New Results on Study of $\xi(2230)$ at BES

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Abstract

Using 8 million J/ψ hadron events and 7 million neutral events collected at Beijing Electron-Positron Collider(BEPC), the BES collaboration has performed studies of the $\xi(2230)$ in J/ψ radiative decays. The paper concentrates on the new preliminary results from decay channels of $J/\psi \to \gamma\pi^0\pi^0$ and $\gamma\eta\eta'$.

1 Introduction

According to the QCD strong interaction theory, there may exist, due to the self-interaction between gluons, gluon bound states — glueball (gg, ggg) in addition to the conventional $q\overline{q}$ meson states. So, search for and study of glueball will be of great significance in testing QCD and understanding the nature of the strong interaction.

The particle $\xi(2230)$, a narrow state with a width of about $20MeV$, was first observed by the MARKIII Collaboration in the radiative decays of J/ψ to K^+K^- and K_sK_s final states[1]. Some experiments claimed that they found structure around $2.2GeV/c^2$ in different process[2, 3, 4], but no other groups found such narrow structure in J/ψ decay[5]. There are many speculations about the nature of $\xi(2230)$. It could be an ordinary $s\overline{s}$ state, 4-quark state, $\Lambda\overline{\Lambda}$ bound state, hybrid state, or a glueball[7, 8, 9, 10].

Recently, the BES Collaboration at BEPC has found the signal of $\xi(2230)$ in $J/\psi \to \gamma p\overline{p}$ and $J/\psi \to \gamma\pi^+\pi^-$ after confirmed in $J/\psi \to \gamma K^+K^-$ and $J/\psi \to K_sK_s$. The measured masses, widths and branching ratios are given[11].

These results indicate that $\xi(2230)$ decays are probably flavor symmetric, and its total width is as narrow as about $20MeV$. These features may make $\xi(2230)$

distinguishable from many other states if the production rate of $\xi(2230)$ in J/ψ radiative decay is relatively large.

However, the knowledge about $\xi(2230)$ is still limited by the experimental results. Therefore, the study of other decay modes, such as $J/\psi \to \gamma\pi^0\pi^0, \gamma\eta\eta'$, etc, is very important in understanding the nature of $\xi(2230)$. for η and η' being considered to be strongly coupled to gluon, the signal appearing to be prominent in $\eta\eta'$ is traditionally regarded as glueball signature.

In other words, if $\xi(2230)$ is a glueball, it sounds that it should appear in $\eta\eta$ and $\eta\eta'$. So far, no obvious $\xi(2230)$ signal was found in final state of $\eta\eta'$, only GAMS has found a peak near $2.22GeV$ in the process:$\pi^- p \to n\eta\eta' \to n4\gamma$, the width is smaller than $100MeV$. It was the first experiment which observed the $\xi(2230)$ in $\eta\eta'$ mass spectrum.

Using 8 million J/ψ events and 7 million neutral events collected at BEPC, the BES collaboration has studied the $\xi(2230)$ in J/ψ radiative decays: $J/\psi \to \gamma\pi^0\pi^0, \gamma\eta\eta'$. Now very preliminary new results have been given.

2 Analysis and Results

1. The study of $J/\psi \to \gamma\pi^0\pi^0(\pi^0 \to 2\gamma)$

   The analysis of J/ψ decay channel $J/\psi \to 5\gamma$ is based on 7×10^6 neutral J/ψ events recorded by BES detector.

   In the events selection of $J/\psi \to \gamma\pi^0\pi^0$, the main background comes from fake photons or $J/\psi \to \omega\eta(\gamma\pi^0\eta)$, $\omega f_2(\gamma 3\pi^0)$, $\gamma\eta(\gamma 3\pi^0)$ or $\gamma\eta'(\gamma\pi^0\pi^0)$. In order to reduce the fake photons from events with no charged tracks, the first level of event selection requires that:

   (1) The hit number in the first layer of BSC should be less than 6;

   (2) Total number of hitted layers is at least 2;

   (3) The energy of photon is greater than $50MeV$;

   (4) The photons should come from interaction region.

2. In the event selection of $J/\psi \to \gamma\pi^0\pi^0$, perform 4-c kinematic fit and get the best five photons with the smallest χ^2. Use the smallest δ value

   $$\delta = (m_{\gamma_1\gamma_2} - 0.135)^2 + (m_{\gamma_3\gamma_4} - 0.135)^2$$

   to obtain the best combination of $2\pi^0$. Finally, we let $\chi^2 < 10.0$ to get five photons in seven clusters and selected the π^0 by $|m_{\pi^0} - 0.135| < 0.05GeV$.

Fig 1 shows the π^0 invariant mass. Fig 2 shows the fitted spectrum of $\pi^0\pi^0$ mass. From the fig 2 we know that

(1) There are 5 peaks in $\pi^0\pi^0$ mass spectrum. the masses of them are

$$\begin{aligned} m &= (1.246 \pm 0.024)GeV/c^2 \\ m &= (1.477 \pm 0.031)GeV/c^2 \\ m &= (1.724 \pm 0.036)GeV/c^2 \\ m &= (2.042 \pm 0.031)GeV/c^2 \\ m &= (2.244 \pm 0.035)GeV/c^2 \end{aligned}$$

respectively.

(2) When we fixed the width $\Gamma = 20MeV$, we obtained the mass and branching ratio of $J/\psi \to \gamma\xi$ and $\xi \to \pi^0\pi^0$.

$$M = (2.244 \pm 0.035)GeV/c^2$$

$$Br(J/\psi \to \gamma\xi) \cdot Br(\xi \to \pi^0\pi^0) = (4.40 \pm 2.20 \pm 1.32) \times 10^{-5}$$

3. The study on $J/\psi \to \gamma\eta\eta'$

An analogous analysis is performed to select $J/\psi \to \gamma\eta\eta', (\eta \to 2\gamma, \eta' \to \gamma\rho^0, \rho^0 \to \pi^+\pi^-)$, the main background coming from $J/\psi \to \rho\pi(\pi^0\pi^+\pi^-)$. Based on 8 million hadron events, we selected two charged tracks events with at least 6 isolated photons only. The charged track need to be come from interaction point region. The deposited energy in shower counter is smaller than $600MeV$. To exclude the $\rho\pi$ events we required $|m_{\pi^+\pi^-} - 0.77| < 0.07GeV/c^2$ and $|p_\rho - 1.45| < 0.04$, where p_ρ is the momentum of ρ. After performing 4-c fit to get best $4\gamma\pi\pi$ events and selecting the events which satisfy $|m_{\pi^+\pi^-} - 0.77| < 0.1GeV/c^2$, we used the smallest δ value to set the best combination of $\eta\eta'$. The definition of δ is

$$\delta = \frac{(m_\eta - 0.547)^2}{\sigma_\eta^2} + \frac{(m_{\eta'} - 0.958)^2}{\sigma_{\eta'}^2}$$

finally we had further cuts:

$$\begin{aligned} |m_{\pi^+\pi^-} - 0.77| &< 0.08GeV/c^2 \\ |m_\eta - 0.547| &< 0.05GeV/c^2 \\ |m_{\eta'} - 0.958| &< 0.05GeV/c^2 \end{aligned}$$

and require $\chi^2 < 15.0$

Fig 3 shows the mass spectrum of $m_{\eta\eta'}$. We found the peak at $2.2GeV/c^2$ region. We also can get the mass with fixed width of $20MeV$:

$$M = (2.249 \pm 0.018)MeV/c^2$$

3 Discussion

The existence of $\xi(2230)$ in radiative decay mode of $J/\psi \to \gamma\pi^0\pi^0$ has been tested. The structures near $1500MeV/c^2$, $1750MeV/c^2$ and $2100MeV/c^2$ which were observed by some other experiments are also found in this study. The signal of $\xi(2230)$ was observed in decay mode of $J/\psi \to \gamma\eta\eta'$ with large statistical error.

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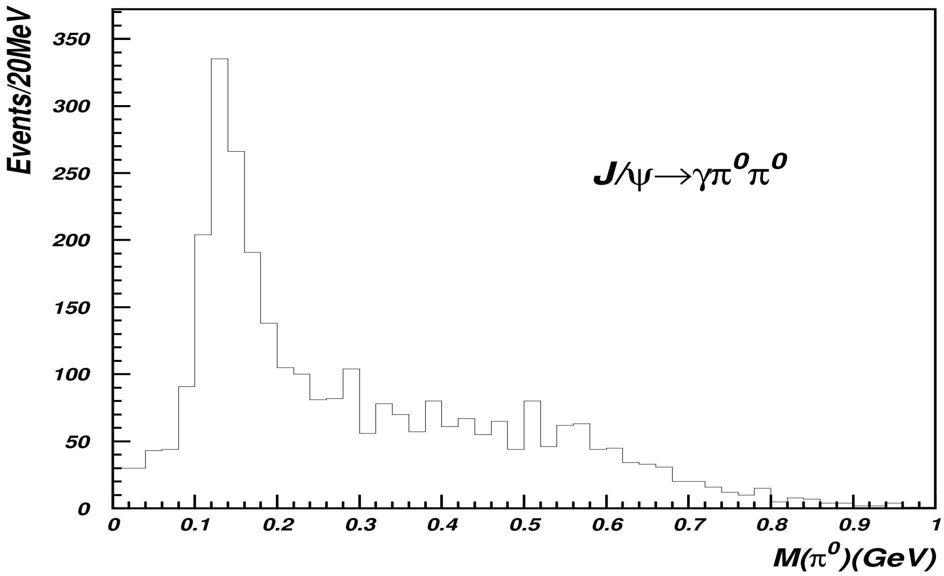

Figure 1: The mass spectrum of π^0 in $J/\psi \to \gamma\pi^0\pi^0$

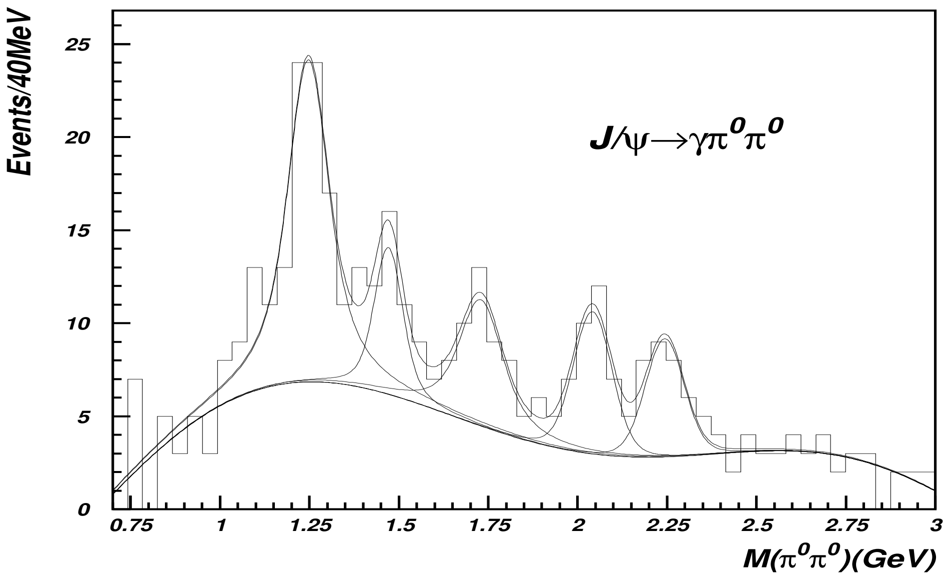

Figure 2: The fitted mass spectrum of $\pi^0\pi^0$ in $J/\psi \to \gamma\pi^0\pi^0$

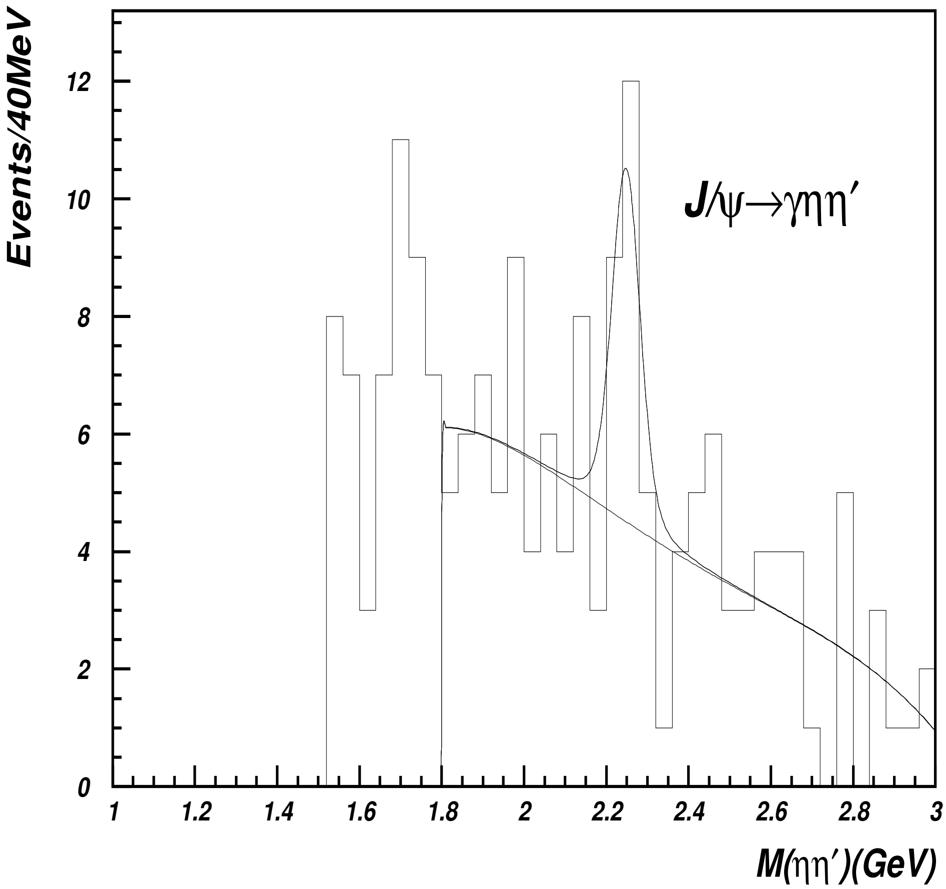

Figure 3: The mass spectrum of $\eta\eta'$ in $J/\psi \to \gamma\eta\eta'$