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Measurements of the decays $B^0 \to \bar{D}^0 p \bar{p}$, $B^0 \to \bar{D}^{*0} p \bar{p}$, $B^0 \to D^- p \bar{p} \pi^+$, and $B^0 \to D^{*-} p \bar{p} \pi^+$

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We present measurements of branching fractions of B^0 decays to multibody final states containing protons, based on 232×10^6 $\Upsilon(4S) \to B\bar{B}$ decays collected with the *BABAR* detector at the SLAC PEP-II asymmetric-energy B factory. We measure the branching fractions $\mathcal{B}(B^0 \to \bar{D}^0 p\bar{p}) = (1.13 \pm 0.06 \pm 0.08) \times 10^{-4}$, $\mathcal{B}(B^0 \to \bar{D}^{*0} p\bar{p}) = (1.01 \pm 0.10 \pm 0.09) \times 10^{-4}$, $\mathcal{B}(B^0 \to D^- p\bar{p}\pi^+) = (3.38 \pm 0.14 \pm 0.29) \times 10^{-4}$, and $\mathcal{B}(B^0 \to D^{*-} p\bar{p}\pi^+) = (4.81 \pm 0.22 \pm 0.44) \times 10^{-4}$ where the first error is statistical and the second systematic. We present a search for the charmed pentaquark state, $\Theta_c(3100)$ observed by H1 and put limits on the branching fraction $\mathcal{B}(B^0 \to \Theta_c \bar{p}\pi^+) \times \mathcal{B}(\Theta_c \to D^{*-} p) < 14 \times 10^{-6}$ and $\mathcal{B}(B^0 \to \Theta_c \bar{p}\pi^+) \times \mathcal{B}(\Theta_c \to D^- p) < 9 \times 10^{-6}$. Upon investigation of the decay structure of the above four B^0 decay modes, we see an enhancement at low $p\bar{p}$ mass and deviations from phase-space in the $\bar{D}\bar{p}$ and $\bar{D}p$ invariant mass spectra.

The observations of the $B^0 \to D^{*-} p\bar{p}\pi^+$[1] and $B^0 \to D^{*-} p\bar{n}$ decays by CLEO [2], and the $B^0 \to \bar{D}^0 p\bar{p}$ and $B^0 \to \bar{D}^{*0} p\bar{p}$ decays by Belle [3] suggest the dominance of multibody final states in decays of B mesons into baryons [4] compared to two-body decays. In this paper we present measurements of the branching fractions for the following four decay modes: $B^0 \to \bar{D}^0 p\bar{p}$, $B^0 \to \bar{D}^{*0} p\bar{p}$, $B^0 \to D^- p\bar{p}\pi^+$, and $B^0 \to D^{*-} p\bar{p}\pi^+$. The study of the modes presented here can help clarify the dynamics of weak decays of B mesons involving baryons [5].

Since the branching fractions of multibody decays are large [6], it is natural to ask whether such final states are actually the products of intermediate two-body channels. If this is the case, then these initial two-body decays could involve proton-antiproton bound states $(p\bar{p})$ [7,8], or charmed pentaquarks [9,10], or heavy charmed baryons. Motivated by these considerations, in particular, the claim of a charmed pentaquark at 3.1 GeV/c^2 by the H1 collaboration [11], the invariant mass spectrum of the proton-antiproton and the invariant mass spectra of the charmed meson and proton are investigated. Throughout this paper, we shall use the terms ''exotic'' and ''nonexotic'' to refer to the ''Dp'' pair with total quark content $\bar{c}quud$ and $\bar{c}q\overline{uu}\,\bar{d}$ respectively (where q is u or d). Specifically, the exotic combinations refer to $D^{(*)-}p$ and $\bar{D}^{(*)0}p$ while the ''nonexotic'' combinations are $D^{(*)-}\bar{p}$ and $\bar{D}^{(*)0}\bar{p}$.

The data used in this analysis were accumulated with the *BABAR* detector [12] at the PEP-II asymmetric-energy e^+e^- storage ring at SLAC. The data sample consists of an integrated luminosity of 212 ± 2 fb^{-1} collected at the $\Upsilon(4S)$ resonance corresponding to $(232 \pm 3) \times 10^6$ $B\bar{B}$ pairs [13]. The *BABAR* detector consists of a silicon vertex tracker (SVT) and a drift chamber (DCH) used for track and vertex reconstruction, an electromagnetic calorimeter (EMC) for detecting photons and electrons, a Cherenkov detector (DIRC) and an instrumented flux return (IFR) used for particle identification (PID). The efficiency of the selection criteria is determined with large samples of GEANT-based [14] Monte Carlo (MC) simulated signal decays.

We select $\bar{D}^0$ decays to $K^+\pi^-$, $K^+\pi^-\pi^0$, and $K^+\pi^-\pi^+\pi^-$ and D^- decays to $K^+\pi^-\pi^-$. We select $\bar{D}^{*0}$ decays to $\bar{D}^0\pi^0$ and D^{*-} decays to $\bar{D}^0\pi^-$. The B

candidates are reconstructed from D or D^* candidates combined with a proton and an antiproton track and a pion track if appropriate. The D candidates are required to have a mass within $\pm 3\sigma$ of the D meson mass, $\hat{m}_D$ [15]. The mass resolution, $\sigma(m_D)$, ranges from 5.1 to 13.0 MeV/c^2 for different D decay channels, the worst resolution corresponding to the mode with a π^0 in the final state. The D^* candidates are selected by requiring the mass difference $\Delta M = (m_{D\pi} - m_D)$ to be within 3σ of the nominal value, $\hat{\Delta M}$, where $\sigma \sim 1.0$ MeV/c^2. Particle identification is required on the proton, antiproton, and pion from the B, and on the kaon from the D decay, using combined information from the energy loss, dE/dx, in the SVT and the DCH and the Cherenkov angle in the DIRC. The proton identification efficiency is roughly 90% with a misidentification rate of less than 2% [12]. To suppress backgrounds of all kinds, vertexing probability requirements are imposed on the D and B candidates. In order to reduce background from $e^+e^- \to q\bar{q}$ events (where q is a u,d,s, or c quark), the cosine of the angle between the thrust axis of the B candidate and that of the rest of the event $|\cos(\theta_{BT})|$ is required to be less than 0.9 and the ratio of the second to the zeroth Fox-Wolfram moments [16] is required to be less than 0.35.

We select events in the region 5.2 GeV/$c^2 < m_{ES} <$ 5.3 GeV/c^2 and $|\Delta E| < 0.1$ GeV, where $m_{ES} = \sqrt{(s/2 + \mathbf{p}_\Upsilon \cdot \mathbf{p}_B)^2/E_\Upsilon^2 - \mathbf{p}_B^2}$ ($\sqrt{s}$ is the total center-of-mass energy, $\mathbf{p}_B$ is the B meson momentum and $(E_\Upsilon, \mathbf{p}_\Upsilon)$ is the $\Upsilon(4S)$ 4-momentum, defined in the laboratory frame), while $\Delta E = p_\Upsilon \cdot p_B/\sqrt{s} - \sqrt{s}/2$ ($p_\Upsilon = (E_\Upsilon, \mathbf{p}_\Upsilon)$, $p_B = (E_B, \mathbf{p}_B)$). The selection is kept loose because these two variables are used in a maximum likelihood fit to extract the signal and background yields simultaneously. If there is more than one B candidate passing these criteria for an event, the candidate is chosen that minimizes $\chi^2 = (m_D - \hat{m}_D)^2/\sigma(m_D)^2 + (\Delta M - \Delta\hat{M})^2/\sigma(\Delta M)^2$ for the modes $B^0 \to \bar{D}^{*0} p\bar{p}$ and $B^0 \to D^{*-} p\bar{p}\pi^+$, and the candidate that minimizes $\chi^2 = (m_D - \hat{m}_D)^2/\sigma(m_D)^2$ for the modes $B^0 \to \bar{D}^0 p\bar{p}$ and $B^0 \to D^- p\bar{p}\pi^+$.

The background for these modes comes from $e^+e^- \to q\bar{q}$ events and from B decays other than those under

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MEASUREMENTS OF THE DECAYS $B^0 \to \bar{D}^0 p \bar{p}$, $B^0 \to \bar{D}^{*0} p \bar{p}$ ...　　　PHYSICAL REVIEW D **74**, 051101(R) (2006)

consideration. In both of these cases, the background comes from selecting random combinations of tracks and thus does not peak in either ΔE or m_{ES}. The one exception is in the case of $B^0 \to \bar{D}^{*0} p \bar{p}$, where there is a possibility of events such as $B^0 \to \bar{D}^0 p \bar{p} \pi^0$ that peak at the B mass in m_{ES}. However, since the π^0 comes from the other B decay in the event, the ΔE distribution does not peak strongly in the signal region.

We perform an unbinned extended maximum likelihood fit to extract the yields. The variables m_{ES} and ΔE are used as discriminating variables to separate signal from background. The data sample is assumed to consist of two components: signal events and combinatorial background events due to random combinations of tracks from both $q\bar{q}$ and $B\bar{B}$ events. For the decay $B^0 \to \bar{D}^{*0} p \bar{p}$, a peaking component is added to account for $B^0 \to \bar{D}^0 p \bar{p} \pi^0$ events.

In addition, the signal is split into correctly reconstructed events (Class I) and misreconstructed events (Class II). The Class II events are signal events where one or more of the tracks from the signal B decay is lost and a track from the other B decay is included in the reconstruction. The fraction of Class II events is determined from MC and varies from nearly 0 for $B^0 \to \bar{D}^0 p \bar{p} \to K^+ \pi^- p \bar{p}$ to almost 50% for $B^0 \to D^{*-} p \bar{p} \pi^+ \to \pi^- K^+ \pi^- \pi^0 p \bar{p} \pi^+$.

In the maximum likelihood fit, each component is modeled by a probability density function (PDF) of the two variables m_{ES} and ΔE,

$$\mathcal{P} = \mathcal{P}(m_{ES}, \Delta E). \qquad (1)$$

The likelihood for the N candidates in the event sample is given by:

$$\mathcal{L} = e^{-N'} \cdot \prod_{i=1}^{N} \{N_{\text{sig}} \cdot [f_I \cdot \mathcal{P}_I^i + f_{II} \cdot \mathcal{P}_{II}^i] + N_{\text{bkg}} \cdot \mathcal{P}_{\text{bkg}}^i\}, \qquad (2)$$

where N' is the sum of the fitted number of signal (N_{sig}) and background (N_{bkg}) events. The background PDF is given by $\mathcal{P}_{\text{bkg}}$, $\mathcal{P}_I$ and $\mathcal{P}_{II}$ are the PDFs of Class I and II events in signal, respectively, and f_I and f_{II} are their corresponding fractions.

The Class I signal events are parameterized with a double Gaussian for both m_{ES} and ΔE. For Class II events, m_{ES} is parameterized with the correlated function $P_{II}(m_{ES}, \Delta E) = G(m_{ES})G_1(\Delta E) + P(m_{ES})G_2(\Delta E)$ where G represents a Gaussian and P a polynomial function. All parameters for the signal PDFs are obtained from signal MC and fixed in the fit with the exceptions of the means of the narrow components of the double-Gaussian distributions for both m_{ES} and ΔE for Class I events, which are allowed to vary. The combinatorial background is parameterized with a threshold function [17] in m_{ES} and a second-order polynomial in ΔE, and all of the parameters are varied in the fit. The peaking background component com-

ing from B decays in the $B^0 \to \bar{D}^{*0} p \bar{p}$ modes is modeled with a nonparametric 2-dimensional PDF in m_{ES} and ΔE and the yield is free in the fit. The m_{ES} distributions for the data and the fit, after selecting events with $|\Delta E| < 20$ MeV, are shown in Fig. 1 for the $\bar{D}^0 \to K^+ \pi^-$ and $D^- \to K^+ \pi^- \pi^-$ decays.

For each event a signal weight is defined as follows:

$$W_{\text{sig}}^i = \frac{\sigma_{\text{sig}}^2 \mathcal{P}_{\text{sig}}^i + \text{cov(sig, bkg)} \mathcal{P}_{\text{bkg}}^i}{N_{\text{sig}} \mathcal{P}_{\text{sig}}^i + N_{\text{bkg}} \mathcal{P}_{\text{bkg}}^i}, \qquad (3)$$

following the method described in Ref. [18]. In Eq. (3), $\mathcal{P}_{\text{sig}}^i$ ($\mathcal{P}_{\text{bkg}}^i$) is the value of the signal (background) PDF for event i; σ_{sig} is the standard deviation of the signal yield; and cov(sig, bkg) denotes the covariance between N_{sig} and N_{bkg}, as obtained from the fit. The normalization of W_{sig}^i is such that their sum equals the total number of signal events, N_{sig}. The sum of W_{sig}^i over a small area of phase space gives the correct distribution of signal in that area.

The branching fraction is obtained as:

$$\mathcal{B} = \sum_i \frac{W_{\text{sig}}^i}{N_{B\bar{B}}} \cdot \epsilon_i \cdot \mathcal{B}_{\text{sub}}, \qquad (4)$$

where the sum is over all events i, $N_{B\bar{B}}$ is the number of $B\bar{B}$ pairs in the sample, ϵ_i is the efficiency for event i, which depends on its position in phase space, and $\mathcal{B}_{\text{sub}}$ is the product of the branching fractions of the charmed meson decays [15,19]. We assume that the $\Upsilon(4S)$ decays with
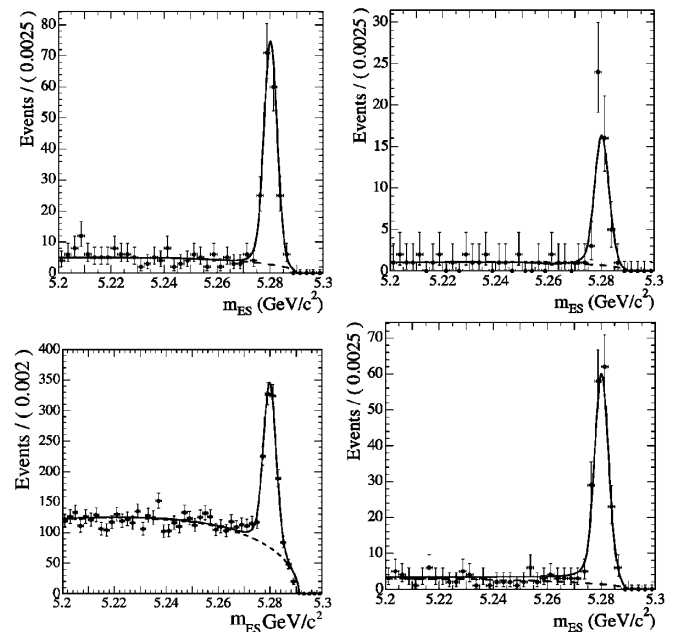

FIG. 1. Fit projections of m_{ES} for (clockwise from top-left) $B^0 \to \bar{D}^0 p \bar{p} (\bar{D}^0 \to K^+ \pi^-)$, $B^0 \to \bar{D}^{*0} p \bar{p} (\bar{D}^0 \to K^+ \pi^-)$, $B^0 \to D^{*-} p \bar{p} \pi^+ (\bar{D}^0 \to K^+ \pi^-)$, and $B^0 \to D^- p \bar{p} \pi^+ (D^- \to K^+ \pi^- \pi^-)$. The dashed line is the background contribution and the solid line is the background plus signal.

equal probability to $B^0\bar{B}^0$ and B^+B^-. The statistical error on the branching fraction is obtained from the fractional error on the signal yield as calculated from the fit.

The largest source of systematic error arises from the uncertainty in the charged track reconstruction efficiency determined from the MC. This systematic error ranges from 3.3% to 8.8% depending on the number of charged tracks in the decay mode. In addition there is a systematic error due to the modeling of the PID efficiency for the protons and kaons of 4.5% for all modes and an additional error of 2% for the pion identification for the modes $B^0 \rightarrow D^- p\bar{p}\pi^+$ and $B^0 \rightarrow D^{*-} p\bar{p}\pi^+$. The uncertainty due to ignoring correlations between m_{ES} and ΔE is estimated to be a few percent by performing fits to Monte Carlo samples that consist of fully simulated signal events embedded with parameterized background events. The uncertainties related to modeling of the signal PDFs are calculated by allowing the ΔE and m_{ES} signal shape parameters for the $B^0 \rightarrow D^- p\bar{p}\pi^+$ mode to vary in the fit and then varying the fixed parameters in the other modes by the differences observed between data and MC in this mode. This error ranges from 0.2% to 2.8%. The fraction of Class II events is varied by 5% per π^0, or 5% for modes with no π^0, to account for the uncertainty due to misreconstructed events and the difference observed is 1% to 5%. The uncertainty arising from binning the efficiency in phase space gives a typical error of 3%. Finally, the errors on the branching fractions of D and D^* decays are included in the systematic uncertainty and range from 2.4% (for $B^0 \rightarrow \bar{D}^0 p\bar{p}$, $\bar{D}^0 \rightarrow K^+\pi^-$) to 6.2% (for $B^0 \rightarrow \bar{D}^{*0} p\bar{p}$, $\bar{D}^0 \rightarrow K^+\pi^-\pi^0$). The total systematic error ranges from 6.3% to 13.3%.

The fitted signal yield and the measured branching fraction for each decay mode is given in Table I. Averaging the branching fractions of the different D decays weighted by their errors and accounting for correlations, we obtain:
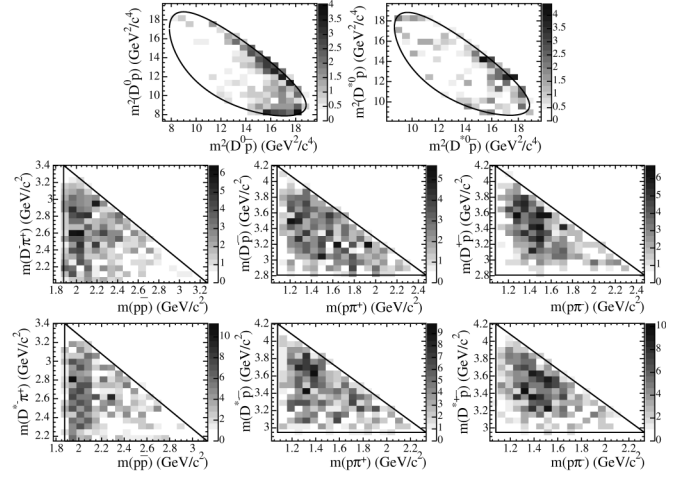

FIG. 2. The distributions of the branching fractions (in units of $10^{-6}/\text{GeV}/c^2$) for $B^0 \rightarrow \bar{D}^0 p\bar{p}$ (top row, left), $B^0 \rightarrow \bar{D}^{*0} p\bar{p}$ (top row, right), $B^0 \rightarrow D^- p\bar{p}\pi^+$ (middle row), and $B^0 \rightarrow D^{*-} p\bar{p}\pi^+$ (bottom row) projected over two invariant mass dimensions.

$$\mathcal{B}(B^0 \rightarrow \bar{D}^0 p\bar{p}) = (1.13 \pm 0.06 \pm 0.08) \times 10^{-4}$$

$$\mathcal{B}(B^0 \rightarrow \bar{D}^{*0} p\bar{p}) = (1.01 \pm 0.10 \pm 0.09) \times 10^{-4}$$

$$\mathcal{B}(B^0 \rightarrow D^- p\bar{p}\pi^+) = (3.38 \pm 0.14 \pm 0.29) \times 10^{-4}$$

$$\mathcal{B}(B^0 \rightarrow D^{*-} p\bar{p}\pi^+) = (4.81 \pm 0.22 \pm 0.44) \times 10^{-4}$$

where the first error is statistical and the second systematic.

We investigate the decay dynamics by projecting the branching fractions obtained with Eq. (4) onto the different invariant mass axes. This method requires that the variables used in the fit are uncorrelated to the variable being projected. The correlations between the invariant masses and ΔE and m_{ES} are observed to be small. Figure 2 shows the two dimensional projections (the Dalitz plots for the 3-body decays) for the four modes under study. Figure 3 shows 1-dimensional projections and the comparison with phase-space distributions for the $p\bar{p}$, $\bar{D}\,\bar{p}$ (nonexotic minimal quark content of $\overline{cu}\,\bar{d}$ or $\bar{c}\,\overline{d}\,\overline{d}$) and $\bar{D}p$ (exotic minimal quark content of $\bar{c}uuud$ or $\bar{c}duud$) invariant masses.

In comparison with phase space, an enhancement at low $p\bar{p}$ mass is seen in all decay channels. Such an enhancement has been observed in other situations [20–23]; indeed, it is also observed in the background $p\bar{p}$ distributions in this analysis. In the left plot of Fig. 4 the $p\bar{p}$ distributions for all four modes have been overlaid removing the events with $M(\bar{D}^{(*)}\bar{p})$ less than 3.1 GeV/c^2 and normalizing to the total area. In addition, each event entering Fig. 4 has been weighted by a phase-space factor and thus the distribution is proportional to the square of the matrix element. The distributions of the four modes show the same behavior. We have also compared our phase-space corrected $p\bar{p}$ distributions (averaged over the four modes) to those measured in $e^+e^- \rightarrow p\bar{p}\gamma$ [21] and $B^+ \rightarrow p\bar{p}K^+$ [22] by
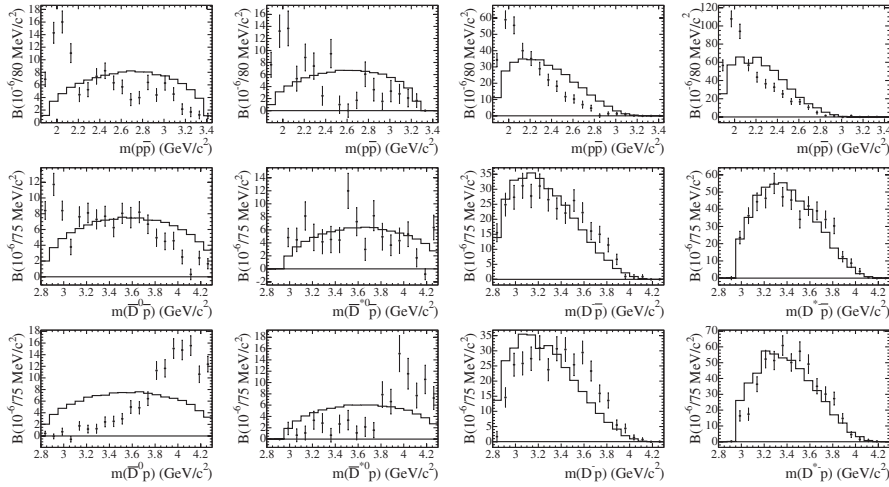
TABLE I. The branching fractions (in units of 10^{-4}) for the B^0 decays considered here. The first error is statistical and the second systematic.

B^0 decay	D decay	N_{sig}	$\mathcal{B}(10^{-4})$
	$K^+\pi^-$	214 ± 16	$1.09 \pm 0.08 \pm 0.08$
$B^0 \rightarrow \bar{D}^0 p\bar{p}$	$K^+\pi^-\pi^0$	514 ± 38	$1.15 \pm 0.08 \pm 0.10$
	$K^+\pi^-\pi^+\pi^-$	320 ± 26	$1.24 \pm 0.10 \pm 0.11$
	$K^+\pi^-$	57 ± 9	$1.21 \pm 0.17 \pm 0.11$
$B^0 \rightarrow \bar{D}^{*0} p\bar{p}$	$K^+\pi^-\pi^0$	104 ± 19	$1.08 \pm 0.14 \pm 0.14$
$\bar{D}^{*0} \rightarrow \bar{D}^0\pi^0$	$K^+\pi^-\pi^+\pi^-$	46 ± 12	$0.75 \pm 0.18 \pm 0.09$
$B^0 \rightarrow D^- p\bar{p}\pi^+$	$K^+\pi^-\pi^-$	1166 ± 47	$3.38 \pm 0.14 \pm 0.29$
	$K^+\pi^-$	241 ± 18	$4.84 \pm 0.40 \pm 0.44$
$B^0 \rightarrow D^{*-} p\bar{p}\pi^+$	$K^+\pi^-\pi^0$	522 ± 32	$4.71 \pm 0.30 \pm 0.50$
$D^{*-} \rightarrow \bar{D}^0\pi^-$	$K^+\pi^-\pi^+\pi^-$	311 ± 24	$5.05 \pm 0.42 \pm 0.59$

FIG. 3.   The branching fraction (B, in units of $10^{-6}/\mathrm{GeV}/c^2$) distributions versus $p\bar{p}$ (top), nonexotic (i.e $\bar{D}\bar{p}$) (middle), exotic (i.e $\bar{D}p$) (bottom) invariant mass for (from left) $B^0 \to \bar{D}^0 p\bar{p}$, $B^0 \to \bar{D}^{*0} p\bar{p}$, $B^0 \to D^- p\bar{p}\pi^+$, and $B^0 \to D^{*-} p\bar{p}\pi^+$ with all D decay modes combined. The solid lines are the distributions expected from a purely phase-space decay.

BABAR, shown on the right of Fig. 4, and again there appears to be good agreement.

Explanations that have been proposed to account for the enhancement observed at the $p\bar{p}$ threshold include a gluonic resonance [24] and short-range correlations between the p and the $\bar{p}$ [25]. The BES collaboration has recently claimed evidence for a resonance decaying to $\pi\pi\eta'$ with a mass of 1834 MeV/c^2 and a width of 68 MeV/c^2 [26]. This resonance should also decay to $p\bar{p}$ and the mass and width measured by BES in $\pi\pi\eta'$ is in agreement with the enhancement seen by BES in the $p\bar{p}$ distribution in $J/\psi \to \gamma p\bar{p}$ decays [23] assuming a Breit-Wigner with corrections for final state interactions [27,28].

With respect to the $\bar{D}\bar{p}$ invariant mass spectra, other than an excess at low mass in the $B^0 \to \bar{D}^0 p\bar{p}$ mode, the plots in the middle row of Fig. 3 are in qualitative agreement with the phase-space histograms. The low-mass excess in $B^0 \to \bar{D}^0 p\bar{p}$ is also easily seen in the Dalitz plot in Fig. 2 and appears again to be a threshold enhancement as

in the $p\bar{p}$ case. While it would be expected that the same effect would be seen in the $B^0 \to \bar{D}^{*0} p\bar{p}$ mode, the statistics are much lower and the mass threshold is higher.

The $\bar{D}p$ distributions, in the bottom row of Fig. 3, we observe a clear tendency to peak toward high $\bar{D}^{(*)0}p$ mass in comparison with phase space for the three-body modes. This is also reflected in the apparent asymmetry in the Dalitz plots. The four body modes are in qualitative agreement with phase-space distributions in the $\bar{D}p$ projections.

The H1 Collaboration has claimed evidence for a charmed pentaquark state decaying to $D^{*-}p$ at 3.1 GeV/c^2 whose width is compatible with their experimental resolution of 7 MeV/c^2. By fitting the D^-p invariant mass spectrum in the decay $B^0 \to D^- p\bar{p}\pi^+$ to a Breit-Wigner plus linear background, we obtain an upper limit on the branching fraction:

$$\mathcal{B}(B^0 \to \Theta_c \bar{p}\pi^+) \times \mathcal{B}(\Theta_c \to D^- p) < 9 \times 10^{-6}, \quad (8)$$

while for the $D^{*-}p$ spectrum in $B^0 \to D^{*-} p\bar{p}\pi^+$ we obtain:

$$\mathcal{B}(B^0 \to \Theta_c \bar{p}\pi^+) \times \mathcal{B}(\Theta_c \to D^{*-} p) < 14 \times 10^{-6} \quad (9)$$

at 90% C.L. For this limit we have assumed the resonance width for the Θ_c to be 25 MeV/c^2, which corresponds to the upper limit on the width given by H1. If we assume a smaller width, the limits decrease.

In conclusion, we have measured the branching fractions of $B^0 \to \bar{D}^0 p\bar{p}$, $B^0 \to \bar{D}^{*0} p\bar{p}$, $B^0 \to D^- p\bar{p}\pi^+$, and $B^0 \to D^{*-} p\bar{p}\pi^+$. The results obtained for the modes $B^0 \to D^{*-} p\bar{p}\pi^+$, $B^0 \to \bar{D}^{*0} p\bar{p}$, and $B^0 \to \bar{D}^0 p\bar{p}$ agree with the previous measurements and have smaller uncertainties while the decay $B^0 \to D^- p\bar{p}\pi^+$ has been measured for the first time. We do not observe any evidence for the charmed pentaquark observed by H1 at $M(D^{*-}p)$ of 3.1 GeV/c^2. In comparison with phase space we observe a low-mass $p\bar{p}$
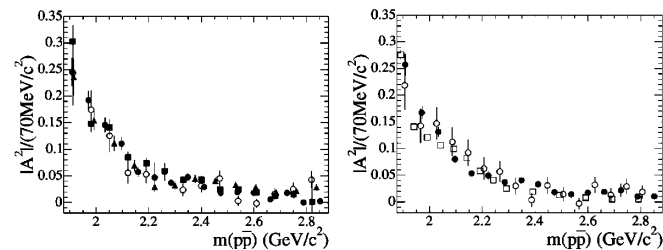

FIG. 4.   Left: The phase-space corrected $p\bar{p}$ invariant mass distributions for all four decay modes: $B^0 \to \bar{D}^0 p\bar{p}$ (triangles), $B^0 \to \bar{D}^{*0} p\bar{p}$ (open circles), $B^0 \to D^- p\bar{p}\pi^+$ (squares), and $B^0 \to D^{*-} p\bar{p}\pi^+$ (closed circles). Right: The $p\bar{p}$ distributions from the present analysis averaged over the four decay modes (closed circles) compared to the distributions obtained in $e^+e^- \to p\bar{p}\gamma$ (open squares) and $B^+ \to p\bar{p}K^+$ (open circles).

enhancement similar to other observations in $p\bar{p}$ production. We also observe a deviation from phase-space structure in the Dp and $\bar{D}p$ invariant mass distributions for the three-body modes.

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