Resonances in $\eta\pi\pi$ and $\omega\omega$ systems studied on the VES setup

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The $\eta\pi\pi$ and $\omega\omega$ systems produced in the $\pi^- Be$ interactions with 37GeV/c π^- beam have been studied at the VES spectrometer. For the unnatural-parity exchange, the isoscalar channels demonstrate similar structures in $\eta\pi^-\pi^+$ and $\omega\omega$ final states, while the amplitudes with $I = 1$ have the same behaviour for $\eta\pi^+\pi^-$ and $\eta\pi^-\pi^0$. The $I = 0$ $J^{PC} = 2^{++}$ amplitudes show the signal of $f_2(1565)$ meson which decays to $a_2(1320)\pi^-$ and $\omega\omega$. The $f_2(1920)$ meson is observed in $\omega\omega$. In the $I = 0$ $J^{PC} = 4^{++}$ intensities there are signals from $f_4(2050)$ and $f_4(2330)$ mesons.

The $I = 1$ $J^{PC} = 3^{--}$ waves demonstrate the presence of $\rho_3(1690)$ meson in $a_2(1320)\pi$ and $\rho\eta$ decay modes. 3^{--} waves at higher masses have complex behaviour and can be modelled by the further 3^{--} resonances.

1. INTRODUCTION

In this report we present the results of the analysis of two charge-exchange reactions:

$$\pi^- p \rightarrow \eta\pi^+\pi^- \ n, \quad \eta \rightarrow \gamma\gamma \tag{1}$$
$$\pi^- p \rightarrow \omega\omega \ n, \quad \omega \rightarrow \pi^+\pi^-\pi^0, \quad \pi^0 \rightarrow \gamma\gamma \tag{2}$$

with 37 GeV/c π^- beam incident on the beryllium target. The experimental data samples include 42,000 events for the reaction (1) and 10,000 events for the reaction (2). We also present some preliminary results for the reaction:

$$\pi^- Be \rightarrow \eta\pi^-\pi^0 \ \ Be, \quad \eta \rightarrow \pi^+\pi^-\pi^0. \tag{3}$$

The most clear picture is observed for the unnatural-parity exchange (UPE) states, which are produced dominantly with small values of $|t| < 0.2$ GeV^2 for the $\eta\pi^-\pi^+$ system and are dominant in the $\omega\omega$ for broader t-interval: $|t| < 1.0$ GeV^2.

Some features for the low-t $\eta\pi^-\pi^+$ events are shown on Fig.1. The $\eta\pi^-\pi^+$ mass spectrum peaks in the region of 1.7 GeV; it demonstrates a bump near 1.3 GeV (which is better pronounced in the high-t sample) and also some shoulder in the 2.3 GeV region. The two-body invariant mass spectra show clear signals from $\rho(770)$, $f_2(1270)$, $a_0(980)$ and $a_2(1320)$ mesons.

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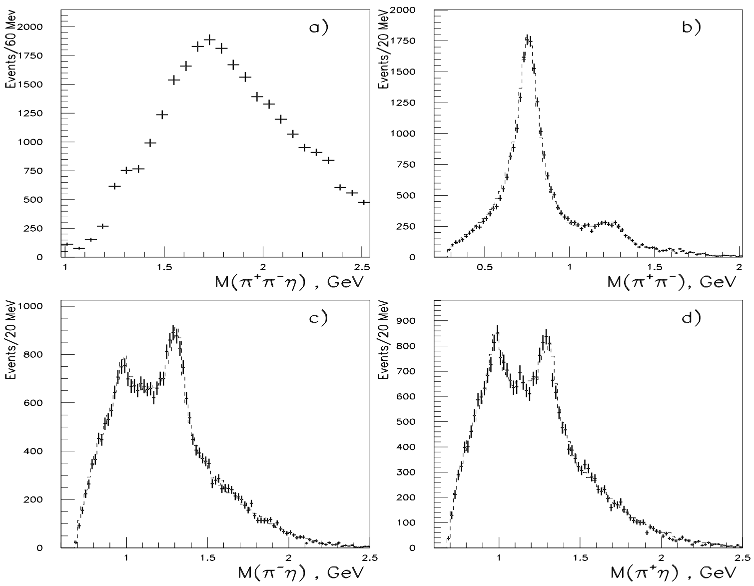

Figure 1. Various spectra for $\eta\pi^-\pi^+$ system.

The $\omega\omega$ features are demonstrated by Fig.2. The two dimensional distribution of the two $\pi^+\pi^-\pi^0$ masses clearly shows the dominant contribution of $\omega\omega$ events. The amount of non-$\omega\omega$ background, which is estimated by PWA-method, is about $\sim 25\%$ for the events within the circular cut, shown on Fig.2 a). The $\omega\omega$ invariant mass spectrum (Fig.2 b)) shows activity near threshold and around 1.9 GeV.

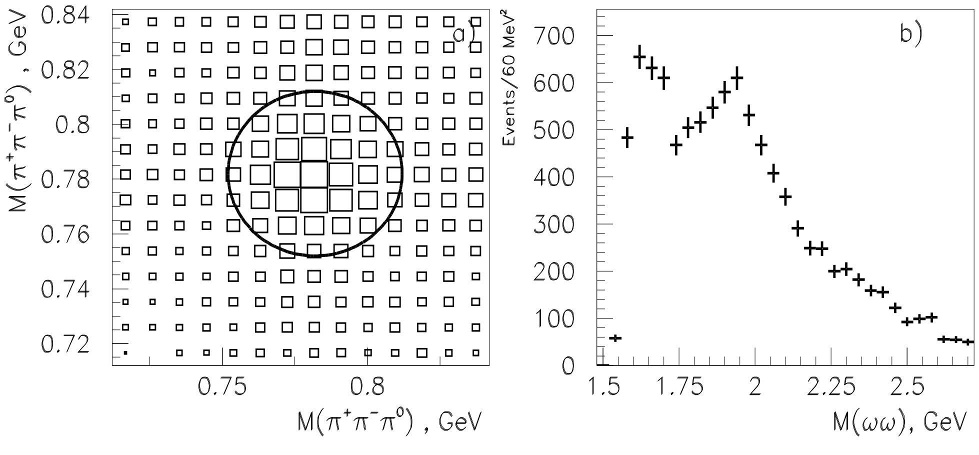

Figure 2. Physical distributions for the $\omega\omega$ system.

Some results on these analysis have already been reported [1,2]. The procedure of the analysis is described in [3]. Now we had completed the full mass-dependent PWA separately for $\eta\pi^-\pi^+$ and $\omega\omega$ final states, in which different models (resonant and non-resonant) have been tried for each spin-parity sector.

2. PWA RESULTS FOR I = 1 STATES

The dominant UPE-wave in $\eta\pi^-\pi^+$ and $\eta\pi^-\pi^0$ systems is $J^{PC} = 1^{--}$ $\rho\eta$ (Fig.3 a),d)). It is described as the coherent sum of Breit-Wigner amplitudes corresponding to $\rho(1450)$, $\rho(1700)$ and $\rho(2150)$ states with PDG parameters.

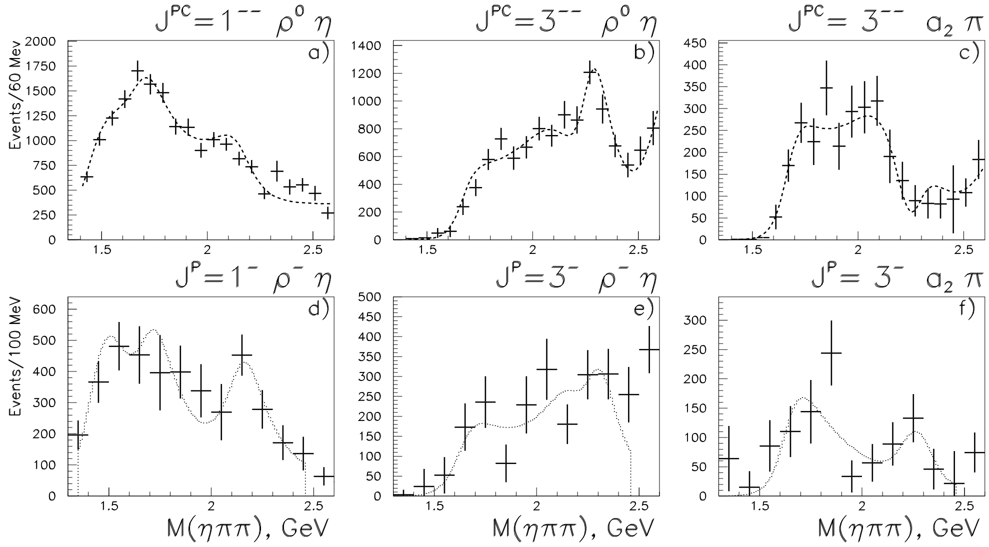

Figure 3. The $I = 1$ $J^{PC} = 1^{--}$ and 3^{--} intensities for $\eta\pi^-\pi^+$ (a-c) and $\eta\pi^-\pi^0$ (d-f).

The $J^{PC} = 3^{--}$ intensities start rapidly in the region of 1.7 GeV and extend up to 2.4 GeV (Fig.3 b),c),e),f)). The $\rho_3(1690)$ meson is clearly seen in $a_2\pi$ and $\rho\eta$ decay modes. The study performed for $\eta\pi^-\pi^+$ final state gives the following $\rho_3(1690)$ parameters:

$$M = 1685 \pm 10 \pm 20 \text{ MeV} \quad \Gamma = 220 \pm 30 \pm 50 \text{ MeV}, \tag{4}$$

$$\frac{BR(\rho_3(1690) \to a_2(1320)\pi)}{BR(\rho_3(1690) \to \rho(770)\eta)} = 5.5 \pm 2.0. \tag{5}$$

Different models were tried to describe the 3^{--} amplitudes in the $\eta\pi^+\pi^-$ final state at high masses: pure non-resonant, one resonance plus smooth background and two-resonance hypothesis. The best description is obtained by introducing two additional resonances: $\rho_3(2100)$ and $\rho_3(2290)$ (later known from PDG). The following parameters of $\rho_3(2290)$ were obtained from the mass-dependent analysis:

$$M = 2290 \pm 20 \ \pm 30 \text{ MeV}, \quad \Gamma = 230 \pm 50 \ \pm 80 \text{ MeV}. \tag{6}$$

3. PWA RESULTS FOR I = 0 STATES

Study of the $I = 0, 2^{++}$ waves is especially interesting because the present experimental results show too many 2^{++} states in the region 1.5-2.4 GeV and this fact can point to the existence of tensor glueballs.

The $f_2(1565)$ meson also called the AX meson is clearly seen in $a_2(1320)\pi$ decay mode. The bump at 1.6 GeV in the 2^{++} $\omega\omega$ intensity is also explained as $f_2(1565)$ meson signal. The mass-dependent fit for $\eta\pi^+\pi^-$ final state gives the following parameters for $f_2(1565)$:

$$M = 1550 \pm 10 \pm 20 \text{ MeV}, \quad \Gamma = 130 \pm 20 \pm 40 \text{ MeV}. \tag{7}$$

The fits in the $\omega\omega$ channel result in the very similar parameters of $f_2(1565)$ meson, but with larger systematic errors.

The clear peak is seen in the 2^{++} $\omega\omega$ intensity at 1.9 GeV which has the parameters:

$$M = 1920 \pm 16 \pm 20 \text{ MeV}, \quad \Gamma = 225 \pm 38 \pm 50 \text{ MeV}. \tag{8}$$

Less pronounced peak is seen near 1.9 GeV in the total 2^{++} $\eta\pi^-\pi^+$ spectrum (Fig.4 c)); it is described by the Breit-Wigner amplitude having parameters (8).

Finally, there is some enhancement in the 2^{++} intensity near 2.3 GeV in both $\eta\pi^-\pi^+$ and $\omega\omega$ channels. The parameters of this bump, however, occured to be model-dependent.

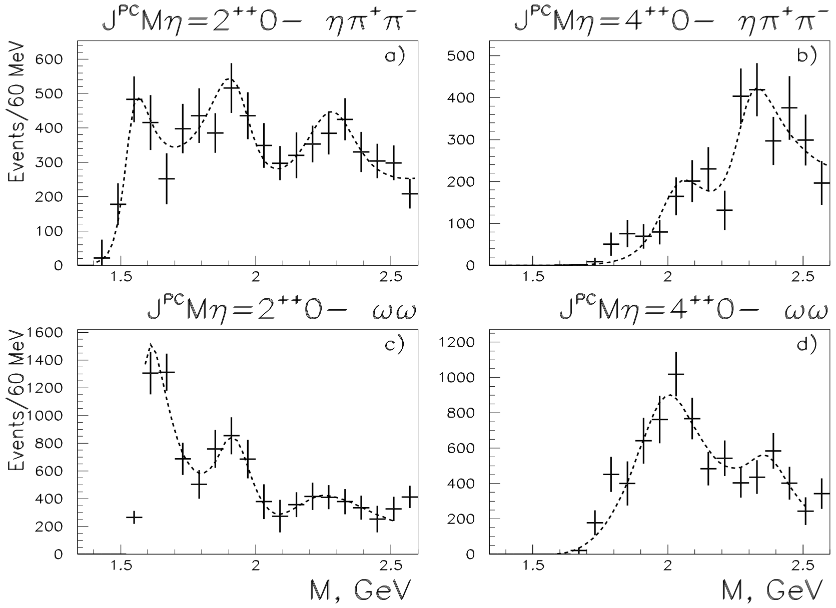

Figure 4. The $I = 0$ $J^{PC} = 2^{++}$ and 4^{++} intensities for $\eta\pi^-\pi^+$ a),b) and $\omega\omega$ c),d).

The $I = 0$ $J^{PC} = 4^{++}$ intensities for $\eta\pi^-\pi^+$ and $\omega\omega$ are shown on Fig. 4 b),d). The $f_4(2040)$ meson is clearly seen in the $\omega\omega$ mode, while both $\eta\pi^-\pi^+$ and $\omega\omega$ channels show some activities near 2.3 GeV, which is described by the $f_4(2330)$ meson contribution. The $f_4(2330)$ meson was systematically studied in the $\eta\pi^-\pi^+$ (mainly in $f_2(1270)\eta$) decay mode, its parameters are:

$$M = 2330 \pm 20 \pm 40 \text{ MeV}, \quad \Gamma = 235 \pm 50 \pm 40 \text{ MeV}. \tag{9}$$

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