FERMILAB-CONF-06-348-E
CDF/PUB/BOTTOM/PUBLIC/8494
September 26, 2006

Rare Decays of Heavy Flavor at the Tevatron

V. Krutelyov
(On behalf of CDF and DØ Collaborations)

Department of Physics, UCSB, Santa Barbara, CA 93105
slava77@fnal.gov

Abstract. In this report I review recent results in the field of rare decays at the Tevatron CDF II and DØ experiments. The presentation is focused on rare decays of charm and bottom mesons with two muons in the final state. This includes improvements over the previously available limits on the following branching ratios: $\mathscr{B}(D^+ \to \pi^+\mu^+\mu^-) < 4.7\times10^{-6}$, $\mathscr{B}(B_s^0 \to \phi\mu^+\mu^-) < 3.2\times10^{-6}$, $\mathscr{B}(B_s^0 \to \mu^+\mu^-) < 1\times10^{-7}$, and $\mathscr{B}(B_d^0 \to \mu^+\mu^-) < 3\times10^{-8}$ all at the 90% confidence level. Also reported are the first direct observation of $D_s^+ \to \phi\pi^+ \to \mu^+\mu^-\pi^+$ with a significance above background of over 7 standard deviations and evidence of $D^+ \to \phi\pi^+ \to \mu^+\mu^-\pi^+$ with a significance of 3.1 and $\mathscr{B}(D^+ \to \phi\pi^+ \to \mu^+\mu^-\pi^+) = (1.75\pm0.7\pm0.5)\times10^{-6}$.

Keywords: Heavy flavor, rare decays, Flavor Changing Neutral Current, Supersymmetry; CDF II, DØ
PACS: 11.30.Pb, 12.15.Mm, 12.60.Jv, 13.20.-v, 13.20.Fc, 13.20.He, 13.85.Qk, 14.40.Lb, 14.40.Nd

1. INTRODUCTION

Historically, rare decays of hadrons have been one of the main interests in the program of high energy physics (further information on this subject can be found in Refs. [1, 2, 3, 4]). Decays with substantially low rates (typically with branching ratios below 10^{-5}), rare decays, not only correspond to properties and conservation laws of the Standard Model (SM), but also provide an invaluable tool in defining or limiting models of the New Physics (NP). Owing to the mass hierarchy of quarks and specifics of the quark mixing in the SM, described by the Cabibbo-Kobayashi-Maskawa (CKM) matrix, rare decays of heavy flavor hadrons are of the most interest.

Based on a final state rare decays can be classified as charmless hadronic, radiative, and leptonic. Here I focus on leptonic decays with two muons in the final state, corresponding to Flavor Changing Neutral Currents (FCNCs).

The FCNCs are suppressed and appear only at the loop level in the SM and vanish in the limit of zero quark masses (Glashow-Iliopoulos-Maiani or GIM mechanism). Suppression of the FCNCs is a paramount property of any viable NP model. Specific to flavor, the FCNCs correspond to $b \to s(d)$ and to $c \to u$ transitions for the bottom and charm decays respectively. While excellent agreement of the SM and experiment in processes like $b \to s\gamma$, $b \to sl^+l^-$, and $K \to \pi\nu\bar{\nu}$ already constrains many NP models, further knowledge on FCNC decays is needed in search for the NP.

Having a high experimental sensitivity to rare decays of heavy flavor mesons requires ability to produce a large number of such mesons as well as to effectively discriminate the signal from backgrounds. Bottom and charm mesons can be produced in abundance both at the e^+e^- B- or charm factories and at the hadron colliders, like the Tevatron. Although the production rates of the heavy flavor are higher at the Tevatron than at the e^+e^- flavor factories by far more abundant light flavor production puts the Tevatron on a similar level of sensitivity. Ability to produce all flavors puts the Tevatron on the forefront in rare decays of hadrons not easily accessible at B-factories, like B_s^0 or Λ_b.

Recent results reported by the CDF and DØ are presented below. I begin with highlights of detector features and common analysis methods. I then overview particular searches: for $D^0 \to \mu^+\mu^-$ at CDF II and for $D^+ \to \pi^+\mu^+\mu^-$ at DØ; for $B_s^0 \to \phi\mu^+\mu^-$ at DØ, and for $B_{s(d)}^0 \to \mu^+\mu^-$ at both experiments. This is followed by a brief conclusion.

2. DETECTORS AND COMMON APPROACH TO RARE DECAY SEARCH

The collider detectors a the Tevatron, CDF II and DØ, described elsewhere [5, 6], are general purpose detectors each having parts with similar functions. Relevant to the analyses presented here are the tracker immersed in the solenoidal field used for precision momentum measurement of charged particles; the silicon vertex detector used to effectively select displaced vertices characteristic to decays of heavy flavor; and the muon detectors (located behind calorimeters and additional steel absorbers) used to identify muons. Rapidity and momentum coverage for muons are $|\eta| \lesssim 2(1)$ and $p_T \gtrsim 3(1.5)$ GeV/c for DØ (CDF II). Better rapidity acceptance and higher quality of the muon identification in

DØ is levered by better tracking precision and lower momentum thresholds for muons at CDF II, which allows both experiments to perform at a similar level in searches for exclusive decays like $H_{b(c)} \to \mu^+\mu^- + X$.

High purity of dimuon selection allows both experiments to effectively trigger on dimuon events, which constitute the dimuon samples used to analyze the rare decays. In addition to the dimuon triggers, the CDF employs the displaced (two-) track trigger which allows to select heavy flavor decays based on the tracks of the decays products alone.

The analyses presented here employ a relative normalization, where an abundant mode ($H_y \to Y$) is used to estimate the rate of a rare mode ($H_x \to X$) collected in the same sample. The branching ratio of the rare mode is given by

$$\mathscr{B}(H_x \to X) = \mathscr{B}(H_y \to Y)\frac{N_X}{N_Y}\frac{\varepsilon_Y}{\varepsilon_X}\frac{f_y}{f_x},$$

where $N_{X(Y)}$ is the number of events or an upper limit in the rare (normalization) mode; ε_X is the total efficiency, a fraction of observed $H_x \to X$ events relative to all such events produced (same for ε_Y); $f_{x(y)}$ is the relative production fraction of $H_{x(y)}$. A benefit of this approach is that if kinematics of both modes is similar, a large part of the systematic uncertainty cancels in the ratio.

The strategy of the analyses is the following. First, pick dimuon events passing baseline selections, like a noticeable momentum to expect a displaced decay vertex and a set of quality requirements to muons and the decay vertex. This gives a sample with an order of $10^3 - 10^4$ events completely dominated by background.[1] At this point the events with mass near the signal meson mass are hidden and the optimal choice of cuts is based on events in the sidebands used to predict backgrounds in the signal region and the signal itself is modeled using the Monte Carlo (MC) simulation. Once the optimization is done events in the signal window are uncovered and the limit on the branching ratio is set.

3. RARE DECAYS OF CHARM MESONS

The c-FCNCs in the SM correspond to the loop diagrams with $\{d,s,b\}$ in the loop where the contribution from non-vanishing s-quark mass dominates. The GIM suppression works in this case due to small masses of d- and s- quarks and a CKM suppression of b-quark contribution. As a result the rare decays are dominated by long distance interactions (ϕ or other internal resonance decays to $\mu^+\mu^-$) [3]. The c-FCNCs can be enhanced in the NP models to rates as high as the present experimental sensitivity. A search for $D^0 \to \mu^+\mu^-$ at CDF II [7] and a search for $D^+ \to \pi^+\mu^+\mu^-$ recently reported by the DØ [8] are reviewed briefly below.

3.1. Search for $D^0 \to \mu^+\mu^-$ at CDF II

The branching ratio of the $D^0 \to \mu^+\mu^-$ in the SM is about 10^{-13} (the short distance contribution is only about 10^{-19}) [3, 7], which in addition to the GIM suppression also has a helicity suppression factor of $(m_\mu/m_D)^2$. This value is substantially lower than experimental limits of about 10^{-6} (including the most recent measurements [9]).

A search for $D^0 \to \mu^+\mu^-$ decay was performed at CDF II using 68 pb^{-1} [7] with normalization to $D^0 \to \pi^+\pi^-$ ($\mathscr{B} \sim 1.4\times10^{-3}$) with events from the two-track trigger sample. The data with reconstructed $\mu^+\mu^-$ in the region within 22 MeV$/c^2$ (2σ) of the mass of D^0 were hidden during the optimization. Two backgrounds contributed in this case: combinatorial (estimated from the high-mass sideband) and mis-identification of $D^0 \to \pi^+\pi^-$ as $D^0 \to \mu^+\mu^-$.

To discriminate signal from background the following variables were used: azimuthal angle between the extrapolated positions of the tracks at muon chambers ($\Delta\phi$), impact parameter of the candidate (d_{xy}) and its decay length projected onto its transverse momentum (L_{xy}) both in the plane transverse to the beam. Values of the cuts where chosen to maximize $S/(1.5+\sqrt{N_{\rm bgd}})$, where $S(N_{\rm bgd})$ is the number of signal (background) events corresponding to the best limit at 99.7% confidence level (C.L.). The optimization yields[2]: $|\Delta\phi| > 0.085$, $|d_{xy}| < 150$ μm, and $L_{xy} < 0.45$ cm.

After applying the optimal requirements 5 events are left in the high-mass dimuon sideband and 1412 ± 54 events are observed in $D^0 \to \pi^+\pi^-$ mode, which corresponds to expected $N_{\rm bgd}$ of $(1.6\pm0.7)_{\rm comb.} + (0.22\pm0.02)_{\rm mis-id.} = 1.8\pm0.7$. No events were observed in the data, corresponding to the upper limit of 2.5×10^{-6} at 90% C.L. This

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[1] The potential sources of combinatorial background are sequential semileptonic $b \to c \to s$ decays, double semileptonic $bb \to \mu^+\mu^- X$ decays, and events with charged particles mis-identified as muons (fake muons).

[2] Note that at the trigger level the candidates are required to have $L_{xy} > 200$ μm.

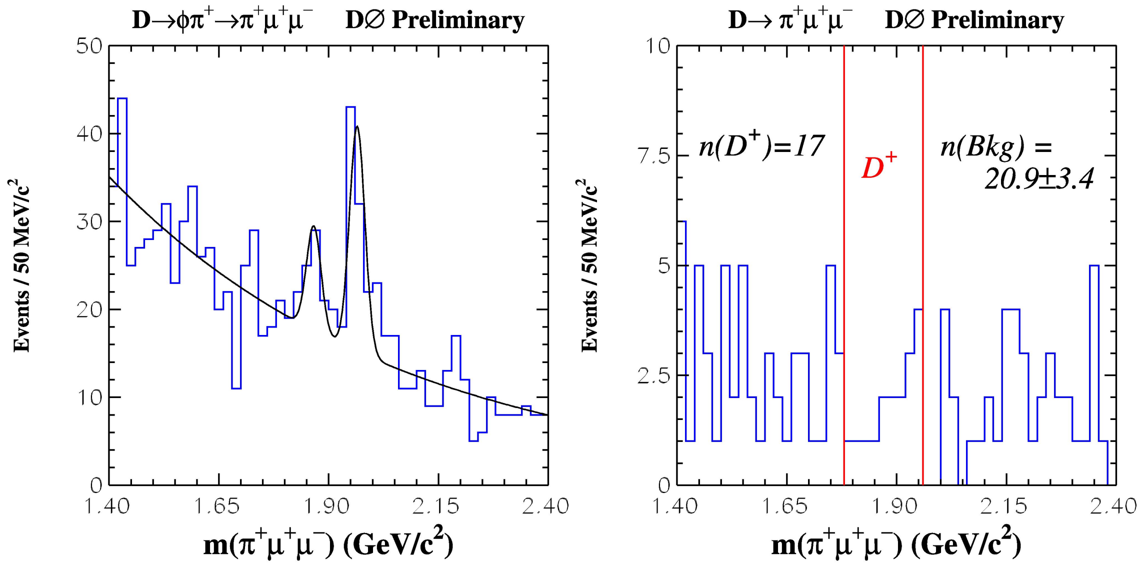

FIGURE 1. The $m_{\pi^+\mu^+\mu^-}$ mass spectrum for the optimized on-resonance (left) and off-resonance (right) selection criteria. The curve on the left plot is the result of the fit to contributions from D^+, D_s^+, and combinatoric backgrounds.

measurement was superseded by a limit of 1.3×10^{-6} at 90% C.L. reported in Ref. [9]. With more than 1 fb^{-1} of data collected by CDF II a substantial improvements to the limit is expected with an updated analysis.

3.2. Search for $D^+ \to \pi^+\mu^+\mu^-$ at DØ

Decays of D^+ and D_s^+ to $\mu^+\mu^-h^+$, where h is a kaon or a pion, are driven by long distance interactions in the SM. Their branching ratios in the SM range from 6.1×10^{-6} for $D_s^+ \to \pi^+\mu^+\mu^-$, and 1×10^{-6} for $D^+ \to \pi^+\mu^+\mu^-$ to 7.1×10^{-9} for $D^+ \to K^+\mu^+\mu^-$, with significant short-distance FCNCs only in $D^+ \to \pi^+\mu^+\mu^-$ ($\mathscr{B} \sim 9.4 \times 10^{-9}$) and $D_s^+ \to K^+\mu^+\mu^-$ ($\mathscr{B} \sim 9 \times 10^{-10}$) [8]. Previous searches for these modes reveal limits of the order of 10^{-5}.

A search for short-distance (off ϕ-resonance) decay $D^+ \to \pi^+\mu^+\mu^-$ was done by DØ using 1 fb^{-1} of data [8]. The analysis was performed in two stages: the branching ratio of $D^+ \to \pi^+\mu^+\mu^-$ on ϕ resonance (with $0.96 < M_{\mu\mu} < 1.06$ GeV$/c^2$) was measured first normalized to $D_s^+ \to \pi^+\mu^+\mu^-$; then the $D^+ \to \pi^+\mu^+\mu^-$ off ϕ resonance was searched for normalized to the resonant part. The data sample was collected using the dimuon trigger.

The following variables were used to discriminate signal from background. Decay vertex significance, S_D, and significance of the impact parameter of the pion track, S_π, both in the plane transverse to the beam. Collinearity or angle between the D-candidate momentum and the vertex displacement from the beamline, Θ_D. Track isolation of the candidate, $I_D = p(D)/\sum p$, where the sum is over tracks with $\Delta R \equiv \sqrt{\Delta\eta^2 + \Delta\phi^2} < 1$ relative to the candidate momentum. Quality of the candidate, $\mathscr{M} = \chi^2_{\rm vtx} + 1/p^2_{T,\pi} + \Delta R^2_\pi$, where $\chi^2_{\rm vtx}$ is for the fit to the decay vertex, $p_{T,\pi}$ is a transverse momentum of the pion in GeV$/c$, and ΔR_π is the distance of the pion track from the dimuon system.

The optimization of these cuts was performed to maximize $\varepsilon/(0.82 + \sqrt{N_{\rm bgd}})$, where ε is the signal efficiency (relative to preselections of $I_D > 0.4$, $S_D > 3$, $S_\pi > 0.5$, and $\Theta_D < 50$ mrad), which corresponds to the maximum expected upper limit at 90% C.L.. The cuts chosen as a result of the optimization are $I_D > 0.44(0.71)$, $S_D > 3.4(9.4)$, $S_\pi > 0.57(1.8)$, $\Theta_D < 32(7)$ mrad, and $\mathscr{M} < 6.1(2.6)$ for the on-resonance (off-resonance) measurement.

The D-candidate mass spectra for on- and off-resonance after the optimal selections are shown in Fig. 1. For the on-resonance case the fit yields 65 ± 11 D_s^+ events and 26 ± 9 D^+ events, which corresponds to about 7σ and 3.1σ significance for D_s^+ and D^+ respectively. The corresponding measurement is $\mathscr{B}(D^+ \to \phi\pi^+ \to \mu^+\mu^-\pi^+) = (1.75 \pm 0.7 \pm 0.5) \times 10^{-6}$, consistent with simple factorization of two sequential decays, and can be compared to the recent CLEO-c measurement of $(2.7\,^{+3.6}_{-1.8} \pm 0.2) \times 10^{-6}$. Off-resonance, the number of observed events in the signal window is 17 consistent with $N_{\rm bgd} = 20.9 \pm 3.4$, corresponding to $\mathscr{B}(D^+ \to \pi^+\mu^+\mu^-) < 4.7 \times 10^{-6}$ at 90% C.L.

4. RARE DECAYS OF BOTTOM MESONS

Rates of the b-FCNCs in the SM are higher than of the similar c-FCNCs and some are within the present experimental sensitivity, like $b \to s\gamma$ and $b \to sl^+l^-$ in B^+ and B^0 decays [1]. This is because the GIM suppression is not effective due to the top-quark in the loop. In the NP models the b-FCNCs can be enhanced by large factors. The results of searches for $B_s^0 \to \phi\mu^+\mu^-$ at DØ and for $B_{s(d)}^0 \to \mu^+\mu^-$ at both experiments are discussed below.

4.1. Search for $B_s^0 \to \phi\mu^+\mu^-$ at DØ

In the SM, the rate of the $B_s^0 \to \phi\mu^+\mu^-$, neglecting the interference effects with $B_s^0 \to J/\psi\phi$ ($\mathscr{B} \sim 6 \times 10^{-5}$ [2]) and $B_s^0 \to \psi(2S)\phi$ ($\mathscr{B} \sim 4 \times 10^{-6}$ [2]) resonant decays, is predicted to be about 1.6×10^{-6} [10]. The previously published limit of $\mathscr{B}(B_s^0 \to \mu^+\mu^-\phi) < 6.7 \times 10^{-5}$ at 95% C.L. comes from CDF I. This decay is related to $b \to sl^+l^-$ transition and by its properties is similar to the observed $B_d^0 \to K^\star l^+l^-$ ($\mathscr{B} = (1.46 \pm 0.25) \times 10^{-6}$ [2]). Observation of $B_s^0 \to \phi\mu^+\mu^-$ and analysis of its kinematics will add important information on the flavor dynamics of b-FCNCs.

The DØ Collaboration has performed a search for $B_s^0 \to \phi\mu^+\mu^-$ using 0.45 fb^{-1} [10] with $B_s^0 \to J/\psi\phi$ used for normalization. The events were collected from the dimuon trigger sample in the range of $0.5 < M_{\mu\mu} < 4.4$ GeV$/c^2$ and with the ϕ-candidate mass within $1008 < m_\phi < 1032$ MeV$/c^2$. With an addition of a good decay vertex and $p_T^B > 5$ GeV$/c$ requirements this defined the baseline sample of 2602 events. At this point the events in the signal window within 188 MeV$/c^2$ (2.5σ) from the world-average $m_{B_s^0}$ were hidden from the optimization. The $B_s^0 \to J/\psi\phi$ events are required to pass the same cuts as the signal except for the dimuon mass to be consistent with J/ψ. In the signal mode events with $2.72 < M_{\mu\mu} < 4.06$ GeV$/c^2$ corresponding to charmonium resonances were removed.

The following variables were used to further discriminate signal from background with values chosen to maximize $\varepsilon/(1+\sqrt{N_{\rm bgd}})$ (corresponding to the best limit at 95% C.L.), where ε is the signal efficiency relative to the baseline selections. Collinearity or pointing angle between the candidate momentum and the displacement of the decay vertex from the beamline, Θ_B. Significance of the candidate decay length, S_B. The track isolation, $I_B = p_B/(p_B + \sum p)$, where the sum is taken over non-candidate tracks momenta with $\Delta R < 1$ relative to the direction of the candidate momentum p_B. The optimal cuts were shown to be: $S_B > 10.3$, $I_B > 0.72$, and $\Theta_B < 0.1$ rad.

In the data $73 \pm 10 \pm 4$ and zero events pass the optimal selections in $B_s^0 \to J/\psi\phi$ and the signal modes respectively with an expected $N_{\rm bgd}$ of 1.6 ± 0.4 and $\varepsilon \approx 54\%$. The resulting limit is $\mathscr{B}(B_s^0 \to \phi\mu^+\mu^-) < 3.2 \times 10^{-6}$ at 90% C.L., which is only about a factor of two above the SM value and is substantially better than the previously published limit.

4.2. Search for $B_{s(d)}^0 \to \mu^+\mu^-$

In the SM, the branching ratio of B_s^0 (B_d^0) decay to $\mu^+\mu^-$ is about 4×10^{-9} (1×10^{-10}) [4], which is helicity-suppressed by a factor of $(m_\mu/m_B)^2$. Compared to the $B_s^0 \to \mu^+\mu^-$, the $B_d^0 \to \mu^+\mu^-$ mode is further suppressed by a factor of $(V_{td}/V_{ts})^2 \sim 0.04$. The present experimental sensitivity to $B_s^0 \to \mu^+\mu^-$ of about 10^{-7} already becomes important in constraining NP scenarios. In the MSSM with large $\tan\beta$ the dominant contribution is from a heavy neutral Higgs exchange (proportional to $\tan^6\beta/m_H^4$), which, considering other constraints, can be as large as the current sensitivity. Observation of the $B_s^0 \to \mu^+\mu^-$ at the Tevatron would be an unequivocal indication of the NP.

The DØ reported a search for $B_s^0 \to \mu^+\mu^-$ using 300 pb^{-1} (the first sample) [11], and a sensitivity study using additional 400 pb^{-1} (the second sample) [12]. The CDF reported results based on 780 pb^{-1} [13], using the method as in the previous study detailed in [4]. Both experiments used dimuon trigger samples and normalized to $B^+ \to J/\psi K^+$.

4.2.1. Search for $B_s^0 \to \mu^+\mu^-$ at DØ

With a dimuon mass resolution near B_s^0 mass of about 90 MeV$/c^2$ B_s^0 and B_d^0 can not be separated. Thus, assuming the contribution from B_d^0 is small, the search is targeted on B_s^0. The preselection of B_s^0 candidates is made from dimuon events with $4.53 < M_{\mu\mu} < 6.15$ GeV$/c^2$ and each muon with $p_T > 2.5$ GeV$/c$. The candidates are required to have a good decay vertex and $p_T^B > 5$ GeV$/c$. These selections leave about 4×10^4 events in the first sample (slightly more in the second sample). At this point events within 270 MeV$/c^2$ from B_s^0 mass are hidden from the optimization procedure.

The cuts on variables S_B, Θ_B, and I_B are chosen to maximize $\varepsilon/(1+\sqrt{N_{\rm bgd}})$ (denoted as in Section 4.1). The optimal cuts for the first (second) data sample are: $I_B > 0.56(0.59)$, $S_B > 18.5(19.5)$, and $\Theta_B < 0.2(0.18)$ rad.

The events in the $B^+ \to J/\psi K^+$ normalization mode are required to pass the same selections as the signal mode, except for the dimuon mass to be consistent with J/ψ, and an addition of kaon track with $p_T > 0.9$ GeV/c.

After applying the optimal selections the number of $B^+ \to J/\psi K^+$ events is $741 \pm 31 \pm 22$ (899 ± 37) in the first (second) data sample. In the signal window within 180 MeV/c^2 from the B_s^0 mass the $N_{\rm bgd}$ is 4.3 ± 1.2 (2.2 ± 0.7) in the first (second) sample. In the signal region 4 events are observed in the first data sample, corresponding to $\mathscr{B}(B_s^0 \to \mu^+\mu^-) < 4 \times 10^{-7}$ at 95% C.L. The signal region in the second sample remains hidden pending a decision on improvements to the analysis. The expected limit using both samples is $\langle \mathscr{B}(B_s^0 \to \mu^+\mu^-) \rangle < 2.3 \times 10^{-7}$ at 95% C.L.

4.2.2. *Search for $B^0_{s(d)} \to \mu^+\mu^-$ at CDF II*

The baseline sample is selected from events with dimuon mass within $4.669 < M_{\mu\mu} < 5.969$ GeV/c^2 and each muon with $p_T > 2$ GeV/c. The B-candidates are required to have $p_T^B > 4$ GeV/c, rapidity in range $|y^B| < 1$, and a decay vertex displaced from the production vertex by 2σ. In addition the B-candidates are required to have a pointing angle (between the candidate momentum and the decay vertex displacement) in range $\Theta < 0.7$ rad and a track isolation ($I = p_T^B/(p_T^B + \sum p_T)$, where the sum is taken over non-candidate tracks with $\Delta R < 1$ relative to the momentum of the candidate) in range $I > 0.5$. At this point, out of 23066 events left, events with $5.169 < M_{\mu\mu} < 5.469$ GeV/c^2 (the signal window is ± 60 MeV/c^2 or 2.5σ around $m_{B_s^0}$ or $m_{B_d^0}$) are hidden from the optimization procedure.

The $B^+ \to J/\psi K^+$ events are required to pass the same baseline selections, except for the dimuon mass to be consistent with J/ψ, and the kaon track passing $p_T > 1$ GeV/c. After sideband subtraction and a small correction for $B^+ \to J/\psi \pi^+$, the number of $B^+ \to J/\psi K^+$ events is estimated to be 5763 ± 101, as shown in Fig. 2.

The following variables are used to discriminate signal from the background: I and Θ (defined above); and the proper lifetime of the candidate $\lambda = c(\vec{L} \cdot \vec{p}) M_{\mu\mu}/(\vec{p})^2$, where $\vec{L}$ is the displacement of the decay vertex. For a better discriminating power variables I, Θ, and $P(\lambda) \equiv \exp(-\lambda/c\tau_B)$ (where τ_B is the world average $B^0_{s(d)}$ lifetime) are combined into a likelihood ratio defined as $L_R = \prod P_s(x_i)/(\prod P_s(x_i) + \prod P_b(x_i))$, where $P_{s(b)}(x_i)$ is the probability for signal (background) of a variable x_i (one of the three). The optimal cut is chosen to minimize the expected upper limit on $\mathscr{B}(B^0_{s(d)} \to \mu^+\mu^-)$ at 90% C.L., and is found to be $L_R > 0.99$.

Two background contributions are considered: combinatorial and mis-identification. The mis-identification ($B \to hh^{(\prime)}$ reconstructed as $\mu^+\mu^-$) is irreducible and is estimated using the mis-identification rates (measured from data as in [7]) and assuming the same selection efficiency for $B \to hh^{(\prime)}$ and $B^0_{s(d)} \to \mu^+\mu^-$ (except for the mass selection).

After applying the optimal cut 1.1 ± 0.4 combinatorial background events are expected in the signal region, same for B_s^0 and B_d^0. The mis-identification background is 0.2 ± 0.1 events for B_s^0 and 1.4 ± 0.2 for B_d^0. In data 1 (2) events pass the optimal cut in the B_s^0 (B_d^0) signal window, as shown in Fig. 2, corresponding to $\mathscr{B}(B_s^0 \to \mu^+\mu^-) < 1.0 \times 10^{-7}$ and $\mathscr{B}(B_d^0 \to \mu^+\mu^-) < 3.0 \times 10^{-8}$ at 95% C.L. These results improve the previous results [14, 15] by a factor of two and can be used to reduce the allowed parameter space of a broad spectrum of SUSY models [4].

Both CDF and DØ limits on $B_s^0 \to \mu^+\mu^-$ can be combined as independent measurements to get a better limit [15]. With more data it is expected that the combined sensitivity would reach the level of 1×10^{-8} by the end of Run II [4], which would make the $B_s^0 \to \mu^+\mu^-$ mode a powerful probe in the search for the New Physics.

5. CONCLUSION

Study of rare decays of the heavy flavor is a substantial part of the program of the CDF II and DØ experiments. Owing to the high production cross section of all heavy flavor species in the $p\bar{p}$ collisions and to the efficient selection methods it is possible to study rare decays not available at other experiments as B-factories. With the continuously increasing amount of data provided by the Tevatron and improvements of the analyses the power of the experiments continues to grow allowing for some of the world best results. New results are available for FCNC decays in both charm and bottom sectors with substantial improvements in the following upper limits: $D^+ \to \pi^+\mu^+\mu^-$ ($\mathscr{B} < 4.7 \times 10^{-6}$ at 90% C.L.), $B_s^0 \to \phi\mu^+\mu^-$ ($\mathscr{B} < 3.2 \times 10^{-6}$ at 90% C.L.), and $B^0_{s(d)} \to \mu^+\mu^-$ ($\mathscr{B}(B_s^0 \to \mu^+\mu^-) < 1 \times 10^{-7}$ and $\mathscr{B}(B_d^0 \to \mu^+\mu^-) < 3 \times 10^{-8}$ at 90% C.L.) decays. In addition, $D_s^+ \to \phi\pi^+ \to \mu^+\mu^-\pi^+$ decay was observed with a significance over 7σ, and evidence of the decay of D^+ into the same final state was reported with a significance of

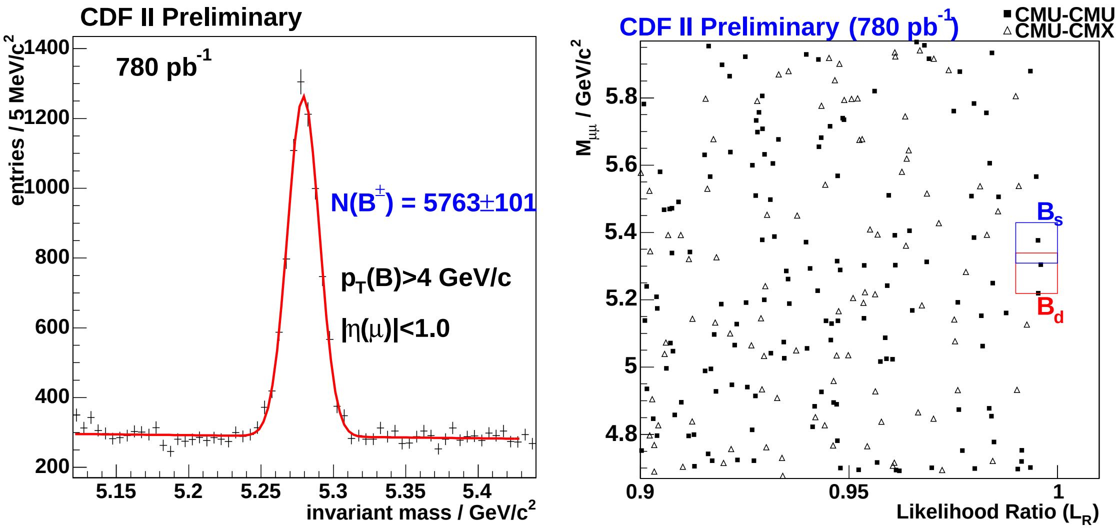

FIGURE 2. The mass spectrum for $B^+ \to J/\psi K^+$ candidate events (left), and the distribution of likelihood value versus dimuon mass for the $B^0_{s(d)} \to \mu^+\mu^-$ candidate events (right).

3.1σ and $\mathscr{B}(D^+ \to \phi\pi^+ \to \mu^+\mu^-\pi^+) = (1.75 \pm 0.7 \pm 0.5) \times 10^{-6}$. Improving sensitivity to $B^0_s \to \mu^+\mu^-$ makes this decay one of the most powerful probes of SUSY with large $\tan\beta$. These results provide new insight into the properties of the FCNC decays, which allows for improved tests of the SM and could ultimately guide us to the New Physics.

ACKNOWLEDGMENTS

I would like to thank the members of CDF and DØ Collaborations and especially the authors of the respective analyses. I would also like to thank the organizers of the conference for the opportunity to present results of these analyses.

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