Baryonic B Decay Results from *BABAR*

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Decays of B mesons into final states containing baryons are much less understood than decays into mesons, and are useful for shedding light on baryon-production mechanisms and intermediate states. We report the results of recent and new studies of such decays, including $B^- \to \Sigma_c(2455)^{++}\overline{p}\pi^-\pi^-$, $\overline{B}^0 \to \Lambda_c^+ p\overline{p}\overline{p}$, and $B \to D^{(*)}p\overline{p}(n\pi)$. Both the total decay rates and the resonant structure are reported.

1 Introduction

From what we know so far, $(6.8 \pm 0.6)\%$ of all B mesons decay to a final state with baryons and $(4.5 \pm 1.2)\%$ decay to a final state with a Λ_c^+ in there [1]. However, presently the sum of all exclusive branching fractions is only about 20% of all baryonic B-decays and also only very little is know about the decay mechanism. B mesons decay dominantly via $b \to c$ transitions while the c quark can be bound into a baryon or a meson. A common feature of processes with baryons in the final state is a threshold enhancement in the invariant baryon-antibaryon mass spectrum [2][3]. This feature may also explain the increase of the branching fraction with higher final state multiplicity and the suppression of two-body decays to baryons [4][5]. In the presented analyses we will measure the branching fraction, search for resonant subchannels and test for the enhancement in the baryon-antibaryon mass spectrum and the increase of the branching fraction with higher final state multiplicity.

2 Study of the decay mode $B \to D^{(*)}p\overline{p}(\pi)(\pi)$ [6]

We study 10 different decay modes and measure the branching fractions shown in table 1, while 6 of them are observed for the first time. The interesting conclusions from this measurements are:

- 4-body modes have a higher branching fraction than the corresponding 5-body modes $\mathcal{B}$(3-body)<$\mathcal{B}$(5-body)<$\mathcal{B}$(4-body)
- all branching fractions are of the same order of magnitude: $\mathcal{B} \approx \mathcal{O}(10^{-4})$

This is especially interesting given that for $B \to \Lambda_c^+\overline{p}\,(n\pi)$ with $n = 1, 2$, the branching fraction is around one order of magnitude higher when there is an additional pion in the final state, while the highest branching fraction is measured for $B^- \to \Lambda_c^+\overline{p}\pi^+\pi^-\pi^-$ [1] and $\mathcal{B}(B \to \Lambda_c^+\overline{p}\pi) \approx \mathcal{O}(10^{-4})$. The reason for this could be the influence of resonant substructures which are very important for the decay modes with a Λ_c^+ in the final state. While for the studied 5-body

decay mode	$\mathcal{B} \pm \sigma_{(\mathrm{stat})} \pm \sigma_{(\mathrm{syst})} (10^{-4})$
$\overline{B}^0 \to D^0 p\overline{p}$	$1.02 \pm 0.04 \pm 0.06$
$\overline{B}^0 \to D^{*0} p\overline{p}$	$0.97 \pm 0.07 \pm 0.09$
$\overline{B}^0 \to D^+ p\overline{p}\pi^-$	$3.32 \pm 0.10 \pm 0.29$
$\overline{B}^0 \to D^{*+} p\overline{p}\pi^-$	$4.55 \pm 0.16 \pm 0.39$
$\boldsymbol{B^- \to D^0 p\overline{p}\pi^-}$	$\mathbf{3.72 \pm 0.11 \pm 0.25}$
$\boldsymbol{B^- \to D^{*0} p\overline{p}\pi^-}$	$\mathbf{3.73 \pm 0.17 \pm 0.27}$
$\boldsymbol{\overline{B}^0 \to D^0 p\overline{p}\pi^-\pi^+}$	$\mathbf{2.99 \pm 0.21 \pm 0.45}$
$\boldsymbol{\overline{B}^0 \to D^{*0} p\overline{p}\pi^-\pi^+}$	$\mathbf{1.91 \pm 0.36 \pm 0.29}$
$\boldsymbol{B^- \to D^+ p\overline{p}\pi^-\pi^-}$	$\mathbf{1.66 \pm 0.13 \pm 0.27}$
$\boldsymbol{B^- \to D^{*+} p\overline{p}\pi^-\pi^-}$	$\mathbf{1.86 \pm 0.16 \pm 0.19}$

Table 1: Measured branching fractions for the different decay modes (decay modes observed for the first time are in bold).

decay modes the 2-body invariant mass distributions agree very well with simulated events using uniform phase space model, it is very different for the studied 3-body and 4-body decay modes.

2.1 3-body decay modes

Fig. 1 shows the 2-body invariant mass distributions for the studied 3-body B-decay modes. The diagrams (c) and (g) show a clear an enhancement in the $p\overline{p}$ mass distribution at threshold. In addition, we observe a clear difference between the invariant mass distributions $m(D^{(*)}p)$ for data and simulated 3-body phase space events, which is shown in (a) and (e).

2.2 4-body decay modes

Fig. 2 and Fig. 3 show the 2-body invariant mass distributions for the studied 4-body B-decay modes. In all decay modes we observe again an enhancement at threshold for the invariant mass distribution $m(p\overline{p})$. In addition we find a narrow structure in $m(p\pi^-)$ which is most prominent in Fig. 2 (d). For the mean and the width of this structure we measure $m = (1497.4 \pm 3.0 \pm 0.9)\,\mathrm{MeV}/c^2$ and $\Gamma = (47 \pm 12 \pm 4)\,\mathrm{MeV}/c^2$ where the first uncertainty is statistical and the second one the systematical uncertainty.

3 Study of the decay mode $\boldsymbol{B^- \to \Sigma_c(2455)^{++}\overline{p}\pi^-\pi^-}$ [7]

In this analysis we assume that $\mathcal{B}(\Sigma_c(2455)^{++} \to \Lambda_c^+\pi^+) = 100\%$ and reconstruct the Λ_c^+ candidate in the decay mode $pK^-\pi^+$ which has a branching fraction of $(5.0 \pm 1.3)\%$. The number of signal events is determined by a fit to a ΔE distribution, with $\Delta E = E_B^* - \sqrt{s}/2$ and the energy of the B-candidate in the e^+e^- rest frame (E_B^*) (Fig. 4). The fit finds $N_{\mathrm{sig}} = 787 \pm 43$ signal events which results in a branching fraction of $\mathcal{B}(B^- \to \Sigma_c(2455)^{++}\overline{p}\pi^-\pi^-) = (2.98 \pm 0.16 \pm 0.15 \pm 0.77) \times 10^{-4}$ where the uncertainties are statistic, systematic, and from

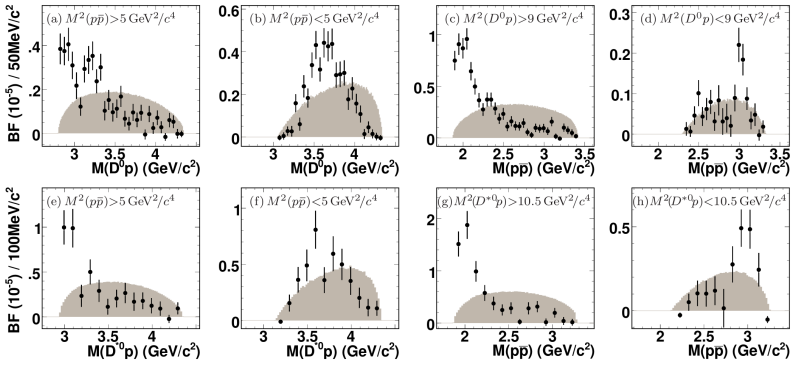

Figure 1: 2-body invariant mass distributions for $\overline{B}^0 \to D^0 p\overline{p}$ (top) and for $\overline{B}^0 \to D^{*0} p\overline{p}$ (bottom), the shaded histogram shows simulated 3-body phase space events

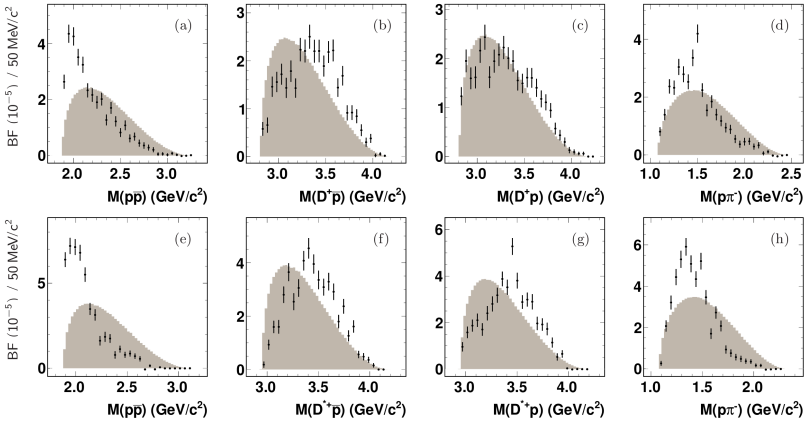

Figure 2: 2-body invariant mass distributions for $\overline{B}^0 \to D^+ p\overline{p}\pi^-$ (top) and for $\overline{B}^0 \to D^{*+} p\overline{p}\pi^-$ (bottom), the shaded histograms show simulated 4-body phase space events

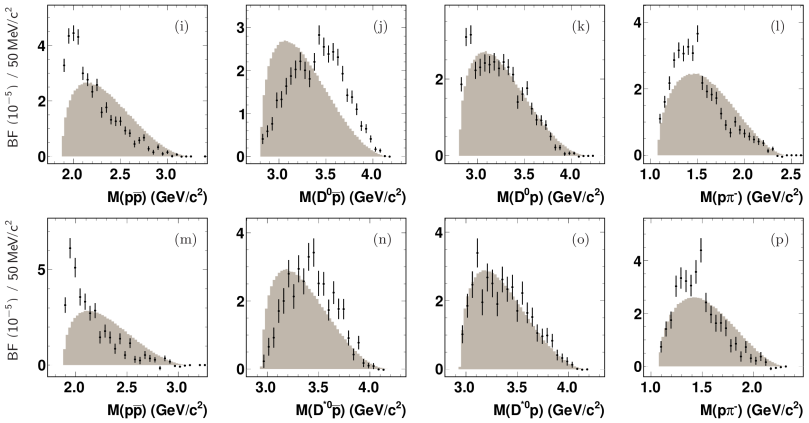

Figure 3: 2-body invariant mass distributions for $B^- \to D^0 p\overline{p}\pi^-$ (top) and for $B^- \to D^{*0} p\overline{p}\pi^-$ (bottom), the shaded histograms show simulated 4-body phase space events

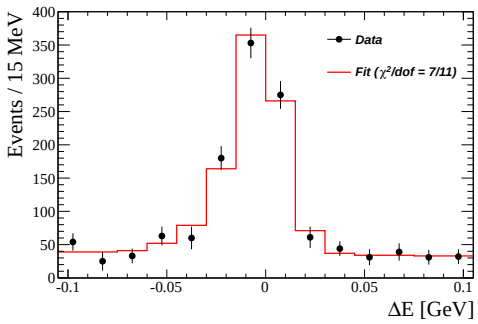

Figure 4: Points with error bars represent the number of Σ_c^{++} candidates obtained by a fit to $\Delta M = m(\Lambda_c^+\pi^+) - m(\Lambda_c^+)$ in every bin of ΔE; the red curves shows the binned fit to data

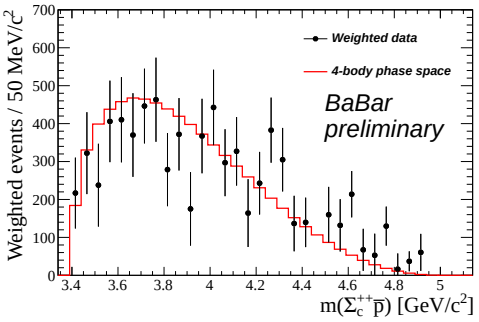

Figure 5: Baryon-antibaryon invariant mass distribution for data signal events after efficiency correction (points with error bars) and weighted simulated 4-body phase space events

the uncertainty on the Λ_c branching fraction. Although we see some structures in the invariant 2-body mass distributions as well as in the invariant mass distribution of $\Sigma_c(2455)^{++}\pi^-\pi^-$, there is no evidence for decays via resonant subchannels. Moreover, we do not observe an enhancement at threshold for the invariant baryon-antibaryon mass distribution (Fig. 5).

4 Study of the decay mode $\overline{B}^0 \to \Lambda_c^+\overline{p}p\overline{p}$

Since there are only baryons in the final state of this decay mode the possibilities for resonant subchannels are limited. However, the momenta of all particles are very low in the e^+e^- rest frame which could enhance the production rate of baryons and in this decay mode one can also look for the enhancement at threshold in the baryon-antibaryon invariant mass distribution using different combinations of the final state particles. As a preliminary result we observe two events after all selection criteria are applied and calculate an upper limit at 90% confidence level of $\mathcal{B}(\overline{B}^0 \to \Lambda_c^+\overline{p}p\overline{p}) \cdot \mathcal{B}(\Lambda_c^+ \to pK^-\pi^+)/0.05 < 6.2 \times 10^{-6}$ in which we divide the product branching fraction by the center value of the known Λ_c^+ branching fraction. This upper limit is already some orders of magnitude lower than the branching fraction for other 4-body baryonic B-decay modes.

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