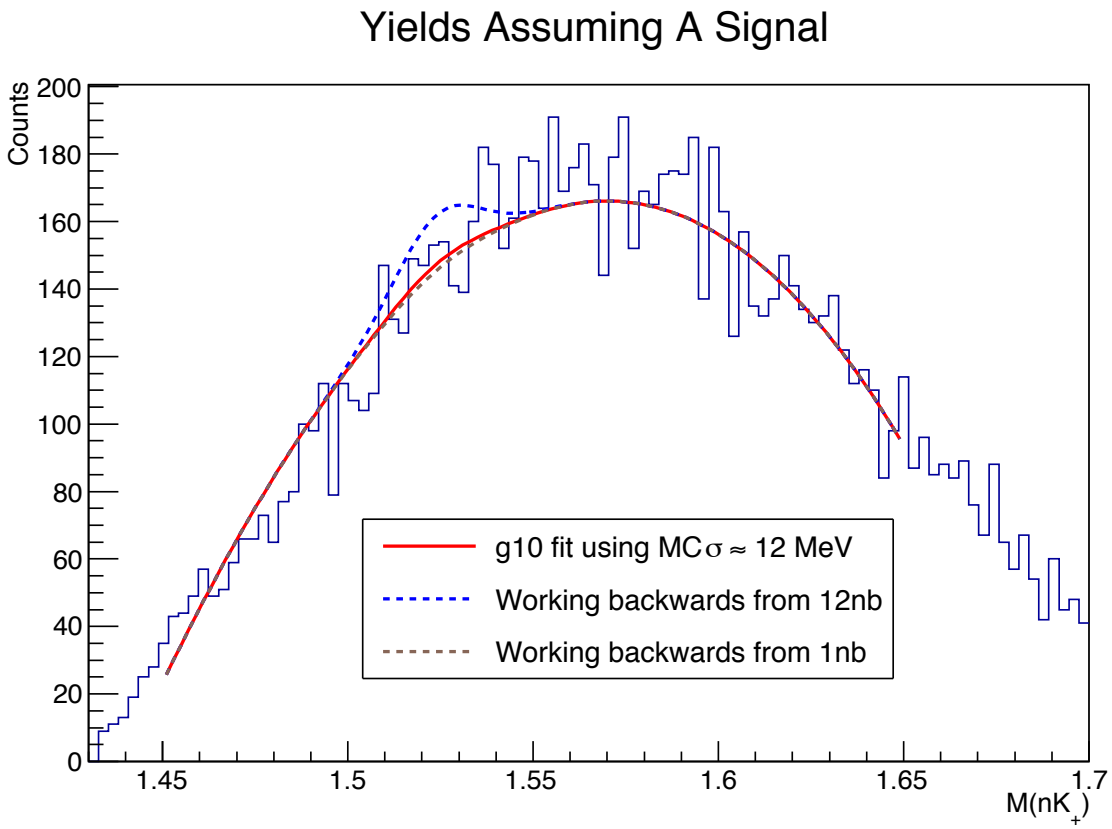


Mass Spectrum fit to polynomial



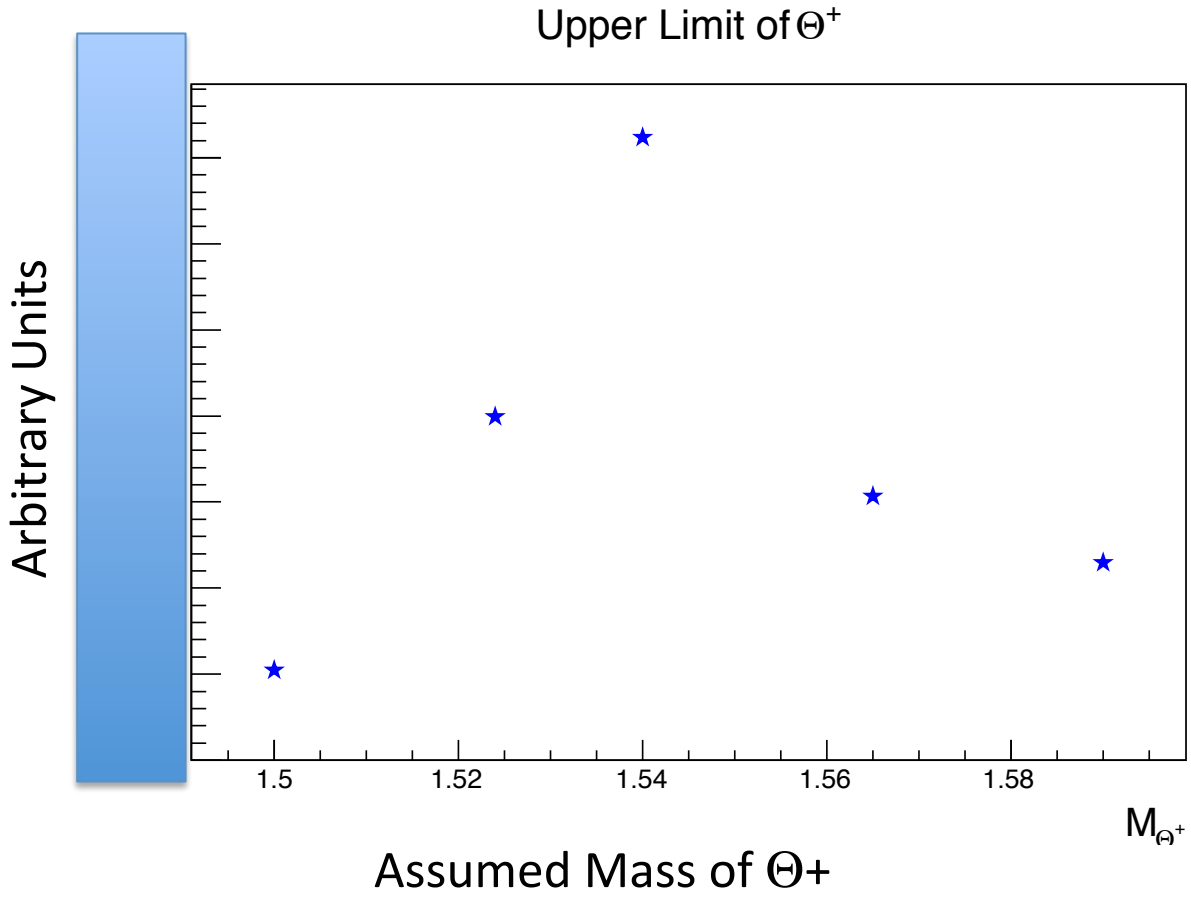
No Θ^+ peak is seen. This uses the same analysis methods as LEPS.

Assume a Θ^+ peak of 12 nb.



Very Preliminary!! LEPS measured a cross section of 12 +/- 2 nb/sr in the angular range of their detector.

In Progress: Cross section upper limit

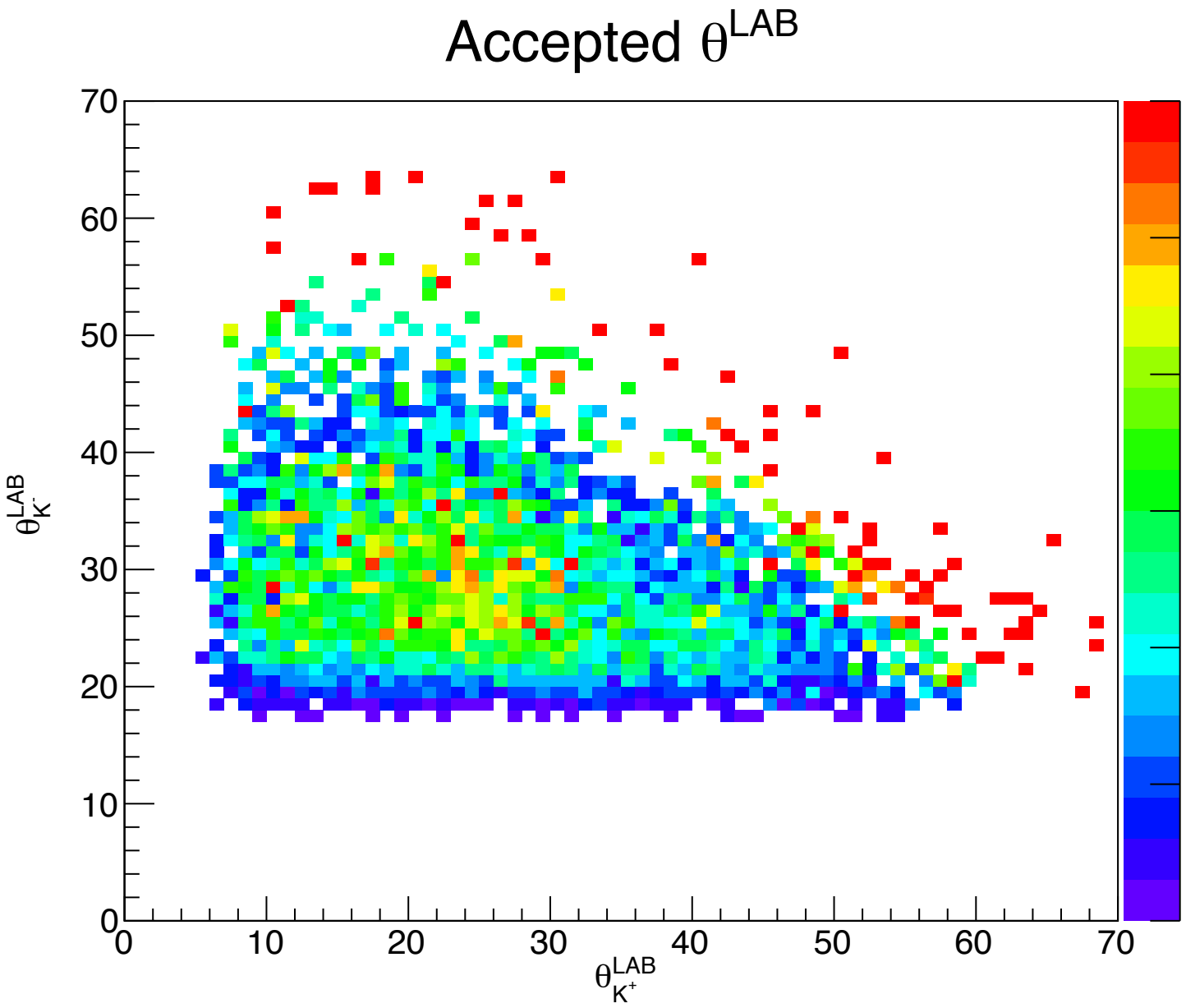


Precise numbers for the upper limit from CLAS data are currently undergoing review. Approval expected soon.

Summary

- CLAS data (g10 run) was analyzed with the goal of closely following the LEPS Θ^+ analysis.
- No peak is seen for a Θ^+ in the CLAS results.
  - A cross section upper limit is in progress.
- Future analysis of other CLAS data (e.g., g13 run) may provide more stringent upper limits.
  - Deuteron target and E_γ range 2 ~ 2.5 GeV.
- CLAS cannot access K^- angle < 17 degrees.
  - Production mechanism could depend on θ_K.

Backup Slides


Accepted θ^LAB
θ_K⁻^LAB
θ_K⁺^LAB
0
10
20
30
40
50
60
70