

LIGHT UNFLAVORED MESONS

($S = C = B = 0$)

For $I = 1$ (π , b , ρ , a): $u\bar{d}$, $(u\bar{u}-d\bar{d})/\sqrt{2}$, $d\bar{u}$;
for $I = 0$ (η , η' , h , h' , ω , ϕ , f , f'): $c_1(u\bar{u} + d\bar{d}) + c_2(s\bar{s})$

π^\pm

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

Mass $m = 139.57018 \pm 0.00035$ MeV ($S = 1.2$)

Mean life $\tau = (2.6033 \pm 0.0005) \times 10^{-8}$ s ($S = 1.2$)

$$c\tau = 7.8045 \text{ m}$$

$\pi^\pm \rightarrow \ell^\pm \nu \gamma$ form factors [a]

$$F_V = 0.017 \pm 0.008$$

$$F_A = 0.0115 \pm 0.0005 \quad (S = 1.2)$$

$$R = 0.059^{+0.009}_{-0.008}$$

π^- modes are charge conjugates of the modes below.

For decay limits to particles which are not established, see the appropriate Search sections (Massive Neutrino Peak Search Test, A^0 (axion), and Other Light Boson (X^0) Searches, etc.).

| π^+ DECAY MODES | Fraction (Γ_i/Γ) | Confidence level | $\frac{p}{\text{MeV}/c}$ |
|---------------------------|--|------------------|--------------------------|
| $\mu^+ \nu_\mu$ | [b] (99.98770 \pm 0.00004) % | | 30 |
| $\mu^+ \nu_\mu \gamma$ | [c] (2.00 \pm 0.25) $\times 10^{-4}$ | | 30 |
| $e^+ \nu_e$ | [b] (1.230 \pm 0.004) $\times 10^{-4}$ | | 70 |
| $e^+ \nu_e \gamma$ | [c] (1.61 \pm 0.23) $\times 10^{-7}$ | | 70 |
| $e^+ \nu_e \pi^0$ | (1.036 \pm 0.006) $\times 10^{-8}$ | | 4 |
| $e^+ \nu_e e^+ e^-$ | (3.2 \pm 0.5) $\times 10^{-9}$ | | 70 |
| $e^+ \nu_e \nu \bar{\nu}$ | < 5 $\times 10^{-6}$ | 90% | 70 |

Lepton Family number (LF) or Lepton number (L) violating modes

| | | | | |
|---------------------|------|-----------|----------------------|----|
| $\mu^+ \bar{\nu}_e$ | L | [d] < 1.5 | $\times 10^{-3}$ 90% | 30 |
| $\mu^+ \nu_e$ | LF | [d] < 8.0 | $\times 10^{-3}$ 90% | 30 |
| $\mu^- e^+ e^+ \nu$ | LF | < 1.6 | $\times 10^{-6}$ 90% | 30 |

π^0

$$J^G(J^{PC}) = 1^-(0^{-+})$$

Mass $m = 134.9766 \pm 0.0006$ MeV ($S = 1.1$)

$$m_{\pi^\pm} - m_{\pi^0} = 4.5936 \pm 0.0005 \text{ MeV}$$

Mean life $\tau = (8.4 \pm 0.6) \times 10^{-17}$ s ($S = 3.0$)

$$c\tau = 25.1 \text{ nm}$$

For decay limits to particles which are not established, see the appropriate Search sections (A^0 (axion) and Other Light Boson (X^0) Searches, etc.).

| π^0 DECAY MODES | Fraction (Γ_i/Γ) | Scale factor/ Confidence level | p (MeV/c) |
|--|----------------------------------|-----------------------------------|----------------|
| 2γ | $(98.798 \pm 0.032) \%$ | S=1.1 | 67 |
| $e^+ e^- \gamma$ | $(1.198 \pm 0.032) \%$ | S=1.1 | 67 |
| γ positronium | $(1.82 \pm 0.29) \times 10^{-9}$ | | 67 |
| $e^+ e^+ e^- e^-$ | $(3.14 \pm 0.30) \times 10^{-5}$ | | 67 |
| $e^+ e^-$ | $(6.2 \pm 0.5) \times 10^{-8}$ | | 67 |
| 4γ | $< 2 \times 10^{-8}$ | CL=90% | 67 |
| $\nu \bar{\nu}$ | $[e] < 2.7 \times 10^{-7}$ | CL=90% | 67 |
| $\nu_e \bar{\nu}_e$ | $< 1.7 \times 10^{-6}$ | CL=90% | 67 |
| $\nu_\mu \bar{\nu}_\mu$ | $< 1.6 \times 10^{-6}$ | CL=90% | 67 |
| $\nu_\tau \bar{\nu}_\tau$ | $< 2.1 \times 10^{-6}$ | CL=90% | 67 |
| $\gamma \nu \bar{\nu}$ | $< 6 \times 10^{-4}$ | CL=90% | 67 |
| Charge conjugation (C) or Lepton Family number (LF) violating modes | | | |
| 3γ | C | $< 3.1 \times 10^{-8}$ | CL=90% 67 |
| $\mu^+ e^-$ | LF | $< 3.8 \times 10^{-10}$ | CL=90% 26 |
| $\mu^- e^+$ | LF | $< 3.4 \times 10^{-9}$ | CL=90% 26 |
| $\mu^+ e^- + \mu^- e^+$ | LF | $< 1.72 \times 10^{-8}$ | CL=90% 26 |

η

$$I^G(J^{PC}) = 0^+(0^-+)$$

Mass $m = 547.51 \pm 0.18$ MeV [*f*] (S = 5.8)

Full width $\Gamma = 1.30 \pm 0.07$ keV [*g*]

C-nonconserving decay parameters

| | |
|----------------------|---|
| $\pi^+ \pi^- \pi^0$ | Left-right asymmetry = $(0.09 \pm 0.17) \times 10^{-2}$ |
| $\pi^+ \pi^- \pi^0$ | Sextant asymmetry = $(0.18 \pm 0.16) \times 10^{-2}$ |
| $\pi^+ \pi^- \pi^0$ | Quadrant asymmetry = $(-0.17 \pm 0.17) \times 10^{-2}$ |
| $\pi^+ \pi^- \gamma$ | Left-right asymmetry = $(0.9 \pm 0.4) \times 10^{-2}$ |
| $\pi^+ \pi^- \gamma$ | β (D-wave) = -0.02 ± 0.07 (S = 1.3) |

Dalitz plot parameter

$$\pi^0 \pi^0 \pi^0 \quad \alpha = -0.031 \pm 0.004 \quad (S = 1.1)$$

| η DECAY MODES | Fraction (Γ_i/Γ) | Scale factor/ Confidence level | p (MeV/c) |
|---|---|-----------------------------------|----------------|
| Neutral modes | | | |
| neutral modes | (71.9 \pm 0.5) % | S=1.3 | — |
| 2γ | [g] (39.38 \pm 0.26) % | S=1.2 | 274 |
| $3\pi^0$ | (32.51 \pm 0.28) % | S=1.2 | 179 |
| $\pi^0 2\gamma$ | (4.4 \pm 1.6) $\times 10^{-4}$ | S=2.0 | 257 |
| $\pi^0 \pi^0 \gamma \gamma$ | < 1.2 $\times 10^{-3}$ | CL=90% | 238 |
| other neutral modes | < 2.8 % | CL=90% | — |
| Charged modes | | | |
| charged modes | (28.0 \pm 0.5) % | S=1.3 | — |
| $\pi^+ \pi^- \pi^0$ | (22.7 \pm 0.4) % | S=1.3 | 174 |
| $\pi^+ \pi^- \gamma$ | (4.69 \pm 0.11) % | S=1.2 | 236 |
| $e^+ e^- \gamma$ | (6.0 \pm 0.8) $\times 10^{-3}$ | S=1.4 | 274 |
| $\mu^+ \mu^- \gamma$ | (3.1 \pm 0.4) $\times 10^{-4}$ | | 253 |
| $e^+ e^-$ | < 7.7 $\times 10^{-5}$ | CL=90% | 274 |
| $\mu^+ \mu^-$ | (5.8 \pm 0.8) $\times 10^{-6}$ | | 253 |
| $e^+ e^- e^+ e^-$ | < 6.9 $\times 10^{-5}$ | CL=90% | 274 |
| $\pi^+ \pi^- e^+ e^-$ | (4.0 $^{+5.3}_{-2.5}$) $\times 10^{-4}$ | S=2.1 | 235 |
| $\pi^+ \pi^- 2\gamma$ | < 2.0 $\times 10^{-3}$ | | 236 |
| $\pi^+ \pi^- \pi^0 \gamma$ | < 5 $\times 10^{-4}$ | CL=90% | 174 |
| $\pi^0 \mu^+ \mu^- \gamma$ | < 3 $\times 10^{-6}$ | CL=90% | 210 |
| Charge conjugation (C), Parity (P), Charge conjugation \times Parity (CP), or Lepton Family number (LF) violating modes | | | |
| $\pi^0 \gamma$ | C < 9 $\times 10^{-5}$ | CL=90% | 257 |
| $\pi^+ \pi^-$ | P, CP < 1.3 $\times 10^{-5}$ | CL=90% | 236 |
| $\pi^0 \pi^0$ | P, CP < 4.3 $\times 10^{-4}$ | CL=90% | 238 |
| $\pi^0 \pi^0 \gamma$ | C < 5 $\times 10^{-4}$ | CL=90% | 238 |
| $\pi^0 \pi^0 \pi^0 \gamma$ | C < 6 $\times 10^{-5}$ | CL=90% | 179 |
| 3γ | C < 4 $\times 10^{-5}$ | CL=90% | 274 |
| $4\pi^0$ | P, CP < 6.9 $\times 10^{-7}$ | CL=90% | 40 |
| $\pi^0 e^+ e^-$ | C [h] < 4 $\times 10^{-5}$ | CL=90% | 257 |
| $\pi^0 \mu^+ \mu^-$ | C [h] < 5 $\times 10^{-6}$ | CL=90% | 210 |
| $\mu^+ e^- + \mu^- e^+$ | LF < 6 $\times 10^{-6}$ | CL=90% | 264 |

$f_0(600)$ ^[i]
or σ

$$I^G(J^{PC}) = 0^+(0^{++})$$

Mass $m = (400\text{--}1200)$ MeV

Full width $\Gamma = (600\text{--}1000)$ MeV

| $\rho(600)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|---|--------------------------------|-------------|
| $\pi\pi$ | dominant | — |
| $\gamma\gamma$ | seen | — |

 $\rho(770)$ [J]

$$J^{PC} = 1^{++}(1^{--})$$

Mass $m = 775.5 \pm 0.4$ MeVFull width $\Gamma = 149.4 \pm 1.0$ MeV $\Gamma_{ee} = 7.02 \pm 0.11$ keV

| $\rho(770)$ DECAY MODES | Fraction (Γ_i/Γ) | Scale factor/ Confidence level | p (MeV/c) |
|---|--|-----------------------------------|----------------|
| $\pi\pi$ | ~ 100 | % | 363 |
| $\rho(770)^\pm$ decays | | | |
| $\pi^\pm\gamma$ | $(4.5 \pm 0.5) \times 10^{-4}$ | S=2.2 | 375 |
| $\pi^\pm\eta$ | $< 6 \times 10^{-3}$ | CL=84% | 153 |
| $\pi^\pm\pi^+\pi^-\pi^0$ | $< 2.0 \times 10^{-3}$ | CL=84% | 254 |
| $\rho(770)^0$ decays | | | |
| $\pi^+\pi^-\gamma$ | $(9.9 \pm 1.6) \times 10^{-3}$ | | 362 |
| $\pi^0\gamma$ | $(6.0 \pm 0.8) \times 10^{-4}$ | | 376 |
| $\eta\gamma$ | $(2.95 \pm 0.30) \times 10^{-4}$ | S=1.2 | 194 |
| $\pi^0\pi^0\gamma$ | $(4.5 \pm 0.8) \times 10^{-5}$ | | 363 |
| $\mu^+\mu^-$ | [k] $(4.55 \pm 0.28) \times 10^{-5}$ | | 373 |
| e^+e^- | [k] $(4.70 \pm 0.08) \times 10^{-5}$ | | 388 |
| $\pi^+\pi^-\pi^0$ | $(1.01^{+0.54}_{-0.36} \pm 0.34) \times 10^{-4}$ | | 323 |
| $\pi^+\pi^-\pi^+\pi^-$ | $(1.8 \pm 0.9) \times 10^{-5}$ | | 251 |
| $\pi^+\pi^-\pi^0\pi^0$ | $< 4 \times 10^{-5}$ | CL=90% | 257 |

 $\omega(782)$

$$J^{PC} = 0^{--}(1^{--})$$

Mass $m = 782.65 \pm 0.12$ MeV (S = 1.9)Full width $\Gamma = 8.49 \pm 0.08$ MeV $\Gamma_{ee} = 0.60 \pm 0.02$ keV

| $\omega(782)$ DECAY MODES | Fraction (Γ_i/Γ) | Scale factor/ Confidence level | p (MeV/c) |
|---|---|-----------------------------------|----------------|
| $\pi^+ \pi^- \pi^0$ | (89.1 \pm 0.7) % | S=1.1 | 327 |
| $\pi^0 \gamma$ | (8.90 $^{+0.27}_{-0.23}$) % | S=1.1 | 380 |
| $\pi^+ \pi^-$ | (1.70 \pm 0.27) % | S=1.4 | 366 |
| neutrals (excluding $\pi^0 \gamma$) | (1.6 $^{+7.4}_{-1.1}$) $\times 10^{-3}$ | | — |
| $\eta \gamma$ | (4.9 \pm 0.5) $\times 10^{-4}$ | | 200 |
| $\pi^0 e^+ e^-$ | (7.7 \pm 0.9) $\times 10^{-4}$ | S=1.1 | 380 |
| $\pi^0 \mu^+ \mu^-$ | (9.6 \pm 2.3) $\times 10^{-5}$ | | 349 |
| $e^+ e^-$ | (7.18 \pm 0.12) $\times 10^{-5}$ | S=1.1 | 391 |
| $\pi^+ \pi^- \pi^0 \pi^0$ | < 2 % | CL=90% | 262 |
| $\pi^+ \pi^- \gamma$ | < 3.6 $\times 10^{-3}$ | CL=95% | 366 |
| $\pi^+ \pi^- \pi^+ \pi^-$ | < 1 $\times 10^{-3}$ | CL=90% | 256 |
| $\pi^0 \pi^0 \gamma$ | (6.7 \pm 1.1) $\times 10^{-5}$ | | 367 |
| $\eta \pi^0 \gamma$ | < 3.3 $\times 10^{-5}$ | CL=90% | 163 |
| $\mu^+ \mu^-$ | (9.0 \pm 3.1) $\times 10^{-5}$ | | 377 |
| 3γ | < 1.9 $\times 10^{-4}$ | CL=95% | 391 |

Charge conjugation (C) violating modes

| | | | | |
|--------------|---|----------------------|--------|-----|
| $\eta \pi^0$ | C | < 1 $\times 10^{-3}$ | CL=90% | 163 |
| $3\pi^0$ | C | < 3 $\times 10^{-4}$ | CL=90% | 330 |

 $\eta'(958)$

$$J^{PC} = 0^+(0^-+)$$

Mass $m = 957.78 \pm 0.14$ MeVFull width $\Gamma = 0.203 \pm 0.016$ MeV (S = 1.3)

| $\eta'(958)$ DECAY MODES | Fraction (Γ_i/Γ) | Scale factor/ Confidence level | p (MeV/c) |
|---|--------------------------------------|-----------------------------------|----------------|
| $\pi^+ \pi^- \eta$ | (44.5 \pm 1.4) % | S=1.1 | 232 |
| $\rho^0 \gamma$ (including non-resonant $\pi^+ \pi^- \gamma$) | (29.4 \pm 0.9) % | S=1.1 | 165 |
| $\pi^0 \pi^0 \eta$ | (20.8 \pm 1.2) % | S=1.2 | 239 |
| $\omega \gamma$ | (3.03 \pm 0.31) % | | 159 |
| $\gamma \gamma$ | (2.12 \pm 0.14) % | S=1.3 | 479 |
| $3\pi^0$ | (1.55 \pm 0.26) $\times 10^{-3}$ | | 430 |
| $\mu^+ \mu^- \gamma$ | (1.04 \pm 0.26) $\times 10^{-4}$ | | 467 |
| $\pi^+ \pi^- \pi^0$ | < 5 % | CL=90% | 428 |
| $\pi^0 \rho^0$ | < 4 % | CL=90% | 111 |
| $\pi^+ \pi^+ \pi^- \pi^-$ | < 1 % | CL=90% | 372 |
| $\pi^+ \pi^+ \pi^- \pi^-$ neutrals | < 1 % | CL=95% | — |

| | | | | |
|--------------------------------------|---------|------------------|--------|-----|
| $\pi^+\pi^+\pi^-\pi^-\pi^0$ | < 1 | % | CL=90% | 298 |
| 6π | < 1 | % | CL=90% | 211 |
| $\pi^+\pi^-\mathrm{e}^+\mathrm{e}^-$ | < 6 | $\times 10^{-3}$ | CL=90% | 458 |
| $\gamma\mathrm{e}^+\mathrm{e}^-$ | < 9 | $\times 10^{-4}$ | CL=90% | 479 |
| $\pi^0\gamma\gamma$ | < 8 | $\times 10^{-4}$ | CL=90% | 469 |
| $4\pi^0$ | < 5 | $\times 10^{-4}$ | CL=90% | 380 |
| $\mathrm{e}^+\mathrm{e}^-$ | < 2.1 | $\times 10^{-7}$ | CL=90% | 479 |

**Charge conjugation (C), Parity (P),
Lepton family number (LF) violating modes**

| | | | | | |
|---------------------------------|---------|---------|------------------|--------|-----|
| $\pi^+\pi^-$ | P, CP | < 2 | % | CL=90% | 458 |
| $\pi^0\pi^0$ | P, CP | < 9 | $\times 10^{-4}$ | CL=90% | 459 |
| $\pi^0\mathrm{e}^+\mathrm{e}^-$ | C [h] | < 1.4 | $\times 10^{-3}$ | CL=90% | 469 |
| $\eta\mathrm{e}^+\mathrm{e}^-$ | C [h] | < 2.4 | $\times 10^{-3}$ | CL=90% | 322 |
| 3γ | C | < 1.0 | $\times 10^{-4}$ | CL=90% | 479 |
| $\mu^+\mu^-\pi^0$ | C [h] | < 6.0 | $\times 10^{-5}$ | CL=90% | 445 |
| $\mu^+\mu^-\eta$ | C [h] | < 1.5 | $\times 10^{-5}$ | CL=90% | 274 |
| $\mathrm{e}\mu$ | LF | < 4.7 | $\times 10^{-4}$ | CL=90% | 473 |

$f_0(980)$ ^[1]

$$I^G(J^{PC}) = 0^+(0^{++})$$

Mass $m = 980 \pm 10$ MeV

Full width $\Gamma = 40$ to 100 MeV

| $f_0(980)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|--|--------------------------------|-------------|
| $\pi\pi$ | dominant | 471 |
| $K\bar{K}$ | seen | † |
| $\gamma\gamma$ | seen | 490 |

$a_0(980)$ ^[1]

$$I^G(J^{PC}) = 1^-(0^{++})$$

Mass $m = 984.7 \pm 1.2$ MeV ($S = 1.5$)

Full width $\Gamma = 50$ to 100 MeV

| $a_0(980)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|--|--------------------------------|-------------|
| $\eta\pi$ | dominant | 322 |
| $K\bar{K}$ | seen | † |
| $\gamma\gamma$ | seen | 492 |

$\phi(1020)$

$$I^G(J^{PC}) = 0^-(1^{--})$$

Mass $m = 1019.460 \pm 0.019$ MeV

Full width $\Gamma = 4.26 \pm 0.05$ MeV ($S = 1.7$)

| $\phi(1020)$ DECAY MODES | Fraction (Γ_i/Γ) | Scale factor/ Confidence level | p (MeV/c) |
|-----------------------------|--|-----------------------------------|----------------|
| $K^+ K^-$ | (49.2 \pm 0.6) % | S=1.2 | 127 |
| $K_L^0 K_S^0$ | (34.0 \pm 0.5) % | S=1.1 | 110 |
| $\rho\pi + \pi^+\pi^-\pi^0$ | (15.3 \pm 0.4) % | S=1.2 | — |
| $\eta\gamma$ | (1.301 \pm 0.024) % | S=1.1 | 363 |
| $\pi^0\gamma$ | (1.25 \pm 0.07) $\times 10^{-3}$ | | 501 |
| e^+e^- | (2.97 \pm 0.04) $\times 10^{-4}$ | S=1.1 | 510 |
| $\mu^+\mu^-$ | (2.86 \pm 0.19) $\times 10^{-4}$ | | 499 |
| ηe^+e^- | (1.15 \pm 0.10) $\times 10^{-4}$ | | 363 |
| $\pi^+\pi^-$ | (7.3 \pm 1.3) $\times 10^{-5}$ | | 490 |
| $\omega\pi^0$ | (5.2 \pm 1.3 \pm 1.1) $\times 10^{-5}$ | | 171 |
| $\omega\gamma$ | < 5 % | CL=84% | 209 |
| $\rho\gamma$ | < 1.2 $\times 10^{-5}$ | CL=90% | 215 |
| $\pi^+\pi^-\gamma$ | (4.1 \pm 1.3) $\times 10^{-5}$ | | 490 |
| $f_0(980)\gamma$ | (4.40 \pm 0.21) $\times 10^{-4}$ | | 39 |
| $\pi^0\pi^0\gamma$ | (1.09 \pm 0.06) $\times 10^{-4}$ | | 492 |
| $\pi^+\pi^-\pi^+\pi^-$ | (3.9 \pm 2.8 \pm 2.2) $\times 10^{-6}$ | | 410 |
| $\pi^+\pi^+\pi^-\pi^-\pi^0$ | < 4.6 $\times 10^{-6}$ | CL=90% | 342 |
| $\pi^0 e^+ e^-$ | (1.12 \pm 0.28) $\times 10^{-5}$ | | 501 |
| $\pi^0\eta\gamma$ | (8.3 \pm 0.5) $\times 10^{-5}$ | | 346 |
| $a_0(980)\gamma$ | (7.6 \pm 0.6) $\times 10^{-5}$ | | 34 |
| $\eta'(958)\gamma$ | (6.2 \pm 0.7) $\times 10^{-5}$ | S=1.1 | 60 |
| $\eta\pi^0\pi^0\gamma$ | < 2 $\times 10^{-5}$ | CL=90% | 293 |
| $\mu^+\mu^-\gamma$ | (1.4 \pm 0.5) $\times 10^{-5}$ | | 499 |
| $\rho\gamma\gamma$ | < 5 $\times 10^{-4}$ | CL=90% | 215 |
| $\eta\pi^+\pi^-$ | < 1.8 $\times 10^{-5}$ | CL=90% | 288 |
| $\eta\mu^+\mu^-$ | < 9.4 $\times 10^{-6}$ | CL=90% | 321 |

 $h_1(1170)$

$$I^G(J^{PC}) = 0^-(1^+ -)$$

Mass $m = 1170 \pm 20$ MeVFull width $\Gamma = 360 \pm 40$ MeV

| $h_1(1170)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|-------------------------|--------------------------------|-------------|
| $\rho\pi$ | seen | 307 |

 $b_1(1235)$

$$I^G(J^{PC}) = 1^+(1^+ -)$$

Mass $m = 1229.5 \pm 3.2$ MeV (S = 1.6)Full width $\Gamma = 142 \pm 9$ MeV (S = 1.2)

| $b_1(1235)$ DECAY MODES | Fraction (Γ_i/Γ) | Confidence level | p (MeV/c) |
|--|--------------------------------|------------------|----------------|
| $\omega\pi$ | dominant | | 348 |
| [D/S amplitude ratio = 0.277 ± 0.027] | | | |
| $\pi^\pm\gamma$ | $(1.6 \pm 0.4) \times 10^{-3}$ | | 607 |
| $\eta\rho$ | seen | | † |
| $\pi^+\pi^+\pi^-\pi^0$ | < 50 % | 84% | 535 |
| $(K\bar{K})^\pm\pi^0$ | < 8 % | 90% | 248 |
| $K_S^0 K_L^0 \pi^\pm$ | < 6 % | 90% | 235 |
| $K_S^0 K_S^0 \pi^\pm$ | < 2 % | 90% | 235 |
| $\phi\pi$ | < 1.5 % | 84% | 147 |

 $a_1(1260)$ ^[m]

$$J^{PC} = 1^-(1^{++})$$

Mass $m = 1230 \pm 40$ MeV ^[n]Full width $\Gamma = 250$ to 600 MeV

| $a_1(1260)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|---|--------------------------------|-------------|
| $(\rho\pi)_{S\text{-wave}}$ | seen | 353 |
| $(\rho\pi)_{D\text{-wave}}$ | seen | 353 |
| $(\rho(1450)\pi)_{S\text{-wave}}$ | seen | † |
| $(\rho(1450)\pi)_{D\text{-wave}}$ | seen | † |
| $\sigma\pi$ | seen | — |
| $f_0(980)\pi$ | not seen | 189 |
| $f_0(1370)\pi$ | seen | † |
| $f_2(1270)\pi$ | seen | † |
| $K\bar{K}^*(892) + \text{c.c.}$ | seen | † |
| $\pi\gamma$ | seen | 608 |

 $f_2(1270)$

$$J^{PC} = 0^+(2^{++})$$

Mass $m = 1275.4 \pm 1.1$ MeVFull width $\Gamma = 185.2^{+3.1}_{-2.5}$ MeV ($S = 1.5$)

| $f_2(1270)$ DECAY MODES | Fraction (Γ_i/Γ) | Scale factor/ Confidence level | p (MeV/c) |
|---|--------------------------------|-----------------------------------|----------------|
| $\pi\pi$ | $(84.7^{+2.5}_{-1.2})\%$ | $S=1.2$ | 623 |
| $\pi^+\pi^-\pi^0$ | $(7.1^{+1.4}_{-2.7})\%$ | $S=1.3$ | 563 |
| $K\bar{K}$ | $(4.6 \pm 0.4)\%$ | $S=2.7$ | 404 |
| $2\pi^+2\pi^-$ | $(2.8 \pm 0.4)\%$ | $S=1.2$ | 559 |
| $\eta\eta$ | $(4.0 \pm 0.8) \times 10^{-3}$ | $S=2.1$ | 327 |

| | | | |
|-------------------------------|----------------------------------|--------|-----|
| $4\pi^0$ | $(3.0 \pm 1.0) \times 10^{-3}$ | | 565 |
| $\gamma\gamma$ | $(1.41 \pm 0.13) \times 10^{-5}$ | | 638 |
| $\eta\pi\pi$ | $< 8 \times 10^{-3}$ | CL=95% | 478 |
| $K^0 K^- \pi^+ + \text{c.c.}$ | $< 3.4 \times 10^{-3}$ | CL=95% | 293 |
| $e^+ e^-$ | $< 6 \times 10^{-10}$ | CL=90% | 638 |

 $f_1(1285)$

$$J^{PC} = 0^+(1^+ +)$$

Mass $m = 1281.8 \pm 0.6$ MeV (S = 1.6)Full width $\Gamma = 24.2 \pm 1.1$ MeV (S = 1.3)

| $f_1(1285)$ DECAY MODES | Fraction (Γ_i/Γ) | Scale factor/ Confidence level | p (MeV/c) |
|---|--------------------------------|-----------------------------------|----------------|
| 4π | $(33.1^{+2.1}_{-1.8})\%$ | S=1.3 | 568 |
| $\pi^0 \pi^0 \pi^+ \pi^-$ | $(22.0^{+1.4}_{-1.2})\%$ | S=1.3 | 566 |
| $2\pi^+ 2\pi^-$ | $(11.0^{+0.7}_{-0.6})\%$ | S=1.3 | 563 |
| $\rho^0 \pi^+ \pi^-$ | $(11.0^{+0.7}_{-0.6})\%$ | S=1.3 | 336 |
| $\rho^0 \rho^0$ | seen | | † |
| $4\pi^0$ | $< 7 \times 10^{-4}$ | CL=90% | 568 |
| $\eta\pi\pi$ | $(52 \pm 16)\%$ | | 482 |
| $a_0(980)\pi$ [ignoring $a_0(980) \rightarrow K\bar{K}$] | $(36 \pm 7)\%$ | | 234 |
| $\eta\pi\pi$ [excluding $a_0(980)\pi$] | $(16 \pm 7)\%$ | | 482 |
| $K\bar{K}\pi$ | $(9.0 \pm 0.4)\%$ | S=1.1 | 308 |
| $K\bar{K}^*(892)$ | not seen | | † |
| $\gamma\rho^0$ | $(5.5 \pm 1.3)\%$ | S=2.8 | 406 |
| $\phi\gamma$ | $(7.4 \pm 2.6) \times 10^{-4}$ | | 236 |

 $\eta(1295)$

$$J^{PC} = 0^+(0^- +)$$

Mass $m = 1294 \pm 4$ MeV (S = 1.6)Full width $\Gamma = 55 \pm 5$ MeV

| $\eta(1295)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|--|--------------------------------|-------------|
| $\eta\pi^+ \pi^-$ | seen | 487 |
| $a_0(980)\pi$ | seen | 244 |
| $\eta\pi^0 \pi^0$ | seen | 490 |
| $\eta(\pi\pi)_S\text{-wave}$ | seen | — |

$\pi(1300)$

$$J^{PC} = 1^-(0^-+)$$

Mass $m = 1300 \pm 100$ MeV [η]Full width $\Gamma = 200$ to 600 MeV

| $\pi(1300)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|---|--------------------------------|-------------|
| $\rho\pi$ | seen | 404 |
| $\pi(\pi\pi)_{S\text{-wave}}$ | seen | — |

 $a_2(1320)$

$$J^{PC} = 1^-(2^{++})$$

Mass $m = 1318.3 \pm 0.6$ MeV ($S = 1.2$)Full width $\Gamma = 107 \pm 5$ MeV [η]

| $a_2(1320)$ DECAY MODES | Fraction (Γ_i/Γ) | Scale factor/ Confidence level | p (MeV/c) |
|---|--------------------------------------|-----------------------------------|----------------|
| $\rho\pi$ | (70.1 \pm 2.7) % | S=1.2 | 417 |
| $\eta\pi$ | (14.5 \pm 1.2) % | | 536 |
| $\omega\pi\pi$ | (10.6 \pm 3.2) % | S=1.3 | 366 |
| $K\bar{K}$ | (4.9 \pm 0.8) % | | 437 |
| $\eta'(958)\pi$ | (5.3 \pm 0.9) $\times 10^{-3}$ | | 288 |
| $\pi^\pm\gamma$ | (2.68 \pm 0.31) $\times 10^{-3}$ | | 652 |
| $\gamma\gamma$ | (9.4 \pm 0.7) $\times 10^{-6}$ | | 659 |
| $\pi^+\pi^-\pi^-$ | < 8 % | CL=90% | 621 |
| e^+e^- | < 6 $\times 10^{-9}$ | CL=90% | 659 |

 $f_0(1370)$ [l]

$$J^{PC} = 0^+(0^{++})$$

Mass $m = 1200$ to 1500 MeVFull width $\Gamma = 200$ to 500 MeV

| $f_0(1370)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|---|--------------------------------|-------------|
| $\pi\pi$ | seen | 672 |
| 4π | seen | 617 |
| $4\pi^0$ | seen | 617 |
| $2\pi^+2\pi^-$ | seen | 612 |
| $\pi^+\pi^-2\pi^0$ | seen | 615 |
| $\rho\rho$ | dominant | † |
| $2(\pi\pi)_{S\text{-wave}}$ | seen | — |
| $\pi(1300)\pi$ | seen | † |

| | | |
|----------------|----------|-----|
| $a_1(1260)\pi$ | seen | 35 |
| $\eta\eta$ | seen | 412 |
| $K\bar{K}$ | seen | 475 |
| $\gamma\gamma$ | seen | 685 |
| e^+e^- | not seen | 685 |

 $\pi_1(1400)$ ^[o]

$$I^G(J^{PC}) = 1^-(1^--)$$

Mass $m = 1376 \pm 17$ MeVFull width $\Gamma = 300 \pm 40$ MeV

| $\pi_1(1400)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|---|--------------------------------|-------------|
| $\eta\pi^0$ | seen | 570 |
| $\eta\pi^-$ | seen | 569 |

 $\eta(1405)$ ^[p]

$$I^G(J^{PC}) = 0^+(0^--)$$

Mass $m = 1409.8 \pm 2.5$ MeV ^[n] (S = 2.2)Full width $\Gamma = 51.1 \pm 3.4$ MeV ^[n] (S = 2.0)

| $\eta(1405)$ DECAY MODES | Fraction (Γ_i/Γ) | Confidence level | p (MeV/c) |
|--|--------------------------------|------------------|----------------|
| $K\bar{K}\pi$ | seen | | 425 |
| $\eta\pi\pi$ | seen | | 563 |
| $a_0(980)\pi$ | seen | | 342 |
| $\eta(\pi\pi)$ S-wave | seen | | — |
| $f_0(980)\eta$ | seen | | † |
| 4π | seen | | 639 |
| $\rho\rho$ | <58 % | 99.85% | † |
| $K^*(892)K$ | seen | | 125 |

 $f_1(1420)$ ^[q]

$$I^G(J^{PC}) = 0^+(1^{++})$$

Mass $m = 1426.3 \pm 0.9$ MeV (S = 1.1)Full width $\Gamma = 54.9 \pm 2.6$ MeV

| $f_1(1420)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|---|--------------------------------|-------------|
| $K \bar{K} \pi$ | dominant | 438 |
| $K \bar{K}^*(892) + \text{c.c.}$ | dominant | 163 |
| $\eta \pi \pi$ | possibly seen | 573 |
| $\phi \gamma$ | seen | 349 |

 $\omega(1420)$ [I]

$$I^G(J^{PC}) = 0^-(1^--)$$

Mass m (1400–1450) MeVFull width Γ (180–250) MeV

| $\omega(1420)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|--|--------------------------------|-------------|
| $\rho \pi$ | dominant | 486 |
| $\omega \pi \pi$ | seen | 444 |
| $b_1(1235) \pi$ | seen | 125 |
| $e^+ e^-$ | seen | 710 |

 $a_0(1450)$ [I]

$$I^G(J^{PC}) = 1^-(0^{++})$$

Mass $m = 1474 \pm 19$ MeVFull width $\Gamma = 265 \pm 13$ MeV

| $a_0(1450)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|---|--------------------------------|-------------|
| $\pi \eta$ | seen | 627 |
| $\pi \eta'(958)$ | seen | 410 |
| $K \bar{K}$ | seen | 547 |
| $\omega \pi \pi$ | seen | 484 |

 $\rho(1450)$ [S]

$$I^G(J^{PC}) = 1^+(1^--)$$

Mass $m = 1459 \pm 11$ MeV [n] ($S = 3.4$)Full width $\Gamma = 147 \pm 40$ MeV [n] ($S = 4.9$)

| $\rho(1450)$ DECAY MODES | Fraction (Γ_i/Γ) | Confidence level | p (MeV/c) |
|--------------------------|--------------------------------|------------------|----------------|
| $\pi\pi$ | seen | | 717 |
| 4π | seen | | 666 |
| $\omega\pi$ | $<2.0\%$ | 95% | 508 |
| e^+e^- | seen | | 730 |
| $\eta\rho$ | $<4\%$ | | 304 |
| $a_2(1320)\pi$ | not seen | | 39 |
| $\phi\pi$ | $<1\%$ | | 355 |
| $K\bar{K}$ | $<1.6 \times 10^{-3}$ | 95% | 537 |
| $\eta\gamma$ | possibly seen | | 627 |

 $\eta(1475)$ [ρ]

$$I^G(J^{PC}) = 0^+(0^-+)$$

Mass $m = 1476 \pm 4$ MeV ($S = 1.4$)Full width $\Gamma = 87 \pm 9$ MeV ($S = 1.6$)

| $\eta(1475)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|---------------------------------|--------------------------------|-------------|
| $K\bar{K}\pi$ | dominant | 477 |
| $K\bar{K}^*(892) + \text{c.c.}$ | seen | 245 |
| $a_0(980)\pi$ | seen | 393 |
| $\gamma\gamma$ | seen | 738 |

 $f_0(1500)$ [ϕ]

$$I^G(J^{PC}) = 0^+(0^{++})$$

Mass $m = 1507 \pm 5$ MeV ($S = 1.2$)Full width $\Gamma = 109 \pm 7$ MeV

| $f_0(1500)$ DECAY MODES | Fraction (Γ_i/Γ) | Scale factor | p (MeV/c) |
|-------------------------|--------------------------------|--------------|----------------|
| $\eta\eta'(958)$ | $(1.9 \pm 0.8)\%$ | 1.7 | 37 |
| $\eta\eta$ | $(5.1 \pm 0.9)\%$ | 1.4 | 518 |
| 4π | $(49.5 \pm 3.3)\%$ | 1.2 | 692 |
| $4\pi^0$ | seen | | 692 |
| $2\pi^+2\pi^-$ | seen | | 688 |
| $\pi\pi$ | $(34.9 \pm 2.3)\%$ | 1.2 | 741 |
| $\pi^+\pi^-$ | seen | | 741 |
| $2\pi^0$ | seen | | 741 |
| $K\bar{K}$ | $(8.6 \pm 1.0)\%$ | 1.1 | 569 |
| $\gamma\gamma$ | not seen | | 754 |

$f'_2(1525)$

$$I^G(J^{PC}) = 0^+(2^{++})$$

Mass $m = 1525 \pm 5$ MeV ^[n]Full width $\Gamma = 73^{+6}_{-5}$ MeV ^[n]

| $f'_2(1525)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|--|----------------------------------|-------------|
| $K\bar{K}$ | $(88.8 \pm 3.1) \%$ | 581 |
| $\eta\eta$ | $(10.3 \pm 3.1) \%$ | 531 |
| $\pi\pi$ | $(8.2 \pm 1.5) \times 10^{-3}$ | 750 |
| $\gamma\gamma$ | $(1.11 \pm 0.14) \times 10^{-6}$ | 763 |

 $\pi_1(1600)$ ^[o]

$$I^G(J^{PC}) = 1^-(1^{-+})$$

Mass $m = 1653^{+18}_{-15}$ MeV ($S = 1.6$)Full width $\Gamma = 225^{+45}_{-28}$ MeV ($S = 1.5$)

| $\pi_1(1600)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|---|--------------------------------|-------------|
| $\pi\pi\pi$ | seen | 799 |
| $\rho^0\pi^-$ | seen | 635 |
| $f_2(1270)\pi^-$ | not seen | 310 |
| $b_1(1235)\pi$ | seen | 350 |
| $\eta'(958)\pi^-$ | seen | 537 |
| $f_1(1285)\pi$ | seen | 307 |

 $\eta_2(1645)$

$$I^G(J^{PC}) = 0^+(2^{-+})$$

Mass $m = 1617 \pm 5$ MeVFull width $\Gamma = 181 \pm 11$ MeV

| $\eta_2(1645)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|--|--------------------------------|-------------|
| $a_2(1320)\pi$ | seen | 242 |
| $K\bar{K}\pi$ | seen | 580 |
| $K^*\bar{K}$ | seen | 404 |
| $\eta\pi^+\pi^-$ | seen | 685 |
| $a_0(980)\pi$ | seen | 496 |
| $f_2(1270)\eta$ | not seen | † |

 $\omega(1650)$ ^[t]

$$I^G(J^{PC}) = 0^-(1^{--})$$

Mass $m = 1670 \pm 30$ MeVFull width $\Gamma = 315 \pm 35$ MeV

| $\omega(1650)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|----------------------------|--------------------------------|-------------|
| $\rho\pi$ | seen | 646 |
| $\omega\pi\pi$ | seen | 617 |
| $\omega\eta$ | seen | 500 |
| e^+e^- | seen | 835 |

 $\omega_3(1670)$

$$I^G(J^{PC}) = 0^-(3^{--})$$

Mass $m = 1667 \pm 4$ MeVFull width $\Gamma = 168 \pm 10$ MeV [n]

| $\omega_3(1670)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|------------------------------|--------------------------------|-------------|
| $\rho\pi$ | seen | 645 |
| $\omega\pi\pi$ | seen | 615 |
| $b_1(1235)\pi$ | possibly seen | 361 |

 $\pi_2(1670)$

$$I^G(J^{PC}) = 1^-(2^{-+})$$

Mass $m = 1672.4 \pm 3.2$ MeV [n] (S = 1.4)Full width $\Gamma = 259 \pm 9$ MeV [n] (S = 1.3)

| $\pi_2(1670)$ DECAY MODES | Fraction (Γ_i/Γ) | Confidence level | p (MeV/c) |
|---------------------------------|--------------------------------|------------------|-------------|
| 3π | $(95.8 \pm 1.4) \%$ | | 809 |
| $f_2(1270)\pi$ | $(56.2 \pm 3.2) \%$ | | 329 |
| $\rho\pi$ | $(31 \pm 4) \%$ | | 648 |
| $\sigma\pi$ | $(10.9 \pm 3.4) \%$ | | — |
| $(\pi\pi)S$ -wave | $(8.7 \pm 3.4) \%$ | | — |
| $K\bar{K}^*(892) + \text{c.c.}$ | $(4.2 \pm 1.4) \%$ | | 455 |
| $\omega\rho$ | $(2.7 \pm 1.1) \%$ | | 304 |
| $\rho(1450)\pi$ | $< 3.6 \times 10^{-3}$ | 97.7% | 154 |
| $b_1(1235)\pi$ | $< 1.9 \times 10^{-3}$ | 97.7% | 366 |
| $f_1(1285)\pi$ | possibly seen | | 323 |
| $a_2(1320)\pi$ | not seen | | 292 |

 $\phi(1680)$

$$I^G(J^{PC}) = 0^-(1^{--})$$

Mass $m = 1680 \pm 20$ MeV [n]Full width $\Gamma = 150 \pm 50$ MeV [n]

| $\phi(1680)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|---------------------------------|--------------------------------|-------------|
| $K\bar{K}^*(892) + \text{c.c.}$ | dominant | 462 |
| $K_S^0 K\pi$ | seen | 621 |
| $K\bar{K}$ | seen | 680 |
| e^+e^- | seen | 840 |
| $\omega\pi\pi$ | not seen | 623 |

 $\rho_3(1690)$

$$J^{PC} = 1^+(3^{--})$$

Mass $m = 1688.8 \pm 2.1$ MeV ^[n]

Full width $\Gamma = 161 \pm 10$ MeV ^[n] ($S = 1.5$)

| $\rho_3(1690)$ DECAY MODES | Fraction (Γ_i/Γ) | Scale factor | p (MeV/c) |
|--|--------------------------------|--------------|-------------|
| 4π | (71.1 \pm 1.9) % | | 790 |
| $\pi^\pm\pi^+\pi^-\pi^0$ | (67 \pm 22) % | | 787 |
| $\omega\pi$ | (16 \pm 6) % | | 655 |
| $\pi\pi$ | (23.6 \pm 1.3) % | | 834 |
| $K\bar{K}\pi$ | (3.8 \pm 1.2) % | | 629 |
| $K\bar{K}$ | (1.58 \pm 0.26) % | 1.2 | 685 |
| $\eta\pi^+\pi^-$ | seen | | 727 |
| $\rho(770)\eta$ | seen | | 520 |
| $\pi\pi\rho$ | seen | | 633 |
| Excluding 2ρ and $a_2(1320)\pi$. | | | |
| $a_2(1320)\pi$ | seen | | 307 |
| $\rho\rho$ | seen | | 334 |

 $\rho(1700)$ ^[s]

$$J^{PC} = 1^+(1^{--})$$

Mass $m = 1720 \pm 20$ MeV ^[n] ($\eta\rho^0$ and $\pi^+\pi^-$ modes)

Full width $\Gamma = 250 \pm 100$ MeV ^[n] ($\eta\rho^0$ and $\pi^+\pi^-$ modes)

| $\rho(1700)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|--------------------------|--------------------------------|-------------|
| $2(\pi^+\pi^-)$ | large | 803 |
| $\rho\pi\pi$ | dominant | 653 |
| $\rho^0\pi^+\pi^-$ | large | 650 |
| $\rho^\pm\pi^\mp\pi^0$ | large | 652 |
| $a_1(1260)\pi$ | seen | 404 |
| $h_1(1170)\pi$ | seen | 447 |
| $\pi(1300)\pi$ | seen | 349 |

| | | |
|---------------------------------|----------|-----|
| $\rho\rho$ | seen | 372 |
| $\pi^+\pi^-$ | seen | 849 |
| $\pi\pi$ | seen | 849 |
| $K\bar{K}^*(892) + \text{c.c.}$ | seen | 496 |
| $\eta\rho$ | seen | 545 |
| $a_2(1320)\pi$ | not seen | 334 |
| $K\bar{K}$ | seen | 704 |
| e^+e^- | seen | 860 |
| $\pi^0\omega$ | seen | 674 |

 $f_0(1710)$ [*u*]

$$J^{PC} = 0^+(0^{++})$$

Mass $m = 1718 \pm 6$ MeV (S = 1.2)Full width $\Gamma = 137 \pm 8$ MeV (S = 1.1)

| $f_0(1710)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|---|--------------------------------|-------------|
| $K\bar{K}$ | seen | 703 |
| $\eta\eta$ | seen | 662 |
| $\pi\pi$ | seen | 849 |

 $\pi(1800)$

$$J^{PC} = 1^-(0^{-+})$$

Mass $m = 1812 \pm 14$ MeV (S = 2.3)Full width $\Gamma = 207 \pm 13$ MeV

| $\pi(1800)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|---|--------------------------------|-------------|
| $\pi^+\pi^-\pi^-$ | seen | 879 |
| $f_0(600)\pi^-$ | seen | — |
| $f_0(980)\pi^-$ | seen | 631 |
| $f_0(1370)\pi^-$ | seen | 368 |
| $f_0(1500)\pi^-$ | not seen | 248 |
| $\rho\pi^-$ | not seen | 732 |
| $\eta\eta\pi^-$ | seen | 661 |
| $a_0(980)\eta$ | seen | 470 |
| $f_0(1500)\pi^-$ | seen | 248 |
| $\eta\eta'(958)\pi^-$ | seen | 376 |
| $K_0^*(1430)K^-$ | seen | † |
| $K^*(892)K^-$ | not seen | 570 |

$\phi_3(1850)$

$$I^G(J^{PC}) = 0^-(3^{--})$$

Mass $m = 1854 \pm 7$ MeVFull width $\Gamma = 87^{+28}_{-23}$ MeV (S = 1.2)

| $\phi_3(1850)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|--|--------------------------------|-------------|
| $K\bar{K}$ | seen | 785 |
| $K\bar{K}^*(892) + \text{c.c.}$ | seen | 602 |

 $f_2(1950)$

$$I^G(J^{PC}) = 0^+(2^{++})$$

Mass $m = 1944 \pm 12$ MeV (S = 1.5)Full width $\Gamma = 472 \pm 18$ MeV

| $f_2(1950)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|---|--------------------------------|-------------|
| $K^*(892)\bar{K}^*(892)$ | seen | 387 |
| $\pi^+\pi^-$ | seen | 962 |
| 4π | seen | 925 |
| $\eta\eta$ | seen | 803 |
| $K\bar{K}$ | seen | 837 |
| $\gamma\gamma$ | seen | 972 |

 $f_2(2010)$

$$I^G(J^{PC}) = 0^+(2^{++})$$

Mass $m = 2011^{+60}_{-80}$ MeVFull width $\Gamma = 202 \pm 60$ MeV

| $f_2(2010)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|---|--------------------------------|-------------|
| $\phi\phi$ | seen | † |

 $a_4(2040)$

$$I^G(J^{PC}) = 1^-(4^{++})$$

Mass $m = 2001 \pm 10$ MeVFull width $\Gamma = 313 \pm 31$ MeV

| $a_4(2040)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|---|--------------------------------|-------------|
| $K\bar{K}$ | seen | 870 |
| $\pi^+\pi^-\pi^0$ | seen | 977 |
| $\rho\pi$ | seen | 844 |
| $f_2(1270)\pi$ | seen | 583 |
| $\omega\pi^-\pi^0$ | seen | 822 |
| $\omega\rho$ | seen | 628 |
| $\eta\pi^0$ | seen | 920 |
| $\eta'(958)\pi$ | seen | 764 |

 $f_4(2050)$

$$I^G(J^{PC}) = 0^+(4^{++})$$

Mass $m = 2025 \pm 10$ MeV ($S = 1.8$)Full width $\Gamma = 225 \pm 18$ MeV ($S = 1.7$)

| $f_4(2050)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|---|--------------------------------------|-------------|
| $\omega\omega$ | not seen | 642 |
| $\pi\pi$ | $(17.0 \pm 1.5) \%$ | 1003 |
| $K\bar{K}$ | $(6.8^{+3.4}_{-1.8}) \times 10^{-3}$ | 884 |
| $\eta\eta$ | $(2.1 \pm 0.8) \times 10^{-3}$ | 852 |
| $4\pi^0$ | $< 1.2 \%$ | 967 |
| $a_2(1320)\pi$ | seen | 572 |

 $f_2(2300)$

$$I^G(J^{PC}) = 0^+(2^{++})$$

Mass $m = 2297 \pm 28$ MeVFull width $\Gamma = 149 \pm 40$ MeV

| $f_2(2300)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|---|--------------------------------|-------------|
| $\phi\phi$ | seen | 529 |
| $K\bar{K}$ | seen | 1037 |
| $\gamma\gamma$ | seen | 1149 |

 $f_2(2340)$

$$I^G(J^{PC}) = 0^+(2^{++})$$

Mass $m = 2339 \pm 60$ MeVFull width $\Gamma = 319^{+80}_{-70}$ MeV

| $f_2(2340)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|---|--------------------------------|-------------|
| $\phi\phi$ | seen | 573 |

STRANGE MESONS

($S = \pm 1, C = B = 0$)

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

K^\pm

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

$$\text{Mass } m = 493.677 \pm 0.016 \text{ MeV } [v] \quad (S = 2.8)$$

$$\text{Mean life } \tau = (1.2385 \pm 0.0024) \times 10^{-8} \text{ s} \quad (S = 2.0)$$

$$c\tau = 3.713 \text{ m}$$

Slope parameter g ^[w]

(See Particle Listings for quadratic coefficients an alternative parameterization related to $\pi\pi$ scattering)

$$K^+ \rightarrow \pi^+ \pi^+ \pi^- = -0.2154 \pm 0.0035 \quad (S = 1.4)$$

$$K^- \rightarrow \pi^- \pi^- \pi^+ = -0.217 \pm 0.007 \quad (S = 2.5)$$

$$K^\pm \rightarrow \pi^\pm \pi^+ \pi^- (g_+ - g_-) / (g_+ + g_-) = (1.5 \pm 2.9) \times 10^{-4}$$

$$K^\pm \rightarrow \pi^\pm \pi^0 \pi^0 = 0.626 \pm 0.007$$

$$K^\pm \rightarrow \pi^\pm \pi^0 \pi^0 (g_+ - g_-) / (g_+ + g_-) = (0.02 \pm 0.19)\%$$

K^\pm decay form factors ^[a,x]

Assuming μ -e universality

$$\lambda_+(K_{\mu 3}^+) = \lambda_+(K_{e 3}^+) = (2.96 \pm 0.05) \times 10^{-2}$$

$$\lambda_0(K_{\mu 3}^+) = (1.96 \pm 0.12) \times 10^{-2}$$

Not assuming μ -e universality

$$\lambda_+(K_{e 3}^+) = (2.96 \pm 0.06) \times 10^{-2}$$

$$\lambda_+(K_{\mu 3}^+) = (2.96 \pm 0.17) \times 10^{-2}$$

$$\lambda_0(K_{\mu 3}^+) = (1.96 \pm 0.13) \times 10^{-2}$$

$K_{e 3}$ form factor quadratic fit

$$\lambda'_+(K_{e 3}^\pm) \text{ linear coeff.} = (2.48 \pm 0.17) \times 10^{-2}$$

$$\lambda''_+(K_{e 3}^\pm) \text{ quadratic coeff.} = (0.19 \pm 0.09) \times 10^{-2}$$

$$K_{e 3}^+ \quad |f_S/f_+| = (-0.3^{+0.8}_{-0.7}) \times 10^{-2}$$

$$K_{e 3}^+ \quad |f_T/f_+| = (-1.2 \pm 2.3) \times 10^{-2}$$

$$K_{\mu 3}^+ \quad |f_S/f_+| = (0.2 \pm 0.6) \times 10^{-2}$$

$$K_{\mu 3}^+ \quad |f_T/f_+| = (-0.1 \pm 0.7) \times 10^{-2}$$

$$K^+ \rightarrow e^+ \nu_e \gamma \quad |F_A + F_V| = 0.148 \pm 0.010$$

$$K^+ \rightarrow \mu^+ \nu_\mu \gamma \quad |F_A + F_V| = 0.165 \pm 0.013$$

$$K^+ \rightarrow e^+ \nu_e \gamma \quad |F_A - F_V| < 0.49$$

$$K^+ \rightarrow \mu^+ \nu_\mu \gamma \quad |F_A - F_V| = -0.24 \text{ to } 0.04, \text{ CL} = 90\%$$

Charge Radius

$$\langle r \rangle = 0.560 \pm 0.031 \text{ fm}$$

CP violation parameters

$$\Delta(K_{\pi\mu\mu}^{\pm}) = -0.02 \pm 0.12$$

T violation parameters

$$K^+ \rightarrow \pi^0 \mu^+ \nu_{\mu} \quad P_T = (-1.7 \pm 2.5) \times 10^{-3}$$

$$K^+ \rightarrow \mu^+ \nu_{\mu} \gamma \quad P_T = (-0.6 \pm 1.9) \times 10^{-2}$$

$$K^+ \rightarrow \pi^0 \mu^+ \nu_{\mu} \quad \text{Im}(\xi) = -0.006 \pm 0.008$$

K^- modes are charge conjugates of the modes below.

| K^+ DECAY MODES | Fraction (Γ_i/Γ) | Scale factor/ Confidence level | p (MeV/c) |
|---|--|-----------------------------------|----------------|
| Leptonic and semileptonic modes | | | |
| $e^+ \nu_e$ | $(1.55 \pm 0.07) \times 10^{-5}$ | | 247 |
| $\mu^+ \nu_{\mu}$ | $(63.44 \pm 0.14) \%$ | S=1.2 | 236 |
| $\pi^0 e^+ \nu_e$ | $(4.98 \pm 0.07) \%$ | S=1.3 | 228 |
| Called K_{e3}^+ . | | | |
| $\pi^0 \mu^+ \nu_{\mu}$ | $(3.32 \pm 0.06) \%$ | S=1.2 | 215 |
| Called $K_{\mu 3}^+$. | | | |
| $\pi^0 \pi^0 e^+ \nu_e$ | $(2.2 \pm 0.4) \times 10^{-5}$ | | 206 |
| $\pi^+ \pi^- e^+ \nu_e$ | $(4.09 \pm 0.09) \times 10^{-5}$ | | 203 |
| $\pi^+ \pi^- \mu^+ \nu_{\mu}$ | $(1.4 \pm 0.9) \times 10^{-5}$ | | 151 |
| $\pi^0 \pi^0 \pi^0 e^+ \nu_e$ | $< 3.5 \times 10^{-6}$ | CL=90% | 135 |
| Hadronic modes | | | |
| $\pi^+ \pi^0$ | $(20.92 \pm 0.12) \%$ | S=1.1 | 205 |
| $\pi^+ \pi^0 \pi^0$ | $(1.757 \pm 0.024) \%$ | S=1.1 | 133 |
| $\pi^+ \pi^+ \pi^-$ | $(5.590 \pm 0.031) \%$ | S=1.1 | 125 |
| Leptonic and semileptonic modes with photons | | | |
| $\mu^+ \nu_{\mu} \gamma$ | [y,z] $(6.2 \pm 0.8) \times 10^{-3}$ | | 236 |
| $\mu^+ \nu_{\mu} \gamma (\text{SD}^+)$ | [aa] $< 3.0 \times 10^{-5}$ | CL=90% | — |
| $\mu^+ \nu_{\mu} \gamma (\text{SD}^+ \text{INT})$ | [aa] $< 2.7 \times 10^{-5}$ | CL=90% | — |
| $\mu^+ \nu_{\mu} \gamma (\text{SD}^- + \text{SD}^- \text{INT})$ | [aa] $< 2.6 \times 10^{-4}$ | CL=90% | — |
| $e^+ \nu_e \gamma (\text{SD}^+)$ | [aa] $(1.52 \pm 0.23) \times 10^{-5}$ | | — |
| $e^+ \nu_e \gamma (\text{SD}^-)$ | [aa] $< 1.6 \times 10^{-4}$ | CL=90% | — |
| $\pi^0 e^+ \nu_e \gamma$ | [y,z] $(2.69 \pm 0.20) \times 10^{-4}$ | | 228 |
| $\pi^0 e^+ \nu_e \gamma (\text{SD})$ | [aa] $< 5.3 \times 10^{-5}$ | CL=90% | 228 |
| $\pi^0 \mu^+ \nu_{\mu} \gamma$ | [y,z] $(2.4 \pm 0.8) \times 10^{-5}$ | | 215 |
| $\pi^0 \pi^0 e^+ \nu_e \gamma$ | $< 5 \times 10^{-6}$ | CL=90% | 206 |

Hadronic modes with photons

| | | | |
|----------------------------------|----------|--------------------------------------|-----|
| $\pi^+ \pi^0 \gamma$ | $[y,z]$ | $(2.75 \pm 0.15) \times 10^{-4}$ | 205 |
| $\pi^+ \pi^0 \gamma (\text{DE})$ | $[z,bb]$ | $(4.4 \pm 0.7) \times 10^{-6}$ | 205 |
| $\pi^+ \pi^0 \pi^0 \gamma$ | $[y,z]$ | $(7.6^{+5.6}_{-3.0}) \times 10^{-6}$ | 133 |
| $\pi^+ \pi^+ \pi^- \gamma$ | $[y,z]$ | $(1.04 \pm 0.31) \times 10^{-4}$ | 125 |
| $\pi^+ \gamma \gamma$ | $[z]$ | $(1.10 \pm 0.32) \times 10^{-6}$ | 227 |
| $\pi^+ 3\gamma$ | $[z]$ | $< 1.0 \times 10^{-4}$ CL=90% | 227 |

Leptonic modes with $\ell\bar{\ell}$ pairs

| | | | |
|-------------------------------|-------------------|-------------------------|-----|
| $e^+ \nu_e \nu \bar{\nu}$ | < 6 | $\times 10^{-5}$ CL=90% | 247 |
| $\mu^+ \nu_\mu \nu \bar{\nu}$ | < 6.0 | $\times 10^{-6}$ CL=90% | 236 |
| $e^+ \nu_e e^+ e^-$ | (2.48 ± 0.20) | $\times 10^{-8}$ | 247 |
| $\mu^+ \nu_\mu e^+ e^-$ | (7.06 ± 0.31) | $\times 10^{-8}$ | 236 |
| $e^+ \nu_e \mu^+ \mu^-$ | (1.7 ± 0.5) | $\times 10^{-8}$ | 223 |
| $\mu^+ \nu_\mu \mu^+ \mu^-$ | < 4.1 | $\times 10^{-7}$ CL=90% | 185 |

**Lepton Family number (LF), Lepton number (L), $\Delta S = \Delta Q$ (SQ)
violating modes, or $\Delta S = 1$ weak neutral current ($S1$) modes**

| | | | | |
|-----------------------------------|--------|-----------------------|--------------------------|-----|
| $\pi^+ \pi^+ e^- \bar{\nu}_e$ | SQ | < 1.2 | $\times 10^{-8}$ CL=90% | 203 |
| $\pi^+ \pi^+ \mu^- \bar{\nu}_\mu$ | SQ | < 3.0 | $\times 10^{-6}$ CL=95% | 151 |
| $\pi^+ e^+ e^-$ | $S1$ | (2.88 ± 0.13) | $\times 10^{-7}$ | 227 |
| $\pi^+ \mu^+ \mu^-$ | $S1$ | (8.1 ± 1.4) | $\times 10^{-8}$ S=2.7 | 172 |
| $\pi^+ \nu \bar{\nu}$ | $S1$ | $(1.5^{+1.3}_{-0.9})$ | $\times 10^{-10}$ | 227 |
| $\pi^+ \pi^0 \nu \bar{\nu}$ | $S1$ | < 4.3 | $\times 10^{-5}$ CL=90% | 205 |
| $\mu^- \nu e^+ e^+$ | LF | < 2.0 | $\times 10^{-8}$ CL=90% | 236 |
| $\mu^+ \nu_e$ | LF | $[d] < 4$ | $\times 10^{-3}$ CL=90% | 236 |
| $\pi^+ \mu^+ e^-$ | LF | < 1.3 | $\times 10^{-11}$ CL=90% | 214 |
| $\pi^+ \mu^- e^+$ | LF | < 5.2 | $\times 10^{-10}$ CL=90% | 214 |
| $\pi^- \mu^+ e^+$ | L | < 5.0 | $\times 10^{-10}$ CL=90% | 214 |
| $\pi^- e^+ e^+$ | L | < 6.4 | $\times 10^{-10}$ CL=90% | 227 |
| $\pi^- \mu^+ \mu^+$ | L | $[d] < 3.0$ | $\times 10^{-9}$ CL=90% | 172 |
| $\mu^+ \bar{\nu}_e$ | L | $[d] < 3.3$ | $\times 10^{-3}$ CL=90% | 236 |
| $\pi^0 e^+ \bar{\nu}_e$ | L | < 3 | $\times 10^{-3}$ CL=90% | 228 |
| $\pi^+ \gamma$ | $[cc]$ | < 2.3 | $\times 10^{-9}$ CL=90% | 227 |

 K^0

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

50% K_S , 50% K_L Mass $m = 497.648 \pm 0.022$ MeV

$$m_{K^0} - m_{K^\pm} = 3.972 \pm 0.027 \text{ MeV} \quad (S = 1.2)$$

Mean Square Charge Radius

$$\langle r^2 \rangle = -0.077 \pm 0.010 \text{ fm}^2$$

***T*-violation parameters in $K^0\text{-}\bar{K}^0$ mixing [x]**

$$\text{Asymmetry } A_T \text{ in } K^0\text{-}\bar{K}^0 \text{ mixing} = (6.6 \pm 1.6) \times 10^{-3}$$

***CPT*-violation parameters [x]**

$$\text{Re } \delta = (2.9 \pm 2.7) \times 10^{-4}$$

$$\text{Im } \delta = (-0.2 \pm 2.0) \times 10^{-5}$$

$$\text{Re}(y), K_{e3} \text{ parameter} = (0.4 \pm 2.5) \times 10^{-3}$$

$$\text{Re}(x_-), K_{e3} \text{ parameter} = (-0.8 \pm 2.5) \times 10^{-3}$$

$$|m_{K^0} - m_{\bar{K}^0}| / m_{\text{average}} < 10^{-18}, \text{ CL} = 90\% [dd]$$

$$(\Gamma_{K^0} - \Gamma_{\bar{K}^0}) / m_{\text{average}} = (8 \pm 8) \times 10^{-18}$$

Tests of $\Delta S = \Delta Q$

$$\text{Re}(x_+), K_{e3} \text{ parameter} = (-0.8 \pm 3.1) \times 10^{-3}$$



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

$$\text{Mean life } \tau = (0.8953 \pm 0.0005) \times 10^{-10} \text{ s} \quad (S = 1.1) \quad \text{Assuming } CPT$$

$$\text{Mean life } \tau = (0.8958 \pm 0.0006) \times 10^{-10} \text{ s} \quad (S = 1.2) \quad \text{Not assuming } CPT$$

$$c\tau = 2.6842 \text{ cm} \quad \text{Assuming } CPT$$

***CP*-violation parameters [ee]**

$$\text{Im}(\eta_{+-0}) = -0.002 \pm 0.009$$

$$\text{Im}(\eta_{000}) = (-0.1 \pm 1.6) \times 10^{-2}$$

$$|\eta_{000}| = |A(K_S^0 \rightarrow 3\pi^0)/A(K_L^0 \rightarrow 3\pi^0)| < 0.018, \text{ CL} = 90\%$$

$$CP \text{ asymmetry } A \text{ in } \pi^+\pi^-e^+e^- = (-1 \pm 4)\%$$

| K_S^0 DECAY MODES | Fraction (Γ_i/Γ) | Confidence level ($\frac{p}{\text{MeV/c}}$) |
|--|--|---|
| Hadronic modes | | |
| $\pi^0\pi^0$ | $(30.69 \pm 0.05) \%$ | 209 |
| $\pi^+\pi^-$ | $(69.20 \pm 0.05) \%$ | 206 |
| $\pi^+\pi^-\pi^0$ | $(3.5^{+1.1}_{-0.9}) \times 10^{-7}$ | 133 |
| Modes with photons or $\ell\bar{\ell}$ pairs | | |
| $\pi^+\pi^-\gamma$ | $[y, ff] \quad (1.79 \pm 0.05) \times 10^{-3}$ | 206 |
| $\pi^+\pi^-e^+e^-$ | $(4.69 \pm 0.30) \times 10^{-5}$ | 206 |
| $\pi^0\gamma\gamma$ | $[ff] \quad (4.9 \pm 1.8) \times 10^{-8}$ | 231 |
| $\gamma\gamma$ | $(2.84 \pm 0.07) \times 10^{-6}$ | 249 |

Semileptonic modes

$$\pi^\pm e^\mp \nu_e \quad [gg] \quad (7.04 \pm 0.09) \times 10^{-4} \quad 229$$

CP violating (CP) and $\Delta S = 1$ weak neutral current (S1) modes

| | | | | | |
|---------------------|----|-------|--|-----|-----|
| $3\pi^0$ | CP | < 1.2 | $\times 10^{-7}$ | 90% | 139 |
| $\mu^+ \mu^-$ | S1 | < 3.2 | $\times 10^{-7}$ | 90% | 225 |
| $e^+ e^-$ | S1 | < 1.4 | $\times 10^{-7}$ | 90% | 249 |
| $\pi^0 e^+ e^-$ | S1 | [ff] | $(3.0 \pm_{-1.2}^{+1.5}) \times 10^{-9}$ | | 231 |
| $\pi^0 \mu^+ \mu^-$ | S1 | | $(2.9 \pm_{-1.2}^{+1.5}) \times 10^{-9}$ | | 177 |



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

$$m_{K_L} - m_{K_S}$$

$$= (0.5292 \pm 0.0009) \times 10^{10} \hbar \text{ s}^{-1} \quad (S = 1.2) \quad \text{Assuming } CPT$$

$$= (3.483 \pm 0.006) \times 10^{-12} \text{ MeV} \quad \text{Assuming } CPT$$

$$= (0.5290 \pm 0.0016) \times 10^{10} \hbar \text{ s}^{-1} \quad (S = 1.2) \quad \text{Not assuming } CPT$$

$$\text{Mean life } \tau = (5.114 \pm 0.021) \times 10^{-8} \text{ s}$$

$$c\tau = 15.33 \text{ m}$$

Slope parameter $g^{[w]}$

(See Particle Listings for quadratic coefficients)

$$K_L^0 \rightarrow \pi^+ \pi^- \pi^0 = 0.678 \pm 0.008 \quad (S = 1.5)$$

 K_L decay form factors $^{[x]}$

Linear parametrization assuming μ -e universality

$$\lambda_+(K_{\mu 3}^0) = \lambda_+(K_{e 3}^0) = (2.84 \pm 0.04) \times 10^{-2}$$

$$\lambda_0(K_{\mu 3}^0) = (1.64 \pm 0.11) \times 10^{-2}$$

Quadratic parametrization assuming μ -e universality

$$\lambda'_+(K_{\mu 3}^0) = \lambda'_+(K_{e 3}^0) = (2.42 \pm 0.14) \times 10^{-2} \quad (S = 1.3)$$

$$\lambda''_+(K_{\mu 3}^0) = \lambda''_+(K_{e 3}^0) = (0.18 \pm 0.05) \times 10^{-2} \quad (S = 1.1)$$

$$\lambda_0(K_{\mu 3}^0) = (1.46 \pm 0.13) \times 10^{-2}$$

Pole parametrization assuming μ -e universality

$$\begin{aligned}
 M_V^\mu (K_{\mu 3}^0) &= M_V^e (K_{e 3}^0) = 877 \pm 5 \text{ MeV} \quad (S = 1.1) \\
 M_S^\mu (K_{\mu 3}^0) &= 1187 \pm 50 \\
 K_{e 3}^0 \quad |f_S/f_+| &= (1.5_{-1.6}^{+1.4}) \times 10^{-2} \\
 K_{e 3}^0 \quad |f_T/f_+| &= (5_{-5}^{+4}) \times 10^{-2} \\
 K_{\mu 3}^0 \quad |f_T/f_+| &= (12 \pm 12) \times 10^{-2} \\
 K_L \rightarrow e^+ e^- \gamma: \quad \alpha_{K^*} &= -0.33 \pm 0.05 \\
 K_L \rightarrow \mu^+ \mu^- \gamma: \quad \alpha_{K^*} &= -0.158 \pm 0.027 \\
 K_L \rightarrow e^+ e^- e^+ e^-: \quad \alpha_{K^*}^{\text{eff}} &= -0.14 \pm 0.22 \\
 K_L \rightarrow \pi^+ \pi^- e^+ e^-: \quad a_1/a_2 &= -0.734 \pm 0.022 \text{ GeV}^2 \\
 K_L \rightarrow \pi^0 2\gamma: \quad a_V &= -0.54 \pm 0.12 \quad (S = 2.8)
 \end{aligned}$$

CP-violation parameters [ee]

$$\begin{aligned}
 A_L &= (0.332 \pm 0.006)\% \\
 |\eta_{00}| &= (2.225 \pm 0.007) \times 10^{-3} \\
 |\eta_{+-}| &= (2.236 \pm 0.007) \times 10^{-3} \\
 |\epsilon| &= (2.232 \pm 0.007) \times 10^{-3} \\
 |\eta_{00}/\eta_{+-}| &= 0.9950 \pm 0.0008 \text{ [hh]} \quad (S = 1.6) \\
 \text{Re}(\epsilon'/\epsilon) &= (1.66 \pm 0.26) \times 10^{-3} \text{ [hh]} \quad (S = 1.6)
 \end{aligned}$$

Assuming *CPT*

$$\begin{aligned}
 \phi_{+-} &= (43.52 \pm 0.05)^\circ \quad (S = 1.2) \\
 \phi_{00} &= (43.50 \pm 0.06)^\circ \quad (S = 1.2) \\
 \phi_\epsilon = \phi_{\text{SW}} &= (43.51 \pm 0.05)^\circ \quad (S = 1.1)
 \end{aligned}$$

Not assuming *CPT*

$$\begin{aligned}
 \phi_{+-} &= (43.4 \pm 0.7)^\circ \quad (S = 1.3) \\
 \phi_{00} &= (43.7 \pm 0.8)^\circ \quad (S = 1.2) \\
 \phi_\epsilon &= (43.5 \pm 0.7)^\circ \quad (S = 1.3)
 \end{aligned}$$

$$\begin{aligned}
 \text{CP asymmetry } A \text{ in } K_L^0 \rightarrow \pi^+ \pi^- e^+ e^- &= (13.7 \pm 1.5)\% \\
 \beta_{CP} \text{ from } K_L^0 \rightarrow e^+ e^- e^+ e^- &= -0.19 \pm 0.07 \\
 \gamma_{CP} \text{ from } K_L^0 \rightarrow e^+ e^- e^+ e^- &= 0.01 \pm 0.11 \quad (S = 1.6) \\
 j \text{ for } K_L^0 \rightarrow \pi^+ \pi^- \pi^0 &= 0.0012 \pm 0.0008 \\
 f \text{ for } K_L^0 \rightarrow \pi^+ \pi^- \pi^0 &= 0.004 \pm 0.006 \\
 |\eta_{+-\gamma}| &= (2.35 \pm 0.07) \times 10^{-3} \\
 \phi_{+-\gamma} &= (44 \pm 4)^\circ \\
 |\epsilon'_{+-\gamma}|/\epsilon &< 0.3, \text{ CL} = 90\%
 \end{aligned}$$

T-violation parameters

$$\text{Im}(\xi) \text{ in } K_{\mu 3}^0 = -0.007 \pm 0.026$$

CPT invariance tests

$$\phi_{00} - \phi_{+-} = (0.2 \pm 0.4)^\circ$$

$$\text{Re}(\frac{2}{3}\eta_{+-} + \frac{1}{3}\eta_{00}) - \frac{\delta_L}{2} = (-3 \pm 35) \times 10^{-6}$$

 $\Delta S = -\Delta Q$ in $K_{\ell 3}^0$ decay

$$\text{Re } x = -0.002 \pm 0.006$$

$$\text{Im } x = 0.0012 \pm 0.0021$$

| K_L^0 DECAY MODES | Fraction (Γ_i/Γ) | Scale factor/ Confidence level | p (MeV/c) |
|--|---|-----------------------------------|----------------|
| Semileptonic modes | | | |
| $\pi^\pm e^\mp \nu_e$ Called K_{e3}^0 . | [<i>gg</i>] (40.53 \pm 0.15) % | S=2.1 | 229 |
| $\pi^\pm \mu^\mp \nu_\mu$ Called $K_{\mu 3}^0$. | [<i>gg</i>] (27.02 \pm 0.07) % | | 216 |
| $(\pi \mu \text{atom}) \nu$ | (1.05 \pm 0.11) $\times 10^{-7}$ | | 188 |
| $\pi^0 \pi^\pm e^\mp \nu$ | [<i>gg</i>] (5.20 \pm 0.11) $\times 10^{-5}$ | | 207 |
| Hadronic modes, including Charge conjugation\timesParity Violating (CPV) modes | | | |
| $3\pi^0$ | (19.56 \pm 0.14) % | S=1.9 | 139 |
| $\pi^+ \pi^- \pi^0$ | (12.56 \pm 0.05) % | | 133 |
| $\pi^+ \pi^-$ | CPV (1.976 \pm 0.008) $\times 10^{-3}$ | | 206 |
| $\pi^0 \pi^0$ | CPV (8.69 \pm 0.04) $\times 10^{-4}$ | S=1.1 | 209 |
| Semileptonic modes with photons | | | |
| $\pi^\pm e^\mp \nu_e \gamma$ | [<i>y,gg,ii</i>] (3.79 \pm 0.08) $\times 10^{-3}$ | | 229 |
| $\pi^\pm \mu^\mp \nu_\mu \gamma$ | (5.64 \pm 0.23) $\times 10^{-4}$ | | 216 |
| Hadronic modes with photons or $\ell\bar{\ell}$ pairs | | | |
| $\pi^0 \pi^0 \gamma$ | < 5.6 $\times 10^{-6}$ | | 209 |
| $\pi^+ \pi^- \gamma$ | [<i>y,ii</i>] (4.17 \pm 0.15) $\times 10^{-5}$ | | 206 |
| $\pi^0 2\gamma$ | [<i>ii</i>] (1.49 \pm 0.08) $\times 10^{-6}$ | S=2.0 | 231 |
| $\pi^0 \gamma e^+ e^-$ | (2.3 \pm 0.4) $\times 10^{-8}$ | | 231 |
| Other modes with photons or $\ell\bar{\ell}$ pairs | | | |
| 2γ | (5.48 \pm 0.05) $\times 10^{-4}$ | S=1.2 | 249 |
| 3γ | < 2.4 $\times 10^{-7}$ | CL=90% | 249 |
| $e^+ e^- \gamma$ | (10.0 \pm 0.5) $\times 10^{-6}$ | S=1.5 | 249 |
| $\mu^+ \mu^- \gamma$ | (3.59 \pm 0.11) $\times 10^{-7}$ | S=1.3 | 225 |
| $e^+ e^- \gamma \gamma$ | [<i>ii</i>] (5.95 \pm 0.33) $\times 10^{-7}$ | | 249 |
| $\mu^+ \mu^- \gamma \gamma$ | [<i>ii</i>] (1.0 $^{+0.8}_{-0.6}$) $\times 10^{-8}$ | | 225 |

**Charge conjugation \times Parity (CP) or Lepton Family number (LF)
violating modes, or $\Delta S = 1$ weak neutral current ($S1$) modes**

| | | | |
|-------------------------------|---------------|----------------------------------|-----|
| $\mu^+ \mu^-$ | $S1$ | $(6.87 \pm 0.11) \times 10^{-9}$ | 225 |
| $e^+ e^-$ | $S1$ | $(9 \pm 6_{-4}) \times 10^{-12}$ | 249 |
| $\pi^+ \pi^- e^+ e^-$ | $S1$ [ii] | $(3.11 \pm 0.19) \times 10^{-7}$ | 206 |
| $\pi^0 \pi^0 e^+ e^-$ | $S1$ | $< 6.6 \times 10^{-9}$ CL=90% | 209 |
| $\mu^+ \mu^- e^+ e^-$ | $S1$ | $(2.69 \pm 0.27) \times 10^{-9}$ | 225 |
| $e^+ e^- e^+ e^-$ | $S1$ | $(3.56 \pm 0.21) \times 10^{-8}$ | 249 |
| $\pi^0 \mu^+ \mu^-$ | $CP, S1$ [jj] | $< 3.8 \times 10^{-10}$ CL=90% | 177 |
| $\pi^0 e^+ e^-$ | $CP, S1$ [jj] | $< 2.8 \times 10^{-10}$ CL=90% | 231 |
| $\pi^0 \nu \bar{\nu}$ | $CP, S1$ [kk] | $< 5.9 \times 10^{-7}$ CL=90% | 231 |
| $e^\pm \mu^\mp$ | LF [gg] | $< 4.7 \times 10^{-12}$ CL=90% | 238 |
| $e^\pm e^\pm \mu^\mp \mu^\mp$ | LF [gg] | $< 4.12 \times 10^{-11}$ CL=90% | 225 |
| $\pi^0 \mu^\pm e^\mp$ | LF [gg] | $< 6.2 \times 10^{-9}$ CL=90% | 217 |

$K^*(892)$

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

$K^*(892)^\pm$ mass $m = 891.66 \pm 0.26$ MeV

$K^*(892)^0$ mass $m = 896.00 \pm 0.25$ MeV ($S = 1.4$)

$K^*(892)^\pm$ full width $\Gamma = 50.8 \pm 0.9$ MeV

$K^*(892)^0$ full width $\Gamma = 50.3 \pm 0.6$ MeV ($S = 1.1$)

| $K^*(892)$ DECAY MODES | Fraction (Γ_i/Γ) | Confidence level | p (MeV/c) |
|--|----------------------------------|------------------|-------------|
| $K \pi$ | ~ 100 | % | 289 |
| $K^0 \gamma$ | $(2.31 \pm 0.20) \times 10^{-3}$ | | 307 |
| $K^\pm \gamma$ | $(9.9 \pm 0.9) \times 10^{-4}$ | | 309 |
| $K \pi \pi$ | $< 7 \times 10^{-4}$ | 95% | 223 |

$K_1(1270)$

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

Mass $m = 1272 \pm 7$ MeV [n]

Full width $\Gamma = 90 \pm 20$ MeV [n]

| $K_1(1270)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|---|--------------------------------|-------------|
| $K \rho$ | $(42 \pm 6) \%$ | 45 |
| $K_0^*(1430) \pi$ | $(28 \pm 4) \%$ | † |
| $K^*(892) \pi$ | $(16 \pm 5) \%$ | 302 |
| $K \omega$ | $(11.0 \pm 2.0) \%$ | † |
| $K f_0(1370)$ | $(3.0 \pm 2.0) \%$ | † |
| γK^0 | seen | 539 |

$K_1(1400)$

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

Mass $m = 1402 \pm 7$ MeVFull width $\Gamma = 174 \pm 13$ MeV ($S = 1.6$)

| $K_1(1400)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|---|--------------------------------|-------------|
| $K^*(892)\pi$ | (94 \pm 6) % | 402 |
| $K\rho$ | (3.0 \pm 3.0) % | 292 |
| $Kf_0(1370)$ | (2.0 \pm 2.0) % | † |
| $K\omega$ | (1.0 \pm 1.0) % | 284 |
| $K_0^*(1430)\pi$ | not seen | † |
| γK^0 | seen | 613 |

 $K^*(1410)$

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

Mass $m = 1414 \pm 15$ MeV ($S = 1.3$)Full width $\Gamma = 232 \pm 21$ MeV ($S = 1.1$)

| $K^*(1410)$ DECAY MODES | Fraction (Γ_i/Γ) | Confidence level | p (MeV/c) |
|---|--------------------------------|------------------|-------------|
| $K^*(892)\pi$ | > 40 % | 95% | 410 |
| $K\pi$ | (6.6 \pm 1.3) % | | 612 |
| $K\rho$ | < 7 % | 95% | 305 |
| γK^0 | seen | | 619 |

 $K_0^*(1430)$ [//]

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

Mass $m = 1414 \pm 6$ MeVFull width $\Gamma = 290 \pm 21$ MeV

| $K_0^*(1430)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|---|--------------------------------|-------------|
| $K\pi$ | (93 \pm 10) % | 613 |

 $K_2^*(1430)$

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

 $K_2^*(1430)^\pm$ mass $m = 1425.6 \pm 1.5$ MeV ($S = 1.1$) $K_2^*(1430)^0$ mass $m = 1432.4 \pm 1.3$ MeV $K_2^*(1430)^\pm$ full width $\Gamma = 98.5 \pm 2.7$ MeV ($S = 1.1$) $K_2^*(1430)^0$ full width $\Gamma = 109 \pm 5$ MeV ($S = 1.9$)

| $K_2^*(1430)$ DECAY MODES | Fraction (Γ_i/Γ) | Scale factor/ Confidence level | p (MeV/c) |
|---|--------------------------------------|-----------------------------------|----------------|
| $K\pi$ | $(49.9 \pm 1.2) \%$ | | 619 |
| $K^*(892)\pi$ | $(24.7 \pm 1.5) \%$ | | 419 |
| $K^*(892)\pi\pi$ | $(13.4 \pm 2.2) \%$ | | 372 |
| $K\rho$ | $(8.7 \pm 0.8) \%$ | S=1.2 | 318 |
| $K\omega$ | $(2.9 \pm 0.8) \%$ | | 311 |
| $K^+\gamma$ | $(2.4 \pm 0.5) \times 10^{-3}$ | S=1.1 | 627 |
| $K\eta$ | $(1.5^{+3.4}_{-1.0}) \times 10^{-3}$ | S=1.3 | 487 |
| $K\omega\pi$ | $< 7.2 \times 10^{-4}$ | CL=95% | 100 |
| $K^0\gamma$ | $< 9 \times 10^{-4}$ | CL=90% | 626 |

 $K^*(1680)$

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

Mass $m = 1717 \pm 27$ MeV (S = 1.4)

Full width $\Gamma = 322 \pm 110$ MeV (S = 4.2)

| $K^*(1680)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|---|--------------------------------|-------------|
| $K\pi$ | $(38.7 \pm 2.5) \%$ | 781 |
| $K\rho$ | $(31.4^{+4.7}_{-2.1}) \%$ | 570 |
| $K^*(892)\pi$ | $(29.9^{+2.2}_{-4.7}) \%$ | 618 |

 $K_2(1770)$ $[mm]$

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

Mass $m = 1773 \pm 8$ MeV

Full width $\Gamma = 186 \pm 14$ MeV

| $K_2(1770)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|---|--------------------------------|-------------|
| $K\pi\pi$ | | 794 |
| $K_2^*(1430)\pi$ | dominant | 288 |
| $K^*(892)\pi$ | seen | 654 |
| $Kf_2(1270)$ | seen | 53 |
| $K\phi$ | seen | 441 |
| $K\omega$ | seen | 607 |

 $K_3^*(1780)$

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

Mass $m = 1776 \pm 7$ MeV (S = 1.1)

Full width $\Gamma = 159 \pm 21$ MeV (S = 1.3)

| $K_3^*(1780)$ DECAY MODES | Fraction (Γ_i/Γ) | Confidence level | p (MeV/c) |
|---|--------------------------------|------------------|----------------|
| $K \rho$ | (31 \pm 9) % | | 613 |
| $K^*(892) \pi$ | (20 \pm 5) % | | 656 |
| $K \pi$ | (18.8 \pm 1.0) % | | 813 |
| $K \eta$ | (30 \pm 13) % | | 719 |
| $K_2^*(1430) \pi$ | < 16 % | 95% | 291 |

$K_2(1820)$ ^[nn]

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

Mass $m = 1816 \pm 13$ MeVFull width $\Gamma = 276 \pm 35$ MeV

| $K_2(1820)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|---|--------------------------------|-------------|
| $K_2^*(1430) \pi$ | seen | 327 |
| $K^*(892) \pi$ | seen | 681 |
| $K f_2(1270)$ | seen | 185 |
| $K \omega$ | seen | 638 |

$K_4^*(2045)$

$$I(J^P) = \frac{1}{2}(4^+)$$

Mass $m = 2045 \pm 9$ MeV ($S = 1.1$)Full width $\Gamma = 198 \pm 30$ MeV

| $K_4^*(2045)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|---|--------------------------------|-------------|
| $K \pi$ | (9.9 \pm 1.2) % | 958 |
| $K^*(892) \pi \pi$ | (9 \pm 5) % | 802 |
| $K^*(892) \pi \pi \pi$ | (7 \pm 5) % | 768 |
| $\rho K \pi$ | (5.7 \pm 3.2) % | 741 |
| $\omega K \pi$ | (5.0 \pm 3.0) % | 738 |
| $\phi K \pi$ | (2.8 \pm 1.4) % | 594 |
| $\phi K^*(892)$ | (1.4 \pm 0.7) % | 363 |

CHARMED MESONS

($C = \pm 1$)

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

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

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

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

CP-violation decay-rate asymmetries

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

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

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

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

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

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

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

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

$$r_V = 1.62 \pm 0.08 \quad (S = 1.5)$$

$$r_2 = 0.83 \pm 0.05$$

$$r_3 = 0.0 \pm 0.4$$

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

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

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 $2\Gamma(K_S^0) = \Gamma(\bar{K}^0)$.

| D^+ DECAY MODES | Fraction (Γ_i/Γ) | Scale factor/ Confidence level | p (MeV/c) |
|--|------------------------------------|-----------------------------------|----------------|
| Inclusive modes | | | |
| e^+ anything | (17.2 \pm 1.9) % | | — |
| K^- anything | (27.5 \pm 2.4) % | | — |
| \bar{K}^0 anything + K^0 anything | (61 \pm 8) % | | — |
| K^+ anything | (5.5 \pm 1.6) % | | — |
| $\bar{K}^*(892)^0$ anything | (23 \pm 5) % | | — |
| $K^*(892)^0$ anything | < 6.6 % | CL=90% | — |
| η anything | [pp] < 13 % | CL=90% | — |
| ϕ anything | < 1.8 % | CL=90% | — |
| ϕe^+ anything | < 1.6 % | CL=90% | — |
| Leptonic and semileptonic modes | | | |
| $e^+ \nu_e$ | < 2.4 $\times 10^{-5}$ | CL=90% | 935 |
| $\mu^+ \nu_\mu$ | (4.4 \pm 0.7) $\times 10^{-4}$ | | 932 |
| $\bar{K}^0 e^+ \nu_e$ | (8.6 \pm 0.5) % | | 868 |
| $\bar{K}^0 \mu^+ \nu_\mu$ | (9.5 \pm 0.8) % | | 865 |
| $K^- \pi^+ e^+ \nu_e$ | (4.5 $^{+1.0}_{-0.8}$) % | S=1.1 | 863 |
| $\bar{K}^*(892)^0 e^+ \nu_e$, $\bar{K}^*(892)^0 \rightarrow K^- \pi^+$ | (3.74 \pm 0.21) % | | 722 |
| $K^- \pi^+ e^+ \nu_e$ nonresonant | < 7 $\times 10^{-3}$ | CL=90% | 863 |
| $K^- \pi^+ \mu^+ \nu_\mu$ | (4.0 \pm 0.5) % | | 851 |
| $\bar{K}^*(892)^0 \mu^+ \nu_\mu$, $\bar{K}^*(892)^0 \rightarrow K^- \pi^+$ | (3.7 \pm 0.3) % | | 717 |
| $K^- \pi^+ \mu^+ \nu_\mu$ nonresonant | (2.1 \pm 0.6) $\times 10^{-3}$ | | 851 |
| $(\bar{K}^*(892)\pi)^0 e^+ \nu_e$ | < 1.2 % | CL=90% | 712 |
| $(\bar{K}\pi\pi)^0 e^+ \nu_e$ non- $\bar{K}^*(892)$ | < 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. | | | |
| $\bar{K}^*(892)^0 e^+ \nu_e$ | (5.61 \pm 0.31) % | S=1.1 | 722 |
| $\bar{K}^*(892)^0 \mu^+ \nu_\mu$ | (5.5 \pm 0.5) % | S=1.1 | 717 |
| $\bar{K}_1(1270)^0 \mu^+ \nu_\mu$ | < 4 % | CL=95% | 493 |
| $\bar{K}_0^*(1430)^0 \mu^+ \nu_\mu$ | < 2.5 $\times 10^{-4}$ | | 388 |
| $\bar{K}_2^*(1430)^0 \mu^+ \nu_\mu$ | < 1.1 % | CL=95% | 380 |
| $\bar{K}^*(1680)^0 \mu^+ \nu_\mu$ | < 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 |
| $\omega e^+ \nu_e$ | $(1.6 \pm_{-0.6}^{+0.7}) \times 10^{-3}$ | | 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 |
| $K^- \pi^+ \pi^+$ | [qq] $(9.51 \pm 0.34) \%$ | S=1.1 | 845 |
| $\bar{K}^*(892)^0 \pi^+,$ $\bar{K}^*(892)^0 \rightarrow K^- \pi^+$ | [rr] $(1.33 \pm 0.11) \%$ | | 714 |
| $\bar{K}_0^*(1430)^0 \pi^+,$ $\bar{K}_0^*(1430)^0 \rightarrow K^- \pi^+$ | [rr] $(2.41 \pm 0.24) \%$ | | 382 |
| $\bar{K}^*(1680)^0 \pi^+,$ $\bar{K}^*(1680)^0 \rightarrow K^- \pi^+$ | [rr] $(4.0 \pm 0.8) \times 10^{-3}$ | | 58 |
| $K^- \pi^+ \pi^+$ nonresonant | [rr] $(9.0 \pm 0.7) \%$ | | 845 |
| $K_S^0 \pi^+ \pi^0$ | [qq] $(7.0 \pm 0.5) \%$ | S=1.2 | 845 |
| $K_S^0 \rho^+$ | $(4.8 \pm 1.1) \%$ | | 677 |
| $\bar{K}^*(892)^0 \pi^+,$ $\bar{K}^*(892)^0 \rightarrow K_S^0 \pi^0$ | $(1.3 \pm 0.6) \%$ | | 714 |
| $K_S^0 \pi^+ \pi^0$ nonresonant | $(9 \pm 7) \times 10^{-3}$ | | 845 |
| $K^- \pi^+ \pi^+ \pi^0$ | [qq] $(5.5 \pm 2.7) \%$ | S=1.2 | 816 |
| $\bar{K}^*(892)^0 \rho^+$ total, $\bar{K}^*(892)^0 \rightarrow K^- \pi^+$ | $(1.3 \pm 0.8) \%$ | | 422 |
| $\bar{K}_1(1400)^0 \pi^+,$ $\bar{K}_1(1400)^0 \rightarrow K^- \pi^+ \pi^0$ | $(1.8 \pm 0.7) \%$ | | 390 |
| $K^- \rho^+ \pi^+$ 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, $\bar{K}^*(892)^0 \rightarrow K^- \pi^+$ | $(4.2 \pm 0.6) \%$ | | 690 |
| $\bar{K}^*(892)^0 \pi^+ \pi^0$ 3-body, $\bar{K}^*(892)^0 \rightarrow K^- \pi^+$ | $(2.7 \pm 0.8) \%$ | | 690 |
| $K^*(892)^- \pi^+ \pi^+$ 3-body, $K^*(892)^- \rightarrow K^- \pi^0$ | $(6 \pm 3) \times 10^{-3}$ | | 688 |
| $K^- \pi^+ \pi^+ \pi^0$ nonresonant | [ss] $(1.0 \pm 0.7) \%$ | | 816 |
| $K_S^0 \pi^+ \pi^+ \pi^-$ | [qq] $(3.11 \pm 0.21) \%$ | S=1.1 | 814 |
| $K_S^0 a_1(1260)^+,$ $a_1(1260)^+ \rightarrow \pi^+ \pi^+ \pi^-$ | $(1.8 \pm 0.3) \%$ | | 328 |
| $\bar{K}_1(1400)^0 \pi^+,$ $\bar{K}_1(1400)^0 \rightarrow K_S^0 \pi^+ \pi^-$ | $(1.8 \pm 0.7) \%$ | | 390 |

| | | | |
|--|---|--------|-----|
| $K^*(892)^- \pi^+ \pi^+$ 3-body, | (1.3 \pm 0.6) % | | 688 |
| $K^*(892)^- \rightarrow K_S^0 \pi^-$ | | | |
| $K_S^0 \rho^0 \pi^+$ total | (1.86 \pm 0.34) % | CL=90% | 610 |
| $K_S^0 \rho^0 \pi^+$ 3-body | (2.2 \pm 2.2) $\times 10^{-3}$ | | 610 |
| $K_S^0 \pi^+ \pi^+ \pi^-$ nonresonant | (3.7 \pm 1.9) $\times 10^{-3}$ | | 814 |
| $K^- 3\pi^+ \pi^-$ | [qq] (5.8 \pm 0.6) $\times 10^{-3}$ | S=1.1 | 772 |
| $\bar{K}^*(892)^0 \pi^+ \pi^+ \pi^-$, | (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 |
| $\bar{K}^*(892)^0 \rightarrow K^- \pi^+$ | | | |
| $K^- \rho^0 \pi^+ \pi^+$ | (1.75 \pm 0.29) $\times 10^{-3}$ | | 524 |
| $K^- 3\pi^+ \pi^-$ nonresonant | (4.1 \pm 3.0) $\times 10^{-4}$ | | 772 |
| $K^+ 2K_S^0$ | (4.7 \pm 2.1) $\times 10^{-3}$ | | 545 |
| $K^+ K^- K_S^0 \pi^+$ | (2.4 \pm 0.6) $\times 10^{-4}$ | | 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 \pm 0.6) % | | 328 |
| $K_S^0 a_2(1320)^+$ | < 1.5 $\times 10^{-3}$ | CL=90% | 199 |
| $\bar{K}^*(892)^0 \rho^+$ total | [ss] (1.8 \pm 1.4) % | | 422 |
| $\bar{K}^*(892)^0 \rho^+$ S-wave | [ss] (1.4 \pm 1.5) % | | 422 |
| $\bar{K}^*(892)^0 \rho^+$ P-wave | < 1 $\times 10^{-3}$ | CL=90% | 422 |
| $\bar{K}^*(892)^0 \rho^+$ D-wave | (8 \pm 7) $\times 10^{-3}$ | | 422 |
| $\bar{K}^*(892)^0 \rho^+$ D-wave longitu- | < 7 $\times 10^{-3}$ | CL=90% | 422 |
| dinal | | | |
| $\bar{K}_1(1270)^0 \pi^+$ | < 7 $\times 10^{-3}$ | CL=90% | 487 |
| $\bar{K}_1(1400)^0 \pi^+$ | (4.3 \pm 1.5) % | S=1.2 | 390 |
| $\bar{K}^*(892)^0 \pi^+ \pi^0$ total | (5.8 \pm 2.9) % | | 690 |
| $\bar{K}^*(892)^0 \pi^+ \pi^0$ 3-body | [ss] (3.6 \pm 2.1) % | | 690 |
| $K^*(892)^- \pi^+ \pi^+$ total | — | | 688 |
| $K^*(892)^- \pi^+ \pi^+$ 3-body | (1.8 \pm 1.1 \pm 0.9) % | S=1.2 | 688 |
| $\bar{K}^*(892)^0 a_1(1260)^+$ | (9.4 \pm 1.9) $\times 10^{-3}$ | | † |

Pionic modes

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

| | | |
|---|----------------------------------|------------|
| $f_2(1270)\pi^+$, | $(4.8 \pm 1.3) \times 10^{-4}$ | 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 |
| $K^+K^-\pi^+$ | [qq] $(1.00 \pm 0.04) \%$ | 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- ϕ | $(1.5^{+0.7}_{-0.6}) \%$ | 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 |
| $K^{*+} \rightarrow K_S^0\pi^+, \bar{K}^{*0} \rightarrow K^-\pi^+$ | | |
| $K_S^0K^-\pi^+\pi^+(\text{non-}K^{*+}\bar{K}^{*0})$ | $< 4 \times 10^{-3}$ | 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 ± 0.7) | % | | 611 |
| $K^{*}(892)^+ \bar{K}^{*}(892)^0$ | (2.6 ± 1.1) | % | | 280 |

Doubly Cabibbo-suppressed modes

| | | | | |
|--|-----------------|------------------|--------|-----|
| $K^+ \pi^0$ | < 4.2 | $\times 10^{-4}$ | CL=90% | 864 |
| $K^+ \pi^+ \pi^-$ | (6.4 ± 0.8) | $\times 10^{-4}$ | | 845 |
| $K^+ \rho^0$ | (2.5 ± 0.7) | $\times 10^{-4}$ | | 678 |
| $K^{*}(892)^0 \pi^+, K^{*}(892)^0 \rightarrow$ | (3.0 ± 0.6) | $\times 10^{-4}$ | | 714 |
| $K^+ \pi^-$ | | | | |
| $K^+ f_0(980), f_0(980) \rightarrow$ | (5.7 ± 3.5) | $\times 10^{-5}$ | | — |
| $\pi^+ \pi^-$ | | | | |
| $K_2^{*}(1430)^0 \pi^+, K_2^{*}(1430)^0 \rightarrow$ | (5.2 ± 3.5) | $\times 10^{-5}$ | | — |
| $K^+ \pi^-$ | | | | |
| $K^+ K^+ K^-$ | (9.0 ± 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 |
| $\pi^+ \phi, \phi \rightarrow e^+ e^-$ | [tt] | $(2.7 \pm_{-1.8}^{+3.6})$ | $\times 10^{-6}$ | | — |
| $\pi^+ \mu^+ \mu^-$ | C1 | < 8.8 | $\times 10^{-6}$ | CL=90% | 917 |
| $\rho^+ \mu^+ \mu^-$ | C1 | < 5.6 | $\times 10^{-4}$ | CL=90% | 757 |
| $K^+ e^+ e^-$ | [uu] | < 6.2 | $\times 10^{-6}$ | CL=90% | 869 |
| $K^+ \mu^+ \mu^-$ | [uu] | < 9.2 | $\times 10^{-6}$ | CL=90% | 856 |
| $\pi^+ e^\pm \mu^\mp$ | LF | [gg] < 3.4 | $\times 10^{-5}$ | CL=90% | 926 |
| $K^+ e^\pm \mu^\mp$ | LF | [gg] < 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

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

$$\text{Mass } m = 1864.5 \pm 0.4 \text{ MeV} \quad (S = 1.1)$$

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

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

$$c\tau = 122.9 \text{ } \mu\text{m}$$

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

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

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

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

$$\Gamma(K_S^0 \pi^+ \pi^- \text{ (in } D^0 \rightarrow \bar{D}^0)) / \Gamma(K_S^0 \pi^+ \pi^-) < 0.0063, \text{ CL} = 95\% \quad \Gamma_0/\Gamma_0$$

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 $2\Gamma(K_S^0) = \Gamma(\bar{K}^0)$.

| D^0 DECAY MODES | Fraction (Γ_i/Γ) | Scale factor/ Confidence level | p (MeV/c) |
|-------------------------------------|--|-----------------------------------|----------------|
| Topological modes | | | |
| 0-prongs | [ww] (19 \pm 6) % | | — |
| 2-prongs | (67 \pm 6) % | | — |
| 4-prongs | [xx] (13.8 \pm 0.5) % | | — |
| 6-prongs | (1.2 \pm 1.3 \pm 0.7) $\times 10^{-3}$ | | — |

Inclusive modes

| | | |
|---------------------------------------|-------------------------------|----------|
| e^+ anything | $[yy]$ (6.71 \pm 0.29) % | — |
| μ^+ anything | (6.5 \pm 0.7) % | — |
| K^- anything | (53 \pm 4) % | S=1.3 — |
| \bar{K}^0 anything + K^0 anything | (42 \pm 5) % | — |
| K^+ anything | (3.4 \pm 0.6 \pm 0.4) % | — |
| $\bar{K}^*(892)^0$ anything | (9 \pm 4) % | — |
| $K^*(892)^0$ anything | (2.8 \pm 1.3) % | — |
| η anything | $[pp] < 13$ % | CL=90% — |
| ϕ anything | (1.7 \pm 0.8) % | — |

Semileptonic modes

| | | |
|---------------------------------------|--------------------------------------|-----|
| $K^- e^+ \nu_e$ | (3.51 \pm 0.11) % | 867 |
| $K^- \mu^+ \nu_\mu$ | (3.19 \pm 0.16) % | 863 |
| $K^*(892)^- e^+ \nu_e$ | (2.17 \pm 0.16) % | 719 |
| $K^*(892)^- \mu^+ \nu_\mu$ | (1.95 \pm 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 \pm 0.19) $\times 10^{-3}$ | 927 |
| $\pi^- \mu^+ \nu_\mu$ | (2.4 \pm 0.4) $\times 10^{-3}$ | 924 |
| $\rho^- e^+ \nu_e$ | (1.9 \pm 0.4) $\times 10^{-3}$ | 771 |

Hadronic modes with one \bar{K}

| | | | |
|---|---|-------|-----|
| $K^- \pi^+$ | (3.80 \pm 0.07) % | S=1.1 | 861 |
| $K_S^0 \pi^0$ | (1.14 \pm 0.12) % | | 860 |
| $K_S^0 \pi^+ \pi^-$ | $[qq]$ (2.90 \pm 0.19) % | | 842 |
| $K_S^0 \rho^0$ | (7.5 \pm 0.6 \pm 0.8) $\times 10^{-3}$ | | 674 |
| $K_S^0 \omega, \omega \rightarrow \pi^+ \pi^-$ | (2.1 \pm 0.6) $\times 10^{-4}$ | | 670 |
| $K_S^0 f_0(980),$ $f_0(980) \rightarrow \pi^+ \pi^-$ | (1.36 \pm 0.30 \pm 0.22) $\times 10^{-3}$ | | 549 |
| $K_S^0 f_2(1270),$ $f_2(1270) \rightarrow \pi^+ \pi^-$ | (1.3 \pm 1.1 \pm 0.7) $\times 10^{-4}$ | | 262 |
| $K_S^0 f_0(1370),$ $f_0(1370) \rightarrow \pi^+ \pi^-$ | (2.5 \pm 0.6) $\times 10^{-3}$ | | † |
| $K^*(892)^- \pi^+,$ $K^*(892)^- \rightarrow K_S^0 \pi^-$ | (1.91 \pm 0.14) % | | 711 |
| $K^*(892)^+ \pi^-,$ $K^*(892)^+ \rightarrow K_S^0 \pi^+$ | $[zz]$ (10 \pm 12 \pm 4) $\times 10^{-5}$ | | 711 |
| $K_0^*(1430)^- \pi^+,$ $K_0^*(1430)^- \rightarrow K_S^0 \pi^-$ | (2.8 \pm 0.6 \pm 0.4) $\times 10^{-3}$ | | 378 |

| | | |
|--|--|-----------|
| $K_2^*(1430)^- \pi^+$, | (3.2 \pm 2.1 \pm 1.1) $\times 10^{-4}$ | 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 \pm 5.9 \pm 1.6) $\times 10^{-4}$ | 842 |
| $K^- \pi^+ \pi^0$ | [qq] (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 \pm 0.36 \pm 0.20) % | 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 \pm 4.6 \pm 1.5) $\times 10^{-3}$ | 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 \pm 0.54 \pm 0.20) % | 844 |
| $K_S^0 \pi^0 \pi^0$ | — | 843 |
| $\bar{K}^*(892)^0 \pi^0$, | (6.3 \pm 1.8 \pm 1.5) $\times 10^{-3}$ | 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 |
| $K^- \pi^+ \pi^+ \pi^-$ | [qq] (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 |
| $\bar{K}^*(892)^0 \rightarrow K^- \pi^+$ | | |
| $K_1(1270)^- \pi^+$, | [ss] (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 |
| $K_S^0 \pi^+ \pi^- \pi^0$ | [qq] (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 \pm 0.8) % | 416 |
| $K^*(892)^- \rightarrow K_S^0 \pi^-$ | | |
| $K_1(1270)^- \pi^+$, | [ss] (2.2 \pm 0.6) $\times 10^{-3}$ | 484 |
| $K_1(1270)^- \rightarrow K_S^0 \pi^- \pi^0$ | | |
| $\bar{K}^*(892)^0 \pi^+ \pi^-$ 3-body, | (2.4 \pm 0.5) $\times 10^{-3}$ | 685 |
| $\bar{K}^*(892)^0 \rightarrow K_S^0 \pi^0$ | | |
| $K_S^0 \pi^+ \pi^- \pi^0$ nonresonant | (1.1 \pm 1.1) % | 812 |
| $K^- \pi^+ \pi^+ \pi^- \pi^0$ | (4.1 \pm 0.4) % | 771 |
| $\bar{K}^*(892)^0 \pi^+ \pi^- \pi^0$, | (1.2 \pm 0.6) % | 643 |
| $\bar{K}^*(892)^0 \rightarrow K^- \pi^+$ | | |
| $K^- \pi^+ \omega$, $\omega \rightarrow \pi^+ \pi^- \pi^0$ | (2.7 \pm 0.5) % | 605 |
| $\bar{K}^*(892)^0 \omega$, | (6.5 \pm 2.4) $\times 10^{-3}$ | 410 |
| $\bar{K}^*(892)^0 \rightarrow K^- \pi^+$, | | |
| $\omega \rightarrow \pi^+ \pi^- \pi^0$ | | |
| $K_S^0 \eta \pi^0$ | (5.2 \pm 1.2) $\times 10^{-3}$ | 721 |
| $K_S^0 a_0(980)$, $a_0(980) \rightarrow \eta \pi^0$ | (6.2 \pm 2.0) $\times 10^{-3}$ | — |
| $\bar{K}^*(892)^0 \eta$, $\bar{K}^*(892)^0 \rightarrow$ | (1.5 \pm 0.5) $\times 10^{-3}$ | — |
| $K_S^0 \pi^0$ | | |
| $K_S^0 2\pi^+ 2\pi^-$ | (2.75 \pm 0.31) $\times 10^{-3}$ | 768 |
| $K_S^0 \rho^0 \pi^+ \pi^-$, no $K^*(892)^-$ | (1.1 \pm 0.7) $\times 10^{-3}$ | — |
| $K^*(892)^- \pi^+ \pi^+ \pi^-$, | (5 \pm 8) $\times 10^{-4}$ | 642 |
| $K^*(892)^- \rightarrow K_S^0 \pi^-$, | | |
| no ρ^0 | | |
| $K^*(892)^- \rho^0 \pi^+$, | (1.7 \pm 0.7) $\times 10^{-3}$ | 230 |
| $K^*(892)^- \rightarrow K_S^0 \pi^-$ | | |
| $K_S^0 2\pi^+ 2\pi^-$ nonresonant | < 1.3 $\times 10^{-3}$ CL=90% | 768 |
| $K^- 3\pi^+ 2\pi^-$ | (2.1 \pm 0.5) $\times 10^{-4}$ | 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 \pm 0.6) $\times 10^{-3}$ | 772 |
| $K_S^0 \omega$ | (1.10 \pm 0.20) % | 670 |
| $K_S^0 \eta'(958)$ | (9.1 \pm 1.4) $\times 10^{-3}$ | 565 |
| $K^- a_1(1260)^+$ | (7.5 \pm 1.1) % | 327 |
| $\bar{K}^0 a_1(1260)^0$ | < 1.9 % CL=90% | 322 |
| $K^- a_2(1320)^+$ | < 2 $\times 10^{-3}$ CL=90% | 197 |
| $\bar{K}^*(892)^0 \pi^+ \pi^-$ total | (2.3 \pm 0.5) % | 685 |
| $\bar{K}^*(892)^0 \pi^+ \pi^-$ 3-body | (1.46 \pm 0.32) % | 685 |
| $\bar{K}^*(892)^0 \rho^0$ | (1.50 \pm 0.33) % | 417 |
| $\bar{K}^*(892)^0 \rho^0$ transverse | (1.6 \pm 0.5) % | 417 |
| $\bar{K}^*(892)^0 \rho^0$ S-wave | (2.9 \pm 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 |
| $K_1(1270)^- \pi^+$ | [ss] $(1.12 \pm 0.31) \%$ | | 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% | — |
| $(\pi^+\pi^-)_{S\text{-wave}}\pi^0$ | < 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 |
| $\eta\pi^0$ | [aaa] $(5.6 \pm 1.4) \times 10^{-4}$ | | 846 |
| $\omega\pi^0$ | [aaa] < 2.6 | $\times 10^{-4}$ CL=90% | 761 |
| $2\pi^+2\pi^-\pi^0$ | $(4.1 \pm 0.5) \times 10^{-3}$ | | 844 |
| $\eta\pi^+\pi^-$ | [aaa] < 1.9 | $\times 10^{-3}$ CL=90% | 827 |
| $\omega\pi^+\pi^-$ | [aaa] $(1.6 \pm 0.5) \times 10^{-3}$ | | 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 |
| $K^+K^-\pi^+\pi^-$ | [bbb] $(2.32 \pm 0.13) \times 10^{-3}$ | | 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, | [ccc] $(2.5 \pm 0.5) \times 10^{-4}$ | | 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 |
| $\phi \gamma$ | $(2.4 \pm_{-0.6}^{+0.7}) \times 10^{-5}$ | 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 | $(10 \pm_{-4}^{+12}) \times 10^{-5}$ | 711 |
| $K^+ \pi^- \pi^0$ | DC | $(3.29 \pm_{-0.27}^{+0.30}) \times 10^{-4}$ | 844 |
| $K^+ \pi^- \pi^+ \pi^-$ | DC | $(2.49 \pm_{-0.19}^{+0.21}) \times 10^{-4}$ | 812 |
| $K^+ \pi^- \pi^+ \pi^-$ (via \bar{D}^0) | C2M | $< 4 \times 10^{-4}$ CL=90% | 812 |
| μ^- 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 |

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

$D^*(2007)^0$

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

I, J, P need confirmation.

$$\text{Mass } m = 2006.7 \pm 0.4 \text{ MeV} \quad (S = 1.1)$$

$$m_{D^{*0}} - m_{D^0} = 142.12 \pm 0.07 \text{ MeV}$$

$$\text{Full width } \Gamma < 2.1 \text{ MeV, CL} = 90\%$$

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

| $D^*(2007)^0$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|---|--------------------------------|-------------|
| $D^0 \pi^0$ | $(61.9 \pm 2.9) \%$ | 43 |
| $D^0 \gamma$ | $(38.1 \pm 2.9) \%$ | 137 |

 $D^*(2010)^\pm$

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

I, J, P need confirmation.

$$\text{Mass } m = 2010.0 \pm 0.4 \text{ MeV} \quad (S = 1.1)$$

$$m_{D^*(2010)^+} - m_{D^+} = 140.64 \pm 0.10 \text{ MeV} \quad (S = 1.1)$$

$$m_{D^*(2010)^+} - m_{D^0} = 145.421 \pm 0.010 \text{ MeV} \quad (S = 1.1)$$

$$\text{Full width } \Gamma = 96 \pm 22 \text{ keV}$$

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

| $D^*(2010)^\pm$ DECAY MODES | Fraction (Γ_i/Γ) | 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 |

 $D_1(2420)^0$

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

I, J, P need confirmation.

$$\text{Mass } m = 2422.3 \pm 1.3 \text{ MeV} \quad (S = 1.2)$$

$$m_{D_1^0} - m_{D^{*+}} = 411.7 \pm 0.8$$

$$\text{Full width } \Gamma = 20.4 \pm 1.7 \text{ MeV}$$

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

| $D_1(2420)^0$ DECAY MODES | Fraction (Γ_i/Γ) | 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.

$$\text{Mass } m = 2461.1 \pm 1.6 \text{ MeV} \quad (S = 1.3)$$

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

$$\text{Full width } \Gamma = 43 \pm 4 \text{ MeV} \quad (S = 1.8)$$

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

| $D_2^*(2460)^0$ DECAY MODES | Fraction (Γ_i/Γ) | 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.

$$\text{Mass } m = 2459 \pm 4 \text{ MeV} \quad (S = 1.7)$$

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

$$\text{Full width } \Gamma = 29 \pm 5 \text{ MeV}$$

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

| $D_2^*(2460)^\pm$ DECAY MODES | Fraction (Γ_i/Γ) | 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 |

CHARMED, STRANGE MESONS

($C = S = \pm 1$)

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

D_s^\pm
was F^\pm

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

$$\text{Mass } m = 1968.2 \pm 0.5 \text{ MeV} \quad (S = 1.1)$$

$$m_{D_s^\pm} - m_{D^\pm} = 98.85 \pm 0.30 \text{ MeV} \quad (S = 1.4)$$

$$\text{Mean life } \tau = (500 \pm 7) \times 10^{-15} \text{ s} \quad (S = 1.3)$$

$$c\tau = 149.9 \mu\text{m}$$

T-violation decay-rate asymmetry

$$A_T(K_S^0 K^\pm \pi^+ \pi^-) = -0.04 \pm 0.07$$

D_s^+ form factors

$$r_2 = 1.32 \pm 0.24 \quad (S = 1.2)$$

$$r_V = 1.72 \pm 0.21$$

$$\Gamma_L/\Gamma_T = 0.72 \pm 0.18$$

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 (Γ_i/Γ) | Scale factor/ Confidence level | p (MeV/c) |
|---------------------------------------|--------------------------------|-----------------------------------|----------------|
| Inclusive modes | | | |
| K^- anything | (13 $^{+14}_{-12}$) % | | — |
| \bar{K}^0 anything + K^0 anything | (39 ± 28) % | | — |
| K^+ anything | (20 $^{+18}_{-14}$) % | | — |
| (non- K \bar{K}) anything | (64 ± 17) % | | — |
| e^+ anything | (8 $^{+6}_{-5}$) % | | — |
| ϕ anything | (18 $^{+15}_{-10}$) % | | — |

Leptonic and semileptonic modes

| | | | |
|---|------------------------------------|-------|-----|
| $\mu^+ \nu_\mu$ | (6.1 \pm 1.9) $\times 10^{-3}$ | S=1.4 | 981 |
| $\tau^+ \nu_\tau$ | (6.4 \pm 1.5) % | | 182 |
| $\phi \ell^+ \nu_\ell$ | [ddd] (2.4 \pm 0.4) % | S=1.1 | 720 |
| $\eta \ell^+ \nu_\ell + \eta'(958) \ell^+ \nu_\ell$ | [ddd] (4.2 \pm 0.8) % | | — |
| $\eta \ell^+ \nu_\ell$ | [ddd] (3.1 \pm 0.6) % | | 908 |
| $\eta'(958) \ell^+ \nu_\ell$ | [ddd] (1.08 \pm 0.35) % | | 751 |

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

| | | | |
|--|------------------------------------|--------|-----|
| $K^+ \bar{K}^0$ | (4.4 \pm 0.9) % | | 850 |
| $K^+ K^- \pi^+$ | [qq] (5.2 \pm 0.9) % | S=1.1 | 805 |
| $\phi \pi^+$ | [eee] (4.4 \pm 0.6) % | S=1.1 | 711 |
| $\phi \pi^+, \phi \rightarrow K^+ K^-$ | (2.16 \pm 0.28) % | S=1.1 | 712 |
| $K^+ \bar{K}^*(892)^0, \bar{K}^{*0} \rightarrow K^- \pi^+$ | (2.5 \pm 0.5) % | | 416 |
| $f_0(980) \pi^+, f_0 \rightarrow K^+ K^-$ | (5.7 \pm 2.5) $\times 10^{-3}$ | | 732 |
| $K^+ \bar{K}_0^*(1430)^0, \bar{K}_0^* \rightarrow K^- \pi^+$ | (4.8 \pm 2.5) $\times 10^{-3}$ | | 218 |
| $K^0 \bar{K}^0 \pi^+$ | — | | 802 |
| $K^*(892)^+ \bar{K}^0$ | [eee] (5.3 \pm 1.3) % | | 683 |
| $K^+ K^- \pi^+ \pi^0$ | — | | 748 |
| $\phi \pi^+ \pi^0$ | [eee] (11 \pm 5) % | | 686 |
| $\phi \rho^+$ | [eee] (8.2 $^{+2.0}_{-2.4}$) % | | 401 |
| $\phi \pi^+ \pi^0$ 3-body | [eee] < 3.1 % | CL=90% | 686 |
| $K^+ K^- \pi^+ \pi^0$ non- ϕ | < 11 % | CL=90% | 748 |
| $K^+ \bar{K}^0 \pi^+ \pi^-$ | (3.1 \pm 0.9) % | | 744 |
| $K^0 K^- \pi^+ \pi^+$ | (5.3 \pm 1.4) % | | 744 |
| $K^*(892)^+ \bar{K}^*(892)^0$ | [eee] (7.0 \pm 2.7) % | | 416 |
| $K^0 K^- \pi^+ \pi^+ (\text{non-}K^* + \bar{K}^{*0})$ | < 3.5 % | CL=90% | 744 |
| $K^+ K^- \pi^+ \pi^+ \pi^-$ | (8.3 \pm 2.0) $\times 10^{-3}$ | | 673 |
| $\phi \pi^+ \pi^+ \pi^-$ | [eee] (1.18 \pm 0.20) % | | 640 |
| $K^+ K^- \rho^0 \pi^+$ non- ϕ | < 2.5 $\times 10^{-4}$ | CL=90% | 248 |
| $\phi \rho^0 \pi^+$ | [eee] (1.24 \pm 0.33) % | | 181 |
| $\phi a_1(1260)^+$ | [eee] (2.9 \pm 0.7) % | | † |
| $K^+ K^- \pi^+ \pi^+ \pi^-$ nonresonant | (8 \pm 7) $\times 10^{-4}$ | | 673 |
| $K_S^0 \bar{K}_S^0 \pi^+ \pi^+ \pi^-$ | (2.7 \pm 1.3) $\times 10^{-3}$ | | 669 |

Hadronic modes without K 's

| | | | |
|--|--|--------|-----|
| $\pi^+ \pi^+ \pi^-$ | (1.22 \pm 0.23) % | S=1.2 | 959 |
| $\pi^+ (\pi^+ \pi^-)_{S\text{-wave}}$ | [fff] (1.06 \pm 0.22) % | | 959 |
| $f_2(1270) \pi^+, f_2 \rightarrow \pi^+ \pi^-$ | (1.2 \pm 0.7) $\times 10^{-3}$ | | 559 |
| $\rho(1450)^0 \pi^+, \rho^0 \rightarrow \pi^+ \pi^-$ | (8 \pm 7) $\times 10^{-4}$ | | 421 |
| $\pi^+ \pi^+ \pi^- \pi^0$ | < 15 % | CL=90% | 935 |
| $\eta \pi^+$ | [eee] (2.11 \pm 0.35) % | | 902 |
| $\omega \pi^+$ | [eee] (3.4 \pm 1.2) $\times 10^{-3}$ | | 822 |

| | | | |
|---------------------------------|--------------------------------|--------|-----|
| $3\pi^+ 2\pi^-$ | $(7.6 \pm 1.6) \times 10^{-3}$ | | 899 |
| $\pi^+ \pi^+ \pi^- \pi^0 \pi^0$ | — | | 902 |
| $\eta \rho^+$ | [eee] $(13.1 \pm 2.6) \%$ | | 724 |
| $\eta \pi^+ \pi^0$ 3-body | [eee] $< 5 \%$ | CL=90% | 885 |
| $3\pi^+ 2\pi^- \pi^0$ | $(4.9 \pm 3.2) \%$ | | 856 |
| $\eta'(958) \pi^+$ | [eee] $(4.7 \pm 0.7) \%$ | | 743 |
| $3\pi^+ 2\pi^- 2\pi^0$ | — | | 803 |
| $\eta'(958) \rho^+$ | [eee] $(12.2 \pm 2.4) \%$ | | 464 |
| $\eta'(958) \pi^+ \pi^0$ 3-body | [eee] $< 1.8 \%$ | CL=90% | 720 |

Modes with one or three K 's

| | | | |
|--|--------------------------------|--------|-----|
| $K^0 \pi^+$ | $< 9 \times 10^{-3}$ | CL=90% | 916 |
| $K^+ \pi^+ \pi^-$ | $(6.6 \pm 1.4) \times 10^{-3}$ | | 900 |
| $K^+ \rho^0$ | $(2.6 \pm 0.7) \times 10^{-3}$ | | 744 |
| $K^+ \rho(1450)^0, \rho^0 \rightarrow \pi^+ \pi^-$ | $(7.0 \pm 2.9) \times 10^{-4}$ | | — |
| $K^*(892)^0 \pi^+, K^{*0} \rightarrow$ | $(1.4 \pm 0.4) \times 10^{-3}$ | | 775 |
| $K^+ \pi^-$ | | | |
| $K^*(1410)^0 \pi^+, K^{*0} \rightarrow$ | $(1.2 \pm 0.4) \times 10^{-3}$ | | — |
| $K^+ \pi^-$ | | | |
| $K^*(1430)^0 \pi^+, K^{*0} \rightarrow$ | $(5 \pm 4) \times 10^{-4}$ | | — |
| $K^+ \pi^-$ | | | |
| $K^+ \pi^+ \pi^-$ nonresonant | $(1.0 \pm 0.4) \times 10^{-3}$ | | 900 |
| $K^+ K^+ K^-$ | $(4.6 \pm 1.8) \times 10^{-4}$ | | 627 |
| ϕK^+ | [eee] $< 6 \times 10^{-4}$ | CL=90% | 606 |

Doubly Cabibbo-suppressed modes

| | | | |
|-----------------|--------------------------------|--|-----|
| $K^+ K^+ \pi^-$ | $(2.7 \pm 1.2) \times 10^{-4}$ | | 805 |
|-----------------|--------------------------------|--|-----|

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

| | | | | |
|--------------------------|-------------------|------------------|--------|-----|
| $\pi^+ e^+ e^-$ | [uu] < 2.7 | $\times 10^{-4}$ | CL=90% | 979 |
| $\pi^+ \mu^+ \mu^-$ | [uu] < 2.6 | $\times 10^{-5}$ | CL=90% | 968 |
| $K^+ e^+ e^-$ | $C1$ < 1.6 | $\times 10^{-3}$ | CL=90% | 922 |
| $K^+ \mu^+ \mu^-$ | $C1$ < 3.6 | $\times 10^{-5}$ | CL=90% | 909 |
| $K^*(892)^+ \mu^+ \mu^-$ | $C1$ < 1.4 | $\times 10^{-3}$ | CL=90% | 765 |
| $\pi^+ e^\pm \mu^\mp$ | LF [gg] < 6.1 | $\times 10^{-4}$ | CL=90% | 976 |
| $K^+ e^\pm \mu^\mp$ | LF [gg] < 6.3 | $\times 10^{-4}$ | CL=90% | 919 |
| $\pi^- e^+ e^+$ | L < 6.9 | $\times 10^{-4}$ | CL=90% | 979 |
| $\pi^- \mu^+ \mu^+$ | L < 2.9 | $\times 10^{-5}$ | CL=90% | 968 |
| $\pi^- e^+ \mu^+$ | L < 7.3 | $\times 10^{-4}$ | CL=90% | 976 |
| $K^- e^+ e^+$ | L < 6.3 | $\times 10^{-4}$ | CL=90% | 922 |
| $K^- \mu^+ \mu^+$ | L < 1.3 | $\times 10^{-5}$ | CL=90% | 909 |
| $K^- e^+ \mu^+$ | L < 6.8 | $\times 10^{-4}$ | CL=90% | 919 |
| $K^*(892)^- \mu^+ \mu^+$ | L < 1.4 | $\times 10^{-3}$ | CL=90% | 765 |

$$D_s^{*\pm}$$

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

J^P is natural, width and decay modes consistent with 1^- .

$$\text{Mass } m = 2112.0 \pm 0.6 \text{ MeV} \quad (S = 1.1)$$

$$m_{D_s^{*\pm}} - m_{D_s^\pm} = 143.8 \pm 0.4 \text{ MeV}$$

$$\text{Full width } \Gamma < 1.9 \text{ MeV, CL} = 90\%$$

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

| D_s^{*+} DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|------------------------|--------------------------------|-------------|
| $D_s^+ \gamma$ | $(94.2 \pm 0.7) \%$ | 139 |
| $D_s^+ \pi^0$ | $(5.8 \pm 0.7) \%$ | 48 |

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

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

J, P need confirmation.

J^P is natural, low mass consistent with 0^+ .

$$\text{Mass } m = 2317.3 \pm 0.6 \text{ MeV}$$

$$m_{D_{s0}^*(2317)^\pm} - m_{D_s^\pm} = 349.1 \pm 0.6 \text{ MeV}$$

$$\text{Full width } \Gamma < 4.6 \text{ MeV, CL} = 90\%$$

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

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

$$\text{Mass } m = 2458.9 \pm 0.9 \text{ MeV} \quad (S = 1.1)$$

$$m_{D_{s1}(2460)^\pm} - m_{D_s^{*\pm}} = 346.9 \pm 1.0 \text{ MeV} \quad (S = 1.2)$$

$$m_{D_{s1}(2460)^\pm} - m_{D_s^\pm} = 490.7 \pm 0.9 \text{ MeV} \quad (S = 1.2)$$

$$\text{Full width } \Gamma < 5.5 \text{ MeV, CL} = 90\%$$

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

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

J, P need confirmation.

$$\text{Mass } m = 2535.35 \pm 0.34 \pm 0.5 \text{ MeV}$$

$$\text{Full width } \Gamma < 2.3 \text{ MeV, CL} = 90\%$$

$D_{s1}(2536)^-$ modes are charge conjugates of the modes below.

| $D_{s1}(2536)^+$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|------------------------------|--------------------------------|-------------|
| $D^*(2010)^+ K^0$ | seen | 150 |
| $D^*(2007)^0 K^+$ | seen | 168 |
| $D^+ K^0$ | not seen | 382 |
| $D^0 K^+$ | not seen | 392 |
| $D_s^{*+} \gamma$ | possibly seen | 388 |

$D_{s2}(2573)^\pm$

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

J^P is natural, width and decay modes consistent with 2^+ .

Mass $m = 2573.5 \pm 1.7$ MeV

Full width $\Gamma = 15^{+5}_{-4}$ MeV

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

| $D_{s2}(2573)^+$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|------------------------------|--------------------------------|-------------|
| $D^0 K^+$ | seen | 436 |
| $D^*(2007)^0 K^+$ | not seen | 246 |

BOTTOM MESONS ($B = \pm 1$)

$$B^+ = u\bar{b}, B^0 = d\bar{b}, \bar{B}^0 = \bar{d}b, B^- = \bar{u}b, \text{ similarly for } B^{*'}\text{'s}$$

B -particle organization

Many measurements of B decays involve admixtures of B hadrons. Previously we arbitrarily included such admixtures in the B^\pm section, but because of their importance we have created two new sections: " B^\pm/B^0 Admixture" for $\Upsilon(4S)$ results and " $B^\pm/B^0/B_s^0/b$ -baryon Admixture" for results at higher energies. Most inclusive decay branching fractions and χ_b at high energy are found in the Admixture sections. $B^0\text{-}\bar{B}^0$ mixing data are found in the B^0 section, while $B_s^0\text{-}\bar{B}_s^0$ mixing data and $B\text{-}\bar{B}$ mixing data for a B^0/B_s^0 admixture

are found in the B_s^0 section. CP -violation data are found in the B^\pm , B^0 , and $B^\pm B^0$ Admixture sections. b -baryons are found near the end of the Baryon section.

The organization of the B sections is now as follows, where bullets indicate particle sections and brackets indicate reviews.

- B^\pm
mass, mean life, branching fractions CP violation
 - B^0
mass, mean life, branching fractions
polarization in B^0 decay, B^0 - \bar{B}^0 mixing, CP violation
 - $B^\pm B^0$ Admixtures
branching fractions, CP violation
 - $B^\pm/B^0/B_s^0/b$ -baryon Admixtures
mean life, production fractions, branching fractions
 χ_b at high energy, V_{cb} measurements
 - B^*
mass
 - B_s^0
mass, mean life, branching fractions
polarization in B_s^0 decay, B_s^0 - \bar{B}_s^0 mixing
 - B_c^\pm
mass, mean life, branching fractions
- At end of Baryon Listings:
- Λ_b
mass, mean life, branching fractions
 - b -baryon Admixture
mean life, branching fractions

B^\pm

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

I, J, P need confirmation. Quantum numbers shown are quark-model predictions.

$$\text{Mass } m_{B^\pm} = 5279.0 \pm 0.5 \text{ MeV}$$

$$\text{Mean life } \tau_{B^\pm} = (1.638 \pm 0.011) \times 10^{-12} \text{ s}$$

$$c\tau = 491.1 \text{ } \mu\text{m}$$

CP violation

$$\begin{aligned}
 A_{CP}(B^+ \rightarrow J/\psi(1S)K^+) &= -0.024 \pm 0.014 \\
 A_{CP}(B^+ \rightarrow J/\psi(1S)\pi^+) &= 0.09 \pm 0.08 \\
 A_{CP}(B^+ \rightarrow J/\psi K^*(892)^+) &= 0.048 \pm 0.033 \\
 A_{CP}(B^+ \rightarrow \psi(2S)K^+) &= -0.025 \pm 0.024 \\
 A_{CP}(B^+ \rightarrow \psi(2S)K^*(892)^+) &= -0.08 \pm 0.21 \\
 A_{CP}(B^+ \rightarrow \chi_{c1}K^+) &= 0.00 \pm 0.08 \\
 A_{CP}(B^+ \rightarrow \chi_{c1}K^*(892)^+) &= -0.5 \pm 0.5 \\
 A_{CP}(B^+ \rightarrow \bar{D}^0\pi^+) &= -0.008 \pm 0.008 \\
 A_{CP}(B^+ \rightarrow D_{CP(+1)}\pi^+) &= 0.035 \pm 0.024 \\
 A_{CP}(B^+ \rightarrow D_{CP(-1)}\pi^+) &= 0.017 \pm 0.026 \\
 A_{CP}(B^+ \rightarrow \bar{D}^0K^+) &= 0.07 \pm 0.04 \\
 r_B(B^+ \rightarrow D^0K^+) &= 0.12 \pm 0.09 \\
 \delta_B(B^+ \rightarrow D^0K^+) &= 104 \pm 50 \text{ degrees} \\
 A_{CP}(B^+ \rightarrow [K^-\pi^+]_D K^+) &= 0.9^{+0.8}_{-0.6} \\
 A_{CP}(B^+ \rightarrow [K^-\pi^+]_{\bar{D}} K^*(892)^+) &= -0.2 \pm 0.6 \\
 A_{CP}(B^+ \rightarrow [K^-\pi^+]_D \pi^+) &= 0.30^{+0.30}_{-0.26} \\
 A_{CP}(B^+ \rightarrow [\pi^+\pi^-\pi^0]_D K^+) &= -0.02 \pm 0.16 \\
 A_{CP}(B^+ \rightarrow D_{CP(+1)}K^+) &= 0.22 \pm 0.14 \quad (S = 1.4) \\
 A_{CP}(B^+ \rightarrow D_{CP(-1)}K^+) &= -0.09 \pm 0.10 \\
 A_{CP}(B^+ \rightarrow \bar{D}^{*0}\pi^+) &= -0.014 \pm 0.015 \\
 A_{CP}(B^+ \rightarrow (D_{CP(+1)}^*)^0\pi^+) &= -0.02 \pm 0.05 \\
 A_{CP}(B^+ \rightarrow (D_{CP(-1)}^*)^0\pi^+) &= -0.09 \pm 0.05 \\
 A_{CP}(B^+ \rightarrow D^{*0}K^+) &= -0.09 \pm 0.09 \\
 r_B^*(B^+ \rightarrow D^{*0}K^+) &= 0.17 \pm 0.11 \\
 \delta_B^*(B^+ \rightarrow D^{*0}K^+) &= -64 \pm 50 \text{ degrees} \\
 A_{CP}(B^+ \rightarrow D_{CP(+1)}^{*0}K^+) &= -0.15 \pm 0.16 \\
 A_{CP}(B^+ \rightarrow D_{CP(-1)}^{*0}K^+) &= 0.13 \pm 0.31 \\
 A_{CP}(B^+ \rightarrow D_{CP(+1)}K^*(892)^+) &= -0.08 \pm 0.21 \\
 A_{CP}(B^+ \rightarrow D_{CP(-1)}K^*(892)^+) &= -0.3 \pm 0.4 \\
 A_{CP}(B^+ \rightarrow K_S^0\pi^+) &= -0.02 \pm 0.07 \quad (S = 1.9) \\
 A_{CP}(B^+ \rightarrow K^+\pi^0) &= 0.04 \pm 0.04 \\
 A_{CP}(B^+ \rightarrow K^+\eta') &= 0.020 \pm 0.025 \\
 A_{CP}(B^+ \rightarrow \eta K^+) &= -0.25 \pm 0.14 \\
 A_{CP}(B^+ \rightarrow \eta K^*(892)^+) &= 0.13 \pm 0.14 \\
 A_{CP}(B^+ \rightarrow \omega K^+) &= -0.02 \pm 0.13 \\
 A_{CP}(B^+ \rightarrow K^{*0}\pi^+) &= 0.07 \pm 0.10 \\
 A_{CP}(B^+ \rightarrow K^+\pi^-\pi^+) &= -0.01 \pm 0.04
 \end{aligned}$$

$$\begin{aligned}
 A_{CP}(B^+ \rightarrow f_0(980) K^+) &= 0.09^{+0.14}_{-0.11} \\
 A_{CP}(B^+ \rightarrow \rho^0 K^+) &= 0.32 \pm 0.16 \\
 A_{CP}(B^+ \rightarrow K_0^*(1430)^0 \pi^+) &= -0.06 \pm 0.04 \\
 A_{CP}(B^+ \rightarrow K^*(892)^+ \pi^0) &= 0.04 \pm 0.29 \\
 A_{CP}(B^+ \rightarrow \rho^0 K^*(892)^+) &= 0.20 \pm 0.31 \\
 A_{CP}(B^+ \rightarrow K^0 K^+) &= 0.15 \pm 0.33 \\
 A_{CP}(B^+ \rightarrow K^+ K_S^0 K_S^0) &= -0.04 \pm 0.11 \\
 A_{CP}(B^+ \rightarrow K^+ K^- K^+) &= 0.02 \pm 0.08 \\
 A_{CP}(B^+ \rightarrow \phi K^+) &= 0.01 \pm 0.07 \\
 A_{CP}(B^+ \rightarrow \phi K^*(892)^+) &= 0.05 \pm 0.11 \\
 A_{CP}(B^+ \rightarrow \eta K^+ \gamma) &= -0.16 \pm 0.11 \\
 A_{CP}(B^+ \rightarrow \pi^+ \pi^0) &= -0.02 \pm 0.07 \\
 A_{CP}(B^+ \rightarrow \pi^+ \pi^- \pi^+) &= -0.01 \pm 0.08 \\
 A_{CP}(B^+ \rightarrow \rho^0 \pi^+) &= -0.07 \pm 0.13 \\
 A_{CP}(B^+ \rightarrow f_2(1270) \pi^+) &= 0.00 \pm 0.25 \\
 A_{CP}(B^+ \rightarrow \rho^+ \pi^0) &= 0.15 \pm 0.12 \\
 A_{CP}(B^+ \rightarrow \rho^+ \rho^0) &= -0.09 \pm 0.16 \\
 A_{CP}(B^+ \rightarrow \omega \pi^+) &= 0.10 \pm 0.22 \quad (S = 1.9) \\
 A_{CP}(B^+ \rightarrow \omega \rho^+) &= 0.05 \pm 0.26 \\
 A_{CP}(B^+ \rightarrow \eta \pi^+) &= -0.05 \pm 0.10 \\
 A_{CP}(B^+ \rightarrow \eta' \pi^+) &= 0.14 \pm 0.16 \\
 A_{CP}(B^+ \rightarrow \eta \rho^+) &= 0.02 \pm 0.18 \\
 A_{CP}(B^+ \rightarrow p \bar{p} \pi^+) &= -0.16 \pm 0.22 \\
 A_{CP}(B^+ \rightarrow p \bar{p} K^+) &= -0.05 \pm 0.11 \\
 \gamma(B^+ \rightarrow D^{(*)} K^+) &= (75 \pm 20)^\circ
 \end{aligned}$$

B^- modes are charge conjugates of the modes below. Modes which do not identify the charge state of the B are listed in the B^\pm/B^0 ADMIXTURE section.

The branching fractions listed below assume 50% $B^0 \bar{B}^0$ and 50% $B^+ B^-$ production at the $\Upsilon(4S)$. We have attempted to bring older measurements up to date by rescaling their assumed $\Upsilon(4S)$ production ratio to 50:50 and their assumed D , D_S , D^* , and ψ branching ratios to current values whenever this would affect our averages and best limits significantly.

Indentation is used to indicate a subchannel of a previous reaction. All resonant subchannels have been corrected for resonance branching fractions to the final state so the sum of the subchannel branching fractions can exceed that of the final state.

For inclusive branching fractions, e.g., $B \rightarrow D^\pm$ anything, the values usually are multiplicities, not branching fractions. They can be greater than one.

| B^+ DECAY MODES | Fraction (Γ_i/Γ) | Scale factor/ Confidence level (MeV/c) | p |
|-------------------|--------------------------------|---|-----|
|-------------------|--------------------------------|---|-----|

Semileptonic and leptonic modes

| | | | |
|--|--|--------|------|
| $\ell^+ \nu_\ell$ anything | [ggg] (10.9 \pm 0.4) % | | — |
| $\bar{D}^0 \ell^+ \nu_\ell$ | [ggg] (2.15 \pm 0.22) % | | 2310 |
| $\bar{D}^{*0}(2007) \ell^+ \nu_\ell$ | [ggg] (6.5 \pm 0.5) % | | 2258 |
| $\bar{D}_1(2420)^0 \ell^+ \nu_\ell$ | (5.6 \pm 1.6) $\times 10^{-3}$ | | 2084 |
| $\bar{D}_2^{*0}(2460)^0 \ell^+ \nu_\ell$ | < 8 $\times 10^{-3}$ | CL=90% | 2066 |
| $D^- \pi^+ \ell^+ \nu_\ell$ | (5.3 \pm 1.0) $\times 10^{-3}$ | | 2306 |
| $D^{*-} \pi^+ \ell^+ \nu_\ell$ | (6.4 \pm 1.5) $\times 10^{-3}$ | | 2254 |
| $\pi^0 \ell^+ \nu_\ell$ | (7.4 \pm 1.1) $\times 10^{-5}$ | | 2638 |
| $\eta \ell^+ \nu_\ell$ | (8 \pm 4) $\times 10^{-5}$ | | 2611 |
| $\omega \ell^+ \nu_\ell$ | [ggg] (1.3 \pm 0.6) $\times 10^{-4}$ | | 2582 |
| $\rho^0 \ell^+ \nu_\ell$ | [ggg] (1.24 \pm 0.23) $\times 10^{-4}$ | | 2583 |
| $p \bar{p} e^+ \nu_e$ | < 5.2 $\times 10^{-3}$ | CL=90% | 2467 |
| $e^+ \nu_e$ | < 1.5 $\times 10^{-5}$ | CL=90% | 2640 |
| $\mu^+ \nu_\mu$ | < 6.6 $\times 10^{-6}$ | CL=90% | 2638 |
| $\tau^+ \nu_\tau$ | < 2.6 $\times 10^{-4}$ | CL=90% | 2340 |
| $e^+ \nu_e \gamma$ | < 2.0 $\times 10^{-4}$ | CL=90% | 2640 |
| $\mu^+ \nu_\mu \gamma$ | < 5.2 $\times 10^{-5}$ | CL=90% | 2638 |

Inclusive modes

| | | | |
|-----------------------|-------------------------------|--------|---|
| $D^0 X$ | (9.8 \pm 1.1) % | | — |
| $\bar{D}^0 X$ | (79 \pm 5) % | | — |
| $D^+ X$ | (3.8 \pm 1.0) % | | — |
| $D^- X$ | (9.8 \pm 1.8) % | | — |
| $D_s^+ X$ | (14 \pm 5 \pm 4) % | | — |
| $D_s^- X$ | < 2.2 % | CL=90% | — |
| $\Lambda_c^+ X$ | (2.9 \pm 1.4 \pm 1.1) % | | — |
| $\bar{\Lambda}_c^- X$ | (3.5 \pm 1.5 \pm 1.2) % | | — |
| $\bar{c} X$ | (98 \pm 6) % | | — |
| $c X$ | (33 \pm 6 \pm 4) % | | — |
| $\bar{c} c X$ | (131 \pm 10 \pm 8) % | | — |

 D , D^* , or D_s modes

| | | | |
|--------------------|--|--|------|
| $\bar{D}^0 \pi^+$ | (4.92 \pm 0.20) $\times 10^{-3}$ | | 2308 |
| $D_{CP(+1)} \pi^+$ | [hhh] (4.0 \pm 0.8) $\times 10^{-3}$ | | — |
| $D_{CP(-1)} \pi^+$ | [hhh] (3.6 \pm 0.8) $\times 10^{-3}$ | | — |
| $\bar{D}^0 \rho^+$ | (1.34 \pm 0.18) % | | 2237 |
| $\bar{D}^0 K^+$ | (4.08 \pm 0.24) $\times 10^{-4}$ | | 2281 |

| | | | |
|---|---------|--|------|
| $D_{CP(+1)} K^+$ | $[hhh]$ | $(3.7 \pm 0.6) \times 10^{-4}$ | — |
| $D_{CP(-1)} K^+$ | $[hhh]$ | $(3.5 \pm 0.5) \times 10^{-4}$ | — |
| $[K^- \pi^+]_D \pi^+$ | $[iii]$ | $(1.7 \pm 0.5) \times 10^{-5}$ | — |
| $[\pi^+ \pi^- \pi^0]_D K^-$ | | $(5.5 \pm 1.2) \times 10^{-6}$ | — |
| $\bar{D}^0 K^*(892)^+$ | | $(6.3 \pm 0.8) \times 10^{-4}$ | 2213 |
| $D_{CP(-1)} K^*(892)^+$ | $[hhh]$ | $(2.0 \pm 0.9) \times 10^{-4}$ | — |
| $D_{CP(+1)} K^*(892)^+$ | $[hhh]$ | $(6.2 \pm 1.5) \times 10^{-4}$ | — |
| $\bar{D}^0 K^+ \bar{K}^0$ | | $(5.5 \pm 1.6) \times 10^{-4}$ | 2189 |
| $\bar{D}^0 K^+ \bar{K}^*(892)^0$ | | $(7.5 \pm 1.7) \times 10^{-4}$ | 2071 |
| $\bar{D}^0 \pi^+ \pi^+ \pi^-$ | | $(1.1 \pm 0.4) \%$ | 2289 |
| $\bar{D}^0 \pi^+ \pi^+ \pi^-$ nonresonant | | $(5 \pm 4) \times 10^{-3}$ | 2289 |
| $\bar{D}^0 \pi^+ \rho^0$ | | $(4.2 \pm 3.0) \times 10^{-3}$ | 2207 |
| $\bar{D}^0 a_1(1260)^+$ | | $(4 \pm 4) \times 10^{-3}$ | 2123 |
| $\bar{D}^0 \omega \pi^+$ | | $(4.1 \pm 0.9) \times 10^{-3}$ | 2206 |
| $D^*(2010)^- \pi^+ \pi^+$ | | $(1.35 \pm 0.22) \times 10^{-3}$ | 2247 |
| $D^- \pi^+ \pi^+$ | | $(1.02 \pm 0.16) \times 10^{-3}$ | 2299 |
| $D^+ K^0$ | $<$ | 5.0×10^{-6} CL=90% | 2278 |
| $\bar{D}^*(2007)^0 \pi^+$ | | $(4.6 \pm 0.4) \times 10^{-3}$ | 2256 |
| $\bar{D}^*(2007)^0 \omega \pi^+$ | | $(4.5 \pm 1.2) \times 10^{-3}$ | 2149 |
| $\bar{D}^*(2007)^0 \rho^+$ | | $(9.8 \pm 1.7) \times 10^{-3}$ | 2181 |
| $\bar{D}^*(2007)^0 K^+$ | | $(3.7 \pm 0.4) \times 10^{-4}$ | 2227 |
| $\bar{D}^*(2007)^0 K^*(892)^+$ | | $(8.1 \pm 1.4) \times 10^{-4}$ | 2156 |
| $\bar{D}^*(2007)^0 K^+ \bar{K}^0$ | $<$ | 1.06×10^{-3} CL=90% | 2132 |
| $\bar{D}^*(2007)^0 K^+ K^*(892)^0$ | | $(1.5 \pm 0.4) \times 10^{-3}$ | 2008 |
| $\bar{D}^*(2007)^0 \pi^+ \pi^+ \pi^-$ | | $(1.03 \pm 0.12) \%$ | 2236 |
| $\bar{D}^*(2007)^0 a_1(1260)^+$ | | $(1.9 \pm 0.5) \%$ | 2063 |
| $\bar{D}^*(2007)^0 \pi^- \pi^+ \pi^+ \pi^0$ | | $(1.8 \pm 0.4) \%$ | 2219 |
| $\bar{D}^{*0} 3\pi^+ 2\pi^-$ | | $(5.7 \pm 1.2) \times 10^{-3}$ | 2196 |
| $D^*(2010)^+ \pi^0$ | $<$ | 1.7×10^{-4} CL=90% | 2255 |
| $D^*(2010)^+ K^0$ | $<$ | 9.0×10^{-6} CL=90% | 2225 |
| $D^*(2010)^- \pi^+ \pi^+ \pi^0$ | | $(1.5 \pm 0.7) \%$ | 2235 |
| $D^*(2010)^- \pi^+ \pi^+ \pi^+ \pi^-$ | | $(2.6 \pm 0.4) \times 10^{-3}$ | 2217 |
| $\bar{D}_1^*(2420)^0 \pi^+$ | | $(1.5 \pm 0.6) \times 10^{-3}$ S=1.3 | 2081 |
| $\bar{D}_1(2420)^0 \pi^+ \times B(\bar{D}_1^0 \rightarrow \bar{D}^0 \pi^+ \pi^-)$ | | $(1.9 \pm 0.5 \pm 0.6) \times 10^{-4}$ | 2081 |
| $\bar{D}_2^*(2462)^0 \pi^+$ | | $(3.4 \pm 0.8) \times 10^{-4}$ | — |
| $\times B(\bar{D}_2^*(2462)^0 \rightarrow D^- \pi^+)$ | | | |
| $\bar{D}_0^*(2308)^0 \pi^+$ | | $(6.1 \pm 1.9) \times 10^{-4}$ | — |
| $\times B(\bar{D}_0^*(2308)^0 \rightarrow D^- \pi^+)$ | | | |
| $\bar{D}_1(2421)^0 \pi^+$ | | $(6.8 \pm 1.5) \times 10^{-4}$ | — |
| $\times B(\bar{D}_1(2421)^0 \rightarrow D^{*-} \pi^+)$ | | | |

| | | |
|---|---|-------------|
| $\bar{D}_2^*(2462)^0 \pi^+$ $\times B(\bar{D}_2^*(2462)^0 \rightarrow D^{*-} \pi^+)$ | $(1.8 \pm 0.5) \times 10^{-4}$ | — |
| $\bar{D}_1'(2427)^0 \pi^+$ $\times B(\bar{D}_1'(2427)^0 \rightarrow D^{*-} \pi^+)$ | $(5.0 \pm 1.2) \times 10^{-4}$ | — |
| $\bar{D}_1(2420)^0 \pi^+ \times B(\bar{D}_1^0 \rightarrow \bar{D}^{*0} \pi^+ \pi^-)$ | $< 6 \times 10^{-6}$ | CL=90% 2081 |
| $\bar{D}_1^*(2420)^0 \rho^+$ | $< 1.4 \times 10^{-3}$ | CL=90% 1995 |
| $\bar{D}_2^*(2460)^0 \pi^+$ | $< 1.3 \times 10^{-3}$ | CL=90% 2063 |
| $\bar{D}_2^*(2460)^0 \pi^+ \times B(\bar{D}_2^{*0} \rightarrow \bar{D}^{*0} \pi^+ \pi^-)$ | $< 2.2 \times 10^{-5}$ | CL=90% 2063 |
| $\bar{D}_2^*(2460)^0 \rho^+$ | $< 4.7 \times 10^{-3}$ | CL=90% 1976 |
| $\bar{D}^0 D_s^+$ | $(1.09 \pm 0.27) \%$ | 1815 |
| $D_{s0}(2317)^+ \bar{D}^0 \times B(D_{s0}(2317)^+ \rightarrow D_s^+ \pi^0)$ | $(7.4 \pm_{-1.9}^{2.3}) \times 10^{-4}$ | 1605 |
| $D_{s0}(2317)^+ \bar{D}^0 \times B(D_{s0}(2317)^+ \rightarrow D_s^{*+} \gamma)$ | $< 7.6 \times 10^{-4}$ | CL=90% 1605 |
| $D_{s0}(2317)^+ \bar{D}^*(2010)^0 \times B(D_{s0}(2317)^+ \rightarrow D_s^+ \pi^0)$ | $(9 \pm 7) \times 10^{-4}$ | — |
| $D_{sJ}(2457)^+ \bar{D}^0 \times B(D_{sJ}(2457)^+ \rightarrow D_s^{*+} \pi^0)$ | $(1.4 \pm_{-0.5}^{0.6}) \times 10^{-3}$ | S=1.3 — |
| $D_{sJ}(2457)^+ \bar{D}^0 \times B(D_{sJ}(2457)^+ \rightarrow D_s^+ \gamma)$ | $(4.7 \pm_{-1.2}^{1.4}) \times 10^{-4}$ | — |
| $D_{sJ}(2457)^+ \bar{D}^0 \times B(D_{sJ}(2457)^+ \rightarrow D_s^+ \pi^+ \pi^-)$ | $< 2.2 \times 10^{-4}$ | CL=90% — |
| $D_{sJ}(2457)^+ \bar{D}^0 \times B(D_{sJ}(2457)^+ \rightarrow D_s^+ \pi^0)$ | $< 2.7 \times 10^{-4}$ | CL=90% — |
| $D_{sJ}(2457)^+ \bar{D}^0 \times B(D_{sJ}(2457)^+ \rightarrow D_s^{*+} \gamma)$ | $< 9.8 \times 10^{-4}$ | CL=90% — |
| $D_{sJ}(2457)^+ \bar{D}^*(2010)^0 \times B(D_{sJ}(2457)^+ \rightarrow D_s^{*+} \pi^0)$ | $(7.6 \pm_{-2.9}^{3.6}) \times 10^{-3}$ | — |
| $D_{sJ}(2457)^+ \bar{D}^*(2010)^0 \times B(D_{sJ}(2457)^+ \rightarrow D_s^+ \gamma)$ | $(1.4 \pm_{-0.6}^{0.7}) \times 10^{-3}$ | — |
| $\bar{D}^0 D_{sJ}(2536)^+ \times B(D_{sJ}(2536)^+ \rightarrow D^*(2007)^0 K^+)$ | $< 2 \times 10^{-4}$ | CL=90% 1447 |
| $\bar{D}^*(2007)^0 D_{sJ}(2536)^+ \times B(D_{sJ}(2536)^+ \rightarrow D^*(2007)^0 K^+)$ | $< 7 \times 10^{-4}$ | CL=90% 1338 |

| | | | | |
|--|---------------------|------------------|--------|------|
| $\bar{D}^0 D_{sJ}(2573)^+ \times$ $B(D_{sJ}(2573)^+ \rightarrow D^0 K^+)$ | < 2 | $\times 10^{-4}$ | CL=90% | 1416 |
| $\bar{D}^*(2007)^0 D_{sJ}(2573)^+ \times$ $B(D_{sJ}(2573)^+ \rightarrow D^0 K^+)$ | < 5 | $\times 10^{-4}$ | CL=90% | 1305 |
| $\bar{D}^0 D_s^{*+}$ | (7.2 \pm 2.6) | $\times 10^{-3}$ | | 1734 |
| $\bar{D}^*(2007)^0 D_s^+$ | (10 \pm 4) | $\times 10^{-3}$ | | 1737 |
| $\bar{D}^*(2007)^0 D_s^{*+}$ | (2.2 \pm 0.7) | % | | 1651 |
| $D_s^{(*)+} \bar{D}^{*0}$ | (2.7 \pm 1.2) | % | | — |
| $\bar{D}^*(2007)^0 D^*(2010)^+$ | < 1.1 | % | CL=90% | 1713 |
| $\bar{D}^0 D^*(2010)^+ +$ $\bar{D}^*(2007)^0 D^+$ | < 1.3 | % | CL=90% | 1792 |
| $\bar{D}^0 D^*(2010)^+$ | (4.6 \pm 0.9) | $\times 10^{-4}$ | | 1792 |
| $\bar{D}^0 D^+$ | (4.8 \pm 1.0) | $\times 10^{-4}$ | | 1866 |
| $\bar{D}^0 D^+ K^0$ | < 2.8 | $\times 10^{-3}$ | CL=90% | 1571 |
| $\bar{D}^*(2007)^0 D^+ K^0$ | < 6.1 | $\times 10^{-3}$ | CL=90% | 1475 |
| $\bar{D}^0 \bar{D}^*(2010)^+ K^0$ | (5.2 \pm 1.2) | $\times 10^{-3}$ | | 1476 |
| $\bar{D}^*(2007)^0 D^*(2010)^+ K^0$ | (7.8 \pm 2.6) | $\times 10^{-3}$ | | 1362 |
| $\bar{D}^0 D^0 K^+$ | (1.37 \pm 0.32) | $\times 10^{-3}$ | S=1.5 | 1577 |
| $\bar{D}^*(2010)^0 D^0 K^+$ | < 3.8 | $\times 10^{-3}$ | CL=90% | — |
| $\bar{D}^0 D^*(2007)^0 K^+$ | (4.7 \pm 1.0) | $\times 10^{-3}$ | | 1481 |
| $\bar{D}^*(2007)^0 D^*(2007)^0 K^+$ | (5.3 \pm 1.6) | $\times 10^{-3}$ | | 1368 |
| $D^- D^+ K^+$ | < 4 | $\times 10^{-4}$ | CL=90% | 1571 |
| $D^- D^*(2010)^+ K^+$ | < 7 | $\times 10^{-4}$ | CL=90% | 1475 |
| $D^*(2010)^- D^+ K^+$ | (1.5 \pm 0.4) | $\times 10^{-3}$ | | 1475 |
| $D^*(2010)^- D^*(2010)^+ K^+$ | < 1.8 | $\times 10^{-3}$ | CL=90% | 1363 |
| $(\bar{D} + \bar{D}^*)(D + D^*)K$ | (3.5 \pm 0.6) | % | | — |
| $D_s^+ \pi^0$ | < 1.7 | $\times 10^{-4}$ | CL=90% | 2270 |
| $D_s^{*+} \pi^0$ | < 2.7 | $\times 10^{-4}$ | CL=90% | 2215 |
| $D_s^+ \eta$ | < 4 | $\times 10^{-4}$ | CL=90% | 2235 |
| $D_s^{*+} \eta$ | < 6 | $\times 10^{-4}$ | CL=90% | 2178 |
| $D_s^+ \rho^0$ | < 3.1 | $\times 10^{-4}$ | CL=90% | 2197 |
| $D_s^{*+} \rho^0$ | < 4 | $\times 10^{-4}$ | CL=90% | 2138 |
| $D_s^+ \omega$ | < 4 | $\times 10^{-4}$ | CL=90% | 2195 |
| $D_s^{*+} \omega$ | < 6 | $\times 10^{-4}$ | CL=90% | 2136 |
| $D_s^+ a_1(1260)^0$ | < 1.8 | $\times 10^{-3}$ | CL=90% | 2079 |
| $D_s^{*+} a_1(1260)^0$ | < 1.3 | $\times 10^{-3}$ | CL=90% | 2015 |
| $D_s^+ \phi$ | < 1.9 | $\times 10^{-6}$ | CL=90% | 2141 |
| $D_s^{*+} \phi$ | < 1.2 | $\times 10^{-5}$ | CL=90% | 2079 |
| $D_s^+ \bar{K}^0$ | < 9 | $\times 10^{-4}$ | CL=90% | 2242 |
| $D_s^{*+} \bar{K}^0$ | < 9 | $\times 10^{-4}$ | CL=90% | 2185 |
| $D_s^+ \bar{K}^*(892)^0$ | < 4 | $\times 10^{-4}$ | CL=90% | 2172 |
| $D_s^{*+} \bar{K}^*(892)^0$ | < 4 | $\times 10^{-4}$ | CL=90% | 2112 |

| | | | | |
|-----------------------------|---------|------------------|--------|------|
| $D_s^- \pi^+ K^+$ | < 7 | $\times 10^{-4}$ | CL=90% | 2222 |
| $D_s^{*-} \pi^+ K^+$ | < 9.8 | $\times 10^{-4}$ | CL=90% | 2164 |
| $D_s^- \pi^+ K^*(892)^+$ | < 5 | $\times 10^{-3}$ | CL=90% | 2138 |
| $D_s^{*-} \pi^+ K^*(892)^+$ | < 7 | $\times 10^{-3}$ | CL=90% | 2076 |

Charmonium modes

| | | | | |
|--|-----------------------|------------------|--------|------|
| $\eta_c K^+$ | (9.1 \pm 1.3) | $\times 10^{-4}$ | | 1753 |
| $\eta'_c K^+$ | (3.4 \pm 1.8) | $\times 10^{-4}$ | | — |
| $J/\psi(1S) K^+$ | (1.008 \pm 0.035) | $\times 10^{-3}$ | | 1683 |
| $J/\psi(1S) K^+ \pi^+ \pi^-$ | (1.07 \pm 0.19) | $\times 10^{-3}$ | S=1.9 | 1612 |
| $h_c(1P) K^+ \times B(h_c(1P) \rightarrow J/\psi \pi^+ \pi^-)$ | < 3.4 | $\times 10^{-6}$ | CL=90% | 1401 |
| $X(3872) K^+$ | < 3.2 | $\times 10^{-4}$ | CL=90% | 1141 |
| $X(3872) K^+ \times B(X \rightarrow J/\psi \pi^+ \pi^-)$ | (1.14 \pm 0.20) | $\times 10^{-5}$ | | 1141 |
| $X(3872) K^+ \times B(X(3872) \rightarrow D^0 \bar{D}^0)$ | < 6.0 | $\times 10^{-5}$ | CL=90% | 1141 |
| $X(3872) K^+ \times B(X(3872) \rightarrow D^+ D^-)$ | < 4.0 | $\times 10^{-5}$ | CL=90% | 1141 |
| $X(3872) K^+ \times B(X(3872) \rightarrow D^0 \bar{D}^0 \pi^0)$ | < 6.0 | $\times 10^{-5}$ | CL=90% | 1141 |
| $X(3872) K^+ \times B(X(3872) \rightarrow J/\psi(1S) \eta)$ | < 7.7 | $\times 10^{-6}$ | CL=90% | 1141 |
| $X(3872)^+ K^0 \times B(X(3872)^+ \rightarrow [jjj] J/\psi(1S) \pi^+ \pi^0)$ | < 2.2 | $\times 10^{-5}$ | CL=90% | — |
| $Y(4260)^0 K^+ \times B(Y^0 \rightarrow J/\psi \pi^+ \pi^-)$ | < 2.9 | $\times 10^{-5}$ | CL=95% | — |
| $J/\psi(1S) K^*(892)^+$ | (1.41 \pm 0.08) | $\times 10^{-3}$ | | 1571 |
| $J/\psi(1S) K(1270)^+$ | (1.8 \pm 0.5) | $\times 10^{-3}$ | | 1390 |
| $J/\psi(1S) K(1400)^+$ | < 5 | $\times 10^{-4}$ | CL=90% | 1308 |
| $J/\psi(1S) \eta K^+$ | (1.08 \pm 0.33) | $\times 10^{-4}$ | | 1510 |
| $J/\psi(1S) \phi K^+$ | (5.2 \pm 1.7) | $\times 10^{-5}$ | S=1.2 | 1227 |
| $J/\psi(1S) \pi^+$ | (4.9 \pm 0.6) | $\times 10^{-5}$ | S=1.5 | 1727 |
| $J/\psi(1S) \rho^+$ | < 7.7 | $\times 10^{-4}$ | CL=90% | 1611 |
| $J/\psi(1S) a_1(1260)^+$ | < 1.2 | $\times 10^{-3}$ | CL=90% | 1414 |
| $J/\psi(1S) p \bar{\Lambda}$ | (1.18 \pm 0.31) | $\times 10^{-5}$ | | 567 |
| $J/\psi(1S) \bar{\Sigma}^0 p$ | < 1.1 | $\times 10^{-5}$ | CL=90% | — |
| $J/\psi(1S) D^+$ | < 1.2 | $\times 10^{-4}$ | CL=90% | 871 |
| $J/\psi(1S) \bar{D}^0 \pi^+$ | < 2.5 | $\times 10^{-5}$ | CL=90% | 665 |
| $\psi(2S) K^+$ | (6.48 \pm 0.35) | $\times 10^{-4}$ | | 1284 |
| $\psi(2S) K^*(892)^+$ | (6.7 \pm 1.4) | $\times 10^{-4}$ | S=1.3 | 1115 |
| $\psi(2S) K^+ \pi^+ \pi^-$ | (1.9 \pm 1.2) | $\times 10^{-3}$ | | 1178 |
| $\psi(3770) K^+$ | (4.9 \pm 1.3) | $\times 10^{-4}$ | | 1220 |

| | | |
|--|--|------------|
| $\psi(3770) K^+$ $\times B(\psi(3770) \rightarrow D^0 \bar{D}^0)$ | $(3.4 \pm 0.9) \times 10^{-4}$ | 1220 |
| $\psi(3770) K^+$ $\times B(\psi(3770) \rightarrow D^+ D^- K^+)$ | $(1.4 \pm 0.8) \times 10^{-4}$ | 1220 |
| $\chi_{c0} \pi^+ \times B(\chi_{c0} \rightarrow \pi^+ \pi^-)$ | $< 3 \times 10^{-7}$ | CL=90% — |
| $\chi_{c0}(1P) K^+$ | $(1.6 \pm_{-0.4}^{+0.5}) \times 10^{-4}$ | 1478 |
| $\chi_{c0} K^*(892)^+$ | $< 2.86 \times 10^{-3}$ | CL=90% — |
| $\chi_{c2} K^+$ | $< 2.9 \times 10^{-5}$ | CL=90% — |
| $\chi_{c2} K^*(892)^+$ | $< 1.2 \times 10^{-5}$ | CL=90% — |
| $\chi_{c1}(1P) K^+$ | $(5.3 \pm 0.7) \times 10^{-4}$ | S=1.7 1411 |
| $\chi_{c1}(1P) K^*(892)^+$ | $(3.6 \pm 0.9) \times 10^{-4}$ | 1265 |

***K* or *K** modes**

| | | |
|---|--|-------------|
| $K^0 \pi^+$ | $(2.41 \pm 0.17) \times 10^{-5}$ | S=1.4 2614 |
| $K^+ \pi^0$ | $(1.21 \pm 0.08) \times 10^{-5}$ | 2615 |
| $\eta' K^+$ | $(7.05 \pm 0.35) \times 10^{-5}$ | 2528 |
| $\eta' K^*(892)^+$ | $< 1.4 \times 10^{-5}$ | CL=90% 2472 |
| ηK^+ | $(2.6 \pm 0.6) \times 10^{-6}$ | S=1.3 2588 |
| $\eta K^*(892)^+$ | $(2.6 \pm 0.4) \times 10^{-5}$ | 2534 |
| ωK^+ | $(5.1 \pm 0.7) \times 10^{-6}$ | 2557 |
| $\omega K^*(892)^+$ | $< 7.4 \times 10^{-6}$ | CL=90% 2503 |
| $a_0^+ K^0$ | $< 3.9 \times 10^{-6}$ | CL=90% — |
| $a_0^0 K^+$ | $< 2.5 \times 10^{-6}$ | CL=90% — |
| $K^*(892)^0 \pi^+$ | $(1.16 \pm 0.19) \times 10^{-5}$ | S=1.8 2562 |
| $K^*(892)^+ \pi^0$ | $(6.9 \pm 2.4) \times 10^{-6}$ | 2562 |
| $K^+ \pi^- \pi^+$ | $(5.6 \pm 0.9) \times 10^{-5}$ | S=2.6 2609 |
| $K^+ \pi^- \pi^+$ nonresonant | $(3.1 \pm_{-0.8}^{+1.0}) \times 10^{-6}$ | 2609 |
| $K^+ f_0(980) \times B(f_0 \rightarrow \pi^+ \pi^-)$ | $(8.9 \pm 1.0) \times 10^{-6}$ | 2524 |
| $f_2(1270)^0 K^+$ | $< 2.3 \times 10^{-6}$ | CL=90% — |
| $f_0^*(1370)^0 K^+ \times B(f_0^*(1370)^0 \rightarrow \pi^+ \pi^-)$ | $< 1.07 \times 10^{-5}$ | CL=90% — |
| $\rho^0(1450) K^+ \times B(\rho^0(1450) \rightarrow \pi^+ \pi^-)$ | $< 1.17 \times 10^{-5}$ | CL=90% — |
| $f_0(1500) K^+ \times B(f_0(1500) \rightarrow \pi^+ \pi^-)$ | $< 4.4 \times 10^{-6}$ | CL=90% 2397 |
| $f_2'(1525) K^+ \times B(f_2'(1525) \rightarrow \pi^+ \pi^-)$ | $< 3.4 \times 10^{-6}$ | CL=90% 2392 |
| $K^+ \rho^0$ | $(5.0 \pm_{-0.8}^{+0.7}) \times 10^{-6}$ | 2558 |
| $K_0^*(1430)^0 \pi^+$ | $(3.8 \pm 0.5) \times 10^{-5}$ | 2448 |
| $K_2^*(1430)^0 \pi^+$ | $< 6.9 \times 10^{-6}$ | CL=90% 2445 |
| $K^*(1410)^0 \pi^+$ | $< 4.5 \times 10^{-5}$ | CL=90% 2448 |

| | | | | |
|---|----------------------------|------------------|--------|------|
| $K^*(1680)^0 \pi^+$ | < 1.2 | $\times 10^{-5}$ | CL=90% | 2358 |
| $K^- \pi^+ \pi^+$ | < 1.8 | $\times 10^{-6}$ | CL=90% | 2609 |
| $K^- \pi^+ \pi^+$ nonresonant | < 5.6 | $\times 10^{-5}$ | CL=90% | 2609 |
| $K_1(1400)^0 \pi^+$ | < 2.6 | $\times 10^{-3}$ | CL=90% | 2451 |
| $K^0 \pi^+ \pi^0$ | < 6.6 | $\times 10^{-5}$ | CL=90% | 2609 |
| $K^0 \rho^+$ | < 4.8 | $\times 10^{-5}$ | CL=90% | 2558 |
| $K^*(892)^+ \pi^+ \pi^-$ | < 1.1 | $\times 10^{-3}$ | CL=90% | 2556 |
| $K^*(892)^+ \rho^0$ | (1.1 \pm 0.4) | $\times 10^{-5}$ | | 2504 |
| $K^*(892)^0 \rho^+$ | (8.9 \pm 2.1) | $\times 10^{-6}$ | | 2504 |
| $K^*(892)^+ K^*(892)^0$ | < 7.1 | $\times 10^{-5}$ | CL=90% | 2484 |
| $K_1(1400)^+ \rho^0$ | < 7.8 | $\times 10^{-4}$ | CL=90% | 2387 |
| $K_2^*(1430)^+ \rho^0$ | < 1.5 | $\times 10^{-3}$ | CL=90% | 2381 |
| $K^+ \bar{K}^0$ | (1.20 \pm 0.32) | $\times 10^{-6}$ | | 2593 |
| $\bar{K}^0 K^+ \pi^0$ | < 2.4 | $\times 10^{-5}$ | CL=90% | 2578 |
| $K^+ K_S^0 K_S^0$ | (1.15 \pm 0.13) | $\times 10^{-5}$ | | 2521 |
| $K_S^0 K_S^0 \pi^+$ | < 3.2 | $\times 10^{-6}$ | CL=90% | 2577 |
| $K^+ K^- \pi^+$ | < 6.3 | $\times 10^{-6}$ | CL=90% | 2578 |
| $K^+ K^- \pi^+$ nonresonant | < 7.5 | $\times 10^{-5}$ | CL=90% | 2578 |
| $K^+ K^+ \pi^-$ | < 1.3 | $\times 10^{-6}$ | CL=90% | 2578 |
| $K^+ K^+ \pi^-$ nonresonant | < 8.79 | $\times 10^{-5}$ | CL=90% | 2578 |
| $K^+ K^*(892)^0$ | < 5.3 | $\times 10^{-6}$ | CL=90% | 2540 |
| $K^+ K^- K^+$ | (3.01 \pm 0.19) | $\times 10^{-5}$ | | 2522 |
| $K^+ \phi$ | (9.0 \pm 0.8) | $\times 10^{-6}$ | S=1.3 | 2516 |
| $f_0(980) K^+ \times B(f_0(980) \rightarrow K^+ K^-)$ | < 2.9 | $\times 10^{-6}$ | CL=90% | 2524 |
| $a_2(1320) K^+ \times B(a_2(1320) \rightarrow K^+ K^-)$ | < 1.1 | $\times 10^{-6}$ | CL=90% | 2449 |
| $f_2'(1525) K^+ \times B(f_2'(1525) \rightarrow K^+ K^-)$ | < 4.9 | $\times 10^{-6}$ | CL=90% | 2392 |
| $\phi(1680) K^+ \times B(\phi(1680) \rightarrow K^+ K^-)$ | < 8 | $\times 10^{-7}$ | CL=90% | 2344 |
| $K^+ K^- K^+$ nonresonant | (2.40 \pm 0.30 / 0.62) | $\times 10^{-5}$ | | 2522 |
| $K^*(892)^+ K^+ K^-$ | < 1.6 | $\times 10^{-3}$ | CL=90% | 2466 |
| $K^*(892)^+ \phi$ | (9.6 \pm 3.0) | $\times 10^{-6}$ | S=1.9 | 2460 |
| $K_1(1400)^+ \phi$ | < 1.1 | $\times 10^{-3}$ | CL=90% | 2339 |
| $K_2^*(1430)^+ \phi$ | < 3.4 | $\times 10^{-3}$ | CL=90% | 2332 |
| $K^+ \phi \phi$ | (2.6 \pm 1.1 / 0.9) | $\times 10^{-6}$ | | 2306 |
| $K^*(892)^+ \gamma$ | (4.03 \pm 0.26) | $\times 10^{-5}$ | | 2564 |
| $K_1(1270)^+ \gamma$ | (4.3 \pm 1.3) | $\times 10^{-5}$ | | 2486 |
| $\eta K^+ \gamma$ | (8.4 \pm 1.8) | $\times 10^{-6}$ | | 2588 |
| $\phi K^+ \gamma$ | (3.4 \pm 1.0) | $\times 10^{-6}$ | | 2516 |
| $K^+ \pi^- \pi^+ \gamma$ | (2.50 \pm 0.28) | $\times 10^{-5}$ | | 2609 |

| | | |
|--------------------------------------|--|-------------|
| $K^*(892)^0 \pi^+ \gamma$ | (2.0 \pm 0.7 \pm 0.6) $\times 10^{-5}$ | 2562 |
| $K^+ \rho^0 \gamma$ | < 2.0 $\times 10^{-5}$ | CL=90% 2558 |
| $K^+ \pi^- \pi^+ \gamma$ nonresonant | < 9.2 $\times 10^{-6}$ | CL=90% 2609 |
| $K_1(1400)^+ \gamma$ | < 1.5 $\times 10^{-5}$ | 2453 |
| $K_2^*(1430)^+ \gamma$ | (1.4 \pm 0.4) $\times 10^{-5}$ | 2447 |
| $K^*(1680)^+ \gamma$ | < 1.9 $\times 10^{-3}$ | CL=90% 2360 |
| $K_3^*(1780)^+ \gamma$ | < 3.9 $\times 10^{-5}$ | CL=90% 2341 |
| $K_4^*(2045)^+ \gamma$ | < 9.9 $\times 10^{-3}$ | CL=90% 2243 |

Light unflavored meson modes

| | | |
|---|--------------------------------------|-------------|
| $\rho^+ \gamma$ | < 1.8 $\times 10^{-6}$ | CL=90% 2583 |
| $\pi^+ \pi^0$ | (5.5 \pm 0.6) $\times 10^{-6}$ | 2636 |
| $\pi^+ \pi^+ \pi^-$ | (1.62 \pm 0.15) $\times 10^{-5}$ | 2630 |
| $\rho^0 \pi^+$ | (8.7 \pm 1.1) $\times 10^{-6}$ | 2581 |
| $\pi^+ f_0(980) \times B(f_0(980) \rightarrow \pi^+ \pi^-)$ | < 3.0 $\times 10^{-6}$ | CL=90% 2547 |
| $\pi^+ f_2(1270)$ | (8.2 \pm 2.5) $\times 10^{-6}$ | 2483 |
| $\rho(1450)^0 \pi^+$ | < 2.3 $\times 10^{-6}$ | CL=90% 2436 |
| $f_0(1370) \pi^+ \times B(f_0(1370) \rightarrow \pi^+ \pi^-)$ | < 3.0 $\times 10^{-6}$ | CL=90% 2460 |
| $f_0(600) \pi^+ \times B(f_0(600) \rightarrow \pi^+ \pi^-)$ | < 4.1 $\times 10^{-6}$ | CL=90% — |
| $\pi^+ \pi^- \pi^+$ nonresonant | < 4.6 $\times 10^{-6}$ | CL=90% 2630 |
| $\pi^+ \pi^0 \pi^0$ | < 8.9 $\times 10^{-4}$ | CL=90% 2631 |
| $\rho^+ \pi^0$ | (1.20 \pm 0.19) $\times 10^{-5}$ | 2581 |
| $\pi^+ \pi^- \pi^+ \pi^0$ | < 4.0 $\times 10^{-3}$ | CL=90% 2621 |
| $\rho^+ \rho^0$ | (2.6 \pm 0.6) $\times 10^{-5}$ | 2523 |
| $a_1(1260)^+ \pi^0$ | < 1.7 $\times 10^{-3}$ | CL=90% 2494 |
| $a_1(1260)^0 \pi^+$ | < 9.0 $\times 10^{-4}$ | CL=90% 2494 |
| $\omega \pi^+$ | (5.9 \pm 1.0) $\times 10^{-6}$ | S=1.2 2580 |
| $\omega \rho^+$ | (1.3 \pm 0.4) $\times 10^{-5}$ | 2522 |
| $\eta \pi^+$ | (4.9 \pm 0.5) $\times 10^{-6}$ | 2609 |
| $\eta' \pi^+$ | (4.0 \pm 0.9) $\times 10^{-6}$ | 2551 |
| $\eta' \rho^+$ | < 2.2 $\times 10^{-5}$ | CL=90% 2492 |
| $\eta \rho^+$ | (8.4 \pm 2.2) $\times 10^{-6}$ | 2553 |
| $\phi \pi^+$ | < 4.1 $\times 10^{-7}$ | CL=90% 2539 |
| $\phi \rho^+$ | < 1.6 $\times 10^{-5}$ | 2480 |
| $a_0^0 \pi^+$ | < 5.8 $\times 10^{-6}$ | CL=90% — |
| $\pi^+ \pi^+ \pi^+ \pi^- \pi^-$ | < 8.6 $\times 10^{-4}$ | CL=90% 2608 |
| $\rho^0 a_1(1260)^+$ | < 6.2 $\times 10^{-4}$ | CL=90% 2433 |
| $\rho^0 a_2(1320)^+$ | < 7.2 $\times 10^{-4}$ | CL=90% 2410 |
| $\pi^+ \pi^+ \pi^+ \pi^- \pi^- \pi^0$ | < 6.3 $\times 10^{-3}$ | CL=90% 2592 |
| $a_1(1260)^+ a_1(1260)^0$ | < 1.3 % | CL=90% 2335 |

Charged particle (h^\pm) modes

$$h^\pm = K^\pm \text{ or } \pi^\pm$$

| | | |
|---------------------|---|------|
| $h^+ \pi^0$ | $(1.6 \pm_{-0.6}^{+0.7}) \times 10^{-5}$ | 2636 |
| ωh^+ | $(1.38 \pm_{-0.24}^{+0.27}) \times 10^{-5}$ | 2580 |
| $h^+ X^0$ (Familon) | $< 4.9 \times 10^{-5}$ CL=90% | — |

Baryon modes

| | | |
|---|---|------|
| $p \bar{p} \pi^+$ | $(3.1 \pm_{-0.7}^{+0.8}) \times 10^{-6}$ | 2439 |
| $p \bar{p} \pi^+$ nonresonant | $< 5.3 \times 10^{-5}$ CL=90% | 2439 |
| $p \bar{p} \pi^+ \pi^+ \pi^-$ | $< 5.2 \times 10^{-4}$ CL=90% | 2369 |
| $p \bar{p} K^+$ | $(5.6 \pm 1.0) \times 10^{-6}$ S=2.4 | 2348 |
| $\Theta(1710)^{++} \bar{p} \times [kkk]$ | $< 9.1 \times 10^{-8}$ CL=90% | — |
| $B(\Theta(1710)^{++} \rightarrow p K^+)$ | | |
| $f_J(2220) K^+ \times B(f_J(2220) \rightarrow [kkk])$ | $< 4.1 \times 10^{-7}$ CL=90% | 2135 |
| $p \bar{p}$ | | |
| $p \bar{\Lambda}(1520)$ | $< 1.5 \times 10^{-6}$ CL=90% | 2322 |
| $p \bar{p} K^+$ nonresonant | $< 8.9 \times 10^{-5}$ CL=90% | 2348 |
| $p \bar{p} K^*(892)^+$ | $(1.03 \pm_{-0.33}^{+0.38}) \times 10^{-5}$ | 2215 |
| $p \bar{\Lambda}$ | $< 4.9 \times 10^{-7}$ CL=90% | 2430 |
| $p \bar{\Lambda} \gamma$ | $(2.2 \pm 0.6) \times 10^{-6}$ | 2430 |
| $p \bar{\Sigma} \gamma$ | $< 4.6 \times 10^{-6}$ CL=90% | 2413 |
| $p \bar{\Lambda} \pi^+ \pi^-$ | $< 2.0 \times 10^{-4}$ CL=90% | 2367 |
| $\Lambda \bar{\Lambda} \pi^+$ | $< 2.8 \times 10^{-6}$ CL=90% | 2358 |
| $\Lambda \bar{\Lambda} K^+$ | $(2.9 \pm_{-0.8}^{+1.0}) \times 10^{-6}$ | 2251 |
| $\bar{\Delta}^0 p$ | $< 3.8 \times 10^{-4}$ CL=90% | 2402 |
| $\Delta^{++} \bar{p}$ | $< 1.5 \times 10^{-4}$ CL=90% | 2402 |
| $D^+ p \bar{p}$ | $< 1.5 \times 10^{-5}$ CL=90% | 1860 |
| $D^*(2010)^+ p \bar{p}$ | $< 1.5 \times 10^{-5}$ CL=90% | 1786 |
| $\bar{\Lambda}_c^- p \pi^+$ | $(2.1 \pm 0.7) \times 10^{-4}$ | 1980 |
| $\bar{\Lambda}_c^- p \pi^+ \pi^0$ | $(1.8 \pm 0.6) \times 10^{-3}$ | 1935 |
| $\bar{\Lambda}_c^- p \pi^+ \pi^+ \pi^-$ | $(2.3 \pm 0.7) \times 10^{-3}$ | 1880 |
| $\bar{\Lambda}_c^- p \pi^+ \pi^+ \pi^- \pi^0$ | $< 1.34\%$ CL=90% | 1822 |
| $\bar{\Sigma}_c(2455)^0 p$ | $< 8 \times 10^{-5}$ CL=90% | 1938 |
| $\bar{\Sigma}_c(2520)^0 p$ | $< 4.6 \times 10^{-5}$ CL=90% | 1904 |
| $\bar{\Sigma}_c(2455)^0 p \pi^0$ | $(4.4 \pm 1.8) \times 10^{-4}$ | 1896 |
| $\bar{\Sigma}_c(2455)^0 p \pi^- \pi^+$ | $(4.4 \pm 1.7) \times 10^{-4}$ | 1845 |
| $\bar{\Sigma}_c(2455)^{--} p \pi^+ \pi^+$ | $(2.8 \pm 1.2) \times 10^{-4}$ | 1845 |
| $\bar{\Lambda}_c(2593)^- / \bar{\Lambda}_c(2625)^- p \pi^+$ | $< 1.9 \times 10^{-4}$ CL=90% | — |

**Lepton Family number (*LF*) or Lepton number (*L*) violating modes, or
 $\Delta B = 1$ weak neutral current (*B1*) modes**

| | | | | | |
|----------------------------|-----------------|-----------------------------|------------------|--------|------|
| $\pi^+ e^+ e^-$ | <i>B1</i> | < 3.9 | $\times 10^{-3}$ | CL=90% | 2638 |
| $\pi^+ \mu^+ \mu^-$ | <i>B1</i> | < 9.1 | $\times 10^{-3}$ | CL=90% | 2633 |
| $\pi^+ \nu \bar{\nu}$ | <i>B1</i> | < 1.0 | $\times 10^{-4}$ | CL=90% | 2638 |
| $K^+ e^+ e^-$ | <i>B1</i> | (8.0 \pm 2.2 \pm 1.9) | $\times 10^{-7}$ | S=1.4 | 2616 |
| $K^+ \mu^+ \mu^-$ | <i>B1</i> | (3.4 \pm 1.9 \pm 1.4) | $\times 10^{-7}$ | S=1.7 | 2612 |
| $K^+ \ell^+ \ell^-$ | <i>B1</i> [ggg] | (5.3 \pm 1.1) | $\times 10^{-7}$ | | 2616 |
| $K^+ \bar{\nu} \nu$ | <i>B1</i> | < 5.2 | $\times 10^{-5}$ | CL=90% | 2616 |
| $K^*(892)^+ e^+ e^-$ | <i>B1</i> | < 4.6 | $\times 10^{-6}$ | CL=90% | 2564 |
| $K^*(892)^+ \mu^+ \mu^-$ | <i>B1</i> | < 2.2 | $\times 10^{-6}$ | CL=90% | 2560 |
| $K^*(892)^+ \ell^+ \ell^-$ | <i>B1</i> [ggg] | < 2.2 | $\times 10^{-6}$ | CL=90% | 2564 |
| $\pi^+ e^+ \mu^-$ | <i>LF</i> | < 6.4 | $\times 10^{-3}$ | CL=90% | 2637 |
| $\pi^+ e^- \mu^+$ | <i>LF</i> | < 6.4 | $\times 10^{-3}$ | CL=90% | 2637 |
| $K^+ e^+ \mu^-$ | <i>LF</i> | < 8 | $\times 10^{-7}$ | CL=90% | 2615 |
| $K^+ e^- \mu^+$ | <i>LF</i> | < 6.4 | $\times 10^{-3}$ | CL=90% | 2615 |
| $K^*(892)^+ e^\pm \mu^\mp$ | <i>LF</i> | < 7.9 | $\times 10^{-6}$ | CL=90% | 2563 |
| $\pi^- e^+ e^+$ | <i>L</i> | < 1.6 | $\times 10^{-6}$ | CL=90% | 2638 |
| $\pi^- \mu^+ \mu^+$ | <i>L</i> | < 1.4 | $\times 10^{-6}$ | CL=90% | 2633 |
| $\pi^- e^+ \mu^+$ | <i>L</i> | < 1.3 | $\times 10^{-6}$ | CL=90% | 2637 |
| $\rho^- e^+ e^+$ | <i>L</i> | < 2.6 | $\times 10^{-6}$ | CL=90% | 2583 |
| $\rho^- \mu^+ \mu^+$ | <i>L</i> | < 5.0 | $\times 10^{-6}$ | CL=90% | 2578 |
| $\rho^- e^+ \mu^+$ | <i>L</i> | < 3.3 | $\times 10^{-6}$ | CL=90% | 2581 |
| $K^- e^+ e^+$ | <i>L</i> | < 1.0 | $\times 10^{-6}$ | CL=90% | 2616 |
| $K^- \mu^+ \mu^+$ | <i>L</i> | < 1.8 | $\times 10^{-6}$ | CL=90% | 2612 |
| $K^- e^+ \mu^+$ | <i>L</i> | < 2.0 | $\times 10^{-6}$ | CL=90% | 2615 |
| $K^*(892)^- e^+ e^+$ | <i>L</i> | < 2.8 | $\times 10^{-6}$ | CL=90% | 2564 |
| $K^*(892)^- \mu^+ \mu^+$ | <i>L</i> | < 8.3 | $\times 10^{-6}$ | CL=90% | 2560 |
| $K^*(892)^- e^+ \mu^+$ | <i>L</i> | < 4.4 | $\times 10^{-6}$ | CL=90% | 2563 |

B^0

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

I, *J*, *P* need confirmation. Quantum numbers shown are quark-model predictions.

$$\text{Mass } m_{B^0} = 5279.4 \pm 0.5 \text{ MeV}$$

$$m_{B^0} - m_{B^\pm} = 0.33 \pm 0.28 \text{ MeV} \quad (S = 1.1)$$

$$\text{Mean life } \tau_{B^0} = (1.530 \pm 0.009) \times 10^{-12} \text{ s}$$

$$c\tau = 458.7 \text{ } \mu\text{m}$$

$$\tau_{B^+}/\tau_{B^0} = 1.071 \pm 0.009 \quad (\text{direct measurements})$$

$B^0\text{-}\overline{B}^0$ mixing parameters

$$\chi_d = 0.188 \pm 0.003$$

$$\Delta m_{B^0} = m_{B_H^0} - m_{B_L^0} = (0.507 \pm 0.005) \times 10^{12} \hbar \text{ s}^{-1}$$

$$= (3.337 \pm 0.033) \times 10^{-10} \text{ MeV}$$

$$x_d = \Delta m_{B^0} / \Gamma_{B^0} = 0.776 \pm 0.008$$

$$\text{Re}(\lambda_{CP} / |\lambda_{CP}|) \text{ Re}(z) = 0.01 \pm 0.05$$

$$\text{Re}(z) = 0.00 \pm 0.12$$

$$\text{Im}(z) = -0.002 \pm 0.033 \quad (S = 1.4)$$

CP violation parameters

$$\text{Re}(\epsilon_{B^0}) / (1 + |\epsilon_{B^0}|^2) = (-1.3 \pm 2.9) \times 10^{-3}$$

$$A_{T/CP} = 0.005 \pm 0.018$$

$$A_{CP}(B^0 \rightarrow D^*(2010)^+ D^-) = 0.03 \pm 0.07$$

$$A_{CP}(B^0 \rightarrow K^*(892)^0 \phi) = 0.01 \pm 0.07$$

$$A_{CP}(B^0 \rightarrow K^+ \pi^-) = -0.113 \pm 0.020$$

$$A_{CP}(B^0 \rightarrow K_S^0 \pi^0) = 0.16 \pm 0.29$$

$$A_{CP}(B^0 \rightarrow \eta K^*(892)^0) = 0.02 \pm 0.11$$

$$A_{CP}(B^0 \rightarrow \rho^+ K^-) = 0.26 \pm 0.15$$

$$A_{CP}(B^0 \rightarrow K^+ \pi^- \pi^0) \text{ non-resonant} = 0.07 \pm 0.11$$

$$A_{CP}(B^0 \rightarrow K^*(892)^+ \pi^-) = -0.05 \pm 0.14$$

$$A_{CP}(B^0 \rightarrow \rho^+ \pi^-) = -0.15 \pm 0.08$$

$$A_{CP}(B^0 \rightarrow \rho^- \pi^+) = -0.53 \pm 0.30$$

$$A_{CP}(B^0 \rightarrow K^*(1430) \gamma) = -0.08 \pm 0.15$$

$$C_{D^*(2010)^- D^+} (B^0 \rightarrow D^*(2010)^- D^+) = 0.20 \pm 0.18$$

$$S_{D^*(2010)^- D^+} (B^0 \rightarrow D^*(2010)^- D^+) = -0.53 \pm 0.32 \quad (S = 1.2)$$

$$C_{D^*(2010)^+ D^-} (B^0 \rightarrow D^*(2010)^+ D^-) = -0.17 \pm 0.23 \quad (S = 1.3)$$

$$S_{D^*(2010)^+ D^-} (B^0 \rightarrow D^*(2010)^+ D^-) = -0.54 \pm 0.27$$

$$C_{D^{*+} D^{*-}} (B^0 \rightarrow D^{*+} D^{*-}) = 0.27 \pm 0.17$$

$$S_{D^{*+} D^{*-}} (B^0 \rightarrow D^{*+} D^{*-}) = -0.2 \pm 0.4 \quad (S = 1.2)$$

$$C_+ (B^0 \rightarrow D^{*+} D^{*-}) = 0.06 \pm 0.17$$

$$S_+ (B^0 \rightarrow D^{*+} D^{*-}) = -0.75 \pm 0.25$$

$$C_- (B^0 \rightarrow D^{*+} D^{*-}) = -0.2 \pm 1.0$$

$$S_- (B^0 \rightarrow D^{*+} D^{*-}) = -1.8 \pm 1.8$$

$$C_{D^+ D^-} (B^0 \rightarrow D^+ D^-) = 0.1 \pm 0.4$$

$$S_{D^+ D^-} (B^0 \rightarrow D^+ D^-) = -0.3 \pm 0.6$$

$$C_{J/\psi(1S) \pi^0} (B^0 \rightarrow J/\psi(1S) \pi^0) = 0.13 \pm 0.24$$

$$S_{J/\psi(1S) \pi^0} (B^0 \rightarrow J/\psi(1S) \pi^0) = -0.4 \pm 0.4 \quad (S = 1.1)$$

$$\begin{aligned}
 C_{\omega K_S^0} (B^0 \rightarrow \omega K_S^0) &= -0.3 \pm 0.5 \\
 S_{\omega K_S^0} (B^0 \rightarrow \omega K_S^0) &= 0.8 \pm 0.7 \\
 C_{\eta'(958) K} (B^0 \rightarrow \eta'(958) K_S^0) &= -0.04 \pm 0.20 \quad (S = 2.5) \\
 S_{\eta'(958) K} (B^0 \rightarrow \eta'(958) K_S^0) &= 0.43 \pm 0.17 \quad (S = 1.5) \\
 C_{f_0(980) K_S^0} (B^0 \rightarrow f_0(980) K_S^0) &= 0.39 \pm 0.28 \\
 S_{f_0(980) K_S^0} (B^0 \rightarrow f_0(980) K_S^0) &= 0.5 \pm 0.4 \\
 C_{K_S K_S K_S} (B^0 \rightarrow K_S K_S K_S) &= -0.41 \pm 0.21 \\
 S_{K_S K_S K_S} (B^0 \rightarrow K_S K_S K_S) &= -0.3^{+0.8}_{-0.7} \quad (S = 2.4) \\
 C_{K^+ K^- K_S^0} (B^0 \rightarrow K^+ K^- K_S^0) &= 0.09 \pm 0.10 \\
 S_{K^+ K^- K_S^0} (B^0 \rightarrow K^+ K^- K_S^0) &= -0.45 \pm 0.13 \\
 C_{\phi K_S^0} (B^0 \rightarrow \phi K_S^0) &= -0.04 \pm 0.17 \\
 S_{\phi K_S^0} (B^0 \rightarrow \phi K_S^0) &= 0.35 \pm 0.21 \\
 C_{K_S^0 \pi^0} (B^0 \rightarrow K_S^0 \pi^0) &= 0.08 \pm 0.14 \\
 S_{K_S^0 \pi^0} (B^0 \rightarrow K_S^0 \pi^0) &= 0.34 \pm 0.28 \\
 C_{K_S^0 \pi^0 \gamma} (B^0 \rightarrow K_S^0 \pi^0 \gamma) &= -0.3 \pm 0.4 \quad (S = 1.5) \\
 S_{K_S^0 \pi^0 \gamma} (B^0 \rightarrow K_S^0 \pi^0 \gamma) &= -0.3^{+0.6}_{-0.5} \quad (S = 1.3) \\
 C_{K^*(892)^0 \gamma} (B^0 \rightarrow K^*(892)^0 \gamma) &= -0.40 \pm 0.23 \\
 S_{K^*(892)^0 \gamma} (B^0 \rightarrow K^*(892)^0 \gamma) &= -0.39 \pm 0.33 \\
 C_{\pi \pi} (B^0 \rightarrow \pi^+ \pi^-) &= -0.36 \pm 0.23 \quad (S = 2.3) \\
 S_{\pi \pi} (B^0 \rightarrow \pi^+ \pi^-) &= -0.49 \pm 0.18 \quad (S = 1.5) \\
 C_{\pi^0 \pi^0} (B^0 \rightarrow \pi^0 \pi^0) &= -0.3 \pm 0.4 \\
 C_{\rho \pi} (B^0 \rightarrow \rho^+ \pi^-) &= 0.30 \pm 0.13 \\
 S_{\rho \pi} (B^0 \rightarrow \rho^+ \pi^-) &= -0.04 \pm 0.23 \quad (S = 1.3) \\
 \Delta C_{\rho \pi} (B^0 \rightarrow \rho^+ \pi^-) &= 0.33 \pm 0.13 \\
 \Delta S_{\rho \pi} (B^0 \rightarrow \rho^+ \pi^-) &= -0.07 \pm 0.22 \quad (S = 1.3) \\
 C_{\rho \rho} (B^0 \rightarrow \rho^+ \rho^-) &= -0.02 \pm 0.17 \\
 S_{\rho \rho} (B^0 \rightarrow \rho^+ \rho^-) &= -0.22 \pm 0.22 \\
 |\lambda| (B^0 \rightarrow c \bar{c} K^0) &= 0.969 \pm 0.028 \\
 |\lambda| (B^0 \rightarrow J/\psi K^*(892)^0) &< 0.25, \text{ CL} = 95\% \\
 \cos 2\beta (B^0 \rightarrow J/\psi K^*(892)^0) &= 1.7^{+0.7}_{-0.9} \quad (S = 1.6) \\
 (S_+ + S_-)/2 (B^0 \rightarrow D^{*-} \pi^+) &= -0.028 \pm 0.017 \quad (S = 1.3) \\
 (S_- - S_+)/2 (B^0 \rightarrow D^{*-} \pi^+) &= -0.001 \pm 0.018 \\
 (S_+ + S_-)/2 (B^0 \rightarrow D^- \pi^+) &= -0.043 \pm 0.030 \\
 (S_- - S_+)/2 (B^0 \rightarrow D^- \pi^+) &= -0.01 \pm 0.04 \\
 \sin(2\beta) &= 0.725 \pm 0.037 \\
 \sin(2\beta_{\text{eff}}) (B^0 \rightarrow \phi K^0) &= 0.50 \pm 0.26 \\
 \sin(2\beta_{\text{eff}}) (B^0 \rightarrow K^+ K^- K_S^0) &= 0.55 \pm 0.25 \\
 |\sin(2\beta + \gamma)| &> 0.35, \text{ CL} = 90\% \\
 \alpha &= (96 \pm 10)^\circ
 \end{aligned}$$

\bar{B}^0 modes are charge conjugates of the modes below. Reactions indicate the weak decay vertex and do not include mixing. Modes which do not identify the charge state of the B are listed in the B^\pm/B^0 ADMIXTURE section.

The branching fractions listed below assume 50% $B^0\bar{B}^0$ and 50% B^+B^- production at the $\Upsilon(4S)$. We have attempted to bring older measurements up to date by rescaling their assumed $\Upsilon(4S)$ production ratio to 50:50 and their assumed D , D_s , D^* , and ψ branching ratios to current values whenever this would affect our averages and best limits significantly.

Indentation is used to indicate a subchannel of a previous reaction. All resonant subchannels have been corrected for resonance branching fractions to the final state so the sum of the subchannel branching fractions can exceed that of the final state.

For inclusive branching fractions, e.g., $B \rightarrow D^\pm$ anything, the values usually are multiplicities, not branching fractions. They can be greater than one.

| B^0 DECAY MODES | Fraction (Γ_i/Γ) | Scale factor/ Confidence level | p (MeV/c) |
|--------------------------------------|--|-----------------------------------|----------------|
| $\ell^+ \nu_\ell$ anything | [ggg] (10.4 \pm 0.4) % | | — |
| $D^- \ell^+ \nu_\ell$ | [ggg] (2.12 \pm 0.20) % | | 2309 |
| $D^*(2010)^- \ell^+ \nu_\ell$ | [ggg] (5.35 \pm 0.20) % | | 2257 |
| $\bar{D}^0 \pi^+ \ell^+ \nu_\ell$ | (3.2 \pm 1.0) $\times 10^{-3}$ | | 2308 |
| $\bar{D}^{*0} \pi^+ \ell^+ \nu_\ell$ | (6.5 \pm 1.5) $\times 10^{-3}$ | | 2256 |
| $\rho^- \ell^+ \nu_\ell$ | [ggg] (2.3 \pm 0.4) $\times 10^{-4}$ | | 2583 |
| $\pi^- \ell^+ \nu_\ell$ | [ggg] (1.36 \pm 0.15) $\times 10^{-4}$ | | 2638 |
| Inclusive modes | | | |
| K^\pm anything | (78 \pm 8) % | | — |
| $D^0 X$ | (6.3 \pm 2.0) % | | — |
| $\bar{D}^0 X$ | (51 \pm 4) % | | — |
| $D^+ X$ | < 5.1 % | CL=90% | — |
| $D^- X$ | (40 \pm 5) % | | — |
| $D_s^+ X$ | (10.9 $^{+4.4}_{-3.2}$) % | | — |
| $D_s^- X$ | < 8.7 % | CL=90% | — |
| $\Lambda_c^+ X$ | < 3.8 % | CL=90% | — |
| $\bar{\Lambda}_c^- X$ | (4.9 $^{+2.5}_{-2.0}$) % | | — |
| $\bar{c} X$ | (104 \pm 8) % | | — |
| $c X$ | (24 \pm 5) % | | — |
| $\bar{c} c X$ | (128 $^{+11}_{-10}$) % | | — |

D , D^* , or D_s modes

| | | | |
|--|--|--------|------|
| $D^- \pi^+$ | $(3.4 \pm 0.9) \times 10^{-3}$ | S=4.1 | 2306 |
| $D^- \rho^+$ | $(7.5 \pm 1.2) \times 10^{-3}$ | | 2235 |
| $D^- K^0 \pi^+$ | $(4.9 \pm 0.9) \times 10^{-4}$ | | 2259 |
| $D^- K^*(892)^+$ | $(4.5 \pm 0.7) \times 10^{-4}$ | | 2211 |
| $D^- \omega \pi^+$ | $(2.8 \pm 0.6) \times 10^{-3}$ | | 2204 |
| $D^- K^+$ | $(2.0 \pm 0.6) \times 10^{-4}$ | | 2279 |
| $D^- K^+ \bar{K}^0$ | $< 3.1 \times 10^{-4}$ | CL=90% | 2188 |
| $D^- K^+ \bar{K}^*(892)^0$ | $(8.8 \pm 1.9) \times 10^{-4}$ | | 2070 |
| $\bar{D}^0 \pi^+ \pi^-$ | $(8.0 \pm 1.6) \times 10^{-4}$ | | 2301 |
| $D^*(2010)^- \pi^+$ | $(2.76 \pm 0.21) \times 10^{-3}$ | | 2255 |
| $D^- \pi^+ \pi^+ \pi^-$ | $(8.0 \pm 2.5) \times 10^{-3}$ | | 2287 |
| $(D^- \pi^+ \pi^+ \pi^-)$ nonresonant | $(3.9 \pm 1.9) \times 10^{-3}$ | | 2287 |
| $D^- \pi^+ \rho^0$ | $(1.1 \pm 1.0) \times 10^{-3}$ | | 2206 |
| $D^- a_1(1260)^+$ | $(6.0 \pm 3.3) \times 10^{-3}$ | | 2121 |
| $D^*(2010)^- \pi^+ \pi^0$ | $(1.5 \pm 0.5) \%$ | | 2248 |
| $D^*(2010)^- \rho^+$ | $(6.8 \pm 0.9) \times 10^{-3}$ | | 2180 |
| $D^*(2010)^- K^+$ | $(2.14 \pm 0.20) \times 10^{-4}$ | | 2226 |
| $D^*(2010)^- K^0 \pi^+$ | $(3.0 \pm 0.8) \times 10^{-4}$ | | 2205 |
| $D^*(2010)^- K^*(892)^+$ | $(3.3 \pm 0.6) \times 10^{-4}$ | | 2155 |
| $D^*(2010)^- K^+ \bar{K}^0$ | $< 4.7 \times 10^{-4}$ | CL=90% | 2131 |
| $D^*(2010)^- K^+ \bar{K}^*(892)^0$ | $(1.29 \pm 0.33) \times 10^{-3}$ | | 2007 |
| $D^*(2010)^- \pi^+ \pi^+ \pi^-$ | $(7.0 \pm 0.8) \times 10^{-3}$ | S=1.3 | 2235 |
| $(D^*(2010)^- \pi^+ \pi^+ \pi^-)$ non-resonant | $(0.0 \pm 2.5) \times 10^{-3}$ | | 2235 |
| $D^*(2010)^- \pi^+ \rho^0$ | $(5.7 \pm 3.2) \times 10^{-3}$ | | 2150 |
| $D^*(2010)^- a_1(1260)^+$ | $(1.30 \pm 0.27) \%$ | | 2061 |
| $D^*(2010)^- \pi^+ \pi^+ \pi^- \pi^0$ | $(1.76 \pm 0.27) \%$ | | 2218 |
| $D^*- 3\pi^+ 2\pi^-$ | $(4.7 \pm 0.9) \times 10^{-3}$ | | 2195 |
| $D^*(2010)^- p \bar{p} \pi^+$ | $(6.5 \pm 1.6) \times 10^{-4}$ | | 1708 |
| $D^*(2010)^- p \bar{n}$ | $(1.5 \pm 0.4) \times 10^{-3}$ | | 1785 |
| $\bar{D}^*(2010)^- \omega \pi^+$ | $(2.9 \pm 0.5) \times 10^{-3}$ | | 2148 |
| $D_1(2420)^- \pi^+ \times B(D_1^- \rightarrow D^- \pi^+ \pi^-)$ | $(8.9 \pm \frac{2.3}{3.5}) \times 10^{-5}$ | | — |
| $D_1(2420)^- \pi^+ \times B(D_1^- \rightarrow D^{*-} \pi^+ \pi^-)$ | $< 3.3 \times 10^{-5}$ | CL=90% | — |
| $\bar{D}_2^*(2460)^- \pi^+$ | $< 2.2 \times 10^{-3}$ | CL=90% | 2064 |
| $D_2^*(2460)^- \pi^+ \times B((D_2^*)^- \rightarrow D^{*-} \pi^+ \pi^-)$ | $< 2.4 \times 10^{-5}$ | CL=90% | — |
| $\bar{D}_2^*(2460)^- \rho^+$ | $< 4.9 \times 10^{-3}$ | CL=90% | 1977 |
| $D^- D^+$ | $(1.9 \pm 0.6) \times 10^{-4}$ | | 1864 |
| $D^- D_s^+$ | $(6.5 \pm 2.1) \times 10^{-3}$ | | 1813 |
| $D^*(2010)^- D_s^+$ | $(8.8 \pm 1.6) \times 10^{-3}$ | | 1735 |

| | | |
|---|--|------|
| $D^- D_s^{*+}$ | $(8.6 \pm 3.4) \times 10^{-3}$ | 1732 |
| $D_s^*(2010)^- D_s^{*+}$ | $(1.79 \pm 0.16) \%$ | 1649 |
| $D_{s0}(2317)^+ K^- \times$ $B(D_{s0}(2317)^+ \rightarrow D_s^+ \pi^0)$ | $(4.3 \pm 1.5) \times 10^{-5}$ | 2097 |
| $D_{s0}(2317)^+ \pi^- \times$ $B(D_{s0}(2317)^+ \rightarrow D_s^+ \pi^0)$ | $< 2.5 \times 10^{-5}$ CL=90% | 2128 |
| $D_{sJ}(2457)^+ K^- \times$ $B(D_{sJ}(2457)^+ \rightarrow D_s^+ \pi^0)$ | $< 9.4 \times 10^{-6}$ CL=90% | — |
| $D_{sJ}(2457)^+ \pi^- \times$ $B(D_{sJ}(2457)^+ \rightarrow D_s^+ \pi^0)$ | $< 4.0 \times 10^{-6}$ CL=90% | — |
| $D_s^- D_s^+$ | $< 1.0 \times 10^{-4}$ CL=90% | 1759 |
| $D_s^{*-} D_s^+$ | $< 1.3 \times 10^{-4}$ CL=90% | 1674 |
| $D_s^{*-} D_s^{*+}$ | $< 2.4 \times 10^{-4}$ CL=90% | 1584 |
| $D_{s0}(2317)^+ D^- \times$ $B(D_{s0}(2317)^+ \rightarrow D_s^+ \pi^0)$ | $(9.7 \pm_{-3.4}^{+4.1}) \times 10^{-4}$ S=1.4 | 1602 |
| $D_{s0}(2317)^+ D^- \times$ $B(D_{s0}(2317)^+ \rightarrow D_s^{*+} \gamma)$ | $< 9.5 \times 10^{-4}$ CL=90% | — |
| $D_{s0}(2317)^+ D_s^*(2010)^- \times$ $B(D_{s0}(2317)^+ \rightarrow D_s^+ \pi^0)$ | $(1.5 \pm 0.6) \times 10^{-3}$ | 1510 |
| $D_{sJ}(2457)^+ D^- \times$ $B(D_{sJ}(2457)^+ \rightarrow D_s^{*+} \pi^0)$ | $(2.0 \pm_{-0.5}^{+0.6}) \times 10^{-3}$ | — |
| $D_{sJ}(2457)^+ D^- \times$ $B(D_{sJ}(2457)^+ \rightarrow D_s^+ \gamma)$ | $(6.6 \pm_{-1.5}^{+1.8}) \times 10^{-4}$ | — |
| $D_{sJ}(2457)^+ D^- \times$ $B(D_{sJ}(2457)^+ \rightarrow D_s^{*+} \gamma)$ | $< 6.0 \times 10^{-4}$ CL=90% | — |
| $D_{sJ}(2457)^+ D^- \times$ $B(D_{sJ}(2457)^+ \rightarrow D_s^+ \pi^+ \pi^-)$ | $< 2.0 \times 10^{-4}$ CL=90% | — |
| $D_{sJ}(2457)^+ D^- \times$ $B(D_{sJ}(2457)^+ \rightarrow D_s^+ \pi^0)$ | $< 3.6 \times 10^{-4}$ CL=90% | — |
| $D_{sJ}(2457)^+ D_s^*(2010) \times$ $B(D_{sJ}(2457)^+ \rightarrow D_s^{*+} \pi^0)$ | $(5.5 \pm_{-2.0}^{+2.5}) \times 10^{-3}$ | — |
| $D_{sJ}(2457)^+ D_s^*(2010) \times$ $B(D_{sJ}(2457)^+ \rightarrow D_s^+ \gamma)$ | $(2.3 \pm_{-0.7}^{+0.9}) \times 10^{-3}$ | — |
| $D^- D_{sJ}(2536)^+ \times$ $B(D_{sJ}(2536)^+ \rightarrow D_s^*(2007)^0 K^+)$ | $< 5 \times 10^{-4}$ CL=90% | 1444 |

| | | | | |
|---|-------------------|------------------|--------|------|
| $D^*(2010)^- D_{sJ}(2536)^+ \times$ $B(D_{sJ}(2536)^+ \rightarrow$ $D^*(2007)^0 K^+)$ | < 7 | $\times 10^{-4}$ | CL=90% | 1336 |
| $D^- D_{sJ}(2573)^+ \times$ $B(D_{sJ}(2573)^+ \rightarrow D^0 K^+)$ | < 1 | $\times 10^{-4}$ | CL=90% | 1413 |
| $D^*(2010)^- D_{sJ}(2573)^+ \times$ $B(D_{sJ}(2573)^+ \rightarrow D^0 K^+)$ | < 2 | $\times 10^{-4}$ | CL=90% | 1302 |
| $D_s^+ \pi^-$ | (2.2 ± 0.7) | $\times 10^{-5}$ | | 2270 |
| $D_s^{*+} \pi^-$ | < 4.1 | $\times 10^{-5}$ | CL=90% | 2215 |
| $D_s^+ \rho^-$ | < 6 | $\times 10^{-4}$ | CL=90% | 2197 |
| $D_s^{*+} \rho^-$ | < 6 | $\times 10^{-4}$ | CL=90% | 2138 |
| $D_s^+ a_1(1260)^-$ | < 2.1 | $\times 10^{-3}$ | CL=90% | 2080 |
| $D_s^{*+} a_1(1260)^-$ | < 1.8 | $\times 10^{-3}$ | CL=90% | 2015 |
| $D_s^- K^+$ | (3.1 ± 0.8) | $\times 10^{-5}$ | | 2242 |
| $D_s^{*-} K^+$ | < 2.5 | $\times 10^{-5}$ | CL=90% | 2185 |
| $D_s^- K^*(892)^+$ | < 8 | $\times 10^{-4}$ | CL=90% | 2172 |
| $D_s^{*-} K^*(892)^+$ | < 9 | $\times 10^{-4}$ | CL=90% | 2112 |
| $D_s^- \pi^+ K^0$ | < 4 | $\times 10^{-3}$ | CL=90% | 2222 |
| $D_s^{*-} \pi^+ K^0$ | < 2.6 | $\times 10^{-3}$ | CL=90% | 2164 |
| $D_s^- \pi^+ K^*(892)^0$ | < 3.1 | $\times 10^{-3}$ | CL=90% | 2138 |
| $D_s^{*-} \pi^+ K^*(892)^0$ | < 1.7 | $\times 10^{-3}$ | CL=90% | 2076 |
| $\bar{D}^0 K^0$ | (5.0 ± 1.4) | $\times 10^{-5}$ | | 2280 |
| $\bar{D}^0 K^+ \pi^-$ | (8.8 ± 1.7) | $\times 10^{-5}$ | | 2261 |
| $\bar{D}^0 K^*(892)^0$ | (5.3 ± 0.8) | $\times 10^{-5}$ | | 2213 |
| $D_2^*(2460)^- K^+ \times$ $B(D_2^*(2460)^- \rightarrow \bar{D}^0 \pi^-)$ | (1.8 ± 0.5) | $\times 10^{-5}$ | | 2031 |
| $\bar{D}^0 K^+ \pi^-$ non-resonant | < 3.7 | $\times 10^{-5}$ | CL=90% | — |
| $\bar{D}^0 \pi^0$ | (2.91 ± 0.28) | $\times 10^{-4}$ | | 2308 |
| $\bar{D}^0 \rho^0$ | (2.9 ± 1.1) | $\times 10^{-4}$ | | 2237 |
| $\bar{D}^0 \eta$ | (2.2 ± 0.5) | $\times 10^{-4}$ | S=1.6 | 2274 |
| $\bar{D}^0 \eta'$ | (1.25 ± 0.23) | $\times 10^{-4}$ | S=1.1 | 2198 |
| $\bar{D}^0 \omega$ | (2.5 ± 0.6) | $\times 10^{-4}$ | S=1.5 | 2235 |
| $D^0 K^+ \pi^-$ | < 1.9 | $\times 10^{-5}$ | CL=90% | 2261 |
| $D^0 K^*(892)^0$ | < 1.8 | $\times 10^{-5}$ | CL=90% | 2213 |
| $\bar{D}^{*0} \gamma$ | < 2.5 | $\times 10^{-5}$ | CL=90% | 2258 |
| $\bar{D}^*(2007)^0 \pi^0$ | (2.7 ± 0.5) | $\times 10^{-4}$ | | 2256 |
| $\bar{D}^*(2007)^0 \rho^0$ | < 5.1 | $\times 10^{-4}$ | CL=90% | 2182 |
| $\bar{D}^*(2007)^0 \eta$ | (2.6 ± 0.6) | $\times 10^{-4}$ | | 2220 |
| $\bar{D}^*(2007)^0 \eta'$ | (1.23 ± 0.35) | $\times 10^{-4}$ | | 2141 |
| $\bar{D}^*(2007)^0 \pi^+ \pi^-$ | (6.2 ± 2.2) | $\times 10^{-4}$ | | 2248 |
| $\bar{D}^*(2007)^0 K^0$ | < 6.6 | $\times 10^{-5}$ | CL=90% | 2227 |
| $\bar{D}^*(2007)^0 K^*(892)^0$ | < 6.9 | $\times 10^{-5}$ | CL=90% | 2157 |

| | | | |
|--|---|--------|------|
| $D^*(2007)^0 K^*(892)^0$ | $< 4.0 \times 10^{-5}$ | CL=90% | 2157 |
| $D^*(2007)^0 \pi^+ \pi^+ \pi^- \pi^-$ | $(2.7 \pm 0.5) \times 10^{-3}$ | | 2219 |
| $D^*(2010)^+ D^*(2010)^-$ | $(8.3 \pm 1.1) \times 10^{-4}$ | | 1711 |
| $\bar{D}^*(2007)^0 \omega$ | $(4.2 \pm 1.1) \times 10^{-4}$ | | 2180 |
| $D^*(2010)^+ D^-$ | $< 6.3 \times 10^{-4}$ | CL=90% | 1790 |
| $D^*(2010)^- D^+ +$ $D^*(2010)^+ D^-$ | $(9.3 \pm 1.5) \times 10^{-4}$ | | 1790 |
| $D^*(2007)^0 \bar{D}^*(2007)^0$ | $< 2.7 \%$ | CL=90% | 1715 |
| $D^- D^0 K^+$ | $(1.7 \pm 0.4) \times 10^{-3}$ | | 1574 |
| $D^- D^*(2007)^0 K^+$ | $(4.6 \pm 1.0) \times 10^{-3}$ | | 1478 |
| $D^*(2010)^- D^0 K^+$ | $(3.1 \pm_{-0.5}^{0.6}) \times 10^{-3}$ | | 1479 |
| $D^*(2010)^- D^*(2007)^0 K^+$ | $(1.18 \pm 0.20) \%$ | | 1366 |
| $D^- D^+ K^0$ | $< 1.7 \times 10^{-3}$ | CL=90% | 1568 |
| $D^*(2010)^- D^+ K^0 +$ $D^- D^*(2010)^+ K^0$ | $(6.5 \pm 1.6) \times 10^{-3}$ | | 1473 |
| $D^*(2010)^- D^*(2010)^+ K^0$ | $(8.8 \pm 1.9) \times 10^{-3}$ | | 1360 |
| $\bar{D}^0 D^0 K^0$ | $< 1.4 \times 10^{-3}$ | CL=90% | 1575 |
| $\bar{D}^0 D^*(2007)^0 K^0 +$ $\bar{D}^*(2007)^0 D^0 K^0$ | $< 3.7 \times 10^{-3}$ | CL=90% | 1478 |
| $\bar{D}^*(2007)^0 D^*(2007)^0 K^0$ | $< 6.6 \times 10^{-3}$ | CL=90% | 1365 |
| $(\bar{D} + \bar{D}^*)(D + D^*)K$ | $(4.3 \pm 0.7) \%$ | | — |

Charmonium modes

| | | | |
|-------------------------------------|----------------------------------|--------|------|
| $\eta_c K^0$ | $(9.9 \pm 1.9) \times 10^{-4}$ | | 1753 |
| $\eta_c K^*(892)^0$ | $(1.6 \pm 0.7) \times 10^{-3}$ | | 1648 |
| $J/\psi(1S) K^0$ | $(8.72 \pm 0.33) \times 10^{-4}$ | | 1683 |
| $J/\psi(1S) K^+ \pi^-$ | $(1.2 \pm 0.6) \times 10^{-3}$ | | 1652 |
| $J/\psi(1S) K^*(892)^0$ | $(1.33 \pm 0.06) \times 10^{-3}$ | | 1571 |
| $J/\psi(1S) \eta K_S^0$ | $(8 \pm 4) \times 10^{-5}$ | | 1508 |
| $J/\psi(1S) \phi K^0$ | $(9.4 \pm 2.6) \times 10^{-5}$ | | 1224 |
| $J/\psi(1S) K(1270)^0$ | $(1.3 \pm 0.5) \times 10^{-3}$ | | 1390 |
| $J/\psi(1S) \pi^0$ | $(2.2 \pm 0.4) \times 10^{-5}$ | | 1728 |
| $J/\psi(1S) \eta$ | $< 2.7 \times 10^{-5}$ | CL=90% | 1672 |
| $J/\psi(1S) \pi^+ \pi^-$ | $(4.6 \pm 0.9) \times 10^{-5}$ | | 1716 |
| $J/\psi(1S) \rho^0$ | $(1.6 \pm 0.7) \times 10^{-5}$ | | 1611 |
| $J/\psi(1S) \omega$ | $< 2.7 \times 10^{-4}$ | CL=90% | 1609 |
| $J/\psi(1S) \phi$ | $< 9.2 \times 10^{-6}$ | CL=90% | 1519 |
| $J/\psi(1S) \eta'(958)$ | $< 6.3 \times 10^{-5}$ | CL=90% | 1546 |
| $J/\psi(1S) K^0 \pi^+ \pi^-$ | $(1.0 \pm 0.4) \times 10^{-3}$ | | 1611 |
| $J/\psi(1S) K^0 \rho^0$ | $(5.4 \pm 3.0) \times 10^{-4}$ | | 1390 |
| $J/\psi(1S) K^*(892)^+ \pi^-$ | $(8 \pm 4) \times 10^{-4}$ | | 1514 |
| $J/\psi(1S) K^*(892)^0 \pi^+ \pi^-$ | $(6.6 \pm 2.2) \times 10^{-4}$ | | 1447 |
| $X(3872)^- K^+$ | $< 5 \times 10^{-4}$ | CL=90% | — |

| | | | | |
|--|-----------------|------------------|--------|------|
| $X(3872)^- K^+ \times$ $B(X(3872)^- \rightarrow$ $J/\psi(1S)\pi^-\pi^0)$ | $[jjj] < 5.4$ | $\times 10^{-6}$ | CL=90% | — |
| $X(3872)K^0 \times B(X \rightarrow$ $J/\psi\pi^+\pi^-)$ | < 1.03 | $\times 10^{-5}$ | CL=90% | 1140 |
| $J/\psi(1S)p\bar{p}$ | < 8.3 | $\times 10^{-7}$ | CL=90% | 862 |
| $J/\psi(1S)\gamma$ | < 1.6 | $\times 10^{-6}$ | CL=90% | 1731 |
| $J/\psi(1S)\bar{D}^0$ | < 1.3 | $\times 10^{-5}$ | CL=90% | 877 |
| $\psi(2S)K^0$ | (6.2 ± 0.6) | $\times 10^{-4}$ | | 1283 |
| $\psi(2S)K^+\pi^-$ | < 1 | $\times 10^{-3}$ | CL=90% | 1238 |
| $\psi(2S)K^*(892)^0$ | (7.2 ± 0.8) | $\times 10^{-4}$ | | 1116 |
| $\chi_{c0}(1P)K^0$ | < 5.0 | $\times 10^{-4}$ | CL=90% | 1477 |
| $\chi_{c0}K^*(892)^0$ | < 7.7 | $\times 10^{-4}$ | CL=90% | — |
| $\chi_{c2}K^0$ | < 2.6 | $\times 10^{-5}$ | CL=90% | — |
| $\chi_{c2}K^*(892)^0$ | < 3.6 | $\times 10^{-5}$ | CL=90% | — |
| $\chi_{c1}(1P)K^0$ | (3.9 ± 0.4) | $\times 10^{-4}$ | | 1411 |
| $\chi_{c1}(1P)K^*(892)^0$ | (3.2 ± 0.6) | $\times 10^{-4}$ | | 1265 |

***K* or *K** modes**

| | | | | |
|--------------------------------|-----------------------|------------------|--------|------|
| $K^+\pi^-$ | (1.82 ± 0.08) | $\times 10^{-5}$ | | 2615 |
| $K^0\pi^0$ | (1.15 ± 0.10) | $\times 10^{-5}$ | | 2614 |
| $\eta'K^0$ | (6.8 ± 0.4) | $\times 10^{-5}$ | | 2528 |
| $\eta'K^*(892)^0$ | < 7.6 | $\times 10^{-6}$ | CL=90% | 2472 |
| $\eta K^*(892)^0$ | (1.77 ± 0.23) | $\times 10^{-5}$ | | 2534 |
| ηK^0 | < 2.0 | $\times 10^{-6}$ | CL=90% | 2587 |
| ωK^0 | (5.5 ± 1.2) | $\times 10^{-6}$ | | 2557 |
| $a_0^0 K^0$ | < 7.8 | $\times 10^{-6}$ | CL=90% | — |
| $a_0^- K^+$ | < 2.1 | $\times 10^{-6}$ | CL=90% | — |
| $K_S^0 X^0$ (Familon) | < 5.3 | $\times 10^{-5}$ | CL=90% | — |
| $\omega K^*(892)^0$ | < 6.0 | $\times 10^{-6}$ | CL=90% | 2503 |
| $K^+ K^-$ | < 3.7 | $\times 10^{-7}$ | CL=90% | 2593 |
| $K^0 \bar{K}^0$ | (1.13 ± 0.38) | $\times 10^{-6}$ | | 2592 |
| $K_S^0 K_S^0 K_S^0$ | (6.2 ± 1.2) | $\times 10^{-6}$ | S=1.3 | 2521 |
| $K^+\pi^-\pi^0$ | (3.7 ± 0.5) | $\times 10^{-5}$ | | 2609 |
| $K^+\rho^-$ | (8.5 ± 2.8) | $\times 10^{-6}$ | S=1.7 | 2559 |
| $(K^+\pi^-\pi^0)$ non-resonant | < 9.4 | $\times 10^{-6}$ | CL=90% | — |
| $K_x^{*0}\pi^0$ | $[III] (6.1 \pm 1.6)$ | $\times 10^{-6}$ | | — |
| $K^0\pi^+\pi^-$ | (4.38 ± 0.29) | $\times 10^{-5}$ | | 2609 |
| $K^0\rho^0$ | < 3.9 | $\times 10^{-5}$ | CL=90% | 2558 |
| $K^0 f_0(980)$ | (5.5 ± 0.9) | $\times 10^{-6}$ | | 2524 |
| $K^*(892)^+\pi^-$ | (1.18 ± 0.15) | $\times 10^{-5}$ | | 2562 |
| $K_x^{*+}\pi^-$ | $[III] (5.1 \pm 1.6)$ | $\times 10^{-6}$ | | — |

| | | | | |
|--------------------------------|--|------------------|--------|------|
| $K^*(892)^0 \pi^0$ | < 3.5 | $\times 10^{-6}$ | CL=90% | 2563 |
| $K_2^*(1430)^+ \pi^-$ | < 1.8 | $\times 10^{-5}$ | CL=90% | 2445 |
| $K^0 K^- \pi^+$ | < 2.1 | $\times 10^{-5}$ | CL=90% | 2578 |
| $K^+ K^- \pi^0$ | < 1.9 | $\times 10^{-5}$ | CL=90% | 2579 |
| $K^0 K^+ K^-$ | $(2.47 \pm 0.23) \times 10^{-5}$ | | | 2522 |
| $K^0 \phi$ | $(8.6 \pm 1.3 \pm 1.1) \times 10^{-6}$ | | | 2516 |
| $K^- \pi^+ \pi^+ \pi^-$ | [mmm] < 2.3 | $\times 10^{-4}$ | CL=90% | 2600 |
| $K^*(892)^0 \pi^+ \pi^-$ | < 1.4 | $\times 10^{-3}$ | CL=90% | 2557 |
| $K^*(892)^0 \rho^0$ | < 3.4 | $\times 10^{-5}$ | CL=90% | 2504 |
| $K^*(892)^0 f_0(980)$ | < 1.7 | $\times 10^{-4}$ | CL=90% | 2468 |
| $K_1(1400)^+ \pi^-$ | < 1.1 | $\times 10^{-3}$ | CL=90% | 2451 |
| $K^- a_1(1260)^+$ | [mmm] < 2.3 | $\times 10^{-4}$ | CL=90% | 2471 |
| $K^*(892)^0 K^+ K^-$ | < 6.1 | $\times 10^{-4}$ | CL=90% | 2466 |
| $K^*(892)^0 \phi$ | $(9.5 \pm 0.9) \times 10^{-6}$ | | | 2460 |
| $\bar{K}^*(892)^0 K^*(892)^0$ | < 2.2 | $\times 10^{-5}$ | CL=90% | 2485 |
| $K^*(892)^0 K^*(892)^0$ | < 3.7 | $\times 10^{-5}$ | CL=90% | 2485 |
| $K^*(892)^+ K^*(892)^-$ | < 1.41 | $\times 10^{-4}$ | CL=90% | 2485 |
| $K_1(1400)^0 \rho^0$ | < 3.0 | $\times 10^{-3}$ | CL=90% | 2388 |
| $K_1(1400)^0 \phi$ | < 5.0 | $\times 10^{-3}$ | CL=90% | 2339 |
| $K_0^*(1430)^0 \phi$ | seen | | | 2336 |
| $K_2^*(1430)^0 \rho^0$ | < 1.1 | $\times 10^{-3}$ | CL=90% | 2381 |
| $K_2^*(1430)^0 \phi$ | seen | | | 2333 |
| $K^*(892)^0 \gamma$ | $(4.01 \pm 0.20) \times 10^{-5}$ | | | 2564 |
| $\eta K^0 \gamma$ | $(8.7 \pm 3.6 \pm 3.1) \times 10^{-6}$ | | | 2587 |
| $K^0 \phi \gamma$ | < 8.3 | $\times 10^{-6}$ | CL=90% | 2516 |
| $K^+ \pi^- \gamma$ | $(4.6 \pm 1.4) \times 10^{-6}$ | | | 2615 |
| $K^*(1410) \gamma$ | < 1.3 | $\times 10^{-4}$ | CL=90% | 2450 |
| $K^+ \pi^- \gamma$ nonresonant | < 2.6 | $\times 10^{-6}$ | CL=90% | 2615 |
| $K^0 \pi^+ \pi^- \gamma$ | $(2.4 \pm 0.5) \times 10^{-5}$ | | | 2609 |
| $K_1(1270)^0 \gamma$ | < 5.8 | $\times 10^{-5}$ | | 2486 |
| $K_1(1400)^0 \gamma$ | < 1.5 | $\times 10^{-5}$ | | 2453 |
| $K_2^*(1430)^0 \gamma$ | $(1.24 \pm 0.24) \times 10^{-5}$ | | | 2447 |
| $K^*(1680)^0 \gamma$ | < 2.0 | $\times 10^{-3}$ | CL=90% | 2360 |
| $K_3^*(1780)^0 \gamma$ | < 8.3 | $\times 10^{-5}$ | CL=90% | 2341 |
| $K_4^*(2045)^0 \gamma$ | < 4.3 | $\times 10^{-3}$ | CL=90% | 2244 |

Light unflavored meson modes

| | | | | |
|-----------------|--------------------------------|------------------|--------|------|
| $\rho^0 \gamma$ | < 4 | $\times 10^{-7}$ | CL=90% | 2583 |
| $\omega \gamma$ | < 8 | $\times 10^{-7}$ | CL=90% | 2582 |
| $\phi \gamma$ | < 8.5 | $\times 10^{-7}$ | CL=90% | 2541 |
| $\pi^+ \pi^-$ | $(4.6 \pm 0.4) \times 10^{-6}$ | | | 2636 |
| $\pi^0 \pi^0$ | $(1.5 \pm 0.5) \times 10^{-6}$ | | S=1.7 | 2636 |
| $\eta \pi^0$ | < 2.5 | $\times 10^{-6}$ | CL=90% | 2610 |

| | | | | |
|---------------------------------------|--------------------------|------------------|--------|------|
| $\eta\eta$ | < 2.0 | $\times 10^{-6}$ | CL=90% | 2582 |
| $\eta'\pi^0$ | < 3.7 | $\times 10^{-6}$ | CL=90% | 2551 |
| $\eta'\eta'$ | < 1.0 | $\times 10^{-5}$ | CL=90% | 2460 |
| $\eta'\eta$ | < 4.6 | $\times 10^{-6}$ | CL=90% | 2522 |
| $\eta'\rho^0$ | < 4.3 | $\times 10^{-6}$ | CL=90% | 2492 |
| $\eta\rho^0$ | < 1.5 | $\times 10^{-6}$ | CL=90% | 2553 |
| $\omega\eta$ | < 1.9 | $\times 10^{-6}$ | CL=90% | 2552 |
| $\omega\eta'$ | < 2.8 | $\times 10^{-6}$ | CL=90% | 2491 |
| $\omega\rho^0$ | < 3.3 | $\times 10^{-6}$ | CL=90% | 2522 |
| $\omega\omega$ | < 1.9 | $\times 10^{-5}$ | CL=90% | 2521 |
| $\phi\pi^0$ | < 1.0 | $\times 10^{-6}$ | CL=90% | 2539 |
| $\phi\eta$ | < 1.0 | $\times 10^{-6}$ | CL=90% | 2511 |
| $\phi\eta'$ | < 4.5 | $\times 10^{-6}$ | CL=90% | 2447 |
| $\phi\rho^0$ | < 1.3 | $\times 10^{-5}$ | CL=90% | 2480 |
| $\phi\omega$ | < 2.1 | $\times 10^{-5}$ | CL=90% | 2479 |
| $\phi\phi$ | < 1.5 | $\times 10^{-6}$ | CL=90% | 2435 |
| $a_0^\mp\pi^\pm$ | < 5.1 | $\times 10^{-6}$ | CL=90% | — |
| $\pi^+\pi^-\pi^0$ | < 7.2 | $\times 10^{-4}$ | CL=90% | 2631 |
| $\rho^0\pi^0$ | (1.8 \pm 0.8) | $\times 10^{-6}$ | S=1.3 | 2581 |
| $\rho^\mp\pi^\pm$ | [gg] (2.28 \pm 0.25) | $\times 10^{-5}$ | | 2581 |
| $\pi^+\pi^-\pi^+\pi^-$ | < 2.3 | $\times 10^{-4}$ | CL=90% | 2621 |
| $\rho^0\rho^0$ | < 1.1 | $\times 10^{-6}$ | CL=90% | 2523 |
| $a_1(1260)^\mp\pi^\pm$ | [gg] < 4.9 | $\times 10^{-4}$ | CL=90% | 2494 |
| $a_2(1320)^\mp\pi^\pm$ | [gg] < 3.0 | $\times 10^{-4}$ | CL=90% | 2473 |
| $\pi^+\pi^-\pi^0\pi^0$ | < 3.1 | $\times 10^{-3}$ | CL=90% | 2622 |
| $\rho^+\rho^-$ | (2.5 \pm 0.4) | $\times 10^{-5}$ | | 2523 |
| $a_1(1260)^0\pi^0$ | < 1.1 | $\times 10^{-3}$ | CL=90% | 2494 |
| $\omega\pi^0$ | < 1.2 | $\times 10^{-6}$ | CL=90% | 2580 |
| $\pi^+\pi^+\pi^-\pi^-\pi^0$ | < 9.0 | $\times 10^{-3}$ | CL=90% | 2609 |
| $a_1(1260)^+\rho^-$ | < 3.4 | $\times 10^{-3}$ | CL=90% | 2433 |
| $a_1(1260)^0\rho^0$ | < 2.4 | $\times 10^{-3}$ | CL=90% | 2433 |
| $\pi^+\pi^+\pi^+\pi^-\pi^-\pi^-$ | < 3.0 | $\times 10^{-3}$ | CL=90% | 2592 |
| $a_1(1260)^+a_1(1260)^-$ | < 2.8 | $\times 10^{-3}$ | CL=90% | 2336 |
| $\pi^+\pi^+\pi^+\pi^-\pi^-\pi^-\pi^0$ | < 1.1 | % | CL=90% | 2572 |

Baryon modes

| | | | | |
|--|-------------------|------------------|--------|------|
| $p\bar{p}$ | < 2.7 | $\times 10^{-7}$ | CL=90% | 2467 |
| $p\bar{p}\pi^+\pi^-$ | < 2.5 | $\times 10^{-4}$ | CL=90% | 2406 |
| $p\bar{p}K^0$ | (2.1 \pm 0.6) | $\times 10^{-6}$ | | 2347 |
| $\Theta(1540)^+\bar{p} \times$ $B(\Theta(1540)^+ \rightarrow pK_S^0)$ | [nnn] < 2.3 | $\times 10^{-7}$ | CL=90% | 2318 |
| $p\bar{p}K^*(892)^0$ | < 7.6 | $\times 10^{-6}$ | CL=90% | 2215 |
| $p\bar{\Lambda}\pi^-$ | (2.6 \pm 0.5) | $\times 10^{-6}$ | | 2401 |
| $p\bar{\Lambda}K^-$ | < 8.2 | $\times 10^{-7}$ | CL=90% | 2308 |

| | | | | | |
|---|---|-----------------|------------------|--------|------|
| $p\bar{\Sigma}^0\pi^-$ | < | 3.8 | $\times 10^{-6}$ | CL=90% | 2383 |
| $\bar{\Lambda}\Lambda$ | < | 6.9 | $\times 10^{-7}$ | CL=90% | 2392 |
| $\Delta^0\bar{\Delta}^0$ | < | 1.5 | $\times 10^{-3}$ | CL=90% | 2335 |
| $\Delta^{++}\bar{\Delta}^{--}$ | < | 1.1 | $\times 10^{-4}$ | CL=90% | 2335 |
| $\bar{D}^0 p\bar{p}$ | (| 1.18 ± 0.22 | $\times 10^{-4}$ | | 1863 |
| $\bar{D}^{*}(2007)^0 p\bar{p}$ | (| 1.2 ± 0.4 | $\times 10^{-4}$ | | 1788 |
| $\bar{\Sigma}_c^{--}\Delta^{++}$ | < | 1.0 | $\times 10^{-3}$ | CL=90% | 1839 |
| $\bar{\Lambda}_c^- p\pi^+\pi^-$ | (| 1.3 ± 0.4 | $\times 10^{-3}$ | | 1934 |
| $\bar{\Lambda}_c^- p$ | (| 2.2 ± 0.8 | $\times 10^{-5}$ | | 2021 |
| $\bar{\Lambda}_c^- p\pi^0$ | < | 5.9 | $\times 10^{-4}$ | CL=90% | 1982 |
| $\bar{\Lambda}_c^- p\pi^+\pi^-\pi^0$ | < | 5.07 | $\times 10^{-3}$ | CL=90% | 1882 |
| $\bar{\Lambda}_c^- p\pi^+\pi^-\pi^+\pi^-$ | < | 2.74 | $\times 10^{-3}$ | CL=90% | 1821 |
| $\bar{\Sigma}_c(2520)^{--}p\pi^+$ | (| 1.6 ± 0.7 | $\times 10^{-4}$ | | 1860 |
| $\bar{\Sigma}_c(2520)^0 p\pi^-$ | < | 1.21 | $\times 10^{-4}$ | CL=90% | 1860 |
| $\bar{\Sigma}_c(2455)^0 p\pi^-$ | (| 10 ± 8 | $\times 10^{-5}$ | S=1.7 | 1895 |
| $\bar{\Sigma}_c(2455)^{--}p\pi^+$ | (| 2.8 ± 0.9 | $\times 10^{-4}$ | | 1895 |
| $\bar{\Lambda}_c(2593)^- / \bar{\Lambda}_c(2625)^- p$ | < | 1.1 | $\times 10^{-4}$ | CL=90% | — |

**Lepton Family number (LF) violating modes, or
 $\Delta B = 1$ weak neutral current (B1) modes**

| | | | | | | |
|---------------------------|----------|---|----------------------------|------------------|--------|------|
| $\gamma\gamma$ | B1 | < | 6.2 | $\times 10^{-7}$ | CL=90% | 2640 |
| e^+e^- | B1 | < | 6.1 | $\times 10^{-8}$ | CL=90% | 2640 |
| $\mu^+\mu^-$ | B1 | < | 3.9 | $\times 10^{-8}$ | CL=90% | 2638 |
| $K^0 e^+e^-$ | B1 | < | 5.4 | $\times 10^{-7}$ | CL=90% | 2616 |
| $K^0 \mu^+\mu^-$ | B1 | (| 2.0 ± 1.3 -1.0 | $\times 10^{-7}$ | S=1.6 | 2612 |
| $K^0 \ell^+\ell^-$ | B1 [ggg] | < | 6.8 | $\times 10^{-7}$ | CL=90% | 2616 |
| $K^*(892)^0 e^+e^-$ | B1 | < | 2.4 | $\times 10^{-6}$ | CL=90% | 2564 |
| $K^*(892)^0 \mu^+\mu^-$ | B1 | (| 1.22 ± 0.38 -0.32 | $\times 10^{-6}$ | | 2560 |
| $K^*(892)^0 \nu\bar{\nu}$ | B1 | < | 1.0 | $\times 10^{-3}$ | CL=90% | 2564 |
| $K^*(892)^0 \ell^+\ell^-$ | B1 [ggg] | (| 1.17 ± 0.30 | $\times 10^{-6}$ | | 2564 |
| $e^\pm\mu^\mp$ | LF [gg] | < | 1.7 | $\times 10^{-7}$ | CL=90% | 2639 |
| $K^0 e^\pm\mu^\mp$ | LF | < | 4.0 | $\times 10^{-6}$ | CL=90% | 2615 |
| $K^*(892)^0 e^\pm\mu^\mp$ | LF | < | 3.4 | $\times 10^{-6}$ | CL=90% | 2563 |
| $e^\pm\tau^\mp$ | LF [gg] | < | 1.1 | $\times 10^{-4}$ | CL=90% | 2341 |
| $\mu^\pm\tau^\mp$ | LF [gg] | < | 3.8 | $\times 10^{-5}$ | CL=90% | 2339 |
| invisible | B1 | < | 2.2 | $\times 10^{-4}$ | CL=90% | — |
| $\nu\bar{\nu}\gamma$ | B1 | < | 4.7 | $\times 10^{-5}$ | CL=90% | 2640 |

B^\pm/B^0 ADMIXTURE **CP violation**

$$A_{CP}(B \rightarrow K^*(892)\gamma) = -0.010 \pm 0.028$$

$$A_{CP}(B \rightarrow s\gamma) = 0.00 \pm 0.04$$

$$A_{CP}(b \rightarrow X_s \ell^+ \ell^-) = -0.22 \pm 0.26$$

The branching fraction measurements are for an admixture of B mesons at the $\Upsilon(4S)$. The values quoted assume that $B(\Upsilon(4S) \rightarrow B\bar{B}) = 100\%$.

For inclusive branching fractions, e.g., $B \rightarrow D^\pm$ anything, the values usually are multiplicities, not branching fractions. They can be greater than one.

\bar{B} modes are charge conjugates of the modes below. Reactions indicate the weak decay vertex and do not include mixing.

| B DECAY MODES | Fraction (Γ_i/Γ) | Scale factor/ Confidence level (MeV/c) | p |
|---|--|---|-----|
| Semileptonic and leptonic modes | | | |
| $B \rightarrow e^+ \nu_e$ anything | [ooo] (10.78 \pm 0.18) % | | — |
| $B \rightarrow \bar{p} e^+ \nu_e$ anything | < 5.9 $\times 10^{-4}$ | CL=90% | — |
| $B \rightarrow \mu^+ \nu_\mu$ anything | [ooo] (10.78 \pm 0.18) % | | — |
| $B \rightarrow \ell^+ \nu_\ell$ anything | [ggg,ooo] (10.78 \pm 0.18) % | | — |
| $B \rightarrow D^- \ell^+ \nu_\ell$ anything | [ggg] (2.8 \pm 0.9) % | | — |
| $B \rightarrow \bar{D}^0 \ell^+ \nu_\ell$ anything | [ggg] (7.2 \pm 1.5) % | | — |
| $B \rightarrow D^{*-} \ell^+ \nu_\ell$ anything | [ppp] (6.7 \pm 1.3) $\times 10^{-3}$ | | — |
| $B \rightarrow \bar{D}^{**} \ell^+ \nu_\ell$ | [ggg,qqq] (2.7 \pm 0.7) % | | — |
| $B \rightarrow \bar{D}_1(2420) \ell^+ \nu_\ell$ anything | (3.8 \pm 1.3) $\times 10^{-3}$ | S=2.4 | — |
| $B \rightarrow D \pi \ell^+ \nu_\ell$ anything + $D^* \pi \ell^+ \nu_\ell$ anything | (2.6 \pm 0.5) % | S=1.5 | — |
| $B \rightarrow D \pi \ell^+ \nu_\ell$ anything | (1.5 \pm 0.6) % | | — |
| $B \rightarrow D^* \pi \ell^+ \nu_\ell$ anything | (1.9 \pm 0.4) % | | — |
| $B \rightarrow \bar{D}_2^*(2460) \ell^+ \nu_\ell$ anything | (4.4 \pm 1.6) $\times 10^{-3}$ | | — |
| $B \rightarrow D^{*-} \pi^+ \ell^+ \nu_\ell$ anything | (1.00 \pm 0.34) % | | — |
| $B \rightarrow D_s^- \ell^+ \nu_\ell$ anything | [ggg] < 7 $\times 10^{-3}$ | CL=90% | — |
| $B \rightarrow D_s^- \ell^+ \nu_\ell K^+$ anything | [ggg] < 5 $\times 10^{-3}$ | CL=90% | — |

| | | | | |
|--|------------------------------------|------------------|--------|------|
| $B \rightarrow D_s^- \ell^+ \nu_\ell K^0$ any-thing | $[ggg] < 7$ | $\times 10^{-3}$ | CL=90% | — |
| $B \rightarrow \ell^+ \nu_\ell$ charm | $(10.61 \pm 0.17) \%$ | | | — |
| $B \rightarrow X_u \ell^+ \nu_\ell$ | $(2.33 \pm 0.22) \times 10^{-3}$ | | | — |
| $B \rightarrow K^+ \ell^+ \nu_\ell$ anything | $[ggg] (6.2 \pm 0.6) \%$ | | | — |
| $B \rightarrow K^- \ell^+ \nu_\ell$ anything | $[ggg] (10 \pm 4) \times 10^{-3}$ | | | — |
| $B \rightarrow K^0 / \bar{K}^0 \ell^+ \nu_\ell$ any-thing | $[ggg] (4.6 \pm 0.5) \%$ | | | — |
| $D, D^*,$ or D_s modes | | | | |
| $B \rightarrow D^\pm$ anything | $(22.8 \pm 1.4) \%$ | | | — |
| $B \rightarrow D^0 / \bar{D}^0$ anything | $(64.0 \pm 3.0) \%$ | | S=1.2 | — |
| $B \rightarrow D^*(2010)^\pm$ anything | $(22.5 \pm 1.5) \%$ | | | — |
| $B \rightarrow D^*(2007)^0$ anything | $(26.0 \pm 2.7) \%$ | | | — |
| $B \rightarrow D_s^\pm$ anything | $[gg] (8.6 \pm 1.2) \%$ | | | — |
| $B \rightarrow D_s^{*\pm}$ anything | $(6.5 \pm 1.2) \%$ | | | — |
| $B \rightarrow D_s^{*\pm} \bar{D}^*(*)$ | $(3.4 \pm 0.7) \%$ | | | — |
| $B \rightarrow D^{(*)} \bar{D}^{(*)} K^0 + D^{(*)} \bar{D}^{(*)} K^\pm$ | $[gg,rrr] (7.1 \pm 2.7 / -1.7) \%$ | | | — |
| $b \rightarrow c \bar{c} s$ | $(22 \pm 4) \%$ | | | — |
| $B \rightarrow D_s^{(*)} \bar{D}^{(*)}$ | $[gg,rrr] (4.0 \pm 0.6) \%$ | | | — |
| $B \rightarrow D^* D^*(2010)^\pm$ | $[gg] < 5.9$ | $\times 10^{-3}$ | CL=90% | 1711 |
| $B \rightarrow D D^*(2010)^\pm + D^* D^\pm$ | $[gg] < 5.5$ | $\times 10^{-3}$ | CL=90% | — |
| $B \rightarrow D D^\pm$ | $[gg] < 3.1$ | $\times 10^{-3}$ | CL=90% | 1866 |
| $B \rightarrow D_s^{(*)\pm} \bar{D}^{(*)} X(n\pi^\pm)$ | $[gg,rrr] (9 \pm 5 / -4) \%$ | | | — |
| $B \rightarrow D^*(2010)\gamma$ | < 1.1 | $\times 10^{-3}$ | CL=90% | 2257 |
| $B \rightarrow D_s^+ \pi^-, D_s^{*+} \pi^-, D_s^+ \rho^-, D_s^{*+} \rho^-, D_s^+ \pi^0, D_s^{*+} \pi^0, D_s^+ \eta, D_s^{*+} \eta, D_s^+ \rho^0, D_s^{*+} \rho^0, D_s^+ \omega, D_s^{*+} \omega$ | $[gg] < 4$ | $\times 10^{-4}$ | CL=90% | — |
| $B \rightarrow D_{s1}(2536)^+ \text{ anything}$ | < 9.5 | $\times 10^{-3}$ | CL=90% | — |
| Charmonium modes | | | | |
| $B \rightarrow J/\psi(1S) \text{ anything}$ | $(1.094 \pm 0.032) \%$ | | S=1.1 | — |
| $B \rightarrow J/\psi(1S) \text{ (direct) anything}$ | $(7.8 \pm 0.4) \times 10^{-3}$ | | S=1.1 | — |
| $B \rightarrow \psi(2S) \text{ anything}$ | $(3.07 \pm 0.21) \times 10^{-3}$ | | | — |
| $B \rightarrow \chi_{c1}(1P) \text{ anything}$ | $(3.86 \pm 0.27) \times 10^{-3}$ | | | — |
| $B \rightarrow \chi_{c1}(1P) \text{ (direct) anything}$ | $(3.18 \pm 0.25) \times 10^{-3}$ | | | — |

| | | | |
|--|--------------------------------------|--------|------|
| $B \rightarrow \chi_{c2}(1P)\text{anything}$ | $(1.3 \pm 0.4) \times 10^{-3}$ | S=1.9 | — |
| $B \rightarrow \chi_{c2}(1P)(\text{direct})\text{anything}$ | $(1.65 \pm 0.31) \times 10^{-3}$ | | — |
| $B \rightarrow \eta_c(1S)\text{anything}$ | $< 9 \times 10^{-3}$ | CL=90% | — |
| $B \rightarrow K Y(3940) \times$ $B(Y(3940) \rightarrow \omega J/\psi)$ | [sss] $(7.1 \pm 3.4) \times 10^{-5}$ | | 1083 |

K or K* modes

| | | | |
|--|----------------------------------|--------|------|
| $B \rightarrow K^\pm \text{anything}$ | [gg] $(78.9 \pm 2.5) \%$ | | — |
| $B \rightarrow K^+ \text{anything}$ | $(66 \pm 5) \%$ | | — |
| $B \rightarrow K^- \text{anything}$ | $(13 \pm 4) \%$ | | — |
| $B \rightarrow K^0/\bar{K}^0 \text{anything}$ | [gg] $(64 \pm 4) \%$ | | — |
| $B \rightarrow K^*(892)^\pm \text{anything}$ | $(18 \pm 6) \%$ | | — |
| $B \rightarrow$ $K^*(892)^0/\bar{K}^*(892)^0 \text{anything}$ | [gg] $(14.6 \pm 2.6) \%$ | | — |
| $B \rightarrow K^*(892)\gamma$ | $(4.2 \pm 0.6) \times 10^{-5}$ | | 2564 |
| $B \rightarrow \eta K \gamma$ | $(8.5 \pm 1.8) \times 10^{-6}$ | | 2588 |
| $B \rightarrow K_1(1400)\gamma$ | $< 1.27 \times 10^{-4}$ | CL=90% | 2453 |
| $B \rightarrow K_2^*(1430)\gamma$ | $(1.7 \pm 0.6) \times 10^{-5}$ | | 2447 |
| $B \rightarrow K_2(1770)\gamma$ | $< 1.2 \times 10^{-3}$ | CL=90% | 2342 |
| $B \rightarrow K_3^*(1780)\gamma$ | $< 3.7 \times 10^{-5}$ | CL=90% | 2341 |
| $B \rightarrow K_4^*(2045)\gamma$ | $< 1.0 \times 10^{-3}$ | CL=90% | 2244 |
| $B \rightarrow K \eta'(958)$ | $(8.3 \pm 1.1) \times 10^{-5}$ | | 2528 |
| $B \rightarrow K^*(892)\eta'(958)$ | $< 2.2 \times 10^{-5}$ | CL=90% | 2472 |
| $B \rightarrow K \eta$ | $< 5.2 \times 10^{-6}$ | CL=90% | 2588 |
| $B \rightarrow K^*(892)\eta$ | $(1.8 \pm 0.5) \times 10^{-5}$ | | 2534 |
| $B \rightarrow K \phi \phi$ | $(2.3 \pm 0.9) \times 10^{-6}$ | | 2306 |
| $B \rightarrow \bar{b} \rightarrow \bar{s} \gamma$ | $(3.43 \pm 0.29) \times 10^{-4}$ | | — |
| $B \rightarrow \bar{b} \rightarrow \bar{s} \text{gluon}$ | $< 6.8 \%$ | CL=90% | — |
| $B \rightarrow \eta \text{anything}$ | $< 4.4 \times 10^{-4}$ | CL=90% | — |
| $B \rightarrow \eta' \text{anything}$ | $(4.2 \pm 0.9) \times 10^{-4}$ | | — |

Light unflavored meson modes

| | | | |
|---|---------------------------|--------|------|
| $B \rightarrow \rho \gamma$ | $< 1.9 \times 10^{-6}$ | CL=90% | 2583 |
| $B \rightarrow \rho/\omega \gamma$ | $< 1.2 \times 10^{-6}$ | CL=90% | — |
| $B \rightarrow \pi^\pm \text{anything}$ | [gg,ttt] $(358 \pm 7) \%$ | | — |
| $B \rightarrow \pi^0 \text{anything}$ | $(235 \pm 11) \%$ | | — |
| $B \rightarrow \eta \text{anything}$ | $(17.6 \pm 1.6) \%$ | | — |
| $B \rightarrow \rho^0 \text{anything}$ | $(21 \pm 5) \%$ | | — |
| $B \rightarrow \omega \text{anything}$ | $< 81 \%$ | CL=90% | — |
| $B \rightarrow \phi \text{anything}$ | $(3.42 \pm 0.13) \%$ | | — |
| $B \rightarrow \phi K^*(892)$ | $< 2.2 \times 10^{-5}$ | CL=90% | 2460 |

Baryon modes

| | | | |
|--|--|--------|------|
| $B \rightarrow \Lambda_c^+ / \bar{\Lambda}_c^-$ anything | (6.4 \pm 1.1) % | | — |
| $B \rightarrow \bar{\Lambda}_c^- e^+$ anything | < 3.2 $\times 10^{-3}$ | CL=90% | — |
| $B \rightarrow \bar{\Lambda}_c^- p$ anything | (3.6 \pm 0.7) % | | — |
| $B \rightarrow \bar{\Lambda}_c^- p e^+ \nu_e$ | < 1.5 $\times 10^{-3}$ | CL=90% | 2021 |
| $B \rightarrow \bar{\Sigma}_c^{--}$ anything | (4.2 \pm 2.4) $\times 10^{-3}$ | | — |
| $B \rightarrow \bar{\Sigma}_c^-$ anything | < 9.6 $\times 10^{-3}$ | CL=90% | — |
| $B \rightarrow \bar{\Sigma}_c^0$ anything | (4.6 \pm 2.4) $\times 10^{-3}$ | | — |
| $B \rightarrow \bar{\Sigma}_c^0 N (N = p \text{ or } n)$ | < 1.5 $\times 10^{-3}$ | CL=90% | 1938 |
| $B \rightarrow \Xi_c^0$ anything | (1.93 \pm 0.30) $\times 10^{-4}$ | S=1.1 | — |
| $\times B(\Xi_c^0 \rightarrow \Xi^- \pi^+)$ | | | |
| $B \rightarrow \Xi_c^+$ anything | (4.5 \pm 1.3 \pm 1.2) $\times 10^{-4}$ | | — |
| $\times B(\Xi_c^+ \rightarrow \Xi^- \pi^+ \pi^+)$ | | | |
| $B \rightarrow p / \bar{p}$ anything | [gg] (8.0 \pm 0.4) % | | — |
| $B \rightarrow p / \bar{p}$ (direct) anything | [gg] (5.5 \pm 0.5) % | | — |
| $B \rightarrow \Lambda / \bar{\Lambda}$ anything | [gg] (4.0 \pm 0.5) % | | — |
| $B \rightarrow \Xi^- / \Xi^+$ anything | [gg] (2.7 \pm 0.6) $\times 10^{-3}$ | | — |
| $B \rightarrow$ baryons anything | (6.8 \pm 0.6) % | | — |
| $B \rightarrow p \bar{p}$ anything | (2.47 \pm 0.23) % | | — |
| $B \rightarrow \Lambda \bar{p} / \bar{\Lambda} p$ anything | [gg] (2.5 \pm 0.4) % | | — |
| $B \rightarrow \Lambda \bar{\Lambda}$ anything | < 5 $\times 10^{-3}$ | CL=90% | — |

**Lepton Family number (LF) violating modes or
 $\Delta B = 1$ weak neutral current (B1) modes**

| | | | | |
|--|----------|---|--------|------|
| $B \rightarrow s e^+ e^-$ | B1 | (4.7 \pm 1.3) $\times 10^{-6}$ | | — |
| $B \rightarrow s \mu^+ \mu^-$ | B1 | (4.3 \pm 1.2) $\times 10^{-6}$ | | — |
| $B \rightarrow s \ell^+ \ell^-$ | B1 [ggg] | (4.5 \pm 1.0) $\times 10^{-6}$ | | — |
| $B \rightarrow K e^+ e^-$ | B1 | (6.0 \pm 1.4 \pm 1.2) $\times 10^{-7}$ | S=1.1 | 2617 |
| $B \rightarrow K^*(892) e^+ e^-$ | B1 | (1.24 \pm 0.37 \pm 0.32) $\times 10^{-6}$ | | 2564 |
| $B \rightarrow K \mu^+ \mu^-$ | B1 | (4.7 \pm 1.1 \pm 1.0) $\times 10^{-7}$ | | 2612 |
| $B \rightarrow K^*(892) \mu^+ \mu^-$ | B1 | (1.19 \pm 0.34 \pm 0.29) $\times 10^{-6}$ | | 2560 |
| $B \rightarrow K \ell^+ \ell^-$ | B1 | (5.4 \pm 0.8) $\times 10^{-7}$ | | 2617 |
| $B \rightarrow K^*(892) \ell^+ \ell^-$ | B1 | (1.05 \pm 0.20) $\times 10^{-6}$ | | 2564 |
| $B \rightarrow e^\pm \mu^\mp s$ | LF [gg] | < 2.2 $\times 10^{-5}$ | CL=90% | — |
| $B \rightarrow \pi e^\pm \mu^\mp$ | LF | < 1.6 $\times 10^{-6}$ | CL=90% | 2637 |
| $B \rightarrow \rho e^\pm \mu^\mp$ | LF | < 3.2 $\times 10^{-6}$ | CL=90% | 2582 |
| $B \rightarrow K e^\pm \mu^\mp$ | LF | < 1.6 $\times 10^{-6}$ | CL=90% | 2616 |
| $B \rightarrow K^*(892) e^\pm \mu^\mp$ | LF | < 6.2 $\times 10^{-6}$ | CL=90% | 2563 |

$B^\pm/B^0/B_s^0/b$ -baryon ADMIXTURE

These measurements are for an admixture of bottom particles at high energy (LEP, Tevatron, $Sp\bar{p}S$).

$$\text{Mean life } \tau = (1.568 \pm 0.009) \times 10^{-12} \text{ s}$$

$$\text{Mean life } \tau = (1.72 \pm 0.10) \times 10^{-12} \text{ s} \quad \text{Charged } b\text{-hadron admixture}$$

$$\text{Mean life } \tau = (1.58 \pm 0.14) \times 10^{-12} \text{ s} \quad \text{Neutral } b\text{-hadron admixture}$$

$$\tau_{\text{charged } b\text{-hadron}}/\tau_{\text{neutral } b\text{-hadron}} = 1.09 \pm 0.13$$

$$|\Delta\tau_b|/\tau_{b,\bar{b}} = -0.001 \pm 0.014$$

The branching fraction measurements are for an admixture of B mesons and baryons at energies above the $\Upsilon(4S)$. Only the highest energy results (LEP, Tevatron, $Sp\bar{p}S$) are used in the branching fraction averages. In the following, we assume that the production fractions are the same at the LEP and at the Tevatron.

For inclusive branching fractions, *e.g.*, $B \rightarrow D^\pm \text{ anything}$, the values usually are multiplicities, not branching fractions. They can be greater than one.

The modes below are listed for a \bar{b} initial state. b modes are their charge conjugates. Reactions indicate the weak decay vertex and do not include mixing.

| \bar{b} DECAY MODES | Fraction (Γ_i/Γ) | Scale factor/ Confidence level | p (MeV/c) |
|-----------------------|--------------------------------|-----------------------------------|----------------|
|-----------------------|--------------------------------|-----------------------------------|----------------|

PRODUCTION FRACTIONS

The production fractions for weakly decaying b -hadrons at high energy have been calculated from the best values of mean lives, mixing parameters, and branching fractions in this edition by the Heavy Flavor Averaging Group (HFAG) as described in the note “ B^0 - \bar{B}^0 Mixing” in the B^0 Particle Listings. Values assume

$$B(\bar{b} \rightarrow B^+) = B(\bar{b} \rightarrow B^0)$$

$$B(\bar{b} \rightarrow B^+) + B(\bar{b} \rightarrow B^0) + B(\bar{b} \rightarrow B_s^0) + B(b \rightarrow b\text{-baryon}) = 100 \text{ \%}.$$

The notation for production fractions varies in the literature (f_d , d_{B^0} , $f(b \rightarrow \bar{B}^0)$, $\text{Br}(b \rightarrow \bar{B}^0)$). We use our own branching fraction notation here, $B(\bar{b} \rightarrow B^0)$.

| | | |
|-------------|----------------------|---|
| B^+ | (39.8 \pm 1.2) % | — |
| B^0 | (39.8 \pm 1.2) % | — |
| B_s^0 | (10.3 \pm 1.4) % | — |
| b -baryon | (10.0 \pm 2.0) % | — |
| B_c | — | — |

DECAY MODES

Semileptonic and leptonic modes

| | | | |
|---|-----------|---|---------|
| ν anything | | (23.1 \pm 1.5) % | — |
| $\ell^+ \nu_\ell$ anything | [ggg] | (10.69 \pm 0.22) % | — |
| $e^+ \nu_e$ anything | | (10.86 \pm 0.35) % | — |
| $\mu^+ \nu_\mu$ anything | | (10.95 $^{+0.29}_{-0.25}$) % | — |
| $D^- \ell^+ \nu_\ell$ anything | [ggg] | (2.2 \pm 0.4) % | S=1.9 — |
| $D^- \pi^+ \ell^+ \nu_\ell$ anything | | (4.9 \pm 1.9) $\times 10^{-3}$ | — |
| $D^- \pi^- \ell^+ \nu_\ell$ anything | | (2.6 \pm 1.6) $\times 10^{-3}$ | — |
| $\bar{D}^0 \ell^+ \nu_\ell$ anything | [ggg] | (6.90 \pm 0.35) % | — |
| $\bar{D}^0 \pi^- \ell^+ \nu_\ell$ anything | | (1.07 \pm 0.27) % | — |
| $\bar{D}^0 \pi^+ \ell^+ \nu_\ell$ anything | | (2.3 \pm 1.6) $\times 10^{-3}$ | — |
| $D^{*-} \ell^+ \nu_\ell$ anything | [ggg] | (2.75 \pm 0.19) % | — |
| $D^{*-} \pi^+ \ell^+ \nu_\ell$ anything | | (4.8 \pm 1.0) $\times 10^{-3}$ | — |
| $D^{*-} \pi^- \ell^+ \nu_\ell$ anything | | (6 \pm 7) $\times 10^{-4}$ | — |
| $\bar{D}_j^0 \ell^+ \nu_\ell$ anything \times B($\bar{D}_j^0 \rightarrow D^{*+} \pi^-$) | [ggg,uuu] | (2.6 \pm 0.9) $\times 10^{-3}$ | — |
| $D_j^- \ell^+ \nu_\ell$ anything \times B($D_j^- \rightarrow D^0 \pi^-$) | [ggg,uuu] | (7.0 \pm 1.9) $\times 10^{-3}$ | — |
| $\bar{D}_2^*(2460)^0 \ell^+ \nu_\ell$ anything \times B($\bar{D}_2^*(2460)^0 \rightarrow$ $D^{*-} \pi^+$) | | < 1.4 $\times 10^{-3}$ CL=90% | — |
| $D_2^*(2460)^- \ell^+ \nu_\ell$ anything \times B($D_2^*(2460)^- \rightarrow$ $D^0 \pi^-$) | | (4.2 $^{+1.5}_{-1.8}$) $\times 10^{-3}$ | — |
| $\bar{D}_2^*(2460)^0 \ell^+ \nu_\ell$ anything \times B($\bar{D}_2^*(2460)^0 \rightarrow$ $D^- \pi^+$) | | (160 \pm 80) % | — |
| charmless $\ell \bar{\nu}_\ell$ | [ggg] | (1.7 \pm 0.5) $\times 10^{-3}$ | — |
| $\tau^+ \nu_\tau$ anything | | (2.48 \pm 0.26) % | — |
| $D^{*-} \tau \nu_\tau$ anything | | (9 \pm 4) $\times 10^{-3}$ | — |
| $\bar{c} \rightarrow \ell^- \bar{\nu}_\ell$ anything | [ggg] | (8.02 \pm 0.19) % | — |
| $c \rightarrow \ell^+ \nu$ anything | | (1.6 $^{+0.4}_{-0.5}$) % | — |

Charmed meson and baryon modes

| | | | |
|--------------------------|------|----------------------------|---|
| \bar{D}^0 anything | | (61.0 \pm 3.1) % | — |
| $D^0 D_s^\pm$ anything | [gg] | (9.1 $^{+3.9}_{-2.8}$) % | — |
| $D^\mp D_s^\pm$ anything | [gg] | (4.0 $^{+2.3}_{-1.8}$) % | — |
| $\bar{D}^0 D^0$ anything | [gg] | (5.1 $^{+2.0}_{-1.8}$) % | — |

| | | |
|--|--------------------------------------|---|
| $D^0 D^\pm$ anything | $[gg]$ (2.7 \pm 1.8 \pm 1.6) % | — |
| $D^\pm D^\mp$ anything | $[gg] < 9 \times 10^{-3}$ CL=90% | — |
| D^- anything | (22.4 \pm 1.8) % | — |
| $D^*(2010)^+$ anything | (17.3 \pm 2.0) % | — |
| $D_1(2420)^0$ anything | (5.0 \pm 1.5) % | — |
| $D^*(2010)^\mp D_s^\pm$ anything | $[gg]$ (3.3 \pm 1.6 \pm 1.3) % | — |
| $D^0 D^*(2010)^\pm$ anything | $[gg]$ (3.0 \pm 1.1 \pm 0.9) % | — |
| $D^*(2010)^\pm D^\mp$ anything | $[gg]$ (2.5 \pm 1.2 \pm 1.0) % | — |
| $D^*(2010)^\pm D^*(2010)^\mp$ anything | $[gg]$ (1.2 \pm 0.4) % | — |
| $\bar{D} D$ anything | (10 \pm 11 \pm 10) % | — |
| $D_2^*(2460)^0$ anything | (4.7 \pm 2.7) % | — |
| D_s^- anything | (15.0 \pm 2.6) % | — |
| D_s^+ anything | (10.1 \pm 3.1) % | — |
| Λ_c^+ anything | (9.7 \pm 2.9) % | — |
| \bar{c}/c anything | $[ttt]$ (116.2 \pm 3.2) % | — |

Charmonium modes

| | | |
|--------------------------|------------------------------------|---|
| $J/\psi(1S)$ anything | (1.16 \pm 0.10) % | — |
| $\psi(2S)$ anything | (4.8 \pm 2.4) $\times 10^{-3}$ | — |
| $\chi_{c1}(1P)$ anything | (1.4 \pm 0.4) % | — |

K or K* modes

| | | |
|-----------------------|------------------------------------|---|
| $\bar{S}\gamma$ | (3.1 \pm 1.1) $\times 10^{-4}$ | — |
| $\bar{S}\bar{\nu}\nu$ | $< 6.4 \times 10^{-4}$ CL=90% | — |
| K^\pm anything | (74 \pm 6) % | — |
| K_S^0 anything | (29.0 \pm 2.9) % | — |

Pion modes

| | | |
|--------------------|---------------------------|---|
| π^\pm anything | (397 \pm 21) % | — |
| π^0 anything | $[ttt]$ (278 \pm 60) % | — |
| ϕ anything | (2.82 \pm 0.23) % | — |

Baryon modes

| | | |
|----------------------|----------------------|---|
| p/\bar{p} anything | (13.1 \pm 1.1) % | — |
|----------------------|----------------------|---|

Other modes

| | | |
|---|--|---|
| charged anything | $[ttt]$ (497 \pm 7) % | — |
| hadron ⁺ hadron ⁻ | (1.7 \pm 1.0 \pm 0.7) $\times 10^{-5}$ | — |
| charmless | (7 \pm 21) $\times 10^{-3}$ | — |

Baryon modes

| | | |
|----------------------------------|----------------------|---|
| $\Lambda/\bar{\Lambda}$ anything | (5.9 \pm 0.6) % | — |
| b -baryon anything | (10.2 \pm 2.8) % | — |

$\Delta B = 1$ weak neutral current ($B1$) modes

$\mu^+ \mu^-$ anything $B1$ $< 3.2 \times 10^{-4}$ CL=90% —

 B^*

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

I, J, P need confirmation. Quantum numbers shown are quark-model predictions.

$$\text{Mass } m_{B^*} = 5325.0 \pm 0.6 \text{ MeV}$$

$$m_{B^*} - m_B = 45.78 \pm 0.35 \text{ MeV}$$

 B^* DECAY MODESFraction (Γ_i/Γ) p (MeV/c) $B\gamma$

dominant

45

BOTTOM, STRANGE MESONS

$(B = \pm 1, S = \mp 1)$

$$B_s^0 = s\bar{b}, \bar{B}_s^0 = \bar{s}b, \quad \text{similarly for } B_s^{*-} \text{'s}$$

 B_s^0

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

I, J, P need confirmation. Quantum numbers shown are quark-model predictions.

$$\text{Mass } m_{B_s^0} = 5367.5 \pm 1.8 \text{ MeV} \quad (S = 1.1)$$

$$\text{Mean life } \tau = (1.466 \pm 0.059) \times 10^{-12} \text{ s}$$

$$c\tau = 439 \text{ } \mu\text{m}$$

 B_s^0 - \bar{B}_s^0 mixing parameters

$$\Delta m_{B_s^0} = m_{B_{sH}^0} - m_{B_{sL}^0} > 14.4 \times 10^{12} \hbar \text{ s}^{-1}, \text{ CL} = 95\%$$

$$> 94.8 \times 10^{-10} \text{ MeV}, \text{ CL} = 95\%$$

$$x_s = \Delta m_{B_s^0} / \Gamma_{B_s^0} > 19.9, \text{ CL} = 95\%$$

$$\chi_s > 0.49878, \text{ CL} = 95\%$$

These branching fractions all scale with $B(\bar{b} \rightarrow B_s^0)$, the LEP B_s^0 production fraction. The first four were evaluated using $B(\bar{b} \rightarrow B_s^0) = (10.7 \pm 1.4)\%$ and the rest assume $B(\bar{b} \rightarrow B_s^0) = 12\%$.

The branching fraction $B(B_s^0 \rightarrow D_s^- \ell^+ \nu_\ell \text{ anything})$ is not a pure measurement since the measured product branching fraction $B(\bar{b} \rightarrow B_s^0) \times B(B_s^0 \rightarrow D_s^- \ell^+ \nu_\ell \text{ anything})$ was used to determine $B(\bar{b} \rightarrow B_s^0)$, as described in the note on “ $B^0 - \bar{B}^0$ Mixing”

For inclusive branching fractions, e.g., $B \rightarrow D^\pm \text{ anything}$, the values usually are multiplicities, not branching fractions. They can be greater than one.

| B_s^0 DECAY MODES | Fraction (Γ_i/Γ) | | Confidence level | p (MeV/c) | |
|------------------------------------|--------------------------------|------------------------------|------------------|----------------|------|
| D_s^- anything | (94 | ± 30) % | | — | |
| $D_s^- \ell^+ \nu_\ell$ anything | [vvv] | (7.9 \pm 2.4) % | | — | |
| $D_s^- \pi^+$ | < 13 | % | | 2321 | |
| $D_s^{(*)+} D_s^{(*)-}$ | (23 | $^{+21}_{-13}$) % | | — | |
| $J/\psi(1S)\phi$ | (9.3 | ± 3.3) $\times 10^{-4}$ | | 1588 | |
| $J/\psi(1S)\pi^0$ | < 1.2 | $\times 10^{-3}$ | 90% | 1787 | |
| $J/\psi(1S)\eta$ | < 3.8 | $\times 10^{-3}$ | 90% | 1734 | |
| $\psi(2S)\phi$ | seen | | | 1121 | |
| $\pi^+ \pi^-$ | < 1.7 | $\times 10^{-4}$ | 90% | 2680 | |
| $\pi^0 \pi^0$ | < 2.1 | $\times 10^{-4}$ | 90% | 2680 | |
| $\eta \pi^0$ | < 1.0 | $\times 10^{-3}$ | 90% | 2654 | |
| $\eta \eta$ | < 1.5 | $\times 10^{-3}$ | 90% | 2627 | |
| $\rho^0 \rho^0$ | < 3.20 | $\times 10^{-4}$ | 90% | 2569 | |
| $\phi \rho^0$ | < 6.17 | $\times 10^{-4}$ | 90% | 2527 | |
| $\phi \phi$ | (1.4 \pm 0.8) | $\times 10^{-5}$ | | 2483 | |
| $\pi^+ K^-$ | < 2.1 | $\times 10^{-4}$ | 90% | 2659 | |
| $K^+ K^-$ | < 5.9 | $\times 10^{-5}$ | 90% | 2638 | |
| $\overline{K}^*(892)^0 \rho^0$ | < 7.67 | $\times 10^{-4}$ | 90% | 2550 | |
| $\overline{K}^*(892)^0 K^*(892)^0$ | < 1.681 | $\times 10^{-3}$ | 90% | 2531 | |
| $\phi K^*(892)^0$ | < 1.013 | $\times 10^{-3}$ | 90% | 2507 | |
| $p \bar{p}$ | < 5.9 | $\times 10^{-5}$ | 90% | 2514 | |
| $\gamma \gamma$ | $B1$ | < 1.48 | $\times 10^{-4}$ | 90% | 2684 |
| $\phi \gamma$ | < 1.2 | $\times 10^{-4}$ | 90% | 2587 | |

**Lepton Family number (LF) violating modes or
 $\Delta B = 1$ weak neutral current (B1) modes**

| | | | | | |
|---------------|----|-------|------------------|-----|------|
| $\mu^+ \mu^-$ | B1 | < 1.5 | $\times 10^{-7}$ | 90% | 2682 |
| $e^+ e^-$ | B1 | < 5.4 | $\times 10^{-5}$ | 90% | 2684 |

| | | | | | |
|--------------------------|------|--------------|------------------|-----|------|
| $e^\pm \mu^\mp$ | LF | $[gg] < 6.1$ | $\times 10^{-6}$ | 90% | 2683 |
| $\phi(1020) \mu^+ \mu^-$ | $B1$ | < 4.7 | $\times 10^{-5}$ | 90% | 2582 |
| $\phi \nu \bar{\nu}$ | $B1$ | < 5.4 | $\times 10^{-3}$ | 90% | 2587 |

BOTTOM, CHARMED MESONS ($B = C = \pm 1$)

$$B_c^+ = c\bar{b}, B_c^- = \bar{c}b, \quad \text{similarly for } B_c^{*'}\text{'s}$$

B_c^\pm

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

I, J, P need confirmation.

Quantum numbers shown are quark-model predictions.

$$\text{Mass } m = 6.286 \pm 0.005 \text{ GeV}$$

$$\text{Mean life } \tau = (0.46_{-0.16}^{+0.18}) \times 10^{-12} \text{ s}$$

B_c^- modes are charge conjugates of the modes below.

| B_c^+ DECAY MODES $\times B(\bar{b} \rightarrow B_c)$ | Fraction (Γ_i/Γ) | Confidence level | P (MeV/c) |
|---|--------------------------------|------------------|----------------|
|---|--------------------------------|------------------|----------------|

The following quantities are not pure branching ratios; rather the fraction $\Gamma_i/\Gamma \times B(\bar{b} \rightarrow B_c)$.

| | | | |
|---|--------------------------------------|-----|------|
| $J/\psi(1S) \ell^+ \nu_\ell \text{ anything}$ | $(5.2_{-2.1}^{+2.4}) \times 10^{-5}$ | — | |
| $J/\psi(1S) \pi^+$ | $< 8.2 \times 10^{-5}$ | 90% | 2377 |
| $J/\psi(1S) \pi^+ \pi^+ \pi^-$ | $< 5.7 \times 10^{-4}$ | 90% | 2357 |
| $J/\psi(1S) a_1(1260)$ | $< 1.2 \times 10^{-3}$ | 90% | 2177 |
| $D^*(2010)^+ \bar{D}^0$ | $< 6.2 \times 10^{-3}$ | 90% | 2474 |

$c\bar{c}$ MESONS

$\eta_c(1S)$

$$I^G(J^{PC}) = 0^+(0^-+)$$

$$\text{Mass } m = 2980.4 \pm 1.2 \text{ MeV} \quad (S = 1.5)$$

$$\text{Full width } \Gamma = 25.5 \pm 3.4 \text{ MeV} \quad (S = 2.0)$$

| $\eta_c(1S)$ DECAY MODES | Fraction (Γ_i/Γ) | Confidence level | P (MeV/c) |
|--|------------------------------------|------------------|----------------|
| Decays involving hadronic resonances | | | |
| $\eta'(958)\pi\pi$ | (4.1 \pm 1.7) % | | 1321 |
| $\rho\rho$ | (2.0 \pm 0.7) % | | 1273 |
| $K^*(892)^0 K^- \pi^+ + \text{c.c.}$ | (2.0 \pm 0.7) % | | 1276 |
| $K^*(892)\bar{K}^*(892)$ | (9.2 \pm 3.4) $\times 10^{-3}$ | | 1194 |
| $K^{*0}\bar{K}^{*0}\pi^+\pi^-$ | (1.5 \pm 0.8) % | | 1071 |
| $\phi K^+ K^-$ | (2.9 \pm 1.4) $\times 10^{-3}$ | | 1102 |
| $\phi\phi$ | (2.7 \pm 0.9) $\times 10^{-3}$ | | 1087 |
| $\phi 2(\pi^+\pi^-)$ | < 4.7 $\times 10^{-3}$ | 90% | 1249 |
| $a_0(980)\pi$ | < 2 % | 90% | 1324 |
| $a_2(1320)\pi$ | < 2 % | 90% | 1194 |
| $K^*(892)\bar{K} + \text{c.c.}$ | < 1.28 % | 90% | 1308 |
| $f_2(1270)\eta$ | < 1.1 % | 90% | 1143 |
| $\omega\omega$ | < 3.1 $\times 10^{-3}$ | 90% | 1268 |
| $\omega\phi$ | < 1.7 $\times 10^{-3}$ | 90% | 1183 |
| $f_2(1270)f_2(1270)$ | (1.0 $^{+0.4}_{-0.5}$) % | | 771 |
| Decays into stable hadrons | | | |
| $K\bar{K}\pi$ | (7.0 \pm 1.2) % | | 1379 |
| $\eta\pi\pi$ | (4.9 \pm 1.8) % | | 1427 |
| $\pi^+\pi^-K^+K^-$ | (1.5 \pm 0.6) % | | 1343 |
| $K^+K^-2(\pi^+\pi^-)$ | (10 \pm 4) $\times 10^{-3}$ | | 1252 |
| $2(K^+K^-)$ | (1.5 \pm 0.7) $\times 10^{-3}$ | | 1053 |
| $2(\pi^+\pi^-)$ | (1.20 \pm 0.30) % | | 1457 |
| $3(\pi^+\pi^-)$ | (2.0 \pm 0.7) % | | 1405 |
| $p\bar{p}$ | (1.3 \pm 0.4) $\times 10^{-3}$ | | 1158 |
| $K\bar{K}\eta$ | < 3.1 % | 90% | 1263 |
| $\pi^+\pi^-p\bar{p}$ | < 1.2 % | 90% | 1025 |
| $\Lambda\bar{\Lambda}$ | < 2 $\times 10^{-3}$ | 90% | 988 |
| Radiative decays | | | |
| $\gamma\gamma$ | (2.8 \pm 0.9) $\times 10^{-4}$ | | 1490 |
| Charge conjugation (C), Parity (P), Lepton family number (LF) violating modes | | | |
| $\pi^+\pi^-$ | P, CP < 8.7 $\times 10^{-4}$ | 90% | 1484 |
| $\pi^0\pi^0$ | P, CP < 5.6 $\times 10^{-4}$ | 90% | 1484 |
| K^+K^- | P, CP < 7.6 $\times 10^{-4}$ | 90% | 1406 |
| $K_S^0 K_S^0$ | P, CP < 4.2 $\times 10^{-4}$ | 90% | 1405 |

$J/\psi(1S)$

$$J^G(J^{PC}) = 0^-(1^{--})$$

Mass $m = 3096.916 \pm 0.011$ MeVFull width $\Gamma = 93.4 \pm 2.1$ keV $\Gamma_{ee} = 5.55 \pm 0.14 \pm 0.02$ keV

| $J/\psi(1S)$ DECAY MODES | Fraction (Γ_i/Γ) | Scale factor/ Confidence level | p (MeV/c) |
|--|--------------------------------|-----------------------------------|----------------|
| hadrons | (87.7 \pm 0.5) % | | — |
| virtual $\gamma \rightarrow$ hadrons | (13.50 \pm 0.30) % | | — |
| $e^+ e^-$ | (5.94 \pm 0.06) % | | 1548 |
| $\mu^+ \mu^-$ | (5.93 \pm 0.06) % | | 1545 |

Decays involving hadronic resonances

| | | | |
|--|--|-------|------|
| $\rho\pi$ | (1.69 \pm 0.15) % | S=2.4 | 1448 |
| $\rho^0\pi^0$ | (5.6 \pm 0.7) $\times 10^{-3}$ | | 1448 |
| $a_2(1320)\rho$ | (1.09 \pm 0.22) % | | 1123 |
| $\omega\pi^+\pi^+\pi^-\pi^-$ | (8.5 \pm 3.4) $\times 10^{-3}$ | | 1392 |
| $\omega\pi^+\pi^+\pi^0$ | (4.0 \pm 0.7) $\times 10^{-3}$ | | 1418 |
| $\omega\pi^+\pi^-$ | (7.2 \pm 1.0) $\times 10^{-3}$ | | 1435 |
| $\omega f_2(1270)$ | (4.3 \pm 0.6) $\times 10^{-3}$ | | 1142 |
| $K^*(892)^0 \bar{K}_2^*(1430)^0 + \text{c.c.}$ | (6.7 \pm 2.6) $\times 10^{-3}$ | | 1012 |
| $\omega K^*(892) \bar{K} + \text{c.c.}$ | (5.3 \pm 2.0) $\times 10^{-3}$ | | 1097 |
| $K^+ \bar{K}^*(892)^- + \text{c.c.}$ | (5.0 \pm 0.4) $\times 10^{-3}$ | | 1373 |
| $K^0 \bar{K}^*(892)^0 + \text{c.c.}$ | (4.2 \pm 0.4) $\times 10^{-3}$ | | 1373 |
| $K_1(1400)^\pm K^\mp$ | (3.8 \pm 1.4) $\times 10^{-3}$ | | 1171 |
| $\omega\pi^0\pi^0$ | (3.4 \pm 0.8) $\times 10^{-3}$ | | 1436 |
| $b_1(1235)^\pm \pi^\mp$ | [gg] (3.0 \pm 0.5) $\times 10^{-3}$ | | 1300 |
| $\omega K^\pm K_S^0 \pi^\mp$ | [gg] (2.9 \pm 0.7) $\times 10^{-3}$ | | 1210 |
| $b_1(1235)^0 \pi^0$ | (2.3 \pm 0.6) $\times 10^{-3}$ | | 1300 |
| $\phi K^*(892) \bar{K} + \text{c.c.}$ | (2.04 \pm 0.28) $\times 10^{-3}$ | | 969 |
| $\omega K \bar{K}$ | (1.9 \pm 0.4) $\times 10^{-3}$ | | 1268 |
| $\omega f_0(1710) \rightarrow \omega K \bar{K}$ | (4.8 \pm 1.1) $\times 10^{-4}$ | | 878 |
| $\phi 2(\pi^+\pi^-)$ | (1.66 \pm 0.23) $\times 10^{-3}$ | | 1318 |
| $\Delta(1232)^{++} \bar{p} \pi^-$ | (1.6 \pm 0.5) $\times 10^{-3}$ | | 1030 |
| $\omega \eta$ | (1.74 \pm 0.20) $\times 10^{-3}$ | S=1.6 | 1394 |
| $\phi K \bar{K}$ | (1.83 \pm 0.24) $\times 10^{-3}$ | S=1.5 | 1179 |
| $\phi f_0(1710) \rightarrow \phi K \bar{K}$ | (3.6 \pm 0.6) $\times 10^{-4}$ | | 875 |
| $p \bar{p} \omega$ | (1.30 \pm 0.25) $\times 10^{-3}$ | S=1.3 | 768 |
| $\Delta(1232)^{++} \bar{\Delta}(1232)^{--}$ | (1.10 \pm 0.29) $\times 10^{-3}$ | | 938 |
| $\Sigma(1385)^- \bar{\Sigma}(1385)^+ (\text{or c.c.})$ | [gg] (1.03 \pm 0.13) $\times 10^{-3}$ | | 697 |
| $p \bar{p} \eta'(958)$ | (9 \pm 4) $\times 10^{-4}$ | S=1.7 | 596 |
| $\phi f_2'(1525)$ | (8 \pm 4) $\times 10^{-4}$ | S=2.7 | 871 |
| $\phi \pi^+ \pi^-$ | (9.4 \pm 1.5) $\times 10^{-4}$ | S=1.7 | 1365 |

| | | | | |
|--|------|----------------------------------|--------|------|
| $\phi K^\pm K_S^0 \pi^\mp$ | [gg] | $(7.2 \pm 0.9) \times 10^{-4}$ | | 1114 |
| $\omega f_1(1420)$ | | $(6.8 \pm 2.4) \times 10^{-4}$ | | 1062 |
| $\phi \eta$ | | $(7.4 \pm 0.8) \times 10^{-4}$ | S=1.5 | 1320 |
| $\Xi(1530)^- \Xi^+$ | | $(5.9 \pm 1.5) \times 10^{-4}$ | | 601 |
| $p K^- \bar{\Sigma}(1385)^0$ | | $(5.1 \pm 3.2) \times 10^{-4}$ | | 646 |
| $\omega \pi^0$ | | $(4.5 \pm 0.5) \times 10^{-4}$ | S=1.4 | 1446 |
| $\phi \eta'(958)$ | | $(4.0 \pm 0.7) \times 10^{-4}$ | S=2.1 | 1192 |
| $\phi f_0(980)$ | | $(3.2 \pm 0.9) \times 10^{-4}$ | S=1.9 | 1182 |
| $\Xi(1530)^0 \Xi^0$ | | $(3.2 \pm 1.4) \times 10^{-5}$ | | 608 |
| $\Sigma(1385)^- \bar{\Sigma}^+ (\text{or c.c.})$ | [gg] | $(3.1 \pm 0.5) \times 10^{-4}$ | | 855 |
| $\phi f_1(1285)$ | | $(2.6 \pm 0.5) \times 10^{-4}$ | S=1.1 | 1032 |
| $\rho \eta$ | | $(1.93 \pm 0.23) \times 10^{-4}$ | | 1396 |
| $\omega \eta'(958)$ | | $(1.82 \pm 0.21) \times 10^{-4}$ | | 1279 |
| $\omega f_0(980)$ | | $(1.4 \pm 0.5) \times 10^{-4}$ | | 1271 |
| $\rho \eta'(958)$ | | $(1.05 \pm 0.18) \times 10^{-4}$ | | 1281 |
| $p \bar{p} \phi$ | | $(4.5 \pm 1.5) \times 10^{-5}$ | | 527 |
| $a_2(1320)^\pm \pi^\mp$ | [gg] | $< 4.3 \times 10^{-3}$ | CL=90% | 1263 |
| $K \bar{K}_2^*(1430)^+ \text{ c.c.}$ | | $< 4.0 \times 10^{-3}$ | CL=90% | 1159 |
| $K_1(1270)^\pm K^\mp$ | | $< 3.0 \times 10^{-3}$ | CL=90% | 1231 |
| $K_2^*(1430)^0 \bar{K}_2^*(1430)^0$ | | $< 2.9 \times 10^{-3}$ | CL=90% | 604 |
| $K^*(892)^0 \bar{K}^*(892)^0$ | | $< 5 \times 10^{-4}$ | CL=90% | 1266 |
| $\phi f_2(1270)$ | | $< 3.7 \times 10^{-4}$ | CL=90% | 1036 |
| $p \bar{p} \rho$ | | $< 3.1 \times 10^{-4}$ | CL=90% | 774 |
| $\phi \eta(1405) \rightarrow \phi \eta \pi \pi$ | | $< 2.5 \times 10^{-4}$ | CL=90% | 946 |
| $\omega f_2'(1525)$ | | $< 2.2 \times 10^{-4}$ | CL=90% | 1003 |
| $\Sigma(1385)^0 \bar{\Lambda}$ | | $< 2 \times 10^{-4}$ | CL=90% | 912 |
| $\Delta(1232)^+ \bar{p}$ | | $< 1 \times 10^{-4}$ | CL=90% | 1100 |
| $\Theta(1540) \bar{\Theta}(1540) \rightarrow$ $K_S^0 p K^- \bar{n} + \text{c.c.}$ | | $< 1.1 \times 10^{-5}$ | CL=90% | — |
| $\Theta(1540) K^- \bar{n} \rightarrow K_S^0 p K^- \bar{n}$ | | $< 2.1 \times 10^{-5}$ | CL=90% | — |
| $\Theta(1540) K_S^0 \bar{p} \rightarrow K_S^0 \bar{p} K^+ n$ | | $< 1.6 \times 10^{-5}$ | CL=90% | — |
| $\bar{\Theta}(1540) K^+ n \rightarrow K_S^0 \bar{p} K^+ n$ | | $< 5.6 \times 10^{-5}$ | CL=90% | — |
| $\bar{\Theta}(1540) K_S^0 p \rightarrow K_S^0 p K^- \bar{n}$ | | $< 1.1 \times 10^{-5}$ | CL=90% | — |
| $\Sigma^0 \bar{\Lambda}$ | | $< 9 \times 10^{-5}$ | CL=90% | 1032 |
| $\phi \pi^0$ | | $< 6.4 \times 10^{-6}$ | CL=90% | 1377 |

Decays into stable hadrons

| | | | |
|-----------------------------|--------------------------------|-------|------|
| $2(\pi^+ \pi^-) \pi^0$ | $(3.37 \pm 0.26) \%$ | | 1496 |
| $3(\pi^+ \pi^-) \pi^0$ | $(2.9 \pm 0.6) \%$ | | 1433 |
| $\pi^+ \pi^- \pi^0$ | $(2.02 \pm 0.14) \%$ | S=1.7 | 1533 |
| $\pi^+ \pi^- \pi^0 K^+ K^-$ | $(1.20 \pm 0.30) \%$ | | 1368 |
| $4(\pi^+ \pi^-) \pi^0$ | $(9.0 \pm 3.0) \times 10^{-3}$ | | 1345 |
| $\pi^+ \pi^- K^+ K^-$ | $(6.2 \pm 0.7) \times 10^{-3}$ | | 1407 |
| $K \bar{K} \pi$ | $(6.1 \pm 1.0) \times 10^{-3}$ | | 1442 |

| | | | | |
|--|-------|----------------------------------|--------|------|
| $p\bar{p}\pi^+\pi^-$ | | $(6.0 \pm 0.5) \times 10^{-3}$ | S=1.3 | 1107 |
| $2(\pi^+\pi^-)$ | | $(3.55 \pm 0.23) \times 10^{-3}$ | | 1517 |
| $3(\pi^+\pi^-)$ | | $(4.3 \pm 0.4) \times 10^{-3}$ | | 1466 |
| $2(\pi^+\pi^-\pi^0)$ | | $(1.62 \pm 0.21) \%$ | | 1468 |
| $2(\pi^+\pi^-)\eta$ | | $(2.26 \pm 0.28) \times 10^{-3}$ | | 1446 |
| $3(\pi^+\pi^-)\eta$ | | $(7.2 \pm 1.5) \times 10^{-4}$ | | 1379 |
| $n\bar{n}\pi^+\pi^-$ | | $(4 \pm 4) \times 10^{-3}$ | | 1106 |
| $\Sigma^0\bar{\Sigma}^0$ | | $(1.31 \pm 0.10) \times 10^{-3}$ | | 988 |
| $2(\pi^+\pi^-)K^+K^-$ | | $(4.7 \pm 0.7) \times 10^{-3}$ | S=1.3 | 1320 |
| $p\bar{p}\pi^+\pi^-\pi^0$ | [www] | $(2.3 \pm 0.9) \times 10^{-3}$ | S=1.9 | 1033 |
| $p\bar{p}$ | | $(2.17 \pm 0.08) \times 10^{-3}$ | | 1232 |
| $p\bar{p}\eta$ | | $(2.09 \pm 0.18) \times 10^{-3}$ | | 949 |
| $p\bar{n}\pi^-$ | | $(2.00 \pm 0.10) \times 10^{-3}$ | | 1174 |
| $n\bar{n}$ | | $(2.2 \pm 0.4) \times 10^{-3}$ | | 1231 |
| $\Xi\bar{\Xi}$ | | $(1.8 \pm 0.4) \times 10^{-3}$ | S=1.8 | 818 |
| $\Lambda\bar{\Lambda}$ | | $(1.54 \pm 0.19) \times 10^{-3}$ | S=2.2 | 1074 |
| $p\bar{p}\pi^0$ | | $(1.09 \pm 0.09) \times 10^{-3}$ | | 1176 |
| $\Lambda\bar{\Sigma}^-\pi^+$ (or c.c.) | [gg] | $(1.06 \pm 0.12) \times 10^{-3}$ | | 950 |
| $pK^-\bar{\Lambda}$ | | $(8.9 \pm 1.6) \times 10^{-4}$ | | 876 |
| $2(K^+K^-)$ | | $(7.8 \pm 1.4) \times 10^{-4}$ | | 1131 |
| $pK^-\bar{\Sigma}^0$ | | $(2.9 \pm 0.8) \times 10^{-4}$ | | 819 |
| K^+K^- | | $(2.37 \pm 0.31) \times 10^{-4}$ | | 1468 |
| $K_S^0 K_L^0$ | | $(1.46 \pm 0.26) \times 10^{-4}$ | S=2.7 | 1466 |
| $\Lambda\bar{\Lambda}\pi^0$ | | $(2.2 \pm 0.6) \times 10^{-4}$ | | 998 |
| $\pi^+\pi^-$ | | $(1.47 \pm 0.23) \times 10^{-4}$ | | 1542 |
| $\Lambda\bar{\Sigma} + \text{c.c.}$ | | $< 1.5 \times 10^{-4}$ | CL=90% | 1034 |
| $K_S^0 K_S^0$ | | $< 1 \times 10^{-6}$ | CL=95% | 1466 |

Radiative decays

| | | | | |
|--|-----|----------------------------------|--------|------|
| $\gamma\eta_c(1S)$ | | $(1.3 \pm 0.4) \%$ | | 114 |
| $\gamma\pi^+\pi^-2\pi^0$ | | $(8.3 \pm 3.1) \times 10^{-3}$ | | 1518 |
| $\gamma\eta\pi\pi$ | | $(6.1 \pm 1.0) \times 10^{-3}$ | | 1488 |
| $\gamma\eta(1405/1475) \rightarrow \gamma K\bar{K}\pi$ | [p] | $(2.8 \pm 0.6) \times 10^{-3}$ | S=1.6 | 1223 |
| $\gamma\eta(1405/1475) \rightarrow \gamma\gamma\rho^0$ | | $(7.8 \pm 2.0) \times 10^{-6}$ | S=1.8 | 1223 |
| $\gamma\eta(1405/1475) \rightarrow \gamma\eta\pi^+\pi^-$ | | $(3.0 \pm 0.5) \times 10^{-4}$ | | — |
| $\gamma\eta(1405/1475) \rightarrow \gamma\gamma\phi$ | | $< 8.2 \times 10^{-5}$ | CL=95% | — |
| $\gamma\rho\rho$ | | $(4.5 \pm 0.8) \times 10^{-3}$ | | 1340 |
| $\gamma\eta_2(1870) \rightarrow \gamma\pi^+\pi^-$ | | $(6.2 \pm 2.4) \times 10^{-4}$ | | — |
| $\gamma\eta'(958)$ | | $(4.71 \pm 0.27) \times 10^{-3}$ | S=1.1 | 1400 |
| $\gamma 2\pi^+ 2\pi^-$ | | $(2.8 \pm 0.5) \times 10^{-3}$ | S=1.9 | 1517 |
| $\gamma f_2(1270) f_2(1270)$ | | $(9.5 \pm 1.7) \times 10^{-4}$ | | 878 |
| $\gamma f_2(1270) f_2(1270)$ (non resonant) | | $(8.2 \pm 1.9) \times 10^{-4}$ | | — |
| $\gamma K^+ K^- \pi^+ \pi^-$ | | $(2.1 \pm 0.6) \times 10^{-3}$ | | 1407 |
| $\gamma f_4(2050)$ | | $(2.7 \pm 0.7) \times 10^{-3}$ | | 886 |

| | | | |
|---|--------------------------------------|----------|------|
| $\gamma\omega\omega$ | $(1.59 \pm 0.33) \times 10^{-3}$ | | 1336 |
| $\gamma\eta(1405/1475) \rightarrow \gamma\rho^0\rho^0$ | $(1.7 \pm 0.4) \times 10^{-3}$ | S=1.3 | 1223 |
| $\gamma f_2(1270)$ | $(1.38 \pm 0.14) \times 10^{-3}$ | | 1286 |
| $\gamma f_0(1710) \rightarrow \gamma K\bar{K}$ | $(8.5^{+1.2}_{-0.9}) \times 10^{-4}$ | S=1.2 | 1075 |
| $\gamma\eta$ | $(9.8 \pm 1.0) \times 10^{-4}$ | S=1.7 | 1500 |
| $\gamma f_1(1420) \rightarrow \gamma K\bar{K}\pi$ | $(7.9 \pm 1.3) \times 10^{-4}$ | | 1220 |
| $\gamma f_1(1285)$ | $(6.1 \pm 0.8) \times 10^{-4}$ | | 1283 |
| $\gamma f_1(1510) \rightarrow \gamma\eta\pi^+\pi^-$ | $(4.5 \pm 1.2) \times 10^{-4}$ | | — |
| $\gamma f'_2(1525)$ | $(4.5^{+0.7}_{-0.4}) \times 10^{-4}$ | | 1173 |
| $\gamma f_2(1950) \rightarrow$ $\gamma K^*(892)\bar{K}^*(892)$ | $(7.0 \pm 2.2) \times 10^{-4}$ | | — |
| $\gamma K^*(892)\bar{K}^*(892)$ | $(4.0 \pm 1.3) \times 10^{-3}$ | | 1266 |
| $\gamma\phi\phi$ | $(4.0 \pm 1.2) \times 10^{-4}$ | S=2.1 | 1166 |
| $\gamma p\bar{p}$ | $(3.8 \pm 1.0) \times 10^{-4}$ | | 1232 |
| $\gamma\eta(2225)$ | $(2.9 \pm 0.6) \times 10^{-4}$ | | 752 |
| $\gamma\eta(1760) \rightarrow \gamma\rho^0\rho^0$ | $(1.3 \pm 0.9) \times 10^{-4}$ | | 1048 |
| $\gamma X(1835)$ | $(2.2 \pm 0.6) \times 10^{-4}$ | | 1006 |
| $\gamma(K\bar{K}\pi)_{JPC=0-+}$ | $(7 \pm 4) \times 10^{-4}$ | S=2.1 | 1442 |
| $\gamma\pi^0$ | $(3.3^{+0.6}_{-0.4}) \times 10^{-5}$ | | 1546 |
| $\gamma p\bar{p}\pi^+\pi^-$ | $< 7.9 \times 10^{-4}$ | CL=90% | 1107 |
| $\gamma\gamma$ | $< 5 \times 10^{-4}$ | CL=90% | 1548 |
| $\gamma\Lambda\bar{\Lambda}$ | $< 1.3 \times 10^{-4}$ | CL=90% | 1074 |
| 3γ | $< 5.5 \times 10^{-5}$ | CL=90% | 1548 |
| $\gamma f_J(2220)$ | $> 2.50 \times 10^{-3}$ | CL=99.9% | 745 |
| $\gamma f_J(2220) \rightarrow \gamma\pi\pi$ | $(8 \pm 4) \times 10^{-5}$ | | — |
| $\gamma f_J(2220) \rightarrow \gamma K\bar{K}$ | $(8.1 \pm 3.0) \times 10^{-5}$ | | — |
| $\gamma f_J(2220) \rightarrow \gamma p\bar{p}$ | $(1.5 \pm 0.8) \times 10^{-5}$ | | — |
| $\gamma f_0(1500)$ | $> (5.7 \pm 0.8) \times 10^{-4}$ | | 1182 |
| γe^+e^- | $(8.8 \pm 1.4) \times 10^{-3}$ | | 1548 |

Lepton Family number (LF) violating modes

| | | | | |
|-------------------|----|------------------------|--------|------|
| $e^\pm\mu^\mp$ | LF | $< 1.1 \times 10^{-6}$ | CL=90% | 1547 |
| $e^\pm\tau^\mp$ | LF | $< 8.3 \times 10^{-6}$ | CL=90% | 1039 |
| $\mu^\pm\tau^\mp$ | LF | $< 2.0 \times 10^{-6}$ | CL=90% | 1035 |

 $\chi_{c0}(1P)$

$$J^{PC} = 0^+(0^{++})$$

Mass $m = 3414.76 \pm 0.35$ MeV (S = 1.2)Full width $\Gamma = 10.4 \pm 0.7$ MeV

| $\chi_{c0}(1P)$ DECAY MODES | Fraction (Γ_i/Γ) | Scale factor/ Confidence level | p (MeV/c) |
|--|---|-----------------------------------|----------------|
| Hadronic decays | | | |
| $2(\pi^+\pi^-)$ | $(2.41 \pm 0.23) \%$ | | 1679 |
| $f_0(980)f_0(980) \rightarrow 2\pi^+2\pi^-$ | $(7.1 \pm 2.3) \times 10^{-4}$ | | — |
| $\pi^+\pi^-K^+K^-$ | $(2.0 \pm 0.4) \%$ | S=1.6 | 1580 |
| $f_0(980)f_0(980) \rightarrow$ $\pi^+\pi^-K^+K^-$ | $(1.7^{+1.1}_{-1.0}) \times 10^{-4}$ | | — |
| $f_0(980)f_0(2200) \rightarrow$ $\pi^+\pi^-K^+K^-$ | $(8.4^{+2.2}_{-2.7}) \times 10^{-4}$ | | — |
| $f_0(1370)f_0(1370) \rightarrow$ $\pi^+\pi^-K^+K^-$ | $< 2.9 \times 10^{-4}$ | CL=90% | — |
| $f_0(1370)f_0(1500) \rightarrow$ $\pi^+\pi^-K^+K^-$ | $< 1.8 \times 10^{-4}$ | CL=90% | — |
| $f_0(1370)f_0(1710) \rightarrow$ $\pi^+\pi^-K^+K^-$ | $(7.1^{+3.8}_{-2.5}) \times 10^{-4}$ | | — |
| $f_0(1500)f_0(1370) \rightarrow$ $\pi^+\pi^-K^+K^-$ | $< 1.4 \times 10^{-4}$ | CL=90% | — |
| $f_0(1500)f_0(1500) \rightarrow$ $\pi^+\pi^-K^+K^-$ | $< 6 \times 10^{-5}$ | CL=90% | — |
| $f_0(1500)f_0(1710) \rightarrow$ $\pi^+\pi^-K^+K^-$ | $< 7 \times 10^{-5}$ | CL=90% | — |
| $\rho^0\pi^+\pi^-$ | $(1.6 \pm 0.5) \%$ | | 1607 |
| $3(\pi^+\pi^-)$ | $(1.19 \pm 0.18) \%$ | | 1633 |
| $K^+\bar{K}^*(892)^0\pi^- + \text{c.c.}$ | $(1.2 \pm 0.4) \%$ | | 1523 |
| $K_1(1270)^+K^- + \text{c.c.} \rightarrow$ $\pi^+\pi^-K^+K^-$ | $(6.7 \pm 2.0) \times 10^{-3}$ | | — |
| $K_1(1400)^+K^- + \text{c.c.} \rightarrow$ $\pi^+\pi^-K^+K^-$ | $< 2.9 \times 10^{-3}$ | CL=90% | — |
| $K^*(892)^0\bar{K}^*(892)^0$ | $(1.8 \pm 0.6) \times 10^{-3}$ | | 1456 |
| $K_0^*(1430)^0\bar{K}_0^*(1430)^0 \rightarrow$ $\pi^+\pi^-K^+K^-$ | $(1.05^{+0.39}_{-0.30}) \times 10^{-3}$ | | — |
| $K_0^*(1430)^0\bar{K}_2^*(1430)^0 + \text{c.c.} \rightarrow$ $\pi^+\pi^-K^+K^-$ | $(8.5^{+2.1}_{-2.6}) \times 10^{-4}$ | | — |
| K^+K^- | $(5.4 \pm 0.6) \times 10^{-3}$ | | 1634 |
| $\pi\pi$ | $(7.2 \pm 0.6) \times 10^{-3}$ | | 1702 |
| $\eta\eta$ | $(1.9 \pm 0.5) \times 10^{-3}$ | | 1617 |
| $\omega\omega$ | $(2.3 \pm 0.7) \times 10^{-3}$ | | 1517 |
| $K^+K^-K_S^0K_S^0$ | $(1.5 \pm 0.5) \times 10^{-3}$ | | 1331 |
| $K^+K^-K^+K^-$ | $(2.1 \pm 0.4) \times 10^{-3}$ | | 1333 |
| $K_S^0K_S^0$ | $(2.8 \pm 0.7) \times 10^{-3}$ | S=1.9 | 1633 |
| $K_S^0K_S^0\pi^+\pi^-$ | $(6.1 \pm 1.1) \times 10^{-3}$ | | 1579 |
| $K_S^0K_S^0p\bar{p}$ | $< 8.8 \times 10^{-4}$ | CL=90% | 884 |

| | | | |
|-------------------------------------|----------------------------------|--------|------|
| $\pi^+ \pi^- p \bar{p}$ | $(2.1 \pm 0.7) \times 10^{-3}$ | S=1.4 | 1320 |
| $\phi \phi$ | $(9 \pm 5) \times 10^{-4}$ | | 1370 |
| $p \bar{p}$ | $(2.24 \pm 0.27) \times 10^{-4}$ | | 1426 |
| $\Lambda \bar{\Lambda}$ | $(4.4 \pm 1.5) \times 10^{-4}$ | | 1292 |
| $\Lambda \bar{\Lambda} \pi^+ \pi^-$ | $< 4.0 \times 10^{-3}$ | CL=90% | 1153 |
| $\Xi^- \Xi^+$ | $< 1.03 \times 10^{-3}$ | CL=90% | 1081 |
| $K_S^0 K^+ \pi^- + \text{c.c.}$ | $< 7 \times 10^{-4}$ | CL=90% | 1610 |

Radiative decays

| | | |
|---------------------|----------------------------------|------|
| $\gamma J/\psi(1S)$ | $(1.30 \pm 0.11) \%$ | 303 |
| $\gamma \gamma$ | $(2.76 \pm 0.33) \times 10^{-4}$ | 1707 |

 $\chi_{c1}(1P)$

$$J^{PC} = 0^+(1^{++})$$

Mass $m = 3510.66 \pm 0.07$ MeV (S = 1.5)Full width $\Gamma = 0.89 \pm 0.05$ MeV

| $\chi_{c1}(1P)$ DECAY MODES | Fraction (Γ_i/Γ) | Scale factor/ Confidence level | p (MeV/c) |
|---|--------------------------------|-----------------------------------|----------------|
|---|--------------------------------|-----------------------------------|----------------|

Hadronic decays

| | | | |
|--|--------------------------------|--------|------|
| $3(\pi^+ \pi^-)$ | $(5.8 \pm 1.4) \times 10^{-3}$ | S=1.2 | 1683 |
| $2(\pi^+ \pi^-)$ | $(7.6 \pm 2.6) \times 10^{-3}$ | | 1728 |
| $\pi^+ \pi^- K^+ K^-$ | $(4.5 \pm 1.0) \times 10^{-3}$ | | 1632 |
| $\rho^0 \pi^+ \pi^-$ | $(3.9 \pm 3.5) \times 10^{-3}$ | | 1657 |
| $K^+ \bar{K}^*(892)^0 \pi^- + \text{c.c.}$ | $(3.2 \pm 2.1) \times 10^{-3}$ | | 1577 |
| $K^*(892)^0 \bar{K}^*(892)^0$ | $(1.6 \pm 0.4) \times 10^{-3}$ | | 1512 |
| $K_S^0 K^+ \pi^- + \text{c.c.}$ | $(2.3 \pm 0.7) \times 10^{-3}$ | | 1661 |
| $\pi^+ \pi^- K_S^0 K_S^0$ | $(7.7 \pm 3.3) \times 10^{-4}$ | | 1630 |
| $\pi^+ \pi^- p \bar{p}$ | $(4.9 \pm 1.9) \times 10^{-4}$ | | 1381 |
| $K^+ K^- K^+ K^-$ | $(3.9 \pm 1.7) \times 10^{-4}$ | | 1393 |
| $p \bar{p}$ | $(6.7 \pm 0.5) \times 10^{-5}$ | | 1484 |
| $\Lambda \bar{\Lambda}$ | $(2.4 \pm 1.0) \times 10^{-4}$ | | 1355 |
| $\Lambda \bar{\Lambda} \pi^+ \pi^-$ | $< 1.5 \times 10^{-3}$ | CL=90% | 1223 |
| $K_S^0 K_S^0 p \bar{p}$ | $< 4.5 \times 10^{-4}$ | CL=90% | 968 |
| $\Xi^- \Xi^+$ | $< 3.4 \times 10^{-4}$ | CL=90% | 1156 |
| $\pi^+ \pi^- + K^+ K^-$ | $< 2.1 \times 10^{-3}$ | | — |
| $K_S^0 K_S^0$ | $< 7 \times 10^{-5}$ | CL=90% | 1683 |

Radiative decays

| | | |
|---------------------|---------------------|-----|
| $\gamma J/\psi(1S)$ | $(35.6 \pm 1.9) \%$ | 389 |
|---------------------|---------------------|-----|

$\chi_{c2}(1P)$

$$J^{PC} = 0^{++}$$

Mass $m = 3556.20 \pm 0.09$ MeVFull width $\Gamma = 2.06 \pm 0.12$ MeV

| $\chi_{c2}(1P)$ DECAY MODES | Fraction (Γ_i/Γ) | Scale factor/ Confidence level | p (MeV/c) |
|---|----------------------------------|-----------------------------------|----------------|
| Hadronic decays | | | |
| $2(\pi^+\pi^-)$ | $(1.23 \pm 0.15) \%$ | | 1751 |
| $\pi^+\pi^-K^+K^-$ | $(9.9 \pm 2.5) \times 10^{-3}$ | S=1.6 | 1656 |
| $3(\pi^+\pi^-)$ | $(8.6 \pm 1.8) \times 10^{-3}$ | | 1707 |
| $\rho^0\pi^+\pi^-$ | $(7 \pm 4) \times 10^{-3}$ | | 1681 |
| $K^+\bar{K}^*(892)^0\pi^- + \text{c.c.}$ | $(4.8 \pm 2.8) \times 10^{-3}$ | | 1602 |
| $K^*(892)^0\bar{K}^*(892)^0$ | $(3.8 \pm 0.8) \times 10^{-3}$ | | 1538 |
| $\phi\phi$ | $(1.9 \pm 0.7) \times 10^{-3}$ | | 1457 |
| $\omega\omega$ | $(2.0 \pm 0.7) \times 10^{-3}$ | | 1597 |
| $\pi\pi$ | $(2.14 \pm 0.25) \times 10^{-3}$ | | 1773 |
| $\eta\eta$ | $< 1.2 \times 10^{-3}$ | CL=90% | 1692 |
| $\pi^+\pi^-K_S^0K_S^0$ | $(2.6 \pm 0.6) \times 10^{-3}$ | | 1655 |
| $K^+K^-K^+K^-$ | $(1.41 \pm 0.35) \times 10^{-3}$ | | 1421 |
| $\pi^+\pi^-p\bar{p}$ | $(1.32 \pm 0.34) \times 10^{-3}$ | | 1410 |
| K^+K^- | $(7.7 \pm 1.4) \times 10^{-4}$ | | 1708 |
| $K_S^0K_S^0$ | $(6.7 \pm 1.1) \times 10^{-4}$ | | 1707 |
| $K_S^0K_S^0p\bar{p}$ | $< 7.9 \times 10^{-4}$ | CL=90% | 1007 |
| $p\bar{p}$ | $(6.6 \pm 0.5) \times 10^{-5}$ | | 1510 |
| $\Lambda\bar{\Lambda}$ | $(2.7 \pm 1.3) \times 10^{-4}$ | | 1385 |
| $\Lambda\bar{\Lambda}\pi^+\pi^-$ | $< 3.5 \times 10^{-3}$ | CL=90% | 1255 |
| $J/\psi(1S)\pi^+\pi^-\pi^0$ | $< 1.5 \%$ | CL=90% | 185 |
| $K_S^0K^+\pi^-\pi^0 + \text{c.c.}$ | $< 1.0 \times 10^{-3}$ | CL=90% | 1685 |
| $\Xi^-\Xi^+$ | $< 3.7 \times 10^{-4}$ | CL=90% | 1190 |
| Radiative decays | | | |
| $\gamma J/\psi(1S)$ | $(20.2 \pm 1.0) \%$ | | 430 |
| $\gamma\gamma$ | $(2.59 \pm 0.19) \times 10^{-4}$ | | 1778 |

$\eta_c(2S)$

$$J^{PC} = 0^+(0^-+)$$

Quantum numbers are quark model predictions.

Mass $m = 3638 \pm 4$ MeV ($S = 1.8$)Full width $\Gamma = 14 \pm 7$ MeV

| $\eta_c(2S)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|--------------------------|--------------------------------|-------------|
| $K\bar{K}\pi$ | seen | 1729 |
| $\gamma\gamma$ | seen | 1819 |

 $\psi(2S)$

$$J^{PC} = 0^-(1^--)$$

Mass $m = 3686.093 \pm 0.034$ MeV ($S = 1.4$)Full width $\Gamma = 337 \pm 13$ keV $\Gamma_{ee} = 2.48 \pm 0.06$ keV

| $\psi(2S)$ DECAY MODES | Fraction (Γ_i/Γ) | Scale factor/ Confidence level | p (MeV/c) |
|--------------------------------------|----------------------------------|-----------------------------------|----------------|
| hadrons | $(97.85 \pm 0.13) \%$ | | — |
| virtual $\gamma \rightarrow$ hadrons | $(1.73 \pm 0.14) \%$ | S=1.5 | — |
| e^+e^- | $(7.35 \pm 0.18) \times 10^{-3}$ | | 1843 |
| $\mu^+\mu^-$ | $(7.3 \pm 0.8) \times 10^{-3}$ | | 1840 |
| $\tau^+\tau^-$ | $(2.8 \pm 0.7) \times 10^{-3}$ | | 489 |

Decays into $J/\psi(1S)$ and anything

| | | | |
|------------------------|----------------------------------|-------|-----|
| $J/\psi(1S)$ anything | $(56.1 \pm 0.9) \%$ | | — |
| $J/\psi(1S)$ neutrals | $(23.0 \pm 0.4) \%$ | | — |
| $J/\psi(1S)\pi^+\pi^-$ | $(31.8 \pm 0.6) \%$ | | 477 |
| $J/\psi(1S)\pi^0\pi^0$ | $(16.46 \pm 0.35) \%$ | | 481 |
| $J/\psi(1S)\eta$ | $(3.09 \pm 0.08) \%$ | | 200 |
| $J/\psi(1S)\pi^0$ | $(1.26 \pm 0.13) \times 10^{-3}$ | S=1.3 | 528 |

Hadronic decays

| | | | |
|--------------------------------------|----------------------------------|-------|------|
| $3(\pi^+\pi^-)\pi^0$ | $(3.5 \pm 1.6) \times 10^{-3}$ | | 1746 |
| $2(\pi^+\pi^-)\pi^0$ | $(2.66 \pm 0.29) \times 10^{-3}$ | | 1799 |
| $\rho a_2(1320)$ | $(2.6 \pm 0.9) \times 10^{-4}$ | | 1500 |
| $p\bar{p}$ | $(2.65 \pm 0.22) \times 10^{-4}$ | S=1.4 | 1586 |
| $\Delta^{++}\bar{\Delta}^{--}$ | $(1.28 \pm 0.35) \times 10^{-4}$ | | 1371 |
| $\Lambda\bar{\Lambda}$ | $(2.5 \pm 0.7) \times 10^{-4}$ | S=3.1 | 1467 |
| $\Sigma^+\bar{\Sigma}^-$ | $(2.6 \pm 0.8) \times 10^{-4}$ | | 1408 |
| $\Sigma^0\bar{\Sigma}^0$ | $(2.1 \pm 0.7) \times 10^{-4}$ | S=2.0 | 1405 |
| $\Sigma(1385)^+\bar{\Sigma}(1385)^-$ | $(1.1 \pm 0.4) \times 10^{-4}$ | | 1218 |
| $\Xi^-\bar{\Xi}^+$ | $(1.5 \pm 0.7) \times 10^{-4}$ | S=3.0 | 1285 |

| | | | |
|--|--|--------|------|
| $\Xi^0 \Xi^0$ | $(2.8 \pm 0.9) \times 10^{-4}$ | | 1292 |
| $\Xi(1530)^0 \Xi(1530)^0$ | $< 8.1 \times 10^{-5}$ | CL=90% | 1025 |
| $\Omega^- \bar{\Omega}^+$ | $< 7.3 \times 10^{-5}$ | CL=90% | 774 |
| $\pi^0 p \bar{p}$ | $(1.33 \pm 0.17) \times 10^{-4}$ | | 1543 |
| $\eta p \bar{p}$ | $(6.0 \pm 1.2) \times 10^{-5}$ | | 1373 |
| $\omega p \bar{p}$ | $(6.9 \pm 2.1) \times 10^{-5}$ | | 1247 |
| $\phi p \bar{p}$ | $< 2.4 \times 10^{-5}$ | CL=90% | 1109 |
| $\pi^+ \pi^- p \bar{p}$ | $(6.0 \pm 0.4) \times 10^{-4}$ | | 1491 |
| $2(\pi^+ \pi^- \pi^0)$ | $(4.5 \pm 1.4) \times 10^{-3}$ | | 1776 |
| $\eta \pi^+ \pi^-$ | $< 1.6 \times 10^{-4}$ | CL=90% | 1791 |
| $\eta \pi^+ \pi^- \pi^0$ | $(9.5 \pm 1.7) \times 10^{-4}$ | | 1778 |
| $\eta' \pi^+ \pi^- \pi^0$ | $(4.5 \pm 2.1) \times 10^{-4}$ | | — |
| $\omega \pi^+ \pi^-$ | $(6.6 \pm 1.7) \times 10^{-4}$ | S=2.7 | 1748 |
| $b_1^\pm \pi^\mp$ | $(3.6 \pm 0.6) \times 10^{-4}$ | | 1635 |
| $b_1^0 \pi^0$ | $(2.4 \pm 0.6) \times 10^{-4}$ | | — |
| $\omega f_2(1270)$ | $(2.0 \pm 0.6) \times 10^{-4}$ | | 1515 |
| $\pi^+ \pi^- K^+ K^-$ | $(7.2 \pm 0.5) \times 10^{-4}$ | | 1726 |
| $\rho^0 K^+ K^-$ | $(2.2 \pm 0.4) \times 10^{-4}$ | | 1616 |
| $K^*(892)^0 \bar{K}_2^*(1430)^0$ | $(1.9 \pm 0.5) \times 10^{-4}$ | | 1418 |
| $K^+ K^- 2(\pi^+ \pi^-)$ | $(1.8 \pm 0.9) \times 10^{-3}$ | | 1654 |
| $K_1(1270)^\pm K^\mp$ | $(1.00 \pm 0.28) \times 10^{-3}$ | | 1581 |
| $K_S^0 K_S^0 \pi^+ \pi^-$ | $(2.2 \pm 0.4) \times 10^{-4}$ | | 1724 |
| $\rho^0 p \bar{p}$ | $(5.0 \pm 2.2) \times 10^{-5}$ | | 1251 |
| $K^+ \bar{K}^*(892)^0 \pi^- + \text{c.c.}$ | $(6.7 \pm 2.5) \times 10^{-4}$ | | 1674 |
| $2(\pi^+ \pi^-)$ | $(2.4 \pm 0.6) \times 10^{-4}$ | S=2.2 | 1817 |
| $\rho^0 \pi^+ \pi^-$ | $(2.2 \pm 0.6) \times 10^{-4}$ | S=1.4 | 1750 |
| $K^+ K^- \pi^+ \pi^- \pi^0$ | $(1.24 \pm 0.10) \times 10^{-3}$ | | 1694 |
| $\omega f_0(1710) \rightarrow \omega K^+ K^-$ | $(5.9 \pm 2.2) \times 10^{-5}$ | | — |
| $K^*(892)^0 K^- \pi^+ \pi^0 + \text{c.c.}$ | $(8.6 \pm 2.2) \times 10^{-4}$ | | — |
| $K^*(892)^+ K^- \pi^+ \pi^- + \text{c.c.}$ | $(9.6 \pm 2.8) \times 10^{-4}$ | | — |
| $K^*(892)^+ K^- \rho^0 + \text{c.c.}$ | $(7.3 \pm 2.6) \times 10^{-4}$ | | — |
| $K^*(892)^0 K^- \rho^+ + \text{c.c.}$ | $(6.1 \pm 1.8) \times 10^{-4}$ | | — |
| $\eta K^+ K^-$ | $< 1.3 \times 10^{-4}$ | CL=90% | 1664 |
| $\omega K^+ K^-$ | $(1.85 \pm 0.25) \times 10^{-4}$ | S=1.1 | 1614 |
| $3(\pi^+ \pi^-)$ | $(3.5 \pm 2.0) \times 10^{-4}$ | S=2.8 | 1774 |
| $p \bar{p} \pi^+ \pi^- \pi^0$ | $(7.3 \pm 0.7) \times 10^{-4}$ | | 1435 |
| $K^+ K^-$ | $(1.0 \pm 0.7) \times 10^{-4}$ | | 1776 |
| $K_S^0 K_L^0$ | $(5.2 \pm 0.7) \times 10^{-5}$ | | 1775 |
| $\pi^+ \pi^- \pi^0$ | $(1.68 \pm 0.26) \times 10^{-4}$ | S=1.4 | 1830 |
| $\rho(2150) \pi \rightarrow \pi^+ \pi^- \pi^0$ | $(1.9 \pm_{-0.4}^{+1.2}) \times 10^{-4}$ | | — |
| $\rho(770) \pi \rightarrow \pi^+ \pi^- \pi^0$ | $(3.2 \pm 1.2) \times 10^{-5}$ | S=1.8 | — |
| $\pi^+ \pi^-$ | $(8 \pm 5) \times 10^{-5}$ | | 1838 |
| $K_1(1400)^\pm K^\mp$ | $< 3.1 \times 10^{-4}$ | CL=90% | 1532 |

| | | | |
|---|--------------------------------------|--------|------|
| $K^+ K^- \pi^0$ | $< 2.96 \times 10^{-5}$ | CL=90% | 1754 |
| $K^+ \bar{K}^*(892)^- + \text{c.c.}$ | $(1.7^{+0.8}_{-0.7}) \times 10^{-5}$ | | 1698 |
| $K^*(892)^0 \bar{K}^0 + \text{c.c.}$ | $(1.09 \pm 0.20) \times 10^{-4}$ | | 1697 |
| $\phi \pi^+ \pi^-$ | $(1.13 \pm 0.29) \times 10^{-4}$ | S=1.7 | 1690 |
| $\phi f_0(980) \rightarrow \pi^+ \pi^-$ | $(6.0 \pm 2.2) \times 10^{-5}$ | | — |
| $2(K^+ K^-)$ | $(6.0 \pm 1.4) \times 10^{-5}$ | | 1499 |
| $\phi K^+ K^-$ | $(7.0 \pm 1.6) \times 10^{-5}$ | | 1546 |
| $2(K^+ K^-) \pi^0$ | $(1.10 \pm 0.28) \times 10^{-4}$ | | 1440 |
| $\phi \eta$ | $(2.8^{+1.0}_{-0.8}) \times 10^{-5}$ | | 1654 |
| $\phi \eta'$ | $(3.1 \pm 1.6) \times 10^{-5}$ | | 1555 |
| $\omega \eta'$ | $(3.2^{+2.5}_{-2.1}) \times 10^{-5}$ | | 1623 |
| $\omega \pi^0$ | $(2.1 \pm 0.6) \times 10^{-5}$ | | 1757 |
| $\rho \eta'$ | $(1.9^{+1.7}_{-1.2}) \times 10^{-5}$ | | 1625 |
| $\rho \eta$ | $(2.2 \pm 0.6) \times 10^{-5}$ | S=1.1 | 1717 |
| $\omega \eta$ | $< 1.1 \times 10^{-5}$ | CL=90% | 1715 |
| $\phi \pi^0$ | $< 4 \times 10^{-6}$ | CL=90% | 1699 |
| $p \bar{p} K^+ K^-$ | $(2.7 \pm 0.7) \times 10^{-5}$ | | 1118 |
| $\Lambda \bar{\Lambda} \pi^+ \pi^-$ | $(2.8 \pm 0.6) \times 10^{-4}$ | | 1346 |
| $\Lambda \bar{p} K^+$ | $(1.00 \pm 0.14) \times 10^{-4}$ | | 1327 |
| $\Lambda \bar{p} K^+ \pi^+ \pi^-$ | $(1.8 \pm 0.4) \times 10^{-4}$ | | 1167 |
| $\phi f'_2(1525)$ | $(4.4 \pm 1.6) \times 10^{-5}$ | | 1321 |
| $\Theta(1540) \bar{\Theta}(1540) \rightarrow K_S^0 p K^- \bar{n} + \text{c.c.}$ | $< 8.8 \times 10^{-6}$ | CL=90% | — |
| $\Theta(1540) K^- \bar{n} \rightarrow K_S^0 p K^- \bar{n}$ | $< 1.0 \times 10^{-5}$ | CL=90% | — |
| $\Theta(1540) K_S^0 \bar{p} \rightarrow K_S^0 \bar{p} K^+ n$ | $< 7.0 \times 10^{-6}$ | CL=90% | — |
| $\bar{\Theta}(1540) K^+ n \rightarrow K_S^0 \bar{p} K^+ n$ | $< 2.6 \times 10^{-5}$ | CL=90% | — |
| $\bar{\Theta}(1540) K_S^0 p \rightarrow K_S^0 p K^- \bar{n}$ | $< 6.0 \times 10^{-6}$ | CL=90% | — |
| $K_S^0 K_S^0$ | $< 4.6 \times 10^{-6}$ | | 1775 |

Radiative decays

| | | | |
|---|--------------------------------|--------|------|
| $\gamma \chi_{c0}(1P)$ | $(9.2 \pm 0.4) \%$ | | 261 |
| $\gamma \chi_{c1}(1P)$ | $(8.7 \pm 0.4) \%$ | | 171 |
| $\gamma \chi_{c2}(1P)$ | $(8.1 \pm 0.4) \%$ | | 128 |
| $\gamma \eta_c(1S)$ | $(2.6 \pm 0.4) \times 10^{-3}$ | | 638 |
| $\gamma \eta_c(2S)$ | $< 2.0 \times 10^{-3}$ | CL=90% | 47 |
| $\gamma \eta'(958)$ | $(1.5 \pm 0.4) \times 10^{-4}$ | | 1719 |
| $\gamma f_2(1270)$ | $(2.1 \pm 0.4) \times 10^{-4}$ | | 1622 |
| $\gamma f_0(1710) \rightarrow \gamma \pi \pi$ | $(3.0 \pm 1.3) \times 10^{-5}$ | | — |
| $\gamma f_0(1710) \rightarrow \gamma K \bar{K}$ | $(6.0 \pm 1.6) \times 10^{-5}$ | | — |

| | | | | |
|---|---------|------------------|--------|------|
| $\gamma\gamma$ | < 1.3 | $\times 10^{-4}$ | CL=90% | 1843 |
| $\gamma\eta$ | < 9 | $\times 10^{-5}$ | CL=90% | 1802 |
| $\gamma\eta(1405) \rightarrow \gamma K \bar{K} \pi$ | < 1.2 | $\times 10^{-4}$ | CL=90% | 1569 |

 $\psi(3770)$

$$J^{PC} = 0^-(1^--)$$

Mass $m = 3771.1 \pm 2.4$ MeV

Full width $\Gamma = 23.0 \pm 2.7$ MeV (S = 1.1)

$\Gamma_{ee} = 0.242^{+0.027}_{-0.024}$ keV (S = 1.1)

In addition to the dominant decay mode to $D\bar{D}$, $\psi(3770)$ was found to decay into the final states containing the J/ψ (BAI 05, ADAM 06). ADAMS 06 and HUANG 06A searched for various decay modes with light hadrons and found a statistically significant signal for the decay to $\phi\eta$ only (ADAMS 06).

| $\psi(3770)$ DECAY MODES | Fraction (Γ_i/Γ) | Scale factor/ Confidence level | p (MeV/c) |
|--|----------------------------------|-----------------------------------|----------------|
| $D\bar{D}$ | dominant | | 281 |
| $D^0\bar{D}^0$ | seen | | 281 |
| D^+D^- | seen | | 247 |
| $J/\psi\pi^+\pi^-$ | $(1.93 \pm 0.28) \times 10^{-3}$ | | 558 |
| $J/\psi\pi^0\pi^0$ | $(8.0 \pm 3.0) \times 10^{-4}$ | | 562 |
| $J/\psi\eta$ | $(9 \pm 4) \times 10^{-4}$ | | 357 |
| $J/\psi\pi^0$ | $< 2.8 \times 10^{-4}$ | CL=90% | 601 |
| e^+e^- | $(1.05 \pm 0.14) \times 10^{-5}$ | S=1.1 | 1886 |
| $K_S^0 K_L^0$ | $< 2.1 \times 10^{-4}$ | CL=90% | 1819 |
| $2(\pi^+\pi^-)$ | $< 1.12 \times 10^{-3}$ | CL=90% | 1860 |
| $2(\pi^+\pi^-)\pi^0$ | $< 1.06 \times 10^{-3}$ | CL=90% | 1842 |
| $\eta\pi^+\pi^-$ | $< 1.24 \times 10^{-3}$ | CL=90% | 1835 |
| $\omega\pi^+\pi^-$ | $< 6.0 \times 10^{-4}$ | CL=90% | 1793 |
| $\eta 3\pi$ | $< 1.34 \times 10^{-3}$ | CL=90% | 1823 |
| $\eta' 3\pi$ | $< 2.44 \times 10^{-3}$ | CL=90% | 1739 |
| $K^+K^-\pi^+\pi^-$ | $< 9.0 \times 10^{-4}$ | CL=90% | 1771 |
| $\phi\pi^+\pi^-$ | $< 4.1 \times 10^{-4}$ | CL=90% | 1736 |
| $\phi f_0(980)$ | $< 4.5 \times 10^{-4}$ | CL=90% | 1599 |
| $K^+K^-\pi^+\pi^-\pi^0$ | $< 2.36 \times 10^{-3}$ | CL=90% | 1740 |
| ηK^+K^- | $< 4.1 \times 10^{-4}$ | CL=90% | 1711 |
| ωK^+K^- | $< 3.4 \times 10^{-4}$ | CL=90% | 1663 |
| $2(K^+K^-)$ | $< 6.0 \times 10^{-4}$ | CL=90% | 1550 |
| ϕK^+K^- | $< 7.5 \times 10^{-4}$ | CL=90% | 1596 |
| $2(K^+K^-)\pi^0$ | $< 2.9 \times 10^{-4}$ | CL=90% | 1492 |
| $p\bar{p}\pi^+\pi^-$ | $< 5.8 \times 10^{-4}$ | CL=90% | 1543 |
| $p\bar{p}\pi^+\pi^-\pi^0$ | $< 1.85 \times 10^{-3}$ | CL=90% | 1489 |

| | | | | |
|-------------------------------------|--------------------------------|------------------|--------|------|
| $\eta p \bar{p}$ | < 5.4 | $\times 10^{-4}$ | CL=90% | 1429 |
| $\omega p \bar{p}$ | < 2.9 | $\times 10^{-4}$ | CL=90% | 1308 |
| $p \bar{p} K^+ K^-$ | < 3.2 | $\times 10^{-4}$ | CL=90% | 1184 |
| $\phi p \bar{p}$ | < 1.3 | $\times 10^{-4}$ | CL=90% | 1176 |
| $\Lambda \bar{\Lambda}$ | < 1.2 | $\times 10^{-4}$ | CL=90% | 1520 |
| $\Lambda \bar{\Lambda} \pi^+ \pi^-$ | < 2.5 | $\times 10^{-4}$ | CL=90% | 1403 |
| $\Lambda \bar{p} K^+$ | < 2.8 | $\times 10^{-4}$ | CL=90% | 1385 |
| $\Lambda \bar{p} K^+ \pi^+ \pi^-$ | < 6.3 | $\times 10^{-4}$ | CL=90% | 1232 |
| $\phi \eta$ | $(3.1 \pm 0.7) \times 10^{-4}$ | | | 1702 |
| $\pi^+ \pi^- \pi^0$ | not seen | | | 1873 |
| $\rho \pi$ | not seen | | | 1803 |
| $\omega \pi^0$ | not seen | | | 1802 |
| $\phi \pi^0$ | not seen | | | 1745 |
| $\rho \eta$ | not seen | | | 1762 |
| $\omega \eta$ | not seen | | | 1761 |
| $\rho \eta'$ | not seen | | | 1673 |
| $\omega \eta'$ | not seen | | | 1671 |
| $\phi \eta'$ | not seen | | | 1605 |
| $K^{*0} \bar{K}^0$ | not seen | | | 1743 |
| $K^{*+} K^-$ | not seen | | | 1744 |
| $b_1 \pi$ | not seen | | | 1682 |

X(3872)

$$I^G(J^{PC}) = 0^?(?^{?+})$$

Quantum numbers not established.

$$\text{Mass } m = 3871.2 \pm 0.5 \text{ MeV} \quad (S = 1.4)$$

$$m_{X(3872)^\pm} - m_{J/\psi} = 775 \pm 4 \text{ MeV}$$

$$m_{X(3872)^\pm} - m_{\psi(2S)}$$

$$\text{Full width } \Gamma < 2.3 \text{ MeV, CL} = 90\%$$

| X(3872) DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|----------------------------|--------------------------------|-------------|
| $\pi^+ \pi^- J/\psi(1S)$ | seen | 649 |
| $D^0 \bar{D}^0$ | not seen | 520 |
| $D^+ D^-$ | not seen | 502 |
| $D^0 \bar{D}^0 \pi^0$ | not seen | 117 |

 $\chi_{c2}(2P)$

$$I^G(J^{PC}) = 0^+(2^{++})$$

$$\text{Mass } m = 3929 \pm 5 \text{ MeV}$$

$$\text{Full width } \Gamma = 29 \pm 10 \text{ MeV}$$

$\psi(4040)$ [xxx]

$$J^{PC} = 0^-(1^--)$$

Mass $m = 4039 \pm 1$ MeVFull width $\Gamma = 80 \pm 10$ MeV $\Gamma_{ee} = 0.86 \pm 0.07$ keV

| $\psi(4040)$ DECAY MODES | Fraction (Γ_i/Γ) | Confidence level | P (MeV/c) |
|--|----------------------------------|------------------|----------------|
| e^+e^- | $(1.07 \pm 0.16) \times 10^{-5}$ | | 2019 |
| $D^0\bar{D}^0$ | seen | | 776 |
| $D^{*0}(2007)\bar{D}^0 + \text{c.c.}$ | seen | | 576 |
| $D^{*0}(2007)\bar{D}^{*0}(2007)$ | seen | | 227 |
| $J/\psi\pi^+\pi^-$ | < 4 | $\times 10^{-3}$ | 90% 794 |
| $J/\psi\pi^0\pi^0$ | < 2 | $\times 10^{-3}$ | 90% 797 |
| $J/\psi\eta$ | < 7 | $\times 10^{-3}$ | 90% 675 |
| $J/\psi\pi^0$ | < 2 | $\times 10^{-3}$ | 90% 823 |
| $J/\psi\pi^+\pi^-\pi^0$ | < 2 | $\times 10^{-3}$ | 90% 746 |
| $\chi_{c1}\gamma$ | < 1.1 | % | 90% 494 |
| $\chi_{c2}\gamma$ | < 1.7 | % | 90% 454 |
| $\chi_{c1}\pi^+\pi^-\pi^0$ | < 1.1 | % | 90% 306 |
| $\chi_{c2}\pi^+\pi^-\pi^0$ | < 3.2 | % | 90% 233 |
| $\phi\pi^+\pi^-$ | < 3 | $\times 10^{-3}$ | 90% 1880 |

 $\psi(4160)$ [xxx]

$$J^{PC} = 0^-(1^--)$$

Mass $m = 4153 \pm 3$ MeVFull width $\Gamma = 103 \pm 8$ MeV $\Gamma_{ee} = 0.83 \pm 0.07$ keV

| $\psi(4160)$ DECAY MODES | Fraction (Γ_i/Γ) | Confidence level | P (MeV/c) |
|--|--------------------------------|------------------|----------------|
| e^+e^- | $(8.1 \pm 0.9) \times 10^{-6}$ | | 2076 |
| $J/\psi\pi^+\pi^-$ | < 3 | $\times 10^{-3}$ | 90% 888 |
| $J/\psi\pi^0\pi^0$ | < 3 | $\times 10^{-3}$ | 90% 891 |
| $J/\psi K^+K^-$ | < 2 | $\times 10^{-3}$ | 90% 324 |
| $J/\psi\eta$ | < 8 | $\times 10^{-3}$ | 90% 786 |
| $J/\psi\pi^0$ | < 1 | $\times 10^{-3}$ | 90% 914 |
| $J/\psi\eta'$ | < 5 | $\times 10^{-3}$ | 90% 385 |
| $J/\psi\pi^+\pi^-\pi^0$ | < 1 | $\times 10^{-3}$ | 90% 847 |
| $\psi(2S)\pi^+\pi^-$ | < 4 | $\times 10^{-3}$ | 90% 353 |
| $\chi_{c1}\gamma$ | < 7 | $\times 10^{-3}$ | 90% 593 |
| $\chi_{c2}\gamma$ | < 1.3 | % | 90% 554 |

| | | | | |
|-------------------------------|-------|------------------|-----|------|
| $\chi_{c1} \pi^+ \pi^- \pi^0$ | < 2 | $\times 10^{-3}$ | 90% | 452 |
| $\chi_{c2} \pi^+ \pi^- \pi^0$ | < 8 | $\times 10^{-3}$ | 90% | 398 |
| $\phi \pi^+ \pi^-$ | < 2 | $\times 10^{-3}$ | 90% | 1941 |

 $\psi(4415)$ [xxx]

$$J^{PC} = 0^-(1^--)$$

Mass $m = 4421 \pm 4$ MeVFull width $\Gamma = 62 \pm 20$ MeV $\Gamma_{ee} = 0.58 \pm 0.07$ keV

| $\psi(4415)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|--|--------------------------------|-------------|
| hadrons | dominant | — |
| $e^+ e^-$ | $(9.4 \pm 3.2) \times 10^{-6}$ | 2210 |

$b\bar{b}$ MESONS

 $\Upsilon(1S)$

$$J^{PC} = 0^-(1^--)$$

Mass $m = 9460.30 \pm 0.26$ MeV ($S = 3.3$)Full width $\Gamma = 54.02 \pm 1.25$ keV $\Gamma_{ee} = 1.340 \pm 0.018$ keV

| $\Upsilon(1S)$ DECAY MODES | Fraction (Γ_i/Γ) | Confidence level | p (MeV/c) |
|--|--------------------------------|------------------|-------------|
| $\tau^+ \tau^-$ | $(2.67^{+0.14}_{-0.16}) \%$ | | 4384 |
| $e^+ e^-$ | $(2.38 \pm 0.11) \%$ | | 4730 |
| $\mu^+ \mu^-$ | $(2.48 \pm 0.05) \%$ | | 4729 |

Hadronic decays

| | | | |
|-----------------------|--------------------------------|-----|------|
| $\eta'(958)$ anything | $(2.8 \pm 0.4) \%$ | | — |
| $J/\psi(1S)$ anything | $(6.5 \pm 0.7) \times 10^{-4}$ | | 4223 |
| χ_{c0} anything | $< 5 \times 10^{-3}$ | 90% | — |
| χ_{c1} anything | $(2.3 \pm 0.7) \times 10^{-4}$ | | — |
| χ_{c2} anything | $(3.4 \pm 1.0) \times 10^{-4}$ | | — |
| $\psi(2S)$ anything | $(2.7 \pm 0.9) \times 10^{-4}$ | | — |
| $\rho \pi$ | $< 2 \times 10^{-4}$ | 90% | 4697 |
| $\pi^+ \pi^-$ | $< 5 \times 10^{-4}$ | 90% | 4728 |
| $K^+ K^-$ | $< 5 \times 10^{-4}$ | 90% | 4704 |
| $p\bar{p}$ | $< 5 \times 10^{-4}$ | 90% | 4636 |
| $\pi^0 \pi^+ \pi^-$ | $< 1.84 \times 10^{-5}$ | 90% | 4725 |

Radiative decays

| | | | |
|---|--------------------------------------|-----|------|
| $\gamma \pi^+ \pi^-$ | $(6.3 \pm 1.8) \times 10^{-5}$ | | 4728 |
| $\gamma \pi^0 \pi^0$ | $(1.7 \pm 0.7) \times 10^{-5}$ | | 4728 |
| $K^+ K^-$ with $2 < m_{K^+ K^-} < 3$ GeV | $(1.14 \pm 0.13) \times 10^{-5}$ | | — |
| $\gamma p \bar{p}$ with $2 < m_{p \bar{p}} < 3$ GeV | $< 6 \times 10^{-6}$ | 90% | — |
| $\gamma 2h^+ 2h^-$ | $(7.0 \pm 1.5) \times 10^{-4}$ | | 4720 |
| $\gamma 3h^+ 3h^-$ | $(5.4 \pm 2.0) \times 10^{-4}$ | | 4703 |
| $\gamma 4h^+ 4h^-$ | $(7.4 \pm 3.5) \times 10^{-4}$ | | 4679 |
| $\gamma \pi^+ \pi^- K^+ K^-$ | $(2.9 \pm 0.9) \times 10^{-4}$ | | 4686 |
| $\gamma 2\pi^+ 2\pi^-$ | $(2.5 \pm 0.9) \times 10^{-4}$ | | 4720 |
| $\gamma 3\pi^+ 3\pi^-$ | $(2.5 \pm 1.2) \times 10^{-4}$ | | 4703 |
| $\gamma 2\pi^+ 2\pi^- K^+ K^-$ | $(2.4 \pm 1.2) \times 10^{-4}$ | | 4658 |
| $\gamma \pi^+ \pi^- p \bar{p}$ | $(1.5 \pm 0.6) \times 10^{-4}$ | | 4604 |
| $\gamma 2\pi^+ 2\pi^- p \bar{p}$ | $(4 \pm 6) \times 10^{-5}$ | | 4563 |
| $\gamma 2K^+ 2K^-$ | $(2.0 \pm 2.0) \times 10^{-5}$ | | 4601 |
| $\gamma \eta'(958)$ | $< 1.6 \times 10^{-5}$ | 90% | 4682 |
| $\gamma \eta$ | $< 2.1 \times 10^{-5}$ | 90% | 4714 |
| $\gamma f_0(980)$ | $< 3 \times 10^{-5}$ | 90% | 4679 |
| $\gamma f'_2(1525)$ | $(3.7^{+1.2}_{-1.1}) \times 10^{-5}$ | | 4607 |
| $\gamma f_2(1270)$ | $(1.00 \pm 0.10) \times 10^{-4}$ | | 4644 |
| $\gamma \eta(1405)$ | $< 8.2 \times 10^{-5}$ | 90% | 4625 |
| $\gamma f_0(1710)$ | $< 1.8 \times 10^{-4}$ | 90% | 4574 |
| $\gamma f_4(2050)$ | $< 5.3 \times 10^{-5}$ | 90% | 4513 |
| $\gamma f_0(2200) \rightarrow \gamma K^+ K^-$ | $< 2 \times 10^{-4}$ | 90% | 4475 |
| $\gamma f_J(2220) \rightarrow \gamma K^+ K^-$ | $< 8 \times 10^{-7}$ | 90% | 4469 |
| $\gamma f_J(2220) \rightarrow \gamma \pi^+ \pi^-$ | $< 6 \times 10^{-7}$ | 90% | — |
| $\gamma f_J(2220) \rightarrow \gamma p \bar{p}$ | $< 1.1 \times 10^{-6}$ | 90% | — |
| $\gamma \eta(2225) \rightarrow \gamma \phi \phi$ | $< 3 \times 10^{-3}$ | 90% | 4469 |
| γX (X = pseudoscalar with $m < 7.2$ GeV) | $< 3 \times 10^{-5}$ | 90% | — |
| $\gamma X \bar{X}$ ($X \bar{X}$ = vectors with $m < 3.1$ GeV) | $< 1 \times 10^{-3}$ | 90% | — |

 $\chi_{b0}(1P)$ [$\gamma\gamma\gamma$]
 $I^G(J^{PC}) = 0^+(0^{++})$
 J needs confirmation.
Mass $m = 9859.44 \pm 0.42 \pm 0.31$ MeV

| $\chi_{b0}(1P)$ DECAY MODES | Fraction (Γ_i/Γ) | Confidence level | $\frac{p}{(\text{MeV}/c)}$ |
|---|--------------------------------|------------------|----------------------------|
| $\gamma \Upsilon(1S)$ | $< 6\%$ | 90% | 391 |

$\chi_{b1}(1P)$ [$\gamma\gamma\gamma$]

$$J^G(J^{PC}) = 0^+(1^{++})$$

J needs confirmation.

$$\text{Mass } m = 9892.78 \pm 0.26 \pm 0.31 \text{ MeV}$$

| $\chi_{b1}(1P)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|---|--------------------------------|-------------|
| $\gamma \Upsilon(1S)$ | (35±8) % | 423 |

 $\chi_{b2}(1P)$ [$\gamma\gamma\gamma$]

$$J^G(J^{PC}) = 0^+(2^{++})$$

J needs confirmation.

$$\text{Mass } m = 9912.21 \pm 0.26 \pm 0.31 \text{ MeV}$$

| $\chi_{b2}(1P)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|---|--------------------------------|-------------|
| $\gamma \Upsilon(1S)$ | (22±4) % | 442 |

 $\Upsilon(2S)$

$$J^G(J^{PC}) = 0^-(1^{--})$$

$$\text{Mass } m = 10.02326 \pm 0.00031 \text{ GeV}$$

$$\text{Full width } \Gamma = 31.98 \pm 2.63 \text{ keV}$$

$$\Gamma_{ee} = 0.612 \pm 0.011 \text{ keV}$$

| $\Upsilon(2S)$ DECAY MODES | Fraction (Γ_i/Γ) | Scale factor/ Confidence level | p (MeV/c) |
|--|--------------------------------|-----------------------------------|----------------|
| $\Upsilon(1S) \pi^+ \pi^-$ | (18.8 ± 0.6) % | | 475 |
| $\Upsilon(1S) \pi^0 \pi^0$ | (9.0 ± 0.8) % | | 480 |
| $\tau^+ \tau^-$ | (1.7 ± 1.6) % | | 4686 |
| $\mu^+ \mu^-$ | (1.93±0.17) % | S=2.2 | 5011 |
| $e^+ e^-$ | (1.91±0.16) % | | 5012 |
| $\Upsilon(1S) \pi^0$ | < 1.1 | $\times 10^{-3}$ CL=90% | 531 |
| $\Upsilon(1S) \eta$ | < 2 | $\times 10^{-3}$ CL=90% | 127 |
| $J/\psi(1S)$ anything | < 6 | $\times 10^{-3}$ CL=90% | 4533 |

Radiative decays

| | | | |
|------------------------|-----------------|-------------------------|------|
| $\gamma \chi_{b1}(1P)$ | (6.9 ± 0.4) % | | 130 |
| $\gamma \chi_{b2}(1P)$ | (7.15±0.35) % | | 110 |
| $\gamma \chi_{b0}(1P)$ | (3.8 ± 0.4) % | | 162 |
| $\gamma f_0(1710)$ | < 5.9 | $\times 10^{-4}$ CL=90% | 4864 |
| $\gamma f'_2(1525)$ | < 5.3 | $\times 10^{-4}$ CL=90% | 4896 |
| $\gamma f_2(1270)$ | < 2.41 | $\times 10^{-4}$ CL=90% | 4930 |
| $\gamma \eta_b(1S)$ | < 5.1 | $\times 10^{-4}$ CL=90% | 697 |

$\chi_{b0}(2P)$ [$\gamma\gamma\gamma$]

$$I^G(J^{PC}) = 0^+(0^{++})$$

 J needs confirmation.

$$\text{Mass } m = 10.2325 \pm 0.0004 \pm 0.0005 \text{ GeV}$$

| $\chi_{b0}(2P)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|---|--------------------------------|-------------|
| $\gamma \Upsilon(2S)$ | $(4.6 \pm 2.1) \%$ | 207 |
| $\gamma \Upsilon(1S)$ | $(9 \pm 6) \times 10^{-3}$ | 743 |

 $\chi_{b1}(2P)$ [$\gamma\gamma\gamma$]

$$I^G(J^{PC}) = 0^+(1^{++})$$

 J needs confirmation.

$$\text{Mass } m = 10.25546 \pm 0.00022 \pm 0.00050 \text{ GeV}$$

$$m_{\chi_{b1}(2P)} - m_{\chi_{b0}(2P)} = 23.5 \pm 1.0 \text{ MeV}$$

| $\chi_{b1}(2P)$ DECAY MODES | Fraction (Γ_i/Γ) | Scale factor | p (MeV/c) |
|---|--------------------------------|--------------|-------------|
| $\omega \Upsilon(1S)$ | $(1.63^{+0.38}_{-0.34}) \%$ | | 135 |
| $\gamma \Upsilon(2S)$ | $(21 \pm 4) \%$ | 1.5 | 230 |
| $\gamma \Upsilon(1S)$ | $(8.5 \pm 1.3) \%$ | 1.3 | 764 |
| $\pi\pi \chi_{b1}(1P)$ | $(8.6 \pm 3.1) \times 10^{-3}$ | | 238 |

 $\chi_{b2}(2P)$ [$\gamma\gamma\gamma$]

$$I^G(J^{PC}) = 0^+(2^{++})$$

 J needs confirmation.

$$\text{Mass } m = 10.26865 \pm 0.00022 \pm 0.00050 \text{ GeV}$$

$$m_{\chi_{b2}(2P)} - m_{\chi_{b1}(2P)} = 13.5 \pm 0.6 \text{ MeV}$$

| $\chi_{b2}(2P)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|---|--------------------------------|-------------|
| $\omega \Upsilon(1S)$ | $(1.10^{+0.34}_{-0.30}) \%$ | 194 |
| $\gamma \Upsilon(2S)$ | $(16.2 \pm 2.4) \%$ | 242 |
| $\gamma \Upsilon(1S)$ | $(7.1 \pm 1.0) \%$ | 777 |
| $\pi\pi \chi_{b2}(1P)$ | $(6.0 \pm 2.1) \times 10^{-3}$ | 229 |

 $\Upsilon(3S)$

$$I^G(J^{PC}) = 0^-(1^{--})$$

$$\text{Mass } m = 10.3552 \pm 0.0005 \text{ GeV}$$

$$\text{Full width } \Gamma = 20.32 \pm 1.85 \text{ keV}$$

$$\Gamma_{ee} = 0.443 \pm 0.008 \text{ keV}$$

| $\Upsilon(3S)$ DECAY MODES | Fraction (Γ_i/Γ) | Scale factor/ Confidence level | p (MeV/c) |
|--|--------------------------------|-----------------------------------|----------------|
| $\Upsilon(2S)$ anything | (10.6 \pm 0.8) % | | 296 |
| $\Upsilon(2S)\pi^+\pi^-$ | (2.8 \pm 0.6) % | S=2.2 | 177 |
| $\Upsilon(2S)\pi^0\pi^0$ | (2.00 \pm 0.32) % | | 190 |
| $\Upsilon(2S)\gamma\gamma$ | (5.0 \pm 0.7) % | | 327 |
| $\Upsilon(1S)\pi^+\pi^-$ | (4.48 \pm 0.21) % | | 813 |
| $\Upsilon(1S)\pi^0\pi^0$ | (2.06 \pm 0.28) % | | 816 |
| $\Upsilon(1S)\eta$ | < 2.2 $\times 10^{-3}$ | CL=90% | 677 |
| $\mu^+\mu^-$ | (2.18 \pm 0.21) % | S=2.1 | 5177 |
| e^+e^- | seen | | 5178 |

Radiative decays

| | | | |
|-----------------------|------------------------------------|--------|------|
| $\gamma\chi_{b2}(2P)$ | (13.1 \pm 1.6) % | S=3.4 | 86 |
| $\gamma\chi_{b1}(2P)$ | (12.6 \pm 1.2) % | S=2.4 | 99 |
| $\gamma\chi_{b0}(2P)$ | (5.9 \pm 0.6) % | S=1.4 | 122 |
| $\gamma\chi_{b0}(1P)$ | (3.0 \pm 1.1) $\times 10^{-3}$ | | 484 |
| $\gamma\eta_b(2S)$ | < 6.2 $\times 10^{-4}$ | CL=90% | — |
| $\gamma\eta_b(1S)$ | < 4.3 $\times 10^{-4}$ | CL=90% | 1001 |

$\Upsilon(4S)$
 or **$\Upsilon(10580)$**

$$J^{PC} = 0^-(1^--)$$

Mass $m = 10.5794 \pm 0.0012$ GeVFull width $\Gamma = 20.5 \pm 2.5$ MeV $\Gamma_{ee} = 0.272 \pm 0.029$ keV (S = 1.5)

| $\Upsilon(4S)$ DECAY MODES | Fraction (Γ_i/Γ) | Confidence level | p (MeV/c) |
|--|-------------------------------------|------------------|----------------|
| $B\bar{B}$ | > 96 % | 95% | 330 |
| B^+B^- | (50.6 \pm 0.8) % | | 335 |
| D_s^+ anything + c.c. | (18.2 \pm 3.2) % | | — |
| $B^0\bar{B}^0$ | (49.4 \pm 0.8) % | | 330 |
| non- $B\bar{B}$ | < 4 % | 95% | — |
| e^+e^- | (1.57 \pm 0.08) $\times 10^{-5}$ | | 5290 |
| $J/\psi(1S)$ anything | < 1.9 $\times 10^{-4}$ | 95% | — |
| D^{*+} anything + c.c. | < 7.4 % | 90% | 5099 |
| ϕ anything | < 2.3 $\times 10^{-3}$ | 90% | 5240 |
| $\Upsilon(1S)$ anything | < 4 $\times 10^{-3}$ | 90% | 1053 |
| $\Upsilon(1S)\pi^+\pi^-$ | < 1.2 $\times 10^{-4}$ | 90% | 1026 |
| $\Upsilon(2S)\pi^+\pi^-$ | < 3.9 $\times 10^{-4}$ | 90% | 468 |

$\Upsilon(10860)$

$$J^{PC} = 0^{-}(1^{-}-)$$

Mass $m = 10.865 \pm 0.008$ GeV ($S = 1.1$)

Full width $\Gamma = 110 \pm 13$ MeV

$\Gamma_{ee} = 0.31 \pm 0.07$ keV ($S = 1.3$)

| $\Upsilon(10860)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|-------------------------------|--------------------------------|-------------|
| $e^+ e^-$ | $(2.8 \pm 0.7) \times 10^{-6}$ | 5432 |
| D_s anything + c.c. | $(45 \pm 11) \%$ | — |

$\Upsilon(11020)$

$$J^{PC} = 0^{-}(1^{-}-)$$

Mass $m = 11.019 \pm 0.008$ GeV

Full width $\Gamma = 79 \pm 16$ MeV

$\Gamma_{ee} = 0.130 \pm 0.030$ keV

| $\Upsilon(11020)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|-------------------------------|--------------------------------|-------------|
| $e^+ e^-$ | $(1.6 \pm 0.5) \times 10^{-6}$ | 5510 |

NOTES

- [a] See the “Note on $\pi^\pm \rightarrow \ell^\pm \nu \gamma$ and $K^\pm \rightarrow \ell^\pm \nu \gamma$ Form Factors” in the π^\pm Particle Listings for definitions and details.
- [b] Measurements of $\Gamma(e^+ \nu_e)/\Gamma(\mu^+ \nu_\mu)$ always include decays with γ 's, and measurements of $\Gamma(e^+ \nu_e \gamma)$ and $\Gamma(\mu^+ \nu_\mu \gamma)$ never include low-energy γ 's. Therefore, since no clean separation is possible, we consider the modes with γ 's to be subreactions of the modes without them, and let $[\Gamma(e^+ \nu_e) + \Gamma(\mu^+ \nu_\mu)]/\Gamma_{\text{total}} = 100\%$.
- [c] See the π^\pm Particle Listings for the energy limits used in this measurement; low-energy γ 's are not included.
- [d] Derived from an analysis of neutrino-oscillation experiments.
- [e] Astrophysical and cosmological arguments give limits of order 10^{-13} ; see the π^0 Particle Listings.
- [f] Due to a new measurement in the average, this is 0.45 MeV larger than the mass we gave in our 2002 edition, 547.30 ± 0.12 MeV.
- [g] Due to removing an old measurement from the average, this is 0.11 keV larger than the width we gave in our 2002 edition, 1.18 ± 0.11 keV. See the $\Gamma(2\gamma)$ data block in the Data Listings.
- [h] C parity forbids this to occur as a single-photon process.
- [i] See the “Note on scalar mesons” in the $f_0(1370)$ Particle Listings . The interpretation of this entry as a particle is controversial.
- [j] See the “Note on $\rho(770)$ ” in the $\rho(770)$ Particle Listings .
- [k] The $\omega\rho$ interference is then due to $\omega\rho$ mixing only, and is expected to be small. If $e\mu$ universality holds, $\Gamma(\rho^0 \rightarrow \mu^+ \mu^-) = \Gamma(\rho^0 \rightarrow e^+ e^-) \times 0.99785$.
- [l] See the “Note on scalar mesons” in the $f_0(1370)$ Particle Listings .
- [m] See the “Note on $a_1(1260)$ ” in the $a_1(1260)$ Particle Listings .
- [n] This is only an educated guess; the error given is larger than the error on the average of the published values. See the Particle Listings for details.
- [o] See the “Note on non- $q\bar{q}$ mesons” in the Particle Listings (see the index for the page number).
- [p] See the “Note on the $\eta(1405)$ ” in the $\eta(1405)$ Particle Listings.
- [q] See the “Note on the $f_1(1420)$ ” in the $\eta(1405)$ Particle Listings.
- [r] See also the $\omega(1650)$ Particle Listings.
- [s] See the “Note on the $\rho(1450)$ and the $\rho(1700)$ ” in the $\rho(1700)$ Particle Listings.
- [t] See also the $\omega(1420)$ Particle Listings.
- [u] See the “Note on $f_0(1710)$ ” in the $f_0(1710)$ Particle Listings .

[v] See the note in the K^\pm Particle Listings.

[w] The definition of the slope parameter g of the $K \rightarrow 3\pi$ Dalitz plot is as follows (see also “Note on Dalitz Plot Parameters for $K \rightarrow 3\pi$ Decays” in the K^\pm Particle Listings):

$$|M|^2 = 1 + g(s_3 - s_0)/m_{\pi^+}^2 + \dots$$

[x] For more details and definitions of parameters see the Particle Listings.

[y] Most of this radiative mode, the low-momentum γ part, is also included in the parent mode listed without γ 's.

[z] See the K^\pm Particle Listings for the energy limits used in this measurement.

[aa] Structure-dependent part.

[bb] Direct-emission branching fraction.

[cc] Violates angular-momentum conservation.

[dd] Derived from measured values of ϕ_{+-} , ϕ_{00} , $|\eta|$, $|m_{K_L^0} - m_{K_S^0}|$, and $\tau_{K_S^0}$, as described in the introduction to “Tests of Conservation Laws.”

[ee] The CP -violation parameters are defined as follows (see also “Note on CP Violation in $K_S \rightarrow 3\pi$ ” and “Note on CP Violation in K_L^0 Decay” in the Particle Listings):

$$\eta_{+-} = |\eta_{+-}|e^{i\phi_{+-}} = \frac{A(K_L^0 \rightarrow \pi^+\pi^-)}{A(K_S^0 \rightarrow \pi^+\pi^-)} = \epsilon + \epsilon'$$

$$\eta_{00} = |\eta_{00}|e^{i\phi_{00}} = \frac{A(K_L^0 \rightarrow \pi^0\pi^0)}{A(K_S^0 \rightarrow \pi^0\pi^0)} = \epsilon - 2\epsilon'$$

$$\delta = \frac{\Gamma(K_L^0 \rightarrow \pi^-\ell^+\nu) - \Gamma(K_L^0 \rightarrow \pi^+\ell^-\nu)}{\Gamma(K_L^0 \rightarrow \pi^-\ell^+\nu) + \Gamma(K_L^0 \rightarrow \pi^+\ell^-\nu)},$$

$$\text{Im}(\eta_{+-0})^2 = \frac{\Gamma(K_S^0 \rightarrow \pi^+\pi^-\pi^0)^{CP \text{ viol.}}}{\Gamma(K_L^0 \rightarrow \pi^+\pi^-\pi^0)},$$

$$\text{Im}(\eta_{000})^2 = \frac{\Gamma(K_S^0 \rightarrow \pi^0\pi^0\pi^0)}{\Gamma(K_L^0 \rightarrow \pi^0\pi^0\pi^0)}.$$

where for the last two relations CPT is assumed valid, *i.e.*, $\text{Re}(\eta_{+-0}) \simeq 0$ and $\text{Re}(\eta_{000}) \simeq 0$.

[ff] See the K_S^0 Particle Listings for the energy limits used in this measurement.

[gg] The value is for the sum of the charge states or particle/antiparticle states indicated.

- [hh] $\text{Re}(\epsilon'/\epsilon) = \epsilon'/\epsilon$ to a very good approximation provided the phases satisfy *CPT* invariance.
- [ii] See the K_L^0 Particle Listings for the energy limits used in this measurement.
- [jj] Allowed by higher-order electroweak interactions.
- [kk] Violates *CP* in leading order. Test of direct *CP* violation since the indirect *CP*-violating and *CP*-conserving contributions are expected to be suppressed.
- [ll] See the “Note on $f_0(1370)$ ” in the $f_0(1370)$ Particle Listings and in the 1994 edition.
- [mm] See the note in the $L(1770)$ Particle Listings in Reviews of Modern Physics **56** No. 2 Pt. II (1984), p. S200. See also the “Note on $K_2(1770)$ and the $K_2(1820)$ ” in the $K_2(1770)$ Particle Listings .
- [nn] See the “Note on $K_2(1770)$ and the $K_2(1820)$ ” in the $K_2(1770)$ Particle Listings .
- [oo] This result applies to $Z^0 \rightarrow c\bar{c}$ decays only. Here ℓ^+ is an average (not a sum) of e^+ and μ^+ decays.
- [pp] 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.
- [qq] 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.
- [rr] These subfractions of the $K^- \pi^+ \pi^+$ mode are uncertain: see the Particle Listings.
- [ss] The two experiments measuring this fraction are in serious disagreement. See the Particle Listings.
- [tt] This is *not* a test for the $\Delta C=1$ weak neutral current, but leads to the $\pi^+ e^+ e^-$ final state.
- [uu] This mode is not a useful test for a $\Delta C=1$ weak neutral current because both quarks must change flavor in this decay.
- [vv] 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.
- [ww] This value is obtained by subtracting the branching fractions for 2-, 4- and 6-prongs from unity.
- [xx] 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.
- [yy] 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 ± 0.20 %.

- [zz] This is a doubly Cabibbo-suppressed mode.
- [aaa] This branching fraction includes all the decay modes of the resonance in the final state.
- [bbb] The experiments on the division of this charge mode amongst its sub-modes disagree, and the submode branching fractions here add up to considerably more than the charged-mode fraction.
- [ccc] However, these upper limits are in serious disagreement with values obtained in another experiment.
- [ddd] For now, we average together measurements of the $X e^+ \nu_e$ and $X \mu^+ \nu_\mu$ branching fractions. This is the *average*, not the *sum*.
- [eee] This branching fraction includes all the decay modes of the final-state resonance.
- [fff] This comes from a K -matrix parametrization of the $\pi^+ \pi^-$ S -wave and is a sum over the $f_0(980)$, $f_0(1300)$, $f_0(1200\text{--}1600)$, $f_0(1500)$, and $f_0(1750)$. Not all of these correspond to particles in our Tables.
- [ggg] An ℓ indicates an e or a μ mode, not a sum over these modes.
- [hhh] An $CP(\pm 1)$ indicates the $CP=+1$ and $CP=-1$ eigenstates of the $D^0\text{--}\bar{D}^0$ system.
- [iii] D denotes D^0 or \bar{D}^0 .
- [jjj] $X(3872)^+$ is a hypothetical charged partner of the $X(3872)$.
- [kkk] $\Theta(1710)^{++}$ is a possible narrow pentaquark state and $G(2220)$ is a possible glueball resonance.
- [lll] Stands for the possible candidates of $K^*(1410)$, $K_0^*(1430)$ and $K_2^*(1430)$.
- [mmm] B^0 and B_s^0 contributions not separated. Limit is on weighted average of the two decay rates.
- [nnn] $\Theta(1540)^+$ denotes a possible narrow pentaquark state.
- [ooo] These values are model dependent.
- [ppp] Here “anything” means at least one particle observed.
- [qqq] D^{**} stands for the sum of the $D(1^1P_1)$, $D(1^3P_0)$, $D(1^3P_1)$, $D(1^3P_2)$, $D(2^1S_0)$, and $D(2^1S_1)$ resonances.
- [rrr] $D^{(*)}\bar{D}^{(*)}$ stands for the sum of $D^*\bar{D}^*$, $D^*\bar{D}$, $D\bar{D}^*$, and $D\bar{D}$.
- [sss] $Y(3940)$ denotes a near-threshold enhancement in the $\omega J/\psi$ mass spectrum.
- [ttt] Inclusive branching fractions have a multiplicity definition and can be greater than 100%.
- [uuu] D_j represents an unresolved mixture of pseudoscalar and tensor D^{**} (P -wave) states.
- [vvv] Not a pure measurement. See note at head of B_s^0 Decay Modes.

[www] Includes $p\bar{p}\pi^+\pi^-\gamma$ and excludes $p\bar{p}\eta$, $p\bar{p}\omega$, $p\bar{p}\eta'$.

[xxx] J^{PC} known by production in e^+e^- via single photon annihilation. I^G is not known; interpretation of this state as a single resonance is unclear because of the expectation of substantial threshold effects in this energy region.

[yyy] Spectroscopic labeling for these states is theoretical, pending experimental information.