

# CHARMED MESONS

## ( $C = \pm 1$ )

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

**$D^\pm$**

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

$$\text{Mass } m = 1869.3 \pm 0.4 \text{ MeV} \quad (S = 1.1)$$

$$\text{Mean life } \tau = (1040 \pm 7) \times 10^{-15} \text{ s}$$

$$c\tau = 311.8 \text{ } \mu\text{m}$$

### 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

$$A_{CP}(K_S^0 \pi^\pm) = -0.016 \pm 0.017$$

$$A_{CP}(K_S^0 K^\pm) = 0.07 \pm 0.06$$

$$A_{CP}(K^+ K^- \pi^\pm) = 0.007 \pm 0.008$$

$$A_{CP}(K^\pm K^{*0}) = 0.005 \pm 0.017$$

$$A_{CP}(\phi \pi^\pm) = -0.001 \pm 0.015$$

$$A_{CP}(\pi^+ \pi^- \pi^\pm) = -0.02 \pm 0.04$$

$$A_{CP}(K_S^0 K^\pm \pi^+ \pi^-) = -0.04 \pm 0.07$$

### T-violation decay-rate asymmetry

$$A_T(K_S^0 K^\pm \pi^+ \pi^-) = 0.02 \pm 0.07$$

### $D^+ \rightarrow \bar{K}^*(892)^0 \ell^+ \nu_\ell$ form factors

$$r_\nu = 1.62 \pm 0.08 \quad (S = 1.5)$$

$$r_2 = 0.83 \pm 0.05$$

$$r_3 = 0.0 \pm 0.4$$

$$\Gamma_L / \Gamma_T = 1.13 \pm 0.08$$

$$\Gamma_+ / \Gamma_- = 0.22 \pm 0.06 \quad (S = 1.6)$$

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	$p$ (MeV/c)
<b>Inclusive modes</b>			
$e^+$ anything	(17.2 $\pm$ 1.9 ) %		—
$K^-$ anything	(27.5 $\pm$ 2.4 ) %		—
$\overline{K}^0$ anything + $K^0$ anything	(61 $\pm$ 8 ) %		—
$K^+$ anything	( 5.5 $\pm$ 1.6 ) %		—
$\overline{K}^*(892)^0$ anything	(23 $\pm$ 5 ) %		—
$K^*(892)^0$ anything	< 6.6 %	CL=90%	—
$\eta$ anything	[ <i>b</i> ] < 13 %	CL=90%	—
$\phi$ anything	< 1.8 %	CL=90%	—
$\phi e^+$ anything	< 1.6 %	CL=90%	—
<b>Leptonic and semileptonic modes</b>			
$e^+ \nu_e$	< 2.4 $\times 10^{-5}$	CL=90%	935
$\mu^+ \nu_\mu$	( 4.4 $\pm$ 0.7 ) $\times 10^{-4}$		932
$\overline{K}^0 e^+ \nu_e$	( 8.6 $\pm$ 0.5 ) %		868
$\overline{K}^0 \mu^+ \nu_\mu$	( 9.5 $\pm$ 0.8 ) %		865
$K^- \pi^+ e^+ \nu_e$	( 4.5 $^{+1.0}_{-0.8}$ ) %	S=1.1	863
$\overline{K}^*(892)^0 e^+ \nu_e$ ,	( 3.74 $\pm$ 0.21 ) %		722
$\overline{K}^*(892)^0 \rightarrow K^- \pi^+$			
$K^- \pi^+ e^+ \nu_e$ nonresonant	< 7 $\times 10^{-3}$	CL=90%	863
$K^- \pi^+ \mu^+ \nu_\mu$	( 4.0 $\pm$ 0.5 ) %		851
$\overline{K}^*(892)^0 \mu^+ \nu_\mu$ ,	( 3.7 $\pm$ 0.3 ) %		717
$\overline{K}^*(892)^0 \rightarrow K^- \pi^+$			
$K^- \pi^+ \mu^+ \nu_\mu$ nonresonant	( 2.1 $\pm$ 0.6 ) $\times 10^{-3}$		851
$(\overline{K}^*(892)\pi)^0 e^+ \nu_e$	< 1.2 %	CL=90%	712
$(\overline{K}\pi\pi)^0 e^+ \nu_e$ non- $\overline{K}^*(892)$	< 9 $\times 10^{-3}$	CL=90%	846
$K^- \pi^+ \pi^0 \mu^+ \nu_\mu$	< 1.7 $\times 10^{-3}$	CL=90%	825
$\pi^0 e^+ \nu_e$	( 4.4 $\pm$ 0.7 ) $\times 10^{-3}$		930
Fractions of some of the following modes with resonances have already appeared above as submodes of particular charged-particle modes.			
$\overline{K}^*(892)^0 e^+ \nu_e$	( 5.61 $\pm$ 0.31 ) %	S=1.1	722
$\overline{K}^*(892)^0 \mu^+ \nu_\mu$	( 5.5 $\pm$ 0.5 ) %	S=1.1	717
$\overline{K}_1(1270)^0 \mu^+ \nu_\mu$	< 4 %	CL=95%	493
$\overline{K}_0^*(1430)^0 \mu^+ \nu_\mu$	< 2.5 $\times 10^{-4}$		388
$\overline{K}_2^*(1430)^0 \mu^+ \nu_\mu$	< 1.1 %	CL=95%	380
$\overline{K}^*(1680)^0 \mu^+ \nu_\mu$	< 1.6 $\times 10^{-3}$		105

$\rho^0 e^+ \nu_e$	$( 2.2 \pm 0.4 ) \times 10^{-3}$			774
$\rho^0 \mu^+ \nu_\mu$	$( 3.4 \pm 0.8 ) \times 10^{-3}$			770
$\omega e^+ \nu_e$	$( 1.6 \begin{smallmatrix} +0.7 \\ -0.6 \end{smallmatrix} ) \times 10^{-3}$			771
$\phi e^+ \nu_e$	$< 2.09$	%	CL=90%	657
$\phi \mu^+ \nu_\mu$	$< 3.72$	%	CL=90%	651
$\eta \ell^+ \nu_\ell$	$< 7$	$\times 10^{-3}$	CL=90%	854
$\eta'(958) \mu^+ \nu_\mu$	$< 1.1$	%	CL=90%	684

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

$K_S^0 \pi^+$	$( 1.47 \pm 0.06 ) \%$		S=1.1	862
$K^- \pi^+ \pi^+$	[c] $( 9.51 \pm 0.34 ) \%$		S=1.1	845
$\bar{K}^*(892)^0 \pi^+$ ,	[d] $( 1.33 \pm 0.11 ) \%$			714
$\bar{K}^*(892)^0 \rightarrow K^- \pi^+$				
$\bar{K}_0^*(1430)^0 \pi^+$ ,	[d] $( 2.41 \pm 0.24 ) \%$			382
$\bar{K}_0^*(1430)^0 \rightarrow K^- \pi^+$				
$\bar{K}^*(1680)^0 \pi^+$ ,	[d] $( 4.0 \pm 0.8 ) \times 10^{-3}$			58
$\bar{K}^*(1680)^0 \rightarrow K^- \pi^+$				
$K^- \pi^+ \pi^+$ nonresonant	[d] $( 9.0 \pm 0.7 ) \%$			845
$K_S^0 \pi^+ \pi^0$	[c] $( 7.0 \pm 0.5 ) \%$		S=1.2	845
$K_S^0 \rho^+$	$( 4.8 \pm 1.1 ) \%$			677
$\bar{K}^*(892)^0 \pi^+$ ,	$( 1.3 \pm 0.6 ) \%$			714
$\bar{K}^*(892)^0 \rightarrow K_S^0 \pi^0$				
$K_S^0 \pi^+ \pi^0$ nonresonant	$( 9 \pm 7 ) \times 10^{-3}$			845
$K^- \pi^+ \pi^+ \pi^0$	[c] $( 6.00 \pm 0.28 ) \%$		S=1.1	816
$\bar{K}^*(892)^0 \rho^+$ total,	$( 1.3 \pm 0.8 ) \%$			422
$\bar{K}^*(892)^0 \rightarrow K^- \pi^+$				
$\bar{K}_1(1400)^0 \pi^+$ ,	$( 1.8 \pm 0.7 ) \%$			390
$\bar{K}_1(1400)^0 \rightarrow K^- \pi^+ \pi^0$				
$K^- \rho^+ \pi^+$ total	$( 2.6 \pm 1.6 ) \%$			613
$K^- \rho^+ \pi^+$ 3-body	$( 9 \pm 6 ) \times 10^{-3}$			613
$\bar{K}^*(892)^0 \pi^+ \pi^0$ total,	$( 4.2 \pm 0.6 ) \%$			690
$\bar{K}^*(892)^0 \rightarrow K^- \pi^+$				
$\bar{K}^*(892)^0 \pi^+ \pi^0$ 3-body,	$( 2.7 \pm 0.8 ) \%$			690
$\bar{K}^*(892)^0 \rightarrow K^- \pi^+$				
$K^*(892)^- \pi^+ \pi^+$ 3-body,	$( 6 \pm 3 ) \times 10^{-3}$			688
$K^*(892)^- \rightarrow K^- \pi^0$				
$K^- \pi^+ \pi^+ \pi^0$ nonresonant	[e] $( 1.0 \pm 0.7 ) \%$			816
$K_S^0 \pi^+ \pi^+ \pi^-$	[c] $( 3.11 \pm 0.21 ) \%$		S=1.1	814
$K_S^0 a_1(1260)^+$ ,	$( 1.8 \pm 0.3 ) \%$			328
$a_1(1260)^+ \rightarrow \pi^+ \pi^+ \pi^-$				
$\bar{K}_1(1400)^0 \pi^+$ ,	$( 1.8 \pm 0.7 ) \%$			390
$\bar{K}_1(1400)^0 \rightarrow K_S^0 \pi^+ \pi^-$				

$K^*(892)^- \pi^+ \pi^+$ 3-body,	( 1.3 ±0.6 ) %		688
$K^*(892)^- \rightarrow K_S^0 \pi^-$			
$K_S^0 \rho^0 \pi^+$ total	( 1.86±0.34 ) %	CL=90%	610
$K_S^0 \rho^0 \pi^+$ 3-body	( 2.2 ±2.2 ) × 10 <sup>-3</sup>		610
$K_S^0 \pi^+ \pi^+ \pi^-$ nonresonant	( 3.7 ±1.9 ) × 10 <sup>-3</sup>		814
$K^- 3\pi^+ \pi^-$	[c] ( 5.8 ±0.6 ) × 10 <sup>-3</sup>	S=1.1	772
$\bar{K}^*(892)^0 \pi^+ \pi^+ \pi^-$ ,	( 1.2 ±0.4 ) × 10 <sup>-3</sup>		645
$\bar{K}^*(892)^0 \rightarrow K^- \pi^+$			
$\bar{K}^*(892)^0 \rho^0 \pi^+$ ,	( 2.3 ±0.4 ) × 10 <sup>-3</sup>		239
$\bar{K}^*(892)^0 \rightarrow K^- \pi^+$			
$K^- \rho^0 \pi^+ \pi^+$	( 1.75±0.29 ) × 10 <sup>-3</sup>		524
$K^- 3\pi^+ \pi^-$ nonresonant	( 4.1 ±3.0 ) × 10 <sup>-4</sup>		772
$K^+ 2K_S^0$	( 4.7 ±2.1 ) × 10 <sup>-3</sup>		545
$K^+ K^- K_S^0 \pi^+$	( 2.4 ±0.6 ) × 10 <sup>-4</sup>		435

Fractions of some of the following modes with resonances have already appeared above as submodes of particular charged-particle modes.

$K_S^0 a_1(1260)^+$	( 3.6 ±0.6 ) %		328
$K_S^0 a_2(1320)^+$	< 1.5 × 10 <sup>-3</sup>	CL=90%	199
$\bar{K}^*(892)^0 \rho^+$ total	[e] ( 1.8 ±1.4 ) %		422
$\bar{K}^*(892)^0 \rho^+$ S-wave	[e] ( 1.4 ±1.5 ) %		422
$\bar{K}^*(892)^0 \rho^+$ P-wave	< 1 × 10 <sup>-3</sup>	CL=90%	422
$\bar{K}^*(892)^0 \rho^+$ D-wave	( 8 ±7 ) × 10 <sup>-3</sup>		422
$\bar{K}^*(892)^0 \rho^+$ D-wave longitudinal	< 7 × 10 <sup>-3</sup>	CL=90%	422
$\bar{K}_1(1270)^0 \pi^+$	< 7 × 10 <sup>-3</sup>	CL=90%	487
$\bar{K}_1(1400)^0 \pi^+$	( 4.3 ±1.5 ) %	S=1.2	390
$\bar{K}^*(892)^0 \pi^+ \pi^0$ total	( 5.8 ±2.9 ) %		690
$\bar{K}^*(892)^0 \pi^+ \pi^0$ 3-body	[e] ( 3.6 ±2.1 ) %		690
$K^*(892)^- \pi^+ \pi^+$ total	—		688
$K^*(892)^- \pi^+ \pi^+$ 3-body	( 1.8 $\begin{smallmatrix} +1.1 \\ -0.9 \end{smallmatrix}$ ) %	S=1.2	688
$\bar{K}^*(892)^0 a_1(1260)^+$	( 9.4 ±1.9 ) × 10 <sup>-3</sup>		†

### Pionic modes

$\pi^+ \pi^0$	( 1.28±0.09 ) × 10 <sup>-3</sup>		925
$\pi^+ \pi^+ \pi^-$	( 3.31±0.21 ) × 10 <sup>-3</sup>		908
$\rho^0 \pi^+$	( 1.07±0.11 ) × 10 <sup>-3</sup>		766
$\pi^+ (\pi^+ \pi^-)_{S\text{-wave}}$	( 1.86±0.18 ) × 10 <sup>-3</sup>		908
$\sigma \pi^+, \sigma \rightarrow \pi^+ \pi^-$	( 1.53±0.32 ) × 10 <sup>-3</sup>		—
$f_0(980) \pi^+$ ,	( 2.1 ±0.5 ) × 10 <sup>-4</sup>		669
$f_0(980) \rightarrow \pi^+ \pi^-$			
$f_0(1370) \pi^+$ ,	( 8 ±6 ) × 10 <sup>-5</sup>		—
$f_0(1370) \rightarrow \pi^+ \pi^-$			

$f_2(1270)\pi^+$ ,	$( 4.8 \pm 1.3 ) \times 10^{-4}$		485
$f_2(1270) \rightarrow \pi^+\pi^-$			
$\pi^+2\pi^0$	$( 4.8 \pm 0.4 ) \times 10^{-3}$		910
$\pi^+\pi^+\pi^-\pi^0$	$( 1.18 \pm 0.09 ) \%$		883
$\eta\pi^+, \eta \rightarrow \pi^+\pi^-\pi^0$	$( 7.9 \pm 0.7 ) \times 10^{-4}$		848
$\omega\pi^+, \omega \rightarrow \pi^+\pi^-\pi^0$	$< 3 \times 10^{-4}$	CL=90%	763
$3\pi^+2\pi^-$	$( 1.68 \pm 0.17 ) \times 10^{-3}$	S=1.1	845

Fractions of some of the following modes with resonances have already appeared above as submodes of particular charged-particle modes.

$\eta\pi^+$	$( 3.50 \pm 0.32 ) \times 10^{-3}$		848
$\omega\pi^+$	$< 3.4 \times 10^{-4}$	CL=90%	763
$\eta\rho^+$	$< 7 \times 10^{-3}$	CL=90%	655
$\eta'(958)\pi^+$	$( 5.3 \pm 1.1 ) \times 10^{-3}$		680
$\eta'(958)\rho^+$	$< 6 \times 10^{-3}$	CL=90%	348

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

$K^+K_S^0$	$( 2.96 \pm 0.19 ) \times 10^{-3}$		792
$K^+K^-\pi^+$	[c] $( 1.00 \pm 0.04 ) \%$	S=1.2	744
$\phi\pi^+, \phi \rightarrow K^+K^-$	$( 3.2 \pm 0.4 ) \times 10^{-3}$		647
$K^+\bar{K}^*(892)^0,$	$( 3.02 \pm 0.35 ) \times 10^{-3}$		613
$\bar{K}^*(892)^0 \rightarrow K^-\pi^+$			
$K^+\bar{K}_0^*(1430)^0,$	$( 3.7 \pm 0.4 ) \times 10^{-3}$		—
$\bar{K}_0^*(1430)^0 \rightarrow K^-\pi^+$			
$K_S^0K_S^0\pi^+$	—		741
$K^*(892)^+K_S^0,$	$( 5.3 \pm 2.3 ) \times 10^{-3}$		611
$K^*(892)^+ \rightarrow K_S^0\pi^+$			
$K^+K^-\pi^+\pi^0$	—		682
$\phi\pi^+\pi^0, \phi \rightarrow K^+K^-$	$( 1.1 \pm 0.5 ) \%$		619
$\phi\rho^+, \phi \rightarrow K^+K^-$	$< 7 \times 10^{-3}$	CL=90%	258
$K^+K^-\pi^+\pi^0$ non- $\phi$	$( 1.5 \begin{smallmatrix} +0.7 \\ -0.6 \end{smallmatrix} ) \%$		682
$K^+K_S^0\pi^+\pi^-$	$( 1.75 \pm 0.21 ) \times 10^{-3}$		678
$K_S^0K^-\pi^+\pi^+$	$( 2.39 \pm 0.23 ) \times 10^{-3}$		678
$K^*(892)^+\bar{K}^*(892)^0,$	$( 5.8 \pm 2.4 ) \times 10^{-3}$		280
$K^{*+} \rightarrow K_S^0\pi^+, \bar{K}^{*0} \rightarrow K^-\pi^+$			
$K_S^0K^-\pi^+\pi^+$ (non- $K^{*+}\bar{K}^{*0}$ )	$< 4 \times 10^{-3}$	CL=90%	678
$K^+K^-\pi^+\pi^-\pi^-$	$( 2.3 \pm 1.2 ) \times 10^{-4}$		600

Fractions of the following modes with resonances have already appeared above as submodes of particular charged-particle modes.

$\phi\pi^+$	$( 6.5 \pm 0.7 ) \times 10^{-3}$		647
$\phi\pi^+\pi^0$	$( 2.3 \pm 1.0 ) \%$		619

$\phi\rho^+$	< 1.5	%	CL=90%	259
$K^*(892)^+ K_S^0$	( 1.6 $\pm$ 0.7 )	%		611
$K^*(892)^+ \bar{K}^*(892)^0$	( 2.6 $\pm$ 1.1 )	%		280

**Doubly Cabibbo-suppressed modes**

$K^+ \pi^0$	< 4.2	$\times 10^{-4}$	CL=90%	864
$K^+ \pi^+ \pi^-$	( 6.4 $\pm$ 0.8 )	$\times 10^{-4}$		845
$K^+ \rho^0$	( 2.5 $\pm$ 0.7 )	$\times 10^{-4}$		678
$K^*(892)^0 \pi^+, K^*(892)^0 \rightarrow$	( 3.0 $\pm$ 0.6 )	$\times 10^{-4}$		714
$K^+ \pi^-$				
$K^+ f_0(980), f_0(980) \rightarrow$	( 5.7 $\pm$ 3.5 )	$\times 10^{-5}$		—
$\pi^+ \pi^-$				
$K_2^*(1430)^0 \pi^+, K_2^*(1430)^0 \rightarrow$	( 5.2 $\pm$ 3.5 )	$\times 10^{-5}$		—
$K^+ \pi^-$				
$K^+ K^+ K^-$	( 9.0 $\pm$ 2.1 )	$\times 10^{-5}$		550

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

$\pi^+ e^+ e^-$	C1	< 7.4	$\times 10^{-6}$	CL=90%	929
$\pi^+ \phi, \phi \rightarrow e^+ e^-$	[f]	( 2.7 $^{+3.6}_{-1.8}$ )	$\times 10^{-6}$		—
$\pi^+ \mu^+ \mu^-$	C1	< 8.8	$\times 10^{-6}$	CL=90%	917
$\rho^+ \mu^+ \mu^-$	C1	< 5.6	$\times 10^{-4}$	CL=90%	757
$K^+ e^+ e^-$	[g]	< 6.2	$\times 10^{-6}$	CL=90%	869
$K^+ \mu^+ \mu^-$	[g]	< 9.2	$\times 10^{-6}$	CL=90%	856
$\pi^+ e^\pm \mu^\mp$	LF	[h] < 3.4	$\times 10^{-5}$	CL=90%	926
$K^+ e^\pm \mu^\mp$	LF	[h] < 6.8	$\times 10^{-5}$	CL=90%	866
$\pi^- e^+ e^+$	L	< 3.6	$\times 10^{-6}$	CL=90%	929
$\pi^- \mu^+ \mu^+$	L	< 4.8	$\times 10^{-6}$	CL=90%	917
$\pi^- e^+ \mu^+$	L	< 5.0	$\times 10^{-5}$	CL=90%	926
$\rho^- \mu^+ \mu^+$	L	< 5.6	$\times 10^{-4}$	CL=90%	757
$K^- e^+ e^+$	L	< 4.5	$\times 10^{-6}$	CL=90%	869
$K^- \mu^+ \mu^+$	L	< 1.3	$\times 10^{-5}$	CL=90%	856
$K^- e^+ \mu^+$	L	< 1.3	$\times 10^{-4}$	CL=90%	866
$K^*(892)^- \mu^+ \mu^+$	L	< 8.5	$\times 10^{-4}$	CL=90%	703

**$D^0$**

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

Mass  $m = 1864.5 \pm 0.4$  MeV (S = 1.1)

$m_{D^\pm} - m_{D^0} = 4.78 \pm 0.10$  MeV (S = 1.1)

Mean life  $\tau = (410.1 \pm 1.5) \times 10^{-15}$  s

$c\tau = 122.9$   $\mu$ m

$|m_{D_1^0} - m_{D_2^0}| < 7 \times 10^{10} \hbar s^{-1}$ , CL = 95% [i]

$(\Gamma_{D_1^0} - \Gamma_{D_2^0})/\Gamma = 2y = (1.4 \pm 1.0) \times 10^{-2}$

$$\Gamma(K^+ \ell^- \bar{\nu}_\ell \text{ (via } \bar{D}^0)) / \Gamma(K^- \ell^+ \nu_\ell) < 0.005, \text{ CL} = 90\%$$

$$\Gamma(K^+ \pi^- \text{ (via } \bar{D}^0)) / \Gamma(K^- \pi^+) < 4.0 \times 10^{-4}, \text{ CL} = 95\%$$

$$\Gamma(K_S^0 \pi^+ \pi^- \text{ (in } D^0 \rightarrow \bar{D}^0)) / \Gamma(K_S^0 \pi^+ \pi^-) < 0.0063, \text{ CL} = 95\%$$

$\Gamma_0 / \Gamma_0$

**CP-violation decay-rate asymmetries**

$$A_{CP}(K^+ K^-) = 0.014 \pm 0.010$$

$$A_{CP}(K_S^0 K_S^0) = -0.23 \pm 0.19$$

$$A_{CP}(\pi^+ \pi^-) = 0.013 \pm 0.012$$

$$A_{CP}(\pi^0 \pi^0) = 0.00 \pm 0.05$$

$$A_{CP}(\pi^+ \pi^- \pi^0) = 0.01^{+0.10}_{-0.09}$$

$$A_{CP}(K_S^0 \phi) = -0.03 \pm 0.09$$

$$A_{CP}(K_S^0 \pi^0) = 0.001 \pm 0.013$$

$$A_{CP}(K^\pm \pi^\mp) = 0.05 \pm 0.04$$

$$A_{CP}(K^\mp \pi^\pm \pi^0) = -0.03 \pm 0.09$$

$$A_{CP}(K^\pm \pi^\mp \pi^0) = 0.00 \pm 0.05$$

$$A_{CP}(K_S^0 \pi^+ \pi^-) = -0.009^{+0.026}_{-0.061}$$

$$A_{CP}(K^\pm \pi^\mp \pi^+ \pi^-) = -0.02 \pm 0.04$$

$$A_{CP}(K^+ K^- \pi^+ \pi^-) = -0.08 \pm 0.07$$

**T-violation decay-rate asymmetry**

$$A_T(K^+ K^- \pi^+ \pi^-) = 0.01 \pm 0.07$$

**CPT-violation decay-rate asymmetry**

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

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] (19 ± 6 ) %		—
2-prongs	(67 ± 6 ) %		—
4-prongs	[k] (13.8 ± 0.5 ) %		—
6-prongs	( 1.2 $\pm$ 1.3 $\pm$ 0.7 ) $\times 10^{-3}$		—

### Inclusive modes

$e^+$ anything	[l] ( 6.71 ± 0.29 ) %		—
$\mu^+$ anything	( 6.5 ± 0.7 ) %		—
$K^-$ anything	( 53 ± 4 ) %	S=1.3	—
$\bar{K}^0$ anything + $K^0$ anything	( 42 ± 5 ) %		—
$K^+$ anything	( 3.4 + - 0.4 ) %		—
$\bar{K}^*(892)^0$ anything	( 9 ± 4 ) %		—
$K^*(892)^0$ anything	( 2.8 ± 1.3 ) %		—
$\eta$ anything	[b] < 13 %	CL=90%	—
$\phi$ anything	( 1.7 ± 0.8 ) %		—

### Semileptonic modes

$K^- e^+ \nu_e$	( 3.51 ± 0.11 ) %		867
$K^- \mu^+ \nu_\mu$	( 3.19 ± 0.16 ) %		863
$K^*(892)^- e^+ \nu_e$	( 2.17 ± 0.16 ) %		719
$K^*(892)^- \mu^+ \nu_\mu$	( 1.95 ± 0.25 ) %		714
$K^- \pi^+ \pi^- \mu^+ \nu_\mu$	< 1.2	$\times 10^{-3}$ CL=90%	821
$(\bar{K}^*(892)\pi)^- \mu^+ \nu_\mu$	< 1.4	$\times 10^{-3}$ CL=90%	692
$\pi^- e^+ \nu_e$	( 2.81 ± 0.19 ) $\times 10^{-3}$		927
$\pi^- \mu^+ \nu_\mu$	( 2.4 ± 0.4 ) $\times 10^{-3}$		924
$\rho^- e^+ \nu_e$	( 1.9 ± 0.4 ) $\times 10^{-3}$		771

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

$K^- \pi^+$	( 3.80 ± 0.07 ) %	S=1.1	861
$K_S^0 \pi^0$	( 1.14 ± 0.12 ) %		860
$K_S^0 \pi^+ \pi^-$	[c] ( 2.90 ± 0.19 ) %		842
$K_S^0 \rho^0$	( 7.5 + - 0.8 ) $\times 10^{-3}$		674
$K_S^0 \omega, \omega \rightarrow \pi^+ \pi^-$	( 2.1 ± 0.6 ) $\times 10^{-4}$		670
$K_S^0 f_0(980),$ $f_0(980) \rightarrow \pi^+ \pi^-$	( 1.36 + - 0.22 ) $\times 10^{-3}$		549
$K_S^0 f_2(1270),$ $f_2(1270) \rightarrow \pi^+ \pi^-$	( 1.3 + - 0.7 ) $\times 10^{-4}$		262
$K_S^0 f_0(1370),$ $f_0(1370) \rightarrow \pi^+ \pi^-$	( 2.5 ± 0.6 ) $\times 10^{-3}$		†
$K^*(892)^- \pi^+,$ $K^*(892)^- \rightarrow K_S^0 \pi^-$	( 1.91 ± 0.14 ) %		711
$K^*(892)^+ \pi^-,$ $K^*(892)^+ \rightarrow K_S^0 \pi^+$	[m] ( 10 + - 12/4 ) $\times 10^{-5}$		711
$K_0^*(1430)^- \pi^+,$ $K_0^*(1430)^- \rightarrow K_S^0 \pi^-$	( 2.8 + - 0.4 ) $\times 10^{-3}$		378



$K_2^*(1430)^- \pi^+$ ,	$( 3.2 \begin{smallmatrix} + 2.1 \\ - 1.1 \end{smallmatrix} ) \times 10^{-4}$	367
$K_2^*(1430)^- \rightarrow K_S^0 \pi^-$		
$K^*(1680)^- \pi^+$ ,	$( 6 \pm 5 ) \times 10^{-4}$	46
$K^*(1680)^- \rightarrow K_S^0 \pi^-$		
$K_S^0 \pi^+ \pi^-$ nonresonant	$( 2.6 \begin{smallmatrix} + 5.9 \\ - 1.6 \end{smallmatrix} ) \times 10^{-4}$	842
$K^- \pi^+ \pi^0$	[c] $(14.1 \pm 0.5 ) \%$	S=1.2 844
$K^- \rho^+$	$(11.0 \pm 0.7 ) \%$	675
$K^- \rho(1700)^+$ ,	$( 8.0 \pm 1.7 ) \times 10^{-3}$	†
$\rho(1700)^+ \rightarrow \pi^+ \pi^0$		
$K^*(892)^- \pi^+$ ,	$( 2.25 \begin{smallmatrix} + 0.36 \\ - 0.20 \end{smallmatrix} ) \%$	711
$K^*(892)^- \rightarrow K^- \pi^0$		
$\bar{K}^*(892)^0 \pi^0$ ,	$( 1.91 \pm 0.24 ) \%$	711
$\bar{K}^*(892)^0 \rightarrow K^- \pi^+$		
$K_0^*(1430)^- \pi^+$ ,	$( 4.6 \pm 2.2 ) \times 10^{-3}$	378
$K_0^*(1430)^- \rightarrow K^- \pi^0$		
$\bar{K}_0^*(1430)^0 \pi^0$ ,	$( 5.8 \begin{smallmatrix} + 4.6 \\ - 1.5 \end{smallmatrix} ) \times 10^{-3}$	379
$\bar{K}_0^*(1430)^0 \rightarrow K^- \pi^+$		
$K^*(1680)^- \pi^+$ ,	$( 1.8 \pm 0.7 ) \times 10^{-3}$	46
$K^*(1680)^- \rightarrow K^- \pi^0$		
$K^- \pi^+ \pi^0$ nonresonant	$( 1.13 \begin{smallmatrix} + 0.54 \\ - 0.20 \end{smallmatrix} ) \%$	844
$K_S^0 \pi^0 \pi^0$	—	843
$\bar{K}^*(892)^0 \pi^0$ ,	$( 6.3 \begin{smallmatrix} + 1.8 \\ - 1.5 \end{smallmatrix} ) \times 10^{-3}$	711
$\bar{K}^*(892)^0 \rightarrow K_S^0 \pi^0$		
$K_S^0 \pi^0 \pi^0$ nonresonant	$( 4.2 \pm 1.1 ) \times 10^{-3}$	843
$K^- \pi^+ \pi^+ \pi^-$	[c] $( 7.72 \pm 0.28 ) \%$	S=1.3 812
$K^- \pi^+ \rho^0$ total	$( 6.4 \pm 0.4 ) \%$	609
$K^- \pi^+ \rho^0$ 3-body	$( 4.9 \pm 2.2 ) \times 10^{-3}$	609
$\bar{K}^*(892)^0 \rho^0$ ,	$( 1.00 \pm 0.22 ) \%$	416
$\bar{K}^*(892)^0 \rightarrow K^- \pi^+$		
$K^- a_1(1260)^+$ ,	$( 3.6 \pm 0.6 ) \%$	327
$a_1(1260)^+ \rightarrow \pi^+ \pi^+ \pi^-$		
$\bar{K}^*(892)^0 \pi^+ \pi^-$ total,	$( 1.5 \pm 0.4 ) \%$	685
$\bar{K}^*(892)^0 \rightarrow K^- \pi^+$		
$\bar{K}^*(892)^0 \pi^+ \pi^-$ 3-body,	$( 9.7 \pm 2.1 ) \times 10^{-3}$	685
$\bar{K}^*(892)^0 \rightarrow K^- \pi^+$		
$K_1(1270)^- \pi^+$ ,	[e] $( 2.9 \pm 0.3 ) \times 10^{-3}$	484
$K_1(1270)^- \rightarrow K^- \pi^+ \pi^-$		
$K^- \pi^+ \pi^+ \pi^-$ nonresonant	$( 1.80 \pm 0.25 ) \%$	812
$K_S^0 \pi^+ \pi^- \pi^0$	[c] $( 5.3 \pm 0.6 ) \%$	812
$K_S^0 \eta, \eta \rightarrow \pi^+ \pi^- \pi^0$	$( 8.6 \pm 1.4 ) \times 10^{-4}$	772
$K_S^0 \omega, \omega \rightarrow \pi^+ \pi^- \pi^0$	$( 9.8 \pm 1.8 ) \times 10^{-3}$	670

$K^*(892)^- \rho^+$ ,	( 2.1 ± 0.8 ) %	416
$K^*(892)^- \rightarrow K_S^0 \pi^-$		
$K_1(1270)^- \pi^+$ ,	[e] ( 2.2 ± 0.6 ) × 10 <sup>-3</sup>	484
$K_1(1270)^- \rightarrow K_S^0 \pi^- \pi^0$		
$\bar{K}^*(892)^0 \pi^+ \pi^-$ 3-body,	( 2.4 ± 0.5 ) × 10 <sup>-3</sup>	685
$\bar{K}^*(892)^0 \rightarrow K_S^0 \pi^0$		
$K_S^0 \pi^+ \pi^- \pi^0$ nonresonant	( 1.1 ± 1.1 ) %	812
$K^- \pi^+ \pi^+ \pi^- \pi^0$	( 4.1 ± 0.4 ) %	771
$\bar{K}^*(892)^0 \pi^+ \pi^- \pi^0$ ,	( 1.2 ± 0.6 ) %	643
$\bar{K}^*(892)^0 \rightarrow K^- \pi^+$		
$K^- \pi^+ \omega$ , $\omega \rightarrow \pi^+ \pi^- \pi^0$	( 2.7 ± 0.5 ) %	605
$\bar{K}^*(892)^0 \omega$ ,	( 6.5 ± 2.4 ) × 10 <sup>-3</sup>	410
$\bar{K}^*(892)^0 \rightarrow K^- \pi^+$ ,		
$\omega \rightarrow \pi^+ \pi^- \pi^0$		
$K_S^0 \eta \pi^0$	( 5.2 ± 1.2 ) × 10 <sup>-3</sup>	721
$K_S^0 a_0(980)$ , $a_0(980) \rightarrow \eta \pi^0$	( 6.2 ± 2.0 ) × 10 <sup>-3</sup>	–
$\bar{K}^*(892)^0 \eta$ , $\bar{K}^*(892)^0 \rightarrow$	( 1.5 ± 0.5 ) × 10 <sup>-3</sup>	–
$K_S^0 \pi^0$		
$K_S^0 2\pi^+ 2\pi^-$	( 2.75 ± 0.31 ) × 10 <sup>-3</sup>	768
$K_S^0 \rho^0 \pi^+ \pi^-$ , no $K^*(892)^-$	( 1.1 ± 0.7 ) × 10 <sup>-3</sup>	–
$K^*(892)^- \pi^+ \pi^+ \pi^-$ ,	( 5 ± 8 ) × 10 <sup>-4</sup>	642
$K^*(892)^- \rightarrow K_S^0 \pi^-$ ,		
no $\rho^0$		
$K^*(892)^- \rho^0 \pi^+$ ,	( 1.7 ± 0.7 ) × 10 <sup>-3</sup>	230
$K^*(892)^- \rightarrow K_S^0 \pi^-$		
$K_S^0 2\pi^+ 2\pi^-$ nonresonant	< 1.3 × 10 <sup>-3</sup> CL=90%	768
$K^- 3\pi^+ 2\pi^-$	( 2.1 ± 0.5 ) × 10 <sup>-4</sup>	713

Fractions of many of the following modes with resonances have already appeared above as submodes of particular charged-particle modes. (Modes for which there are only upper limits and  $\bar{K}^*(892)\rho$  submodes only appear below.)

$K_S^0 \eta$	( 3.8 ± 0.6 ) × 10 <sup>-3</sup>	772
$K_S^0 \omega$	( 1.10 ± 0.20 ) %	670
$K_S^0 \eta'(958)$	( 9.1 ± 1.4 ) × 10 <sup>-3</sup>	565
$K^- a_1(1260)^+$	( 7.5 ± 1.1 ) %	327
$\bar{K}^0 a_1(1260)^0$	< 1.9 % CL=90%	322
$K^- a_2(1320)^+$	< 2 × 10 <sup>-3</sup> CL=90%	197
$\bar{K}^*(892)^0 \pi^+ \pi^-$ total	( 2.3 ± 0.5 ) %	685
$\bar{K}^*(892)^0 \pi^+ \pi^-$ 3-body	( 1.46 ± 0.32 ) %	685
$\bar{K}^*(892)^0 \rho^0$	( 1.50 ± 0.33 ) %	417
$\bar{K}^*(892)^0 \rho^0$ transverse	( 1.6 ± 0.5 ) %	417
$\bar{K}^*(892)^0 \rho^0$ S-wave	( 2.9 ± 0.6 ) %	417

$\bar{K}^*(892)^0 \rho^0$ S-wave long.	< 3	$\times 10^{-3}$ CL=90%	417
$\bar{K}^*(892)^0 \rho^0$ P-wave	< 3	$\times 10^{-3}$ CL=90%	417
$\bar{K}^*(892)^0 \rho^0$ D-wave	( 2.0 $\pm$ 0.6 ) %		417
$K^*(892)^- \rho^+$	( 6.4 $\pm$ 2.5 ) %		417
$K^*(892)^- \rho^+$ longitudinal	( 3.1 $\pm$ 1.2 ) %		417
$K^*(892)^- \rho^+$ transverse	( 3.4 $\pm$ 2.0 ) %		417
$K^*(892)^- \rho^+$ P-wave	< 1.5	% CL=90%	417
$K_1(1270)^- \pi^+$	[e] ( 1.12 $\pm$ 0.31 ) %		484
$K_1(1400)^- \pi^+$	< 1.2	% CL=90%	386
$\bar{K}_1(1400)^0 \pi^0$	< 3.7	% CL=90%	387
$\bar{K}^*(892)^0 \pi^+ \pi^- \pi^0$	( 1.8 $\pm$ 0.9 ) %		643
$K^- \pi^+ \omega$	( 3.0 $\pm$ 0.6 ) %		605
$\bar{K}^*(892)^0 \omega$	( 1.1 $\pm$ 0.4 ) %		410
$K^- \pi^+ \eta'(958)$	( 7.2 $\pm$ 1.8 ) $\times 10^{-3}$		479
$\bar{K}^*(892)^0 \eta'(958)$	< 1.1	$\times 10^{-3}$ CL=90%	118

### Hadronic modes with three K's

$K_S^0 K^+ K^-$	( 4.58 $\pm$ 0.34 ) $\times 10^{-3}$		544
$K_S^0 a_0(980)^0, a_0^0 \rightarrow K^+ K^-$	( 3.0 $\pm$ 0.4 ) $\times 10^{-3}$		—
$K^- a_0(980)^+, a_0^+ \rightarrow K^+ K_S^0$	( 6.1 $\pm$ 1.8 ) $\times 10^{-4}$		—
$K^+ a_0(980)^-, a_0^- \rightarrow K^- K_S^0$	< 1.1	$\times 10^{-4}$ CL=95%	—
$K_S^0 f_0(980), f_0 \rightarrow K^+ K^-$	< 1.0	$\times 10^{-4}$ CL=95%	—
$K_S^0 \phi, \phi \rightarrow K^+ K^-$	( 2.10 $\pm$ 0.16 ) $\times 10^{-3}$		520
$K_S^0 f_0(1400), f_0 \rightarrow K^+ K^-$	( 1.7 $\pm$ 1.1 ) $\times 10^{-4}$		—
$3K_S^0$	( 9.3 $\pm$ 1.3 ) $\times 10^{-4}$		538
$K^+ K^- K^- \pi^+$	( 2.11 $\pm$ 0.31 ) $\times 10^{-4}$		434
$K^+ K^- \bar{K}^*(892)^0,$ $\bar{K}^*(892)^0 \rightarrow K^- \pi^+$	( 4.2 $\pm$ 1.7 ) $\times 10^{-5}$		†
$K^- \pi^+ \phi, \phi \rightarrow K^+ K^-$	( 3.8 $\pm$ 1.6 ) $\times 10^{-5}$		422
$\phi \bar{K}^*(892)^0,$ $\phi \rightarrow K^+ K^-,$ $\bar{K}^*(892)^0 \rightarrow K^- \pi^+$	( 1.01 $\pm$ 0.20 ) $\times 10^{-4}$		†
$K^+ K^- K^- \pi^+$ nonresonant	( 3.2 $\pm$ 1.4 ) $\times 10^{-5}$		434
$K_S^0 K_S^0 K^\pm \pi^\mp$	( 6.1 $\pm$ 1.3 ) $\times 10^{-4}$		427

### Pionic modes

$\pi^+ \pi^-$	( 1.364 $\pm$ 0.032 ) $\times 10^{-3}$		922
$\pi^0 \pi^0$	( 7.9 $\pm$ 0.8 ) $\times 10^{-4}$		922
$\pi^+ \pi^- \pi^0$	( 1.31 $\pm$ 0.06 ) %		907
$\rho^+ \pi^-$	( 10.0 $\pm$ 0.6 ) $\times 10^{-3}$		764
$\rho^0 \pi^0$	( 3.2 $\pm$ 0.4 ) $\times 10^{-3}$		764
$\rho^- \pi^+$	( 4.5 $\pm$ 0.4 ) $\times 10^{-3}$		764
$f_0(980) \pi^0, f_0(980) \rightarrow$ $\pi^+ \pi^-$	< 3.4	$\times 10^{-6}$ CL=95%	—

$f_0(600)\pi^0, f_0(600) \rightarrow$	$< 2.7$	$\times 10^{-5}$ CL=95%	–
$\pi^+\pi^-$			
$(\pi^+\pi^-)_{S\text{-wave}}\pi^0$	$< 2.5$	$\times 10^{-4}$ CL=95%	907
$3\pi^0$	$< 3.5$	$\times 10^{-4}$ CL=90%	908
$2\pi^+2\pi^-$	$( 7.31 \pm 0.27 )$	$\times 10^{-3}$	879
$\pi^+\pi^-2\pi^0$	$( 9.8 \pm 0.9 )$	$\times 10^{-3}$	882
$\eta\pi^0$	[ $\eta$ ] $( 5.6 \pm 1.4 )$	$\times 10^{-4}$	846
$\omega\pi^0$	[ $\eta$ ] $< 2.6$	$\times 10^{-4}$ CL=90%	761
$2\pi^+2\pi^-\pi^0$	$( 4.1 \pm 0.5 )$	$\times 10^{-3}$	844
$\eta\pi^+\pi^-$	[ $\eta$ ] $< 1.9$	$\times 10^{-3}$ CL=90%	827
$\omega\pi^+\pi^-$	[ $\eta$ ] $( 1.6 \pm 0.5 )$	$\times 10^{-3}$	738
$3\pi^+3\pi^-$	$( 4.0 \pm 1.1 )$	$\times 10^{-4}$	795

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

$K^+K^-$	$( 3.84 \pm 0.10 )$	$\times 10^{-3}$	791
$2K_S^0$	$( 3.7 \pm 0.7 )$	$\times 10^{-4}$	788
$K_S^0K^-\pi^+$	$( 3.4 \pm 0.5 )$	$\times 10^{-3}$ S=1.1	739
$\bar{K}^*(892)^0K_S^0,$	$< 6$	$\times 10^{-4}$ CL=90%	608
$\bar{K}^*(892)^0 \rightarrow K^-\pi^+$			
$K^*(892)^+K^-, K^*(892)^+ \rightarrow$	$( 1.2 \pm 0.3 )$	$\times 10^{-3}$	610
$K_S^0\pi^+$			
$K_S^0K^-\pi^+$ nonresonant	$( 1.1 \pm 1.1 )$	$\times 10^{-3}$	739
$K_S^0K^+\pi^-$	$( 2.6 \pm 0.5 )$	$\times 10^{-3}$	739
$K^*(892)^0K_S^0, K^*(892)^0 \rightarrow$	$< 3$	$\times 10^{-4}$ CL=90%	608
$K^+\pi^-$			
$K^*(892)^-K^+, K^*(892)^- \rightarrow$	$( 7 \pm 4 )$	$\times 10^{-4}$	610
$K_S^0\pi^-$			
$K_S^0K^+\pi^-$ nonresonant	$( 1.9 \pm 1.1 )$	$\times 10^{-3}$	739
$K^+K^-\pi^0$	$( 1.3 \pm 0.4 )$	$\times 10^{-3}$	743
$K_S^0K_S^0\pi^0$	$< 5.9$	$\times 10^{-4}$	740
$K^+K^-\pi^+\pi^-$	[ $o$ ] $( 2.32 \pm 0.13 )$	$\times 10^{-3}$	676
$\phi\pi^+\pi^-$ 3-body, $\phi \rightarrow$	$( 2.3 \pm 2.3 )$	$\times 10^{-5}$	614
$K^+K^-$			
$\phi\rho^0, \phi \rightarrow K^+K^-$	$( 6.7 \pm 0.6 )$	$\times 10^{-4}$	250
$K^+K^-\rho^0$ 3-body	$( 5 \pm 7 )$	$\times 10^{-5}$	302
$f_0(980)\pi^+\pi^-, f_0 \rightarrow K^+K^-$	$( 3.5 \pm 0.9 )$	$\times 10^{-4}$	–
$K^*(892)^0K^\mp\pi^\pm$ 3-body,	[ $p$ ] $( 2.5 \pm 0.5 )$	$\times 10^{-4}$	531
$K^{*0} \rightarrow K^\pm\pi^\mp$			
$K^*(892)^0\bar{K}^*(892)^0, K^{*0} \rightarrow$	$( 7 \pm 5 )$	$\times 10^{-5}$	272
$K^\pm\pi^\mp$			
$K_1(1270)^\pm K^\mp,$	$( 7.6 \pm 1.7 )$	$\times 10^{-4}$	–
$K_1(1270)^\pm \rightarrow K^\pm\pi^+\pi^-$			
$K_1(1400)^\pm K^\mp,$	$( 5.1 \pm 1.2 )$	$\times 10^{-4}$	–
$K_1(1400)^\pm \rightarrow K^\pm\pi^+\pi^-$			

$K_S^0 K_S^0 \pi^+ \pi^-$	$( 1.26 \pm 0.24 ) \times 10^{-3}$	673
$K_S^0 K^- \pi^+ \pi^+ \pi^-$	$< 1.5 \times 10^{-4}$ CL=90%	595
$K^+ K^- \pi^+ \pi^- \pi^0$	$( 3.1 \pm 2.0 ) \times 10^{-3}$	600

Fractions of most of the following modes with resonances have already appeared above as submodes of particular charged-particle modes.

$\bar{K}^*(892)^0 K_S^0$	$< 8 \times 10^{-4}$ CL=90%	608
$K^*(892)^+ K^-$	$( 3.7 \pm 0.8 ) \times 10^{-3}$	610
$K^*(892)^0 K_S^0$	$< 4 \times 10^{-4}$ CL=90%	608
$K^*(892)^- K^+$	$( 2.0 \pm 1.1 ) \times 10^{-3}$	610
$\phi \pi^0$	$( 7.4 \pm 0.5 ) \times 10^{-4}$	644
$\phi \eta$	$( 1.4 \pm 0.4 ) \times 10^{-4}$	489
$\phi \omega$	$< 2.1 \times 10^{-3}$ CL=90%	237

### Radiative modes

$\rho^0 \gamma$	$< 2.4 \times 10^{-4}$ CL=90%	771
$\omega \gamma$	$< 2.4 \times 10^{-4}$ CL=90%	768
$\phi \gamma$	$( 2.4 \begin{smallmatrix} + 0.7 \\ - 0.6 \end{smallmatrix} ) \times 10^{-5}$	654
$\bar{K}^*(892)^0 \gamma$	$< 7.6 \times 10^{-4}$ CL=90%	719

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

$K^+ \ell^- \bar{\nu}_\ell$ (via $\bar{D}^0$ )	C2M	$< 1.8 \times 10^{-4}$ CL=90%	—
$K^+$ or $K^*(892)^+ e^- \bar{\nu}_e$ (via $\bar{D}^0$ )	C2M	$< 6 \times 10^{-5}$ CL=90%	—
$K^+ \pi^-$	DC	$( 1.43 \pm 0.04 ) \times 10^{-4}$	861
$K^+ \pi^-$ (via $\bar{D}^0$ )	C2M	$< 1.5 \times 10^{-5}$ CL=95%	861
$K_S^0 \pi^+ \pi^-$ (in $D^0 \rightarrow \bar{D}^0$ )	C2M	$< 1.8 \times 10^{-4}$ CL=95%	—
$K^*(892)^+ \pi^-$ , $K^*(892)^+ \rightarrow K_S^0 \pi^+$	DC	$( 10 \begin{smallmatrix} + 12 \\ - 4 \end{smallmatrix} ) \times 10^{-5}$	711
$K^+ \pi^- \pi^0$	DC	$( 3.29 \begin{smallmatrix} + 0.30 \\ - 0.27 \end{smallmatrix} ) \times 10^{-4}$	844
$K^+ \pi^- \pi^+ \pi^-$	DC	$( 2.49 \begin{smallmatrix} + 0.21 \\ - 0.19 \end{smallmatrix} ) \times 10^{-4}$	812
$K^+ \pi^- \pi^+ \pi^-$ (via $\bar{D}^0$ )	C2M	$< 4 \times 10^{-4}$ CL=90%	812
$\mu^-$ anything (via $\bar{D}^0$ )	C2M	$< 4 \times 10^{-4}$ CL=90%	—

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

$\gamma \gamma$	C1	$< 2.6 \times 10^{-5}$ CL=90%	932
$e^+ e^-$	C1	$< 1.2 \times 10^{-6}$ CL=90%	932
$\mu^+ \mu^-$	C1	$< 1.3 \times 10^{-6}$ CL=90%	926
$\pi^0 e^+ e^-$	C1	$< 4.5 \times 10^{-5}$ CL=90%	927
$\pi^0 \mu^+ \mu^-$	C1	$< 1.8 \times 10^{-4}$ CL=90%	915

$\eta e^+ e^-$	<i>CI</i>	< 1.1	$\times 10^{-4}$ CL=90%	852
$\eta \mu^+ \mu^-$	<i>CI</i>	< 5.3	$\times 10^{-4}$ CL=90%	838
$\pi^+ \pi^- e^+ e^-$	<i>CI</i>	< 3.73	$\times 10^{-4}$ CL=90%	922
$\rho^0 e^+ e^-$	<i>CI</i>	< 1.0	$\times 10^{-4}$ CL=90%	771
$\pi^+ \pi^- \mu^+ \mu^-$	<i>CI</i>	< 3.0	$\times 10^{-5}$ CL=90%	894
$\rho^0 \mu^+ \mu^-$	<i>CI</i>	< 2.2	$\times 10^{-5}$ CL=90%	754
$\omega e^+ e^-$	<i>CI</i>	< 1.8	$\times 10^{-4}$ CL=90%	768
$\omega \mu^+ \mu^-$	<i>CI</i>	< 8.3	$\times 10^{-4}$ CL=90%	751
$K^- K^+ e^+ e^-$	<i>CI</i>	< 3.15	$\times 10^{-4}$ CL=90%	791
$\phi e^+ e^-$	<i>CI</i>	< 5.2	$\times 10^{-5}$ CL=90%	654
$K^- K^+ \mu^+ \mu^-$	<i>CI</i>	< 3.3	$\times 10^{-5}$ CL=90%	709
$\phi \mu^+ \mu^-$	<i>CI</i>	< 3.1	$\times 10^{-5}$ CL=90%	631
$\overline{K}^0 e^+ e^-$		[ <i>g</i> ] < 1.1	$\times 10^{-4}$ CL=90%	866
$\overline{K}^0 \mu^+ \mu^-$		[ <i>g</i> ] < 2.6	$\times 10^{-4}$ CL=90%	852
$K^- \pi^+ e^+ e^-$	<i>CI</i>	< 3.85	$\times 10^{-4}$ CL=90%	861
$\overline{K}^*(892)^0 e^+ e^-$		[ <i>g</i> ] < 4.7	$\times 10^{-5}$ CL=90%	719
$K^- \pi^+ \mu^+ \mu^-$	<i>CI</i>	< 3.59	$\times 10^{-4}$ CL=90%	829
$\overline{K}^*(892)^0 \mu^+ \mu^-$		[ <i>g</i> ] < 2.4	$\times 10^{-5}$ CL=90%	700
$\pi^+ \pi^- \pi^0 \mu^+ \mu^-$	<i>CI</i>	< 8.1	$\times 10^{-4}$ CL=90%	863
$\mu^\pm e^\mp$	<i>LF</i>	[ <i>h</i> ] < 8.1	$\times 10^{-7}$ CL=90%	929
$\pi^0 e^\pm \mu^\mp$	<i>LF</i>	[ <i>h</i> ] < 8.6	$\times 10^{-5}$ CL=90%	924
$\eta e^\pm \mu^\mp$	<i>LF</i>	[ <i>h</i> ] < 1.0	$\times 10^{-4}$ CL=90%	848
$\pi^+ \pi^- e^\pm \mu^\mp$	<i>LF</i>	[ <i>h</i> ] < 1.5	$\times 10^{-5}$ CL=90%	911
$\rho^0 e^\pm \mu^\mp$	<i>LF</i>	[ <i>h</i> ] < 4.9	$\times 10^{-5}$ CL=90%	767
$\omega e^\pm \mu^\mp$	<i>LF</i>	[ <i>h</i> ] < 1.2	$\times 10^{-4}$ CL=90%	764
$K^- K^+ e^\pm \mu^\mp$	<i>LF</i>	[ <i>h</i> ] < 1.8	$\times 10^{-4}$ CL=90%	754
$\phi e^\pm \mu^\mp$	<i>LF</i>	[ <i>h</i> ] < 3.4	$\times 10^{-5}$ CL=90%	648
$\overline{K}^0 e^\pm \mu^\mp$	<i>LF</i>	[ <i>h</i> ] < 1.0	$\times 10^{-4}$ CL=90%	862
$K^- \pi^+ e^\pm \mu^\mp$	<i>LF</i>	[ <i>h</i> ] < 5.53	$\times 10^{-4}$ CL=90%	848
$\overline{K}^*(892)^0 e^\pm \mu^\mp$	<i>LF</i>	[ <i>h</i> ] < 8.3	$\times 10^{-5}$ CL=90%	714
$\pi^- \pi^- e^+ e^+ + \text{c.c.}$	<i>L</i>	< 1.12	$\times 10^{-4}$ CL=90%	922
$\pi^- \pi^- \mu^+ \mu^+ + \text{c.c.}$	<i>L</i>	< 2.9	$\times 10^{-5}$ CL=90%	894
$K^- \pi^- e^+ e^+ + \text{c.c.}$	<i>L</i>	< 2.06	$\times 10^{-4}$ CL=90%	861
$K^- \pi^- \mu^+ \mu^+ + \text{c.c.}$	<i>L</i>	< 3.9	$\times 10^{-4}$ CL=90%	829
$K^- K^- e^+ e^+ + \text{c.c.}$	<i>L</i>	< 1.52	$\times 10^{-4}$ CL=90%	791
$K^- K^- \mu^+ \mu^+ + \text{c.c.}$	<i>L</i>	< 9.4	$\times 10^{-5}$ CL=90%	709
$\pi^- \pi^- e^+ \mu^+ + \text{c.c.}$	<i>L</i>	< 7.9	$\times 10^{-5}$ CL=90%	911
$K^- \pi^- e^+ \mu^+ + \text{c.c.}$	<i>L</i>	< 2.18	$\times 10^{-4}$ CL=90%	848
$K^- K^- e^+ \mu^+ + \text{c.c.}$	<i>L</i>	< 5.7	$\times 10^{-5}$ CL=90%	754

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

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

$I, J, P$  need confirmation.

Mass  $m = 2006.7 \pm 0.4$  MeV ( $S = 1.1$ )  
 $m_{D^{*0}} - m_{D^0} = 142.12 \pm 0.07$  MeV  
 Full width  $\Gamma < 2.1$  MeV, CL = 90%

$\bar{D}^*(2007)^0$  modes are charge conjugates of modes below.

$D^*(2007)^0$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$D^0 \pi^0$	(61.9±2.9) %	43
$D^0 \gamma$	(38.1±2.9) %	137

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

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

$I, J, P$  need confirmation.

Mass  $m = 2010.0 \pm 0.4$  MeV ( $S = 1.1$ )  
 $m_{D^*(2010)^+} - m_{D^+} = 140.64 \pm 0.10$  MeV ( $S = 1.1$ )  
 $m_{D^*(2010)^+} - m_{D^0} = 145.421 \pm 0.010$  MeV ( $S = 1.1$ )  
 Full width  $\Gamma = 96 \pm 22$  keV

$D^*(2010)^-$  modes are charge conjugates of the modes below.

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

### $D_1(2420)^0$

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

$I, J, P$  need confirmation.

Mass  $m = 2422.3 \pm 1.3$  MeV ( $S = 1.2$ )  
 $m_{D_1^0} - m_{D^{*+}} = 411.7 \pm 0.8$   
 Full width  $\Gamma = 20.4 \pm 1.7$  MeV

$\bar{D}_1(2420)^0$  modes are charge conjugates of modes below.

$D_1(2420)^0$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$D^*(2010)^+ \pi^-$	seen	355
$D^0 \pi^+ \pi^-$	seen	426
$D^+ \pi^-$	not seen	474
$D^{*0} \pi^+ \pi^-$	not seen	281

**$D_2^*(2460)^0$** 

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

 $J^P = 2^+$  assignment strongly favored.

Mass  $m = 2461.1 \pm 1.6$  MeV (S = 1.3)

$m_{D_2^{*0}} - m_{D^+} = 593.9 \pm 0.8$

Full width  $\Gamma = 43 \pm 4$  MeV (S = 1.8)

 $\bar{D}_2^*(2460)^0$  modes are charge conjugates of modes below.

<b><math>D_2^*(2460)^0</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$D^+ \pi^-$	seen	506
$D^*(2010)^+ \pi^-$	seen	389
$D^0 \pi^+ \pi^-$	not seen	462
$D^{*0} \pi^+ \pi^-$	not seen	325

 **$D_2^*(2460)^\pm$** 

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

 $J^P = 2^+$  assignment strongly favored.

Mass  $m = 2459 \pm 4$  MeV (S = 1.7)

$m_{D_2^*(2460)^\pm} - m_{D_2^*(2460)^0} = 2.4 \pm 1.7$  MeV

Full width  $\Gamma = 29 \pm 5$  MeV

 $D_2^*(2460)^\pm$  modes are charge conjugates of modes below.

<b><math>D_2^*(2460)^\pm</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$D^0 \pi^+$	seen	507
$D^{*0} \pi^+$	seen	390
$D^+ \pi^+ \pi^-$	not seen	456
$D^{*+} \pi^+ \pi^-$	not seen	319



## 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] This is a weighted average of  $D^\pm$  (44%) and  $D^0$  (56%) branching fractions. See “ $D^+$  and  $D^0 \rightarrow (\eta \text{ anything}) / (\text{total } D^+ \text{ and } D^0)$ ” under “ $D^+$  Branching Ratios” in the Particle Listings.
- [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  $K^- \pi^+ \pi^+$  mode are uncertain: see the Particle Listings.
- [e] The two experiments measuring this fraction are in serious disagreement. See the Particle Listings.
- [f] This is *not* a test for the  $\Delta C=1$  weak neutral current, but leads to the  $\pi^+ e^+ e^-$  final state.
- [g] This mode is not a useful test for a  $\Delta C=1$  weak neutral current because both quarks must change flavor in this decay.
- [h] The value is for the sum of the charge states or particle/antiparticle states indicated.
- [i] This  $D_1^0 - D_2^0$  limit is inferred from the  $D^0 - \bar{D}^0$  mixing ratio  $\Gamma(K^+ \pi^- (\text{via } \bar{D}^0)) / \Gamma(K^- \pi^+)$  near the end of the  $D^0$  Listings.
- [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  $K^- \pi^+ \pi^+ \pi^-$ ,  $K^- \pi^+ \pi^+ \pi^- \pi^0$ ,  $\bar{K}^0 2\pi^+ 2\pi^-$ ,  $2\pi^+ 2\pi^-$ ,  $2\pi^+ 2\pi^- \pi^0$ ,  $K^+ K^- \pi^+ \pi^-$ , and  $K^+ K^- \pi^+ \pi^- \pi^0$ , branching fractions.
- [l] 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  $6.14 \pm 0.20$  %.
- [m] This is a doubly Cabibbo-suppressed mode.
- [n] This branching fraction includes all the decay modes of the resonance in the final state.
- [o] The experiments on the division of this charge mode amongst its submodes disagree, and the submode branching fractions here add up to considerably more than the charged-mode fraction.
- [p] However, these upper limits are in serious disagreement with values obtained in another experiment.