

To be submitted to Physical Review Letters

SLAC-PUB-586
UCRL-18756

UNIVERSITY OF CALIFORNIA

Lawrence Radiation Laboratory
Berkeley, California

AEC Contract No. W-7405-eng-48

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ABSTRACT

The $K\pi\pi$ enhancement at 1780 MeV (the "L Meson") is copiously produced in our K^+p experiment at 12 GeV/c. We show that this "meson" can be explained as a threshold enhancement in the $K_N(1420)\pi$ system. We see no evidence for this enhancement in channels other than $K_N(1420)\pi$; therefore a resonance interpretation is not required.

A $K\pi\pi$ enhancement at about 1780 MeV has been observed in a number of experiments studying $K^{\pm}p$ and $K^{-}d$ interactions.¹⁻⁵ Observations of this enhancement in the $K^{*}(890)\pi$, $K_N(1420)\pi$, $K\rho$, and $K\omega$ channels have been reported.

In this experiment the L enhancement is studied in the reaction $K^+p \rightarrow L^+p$ with incident K^+ momentum of 12 GeV/c. We find it can be explained as a threshold enhancement in the $K_N(1420)\pi$ system in the reaction $K^+p \rightarrow K_N(1420)\pi p$. In addition we find a similar peak starting at $K\pi\pi$ threshold for any restricted $K\pi$ mass interval independent of $K\pi$ resonance formation. This suggests that the L enhancement is due to the general behavior of the $K\pi\pi$ mass distribution for a restricted $K\pi$ mass interval, rather than to the production of a resonance. We find no evidence for an L enhancement in the $K^{*}(890)\pi$, $K\rho$, or $K\omega$ channels.

The data for this experiment were obtained in a 600 000-picture exposure of the SLAC 82-inch hydrogen bubble chamber to an rf-separated 12-GeV/c K^+ beam.⁶

The properties of the L enhancement were studied by using the reactions

$$K^+p \rightarrow K^+p \pi^+ \pi^- \quad (14310 \text{ events}), \quad (1)$$

$$K^+p \rightarrow K^+p \pi^+ \pi^- \pi^0 \quad (10288 \text{ events}). \quad (2)$$

These events come from an analysis of approximately 1/3 of the total 30-eV/ μb path length.⁷ Only events of reaction (2) with lab momentum of the proton less than 1 GeV/c were included in this analysis. This cut does not affect the L signal in this channel, since almost all of the L events produced in reaction (1) are associated with $P_p < 1$ GeV/c.

Figure 1a shows the $K^+\pi^-$ invariant-mass distribution for all events of reaction (1). $K^*(890)$ and $K_N(1420)$ production is evident. Figure 1b displays the $K\pi\pi$ invariant mass for the same events. The well-known Q enhancement⁵ appears as a very striking peak centered near 1300 MeV with a width of about 250 MeV. The L enhancement is also clearly seen as a broad peak centered at about 1780 MeV.⁸ Figure 1c displays the $K\pi\pi$ mass distribution for events whose $K\pi$ invariant mass lies in a band centered around the $K_N(1420)$.⁹ This selection is seen to greatly enhance the L signal; in fact, the L enhancement in Fig. 1b appears undiminished by the selections which gave Fig. 1c. When the Δ^{++} events are removed (shaded histogram of Fig. 1c) an especially clean L signal is seen, reduced in size, however.¹⁰

It appears from Fig. 1c that the enhancement at 1780 MeV in Fig. 1b is associated with the threshold of a single channel, $K_N(1420)\pi$.

In order to further clarify this observation we have looked at the $K\pi\pi$ mass distribution for different bands of $K\pi$ mass in 180-MeV intervals. We find the results shown in Fig. 2. Each interval in the $K\pi$ mass produces a threshold enhancement similar to the L (or Q) at a mass value which moves with the threshold.¹¹ This general behavior of the $K\pi\pi$ mass distribution when a restriction is imposed on the $K\pi$ mass implies that for every $K\pi$ enhancement there will be a corresponding threshold enhancement in the $K\pi\pi$ mass distribution.¹²

A crucial test on the possible resonant nature of the L enhancement is the existence of other decay modes. We have made a search for the $K^*(890)\pi$, $K\rho$, and $K\omega$ decay modes which have been previously reported. Figure 3a is a plot of the $K\pi\pi$ mass of reaction (1) for events whose $K^+\pi^-$ mass forms a $K^*(892)$ (Δ^{++} events have been removed). This distribution

shows no evidence for a $K^*(890)\pi$ enhancement at 1780 MeV. Although one could envision a background distribution that would indicate an excess of events in the L region, there is no indication of a Breit-Wigner-type structure at 1780 MeV. Some experimenters have concluded that the L enhancement does exist in $K^*(890)\pi$,¹³ however, their evidence appears inconclusive in view of the uncertainty in the background and the relatively limited statistics of their experiments.

Figure 3b shows the $K\pi\pi$ mass distribution of reaction (1) for events whose $\pi\pi$ invariant mass lies in the ρ band. The shaded part of the histogram represents the contribution from the $K_N(1420)$ events which contaminate the ρ sample. As is seen, the excess of events in the L region is associated with the $K_N(1420)$ rather than with a genuine $K\rho$ decay mode of the L.

Figure 3c displays the $\pi^+\pi^-\pi^0$ invariant mass for reaction (2). The ω meson is clearly seen. Figure 3d shows the plot of $K^+\pi^+\pi^-\pi^0$ mass for the ω events. There is no evidence for a $K\omega$ enhancement at 1780 MeV.

In conclusion, our data show that the L enhancement is a result of copious production of $K_N(1420)$ with no evidence for the other previously reported decay modes.

We gratefully acknowledge the assistance of the staff of the Stanford Linear Accelerator and the 82-Inch Bubble Chamber in obtaining the data for this experiment. We also acknowledge the LRL Group A Scanning and Measuring Group for their help in data reduction. We thank Dr. E. L. Berger for helpful discussions concerning the multiperipheral model.

Footnotes and References

*Work done under the auspices of the U. S. Atomic Energy Commission.

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Brussels, Belgium.

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3. J. Berlinghieri, M. S. Farber, T. Ferbel, B. Forman, A. C. Melissinos, Y. Yamanouchi, and H. Yuta, *Phys. Rev. Letters* 18, 1087 (1967).
4. M. Jobs, W. Matt, G. Bassompierre, Y. Goldschmidt-Clermont, A. Grant, V. P. Henri, I. Hughes, B. Jongejans, R. L. Lander, D. Linglin, F. Muller, J. M. Perreau, I. Saitov, R. Sekulin, G. Wolf, W. DeBaere, J. Debaisieu, P. Dufour, F. Grard, J. Heughebaert, L. Pape, P. Peeters, F. Verbeure, and R. Windmolders, *Phys. Letters* 26B, 49 (1967).
5. For a good summary of the experimental status of $K\pi\pi$ mass spectroscopy see G. Goldhaber, Meson Spectroscopy (W. A. Benjamin, Inc., 1967) p. 209.

6. S. Flatté, Lawrence Radiation Laboratory Group A Physics Note 646, 1966.
7. Events with a $K^0\pi^0$ instead of $K^+\pi^-$ in reaction (1) have also been analyzed, and are consistent with the results reported here.
8. It is very difficult to estimate the width for this enhancement, since it depends on the background estimate. However, the width is larger than observed in other experiments, where the values range from 60 to 130 MeV (see Ref. 1-5). The resolution of this experiment is about 12 MeV in this mass region. We have plotted the data of Fig. 1b in smaller mass intervals, but no significant fine structure has appeared. In particular we have no evidence for the $K^*(1660)$ reported in Ref. 4.
9. The bands in invariant mass used to define events of various resonances are

| | | |
|---------------------|---|-----------------------------------|
| $K_N(1420)$ | : | $1.33 < M(K^+\pi^-) < 1.51$ |
| $K^*(892)$ | : | $.84 < M(K^+\pi^-) < 0.94$ |
| $\Delta^{++}(1236)$ | : | $M(p\pi^+) < 1.5$ |
| ρ | : | $.66 < M(\pi^+\pi^-) < 0.86$ |
| ω | : | $.75 < M(\pi^+\pi^-\pi^0) < 0.81$ |

10. The reflection of the decay angular distribution of the $\Delta^{++}(1236)$ produces the broad enhancement at a mass of about 2.8 GeV in Fig. 1c. It also produces a broad enhancement of about the same number of events under the L region.
11. An explanation for the $K\pi\pi$ peaking at threshold for any fixed $K\pi$ mass can be found in the double-Regge-pole model, which gives a good qualitative fit to the threshold enhancements that we see.

12. We have investigated the momentum transfer and decay angular distribution of this threshold enhancement as a function of $K\pi$ mass and find no significant anomalies in the L region.
13. See Refs. 1 and 3; also note that some other experimenters observed the absence of a $K^*(890)\pi$ decay mode for the L enhancement [E. L. Berger and G. Goldhaber (Lawrence Radiation Laboratory), private communications].

Figure Captions

Fig. 1. (a) $K^+\pi^-$ invariant mass for reaction (1).

(b) $K\pi\pi$ invariant mass for reaction (1).

(c) $K\pi\pi$ invariant mass for the $K^*(1420)$ events of reaction (1).

Shaded events have the $\Delta^{++}(1236)$ removed.

Fig. 2. $K\pi\pi$ invariant mass distribution of reaction (1) for various intervals of $K\pi$ invariant mass. The $K\pi$ mass intervals (in GeV) chosen are (from left to right): 0.97 to 1.15, 1.15 to 1.33, 1.33 to 1.51, 1.51 to 1.69, and 1.69 to 1.87.

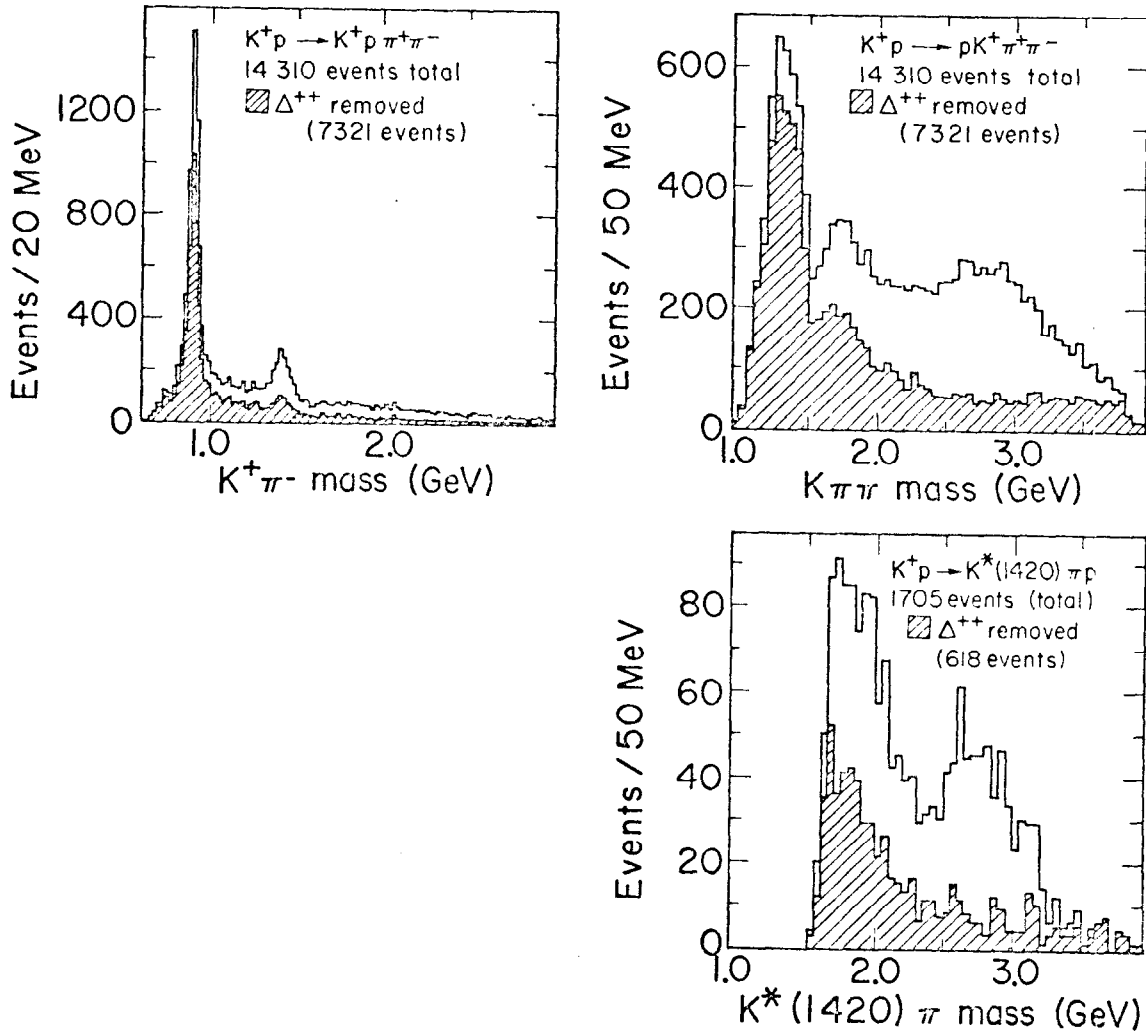
Fig. 3. Search for non- $K^*(1420)\pi$ decay modes of the L enhancement.

(a) $K\pi\pi$ invariant mass of reaction (1) for $K^*(890)$ events.

(b) $K\pi\pi$ invariant mass of reaction (1) for events whose $\pi\pi$ mass lies in the ρ band. Shaded events are the contribution of the $K^*(1420)$ events which overlap the ρ band.

(c) Invariant mass of $\pi^+\pi^-\pi^0$ for events of reaction (2).

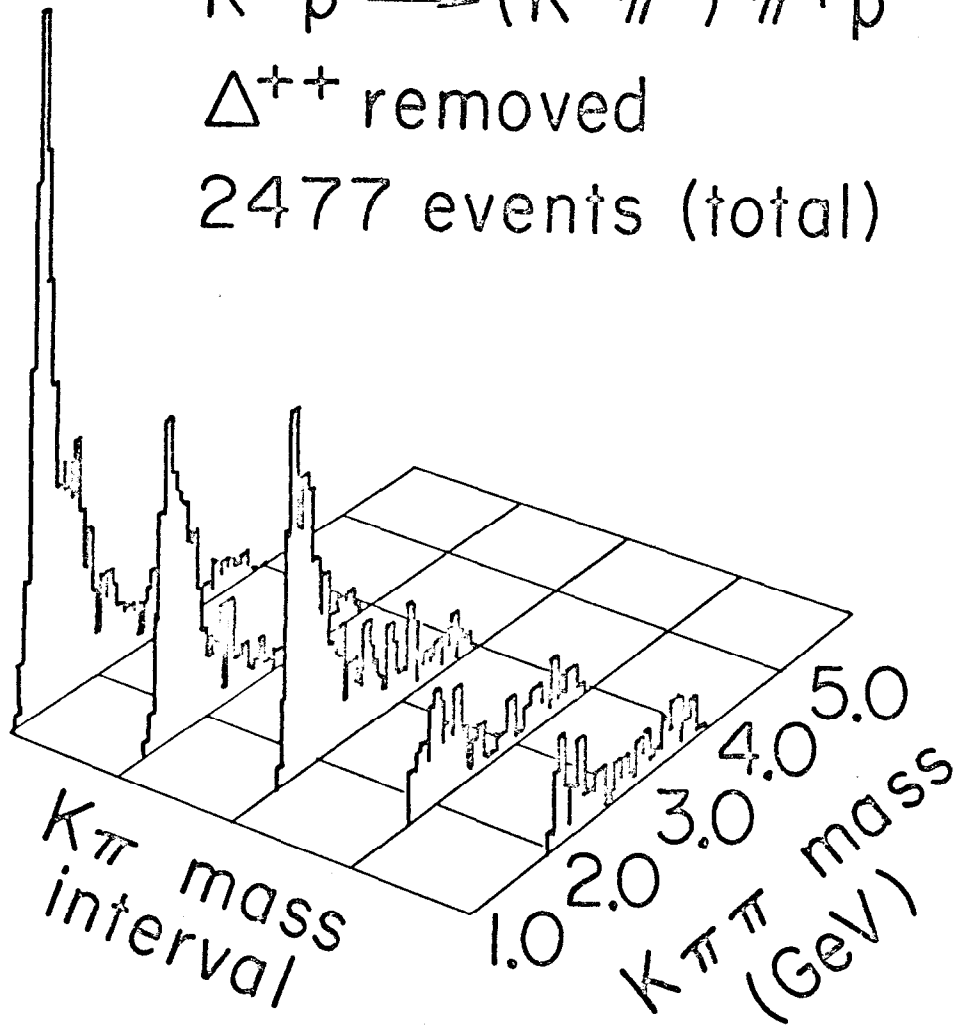
(d) $K\pi\pi\pi$ invariant mass of reaction (2) for ω events.



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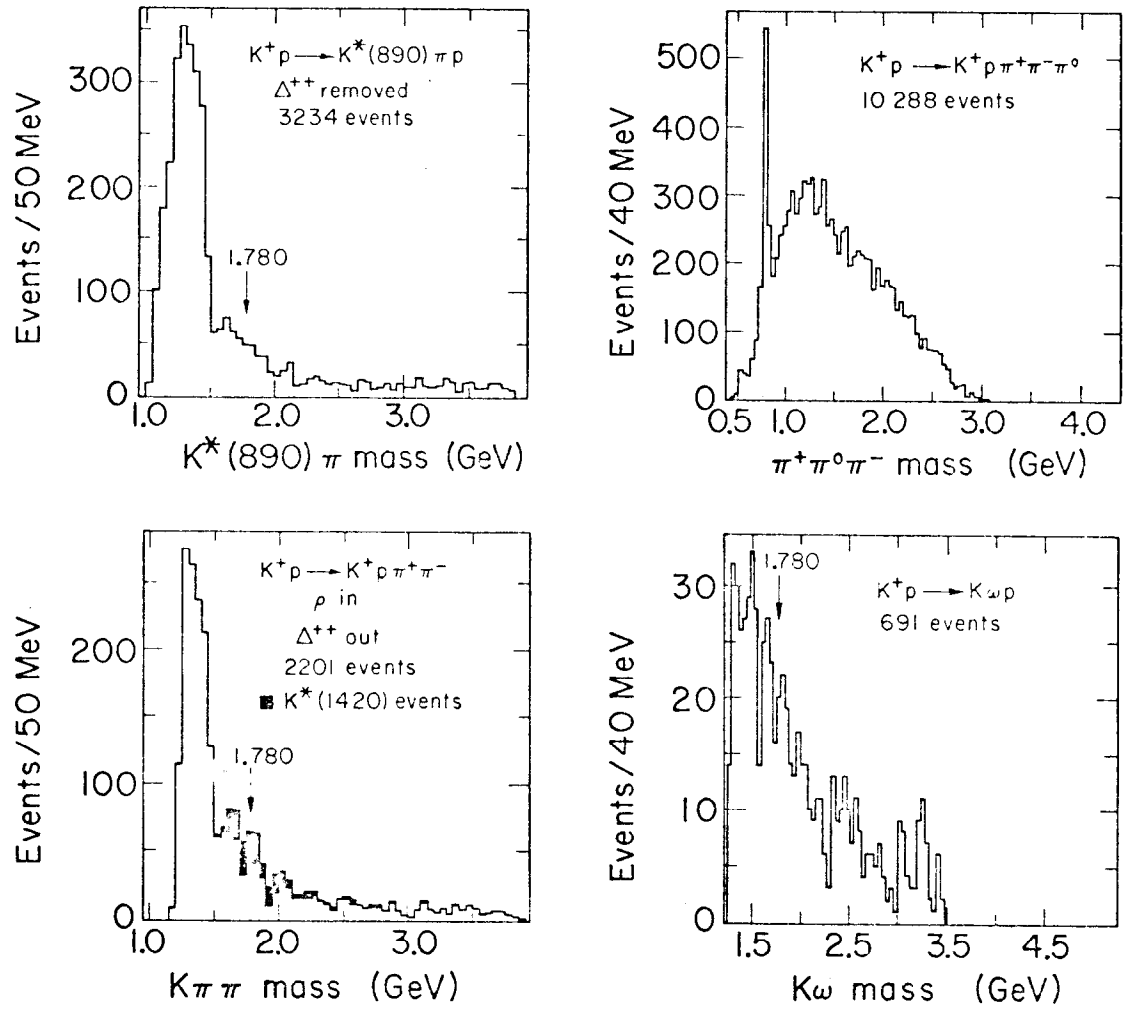
Fig. 1

$K^+ p \rightarrow (K^+ \pi^-) \pi^+ p$
 Δ^{++} removed
2477 events (total)



XBL693-2181

Fig. 2



XBL 693-2182

Fig. 3