the "π" and "K" components of $\theta_{\mu\nu}{}^{i}(x)$.

[13]We thank Dr. Peter Cook for a useful remark on this point.

[14]The currently available data do not seem to confirm the $k(725)$ at all. This particle, therefore, need not be taken seriously. See Ref. 9.

NEW MEASUREMENT OF THE $_{\Lambda}H^3$ LIFETIME*

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We have measured the mean life of $_{\Lambda}H^3$ to be $(2.32_{-0.34}^{+0.45})\times10^{-10}$ sec. This does not agree with previous measurements but is completely consistent with theoretical expectations.

Studies of the light hypernuclei have played a major role in understanding the Λ-N interaction. The properties of $_{\Lambda}H^3$, the simplest known hypernucleus, should be especially amenable to theoretical understanding. The latest calculation[1] of the $_{\Lambda}H^3$ mean life for spin $\frac{1}{2}$ yields $0.97\tau_{\Lambda}$, or 2.45×10^{-10} sec.

Previous experimental results of $(0.95_{-0.15}^{+0.19})\times10^{-10}$ sec [2] and $(0.7_{-0.3}^{+0.5})\times10^{-10}$ sec [3] showed a large deviation from the theoretical result, which has engendered some doubt of the validity of the Λ-N phenomenology. Recent experiments[4] have tended to disagree with earlier results.

In our experiment, a K^- beam from the zero-gradient synchrotron was stopped in the Argonne National Laboratory–Carnegie-Mellon University 25-cm superconducting-magnet helium bubble chamber.[5] This chamber, with its precise optical system and high magnetic field (41 kG), allows excellent kinematic discrimination. The lifetime of $_{\Lambda}H^3$ was measured using the reactions

$$K^- + He^4 \to {}_{\Lambda}H^3 + \pi^- + p, \quad (1)$$

$$_{\Lambda}H^3 \to \pi^- + He^3, \quad (1a)$$

$$\to \pi^- + p + d, \quad (1b)$$

$$\to \pi^- + p + p + n. \quad (1c)$$

The Argonne and Carnegie groups did independent experiments using different scanning rules, computer programs, and analysis procedures. The data were merged to give the results reported here after the two experiments were scrutinized for agreement.

The scanning procedures were designed to avoid potential systematic errors, such as biases against short $_{\Lambda}H^3$ tracks. In the Carnegie-Mellon University group, the scanners were instructed to look first for any incident K^- which interacted leading to at least three outgoing tracks (regardless of evidence of a secondary vertex). At Argonne National Laboratory, the scanners were instructed to search for all events with two emergent π^- (plus anything else). These events are rare, and scanning was difficult, so each frame was scanned at least twice, yielding an overall scanning efficiency estimated to be $(87\pm7)\%$. Two checks for a possible bias against short tracks were made: First, the lifetime using events found in only one of two scans agrees with that from events found in both scans. Second, the lifetime was studied as a function of minimum track length, as described below.

In the kinematic analysis, constrained two-vertex fits (production and decay) were expected for all events except three- and four-body one-prong decays and four-body two-prong decays. The distribution among decay modes and topologies of the 52 fitted events with length >1 mm is given in Table I. The mean-life like-

Table I. Distribution among decay modes and topologies for 52 events, with ${}_\Lambda H^3$ length > 1 mm, dip < 65°, and two-vertex fit with χ^2 probability > 1%.

	$\pi^- + He^3$	$\pi^- + p + d$	$\pi^- + p + p + n$	Total
1-prong	12	4		16
2-prong	8	10	0	18
3-prong	n.a.	17	1	18
Total	20	32		52

lihood function for this sample is shown in Fig. 1 and yields $\tau = (2.32^{+0.45}_{-0.34}) \times 10^{-10}$ sec. The lifetime obtained using only the 35 in-flight decays is $(1.85^{+0.80}_{-0.43}) \times 10^{-10}$ sec. All two-body decays give a lifetime of $(3.0^{+1.2}_{-0.7}) \times 10^{-10}$ sec.

As an overall test of the analysis procedures used, the lifetime of the Σ^+ was measured using 56 events from the reaction

$$K^- + He^4 \to \Sigma^+ + \pi^- + H^3. \qquad (2)$$

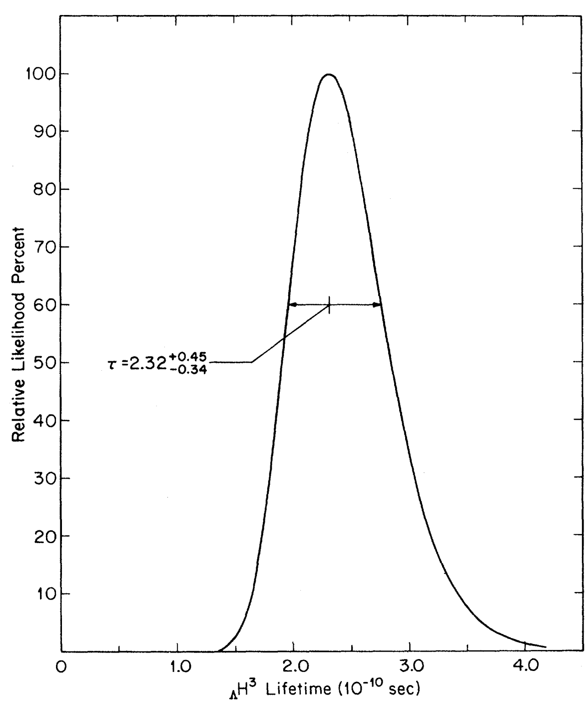

FIG. 1. The likelihood function for mean life of 52 ${}_\Lambda H^3$ decays detailed in Table I. Of these, 35 decay in flight, and 17 at rest (i.e., with momentum ≤170 MeV/c). The likelihood function used is

$$\mathfrak{L}(\tau) = \prod_{i=1}^{N_a} \frac{1}{\tau} \exp\left(-\frac{t_i}{\tau}\right) \prod_{j=1}^{N_b} \exp\left(-\frac{t_j}{\tau}\right)$$

where the events $1 \cdots N_a$ decay in flight and the events $1 \cdots N_b$ decay at rest with moderation time t_j.

We obtained $\tau_{\Sigma^+} = (0.72 \pm 0.10) \times 10^{-10}$ sec, in good agreement with the known value.

We have carefully studied a potentially serious background in the three-prong ${}_\Lambda H^3$ decays. There is a significant probability that in the reaction

$$K^- + He^4 \to \pi^- + p + d + \Lambda, \qquad (3)$$

the Λ will decay in spatial coincidence with the deuteron track (i.e., within ~1 track diameter). In such cases the effective mass of the Λ-d combination can be close enough to that of ${}_\Lambda H^3$ to give a two-vertex fit. Of the 18 three-prong decays which fit Reaction (1), 17 also fit Reaction (3) about equally well. The distribution of Λ-d effective mass obtained from the production vertex is shown for all three-prong decay candidates in Fig. 2(a). We estimated by extrapolation that approximately one apparent ${}_\Lambda H^3$ event might be background. Studies

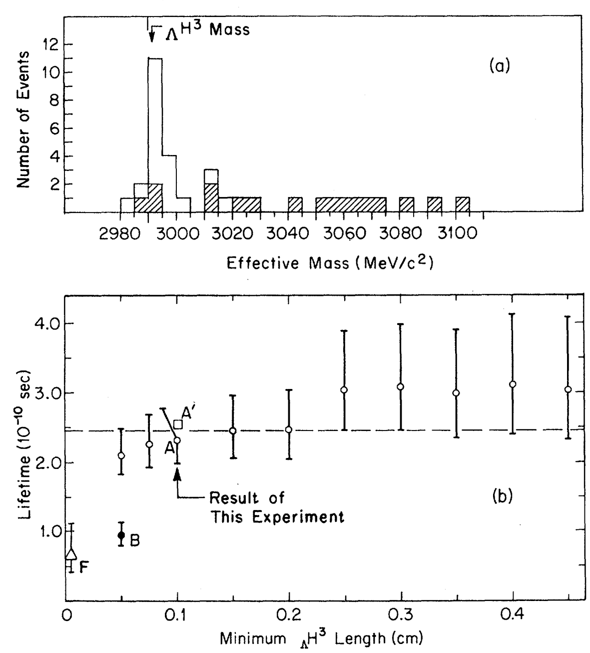

FIG. 2. (a) The Λ-d effective-mass distribution for all acceptable three-prong decay candidates obtained from the production vertex alone. Open squares represent events that have a two-vertex fit for the ${}_\Lambda H^3$ hypothesis. (b) The dependence of the calculated mean life on the minimum accepted ${}_\Lambda H^3$ track length. The horizontal line is the theoretical prediction of Rayet and Dalitz. Point B is the result of Block et al., and point F that Fortney (see Refs. 1-3). Point F, measured in a propane bubble chamber, is shown at an arbitrary value of the abscissa. Point A is obtained from our sample of 52 events detailed in Table I, and moves to A' if the three shortest-lived three-prong events are removed.

of a sample of Reaction-(3) events in which the Λ decays without overlaying the p or d tracks also yielded an estimated background of approximately one event for track length ≥ 1 mm. This background estimate increases rapidly with shorter track lengths.

The dependence of the mean life on the minimum accepted ${}_{\Lambda}H^3$ track length is shown in Fig. 2(b). If no biases are present, the points should fall on a horizontal line. A scanning bias against short ${}_{\Lambda}H^3$ tracks will produce a negative slope, whereas Λ-d coincidence background will produce a positive slope. The data exhibit a net positive slope which has $\lesssim 10\%$ chance of being a statistical fluctuation. If this positive slope were indeed caused by background events, the effect should be enhanced for the in-flight decays. We have observed no such enhancement. In Fig. 2(b) the difference between points A' and A provides a measure of the maximum slope that could arise from three background events.

With respect to possible causes of the slope in Fig. 2(b), we note that our background estimates could be invalid if there were a narrow, slightly unbound (Λ-d) resonance. Another speculative possibility is that the spin-$\frac{3}{2}$ ${}_{\Lambda}H^3$ state is bound. In this case we would have measured a combination of lifetimes, and the lifetime from two-body decays would be less than that from three-body decays, a possibility not supported (but not definitely excluded) by the data. In the absence of substantial evidence for a (Λ-d) resonance or a spin-$\frac{3}{2}$ bound state we assume that the slope beyond 1 mm arises from a statistical fluctuation. We therefore quote a lifetime result based on this smallest length cut which provides a sample free from significant systematic error caused by scanning bias or (Λ-d) accidental coincidences.

The data of Table I yield a value for the decay branching ratio

$$R_3 = \frac{{}_{\Lambda}H^3 \to \pi^- + He^3}{(\text{all } \pi^- \text{ modes})} = 0.38 \pm 0.09,$$

in agreement with earlier measurements.[6] According to an argument by Dalitz and Liu,[7] this implies a value of $B_{\Lambda} = 0.17 \pm 0.07$ MeV, if the spin is $\frac{1}{2}$.

We wish to thank our scanners for their painstaking work, and to acknowledge the generous assistance of the zero-gradient synchrotron staff in making this exposure.

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