International Journal of Modern Physics A

Evidence for $B_s^{(*)}$ Production at the Υ(5S)

R. Sia
Representing the CLEO Collaboration
Department of Physics, Syracuse University, Syracuse, New York 13244
E-mail: rsia@phy.syr.edu

Based on data collected by the CLEO III detector at CESR, we started a series of investigations to open the mysteries of the Υ(5S) resonance decay properties. B_s mesons are expected to decay predominantly into D_s meson, while the lighter B mesons decay into D_s only about 10% of the time. We exploit this difference to present the first evidence of a substantial production of B_s mesons at the Υ(5S) resonance. We make here a preliminary model dependent estimate of the ratio of $B_s^{(*)}\overline{B}_s^{(*)}$ to the total $b\bar{b}$ quark pair production at the Υ(5S) energy to be $(21 \pm 3 \pm 9)\%$.

1. Introduction

An enhancement in the total e^+e^- annihilation cross-section into hadrons was discovered at CESR long ago[1] ,[2] ,[3] at 10.865±0.008 GeV. This effect was named the Υ(5S) resonance. Potential models[4] predict the different relative decay rates of the Υ(5S) into combinations of $B^{(*)}\overline{B}^{(*)}$ and $B_s^{(*)}\overline{B}_s^{(*)}$. In a simple spectator model the B_s decays into the D_s nearly all the time. Since the $B \to D_sX$ branching ratio has already been measured to be $(10.5 \pm 2.6 \pm 2.5)\%$,[5] we expect a large difference between the D_s yields at the Υ(5S) and the Υ(4S) that we examine in this paper and that can lead to an estimate of the size of the $B_s^{(*)}\overline{B}_s^{(*)}$ component at the Υ(5S). By the Υ(5S) here, we mean the production of any B meson species including B_u, B_d and B_s that occurs at an e^+e^- center-of-mass energy of 10.87 GeV.

2. Analysis Technique

The data sample we used for this analysis consists of 0.42 fb^{-1} of data taken on the Υ(5S) resonance, 6.34 fb^{-1} of data collected on the $\Upsilon(4S)$ and 2.32 fb^{-1} of data taken in the continuum below the Υ(4S). We reconstruct D_s mesons via the $D_s^+ \to \phi\pi^+$ decay mode using the $\phi \to K^+K^-$ channel (Charge conjugate decays are implied throughout this paper). Details about track and event selection criteria are available elsewhere.[4] We consider D_s candidates having a momentum less than or equal to half of the beam energy, the limit from a B decay. To remove at first order differences between continuum data taken just below the Υ(4S), at the Υ(4S) and at the Υ(5S) we choose to work with the variable x which is the D_s momentum divided by the beam energy. The number of signal events is determined by subtracting the scaled continuum data below the Υ(4S) from the Υ(4S) and from the Υ(5S) data.[4] The x dependent D_s detection efficiencies of the two datasets are consistent with each other and have values around 30%.

3. D_s production rates at the Υ(4S) and the Υ(5S)

In Fig. 1(a) and 1(b), we show the x distribution of the inclusive D_s yields from the Υ(4S) and the Υ(5S) decays respectively. Using $6,420,910 \pm 5,738 \pm 240,542$

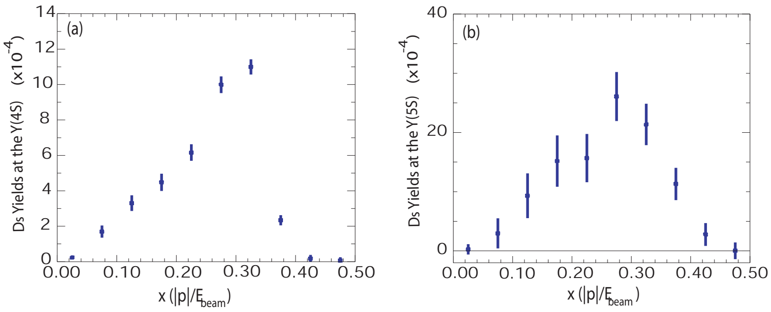

Fig. 1. D_s yields vs x from: (a) the Υ(4S) decays, (b) the Υ(5S) decays. Both plots are continuum subtracted, efficiency corrected, and normalized to the number of resonance events (Preliminary). The partial production rates at the different energies vs. x are available.[4]

of Υ(4S) resonance events and $131,396 \pm 810 \pm 26,546$ of Υ(5S) resonance events above the four-flavor continuum, we find $\mathcal{B}(\Upsilon(4S) \to D_sX) \cdot \mathcal{B}(D_s \to \phi\pi) = (8.0 \pm 0.3 \pm 0.4) \cdot 10^{-3}$ and $\mathcal{B}(\Upsilon(5S) \to D_sX) \cdot \mathcal{B}(D_s \to \phi\pi) = (20 \pm 2 \pm 4) \cdot 10^{-3}$, thus demonstrating a much larger production of D_s at the Υ(5S) energy than at the Υ(4S), i. e. $\mathcal{B}(\Upsilon(5S) \to D_sX)/\mathcal{B}(\Upsilon(4S) \to D_sX) = 2.5 \pm 0.3 \pm 0.6$. Using $\mathcal{B}(D_s \to \phi\pi^+) = (3.6 \pm 0.9)\%$,[5] we measure $\mathcal{B}(\Upsilon(4S) \to D_sX)$ to be $(22.3 \pm 0.7 \pm 5.7)\%$ hence $\mathcal{B}(B \to D_sX) = (11.1 \pm 0.4 \pm 2.9)\%$ which is in a good agreement with the PDG[5] value of $(10.5 \pm 2.6 \pm 2.5)\%$. In addition, we find $\mathcal{B}(\Upsilon(5S) \to D_sX) = (55.0 \pm 5.2 \pm 17.8)\%$.

4. B_s production at the Υ(5S)

In Fig. 2, we show the D_s meson yields vs. x from the Υ(5S) with the Υ(4S) spectrum subtracted. The spectrum shows a significant excess of D_s at the Υ(5S), which is a significant evidence for B_s production at the Υ(5S). The branching ratio we measure $\mathcal{B}(B \to D_sX)$ comes in fact either from the the $W^- \to \bar{c}s$ or from the $b \to c$ piece if it manages to create an $s\bar{s}$ pair through fragmentation as shown in Fig. 3(a) and 3(b) respectively. Similarly, the production of D_s mesons from B_s decay arises from two dominant processes as well. Fig. 3(c) and 3(d) show a large, possible greater than 100% D_s rate; here the primary $b \to c$ transition has the charm quark pairing with the spectator anti-strange quark. D_s

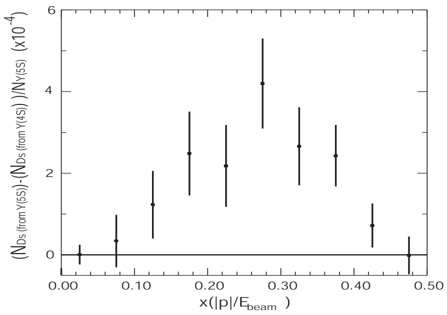

Fig. 2. The enhancement of D_s yields at the Υ(5S) vs x (no efficiency correction, Preliminary).

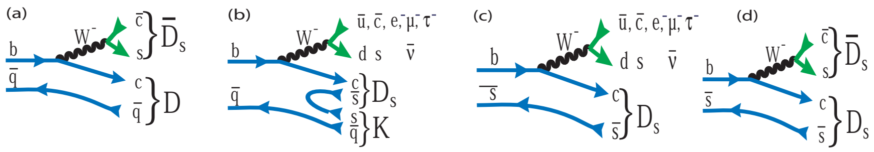

Fig. 3. Dominant decay diagrams for a B and B_s meson into D_s mesons (q can be here either a u or a d quark).

can also be produced from the upper vertex in Fig. 3(c) when the $W^- \to \overline{c}s$ and these two quarks form a color singlet pair. The chances of this occurring should be similar to the chance of getting an upper-vertex D_s in B decay (Fig. 3(a)). However, It is possible that some D_s are lost from these processes since any $c\overline{s}$ pairs in Fig. 3(c) and 3(d) could fragment into a kaon with a D particle instead of a D_s by producing a $u\overline{u}$ or $d\overline{d}$. These considerations lead to a model dependent estimate of $\mathcal{B}(B_s \to D_s X) = (92 \pm 11)\%$. Based on this estimate and using the measured product branching fractions $\mathcal{B}(\Upsilon(5S) \to D_s X) \cdot \mathcal{B}(D_s \to \phi\pi^+)$ and $\mathcal{B}(\Upsilon(4S) \to D_s X) \cdot \mathcal{B}(D_s \to \phi\pi^+)$, we find the ratio of $B_s^{(*)}\overline{B}_s^{(*)}$ to the total $b\overline{b}$ quark pair production at the Υ(5S) energy

$$\mathcal{B}(\Upsilon(5S) \to B_s^{(*)}\overline{B}_s^{(*)}) = (21 \pm 3 \pm 9)\%$$

I gratefully acknowledge my advisor Professor S. Stone for all his guidance and help.

References

1. D. Besson *et al.* (CLEO Collaboration), Phys. Rev. Lett **54**, 381 (1985).
2. J. Lee-Franzini *et al.* (CUSB Collaboration), Phys. Rev. Lett **65**, 2947 (1990).
3. D. M. Lovelock *et al.* (CUSB Collaboration), Phys. Rev. Lett **54**, 377 (1985).
4. D. Asner et al. [CLEO Collaboration], [arXiv:hep-ex/0408070]
5. "Review of Particle Physics", K. Hagiwara *et al.* Phys. Rev. D 66, 010001 (2002,2003)