

## Measurement of Inclusive $D_s$ , $D^0$ , and $J/\psi$ Rates and Determination of the $B_s^{(*)}\bar{B}_s^{(*)}$ Production Fraction in $b\bar{b}$ Events at the $\Upsilon(5S)$ Resonance

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The inclusive production of  $D_s$ ,  $D^0$ , and  $J/\psi$  mesons is studied using a  $1.86 \text{ fb}^{-1}$  data sample collected on the  $Y(5S)$  resonance with the Belle detector at the KEKB asymmetric-energy  $e^+e^-$  collider. The number of  $b\bar{b}$  events in this  $Y(5S)$  data sample is determined. We measure the branching fractions  $\mathcal{B}(Y(5S) \rightarrow D_s X)/2 = (23.6 \pm 1.2 \pm 3.6)\%$ ,  $\mathcal{B}(Y(5S) \rightarrow D^0 X)/2 = (53.8 \pm 2.0 \pm 3.4)\%$ , and  $\mathcal{B}(Y(5S) \rightarrow J/\psi X)/2 = (1.030 \pm 0.080 \pm 0.067)\%$ . From the  $D_s$  and  $D^0$  inclusive branching fractions the ratio  $f_s = (18.0 \pm 1.3 \pm 3.2)\%$  of  $B_s^{(*)} \bar{B}_s^{(*)}$  to the total  $b\bar{b}$  quark pair production at the  $Y(5S)$  energy is obtained in a model-dependent way.

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The possibility of studying  $B_s$  decays at very high luminosity  $e^+e^-$  colliders running at the energy of the  $Y(5S)$  resonance has been discussed in several theoretical papers [1–3]. Studies of the  $B_s$  meson properties at the  $Y(5S)$ , both alone and in comparison with those of its lighter cousins  $B^0$  and  $B^+$ , may provide important insights into the Cabibbo-Kobayashi-Maskawa matrix and hadronic structure, as well as sensitivity to new physics phenomena [4]. To date, most studies of  $B_s$  have been performed at hadron colliders, where high production rates are tempered by limited triggering and detection capabilities. As  $B$  factories have amply demonstrated for  $B^0$  and  $B^+$ , the kinematic cleanliness of resonant near-threshold exclusive pair production ( $e^+e^- \rightarrow Y(4S) \rightarrow B\bar{B}$ ), combined with a high triggering efficiency and the ability to measure neutral particles, can open up a complementary realm of sensitivity to new phenomena. The  $Y(5S)$  could play a similar role for  $B_s$  that the  $Y(4S)$  has played for  $B$ .

To test the experimental feasibility of  $B_s$  studies in  $Y(5S)$  events, a sample of  $1.86 \text{ fb}^{-1}$  was collected with the Belle detector over 3 days in June 2005. Earlier an  $Y(5S)$  data sample of  $\sim 0.1 \text{ fb}^{-1}$  was taken at CESR [5–7]

and, more recently, a data set of  $0.42 \text{ fb}^{-1}$  was collected by CLEO [8,9]. We report here the first results obtained by Belle, a determination of the number of  $b\bar{b}$  events in the  $Y(5S)$  data sample, a measurement of the inclusive rate of  $Y(5S)$  events to  $D_s$ ,  $D^0$ , and  $J/\psi$ , and derivation of the fraction of  $b\bar{b}$  events containing  $B_s$ .

The Belle detector [10] has operated since 1999 at KEKB [11], an asymmetric-energy double storage ring designed to collide 8 GeV electrons and 3.5 GeV positrons and produce  $Y(4S)$  mesons with a boost of  $\beta\gamma = 0.425$ . The recent data sample of  $1.86 \text{ fb}^{-1}$  was taken at the  $Y(5S)$  energy of  $\sim 10\,869 \text{ MeV}$ , under exactly the same experimental conditions as in  $Y(4S)$  and continuum runs, except that both beam energies were increased by  $\sim 2.7\%$ , keeping the center-of-mass (c.m.) boost unchanged. Another data sample of  $3.67 \text{ fb}^{-1}$  collected at a c.m. energy 60 MeV below the  $Y(4S)$  just before the  $Y(5S)$  data taking is used in this analysis to evaluate continuum contributions.

Only clean decay modes  $D_s^+ \rightarrow \phi\pi^+$  ( $\phi \rightarrow K^+K^-$ ),  $D^0 \rightarrow K^-\pi^+$ , and  $J/\psi \rightarrow \mu^+\mu^-$  are reconstructed. Charge-conjugate modes are implicitly included everywhere in this Letter. The standard track reconstruction

and particle identification procedures are used [10]. The invariant mass of  $\phi \rightarrow K^+ K^-$  candidates is required to be within  $\pm 12 \text{ MeV}/c^2$  of the nominal  $\phi$  mass. For the  $D_s^+ \rightarrow \phi \pi^+$  decay mode, the helicity angle distribution is expected to be proportional to  $\cos^2 \theta_{\text{hel}}^{D_s^+}$ ; therefore, the requirement  $|\cos \theta_{\text{hel}}^{D_s^+}| > 0.25$  is applied. The helicity angle  $\theta_{\text{hel}}^{D_s^+}$  is defined as the angle between the directions of the  $K^+$  and  $D_s^+$  momenta in the  $\phi$  rest frame.

In the energy region of the  $Y(5S)$ , hadronic events can be classified into three physics categories:  $u\bar{u}$ ,  $d\bar{d}$ ,  $s\bar{s}$ ,  $c\bar{c}$  continuum events,  $b\bar{b}$  continuum events, and  $Y(5S)$  events. The  $b\bar{b}$  continuum and the  $Y(5S)$  events always produce final states with a pair of  $B$  or  $B_s$  mesons and, therefore, cannot be topologically separated. We define the  $b\bar{b}$  continuum and  $Y(5S)$  events collectively as  $b\bar{b}$  events, everywhere in this analysis. All  $b\bar{b}$  events are expected to hadronize in one of the following final states:  $B\bar{B}$ ,  $B\bar{B}^*$ ,  $B^*\bar{B}$ ,  $B^*\bar{B}^*$ ,  $B\bar{B}\pi$ ,  $B\bar{B}^*\pi$ ,  $B^*\bar{B}\pi$ ,  $B^*\bar{B}^*\pi$ ,  $B\bar{B}\pi\pi$ ,  $B_s^0\bar{B}_s^0$ ,  $B_s^0\bar{B}_s^*$ ,  $B_s^*\bar{B}_s^0$ , or  $B_s^*\bar{B}_s^*$ . Here  $B$  denotes a  $B^0$  or a  $B^+$  meson and  $\bar{B}$  denotes a  $\bar{B}^0$  or a  $B^-$  meson. The excited states decay to their ground states via  $B^* \rightarrow B\gamma$  and  $B_s^* \rightarrow B_s^0\gamma$  [12].

An energy scan was performed just before the  $Y(5S)$  data taken to find the peak position of the  $Y(5S)$  resonance. An integrated luminosity of  $\sim 30 \text{ pb}^{-1}$  was collected at five values of  $e^+e^-$  c.m. energy between 10825 and 10905 MeV at intervals of 20 MeV. The ratio of the number of hadronic events with  $R_2 > 0.2$  to the number of Bhabha events is measured as a function of the c.m. energy (Fig. 1). Here,  $R_2$  is the normalized second Fox-Wolfram moment [13]. This ratio is expected to have a Breit-Wigner function shape corresponding to the  $Y(5S)$  resonance, above a flat background. Fixing the width value to the PDG value  $\Gamma = 110 \text{ MeV}/c^2$  [12], the mean mass value is found from the fit to be  $M = (10868 \pm 6 \pm 14) \text{ MeV}/c^2$ , where the first error is statistical and the second error is a systematic uncertainty, dominated by the variation of background contributions with c.m. energy.

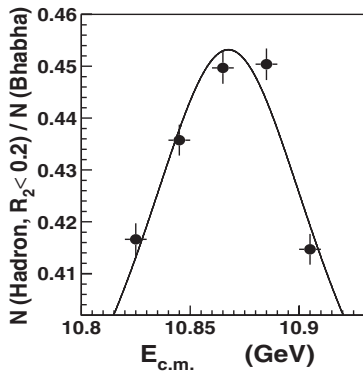


FIG. 1. The ratio of the number of hadronic events with  $R_2 > 0.2$  to the number of Bhabha events, as a function of the  $e^+e^-$  c.m. energy. Only statistical errors are shown. The curve is the result of the fit described in the text.

This value is in good agreement with the PDG value  $M_{Y(5S)} = (10865 \pm 8) \text{ MeV}/c^2$  [12]. The fit value obtained above is treated only as a systematic check rather than as a measurement, as the energy range scanned is small compared to the  $Y(5S)$  width, and uncertainties due to background contributions are not well known. Finally, the energy of 10869 MeV was set for subsequent  $Y(5S)$  runs.

The  $u\bar{u}$ ,  $d\bar{d}$ ,  $s\bar{s}$ ,  $c\bar{c}$  continuum subtraction method is applied to obtain the number of  $b\bar{b}$  events in the  $Y(5S)$  data sample:

$$N_{5S}^{b\bar{b}} = \frac{1}{\epsilon_{5S}^{b\bar{b}}} \left( N_{5S}^{\text{had}} - N_{\text{cont}}^{\text{had}} \frac{\mathcal{L}_{5S}}{\mathcal{L}_{\text{cont}}} \frac{E_{\text{cont}}^2}{E_{5S}^2} \frac{\epsilon_{5S}^{\text{con}}}{\epsilon_{\text{cont}}^{\text{con}}} \right). \quad (1)$$

Here  $N_{5S}^{b\bar{b}}$  is the number of  $b\bar{b}$  events in the  $Y(5S)$  data sample, and  $N_{5S}^{\text{had}}$  and  $N_{\text{cont}}^{\text{had}}$  are the numbers of hadronic events in the  $Y(5S)$  and continuum data samples, respectively. A few percent contribution of  $\tau^+\tau^-$ , QED,  $\gamma\gamma$ , and beam-gas events partially cancels in Eq. (1), and the corresponding small systematic uncertainty is included in the full systematic uncertainty. The efficiency to select a  $b\bar{b}$  event in the  $Y(5S)$  data sample,  $\epsilon_{5S}^{b\bar{b}} = (99 \pm 1)\%$ , and the efficiency ratio for continuum events in the  $Y(5S)$  and continuum data samples,  $\epsilon_{5S}^{\text{con}}/\epsilon_{\text{cont}}^{\text{con}} = 1.007 \pm 0.003$ , are obtained from Monte Carlo (MC) simulation. The hadronic cross section varies with the c.m. energy as  $1/E^2$  and a corresponding correction is applied. The c.m. energies for the  $Y(5S)$  and continuum data sets are  $E_{5S} = 10869 \text{ MeV}$  and  $E_{\text{cont}} = 10520 \text{ MeV}$ , respectively, with a  $\sim 5 \text{ MeV}$  accuracy of the collider absolute c.m. energy calibration. The integrated luminosity ratio  $\mathcal{L}_{5S}/\mathcal{L}_{\text{cont}} = 0.5061 \pm 0.0020$  is calculated using the standard Belle luminosity measurement procedure with Bhabha events. The small statistical uncertainty on this ratio can be neglected.

The value of and uncertainty on the luminosity ratio is further checked using high-momentum charged tracks,  $K_S^0$  mesons, and  $D^0$  mesons. To compare  $Y(5S)$  and continuum production, normalized momentum distributions are used. The normalized momentum of a particle  $h$  is defined as  $x(h) = P(h)/P_{\text{max}}(h)$ , where  $P(h)$  is the measured momentum of that particle, and  $P_{\text{max}}(h)$  is the expected value of its momentum if it were produced in the process  $e^+e^- \rightarrow h\bar{h}$  at the same c.m. energy. Fitting a constant to the distributions of the  $Y(5S)$  and continuum data set ratios  $x(h)_{5S}/x(h)_{\text{cont}}$  for  $0.5 < x(h) < 0.9$  and applying small corrections due to the difference between the  $Y(5S)$  and continuum final state particle multiplicities, which were obtained from MC simulation, the ratios  $0.471 \pm 0.005$ ,  $0.471 \pm 0.005$ , and  $0.477 \pm 0.005$  are determined for  $h = \pi^+$ ,  $K_S^0$ , and  $D^0$ , respectively. These values agree with the energy-corrected luminosity ratio of  $0.4740 \pm 0.0019$  obtained from Bhabha event measurements, where the factor  $E_{\text{cont}}^2/E_{5S}^2$  was applied to correct for the hadronic cross-section energy dependence.

From Eq. (1) we obtain the number of  $b\bar{b}$  events in the  $Y(5S)$  data sample,  $N_{5S}^{b\bar{b}} = (5.61 \pm 0.03_{\text{stat}} \pm 0.29_{\text{syst}}) \times 10^5$ . The total systematic uncertainty of  $\sim 5\%$  includes all systematic errors on parameters used in Eq. (1). Finally, the  $b\bar{b}$  production cross section at the  $Y(5S)$  is measured to be  $(0.302 \pm 0.015)$  nb, in good agreement with the CLEO value of  $(0.310 \pm 0.052)$  nb [8].

The method for inclusive  $D_s$  ( $D_s \equiv D_s^\pm$ ) analysis of  $Y(5S)$  data developed in Ref. [8] is applied here. The  $D_s$  signals ( $D_s^+ \rightarrow \phi\pi^+$ ,  $\phi \rightarrow K^+K^-$ ) in the  $Y(5S)$  and continuum data samples are shown in Fig. 2(a) for the normalized  $D_s$  momentum region  $x(D_s) < 0.5$ , where a  $b\bar{b}$  contribution is expected. Here and throughout this Letter, the continuum distributions are normalized to the  $Y(5S)$  distributions using the energy-corrected luminosity ratio. To extract the number of  $D_s$  mesons, the  $D_s$  mass distribution is fitted by a Gaussian to describe the signal and a linear function to describe the background. The Gaussian width is fixed to the value obtained from MC simulation; the Gaussian mean value and normalization and the background parameters are allowed to float. The same mass fit procedure, but with the Gaussian mean value fixed to that obtained from the fit of the  $D_s$  signal in the  $x(D_s) < 0.5$  range, is repeated in each bin of  $x(D_s)$  in order to obtain the  $D_s$  yield as a function of the normalized momentum,  $x(D_s)$ . The  $x(D^0)$  and  $x(J/\psi)$  distributions discussed below are obtained using the same fit procedures.

The normalized momentum  $x(D_s)$  distributions are shown in Fig. 2(b) for the  $Y(5S)$  and continuum data samples. These two distributions agree well in the region  $x(D_s) > 0.5$ , where  $b\bar{b}$  events cannot contribute. The excess of events in the region  $x(D_s) < 0.5$  corresponds to inclusive  $D_s$  production in  $b\bar{b}$  events.

The fully corrected  $x(D_s)$  distribution for  $b\bar{b}$  events is obtained, subtracting the continuum contribution and applying a bin-by-bin efficiency correction, obtained from the MC simulation. Summing over all bins within the interval  $x(D_s) < 0.5$  and dividing by the  $D_s^+$  and  $\phi$  decay branching fractions and by the number of  $b\bar{b}$  events in the  $Y(5S)$  data sample, the inclusive branching fraction

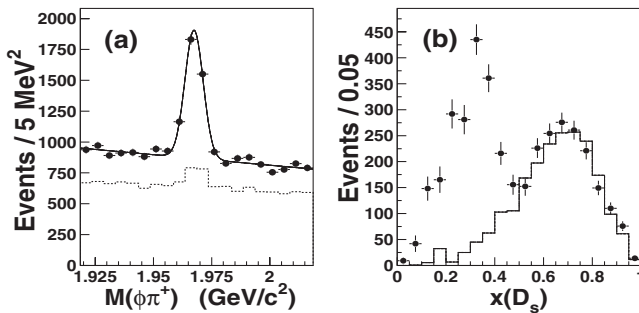


FIG. 2. The  $D_s$  signal in the region  $x(D_s) < 0.5$  (a) and the  $D_s$  normalized momentum  $x(D_s)$  (b). The points with error bars are the  $Y(5S)$  data, while the histograms show the normalized continuum (here and in Figs. 3 and 4).

$\mathcal{B}(Y(5S) \rightarrow D_s X)/2 = (23.6 \pm 1.2 \pm 3.6)\%$  is obtained. In the calculations the PDG value  $\mathcal{B}(D_s^+ \rightarrow \phi\pi^+) = (4.4 \pm 0.6)\%$  [12] is used. The  $Y(5S)$  inclusive branching fraction is multiplied by a factor of 1/2 to compare with  $B_{(s)}$  branching fractions. As explained above, continuum  $b\bar{b}$  production cannot be separated from  $Y(5S)$  events and therefore continuum  $b\bar{b}$  production is included in the  $Y(5S) \rightarrow D_s X$  branching fraction. The latter is therefore defined as the average number of  $D_s$  mesons produced in  $b\bar{b}$  events at the  $Y(5S)$  energy.

The dominant contributions to the systematic uncertainty on the branching fraction measurement are the uncertainties due to the  $\mathcal{B}(D_s^+ \rightarrow \phi\pi^+)$  measurement of 14%, to the number of  $b\bar{b}$  events of 5%, to the track reconstruction efficiency and particle identification of 4%, and to the fit procedure of 2%.

The obtained inclusive branching fraction agrees well with the branching fraction  $\mathcal{B}(Y(5S) \rightarrow D_s X)/2 = (22.4 \pm 2.1 \pm 5.0)\%$  obtained by CLEO [8]. The value of  $\mathcal{B}(Y(5S) \rightarrow D_s X)/2$  is significantly larger than the branching fraction  $\mathcal{B}(B \rightarrow D_s X) = (8.7 \pm 1.2)\%$ , which we calculate by combining the PDG average [12] with the recent CLEO result [8] adjusted to the value  $\mathcal{B}(D_s^+ \rightarrow \phi\pi^+) = (4.4 \pm 0.6)\%$ . The significant increase of  $D_s$  production at the  $Y(5S)$  as compared to that at the  $Y(4S)$  indicates a sizable  $B_s$  production rate.

The fraction  $f_s$  of  $B_s^{(*)}\bar{B}_s^{(*)}$  events among all  $b\bar{b}$  events at the  $Y(5S)$  satisfies the following relation:

$$\mathcal{B}(Y(5S) \rightarrow D_s X)/2 = f_s \mathcal{B}(B_s \rightarrow D_s X) + (1 - f_s) \mathcal{B}(B \rightarrow D_s X), \quad (2)$$

where  $\mathcal{B}(B_s \rightarrow D_s X)$  and  $\mathcal{B}(B \rightarrow D_s X)$  are the average number of  $D_s$  mesons produced in  $B_s$  and  $B$  decays, respectively. Using our measurement of  $\mathcal{B}(Y(5S) \rightarrow D_s X)$ , the measured value of  $\mathcal{B}(B \rightarrow D_s X) = (8.7 \pm 1.2)\%$  [8,12], and the model-dependent estimate  $\mathcal{B}(B_s \rightarrow D_s X) = (92 \pm 11)\%$  [8], we determine  $f_s = (17.9 \pm 1.4 \pm 4.1)\%$ . The systematic uncertainty on  $f_s$  is obtained by propagating the systematic uncertainties on the branching fractions included in Eq. (2), taking into account the correlation induced by  $\mathcal{B}(D_s^+ \rightarrow \phi\pi^+)$ .

The inclusive production of  $D^0$  mesons (including both  $D^0$  and  $\bar{D}^0$ ) at the  $Y(5S)$  is studied applying a procedure similar to that used for the  $D_s$  case. As shown in Fig. 3(a), large  $D^0$  signals ( $D^0 \rightarrow K^-\pi^+$ ) are seen in the  $Y(5S)$  and continuum data samples. The number of  $D^0$  mesons as a function of  $x(D^0)$  is shown in Fig. 3(b) for both samples. These two distributions agree well in the region  $x(D^0) > 0.5$ .

After continuum subtraction and efficiency correction, the inclusive branching fraction  $\mathcal{B}(Y(5S) \rightarrow D^0 X)/2 = (53.8 \pm 2.0 \pm 3.4)\%$  is determined. This branching fraction is defined as the average number of  $D^0$  and  $\bar{D}^0$  mesons produced per  $b\bar{b}$  event. The dominant sources of system-



atic uncertainties are similar to the  $D_s$  analysis, except that the PDG value  $\mathcal{B}(D^0 \rightarrow K^- \pi^+) = (3.80 \pm 0.07)\%$  has much better accuracy than  $\mathcal{B}(D_s^+ \rightarrow \phi \pi^+)$ .

The value obtained for  $\mathcal{B}(Y(5S) \rightarrow D^0 X)/2$  is lower than the PDG value  $\mathcal{B}(B \rightarrow D^0 X) = (64.0 \pm 3.0)\%$  [12], as expected, if there is sizable  $B_s$  production at the  $Y(5S)$ . The rate of  $D^0$  production in  $B_s$  decays can be estimated in a way similar to that described in Ref. [8]. Assuming that  $D^0$  mesons are dominantly produced from conventional  $b \rightarrow c$  processes through a fragmentation mechanism with additional  $u\bar{u}$  quark pair creation, the branching fraction is expected to be  $\mathcal{B}(B_s \rightarrow D^0 X) = (8 \pm 7)\%$ . Using the inclusive  $D^0$  production branching fraction of the  $Y(5S)$ ,  $B$ , and  $B_s$  decays and replacing  $D_s$  by  $D^0$  in Eq. (2), the ratio  $f_s = (18.1 \pm 3.6 \pm 7.5)\%$  of  $B_s^{(*)}\bar{B}_s^{(*)}$  events to all  $b\bar{b}$  events at the  $Y(5S)$  is obtained. The systematic error is dominated by the systematic uncertainties from  $\mathcal{B}(Y(5S) \rightarrow D^0 X)/2$  and  $\mathcal{B}(B \rightarrow D^0 X)$  and is slightly affected by the uncertainty on the model-dependent assumption for the  $\mathcal{B}(B_s \rightarrow D^0 X)$  value. Although the  $D_s$  inclusive analysis provides better accuracy on  $f_s$ , the  $D^0$  inclusive analysis is an independent method, where the uncertainty due to the  $D^0$  decay branching fraction is small and the uncertainty on the number of  $b\bar{b}$  events dominates. Moreover, the correlation between  $f_s$  and the number of  $b\bar{b}$  events is positive in the  $D^0$  analysis and is negative in the  $D_s$  analysis.

Using the  $f_s$  value obtained in the  $D^0$  inclusive analysis, the inclusive branching fraction  $\mathcal{B}(B_s \rightarrow D_s X)$  can be extracted from Eq. (2). Using the results of the present analysis, and taking into account the correlation between our measurements of  $\mathcal{B}(Y(5S) \rightarrow D_s X)$  and  $\mathcal{B}(Y(5S) \rightarrow D^0 X)$ , we obtain  $\mathcal{B}(B_s \rightarrow D_s X) = (91 \pm 18 \pm 41)\%$ , in agreement with expectations within large errors.

The inclusive production of  $J/\psi$  mesons is studied in the decay mode  $J/\psi \rightarrow \mu^+ \mu^-$ . As shown in Fig. 4(a), the  $Y(5S)$  data sample contains a prominent  $J/\psi$  signal, whereas the  $J/\psi$  signal in continuum is small. The  $x(J/\psi)$  distributions are shown in Fig. 4(b) for the  $Y(5S)$  and continuum data samples. As expected,  $J/\psi$  production in the continuum region  $x(J/\psi) > 0.5$  is smaller than in the low  $x(J/\psi)$  region where  $B$  and  $B_s$  mesons can contribute.

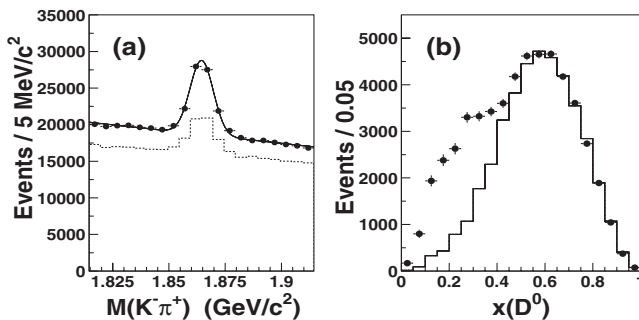


FIG. 3. The  $D^0$  signal in the region  $x(D^0) < 0.5$  (a) and the  $D^0$  normalized momentum  $x(D^0)$  (b).

The difference of these distributions in the region  $x(J/\psi) < 0.5$  is corrected for efficiency to obtain the inclusive  $J/\psi$  spectrum in  $b\bar{b}$  events. Using the PDG value  $\mathcal{B}(J/\psi \rightarrow \mu^+ \mu^-) = (5.88 \pm 0.10)\%$  [12], the inclusive branching fraction  $\mathcal{B}(Y(5S) \rightarrow J/\psi X)/2 = (1.030 \pm 0.080 \pm 0.067)\%$  is obtained. Systematic uncertainties are similar to those in the  $D_s$  analysis and are dominated by the uncertainty on the number of  $b\bar{b}$  events. The  $Y(5S)$  branching fraction can be compared with  $\mathcal{B}(B \rightarrow J/\psi X) = (1.094 \pm 0.032)\%$  [12], because the inclusive  $J/\psi$  production rates in  $B$  and  $B_s$  decays are expected to be approximately equal. Conversely, assuming the equality of inclusive  $J/\psi$  branching fractions in  $B$  and  $B_s$  decays, we can obtain the number of  $b\bar{b}$  events. This cross-check can be important for future large statistics  $Y(5S)$  measurements.

In conclusion, the inclusive production of  $D_s$ ,  $D^0$ , and  $J/\psi$  mesons has been studied in  $e^+e^-$  collisions at the  $Y(5S)$  energy. The precise measurement of  $\mathcal{B}(Y(5S) \rightarrow D_s X)$  and  $\mathcal{B}(Y(5S) \rightarrow J/\psi X)$  branching fractions are performed. Clear evidence of sizable  $B_s$  production is observed. The fraction of  $B_s^{(*)}\bar{B}_s^{(*)}$  events among all  $b\bar{b}$  events produced at the  $Y(5S)$  energy is determined from the inclusive  $D_s$  and  $D^0$  analyses to be  $f_s = (17.9 \pm 1.4 \pm 4.1)\%$  and  $f_s = (18.1 \pm 3.6 \pm 7.5)\%$ , respectively. Combining these two  $f_s$  measurements and taking into account the anticorrelated systematic uncertainty due to the number of  $b\bar{b}$  events, the value  $f_s = (18.0 \pm 1.3 \pm 3.2)\%$  is obtained. This measurement agrees with the CLEO value of  $f_s = (16.0 \pm 2.6 \pm 5.8)\%$  [8], but has a total relative uncertainty that is a factor of 2 smaller. The  $B_s$  production rate over all  $b\bar{b}$  events at the  $Y(5S)$  is somewhat larger than the fraction of  $B_s$  mesons produced from the  $\bar{b}$  quark in  $Z \rightarrow b\bar{b}$  decays at LEP,  $\mathcal{B}(\bar{b} \rightarrow B_s) = (10.2 \pm 0.9)\%$  [12]. The large  $f_s$  value measured here indicates very good potential for future  $B_s$  studies at high luminosity asymmetric-energy  $B$  factories running at the  $Y(5S)$  resonance.

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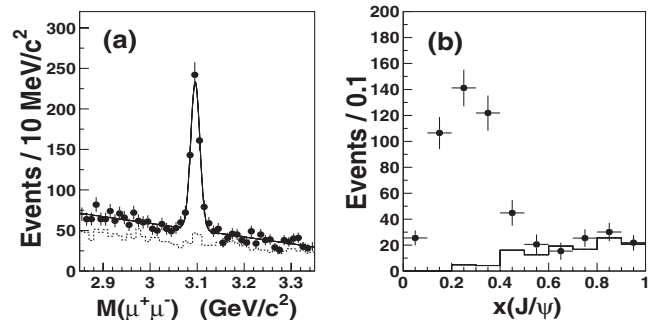


FIG. 4. The  $J/\psi$  signal in the region  $x(J/\psi) < 0.5$  (a) and the  $J/\psi$  normalized momentum  $x(J/\psi)$  (b).

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