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B_s, B_c and b-baryons

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Abstract. We present the latest measurements on masses, lifetimes and branching fractions for the B_s and B_c mesons as well as for b-baryons. For the B_s meson we discuss as well the latest results on mixing. These results were produced by the CDF and D0 experiments at Fermilab or by earlier LEP and PEPII experiments.

INTRODUCTION

In this paper we are reviewing recent results on the properties of heavy B mesons and baryons. These include mass, lifetime and branching fraction measurements. For the B_s meson we are also reviewing mixing. The majority of the experimental results reported in this review come from the CDF and D0 experiments at Fermilab recording $p\bar{p}$ collisions at $\sqrt{s}$ =1.96 TeV. Some of the reported results come as well from earlier e^+e^- experiments at LEP and PEPII.

This paper is organized as follows. In section 1 we report briefly on the performance of the Tevatron, the main features of the CDF and D0 detectors as well as their B physics data sets. In sections 2 and 3 we describe results on the B_s and B_c mesons respectively, and in section 4 we describe results on b-baryons. In section 5 we discuss conclusions and prospects.

1. TEVATRON AND THE CDF AND D0 DATA SAMPLES

From August 1992 to February 1996 (Run I) the CDF and D0 detectors collected data samples of approximately 110 pb^{-1} each of $p\bar{p}$ collisions at $\sqrt{s} = 1.8$ TeV. In Run I the crossing time was 3.5 μs for 6 bunches and the typical luminosity of order 10^{31} cm^{-2}sec^{-1}. Run II physics quality data started in March 2002. By September 2005, the Tevatron has delivered more than 1 fb^{-1} of data to each of the CDF and D0 detectors of $p\bar{p}$ collisions at $\sqrt{s} = 1.96$ TeV. In Run II the crossing time is 396 ns for 36 bunches and the typical luminosity so far of order 10^{32} cm^{-2}sec^{-1}.

For the B physics results reported here, CDF uses up to 360 pb^{-1} of data while D0 uses up to 490 pb^{-1} of data. These data sets are collected with three major trigger categories: dilepton triggers, single lepton triggers and triggers with displaced vertices. The dilepton triggers provide millions of J/ψ's, $\sim$ 80% of which come from b decays. The single lepton triggers provide a large sample of b-hadrons decaying semileptonically, and sample sizes of up to $\sim$ 100 thousand lepton plus D events are achieved. The trig-

TABLE 1. Summary of new B_s^0 lifetime results

	CDF J/ψ modes 240 pb^{-1}	**D0 J/ψ modes 220 pb^{-1}**	**CDF hadronic 360 pb^{-1}**	**D0 semileptonic 400 pb^{-1}**
$\tau(B_s^0)$ ps	1.369±0.100	1.444±0.096	1.598±0.097±0.017	1.420±0.043±0.057
$\tau(B_s^0)/\tau(B_d^0)$	0.890±0.072	0.980±0.073		

gers with displaced vertices provide a large number of b-hadrons decaying hadronically. From these samples several thousand of fully reconstructed hadronic b decays are obtained. At present only CDF implements this type of trigger.

2. THE B_S MESON

Mass and lifetime

Using 220 pb^{-1} of Run II data CDF was able to present the most precise individual measurements, to date, for the masses of B^+, B^0, B_s^0 and Λ_b^0 [1].These measurements were made with exclusively reconstructed final states containing a $J/\psi \to \mu^+\mu^-$, and the systematic uncertainties achieved for the B meson masses were of the order of one third of an MeV.

The B_s^0 mass measurement was made by reconstructing 185±13 signal events in the decay channel $B_s^0 \to J/\psi\phi$ where $\phi \to K^+K^-$, and the mass was measured to be $m(B_s^0) = 5366.01 \pm 0.73(\text{stat}) \pm 0.33(\text{syst})$ MeV/c^2. This measurement has better uncertainty than the current world average (WA).

The lifetime of b-hadrons is governed primarily by the decay of the b quark, however contributions from the spectator quarks can be up to $\sim$ 15%. Presently these spectator effects are mostly calculated in the framework of the Heavy Quark Expansion Theory [2]. Theory errors on the ratio of the B_s^0 and B_d^0 lifetimes is of the order of 1%.

A summary of new B_s^0 lifetime measurements by CDF and D0 is presented in Table 1. Using 400 pb^{-1} of Run II data taken with a single lepton trigger D0 performed the best available, to date, measurement of the B_s^0 lifetime (see Fig. 1(left) and Table 1). With 360 pb^{-1} of Run II data and triggering on displaced vertices CDF has measured for the first time the lifetime of B mesons using fully reconstructed hadronic decays like $B \to D\pi$ or $B \to D3\pi$; the small systematic error indicates a good control of the turn-on of the secondary vertex trigger efficiency (see Fig. 1(right) and Table 1). The winter 2005 HFAG WA for $\tau(B_s^0)$ was 1.479±0.044 *ps* for $B_s^0 \to D_s^+X$ decays and 1.404±0.066 *ps* for fully exclusive $B_s^0 \to J/\psi\phi$ decays [3].

B_s^0 Mixing

Within the framework of the standard model (SM), the B_s^0 mesons are supposed to mix in such a way that the mass and decay width differences between the heavy

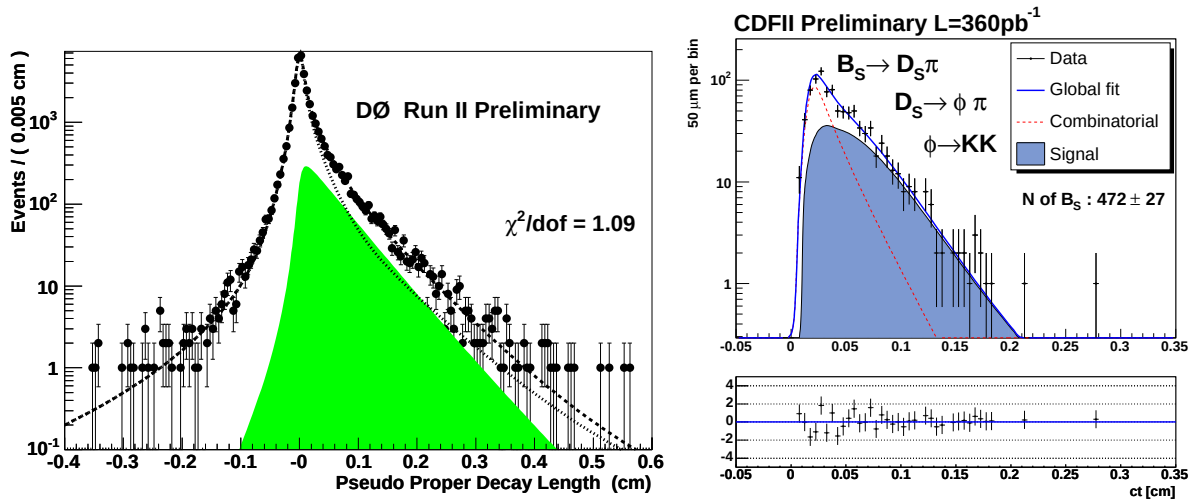

FIGURE 1. (left) D0 pseudo-proper decay length distribution for B_s^0 semileptonic data with the result of the fit superimposed. The dotted curve represents the combinatorial background and the filled histogram represents the B_s^0 signal. (right) The lifetime projection from the combined mass-lifetime fit on the $B_s^0 \to D_s^- \pi^+$ decay mode at CDF.

and light eigenstates, $\Delta m_s \equiv M_H - M_L$ and $\Delta\Gamma_s \equiv \Gamma_L - \Gamma_H$, are sizeable. The mixing phase $\delta\phi$ is small and to a good approximation the two mass eigenstates correspond to CP eigenstates. New phenomena may alter $\delta\phi$, leading to a reduction of the observed $\Delta\Gamma_s/\Gamma_s$ compared to the SM prediction. The frequency of the oscillation of the $B_s^0(B_d^0)$ flavor eigenstates into one another is proportional to the difference in mass between the two eigenstates and it is related to the CKM matrix element $|V_{ts}|(|V_{td}|)$.

Two different types of analyses have been performed so far to access B_s^0 mixing: the first one constrains Δm_s by measuring $\Delta\Gamma_s$ while the second one is fitting the amplitude of B_s^0 oscillations ($A(t) \sim D$ x $\cos(\Delta \mathrm{m_s t})$). The status of those two analyses will be discussed in the following subsections.

A measurement of both mixing frequencies Δm_d and Δm_s would yield a measurement of the ratio of the $|V_{td}|$ and $|V_{ts}|$ matrix elements, with a theoretical uncertainty of about 5%, thus providing a strong constraint in global fits of the Unitarity triangle. If Δm_s is too large to be directly measured, a measurement of $\Delta\Gamma_s$ could serve instead, along with Δm_d, in tests of the unitarity of the CKM matrix.

$\Delta\Gamma_s$

Within the standard model Δm_s and $\Delta\Gamma_s$ are related with the following theoretical relation [4]:

$$\frac{\Delta m_s}{\Delta\Gamma_s} \approx \frac{2}{3\pi}\frac{m_t^2}{m_b^2}(1-\frac{8}{3}\frac{m_c^2}{m_b^2})^{-1}h(\frac{m_t^2}{M_W^2}) \tag{1}$$

So, according to (1), measuring $\Delta\Gamma_s$ leads to Δm_s as well.

TABLE 2. Lifetimes and decay width difference for the heavy and light B_s^0 states

	$\Delta\Gamma_s/\overline{\Gamma}_s$	$<\tau>$ **ps**	τ_L **ps**	τ_H **ps**
CDF	$0.65^{+0.25}_{-0.33}$	$1.40^{+0.15}_{-0.13}$	$1.05^{+0.16}_{-0.13}$	$2.07^{+0.58}_{-0.46}$
D0	$0.21^{+0.33}_{-0.45}$	$1.39^{+0.15}_{-0.16}$	$1.23^{+0.16}_{-0.13}$	$1.52^{+0.39}_{-0.43}$

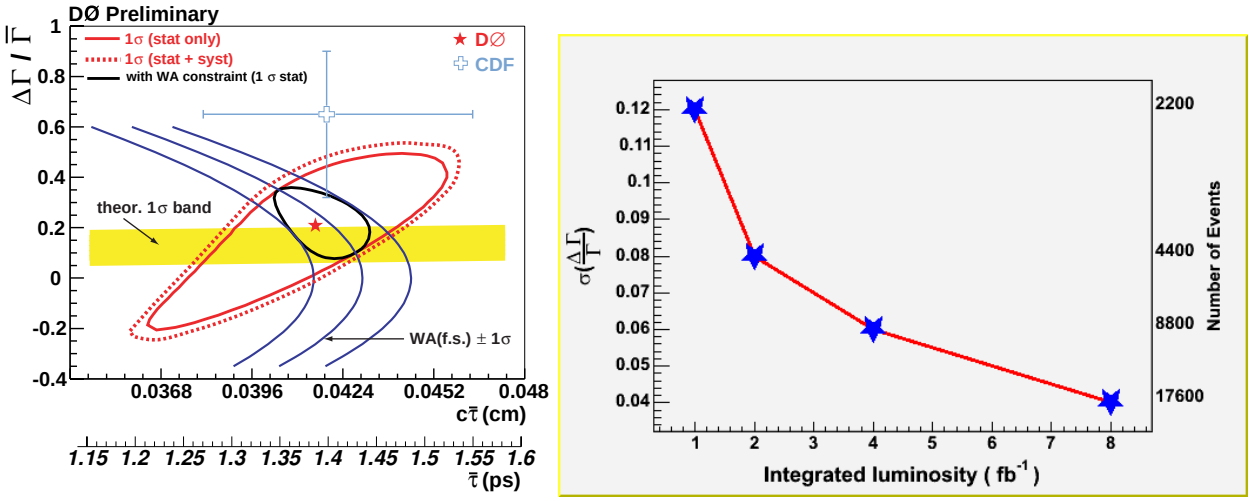

FIGURE 2. (left) $\Delta\Gamma_s/\overline{\Gamma}_s$ vs average lifetime. The D0 one-σ contours are compared to a one-σ band for the world average measurement based on flavor-specific decays. The CDF measurment as well as the SM theoretical prediction are also shown. (right) Projection of the uncertainty on $\Delta\Gamma_s/\overline{\Gamma}_s$ as a function of integrated luminosity per Tevatron experiment in Run II.

In order to measure the decay width difference, $\Delta\Gamma_s$, we need to disentagle the heavy and light B_s^0 mass eigenstates and measure their lifetimes separately. Since the B_s^0 mass eigenstates correspond also to the CP eigenstates, we can disentagle them by identifying the CP even and CP odd contributions to the final states. This is more staightforward when a pseudoscalar state decays to two vector mesons. The decay $B_s^0 \to J/\psi\phi$ is a pseudoscalar to vector-vector transition and is characterized by three amplitudes corresponding to transitions in which the J/ψ and ϕ have a relative orbital angular momentum L of 0, 1, or 2. The observed final state particles for the B_s^0, $\overline{B}_s^0$ decays ($\mu^+\mu^-K^+K^-$) have definite CP which depends on L. Time-dependent angular analysis for $B_s \to J/\psi\phi$ together with lifetime measurements can help separate heavy and light mass eigenstates.

In Table 2 we present the relative width difference between the heavy and light mass eigenstates, $\Delta\Gamma_s/\overline{\Gamma}_s$, the average lifetime of the (B_s^0, $\overline{B}_s^0$) system and the mean lifetimes of the light and heavy B_s^0 eigenstates as measured by the CDF [5] and D0 [6] experiments.

In Fig. 2(left) we show $\Delta\Gamma_s/\overline{\Gamma}_s$ vs average lifetime as measured by the CDF and D0 experiments and in comparison with the theoretical expectation [7]. In Fig. 2(right) we show the expected precision on the measurement of $\Delta\Gamma_s/\overline{\Gamma}_s$ as a function of integrated luminosity per Tevatron experiment. The estimate presented here is based on D0 studies

and the assumption that the CDF net sensitivity is about the same (CDF has a better mass resolution, hence less background under the signal, while D0 has a larger polar angle coverage) [8].

Δm_s

Very precise measurements of Δm_d have been available for some time, and are currently dominated by the results of the B factories [9]. Recent CDF and D0 measurements are consistent with those results [10].

Δm_s is constrained to be larger than 14.5 ps^{-1} at 95% CL from previous work by the LEP experiments, SLD and CDF (Run I). On the basis of the same work the sensitivity (expected limit) is equal to 18.2 ps^{-1}. Both CDF [11] and D0 [12] have recently obtained new limits on Δm_s.

Using 355 pb^{-1} of Run II data CDF made two parallel measurements for Δm_s using both fully reconstructed hadronic decays and semileptonic decays with a fully reconstructed $D_s^{\pm}$ meson. In the former case about 900 $B_s^0 \to D_s^{\pm}\pi^{\mp}$ were reconstructed after summing over three possible $D_s^{\pm}$ decay modes: $\phi\pi^{\pm}$, $K^{*0}K^{\pm}$ and $\pi^+\pi^-\pi^+$. The semileptonic analysis yielded about 7500 $B_s^0 \to D_s^{\pm}l^{\mp}\nu$ events summing over the three above mentioned $D_s^{\pm}$ decay channels, however the proper time resolution was worse because of the incomplete knowledge of the decay kinematics due to the missing neutrino. For the results presented here flavor tagging was performed using only opposite -side taggers. The tag sign is provided either by the sign of the electron or muon or by the average weighed charge of the tracks in a jet. A combined tagging power (εD^2) of the order of 1.4% was obtained.

CDF performed an amplitude scan as a function of Δm_s [13] on both samples and then combined them to obtain a 95% CL limit of 7.9 ps^{-1} and a sensitivity of 8.4 ps^{-1}. In Fig. 3(left) we show the amplitude scan result which is clearly dominated by the statistical error.

Using 460 pb^{-1} of Run II data D0 measured Δm_s in a large semileptonic sample of $B_s^0 \to \mu^+ D_s^- X$ decays where the D_s^- is fully reconstructed. The opposite-side muon tagging method was used for the initial state flavor determination and the tagging power was of the order of 1.1%.

In Fig. 3(right) we show the D0 amplitude scan as a function of Δm_s. A 95% CL limit of 5.0 ps^{-1} and a sensitivity of 4.6 ps^{-1} were obtained.

These new results have not improved yet the $\Delta m_s > 14.5$ ps^{-1} WA limit, but have extented the sensitivity to 18.5 ps^{-1}.

In Fig. 4(left) we show the 5σ observation projected sensitivity of Δm_s for the combined hadronic and semileptonic CDF analyses as a function of integrated luminosity per Tevatron experiment in Run II [8]. The improvements assumed are listed in the figure. Similar projected sensitivities were assumed for the CDF and D0 experiments. The horizontal axis is interpreted as integrated luminosity per experiment under the assumption that only half of the delivered luminosity is effectively usable by the experiments.

The value of Δm_s predicted by SM on the basis of the analysis of all available B and Kaon physics data is $\Delta m_s = 18.5 \pm 1.6$ ps^{-1}, and the expected 95% CL range 15.7 to 23

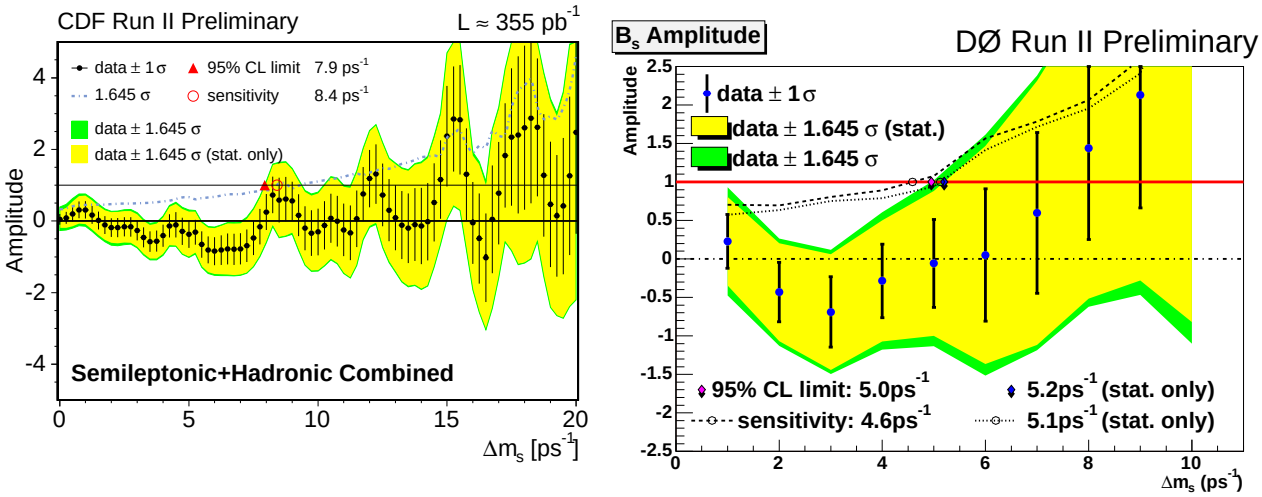

FIGURE 3. (left) CDF amplitude scan combining hadronic and semileptonic B_s^0 signals. (right) D0 amplitude scan using semileptonic B_s^0 signals.

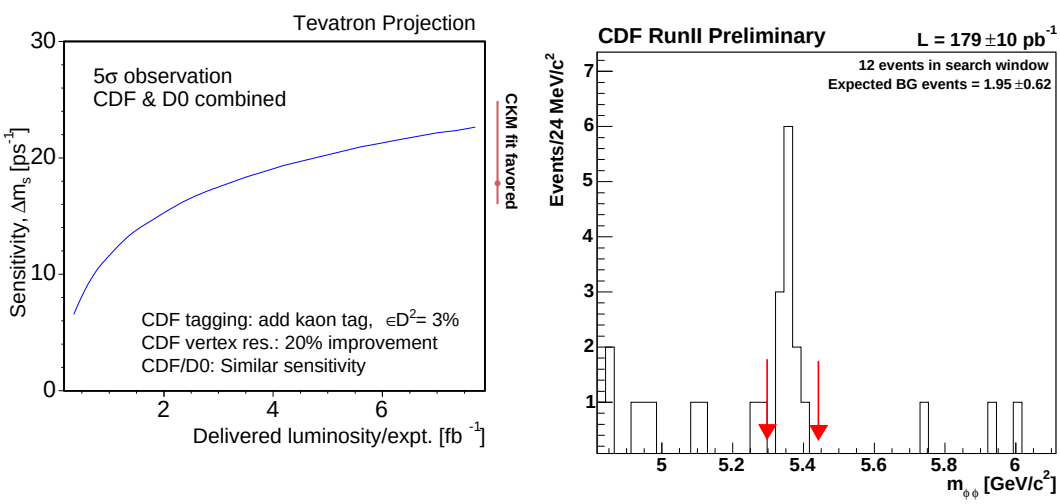

FIGURE 4. (left) Δm_s sensitivity as a function of delivered luminosity per Tevatron experiment in Run II. (right) The CDF $K^+K^-K^+K^-$ invariant mass distribution from the decay $B_s^0 \to \phi\phi$.

ps^{-1} [14]. All SM extensions predict a larger value, of at least 30 ps^{-1}.

Branching fractions - Rare decays

CDF presented the first evidence of charmless decays of the B_s^0 meson, $B_s^0 \to \phi\phi$ on the basis of 179 pb^{-1} of Run II data. A "blind" search was performed fixing the selection requirements and evaluating the combinatorial background from independent samples before examining the signal region in the data. The $B_s^0 \to \phi\phi$ candidate mass distribution is shown in Fig. 4(right). In a region of ± 72 MeV/c^2 around the world

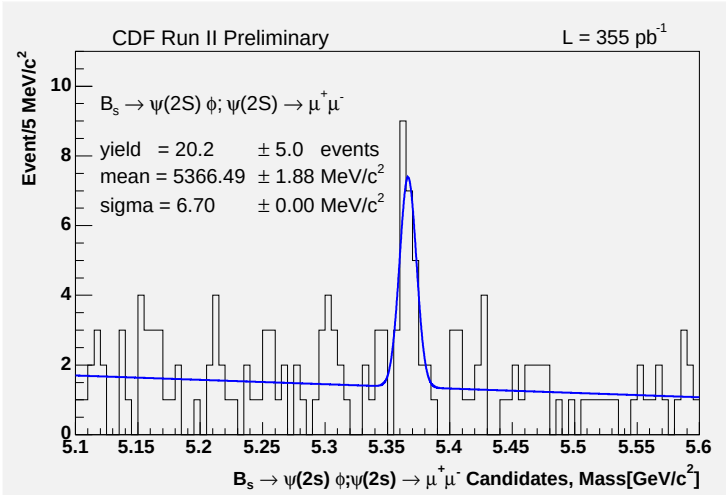

FIGURE 5. Invariant mass distribution of $\mu^+\mu^-K^+K^-$ from the decay $B_s^0 \to \psi(2S)\phi$. The fitting function is a single Gaussian for the signal and a first order polynomial for the background.

average B_s^0 mass, corresponding to a window three times the expected mass resolution, 8 events were observed. Using the $B_s^0 \to J/\psi\phi$ sample for normalization CDF derived $Br(B_s^0 \to \phi\phi) = (14^{+6}_{-5}(stat) \pm 6(syst))\text{x}10^{-6}$. The corresponding theoretical predictions vary in the range 18-37 x 10^{-6}.

Using 360 pb^{-1} of Run II data CDF presented as well the first observation of the decay $B_s^0 \to \psi(2S)\phi$ in both the $\psi(2S) \to \mu^+\mu^-$ (5.02 σ) and $\psi(2S) \to J/\psi\pi^+\pi^-$ (4.16 σ) decays for a combined significance of 6.35 σ. Figure 5 shows the $\mu^+\mu^-K^+K^-$ invariant mass distribution with a fit to the data superimposed. Using the $B_s^0 \to J/\psi\phi; J/\psi \to \mu^+\mu^-$ signal as a control sample and for normalization, CDF derived $Br(B_s^0 \to \psi(2S)\phi)/Br(B_s^0 \to J/\psi\phi) = 0.52 \pm 0.13$ (stat) $\pm$ 0.06 (BR) $\pm$ 0.04 (syst).

Within SM, Flavor Changing Neutral Current (FCNC) decays are highly suppressed and can only occur through higher order diagrams. The SM expectations for the branching ratios of $B_s^0 \to \mu^+\mu^-$ and $B_d^0 \to \mu^+\mu^-$ are $Br(B_s^0 \to \mu^+\mu^-) = (3.42 \pm 0.54)\text{x}10^{-9}$ and $Br(B_d^0 \to \mu^+\mu^-) = (1.00 \pm 0.14)\text{x}10^{-10}$ [15], which are about two orders of magnitude smaller than the current experimental sensitivity. However, new physics contributions can significantly enhance these branching fractions.

For the $B_s^0 \to \mu^+\mu^-$, both CDF and D0 performed "blind" search analyses and used the $B^\pm \to J/\psi K^\pm$ decay as a control sample and for normalization. Using 240 pb^{-1} of Run II data D0 found 4 B_s^0 candidates on an expected background of 4.3 $\pm$ 1.2 events and established an upper limit of $Br(B_s^0 \to \mu^+\mu^-) < 3.7\text{x}10^{-7}$ at 95% CL. Using 364 pb^{-1} of Run II data CDF also searched for the $B_{s(d)}^0 \to \mu^+\mu^-$ decays. As shown in Fig. 6(left) CDF observes no candidate events within the signal window of $\pm$ 60 MeV ($\pm$2.5 σ) about the world average of B_s^0 or B_d^0 mass. They expected 0.81$\pm$0.12 and 0.66$\pm$0.13 events for the central-central and central-extension channels respectively. They established limits of $Br(B_s^0 \to \mu^+\mu^-) < 2.0\text{x}10^{-7}$ and $Br(B_d^0 \to \mu^+\mu^-) < 4.9\text{x}10^{-8}$ at 95% CL.

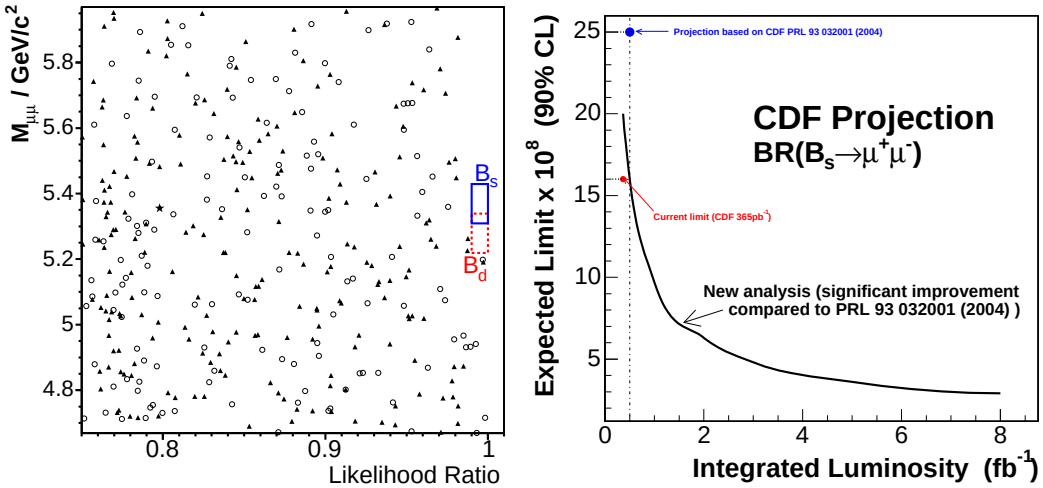

FIGURE 6. (left) The $\mu^+\mu^-$ invariant mass distribution versus likelihood ratio for events satisfying baseline requirements for central-central (solid triangle) and central-extension (open circle) channels. The B_s^0 (solid box) and B_d^0 (dashed box) signal regions are also shown. (right) The expected limit on the branching ratio of $B_s^0 \to \mu^+\mu^-$ as a function of delivered luminosity per Tevatron experiment.

Using a Bayesian integration technique and taking into account correlated and uncorrelated systematic uncertainties the combined CDF and D0 limits are $Br(B_s^0 \to \mu^+\mu^-) <$ 1.6x10^{-7} and $Br(B_d^0 \to \mu^+\mu^-) <$ 3.8x10^{-8} at 95%. In Fig. 6(right) we show the expected $B_s^0 \to \mu^+\mu^-$ limit projection from CDF as a function of the delivered luminosity per Tevatron experiment in Run II. The projection is based on the current CDF optimization of the selection requirements. A re-optimization at about 1 or 2 fb^{-1} of luminosity could help improve this projection.

Using about 300 pb^{-1} of Run II data D0 performed a "blind" search for the decay $B_s^0 \to \mu^+\mu^-\phi$. They expected 1.6±0.4 background events and they observed none in the search window. They established a limit of $Br(B_s^0 \to \mu^+\mu^-\phi) <$ 4.1x10^{-6} at 90% CL.

3. THE B_C MESON

The $B_c^\pm$ meson is made of a bottom-charm antiquark-quark pair. Nonrelativistic potential models predict the $\bar{b}$ and c quarks to be tightly bound with a ground state mass in the approximate range 6200-6300 MeV/c^2 [16, 17, 18]. Recent QCD-based perturbative computations up to $\mathcal{O}(\alpha_s^4)$ predict $M(B_c)$ to be 6307 $\pm$ 17 MeV/c^2 [19]. Most recently, a three-flavor lattice QCD calculation obtains $M(B_c) = 6304 \pm 12(\text{stat} \oplus \text{syst})\ ^{+18}_{-0}$(cutoff effects) MeV/$c^2$ [20]. The predicted $B_c^\pm$ lifetime is in the range of 0.4-1.4 ps [21].

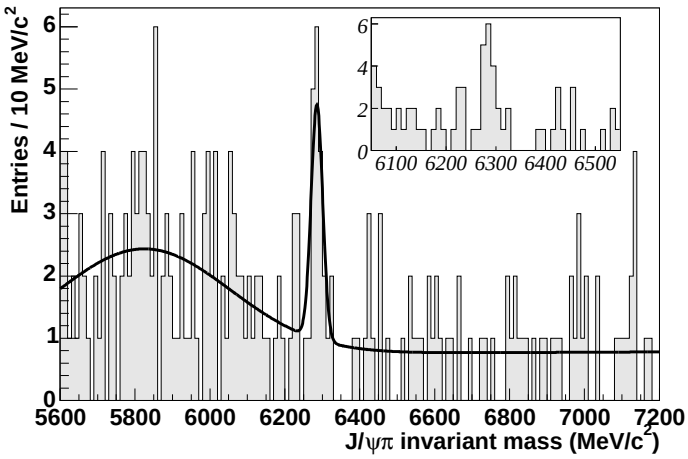

FIGURE 7. The invariant mass distribution of the $J/\psi\pi^{\pm}$ candidates and results of an unbinned likelihood fit in the search window. The inset shows the peak section of the distribution. The broad enhancement below 6.2 GeV/c^2 is attributable to partially reconstructed $B_c^{\pm}$ mesons.

Mass and lifetime

The CDF collaboration made the first observation of the $B_c^{\pm}$ meson in the semileptonic decay channels $B_c^{\pm} \to J/\psi l^{\pm} \nu_l X$, in a sample of 110 pb^{-1} of data in Run I [22]. With a signal of $20.4^{+6.2}_{-5.5}$ events, the $B_c^{\pm}$ mass and lifetime were measured to be 6.40 $\pm$ 0.39(stat) $\pm$ 0.13(syst) GeV/c^2 and 0.46 $^{+0.18}_{-0.16}$ (stat) $\pm$ 0.03 (syst) ps respectively. In August 2004, the D0 Collaboration reported a preliminary observation of a $B_c^{\pm}$ signal in the decay channel $B_c^{\pm} \to J/\psi \mu^{\pm} \nu_{\mu} X$ in a sample of 210 pb^{-1} of Run II data [23]. On the basis of 95 $\pm$ 12 $\pm$ 11 signal events their analysis yielded a B_c mass of $5.95^{+0.14}_{-0.13}$(stat) $\pm$ 0.34(syst) GeV/c^2 and a lifetime of 0.448 $^{+0.123}_{-0.096}$ (stat) $\pm$ 0.121 (syst) ps.

Using approximately 360 pb^{-1} of Run II data CDF searched for the exclusive decay mode $B_c^{\pm} \to J/\psi\pi^{\pm}$. The search window was chosen to correspond to the ± 2 standard deviation region around the CDF Run I measurement of the $B_c^{\pm}$ mass; it was 5.6-7.2 GeV/c^2, approximately 100 times wider than the expected $B_c^{\pm}$ mass resolution. A global unbinned likelihood fit to the $J/\psi\pi^{\pm}$ spectrum over the entire mass range yielded a $B_c^{\pm}$ mass of 6285.7 $\pm$ 5.3(stat) $\pm$ 1.2(syst) MeV/c^2 for a signal of 14.6 $\pm$ 4.6 signal events on a background of 7.1 $\pm$ 0.9 events within a region of ± 2 standard deviations from this mass value (see Fig. 7) [24]. This peak is consistent with a narrow particle state which decays weakly, and is interpreted as the first evidence for fully reconstructed decays of the $B_c^{\pm}$ meson. The probability that a random background fluctuation would generate such a peak anywhere in the search window was calculated to be 0.012%. The mass value agrees with the much less precise mass values found in $B_c^{\pm}$ semileptonic decays. There is also good agreement with recent theoretical predictions for the $B_c^{\pm}$ mass around 6300 MeV/c^2 [19, 20].

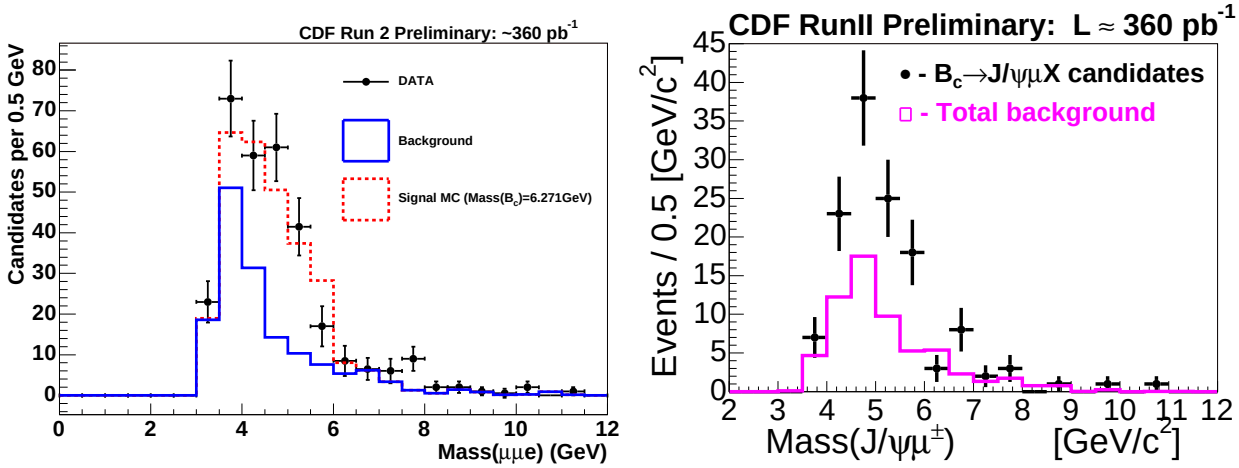

FIGURE 8. (left) $J/\psi e$ mass distribution for total background and data. (right) $J/\psi\mu$ mass distribution for total background and data.

Branching fractions

Using 360 pb^{-1} of Run II data CDF performed the $B_c^{\pm}$ search in semileptonic channels as well. A signal of 114.9 $\pm$ 15.5 (stat) $\pm$ 13.6 (syst) events (5.9 σ) was observed in the $B_c^{\pm} \to J/\psi e^{\pm}\nu$ channel (see Fig. 8(left)). The cross section times the branching fraction for $B_c^{\pm} \to J/\psi e^{\pm}\nu$ relative to $B^{\pm} \to J/\psi K^{\pm}$ was measured to be 0.282 $\pm$ 0.038(stat) $\pm$ 0.074 (syst) in the kinematic region of $p_T(B) > 4.0$ GeV/c and $|y(B)| < 1.0$. Similarly, an excess of 59.1 $\pm$ 12.5 events (5.2 σ) was observed in the $B_c^{\pm} \to J/\psi\mu^{\pm}\nu$ (see Fig. 8(right)). The cross section times the branching fraction for $B_c^{\pm} \to J/\psi\mu^{\pm}\nu$ relative to $B^{\pm} \to J/\psi K^{\pm}$ was measured to be 0.249 $\pm$ 0.045(stat) $^{+0.107}_{-0.076}$ (syst) in the kinematic region of $p_T(B) > 4.0$ GeV/c and $|y(B)| < 1.0$.

4. *B*-BARYONS

As discussed earlier, using 220 pb^{-1} of Run II data CDF was able to present the most precise measurement, to date, for the Λ_b^0 mass [1]. The Λ_b mass measurement was made by reconstructing 89$\pm$10 signal events in the decay channel $\Lambda_b^0 \to J/\psi\Lambda^0$ where $\Lambda^0 \to p\pi^-$ and $J/\psi \to \mu^+\mu^-$. The mass was measured to be $m(\Lambda_b) = 5619.7 \pm 1.2$(stat) $\pm$ 1.2(syst) MeV/c^2. This measurement has better uncertainty than the world average.

Using 250 pb^{-1} of Run II data D0 reconstructed 61$\pm$12 signal events in the exclusive decay channel $\Lambda_b^0 \to J/\psi\Lambda^0$ where $\Lambda^0 \to p\pi^-$ and $J/\psi \to \mu^+\mu^-$ and measured the Λ_b^0 lifetime. The Λ_b^0 lifetime was determined to be $1.22^{+0.22}_{-0.18}$ (stat)$\pm$0.04(syst) *ps* [25] (see Fig. 9). The winter 2005 HFAG world average for $\tau(\Lambda_b^0)$ was 1.232$\pm$0.072 *ps* and $\tau(\Lambda_b^0)/\tau(B^0)$ equal to 0.806$\pm$0.047 [3]. The Ξ_b lifetime has not been updated recently. The winter 2005 HFAG world average is equal to $1.39^{+0.34}_{-0.28}$ *ps* and it refers to a mixture of Ξ_b^0 and $\Xi_b^{\pm}$. This value is based on older measurements performed by the DELPHI

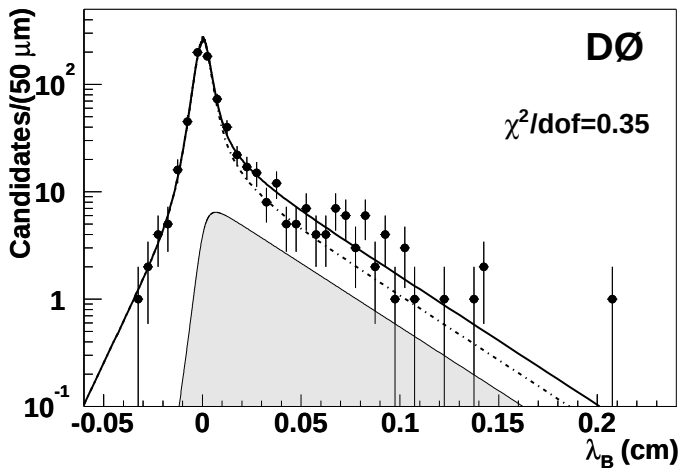

FIGURE 9. Proper decay length distribution for Λ_b^0 candidates. The points are the data, and the solid curve is the sum of fitted contributions from signal (gray) and the background (dashed-dotted line).

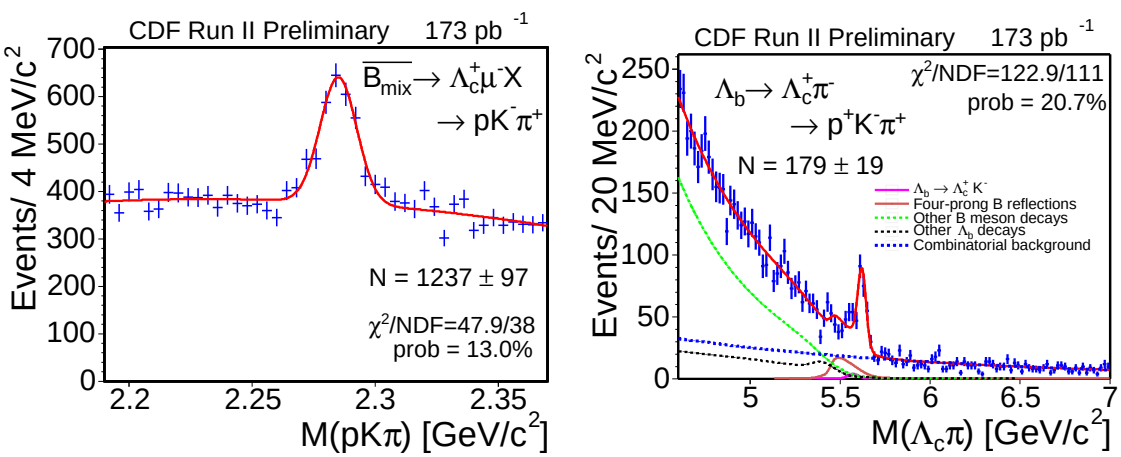

FIGURE 10. (left) The M(pKπ) invariant mass distribution (right) The M($\Lambda_c\pi$) invariant mass distribution. The results of an unbinned likelihood fit are superimposed on the histograms and a χ^2 probability is calculated.

and ALEPH experiments.

Using a Run II sample of 173 pb^{-1} CDF presented the first measurement of the ratio of branching fractions $Br(\Lambda_b \to \Lambda_c^+ \mu^- \bar{\nu_\mu})/\ Br(\Lambda_b \to \Lambda_c^+ \pi^-)$ which is a good test of HQET. This analysis used the displaced vertex trigger and reconstructed 1237±97 $\bar{B} \to \Lambda_c^+ \mu^- X$ decays (see Fig. 10(left)) and 179±19 $\Lambda_b \to \Lambda_c^+ \pi^-$ decays (see Fig. 10(right)). In the process of this analysis CDF also observed several Λ_b^0 semileptonic decays which have never been seen before: $\Lambda_b^0 \to \Lambda_c(2593)^+ \mu^- X$, $\Lambda_b^0 \to \Lambda_c(2625)^+ \mu^- X$, $\Lambda_b^0 \to \Sigma_c^0 \pi^+ \mu^- X$, and $\Lambda_b^0 \to \Sigma_c^{++} \pi^- \mu^- X$. They measured the $Br(\Lambda_b^0 \to \Lambda_c^+ \mu^- \bar{\nu_\mu})/$ $Br(\Lambda_b^0 \to \Lambda_c^+ \pi^-)$ to be equal to 20.0±3.0(stat)±1.2 (syst)$^{+0.7}_{-2.1}$(BR)±0.5 (UBR), where UBR stands for unmeasured branching fractions.

5. CONCLUSIONS-PROSPECTS

More than 1 fb^{-1} of $p\bar{p}$ collisions has been already delivered by the Tevatron, and many new results have been recently produced by the CDF and D0 experiments. As the Tevatron is expected to provide between 4.1 and 8.2 fb^{-1} by October 2009, a lot of answers to explored and yet unexplored questions and a lot of surprises are awaiting.

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