TABLE I. Characteristics of unusual $\pi-\mu$ decays.

Event	Type of emulsion	Range of μ-meson track in microns	Energy of μ-meson in Mev	Measured angle between directions of π- and μ-meson tracks	Energy in Mev of π-meson assuming decay in flight
1[a]	C-2	120	1.6	73	5.0
2[a]	C-2	185	2.1	20	16.6
3[a]	G-5	290	2.7	59	6.6
4[a]	G-5	416	3.3	51	8.3
5[a]	G-5	430	3.35	26	15.4
6[a]	G-5	441	3.4	56	5.1
7[a]	G-5	470	3.35	28	15.4
8	C-2	258	2.5	93	1.7
9	C-2	260	2.5	113	0.7
10	G-5	444	3.4	160	0.03
11	G-5	476	3.5	117	0.09
12	C-2	828	4.8	10	0.05
13	G-5	1035	5.5	55	0.5

[a] Events which do not appear to be decays in flight of the π-mesons.

events 1 through 7 are due to the decay in flight of the π-mesons, the energy of the π-mesons at the time they decayed can be calculated from the directions of the π- and μ-mesons and the ranges of the μ-meson tracks. In events 1 through 7 the grain density near the ends of the π-meson tracks is clearly inconsistent with the assumption of decay in flight of the π-mesons. However, it cannot be entirely ruled out that the π-mesons were scattered through a large angle in the last one or two grains and subsequently decayed in flight in the backward direction. From a study of the large angle scatterings near the end of the π-meson tracks of normal $\pi-\mu$ decays, it was found that the probability of large angle scatterings is quite small, hence the probability that a π-meson would be scattered and subsequently decay in flight is extremely small ($\sim 10^{-5}$). For this reason it seems quite certain that the short ranges of the μ-meson tracks in events 1 through 7 are not due to the decay in flight of the π-mesons. A decay electron track is observed from the end of each of the μ-meson tracks which stopped in G-5 plates. A study of the grain density and the total energy of the δ-rays along the μ-meson tracks indicate that the μ-mesons were ejected with a lower velocity than in normal $\pi-\mu$ decays. The range distribution of μ-mesons from π-meson decays in C-2 plates has been studied. From this study it is concluded that the events where the ranges of the μ-meson tracks are less than 480 microns cannot be due to straggling. Correcting for the increased probability that short μ-meson tracks will end in the emulsion, the ratio of unusual $\pi-\mu$ decays (range of the μ-meson track <480 microns) to normal $\pi-\mu$ decays is then $2.8\pm1.2\times10^{-4}$ if the events which can be explained by decay in flight are not included. A micro-projection drawing of event 4 is shown in Fig. 1.

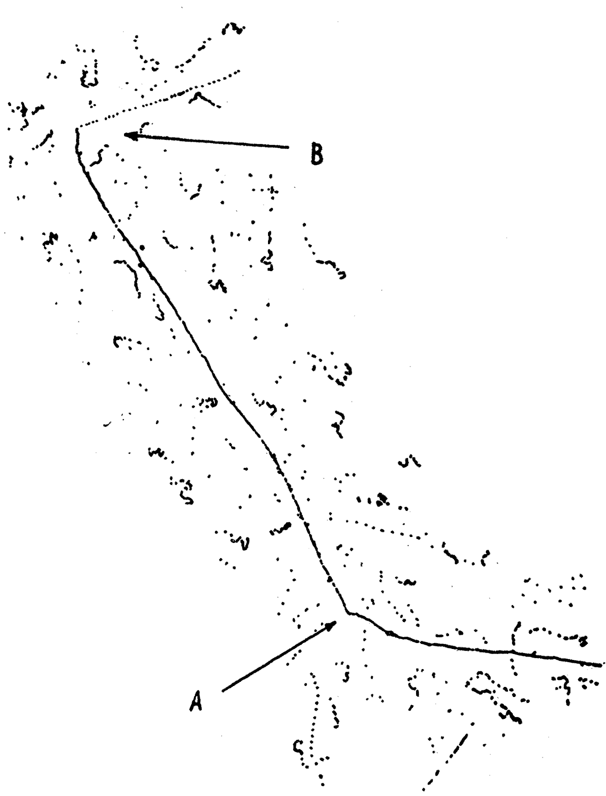

FIG. 1. An unusual $\pi-\mu-e$ decay which is listed as event 4. The $\pi-\mu$ junction is indicated by arrow A and the $\mu-e$ junction by arrow B. The range of the μ-meson track is 416 microns. The normal range of the μ-meson tracks from decays is about 600 microns.

Short μ-meson tracks from π-meson decays have also been found by Powell,[4] Smith,[5] and Seifert, Bramson, and Havens.[6] A theoretical explanation of the occurrence of unusual $\pi-\mu$ decays in terms of soft photon emission has been given independently by Primakoff,[7] Eguchi,[8] and Nakano, Nishimura, and Yamaguchi.[9] The percentage of unusual $\pi-\mu$ decays and the energy distribution of the μ-mesons appear to be in general agreement with the theoretical predictions based on a soft photon emission accompanying the charge acceleration of the μ-mesons from the π-meson decays.

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Polarization of D-D Neutrons*

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AN attempt has been made to detect the polarization of the fast neutrons of the D-D reaction at very low bombarding energies. Various descriptions[1,2] of the interactions in the D-D reaction result in the possibility of a polarization of the D-D neutrons. A method proposed by Schwinger[3] to detect polarization of fast neutrons was used in this experiment. The experimental arrangement is shown in Fig. 1.

Following Schwinger's notation, $P_1(\theta_1)$ is the fraction polarized of neutrons emerging from source at angle θ_1 and $P_2(\theta_2)$ is the fraction of the neutrons polarized by the Pb scatterer emerging from the scatterer at angle θ_2. The ratio of the neutron intensities, I, at positions 1 and 2 is given by

$$R=\frac{I_2}{I_1}=\frac{1+P_1(\theta_1)P_2(\theta_2)}{1-P_1(\theta_1)P_2(\theta_2)}.$$

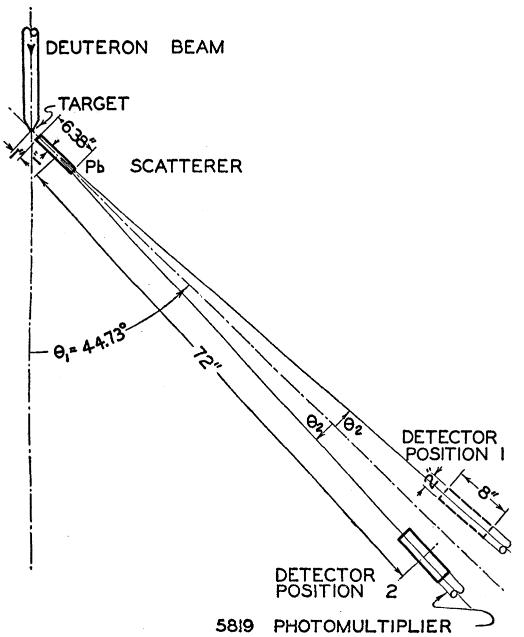

FIG. 1. Experimental arrangement.

For a given θ_1 this ratio may be solved for the polarization $P_1(\theta_1)$ if $P_2(\theta_2)$ is known.

θ_1 was 45° in center-of-mass coordinates, and the ratio R was measured for two angles $\theta_2=3.23°$ and 4.47°. At $\theta_2=4.47°$, $R=1.2 \pm 0.2$; and at $\theta_2=3.23°$, $R=1.5\pm 0.2$. The value of $P_2(\theta_2)$ can be computed as in Schwinger's discussion, giving values of the polarization $P_1(45°)$ to be 30 percent from R at $\theta_2=4.47°$ and 40 percent ± 20 percent from R at $\theta_2=3.23°$.

The chief uncertainty in the experimental data is due to the background count, and the experiment is being repeated to lower the uncertainties.

The neutrons were detected by a liquid xylene-terphenyl mixture coupled to a 5819 photomultiplier. The details of the experimental arrangement and the revised data will appear in a subsequent article.

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The Decay of Rubidium 87

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SINCE the discovery of natural radioactivity in rubidium by Thomson[1] in 1905, much work has been done in an attempt to evaluate its properties. Strassman and Walling,[2] evaluating the half-life from a determination of the ratio of Sr^{87} to Rb^{87} in a lepidolite sample of known geologic age, obtained the value $T_{\frac{1}{2}}=6.3\times 10^{10}$ years. In addition many determinations of the half-life have been made by counting methods.[3–5] Recent results range from $5.8\pm 1.0\times 10^{10}$ years to $6.5\pm 0.6\times 10^{10}$ years. Most of the values obtained must be carefully evaluated, since in many of the cases thick sources or backings were used, and in some it was found necessary to make assumptions concerning the decay scheme.

Experiments giving information about the decay products have been in disagreement. By means of absorption measures, Hoffman[6] (1924) and Mühlhoff[7] (1930) found evidence of a weak beta-radiation accompanying a stronger one. Ollano[8] (1941) reported at least five electron lines lying over a continuous background. The absorption work of Eklund[3] (1945) indicated simple beta-decay. Haxel *et al.*[4] (1948) found up to 30 percent coincidences between the front and back sides of the source and attributed them to a beta-particle in coincidence with a 100-percent-converted gamma-ray. Curran *et al.*[5] (1951), using a proportional counter, obtained an energy spectrum of the beta-disintegration from which they concluded that the process is simple beta-dacay.

The present work was undertaken to re-evaluate the half-life and to provide further information about the decay scheme. In measuring the half-life of Rb^{87}, the cell counter described by Sawyer and Wiedenbeck[9] was used. A thin aluminized zapon film of about 0.025 mg/cm², upon which RbCl was vaporized, served as the cathode. The two sections were operated in parallel. With this arrangement the results are essentially independent of the decay scheme. Data were obtained for various source and backing thicknesses (Fig. 1). The specific activity extrapolated to zero thickness is 478 counts/g RbCl/sec; this, combined with Nier's value[10] for the isotopic abundance, gives $T_{\frac{1}{2}}=6.23\pm 0.3\times 10^{10}$ years. (Using Paul's[11] more recent value for this abundance, one obtains $T_{\frac{1}{2}}=6.29\times 0.3\times 10^{10}$ years.)

An investigation was then carried out to determine whether or not there are coincidences between beta-particles and conversion electrons. The counter mentioned above was modified by insulating the source from the rest of the counter and placing wire screens on both sides of the source, between the source and the cell counters. The screens were placed about 2 cm from the source, thus enabling a negative screen potential to discriminate against low energy electrons coming from the source. The two cell counters were

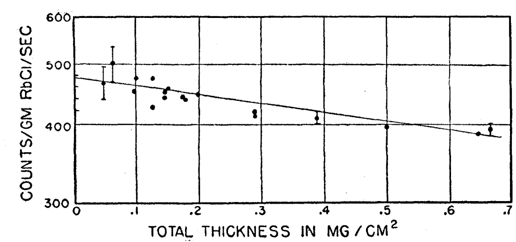

FIG. 1. Counting rate *versus* total source-plus-backing thickness. A zero-thickness activity of 478 counts per g RbCl per sec was obtained.

operated in coincidence, and a third cell counter was placed in anticoincidence to eliminate cosmic-ray effects. Coincidences which occur when the screen is at a negative potential arise either from a two-particle disintegration in which each particle has sufficient energy to traverse the 2 cm of counter gas between the source and the screen, or else from a single particle disintegration in which the particle is scattered from the sensitive region of one counter into the sensitive region of the other counter. When the screens are positive with respect to the source, there is superimposed on the above effect those real coincidences which arise from low energy particles which cannot traverse the 2 cm of counter gas, as well as coincidences due to a single particle which is scattered from one side of the source to the other in the region between the two screens.

Preliminary work was carried out with a group of single beta-emitters having different upper energies. These included Ni^{63}(50 kev), S^{35}(169 kev), Ca^{45}(260 kev), and P^{32}(1.7 Mev). The coincidence curves for these elements varied slightly with the energy of the emitted radiation. Changing the source activity by a factor of 100 and the resolving time of the coincidence circuit from 8 to 30 microseconds had no effect on the shape of the curves. Decreasing the gas pressure in the counter lowered the curves on the screen positive side (by reducing gas scattering), and it raised the curves on the screen-negative side (by increasing the mean free path).

Curves were taken for Rb^{87} sources of varying thicknesses. The Curve obtained for the thinnest source, 0.04 mg/cm², most closely resembled the curves for S^{35} and Ca^{45}. Figure 2 shows the curves