Measurement of D^0-$\overline{D}^0$ mixing parameters using $D^0 \to K^0_S\pi^+\pi^-$ and $D^0 \to K^0_S K^+ K^-$ decays

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The following includes supplementary material for the Electronic Physics Auxiliary Publication Service.

TABLE I: $D^0 \to K^0_S\pi^+\pi^-$ complex amplitudes, $\pi\pi$ P-vector and $K\pi$ S-wave parameters, and fit fractions, as obtained from the mixing fit. The $\pi\pi$ S-wave parameters β_5, $f_{14}^{\rm prod}$, and $f_{15}^{\rm prod}$ are fixed to zero due to the lack of sensitivity. We also report the mass and the width of the $K^*(892)^{\mp}$ resonance. Errors are statistical only. The fit fraction is defined as the integral over the entire DP of a single component divided by the coherent sum of all components. The sum of fit fractions is 103.3%. A detailed description of the parameters can be found elsewhere [1]. Equations (14) and (15) in [1] have been corrected as follows, $\mathcal{A}_{K\pi\ L=0}(s) = T_{K\pi\ L=0}(s)/\rho(s)$, where $\rho(s) = q/\sqrt{s}$ is the phase-space factor and $T_{K\pi\ L=0}(s) = F\sin(\delta_F+\phi_F)e^{i(\delta_F+\phi_F)} + R\sin\delta_R e^{i(\delta_R+\phi_R)}e^{i2(\delta_F+\phi_F)}$, with $\tan\delta_R = M_{K_0^*(1430)}\Gamma_{K_0^*(1430)}(s)/(M^2_{K_0^*(1430)}-s)$, $\cot\delta_F = 1/(aq)+rq/2$, s the invariant mass squared of the $K\pi$ system, and q the momentum of the kaon (or pion) in the $K\pi$ rest frame [2]. The symbol † indicates the parameters fixed in the mixing fit to the values extracted from a time-integrated DP fit to the same data. The results from this time-integrated DP fit for the amplitude model parameters agree within statistical errors with the results reported here.

Component	Amplitude	Phase (rad)	Fit fraction (%)
$K^*(892)^-$	1.735 ± 0.005	2.331 ± 0.004	57.0
$\rho(770)^0$	1	0	21.1
$K_0^*(1430)^-$	2.650 ± 0.015	1.497 ± 0.007	6.1
$K_2^*(1430)^-$	1.303 ± 0.013	2.498 ± 0.012	1.9
$\omega(782)$	0.0420 ± 0.0006	2.046 ± 0.014	0.6
$K^*(892)^+$	0.164 ± 0.003	-0.768 ± 0.019	0.6
$K^*(1680)^-$	0.90 ± 0.03	-2.97 ± 0.04	0.3
$f_2(1270)$	0.410 ± 0.013	2.88 ± 0.03	0.3
$K_0^*(1430)^+$	0.145 ± 0.014	1.78 ± 0.10	< 0.1
$K_2^*(1430)^+$	0.115 ± 0.013	2.69 ± 0.11	< 0.1
⌈ $\pi\pi$ S-wave			15.4
β_1	5.54 ± 0.06	-0.054 ± 0.007	
β_2	15.64 ± 0.06	-3.125 ± 0.005	
β_3	44.6 ± 1.2	2.731 ± 0.015	
β_4	9.3 ± 0.2	2.30 ± 0.02	
$f_{11}^{\rm prod}$	$11.43 \pm 0.11^\dagger$	$-0.005 \pm 0.009^\dagger$	
$f_{12}^{\rm prod}$	$15.5 \pm 0.4^\dagger$	$-1.13 \pm 0.02^\dagger$	
$f_{13}^{\rm prod}$	$7.0 \pm 0.7^\dagger$	$0.99 \pm 0.11^\dagger$	
	Parameter value		
⌊ $s_0^{\rm prod}$	-3.92637		
⌈ $K\pi$ S-wave parameters			
$M_{K_0^*(1430)}$ (MeV/c^2)	$1421.5 \pm 1.6^\dagger$		
$\Gamma_{K_0^*(1430)}$ (MeV/c^2)	$247 \pm 3^\dagger$		
F	$0.62 \pm 0.04^\dagger$		
ϕ_F (rad)	$-0.100 \pm 0.010^\dagger$		
R	1		
ϕ_R (rad)	$1.10 \pm 0.02^\dagger$		
a (GeV/c^{-1})	$0.224 \pm 0.003^\dagger$		
⌊ r (GeV/c^{-1})	$-15.01 \pm 0.13^\dagger$		
⌈ $K^*(892)$ parameters			
$M_{K^*(892)}$ (MeV/c^2)	$893.70 \pm 0.07^\dagger$		
⌊ $\Gamma_{K^*(892)}$ (MeV/c^2)	$46.74 \pm 0.15^\dagger$		

TABLE II: $D^0 \to K^0_S K^+ K^-$ complex amplitudes and fit fractions, as obtained from the mixing fit. We also report the mass and the width of the $\phi(1020)$ resonance, and the $a_0(980)$ coupling constant to $K\overline{K}$ as determined from the fit. Errors are statistical only. The fit fraction is defined as the integral over the entire DP of a single component divided by the coherent sum of all components. The sum of fit fractions is 163.4%. A detailed description of the parameters can be found elsewhere [1]. The symbol † indicates the parameters fixed in the mixing fit to the values extracted from a time-integrated DP fit to the same data. The results from this time-integrated DP fit for the amplitude model parameters agree within statistical errors with the results reported here.

Component	Amplitude	Phase (rad)	Fit fraction (%)
$a_0(980)^0$	1	0	51.8
$\phi(1020)$	0.2313 ± 0.0011	-0.977 ± 0.008	44.1
$a_0(1450)^+$	$0.93 \pm 0.03^\dagger$	$1.66 \pm 0.07^\dagger$	25.6
$a_0(980)^+$	0.635 ± 0.006	-2.91 ± 0.02	19.5
$a_0(1450)^0$	$0.83 \pm 0.10^\dagger$	$-1.93 \pm 0.12^\dagger$	19.3
$f_0(1370)$	$0.16 \pm 0.05^\dagger$	$0.2 \pm 0.2^\dagger$	1.7
$f_2(1270)$	0.385 ± 0.015	0.06 ± 0.04	0.7
$a_0(980)^-$	0.125 ± 0.008	2.47 ± 0.04	0.7

$\phi(1020)$ and $a_0(980)$ parameters	Value
$M_{\phi(1020)}$ (MeV/c^2)	$1019.55 \pm 0.02^\dagger$
$\Gamma_{\phi(1020)}$ (MeV/c^2)	$4.60 \pm 0.04^\dagger$
$g_{K\overline{K}}$ (MeV/c^2)	$537 \pm 9^\dagger$

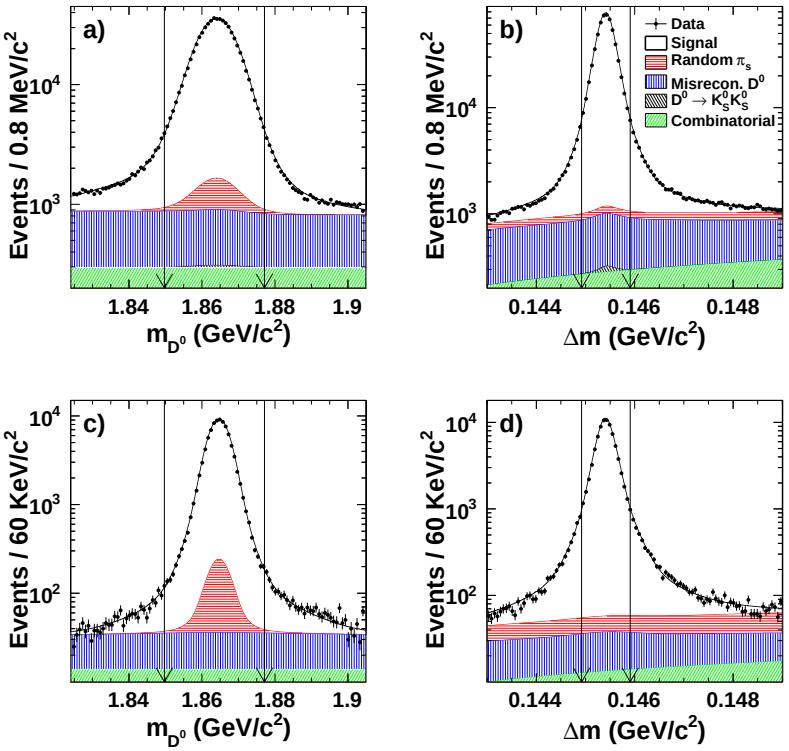

FIG. 1: (color online) Distributions of m_{D^0} and Δm for (a,b) $K^0_S\pi^+\pi^-$ and (c,d) $K^0_S K^+ K^-$ data after all selection criteria (points). The curves superimposed represent the fit projections for signal plus background (solid lines) and for different background components (shaded regions). The arrows indicate the definition of the signal region.

[1] B. Aubert *et al.* (*BABAR* Collaboration), Phys. Rev. D **78**, 034023 (2008).

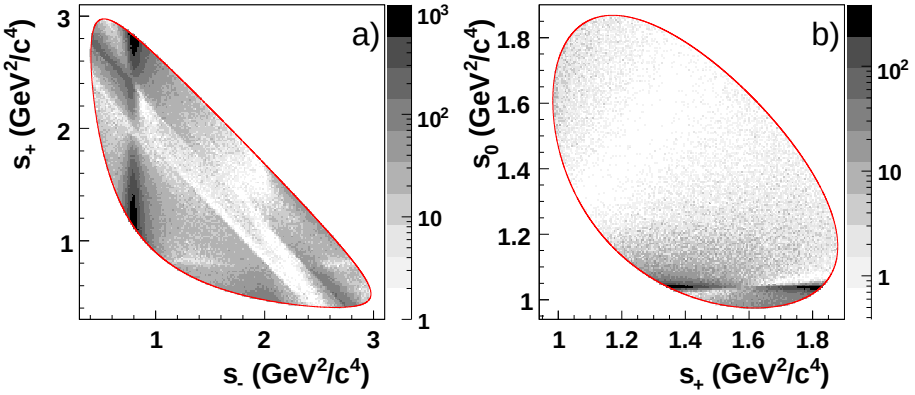

FIG. 2: DP distributions for (a) $D^0 \to K^0_S\pi^+\pi^-$ and (b) $D^0 \to K^0_S K^+K^-$ data after all selection criteria, in the signal region. The gray scale indicates the number of events per bin. The solid lines show the kinematic limits of the D^0 decay. The s_0 DP variable is defined as $s_0 = m^2(h^+h^-)$. For $\overline{D}^0$ decays the variables s_- and s_+ are interchanged.

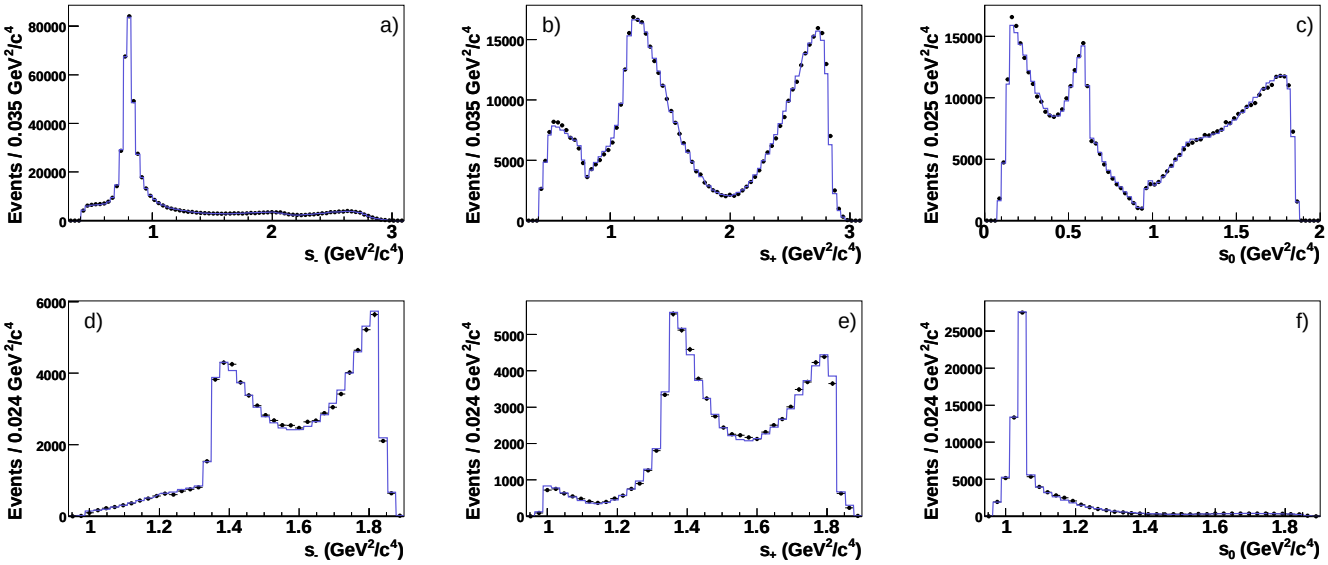

FIG. 3: DP projections for (a,b,c) $D^0 \to K^0_S\pi^+\pi^-$ and (d,e,f) $D^0 \to K^0_S K^+K^-$ data after all selection criteria, in the signal region (points). The histograms represent the mixing fit projections. For $\overline{D}^0$ decays the variables s_- and s_+ are interchanged.

[2] D. Aston *et al.* (LASS Collaboration), Nucl. Phys. B **296**, 493 (1988); W. Dunwoodie, private communication.

TABLE III: Summary of the contributions to the experimental systematic uncertainty on the mixing parameters.

Source	$x/10^{-3}$	$y/10^{-3}$
Analysis biases and fitting procedure (Monte Carlo statistics)	0.75	0.66
Selection criteria	0.47	0.57
Signal and background yields	0.11	0.07
Efficiency variations across the DP	0.37	0.18
Modeling of the DP distributions for misreconstructed D^0 decays	0.33	0.14
Modeling of the proper-time distributions for signal and misreconstructed D^0 decays	0.13	0.13
Modeling of the proper-time error distributions for signal and misreconstructed D^0 decays	0.06	0.09
Misidentification of the D^0 flavor for signal and random π_s^+ events	0.49	0.40
Mixing in the random π_s^+ background component	0.10	0.08
PDF normalization	0.11	0.05
Misalignment of the detector	0.28	0.83
Total experimental systematic uncertainty	1.18	1.30

TABLE IV: Summary of the contributions to the D^0 decay amplitude model systematic uncertainty on the mixing parameters.

Source	$x/10^{-3}$	$y/10^{-3}$
Breit-Wigner parameters and alternative GS lineshapes	0.35	0.12
Alternative K-matrix solutions and P-vector parameterization	0.13	0.19
$K\pi$ S- and P-waves, and $\pi\pi$ S-wave parameters	0.68	0.53
Form factors	0.25	0.23
Angular dependence	0.05	0.17
Add/remove resonances	0.17	0.23
Total amplitude model systematic uncertainty	0.83	0.69