Observations on S Particles*

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SINCE March, 1954, the Princeton cloud-chamber group has been operating a dual cloud chamber similar to that of the Ecole Polytechnique.[1] The upper or magnet chamber has been described previously.[2] The lower or multiplate chamber has an illuminated region approximately 20 in.×20 in.×7 in. and the illuminated regions of both chambers are separated by 8 in. The material in the lower chamber has been in succession seven $\frac{1}{2}$-in. Pb plates and seven $\frac{1}{2}$-in. Cu plates. More recently, eleven tungsten plates each approximately 0.6 in. thick for a total of 290 g/cm^2 in the vertical direction have been installed. In this paper it is intended to describe those events in which either the primary or secondary of the S event[3] was observed in both chambers.

We have observed five S events whose primary masses were measurable by a momentum-range method. In one of these the secondary proceeded back into the upper chamber so that its momentum could be ascertained. In one other event the secondary stopped in the lower chamber. In all events the secondary traversed more than 30 g/cm^2 of copper, and no associated γ's were observed.

In a sixth event the primary was not observed in the upper chamber, but the secondary traveled back through the upper chamber for a distance of 30 cm. The measurements on this event are given in Table I.

TABLE I. Measurements on secondary particle in event 161–48942.

Measured momentum in upper chamber	Range in material between chambers	Range in plates of lower chamber
147 ± 3.5 Mev/c	25.4 ± 1 g/cm^2 Cu	15.4 ± 1 g/cm^2 Cu

To obtain the momentum of the secondary at the point of decay (p^*) one has to assume its mass and then use range-energy relations. Assuming the secondary is a μ meson and using the tables of Aron, Hoffman, and Williams,[4] we obtain $p^*=222\pm4$ Mev/c. Using the corrections to these tables described in the following Letter, we obtain 221 ± 4 Mev/c. On the assumed decay scheme $K_{\mu2}\rightarrow\mu+\nu$ the mass of the primary becomes $915\pm15m_e$ or $912\pm15m_e$, respectively. If, on the other hand, one assumes the secondary is a π meson and analyzes the event as a $\theta^+\rightarrow\pi^++\pi^0$ the secondary momentum becomes 235 ± 4 Mev/c when one uses reference 4, and 234 ± 4 Mev/c corrected, with the primary mass $1065\pm15m_e$ and $1062\pm15m_e$, respectively. This is inconsistent with the assumed decay scheme if the θ has a mass near that of the τ meson.[2,5]

In event number 244–96322, in which both primary and secondary are observed in the upper chamber, the secondary range and total momentum are not so well defined because it is impossible to determine whether or not the secondary traveled through a vertical counter wall of 8.5 g/cm^2 of Cu placed between the chambers. However, it appears in the upper chamber as a minimum ionizing track of momentum 117 ± 3 Mev/c after traversing a minimum of 51 g/cm^2 of Cu. The primary mass was measured as $(860_{-90}^{+70})m_e$ and it is therefore felt that this event is a well-established $K_{\mu2}$ heavy meson.

In event 242–94370 the secondary had a range of 63–83 g/cm^2 Cu. The masses of the five primaries when one uses reference 4 are (780 ± 90), (900 ± 80), (1080 ± 180), (935 ± 80), and $(860_{-90}^{+70})m_e$. The weighted mean of all five is $(891\pm40)m_e$, and for the two cases in which the secondary has a range greater than 50 g/cm^2 Cu it is $(905_{-80}^{+65})m_e$. When corrected for changes in the range-energy curves, these become $(900\pm40)m_e$ and $(914_{-80}^{+65})m_e$, respectively. These mass measurements coupled with the well-determined secondary of event 161–48942 are considered as confirming the evidence that the $K_{\mu2}$ has a mass lower than the τ meson, as indicated by the Paris group.[6]

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[2] Hodson, Ballam, Arnold, Harris, Rau, Reynolds, and Treiman, Phys. Rev. **96**, 1089 (1954).
[3] S events were first described by the Massachusetts Institute of Technology group, e.g., Bridge, Courant, DeStaebler, and Rossi, Phys. Rev. **91**, 1024 (1953).
[4] Aron, Hoffman, and Williams, U. S. Atomic Energy Commission Report AECU-663 (unpublished).
[5] Bridge, De Staebler, Rossi, and Sreekantan, Nuovo cimento (to be published).
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Masses of S Particles*

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MASS determinations of stopping K-mesons have been reported by several cloud-chamber groups.[1–3] Two methods are available when the so-called double cloud-chamber technique is used. (1) The mass of the K-meson is measured "directly" by a momentum range method. (2) The mass of the K-meson is determined by measuring the range of the charged decay product, assuming the nature of both the charged and neutral decay procucts, and treating the event as a two-body decay. This second method is available also when a single cloud chamber is used, containing plates of suitable stopping material.