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Precise measurement of the branching ratio of $B^0 \to D^{*-}\pi^+\pi^-\pi^+$ at *BABAR*

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Using a sample of $(470.9 \pm 2.8) \times 10^6$ $B\bar{B}$ pairs, we measure the decay branching fraction $\mathscr{B}(B^0 \to D^{*-}\pi^+\pi^-\pi^+) = (7.26 \pm 0.11 \pm 0.31) \times 10^{-3}$, where the first uncertainty is statistical and the second uncertainty is systematic. The measurement is 2.4 times more precise than the current world average value. This branching fraction includes singly-charmed B^0 decays only and is obtained by removing the dominant doubly-charmed B^0 decay contribution from the contaminated branching fraction of $(7.37 \pm 0.11 \pm 0.31) \times 10^{-3}$.

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1. Introduction

The branching fraction ratio $R^{(*)} = \frac{\mathscr{B}(\bar{B}\to D^{(*)}\tau^-\bar{\nu}_\tau)}{\mathscr{B}(\bar{B}\to D^{(*)}l^-\bar{\nu})}$, where $l = e$ or μ, was measured by *BABAR* [1], Belle [2] and LHCb [3]. The combined result is deviate from the standard model (SM) prediction by 3.9σ [4]. A new measurement at a hadonic collider of $\mathscr{B}(B^0 \to D^{*-}\tau^+\nu_\tau)$ using $\tau^+ \to \pi^+\pi^-\pi^+\bar{\nu}_\tau$, normalized to $\mathscr{B}(B^0 \to D^{*-}\pi^+\pi^-\pi)$, may improve the precision and find more deviation from the SM. This new possibility needs a precise measurement of $\mathscr{B}(B^0 \to D^{*-}\pi^+\pi^-\pi^+)$. This proceeding describes such a precision measurement at *BABAR* with $(470.9 \pm 2.8) \times 10^6$ $B\bar{B}$ pairs (the charge conjugates is implied).

2. Event selection

The $B^0 \to D^{*-}\pi^+\pi^-\pi^+$ decay candidates are reconstructed with $D^{*-} \to \bar{D}^0\pi^- \to K^+\pi^-\pi^-$. The non-$B\bar{B}$ decays are suppressed. The B^0 candidates are required to have center-of-mass (c.m.) energies within ± 90 MeV of the beam c.m. energy E_{beam}. Then the energy-substituted mass $m_{ES} = \sqrt{E_{beam}^2 - p_B^2}$ of the B^0 candidates, where p_B is the c.m. momentum of the B^0 candidate, is shown in Fig. 1 (left) together with these of signal and background Monte-Carlo (MC) simulated samples. Then a model composed by a signal (Crystal Ball function), a non-peaking background (ARGUS function) and a peaking background (Gaussian function) is used to fit the m_{ES} spectrum as shown in Fig. 1 (right), and the fitted yield of signal candidates is 17767 ± 324.

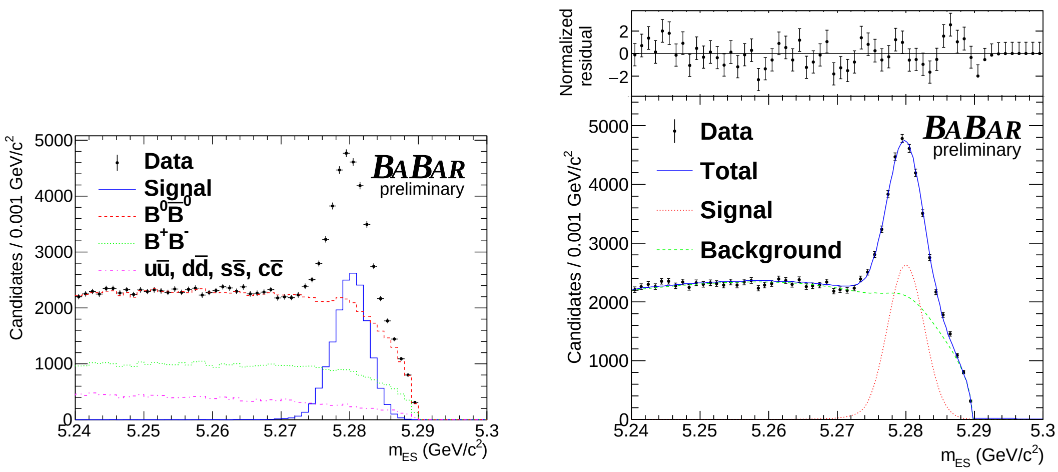

Figure 1: Left: The m_{ES} distribution of B^0 candidates in data and MC simulation. The points indicate the data. The solid histogram indicates the MC-simulated signal. The backgrounds are shown as stacked histograms. The $B^0 \to D^{*-}D_s^+$ decays are included in the signal histogram. Right: The unbinned extended-maximum-likelihood fit to the m_{ES} spectrum of data. The total fit is shown by the solid curve, the signal component is shown by the dotted curve, and the background component is shown by the dashed curve.

3. The 3π mass and preliminary results

After a subtraction of the normalized background estimated by the sideband of B^0 peak on the m_{ES} spectrum, the 3π $(\pi^+\pi^-\pi^+)$ mass of the $B^0 \to D^{*-}\pi^+\pi^-\pi^+$ candidates under the B^0 peak is calculated as shown in Fig. 2. The a_1^+ predominate the 3π mass spectrum and the D_s^+ signal is also clear. The reconstruction efficiency as a function of the 3π mass is estimated by MC simulated events. After the integration of the efficiency corrected 3π mass spectrum, the number of the produced signal events in the experiment can be estimated. The result of $\mathscr{B}(B^0 \to D^{*-}\pi^+\pi^-\pi^+)$ is $(7.26 \pm 0.11 \pm 0.31) \times 10^3$, where the D_s^+ contribution is removed, the first uncertainy is statistical and the second is systematic. The result with D_s^+ contribution included is $(7.37 \pm 0.11 \pm 0.31) \times 10^{-3}$.

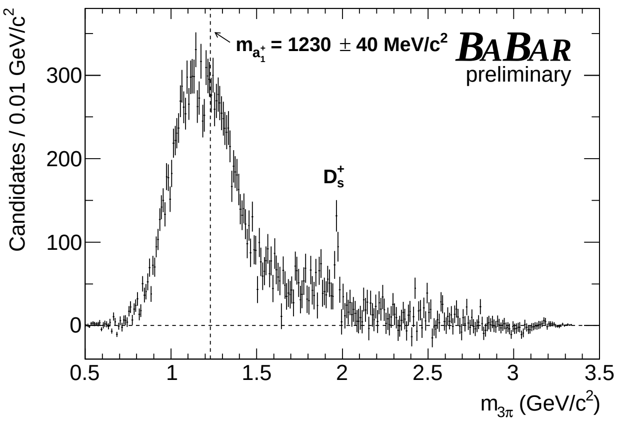

Figure 2: The background-subtracted invariant mass spectrum of the 3π system. The indicated mass of the a_1^+ resonance is obtained from PDG [5].

4. Summary

A precise measurement of the branching fraction of $B^0 \to D^{*-}\pi^+\pi^-\pi^+$ was performed at BABAR. The result is consistent with the current world average $(7.0 \pm 0.8) \times 10^3$ [5], but the precision is improved by a factor of 2.4. This result can be combined with a future measurement of $\mathscr{B}(B^0 \to D^{*-}\tau^+\nu_\tau)/\mathscr{B}(B^0 \to D^{*-}\pi^+\pi^-\pi^+)$ at a hadronic collider using $\tau^+ \to \pi^+\pi^-\pi^+\bar{\nu}_\tau$ to determine one more precise result of $\mathscr{B}(B^0 \to D^{*-}\tau^+\nu_\tau)$, which could yield a further deviation of $R(D^*)$ from the SM prediction.

References

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