A PARTIAL WAVE ANALYSIS OF THE $K^-\phi$ SYSTEM PRODUCED IN THE REACTION

$K^-p \rightarrow K^+K^-K^-p$ at 18.5 GeV/c

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ABSTRACT

About 15000 $K^-\phi$ events have been collected in the CERN Ω^1 spectrometer. A partial wave decomposition of the $K^-\phi$ system is performed. The $1^+S_0^+$ wave is dominant. The $0^-P_0^+$ and $2^-P_0^+$ waves are important and show resonant behaviour at ~ 1.83 GeV ($\Gamma \sim 0.25$ GeV) and ~ 1.73 GeV ($\Gamma \sim 0.22$ GeV) respectively. The first one can be interpreted as the second radial excitation of the kaon while the second one can be identified as one of the two L mesons.

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1. INTRODUCTION

The diffraction of π or K mesons into a π or a K plus two pions has been extensively studied [1] and although the mechanism of diffraction is not fully understood, it can qualitatively be described in the following manner. The incident meson dissociates into two mesons using a $q\bar{q}$ pair out of the sea and one of the fragments (mainly the lightest) scatters on the target (Deck model). Rescattering of the two fragments and direct production are also present, giving rise to resonant final states (e.g., A_1 , A_3 , Q_1 , Q_2). In the cases such as $\pi \rightarrow \rho\pi$, $K \rightarrow K^*\pi$, $K\rho$, the extra $q\bar{q}$ pair is a $u\bar{u}$ or a $d\bar{d}$ pair. It may however be an $s\bar{s}$ pair and can be observed in the diffractive channels $\pi \rightarrow K^*K$ and $K \rightarrow K\phi$, but limited information on these channels is available [2-3].

In this paper, we present a partial wave analysis of the $K^-\phi$ system produced in the diffraction of 18.5 GeV/c K^- mesons in an experiment performed at the CERN Ω' spectrometer.

2. LAYOUT AND DATA HANDLING

2.1 Apparatus and trigger

The layout of the Ω' spectrometer [4] as used in this experiment is shown in fig. 1. In the RF separated beam, the incident K^- 's were identified by a CEDAR Cerenkov counter. Their momentum and direction were determined by a scintillation counter hodoscope and a set of MWPC's. The beam was further delineated by a set of scintillation counters before entering a 60 cm long hydrogen target.

The trigger selected final states with a K^+/p with momentum bigger than 2.8 GeV/c. Two triggering conditions were used [5]:

- (a) "Slow trigger": a correlated coincidence in the two large scintillation counter hodoscopes H_1 and H_2 sandwiching the right part of the freon filled Cerenkov counter C_1 , no light in the corresponding cells of C_1 , and no correlated hit in the downstream hodoscope H_3 . This trigger condition selected K^+ with momentum between 2.8 and 10.4 GeV/c and protons with momentum above 2.8 GeV/c.

- (b) "Fast trigger": a correlated coincidence in the three hodoscopes H_1 , H_2 , and H_3 , and no light in the corresponding cells of the nitrogen filled Cerenkov counter C_2 . This trigger condition selected K^+ and protons with momentum above 2.8 GeV/c.

In addition to these conditions, an interaction in the target was further selected by requiring a multiplicity around the target between 2 and 7 and no hit in the beam veto counter V_B . The multiplicity was measured by means of two planes of a MWPC (HPC1) with 500 μ m wire spacing placed after the target and by a 24-element barrel counter (TS) surrounding the target. Furthermore events with one or more fast π^0 were reduced using as downstream γ -veto counter the hodoscopes H_3 and H_4 with 1.5 cm of lead in between. Four rectangular γ counters (V_1 , V_2 , V_3 , V_4) placed around the target were not used in the trigger but only in the analysis. The secondary tracks were detected by a system of 11 MWPC's (adding up to 27 planes) and by two large drift chambers DC_1 and DC_2 (8 planes).

The total number of triggers collected is 7.2 million.

2.2 Off-line analysis

The recorded interactions were processed in the pattern recognition and geometry program TRIDENT [6]. However, the full reconstruction package has been used only for events which have a reconstructed beam track, a reconstructed track compatible with the triggering conditions and a charged multiplicity (computed by counting the number of clusters found in the downstream MWPC's) between 2 and 7. This reduced the sample to $3.7 \cdot 10^6$ events. The beam flux sensitivity is 12 events nb^{-1} .

2.3 Selection of the events

The events corresponding to the reaction

$$K^- p \rightarrow K^- \phi p \quad (1)$$

$$\quad \quad \quad \searrow \quad \nearrow$$

$$\quad \quad \quad K^+ K^-$$

have been selected from the four prong (++--) sample and from the three prong (+--) one as well, since protons are expected to be slow and thus to

be partly undetected by the MWPC system. Slow K^- 's are also lost but this loss does not affect the study of the diffractive $K^- \phi$ system. In order to ensure homogeneity in the selection criteria for the three and four-prong samples, the slow positive track has been treated as missing in the four-prong sample. The following criteria have been used in sequence to define the $K^- \phi p$ sample:

- (a) The events are required to have a reconstructed beam, and the main vertex in hydrogen.
- (b) Assigning the kaon mass to the triggering track and to the negative tracks, the events are required to have at least one of the two $K^+ K^-$ combinations (fig. 2) inside the ϕ region, namely

$$1.010 \leq M(K^+ K_{1,2}^-) < 1.030 \text{ GeV.}$$

- (c) The missing mass to the three kaons exhibits a strong proton signal (fig. 3). The events belonging to channel (1) are selected by the cut

$$0.850 \leq MM(K^+ K^- K^-) \leq 1.050 \text{ GeV.}$$

These criteria select 13900 three prong and 3300 four prong events.

In order to estimate the background level in this sample, we have used the following method. The $K^+ K^-$ mass distribution of the events satisfying criterion (a) has been plotted for 22 slices of 50 MeV in the missing mass to the three kaons. In each slice, the number of ϕ events has been determined and plotted as a function of $MM(K^+ K^- K^-)$. This distribution (not shown) peaks at the proton mass, and has been fitted to a gaussian plus a second order polynomial background. We have found that 17650 ± 250 events satisfying criterion (a) belong to the $K^- \phi p$ channel. If in addition we impose the ϕ and proton cuts defined in (b) and (c), we find that there are 14300 ± 200 $K \phi p$ events in our sample of 17200 events. The background level is thus $(17 \pm 1)\%$.

To reduce this background, additional information is used:

- (a) Events with more than one track which did not fit with the main vertex are removed (1%). No significant loss of good events is produced.

- (b) Events with more than one hit in the γ counter surrounding the target were discarded (1.5%). Again no significant loss is observed.
- (c) Contamination from the K^- beam decay into $\pi^+\pi^-\pi^-$ is removed by rejecting those events for which the $\pi^+\pi^-\pi^-$ mass is below 0.56 GeV and the Cerenkov information is not compatible with a three kaon hypothesis. The Cerenkov compatibility for the two negative kaons is not required for the other events since events in which one of the kaons decayed before the Cerenkov counters would thus be antiselected.
- (d) In the four-prong sample, the background is further reduced by a loose cut on the $\delta = M^2(K^+K^-K^-) - MM^2(p)$ distribution, namely $|\delta| \leq 3 \text{ GeV}^2$.

We are thus left with 15348 events for reaction (1) in which we estimate the number of background events to be 2250 ± 200 and the number of good events rejected by the cuts to be 3800 ± 300 .

In addition, a localized inefficiency of the MWPC's near their median horizontal plane produced a loss of tracks with dip angle around 6 mrad. All the events with a track in the region of this loss (15%) were removed. Proper correction has been applied in the analysis.

Finally, the amplitude analysis described below is limited to the 7710 events with a $K^-\phi$ mass less than 2.2 GeV, a momentum transfer to the proton t' less than 0.8 GeV^2 and a K^-p mass above 1.95 GeV in order to eliminate the quasi-two-body production of $\Lambda(1520)$ and hyperons around 1.8 GeV which is present in the K^-p spectrum (fig. 5).

3. FORMALISM

3.1 The $H(LM\bar{m})$ moments

The physical properties of the $K^-\phi$ system can be described in terms of six variables:

- $M(K^-\phi)$ and t (or t') which define the kinematics of the reaction;

- $\cos\theta_1$ and ϕ_1 (in short Ω_1) which define the direction of the ϕ in the $K^- \phi$ rest frame (the Gottfried-Jackson frame will be used in the following analysis);
- $\cos\theta_2$ and ϕ_2 (in short Ω_2) which define the K^+ direction in the ϕ helicity-system with y-axis perpendicular to the beam and the $K^- \phi$ directions in the ϕ rest frame.

The angular information is contained in the moments which are defined as

$$H(LM\ell m) = \sqrt{4\pi} \sum_{\text{events}} \sqrt{(2L+1)} D_{Mm}^L(\phi_1, \theta_1, 0) Y_m^{\ell*}(\theta_2, \phi_2) \quad (2)$$

These moments depend on the mass and momentum transfer t' of the $K^- \phi$ system. Note that only moments with $M \geq 0$ are independent due to the symmetry properties of the D and Y functions and that moments with $M = 0$ are real.

The H moments can be related to the production density matrix ρ and the decay helicity amplitudes F_λ^A by the expression [7]

$$H(LM\ell m) = \frac{3 \langle 1010 | \ell 0 \rangle}{\sqrt{(2L+1)(2\ell+1)}} \sum_{AA' \lambda \mu \lambda' \mu'} (-1)^{\mu'} \sqrt{(2J+1)(2J'+1)} \rho_{\mu\mu'}^{AA'} F_\lambda^A F_{\lambda'}^{A'*} \quad (3)$$

$$x \langle J_\mu J' - \mu' | LM \rangle \langle J_\lambda J' - \lambda' | Lm \rangle \langle 1\lambda 1 - \lambda' | \ell m \rangle,$$

where A is the spin parity J^P of the contributing states, μ is the corresponding helicity and λ is the helicity of the ϕ . From parity conservation at the production and decay of the $K^- \phi$ system, we have

$$\rho_{-\mu-\mu'}^{AA'} = \eta \eta' (-1)^{\mu-\mu'} \rho_{\mu\mu'}^{AA'} \quad \text{and} \quad F_{-\lambda}^A = -\eta F_\lambda^A \quad (4)$$

where $\eta = P(-1)^J$ is the naturality of the spin state A. These parity considerations lead to the fact that the moments are real (imaginary) for ℓ even (odd). In fact, the H moments should be zero for $\ell = 1$, due to the term $\langle 1010 | \ell 0 \rangle$ in (3).

3.2 Amplitude formalism

The only assumption we shall make in the following is that we have spin coherence at the proton vertex, i.e. the production amplitude of the $K^-\phi$ system does not depend on the initial and final proton helicity. With this assumption, we may write the density matrix in terms of the production amplitudes H

$$\rho_{\mu\mu'}^{AA'} = H_{\mu}^A H_{\mu'}^{A'*} \quad . \quad (5)$$

This assumption will allow us to perform a full spin parity analysis which is almost model independent. The H moments will then depend only on the helicity amplitudes

$$f_{\lambda\mu}^A = F_{\lambda}^A H_{\mu}^A \quad . \quad (6)$$

It is advantageous to use the canonical invariant amplitudes $g_{\mu}^A(L')$ describing the $L'S$ coupling of the $K^-\phi$ system where L' is the orbital angular momentum of the $K^-\phi$ system and S is the spin of the ϕ meson. The f and g amplitudes are related by

$$\sqrt{2J+1} f_{0\mu}^A = \sqrt{J} g_{\mu}^A(J-1) - \sqrt{J+1} g_{\mu}^A(J+1) \quad (7a)$$

$$\sqrt{2(2J+1)} f_{1\mu}^A = \sqrt{J+1} g_{\mu}^A(J-1) + \sqrt{J} g_{\mu}^A(J+1)$$

for the unnatural parity series ($\eta = -$) and by

$$\sqrt{2} f_{1\mu}^A = g_{\mu}^A(J) \quad , \quad f_{0\mu}^A = 0 \quad (7b)$$

for the natural parity series ($\eta = +$).

The amplitudes $g_{\mu}^A(L')$ can finally be split into their parts symmetric and antisymmetric in μ which are asymptotically related to the naturality ϵ of the exchange. Note that for $\mu = 0$, the unnatural parity series can only be produced by natural parity exchange and vice versa.

4. DATA ANALYSIS

4.1 Acceptance

We have performed a detailed acceptance calculation with a Monte-Carlo program. The different sources of loss have been taken into account:

- (a) The triggering condition.
- (b) The absorption of the incoming kaon in hydrogen and the decay of the triggering kaon.
- (c) The cuts on the dip angle distribution of the outgoing kaons.
- (d) The cuts on the K^+K^- mass and on the K^-p effective mass (see sect. 2.5).

For each of the 16 mass bins spanning the 1.5-2.2 GeV mass range, 5000 events were produced according to an exponential t' distribution in the 0-0.8 GeV² range and to flat Ω_1 and Ω_2 distributions. Each of these "physical" events gave rise to 500 "geographical" events corresponding to 5 positions of the primary vertex inside the target and 100 orientations around the beam. These 500 events were then sent through the model apparatus yielding an acceptance for each "physical" event, say $A(M(K^- \phi), t', \Omega_1, \Omega_2)$.

4.2 Amplitude analysis

In order to perform an amplitude analysis of the $K^- \phi$ system, we need to determine the true moments H_λ^{prod} ($\lambda = LM\Omega m$) as functions of $M(K^- \phi)$ and/or t' . One can easily show (see for example [8]) that these true moments are related to the observed moments H_λ^{obs} by the linear relations

$$H_\lambda^{\text{obs}} = \sum_{\lambda'} A_{\lambda\lambda'} H_{\lambda'}^{\text{prod}} \quad (8)$$

where

$$A_{\lambda\lambda'}(M(K^- \phi), t') = \int d\Omega_1 d\Omega_2 Z_\lambda(\Omega_1, \Omega_2) A(M(K^- \phi), t', \Omega_1, \Omega_2) Z_{\lambda'}^*(\Omega_1, \Omega_2) \quad (9)$$

and the Z function stands for

$$Z_{\lambda} = \sqrt{4\pi/(2L+1)} D_{Mm}^L(\phi_1, \theta_1, 0) Y_m^{L*}(\theta_2, \phi_2), \quad \lambda = (LM\ell m).$$

The $A_{\lambda\lambda}$ matrix has been calculated by the Monte-Carlo method.

We directly fit the intensity and phase of each of the waves to the observed moments H_{λ}^{obs} using eqs (3) to (8). In the fit, the 57 moments $L \leq 4$, $M \leq 2$, $\ell = 0, 2$ and $|m| \leq 2$ have been used.

As a check of the method, we generated events according to several admixtures of amplitudes, applied acceptance cuts, computed the moments and determined the amplitudes with the fitting program. The fitted amplitudes were found to be in very good agreement with the input amplitudes.

The set of waves $|J^P L' \mu^{\epsilon}\rangle$ used in the analysis is the following:

$$1^+ S0^+ \quad 1^+ S1^+ \quad 0^- P0^+ \quad 2^- P0^+ \quad 2^- P1^+ \quad 1^+ D0^+ \quad 2^+ D1^+ \quad 1^- P1^+$$

All the fitted intensities together with the phases of the $2^- P0^+$ and $0^- P0^+$ waves with respect to the $1^+ S0^+$ wave obtained using this set are displayed in fig. 5. The comparison between the observed moments and the predictions from the fit is made in fig. 6. With the above set of waves, the true moments with $\ell = 1$ or with $L \geq 5$ are zero but, due to acceptance effects, the corresponding observed moments are not all zero (fig. 6(c)). These moments are well reproduced with our model showing that contributions of waves with $J \geq 3$ and of states beneath the ϕ are not required.

5. RESULTS

5.1 Cross section

From the above analysis, we calculate the corrected $K^-\phi$ mass spectrum (fig. 7) for channel (1). The corrected number of events with $M(K\phi) < 2.2$ GeV, $t' < 0.8$ GeV² is 32000 ± 800 . If we account for the cuts described in sect. 2.3 on the ϕ mass and the missing mass to the three kaons, the events with no reconstructed beam track, those lost in the reconstruction chain and the ϕ branching ratio to K^+K^- , we obtain the cross section

$$\sigma(K^-p \rightarrow K^- \phi p) = 10.5 \pm 0.6 \text{ } \mu\text{b}$$

for $M(K^- \phi) < 2.2 \text{ GeV}$ and $t' < 0.8 \text{ GeV}^2$. The cross section at $8.25 \text{ GeV}/c$ in the same conditions is $18.3 \pm 2 \text{ } \mu\text{b}$ [3]. Assuming a cross section dependence of the form p_{lab}^{-n} and using the $8.25 \text{ GeV}/c$ value, we obtain $n \approx 0.7 \pm 0.2$ in agreement with the hypothesis of a dominant diffractive mechanism. In addition, the cross section value predicted by this law at $14.3 \text{ GeV}/c$ is $\sim 11.5 \text{ } \mu\text{b}$ and compares well with the value of $12 \pm 1.5 \text{ } \mu\text{b}$ for $M(K\phi) < 2 \text{ GeV}$ published at that incident momentum [9].

5.2 Discussion

From the results of the fit, we observe that:

- (a) The 1^+S0^+ wave is dominant, and has a broad threshold structure around 1.7 GeV .
- (b) The 2^-P0^+ wave peaks around 1.75 GeV and its phase with respect to the 1^+S0^+ wave increases by about 120° when the $K\phi$ mass goes from threshold to 2.2 GeV .
- (c) The 0^-P0^+ wave peaks at 1.85 GeV and its phase with respect to the 1^+S0^+ wave also increases by about 140° from threshold to 2.2 GeV .
- (d) The natural spin parity wave 1^-P1^+ shows a structure around 1.85 GeV in the intensity but not in the phase. The other waves are small and structureless.

If one assumes that the phase of 1^+S0^+ wave is slowly varying as expected from a Deck mechanism, the intensity and phase of the 2^-P0^+ and 0^-P0^+ waves are suggestive of a resonant behaviour. The intensity of each of these waves can indeed be fitted to relativistic Breit-Wigner functions with respective parameters.

$$\begin{array}{lll} J^P = 2^- & M \approx 1.73 \text{ GeV} & \Gamma \approx 0.22 \text{ GeV} \\ J^P = 0^- & M \approx 1.83 \text{ GeV} & \Gamma \approx 0.25 \text{ GeV} \end{array} .$$

In addition, the corresponding predicted phases match the data (fig. 5) provided one assumes that the 1^+S wave has a constant phase; the relative phase between the two Breit-Wigner functions is found to be $\sim 120^\circ$.

In order to ascertain whether this interpretation is correct and to understand the 1^+S0^+ wave, we have attempted to describe the data with a Deck model. For this purpose, we have first used the simple Deck model discussed in ref. [10] for the $K\phi$ system and corresponding to the graph of fig. 8(a). In this model, the Deck amplitude reads

$$A = -2 g_{\phi K\bar{K}} q_\phi \frac{\exp[b_K(t_2 - m_K^2)]}{m_K^2 - t_2} i s_{Kp} \sigma_{Kp} \exp(B_K t/2) \quad (10)$$

where t_2 is the momentum transfer from the incident K^- to the ϕ , q_ϕ is the initial K^- momentum in the ϕ rest frame for $t_2 = 0$, and s_{Kp} is the invariant mass squared of the K^-p final system. The $\phi K\bar{K}$ coupling constant $g_{\phi K\bar{K}}$ is taken equal to $4.36^{(*)}$, m_K is the mass of the kaon, σ_{Kp} is the total K^-p cross section set here to 19 mb, B_K is the slope of the K^-p elastic scattering 4-momentum transfer distribution and b_K is the slope of the form factor. Based on physics arguments, Berger and Donohue [10] suggest the values $B_K = 8 \text{ GeV}^{-2}$ and $b_K = 1 \text{ GeV}^{-2}$. A contribution of the graph with ϕ exchange of fig. 8(b) leading to t -channel helicity non conservation [10] is expected to be suppressed by more than one order of magnitude with respect to the K exchange term and has been neglected. This is in agreement with our data in which the $K\phi$ S -wave satisfies approximate t -channel helicity conservation, i.e. weak 1^+S1^+ wave.

The absolute predictions for the 1^+S0^+ and 2^-P0^+ waves given by the model are shown in fig. 5(a) (dashed dotted curves). The other waves and in particular the 0^-P0^+ wave are predicted to be smaller than the 1^+S wave by about two orders of magnitude. In addition, as the Deck amplitude (10) is

(*) This value of the coupling constant has been determined from the measured value of the ϕ width and the simple formula valid for the decay $1^- \rightarrow 0^- + 0^-$

$$\frac{\Gamma_\phi}{m_\phi} = \frac{g_{\phi K\bar{K}}^2}{4\pi} \left(1 - 4 \frac{m_K^2}{m_\phi^2} \right)^{3/2}$$

purely imaginary, all the partial waves are also purely imaginary and therefore the 2^-P-1^+S relative phase is predicted to be zero. These features contrast with the data. A disagreement also appears when comparing the 4-momentum transfer distributions ($d\sigma/dt$): the slope predicted by the model is of the order of 9 GeV^{-2} in our mass range whereas in the data it is of the order of 5 GeV^{-2} . Decreasing the value of B from 8 to 4 GeV^{-2} in order to reproduce the experimental slope of $d\sigma/dt$ is not however sufficient to reproduce satisfactorily the 1^+S intensity. Furthermore, this simple Deck model is unable to account for the 0^-P wave.

We have also tried to improve the fit to the data by allowing the $K\phi$ system produced by the Deck mechanism to rescatter through resonances and by adding direct resonance production [11]. Such a procedure was successful in interpreting the 1^+S wave in the $\pi\pi\pi$ and $K\pi\pi$ systems [1]. In Bowler's model [11], the modified Deck amplitude reads

$$A = \frac{D [M_0 - M + (\alpha g^2/2)] + C e^{at} e^{i\varphi} (g^2/2)}{M_0 - M - i(g^2/2)k} \quad (11)$$

where D is the pure Deck partial wave, M_0 the resonance mass, g^2 a coupling connected to its width and k is the $K\phi$ phase space at mass M . The first term in the numerator is the rescattering term and the second one represents the direct production of a resonance with slope $2a$ and relative phase φ . α was taken to be 0.4 GeV and a to be 3.5 GeV^{-2} as in ref. [1].

The amplitude (11) gives satisfactory fits to the 1^+S wave (fig. 5(a)) if one assumes the presence of a 1^+ resonance of mass $M = 1.84 \text{ GeV}$ and width $\Gamma = 0.25 \text{ GeV}$ roughly in the position of a $1^+ K\pi\pi$ resonance claimed in ref. [1]. It is interesting to note that as the fitted value of φ is approximately zero, the direct production term is real. However, one should not that in order to achieve a good fit, the Deck term has to be multiplied by a factor ≈ 0.5 which can be due to absorption of the Deck amplitude. The predicted 1^+S phase, shown in fig. 5(a), increases by $\sim 50^\circ$ between 1.5 and 1.9 GeV and decreases beyond. Such a phase variation is too slow to account for the observed 2^-P and 0^-P phases. The relative phases of the two relativistic Breit-Wigner functions with respect to the predicted 1^+S phase is however in agreement with the data (fig. 5(a)).

On the contrary, the amplitude (11) cannot describe both the intensity and phase of the 2^-P wave unless the Deck term is set to zero indicating a pure resonance behaviour.

As a conclusion, our analysis of the $K\tilde{\phi}$ suggests the existence of a 0^- resonance around 1.83 GeV with ~ 0.25 GeV width. This resonance could be the second radial excitation of the kaon, the first one having been found at SLAC [12] and recently confirmed [1]. An indication for the corresponding radial excitation of the pion has been recently presented [13]. In addition, there is support for the presence of a 0.22 GeV wide resonance around 1.73 GeV with spin 2^- which could be connected with the 2^- resonances seen in the $K\pi\pi$ decay mode (L region) [1]. Finally, one cannot rule out the presence of a 1^+ resonance at about 1.84 GeV with width ~ 0.25 GeV; such a resonance has already been suggested in ref. [1].

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FIGURE CAPTIONS

- Fig. 1 Layout of the Ω' spectrometer.
- Fig. 2 Inclusive uncorrected K^+K^- effective mass distribution for (a) the three prong $+-$ and (b) the four prong $++--$ events (two combinations per event).
- Fig. 3 Uncorrected missing mass to the $K^+K^-K^-$ system when a K^+K^- combination is in the ϕ region ($1.01 \leq M(K^+K^-) \leq 1.03$ GeV). (a) and (b) as in fig. 2.
- Fig. 4 Uncorrected K^-p mass spectrum recoiling off the ϕ .
- Fig. 5 Intensities and phases with respect to the $1^+S_0^+$ wave of the fitted waves. The solid curves on the intensity plots are the result of fits to Breit-Wigner functions and those on the phase plots are the fit predictions up to a global phase. The dashed dotted line is the prediction of the simple Deck model and the dashed line is the result of a fit to the model of ref. [11].
- Fig. 6 Comparison between the observed (+) and predicted (●) moments.
- Fig. 7 Corrected $K^- \phi$ mass spectrum for $t' < 0.8$ GeV².
- Fig. 8 Graphs of the Deck model for (a) K and (b) ϕ exchange.

Fig. 1

Fig. 2

Fig. 3

Fig. 4

Fig. 5(a)

Fig. 5(b)

Fig. 6

Fig. 7

Fig. 8