CERN - EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

Submitted to
Nuclear Physics B.

CERN/EP/PHYS 77-45
1 September 1977

NON-STRANGE VECTOR MESON PRODUCTION IN K^-p INTERACTIONS AT 4.2 GeV/c

Amsterdam-CERN-Nijmegen-Oxford Collaboration

M.J. LOSTY, S.-O. HOLMGREN^(*), M. AGUILAR-BENITEZ^(**), F. BARREIRO^(***),
R.J. HEMINGWAY and R.P. WORDEN⁽⁺⁾
CERN, European Organization for Nuclear Research, Geneva.

G.G.G. MASSARO, R. BLOKZIJL, J.C. KLUYVER and G.F. WOLTERS⁽⁺⁺⁾
Zeeman Laboratorium, Universiteit van Amsterdam⁽⁺⁺⁾, Amsterdam.

J.J. TIMMERMANS⁽⁺⁺⁺⁾, J.S.M. VERGEEST and R.T. VAN DE WALLE
Fysisch Laboratorium, Universiteit van Nijmegen⁽⁺⁺⁾, Nijmegen.

J. WELLS, B. FOSTER, P. GROSSMANN and L. LYONS
Nuclear Physics Laboratory, Oxford University, Oxford.

(*) CERN Fellow from the University of Stockholm, Sweden.

(**) Now at the Junta de Energia Nuclear, Madrid, Spain.

(***) Now at the Massachusetts Institute of Technology, U.S.A.

(+) Now with Logica Ltd., London, U.K.

(++) This investigation is supported by the joint research programmes
of FOM and ZWO.

(+++) Now at CERN, Geneva, Switzerland.

MJL/mk

ABSTRACT

The vector meson production, hypercharge exchange reactions $K^- p \rightarrow (\phi, \omega, \rho) \Lambda$ and $(\phi, \rho) \Sigma^0$ are studied at 4.2 GeV/c incident momentum. The data come from a high statistics bubble chamber experiment with a sensitivity of ~ 120 events/ μb . Total and differential cross sections are presented. The vector meson density matrix elements and hyperon polarization are investigated as functions of momentum transfer. Amplitude analyses are performed for all five reactions. The results are compared with duality and quark model predictions, as well as used to test current ideas in two-body phenomenology.

1. INTRODUCTION

In this paper we present an analysis of the vector meson production, hypercharge exchange reactions

$$\bar{K}^- p \rightarrow \phi \Lambda \quad (A)$$

$$\bar{K}^- p \rightarrow \omega \Lambda \quad (B)$$

$$\bar{K}^- p \rightarrow \rho \Lambda \quad (C)$$

$$\bar{K}^- p \rightarrow \phi \Sigma^0 \quad (D)$$

$$\bar{K}^- p \rightarrow \rho \Sigma^0, \quad (E)$$

at 4.2 GeV/c incident momentum.

Reactions with vector meson production provide one of the most important experimental testing grounds for two-body phenomenology. Of these reactions, those with a weakly decaying hyperon in the final state have an interesting feature in that they offer the possibility of an almost complete and model independent amplitude analysis without requiring a polarized target. However, since in general the production cross sections are smaller and the final states more complex, they have been studied with less statistical accuracy than reactions offering no polarization information. It is the purpose of this paper to make up for some of this deficiency by presenting an analysis with statistics improved by a factor of five to ten over those previously available [1,2]. Data on reactions (A)-(E) have already been presented by the collaboration at a statistical level of ~ 12 events/ μb [1]. This paper extends that analysis to a level of ~ 120 events/ μb .

The contents of the paper may be summarized as follows. Sect. 2 describes the experimental details, including the separation of samples of events of reactions (A)-(E). The total and differential cross sections are given in sect. 3. In sect. 4 our method for determining the production amplitudes for all five reactions is described and the results presented. The observables (hyperon polarization and vector meson spin density matrix elements) are constructed from the amplitudes in sect. 5. In sect. 6 we discuss our results and make various compar-

isons with theoretical predictions, including a comparison of $K^- p \rightarrow \phi(\Lambda, \Sigma^0)$ with the SU(3) related reactions $\pi^- p \rightarrow K^*(890) (\Lambda, \Sigma^0)$ using published data at 3.93 GeV/c [3]. Finally, sect. 7 is left for our conclusions.

2. EXPERIMENTAL DETAILS

The data used in this analysis come from 3×10^6 photographs of the CERN 2m HBC obtained in several exposures to K^- beams at momenta from 4.09 to 4.25 GeV/c. The momentum resolution for each run was $\Delta p/p \approx 2/3\%$ and the average momentum for the entire exposure was 4.15 GeV/c. The beam contamination (deduced from a δ -ray count) was estimated to be $\lesssim 2\%$ for π^- and $\lesssim 3\%$ for μ^- . The absolute normalization of all cross sections to be presented in this paper has been based on a count of τ disintegrations.

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

$$K^- p \rightarrow \Lambda K^+ K^- \quad 3982 \text{ events} \quad (1)$$

$$K^- p \rightarrow \Lambda K_S^0 K_L^0 \quad 1451 \text{ events} \quad (1')$$

$$K^- p \rightarrow \Lambda \pi^+ \pi^- \pi^0 \quad 59475 \text{ events} \quad (2)$$

$$K^- p \rightarrow \Lambda \pi^+ \pi^- \quad 19074 \text{ events} \quad (3)$$

$$K^- p \rightarrow \Sigma^0 K^+ K^- \quad 2122 \text{ events} \quad (4)$$

$$K^- p \rightarrow \Sigma^0 \pi^+ \pi^- \quad 10161 \text{ events.} \quad (5)$$

Channel (1') comes from topology "zero-prong + 2 V^0 " and is unambiguous with other final states^(*). Channels (1)-(5) come from events having topology "two-prong + V^0 ", a large fraction of which is kinematically ambiguous even after utilizing bubble-density information. No problem arises for reaction (B), since the majority of events giving acceptable kinematic fits to channel (2), but ambiguous with other final

(*) Channel (1') also includes a $\sim 13\%$ contribution from $K^- p \rightarrow \Lambda K_S^0 K_S^0$, where one of the K_S^0 decays either via the neutral mode or outside the fiducial volume of the bubble chamber.

states, have 3π mass well above the ω mass. In addition, the background under the ω is small^(*). However, there are large regions of kinematic overlap between, for example, channels (1) and (4), channels (2) and (5) and channels (3) and (5). Our procedure for distinguishing between various hypotheses was to prefer that fit with the highest number of constraints. To further purify the samples we have uniformly excluded those events having χ^2 probability of fit less than 1%.

The success of this procedure may be judged from fig. 1 where we show the effective mass recoiling against the K^+K^- or $\pi^+\pi^-$ system for events assigned to channels (1) and (3) (figs 1(a), (c)) and (4) and (5) (figs 1(b), (d)). The distributions are well centered at the Λ and Σ^0 mass, respectively. In the case of channels (4) and (5), a further check on the purities of the samples is provided by the isotropy of the angular distribution of the Λ in the Σ^0 rest frame. Figs 2(a) and (c) show the distributions of the angle with respect to the Σ^0 line-of-flight and figs 2(b) and (d) those of the angle with respect to the production normal for events having K^+K^- mass in the ϕ region (1.010 - 1.035 GeV) or $\pi^+\pi^-$ mass in the ρ region (0.52 - 0.92 GeV). All distributions are consistent with isotropy.

The analysis to be presented below has been performed with samples of events contained within a limited fiducial volume of the bubble chamber. The events were therefore weighted to account for losses due to Λ (or K_S^0) decays occurring outside the fiducial volume as well as too close to the production vertex so as to be missed at the scanning stage.

3. TOTAL AND DIFFERENTIAL CROSS SECTIONS

To illustrate the general features of the data, we give in fig. 3 Dalitz plots and Chew-Low plots for the channels (1), (1'), (3), (4) and (5) and the Chew-Low plot for channel (2). Very strong resonance

(*) We cannot exclude a contamination of $< 5\%$ from $\omega\Sigma^0$ to our $\omega\Lambda$ sample.

structures are seen in all these plots. In the Dalitz plots for channels (1), (1') and (4) (figs 3(a), (c) and (h)) narrow-bands due to the ϕ meson are clearly evident and are moreover not contaminated with any significant E^* production. The corresponding Chew-Low plots of figs 3(b), (d) and (i) show that the ϕ is only produced in the forward direction^(*). On the contrary, strong backward as well as forward production is observed for the ω meson as can be seen in fig. 3(e). The Dalitz plots for channels (3) and (5) (figs 3(f) and (j)) show that these final states are dominated by resonance production (ρ , f , $\Sigma(1385)$ and structure in the $\Sigma(1670)$ region). One notices that the broad ρ -meson bands which are of interest overlap with the Y^* bands. The corresponding Chew-Low plots (figs 3(g) and (k)) show that the ρ , like the ω , is produced in both forward and backward directions.

Fig. 4 shows the effective mass distributions of the meson systems recoiling against the Λ or Σ^0 hyperons for channels (1)-(5). In order to determine total cross sections for reactions (A), (B) and (D), the corresponding distributions in fig. 4 were fitted with p-wave relativistic Breit-Wigner functions and phase space backgrounds modified by, at most, second order polynomials. The experimental resolution was folded in. The resonance parameters were fixed at those values given by the Particle Data Group [4]. Fig. 5 shows the data and fitted distributions in detail and a summary of the results is presented in table 1. The errors quoted for the total cross sections have been increased to cover a possible systematic normalization error of 5%.

From the results of the fits shown in figs 5(a) and (b) we have calculated the branching ratio

$$R = \frac{\phi \rightarrow K^0 K_L^0}{\phi \rightarrow K^+ K^-},$$

(*) We call those events forward (backward) which have $\cos \theta^* > 0$ ($\cos \theta^* < 0$), where θ^* is the angle between the initial K^- and final meson directions in the overall centre of mass. See sect. 6 for an estimate of the upper limits for backward ϕ production.

and obtained $R = 0.82 \pm 0.08$, to be compared with the value given by the Particle Data Group of $R = 0.75 \pm 0.08$ [4].

The differential cross sections for reactions (A), (B) and (D) were determined by counting events in the ϕ or ω mass regions (see table 1) for each t' or u' bin^(*) and normalizing to the total cross sections. This procedure is well justified in view of the small backgrounds and narrow resonance widths.

For reactions (C) and (E) the situation is different in two respects. Firstly, the ρ -meson has a broad width and stands on a substantial background in each case. Secondly, in the forward direction the ρ - ω interference changes the line shape of the resonance. This last effect has been studied in detail in a previous publication [5], where the conventional mass matrix formalism [6] as well as an alternative model [7] for ρ - ω interference were fitted to our data. We reproduce here the results of those fits in figs 5(e) and (f). Both models can be seen to give a good description of the data in the effective mass interval considered ($0.52 < m(\pi^+\pi^-) < 0.92$ GeV). There is, however, a difference between the two models when calculating the correction due to that part of the resonance cross section falling outside the above interval. This correction amounts to $\sim 30\%$ for the conventional model and $\sim 8\%$ for the alternative model. In the case of reaction (E), where the signal to background ratio is smaller, we used a narrower mass interval ($0.65 < m(\pi^+\pi^-) < 0.85$ GeV). The corrections are then $\sim 51\%$ for the conventional model and $\sim 29\%$ for the alternative model.

In order to determine the total and differential cross section for reaction (C), we actually used the results of the amplitude analysis, anticipating the discussion in sect. 4. This implies that the $\pi\pi$ decay angular distribution as well as the mass spectrum was used in the determination of the cross section. In the forward region ($t' < 1.6$ GeV²)

(*) 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 or Σ^0 hyperon.

we performed the amplitude analysis using both the conventional model and the alternative model for ρ - ω interference. The two models were found to give consistent results, except for the overall normalization. This uncertainty in the overall normalization should be borne in mind throughout the remainder of the paper. We have chosen to present the results obtained using the alternative model. Thus the correction to the cross section for Breit-Wigner tails amounted to $\sim 8\%$. For $t' > 1.6 \text{ GeV}^2$ our data show no evidence for ρ - ω interference. Therefore we used a simple p-wave relativistic Breit-Wigner to parametrize the ρ line shape, the correction then amounting to $\sim 34\%$.

Reaction (E) was treated in a similar way to that outlined above, except that we used a narrower mass interval to define our sample (table 1).

The total cross sections for reactions (C) and (E) are given in table 1. The errors quoted include the 5% systematic error discussed above, but do not take into account theoretical uncertainties in the parametrizations employed.

The differential cross sections for all five reactions (A)-(E) are presented in figs 6, 7 and table 2. The errors are statistical only. As a quantitative illustration of the peripheral nature of these reactions, we give in table 3 the results of fits to the differential cross sections with simple exponential forms.

The Λ and Σ^0 polarizations^(*) are also given in figs 6, 7 and table 2 as functions of t' and u' . Again anticipating the discussion in sect. 4, the polarizations were obtained from the results of the amplitude analyses, i.e. imposing all possible constraints.

We now make a few qualitative remarks concerning the differential cross sections and hyperon polarizations of reactions (A)-(E).

(*) The polarization was defined using a consistent definition of the production normal over the entire angular range; $\hat{n} = \hat{p} \times \hat{Y}$ in the overall centre of mass, where $\hat{p}$ and $\hat{Y}$ are unit vectors in the direction of the incident proton and final hyperon, respectively.

$\bar{K}^- p \rightarrow \phi \Lambda$

The differential cross section for reaction (A) shows a strong forward peak with a turnover at $t' \sim 0$. There is no observed cross section in the backward direction ($u' < 1 \text{ GeV}^2$) and in fig. 6 we indicate the 95% confidence level upper limit (see sect. 6 for further discussion). The polarization is large and negative except in the very forward direction.

$\bar{K}^- p \rightarrow \omega \Lambda$

In the case of ω production, the differential cross section exhibits strong forward and backward peaks as well as significant production at 90° . There are clear dips at $t' \sim 0$ and $u' \sim 0.3 \text{ GeV}^2$ as well as possible structure near 90° . The polarization is large, positive in the forward direction and negative in the backward direction.

$\bar{K}^- p \rightarrow \rho \Lambda$

The broad features of ρ production resemble those of ω production to a very large extent. There are indications of a turnover in the forward direction as well as of a dip at $u' \sim 0.3 \text{ GeV}^2$. Significant 90° cross section is observed. The polarization is large, and as in the case of ω production, positive in the forward direction and negative in the backward direction.

$\bar{K}^- p \rightarrow \phi \Sigma^0$

Just as in reaction (A), the ϕ is only produced in the forward direction. The differential cross section exhibits a dip at $t' \sim 0$. The polarization is large and positive.

$\bar{K}^- p \rightarrow \rho \Sigma^0$

ρ production with a Σ^0 hyperon again shows both forward and backward peaks. No appreciable turnover in the forward direction can be observed in the differential cross section. The polarization is considerably smaller than in reaction (C) and on the average negative in the forward direction and positive in the backward direction (except near $u' \sim 0$).

4. AMPLITUDE ANALYSIS

The reactions presented in this work all belong to a special class; they are hypercharge exchange reactions with an asymmetric weak hyperon decay observed in the final state. For this kind of reaction, using the

spin analysing power of the weak decay, it is possible, in a model independent way, to determine all but two parameters in a complete set of production amplitudes [8]. If one adopts a transversity^(*) frame for the spin quantization of these amplitudes, T_{qp}^r (p, q and r are the transversities of the initial proton, the final hyperon and the final vector meson respectively), the unknown parameters are the overall phases of two groups of amplitudes with $p = + 1/2$ and $p = - 1/2$.

The exact definition of the reference frames used is illustrated in fig. 8. The amplitude analyses were performed using a general spin program [9] already used to analyse other reactions from the experiment [10]. The formalism developed allows a dominant reaction, e.g. of the type $0^- 1/2^+ \rightarrow 1^- 1/2^+$, to be treated coherently with background processes. This feature is not needed for those reactions involving the ϕ and ω mesons where the backgrounds are negligible, but is essential in the case of ρ production where there is an important background contribution which we attribute to the process $0^- 1/2^+ \rightarrow 0^+ 1/2^+$.

The full amplitude^(**) for the reaction $K^- p \rightarrow M\Lambda$ and subsequent decay of the Λ hyperon and meson system M into two or three pseudoscalars is written in terms of the transversity production amplitudes as

$$F_{\mu p}(s, t', m, R_3, R_4) = \sum_{Jr} D_{r0}^{J*}(R_3) D_{q\mu}^{1/2*}(R_4) T_{qp}^r(s, t') f(J, m) g_{\mu},$$

where $\sqrt{s}$ is the overall centre of mass energy and t' (or u') is the four-momentum transfer. The meson system M has mass m and spin J . μ is the helicity of the decay proton from the Λ . R_3 and R_4 are rotations describing the decay of the meson M and the Λ in the frames defined in

(*) Transversity frames have the normal to the production plane as quantization axis.

(**) The formalism given here applies to reactions (A)-(C) with Λ hyperons. The formalism for reactions (D) and (E) is slightly more complicated but essentially given by the replacement $D_{q\mu}^{1/2}(R_4) \rightarrow D_{qv}^{1/2}(R_5) D_{v\mu}^{1/2}(R_4)$, where R_5 describes the $\Sigma^0 \rightarrow \Lambda\gamma$ decay.

fig. 8. $f(J, m)$ is the decay amplitude for the meson system M. The Λ decay helicity amplitudes are given by

$$|g_{\pm}|^2 = 1/2 (1 \pm \alpha),$$

where α is the Λ decay asymmetry parameter. In the case of an unpolarized target, parity conservation in the production process gives the following relation for the transversity amplitudes [11];

$$T_{qp}^r = -P(-1)^{q-p+r} T_{qp}^r,$$

which implies that for meson spin parity $J^P = 1^-$ there are six non-zero amplitudes^(*),

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

When we allow for $J^P = 0^+$ background we have two additional amplitudes, T_{-+}^s and T_{+-}^s .

We performed maximum likelihood fits to the data in bins of t' and u' with T_{qp}^r (and T_{qp}^s in reactions (C) and (E)) as free parameters. The theoretical intensity function was written

$$I(s, t, m, R_3, R_4) = N \sum_{\mu p} |F_{\mu p}|^2,$$

where N is a normalization constant. Each event entering the likelihood function was given a weight to compensate for Λ or K_s^0 detection inefficiencies. This weight was on average 1.12 and never exceeded ~ 1.5 . The amplitudes were parametrized in terms of real and imaginary parts. In this way one avoids numerical problems which may occur when some amplitudes are small if one uses moduli and phases as parameters. For the actual presentation however, we transform to moduli and relative phases.

In the "pure" spin cases (reactions (A), (B) and (D)) $f(J, m)$ are constants, while for the "mixed" spin cases (reactions (C) and (E)) we have two different amplitudes, $f(1, m)$ for the vector meson (ρ) and $f(0, m)$

(*) We use the short-hand + or - for + 1/2 and - 1/2 respectively.

for the background (ϵ). For forward ρ production we used a decay amplitude $f(l, m)$ which takes the ρ - ω interference into account. The analysis presented in this paper was performed using the alternative model for ρ - ω interference mentioned in sect. 3 and fitted to our data in ref [5]. It was, however, checked that the conventional model gives compatible results. In the case of backward ρ production we observe no significant ρ - ω interference, so $f(l, m)$ was taken to be a p-wave Breit-Wigner with mass and width fixed at the values given in ref. [4]. For the background decay amplitude we used a broad Breit-Wigner with parameters taken from the fit in ref. [5] ($m = 860$ MeV and $\Gamma = 895$ MeV).

As can be seen from the Dalitz plots for the $(\Lambda, \Sigma^0) \pi^+ \pi^-$ final states (figs 1(f), (j)) the ρ -bands overlap substantially with the $\Sigma^+(1385)$ and $\Sigma^+(1670)$ bands. Therefore, in order not to bias the decay angular distribution of the $\pi^+ \pi^-$ system only events with $\Lambda \pi^+$ or $\Sigma^0 \pi^+$ effective mass greater than 1.8 GeV were used. This cut was taken into account in the normalization of the likelihood function.

The amplitude errors were calculated from second derivatives of the likelihood function in the usual way. These errors would not be meaningful if the likelihood function deviated strongly from the ideal Gaussian form near the maximum. We have found that the most important deviation from this ideal behaviour is caused by ambiguities - cases where two or more different sets of amplitudes fit the data almost equally well.

The joint decay angular distribution in the "pure" spin case^(*) gives ten observables from which, in principle, one can algebraically solve for the six amplitudes uniquely (apart from the two undetermined phases). However, if the natural parity exchange amplitude T_{++}^0 is zero, one can interchange the moduli of T_{-+}^1 and T_{-+}^{-1} (keeping their relative phase unchanged) without changing any of the 12 observables; so there is a fundamental two-fold ambiguity in the amplitudes. Similarly if T_{--}^0 is zero, there is an ambiguity between T_{+-}^1 and T_{+-}^{-1} . In practice, whenever T_{++}^0 or T_{--}^0 is not

(*) We found no similar ambiguities for reactions (C) and (E) where the meson system has "mixed" spin.

large, one may find two sets of amplitudes with almost equal likelihood - even with very high statistics. We found this happened quite often in the ϕ and ω reactions - in particular when the ω is produced in the backward direction. Wherever such ambiguities exist, we present both solutions.

From the "mechanism" for these ambiguities it is clear that if one makes the transformation to Byers-Yang type amplitudes [12], the ambiguities will appear in the phases and not in the moduli. These amplitudes have another advantage in that, in the forward direction, they can be simply interpreted in terms of t-channel exchange mechanisms. We have therefore chosen to present the results in terms of the following Byers-Yang type amplitudes:

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

In the high energy limit, $a_{\pm}$ is due to natural parity exchange, whereas $b_{\pm}$ and $c_{\pm}$ are due to unnatural parity exchange with s-channel meson helicity 0 and 1, respectively. One can also define s-channel helicity amplitudes which correspond to the exchange of a definite t-channel naturality [13]. Table 4 relates these amplitudes to the normal helicity amplitudes (H) with the Jacob and Wick phase convention [14], as well as to our Byers-Yang type amplitudes and the transversity amplitudes.

We have made several tests that the amplitudes obtained from the fits represent the data adequately. We generated Monte-Carlo events according to the fitted amplitudes and compared, for example, the decay angular distributions and joint decay correlations (evaluated by the method of moments) with the data. The agreement was found to be satisfactory. For all the reactions (A)-(E) these tests indicated that the amplitudes do indeed fit the data - increasing our confidence that backgrounds from other channels and biases in the data are small.

The amplitudes for the reactions (A)-(E) are presented in figs 9-16 and table 5 as functions of t' and u' . These results show several examples of the type of ambiguities discussed above. The typical features are small differences in the moduli and often large differences in the phases.

5. SPIN DENSITY MATRIX AND POLARIZATION

From the transversity amplitudes defined in sect. 4 we constructed the transversity density matrix for the vector meson system;

$$\rho_{mn}^T = \sum_p T_{qp}^m T_{qp}^{n*}.$$

The s-channel helicity density matrix was then determined by rotating this according to

$$\rho_{mn}^H = \sum_{ij} D_{mi}^1(-R) \rho_{ij}^T D_{jn}^1(R),$$

where $R = R(\pi/2, \pi/2, \pi/2)$. This procedure automatically imposes the positivity and rank conditions on the density matrix. In fig. 17 and table 6 we present the normalized ($\text{Tr} \rho = 1$) helicity density matrices for reactions (A)-(E) as functions of t' and u' .

In the forward direction and to order $1/s$, the combinations $\rho_{11\pm} = \rho_{11} \pm \rho_{1-1}$ measure the contribution from natural and unnatural parity exchange, respectively, for meson helicity 1. Similarly, ρ_{00} measures the contribution from unnatural parity exchange for meson helicity 0. The corresponding contributions to the cross section are given in figs 18, 19 and table 7 as functions of t' for the reactions (A)-(E). For the Λ reactions (A), (B) and (C) both naturalities are important but, except in the forward direction ($t' \lesssim 0.2 \text{ GeV}^2$), natural parity exchange gives the larger contribution. In the Σ^0 reactions (D) and (E) unnatural parity exchange is very small and is not shown in fig. 19.

The Λ or Σ^0 hyperon polarizations were determined from

$$P = 2 \sum_{pr} q |T_{qp}^r|^2 / \sum_{pr} |T_{qp}^r|^2$$

and have already been presented in figs 6, 7 and table 2.

The polarization can be separated into contributions from the three different naturality exchange sectors discussed above. This can be conveniently expressed in terms of the Byers-Yang type amplitudes introduced in sect. 4. Hence,

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

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

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

correspond to natural parity exchange, unnatural parity exchange, meson helicity 0 and meson helicity 1, respectively. Note that each of these quantities is normalized such that the allowed range is -1 to +1. This may give rise to large fluctuations when the corresponding amplitudes are small, but on the other hand the properties of each exchange sector stand out more clearly than if one normalises to the total polarization.

The natural and unnatural parity exchange contribution to the polarization are presented as functions of t' for reactions (A)-(E) in fig. 20 and table 8. The contributions from unnatural parity exchange in the Σ^0 reactions (D) and (E) are very small and we could not reliably determine P_U^0 and P_U^1 . Thus we present only P_N for these reactions. In most of the distributions the polarization is significantly non-zero over large portions of the t' -range. This is particularly true in the case of P_N for the ϕ reactions (A) and (D) which seem to have almost unit polarization; negative for Λ and positive for Σ^0 .

6. DISCUSSION OF RESULTS

6.1 Forward Production

In the forward direction, except for a small region close to $t' = 0$, all the reactions (A)-(E) are dominated by natural parity exchange (see figs 9-13 and 18, 19). This is particularly true in the case of the Σ^0 production reactions (D) and (E), in agreement with SU(6) which predicts the contribution of $K(J^{PC} = 0^{-+})$ and $K_B(J^{PC} = 1^{+})^{(*)}$ exchange to these reactions to be small (for example see ref. [15]). The natural parity Regge poles $K^*(J^{PC} = 1^{--})$ and $K^{**}(J^{PC} = 2^{++})$ are known to have a mainly s-channel helicity non-flip coupling at the $p \rightarrow \Lambda/\Sigma$ vertex [16], since for example no forward dips are observed in the pseudoscalar production, hypercharge exchange reactions $K^- p \rightarrow (\pi, \eta, \eta')$ [17] and $K^- p \rightarrow \pi^- \Sigma^+$ [18]. On the other hand, the coupling at the $K^- \rightarrow (\phi, \omega, \rho)$ vertex is spin-flip (natural parity exchange can only contribute to vector meson helicity 1). Hence, natural parity exchange contributes mainly to an overall helicity flip^(**) $n = 1$ amplitude, which vanishes like $\sqrt{-t}$ in the forward direction. This is connected to the forward turnover which we observe in $d\sigma/dt'$ for all these reactions and which is particularly marked in the natural parity exchange contribution, $a_{\pm}$ (figs 9-13) and $\rho_{11+} d\sigma/dt'$ (figs 18, 19).

Unnatural parity exchange with vector meson helicity zero ($\rho_{00} d\sigma/dt'$ in fig. 18) shows a steep t' dependence (the slope $b \sim 5 \text{ GeV}^{-2}$) and is as important as natural parity exchange for the Λ reactions (A)-(C) close to $t' = 0$. The data indicate a flattening-off towards $t' = 0$ for $K^- p \rightarrow (\rho, \omega)\Lambda$ but not for $K^- p \rightarrow \phi\Lambda$.

(*) C-parity is of course only defined for neutral non-strange mesons. We use it here simply to indicate to which nonet the strange particle is assigned.

(**) The overall helicity flip for the reaction $1 + 2 \rightarrow 3 + 4$ is defined as $n = |\lambda_1 - \lambda_3 - \lambda_2 + \lambda_4|$. Angular momentum conservation requires that amplitudes vanish in the forward direction like $t^{n/2}$.

The relative contributions of the Regge trajectories exchanged in a two-body reaction to each helicity amplitude are predicted by SU(3). In the case of unnatural parity exchange, by generalized C-parity arguments [8(b), 19], a given trajectory will couple exclusively either to helicity flip or helicity non-flip at the baryon vertex. This selection rule is, however, strictly only valid in the limit of exact SU(3), but we shall assume it to be good enough for the qualitative conclusions we draw in the following. A summary of the possible exchange contributions to the helicity amplitudes for reactions (A)-(E) is given in table 9. Since K and K_B exchange can couple only to helicity flip at the baryon vertex, one expects $\rho_{00} d\sigma/dt' \rightarrow 0$ as $t' \rightarrow 0$ if these exchanges dominate. The data, however, show large cross sections at $t' \sim 0$ (fig. 18), providing evidence for contributions from $K_A(1^{++})$ or $K_Z(2^{--})$ types of exchanges, which couple only to helicity non-flip at the baryon vertex.

If amplitudes were given completely by factorizing Regge poles, then in the forward direction only one helicity amplitude, having vector meson helicity 0, would survive at $t' = 0^{(*)}$. Hence, ρ_{11} should vanish as $t' \rightarrow 0$. The fact that it does not (fig. 17) is direct evidence for some conspiring contribution, such as an absorptive Regge cut.

SU(3) together with factorization predicts the following relations between amplitudes for our vector meson reactions (see table 9):

$$A(K^- p \rightarrow \omega \Lambda) = A(K^- p \rightarrow \rho \Lambda) \quad (i)$$

$$A(K^- p \rightarrow \phi \Lambda) = -A(\pi^- p \rightarrow K^* \Lambda) \quad (ii)$$

$$A(K^- p \rightarrow \phi \Sigma^0) = -A(\pi^- p \rightarrow K^* \Sigma^0) \quad (iii)$$

(*) A factorizing Regge pole amplitude goes like $t^{(n+x)/2}$ at small t , while an absorbed Regge amplitude might go like the kinematical limit, $t^{n/2}$, where $n + x = |\lambda_1 - \lambda_3| + |\lambda_2 - \lambda_4|$.

which implies that all the observables for these pairs of reactions must be equal^(*). Relations (i) - (iii) assume ideal mixing in the vector meson nonet as well as the validity of the Zweig rule [20]. The same predictions can be obtained from quark additivity [21].

Relation (i) can be studied directly at the amplitude level by comparing figs 10 and 11. The amplitudes $b_{\pm}$ agree well as does c_{-} , but c_{+} appears to be somewhat larger in the $\omega\Lambda$ reaction. The $a_{\pm}$ amplitudes differ in shape below $t' \sim 0.3 \text{ GeV}^2$, although the magnitudes are in rough agreement. The biggest difference between the two reactions occurs for a_{-} , both in magnitude and shape. Similar qualitative conclusions can be drawn from figs 17, 18. It must be pointed out, however, that the errors in the case of the $\rho\Lambda$ reaction are fairly large in the forward direction, reflecting the fact that the s-wave background peaks at small t' (fig. 11). In addition, there is a possible $\sim 30\%$ normalization error for reaction (C) due to theoretical uncertainties in parametrizing the ρ - ω interference phenomenon. For these reasons, we wish to stress the similarities between the two reactions, rather than the differences.

Relations (ii) and (iii) are tested in figs 21 and 22 where we compare the observables for reactions (A) and (D) with those from the corresponding pion induced reactions at 3.93 GeV/c [3]. The agreement between the two sets of observables is good in each case and thus the SU(3) predictions are well supported.

If in addition to SU(3) one makes the further assumption that Regge poles are exchange degenerate (EXD), one obtains the following relations between ω or ρ production and ϕ production (see table 9):

$$\sigma(\phi\Lambda) = 2 \sigma(\omega\Lambda) = 2 \sigma(\rho\Lambda) \quad (\text{iv})$$

(*) We do not make any phase space corrections to take into account the differences in external masses. These corrections are at most $\sim 10\%$.

$$\sigma(\phi\Sigma^0) = [2 \sigma(\omega\Sigma^0)]^{(*)} = 2 \sigma(\rho\Sigma^0). \quad (v)$$

Reactions of the type (B), (C) and (E) are sometimes called "real" reactions, since they are described by non-planar duality diagrams, corresponding to real production amplitudes. (Real production amplitudes are also implied by strong EXD). On the other hand, reactions involving ϕ production (such as (A) and (D)) are called "rotating" reactions since the amplitudes have a rotating phase. In figs 18 and 19 we compare the differential cross sections for the "rotating" reactions $K^-p \rightarrow \phi\Lambda$ and $K^-p \rightarrow \phi\Sigma^0$ with those for the "real" reactions $K^-p \rightarrow (\omega, \rho)\Lambda$ and $K^-p \rightarrow \rho\Sigma^0$. The comparison is made separately for the natural and unnatural parity exchange contributions. Relation (iv) is significantly violated for both $\sigma_+ = \rho_{11+} d\sigma/dt'$ and $\sigma_- = \rho_{00} d\sigma/dt'$. The "real" reactions have larger cross sections than the "rotating" reaction. However, $\sigma_- = \rho_{11-} d\sigma/dt'$ for the Λ reactions and σ_+ for the Σ^0 reactions approximately agree with (iv) and (v), respectively.

The relative success of SU(3) (or quark additivity) in relating different vector meson production, hypercharge exchange reactions has been noted before, as has also the failure of EXD for these reactions in the medium energy range [1,2].

It is interesting to compare our results with those for $K^-p \rightarrow \phi(\Lambda, \Sigma^0)$ and $K^-p \rightarrow \rho(\Lambda, \Sigma^0)$ at 13 GeV/c [22], where the EXD predictions work much better for σ_+ than they do for the Λ reactions at our energy. This could be connected with the fact that, as in our Σ^0 reactions, natural parity exchange is dominant at 13 GeV/c, if the EXD violations were due to an unnatural parity exchange cut.

Our results can also be compared with those for pairs of line reversed reactions where similar EXD predictions are found to be violated. For example in the case of hypercharge exchange reactions over a variety of incident momenta, $\sigma(K^-n \rightarrow \pi^-\Lambda) > \sigma(\pi^-p \rightarrow K^0\Lambda)$ [16], $\sigma(K^-p \rightarrow \pi^-\Sigma^+) > \sigma(\pi^+p \rightarrow K^+\Sigma^+)$ [18,23] and $\sigma(K^-p \rightarrow \pi^-\Sigma^+(1385)) > \sigma(\pi^+p \rightarrow K^+\Sigma^+(1385))$ [10,24]. Similarly in the case of non-strangeness exchange, $\sigma(K^+n \rightarrow K^0p) > \sigma(K^-p \rightarrow \bar{K}^0n)$ [25] and $\sigma(K^+p \rightarrow K^0\Delta^{++}) > \sigma(K^-n \rightarrow \bar{K}^0\Delta^-)$ [26]. The trend is always the same; the "real" reaction has a larger cross section than the "rotating" reaction. Only in the case

(*) The reaction $K^-p \rightarrow \omega\Sigma^0$ cannot be easily studied in a bubble chamber since it involves two neutral particles in the final state.

of reactions where π exchange is allowed is the trend reversed. For example the "rotating" reaction $K^- p \rightarrow \bar{K}^{*0} n$ has larger cross section than the "real" reaction $K^+ n \rightarrow K^{*0} p$ [27].

Strict EXD (or duality together with exoticity) furthermore predicts zero polarization (real helicity amplitudes) for $K^- p \rightarrow (\omega, \rho)\Lambda$ and $K^- p \rightarrow \rho \Sigma^0$. The large polarizations observed particularly in the first two of these reactions are therefore again evidence for strong breaking of EXD. If one assumes that the $n = 0$ natural parity exchange amplitude is modified in a similar way, by absorption for example, in reactions of the type $0^- 1/2^+ \rightarrow 0^- 1/2^+ (H_{++})$ and $0^- 1/2^+ \rightarrow 1^- 1/2^+ (H_{+-}^1)$, one would expect [28]

$$P_N(K^- p \rightarrow \omega\Lambda) \sim - P(K^- p \rightarrow \pi^0\Lambda).$$

Both these polarizations are however positive (see fig. 20 and ref. [17]) which implies different signs (phase differences between flip and non-flip amplitudes) for the EXD breaking in vector meson production reactions and pseudoscalar meson production reactions proceeding via hypercharge exchange.

We can use the results of the amplitude analysis to find out in which amplitudes the EXD breaking occurs. In particular, we can look at the moduli of the mixed amplitudes [29] $A_{\lambda_4}^{\lambda_3}$ and $B_{\lambda_4}^{\lambda_3}$, which can be deduced from the amplitude analysis and are related to helicity amplitudes $H_{\lambda_4\lambda_2}^{\lambda_3}$ by

$$H_{\lambda_4\lambda_2}^{\lambda_3} = A_{\lambda_4}^{\lambda_3} + B_{\lambda_4}^{\lambda_3}$$

$$H_{\lambda_4-\lambda_2}^{\lambda_3} = i \left[A_{\lambda_4}^{\lambda_3} - B_{\lambda_4}^{\lambda_3} \right].$$

If, as implied by EXD, the two helicity amplitudes $H_{\lambda_4\lambda_2}^{\lambda_3}$ and $H_{\lambda_4-\lambda_2}^{\lambda_3}$ are both real then the corresponding mixed amplitudes $A_{\lambda_4}^{\lambda_3}$ and $B_{\lambda_4}^{\lambda_3}$ must have equal moduli. Fig. 23 shows the moduli of the mixed amplitudes for $K^- p \rightarrow \omega\Lambda$. Over the whole t' range $|A_{\frac{1}{2}}^1|$ and $|B_{\frac{1}{2}}^1|$ are definitely unequal,

so the non-flip (at the baryon vertex) amplitude H_{++}^1 and the spin-flip amplitude H_{+-}^1 cannot both be real. Similar conclusions can be drawn for H_{++}^0 and H_{+-}^0 , whereas H_{++}^{-1} and H_{+-}^{-1} are compatible with being both real. This is what would be expected if EXD breaking is mainly due to absorption^(*).

For the reactions $K^- p \rightarrow \phi \Lambda$ and $K^- p \rightarrow \phi \Sigma^0$ the predictions of EXD are not so simple, since the phase of the $K^* K^{**}$ contribution ($e^{-i\pi\alpha_{K^*}}$) and the phase of the $K-K_B$ contribution ($e^{-i\pi\alpha_K}$), and other possible contributions (table 9), could be different. Therefore, there are no simple predictions for helicity amplitudes in these cases.

It is interesting to compare the polarizations for "real" and "rotating" reactions. We can draw the following qualitative conclusions from fig. 20, making the simplifying assumption that the reactions are dominated by pure Regge pole exchange and absorption effects can be ignored.

The opposite signs of P_N for $K^- p \rightarrow (\omega, \rho) \Lambda$ and $K^- p \rightarrow \phi \Lambda$ can be understood from the fact that the SU(3) coupling constant for K^* exchange changes sign under $\phi \rightarrow (\omega, \rho)$, while it does not for K^{**} exchange (see table 9). It has been pointed out that P_N should change sign under $\Lambda \rightarrow \Sigma$ for reactions where the same vector meson is produced (for example see ref. [2(d)]). This prediction is well fulfilled for $K^- p \rightarrow \phi(\Lambda, \Sigma^0)$, but the relatively large errors in the case of reaction (E) do not allow a similar conclusion to be drawn for $K^- p \rightarrow \rho(\Lambda, \Sigma^0)$.

The observation of non-zero polarization for unnatural parity exchange implies the presence of more than simple K exchange. One may write the contribution to this polarization in the following symbolic way (table 9):

$$P_U \propto \text{Im} \left[(K)_{+-} (K_A)_{++}^* \right] + \text{Im} \left[(K_B)_{+-} (K_Z)_{++}^* \right] \\ + \text{Im} \left[(K)_{+-} (K_Z)_{++}^* \right] + \text{Im} \left[(K_B)_{+-} (K_A)_{++}^* \right] \\ + \text{Im} \left[(K)_{+-} (K_B)_{++}^* \right] + \text{Im} \left[(K_A)_{+-} (K_Z)_{++}^* \right].$$

(*) One amplitude in each of the first two pairs is an $n = 0$ amplitude (H_{+-}^1 and H_{++}^0), whereas the last pair of amplitudes are $n = 1$ and $n = 2$, respectively.

The two last terms are zero in the limit of exact SU(3). Of the remaining terms the third and fourth would change sign under $\phi \rightarrow (\omega, \rho)$, while the first and second would not.

The data show substantial unnatural parity polarization. P_U^0 is positive on average for all three Λ reactions (A), (B) and (C). On the other hand for $t' \lesssim 0.8 \text{ GeV}^2$, P_U^1 changes sign under $\phi \rightarrow \omega$ (in view of the large errors, no definite conclusions can be drawn from reaction (C)). From these observations we conclude that the data seem to require the exchange of at least two unnatural parity trajectories in addition to the K trajectory.

Throughout this section we have made general phenomenological comments without reference to specific model calculations. It should be clear from these comments that any model for reactions (A)-(E) has to be quite sophisticated in order to describe the detailed features of our data. Kane and Seidl [30] have given a comprehensive account of a sophisticated Regge pole exchange model with absorption, which successfully describes a considerable amount of data for non-hypercharge exchange reactions. We have preferred to use the Regge pole model of ref. [13], but modifying the amplitudes according to the absorptive prescriptions of Kane and Seidl. Details of the calculations can be found in ref. [31]. The results are superimposed on the Byers-Yang amplitudes for reactions (A) and (B) in figs 9 and 10. The model adequately reproduces the shape and relative phases of some of the amplitudes. For example, the relative contributions of the proton spin "up" and spin "down" amplitudes (and hence the $\phi\Lambda$ and to a lesser extent the $\omega\Lambda$ polarizations) are reasonably well reproduced. However, the model fails to describe the majority of the amplitudes at small t' . Since the main emphasis in this paper is to present the data we have made no attempt to change or fit parameters in the model in order to obtain a better description of the data. On the other hand, we find it encouraging that the model does indeed describe some important features.

We conclude this section with a brief reference to the additive quark model, which can be used to relate reactions proceeding via the same quark-quark interaction. Thus we have already seen that the predictions (i) - (iii) were rather well fulfilled. However, we have

tested relations in which the final state baryon, as well as the initial state baryon, is the same for both reactions. Using the SU(6) baryon wave functions, Lipkin and Scheck [32] have derived the following sum rule for reactions which have different final state baryons:

$$\sigma(K^- p \rightarrow m^0 \Lambda) = 3[\sigma(K^- p \rightarrow m^0 \Sigma^0) + \sigma(K^- p \rightarrow m^0 \Sigma^0(1385))],$$

where m^0 is any neutral meson. This sum rule is badly violated by experiment. However, it is possible to construct a quark spectator model which gives a new sum rule in better agreement with the data. We merely wish to point out here that, using such a model, the unknown relative phase between the two groups of transversity amplitude with initial proton spin "up" and initial proton spin "down" can be derived from the data. Thus the complete set of helicity amplitudes, apart from an overall phase, can be extracted. An analysis along these lines is in progress [33].

6.2 Backward Production

As already pointed out in sect. 3 we observe no signal for backward ϕ production either in reaction (A) or in reaction (D). The cross section for $u' < 1 \text{ GeV}^2$ is $< 0.4 \text{ } \mu\text{b}$ with 95% confidence for both reactions (see table 2 and figs 6 and 7). This should be compared to the cross sections for backward ω and ρ production in reactions (B) and (E), where we observe $(19.0 \pm 0.7) \text{ } \mu\text{b}$ and $(6.1 \pm 0.7) \text{ } \mu\text{b}$, respectively, for $u' < 1 \text{ GeV}^2$. Any baryon exchange mechanism for backward ϕ production is suppressed by the quark-line rule (Zweig rule [20]), whereas a direct channel resonance mechanism is not so suppressed. From the above we see that backward ϕ production is suppressed by factors of $\sim 50 : 1$ and $\sim 15 : 1$ for the Λ and Σ^0 reactions, respectively, confirming that baryon exchange is the dominant mechanism for backward production at our energy. An essential condition for this suppression to occur is ideal mixing in the vector meson nonet. Following a suggestion by Lipkin [34], we can use our

results to give an upper limit for the deviation θ from ideal mixing;

$$\tan^2 \theta = \frac{g_{NN\phi}^2}{g_{NN\omega}^2} = \frac{\sigma(K^- p \rightarrow \Lambda\phi)_{\text{back}}}{\sigma(K^- p \rightarrow \Lambda\omega)_{\text{back}}} < \frac{0.4}{19.0} = 0.02 \text{ (95\% C.L.)},$$

which corresponds to $\theta < 8^\circ$.

In the backward direction the data for $K^- p \rightarrow \Lambda\omega$ and $K^- p \rightarrow \Lambda\rho$ (reactions (B) and (C)) show two interesting features (fig. 6):

- (a) The cross section is very flat in u' ($d\sigma/du' \sim e^{-u'}$).
- (b) There is a significant (particularly in reaction (B)) dip at $u' = 0.2 - 0.3 \text{ GeV}^2$, where the nucleon Regge trajectory passes through $\alpha = -1/2$.

In the first respect this resembles backward photoproduction reactions ($\gamma p \rightarrow n\pi^+$, $p\pi^0$ and $\gamma n \rightarrow p\pi^-$) more closely than it resembles other nucleon exchange reactions ($\pi^+ p \rightarrow p\pi^+$, $K^- p \rightarrow \Lambda\pi^0$), as might be expected from vector dominance. However, in (b) it resembles $\pi^+ p \rightarrow p\pi^+$ and $K^- p \rightarrow \Lambda\pi^0$ more closely than photoproduction reactions. For the reaction $K^- p \rightarrow \Sigma^0 \rho$ the differential cross section (fig. 7) has a somewhat different shape, which might be due to the fact that both isospin $I = 1/2$ and $I = 3/2$ exchange can contribute in this case.

For all the reactions which exhibit backward production ((B), (C) and (E)), the polarization changes sign between the forward and backward hemispheres (figs 6 and 7). This is particularly true in the case of reactions (B) and (C) where the shape of the polarization distribution in the backward direction is such that it forms an approximate mirror image of the corresponding distribution in the forward direction. Again this is somewhat less clear in the case of reaction (E).

We have already seen that in the forward direction, the observables for the ω and ρ production reactions (B) and (C) are approximately equal. In the backward direction this is not the case. For example, figs 17(f) and 17(g) show that the density matrix elements are not the same, since both ρ_{1-1} and ρ_{10} tend to have opposite signs for the two reactions over

the entire u' range. Fig. 24 shows the diagrams allowed by the quark-line rule for forward and backward ω and ρ production. In the forward direction, the final state meson can only be formed by a $u\bar{u}$ quark pair. Since ω and ρ are linear combinations of $u\bar{u}$ and $d\bar{d}$ (with the same sign for $u\bar{u}$ and opposite for $d\bar{d}$), the production amplitudes are predicted to be equal. On the other hand, in the backward direction two planar diagrams and one non-planar diagram can contribute. Two of the diagrams give a $u\bar{u}$ pair, while the third gives a $d\bar{d}$ pair. The production amplitudes will depend on the relative strengths and phases of the diagrams contributing and thus in general will not be equal for ω and ρ production if some $d\bar{d}$ is produced.

There is a striking similarity between the density matrix elements for the ω produced in the backward direction of reaction (B) (fig. 17(f)) and those observed in backward $K^-p \rightarrow \Lambda(1520)\omega$ in the same experiment [35]. This similarity might be explained by a simple factorization argument for N_α exchange.

7. CONCLUSIONS

A detailed analysis of the vector meson production, hypercharge exchange reactions $K^-p \rightarrow (\phi, \omega, \rho)\Lambda$ and $K^-p \rightarrow (\phi, \rho)\Sigma^0$ at 4.2 GeV/c incident momentum has been performed. The statistical sensitivity of the data presented here is at least five times greater than that previously available in the medium energy range. Total cross sections have been given, as well as the differential cross sections over the complete angular range. The asymmetric weak decay of the Λ hyperon observed in the final states allowed an almost complete determination of the transversity production amplitudes governing all five reactions. The amplitudes have been presented in detail in both the forward and, except for the ϕ reactions, backward directions as functions of momentum transfer. The Λ and Σ^0 polarizations and vector meson density matrices have been derived from the amplitudes.

In the forward direction, natural parity exchange has been shown to be dominant, especially in the case of the Σ^0 reactions. SU(3) predictions (or those of the additive quark model) have been tested and shown to be well fulfilled by the data. Strong violations of strict exchange degeneracy have been noted and investigated in detail. Evidence has been presented that absorption plays an important rôle in describing these reactions and a Regge pole model modified by absorptive corrections has been compared with the data.

In the backward direction, the high statistics afforded by this experiment allowed a determination of the production amplitudes for $K^-p \rightarrow (\omega, \rho)\Lambda$ and $K^-p \rightarrow \rho\Sigma^0$. This is the first time that such an analysis has been performed. Upper limits for ϕ production have been given and used to estimate the deviation from ideal mixing in the vector meson nonet.

We are indebted to the operating crews of the CERN PS and 2m HBC and to the constructors of the beam. We should like to thank the scanning, measuring and computing staff at each of our laboratories. It is a pleasure to acknowledge the help given by Dr. A.C. Irving in performing the model calculations described in sect. 6.1, as well as many fruitful discussions with him and Dr. B. Schrempp.

REFERENCES

- [1] A.J. de Groot et al., Nucl. Physics B74 (1974) 77.
- [2] (a) A.G. Clark and L. Lyons, Nucl. Physics B38 (1972) 37.
 (b) A. Rougé et al., Nucl. Physics B44 (1972) 365.
 (c) M. Aguilar-Benitez et al., Phys. Review D6 (1972) 29.
 (d) R.D. Field et al., Phys. Review D6 (1972) 1863.
 (e) R.D. Field et al., Phys. Review D7 (1973) 2036.
 (f) L. Lyons, A.M. Cooper and A.G. Clark, " $K^-p \rightarrow \Lambda^0$ or Σ^0 + vector Meson at 3.1-3.6 GeV/c", Oxford University preprint 87 (1976).
- [3] D. Yaffe et al., Nucl. Physics B75 (1974) 365.
- [4] Review of Particle Properties, Particle Data Group, Rev. Mod. Physics 48 (1976) No. 2, Part II.
- [5] S.O. Holmgren et al., Phys. Letters 66B (1977) 191.
- [6] A.S. Goldhaber, G.C. Fox and C. Quigg, Phys. Letters 30B (1969) 249 and references therein.
- [7] A. Bramon and Y. Srivastava, Phys. Letters 47B (1973) 265.
- [8] (a) A. Abramovich et al., Phys. Letters 39B (1972) 353.
 (b) A.D. Martin, in Proc. 7th "Rencontre de Moriond" (1972) 349.
 For a complete list of references to experimental papers in this field see ref. [35].
- [9] R.P. Worden, in preparation.
- [10] S.O. Holmgren et al., Nucl. Physics B119 (1977) 261.
- [11] A. Kotanski, Acta Phys. Polonica 29 (1966) 699 and 30 (1966) 629.
- [12] N. Byers and C.N. Yang, Phys. Review B135 (1964) 796.
- [13] A.C. Irving and R.P. Worden, "Regge Phenomenology", to be published in Phys. Reports.
- [14] M. Jacob and G.C. Wick, Annals of Physics 7 (1959) 404.
- [15] M.M. Nagels et al., Nucl. Physics B109 (1976) 1.
- [16] G.C. Fox and C. Quigg, Annual Review of Nuclear Science 23 (1973) 219.
- [17] F. Marzano et al., "The Reactions $K^-p \rightarrow \Lambda\pi^0$, $\Lambda\eta$, $\Lambda\eta'$ at 4.2 GeV/c", CERN/EP/PHYS 77-5 (1977) and to be published in Nucl. Physics B.
- [18] G.G.G. Massaro et al., Phys. Letters 66B(1977) 385.

REFERENCES (Cont'd)

- [19] R.D. Field, Phys. Letters 39B (1972) 389 and Review Talk at the Conference on $\pi\pi$ Scattering and Related Topics, Tallahassee (1973) p. 153 (The American Institute of Physics, New York 1973).
- [20] S. Okubo, Phys. Letters 5 (1963) 165.
G. Zweig in "Symmetries in Elementary Particle Physics", Academic Press, New York (1965) 192.
J. Iizuka, Suppl. to Prog. of Theor. Physics 37-38 (1966) 21.
- [21] A. Białas and K. Zalewski, Nucl. Physics B6 (1968) 449.
- [22] G.W. Brandenburg et al., Nucl. Physics B104 (1976) 413.
- [23] A. Berglund et al., Phys. Letters 57B (1975) 100.
- [24] A. Berglund et al., Phys. Letters 60B (1975) 117.
- [25] R. Diebold et al., Phys. Rev. Letters 32 (1974) 904.
- [26] J.J. Phelan et al., Phys. Letters 61B (1976) 483.
- [27] A.C. Irving and C. Michael, Nucl. Physics B82 (1974) 282.
- [28] C. Michael, Review Talk at the 16th Int. Conf. on High Energy Physics, Chicago (1972).
- [29] R.P. Worden, Nucl. Physics B96 (1975) 509.
- [30] G.L. Kane and A. Seidl, Rev. Mod. Physics 48 (1976) No. 2, part 1.
- [31] J. Wells, D. Phil. Thesis, Oxford University (1977).
- [32] H.J. Lipkin and F. Scheck, Phys. Rev. Letters 18 (1967) 347.
- [33] J.C. Kluyver et al., "New Quark Model Relations for Hypercharge Exchange Reactions", Amsterdam preprint (1977).
M. Zraček et al., "Test of an Additive Diquark Spectator Model for Meson-baryon Quasi-two-body Reactions, Nijmegen preprint (1977).
- [34] H.J. Lipkin, Phys. Letters 60B (1976) 371.
- [35] M. Aguilar-Benítez et al., "Study of Hypercharge Exchange Reactions of the Type $K^+ p \rightarrow 1^- \frac{3}{2}^+$ at 4.2 GeV/c", CERN/D.Ph.II/PHYS 75-23 Rev. (1975) and to be published in Nucl. Physics B.

TABLE CAPTIONS

- Table 1 Results of fits to mass spectra.
- Table 2 (a) Differential cross sections. The errors are statistical only.
(b) Hyperon polarizations.
- Table 3 Results of fits to differential cross sections with simple exponential forms. The parametrization used and the range of t' or u' over which the fit was performed are indicated in each case.
- Table 4 Relationship between the helicity amplitudes defined in [13], which (to order $1/s$) correspond to a definite naturality in the t -channel and the helicity amplitudes (H) with the phase convention of Jacob and Wick [14]. Natural parity exchange amplitudes are denoted by N, unnatural parity exchange amplitudes by U. The table also relates the helicity amplitudes to the Byers-Yang type amplitudes defined in the text and to the transversity amplitudes.
- Table 5 Moduli and relative phases of the Byers-Yang amplitudes as functions of t' or u' for: (a) $K^- p \rightarrow \phi \Lambda$; (b) $K^- p \rightarrow \omega \Lambda$; (c) $K^- p \rightarrow \rho \Lambda$; (d) $K^- p \rightarrow \phi \Sigma^0$; (e) $K^- p \rightarrow \rho \Sigma^0$; (f) $K^- p \rightarrow \Lambda \omega$; (g) $K^- p \rightarrow \Lambda \rho$; (h) $K^- p \rightarrow \Sigma^0 \rho$. The s -wave background amplitudes (T_{-+}^s and T_{+-}^s) are also given for reactions (C) and (E). The units for the moduli are $(\mu\text{b}/\text{GeV})^{1/2}$ and those for the phases are radians.
- Table 6 Vector meson s -channel helicity spin density matrix elements as functions of t' or u' for: (a) $K^- p \rightarrow \phi \Lambda$; (b) $K^- p \rightarrow \omega \Lambda$; (c) $K^- p \rightarrow \rho \Lambda$; (d) $K^- p \rightarrow \phi \Sigma^0$; (e) $K^- p \rightarrow \rho \Sigma^0$; (f) $K^- p \rightarrow \Lambda \omega$; (g) $K^- p \rightarrow \Lambda \rho$; (h) $K^- p \rightarrow \Sigma^0 \rho$.

- Table 7 Natural and unnatural parity exchange contributions to the differential cross section for: (a) $K^-p \rightarrow \phi\Lambda$; (b) $K^-p \rightarrow \omega\Lambda$; (c) $K^-p \rightarrow \rho\Lambda$; (d) $K^-p \rightarrow \phi\Sigma^0$; (e) $K^-p \rightarrow \rho\Sigma^0$. The notation is $\sigma_+ = \rho_{11+} d\sigma/dt'$, $\sigma_0 = \rho_{00} d\sigma/dt'$ and $\sigma_- = \rho_{11-} d\sigma/dt'$.
- Table 8 Natural and unnatural parity exchange contribution to the hyperon polarization as functions of t' for: (a) $K^-p \rightarrow \phi\Lambda$; (b) $K^-p \rightarrow \omega\Lambda$; (c) $K^-p \rightarrow \rho\Lambda$; (d) $K^-p \rightarrow \phi\Sigma^0$; (e) $K^-p \rightarrow \rho\Sigma^0$.
- Table 9 Regge trajectories contributing to the helicity amplitudes of definite t-channel naturality [8(b),18]. In the case of unnatural parity exchange, the separation is only valid in the limit of exact SU(3).

TABLE 1

Final state	Fitted No. of events (a)	Cross section (b) (μb)	Mass cut (GeV)	Events Inside mass cut (a)	Background inside mass cut (%)
$\phi \Lambda \rightarrow K^+ K^-$	1942	66 ± 4	1.010 - 1.035	1573	2 ± 1
$\phi \Lambda \rightarrow K_S^0 K_L^0$	1112		1.010 - 1.035	843	1 ± 2
$\omega \Lambda \rightarrow \pi^+ \pi^- \pi^0$	5820	91 ± 8	0.760 - 0.810	4479	6 ± 1
$\rho \Lambda \rightarrow \pi^+ \pi^-$	-	82 ± 8	0.520 - 0.920	4125 ^(c)	$\sim 30^{(c)}$
$\phi \Sigma^0 \rightarrow K^+ K^-$	1134	34 ± 3	1.010 - 1.035	909	2 ± 2
$\rho \Sigma \rightarrow \pi^+ \pi^-$	-	30 ± 3	0.650 - 0.850	1982 ^(c)	$\sim 25^{(c)}$

(a) Corrected for Λ and K_S^0 detection efficiency.

(b) Fully corrected for Λ and K_S^0 unseen decay modes and other vector meson decay modes [4].

(c) After excluding events with Mass ($\Lambda\pi^+$ or $\Sigma^0\pi^+$) < 1.8 GeV.

TABLE 2(a)

Differential cross sections

$K^- p \rightarrow \phi \Lambda$		$K^- p \rightarrow \omega \Lambda$		$K^- p \rightarrow \rho \Lambda$		$K^- p \rightarrow \phi \Sigma^0$		$K^- p \rightarrow \rho \Sigma^0$	
t' (GeV ²)	$\frac{d\sigma}{dt'}$ ($\mu\text{b}/\text{GeV}^2$)	t' (GeV ²)	$\frac{d\sigma}{dt'}$ ($\mu\text{b}/\text{GeV}^2$)	t' (GeV ²)	$\frac{d\sigma}{dt'}$ ($\mu\text{b}/\text{GeV}^2$)	t' (GeV ²)	$\frac{d\sigma}{dt'}$ ($\mu\text{b}/\text{GeV}^2$)	t' (GeV ²)	$\frac{d\sigma}{dt'}$ ($\mu\text{b}/\text{GeV}^2$)
0.00-0.05	95 $\pm$ 8	0.00-0.05	70 $\pm$ 6	0.00-0.05	83 $\pm$ 15	0.00-0.10	29 $\pm$ 3	0.00-0.15	26 $\pm$ 4
0.05-0.10	114 $\pm$ 8	0.05-0.10	83 $\pm$ 6	0.05-0.10	88 $\pm$ 9	0.10-0.20	34 $\pm$ 4	0.15-0.30	23 $\pm$ 3
0.10-0.15	109 $\pm$ 8	0.10-0.15	93 $\pm$ 6	0.10-0.15	83 $\pm$ 10	0.20-0.30	42 $\pm$ 4	0.30-0.50	19 $\pm$ 2
0.15-0.20	118 $\pm$ 9	0.15-0.20	92 $\pm$ 6	0.15-0.20	69 $\pm$ 8	0.30-0.40	31 $\pm$ 4	0.50-0.80	9.5 $\pm$ 1.0
0.20-0.25	81 $\pm$ 7	0.20-0.25	75 $\pm$ 6	0.20-0.30	63 $\pm$ 6	0.40-0.50	29 $\pm$ 4	0.80-1.20	5.4 $\pm$ 0.9
0.25-0.30	83 $\pm$ 7	0.25-0.30	76 $\pm$ 6	0.30-0.40	65 $\pm$ 5	0.50-0.60	25 $\pm$ 3	1.20-1.60	2.8 $\pm$ 1.0
0.30-0.35	75 $\pm$ 7	0.30-0.35	64 $\pm$ 5	0.40-0.50	40 $\pm$ 4	0.60-0.70	27 $\pm$ 3	1.60-2.30	1.6 $\pm$ 0.4
0.35-0.40	63 $\pm$ 6	0.35-0.40	56 $\pm$ 5	0.50-0.60	40 $\pm$ 4	0.70-0.80	19 $\pm$ 3	2.30-3.00	1.2 $\pm$ 0.3
0.40-0.45	54 $\pm$ 6	0.40-0.45	47 $\pm$ 4	0.60-0.80	22 $\pm$ 2	0.80-1.00	15 $\pm$ 2		
0.45-0.50	53 $\pm$ 6	0.45-0.50	37 $\pm$ 4	0.80-1.00	12 $\pm$ 2	1.00-1.20	11 $\pm$ 2		
0.50-0.55	49 $\pm$ 5	0.50-0.55	45 $\pm$ 4	1.00-1.20	10 $\pm$ 1	1.20-1.40	7.5 $\pm$ 1.2		
0.55-0.60	40 $\pm$ 5	0.55-0.60	39 $\pm$ 4	1.20-1.60	7.8 $\pm$ 1.1	1.40-1.60	6.0 $\pm$ 1.1		
0.60-0.65	39 $\pm$ 5	0.60-0.65	33 $\pm$ 4	1.60-2.30	7.7 $\pm$ 0.8	1.60-1.80	5.6 $\pm$ 1.1		
0.65-0.70	37 $\pm$ 5	0.65-0.70	30 $\pm$ 4	2.30-3.00	4.1 $\pm$ 0.7	1.80-2.70	0.9 $\pm$ 0.2		
0.70-0.80	31 $\pm$ 3	0.70-0.80	23 $\pm$ 2						
0.80-0.90	22 $\pm$ 3	0.80-0.90	16 $\pm$ 2						
0.90-1.00	22 $\pm$ 3	0.90-1.00	19 $\pm$ 2						
1.00-1.10	20 $\pm$ 2	1.00-1.10	15 $\pm$ 2						
1.10-1.20	13 $\pm$ 2	1.10-1.20	11 $\pm$ 2						
1.20-1.40	7.5 $\pm$ 1.0	1.20-1.40	10 $\pm$ 1						
1.40-1.60	5.7 $\pm$ 0.9	1.40-1.60	7.5 $\pm$ 0.9						
1.60-1.80	2.9 $\pm$ 0.7	1.60-1.80	4.5 $\pm$ 0.7						
1.80-2.75	0.8 $\pm$ 0.2	1.80-2.00	6.3 $\pm$ 0.8						
		2.00-2.20	3.9 $\pm$ 0.7						
		2.20-2.40	2.8 $\pm$ 0.6						
		2.40-2.60	3.8 $\pm$ 0.7						
		2.60-2.80	4.6 $\pm$ 0.7						
		2.80-3.00	4.6 $\pm$ 0.7						

TABLE 2(a) (Cont'd)

u' (GeV ²)	$\frac{d\sigma}{du'}$ ($\mu\text{b}/\text{GeV}^2$)	u' (GeV ²)	$\frac{d\sigma}{du'}$ ($\mu\text{b}/\text{GeV}^2$)	u' (GeV ²)	$\frac{d\sigma}{du'}$ ($\mu\text{b}/\text{GeV}^2$)	u' (GeV ²)	$\frac{d\sigma}{du'}$ ($\mu\text{b}/\text{GeV}^2$)	u' (GeV ²)	$\frac{d\sigma}{du'}$ ($\mu\text{b}/\text{GeV}^2$)
0.00-1.00	< 0.39	0.00-0.10	27 $\pm$ 3	0.00-0.20	16 $\pm$ 4	0.00-1.00	< 0.38	0.00-0.20	13 $\pm$ 2
1.00-2.75	0.25 $\pm$ 0.07	0.10-0.20	17 $\pm$ 2	0.20-0.50	5.5 $\pm$ 2.0	1.00-2.70	0.14 $\pm$ 0.06	0.20-0.50	4.7 $\pm$ 1.6
		0.20-0.30	17 $\pm$ 2	0.50-0.80	15 $\pm$ 2			0.50-0.80	4.2 $\pm$ 0.8
		0.30-0.40	17 $\pm$ 2	0.80-1.20	12 $\pm$ 2			0.80-1.20	4.1 $\pm$ 0.7
		0.40-0.50	22 $\pm$ 2	1.20-1.60	9.5 $\pm$ 2.0			1.20-1.60	2.5 $\pm$ 0.6
		0.50-0.60	23 $\pm$ 2	1.60-2.30	5.5 $\pm$ 0.8			1.60-2.30	1.9 $\pm$ 0.6
		0.60-0.70	20 $\pm$ 2	2.30-3.00	4.1 $\pm$ 0.7			2.30-3.00	2.4 $\pm$ 0.5
		0.70-0.80	19 $\pm$ 2						
		0.80-0.90	12 $\pm$ 2						
		0.90-1.00	17 $\pm$ 2						
		1.00-1.10	13 $\pm$ 2						
		1.10-1.20	11 $\pm$ 2						
		1.20-1.30	9.4 $\pm$ 1.4						
		1.30-1.40	12 $\pm$ 2						
		1.40-1.60	7.0 $\pm$ 0.9						
		1.60-1.80	6.0 $\pm$ 0.9						
		1.80-2.00	4.6 $\pm$ 0.8						
		2.00-2.20	5.6 $\pm$ 0.8						
		2.20-2.40	3.9 $\pm$ 0.7						
		2.40-2.60	4.2 $\pm$ 0.7						
		2.60-2.80	3.6 $\pm$ 0.6						
		2.80-3.00	3.7 $\pm$ 0.7						

TABLE 2(b)

Polarizations

$\bar{K} p \rightarrow \phi \Lambda$		$\bar{K} p \rightarrow \omega \Lambda$		$\bar{K} p \rightarrow \rho \Lambda$		$\bar{K} p \rightarrow \rho \Sigma^0$		$\bar{K} p \rightarrow \rho \Sigma^0$	
t' (GeV ²)	P	t' (GeV ²)	P	t' (GeV ²)	P	t' (GeV ²)	P	t' (GeV ²)	P
0.00-0.05	0.25±0.13	0.00-0.05	0.35±0.20	0.00-0.05	0.41±0.18	0.00-0.15	0.62±0.22	0.00-0.15	0.37±0.37
0.05-0.10	0.13±0.15	0.05-0.10	0.22±0.19	0.05-0.10	0.53±0.21	0.15-0.30	0.71±0.15	0.15-0.30	-0.66±0.34
0.10-0.15	-0.17±0.15	0.10-0.15	0.03±0.17	0.10-0.15	0.59±0.22	0.30-0.50	0.64±0.36	0.30-0.50	-0.02±0.33
0.15-0.20	-0.03±0.14	0.15-0.20	0.36±0.14	0.15-0.20	0.63±0.18	0.50-0.80	0.91±0.08	0.50-0.80	-0.07±0.41
0.20-0.30	-0.08±0.10	0.20-0.30	0.40±0.14	0.20-0.30	0.32±0.18	0.80-1.20	0.40±0.47	0.80-1.20	0.08±0.37
0.30-0.40	-0.34±0.14	0.30-0.40	0.38±0.16	0.30-0.40	0.55±0.24	1.20-1.60	0.77±0.25	1.20-1.60	-0.44±0.61
0.40-0.50	-0.45±0.14	0.40-0.50	0.34±0.17	0.40-0.50	0.79±0.15	1.60-2.30	0.69±0.64	1.60-2.30	-0.62±0.24
0.50-0.60	-0.41±0.15	0.50-0.60	0.55±0.17	0.50-0.60	0.60±0.19	2.30-3.00		2.30-3.00	-0.55±0.62
0.60-0.80	-0.45±0.14	0.60-0.80	0.54±0.15	0.60-0.80	0.29±0.19				
0.80-1.00	-0.22±0.17	0.80-1.00	0.40±0.18	0.80-1.00	0.67±0.23				
1.00-1.60	-0.20±0.17	1.00-1.20	0.77±0.13	1.00-1.20	0.57±0.21				
1.60-2.75	-0.05±0.36	1.20-1.60	0.90±0.14	1.20-1.60	0.21±0.24				
		1.60-2.20	0.20±0.21	1.60-2.30	0.55±0.17				
		2.20-3.00	-0.19±0.20	2.30-3.00	0.22±0.28				
$\bar{K} p \rightarrow \phi \Lambda$		$\bar{K} p \rightarrow \omega \Lambda$		$\bar{K} p \rightarrow \rho \Lambda$		$\bar{K} p \rightarrow \rho \Sigma^0$		$\bar{K} p \rightarrow \rho \Sigma^0$	
u' (GeV ²)	P	u' (GeV ²)	P	u' (GeV ²)	P	u' (GeV ²)	P	u' (GeV ²)	P
0.00-0.20	-0.21±0.21	0.00-0.20	-0.21±0.21	0.00-0.20	0.36±0.22	0.00-0.20		0.00-0.20	-0.84±0.18
0.20-0.40	-0.41±0.21	0.20-0.40	-0.41±0.21	0.20-0.50	0.13±0.48	0.20-0.50		0.20-0.50	0.81±0.31
0.40-0.60	-0.15±0.20	0.40-0.60	-0.15±0.20	0.50-0.80	-0.62±0.18	0.50-0.80		0.50-0.80	0.68±0.32
0.60-0.80	-0.41±0.18	0.60-0.80	-0.41±0.18	0.80-1.20	-0.29±0.30	0.80-1.20		0.80-1.20	0.29±0.46
0.80-1.20	-0.81±0.11	0.80-1.20	-0.81±0.11	1.20-1.60	-0.47±0.23	1.20-1.60		1.20-1.60	-0.34±0.46
1.20-1.60	-0.53±0.18	1.20-1.60	-0.53±0.18	1.60-2.30	-0.20±0.17	1.60-2.30		1.60-2.30	0.10±0.41
1.60-2.20	-0.21±0.21	1.60-2.20	-0.21±0.21	2.30-3.60	0.26±0.31	2.30-3.00		2.30-3.00	0.02±0.48
2.20-3.00	0.52±0.20	2.20-3.00	0.52±0.20						

TABLE 3

CERN/EP/PHYS 77-45

Results of fits to differential cross sections

Final State	t' or u' range (GeV ²)	Form used	b (GeV ⁻²)
$\phi \Lambda$	0. - 1.0	t'. exp (-bt')	5.2 $\pm$ 0.2
$\omega \Lambda$	0. - 1.0	t'. exp (-bt')	5.2 $\pm$ 0.2
$\rho \Lambda$	0. - 1.0	t'. exp (-bt')	5.6 $\pm$ 0.2
$\phi \Sigma^0$	0. - 1.0	t'. exp (-bt')	3.8 $\pm$ 0.2
$\rho \Sigma^0$	0. - 1.2	t'. exp (-bt')	5.0 $\pm$ 0.2
$\Lambda \omega$	0.5 - 2.0	exp (-bu')	1.2 $\pm$ 0.1
$\Lambda \omega$	0.5 - 2.3	exp (-bu')	0.8 $\pm$ 0.1
$\Sigma^0 \rho$	0.2 - 2.3	exp (-bu')	0.6 $\pm$ 0.2

TABLE 4

Overall helicity flip (n)	Naturality conserving helicity amplitudes	Helicity amplitudes	Byers-Yang amplitudes	Transversity amplitudes
1	N_{++}^1	$\frac{1}{\sqrt{2}} (H_{++}^1 + H_{++}^{-1})$	$-\frac{i}{\sqrt{2}} (a_+ + a_-)$	$\frac{i}{\sqrt{2}} (T_{++}^0 + T_{--}^0)$
0, 2	N_{+-}^1	$\frac{1}{\sqrt{2}} (H_{+-}^1 + H_{+-}^{-1})$	$\frac{1}{\sqrt{2}} (a_+ - a_-)$	$\frac{1}{\sqrt{2}} (-T_{++}^0 + T_{--}^0)$
0	U_{++}^0	H_{++}^0	$\frac{1}{\sqrt{2}} (b_+ + b_-)$	$\frac{1}{2} (T_{+-}^1 + T_{-+}^{-1} - T_{+-}^{-1} - T_{-+}^1)$
1	U_{+-}^0	H_{+-}^0	$\frac{i}{\sqrt{2}} (b_+ - b_-)$	$\frac{i}{2} (T_{+-}^1 + T_{-+}^{-1} + T_{+-}^{-1} + T_{-+}^1)$
1	U_{++}^1	$\frac{1}{\sqrt{2}} (H_{++}^1 - H_{++}^{-1})$	$\frac{1}{\sqrt{2}} (c_+ + c_-)$	$\frac{i}{2} (-T_{+-}^1 + T_{-+}^{-1} + T_{+-}^{-1} - T_{-+}^1)$
0, 2	U_{+-}^1	$\frac{1}{\sqrt{2}} (H_{+-}^1 - H_{+-}^{-1})$	$\frac{i}{\sqrt{2}} (c_+ - c_-)$	$\frac{1}{2} (T_{+-}^1 - T_{-+}^{-1} + T_{+-}^{-1} - T_{-+}^1)$

TABLE 5(a)

 $K p \rightarrow \phi \Lambda$

τ' (GeV ²)	a_+	b_+	c_+	a_-	b_-	c_-
0.00 - 0.05	2.21 ± 1.11	0.93 ± 1.40	$4.71 \pm .62$	3.77 ± 0.77	7.36 ± 0.51	1.55 ± 0.96
0.05 - 0.10	3.58 ± 1.25	1.06 ± 1.54	3.56 ± 1.01	6.02 ± 0.78	6.65 ± 0.54	2.87 ± 1.28
0.10 - 0.15	1.31 ± 1.38	3.19 ± 1.26	3.70 ± 1.06	6.34 ± 0.58	5.41 ± 0.77	3.78 ± 0.96
0.15 - 0.20	0.61 ± 1.67	0.72 ± 1.39	2.71 ± 1.35	7.10 ± 0.50	4.85 ± 0.54	5.56 ± 0.76
0.20 - 0.30	0.48 ± 1.31	2.69 ± 0.76	1.34 ± 1.12	6.09 ± 0.36	2.85 ± 0.66	5.58 ± 0.41
0.30 - 0.40	0.42 ± 1.60	2.93 ± 0.79	1.88 ± 1.38	5.94 ± 0.36	2.84 ± 0.69	3.92 ± 0.62
0.40 - 0.50	0.18 ± 0.94	3.49 ± 0.48	1.98 ± 1.00	5.08 ± 0.36	0.40 ± 1.34	3.97 ± 0.51
0.50 - 0.60	0.36 ± 1.27	1.18 ± 0.78	2.72 ± 0.70	4.90 ± 0.35	2.55 ± 0.47	2.68 ± 0.67
0.60 - 0.80	0.65 ± 1.10	0.43 ± 0.79	2.62 ± 0.42	4.27 ± 0.28	2.50 ± 0.30	1.67 ± 0.52
0.80 - 1.00	0.93 ± 0.90	0.66 ± 0.78	0.52 ± 1.11	3.59 ± 0.33	1.75 ± 0.37	2.18 ± 0.36
1.00 - 1.60	1.10 ± 0.40	1.06 ± 0.31	0.24 ± 0.48	2.25 ± 0.22	1.41 ± 0.25	0.98 ± 0.19
ALTERNATIVE SOLUTIONS						
0.30 - 0.40	1.58 ± 1.09	3.07 ± 0.71	2.48 ± 1.02	5.69 ± 0.46	2.71 ± 0.69	3.66 ± 0.65
0.40 - 0.50	0.22 ± 0.93	3.49 ± 0.49	2.01 ± 1.01	5.08 ± 0.36	0.51 ± 1.43	3.97 ± 0.52

τ' (GeV ²)	$\delta(b_+, a_+)$	$\delta(b_+, c_+)$	$\delta(c_+, a_+)$	$\delta(b_-, a_-)$	$\delta(b_-, c_-)$	$\delta(c_-, a_-)$
0.00 - 0.05	0.10 ± 1.86	0.60 ± 1.77	-0.50 ± 0.68	1.96 ± 0.64	2.59 ± 0.79	-0.63 ± 0.90
0.05 - 0.10	-1.32 ± 1.30	-1.12 ± 1.59	-0.20 ± 1.15	1.30 ± 0.34	0.73 ± 0.57	0.57 ± 0.65
0.10 - 0.15	-2.55 ± 1.07	-2.58 ± 0.93	0.03 ± 1.21	1.92 ± 0.29	0.62 ± 0.41	1.30 ± 0.40
0.15 - 0.20	-2.61 ± 3.26	-2.75 ± 2.49	0.14 ± 2.67	1.48 ± 0.26	0.83 ± 0.25	0.65 ± 0.26
0.20 - 0.30	-1.48 ± 2.76	-3.00 ± 1.83	1.52 ± 3.93	1.48 ± 0.33	0.59 ± 0.38	0.90 ± 0.22
0.30 - 0.40	-2.85 ± 3.63	1.73 ± 0.76	1.70 ± 3.87	1.96 ± 0.36	1.09 ± 0.38	0.87 ± 0.27
0.40 - 0.50	2.31 ± 5.51	1.72 ± 0.50	0.59 ± 5.48	-1.73 ± 3.13	-2.30 ± 3.13	0.57 ± 0.42
0.50 - 0.60	-1.17 ± 3.60	0.02 ± 1.66	-1.19 ± 3.41	2.40 ± 0.44	2.17 ± 0.48	0.23 ± 0.45
0.60 - 0.80	2.97 ± 2.55	0.61 ± 2.62	2.37 ± 2.94	2.91 ± 0.29	2.20 ± 0.56	0.71 ± 0.62
0.80 - 1.00	-1.50 ± 1.67	0.93 ± 2.72	-2.43 ± 2.11	2.98 ± 0.40	1.94 ± 0.29	1.04 ± 0.36
1.00 - 1.60	-2.17 ± 1.03	0.42 ± 2.86	-2.59 ± 3.20	1.85 ± 0.39	0.89 ± 0.40	0.96 ± 0.47
ALTERNATIVE SOLUTIONS						
0.30 - 0.40	-2.29 ± 0.86	-1.64 ± 0.47	-0.65 ± 0.87	1.93 ± 0.40	1.06 ± 0.39	0.87 ± 0.33
0.40 - 0.50	3.05 ± 4.44	-1.74 ± 0.49	-1.49 ± 4.41	-1.57 ± 2.11	-2.14 ± 2.10	0.57 ± 0.41

TABLE 5(b)
 $\bar{K} p \rightarrow \omega \Lambda$

t' (GeV ²)	a_+	b_+	c_+	a_-	b_-	c_-
0.00 - 0.05	3.61 ± 0.72	2.50 ± 1.26	1.88 ± 0.92	3.61 ± 0.72	5.36 ± 0.70	2.37 ± 0.82
0.05 - 0.10	4.08 ± 0.91	3.07 ± 0.93	2.68 ± 0.77	3.93 ± 0.87	5.67 ± 0.62	1.46 ± 1.34
0.10 - 0.15	3.28 ± 1.10	2.72 ± 0.93	2.96 ± 0.79	5.37 ± 0.76	5.73 ± 0.55	2.08 ± 0.88
0.15 - 0.20	4.81 ± 0.74	1.61 ± 1.19	0.92 ± 1.08	5.04 ± 0.68	4.98 ± 0.55	3.73 ± 0.51
0.20 - 0.30	6.41 ± 0.47	1.37 ± 0.91	2.63 ± 0.67	3.79 ± 0.71	3.33 ± 0.47	1.53 ± 1.01
0.30 - 0.40	5.68 ± 0.50	1.27 ± 1.27	3.14 ± 0.42	2.69 ± 0.98	2.50 ± 0.62	1.80 ± 0.62
0.40 - 0.50	4.90 ± 0.44	1.33 ± 0.81	2.28 ± 0.59	2.80 ± 0.69	1.61 ± 0.72	1.95 ± 0.68
0.50 - 0.60	4.95 ± 0.41	2.08 ± 0.47	1.70 ± 0.63	1.46 ± 1.11	1.44 ± 0.68	2.34 ± 0.53
0.60 - 0.80	3.86 ± 0.30	1.09 ± 0.42	1.34 ± 0.40	1.84 ± 0.52	1.45 ± 0.44	2.14 ± 0.31
0.80 - 1.00	2.95 ± 0.33	0.89 ± 0.34	1.06 ± 0.49	1.84 ± 0.45	0.85 ± 0.43	1.75 ± 0.39
1.00 - 1.20	2.97 ± 0.23	0.94 ± 0.36	0.62 ± 0.36	0.51 ± 0.64	1.17 ± 0.44	1.30 ± 0.35
1.20 - 1.60	2.54 ± 0.19	0.50 ± 0.41	0.22 ± 0.60	0.39 ± 0.82	1.00 ± 0.29	1.14 ± 0.22
ALTERNATIVE SOLUTIONS						
0.00 - 0.05	3.51 ± 0.74	2.58 ± 1.26	1.48 ± 1.29	3.70 ± 0.70	5.32 ± 0.69	2.68 ± 0.86
0.40 - 0.50	4.83 ± 0.45	1.06 ± 0.74	2.32 ± 0.66	2.92 ± 0.67	1.79 ± 0.51	1.95 ± 0.67
0.50 - 0.60	4.95 ± 0.40	2.07 ± 0.45	1.69 ± 0.63	1.51 ± 1.05	1.37 ± 0.69	2.35 ± 0.52
0.60 - 0.80	3.89 ± 0.29	1.07 ± 0.43	1.46 ± 0.36	1.76 ± 0.52	1.48 ± 0.44	2.06 ± 0.32
1.00 - 1.20	2.99 ± 0.22	0.95 ± 0.36	0.67 ± 0.36	0.41 ± 0.65	1.15 ± 0.46	1.26 ± 0.36

TABLE 5(b) (Cont'd)

t' (GeV ²)	$\delta(b_+, a_+)$	$\delta(b_+, c_+)$	$\delta(c_+, a_+)$	$\delta(b_+, a_-)$	$\delta(b_+, c_-)$	$\delta(c_-, a_-)$
0.00 - 0.05	2.04 ± 2.63	-0.88 ± 0.96	2.92 ± 2.14	1.51 ± 1.49	1.35 ± 0.35	0.17 ± 1.68
0.05 - 0.10	-2.93 ± 0.74	-0.03 ± 0.55	-2.89 ± 0.73	1.14 ± 0.56	-0.79 ± 0.74	1.93 ± 0.93
0.10 - 0.15	-2.31 ± 0.80	-0.29 ± 0.57	-2.02 ± 0.68	0.40 ± 0.40	-0.68 ± 0.43	1.08 ± 0.51
0.15 - 0.20	-0.29 ± 0.96	0.35 ± 1.24	-0.64 ± 1.33	0.33 ± 0.38	-0.33 ± 0.31	0.66 ± 0.41
0.20 - 0.30	-0.03 ± 0.84	-0.03 ± 0.84	0.00 ± 0.48	1.78 ± 0.78	0.27 ± 1.58	1.50 ± 1.37
0.30 - 0.40	-1.77 ± 0.84	-0.89 ± 0.59	-0.89 ± 0.45	-2.87 ± 1.42	0.10 ± 0.60	-2.97 ± 1.73
0.40 - 0.50	-0.47 ± 0.67	0.81 ± 0.58	-1.27 ± 0.51	1.86 ± 1.25	0.83 ± 0.78	1.03 ± 1.06
0.50 - 0.60	-1.47 ± 0.59	0.11 ± 0.85	-1.57 ± 0.66	-0.49 ± 1.57	-1.26 ± 0.60	0.77 ± 1.52
0.60 - 0.80	-0.28 ± 0.63	-0.02 ± 0.79	-0.25 ± 0.91	-1.05 ± 0.84	1.33 ± 0.31	-2.38 ± 0.88
0.80 - 1.00	1.07 ± 1.06	2.53 ± 0.69	-1.46 ± 0.84	0.71 ± 0.72	0.63 ± 0.70	0.08 ± 0.57
1.00 - 1.20	-0.30 ± 0.51	0.13 ± 0.86	-0.42 ± 0.97	0.47 ± 1.26	-1.46 ± 0.42	1.93 ± 1.34
1.20 - 1.80	-1.09 ± 1.94	0.95 ± 3.28	-2.03 ± 2.04	-0.50 ± 2.16	-1.72 ± 0.37	1.22 ± 2.14
ALTERNATIVE SOLUTIONS						
0.00 - 0.05	0.38 ± 2.17	0.85 ± 1.02	-0.46 ± 2.24	2.29 ± 1.14	-1.34 ± 0.28	-2.66 ± 1.16
0.40 - 0.50	-1.30 ± 0.96	-0.05 ± 0.97	-1.25 ± 0.54	0.18 ± 0.99	-1.11 ± 0.57	1.29 ± 0.84
0.50 - 0.60	-0.96 ± 0.60	0.21 ± 0.78	-1.17 ± 0.64	3.13 ± 1.54	1.19 ± 0.65	1.94 ± 1.37
0.60 - 0.80	0.65 ± 0.65	-0.25 ± 0.68	0.90 ± 0.75	0.84 ± 0.92	-1.34 ± 0.33	2.18 ± 1.02
1.00 - 1.20	-0.39 ± 0.49	0.34 ± 0.80	-0.73 ± 0.90	-0.02 ± 1.58	1.48 ± 0.45	-1.51 ± 1.69

TABLE 5(c)

 $\bar{K}^0 \rightarrow \rho^0 \Lambda$

τ' (GeV ²)	a_+	b_+	c_+	a_-	b_-	c_-	T_{-+}^S	T_{+-}^S
0.00 - 0.05	3.73 ± 0.97	0.71 ± 1.32	3.07 ± 1.05	3.83 ± 0.90	6.54 ± 1.36	1.33 ± 3.76	4.20 ± 1.84	5.26 ± 1.63
0.05 - 0.10	5.36 ± 0.63	2.85 ± 1.20	2.58 ± 0.68	2.44 ± 0.95	6.03 ± 0.85	1.51 ± 0.68	2.42 ± 1.06	4.36 ± 0.86
0.10 - 0.15	5.23 ± 0.66	2.86 ± 1.43	1.77 ± 0.70	2.38 ± 1.16	6.10 ± 0.98	1.14 ± 0.83	3.26 ± 0.91	3.55 ± 0.85
0.15 - 0.20	4.94 ± 0.66	1.69 ± 1.27	1.14 ± 0.63	2.93 ± 1.00	5.40 ± 0.78	1.47 ± 0.56	3.13 ± 1.01	3.92 ± 0.85
0.20 - 0.30	5.45 ± 0.39	3.61 ± 0.70	2.22 ± 0.47	1.85 ± 0.85	3.16 ± 0.92	1.19 ± 0.62	2.71 ± 0.68	2.77 ± 0.72
0.30 - 0.40	5.47 ± 0.40	2.05 ± 1.16	1.98 ± 0.94	2.55 ± 0.69	4.05 ± 0.75	2.06 ± 0.84	0.41 ± 2.62	2.67 ± 0.75
0.40 - 0.50	5.07 ± 0.39	0.20 ± 0.90	1.11 ± 0.60	1.72 ± 0.78	2.63 ± 0.55	1.71 ± 0.52	1.04 ± 0.74	2.53 ± 0.56
0.50 - 0.60	4.65 ± 0.39	1.92 ± 0.63	1.41 ± 0.52	1.52 ± 0.82	2.58 ± 0.70	1.89 ± 0.48	1.73 ± 0.64	2.06 ± 0.77
0.60 - 0.80	3.08 ± 0.33	1.15 ± 0.58	1.95 ± 0.34	1.68 ± 0.56	1.80 ± 0.56	1.30 ± 0.59	0.50 ± 0.53	2.33 ± 0.44
0.80 - 1.00	2.81 ± 0.26	0.57 ± 0.63	1.23 ± 0.34	0.45 ± 1.01	1.38 ± 0.46	0.74 ± 0.54	1.31 ± 0.55	2.07 ± 0.48
1.00 - 1.20	2.46 ± 0.23	0.73 ± 0.48	1.19 ± 0.35	0.51 ± 0.64	1.02 ± 0.43	1.01 ± 0.45	0.71 ± 0.35	0.66 ± 0.52
1.20 - 1.60	1.86 ± 0.23	1.20 ± 0.31	0.77 ± 0.25	1.03 ± 0.31	0.77 ± 0.44	0.85 ± 0.29	0.48 ± 0.31	1.39 ± 0.31

τ' (GeV ²)	$\delta(b_+, a_+)$	$\delta(b_+, c_+)$	$\delta(c_+, a_+)$	$\delta(b_-, a_-)$	$\delta(b_-, c_-)$	$\delta(c_-, a_-)$	$\delta(T_{-+}^S, a_+)$	$\delta(T_{+-}^S, a_-)$
0.00 - 0.05	1.11 ± 2.64	-0.32 ± 3.33	1.44 ± 1.54	1.12 ± 0.75	1.68 ± 0.92	-0.56 ± 1.51	1.84 ± 0.94	-0.70 ± 0.69
0.05 - 0.10	-2.89 ± 0.67	-1.16 ± 0.47	-1.73 ± 0.65	-0.16 ± 0.67	-0.44 ± 0.57	0.27 ± 0.77	-1.13 ± 0.85	-2.20 ± 0.60
0.10 - 0.15	-1.16 ± 0.74	-0.09 ± 0.54	-1.06 ± 0.62	1.73 ± 1.04	0.93 ± 0.60	0.79 ± 1.10	0.41 ± 0.60	-0.57 ± 1.01
0.15 - 0.20	0.31 ± 0.76	1.90 ± 0.90	-1.60 ± 0.71	-0.20 ± 0.61	0.29 ± 0.55	-0.49 ± 0.84	1.33 ± 0.52	-1.97 ± 0.65
0.20 - 0.30	-2.14 ± 0.37	0.05 ± 0.34	-2.19 ± 0.36	-2.93 ± 0.69	-0.52 ± 0.56	-2.42 ± 0.86	-0.20 ± 0.36	0.82 ± 0.67
0.30 - 0.40	-3.04 ± 4.45	-0.19 ± 1.44	-2.85 ± 3.11	0.14 ± 2.24	0.12 ± 0.35	0.02 ± 2.29	2.74 ± 2.97	-1.61 ± 2.34
0.40 - 0.50	3.00 ± 4.32	-0.59 ± 3.95	-2.69 ± 0.92	-1.99 ± 0.62	0.04 ± 0.40	-2.03 ± 0.70	0.91 ± 0.84	1.87 ± 0.59
0.50 - 0.60	-2.57 ± 0.67	0.73 ± 0.54	2.98 ± 0.81	-1.09 ± 1.18	-0.36 ± 0.39	-0.72 ± 1.16	-0.78 ± 0.71	2.85 ± 1.03
0.60 - 0.80	-1.64 ± 0.60	-0.63 ± 0.66	-1.01 ± 0.53	2.65 ± 1.00	-0.42 ± 0.49	3.07 ± 1.06	0.24 ± 1.07	0.06 ± 1.00
0.80 - 1.00	-0.55 ± 0.93	1.67 ± 0.92	-2.22 ± 0.57	-2.47 ± 2.26	0.59 ± 0.66	-3.06 ± 2.18	0.20 ± 0.68	0.39 ± 2.21
1.00 - 1.20	-1.66 ± 0.91	-0.74 ± 0.94	-0.92 ± 0.61	-2.07 ± 1.47	2.04 ± 0.85	2.17 ± 1.44	-2.02 ± 0.75	-1.09 ± 1.35
1.20 - 1.60	1.83 ± 0.66	-1.02 ± 0.45	2.86 ± 0.67	-0.43 ± 0.73	-0.64 ± 0.61	0.21 ± 0.76	-1.12 ± 0.88	-2.97 ± 0.66

TABLE 5 (d)

 $\bar{K}^0 \rightarrow \phi \Sigma^0$

t' (GeV ²)	a_+	b_+	c_+	a_-	b_-	c_-
0.00	4.65 ± 0.32	1.60 ± 0.77	1.91 ± 0.61	0.14 ± 1.14	1.88 ± 0.82	1.32 ± 0.96
0.15	5.76 ± 0.36	2.23 ± 0.44	0.83 ± 1.22	0.59 ± 2.04	0.23 ± 1.27	1.73 ± 0.68
0.30	4.67 ± 0.64	0.45 ± 0.87	0.35 ± 1.54	2.25 ± 1.23	0.85 ± 0.58	1.37 ± 0.65
0.50	4.63 ± 0.22	0.85 ± 0.48	0.51 ± 0.56	0.26 ± 1.46	0.57 ± 0.77	0.65 ± 0.65
0.80	2.92 ± 0.55	0.92 ± 0.46	0.34 ± 0.33	1.66 ± 0.94	0.35 ± 1.04	0.15 ± 0.50
1.20	2.40 ± 0.31	0.66 ± 0.56	0.47 ± 0.62	0.47 ± 1.14	0.51 ± 0.75	0.81 ± 0.55

t' (GeV ²)	$\delta(b_+, a_+)$	$\delta(b_+, c_+)$	$\delta(c_+, a_+)$	$\delta(b_-, a_-)$	$\delta(b_-, c_-)$	$\delta(c_-, a_-)$
0.00	0.64 ± 0.82	0.83 ± 1.18	-0.19 ± 0.62	-0.84 ± 5.91	-2.81 ± 1.68	1.97 ± 5.80
0.15	1.44 ± 0.61	-0.94 ± 1.46	2.38 ± 1.56	-1.20 ± 7.46	2.87 ± 8.26	2.21 ± 3.96
0.30	2.96 ± 2.14	0.09 ± 6.55	2.87 ± 7.02	-2.95 ± 2.49	-0.10 ± 2.86	-2.85 ± 3.51
0.50	1.84 ± 0.92	-1.12 ± 1.26	2.97 ± 1.20	-0.96 ± 5.67	-3.14 ± 3.40	2.18 ± 5.57
0.80	2.33 ± 0.97	0.10 ± 1.29	2.23 ± 1.34	-2.33 ± 2.70	-0.13 ± 3.20	-2.21 ± 3.33
1.20	0.97 ± 1.03	-0.79 ± 1.74	1.77 ± 1.27	0.01 ± 2.89	2.16 ± 2.09	-2.14 ± 2.22

TABLE 5 (e)

 $\bar{K}^0 \rightarrow \rho \Sigma^0$

t' (GeV ²)	a_+	b_+	c_+	a_-	b_-	c_-	T^{S+-}
0.00 - 0.15	3.83 ± 0.57	1.21 ± 0.83	1.35 ± 0.63	2.27 ± 0.93	1.10 ± 0.55	1.53 ± 0.58	1.40 ± 0.92
0.15 - 0.30	1.61 ± 1.10	1.14 ± 0.54	1.24 ± 0.44	4.06 ± 0.47	0.96 ± 0.59	0.62 ± 0.62	2.10 ± 0.64
0.30 - 0.50	2.88 ± 0.56	0.26 ± 0.49	0.92 ± 0.59	3.00 ± 0.55	0.41 ± 0.50	1.03 ± 0.62	0.93 ± 0.68
0.50 - 0.80	1.98 ± 0.50	0.39 ± 0.44	0.75 ± 0.60	1.92 ± 0.53	0.12 ± 0.50	1.08 ± 0.43	0.59 ± 0.53
0.80 - 1.20	1.42 ± 0.38	0.21 ± 0.41	0.10 ± 0.46	1.56 ± 0.35	0.63 ± 0.35	0.70 ± 0.27	0.29 ± 0.54
1.20 - 1.60	0.29 ± 0.54	0.75 ± 0.59	0.11 ± 0.40	1.19 ± 0.23	0.83 ± 0.62	0.06 ± 0.41	0.84 ± 0.65

t' (GeV ²)	$\delta(b_+, a_+)$	$\delta(b_+, c_+)$	$\delta(c_+, a_+)$	$\delta(b_-, a_-)$	$\delta(b_-, c_-)$	$\delta(c_-, a_-)$	$\delta(T^{S+-}, a_-)$
0.00 - 0.15	-0.06 ± 0.62	-1.78 ± 0.69	1.72 ± 0.61	2.46 ± 1.11	-0.06 ± 0.79	2.52 ± 0.92	-2.26 ± 0.90
0.15 - 0.30	-1.16 ± 1.29	-0.09 ± 0.62	-1.06 ± 1.46	2.44 ± 0.72	-0.71 ± 0.89	-3.14 ± 1.07	1.02 ± 0.48
0.30 - 0.50	-2.24 ± 2.78	1.86 ± 2.90	2.18 ± 0.89	-1.94 ± 1.71	1.02 ± 1.62	-2.96 ± 0.81	-1.28 ± 0.93
0.50 - 0.80	-2.15 ± 2.01	2.19 ± 1.45	1.94 ± 1.63	1.00 ± 4.06	1.14 ± 3.92	-0.13 ± 1.10	3.08 ± 1.09
0.80 - 1.20	-1.73 ± 2.03	2.48 ± 5.10	2.07 ± 4.51	1.16 ± 0.92	1.57 ± 0.66	-0.41 ± 0.88	-1.43 ± 1.96
1.20 - 1.60	-0.63 ± 1.89	1.54 ± 2.30	-2.17 ± 2.87	1.03 ± 0.89	-1.73 ± 4.49	2.75 ± 4.39	1.54 ± 1.19

TABLE 5 (f)

 $\bar{K} p \rightarrow \Lambda \omega$

u^+ (GeV ²)	a_+	b_+	c_+	a_-	b_-	c_-
0.00 - 0.20	2.06 ± 0.47	1.73 ± 0.31	2.25 ± 0.46	2.40 ± 0.42	0.49 ± 0.59	2.11 ± 0.47
0.20 - 0.40	1.15 ± 0.38	2.07 ± 0.31	2.54 ± 0.37	1.13 ± 0.40	0.73 ± 0.53	1.80 ± 0.47
0.40 - 0.60	1.97 ± 0.35	1.92 ± 0.62	2.99 ± 0.36	1.23 ± 0.50	1.76 ± 0.66	1.87 ± 0.51
0.60 - 0.80	1.14 ± 0.47	1.81 ± 0.29	2.48 ± 0.34	2.12 ± 0.34	0.67 ± 0.37	2.03 ± 0.37
0.80 - 1.20	0.21 ± 0.37	0.64 ± 0.53	2.85 ± 0.18	2.10 ± 0.17	1.00 ± 0.31	0.55 ± 0.46
1.20 - 1.60	1.30 ± 0.27	0.59 ± 0.38	2.36 ± 0.19	1.06 ± 0.33	0.38 ± 0.42	0.56 ± 0.61
ALTERNATIVE SOLUTIONS						
0.00 - 0.20	2.05 ± 0.48	1.70 ± 0.35	2.20 ± 0.48	2.40 ± 0.42	0.57 ± 0.64	2.16 ± 0.47
0.20 - 0.40	1.42 ± 0.37	2.13 ± 0.27	2.63 ± 0.36	0.74 ± 0.63	0.52 ± 0.55	1.70 ± 0.48
0.40 - 0.60	1.88 ± 0.39	1.90 ± 0.66	2.91 ± 0.36	1.39 ± 0.48	1.77 ± 0.71	2.01 ± 0.46
0.60 - 0.80	1.24 ± 0.49	1.79 ± 0.29	2.56 ± 0.35	2.05 ± 0.39	0.66 ± 0.39	1.96 ± 0.40
0.80 - 1.20	0.28 ± 0.38	0.72 ± 0.48	2.84 ± 0.18	2.09 ± 0.17	0.96 ± 0.32	0.52 ± 0.48

u^+ (GeV ²)	$\delta(b_+, a_+)$	$\delta(b_+, c_+)$	$\delta(c_+, a_+)$	$\delta(b_-, a_-)$	$\delta(b_-, c_-)$	$\delta(c_-, a_-)$
0.00 - 0.20	-2.95 ± 0.89	-0.62 ± 0.58	-2.33 ± 0.73	-0.10 ± 1.75	-0.83 ± 1.77	0.73 ± 0.70
0.20 - 0.40	-0.91 ± 0.52	-1.21 ± 0.27	0.30 ± 0.56	-0.85 ± 0.99	-2.55 ± 0.89	1.69 ± 0.83
0.40 - 0.60	-0.97 ± 0.46	-1.53 ± 0.31	0.57 ± 0.54	0.34 ± 0.70	-2.10 ± 0.60	2.45 ± 0.83
0.60 - 0.80	-0.49 ± 0.93	2.58 ± 0.44	-3.06 ± 0.95	-0.69 ± 0.93	0.03 ± 0.76	-0.72 ± 0.75
0.80 - 1.20	-3.00 ± 1.90	1.90 ± 0.44	1.38 ± 1.77	0.28 ± 0.55	2.28 ± 1.00	-2.00 ± 0.95
1.20 - 1.60	-0.36 ± 0.49	1.51 ± 0.33	-1.87 ± 0.49	0.08 ± 1.26	0.01 ± 2.81	0.08 ± 2.61
ALTERNATIVE SOLUTIONS						
0.00 - 0.20	-2.23 ± 1.06	0.21 ± 0.93	-2.44 ± 0.79	-0.75 ± 1.05	-1.49 ± 0.75	0.74 ± 0.66
0.20 - 0.40	-0.01 ± 0.41	1.30 ± 0.23	-1.31 ± 0.44	2.18 ± 1.98	2.74 ± 1.24	-0.56 ± 1.53
0.40 - 0.60	-0.29 ± 0.53	1.49 ± 0.34	-1.78 ± 0.68	0.90 ± 0.62	2.09 ± 0.57	-1.19 ± 0.70
0.60 - 0.80	0.14 ± 0.82	-2.52 ± 0.50	2.66 ± 0.88	-0.10 ± 1.08	0.10 ± 0.79	-0.20 ± 0.96
0.80 - 1.20	-0.44 ± 1.35	-1.88 ± 0.37	1.44 ± 1.35	0.28 ± 0.62	2.29 ± 1.04	-2.01 ± 1.03

TABLE 5(g)
 $\bar{K} p \rightarrow \Lambda p$

u' (GeV ²)	a_+	b_+	c_+	a_-	b_-	c_-	T_{-+}^A	T_{+-}^S
0.00 - 0.20	0.84 ± 0.58	0.15 ± 0.74	0.18 ± 0.46	2.24 ± 0.45	2.79 ± 0.53	1.52 ± 0.37	4.62 ± 0.45	2.59 ± 0.68
0.20 - 0.50	1.19 ± 0.45	0.33 ± 0.48	0.28 ± 0.38	1.47 ± 0.44	0.76 ± 0.99	1.05 ± 0.44	3.70 ± 0.35	1.46 ± 0.82
0.50 - 0.80	1.44 ± 0.39	1.95 ± 0.41	2.08 ± 0.28	1.90 ± 0.34	0.51 ± 0.56	0.61 ± 0.45	2.38 ± 0.42	1.84 ± 0.48
0.80 - 1.20	1.11 ± 0.52	1.12 ± 0.43	0.71 ± 0.35	2.38 ± 0.29	1.33 ± 0.51	1.03 ± 0.35	2.36 ± 0.40	1.78 ± 0.48
1.20 - 1.60	0.90 ± 0.47	1.27 ± 0.70	0.54 ± 0.32	2.26 ± 0.26	1.12 ± 0.45	0.70 ± 0.29	2.22 ± 0.37	1.45 ± 0.42

u' (GeV ²)	$\delta(b_+, a_+)$	$\delta(b_+, c_+)$	$\delta(c_+, a_+)$	$\delta(b_-, a_-)$	$\delta(b_-, c_-)$	$\delta(c_-, a_-)$	$\delta(T_{-+}^A, a_+)$	$\delta(T_{+-}^S, a_-)$
0.00 - 0.20	-2.88 ± 3.49	-0.87 ± 4.37	-2.01 ± 2.50	-0.15 ± 0.59	2.97 ± 0.40	-3.12 ± 0.61	0.13 ± 0.84	-2.19 ± 0.63
0.20 - 0.50	1.14 ± 1.12	2.21 ± 1.57	-1.07 ± 1.25	-1.74 ± 1.25	-1.62 ± 0.99	-0.12 ± 0.94	1.77 ± 0.53	-3.13 ± 0.80
0.50 - 0.80	-2.93 ± 0.49	0.72 ± 0.31	2.63 ± 0.41	0.30 ± 1.01	-1.73 ± 1.26	2.04 ± 1.04	-1.58 ± 0.43	-2.93 ± 0.60
0.80 - 1.20	0.94 ± 0.76	0.33 ± 0.57	0.62 ± 0.82	-3.00 ± 0.60	-0.63 ± 0.56	-2.37 ± 0.59	-2.25 ± 0.69	1.57 ± 0.45
1.20 - 1.60	-2.81 ± 0.82	1.20 ± 0.59	2.27 ± 1.00	0.64 ± 0.53	0.01 ± 0.48	0.63 ± 0.51	-0.18 ± 0.73	-1.96 ± 0.52

TABLE 5(h)
 $\bar{K} p \rightarrow \Sigma^0 p$

u' (GeV ²)	a_+	b_+	c_+	a_-	b_-	c_-	T_{-+}^s	T_{+-}^s
0.00 - 0.20	0.08 ± 0.82	0.43 ± 0.46	2.31 ± 0.39	2.57 ± 0.27	0.73 ± 0.42	0.72 ± 0.83	0.89 ± 0.85	1.79 ± 0.57
0.20 - 0.50	1.45 ± 0.37	0.43 ± 0.41	0.33 ± 0.72	0.39 ± 0.69	0.44 ± 0.31	1.40 ± 0.34	1.17 ± 0.68	1.83 ± 0.59
0.50 - 0.80	1.34 ± 0.18	0.23 ± 0.29	0.78 ± 0.45	0.10 ± 0.44	0.14 ± 0.26	1.31 ± 0.33	0.80 ± 0.42	0.10 ± 0.60
0.80 - 1.20	1.15 ± 0.21	0.38 ± 0.30	1.15 ± 0.44	0.05 ± 0.81	0.30 ± 0.73	1.12 ± 0.47	0.31 ± 0.35	0.58 ± 0.44
1.20 - 1.60	0.86 ± 0.37	0.43 ± 0.23	1.09 ± 0.19	0.57 ± 0.50	0.25 ± 0.40	0.20 ± 0.43	0.85 ± 0.34	0.53 ± 0.47

u' (GeV ²)	$\delta(b_+, a_+)$	$\delta(b_+, c_+)$	$\delta(c_+, a_+)$	$\delta(b_-, a_-)$	$\delta(b_-, c_-)$	$\delta(c_-, a_-)$	$\delta(T_{-+}^s, a_+)$	$\delta(T_{+-}^s, a_-)$
0.00 - 0.20	-2.25 ± 9.99	2.86 ± 1.76	1.17 ± 9.65	-1.11 ± 0.82	-0.54 ± 1.42	-0.57 ± 1.22	-0.02 ± 9.70	0.08 ± 0.70
0.20 - 0.50	0.78 ± 1.41	3.01 ± 2.90	-2.23 ± 2.68	-1.22 ± 1.83	-0.43 ± 0.80	-0.79 ± 1.68	-0.94 ± 0.94	-0.51 ± 1.70
0.50 - 0.80	-0.03 ± 1.94	-2.97 ± 2.11	2.94 ± 1.33	-0.86 ± 5.29	0.06 ± 3.16	-0.91 ± 4.53	-1.43 ± 0.99	-0.04 ± 7.89
0.80 - 1.20	3.06 ± 1.49	2.94 ± 4.42	0.12 ± 3.47	-1.22 ± 9.99	-0.98 ± 1.35	-0.24 ± 9.99	2.23 ± 1.85	1.66 ± 9.99
1.20 - 1.60	1.36 ± 0.96	-0.17 ± 0.73	1.53 ± 0.77	-0.36 ± 2.00	1.37 ± 2.56	-1.74 ± 2.05	-0.68 ± 0.87	0.28 ± 1.27

TABLE 6

τ' (GeV ²)	ρ_{11}	ρ_{1-1}	Re ρ_{10}
(a) $\bar{K}^+ p \rightarrow \phi \Lambda$			
0.00 - 0.05	.22 ± .03	-.03 ± .05	-.04 ± .04
0.05 - 0.10	.30 ± .02	.12 ± .04	.10 ± .03
0.10 - 0.15	.32 ± .03	.06 ± .04	.04 ± .03
0.15 - 0.20	.39 ± .02	.06 ± .05	.10 ± .03
0.20 - 0.30	.41 ± .02	.03 ± .04	.08 ± .02
0.30 - 0.40	.38 ± .02	.12 ± .04	.04 ± .03
0.40 - 0.50	.39 ± .03	.05 ± .05	-.03 ± .03
0.50 - 0.60	.42 ± .02	.10 ± .05	-.01 ± .03
0.60 - 0.80	.41 ± .02	.13 ± .04	-.03 ± .03
0.80 - 1.00	.42 ± .02	.20 ± .05	-.04 ± .03
1.00 - 1.60	.35 ± .02	.25 ± .04	.07 ± .03
(b) $\bar{K}^+ p \rightarrow \omega \Lambda$			
0.00 - 0.05	.25 ± .03	.12 ± .04	.06 ± .03
0.05 - 0.10	.25 ± .03	.14 ± .04	.12 ± .03
0.10 - 0.15	.28 ± .03	.14 ± .04	.13 ± .03
0.15 - 0.20	.35 ± .02	.19 ± .04	.15 ± .02
0.20 - 0.30	.42 ± .02	.30 ± .03	.08 ± .02
0.30 - 0.40	.43 ± .02	.22 ± .04	.08 ± .02
0.40 - 0.50	.45 ± .02	.25 ± .04	.07 ± .02
0.50 - 0.60	.42 ± .02	.22 ± .04	.08 ± .03
0.60 - 0.80	.44 ± .02	.21 ± .04	.06 ± .02
0.80 - 1.00	.46 ± .02	.22 ± .05	.02 ± .03
1.00 - 1.20	.42 ± .03	.26 ± .05	.04 ± .03
1.20 - 1.60	.43 ± .02	.29 ± .04	-.01 ± .03
(c) $\bar{K}^+ p \rightarrow \rho \Lambda$			
0.00 - 0.05	.24 ± .07	.10 ± .05	.01 ± .05
0.05 - 0.10	.25 ± .04	.15 ± .04	.09 ± .03
0.10 - 0.15	.23 ± .04	.17 ± .04	.08 ± .03
0.15 - 0.20	.27 ± .04	.22 ± .04	.07 ± .03
0.20 - 0.30	.32 ± .03	.21 ± .03	.13 ± .02
0.30 - 0.40	.34 ± .03	.22 ± .03	.13 ± .02
0.40 - 0.50	.41 ± .03	.31 ± .04	.08 ± .02
0.50 - 0.60	.37 ± .04	.23 ± .04	.12 ± .03
0.60 - 0.80	.40 ± .04	.15 ± .05	.12 ± .03
0.80 - 1.00	.41 ± .05	.24 ± .07	.04 ± .04
1.00 - 1.20	.42 ± .04	.19 ± .07	.01 ± .05
1.20 - 1.60	.37 ± .05	.20 ± .06	.09 ± .04

τ' (GeV ²)	ρ_{11}	ρ_{1-1}	Re ρ_{10}
(d) $\bar{K}^+ p \rightarrow \phi \Sigma^0$			
0.00 - 0.15	.41 ± .03	.25 ± .05	-.01 ± .03
0.15 - 0.30	.44 ± .02	.35 ± .04	.01 ± .03
0.30 - 0.50	.48 ± .02	.42 ± .04	.03 ± .02
0.50 - 0.80	.48 ± .02	.45 ± .03	-.01 ± .01
0.80 - 1.20	.46 ± .02	.45 ± .03	.02 ± .02
1.20 - 1.60	.45 ± .03	.34 ± .08	.00 ± .04
(e) $\bar{K}^+ p \rightarrow \rho \Sigma^0$			
0.00 - 0.15	.45 ± .04	.29 ± .06	.04 ± .03
0.15 - 0.30	.45 ± .03	.37 ± .05	.06 ± .02
0.30 - 0.50	.49 ± .01	.40 ± .04	.01 ± .02
0.50 - 0.80	.49 ± .02	.31 ± .05	-.01 ± .03
0.80 - 1.20	.46 ± .04	.37 ± .06	.00 ± .04
1.20 - 1.60	.27 ± .08	.27 ± .09	.00 ± .06

u' (GeV ²)	ρ_{11}	ρ_{1-1}	Re ρ_{10}
(f) $\bar{K}^+ p \rightarrow \Lambda \omega$			
0.00 - 0.20	.43 ± .02	.01 ± .05	.12 ± .03
0.20 - 0.40	.36 ± .03	-.21 ± .05	.03 ± .04
0.40 - 0.60	.36 ± .02	-.14 ± .04	-.04 ± .03
0.60 - 0.80	.41 ± .02	-.11 ± .05	-.09 ± .03
0.80 - 1.20	.45 ± .02	-.14 ± .04	-.05 ± .03
1.20 - 1.60	.47 ± .02	-.17 ± .05	.02 ± .03
(g) $\bar{K}^+ p \rightarrow \Lambda \rho$			
0.00 - 0.20	.25 ± .06	.11 ± .07	-.19 ± .04
0.20 - 0.50	.44 ± .12	.22 ± .15	-.01 ± .10
0.50 - 0.80	.36 ± .05	.03 ± .06	.15 ± .04
0.80 - 1.20	.37 ± .05	.23 ± .06	.11 ± .03
1.20 - 1.60	.35 ± .06	.27 ± .07	.08 ± .03
(h) $\bar{K}^+ p \rightarrow \Sigma^0 \rho$			
0.00 - 0.20	.47 ± .03	.03 ± .07	-.03 ± .04
0.20 - 0.50	.46 ± .03	.02 ± .11	.06 ± .07
0.50 - 0.80	.49 ± .02	-.06 ± .09	.00 ± .06
0.80 - 1.20	.47 ± .06	-.15 ± .08	-.04 ± .06
1.20 - 1.60	.45 ± .04	-.04 ± .11	.13 ± .06

TABLE 7

CERN/EP/PHYS 77-45

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) $\bar{K}^0 p \rightarrow \phi \Lambda$			
0.00 - 0.05	19.1 ± 5.6	55.1 ± 7.2	24.5 ± 5.6
0.05 - 0.10	49.0 ± 7.0	45.4 ± 6.6	20.9 ± 5.5
0.10 - 0.15	42.0 ± 6.6	39.5 ± 6.4	28.0 ± 5.8
0.15 - 0.20	50.8 ± 6.9	24.0 ± 5.3	38.2 ± 6.6
0.20 - 0.30	37.3 ± 4.3	15.3 ± 3.2	33.0 ± 4.0
0.30 - 0.40	35.4 ± 4.2	16.6 ± 3.5	18.9 ± 3.7
0.40 - 0.50	25.8 ± 3.7	12.3 ± 3.1	19.7 ± 3.5
0.50 - 0.60	24.2 ± 3.4	7.9 ± 2.4	14.6 ± 2.8
0.60 - 0.80	18.7 ± 2.1	6.4 ± 1.5	9.7 ± 1.7
0.80 - 1.00	13.7 ± 1.7	3.5 ± 1.1	5.0 ± 1.2
1.00 - 1.60	6.3 ± 0.7	3.1 ± 0.5	1.0 ± 0.4
(b) $\bar{K}^0 p \rightarrow \omega \Lambda$			
0.00 - 0.05	26.0 ± 4.5	35.0 ± 5.1	9.2 ± 3.4
0.05 - 0.10	32.1 ± 5.1	41.6 ± 5.5	9.4 ± 2.9
0.10 - 0.15	39.8 ± 5.6	40.2 ± 5.4	13.1 ± 3.6
0.15 - 0.20	46.5 ± 5.5	27.4 ± 4.4	14.7 ± 3.4
0.20 - 0.30	55.5 ± 4.0	13.0 ± 2.7	9.3 ± 2.4
0.30 - 0.40	39.5 ± 3.5	7.9 ± 2.2	13.1 ± 2.5
0.40 - 0.50	31.9 ± 3.1	4.4 ± 1.6	9.0 ± 2.0
0.50 - 0.60	26.6 ± 2.8	6.4 ± 1.8	8.3 ± 1.9
0.60 - 0.80	18.3 ± 1.7	3.3 ± 1.0	6.4 ± 1.2
0.80 - 1.00	12.1 ± 1.4	1.5 ± 0.7	4.2 ± 1.0
1.00 - 1.20	9.1 ± 1.2	2.2 ± 0.9	2.1 ± 0.8
1.20 - 1.60	6.6 ± 0.7	1.2 ± 0.5	1.3 ± 0.4
(c) $\bar{K}^0 p \rightarrow \rho \Lambda$			
0.00 - 0.05	28.6 ± 6.1	43.3 ± 18.0	11.2 ± 6.6
0.05 - 0.10	34.7 ± 5.9	44.5 ± 9.3	8.9 ± 3.5
0.10 - 0.15	33.0 ± 5.4	45.3 ± 9.9	4.4 ± 2.3
0.15 - 0.20	32.9 ± 5.3	32.1 ± 8.4	3.5 ± 2.1
0.20 - 0.30	33.1 ± 3.6	23.1 ± 5.3	6.4 ± 1.9
0.30 - 0.40	36.5 ± 3.7	20.6 ± 4.8	8.2 ± 2.2
0.40 - 0.50	28.7 ± 3.1	7.0 ± 2.8	4.1 ± 1.6
0.50 - 0.60	23.9 ± 3.0	10.3 ± 3.6	5.6 ± 1.8
0.60 - 0.80	12.3 ± 1.6	4.5 ± 1.8	5.5 ± 1.4
0.80 - 1.00	8.1 ± 1.4	2.2 ± 1.3	2.1 ± 0.9
1.00 - 1.20	6.3 ± 1.0	1.6 ± 1.0	2.4 ± 0.8
1.20 - 1.60	4.5 ± 0.7	2.0 ± 0.9	1.3 ± 0.5

TABLE 7 (Cont'd)

t' (GeV ²)	σ_+ ($\mu\text{b}/\text{GeV}^2$)	σ_0 ($\mu\text{b}/\text{GeV}^2$)	σ_- ($\mu\text{b}/\text{GeV}^2$)
(d) $\bar{K}^0 p \rightarrow \phi \Sigma^0$			
0.00 - 0.15	21.6 ± 2.9	6.1 ± 2.2	5.4 ± 2.0
0.15 - 0.30	33.4 ± 3.6	5.0 ± 1.8	3.7 ± 1.8
0.30 - 0.50	26.9 ± 2.6	0.9 ± 0.9	2.0 ± 1.3
0.50 - 0.80	21.5 ± 1.8	1.0 ± 0.8	0.7 ± 0.8
0.80 - 1.20	11.3 ± 1.2	1.0 ± 0.6	0.1 ± 0.2
1.20 - 1.60	6.0 ± 0.9	0.7 ± 0.5	0.9 ± 0.6
(e) $\bar{K}^0 p \rightarrow \rho \Sigma^0$			
0.00 - 0.15	19.8 ± 2.4	2.7 ± 2.2	4.2 ± 1.8
0.15 - 0.30	19.1 ± 2.2	2.2 ± 1.4	1.9 ± 1.2
0.30 - 0.50	17.3 ± 1.7	0.2 ± 0.4	1.9 ± 0.9
0.50 - 0.80	7.6 ± 0.9	0.2 ± 0.3	1.7 ± 0.6
0.80 - 1.20	4.4 ± 0.7	0.4 ± 0.4	0.5 ± 0.4
1.20 - 1.60	1.5 ± 0.5	1.2 ± 0.8	0.0 ± 0.1

TABLE 8

t' (GeV ²)	P_N	P_U^0	P_U^1
(a) $K^- p \rightarrow \phi \Lambda$			
0.00 - 0.05	$-.49 \pm .48$	$.97 \pm .09$	$-.80 \pm .24$
0.05 - 0.10	$-.48 \pm .35$	$.95 \pm .14$	$-.21 \pm .65$
0.10 - 0.15	$-.92 \pm .17$	$.48 \pm .39$	$.02 \pm .50$
0.15 - 0.20	$-.99 \pm .08$	$.96 \pm .16$	$.62 \pm .37$
0.20 - 0.30	$-.99 \pm .07$	$.06 \pm .47$	$.89 \pm .18$
0.30 - 0.40	$-.99 \pm .08$	$-.03 \pm .47$	$.62 \pm .52$
0.40 - 0.50	$-.99 \pm .03$	$-.97 \pm .18$	$.60 \pm .38$
0.50 - 0.60	$-.99 \pm .08$	$.65 \pm .44$	$-.01 \pm .47$
0.60 - 0.80	$-.95 \pm .15$	$.94 \pm .21$	$-.42 \pm .35$
0.80 - 1.00	$-.87 \pm .24$	$.75 \pm .57$	$.89 \pm .46$
1.00 - 1.60	$-.61 \pm .27$	$.27 \pm .40$	$.89 \pm .43$
(b) $K^- p \rightarrow \omega \Lambda$			
0.00 - 0.05	$.00 \pm .36$	$.64 \pm .36$	$.23 \pm .70$
0.05 - 0.10	$.04 \pm .42$	$.54 \pm .27$	$-.54 \pm .80$
0.10 - 0.15	$-.46 \pm .36$	$.63 \pm .24$	$-.34 \pm .56$
0.15 - 0.20	$-.05 \pm .27$	$.81 \pm .28$	$.89 \pm .27$
0.20 - 0.30	$.48 \pm .19$	$.71 \pm .37$	$-.49 \pm .65$
0.30 - 0.40	$.63 \pm .26$	$.59 \pm .78$	$-.51 \pm .32$
0.40 - 0.50	$.51 \pm .24$	$.19 \pm .96$	$-.16 \pm .55$
0.50 - 0.60	$.84 \pm .24$	$-.35 \pm .55$	$.31 \pm .49$
0.60 - 0.80	$.63 \pm .21$	$.27 \pm .57$	$.43 \pm .32$
0.80 - 1.00	$.44 \pm .27$	$-.04 \pm .75$	$.47 \pm .50$
1.00 - 1.20	$.94 \pm .15$	$.21 \pm .63$	$.63 \pm .45$
1.20 - 1.60	$.95 \pm .19$	$.60 \pm .65$	$.93 \pm .39$
(c) $K^- p \rightarrow \rho \Lambda$			
0.00 - 0.05	$-.03 \pm .44$	$.98 \pm .09$	$-.68 \pm 1.6$
0.05 - 0.10	$.66 \pm .26$	$.63 \pm .30$	$-.49 \pm .44$
0.10 - 0.15	$.66 \pm .33$	$.64 \pm .36$	$-.41 \pm .81$
0.15 - 0.20	$.48 \pm .34$	$.82 \pm .26$	$.25 \pm .66$
0.20 - 0.30	$.79 \pm .19$	$-.13 \pm .42$	$-.55 \pm .44$
0.30 - 0.40	$.64 \pm .19$	$.59 \pm .45$	$.04 \pm .85$
0.40 - 0.50	$.79 \pm .19$	$.99 \pm .10$	$.41 \pm .63$
0.50 - 0.60	$.81 \pm .21$	$.29 \pm .45$	$.28 \pm .49$
0.60 - 0.80	$.54 \pm .29$	$.42 \pm .59$	$-.38 \pm .48$
0.80 - 1.00	$.95 \pm .22$	$.71 \pm .61$	$-.47 \pm .67$
1.00 - 1.20	$.92 \pm .21$	$.33 \pm .75$	$-.16 \pm .65$
1.20 - 1.60	$.53 \pm .28$	$-.42 \pm .56$	$.09 \pm .55$

TABLE 8 (Cont'd)

CERN/EP/PHYS 77-45

t' (GeV ²)	P_N	P_U^0	P_U^1
	(d) $K^- p \rightarrow \phi \Sigma^0$		
0.00 - 0.15	.99 ± .03		
0.15 - 0.30	.98 ± .14		
0.30 - 0.50	.62 ± .41		
0.50 - 0.80	.99 ± .07		
0.80 - 1.20	.51 ± .55		
1.20 - 1.60	.93 ± .36		
	(e) $K^- p \rightarrow \rho \Sigma^0$		
0.00 - 0.15	.48 ± .41		
0.15 - 0.30	-.73 ± .37		
0.30 - 0.50	-.04 ± .37		
0.50 - 0.80	.03 ± .51		
0.80 - 1.20	-.10 ± .46		
1.20 - 1.60	-.89 ± .42		

TABLE 9

CERN/EP/PHYS 77-45

Amplitudes	"Real" reactions $K^- p \rightarrow (\rho, \omega)(\Lambda, \Sigma^0)$	"Rotating" reactions $K^- p \rightarrow \phi(\Lambda, \Sigma^0)$
N_{++}^1, N_{+-}^1	$K^{**} - K^*$	$\sqrt{2} (K^{**} + K^*)$
U_{++}^0, U_{++}^1	$K_A - K_Z$	$\sqrt{2} (K_A + K_Z)$
U_{+-}^0, U_{+-}^1	$K - K_B$	$\sqrt{2} (K + K_B)$

FIGURE CAPTIONS

- Fig. 1 Missing mass to the K^+K^- or $\pi^+\pi^-$ system for events assigned to the channels, (a) $K^-p \rightarrow \Lambda K^+K^-$; (b) $K^-p \rightarrow \Sigma^0 K^+K^-$; (c) $K^-p \rightarrow \Lambda \pi^+\pi^-$; (d) $K^-p \rightarrow \Sigma^0 \pi^+\pi^-$.
- Fig. 2 Σ^0 decay angular distributions. For events assigned to the channel $K^-p \rightarrow \Sigma^0 K^+K^-$ and with K^+K^- mass in the ϕ region (1.010 - 1.035 GeV): (a) $\cos \theta_H$; (b) $\cos \theta_N$. For events assigned to the channel $K^-p \rightarrow \Sigma^0 \pi^+\pi^-$ and with $\pi^+\pi^-$ mass in the ρ region (0.52 - 0.92 GeV): (c) $\cos \theta_H$; (d) $\cos \theta_N \cdot \theta_H (\theta_N)$ is the angle between the Λ in the Σ^0 rest frame and the Σ^0 line-of-flight (production normal).
- Fig. 3 (a) Dalitz plot and (b) Chew-Low plot for $K^-p \rightarrow \Lambda K^+K^-$; (c) Dalitz plot and (d) Chew-Low plot for $K^-p \rightarrow \Lambda K_S^0 K_L^0$; (e) Chew-Low plot for $K^-p \rightarrow \Lambda \pi^+\pi^-\pi^0$; (f) Dalitz plot and (g) Chew-Low plot for $K^-p \rightarrow \Lambda \pi^+\pi^-$; (h) Dalitz plot and (i) Chew-Low plot for $K^-p \rightarrow \Sigma^0 K^+K^-$; (j) Dalitz plot and (k) Chew-Low plot for $K^-p \rightarrow \Sigma^0 \pi^+\pi^-$.
- Fig. 4 Effective mass distributions: (a) mass (K^+K^-) from $K^-p \rightarrow \Lambda K^+K^-$; (b) mass ($K_S^0 K_L^0$) from $K^-p \rightarrow \Lambda K_S^0 K_L^0$; (c) mass ($\pi^+\pi^-\pi^0$) from $K^-p \rightarrow \Lambda \pi^+\pi^-\pi^0$; (d) mass ($\pi^+\pi^-$) from $K^-p \rightarrow \Lambda \pi^+\pi^-$; (e) mass (K^+K^-) from $K^-p \rightarrow \Sigma^0 K^+K^-$; (f) mass ($\pi^+\pi^-$) from $K^-p \rightarrow \Sigma^0 \pi^+\pi^-$.
- Fig. 5 Effective mass distributions in the vector meson mass regions: (a) mass (K^+K^-) from $K^-p \rightarrow \Lambda K^+K^-$; (b) mass ($K_S^0 K_L^0$) from $K^-p \rightarrow \Lambda K_S^0 K_L^0$; (c) mass ($\pi^+\pi^-\pi^0$) from $K^-p \rightarrow \Lambda \pi^+\pi^-\pi^0$; (d) mass (K^+K^-) from $K^-p \rightarrow \Sigma^0 K^+K^-$; (e) and (f) mass ($\pi^+\pi^-$) from $K^-p \rightarrow (\Lambda, \Sigma^0) \pi^+\pi^-$ with mass ($\Lambda \pi^+$) or mass ($\Sigma^0 \pi^+$) > 1.8 GeV and $t' < 1.0$ GeV². The solid curves in (a)-(d) represent the results of the fits described in the text, the dashed curves the background. The curves in (e)-(f) are taken from [5]. The fit with the conventional mass matrix formalism of ρ - ω interference [6] is shown in (e); the fit with the model

FIGURE CAPTIONS (Cont'd)

of [7] is shown in (f). The background is also shown in both cases. The dashed curves represent a fit with a p-wave Breit-Wigner for the ρ assuming the standard width of 150 MeV [4].

- Fig. 6 Differential cross sections and Λ polarization for the reaction $K^-p \rightarrow \phi\Lambda$, $K^-p \rightarrow \omega\Lambda$ and $K^-p \rightarrow \rho\Lambda$. The abscissae have t' running from left to right and u' running from right to left. The break occurs at a point corresponding to 90° scattering in the overall centre of mass.
- Fig. 7 Differential cross sections and Σ^0 polarization for the reactions $K^-p \rightarrow \phi\Sigma^0$ and $K^-p \rightarrow \rho\Sigma^0$ (see also fig. 6).
- Fig. 8 Reference frames used in the amplitude analyses.
- Fig. 9 Moduli and relative phases of the Byers-Yang amplitudes for $K^-p \rightarrow \phi\Lambda$ as functions of t' . The curves are the predictions of the model described in the text.
- Fig. 10 Moduli and relative phases of the Byers-Yang amplitudes for $K^-p \rightarrow \omega\Lambda$ as functions of t' . The curves are the predictions of the model described in the text.
- Fig. 11 Moduli and relative phases of the Byers-Yang amplitudes for $K^-p \rightarrow \rho\Lambda$ as functions of t' . The $\pi^+\pi^-$ s-wave background amplitudes (T_{-+}^s and T_{+-}^s) are also shown.
- Fig. 12 Moduli and relative phases of the Byers-Yang amplitudes for $K^-p \rightarrow \phi\Sigma^0$ as functions of t' .
- Fig. 13 Moduli and relative phases of the Byers-Yang amplitudes for $K^-p \rightarrow \rho\Sigma^0$ as functions of t' . The $\pi^+\pi^-$ s-wave background amplitudes (T_{-+}^s and T_{+-}^s) are also shown.

FIGURE CAPTIONS (cont'd)

- Fig. 14 Moduli and relative phases of the Byers-Yang amplitudes for $K^-p \rightarrow \Lambda\omega$ as functions of u' .
- Fig. 15 Moduli and relative phases of the Byers-Yang amplitudes for $K^-p \rightarrow \Lambda\rho$ as functions of u' . The $\pi^+\pi^-$ s-wave background amplitudes (T_{-+}^s and T_{+-}^s) are also shown.
- Fig. 16 Moduli and relative phases of the Byers-Yang amplitudes for $K^-p \rightarrow \Sigma^0\rho$ as functions of u' . The $\pi^+\pi^-$ s-wave background amplitudes (T_{-+}^s and T_{+-}^s) are also shown.
- Fig. 17 Vector meson spin density matrix elements in the s-channel helicity frame for: (a) $K^-p \rightarrow \phi\Lambda$; (b) $K^-p \rightarrow \omega\Lambda$; (c) $K^-p \rightarrow \rho\Lambda$; (d) $K^-p \rightarrow \phi\Sigma^0$; (e) $K^-p \rightarrow \rho\Sigma^0$, as functions of t' and for: (f) $K^-p \rightarrow \Lambda\omega$; (g) $K^-p \rightarrow \Lambda\rho$; (h) $K^-p \rightarrow \Sigma^0\rho$, as functions of u' .
- Fig. 18 Natural and unnatural parity exchange contributions to the differential cross sections for $K^-p \rightarrow \phi\Lambda$ ($\blacktriangle$), $K^-p \rightarrow \omega\Lambda$ ($\bullet$) and $K^-p \rightarrow \rho\Lambda$ (O). (a) $\sigma_+ = \rho_{11+} d\sigma/dt'$; (b) $\sigma_0 = \rho_{00} d\sigma/dt'$; (c) $\sigma_- = \rho_{11-} d\sigma/dt'$. The cross sections for the reactions $K^-p \rightarrow \omega\Lambda$ and $K^-p \rightarrow \rho\Lambda$ have been multiplied by a factor 2.
- Fig. 19 Natural parity exchange contributions to the differential cross sections ($\sigma_+ = \rho_{11+} d\sigma/dt'$) for $K^-p \rightarrow \phi\Sigma^0$ ($\blacktriangle$) and $K^-p \rightarrow \rho\Sigma^0$ ($\bullet$). The cross section for $K^-p \rightarrow \rho\Sigma^0$ has been multiplied by a factor 2.
- Fig. 20 Hyperon polarization as a function of t' for natural parity exchange (P_N), unnatural parity exchange, vector meson helicity 0 (P_U^0) and unnatural parity exchange, vector meson helicity 1 (P_U^1). See the text for details of the normalization used: (a) $K^-p \rightarrow \phi\Lambda$; (b) $K^-p \rightarrow \omega\Lambda$; (c) $K^-p \rightarrow \rho\Lambda$; (d) $K^-p \rightarrow \phi\Sigma^0$ and (e) $K^-p \rightarrow \rho\Sigma^0$.

FIGURE CAPTIONS (Cont'd)

- Fig. 21 Differential cross sections, Λ polarization and vector meson spin density matrix elements in the s-channel helicity frame for $K^-p \rightarrow \phi\Lambda$ (●) and $\pi^-p \rightarrow K^*(890)\Lambda$ at 3.93 GeV/c (○) [3]:
(a) $d\sigma/dt'$; (b) polarization; (c) ρ_{11} ; (d) ρ_{1-1} ; (e) $\text{Re } \rho_{10}$.
- Fig. 22 Differential cross sections, Σ^0 polarization and vector meson spin density matrix elements in the s-channel helicity frame for $K^-p \rightarrow \phi\Sigma^0$ (●) and $\pi^-p \rightarrow K^*(890)\Sigma^0$ at 3.93 GeV/c (○) [3]:
(a) $d\sigma/dt'$; (b) polarization; (c) ρ_{11} ; (d) ρ_{1-1} ; (e) $\text{Re } \rho_{10}$.
- Fig. 23 Moduli of the mixed amplitudes (see text) for $K^-p \rightarrow \omega\Lambda$ as functions of t' .
- Fig. 24 Quark model diagrams for the reactions $K^-p \rightarrow (\omega, \rho)\Lambda$ in the forward and backward directions.

fig. 1

fig. 2

fig. 3(a)(b)(c)(d)

fig. 3(e)(f)(g)

fig. 3(h)(i)(j)(k)

fig. 4

fig. 5

fig. 6

fig. 7

S - channel C.M. frame

fig. 8

fig. 9

fig. 10

fig.11

fig.12

fig.13

fig. 1-

fig.15

fig.16

fig.17

fig.18

fig.19

fig.20

fig.21

fig.22

fig.23

Forward Production

Backward Production

fig. 24