Production and Decay of Ω_c^0

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We present an analysis of inclusive Ω_c^0 baryon production and decays in 230.5 fb^{-1} of data recorded
with the *BABAR* detector. Ω_c^0 baryons are reconstructed in four final states ($\Omega^- \pi^+$, $\Omega^- \pi^+ \pi^0$,
$\Omega^- \pi^+ \pi^+ \pi^-$, $\Xi^- K^- \pi^+ \pi^+$) and the corresponding ratios of branching fractions are measured. We

also measure the momentum spectrum in the e^+e^- center-of-mass frame. From the spectrum, we observe Ω_c^0 production from B decays and in $c\bar{c}$ events, and extract the two rates of production.

The Ω_c^0 (css) is the heaviest weakly-decaying singly-charmed baryon. It has been observed independently in several decay modes by different experiments [1] and in a variety of production environments, including e^+e^- colliders operating at the $\Upsilon(4S)$ resonance [2–4], photoproduction [5–7], and hyperon beams [8]. So far, B meson decays to Ω_c^0 have not been observed. Several different mechanisms could contribute, principally weak decays of the following forms: $b \to c\bar{c}s$ (e.g., $B^- \to \Omega_c^0 \bar{\Xi}_c^-$); $b \to c\bar{u}s$ (e.g., $B^- \to \Omega_c^0 \bar{\Sigma}^-$); and $b \to c\bar{u}d$ (e.g., $B^- \to \Omega_c^0 \bar{\Xi}^0 \pi^-$). Beyond the requirement to produce at least one $s\bar{s}$ pair during fragmentation, we would expect these three types of decays to be further suppressed by the limited phase space, by $|V_{us}|^2$, and by needing to produce a second $s\bar{s}$ pair, respectively. Theoretical predictions for branching fractions of individual two-body contributions vary from $\mathcal{O}(10^{-5})$ to $\mathcal{O}(10^{-3})$ [9–11].

In this Letter, we present a study of the Ω_c^0 baryon, reconstructed in four decay modes: $\Omega^-\pi^+$, $\Omega^-\pi^+\pi^0$, $\Omega^-\pi^+\pi^+\pi^-$, and $\Xi^-K^-\pi^+\pi^+$ [12]. We measure the ratios of branching fractions for these modes, normalizing to $\mathcal{B}(\Omega_c^0 \to \Omega^-\pi^+)$. The previous most precise measurements of these ratios are from an analysis of approximately 45 events from six Ω_c^0 decay modes [3]. We then measure the spectrum of the Ω_c^0 momentum in the e^+e^- center-of-mass frame (p^*) and observe significant production of Ω_c^0 baryons in the decays of B mesons.

The data for this analysis were recorded with the *BABAR* detector at the Stanford Linear Accelerator Center PEP-II asymmetric-energy e^+e^- collider. The detector is described in detail elsewhere [13]. A total integrated luminosity of 230.5 fb^{-1} is used, of which 208.9 fb^{-1} were collected at the $\Upsilon(4S)$ resonance (corresponding to 232×10^6 $B\bar{B}$ pairs) and 21.6 fb^{-1} were collected 40 MeV below the $B\bar{B}$ production threshold.

Simulated events with the Ω_c^0 decaying into the relevant final states are generated for the processes $e^+e^- \to c\bar{c} \to \Omega_c^0 X$ and $e^+e^- \to \Upsilon(4S) \to B\bar{B} \to \Omega_c^0 X$, where X represents the rest of the event. The PYTHIA simulation package [14] is used for the $c\bar{c}$ fragmentation and for B decays to Ω_c^0, and the GEANT4 [15] package is used to simulate the detector response. To investigate possible background contributions, additional samples of generic Monte Carlo (MC) events are used, equivalent to 990 fb^{-1} for $\Upsilon(4S)$ events ($e^+e^- \to \Upsilon(4S) \to B\bar{B}$), plus 320 fb^{-1} for $c\bar{c}$ continuum events ($e^+e^- \to c\bar{c}$) and 340 fb^{-1} for light quark continuum events ($e^+e^- \to q\bar{q}$, $q = u, d, s$).

The reconstruction of an Ω_c^0 candidate begins by identifying a proton, combining it with an oppositely charged track interpreted as a π^-, and fitting the tracks to a common vertex to form a Λ candidate. The Λ is then combined with a negatively charged track interpreted as a K^- (π^-) and fit to a common vertex to form an Ω^- (Ξ^-) candidate. For each intermediate hyperon (Λ, Ξ^-, Ω^-), we require the invariant mass to be within 4.5 MeV/c^2 of its nominal value (corresponding to approximately 4, 3, and 3 times the detector resolution, respectively). We form π^0 candidates from pairs of photons in the electromagnetic calorimeter, requiring the energy of each photon to be above 80 MeV and the combined energy to be above 200 MeV. We require the invariant mass of the π^0 candidate, computed at the event primary vertex, to be in the range 120–150 MeV/c^2.

Each Ω^- (Ξ^-) candidate that passes the requirements is then combined with one or three additional tracks that are identified as pions or kaons as appropriate. For the $\Omega^-\pi^+\pi^0$ final state, we also combine the hyperon and π^+ with a π^0. The Ω_c^0 candidate daughters are refit to a common vertex with their masses constrained to the nominal values. From this fit, we extract the decay vertices and associated uncertainties of the Ω_c^0 and the intermediate hyperons, the four-momenta of the particles, and the Ω_c^0 candidate mass. For each intermediate hyperon, we require a positive scalar product of the momentum vector in the laboratory frame and the displacement vector from its production vertex to its decay vertex.

To further suppress the background, we compute the likelihood ratio $\mathcal{L} = \prod_i p_i^S(x_i)/[\prod_i p_i^S(x_i) + \prod_i p_i^B(x_i)]$ for each Ω_c^0 candidate, where the index i refers to the likelihood variables x_i, and $p_i(x_i)$ are the probability density functions for signal (S) and background (B). For a given Ω_c^0 candidate, $\mathcal{L}$ has a value between 0 and 1. The likelihood variables x_i are the logarithm of the Ω^- or Ξ^- decay length significance, which is defined as the distance between the production and decay vertices divided by the uncertainty on that distance; the momentum of the Ω^- or Ξ^- in the e^+e^- rest frame; the total momentum of the mesons recoiling against the Ω^- or Ξ^- in the e^+e^- rest frame; and, for the $\Omega^-\pi^+\pi^0$ mode, the π^0 momentum in the laboratory frame. These variables (particularly the decay length significance) cover the expected range effectively with a limited number of bins. The distributions of these variables for the signal hypothesis are derived from signal MC simulations, and for the background hypothesis from generic MC events in which contributions from real Ω_c^0 are excluded. Separate distributions are used for each final state when measuring ratios of branching fractions, and for each momentum range when measuring the momentum spectrum.

To measure the ratios of branching fractions, we require that $p^* > 2.4$ GeV/c in order to suppress combinatoric

background. Since the kinematic limit for Ω_c^0 produced in B decays at *BABAR* is $p_{\max}^* = 2.02$ GeV/c, only Ω_c^0 produced in the $c\bar{c}$ continuum are retained. We also require that the value of $\mathcal{L}$ for each candidate is greater than a threshold $\mathcal{L}_0$, chosen to maximize the expected signal significance for a given final state based on simulated events. We perform an unbinned maximum likelihood fit to the mass distributions shown in Fig. 1. The signal line shape is parameterized as the sum of two Gaussian functions with a common mean; the background is parameterized as a first-order polynomial. In the fits to the data, the signal yield is a free parameter; the widths and relative amplitudes of the two Gaussian functions are fixed to values determined from a fit to simulated signal events. The mean mass is also a free parameter, except for the $\Xi^- K^- \pi^+ \pi^+$ final state where we fix it to the central value obtained in $\Omega_c^0 \to \Omega^- \pi^+$ in order to ensure proper fit convergence. The masses are found to be consistent with

one another and with the current world average [1] within uncertainties.

The numbers of signal events are 177 ± 16, 64 ± 15, 25 ± 8, and 45 ± 12 (statistical uncertainties only) for the final states $\Omega^- \pi^+$, $\Omega^- \pi^+ \pi^0$, $\Omega^- \pi^+ \pi^+ \pi^-$, and $\Xi^- K^- \pi^+ \pi^+$, respectively. These correspond to statistical significances of 18, 5.1, 4.2, and 4.3 standard deviations, respectively, where the significance is defined as $\sqrt{2\Delta\ell}$ and $\Delta\ell$ is the change in the logarithm of the likelihood between the fits with and without an Ω_c^0 signal component. The fitted yields are then corrected for efficiency, which is defined as the fraction of simulated signal events, generated in the appropriate p^* range, that are reconstructed and pass all selection criteria. Including the loss of efficiency due to the Λ and Ω^- branching fractions, we obtain efficiencies of $(8.6 \pm 0.6)\%$, $(2.5 \pm 0.3)\%$, $(4.3 \pm 0.4)\%$, and $(4.7 \pm 0.5)\%$ for the four final states, where the uncertainties include systematic effects and are partially correlated. The systematic uncertainties on, and corrections to, the ratios of branching fractions are listed in Table I and discussed further later. We measure the ratios to be

$$\frac{\mathcal{B}(\Omega_c^0 \to \Omega^- \pi^+ \pi^0)}{\mathcal{B}(\Omega_c^0 \to \Omega^- \pi^+)} = 1.27 \pm 0.31(\text{stat}) \pm 0.11(\text{syst}),$$

$$\frac{\mathcal{B}(\Omega_c^0 \to \Omega^- \pi^+ \pi^+ \pi^-)}{\mathcal{B}(\Omega_c^0 \to \Omega^- \pi^+)} = 0.28 \pm 0.09(\text{stat}) \pm 0.01(\text{syst}),$$

$$\frac{\mathcal{B}(\Omega_c^0 \to \Xi^- K^- \pi^+ \pi^+)}{\mathcal{B}(\Omega_c^0 \to \Omega^- \pi^+)} = 0.46 \pm 0.13(\text{stat}) \pm 0.03(\text{syst}).$$

We also measure the p^* spectrum of Ω_c^0 in order to study the production rates in both $c\bar{c}$ and $B\bar{B}$ events. Only the $\Omega^- \pi^+$ final state is used. The same reconstruction, optimization of selection criteria, and fitting procedures described above are applied, except that no requirement on p^* is made. Instead, the Ω_c^0 candidates are divided into nine equal intervals of p^* covering the range 0.0–4.5 GeV/c.
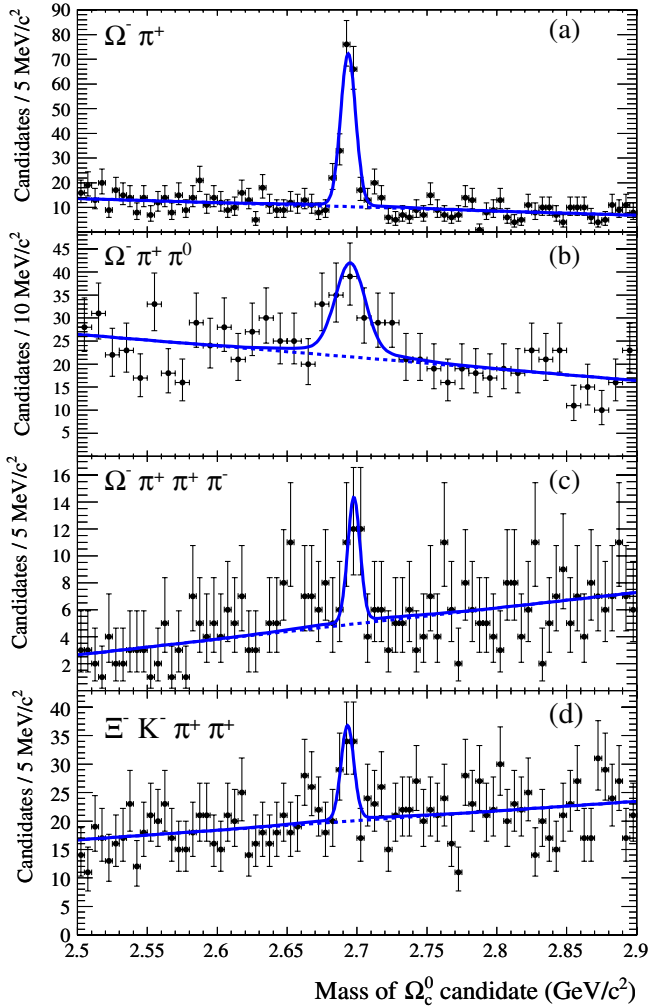

FIG. 1 (color online). The invariant mass spectra for candidates passing the selection criteria. The data are fit with a double Gaussian line shape on a linear background.

TABLE I. Systematic uncertainties on the ratios of branching fractions, where $R_1 \equiv \mathcal{B}(\Omega_c^0 \to \Omega^- \pi^+ \pi^0)/\mathcal{B}(\Omega_c^0 \to \Omega^- \pi^+)$, $R_2 \equiv \mathcal{B}(\Omega_c^0 \to \Omega^- \pi^+ \pi^+ \pi^-)/\mathcal{B}(\Omega_c^0 \to \Omega^- \pi^+)$, and $R_3 \equiv \mathcal{B}(\Omega_c^0 \to \Xi^- K^- \pi^+ \pi^+)/\mathcal{B}(\Omega_c^0 \to \Omega^- \pi^+)$.

Effect	R_1	R_2	R_3
Finite MC sample size	0.7%	0.7%	0.8%
Intermediate resonances in Ω_c^0 decay	1.3%	2.6%	3.7%
Signal lineshape	1.0%	1.0%	1.0%
Dependence on the fit procedure	1.5%	1.5%	1.5%
Hyperon branching fractions	⋯	⋯	1.0%
Particle identification efficiency	1.0%	1.0%	1.0%
Tracking efficiency	0.0%	2.8%[a]	2.8%[a]
p^* spectrum mismodeling	1.5%	0.6%	3.5%
π^0 fitting and efficiency	7.8%[b]	⋯	⋯
Total systematic uncertainty	8.3%	4.4%	6.3%

[a]A relative correction of $+0.5\%$ applies to R_2 and R_3.
[b]A relative correction of $+1.1\%$ applies to R_1.

We again require $\mathcal{L} > \mathcal{L}_0$ and compute the efficiency in each p^* interval as before with simulated signal events. In the numerator of the efficiency, we count events with measured p^* in the appropriate interval, and in the denominator, we count events with generated p^* in that interval: this definition removes the slight broadening effect of the detector momentum resolution. We also take into account a small difference in efficiency between $c\bar{c}$ and $B\bar{B}$ events. The efficiency-corrected yield in each p^* interval is shown in Fig. 2.

The systematic uncertainties are divided into two categories: normalization effects, which are treated as fully correlated between all p^* intervals, and shape effects, which are treated as uncorrelated between different p^* intervals. The normalization uncertainties are due to the mass resolution, which is determined from the MC simulation and checked with studies of the control modes $\Xi_c^0 \rightarrow \Xi^- \pi^+$ and $\Xi_c^+ \rightarrow \Xi^- \pi^+ \pi^+$ (2.4%); the Λ and Ω^- branching fractions [1] (1.3%); and the tracking efficiency, which is corrected for data-MC discrepancies with control samples of τ decays (5.9%). The shape uncertainties are due to the limited size of MC samples ($< 1\%$); dependence on the fit procedure (1.5%); modeling of the p^* spectrum, which can affect the weighted average efficiency within a p^* bin (0–6%); the signal line shape parameterization (1.0%); and the particle identification efficiency (2.0%). When fitting fragmentation functions (see below), we consider only the statistical and shape uncertainties, added in quadrature. When quoting total yields and rates, we include the normalization uncertainties, along with a relative correction of $+1.0\%$ due to a known data-MC discrepancy in tracking efficiency.

The double-peak structure seen in the p^* spectrum is due to two production mechanisms: the peak at lower p^* is due

to Ω_c^0 production in B meson decays, and the peak at higher p^* is due to Ω_c^0 production from the $c\bar{c}$ continuum. This is consistent with the pattern observed in Λ_c^+ and Ξ_c^0 spectra measured for e^+e^- annihilation at $\sqrt{s} = 10.6$ GeV [16–18]. We fit the p^* spectrum with the Bowler fragmentation function [19] for $p^* > 2$ GeV/c. We then extract the continuum yield as the sum of the data points above 2 GeV/c plus the integral of the extrapolated function below 2 GeV/c. Similarly, the yield from B decays is the sum of the data points below 2 GeV/c minus the integral of the extrapolated function below 2 GeV/c. Note that we do not fit a fragmentation function to the data below 2 GeV/c. We obtain yields of 2583 ± 289 and 2426 ± 414 for Ω_c^0 produced in the continuum and in B decays, respectively, where the uncertainty includes all statistical and experimental effects. An additional model uncertainty arises from the extrapolation of the continuum tail for $p^* < 2$ GeV/c. To estimate this, we repeat the p^* spectrum fit and yield measurement with other fragmentation functions: Collins and Spiller (CS) [20], two versions of the phenomenological model of Kartvelishvili *et al.* (KLP-M and KLP-B) [21,22] and the Peterson model [23]. The CS and KLP-M fits are inconsistent with the data for $p^* > 2$ GeV/c. The rms of the yields from the three other fits is 240 events and is taken as the model uncertainty for the B and continuum Ω_c^0 yields. Dividing the Ω_c^0 yield in B decays by the total number of B mesons in the data sample, we obtain the branching fraction product $\mathcal{B}(B \rightarrow \Omega_c^0 X)\mathcal{B}(\Omega_c^0 \rightarrow \Omega^- \pi^+) = [5.2 \pm 0.9(\text{exp}) \pm 0.5(\text{model})] \times 10^{-6}$, where X represents the rest of the B meson decay products. Dividing the Ω_c^0 yield from the continuum by the integrated luminosity and correcting for the small variation in cross-section with $\sqrt{s}$, we obtain the cross-section product at $\sqrt{s} = 10.58$ GeV: $\sigma(e^+e^- \rightarrow \Omega_c^0 X)\mathcal{B}(\Omega_c^0 \rightarrow \Omega^- \pi^+) = [11.2 \pm 1.3(\text{exp}) \pm 1.0(\text{model})]$ fb, where X represents the rest of the event. As a cross check, we also make model-independent estimates of the yields from the continuum and from B decays by subtracting the data below the $\Upsilon(4S)$ threshold. Within large uncertainties, these are consistent with the yields measured above.

It is thus clear that decays of B mesons to Ω_c^0 occur at a significant rate. Assuming the absolute branching fraction $\mathcal{B}(\Omega_c^0 \rightarrow \Omega^- \pi^+) \sim 1\%$, we conclude that $\mathcal{B}(B \rightarrow \Omega_c^0 X) \sim$ few $\times 10^{-4}$. This is substantially lower than the inclusive B meson branching fractions to the charmed baryons Λ_c^+ and Ξ_c, which are $\sim$ few $\times 10^{-2}$ [16–18]. One possible explanation for this is that both Λ_c^+ and Ξ_c can be produced in a $b \rightarrow c\bar{c}s$ transition without creating an $s\bar{s}$ pair from the vacuum, whereas at least one $s\bar{s}$ pair must be created for Ω_c^0 production. It is also possible that phase space suppression in B decays to baryons becomes significant when very close to threshold.

In conclusion, we have studied the Ω_c^0 baryon at *BABAR* through four hadronic decay modes, using 230.5 fb^{-1} of data. We measure the ratios of branching fractions for four
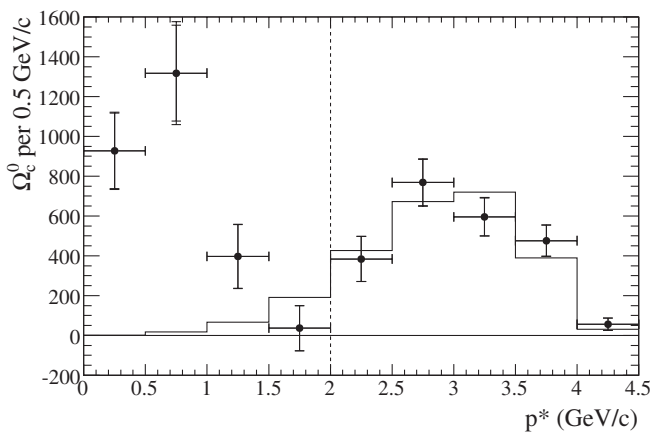

FIG. 2. The background-subtracted and efficiency-corrected $\Omega_c^0 p^*$ spectrum. The black points represent the data, with vertical error bars giving the sum in quadrature of statistical and uncorrelated systematic uncertainties. The solid histogram shows the Bowler fragmentation function, binned and fit to the data for $p^* > 2$ GeV/c (vertical, dashed line).

modes, significantly improving upon the previous values [3]. We have also measured the p^* spectrum and found comparable production rates of Ω_c^0 baryons from the continuum and from B meson decays. The inclusive B branching fraction to Ω_c^0 is found to be substantially lower than those to Ξ_c^0 and Λ_c^+ baryons, assuming the relevant baryon weak decay branching fractions are of the same order of magnitude.

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[1] W.-M. Yao *et al.* (Particle Data Group), J. Phys. G **33**, 1 (2006).

[2] H. Albrecht *et al.* (ARGUS Collaboration), Phys. Lett. B **288**, 367 (1992).

[3] D. Cronin-Hennessy *et al.* (CLEO Collaboration), Phys. Rev. Lett. **86**, 3730 (2001).

[4] R. Ammar *et al.* (CLEO Collaboration), Phys. Rev. Lett. **89**, 171803 (2002).

[5] P. L. Frabetti *et al.* (E687 Collaboration), Phys. Lett. B **300**, 190 (1993).

[6] P. L. Frabetti *et al.* (E687 Collaboration), Phys. Lett. B **338**, 106 (1994).

[7] J. M. Link *et al.* (FOCUS Collaboration), Phys. Lett. B **561**, 41 (2003).

[8] M. I. Adamovich *et al.*, Phys. Lett. B **358**, 151 (1995).

[9] P. Ball and H. G. Dosch, Z. Phys. C **51**, 445 (1991).

[10] S. M. Sheikholeslami and M. P. Khanna, Phys. Rev. D **44**, 770 (1991).

[11] V. L. Chernyak and I. R. Zhitnitsky, Nucl. Phys. B **345**, 137 (1990).

[12] The use of charge conjugate modes is implied throughout.

[13] B. Aubert *et al.* (*BABAR* Collaboration), Nucl. Instrum. Methods Phys. Res., Sect. A **479**, 1 (2002).

[14] T. Sjöstrand *et al.*, Comput. Phys. Commun. **135**, 238 (2001).

[15] S. Agostinelli *et al.*, Nucl. Instrum. Methods Phys. Res., Sect. A **506**, 250 (2003).

[16] R. Seuster *et al.* (Belle Collaboration), Phys. Rev. D **73**, 032002 (2006).

[17] B. Aubert *et al.* (*BABAR* Collaboration), Phys. Rev. D **75**, 012003 (2007).

[18] B. Aubert *et al.* (*BABAR* Collaboration), Phys. Rev. Lett. **95**, 142003 (2005).

[19] M. G. Bowler, Z. Phys. C **11**, 169 (1981).

[20] P. D. B. Collins and T. P. Spiller, J. Phys. G **11**, 1289 (1985).

[21] V. G. Kartvelishvili, A. K. Likhoded, and V. A. Petrov, Phys. Lett. B **78**, 615 (1978).

[22] V. G. Kartvelishvili and A. K. Likhoded, Sov. J. Nucl. Phys. **29**, 390 (1979).

[23] C. Peterson, D. Schlatter, I. Schmitt, and P. M. Zerwas, Phys. Rev. D **27**, 105 (1983).