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Heavy Flavor Results from DØ

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Abstract

Presented are summaries of four heavy flavour analyses by the DØ Collaboration between August 2011 and June 2012. Using up to 10.4 fb^{-1} of $p\overline{p}$ collisions at $\sqrt{s}$ = 1.96 TeV accumulated by the DØ detector at the Fermilab Tevatron collider, we find evidence for the two-body decay $B_s^0 \rightarrow J/\psi f_2'(1525)$ and measure the branching fraction of these decays relative to $B_s^0 \rightarrow J/\psi\phi$ as $R_{f_2'/\phi} = 0.22 \pm 0.05$ (stat.) ± 0.04 (syst). The Λ_b^0 lifetime is measured using the fully reconstructed decay $\Lambda_b^0 \rightarrow J/\psi\Lambda^0$, along with the lifetime of the topologically similar decay channel $B_d^0 \rightarrow J/\psi K_S^0$. The analyses yields results of $\tau(\Lambda_b^0) = 1.303 \pm 0.075$ (stat.) ± 0.035 (syst.) ps, $\tau(B_d^0) = 1.508 \pm 0.025$ (stat.) ± 0.043 (syst.) ps, and $\tau(\Lambda_b^0)/\tau(B_d^0) = 0.864 \pm 0.052$ (stat.) ± 0.033 (syst.) ps. A narrow mass state is observed that decays into $\Upsilon(1S) + \gamma$ with an invariant mass of 10.551 ± 0.014 (stat.) ± 0.017 (syst.) GeV/c^2. Finally, the semileptonic charge asymmetry is measured to be $a_{sl}^s = [-1.08 \pm 0.72$ (stat.) ± 0.17 (syst.)] % using the decay channel $B_s^0(\overline{B}_s^0) \rightarrow D_s^{\mp}\mu^{\pm}X$.

Keywords: Experimental, particle, physics, DØ, flavor

1. The DØ experiment

The DØ experiment was one of two general purpose particle detector experiments on the Tevatron $p\overline{p}$ collider at Fermilab. The DØ detector consists of a central silicon microstrip tracker (SMT), a central fibre tracker (CFT), a calorimetry system and muon detectors. It is described in detail in Refs. [1, 2, 3]. The SMT and CFT are housed within a 1.9 T superconducting solenoidal magnet, and are designed to optimize tracking and vertexing for pseudorapidites $|\eta| < 3$, where $\eta = -\ln[\tan(\theta/2)]$ and θ is the polar angle with respect to the beam direction.

The SMT can reconstruct the $p\overline{p}$ interaction vertex (PV) for interactions with at least three tracks to a precision of 40 μm in the plane transverse to the beam direction, and can determine the impact parameter of any track relative to the PV with a precision between 20 μm and 50 μm.

The muon detector consists of a central muon system, which covers the pseudorapidity region $|\eta| < 1$, and a forward muon system, covering the region $1 < |\eta| < 2$. Both systems consist of three layers of drift tubes and scintillators. Between the inner layer and two outer layers is a 1.8 T toroidal magnet system. Both the solenoidal and toroidal magnet systems regularly had their polarities reversed so that entire recorded dataset is split approximately equally between the four combinations of polarities.

The analyses in this article use the dataset recorded by DØ, which corresponds to 10.4 fb^{-1} of integrated luminosity from the second major running period between 2002 and 2011. Each analysis uses events collected using single-muon and dimuon triggers.

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2. Study of the decay $B_s^0 \to J/\psi f_2'(1525)$ [4]

2.1. Introduction

The LHCb Collaboration reported the first observation of the decay chain $B_s^0 \to J/\psi f_2'(1525)$, $f_2' \to K^+K^-$ [5]. This DØ analysis aims to further investigate this decay, including the spin-state of the K^+K^- resonance, and to measure the branching fraction relative to the well established decay $B_s^0 \to J/\psi\phi$.

2.2. Selection

B_s^0 candidates are formed from oppositely charged muon pairs in the invariant mass range $2.9 < M(\mu\mu) < 3.3$ GeV/c^2 and a pair of oppositely charged particles which are assigned the charged kaon mass. To suppress background from $B_d^0 \to J/\psi K^*(892)$ we require the kaon pair candidates to have an invariant mass greater than 1 GeV/c^2 when assigning one track the charged pion mass. To reject prompt background, the proper decay length, $ct = M_B \vec{L}^B_{xy} \cdot \vec{p}/(p_T^2)$, is required to be greater than 200 μm, where M_B is the world-average B_s^0 mass [6], $\vec{p}$ is the particle momentum, and p_T is the particle momentum transverse to the beam direction. To remove poorly reconstructed events we require the uncertainty of the proper decay length to be less than 100 μm.

2.3. Signal extraction

The distribution of the B_s^0 candidate mass is shown in Fig. 1. The contribution from the process $B_s^0 \to J/\psi f_0(1500)$ is deemed negligible from examining the mass distribution of the two kaon candidate tracks when each is assigned the charged pion mass. No significant peak is observed at $M(\pi\pi) = 1.5$ GeV/c^2, discounting the dipion decay favoring $f_0(1500)$ meson. The B_s^0 candidate mass resonance can result from the process $B_d^0 \to J/\psi K_J^*(1430)$, $K_J^* \to K^\pm\pi^\mp$, where $J = 0$, 2. These processes are accounted for by simulating the $M(K^+K^-)$ distributions for misidentified $K^\pm\pi^\mp$ candidates to produce mass distribution templates in steps of 50 MeV/c^2 between 1.30 and 2.00 GeV/c^2. These templates are used in the $M(\mu^+\mu^-K^+K^-)$ distribution fit per $M(K^+K^-)$ range, where the $B_s^0 \to J/\psi f_2'(1525)$ contribution is modelled with the sum of two Gaussian functions.

2.4. Spin of the K^+K^- state

The spin state of the K^+K^- candidates described in section 2.3 are investigated. Though a K^+K^- system can be in any natural parity state, the values of $J = 0$, 1, and 2 are examined as possibilities for the spin of the observed structure. The final state of the decay can be described by three independent angles: θ_H is the angle between the μ^+ and B_s^0 directions in the J/ψ rest frame, ψ is the angle of the K^+ meson with respect to the B_s^0 direction in the K^+K^- rest frame, and ϕ_H is the angle between the $\mu^+\mu^-$ and K^+K^- decay planes. The angular distribution for the decay of a spinless meson into the spin-one J/ψ meson can be expressed in terms of $H_1 = \cos\theta_H$, $H_2 = \cos\psi$, and ϕ_H as follows [7]:

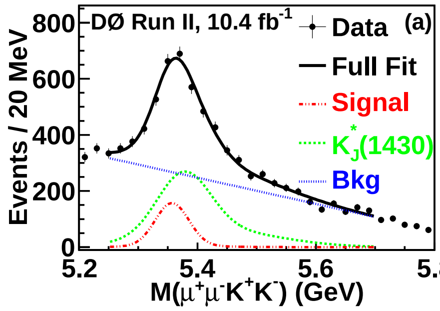

Figure 1: Mass distribution of the B_s^0 candidate for $1.45 < M(K^+K^-) < 1.60$ GeV/c^2. This uses MC generated mass distribution templates for the decays contributing to the peak. With the inclusion of the signal channel the P-value of the fit is 0.338. Without it, the P value falls to 4.5x10^{-5}. 578 ± 100 $B_s^0 \to J/\psi K^+K^-$ candidates are extracted.

$$\frac{d\Gamma}{d\Omega} \propto \left|\sum A_{Jm} Y_1^m(\cos\theta_H, \phi_H) Y_J^{-m}(-\cos\phi, 0)\right|^2 D(\Omega), \tag{1}$$

where Y_J^m are spherical harmonics, A_{Jm} are complex amplitudes corresponding to spin J and helicity m, and Ω is either H_1, ϕ_H, or H_2. The sum extends over equal helicities of the daughter particles, $m = 0, \pm 1$. The factor D is the acceptance of the event selection.

Fig. 2 shows the predicted angular distributions as a function of $|\cos\psi|$ and the results from data. $J = 2$ is favored with a fit probability of 0.30, identifying the peak as the $f_2'(1525)$ meson. $J = 0$, 1 are disfavored with fit probabilities of 2.4×10^{-2} and 2.2×10^{-2} respectively. The data is also consistent with a coherent superposition of $J = 0$ and $J = 2$ states with a fit probability of 0.61.

2.5. Relative branching ratio with $B_s^0 \to J/\psi\phi$

Terms common to the branching ratios of $B_s^0 \to J/\psi f_2'(1525)$ and $B_s^0 \to J/\psi\phi$ cancel in their ratio. The relative branching fraction, $R_{f_2'/\phi}$, requires only the yields of the two decays ($N_{B_s^0 \to J/\psi f_2'(1525)}$ and $N_{B_s^0 \to J/\psi\phi}$), and the reconstruction efficiencies of the decay modes

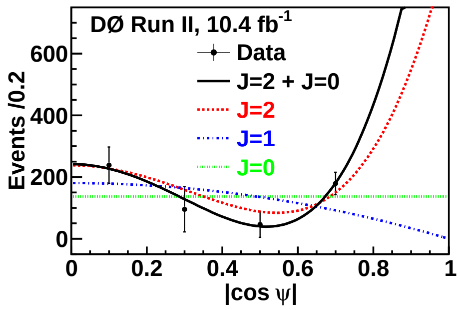

Figure 2: The $|\cos\psi|$ angular distribution of the K^+K^- peak between $1.45 < M(K^+K^-) < 1.60$ GeV/c^2. The curves are best fits assuming pure $J = 0$ (dashed), pure $J = 1$ (dash-dot), pure $J = 2$ (dot), and a coherent sum of $J = 0$ and $J = 2$ (solid).

($\epsilon_{\rm reco}^{B_s^0\to J/\psi f_2'(1525)}$ and $\epsilon_{\rm reco}^{B_s^0\to J/\psi\phi}$):

$$R_{f_2'/\phi} = \frac{\mathcal{B}(B_s^0 \to J/\psi f_2'(1525);\ f_2'(1525)\to K^+K^-)}{\mathcal{B}(B_s^0\to J/\psi\phi;\ \phi\to K^+K^-)} = \frac{N_{B_s^0\to J/\psi f_2'(1525)} \times \epsilon_{\rm reco}^{B_s^0\to J/\psi f_2'(1525)}}{N_{B_s^0\to J/\psi\phi}\times \epsilon_{\rm reco}^{B_s^0\to J/\psi\phi}}. \quad (2)$$

$N_{B_s^0\to J/\psi f_2'(1525)} = 578 \pm 100$ is determined in the mass range $1.4 < M(K^+K^-) < 1.7$ GeV/c^2 and $N_{B_s^0\to J/\psi\phi} = 3790 \pm 78$ between $1.01 < M(K^+K^-) < 1.03$ GeV/c^2. The efficiencies are determined using simulated data. The measured ratio of branching fractions is $R_{f_2'/\phi} = 0.22 \pm 0.05$ (stat.) ± 0.04 (syst.).

3. Measurement of the Λ_b lifetime in the exclusive decay $\Lambda_b \to J/\psi\Lambda$ [8]

3.1. Introduction

A recent measurement produced by the CDF Collaboration of the Λ_b^0 lifetime ($\tau(\Lambda_b^0)$) using $\Lambda_d^0 \to J/\psi\Lambda^0$ [9] provides the single most precise measurement of $\tau(\Lambda_b^0)$, but is more than two standard deviations larger than the world average [6]. Their measurement of the lifetime ratio, $\tau(\Lambda_b^0)/\tau(B_d^0) = 1.020 \pm 0.030$ (stat.) ± 0.008 (syst.), is higher than the heavy quark effective theory (HQET) [10] calculation, 0.88 ± 0.05 [11]. However, measurements in alternative channels by the DØ Collaboration [12, 13], CDF Collaboration [14, 15], DELPHI Collaboration [16], OPAL Collaboration [17], and ALEPH Collaboration [18] are in agreement with the theoretical predictions. More measurements of the Λ_b^0 lifetime and the ratio of $\tau(\Lambda_b^0)/\tau(B^0)$ are required to test this discrepancy. This section describes the DØ Collaboration's measurement of these values in the $\Lambda_b^0 \to J/\psi\Lambda^0$ channel and the topologically similar channel of $B_d^0 \to J/\psi K_S^0$. The latter channel allows for a cross-check of the measurement procedure and allows the lifetime ratio to be measured directly.

3.2. Λ_b^0 and B_d^0 selection

$J/\psi \to \mu^+\mu^-$ candidates are reconstructed from single muon and dimuon triggers. These triggers do not rely on the displacement of tracks from the interaction point. The dimuon invariant mass is required to be in the range $2.80 < M(\mu^+\mu^-) < 3.35$ GeV/c^2. Candidates of the decay $\Lambda^0 \to p\pi^-$ are found by combining pairs of oppositely charged tracks which produced an invariant mass in the range $1.105 < M(p\pi^-) < 1.127$ GeV/c^2. The track with the larger p_T is assigned the proton mass, which is an assumption ratified by MC simulations. To suppress contamination from the decays of more massive baryons, such as $\Sigma^0 \to \Lambda^0\gamma$ and $\Xi^0 \to \Lambda^0\pi^0$, the Λ^0 momentum vector is required to point within one degree back to the J/ψ vertex. The same requirement is made of the K_S^0 candidates, apart from requiring an invariant mass in the region $0.470 < M(\pi^+\pi^-) < 0.525$ GeV/c^2 when the tracks are assigned the charged pion mass. Track pairs which simultaneously produce a candidate for a Λ^0 and K_S^0 are discarded from both samples.

Λ_b^0 candidates are reconstructed by performing a kinematic fit that constrains the dimuon invariant mass to the world-average J/ψ mass [6], and the Λ^0 and two muon tracks to a common vertex. The invariant mass of the Λ_b^0 candidate is required to be in the region $5.15 < M(\mu^+\mu^-p\pi^-) < 6.05$ GeV/c^2. B_d^0 candidates are reconstructed in the same fashion, but in the invariant mass window of $4.9 < M(\mu^+\mu^-\pi^+\pi^-) < 5.7$ GeV/c^2.

3.3. Lifetime fitting and results

In order to extract the lifetimes, separate unbinned maximum likelihood fits are performed for the Λ_b^0 and B_d^0 samples. The likelihood is a function of the mass of candidate j, m_j, proper decay length, λ_j, and the uncertainty on the proper decay length, σ_j^λ. The parametrization of each factor is described in the publication [8].

The maximum likelihood fits to the data yield 755 ± 49 Λ_b^0 candidates and 5671 ± 126 B_d^0 candidates. The Λ_b^0 lifetime is extracted as $\tau(\Lambda_b^0) = 1.303 \pm 0.075$ (stat.) ± 0.035 (syst.) ps, which is consistent with the world-average, 1.425 ± 0.032 ps [6]. The B_d^0 lifetime is extracted as $\tau(B_d^0) = 1.508 \pm 0.025$ (stat.) ± 0.043 (syst.) ps, which is in good agreement with the world-average, 1.519 ± 0.007 ps [6]. From these measurements, the ratio of the lifetimes is $\tau(\Lambda_b^0)/\tau(B_d^0) = 0.864 \pm 0.052$ (stat.) ± 0.033 (syst.). This result is in good agreement with the HQET prediction, 0.88 ± 0.05 [11] and is compatible with the world-average, 1.00 ± 0.06 [6], but differs with the latest CDF Collaboration measurement, 1.02 ± 0.03 [9] by 2.2 standard deviations.

4. Confirmation of a new narrow state decaying to Υ(1S)+γ [19]

4.1. Introduction

The ATLAS Collaboration has published the observation of a new particle decaying into the Υ(1S)+γ channel with an invariant mass of 10.530 ± 0.005 (stat.)±0.009 (syst.) GeV/c^2, which they interpret as the χ_b(3P) system [20]. The DØ Collaboration has conducted a search for this state using a 1.3 fb^{-1} subset of integrated luminosity from the DØ dataset which was collected between April 2002 and February 2006.

4.2. Selection

The event selection is tuned to maximize the signal significances of known χ_b(1P) and χ_b(2P) states decaying to Υ(1S)+γ, where Υ(1S)→ $\mu^+\mu^-$, along with χ_c states which are observed in the analogous $J/\psi + \gamma$ decay mode. Selecting events in the mass region $9.1 < M(\mu\mu) < 9.7$ GeV/c^2 and performing a background subtraction, approximately 275k Υ(1S) candidates are found.

The energies of photons produced from quarkonia decay are typically too low to be precisely measured in the DØ calorimeter, whereas the tracking system provides excellent resolution in this kinematic region. For this reason, photons are detected via their conversions into e^+e^- pairs instead. It is required that the invariant mass of the converted e^+e^- pair is $M(e^+e^-) < 80$ MeV/c^2. The selection criteria for the e^+e^- pairs are confirmed by studying the double conversion pairs from $\pi^0 \to \gamma\gamma$ decays.

4.3. Results

The photon and Υ(1S) candidates are combined. The resulting mass distribution, $\Delta M = M(\mu^+\mu^-\gamma) - M(\mu^+\mu^-)$, reveals peaks corresponding to the χ_b(1P) and χ_b(2P) at $\Delta M \approx 0.4$ GeV/c^2 and $\Delta M \approx 0.8$ GeV/c^2 respectively. A third peak can be seen at $\Delta M \approx 1.0$ GeV/c^2, which is consistent with the recent observation by the ATLAS Collaboration, but the mass resolution is not fine enough to separate the splitting of the known χ_b states, and so we find no indication of substructure in the mass region of the new state.

The measured values are shifted due to energy loss of the e^+e^-. To account for this, a scale factor of 0.96±0.01 is determined by comparing world-average values to the measurements and assuming an equal mixture of $J = 1$ and $J = 2$ components for each χ_b state [6]. The measured masses of the χ_c states and the π^0 have a shift consistent with this scale factor.

The mass distribution of the combinatorial background is determined from data by combining Υ(1S) and γ candidates from different events. The mass distribution $M = M(\mu^+\mu^-\gamma) - M(\mu^+\mu^-) + m(\Upsilon(1S))$, where $m(\Upsilon(1S))$ is the world-average value 9.4603 GeV/c^2 [6], can be seen in Fig. 3. The widths of each peak are compatible with the resolution of the DØ detector. The fit yields 65±11 events for the new state above background which corresponds to a significance of 5.6 standard deviations when taking into account the look-elsewhere effect. The mass of the new state after energy loss correction is 10.551 ± 0.014 (stat.) ±0.017 (syst.) GeV/c^2, which is consistent with the ATLAS result. Further analysis is required to determine whether this structure is due to the χ_b(3P) system or some exotic bottom-quark state.

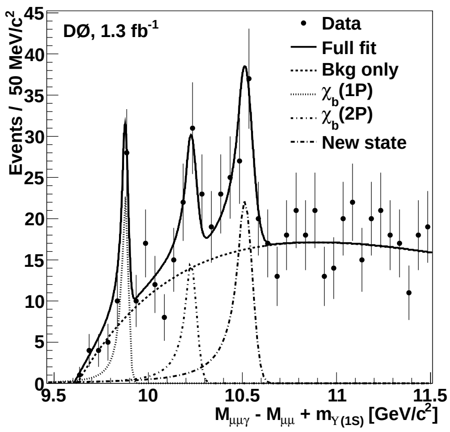

Figure 3: The distribution of $M(\mu\mu\gamma) - M(\mu\mu) + m(\Upsilon(1S))$. $m(\Upsilon(1S))$ is the world-average value 9.4603 GeV/c^2 [6]

5. Measurement of the semileptonic charge asymmetry using $B_s^0 \to D_s^-\mu^+X$ decays [21]

5.1. Introduction

Charge-parity (CP) violation has been observed in the decay and mixing of neutral mesons containing strange, charm, and bottom quarks, consistent with the presence of a single complex phase in the CKM matrix. An observation of anomalously large CP violation in B_s^0 oscillations could be an indication of physics beyond the standard model [22]. A measurement of the same-sign dimuon asymmetry, A^b_{sl}, performed by the DØ Collaboration has suggested anomalously large CP violation in the oscillated B meson system, with $A^b_{sl} = C_d a^d_{sl} + C_s a^s_{sl} = [-0.787 \pm 0.172 \text{ (stat.)} \pm 0.021 \text{ (syst.)}]\%$ [23, 24], where $a^{s(d)}_{sl}$ is the time-integrated flavor-specific semileptonic charge asymmetry in $B^0_{s(d)}$ decays that have undergone mixing,

$$a^{s(d)}_{sl} = \frac{\Gamma(Y) - \Gamma(\overline{Y})}{\Gamma(Y) + \Gamma(\overline{Y})}, \tag{3}$$

$$\begin{pmatrix} Y: & \overline{B}^0_{s(d)} \to B^0_{s(d)} \to l^+ \nu X \\ \overline{Y}: & B^0_{s(d)} \to \overline{B}^0_{s(d)} \to l^- \nu \overline{X} \end{pmatrix}$$

and $C_{d(s)}$ is the fraction of $B^0_{d(s)}$ events. The value of a^s_{sl} from this measurement is $a^s_{sl} = (-1.81 \pm 1.06)\%$ [24]. The SM prediction is $a^s_{sl} = (1.9 \pm 0.3) \times 10^{-5}$ [22], and is negligible compared to current experimental precision. The analysis in this section is complimentary and independent to [24] and investigates a^s_{sl} in the channel $B^0_s \to D_s \mu X$, where $D^-_s \to \phi \pi^-$ and $\phi \to K^+ K^-$.

5.2. Selection and raw asymmetry

$D^{\mp}_s \mu^{\pm}$ candidates are reconstructed using various track quality requirements and a likelihood ratio multivariate analysis [21], producing B^0_s candidates which are consistent with semileptonic decays in the mass window $2.6 < M(\mu^{\pm} D^{\mp}) < 5.4$ GeV/c^2. The flavor of the B^0_s meson at time of decay is identified by the charge of the associated muon. The 'raw' asymmetry, A, is extracted by simultaneously fitting the mass distribution of all $D^{\mp}_s$ candidates and the distribution of events with μ^+ only minus the distribution of events with μ^- only:

$$A = \frac{N(\mu^+ D^-_s) - N(\mu^- D^+_s)}{N(\mu^+ D^-_s) + N(\mu^- D^+_s)}, \tag{4}$$

where N denotes the signal yield of that sample subset. A is contaminated with detector asymmetries, reconstruction efficiency asymmetries between positively and negatively charged tracks, and an unknown fraction of events which did not originate from an oscillated B^0_s meson. Thus a^s_{sl} is given by

$$a^s_{sl} = \frac{A - A_\mu - A_{\text{track}}}{F^{\text{osc}}_{B^0_s}}, \tag{5}$$

where A_μ is the reconstruction asymmetry between muons and antimuons [25], A_{track} is the residual asymmetry between positively and negatively charged tracks, and $F^{\text{osc}}_{B^0_s}$ is a dilution factor to correct the measured asymmetry for the fraction of events in which the $D^{\mp}\mu^{\pm}$ originated from a B^0_s that has oscillated.

A total of $215,763 \pm 1,467$ $D^{\mp}\mu^{\pm}$ signal decays are reconstructed. However, to account for a non-uniform acceptance and reconstruction efficiency difference between positively and negatively charged tracks in the DØ detector, the events are weighted so that the number of events for each solenoid-toroid polarity system combination $(\pm, \pm)$ is equalized. This equalizes the efficiencies for both track polarities, and so cancels the detector asymmetries to first order in the numerator of Eqn. 4. This process reduces the signal yield to $203,513 \pm 1,337$. The weighted mass distribution is shown in Fig. 4. The raw asymmetry is measured as $A = [-0.40 \pm 0.33 \text{ (stat.)} \pm 0.05 \text{ (syst.)}]\%$.

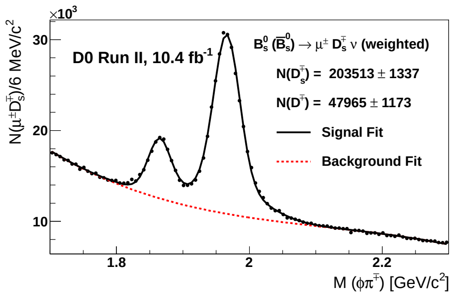

Figure 4: The weighted $K^+K^-\pi^-$ invariant mass distribution. The solid line is the signal fit, the dashed line is shows the combinatorial background fit. The lower mass peak is due to $D^- \to \phi\pi^-$ events, and the larger peak is due to the signal D^-_s meson decays.

5.3. Background asymmetries and dilution

The residual track asymmetry, A_{track}, is investigated using $K^0_S \to \pi^+\pi^-$ and $K^{*\pm} \to K^0_S \pi^{\pm}$ decays [23, 26]. No asymmetries are found, so no correction for the tracking asymmetries are applied. The tracking asymmetry of charged pions is studied using MC simulations of the DØ detector, and is found to be less than 0.05%. A systematic uncertainty of this magnitude is assigned. As the final state muon and pion have opposite charges, any remaining track asymmetries cancel to first order.

The residual reconstruction asymmetry of the muon system, A_μ, is measured using $J/\psi \to \mu^+\mu^-$ decays [23, 24, 26]. This asymmetry is a function of the p_T and $|\eta|$ of the muons, and so the correction is obtained by creating a weighted average over the normalized yields from fits to the $M(D^{\mp})$ system. The resulting correction is $A_\mu = [0.11 \pm 0.06 \text{ (syst.)}]\%$.

The dilution fraction, $F^{\text{osc}}_{B^0_s}$, requires MC simulation. Although the time-intergrated oscillation probability of B^0_s mesons is essentially 50%, $D^{\mp}_s$ candidates can also originate from oscillated and non-oscillated B^0_d mesons,

$B^{\pm}$ mesons, and prompt $c\bar{c}$ production. The fraction is found to be $F^{\rm osc}_{B^0_s} = 0.465$.

5.4. Results

Using Eqn. 5 the resulting time-integrated flavor-specific semileptonic charge asymmetry is found to be a^s_{sl} = [−1.08 ± 0.72 (stat.) ± 0.17 (syst.)] %, which supersedes the previous DØ Collaboration a^s_{sl} measurement [27], and is in agreement with the SM prediction. This result can be combined with the two A^b_{sl} measurements split by muon impact parameter requirements [24] and the world-average a^d_{sl} measurement from the B factories, $a^d_{sl} = (-0.05 \pm 0.56)\%$ [28]. This provides values of $a^s_{sl} = (-1.40 \pm 0.57)\%$ and $a^d_{sl} = (-0.22 \pm 0.32)\%$, which corresponds to a 3.0 standard deviation difference with the standard model. This combination can be seen in Fig. 5.

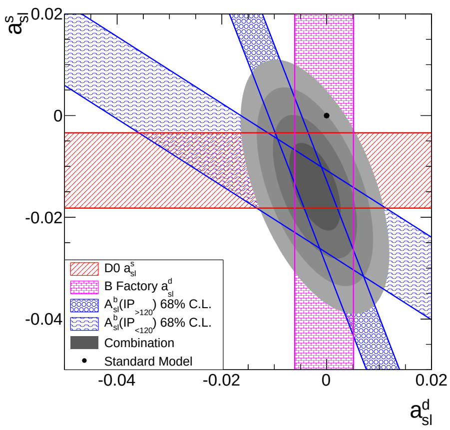

Figure 5: The result of combining two measurements of A^b_{sl} [24], the world-average a^d_{sl} measurement from B factories [28], and a^s_{sl} from this analysis. The bands represent the ± 1 standard deviation uncertainties, and the ellipses represent 1 to 4 standard two-dimensional deviations C.L. regions from the combination of results.

6. Conclusions

Discussed are four recent DØ Collaboration analyses in the heavy flavor sector: the investigation of the two body decay $B^0_s \rightarrow J/\psi f'_2(1525)$, and its branching ratio relative to the decay $B^0_s \rightarrow J/\psi\phi$ as $R_{f'_2/\phi} = 0.22 \pm$ 0.05 (stat.) ±0.04 (syst), the measurement of the $\Lambda^0_b \rightarrow J/\psi\Lambda^0$ lifetime relative to the channel $B^0_d \rightarrow J/\psi K^0_S$, $\tau(\Lambda^0_b)/\tau(B^0_d)$ = 0.864 ± 0.052 (stat.) ±0.033 (syst.) ps, the confirmation of a narrow mass state that decays into Υ(1S) $+\gamma$ with an invariant mass of 10.551 ± 0.014 (stat.) ±0.017 (syst.) GeV/c^2, and the measurement of the semileptonic charge asymmetry, a^s_{sl} = [−1.08 ± 0.72 (stat.) ±0.17 (syst.)] % using the decay channel $B^0_s(\overline{B}^0_s) \rightarrow D^{\mp}_s \mu^{\pm} X$. These are just 4 of 53 DØ Collaboration analyses approved for public release between August 2011 and Summer 2012. DØ is still competitive in the era of the LHC, especially in the field of CP violation, where the initial $p\overline{p}$ state and regular reversal of the DØ magnet systems significantly simplifies the extraction of underlying asymmetries and reduces the associated systematic uncertainties.

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