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V. Picciarelli[x]: DIFFRACTIVE CONTRIBUTIONS IN THE $\pi^+ n \longrightarrow$ $\longrightarrow p\pi^+\pi^-$ PROCESS AT 5.1 AND 9 GeV/c.

We report on a study of the diffractive contributions in the reaction $\pi^+ n \longrightarrow p\pi^+\pi^-$ at 5.1 and 9.0 GeV/c. The low $(p\pi^-)$ mass characteristics are interpreted using a diffractive model.

1. - INTRODUCTION -

The three-body reaction

(1) $$\pi N \rightarrow N\pi\pi$$

studied at various energies shows a large diffractive contribution[1]. Until now it is not clear if this contribution is due to Pomeron exchange (Fig. 1a) or to diffraction dissociation (Fig. 1b). In fact, as clearly pointed out by Morrison[2], there is no evidence to show that these mechanisms are different. Many models have been used to explain some characteristics of this diffractive contribution in reaction (1) [3].

Our analysis concerns the study of the reaction

(2) $$\pi^+ n \rightarrow p\pi^+\pi^-$$

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obtained in two bubble chamber experiments at 5.1 and 9 GeV/c. Selection criteria, cross-sections, and some general characteristics of process (2) can be found in Armenise et al.[4].

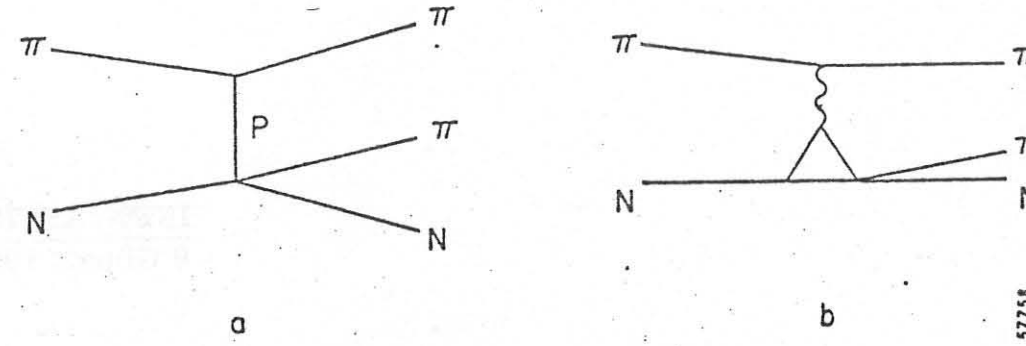

FIG. 1 - a) Pomeron exchange diagram; b) Diffraction dissociation diagram.

First we discuss the evidence for diffractive contributions in the low $(p\pi^-)$ mass region, and then their possible influence on the high dipion mass resonance production (g meson).

2. - DIFFRACTIVE CONTRIBUTION EVIDENCE AND LOW $(p\pi^-)$ MASS REGION -

Reaction (2) has been studied in the Van Hove longitudinal phase space[1c]. The results of this analysis give evidence for a diffractive contribution dominance in the $\omega < 120^o$ region[(x)]: the cross-sections in this region are energy-independent. As shown in Fig. 2, the $\omega < 120^o$ region is mainly associated with the low $(p\pi^-)$ mass region, and the $(p\pi^-)$ mass spectra given in Figs. 3a) and 3b) show a bump which is not explained by a statistical phase-space. The A-values, obtained by fitting the exponential law $e^{-At'}$ $(t' = |t - t_{min}|)$ with the differential $dN/dt'_{\pi^+_{in}\pi^+_{out}}$ cross-sections in different $(p\pi^-)$ mass regions, are shown in Figs. 3c and 3d. The A parameter values change from 10-13 $(GeV/c)^{-2}$ at threshold (compatible with the elastic scattering slope values) to 3.0-5.0 $(GeV/c)^{-2}$ for higher $(p\pi^-)$ masses (1.7-2.0 GeV/ A shrinking effect seems to be present in each $(p\pi^-)$ mass region: the A- values are larger at 9 GeV/c. A fit with the formula:

$$A = A_o\left(\frac{m}{m_o}\right)^{\alpha} \qquad (3)$$

(x) - ω is the angle defining the position of events in the Van Hove plot (Ref. 1c).

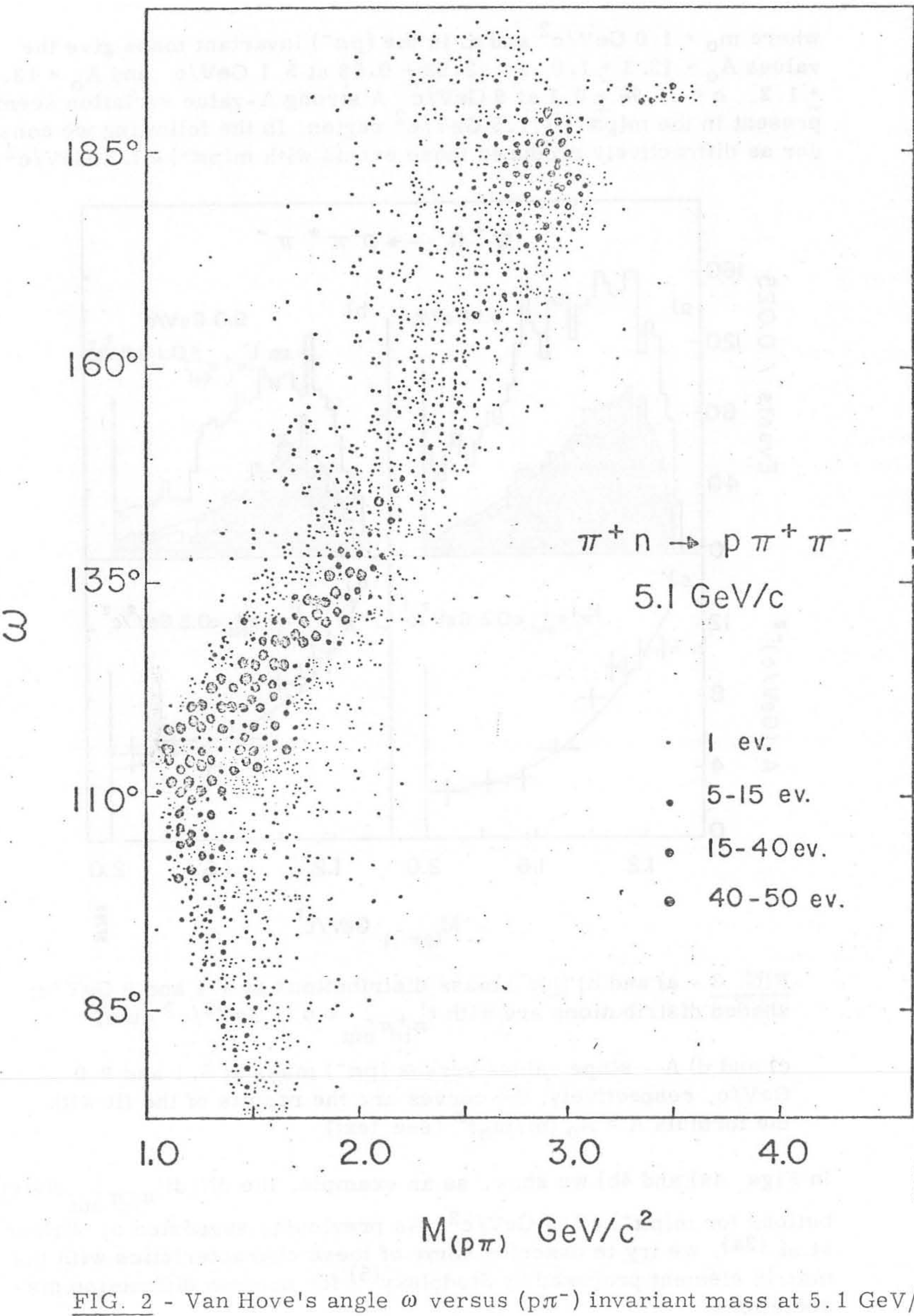

FIG. 2 - Van Hove's angle ω versus $(p\pi^-)$ invariant mass at 5.1 GeV/c.

where $m_o = 1.0$ GeV/c^2 and m is the ($p\pi^-$) invariant mass give the values $A_o = 13.3 \pm 1.0$, $\alpha = -2.98 \pm 0.08$ at 5 1 GeV/c and $A_o = 13.1 \pm 1.2$, $\alpha = -1.96 \pm 0$ 1 at 9 GeV/c. A strong A-value variation seems present in the $m(p\pi^-) < 1.5$ GeV/c^2 region. In the following we consider as diffractively produced those events with $m(p\pi^-) < 1.5$ GeV/c^2.

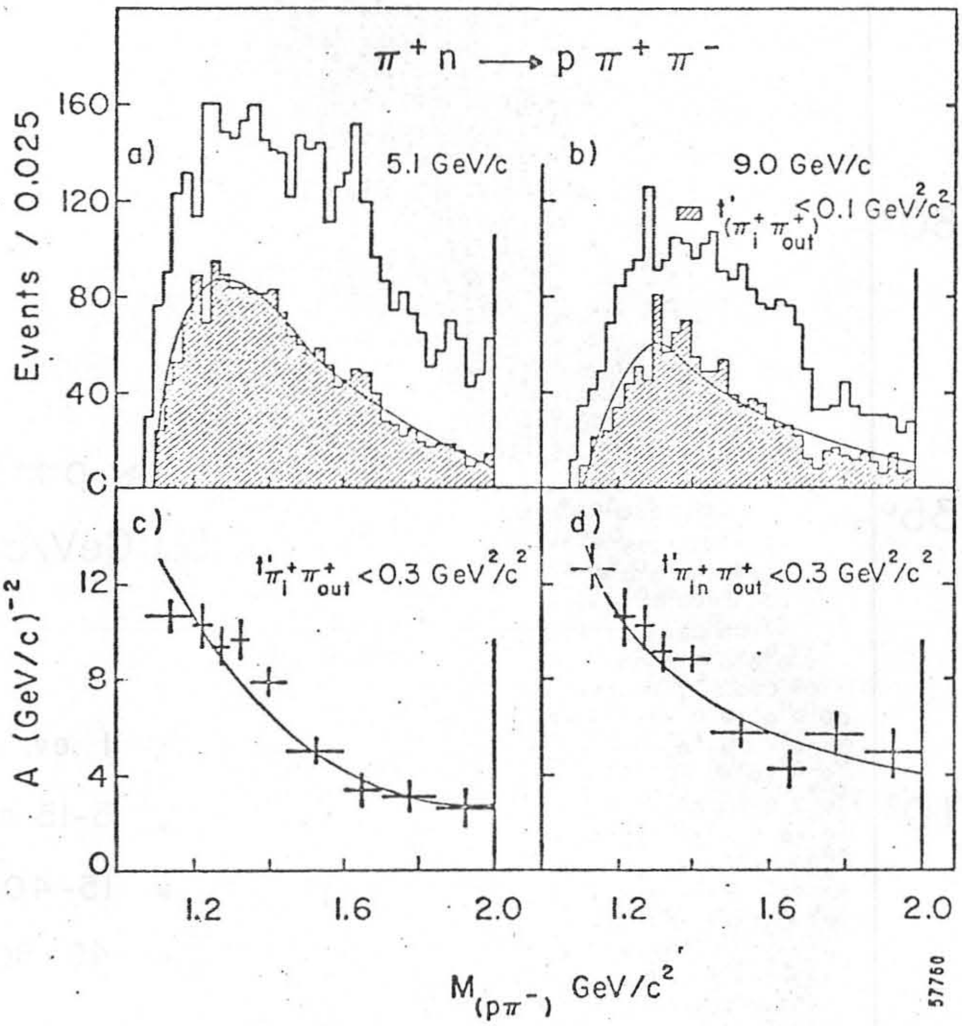

FIG. 3 - a) and b) ($p\pi^-$) mass distributions at 5.1 and 9 GeV/c; shaded distributions are with $t'_{\pi^+_{in}\pi^+_{out}} < 0.1$ GeV^2/c^2 cuts.

c) and d) A - slope values versos ($p\pi^-$) mass at 5.1 and 9.0 GeV/c, respectively; the curves are the results of the fit with the formula $A = A_o\,(m/m_o)^{\alpha}$ (see text)

In Figs 4a) and 4b) we show, as an example, the $dN/dt'_{\pi^+_{in}\pi^+_{out}}$ distributions for $m(p\pi^-) < 1.5$ GeV/c^2. As previously suggested by Walker et al.[3a], we try to describe some of these characteristics with the matrix element proposed by Stodolsky[5] for neutron diffraction dissociations:

$$(4) \qquad |M|^2 = p_{cm}^{\pi N} \frac{e^{-a\Delta_o^2}}{\Delta_o^2},$$

where $p_{cm}^{\pi N}$ is the proton momentum in the $(p\pi^-)$ centre-of-mass system; $\Delta_o = (m^2_{p\pi} - m^2_N)/2p_{lab}$; a is a diffractive parameter.

As can be seen from the curves reported in Figs. 3a, 3b, and 4a, 4b, the agreement between the experimental results and the matrix elements in Eq. (4) is quite good. ($a = 10.\ GeV^{-2}$).

The cos θ_{np} distributions for $m(p\pi^-) < 1.5\ GeV/c^2$ and $t'_{\pi^+_{in}\pi^+_{out}} < 0.1\ (GeV/c)^2$ are shown in Figs. 4c and 4d. These distributions are strongly asymmetric, but the $\cos\theta_{np} \sim 1.0$ region corresponds to the cos $\theta_{\pi^+_{in}\pi^+_{out}} \sim 1.0$ values[(x)].

However, the ρ and f angular distributions collimated near the cos $\theta_{\pi^+_{in}\pi^+_{out}} \simeq \pm 1$ values can be responsible for the rich contribution at cos $\theta_{np} \sim 1$. Selecting out the ρ and f events makes the cos θ_{np} distributions isotropic (shaded area in Figs. 4c) and 4d). This fact is compatible with a $J^P = 1/2^+,\ 1/2^-$ state for the $(p\pi^-)$ system, and the first assumption is also compatible with Morrison's rule $\Delta P = (-1)^{\Delta J}$ for the diffractive production[(6)].

In conclusion, the characteristics of low $(p\pi^-)$ mass seem to be in agreement with the diffraction dissociation dominance and with the matrix element proposed by Stodolsky.

A similar conclusion has been reached by Walker et al.[(3a)] for a different final state.

3. - DIFFRACTIVE CONTRIBUTIONS AND THE HIGH DIPION MASS REGION [$m(2\pi) > 1.5\ GeV/c^2$].

It has been shown in Ref. 1c that the high dipion mass corresponds to ω angles smaller than 120^o (diffractive region). There are other indications of the presence of diffractive contributions in the $m(2\pi) > 1.5\ GeV/c^2$ mass region.

First of all the $\phi_{\pi^+_{in}\pi^+_{out}}$ azimuthal angular distribution for the dipion system are not flat for $m(2\pi) > 1.5\ GeV/c^2$ at 5.1 and 9 GeV/c (they should be isotropic in the OPE hypothesis). This could

(x) - θ_{np} ($\theta_{\pi^+_{in}\pi^+_{out}}$) is the angle between the incoming neutron (π^+_{in}) and the outgoing proton (π^+_{out}) in the $p\pi^-$ ($\pi^+\pi^-$) Jackson system.

be an indication of a contribution that is different from the prediction of the OPE in the high dipion mass region. For comparison, the $\phi_{\pi^+_{in}\pi^+_{out}}$ distributions in the f mass region, reported elsewhere(7) for reaction (2), are compatible with isotropy at both energies.

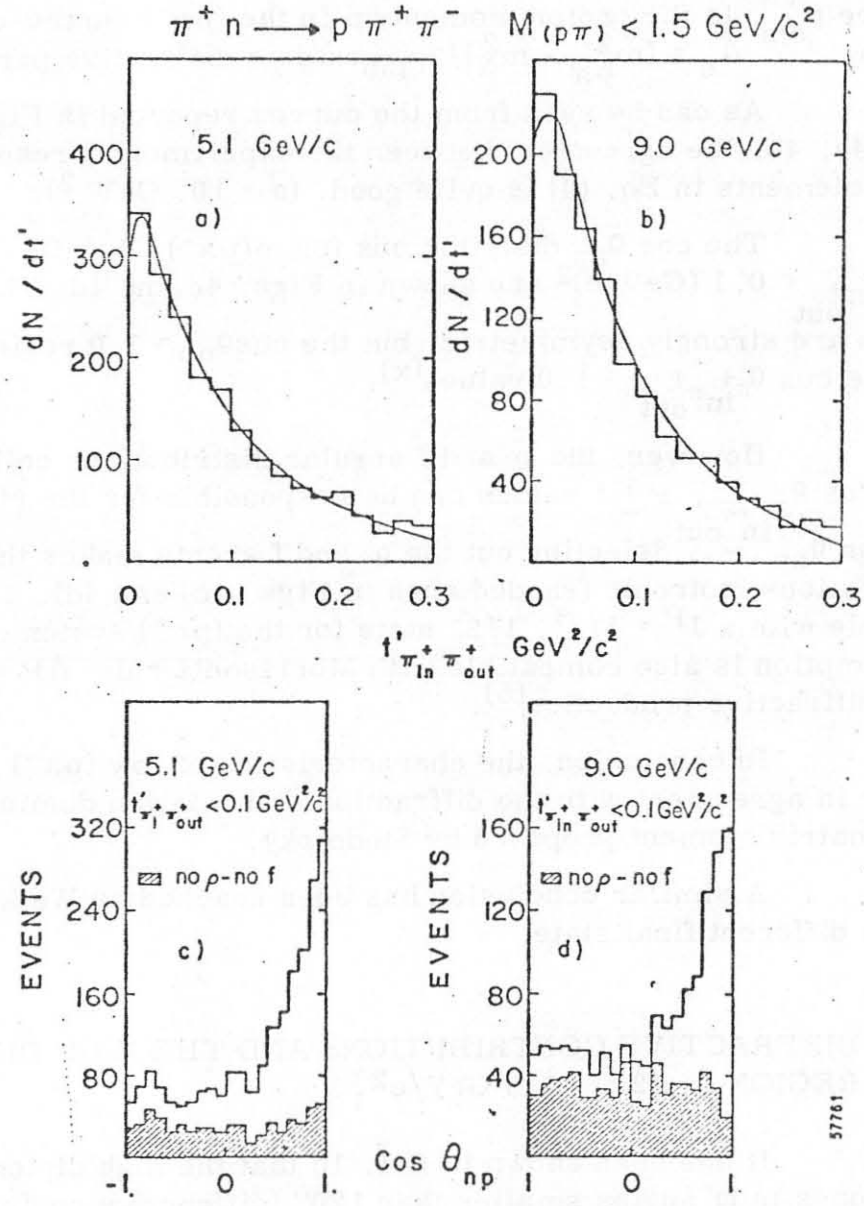

FIG. 4 - a) and b) $dN/dt'_{\pi^+_{in}\pi^+_{out}}$ distribution at 5.1 and 9 GeV/c. The reported curves are the results obtained using the Stodolsky formula.
c) and d) cos θ_{np} angular distributions at 5.1 and 9.0 GeV/c for $m(p\pi^-) < 1.5$ GeV/c² and $t' < 0.1$ GeV²/c² shaded distributions are obtained by excluding ρ and f events.

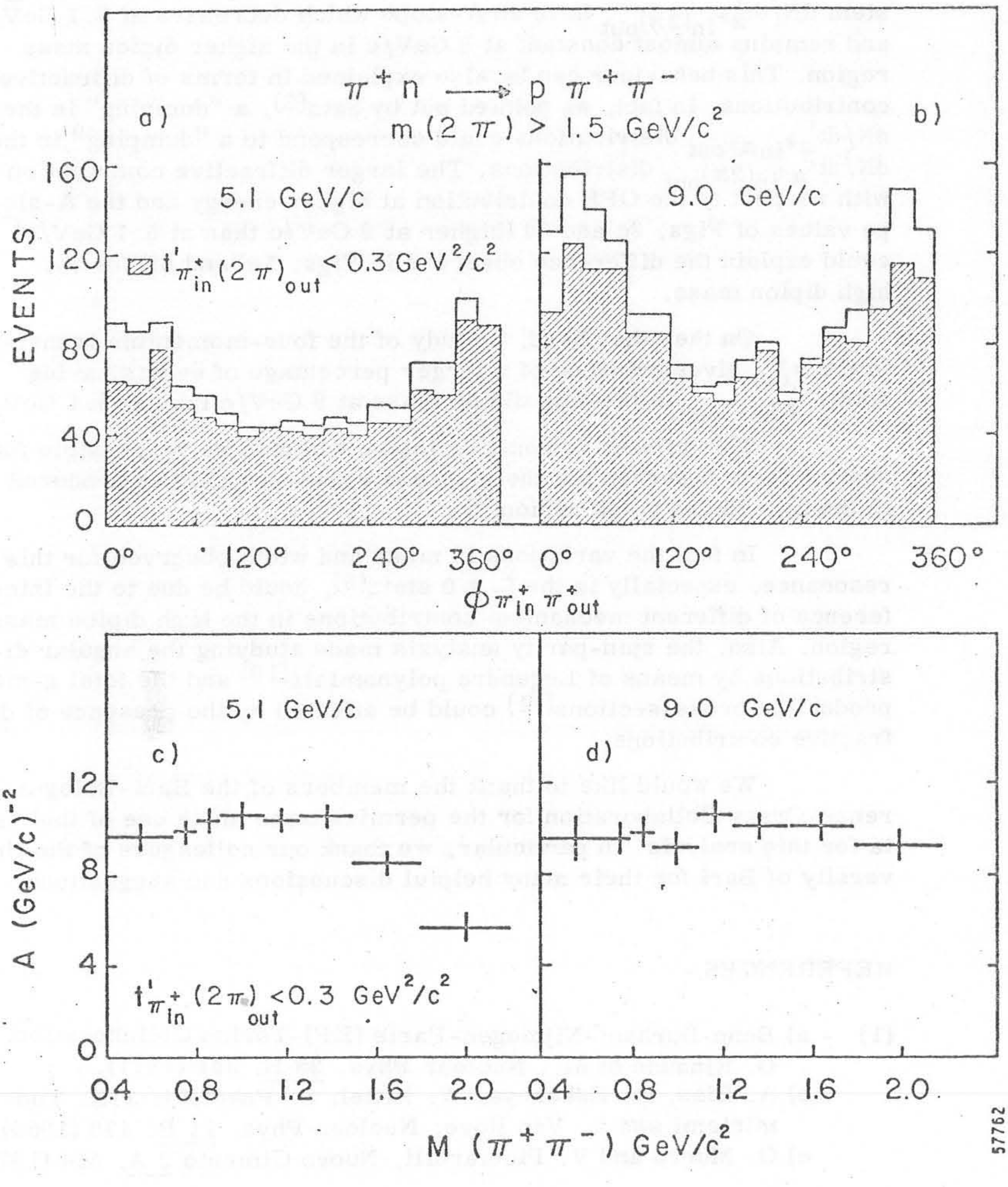

FIG. 5 - a) and b) Azimuthal angle $\phi_{\pi^+_{in}\pi^+_{out}}$ in the Jackson frame for events with $m(\pi^+\pi^-) > 1.5$ GeV/c^2 at 5.1 and 9.0 GeV/c. c) and d) A-slope values for $dN/dt'_{\pi^+_{in}(2\pi)_{out}}$ distributions versus $m(\pi^+\pi^-)$ at 5.1 and 9.0 GeV/c.

Another interesting effect for the high dipion mass region is shown in Figs. 5c) and 5d). The differential cross-sections for the dipion system $dN/dt'_{\pi^+_{in}(2\pi)_{out}}$ have an A-slope which decreases at 5.1 GeV/c and remains almost constant at 9 GeV/c in the higher dipion mass region. This behaviour can be also explained in terms of diffractive contributions. In fact, as pointed out by Satz[8], a "dumping" in the $dN/dt'_{\pi^+_{in}\pi^+_{out}}$ distributions could correspond to a "dumping" in the $dN/dt'_{\pi^+_{in}(2\pi)_{out}}$ distributions. The larger diffractive contribution with respect to the OPE contribution at higher energy and the A-slope values of Figs. 3c and 3d (higher at 9 GeV/c than at 5.1 GeV/c) could explain the difference observed in Figs. 5e) and 5f) for the high dipion mass.

On the other hand, a study of the four-momentum transfer to the π^+_{out} gives evidence of a larger percentage of events having small $t'_{\pi^+_{in}\pi^+_{out}}$ in the high dipion mass at 9 GeV/c than at 5.1 GeV/c.

The diffractive contributions could also be responsible for some effects observed for the g-meson resonance usually produced in the high dipion mass region[9].

In fact the variations in mass and width observed for this resonance, especially in the $I_z = 0$ state[9], could be due to the interference of different mechanism contributions in the high dipion mass region. Also, the spin-parity analysis made studying the angular distributions by means of Legendre polynomials[10] and the total g-meson production cross-sections[11] could be affected by the presence of diffractive contributions.

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