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Ernest O. Lawrence Radiation Laboratory

40 000 TAU DECAYS

Terry S. Mast, Lawrence K. Gershwin, Margaret Alston-Garnjost, Roger O. Bangerter, Angela Barbaro-Galtieri, Joseph J. Murray, Frank T. Solmitz, Robert D. Tripp, and Bryan R. Webber

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An exposure of 1.3×10^6 pictures in the Berkeley 25-inch hydrogen bubble chamber has yielded about 50 000 $K^- \rightarrow \pi^- \pi^- \pi^+$ decays in flight. The K^- momenta range from 270 to 470 MeV/c.

A preliminary analysis has been made of the pion spectra. Events were accepted if they satisfied the following conditions:

(a) The decay occurred within a restricted fiducial volume.

(b) The confidence level for the four-constraint kinematic fit was $>0.1\%$.

(c) Each pion had a fitted momentum in the laboratory system greater than 30 MeV/c.

These conditions reduced our sample to 42 640 events. Each event was weighted for Coulomb interactions[1] and for the cut on pion momentum. The mean Coulomb weight was 1.034, and the mean weight for low-momentum pions was 1.036. The distribution of the decay in the K^- rest frame shows a small dependence on the beam direction and scanning plane. We think this does not significantly affect the results and that remeasurements of failing events will make the distribution more isotropic.

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††Present address: SLAC, Stanford, California.

Systematic effects from uncertainty in the position on the Dalitz plot have not yet been investigated.

The usual variables x and y were defined from the pion kinetic energies in the K^- rest frame:

$$x = \sqrt{3}\,|(T_{\pi_1^-} - T_{\pi_2^-})|/Q,$$
$$y = (3T_{\pi^+} - Q)/Q.$$

The y projection of the Dalitz plot (Fig. 1) was weighted for phase space and normalized to 1.0 at $y = 0.0$. A least-squares fit of the projection to the form $1 + ay + by^2$ gave $a = 0.239 \pm 0.010$ and $b = -0.006 \pm 0.021$, with an 89% confidence level. A fit to the form $1 + ay$ gave $a = 0.240 \pm 0.010$, with a 92% confidence level. The importance of the Coulomb corrections is emphasized by a fit made without them which gave $a = 0.204 \pm 0.010$, with a confidence level of 20%.

The events for the x projection (Fig. 2) were weighted by phase space and $1/(1 + 0.24y)$. The best least-squares fit for this was to a constant. The confidence level for this fit was low (0.005%) due to the low point at $x = 0.6$. A search for a systematic effect producing this large fluctuation has so far been unsuccessful. The fit failed to improve when an x^2 dependence was introduced.

The dependence on the variables ρ and θ, where $x = \rho \sin\theta$ and $y = \rho\cos\theta$, has been investigated, and the distribution seems to be consistent with the simple $1 + a\rho\cos\theta$.

CP invariance predicts the decay spectra of K^- and K^+ to be identical. The $|\vec{\Delta I}| = 1/2$ rule, with a linear approximation to the matrix element, predicts

$$\alpha_{\tau'}/\alpha_\tau = -2 \text{ and } \alpha_{K_2^0}/\alpha_\tau = -2,$$

where $a = \alpha M_K Q/m_\pi^2$. The experimental results (Table I) show good agreement between the slopes of the spectra for τ^+ and for τ^-. The two results for K_2^0 decay are not consistent with each other; only one of them (Nefkens et al.[9]) is consistent with the $\Delta I = 1/2$ prediction. The slopes for τ'^+ are only in fair agreement with the $|\vec{\Delta I}| = 1/2$ rule.

Table I. Experimental results ($a = \alpha M_K Q/m_\pi^2$).

	Events	Reference	a	α
τ^-	42 640	This expt.	0.240 ± 0.010	
	948	Smith et al. (2)	0.20 ± 0.065	
	1 347	Ferro-Luzzi et al. (3)	0.28 ± 0.045	
	44 935	average =	0.241 ± 0.010	0.127 ± 0.005
τ^+	6 752	Grauman et al. (4)	0.228 ± 0.030	
	6 786	Plano (5)	0.28 ± 0.03	
	3 587	Huetter et al. (6)	0.21 ± 0.04	
	899	McKenna et al. (7)	0.25 ± 0.06	
	18 024	average =	0.243 ± 0.018	0.128 ± 0.009
K_2^0	1 350	Hopkins et al. (8)		-0.40 ± 0.02
	1 198	Nefkens et al. (9)		-0.28 ± 0.03
τ'^+	1 874	Bisi et al. (10)		-0.40 ± 0.07
	1 792	Kalmus et al. (11)		-0.32 ± 0.03

Footnote and References

1. Following Dalitz, Proc. Phys. Soc. 69, 527 (1956), it is assumed that the Coulomb interactions between pions i and j multiplies the phase space by a factor $x/(e^x - 1)$, where $x = 2\pi e_i e_j / v_{ij}$ and v_{ij} is the relative velocity between the pions.
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Figure Captions

Fig. 1. Distribution in y weighted for phase space, Coulomb interactions, and a cut on low-momentum pions. The line is a best fit to $1 + ay$, where $a = 0.240 \pm 0.010$.

Fig. 2. Distribution in x weighted for phase space, Coulomb interactions, a cut on low-momentum pions, and also weighted by $1/(1 + 0.24\ y)$.

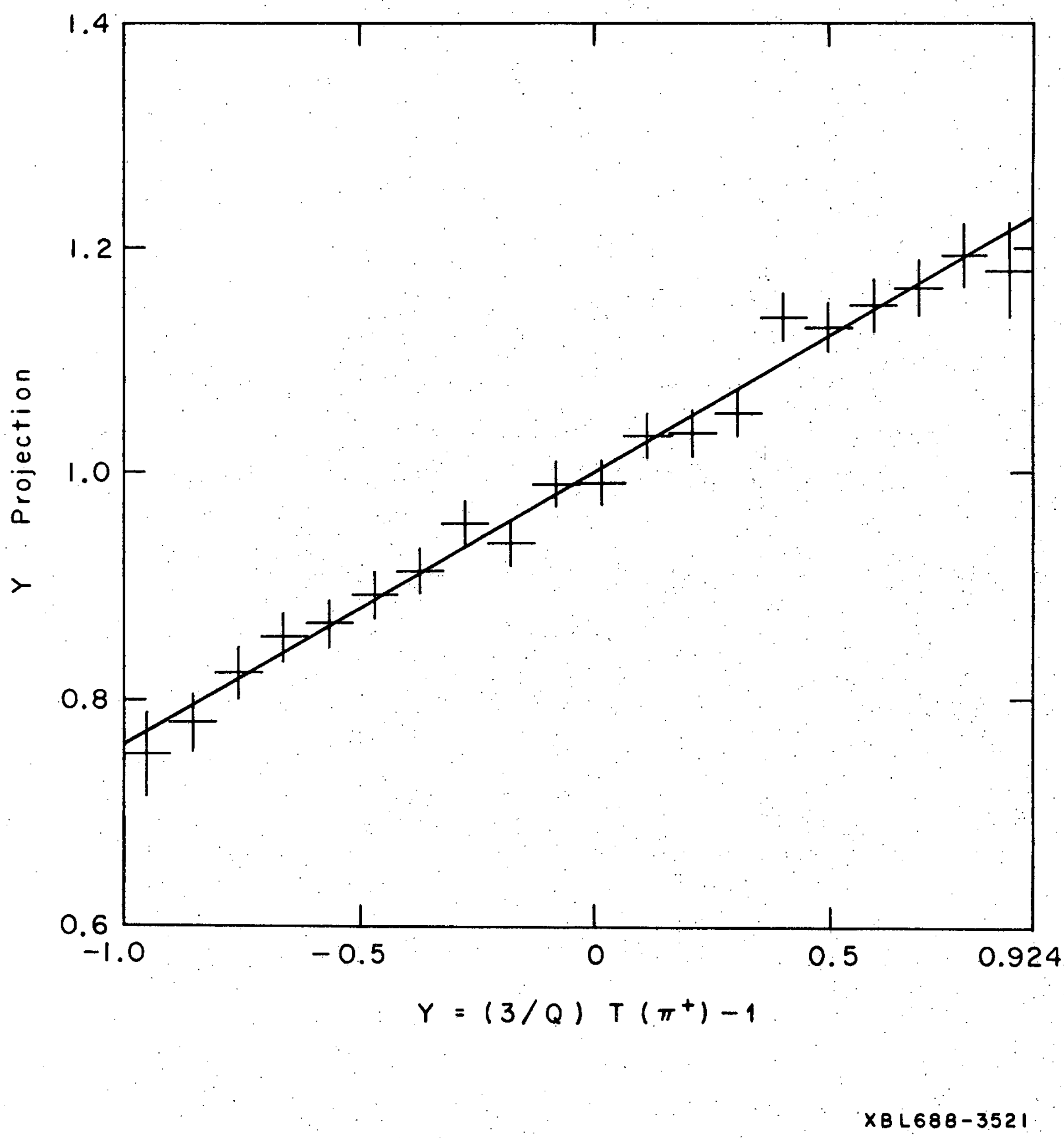

Fig. 1

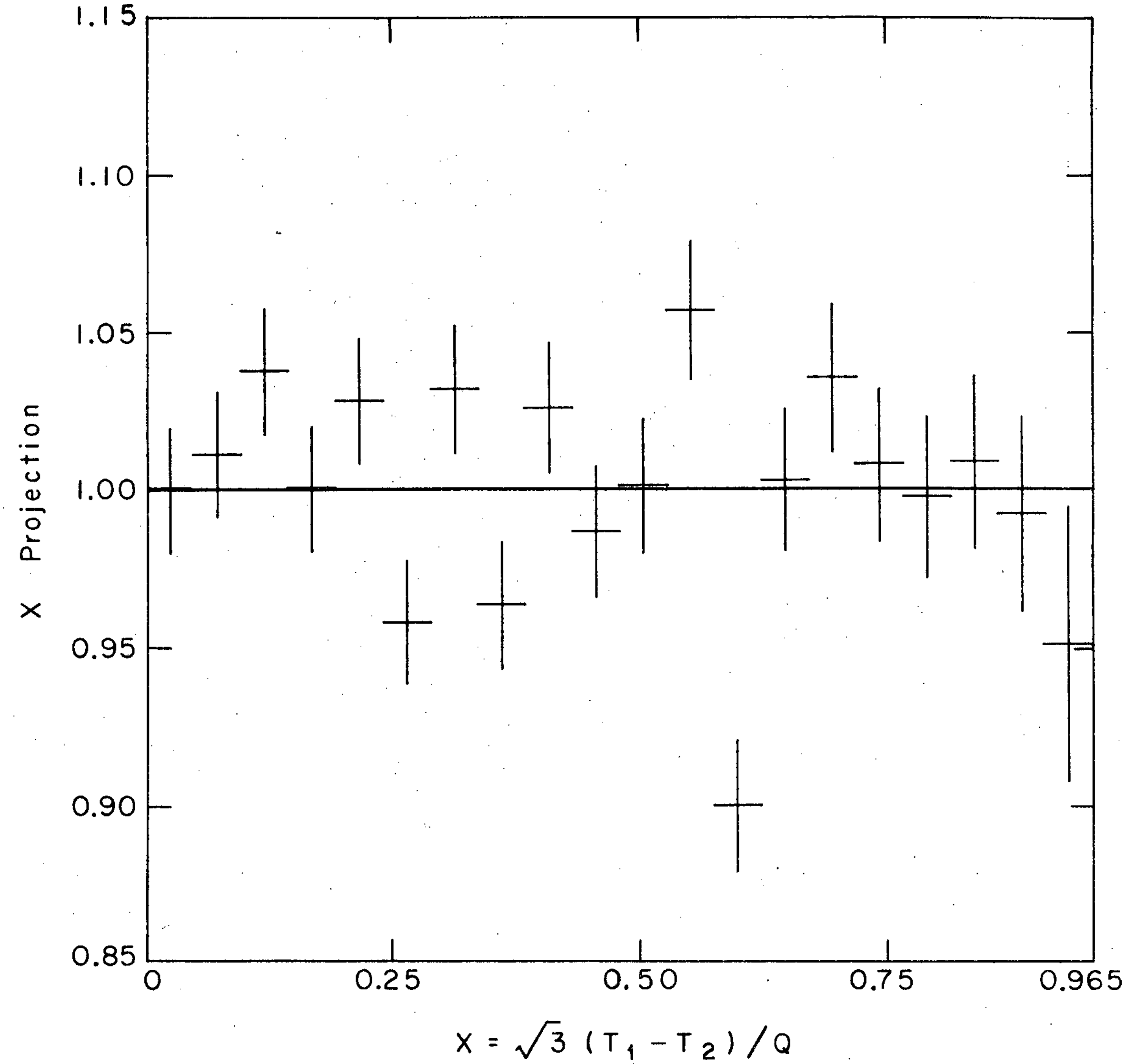

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Fig. 2