Observation of Decays $B^0 \to D_s^{(*)+}\pi^-$ and $B^0 \to D_s^{(*)-}K^+$

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We report the observation of decays $B^0 \to D_s^{(*)+}\pi^-$ and $B^0 \to D_s^{(*)-}K^+$ in a sample of 230×10^6 $\Upsilon(4S) \to B\bar{B}$ events recorded with the *BABAR* detector at the SLAC PEP-II asymmetric-energy e^+e^- storage ring. We measure the branching fractions $\mathcal{B}(B^0 \to D_s^+\pi^-) = (1.3 \pm 0.3(\text{stat}) \pm 0.2(\text{syst})) \times 10^{-5}$, $\mathcal{B}(B^0 \to D_s^-K^+) = (2.5 \pm 0.4(\text{stat}) \pm 0.4(\text{syst})) \times 10^{-5}$, $\mathcal{B}(B^0 \to D_s^{*+}\pi^-) = (2.8 \pm 0.6(\text{stat}) \pm 0.5(\text{syst})) \times 10^{-5}$, and $\mathcal{B}(B^0 \to D_s^{*-}K^+) = (2.0 \pm 0.5(\text{stat}) \pm 0.4(\text{syst})) \times 10^{-5}$. The significances of the measurements to differ from zero are 5, 9, 6, and 5 standard deviations, respectively. This is the first observation of $B^0 \to D_s^+\pi^-$, $B^0 \to D_s^{*+}\pi^-$, and $B^0 \to D_s^{*-}K^+$ decays.

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Within the Cabibbo-Kobayashi-Maskawa (CKM) model of quark-flavor mixing [1], *CP* violation manifests itself as a nonzero area of the unitarity triangle [2]. One of the important experimental tests of the model is the determination of the angle $\gamma = \arg(-V_{ud}V_{ub}^*/V_{cd}V_{cb}^*)$ of the unitarity triangle. A measurement of $\sin(2\beta + \gamma)$ can be obtained from the study of the time dependence of the B^0, $\bar{B}^0 \to D^{(*)-}\pi^+$ [3] decay rates, and specifically of the interference between the CKM-favored B^0 decay amplitude and CKM-suppressed $\bar{B}^0$ amplitude [4]. The first measurements of the *CP* asymmetry in decays $B^0 \to D^{(*)\mp}\pi^\pm$ have recently been published [5].

The measurement of $\sin(2\beta + \gamma)$ in $B^0 \to D^{(*)\mp}\pi^\pm$ decays requires knowledge of the ratios of the decay amplitudes, $r(D^{(*)}\pi) = |A(B^0 \to D^{(*)+}\pi^-)/A(B^0 \to D^{(*)-}\pi^+)|$. The *CP*-violating observables in $B^0 \to D^{(*)\mp}\pi^\pm$ decays are proportional to $r(D^{(*)}\pi)$ [4,5]. However, direct measurement of the branching fractions $\mathcal{B}(B^0 \to D^{(*)+}\pi^-)$ is not possible with the currently available data sample due to the presence of the overwhelming background from $\bar{B}^0 \to D^{(*)+}\pi^-$. However, assuming SU(3) flavor symmetry, $r(D^{(*)}\pi)$ can be related to the branching fraction (BF) of the decay $B^0 \to D_s^{(*)+}\pi^-$ [4]:

$$r(D^{(*)}\pi) = \tan\theta_c \frac{f_{D^{(*)}}}{f_{D_s^{(*)}}} \sqrt{\frac{\mathcal{B}(B^0 \to D_s^{(*)+}\pi^-)}{\mathcal{B}(B^0 \to D^{(*)-}\pi^+)}}, \qquad (1)$$

where θ_c is the Cabibbo angle, $f_{D^{(*)}}$ and $f_{D_s^{(*)}}$ are $D^{(*)}$ and $D_s^{(*)}$ decay constants [6]. Other SU(3)-breaking effects are believed to affect $r(D^{(*)}\pi)$ by less than 30% [5].

Since $B^0 \to D_s^{(*)+}\pi^-$ has four different quark flavors in the final state, only a single amplitude contributes to the decay [Fig. 1(c)]. On the other hand, there are two diagrams contributing to $B^0 \to D^{(*)-}\pi^+$ and $B^0 \to D^{(*)+}\pi^-$: tree amplitudes [Figs. 1(a) and 1(b)] and color-suppressed direct W-exchange amplitudes [Figs. 1(d) and 1(e)]. The latter are assumed to be negligibly small in Eq. (1). The decays $B^0 \to D_s^{(*)-}K^+$ [Fig. 1(f)] probe the size of the W-exchange amplitudes relative to the dominant processes $B^0 \to D^{(*)-}\pi^+$. The rate of $B^0 \to D_s^{(*)-}K^+$ decays could be enhanced by final state rescattering [7], in addition to the W-exchange amplitude. The relative rates of $B^0 \to D_s^{(*)-}K^{(*)+}$ decays could shed light on the decay dynamics, including relative contributions of short- and long-distance effects [8].

The branching fractions $\mathcal{B}(B^0 \to D_s^+\pi^-)$ and $\mathcal{B}(B^0 \to D_s^-K^+)$ have been measured previously by the *BABAR* [9] and Belle [10] collaborations, but the decays $B^0 \to D_s^{*+}\pi^-$ and $B^0 \to D_s^{*-}K^+$ have never been observed. In this Letter we present new measurements of the decays $B^0 \to D_s^{(*)+}\pi^-$ and $B^0 \to D_s^{(*)-}K^+$. The analysis uses a sample of 230×10^6 $\Upsilon(4S)$ decays into $B\bar{B}$ pairs collected with the *BABAR* detector at the SLAC PEP-II asymmetric-energy B factory [11].

Since the *BABAR* detector is described in detail elsewhere [12], only the components that are crucial to this analysis are summarized here. Charged-particle tracking is provided by a five-layer double-sided silicon vertex tracker (SVT) and a 40-layer drift chamber (DCH). Ionization energy loss (dE/dx) in the DCH and SVT and Cherenkov radiation detected in a ring-imaging device are used for charged-particle identification. Photons are identified and measured using the electromagnetic calorimeter (EMC), which is comprised of 6580 thallium-doped CsI crystals. These systems are mounted inside a 1.5 T solenoidal superconducting magnet. We use the GEANT4 [13] software to simulate interactions of particles traversing the *BABAR* detector, taking into account the varying detector conditions and beam backgrounds.

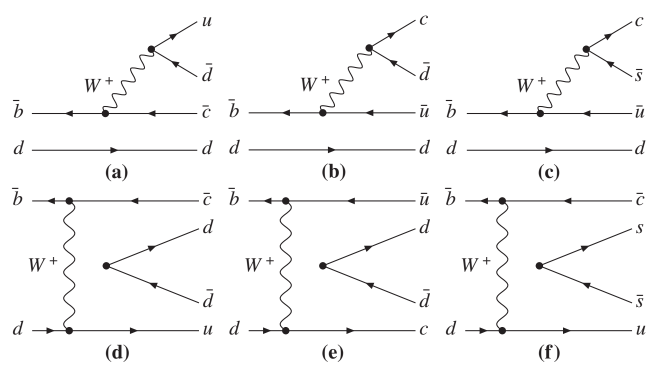

FIG. 1. Dominant Feynman diagrams for (a) CKM-favored decay $B^0 \to D^{(*)-}\pi^+$, (b) doubly CKM-suppressed decay $B^0 \to D^{(*)+}\pi^-$, and (c) the SU(3) flavor symmetry related decays $B^0 \to D_s^{(*)+}\pi^-$; (d) the color-suppressed W-exchange contributions to $B^0 \to D^{(*)-}\pi^+$, (e) $B^0 \to D^{(*)+}\pi^-$, and (f) decay $B^0 \to D_s^{(*)-}K^+$.

Candidates for D_s^+ mesons are reconstructed in the modes $D_s^+ \to \phi\pi^+$, $K_S^0 K^+$, and $\bar{K}^{*0} K^+$, with $\phi \to K^+K^-$, $K_S^0 \to \pi^+\pi^-$, and $\bar{K}^{*0} \to K^-\pi^+$. The K_S^0 candidates are formed from two oppositely charged tracks, and their momenta are required to make an angle $|\theta_{\rm flight}| < 11°$ with the line connecting their vertex and e^+e^- interaction point (IP). All other tracks are required to originate from the IP, whose average position and size are determined hourly using two-prong and hadronic events. In order to reject background from $D^+ \to K_S^0\pi^+$ or $\bar{K}^{*0}\pi^+$, the K^+ candidate in the reconstruction of $D_s^+ \to K_S^0 K^+$ or $\bar{K}^{*0}K^+$ is required to satisfy positive kaon identification criteria with an efficiency of 85% and 5% pion misidentification probability. The same selection is used to identify kaon daughters of the B mesons in decays $B^0 \to D_s^{(*)-}K^+$. In all other cases, kaons are not positively identified, but instead candidates passing pion selection are rejected. Such "pion veto" has an efficiency of 95% for kaons and 20% for pions. Pion daughters of B mesons in the decays $B^0 \to D_s^{(*)+}\pi^-$ are required to be positively identified. Decay products of ϕ, $\bar{K}^{*0}$, K_S^0, D_s^+, and B^0 candidates are constrained to originate from a single vertex.

We reconstruct D_s^{*+} candidates in the mode $D_s^{*+} \to D_s^+\gamma$ by combining D_s^+ and photon candidates. Photon candidates are required to be consistent with an electromagnetic shower in the EMC, and have an energy greater than 100 MeV in the laboratory frame. When forming a D_s^{*+}, the D_s^+ candidate is required to have invariant mass within 10 MeV$/c^2$ of the nominal value [14].

After an initial preselection, we identify signal candidates using a likelihood ratio $R_L = \mathcal{L}_{\rm sig}/(\mathcal{L}_{\rm sig} + \mathcal{L}_{\rm bkg})$, where $\mathcal{L}_{\rm sig} = \prod_i \mathcal{P}_{\rm sig}(x_i)$ is the multivariate likelihood for signal events and $\mathcal{L}_{\rm bkg} = \prod_i \mathcal{P}_{\rm bkg}(x_i)$ is the likelihood for background events. The ratio R_L has a maximum at $R_L = 1$ for signal events, and at $R_L = 0$ for background originating from continuum events. It also discriminates well against generic B decays without a real D_s^+ meson in the final state. The likelihoods $\mathcal{L}_{\rm sig}$ and $\mathcal{L}_{\rm bkg}$ are computed as products of the probability density functions (PDFs) $\mathcal{P}_{\rm sig}(x_i)$ and $\mathcal{P}_{\rm bkg}(x_i)$ for a number of selection variables x_i: invariant masses of the ϕ, $\bar{K}^{*0}$ and K_S^0 candidates, χ^2 confidence level of the vertex fit for the B^0 and D_s^+ mesons, the helicity angles of the ϕ, $\bar{K}^{*0}$, and D_s^{*+} meson decays, the mass difference $\Delta m(D_s^{*+}) = m(D_s^{*+}) - m(D_s^+)$, the polar angle θ_B of the B candidate momentum vector with respect to the beam axis in the e^+e^- center-of-mass (c.m.) frame, the angle θ_T between the thrust axis of the B candidate and the thrust axis of all other particles in the event in c.m. frame, and event topology variable $\mathcal{F}$, discussed below. We have determined the correlations among these variables to be negligibly small. The helicity angle θ_H is defined as the angle between one of the decay products of a vector meson and the flight direction of its parent particle, in the meson's rest frame. Polarization of the vector mesons in the signal decays causes $\cos^2\theta_H$ (ϕ and $\bar{K}^{*0}$) or $\sin^2\theta_H$ (D_s^{*+}) distributions, while the random background combinations tend to produce a more uniform distribution in $\cos\theta_H$.

Variables $\cos\theta_B$, $\cos\theta_T$, and $\mathcal{F}$ discriminate between spherically-symmetric $B\bar{B}$ events and jetty continuum background. $B\bar{B}$ pairs form a nearly uniform $|\cos\theta_T|$ distribution, while $|\cos\theta_T|$ distribution for the continuum peaks at 1. A linear (Fisher) discriminant $\mathcal{F}$ is derived from the values of sphericity and thrust for the event, and the two Legendre moments L_0 and L_2 of the energy flow around the B-candidate thrust axis [15]. Finally, the polar angle θ_B is distributed as $\sin^2\theta_B$ for real B decays, while being nearly flat in $\cos\theta_B$ for the continuum.

We select $B^0 \to D_s^+\pi^-$ and $B^0 \to D_s^-K^+$ candidates that satisfy $R_L > 0.75$, and accept $B^0 \to D_s^{*+}\pi^-$ and $B^0 \to D_s^{*-}K^+$ candidates with $R_L > 0.8$. We measure the relative efficiency ε_{R_L} of the R_L selection in a copious data sample of decays $B^0 \to D^-\pi^+$ ($D^- \to K^+\pi^-\pi^-$, $K_S^0\pi^-$) and $B^+ \to \bar{D}^{*0}\pi^+$ ($\bar{D}^{*0} \to \bar{D}^0\gamma$, $D^0 \to K^-\pi^+$) in which the kinematics is similar to that of our signal events, and find that it is consistent with Monte Carlo estimates $\varepsilon_{R_L} \approx 70\%$. The fraction of continuum background events passing the selection varies between 2% and 15%, depending on the mode.

We identify the signal using the invariant mass $m(D_s)$ of D_s candidates and two kinematic variables $m_{\rm ES}$ and ΔE. The first is the beam-energy-substituted mass $m_{\rm ES} = \sqrt{(s/2 + \mathbf{p}_i \cdot \mathbf{p}_B)^2/E_i^2 - \mathbf{p}_B^2}$, where $\sqrt{s}$ is the total c.m. energy, $(E_i, \mathbf{p}_i)$ is the four-momentum of the initial e^+e^- system and $\mathbf{p}_B$ is the B^0 candidate momentum, both measured in the laboratory frame. The second variable is $\Delta E = E_B^* - \sqrt{s}/2$, where E_B^* is the B^0 candidate energy in the c.m. frame. For signal events, the $m_{\rm ES}$ distribution is Gaussian centered at the B meson mass with a resolution of about 2.5 MeV$/c^2$, and the ΔE distribution has a maximum near zero with a resolution of about 17 MeV. The invariant mass $m(D_s)$ has a resolution of (5–6) MeV$/c^2$, depending on the D_s^+ decay mode. We define a fit region $5.2 < m_{\rm ES} < 5.3$ GeV$/c^2$, $|\Delta E| < 36$ MeV, and $|m(D_s) - m(D_s)_{\rm PDG}| < 50$ MeV$/c^2$ for $B^0 \to D_s^+\pi^-$ and $B^0 \to D_s^-K^+$ candidates, where $m(D_s)_{\rm PDG}$ is the world average D_s mass [14]. For $B^0 \to D_s^{*+}\pi^-$ and $B^0 \to D_s^{*-}K^+$, we require $|m(D_s) - m(D_s)_{\rm PDG}| < 10$ MeV$/c^2$.

Less than 20% of the selected events in the $B^0 \to D_s^{*+}\pi^-$ and $B^0 \to D_s^{*-}K^+$ channels and less than 4% in $B^0 \to D_s^+\pi^-$ and $B^0 \to D_s^-K^+$ channels contain two or more candidates that satisfy the criteria listed above. In such events we select a single B^0 candidate based on an event χ^2 formed with $m(D_s)$ (both D_s^+ and D_s^{*+} modes) and $\Delta m(D_s^{*+})$ (D_s^{*+} modes) and their average uncertainties, and the ΔE variable. Such selection does not bias background distributions significantly.

Four classes of background contribute to the fit region. First is the *combinatorial background*, in which a true or fake $D_s^{(*)}$ candidate is combined with a randomly-selected pion or kaon. Second, B meson decays such as $\bar{B}^0 \to D^{(*)+}\pi^-$, ρ^- with $D^+ \to K_S^0\pi^+$ or $\bar{K}^{*0}\pi^+$ can constitute a background for the $B^0 \to D_s^{(*)+}\pi^-$ modes if the pion in the D decay is misidentified as a kaon (*reflection background*). The reflection background has nearly the same $m_{\rm ES}$ distribution as the signal but different distributions in ΔE and $m(D_s)$. The corresponding backgrounds for the $B^0 \to D_s^- K^+$ mode ($B^0 \to D^- K^{(*)+}$) are negligible. Third, rare B decays into the same final state, such as $B^0 \to \bar{K}^{(*)0}K^+\pi^-$ or $\bar{K}^{(*)0}K^+K^-$ (*charmless background*), have the same $m_{\rm ES}$ and ΔE distributions as the $B^0 \to D_s^+\pi^-$ or $B^0 \to D_s^- K^+$ signal, but are nearly flat in $m(D_s)$. The charmless background is significant in $B^0 \to D_s^+\pi^-$ and $B^0 \to D_s^- K^+$ decays, but is negligible for $B^0 \to D_s^{*+}\pi^-$ and $B^0 \to D_s^{*-}K^+$. Finally, *crossfeed background* from misidentification of $\bar{B}^0 \to D_s^{(*)-}\pi^+$ events as $B^0 \to D_s^{(*)-}K^+$ signal, and vice versa, needs to be taken into account.

We perform a two-dimensional unbinned extended maximum-likelihood fit to the $m_{\rm ES}$ and $m(D_s)$ distributions to extract $\mathcal{B}(B^0 \to D_s^+\pi^-)$ and $\mathcal{B}(B^0 \to D_s^- K^+)$ and constrain the contributions from charmless background modes. Charmless backgrounds are negligible for $B^0 \to D_s^{*+}\pi^-$ and $B^0 \to D_s^{*-}K^+$, and we determine the BFs of these decays with a one-dimensional fit to the $m_{\rm ES}$ distribution. For each B decay, we simultaneously fit distributions in three D_s^+ decay modes, constraining the signal BFs to a common value. The likelihood function contains the contributions of the signal and the four background components discussed above. The combinatorial background is described in $m_{\rm ES}$ by a threshold function [16], $dN/dx \propto x\sqrt{1-2x^2/s}\exp[-\xi(1-2x^2/s)]$. In $m(D_s)$, the combinatorial background is well described by a combination of a first-order polynomial (fake D_s^+ candidates) and a Gaussian with (5–6) MeV$/c^2$ resolution (true D_s^+ candidates). The charmless background is parameterized by the signal Gaussian shape in $m_{\rm ES}$ and a first-order polynomial in $m(D_s)$.

For $B^0 \to D_s^+\pi^-$ and $B^0 \to D_s^- K^+$ decays, the fit determines 14 free parameters: the shape of the combinatorial background ξ (1 parameter for all D_s^+ modes), the slope of the combinatorial and charmless backgrounds in $m(D_s)$ (3 parameters), the fraction of true D_s^+ candidates in combinatorial background (3), the number of combinatorial background events (3), the number of charmless events (3), and the BF of the signal mode (1). The signal yields for each D_s^+ mode are expressed as $N_{{\rm sig}i} = N_{B\bar{B}}\mathcal{B}_{\rm sig}\mathcal{B}_i\varepsilon_i$, where $N_{B\bar{B}} = 230 \times 10^6$, $\mathcal{B}_i$ is the D_s^+ BF for the mode, ε_i is the reconstruction efficiency, and $\mathcal{B}_{\rm sig}$ is the BF (fit parameter) for the decay. For the $B^0 \to D_s^{*+}\pi^-$ and $B^0 \to D_s^{*-}K^+$ decays, 5 free parameters are determined by the fit: ξ (1 parameter for all D_s^+ modes), the number of combinatorial background events (3), and the BF of the signal mode (1). The signal efficiency ε_i varies between 6.7% and 29.3%, depending on the mode. The BFs of the channels contributing to the reflection background are fixed in the fit to the current world average values [14], and the BFs of the crossfeed backgrounds are determined by iterating the fits over each B decay mode. The fit samples contain 1305 events for $B^0 \to D_s^+\pi^-$, 132 for $B^0 \to D_s^{*+}\pi^-$, 539 for $B^0 \to D_s^- K^+$, and 41 events for $B^0 \to D_s^{*-}K^+$ mode. The results of the fits are shown in Fig. 2 and summarized in Table I.

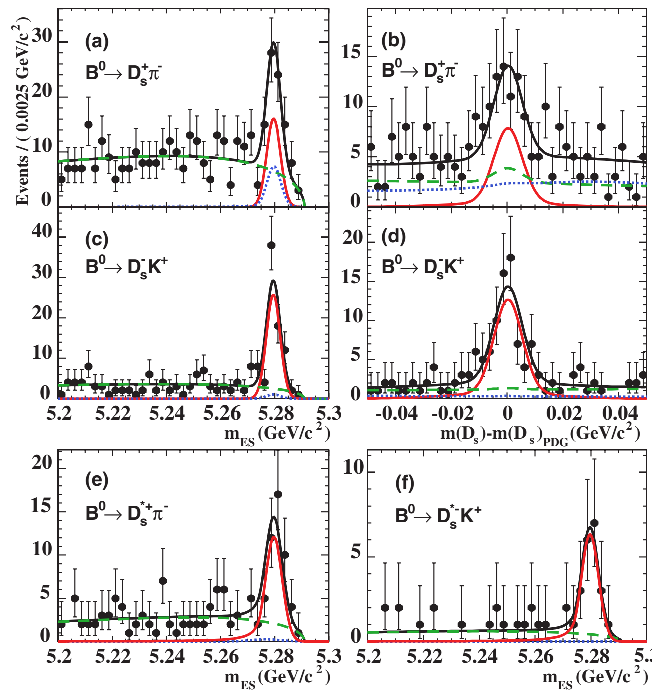

FIG. 2 (color online). (a),(c),(e),(f) $m_{\rm ES}$ projection of the fit with $|m(D_s^+) - m(D_s^+)_{\rm PDG}| < 10$ MeV$/c^2$ and (b),(d) $m(D_s)$ projection with $5.275 < m_{\rm ES} < 5.285$ GeV for (a),(b) $B^0 \to D_s^+\pi^-$, (c),(d) $B^0 \to D_s^- K^+$, (e) $B^0 \to D_s^{*+}\pi^-$, and (f) $B^0 \to D_s^{*-}K^+$. Bins with zero events are omitted for clarity. The black solid curve corresponds to the full PDF from the combined fit to all D_s^+ decay modes. Individual contributions are shown as solid red lines (signal PDF), green dashed lines (combinatorial background), and blue dotted lines (sum of reflection, charmless, and crossfeed backgrounds) curves.

Systematic errors are dominated by 13% relative uncertainty for $\mathcal{B}(D_s^+ \to \phi\pi^+)$ [17]. The relative BF uncertainties for $\mathcal{B}(D_s^+ \to \bar{K}^{*0}K^+)/\mathcal{B}(D_s^+ \to \phi\pi^+)$ and $\mathcal{B}(D_s^+ \to K_S^0 K^+)/\mathcal{B}(D_s^+ \to \phi\pi^+)$ contribute 5%–7%, depending on the decay channel. Uncertainties in the selection efficiency are estimated to be 3% for D_s^+ modes and 7% for D_s^{*+} modes. The uncertainties in the reflection and crossfeed backgrounds are below 1% for all decay channels. Other systematic errors include the uncertainties in tracking (5%), photon (3%), and K_s^0 reconstruction (0.2%–0.5%), charged-kaon identification (1%) efficiencies, and variations of the PDF shapes between data and

TABLE I. The results of the fit for the branching ratios. Shown are the probability (P_{bkg}) of the data being consistent with the background in the absence of signal, and the measured branching fraction $\mathcal{B}$. The first uncertainty is statistical, and the second is systematic.

B mode	P_{bkg}	$\mathcal{B}(10^{-5})$	$\mathcal{B} \times \mathcal{B}(D_s^+ \to \phi\pi^+)(10^{-6})$
$B^0 \to D_s^+ \pi^-$	3×10^{-6}	$1.3 \pm 0.3 \pm 0.2$	$0.63 \pm 0.15 \pm 0.05$
$B^0 \to D_s^{*+} \pi^-$	3×10^{-8}	$2.8 \pm 0.6 \pm 0.5$	$1.32 \pm 0.27 \pm 0.15$
$B^0 \to D_s^- K^+$	3×10^{-19}	$2.5 \pm 0.4 \pm 0.4$	$1.21 \pm 0.17 \pm 0.11$
$B^0 \to D_s^{*-} K^+$	2×10^{-5}	$2.0 \pm 0.5 \pm 0.4$	$0.97 \pm 0.24 \pm 0.12$

Monte Carlo calculations ([1%–5%], depending on decay mode).

The ratio $P_{bkg} = \mathcal{L}_0/\mathcal{L}_{max}$, where $\mathcal{L}_{max}$ is the maximum-likelihood value, and $\mathcal{L}_0$ is the likelihood for a fit with the signal contribution set to zero, describes the probability of the background to fluctuate to the observed number of events. The values P_{bkg} in Table I include all systematic uncertainties, which are assumed to be Gaussian-distributed. They correspond to the significance of signal observation of 5 ($B^0 \to D_s^+ \pi^-$), 6 ($B^0 \to D_s^{*+} \pi^-$), 9 ($B^0 \to D_s^- K^+$), and 5 ($B^0 \to D_s^{*-} K^+$) standard deviations. This is the first observation of $B^0 \to D_s^+ \pi^-$, $B^0 \to D_s^{*+} \pi^-$, and $B^0 \to D_s^{*-} K^+$ decays.

Assuming the SU(3) relation, Eq. (1), we determine $r(D\pi) = (1.29 \pm 0.15(\text{stat}) \pm 0.13(\text{syst})) \times 10^{-2}$, and $r(D^*\pi) = (1.87 \pm 0.19(\text{stat}) \pm 0.19(\text{syst})) \times 10^{-2}$, which implies small CP asymmetries in $B^0 \to D^{(*)\mp} \pi^\pm$ decays. The branching fractions for $B^0 \to D_s^{(*)-} K^+$ are small compared to the dominant decays $B^0 \to D^{(*)-} \pi^+$, implying relatively insignificant contributions from the color-suppressed W-exchange diagrams. These results supersede our previously published measurements [9].

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[1] N. Cabibbo, Phys. Rev. Lett. **10**, 531 (1963); M. Kobayashi and T. Maskawa, Prog. Theor. Phys. **49**, 652 (1973).

[2] C. Jarlskog, in *CP Violation*, edited by C. Jarlskog (World Scientific, Singapore, 1988).

[3] Charge conjugation is implied throughout this Letter, unless explicitly stated.

[4] I. Dunietz, Phys. Lett. B **427**, 179 (1998).

[5] B. Aubert *et al.* (*BABAR* Collaboration), Phys. Rev. Lett. **92**, 251801 (2004); Phys. Rev. D **71**, 112003 (2005); T. Sarangi *et al.* (Belle Collaboration), Phys. Rev. Lett. **93**, 031802 (2004).

[6] C. Aubin *et al.*, Phys. Rev. Lett. **95**, 122002 (2005); D. Becirevic, hep-ph/0310072.

[7] B. Blok *et al.*, Phys. Rev. Lett. **78**, 3999 (1997).

[8] S. Mantry *et al.*, Phys. Rev. D **68**, 114009 (2003).

[9] B. Aubert *et al.* (*BABAR* Collaboration), Phys. Rev. Lett. **90**, 181803 (2003).

[10] P. Krokovny *et al.* (Belle Collaboration), Phys. Rev. Lett. **89**, 231804 (2002).

[11] PEP-II Conceptual Design Report, No. SLAC-0418, 1993.

[12] B. Aubert *et al.* (*BABAR* Collaboration), Nucl. Instrum. Methods Phys. Res., Sect. A **479**, 1 (2002).

[13] S. Agostinelli *et al.* (GEANT4 Collaboration), Nucl. Instrum. Methods Phys. Res., Sect. A **479**, 1 (2002).

[14] S. Eidelman *et al.* (Particle Data Group), Phys. Lett. B **592**, 1 (2004).

[15] B. Aubert *et al.* (*BABAR* Collaboration), Phys. Rev. Lett. **89**, 281802 (2002); Phys. Rev. D **70**, 032006 (2004).

[16] H. Albrecht *et al.* (ARGUS Collaboration), Z. Phys. C **48**, 543 (1990).

[17] B. Aubert *et al.* (*BABAR* Collaboration), Phys. Rev. D **71**, 091104 (2005).