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December 2, 1960

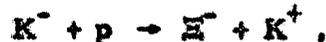
Ξ^- PRODUCTION BY K^- MESONS

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The Berkeley 30-inch propane chamber was operated in a 1.17-Bev/c K^- beam¹ at the Bevatron to produce cascade particles. Out of the 100,000 pictures taken there have been 18 positively identified negative cascade decays with the decay mode $\Xi^- \rightarrow \Lambda + \pi^-$. Of these, six were produced with a K^+ meson and three were accompanied by a visible θ_1 decay. Three of the events with a K^+ satisfy the kinematics for the hydrogen interaction



and the other three are assumed to have been produced from protons in carbon. Two of the K^+ decayed in the chamber and the other four were identified by comparing momentum and ionization. Since only one-third of the K^0 produced in the interaction



decay into a visible mode, it is quite consistent to attribute the nine events in which no positive-strangeness K particle was observed to the neutral mode of the θ_1 decay, to the θ_2 decay, or to a K^+ that could not be distinguished from a proton.

The 18 events were selected from a sample of 47 in which a V particle was thought to come from a prong of a K^- interaction which appeared to decay into a π^- . The selection consisted of a series of two single-origin constraints on an IBM 704 calculator: (a) the Q of the V particle was required to be consistent with that of a Λ , 37 Mev, and its line of flight consistent with the assumed Ξ^- decay origin; (b) the Λ and the π^- were required to be coplanar with the assumed Ξ^- and to balance transverse momentum. Revised estimates

of the momentum and angles of the Λ and π^- were obtained from the constraint program and the average mass of the Ξ^- for the 18 surviving events, weighted by the estimated probable error of each event, was found to be

$$M_{\Xi^-} = 1317.9 \pm 1.9 \text{ Mev.}$$

The mean life of the Ξ^- has been determined by means of a modification of the statistical method of Bartlett² which accounts for the necessity of seeing the Λ decay before the Ξ^- leaves the chamber. The possible time for decay was determined by calculating the time of flight to the boundary of the fiducial region, which was chosen to allow a minimum of 4 cm for the measurement of the Λ decay. In all cases the correction due to finite chamber size is small, and the total correction amounts to less than 10% of the uncorrected mean of the actual flight times. The flight times include dE/dx corrections and the possible times were modified for those cases in which the Ξ^- would have come to rest before leaving the chamber. Figure 1 shows a plot of Bartlett's S function as a function of $1/\tau$. This function is zero at the most probable lifetime and ± 1 at the best estimate of the standard error. Figure 2 is a cumulative histogram of the calculated times of flight, t_i , and indicates a considerable scanning bias against flight times less than 0.5×10^{-10} sec. An estimate of the total number of events was obtained by fitting those events with a time of flight greater than 0.5×10^{-10} sec to the exponential $N_0 e^{-t/\tau}$. The revised mean life consistent with this procedure required the addition of seven events in the interval from zero to 0.5×10^{-10} sec, and was found to be

$$\tau = 1.28 \times 10^{-10} \begin{matrix} +0.41 \\ -0.25 \end{matrix} \text{ sec.}$$

The S function corrected for scanning bias is shown as the solid line b in Fig. 1. This mean life is considerably shorter than that found by Trilling and Neugebauer.³ However, their events at high cascade momentum required much greater corrections for chamber size. The dotted line c in Fig. 1 shows the S function for their six events combined with our 25 (including corrections for scanning bias), and it is seen that the combined mean life falls within our error.

A violation of parity conservation in the cascade decay will manifest itself as a fore-aft asymmetry in the Λ decay, the Ξ^- serving to polarize the Λ with the strength $a_{\Xi\Lambda}$ which is then analyzed by the Λ decay. Denoting the direction of the Λ in the Ξ^- rest frame as $\hat{\Lambda}$ and the direction of the proton in the Λ center of mass as \hat{P} , the distribution of $\hat{\Lambda} \cdot \hat{P}$ is⁴

$$P(\hat{\Lambda} \cdot \hat{P}) d(\hat{\Lambda} \cdot \hat{P}) = \frac{1}{2} [1 + (a_{\Xi\Lambda}) (\hat{\Lambda} \cdot \hat{P})] d(\hat{\Lambda} \cdot \hat{P}).$$

We have found, on the basis of the above 18 events,

$$(a_{\Xi\Lambda}) = -0.65 \pm 0.35,$$

using $(a_{\Xi\Lambda}) = \frac{3}{N} \sum_i (\hat{\Lambda} \cdot \hat{P})_i$ as the best estimator. The negative sign shows the helicity of the Λ from the Ξ^- to be opposite to that of the proton from Λ decay. Birge and Fowler⁵ find the helicity of the proton to be positive, implying that the helicity of the Λ is negative. Using the best estimate of the magnitude of $a_{\Xi\Lambda}$ is as 0.95 ± 0.07 ⁶ and the sign of p_{Λ} as determined by Birge and Fowler, we find

$$a_{\Xi} = 0.69 \pm 0.36.$$

The possibility of an up-down asymmetry of the decay π^- from $\Xi^- \rightarrow \Lambda + \pi^-$ produced in the reaction



has been examined, and $(a_{\Xi}P)$ is -0.28 ± 0.40 where P is the polarization of the Ξ^- in production and a_{Ξ} the decay asymmetry parameter. There seems to be no indication that the Ξ^- produced in this manner from carbon are polarized.

In the 100,000 pictures we had a total of $1.5 \pm 0.2 \times 10^7$ cm of K^- track length. After adding seven events to correct for scanning bias and then 50% to correct for the unobserved neutral decay mode of the Λ , we estimate the total number of Ξ^- to be 37.5. On this basis the Ξ^- production cross section in the reaction $K^- + N \rightarrow \Xi^- + K$ is

$$\sigma_{\Xi^-} = 18 \pm 5 \text{ } \mu\text{b/nucleon}$$

assuming an $A^{2/3}$ correction for shielding in the carbon nucleus.

FOOTNOTES AND REFERENCES

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FIGURE CAPTIONS

Fig. 1. Bartlett's $S(\tau)$ function with a Δ lifetime correction for (a), the 18 observed Ξ^- from this experiment, (b) this experiment corrected for scanning bias, and (c) the corrected data of this experiment combined with six events from Trilling and Neugeberger.³

Fig. 2. A cumulative histogram of the times of flight of the Ξ^- . The solid line is the best fit of those events with $t_i > 0.5 \times 10^{-10}$ sec to an exponential.

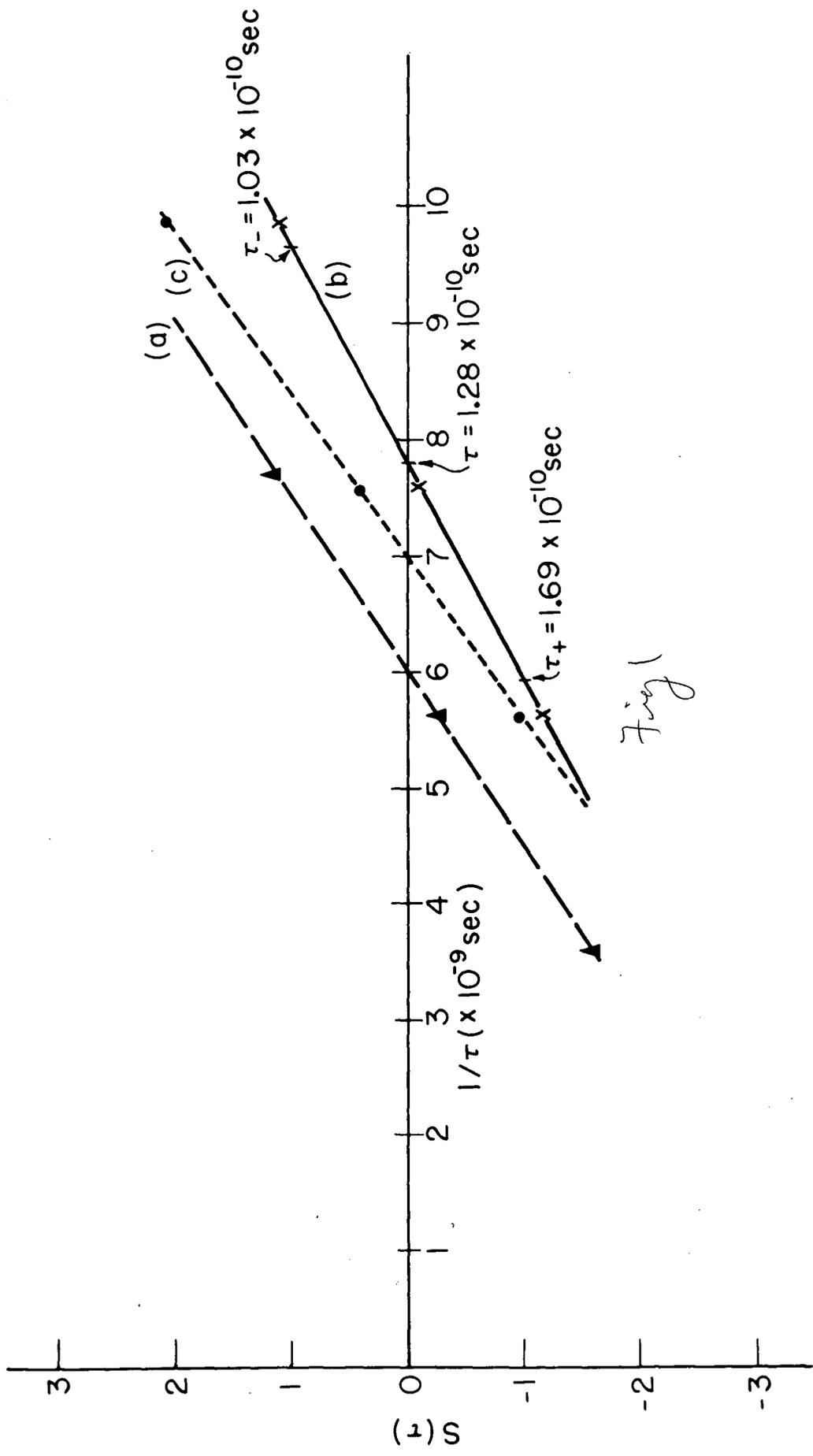


Fig 1

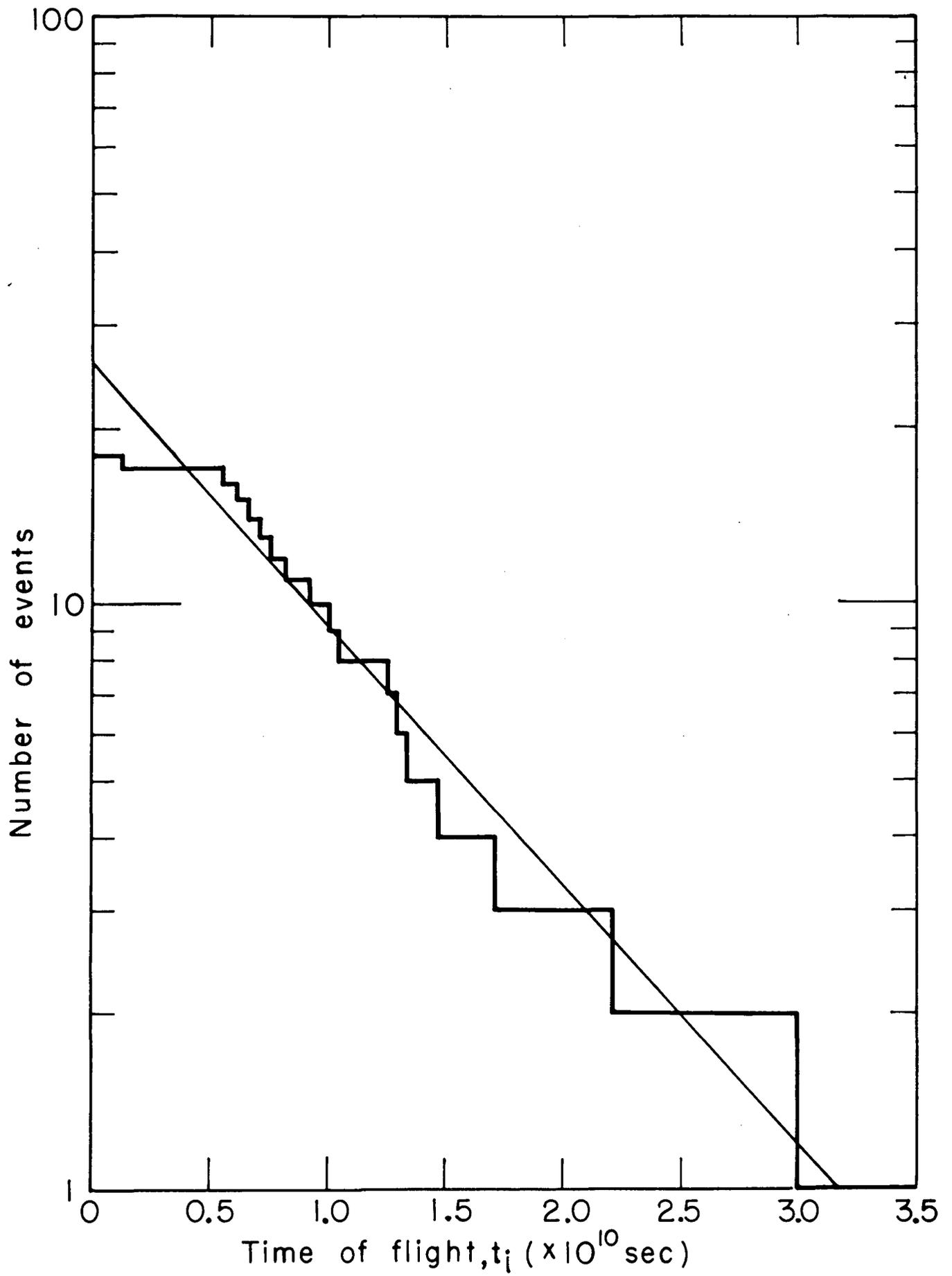


Fig 2