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Authors
Bland, R.W.
Goldhaber, G.
Hall, B.H.
et al.

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University of California

Ernest O. Lawrence Radiation Laboratory

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A SEARCH FOR A K^* BELOW $K\pi$ THRESHOLD†

Roger W. Bland, Gerson Goldhaber, Bronwyn H. Hall, and George H. Trilling

Department of Physics and Lawrence Radiation Laboratory
University of California, Berkeley, California

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ABSTRACT

Glashow and Weinberg recently predicted on the basis of current algebra considerations that a scalar K^* meson may exist, with a mass below $K\pi$ threshold and decaying predominantly via the $K\gamma\gamma$ mode. We have searched for the production of this particle by K^+ mesons on hydrogen, near 1 BeV/c. We see no evidence for its existence, and we set upper limits on its production cross section.

If we consider the well-known mesons in terms of the $q\bar{q}$ model and particularly focus our attention on the K^*'s, we note that there are reliable candidates for the $^1S_0$, the $^3S_1$, and the $^3P_2$ states--namely the K meson itself, the $K^*(891)$, and the $K^*(1420)$, respectively. There are reasonable candidates for the $^3P_1$ and $^1P_1$ states--the $K^*(1250)$ and $K^*(1320)$--and finally there are even candidates for $L > 1$ states--the $K^*(1790)$ or L meson, a possible K^* at 1600 MeV, and more recently the $\bar{\Lambda}N$ enhancement at 2240 MeV.[1,2] There is one notable gap in this picture, namely the lack of clear-cut evidence for the $^3P_0$ state or a scalar K^*; let us call it K^*_S. The only hints for such a particle are the observation of a mass-dependent asymmetry[3] in the $K\pi$ angular distribution in the $K^*(890)$ mass region and a slight mass enhancement at 1080 MeV.[4]

Glashow and Weinberg recently suggested the existence of a scalar K^* having a mass below the $K\pi$ threshold and decaying via the $K\gamma\gamma$ mode.[5] Their suggestion has motivated us to search for such an object in the mass region between M_K and $M_K + M_\pi$. We have searched for the production of K_S^* in the reaction

$$K^+p \rightarrow K_S^{*+}p \quad , \quad K_S^{*+} \rightarrow K^+ + (\text{neutrals}) \ . \qquad (1)$$

Since reaction (1) is kinematically underconstrained, we have looked for the K_S^* in the spectrum of the missing mass recoiling against the final-state proton.

The data were obtained in an exposure of the LRL 25-inch bubble chamber filled with hydrogen, to a separated K^+ beam at the Bevatron. The beam momenta were 860, 960, and 1200 MeV/c. All events were measured on the Flying Spot Digitizer (FSD), and failing events were remeasured once on the FSD. Kinematical fitting was done with the FOG-CLOUDY-FAIR sequence of programs. Further remeasures were carried out on hand-operated measuring machines. All kinematical ambiguities were resolved by inspection of ionization on the scan table.[6] After analysis all events can be placed into the following categories[7]:

I. Events identified (by fitting and ionization) as elastic scatters; 22,198 events.

II. Events identified as single pion production -- $K^o\pi^+p$, $K^+\pi^op$, or $K^+\pi^+n$ final states; 7,602 events.

III. Events identified as pion- or proton-induced events, due to beam contamination; 369 events.

IV. Events with no acceptable fit; 106 events.

One can now ask where events corresponding to reaction (1) could be hidden. The answer depends on the mass of K_S^*. If it lies close to M_K, then events could be misidentified as elastic scatters (I). If it is close to $M_K + M_\pi$, some such events could be misidentified as single-pion-production events (II). In any case, they could be in categories III and IV. Furthermore, it is clear that $K^+\pi^+n$ events, where the absence of the proton is evident from ionization estimates, and events with a visible K_1^0 decay do not correspond to reaction (1) and can be excluded from further consideration.

To eliminate events with large measuring errors for the secondary proton, we have used only events for which the proton azimuth about the beam direction is within ± 45 deg of the plane facing the cameras, reducing the sample by a factor of 2. We have also considered the subsample with laboratory momentum $p_{proton} < 500$ MeV/c, corresponding to $|t| < 0.24$ $(BeV/c)^2$. This decreases the sample by another factor of about three, but increases our mass resolution considerably.

In Fig. 1 we show distributions of M^+, the mass recoiling against the final-state proton, for the 1200-MeV/c data only. Events from categories I, II, III, and IV have been included. The shaded regions include only events with $p_{proton} < 500$ MeV/c. In the insert we show an enlargement of the mass region of interest.

We have divided the region $534 < M^+ < 634$ MeV into four 25-MeV regions (indicated on Fig. 1 as regions A, B, C, and D), corresponding roughly to the experimental width of the elastic-scattering peak. We have estimated the background for the total sample in each of these regions by making a smooth interpolation of the populations of intervals on both sides of a given bin, but ignoring the number of events in the bin under consideration. For a 95% confidence level upper limit to the K_S^* signal in each bin, we take twice the standard error and add the difference between the observed population and the background, if that difference is positive. For the $p_{proton} < 500$ MeV/c sample, we assume the background to be zero, and find a 95% confidence level upper limit using the properties of the Poisson distribution. These upper limits to the cross sections are given in Table I. At 1200 MeV/c the cross sections for the total sample may be compared with the 1.4-mb cross section for production of the $K^*(891)$.

We wish to express our gratitude to Howard S. White, Jr., and the FSD Group, and to our scanning and measuring staff for their essential contributions to this experiment.

FOOTNOTES AND REFERENCES

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4. Gerson Goldhaber, Rapporteur Talk, Proceedings of the XIIIth International Conference on High Energy Physics, Berkeley 1966 (University of California Press, Berkeley, 1967), p. 103.

5. S. L. Glashow and S. Weinberg, Phys. Rev. Letters 20, 224 (1968).

6. To eliminate failing events due to obscured beam tracks, total beam editing was adopted; that is, the measured beam momentum and angles were replaced by average values obtained from a small sample of four-constraint fits, with the widths of the distributions used as errors.

7. Production of two missing neutrals is negligible at the momenta considered.

Table I. Cross-section limits for K_S^* production.

Incident laboratory momentum (MeV/c)	μb/event	Mass region (MeV)	Upper limit to K_S^* signal for all events (μb)	Upper limit to K_S^* signal for events with p_{proton} < 500 MeV/c (μb)
860	2.8	534-559 (A)	--	41
		559-584 (B)	62	45
		584-609 (C)	31	22
		609-634 (D)	26	22
960	4.9	534-559 (A)	--	58
		559-584 (B)	112	44
		584-609 (C)	39	28
		609-634 (D)	49	37
1200	4.0	534-559 (A)	--	48
		559-584 (B)	68	23
		584-609 (C)	48	48
		609-634 (D)	40	36

FIGURE LEGEND

Fig. 1. The recoiling mass distribution, M^+ for the 1200-MeV/c data, 4317 events. The insert shows the region of the K_S^* search in detail.

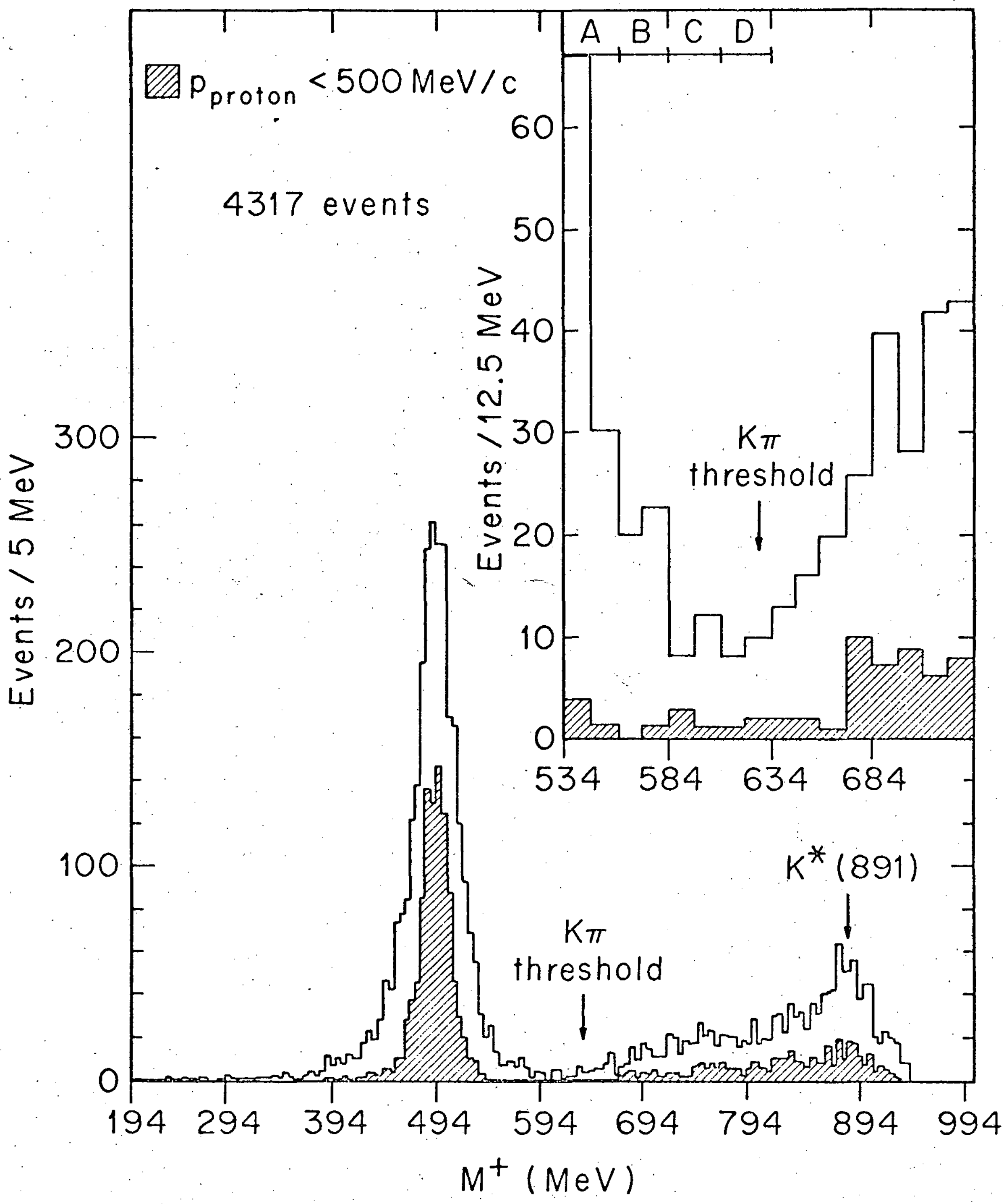

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Fig. 1