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ABSTRACT

In G.5 emulsion stacks exposed to secondary particles from targets bombarded by 4.8 to 5.7 Bev protons, six τ mesons were observed. Measurements of the ranges and directions of the emission of the decay products have been made. From these measurements a Q value of 74.9 ± 0.2 Mev for the τ decay is obtained. Data are also provided for a study of the statistical correlation between the initial direction of the τ meson and the plane of decay and the direction of the unlike-sign pion.

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One of the first experimental techniques employed in Bevatron research programs was the exposure of stacks of Ilford G.5 emulsions to the secondary particles from a target bombarded by 4.8- to 5.7-Bev protons. A re-entrant well permitted placement of the emulsions at 90° to the beam direction and within 10 inches of the bombarded target. With this geometry, the proper flight time plus the proper time for 125-Mev K-particles to be brought to rest in the emulsion was about 1.5×10^{-9} second. This report describes some of the results obtained from two such exposures: first, a 2-by-4-inch stack of 20 sheets of emulsion 600 μ thick, and second, a 2-inch cube of emulsion. The latter exposure was primarily for a τ meson study.

All together, six τ-mesons were observed in the 10.7 cm^3 of emulsion scanned by area. In five cases, the charges of all three pions could be determined. All decays were consistent with $\tau^{+} \rightarrow \pi^{-} + 2\pi^{+}$. No alternate modes of decay, i.e., $\tau^{+} \rightarrow \pi^{+} + 2\pi^{0}$, were specifically sought. The tabulation of the data is given in Table I, where the entries in parentheses were calculated from the measured quantities. Particles 1 and 2 refer to the π^{+} mesons and Particle 3 refers to the π^{-} meson. Only in the events (τ, τ_3 and τ_6), where not all pions came to rest in the emulsion stack, were angle measurements taken. Here δ is a measure of the coplanarity of these events, and is the amount (in degrees) by which the vector $\vec{r}_3$ lies out of the plane formed by the vectors $\vec{r}_1$ and $\vec{r}_2$. The range-energy relation for the pions in emulsion was evaluated from Vigneron's calculated data, extended by Barkas,[1] and using a pion mass of 0.1487 M_p.

The error listed on each Q value includes estimations for range straggle of the pions (generally about 1.8%) and observer error in range and angle measurements (taken to be 1% and 0.5°, respectively). From these data the average value of Q for the decay of the τ meson is 74.9 ± 0.4 Mev from internal consistency and 74.9 ± 0.2 Mev from external consistency.

Pertinent to the problem of the spin and parity of the τ meson is the energy distribution of the odd-charged pion (Particle 3). No attempt will be made to compare the five events reported herein with the theories of Dalitz[2] and Fabri[3] other than to comment that the energy distribution is consistent with a symmetric, and perhaps flat, distribution.[4]

Another possible means for detecting the spin of the τ meson is the study of the orientation of the plane of the decay of the τ meson with respect to the direction of emission of the τ particle.[5,6] In the decays where the charges of the pions are known, information related to this problem can also be obtained from the relative directions of the unlike pion and the τ meson at its point of production.

The geometry used in the well exposures afford an opportunity for the measurements of these parameters. The direction of emission of the τ meson is known to $\pm 5^\circ$. The uncertainty arises from the finite extent of the target, and from assuming no large angle scattering in the target. In all cases, the initial direction of the τ meson was taken to be along the "x" direction of the emulsion and parallel to the surface. The magnetic field in the region of the target and re-entrant well was approximately 100 gausses.

Table II tabulates the following data:

a) $\theta_{n\tau}$, the angle between the emission of the τ and the normal to the plane of decay.

b) δ_n, the angle between the normal to the plane of decay and the plane of the emulsion.

c) $\theta_{\pi\tau}$, the angle between the direction of emission of the unlike π meson and the direction of the emission of the τ.

d) δ_π, the angle between the direction of the unlike π meson and the plane of the emulsion.

δ_n and δ_π were measured primarily as a check for observational bias. For isotropic distributions of δ_n and δ_π, 50% of the events should have angles greater than 30°. The observed ratio is 5/9.

REFERENCES

1. W. H. Barkas and D. M. Young, University of California Radiation Laboratory Report No. UCRL-2579 (rev.).

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3. Fabri, Nuovo cimento $\underline{11}$, 479 (1954).

4. Report of the Proceedings of the 1955 Rochester High-Energy Conference.

5. F. G. Houtermanns, private communication.

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Table I

τ-Meson Data

	R_1^+ (mm)	R_2^+ (mm)	R_3^- (mm)	T_1^+ (Mev)	T_2^+ (Mev)	T_3^- (Mev)	θ_{12}°	θ_{23}°	θ_{31}°	$\Sigma\theta^\circ$	δ°	Q Mev
τ_1	5.39	10.84	--	16.2	24.3	(34.0)	96°45'	139°8'	123°2'	358°55'	1°23'	74.5±0.75
τ_2	6.15	28.32	4.53	17.6	43.2	14.7	(150°23')	(147°6')	(62°31')			75.5±0.86
τ_3	6.01	7.46	--	17.3	19.6	(37.5)[a]	85°42'	138°22'	135°58'	360°2'	0°37'	74.4±0.71
τ_4	6.51	19.53	9.43	18.2	34.7	22.4	(128°27')	(135°30')	(96°3')			75.3±0.81
τ_5	6.65	22.21	7.17	18.3	37.4	19.2	(136°2')	(137°25')	(86°35')			74.9±0.87
τ_6	3.48	--	--	12.6	(27.3)[b]	(35.2)[b]	95°13'	144°54'	119°55'	360°2'	1°04'	75.1±1.6

[a] Negative pion suffered an inelastic collision (2-prong star) 12.4 mm from point of decay, i.e. at T_{π^-} = 23.0 Mev.

[b] Charge unknown.

Table II

	$\theta_{n\tau}$	δ_n	$\theta_{\pi\tau}$	δ_π
		Angular Correlations in τ-Meson Decay		
τ_1	$14°12'$	$0°$	$90°39'$	$83°16'$
τ_2	$51°4'$	$46°22'$	$63°48'$	$1°52'$
τ_3	$26°30'$	$17°6'$	$118°51'$	$28°58'$
τ_4	$55°40'$	$55°24'$	$41°56'$	$31°45'$
τ_6	$38°39'$	$36°22'$		