

Search for h_c via inclusive B decay (expectation for discussion)

Belle Charmonium meeting

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Introduction

- Recent observations of h_c by CLEO and E835

[1] CLEO : hep-ex/0410090

[2] E835 : hep-ex/0410085

- Fang Fang has searched for h_c via exclusive B decay

$B \rightarrow h_c K, h_c \rightarrow \gamma \eta_c, \eta_c \rightarrow K_S K^+ \pi^-$, and reported 90% C.L. upper limit at ICHEP04

$$Br(B \rightarrow h_c K) < 3.2 \times 10^{-4} \text{ at } 90\% \text{ C.L.}$$

- Ideas/suggestions/proposals for the search

[3] T. Barnes, T. Browder and S Tuan, hep-ph/0408081;

[4] S. Godfrey, hep-ph/0501083.

Luminosity, BF and efficiency

- using 300 fb^{-1} data

- QCD predicts :

1) $Br(B \rightarrow h_c X) = 0.13\%$ (or larger)

[5] E. Eichten et al., phys. Rev. Lett. 89,162002(2002)

[6] M. Beneke et al., phys. Rev. D59, 054003(1999)

2) $Br(h_c \rightarrow \gamma \eta_c) = 37.7\%$ see ref. [4]

- Assuming efficiency 5% (see [7] Belle, Phys. Rev. Lett. 07801(2003))

Decay *efficiency*

$$B^+ \rightarrow \eta_c K^+$$

$$\eta_c \rightarrow K_S K^- \pi^+ \quad 16.4\%$$

$$\eta_c \rightarrow K^+ K^- \pi^0 \quad 8.8\%$$

$$\eta_c \rightarrow p \bar{p} \quad 34.0\%$$

$$\eta_c \rightarrow K^{*0} K^- \pi^+ \quad 5.1\%$$

Decay *efficiency*

$$B^0 \rightarrow \eta_c K_S^0$$

$$\eta_c \rightarrow K_S K^- \pi^+ \quad 15.5\%$$

$$\eta_c \rightarrow K^+ K^- \pi^0 \quad 9.5\%$$

$$\eta_c \rightarrow p \bar{p} \quad 34.9\%$$

$$\eta_c \rightarrow K^{*0} K^- \pi^+ \quad 3.75\%$$

Number of signal events

- Observable Br in total is about **6.5%** that depends on how many decay modes included.

$$Br(\eta_c \rightarrow K^*(892)^0 K^- \pi^+) = 2.0\%, \quad Br(\eta_c \rightarrow K^*(892)^0 \bar{K}^*(892)^0) = 0.42\%$$

$$Br(\eta_c \rightarrow \pi^+ \pi^- K^+ K^-) = 1.5\%, \quad Br(\eta_c \rightarrow 2(K^+ K^-)) = 0.15\%,$$

$$Br(\eta_c \rightarrow \phi K^+ K^-) = 0.29\%, \quad Br(\eta_c \rightarrow \phi\phi) = 0.26\%$$

$$Br(\eta_c \rightarrow K^+ K_s^0 \pi^-) = 1.7\% (BES), \quad Br(\eta_c \rightarrow p \bar{p}) = 0.13\%,$$

Others (to be explored?)

$$Br(\eta_c \rightarrow K^+ K^- \pi^0) = 1.7\%, \quad Br(\eta_c \rightarrow \eta' \pi^+ \pi^-) = 2.1\%, \quad Br(\eta_c \rightarrow \eta \pi^+ \pi^-) = 2.5\%$$

- One expect that number of h_c signal events

$$Br(\eta_c \rightarrow p \bar{p}, \dots) \quad N_{\text{exp}}(B \rightarrow h_c X, h_c \rightarrow \gamma \eta_c, \eta_c \rightarrow p \bar{p}, \dots)$$

$$1\% \quad 150$$

$$5\% \quad 750$$

$$10\% \quad 1500$$

Expected h_c signal width

- Compared with $B \rightarrow \chi_{c1} X$ ([8] Belle hep-ex/0202028)
 - Clear signal is seen for inclusive $B \rightarrow \chi_{c1} X$ decays
 - χ_{c1} physical width is 0.91 MeV
 - χ_{c1} signal width is 10 MeV (resolution dominated)
- Inclusive h_c signal for $B \rightarrow h_c X$, $h_c \rightarrow \gamma \eta_c$, $\eta_c \rightarrow p \bar{p}, 2(K^+ K^-)$
 - is expected to have 20 MeV width including
 - 17.3 MeV (physical width)
 - 10 MeV (resolution)

Expected h_c signal yield

- We know $Br(B^+ \rightarrow \chi_{c1} K^+) = Br(B^+ \rightarrow \chi_{c0} K^+)$
Thus assuming $Br(B^+ \rightarrow \chi_{c1} X) = Br(B^+ \rightarrow \chi_{c0} X)$
- Belle did not see $B \rightarrow \chi_{c0} X$ signal, because of signal width 14 MeV and (mainly) low statistics.
 - expected χ_{c0} signal width is $\sqrt{10.1^2 + 10^2} = 14 \text{ MeV}$,
here χ_{c0} physical width = 10.1 MeV.
 - Low $Br(\chi_{c0} \rightarrow \gamma J / \psi) = 1.18\%$ while $Br(\chi_{c1} \rightarrow \gamma J / \psi) = 31.6\%$
 - Belle observe $N_{obs}(B \rightarrow \chi_{c1} X) = 2391 \pm 142$ events.
 - Thus $N_{obs}(B \rightarrow \chi_{c0} X) = 2391 \times 1.18 / 31.6 = 89$ events are expected.

Expected h_c signal yield

- Signal width and yields (observed or expected)

Decay	Measured width MeV	Number of events	See signal ?
$B \rightarrow \chi_{c0} X$	14	89 (expected)	No
$B \rightarrow \chi_{c1} X$	10	2391 (observed)	Yes
$B \rightarrow \chi_{c2} X$	10	611 (observed)	Yes
$B \rightarrow h_c X$	~20	750 to 1500 (expected)	Hopeful

- Essential to include more η_c decay modes (with Br = 5-10%).
- Efficiency in fact is more than 5% used in estimation
- Hopeful to see signal, if QCD works.
- Otherwise, to give a upper limit