A possible set of flavour exotic 4-quark states in J/ψ decays

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Abstract

A search for $Q^2\bar{Q}^2$ states with quantum number of I=2,$I_3 = +2, +1, 0, -1, -2$ were carried out in $J/\psi \to \rho\rho + \pi\pi$ decay channels, based on about 8X10^6 J/ψ event from BES. Five states with mass of M($\rho\rho$) at about 1.75 GeV were found.These states could be explained as $Q^2\bar{Q}^2$ states with quantum number of I=2, I_3=+2,+1,0,-1,-2.

I.Introduction

The structure of hadrons can be described very well by Quark Model. According to QCD theory, there should exist glueball,hybrid,$Q^2\bar{Q}^2$ and $Q^4\bar{Q}$ state. Up to now, there are several glueball candidates. For a complete understanding of QCD, in addition to search for glueball, one must put great effort to search for hybrid,$Q^2\bar{Q}^2$ and $Q^4\bar{Q}$ states. There are some theoretical discussions on $Q^2\bar{Q}^2$ states[1][2].
Experimentally the difficulty to search for $Q^2\bar{Q}^2$ states is that the width of $Q^2\bar{Q}^2$ state may be too wide to be seen. ARGUS Collaboration[3]found a wide resonance in $e^+e^- \to e^+e^-\rho^0\rho^0$, M($\rho^0\rho^0$)=1.65GeV, $\Gamma = (400 \pm 200)$MeV, with the quantum number of $I^G(J^{PC}) = 2^+(2^{++})$. Since the normal meson is composed by $Q\bar{Q}$,the maximum value of isospin of the normal meson is I=1. If a meson with isospin I=2, such meson will be the flavour exotic state. If the flavour exotic I=2 meson states do exist, the I=2 meson will have 5 component, that is I_3=+2,+1,0,-1,-2.
$\rho^+\rho^+$ will be the I=2 $I_3 = +2$ flavour exotic 4-quark state and $\rho^-\rho^-$ will be another I=2 $I_3 = -2$ flavour exotic 4-quark state. A search for $Q^2\bar{Q}^2$ states with quantum number of I=2 and I_3=+2,+1,0,-1,-2, in J/ψ decays were carried out based on about 8X10^6 J/ψ event from BES in following channels:

$$J/\psi \to \rho^+\rho^+ + \pi^-\pi^-$$
$$J/\psi \to \rho^-\rho^- + \pi^+\pi^+$$
$$J/\psi \to \rho^+\rho^0 + \pi^-\pi^0$$
$$J/\psi \to \rho^-\rho^0 + \pi^+\pi^0$$
$$J/\psi \to \rho^+\rho^- + \pi^+\pi^-$$

Five states with mass of M($\rho\rho$) at about 1.75 GeV were found.These states could be explained as $Q^2\bar{Q}^2$ states with quantum number of I=2 I_3=+2,+1,0,-1,-2 flavour exotic states.

II.Events selections

The final states of $J/\psi \to \rho\rho + \pi\pi$ are π^+,π^-,π^+,π^-,π^0,π^0.
(1) The criteria of selections for charged tracks:
The numbers of charged tracks N_{charge}=4 was required. Requiring M_{fit}=2 or -19 to get good quarlity of charged tracks. The total charge of these four charged tracks should equal to zero. To guarantee the tracks come from interaction point, requiring:

$$\sqrt{X_0^2 + Y_0^2} < 2cm$$

$$| Z_0 | < 20cm$$

We take the tracks in the barrel part only. Using TOF or dE/dX information to identify pions, requiring the weight W(π)>W(K,P).
(2)The criteria of selections for photons:
The numbers of photon are larger than 4 and less than 16. To reject fake photons, $E_\gamma > 50MeV$ was required. ¿From selected photons and 4π informations, a 4C-fit was made to select 4 good photons, if χ^2<50, then take the selected 4 photons as 4 real photons.
(3)From the selected 4 real photons, using diffirent combination to select π^0,π^0 events, requiring |M($\gamma\gamma$)$_1$-0.135|<60MeV and |M($\gamma\gamma$)$_2$-0.135|<60MeV. Fig.1.shows the $M(\gamma\gamma)_1$ VS $M(\gamma\gamma)_2$,it can be seen that there are clear peaks of π_1^0 and π_2^0.

III. Preliminary results

The preliminary results of

$$J/\psi \to \rho^+\rho^+ + \pi^-\pi^-$$
$$J/\psi \to \rho^-\rho^- + \pi^+\pi^+$$
$$J/\psi \to \rho^+\rho^0 + \pi^-\pi^0$$
$$J/\psi \to \rho^-\rho^0 + \pi^+\pi^0$$
$$J/\psi \to \rho^+\rho^- + \pi^+\pi^-$$

are shown in Fig.2. and Fig.3.

Fig.2.(a) shows M(ρ^+) VS $M(\rho^+)$, Fig.2.(b) shows M(ρ^-) VS $M(\rho^-)$, Fig.2.(c) shows M(ρ^+) VS $M(\rho^0)$, Fig.2.(d) shows M(ρ^-) VS $M(\rho^0)$, Fig.2.(e) shows M(ρ^+) VS $M(\rho^-)$, Fig.2.(f) shows M(ρ^0) VS $M(\rho^0)$.

Fig.3. shows the distributions of M($\rho\rho$). Fig.3.(a) shows the distribution of M($\rho^+\rho^+$), Fig.3.(b) shows the distribution of M($\rho^-\rho^-$), Fig.3.(c) shows the distribution of M($\rho^+\rho^0$), Fig.3.(d) shows the distribution of M($\rho^-\rho^0$), Fig.3.(e) shows the distribution of M($\rho^+\rho^-$), Fig.3.(f) shows the distribution of M($\rho^0\rho^0$).

It can be seen that there are M($\rho^+\rho^+$), M($\rho^-\rho^-$), M($\rho^+\rho^0$), M($\rho^-\rho^0$) and M($\rho^+\rho^-$) peak at about 1.75GeV, but there is no M($\rho^0\rho^0$) peak, since the charge-conjugation is violated in the channel of $J/\psi \rightarrow \rho^0\rho^0 + \pi^0\pi^0$.

The BR($J/\psi \rightarrow \pi^+\pi^+\pi^-\pi^-\pi^0\pi^0$) is (14.0±1.4)X$10^{-4}$[4], we have about 8X$10^6$ J/ψ event, we will have about 10^4 $\pi^+\pi^+\pi^-\pi^-\pi^0\pi^0$ event as our data sample. We generated 10^4 of $J/\psi \rightarrow \pi^+\pi^+\pi^-\pi^-\pi^0\pi^0$ Monte Carlo events and made a Monte Carlo phase space simulations.The contribution from phace space is shown in Fig.4, it is clear that the contribution from phace space is negligible.

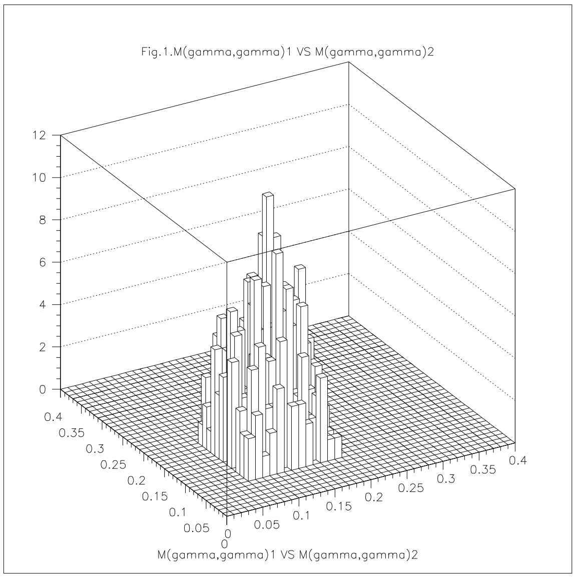

Figure 1:

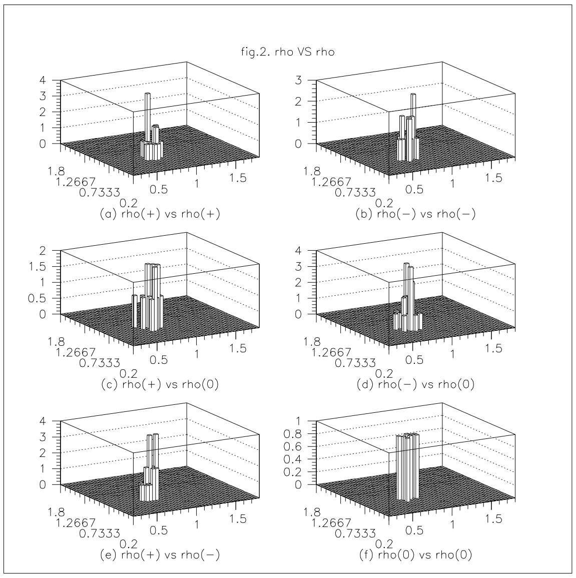

Figure 2:

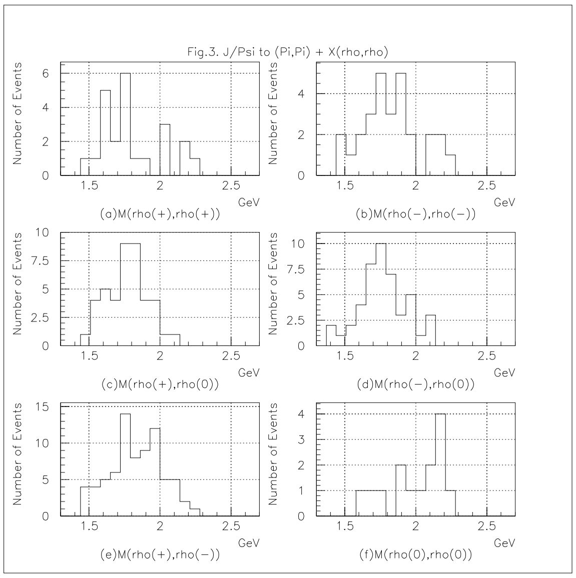

Figure 3:

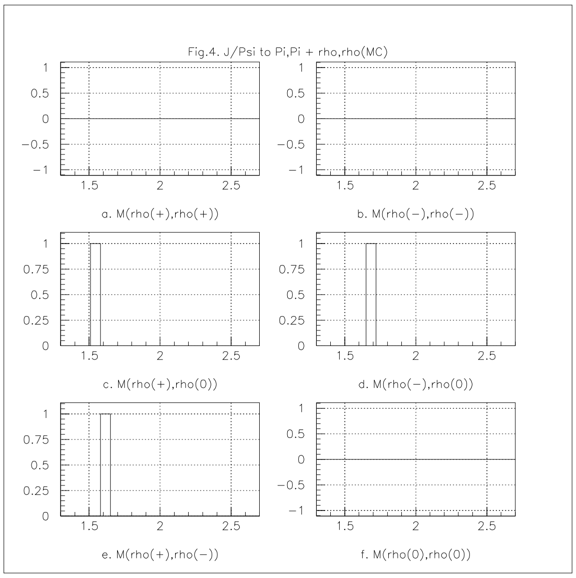

Figure 4:

IV.Conclusion and Discussion

From our preliminary result,it seems that a possible set of flavour exotic 4-quark state is $\rho^+\rho^+$, $\rho^+\rho^0$,$\rho^+\rho^-$,$\rho^-\rho^0$ and $\rho^-\rho^-$, it seems that they are the possible five component of I=2,I_3=+2,+1,0,-1,-2 flavour exotic 4-quark state, with mass at about 1.75GeV. All of above results needs cross chech and comfirmatiom.

References:

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