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A MASS DETERMINATION OF THE τ^- MESON

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ABSTRACT

Four τ^- meson decays in flight were observed in a 10-inch liquid hydrogen bubble chamber. The mass of the τ^- meson as determined by a kinematical analysis of the events is $963 \pm 10\ m_e$.

A MASS DETERMINATION OF THE τ^- MESON†

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During the course of an investigation of the interaction of K^- mesons with hydrogen, four τ^--meson decays in flight were observed in a 10-inch liquid hydrogen bubble chamber.

The first evidence for the existence of the τ^- meson was the decay in flight observed with a magnetic cloud chamber at Cal Tech.[1] A mass of $968 \pm 18\ m_e$ was calculated for the τ^- meson. Fretter and co-workers have observed a τ^- meson decay in flight and have computed a mass of $964 \pm 6\ m_e$.[2] A similar event has been observed at Manchester, and at Paris and possibly at Princeton.[3] No mass measurements are available for these mesons.

The τ^- meson decays into two π^- mesons and one π^+ meson. The sign of the charge and the recognition of the π meson are readily obtained from the bubble chamber pictures. A photograph of event No. 42634 is shown in Fig. 1. The bubble chamber was located in a magnetic field of 11,000 gauss and placed alongside the Bevatron so that the K^- meson beam of approximately 200 Mev/c momentum could enter the cylindrical side of the chamber.

The steroscopic photographs of the four events were reprojected and analyzed in the following manner. Let us represent directions in the bubble chamber with the x-y plane lying parallel to the face of the chamber and the z axis along the chamber axis and parallel to the magnetic field. Further, the projection of the path of the K meson on the x-y plane is in the y direction. The angle ψ in the x-y plane, between the π-meson track projection and the y axis for each π meson, was measured. The radius of curvature of each π meson was measured, and with the aid of the stereo-views, the angle of dip or rise, λ, between the π meson track and the x-y plane was determined.

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1 V. A. J. van Lint and G. H. Trilling, Phys. Rev. 92, 1089A (1953).

2 Aggson, Fretter, Friesen, Hansen, Kepler, and Lagarrigue, Phys. Rev. 102, 243 (1956).

3 Sixth Rochester Conference Report, 1956, Section V, page 5.

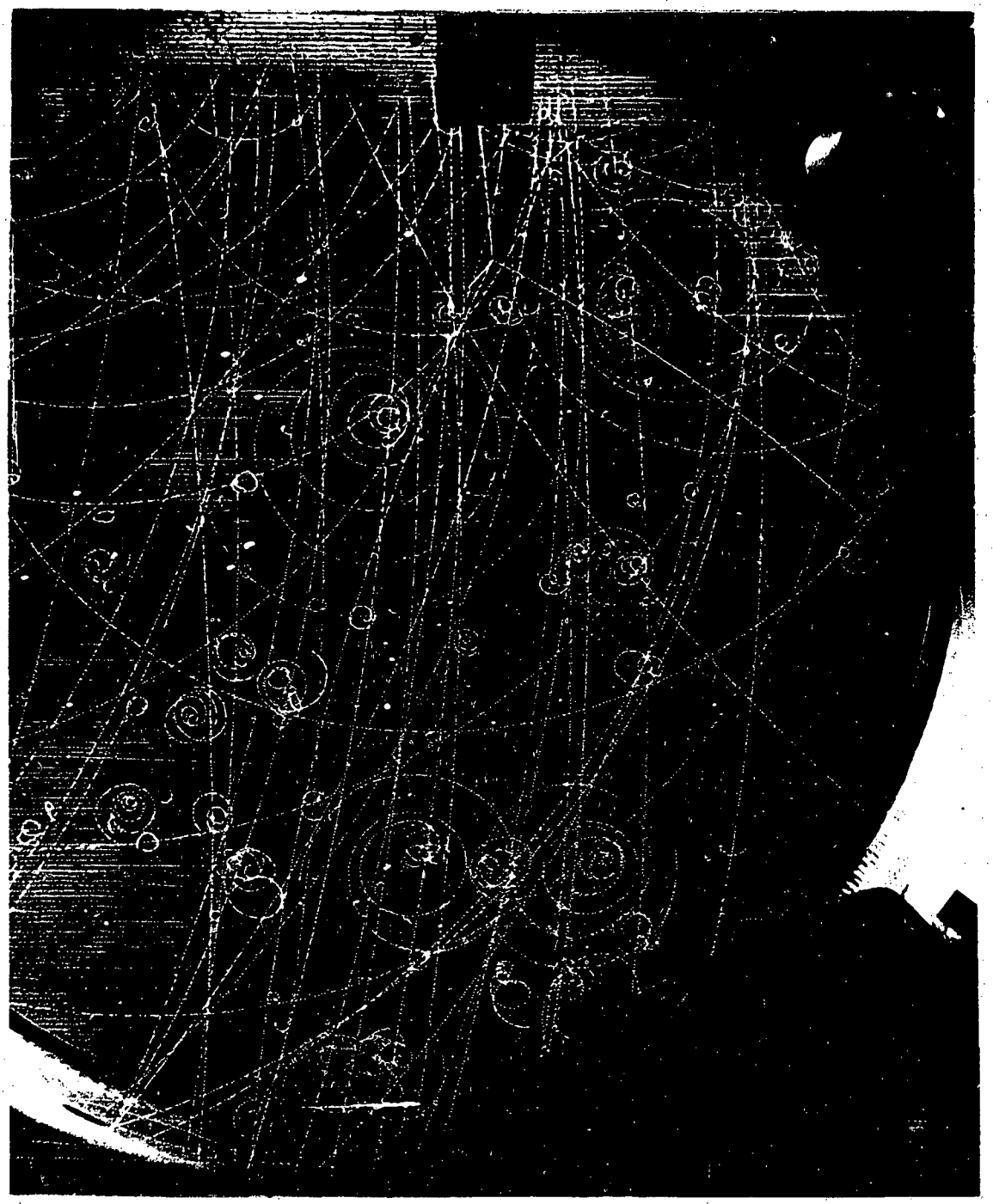

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Fig. 1. Bubble chamber photo of τ^- meson decay.

Table I

Momentum and energy for π mesons observed in τ-meson decays

Event	No. 42634	No. 44270	No. 48366	No. 61760
p_{π_1} (Mev/c)	111.	82.4	96.6	106.5
p_{π_2} (Mev/c)	36.	60.3	72.0	118.2
p_{π_3} (Mev/c)	174.	140.5	104.3	85.9
ψ_1	-60.5°	-121.4°	-36°	-66.7°
ψ_2	+46.2°	+19.0°	+2°	+28.6°
ψ_3	+29.1°	+21.1°	+96°	+64.9°
λ_1	-11.3°	-10.17°	-16.7°	+4.8°
λ_2	+52.°	-21.8°	-44.1°	+7.86°
λ_3	-3.5°	+7.22°	+56.8°	-62.4°
T_{π_1} (Mev)	38.5	22.2	29.3	35.7
T_{π_2} (Mev)	4.6	12.4	17.3	43.8
T_{π_3} (Mev)	83.0	58.4	34.3	24.2
T (Mev)	126.1	93.0	80.9	103.7
Py (Mev)	220.8	140.7	122.5	161.7
m_{τ^-}(Mev)	497	492	484	496

Mean: 492 ± 5 Mev,
963 ± 10 m_e.

Table I lists the angles, the momenta of each π meson as determined by its radius of curvature, and the kinetic energies as calculated from the momenta. Using conservation of longitudinal momentum (Py), one finds the mass of the τ^- by

$$m_k = [(3m_{\pi^\pm} + T)^2 - P_y^2]^{1/2}.$$

It should be noted that conservation of transverse momentum (P_x and P_z) affords independent checks on internal consistency of the measured momenta.

The angles ψ can be measured to $\pm 1^\circ$. The angles λ can be measured to $\pm 2^\circ$. The radii of curvature and consequently the momenta are reliable to $\pm 10\%$. This is the greatest source of error and must be conservatively estimated because of the presence of turbulence in the chamber. Most of the above momenta are reliable to $\pm 5\%$. A $\pm 10\%$ error in total momentum leads to an error of 1% in the mass of the τ meson. However, the conservation of transverse momentum was observed to hold to within $\pm 5\%$, for each event, and this should make the estimated $\pm 1\%$ uncertainty in mass a most conservative estimate. The internal consistency of the four events also lends credence to the assigned error. The τ^- meson mass, as determined in this experiment, is $963 \pm 10\ m_e$ and can be compared with the τ^+ mass[4] of $966 \pm 2\ m_e$.

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[4] Sixth Rochester Conference Report, 1956 Section V, page 25.

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