FORM FACTORS IN $K^+_{\mu 3}$ DECAY

George Gidal, Wilson M. Powell, Robert T., Pu, Carl Sandler,
Lawrence Radiation Laboratory, USA
Ugo Camerini, W. F. Fray, Ronald Hantmann, Robert March, David Murphree
Department of Physics, University of W sconsin, USA
Sergio Natali
Istituto di Fisica, Universitá di Bari, Italia
(Presented by Ugo CAMERINI)

In an exposure of the Lawrence Radiation Laboratory's 30-inch heavy liquid chamber, filled with C_3F_8 to stop K^+ from the Bevatron, we have found about 12000 examples of the decay mode $K^+_{\mu 3}$ in which the muon stops in the chamber. For about 800 of these events both photons from the π^0 decay convert in the chamber, giving a sample of kinematically over-determined (two-constraint) events. We report here preliminary results of an analysis of events from these classes.

In the universal (V — A) Fermi interaction, K_{e3} decay modes have a matrix element of the current-current form

$$\langle \pi | J_\nu | K \rangle \langle \nu | \gamma_\mu (1+\gamma_5) | e \rangle .$$

The leading term, which contains all of the strong-interaction effects, may be expanded in the form [1]

$$f_+ (q_K + q_\pi) + f_- (q_k - q_\pi)$$

where f_+ and f_- should be constant or slowly varying functions of the four-momentum transfer. With the exception of the absolute decay rate, all observable quantities are uniquely determined by the ratio $\xi = f_-/f_+$. Since the event is completely determined by two kinematic quantities plus the components of the muon polarization in the decay plane, four independent measurements of ξ are possible, and their agreement constitutes a test of the theory. In addition, the relative $K_{\mu 3} - K_{e3}$ branching ratio is a function of ξ and agreement with values obtained from this ratio tests μ—e universality.

The longitudinal polarization was measured over the range $38 < T_\mu < 96$ MeV. To permit a substantial component of the polarization to be parallel to the magnetic field, we used 2988 events in which the muon stopped in the chamber and the dip of the muon track was greater than 12 deg. We obtained an average polarization

$$\langle P_\mu \rangle = 0.74 \pm 0.16 \quad (28 < T_\mu < 36 \text{ MeV}).$$

The energy dependence of the polarization, along with predictions for various values of ξ is shown in Fig. 1. We made a direct likelihood fit for ξ; the results appear in Fig. 2, the central values obtained are

$$\xi = -0.15 \pm 0.90 \text{ or } -4.05 \pm 0.75.$$

The ambiguity does not overlap that of branching ratio experiments [2], and thus it can be stated with some confidence that the $\xi = -0.15$ solution is the physically meaningful one. Further details of this experiment will be reported elsewhere [3].

We have also analyzed 178 of the events in which conversion pairs are seen. In these events the π^0 momentum is determined to about 5% accuracy from kinematic fitting, and the muon momentum is known to be about 2% from its range. Thus the events are well determined kinematically, and any convenient set of kinematic variables may be chosen to represent the event. We have chosen the kinetic energies of the muon and π^0. A Dalitz plot of the events, corrected for detection efficiency, is shown in Fig. 3.

The principal difficulty in analyzing these events lies in evaluating the detection efficiency as a function of T_μ and T_π. Thus we have restricted this preliminary analysis to the region $15 < T_\mu < 85$ MeV, in which the correlation between these variables is not expected to be significant. This region contains 138 events.

Fig. 4 gives χ^2 for the Dalitz plot (10 degrees of freedom) as a function of ξ; again we find

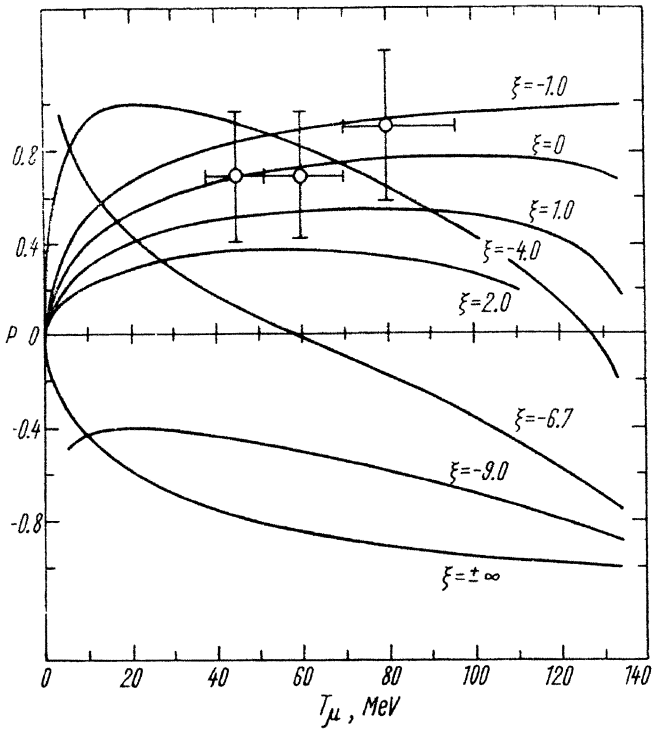

Fig. 1. Muon longitudinal polarization as a function of kinetic energy, compared with predictions for various values of ξ.

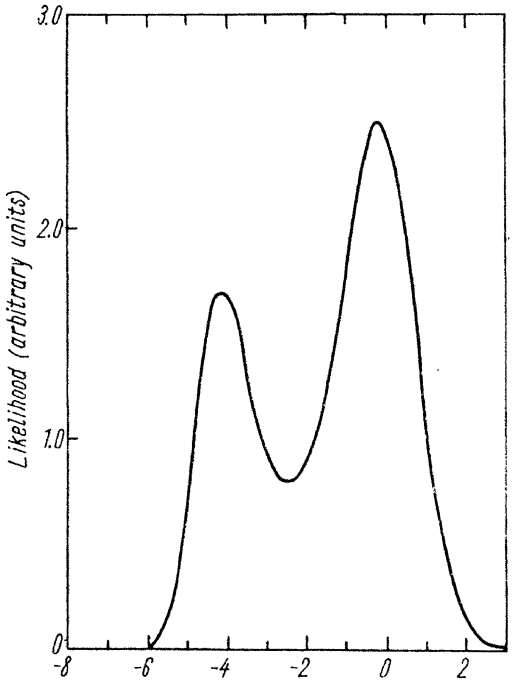

Fig. 2. Likelihood function for ξ in polarization measurement.

an ambiguity. If we add to the statistical error an allowance for uncertainty in the detection-efficiency calculations, the two solutions are

$$\xi = +1.3 \pm 0.9 \text{ and } -5.2 \pm 0.7.$$

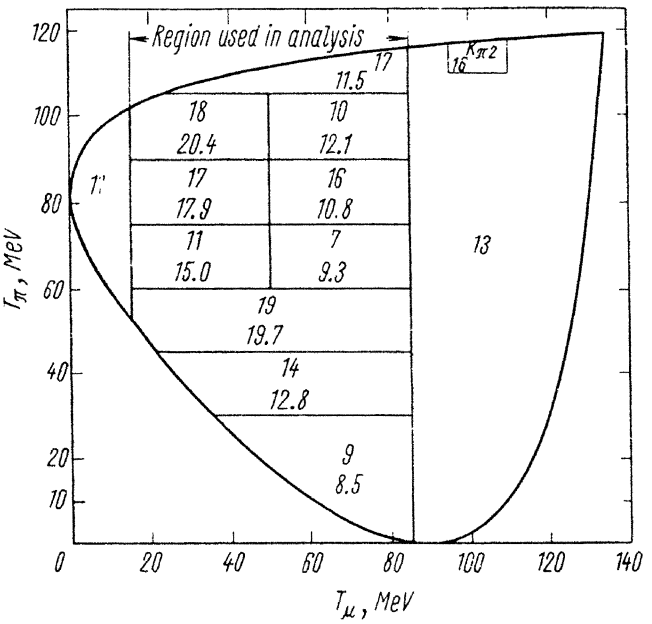

Fig. 3. Diagram of Dalitz plot, giving observed numbers of events (integers) and prediction for ξ = +1.3, corrected for detection efficiency.

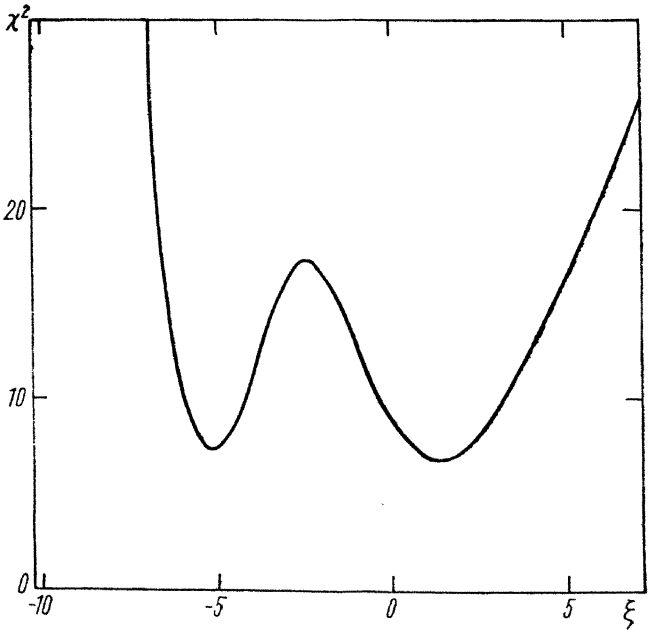

Fig. 4. χ^2 for Dalitz plot in Fig. 3, with nine degrees of freedom, as a function of ξ.

A weighted mean with the polarization data gives

$$\xi = +0.6 \pm 0.7 \text{ and } -4.7 \pm 0.6.$$

The first solution is favored, since it is consistent with the value obtained in recent branching-ratio and muon-spectrum experiments [2, 4]. Thus, to the present level of statistical accuracy, a universal $V - A$ theory with $\mu - e$ universality seems adequate to explain $K_{l_3}^+$ decay.

REFERENCES

1. Brene N. et al. Nucl. Phys., **22,** 553 (1961).
2. Roe B. P. et al. Phys. Rev. Lett., **7,** 346 (1961); Dobbs J. M. et al. Phys. Rev. Lett., **8,** 295 (1962); Bisi V. et al. Phys. Rev. Lett., **12,** 490 (1964); Roe B. P. et al. Bull. Amer. Phys. Soc., **9,** 34 (1964); Shaklee F. S. Thesis. University of Michigan (unupblished) May 1964; Jensen G. L. Thesis. University of Michigan (unpublished) May 1964.
3. Gidal G. et al. Lawrence Radiation Laboratory Report UCRL-11448 (1964) [submitted to Phys. Rev. Lett.],
4. Smirnitski V. A. and Weissenberg A. O. Phys. Rev. Lett., **12,** 233 (1964); Luers D. et al. Phys. Rev., **133,** B1277 (1964); Fisher G. P. et al. Bull. Amer. Phys. Soc., **9,** 35 (1964).