BOTTOMIUM PRODUCTION AND B_S^0 MIXING AT THE DØ EXPERIMENT *

THORSTEN KUHL

Universität Mainz,
Insitut für Physik
Staudingerweg 7,
55120 Mainz, Germany
E-mail: Thorsten.Kuhl@uni-mainz.de

The observation of the $X(3872)$ in the $J/\Psi\pi^+\pi^-$ channel, with J/Ψ decaying to $\mu^+\mu^-$, in $p\bar{p}$ collisions at $\sqrt{s} = 1.96\,\mathrm{GeV}$ [1] is reported. Using approximately $230\,\mathrm{pb}^{-1}$ of data collected with the DØ detector we observe 522 ± 100 candidates, which have a similar production and decay characteristics as the $\Psi(2S)$. The measurements of the inlcusive production cross section of the $\Upsilon(1S)$ using the $\Upsilon(1S) \to \mu^+\mu^-$ decay mode for a data sample of $160\,\mathrm{pb}^{-1}$ is presented [2]. The first direct two-sided bound on the B_s^0 oscillation frequency using a large sample of B_s^0 semileptonic decays in the decay channel $B_s^0 \to \mu^+ D_s^- X, D_s^- \to \phi\pi^-, \phi \to K^+K^-$ corresponding to an intgrated luminosity of $1\,\mathrm{fb}^{-1}$ is presented [3]. A likelihood scan over the oscillation frequency Δm_s gives a most probable value of $\Delta m_s = 19\,\mathrm{ps}^{-1}$ with a range of $17\,\mathrm{ps}^{-1} < \Delta m_s < 21\,\mathrm{ps}^{-1}$ at 90% C.L..

1. Introduction

The DØ experiment [4] is a ideal place to study B-physics. Especially final states including muons are easily to access using the muon system with a angular accepance up to $|\eta| = 2.0$. The measurement of bottomium final states using only about one fifth of the data and the observation of B_s^0 mixing using the full data set of about $1\,\mathrm{fb}^{-1}$ are presented.

2. Measurement of inclusive differential cross section for $\Upsilon(1S)$ production

For the selection two scintilator based muon are required at the trigger level 1. One of these muons has to be confirmed at the level 2 stage. Further two

*This work is supported by the Bundesministerum für Bildung und Forschung, Förderkennzeichen 05HF4UMA/4

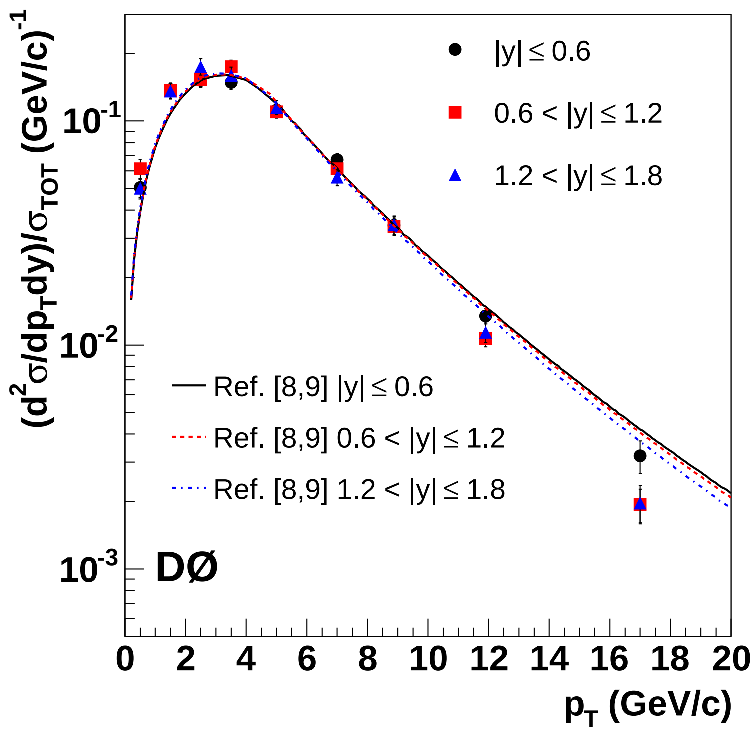

Figure 1. Normalized differential cross sections vs p_t for the $\Upsilon(1S)$ production compared with theory predictions.

isolated muons with a transverse momentum of at least 3 GeV and $|\eta| < 2.2$ are demanded. This leads to an $\Upsilon(1S)$ sample of 46625 ± 939 events for $\eta < 1.8$ using an integrated luminosity of 159pb^{-1}. The cross section for $|\eta| < 0.6$ was measured to $732 \pm 19\,(\text{stat}) \pm 73\,(\text{syst}) \pm 48\,(\text{lumi})\,\text{pb}$. This agrees well with earlier CDF measurements. The ratio of the cross section for $0.6 < \eta < 1.2$ and $1.2 < \eta < 1.8$ to that for the $|\eta| < 0.6$ region was measured to 1.04 ± 0.14 and 0.8 ± 0.11 compared to the Monte Carlo prediction of 0.93 and 0.84. The differential cross section for different p_T bins shown in Figure 1 also agrees well with the theoretical prediction [5,6].

3. Observation and Properties of the X(3872)

The X(3872) was observed in the $X(3672) \to J/\Psi\pi^+\pi^-$ $J/\Psi \to \mu^+\mu^-$ channel using an integrated luminosity of $230\,\text{pb}^{-1}$. The sample consists of

522 ± 100 events and the mass difference between the X(3872) and J/Ψ was measured to $\Delta m = 774.9 \pm 3.1(\text{stat})\,\text{GeV}/c^2$. When the data were seperated according to production and decay variables no significant differences between the X(3872) and the $c\bar{c}$ state $\Psi(2S)$ were found.

4. B_s^0 mixing measurement

The phenomenon of $B_d^0 - \bar{B}_d^0$ meson oscillation is well established with a precise measured oscillation frequency Δm_d Since the CKM matrix element V_{ts} is larger than V_{td} the expected frequency Δm_s of $B_s^0 - \bar{B}_s^0$ oscillation is higher. If the Standard Model is correct and if information from current measurements of B_s^0 are not included, the global fits to the unitarity triangle favor $\Delta m_s = 20.9^{+4.5}_{-4.2}\,\text{ps}^{-1}$ [7].
The data corresponds to approximal 1fb^{-1}. No explicit trigger requirement was made, although most of the sample was collected with a single muon trigger. For the measurement, first the full decay chain was reconstructed. After loose preselection cuts a likelihood ratio selection method was used to further improve the B_s^0 signal selection. To construct the pdf functions of the discriminating variables, background sidebands and sideband-substracted signal was used. The variables include D_s^- properties as well as global event properties like the isolation of the B_s decay products. 26710 ± 556 candidates were selected with a signal to background ratio of about two to one.
Afterwards the initial state tagging was performed with a combined opposite flavor tagger d_{tag}using μ, jet charge and event charge information. The dilution was calculated eventwise. The effciency ϵ of the tagging procedure is 20.9% while the overall tagging power is $\epsilon D^2 = 2.48 \pm 0.24\%$. The correction of the missing neutrino momentum was done with a K-function which depends on the reconstructed mass x_{mb}.

The probability that an event is oscillated/ not oscillated depending on visual proper decay length l, the K-function and the tagging d_{tag} is:

$$p^{osc./not\ osc.} = \frac{1}{2}\frac{K}{c\tau_{B_s^0}} \exp - \frac{K}{c\tau_{B_s^0}}[1 \pm d_{tag}\cos(\Delta m_s \times \frac{Kl}{c})$$

For the B_s lifetime $\tau_{B_s^0}$ the world average was used. Figure 2 shows the likelihood function for different Δm_s values using this equation. The minimum at $19\,\text{ps}^{-1}$ indicates a oscillation frequency of $17 < \Delta m_s < 21\text{ps}^{-1}$ at 90% convidence level. Using 1000 parametrized Monte Carlo samples with similar statistics, it was determined that for a true value of $\Delta m_s = 19\,\text{ps}^{-1}$ the probablity was 15% for measuring a value in the $17 < \Delta m_s < 21\text{ps}^{-1}$ range with a $-\Delta \log L$ lower by at least 1.9 than the corresponding value at

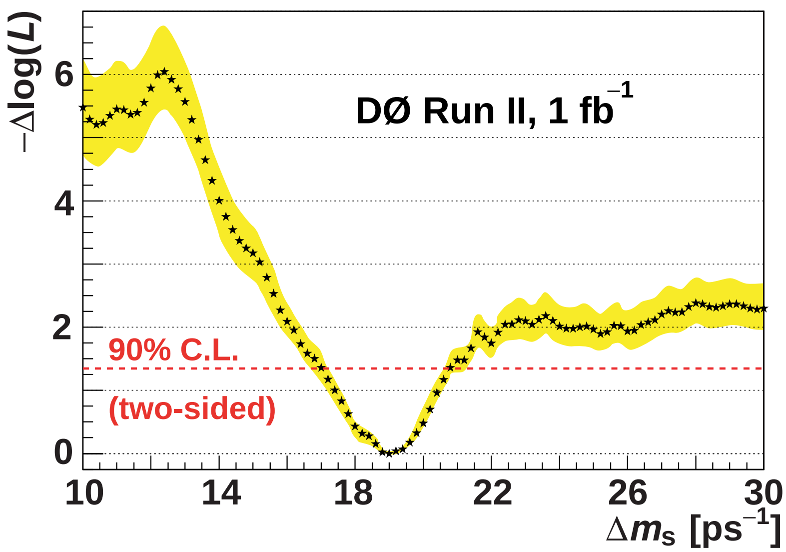

Figure 2. Value of $-\Delta \log L$ as a function of oscillation frequency Δm_s. Stars do not include systematc uncertancies, and the shaded band represents the envelope of all $\log L$ scan curves of different systematic uncertancies

$25\,\mathrm{ps}^{-1}$. The plateau of the likelihood arround this value ($25\,\mathrm{ps}^{-1}$) shows that the experiment does not have suffcient resolution to measure an oscillation for such high Δm_s values.

In summary,a study of $B_s^0 - \bar{B}_s^0$ oscillation was performed using $B_s^0 \to \mu^+ D_s X$ decays. The likelihood curve prefers a value of $19\,\mathrm{ps}^{-1}$ while oscillation frequencies of less than $14.8\,\mathrm{ps}^{-1}$ are excluded by 95% C.L. This result agrees well with the oscillation frequency published by the CDF experiment of $\Delta m_s = 17.31^{-0.33}_{+0.18}(\mathrm{stat}) \pm 0.07\,(\mathrm{syst}) ps^{-1}$ a few months later [8].

References

1. V. M. Abazov *et al.* [D0 Collaboration], Phys. Rev. Lett. **93** (2004) 162002.
2. V. M. Abazov *et al.* [D0 Collaboration], Phys. Rev. Lett. **94** (2005) 232001.
3. V. M. Abazov *et al.* [D0 Collaboration], Phys. Rev. Lett. **97** (2006) 021802
4. V. M. Abazov *et al.* [D0 Collaboration], "The upgraded DØ detector,", arXiv:physics/0507191.
5. E. L. Berger, J. w. Qiu and Y. l. Wang, Phys. Rev. D **71** (2005) 034007
6. E. L. Berger, J. W. Qiu and Y. Wang, Int. J. Mod. Phys. A **20** (2005) 3753
7. J. Charles *et al.* [CKMfitter Group], Eur. Phys. J. C **41** (2005) 1
8. A. Abulencia [CDF - Run II Collaboration],arXiv:hep-ex/0606027.