

# CHARMED MESONS

## ( $C = \pm 1$ )

$$D^+ = c\bar{d}, D^0 = c\bar{u}, \bar{D}^0 = \bar{c}u, D^- = \bar{c}d, \quad \text{similarly for } D^{*'}\text{'s}$$

 **$D^\pm$** 

$$I(J^P) = \frac{1}{2}(0^-)$$

$$\text{Mass } m = 1869.66 \pm 0.05 \text{ MeV}$$

$$\text{Mean life } \tau = (1033 \pm 5) \times 10^{-15} \text{ s}$$

$$c\tau = 309.8 \text{ } \mu\text{m}$$

### c-quark decays

$$\Gamma(c \rightarrow \ell^+ \text{ anything}) / \Gamma(c \rightarrow \text{ anything}) = 0.096 \pm 0.004 \text{ [a]}$$

$$\Gamma(c \rightarrow D^*(2010)^+ \text{ anything}) / \Gamma(c \rightarrow \text{ anything}) = 0.255 \pm 0.017$$

### CP-violation decay-rate asymmetries

$$A_{CP}(\mu^\pm \nu) = (8 \pm 8)\%$$

$$A_{CP}(K_L^0 e^\pm \nu) = (-0.6 \pm 1.6)\%$$

$$A_{CP}(K_S^0 \pi^\pm) = (-0.41 \pm 0.09)\%$$

$$A_{CP}(K_L^0 K^\pm) \text{ in } D^\pm \rightarrow K_L^0 K^\pm = (-4.2 \pm 3.4) \times 10^{-2}$$

$$A_{CP}(K^\mp 2\pi^\pm) = (-0.18 \pm 0.16)\%$$

$$A_{CP}(K^\mp \pi^\pm \pi^\pm \pi^0) = (-0.3 \pm 0.7)\%$$

$$A_{CP}(K_S^0 \pi^\pm \pi^0) = (-0.1 \pm 0.7)\%$$

$$A_{CP}(K_S^0 \pi^\pm \eta) \text{ in } D^\pm \rightarrow K_S^0 \pi^\pm \eta = (-0.9 \pm 3.1) \times 10^{-2}$$

$$A_{CP}(K_S^0 \pi^\pm \pi^+ \pi^-) = (0.0 \pm 1.2)\%$$

$$A_{CP}(K^\pm \pi^+ \pi^- \pi^0) \text{ in } D^\pm \rightarrow K^\pm \pi^+ \pi^- \pi^0 = -0.04 \pm 0.06$$

$$A_{CP}(\pi^\pm \pi^0) = (0.4 \pm 1.3)\% \quad (S = 1.7)$$

$$A_{CP}(\pi^\pm \eta) = (0.3 \pm 0.5)\%$$

$$A_{CP}(\pi^\pm \pi^0 \eta) \text{ in } D^\pm \rightarrow \pi^\pm \pi^0 \eta = (-6 \pm 7) \times 10^{-2}$$

$$A_{CP}(\pi^\pm \eta \eta) \text{ in } D^\pm \rightarrow \pi^\pm \eta \eta = (8 \pm 9) \times 10^{-2}$$

$$A_{CP}(\pi^\pm \eta'(958)) = (0.41 \pm 0.23)\% \quad (S = 1.2)$$

$$A_{CP}(\bar{K}^0 / K^0 K^\pm) = (0.11 \pm 0.17)\%$$

$$A_{CP}(K_S^0 K^\pm) = (-0.01 \pm 0.07)\%$$

$$A_{CP}(K_S^0 K^\pm \pi^0) \text{ in } D^\pm \rightarrow K_S^0 K^\pm \pi^0 = (1 \pm 4) \times 10^{-2}$$

$$A_{CP}(K_L^0 K^\pm \pi^0) \text{ in } D^\pm \rightarrow K_L^0 K^\pm \pi^0 = (-1 \pm 4) \times 10^{-2}$$

$$A_{CP}(K^+ K^- \pi^\pm) = (0.37 \pm 0.29)\%$$

$$A_{CP}(K^\pm K^{*0}) = (-0.3 \pm 0.4)\%$$

$$A_{CP}(\phi \pi^\pm) = (0.01 \pm 0.09)\% \quad (S = 1.8)$$

$$A_{CP}(K^\pm K_0^*(1430)^0) = (8_{-6}^{+7})\%$$

$$A_{CP}(K^\pm K_2^*(1430)^0) = (43_{-26}^{+20})\%$$

$$A_{CP}(K^\pm K_0^*(700)) = (-12_{-13}^{+18})\%$$

$$\begin{aligned}
A_{CP}(a_0(1450)^0 \pi^\pm) &= (-19^{+14}_{-16})\% \\
A_{CP}(\phi(1680) \pi^\pm) &= (-9 \pm 26)\% \\
A_{CP}(\pi^\pm 2\pi^0) \text{ in } D^\pm \rightarrow \pi^\pm 2\pi^0 &= (5.6 \pm 2.7)\% \\
A_{CP}(\pi^+ \pi^- \pi^\pm) &= (0.5 \pm 2.0)\% \\
A_{CP}(2\pi^\pm \pi^\mp \pi^0) \text{ in } D^\pm \rightarrow 2\pi^\pm \pi^\mp \pi^0 &= (0.3 \pm 2.0)\% \\
A_{CP}(2\pi^\pm \pi^\mp 2\pi^0) \text{ in } D^\pm \rightarrow 2\pi^\pm \pi^\mp 2\pi^0 &= (-4 \pm 4)\% \\
A_{CP}(\pi^+ \pi^- \pi^\pm \eta) \text{ in } D^\pm \rightarrow \pi^+ \pi^- \pi^\pm \eta &= (3 \pm 5) \times 10^{-2} \\
A_{CP}(K_S^0 K^\pm \pi^+ \pi^-) &= (-4 \pm 7)\% \\
A_{CP}(K^\pm \pi^0) &= (-3 \pm 5)\% \\
A_{CP}(K^\pm \eta) \text{ in } D^\pm \rightarrow K^\pm \eta &= (-6 \pm 11) \times 10^{-2}
\end{aligned}$$

### $\chi^2$ tests of CP-violation (CPV)

$$\begin{aligned}
\text{Local CPV in } D^\pm \rightarrow \pi^+ \pi^- \pi^\pm &= 78.1\% \\
\text{Local CPV in } D^\pm \rightarrow K^+ K^- \pi^\pm &= 31\% \\
\text{Local CPV in } D^\pm \rightarrow K^+ K^- K^\pm &= 31.6\%
\end{aligned}$$

### CP violating asymmetries of P-odd (T-odd) moments

$$\begin{aligned}
A_T(K_S^0 K^\pm \pi^+ \pi^-) &= (-3 \pm 8) \times 10^{-3} \text{ [b]} \quad (S = 1.1) \\
A_{Tviol}(K^+ K^- K_S^0 \pi^\pm) \text{ in } D^\pm \rightarrow K^+ K^- K_S^0 \pi^\pm &= (-3.3 \pm 2.7)\%
\end{aligned}$$

### $D^+$ form factors

$$\begin{aligned}
f_+(0)|V_{cs}| \text{ in } \overline{K}^0 \ell^+ \nu_\ell &= 0.719 \pm 0.011 \quad (S = 1.6) \\
r_1 \equiv a_1/a_0 \text{ in } \overline{K}^0 \ell^+ \nu_\ell &= -2.13 \pm 0.14 \\
r_2 \equiv a_2/a_0 \text{ in } \overline{K}^0 \ell^+ \nu_\ell &= -3 \pm 12 \quad (S = 1.5) \\
f_+(0)|V_{cd}| \text{ in } \pi^0 \ell^+ \nu_\ell &= 0.1407 \pm 0.0025 \\
r_1 \equiv a_1/a_0 \text{ in } \pi^0 \ell^+ \nu_\ell &= -2.00 \pm 0.13 \\
r_2 \equiv a_2/a_0 \text{ in } \pi^0 \ell^+ \nu_\ell &= -4 \pm 5 \\
f_+(0)|V_{cd}| \text{ in } D^+ \rightarrow \eta \ell^+ \nu_\ell \ (\ell = e \text{ or } \nu) &= (8.4 \pm 0.4) \times 10^{-2} \\
r_1 \equiv a_1/a_0 \text{ in } D^+ \rightarrow \eta e^+ \nu_e &= -5.3 \pm 2.7 \quad (S = 1.9) \\
r_\nu \equiv V(0)/A_1(0) \text{ in } D^+ \rightarrow \omega e^+ \nu_e &= 1.24 \pm 0.11 \\
r_2 \equiv A_2(0)/A_1(0) \text{ in } D^+ \rightarrow \omega e^+ \nu_e &= 1.06 \pm 0.16 \\
r_\nu \equiv V(0)/A_1(0) \text{ in } D^+, D^0 \rightarrow \rho e^+ \nu_e &= 1.64 \pm 0.10 \quad (S = 1.2) \\
r_2 \equiv A_2(0)/A_1(0) \text{ in } D^+, D^0 \rightarrow \rho e^+ \nu_e &= 0.84 \pm 0.06 \\
r_\nu \equiv V(0)/A_1(0) \text{ in } \overline{K}^*(892)^0 \ell^+ \nu_\ell &= 1.49 \pm 0.05 \quad (S = 2.1) \\
r_2 \equiv A_2(0)/A_1(0) \text{ in } \overline{K}^*(892)^0 \ell^+ \nu_\ell &= 0.802 \pm 0.021 \\
r_3 \equiv A_3(0)/A_1(0) \text{ in } \overline{K}^*(892)^0 \ell^+ \nu_\ell &= 0.0 \pm 0.4 \\
\Gamma_L/\Gamma_T \text{ in } \overline{K}^*(892)^0 \ell^+ \nu_\ell &= 1.13 \pm 0.08 \\
\Gamma_+/\Gamma_- \text{ in } \overline{K}^*(892)^0 \ell^+ \nu_\ell &= 0.22 \pm 0.06 \quad (S = 1.6)
\end{aligned}$$

Most decay modes (other than the semileptonic modes) that involve a neutral  $K$  meson are now given as  $K_S^0$  modes, not as  $\bar{K}^0$  modes. Nearly always it is a  $K_S^0$  that is measured, and interference between Cabibbo-allowed and doubly Cabibbo-suppressed modes can invalidate the assumption that  $2\Gamma(K_S^0) = \Gamma(\bar{K}^0)$ .

<b>D<sup>+</sup> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	Scale factor/ Confidence level	$\rho$ (MeV/c)
<b>Inclusive modes</b>			
$e^+$ semileptonic	(16.07 $\pm$ 0.30 ) %		—
$\mu^+$ anything	(17.6 $\pm$ 3.2 ) %		—
$K^-$ anything	(25.7 $\pm$ 1.4 ) %		—
$K_S^0$ anything	(33.1 $\pm$ 0.4 ) %		—
$K^+$ anything	( 5.9 $\pm$ 0.8 ) %		—
$K^*(892)^-$ anything	( 6 $\pm$ 5 ) %		—
$\bar{K}^*(892)^0$ anything	(23 $\pm$ 5 ) %		—
$K^*(892)^0$ anything	< 6.6	% CL=90%	—
$\eta$ anything	( 6.3 $\pm$ 0.7 ) %		—
$\eta'$ anything	( 1.04 $\pm$ 0.18 ) %		—
$\phi$ anything	( 1.12 $\pm$ 0.04 ) %		—
$\pi^+\pi^+\pi^-$ anything	(15.25 $\pm$ 0.20 ) %		—
<b>Leptonic and semileptonic modes</b>			
$e^+\nu_e$	< 8.8	$\times 10^{-6}$ CL=90%	935
$\gamma e^+\nu_e$	< 3.0	$\times 10^{-5}$ CL=90%	935
$\mu^+\nu_\mu$	( 3.74 $\pm$ 0.17 )	$\times 10^{-4}$	932
$\tau^+\nu_\tau$	( 1.20 $\pm$ 0.27 )	$\times 10^{-3}$	90
$\bar{K}^0 e^+\nu_e$	( 8.72 $\pm$ 0.09 ) %		869
$\bar{K}^0 \mu^+\nu_\mu$	( 8.76 $\pm$ 0.19 ) %		865
$K^-\pi^+ e^+\nu_e$	( 4.02 $\pm$ 0.18 ) %	S=3.2	864
$\bar{K}^*(892)^0 e^+\nu_e, \bar{K}^*(892)^0 \rightarrow$ $K^-\pi^+$	( 3.77 $\pm$ 0.17 ) %		722
$(K^-\pi^+) [0.8-1.0]\text{GeV} e^+\nu_e$	( 3.39 $\pm$ 0.09 ) %		864
$(K^-\pi^+)_{S\text{-wave}} e^+\nu_e$	( 2.28 $\pm$ 0.11 )	$\times 10^{-3}$	—
$\bar{K}^*(1410)^0 e^+\nu_e,$ $\bar{K}^*(1410)^0 \rightarrow K^-\pi^+$	< 6	$\times 10^{-3}$ CL=90%	—
$\bar{K}_2^*(1430)^0 e^+\nu_e,$ $\bar{K}_2^*(1430)^0 \rightarrow K^-\pi^+$	< 5	$\times 10^{-4}$ CL=90%	—
$K^-\pi^+ e^+\nu_e$ nonresonant	< 7	$\times 10^{-3}$ CL=90%	864
$\bar{K}^*(892)^0 e^+\nu_e$	( 5.40 $\pm$ 0.10 ) %	S=1.1	722
$K^-\pi^+ \mu^+\nu_\mu$	( 3.65 $\pm$ 0.34 ) %		851
$\bar{K}^*(892)^0 \mu^+\nu_\mu,$ $\bar{K}^*(892)^0 \rightarrow K^-\pi^+$	( 3.52 $\pm$ 0.10 ) %		717
$K^-\pi^+ \mu^+\nu_\mu$ nonresonant	( 1.9 $\pm$ 0.5 )	$\times 10^{-3}$	851

$\bar{K}^*(892)^0 \mu^+ \nu_\mu$	( 5.27 ± 0.15 ) %	717
$K^- \pi^+ \pi^0 \mu^+ \nu_\mu$	< 1.5 × 10 <sup>-3</sup> CL=90%	825
$\bar{K}_1(1270)^0 e^+ \nu_e, \bar{K}_1^0 \rightarrow$ $K^- \pi^+ \pi^0$	( 1.06 ± 0.15 ) × 10 <sup>-3</sup>	–
$\bar{K}_0^*(1430)^0 \mu^+ \nu_\mu$	< 2.3 × 10 <sup>-4</sup> CL=90%	380
$\bar{K}^*(1680)^0 \mu^+ \nu_\mu$	< 1.5 × 10 <sup>-3</sup> CL=90%	105
$\pi^0 e^+ \nu_e$	( 3.72 ± 0.17 ) × 10 <sup>-3</sup> S=2.0	930
$\pi^0 \mu^+ \nu_\mu$	( 3.50 ± 0.15 ) × 10 <sup>-3</sup>	927
$\eta e^+ \nu_e$	( 1.11 ± 0.07 ) × 10 <sup>-3</sup>	855
$\eta \mu^+ \nu_\mu$	( 1.04 ± 0.11 ) × 10 <sup>-3</sup>	851
$\pi^- \pi^+ e^+ \nu_e$	( 2.49 ± 0.11 ) × 10 <sup>-3</sup> S=1.2	924
$f_0(500)^0 e^+ \nu_e, f_0(500)^0 \rightarrow$ $\pi^+ \pi^-$	( 6.4 ± 0.6 ) × 10 <sup>-4</sup>	–
$\rho^0 e^+ \nu_e$	( 1.90 ± 0.10 ) × 10 <sup>-3</sup> S=1.2	774
$\rho^0 \mu^+ \nu_\mu$	( 2.4 ± 0.4 ) × 10 <sup>-3</sup>	770
$\omega e^+ \nu_e$	( 1.69 ± 0.11 ) × 10 <sup>-3</sup>	771
$\omega \mu^+ \nu_\mu$	( 1.77 ± 0.21 ) × 10 <sup>-3</sup>	767
$\eta'(958) e^+ \nu_e$	( 2.0 ± 0.4 ) × 10 <sup>-4</sup>	690
$a(980)^0 e^+ \nu_e, a(980)^0 \rightarrow \eta \pi^0$	( 1.7 $\begin{smallmatrix} + 0.8 \\ - 0.7 \end{smallmatrix}$ ) × 10 <sup>-4</sup>	–
$b_1(1235)^0 e^+ \nu_e, b_1^0 \rightarrow \omega \pi^0$	< 1.75 × 10 <sup>-4</sup> CL=90%	–
$\phi e^+ \nu_e$	< 1.3 × 10 <sup>-5</sup> CL=90%	657
$D^0 e^+ \nu_e$	< 1.0 × 10 <sup>-4</sup> CL=90%	5

### Hadronic modes with a $\bar{K}$ or $\bar{K}K\bar{K}$

$K_S^0 \pi^+$	( 1.562 ± 0.031 ) % S=1.7	863
$K_L^0 \pi^+$	( 1.46 ± 0.05 ) %	863
$K^- 2\pi^+$	[c] ( 9.38 ± 0.16 ) % S=1.6	846
$(K^- \pi^+)_{S\text{-wave}} \pi^+$	( 7.52 ± 0.17 ) %	846
$\bar{K}_0^*(1430)^0 \pi^+,$	[d] ( 1.25 ± 0.06 ) %	382
$\bar{K}_0^*(1430)^0 \rightarrow K^- \pi^+$		
$\bar{K}^*(892)^0 \pi^+,$	( 1.04 ± 0.12 ) %	714
$\bar{K}^*(892)^0 \rightarrow K^- \pi^+$		
$\bar{K}^*(1410)^0 \pi^+, \bar{K}^{*0} \rightarrow$	not seen	381
$\bar{K}_2^*(1430)^0 \pi^+,$	[d] ( 2.3 ± 0.7 ) × 10 <sup>-4</sup>	371
$\bar{K}_2^*(1430)^0 \rightarrow K^- \pi^+$		
$\bar{K}^*(1680)^0 \pi^+,$	[d] ( 2.2 ± 1.1 ) × 10 <sup>-4</sup>	58
$\bar{K}^*(1680)^0 \rightarrow K^- \pi^+$		
$K^- (2\pi^+)_{I=2}$	( 1.45 ± 0.26 ) %	–
$K_S^0 \pi^+ \pi^0$	[c] ( 7.36 ± 0.20 ) %	845
$K_S^0 \rho^+$	( 6.14 $\begin{smallmatrix} + 0.60 \\ - 0.35 \end{smallmatrix}$ ) %	677
$K_S^0 \rho(1450)^+, \rho^+ \rightarrow \pi^+ \pi^0$	( 1.5 $\begin{smallmatrix} + 1.2 \\ - 1.4 \end{smallmatrix}$ ) × 10 <sup>-3</sup>	–

$\bar{K}^*(892)^0 \pi^+$ ,	$(2.64 \pm 0.32) \times 10^{-3}$	714
$\bar{K}^*(892)^0 \rightarrow K_S^0 \pi^0$		
$\bar{K}_0^*(1430)^0 \pi^+$ , $\bar{K}_0^{*0} \rightarrow$	$(2.7 \pm 0.9) \times 10^{-3}$	—
$K_S^0 \pi^0$		
$\bar{K}_0^*(1680)^0 \pi^+$ , $\bar{K}_0^{*0} \rightarrow$	$(10 \begin{smallmatrix} +7 \\ -10 \end{smallmatrix}) \times 10^{-4}$	—
$K_S^0 \pi^0$		
$\bar{\kappa}^0 \pi^+$ , $\bar{\kappa}^0 \rightarrow K_S^0 \pi^0$	$(6 \begin{smallmatrix} +5 \\ -4 \end{smallmatrix}) \times 10^{-3}$	—
$K_S^0 \pi^+ \pi^0$ nonresonant	$(3 \pm 4) \times 10^{-3}$	845
$K_S^0 \pi^+ \pi^0$ nonresonant and	$(1.37 \begin{smallmatrix} +0.21 \\ -0.40 \end{smallmatrix}) \%$	—
$\bar{\kappa}^0 \pi^+$		
$(K_S^0 \pi^0)_{S\text{-wave}} \pi^+$	$(1.27 \begin{smallmatrix} +0.27 \\ -0.33 \end{smallmatrix}) \%$	845
$K_S^0 \pi^+ \omega$	$(7.1 \pm 0.5) \times 10^{-3}$	606
$K_S^0 \pi^+ \eta$	$(1.31 \pm 0.05) \%$	722
$K_S^0 \pi^+ \eta'(958)$	$(1.90 \pm 0.21) \times 10^{-3}$	481
$K^- 2\pi^+ \pi^0$	[e] $(6.25 \pm 0.18) \%$	817
$K_S^0 2\pi^+ \pi^-$	[e] $(3.10 \pm 0.09) \%$	814
$K_S^0 \pi^+ 2\pi^0$	$(2.89 \pm 0.09) \%$	817
$K_S^0 a_1(1260)^+$ , $a_1^+ \rightarrow$	$(8.7 \pm 1.6) \times 10^{-3}$	—
$\rho(770)^+ \pi^0$		
$K_S^0 a_1(1260)^+$ , $a_1^+ \rightarrow$	$(1.0 \pm 0.6) \times 10^{-3}$	—
$f_0(500) \pi^+$ , $f_0 \rightarrow \pi^0 \pi^0$		
$\bar{K}_1(1400)^0 \pi^+$ , $\bar{K}_1^0 \rightarrow$	$(2.3 \pm 0.4) \times 10^{-3}$	—
$\bar{K}^*(892)^0 \pi^0$ , $\bar{K}^{*0} \rightarrow$		
$K_S^0 \pi^0$		
$\bar{K}^*(892)^0 \rho^+$ , $\bar{K}^{*0} \rightarrow K_S^0 \pi^0$	$(9.7 \pm 0.9) \times 10^{-3}$	—
$\bar{K}^*(892)^0 \pi^+ \pi^0$ non-resonant,	$(2.6 \pm 0.7) \times 10^{-3}$	—
$\bar{K}^{*0} \rightarrow K_S^0 \pi^0$		
$K_S^0 \rho^+ \pi^0$ non-resonant	$(4.8 \pm 0.5) \times 10^{-3}$	—
$K^- 2\pi^+ \eta$	$(1.35 \pm 0.12) \times 10^{-3}$	657
$K_S^0 \pi^+ \pi^0 \eta$	$(1.22 \pm 0.25) \times 10^{-3}$	657
$K^- 3\pi^+ \pi^-$	[c] $(5.7 \pm 0.5) \times 10^{-3}$	S=1.1 772
$\bar{K}^*(892)^0 2\pi^+ \pi^-$ ,	$(1.2 \pm 0.4) \times 10^{-3}$	645
$\bar{K}^*(892)^0 \rightarrow K^- \pi^+$		
$\bar{K}^*(892)^0 \rho^0 \pi^+$ ,	$(2.3 \pm 0.4) \times 10^{-3}$	239
$\bar{K}^*(892)^0 \rightarrow K^- \pi^+$		
$\bar{K}^*(892)^0 a_1(1260)^+$	[f] $(9.3 \pm 1.9) \times 10^{-3}$	†
$K^- \rho^0 2\pi^+$	$(1.72 \pm 0.28) \times 10^{-3}$	524
$K^- 3\pi^+ \pi^-$ nonresonant	$(4.0 \pm 2.9) \times 10^{-4}$	772
$K_S^0 2\pi^+ \pi^- \pi^0$	$(1.53 \pm 0.08) \%$	773
$K_S^0 \pi^+ 3\pi^0$	$(5.5 \pm 0.5) \times 10^{-3}$	776

$K^- 2\pi^+ 2\pi^0$	$( 4.95 \pm 0.32 ) \times 10^{-3}$	776
$K^+ 2K_S^0$	$( 2.54 \pm 0.13 ) \times 10^{-3}$	545
$K^+ K^- K_S^0 \pi^+$	$( 2.4 \pm 0.5 ) \times 10^{-4}$	436

**Pionic modes**

$\pi^+ \pi^0$	$( 1.247 \pm 0.033 ) \times 10^{-3}$	925
$2\pi^+ \pi^-$	$( 3.27 \pm 0.09 ) \times 10^{-3}$	909
$\rho^0 \pi^+$	$( 8.4 \pm 0.8 ) \times 10^{-4}$	767
$\pi^+ (\pi^+ \pi^-)_{S\text{-wave}}$	$( 2.01 \pm 0.06 ) \times 10^{-3}$	909
$\sigma \pi^+, \sigma \rightarrow \pi^+ \pi^-$	$( 1.38 \pm 0.10 ) \times 10^{-3}$	–
$f_0(980) \pi^+, f_0 \rightarrow \pi^+ \pi^-$	$( 1.57 \pm 0.32 ) \times 10^{-4}$	669
$f_0(1370) \pi^+, f_0 \rightarrow \pi^+ \pi^-$	$( 8 \pm 4 ) \times 10^{-5}$	–
$\omega \pi^+, \omega \rightarrow \pi^+ \pi^-$	$( 3.4 \pm 0.5 ) \times 10^{-6}$	–
$f_2(1270) \pi^+, f_2 \rightarrow \pi^+ \pi^-$	$( 4.58 \pm 0.28 ) \times 10^{-4}$	485
$\rho(1450)^0 \pi^+, \rho^0 \rightarrow \pi^+ \pi^-$	$( 1.8 \pm 0.5 ) \times 10^{-4}$	338
$\rho(1700)^0 \pi^+, \rho^0 \rightarrow \pi^+ \pi^-$	$( 1.9 \pm 0.5 ) \times 10^{-4}$	–
$f_0(1500) \pi^+, f_0 \rightarrow \pi^+ \pi^-$	$( 1.1 \pm 0.4 ) \times 10^{-4}$	–
$f_0(1710) \pi^+, f_0 \rightarrow \pi^+ \pi^-$	$< 5 \times 10^{-5} \text{CL}=95\%$	–
$f_0(1790) \pi^+, f_0 \rightarrow \pi^+ \pi^-$	$< 7 \times 10^{-5} \text{CL}=95\%$	–
$(\pi^+ \pi^+)_{S\text{-wave}} \pi^-$	$< 1.2 \times 10^{-4} \text{CL}=95\%$	909
$2\pi^+ \pi^- \text{ nonresonant}$	$< 1.1 \times 10^{-4} \text{CL}=95\%$	909
$\pi^+ 2\pi^0$	$( 4.61 \pm 0.15 ) \times 10^{-3}$	910
$2\pi^+ \pi^- \pi^0$	$( 1.165 \pm 0.030 ) \%$	883
$\pi^+ 3\pi^0$	$( 4.17 \pm 0.26 ) \times 10^{-3}$	885
$\pi^+ 4\pi^0$	$( 1.9 \pm 0.4 ) \times 10^{-3}$	851
$2\pi^+ \pi^- 2\pi^0$	$( 1.07 \pm 0.05 ) \%$	848
$3\pi^+ 2\pi^-$	$( 1.66 \pm 0.16 ) \times 10^{-3}$	S=1.1 845
$2\pi^+ \pi^- 3\pi^0$	$( 3.42 \pm 0.35 ) \times 10^{-3}$	803
$3\pi^+ 2\pi^- \pi^0$	$( 2.34 \pm 0.27 ) \times 10^{-3}$	799
$\eta \pi^+$	$( 3.77 \pm 0.09 ) \times 10^{-3}$	848
$\eta \pi^+ \pi^0$	$( 2.05 \pm 0.35 ) \times 10^{-3}$	S=2.2 831
$\eta 2\pi^+ \pi^-$	$( 3.41 \pm 0.20 ) \times 10^{-3}$	798
$\eta \pi^+ 2\pi^0$	$( 3.20 \pm 0.33 ) \times 10^{-3}$	801
$\eta \pi^+ 3\pi^0$	$( 2.9 \pm 0.5 ) \times 10^{-3}$	759
$\eta 2\pi^+ \pi^- \pi^0$	$( 3.88 \pm 0.34 ) \times 10^{-3}$	755
$\eta \eta \pi^+$	$( 2.96 \pm 0.26 ) \times 10^{-3}$	700
$\omega \pi^+$	$( 2.8 \pm 0.6 ) \times 10^{-4}$	764
$\omega \pi^+ \pi^0$	$( 3.9 \pm 0.9 ) \times 10^{-3}$	742
$\eta'(958) \pi^+$	$( 4.97 \pm 0.19 ) \times 10^{-3}$	681
$\eta'(958) \pi^+ \pi^0$	$( 1.6 \pm 0.5 ) \times 10^{-3}$	654

**Hadronic modes with a  $K\bar{K}$  pair**

$K_S^0 K^+$	$( 3.04 \pm 0.09 ) \times 10^{-3}$	S=2.2 793
$K_L^0 K^+$	$( 3.21 \pm 0.16 ) \times 10^{-3}$	793
$K_S^0 K^+ \pi^0$	$( 5.07 \pm 0.30 ) \times 10^{-3}$	744

$K^*(892)^+ K_S^0, K^{*+} \rightarrow$	$( 2.89 \pm 0.30 ) \times 10^{-3}$	612
$\bar{K}^*(892)^0 K^+, \bar{K}^{*0} \rightarrow$	$( 5.2 \pm 1.4 ) \times 10^{-4}$	613
$K_L^0 K^+ \pi^0$	$( 5.24 \pm 0.31 ) \times 10^{-3}$	744
$K^+ K^- \pi^+$	[c] $( 9.68 \pm 0.18 ) \times 10^{-3}$	744
$K^+ \bar{K}^*(892)^0,$	$( 2.49 \pm 0.08 ) \times 10^{-3}$	613
$\bar{K}^*(892)^0 \rightarrow K^- \pi^+$	$( 2.49 \pm 0.13 ) \times 10^{-3}$	
$K^+ \bar{K}_0^*(1430)^0,$	$( 1.82 \pm 0.35 ) \times 10^{-3}$	—
$\bar{K}_0^*(1430)^0 \rightarrow K^- \pi^+$		
$K^+ \bar{K}_2^*(1430)^0, \bar{K}_2^* \rightarrow$	$( 1.6 \pm 1.2 ) \times 10^{-4}$	—
$K^- \pi^+$		
$K^+ \bar{K}_0^*(700), \bar{K}_0^* \rightarrow K^- \pi^+$	$( 6.8 \pm 3.5 ) \times 10^{-4}$	—
	$( 6.8 \pm 2.1 ) \times 10^{-4}$	
$a_0(1450)^0 \pi^+, a_0^0 \rightarrow$	$( 4.5 \pm 7.0 ) \times 10^{-4}$	—
$K^+ K^-$	$( 4.5 \pm 1.8 ) \times 10^{-4}$	
$\phi(1680) \pi^+, \phi \rightarrow K^+ K^-$	$( 4.9 \pm 4.0 ) \times 10^{-5}$	—
	$( 4.9 \pm 1.9 ) \times 10^{-5}$	
$\phi \pi^+, \phi \rightarrow K^+ K^-$	$( 2.69 \pm 0.07 ) \times 10^{-3}$	647
	$( 2.69 \pm 0.08 ) \times 10^{-3}$	
$\phi \pi^+$	$( 5.70 \pm 0.14 ) \times 10^{-3}$	647
$K^+ K^- \pi^+ \pi^0$	$( 6.62 \pm 0.32 ) \times 10^{-3}$	682
$K_S^0 K_S^0 \pi^+$	$( 2.70 \pm 0.13 ) \times 10^{-3}$	741
$K_S^0 K_S^0 \pi^+ \pi^0$	$( 1.34 \pm 0.21 ) \times 10^{-3}$	679
$K_S^0 K^+ \eta$	$( 1.8 \pm 0.5 ) \times 10^{-4}$	516
$K^+ K_S^0 \pi^+ \pi^-$	$( 1.89 \pm 0.13 ) \times 10^{-3}$	678
$K_S^0 K^+ \pi^0 \pi^0$	$( 5.8 \pm 1.3 ) \times 10^{-4}$	683
$K_S^0 K^- 2\pi^+$	$( 2.27 \pm 0.13 ) \times 10^{-3}$	678
$K^+ K^- 2\pi^+ \pi^-$	$( 2.3 \pm 1.2 ) \times 10^{-4}$	601

A few poorly measured branching fractions:

$\phi \pi^+ \pi^0$	$( 2.3 \pm 1.0 ) \%$	619
$\phi \rho^+$	$< 1.5 \%$	CL=90% 260
$K^+ K^- \pi^+ \pi^0$ non- $\phi$	$( 1.5 \pm 0.7 ) \%$	682
	$( 1.5 \pm 0.6 ) \%$	

### Doubly Cabibbo-suppressed modes

$K^+ \pi^0$	$( 2.08 \pm 0.21 ) \times 10^{-4}$	S=1.4	864
$K^+ \eta$	$( 1.25 \pm 0.16 ) \times 10^{-4}$	S=1.1	776
$K^+ \eta'(958)$	$( 1.85 \pm 0.20 ) \times 10^{-4}$		571
$K^+ 2\pi^0$	$( 2.1 \pm 0.4 ) \times 10^{-4}$		847
$K^*(892)^+ \pi^0$	$( 3.4 \pm 1.4 ) \times 10^{-4}$		714
$K^+ \pi^+ \pi^-$	$( 4.91 \pm 0.09 ) \times 10^{-4}$		846
$K^+ \rho^0$	$( 1.9 \pm 0.5 ) \times 10^{-4}$		679
$K^+ \eta \pi^0$	$( 2.1 \pm 0.5 ) \times 10^{-4}$		726

$K^*(892)^+\eta$	$(4.4 \pm_{-1.5}^{+1.8}) \times 10^{-4}$	586
$K^*(892)^0\pi^+, K^*(892)^0 \rightarrow K^+\pi^-$	$(2.3 \pm 0.4) \times 10^{-4}$	714
$K^+ f_0(980), f_0(980) \rightarrow \pi^+\pi^-$	$(4.4 \pm 2.6) \times 10^{-5}$	–
$K_2^*(1430)^0\pi^+, K_2^*(1430)^0 \rightarrow K^+\pi^-$	$(3.9 \pm 2.7) \times 10^{-5}$	–
$K^+\pi^+\pi^-$ nonresonant	not seen	846
$K^+\pi^+\pi^-\pi^0$	$(1.21 \pm 0.09) \times 10^{-3}$	817
$K^+\pi^+\pi^-\pi^0$ nonresonant	$(1.10 \pm 0.07) \times 10^{-3}$	817
$K^+\omega$	$(5.7 \pm_{-2.1}^{+2.5}) \times 10^{-5}$	675
$2K^+K^-$	$(6.14 \pm 0.11) \times 10^{-5}$	550
$\phi(1020)^0 K^+$	$< 2.1 \times 10^{-5}$ CL=90%	–
$K^+\phi(1020), \phi \rightarrow K^+K^-$	$(4.4 \pm 0.6) \times 10^{-6}$	–
$K^+(K^+K^-)$ <i>S-wave</i>	$(5.77 \pm 0.12) \times 10^{-5}$	550

**$\Delta C = 1$  weak neutral current (C1) modes, or Lepton Family number (LF), or Lepton number (L), or Baryon number (B) violating modes**

$\pi^+e^+e^-$	C1	$< 1.1 \times 10^{-6}$ CL=90%	930
$\pi^+\pi^0e^+e^-$		$< 1.4 \times 10^{-5}$ CL=90%	925
$\pi^+\phi, \phi \rightarrow e^+e^-$	[g]	$(1.7 \pm_{-0.9}^{+1.4}) \times 10^{-6}$	–
$\pi^+\mu^+\mu^-$	C1	$< 6.7 \times 10^{-8}$ CL=90%	918
$\pi^+\phi, \phi \rightarrow \mu^+\mu^-$	[g]	$(1.8 \pm 0.8) \times 10^{-6}$	–
$\rho^+\mu^+\mu^-$	C1	$< 5.6 \times 10^{-4}$ CL=90%	757
$K^+e^+e^-$	[h]	$< 8.5 \times 10^{-7}$ CL=90%	870
$K^+\pi^0e^+e^-$		$< 1.5 \times 10^{-5}$ CL=90%	864
$K_S^0\pi^+e^+e^-$		$< 2.6 \times 10^{-5}$ CL=90%	–
$K_S^0K^+e^+e^-$		$< 1.1 \times 10^{-5}$ CL=90%	792
$K^+\mu^+\mu^-$	[h]	$< 5.4 \times 10^{-8}$ CL=90%	856
$\pi^+e^+\mu^-$	LF	$< 2.1 \times 10^{-7}$ CL=90%	927
$\pi^+e^-\mu^+$	LF	$< 2.2 \times 10^{-7}$ CL=90%	927
$K^+e^+\mu^-$	LF	$< 7.5 \times 10^{-8}$ CL=90%	866
$K^+e^-\mu^+$	LF	$< 1.0 \times 10^{-7}$ CL=90%	866
$\pi^-2e^+$	L	$< 5.3 \times 10^{-7}$ CL=90%	930
$\pi^-2\mu^+$	L	$< 1.4 \times 10^{-8}$ CL=90%	918
$\pi^-e^+\mu^+$	L	$< 1.3 \times 10^{-7}$ CL=90%	927
$\rho^-2\mu^+$	L	$< 5.6 \times 10^{-4}$ CL=90%	757
$K^-2e^+$	L	$< 9 \times 10^{-7}$ CL=90%	870
$K_S^0\pi^-2e^+$		$< 3.3 \times 10^{-6}$ CL=90%	863
$K^-\pi^02e^+$		$< 8.5 \times 10^{-6}$ CL=90%	864
$K^-2\mu^+$	L	$< 1.0 \times 10^{-5}$ CL=90%	856
$K^-e^+\mu^+$	L	$< 1.9 \times 10^{-6}$ CL=90%	866

$K^*(892)^- 2\mu^+$	$L$	$< 8.5$	$\times 10^{-4}$ CL=90%	703
$\Lambda e^+$	$L, B$	$< 1.1$	$\times 10^{-6}$ CL=90%	602
$\bar{\Lambda} e^+$	$L, B$	$< 6.5$	$\times 10^{-7}$ CL=90%	602
$\Sigma^0 e^+$	$L, B$	$< 1.7$	$\times 10^{-6}$ CL=90%	554
$\bar{\Sigma}^0 e^+$	$L, B$	$< 1.3$	$\times 10^{-6}$ CL=90%	554
$\bar{n} e^+$		$< 1.43$	$\times 10^{-5}$ CL=90%	699
$n e^+$		$< 2.91$	$\times 10^{-5}$ CL=90%	699

$D^0$

$$I(J^P) = \frac{1}{2}(0^-)$$

$$\text{Mass } m = 1864.84 \pm 0.05 \text{ MeV}$$

$$m_{D^\pm} - m_{D^0} = 4.822 \pm 0.015 \text{ MeV}$$

$$\text{Mean life } \tau = (410.3 \pm 1.0) \times 10^{-15} \text{ s}$$

$$c\tau = 123.01 \text{ } \mu\text{m}$$

### Mixing and related parameters

$$|m_{D_1^0} - m_{D_2^0}| = (0.997 \pm 0.116) \times 10^{10} \hbar \text{ s}^{-1}$$

$$(\Gamma_{D_1^0} - \Gamma_{D_2^0})/\Gamma = 2y = (1.394 \pm 0.056) \times 10^{-2}$$

$$|q/p| = 0.995 \pm 0.016$$

$$A_\Gamma = (0.089 \pm 0.113) \times 10^{-3}$$

$$\phi^{K_S^0 \pi \pi} = 0.02_{-0.05}^{+0.04}$$

$$K^+ \pi^- \text{ relative strong phase: } \cos \delta = 0.990 \pm 0.025$$

$$K^- \pi^+ \pi^0 \text{ coherence factor } R_{K \pi \pi^0} = 0.792 \pm 0.033$$

$$K^- \pi^+ \pi^0 \text{ average relative strong phase } \delta^{K \pi \pi^0} = (198 \pm 10)^\circ$$

$$K^- \pi^- 2\pi^+ \text{ coherence factor } R_{K 3\pi} = 0.52_{-0.09}^{+0.10}$$

$$K^- \pi^- 2\pi^+ \text{ average relative strong phase } \delta^{K 3\pi} = (149_{-16}^{+26})^\circ \quad (S = 1.4)$$

$$D^0 \rightarrow K^- \pi^- 2\pi^+, R_{K 3\pi} (y \cos \delta^{K 3\pi} - x \sin \delta^{K 3\pi}) = (-3.0 \pm 0.7) \times 10^{-3} \text{ TeV}^{-1}$$

$$K_S^0 K^+ \pi^- \text{ coherence factor } R_{K_S^0 K \pi} = 0.70 \pm 0.08$$

$$K_S^0 K^+ \pi^- \text{ average relative strong phase } \delta^{K_S^0 K \pi} = (0 \pm 16)^\circ$$

$$K^* K \text{ coherence factor } R_{K^* K} = 0.94 \pm 0.12$$

$$K^* K \text{ average relative strong phase } \delta^{K^* K} = (-17 \pm 18)^\circ$$

### CP-even fractions (labeled by the $D^0$ decay)

$$\text{CP-even fraction in } D^0 \rightarrow K_S^0 \pi^+ \pi^- \pi^0 \text{ decays} = (23.6 \pm 0.9)\%$$

$$\text{CP-even fraction in } D^0 \rightarrow \pi^+ \pi^- \pi^0 \text{ decays} = (97.3 \pm 1.7)\%$$

$$\text{CP-even fraction in } D^0 \rightarrow \pi^+ \pi^- \pi^+ \pi^- \text{ decays} = (74.6 \pm 1.6)\% \quad (S = 1.2)$$

$$\text{CP-even fraction in } D^0 \rightarrow \pi^+ \pi^- 2\pi^0 \text{ decays} = 0.68 \pm 0.08$$

$$\begin{aligned}
&CP\text{-even fraction in } D^0 \rightarrow 2\pi^+ 2\pi^- \pi^0 \text{ decays} = 0.44 \pm 0.10 \\
&CP\text{-even fraction in } D^0 \rightarrow \pi^+ \pi^- 3\pi^0 \text{ decays} = 0.52^{+0.34}_{-0.27} \\
&CP\text{-even fraction in } D^0 \rightarrow 2\pi^+ 2\pi^- 2\pi^0 \text{ decays} = 0.79 \pm 0.26 \\
&CP\text{-even fraction in } D^0 \rightarrow K^+ K^- \pi^0 \text{ decays} = (73 \pm 6)\% \\
&CP\text{-even fraction in } D^0 \rightarrow K^+ K^- \pi^+ \pi^- \text{ decays} = (74.1 \pm 3.0)\%
\end{aligned}$$

### **CP-violation decay-rate asymmetries (labeled by the $D^0$ decay)**

$$\begin{aligned}
A_{CP}(K^+ K^-) &= (4 \pm 5) \times 10^{-4} \\
A_{CP}(2K_S^0) &= (-1.9 \pm 1.1)\% \quad (S = 1.1) \\
A_{CP}(\pi^+ \pi^-) &= (0.13 \pm 0.14)\% \\
A_{CP}(\pi^0 \pi^0) &= (0.0 \pm 0.6)\% \\
A_{CP}(\rho\gamma) &= (6 \pm 15) \times 10^{-2} \\
A_{CP}(\phi\gamma) &= (-9 \pm 7) \times 10^{-2} \\
A_{CP}(\overline{K}^*(892)^0 \gamma) &= (-0.3 \pm 2.0) \times 10^{-2} \\
A_{CP}(\pi^+ \pi^- \pi^0) &= (0.4 \pm 0.4)\% \\
A_{CP}(\eta \pi^+ \pi^-) \text{ in } D^0, \overline{D}^0 &\rightarrow \eta \pi^+ \pi^- = (0.9 \pm 1.3) \times 10^{-2} \\
A_{CP}(\rho(770)^+ \pi^- \rightarrow \pi^+ \pi^- \pi^0) &= (1.2 \pm 0.9)\% [i] \\
A_{CP}(\rho(770)^0 \pi^0 \rightarrow \pi^+ \pi^- \pi^0) &= (-3.1 \pm 3.0)\% [i] \\
A_{CP}(\rho(770)^- \pi^+ \rightarrow \pi^+ \pi^- \pi^0) &= (-1.0 \pm 1.7)\% [i] \\
A_{CP}(\rho(1450)^+ \pi^- \rightarrow \pi^+ \pi^- \pi^0) &= (0 \pm 70)\% [i] \\
A_{CP}(\rho(1450)^0 \pi^0 \rightarrow \pi^+ \pi^- \pi^0) &= (-20 \pm 40)\% [i] \\
A_{CP}(\rho(1450)^- \pi^+ \rightarrow \pi^+ \pi^- \pi^0) &= (6 \pm 9)\% [i] \\
A_{CP}(\rho(1700)^+ \pi^- \rightarrow \pi^+ \pi^- \pi^0) &= (-5 \pm 14)\% [i] \\
A_{CP}(\rho(1700)^0 \pi^0 \rightarrow \pi^+ \pi^- \pi^0) &= (13 \pm 9)\% [i] \\
A_{CP}(\rho(1700)^- \pi^+ \rightarrow \pi^+ \pi^- \pi^0) &= (8 \pm 11)\% [i] \\
A_{CP}(f_0(980) \pi^0 \rightarrow \pi^+ \pi^- \pi^0) &= (0 \pm 35)\% [i] \\
A_{CP}(f_0(1370) \pi^0 \rightarrow \pi^+ \pi^- \pi^0) &= (25 \pm 18)\% [i] \\
A_{CP}(f_0(1500) \pi^0 \rightarrow \pi^+ \pi^- \pi^0) &= (0 \pm 18)\% [i] \\
A_{CP}(f_0(1710) \pi^0 \rightarrow \pi^+ \pi^- \pi^0) &= (0 \pm 24)\% [i] \\
A_{CP}(f_2(1270) \pi^0 \rightarrow \pi^+ \pi^- \pi^0) &= (-4 \pm 6)\% [i] \\
A_{CP}(\sigma(400) \pi^0 \rightarrow \pi^+ \pi^- \pi^0) &= (6 \pm 8)\% [i] \\
A_{CP}(\text{nonresonant } \pi^+ \pi^- \pi^0) &= (-13 \pm 23)\% [i] \\
A_{CP}(\pi^+ \pi^- 2\pi^0) \text{ in } D^0, \overline{D}^0 &\rightarrow \pi^+ \pi^- 2\pi^0 = (-2.5 \pm 2.0)\% \\
A_{CP}(a_1(1260)^+ \pi^- \rightarrow 2\pi^+ 2\pi^-) &= (5 \pm 6)\% \\
A_{CP}(a_1(1260)^- \pi^+ \rightarrow 2\pi^+ 2\pi^-) &= (14 \pm 18)\% \\
A_{CP}(\pi(1300)^+ \pi^- \rightarrow 2\pi^+ 2\pi^-) &= (-2 \pm 15)\% \\
A_{CP}(\pi(1300)^- \pi^+ \rightarrow 2\pi^+ 2\pi^-) &= (-6 \pm 30)\% \\
A_{CP}(a_1(1640)^+ \pi^- \rightarrow 2\pi^+ 2\pi^-) &= (9 \pm 26)\% \\
A_{CP}(\pi_2(1670)^+ \pi^- \rightarrow 2\pi^+ 2\pi^-) &= (7 \pm 18)\% \\
A_{CP}(\sigma f_0(1370) \rightarrow 2\pi^+ 2\pi^-) &= (-15 \pm 19)\% \\
A_{CP}(\sigma \rho(770)^0 \rightarrow 2\pi^+ 2\pi^-) &= (3 \pm 27)\%
\end{aligned}$$

$$\begin{aligned}
A_{CP}(2\rho(770)^0 \rightarrow 2\pi^+ 2\pi^-) &= (-6 \pm 6)\% \\
A_{CP}(2f_2(1270) \rightarrow 2\pi^+ 2\pi^-) &= (-28 \pm 24)\% \\
A_{CP}(\pi^+ \pi^- \pi^0 \eta) \text{ in } D^0, \bar{D}^0 &\rightarrow \pi^+ \pi^- \pi^0 \eta = (-6 \pm 6) \times 10^{-2} \\
A_{CP}(K^+ K^- \pi^0) &= (-1.0 \pm 1.7)\% \\
A_{CP}(K^*(892)^+ K^- \rightarrow K^+ K^- \pi^0) &= (-0.9 \pm 1.3)\% [i] \\
A_{CP}(K^*(1410)^+ K^- \rightarrow K^+ K^- \pi^0) &= (-21 \pm 24)\% [i] \\
A_{CP}((K^+ \pi^0)_{S\text{-wave}} K^- \rightarrow K^+ K^- \pi^0) &= (7 \pm 15)\% [i] \\
A_{CP}(\phi(1020) \pi^0 \rightarrow K^+ K^- \pi^0) &= (1.1 \pm 2.2)\% [i] \\
A_{CP}(f_0(980) \pi^0 \rightarrow K^+ K^- \pi^0) &= (-3 \pm 19)\% [i] \\
A_{CP}(a_0(980)^0 \pi^0 \rightarrow K^+ K^- \pi^0) &= (-5 \pm 16)\% [i] \\
A_{CP}(f'_2(1525) \pi^0 \rightarrow K^+ K^- \pi^0) &= (0 \pm 160)\% [i] \\
A_{CP}(K^*(892)^- K^+ \rightarrow K^+ K^- \pi^0) &= (-5 \pm 4)\% [i] \\
A_{CP}(K^*(1410)^- K^+ \rightarrow K^+ K^- \pi^0) &= (-17 \pm 29)\% [i] \\
A_{CP}((K^- \pi^0)_{S\text{-wave}} K^+ \rightarrow K^+ K^- \pi^0) &= (-10 \pm 40)\% [i] \\
A_{CP}(K^+ K^- \eta) \text{ in } D^0, \bar{D}^0 &\rightarrow K^+ K^- \eta = (-1.4 \pm 3.5) \times 10^{-2} \\
A_{CP}(\phi(1020) \eta \rightarrow K^+ K^- \eta) \text{ in } D^0, \bar{D}^0 &\rightarrow \phi(1020) \eta = (-2 \pm 4) \times 10^{-2} \\
A_{CP}(K_S^0 \pi^0) &= (-0.20 \pm 0.17)\% \\
A_{CP}(K_S^0 \eta) &= (0.5 \pm 0.5)\% \\
A_{CP}(K_S^0 \eta') &= (1.0 \pm 0.7)\% \\
A_{CP}(K_S^0 \phi) &= (-3 \pm 9)\% \\
A_{CP}(K^- \pi^+) &= (0.2 \pm 0.5)\% \\
A_{CP}(K^+ \pi^-) &= (-0.9 \pm 1.4)\% \\
A_{CP}(D_{CP}(\pm 1) \rightarrow K^\mp \pi^\pm) &= (13.1 \pm 1.0)\% \\
A_{CP}(K^- \pi^+ \pi^0) &= (0.1 \pm 0.5)\% \\
A_{CP}(K^+ \pi^- \pi^0) &= (0 \pm 5)\% \\
A_{CP}(K_S^0 \pi^+ \pi^-) &= (-0.1 \pm 0.8)\% \\
A_{CP}(K^\mp \pi^\pm \eta) \text{ in } D^0, \bar{D}^0 &\rightarrow K^\mp \pi^\pm \eta = (-1.9 \pm 1.6) \times 10^{-2} \\
A_{CP}(K_S^0 \pi^0 \eta) \text{ in } D^0, \bar{D}^0 &\rightarrow K_S^0 \pi^0 \eta = (-3.9 \pm 3.3) \times 10^{-2} \\
A_{CP}(K^\mp \pi^\pm \pi^0 \eta) \text{ in } D^0, \bar{D}^0 &\rightarrow K^\mp \pi^\pm \pi^0 \eta = (-8 \pm 5) \times 10^{-2} \\
A_{CP}(K^*(892)^- \pi^+ \rightarrow K_S^0 \pi^+ \pi^-) &= (0.4 \pm 0.5)\% \\
A_{CP}(K^*(892)^+ \pi^- \rightarrow K_S^0 \pi^+ \pi^-) &= (1 \pm 6)\% \\
A_{CP}(\bar{K}^0 \rho^0 \rightarrow K_S^0 \pi^+ \pi^-) &= (-0.1 \pm 0.5)\% \\
A_{CP}(\bar{K}^0 \omega \rightarrow K_S^0 \pi^+ \pi^-) &= (-13 \pm 7)\% \\
A_{CP}(\bar{K}^0 f_0(980) \rightarrow K_S^0 \pi^+ \pi^-) &= (-0.4 \pm 2.7)\% \\
A_{CP}(\bar{K}^0 f_2(1270) \rightarrow K_S^0 \pi^+ \pi^-) &= (-4 \pm 5)\% \\
A_{CP}(\bar{K}^0 f_0(1370) \rightarrow K_S^0 \pi^+ \pi^-) &= (-1 \pm 9)\% \\
A_{CP}(\bar{K}^0 \rho^0(1450) \rightarrow K_S^0 \pi^+ \pi^-) &= (-4 \pm 10)\% \\
A_{CP}(\bar{K}^0 f_0(600) \rightarrow K_S^0 \pi^+ \pi^-) &= (-3 \pm 5)\% \\
A_{CP}(K^*(1410)^- \pi^+ \rightarrow K_S^0 \pi^+ \pi^-) &= (-2 \pm 9)\% \\
A_{CP}(K_0^*(1430)^- \pi^+ \rightarrow K_S^0 \pi^+ \pi^-) &= (4 \pm 4)\% \\
A_{CP}(K_0^*(1430)^+ \pi^- \rightarrow K_S^0 \pi^+ \pi^-) &= (12 \pm 15)\%
\end{aligned}$$

$$\begin{aligned}
 A_{CP}(K_2^*(1430)^- \pi^+ \rightarrow K_S^0 \pi^+ \pi^-) &= (3 \pm 6)\% \\
 A_{CP}(K_2^*(1430)^+ \pi^- \rightarrow K_S^0 \pi^+ \pi^-) &= (-10 \pm 32)\% \\
 A_{CP}(K^- \pi^+ \pi^+ \pi^-) &= (0.2 \pm 0.5)\% \\
 A_{CP}(K^+ \pi^- \pi^+ \pi^-) &= (-2 \pm 4)\% \\
 A_{CP}(K^+ K^- \pi^+ \pi^-) &= (1.3 \pm 1.7)\% \\
 A_{CP}(2K_S^0 \pi^+ \pi^-) \text{ in } D^0, \bar{D}^0 \rightarrow 2K_S^0 \pi^+ \pi^- &= (-2.5 \pm 1.4) \times 10^{-2} \\
 A_{CP}(K_1^*(1270)^+ K^- \rightarrow K^+ K^- \pi^+ \pi^-) &= (-2.3 \pm 1.7)\% \\
 A_{CP}(K_1^*(1270)^+ K^- \rightarrow K^{*0} \pi^+ K^-) &= (-1 \pm 10)\% \\
 A_{CP}(K_1^*(1270)^- K^+ \rightarrow \bar{K}^{*0} \pi^- K^+) &= (-10 \pm 32)\% \\
 A_{CP}(K_1^*(1270)^- K^+ \rightarrow K^+ K^- \pi^+ \pi^-) &= (1.7 \pm 3.5)\% \\
 A_{CP}(K_1^*(1270)^+ K^- \rightarrow \rho^0 K^+ K^-) &= (-7 \pm 17)\% \\
 A_{CP}(K_1^*(1270)^- K^+ \rightarrow \rho^0 K^- K^+) &= (10 \pm 13)\% \\
 A_{CP}(K_1(1400)^+ K^- \rightarrow K^+ K^- \pi^+ \pi^-) &= (-4.4 \pm 2.1)\% \\
 A_{CP}(K^*(1410)^+ K^- \rightarrow K^{*0} \pi^+ K^-) &= (-20 \pm 17)\% \\
 A_{CP}(K^*(1410)^- K^+ \rightarrow \bar{K}^{*0} \pi^- K^+) &= (-1 \pm 14)\% \\
 A_{CP}(K^*(1680)^+ K^- \rightarrow K^+ K^- \pi^+ \pi^-) &= (-17 \pm 29)\% \\
 A_{CP}(K^{*0} \bar{K}^{*0}) \text{ in } D^0, \bar{D}^0 \rightarrow K^{*0} \bar{K}^{*0} &= (-5 \pm 14)\% \\
 A_{CP}(K^{*0} \bar{K}^{*0} \text{ S-wave}) &= (-3.9 \pm 2.2)\% \\
 A_{CP}(\phi \rho^0) \text{ in } D^0, \bar{D}^0 \rightarrow \phi \rho^0 &= (1 \pm 9)\% \\
 A_{CP}(\phi \rho^0 \text{ S-wave}) &= (-3 \pm 5)\% \\
 A_{CP}(\phi \rho^0 \text{ D-wave}) &= (-37 \pm 19)\% \\
 A_{CP}(\phi(\pi^+ \pi^-)_{\text{S-wave}}) &= (6 \pm 6)\% \\
 A_{CP}(K^*(892)^0 (K^- \pi^+)_{\text{S-wave}}) &= (-10 \pm 40)\% \\
 A_{CP}(K^+ K^- \pi^+ \pi^- \text{ non-resonant}) &= (8 \pm 20)\% \\
 A_{CP}((K^- \pi^+)_{\text{P-wave}} (K^+ \pi^-)_{\text{S-wave}}) &= (3 \pm 11)\% \\
 A_{CP}(K^+ K^- \mu^+ \mu^-) \text{ in } D^0, \bar{D}^0 \rightarrow K^+ K^- \mu^+ \mu^- &= (-2 \pm 6)\% \\
 A_{CP}(\pi^+ \pi^- \mu^+ \mu^-) \text{ in } D^0, \bar{D}^0 \rightarrow \pi^+ \pi^- \mu^+ \mu^- &= (2.9 \pm 2.1)\%
 \end{aligned}$$

### CP-violation asymmetry difference

$$\Delta A_{CP} = A_{CP}(K^+ K^-) - A_{CP}(\pi^+ \pi^-) = (-0.154 \pm 0.029)\%$$

### $\chi^2$ tests of CP-violation (CPV) p-values

$$\begin{aligned}
 \text{Local CPV in } D^0, \bar{D}^0 \rightarrow \pi^+ \pi^- \pi^0 &= 10.6\% \\
 \text{Local CPV in } D^0, \bar{D}^0 \rightarrow \pi^+ \pi^- \pi^+ \pi^- &= (0.6 \pm 0.2)\% \\
 \text{Local CPV in } D^0, \bar{D}^0 \rightarrow K_S^0 \pi^+ \pi^- &= 96\% \\
 \text{Local CPV in } D^0, \bar{D}^0 \rightarrow K^+ K^- \pi^0 &= 16.6\% \\
 \text{Local CPV in } D^0, \bar{D}^0 \rightarrow K^+ K^- \pi^+ \pi^- &= 9.1\%
 \end{aligned}$$

### T-violation decay-rate asymmetry

$$\begin{aligned}
 A_T(K^+ K^- \pi^+ \pi^-) &= (2.9 \pm 2.2) \times 10^{-3} [b] \\
 A_{T\text{viol}}(2K_S^0 \pi^+ \pi^-) \text{ in } D^0, \bar{D}^0 \rightarrow 2K_S^0 \pi^+ \pi^- &= (-1.9 \pm 1.4) \times 10^{-2} \\
 A_{T\text{viol}}(K_S^0 \pi^+ \pi^- \pi^0) \text{ in } D^0, \bar{D}^0 \rightarrow K_S^0 \pi^+ \pi^- \pi^0 &= (-0.3^{+1.4}_{-1.6}) \times 10^{-3}
 \end{aligned}$$

**CPT-violation decay-rate asymmetry**

$$A_{CPT}(K^\mp \pi^\pm) = 0.008 \pm 0.008$$

**Form factors**

$$r_V \equiv V(0)/A_1(0) \text{ in } D^0 \rightarrow K^*(892)^- \ell^+ \nu_\ell = 1.46 \pm 0.07$$

$$r_2 \equiv A_2(0)/A_1(0) \text{ in } D^0 \rightarrow K^*(892)^- \ell^+ \nu_\ell = 0.68 \pm 0.06$$

$$f_+(0) \text{ in } D^0 \rightarrow K^- \ell^+ \nu_\ell = 0.736 \pm 0.004$$

$$f_+(0)|V_{cs}| \text{ in } D^0 \rightarrow K^- \ell^+ \nu_\ell = 0.7166 \pm 0.0030$$

$$r_1 \equiv a_1/a_0 \text{ in } D^0 \rightarrow K^- \ell^+ \nu_\ell = -2.40 \pm 0.16$$

$$r_2 \equiv a_2/a_0 \text{ in } D^0 \rightarrow K^- \ell^+ \nu_\ell = 5 \pm 4$$

$$f_+(0) \text{ in } D^0 \rightarrow \pi^- \ell^+ \nu_\ell = 0.637 \pm 0.009$$

$$f_+(0)|V_{cd}| \text{ in } D^0 \rightarrow \pi^- \ell^+ \nu_\ell = 0.1436 \pm 0.0026 \quad (S = 1.5)$$

$$r_1 \equiv a_1/a_0 \text{ in } D^0 \rightarrow \pi^- \ell^+ \nu_\ell = -1.97 \pm 0.28 \quad (S = 1.4)$$

$$r_2 \equiv a_1/a_0 \text{ in } D^0 \rightarrow \pi^- \ell^+ \nu_\ell = -0.2 \pm 2.2 \quad (S = 1.7)$$

Most decay modes (other than the semileptonic modes) that involve a neutral  $K$  meson are now given as  $K_S^0$  modes, not as  $\bar{K}^0$  modes. Nearly always it is a  $K_S^0$  that is measured, and interference between Cabibbo-allowed and doubly Cabibbo-suppressed modes can invalidate the assumption that  $2\Gamma(K_S^0) = \Gamma(\bar{K}^0)$ .

<b><math>D^0</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	Scale factor/ Confidence level	$p$ (MeV/c)
<b>Topological modes</b>			
0-prongs	[j] (15 ± 6 ) %		—
2-prongs	(71 ± 6 ) %		—
4-prongs	[k] (14.6 ± 0.5 ) %		—
6-prongs	[l] ( 6.5 ± 1.3 ) × 10 <sup>-4</sup>		—
<b>Inclusive modes</b>			
e <sup>+</sup> anything	[n] ( 6.49 ± 0.11 ) %		—
μ <sup>+</sup> anything	( 6.8 ± 0.6 ) %		—
K <sup>-</sup> anything	(54.7 ± 2.8 ) %	S=1.3	—
K <sub>S</sub> <sup>0</sup> anything	(20.75 ± 0.23 ) %		—
K <sup>+</sup> anything	( 3.4 ± 0.4 ) %		—
K*(892) <sup>-</sup> anything	(15 ± 9 ) %		—
$\bar{K}^*(892)^0$ anything	( 9 ± 4 ) %		—
K*(892) <sup>+</sup> anything	< 3.6 %	CL=90%	—
K*(892) <sup>0</sup> anything	( 2.8 ± 1.3 ) %		—
η anything	( 9.5 ± 0.9 ) %		—
η' anything	( 2.48 ± 0.27 ) %		—
φ anything	( 1.08 ± 0.04 ) %		—
π <sup>+</sup> π <sup>+</sup> π <sup>-</sup> anything	(17.60 ± 0.25 ) %		—
invisibles	< 9.4 × 10 <sup>-5</sup>	CL=90%	—

**Semileptonic modes**

$K^- e^+ \nu_e$	$( 3.549 \pm 0.026 ) \%$	S=1.2	867
$K^- \mu^+ \nu_\mu$	$( 3.41 \pm 0.04 ) \%$		864
$K^*(892)^- e^+ \nu_e$	$( 2.15 \pm 0.16 ) \%$		719
$K^*(892)^- \mu^+ \nu_\mu$	$( 1.89 \pm 0.24 ) \%$		714
$K^- \pi^0 e^+ \nu_e$	$( 1.6 \begin{smallmatrix} + 1.3 \\ - 0.5 \end{smallmatrix} ) \%$		861
$\bar{K}^0 \pi^- e^+ \nu_e$	$( 1.44 \pm 0.04 ) \%$		860
$(\bar{K}^0 \pi^-)_{S-wave} e^+ \nu_e$	$( 7.9 \pm 1.7 ) \times 10^{-4}$		860
$K^- \pi^+ \pi^- e^+ \nu_e$	$( 2.8 \begin{smallmatrix} + 1.4 \\ - 1.1 \end{smallmatrix} ) \times 10^{-4}$		843
$K_1(1270)^- e^+ \nu_e$	$( 1.01 \pm 0.18 ) \times 10^{-3}$		511
$K^- \pi^+ \pi^- \mu^+ \nu_\mu$	$< 1.3 \times 10^{-3}$	CL=90%	821
$(\bar{K}^*(892)\pi)^- \mu^+ \nu_\mu$	$< 1.5 \times 10^{-3}$	CL=90%	692
$\pi^- e^+ \nu_e$	$( 2.91 \pm 0.04 ) \times 10^{-3}$		927
$\pi^- \mu^+ \nu_\mu$	$( 2.67 \pm 0.12 ) \times 10^{-3}$	S=1.3	924
$\pi^- \pi^0 e^+ \nu_e$	$( 1.45 \pm 0.07 ) \times 10^{-3}$		922
$\rho^- e^+ \nu_e$	$( 1.50 \pm 0.12 ) \times 10^{-3}$	S=1.9	771
$\rho^- \mu^+ \nu_\mu$	$( 1.35 \pm 0.13 ) \times 10^{-3}$		767
$a(980)^- e^+ \nu_e, a^- \rightarrow \eta \pi^-$	$( 1.33 \begin{smallmatrix} + 0.34 \\ - 0.30 \end{smallmatrix} ) \times 10^{-4}$		–
$b_1(1235)^- e^+ \nu_e, b_1^- \rightarrow \omega \pi^-$	$< 1.12 \times 10^{-4}$	CL=90%	–

**Hadronic modes with one  $\bar{K}$** 

$K^- \pi^+$	$( 3.947 \pm 0.030 ) \%$	S=1.2	861
$K_S^0 \pi^0$	$( 1.240 \pm 0.022 ) \%$		860
$K_L^0 \pi^0$	$( 9.76 \pm 0.32 ) \times 10^{-3}$		860
$K_L^0 \eta$	$( 4.34 \pm 0.16 ) \times 10^{-3}$		772
$K_L^0 \eta'$	$( 8.12 \pm 0.35 ) \times 10^{-3}$	S=1.3	565
$K_L^0 \omega$	$( 1.16 \pm 0.04 ) \%$		670
$K_S^0 \pi^+ \pi^-$	[c] $( 2.80 \pm 0.18 ) \%$	S=1.1	842
$K_S^0 \rho^0$	$( 6.3 \begin{smallmatrix} + 0.6 \\ - 0.8 \end{smallmatrix} ) \times 10^{-3}$		674
$K_S^0 \omega, \omega \rightarrow \pi^+ \pi^-$	$( 2.0 \pm 0.6 ) \times 10^{-4}$		670
$K_S^0 (\pi^+ \pi^-)_{S-wave}$	$( 3.3 \pm 0.8 ) \times 10^{-3}$		842
$K_S^0 f_0(980), f_0 \rightarrow \pi^+ \pi^-$	$( 1.20 \begin{smallmatrix} + 0.40 \\ - 0.23 \end{smallmatrix} ) \times 10^{-3}$		549
$K_S^0 f_0(1370), f_0 \rightarrow \pi^+ \pi^-$	$( 2.8 \begin{smallmatrix} + 0.9 \\ - 1.3 \end{smallmatrix} ) \times 10^{-3}$		†
$K_S^0 f_2(1270), f_2 \rightarrow \pi^+ \pi^-$	$( 9 \begin{smallmatrix} + 10 \\ - 6 \end{smallmatrix} ) \times 10^{-5}$		262
$K^*(892)^- \pi^+, K^{*-} \rightarrow K_S^0 \pi^-$	$( 1.64 \begin{smallmatrix} + 0.14 \\ - 0.17 \end{smallmatrix} ) \%$		711
$K_0^*(1430)^- \pi^+, K_0^{*-} \rightarrow K_S^0 \pi^-$	$( 2.67 \begin{smallmatrix} + 0.40 \\ - 0.32 \end{smallmatrix} ) \times 10^{-3}$		378

$K_2^*(1430)^- \pi^+, K_2^{*-} \rightarrow$ $K_S^0 \pi^-$	$( 3.4 \pm_{-1.0}^{+1.9} ) \times 10^{-4}$		367
$K^*(1680)^- \pi^+, K^{*-} \rightarrow$ $K_S^0 \pi^-$	$( 4.4 \pm 3.5 ) \times 10^{-4}$		46
$K^*(892)^+ \pi^-, K^{*+} \rightarrow$ $K_S^0 \pi^+$	[o] $( 1.13 \pm_{0.34}^{+0.60} ) \times 10^{-4}$		711
$K_0^*(1430)^+ \pi^-, K_0^{*+} \rightarrow$ $K_S^0 \pi^+$	[o] $< 1.4$	$\times 10^{-5}$	CL=95% -
$K_2^*(1430)^+ \pi^-, K_2^{*+} \rightarrow$ $K_S^0 \pi^+$	[o] $< 3.4$	$\times 10^{-5}$	CL=95% -
$K_S^0 \pi^+ \pi^-$ nonresonant	$( 2.5 \pm_{-1.6}^{+6.0} ) \times 10^{-4}$		842
$K^- \pi^+ \pi^0$	[c] $( 14.4 \pm 0.6 ) \%$	S=2.2	844
$K^- \rho^+$	$( 11.2 \pm 0.7 ) \%$		675
$K^- \rho(1700)^+, \rho^+ \rightarrow \pi^+ \pi^0$	$( 8.2 \pm 1.8 ) \times 10^{-3}$		†
$K^*(892)^- \pi^+, K^*(892)^- \rightarrow$ $K^- \pi^0$	$( 2.31 \pm_{0.20}^{+0.40} ) \%$		711
$\bar{K}^*(892)^0 \pi^0, \bar{K}^*(892)^0 \rightarrow$ $K^- \pi^+$	$( 1.95 \pm 0.25 ) \%$		711
$K_0^*(1430)^- \pi^+, K_0^{*-} \rightarrow$ $K^- \pi^0$	$( 4.8 \pm 2.2 ) \times 10^{-3}$		378
$\bar{K}_0^*(1430)^0 \pi^0, \bar{K}_0^{*0} \rightarrow$ $K^- \pi^+$	$( 5.9 \pm_{-1.6}^{+5.0} ) \times 10^{-3}$		379
$K^*(1680)^- \pi^+, K^{*-} \rightarrow$ $K^- \pi^0$	$( 1.9 \pm 0.7 ) \times 10^{-3}$		46
$K^- \pi^+ \pi^0$ nonresonant	$( 1.15 \pm_{-0.20}^{+0.60} ) \%$		844
$K_S^0 2\pi^0$	$( 9.1 \pm 1.1 ) \times 10^{-3}$	S=2.2	843
$K_L^0 \pi^0 \pi^0$	$( 1.26 \pm 0.06 ) \%$		843
$K_S^0 (2\pi^0)_{S-wave}$	$( 2.6 \pm 0.7 ) \times 10^{-3}$		-
$\bar{K}^*(892)^0 \pi^0, \bar{K}^{*0} \rightarrow K_S^0 \pi^0$	$( 8.1 \pm 0.7 ) \times 10^{-3}$		711
$\bar{K}^*(1430)^0 \pi^0, \bar{K}^{*0} \rightarrow$ $K_S^0 \pi^0$	$( 4 \pm 23 ) \times 10^{-5}$		-
$\bar{K}^*(1680)^0 \pi^0, \bar{K}^{*0} \rightarrow$ $K_S^0 \pi^0$	$( 1.0 \pm 0.4 ) \times 10^{-3}$		-
$K_S^0 f_2(1270), f_2 \rightarrow 2\pi^0$	$( 2.3 \pm 1.1 ) \times 10^{-4}$		-
$2K_S^0, \text{one } K_S^0 \rightarrow 2\pi^0$	$( 3.2 \pm 1.1 ) \times 10^{-4}$		-
$K_S^0 3\pi^0$	$( 7.6 \pm 0.4 ) \times 10^{-3}$		815
$K^- 2\pi^+ \pi^-$	[c] $( 8.22 \pm 0.14 ) \%$		813
$K^- \pi^+ \rho^0$ total	$( 6.87 \pm 0.31 ) \%$		609
$K^- \pi^+ \rho^0$ 3-body	$( 6.1 \pm 1.6 ) \times 10^{-3}$		609
$\bar{K}^*(892)^0 \rho^0, \bar{K}^{*0} \rightarrow$ $K^- \pi^+$	$( 1.01 \pm 0.05 ) \%$		416

$\bar{K}^*(892)^0 \rho^0$ transverse,	( 1.2 ± 0.4 ) %	417
$\bar{K}^{*0} \rightarrow K^- \pi^+$		
$K^- a_1(1260)^+$ , $a_1^+ \rightarrow$	( 4.32 ± 0.32 ) %	327
$\rho^0 \pi^+$		
$K_1(1270)^- \pi^+$ , $K_1^- \rightarrow$	( 3.9 ± 0.4 ) × 10 <sup>-3</sup>	–
$K^- \pi^+ \pi^-$ total		
$K_1(1270)^- \pi^+$ , $K_1^- \rightarrow$	( 6.6 ± 2.3 ) × 10 <sup>-4</sup>	484
$\bar{K}^*(892)^0 \pi^-$ , $\bar{K}^{*0} \rightarrow$		
$K^- \pi^+$		
$K^- 2\pi^+ \pi^-$ nonresonant	( 1.81 ± 0.07 ) %	813
$K_S^0 \pi^+ \pi^- \pi^0$	[ $\rho$ ] ( 5.2 ± 0.6 ) %	813
$K_S^0 \eta$ , $\eta \rightarrow \pi^+ \pi^- \pi^0$	( 1.17 ± 0.03 ) × 10 <sup>-3</sup>	772
$K_S^0 \omega$ , $\omega \rightarrow \pi^+ \pi^- \pi^0$	( 9.9 ± 0.6 ) × 10 <sup>-3</sup>	670
$K^- \pi^+ 2\pi^0$	( 8.86 ± 0.23 ) %	815
$K^- \pi^+ 3\pi^0$	( 9.5 ± 0.4 ) × 10 <sup>-3</sup>	774
$K^- \pi^+ \pi^- 2\pi^0$	( 1.27 ± 0.06 ) %	773
$K^- 2\pi^+ \pi^- \pi^0$	( 4.3 ± 0.4 ) %	771
$\bar{K}^*(892)^0 \pi^+ \pi^- \pi^0$ , $\bar{K}^{*0} \rightarrow$	( 1.3 ± 0.6 ) %	643
$K^- \pi^+$		
$\bar{K}^*(892)^0 \omega$ , $\bar{K}^{*0} \rightarrow$	( 6.5 ± 3.0 ) × 10 <sup>-3</sup>	410
$K^- \pi^+$ , $\omega \rightarrow \pi^+ \pi^- \pi^0$		
$K^- \pi^+ \omega$	( 3.39 ± 0.10 ) %	605
$\bar{K}^*(892)^0 \omega$	( 1.1 ± 0.5 ) %	410
$K_S^0 \pi^0 \omega$	( 8.5 ± 0.6 ) × 10 <sup>-3</sup>	605
$K_S^0 \eta \pi^0$	( 1.01 ± 0.05 ) %	721
$K_S^0 a_0(980)$ , $a_0 \rightarrow \eta \pi^0$	( 1.20 ± 0.28 ) %	–
$\bar{K}^*(892)^0 \eta$ , $\bar{K}^{*0} \rightarrow K_S^0 \pi^0$	( 2.9 ± 0.7 ) × 10 <sup>-3</sup>	–
$K^- \pi^+ \eta$	( 1.88 ± 0.05 ) %	S=1.4 721
$K^*(892)^0 \eta$ , $K^{*0} \rightarrow K^- \pi^+$	( 8.9 $\begin{smallmatrix} + 0.8 \\ - 0.6 \end{smallmatrix}$ ) × 10 <sup>-3</sup>	–
$a_0(980)^+ K^-$ , $a_0^+ \rightarrow \eta \pi^+$	( 7.4 $\begin{smallmatrix} + 0.9 \\ - 0.7 \end{smallmatrix}$ ) × 10 <sup>-3</sup>	–
$K_2^*(1980)^- \pi^+$ , $K_2^{*-} \rightarrow$	( 2.2 $\begin{smallmatrix} + 1.7 \\ - 1.9 \end{smallmatrix}$ ) × 10 <sup>-4</sup>	–
$K^- \eta$		
$K^- \pi^+ \pi^0 \eta$	( 4.49 ± 0.27 ) × 10 <sup>-3</sup>	656
$K_S^0 \pi^+ \pi^- \eta$	( 2.80 ± 0.21 ) × 10 <sup>-3</sup>	651
$K_S^0 2\pi^0 \eta$	( 1.76 ± 0.26 ) × 10 <sup>-3</sup>	656
$K_S^0 2\pi^+ 2\pi^-$	( 2.66 ± 0.30 ) × 10 <sup>-3</sup>	768
$K_S^0 \rho^0 \pi^+ \pi^-$ , no $K^*(892)^-$	( 1.1 ± 0.7 ) × 10 <sup>-3</sup>	–
$K^*(892)^- 2\pi^+ \pi^-$ ,	( 5 ± 7 ) × 10 <sup>-4</sup>	642
$K^*(892)^- \rightarrow K_S^0 \pi^-$ ,		
no $\rho^0$		

$K^*(892)^-\rho^0\pi^+$ ,	$(1.6 \pm 0.6) \times 10^{-3}$	230
$K^*(892)^-\rightarrow K_S^0\pi^-$		
$K_S^0 2\pi^+ 2\pi^-$ nonresonant	$< 1.2 \times 10^{-3}$	CL=90% 768
$K^- 3\pi^+ 2\pi^-$	$(2.2 \pm 0.6) \times 10^{-4}$	713

Fractions of some of the following modes with resonances have already appeared above as submodes of particular charged-particle modes. These nine modes below are all corrected for unseen decays of the resonances.

$K_S^0\eta$	$(5.09 \pm 0.13) \times 10^{-3}$	772
$K_S^0\omega$	$(1.11 \pm 0.06) \%$	670
$K_S^0\eta'(958)$	$(9.49 \pm 0.32) \times 10^{-3}$	565
$\overline{K}^*(892)^0\pi^+\pi^-\pi^0$	$(1.9 \pm 0.9) \%$	643
$\overline{K}^*(892)^0\eta$	$(1.41 \pm 0.12) \%$	583
$K^-\pi^+\eta'(958)$	$(6.43 \pm 0.34) \times 10^{-3}$	479
$K_S^0\eta'(958)\pi^0$	$(2.52 \pm 0.27) \times 10^{-3}$	479
$\overline{K}^*(892)^0\eta'(958)$	$< 1.0 \times 10^{-3}$	CL=90% 119

### Hadronic modes with three K's

$K_S^0 K^+ K^-$	$(4.42 \pm 0.32) \times 10^{-3}$	544
$K_S^0 a_0(980)^0, a_0^0 \rightarrow K^+ K^-$	$(2.9 \pm 0.4) \times 10^{-3}$	-
$K^- a_0(980)^+, a_0^+ \rightarrow K^+ K_S^0$	$(5.9 \pm 1.8) \times 10^{-4}$	-
$K^+ a_0(980)^-, a_0^- \rightarrow K^- K_S^0$	$< 1.1 \times 10^{-4}$	CL=95% -
$K_S^0 f_0(980), f_0 \rightarrow K^+ K^-$	$< 9 \times 10^{-5}$	CL=95% -
$K_S^0 \phi, \phi \rightarrow K^+ K^-$	$(2.03 \pm 0.15) \times 10^{-3}$	520
$K_L^0 \phi$	$(4.14 \pm 0.23) \times 10^{-3}$	521
$K_S^0 f_0(1370), f_0 \rightarrow K^+ K^-$	$(1.7 \pm 1.1) \times 10^{-4}$	-
$3K_S^0$	$(7.5 \pm 0.7) \times 10^{-4}$	S=1.4 539
$K^+ 2K^- \pi^+$	$(2.25 \pm 0.32) \times 10^{-4}$	434
$K^+ K^- \overline{K}^*(892)^0, \overline{K}^{*0} \rightarrow K^- \pi^+$	$(4.5 \pm 1.8) \times 10^{-5}$	†
$K^- \pi^+ \phi, \phi \rightarrow K^+ K^-$	$(4.0 \pm 1.7) \times 10^{-5}$	422
$\phi \overline{K}^*(892)^0, \phi \rightarrow K^+ K^-, \overline{K}^{*0} \rightarrow K^- \pi^+$	$(1.08 \pm 0.21) \times 10^{-4}$	†
$K^+ 2K^- \pi^+$ nonresonant	$(3.4 \pm 1.5) \times 10^{-5}$	434
$2K_S^0 K^\pm \pi^\mp$	$(5.9 \pm 1.3) \times 10^{-4}$	427

### Pionic modes

$\pi^+ \pi^-$	$(1.454 \pm 0.024) \times 10^{-3}$	S=1.4 922
$2\pi^0$	$(8.26 \pm 0.25) \times 10^{-4}$	923
$\pi^+ \pi^- \pi^0$	$(1.49 \pm 0.07) \%$	S=2.3 907
$\rho^+ \pi^-$	$(1.01 \pm 0.05) \%$	764
$\rho^0 \pi^0$	$(3.86 \pm 0.24) \times 10^{-3}$	764

$\rho^- \pi^+$	$( 5.15 \pm 0.26 ) \times 10^{-3}$	764
$\rho(1450)^+ \pi^-, \rho^+ \rightarrow \pi^+ \pi^0$	$( 1.6 \pm 2.1 ) \times 10^{-5}$	—
$\rho(1450)^0 \pi^0, \rho^0 \rightarrow \pi^+ \pi^-$	$( 4.5 \pm 2.0 ) \times 10^{-5}$	—
$\rho(1450)^- \pi^+, \rho^- \rightarrow \pi^- \pi^0$	$( 2.7 \pm 0.4 ) \times 10^{-4}$	—
$\rho(1700)^+ \pi^-, \rho^+ \rightarrow \pi^+ \pi^0$	$( 6.1 \pm 1.5 ) \times 10^{-4}$	—
$\rho(1700)^0 \pi^0, \rho^0 \rightarrow \pi^+ \pi^-$	$( 7.4 \pm 1.8 ) \times 10^{-4}$	—
$\rho(1700)^- \pi^+, \rho^- \rightarrow \pi^- \pi^0$	$( 4.8 \pm 1.1 ) \times 10^{-4}$	—
$f_0(980) \pi^0, f_0 \rightarrow \pi^+ \pi^-$	$( 3.7 \pm 0.9 ) \times 10^{-5}$	—
$f_0(500) \pi^0, f_0 \rightarrow \pi^+ \pi^-$	$( 1.22 \pm 0.22 ) \times 10^{-4}$	—
$f_0(1370) \pi^0, f_0 \rightarrow \pi^+ \pi^-$	$( 5.5 \pm 2.1 ) \times 10^{-5}$	—
$f_0(1500) \pi^0, f_0 \rightarrow \pi^+ \pi^-$	$( 5.8 \pm 1.6 ) \times 10^{-5}$	—
$f_0(1710) \pi^0, f_0 \rightarrow \pi^+ \pi^-$	$( 4.6 \pm 1.6 ) \times 10^{-5}$	—
$f_2(1270) \pi^0, f_2 \rightarrow \pi^+ \pi^-$	$( 1.97 \pm 0.21 ) \times 10^{-4}$	—
$\pi^+ \pi^- \pi^0$ nonresonant	$( 1.3 \pm 0.4 ) \times 10^{-4}$	907
$3\pi^0$	$( 2.0 \pm 0.5 ) \times 10^{-4}$	908
$2\pi^+ 2\pi^-$	$( 7.56 \pm 0.20 ) \times 10^{-3}$	880
$a_1(1260)^+ \pi^-, a_1^+ \rightarrow$	$( 4.53 \pm 0.31 ) \times 10^{-3}$	—
$2\pi^+ \pi^-$ total		
$a_1(1260)^+ \pi^-, a_1^+ \rightarrow$	$( 3.13 \pm 0.21 ) \times 10^{-3}$	—
$\rho^0 \pi^+$ S-wave		
$a_1(1260)^+ \pi^-, a_1^+ \rightarrow$	$( 1.9 \pm 0.5 ) \times 10^{-4}$	—
$\rho^0 \pi^+$ D-wave		
$a_1(1260)^+ \pi^-, a_1^+ \rightarrow$	$( 6.4 \pm 0.7 ) \times 10^{-4}$	—
$\sigma \pi^+$		
$a_1(1260)^- \pi^+, a_1^- \rightarrow$	$( 2.3 \pm 0.9 ) \times 10^{-4}$	—
$\rho^0 \pi^-$ S-wave		
$a_1(1260)^- \pi^+, a_1^- \rightarrow \sigma \pi^-$	$( 6.0 \pm 3.4 ) \times 10^{-5}$	—
$\pi(1300)^+ \pi^-, \pi(1300)^+ \rightarrow$	$( 5.1 \pm 2.7 ) \times 10^{-4}$	—
$\sigma \pi^+$		
$\pi(1300)^- \pi^+, \pi(1300)^- \rightarrow$	$( 2.3 \pm 2.2 ) \times 10^{-4}$	—
$\sigma \pi^-$		
$a_1(1640)^+ \pi^-, a_1^+ \rightarrow$	$( 3.2 \pm 1.6 ) \times 10^{-4}$	—
$\rho^0 \pi^+$ D-wave		
$a_1(1640)^+ \pi^-, a_1^+ \rightarrow \sigma \pi^+$	$( 1.8 \pm 1.4 ) \times 10^{-4}$	—
$\pi_2(1670)^+ \pi^-, \pi_2^+ \rightarrow$	$( 2.0 \pm 0.9 ) \times 10^{-4}$	—
$f_2(1270)^0 \pi^+, f_2^0 \rightarrow$		
$\pi^+ \pi^-$		
$\pi_2(1670)^+ \pi^-, \pi_2^+ \rightarrow \sigma \pi^+$	$( 2.6 \pm 1.0 ) \times 10^{-4}$	—
$2\rho^0$ total	$( 1.85 \pm 0.13 ) \times 10^{-3}$	518
$2\rho^0$ , parallel helicities	$( 8.3 \pm 3.2 ) \times 10^{-5}$	—
$2\rho^0$ , perpendicular helicities	$( 4.8 \pm 0.6 ) \times 10^{-4}$	—
$2\rho^0$ , longitudinal helicities	$( 1.27 \pm 0.10 ) \times 10^{-3}$	—
$2\rho(770)^0$ , S-wave	$( 1.8 \pm 1.3 ) \times 10^{-4}$	—

$2\rho(770)^0$ , $P$ -wave		$( 5.3 \pm 1.3 ) \times 10^{-4}$	—
$2\rho(770)^0$ , $D$ -wave		$( 6.2 \pm 3.0 ) \times 10^{-4}$	—
Resonant $(\pi^+\pi^-)\pi^+\pi^-$		$( 1.51 \pm 0.12 ) \times 10^{-3}$	—
3-body total			
$\sigma\pi^+\pi^-$		$( 6.2 \pm 0.9 ) \times 10^{-4}$	—
$\sigma\rho(770)^0$		$( 5.0 \pm 2.5 ) \times 10^{-4}$	—
$f_0(980)\pi^+\pi^-$ , $f_0 \rightarrow$		$( 1.8 \pm 0.5 ) \times 10^{-4}$	—
$\pi^+\pi^-$			
$f_2(1270)\pi^+\pi^-$ , $f_2 \rightarrow$		$( 3.7 \pm 0.6 ) \times 10^{-4}$	—
$\pi^+\pi^-$			
$2f_2(1270)$ , $f_2 \rightarrow \pi^+\pi^-$		$( 1.6 \pm 1.8 ) \times 10^{-4}$	—
$f_0(1370)\sigma$ , $f_0 \rightarrow$		$( 1.6 \pm 0.5 ) \times 10^{-3}$	—
$\pi^+\pi^-2\pi^0$		$( 1.002 \pm 0.031 ) \%$	882
$4\pi^0$		$( 7.6 \pm 1.1 ) \times 10^{-4}$	883
$\eta\pi^0$	[ $q$ ]	$( 6.3 \pm 0.6 ) \times 10^{-4}$	S=1.1 846
$\omega\pi^0$	[ $q$ ]	$( 1.17 \pm 0.35 ) \times 10^{-4}$	761
$\omega\eta$		$( 1.98 \pm 0.18 ) \times 10^{-3}$	S=1.1 648
$2\pi^+2\pi^-\pi^0$		$( 3.46 \pm 0.21 ) \times 10^{-3}$	844
$\pi^+\pi^-3\pi^0$		$( 1.53 \pm 0.21 ) \times 10^{-3}$	847
$2\pi^+2\pi^-2\pi^0$		$( 4.8 \pm 0.4 ) \times 10^{-3}$	798
$\eta\pi^+\pi^-$	[ $q$ ]	$( 1.16 \pm 0.07 ) \times 10^{-3}$	827
$\omega\pi^+\pi^-$	[ $q$ ]	$( 1.33 \pm 0.20 ) \times 10^{-3}$	738
$\omega\pi^0\pi^0$		$< 1.10 \times 10^{-3}$	CL=90% 740
$\eta2\pi^0$		$( 3.8 \pm 1.3 ) \times 10^{-4}$	829
$\pi^+\pi^-\pi^0\eta$		$( 3.23 \pm 0.22 ) \times 10^{-3}$	797
$\eta3\pi^0$		$( 2.36 \pm 0.28 ) \times 10^{-3}$	799
$\eta2\pi^+2\pi^-$		$( 6.0 \pm 1.2 ) \times 10^{-4}$	751
$3\pi^+3\pi^-$		$( 4.3 \pm 1.2 ) \times 10^{-4}$	795
$\eta'(958)\pi^0$		$( 9.2 \pm 1.0 ) \times 10^{-4}$	678
$\eta'(958)\pi^+\pi^-$		$( 4.5 \pm 1.7 ) \times 10^{-4}$	650
$2\eta$		$( 2.11 \pm 0.19 ) \times 10^{-3}$	S=2.2 754
$2\eta\pi^0$		$( 7.3 \pm 2.2 ) \times 10^{-4}$	699
$2\eta\pi^+\pi^-$		$( 8.5 \pm 1.4 ) \times 10^{-4}$	623
$3\eta$		$< 1.3 \times 10^{-4}$	CL=90% 421
$\eta\eta'(958)$		$( 1.01 \pm 0.19 ) \times 10^{-3}$	537

### Hadronic modes with a $K\bar{K}$ pair

$K^+K^-$		$( 4.08 \pm 0.06 ) \times 10^{-3}$	S=1.6 791
$2K_S^0$		$( 1.41 \pm 0.05 ) \times 10^{-4}$	S=1.1 789
$K_S^0K^-\pi^+$		$( 3.3 \pm 0.5 ) \times 10^{-3}$	S=1.1 739
$\bar{K}^*(892)^0K_S^0$ , $\bar{K}^{*0} \rightarrow$		$( 8.2 \pm 1.6 ) \times 10^{-5}$	608
$K^-\pi^+$			
$K^*(892)^+K^-$ , $K^{*+} \rightarrow$		$( 1.89 \pm 0.30 ) \times 10^{-3}$	—
$K_S^0\pi^+$			

$\bar{K}^*(1410)^0 K_S^0, \bar{K}^{*0} \rightarrow$ $K^- \pi^+$	$(1.3 \pm 1.9) \times 10^{-4}$		—
$K^*(1410)^+ K^-, K^{*+} \rightarrow$ $K_S^0 \pi^+$	$(3.2 \pm 1.9) \times 10^{-4}$		—
$(K^- \pi^+)_{S\text{-wave}} K_S^0$	$(6.0 \pm 2.9) \times 10^{-4}$		739
$(K_S^0 \pi^+)_{S\text{-wave}} K^-$	$(3.9 \pm 1.0) \times 10^{-4}$		739
$a_0(980)^- \pi^+, a_0^- \rightarrow K_S^0 K^-$	$(1.3 \pm 1.4) \times 10^{-4}$		—
$a_0(1450)^- \pi^+, a_0^- \rightarrow$ $K_S^0 K^-$	$(2.5 \pm 2.0) \times 10^{-5}$		—
$a_2(1320)^- \pi^+, a_2^- \rightarrow$ $K_S^0 K^-$	$(5 \pm 5) \times 10^{-6}$		—
$\rho(1450)^- \pi^+, \rho^- \rightarrow K_S^0 K^-$	$(4.6 \pm 2.5) \times 10^{-5}$		—
$K_S^0 K^+ \pi^-$	$(2.17 \pm 0.35) \times 10^{-3}$	S=1.1	739
$K^*(892)^0 K_S^0, K^{*0} \rightarrow$ $K^+ \pi^-$	$(1.12 \pm 0.21) \times 10^{-4}$		608
$K^*(892)^- K^+, K^{*-} \rightarrow$ $K_S^0 \pi^-$	$(6.2 \pm 1.1) \times 10^{-4}$		—
$K^*(1410)^0 K_S^0, K^{*0} \rightarrow$ $K^+ \pi^+$	$(5 \pm 8) \times 10^{-5}$		—
$K^*(1410)^- K^+, K^{*-} \rightarrow$ $K_S^0 \pi^-$	$(2.6 \pm 2.0) \times 10^{-4}$		—
$(K^+ \pi^-)_{S\text{-wave}} K_S^0$	$(3.7 \pm 1.9) \times 10^{-4}$		739
$(K_S^0 \pi^-)_{S\text{-wave}} K^+$	$(1.4 \pm 0.6) \times 10^{-4}$		739
$a_0(980)^+ \pi^-, a_0^+ \rightarrow K_S^0 K^+$	$(6 \pm 4) \times 10^{-4}$		—
$a_0(1450)^+ \pi^-, a_0^+ \rightarrow$ $K_S^0 K^+$	$(3.2 \pm 2.5) \times 10^{-5}$		—
$\rho(1700)^+ \pi^-, \rho^+ \rightarrow K_S^0 K^+$	$(1.1 \pm 0.6) \times 10^{-5}$		—
$K^+ K^- \pi^0$	$(3.42 \pm 0.15) \times 10^{-3}$		743
$K^*(892)^+ K^-, K^*(892)^+ \rightarrow$ $K^+ \pi^0$	$(1.52 \pm 0.08) \times 10^{-3}$		—
$K^*(892)^- K^+, K^*(892)^- \rightarrow$ $K^- \pi^0$	$(5.4 \pm 0.4) \times 10^{-4}$		—
$(K^+ \pi^0)_{S\text{-wave}} K^-$	$(2.43 \pm 0.18) \times 10^{-3}$		743
$(K^- \pi^0)_{S\text{-wave}} K^+$	$(1.3 \pm 0.5) \times 10^{-4}$		743
$f_0(980) \pi^0, f_0 \rightarrow K^+ K^-$	$(3.6 \pm 0.6) \times 10^{-4}$		—
$\phi \pi^0, \phi \rightarrow K^+ K^-$	$(6.6 \pm 0.4) \times 10^{-4}$		—
$2K_S^0 \pi^0$	$< 1.45 \times 10^{-4}$	CL=90%	740
$K^+ K^- \eta$	$(5.9 \pm 1.9) \times 10^{-5}$		514
$\phi(1020) \eta$	$(1.84 \pm 0.12) \times 10^{-4}$		489
$K^+ K^- \eta$ nonresonant	$(9.9 \pm_{-0.8}^{0.9}) \times 10^{-5}$		514
$2K_S^0 \eta$	$(1.3 \pm 0.6) \times 10^{-4}$		508
$K^+ K^- \pi^0 \pi^0$	$(6.9 \pm 0.8) \times 10^{-4}$		681

$K^+ K^- \pi^+ \pi^-$	$( 2.47 \pm 0.11 ) \times 10^{-3}$	677
$\phi(\pi^+ \pi^-)_{S\text{-wave}}, \phi \rightarrow$	$( 10 \pm 5 ) \times 10^{-5}$	614
$K^+ K^-$		
$(\phi \rho^0)_{S\text{-wave}}, \phi \rightarrow K^+ K^-$	$( 6.9 \pm 0.6 ) \times 10^{-4}$	250
$(\phi \rho^0)_{P\text{-wave}}, \phi \rightarrow K^+ K^-$	$( 4.0 \pm 1.9 ) \times 10^{-5}$	—
$(\phi \rho^0)_{D\text{-wave}}, \phi \rightarrow K^+ K^-$	$( 4.2 \pm 1.4 ) \times 10^{-5}$	—
$(K^*(892)^0 \bar{K}^*(892)^0)_{S\text{-wave}},$	$( 2.24 \pm 0.13 ) \times 10^{-4}$	—
$K^{*0} \rightarrow K^\pm \pi^\mp$		
$(K^*(892)^0 \bar{K}^*(892)^0)_{P\text{-wave}},$	$( 1.20 \pm 0.08 ) \times 10^{-4}$	—
$K^* \rightarrow K^\pm \pi^\mp$		
$(K^*(892)^0 \bar{K}^*(892)^0)_{D\text{-wave}},$	$( 4.7 \pm 0.4 ) \times 10^{-5}$	—
$K^* \rightarrow K^\pm \pi^\mp$		
$K^*(892)^0 (K^- \pi^+)_{S\text{-wave}}$	$( 1.4 \pm 0.6 ) \times 10^{-4}$	—
3-body, $K^{*0} \rightarrow K^+ \pi^-$		
$K_1(1270)^+ K^-, K_1^+ \rightarrow$	$( 1.4 \pm 0.9 ) \times 10^{-4}$	—
$K^{*0} \pi^+$		
$K_1(1270)^+ K^-, K_1^+ \rightarrow$	$( 1.5 \pm 0.5 ) \times 10^{-4}$	—
$K^*(1430)^0 \pi^+, K^{*0} \rightarrow$		
$K^+ \pi^-$		
$K_1(1270)^+ K^-, K_1^+ \rightarrow$	$( 2.2 \pm 0.6 ) \times 10^{-4}$	—
$\rho^0 K^+$		
$K_1(1270)^+ K^-, K_1^+ \rightarrow$	$( 1.5 \pm 1.2 ) \times 10^{-5}$	—
$\omega(782) K^+, \omega \rightarrow \pi^+ \pi^-$		
$K_1(1270)^- K^+, K_1^- \rightarrow$	$( 1.3 \pm 0.4 ) \times 10^{-4}$	—
$\rho^0 K^-$		
$K_1(1400)^+ K^-, K_1^+ \rightarrow$	$( 4.6 \pm 0.4 ) \times 10^{-4}$	—
$K^*(892)^0 \pi^+, K^{*0} \rightarrow$		
$K^+ \pi^-$		
$K^*(1410)^- K^+, K^{*-} \rightarrow$	$( 7.0 \pm 1.1 ) \times 10^{-5}$	—
$\bar{K}^{*0} \pi^-$		
$K_1(1680)^+ K^-, K_1^+ \rightarrow$	$( 8.9 \pm 3.2 ) \times 10^{-5}$	—
$K^{*0} \pi^+, K^{*0} \rightarrow K^+ \pi^-$		
$K^+ K^- \pi^+ \pi^-$ non-resonant	$( 2.7 \pm 0.6 ) \times 10^{-4}$	—
$2K_S^0 \pi^+ \pi^-$	$( 5.3 \pm 0.9 ) \times 10^{-4}$	673
$K_S^0 K^- \pi^+ \pi^0$	$( 1.32 \pm 0.16 ) \times 10^{-3}$	677
$K_S^0 K^+ \pi^- \pi^0$	$( 6.5 \pm 0.7 ) \times 10^{-4}$	677
$K_S^0 K^- 2\pi^+ \pi^-$	$< 1.4 \times 10^{-4}$	CL=90% 595
$K^+ K^- \pi^+ \pi^- \pi^0$	$( 3.1 \pm 2.0 ) \times 10^{-3}$	600

Other  $K\bar{K}X$  modes. They include all decay modes of the  $\phi$ ,  $\eta$ , and  $\omega$ .

$\phi \pi^0$	$( 1.17 \pm 0.04 ) \times 10^{-3}$	645
$\phi \eta$	$( 1.8 \pm 0.5 ) \times 10^{-4}$	489
$\phi \omega$	$( 6.5 \pm 1.0 ) \times 10^{-4}$	238

**Radiative modes**

$\rho^0 \gamma$		$( 1.82 \pm 0.32 ) \times 10^{-5}$		771
$\omega \gamma$		$< 2.4$	$\times 10^{-4}$	CL=90% 768
$\phi \gamma$		$( 2.81 \pm 0.19 ) \times 10^{-5}$		654
$\overline{K}^*(892)^0 \gamma$		$( 4.1 \pm 0.7 ) \times 10^{-4}$		719

**Doubly Cabibbo suppressed (DC) modes or  $\Delta C = 2$  forbidden via mixing (C2M) modes**

$K^+ \ell^- \bar{\nu}_\ell$ via $\overline{D}^0$		$[r] < 2.2$	$\times 10^{-5}$	CL=90%	–
$K^+$ or $K^*(892)^+$ $e^- \bar{\nu}_e$ via $\overline{D}^0$		$< 6$	$\times 10^{-5}$	CL=90%	–
$K^+ \pi^-$	DC	$( 1.50 \pm 0.07 ) \times 10^{-4}$		S=3.0	861
$K^+ \pi^-$ via DCS		$( 1.363 \pm 0.025 ) \times 10^{-4}$			–
$K^+ \pi^-$ via $\overline{D}^0$		$< 1.6$	$\times 10^{-5}$	CL=95%	861
$K_S^0 \pi^+ \pi^-$ in $D^0 \rightarrow \overline{D}^0$		$< 1.8$	$\times 10^{-4}$	CL=95%	–
$K^*(892)^+ \pi^-$ , $K^{*+} \rightarrow K_S^0 \pi^+$	DC	$( 1.13 \begin{smallmatrix} + \\ - \end{smallmatrix} \begin{smallmatrix} 0.60 \\ 0.34 \end{smallmatrix} ) \times 10^{-4}$			711
$K_0^*(1430)^+ \pi^-$ , $K_0^{*+} \rightarrow K_S^0 \pi^+$	DC	$< 1.4$	$\times 10^{-5}$		–
$K_2^*(1430)^+ \pi^-$ , $K_2^{*+} \rightarrow K_S^0 \pi^+$	DC	$< 3.4$	$\times 10^{-5}$		–
$K^+ \pi^- \pi^0$	DC	$( 3.06 \pm 0.16 ) \times 10^{-4}$		S=1.4	844
$K^+ \pi^- \pi^0$ via $\overline{D}^0$		$( 7.6 \begin{smallmatrix} + \\ - \end{smallmatrix} \begin{smallmatrix} 0.5 \\ 0.6 \end{smallmatrix} ) \times 10^{-4}$			–
$K^+ \pi^- 2\pi^0$		$< 3.6$	$\times 10^{-4}$	CL=90%	815
$K^+ \pi^+ 2\pi^-$ via DCS		$( 2.49 \pm 0.07 ) \times 10^{-4}$			–
$K^+ \pi^+ 2\pi^-$	DC	$( 2.65 \pm 0.06 ) \times 10^{-4}$			813
$K^+ \pi^+ 2\pi^-$ via $\overline{D}^0$		$( 7.9 \pm 3.0 ) \times 10^{-6}$			812
$\mu^-$ anything via $\overline{D}^0$		$< 4$	$\times 10^{-4}$	CL=90%	–

 **$\Delta C = 1$  weak neutral current (C1) modes,  
Lepton Family number (LF) violating modes,  
Lepton (L) or Baryon (B) number violating modes**

$\gamma \gamma$	C1	$< 8.5$	$\times 10^{-7}$	CL=90%	932
$e^+ e^-$	C1	$< 7.9$	$\times 10^{-8}$	CL=90%	932
$\mu^+ \mu^-$	C1	$< 3.1$	$\times 10^{-9}$	CL=90%	926
$\pi^0 e^+ e^-$	C1	$< 4$	$\times 10^{-6}$	CL=90%	928
$\pi^0 \mu^+ \mu^-$	C1	$< 1.8$	$\times 10^{-4}$	CL=90%	915
$\pi^0 \nu \bar{\nu}$		$< 2.1$	$\times 10^{-4}$	CL=90%	928
$\eta e^+ e^-$	C1	$< 3$	$\times 10^{-6}$	CL=90%	852
$\eta \mu^+ \mu^-$	C1	$< 5.3$	$\times 10^{-4}$	CL=90%	838
$\pi^+ \pi^- e^+ e^-$	C1	$< 7$	$\times 10^{-6}$	CL=90%	922
$\rho^0 e^+ e^-$	C1	$< 1.0$	$\times 10^{-4}$	CL=90%	771
$\pi^+ \pi^- \mu^+ \mu^-$	C1	$( 9.6 \pm 1.2 ) \times 10^{-7}$			894
$\pi^+ \pi^- \mu^+ \mu^-$ (non-res)		$< 5.5$	$\times 10^{-7}$	CL=90%	–

$\rho^0 \mu^+ \mu^-$	<i>C1</i>	$< 2.2$	$\times 10^{-5}$	CL=90%	754
$\omega e^+ e^-$	<i>C1</i>	$< 6$	$\times 10^{-6}$	CL=90%	768
$\omega \mu^+ \mu^-$	<i>C1</i>	$< 8.3$	$\times 10^{-4}$	CL=90%	751
$K^- K^+ e^+ e^-$	<i>C1</i>	$< 1.1$	$\times 10^{-5}$	CL=90%	791
$\phi e^+ e^-$	<i>C1</i>	$< 5.2$	$\times 10^{-5}$	CL=90%	654
$K^- K^+ \mu^+ \mu^-$	<i>C1</i>	$( 1.54 \pm 0.32 )$	$\times 10^{-7}$		710
$K^- K^+ \mu^+ \mu^-$ (non-res)		$< 3.3$	$\times 10^{-5}$	CL=90%	–
$\phi \mu^+ \mu^-$	<i>C1</i>	$< 3.1$	$\times 10^{-5}$	CL=90%	631
$\overline{K}^0 e^+ e^-$		[ <i>h</i> ] $< 2.4$	$\times 10^{-5}$	CL=90%	866
$\overline{K}^0 \mu^+ \mu^-$		[ <i>h</i> ] $< 2.6$	$\times 10^{-4}$	CL=90%	852
$K^- \pi^+ e^+ e^-$ , $675 < m_{ee} < 875$ MeV		$( 4.0 \pm 0.5 )$	$\times 10^{-6}$		–
$K^- \pi^+ e^+ e^-$ , $1.005 < m_{ee} < 1.035$ GeV		$< 5$	$\times 10^{-7}$	CL=90%	–
$\overline{K}^*(892)^0 e^+ e^-$		[ <i>h</i> ] $< 4.7$	$\times 10^{-5}$	CL=90%	719
$K^- \pi^+ \mu^+ \mu^-$	<i>C1</i>	$< 3.59$	$\times 10^{-4}$	CL=90%	829
$K^- \pi^+ \mu^+ \mu^-$ , $675 < m_{\mu\mu} < 875$ MeV		$( 4.2 \pm 0.4 )$	$\times 10^{-6}$		–
$\overline{K}^*(892)^0 \mu^+ \mu^-$		[ <i>h</i> ] $< 2.4$	$\times 10^{-5}$	CL=90%	700
$\pi^+ \pi^- \pi^0 \mu^+ \mu^-$	<i>C1</i>	$< 8.1$	$\times 10^{-4}$	CL=90%	863
$\mu^\pm e^\mp$	<i>LF</i>	[ <i>s</i> ] $< 1.3$	$\times 10^{-8}$	CL=90%	929
$\pi^0 e^\pm \mu^\mp$	<i>LF</i>	[ <i>s</i> ] $< 8.0$	$\times 10^{-7}$	CL=90%	924
$\eta e^\pm \mu^\mp$	<i>LF</i>	[ <i>s</i> ] $< 2.25$	$\times 10^{-6}$	CL=90%	848
$\pi^+ \pi^- e^\pm \mu^\mp$	<i>LF</i>	[ <i>s</i> ] $< 1.71$	$\times 10^{-6}$	CL=90%	911
$\rho^0 e^\pm \mu^\mp$	<i>LF</i>	[ <i>s</i> ] $< 5.0$	$\times 10^{-7}$	CL=90%	767
$\omega e^\pm \mu^\mp$	<i>LF</i>	[ <i>s</i> ] $< 1.71$	$\times 10^{-6}$	CL=90%	764
$K^- K^+ e^\pm \mu^\mp$	<i>LF</i>	[ <i>s</i> ] $< 1.00$	$\times 10^{-6}$	CL=90%	754
$\phi e^\pm \mu^\mp$	<i>LF</i>	[ <i>s</i> ] $< 5.1$	$\times 10^{-7}$	CL=90%	648
$\overline{K}^0 e^\pm \mu^\mp$	<i>LF</i>	[ <i>s</i> ] $< 1.74$	$\times 10^{-6}$	CL=90%	863
$K^- \pi^+ e^\pm \mu^\mp$	<i>LF</i>	[ <i>s</i> ] $< 1.90$	$\times 10^{-6}$	CL=90%	848
$\overline{K}^*(892)^0 e^\pm \mu^\mp$	<i>LF</i>	[ <i>s</i> ] $< 1.25$	$\times 10^{-6}$	CL=90%	714
$2\pi^- 2e^+$	<i>L</i>	$< 9.1$	$\times 10^{-7}$	CL=90%	922
$2\pi^- 2\mu^+$	<i>L</i>	$< 1.52$	$\times 10^{-6}$	CL=90%	894
$K^- \pi^- 2e^+$	<i>L</i>	$< 5.0$	$\times 10^{-7}$	CL=90%	861
$K^- \pi^- 2\mu^+$	<i>L</i>	$< 5.3$	$\times 10^{-7}$	CL=90%	829
$2K^- 2e^+$	<i>L</i>	$< 3.4$	$\times 10^{-7}$	CL=90%	791
$2K^- 2\mu^+$	<i>L</i>	$< 1.0$	$\times 10^{-7}$	CL=90%	710
$\pi^- \pi^- e^+ \mu^+$	<i>L</i>	$< 3.06$	$\times 10^{-6}$	CL=90%	911
$K^- \pi^- e^+ \mu^+$	<i>L</i>	$< 2.10$	$\times 10^{-6}$	CL=90%	848
$2K^- e^+ \mu^+$	<i>L</i>	$< 5.8$	$\times 10^{-7}$	CL=90%	754
$p e^-$	<i>L,B</i>	$< 2.2$	$\times 10^{-6}$	CL=90%	696
$\overline{p} e^+$	<i>L,B</i>	$< 1.2$	$\times 10^{-6}$	CL=90%	696

**$D^*(2007)^0$** 

$$I(J^P) = \frac{1}{2}(1^-)$$

Mass  $m = 2006.85 \pm 0.05$  MeV (S = 1.1) $m_{D^{*0}} - m_{D^0} = 142.014 \pm 0.030$  MeV (S = 1.5)Full width  $\Gamma < 2.1$  MeV, CL = 90% $\bar{D}^*(2007)^0$  modes are charge conjugates of modes below.

<b><math>D^*(2007)^0</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	Confidence level	$p$ (MeV/c)
$D^0 \pi^0$	(64.7 $\pm$ 0.9) %		43
$D^0 \gamma$	(35.3 $\pm$ 0.9) %		137
$D^0 e^+ e^-$	( 3.91 $\pm$ 0.33) $\times 10^{-3}$		137
$\mu^+ \mu^-$	< 2.5 $\times 10^{-8}$	90%	998
$e^+ e^-$	< 1.7 $\times 10^{-6}$	90%	1003

 **$D^*(2010)^\pm$** 

$$I(J^P) = \frac{1}{2}(1^-)$$

Mass  $m = 2010.26 \pm 0.05$  MeV $m_{D^*(2010)^+} - m_{D^+} = 140.603 \pm 0.015$  MeV $m_{D^*(2010)^+} - m_{D^0} = 145.4258 \pm 0.0017$  MeVFull width  $\Gamma = 83.4 \pm 1.8$  keV $D^*(2010)^-$  modes are charge conjugates of the modes below.

<b><math>D^*(2010)^\pm</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$D^0 \pi^+$	(67.7 $\pm$ 0.5) %	39
$D^+ \pi^0$	(30.7 $\pm$ 0.5) %	38
$D^+ \gamma$	( 1.6 $\pm$ 0.4) %	136

 **$D_0^*(2300)$** 

$$I(J^P) = \frac{1}{2}(0^+)$$

was  $D_0^*(2400)$ Mass  $m = 2343 \pm 10$  MeV (S = 1.5)Full width  $\Gamma = 229 \pm 16$  MeV

<b><math>D_0^*(2300)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$D \pi^\pm$	seen	411

**$D_1(2420)$** 

$$I(J^P) = \frac{1}{2}(1^+)$$

Mass  $m = 2422.1 \pm 0.6$  MeV (S = 1.7) $m_{D_1(2420)^0} - m_{D^{*+}} = 411.8 \pm 0.6$  MeV (S = 1.7) $m_{D_1(2420)^\pm} - m_{D_1(2420)^0} = 4 \pm 4$  MeVFull width  $\Gamma = 31.3 \pm 1.9$  MeV (S = 2.8) $\bar{D}_1(2420)$  modes are charge conjugates of modes below.

<b><math>D_1(2420)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$D^*(2007)^0 \pi$	seen	359

 **$D_1(2430)^0$** 

$$I(J^P) = \frac{1}{2}(1^+)$$

Mass  $m = 2412 \pm 9$  MeVFull width  $\Gamma = 314 \pm 29$  MeV

<b><math>D_1(2430)^0</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$D^*(2010)^+ \pi^-$	seen	345

 **$D_2^*(2460)$** 

$$I(J^P) = \frac{1}{2}(2^+)$$

Mass  $m = 2461.1 \pm 0.8$  MeV (S = 6.3) $m_{D_2^*(2460)^0} - m_{D^+} = 591.5 \pm 0.8$  MeV (S = 6.0) $m_{D_2^*(2460)^0} - m_{D^{*+}} = 450.9 \pm 0.8$  MeV (S = 6.0) $m_{D_2^*(2460)^\pm} - m_{D_2^*(2460)^0} = 2.4 \pm 1.7$  MeVFull width  $\Gamma = 47.3 \pm 0.8$  MeV (S = 1.5) $\bar{D}_2^*(2460)$  modes are charge conjugates of modes below.

<b><math>D_2^*(2460)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$D \pi^-$	seen	509
$D^*(2010) \pi^-$	seen	389

 **$D_3^*(2750)$** 

$$I(J^P) = \frac{1}{2}(3^-)$$

Mass  $m = 2763.1 \pm 3.2$  MeV (S = 2.1)Full width  $\Gamma = 66 \pm 5$  MeV

<b><math>D_3^*(2750)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$\rho$ (MeV/c)
$D\pi$	seen	743
$D^+\pi^-$	seen	739
$D^0\pi^\pm$	seen	743
$D^*\pi$	seen	639
$D^{*+}\pi^-$	seen	639

## NOTES

- [a] This result applies to  $Z^0 \rightarrow c\bar{c}$  decays only. Here  $\ell^+$  is an average (not a sum) of  $e^+$  and  $\mu^+$  decays.
- [b] See the Particle Listings for the (complicated) definition of this quantity.
- [c] The branching fraction for this mode may differ from the sum of the submodes that contribute to it, due to interference effects. See the relevant papers in the Particle Listings.
- [d] These subfractions of the  $K^-2\pi^+$  mode are uncertain: see the Particle Listings.
- [e] See the listings under " $D \rightarrow K\pi\pi\pi$  partial wave analyses" and our 2008 Review (Physics Letters **B667** 1 (2008)) for measurements of submodes of this mode.
- [f] The unseen decay modes of the resonances are included.
- [g] This is *not* a test for the  $\Delta C=1$  weak neutral current, but leads to the  $\pi^+\ell^+\ell^-$  final state.
- [h] This mode is not a useful test for a  $\Delta C=1$  weak neutral current because both quarks must change flavor in this decay.
- [i] In the 2010 *Review*, the values for these quantities were given using a measure of the asymmetry that was inconsistent with the usual definition.
- [j] This value is obtained by subtracting the branching fractions for 2-, 4- and 6-prongs from unity.
- [k] This is the sum of our  $K^-2\pi^+\pi^-$ ,  $K^-2\pi^+\pi^-\pi^0$ ,  $\bar{K}^02\pi^+2\pi^-$ ,  $K^+2K^-\pi^+$ ,  $2\pi^+2\pi^-$ ,  $2\pi^+2\pi^-\pi^0$ ,  $K^+K^-\pi^+\pi^-$ , and  $K^+K^-\pi^+\pi^-\pi^0$ , branching fractions.
- [l] This is the sum of our  $K^-3\pi^+2\pi^-$  and  $3\pi^+3\pi^-$  branching fractions.
- [n] The branching fractions for the  $K^-e^+\nu_e$ ,  $K^*(892)^-e^+\nu_e$ ,  $\pi^-e^+\nu_e$ , and  $\rho^-e^+\nu_e$  modes add up to  $6.17 \pm 0.17$  %.
- [o] This is a doubly Cabibbo-suppressed mode.
- [p] Submodes of the  $D^0 \rightarrow K_S^0\pi^+\pi^-\pi^0$  mode with a  $K^*$  and/or  $\rho$  were studied by COFFMAN 92B, but with only 140 events. With nothing new

for 18 years, we refer to our 2008 edition, Physics Letters **B667** 1 (2008), for those results.

- [*q*] This branching fraction includes all the decay modes of the resonance in the final state.
- [*r*] This limit assumes the average of  $B(D^0 \rightarrow K^- e^+ \nu_e)$  and  $B(D^0 \rightarrow K^- \mu^+ \nu_\mu)$  for the  $B(D^0 \rightarrow K^- \ell^+ \nu_\ell)$  value.
- [*s*] The value is for the sum of the charge states or particle/antiparticle states indicated.