

Absorption measurements indicated that the maximum beta-energy for the five-hour plutonium activity is approximately 0.5 Mev. Absorption and decay data are shown in Figs. 1 and 2.

From these results, we conclude that the five-hour activity is due to a plutonium isotope, most probably  $\text{Pu}^{243}$ . The mass 243 is favored by the following considerations: 1. The difference in yield of five-hour activity from this plutonium sample and from another sample of plutonium containing smaller amounts of  $\text{Pu}^{240}$ ,  $\text{Pu}^{241}$ , and  $\text{Pu}^{242}$  fits best with the assumption that the activity was produced by neutron excitation of  $\text{Pu}^{242}$ . Moreover, except for the unlikely possibility of a short-lived isomer of the observed long-lived  $\text{Pu}^{242}$ , all plutonium isotopes of lower mass which could conceivably have been formed are long-lived. 2. Odd mass plutonium isotopes 243 or greater are certainly beta-unstable since  $\text{Pu}^{241}$  is beta-unstable. 3. Plutonium isotopes of mass higher than 243 can almost certainly be ruled out from considerations of yield and the maximum energy of the new beta-ray activity.

The capture cross section of  $\text{Pu}^{242}$  for pile neutrons, based on the yield of the five-hour activity from five separate irradiations, was estimated to be of the order of one hundred barns. The individual yields, corresponding to 90, 97, 112, 94, and 113 barns, were in close agreement, but the absolute value is uncertain by at least 50 percent because the  $\text{Pu}^{242}$  content of the sample was only about twofold above the limit of mass-spectrometric detection.

<sup>1</sup> M. C. Inghram and D. C. Hess (private communication).

### Short $\mu$ -Meson Tracks from $\pi$ -Meson Decays\*

W. F. FRY

Department of Physics, Iowa State College, Ames, Iowa

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A GROUP of Ilford C2 200-micron plates were exposed in a spiral orbit spectrometer<sup>1</sup> to the Berkeley cyclotron. The plates were arranged in such a manner that  $\pi$ -mesons of opposite signs entered the emulsions from opposite directions.

A search for unusual  $\pi$ - $\mu$ -decays has been continued.<sup>2</sup> A total of 3018  $\pi$ - $\mu$ -decays have been studied where both the  $\pi$ - and  $\mu$ -meson tracks stopped in the emulsion. Four cases were found

TABLE I. Data for four  $\pi$ -meson decays with short  $\mu$ -meson tracks.

Event	Range of $\mu$ -track, in microns	Angle between directions of $\pi$ - and $\mu$ -tracks, degrees	Energy in Mev of $\pi$ -meson, assuming decay in flight
1	260	113	0.73
2	258	93	1.7
3	185	20	16.6
4	120	73	5.0

where the  $\mu$ -meson tracks are unusually short. The ranges of these  $\mu$ -meson tracks are given in Table I.

Photomicrographs of events 1 and 3 are shown in Figs. 1 and 2. Four additional  $\pi$ - $\mu$ -decays have been found where the lengths of the  $\mu$ -meson tracks are between 485 and 500 microns. Sixteen  $\pi$ - $\mu$ -decays were found where the ranges of the  $\mu$ -meson tracks are between 500 and 520 microns. These twenty events may be examples of extreme straggling. The average range of the  $\mu$  meson tracks from  $\pi$ -meson decays is about 594 microns in these plates.

Two events were found which appear to be  $\pi$ - $\mu$ -decays. The  $\mu$ -meson tracks are 57 and 25 microns long. Since the  $\mu$ -meson tracks are short, it seems difficult to establish that these two events are  $\pi$ - $\mu$ -decays and not scattered  $\mu$ -mesons.

If the short ranges of the  $\mu$ -mesons in events 3 and 4 were due to the decay in flight of the  $\pi$ -mesons, the energy of the  $\pi$ -mesons at the time of decay would be 16.6 and 5 Mev, respectively. The

grain density near the end of the  $\pi$ -meson tracks is much greater than along a 5-Mev meson track; hence it is concluded that the short ranges of the  $\mu$ -mesons in events 3 and 4 are not due to the decay in flight of the  $\pi$ -mesons.

In all of the 26 cases where the  $\mu$ -meson tracks are shorter than 520 microns, the  $\pi$ -mesons entered the emulsions from such a direction as to indicate that the  $\pi$ -mesons were positively charged. Approximately 3300  $\pi$ -meson events have been studied in these plates. Only 5  $\pi$ -meson events have been observed where the sign of the charge, as determined from the direction of the  $\pi$ -meson,

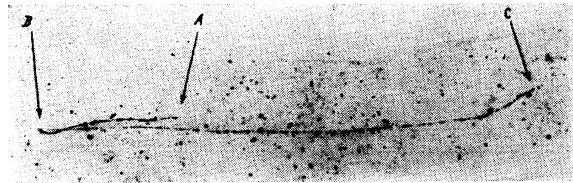


FIG. 1. Photomicrograph of an usual  $\pi$ - $\mu$ -decay. The  $\pi$ -meson enters the emulsion at point A and decays at point B. The  $\mu$ -meson stops at point C. The  $\mu$ -meson track is only 260 microns long. The grain density near the end of the  $\pi$ -track is much greater than along the beginning of the  $\mu$ -track.

is inconsistent with the phenomena associated with the meson. Since no conclusive evidence has been found for the decay of negative  $\pi$ -mesons in photographic emulsions, and since the scattering in the spectrometer is small, it is concluded that the  $\pi$ -mesons which give rise to the short  $\mu$ -meson tracks are positively charged. It is believed that events 1 through 4 are examples of an alternative mode of  $\pi$ -meson decay.

An unusual  $\pi$ - $\mu$ -decay was found by Smith,<sup>3</sup> where the  $\mu$ -track is 275 microns long. Another  $\pi$ - $\mu$ -decay was found by Powell.<sup>4</sup>

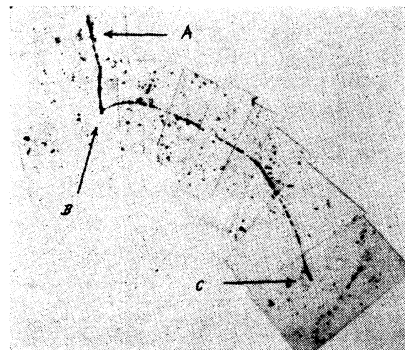


FIG. 2. Photomicrograph of a  $\pi$ - $\mu$ -decay where the  $\mu$ -meson track is only 185 microns long. The track of the  $\pi$ -meson is indicated by arrow A. The  $\pi$ -meson decay is indicated by arrow B. The  $\mu$ -meson track ends at point C. The track of the  $\mu$ -meson is more nearly perpendicular to the plane of the emulsion than the  $\pi$ -meson track; nevertheless, the grain density is greater near the end of the  $\pi$ -meson track than along the beginning of the  $\mu$ -meson track.

The  $\mu$ -track did not end in the emulsion, but by grain counting and scattering it was estimated that the  $\mu$ -track would have been less than 350 microns long.

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<sup>1</sup> R. Sagane and P. C. Giles, *Phys. Rev.* **81**, 653 (1951).

<sup>2</sup> W. F. Fry, *Nuovo cimento*, to be published.

<sup>3</sup> F. M. Smith, Reported at the Washington Meeting, American Physical Society (1951).

<sup>4</sup> C. F. Powell, *Cosmic Radiation*, Colston Papers (Butterworth Scientific Publications, London, 1949).

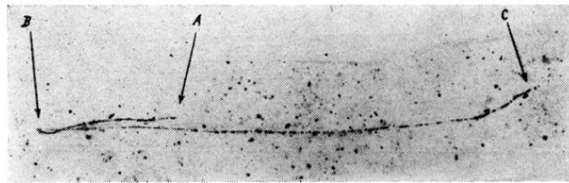


FIG. 1. Photomicrograph of an usual  $\pi - \mu$ -decay. The  $\pi$ -meson enters the emulsion at point *A* and decays at point *B*. The  $\mu$ -meson stops at point *C*. The  $\mu$ -meson track is only 260 microns long. The grain density near the end of the  $\pi$ -track is much greater than along the beginning of the  $\mu$ -track.

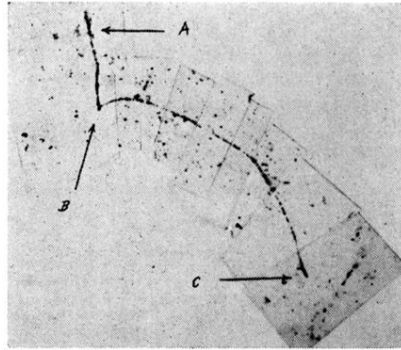


FIG. 2. Photomicrograph of a  $\pi$ - $\mu$ -decay where the  $\mu$ -meson track is only 185 microns long. The track of the  $\pi$ -meson is indicated by arrow *A*. The  $\pi$ -meson decay is indicated by arrow *B*. The  $\mu$ -meson track ends at point *C*. The track of the  $\mu$ -meson is more nearly perpendicular to the plane of the emulsion than the  $\pi$ -meson track; nevertheless, the grain density is greater near the end of the  $\pi$ -meson track than along the beginning of the  $\mu$ -meson track.