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ANALYSIS OF THE TAU-MESON DECAY AND EVIDENCE FOR THE BETA DECAY OF A K MESON

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ABSTRACT

Secondary particles produced by bombarding a target with 4.8-to 5.7-Bev protons were stopped in Ilford G. 5 emulsion. Scanning of the tracks in 10.7 cm^3 of emulsion disclosed six τ mesons whose decays were consistent with $\tau^+ \rightarrow \pi^- + 2\pi^+$; evidence for a K electron was found.

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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 on the order of 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, $\tau^+ \rightarrow \pi^+ + 2\pi^0$, were observed. 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_1, 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 on the order of 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]

In the first emulsion stack exposed to the secondary particles from a target bombarded by 4.8-Bev protons, one of the secondaries from a K meson had sufficient range (10.25 mm) to enable one to estimate the mass of the secondary by multiple scattering vs ionization. The properties of this particle were characteristic of a beta particle. A photomicrograph of the decay is shown in Fig. 1. Figure 2 is a plot of $p\beta c$ in Mev vs range of the secondary in millimeters. Superimposed upon the experimental points is the expected rate of energy loss due to bremsstrahlung for a particle of electronic mass, arbitrarily normalized to the 1.25-mm point. The ratio of ionization of the secondary to that of fast electrons is 1.032 ± 0.028, with no apparent increase of ionization with increasing range.

The $p\beta c$ of the secondary at the point of decay is 125 ± 18 Mev. A mu meson of this $p\beta c$ would have an ionization of $1.22\ I_{min.}$, and have an energy loss due to ionization of approximately 8 Mev/cm. The amount of $p\beta c$ loss actually observed was 25 Mev between the ranges of 1.25 and 9.50 mm. Figures 3A and 3B are plots of percent transparency and integral gap length vs residual range for π, τ, and K mesons. From these measurements the mass of the K_e^+ is given to be $988 \pm 40\ m_e$.

The first K_e event was reported by Friedlander, et al.[5] The $p\beta c$ of this event was approximately 90 Mev. Subsequent events that have been found of this type strongly indicate at least a three-body decay process.[4,6]

I wish to acknowledge the aid given me by the Bevatron crew, under the directorship of Dr. Edward Lofgren, in making the exposures. Miss Roberta Daily and Miss Hester Lowe contributed their skills in scanning a large part of the emulsions required for this report.

This work was performed under the auspices of the U. S. Atomic Energy Commission.

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}^o	θ_{23}^o	θ_{31}^o	$\Sigma\theta^o$	δ^o	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±.75
τ_2	6.15	28.32	4.53	17.6	43.2	14.7	(150°23')	(147°6')	(62°31')	-	-	75.5±.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±.71
τ_4	6.51	19.53	9.43	18.2	34.7	22.4	(128°28')	(135°30')	(96°3')	-	-	75.3±.81
τ_5	6.65	22.21	7.17	18.3	37.4	19.2	(136°2')	(137°23')	(86°35')	-	-	74.9±.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.

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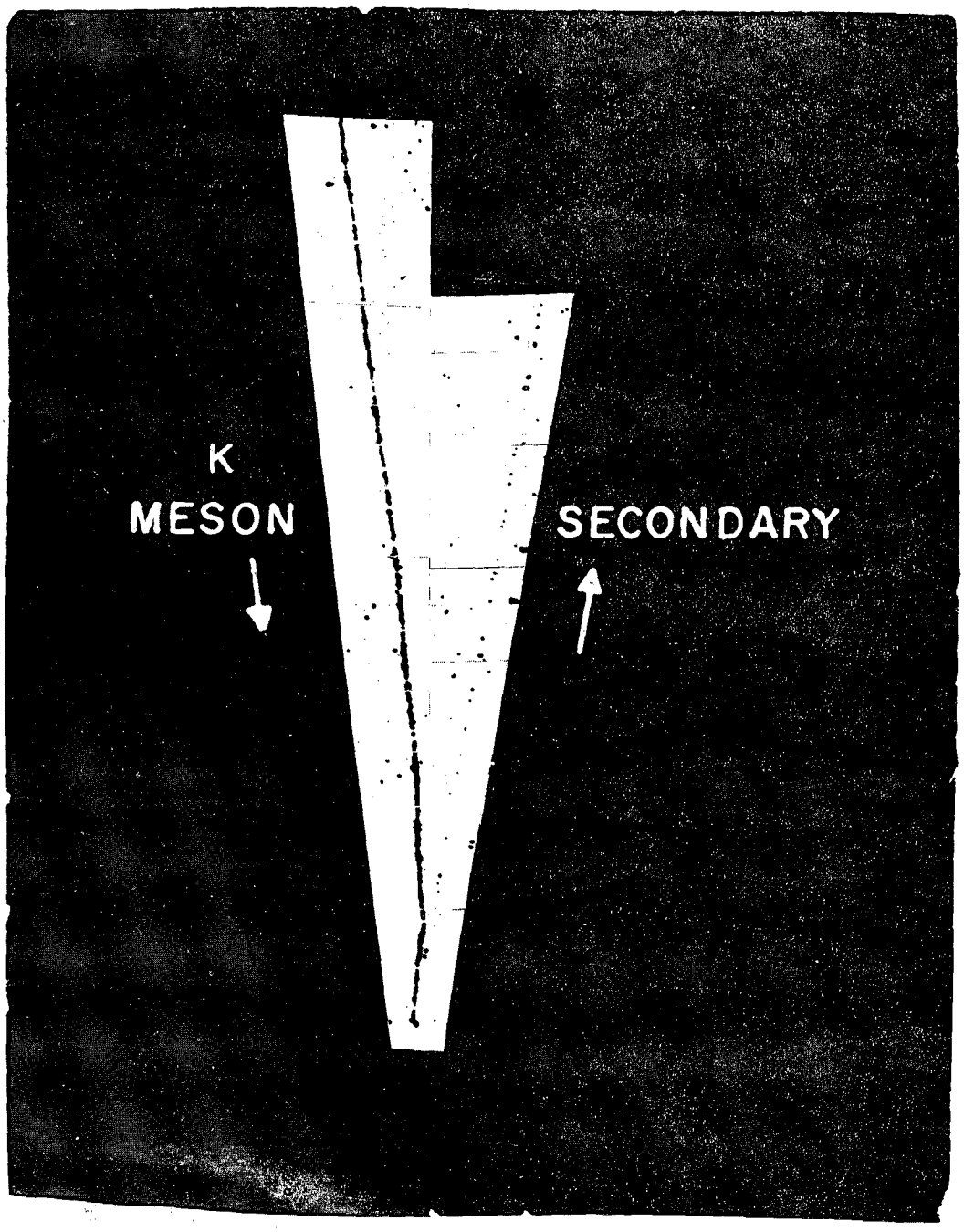

ZN-1270

Fig. 1. Photomicrograph of K_e decay point.

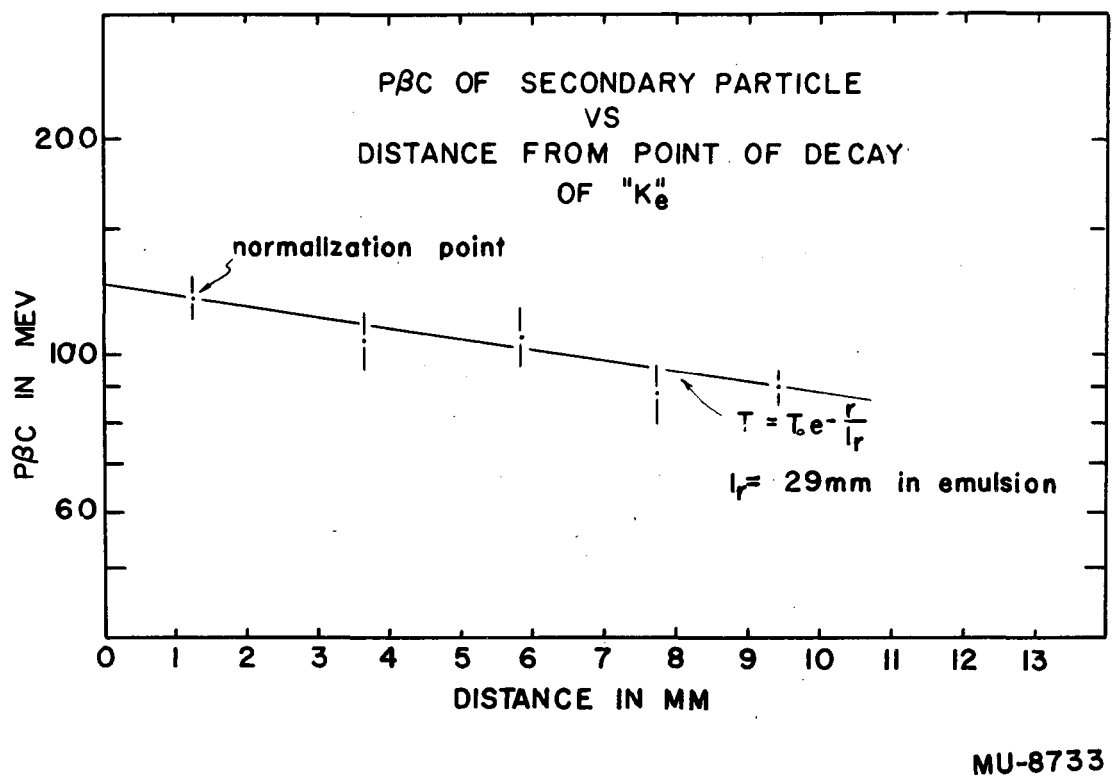

Fig. 2. Plot of pβc in Mev of secondary vs range in millimeters from point of decay.

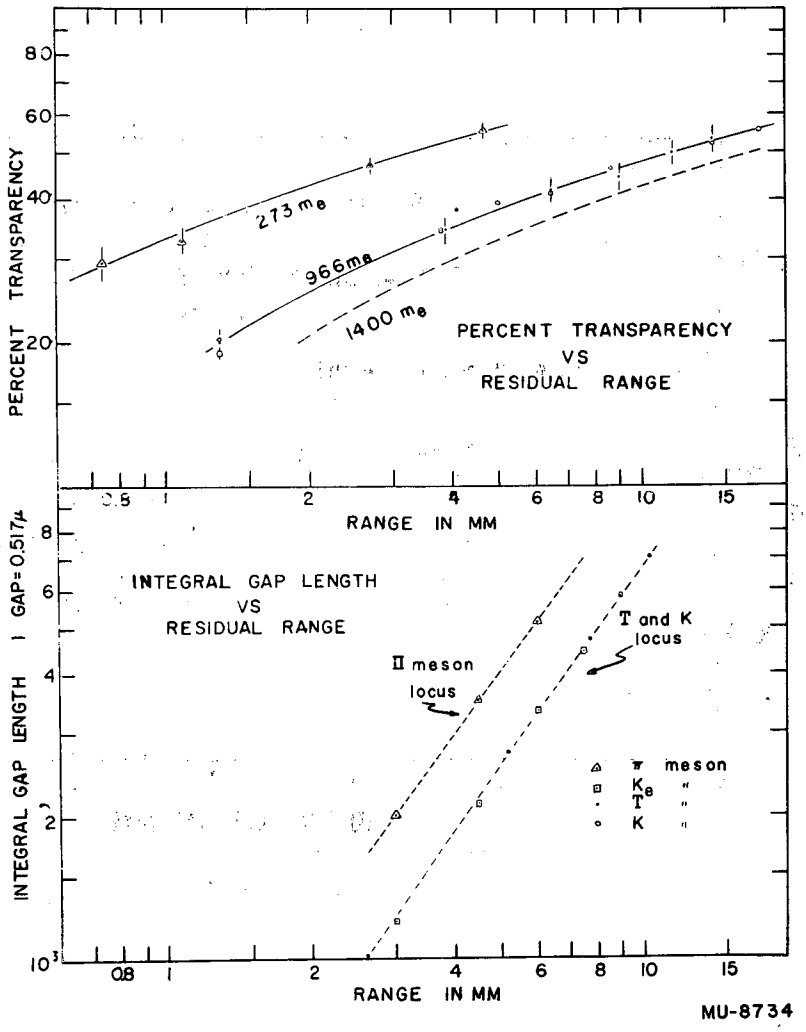

Fig. 3A and B. Percent transparency and integral gap length vs residus range of π, τ, and K mesons.

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