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DALITZ PLOT ANALYSIS OF $D^0 \to \bar{K}^0 K^+ K^-$ AND D_{sJ} STATES AT BABAR

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Abstract. A Dalitz plot analysis of D^0 events reconstructed in the hadronic decay $D^0 \to \bar{K}^0 K^+ K^-$ is presented here. The analysis is based on a data sample of 91.5 fb^{-1}. Herewith enclosed is an updated, preliminary analysis of D_{sJ} states using 125 fb^{-1}. All data have been collected with the BaBar detector at the PEP-II asymmetric-energy e^+e^- storage rings at SLAC running at center-of-mass energies on and 40 MeV below the $\Upsilon(4S)$ resonance.

1 Introduction

Although the BaBar project is mostly known as a B meson factory there is much more than B physics which can be done at this facility. The copious production of $c\bar{c}$ pairs from the continuum and high integrated luminosity, makes BaBar an excellent laboratory where to study the charm production and decays. In this paper we show results on a the study of $D^0 \to \bar{K}^0 K^+ K^-$ decay [1] and D_{sJ} states [2].

2 Dalitz plot analysis of $D^0 \to \bar{K}^0 K^+ K^-$

Dalitz plot analyses are useful in providing new information on resonances that contribute to three-body final states. They can help to enlighten old puzzles related to light meson spectroscopy, in particular on the structure of scalar mesons.

In order to obtain a measurement of the branching ratio $BR = \frac{\Gamma(D^0 \to \bar{K}^0 K^+ K^-)}{\Gamma(D^0 \to \bar{K}^0 \pi^+ \pi^-)}$, $D^0 \to \bar{K}^0 K^+ K^-$ and $D^0 \to \bar{K}^0 \pi^+ \pi^-$ decays are selected by requiring they come from a D^{*+}. The result is:

$$BR = \frac{\Gamma(D^0 \to \bar{K}^0 K^+ K^-)}{\Gamma(D^0 \to \bar{K}^0 \pi^+ \pi^-)} = (15.8 \pm 0.1(stat.) \pm 0.5(syst.)) \times 10^{-2}.$$

The Dalitz plot of the $D^0 \to \bar{K}^0 K^+ K^-$ is shown in Fig. 1. We observe a strong interference between the $\phi(1020)$ and a scalar meson which is identified as mostly due to the $a_0(980)$ resonance. The contribution of $a_0(980)^+$, in the right bottom corner, can also be observed. A partial wave analysis in the low mass K^+K^- region allows the K^+K^- scalar (S) and vector components (P) to be separated solving the following system of equations [3]:

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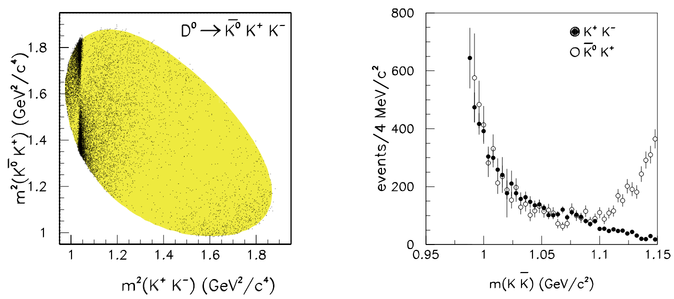

Figure 1: (Left) Dalitz plot of $D^0 \to \bar{K}^0 K^+ K^-$. (Right) Comparison between the scalar K^+K^- and the $\bar{K}^0 K^+$ phase space corrected mass distributions.

$$\sqrt{4\pi}\left\langle Y_0^0 \right\rangle = S^2 + P^2$$

$$\sqrt{4\pi}\left\langle Y_1^0 \right\rangle = 2|S||P|cos\phi_{SP} \qquad \sqrt{4\pi}\left\langle Y_2^0 \right\rangle = \frac{2}{\sqrt{5}}P^2$$

where $\left\langle Y_L^0 \right\rangle_{L=0,1,2}$ are the efficiency corrected spherical harmonic moments. The resulting scalar K^+K^- and $\bar{K}^0 K^+$ phase space corrected mass distributions are shown in Fig. 1 and show a good agreement. This supports the hypothesis that the $f_0(980)$ contribution is small, since $f_0(980)$ has isospin zero and therefore it cannot decay to $\bar{K}^0 K^+$.

The K^+K^- S and P wave mass spectra, the $\bar{K}^0 K^+$ mass spectrum and the phase difference ϕ_{SP} have been fitted simultaneously using a coupled channel Breit Wigner to describe the $a_0(980)$. The fit gives a measurement of $g_{\bar{K}K}$ which describe the $a_0(980)$ couplings to the $\bar{K}K$ system:

$$g_{\bar{K}K} = 464 \pm 29\,(\mathrm{MeV})^{1/2}.$$

An unbinned maximum likelihood fit has been performed for the decay $D^0 \to \bar{K}^0 K^+ K^-$ in order to use the distribution of events in the Dalitz plot to determine the relative amplitudes and phases of intermediate resonant and non-resonant states. The results of the Dalitz plot analysis can be summarised as follows (Table 1). *a)* The decay is dominated by $D^0 \to \bar{K}^0 a_0(980)^0$, $D^0 \to \bar{K}^0 \phi(1020)$ and $D^0 \to K^- a_0(980)^+$. *b)* The $f_0(980)$ contribution is consistent with zero. *c)* The Double Cabibbo Suppressed contribution is consistent with zero. *d)* The remaining contribution is not consistent with being uniform, but can be described by the tail of a broad resonance, the $f_0(1400)$.

A search for CP asymmetries on the Dalitz plot has been performed. We have observed no statistically relevant asymmetries in fractions, amplitudes, or phases between D^0 and $\bar{D}^0$.

Final state	Amplitude	Phase(radians)	Fraction(%)
$\bar{K}^0 a_0(980)^0$	1.(fixed)	0.(fixed)	$66.4 \pm 1.6 \pm 7.0$
$\bar{K}^0 \phi(1020)$	$0.437 \pm 0.006 \pm 0.060$	$1.91 \pm 0.02 \pm 0.10$	$45.9 \pm 0.7 \pm 0.7$
$K^- a_0(980)^+$	$0.460 \pm 0.017 \pm 0.056$	$3.59 \pm 0.05 \pm 0.20$	$13.4 \pm 1.1 \pm 3.7$
$\bar{K}^0 f_0(1400)$	$0.435 \pm 0.033 \pm 0.162$	$-2.63 \pm 0.10 \pm 0.71$	$3.8 \pm 0.7 \pm 2.3$
$\bar{K}^0 f_0(980)$			$0.4 \pm 0.2 \pm 0.8$
$K^+ a_0(980)^-$			$0.8 \pm 0.3 \pm 0.8$
Sum			130.7 ± 2.2

Table 1: Results from the Dalitz plot analysis of $D^0 \to \bar{K}^0 K^+ K^-$.

3 D_{sJ} states

The unexpected discovery of narrow D_{sJ} states [4] [5] has raised new interest in the study of the charm spectroscopy. Here we report new preliminary results in the study of these D_{sJ} states.

3.1 $D^*_{sJ}(2317)^+$ and $D_{sJ}(2460)^+$ states

All the final states explored in this analysis involve one D_s^+ candidate decaying to $K^+K^-\pi^+$ where backgrounds are suppressed by selecting decays to $\bar{K}^{*0}K^+$ and $\phi\pi^+$.

$\boldsymbol{D_s^+\pi^0}$ **system** (Fig. 2). In this selection, a cut on the π^0 momentum ($p_{\pi^0} > 400$ MeV/c) entirely eliminates the $D_s^*(2112)^+ \to D_s^+\pi^0$ signal. Estimates of the yield and the mass of the $D^*_{sJ}(2317)^+$ are obtained using an unbinned likelihood fit of the $D_s^+\pi^0$ mass spectrum. A reflection is produced by the $D_{sJ}(2460)^+ \to D_s^*(2112)^+\pi^0$ decay. Due to a kinematic coincidence, this reflection has a mean mass that is close to the $D^*_{sJ}(2317)^+$. These is no evidence of $D_{sJ}(2460)^+ \to D_s^+\pi^0$ decay for which we measure a 95% CL upper limit:

$$\frac{\mathcal{B}r(D_{sJ}(2460)^+ \to D_s^+\pi^0)}{\mathcal{B}r(D_{sJ}(2460)^+ \to D_s^+\pi^0\gamma)} < 0.11.$$

$\boldsymbol{D_s^{*+}\pi^0}$ **system** (not shown). Estimates of the yield and mass of the $D^*_{sJ}(2317)^+$ are obtained using an unbinned likelihood fit of the $D_s^{*+}\pi^0$ mass spectrum. A reflection close to the $D_{sJ}(2460)^+$ mass is produced by $D^*_{sJ}(2317)^+ \to D_s^+\pi^0$ decays combined with unassociated γ particles.

$\boldsymbol{D_s^+\gamma}$ **system** (not shown). There are two clearly visible structures in this spectrum on top of a gradually falling background distribution. The higher mass structure corresponds to the $D_{sJ}(2460)^+$ meson. The lower mass structure is a combination of reflections. The observation of $D_{sJ}(2460)^+ \to D_s^+\gamma$, prevents it from having $J^P = 0^\pm$. We measure a branching fraction:

$$\frac{\mathcal{B}r(D_{sJ}(2460)^+ \to D_s^+\gamma)}{\mathcal{B}r(D_{sJ}(2460)^+ \to D_s^+\pi^0\gamma)} = 0.375 \pm 0.054(stat.) \pm 0.057(syst.).$$

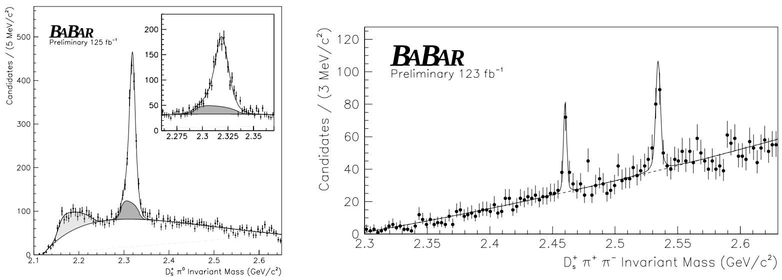

Figure 2: (Left)The $D_s^+\pi^0$ and (Right) the $D_s^+\pi^+\pi^-$ invariant mass distributions.

$\boldsymbol{D_s^+\pi^+\pi^-}$ **system** (Fig. 2). To form $D_s^+\pi^+\pi^-$ candidates, each D_s^+ is combined with π^+ and π^- candidates having a momentum above 250 MeV/c. We observe two structures which correspond to $D_{sJ}(2460)^+$ and to $D_{s1}(2536)^+$ respectively. We measure a branching fraction:

$$\frac{\mathcal{B}r(D_{sJ}(2460)^+ \to D_s^+\pi^+\pi^-)}{\mathcal{B}r(D_{sJ}(2460)^+ \to D_s^+\pi^0\gamma)} = 0.082 \pm 0.018(stat.) \pm 0.011(syst.).$$

$\boldsymbol{D_s^+\pi^\pm}$ **systems** (not shown). There is no evidence for isovector partners of $D_{sJ}^*(2317)^+$ in $D_s^+\pi^+$ and $D_s^+\pi^-$ systems [6].

¿From this studies, we have obtained new preliminary measurements of the $D_{sJ}^*(2317)^+$ and $D_{sJ}(2460)^+$ masses:

$$m(D_{sJ}^*(2317)^+) = 2318.9 \pm 0.3(stat.) \pm 0.9(syst.) \quad \mathrm{MeV/c^2}$$
$$m(D_{sJ}^*(2460)^+) = 2459.4 \pm 0.3(stat.) \pm 1.0(syst.) \quad \mathrm{MeV/c^2}$$

3.2 $D_{sJ}(2632)^+$ state

Recently, the SELEX collaboration [7] has reported a narrow state in the $D_s^+\eta$ and D^0K^+ mass distributions.

$\boldsymbol{D_s^+\eta}$ **system**. After selecting $D_s^+ \to K^+K^-\pi^+$ and $\eta \to \gamma\gamma$ decays, a bi-dimensional background subtraction has been performed. The $D_s^+\eta$ mass distribution is shown in Fig. 3. There is no evidence for a $D_{sJ}(2632)^+$ state.

$\boldsymbol{D^0K^+}$ **system** (Fig. 3). The D^0K^+ mass spectrum has been investigated using 3.7×10^6 $D^0 \to K^-\pi^+$ decays. There is no evidence for structure in the 2.632 GeV/c^2 mass region.

$\boldsymbol{D^{*+}K_s^0}$ **system** (Fig. 3). The $D^{*+}K_s^0$ mass spectrum has been investigated using the $D^{*+} \to D^0\pi^+$ and $K_s^0 \to \pi^+\pi^-$ decay modes. The large, narrow peak

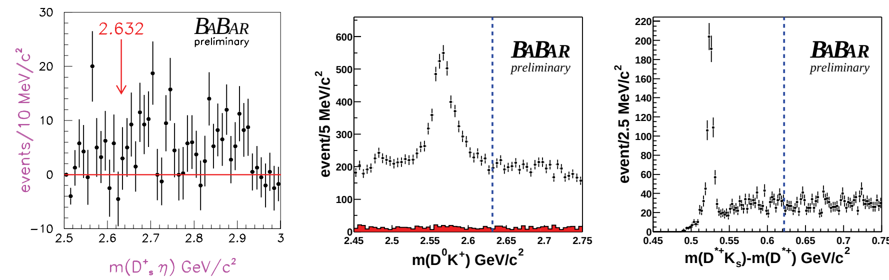

Figure 3: (Left) The $D_s^+\eta$ invariant mass distribution after background subtraction. (Middle) The D^0K^+ invariant mass distribution. The shaded histogram is the invariant mass distribution of wrong sign D^0K^- combinations. (Right) The distribution of the difference in invariant mass of the $D^{*+}K_s^0$ combination and D^{*+} candidate. The vertical lines indicate the mass location of the expected $D_{sJ}(2632)^+$ state.

just above the threshold results from the production of the $D_{s1}(2536)^+$. There is no evidence for production of $D_{sJ}(2632)^+$ state.

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