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STUDY OF THE REACTIONS $\pi^- p \rightarrow K^0(890) \Lambda$,
 $K^0(890) \Sigma^0$ AND $K^0(890) \Sigma^0(1385)$ AT 3.95 GeV/c

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ABSTRACT

The reactions $\pi^- p \rightarrow K^0(890) \Lambda$, $K^0(890) \Sigma^0$ and $K^0(890) \Sigma^0(1385)$ are studied at an incident momentum of 3.95 GeV/c using data from a high statistics bubble chamber experiment corresponding to ~ 90 events/ μb . The differential cross sections, density matrix elements of the vector meson and hyperon polarizations are presented. A transversity amplitude analysis is performed for each of the reactions. The results are compared with those obtained for the SU(3) related processes $K^- p \rightarrow \phi \Lambda$, $\phi \Sigma^0$, $\phi \Sigma^0(1385)$ and $\rho^- \Sigma^+(1385)$ and with predictions of the additive quark model and SU(6) sum rules.

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1. INTRODUCTION

In this paper we present detailed experimental information on the quasi two-body hypercharge exchange processes

$$\pi^- p \rightarrow K^0(890)\Lambda \quad (A)$$

$$\pi^- p \rightarrow K^0(890)\Sigma^0 \quad (B)$$

$$\pi^- p \rightarrow K^0(890)\Sigma^0(1385) \quad (C)$$

using data from a high statistics hydrogen bubble chamber experiment. These reactions have been investigated earlier in this energy range using the same technique [1]-[3], but the statistical level of this experiment is significantly larger (approximately a factor 3). Some specific properties of these reactions (such as backward production of the process $\pi^- p \rightarrow K^0(890)\Lambda$) have also been investigated with larger data samples in counter techniques.

The dynamical behaviour of these reactions will be investigated in terms of total and differential cross sections and density matrix elements (or polarization) of the vector meson and hyperon resonances. The asymmetric weak decay of the Λ will be used in a model independent way to extract an almost complete set of the transversity amplitudes governing these reactions. All these quantities will be discussed in the context of two-body phenomenology (SU(3) relations, duality and exchange degeneracy, additive quark model, SU(6) sum rules, exchange mechanisms, backward production).

The information presented in this paper complements the detailed studies of several quasi two-body reactions of the type $0^- 1/2^+ \rightarrow 1^- 1/2^+$ and $0^- 1/2^+ \rightarrow 1^- 3/2^+$ performed by the Amsterdam-CERN-Nijmegen-Oxford Collaboration. This collaboration has recently analyzed the processes $K^- p \rightarrow \phi\Lambda$, $\omega\Lambda$, $\rho\Lambda$, $\phi\Sigma^0$ and $\rho\Sigma^0$ at the level of ~ 120 events/ μb [4] and the processes $K^- p \rightarrow \rho^- \Sigma^+(1385)$ and $\phi\Sigma^0(1385)$ at the level of 65 events/ μb [5].

The paper is organized as follows. A brief description of the experimental features of the final states of interest for this study is presented in sect. 2. The total and differential cross sections are given in sect. 3. The results of the transversity amplitude analyses are shown in sect. 4. The density matrix elements of the vector and hyperon resonances are calculated in sect. 5. A summary of the results on the reactions $K^- p \rightarrow \phi \Sigma^0(1385)$ and $K^- p \rightarrow \rho^- \Sigma^+(1385)$ using the final available sample corresponding to approximately 128 events/ μb is given in sect. 6. The comparison of the reactions $\pi^- p \rightarrow K^0(890)$ (Λ , Σ^0 , $\Sigma^0(1385)$) with the SU(3) related process $K^- p \rightarrow \phi(\Lambda$, Σ^0 , $\Sigma^0(1385))$ as well as other phenomenological considerations are presented in sect. 7. Some concluding remarks are made in sect. 8.

In this paper we used for the determination of the physical observables the same methods that were discussed in [4], [5].

2. EXPERIMENTAL DETAILS

The data used for the analysis of the reactions

$$\pi^- p \rightarrow K^0(890) \Lambda \quad (\text{A})$$

$$\pi^- p \rightarrow K^0(890) \Sigma^0 \quad (\text{B})$$

$$\pi^- p \rightarrow K^0(890) \Sigma^0(1385) \quad (\text{C})$$

come from several exposures of the CERN 2 m hydrogen bubble chamber to π^- meson beams of average momentum 3.95 GeV/c. The statistical sensitivity is approximately 90 events/ μb . The events used for this study are found in the two-prong + vee topology. The absolute normalization of all cross sections has been based on a count of interactions and beam tracks inside the fiducial volume.

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

$$\pi^- p \rightarrow \Lambda K^+ \pi^- \quad 3553 \text{ events} \quad (3915 \text{ events}) \quad (1)$$

$$\pi^- p \rightarrow \Sigma^0 K^+ \pi^- \quad 1619 \text{ events} \quad (1765 \text{ events}) \quad (2)$$

$$\pi^- p \rightarrow \Lambda K^+ \pi^- \pi^0 \quad 5003 \text{ events} \quad (5400 \text{ events}) \quad (3)$$

where the quoted numbers 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 decays occurring outside the fiducial volume as well as too close to the production vertex (≤ 3 mm) to be found at the scanning stage.

A large fraction of events fitting the mass assignments corresponding to the final states (1), (2) and (3) are kinematically ambiguous even after utilizing bubble density information. Our procedure for selecting samples of events for the final states (1), (2) and (3) has been the following

(a) $\pi^- p \rightarrow \Lambda K^+ \pi^-$

After imposing a cut of 1% in the χ^2 -probability the only ambiguity left was with the 2-constrained (2C) fit hypothesis $\Sigma^0 K^+ \pi^-$ and 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 the one obtained for the non ambiguous $\Sigma^0 K^+ \pi^-$ events clearly indicates that a large majority of the ambiguous events are indeed $\Lambda K^+ \pi^-$ events. By assigning all the ambiguous events to the $\Lambda K^+ \pi^-$ hypothesis, a contamination of $\sim 1\%$ is introduced.

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

After imposing a cut of 4% in the χ^2 -probability, the ambiguities left were with the 4C hypothesis $\Lambda K^+ \pi^-$ (41% of the sample) and with the 1C hypothesis $\Lambda K^+ \pi^- \pi^0$ (21% of the sample). The ambiguity with the $\Lambda K^+ \pi^-$

was discussed in the previous paragraph and solved in favour of the $4C$ hypothesis. The loss of true $\Sigma^0 K^+ \pi^-$ events into the $\Lambda K^+ \pi^-$ sample was estimated to be of the order of 2% of the final selected sample. To solve the ambiguity with the $\Lambda K^+ \pi^- \pi^0$ channel we have plotted the effective mass squared recoiling against the $K^+ \pi^-$ system, calculated with measured quantities. The distribution obtained using the non ambiguous $\Sigma^0 K^+ \pi^-$ and $\Lambda K^+ \pi^- \pi^0$ events plus the events having only this type of ambiguity is shown in fig. 1. Clear Σ^0 and $\Sigma^0(1385)$ signals are seen. The background is very small especially under the Σ^0 . In view of this it was decided to assign to the $\Sigma^0 K^+ \pi^-$ ($\Lambda K^+ \pi^- \pi^0$) final state the events having a recoiling mass squared to the $K^+ \pi^-$ system smaller (bigger) than 1.62 GeV^2 . This selection attributes 90% and 10% of the ambiguous events to the final states $\Sigma^0 K^+ \pi^-$ and $\Lambda K^+ \pi^- \pi^0$ respectively. The contamination of channel (3) in channel (2) introduced by this procedure is of the order of 1-2% of the finally selected sample.

(c) $\pi^- p \rightarrow \Lambda K^+ \pi^- \pi^0$

After imposing a cut of 2% in the χ^2 probability, 67% of the events gave a unique fit. The main ambiguities affecting the remaining sample were with the hypothesis $\Sigma^0 K^+ \pi^-$ ($\sim 10\%$), $\Lambda \pi^+ \pi^-$ (K^0) ($\sim 20\%$) and $\Lambda \pi^+ \pi^-$ + missing neutrals ($\sim 5\%$). The ambiguity with the $\Sigma^0 K^+ \pi^-$ channel has been discussed in the previous paragraph. The small number of ambiguous events with the multineutral final state (~ 280 events) were assigned to the $\Lambda K^+ \pi^- \pi^0$ channel. The relevant distributions studied agree well with this choice. The remaining contamination is of the order of 1%.

The ambiguity with the $\Lambda \pi^+ \pi^-$ (K^0) hypothesis is more difficult to solve since momentum balance holds independently of the mass assignments. Therefore we concentrated our attention on the missing energies E_m^1 , E_m^2 defined by

$$E_m^1 = E_{\pi^-} + m_p - E_{\Lambda} - E_{K^+} - E_{\pi^-} - E_{\pi^0}$$

$$E_m^2 = E_{\pi^-} + m_p - E_{\Lambda} - E_{\pi^+} - E_{\pi^-} - E_{K^0},$$

where the energies of the particles were calculated using the unfitted momenta and where the π^0 (K^0) momentum was calculated applying momentum conservation. In the absence of significant systematic errors (a possibility which can be reasonably excluded by studying the missing momentum in the 4C fit events) E_m^1 will be centred at ≈ 0 and have a symmetric shape for a real $\pi^- p \rightarrow \Lambda K^+ \pi^- \pi^0$ event, and will be displaced by a given amount Δ_1 for a real $\pi^- p \rightarrow \Lambda \pi^+ \pi^-$ (K^0) event and E_m^2 will be centered at $\approx \Delta_2$ for a real $\pi^- p \rightarrow \Lambda K^+ \pi^- \pi^0$ event and centred around 0 for a real $\pi^- p \rightarrow \Lambda \pi^+ \pi^-$ (K^0) event.

A careful study of the E_m distributions for different selections based on the kinematic probabilities, leads us to the conclusion that the best separation (the one which simultaneously maximizes the number of real $\pi^- p \rightarrow \Lambda K^+ \pi^- \pi^0$ events in the sample and minimizes the contamination from unwanted $\pi^- p \rightarrow \Lambda \pi^+ \pi^-$ (K^0) events) is achieved assigning to the $\Lambda K^+ \pi^- \pi^0$ final state all the events having $P_1(\chi^2) \geq 0.75 P_2(\chi^2)$, where $P_1(\chi^2)$ and $P_2(\chi^2)$ are the kinematic probabilities for the $\Lambda K^+ \pi^- \pi^0$ and $\Lambda \pi^+ \pi^-$ (K^0) hypotheses respectively. With this selection 68% of this kind of ambiguous events were assigned to the hypothesis $\Lambda K^+ \pi^- \pi^0$. We have estimated the contamination in the final sample selected with these criteria to be smaller than 5%.

The cross sections corrected for throughput efficiencies and unseen decay modes were calculated to be

$$\begin{aligned}\sigma(\pi^- p \rightarrow \Lambda K^+ \pi^-) &= 79 \pm 3 \mu\text{b} \\ \sigma(\pi^- p \rightarrow \Sigma^0 K^+ \pi^-) &= 35 \pm 2 \mu\text{b} \\ \sigma(\pi^- p \rightarrow \Lambda K^+ \pi^- \pi^0) &= 106 \pm 5 \mu\text{b}.\end{aligned}$$

3. TOTAL AND DIFFERENTIAL CROSS SECTIONS

The dominant feature of the three-body final states (1) and (2) is strong peripheral production of K(890) and K(1420) resonances, as can be seen in the Dalitz plots, effective mass distributions and Chew-Low plots of

figs 2-7. The total cross sections for the reactions (A) and (B) were calculated by performing fits to the $K^+\pi^-$ mass distributions with a form which included Breit-Wigner functions, with energy dependent widths [6] for the $K(890)$ and $K(1420)$ resonances together with a third order polynomial in the mass for the background. The $K(890)$ and $K(1420)$ resonance parameters were fixed to the values given by the Particle Data Group [7]. The number of $K^0(890)$ and $K^0(1420)$ events obtained in these fits was 2047 ± 58 and 472 ± 36 for reaction (A) and 1074 ± 46 and 170 ± 34 for reaction (B). The production cross sections corrected for Λ unseen decay modes and other meson decay modes were calculated to be

$$\begin{aligned}\sigma(\pi^- p \rightarrow K^0(890)\Lambda) &= 62 \pm 3 \quad \mu\text{b} \\ \sigma(\pi^- p \rightarrow K^0(890)\Sigma^0) &= 32 \pm 2 \quad \mu\text{b} \\ \sigma(\pi^- p \rightarrow K^0(1420)\Lambda) &= 29 \pm 2 \quad \mu\text{b} \\ \sigma(\pi^- p \rightarrow K^0(1420)\Sigma^0) &= 10 \pm 2 \quad \mu\text{b} ,\end{aligned}$$

which are in good agreement with previous measurements in this energy region [1,3].

For further analysis we defined samples of reactions (A) and (B) by imposing the following selection in the $K^+\pi^-$ effective mass distribution

$$0.83 \leq M(K^+\pi^-) \leq 0.96 \text{ GeV}.$$

In this region we obtain 1576 events (1753 weighted events) for reaction (A) and 779 events (855 weighted events) for reaction (B). The background level was estimated to be 9% and 4% respectively. In the determination of the properties of these reactions the background effects were not included.

The differential cross sections were obtained using all the events in the mass region defined above and normalizing to the total cross sections. Using control regions, we have checked that the small background contamination does not affect the shape of the distributions. In figs 8-9 and tables 1-2 we present the differential cross sections in the forward and backward hemispheres. A strong forward peak with a

flattening off at $t' = 0^{(*)}$ is observed in reaction (A). This is in agreement with the data obtained at 4.5 GeV/c [2]. For reaction (B) the forward cross section suggests the possible existence of a dip structure at $t' \sim 0$ GeV². Both reactions show peaks at small u' values indicating the presence of baryon exchange. For reaction (A) the integrated cross section in the u' interval 0.0 - 0.3 GeV² has been measured from 3 to 6 GeV/c at the Argonne ZGS using the effective mass spectrometer facility [8]. At 4 GeV/c they quote a cross section of 2.30 ± 0.39 μ b to be compared with the value 1.9 ± 0.3 μ b obtained in our experiment. A discussion on backward production will be presented in sect. 7.

Evidence for the quasi two-body process

$$K^- p \rightarrow K^0(890) \Sigma^0(1385)$$

is obtained by observing the scatter diagram $M(K^+ \pi^-)$ vs $M(\Lambda \pi^0)$ shown in fig. 10, where an accumulation of events in the cross area $K^0(890) - \Sigma^0(1385)$ is seen. The $M(K^+ \pi^-)$ and $M(\Lambda \pi^0)$ effective mass distributions are presented in fig. 11. Clean signals of $K^0(890)$ and $\Sigma^0(1385)$ resonances are observed. As the shaded histograms of fig. 11 show, these signals are enhanced with respect to the background when the selections

$$1.34 \leq M(\Lambda \pi^0) \leq 1.44 \text{ GeV}$$

or

$$0.84 \leq M(K^+ \pi^-) \leq 0.94 \text{ GeV}$$

are imposed.

(*) $t'(u')$ is defined as $t_{\max} - t$ ($u_{\max} - u$) where $t(u)$ is the square of the four-momentum transfer from the target (beam) to the outgoing Λ , Σ^0 or $\Sigma(1385)$.

To calculate the total cross section of reaction (C) the slicing technique [9] was applied using for the $K^0(890)$ and $\Sigma^0(1385)$ resonances the PDG values and taking into account the experimental resolution. For the reaction (C) 867 ± 80 events were obtained. After correcting for the other decay modes of the $K^0(890)$ and $\Sigma^0(1385)$ the following cross section was obtained

$$\sigma(\pi^- p \rightarrow K^0(890) \Sigma^0(1385)) = 30 \pm 3 \mu\text{b}$$

in good agreement with previous determinations in the same energy range [1-3].

In the sample defined by the simultaneous mass selections given above ($0.84 - 0.94 \text{ GeV}$, $1.34 - 1.44 \text{ GeV}$), the background contamination was calculated to be $29 \pm 7\%$.

In the forward region, $0.0 \leq t' \leq 1.2 \text{ GeV}^2$, the same procedure gives a value of $25 \pm 2 \mu\text{b}$ for the integrated cross section, with a background contamination of $20 \pm 7\%$. The differential cross section for $t' \leq 1.2 \text{ GeV}^2$ was calculated using all the events in the resonance overlap region and the background effects were neglected. The numbers of events so obtained were normalized to the integrated forward cross section calculated with the slicing technique. In fig. 12 and table 3 we present this differential cross section. We have investigated in a simple way the background effects by subtracting from the dN/dt' distribution (N means number of events) for the events in the reaction sample (defined by $0.84 \text{ GeV} \leq M(K\pi) \leq 0.94 \text{ GeV}$ and $1.34 \text{ GeV} \leq M(\Lambda\pi) \leq 1.44 \text{ GeV}$) the same distribution for events in the control regions adjacent to the $\Sigma^0(1385)$ mass band ($0.84 \text{ GeV} \leq M(K\pi) \leq 0.94 \text{ GeV}$; $1.27 \text{ GeV} \leq M(\Lambda\pi) \leq 1.32 \text{ GeV}$ and $1.46 \leq M(\Lambda\pi) \leq 1.51 \text{ GeV}$). Within the statistical errors no significant differences were observed between the shapes of the distributions. No clear flattening off at $t' = 0$ is observed in this differential cross section.

The backward^(*) over total cross section ratios for the reactions (A), (B) and (C) were calculated to be 0.10 ± 0.01 , 0.12 ± 0.01 and 0.10 ± 0.02 respectively.

The slopes of the differential cross sections were measured to be

$$2.4 \pm 0.2 \text{ GeV}^{-2} \quad \text{in } 0.2 \leq t' \leq 1.0 \text{ GeV}^2 \quad \text{for reaction (A)}$$

$$2.3 \pm 0.2 \text{ GeV}^{-2} \quad \text{in } 0.2 \leq t' \leq 1.0 \text{ GeV}^2 \quad \text{for reaction (B)}$$

$$2.1 \pm 0.2 \text{ GeV}^{-2} \quad \text{in } 0.0 \leq t' \leq 1.0 \text{ GeV}^2 \quad \text{for reaction (C)}.$$

The lower limit in the fits of the differential cross sections for the reactions (A) and (B) were chosen in order to eliminate the non-exponential behaviour of these distributions at low t' .

4. TRANSVERSITY AMPLITUDE ANALYSIS

Following the formalism described in [4], we have used the information contained in the joint decay distributions of the processes

$$\begin{array}{l} \pi^- p \rightarrow K^0(890)\Lambda \\ \quad \downarrow \quad \downarrow \\ \quad K^+ \pi^- \quad p \pi^- \\ \\ \pi^- p \rightarrow K^0(890)\Sigma^0 \\ \quad \downarrow \quad \downarrow \\ \quad K^+ \pi^- \quad \Lambda \gamma \\ \quad \quad \quad \downarrow \\ \quad \quad \quad p \pi^- \end{array}$$

to perform a transversity amplitude analysis of the reactions

$\pi^- p \rightarrow K^0(890)\Lambda$ and $\pi^- p \rightarrow K^0(890)\Sigma^0$. As it is known [10], from the decay

(*) The backward cross section was defined as the integrated cross section in the hemisphere $-1.0 \leq \cos\theta \leq 0.0$, where θ is the angle between the incoming π^- and the outgoing $K^0(890)$ measured in the overall centre of mass.

correlations it is possible to determine an almost complete set of amplitudes. In the absence of target polarization information, two quantities remain unmeasurable which are the absolute phases of the two sets of amplitudes (one having initial proton spin up and the other having proton spin down).

In this approach, the basic s channel transversity^(*) amplitudes were obtained by a maximum likelihood analysis of the decay distributions in bins of t' and u' . The regions $t' < 1.5 \text{ GeV}^2$ and $u' < 1.5 \text{ GeV}^2$ were covered by this analysis.

Instead of giving the results of the fits in terms of the s channel transversity amplitudes

$$\left(T_{-+}^{-1}, T_{++}^0, T_{-+}^1 \right), \left(T_{+-}^{-1}, T_{--}^0, T_{+-}^1 \right),$$

(where in T_{mn}^v , n, m and v are the initial proton, the final hyperon and the final vector meson transversities respectively), we have used Byers-Yang amplitudes [11] which are related to them in the following way

$$\begin{aligned} a_{\pm} &= - T_{\pm\pm}^0 \\ b_{\pm} &= \pm \frac{1}{\sqrt{2}} \left(T_{\mp\pm}^1 + T_{\mp\pm}^{-1} \right) \\ c_{\pm} &= \pm \frac{i}{\sqrt{2}} \left(-T_{\mp\pm}^1 + T_{\mp\pm}^{-1} \right). \end{aligned}$$

In the forward region and to order $1/s$, $a_{\pm}$ project out the natural parity contribution to the production of helicity 1 $K^0(890)$, whereas $b_{\pm}$ and $c_{\pm}$ correspond to the production via unnatural parity exchange of the $K^0(890)$ in the helicity 0 and 1 states respectively.

The results are presented in figs 13 and 14 and in tables 4 and 5. Ambiguous solutions may occur [4], in which case both are given. Notice that the phases are relative and that the following normalization condition has been used

$$|a_+|^2 + |a_-|^2 + |b_+|^2 + |b_-|^2 + |c_+|^2 + |c_-|^2 = d\sigma/dt' (= d\sigma/du').$$

(*) The z axis in the transversity frame is perpendicular to the production plane, and the y axis is parallel to the direction of the hyperon.

As it was discussed in [5], it is possible to extract from the information contained in the six angle joint decay distribution of the process

the moduli of the twelve transversity amplitudes describing the process and ten relative phases between these amplitudes. These 22 quantities fully summarize all the information that can be obtained from the study of the decay correlations. The method of analysis, as well as the approximations, notations and checks on the goodness and uniqueness of the solutions follow the ones described in [5]. Due to the limited statistics we have used all the events in the forward momentum transfer region ($0.0 \leq t' \leq 1.2 \text{ GeV}^2$) and in the reaction sample (sect. 3) to extract the 22 parameters. The background contamination was not taken into account in the analysis. However, all the experimental distributions were well described by the projections of the fit. The values of the amplitudes obtained in this manner are listed in table 6. The moduli of the amplitudes are normalized according to the prescription

$$\sum_{mn} |T_{mn}^v|^2 = 1.$$

5. SPIN DENSITY MATRICES AND POLARIZATION

From the fitted transversity amplitudes T_{mn}^v we have constructed the full spin density matrix in the s channel transversity reference frame

$$\rho_{mm'}^{vv'} = \sum_n T_{mn}^v T_{m'n}^{v'*}.$$

The density matrix in the corresponding s channel helicity reference frame was calculated via the transformation

$$H_{\rho_{ss'}}^{rr'} = \sum_{vv'mm'} D_{rv}^1(-R) D_{sm}^J(-R) T_{\rho_{mm'}}^{vv'} D_{m's'}^J(R) D_{v'r'}^1(R) ,$$

where R represents a rotation with Euler angles $(\pi/2, \pi/2, \pi/2)$ and $J = 1/2$ for reactions (A), (B) and $J = 3/2$ for reaction (C). Using the normalization condition

$$\sum_{mnv} |T_{mn}^v|^2 = 1$$

we obtain the trace condition for the density matrix

$$\sum_{rs} \rho_{ss}^{rr} = 1 .$$

From the complete density matrix we can calculate the single vector and hyperon density matrix elements

$$\rho^{rr'} = \sum_s \rho_{ss}^{rr'} .$$

$$\rho_{ss'} = \sum_r \rho_{ss'}^{rr} .$$

In the forward region and to order $1/s$ the s channel helicity density matrix elements ρ_{00} and $\rho_- = \rho_{11} - \rho_{1-1}$ project out the unnatural parity exchange contribution to the production of the helicity 0 and 1 states respectively, whereas $\rho_+ = \rho_{11} + \rho_{1-1}$ corresponds to the production of the helicity 1 state via natural parity exchange.

The hyperon polarization was constructed from the amplitudes according to

$$P = \frac{2 \sum_{mnv} m |T_{mn}^v|^2}{\sum_{mnv} |T_{mn}^v|^2} .$$

The polarization can be separated into contributions from the three different exchange sectors (natural parity exchange, unnatural parity exchange, meson helicity 0 and meson helicity 1 respectively).

For reactions (A) and (B) these contributions can be expressed in terms of Byers Yang amplitudes according to

$$P_N^1 = \frac{|a_+|^2 - |a_-|^2}{|a_+|^2 + |a_-|^2}$$

$$P_U^0 = \frac{|b_-|^2 - |b_+|^2}{|b_+|^2 + |b_-|^2}$$

$$P_U^1 = \frac{|c_-|^2 - |c_+|^2}{|c_+|^2 + |c_-|^2} .$$

Notice that each of these quantities is normalized so that the allowed range is -1 to +1 and that

$$\rho_{00} P_U^0 + \rho_- P_U^1 + \rho_+ P_N^1 = P .$$

The density matrix elements of the $K^0(890)$ and the hyperon polarization in the reactions (A) and (B) are presented in figs 15-18 and in tables 7-10. For reaction (C) the $K^0(890)$ and $\Sigma^0(1385)$ density matrix elements are given in figs 19-20 and in tables 11 and 12. For this reaction we have calculated the average polarization in the t' intervals $0.0 \leq t' \leq 0.4$ and $0.4 \leq t' \leq 1.2 \text{ GeV}^2$ and obtained the values 0.08 ± 0.09 and 0.36 ± 0.12 respectively.

The contributions to the differential cross section from natural parity exchange ($\sigma_+ = (\rho_{11} + \rho_{1-1}) d\sigma/dt'$) and unnatural parity exchange ($\sigma_0 = \rho_{00} d\sigma/dt'$ and $\sigma_- = (\rho_{11} - \rho_{1-1}) d\sigma/dt'$) for the reactions (A), (B) and (C) are presented in table 13.

6. REACTIONS $K^- p \rightarrow \phi \Sigma^0(1385)$ and $K^- p \rightarrow \rho^- \Sigma^+(1385)$ AT 4.2 GeV/c

In this section we present results for reactions

$$K^- p \rightarrow \phi \Sigma^0(1385) \quad (D)$$

$$K^- p \rightarrow \rho^- \Sigma^+(1385) \quad (E)$$

using the final data sample obtained by the Amsterdam-CERN-Nijmegen-Oxford Collaboration and which corresponds to approximately 128 events/ μb . The results presented here were obtained using similar methods to the ones discussed in [5] and which were used in the study of reaction (C).

For the final state

$$K^- p \rightarrow \Lambda K^+ K^- \pi^0$$

the number of events satisfying the various selection criteria described in [5] was 3926 which corresponds to 4301 weighted events. The total cross section for the process (D) calculated with the slicing technique and corrected for vector meson and hyperon unseen decay modes was

$$\sigma(K^- p \rightarrow \phi \Sigma^0(1385)) = 27 \pm 3 \mu\text{b}.$$

In the forward momentum transfer region $0.0 \leq t' \leq 1.2 \text{ GeV}^2$ the integrated cross section was calculated to be $25 \pm 3 \mu\text{b}$. The differential cross section and the ϕ and $\Sigma^0(1385)$ density matrix elements are given in tables 3, 11 and 12.

For the final state

$$K^- p \rightarrow \Lambda \pi^+ \pi^- \pi^0$$

the number of events obtained after applying the selection criteria of [4] were 62 503 (69 342 weighted events). The total cross section for the process (E) was calculated with the slicing technique. The

value $91 \pm 5 \mu\text{b}$ was obtained. In the forward direction ($0.0 \leq t' \leq 1.2 \text{ GeV}^2$) the integrated cross section was measured to be $71 \pm 3 \mu\text{b}$ and the background in the sample, defined by $0.66 \leq M(\pi^-\pi^0) \leq 0.88 \text{ GeV}$, $1.34 \leq M(\Lambda\pi^+) \leq 1.44 \text{ GeV}$, was estimated to be $19 \pm 2\%$. In tables 14, 15 and 16 we give the values of the differential cross section and the ρ^- and $\Sigma^+(1385)$ helicity density matrix elements.

In the relations derived from SU(3) and exchange degeneracy, which will be discussed in sect. 7.1.3, the reaction entering in the equality is $K^-p \rightarrow \rho^0\Sigma^0(1385)$. Assuming $I = 1/2$ t channel isospin exchange, the cross section for this process is $1/4$ of the cross section for the cleaner reaction $K^-p \rightarrow \rho^-\Sigma^+(1385)$. We have checked that there is no significant $I = 3/2$ t channel isospin exchange by measuring the forward cross section in the region $0.0 \leq t' \leq 1.2 \text{ GeV}^2$ of the process $K^-p \rightarrow \rho^+\Sigma^-(1385)$. A two standard deviation upper limit of $1 \mu\text{b}$ was obtained. In view of this, we will use in the discussion on exchange degeneracy, the equality $2\sigma(K^-p \rightarrow \rho^0\Sigma^0(1385)) = \frac{1}{2}\sigma(K^-p \rightarrow \rho^-\Sigma^+(1385))$.

7. DISCUSSION OF RESULTS

7.1 Forward Production

7.1.1 Exchange mechanisms

The Byers-Yang amplitudes presented in figs 13 and 14 and tables 4 and 5 clearly indicate that whereas both natural and unnatural parity exchanges are important for the process $\pi^-p \rightarrow K^0(890)\Lambda$, the natural parity exchange is the dominant production mechanism for the reaction $\pi^-p \rightarrow K^0(890)\Sigma^0$. These observations are expected within the SU(6) framework [12] which predicts small couplings of the unnatural parity trajectories to the $p\Sigma^0$ baryon vertex [4].

At small t' our data show a turnover in the natural parity exchange amplitudes a_- and a_+ for the reactions (A) and (B) respectively. This is a consequence of the fact that these amplitudes correspond mainly to

helicity flip $n = 1^{(*)}$, which should vanish like $\sqrt{t'}$ in the forward direction. On the other hand the unnatural parity exchange amplitude b_- for reaction (A) is peaked at $t' = 0$.

The forms of the natural parity exchange amplitudes $a_{\pm}$ of reactions (A) and (B) are very similar if we exchange a_- and a_+ when going from one to the other. Since in the quark model the strange quark has its spin parallel to the Λ spin but antiparallel to the Σ^0 spin our observation indicates that the quark amplitudes [13] for natural parity exchange are very similar in the two reactions.

In figs 21 and 22 we summarize for several reactions in which a vector meson is produced recoiling against a Λ or Σ^0 hyperon the contributions to the differential cross sections due to natural ($\sigma_+ = (\rho_{11} + \rho_{1-1}) d\sigma/dt'$) and unnatural ($\sigma_0 = \rho_{00} d\sigma/dt'$, $\sigma_- = (\rho_{11} - \rho_{1-1}) d\sigma/dt'$) parity exchange mechanisms. The remarks made in the previous paragraphs give the general trend of these distributions.

For the reaction $\pi^- p \rightarrow K^0(890) \Sigma^0(1385)$, the data shown in fig. 23 indicate that the unnatural parity contribution to forward production is large and has a steeper t' dependence than the natural part.

7.1.2 SU(3) and factorization

Using SU(3) and factorization it is possible to derive relations among reactions exchanging the same particles in the t channel. This is, for example, the case for the hypercharge exchange processes under study. At the level of the spin amplitudes $F_{\{\lambda\}}$ ($\{\lambda\}$ refers to helicity or transversity indices) the following equality can be derived

$$F_{\{\lambda\}}(K^- p \rightarrow \phi Y) = - F_{\{\lambda\}}(\pi^- p \rightarrow K^0(890) Y)$$

where

$$Y = \Lambda, \Sigma^0 \text{ or } \Sigma^0(1385).$$

(*) The helicity flip n for the reaction $1 + 2 \rightarrow 3 + 4$ is defined by $n = |\lambda_1 - \lambda_3 - \lambda_2 + \lambda_4|$.

These equalities assume that there is no $I = 3/2$ t channel exchange contributions. For the $\pi^- p \rightarrow K(890)\Sigma$ and $K(890)\Sigma(1385)$ we observe small but significant $I = 3/2$ t channel exchange amplitudes. This implies that we cannot expect that the above equations for Σ^0 and $\Sigma^0(1385)$ will be satisfied better than within $\sim 20\%$.

For reactions involving a Λ or Σ^0 in the final state these relations have been extensively studied in the past [2,3,4,9,14-17]. Most of the analyses used differential cross sections and density matrix elements although for the Λ reactions some comparison in terms of the moduli of the Byers-Yang amplitudes [17] or transversity amplitudes [3] have been made.

In this paper we compare the reactions

$$K^- p \rightarrow \phi\Lambda \quad \text{and} \quad \pi^- p \rightarrow K^0(890)\Lambda$$

$$K^- p \rightarrow \phi\Sigma^0 \quad \text{and} \quad \pi^- p \rightarrow K^0(890)\Sigma^0$$

at the level of the Byers-Yang amplitudes. For the $K^- p$ reactions we used the data from the ACNO Collaboration [4] which has a statistical sensitivity of ~ 120 events/ μb . The values of the amplitudes for these reactions are shown in figs 24 and 25. The comparison of these distributions with those given in figs 13 and 14 shows very good overall agreement between the two sets of amplitudes. A χ^2 test gives $\chi^2/N_{\text{DF}} = 65/70$ and $39/50$ for the Λ and Σ^0 reactions respectively. We observe however two small but significant discrepancies. The a_- amplitude for the $\phi\Lambda$ reaction has a smaller slope than that of the $K^0(890)\Lambda$ reaction for $t' > 0.6 \text{ GeV}^2$. This effect is more clearly seen in fig. 21(a). We have checked that this effect is not caused by deficiencies in the background subtractions and it can also be observed in the comparison of the total differential cross sections. Discrepancies are also observed between the reactions $K^- p \rightarrow \omega\Lambda$ and $K^- p \rightarrow \rho\Lambda$ [4]. The other effect concerns the phases $\delta(b_+, a_+)$ for the Σ^0 reactions which appear to have different values.

In a previous publication [5] this SU(3) relation was also investigated for the reactions involving the $\Sigma^0(1385)$ although using smaller samples (~ 65 events/ μb for the $K^- p$ reaction and ~ 25 events/ μb for the $\pi^- p$

reaction). In this paper we perform a more detailed comparison of the reactions

$$\bar{K}^- p \rightarrow \phi \Sigma^0(1385) \text{ and } \pi^- p \rightarrow K^0(890) \Sigma^0(1385)$$

using for the $\bar{K}^- p$ reaction the updated data discussed in sect. 6. In the forward region $0.0 \leq t' \leq 1.2 \text{ GeV}^2$ the integrated cross sections were calculated to be $25 \pm 3 \text{ } \mu\text{b}$ and $25 \pm 2 \text{ } \mu\text{b}$ respectively. The shapes of the differential cross sections presented in fig. 26 show excellent agreement. The values of the vector meson and hyperon density matrix elements measured in both reactions and given in tables 11 and 12 and figs 19 and 20 show also good agreement although some differences are observed for ρ_{1-1} .

A more detailed test of this SU(3) prediction can be made in terms of the transversity amplitudes governing these two processes.

Due to limited statistics, we have been forced to extract average values of the amplitudes in the overall momentum transfer region $0.0 \leq t' \leq 1.2 \text{ GeV}^2$. With the values listed in table 6, we have compared the moduli and phases of the amplitudes using a χ^2 test. For the 12 moduli the χ^2 was 7, whereas for the 10 phases we got a χ^2 of 15. Again this result confirms the approximate validity of the SU(3) prediction.

7.1.3 SU(3) and exchange degeneracy

Assuming SU(3), factorization and exchange degeneracy of the exchanged Regge poles, one obtains the following relations between ω or ρ production and ϕ or $K(890)$ productions

$$\sigma(\pi^- p \rightarrow K^0(890)Y) = \sigma(K^- p \rightarrow \phi Y) = 2\sigma(K^- p \rightarrow \omega Y) = 2\sigma(K^- p \rightarrow \rho Y)$$

where

$$Y = \Lambda, \Sigma^0, \Sigma^0(1385).$$

For the Λ and Σ^0 reactions this relation has been studied by the ACNO collaboration [4].

In this paper we have extended this analysis to the reactions involving the production of $\Sigma(1385)$. In fig. 26 we present the differential cross sections for the "real" reaction (described by a non-planar duality diagram) $\bar{K}^- p \rightarrow \rho^0 \Sigma^0(1385)$ (sect. 6) and for the "rotating" reactions

(described by planar duality diagrams) $\pi^- p \rightarrow K^0(890) \Sigma^0(1385)$ and $K^- p \rightarrow \phi \Sigma^0(1385)$. The "real" reaction has a larger cross section than the "rotating" ones, the difference essentially being due to the larger unnatural parity cross section (in both the helicity 0 and 1 states) of the $K^- p \rightarrow \rho \Sigma(1385)$ reaction as the distributions given in fig. 23 show. Within the large errors the exchange degeneracy predictions are satisfied by the cross sections due to natural parity exchange.

The pattern of exchange degeneracy breaking observed in the $\Sigma(1385)$ reactions is different from the one observed in the Λ and Σ^0 processes.

For the Λ reactions (fig. 21) the discrepancies with the exchange degeneracy predictions appear in both the σ_+ and σ_0 cross sections, whereas for the Σ^0 reactions (fig. 22) the deviations are smaller, concentrated at very low values of t' and appearing in σ_+ (which accounts for almost all the cross section).

7.1.4 Additive quark model

In this section we present the results of a test of the quark model predictions for the reaction $\pi^- p \rightarrow K^0(890) \Sigma^0(1385)$. In terms of the $K^0(890)$ and $\Sigma^0(1385)$ helicity density matrix elements these relations can be expressed in the following way [13]

$$\text{Class A : } \rho_{11} + \rho_{1-1} = \frac{4}{3} \rho_{\frac{3}{2} \frac{3}{2}} + \frac{4}{\sqrt{3}} \rho_{\frac{3}{2} -\frac{1}{2}} \quad (\text{A1})$$

$$\text{Class B : } \rho_{11} = \frac{4}{3} \rho_{\frac{3}{2} \frac{3}{2}} \quad (\text{B1})$$

$$\rho_{1-1} = \frac{4}{\sqrt{3}} \text{Re } \rho_{\frac{3}{2} -\frac{1}{2}} \quad (\text{B2})$$

$$\rho_{10} = \frac{4}{\sqrt{6}} \rho_{\frac{3}{2} \frac{1}{2}} \quad (\text{B3})$$

$$\text{Class C : } \text{Re } \rho_{\frac{3}{2} \frac{1}{2}} = 0 \quad (\text{C1})$$

$$\text{Re } \rho_{10} = 0 \quad (\text{C2})$$

The results of the study of the equalities (A1) - (B1) - (B2) - (B3) is shown in fig. 27. Agreement is observed within the errors. Relation (C2) is also in good agreement with the data. Equality (C1) seems to be less well satisfied (figs 19(b) and 20(c) respectively).

For completeness we have performed a χ^2 test to check the compatibility of the data with the class A relations involving the moduli of the transversity amplitudes

$$\begin{aligned}
 T^0_{-\frac{3}{2} \frac{1}{2}} &= 0 \\
 T^0_{\frac{3}{2} -\frac{1}{2}} &= 0 \\
 T^0_{\frac{1}{2} \frac{1}{2}} &= T^0_{-\frac{1}{2} -\frac{1}{2}} \\
 T^1_{\frac{3}{2} \frac{1}{2}} &= \sqrt{3} T^1_{\frac{1}{2} -\frac{1}{2}} \\
 T^1_{-\frac{1}{2} \frac{1}{2}} &= \frac{1}{\sqrt{3}} T^1_{-\frac{3}{2} -\frac{1}{2}} \\
 T^{-1}_{\frac{3}{2} \frac{1}{2}} &= \sqrt{3} T^{-1}_{\frac{1}{2} -\frac{1}{2}} \\
 T^{-1}_{-\frac{1}{2} \frac{1}{2}} &= \frac{1}{\sqrt{3}} T^{-1}_{-\frac{3}{2} -\frac{1}{2}} .
 \end{aligned}$$

A χ^2 of 12 was obtained indicating good agreement of the data with the class A predictions. A more detailed analysis along these lines has recently been performed for the $K^- p \rightarrow \rho^- \Sigma^+(1385)$ reaction and the relations given by the additive quark model were found to be satisfied by the data [5].

The results discussed above and the studies made on other reactions of the type $0^- 1/2^+ \rightarrow 1^- 3/2^+$ (such as $\pi^+ p \rightarrow \rho^0 \Delta^{++}$, $\pi^+ p \rightarrow \omega \Delta^{++}$) indicate that the very simple quark model reproduces the gross features of this class of reactions.

7.1.5 A SU(6) sum rule

In 7.1.2 we have investigated some predictions derived from SU(3) and factorization for reactions having the same baryon vertex. These predictions can also be derived in the context of the additive quark model. Similar arguments can also be applied to the meson vertex in the hypercharge exchange reaction

$$M^- + p \rightarrow M^0 + \text{neutral hyperon},$$

where M^0 is any neutral meson and the neutral hyperon is a three quark state with zero orbital angular momentum (Λ , Σ^0 , $\Sigma^0(1385)$).

Recently a sum rule has been proposed which maintains the amplitude structure implied by additivity but relaxes the SU(6) requirement for the baryon wave function introducing a diquark structure [18]-[19]. This relation

$$\sigma(\Lambda) \sim \sigma(\Sigma^0) + \sigma(\Sigma^0(1385))$$

has been successfully investigated for different reactions. Amongst these, for the hypercharge exchange processes

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

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

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

In fig. 28 we present the results of a similar analysis using the data from reactions

$$\pi^- p \rightarrow K^0(890) (\Lambda, \Sigma^0, \Sigma^0(1385)).$$

We found that our distributions are in agreement with this relation.

7.2 Backward production

A considerable amount of data on backward $\pi^- p \rightarrow K^0(890)\Lambda$ production has recently been presented and discussed in terms of differential cross sections and Λ polarization. Measurements have been performed at 3, 4, 5 and 6 GeV/c [8], 8 and 10.7 GeV/c [20,21]. The differential cross sections for the reactions $\pi^- p \rightarrow K^0(890)\Lambda$ and $\pi^- p \rightarrow K^0(890)\Sigma^0$ in this experiment have been presented in tables 1 and 2 and figs 8 and 9. We have determined the production amplitudes in the interval $0.0 \leq u \leq 1.5 \text{ GeV}^2$ as described in sect. 4, and they are shown in tables 4 and 5. From these we obtained the $K^0(890)$ density matrix elements and the hyperon polarization presented in tables 7-10.

Our data for the Λ reaction is in good agreement with the data obtained at 4.0 GeV/c [8]. As can be seen in tables 9 and 10 the polarizations for the Λ and Σ^0 in the backward region are again opposite, the Λ now being positively polarized. The positive Λ polarization supports the conclusion of ref. [21], which reports similar measurements at 8 GeV/c on this reaction, that backward production of $\pi^- p \rightarrow K^0(890)\Lambda$ is dominated by unnatural parity exchange, Σ_β or Σ_δ .

8. CONCLUSIONS

In this paper we have presented a detailed analysis of the hypercharge exchange reactions $\pi^- p \rightarrow K^0(890)\Lambda$, $K^0(890)\Sigma^0$ and $K^0(890)\Sigma^0(1385)$ at 3.95 GeV/c incident momentum. The statistical sensitivity of this experiment is three times larger than that previously available at this energy. The data has been discussed in terms of total and differential cross sections, hyperon polarizations and vector meson helicity density matrix elements. The asymmetric weak decay of the Λ hyperon detected in the final state has permitted to reconstruct in a model independent way the transversity (or Byers Yang) amplitudes governing these processes. In the forward region we have measured the relative importance of the natural and unnatural parity t channel exchange contributions. The three reactions show very different behaviour. The Σ^0 reaction is dominated

by natural parity exchange, the $\Sigma^0(1385)$ process has a larger contribution from unnatural parity exchange and the Λ reaction presents important contributions from both types of mechanisms. The SU(3) and quark model predictions for reactions having the same baryon vertex have been tested and are in good agreement with the data. The failure of exchange degeneracy already known for the Λ and Σ^0 reactions has been observed when the $\Sigma(1385)$ is produced. The relation between the Λ , Σ^0 and $\Sigma^0(1385)$ reactions has also been investigated in the context of a recently proposed sum rule.

In the backward region the Λ and Σ^0 reactions have substantial cross sections indicating baryon exchange. The positive polarization of the Λ indicates that for $\pi^- p \rightarrow K^0(890)\Lambda$ unnatural parity exchange is dominating at small u' .

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TABLE CAPTIONS

- Table 1 Differential cross sections for the reaction $\pi^- p \rightarrow K^0(890)\Lambda$.
- Table 2 Differential cross sections for the reaction $\pi^- p \rightarrow K^0(890)\Sigma^0$.
- Table 3 Differential cross sections for the reactions $\pi^- p \rightarrow K^0(890)\Sigma^0(1385)$ and $K^- p \rightarrow \phi \Sigma^0(1385)$.
- Table 4 Byers-Yang amplitudes for the reaction $\pi^- p \rightarrow K^0(890)\Lambda$. Units are $(\mu\text{b}/\text{GeV}^2)^{\frac{1}{2}}$ and radians for moduli and phases respectively.
- Table 5 Byers-Yang amplitudes for the reaction $\pi^- p \rightarrow K^0(890)\Sigma^0$. Units are $(\mu\text{b}/\text{GeV}^2)^{\frac{1}{2}}$ and radians for moduli and phases respectively.
- Table 6 s channel transversity amplitudes for the reactions $\pi^- p \rightarrow K^0(890)\Sigma^0(1385)$ and $K^- p \rightarrow \phi \Sigma^0(1385)$.
- Table 7 Density matrix elements of the $K^0(890)$ in the s channel helicity frame in the reaction $\pi^- p \rightarrow K^0(890)\Lambda$.
- Table 8 Density matrix elements of the $K^0(890)$ in the s channel helicity frame, in the reaction $\pi^- p \rightarrow K^0(890)\Sigma^0$.
- Table 9 Polarization and polarization components of the Λ in the reaction $\pi^- p \rightarrow K^0(890)\Lambda$.
- Table 10 Polarization and polarization components of the Σ^0 in the reaction $\pi^- p \rightarrow K^0(890)\Sigma^0$.
- Table 11 Density matrix elements of the $K^0(890)(\phi)$ in the s channel helicity frame in the reaction $\pi^- p \rightarrow K^0(890)\Sigma^0(1385)$ ($K^- p \rightarrow \phi \Sigma^0(1385)$).
- Table 12 Density matrix elements of the $\Sigma^0(1385)$ in the s channel helicity frame in the reactions $\pi^- p \rightarrow K^0(890)\Sigma^0(1385)$ and $K^- p \rightarrow \phi \Sigma^0(1385)$.

TABLE CAPTIONS (Cont'd)

Table 13 Natural and unnatural parity exchange contributions to the differential cross section: (a) for the reaction $\pi^- p \rightarrow K^0(890)\Lambda$, (b) for the reaction $\pi^- p \rightarrow K^0(890)\Sigma^0$ and (c) for the reaction $\pi^- p \rightarrow K^0(890)\Sigma^0(1385)$.

Table 14 Differential cross section for the reaction $K^- p \rightarrow \rho^- \Sigma^+(1385)$.

Table 15 Density matrix elements of the ρ^- in the s channel helicity frame in the reaction $K^- p \rightarrow \rho^- \Sigma^+(1385)$.

Table 16 Density matrix elements of the $\Sigma^+(1385)$ in the s channel helicity frame in the reaction $K^- p \rightarrow \rho^- \Sigma^+(1385)$.

TABLE 1

t' (GeV ²)	$\frac{d\sigma}{dt'}$ ($\mu\text{b}/\text{GeV}^2$)	u' (GeV ²)	$\frac{d\sigma}{du'}$ ($\mu\text{b}/\text{GeV}^2$)
0.00 - 0.05	96.3 $\pm$ 9.3	0.00 - 0.10	8.4 $\pm$ 1.9
0.05 - 0.10	98.9 $\pm$ 9.4	0.10 - 0.20	5.1 $\pm$ 1.4
0.10 - 0.15	95.3 $\pm$ 9.2	0.20 - 0.30	5.2 $\pm$ 1.5
0.15 - 0.20	93.1 $\pm$ 9.1	0.30 - 0.40	5.6 $\pm$ 1.6
0.20 - 0.25	85.5 $\pm$ 8.6	0.40 - 0.60	3.7 $\pm$ 0.9
0.25 - 0.30	81.0 $\pm$ 8.4	0.60 - 0.80	2.2 $\pm$ 0.7
0.30 - 0.35	71.1 $\pm$ 7.8	0.80 - 1.10	1.7 $\pm$ 0.5
0.35 - 0.40	60.5 $\pm$ 7.1	1.10 - 1.40	1.5 $\pm$ 0.5
0.40 - 0.45	48.3 $\pm$ 6.3	1.40 - 1.70	1.5 $\pm$ 0.5
0.45 - 0.50	35.9 $\pm$ 5.4	1.70 - 2.10	1.1 $\pm$ 0.4
0.50 - 0.55	40.8 $\pm$ 5.8	2.10 - 2.50	1.1 $\pm$ 0.3
0.55 - 0.60	31.6 $\pm$ 5.1		
0.60 - 0.65	22.1 $\pm$ 4.2		
0.65 - 0.70	29.4 $\pm$ 4.9		
0.70 - 0.75	32.4 $\pm$ 5.1		
0.75 - 0.80	20.6 $\pm$ 4.1		
0.80 - 0.85	20.6 $\pm$ 4.1		
0.85 - 0.90	13.6 $\pm$ 3.3		
0.90 - 0.95	20.8 $\pm$ 4.1		
0.95 - 1.00	16.9 $\pm$ 3.6		
1.00 - 1.05	16.1 $\pm$ 3.6		
1.05 - 1.10	8.5 $\pm$ 2.6		
1.10 - 1.15	13.6 $\pm$ 3.3		
1.15 - 1.20	7.6 $\pm$ 2.4		
1.20 - 1.30	5.8 $\pm$ 1.5		
1.30 - 1.40	4.2 $\pm$ 1.3		
1.40 - 1.55	2.8 $\pm$ 0.9		
1.55 - 1.75	1.9 $\pm$ 0.6		
1.75 - 2.10	1.2 $\pm$ 0.4		
2.10 - 2.65	1.1 $\pm$ 0.3		

TABLE 2

t' (GeV ²)	$\frac{d\sigma}{dt'} (\mu\text{b}/\text{GeV}^2)$	u' (GeV ²)	$\frac{d\sigma}{dt'} (\mu\text{b}/\text{GeV}^2)$
0.00 - 0.05	32.4 $\pm$ 5.4	0.00 - 0.20	4.6 $\pm$ 1.0
0.05 - 0.10	30.6 $\pm$ 5.2	0.20 - 0.40	2.3 $\pm$ 0.7
0.10 - 0.15	51.0 $\pm$ 6.9	0.40 - 0.80	1.4 $\pm$ 0.4
0.15 - 0.20	35.4 $\pm$ 5.6	0.80 - 1.10	1.5 $\pm$ 0.5
0.20 - 0.25	45.4 $\pm$ 6.5	1.10 - 1.60	0.9 $\pm$ 0.3
0.25 - 0.30	42.0 $\pm$ 6.2	1.60 - 2.10	0.8 $\pm$ 0.3
0.30 - 0.35	33.6 $\pm$ 5.5	2.10 - 2.50	1.2 $\pm$ 0.4
0.35 - 0.40	31.2 $\pm$ 5.3		
0.40 - 0.45	29.1 $\pm$ 5.1		
0.45 - 0.50	27.9 $\pm$ 5.0		
0.50 - 0.55	21.9 $\pm$ 4.3		
0.55 - 0.60	24.3 $\pm$ 4.6		
0.60 - 0.65	20.5 $\pm$ 4.2		
0.65 - 0.70	16.3 $\pm$ 3.7		
0.70 - 0.75	12.3 $\pm$ 3.2		
0.75 - 0.80	12.1 $\pm$ 3.2		
0.80 - 0.85	8.0 $\pm$ 2.6		
0.85 - 0.90	9.7 $\pm$ 2.8		
0.90 - 0.95	11.6 $\pm$ 3.2		
0.95 - 1.00	8.2 $\pm$ 2.6		
1.00 - 1.05	11.9 $\pm$ 3.2		
1.05 - 1.15	4.5 $\pm$ 1.4		
1.15 - 1.30	2.8 $\pm$ 0.9		
1.30 - 1.50	2.1 $\pm$ 0.7		
1.50 - 1.85	1.4 $\pm$ 0.4		
1.85 - 2.55	1.2 $\pm$ 0.3		

TABLE 3

t' (GeV ²)	$\pi^- p \rightarrow K^0(890)\Sigma^0(1385)$	$K^- p \rightarrow \phi\Sigma^0(1385)$
	$d\sigma/dt'$ ($\mu\text{b}/\text{GeV}^2$)	$d\sigma/dt'$ ($\mu\text{b}/\text{GeV}^2$)
0.00 - 0.05	52.7 ± 8.4	58.6 ± 7.3
0.05 - 0.10	42.0 ± 7.7	38.5 ± 6.4
0.10 - 0.15	44.5 ± 8.0	43.1 ± 6.4
0.15 - 0.20	33.7 ± 6.7	37.5 ± 6.4
0.20 - 0.30	31.7 ± 4.9	33.9 ± 4.2
0.30 - 0.40	30.0 ± 4.7	26.1 ± 3.6
0.40 - 0.50	21.4 ± 3.9	23.8 ± 3.7
0.50 - 0.60	21.8 ± 4.0	19.2 ± 3.2
0.60 - 0.70	15.2 ± 2.9	12.8 ± 2.7
0.70 - 0.80	12.3 ± 2.7	12.8 ± 2.7
0.80 - 1.00	7.9 ± 1.5	9.2 ± 1.6
1.00 - 1.20	4.7 ± 1.2	6.7 ± 1.4

TABLE 4

t' (GeV ²)	a_+	b_+	c_+	a_-	b_-	c_-
0.0 - 0.1	1.82 ± 1.31	1.34 ± 1.65	3.16 ± 0.83	6.31 ± 0.52	6.07 ± 0.49	2.44 ± 0.93
0.1 - 0.2	1.96 ± 1.67	0.97 ± 1.00	3.15 ± 0.70	6.97 ± 0.55	5.16 ± 0.44	2.43 ± 0.68
0.2 - 0.3	3.02 ± 1.09	3.43 ± 0.82	2.22 ± 0.99	6.17 ± 0.62	2.86 ± 0.91	3.61 ± 0.69
0.3 - 0.4	0.48 ± 1.18	1.91 ± 1.08	1.75 ± 1.11	5.63 ± 0.40	3.47 ± 0.60	4.09 ± 0.55
0.4 - 0.6	2.02 ± 0.75	2.06 ± 0.59	0.33 ± 1.67	4.32 ± 0.39	1.95 ± 0.64	2.99 ± 0.36
0.6 - 0.8	0.64 ± 0.72	1.79 ± 0.52	1.69 ± 0.79	3.11 ± 0.34	1.79 ± 0.49	2.60 ± 0.48
0.8 - 1.0	0.53 ± 1.32	0.59 ± 1.36	0.23 ± 1.31	2.41 ± 0.40	2.60 ± 0.40	2.15 ± 0.33
1.0 - 1.5	0.71 ± 0.56	1.00 ± 0.38	0.91 ± 0.47	1.36 ± 0.34	1.53 ± 0.27	0.82 ± 0.46
Alternative solution						
1.0 - 1.5	0.54 ± 0.49	0.93 ± 0.39	0.81 ± 0.47	1.45 ± 0.26	1.57 ± 0.25	0.91 ± 0.39
t' (GeV ²)	$\delta(b_+, a_+)$	$\delta(b_+, c_+)$	$\delta(c_+, a_+)$	$\delta(b_-, a_-)$	$\delta(b_-, c_-)$	$\delta(c_-, a_-)$
0.0 - 0.1	1.72 ± 1.47	1.97 ± 1.16	-0.25 ± 0.85	1.27 ± 0.30	1.19 ± 0.37	0.08 ± 0.34
0.1 - 0.2	1.53 ± 4.13	3.11 ± 2.21	-1.58 ± 2.91	1.46 ± 0.33	0.00 ± 1.08	1.46 ± 0.95
0.2 - 0.3	-2.73 ± 0.72	-1.72 ± 0.57	-1.01 ± 0.72	2.01 ± 0.47	0.73 ± 0.47	1.28 ± 0.38
0.3 - 0.4	-3.11 ± 2.42	-2.89 ± 1.55	-0.22 ± 2.51	2.19 ± 0.32	1.02 ± 0.31	1.17 ± 0.28
0.4 - 0.6	-1.22 ± 0.94	1.04 ± 3.01	-2.26 ± 2.73	2.20 ± 0.37	1.28 ± 0.35	0.92 ± 0.34
0.6 - 0.8	-2.87 ± 1.07	-0.45 ± 1.58	-2.42 ± 1.76	3.06 ± 0.40	2.50 ± 0.49	0.55 ± 0.46
0.8 - 1.0	-2.90 ± 2.93	1.20 ± 5.61	2.18 ± 5.11	2.54 ± 0.40	1.85 ± 0.26	0.69 ± 0.45
1.0 - 1.5	-2.24 ± 1.17	-1.45 ± 0.79	-0.79 ± 0.77	2.67 ± 0.73	1.70 ± 0.59	0.97 ± 0.51
Alternative solution						
1.0 - 1.5	1.19	1.31	-0.40 ± 0.94	2.52 ± 0.48	1.57 ± 0.47	0.95 ± 0.42

TABLE 4 (Cont'd)

u' (GeV ²)	a_+	b_+	c_+	a_-	b_-	c_-
0.0 - 0.5	1.51 ± 0.27	0.82 ± 0.41	0.30 ± 0.48	0.79 ± 0.44	0.72 ± 0.48	1.32 ± 0.24
0.5 - 1.5	0.54 ± 0.25	0.52 ± 0.29	0.42 ± 0.21	0.51 ± 0.23	0.81 ± 0.24	0.46 ± 0.26
u' (GeV ²)	$\delta(b_+, a_+)$	$\delta(b_+, c_+)$	$\delta(c_+, a_+)$	$\delta(b_-, a_-)$	$\delta(b_-, c_-)$	$\delta(c_-, a_-)$
0.0 - 0.5	1.27 ± 0.83	1.76 ± 1.57	$- 0.49 \pm 1.44$	$- 2.37 \pm 1.13$	$- 2.52 \pm 0.81$	0.15 ± 0.83
0.5 - 1.5	1.91 ± 1.56	$- 3.00 \pm 1.01$	$- 1.38 \pm 1.80$	$- 2.45 \pm 1.00$	0.63 ± 1.04	$- 3.09 \pm 1.20$

TABLE 5

t' (GeV ²)	a_+	b_+	c_+	a_-	b_-	c_-
0.0 - 0.2	4.96 ± 0.33	2.13 ± 0.79	0.76 ± 0.97	0.53 ± 1.97	1.94 ± 0.90	1.89 ± 0.56
0.2 - 0.4	5.33 ± 0.54	2.00 ± 0.44	0.44 ± 0.91	1.55 ± 1.72	0.42 ± 1.01	1.96 ± 0.45
0.4 - 0.6	4.76 ± 0.28	0.93 ± 0.99	0.15 ± 0.86	0.39 ± 1.80	1.01 ± 0.89	1.20 ± 0.38
0.6 - 1.0	3.41 ± 0.17	0.19 ± 0.40	0.77 ± 0.33	0.30 ± 1.80	0.02 ± 0.38	0.02 ± 1.17
1.0 - 1.5	1.67 ± 0.20	0.23 ± 0.48	0.43 ± 0.27	0.21 ± 0.74	0.79 ± 0.29	0.12 ± 0.46
Alternative solution						
0.4 - 0.6	4.76 ± 0.26	0.98 ± 1.00	0.19 ± 0.90	0.24 ± 1.99	0.96 ± 0.99	1.20 ± 0.39
t' (GeV ²)	$\delta(b_+, a_+)$	$\delta(b_+, c_+)$	$\delta(c_+, a_+)$	$\delta(b_-, a_-)$	$\delta(b_-, c_-)$	$\delta(c_-, a_-)$
0.0 - 0.2	- 3.01 ± 0.70	- 0.47 ± 1.70	- 2.54 ± 1.52	- 2.57 ± 3.70	2.90 ± 2.04	0.81 ± 4.30
0.2 - 0.4	- 1.46 ± 0.72	- 3.11 ± 3.17	1.65 ± 3.23	1.12 ± 4.27	0.26 ± 4.04	0.86 ± 2.93
0.4 - 0.6	- 1.88 ± 1.26	- 2.50 ± 5.68	0.62 ± 5.96	2.47 ± 4.62	2.19 ± 1.25	0.28 ± 4.67
0.6 - 1.0	1.28 ± 1.78	- 2.31 ± 1.98	- 2.70 ± 1.37	- 1.00 ± 20.65	- 2.91 ± 79.83	1.91 ± 76.10
1.0 - 1.5	0.18 ± 1.90	1.66 ± 2.18	- 1.48 ± 1.02	- 0.03 ± 3.19	- 0.65 ± 4.84	0.63 ± 5.46
Alternative solution						
0.4 - 0.6	- 1.92 ± 1.19	- 2.43 ± 4.71	0.50 ± 4.95	1.01 ± 7.86	- 2.14 ± 1.30	- 3.14 ± 7.97

TABLE 5 (Cont'd)

u' (GeV ²)	a_+	b_+	c_+	a_-	b_-	c_-
0.0 - 1.5	0.18 ± 0.55	0.38 ± 0.51	0.30 ± 0.48	0.98 ± 0.14	0.67 ± 0.28	0.39 ± 0.31
Alternative solution						
0.0 - 1.5	0.34 ± 0.53	0.47 ± 0.46	0.35 ± 0.32	0.94 ± 0.22	0.62 ± 0.34	0.35 ± 0.28
u' (GeV ²)	$\delta(b_+, a_+)$	$\delta(b_+, c_+)$	$\delta(c_+, a_+)$	$\delta(b_-, a_-)$	$\delta(b_-, c_-)$	$\delta(c_-, a_-)$
0.0 - 1.5	0.04 ± 4.80	1.73 ± 2.51	-1.69 ± 3.46	-2.90 ± 0.98	0.81 ± 1.05	2.57 ± 0.87
Alternative solution						
0.0 - 1.5	2.42 ± 1.85	-1.55 ± 1.29	-2.32 ± 1.62	-3.00 ± 1.08	0.73 ± 1.12	2.55 ± 0.95

TABLE 6

	$\pi^- p \rightarrow K^0(890)\Sigma^0(1385)$ (552 events)	$K^- p \rightarrow \phi\Sigma^0(1385)$ (505 events)
T_{31}^1	$.56 \pm .04$	$.62 \pm .04$
T_{-11}^1	$.17 \pm .07$	$.05 \pm .07$
T_{11}^0	$.50 \pm .04$	$.36 \pm .07$
T_{-31}^0	$.11 \pm .06$	$.04 \pm .05$
T_{31}^{-1}	$.07 \pm .05$	$.05 \pm .05$
T_{-11}^{-1}	$.14 \pm .08$	$.13 \pm .06$
T_{1-1}^1	$.36 \pm .06$	$.40 \pm .06$
T_{-3-1}^1	$.20 \pm .08$	$.23 \pm .09$
T_{3-1}^0	$.20 \pm .09$	$.25 \pm .08$
T_{-1-1}^0	$.29 \pm .12$	$.36 \pm .08$
T_{1-1}^{-1}	$.10 \pm .07$	$.11 \pm .08$
T_{-3-1}^{-1}	$.27 \pm .13$	$.23 \pm .02$
δ_{-11}^1	$4.89 \pm .52$	0.32 ± 2.12
δ_{11}^0	$1.14 \pm .24$	$1.34 \pm .43$
δ_{-31}^0	$5.84 \pm .74$	$5.73 \pm .62$
δ_{31}^{-1}	$5.86 \pm .84$	4.90 ± 1.86
δ_{-11}^{-1}	$6.02 \pm .80$	$1.44 \pm .80$
δ_{-3-1}^1	$3.33 \pm .53$	$4.39 \pm .64$
δ_{3-1}^0	$3.77 \pm .57$	$2.61 \pm .55$
δ_{-1-1}^0	$4.56 \pm .98$	$1.38 \pm .83$
δ_{1-1}^{-1}	$4.05 \pm .96$	4.11 ± 1.04
δ_{-3-1}^{-1}	$4.05 \pm .39$	$5.23 \pm .66$

TABLE 7

t' (GeV ²)	ρ_{00}	ρ_{1-1}	$\text{Re}\rho_{10}$
0.0 - 0.1	0.40 ± 0.05	0.14 ± 0.04	0.03 ± 0.03
0.1 - 0.2	0.29 ± 0.04	0.19 ± 0.04	0.07 ± 0.02
0.2 - 0.3	0.23 ± 0.05	0.17 ± 0.04	0.05 ± 0.03
0.3 - 0.4	0.23 ± 0.05	0.09 ± 0.05	0.04 ± 0.03
0.4 - 0.6	0.20 ± 0.04	0.17 ± 0.04	0.04 ± 0.03
0.6 - 0.8	0.25 ± 0.06	0.01 ± 0.06	$- 0.03 \pm 0.04$
0.8 - 1.0	0.40 ± 0.08	0.04 ± 0.06	$- 0.06 \pm 0.05$
1.0 - 1.5	0.46 ± 0.08	0.06 ± 0.06	$- 0.01 \pm 0.05$
u' (GeV ²)			
0.0 - 0.5	0.20 ± 0.07	0.09 ± 0.08	$- 0.10 \pm 0.04$
0.5 - 1.5	0.50 ± 0.13	0.05 ± 0.08	0.03 ± 0.06

TABLE 8

t' (GeV ²)	ρ_{00}	ρ_{1-1}	$\text{Re}\rho_{10}$
0.0 - 0.2	0.22 ± 0.05	0.28 ± 0.04	$- 0.04 \pm 0.03$
0.2 - 0.4	0.11 ± 0.04	0.34 ± 0.04	0.00 ± 0.02
0.4 - 0.6	0.07 ± 0.04	0.41 ± 0.04	$- 0.02 \pm 0.03$
0.6 - 1.0	0.00 ± 0.01	0.45 ± 0.04	$- 0.01 \pm 0.02$
1.0 - 1.5	0.18 ± 0.10	0.36 ± 0.07	0.01 ± 0.05
u' (GeV ²)			
0.0 - 1.5	0.33 ± 0.09	0.20 ± 0.08	0.06 ± 0.05

TABLE 9

t' (GeV^2)	P	P_N	P_U^0	P_U^1
0.0 - 0.1	$- 0.06 \pm 0.14$	$- 0.85 \pm 0.22$	0.91 ± 0.23	$- 0.25 \pm 0.55$
0.1 - 0.2	$- 0.24 \pm 0.14$	$- 0.85 \pm 0.25$	0.93 ± 0.14	$- 0.26 \pm 0.41$
0.2 - 0.3	$- 0.29 \pm 0.16$	$- 0.61 \pm 0.28$	$- 0.18 \pm 0.50$	0.45 ± 0.47
0.3 - 0.4	$- 0.14 \pm 0.14$	$- 0.99 \pm 0.14$	0.53 ± 0.49	0.69 ± 0.38
0.4 - 0.6	$- 0.16 \pm 0.15$	$- 0.64 \pm 0.26$	$- 0.05 \pm 0.57$	0.98 ± 0.24
0.6 - 0.8	$- 0.21 \pm 0.19$	$- 0.92 \pm 0.18$	0.00 ± 0.51	0.41 ± 0.51
0.8 - 1.0	0.30 ± 0.19	$- 0.91 \pm 0.46$	0.90 ± 0.45	0.98 ± 0.26
1.0 - 1.5	$- 0.03 \pm 0.24$	$- 0.58 \pm 0.67$	0.39 ± 0.44	$- 0.11 \pm 1.01$
u' (GeV^2)				
0.0 - 0.5	0.53 ± 0.26			
0.5 - 1.5	0.24 ± 0.32			

TABLE 10

t' (GeV^2)	P	P_N	P_U^0	P_U^1
0.0 - 0.2	0.71 ± 0.15	0.98 ± 0.17	$- 0.10 \pm 0.79$	0.72 ± 0.72
0.2 - 0.4	0.66 ± 0.27	0.84 ± 0.34	$- 0.92 \pm 0.40$	0.90 ± 0.40
0.4 - 0.6	0.92 ± 0.16	0.99 ± 0.12	0.09 ± 1.83	0.97 ± 0.37
0.6 - 1.0	0.88 ± 0.15	0.99 ± 0.18	$- 0.98 \pm 0.73$	$- 1.00 \pm 0.12$
1.0 - 1.5	0.85 ± 0.22	0.97 ± 0.22	0.84 ± 0.67	$- 0.87 \pm 1.01$
u' (GeV^2)				
0.0 - 1.5	$- 0.31 \pm 0.47$			

TABLE 11

t' (GeV ²)	$\pi^- p \rightarrow K^0(890)\Sigma^0(1385)$			$K^- p \rightarrow \phi\Sigma^0(1385)$		
	ρ_{00}	$\text{Re}\rho_{10}$	ρ_{1-1}	ρ_{00}	$\text{Re}\rho_{10}$	ρ_{1-1}
0.0 - 0.1	.41 $\pm$.08	- .05 $\pm$.04	.05 $\pm$.06	.41 $\pm$.08	.06 $\pm$.05	.06 $\pm$.06
0.1 - 0.2	.41 $\pm$.08	- .03 $\pm$.04	.13 $\pm$.06	.33 $\pm$.09	- .06 $\pm$.07	- .06 $\pm$.05
0.2 - 0.3	.21 $\pm$.07	- .04 $\pm$.05	- .01 $\pm$.07	.26 $\pm$.07	.11 $\pm$.05	.11 $\pm$.07
0.3 - 0.4	.26 $\pm$.08	- .06 $\pm$.05	.20 $\pm$.07	.39 $\pm$.10	- .07 $\pm$.07	- .02 $\pm$.08
0.4 - 0.6	.40 $\pm$.07	.05 $\pm$.05	.08 $\pm$.06	.26 $\pm$.08	- .02 $\pm$.05	- .08 $\pm$.07
0.6 - 0.8	.32 $\pm$.08	- .01 $\pm$.06	.13 $\pm$.07	.61 $\pm$.10	.00 $\pm$.05	- .04 $\pm$.07
0.8 - 1.2	.52 $\pm$.09	.13 $\pm$.06	- .05 $\pm$.07	.32 $\pm$.09	.02 $\pm$.05	.05 $\pm$.07

TABLE 12

t' (GeV ²)	$\pi^- p \rightarrow K^0(890)\Sigma^0(1385)$			$K^- p \rightarrow \phi\Sigma^0(1385)$		
	$\rho_{\frac{1}{2}\frac{1}{2}}$	$\text{Re}\rho_{\frac{3}{2}-\frac{1}{2}}$	$\text{Re}\rho_{\frac{3}{2}\frac{1}{2}}$	$\rho_{\frac{1}{2}\frac{1}{2}}$	$\text{Re}\rho_{\frac{3}{2}-\frac{1}{2}}$	$\text{Re}\rho_{\frac{3}{2}\frac{1}{2}}$
0.0 - 0.1	.25 $\pm$.05	.04 $\pm$.05	.00 $\pm$.05	.33 $\pm$.05	- .03 $\pm$.05	.06 $\pm$.06
0.1 - 0.2	.31 $\pm$.06	- .07 $\pm$.05	.09 $\pm$.06	.32 $\pm$.06	- .03 $\pm$.05	.08 $\pm$.06
0.2 - 0.3	.34 $\pm$.05	.08 $\pm$.06	.06 $\pm$.05	.28 $\pm$.07	- .03 $\pm$.06	.08 $\pm$.07
0.3 - 0.4	.32 $\pm$.07	- .02 $\pm$.07	.10 $\pm$.07	.43 $\pm$.07	- .02 $\pm$.07	.06 $\pm$.07
0.4 - 0.6	.24 $\pm$.05	.09 $\pm$.06	.04 $\pm$.05	.23 $\pm$.06	.00 $\pm$.06	.13 $\pm$.05
0.6 - 0.8	.15 $\pm$.06	.06 $\pm$.07	.05 $\pm$.06	.25 $\pm$.08	- .01 $\pm$.08	- .08 $\pm$.08
0.8 - 1.2	.17 $\pm$.06	- .20 $\pm$.06	.07 $\pm$.08	.25 $\pm$.06	- .12 $\pm$.07	.05 $\pm$.07

TABLE 13

t' (GeV ²)	σ_+ ($\mu\text{b}/\text{GeV}^2$)	σ_0 ($\mu\text{b}/\text{GeV}^2$)	σ_- ($\mu\text{b}/\text{GeV}^2$)
(a) $\pi^- p \rightarrow K^0(890)\Lambda$			
0.0 - 0.1	43.1 ± 5.4	38.7 ± 5.1	15.9 ± 4.0
0.1 - 0.2	52.4 ± 5.7	27.7 ± 4.5	15.8 ± 3.9
0.2 - 0.3	47.3 ± 5.4	20.0 ± 4.1	17.9 ± 3.8
0.3 - 0.4	31.9 ± 4.4	15.7 ± 3.7	19.8 ± 3.8
0.4 - 0.6	22.7 ± 2.6	8.0 ± 1.9	9.0 ± 1.9
0.6 - 0.8	10.1 ± 1.9	6.4 ± 1.6	9.6 ± 1.9
0.8 - 1.0	6.1 ± 1.4	7.1 ± 1.5	4.7 ± 1.3
1.0 - 1.5	2.4 ± 0.6	3.3 ± 0.6	1.5 ± 0.5
(b) $\pi^- p \rightarrow K^0(890)\Sigma^0$			
0.0 - 0.2	24.9 ± 2.7	8.3 ± 1.9	4.1 ± 1.6
0.2 - 0.4	30.8 ± 2.9	4.2 ± 1.6	4.0 ± 1.6
0.4 - 0.6	22.9 ± 2.4	1.9 ± 1.2	1.5 ± 0.9
0.6 - 1.0	11.7 ± 1.7	0.0 ± 0.1	0.6 ± 0.5
1.0 - 1.5	2.9 ± 0.6	0.7 ± 0.4	0.2 ± 0.2
(c) $\pi^- p \rightarrow K^0(890)\Sigma^0(1385)$			
0.0 - 0.1	16.4 ± 3.3	19.4 ± 4.5	11.6 ± 3.6
0.1 - 0.2	16.6 ± 3.5	16.0 ± 3.8	6.5 ± 2.9
0.2 - 0.3	12.2 ± 2.1	6.7 ± 2.4	12.8 ± 2.9
0.3 - 0.4	17.1 ± 3.7	7.8 ± 2.7	5.1 ± 2.5
0.4 - 0.6	8.2 ± 1.8	8.6 ± 1.8	4.8 ± 1.6
0.6 - 0.8	6.5 ± 1.4	4.4 ± 1.3	2.9 ± 1.2
0.8 - 1.2	1.2 ± 0.5	3.3 ± 0.7	1.8 ± 0.5

TABLE 14

t' (GeV ²)	$d\sigma/dt'$ ($\mu\text{b}/\text{GeV}^2$)
.00 - .02	267.0 ± 19.8
.02 - .04	218.0 ± 17.6
.04 - .07	187.7 ± 13.6
.07 - .10	139.3 ± 11.3
.10 - .15	131.1 ± 9.0
.15 - .20	97.8 ± 7.5
.20 - .25	76.8 ± 6.5
.25 - .30	76.8 ± 6.5
.30 - .35	77.6 ± 6.5
.35 - .40	52.8 ± 5.2
.40 - .45	60.4 ± 5.6
.45 - .50	55.8 ± 5.4
.50 - .55	43.8 ± 4.7
.55 - .60	48.6 ± 5.0
.60 - .70	32.5 ± 2.9
.70 - .80	31.0 ± 2.9
.80 - .90	23.7 ± 2.5
.90 - 1.00	25.8 ± 2.6
1.00 - 1.10	24.2 ± 2.5
1.10 - 1.20	19.6 ± 2.2

TABLE 15

t' (GeV ²)	ρ_{00}	$\text{Re}\rho_{10}$	ρ_{1-1}
.00 - .02	.59 $\pm$.05	.04 $\pm$.03	.00 $\pm$ 0.4
.02 - .04	.68 $\pm$.05	.13 $\pm$.03	- .07 $\pm$.03
.04 - .07	.43 $\pm$.05	.12 $\pm$.03	- .03 $\pm$.04
.07 - .10	.61 $\pm$.05	.13 $\pm$.04	- .04 $\pm$.04
.10 - .15	.51 $\pm$.04	.19 $\pm$.03	- .09 $\pm$.03
.15 - .20	.46 $\pm$.05	.19 $\pm$.03	- .09 $\pm$.04
.20 - .25	.48 $\pm$.06	.22 $\pm$.03	- .16 $\pm$.04
.25 - .30	.45 $\pm$.06	.21 $\pm$.03	- .14 $\pm$.04
.30 - .35	.49 $\pm$.05	.21 $\pm$.03	- .08 $\pm$.05
.35 - .40	.38 $\pm$.06	.19 $\pm$.04	- .22 $\pm$.05
.40 - .45	.39 $\pm$.06	.23 $\pm$.03	.03 $\pm$.06
.45 - .50	.26 $\pm$.06	.16 $\pm$.03	- .11 $\pm$.06
.50 - .55	.23 $\pm$.06	.20 $\pm$.04	- .10 $\pm$.06
.55 - .60	.20 $\pm$.07	.17 $\pm$.04	- .19 $\pm$.06
.60 - .70	.42 $\pm$.06	.18 $\pm$.04	- .12 $\pm$.05
.70 - .80	.33 $\pm$.06	.20 $\pm$.04	- .13 $\pm$.05
.80 - .90	.36 $\pm$.07	.20 $\pm$.04	- .09 $\pm$.06
.90 - 1.00	.24 $\pm$.06	.14 $\pm$.04	- .05 $\pm$.06
1.00 - 1.10	.31 $\pm$.07	.18 $\pm$.04	- .09 $\pm$.06
1.10 - 1.20	.10 $\pm$.06	.12 $\pm$.04	- .02 $\pm$.07

TABLE 16

t' (GeV ²)	$\rho_{\frac{1}{2}\frac{1}{2}}$	$\text{Re}\rho_{\frac{3}{2}\frac{1}{2}}$	$\text{Re}\rho_{\frac{3}{2}-\frac{1}{2}}$
.00 - .02	.35 $\pm$.04	- .03 $\pm$.03	.03 $\pm$.03
.02 - .04	.36 $\pm$.04	.05 $\pm$.04	- .01 $\pm$.04
.04 - .07	.34 $\pm$.04	- .02 $\pm$.04	.00 $\pm$.03
.07 - .10	.39 $\pm$.04	.08 $\pm$.04	- .11 $\pm$.03
.10 - .15	.29 $\pm$.03	.08 $\pm$.03	.02 $\pm$.03
.15 - .20	.34 $\pm$.04	.06 $\pm$.04	- .08 $\pm$.03
.20 - .25	.34 $\pm$.04	.07 $\pm$.04	- .11 $\pm$.04
.25 - .30	.29 $\pm$.04	.14 $\pm$.04	- .16 $\pm$.04
.30 - .35	.24 $\pm$.04	.10 $\pm$.04	.02 $\pm$.04
.35 - .40	.30 $\pm$.05	.11 $\pm$.05	- .04 $\pm$.05
.40 - .45	.26 $\pm$.05	.20 $\pm$.04	- .02 $\pm$.05
.45 - .50	.21 $\pm$.05	- .01 $\pm$.05	- .07 $\pm$.05
.50 - .55	.18 $\pm$.05	.10 $\pm$.05	- .06 $\pm$.06
.55 - .60	.22 $\pm$.05	.15 $\pm$.05	- .04 $\pm$.05
.60 - .70	.23 $\pm$.04	.14 $\pm$.04	.01 $\pm$.05
.70 - .80	.32 $\pm$.04	.22 $\pm$.05	- .03 $\pm$.04
.80 - .90	.17 $\pm$.05	.05 $\pm$.05	- .01 $\pm$.06
.90 - 1.00	.22 $\pm$.05	.13 $\pm$.05	- .22 $\pm$.05
1.00 - 1.10	.19 $\pm$.05	.14 $\pm$.05	- .02 $\pm$.05
1.10 - 1.20	.08 $\pm$.05	.02 $\pm$.05	- .04 $\pm$.06

FIGURE CAPTIONS

- Fig. 1 Distribution of effective mass squared recoiling against the $K^+\pi^-$ system for events of the final states $\Sigma^0 K^+\pi^-$ and/or $\Lambda K^+\pi^-\pi^0$ (unique and ambiguous events).
- Fig. 2 $M^2(K^+\pi^-)$ vs $M^2(\Lambda\pi^-)$ distribution for reaction $\pi^-p \rightarrow \Lambda K^+\pi^-$.
- Fig. 3 (a), (b) and (c) $K^+\pi^-$, $\Lambda\pi^-$ and ΛK^+ effective mass distributions for reaction $\pi^-p \rightarrow \Lambda K^+\pi^-$.
- Fig. 4 $M^2(K^+\pi^-)$ vs $t_{p-\Lambda}$ distribution for reaction $\pi^-p \rightarrow \Lambda K^+\pi^-$.
- Fig. 5 $M^2(K^+\pi^-)$ vs $M^2(\Sigma^0\pi^-)$ distribution for reaction $\pi^-p \rightarrow \Sigma^0 K^+\pi^-$.
- Fig. 6 (a), (b) and (c) $K^+\pi^-$, $\Sigma^0\pi^-$ and $\Sigma^0 K^+$ effective mass distributions for reaction $\pi^-p \rightarrow \Sigma^0 K^+\pi^-$.
- Fig. 7 $M^2(K^+\pi^-)$ vs $t_{p-\Sigma^0}$ distribution for reaction $\pi^-p \rightarrow \Sigma^0 K^+\pi^-$.
- Fig. 8 Differential cross sections ($d\sigma/dt'$, $d\sigma/du'$) for reaction $\pi^-p \rightarrow K^0(890)\Lambda$.
- Fig. 9 Differential cross sections ($d\sigma/dt'$, $d\sigma/du'$) for reaction $\pi^-p \rightarrow K^0(890)\Sigma^0$.
- Fig. 10 $M(K^+\pi^-)$ vs $M(\Lambda\pi^0)$ distribution for reaction $\pi^-p \rightarrow \Lambda K^+\pi^-\pi^0$.
- Fig. 11 (a) and (b) $K^+\pi^-$ and $\Lambda\pi^0$ effective mass distributions for reaction $\pi^-p \rightarrow \Lambda K^+\pi^-\pi^0$. The shaded histograms are the same mass spectra after the selection ($1.34 \leq M(\Lambda\pi^0) \leq 1.44$ GeV), ($0.84 \leq M(K^+\pi^-) \leq 0.94$ GeV).
- Fig. 12 Differential cross section ($d\sigma/dt'$) for reaction $\pi^-p \rightarrow K^0(890) \Sigma^0(1385)$.

FIGURE CAPTIONS (Cont'd)

- Fig. 13 Moduli and relative phases of the Byers-Yang amplitudes for the reaction $\pi^- p \rightarrow K^0(890) \Lambda$ as a function of t' . The open circles correspond to an ambiguous solution.
- Fig. 14 Moduli and relative phases of the Byers Yang amplitudes for the reaction $\pi^- p \rightarrow K^0(890) \Sigma^0$ as a function of t' . The open circles correspond to an ambiguous solution.
- Fig. 15 (a), (b) and (c) ρ_{00} , ρ_{1-1} and $\text{Re}\rho_{10}$ density matrix elements of the $K^0(890)$ in the s-channel helicity frame, in the reaction $\pi^- p \rightarrow K^0(890) \Lambda$.
- Fig. 16 (a), (b) and (c) ρ_{00} , ρ_{1-1} and $\text{Re}\rho_{10}$ density matrix elements of the $K^0(890)$, in the s-channel helicity frame, in the reaction $\pi^- p \rightarrow K^0(890) \Sigma^0$.
- Fig. 17 (a), (b), (c) and (d) P , P_N , P_U^0 and P_U^1 polarizations of the Λ in the reaction $\pi^- p \rightarrow K^0(890) \Lambda$.
- Fig. 18 (a), (b), (c) and (d) P , P_N , P_U^0 and P_U^1 polarizations of the Σ^0 in the reaction $\pi^- p \rightarrow K^0(890) \Sigma^0$.
- Fig. 19 (a), (b) and (c) ρ_{00} , $\text{Re} \rho_{10}$ and ρ_{1-1} density matrix elements of the $K^0(890)$ (black dots) and ϕ (open circles) in the reactions $\pi^- p \rightarrow K^0(890) \Sigma^0(1385)$ and $K^- p \rightarrow \phi \Sigma^0(1385)$.
- Fig. 20 (a), (b) and (c) $\rho_{\frac{1}{2} \frac{1}{2}}$, $\text{Re} \rho_{\frac{3}{2} - \frac{1}{2}}$ and $\text{Re}\rho_{\frac{3}{2} \frac{1}{2}}$ density matrix elements of the $\Sigma^0(1385)$ in the reactions $\pi^- p \rightarrow K^0(890) \Sigma^0(1385)$ (black dots) and $K^- p \rightarrow \phi \Sigma^0(1385)$ (open circles).
- Fig. 21 Natural and unnatural parity exchange contributions to the differential cross sections for $\pi^- p \rightarrow K^0(890) \Lambda$ (Δ), $K^- p \rightarrow \phi \Lambda$ ($\blacktriangle$), $K^- p \rightarrow \omega \Lambda$ ($\bullet$) and $K^- p \rightarrow \rho \Lambda$ ($\circ$).

FIGURE CAPTIONS (Cont'd)

(a) $\sigma_+ = \rho_+ d\sigma/dt'$; (b) $\sigma_0 = \rho_{00} d\sigma/dt'$; (c) $\sigma_- = \rho_- d\sigma/dt'$.
The cross sections for the reactions $\bar{K}p \rightarrow \omega\Lambda$ and $\bar{K}p \rightarrow \rho\Lambda$
have been multiplied by a factor 2.

Fig. 22 Natural parity exchange contribution to the differential cross sections ($\sigma_+ = \rho_+ d\sigma/dt'$) for $\pi^-p \rightarrow K^0(890)\Sigma^0$ (Δ), $\bar{K}p \rightarrow \phi\Sigma^0$ ($\blacktriangle$) and $\bar{K}p \rightarrow \rho\Sigma^0$ ($\bullet$). The cross section for $\bar{K}p \rightarrow \rho\Sigma^0$ has been multiplied by a factor 2.

Fig. 23 Natural and unnatural parity exchange contributions to the differential cross sections for $\pi^-p \rightarrow K^0(890)\Sigma^0(1385)$ (Δ), $\bar{K}p \rightarrow \phi\Sigma^0(1385)$ ($\blacktriangle$) and $\bar{K}p \rightarrow \rho^-\Sigma^+(1385)$ ($\circ$): (a) $\sigma_+ = \rho_+ d\sigma/dt'$; (b) $\sigma_0 = \rho_{00} d\sigma/dt'$; (c) $\sigma_- = \rho_- d\sigma/dt'$. The cross section for $\bar{K}p \rightarrow \rho^-\Sigma^+(1385)$ has been multiplied by a factor 1/2.

Fig. 24 Moduli and relative phases of the Byers-Yang amplitudes for the reaction $\bar{K}p \rightarrow \phi\Lambda$ as a function of t' . The open circles correspond to an ambiguous solution.

Fig. 25 Moduli and relative phases of the Byers-Yang amplitudes for the reaction $\bar{K}p \rightarrow \phi\Sigma^0$ as a function of t' .

Fig. 26 Differential cross sections for the reactions $\pi^-p \rightarrow K^0(890)\Sigma^0(1385)$ ($\blacktriangle$), $\bar{K}p \rightarrow \phi\Sigma^0(1385)$ (Δ) and $\bar{K}p \rightarrow \rho^-\Sigma^+(1385)$ ($\bullet$). The cross section for $\bar{K}p \rightarrow \rho^-\Sigma^+(1385)$ has been multiplied by a factor 1/2.

Fig. 27 (a), (b), (c) and (d) Study of the quark model predictions (A1), (B1), (B2) and (B3). The black dots (open circles) are the left hand side (right hand side) of the equalities given in the text.

FIGURE CAPTIONS (Cont'd)

- Fig. 28 (a) Differential cross section of the reaction $\pi^- p \rightarrow K^0(890)\Lambda$ (black dots) and sum of the differential cross sections of the reactions $\pi^- p \rightarrow K^0(890)\Sigma^0$ and $\pi^- p \rightarrow K^0(890)\Sigma^0(1385)$ (open circles);
- (b) and (c) refer to the natural and unnatural parity exchange contributions to the differential cross sections.

Fig. 1

Fig. 2

Fig. 3

Fig. 4

Fig. 5

Fig. 6

Fig. 7

Fig. 8

Fig. 9

Fig. 10

Fig.11

Fig.12

$$\pi^- p \longrightarrow K(890) \Lambda$$

Fig.13

$$\pi^- p \longrightarrow K(890) \Sigma^0$$

Fig.14

Fig.15

Fig.16

Fig.17

Fig.18

Fig.19

Fig.20

Fig.21

Fig.23

$$K^- p \rightarrow \phi \Lambda$$

Fig.24

$$K^- p \rightarrow \phi \Sigma^0$$

Fig.25

Fig.26

Fig.27

Fig. 28