Observation of Chic2->etapetap and Chic0,2->etaetap

XIAO Suyu from IHEP

20171222

Motivation

- The ratio of the decay branching fractions between J/psi->wf0(1710) and J/psi->phif0(1710) encodes the production mechanisms of light quark contents via the Okubo-Zweig-Iizuka(OZI) rule violations.

- Apart from the singly OZI(SOZI) disconnected process, the doubly OZI(DOZI) disconnected process may play a crucial role in the production of isospin-0 light meson pairs, for instance, in Chicj->f0f0', ww, phiphi, wphi,etaeta, etaetap and etapetap.

- For Chic0,2->PP decays, most of them have been well measured except for the processes with final states containing an etap meson.

- Measurements of Chic0,2->etapetap and etaetap are desirable and crucial to disentangle the roles played by OZI violation in charmonium decay.

Data Sets

- 448.1*10^6 psi(3686) events
- (107.0+-0.8)*10^6 for 2009
- (341.1+-2.1)*10^6 for 2012

Decay modes

- Chic0,2->etapetap
  - mode A: both etap decay to gamma pip pim
  - mode B: both etap decay to eta pip pim
  - mode C: one to gamma pip pim, one to eta pip pim
- Chic0,2->etaetap
  - mode I: etap decays to gamma pip pim
  - mode II: etap decays to eta pip pim

Event Selection

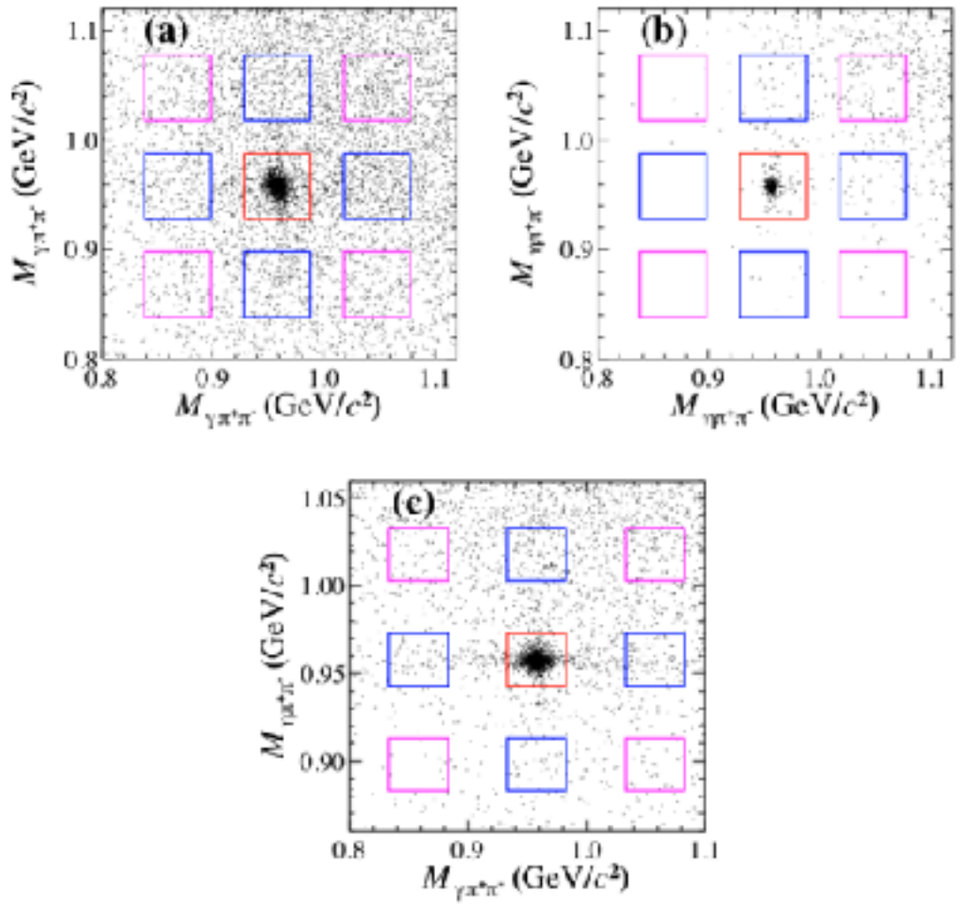

Figure 1. Scatter plots of M_i versus M_j of the candidate events for modes (a) A, (b) B, and (c) C from the $\psi(3686)$ data. The boxes denote the signal and background regions described in the text.

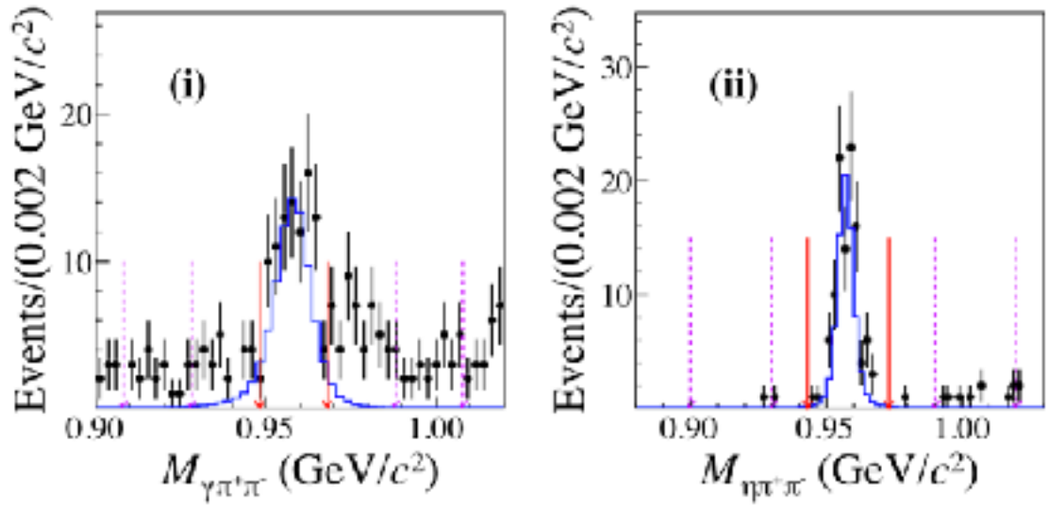

Figure 2. The M_i distributions of the η' candidate events for modes (i) I and (ii) II. In each plot, the dots with error bars are for the $\psi(3686)$ data, and the histograms are for the signal MC samples, the solid arrows show the η' signal regions and the dashed ones show sideband regions.

Data Analysis

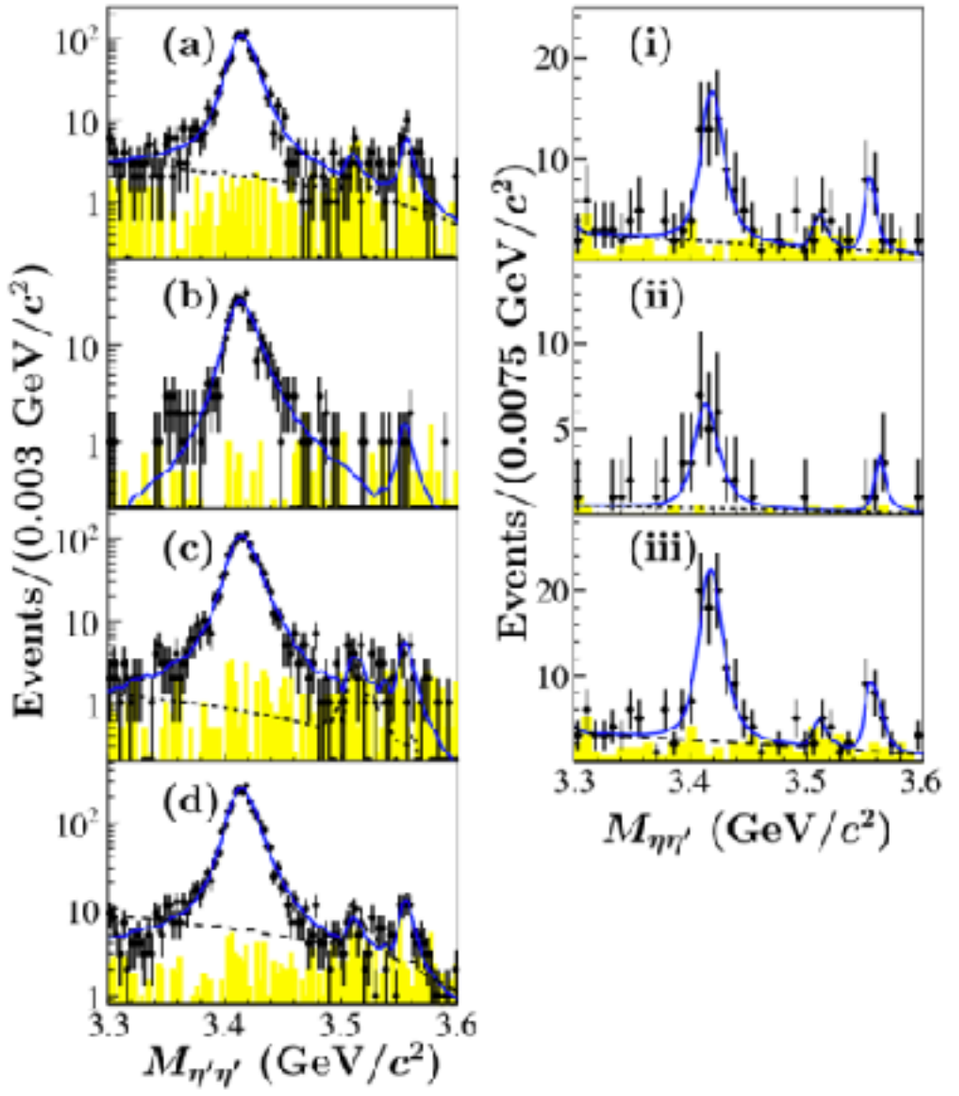

Figure 3. Left column shows the simultaneous fits for $\chi_{c0,2} \to \eta'\eta'$. (a) Mode A. (b) Mode B. (c) Mode C. (d) Sum of (a), (b), and (c). Right column shows the simultaneous fits for $\chi_{c0,2} \to \eta\eta'$. (i) Mode I. (ii) Mode II. (iii) Sum of (i) and (ii). In all of the above plots, the dots with error bars denote the $\psi(3686)$ data, the solid line denotes the overall fit results, the dashed line denotes the backgrounds and the yellow histogram shows the normalized events in the η' sideband regions.

Data Analysis

Table I. The results for $\chi_{c0,2} \to \eta'\eta'/\eta\eta'$. $\mathcal{B}$ denotes branching fraction.

Decay channel	$\chi_{c0} \to \eta'\eta'$			$\chi_{c2} \to \eta'\eta'$			$\chi_{c0} \to \eta\eta'$		$\chi_{c2} \to \eta\eta'$	
η' decay mode	Mode A	Mode B	Mode C	Mode A	Mode B	Mode C	Mode I	Mode II	Mode I	Mode II
Efficiency(%)	12.9 ± 0.1	11.9 ± 0.1	13.0 ± 0.1	14.0 ± 0.1	14.8 ± 0.1	14.9 ± 0.1	12.7 ± 0.1	9.0 ± 0.1	14.7 ± 0.1	10.4 ± 0.1
Signal number	1057 ± 15	329 ± 5	1238 ± 17	22.7 ± 2.6	8.1 ± 0.9	28.1 ± 3.3	59.9 ± 5.3	24.1 ± 2.1	14.3 ± 2.8	5.5 ± 1.1
$\mathcal{B}$ (This work)	$(2.19 \pm 0.03 \pm 0.14) \times 10^{-3}$			$(4.76 \pm 0.56 \pm 0.38) \times 10^{-5}$			$(8.92 \pm 0.84 \pm 0.65) \times 10^{-5}$		$(2.27 \pm 0.43 \pm 0.25) \times 10^{-5}$	
$\mathcal{B}$ (PDG) [2]	$(1.96 \pm 0.21) \times 10^{-3}$			$< 1.0 \times 10^{-4}$			$< 23 \times 10^{-5}$		$< 6.0 \times 10^{-5}$	

Systematic uncertainties

Table II. The systematic uncertainties (in %) in the branching fraction measurement.

Decay channel	$\chi_{c0} \to$		$\chi_{c2} \to$	
	$\eta'\eta'$	$\eta\eta'$	$\eta'\eta'$	$\eta\eta'$
$N_{\psi(3686)}$	0.6	0.6	0.6	0.6
Tracking	4.0	2.0	4.0	2.0
Photon efficiency	2.2	2.6	2.2	2.6
η reconstruction	0.7	1.3	0.7	1.3
η' mass window	1.0	1.7	1.0	1.7
Kinematic fit	0.7	1.0	0.6	1.7
$\chi_{c0,2}$ signal fitting	1.1	5.0	3.9	9.5
Intermediate state $\mathcal{B}$	3.8	3.1	4.4	3.8
Veto $\pi^+\pi^- J/\psi$	0.1	-	0.9	-
Veto $\psi(3686) \to \pi^0 + X$	0.2	1.0	2.1	0.2
Veto $J/\psi \to \gamma\eta'$	-	0.8	-	1.5
Total	6.3	7.3	8.0	11.2

Summary

- Chic2->etapetap, Chic0->etaetap, Chic2->etaetap are observed for the first time with significances of 9.6sigma, 13.4sigma, 7.5sigma respectively, and the corresponding branching fractions are measured

- Branching fraction of Chic0->etapetap is also measured with improved precision.

- B(chic0->etapetap)/B(chic2->etapetap)=45, one order larger than the ratios for other pseudoscalar meson pairs. This may initiate further studies about the dynamics of chic0,2->PP.