UCRL 3340

UNIVERSITY OF CALIFORNIA

Radiation Laboratory

TWO-WEEK LOAN COPY

This is a Library Circulating Copy which may be borrowed for two weeks. For a personal retention copy, call Tech. Info. Division, Ext. 5545

BERKELEY, CALIFORNIA

DISCLAIMER

This document was prepared as an account of work sponsored by the United States Government. While this document is believed to contain correct information, neither the United States Government nor any agency thereof, nor the Regents of the University of California, nor any of their employees, makes any warranty, express or implied, or assumes any legal responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by its trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof, or the Regents of the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof or the Regents of the University of California.

UCRL-3340

UNIVERSITY OF CALIFORNIA

Radiation Laboratory
Berkeley, California

Contract No. W-7405-eng-48

DECAY MODES OF NEGATIVE K MESONS

A. Gösta Ekspong and Gerson Goldhaber

March 14, 1956

Printed for the U. S. Atomic Energy Commission

DECAY MODES OF NEGATIVE K MESONS*

A. Gösta Ekspong† and Gerson Goldhaber

Radiation Laboratory, Department of Physics
University of California, Berkeley, California

March 14, 1956

As is well known, when negative K mesons are brought to rest they undergo capture in the atomic orbits and finally nuclear absorption. The competition between nuclear absorption and decay from the atomic orbits appears to be in favor of the absorption process. To study the decay modes of negative K mesons it is thus necessary to observe decays in flight. In a study of negative-K-meson interaction and lifetime,[1,2] we have observed four decays in flight in nuclear emulsions. In two of these cases it was possible to establish the nature of the decay scheme. In the other two the secondary particles were emitted with large dip angles, and such an analysis was thus not possible. One of the two cases analyzed is consistent with the decay $K^- \rightarrow \pi^- + \pi^0$, and the other with the decay $K^- \rightarrow e^- + 2$ neutral particles.

---

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

† On leave of absence from the University of Uppsala, Uppsala, Sweden.
Supported by a grant from Atomkommittén, Sweden.

[1] Goldhaber, Goldhaber, Iloff, Lannutti, Webb, Widgoff, Pevsner, and Ritson, Proceedings of the 1955 Pisa Conference, Nuovo Cimento (to be published).

[2] Iloff, Goldhaber, Goldhaber, Lannutti, Gilbert, Violet, White, Fournet, Pevsner, Ritson, and Widgoff, Phys. Rev. (to be published).

The first case consisted of a K-meson track (as determined from multiple scattering and ionization measurements), that gave rise to a secondary emitted at $96.7^{\circ} \pm 0.2^{\circ}$. The decay occurred at a velocity of $\beta_K = 0.383 \pm 0.013$, as determined from ionization measurements (the normalized gap coefficient is $g^* = 4.25 \pm 0.19$ at 1.4 mm from the decay point). The secondary particle had a dip angle of 13.5° and left the stack after an observed range of 4.9 cm. Scattering and blob-density measurements on the secondary in two different parts of the track are shown in Fig. 1. In the same figure are shown blob-density measurements on a calibration track, known to be a π^- meson (as it gives rise to a σ star), for which $p\beta$ has been deduced from its range. Known systematic errors --noise, effect of dip angle, and distortion-- have been corrected for. These observations give the mass of the secondary as $m = 265 \pm 30\ m_e$ and thus it was most probably a π meson. At the point of decay the momentum of the secondary, now considered as a π meson, was $p = 170 \pm 9$ Mev/c. The transformed momentum in the rest system of the K- meson was found to be $p^* = 202 \pm 12$ Mev/c. This value is consistent with that observed in the decay at rest of positive $K_{\pi 2}$ mesons ($p^* = 205$ Mev/c.). This fact suggests that the decay scheme was $K^- \rightarrow \pi^- + \pi^0$. Assuming this to be the correct decay scheme, we obtain the mass of the negative K meson as $m_K = 957 \pm 40\ m_e$, which is in good agreement with other measurements.[3]

Figure 2 shows the expected momentum of the secondary particle, (in the laboratory system) as a function of the K-meson momentum (assuming $m_{K^-} = m_{\pi^+} = 965\ m_e$). The experimental point (full circle) again shows good agreement with the $K_{\pi 2}$ mode. If we omit the evidence on the mass of the secondary, shown in Fig. 1, and make the assumption that the secondary was a μ meson (triangle in Fig. 2), the $K_{\mu 2}$ mode can be definitely ruled out for this case. However, the $K_{\mu 3}$ decay mode is a dynamically possible one, contradicted only by the observed mass of the secondary particle.

---

[3] Hornbostel and Salant, Phys. Rev. 99, 338 (1955);
Chupp, Goldhaber, Goldhaber, and Webb, Proceedings of the 1955 Pisa Conference Nuovo Cimento (to be published);
Webb, Chupp, Goldhaber, and Goldhaber, Phys. Rev. 101, 1212 (1956);
Gilbert, Violet, and White, private communication.

In the second case the K meson had a momentum of $p = 350 \pm 25$ Mev/c at the decay point. The secondary particle was emitted at an angle of 79.6°. The measured relative ionization was, from blob density, $g/g_{min} = 1.04 \pm 0.05$. Multiple-scattering measurements gave $p\beta = 37 \pm 4$ Mev/c over the first 3.5 mm of track, and $p\beta = 25 \pm 4$ Mev/c over the following 2 mm. From these observations we concluded that the secondary particle was an electron of about 30 Mev energy. A transformation to the rest system of the K meson leaves the energy of the electron practically unaltered. This case is thus consistent with the decay mode $K^-_{e3} \rightarrow e^- + 2$ neutral particles.[4]

The two cases discussed above showed no evidence of any blobs, which implies that we are dealing with decays in flight rather than nuclear interactions. As discussed previously,[2] there is an upper limit of 15% to the number of apparent decays in flight that could actually be interactions in flight.

It may thus be noted that negative K-meson decay modes so far observed include the $K^-_{\pi 2}$, K^-_{e3}, and τ^- (the last was established in cloud chamber work.[5])

---

[4] Williams, Haskin, Koshiba, and Schein, Phys. Rev. 100, 1547 (1955), discuss an example of a 74 Mev electron emitted as the only prong from a K^- meson assumed to be at rest.

[5] Van Lint and Trilling, Phys. Rev. 92, 1089 (1953);
Le Prince-Ringuet, Proceedings of Rochester Conference 1955;
Aggson, Fretter, Friesen, Hansen, Kepler, and Lagarrigue, Phys. Rev. (in press).

FIGURE CAPTIONS

Fig. 1. Blob density versus $p\beta$ for the secondary particle (case I).

Fig. 2. Computed curves for the momentum of the secondary particle (in the laboratory system, for 96.7° emission angle) as a function of K-meson momentum (case I). Experimental point is plotted for the assumptions
(a) that the secondary is a π (circle),
(b) that the secondary is a μ (triangle).

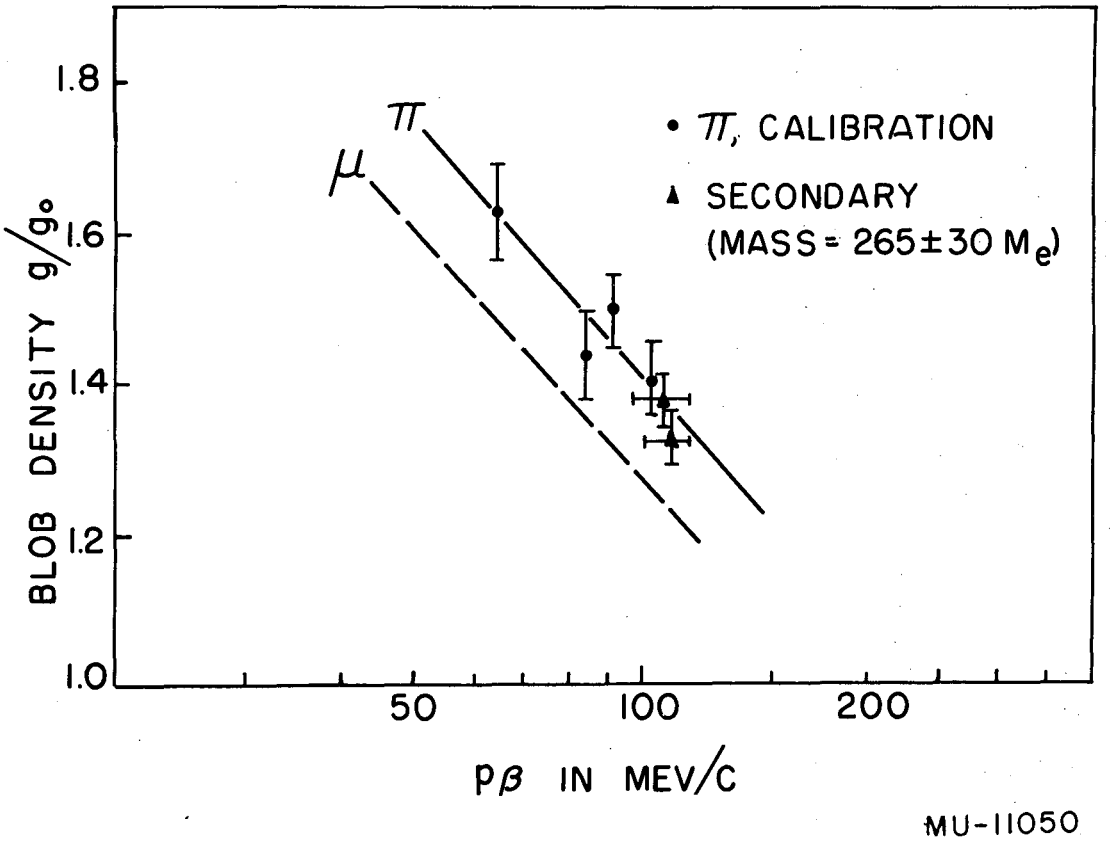
1.8
1.6
1.4
1.2
1.0
BLOB DENSITY g/g₀
π
μ
• π, CALIBRATION
▲ SECONDARY
(MASS = 265±30 Me)
50
100
200
pβ IN MEV/C
MU-11050

Figure 1

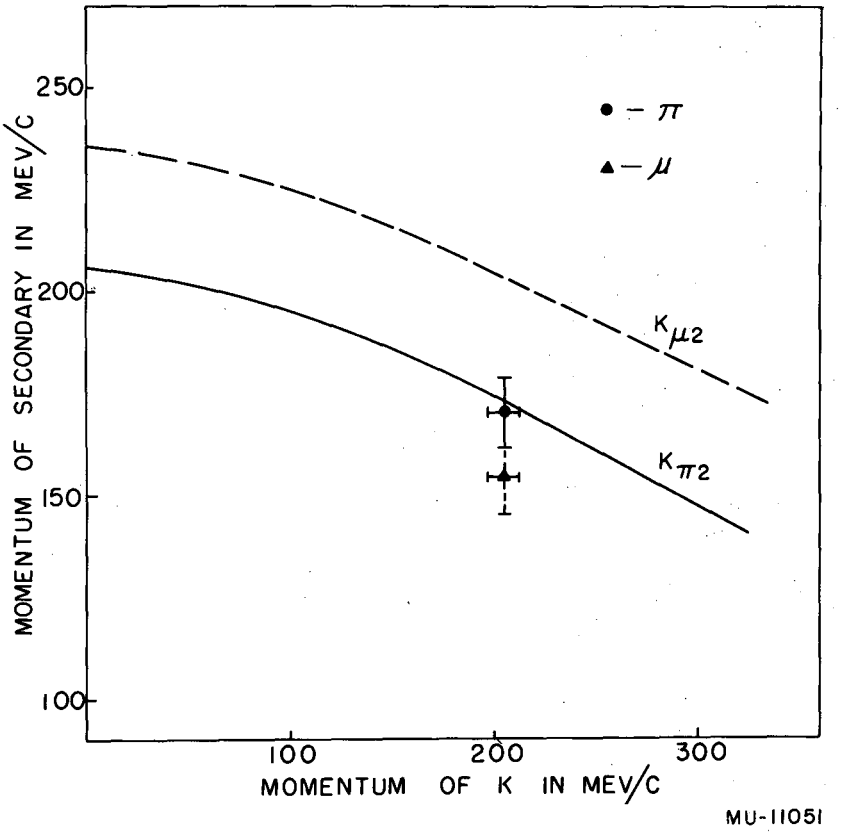
250
200
150
100
MOMENTUM OF SECONDARY IN MEV/C
● – π
▲ – μ
$K_{\mu 2}$
$K_{\pi 2}$
100
200
300
MOMENTUM OF K IN MEV/C
MU-11051

Figure 2