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DOUBLE REGGE MODEL FOR NON DIFFRACTIVE A_1 PRODUCTION

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A B S T R A C T

We show that a Reggeized double-nucleon-exchange model is able to reproduce qualitatively the non-diffractive A_1 *production recently observed in the reaction* $K^- p \to \Sigma^- \pi^+ \pi^- \pi^+$ *at* 4.15 GeV/c.

The $A_1(J^P = 1^+)$ enhancement has been source of several controversies between the resonance and Deck-effect schemes.

In general, quark models require the existence of the A_1 meson [1]. However, Ascoli et al. [2] showed that in the reaction $\pi N \rightarrow (\pi\pi\pi)N$, where the A_1 was first observed, the 1^+ phase shift of the three-pion system does not present a resonant behaviour. This fact favours the explanation of the A_1 diffractive production by the Drell-Hiida-Deck (DHD) model [3].

Recently the Amsterdam-CERN-Nijmegen-Oxford collaboration [4] observed the A_1^+ backward production in the reaction

$$K^- p \rightarrow \Sigma^- \pi^+ \pi^- \pi^+ \qquad (1)$$

at the incident K^- momentum value of 4.15 GeV/c. The reported mass and width are (1.041 ± 0.013) GeV and (230 ± 0.050) MeV, respectively. The A_1^- and A_1^0 backward production is not clear. It seems that no important signal is found in these cases, in evident disagreement with theoretical predictions [1]. Concerning other 1^+ states, as the B and Q mesons, the experimental situation is similar.

The DHD model cannot be applied to reaction (1) since it is non-diffractive. Therefore, the interpretation as a resonance seems to be more plausible. However, we will show here that the A_1 bump can be explained by a double-exchange model. We think that the bump is not due to diffractive effects in the Deck model but rather to kinematical reflections characteristic of peripheral double-exchange models of which the Deck is a particular case. Of course this applies only to sufficiently low energies as it is the case in this experiment. At higher energies, the diffractive dissociation processes are dominant. In fact, there exist models that reproduce non-resonant bumps in two final particles invariant mass distribution. For example, in reference [5], a double-nucleon-exchange model is used to explain the "ABC" effect in the reaction $pn \rightarrow d + (\pi\pi)^0$. In this paper is also pointed out the difference in the energy behaviour between a diffractive Deck and a double-exchange model. And this is observed experimentally: the A_1, Q, ... produced diffractively are energyindependent whereas the "ABC" effect disappears very rapidly as energy increases.

We propose here an explanation to the A_1^+ backward enhancement by a Reggeized double-nucleon-exchange model (see figure 1) to which corresponds the following amplitude [6]:

$$A(s,s_1,s_2,t_1,t_2) = \xi_1\xi_{21}\ s^{\alpha_1(t_1)}\ s_2^{\alpha_2(t_2)-\alpha_1(t_1)}\ V_{12}\ +$$

$$+\ \xi_2\xi_{12}\ s^{\alpha_2(t_2)}\ s_1^{\alpha_1(t_1)-\alpha_2(t_2)}\ V_{21} \qquad (2)$$

where

$$\alpha_i(t_i) = \alpha_i'(t_i-m^2)$$

$$\xi_i = \tau_i + e^{-i\pi\alpha_i(t_i)}$$

$$\xi_{ij} = \tau_i\tau_j + e^{-i\pi[\alpha_i(t_i)-\alpha_j(t_j)]} \qquad (i,j = 1,2)$$

$$V_{ij} = V_0/\{\alpha_i(t_i)[\alpha_j(t_j)-\alpha_i(t_i)]\}\ ,$$

$\tau_1 = \tau_2 = 1$ are the signature factors, α_i' the slopes of the Regge trajectories α_i, m the nucleon mass, V_0 a constant and the kinematical variables are defined as follows: $s = (p_a+p_b)^2$, $s_1 = (p_1+p_2)^2$, $s_2 = (p_2+p_3)^2$, $t_1 = (p_a-p_1)^2$, $t_2 = (p_b-p_3)^2$, where p_i $(i = a,b,1,2,3)$ is the four momentum of the external particle $\underline{i}$. Actually we took $\alpha_i = \bar{\alpha}_N = \alpha_N - \frac{1}{2}$, α_N being the usual nucleon trajectory. We have not accounted for the Δ-exchange because of the small signal observed [4] in the double-charge-exchange reaction $K^- p \to \Sigma^+ (\pi\pi\pi)^-$.

The amplitude (2) derived in [6] is the sum of all duality diagrams. Here we would like only to recall its main features.

(i) The derivation is based on general analiticity properties and duality that allow to write without ambiguity any contribution of double-Regge-exchange in $2 \to 3$ reactions. The amplitude has no simultaneous singularities in s_1 and s_2, i.e., it does not violate the "non-overlapping channel discontinuities" rule [7].

(ii) It takes into account the Regge phases and the one related to the Toller angle.

The cross-sections have been obtained by a Monte-Carlo procedure (GO CERN-program [8]). Our only parameter is an overall normalization constant, determined by the $(\rho\pi)$

mass distribution, shown in fig. 2. The results obtained by our model are represented by a continuous curve. We obtain a good agreement with the experimental data in the A_1 region. In fig. 3 we show the t_1 momentum transfer distribution. We see that the slope at small t_1 is reasonably well reproduced. Figure 4 presents a prediction for the $\cos\Theta_{G.J.}$ distribution. ($\Theta_{G.J.}$ is the angle between the pion and the proton momentum in the ($\rho\pi$) rest frame). All these curves were obtained with $\alpha'_N = 1$.

Let us make some comments. Our results describe qualitatively well the data in the A_1 region as it was intended. To a more complete fit it is necessary to consider the contribution of the resonance A_2. Our model does not exclude the existence of resonances. However, by duality arguments, the double exchange graph cannot be added to a direct resonance production (i.e., a Breit-Wigner formula for the A_1) otherwise we make double-counting. In reference [5] an analogous situation is discussed.

Recently Berger and Basdevant [9] proposed to explain the A_1 puzzle in diffractive reactions as a mixing of resonance and Deck effect. We can ask whether this model is able to explain the backward A_1 production.

We think that the experimental results in reference [4] are crucial to understand the A_1 puzzle and that the present work can contribute to the comprehension, by the duality point of view, of the complex behaviour of 1^+ states.

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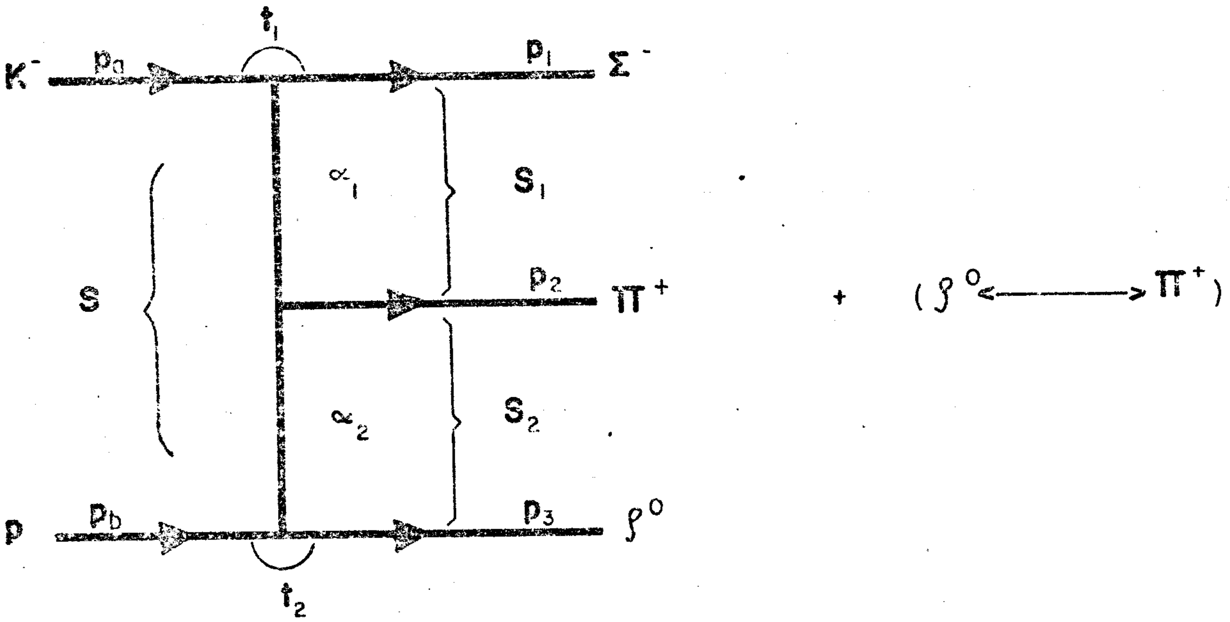

Figure 1

Double-exchange graph for $K^{-}p \to \Sigma^{-}\rho^{0}\pi^{+}$

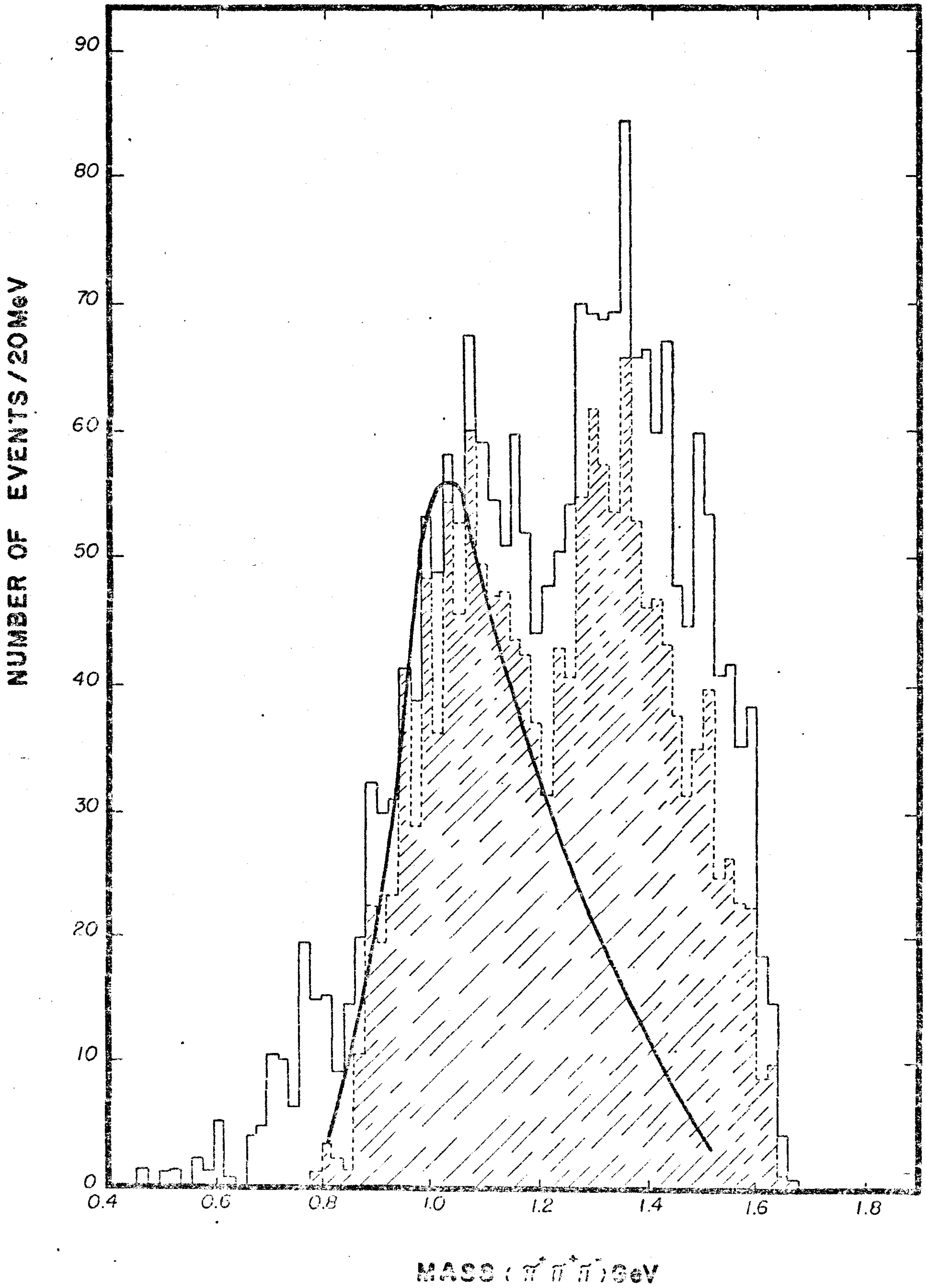

Figure 2

Invariant $(\pi^+\pi^+\pi^-)$ mass distribution

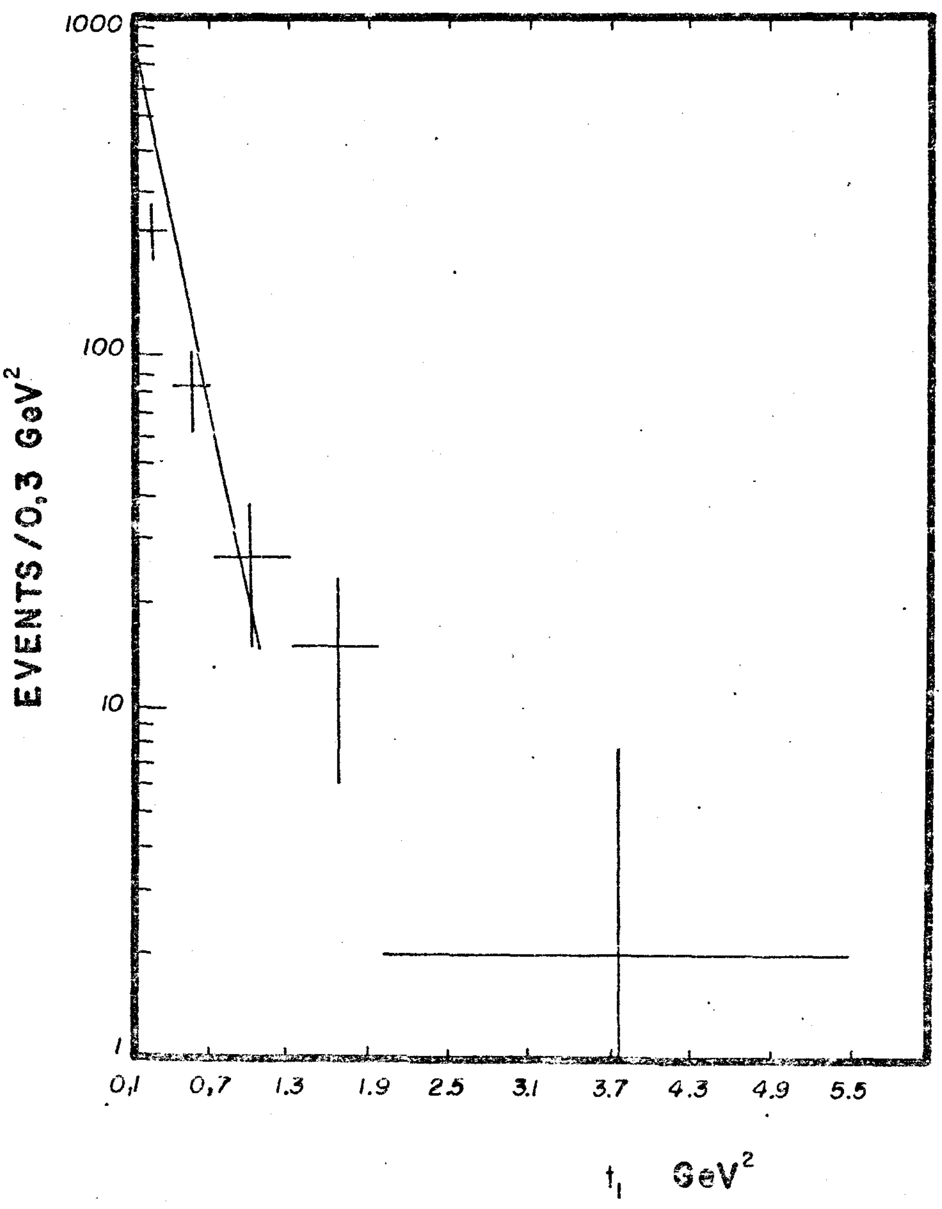

Figure 3

$t_1(K^-, \Sigma^-)$ momentum-transfer distribution

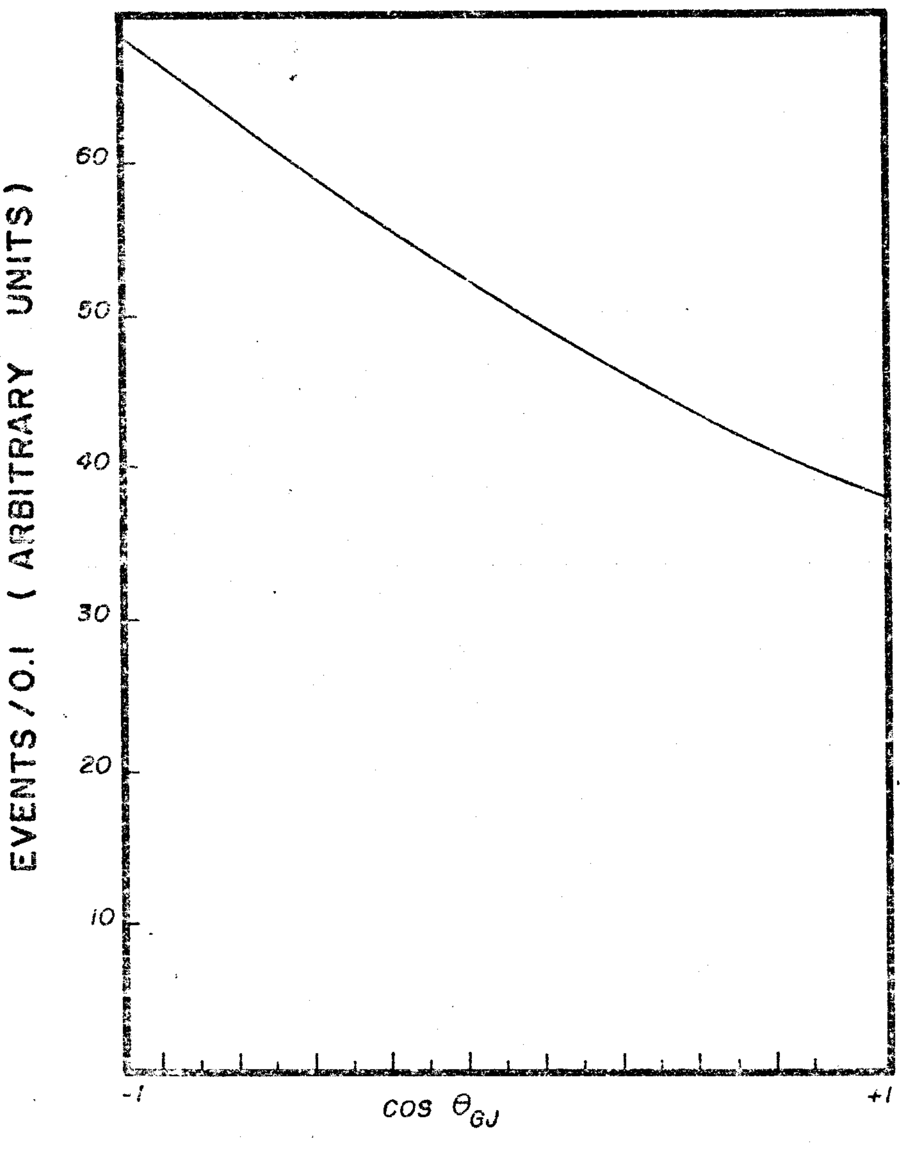

Figure 4

Prediction for the distribution in cosinus of the Gottfried-Jackson angle

R E F E R E N C E S

[1] - see for a brief review and list of references H. E. Haber and G.L. Kane, University of Michigan pre-print UM HE 77-9. (1977)

[2] Yu. M. Antipov et al. N.P. 63B (1973), 141; (1973) 153. G. Ascoli - Proceedings of VI Int. Conf. on High-Energy Physics - Chicago, Batavia, vol. 1, p. 3 (1973).

[3] S.D. Drell and K. Hiida - P.R.L. 7, 199 (1961)
R. T. Deck - P.R.L.13, 169 (1964)
E. L. Berger - P.R. 166, 1525 (1968)

[4] Amsterdam-CERN-Nijmegen-Oxford collaboration - CERN/ EP/PHYS-77 (1977)

[5] J.C. Anjos, D. Levy, A. Santoro - N.C. 33A, 23 (1976)

[6] C. Cohen-Tannoudji, A. Santoro, M. Souza - N.P. 95B, 445 (1975)

[7] R.C. Brower, C.E. De Tar and J.H. Weis - P. Reports 14, 257 (1974) and references therein.

[8] Program GO(HYDRA), CERN TC Program Library Manual (1974).

[9] J.L. Basdevant, E.L. Berger - ANL-REP-PR-77-02 (1977).