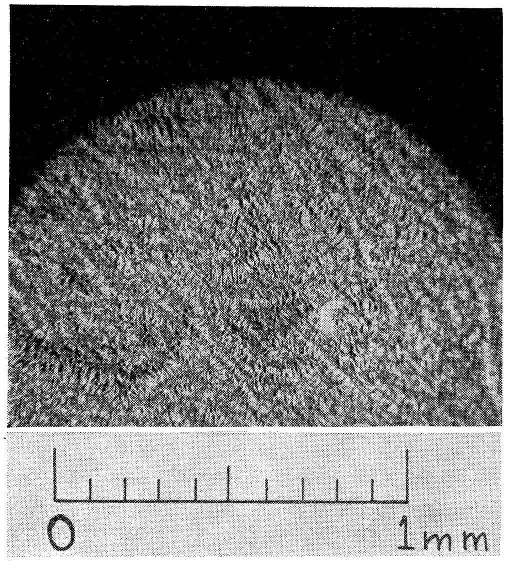

FIG. 1. Photomicrograph of powder pattern obtained on tape placed near the pole.

detected by the abrupt, large decrease in the slope of the resistance as a function of field. The field at which penetration occurs is $\frac{2}{3}$ of the threshold field value. The threshold field was thereby determined to be about 800 oersted. After initial penetration, the external field was further increased to about 0.8 of the threshold value, corresponding to a ratio of magnetic induction to critical field inside the sphere of about 0.4 The external field was then reduced to zero, and the apparatus warmed up.

Figure 1 is a photomicrograph of a powder pattern obtained on the tape placed at the pole on the outside of the hemisphere. The light areas are the magnetized regions where the iron powder has collected, and these correspond to the regions of normal phase in the sample. The pattern is complicated, but it is clear that the distances between the regions are about 0.05 mm. Similar patterns were obtained on the tape placed between the hemispheres, and qualitatively similar results were obtained with three different samples. The tape placed on the outside seems to become more strongly magnetized and thus exhibit clearer patterns, probably because the magnetic field at the outer surface has a component which lies in the tape as well as one transverse to it.

We hope that this extremely simple technique can be used to explore aspects of the intermediate state in which further investigations are needed.[5]

* This work has been supported by a joint program of the U. S. Office of Naval Research, the Rutgers University Research Council, and the Radio Corporation of America.

[1] A. Meshkovsky and A. Shalnikov, J. Phys. (U.S.S.R.) **11**, 1 (1947).

[2] For a review of the later work which is printed in Russian see D. Shoenberg, *Superconductivity* (Cambridge University Press, London, 1952), pp. 103–110.

[3] "Scotch" Brand Sound Recording Tape No. 111A, Minnesota Mining & Manufacturing Company, St. Paul, Minnesota.

[4] B. F. Murphy and H. K. Smith, Audio Engineering **33**, 12 (1949).

[5] *Note added in proof.*—Another technique, quite different from the one above, has been recently reported by Schawlow, Matthias, Lewis, and Devlin, Phys. Rev. **95**, 1344 (1954).

Magnetic Cloud Chamber Study of $V^{\pm}$ Events*

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THE object of this note is to give a preliminary report of the $V^{\pm}$ events observed to date with the rectangular magnet chamber.[1]

The transverse momentum p_y has been measured for 31 cases[2] with an average uncertainty of ±5 percent.

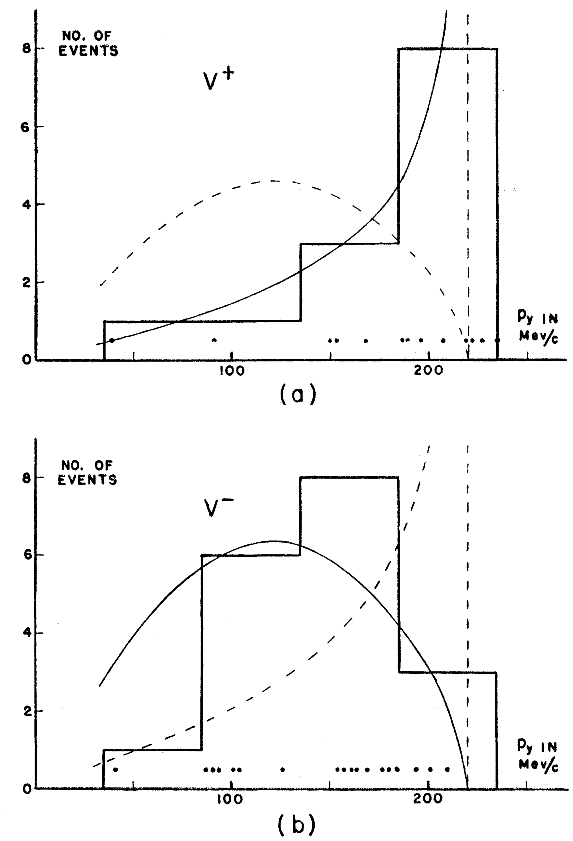

FIG. 1. The distributions of transverse momenta of $V^{\pm}$ events. The histograms give the number of events per 50-Mev/c interval. (a) is the distribution for V^{+} (13 events) and (b) for V^{-} (18 events). The values of the individual p_y's are indicated by the dots. Events with $p_y \leqslant 35$ Mev/c are omitted in order not to include possible π–μ decays. The theoretical distributions for a two-body decay (with $p'=220$ Mev/c) and for a three-body decay (with $p'_{\max}=220$ Mev/c) are shown by the solid line and by the dashed line in (a), and by the dashed line and by the solid line in (b). The average uncertainty in p_y is 5 percent and the errors are not folded into the theoretical distributions.

The distributions for V^+ (13 cases) and V^- (18 cases) are shown separately in Fig. 1. Although the statistics are limited, there is preliminary indication of a charge asymmetry. The distribution for V^+ is peaked near the highest observed values; for V^- the distribution appears to be broader and the center of gravity occurs at a lower value of p_y. Further indication for charge asymmetry is found in the distributions of decay points in the chamber shown in Fig. 2. The V^+ decays appear to be more or less uniformly distributed throughout the chamber, whereas the V^- decays appear to occur predominantly in the top half. Since the distributions of the longitudinal momentum of the secondary p_x are not much different for V^+ and V^- decays (the mean value of p_x is 575 Mev/c for V^+ and 732 Mev/c for V^-), this asymmetry in the distributions of decay points probably reflects a difference in lifetime. A detailed lifetime analysis will be reported in a later publication. Taken together, the two effects (difference in p_y distribution and in lifetime) provide reasonable evidence for a charge asymmetry in the $V^\pm$ events. Such a charge asymmetry in p_y distribution as well as in lifetime has not been previously observed in the magnetic cloud chamber work on $V^\pm$ events.[3–6]

The p_y distribution of V^+ events suggests, or at least is entirely compatible with, a two-body decay process with $p' \sim 220$ Mev/c, the momentum of the secondary in the c.m. system. This interpretation is further supported by three V^+ events (R-112,[7] R-390,[8] R-521) in which the primaries are well measurable and p' can be computed. The computed values of p' for these three events are 231 ± 15, 222 ± 6, 219 ± 8 Mev/c and are consistent with a unique value $p'=222\pm5$ Mev/c (the weighted mean of the three values).[9] Thus the present data provides preliminary evidence for a long-lived K^+ particle with mass about 1000 m_e which decays into an

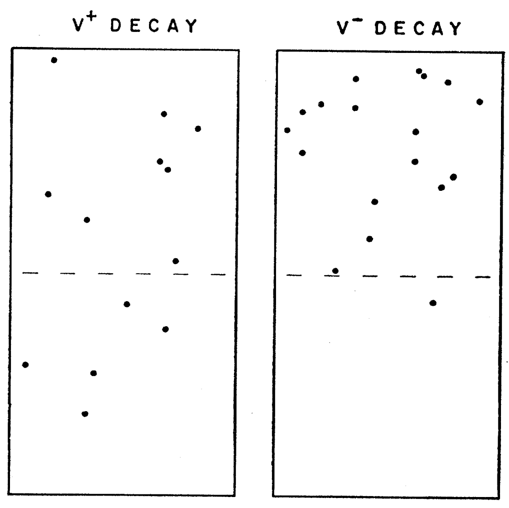

Fig. 2. The distributions of decay points in the chamber. The illuminated region of the chamber is 11 in. wide, 22 in. high and 5 in. deep. The decay points as seen from the central camera are shown by the dots.

L^+ meson and one neutral fragment of mass not greater than that of a π^0.

Gregory *et al.*[10] present evidence for a long-lived positive particle, $K_\mu^+ \rightarrow \mu^+ + \nu$, with a directly measured mass of $914\pm20 m_e$. In two cases, the ranges of the positive secondary are in the intervals (83.5–90.5) and (88–101) g/cm^2 of lead. These are consistent with a unique value of 90 g/cm^2 which corresponds to $p'=220$ Mev/c for a muon. Hodson *et al.*[11] report a remarkable photograph which may represent $\theta^+ \rightarrow \pi^+ + (\pi^0 \rightarrow 4e)$ $\pm 212\pm20$ Mev. Bridge *et al.*[12] report three S-particle secondaries with ranges in the intervals (100–140), (92–108), and (100–104) g/cm^2 of lead. These are consistent with a unique range of 102 g/cm^2 which corresponds to $p'=236$ Mev/c for a muon and $p'=266$ Mev/c for a pion. In this work the signs of the particles are not determined.

If the V^- data represent a homogeneous group, the p_y-distribution does not suggest a two-body decay process. This conclusion is confirmed by one event (R-156; $p_y=87\pm2$ Mev/c) in which the primary is measurable and the computed value of p' is less than 140 Mev/c.

In another V^- event (R-423;[8] $p_y=101\pm4$ Mev/c) the charged secondary is identified to be a π^- meson from π-μ decay. This event is entirely compatible with the suggested alternate decay mode of the τ meson, $\tau^\pm \rightarrow \pi^\pm + 2\pi^0$,[13] for which $p'_{\max}=132$ Mev/c. However, there is difficulty in explaining the majority of V^- events with $p_y \leqslant 132$ Mev/c in this way since the observed decay points in the chamber suggest that the lifetime is much shorter than that of the τ (about 10^{-8} sec).[14] There is, in fact, a tendency for V^- events with low p_y to decay near the very top of the chamber, but the statistics are insufficient to regard this as more than the most preliminary sort of evidence for two groups.

We have not, as yet, observed an example of the cascade decay,[4,15] $Y^- \rightarrow \Lambda^0 + \pi^-$. In view of the lifetime of Λ^0 it is very unlikely that more than a few V^- events are decays of this type.

The highest p_y values observed so far by us are in the neighborhood of 220 Mev/c. A K particle with mass substantially greater than $1000 m_e$[16] would give p_y values substantially greater than 220 Mev/c,[17] providing the neutral fragments (or fragment) are light. The absence of any much higher p_y values indicates that at most very few of the present $V^\pm$ events can be attributed to such a decay.

* Assisted by the U. S. Office of Ordnance Research and by grant of the Frederick Gardner Cottrell Fund of the Research Corporation.

[1] Thompson, Buskirk, Etter, Karzmark, and Rediker, Phys. Rev. **90**, 329 (1953).

[2] Exclusive of (a) π–μ decays, (b) angular deflections with visible recoil blobs at the points of deflection, (c) events with $p_y \leqslant 35$ Mev/c. The last condition is imposed in order not to include possible π–μ decays. Also five $V^\pm$ events (two V^+, two V^-, one $V^?$) are not suitable foi measurement and are excluded from analysis.

[3] Proceedings of the Bagnères Conference, 1953 (unpublished).
[4] Armenteros, Barker, Butler, Cachon, and York, Phil. Mag. 43, 597 (1952).
[5] Buchanan, Cooper, Millar, and Newth (private communication). We are indebted to Dr. Newth for sending us a prepublication copy of this paper.
[6] York, Leighton, and Bjornerud, Phys. Rev. 95, 159 (1954). These authors report two groups of $V^{\pm}$ events. One group consists predominantly of a very short-lived positive particle with a probable two-body decay process and can be interpreted in terms of the hyperonic decay, $Y^+ \rightarrow (\text{nucleon})^{+,0} + \pi^{0,+}$. The other group with a longer mean lifetime is concluded to be consistent, in every respect, with the decay process $K^{\pm} \rightarrow \mu^{\pm} + 2$ light neutral particles ($M_K \sim 1000 m_e$). From the consideration of lifetime, our data should be compared to the latter group in which York *et al.* do not report a charge asymmetry apart from a negative excess.
[7] Thompson, Buskirk, Karzmark, and Rediker, Phys. Rev. 92, 209 (1953).
[8] Kim, Burwell, Cohn, Karzmark, and Thompson, Phys. Rev. 95, 661 (1954).
[9] In two events (R-112, R-390) the primaries are heavily ionizing and our mass estimates are consistent with the value of $1000 m_e$. However, in all three events, the p_y values are high and p' is not very sensitive either to the primary mass or to whether the secondary is π or μ. The value of p' obtained in the present experiment may be used as a basis for calculation of the $K^{\pm}$ particle mass for various assumptions as to the nature of the decay fragments. The results are: $917 \pm 19 m_e$ for ($\mu^+ + \nu$ or γ), $948 \pm 18 m_e$ for ($\pi^+ + \nu$ or γ), $991 \pm 17 m_e$ for ($\mu^+ + \pi^0$), and $1022 \pm 17 m_e$ for ($\pi^+ + \pi^0$).
[10] Gregory, Lagarrigue, Leprince-Ringuet, Muller, and Peyrou, Nuovo cimento 11, 292 (1954).
[11] A. L. Hodson *et al.*, post deadline paper, Washington Meeting of the Am. Phys. Soc. ,May, 1954.
[12] Bridge, Courant, Dayton, DeStaebler, Rossi, Safford, and Willard (private communication). We are indebted to Dr. Bridge for sending us a prepublication copy of this paper.
[13] Crussard, Kaplon, Klarmann, and Noon, Phys. Rev. 93, 253 (1954), also Phys. Rev. 95, 584 (1954). Report on the Padua Conference, 1954 (unpublished).
[14] This point is further supported by the frequency of the ordinary τ decays observed in our chamber. We have observed only one τ^+ decay.
[15] Anderson, Cowan, Leighton, and van Lint, Phys. Rev. 92, 1089 (1953).
[16] The possible existence of a particle of mass about $1400 m_e$ has been reported by D. H. Perkins and P. H. Fowler, Proceedings of the Duke Conference, 1953.
[17] Such an example is reported in reference 5.

Alpha-Emitting Isomer Polonium 211†

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SPIESS[1] has recently found that the α-particle bombardment of ${}_{82}Pb^{208}$ produces two short-lived α emitters belonging to ${}_{84}Po^{211}$, with $E_\alpha{}^{(1)} = 7.14$ Mev, $T_{\frac{1}{2}}{}^{(1)} = 25$ sec, and $E_\alpha{}^{(2)} = 7.43$ Mev, $T_{\frac{1}{2}}{}^{(2)} = 0.52$ sec. He concluded that these two states are isomeric states of ${}_{84}Po^{211}$, the 25-sec state being the ground state and the 0.52-sec state being an excited state having a low spin and an excitation energy of 0.3 Mev. He points out, however, that this explanation leads to a difficulty; in the K-capture decay ${}_{85}At^{211} \rightarrow {}_{84}Po^{211}$ only the 0.52-sec activity is observed. Since, according to shell theory, the ground state of both ${}_{84}Po^{211}$ and ${}_{85}At^{211}$ have spin 9/2, it is hard to understand why the 25-sec activity is not also found. Spiess also observed long-range α particles of low intensity, but did not identify them. We have investigated these long-range α particles and have shown that they are from ${}_{84}Po^{211}$. Our results lead to the revised decay scheme shown in Fig. 1. The 0.52-sec state appears as the ground state, and the difficulty mentioned by Spiess thus disappears. The 7.14-Mev α decay does not take place from the ground state of ${}_{84}Po^{211}$ but occurs from a 1.30-Mev 25-sec level and goes to the $i_{13/2}$ state of ${}_{82}Pb^{207}$.

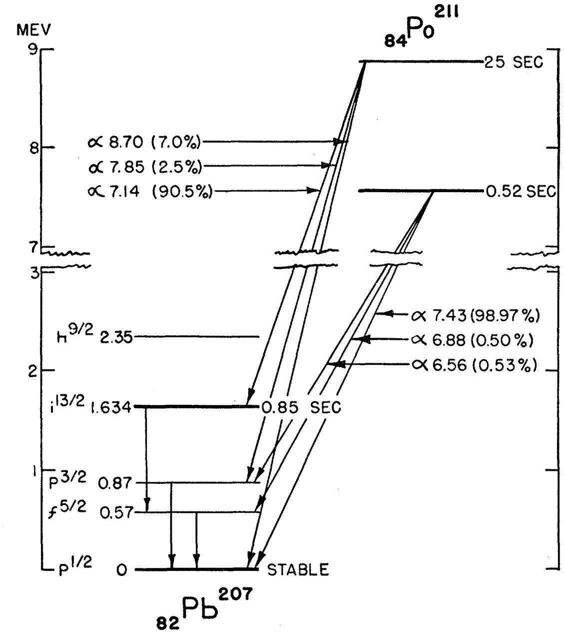

FIG. 1. Decay scheme of ${}_{84}Po^{211}$.

The decay scheme shown in Fig. 1 was deduced from the experiments 1–5 described below. In all of these experiments a thin lead foil was bombarded by α particles for 1 minute and measurements were started about 30 seconds after the end of the bombardment.

(1) The measurements of the energy of the α particles, made with an ionization chamber, gave peaks at 7.14 ± 0.05 Mev, 7.85 ± 0.05 Mev, and 8.70 ± 0.05 Mev. Figure 2 shows the pulse-height distribution. The differences in the α-disintegration energies: $8.87 - 7.28 = 1.59 \pm 0.07$ Mev and $8.87 - 8.00 = 0.87 \pm 0.07$ Mev agree with the excitation energies of the $i_{13/2}(E = 1.63$ Mev) and the $p_{3/2}(E = 0.87$ Mev) states of ${}_{82}Pb^{207}$.[2]

(2) The three α groups ($E = 7.14$, 7.85, and 8.70 Mev) all have the same half-life of 25 sec. A fourth weak group at 6.58 ± 0.05 Mev decays with a half-life of about 2.1 minutes and probably belongs to ${}_{83}Bi^{211}$.

(3) The intensity ratios of the three groups remain unchanged while varying the bombarding α energy from 21.3 to 24 Mev, thereby changing the cross sections by a factor of about 3. These results indicate that all three groups are emitted from the same level of ${}_{84}Po^{211}$.

(4) γ-ray measurements with sodium iodide scin-