# CHARMED, STRANGE MESONS ($C = \pm 1$, $S = \pm 1$) (including possibly non-$q\overline{q}$ states)

$D_s^+ = c\overline{s}$, $D_s^- = \overline{c}s$, similarly for $D_s^*$'s

## $D_s^\pm$

$I(J^P) = 0(0^-)$

Mass $m = 1968.35 \pm 0.07$ MeV
$m_{D_s^\pm} - m_{D^\pm} = 98.69 \pm 0.05$ MeV
Mean life $\tau = (501.2 \pm 2.2) \times 10^{-15}$ s (S = 1.3)
$c\tau = 150.3$ $\mu$m

### *CP*-violating decay-rate asymmetries

$A_{CP}(\mu^\pm\nu) = (-0.2 \pm 2.5)\%$
$A_{CP}(\tau^\pm\nu)$ in $D_s^+ \to \tau^+\nu_\tau$, $D_s^- \to \tau^-\overline{\nu}_\tau = (3 \pm 5)\%$
$A_{CP}(K^\pm K_S^0) = (0.09 \pm 0.26)\%$
$A_{CP}(K^\pm K_L^0)$ in $D_s^\pm \to K^\pm K_L^0 = (-1.1 \pm 2.7) \times 10^{-2}$
$A_{CP}(K^+K^-\pi^\pm) = (-0.5 \pm 0.9)\%$
$A_{CP}(\phi\pi^\pm) = (-0.38 \pm 0.27)\%$
$A_{CP}(K^\pm K_S^0\pi^0) = (-2 \pm 6)\%$
$A_{CP}(2K_S^0\pi^\pm) = (3 \pm 5)\%$
$A_{CP}(K^+K^-\pi^\pm\pi^0) = (0.0 \pm 3.0)\%$
$A_{CP}(K^\pm K_S^0\pi^+\pi^-) = (-6 \pm 5)\%$
$A_{CP}(K_S^0 K^\mp 2\pi^\pm) = (4.1 \pm 2.8)\%$
$A_{CP}(\pi^+\pi^-\pi^\pm) = (-0.7 \pm 3.1)\%$
$A_{CP}(\pi^\pm\eta) = (0.32 \pm 0.31)\%$
$A_{CP}(\pi^\pm\eta') = (-0.06 \pm 0.22)\%$ (S = 1.6)
$A_{CP}(\eta\pi^\pm\pi^0) = (-1 \pm 4)\%$
$A_{CP}(\eta'\pi^\pm\pi^0) = (0 \pm 8)\%$
$A_{CP}(K^\pm\pi^0) = (2 \pm 4)\%$ (S = 1.2)
$A_{CP}(\overline{K}^0/K^0\pi^\pm) = (0.4 \pm 0.5)\%$
$A_{CP}(K_S^0\pi^\pm) = (0.20 \pm 0.18)\%$
$A_{CP}(K^\pm\pi^+\pi^-) = (3.7 \pm 2.7)\%$
$A_{CP}(K_S^0\pi^+\pi^0)$ in $D_s^\pm \to K_S^0\pi^\pm\pi^0 = (3 \pm 6)\%$
$A_{CP}(K^\pm\pi^+\pi^-\pi^0)$ in $D_s^\pm \to K^\pm\pi^+\pi^-\pi^0 = (7 \pm 5) \times 10^{-2}$
$A_{CP}(K^\pm\eta) = (1.8 \pm 1.9)\%$
$A_{CP}(K^\pm\eta'(958)) = (6 \pm 19)\%$

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

Local *CPV* in $D_s^\pm \to K^+K^-K^\pm = 0.133$
$A_T(K_S^0 K^\pm \pi^+ \pi^-) = (-8 \pm 6) \times 10^{-3}$ [a]

### $D_s^+ \to \phi \ell^+ \nu_\ell$ form factors

$r_2 = 0.83 \pm 0.08$ (S = 1.8)
$r_v = 1.76 \pm 0.07$ (S = 1.1)
$\Gamma_L/\Gamma_T = 0.72 \pm 0.18$
$f_+(0)\,|V_{cs}|$ in $D_s^+ \to \eta e^+ \nu_e = 0.452 \pm 0.010$
$f_+(0)\,|V_{cs}|$ in $D_s^+ \to \eta' e^+ \nu_e = 0.525 \pm 0.026$
$f_+(0)|V_{cd}|$ in $D_s^+ \to K^0 e^+ \nu_e = 0.162 \pm 0.019$
$r_v \equiv V(0)/A_1(0)$ in $D_s^+ \to K^*(892)^0 e^+ \nu_e = 1.7 \pm 0.4$
$r_2 \equiv A_2(0)/A_1(0)$ in $D_s^+ \to K^*(892)^0 e^+ \nu_e = 0.77 \pm 0.29$
$f_{D_s^+}\,|V_{cs}|$ in $D_s^+ \to \mu^+ \nu_\mu = 241.8 \pm 3.3$ MeV
$f_{D_s^+}\,|V_{cs}|$ in $D_s^+ \to \tau^+ \nu_\tau = 246.6 \pm 2.5$ MeV

Unless otherwise noted, the branching fractions for modes with a resonance in the final state include all the decay modes of the resonance. $D_s^-$ modes are charge conjugates of the modes below.

| $D_s^+$ DECAY MODES | | Fraction ($\Gamma_i/\Gamma$) | Scale factor/ Confidence level | $p$ (MeV/$c$) |
|---|---|---|---|---|
| **Inclusive modes** | | | | |
| $e^+$ semileptonic | [b] | ( 6.33 ±0.15 ) % | | – |
| $\pi^+$ anything | | (119.3 ±1.4 ) % | | – |
| $\pi^-$ anything | | ( 43.2 ±0.9 ) % | | – |
| $\pi^0$ anything | | (123 ±7 ) % | | – |
| $K^-$ anything | | ( 18.7 ±0.5 ) % | | – |
| $K^+$ anything | | ( 28.9 ±0.7 ) % | | – |
| $K_S^0$ anything | | ( 19.0 ±1.1 ) % | | – |
| $\eta$ anything | [c] | ( 29.9 ±2.8 ) % | | – |
| $\omega$ anything | | ( 6.1 ±1.4 ) % | | – |
| $\eta'$ anything | [d] | ( 10.3 ±1.4 ) % | S=1.1 | – |
| $f_0(980)$ anything, $f_0 \to \pi^+\pi^-$ | | < 1.3 % | CL=90% | – |
| $\phi$ anything | | ( 15.7 ±1.0 ) % | | – |
| $K^+K^-$ anything | | ( 15.8 ±0.7 ) % | | – |
| $K_S^0 K^+$ anything | | ( 5.8 ±0.5 ) % | | – |
| $K_S^0 K^-$ anything | | ( 1.9 ±0.4 ) % | | – |
| $2K_S^0$ anything | | ( 1.70 ±0.32 ) % | | – |
| $2K^+$ anything | | < 2.6 | $\times 10^{-3}$ CL=90% | – |
| $2K^-$ anything | | < 6 | $\times 10^{-4}$ CL=90% | – |
| $2\pi^+\pi^-$ + anything | | ( 32.8 ±0.7 ) % | | – |

## Leptonic and semileptonic modes

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $e^+\nu_e$ | | $<$ | 8.3 | | $\times 10^{-5}$ | CL=90% | 984 |
| $\mu^+\nu_\mu$ | | ( | 5.35 | $\pm 0.12$ ) | $\times 10^{-3}$ | | 981 |
| $\tau^+\nu_\tau$ | | ( | 5.36 | $\pm 0.10$ ) | % | | 182 |
| $\gamma e^+\nu_e$ | | $<$ | 1.3 | | $\times 10^{-4}$ | CL=90% | 984 |
| $K^+K^-e^+\nu_e$ | | | — | | | | 851 |
| $K_S^0K_S^0e^+\nu_e$ | | $<$ | 3.8 | | $\times 10^{-4}$ | CL=90% | 849 |
| $\phi e^+\nu_e$ | [e] | ( | 2.39 | $\pm 0.16$ ) | % | S=1.3 | 720 |
| $K_1(1270)^0e^+\nu_e$ | | $<$ | 4.1 | | $\times 10^{-4}$ | CL=90% | 585 |
| $b_1(1235)^0e^+\nu_e$, $b_1^0 \to \omega\pi^0$ | | $<$ | 6.4 | | $\times 10^{-4}$ | CL=90% | – |
| $\phi\mu^+\nu_\mu$ | | ( | 2.24 | $\pm 0.11$ ) | % | | 715 |
| $\eta e^+\nu_e + \eta'(958)e^+\nu_e$ | [e] | ( | 3.03 | $\pm 0.24$ ) | % | | – |
| $\eta e^+\nu_e$ | [e] | ( | 2.26 | $\pm 0.06$ ) | % | | 908 |
| $\eta'(958)e^+\nu_e$ | [e] | ( | 8.0 | $\pm 0.4$ ) | $\times 10^{-3}$ | | 751 |
| $\eta\mu^+\nu_\mu$ | | ( | 2.4 | $\pm 0.5$ ) | % | | 905 |
| $\eta'(958)\mu^+\nu_\mu$ | | ( | 1.1 | $\pm 0.5$ ) | % | | 747 |
| $\omega e^+\nu_e$ | [f] | $<$ | 2.0 | | $\times 10^{-3}$ | CL=90% | 829 |
| $K^0e^+\nu_e$ | | ( | 3.4 | $\pm 0.4$ ) | $\times 10^{-3}$ | | 921 |
| $K^*(892)^0e^+\nu_e$ | [e] | ( | 2.15 | $\pm 0.28$ ) | $\times 10^{-3}$ | S=1.1 | 782 |
| $f_0(500)e^+\nu_e$, $f_0 \to \pi^0\pi^0$ | | $<$ | 7.3 | | $\times 10^{-4}$ | CL=90% | – |
| $f_0(980)e^+\nu_e$, $f_0 \to \pi^0\pi^0$ | | ( | 7.9 | $\pm 1.5$ ) | $\times 10^{-4}$ | | – |
| $f_0(980)\mu^+\nu_\mu$, $f_0 \to K^+K^-$ | | $<$ | 5.45 | | $\times 10^{-4}$ | CL=90% | – |
| $a_0(980)^0e^+\nu_e$, $a_0^0 \to \pi^0\eta$ | | $<$ | 1.2 | | $\times 10^{-4}$ | CL=90% | – |
| $\pi^0e^+\nu_e$ | | $<$ | 6.4 | | $\times 10^{-5}$ | CL=90% | 980 |

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

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $K^+K_S^0$ | | ( | 1.450 | $\pm 0.035$ ) | % | | 850 |
| $K^+K_L^0$ | | ( | 1.49 | $\pm 0.06$ ) | % | | 850 |
| $K^+\overline{K}^0$ | | ( | 2.95 | $\pm 0.14$ ) | % | | 850 |
| $K^+K^-\pi^+$ | [g] | ( | 5.37 | $\pm 0.10$ ) | % | S=1.1 | 805 |
| $\phi\pi^+$ | [e,h] | ( | 4.5 | $\pm 0.4$ ) | % | | 712 |
| $\phi\pi^+$, $\phi \to K^+K^-$ | [h] | ( | 2.21 | $\pm 0.06$ ) | % | | 712 |
| $K^+\overline{K}^*(892)^0$ | | ( | 12.7 | $^{+4.0}_{-3.1}$ ) | % | | 685 |
| $K^+\overline{K}^*(892)^0$, $\overline{K}^{*0} \to K^-\pi^+$ | | ( | 2.58 | $\pm 0.06$ ) | % | | 416 |
| $K^+\overline{K}^*(892)^0$, $\overline{K}^{*0} \to K_S^0\pi^0$ | | ( | 4.8 | $\pm 0.5$ ) | $\times 10^{-3}$ | | – |
| $f_0(980)\pi^+$, $f_0 \to K^+K^-$ | | ( | 1.11 | $\pm 0.19$ ) | % | | 732 |
| $f_0(1370)\pi^+$, $f_0 \to K^+K^-$ | | ( | 7.1 | $\pm 2.9$ ) | $\times 10^{-4}$ | | – |
| $f_0(1710)\pi^+$, $f_0 \to K^+K^-$ | | ( | 6.7 | $\pm 2.8$ ) | $\times 10^{-4}$ | | 198 |
| $a_0(980)^+\pi^0$, $a_0^+ \to K^+K_S^0$ | | ( | 1.1 | $\pm 0.4$ ) | $\times 10^{-3}$ | | – |
| $a_0(1710)^+\pi^0$, $a_0^+ \to K^+K_S^0$ | | ( | 3.5 | $\pm 0.6$ ) | $\times 10^{-3}$ | | – |

| | | | | | |
|---|---|---|---|---|---|
| $K^+\overline{K}_0^*(1430)^0,\ \overline{K}_0^* \to K^-\pi^+$ | | ( 1.76 ±0.25 ) × $10^{-3}$ | | | 218 |
| $K^+\overline{K}^*(1410)^0,\ \overline{K}_0^* \to K_S^0\pi^0$ | | ( 8.8 ±2.8 ) × $10^{-4}$ | | | – |
| $K^+K_S^0\pi^0$ | | ( 1.47 ±0.07 ) % | | | 805 |
| $K^*(892)^+K_S^0,\ K^{*+} \to K^+\pi^0$ | | ( 2.04 ±0.33 ) × $10^{-3}$ | | | – |
| $2K_S^0\pi^+$ | | ( 7.1 ±0.4 ) × $10^{-3}$ | | S=1.3 | 802 |
| $f_0(980)\pi^+,\ f_0 \to K_S^0K_S^0$ | | < 1.8 | × $10^{-4}$ | CL=90% | – |
| $f_0(1710)\pi^+,\ f_0 \to K_S^0K_S^0$ | | ( 3.3 ±0.4 ) × $10^{-3}$ | | | – |
| $K^*(892)^+K_S^0,\ K^{*+} \to K_S^0\pi^+$ | | ( 3.09 ±0.33 ) × $10^{-3}$ | | | 683 |
| $K^0\overline{K}^0\pi^+$ | | — | | | 802 |
| $K^*(892)^+\overline{K}^0$ | [e] | ( 5.4 ±1.2 ) % | | | 683 |
| $K^+K^-\pi^+\pi^0$ | | ( 5.50 ±0.24 ) % | | S=1.3 | 748 |
| $\phi\rho^+$ | [e] | ( 5.59 ±0.34 ) % | | | 401 |
| $\overline{K}_1(1270)^0K^+,\ \overline{K}_1(1270)^0 \to K^-\rho^+$ | | ( 5.7 ±0.6 ) × $10^{-3}$ | | | – |
| $\overline{K}_1(1270)^0K^+,\ \overline{K}_1(1270)^0 \to K^*(892)\pi$ | | ( 1.31 ±0.25 ) % | | | – |
| $\overline{K}_1(1400)^0K^+,\ \overline{K}_1(1400)^0 \to K^*(892)\pi$ | | ( 2.0 ±0.4 ) % | | | – |
| $a_0(980)^0\rho^+,\ a_0^0 \to K^+K^-$ | | ( 1.9 ±0.4 ) × $10^{-3}$ | | | – |
| $f_1(1420)^0\pi^+,\ f_1(1420)^0 \to K^*(892)^\mp K^\pm$ | | ( 3.9 ±0.7 ) × $10^{-3}$ | | | – |
| $f_1(1420)^0\pi^+,\ f_1(1420)^0 \to a_0(980)^0\pi^0,\ a_0(980)^0 \to K^+K^-$ | | ( 4.0 ±1.4 ) × $10^{-4}$ | | | – |
| $\eta(1475)\pi^+,\ \eta(1475) \to a_0(980)^0\pi^0,\ a_0(980)^0 \to K^+K^-$ | | ( 7.0 ±2.8 ) × $10^{-4}$ | | | – |
| $K_S^0K^-2\pi^+$ | | ( 1.53 ±0.08 ) % | | S=1.5 | 744 |
| $K^+K^-K_S^0\pi^+$ | | ( 1.29 ±0.18 ) × $10^{-4}$ | | | 527 |
| $K^*(892)^+\overline{K}^*(892)^0$ | [e] | ( 5.64 ±0.35 ) % | | | 417 |
| $\eta(1475)K_S^0,\ \eta \to K^*(892)^0\pi^+,\ K^{*0} \to K^-\pi^+$ | | ( 3.4 ±1.0 ) × $10^{-4}$ | | | – |
| $\eta(1475)\pi^+,\ \eta \to \overline{K}^*(892)^+K^-,\ \overline{K}^{*+} \to K_S^0\pi^+$ | | ( 3.4 ±1.0 ) × $10^{-4}$ | | | – |
| $\eta(1475)\pi^+,\ \eta \to a_0(980)^-\pi^+,\ a_0^- \to K_S^0K^-$ | | ( 1.7 ±0.9 ) × $10^{-3}$ | | | – |

| | | | | | | |
|---|---|---|---|---|---|---|
| $f_1(1285)\pi^+,\ f_1 \to a_0(980)^-\pi^+,\ a_0^- \to K_S^0 K^-$ | | ( 3.4 | $\pm 0.8$ ) $\times 10^{-4}$ | | | – |
| $K^+ K_S^0 \pi^+\pi^-$ | | ( 9.5 | $\pm 0.8$ ) $\times 10^{-3}$ | | S=1.1 | 744 |
| $K^+ K^- 2\pi^+\pi^-$ | | ( 6.6 | $\pm 0.6$ ) $\times 10^{-3}$ | | | 673 |
| $\phi 2\pi^+\pi^-$ | [e] | ( 1.21 | $\pm 0.16$ ) % | | | 640 |
| $\phi\rho^0\pi^+,\ \phi \to K^+K^-$ | | ( 4.9 | $\pm 0.7$ ) $\times 10^{-3}$ | | | 181 |
| $\phi a_1(1260)^+,\ \phi \to K^+K^-,\ a_1^+ \to \rho^0\pi^+$ | | ( 7.4 | $\pm 1.2$ ) $\times 10^{-3}$ | | | † |
| $\phi 2\pi^+\pi^-$ non-$\rho,\ \phi \to K^+K^-$ | | ( 1.4 | $\pm 0.5$ ) $\times 10^{-3}$ | | | – |
| $K^+ K^- \rho^0\pi^+$ non-$\phi$ | | < 2.0 | | $\times 10^{-4}$ | CL=90% | 249 |
| $K^+ K^- 2\pi^+\pi^-$ nonresonant | | ( 1.0 | $\pm 0.4$ ) $\times 10^{-3}$ | | | 673 |
| $2K_S^0 2\pi^+\pi^-$ | | ( 7.8 | $\pm 3.3$ ) $\times 10^{-4}$ | | | 669 |

## Hadronic modes without $K$'s

| | | | | | | |
|---|---|---|---|---|---|---|
| $\pi^+\pi^0$ | | < 1.2 | | $\times 10^{-4}$ | CL=90% | 975 |
| $2\pi^+\pi^-$ | | ( 1.08 | $\pm 0.04$ ) % | | | 959 |
| $\rho^0\pi^+$ | | ( 1.12 | $\pm 0.17$ ) $\times 10^{-4}$ | | | 825 |
| $\pi^+(\pi^+\pi^-)_{S-\text{wave}}$ | [i] | ( 9.12 | $\pm 0.35$ ) $\times 10^{-3}$ | | | 959 |
| $f_2(1270)\pi^+,\ f_2 \to \pi^+\pi^-$ | | ( 1.40 | $\pm 0.11$ ) $\times 10^{-3}$ | | | 559 |
| $f_2'(1525)^0\pi^+,\ f_2' \to \pi^+\pi^-$ | | ( 5.7 | $\pm 2.0$ ) $\times 10^{-6}$ | | | – |
| $\rho(1450)^0\pi^+,\ \rho^0 \to \pi^+\pi^-$ | | ( 1.8 | $\pm 0.6$ ) $\times 10^{-4}$ | | | 421 |
| $\rho(1700)^0\pi^+,\ \rho^0 \to \pi^+\pi^-$ | | ( 4 | $\pm 4$ ) $\times 10^{-5}$ | | | – |
| $\pi^+ 2\pi^0$ | | ( 5.2 | $\pm 0.5$ ) $\times 10^{-3}$ | | S=1.1 | 961 |
| $f_0(980)\pi^+,\ f_0 \to \pi^0\pi^0$ | | ( 2.9 | $\pm 0.6$ ) $\times 10^{-3}$ | | | – |
| $f_0(1370)\pi^+,\ f_0 \to \pi^0\pi^0$ | | ( 1.3 | $\pm 0.6$ ) $\times 10^{-3}$ | | | – |
| $f_2(1270)\pi^+,\ f_2 \to \pi^0\pi^0$ | | ( 5.0 | $\pm 3.5$ ) $\times 10^{-4}$ | | | – |
| $2\pi^+\pi^-\pi^0$ | | | — | | | 935 |
| $\eta\pi^+$ | [e] | ( 1.67 | $\pm 0.09$ ) % | | S=1.1 | 902 |
| $\omega\pi^+$ | [e] | ( 1.92 | $\pm 0.30$ ) $\times 10^{-3}$ | | | 822 |
| $\omega\pi^+,\ \omega \to \pi^+\pi^-$ | | ( 3.9 | $\pm 0.5$ ) $\times 10^{-5}$ | | | – |
| $3\pi^+ 2\pi^-$ | | ( 7.8 | $\pm 0.8$ ) $\times 10^{-3}$ | | | 899 |
| $2\pi^+\pi^- 2\pi^0$ | | | — | | | 902 |
| $\eta\rho^+$ | [e] | ( 8.9 | $\pm 0.8$ ) % | | | 724 |
| $\eta\pi^+\pi^0$ | | ( 9.5 | $\pm 0.5$ ) % | | | 885 |
| $\eta(\pi^+\pi^0)_{\ P-wave}$ | | ( 5.1 | $\pm 3.1$ ) $\times 10^{-3}$ | | | 885 |
| $a_0(980)^{+0}\pi^{0+},\ a_0(980)^{+0} \to \eta\pi^{+0}$ | | ( 2.2 | $\pm 0.4$ ) % | | | – |
| $\omega\pi^+\pi^0$ | [e] | ( 2.8 | $\pm 0.7$ ) % | | | 802 |
| $2\pi^+\pi^-\eta$ | | ( 3.12 | $\pm 0.16$ ) % | | | 855 |

| | | | | |
|---|---|---|---|---|
| $a_1(1260)^+\eta$, $a_1^+ \to$ $\rho(770)^0\pi^+$, $\rho^0 \to$ $\pi^+\pi^-$ | | ( 1.73 ±0.16 ) % | | – |
| $a_1(1260)^+\eta$, $a_1^+ \to$ $f_0(500)\pi^+$, $f_0 \to \pi^+\pi^-$ | | ( 2.5 ±0.9 ) $\times 10^{-3}$ | | – |
| $a_0(980)^+\rho(770)^0$, $a_0^+ \to$ $\eta\pi^+$ | | ( 2.1 ±0.9 ) $\times 10^{-3}$ | | – |
| $\eta(1405)\pi^+$, $\eta(1405) \to$ $a_0(980)^-\pi^+$, $a_0^- \to$ $\eta\pi^-$ | | ( 2.2 ±0.7 ) $\times 10^{-4}$ | | – |
| $\eta(1405)\pi^+$, $\eta(1405) \to$ $a_0(980)^+\pi^-$, $a_0^+ \to$ $\eta\pi^+$ | | ( 2.2 ±0.7 ) $\times 10^{-4}$ | | – |
| $f_1(1420)\pi^+$, $f_1 \to$ $a_0(980)^-\pi^+$, $a_0^- \to$ $\eta\pi^-$ | | ( 5.9 ±1.8 ) $\times 10^{-4}$ | | – |
| $f_1(1420)\pi^+$, $f_1 \to$ $a_0(980)^+\pi^-$, $a_0^+ \to$ $\eta\pi^+$ | | ( 5.3 ±1.8 ) $\times 10^{-4}$ | | – |
| $3\pi^+2\pi^-\pi^0$ | | ( 4.9 ±3.2 ) % | | 856 |
| $\omega 2\pi^+\pi^-$ | [e] | ( 1.6 ±0.5 ) % | | 766 |
| $\eta'(958)\pi^+$ | [d,e] | ( 3.94 ±0.25 ) % | | 743 |
| $3\pi^+2\pi^-2\pi^0$ | | — | | 803 |
| $\omega\eta\pi^+$ | [e] | ( 5.4 ±1.3 ) $\times 10^{-3}$ | | 654 |
| $\eta'(958)\rho^+$ | [d,e] | ( 5.8 ±1.5 ) % | | 465 |
| $\eta'(958)\pi^+\pi^0$ | | ( 6.08 ±0.29 ) % | | 720 |
| $\eta'(958)\pi^+\pi^0$ nonresonant | | < 5.1 % | CL=90% | 720 |

**Modes with one or three $K$'s**

| | | | | |
|---|---|---|---|---|
| $K^+\pi^0$ | | ( 7.4 ±0.5 ) $\times 10^{-4}$ | | 917 |
| $K^0_S\pi^+$ | | ( 1.09 ±0.05 ) $\times 10^{-3}$ | | 916 |
| $K^+\eta$ | [e] | ( 1.73 ±0.08 ) $\times 10^{-3}$ | | 835 |
| $K^+\omega$ | [e] | ( 9.9 ±1.5 ) $\times 10^{-4}$ | | 741 |
| $K^+\eta'(958)$ | [e] | ( 2.64 ±0.24 ) $\times 10^{-3}$ | | 646 |
| $K^+\pi^+\pi^-$ | | ( 6.20 ±0.19 ) $\times 10^{-3}$ | | 900 |
| $K^+\rho^0$ | | ( 2.17 ±0.25 ) $\times 10^{-3}$ | | 745 |
| $K^+\rho(1450)^0$, $\rho^0 \to \pi^+\pi^-$ | | ( 7.2 ±1.7 ) $\times 10^{-4}$ | | – |
| $K^+ f_0(500)$, $f_0 \to \pi^+\pi^-$ | | ( 4.5 ±3.0 ) $\times 10^{-4}$ | | – |
| $K^+ f_0(980)$, $f_0 \to \pi^+\pi^-$ | | ( 2.8 ±1.1 ) $\times 10^{-4}$ | | – |
| $K^+ f_0(1370)$, $f_0 \to \pi^+\pi^-$ | | ( 1.2 ±0.6 ) $\times 10^{-3}$ | | – |
| $K^*(892)^0\pi^+$, $K^{*0} \to$ $K^+\pi^-$ | | ( 1.67 ±0.26 ) $\times 10^{-3}$ | | 775 |
| $K^*(1410)^0\pi^+$, $K^{*0} \to$ $K^+\pi^-$ | | ( 6 ±4 ) $\times 10^{-4}$ | | – |

| | | | |
|---|---|---|---|
| $K^*(1430)^0\pi^+,\ K^{*0}\to K^+\pi^-$ | ( 9.3 ±3.1 ) × $10^{-4}$ | | – |
| $K^+\pi^+\pi^-$ nonresonant | ( 9.9 ±3.2 ) × $10^{-4}$ | | 900 |
| $K^0_S\pi^+\pi^0$ | ( 5.38 ±0.32 ) × $10^{-3}$ | | 899 |
| $K^0_S\rho(770)^+,\ \rho^+\to\pi^+\pi^0$ | ( 2.7 ±0.5 ) × $10^{-3}$ | | – |
| $K^0_S\rho(1450)^+,\ \rho^+\to\pi^+\pi^0$ | ( 1.10 ±0.34 ) × $10^{-3}$ | | – |
| $K^*(892)^0\pi^+,\ K^{*0}\to K^0_S\pi^0$ | ( 4.5 ±1.3 ) × $10^{-4}$ | | – |
| $K^*(892)^+\pi^0,\ K^{*+}\to K^0_S\pi^+$ | ( 2.5 ±0.8 ) × $10^{-4}$ | | – |
| $K^*(1410)^0\pi^+,\ K^{*0}\to K^0_S\pi^0$ | ( 1.8 ±0.9 ) × $10^{-4}$ | | – |
| $K^0_S 2\pi^+\pi^-$ | ( 2.8 ±1.0 ) × $10^{-3}$ | | 870 |
| $K^+\pi^+\pi^-\pi^0$ | ( 9.7 ±0.6 ) × $10^{-3}$ | | 873 |
| $K^*(892)^0\rho^+,\ K^{*0}\to K^+\pi^-$ | ( 3.9 ±0.4 ) × $10^{-3}$ | | – |
| $K^*(892)^+\rho^0,\ K^{*+}\to K^+\pi^0$ | ( 4.2 ±1.2 ) × $10^{-4}$ | | – |
| $K_1(1270)^0\pi^+,\ K_1^0\to K^+\rho^-$ | ( 3.9 ±1.3 ) × $10^{-4}$ | | † |
| $K_1(1400)^0\pi^+,\ K_1^0\to K^*(890)^+\pi^-,\ K^{*+}\to K^+\pi^0$ | ( 5.4 ±0.9 ) × $10^{-4}$ | | – |
| $K_1(1400)^0\pi^+,\ K_1^0\to K^*(890)^0\pi^0,\ K^{*0}\to K^+\pi^-$ | ( 5.9 ±1.0 ) × $10^{-4}$ | | – |
| $K^+a_1(1260)^0,\ a_1\to\rho^+\pi^-$ | ( 1.8 ±1.1 ) × $10^{-4}$ | | – |
| $K^+a_1(1260)^0,\ a_1\to\rho^-\pi^+$ | ( 1.8 ±1.1 ) × $10^{-4}$ | | – |
| $K^+\pi^+\pi^-\pi^0$ nonresonant | ( 9.2 ±2.4 ) × $10^{-4}$ | | 873 |
| $(K^+\pi^0)_{\ P-wave}\rho^0$ | ( 1.01 ±0.21 ) × $10^{-3}$ | | 688 |
| $K^+\omega\pi^0$ | [e] < 8.2 × $10^{-3}$ | CL=90% | 684 |
| $K^+\omega\pi^+\pi^-$ | [e] < 5.4 × $10^{-3}$ | CL=90% | 603 |
| $K^+\omega\eta$ | [e] < 7.9 × $10^{-3}$ | CL=90% | 366 |
| $2K^+K^-$ | ( 2.15 ±0.20 ) × $10^{-4}$ | | 628 |
| $\phi K^+,\ \phi\to K^+K^-$ | ( 8.8 ±2.0 ) × $10^{-5}$ | | – |

## Doubly Cabibbo-suppressed modes

| | | | |
|---|---|---|---|
| $2K^+\pi^-$ | ( 1.274±0.031) × $10^{-4}$ | | 805 |
| $K^+K^*(892)^0,\ K^{*0}\to K^+\pi^-$ | ( 6.0 ±3.4 ) × $10^{-5}$ | | – |

## Baryon-antibaryon mode

| | | | |
|---|---|---|---|
| $p\overline{n}$ | ( 1.22 ±0.11 ) × $10^{-3}$ | | 295 |
| $p\overline{p}e^+\nu_e$ | < 2.0 × $10^{-4}$ | CL=90% | 296 |

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

| | | | | | | |
|---|---|---|---|---|---|---|
| $\pi^+ e^+ e^-$ | | [j] | < | 5.5 | $\times 10^{-6}$ CL=90% | 979 |
| $\pi^+ \phi,\ \phi \to\ e^+ e^-$ | | [k] | ( | $6\ ^{+8}_{-4}$ ) $\times 10^{-6}$ | | – |
| $\pi^+ \mu^+ \mu^-$ | | [j] | < | 1.8 | $\times 10^{-7}$ CL=90% | 968 |
| $K^+ e^+ e^-$ | *C1* | | < | 3.7 | $\times 10^{-6}$ CL=90% | 922 |
| $K^+ \mu^+ \mu^-$ | *C1* | | < | 1.4 | $\times 10^{-7}$ CL=90% | 909 |
| $K^*(892)^+ \mu^+ \mu^-$ | *C1* | | < | 1.4 | $\times 10^{-3}$ CL=90% | 765 |
| $\pi^+ e^+ \mu^-$ | *LF* | | < | 1.1 | $\times 10^{-6}$ CL=90% | 976 |
| $\pi^+ e^- \mu^+$ | *LF* | | < | 9.4 | $\times 10^{-7}$ CL=90% | 976 |
| $K^+ e^+ \mu^-$ | *LF* | | < | 7.9 | $\times 10^{-7}$ CL=90% | 919 |
| $K^+ e^- \mu^+$ | *LF* | | < | 5.6 | $\times 10^{-7}$ CL=90% | 919 |
| $\pi^- 2e^+$ | *L* | | < | 1.4 | $\times 10^{-6}$ CL=90% | 979 |
| $\pi^- 2\mu^+$ | *L* | | < | 8.6 | $\times 10^{-8}$ CL=90% | 968 |
| $\pi^- e^+ \mu^+$ | *L* | | < | 6.3 | $\times 10^{-7}$ CL=90% | 976 |
| $K^- 2e^+$ | *L* | | < | 7.7 | $\times 10^{-7}$ CL=90% | 922 |
| $K^- 2\mu^+$ | *L* | | < | 2.6 | $\times 10^{-8}$ CL=90% | 909 |
| $K^- e^+ \mu^+$ | *L* | | < | 2.6 | $\times 10^{-7}$ CL=90% | 919 |
| $K^*(892)^- 2\mu^+$ | *L* | | < | 1.4 | $\times 10^{-3}$ CL=90% | 765 |

## $D_s^{*\pm}$

$I(J^P) = 0(1^-)$

Mass $m = 2112.2 \pm 0.4$ MeV
$m_{D_s^{*\pm}} - m_{D_s^{\pm}} = 143.8 \pm 0.4$ MeV
Full width $\Gamma < 1.9$ MeV, CL = 90%

$D_s^{*-}$ modes are charge conjugates of the modes below.

| $D_s^{*+}$ DECAY MODES | Fraction ($\Gamma_i/\Gamma$) | $p$ (MeV/$c$) |
|---|---|---|
| $D_s^+ \gamma$ | (93.6 ±0.4 ) % | 139 |
| $D_s^+ \pi^0$ | ( 5.77±0.35) % | 48 |
| $D_s^+ e^+ e^-$ | ( 6.7 ±1.6 ) $\times 10^{-3}$ | 139 |
| $e^+ \nu_e$ | ( 2.1 $^{+1.2}_{-0.9}$ ) $\times 10^{-5}$ | 1056 |

## $D_{s0}^*(2317)^{\pm}$

$I(J^P) = 0(0^+)$
*J*, *P* need confirmation.
$J^P$ is natural, low mass consistent with $0^+$.

See the review on "Heavy Non-$q\overline{q}$ Mesons."

Mass $m = 2317.8 \pm 0.5$ MeV
$m_{D^*_{s0}(2317)^\pm} - m_{D^\pm_s} = 349.4 \pm 0.5$ MeV
Full width $\Gamma < 3.8$ MeV, CL = 95%

$D^*_{s0}(2317)^-$ modes are charge conjugates of modes below.

| $D^*_{s0}(2317)^\pm$ DECAY MODES | Fraction ($\Gamma_i/\Gamma$) | Confidence level | $p$ (MeV/$c$) |
|---|---|---|---|
| $D^+_s\pi^0$ | $(100^{+\ 0}_{-20})$ % | | 298 |
| $D^+_s\gamma$ | $< 5$ % | 90% | 323 |
| $D^*_s(2112)^+\gamma$ | $< 6$ % | 90% | – |
| $D^+_s\gamma\gamma$ | $< 18$ % | 95% | 323 |
| $D^*_s(2112)^+\pi^0$ | $< 11$ % | 90% | – |
| $D^+_s\pi^+\pi^-$ | $< 4 \times 10^{-3}$ | 90% | 194 |
| $D^+_s\pi^0\pi^0$ | not seen | | 205 |

## $D_{s1}(2460)^\pm$

$I(J^P) = 0(1^+)$

See the review on "Heavy Non-$q\overline{q}$ Mesons."
Mass $m = 2459.5 \pm 0.6$ MeV (S = 1.1)
$m_{D_{s1}(2460)^\pm} - m_{D^{*\pm}_s} = 347.3 \pm 0.7$ MeV (S = 1.2)
$m_{D_{s1}(2460)^\pm} - m_{D^\pm_s} = 491.1 \pm 0.6$ MeV (S = 1.1)
Full width $\Gamma < 3.5$ MeV, CL = 95%

$D_{s1}(2460)^-$ modes are charge conjugates of the modes below.

| $D_{s1}(2460)^+$ DECAY MODES | Fraction ($\Gamma_i/\Gamma$) | Scale factor/ Confidence level | $p$ (MeV/$c$) |
|---|---|---|---|
| $D^{*+}_s\pi^0$ | $(48 \pm 11)$ % | | 297 |
| $D^+_s\gamma$ | $(18 \pm 4)$ % | | 442 |
| $D^+_s\pi^+\pi^-$ | $(4.3 \pm 1.3)$ % | S=1.1 | 363 |
| $D^{*+}_s\gamma$ | $< 8$ % | CL=90% | 323 |
| $D^*_{s0}(2317)^+\gamma$ | $(3.7^{+\ 5.0}_{-\ 2.4})$ % | | 138 |

## $D_{s1}(2536)^\pm$

$I(J^P) = 0(1^+)$
$J$, $P$ need confirmation.

Mass $m = 2535.11 \pm 0.06$ MeV
$m_{D_{s1}(2536)^\pm} - m_{D^*_s(2111)} = 422.9 \pm 0.4$ MeV
$m_{D_{s1}(2536)^\pm} - m_{D^*(2010)^\pm} = 524.85 \pm 0.04$ MeV
$m_{D_{s1}(2536)^\pm} - m_{D^*(2007)^0} = 528.26 \pm 0.05$ MeV (S = 1.1)
Full width $\Gamma = 0.92 \pm 0.05$ MeV

Branching fractions are given relative to the one **DEFINED AS 1**.
$D_{s1}(2536)^-$ modes are charge conjugates of the modes below.

| $D_{s1}(2536)^+$ DECAY MODES | Fraction ($\Gamma_i/\Gamma$) | Confidence level | $p$ (MeV/$c$) |
|---|---|---|---|
| $D^*(2010)^+ K^0$ | 0.85 ±0.12 | | 149 |
| $(D^*(2010)^+ K^0)_{S-wave}$ | 0.61 ±0.09 | | 149 |
| $K^0_S D^*(2010)^+$ | 0.48 ±0.07 | | 149 |
| $D^+ \pi^- K^+$ | 0.028±0.005 | | 176 |
| $D^*(2007)^0 K^+$ | **DEFINED AS 1** | | 167 |
| $D^+ K^0$ | <0.34 | 90% | 381 |
| $D^0 K^+$ | <0.12 | 90% | 391 |
| $D_s^{*+} \gamma$ | possibly seen | | 388 |
| $D_s^+ \pi^+ \pi^-$ | seen | | 437 |

## $D^*_{s2}(2573)$

$I(J^P) = 0(2^+)$

Mass $m = 2569.1 \pm 0.8$ MeV (S = 2.4)
$m_{D^*_{s2}(2573)} - m_{D^0} = 704 \pm 3.2$ MeV
Full width $\Gamma = 16.9 \pm 0.7$ MeV

$D^*_{s2}(2573)^-$ modes are charge conjugates of the modes below.

| $D^*_{s2}(2573)^+$ DECAY MODES | Fraction ($\Gamma_i/\Gamma$) | $p$ (MeV/$c$) |
|---|---|---|
| $D^0 K^+$ | seen | 431 |
| $D^*(2007)^0 K^+$ | not seen | 238 |
| $D^+ K^0_S$ | seen | 422 |
| $D^{*+} K^0_S$ | seen | 225 |

## $D^*_{s1}(2700)^\pm$

$I(J^P) = 0(1^-)$

Mass $m = 2714 \pm 5$ MeV (S = 1.5)
Full width $\Gamma = 122 \pm 10$ MeV

| $D^*_{s1}(2700)^\pm$ DECAY MODES | Fraction ($\Gamma_i/\Gamma$) | $p$ (MeV/$c$) |
|---|---|---|
| $D^0 K^+$ | seen | 579 |
| $D^+ K^0_S$ | seen | 573 |
| $D^{*0} K^+$ | seen | 438 |
| $D^{*+} K^0_S$ | seen | 431 |

## $D_{s3}^{*}(2860)^{\pm}$

$I(J^P) = 0(3^-)$

Mass $m = 2860 \pm 7$ MeV
Full width $\Gamma = 53 \pm 10$ MeV

| $D_{s3}^{*}(2860)^{\pm}$ DECAY MODES | Fraction ($\Gamma_i/\Gamma$) | $p$ (MeV/$c$) |
|---|---|---|
| $D^0 K^+$ | seen | 710 |
| $D^+ K_S^0$ | seen | 704 |
| $D^{*0} K^+$ | seen | 589 |
| $D^{*+} K_S^0$ | seen | 584 |

NOTES

[a] See the Particle Listings for the (complicated) definition of this quantity.

[b] This is the purely $e^+$ semileptonic branching fraction: the $e^+$ fraction from $\tau^+$ decays has been subtracted off. The sum of our (non-$\tau$) $e^+$ exclusive fractions — an $e^+\nu_e$ with an $\eta$, $\eta'$, $\phi$, $K^0$, or $K^{*0}$ — is $5.99 \pm 0.31$ %.

[c] This fraction includes $\eta$ from $\eta'$ decays.

[d] The sum of our exclusive $\eta'$ fractions — $\eta' e^+ \nu_e$, $\eta' \mu^+ \nu_\mu$, $\eta' \pi^+$, $\eta' \rho^+$, and $\eta' K^+$ — is $11.8 \pm 1.6$%.

[e] This branching fraction includes all the decay modes of the final-state resonance.

[f] A test for $u\overline{u}$ or $d\overline{d}$ content in the $D_s^+$. Neither Cabibbo-favored nor Cabibbo-suppressed decays can contribute, and $\omega-\phi$ mixing is an unlikely explanation for any fraction above about $2 \times 10^{-4}$.

[g] 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.

[h] We decouple the $D_s^+ \to \phi\pi^+$ branching fraction obtained from mass projections (and used to get some of the other branching fractions) from the $D_s^+ \to \phi\pi^+$, $\phi \to K^+K^-$ branching fraction obtained from the Dalitz-plot analysis of $D_s^+ \to K^+K^-\pi^+$. That is, the ratio of these two branching fractions is not exactly the $\phi \to K^+K^-$ branching fraction 0.491.

[i] This is the average of a model-independent and a $K$-matrix parametrization of the $\pi^+\pi^-$ $S$-wave and is a sum over several $f_0$ mesons.

[j] This mode is not a useful test for a $\Delta C$=1 weak neutral current because both quarks must change flavor in this decay.

[*k*] This is *not* a test for the $\Delta C$=1 weak neutral current, but leads to the $\pi^+ \ell^+ \ell^-$ final state.