To be pr... ON HIGH ENERGY
PHYSICS
Palerm...

1975 High energy particle physics conference.
Palermo, Italy, 23-28 June 1975.

CEA-CONF--3271
FR76 00942

PARTIAL WAVE ANALYSIS OF THE LOW MASS $\overline{K}^\circ \pi^+\pi^-$ SYTEM PRODUCED IN THE REACTION $K^-p \to \overline{K}^\circ\pi^+\pi^-n$ AT 3.95 AND 14.3 GEV/c

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ABSTRACT

A partial wave analysis of spin-parity of the $(\overline{K}^\circ\pi^+\pi^-)$ system in the mass range $M(\overline{K}^\circ\pi^+\pi^-) < 1.6$ GeV is presented at 3.95 and 14.3 GeV/c. We find an important contribution of 0^- and 1^+ states, the unnatural spin-parity accounting for more than 3/4 of the events at 3.95 GeV/c and for more than half at 14.3 GeV/c. Natural parity exchange is dominant at both energies. A fit of the cross sections of several states to $\sigma \propto P_{lab}^{-n}$ gives n between $\sim$ 1.5 to 2.0.

We present the results of an analysis of spin-parity in the low mass range of the system $\bar{K}^{\circ}\pi^{+}\pi^{-}$ produced in the reaction.

$$K^{-}p \rightarrow \bar{K}^{\circ}\pi^{+}\pi^{-}n \qquad (1)$$

at 3.95 and 14.3 GeV/c.
The analysis was performed using a modified version[1] of the partial wave program of the university of Illinois group[2], using data from two bubble chamber experiments in the CERN 2 m HBC.

For the sample at 14.3 GeV/c, we excluded the events with missing mass squared greater than 1.5 GeV^{2}. We obtained 1560 events at 3.95 GeV/c and 1696 at 14.3 GeV/c, corresponding to the channel cross-sections of (940 $\pm$ 140) μb and (195 $\pm$ 15) μb respectively. The interest of this analysis is to compare the non-diffractive channel (1) with the diffractive reactions.

$$K^{-}p \rightarrow (K\,\pi\pi)^{-}p \qquad (2)$$

in which the low (K ππ) mass is dominated by the Q bump
We therefore limited our study to events in which the (Kππ) mass is in the interval 1.0 to 1.6 GeV and the four-momentum transfer $|t| < 1.0$ GeV^{2}.

With the above cuts, figs. 1 and 2 show the mass distributions of $(\bar{K}^{\circ}\pi^{+}\pi^{-})$, $(n\pi^{+})$, $(K^{\circ}\pi^{-})$ and $(\pi^{+}\pi^{-})$ at both energies. The $(\bar{K}^{\circ}\pi^{+}\pi^{-})$ mass spectra show a $K^{*}(1420)$ signal superimposed upon a background, however the ratio of signal to background is higher at 14.3 GeV/c. The $(\bar{K}^{\circ}\pi^{-})$ mass distribution is dominated by the $K^{*-}(890)$, whereas the $(\pi^{+}\pi^{-})$ spectrum has little, if any, ρ° signal. The $(n\pi^{+})$ mass spectrum displays a $\Delta^{+}(1236)$ signal for the 3.95 GeV/c data but not for the 14.3 GeV/c. In addition to the cuts on $(\bar{K}^{\circ}\pi^{+}\pi^{-})$ mass and $|t|$, we also removed events, at both energies, in which the $(n\pi^{+})$ mass was less than 1.4 GeV.

The final sample on which the analysis is based is then 338 events at 3.95 GeV/c and 249 events at 14.3 GeV/c.

Let us recall that this analysis consists of fitting the data to a serie of $|J^P LM^\eta >$ states, where J^P is the spin-parity of the $K\pi\pi$ system while L is the orbital angular momentum between the di-meson and the remaining meson in an assumed decay of the $K\pi\pi$ system into an intermediate state consisting of a 2 meson system and a third meson, M is the 2 component of the $K\pi\pi$ angular momentum in the Gottfried-Jackson system and η is the eigenvalue of the reflection operator in the production plane of the $K\pi\pi$. The fitting procedure assumes a mass dependence of the type Breit-Wigner, with M_o = 1.42 GeV and Γ = 0.1 GeV for the 2^+ wave. For the other states the mass dependence was taken as a straight line originating at the 3-meson threshold, and having variable slope.

The results of this analysis are given in table 1 where the cross section for each state is given in microbarns. Initially there had been an additional incoherent flat background term, but having verified that it did not contribute significantly, this term was removed in order to reduce the errors. For similar reasons we removed the 1^-PO^- state at 3.95 GeV/c. As for the $J^P = 0^-$ state, the physical results did not change if we took either the $K\pi$ or the $K\varepsilon$ as decay mode ; we took finally $K\pi$ because it gives slightly better fit. The

$|1^+S1^+ >$ and $|1^+S1^- >$ states give appreciable contributions at 3.95 GeV/c, but not at 14.3 GeV/c, where within about one standard deviation the number of events decaying into either $K^*\pi$ or $K\rho$ is consistent with zero. In addition, we verified that relaxing the coherence constraints between the $K\rho$ and $K^*\pi$ decay modes of the $|1^+SO^+ >$ does not significantly improve the fit.

Our results confirm [3] that, like in the reactions $K^-p \to (K\pi\pi)^-p$ at the same energies [4,5] the charge exchange reaction (1) at low $K\pi\pi$ mass is dominated by production of states of unnatural spin-parity ; at 3.95 GeV/c they account for more than 3/4 of the events and at 14.3 GeV/c for more than one half. We also notice that the natural parity exchange is dominant at both energies. The presence of the 1^+ states in reaction (1) implies the ~~exchange of an isospin~~ I = 1 object in the production of the Q at both energies, as we have shown previously [6,7]. Such exchange can partially account for the "cross-over" effect observed in the differential cross sections of the reactions $K^{\pm}p \to Q^{\pm}p$ [6]. Along this line of reasoning, if the production of the $|2^+D1^+\rangle$ state were dominated by ρ exchange we should expect, on the basis of the cross sections for reaction (2), to obtain cross sections of the order of 50 μb at 3.95 GeV/c and 30 μb at 14.3 GeV/c. The values are much bigger than the ones given in table 1. The production of the $|2^+D1^+\rangle$ state is then dominated by ω exchange.

In order to examine the energy dependence of the cross sections for channel (1) and for different states, we have parametrized the cross sections in the form $\propto P_{lab}^{-n}$. The values of n are listed in table 2. We notice that these values are of the order of $\sim$1.5 to 2.0 for natural and unnatural J^P states, and that they are bigger than the ones known for the diffractive reaction (2) (n from $\sim$0 to 0.5).

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TABLE CAPTION

TABLE 1 : Results of the partial wave analysis of $K^{\circ}\pi^{+}\pi^{-}$ system at 3.95 GeV/c and 14.3 GeV/c.

TABLE 2 : Fitted values of the exponent n from the expression $\sigma \propto P_{lab}^{-n}$ for various states.

TABLE 1

$J^P L M^n$	Decay mode	3.95 GeV/c μb	14.3 GeV/c μb
$0^- 0^+$	$K\pi$	109 ± 18	11 ± 2
$1^+ S 0^+$	$K^*\pi$	97 ± 18	7 ± 2
$1^+ S 0^+$	$K\rho$	13 ± 6	2 ± 1
$1^+ S 1^+$	$K^*\pi$	43 ± 16	-
$2^+ S 1^+$	$K\rho$	6 ± 3	-
$2^+ D 1^+$	$K^*\pi$	19 ± 6	2 ± 1
$1^- P 0^-$	$K^*\pi$	-	3 ± 1
$1^+ S 1^-$	$K^*\pi$	48 ± 12	-
$1^+ S 1^-$	$K\rho$	6 ± 3	-
[illegible]$^+ D 0^-$	$K^*\pi$	11 ± 11	6 ± 1
		352	31

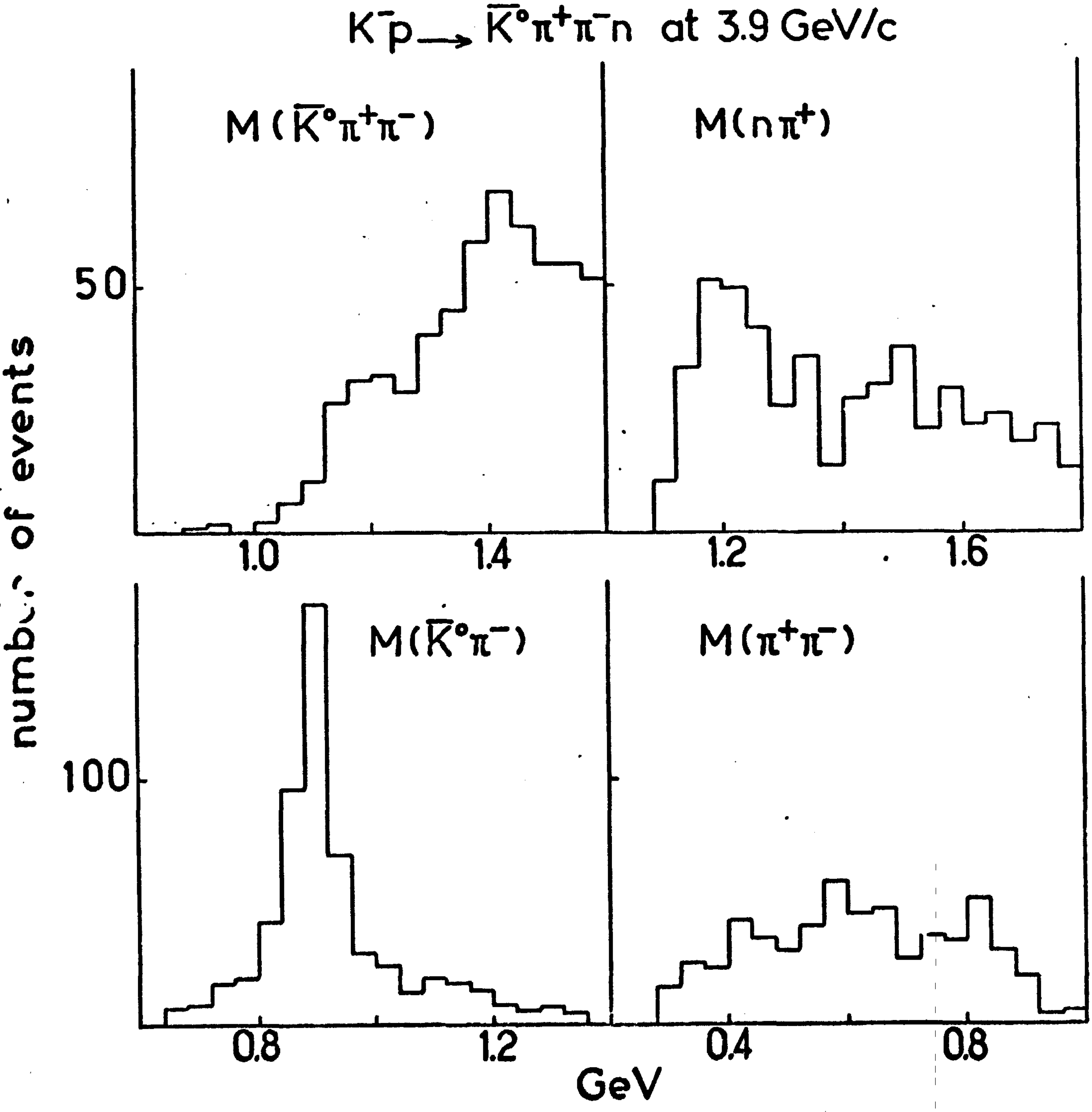
TABLE 2

	n
$K^- p \to K^\circ \pi^+ \pi^- n$	$1.22 \pm .13$
$K^- p \to K^\circ \pi^+ \pi^- n$	$1.53 \pm .66$
With $\left\{ \begin{array}{l} \lvert t \rvert \quad 1.\ GeV^2 \\ M(K^\circ \pi^+ \pi^-) < 1.6\ GeV \\ M(n\pi^+) > 1.4\ GeV \end{array} \right.$	
All 2^+	$1.02 \pm .44$
$1^+ SO^+$	$1.93 \pm .27$
$0^- SO^+$	$1.78 \pm .19$

FIGURE CAPTION

FIG. 1 : The $(K^\circ\pi^+\pi^-)$, $(n\pi^+)$, $(K^\circ\pi^-)$ and $(\pi^+\pi^-)$ mass spectra at 3.95 GeV/c for $|t| < 1.0$ GeV^2 and $M(K^\circ\pi^+\pi^-) < 1.6$ GeV

FIG. 2 : The $(K^\circ\pi^+\pi^-)$, $(n\pi^+)$, $(K^\circ\pi^-)$ and $(\pi^+\pi^-)$ mass spectra at 14.3 GeV/c for $|t| < .10$ GeV^2 and $M(K^\circ\pi^+\pi^-) < 1.6$ GeV.



K⁻p ⟶ K̄°π⁺π⁻n at 3.9 GeV/c
M(K̄°π⁺π⁻)
M(nπ⁺)
M(K̄°π⁻)
M(π⁺π⁻)
of events
50
100
1.0
1.4
1.2
1.6
0.8
1.2
0.4
0.8
GeV

Fig.1

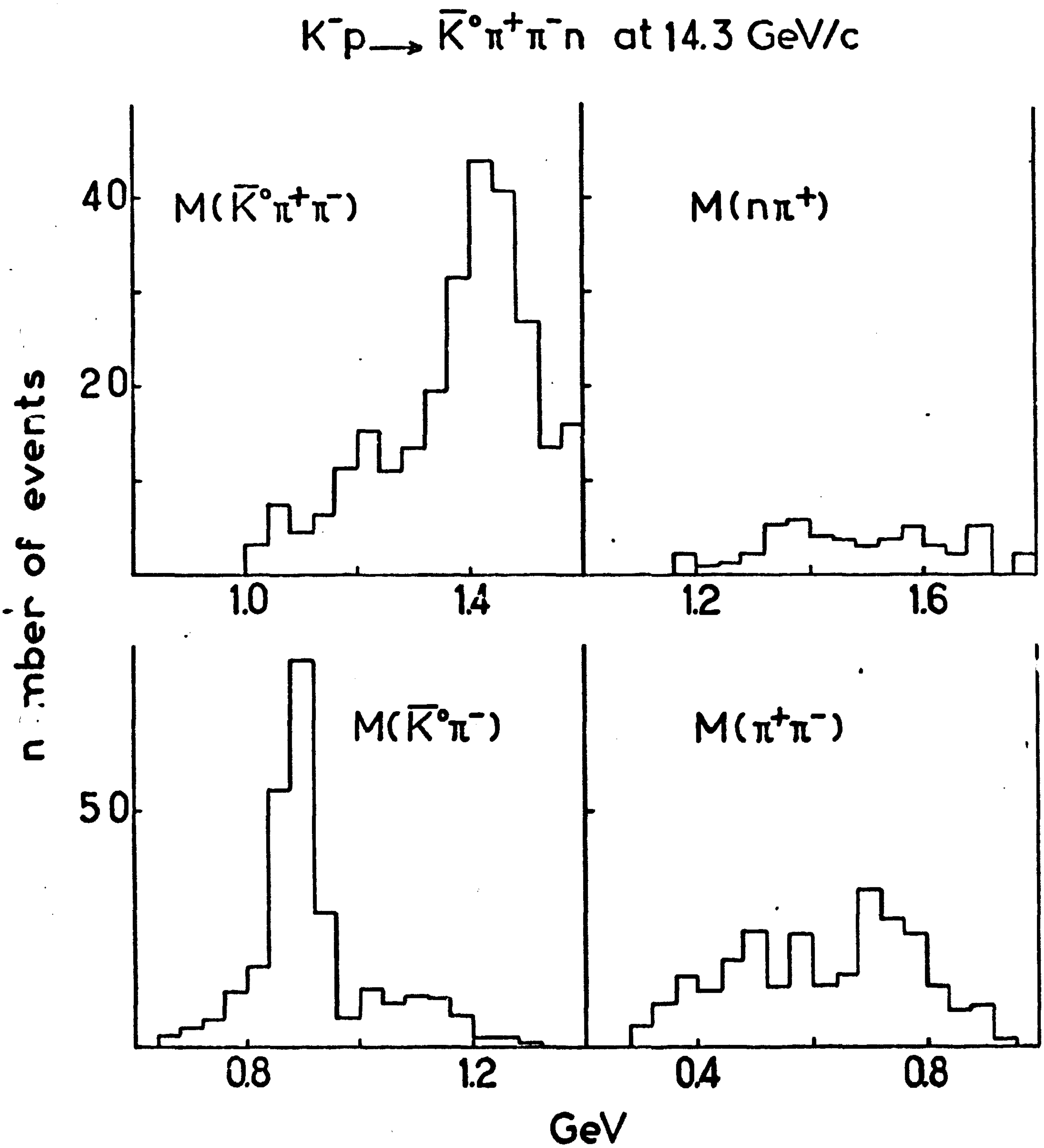


Fig.2

[redacted]