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Branching Fraction for $B^+ \to \pi^0 \ell^+ \nu$, Measured in $\Upsilon(4S) \to B\overline{B}$ Events Tagged by $B^- \to D^0 \ell^- \overline{\nu}(X)$ Decays

The BABAR Collaboration

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Abstract

We report a preliminary branching fraction of $(1.80 \pm 0.37_{\mathrm{stat.}} \pm 0.23_{\mathrm{syst.}}) \times 10^{-4}$ for the charmless exclusive semileptonic $B^+ \to \pi^0 \ell^+ \nu$ decay, where ℓ can be either a muon or an electron. This result is based on data corresponding to an integrated luminosity of $81\,\mathrm{fb}^{-1}$ collected at the $\Upsilon(4S)$ resonance with the BABAR detector. The analysis uses $B\overline{B}$ events that are tagged by a B meson reconstructed in the semileptonic $B^- \to D^0 \ell^- \overline{\nu}(X)$ decays, where X can be either a γ or a π^0 from a D^* decay.

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1 INTRODUCTION

Measurements at B Factories have significantly improved our knowledge of CP violation in the $B^0 - \overline{B}^0$ system. In particular, the angle β of the Unitarity Triangle (see Figure 1) has been measured to a 5% accuracy from time-dependent CP asymmetries in $b \to c\bar{c}s$ decays.

On the other hand, experimental determination of the other two angles and of the lengths of the two sides (with the third side normalized to unit length) have yet to achieve comparable precision. The uncertainty in the length of the side opposite to the angle β is dominated by the smallest CKM matrix element, $|V_{ub}|$. Improved determination of $|V_{ub}|$ therefore translates directly to a more stringent test of the Standard Model prediction.

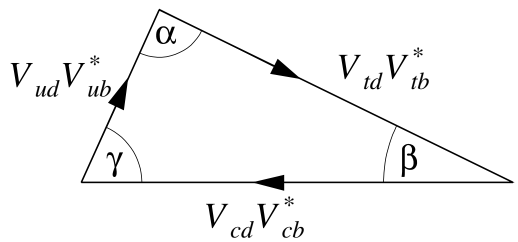

Figure 1: Representation of the Unitarity Triangle

Charmless semileptonic decays of B mesons provide the best probe for $|V_{ub}|$. Measurements can be done either exclusively or inclusively, i.e., with or without specifying the hadronic final state. Since both approaches suffer from significant theoretical uncertainties, it is important to pursue both types of measurements and test their consistency.

The exclusive $B \to X_u \ell\nu$ decay rates are related to $|V_{ub}|$ through form factors (FF). In the simplest case of $B \to \pi\ell\nu$, the differential decay rate (assuming massless leptons) is given by

$$\frac{d\Gamma(B^0 \to \pi^-\ell^+\nu)}{dq^2} = 2\frac{d\Gamma(B^+ \to \pi^0\ell^+\nu)}{dq^2} = \frac{G_F^2|V_{ub}|^2}{24\pi^3}|f_+(q^2)|^2 p_\pi^3, \tag{1}$$

where G_F is the Fermi constant, q^2 is the invariant-mass squared of the lepton-neutrino system and p_π is the pion momentum in the B frame. The FF $f_+(q^2)$ is calculated with a variety of approaches. Major improvements achieved recently in the calculation of the FF, based on light-cone sum rules [1] and unquenched lattice QCD [2, 3] calculations, should allow a competitive determination of $|V_{ub}|$ using exclusive semileptonic decays.

In this paper, we use the ISGW2 model [4]. Alternate calculations [1, 2, 3] are considered to estimate model dependence of the result. Measurements of the branching fraction $\mathcal{B}(B \to \pi\ell\nu)$ have been reported by CLEO [5], Belle [6], and *BABAR* [7]. The CLEO and *BABAR* measurements use neutrino reconstruction in untagged $B\overline{B}$ events; the Belle measurement uses semileptonic tags. *BABAR* has also reported a measurement of the total branching fraction $\mathcal{B}(B \to \pi\ell\nu)$ using fully-reconstructed hadronic tags [8].

In this paper, we report a preliminary branching fraction measurement from a study of the $B^+ \to \pi^0\ell^+\nu$ decay, using event samples tagged by $B^- \to D^0\ell^-\overline{\nu}(X)$ decays.[4] A similar study of the $B^0 \to \pi^-\ell^+\nu$ decay is reported in a separate paper [9].

[4]Charge-conjugate modes are implied throughout this paper.

We look for combinations of a D^0 meson and a charged lepton (e^- or μ^-) that are kinematically consistent with $B^- \to D^0\ell^-\overline{\nu}(X)$ decays. For each such B candidate, we define the signal side as the tracks and neutral clusters that are not associated with the candidate. We search in the signal side for a signature of a $B^+ \to \pi^0\ell^+\nu$ decay. We take advantage of the simple kinematics of the $B^+ \to \pi^0\ell^+\nu$ process and extract the signal yield. We calculate the branching fraction using the signal efficiency predicted by a Monte Carlo (MC) simulation. We correct for the data-MC efficiency differences using control samples in which both B mesons decay to tagging modes.

2 THE *BABAR* DETECTOR AND DATASET

This measurement uses the e^+e^- colliding-beam data collected with the *BABAR* detector [10] at the PEP-II storage ring. The data sample analyzed contains 88 million $e^+e^- \to B\overline{B}$ events, where $B\overline{B}$ stands for B^+B^- or $B^0\overline{B}^0$, which corresponds to an integrated luminosity of $81\,\mathrm{fb}^{-1}$ on the $\Upsilon(4S)$ resonance. In addition, a smaller sample ($10\,\mathrm{fb}^{-1}$) of off-resonance data recorded approximately 40 MeV below the resonance is used for background subtraction and validation purposes.

We also use several samples of simulated $B\overline{B}$ events to evaluate the signal and background efficiencies. Charmless semileptonic decays $B \to X_u\ell\nu$ are simulated as a mixture of exclusive channels ($X_u = \pi$, η, η', ρ, and ω) based on the ISGW2 model [4] and decays to non-resonant hadronic states [11].

3 ANALYSIS METHOD

The event selection has been developed blind, that is, the analysis was first optimized using MC simulation to obtain the largest expected statistical significance of the signal yield; only then was it applied to data.

3.1 Event Selection

We search for candidate $B\overline{B}$ events in which one B meson decayed as $B^- \to D^0\ell^-\overline{\nu}(X)$, $\overline{B}^0 \to D^+\ell^-\overline{\nu}$ or $\overline{B}^0 \to D^{*+}\ell^-\overline{\nu}$, with $D^{*+} \to D^0\pi^+$. The D mesons are reconstructed in the $D^0 \to K^-\pi^+$, $K^-\pi^+\pi^-\pi^+$, $K^-\pi^+\pi^0$, and $D^+ \to K^-\pi^+\pi^+$ channels. Charged B tags are used to select the $B^+ \to \pi^0\ell^+\nu$ decay mode. The D^0 candidates from charged B tags are kept if their reconstructed mass lies within 10σ of the fitted mean of the D^0 mass distribution, where σ is the experimental resolution. The signal region corresponds to $|m_{D^0}^{\mathrm{reco}} - m_{D^0}^{\mathrm{fitted}}| \leq 3\sigma$. We define sideband regions, which are used to subtract the combinatorial background, as $3\sigma < |m_{D^0}^{\mathrm{reco}} - m_{D^0}^{\mathrm{fitted}}| \leq 10\sigma$. The neutral B^0 tags are used to reject $B^0\overline{B}^0$ events which are a background for the present analysis. In this case, a tighter D^0 mass selection, within 3σ, is applied. The same mass window is used for $D^\pm$. The σ values vary between $5\,\mathrm{MeV}/c^2$ and $13\,\mathrm{MeV}/c^2$ depending on the D decay channel.

Candidate $D^{*+} \to D^0\pi^+$ decays are required to have a mass difference, $m_{D^{*+}} - m_{D^0}$, of $\pm$ 5 MeV/c^2 around its expected value (145.4 MeV/c^2). When a D^0 meson is identified as being part of a $\overline{B}^0 \to D^{*+}\ell^-\overline{\nu}(X)$ tag, the corresponding $B^- \to D^0\ell^-\overline{\nu}(X)$ tag is dropped. Note that $D^* \to D\pi^0/\gamma$ are not explicitly reconstructed.

The $D^{(*)}$ candidates are combined with electrons or muons to identify a $B \to D^{(*)}\ell\nu(X)$ candidate. The lepton must have a center-of-mass momentum[5] $p_\ell^* > 1.0\,\mathrm{GeV}/c$. The charge of the lepton must be the same as that of the kaon from the D candidate.

[5]Variables denoted with a star (x^*) are measured in the $\Upsilon(4S)$ rest frame; others are in the laboratory frame

Referring to the tag-side $D^{(*)}\ell$ combination as the "Y" system, we calculate the cosine of θ_{BY}, the angle between $\mathbf{p}_B^*$ and $\mathbf{p}_Y^*$ as

$$\cos\theta_{BY} = \frac{2E_B^* E_Y^* - m_B^2 - m_Y^2}{2p_B^* p_Y^*}. \tag{2}$$

Equation (2) assumes that a $B \to D^{(*)}\ell\nu(X)$ decay has been correctly reconstructed, and the only undetected particle in the final state is the neutrino. If that is the case, $\cos\theta_{BY}$ should be between -1 and $+1$ within experimental resolution. If the tag has been incorrectly reconstructed, Equation (2) does not give a cosine of a physical angle, and $\cos\theta_{BY}$ is distributed more broadly. We require $-2.5 < \cos\theta_{BY} < +1.1$. The asymmetric range chosen for the $\cos\theta_{BY}$ cut reflects the fact that a large fraction of the signal events contain a $B^- \to D^{*0}\ell^-\overline{\nu}$ decay in which the soft π^0 or γ was not accounted for. Such events tend to populate the $\cos\theta_{BY}$ distribution between -2.5 and -1.0.

There is often more than one remaining $D^{(*)}\ell\nu(X)$ candidate in an event. When this happens, we select the candidate with the smallest value of $|\cos\theta_{BY}|$. The average number of $D^{(*)}\ell\nu(X)$ candidates per signal event is 1.2 according to the MC simulation. If at this point the best candidate represents a B^0 decay (i.e., $\overline{B}^0 \to D^{(*)+}\ell^-\overline{\nu}$), the event is discarded.

From each event with a $B^- \to D^0\ell^-\overline{\nu}(X)$ candidate, we remove the tracks and the neutral clusters that compose $D^0\ell^-$. We then search for a $B^+ \to \pi^0\ell^+\nu$ candidate in the remaining part (signal side) of the event, which must contain an identified lepton and a pair of photons from $\pi^0 \to \gamma\gamma$ that satisfy $115\,\mathrm{MeV}/c^2 < m_{\gamma\gamma} < 150\,\mathrm{MeV}/c^2$. The two leptons in a candidate event must be oppositely charged.

In order to suppress non-$B\overline{B}$ backgrounds, which have a more jet-like topology than $B\overline{B}$ events, we require the ratio R_2 of the second and zeroth Fox-Wolfram moments [12], computed using all charged tracks and unassociated neutral clusters in the event, to be smaller than 0.5.

In addition, we require the momenta of the π^0 and lepton to satisfy $|p_{\pi^0}^*|+|p_\ell^*| \geq 2.6\,\mathrm{GeV}/c$. This cut removes more than 95% of the $B\overline{B}$ background events while retaining nearly the entire phase space of the $B^+ \to \pi^0\ell^+\nu$ signal. In the limit of massless leptons and π^0s, this cut corresponds to the kinematic limit for the neutrino energy, $E_\nu^* \leq 2.7$ GeV.

Analogously to $\cos\theta_{BY}$, we can calculate the cosine of $\theta_{B\pi^0\ell}$, the angle between $\mathbf{p}_B^*$ and $\mathbf{p}_{\pi^0\ell}^*$ as

$$\cos\theta_{B\pi^0\ell} = \frac{2E_B^* E_{\pi^0\ell}^* - m_B^2 - m_{\pi^0\ell}^2}{2p_B^* p_{\pi^0\ell}^*}. \tag{3}$$

This variable, again, should be between -1 and $+1$ for the signal events, and distributed broadly for the background. We require $-1.1 < \cos\theta_{B\pi^0\ell} < +1.0$.

If a signal event has been correctly reconstructed in the $B^- \to D^0\ell^-\overline{\nu}$ and $B^+ \to \pi^0\ell^+\nu$ decays, no other particles should be present. In reality, such events often contain extra neutral particles. Some of them come from soft π^0s and/or photons from decays of D^{*0} or heavier charmed mesons. We identify the photons that may have come from $D^{*0} \to D^0\pi^0$ and $D^0\gamma$ decays by combining them with the D^0 meson candidate; if the combination satisfies $m_{D^0\gamma(\gamma)} - m_{D^0} < 150\,\mathrm{MeV}/c^2$ and $\cos\theta_{BY'} < 1.1$, where Y' stands for the $D^0\gamma(\gamma)\ell$ system, the photons are considered as a part of the tag system and removed from the signal system.

At this point, we require that the event contains no charged tracks besides the $B^- \to D^0\ell^-\overline{\nu}(X)$ and $B^+ \to \pi^0\ell^+\nu$ candidates ($T_{extra} = 0$). We further require the total residual neutral energy of the event in the center-of-mass system to be less than 300 MeV ($E_{extra} \leq 300\,\mathrm{MeV}$).

To simplify the signal extraction procedure, only events with a single $B^+ \to \pi^0 \ell^+ \nu$ candidate passing all the selections are kept. Only 1.6% of the MC signal events have more than one such candidate.

Distributions of the selected events in $\cos\theta_{B,\pi^0\ell}$ and the difference between the reconstructed and fitted D^0 mass are shown in Figure 2. These variables are used to extract the signal yield.

3.2 Signal Yield

We extract the total signal yield as

$$N = N_{\rm on} - N_{\rm off} - N_{\rm MC} \frac{N_{\rm on}^{SB} - N_{\rm off}^{SB}}{N_{\rm MC}^{SB}}, \tag{4}$$

where $N_{\rm on}$, $N_{\rm off}$, and $N_{\rm MC}$ are the numbers of events in the signal region in the on-resonance data, off-resonance data, and simulated $B\overline{B}$ background, respectively, after the D^0-mass sideband subtraction. Note that this subtraction is performed with the assumption that the D^0 mass non-peaking background is linearly distributed over the range $\pm 10\sigma$ around the nominal D^0 mass. The good fit of a straight line to the sideband distribution indicates that this assumption is reasonable. The numbers $N_{\rm off}$ and $N_{\rm MC}$ are scaled according to the integrated luminosity of the on-resonance data. The "SB" in superscript indicates a $\cos\theta_{B\pi^0\ell}$ sideband region defined as $-20 \leq \cos\theta_{B\pi^0\ell} \leq -1.5$. The ratio $(N_{\rm on}^{SB} - N_{\rm off}^{SB})/N_{\rm MC}^{SB}$ is used to correct for the effect of data/MC discrepancies in the D^0-mass peaking background yield selected in the signal region $-1.1 \leq \cos\theta_{B\pi^0\ell} \leq 1.0$. We assume that this ratio has the same value in the signal region since both regions are mostly populated by events in which the tag-side decay is $B^- \to D^{(*)0}\ell^-\overline{\nu}$. The ratio is found to be $1.02 \pm 0.11 \pm 0.35$ where the first error is statistical and the second error is a systematic uncertainty derived from the variation of the ratio when it is computed in three statistically independent bins of the $-20 \leq \cos\theta_{B,\pi^0\ell} \leq -1.5$ region.

We find no off-resonance events in the signal and D^0 mass sideband regions. The statistical uncertainty on these numbers, derived from the corresponding Poisson intervals, is large. Moreover, this uncertainty would have to be scaled by a large factor (≈ 8) to match the integrated luminosity of the on-resonance data. This would result in a large error on the background subtraction, and calls for a special treatment. Thus, we consider the alternative of computing the continuum background yield using a factorized efficiency ($\epsilon_{\rm MULT}$) equal to the product of the individual efficiencies of the last two cuts of the event selection, $T_{extra} = 0$ and $E_{extra} \leq 0.300\,\text{GeV}$, which have a high power of background suppression. The direct use of $\epsilon_{\rm MULT}$ would be justified if these two cuts were uncorrelated. The variation between the usual efficiency and $\epsilon_{\rm MULT}$ has been studied as the T_{extra} and E_{extra} cuts were progressively relaxed. From the difference in the behavior of these two estimators, a correction factor has been derived and a systematic uncertainty has been added to the multiplied efficiency: $\epsilon_{\rm MULT}^{Corrected} = (0.35 \pm 0.35)\epsilon_{\rm MULT}$. The resulting off-resonance event yield in the signal region, after the D^0-mass sideband subtraction and scaled to the integrated luminosity of the on-resonance data, is -0.3 ± 2.5.

We find $N_{\rm on} = 52.0 \pm 8.1$ events in the signal region, $-1.1 < \cos\theta_{B\pi^0\ell} < +1.0$, after the D^0-mass sideband subtraction, of which 6.7 ± 2.0, 0.6 ± 0.9, and -0.3 ± 2.5 events are estimated to be B^+B^-, $B^0\overline{B}^0$ and non-$B\overline{B}$ backgrounds, respectively. The errors are statistical. The signal yield is therefore 44.9 ± 8.7 events. The corresponding yields before the D^0-mass sideband subtraction are 61 ± 7.8, 9.0 ± 1.9, 1.6 ± 0.8 and 1.5 ± 1.7 for on-resonance data, B^+B^-, $B^0\overline{B}^0$ and non-$B\overline{B}$ backgrounds, respectively. Figure 3 illustrates the yields for both data and MC samples and thus the significance of the signal.

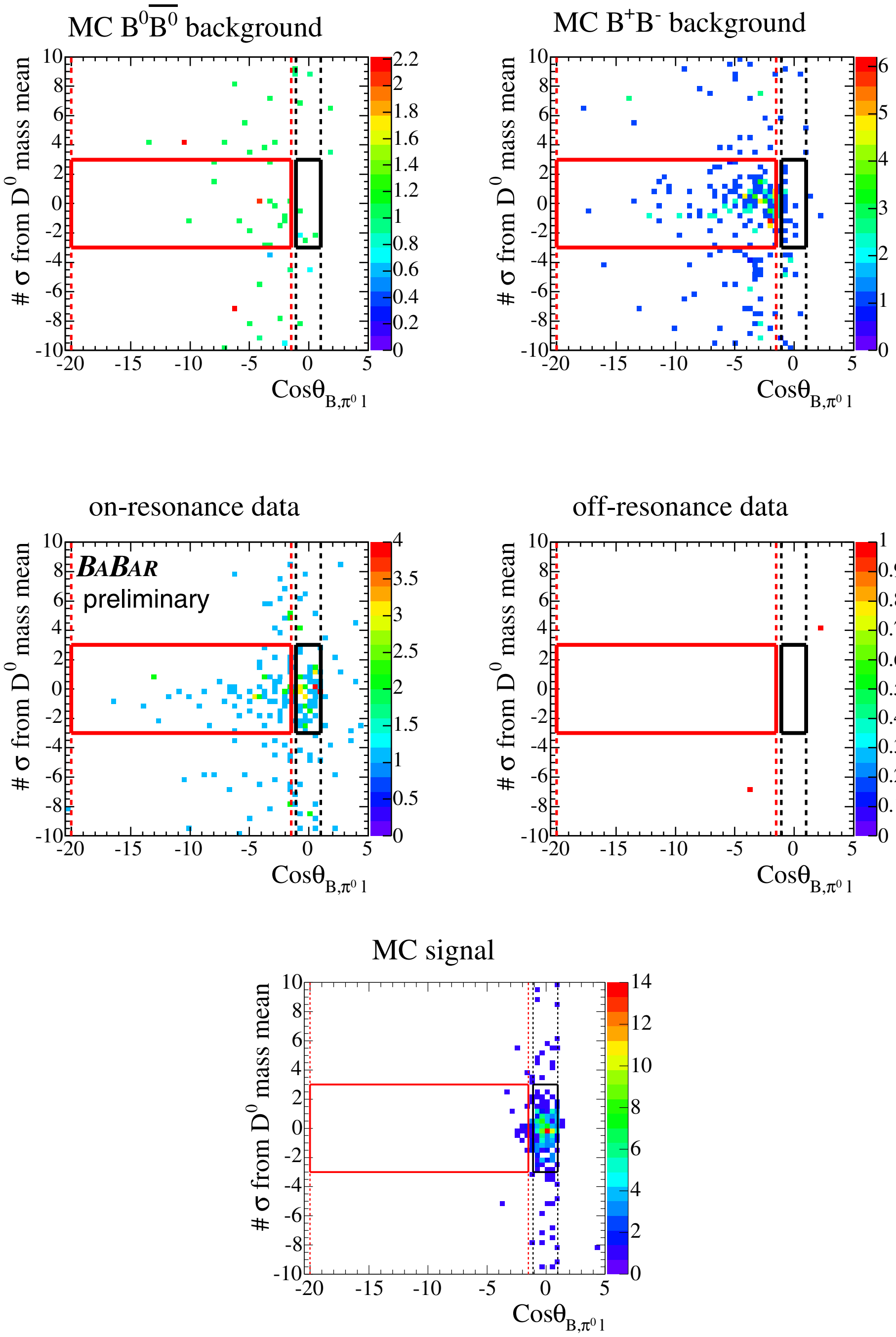

Figure 2: Event distributions after all cuts (except on the variables shown), in the D^0 mass - $\cos\theta_{B,\pi^0\ell}$ plane. The signal region is bounded by the black box: the reconstructed D^0 mass values must be within 3σ of their fitted mean (σ is the experimental resolution on the D^0 meson mass) and values of $\cos\theta_{B,\pi^0\ell}$ must lie between -1.1 and +1.0. The $-20 \leq \cos\theta_{B,\pi^0\ell} \leq -1.5$ region is defined as the $\cos\theta_{B,\pi^0\ell}$ sideband while the D^0-mass sideband regions correspond to $3\sigma < |m_{D^0}^{\mathrm{reco}} - m_{D^0}^{\mathrm{fitted}}| \leq 10\sigma$. The MC $B\overline{B}$ and off-resonance distributions are not scaled to the integrated luminosity of the on-resonance data.

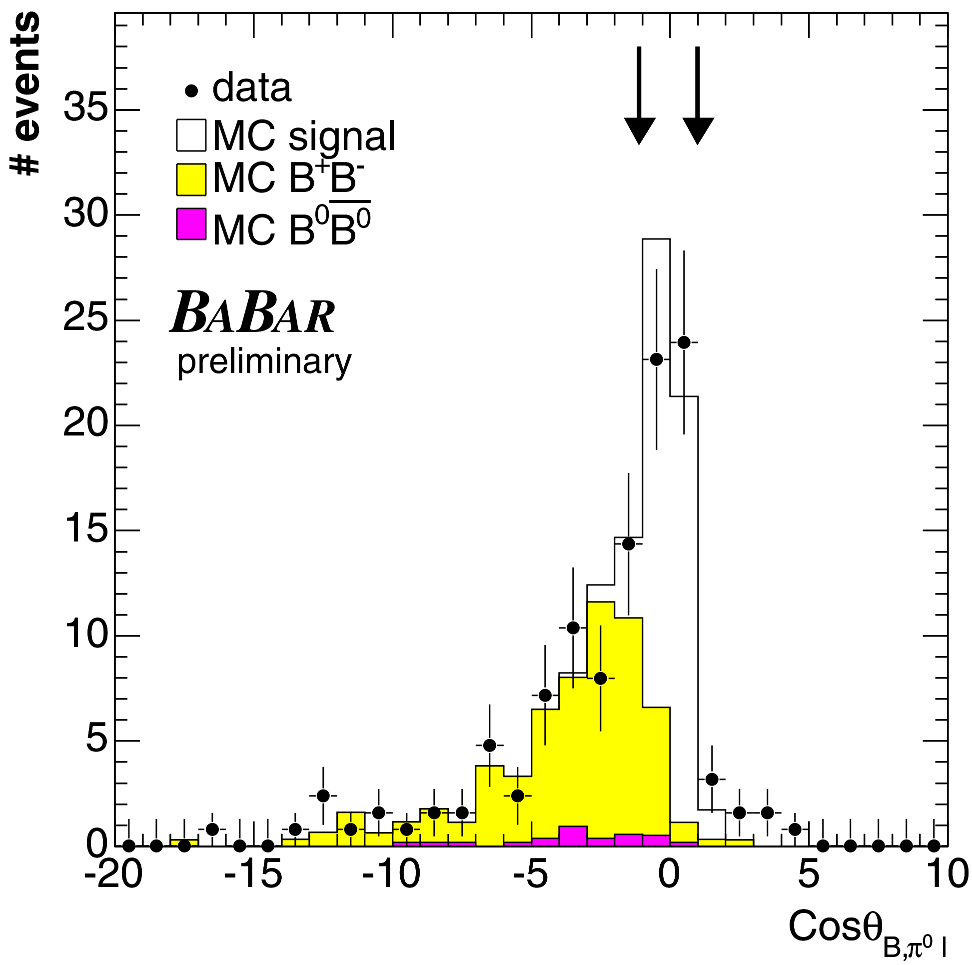

Figure 3: $\cos\theta_{B\pi^0\ell}$ distribution, after all other cuts, for events having the reconstructed D^0 mass values within 3σ of their fitted mean. The points are the on-resonance data and the error bars are statistical only. In order to illustrate the final yields and the significance of the signal, each distribution (on-resonance data, MC signal, MC B^+B^- and MC $B^0\overline{B}^0$) is rescaled to the number of events found after the D^0-mass sideband subtraction. Note that the off-resonance data, due to their special treatment (see Section 3.2), are not shown. The final $\cos\theta_{B\pi^0\ell}$ selection is between -1.1 and 1.0, delimited by the arrows.

3.3 Signal Efficiencies

The signal yield is expressed in terms of the efficiency $\varepsilon^{\mathrm{data}}$, computed using a sum of $B^+ \to \pi^0 e^+ \nu$ and $B^+ \to \pi^0 \mu^+ \nu$ decays, as

$$N = 2\varepsilon^{\mathrm{data}} \mathcal{B}(B^+ \to \pi^0 \ell^+ \nu) N_B, \tag{5}$$

where the factor of two comes from using electrons or muons in the branching fraction, and N_B is the number of $B^\pm$ mesons in the data sample. Using the $\Upsilon(4S) \to B^0 \overline{B}^0$ branching fraction $f_{00} = \frac{1}{2}$, the number N_B equals $2(1 - f_{00}) N_{B\overline{B}}$, where $N_{B\overline{B}}$ is the number of $B\overline{B}$ events in the data sample and the factor of two comes from having two B mesons in each event.

We use the signal Monte Carlo simulation to provide an estimate of the total efficiency:

$$\varepsilon^{\mathrm{MC}} = (1.40 \pm 0.10) \times 10^{-3}, \tag{6}$$

The uncertainty is due to Monte Carlo statistics.

We evaluate the data-MC difference of the $B^- \to D^0 \ell^- \overline{\nu}(X)$ selection efficiencies using the double-tag events, in which both B mesons decay to $D^0 \ell \nu(X)$. Properties of the $B^- \to D^0 \ell^- \overline{\nu}(X)$ tags such as the composition of the D^0 decay channels are similar between the tagged-signal and double-tag events. The number of double-tag events is proportional to the square of the tagging efficiency after subtracting the small contribution from background.

The selection criteria for the double-tag events follow the main analysis as closely as possible. In each event, we look for two $D^0 \ell \nu(X)$ tags that do not overlap with each other. We remove all particles that are used in the tags and require that there be no charged tracks. The E_{extra} cut is increased from 300 MeV to 600 MeV; this reflects the fact that the residual neutral energy in a signal event comes from the tag-side B decay, and a double-tag event contains two such decays.

From the study of the double-tag events we extract the efficiency correction factor

$$\frac{\varepsilon^{\mathrm{data}}}{\varepsilon^{\mathrm{MC}}} = 1.005 \pm 0.039.$$

The error includes both the statistical and systematic uncertainties. For the latter, we considered the difference in the results when the selection criteria are varied, the residual background after the D^0-mass sideband subtraction, due to possible non-linearities in the background vs. the reconstructed Dz mass, and the uncertainties in the exclusive $B \to X_c \ell \nu$ branching fractions.

4 SYSTEMATIC UNCERTAINTIES

The significant sources of systematic uncertainties considered and their impact on the measured branching fraction are summarized in Table 1.

The systematic error is dominated by the size of the available MC samples. This includes both the signal MC sample for evaluating the signal efficiency and the generic $B\overline{B}$ MC samples for the background subtraction.

The systematic uncertainties associated with the signal π^0 efficiency, the identification of the signal lepton and its tracking efficiency are derived from detailed studies of the discrepancies in particle reconstruction between MC simulation and data. In particular, the systematic uncertainty in signal π^0 efficiency is obtained by comparing the ratio of the $\tau^- \to h^- \pi^0 \pi^0 \nu$ yield to the $\tau^- \to h^- \pi^0 \nu$ yield in data and simulation, using $e^+ e^- \to \tau^+ \tau^-$ events. The uncertainty associated with the tagging efficiency was evaluated by using double-tag events (see Section 3.3).

Table 1: Fractional systematic errors on the branching fraction.

Systematics	$\sigma_{\mathcal{B}}/\mathcal{B}$
MC $B\overline{B}$ statistics	$\pm 4.6\%$
MC signal statistics	$\pm 7.3\%$
$(N_{\text{on}}^{SB} - N_{\text{off}}^{SB})/N_{\text{MC}}^{SB}$ ratio	$\pm 6.0\%$
Signal lepton tracking	$\pm 0.8\%$
Signal lepton ID	$\pm 3.3\%$
Signal π^0 efficiency	$\pm 5.0\%$
Tagging efficiency	$\pm 3.9\%$
$B \to \pi \ell \nu$ FF	$\pm 1.5\%$
$\mathcal{B}(B \to X_{c/u} \ell \nu)$ background	$\pm 1.1\%$
$N_{B\overline{B}}$	$\pm 1.1\%$
Total	$\pm 12.9\%$

For the $B \to \pi \ell \nu$ form factor, we used the ISGW2 model [4]. The related systematic uncertainty is evaluated by reweighting [13] the simulated signal events to reproduce the q^2 distribution predicted by the Ball-Zwicky, HPQCD and FNAL calculations [1, 2, 3]. This uncertainty corresponds to the spread between calculations. The form factor affects the branching fraction through the q^2 dependence of the signal efficiency. Only the shape and not the normalization of the form factor is relevant for the measurement of the branching fraction.

Background events are mostly from $B \to X_c \ell \nu$ decays, with a small contribution from $B \to X_u \ell \nu$ decays. For many of these decays, the branching fractions are not well known. To evaluate the associated uncertainty, the branching fractions of these decays were varied simultaneously within their uncertainties [14]. The resulting variation in the $B^+ \to \pi^0 \ell^+ \nu$ branching fraction was taken to be the corresponding systematic uncertainty.

In addition to the studies discussed above, we performed crosschecks to ensure that the simulation was adequately modeling the data close to the signal region, before unblinding the data. In particular, we've studied the data-MC agreement in sidebands of $\cos\theta_{B\pi^0\ell}$ and E_{extra}, and observed no variation beyond expected statistical fluctuations.

5 RESULTS AND SUMMARY

Using event samples tagged by $B^- \to D^0 \ell^- \overline{\nu}(X)$ decays, we determine the exclusive branching fraction $\mathcal{B}(B^+ \to \pi^0 \ell^+ \nu)$. From the signal yield and the efficiencies evaluated in Section 3, we extract a preliminary result

$$\mathcal{B}(B^+ \to \pi^0 \ell^+ \nu) = (1.80 \pm 0.37_{\text{stat.}} \pm 0.23_{\text{syst.}}) \times 10^{-4}.$$

Table 2 summarizes the measurements of $\mathcal{B}(B \to \pi \ell \nu)$ by the BABAR collaboration. Assuming isospin symmetry and the ratio of B lifetimes $\tau_{B^+}/\tau_{B^0} = 1.081 \pm 0.015$ [14], the measurements agree with each other with $\chi^2 = 10.3$ for 5 degrees of freedom, which corresponds to a one-sided probability of 7%.

We plan to extract $|V_{ub}|$ in the next version of this analysis, which will also include more data.

Table 2: Preliminary *BABAR* measurements of $\mathcal{B}(B \to \pi \ell \nu)$. The last row shows this measurement and the $B^0 \to \pi^- \ell^+ \nu$ measurement in Ref. [9]

Technique	$\mathcal{B}(B^0 \to \pi^- \ell^+ \nu) \times 10^4$	$\mathcal{B}(B^+ \to \pi^0 \ell^+ \nu) \times 10^4$
Neutrino reco. [7]	$1.41 \pm 0.17 \pm 0.20$	$0.70 \pm 0.10 \pm 0.10$
Hadronic tag [8]	$0.89 \pm 0.34 \pm 0.12$	$0.91 \pm 0.28 \pm 0.14$
Semileptonic tag	$1.03 \pm 0.25 \pm 0.13$	$1.80 \pm 0.37 \pm 0.23$

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