Recent Results from BESIII

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In this talk, we will present some recent results on charmonium spectroscopy and hadron spectroscopy from BESIII experiment, including the measurements of the masses and widths of h_c, η_c, $\eta_c(2S)$ and some new resonances around 2 GeV. The results are based on a data sample of 106 million ψ' events and 226 million J/ψ events collected with the BESIII detector at the BEPCII collider.

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1. Introduction

In this paper, some recent results from BESIII experiment on charmonium spectroscopy and hadron spectroscopy are presented based on about 106 million ψ' events and 226 million J/ψ events collected by the BESIII detector at the BEPCII collider.

2. Observation of h_c

Using the largest ψ' sample collected by the BESIII, we study the 16 specific decay processes of η_c in the decay chain of $\psi' \to \pi^0 h_c$, $h_c \to \gamma \eta_c$. Figure 1 shows the π^0 recoil-mass spectrum of the sum of the 16 decay modes. A simultaneous fit to the 16 π^0 recoil-mass spectra yields $M(h_c) = 3525.31 \pm 0.11 \pm 0.15 \text{MeV}/c^2$ and $\Gamma(h_c) = 0.70 \pm 0.28 \pm 0.25 \text{MeV}$. These preliminary results are consistent with the previous BESIII inclusive measurement [1].
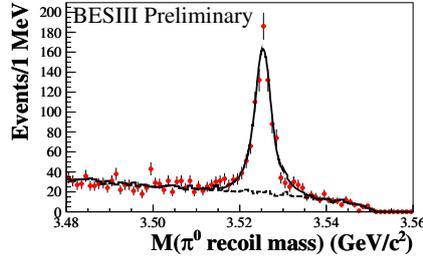

Figure 1: The summed π^0 recoil-mass spectrum of 16 specific decay processes of η_c in the decay chain of $\psi' \to \pi^0 h_c$, $h_c \to \gamma \eta_c$, where the line is the fit result.

3. Measurement of the η_c properties

Based on the ψ' sample, the η_c mass and width are measured in the radiative transition $\psi' \to \gamma \eta_c$, where η_c are reconstructed from six decay modes: $K_S^0 K \pi$, $K^+ K^- \pi^0$, $\pi^+ \pi^- \eta$, $K_S^0 K 3\pi$, $K^+ K^- \pi^+ \pi^- \pi^0$ and $3(\pi^+ \pi^-)$. A simultaneous fit with the unique η_c mass and width is performed on the η_c mass spectra, where the interference between η_c and non-resonance decays is considered and the quantum number of the non-η_c components are assumed to be 0^{-+}. Assuming an universal relative phase between the two amplitudes, we obtain η_c mass and width, $M = 2984.2 \pm 0.6 \pm 0.5 \text{ MeV}/c^2$ and $\Gamma = 31.4 \pm 1.2 \pm 0.6 \text{ MeV}$, respectively, as well as the relative phase $\phi = 2.41 \pm 0.06 \pm 0.04$ rad. Figure 2 shows the fit results in the six η_c decay modes.

4. Observation of the M1 transition $\psi' \to \gamma \eta_c(2S)$

BESIII observed the M1 transition $\psi' \to \gamma \eta_c(2S)$ with the decay mode $\eta_c(2S) \to K_S^0 K \pi$. Figure 3 shows the preliminary result for the $K_S^0 K \pi$ invariant mass distribution, here the three-constraints kinematic fit has been applied (the energy of the photon is allowed to be floating). With the width of $\eta_c(2S)$ fixed to PDG value, we measure mass of $\eta_c(2S)$ to be $3638.5 \pm 2.3 \pm 1.0$

MeV/c^2 and the $BR(\psi' \to \gamma\eta_c(2S)) \times BR(\eta_c(2S) \to K_s K^{\pm}\pi^{\mp})$ to be $(2.98 \pm 0.57 \pm 0.48) \times 10^{-6}$. The statistical significance for the M1 transition $\psi' \to \gamma\eta_c(2S)$ is more than 6.0σ. Combining the result $B(\eta_c(2S) \to K\overline{K}\pi) = (1.9 \pm 0.4 \pm 1.1)\%$ from BABAR [2], the M1 transition rate for $\psi' \to \gamma\eta_c(2S)$ is derived as $BR(\psi' \to \gamma\eta_c(2S)) = (4.7 \pm 0.9 \pm 3.0) \times 10^{-4}$, which is consistent with the CLEOc's upper limit [3].

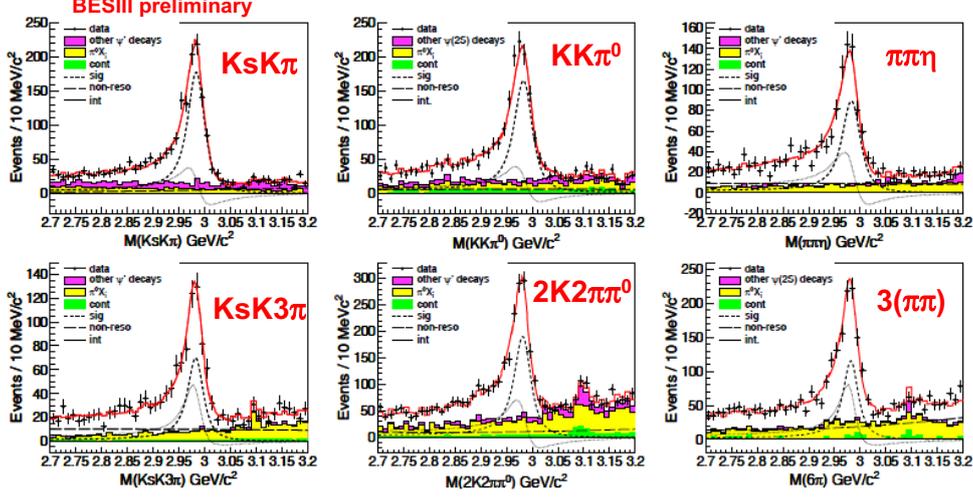**Figure 2:** The mass spectra for different decay modes, where the line is the result of the simultaneous fit.
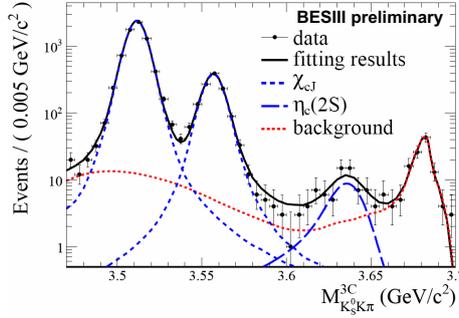

Figure 3: The invariant mass spectrum of $K_S^0 K\pi$ from $\psi' \to \gamma K_S^0 K\pi$.

5. Observation of new resonances in $J/\psi \to \gamma\eta'\pi^+\pi^-$ and in $J/\psi \to \omega\eta\pi^+\pi^-$

The X(1835) was first observed in the $J/\psi \to \gamma\eta'\pi^+\pi^-$ with statistical significance of 7.7σ by the BESII experiment. A high statistical J/ψ data sample collected with the BESIII provides an opportunity to confirm the existence of the X(1835) and search for other new resonances. The $\eta'\pi^+\pi^-$ invariant mass spectrum for the combined two η' decays, $\eta' \to \gamma\rho$ and $\eta' \to \pi^+\pi^-\eta$, is presented in Figure 4(a). The X(1835) resonance is clearly seen. Additional peaks are observed around 2.1 and 2.3 GeV/c^2, denoted as X(2120) and X(2370). The mass and width of X(1835)

are measured to be $M = 1836.5 \pm 3.0^{+5.6}_{-2.1}$ MeV/c^2 and $\Gamma = 190 \pm 9^{+38}_{-36}$MeV with significance larger than 20σ. The mass and width for $X(2120)$ ($X(2370)$) are determined to be $M = 2122.4 \pm 6.7^{+4.7}_{-2.7}$MeV/c^2 ($M = 2376.3 \pm 8.7^{+3.2}_{-4.3}$MeV/c^2) and $\Gamma = 83 \pm 16^{+31}_{-11}$MeV ($\Gamma = 83 \pm 17^{+44}_{-6}$MeV) with significance of 7.2σ(6.4σ). For more details, we refer to Ref. [4].

The decay $J/\psi \to \omega\eta\pi^+\pi^-$, in which the ω decays to $\pi^+\pi^-\pi^0$ and the η/π^0 decays to a pair of photons, is studied to search for the X(1835). The $\eta\pi^+\pi^-$ invariant mass spectrum with events in the $a_0(980)$ mass window is shown in Figure 4 (b). Both $f_1(1285)$ and $\eta(1405)$ are observed significantly. A clear peak around 1900 MeV, denoted as $X(1870)$ is also seen. A fit with three resonances with simple BW formula yields a mass $M = 1877.3 \pm 6.3^{+3.4}_{-7.4}$MeV/c^2 and a width $\Gamma = 57 \pm 12^{+19}_{-4}$MeV for the $X(1870)$ structure with statistical significance of 7.2σ. More details on the data analysis can be found in Ref. [5].
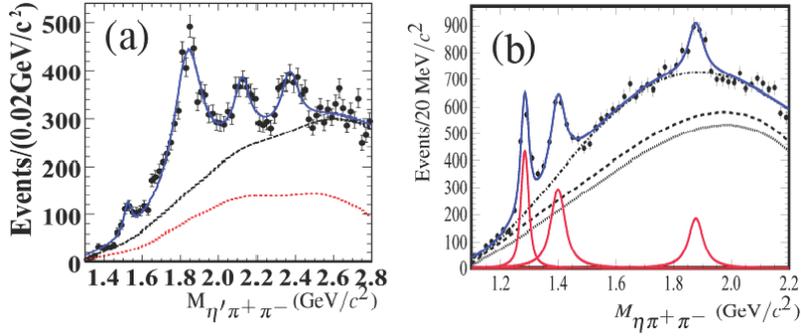

Figure 4: (a) The $\eta'\pi^+\pi^-$ invariant mass distribution for the selected $J/\psi \to \gamma\eta'\pi^+\pi^-$ events from the two η' decay modes, (b) the $\eta\pi^+\pi^-$ invariant mass distribution for the selected $J/\psi \to \omega\eta\pi^+\pi^-$ events in $a_0(980)$ mass window. Figures are taken from Refs. [4] and [5], and described there in more detail.

6. Summary and outlook

Some recent results on charmonium spectroscopy and hadron spectroscopy from BESIII experiment are shown based on a data sample of 106 million ψ' and about 226 million J/ψ events. In 2010 and 2011, BESIII have acquired nearly 3 fb^{-1} of data at the $\psi(3770)$ resonance. This sample allows BESIII to begin the charm physics program, including the mixing and CP violation studies, as well measurements of absolute branching fractions and studies of semi-leptonic decays.

References

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