The search for the Θ^{++}

Motivation

- QCD does not exclude penta-quark systems
- So far only bound triplet-quark and quark-antiquark systems found
- Search for a family of penta-quark systems (5 quarks)
- Experimental evidence of penta-quark systems
- Predictions of
  Θ^-, Θ^0, Θ^+, Θ^{++} and Θ^{+++}

Interpretation of the Θ^+ as an isotensor pentaquark with weakly decaying partners

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Abstract

The $\Theta^+(1540)$, recently observed at LEPS, DIANA and CLAS, is hypothesized to be an isotensor resonance. This implies the existence of a multiplet where the Θ^{++}, Θ^+ and Θ^0 have isospin-violating strong decays, and the Θ^{+++} and Θ^- have weak decays and so are long-lived. Production mechanisms for the weakly-decaying states are discussed. The J^P assignment of the Θ is most likely $1/2^-$ or $3/2^-$.

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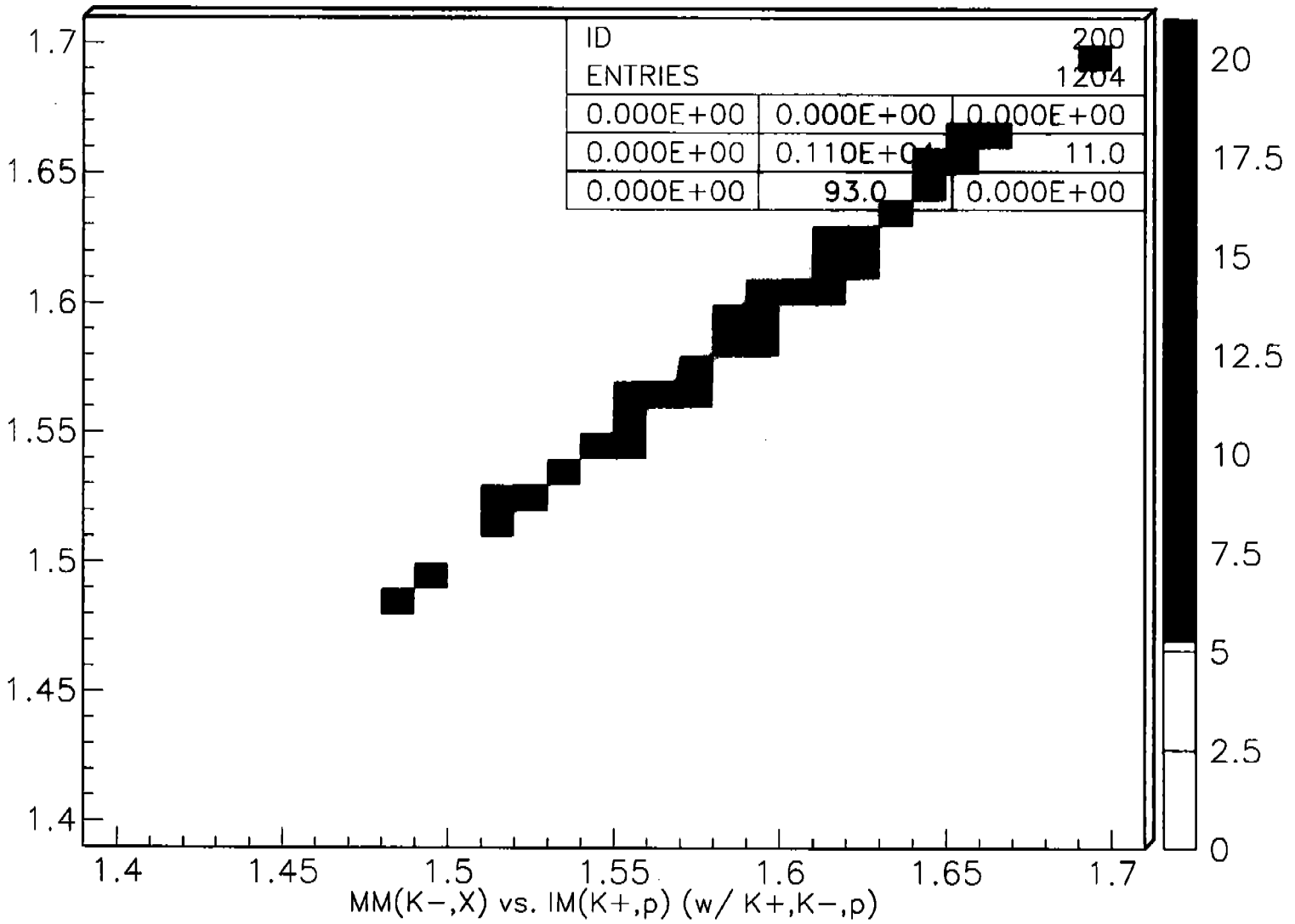
Objective

- Search for Θ^{++} in the reaction $\gamma p \rightarrow K^- \Theta^{++}$
- Assume strong decay of the Θ^{++} into p and K^+
- Require all three particles of final state, namely p, K^+ and K^-
- Identify possible reflections from other reactions

The analysis

- Part of hyperon resonance analysis
- Beam energy $E_\gamma = 0.5 \ldots 2.4$ GeV
  threshold$_{K^-\Theta^{++}} = 1.85$ GeV
- Exactly one K^+, one K^- and one proton in final state
- 35 MeV cut on $|m_X - m_{(K^+,p)}|$ for $\gamma p \to K^- X$ and $\gamma p \to K^- K^+ p$
- Cut on m_X for $\gamma p \to K^+ X$ and $m_{(K^-,p)}$ for $\gamma p \to K^- K^+ p$, and cut on $E_\gamma^{Threshold}$, reject $\Lambda(1520)$ and $\Lambda(1670)$
- Cut on m_X for $\gamma p \to pX$ and $m_{(K^+,K^-)}$ for $\gamma p \to K^- K^+ p$, and cut on $E_\gamma^{Threshold}$, reject ϕ
- Is there a Θ^{++} signal ?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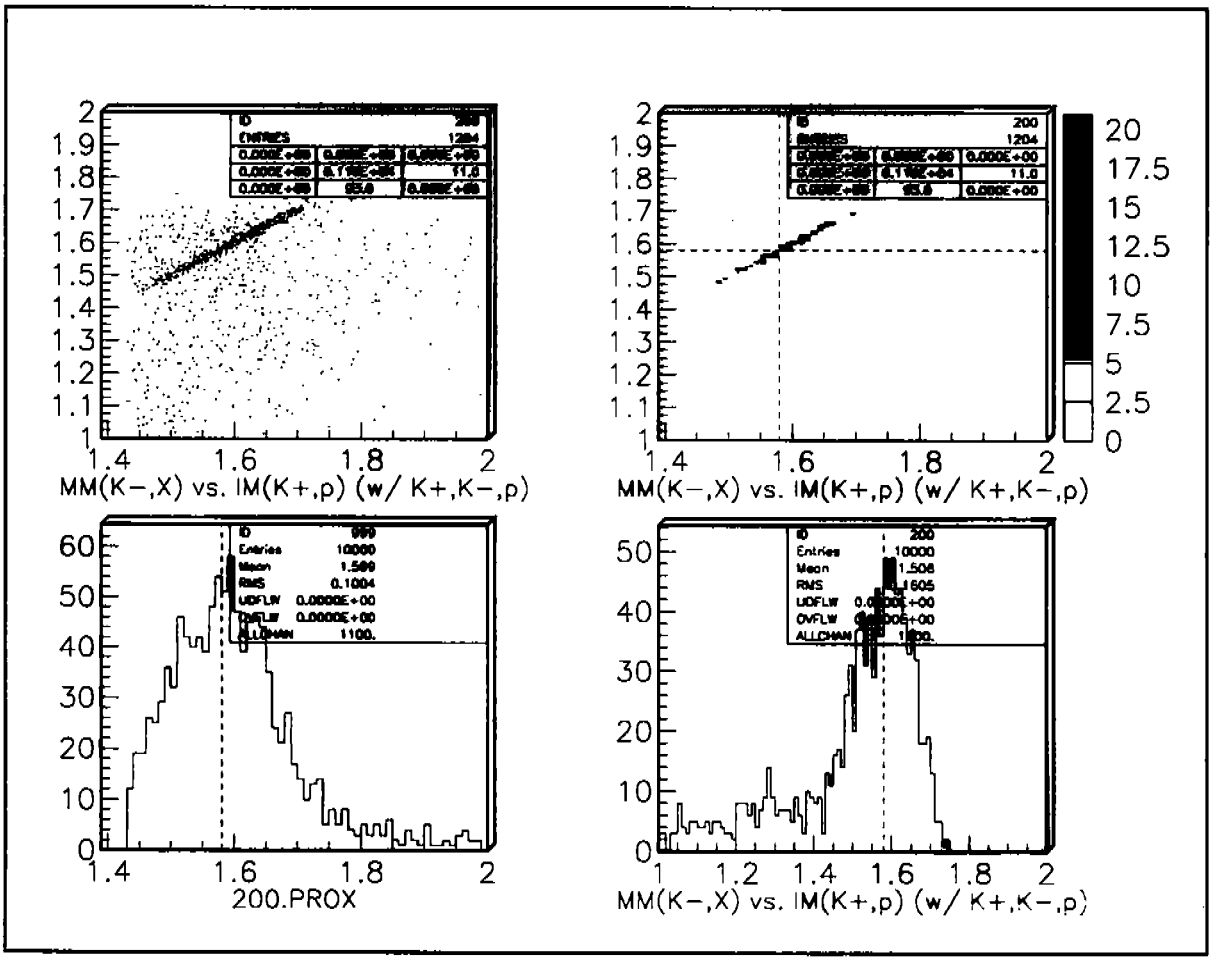
0
MM(K−,X) vs. IM(K+,p) (w/ K+,K−,p)

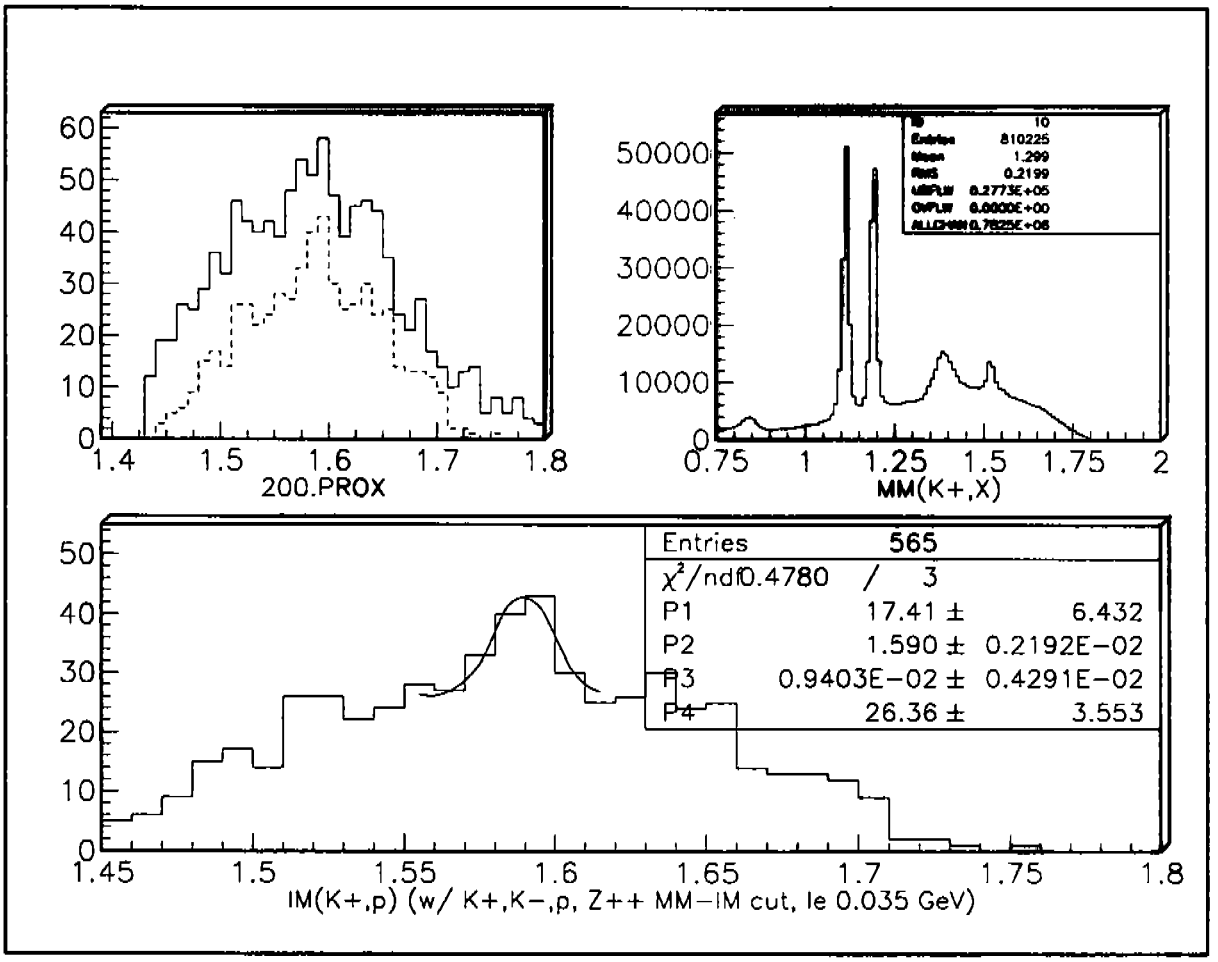
Missing mass vs. inv. mass

- Missing mass m_X for $\gamma p \rightarrow K^- X$, whereby K^+ and p also identified
- Invariant mass $m_{(K^+,p)}$ for $\gamma p \rightarrow K^- K^+ p$



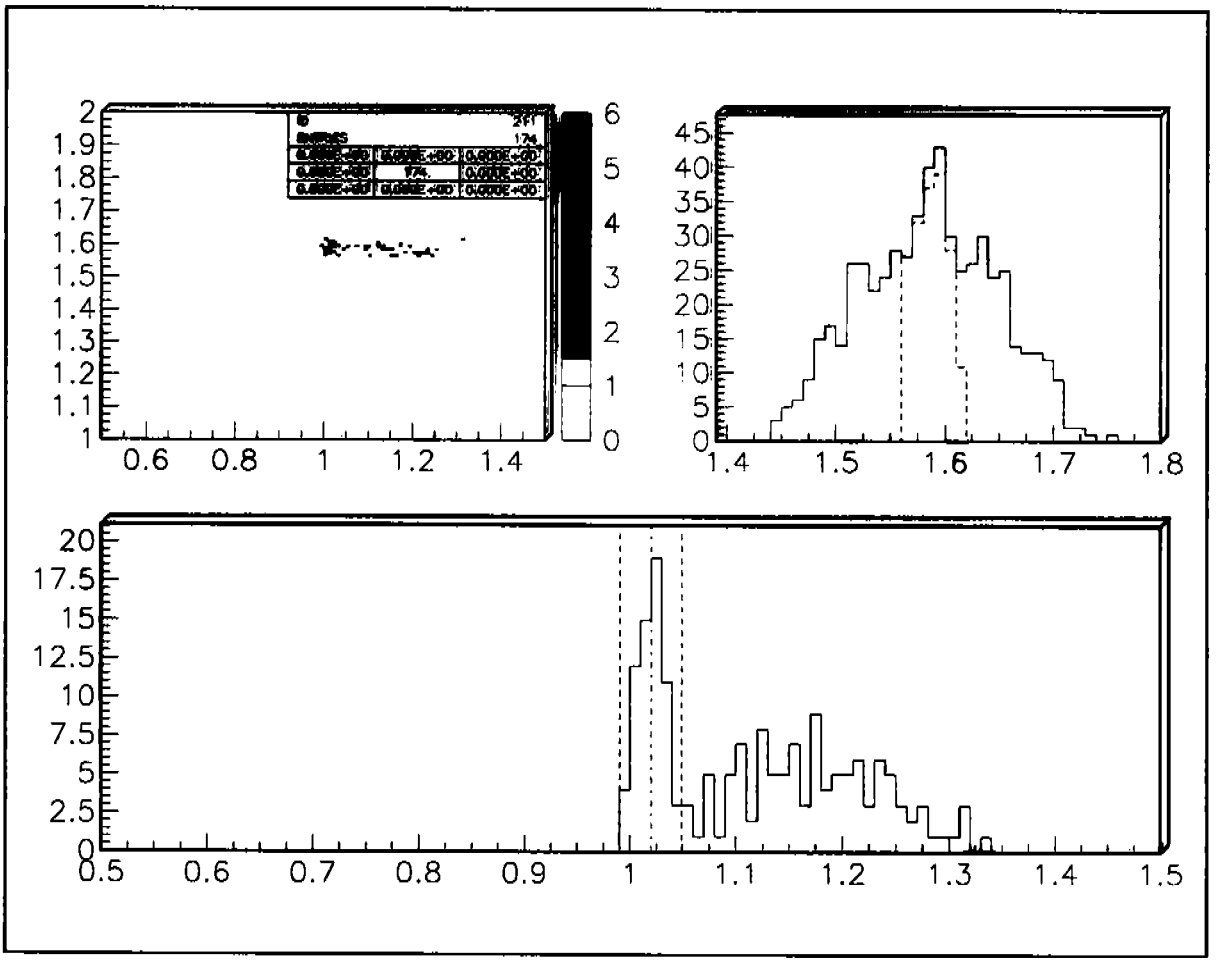
Θ^{++} signal

- Cut on $|m_X - m_{(K^+,p)}|$ for $\gamma p \rightarrow K^- X$ and $\gamma p \rightarrow K^- K^+ p$
- Invariant mass $m_{(K^+,p)}$ for $\gamma p \rightarrow K^- K^+ p$



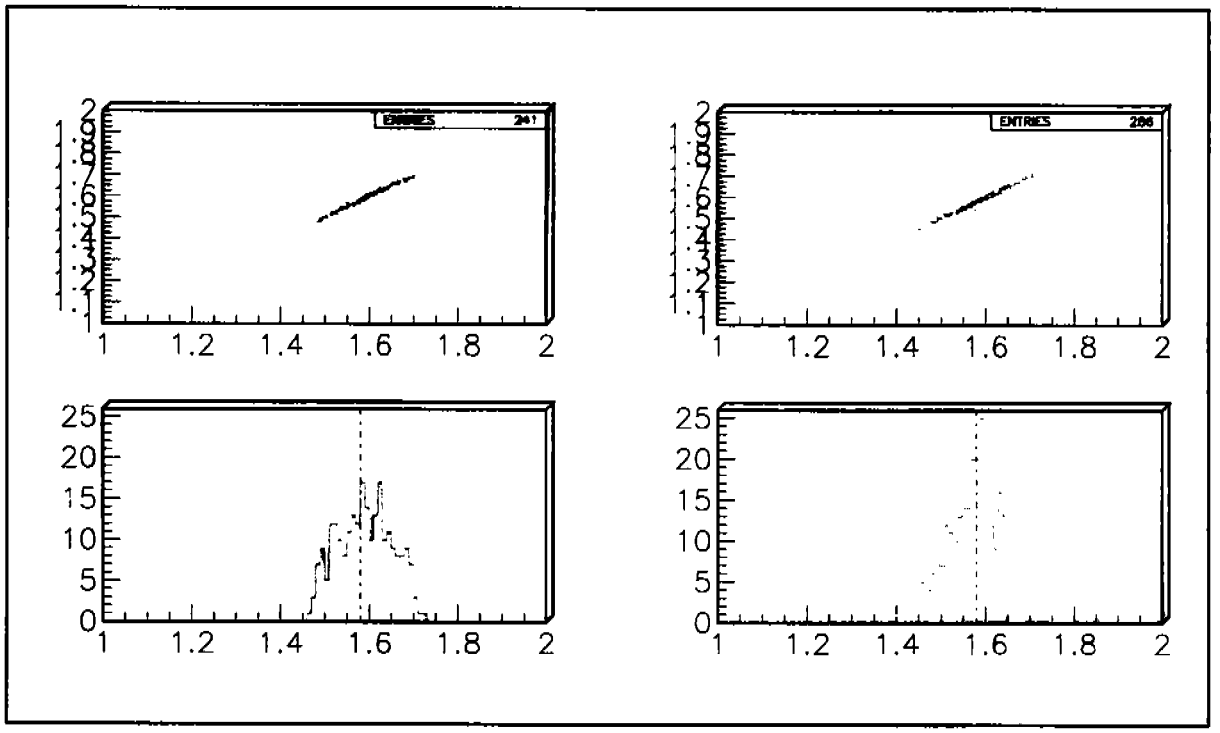
The ϕ within the "Θ^{++}"

- Cut on Θ^{++} signal
- Cut on $E_{\gamma}^{Threshold}$
- $m^2_{(K-,K+)} > 0$



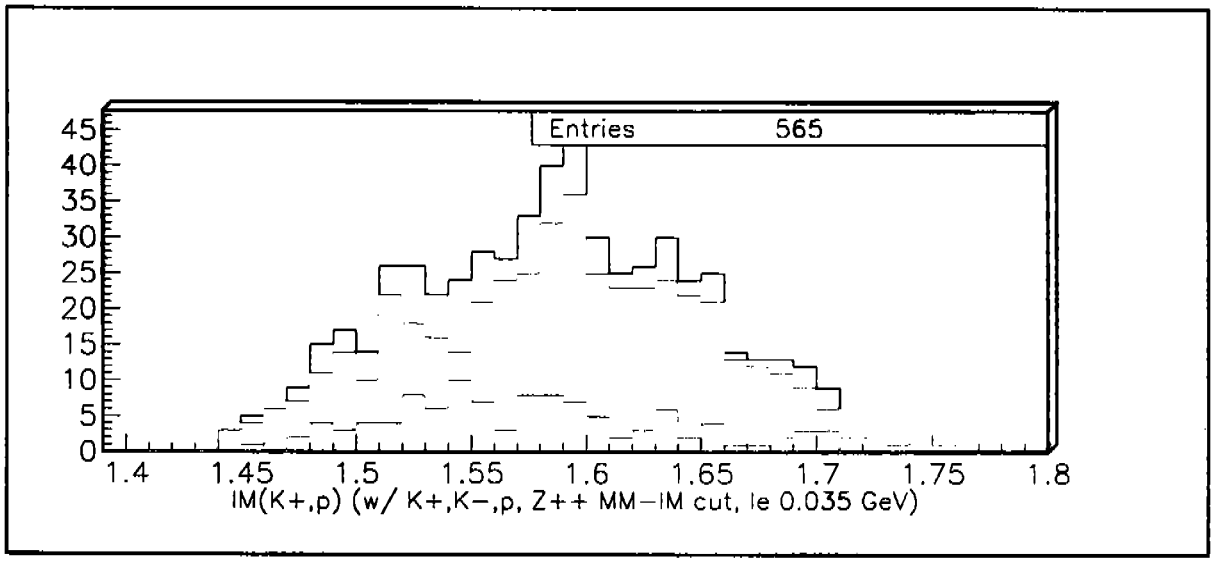
The "Θ^{++}" within the $\Lambda(1520)$

- 35 MeV cut on $|m_X - m_{(K^-,p)}|$ with $\gamma p \rightarrow K^+ X$
- 35 MeV cut on $|m_X - m_{(K^+,p)}|$ with $\gamma p \rightarrow K^- X$
- Compare Θ^{++} signal in $m_{(K^+,p)}$ for $\Lambda(1520)$ events (green) and rest (red)



Θ^{++} w/o ϕ, $\Lambda(1520)$ & $\Lambda(1670)$

- Remove ϕ, $\Lambda(1520)$ and $\Lambda(1670)$ events
- Plot $m_{(K^+,p)}$ for remaining Θ^{++} signal
- Compare distributions
  - Original signal (black)
  - Either ϕ or Y* (red)
  - Remainder of Θ^{++} (green) – "It's dead, Jim"
- What is a peak or bump?



Summary

- A peak can be seen in the correlated invariant and missing mass distributions, suggested Θ^{++} candidate.
- This peak can be dismissed as reflection mainly from ϕ production and a smaller contribution from Y* production.
- We need to see what this means for the existence of Θ^{+} (S. Capstick).

$\gamma p \rightarrow K^+ K^- p$

$\gamma p \rightarrow K^- \Theta^{++}$ with $\Theta^{++} \rightarrow p K^+$

$\gamma p \rightarrow K^+ \Lambda(1520)$ with $\Lambda(1520) \rightarrow p K^-$

$\gamma p \rightarrow \phi p$ with $\phi \rightarrow K^+ K^-$