THE REACTIONS $K^-p \rightarrow \pi^+ \Sigma(1385)^+$ AT 8.25 GeV/c

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Collaboration

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Abstract

The reactions $K^-p \rightarrow \pi^+ \Sigma(1385)^+$ are studied at an incident laboratory momentum of 8.25 GeV/c using data from a high statistics (≈ 180 events/ μ b) bubble chamber experiment. In the case of the reaction $K^-p \rightarrow \pi^- \Sigma(1385)^+$ an amplitude analysis is performed and the complete $\Sigma(1385)^+$ spin density matrix is extracted as a function of t' . The results are compared with the predictions of the additive quark model. In the case of the reaction $K^-p \rightarrow \pi^+ \Sigma(1385)^-$ the cross-sections for forward and backward production are determined.

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1. Introduction

In order to understand the underlying dynamics of strong interaction processes it is clearly important to determine the production amplitudes. As is well known, for a certain class of reactions involving a weakly decaying hyperon in the final state it is possible to make an almost complete determination of the production amplitudes in a model independent way without the use of a polarized target. However, since these amplitudes vary with t' it is only possible to carry out this process satisfactorily using data from a high-statistics experiment.

In this paper analyses are presented of two such reactions

$$K^-p \rightarrow \pi^- \Sigma(1385)^+ , \quad \Sigma(1385)^+ \rightarrow \Lambda \pi^+ \quad (1)$$

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

at an incident laboratory momentum of 8.25 GeV/c, where existing data [1] are relatively sparse. Previously, amplitude analyses of these reactions have been performed in a similar experiment at 4.2 GeV/c [2]. Reaction (1) has also been studied at 7.0 GeV/c [3] and 11.5 GeV/c [4] using the SLAC hybrid facility.

The data used derive from a high statistics experiment involving 5.3×10^6 photographs of the CERN 2m hydrogen bubble chamber exposed to a K^- beam of mean momentum 8.23 GeV/c. The sensitivity of the experiment is approximately 180 events/ μ b. Sect. 2 of this paper contains a general description of the data relevant to reactions (1) and (2), and total and differential cross-sections are given. In sect. 3 the formalism for extracting production amplitudes from the $\Sigma(1385)$ sequential decay angular distribution is described and the results presented. The complete spin density matrix in the s-channel helicity frame is constructed from the

amplitudes in sect. 4. In sect. 5 the results are discussed in terms of the additive quark model and Regge theory. Finally, sect. 6 contains the conclusions drawn from the work.

2. Total and differential cross-sections

2.1 General features of data

A sample of 6950 events with a visible Λ decay and kinematically fitting the channel

$$K^-p \rightarrow \Lambda\pi^+\pi^-, \quad \Lambda \rightarrow p\pi^- \quad (3)$$

with a χ^2 probability greater than 0.1% has been extracted. The only significant ambiguity is with the channel $K^-p \rightarrow \Sigma^0\pi^+\pi^-$ but examination of the Σ^0 decay distribution shows that the ambiguous events (approximately 80% of the total) are properly classified as examples of channel (3). After correcting for Λ detection efficiency and neutral decays, the cross-section for channel (3) is determined to be $67 \pm 3 \mu\text{b}$, to be compared with an older value of $58 \pm 10 \mu\text{b}$ [5]. The absolute normalisation is based on a count of τ decays.

The general features of the $\Lambda\pi^+\pi^-$ final state are illustrated by the Dalitz plot in fig. 1a and the Chew-Low plots in figs. 1b and 1c. In the $\Lambda\pi^+$ system a clear $\Sigma(1385)^+$ signal can be seen, as well as structure in the region of the $\Sigma(1670)$. The $\Sigma(1385)^-$ signal in the $\Lambda\pi^-$ system is, however, far less obvious. The Dalitz plot also shows bands of events corresponding to the ρ and f mesons but any overlap with the $\Sigma(1385)^+$ is negligible. Fig. 1b shows that the $\Sigma(1385)^+$ is predominantly produced in the forward*

* In the present paper 'forward' is used to mean $\hat{\vec{k}}^- \cdot \hat{\vec{\pi}} > 0$ in the overall centre of mass system where $\hat{\vec{\pi}}$ is the direction of the pion not in the resonance combination.

direction but there is also a small amount in the backward region. Fig. 1c suggests that such $\Sigma(1385)^-$ production as there is, is slightly cleaner in the backward direction.

The $\Lambda\pi^+$ and $\Lambda\pi^-$ effective mass spectra are given in figs. 2a and 2b respectively. There is little background under the strong $\Sigma(1385)^+$ signal but there is only a weak $\Sigma(1385)^-$ peak on a relatively significant background.

2.2 Total cross-sections

The total cross-sections for reactions (1) and (2) have been determined by fitting the distributions in figs. 2a and 2b to Breit-Wigner functions and phase-space backgrounds in the mass region below 1.5 GeV. The effects of experimental resolution (approximately Gaussian with $\sigma = 2.7$ MeV) have also been included. Several previous experiments [2,6,7] have found that it is not possible to obtain a good fit to the $\Lambda\pi^+$ mass spectrum in the $\Sigma(1385)$ region with a p-wave Breit-Wigner of the form given by Jackson [8]. This observation is confirmed by the present experiment. The data show a more symmetrical form which can be well fitted if the resonance width is given an s-wave energy dependence. Explicitly, the following form has been used:-

$$BW(m) \propto \frac{m_0 \Gamma}{(m_0^2 - m^2)^2 + m_0^2 \Gamma^2}$$

$$\text{with } \Gamma = \Gamma_0 \frac{q}{q_0} \frac{m_0}{m}.$$

Here m_0 and Γ_0 are the $\Sigma(1385)$ mass and width respectively and m is the mass of the $\Lambda\pi^+$ system; $q(q_0)$ is the momentum of the Λ or π^+ in the $\Lambda\pi^+$ rest frame for a $\Lambda\pi^+$ system of mass $m(m_0)$. There is no such difficulty in fitting the weak $\Sigma(1385)^-$ signal and a p-wave Breit-Wigner has been used.

The data and fitted distributions are shown in figs. 3a and 3b and the results of the fits are summarized in Table 1. After correcting for Λ detection efficiency, unseen decay modes and other $\Sigma(1385)$ modes [9] the cross-section for reaction (1) has been determined to be $19 \pm 1 \mu\text{b}$ and that for reaction (2) to be $0.5 \pm 0.2 \mu\text{b}$. Fig. 4 shows the available data on reaction (1) between 4 and 16 GeV/c [1,2,3,4,10]. It is seen that the present value is in excellent agreement with the trend of the other data. A fit to the form $\sigma_{\text{TOT}} \propto P_{\text{LAB}}^{-n}$ gives $n = 2.05 \pm 0.08$ and its predictions are shown in fig. 4.

The value found for the mass of the $\Sigma(1385)^+$ is slightly higher than the Particle Data Group value of $1382.3 \pm 0.4 \text{ MeV}$ [9] but the measurement of the width is in good agreement with the corresponding value of $35 \pm 1 \text{ MeV}$. The mass and width found for the $\Sigma(1385)^-$ are also in good agreement with the P.D.G. values, within the significantly greater errors.

2.3 Differential cross-sections

The differential cross-section for reaction (1) has been calculated by counting the number of events with $1300 < M(\Lambda\pi^+) < 1470 \text{ MeV}$ in a given t' or u' bin. (Here t' is defined as $t_{\text{max}} - t$ where t is the square of the four-momentum transfer from K^- to π^- and t_{max} is the value of t when $\hat{K}^- \cdot \hat{\pi}^- = +1$; u' is defined similarly, in relation to backward scattering). Corrections have been made for the Breit-Wigner tails and the small amount of background which was assumed independent of t' . The results are presented in Table 2 and fig. 5a.

The differential cross-section is peaked forward and backward and there is a definite dip as $t' \rightarrow 0$. Fitting $d\sigma/dt'$ for $t' < 0.8 \text{ GeV}^2$ to the form $at'e^{-bt'}$ gives a satisfactory fit with $b = 7.1 \pm 0.2 \text{ GeV}^{-2}$, as shown in fig. 5b.

Within the framework of the Regge pole exchange model, the ratio of the differential cross-sections at two different centre of mass energies $\sqrt{s_1}$ and $\sqrt{s_2}$ but at the same momentum transfer t is given by

$$\frac{d\sigma}{dt}(s_1, t) / \frac{d\sigma}{dt}(s_2, t) = (s_1/s_2)^{2\alpha_{\text{EFF}}(t)-2}$$

where $\alpha_{\text{EFF}}(t)$ is the effective trajectory function. The present data have been compared with those obtained at 4.2 GeV/c [2] at 16 values of t between -0.05 and -1.2 GeV^2 and the results have been fitted to the form $\alpha_{\text{EFF}}(t) = \alpha_0 + \alpha' t$. An excellent fit ($\chi^2 = 13.6$) is obtained with $\alpha_0 = 0.22 \pm 0.05$ and $\alpha' = 0.94 \pm 0.11$. The data fitted and the effective trajectory are shown in fig. 6. It can be seen that the effective trajectory passes close to the $K^*(890)$ and the $K^{**}(1430)$ so that the energy dependence of the differential cross-section for reaction (1) is consistent with the hypothesis that the reaction is dominated by K^*/K^{**} exchange.

In the case of reaction (2) the low number of events makes it impracticable to extract the differential cross-section. However, separate fits to the mass plots for forward and backward events give the following cross-section estimates:

$$\begin{aligned}\sigma(\text{forward}) &= 0.1 \pm 0.1 \text{ } \mu\text{b} \\ \sigma(\text{backward}) &= 0.3 \pm 0.1 \text{ } \mu\text{b}\end{aligned}$$

3. Amplitude analysis

3.1 Formalism

In the present experiment there are only sufficient events to carry out an amplitude analysis of reaction (1) and the following account will refer, where necessary, explicitly to this case.

It is convenient to work in an s-transversity frame in which the z-axis is normal to the production plane (parallel to $\hat{\mathbf{K}}^- \times \hat{\pi}^-$). Following [2] the y-axis is taken to be opposite to the π^- direction in the overall centre of mass. The relation of this frame to the s-helicity frame is shown in fig. 7.

The reaction is described by transversity amplitudes T_{db} where b is the transversity (i.e the spin projection along z_T) of the initial proton and d the transversity of the $\Sigma(1385)^+$. Parity conservation in the production process leads to the condition

$$T_{db} = (-1)^{d-b} T_{db}$$

and so, at a given t' , there are only 4 non-zero amplitudes

$$T_{11}, T_{-31}, T_{-1-1}, T_{3-1}$$

(For typographical ease, when amplitudes and density matrix elements are written with explicit numerical indices these indices have been doubled).

In terms of these amplitudes the spin density matrix elements of the $\Sigma(1385)$ in the transversity frame are given by

$$\rho_{11} = |T_{11}|^2, \quad \rho_{-3-3} = |T_{-31}|^2,$$

$$\rho_{1-3} = T_{11} T_{-31}^*,$$

$$\rho_{-1-1} = |T_{-1-1}|^2, \quad \rho_{33} = |T_{3-1}|^2$$

$$\rho_{-13} = T_{-1-1} T_{3-1}^*$$

(The general relation is $\rho_{dd'} = \sum_b T_{db} T_{d'b}^*$)

The sequential decay angular distribution is of course determined by this density matrix. In detail, the angular distribution is proportional to

$$\sum_{dd'ee'f} \rho_{dd'de} D^{(3/2)}(R) * D^{(3/2)}_{d'e'}(R) |g_f|^2 D^{(1/2)}_{ef}(R') * D^{(1/2)}_{e'f}(R')$$

where $R = (\phi, \theta, 0)$ is determined by the decay angles θ, ϕ of the $\Sigma(1385)$ in the transversity frame and $R' = (\phi', \theta', 0)$ is determined by the decay angles θ', ϕ' of the Λ in the transversity frame rotated by R . The Λ decay helicity amplitudes are given by $|g_{\pm 1/2}|^2 = 1/2(1 \pm \alpha)$ where α is the Λ decay asymmetry parameter.

It is easily seen from the expression for $\rho_{dd'}$, that amplitudes T_{db} with $b = +1/2$ do not interfere with those with $b = -1/2$. It is therefore impossible in this experiment to determine the relative phase of the two sets of amplitudes. Hence it is permissible to take T_{11} and T_{-1-1} to be real and positive so that the angular distribution is determined by six real numbers:

$$T_{11}, \text{Re}T_{-31}, \text{Im}T_{-31}, T_{-1-1}, \text{Re}T_{3-1}, \text{Im}T_{3-1}.$$

Alternatively one can take the view that the magnitudes of all four amplitudes are determined together with two relative phases but fitting is best done in terms of the six quantities listed.

3.2 Results of fits

The transversity amplitudes have been determined as functions of t' by maximum likelihood fits to the data applying the normalization constraint

$$\sum_{db} |T_{db}|^2 = 1, \text{ which automatically normalizes } \rho \text{ to unity.}$$

The t' bins have been chosen so as to contain at least 100 events as long as this could be done without making the bins so wide that the assumption that the amplitudes are constant across them becomes unreasonable. The $\Lambda\pi^+$ mass slice (1300–1470 MeV) has been chosen to retain as many events as possible whilst keeping the background effectively negligible. In view of the smallness of the background no attempt has been made to include any background amplitudes.

Random searches have been made in each t' bin but no ambiguous solutions have been found. The errors on the fitted amplitudes have been calculated from the second derivative matrix of the likelihood function at the maximum. The quality of the fits has been checked by comparing the predicted moments of the sequential decay angular distribution with their experimental values. Correlations amongst the moments make a quantitative test difficult but the agreement seems satisfactory. The projections of the angular distribution onto the variables $\cos\theta$, ϕ , $\cos\theta'$ and ϕ' have also been examined and show satisfactory agreement between the data and the fits. The projected distributions from a typical t' -bin are shown in fig. 8.

Table 3 gives the results of the fits in terms of the six quantities varied in the fits. These results are displayed in slightly different form in fig. 9 which shows the magnitudes of the four amplitudes and the two relative phases as functions of t' . When the magnitude of an amplitude is close to zero its phase is of course poorly determined, as happens for $T_{-3\ 1}$ in the 5th and 10th t' bins. Nevertheless the phases show reasonably consistent behaviour as will be discussed further in sect. 5.

4. Spin density matrix elements and polarization

The complete $\sum (1385)^+$ s-channel helicity spin density matrix ρ^H has been determined by rotating the transversity density matrix ρ^T , defined in sect. 3, according to

$$\rho^H = D^{(3/2)}(R_d) \rho^T D^{(3/2)}(R_d)^\dagger$$

where $R_d = (\pi/2, \pi/2, \pi/2)$ takes the helicity axes into the transversity axes. (In comparison with other references note that $(-\pi/2, -\pi/2, -\pi/2)$ is equivalent to R_d in this situation). This procedure automatically imposes normalization, positivity and rank conditions. Direct determination of the helicity density matrix gives good agreement for parameters and errors. The results of the rotation are presented in Table 4 and fig. 10.

The polarization of the $\sum (1835)^+$, defined by

$$P = 2/3 \sum_{db} d |T_{db}|^2$$

has been calculated and is completely consistent with zero, for $t' < 1 \text{ GeV}^2$.

5. Discussion of results

In the forward direction, reaction (1) is expected to be dominated by the exchange of K^* and K^{**} reggeons and supporting evidence for this has been presented in sect. 2.3. The well-known [2-4] turn-over of the differential cross-section at $t' = 0$ is explained by the fact that these reggeons have mainly helicity flip couplings to the baryon vertex which vanish as $t' \rightarrow 0$. Reaction (2), on the other hand, requires an exotic exchange in the forward direction and its cross-section is therefore strongly suppressed.

It is of interest to note that the backward cross-section for reaction (2) falls far more rapidly than that for reaction (1) between 4.2 and 8.25 GeV/c.

The predictions of the additive quark model (AQM) [11] may be tested either in terms of the transversity amplitudes or the s-channel helicity density matrix. For reaction (1) the model predicts

$$T_{-3 \ 1} = T_{3 \ -1} = 0 \quad \text{and} \quad |T_{1 \ 1}| = |T_{-1 \ -1}| = 1/\sqrt{2}.$$

It can be seen from fig. 9 and Table 3 that these relations are quite well obeyed but nevertheless there are some significant discrepancies. As found in [2], $T_{-3 \ 1}$ and $T_{3 \ -1}$ are non-zero near the forward direction and their phases behave consistently as functions of t' . The phase of $T_{-3 \ 1}$ (relative to $T_{1 \ 1}$) is roughly constant at about -100° . Also the phase of $T_{3 \ -1}$ varies from positive to negative values as t' increases. These are in contrast to the erratic behaviour that would be expected if the amplitudes really were zero. Again as found at 4.2 GeV/c, $|T_{1 \ 1}|$ tends to be bigger than $|T_{-1 \ -1}|$.

For the s-channel helicity density matrix the AQM makes the following predictions:-

$$\rho_{3 \ 3} = 3/8, \quad \rho_{1 \ 1} = 1/8, \quad \text{Re } \rho_{-1 \ 3} = \sqrt{3}/8$$

and all other elements zero. These predictions are also well obeyed (see fig. 10) except near $t' = 0$. The diagonal elements $\rho_{3 \ 3}$ and $\rho_{1 \ 1}$ (totally correlated by the trace condition) differ from their predicted values only in the first t' bin; $\text{Re } \rho_{1 \ 3}$ and $\text{Re } \rho_{-1 \ 3}$ differ consistently from their predicted values for $t' < 0.2 \text{ GeV}^2$. The general agreement with [2] obtained using independent analysis programs

confirms the existence of these discrepancies from the AQM. They are, presumably, manifestations of double quark scattering [12].

Finally, the AQM predicts that the polarization of the $\Sigma(1385)^+$ should be zero, as found in this experiment.

6. Conclusions

The reactions $K^-p \rightarrow \pi^+ \Sigma(1385)^+$ have been studied at 8.25 GeV/c with far greater sensitivity than has previously been available at this momentum. This has allowed a complete determination of the density matrix of the $\Sigma(1385)^+$ in the reaction $K^-p \rightarrow \pi^+ \Sigma(1385)^+$ for $t' < 1 \text{ GeV}^2$. In turn this leads to a determination of the production amplitudes for the reaction, apart from the overall phase and the phase difference between two sets of amplitudes. Several small but significant deviations from the additive quark model are observed. The differential cross section for the reaction is measured in both the forward and backward directions. The 'exotic' reaction $K^-p \rightarrow \pi^+ \Sigma(1385)^-$ is found to have a relatively small cross-section in both directions.

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Table captions

1. Results of fits to the $\Lambda\pi$ mass spectra below 1.5 GeV.
2. Differential cross-section for the reaction $K^-p \rightarrow \pi^-\Sigma(1385)^+$ as a function of t' and u' . The numbers of events are those in the mass interval 1300-1470 MeV and are corrected for Λ detection efficiency. The differential cross-section has been corrected for background and Breit-Wigner tails as well as for neutral Λ decays and other $\Sigma(1385)$ decay modes. The errors are statistical only. The overall normalization error is estimated to be $\pm 5\%$.
3. Real and imaginary parts of the transversity amplitudes for the reaction $K^-p \rightarrow \pi^-\Sigma(1385)^+$ as functions of t' , with the phase convention that $T_{1\ 1}$ and $T_{-1\ -1}$ are real and positive.
4. s-channel helicity density matrix elements for the $\Sigma(1385)^+$ in the reaction $K^-p \rightarrow \pi^-\Sigma(1385)^+$.

Table 1

	Mass (MeV)	Width (MeV)	Number of $\sum$ (1385)events ^{a)}	Number in mass slice ^{b)}	Background in mass slice	χ^2 /NDF
$\Lambda\pi^+$	1384.1 ± 0.7	37.2 ± 2.0	1897	1828	1%	25.9/34
$\Lambda\pi^-$	1389 ± 5	27 ± 11	46	-	-	3.7/7

a) Corrected for Λ detection efficiency

b) The mass slice used for later analysis is defined by

$$1300 < M(\Lambda\pi^+) < 1470 \text{ MeV}$$

Table 2

t' bin (GeV ²)	Number of events	$\frac{d\sigma}{dt'}$ ($\mu\text{b/GeV}^2$)
0 - 0.05	108	22.3 ± 2.3
0.05 - 0.10	215	44.3 ± 3.4
0.10 - 0.15	204	42.0 ± 3.2
0.15 - 0.20	226	46.7 ± 3.4
0.20 - 0.25	193	39.9 ± 3.1
0.25 - 0.30	161	33.1 ± 2.8
0.30 - 0.35	128	26.5 ± 2.5
0.35 - 0.40	107	22.1 ± 2.3
0.40 - 0.45	69	14.1 ± 1.8
0.45 - 0.50	94	19.3 ± 2.2
0.50 - 0.55	56	11.6 ± 1.6
0.55 - 0.60	46	9.4 ± 1.5
0.60 - 0.65	43	8.9 ± 1.5
0.65 - 0.70	35	7.1 ± 1.3
0.70 - 0.80	31	3.19 ± 0.63
0.80 - 1.00	42	2.18 ± 0.37
1.00 - 1.40	30	0.78 ± 0.15
1.40 - 2.00	11	0.192 ± 0.061
2.00 - 6.81	11	0.0227 ± 0.0076

u' bin (GeV ²)	Number of events	$\frac{d\sigma}{du'}$ ($\mu\text{b/GeV}^2$)
0 - 1.00	39	0.401 ± 0.077
1.00 - 2.00	12	0.125 ± 0.042
2.00 - 6.81	4	0.0084 ± 0.0049

Table 3

t'bin (GeV ²)	Number of events	T _{1 1}	ReT _{-3 1}	ImT _{-3 1}	T ₋₁₋₁	ReT ₃₋₁	ImT ₃₋₁
0-0.05	108	0.59±0.10	0.20±0.15	-0.08±0.16	0.57±0.12	0.11±0.16	0.52±0.11
0.05-0.10	215	0.73±0.07	0.01±0.09	-0.20±0.08	0.61±0.08	-0.15±0.09	0.16±0.09
0.10-0.15	204	0.70±0.08	-0.03±0.10	-0.33±0.11	0.63±0.08	0.06±0.10	-0.02±0.10
0.15-0.20	226	0.67±0.08	-0.17±0.10	-0.21±0.09	0.68±0.07	0.00±0.09	-0.09±0.10
0.20-0.25	193	0.73±0.07	-0.05±0.10	0.00±0.10	0.66±0.08	-0.08±0.10	0.15±0.11
0.25-0.30	161	0.71±0.08	0.00±0.09	-0.07±0.09	0.69±0.08	0.04±0.09	-0.05±0.10
0.30-0.35	128	0.65±0.10	-0.19±0.12	0.20±0.13	0.69±0.09	0.10±0.12	0.02±0.12
0.35-0.40	107	0.80±0.08	-0.02±0.11	-0.13±0.11	0.58±0.11	0.06±0.12	-0.04±0.13
0.40-0.50	162	0.72±0.08	0.10±0.09	-0.02±0.11	0.67±0.09	-0.15±0.11	-0.02±0.10
0.50-0.65	145	0.73±0.09	-0.03±0.09	-0.01±0.08	0.67±0.09	0.03±0.09	-0.09±0.09
0.65-1.00	108	0.81±0.08	0.00±0.13	-0.13±0.14	0.56±0.12	-0.10±0.17	-0.05±0.15

Table 4

t'bin (GeV ²)	$\rho_{3\ 3}$	$\rho_{1\ 1}$	Rep _{1 3}	Imp _{1 3}	Rep _{-1 3}	Imp _{-1 3}	Imp _{-3 3}	Imp _{-1 1}
0-0.05	0.21±0.05	0.29±0.05	0.17±0.05	0.07±0.07	0.12±0.05	0.12±0.07	-0.05±0.09	0.06±0.12
0.05-0.10	0.39±0.03	0.11±0.03	0.12±0.03	0.06±0.05	0.16±0.03	-0.02±0.05	0.02±0.08	-0.06±0.05
0.10-0.15	0.34±0.03	0.16±0.03	0.11±0.04	-0.01±0.06	0.17±0.04	-0.12±0.05	0.08±0.09	-0.03±0.06
0.15-0.20	0.41±0.03	0.09±0.03	0.04±0.03	-0.05±0.05	0.15±0.03	-0.10±0.05	0.05±0.09	0.03±0.04
0.20-0.25	0.41±0.03	0.09±0.03	0.05±0.04	0.03±0.06	0.18±0.03	0.05±0.06	0.03±0.10	-0.01±0.05
0.25-0.30	0.36±0.03	0.14±0.03	0.01±0.04	0.00±0.06	0.22±0.02	-0.04±0.05	0.03±0.09	0.01±0.06
0.30-0.35	0.38±0.04	0.12±0.04	-0.06±0.05	-0.08±0.07	0.16±0.04	0.07±0.07	0.07±0.11	0.07±0.06
0.35-0.40	0.36±0.04	0.14±0.04	0.04±0.05	0.05±0.07	0.21±0.03	-0.06±0.06	0.13±0.10	-0.02±0.07
0.40-0.50	0.38±0.03	0.12±0.03	0.00±0.04	0.06±0.06	0.19±0.03	-0.01±0.06	-0.05±0.10	-0.08±0.05
0.50-0.65	0.37±0.04	0.13±0.04	-0.03±0.04	0.01±0.06	0.21±0.02	-0.03±0.05	0.05±0.10	0.01±0.05
0.65-1.00	0.39±0.04	0.11±0.04	0.04±0.05	0.09±0.07	0.19±0.04	-0.06±0.09	0.11±0.14	-0.07±0.07

Figure captions

1. (a) Dalitz plot for the channel $K^-p \rightarrow \Lambda\pi^+\pi^-$; (b) and (c) Chew-Low plots for the reactions $K^-p \rightarrow (\Lambda\pi^+)\pi^-$ and $K^-p \rightarrow (\Lambda\pi^-)\pi^+$ respectively.
2. (a) $\Lambda\pi^+$ and (b) $\Lambda\pi^-$ effective mass distributions in the channel $K^-p \rightarrow \Lambda\pi^+\pi^-$.
3. (a) $\Lambda\pi^+$ and (b) $\Lambda\pi^-$ effective mass distributions. The curves show the results of the fits described in the text.
4. Total cross-section for the reaction $K^-p \rightarrow \pi^-\Sigma(1385)^+$ as a function of laboratory momentum. The line shows the result of fitting the data to the form $\sigma_{TOT} \propto p_{LAB}^{-n}$
5. (a) Differential cross-section for the reaction $K^-p \rightarrow \pi^-\Sigma(1385)^+$ (Note the break in the scale on the t'/u' axis); (b) Differential cross-section for $t' < 0.8 \text{ GeV}^2$ and showing the result of the fit described in the text.
6. Effective trajectory for the reaction $K^-p \rightarrow \pi^-\Sigma(1385)^+$ calculated from the energy dependence of the differential cross-section between 4.2 and 8.25 GeV/c. The solid line is a straight line fit to the data.
7. Definition of axes in the overall centre of mass frame:
(x_T, y_T, z_T) define the s-transversity frame,
(x_H, y_H, z_H) define the s-helicity frame

8. Projected angular distributions of the $\Sigma(1385)^+$ sequential decay for $0.15 < t' < 0.20 \text{ GeV}^2$. The curves show the predictions of the maximum likelihood fit to the joint distribution
9. Moduli and relative phases of the transversity amplitudes for the reaction $K^-p \rightarrow \pi^- \Sigma(1385)^+$
10. $\Sigma(1385)^+$ density matrix elements in the s-channel helicity frame. The dashed lines show the predictions of the additive quark model.

Figure 1

Figure 2

Figure 3

Figure 4

Figure 5

Figure 6

Figure 7

Figure 8

Figure 9

Figure 10