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Study of the Decays $B^- \to D^{(*)+}\pi^-\pi^-$

The *BABAR* Collaboration

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Abstract

We report on analyses of B^- mesons decaying into $D^{*+}\pi^-\pi^-$ and $D^+\pi^-\pi^-$ final states using 89 million B^- decays collected by the *BABAR* detector at the PEP-II asymmetric-energy B Factory. Preliminary measurements are given for the inclusive branching fractions for $B^- \to D^{*+}\pi^-\pi^-$ and $B^- \to D^+\pi^-\pi^-$, and for the exclusive branching fractions for $B^- \to D_1(2420)^0\pi^-$ and $B^- \to D_2^*(2460)^0\pi^-$, where $D_1(2420)^0$ and $D_2^*(2460)^0$ are the two narrow $c\bar{u}$ P-wave states. The ratio $\mathcal{B}(B^- \to D_2^*(2460)^0\pi^-)/\mathcal{B}(B^- \to D_1(2420)^0\pi^-)$ is measured to be $0.80 \pm 0.07 \pm 0.16$.

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1 INTRODUCTION

Heavy Quark Effective Theory (HQET) takes as its starting point the Heavy Quark Symmetry (HQS) limit in which the masses of both the initial- and final-state heavy quarks in a decay are taken to be infinite [1, 2]. Orbitally excited states of the D meson, typically denoted D_J (or D^{**}), provide a unique opportunity to test HQET. The simplest D_J meson consists of a charm quark and a light quark in an orbital angular momentum $L = 1$ (P-wave) state. The spectroscopy of P-wave D mesons is summarized in Ref. [2]. In the HQS limit ($m_c \gg \Lambda_{QCD}$), analogous to the hydrogen atom, the spin of the charm quark decouples from the other angular momenta, the angular momentum sum $\mathbf{j} = \mathbf{S}_q + \mathbf{L}$ of the light quark spin $\mathbf{S}_q$ and the orbital angular momentum $\mathbf{L}$ is conserved, and j is a good quantum number. Therefore, one expects one doublet of states with $j = 3/2$ and one doublet with $j = 1/2$ [3]. In the limit of a light charm quark ($m_c \ll \Lambda_{QCD}$), analogous to positronium, the $L = 1$ combines with the total spin of $S = 0$ or 1 to produce a singlet state with $J = 1$ and $S = 0$, and a triplet of states with $J = 0, 1, 2$ and $S = 1$ [2]. The $J = 0$ state must have $j = 1/2$ and the $J = 2$ state $j = 3/2$. However, the two $J = 1$ states may be a mixture of $j = 1/2$ and $j = 3/2$. The details of this mixing probe the breaking of the Heavy Quark Symmetry due to the finite mass of the charm quark [4].

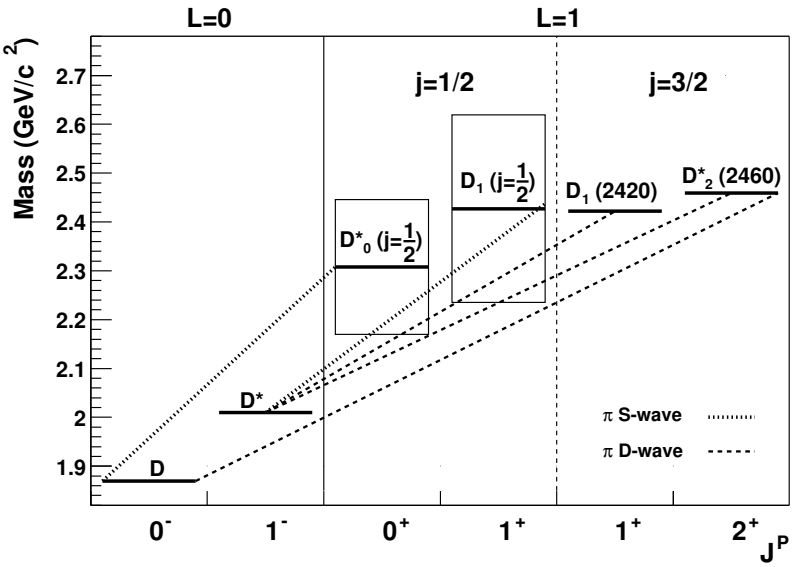

Figure 1: Mass spectrum for $c\bar{q}$ states. The open boxes indicate that the $D_0^*(j = 1/2)$ and $D_1(j = 1/2)$ are expected to be wide. Lines between levels show anticipated pion transitions. Narrow masses are from Ref. [7], wide masses and widths are from Ref. [9].

We label the four neutral D-meson P-wave states[7] as $D_0^*(j = 1/2)^0$, $D_1(2420)^0$, $D_1(j = 1/2)^0$, and $D_2^*(2460)^0$ and show the mass spectrum and expected transitions in Fig. 1. The conservation of parity and angular momentum restricts the final states and partial waves that are allowed in the decays of the various D_J mesons. The resonances that decay through a D-wave are expected to be narrow (20–30 MeV) and the resonances that decay through an S-wave are expected to be wide (a few hundred MeV). The $D_2^*(2460)^0$ can only decay via a D-wave and the $D_0^*(j = 1/2)^0$

[7]Charged conjugate states are implied throughout the paper.

can only decay via an S-wave. The $D_1(j=1/2)^0$ and $D_1(2420)^0$ may decay via S-wave or D-wave. In the HQS limit, the $D_1(2420)^0$ will decay only via D-wave and is therefore a narrow resonance. Analogously, the $D_1(j=1/2)^0$ will decay only via S-wave and is therefore a broad resonance.

The members of the isospin doublet of narrow resonances, $D_2^*(2460)^0$ and $D_1(2420)^0$, have been observed by many experiments [6]. The properties of the D_J^0 mesons as listed in the 2002 Review of Particle Physics are given in Table 1.

Table 1: Properties of $L=1$ D_J^0 mesons. Masses and widths are from Ref. [7].

State	J^P	Mass (MeV/c^2)	Width (MeV)	Decays	Partial waves	HQS allowed
$D_0^*(j=1/2)^0$	0^+	—	—	$D\pi$	S	S
$D_1(2420)^0$	1^+	2422.2 ± 1.8	$18.9^{+4.6}_{-3.5}$	$D^*\pi$	S,D	D
$D_1(j=1/2)^0$	1^+	—	—	$D^*\pi$	S,D	S
$D_2^*(2460)^0$	2^+	2458.9 ± 2.0	23 ± 5	$D^*\pi,\ D\pi$	D	D

Predictions based on HQET can differ due to variations in the calculational techniques employed. One such case involves the ratio of the branching fractions, $\mathcal{B}$, for the two narrow states

$$R \equiv \frac{\mathcal{B}(B^- \to D_2^*(2460)^0\pi^-)}{\mathcal{B}(B^- \to D_1(2420)^0\pi^-)}. \quad (1)$$

Reference [10] obtains values of R between 0 and 1.5. Reference [11] predicts $R \approx 0.35$.

In this paper we present preliminary measurements of the inclusive branching fractions for $B^- \to D^{*+}\pi^-\pi^-$ and $B^- \to D^+\pi^-\pi^-$, the exclusive branching fractions for $B^- \to D_1(2420)^0\pi^-$ and $B^- \to D_2^*(2460)^0\pi^-$, and R.

2 THE *BABAR* DETECTOR AND DATASET

The data used in this analysis were collected with the *BABAR* detector at the PEP-II e^+e^- asymmetric-energy storage ring during the years 1999 - 2002. The sample corresponds to an integrated luminosity of 81.9 fb^{-1} accumulated on the $\Upsilon(4S)$ resonance ("on-resonance") and 9.6 fb^{-1} accumulated at an e^+e^- center-of-mass (CM) energy about 40 MeV below the $\Upsilon(4S)$ resonance ("off-resonance"), which are used for $q\bar{q}$ background studies. The on-resonance sample corresponds to (88.9 ± 0.9) million $B\overline{B}$ pairs.

A detailed description of the *BABAR* detector can be found elsewhere [12]. Charged particle trajectories are measured by a five-layer double-sided silicon vertex tracker (SVT) and a 40-layer drift chamber (DCH), which lie within a 1.5 T solenoidal magnetic field. Charged particle identification is achieved by combining ionization-energy loss (dE/dx) measurements in the DCH and SVT with information from the ring-imaging Cherenkov detector. Photons are identified in a CsI(Tl) electromagnetic calorimeter. The instrumented flux return is equipped with resistive plate chambers for muon and neutral hadron identification.

Table 2: Summary of selection criteria for each mode. Masses are given in MeV/c^2, energies are in MeV, and the K^0_s flight length is in cm. The $|\Delta E|$ requirement is not applied for the measurements of the inclusive $B^- \to D^{*+}\pi^-\pi^-$ and $B^- \to D^+\pi^-\pi^-$ branching fractions. The selection criteria are described in more detail in the text.

	$B \to D^{*+}\pi^-\pi^-$, $D^{*+} \to D^0\pi^+$ $D^0 \to$				$B \to D^+\pi^-\pi^-$ $D^+ \to$	
Selection Criteria	$K^-\pi^+$	$K^-\pi^+\pi^0$	$K^-\pi^+\pi^-\pi^+$	$K^0_S\pi^+\pi^-$	$K^-\pi^+\pi^+$	$K^0_S\pi^+$
$\lvert\cos\theta_{\rm thrust}\rvert$	< 0.95	< 0.95	< 0.95	< 0.95	< 0.95	< 0.95
R_2	< 0.8	< 0.7	< 0.8	< 0.7	< 0.35	< 0.35
$\lvert\delta m(\pi^0)\rvert$	—	< 18	—	—	—	—
$E_{\rm min}(\gamma)$	—	> 35	—	—	—	—
$\lvert\delta m(K^0_S)\rvert$	—	—	—	< 9	—	< 9
K^0_S flight length	—	—	—	> 0.1	—	> 0.1
Dalitz weight	—	> 0.01	—	—	—	—
$\lvert\delta[m(D^{*+}) - m(D^0)]\rvert$	< 3.0	< 2.6	< 2.8	< 3.0	—	—
$\lvert\delta m(D^0)\rvert$	< 31	< 29	< 15	< 21	—	—
$\lvert\delta m(D^+)\rvert$	—	—	—	—	< 15	< 15
$m_{\rm ES}$	> 5274	> 5274	> 5274	> 5274	> 5274	> 5271
$\lvert\Delta E\rvert$	< 28	< 26	< 24	< 32	< 26	< 28

3 ANALYSIS METHOD

We reconstruct the B^- decays to the final states $D^{*+}\pi^-\pi^-$ and $D^+\pi^-\pi^-$ for study of the properties of the D^0_J resonances. D^{*+} candidates are reconstructed by combining D^0 candidates and a π^+. D^0 candidates are reconstructed in the modes: $D^0 \to K^-\pi^+$, $D^0 \to K^-\pi^+\pi^0$, $D^0 \to K^-\pi^+\pi^-\pi^+$, and $D^0 \to K^0_s\pi^+\pi^-$. D^+ candidates are reconstructed in the modes: $D^+ \to K^-\pi^+\pi^+$ and $D^+ \to K^0_s\pi^+$. As indicated in Table 1, we expect the decay $B^- \to D^{*+}\pi^-\pi^-$ to proceed dominantly through the intermediate states $D^*_2(2460)^0\pi^-$, $D_1(2420)^0\pi^-$, and $D_1(j = 1/2)^0\pi^-$, which involve the two narrow D^0_J resonances and the wide $D_1(j = 1/2)^0$ resonance respectively. A contribution from the three-body decay $B^- \to D^{*+}\pi^-\pi^-$ (nonresonant) is also possible. The decay $B^- \to D^+\pi^-\pi^-$ is expected to proceed primarily through the intermediate states $D^*_2(2460)^0\pi^-$ and $D^*_0(j = 1/2)^0\pi^-$ with a contribution from three-body nonresonant decay of $B^- \to D^+\pi^-\pi^-$.

The selection criteria are optimized by maximizing $S^2/(S+B)$, where the signal yield S is based on signal Monte Carlo and the branching fractions presented by the BELLE collaboration [8], and the expected background yield B is determined from generic $B\bar{B}$ MC (after removing the signal events) and off-resonance data.

The complete set of selection criteria is given in Table 2. Suppression of background from nonresonant $q\bar{q}$ production is provided by two topological requirements. In particular, we employ restrictions on the magnitude of the cosine of the thrust angle, $\theta_{\rm thrust}$, defined as the angle between the thrust axis of the particles that form the reconstructed B^- candidate and the thrust axis of the remaining tracks and neutral clusters in the event. We also select on the ratio of the second to the zeroth Fox-Wolfram moment [13], R_2, to gain additional discrimination between signal events and those from continuum background. Neutral pion candidates are used in the reconstruction of D^0 via the $K\pi\pi^0$ decay mode and are selected based on the π^0 mass, $m(\pi^0)$, and the minimum photon

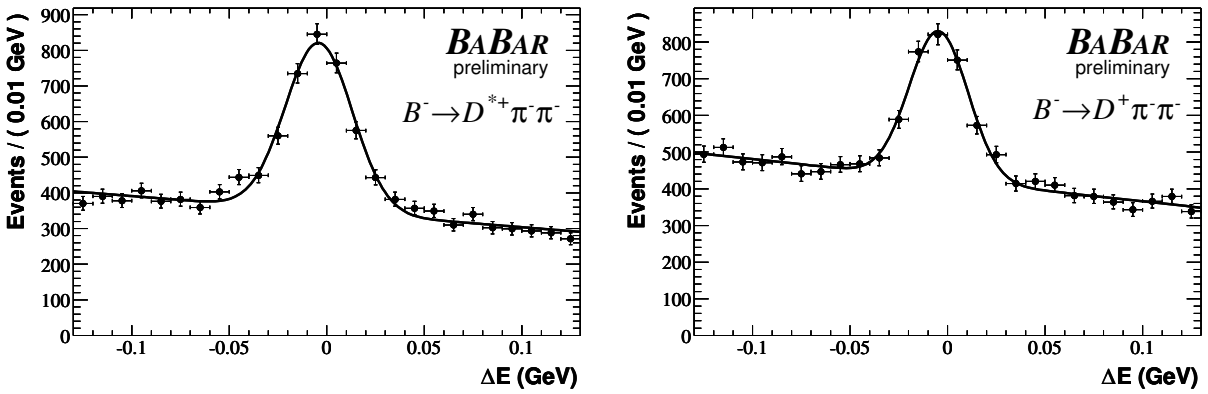

Figure 2: Distributions of ΔE for the selected $B^- \to D^{*+}\pi^-\pi^-$ (left) and $B^- \to D^+\pi^-\pi^-$ (right) candidates in the $m_{\rm ES}$ signal region. The signal is fit with a Gaussian and the background is fit with a linear function.

energy, $E_{\rm min}(\gamma)$. Kaon track selection is based on information from the tracking and DIRC systems and has an efficiency of about 80%. Charged pion tracks in all modes are required **not** to satisfy the kaon track selection. The K^0_S candidates are reconstructed using two charged tracks with an invariant mass, $m(K^0_S)$, within a region around the nominal K^0_S mass. In addition, a constraint on the flight distance of the K^0_S candidate from the primary vertex significantly reduces background from combinatorics. For the $D^0 \to K^-\pi^+\pi^0$ mode, intermediate resonant states, such as $K^-\rho^+$, $K^{*0}(892)\pi^0$ and $K^{*-}(892)\pi^+$, are exploited by the use of a Dalitz weight criteria which selects 71% of real $D^0 \to K^-\pi^+\pi^0$ events and rejects 72% of fake $D^0 \to K^-\pi^+\pi^0$ events. The masses of the D^0 and D^+ candidates are required to be in a region around their nominal values. For D^{*+} candidates, the mass difference, $\Delta m = m(D^{*+}) - m(D^0)$, is required to be in a region around the nominal value. The widths of these regions are dependent on the decay mode of the D^0 or D^+ and are determined from the optimization (see Table 2).

B^- candidates are reconstructed by combining either a D^{*+} or D^+ candidate with two π^- mesons. The standard kinematic variables, $m_{\rm ES}$ and ΔE, define the signal region and are computed as follows:

$$m_{\rm ES} = \sqrt{(E^*_{\rm beam})^2 - (\sum_i \mathbf{p}^*_i)^2}, \quad (2)$$

$$\Delta E = \sum_i \sqrt{m_i^2 + (\mathbf{p}^*_i)^2} - E^*_{\rm beam}, \quad (3)$$

where $E^*_{\rm beam}$ is the beam energy in the $\Upsilon(4S)$ CM frame, $\mathbf{p}^*_i$ is the CM momentum of particle i in the candidate B^--meson system, and m_i is the mass of particle i. For signal events, the beam-energy-substituted B^- mass, $m_{\rm ES}$, peaks at m_B. The quantity ΔE is used to determine whether a candidate system of particles has total energy consistent with the beam energy in the CM frame.

For each decay mode, we fit the ΔE distributions of the selected $B^- \to D^{*+}\pi^-\pi^-$ and $B^- \to D^+\pi^-\pi^-$ candidates in the $m_{\rm ES}$ signal region (see Table 2) with a Gaussian for the signal and a linear function for the background. The resolution of the ΔE distributions is about 18 MeV. The number of events with multiple B candidates is found to be about 15% for the mode containing π^0 and $2-5$% for the rest. The results of the fit are shown in Table 3 and Fig. 2.

The inclusive $B^- \to D^{(*)+}\pi^-\pi^-$ branching fraction for each D^0/D^+ decay mode k ($k = K^-\pi^+$, $K^-\pi^+\pi^0$, $K^-\pi^+\pi^-\pi^+$, and $K^0_S\pi^+\pi^-$ for D^0, and $k = K^-\pi^+\pi^+$, $K^0_S\pi^+$ for D^+) is given by the relation

$$\mathcal{B}_k = \frac{N_{\mathrm{signal},k}}{(\epsilon_k \cdot \mathcal{B}(D^{(*)+})_k) \cdot N(B^-)}, \tag{4}$$

where $N_{\mathrm{signal},k}$ is the fitted signal yield, ϵ_k is the $B^- \to D^{(*)+}\pi^-\pi^-$ reconstruction efficiency, as determined from Monte Carlo simulations, averaged over all contributing D^0_J resonances and nonresonant three-body decay, $\mathcal{B}(D^{*+})_k$ is the product of the branching ratio for $D^{*+} \to D^0\pi^+$ ($= (67.7 \pm 0.5)\%$) and the D^0 branching fraction for decay mode k, $\mathcal{B}(D^+)_k$ is the D^+ branching fraction for decay mode k [7], $N(B^-) = (88.9 \pm 0.9) \times 10^6$. The values of these quantities, along with the resultant branching fraction for each decay mode, are given in Table 3. The average $B^- \to D^{*+}\pi^-\pi^-$ and $B^- \to D^+\pi^-\pi^-$ branching ratios, which are calculated as the weighted mean of the branching ratios measured for the different D^0 or D^+ decay modes, are also given. The weight for each D^0 or D^+ decay mode is the inverse of the statistical uncertainty for that mode.

Table 3: Number of signal candidates from the fit to the ΔE distribution, average efficiency, and measured branching fraction. Uncertainties are statistical only.

Decay Mode	N_{Signal}	Avg. ϵ_k (%)	Br. Frac. (%)
$B^- \to D^{*+}\pi^-\pi^-$			
$D^0 \to$ all modes	1997 ± 81	–	1.22 ± 0.05
$D^0 \to K^-\pi^+$	571 ± 36	21.3 ± 0.9	1.17 ± 0.07
$D^0 \to K^-\pi^+\pi^0$	735 ± 56	7.6 ± 0.4	1.23 ± 0.09
$D^0 \to K^-\pi^+\pi^-\pi^+$	627 ± 42	9.9 ± 0.5	1.41 ± 0.09
$D^0 \to K^0_s\pi^+\pi^-$	48 ± 13	5.5 ± 0.5	0.72 ± 0.19
$B^- \to D^+\pi^-\pi^-$			
$D^+ \to$ all modes	1514 ± 78	–	0.87 ± 0.04
$D^+ \to K^-\pi^+\pi^+$	1417 ± 76	20.4 ± 0.6	0.86 ± 0.05
$D^+ \to K^0_s\pi^+$	88 ± 17	10.5 ± 0.5	1.00 ± 0.19

For each B^- candidate in the (m_{ES}, ΔE) signal region (as defined in Table 2), the exclusive D_J candidates are formed, by combining the $D^{(*)+}$ daughter with the slower of the two pions from the B^- decay. The $D^{*+}\pi^-$ and $D^+\pi^-$ mass distributions are shown for the $B^- \to D^{*+}\pi^-\pi^-$ and $B^- \to D^+\pi^-\pi^-$ final states respectively in Figure 3 summed over all D^0/D^+ decay modes. In this preliminary analysis, we do not attempt to fit the $B^- \to D^{(*)+}\pi^-\pi^-$ Dalitz distributions. Upper and lower ΔE sidebands, defined by $|\Delta E| > 60$ MeV, each with half the width of signal region, are used to estimate the background under the D_J mass peak.

Assuming the decay chain $B^- \to D^0_J\pi^- \to D^{(*)+}\pi^-\pi^-$, we perform an unbinned maximum likelihood fit to the $m(D^{(*)+}\pi^-)$ distribution of the ΔE signal region and sidebands to obtain the mass and width of each narrow D^0_J resonance. In the fit we describe the signal $m(D^{(*)+}\pi^-)$ distribution with a non-relativistic Breit-Wigner shape convolved with a Gaussian function that represents the detector resolution. For the $B^- \to D^{*+}\pi^-\pi^-$ case, we fit simultaneously all D^0 decay modes to extract the mass and width of both the $D_1(2420)^0$ and the $D^*_2(2460)^0$. For the $B^- \to D^+\pi^-\pi^-$ case, we fit simultaneously all D^+ decay modes to extract the mass and width of the $D^*_2(2460)^0$. For the present analysis, the broad D^0_J resonances and nonresonant B^- decay

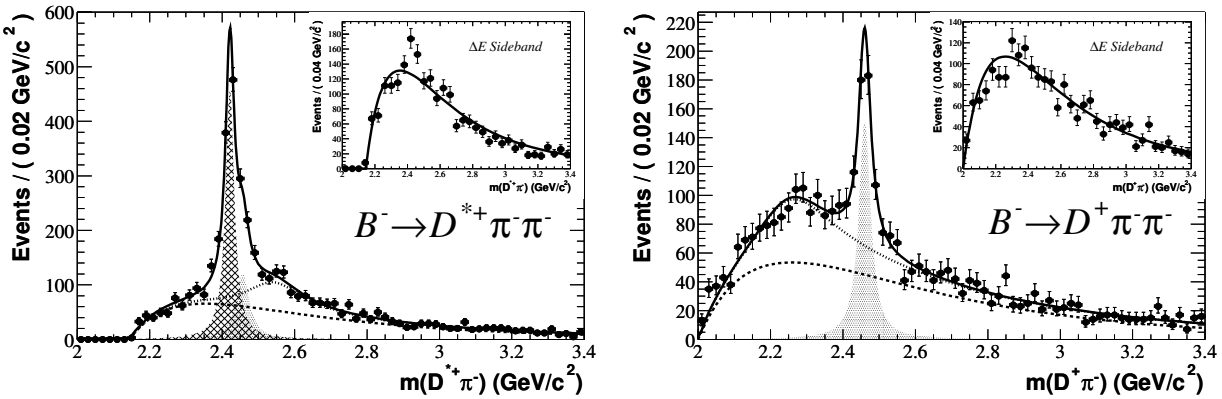

Figure 3: $m(D^{(*)+}\pi^-)$ shown for the $D^{*+}\pi^-\pi^-$ candidates (left) and $D^+\pi^-\pi^-$ candidates (right). The data corresponding to the signal region is shown overlaid with the fit result. A fit to the data in the ΔE sideband region is shown with a dashed line. An enlarged view of the background shape can be seen in the inset, which shows the ΔE sideband region with a larger ($\times 2$) bin size. The dotted line shows a fit to the sum of the background (dashed line) and the contribution from the wide D_J states. The contributions from the $D_1(2420)^0$ and $D_2^*(2460)^0$ are shown with hashed and solid areas, respectively. The fitting procedure is described in the text.

modes are not distinguished from each other. In the fit for each decay mode, the broad resonances are described by a relativistic Breit-Wigner shape. The combinatorial background, determined primarily by events in the ΔE sidebands, is described by a threshold function. The small excess at the signal mass seen in the inset plot for the $D^{*+}\pi^-\pi^-$ mode in Fig. 3, showing data from the ΔE sideband region, is found from Monte Carlo studies to be due to self crossfeed from true D_J states that are combined with a wrong pion and which therefore misreconstruct the B^-. We account for the excess as a systematic uncertainty.

To obtain the yield for each D^0/D^+ decay mode, similar fits are performed on each mode separately with the mass and width values of the narrow resonances ($D_1(2420)^0$ and $D_2^*(2460)^0$) fixed to those found from the global fit over all modes. Since the mass and width of the $D_2^*(2460)^0$ are found from both the $m(D^{*+}\pi^-)$ and $m(D^+\pi^-)$ global fits, the fixed values used are the weighted average of the two.

For each D^0 or D^+ decay mode, the calculation of the exclusive branching ratios from the yields and efficiencies is analogous to the inclusive case (see Eq. 4). The exclusive efficiencies, as determined from Monte Carlo simulations, and the yields and resultant branching fractions for each decay mode are given in Table 4. The weighted averages of the branching ratios found for the individual D^0 and D^+ decay modes are also given.

Quantitative study of the wide resonances, $D_0^*(j = 1/2)^0$ and $D_1(j = 1/2)^0$, requires a Dalitz analysis and will form the basis of a subsequent publication. Interference between the two D_1^0 resonances in the decay $B^- \to D^{*+}\pi^-\pi^-$ is, therefore, not within the scope of the present paper.

4 STUDIES OF SYSTEMATIC UNCERTAINTIES

As listed in Table 5, the systematic uncertainties on the measurement of the inclusive $B^- \to D^{(*)+}\pi^-\pi^-$ and exclusive $B^- \to D_J^0\pi^-$ branching fractions are due to sources such as tracking and

Table 4: Reconstruction efficiencies for $m(D^{*+}\pi^-)$ and $m(D^+\pi^-)$ fits for each mode as determined from $B^- \to D^0_J\pi^-$ simulated events, D^0_J signal yields, and D^0_J branching ratios for each resonance. "$D^0/D^+ \to$ all modes" branching fractions correspond to a weighted average of the individual modes.

	Reconstruction Eff.		Yield		Br. Ratio ($\times 10^{-3}$)	
Decay Mode	$D_1(2420)^0$	$D_2^*(2460)^0$	$D_1(2420)^0$	$D_2^*(2460)^0$	$D_1(2420)^0$	$D_2^*(2460)^0$
	$B^- \to D^0_J\pi^- \to D^{*+}\pi^-\pi^-$					
$D^0 \to$ all modes			887 ± 44	307 ± 41	0.59 ± 0.03	0.18 ± 0.03
$D^0 \to K^-\pi^+$	19.8 ± 0.3	20.9 ± 0.4	227 ± 22	110 ± 21	0.50 ± 0.05	0.23 ± 0.04
$D^0 \to K^-\pi^+\pi^0$	7.0 ± 0.2	7.2 ± 0.2	319 ± 27	94 ± 25	0.58 ± 0.05	0.17 ± 0.04
$D^0 \to K^-\pi^+\pi^-\pi^+$	8.8 ± 0.2	9.4 ± 0.2	304 ± 26	97 ± 23	0.77 ± 0.07	0.23 ± 0.05
$D^0 \to K^0_s\pi^+\pi^-$	5.9 ± 0.2	6.1 ± 0.2	44 ± 8	0 ± 5	0.61 ± 0.11	0.00 ± 0.07
	$B^- \to D^0_J\pi^- \to D^+\pi^-\pi^-$					
$D^+ \to$ all modes			—	465 ± 33	—	0.29 ± 0.02
$D^+ \to K^-\pi^+\pi^+$	—	18.3 ± 0.3	—	430 ± 32	—	0.29 ± 0.02
$D^+ \to K^0_s\pi^+$	—	9.6 ± 0.2	—	30 ± 8	—	0.37 ± 0.10

π^0 reconstruction efficiencies, particle identification, input branching fractions, and B-counting, and from uncertainties in modeling the wide resonances, our methods for determining the efficiencies for reconstructing resonant and nonresonant decays, and in fitting the narrow resonances.

Because very little is known of the wide resonances, $D_0^*(j = 1/2)^0$ and $D_1(j = 1/2)^0$, and the nonresonant decays of B^-, describing the shape of the wide resonances is difficult. To estimate the uncertainty due to our description, we fix the mass and the width of the wide resonances to those of the BELLE Collaboration [8], and the differences between fitting with fixed mass and width of the wide resonance and fitting with floating mass and width are taken as a systematic uncertainty. We estimate a 4% systematic uncertainty due the combination true D_J states with the incorrect pion. We estimate a contribution to the systematic uncertainty due to multiple signal candidates in an event from the difference in the branching fractions between using the candidate with $m_{\rm ES}$ closest to the nominal value and using all candidates. We estimate the uncertainty in our determination of the efficiencies of the resonant and nonresonant states from the spread among the efficiencies, for each decay mode, of the various resonant and nonresonant states (as determined from Monte Carlo simulations). To estimate the uncertainty on the yields from our fits to the narrow resonances, we vary the masses and widths of the $D_1(2420)^0$ and $D_2^*(2460)^0$ in the fits to the $m(D^{(*)+}\pi^-)$ distributions in each D^0 and D^+ decay mode by one sigma around their values as determined in the global (all decay modes included) fits. Uncertainties on the input branching fractions are taken from the Review of Particle Physics [7].

5 SUMMARY

We present preliminary results from the study of B^- decays to $D^{*+}\pi^-\pi^-$ and $D^+\pi^-\pi^-$. The inclusive branching fractions for $B^- \to D^{*+}\pi^-\pi^-$ and $B^- \to D^+\pi^-\pi^-$, and the exclusive branching fractions for $(B^- \to D_1(2420)^0\pi^-)\times(D_1(2420)^0 \to D^{*+}\pi^-)$, $(B^- \to D_2^*(2460)^0\pi^-)\times(D_2^*(2460)^0 \to D^{*+}\pi^-)$, and $(B^- \to D_2^*(2460)^0\pi^-) \times (D_2^*(2460)^0 \to D^+\pi^-)$ are summarized in Table 6 and com-

Table 5: Sources of systematic uncertainties in fractions. "Bachelor" pions are those (two) pions that do not originate from the decay of a D^{*+}, D^+, or D^0. The upper range of the uncertainties is dominated by contributions from the K_s modes which have only a small contribution to the total branching fraction measurements (see Table 4). For the $B^- \to D^+\pi^-\pi^-$, $D^+ \to K^0_s\pi^+$ mode for the $D^*_2(2460)^0$, this uncertainty is 23%.

Correlated Systematic Uncertainties	
Uncertainties on Tracking efficiency:	
bachelor pions	3.5%
all other tracks	1.3%
Uncertainties on Particle ID (kaon efficiency)	2.5%
Efficiency difference among the resonant and nonresonant decay:	
K^- modes	$(3-4)\%$
K_s modes	$(8-13)\%$
Multiple B candidates	$(2-15)\%$
B-counting	1.1%
D^{*+} branching fractions for $D^{*+}\pi^-\pi^-$ results	0.7%
Uncorrelated Systematic Uncertainties	
π^0 efficiency	7.7%
K^0_S efficiency	3%
D^0 and D^+ branching fractions	$(2.3-6.2)\%$
Monte Carlo statistics	$(1.5-5.2)\%$
$K^0 \to K^0_S \to \pi^+\pi^-$ branching fraction	0.4%
Systematic Uncertainties on Exclusive BF	
Uncertainties in the description of the wide resonances	$(4.5-11.8)\%$
Peaking background from real D_J + wrong π	4%
Uncertainty in $D_1(2420)^0$ and $D^*_2(2460)^0$ fit	$(0.3-7.4)\%$

pared with results from BELLE and CLEO. Good agreement is seen between all three experiments for all five results. Determinations of R (see Eq. 1) are also in agreement among the three experiments and are consistent with the range expected in Ref. [10]. However, the measurements of R differ significantly (by a factor of ~ 2) from the expectation of $R \approx 0.35$ given in Ref. [11], and may thus provide some discrimination between the various HQET based calculations.

Table 6: Measurements of the branching fractions for B^- decays to the $D^{*+}\pi^-\pi^-$ and $D^+\pi^-\pi^-$ final states. The first uncertainty is statistical, the second is systematic. The third uncertainty in the BELLE results is an additional systematic due to choice of selection criteria. Uncertainties on R for BELLE and CLEO are the sum in quadrature of the statistical and systematic uncertainties.

	BABAR (preliminary)	BELLE [9]	CLEO [5]
	Branching Fraction (10^{-3})		
$B^- \to D^{*+}\pi^-\pi^-$	$\mathbf{1.22 \pm 0.05 \pm 0.18}$	$1.24 \pm 0.08 \pm 0.22$	$1.9 \pm 0.7 \pm 0.3$
$B^- \to D^+\pi^-\pi^-$	$\mathbf{0.87 \pm 0.04 \pm 0.13}$	$1.02 \pm 0.04 \pm 0.15$	< 1.4 (90% C.L.)
$(B^- \to D_1(2420)^0\pi^-)$ $\times (D_1(2420)^0 \to D^{*+}\pi^-)$	$\mathbf{0.59 \pm 0.03 \pm 0.11}$	$0.68 \pm 0.07 \pm 0.13 \pm 0.03$	$0.69^{+0.18}_{-0.14} \pm 0.12$
$(B^- \to D_2^*(2460)^0\pi^-)$ $\times (D_2^*(2460)^0 \to D^{*+}\pi^-)$	$\mathbf{0.18 \pm 0.03 \pm 0.05}$	$0.18 \pm 0.03 \pm 0.03 \pm 0.02$	$0.31 \pm 0.08 \pm 0.05$
$(B^- \to D_2^*(2460)^0\pi^-)$ $\times (D_2^*(2460)^0 \to D^+\pi^-)$	$\mathbf{0.29 \pm 0.02 \pm 0.05}$	$0.34 \pm 0.03 \pm 0.06 \pm 0.04$	—
	$R \equiv \mathcal{B}(B^- \to D_2^*(2460)^0\pi^-)/\mathcal{B}(B^- \to D_1(2420)^0\pi^-)$		
	$\mathbf{0.80 \pm 0.07 \pm 0.16}$	0.77 ± 0.15	1.8 ± 0.8

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