Comment on the Narrow Structure claimed by Amaryan et al.

Ken Hicks

Workshop on Hadron Dynamics

Pusan, Korea, 20-Nov-2012

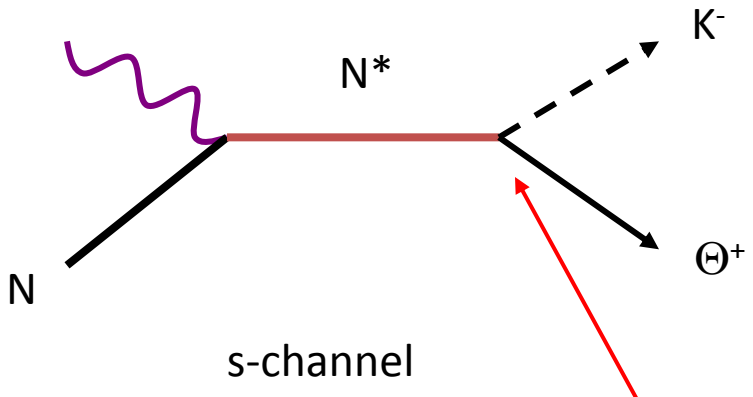
Outline

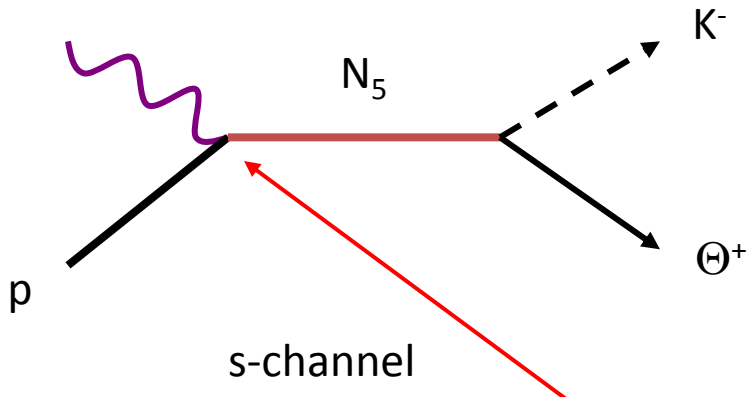
- Brief review of Θ^+ results.
- Brief review of paper by Amaryan et al.
- CLAS Collaboration view of this paper
- Discussion: possible explanation
- Summary

Experimental Situation for Θ^+

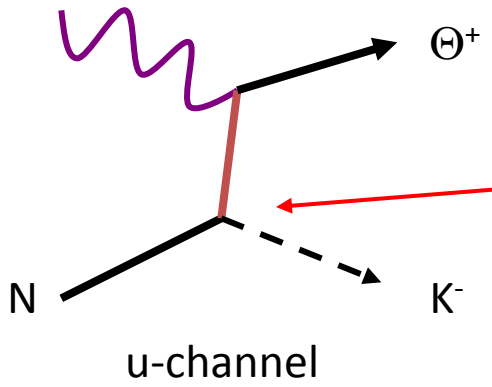
- There are many null results.
  - No Θ^+ from e^+e^- or high energy collisions.
  - 4-5 positive experiments repeated, all null.
- Only 2 results still appear viable:
  - LEPS $\gamma d \rightarrow K^+ K^- X$ (forward angle).
  - DIANA bubble chamber data (nucleus)

Suppressed Kinematics





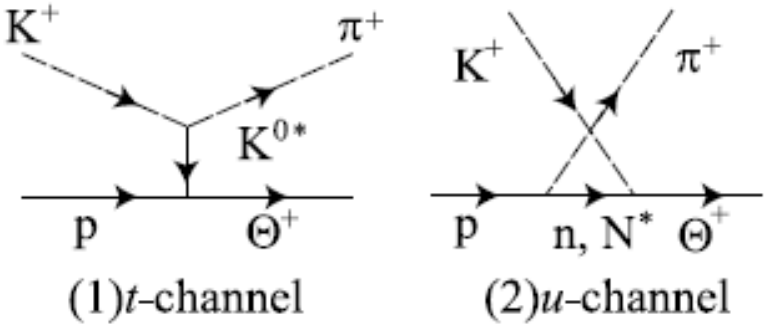
U-spin suppressed



Requires 2 qq $\bar{p}$air production (OZI suppressed).

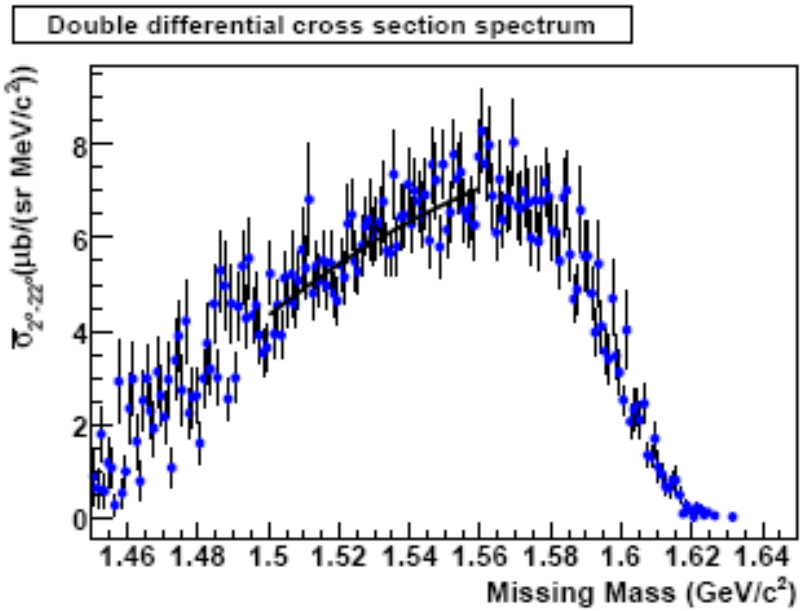
Forward-angle production is preferred.

KEK experiment



Miwa et al., The E559 Collaboration
arXiv:0712.3839.

Backward angles not detected in this experiment.

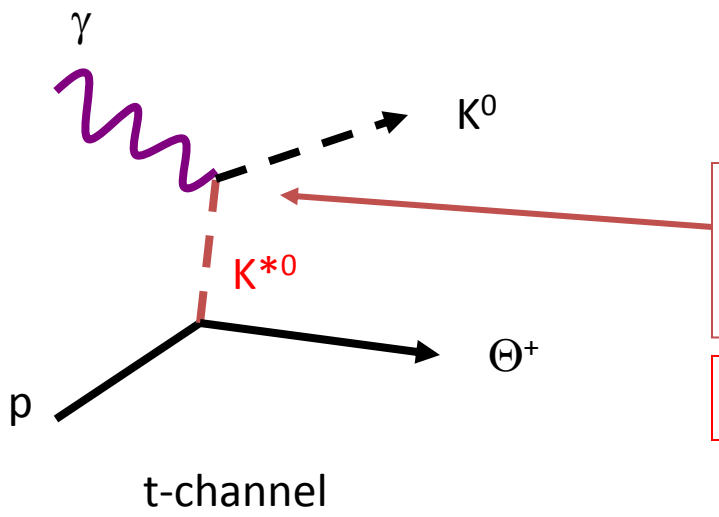


Lack of signal means either:
1) **Θ+ does not exist**
2) **K* coupling is very small.**

Upper limit is 3.5 μb/sr (2°-22°), much small than theory estimate.

Photoproduction Experiments

The s- and u-channel diagrams are suppressed, and no contact diagram.



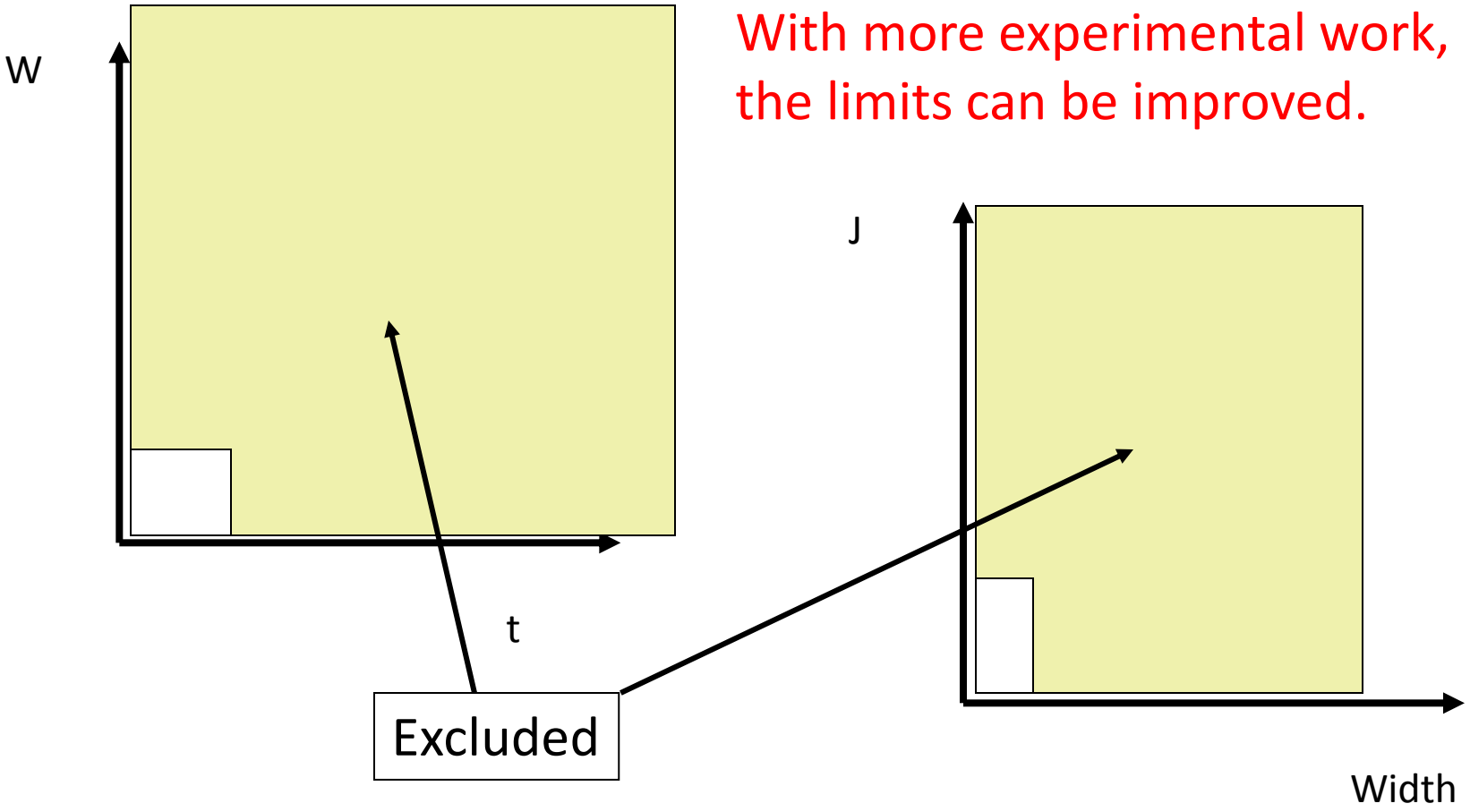
For a neutral particle, this must be a M1 (spin-flip) operator.

Here, the exchange particle must be a K^{*0}.

If the coupling vertex $N\Theta^{+}K^{*}$ is small, then this could explain why the CLAS proton experiments give a null result.

Exclusion Regions for Θ^+

The Θ^+ is "painted into a corner". With more experimental work, the limits can be improved.



Paper by Amaryan et al.

PHYSICAL REVIEW C **85**, 035209 (2012)

Observation of a narrow structure in $^1\mathrm{H}(\gamma,K^0_S)X$ via interference with ϕ-meson production

M. J. Amaryan,[1,*] G. Gavalian,[1] C. Nepali,[1] M. V. Polyakov,[2,3] Ya. Azimov,[3] W. J. Briscoe,[4] G. E. Dodge,[1] C. E. Hyde,[1] F. Klein,[5] V. Kuznetsov,[6,7] I. Strakovsky,[4] and J. Zhang[8]

[1]*Old Dominion University, Norfolk, Virginia 23529, USA*
[2]*Institut für Theoretische Physik II, Ruhr–Universität Bochum, D-44780 Bochum, Germany*
[3]*Petersburg Nuclear Physics Institute, Gatchina, St. Petersburg 188300, Russia*
[4]*The George Washington University, Washington, DC 20052, USA*
[5]*Catholic University of America, Washington, DC 20064, USA*
[6]*Kyungpook National University, 702-701, Daegu, Republic of Korea*
[7]*Institute for Nuclear Research, 117312, Moscow, Russia*
[8]*Thomas Jefferson National Accelerator Facility, Newport News, Virginia 23606, USA*

Subset of CLAS Collaboration

(Received 20 October 2011; revised manuscript received 29 February 2012; published 26 March 2012; publisher error corrected 29 March 2012)

We report observation of a narrow peak structure at ~1.54 GeV with a Gaussian width $\sigma = 6$ MeV in the missing mass of K_S in the reaction $\gamma + p \to pK_SK_L$. The observed structure may be due to the interference between a strange (or antistrange) baryon resonance in the pK_L system and the $\phi(K_SK_L)$ photoproduction leading to the same final state. The statistical significance of the observed excess of events estimated as the log-likelihood ratio of the resonant signal + background hypothesis and the ϕ-production-based background-only hypothesis corresponds to 5.3σ.

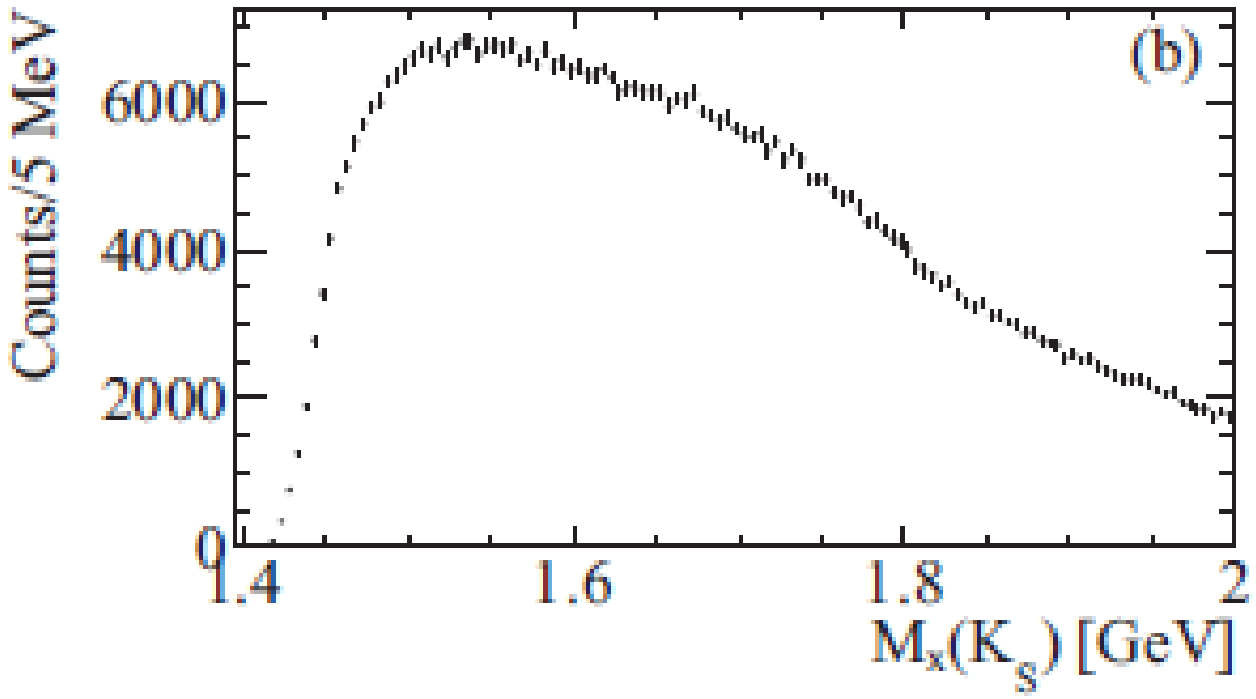
What they claim to see

We report observation of a narrow peak structure at ~1.54 GeV with a Gaussian width $\sigma = 6$ MeV in the missing mass of K_S in the reaction $\gamma + p \rightarrow pK_SK_L$. The observed structure may be due to the interference between a strange (or antistrange) baryon resonance in the pK_L system and the $\phi(K_SK_L)$ photoproduction leading to the same final state. The statistical significance of the observed excess of events estimated as the log-likelihood ratio of the resonant signal + background hypothesis and the ϕ-production-based background-only hypothesis corresponds to 5.3σ.

1) Photoproduction on the proton, K_S^0 detected.
2) Possible interference with ϕ-meson could enhance signal.
3) Requires OVERLAP with ϕ kinematics.
4) Narrow peak in mass of pK_S at 1.54 GeV, narrow width.
5) Log-likelihood statistical analysis: 5.3σ (after t-cut)

Missing Mass: cut ABOVE ϕ-mass

From: Amaryan et al., PRC 85, 035209 (2012)



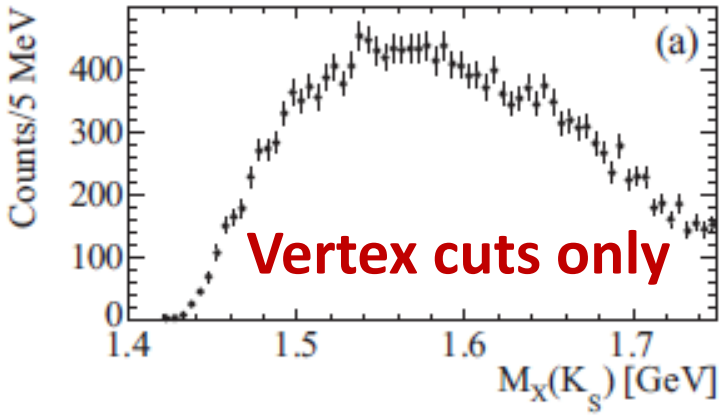
Notes:

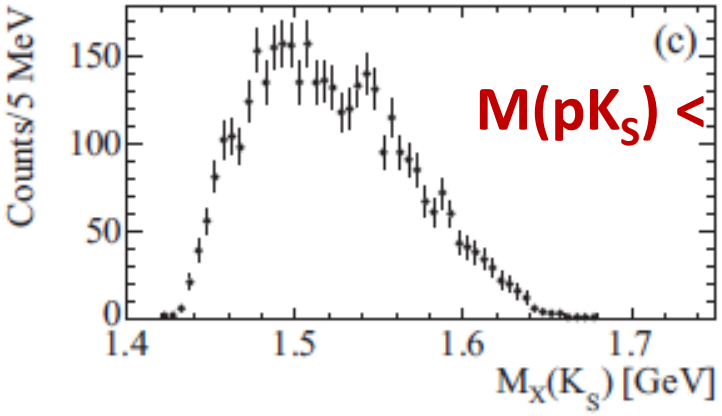
1) Standard particle identification: exclusive pK_SK_L final state
2) Cut on $M(K_SK_L) > 1.04$ GeV: **reproduces published CLAS data**

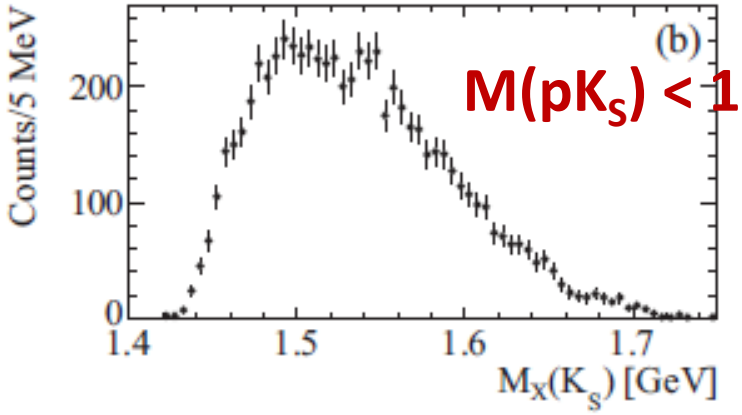
Missing mass: cut ON ϕ-mass

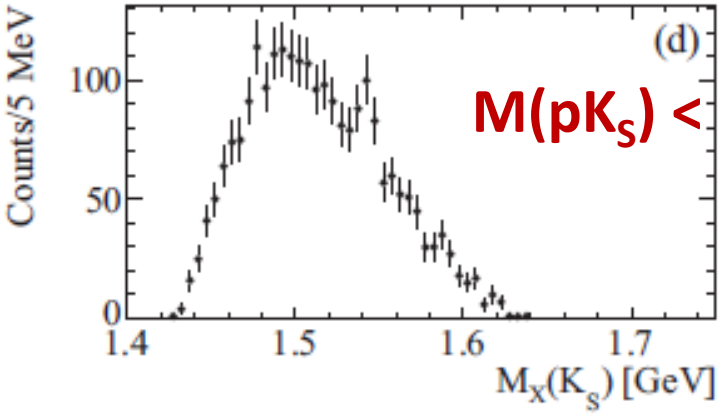
To reduce background from Y* states, cut on invariant mass M(pK_S).

From: Amaryan et al., PRC 85, 035209 (2012)





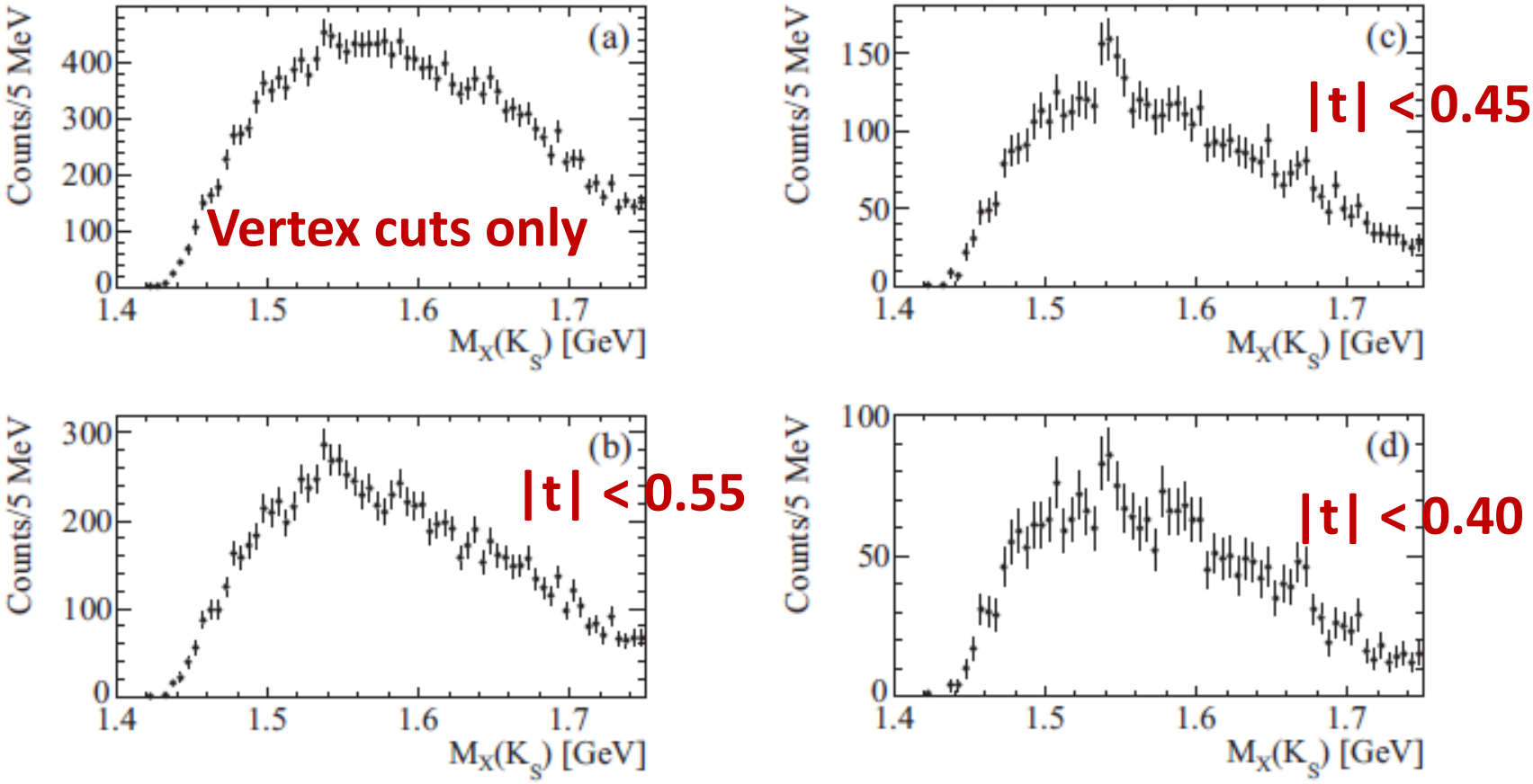




Missing mass: cut ON ϕ-mass

To enhance interference with ϕ-production, cut on $|t|$.

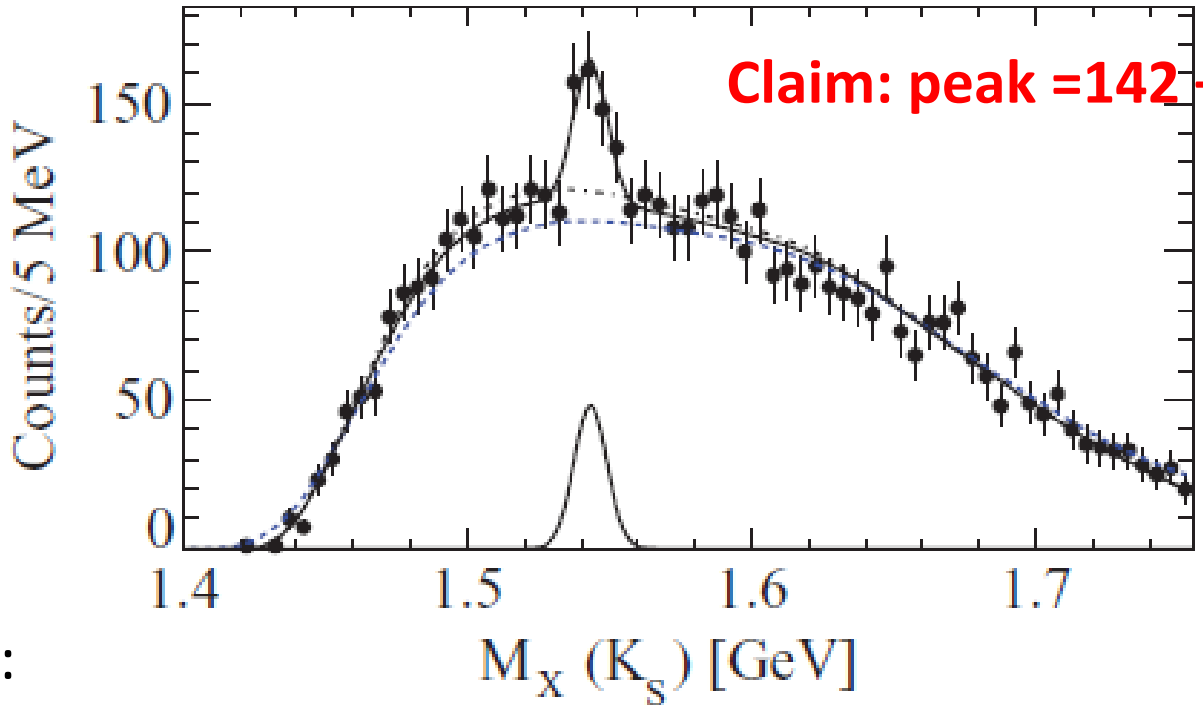
From: Amaryan et al., PRC 85, 035209 (2012)



Fit to peak with MC background

Choose cut on $|t| < 0.45$ GeV^2 (with cut on ϕ-mass and K_S vertex)

From: Amaryan et al., PRC 85, 035209 (2012)



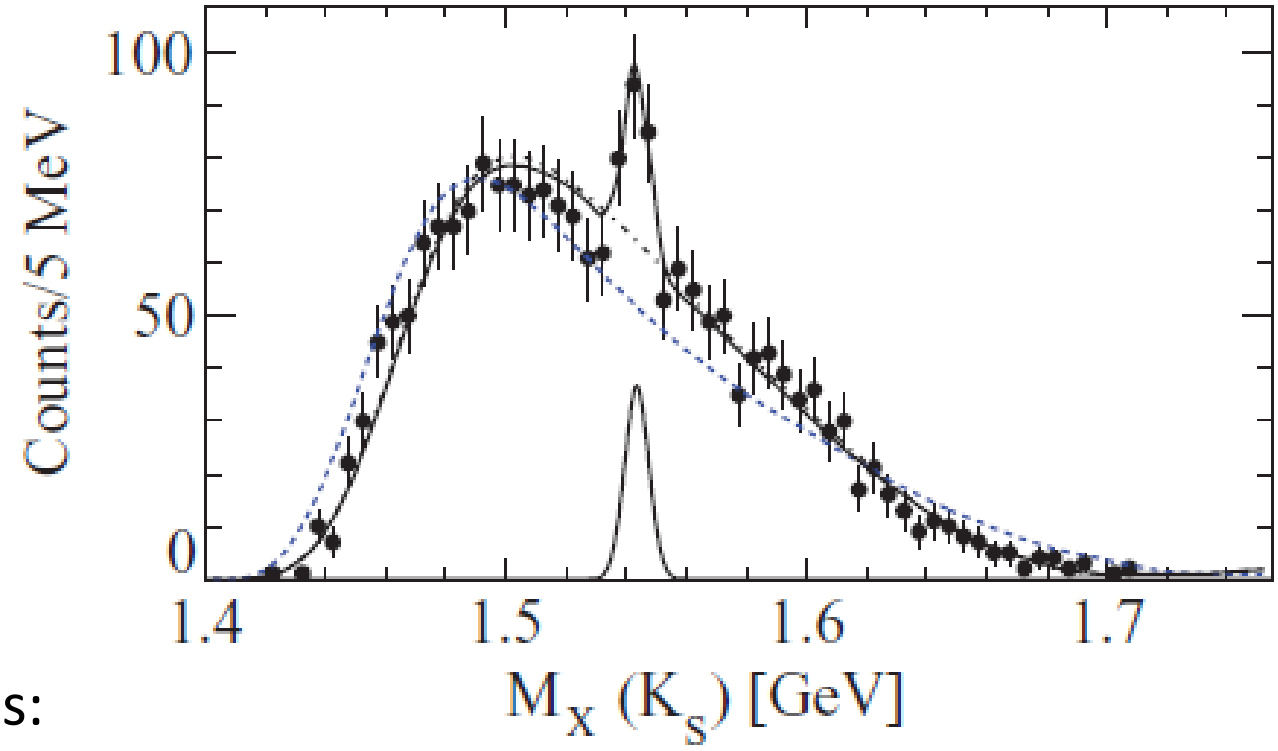
Notes:

1) MC is from pure ϕ-production models (dashed, dot-dash)
2) Log-likelihood compares solid and dot-dash: **5.3σ**.

For comparison: both cuts

Choose cuts on $|t| < 0.45$ GeV^2 and $M(PK_S) < 1.56$ GeV (plus ϕ).

From: Amaryan et al., PRC 85, 035209 (2012)



Notes:

1) Same MC (fits background also for these cuts).
2) Fewer counts, so statistical significance only 4σ.

CLAS Collaboration Response

- An analysis review was carried out by a committee of 5 CLAS members.
  - They recommended that this analysis not go forward as a CLAS paper.
  - Reason: results are too dependent on the t-cut
- A collaboration-wide vote to proceed with this analysis as a CLAS publication did not pass.

CLAS Coordinating Committee

- Requested the following text be added to the paper by Amaryan et al.:

> The interpretation of experimental results obtained in this analysis reflects the opinion of the authors and not that of the CLAS Collaboration as a whole.

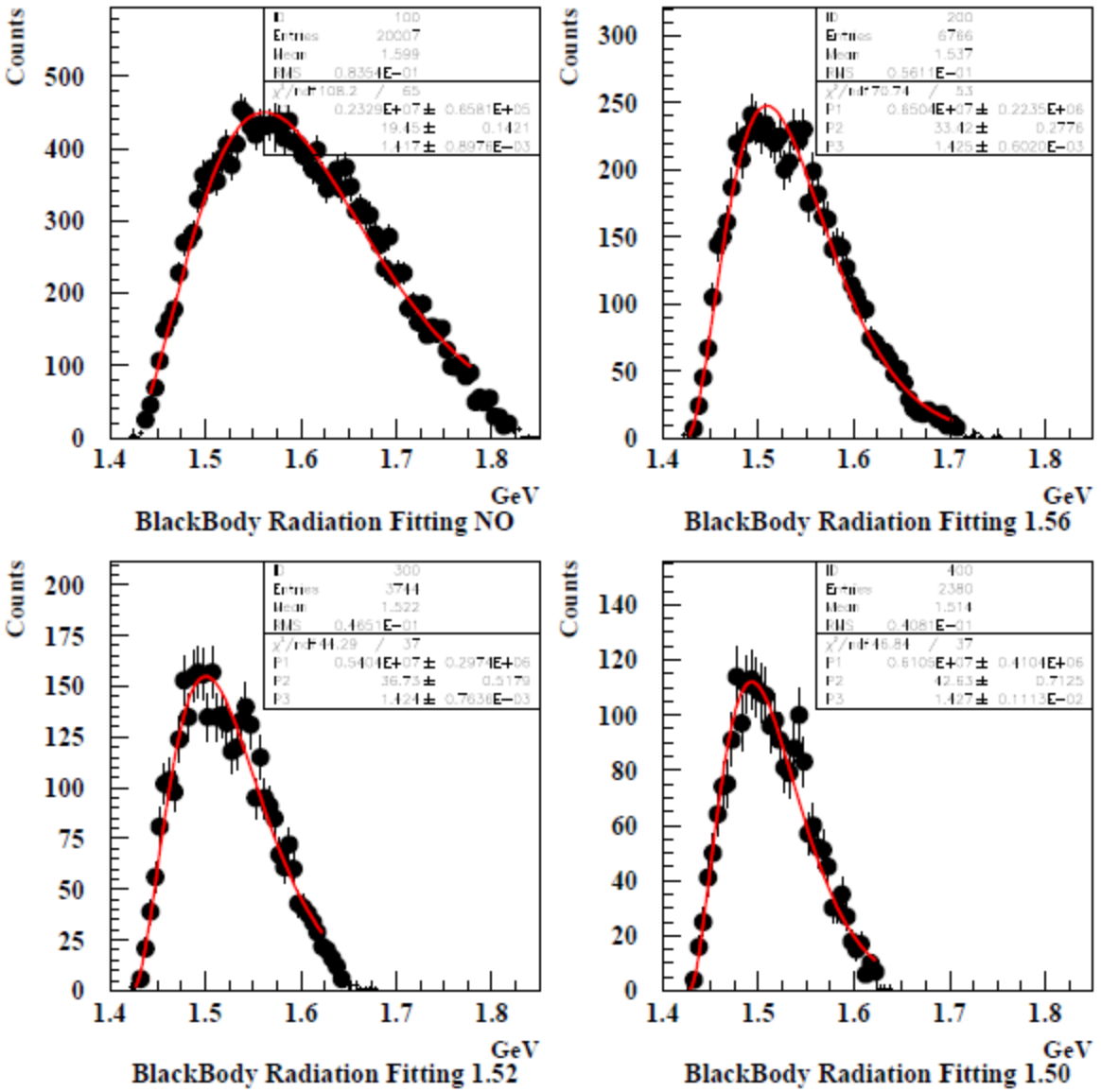
No-peak fits

Here are the same mass-cut figures, but now plotted with a new background shape, and no peak.

The reduced χ^2 is about 1.5 (all cases) so these fits are OK.

(Fits by W. Tang)

Data points only are from Amaryan et al, PRC 2012.

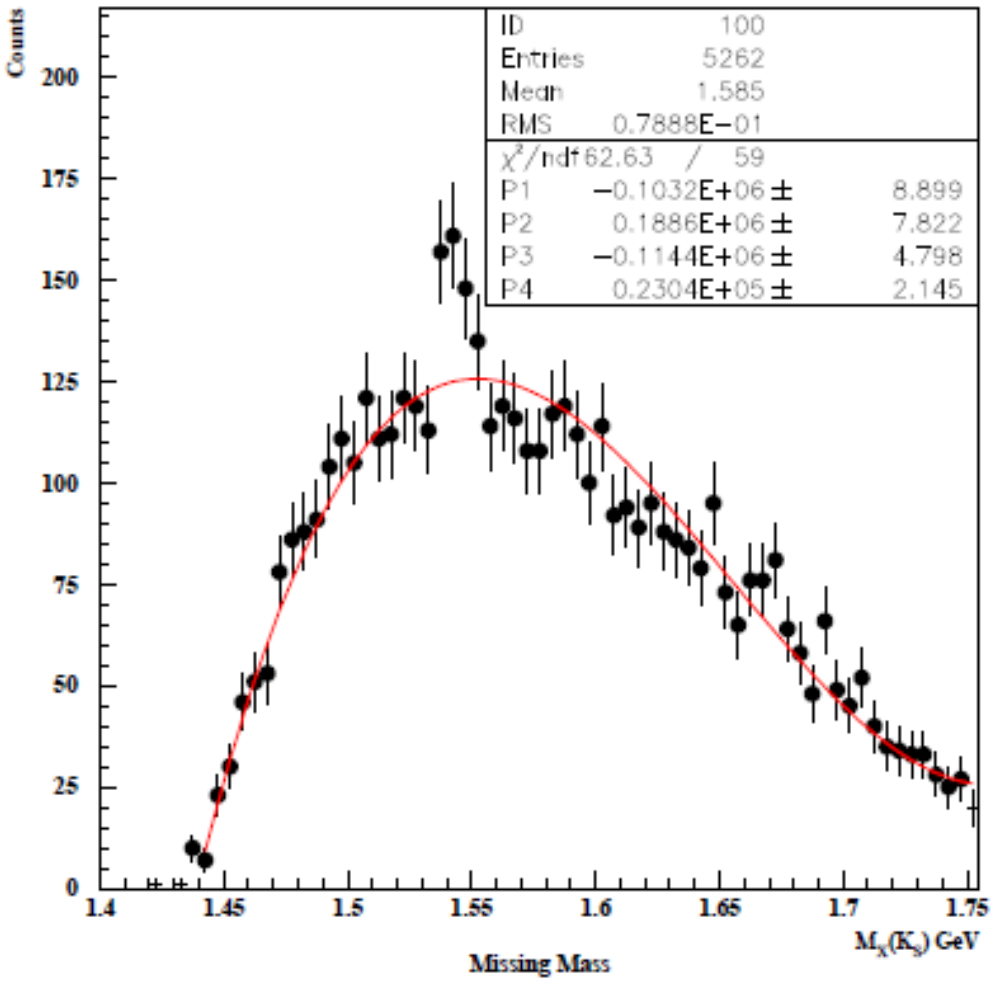


After t-cut: how many counts?

Here is the "best" t-cut spectrum, used for final results by Amaryan et al.

In 3-bins at M_x=1.54 GeV above the background shown, the number of counts in the "peak" is ~**90 counts**.

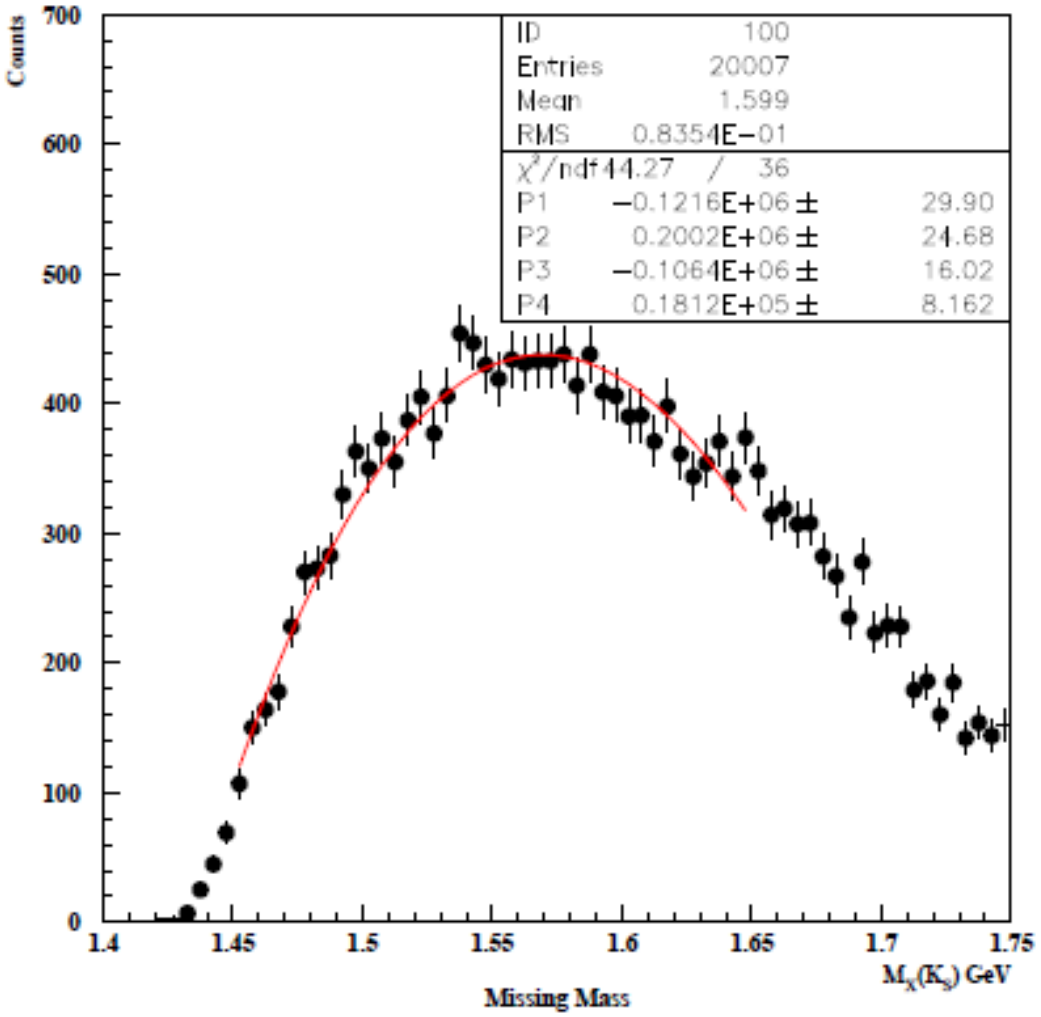
Data points only are from Amaryan et al, PRC 2012.



Before t-cut: how many counts?

Here, we look at the data before any t-cut. The number of counts above background at M_x=1.54 GeV is about **60 counts**. Under the peak, the background has 1260 counts. (We use the same 3 bins.) The "peak" significance is estimated at < 2σ.

Data points only are from Amaryan et al, PRC 2012.



Counts: a quick summary

- Amaryan et al. claim after the "best" t-cut:
  - 142 +/- 46 counts, significance ~5σ.
- CLAS Collaboration estimate after same t-cut:
  - 90 +/- 25 counts, significance ~3.5σ.
- CLAS Collab. Estimate before any t-cut:
  - 60 +/- 35 counts, significance ~2σ.
- Question: how can the counts in the peak increase after applying a t-cut?
  - Could this be a statistical fluctuation??

Discussion: qualifying remarks

- First, Amaryan et al. are not here to defend their position. They should have that chance.
- Second, there is a possible t-cut behavior:
  - This may be an interference with a p-wave resonance, so angular interference effects are possible: it could increase counts after a cut.
- Bottom line: evidence for a new resonance requires should be more convincing.
  - The CLAS Collaboration was not convinced.

Summary

- There was no fault found in the data analysis of the paper by Amaryan et al.
  - However, there was disagreement between the CLAS Collaboration and the authors about the interpretation of the results after a t-cut.
- If there is a narrow structure at M_x=1.54 GeV in this reaction at the significance claimed by Amaryan et al., then it has strange behavior.
  - The counts in the peak after the t-cut seems to be more than the counts before any t-cut.