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CERN - EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

Submitted to
Nuclear Physics B

CERN/EP/PHYS 78-36
11 Septembre 1978

A STUDY OF INCLUSIVE Λ , Σ^0 AND

$\Sigma(1385)$ PRODUCTION IN K^-p INTERACTIONS AT 8.25 GeV/c

Birmingham⁽¹⁾-CERN⁽²⁾-Glasgow⁽³⁾-Michigan State⁽⁴⁾(*)-Paris⁽⁵⁾(**) Collaboration
M. BAUBILLIER⁽⁵⁾, I.J. BLOODWORTH⁽¹⁾, G.J. BOSSEN⁽²⁾, A. BURNS⁽³⁾,
J.N. CARNEY⁽¹⁾, M.J. CORDEN⁽¹⁾, C.A. COWAN⁽¹⁾, G.F. COX⁽¹⁾, C.J. DE LIMA⁽¹⁾,
D. DIXON⁽³⁾, J.B. KINSON⁽¹⁾, K. KNUDSON⁽²⁾, F. LEVY⁽⁵⁾, H. McCANN⁽³⁾,
M. MacDERMOTT⁽¹⁾, P.J. NEGUS⁽³⁾, B. OH⁽⁴⁾, M. PRATAP⁽⁴⁾, E. QUERCIGH⁽²⁾,
M. RIVOAL⁽⁵⁾, J.M. SCARR⁽³⁾, J.C. SHIERS⁽¹⁾, G. SMITH⁽⁴⁾, D. TEODORO⁽²⁾,
O. VILLALOBOS BAILLIE⁽¹⁾, M.F. VOTRUBA⁽¹⁾, J. WHITMORE⁽⁴⁾, R. ZITOUN⁽⁵⁾.

ABSTRACT

Inclusive Λ production has been studied in K^-p interactions at 8.25 GeV/c using about 69 000 events; the total cross section is found to be $(3.35 \pm 0.20)\text{mb}$. A comparison has been made with Σ^0 and $\Sigma(1385)$ inclusive production. Their influence on the inclusive Λ production is discussed. The inclusive Λ cross section and polarization is interpreted in terms of the triple Regge model. In the target fragmentation region an effective Regge trajectory is determined which lies closer to the K than to the K^* . In the beam fragmentation region the cross section data indicate an effective Regge trajectory which corresponds to the nucleon, while the polarization data require additional Regge exchanges to be present.

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- (1) Physics Department, University of Birmingham, Birmingham, U.K.
(2) CERN, European Organization for Nuclear Research, Geneva, Switzerland
(3) Department of Natural Philosophy, University of Glasgow, Glasgow, U.K.
(4) Michigan State University, East Lansing, Michigan, U.S.A.
(5) LPNHE, University of Paris VI, Paris, France.
(*) Work supported by the National Science Foundation, U.S.A.
(**) Laboratory associated to IN2P3

1. INTRODUCTION

The inclusive reaction

$$K^- p \rightarrow \Lambda + X \quad (1)$$

gives a possible way of studying off-shell $K\bar{K}$ and $p\bar{p}$ scattering through an analysis of the target and beam fragmentation regions. In the target fragmentation region the initial proton is transformed into a Λ particle by a Regge exchange with the external quantum numbers of the K meson; whereas in the beam fragmentation region baryon exchange induces the transformation of the incoming K^- into the observed Λ .

Information on reaction (1) is now available in the p_{lab} range from 4 to 32 GeV/c [1-8] and triple Regge analyses performed in some of these experiments [2,4,7] have found evidence that the exchange in the target fragmentation region is in fact a mixture of the K and K^* trajectories. The behaviour in the beam fragmentation region is well described by the exchange of the nucleon trajectory.

In this study, based on a new high statistics bubble chamber experiment, we have performed a triple Regge analysis including polarization information. We also study the influence of Σ^0 and $\Sigma(1385)$ production on the Λ sample. In particular, it is shown that the reaction

$$K^- p \rightarrow \Sigma^0 + X \quad (2)$$

has similar properties to reaction (1) except for polarization.

The data used in this analysis and their general features are presented in sect. 2 and sect. 3 respectively. A distinction between "true" Λ and Λ coming from Σ^0 is made in sect. 4 where Σ^0 production is studied and sect. 5 is devoted to $\Sigma(1385)$ production. Finally, the triple Regge analysis is discussed in sect. 6 and conclusions are drawn in sect. 7.

2. EXPERIMENTAL SAMPLE

The data come from exposures of the CERN 2m HBC to an rf separated beam of 8.25 GeV/c K^- particles. The present sample has been obtained from 1.5 million pictures corresponding to about 50 events/ μ b. This represents about 1/3 of the final sensitivity.

The scanning and measuring was restricted to events with at least one visible V^0 . The events were measured at CERN and Paris with spiral readers, in Birmingham with an HPD, in Glasgow with SMP's and in Michigan by conventional hand measuring devices. After processing the measurements through standard geometry-kinematics program chains, ionization information was used to reduce the ambiguities between different mass hypotheses. About 69 000 V^0 's with $(p\pi^-)$ effective mass in the range 1.110 - 1.122 GeV gave an associated Λ fit with a confidence level better than 5%.

In order to study γ and K_s^0 contamination, effective masses have been calculated for each accepted Λ assuming the decay particles are e^+e^- and $\pi^+\pi^-$ respectively. Removing the events with $M(e^+e^-)$ below 0.02 GeV eliminates a clear γ contamination. The loss of good Λ 's due to this procedure is less than 0.5%. The $(\pi^+\pi^-)$ mass spectrum shows a K_s^0 contamination estimated to be 0.5%. Since this is small, the Λ/K_s^0 ambiguities have been resolved in favour of the Λ . The final Λ sample consists of 63 339 events inside the fiducial volume.

Cross section normalization was determined from the observed number of beam τ decays within the same fiducial volume. After corrections for scanning and measuring efficiencies, geometrical losses, the cuts mentioned above, and unseen decay modes of the Λ , the Λ inclusive cross section is determined to be (3.35 ± 0.20) mb. Included in this figure are Λ 's resulting from Σ^0 decay. In this paper we will not distinguish between these Λ particles and the "true" produced ones, except in sect. 4 where Σ^0 production is studied.

All total and differential cross sections presented are corrected for geometrical losses and unseen decay modes. The average weight to compensate for the rejection of Λ 's with a short projected length or decaying outside the fiducial volume was found to be 1.15.

3. GENERAL FEATURES OF THE REACTION $K^- p \rightarrow \Lambda + X$

3.1 Momentum distributions

The invariant inclusive cross section can be written in terms of the variable $x = p_L/p_{\max}$ as

$$F(x) = \frac{1}{\pi p_{\max}} \int_E \frac{d^2\sigma}{dx dp_T^2} dp_T^2,$$

where E , $p_{\max}$ and p_T are respectively the total energy, the maximum longitudinal and the transverse momentum of the Λ in the overall c.m. system. This is shown in fig. 1 together with results published at 4.2 [2] and 14.3 [1] GeV/c; the absence of scaling in this energy range is confirmed. The change of the shape of the distribution is reflected in the mean weighted x value $\langle x \rangle_E$. At 8.25 GeV/c $\langle x \rangle_E = -0.155 \pm 0.002$, to be compared to $\langle x \rangle_E = -0.141 \pm 0.005$ at 3.93 GeV/c [1] and which is $\langle x \rangle = -0.183 \pm 0.005$ at 14.3 GeV/c [1].

The $d\sigma/dp_T^2$ distribution for reaction (1) follows the exponential law

$$\frac{d\sigma}{dp_T^2} = A e^{-Bp_T^2}$$

in the range 0-2 (GeV/c)². The fitted slope parameter is $B = 3.39 \pm 0.02$ (GeV/c)⁻² and the corresponding $\langle p_T^2 \rangle$ and $\langle p_T \rangle$ values are respectively (0.295 ± 0.002) (GeV/c)² and (0.481 ± 0.002) (GeV/c). Fig. 2 shows the increase of $\langle p_T \rangle$ with incident energy up to 32 GeV/c. The mean transverse momentum shows the usual dependence on x (fig. 3).

3.2 Recoiling mass system

The distribution of the mass, M , of the system recoiling from the Λ is shown in fig. 4(a); the contributions of the target ($|t_{p\Lambda}| < 1.5$ GeV²) and the beam ($|u_{p\Lambda}| < 1.5$ GeV²) fragmentation regions are shown separately in figs 4(b) and 4(c). The π^0 , η , $\rho^0 - \omega$, η' , ϕ and A_2 signals are present in the target fragmentation region described by virtual " K^+ " K^- scattering whereas in the beam fragmentation region, only some π^0 , $\rho^0 - \omega$ and ϕ can be seen, corresponding to an off-shell " $\bar{p}$ " p coupling.

3.3 Λ polarization

The polarization p_Λ of the Λ is given by

$$p_\Lambda = \frac{3}{\alpha} \frac{\sum_{i=1}^N W_i \vec{q}_i \cdot \vec{n}_i}{\sum_{i=1}^N W_i},$$

where $\vec{q}$ is the unit vector along the direction of the proton in the Λ rest frame, $\vec{n}$ the unit vector normal to the Λ production plane and W is the weight of an event; α is the decay asymmetry parameter (taken as $\alpha = 0.647$) and N is the number of observed events.

Fig. 5 shows this polarization as a function of x . The general trend of the polarization behaviour is very similar to that obtained at various other beam momenta [1,3,5]. The Λ has no polarization when produced backwards in the overall center of mass region, except in the resonance region ($x \approx -1$); on the contrary, significant negative polarization is found in the forward region, in particular in the extreme forward region ($x \approx 1$) which is dominated by the baryon exchange process $K^- p \rightarrow \Lambda \pi^0$. Fig. 6 shows that p_Λ increases in magnitude with p_T in the beam fragmentation region. The variation of p_Λ with M^2 (fig. 7) will be discussed in the framework of the tripple Regge model in sect. 6.

The influence of Λ 's coming from Σ^0 decays on the "true" Λ polarization will be discussed in the next section.

4. Σ^0 PRODUCTION

In addition to the intrinsic interest of Σ^0 production, it is also important to investigate its effect on inclusive Λ production.

In our sample, there are about 9000 events with a Σ^0 fit. However, about 2/3 of them are ambiguous with a higher constrained Λ fit; such Σ^0 fits have been eliminated. The final sample has been obtained by removing events with a confidence level less than 10% or a neutral missing mass (including the Λ) at the production vertex outside the Σ^0 mass region (1.06 to 1.34 GeV). For the accepted events, the cosine of the angle between the Σ^0 direction in the overall c.m. system and the Λ direction

in the Σ^0 rest frame has been found to have a flat distribution, indicating that the final sample is free from serious contamination. We are left with 1707 events corresponding to the reaction

$$K^- p \rightarrow \Sigma^0 + \bar{X}, \text{ with no unseen neutral in } \bar{X}. \quad (3)$$

The corresponding cross section is evaluated to be $(110 \pm 10)\mu\text{b}^{(*)}$. For comparison we have also studied the reaction

$$K^- p \rightarrow \Lambda + \bar{X}, \text{ with no unseen neutral in } \bar{X}. \quad (4)$$

Events belonging to this channel are normally 4C fit events; we have 4682 such events corresponding to a cross section of $(265 \pm 15)\mu\text{b}^{(*)}$. Hence the $\Sigma^0/(\Lambda + \Sigma^0)$ cross section ratio for reactions (3) and (4) is 30%, which agrees with the value of 25% found at 14.3 GeV/c in the corresponding total inclusive reactions [7].

In fig. 8 we show the invariant x distributions for both reactions (3) and (4); they are similar in shape but different from the total inclusive distribution shown in fig. 1. The p_T^2 distributions follow an exponential law with $\langle p_T^2 \rangle$ being $(0.34 \pm 0.01)(\text{GeV}/c)^2$ for reaction (3) and $(0.325 \pm 0.005)(\text{GeV}/c)^2$ for reaction (4). These values are compatible, but slightly higher than the overall value of $(0.295 \pm 0.002)(\text{GeV}/c)^2$. Finally, the M distributions (fig. 9) are also similar, but different from the total M distribution (fig. 4(a)). The differences between the reactions (3) and (4) on one hand and reaction (1) on the other can be attributed to the absence of unseen neutrals, in particular the π^0 , in the $\bar{X}$ system. For instance, this suppresses the η , ω , η' and A_2 signals in the $M(\bar{X})$ distributions.

(*) Quoted errors are statistical only.

As far as the preceding distributions are concerned, Λ and Σ^0 production have similar properties. Extrapolation to the total inclusive reaction would imply that it is unnecessary to remove the Σ^0 contamination.

We can furthermore study the Σ^0 polarization. The decay angular distribution is given by [9]

$$\frac{dN}{d\cos\theta d\cos\psi} = A \left[1 - \alpha P_{\Sigma} \cos\theta \cos\psi \right],$$

where θ is the angle between the Λ and the normal to the production plane, and ψ is the angle between the decay proton (in the Λ rest frame) and the Λ (in the Σ^0 rest frame). This provides the P_{Σ} value by the formula

$$P_{\Sigma} = - \frac{9}{\alpha} \langle \cos\theta \cos\psi \rangle .$$

This polarization has been calculated in 4 bins of x (table 1) and compared to the polarization of the Λ in the corresponding reaction (4). Negative polarization is found in the backward region where the Λ is unpolarized, and, on the contrary, there is no polarization in the forward region where the Λ is strongly polarized. The contribution of the Σ^0 to the observed polarization can be estimated by the formula

$$P_{\Lambda}^{\text{observed}} = 0.7 P_{\Lambda}^{\text{true}} + 0.3 P_{\Lambda}^{\Sigma^0},$$

where $P_{\Lambda}^{\Sigma^0}$ is the component of the polarization of the Λ coming from the Σ^0 decay along the normal to this Λ "production" plane^(*). We see in table 1 that $P_{\Lambda}^{\Sigma^0}$ is almost equal to zero so that the Σ^0 contribution to the overall Λ sample attenuates the "true" Λ polarization by a factor 0.7.

(*) It should be noted that the Σ^0 production plane differs from the plane in which the Λ decaying from the Σ^0 is produced. Such a Λ is polarized along its line-of-flight in the Σ^0 rest frame.

5. $\Sigma(1385)$ INCLUSIVE PRODUCTION

5.1 Total cross sections

The inclusive $\Lambda\pi^+$, $\Lambda\pi^-$ and $\Lambda\pi^0$ effective mass distributions are shown in fig. 10. Copious $\Sigma(1385)$ production is seen; no other resonance seems to be abundantly produced. The inclusive cross sections have been calculated by fitting the mass distributions to the formula

$$\frac{d\sigma}{dM_{\Lambda\pi}} = BG (1 + \lambda BW),$$

where BG represents the background and BW is a relativistic Breit-Wigner function with an energy independent width. The background was parametrized by a sixth order polynomial. The fitted values of mass, width and cross section (corrected for unseen decay modes) for the charged $\Sigma(1385)$ are given in table 2. The use of the background expression

$$BG = (M - M_{th})^a e^{-bM}, \quad M_{th} = 1.255 \text{ GeV}/c^2$$

gives within errors the same results.

Fig. 11 summarizes available data on $\Sigma(1385)^\pm$ inclusive cross sections [10-13]. It can be seen that the $\Sigma(1385)^-$ cross section remains constant over the whole range of incident momentum at about 250 μb , whereas the $\Sigma(1385)^+$ cross section decreases to about 350 μb for $P_{\text{beam}} \gtrsim 15 \text{ GeV}$.

The problem of the determination of the $\Sigma(1385)^0$ cross section is similar to that of the Σ^0 . We have calculated the cross section for the reaction

$$K^- p \rightarrow \Sigma(1385)^0 + \bar{X}, \quad \text{with no unseen neutral in } \bar{X}, \quad (5)$$

which can be compared to reactions (3) and (4). This cross section has been obtained by a fit similar to that of charged $\Sigma(1385)$ except that the

$\Sigma(1385)^0$ width has been fixed to 40 MeV. The fitted mass obtained is 1.389 ± 0.003 GeV and the cross section for reaction (5) corrected for unseen decay modes is $(30 \pm 8)\mu\text{b}$.

5.2 Differential cross sections

Each differential cross section has been obtained by fitting the $\Lambda\pi^\pm$ effective mass for different intervals of the studied variable. The masses and widths of the $\Sigma(1385)$ have been fixed to the values listed in table 2; the exponential form of the BG term has been used. It has been checked that the integral of each differential cross section gives the correct total cross section.

Fig. 12 displays the invariant cross sections $F(x)$ for $\Sigma(1385)^+$ and $\Sigma(1385)^-$ production. The distributions differ considerably in the $x \approx -1$ region. This behaviour can be understood in terms of kaon exchange which is allowed for $\Sigma(1385)^+$ production only. In the central and beam fragmentation regions the distributions are very similar. This indicates the absence of a significant contribution from neutron exchange to $\Sigma(1385)^-$ production in the beam fragmentation region.

As in the case of inclusive Λ production, both $\Sigma(1385)^\pm$ invariant distributions do not show a scaling behaviour compared to the same Λ distributions at 4.2 and 16 GeV/c [10-12].

The $d\sigma/dp_T^2$ distributions, plotted in fig. 13, are exponential for both charges over the range $0 - 1.8$ (GeV/c)². The fitted slope parameters are $B = (2.93 \pm 0.11)(\text{GeV/c})^{-2}$ for $\Sigma(1385)^+$ and $B = (2.97 \pm 0.17)(\text{GeV/c})^{-2}$ for $\Sigma(1385)^-$; they correspond to mean values of p_T^2 of $(0.341 \pm 0.013)(\text{GeV/c})^2$ and $(0.337 \pm 0.020)(\text{GeV/c})^2$ respectively.

The above procedure has also been applied to obtain the distribution of the mass recoiling from the $\Sigma(1385)^\pm$. The overall shape of the distributions is similar to that for the mass recoiling from the Λ (fig. 4(a)); in particular the $\pi^\pm$ peak is present (not shown).

5.3 Influence of $\Sigma(1385)$ on distributions for inclusive Λ production

The total $\Sigma(1385)$ production constitutes about 25% of the inclusive Λ cross section. To study the influence on the Λ inclusive distributions, we have subtracted (in a similar way to that described in sect. 5.2) the contribution to the $F(x)$ and M distributions of Λ 's decaying from charged $\Sigma(1385)$ production. As the p_T^2 distributions are similar for Λ and $\Sigma(1385)^\pm$, we have not performed any subtraction for this quantity.

Fig. 14 shows $F(x)$ for inclusive Λ production before and after subtraction. It is seen that the elimination of the $\Sigma(1385)$ increases the relative contribution of the fragmentation regions.

The effect on the M^2 distributions is shown in fig. 15 for total, target and beam fragmentation regions. In the beam fragmentation region the $\Sigma(1385)$ contribution does not change the shape of the distribution while in the overall and target fragmentation distributions the large mass regions are more depopulated.

6. TRIPLE REGGE ANALYSIS

Under the assumption of large s , M^2 and s/M^2 the inclusive double differential cross section for reaction $b \rightarrow c$ is given in the Mueller-Regge formalism by

$$\frac{d^2\sigma}{dt d(M^2/s)} = \sum_{ijk} G_{ijk}(0,t,t) \left(\frac{M^2}{s}\right)^{\alpha_k(0)-\alpha_i(t)-\alpha_j(t)} s^{\alpha_k(0)-1}, \quad (6)$$

where the summation over i, j and k corresponds to a summation over the Regge trajectories coupling to the $a\bar{c}$ and $b\bar{b}$ vertices respectively. Similarly, the polarization of the particle c is given, in the same formalism, by [3]

$$P_\Lambda \frac{d^2\sigma}{dt d(M^2/s)} = \sum_{ijk} P_{ijk}(0,t,t) \left(\frac{M^2}{s}\right)^{\alpha_k(0)-\alpha_i(t)-\alpha_j(t)} s^{\alpha_k(0)-1}. \quad (7)$$

For the sake of simplicity, the exchange of an effective trajectory is considered.

At the present time, such an analysis has already been performed for reaction (1) on the $d^2\sigma/dt d(M^2/s)$ distributions [2,4,7]. The polarization formula (7) has so far only provided a qualitative explanation for the polarization data [3,5,7]. In this section, we describe a triple Regge analysis with s dependence and polarization effects included.

The Λ sample described in sect. 3 has been used. The Λ 's originating from Σ^0 or $\Sigma(1385)$ decay were not eliminated since the results in sect. 4 and 5.3 indicate that this will have little effect.

6.1 Fixed s analysis of the M^2 distribution

In the target and beam fragmentation regions, defined respectively as $|t| < 1.5 \text{ GeV}^2$ and $|u| < 1.5 \text{ GeV}^2$, the $d^2\sigma/dt d(M^2/s)$ distributions have been fitted for various momentum transfer intervals to the formula

$$\frac{d^2\sigma}{dt d(M^2/s)} = G(t) \left(\frac{M^2}{s} \right)^{b(t)},$$

where $G(t)$ and $b(t)$ are the parameters. Successful fits are obtained for data above the resonance region ($M^2/s \gtrsim 0.1$). The values of b fitted in the beam (t) and target (u) fragmentation region are given in table 3. A linear fit has been performed for $b(t)$ and $b(u)$ yielding the following results

$$b(t) = (0.39 \pm 0.06) - (1.72 \pm 0.07)t$$

$$b(u) = (0.91 \pm 0.13) - (1.58 \pm 0.12)u.$$

6.2 $\alpha_k(0)$ values

From the values of b evaluated in the previous paragraph, one can determine the parameters of the exchanged trajectory i from the relation

$$b(t) = \alpha_k(0) - 2\alpha_i(t),$$

but this requires the evaluation of $\alpha_k(0)$. In principle, one should

obtain this value by fitting in both fragmentation regions the $d^2\sigma/dt d(M^2/s)$ distributions or the equivalent $(E/\pi p_{\max}) d^2\sigma/dx dp_T^2$ at different energies to the $s^{\alpha_k(0)-1}$ power law. Since more data are available on the $F(x)$ distribution, we have used this integrated distribution to calculate $\alpha_k(0)$.

In fig. 16, we have plotted the $F(x)$ values for different s values [1-8] at $|x| = 0.45, 0.55, 0.65$ and 0.75 . Fits for positive x values and for negative x values give

$$\alpha_k(0) = 0.078 \pm 0.013 \text{ for the target fragmentation region}$$

and

$$\alpha_k(0) = 0.047 \pm 0.020 \text{ for the beam fragmentation region.}$$

The first value, corresponding to the trajectory coupling to $K\bar{K}$, is suggestive of the $\phi - f'$ trajectory [14]. The second value, corresponding to the trajectory coupling to $\bar{p}p$, has an intercept indicating significant contributions from the exotic $\bar{p}p$ channel [15].

6.3 Effective trajectories

From these values of $\alpha_k(0)$ we are able to deduce the parameters of the effectively exchanged trajectories (fig. 17). Straight line fits give

$$\alpha_i(t) = (-0.15 \pm 0.04) + (0.86 \pm 0.04)t$$

and

$$\alpha_i(u) = (-0.43 \pm 0.07) + (0.79 \pm 0.06)u.$$

In the target fragmentation region our fitted trajectory, favours the K over the $K^*(890)$ trajectory. In the beam fragmentation region, the results are compatible with the nucleon trajectory.

The effect of the $\Sigma(1385)^{\pm}$ production on the trajectories can be estimated from fig. 15. No influence on the trajectory is detected in the beam fragmentation region. In the target fragmentation region $\Sigma(1385)$ production contributes

preferentially to the high M^2 values; its subtraction will lower the $b(t)$ values by approximately 0.10. This could cause a rise of the 'K' effective trajectory by at most 0.05.

6.4 Polarization effects

In the target fragmentation region we have found that the Λ polarization is zero outside the resonance region (fig. 7). Hence no additional information on the production mechanism can be obtained.

Fig. 18(b) shows the polarization cross section

$$P_{\Lambda} \frac{d^2\sigma}{du d(M^2/s)}$$

for various intervals of u . The curves show the results of fits as a function of M^2/s (for $M^2/s < 0.4$) to eq. (7), which for this purpose has been rewritten as

$$P_{\Lambda} \frac{d^2\sigma}{du d(M^2/s)} = P(u) \left(\frac{M^2}{s}\right) b'(u)$$

The values of $b'(u)$ obtained are indicated in fig. 18(b) and are significantly lower than the values of $b(u)$ obtained from fits to the differential cross section (fig. 18(a)). This difference arises since $|P_{\Lambda}|$ (as opposed to $P_{\Lambda} d^2\sigma/du d(M^2/s)$) falls with increasing M^2/s (fig. 18(c)).

If we attempt to interpret the polarization as arising from interference between only two nucleon trajectories, the additional trajectory, which is assumed to give a minor contribution to the inclusive cross section, must lie above the nucleon trajectory, which seems improbable. It therefore appears, that more trajectories must be involved, so as to retain the nucleon trajectory (N_{α}) lying highest.

7. CONCLUSIONS

The most important features from this analysis are the following:

(a) Scaling properties

No evidence for scaling in Λ or $\Sigma(1385)$ production is found in the invariant cross sections. Backward and forward Λ production proceeding by kaonic and baryonic exchanges respectively decrease as p_{lab} increases. Similarly, $\Sigma(1385)^+$ backward production (involving kaon exchange) also decreases whereas forward $\Sigma(1385)^+$ production is not observed; this is further evidence for the suppression of Δ exchange [15].

(b) Comparison of Λ and Σ^0 production

Σ^0 production has been studied in the channels with no unseen neutral particle and compared to the corresponding Λ channels. Strong similarities are found in the momentum and recoiling mass distributions. Differences occur in the polarization values as the Λ is polarized mainly in the beam fragmentation region and the Σ^0 in the target fragmentation region.

(c) Cross sections

We estimate that direct (i.e. not a decay product of Σ^0 or $\Sigma(1385)$) Λ production amounts to about 1600 μb whereas the direct Σ^0 cross section is about 900 μb . The $\Sigma(1385)^+$ cross section is about 435 μb and 270 μb for positive and negative charges respectively and is estimated to be 215 μb for neutral $\Sigma(1385)$ production. These estimates are based on the assumption that the ratio of events with no unseen neutral particle to the total number of events is the same for inclusive Λ , Σ^0 and $\Sigma(1385)$ production.

(d) Triple Regge analysis

In the target fragmentation region, our data favour the K trajectory rather than the $K^*(890)$ trajectory, while the nucleon trajectory is dominant in the beam fragmentation region. The polarization has been shown to follow the triple Regge formula. Its non zero value for $|u| < 1.5 \text{ GeV}^2$ suggests the existence of other exchanges in addition to the nucleon trajectory.

We wish to acknowledge the help of the operating crews of the CERN PS and the 2m hydrogen bubble chamber and the constructors of the rf beam. We would like to thank the scanning, measuring and computing staffs at each of our laboratories. The Birmingham and Glasgow groups wish to thank the Science Research Council for their financial support.

REFERENCES

- [1] A. Borg et al., Nuovo Cimento 22A (1974) 559.
- [2] S.N. Ganguli et al., Nuovo Cimento 44A (1978) 345.
- [3] S.U. Chung et al., Phys. Rev. D11 (1975) 1010.
- [4] E. Simopoulou et al., Nucl. Phys. B96 (1975) 413.
- [5] H. Grässler et al., Nucl. Phys. B136 (1978) 386.
- [6] W. Barletta et al., Nucl. Phys. B51 (1973) 499.
- [7] A. Borg, Thesis (1977), Université P. et M. Curie, Paris.
- [8] P. Bellière et al., Nucl. Phys. B90 (1975) 20.
- [9] R. Gatto, Phys. Rev. 109 (1957) 610.
- [10] F. Barreiro et al., Nucl. Phys. B126 (1977) 319.
- [11] H. Grässler et al., Nucl. Phys. B118 (1977) 189.
- [12] M. Bardadin-Otwinowska et al., Nucl. Phys. B98 (1975) 418.
- [13] C. Cochet et al., Palermo Conference (1975).
- [14] T. Inami and H.I. Miettinen, Phys. Lett. 49B (1974) 67.
- [15] M.R. Pennington, Nucl. Phys. B137 (1978) 77.

TABLE CAPTIONS

Table 1 Λ and Σ^0 polarization as a function of x in reaction (3) and (4).

Table 2 Fitted values of mass, width and cross section for $\Sigma(1385)^\pm$.

Table 3 Fitted values of the b parameter.

TABLE 1

x	-1.0 to -0.5	-0.5 to 0.0	0.0 to 0.5	0.5 to 1.0
P_{Σ}	-0.43 ± 0.16	-0.01 ± 0.19	-0.28 ± 0.23	$+0.09 \pm 0.40$
$P_{\Lambda+C}$	-0.02 ± 0.06	-0.08 ± 0.06	-0.16 ± 0.07	-0.39 ± 0.13
$P_{\Lambda}^{\Sigma^0}$	$+0.05 \pm 0.02$	0.00 ± 0.021	0.00 ± 0.01	$+0.01 \pm 0.01$

TABLE 2

	Mass (GeV)	Width (GeV)	Cross section (μb)
$\Sigma(1385)^+$	1.381 ± 0.002	0.037 ± 0.002	433 ± 30
$\Sigma(1385)^-$	1.383 ± 0.001	0.044 ± 0.004	269 ± 25

TABLE 3

$ t $ interval	$\frac{M^2}{s}$ range	Weighted number of events	$b(t)$	$ u $ interval	$\frac{M^2}{s}$ range	Weighted number of events	$b(u)$
0.0 - 0.2	0.075 - 0.150	1179	0.50 ± 0.15	0.0 - 0.2	0.075 - 0.125	70	-
0.2 - 0.4	0.075 - 0.250	2668	0.95 ± 0.06	0.2 - 0.4	0.075 - 0.225	460	1.42 ± 0.18
0.4 - 0.6	0.075 - 0.350	3439	1.20 ± 0.05	0.4 - 0.6	0.075 - 0.300	832	1.64 ± 0.12
0.6 - 0.8	0.100 - 0.400	3400	1.69 ± 0.06	0.6 - 0.8	0.075 - 0.350	1193	2.02 ± 0.11
0.8 - 1.0	0.100 - 0.425	2926	1.88 ± 0.06	0.8 - 1.0	0.125 - 0.400	1503	2.48 ± 0.12
1.0 - 1.2	0.125 - 0.475	3012	2.22 ± 0.07	1.0 - 1.2	0.100 - 0.425	1832	2.55 ± 0.09
1.2 - 1.4	0.150 - 0.475	2418	2.69 ± 0.10	1.2 - 1.4	0.100 - 0.450	1932	3.04 ± 0.11
1.4 - 1.6	0.150 - 0.500	2436	3.01 ± 0.11	1.4 - 1.6	0.125 - 0.475	2257	3.26 ± 0.12

FIGURE CAPTIONS

- Fig. 1 Invariant cross sections for reaction (1). The full line is our data; ● and X refers to data at 4.2 [2] and 14.3 [1] GeV/c respectively.
- Fig. 2 Variation of $\langle p_T \rangle$ with p_{lab} .
- Fig. 3 Variation of $\langle p_T \rangle$ with x . Whenever not indicated errors are smaller than the dot size.
- Fig. 4 Recoiling mass spectrum (a) for all events, (b) for events with $|t| < 1.5 \text{ GeV}^2$ and (c) for events with $|u| < 1.5 \text{ GeV}^2$.
- Fig. 5 Λ polarization as a function of x . Whenever not indicated errors are smaller than the dot size.
- Fig. 6 Λ polarization as a function of p_T in the target (●) and beam (x) fragmentation regions. Whenever not indicated errors are smaller than the dot size.
- Fig. 7 Λ polarization as a function of M^2 in the target (●) and beam (x) fragmentation regions. Whenever not indicated errors are smaller than the dot size.
- Fig. 8 Invariant cross sections for reaction (3) (solid curve) and (4) (dashed curve).
- Fig. 9 Recoiling mass spectrum for reaction (3) (solid curve) and (4) (dashed curve).
- Fig. 10 Effective mass distributions for (a) $\Lambda\pi^+$, (b) $\Lambda\pi^-$ and (c) $\Lambda\pi^0$. The curve refer to the fits described in the text.
- Fig. 11 Inclusive cross sections for $\Sigma(1385)^+$ (●) and $\Sigma(1385)^-$ (▲) as a function of p_{lab} .

FIGURE CAPTIONS (Cont'd)

- Fig. 12 Invariant cross sections for $\Sigma(1385)^+$ ($\bullet$) and $\Sigma(1385)^-$ ($\blacktriangle$).
- Fig. 13 $d\sigma/dp_T^2$ distribution for (a) $\Sigma(1385)^+$ and (b) $\Sigma(1385)^-$.
- Fig. 14 Invariant cross section of the Λ before and after subtraction of $\Sigma(1385)^\pm$ contribution.
- Fig. 15 M^2 distribution off the Λ before (dashed curve) and after (solid curve) subtraction of $\Sigma(1385)^+$ for (a) all events, (b) target and (c) beam fragmentation regions.
- Fig. 16 Variation of $F(x)$ with s for (a) $x < 0$ and (b) $x > 0$. The lines show the result of the fits described in the text.
- Fig. 17 Effective trajectories in (a) target and (b) beam fragmentation regions. The lines show the result of the fits described in the text.
- Fig. 18 Cross section (a), polarized cross section (b) and polarization (c) in the beam fragmentation region. The curves in fig. (a) and (b) come from a fit of the data to eq. (6) and (7) respectively.

Fig. 1

Fig. 2

Fig. 3

Fig. 4

Fig. 5

Fig. 6

Fig. 7

Fig. 8

Fig. 9

Fig. 10

Fig. 11

Fig. 12

Fig. 13

Fig. 14

Fig. 15

Fig. 16

Fig. 17

Fig. 18