PROCEEDINGS OF SCIENCE

Dalitz-plot analysis of $B^0 \rightarrow \bar{D}^0\pi^+\pi^-$

Thomas Latham[*†]
University of Warwick
E-mail: `t.latham@warwick.ac.uk`

We report preliminary results of a Dalitz-plot analysis of the decay $B^0 \rightarrow \bar{D}^0\pi^+\pi^-$ using a data sample of 470.9 ± 2.8 million $B\bar{B}$ events collected with the BABAR detector at the $\Upsilon(4S)$ resonance. We find contributions from the intermediate resonances $D_2^*(2460)^-$, $D_0^*(2400)^-$, $\rho(770)^0$ and $f_2(1270)$ as well as a $\pi^+\pi^-$ S-wave term, a $\bar{D}^0\pi^-$ nonresonant S-wave term and a virtual $D^*(2010)^-$ amplitude. We measure the branching fractions of the contributing decays.

35th International Conference of High Energy Physics
July 22-28, 2010
Paris, France

[*]Speaker.
[†]On behalf of the BABAR Collaboration.

PoS(ICHEP 2010)250

1. Introduction

The $\bar{D}^0\pi^+\pi^-$ Dalitz plot (DP) contains many interesting contributions including colour suppressed Dh^0 decays and D^{**} resonances. The branching fractions of $B \to D^{**}$ transitions are of interest to help address discrepancies between theory and experiment in $B \to D^{**}\ell\nu$ decays, while the branching fractions of $B \to D\rho$ decays are related by isospin and, when combined, can give insight into strong interaction phases. Furthermore, if the D is reconstructed in a *CP* eigenstate, a time-dependent Dalitz-plot analysis can be performed which is sensitive to both $\sin 2\beta$ and $\cos 2\beta$ [1, 2]. For such an analysis, it is necessary to have a good understanding of the composition of the $B^0 \to \bar{D}^0\pi^+\pi^-$ DP, which can be best studied in the $\bar{D}^0 \to K^+\pi^-$ decay mode. The $B^0 \to \bar{D}^0\pi^+\pi^-$ decay has been previously studied by Belle [3]. Here we present preliminary results from the first study of this decay by *BABAR* using the complete *BABAR* $\Upsilon(4S)$ dataset of 470.9 ± 2.8 million $B\bar{B}$ events. For greater detail of the analysis see Ref. [4].

2. Selection and Backgrounds

We reconstruct $B^0 \to \bar{D}^0\pi^+\pi^-$ candidates by combining a $\bar{D}^0$ candidate with two oppositely charged pion candidates. We reconstruct $\bar{D}^0$ mesons in the decay channel $K^+\pi^-$. Signal events are distinguished from background using two almost uncorrelated kinematic variables: the difference ΔE between the CM energy of the B candidate and $\sqrt{s}/2$, and the beam-energy-substituted mass $m_{\rm ES} = \sqrt{s/4 - \mathbf{p}_B^2}$, where $\sqrt{s}$ is the total CM energy and $\mathbf{p}_B$ is the momentum of the candidate B meson in the CM frame. We require signal candidates to have $-0.075\,\text{GeV} < \Delta E < 0.075\,\text{GeV}$ and $5.272\,\text{GeV}/c^2 < m_{\rm ES} < 5.286\,\text{GeV}/c^2$. We exclude candidates consistent with the abundant $B^0 \to D^*(2010)^-\pi^+$ decay by rejecting events which contain a candidate with $D\pi^\pm$ invariant mass below $2.02\,\text{GeV}/c^2$. To suppress the background contribution from continuum $e^+e^- \to q\bar{q}$ $(q = u,d,s,c)$ events, we construct a neural network (NN) discriminant that combines event shape information. The efficiency for signal events to pass all the selection criteria is determined as a function of position in the DP from a Monte Carlo (MC) simulation. In addition to the background from continuum processes, we expect backgrounds from other $B\bar{B}$ decays. We classify such backgrounds in six categories based on their ΔE and $m_{\rm ES}$ distributions as determined from large MC samples. The different $B\bar{B}$ background categories also have different DP distributions. We expect approximately 5000 $q\bar{q}$ and 17,000 $B\bar{B}$ background events in the data sample.

3. Maximum Likelihood Fit

We perform an extended unbinned maximum likelihood fit to the signal candidates using the variables $m_{\rm ES}$, ΔE and the Dalitz-plot co-ordinates as discriminating variables. We simultaneously determine the yields of the event categories and the properties of the signal Dalitz-plot model.

The signal component is subdivided into two parts, which are separated depending on the quality of the reconstruction of the kinematics of the daughter particles. We refer to these subdivisions as "correctly reconstructed" (CR) and "self-cross-feed" (SCF). Both CR and SCF events have the same underlying physics PDF, but due to misreconstruction SCF events have reconstructed DP positions that differ from their true values. The fit accounts for the variation of the relative fraction

PoS(ICHEP 2010)250

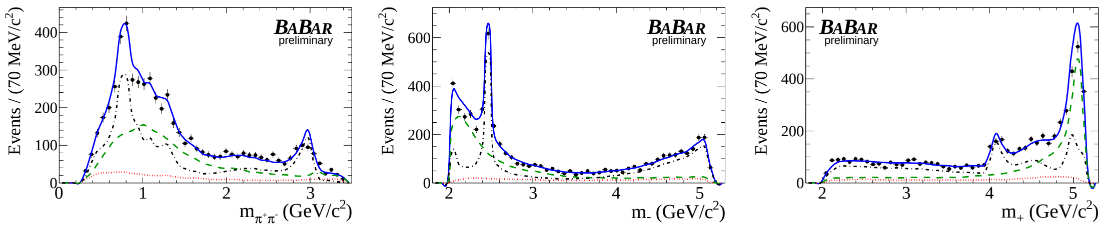

Figure 1: Projections of the fit results onto the invariant masses. The background components have been suppressed by additional requirements ($5.276\,\mathrm{GeV}/c^2 < m_{\mathrm{ES}} < 5.282\,\mathrm{GeV}/c^2$ and $|\Delta E| < 20\,\mathrm{MeV}$). The points with error bars show the data, the red dotted lines show the continuum background, the green dashed lines show the total background, the black dot-dashed lines show the signal, and the blue solid lines show the total fit result.

of CR and SCF events over the Dalitz plot and also for the migration of SCF events from their true DP position. Furthermore the CR and SCF signal events have different distributions in both ΔE and m_{ES}. We determine a nominal signal DP model using information from previous studies of $B^0 \to \bar{D}^0\pi^+\pi^-$ [3] and $B^+ \to D^-\pi^+\pi^+$ [5, 6], and the change in the fit likelihood value observed when omitting or adding resonances. We use an isobar model consisting of contributions from the $D_2^*(2460)$, $D_0^*(2400)$, $\rho(770)^0$ and $f_2(1270)$ resonances. We also find it necessary to include contributions from a virtual D^* ($D_v^*(2010)$) amplitude, a nonresonant $D\pi$ S-wave and a $\pi^+\pi^-$ S-wave, which is modelled using the K-matrix formalism.

4. Results

The fit gives a yield of 5098 ± 102 signal events. Yields of the various background categories are in line with expectation. Projections of the fit result onto each of the two-particle invariant masses are shown in Figure 1. In Table 1 we give results for the branching fractions. The inclusive $B^0 \to \bar{D}^0\pi^+\pi^-$ branching fraction is calculated by dividing the signal yield by the average efficiency determined from the nominal model, by the number of $B\bar{B}$ pairs in the data sample, and by the branching fraction for the $\bar{D}^0 \to K^+\pi^-$ decay. The product branching fractions for the contributing decay modes are obtained by multiplying the inclusive branching fraction by the relevant fit fraction. Where possible, these have also been corrected for subdecay branching fractions. A number of sources of systematic and DP model uncertainty have been considered and the relevant uncertainties evaluated. The largest experimental systematic uncertainty originates from the variation of the relative fraction of CR and SCF signal events.

5. Summary

We measure the inclusive branching fraction and find the Dalitz plot to be composed of contributions from $D_2^*(2460)^-$, $D_0^*(2400)^-$, $\rho(770)^0$ and $f_2(1270)$ as well as a $\pi^+\pi^-$ S-wave, a $D\pi$ nonresonant S-wave term and a virtual $D_v^*(2010)^-$ contribution. Our results for the inclusive branching fraction and for the color-suppressed decays $B^0 \to \rho(770)^0\bar{D}^0$ and $B^0 \to f_2(1270)\bar{D}^0$ are consistent with those from Belle and (for $\rho(770)^0\bar{D}^0$) with theoretical predictions [7, 8]. However, we

Resonance	Fit Fraction (%)	$\mathscr{B}(B^0 \to \text{Mode}) \times\mathscr{B}(R \to hh)$ (10^{-4})	$\mathscr{B}(B^0 \to \text{Mode})$ (10^{-4})
Inclusive $B^0 \to \bar{D}^0\pi^+\pi^-$	$\cdots$	$\cdots$	8.81±0.18±0.76±0.78±0.11
$D_2^*(2460)^-\pi^+$	20.5±0.9±1.3±3.7	1.80±0.09±0.19±0.37±0.02	$\cdots$
$D_0^*(2400)^-\pi^+$	24.8±2.5±3.0±12.9	2.18±0.23±0.33±1.15±0.03	$\cdots$
$\rho(770)^0\bar{D}^0$	33.4±2.0±5.2±10.0	2.94±0.19±0.53±0.92±0.04	2.98±0.19±0.53±0.93±0.04
$f_2(1270)\bar{D}^0$	9.8±1.1±1.6±3.4	0.86±0.10±0.16±0.31±0.01	1.02±0.12±0.18±0.36±0.03
$D_v^*(2010)^-\pi^+$	15.8±0.9±1.2±3.7	1.39±0.08±0.16±0.35±0.02	$\cdots$
$D\pi$ nonresonant	18.4±2.3±4.3±13.6	1.62±0.21±0.41±1.21±0.02	$\cdots$
K matrix total	25.6±2.5±3.2±6.1	2.26±0.22±0.34±0.58±0.03	$\cdots$

Table 1: Branching fraction results from the fit to data. The first uncertainty is statistical, the second is systematic, the third is due to the Dalitz-plot model, and the fourth (where present) is due to secondary branching fractions. The third column gives the product of the branching fraction of the B decay to the mode listed in the leftmost column with that of the intermediate resonance decay to the final state particles.

find the product branching fractions for the broad and narrow D^{**} states ($D_0^*(2400)$ and $D_2^*(2460)$, respectively) to have similar values. This result disagrees with the analysis by Belle, which found a much smaller value for the $D_0^*(2400)$ branching fraction.

Acknowledgments

I would like to thank Tim Gershon for his invaluable assistance in the preparation of this document and the conference presentation. This work is supported in part by the United Kingdom's Science and Technology Facilities Council.

References

[1] J. Charles, A. Le Yaouanc, L. Oliver, O. Pene and J. C. Raynal, $B_d^0(t) \to$ *DPP time-dependent Dalitz plots, CP-violating angles* 2β, $2\beta+\gamma$, *and discrete ambiguities,* Phys. Lett. B **425** (1998) 375 [Erratum-ibid. B **433** (1998) 441] [arXiv:hep-ph/9801363].

[2] T. Latham and T. Gershon, *A Method to Measure* $\cos 2\beta$ *Using Time-Dependent Dalitz Plot Analysis of* $B^0 \to D_{CP}\pi^+\pi^-$, J. Phys. G **36** (2009) 025006 [arXiv:0809.0872 [hep-ph]].

[3] A. Kuzmin *et al.* [Belle Collaboration], *Study of* $\bar{B}^0 \to D^0\pi^+\pi^-$ *decays,* Phys. Rev. D **76** (2007) 012006 [arXiv:hep-ex/0611054].

[4] P. del Amo Sanchez *et al.* [BABAR Collaboration], *Dalitz-plot Analysis of* $B^0 \to \bar{D}^0\pi^+\pi^-$, arXiv:1007.4464 [hep-ex].

[5] B. Aubert *et al.* [BABAR Collaboration], *Dalitz Plot Analysis of* $B^- \to D^+\pi^-\pi^-$, Phys. Rev. D **79** (2009) 112004 [arXiv:0901.1291 [hep-ex]].

[6] K. Abe *et al.* [Belle Collaboration], *Study of* $B^- \to D^{**0}\pi^-(D^{**0} \to D^{(*)+}\pi^-)$ *decays,* Phys. Rev. D **69** (2004) 112002 [arXiv:hep-ex/0307021].

[7] C. K. Chua, W. S. Hou and K. C. Yang, *Final state rescattering and color-suppressed* $\bar{B}^0 \to D^{(*)0}h^0$ *decays,* Phys. Rev. D **65** (2002) 096007 [arXiv:hep-ph/0112148].

[8] Y. Y. Keum, T. Kurimoto, H. N. Li, C. D. Lu and A. I. Sanda, *Nonfactorizable contributions to* $B \to D^{(*)}M$ *decays,* Phys. Rev. D **69** (2004) 094018 [arXiv:hep-ph/0305335].