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STUDY OF THE REACTIONS $\pi^- p \rightarrow K^0 \Sigma^0(1385)$ AND
 $\pi^- p \rightarrow K^+ \Sigma^-(1385)$ AT 3.95 GeV/c

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ABSTRACT

The reactions $\pi^- p \rightarrow K^0 \Sigma^0(1385)$ and $\pi^- p \rightarrow K^+ \Sigma^-(1385)$ are studied at an incident momentum of 3.95 GeV/c using data from a high statistics bubble chamber experiment corresponding to approximately 90 events/microbarn. The total and differential cross sections and the density matrix elements of the $\Sigma(1385)$ are presented. The results are compared with those obtained for the related processes $\pi^+ p \rightarrow K^+ \Sigma^+(1385)$ and $K^- p \rightarrow \pi^+ \Sigma^+(1385)$ in this energy range. Evidence is presented for the existence of production mechanisms with exotic exchanges in the t channel.

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1. INTRODUCTION

In this paper we present a study of the processes

$$\pi^- p \rightarrow K^0 \Sigma^0(1385) \quad (1)$$

$$\pi^- p \rightarrow K^+ \Sigma^-(1385) \quad (2)$$

at 3.95 GeV/c, using data corresponding to approximately 90 events/ μb . Previous studies of reactions (1), (2) at similar energies include those at 3.8 - 4.2 GeV/c (5.6 events/ μb) [1,2], 4.5 GeV/c (31.4 events/ μb) and 6.0 GeV/c (18 events/ μb) [3,4].

We have determined the total and differential cross sections of these two reactions. The large statistics of this experiment permits to extract a significant cross section for the reaction $\pi^- p \rightarrow K^+ \Sigma^-(1385)$ in the forward direction. The production mechanism for this scattering process implies the exchange of exotic meson quantum numbers in the t channel. Additional evidence for this type of exchange mechanism is obtained comparing the differential cross sections for the processes $\pi^- p \rightarrow K^0 \Sigma^0(1385)$ and $\pi^+ p \rightarrow K^+ \Sigma^+(1385)$. The study of these processes affords a determination of the ratio of the $I = 3/2$ and $I = 1/2$ isospin exchange amplitudes. We have measured the helicity density matrix elements of the $\Sigma(1385)$ and the production transversity amplitudes of reaction (1) using the information contained in the sequential decay of the $\Sigma(1385)$. These quantities are discussed in the context of the additive quark model for meson-baryon scattering. It appears that the gross features of the data are reproduced by this model although some deviations are observed in the most forward region.

The reactions (1) and (2) belong to the same spin class ($0^- 1/2^+ \rightarrow 0^- 3/2^+$) as the processes

$$K^- p \rightarrow \pi^- \Sigma^+(1385) \quad (3)$$

$$K^- p \rightarrow \pi^+ \Sigma^-(1385) \quad (4)$$

which have been extensively studied at 4.2 GeV/c by the Amsterdam-CERN-Nijmegen-Oxford Collaboration [5] at the level of 80 events/ μb . These reactions give evidence for the existence of a significant $I = 3/2$ t channel exchange mechanism. A reanalysis of these channels using the finally available statistics of 128 events/ μb will be presented here.

The paper is organized as follows. A brief description of the relevant experimental details for the final states under study is presented in sect. 2. The results of Dalitz plot analyses leading to the determination of the total cross sections, as well as the calculation of the differential cross sections for the reactions (1) and (2) are presented in sect. 3. In this section we also give a brief description of the updating of the related K^-p channels and present results on differential cross sections. In sect. 4 we give the transversity amplitudes and density matrix elements for the reactions (1)-(4). A phenomenological discussion of these processes and related ones is given in sect. 5. Special emphasis is given to the $I = 3/2$ t channel exchange mechanisms throughout this paper. The conclusions are given in sect. 6.

2. THE FINAL STATES $\pi^-p \rightarrow \Lambda K^0 \pi^0$ AND $\pi^-p \rightarrow \Lambda K^+ \pi^-$

The data for the analysis of the reactions

$$\pi^-p \rightarrow K^0 \Sigma^0(1385) \quad (1)$$

$$\pi^-p \rightarrow K^+ \Sigma^-(1385) \quad (2)$$

come from exposures of the CERN 2m hydrogen bubble chamber to π^- beams of momenta: 3.93 GeV/c for 50% of the data, 3.96 for 20% and 4.01 for the remaining 30%. The events used for this study are found in the zero-prong plus two vees and two-prong plus vee topologies and the statistical sensitivity is approximately 90 events/ μb .

We have extracted samples of reactions (1) and (2) from events with a visible Λ decay and kinematically compatible with the final states

$$\pi^- p \rightarrow \Lambda K_S^0 \pi^0, \quad 1154 \text{ events (1412 events)} \quad (5)$$

$$\pi^- p \rightarrow \Lambda K^+ \pi^-, \quad 3650 \text{ events (4047 events)} \quad (6)$$

where the quoted number of events refer to the final samples used in the analysis after applying appropriate selection criteria. In parenthesis we give the corresponding number of events weighted to account for losses due to Λ and K_S^0 decays occurring outside the fiducial volume or too close to the production vertex (< 3 mm) to be seen at the scanning stage.

After imposing a 4% cut in the kinematic probability, 87% of the events fitting channel (5) had a unique interpretation. The remaining 13% were ambiguous with the final state $\pi^- p \rightarrow \Sigma^0 K_S^0$. As discussed elsewhere [6], a combined study of the χ^2 fit probability and missing mass squared to the ΛK_S^0 system shows that by assigning these events to the $\Sigma^0 K_S^0$ channel we obtain a good $\Lambda K_S^0 \pi^0$ sample with a loss of less than 2% of good events.

The method of selecting events for channel (6) has been discussed in [7]. After imposing a cut of 1% in the χ^2 probability the only ambiguity left was with the 2-constrained fit hypothesis $\Sigma^0 K^+ \pi^-$ which accounted for 39% of the sample. The $\Sigma^0 \rightarrow \Lambda \gamma$ decay angular distribution for these ambiguous events is restricted to a region corresponding to the minimum possible γ momentum. The comparison of this distribution with that of the non ambiguous $\Sigma^0 K^+ \pi^-$ events clearly indicates that the vast majority of the ambiguous events are indeed $\Lambda K^+ \pi^-$ events. By assigning all of them to the $\Lambda K^+ \pi^-$ hypothesis, a contamination of about 1% is introduced.

The cross sections for the channels (5) and (6) corrected for throughput efficiencies and K^0 and Λ unseen decay modes were calculated to be

$$\sigma(\pi^- p \rightarrow \Lambda K_S^0 \pi^0) = 72 \pm 4 \text{ } \mu\text{b}$$

$$\sigma(\pi^- p \rightarrow \Lambda K^+ \pi^-) = 79 \pm 3 \text{ } \mu\text{b}.$$

The cross sections for these channels have been previously measured at 3.89 and 4.16 GeV/c [2]. The values $98 \pm 21 \mu\text{b}$ and $68 \pm 15 \mu\text{b}$ were obtained for channel (5), and for channel (6) the values $99 \pm 13 \mu\text{b}$ and $88 \pm 11 \mu\text{b}$ were quoted. A determination of the cross section for channel (6) using a fraction of the data discussed here [8] gave the value $78 \pm 4 \mu\text{b}$ in good agreement with our present calculation.

3. TOTAL AND DIFFERENTIAL CROSS SECTIONS

The dominant features of the three-body final states (5) and (6) are copious production of the K(890) and K(1420) meson resonances as well as the $\Sigma(1385)$ hyperon. The Dalitz plots and effective mass projections are given in figs 1-4.

To calculate the cross sections for the quasi two-body processes (1), (2) we have performed maximum likelihood analyses of the two dimensional diagrams $M(\Lambda\pi)$ vs $M(K\pi)$. The probability functions used contained terms describing the production (Breit Wigner shapes) and decay distribution (expressed in terms of the diagonal s channel helicity density matrix elements) of the K(890), K(1420), $\Sigma(1385)$ and N(1700) resonances. A phase space term was also included. For the $\Sigma(1385)$ states we used the following parameters

$$\Sigma^0(1385): M = 1381.1 \pm 2.7 \text{ MeV} \quad \Gamma = 40.1 \pm 7.3 \text{ MeV}$$

$$\Sigma^-(1385): M = 1380.0 \pm 2.5 \text{ MeV} \quad \Gamma = 31.3 \pm 6.5 \text{ MeV}$$

obtained in preliminary fits to the $\Lambda\pi$ effective mass distribution, whereas for the other resonances we used the values given by the Particle Data Group [9].

The results of the fits are given in table 1 and the projections on the $K\pi$, $\Lambda\pi$ and ΛK effective mass distributions are shown in figs 3 and 4. As can be seen the different distributions are well reproduced by the fits. The cross sections for the relevant processes obtained from

the two different final states and corrected for all the unseen decay modes are quoted in table 2. Within the errors the cross sections for $K^0(890)$ and $K^0(1420)$ production determined from the two channels are consistent.

For the reaction (1) the cross section obtained here

$$\sigma(\pi^- p \rightarrow K^0 \Sigma^0(1385)) = 22 \pm 2 \mu\text{b}$$

is compatible with the value $17 \pm 2 \mu\text{b}$ obtained at 4.5 GeV/c [4].

As it will be shown later, from channel (2) we obtain evidence for the presence of exotic quantum numbers in the t channel. The cross section being small, we have used a second approach for its determination. As fig. 2 shows a large fraction of the background under the $\Sigma^-(1385)$ is due to the reflection of $K^0(890)$ production. The shaded distribution in fig. 4(b) shows the $\Lambda\pi^-$ effective mass distribution after removing the $K^0(890)$ band ($0.84 \leq M(K^+\pi^-) \leq 0.94$ GeV). The signal to background ratio in the $\Sigma^-(1385)$ region is clearly improved. On the other hand, the $K^0(890)$ distorts, as fig. 5 shows, a limited region of the polar s channel helicity decay distribution of the $\Lambda\pi^-$ system ($0.48 \leq \cos\theta_{\Lambda\pi^-} \leq 0.84$). Elsewhere the distribution is flat and therefore the $K^0(890)$ contribution can easily be eliminated. In general, the $\Sigma^-(1385)$ polar decay distribution has a more complicated shape and the overlap cannot be so easily corrected for. The method we have adopted is as follows. A fit to the two-dimensional distribution $M(\Lambda\pi^-)$ vs $\cos\theta_{\Lambda\pi^-}$ is performed in the region $1.30 \leq M(\Lambda\pi^-) \leq 1.50$ GeV after removing the $\cos\theta_{\Lambda\pi^-}$ region affected by the $K^0(890)$ reflection. In this fit the background is assumed to have smooth mass behaviour and no angular dependence, whereas the $\Sigma^-(1385)$ decay distribution is expressed in terms of the $\rho_{\frac{3}{2}\frac{3}{2}}$ density matrix element. After correcting for the removed $\cos\theta_{\Lambda\pi^-}$ interval and for $\Sigma^-(1385)$ tails we get the value $4.2 \pm 0.5 \mu\text{b}$ for the cross section of the reaction (2). This value is in good agreement with the one obtained in the Dalitz plot analysis. The method will be used later in the calculation of the differential cross sections and density matrix elements.

The production properties of the $\Sigma(1385)$ in the reactions (1) and (2) are illustrated by the Chew Low distributions $M(\Lambda\pi)$ vs $t(p \rightarrow \Lambda\pi)$ given in figs 6 and 7. In order to reduce the background contamination we have removed the $K^0(890)$ band. The $\Sigma^0(1385)$ production is concentrated at low values of t ($t \leq 1.0 \text{ GeV}^2$) with rather small contribution at small u (largest value of t)^(*). Within the limited statistics the $\Sigma^-(1385)$ seems to have a flatter behaviour. The cross section peaks at low values of t and u , but is not negligible for $t \geq 1.0 \text{ GeV}^2$.

If $\Sigma(1385)$ production is interpreted in terms of t channel or u channel particle exchanges, four different types of mechanisms are possible. In the forward direction (low t') reaction (1) will be dominated by the exchange of $K(890)$ and $K(1420)$, whereas reaction (2) will be dominated by $I = 3/2$ exchange. In the backward direction (low u') reaction (1) will go via an $I = 1$ hyperon exchange, whereas in reaction (2) both $I = 0$ and $I = 1$ hyperons could be exchanged. Experimental evidence for each of the four processes is given in fig. 8, where the $\Lambda\pi$ effective mass distributions are displayed for cuts in t' ($t' \leq 1.0 \text{ GeV}^2$) or u' ($u' \leq 1.0 \text{ GeV}^2$). The curves are the results of fits described below.

For reaction (1) the integrated differential cross sections for $t' \leq 1.0 \text{ GeV}^2$ and $u' \leq 1.0 \text{ GeV}^2$ were calculated fitting the $\Lambda\pi^0$ spectra with a Breit Wigner form and a smooth polynomial background. The following values were obtained

$$\sigma(\pi^- p \rightarrow K^0 \Sigma^0(1385)) = 20 \pm 2 \text{ } \mu\text{b} \text{ for } t' \leq 1.0 \text{ GeV}^2$$

$$\sigma(\pi^- p \rightarrow K^0 \Sigma^0(1385)) = 1.0 \pm 0.5 \text{ } \mu\text{b} \text{ for } u' \leq 1.0 \text{ GeV}^2.$$

The differential cross section in the forward region was calculated subtracting from the t' distribution for events in the $\Sigma(1385)$ region

(*) $t(u)$ is defined as the modulus of the square of the four-momentum transfer from the target (beam) to the outgoing $\Sigma(1385)$ • t' is $t - t_{\min}$ and u' is $u - u_{\min}$.

($1.34 \leq M(\Lambda\pi^0) \leq 1.44$ GeV), the t' distribution obtained for the events in the control region ($1.29 \leq M(\Lambda\pi^0) \leq 1.34$ GeV and $1.44 \leq M(\Lambda\pi^0) \leq 1.49$ GeV). The resulting number of events were normalized to the integrated cross section given above. The values of the differential cross section are shown in table 3 and fig. 9. At low t' the distribution has a rather smooth behaviour with no indication of a dip at $t' \sim 0$ GeV². Due to the small value of the cross section in the backward region we did not attempt to obtain its detailed form. We notice that, within the errors, all the cross section for the process (1) takes place for t' or u' smaller than 1.0 GeV².

As indicated above, our data for channel (2) gives clear evidence for the existence of a production process dominated by the exchange of $I = 3/2$ in the t channel (fig. 8(c)). First evidence for K^+ forward production in the reaction $\pi^- p \rightarrow K^+ \Sigma^-(1385)$ in this energy range was reported in [3] using data at 4.5 and 6.0 GeV/c. The basic observation made in that experiment was that the $\Lambda\pi^-$ effective mass squared distribution for the forward hemisphere ($\cos\theta_{\pi^-}^*, K^+ \geq 0$) did show a significant $\Sigma^-(1385)$ signal. The corresponding cross section in this "forbidden" hemisphere was measured to be 0.9 ± 0.25 μ b at 4.5 GeV/c. Its upper limit at 6 GeV/c was 0.3 μ b at 99% confidence level. From the analysis it was concluded that neither a simple kinematic reflection due to $K^+ \pi^-$ scattering nor effects due to s channel resonances could explain the observed forward peak.

The similar evidence provided by our experiment is given in fig. 10 where we show the $\Lambda\pi^-$ effective mass squared distribution for the forward and backward hemispheres, after excluding the $K^0(890)$ band. For completeness we also show the distributions obtained at 4.5 GeV/c. In the forward hemisphere our cross section for this process is 2.6 ± 0.3 μ b and was calculated excluding the $K^0(890)$ reflection and fitting the diagram $M(\Lambda\pi^-)$ vs $\cos\theta_{\Lambda\pi^-}$ in the manner described above. We have also calculated the integrated cross sections for $t' \leq 1.0$ and

$u' \leq 1.0 \text{ GeV}^2$ and the following values were obtained

$$\sigma(\pi^- p \rightarrow K^+ \Sigma^-(1385)) = 1.9 \pm 0.4 \text{ } \mu\text{b} \quad \text{for } t' \leq 1.0 \text{ GeV}^2$$

$$\sigma(\pi^- p \rightarrow K^+ \Sigma^-(1385)) = 1.1 \pm 0.3 \text{ } \mu\text{b} \quad \text{for } u' \leq 1.0 \text{ GeV}^2.$$

Due to the limited statistics we have calculated the forward differential cross section in only two t' intervals. The values $7.6 \pm 1.8 \text{ } \mu\text{b/GeV}^2$ and $0.7 \pm 0.4 \text{ } \mu\text{b/GeV}^2$ were obtained for the t' intervals $0.0 - 0.2 \text{ GeV}^2$ and $0.2 - 1.0 \text{ GeV}^2$ respectively.

Additional information giving evidence for the existence of $I = 3/2$ t channel exchanges can be obtained from the comparison of the differential cross sections for the processes

$$\pi^- p \rightarrow K^0 \Sigma^0(1385) \quad (1)$$

$$\pi^+ p \rightarrow K^+ \Sigma^+(1385). \quad (7)$$

In the absence of $I = 3/2$ exchanges these cross sections are related in a very simple way

$$\frac{d\sigma}{dt'} (\pi^+ p \rightarrow K^+ \Sigma^+(1385)) = 2 \frac{d\sigma}{dt'} (\pi^- p \rightarrow K^0 \Sigma^0(1385)).$$

The differential cross section for process (7) has been measured in this energy range by various techniques and for different ranges of the momentum transfer [10-13].

The data from [10] and [13] cover the range $t' \leq 1.0 \text{ GeV}^2$ and are presented in fig. 9. They agree well over their common range and therefore the observed violation of the equality just given can hardly be attributed to possible uncertainties in the data normalization. For a more quantitative discussion, we will use the bubble chamber data obtained by [13] at 3.7 GeV/c since it extends to smaller t' values than that of [10]. The total cross section for the reaction $\pi^+ p \rightarrow K^+ \Sigma^+(1385)$ at 3.7 GeV/c was measured to be $29 \pm 5 \text{ } \mu\text{b}$ of which we estimate $21 \pm 4 \text{ } \mu\text{b}$

correspond to the integrated cross section for $t' \leq 1.0 \text{ GeV}^2$. This value is clearly incompatible with the value of two times $20 \pm 2 \mu\text{b}$ expected from the related $\pi^- p \rightarrow K^0 \Sigma^0(1385)$ if only $I = 1/2$ exchanges are present. As will be discussed later a possible explanation of this discrepancy is the existence of a non negligible $I = 3/2$ t channel exchange mechanism.

The existence of $I = 3/2$ t channel exchanges has also been established in a large bubble chamber experiment performed by the ACNO collaboration [5] who observe a significant cross section for the line reversed process

$$K^- p \rightarrow \pi^+ \Sigma^-(1385) \quad (4)$$

at $4.2 \text{ GeV}/c$ and for $t' \leq 0.5 \text{ GeV}^2$. In the following we present an updating of the results for reactions

$$K^- p \rightarrow \pi^- \Sigma^+(1385) \quad (3)$$

$$K^- p \rightarrow \pi^+ \Sigma^-(1385) \quad (4)$$

using the final data sample obtained by the ACNO Collaboration and which corresponds to approximately $128 \text{ events}/\mu\text{b}$. The results presented here were obtained using similar methods to the ones described in [5].

For the final state of interest

$$K^- p \rightarrow \Lambda \pi^+ \pi^-$$

we have extracted a sample of 22886 events (25659 weighted events). The total cross sections for the reactions (3) and (4) were measured to be

$$\sigma(K^- p \rightarrow \pi^- \Sigma^+(1385)) = 78 \pm 3 \mu\text{b}$$

$$\sigma(K^- p \rightarrow \pi^+ \Sigma^-(1385)) = 11 \pm 1 \mu\text{b}.$$

The integrated differential cross sections for reactions (3) and (4) in the forward ($t' \leq 1.0 \text{ GeV}^2$) and backward ($u' \leq 1.0 \text{ GeV}^2$) regions were calculated to be

$$\begin{aligned}\sigma(K^- p \rightarrow \pi^- \Sigma^+(1385)) &= 64 \pm 3 \text{ } \mu\text{b} \quad \text{for } t' \leq 1.0 \text{ GeV}^2 \\ \sigma(K^- p \rightarrow \pi^- \Sigma^+(1385)) &= 2.3 \pm 0.3 \text{ } \mu\text{b} \quad \text{for } u' \leq 1.0 \text{ GeV}^2 \\ \sigma(K^- p \rightarrow \pi^+ \Sigma^-(1385)) &= 2.4 \pm 0.4 \text{ } \mu\text{b} \quad \text{for } t' \leq 1.0 \text{ GeV}^2 \\ \sigma(K^- p \rightarrow \pi^+ \Sigma^-(1385)) &= 6.7 \pm 0.4 \text{ } \mu\text{b} \quad \text{for } u' \leq 1.0 \text{ GeV}^2.\end{aligned}$$

The results of the fits leading to the determination of these values are shown in fig. 11.

The calculation of the differential cross section for reaction (3) was made following the approach discussed in [5] and corrected for the background contribution. This background was estimated in each t' bin individually; this requires wider bins than the ones used in [5], where the background estimates were interpolated from mass fits in combined t' bins. Since ρ production overlaps with the $\Sigma^-(1385)$ production at low t' and significantly distorts its s channel polar helicity decay distribution we removed this reflection ($0.56 \leq \cos\theta_{\Lambda\pi^-} \leq 0.84$) and performed fits to the diagram $M(\Lambda\pi^-)$ vs $\cos\theta_{\Lambda\pi^-}$ in the manner described above. The cross sections have been corrected for this cut. The forward differential cross sections for reactions (3) and (4) are given in tables 4 and 5 and in fig. 9.

The prediction obtained assuming exchange degeneracy (EXD) of the $K(890)$ and $K(1420)$ trajectories

$$\frac{d\sigma}{dt'} (K^- p \rightarrow \pi^- \Sigma^+(1385)) = \frac{d\sigma}{dt'} (\pi^+ p \rightarrow K^+ \Sigma^+(1385)) = 2 \frac{d\sigma}{dt'} (\pi^- p \rightarrow K^0 \Sigma^0(1385))$$

is clearly violated in this energy range, as fig. 9 illustrates. The existence of $I = 3/2$ t channel exchanges modifies in a non trivial way this relation. In fact it is possible to explain the large difference between $d\sigma/dt' (K^- p \rightarrow \pi^- \Sigma^+(1385))$ and $2 d\sigma/dt' (\pi^- p \rightarrow K^0 \Sigma^0(1385))$

($24 \pm 5 \mu\text{b}$ for $t' < 1.0 \text{ GeV}^2$) preserving the EXD of the $I = 1/2$ trajectories. However this implies maximum and opposite interference between $T^{\frac{3}{2}}$ and $T^{\frac{1}{2}}$ ($T'^{\frac{3}{2}}$ and $T'^{\frac{1}{2}}$) in the two reactions. Recent experimental studies of reaction (3) and (4) at 7.0 and 11.5 GeV/c indicate that EXD holds at these higher energies [14].

At this point it is interesting to remark that in the most forward region ($t' \leq 1.0 \text{ GeV}^2$) the cross sections for the two line reversed forbidden processes

$$\pi^- p \rightarrow K^+ \Sigma^- (1385) \quad (2)$$

$$K^- p \rightarrow \pi^+ \Sigma^- (1385) \quad (4)$$

are approximately equal and seem to be more important for t' smaller than $\sim 0.2 \text{ GeV}^2$. This line reversal symmetry has been shown to be important when discussing baryonium systematics [15].

4. DENSITY MATRIX ELEMENTS AND TRANSVERSITY AMPLITUDES

In order to calculate the helicity density matrix elements of the $\Sigma^0(1385)$ in reaction (1), we have used a mass dependent analysis of the $\Sigma^0(1385)$ s channel decay distribution which takes into account the background under the resonance. In the region $1.30 \leq M(\Lambda\pi^0) \leq 1.50 \text{ GeV}$ we have performed maximum likelihood fits with a probability function of the form

$$W(M, \cos\theta, \phi) = \alpha |f(M)|^2 W(\cos\theta, \phi) + (1 - \alpha) (a + b M),$$

where α is the fraction of $\Sigma^0(1385)$ events, $f(M)$ is the Breit Wigner amplitude and $W(\cos\theta, \phi)$ is the form of the $\Sigma(1385)$ decay distribution expressed in terms of density matrix elements. The background, being on the average of the order of 25%, was assumed to have linear dependence in the mass and an isotropic decay angular distribution. The results of this analysis as a function of t' are listed in table 6 and shown in fig. 12.

Within the large errors, our measurements are not far from the predictions of the additive quark model

$$\rho_{\frac{1}{2} \frac{1}{2}} = 0.125$$

$$\text{Re } \rho_{\frac{3}{2} - \frac{1}{2}} = 0.216$$

$$\text{Re } \rho_{\frac{3}{2} \frac{1}{2}} = 0.$$

In recent analyses [5,16-18] of the related process

$$K^- p \rightarrow \pi^- \Sigma^+(1385)$$

a clear violation was detected of these quark model predictions in the most forward direction ($0.0 \leq t' \leq 0.3 \text{ GeV}^2$). The studies were made at the level of transversity amplitudes and complete density matrices. As it is known, the sequential decay of the $\Sigma(1385)$ and the Λ decay asymmetry afford a model independent measurement of the full density matrix as well as an almost complete set of transversity amplitudes. The results of our analysis using the final available sample are given in tables 7 and 8 and figs 13 and 14. In terms of the transversity amplitudes the additive quark model predictions can be written as [19]

$$|T_{\frac{1}{2} \frac{1}{2}}| = |T_{-\frac{1}{2} - \frac{1}{2}}| = 1/\sqrt{2}$$

$$|T_{\frac{3}{2} - \frac{1}{2}}| = |T_{-\frac{3}{2} \frac{1}{2}}| = 0.$$

The data shown in figs 13 and 14 illustrate the size of the observed deviations with respect to these predictions.

In this paper we present a tentative determination of these amplitudes for the reaction $\pi^- p \rightarrow K^0 \Sigma^0(1385)$ using a mass dependent analysis of the sequential $\Sigma^0(1385)$ decay distribution and all the events in the momentum transfer region $0.0 \leq t' \leq 0.3 \text{ GeV}^2$. The following

values of the moduli of the amplitudes were obtained

$$|T_{\frac{1}{2} \frac{1}{2}}| = 0.77 \pm 0.07$$

$$|T_{-\frac{1}{2} -\frac{1}{2}}| = 0.40 \pm 0.10$$

$$|T_{\frac{3}{2} -\frac{1}{2}}| = 0.49 \pm 0.10$$

$$|T_{-\frac{3}{2} \frac{1}{2}}| = 0.11 \pm 0.12$$

which represent a significant disagreement with the quark model predictions.

These results suggest that although the simple quark model reproduces the gross features of the $\pi^- p \rightarrow K^0 \Sigma^0(1385)$ and $K^- p \rightarrow \pi^- \Sigma^+(1385)$ channels, some deviations are detected at low values of t' . These effects have been investigated to some extent in a previous analysis of the reactions $K^- p \rightarrow \pi^+ \Sigma^+(1385)$ in the forward region [5]. It was then suggested that a plausible explanation of the observed effects could be made in terms of the non negligible $I = 3/2$ t channel exchange contribution. The double quark scattering model of Bialas and Zalewski [20] for the $I = 3/2$ exchange process predicts that the double transversity flip amplitudes dominate this type of reaction leading to a value of $\rho_{\frac{1}{2} \frac{1}{2}} = 0.375$.

However, Bialas and Zalewski when formulating their model assumed from the then available experimental information that the cross sections for the corresponding $0_{\frac{1}{2}}^{+} \rightarrow 0_{\frac{1}{2}}^{+}$ processes (e.g. $K^- p \rightarrow \pi^+ \Sigma^-$, $K^- p \rightarrow K^+ \Xi^-$) were zero; this information is invalidated by new results showing significant cross sections for some $0_{\frac{1}{2}}^{+}$ processes [21-22]

We have nevertheless made a determination of the density matrix elements of the $\Sigma^-(1385)$ in the reaction $\pi^- p \rightarrow K^+ \Sigma^-(1385)$ for $t' \leq 0.5 \text{ GeV}^2$ and obtained the values

$$\rho_{\frac{1}{2} \frac{1}{2}} = 0.40 \pm 0.11$$

$$\text{Re } \rho_{\frac{3}{2} -\frac{1}{2}} = -0.03 \pm 0.12$$

$$\text{Re } \rho_{\frac{3}{2} \frac{1}{2}} = -0.18 \pm 0.12$$

which are consistent with the prescription given above. On the other hand the results obtained for the reaction $K^- p \rightarrow \pi^+ \Sigma^-(1385)$, shown in table 9, give values of $\rho_{\frac{1}{2} \frac{1}{2}}$ systematically smaller than the one calculated in the context of the Bialas and Zalewski model. A more detailed investigation of this model requires a determination of the basic transversity amplitudes. A study performed along these lines has been made but due to the limited statistics, the results are rather inconclusive.

5. DISCUSSION OF THE RESULTS

5.1 The $I = 3/2$ t channel exchange amplitude

The amplitudes responsible for the forward production (low t') of the $\Sigma(1385)$ in reactions (1) and (2) can be expressed in terms of amplitudes with well defined isospin in the t channel

$$A(\pi^- p \rightarrow K^0 \Sigma^0(1385)) = \frac{\sqrt{2}}{3} T^{\frac{3}{2}} + \frac{\sqrt{2}}{3} T^{\frac{1}{2}}$$

$$A(\pi^- p \rightarrow K^+ \Sigma^-(1385)) = T^{\frac{3}{2}}.$$

Using the integrated values of the differential cross sections for reactions (1) and (2) for $t' < 0.2 \text{ GeV}^2$ and $t' < 1.0 \text{ GeV}^2$, we obtain the following bounds for the ratio of the amplitudes

$$0.18 \pm 0.02 \leq |T^{\frac{3}{2}}|/|T^{\frac{1}{2}}| \leq 0.29 \pm 0.06 \quad \text{for } t' < 0.2 \text{ GeV}^2$$

$$0.13 \pm 0.02 \leq |T^{\frac{3}{2}}|/|T^{\frac{1}{2}}| \leq 0.17 \pm 0.02 \quad \text{for } t' < 1.0 \text{ GeV}^2 .$$

In the same manner we can write the amplitudes for the reactions (3) and (4) in the form

$$A(K^- p \rightarrow \pi^- \Sigma^+(1385)) = \frac{1}{3} T'^{\frac{3}{2}} + \frac{2}{3} T'^{\frac{1}{2}}$$

$$A(K^- p \rightarrow \pi^+ \Sigma^-(1385)) = T'^{\frac{3}{2}}$$

and calculate a ratio between the t channel isospin amplitudes.

We have obtained the bounds

$$0.12 \pm 0.01 \leq |T'^{\frac{3}{2}}|/|T'^{\frac{1}{2}}| \leq 0.14 \pm 0.01 \quad \text{for } t' < 0.2 \text{ GeV}^2$$

$$0.14 \pm 0.02 \leq |T'^{\frac{3}{2}}|/|T'^{\frac{1}{2}}| \leq 0.16 \pm 0.02 \quad \text{for } t' < 1.0 \text{ GeV}^2$$

which indicate that although, for $t' < 1.0 \text{ GeV}^2$, the ratios obtained using the π^- and K^- reactions are in excellent agreement, the differential behaviour is different; the relative strength of the $I = 3/2$ amplitude with respect to the $I = 1/2$ amplitude is more important in the $\pi^- p \rightarrow K \Sigma(1385)$ reactions than in the $K^- p \rightarrow \pi \Sigma(1385)$ ones for $t' \leq 0.2 \text{ GeV}^2$.

The determination of the ratio between the $I = 3/2$ and $I = 1/2$ t channel amplitudes from the $\pi^- p \rightarrow K^+ \Sigma^-(1385)$ and $\pi^- p \rightarrow K^0 \Sigma^0(1385)$ permits to analyse quantitatively the difference between the cross sections for the processes $\pi^+ p \rightarrow K^+ \Sigma^+(1385)$ and $\pi^- p \rightarrow K^0 \Sigma^0(1385)$. From the form of the amplitude for process (7)

$$A(\pi^+ p \rightarrow K^+ \Sigma^+(1385)) = \frac{1}{3} T'^{\frac{3}{2}} - \frac{2}{3} T'^{\frac{1}{2}}$$

and the bounds obtained for the ratio $|T'^{\frac{3}{2}}|/|T'^{\frac{1}{2}}|$, we have derived the following inequalities

$$- 7.5 \pm 2.5 \text{ } \mu\text{b} \leq \sigma(\pi^+ p \rightarrow K^+ \Sigma^+(1385)) - 2\sigma(\pi^- p \rightarrow K^0 \Sigma^0(1385)) \leq 10.5 \pm 3 \text{ } \mu\text{b} \\ \text{for } t' < 0.2 \text{ GeV}^2$$

$$- 16 \pm 4 \text{ } \mu\text{b} \leq \sigma(\pi^+ p \rightarrow K^+ \Sigma^+(1385)) - 2\sigma(\pi^- p \rightarrow K^0 \Sigma^0(1385)) \leq 20 \pm 5 \text{ } \mu\text{b} \\ \text{for } t' < 1.0 \text{ GeV}^2.$$

The experimental values for these differences, calculated with the π^+p data at 3.7 GeV/c [13], are $-5 \pm 3 \mu\text{b}$ and $-20 \pm 6 \mu\text{b}$. They are consistent with the bounds given above and tend to indicate that the phase difference between the two isospin amplitudes is close to 180 degrees.

Within the large statistical errors and possible systematic effects the data presented here for the channels $\pi^-p \rightarrow K^0\Sigma^0(1385)$, $\pi^-p \rightarrow K^+\Sigma^-(1385)$ and $\pi^+p \rightarrow K^+\Sigma^+(1385)$ appear to be consistent with an important $I = 3/2$ t channel exchange amplitude which is relatively more important at very small values of t' . The contribution of the $I = 3/2$ amplitude is basically of the same order in the processes $\pi^-p \rightarrow K\Sigma(1385)$ and $K^-p \rightarrow \pi\Sigma(1385)$. These results suggest that the $I = 3/2$ t channel exchange amplitude is at the origin of the observed violations of the additive quark model.

5.2 A SU(6) SUM RULE

In the context of the additivity assumption for the quark model and the SU(6) wave functions for baryons, it is possible to relate the cross sections for the hypercharge exchange processes

$$M^- + p \rightarrow M^0 + (\Lambda, \Sigma^0, \Sigma^0(1385)).$$

The standard formulation of the relation among the three cross sections is not in agreement with the available experimental data. Recently a sum rule has been proposed which maintains the amplitude structure implied by additivity but relaxes the SU(6) requirements for the baryon wave function introducing a diquark structure [23]-[24]. The relation which emerges from these considerations

$$\sigma(\Lambda) = f[\sigma(\Sigma^0) + \sigma(\Sigma^0(1385))]$$

with $f \sim 1$ seems to be valid for many reactions.

In fig. 15 we present the results of a similar analysis using data from reactions

$$\pi^-p \rightarrow K^0(\Lambda, \Sigma^0, \Sigma^0(1385)).$$

For the Λ and Σ^0 reactions we have used the differential cross sections measured in this experiment [6]. On the average, we found that our distributions are in agreement with this prescription, although the factor f shows some dependence on the variable t' . It seems to be larger at $t' \approx 0$ and decreases with increasing t' .

Some deviations might however be expected in view of the significant $I = 3/2$ t channel exchange contribution to the $\pi^- p \rightarrow K^0 \Sigma^0(1385)$ reaction since this contribution does not necessarily follow the diquark spectator picture.

5.3 Backward production

In the backward region, $u' \leq 1.0 \text{ GeV}^2$, the processes

$$\pi^- p \rightarrow \Sigma^0(1385)K^0 \quad (1)$$

$$\pi^- p \rightarrow \Sigma^-(1385)K^+ \quad (2)$$

are dominated by the exchange of hyperons with isospin $I = 1$ (reaction (1)) and isospin $I = 0, 1$ (reaction (2)). The cross sections for these processes were given in sect. 3 and are of the order of $1 \mu\text{b}$. These production mechanisms implying the exchange of hyperons are weaker than the ones which go via exotic meson exchanges.

Using the integrated values of the differential cross sections for reactions (1) and (2) in the region $u' \leq 1.0 \text{ GeV}^2$ and using the expressions for the amplitudes

$$A(\pi^- p \rightarrow \Sigma^0(1385)K^0) = \frac{1}{\sqrt{2}} T^1$$

$$A(\pi^- p \rightarrow \Sigma^-(1385)K^+) = \frac{1}{2} T^1 + \frac{1}{\sqrt{6}} T^0$$

we obtain the following limits for the ratio of the amplitudes with isospin $I = 0, 1$ hyperon u channel exchange

$$0.3 \pm 0.1 \leq |T^1|/|T^0| \leq 1.7 \pm 1.4.$$

In a similar way we obtain from the cross sections for the processes

$$K^- p \rightarrow \Sigma^+(1385)\pi^- \quad (3)$$

$$K^- p \rightarrow \Sigma^-(1385)\pi^+ \quad (4)$$

the ratio of the amplitudes with isospin $I = 3/2, 1/2$ baryon u channel exchange

$$0.5 \pm 0.1 \leq |T^{\frac{3}{2}}|/|T^{\frac{1}{2}}| \leq 0.9 \pm 0.3.$$

Within the large errors these results indicate that both possible isospin exchanges contribute to the production mechanisms and are of the same order of magnitude.

6. CONCLUSIONS

In this paper we have presented a study of the processes

$$\pi^- p \rightarrow K^0 \Sigma^0(1385)$$

$$\pi^- p \rightarrow K^+ \Sigma^-(1385)$$

at 3.95 GeV/c. The total and differential cross sections and the $\Sigma(1385)$ density matrix elements have been presented. The large statistics of this experiment has permitted to establish a significant cross section for the process $\pi^- p \rightarrow K^+ \Sigma^-(1385)$ in the forward direction which implies the exchange of exotic meson quantum numbers in the t channel. The observed differences between the reactions $\pi^- p \rightarrow K^0 \Sigma^0(1385)$ and $\pi^+ p \rightarrow K^+ \Sigma^+(1385)$ are quantitatively consistent with these results.

We have updated the data on the reactions

$$K^- p \rightarrow \pi^- \Sigma^+(1385)$$

$$K^- p \rightarrow \pi^+ \Sigma^-(1385)$$

which give complementary evidence for the existence of an important $I = 3/2$ t channel exchange mechanism.

The relative importance of the various isospin exchanges has been calculated for the $\pi^- p \rightarrow K \Sigma(1385)$ and $K^- p \rightarrow \pi \Sigma(1385)$ and small differences are found.

The presence of a significant $I = 3/2$ amplitude seems to be at the origin of the deviations observed when testing the quark model predictions although our data do not support specific calculations of a double quark scattering model. We also compare the processes $\pi^- p \rightarrow K^0 \Lambda$, $K^0 \Sigma^0$ and $K^0 \Sigma^0(1385)$ in the context of a di-quark model and present some results on processes dominated by baryon exchanges.

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TABLE CAPTIONS

- Table 1 Results of the fits to $M(\Lambda\pi)$ vs $M(K\pi)$ diagrams.
- Table 2 Cross sections for the processes $\pi^- p \rightarrow K^0(890)\Lambda$, $K^0(1420)\Lambda$
and $\pi^- p \rightarrow K\Sigma(1385)$.
- Table 3 Forward differential cross section for the reaction
 $\pi^- p \rightarrow K^0\Sigma^0(1385)$.
- Table 4 Forward differential cross section for the reaction $K^- p \rightarrow \pi^- \Sigma^+(1385)$.
- Table 5 Forward differential cross section for the reaction $K^- p \rightarrow \pi^+ \Sigma^-(1385)$.
- Table 6 s channel helicity density matrix elements of the $\Sigma^0(1385)$ in
the reaction $\pi^- p \rightarrow K^0\Sigma^0(1385)$.
- Table 7 s channel transversity amplitudes for the reaction $K^- p \rightarrow \pi^- \Sigma^+(1385)$.
- Table 8 s channel helicity density matrix elements of the $\Sigma^+(1385)$ from
reaction $K^- p \rightarrow \pi^- \Sigma^+(1385)$.
- Table 9 s channel helicity density matrix elements of the $\Sigma^-(1385)$
from reaction $K^- p \rightarrow \pi^+ \Sigma^-(1385)$.

TABLE 1

Parameters (Fractions, ρ_{mm})	Final state	
	$\pi^- p \rightarrow \Lambda K^0 \pi^0$ s	$\pi^- p \rightarrow \Lambda K^+ \pi^-$
%[K(890)]	23.0 $\pm$ 1.6	50.3 $\pm$ 1.0
%[K(1420)]	6.2 $\pm$ 1.5	11.0 $\pm$ 1.0
%[$\Sigma(1385)$]	26.4 $\pm$ 1.5	4.4 $\pm$ 0.5
%[N(1700)]	-	4.7 $\pm$ 0.8
ρ_{00} [K(890)]	0.34 $\pm$ 0.05	0.27 $\pm$ 0.02
ρ_{00} [K(1420)]	0.11 $\pm$ 0.13	0.08 $\pm$ 0.06
ρ_{11} [K(1420)]	0.20 $\pm$ 0.09	0.24 $\pm$ 0.03
ρ_{33} [$\Sigma(1385)$] 22	0.36 $\pm$ 0.03	0.19 $\pm$ 0.06

TABLE 2

Process	Final state	
	$\pi^- p \rightarrow \Lambda K^0 \pi^0$	$\pi^- p \rightarrow \Lambda K^+ \pi^-$
$\pi^- p \rightarrow K^0(890)\Lambda$	49.8 $\pm$ 4.3 μ b	59.7 $\pm$ 2.9 μ b
$\pi^- p \rightarrow K^0(1420)\Lambda$	27.4 $\pm$ 6.8 μ b	26.5 $\pm$ 2.8 μ b
$\pi^- p \rightarrow K\Sigma(1385)$	21.7 $\pm$ 1.7 μ b	4.0 $\pm$ 0.4 μ b

TABLE 3

t' (GeV ²)	$d\sigma/dt'(\mu\text{b/GeV}^2)$
0.0 - 0.1	34.0 ± 8.4
0.1 - 0.2	32.1 ± 8.4
0.2 - 0.3	32.8 ± 7.6
0.3 - 0.4	38.2 ± 7.2
0.4 - 0.5	20.3 ± 6.3
0.5 - 0.7	8.7 ± 3.2
0.7 - 1.0	10.9 ± 2.3

TABLE 4

t' (GeV ²)	$d\sigma/dt'(\mu\text{b/GeV}^2)$
0.00 - 0.05	68.0 ± 4.6
0.05 - 0.10	100.0 ± 5.8
0.10 - 0.15	131.4 ± 7.2
0.15 - 0.20	140.0 ± 7.4
0.20 - 0.25	131.4 ± 7.2
0.25 - 0.30	107.4 ± 6.7
0.30 - 0.35	99.2 ± 6.5
0.35 - 0.40	87.4 ± 6.0
0.40 - 0.45	69.8 ± 5.3
0.45 - 0.50	59.0 ± 5.0
0.50 - 0.55	50.4 ± 4.6
0.55 - 0.60	42.4 ± 4.3
0.60 - 0.65	37.0 ± 3.8
0.65 - 0.70	33.8 ± 3.6
0.70 - 0.75	27.6 ± 3.1
0.75 - 0.80	29.6 ± 3.6
0.80 - 0.85	20.4 ± 2.9
0.85 - 0.90	12.8 ± 2.2
0.90 - 0.95	14.0 ± 2.4
0.95 - 1.00	12.2 ± 2.2
1.00 - 1.10	9.5 ± 1.2
1.10 - 1.20	9.9 ± 1.2
1.20 - 1.40	4.7 ± 0.6
1.40 - 1.65	2.4 ± 0.4
1.65 - 2.00	1.6 ± 0.2

TABLE 5

t' (GeV ²)	$d\sigma/dt'$ (μb/GeV ²)
0.00 - 0.25	5.4 ± 1.5
0.25 - 0.50	2.6 ± 0.7
0.50 - 1.00	0.8 ± 0.3

TABLE 6

t' (GeV ²)	$\rho_{\frac{1}{2} \frac{1}{2}}$	$\text{Re}\rho_{\frac{3}{2} -\frac{1}{2}}$	$\text{Re}\rho_{\frac{3}{2} \frac{1}{2}}$
0.00 - 0.15	$.18 \pm .07$	$.13 \pm .08$	$.08 \pm .07$
0.15 - 0.30	$.12 \pm .05$	$.14 \pm .04$	$.17 \pm .05$
0.30 - 0.45	$.08 \pm .06$	$.10 \pm .07$	$.03 \pm .06$
0.45 - 0.70	$.17 \pm .05$	$.22 \pm .06$	$.10 \pm .08$
0.70 - 1.00	$.01 \pm .11$	$.16 \pm .10$	$-.01 \pm .08$

TABLE 7

$\delta_1(\delta_2)$ are the relative phases between the amplitudes

$T_{\frac{3}{2}-\frac{1}{2}}$ and $T_{-\frac{1}{2}-\frac{1}{2}}$ ($T_{\frac{1}{2}-\frac{1}{2}}$ and $T_{-\frac{3}{2}-\frac{1}{2}}$)

t' (GeV ²)	$T_{\frac{3}{2}-\frac{1}{2}}$	$T_{\frac{1}{2}-\frac{1}{2}}$	$T_{-\frac{1}{2}-\frac{1}{2}}$	$T_{-\frac{3}{2}-\frac{1}{2}}$	δ_1	δ_2
0.00 - 0.05	.27 + .11	.78 + .08	.49 + .10	.27 + .08	2.82 + .46	1.37 + .27
0.05 - 0.10	.21 + .08	.81 + .04	.49 + .07	.24 + .06	2.12 + .39	1.25 + .23
0.00 - 0.15	.23 + .06	.64 + .05	.72 + .05	.14 + .06	2.31 + .24	1.18 + .36
0.15 - 0.20	.09 + .06	.72 + .04	.68 + .05	.11 + .06	3.26 + .69	1.51 + .53
0.20 - 0.25	.12 + .07	.82 + .04	.55 + .06	.11 + .05	2.84 + .50	1.89 + .44
0.25 - 0.30	.02 + .08	.86 + .04	.50 + .07	.11 + .05	.93 + 3.46	2.00 + .47
0.30 - 0.40	.10 + .06	.69 + .04	.71 + .04	.11 + .06	1.98 + .55	2.27 + .51
0.40 - 0.50	.05 + .06	.76 + .04	.65 + .05	.02 + .05	2.19 + 1.11	1.34 + 2.42
0.50 - 0.70	.05 + .05	.72 + .04	.68 + .04	.12 + .06	4.35 + 1.16	2.71 + .42
0.70 - 0.90	.05 + .07	.72 + .06	.69 + .06	.02 + .03	1.62 + 1.40	.92 + 2.89
0.90 - 1.30	.03 + .06	.43 + .09	.90 + .04	.11 + .10	2.54 + 2.03	6.18 + .90
1.30 - 2.00	.11 + .13	.54 + .15	.83 + .10	.07 + .16	1.81 + 1.25	5.43 + 2.35

TABLE 8

$t'(\text{GeV}^2)$	$\rho_{\frac{3}{2}} \frac{1}{2}$	$\rho_{\frac{1}{2}} \frac{1}{2}$	$\text{Re} \rho_{\frac{3}{2}} \frac{1}{2}$	$\text{Im} \rho_{\frac{3}{2}} \frac{1}{2}$	$\text{Re} \rho_{\frac{3}{2}} - \frac{1}{2}$	$\text{Im} \rho_{\frac{3}{2}} - \frac{1}{2}$	$\text{Im} \rho_{\frac{3}{2}} - \frac{3}{2}$	$\text{Im} \frac{1}{2} - \frac{1}{2}$
0.00 - 0.05	.38 $\pm$.04	.12 $\pm$.04	.12 $\pm$.05	-.12 $\pm$.04	.13 $\pm$.04	.08 $\pm$.04	-.07 $\pm$.11	.12 $\pm$.04
0.05 - 0.10	.35 $\pm$.03	.15 $\pm$.03	.14 $\pm$.03	-.12 $\pm$.03	.17 $\pm$.02	.05 $\pm$.03	-.11 $\pm$.06	.11 $\pm$.03
0.10 - 0.15	.39 $\pm$.02	.11 $\pm$.02	.10 $\pm$.02	-.02 $\pm$.03	.16 $\pm$.02	-.02 $\pm$.03	.11 $\pm$.06	.04 $\pm$.03
0.15 - 0.20	.39 $\pm$.02	.11 $\pm$.02	.03 $\pm$.02	-.03 $\pm$.03	.20 $\pm$.02	.04 $\pm$.03	.00 $\pm$.06	.04 $\pm$.03
0.20 - 0.25	.41 $\pm$.02	.09 $\pm$.02	.05 $\pm$.03	-.09 $\pm$.03	.18 $\pm$.02	.03 $\pm$.02	-.13 $\pm$.06	.06 $\pm$.02
0.25 - 0.30	.39 $\pm$.02	.11 $\pm$.02	.05 $\pm$.03	-.09 $\pm$.03	.20 $\pm$.02	.04 $\pm$.03	-.21 $\pm$.05	.05 $\pm$.03
0.30 - 0.40	.40 $\pm$.01	.10 $\pm$.01	.06 $\pm$.02	.01 $\pm$.03	.19 $\pm$.01	.00 $\pm$.04	.01 $\pm$.05	-.01 $\pm$.03
0.40 - 0.50	.38 $\pm$.02	.12 $\pm$.02	.02 $\pm$.02	-.04 $\pm$.03	.21 $\pm$.01	-.01 $\pm$.03	-.04 $\pm$.06	.03 $\pm$.03
0.50 - 0.70	.41 $\pm$.02	.09 $\pm$.02	.00 $\pm$.03	.01 $\pm$.03	.19 $\pm$.02	.03 $\pm$.02	-.05 $\pm$.05	-.02 $\pm$.02
0.70 - 0.90	.37 $\pm$.02	.13 $\pm$.02	.02 $\pm$.03	-.01 $\pm$.04	.22 $\pm$.01	-.01 $\pm$.03	-.01 $\pm$.07	.01 $\pm$.04
0.90 - 1.30	.36 $\pm$.03	.14 $\pm$.03	.01 $\pm$.03	.12 $\pm$.04	.22 $\pm$.01	-.01 $\pm$.04	.26 $\pm$.06	-.04 $\pm$.05
1.30 - 2.00	.38 $\pm$.05	.12 $\pm$.05	.02 $\pm$.08	.08 $\pm$.08	.20 $\pm$.04	-.06 $\pm$.06	.16 $\pm$.15	-.05 $\pm$.08

TABLE 9

$t' \text{ (GeV}^2\text{)}$	$\rho_{\frac{1}{2} \frac{1}{2}}$	$\text{Re}\rho_{\frac{3}{2} -\frac{1}{2}}$	$\text{Re}\rho_{\frac{3}{2} \frac{1}{2}}$
0.00 - 0.25	.23 $\pm$.08	.18 $\pm$.06	-0.01 $\pm$.09
0.25 - 0.50	.05 $\pm$.08	.07 $\pm$.09	-0.01 $\pm$.10
0.50 - 1.00	.13 $\pm$.05	.14 $\pm$.06	-0.04 $\pm$.08

FIGURE CAPTIONS

- Fig. 1 $M(K_S^0\pi^0)$ vs $M(\Lambda\pi^0)$ distribution for the final state $\pi^-p \rightarrow \Lambda K_S^0\pi^0$.
- Fig. 2 $M(K^+\pi^-)$ vs $M(\Lambda\pi^-)$ distribution for the final state $\pi^-p \rightarrow \Lambda K^+\pi^-$.
- Fig. 3 (a),(b),(c) $M(K_S^0\pi^0)$, $M(\Lambda\pi^0)$, $M(\Lambda K_S^0)$ effective mass distributions for the final state $\pi^-p \rightarrow \Lambda K_S^0\pi^0$. The curves are the results of the Dalitz plot fit discussed in the text.
- Fig. 4 (a),(b),(c) $M(K^+\pi^-)$, $M(\Lambda\pi^-)$, $M(\Lambda K^+)$ effective mass distributions for the final state $\pi^-p \rightarrow \Lambda K^+\pi^-$. The curves are the results of the Dalitz plot fit discussed in the text. The shaded histogram of (b) has been obtained antiselecting events with $0.84 \leq M(K^+\pi^-) \leq 0.94$ GeV.
- Fig. 5 s channel helicity polar decay distribution of the $\Lambda\pi^-$ system from channel $\pi^-p \rightarrow \Lambda K^+\pi^-$. Only events with $1.3 \leq M(\Lambda\pi^-) \leq 1.5$ GeV were considered. The shaded area corresponds to events with $0.84 \leq M(K^+\pi^-) \leq 0.94$ GeV.
- Fig. 6 Chew Low distribution $M(\Lambda\pi^0)$ vs $t(p, \Lambda\pi^0)$ for the reaction $\pi^-p \rightarrow \Lambda K_S^0\pi^0$. Events with $0.84 \leq M(K_S^0\pi^0) \leq 0.94$ GeV were removed.
- Fig. 7 Chew Low distribution $M(\Lambda\pi^-)$ vs $t(p, \Lambda\pi^-)$ for the reaction $\pi^-p \rightarrow \Lambda K^+\pi^-$. Events with $0.84 \leq M(K^+\pi^-) \leq 0.94$ GeV were removed.
- Fig. 8 $\Lambda\pi$ effective mass spectra for the channels $\pi^-p \rightarrow \Lambda K_S^0\pi^0$ and $\pi^-p \rightarrow \Lambda K^+\pi^-$
- (a) $\Lambda\pi^0$ for $t' \leq 1.0$ GeV²
 - (b) $\Lambda\pi^0$ for $u' \leq 1.0$ GeV²
 - (c) $\Lambda\pi^-$ for $t' \leq 1.0$ GeV²
 - (d) $\Lambda\pi^-$ for $u' \leq 1.0$ GeV².

The curves show the results of the fits described in the text.
In (c) the events with $0.84 \leq M(K^+\pi^-) \leq 0.94$ GeV were removed.

FIGURE CAPTIONS (Cont'd)

Fig. 9 Forward differential cross sections for the processes $\pi^- p \rightarrow K^0 \Sigma^0(1385)$ at 3.95 GeV/c (open dots), $\pi^+ p \rightarrow K^+ \Sigma^+(1385)$ at 3.7 GeV/c (black squares), $\pi^+ p \rightarrow K^+ \Sigma^+(1385)$ at 4.0 GeV/c (black triangles) and $K^- p \rightarrow \pi^- \Sigma^+(1385)$ at 4.2 GeV/c (black dots). The cross section for the first process has been multiplied by a factor 2.

Fig. 10 $\Lambda\pi^-$ effective mass squared distribution for the channel $\pi^- p \rightarrow \Lambda K^+ \pi^-$.
 (a) for events with $\cos\theta_{\pi^-, K^+}^* \geq 0$
 (b) for events with $\cos\theta_{\pi^-, K^+}^* \leq 0$.
 Events with $0.84 \leq M(K^+ \pi^-) \leq 0.94$ GeV have been removed. The shaded spectra are the same distributions obtained at 4.5 GeV/c [3].

Fig. 11 $\Lambda\pi$ effective mass spectra for the channel $K^- p \rightarrow \Lambda\pi^+ \pi^-$
 (a) $\Lambda\pi^+$ for $t' \leq 1.0$ GeV²
 (b) $\Lambda\pi^+$ for $u' \leq 1.0$ GeV²
 (c) $\Lambda\pi^-$ for $t' \leq 1.0$ GeV²
 (d) $\Lambda\pi^-$ for $u' \leq 1.0$ GeV².

The curves show the results of the fits given in the text.
 In (c) the events with $0.66 \leq M(\pi^+ \pi^-) \leq 0.88$ GeV were removed.

Fig. 12 s channel helicity density matrix elements of the hyperon in the reactions $\pi^- p \rightarrow K^0 \Sigma^0(1385)$ (open dots) and $K^- p \rightarrow \pi^- \Sigma^+(1385)$ (black dots).

Fig. 13 s channel transversity amplitudes for the reaction $K^- p \rightarrow \pi^- \Sigma^+(1385)$. The dotted lines are the predictions of the additive quark model.

FIGURE CAPTIONS (Cont'd)

- Fig. 14 s channel helicity density matrix elements of the $\Sigma^+(1385)$ from reaction $K^- p \rightarrow \pi^- \Sigma^+(1385)$.
- Fig. 15 Differential cross section of the reaction $\pi^- p \rightarrow K^0 \Lambda$ (black dots) and sum of the differential cross sections of the reactions $\pi^- p \rightarrow K^0 \Sigma^0$ and $\pi^- p \rightarrow K^0 \Sigma^0(1385)$ (open circles).

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