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June, 1964

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AN ANALYSIS OF K_{e4}^{+} DECAYS*

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June, 1964

We have studied the four-body decays

$$K^{+} \rightarrow \pi^{+} + \pi^{-} + e^{+} + \nu, \quad (1)$$

$$K^{+} \rightarrow \pi^{+} + \pi^{+} + e^{-} + \bar{\nu}, \quad (2)$$

using K^{+} mesons stopped in the Berkeley 30-inch heavy liquid chamber. Reaction (2) violates the $\Delta S = \Delta Q$ selection rule, while reaction (1) is permitted. The decay (1) can proceed through either a vector or axial vector current, but the vector part is expected to be inhibited by the angular momentum barrier; in reaction (2), the vector part is even more inhibited. Hence these decay modes can be used to test the validity of this selection rule for axial vector currents. This decay mode also affords an excellent opportunity to study the $\pi - \pi$ interaction at low energies independent of all other strong interactions.

A total of 250 000 pictures was taken, containing 2.90×10^{6} stopping K^{+} mesons. The chamber was filled with a light freon (C_3F_8), which has a density of 1.22 g/cc and a radiation length of 28 cm. Because of the high stopping power and low radiation length, about 80% of the positrons or electrons and 90% of the π's from K_{e4} decays stopped in the chamber. Figure 1 shows one of the better K_{e4}'s.

At least two of the three prongs were required to stop in the chamber. The major sources of background that had to be eliminated from the K_{e4} candidates were: (a) τ decays at rest in which one π was very slow and decayed immediately into a μ, which decayed into a positron, giving the appearance of two π's and a positron ("Collinear τ's" of which there were about 800); (b) τ decays in flight in which one prong left the chamber and was tentatively assumed to be a positron; (c) $K_{\pi 2}$, τ, and $K_{\mu 3}$ decays in which one of the γ's from the π^0 mesons internally converted with one electron leaving the chamber (Dalitz pairs).

The background events from τ's were readily eliminated by measurement and fitting of the events. The Dalitz pairs were eliminated by rejecting all events in which the track leaving the chamber had charge opposite that of the $e^{\pm}$ observed stopping in the chamber.

About five events were rejected for more complicated reasons. Rarer backgrounds were investigated; they contribute about two events to the K_{e4} sample. All the accepted events were required to fit K_{e4}'s. One K_{e^-4} candidate was rejected because it did not fit a K_{e4} but did fit a τ with a π^- charge exchange and subsequent γ-ray conversion.

A total of 75 events of type (1) were found in two complete scans of the film. This has to be corrected for the scanning efficiency of 85%, for the 20% bias against detecting events with a steep prong, and the 10% loss due to the above acceptance criteria. The total estimated number of events is 120. We found 155 000 τ's during the first K_{e4} scan with an efficiency of 97%. From these numbers we found the branching ratio of K^+_{e4}/τ to be $(7.8 \pm 1.6) \times 10^{-4}$, and a branching ratio K^+_{e4}/K^+ (total) to be $(4.3 \pm 0.9) \times 10^{-5}$, assuming a τ/K^+ branching ratio of $(5.52 \pm 0.13)\%$.[1] The error quoted in the K_{e4} branching ratio contains a 12% statistical error and a 15% error due to the uncertainty in bias corrections.

The rate is somewhat higher than previously reported[2] and in closer agreement with the prediction of 7.7×10^{-5} by Shabalin,[3] although still somewhat lower.

No events of type (2) were found. Therefore, this experiment shows no evidence for a violation of the $\Delta S = +\Delta Q$ rule for axial currents. However, this experiment is not as sensitive a test of the rule as the 75 events would make it appear. We estimate the upper limit of the violation parameter X to be 0.2 with 95% confidence $\left[X = \frac{A(\Delta Q = -\Delta S)}{A(\Delta Q = +\Delta S)}\right]$. Recent experiments testing the $\Delta S = \Delta Q$ rule in the K^0_{e3} decays involve only vector currents, whereas the K_{e4} decays are predominantly axial vector. Since the rule need not be equally valid for both currents, the results of the two experiments do not have to agree.

Figure 2 shows the invariant-mass plot for the dipion system for 69 K_{e4} events for which reliable measurements are at present available. Curve (a) shows the distribution obtained from s-wave phase space, and curve (b) shows a 400-MeV resonance with a width of 100 MeV, as proposed by Brown and Singer.[4] Curve (a) is a good fit to the data ($\chi^2 = 4.0$ for four degrees of freedom). The data are incompatible with curve (b) ($\chi^2 = 40$, four degrees of freedom). The effect of a nonresonant attractive $\pi\pi$ interaction would be to move the peak of curve (a) to lower mass values. The peak of curve (b) moves to higher mass values if the width of the resonance is reduced.[5]

The angular correlations between the π's and the dipion momentum and between the $\pi\pi$ plane and $e\nu$ plane are being examined. These are sensitive to s-p interference and can be used to estimate the difference in the s- and p-wave phase shift.[6] These results will be reported at a later date.

We would like to acknowledge the help of the Bevatron staff, the 30-inch bubble chamber crew, and the scanning and measuring staff at both laboratories. We are indebted to Dr. Nicola Cabibbo and Dr. B. Sakita for helpful discussions.

FOOTNOTES AND REFERENCES

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

1. A. Callahan, R. H. March, and R. Stark, Determination of the τ^+ Branching Ratio, submitted to Physical Review.

2. R. W. Birge, R. P. Ely, G. Gidal, G. E. Kalmus, A. Kernan, W. M. Powell, U. Camerini, W. F. Fry, J. Gaidos, R. H. March, and S. Natali, Phys. Rev. Letters 11, 35 (1963).

3. E. P. Shabalin, Zh. Eksperim. i Teor. Fiz. 39, 345 (1960).

4. L. M. Brown and P. Singer, Phys. Rev. 133, 812 (1964).

5. L. M. Brown and H. Faier, Phys. Rev. Letters 12, 514 (1964).

6. N. Cabibbo and A. Maksymowicz, Key Decays and the Determination of Low-Energy Pion-Pion Phase Shifts (UCRL-11437, May 1964), Presented at 1964 International Conference on High Energy Physics, held at Dubna, U. S. S. R.

Figure Captions

Fig. 1. $K^+ \text{(rest)} \rightarrow \pi^+ + \pi^- + e^+ + \nu$
$\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad \lfloor\!\!\rightarrow \mu^+ \rightarrow e^+$

Fig. 2. Effective-mass plot of dipion for 69 K_{e4} decays. Curve (a) shows the distribution obtained from s-wave phase space, and curve (b) shows the effect of a 400-MeV resonance of width 100 MeV.

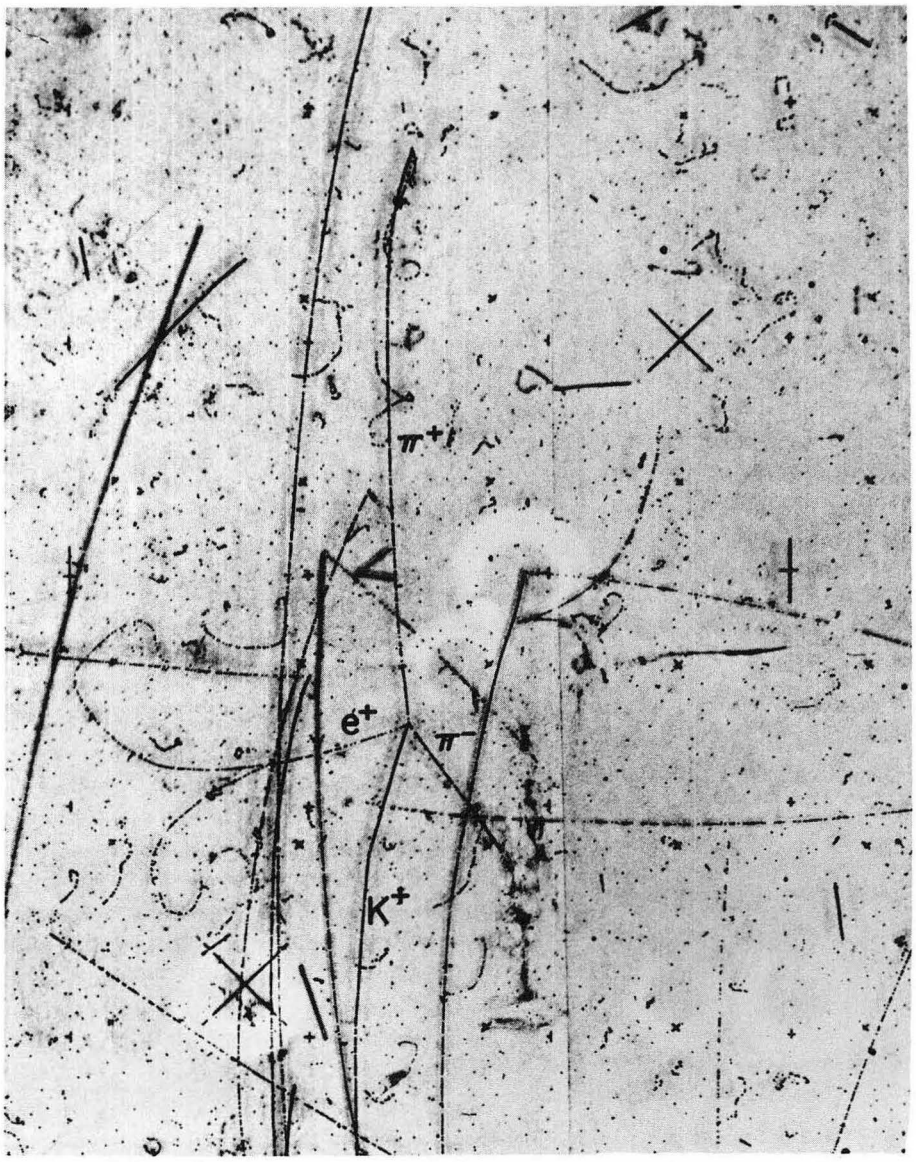

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Fig. 1

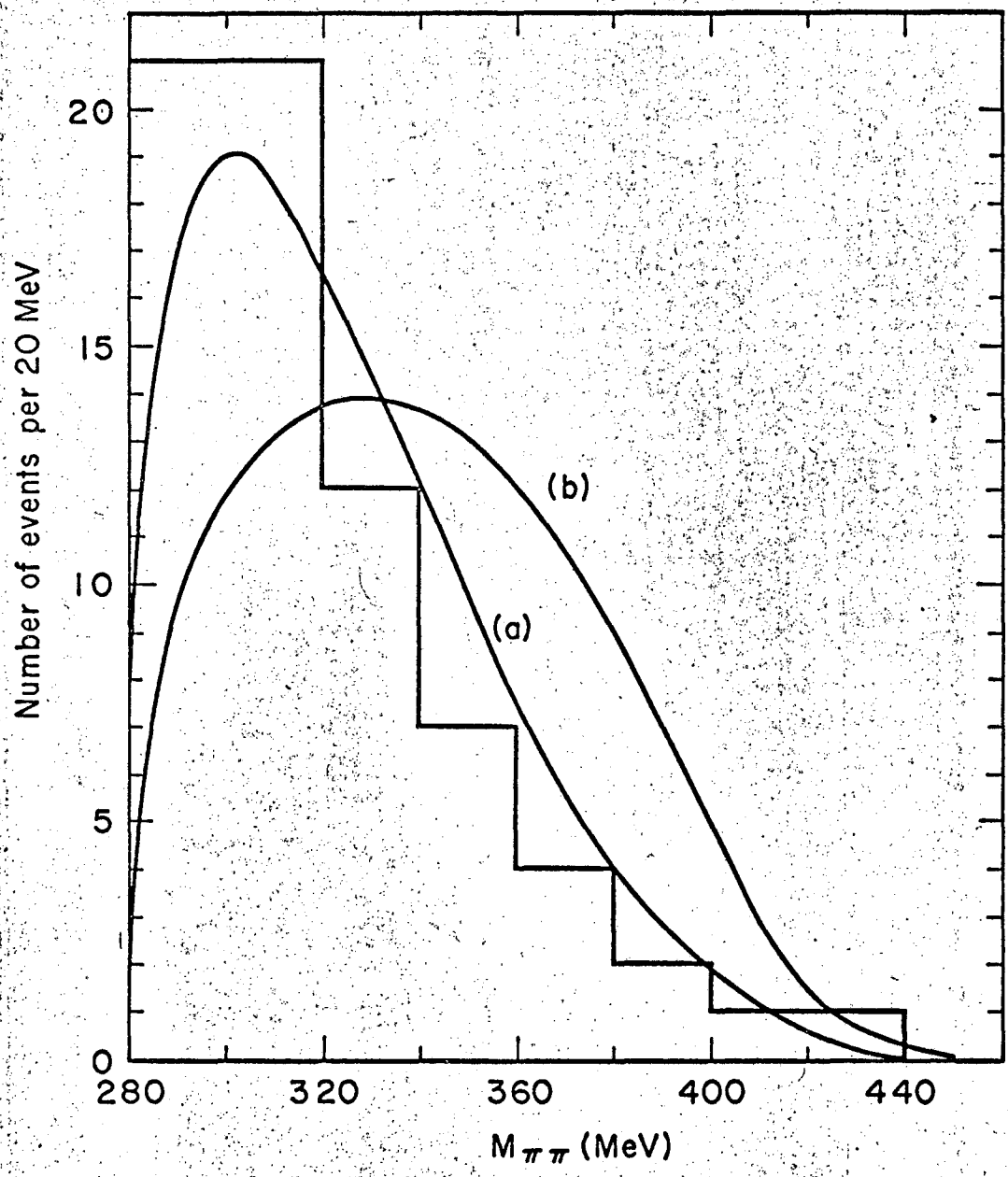

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Fig. 2.