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ANTIXI PRODUCTION IN K^+p INTERACTIONS AT 9 BeV/c^+

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August 9, 1967

We have observed charged antixi production in K^+p interactions at 9 BeV/c with $\sigma = 5.3$ μb. Nothing observed indicates that these antixi hyperons are decay products of an intermediate resonance. We have found no event consistent with antiomega production.

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Production of antihyperons has until now been studied mainly in interactions of antiprotons with protons[1-6]. However, availability of high-energy secondary meson beams makes the study of antihyperon production energetically possible in meson-nucleon experiments[7,8]. In the interactions of K^+ mesons with protons we have observed evidence for antibaryon and antihyperon production. We present results of a search for antihyperons of strangeness equal to or greater than two, namely antixi and antiomega[9]. All together twelve events found have been clearly identified by kinematics and ionization as involving antixi production; and no events were found involving antiomega production.

The Brookhaven National Laboratory 80-inch hydrogen bubble chamber was exposed to a rf-separated K^+ meson beam at 9 BeV/c incident momentum at the

Alternating Gradient Synchrotron[10]. A total of 100,000 stereo photographs was taken with the Berkeley camera system[11]. The film was scanned for interactions yielding two charged secondaries with at least one kink and an associated neutral-decay vee, which were candidates for the chains of decay

$$\bar{\Omega}^+ \to \bar{\Xi}^+ \pi^0$$
$$\hookrightarrow \bar{\Lambda}^0 \pi^+$$
$$\hookrightarrow \bar{p} \pi^+ , \qquad (1)$$

$$\bar{\Omega}^+ \to \bar{\Lambda}^0 K^+$$
$$\hookrightarrow \bar{p} \pi^+ , \qquad (2)$$

and

$$\bar{\Xi}^+ \to \bar{\Lambda}^0 \pi^+$$
$$\hookrightarrow \bar{p} \pi^+ . \qquad (3)$$

These events were digitized on a conventional Franckenstein and then spatially reconstructed and kinematically fitted in the program TVGP-SQUAW on the CDC 6600 computer[12]. Each event was fitted to all decay hypotheses, as well as to multivertex hypotheses for the production and the entire decay chain involving all possible hyperons and antihyperons.

For this sample of film we have a total path length equivalent to approximately 0.2 μb per event. No event has been observed which is kinematically consistent with the hypothesis of antiomega production and with decay via channels (1) or (2). One event observed in either decay mode would imply a production cross section of about 0.5 μb[13].

Twelve charged antixi events were identified for which the complete chain of decay (3) was visible[14]. In Table I we list the cross section of the final states into which these twelve events are distributed[15]. The mass of the antixi was also fitted from its decay products for each event,

and a weighted average of these events gives $M(\bar{\Xi}^+) = 1321.7 \pm 0.6$ MeV. Here the error quoted is the statistical error only, as we do not yet have a reliable estimate of the possible systematic error. The lifetime of the antixi obtained from our measurements is $\tau(\bar{\Xi}^+) = (1.9^{+0.7}_{-0.5}) \times 10^{-10}$ sec, which was obtained by a maximum-likelihood technique. The likelihood function is defined as

$$L(\tau) = \prod_i \left[\frac{\exp(-t_i / \tau)}{\tau \left[\exp(-t_i^{min} / \tau) - \exp(-t_i^{max} / \tau) \right]} \right] \qquad (4)$$

in which τ is the assumed lifetime, t_i is the observed lifetime for each event, t_i^{min} is the lower limit due to minimum observable track length in the bubble chamber (0.5 cm), and t_i^{max} is the upper limit due to the finite fiducial volume.

We have also investigated the antixi production mechanism (B = −1 and S = +2) from interactions with the initial K^+p state (B = +1 and S = +1). Two possible diagrams we have considered are shown in Fig. 1. Figure 1a shows the peripheral production of a hypothetical intermediate boson state with S = +1, which decays subsequently into $\bar{\Xi}^+\Lambda^0$ or into $\bar{\Xi}^+\Sigma^0$, and Fig. 1b shows the interaction with hyperon exchange. This second diagram would be favored if states with B = 2 and S = −1 existed.

In Fig. 2 we show a Dalitz plot in which $M^2(\bar{\Xi}\,Y)$ is plotted against $M^2(YN)$ for all events. For reactions (A) through (E), Y refers to Σ, Λ, or missing mass of S = −1, whereas for reactions (F) and (G) Y refers to Λ and $\Lambda\pi$. The two envelopes corresponding to the kinematical boundaries of the final states $\bar{\Xi}\Lambda p$ and $\bar{\Xi}MM(1650)p$ are drawn to illustrate the dependence of the kinematical boundary on the rest energy of the final states. We find no clear indication of any resonant states in either $\bar{\Xi}Y$

or YN systems. The production angular distributions as well as the correlations between the production angles of the final-state particles are shown in Fig. 3. It appears that there are no strong correlations and that all distributions are consistent with isotropy.

We thank R. Shutt and the staff of the 80-Inch Bubble Chamber and H. Foelsche and the AGS Staff for helping with our exposure. We thank B. Sheldon for coordinating the scanning and measuring. We also thank R. W. Bland, J. A. Kadyk, and G. H. Trilling for important contributions in the earlier stages of the experiment. Finally we acknowledge the excellent effort of our programming staff, in particular J. Alvarez and E. R. Burns.

FOOTNOTES AND REFERENCES

+ Work done under the auspices of the U.S. Atomic Energy Commission

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11) The Berkeley camera system was developed by Duane Norgren and Daniel Curtis. We wish to thank Curtis for his contribution during the exposure at the AGS.

12) F. T. Solmitz, A. D. Johnson, and T. B. Day, Three-View Geometry Program, Alvarez Group Programming Note P-117; O. I. Dahl, T. B. Day, and F. T. Solmitz, SQUAW, Alvarez Programming Note No. P-126; Lawrence Radiation Laboratory, Berkeley, California.

13) The cross section is estimated for the reaction $K^+p \rightarrow \bar{\Omega}^+ \Lambda^o \Sigma^+$ and corrected for invisible Λ^o and $\bar{\Lambda}^o$ decays. The threshold for this reaction is 3.98 BeV, whereas the cm. energy in this experiment is 4.26 BeV.

14) We have not searched for $\bar{\Xi}^o$ events because the decay fit is under-constrained.

15) Two events of the reaction $K^+p \rightarrow \bar{\Xi}^+\Sigma^+n$ can also be interpreted as $\pi^+p \rightarrow \bar{\Xi}^+\ \Sigma^+\ \Lambda^o$. The upper limit of pion contamination in this experiment is 1.3%, and this would imply a lower limit to the cross section of 90 μb, which makes this interpretation rather unlikely.

FIGURE CAPTIONS

Fig. 1 Two possible diagrams for antixi production involving (a) boson exchange and (b) hyperon exchange.

Fig. 2 Dalitz plot for the 12 antixi events. The envelopes are the kinematical boundaries for the final states $\bar{\Xi}\Lambda P$ and $\bar{\Xi}MM(1650)p$. The two final states $\bar{\Xi}^{+}\Lambda^{o}\pi^{+}n$ and $\bar{\Xi}^{+}\Lambda^{o}\pi^{o}p$ are each represented by two points, one for each of the two possible mass combinations $\bar{\Xi}\Lambda$ and $\bar{\Xi}\Lambda\pi$.

Fig. 3 Angular distributions for the 12 antixi events. The two final states $\bar{\Xi}^{+}\Lambda^{o}\pi^{+}n$ and $\bar{\Xi}^{+}\Lambda^{o}\pi^{o}p$ are each represented by two points, one for each of the two possible mass combinations, $\bar{\Xi}\Lambda$ and $\bar{\Xi}\Lambda\pi$.

TABLE I

Reaction	Final State	No. of Events	Cross Section (μb)
1	$\Xi^+\Lambda^o p$	1	0.5
2	$\Xi^+\Sigma^o p$	2	0.8
3	$\Xi^+ mmp$	3	0.8
4	$\Xi^+\Sigma^+ n$	3	1.6
5	$\Xi^+\Sigma^+ mm$	1	0.6
6	$\Xi^+\Lambda^o\pi^+ n$	1	0.5
7	$\Xi^+\Lambda^o\pi^o p$	1	0.5
	All Events	12	5.3

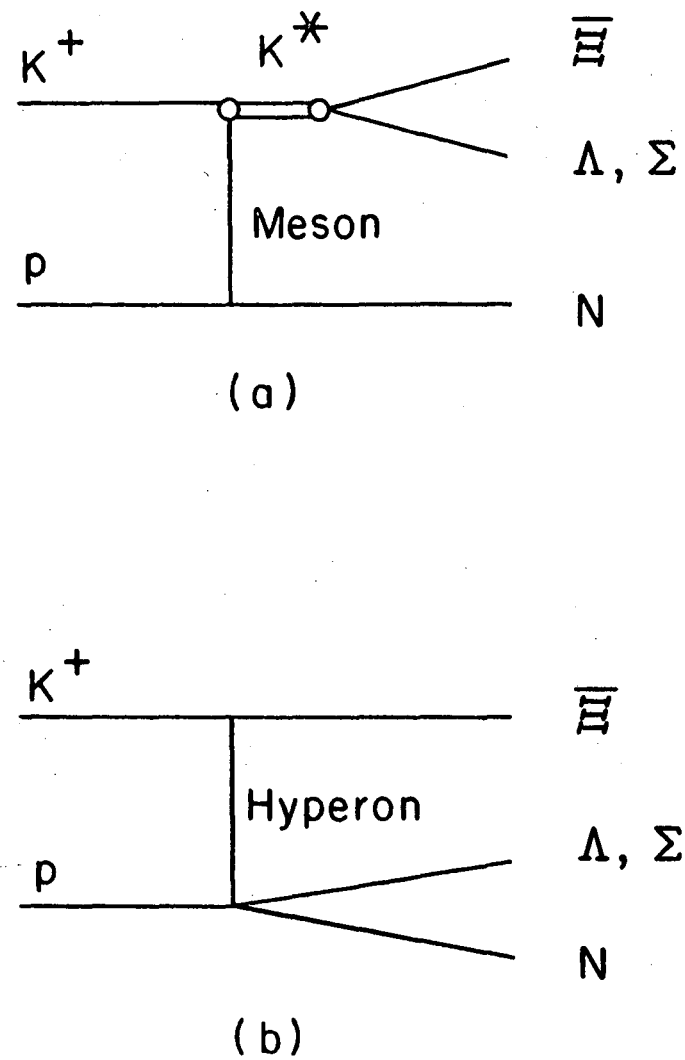

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Fig. 1

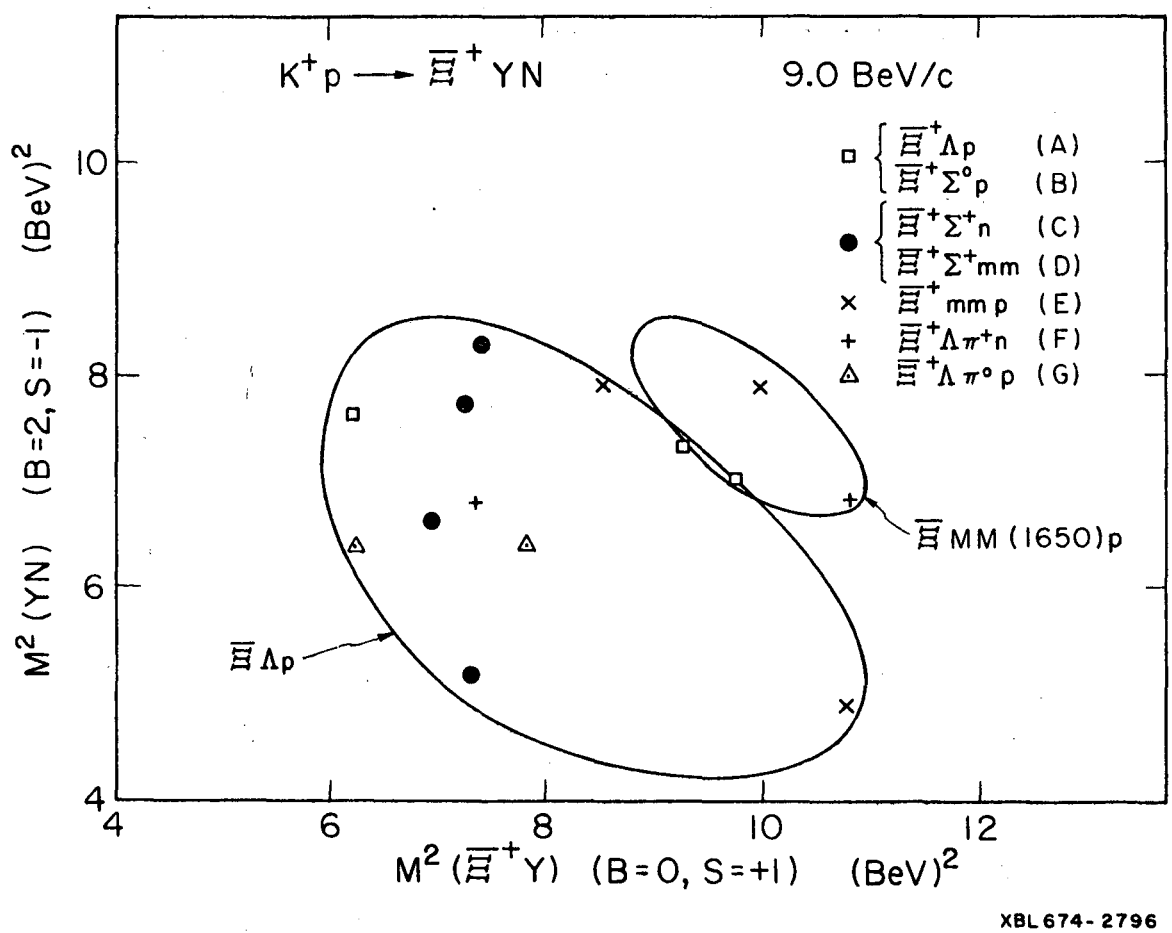
K+p → Ξ̄+ YN
9.0 BeV/c
Ξ̄+Λp (A)
Ξ̄+Σ°p (B)
Ξ̄+Σ+n (C)
Ξ̄+Σ+mm (D)
Ξ̄+mm p (E)
Ξ̄+Λπ+n (F)
Ξ̄+Λπ°p (G)
Ξ̄ MM (1650)p
Ξ̄ Λp
M2 (YN) (B=2, S=-1) (BeV)2
M2 (Ξ̄+Y) (B=0, S=+1) (BeV)2
4
6
8
10
12
XBL 674-2796

Fig. 2

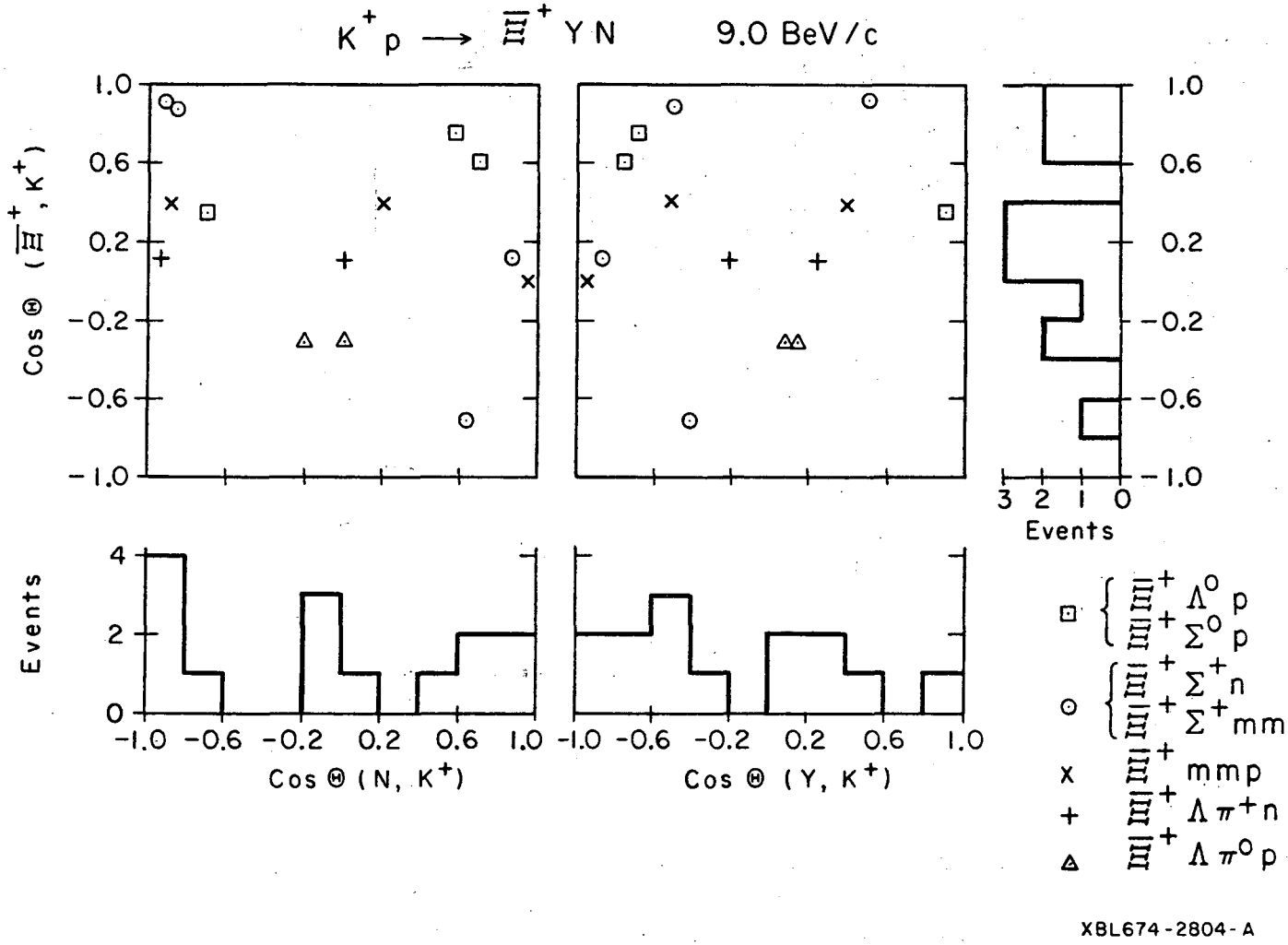
K+ p → Ξ̄+ Y N 9.0 BeV/c
Cos Θ (Ξ̄+, K+)
Events
Cos Θ (N, K+)
Cos Θ (Y, K+)
Events
Ξ̄+ Λ0 p
Ξ̄+ Σ0 p
Ξ̄+ Σ+ n
Ξ̄+ Σ+ mm
Ξ̄+ mmp
Ξ̄+ Λ π+ n
Ξ̄+ Λ π0 p
XBL674-2804-A

Fig. 3

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