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As an initial step in the study of K-particles, stacks of nuclear emulsions have been exposed at the Bevatron in two positions. (a) Exposure in the direct proton beam (proton energies 4.8 and 5.7 Bev): For this purpose the stacks were mounted on a plunging probe with a "lip target."[1] This probe assembly was plunged into the vacuum chamber during the last part of the accelerating cycle. (b) Exposure to secondaries emitted at 90° to the target (proton energies 4.8 and 6.1 Bev): Stacks were placed in a re-entrant well at a distance of about 10 inches from the target. (Time of flight for K-particles observed is about 10^{-9} sec.) A 0.1-inch aluminum wall was the only intervening material.

In 2.5 cm^3 of emulsion scanned to date, 35 K-particles and 5τ-mesons have been found. In Table I mass measurements on 22 of these K-particles and 3 τ-mesons are given. The mass measurements were obtained (a) by grain count vs range in the region of 1 to 3 cm residual range,[2] and (b) by "opacity" measurements[3] for short K-particle track lengths in the region of 0.5 to 1.5 cm residual range. Each of the above measurements was directly calibrated against protons. For quick identification of K-particles a constant sagitta measurement was carried out over the last 7 mm residual range using the Pl cell scheme of Biswas et al.[4] with the cell scheme fed automatically into the microscope.[5] The weighted average of all mass measurements gives

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*Assisted by the Office of Naval Research; now at the Phys. Dept., Univ. of Birmingham, Birmingham, England.

1 E. McMillan, Rev. Sci. Instr. 22, 117 (1951).

2 M. Tchang-Fong Huang, Comptes rendus 238, 1790 (1954).

3 The "opacity" A is given by A = 1-G where G is the integral gap length. (Private communication H. H. Heckman).

4 Biswas, George, and Peters, Proc. Indian Acad. Sci. 38, 418, (1953).

5 S. J. Goldsack and G. Goldhaber, Bull. Am. Phys. Soc. Paper U11, Berkeley Meeting 1954. Further details on the cell-scheme mechanism will be published elsewhere.

Table I

Particle	Mass		Secondary			
	I-R	Const. Sagitta	Dip Angle	pβ	b/b_p	I/I_o
K_1 [a]	1010 ± 30 [c]	895 ± 230	28°	-	-	
K_2 [a]		700 ± 180	0	189 ± 25	0.89 ± 0.04	
K_3 [a]	815 ± 70 [c]	940 ± 250	44°	-	-	
K_4 [a]	934 ± 30 [c]	880 ± 230	4.5°	185 ± 20	1.14 ± 0.06	
K_5 [a]	962 ± 30 [c]	880 ± 200	26°	150 ± 30	~1.	
K_6 [a]	947 ± 100 [c]	1460 ± 370	56°	-	-	
K_7 [a]	820 ± 60 [c]	-	17°	-	-	
K_8 [a]	875 ± 40 [c]	1010 ± 280	0°	56 ± 8	0.968 ± 0.04	
K_9 [a]	975 ± 50 [c]	1320 ± 350	no secondary found			
K_{10} [a]	988 ± 45 [d]		7°	135 ± 22		1.16 ± 0.05
K_{11} [a]	938 ± 125 [d]					
K_{12} [a]		795 ± 190				
K_{13} [a]	846 ± 75 [d]		18°			
K_{14} [a]	1035 ± 70 [d]	690 ± 170	17°			2.48 ± 0.05
K_{15} [a]	1035 ± 80 [d]		43°			
K_{16} [a]	941 ± 40 [d]		15°			
K_{17} [a]	836 ± 65 [d]		83°			
K_{18} [a]	875 ± 70 [d]		63°			
K_{19} [a]	927 ± 45 [d]		26°			
K_{20} [a]	891 ± 45 [d]		24°			
K_{21} [b]	881 ± 65 [d]		3°	160 ± 20		1.19 ± 0.03
K_{22} [b]		1280 ± 330		135 ± 24		1.17 ± 0.07
			Q value			
τ_1 [a]	-	-	82.8 ± 6			
τ_2 [a]	-	1220 ± 420	75.1 ± 3			
τ_3 [b]	952 ± 45 [d]	-	78.0 ± 5			
τ_4 [b]	932 ± 45 [d]	-	-			
τ_5 [a]	-	-	71.3 ± 3			

[a] Found in well exposure giving a time of flight of about 10^{-9} sec.
[b] Found in the direct proton beam. Time of flight is 1×10^{-10}-3×10^{-10} sec.
[c] Grain count vs range.
[d] Opacity[3] vs range.

936 $m_e \pm 11 m_e$ for the K-particles observed. The measurements were checked for internal-external consistency and were found to be consistent. The mass value quoted above would indicate the presence of K-particles in our sample (presumably the $K_{\mu 2}$[6]) of a mass lighter than the τ mass (965 m_e). As the ionization-range methods are the only ones contributing appreciably to the weighted average, a further possible systematic error cannot be excluded, however. We do not feel, therefore, that a mass different from the τ-meson mass is necessarily established by these measurements.

Multiple-scattering and ionization measurements were carried out on secondaries with dip angles less than 10°. The secondary of K_8 was identified to be an electron of 60 ± 6 Mev.[7] Table II gives the results of the blob count and multiple-scattering measurements on the secondary of K_8. Column 6, Table II gives the measured blob density for the secondary. For comparison we give in Column 7 the expected grain density for a μ-meson corresponding to the measured $p\beta$. From this comparison it is clear that a much lighter particle (i.e., electron) is present. The secondary of K_{14} can be interpreted as being either a π from the alternate decay of the τ-meson ($\tau^{+} \rightarrow 2\pi^{0} + \pi^{+}$) or a slow μ from the decay of a $K_{\mu 3}$. K_9 is a case where no secondary was found. All the other secondaries are consistent with L-mesons or electrons. K_1 (see Fig. 1) undergoes an elastic scattering from a light nucleus (with visible recoil) in the emulsion. The scattering angle is $79^{\circ} \pm 1^{\circ}$ and the recoil angle is $55^{\circ} \pm 5^{\circ}$ with the incident direction. The residual range of the K_1 particle after the scattering is 960 μ, corresponding to an energy of about 10.5 Mev, which is well above the Coulomb barrier.

Of the 35 K-particles found to date, 34 (presumably positive) decayed into single charged secondaries. Only one, K_9, can be interpreted to be negative since no secondary has been found. No K-particles giving rise to stars at the end of the range have been found in this survey.

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[6] Le Prince-Ringuet, Proceedings of the Fifth Rochester Conference on High-Energy Physics, 1955.

[7] The first example of this type of decay was found by Friedlander, Keef, Menon, and Van Rossum Phil. Mag. 45, 1043 (1954). From this and further cases reported at the 1955 Rochester High-Energy Conference, a three-body decay process can be inferred.

Table II

MEASUREMENTS ON K_8 SECONDARY

Plate	Length per plate (mm)	Distance from decay point (mm)	Average dip angle	pβ Mev/C	b/b_p	Expected g/g_p for μ-meson
8-18	8.9	2.2	$\sim 0^{\circ}$	56 ± 8	0.968 ± 0.04	1.50
8-18	---	6.7	5°	37 ± 5	0.960 ± 0.04	1.97
8-17	2.6	9.5	13°	38 ± 8	0.947 ± 0.05	1.93
8-16	1.9	12.5	17.5°	31 ± 7	0.88 ± 0.05	2.24
8-15	1.5	14.1	22°	38 ± 10	1.01 ± 0.09	1.93
8-14	1.1	15.4	29°	28 ± 8	1.05 ± 0.10	2.42
8-13	0.9	16.4	32.5°	29 ± 10	~1	2.34
8-12	0.4	17.0	55°	10 ± 4	~1	---

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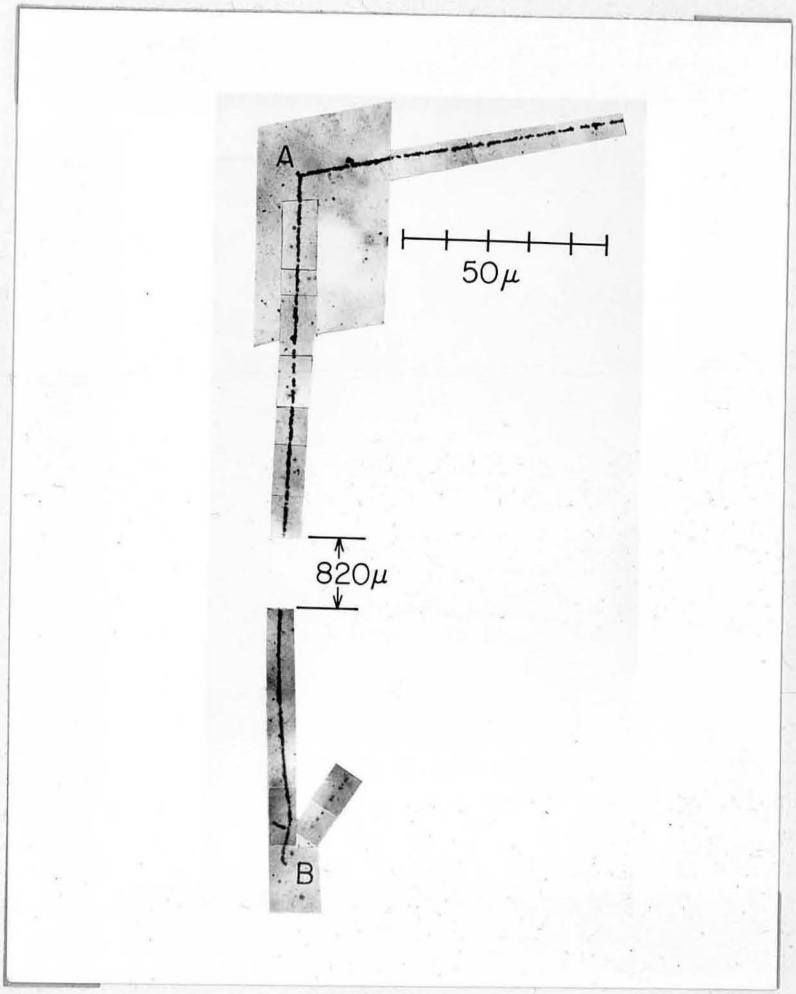

Fig. 1
Elastic scattering of K_1 from light element. K_1 scatters at A and decays at B into lightly ionizing secondary.