Review of Exclusive $B \to D^{(*,**)}\ell\nu$ Decays – Branching Fractions, Form-factors and $|V_{cb}|$

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This paper reviews semileptonic decays of B-mesons to states containing charm mesons, *i.e.*, D, D^*, D^{**} and possible non-resonant $D^{(*)}n\pi$ states as well. The paper covers measurement of branching fractions, form-factors and, most importantly, the magnitude of the CKM matrix element V_{cb}.

1. Introduction

After the discovery of CP violation in the B system, and the precision measurement of the angle β, the experimental focus has been squarely aimed at over-constraining the Cabibbo-Kobayashi-Maskawa (CKM) matrix [1]. In particular the information on the side R_b opposite to the angle β is crucial to test the standard model prediction for CP violation. In the Wolfenstein parametrization $|R_b| = \lambda^{-1}(1 - \lambda^2/2)|V_{ub}/V_{cb}|$ where $\lambda = |V_{us}|/\sqrt{|V_{us}|^2 + |V_{ud}|^2} \approx 0.226$, so a precision measurement of R_b require the measurement of $|V_{ub}|$ and $|V_{cb}|$ with high accuracy. Moreover the parameters $|V_{ub}|$ and $|V_{cb}|$ play a special role in the CKM matrix, because they can be extracted tree level decays, so their values are to high accuracy, independent of any new physics contributions.

To extract $|V_{cb}|$ semileptonic decays are the best tool. At tree level the quark transition $b \to c\ell\nu$ factorizes into an hadronic and a leptonic current and the vertex is proportional to $|V_{cb}|$.There are two experimental methods to determine $|V_{cb}|$: the **exclusive** method, where $|V_{cb}|$ is extracted by studying the exclusive $\bar{B} \to D^{(*)}\ell^-\bar{\nu}$ decay process; and the **inclusive** method, which uses the semileptonic decay width of b-hadron decays. In both methods, the extraction of $|V_{cb}|$ is systematics limited and the dominant errors are from theory. The inclusive and exclusive determinations of $|V_{cb}|$ rely on different theoretical calculations and make use of different techniques which, to a large extent, have uncorrelated experimental uncertainties. This makes the comparison between inclusive and exclusive decays a powerful test of our understanding of semileptonic decays. The latest determinations differ by more than 2σ, with the inclusive method having an error half of the size of the exclusive one.

The exclusive $|V_{cb}|$ determination is obtained by studying the decays $B \to D^*\ell\nu$ and $B \to D\ell\nu$. The exclusive measurements of a single hadronic final state, e.g. the ground state D or D^*, restrict the dynamics of the process. The remaining degrees of freedom, usually connected to different helicity states of the charmed hadron, can be expressed in terms of form factors, depending on the momentum transfer of the process. The shapes of those form factors are unknown but can be measured. However, the overall normalization of these functions need to be determined from theoretical calculations Based on current measurements [2] the rate of inclusive semileptonic B decays exceeds the sum of the measured exclusive decay rates. While $\overline{B} \to D\ell^-\bar{\nu}_\ell$ and $D^*\ell^-\bar{\nu}_\ell$ decays account for about 70% of this total, the contribution of decays to other charm states, including resonant and non-resonant $D^{(*)}\pi\ell^-\bar{\nu}_\ell$ (denoted by $D^{**}\ell^-\bar{\nu}_\ell$), is not yet well measured and may help to explain the inclusive-exclusive discrepancy. Improved measurements of $\overline{B} \to X_c\ell^-\bar{\nu}_\ell$ decays will enhance the accuracy of the extraction of $|V_{ub}|$, since analyses are extending into kinematic regions in which these decays represent a sizable background.

This paper will cover the latest exclusive measurements of $|V_{cb}|$, semileptonic branching fractions to the higher mass D^{**} states, and measurements that aim to understand the discrepancy between the inclusive semileptonic rate and that of the sum of exclusive states.

2. $B \to D^{(*)}\ell\nu$

In the limit of small lepton masses the partial decay rate for $\overline{B} \to D\ell^-\bar{\nu}_\ell$ can be expressed in terms of a single form factor, $\mathcal{G}(w)$,

$$\frac{\mathrm{d}\Gamma(B \to D\ell\nu)}{\mathrm{d}w} = \frac{G_F^2}{48\pi^3\hbar} M_D^3 (M_B + M_D)^2 (w^2-1)^{3/2} \mid V_{cb}\mid^2 \mathcal{G}^2(w), \quad (1)$$

where M_B and M_D are the masses of the B and D mesons. The variable w denotes the product of the B and D meson four-velocities V_B and V_D,

$$w = V_B \cdot V_D = \frac{(M_B^2 + M_D^2 - q^2)}{(2M_B M_D)}, \quad (2)$$

where $q^2 \equiv (p_B - p_D)^2$, and p_B and p_D refer to the four-momenta of the B and D mesons. Its lower limit, $w = 1$, corresponds to zero recoil of the D meson, *i.e.* the maximum q^2. The upper limit, $w = 1.59$,

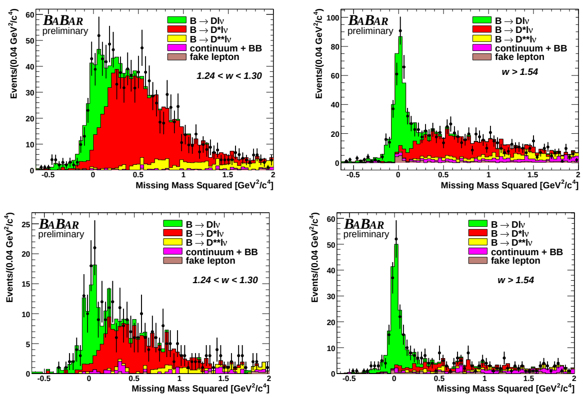

Figure 1: Babar fit to the $m^2_{\rm miss}$ distribution, in two different w intervals, for $B^- \rightarrow D^0\ell^-\bar{\nu}_\ell$ (top) and $\overline{B}^0 \rightarrow D^+\ell^-\bar{\nu}_\ell$ (bottom).

corresponds to $q^2 = 0$ and the maximum D momentum. Since the B momentum is known from the fully reconstructed $B_{\rm tag}$ in the same event, w can be reconstructed with good precision, namely to ~ 0.01, which corresponds to about 2% of the full kinematic range. In the limit of infinite quark masses $\mathcal{G}(w)$ coincides with the Isgur-Wise function [3], normalized to unity at zero recoil. Corrections to this prediction have recently been calculated with improved precision, based on unquenched lattice QCD [7], specifically $\mathcal{G}(1) = 1.074 \pm 0.018 \pm 0.016$. Thus $|V_{cb}|$ can be extracted by extrapolating the differential decay rates to $w = 1$. To reduce the uncertainties associated with this extrapolation, constraints on the shape of the form factors are highly desirable. Several functional forms have been proposed [5] that express the non-linear dependence of the form factor on w in terms of a single shape parameter, ρ^2.

BaBar recently performed a measurement [13] of the CKM matrix element $|V_{cb}|$ and the form-factor slope ρ^2 for $\overline{B} \rightarrow D\ell^-\bar{\nu}_\ell$ decays based on 417 fb^{-1} of data, using semileptonic decays in $B\overline{B}$ events in which the hadronic decay of the second B meson is fully reconstructed. A χ^2 fit to the w distribution for $\overline{B} \rightarrow D\ell^-\bar{\nu}_\ell$ decays was performed. To obtain the semileptonic $\overline{B} \rightarrow D\ell^-\bar{\nu}_\ell$ signal yield in the different w intervals, a one-dimensional extended binned maximum likelihood fit was performed on the $m^2_{\rm miss}$ distributions shown in Fig. 2. The branching fraction and form factors were measured to be $\mathcal{B}(B^- \rightarrow D^0\ell^-\bar{\nu}_\ell) = (2.34 \pm 0.07_{stat.} \pm 0.07_{syst.})\%$ and $\rho^2_D = 1.20 \pm 0.09_{stat.} \pm 0.04_{syst.}$ respectively, yielding $\mathcal{G}(1)|V_{cb}| = (43.0 \pm 1.9_{stat.} \pm 1.4_{syst.}) \times 10^{-3}$.

The analysis of $B \rightarrow D^*l\nu$ is more complex than $Dl\nu$. There are three form-factors called A_1, A_2 and V. To separate them an analysis in the three angles (θ_l, θ_V and χ) and w is needed. HQET relates the three form-factors describing the decay to a single common form-factor called the Isgur-Wise function. The CLN [4] formalism provide the w dependence of $R_1(w)$ and $R_2(w)$ and a parameterization in terms of the slope ρ^2 at $w = 1$ of the common form-factor $h_{A_1}(w)$. In fitting for the form-factors the intercepts $R_1(w = 1)$, $R_2(w = 1)$ and ρ^2 are taken as independent parameters. The CLN parameterizations are

$$R_1(w) = 1.27 - 0.12(w-1) + 0.05(w-1)^2, \qquad (3)$$

$$R_2(w) = 0.79 + 0.15(w-1) - 0.04(w-1)^2 \qquad (4)$$

for the form-factor ratio parameters and

$$h_{A_1}(w) = h_{A_1}(1)(1-8\rho^2 z+(53\rho^2-15)z^2-(231\rho^2-91)z^3 \qquad (5)$$

for the common 'Isgur-Wise' like form-factor. Outside the heavy quark limit $h_{A_1}(w = 1)$ must be taken from theory. The best estimate comes from lattice QCD [6]. It is $0.919^{+0.030}_{-0.035}$.

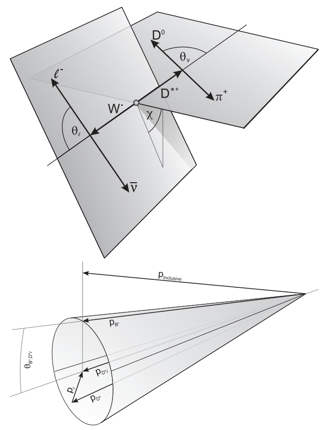

Figure 2: The definition of the four kinematic variables w, $\cos\theta_V$, $\cos\theta_\ell$ (top) and χ and a sketch of the reconstruction of the signal B momentum using momentum conservation (bottom).

In Belle the decay cascade $\bar{B}^0 \rightarrow D^{*+}\ell^-\bar{\nu}$, $D^{*+} \rightarrow D^0\pi^+$ and $D^0 \rightarrow K^-\pi^+$ or $D^0 \rightarrow K^-\pi^+\pi^+\pi^-$ is reconstructed, to either an electron or a muon. Due to momentum conservation, the spatial momentum of the signal B lies on a cone around the spatial momentum of the $D^*\ell$ system. The inclusive sum of the entire remaining event is used to obtain the best B candiate by orthogonal projection, as sketched in Fig. 2. The parameters $\mathcal{F}(1)\,|V_{cb}|$, ρ^2, $R_1(1)$ and $R_2(1)$ are obtained by a binned least squares fit to the four one-dimensional marginal distributions of the decay width: $w = v_B \cdot v_{D^*}$ and the three angles $\cos\theta_V$, $\cos\theta_\ell$ and χ, defined in Fig. 2. . The bin-to-bin correlations between these one dimensional histograms have to be considered. Only the branching ratio of the mode $D^0 \rightarrow K^-\pi^+$ is used as an external parameter. The branching ratio of the mode

$D^0 \to K^-\pi^+\pi^+\pi^-$ is determined by fitting the ratio between the two D^0 channels, $R_{K3\pi/K\pi}$. A χ^2 function is formed for each of the four channels separately and the sum of these four χ^2's is minimized. The preliminary results of the fit are $\rho^2 = 1.293 \pm 0.045 \pm 0.029$, $R_1(1) = 1.495 \pm 0.050 \pm 0.062$, $R_2(1) = 0.844 \pm 0.034 \pm 0.019$, $R_{K3\pi/K\pi} = 2.153 \pm 0.011$, $\mathcal{B}(B^0 \to D^{*-}\ell^+\nu_\ell) = (4.42 \pm 0.03 \pm 0.25)\%$ and $\mathcal{F}(1)\,|V_{cb}| = (34.4 \pm 0.2 \pm 1.0) \times 10^{-3}$, shown in Fig. 2. The χ^2/n.d.f. of the fit is 138.8/155. The systematic error of the HQET parameters is dominated by the background uncertainty, whereas the tracking efficiency error dominates V_{cb}. The value obtained for $\mathcal{F}(1)\,|V_{cb}|$ is one of the lowest obtained by recent measurements, but in acceptable agreement with measurements by BaBar [10].

Babar performed a global measurement [11] based on 207 fb^{-1} of data, where $D^0\ell^-$ and $D^+\ell^-$ pairs are reconstructed, and a fit is performed to their kinematic properties to determine the branching fractions and form factor parameters of the dominant semileptonic decays $\overline{B} \to D^{(*)}\ell^-\bar{\nu}_\ell$. A three-dimensional χ^2 fit is performed to: p_D, the D momentum in the Center of Mass (CM) frame, p_ℓ, the lepton momentum in the CM frame, and $\cos\theta_{BD\ell} = (2E_BE_{D\ell} - m_B^2m_{D\ell}^2)/(2p_Bp_{D\ell})$. The energy, momentum and invariant mass corresponding to the sum of the D and lepton four vectors in the CM frame are denoted $E_{D\ell}$, $p_{D\ell}$, and $m_{D\ell}$, respectively. Kinematic restrictions are imposed to reduce the contribution of backgrounds from semileptonic decays to final state hadronic systems more massive than D and from other sources of $D\ell$ combinations, requiring $-2 < \cos\theta_{BD\ell} < 1.1$, 1.2 GeV/$c$ $< p_\ell <$ 2.35 GeV/c and 0.8 GeV/c $< p_D <$ 2.25 GeV/c. From the χ^2 fit Babar measures the $\overline{B} \to D\ell^-\bar{\nu}_\ell$ and $\overline{B} \to D^*\ell^-\bar{\nu}_\ell$ branching fractions and form-factor parameters, that are then used to determine the products $\mathcal{G}(1)|V_{cb}|$ and $\mathcal{F}(1)|V_{cb}|$, where $\mathcal{G}(1)$ and $\mathcal{F}(1)$ are the form-factors at the point of zero-recoil. The $\overline{B} \to D^{**}\ell^-\bar{\nu}_\ell$ rate is fixed in the fit to recent measurements [2] and the semileptonic decay rates for B and $\overline{B}^0$ are assumed to be equal, e.g. $\Gamma(B^- \to D^0\ell^-\bar{\nu}_\ell) = \Gamma(\overline{B}^0 \to D^+\ell^-\bar{\nu}_\ell)$. Babar measured the branching fractions $\mathcal{B}(B^- \to D^0\ell^-\bar{\nu}_\ell) = (2.36 \pm 0.03_{stat.} \pm 0.12_{syst.})\%$ and $\mathcal{B}(B^- \to D^{*0}\ell^-\bar{\nu}_\ell) = (5.37 \pm 0.02_{stat.} \pm 0.21_{syst.})\%$ and the form factor parameters $\rho_D^2 = 1.22 \pm 0.04_{stat.} \pm 0.07_{syst.}$ ($\rho_{D^*}^2 = 1.21 \pm 0.02_{stat.} \pm 0.07_{syst.}$) for $\overline{B} \to D\ell^-\bar{\nu}_\ell$ ($\overline{B} \to D^*\ell^-\bar{\nu}_\ell$, yielding $\mathcal{G}(1)|V_{cb}| = (43.8 \pm 0.8_{stat.} \pm 2.3_{syst.}) \times 10^{-3}$, and $\mathcal{F}(1)|V_{cb}| = (35.7 \pm 0.2_{stat.} \pm 1.2_{syst.}) \times 10^{-3}$.

HFAG has averaged the $\mathcal{G}(1)|V_{cb}| - \rho^2$ results from four experiments, shown in Figure 4, and $\mathcal{F}(1)|V_{cb}| - \rho^2$ results from six experiments, shown in Figure 5.

3. Higher mass states: D^{**}, $D^{(*)}\pi$, etc.

The so-called D^{**} states and $D^*n\pi$ are the dominant backgrounds to $Dl\nu$ and $D^*l\nu$ and the lack of understanding of these backgrounds is a major source of systematic error for V_{cb}, ρ^2 and the form-factor ratios R_1 and R_2. Recent analyses by Belle and Babar measured the semi-inclusive rate to $B \to D^{(*)}\pi\ell\nu$ decays, for both charged and neutral B mesons, and attempted to isolated the excited D contributions to the $D^{(*)}\pi$ final state. The signal B meson is reconstructed in the semileptonic mode of interest ($p_{\rm sl}$) and the remaining event is then combined via a full reconstruction method. The missing mass squared spectrum, is used to identify signal events. The signal window is defined as $|m_\nu^2| < 0.1\,\mathrm{GeV}^2$ and backgrounds are estimated using MC simulation.

In the Belle measurement [19] D^{**} signals are extracted via simultaneous unbinned likelihood fits to the signal and background $D^{(*)}$ mass spectra. The results of the fit can be seen in Fig. 3. The signal functions, shown as the solid lines in the figure, describe each D^{**} state by a relativistic Breit-wigner function. A non-resonant part is modeled by the Goity-Roberts model [15], its contribution is consistent with zero in all cases. To further investigate the $D\pi$ mass spectrum, also a $D_\nu^* + D_2^*$ hypothesis is tested. The D_ν^* contribution is described by a tail of the Breit-wigner function. Fit results for this combination are shown as a dashed line. The signal yields and branching fractions obtained from this fit can be seen in Tab. I.

Table I Belle results from their $D^{(*)}\pi$ pair invariant mass study. $\mathcal{B}(\text{mode}) \equiv \mathcal{B}(B \to D^{**}\ell\nu) \times \mathcal{B}(D^{**} \to D^{(*)}\pi)$. The first error is statistical and the second is systematic.

$B \to D^*\pi\ell\nu$ states		
Mode	Yield	$\mathcal{B}$, [%]
$B^+ \to \bar{D}_1^{'0}\ell^+\nu$	-5 ± 11	< 0.07 @ 90% C.L.
$B^+ \to \bar{D}_1^0\ell^+\nu$	81 ± 13	$0.42 \pm 0.07 \pm 0.07$
$B^+ \to \bar{D}_2^0\ell^+\nu$	35 ± 11	$0.18 \pm 0.06 \pm 0.03$
$B^0 \to D_1^{'-}\ell^+\nu$	4 ± 8	< 0.5 @ 90% C.L.
$B^0 \to D_1^-\ell^+\nu$	20 ± 7	$0.54 \pm 0.19 \pm 0.09$
$B^0 \to D_2^{*-}\ell^+\nu$	1 ± 6	< 0.3 @ 90% C.L.
$B \to D\pi\ell\nu$ states		
Mode	Yield	$\mathcal{B}$, [%]
$B^+ \to \bar{D}_0^{*0}\ell^+\nu$	102 ± 19	$0.24 \pm 0.04 \pm 0.06$
$B^+ \to \bar{D}_2^{*0}\ell^+\nu$	94 ± 13	$0.22 \pm 0.03 \pm 0.04$
$B^0 \to D_0^{*-}\ell^+\nu$	61 ± 22	$0.20 \pm 0.07 \pm 0.05$
$B^0 \to D_2^{*-}\ell^+\nu$	68 ± 13	$0.22 \pm 0.04 \pm 0.04$

Babar has measured $\overline{B} \to D^{**}\ell^-\bar{\nu}_\ell$ [14], from a sample based on 417 fb^{-1} of data. D^{**} mesons are reconstructed in the $D^{(*)}\pi^\pm$ decay modes. Signal yields for the $\overline{B} \to D^{**}\ell^-\bar{\nu}_\ell$ decays are extracted through a

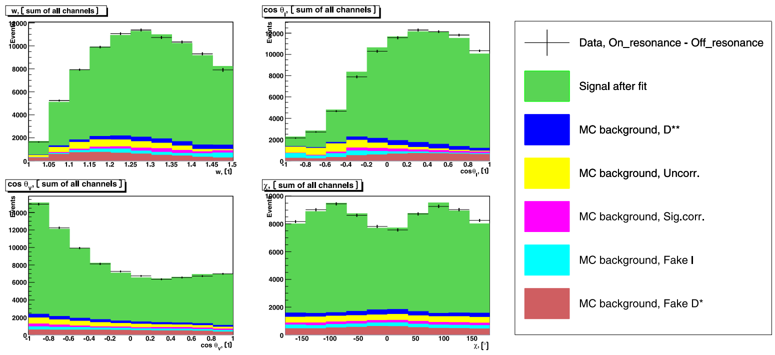

Figure 3: Result of the Belle fit to the four kinematic variables described in the text. The data points are continuum subtracted and the histograms represent the various signal and background components.

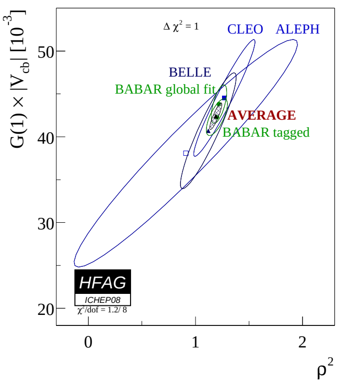

Figure 4: Summer 2008 plot of $\mathcal{G}(1)|V_{cb}|$ vs. ρ^2 from HFAG.

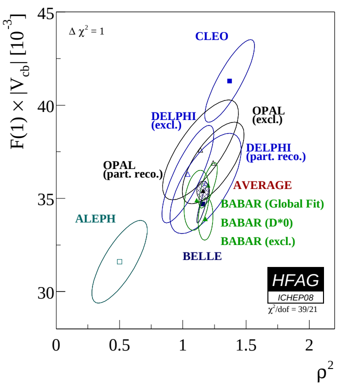

Figure 5: Summer 2008 plot of $\mathcal{F}(1)|V_{cb}|$ vs. ρ^2 from HFAG.

simultaneous unbinned maximum likelihood fit to the four invariant mass difference $M(D^{(*)}\pi) - M(D^{(*)})$ distributions. The $\overline{B} \to D^{**}\ell^-\bar{\nu}_\ell$ decay modes are observed corresponding to the four D^{**} states predicted by Heavy Quark Symmetry [3] with a significance greater than 6 standard deviations, including systematic uncertainties. Results are consistent with Ref. [12] for the sum of the different D^{**} branching fractions. The rate for the D^{**} narrow states is in good agreement with recent measurements [16, 17], the one for the broad states is in agreement with DELPHI [18], but does not agree with the D_1' limit of Belle [19]. The rate for the broad states is found to be large.

HFAG provides averages of the narrow states, $B \to D_1\ell\nu$ and $B \to D_2\ell\nu$, shown in Fig. 7, and 8 respectively.

3.1. $\overline{B} \to D^{(*)}(\pi)\ell^-\bar{\nu}_\ell$ Decays

A simultaneous measurement of the $\overline{B} \to D^{(*)}(\pi)\ell^-\bar{\nu}_\ell$ branching fractions has been performed by Babar [12] on a data sample of about 341 fb^{-1} with a fully reconstructed B meson. To determine the B semileptonic signal yields, a one-dimensional extended binned maximum likelihood fit is performed to the m^2_{miss} distributions. To reduce the systematic uncertainties, they measured the exclusive $\mathcal{B}(\overline{B} \to D^{(*)}(\pi)\ell^-\bar{\nu}_\ell)$ branching fractions relative to the inclusive semileptonic branching fraction. The accuracy of the branching fraction measurements for the $\overline{B} \to D^{(*)}(\pi)\ell^-\bar{\nu}_\ell$ decays is comparable to that of the current world average [2]. By comparing the sum of the measured branching fractions for $\overline{B} \to D^{(*)}(\pi)\ell^-\bar{\nu}_\ell$ with the inclusive $\overline{B} \to X_c\ell^-\bar{\nu}_\ell$ branching fraction [2], a $(11 \pm 4)\%$ discrepancy is observed, most likely due to $\overline{B} \to D^{(*)}n\pi\ell^-\bar{\nu}_\ell$ decays with $n > 1$.

4. Summary and outlook

In Table II we summarise the recent exclusive charmed semileptonic B decay measurements by Belle and BaBar (if multiple measurements exist, the most accurate measurement from each experiment has been

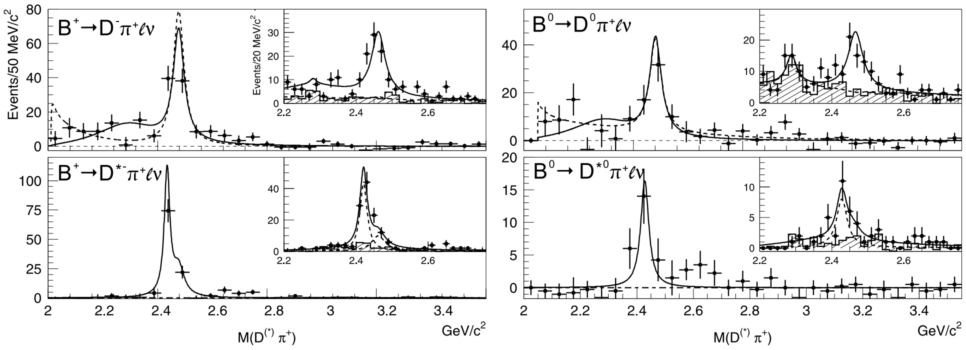

Figure 6: Hadronic invariant mass distributions measured by Belle [19] for $B^+ \to D^- \pi^+ \ell^+ \nu$, $B^+ \to D^{*-} \pi^+ \ell^+ \nu$, $B^0 \to \bar{D}^0 \pi^+ \ell^+ \nu$ and $B^0 \to \bar{D}^{*0} \pi^+ \ell^+ \nu$. Insets show the distributions before background subtraction. The hatched histograms show the background.

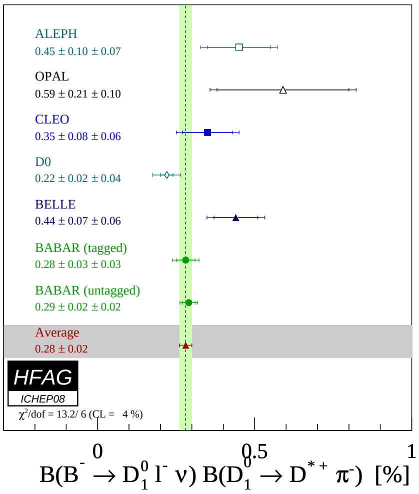

Figure 7: HFAG average of $B \to D_1(D^* \pi)\ell\nu$ and $D_1 \to D^* \pi$.

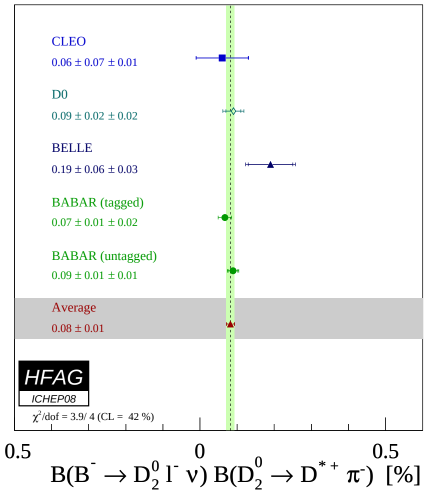

Figure 8: HFAG average of $B \to D_2(D^* \pi)\ell\nu$ and $D_2 \to D^* \pi$.

taken). This table highlights the discrepancy between the current inclusive meausured rates and the sum of the exclusive measurements. This discrepancy provides a serious challenge in understanding semileptonic B decays. To resolve this problem we require further contributions from both theory and experiment. From theory we require solid theory predictions for spin-2 states implemented in the MC, and theoretical constraints on the high mass states. Measurements of contributions from $D^* \pi\pi$ through wide states are necessary, though difficult to measure. A full spin-parity analysis will be required to extract phase shifts, which may not be feasible with the current generation of B factories. Theoretical predictions from HQET need to be tested, requiring higher precision form-factor measurements. Furthermore we must understand the discrepancy between $D^* l\nu$ measured in B^0 and B^+ decays, though this discrepancy is only of order 2 σ.

The HFAG world average of $\mathcal{F}(1)|V_{cb}|$ is $35.41 \pm 0.52 \times 10^{-3}$, $\mathcal{G}(1)|V_{cb}|$ is $42.3 \pm 4.5 \times 10^{-3}$. The form-factor parameters R_1 and R_2 have been measured to be 1.369 ± 0.064 and 0.846 ± 0.038, respectively. Two narrow contributions to the high mass region are known at the $10-20\%$ level. The accuracy on the exclusive $\overline{B} \to X_c \ell^- \bar{\nu}_\ell$ branching fraction measurement has reached the 3-4% level for $\overline{B} \to D^{(*)} \ell^- \bar{\nu}_\ell$ and the 10% level for $\overline{B} \to D^{**} \ell^- \bar{\nu}_\ell$. A 10% difference between the sum of the $\overline{B} \to D^{(*,**)} \ell^- \bar{\nu}_\ell$ rates and the inclusive rate is observed: in order to resolve this puzzle, additional measurements at the B-factories are required.

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Table II Inclusive versus sum of exclusive measured branching fractions.

$\mathcal{B}(\%)$	BaBar		Belle		HFAG	
	B^0	B^-	B^0	B^-	B^0	B^-
$B \to D\ell\nu$	2.20 ± 0.16	2.30 ± 0.10	2.09 ± 0.16	–	2.16 ± 0.12	2.32 ± 0.09
$B \to D^*\ell\nu$	4.53 ± 0.14	5.37 ± 0.21	4.42 ± 0.25	–	5.05 ± 0.10	5.66 ± 0.18
$B \to D\pi\ell\nu$	0.42 ± 0.09	0.42 ± 0.07	0.43 ± 0.09	0.42 ± 0.06	0.43 ± 0.06	0.42 ± 0.05
$B \to D^*\pi\ell\nu$	0.48 ± 0.09	0.59 ± 0.06	0.57 ± 0.22	0.68 ± 0.11	0.49 ± 0.08	0.61 ± 0.05
Σ(Exc.)	7.63 ± 0.25	8.68 ± 0.25	7.51 ± 0.73	–	8.13 ± 0.19	9.01 ± 0.21
Inc.	10.14± 0.43	10.90 ± 0.47	10.46 ± 0.38	11.17 ± 0.38	10.33 ± 0.28	10.99 ± 0.28
Inc. - Σ(Exc.)	2.51 ± 0.50	2.22 ± 0.53	2.95 ± 0.82	–	2.20 ± 0.34	1.98 ± 0.35

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