Recent progress on h_c and χ_c at BESIII

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Based on about 110M ψ' data sample taken at BESIII detector in 2009, we study the decay of h_c and χ_c. We observed the clear h_c signal in the inclusive decays with and without E1-tagged. Therefore, the h_c signal is further confirm. Meanwhile, we measure the width of h_c for the first time. For χ_c decay, we measure the branching fractions of $\chi_{c0,2} \to PP(P = \pi^0, \eta)$ which are consistent with CLEO's. In addition, we confirmed the decay mode of $\chi_{c0,2} \to \omega\omega, \phi\phi$ and first observed the decay mode of $\chi_{c1} \to \omega\omega, \phi\phi$ which are regarded to be highly suppressed in theory. We also observed the DOZI decay mode of $\chi_c \to \omega\phi$.

1 Introduction

Compared to the vector charmonium states J/ψ and ψ', the χ_{cJ} and h_c are not well studied experimentally and theoretically. In particularly for h_c. Unlike J/ψ and ψ', h_c and χ_{cJ} can not be produced directly in e^+e^- collisions. For h_c, it can only be produced via the magnetic transition of ψ' accompanying by a π^0. Due to the fact that the two photon from π^0 decay are very soft, as well as the lack of understanding on h_c decay modes, it make it very difficult for one to reconstruct the h_c state. Someone predict that the dominant decay mode of h_c is the E1 mode, i.e. $h_c \to \gamma\eta_c$. One is easy to estimate the energy distribution of this E1 photon is about 500 MeV. Experimentally, if we require that such a photon is essential, we take this mode as E1-tagged. For χ_{cJ} decay, the color-octet theory can account for many experimental results, but the theoretical and experimental uncertainties are still large [1,2,3]. New and improved measurements of the branching fraction of the hadronic χ_{cJ} decay channels are mandatory to further test the Color Octet Model(COM) in P-wave charmonium decays. In a recent paper by Zhao [4], it is pointed out that the decay of $\chi_{c0,2}$ in to vector meson pairs(VV), pseudoscalars pairs(PP), and scalar pairs(SS) can be investigated in a general factorization scheme. The purpose is to clarify the role played by the OZI-rule violations and SU(3) flavor breakings in the decay transitions, and their correlations with the final-state meson wavefunctions. Experimental data may suggest that the role of OZI-rule violations is quite different for VV,PP and SS pair production in χ_{c0} decays. While in the PP channel the contribution from the doubly OZI-suppressed processes may be small, large OZI-rule violations may occur in the $\chi_{c0,2} \to SS$ channel due to glueball-$q\bar{q}$ mixing. More precise and new measurements of χ_{cJ} decays may lead to a better understanding on the structure of light scalar mesons.

2 h_c study

The detailed introduction about how to select charged tracks and EMC showers as well as the π^0 candidates can be found in the published paper [6]. Here, we just introduce the general event-level selection criteria. Candidate events must have at least two charged tracks. The continuum background can be suppressed by E_{tot} requirement and the background from $\psi(2S) \to \pi^+\pi^- J/\psi$ and $\psi(2S) \to \pi^0\pi^0 J/\psi$ can be suppressed by the recoiling mass of charged and neutral $\pi\pi$ pair. For E1-tagged mode, we require one photon in the energy range 465-535 MeV. Fig. 1 shows the inclusive π^0 recoil-mass spectra after applying the above selection criteria. The measured results are listed below: $M(h_c) = 3525.40 \pm 0.13 \pm 0.18 MeV/c^2, \Gamma(h_c) = 0.73 \pm 0.45 \pm 0.28 MeV (< 1.44 MeV at 90\% C.L.), \mathcal{B}(\psi' \to \pi^0 h_c) = (8.4 \pm 1.3 \pm 1.0)^{-4}, \mathcal{B}(\psi' \to \pi^0 h + c) \times B(h_c \to \gamma\eta_c) = (4.58 \pm 0.40 \pm 0.50) \times 10^{-4}$, and $\mathcal{B}(h_c \to \gamma\eta_c) = (54.3 \pm 6.7 \pm 5.2)\%$. Our measurements confirm CLEO's results. What is more important is that we give some first measurements.

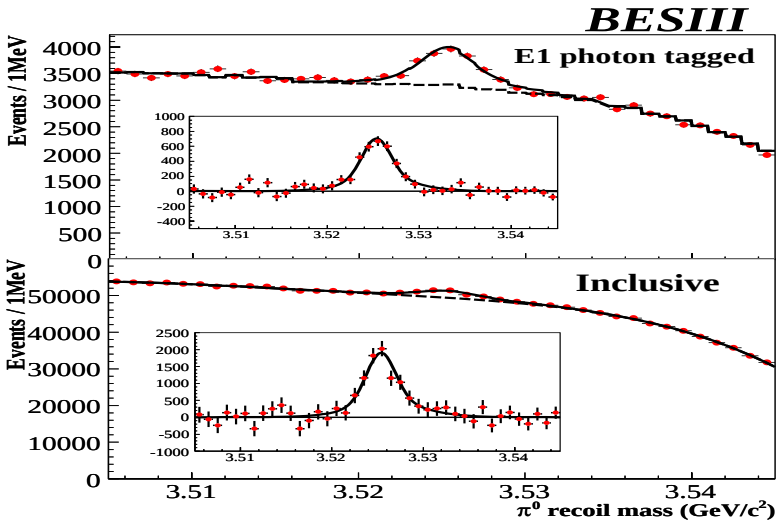

Figure 1: (up)The π^0 recoiling-mass spectrum and fit for the E1-tagged analysis of $\psi' \to \pi^0 h_c, h_c \to \gamma\eta_c$.. (down) for the inclusive analysis of $\psi' \to \pi^0 h_c$.

3 χ_{cJ} study

3.1 $\chi_{c0,2} \to PP(P = \pi^0, \eta)$

Recently, CLEO collaboration has published new results on the $\mathcal{B}(\chi_{c0,2} \to \pi^0\pi^0)$ with much improved precision compared to the previous measurements [5], but their results are about 2σ larger than the PDG's values. CLEO also measured $\chi_{c2} \to \eta\eta$ for the first itme. At BESIII, we studied both $\pi^0\pi^0$ and $\eta\eta$ modes with 5γ final state and the results have been published. [7]. Table 1 listed the measured results for BESIII,CLEO and PDG. One can find that some of our results are consistent with CLEO's. Fig. 2 and **??** shows the radiative photon energy distribution for $\gamma\pi^0\pi^0$ and $\gamma\eta\eta$ final states, respectively. Two clear bumps corresponding to $\chi_{c0,2}$ can be seen in both plots.

3.2 $\chi_{cJ} \to VV(V = \omega, \phi)$

Experimental data χ_{cJ} decays into a pair of vector is rare due to helixity amplitude suppression. Branching fractions are only published for $\chi_{cJ} \to \phi\phi$ and $\chi_{cJ} \to \omega\omega$ according to the BESII's measurements [8] and [9]. Table 2 list the measured results at BESII. Due to imperfect detection

Table 1: Branching fraction of $\chi_{c0,2} \to PP$. The final error items for both BESIII and CLEO are from the uncertainties of $\mathcal{B}(\psi' \to \gamma\chi_{cJ})$

Mode		$\chi_{c0}(\times 10^{-3})$	$\chi_{c2}(\times 10^{-3})$
$\pi^0\pi^0$	BESIII	$3.23 \pm 0.03 \pm 0.23 \pm 0.14$	$0.88 \pm 0.02 \pm 0.06 \pm 0.04$
	CLEO	$2.94 \pm 0.07 \pm 0.32 \pm 0.15$	$0.68 \pm 0.03 \pm 0.07 \pm 0.04$
	PDG	2.43 ± 0.20	0.71 ± 0.08
$\eta\eta$	BESIII	$3.44 \pm 0.10 \pm 0.24 \pm 0.13$	$0.65 \pm 0.04 \pm 0.05 \pm 0.03$
	CLEO	$3.18 \pm 0.13 \pm 0.31 \pm 0.16$	$0.51 \pm 0.05 \pm 0.05 \pm 0.03$
	PDG	2.4 ± 0.4	< 0.5

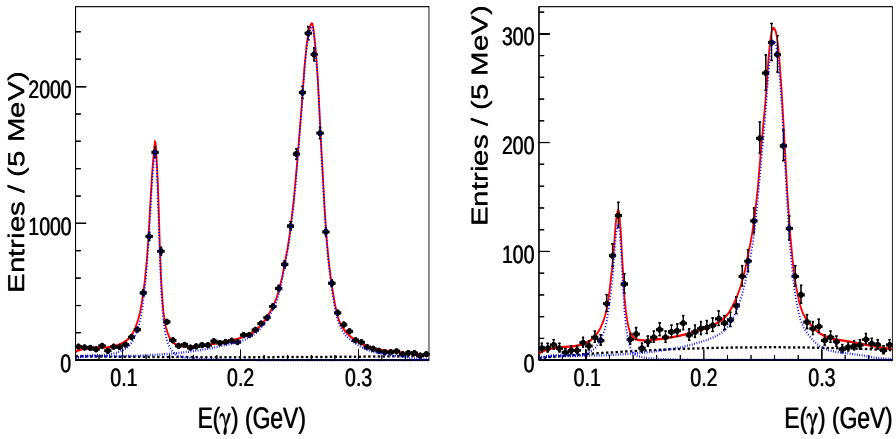

Figure 2: Radiative photon energy distribution of $\chi_c \to \pi^0\pi^0$ events.

resolution and low statistics, we just report the observation of $\chi_{c0,2}$ at that time, hard to judge that there is any χ_{c1} signal in $\phi\phi$ and $\omega\omega$ final state. For the doubly OZI decay mode, $\chi_{cJ} \to \omega\phi$, no any measurement is available before. With the large ψ' data sample taken at BESIII, we observed the clear $\chi_{c0,1,2} \to \omega\omega, \phi\phi$. Particularly, the χ_{c1} signal is firstly observed. Fig. 3 and 4 show the $M_{\phi\phi}$ and $M_{\omega\omega}$ distribution, respectively. Clear χ_{cJ} signal can be seen. For doubly OZI decay, $\chi_{cJ} \to \omega\phi$. We also observed the clear $\chi_{c0,1}$ signal(see fig. 5).

Table 2: Branching fractions of $\chi_{c0,2} \to \phi\phi, \omega\omega$ measured by BESII.

Mode	$\chi_{c0}(\times 10^{-3})$	$\chi_{c2}(\times 10^{-3})$
$\phi\phi$	0.93 ± 0.20	1.5 ± 0.3
$\omega\omega$	2.3 ± 0.7	2.0 ± 0.7

4 conclusion

BESIII has collected a large ψ' data sample. We have performed many study on h_c and χ_c. Some results have been published and some are in progress.

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I would like to thank my colleagues of BESIII collaboration. I would also like to thank the organizer for warm hospitality at La Thulei.

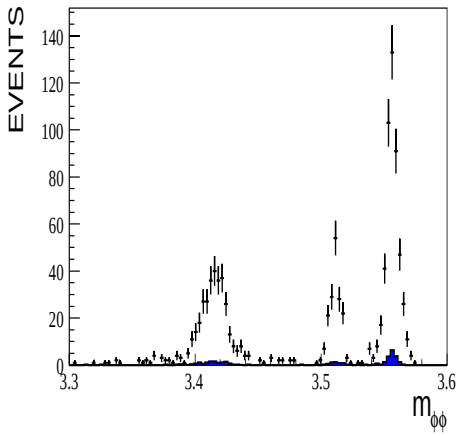

Figure 3: Invariant mass of $\phi\phi$ final state.

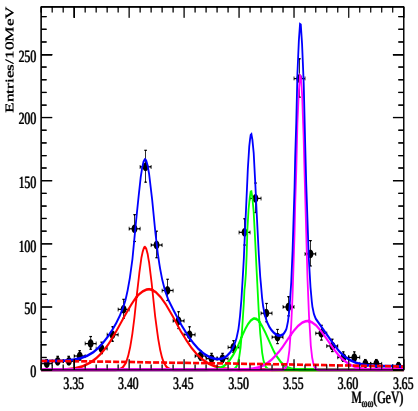

Figure 4: Invariant mass of $\omega\omega$ final state.

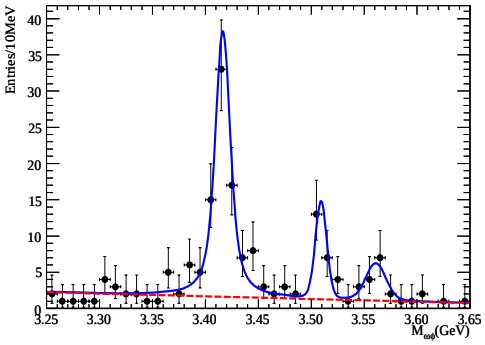

Figure 5: Invariant mass of $\omega\phi$ final state.

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