EXAMPLE OF THE DECAY $\Lambda^0 \to p+\mu^- +\bar{\nu}$*

F. Eisler, J. M. Gaillard,† J. Keren, M. Schwartz,‡ and S. Wolf
Columbia University, New York, New York, and Brookhaven National Laboratory, Upton, New York

(Received July 25, 1961)

The decay $\Lambda^0 \to p+\mu^- +\bar{\nu}$, while expected, has not yet been reported to the knowledge of the authors. We report here a clear case of such a decay found in an exposure taken in the 20-in. BNL hydrogen bubble chamber.

The exposure was taken in a carefully constructed π^- beam of energy 900 Mev and resolution 0.15%. The beam energy has been further confirmed by the analysis of over 1000 normal $\Lambda^0 K^0$ events. A picture of the event is shown in Fig. 1. The incident beam track, (1), interacts at a position 13 cm inside the chamber entrance which corresponds to an energy of 900 Mev. The Λ^0, (2), goes 5.6 cm before decaying, a distance less than 2 mean lives. Track (3) is a proton. The μ^-, track (4), goes 9.6 cm before coming to rest and decaying into an electron, (5), which leaves the chamber through the top window.

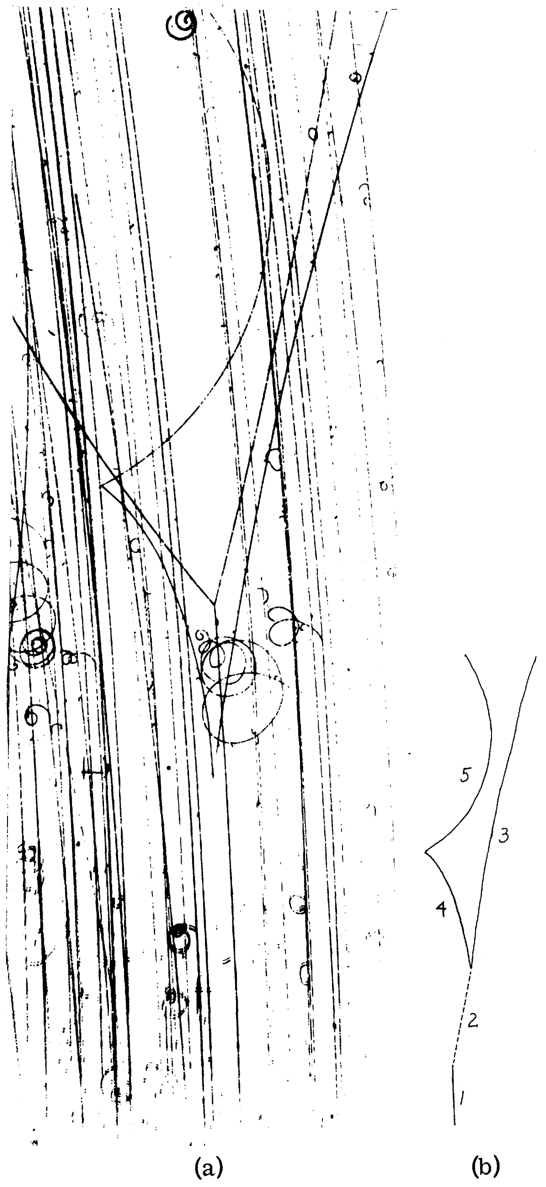

FIG. 1. (a) Photograph of the event. (b) Tracing of the pertinent tracks (reduced).

Four views of the event are available and were used in the measurement. The measurements and assigned errors are given in Table I.

From the production angle of 16° ± 0.8° and known beam energy, the Λ^0 momentum is 495^{+15}_{-10} Mev/c. Under the assumption of the decay $\Lambda^0 \to p+\mu^- +\bar{\nu}$, the calculated neutrino energy from momentum balance is 79 ± 15 Mev/c, giving a total final Λ^0 energy of 1223 Mev ± 20 Mev from summing the energy of its decay products. This energy and the momentum taken above, yield a mass for the Λ^0 of 1118 ± 21 Mev, in good agreement with the known Λ^0 mass.

The competing decay sequence $\Lambda^0 \to \pi^- + p$, $\pi^- \to \mu^- + \bar{\nu}$ is found to be very unlikely. The major points against this interpretation are as follows:

(a) The proton momentum would have to be 475 ± 20 Mev/c for this interpretation to hold. It is measured as 412 ± 20 Mev/c.

(b) If one assumes a pion to have been produced, then its direction would have been such as to make too large an angle with the μ, by about twice the measurement error.

(c) There is less than 1 mm of possible flight path for the π^- since no sign of it is detected visually. The mean decay path for a π^- with the required energy would be 5 meters.

The above combine to give this interpretation a probability of occurrence of the order of less than 10^{-5}.

Other possibilities for this event are:

(1) It originates at the wall of the chamber, rather than at the observed pion ending. It would have had to travel 5 mean lives before decay.

(2) The Λ^0 scatters in the chamber before decay, with no visible recoil.

Each of these possibilities seems even more remote than the one previously explored since

Table I. Summary of measured data.

Tracks		Length measured (cm)	Azimuth (deg)	Dip (deg)	Momentum (Mev/*c*)
$(\pi^-)_{\text{in}}$	(1)	2.5	62.5 ±0.5	89.8 ±1.0	1030 ±2
Λ^0	(2)	5.6	50.6 ±0.2	100.8 ±0.4	495^{+15}_{-10}[a]
P	(3)	23.0	56.3 ±0.3	110 ±0.4	412 ±20
μ	(4)	9.4	50.8 ±1.5	40.5 ±1.5	56 ±1 (range)

[a] Fitted quantity.

one must still require the decay of the pion within 1 mm.

From these different results, we conclude that this event has to be interpreted as a muonic decay of the Λ^0 particle. Theoretically, the rate for this decay mode is predicted to be 2.4×10^{-3}.[1]

The above-described event is one of a sample of 3000 Λ^0's presently being analyzed. Our systematic study of these events has as yet not been completed and we cannot set an upper limit on the rate of the decay.

We would like to express our gratitude to Dr. J. Steinberger for valuable discussions. We would also like to thank Dr. R. Shutt and the members of the BNL Bubble Chamber Group for their invaluable aid in obtaining the pictures and Mrs. Frances Joyce for having found the event.

---

*Work was supported by the U. S. Atomic Energy Commission.

†On leave of absence from Centre d'Etudes Nucleaires de Saclay, Seine et Oise, France.

‡Alfred P. Sloan Research Fellow.

[1] See, for example, L. Okun', Ann. Rev. Nuclear Sci. 9, 61 (1959).

CHARGE ASYMMETRIES IN THE ANGULAR DISTRIBUTION OF π AND K MESONS FROM ANTIPROTON ANNIHILATIONS IN FLIGHT

B. C. Maglić, G. R. Kalbfleisch, and M. L. Stevenson
Lawrence Radiation Laboratory, University of California, Berkeley, California

(Received July 27, 1961)

Presented here are the results of our search for a difference in the angular distributions of negative and positive π and K mesons produced in $\bar{p}p$ annihilations, at the center-of-mass momentum of 657±16 Mev/*c* (1.6 Bev/*c* in the lab). There have been no direct theoretical predictions for such a difference. The statistical model prescribes an isotropic distribution for mesons of all charges.[1] However, the model of Koba and Takeda[2] assumes that 2 or 3 annihilation pions are emitted from the antiproton and proton clouds. For annihilations in flight, the instantaneous momentum of the pions from the $\bar{p}$ cloud will have a component parallel to the $\bar{p}$ momentum, in addition to their internal momenta. Since the model assumes that the pion cloud does not interact with the annihilation of the cores, it is reasonable to expect this component of the pion momentum to produce an excess of π^- over π^+ in the antiproton direction (forward). An equal excess of π^+ should also be expected in the direction of the proton (backward). Evidence for such an effect has been scarce prior to this experiment. Angular distributions of pions of both charges from $\bar{p}p$ annihilations in propane at a c.m. momentum of 470 Mev/*c* (1.05 Bev/*c* lab) have not shown statistically significant deviation from isotropy.[3] A study of $\bar{p}p$ annihilations into two pions[4] at our momentum is also consistent with an isotropic distribution (8 π^- emitted forward, and 12 π^- emitted backward). However, annihilations into K^+K^- pairs[4] suggest forward peaking for K^- (8 of the 11 K^- were emitted in the forward direction).[5]

Our analysis was done on two samples of events: (i) 1620 events of the type $\bar{p}+p\rightarrow n\pi$, with $n=4, 5, \ldots, 8$; and (ii) 287 events of the type $\bar{p}+p\rightarrow\bar{K}+K+n\pi$, with $n=1, 2, 3$, and 4—in which at least one of the K mesons was observed to decay in the chamber. These events were observed inside a central volume of the 72-in. hydrogen bubble cham-