

# LIGHT UNFLAVORED MESONS

## ( $S = C = B = 0$ )

For  $I = 1$  ( $\pi, \rho, \omega$ ):  $u\bar{d}, (u\bar{u}-d\bar{d})/\sqrt{2}, d\bar{u}$ ;  
 for  $I = 0$  ( $\eta, \eta', h, h', \omega, \phi, f, f'$ ):  $c_1(u\bar{u} + d\bar{d}) + c_2(s\bar{s})$

$\pi^\pm$

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

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]

$$F_V = 0.0254 \pm 0.0017$$

$$F_A = 0.0119 \pm 0.0001$$

$$F_V \text{ slope parameter } a = 0.10 \pm 0.06$$

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

$\pi^-$  modes are charge conjugates of the modes below.

For decay limits to particles which are not established, see the section on Searches for Axions and Other Very Light Bosons.

$\pi^+$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	Confidence level	$p$ (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] ( 7.39 $\pm$ 0.05 ) $\times 10^{-7}$		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

$\pi^0$

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

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  $\tau = (8.4 \pm 0.4) \times 10^{-17}$  s ( $S = 2.3$ )

$$c\tau = 25.2 \text{ nm}$$

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.).

$\pi^0$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	Scale factor/ Confidence level	$p$ (MeV/c)
$2\gamma$	$(98.823 \pm 0.034) \%$	S=1.5	67
$e^+ e^- \gamma$	$(1.174 \pm 0.035) \%$	S=1.5	67
$\gamma$ positronium	$(1.82 \pm 0.29) \times 10^{-9}$		67
$e^+ e^+ e^- e^-$	$(3.34 \pm 0.16) \times 10^{-5}$		67
$e^+ e^-$	$(6.46 \pm 0.33) \times 10^{-8}$		67
$4\gamma$	$< 2$	$\times 10^{-8}$ 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
<b>Charge conjugation (C) or Lepton Family number (LF) violating modes</b>			
$3\gamma$	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 $< 3.6$	$\times 10^{-10}$ CL=90%	26

## $\eta$

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

Mass  $m = 547.853 \pm 0.024$  MeV

Full width  $\Gamma = 1.30 \pm 0.07$  keV

### C-nonconserving decay parameters

$$\pi^+ \pi^- \pi^0 \text{ left-right asymmetry} = (0.09^{+0.11}_{-0.12}) \times 10^{-2}$$

$$\pi^+ \pi^- \pi^0 \text{ sextant asymmetry} = (0.12^{+0.10}_{-0.11}) \times 10^{-2}$$

$$\pi^+ \pi^- \pi^0 \text{ quadrant asymmetry} = (-0.09 \pm 0.09) \times 10^{-2}$$

$$\pi^+ \pi^- \gamma \text{ left-right asymmetry} = (0.9 \pm 0.4) \times 10^{-2}$$

$$\pi^+ \pi^- \gamma \beta \text{ (D-wave)} = -0.02 \pm 0.07 \quad (S = 1.3)$$

### CP-nonconserving decay parameters

$$\pi^+ \pi^- e^+ e^- \text{ decay-plane asymmetry } A_\phi = (-0.6 \pm 3.1) \times 10^{-2}$$

### Dalitz plot parameter

$$\pi^0 \pi^0 \pi^0 \quad \alpha = -0.0315 \pm 0.0015$$

$\eta$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	Scale factor/ Confidence level	$p$ (MeV/c)	
<b>Neutral modes</b>				
neutral modes	(71.90±0.34) %	S=1.2	—	
2 $\gamma$	(39.31±0.20) %	S=1.1	274	
3 $\pi^0$	(32.57±0.23) %	S=1.1	179	
$\pi^0 2\gamma$	( 2.7 ±0.5 ) × 10 <sup>-4</sup>	S=1.1	257	
2 $\pi^0 2\gamma$	< 1.2 × 10 <sup>-3</sup>	CL=90%	238	
4 $\gamma$	< 2.8 × 10 <sup>-4</sup>	CL=90%	274	
invisible	< 6 × 10 <sup>-4</sup>	CL=90%	—	
<b>Charged modes</b>				
charged modes	(28.10±0.34) %	S=1.2	—	
$\pi^+ \pi^- \pi^0$	(22.74±0.28) %	S=1.2	174	
$\pi^+ \pi^- \gamma$	( 4.60±0.16) %	S=2.1	236	
$e^+ e^- \gamma$	( 7.0 ±0.7 ) × 10 <sup>-3</sup>	S=1.5	274	
$\mu^+ \mu^- \gamma$	( 3.1 ±0.4 ) × 10 <sup>-4</sup>		253	
$e^+ e^-$	< 2.7 × 10 <sup>-5</sup>	CL=90%	274	
$\mu^+ \mu^-$	( 5.8 ±0.8 ) × 10 <sup>-6</sup>		253	
2 $e^+ 2e^-$	< 6.9 × 10 <sup>-5</sup>	CL=90%	274	
$\pi^+ \pi^- e^+ e^- (\gamma)$	( 2.68±0.11) × 10 <sup>-4</sup>		235	
$e^+ e^- \mu^+ \mu^-$	< 1.6 × 10 <sup>-4</sup>	CL=90%	253	
2 $\mu^+ 2\mu^-$	< 3.6 × 10 <sup>-4</sup>	CL=90%	161	
$\mu^+ \mu^- \pi^+ \pi^-$	< 3.6 × 10 <sup>-4</sup>	CL=90%	113	
$\pi^+ \pi^- 2\gamma$	< 2.0 × 10 <sup>-3</sup>		236	
$\pi^+ \pi^- \pi^0 \gamma$	< 5 × 10 <sup>-4</sup>	CL=90%	174	
$\pi^0 \mu^+ \mu^- \gamma$	< 3 × 10 <sup>-6</sup>	CL=90%	210	
<b>Charge conjugation (C), Parity (P), Charge conjugation × Parity (CP), or Lepton Family number (LF) violating modes</b>				
$\pi^0 \gamma$	C	< 9 × 10 <sup>-5</sup>	CL=90%	257
$\pi^+ \pi^-$	P,CP	< 1.3 × 10 <sup>-5</sup>	CL=90%	236
2 $\pi^0$	P,CP	< 3.5 × 10 <sup>-4</sup>	CL=90%	238
2 $\pi^0 \gamma$	C	< 5 × 10 <sup>-4</sup>	CL=90%	238
3 $\pi^0 \gamma$	C	< 6 × 10 <sup>-5</sup>	CL=90%	179
3 $\gamma$	C	< 1.6 × 10 <sup>-5</sup>	CL=90%	274
4 $\pi^0$	P,CP	< 6.9 × 10 <sup>-7</sup>	CL=90%	40
$\pi^0 e^+ e^-$	C	[f] < 4 × 10 <sup>-5</sup>	CL=90%	257
$\pi^0 \mu^+ \mu^-$	C	[f] < 5 × 10 <sup>-6</sup>	CL=90%	210
$\mu^+ e^- + \mu^- e^+$	LF	< 6 × 10 <sup>-6</sup>	CL=90%	264

**$f_0(600)$  [g]**  
or  $\sigma$

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

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

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

<b><math>f_0(600)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$\pi\pi$	dominant	—
$\gamma\gamma$	seen	—

**$\rho(770)$  [h]**

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

Mass  $m = 775.49 \pm 0.34$  MeV

Full width  $\Gamma = 149.1 \pm 0.8$  MeV

$\Gamma_{ee} = 7.04 \pm 0.06$  keV

<b><math>\rho(770)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	Scale factor/ Confidence level	$p$ (MeV/c)
$\pi\pi$	$\sim 100$	%	363
<b><math>\rho(770)^\pm</math> decays</b>			
$\pi^\pm\gamma$	( $4.5 \pm 0.5$ ) $\times 10^{-4}$	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
<b><math>\rho(770)^0</math> decays</b>			
$\pi^+\pi^-\gamma$	( $9.9 \pm 1.6$ ) $\times 10^{-3}$		362
$\pi^0\gamma$	( $6.0 \pm 0.8$ ) $\times 10^{-4}$		376
$\eta\gamma$	( $3.00 \pm 0.20$ ) $\times 10^{-4}$		194
$\pi^0\pi^0\gamma$	( $4.5 \pm 0.8$ ) $\times 10^{-5}$		363
$\mu^+\mu^-$	[i] ( $4.55 \pm 0.28$ ) $\times 10^{-5}$		373
$e^+e^-$	[i] ( $4.72 \pm 0.05$ ) $\times 10^{-5}$		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
$\pi^+\pi^-\pi^0\pi^0$	( $1.6 \pm 0.8$ ) $\times 10^{-5}$		257
$\pi^0e^+e^-$	< 1.2 $\times 10^{-5}$	CL=90%	376

**$\omega(782)$**

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

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

<b><math>\omega(782)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	Scale factor/ Confidence level	$p$ (MeV/c)
$\pi^+\pi^-\pi^0$	(89.2 $\pm$ 0.7) %		327
$\pi^0\gamma$	( 8.28 $\pm$ 0.28) %	S=2.1	380
$\pi^+\pi^-$	( 1.53 $^{+0.11}_{-0.13}$ ) %	S=1.2	366
neutrals (excluding $\pi^0\gamma$ )	( 8 $^{+8}_{-5}$ ) $\times 10^{-3}$	S=1.1	–
$\eta\gamma$	( 4.6 $\pm$ 0.4 ) $\times 10^{-4}$	S=1.1	200
$\pi^0e^+e^-$	( 7.7 $\pm$ 0.6 ) $\times 10^{-4}$		380
$\pi^0\mu^+\mu^-$	( 1.3 $\pm$ 0.4 ) $\times 10^{-4}$	S=2.1	349
$e^+e^-$	( 7.28 $\pm$ 0.14) $\times 10^{-5}$	S=1.3	391
$\pi^+\pi^-\pi^0\pi^0$	< 2 $\times 10^{-4}$	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
$\pi^0\pi^0\gamma$	( 6.6 $\pm$ 1.1 ) $\times 10^{-5}$		367
$\eta\pi^0\gamma$	< 3.3 $\times 10^{-5}$	CL=90%	162
$\mu^+\mu^-$	( 9.0 $\pm$ 3.1 ) $\times 10^{-5}$		377
$3\gamma$	< 1.9 $\times 10^{-4}$	CL=95%	391
<b>Charge conjugation (C) violating modes</b>			
$\eta\pi^0$	C < 2.1 $\times 10^{-4}$	CL=90%	162
$2\pi^0$	C < 2.1 $\times 10^{-4}$	CL=90%	367
$3\pi^0$	C < 2.3 $\times 10^{-4}$	CL=90%	330

**$\eta'(958)$**

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

Mass  $m = 957.78 \pm 0.06$  MeV

Full width  $\Gamma = 0.199 \pm 0.009$  MeV

<b><math>\eta'(958)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	Confidence level	$P$ (MeV/c)
$\pi^+\pi^-\eta$	(43.4 $\pm$ 0.7 ) %		232
$\rho^0\gamma$ (including non-resonant $\pi^+\pi^-\gamma$ )	(29.3 $\pm$ 0.6 ) %		165
$\pi^0\pi^0\eta$	(21.6 $\pm$ 0.8 ) %		239
$\omega\gamma$	( 2.75 $\pm$ 0.22) %		159
$\gamma\gamma$	( 2.18 $\pm$ 0.08) %		479
$3\pi^0$	( 1.68 $\pm$ 0.22) $\times 10^{-3}$		430
$\mu^+\mu^-\gamma$	( 1.07 $\pm$ 0.26) $\times 10^{-4}$		467
$\pi^+\pi^-\mu^+\mu^-$	< 2.2 $\times 10^{-4}$	90%	401
$\pi^+\pi^-\pi^0$	( 3.6 $^{+1.1}_{-0.9}$ ) $\times 10^{-3}$		428
$\pi^0\rho^0$	< 4 %	90%	111
$2(\pi^+\pi^-)$	< 2.4 $\times 10^{-4}$	90%	372
$\pi^+\pi^-2\pi^0$	< 2.6 $\times 10^{-3}$	90%	376
$2(\pi^+\pi^-)$ neutrals	< 1 %	95%	—
$2(\pi^+\pi^-)\pi^0$	< 1.9 $\times 10^{-3}$	90%	298
$2(\pi^+\pi^-)2\pi^0$	< 1 %	95%	197
$3(\pi^+\pi^-)$	< 5 $\times 10^{-4}$	90%	189
$\pi^+\pi^-e^+e^-$	( 2.4 $^{+1.3}_{-1.0}$ ) $\times 10^{-3}$		458
$\gamma e^+e^-$	< 9 $\times 10^{-4}$	90%	479
$\pi^0\gamma\gamma$	< 8 $\times 10^{-4}$	90%	469
$4\pi^0$	< 5 $\times 10^{-4}$	90%	380
$e^+e^-$	< 2.1 $\times 10^{-7}$	90%	479
invisible	< 9 $\times 10^{-4}$	90%	—

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

$\pi^+\pi^-$	$P, CP$	< 2.9 $\times 10^{-3}$	90%	458
$\pi^0\pi^0$	$P, CP$	< 1.0 $\times 10^{-3}$	90%	459
$\pi^0e^+e^-$	$C$ [f]	< 1.4 $\times 10^{-3}$	90%	469
$\eta e^+e^-$	$C$ [f]	< 2.4 $\times 10^{-3}$	90%	322
$3\gamma$	$C$	< 1.0 $\times 10^{-4}$	90%	479
$\mu^+\mu^-\pi^0$	$C$ [f]	< 6.0 $\times 10^{-5}$	90%	445
$\mu^+\mu^-\eta$	$C$ [f]	< 1.5 $\times 10^{-5}$	90%	273
$e\mu$	$LF$	< 4.7 $\times 10^{-4}$	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

<b><math>f_0(980)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (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  $m = 980 \pm 20$  MeV

Full width  $\Gamma = 50$  to 100 MeV

<b><math>a_0(980)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$\eta\pi$	dominant	319
$K\bar{K}$	seen	†
$\gamma\gamma$	seen	490

**$\phi(1020)$**

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

Mass  $m = 1019.455 \pm 0.020$  MeV (S = 1.1)

Full width  $\Gamma = 4.26 \pm 0.04$  MeV (S = 1.4)

<b><math>\phi(1020)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	Scale factor/ Confidence level	$p$ (MeV/c)
$K^+K^-$	(48.9 $\pm$ 0.5 ) %	S=1.1	127
$K_L^0 K_S^0$	(34.2 $\pm$ 0.4 ) %	S=1.1	110
$\rho\pi + \pi^+\pi^-\pi^0$	(15.32 $\pm$ 0.32 ) %	S=1.1	—
$\eta\gamma$	( 1.309 $\pm$ 0.024 ) %	S=1.2	363
$\pi^0\gamma$	( 1.27 $\pm$ 0.06 ) $\times 10^{-3}$		501
$\ell^+\ell^-$	—		510
$e^+e^-$	( 2.954 $\pm$ 0.030 ) $\times 10^{-4}$	S=1.1	510
$\mu^+\mu^-$	( 2.87 $\pm$ 0.19 ) $\times 10^{-4}$		499
$\eta e^+e^-$	( 1.15 $\pm$ 0.10 ) $\times 10^{-4}$		363
$\pi^+\pi^-$	( 7.4 $\pm$ 1.3 ) $\times 10^{-5}$		490
$\omega\pi^0$	( 4.7 $\pm$ 0.5 ) $\times 10^{-5}$		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
$f_0(980)\gamma$	( 3.22 $\pm$ 0.19 ) $\times 10^{-4}$	S=1.1	39
$\pi^0\pi^0\gamma$	( 1.13 $\pm$ 0.06 ) $\times 10^{-4}$		492
$\pi^+\pi^-\pi^+\pi^-$	( 4.0 $^{+2.8}_{-2.2}$ ) $\times 10^{-6}$		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
$\pi^0\eta\gamma$	( 7.27 $\pm$ 0.30 ) $\times 10^{-5}$	S=1.5	346
$a_0(980)\gamma$	( 7.6 $\pm$ 0.6 ) $\times 10^{-5}$		39
$K^0\bar{K}^0\gamma$	< 1.9 $\times 10^{-8}$	CL=90%	110
$\eta'(958)\gamma$	( 6.25 $\pm$ 0.21 ) $\times 10^{-5}$		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
$\rho\gamma\gamma$	< 1.2 $\times 10^{-4}$	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
<b>Lepton Family number (LF) violating modes</b>			
$e^\pm\mu^\mp$	LF < 2 $\times 10^{-6}$	CL=90%	504



**$h_1(1170)$**

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

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

<b><math>h_1(1170)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (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><math>b_1(1235)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	Confidence level	$p$ (MeV/c)
$\omega\pi$	dominant		348
$[D/S \text{ amplitude ratio} = 0.277 \pm 0.027]$			
$\pi^\pm\gamma$	$(1.6 \pm 0.4) \times 10^{-3}$		607
$\eta\rho$	seen		†
$\pi^+\pi^+\pi^-\pi^0$	< 50 %	84%	535
$K^*(892)^\pm K^\mp$	seen		†
$(K\bar{K})^\pm\pi^0$	< 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

**$a_1(1260)$  <sup>[k]</sup>**

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

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

<b><math>a_1(1260)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (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	†
$K K^*(892) + \text{c.c.}$	seen	†
$\pi\gamma$	seen	608

## $f_2(1270)$

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

Mass  $m = 1275.1 \pm 1.2$  MeV (S = 1.1)

Full width  $\Gamma = 185.1^{+2.9}_{-2.4}$  MeV (S = 1.5)

$f_2(1270)$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	Scale factor/ Confidence level	$\rho$ (MeV/c)
$\pi\pi$	(84.8 $^{+2.4}_{-1.2}$ ) %	S=1.2	623
$\pi^+\pi^-2\pi^0$	( 7.1 $^{+1.4}_{-2.7}$ ) %	S=1.3	562
$K\bar{K}$	( 4.6 $\pm 0.4$ ) %	S=2.8	403
$2\pi^+2\pi^-$	( 2.8 $\pm 0.4$ ) %	S=1.2	559
$\eta\eta$	( 4.0 $\pm 0.8$ ) $\times 10^{-3}$	S=2.1	326
$4\pi^0$	( 3.0 $\pm 1.0$ ) $\times 10^{-3}$		564
$\gamma\gamma$	( 1.64 $\pm 0.19$ ) $\times 10^{-5}$	S=1.9	638
$\eta\pi\pi$	< 8 $\times 10^{-3}$	CL=95%	477
$K^0K^-\pi^+ + c.c.$	< 3.4 $\times 10^{-3}$	CL=95%	293
$e^+e^-$	< 6 $\times 10^{-10}$	CL=90%	638

## $f_1(1285)$

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

Mass  $m = 1281.8 \pm 0.6$  MeV (S = 1.6)

Full width  $\Gamma = 24.3 \pm 1.1$  MeV (S = 1.4)

$f_1(1285)$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	Scale factor/ Confidence level	$\rho$ (MeV/c)
$4\pi$	(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
$4\pi^0$	seen		†
$\eta\pi\pi$	< 7 $\times 10^{-4}$	CL=90%	568
$\eta\pi\pi$	(52 $\pm 5$ ) %		482
$a_0(980)\pi$ [ignoring $a_0(980) \rightarrow K\bar{K}$ ]	(36 $\pm 7$ ) %		238
$\eta\pi\pi$ [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

## $\eta(1295)$

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

Mass  $m = 1294 \pm 4$  MeV ( $S = 1.6$ )

Full width  $\Gamma = 55 \pm 5$  MeV

$\eta(1295)$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$\eta\pi^+\pi^-$	seen	487
$a_0(980)\pi$	seen	248
$\eta\pi^0\pi^0$	seen	490
$\eta(\pi\pi)$ S-wave	seen	—

## $\pi(1300)$

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

Mass  $m = 1300 \pm 100$  MeV [1]

Full width  $\Gamma = 200$  to  $600$  MeV

$\pi(1300)$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$\rho\pi$	seen	404
$\pi(\pi\pi)$ S-wave	seen	—

## $a_2(1320)$

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

Mass  $m = 1318.3^{+0.5}_{-0.6}$  MeV ( $S = 1.2$ )

Full width  $\Gamma = 107 \pm 5$  MeV [1]

$a_2(1320)$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	Scale factor/ Confidence level	$p$ (MeV/c)
$3\pi$	(70.1 $\pm$ 2.7 ) %	S=1.2	624
$\eta\pi$	(14.5 $\pm$ 1.2 ) %		535
$\omega\pi\pi$	(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
$e^+e^-$	< 5 $\times 10^{-9}$	CL=90%	659

**$f_0(1370)$**  <sup>[j]</sup>

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

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

<b><math>f_0(1370)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$\pi\pi$	seen	672
$4\pi$	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	411
$K\bar{K}$	seen	475
$K\bar{K}n\pi$	not seen	†
$6\pi$	not seen	508
$\omega\omega$	not seen	†
$\gamma\gamma$	seen	685
$e^+e^-$	not seen	685

**$\pi_1(1400)$**  <sup>[m]</sup>

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

Mass  $m = 1354 \pm 25$  MeV ( $S = 1.8$ )  
 Full width  $\Gamma = 330 \pm 35$  MeV

<b><math>\pi_1(1400)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$\eta\pi^0$	seen	557
$\eta\pi^-$	seen	556

**$\eta(1405)$**  <sup>[n]</sup>

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

Mass  $m = 1409.8 \pm 2.5$  MeV <sup>[l]</sup> ( $S = 2.2$ )  
 Full width  $\Gamma = 51.1 \pm 3.4$  MeV <sup>[l]</sup> ( $S = 2.0$ )

<b><math>\eta(1405)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	Confidence level	$p$ (MeV/c)
$K\bar{K}\pi$	seen		425
$\eta\pi\pi$	seen		563
$a_0(980)\pi$	seen		345
$\eta(\pi\pi)_{S\text{-wave}}$	seen		—
$f_0(980)\eta$	seen		†
$4\pi$	seen		639
$\rho\rho$	<58 %	99.85%	†
$\rho^0\gamma$	seen		492
$K^*(892)K$	seen		125

**$f_1(1420)$  [o]**

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

Mass  $m = 1426.4 \pm 0.9$  MeV (S = 1.1)

Full width  $\Gamma = 54.9 \pm 2.6$  MeV

<b><math>f_1(1420)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (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

**$\omega(1420)$  [p]**

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

Mass  $m$  (1400–1450) MeV

Full width  $\Gamma$  (180–250) MeV

<b><math>\omega(1420)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$\rho\pi$	dominant	486
$\omega\pi\pi$	seen	444
$b_1(1235)\pi$	seen	125
$e^+e^-$	seen	710

**$a_0(1450)$  [j]**

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

Mass  $m = 1474 \pm 19$  MeV

Full width  $\Gamma = 265 \pm 13$  MeV

<b><math>a_0(1450)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$\pi \eta$	seen	627
$\pi \eta'(958)$	seen	410
$K \bar{K}$	seen	547
$\omega \pi \pi$	seen	484
$a_0(980) \pi \pi$	seen	342
$\gamma \gamma$	seen	737

**$\rho(1450)$  [q]**

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

Mass  $m = 1465 \pm 25$  MeV [l]  
 Full width  $\Gamma = 400 \pm 60$  MeV [l]

<b><math>\rho(1450)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$\pi \pi$	seen	720
$4\pi$	seen	669
$e^+ e^-$	seen	732
$\eta \rho$	possibly seen	310
$a_2(1320) \pi$	not seen	54
$K \bar{K}$	not seen	541
$K \bar{K}^*(892) + \text{c.c.}$	possibly seen	229
$\eta \gamma$	possibly seen	630

**$\eta(1475)$  [n]**

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

Mass  $m = 1476 \pm 4$  MeV (S = 1.3)  
 Full width  $\Gamma = 85 \pm 9$  MeV (S = 1.5)

<b><math>\eta(1475)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$K \bar{K} \pi$	dominant	477
$K \bar{K}^*(892) + \text{c.c.}$	seen	245
$a_0(980) \pi$	seen	396
$\gamma \gamma$	seen	738

**$f_0(1500)$  [m]**

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

Mass  $m = 1505 \pm 6$  MeV (S = 1.3)  
 Full width  $\Gamma = 109 \pm 7$  MeV

<b><math>f_0(1500)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	Scale factor	$p$ (MeV/c)
$\pi\pi$	(34.9±2.3) %	1.2	741
$\pi^+\pi^-$	seen		740
$2\pi^0$	seen		741
$4\pi$	(49.5±3.3) %	1.2	691
$4\pi^0$	seen		691
$2\pi^+2\pi^-$	seen		687
$2(\pi\pi)_{S\text{-wave}}$	seen		—
$\rho\rho$	seen		†
$\pi(1300)\pi$	seen		144
$a_1(1260)\pi$	seen		218
$\eta\eta$	( 5.1±0.9) %	1.4	516
$\eta\eta'(958)$	( 1.9±0.8) %	1.7	†
$K\bar{K}$	( 8.6±1.0) %	1.1	568
$\gamma\gamma$	not seen		753

**$f'_2(1525)$**

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

Mass  $m = 1525 \pm 5$  MeV [1]

Full width  $\Gamma = 73^{+6}_{-5}$  MeV [1]

<b><math>f'_2(1525)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$K\bar{K}$	(88.7 ±2.2) %	581
$\eta\eta$	(10.4 ±2.2) %	530
$\pi\pi$	( 8.2 ±1.5 ) × 10 <sup>-3</sup>	750
$\gamma\gamma$	( 1.11±0.14) × 10 <sup>-6</sup>	763

**$\pi_1(1600)$  [m]**

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

Mass  $m = 1662^{+8}_{-9}$  MeV

Full width  $\Gamma = 241 \pm 40$  MeV (S = 1.4)

$\pi_1(1600)$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$\pi\pi\pi$	not seen	803
$\rho^0\pi^-$	not seen	641
$f_2(1270)\pi^-$	not seen	318
$b_1(1235)\pi$	seen	357
$\eta'(958)\pi^-$	seen	543
$f_1(1285)\pi$	seen	314

### $\eta_2(1645)$

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

Mass  $m = 1617 \pm 5$  MeV

Full width  $\Gamma = 181 \pm 11$  MeV

$\eta_2(1645)$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (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	499
$f_2(1270)\eta$	not seen	†

### $\omega(1650)$ <sup>[r]</sup>

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

Mass  $m = 1670 \pm 30$  MeV

Full width  $\Gamma = 315 \pm 35$  MeV

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

### $\omega_3(1670)$

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

Mass  $m = 1667 \pm 4$  MeV

Full width  $\Gamma = 168 \pm 10$  MeV <sup>[l]</sup>



$\omega_3(1670)$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (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  $m = 1672.2 \pm 3.0$  MeV [1] ( $S = 1.4$ )

Full width  $\Gamma = 260 \pm 9$  MeV [1] ( $S = 1.2$ )

$\pi_2(1670)$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	Confidence level	$p$ (MeV/c)
$3\pi$	(95.8±1.4) %		809
$f_2(1270)\pi$	(56.3±3.2) %		329
$\rho\pi$	(31 ±4 ) %		648
$\sigma\pi$	(10.9±3.4) %		—
$(\pi\pi)$ s-wave	( 8.7±3.4) %		—
$K\bar{K}^*(892)+$ c.c.	( 4.2±1.4) %		455
$\omega\rho$	( 2.7±1.1) %		304
$\gamma\gamma$	< 2.8 $\times 10^{-7}$	90%	836
$\rho(1450)\pi$	< 3.6 $\times 10^{-3}$	97.7%	147
$b_1(1235)\pi$	< 1.9 $\times 10^{-3}$	97.7%	365
$f_1(1285)\pi$	possibly seen		323
$a_2(1320)\pi$	not seen		292

### $\phi(1680)$

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

Mass  $m = 1680 \pm 20$  MeV [1]

Full width  $\Gamma = 150 \pm 50$  MeV [1]

$\phi(1680)$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$K\bar{K}^*(892)+$ 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
$K^+K^-\pi^+\pi^-$	seen	544

**$\rho_3(1690)$**

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

Mass  $m = 1688.8 \pm 2.1$  MeV [1]

Full width  $\Gamma = 161 \pm 10$  MeV [1] (S = 1.5)

<b><math>\rho_3(1690)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	Scale factor	$p$ (MeV/c)
$4\pi$	(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 $2\rho$ and $a_2(1320)\pi$ .			
$a_2(1320)\pi$	seen		307
$\rho \rho$	seen		334

**$\rho(1700)$  [q]**

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

Mass  $m = 1720 \pm 20$  MeV [1] ( $\eta\rho^0$  and  $\pi^+\pi^-$  modes)

Full width  $\Gamma = 250 \pm 100$  MeV [1] ( $\eta\rho^0$  and  $\pi^+\pi^-$  modes)

<b><math>\rho(1700)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (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
$K \bar{K}^*(892) + c.c.$	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

**$f_0(1710)$**  [s]

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

Mass  $m = 1720 \pm 6$  MeV (S = 1.6)

Full width  $\Gamma = 135 \pm 8$  MeV (S = 1.1)

<b><math>f_0(1710)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$K\bar{K}$	seen	704
$\eta\eta$	seen	663
$\pi\pi$	seen	849
$\omega\omega$	seen	357

**$\pi(1800)$**

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

Mass  $m = 1812 \pm 12$  MeV (S = 2.3)

Full width  $\Gamma = 208 \pm 12$  MeV

<b><math>\pi(1800)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (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	250
$\rho\pi^-$	not seen	732
$\eta\eta\pi^-$	seen	661
$a_0(980)\eta$	seen	473
$a_2(1320)\eta$	not seen	†
$f_2(1270)\pi$	not seen	442
$f_0(1370)\pi^-$	not seen	368
$f_0(1500)\pi^-$	seen	250
$\eta\eta'(958)\pi^-$	seen	375
$K_0^*(1430)K^-$	seen	†
$K^*(892)K^-$	not seen	570

**$X(1835)$**

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

Mass  $m = 1835.7^{+4.0}_{-3.1}$  MeV

Full width  $\Gamma = 99 \pm 50$  MeV (S = 2.8)

<b>X(1835) DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$p\bar{p}$	seen	†
$\pi^+\pi^-\eta'$	seen	630
$\omega\phi$	seen	173

### $\phi_3(1850)$

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

Mass  $m = 1854 \pm 7$  MeV

Full width  $\Gamma = 87^{+28}_{-23}$  MeV ( $S = 1.2$ )

<b><math>\phi_3(1850)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$K\bar{K}$	seen	785
$K\bar{K}^*(892) + \text{c.c.}$	seen	602

### $\pi_2(1880)$

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

Mass  $m = 1895 \pm 16$  MeV

Full width  $\Gamma = 235 \pm 34$  MeV

### $f_2(1950)$

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

Mass  $m = 1944 \pm 12$  MeV ( $S = 1.5$ )

Full width  $\Gamma = 472 \pm 18$  MeV

<b><math>f_2(1950)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$K^*(892)\bar{K}^*(892)$	seen	387
$\pi^+\pi^-$	seen	962
$\pi^0\pi^0$	seen	963
$4\pi$	seen	925
$\eta\eta$	seen	803
$K\bar{K}$	seen	837
$\gamma\gamma$	seen	972
$p\bar{p}$	seen	254

### $f_2(2010)$

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

Mass  $m = 2011^{+60}_{-80}$  MeV

Full width  $\Gamma = 202 \pm 60$  MeV

$f_2(2010)$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$\phi\phi$	seen	†
$K\bar{K}$	seen	876

### $a_4(2040)$

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

$$\text{Mass } m = 1996^{+10}_{-9} \text{ MeV} \quad (S = 1.1)$$

$$\text{Full width } \Gamma = 255^{+28}_{-24} \text{ MeV} \quad (S = 1.3)$$

$a_4(2040)$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$K\bar{K}$	seen	868
$\pi^+\pi^-\pi^0$	seen	974
$\rho\pi$	seen	841
$f_2(1270)\pi$	seen	580
$\omega\pi^-\pi^0$	seen	819
$\omega\rho$	seen	624
$\eta\pi^0$	seen	918
$\eta'(958)\pi$	seen	761

### $f_4(2050)$

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

$$\text{Mass } m = 2018 \pm 11 \text{ MeV} \quad (S = 2.1)$$

$$\text{Full width } \Gamma = 237 \pm 18 \text{ MeV} \quad (S = 1.9)$$

$f_4(2050)$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$\omega\omega$	seen	637
$\pi\pi$	$(17.0 \pm 1.5) \%$	1000
$K\bar{K}$	$(6.8^{+3.4}_{-1.8}) \times 10^{-3}$	880
$\eta\eta$	$(2.1 \pm 0.8) \times 10^{-3}$	848
$4\pi^0$	$< 1.2 \%$	964
$a_2(1320)\pi$	seen	567

### $\phi(2170)$

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

$$\text{Mass } m = 2175 \pm 15 \text{ MeV} \quad (S = 1.6)$$

$$\text{Full width } \Gamma = 61 \pm 18 \text{ MeV}$$

$\phi(2170)$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$e^+ e^-$	seen	1087
$\phi f_0(980)$	seen	427
$K^+ K^- f_0(980) \rightarrow$ $K^+ K^- \pi^+ \pi^-$	seen	—
$K^+ K^- f_0(980) \rightarrow K^+ K^- \pi^0 \pi^0$	seen	—
$K^{*0} K^\pm \pi^\mp$	not seen	770
$K^*(892)^0 \bar{K}^*(892)^0$	not seen	622

**$f_2(2300)$**

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

Mass  $m = 2297 \pm 28$  MeV

Full width  $\Gamma = 149 \pm 40$  MeV

$f_2(2300)$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (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  $m = 2339 \pm 60$  MeV

Full width  $\Gamma = 319^{+80}_{-70}$  MeV

$f_2(2340)$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$\phi\phi$	seen	573
$\eta\eta$	seen	1033

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

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

**$K^\pm$**

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

Mass  $m = 493.677 \pm 0.016$  MeV [t] ( $S = 2.8$ )

Mean life  $\tau = (1.2380 \pm 0.0021) \times 10^{-8}$  s ( $S = 1.9$ )

$$c\tau = 3.712 \text{ m}$$

### Slope parameter $g$ <sup>[u]</sup>

(See Particle Listings for quadratic coefficients and alternative parametrization related to  $\pi\pi$  scattering)

$$K^\pm \rightarrow \pi^\pm \pi^+ \pi^- \quad g = -0.21134 \pm 0.00017$$

$$(g_+ - g_-) / (g_+ + g_-) = (-1.5 \pm 2.2) \times 10^{-4}$$

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

$$(g_+ - g_-) / (g_+ + g_-) = (1.8 \pm 1.8) \times 10^{-4}$$

### $K^\pm$ decay form factors <sup>[a,v]</sup>

Assuming  $\mu$ - $e$  universality

$$\lambda_+(K_{\mu 3}^+) = \lambda_+(K_{e 3}^+) = (2.97 \pm 0.05) \times 10^{-2}$$

$$\lambda_0(K_{\mu 3}^+) = (1.95 \pm 0.12) \times 10^{-2}$$

Not assuming  $\mu$ - $e$  universality

$$\lambda_+(K_{e 3}^+) = (2.98 \pm 0.05) \times 10^{-2}$$

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

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

$K_{e 3}$  form factor quadratic fit

$$\lambda'_+(K_{e 3}^\pm) \text{ linear coeff.} = (2.49 \pm 0.17) \times 10^{-2}$$

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

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

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

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

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

$$K^+ \rightarrow e^+ \nu_e \gamma \quad |F_A + F_V| = 0.133 \pm 0.008 \quad (S = 1.3)$$

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

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

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

### Charge Radius

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

### $CP$ violation parameters

$$\Delta(K_{\pi e e}^\pm) = (-2.2 \pm 1.6) \times 10^{-2}$$

$$\Delta(K_{\pi \mu \mu}^\pm) = 0.010 \pm 0.023$$

$$\Delta(K_{\pi \pi \gamma}^\pm) = (0.0 \pm 1.2) \times 10^{-3}$$

$$A_{FB}(K_{\pi \mu \mu}^\pm) = \frac{\Gamma(\cos(\theta_{K\mu}) > 0) - \Gamma(\cos(\theta_{K\mu}) < 0)}{\Gamma(\cos(\theta_{K\mu}) > 0) + \Gamma(\cos(\theta_{K\mu}) < 0)} < 2.3 \times 10^{-2}, \text{ CL}$$

$$= 90\%$$

### 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.

<b><math>K^+</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	Scale factor/ Confidence level	$p$ (MeV/c)
<b>Leptonic and semileptonic modes</b>			
$e^+ \nu_e$	$(1.584 \pm 0.020) \times 10^{-5}$		247
$\mu^+ \nu_\mu$	$(63.55 \pm 0.11) \%$	S=1.2	236
$\pi^0 e^+ \nu_e$	$(5.07 \pm 0.04) \%$	S=2.1	228
Called $K_{e3}^+$ .			
$\pi^0 \mu^+ \nu_\mu$	$(3.353 \pm 0.034) \%$	S=1.8	215
Called $K_{\mu 3}^+$ .			
$\pi^0 \pi^0 e^+ \nu_e$	$(2.2 \pm 0.4) \times 10^{-5}$		206
$\pi^+ \pi^- e^+ \nu_e$	$(4.09 \pm 0.10) \times 10^{-5}$		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
<b>Hadronic modes</b>			
$\pi^+ \pi^0$	$(20.66 \pm 0.08) \%$	S=1.2	205
$\pi^+ \pi^0 \pi^0$	$(1.761 \pm 0.022) \%$	S=1.1	133
$\pi^+ \pi^+ \pi^-$	$(5.59 \pm 0.04) \%$	S=1.3	125
<b>Leptonic and semileptonic modes with photons</b>			
$\mu^+ \nu_\mu \gamma$	[w,x] $(6.2 \pm 0.8) \times 10^{-3}$		236
$\mu^+ \nu_\mu \gamma$ (SD <sup>+</sup> )	[a,y] $(1.33 \pm 0.22) \times 10^{-5}$		—
$\mu^+ \nu_\mu \gamma$ (SD <sup>+</sup> INT)	[a,y] $< 2.7 \times 10^{-5}$	CL=90%	—
$\mu^+ \nu_\mu \gamma$ (SD <sup>-</sup> + SD <sup>-</sup> INT)	[a,y] $< 2.6 \times 10^{-4}$	CL=90%	—
$e^+ \nu_e \gamma$	$(9.4 \pm 0.4) \times 10^{-6}$		247
$\pi^0 e^+ \nu_e \gamma$	[w,x] $(2.56 \pm 0.16) \times 10^{-4}$		228
$\pi^0 e^+ \nu_e \gamma$ (SD)	[a,y] $< 5.3 \times 10^{-5}$	CL=90%	228
$\pi^0 \mu^+ \nu_\mu \gamma$	[w,x] $(1.25 \pm 0.25) \times 10^{-5}$		215
$\pi^0 \pi^0 e^+ \nu_e \gamma$	$< 5 \times 10^{-6}$	CL=90%	206



### Hadronic modes with photons or $l\bar{l}$ pairs

$\pi^+\pi^0\gamma$ (INT)		$(-4.2 \pm 0.9) \times 10^{-6}$	–
$\pi^+\pi^0\gamma$ (DE)	[w,z]	$(6.0 \pm 0.4) \times 10^{-6}$	205
$\pi^+\pi^0\pi^0\gamma$	[w,x]	$(7.6 \pm_{-3.0}^{6.0}) \times 10^{-6}$	133
$\pi^+\pi^+\pi^-\gamma$	[w,x]	$(1.04 \pm 0.31) \times 10^{-4}$	125
$\pi^+\gamma\gamma$	[w]	$(1.10 \pm 0.32) \times 10^{-6}$	227
$\pi^+3\gamma$	[w]	$1.0 \times 10^{-4}$ CL=90%	227
$\pi^+e^+e^-\gamma$		$(1.19 \pm 0.13) \times 10^{-8}$	227

### Leptonic modes with $l\bar{l}$ 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
$e^+\nu_e e^+e^-$	(	$2.48 \pm 0.20$	$) \times 10^{-8}$	247
$\mu^+\nu_\mu e^+e^-$	(	$7.06 \pm 0.31$	$) \times 10^{-8}$	236
$e^+\nu_e\mu^+\mu^-$	(	$1.7 \pm 0.5$	$) \times 10^{-8}$	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	(	$3.00 \pm 0.09$	$) \times 10^{-7}$	227	
$\pi^+\mu^+\mu^-$	S1	(	$9.4 \pm 0.6$	$) \times 10^{-8}$ S=2.6	172	
$\pi^+\nu\bar{\nu}$	S1	(	$1.7 \pm 1.1$	$) \times 10^{-10}$	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]	<	1.1	$\times 10^{-9}$ 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	
$\pi^+\gamma$	[aa]	<	2.3	$\times 10^{-9}$ CL=90%	227	

**$K^0$**

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

50%  $K_S$ , 50%  $K_L$

$$\text{Mass } m = 497.614 \pm 0.024 \text{ MeV} \quad (S = 1.6)$$

$$m_{K^0} - m_{K^\pm} = 3.937 \pm 0.028 \text{ MeV} \quad (S = 1.8)$$

### Mean Square Charge Radius

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

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

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

**CPT-violation parameters** [v]

$$\text{Re } \delta = (2.3 \pm 2.7) \times 10^{-4}$$

$$\text{Im } \delta = (0.4 \pm 2.1) \times 10^{-5}$$

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

$$\text{Re}(x_-), K_{e3} \text{ parameter} = (-2.9 \pm 2.0) \times 10^{-3}$$

$$|m_{K^0} - m_{\bar{K}^0}| / m_{\text{average}} < 8 \times 10^{-19}, \text{ CL} = 90\% \text{ [bb]}$$

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

**Tests of  $\Delta S = \Delta Q$**

$$\text{Re}(x_+), K_{e3} \text{ parameter} = (-0.9 \pm 3.0) \times 10^{-3}$$



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

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

Mean life  $\tau = (0.8958 \pm 0.0005) \times 10^{-10}$  s Not assuming CPT  
 $c\tau = 2.6842$  cm Assuming CPT

**CP-violation parameters** [cc]

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

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

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

$$\text{CP asymmetry } A \text{ in } \pi^+ \pi^- e^+ e^- = (-0.4 \pm 0.8)\%$$

$K_S^0$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	Scale factor/ Confidence level	$p$ (MeV/c)
<b>Hadronic modes</b>			
$\pi^0 \pi^0$	(30.69 ± 0.05) %		209
$\pi^+ \pi^-$	(69.20 ± 0.05) %		206
$\pi^+ \pi^- \pi^0$	( 3.5 $\begin{smallmatrix} +1.1 \\ -0.9 \end{smallmatrix}$ ) × 10 <sup>-7</sup>		133
<b>Modes with photons or <math>\ell\bar{\ell}</math> pairs</b>			
$\pi^+ \pi^- \gamma$	[x, dd] ( 1.79 ± 0.05 ) × 10 <sup>-3</sup>		206
$\pi^+ \pi^- e^+ e^-$	( 4.79 ± 0.15 ) × 10 <sup>-5</sup>		206
$\pi^0 \gamma \gamma$	[dd] ( 4.9 ± 1.8 ) × 10 <sup>-8</sup>		231
$\gamma \gamma$	( 2.63 ± 0.17 ) × 10 <sup>-6</sup>	S=3.0	249
<b>Semileptonic modes</b>			
$\pi^\pm e^\mp \nu_e$	[ee] ( 7.04 ± 0.08 ) × 10 <sup>-4</sup>		229
<b>CP violating (CP) and <math>\Delta S = 1</math> weak neutral current (S1) modes</b>			
$3\pi^0$	CP < 1.2 × 10 <sup>-7</sup>	CL=90%	139
$\mu^+ \mu^-$	S1 < 3.2 × 10 <sup>-7</sup>	CL=90%	225
$e^+ e^-$	S1 < 9 × 10 <sup>-9</sup>	CL=90%	249
$\pi^0 e^+ e^-$	S1 [dd] ( 3.0 $\begin{smallmatrix} +1.5 \\ -1.2 \end{smallmatrix}$ ) × 10 <sup>-9</sup>		230
$\pi^0 \mu^+ \mu^-$	S1 ( 2.9 $\begin{smallmatrix} +1.5 \\ -1.2 \end{smallmatrix}$ ) × 10 <sup>-9</sup>		177



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

$$\begin{aligned}
 & m_{K_L} - m_{K_S} \\
 &= (0.5292 \pm 0.0009) \times 10^{10} \hbar \text{ s}^{-1} \quad (S = 1.2) \quad \text{Assuming } CPT \\
 &= (3.483 \pm 0.006) \times 10^{-12} \text{ MeV} \quad \text{Assuming } CPT \\
 &= (0.5290 \pm 0.0015) \times 10^{10} \hbar \text{ s}^{-1} \quad (S = 1.1) \quad \text{Not assuming } \\
 & \quad \quad \quad CPT \\
 & \text{Mean life } \tau = (5.116 \pm 0.021) \times 10^{-8} \text{ s} \quad (S = 1.1) \\
 & \quad \quad \quad c\tau = 15.34 \text{ m}
 \end{aligned}$$

**Slope parameter  $g$  [ $\mu$ ]**

(See Particle Listings for quadratic coefficients)

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

**$K_L$  decay form factors [ $\nu$ ]**

Linear parametrization assuming  $\mu$ -e universality

$$\lambda_+(K_{\mu 3}^0) = \lambda_+(K_{e 3}^0) = (2.82 \pm 0.04) \times 10^{-2} \quad (S = 1.1)$$

$$\lambda_0(K_{\mu 3}^0) = (1.38 \pm 0.18) \times 10^{-2} \quad (S = 2.2)$$

Quadratic parametrization assuming  $\mu$ - $e$  universality

$$\lambda'_+(K_{\mu 3}^0) = \lambda'_+(K_{e 3}^0) = (2.40 \pm 0.12) \times 10^{-2} \quad (S = 1.2)$$

$$\lambda''_+(K_{\mu 3}^0) = \lambda''_+(K_{e 3}^0) = (0.20 \pm 0.05) \times 10^{-2} \quad (S = 1.2)$$

$$\lambda_0(K_{\mu 3}^0) = (1.16 \pm 0.09) \times 10^{-2} \quad (S = 1.2)$$

Pole parametrization assuming  $\mu$ - $e$  universality

$$M_V^\mu(K_{\mu 3}^0) = M_V^e(K_{e 3}^0) = 878 \pm 6 \text{ MeV} \quad (S = 1.1)$$

$$M_S^\mu(K_{\mu 3}^0) = 1252 \pm 90 \text{ MeV} \quad (S = 2.6)$$

$$K_{e 3}^0 \quad |f_S/f_+| = (1.5_{-1.6}^{+1.4}) \times 10^{-2}$$

$$K_{e 3}^0 \quad |f_T/f_+| = (5_{-5}^{+4}) \times 10^{-2}$$

$$K_{\mu 3}^0 \quad |f_T/f_+| = (12 \pm 12) \times 10^{-2}$$

$$K_L \rightarrow \ell^+ \ell^- \gamma, K_L \rightarrow \ell^+ \ell^- \ell'^+ \ell'^-: \alpha_{K^*} = -0.205 \pm 0.022 \quad (S = 1.8)$$

$$K_L^0 \rightarrow \ell^+ \ell^- \gamma, K_L^0 \rightarrow \ell^+ \ell^- \ell'^+ \ell'^-: \alpha_{DIP} = -1.69 \pm 0.08 \quad (S = 1.7)$$

$$K_L \rightarrow \pi^+ \pi^- e^+ e^-: a_1/a_2 = -0.737 \pm 0.014 \text{ GeV}^2$$

$$K_L \rightarrow \pi^0 2\gamma: a_V = -0.43 \pm 0.06 \quad (S = 1.5)$$

### **CP-violation parameters** [cc]

$$A_L = (0.332 \pm 0.006)\%$$

$$|\eta_{00}| = (2.221 \pm 0.011) \times 10^{-3} \quad (S = 1.8)$$

$$|\eta_{+-}| = (2.232 \pm 0.011) \times 10^{-3} \quad (S = 1.8)$$

$$|\epsilon| = (2.228 \pm 0.011) \times 10^{-3} \quad (S = 1.8)$$

$$|\eta_{00}/\eta_{+-}| = 0.9951 \pm 0.0008^{[ff]} \quad (S = 1.6)$$

$$\text{Re}(\epsilon'/\epsilon) = (1.65 \pm 0.26) \times 10^{-3}^{[ff]} \quad (S = 1.6)$$

Assuming *CPT*

$$\phi_{+-} = (43.51 \pm 0.05)^\circ \quad (S = 1.1)$$

$$\phi_{00} = (43.52 \pm 0.05)^\circ \quad (S = 1.1)$$

$$\phi_\epsilon = \phi_{SW} = (43.51 \pm 0.05)^\circ \quad (S = 1.1)$$

Not assuming *CPT*

$$\phi_{+-} = (43.4 \pm 0.7)^\circ \quad (S = 1.3)$$

$$\phi_{00} = (43.7 \pm 0.8)^\circ \quad (S = 1.2)$$

$$\phi_\epsilon = (43.5 \pm 0.7)^\circ \quad (S = 1.3)$$

$$CP \text{ asymmetry } A \text{ in } K_L^0 \rightarrow \pi^+ \pi^- e^+ e^- = (13.7 \pm 1.5)\%$$

$$\beta_{CP} \text{ from } K_L^0 \rightarrow e^+ e^- e^+ e^- = -0.19 \pm 0.07$$

$$\gamma_{CP} \text{ from } K_L^0 \rightarrow e^+ e^- e^+ e^- = 0.01 \pm 0.11 \quad (S = 1.6)$$

$$j \text{ for } K_L^0 \rightarrow \pi^+ \pi^- \pi^0 = 0.0012 \pm 0.0008$$

$$f \text{ for } K_L^0 \rightarrow \pi^+ \pi^- \pi^0 = 0.004 \pm 0.006$$

$$|\eta_{+-\gamma}| = (2.35 \pm 0.07) \times 10^{-3}$$

$$\phi_{+-\gamma} = (44 \pm 4)^\circ$$

$$|\epsilon'_{+-\gamma}|/\epsilon < 0.3, \text{ CL} = 90\%$$

$$|g_{E1}| \text{ for } K_L^0 \rightarrow \pi^+ \pi^- \gamma < 0.21, \text{ CL} = 90\%$$

### **T-violation parameters**

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

### **CPT invariance tests**

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

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

### **$\Delta S = -\Delta Q$ 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 ( $\Gamma_i/\Gamma$ )	Scale factor/ Confidence level	$p$ (MeV/c)
<b>Semileptonic modes</b>			
$\pi^\pm e^\mp \nu_e$ Called $K_{e3}^0$ .	[ee] (40.55 $\pm$ 0.11 ) %	S=1.7	229
$\pi^\pm \mu^\mp \nu_\mu$ Called $K_{\mu3}^0$ .	[ee] (27.04 $\pm$ 0.07 ) %	S=1.1	216
$(\pi \mu \text{atom})\nu$	( 1.05 $\pm$ 0.11 ) $\times 10^{-7}$		188
$\pi^0 \pi^\pm e^\mp \nu$	[ee] ( 5.20 $\pm$ 0.11 ) $\times 10^{-5}$		207
$\pi^\pm e^\mp \nu e^+ e^-$	[ee] ( 1.26 $\pm$ 0.04 ) $\times 10^{-5}$		229
<b>Hadronic modes, including Charge conjugation <math>\times</math> Parity Violating (CPV) modes</b>			
$3\pi^0$	(19.52 $\pm$ 0.12 ) %	S=1.6	139
$\pi^+ \pi^- \pi^0$	(12.54 $\pm$ 0.05 ) %		133
$\pi^+ \pi^-$	CPV [gg] ( 1.966 $\pm$ 0.010 ) $\times 10^{-3}$	S=1.5	206
$\pi^0 \pi^0$	CPV ( 8.65 $\pm$ 0.06 ) $\times 10^{-4}$	S=1.8	209
<b>Semileptonic modes with photons</b>			
$\pi^\pm e^\mp \nu_e \gamma$	[x,ee,hh] ( 3.79 $\pm$ 0.06 ) $\times 10^{-3}$		229
$\pi^\pm \mu^\mp \nu_\mu \gamma$	( 5.65 $\pm$ 0.23 ) $\times 10^{-4}$		216
<b>Hadronic modes with photons or <math>l\bar{l}</math> pairs</b>			
$\pi^0 \pi^0 \gamma$	< 2.43 $\times 10^{-7}$	CL=90%	209
$\pi^+ \pi^- \gamma$	[x,hh] ( 4.15 $\pm$ 0.15 ) $\times 10^{-5}$	S=2.8	206
$\pi^+ \pi^- \gamma$ (DE)	( 2.84 $\pm$ 0.11 ) $\times 10^{-5}$	S=2.0	206
$\pi^0 2\gamma$	[hh] ( 1.273 $\pm$ 0.034 ) $\times 10^{-6}$		231
$\pi^0 \gamma e^+ e^-$	( 1.62 $\pm$ 0.17 ) $\times 10^{-8}$		230
<b>Other modes with photons or <math>l\bar{l}</math> pairs</b>			
$2\gamma$	( 5.47 $\pm$ 0.04 ) $\times 10^{-4}$	S=1.1	249
$3\gamma$	< 2.4 $\times 10^{-7}$	CL=90%	249
$e^+ e^- \gamma$	( 9.4 $\pm$ 0.4 ) $\times 10^{-6}$	S=2.0	249
$\mu^+ \mu^- \gamma$	( 3.59 $\pm$ 0.11 ) $\times 10^{-7}$	S=1.3	225
$e^+ e^- \gamma \gamma$	[hh] ( 5.95 $\pm$ 0.33 ) $\times 10^{-7}$		249
$\mu^+ \mu^- \gamma \gamma$	[hh] ( 1.0 $^{+0.8}_{-0.6}$ ) $\times 10^{-8}$		225
<b>Charge conjugation <math>\times</math> Parity (CP) or Lepton Family number (LF) violating modes, or <math>\Delta S = 1</math> weak neutral current (S1) modes</b>			
$\mu^+ \mu^-$	S1 ( 6.84 $\pm$ 0.11 ) $\times 10^{-9}$		225
$e^+ e^-$	S1 ( 9 $^{+6}_{-4}$ ) $\times 10^{-12}$		249
$\pi^+ \pi^- e^+ e^-$	S1 [hh] ( 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

$\pi^0 \mu^+ \mu^-$	$CP, S1$ $[ii] < 3.8$	$\times 10^{-10}$	CL=90%	177
$\pi^0 e^+ e^-$	$CP, S1$ $[ii] < 2.8$	$\times 10^{-10}$	CL=90%	230
$\pi^0 \nu \bar{\nu}$	$CP, S1$ $[jj] < 2.6$	$\times 10^{-8}$	CL=90%	231
$\pi^0 \pi^0 \nu \bar{\nu}$	$S1$ $< 4.7$	$\times 10^{-5}$	CL=90%	209
$e^\pm \mu^\mp$	$LF$ $[ee] < 4.7$	$\times 10^{-12}$	CL=90%	238
$e^\pm e^\pm \mu^\mp \mu^\mp$	$LF$ $[ee] < 4.12$	$\times 10^{-11}$	CL=90%	225
$\pi^0 \mu^\pm e^\mp$	$LF$ $[ee] < 7.6$	$\times 10^{-11}$	CL=90%	217
$\pi^0 \pi^0 \mu^\pm e^\mp$	$LF$ $< 1.7$	$\times 10^{-10}$	CL=90%	159

### **$K^*(892)$**

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

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

Mass  $m = 895.5 \pm 0.8$  MeV

$K^*(892)^0$  mass  $m = 895.94 \pm 0.22$  MeV (S = 1.4)

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

Full width  $\Gamma = 46.2 \pm 1.3$  MeV

$K^*(892)^0$  full width  $\Gamma = 48.7 \pm 0.8$  MeV (S = 1.7)

<b><math>K^*(892)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	Confidence level	$p$ (MeV/c)
$K \pi$	$\sim 100$	%	289
$K^0 \gamma$	$(2.39 \pm 0.21) \times 10^{-3}$		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 [1]

Full width  $\Gamma = 90 \pm 20$  MeV [1]

<b><math>K_1(1270)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$K \rho$	$(42 \pm 6) \%$	45
$K_0^*(1430) \pi$	$(28 \pm 4) \%$	†
$K^*(892) \pi$	$(16 \pm 5) \%$	302
$K \omega$	$(11.0 \pm 2.0) \%$	†
$K f_0(1370)$	$(3.0 \pm 2.0) \%$	†
$\gamma K^0$	seen	539

### **$K_1(1400)$**

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

Mass  $m = 1403 \pm 7$  MeV

Full width  $\Gamma = 174 \pm 13$  MeV (S = 1.6)

<b><math>K_1(1400)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$K^*(892)\pi$	(94 $\pm$ 6) %	402
$K\rho$	(1.2 $\pm$ 0.6) %	292
$Kf_0(1370)$	(2.0 $\pm$ 2.0) %	†
$K\omega$	(1.0 $\pm$ 1.0) %	284
$K_0^*(1430)\pi$	not seen	†
$\gamma K^0$	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)

<b><math>K^*(1410)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	Confidence level	$p$ (MeV/c)
$K^*(892)\pi$	> 40 %	95%	410
$K\pi$	(6.6 $\pm$ 1.3) %		612
$K\rho$	< 7 %	95%	305
$\gamma K^0$	seen		619

### **$K_0^*(1430)$ <sup>[kk]</sup>**

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

Mass  $m = 1425 \pm 50$  MeV

Full width  $\Gamma = 270 \pm 80$  MeV

<b><math>K_0^*(1430)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$K\pi$	(93 $\pm$ 10) %	619

### **$K_2^*(1430)$**

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

$K_2^*(1430)^\pm$  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)



<b><math>K_2^*(1430)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	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	486
$K\omega\pi$	$< 7.2 \times 10^{-4}$	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)

<b><math>K^*(1680)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$K\pi$	$(38.7 \pm 2.5) \%$	781
$K\rho$	$(31.4^{+5.0}_{-2.1}) \%$	570
$K^*(892)\pi$	$(29.9^{+2.2}_{-5.0}) \%$	618

### **$K_2(1770)$ <sup>[1]</sup>**

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

Mass  $m = 1773 \pm 8$  MeV

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

<b><math>K_2(1770)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$K\pi\pi$		794
$K_2^*(1430)\pi$	dominant	288
$K^*(892)\pi$	seen	654
$Kf_2(1270)$	seen	55
$K\phi$	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)

<b><math>K_3^*(1780)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	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

**$K_2(1820)$   $[mm]$**

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

Mass  $m = 1816 \pm 13$  MeV

Full width  $\Gamma = 276 \pm 35$  MeV

<b><math>K_2(1820)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$K_2^*(1430)\pi$	seen	327
$K^*(892)\pi$	seen	681
$K f_2(1270)$	seen	186
$K\omega$	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

<b><math>K_4^*(2045)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (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

## ( $C = \pm 1$ )

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

$D^\pm$

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

$$\text{Mass } m = 1869.57 \pm 0.16 \text{ MeV} \quad (S = 1.1)$$

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

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

### c-quark decays

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

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

### CP-violation decay-rate asymmetries

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

$$A_{CP}(K_S^0 \pi^\pm) = (-0.80 \pm 0.26)\%$$

$$A_{CP}(K^\mp 2\pi^\pm) = (-0.1 \pm 1.0)\%$$

$$A_{CP}(K^\mp \pi^\pm \pi^\pm \pi^0) = (1.0 \pm 1.3)\%$$

$$A_{CP}(K_S^0 \pi^\pm \pi^0) = (0.3 \pm 0.9)\%$$

$$A_{CP}(K_S^0 \pi^\pm \pi^+ \pi^-) = (0.1 \pm 1.3)\%$$

$$A_{CP}(\pi^\pm \pi^0) = (2.9 \pm 2.9)\%$$

$$A_{CP}(\pi^\pm \eta) = (-2.0 \pm 2.3)\%$$

$$A_{CP}(\pi^\pm \eta'(958)) = (-4.0 \pm 3.4)\%$$

$$A_{CP}(K_S^0 K^\pm) = (-0.1 \pm 0.6)\%$$

$$A_{CP}(K^+ K^- \pi^\pm) = (0.3 \pm 0.6)\%$$

$$A_{CP}(K^\pm K^{*0}) = (0.1 \pm 1.3)\%$$

$$A_{CP}(\phi \pi^\pm) = (-0.9 \pm 1.1)\%$$

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

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

$$A_{CP}(K^\pm K_0^*(800)) = (-12_{-13}^{+18})\%$$

$$A_{CP}(a_0(1450)^0 \pi^\pm) = (-19_{-16}^{+14})\%$$

$$A_{CP}(\phi(1680) \pi^\pm) = (-9 \pm 26)\%$$

$$A_{CP}(\pi^+ \pi^- \pi^\pm) = (-2 \pm 4)\%$$

$$A_{CP}(K_S^0 K^\pm \pi^+ \pi^-) = (-4 \pm 7)\%$$

$$A_{CP}(K^\pm \pi^0) = (-4 \pm 11)\%$$

### T-violation decay-rate asymmetry

$$A_T(K_S^0 K^\pm \pi^+ \pi^-) = 0.02 \pm 0.07 \text{ } [oo]$$

### $D^+$ form factors

$$\begin{aligned}
 f_+(0)|V_{cs}| \text{ in } \overline{K}^0 \ell^+ \nu_\ell &= 0.707 \pm 0.013 \\
 r_1 \equiv a_1/a_0 \text{ in } \overline{K}^0 \ell^+ \nu_\ell &= -1.7 \pm 0.5 \\
 r_2 \equiv a_2/a_0 \text{ in } \overline{K}^0 \ell^+ \nu_\ell &= -14 \pm 11 \\
 f_+(0)|V_{cd}| \text{ in } \pi^0 \ell^+ \nu_\ell &= 0.146 \pm 0.007 \\
 r_1 \equiv a_1/a_0 \text{ in } \pi^0 \ell^+ \nu_\ell &= -1.4 \pm 0.9 \\
 r_2 \equiv a_2/a_0 \text{ in } \pi^0 \ell^+ \nu_\ell &= -4 \pm 5 \\
 r_v \equiv V(0)/A_1(0) \text{ in } \overline{K}^*(892)^0 \ell^+ \nu_\ell &= 1.62 \pm 0.08 \quad (S = 1.5) \\
 r_2 \equiv A_2(0)/A_1(0) \text{ in } \overline{K}^*(892)^0 \ell^+ \nu_\ell &= 0.83 \pm 0.05 \\
 r_3 \equiv A_3(0)/A_1(0) \text{ in } \overline{K}^*(892)^0 \ell^+ \nu_\ell &= 0.0 \pm 0.4 \\
 \Gamma_L/\Gamma_T \text{ in } \overline{K}^*(892)^0 \ell^+ \nu_\ell &= 1.13 \pm 0.08 \\
 \Gamma_+/\Gamma_- \text{ in } \overline{K}^*(892)^0 \ell^+ \nu_\ell &= 0.22 \pm 0.06 \quad (S = 1.6)
 \end{aligned}$$

Most decay modes (other than the semileptonic modes) that involve a neutral  $K$  meson are now given as  $K_S^0$  modes, not as  $\overline{K}^0$  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  $2\Gamma(K_S^0) = \Gamma(\overline{K}^0)$ .

$D^+$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	Scale factor/ Confidence level	$p$ (MeV/c)
<b>Inclusive modes</b>			
$e^+$ semileptonic	(16.07±0.30) %		—
$\mu^+$ anything	(17.6 ±3.2 ) %		—
$K^-$ anything	(25.7 ±1.4 ) %		—
$\overline{K}^0$ anything + $K^0$ anything	(61 ±5 ) %		—
$K^+$ anything	( 5.9 ±0.8 ) %		—
$K^*(892)^-$ anything	( 6 ±5 ) %		—
$\overline{K}^*(892)^0$ anything	(23 ±5 ) %		—
$K^*(892)^0$ anything	< 6.6 %	CL=90%	—
$\eta$ anything	( 6.3 ±0.7 ) %		—
$\eta'$ anything	( 1.04±0.18) %		—
$\phi$ anything	( 1.03±0.12) %		—
<b>Leptonic and semileptonic modes</b>			
$e^+ \nu_e$	< 8.8 × 10 <sup>-6</sup>	CL=90%	935
$\mu^+ \nu_\mu$	( 3.82±0.33) × 10 <sup>-4</sup>		932
$\tau^+ \nu_\tau$	< 1.2 × 10 <sup>-3</sup>	CL=90%	90
$\overline{K}^0 e^+ \nu_e$	( 8.83±0.22) %		869
$\overline{K}^0 \mu^+ \nu_\mu$	( 9.2 ±0.6 ) %		865
$K^- \pi^+ e^+ \nu_e$	( 3.5 <sup>+0.7</sup> <sub>-0.6</sub> ) %		864
$\overline{K}^*(892)^0 e^+ \nu_e,$ $\overline{K}^*(892)^0 \rightarrow K^- \pi^+$	( 3.68±0.21) %		722

$K^- \pi^+ e^+ \nu_e$ nonresonant	$< 7 \times 10^{-3}$	CL=90%	864
$K^- \pi^+ \mu^+ \nu_\mu$	$( 3.8 \pm 0.4 ) \%$		851
$\bar{K}^*(892)^0 \mu^+ \nu_\mu,$	$( 3.7 \pm 0.3 ) \%$		717
$\bar{K}^*(892)^0 \rightarrow K^- \pi^+$			
$K^- \pi^+ \mu^+ \nu_\mu$ nonresonant	$( 2.0 \pm 0.5 ) \times 10^{-3}$		851
$K^- \pi^+ \pi^0 \mu^+ \nu_\mu$	$< 1.6 \times 10^{-3}$	CL=90%	825
$\pi^0 e^+ \nu_e$	$( 4.05 \pm 0.18 ) \times 10^{-3}$		930
$\eta e^+ \nu_e$	$( 1.33 \pm 0.21 ) \times 10^{-3}$		855
$\rho^0 e^+ \nu_e$	$( 2.2 \pm 0.4 ) \times 10^{-3}$		774
$\rho^0 \mu^+ \nu_\mu$	$( 2.4 \pm 0.4 ) \times 10^{-3}$		770
$\omega e^+ \nu_e$	$( 1.6^{+0.7}_{-0.6} ) \times 10^{-3}$		771
$\eta'(958) e^+ \nu_e$	$< 3.5 \times 10^{-4}$	CL=90%	689
$\phi e^+ \nu_e$	$< 1.6 \times 10^{-4}$	CL=90%	657

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

$\bar{K}^*(892)^0 e^+ \nu_e$	$( 5.53 \pm 0.13 ) \%$		722
$\bar{K}^*(892)^0 \mu^+ \nu_\mu$	$( 5.28 \pm 0.15 ) \%$		717
$\bar{K}_0^*(1430)^0 \mu^+ \nu_\mu$	$< 2.4 \times 10^{-4}$		380
$\bar{K}^*(1680)^0 \mu^+ \nu_\mu$	$< 1.5 \times 10^{-3}$		105

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

$K_S^0 \pi^+$	$( 1.47 \pm 0.07 ) \%$	S=2.0	863
$K_L^0 \pi^+$	$( 1.46 \pm 0.05 ) \%$		863
$K^- 2\pi^+$	[pp] $( 9.13 \pm 0.19 ) \%$	S=1.1	846
$(K^- \pi^+)_{S\text{-wave}} \pi^+$	$( 7.31 \pm 0.19 ) \%$		846
$\bar{K}_0^*(1430)^0 \pi^+,$	[qq] $( 1.21 \pm 0.06 ) \%$		382
$\bar{K}_0^*(1430)^0 \rightarrow K^- \pi^+$			
$\bar{K}^*(892)^0 \pi^+,$	$( 1.01 \pm 0.11 ) \%$		714
$\bar{K}^*(892)^0 \rightarrow K^- \pi^+$			
$\bar{K}^*(1410)^0 \pi^+, \bar{K}^{*0} \rightarrow$	not seen		381
$K^- \pi^+$			
$\bar{K}_2^*(1430)^0 \pi^+,$	[qq] $( 2.2 \pm 0.7 ) \times 10^{-4}$		371
$\bar{K}_2^*(1430)^0 \rightarrow K^- \pi^+$			
$\bar{K}^*(1680)^0 \pi^+,$	[qq] $( 2.1 \pm 1.1 ) \times 10^{-4}$		58
$\bar{K}^*(1680)^0 \rightarrow K^- \pi^+$			
$K^- (2\pi^+)_{I=2}$	$( 1.41 \pm 0.26 ) \%$		—
$K_S^0 \pi^+ \pi^0$	[pp] $( 6.99 \pm 0.27 ) \%$		845
$K_S^0 \rho^+$	$( 4.8 \pm 1.0 ) \%$		677
$\bar{K}^*(892)^0 \pi^+,$	$( 1.3 \pm 0.6 ) \%$		714
$\bar{K}^*(892)^0 \rightarrow K_S^0 \pi^0$			
$K_S^0 \pi^+ \pi^0$ nonresonant	$( 9 \pm 7 ) \times 10^{-3}$		845

$K^- 2\pi^+ \pi^0$	[rr]	$(5.99 \pm 0.18) \%$		816
$K_S^0 2\pi^+ \pi^-$	[rr]	$(3.12 \pm 0.11) \%$		814
$K^- 3\pi^+ \pi^-$	[pp]	$(5.6 \pm 0.5) \times 10^{-3}$	S=1.1	772
$\bar{K}^*(892)^0 2\pi^+ \pi^-$ ,		$(1.2 \pm 0.4) \times 10^{-3}$		645
$\bar{K}^*(892)^0 \rightarrow K^- \pi^+$				
$\bar{K}^*(892)^0 \rho^0 \pi^+$ ,		$(2.2 \pm 0.4) \times 10^{-3}$		239
$\bar{K}^*(892)^0 \rightarrow K^- \pi^+$				
$\bar{K}^*(892)^0 a_1(1260)^+$	[ss]	$(9.0 \pm 1.8) \times 10^{-3}$		†
$K^- \rho^0 2\pi^+$		$(1.68 \pm 0.27) \times 10^{-3}$		524
$K^- 3\pi^+ \pi^-$ nonresonant		$(3.9 \pm 2.9) \times 10^{-4}$		772
$K^+ 2K_S^0$		$(4.5 \pm 2.0) \times 10^{-3}$		545
$K^+ K^- K_S^0 \pi^+$		$(2.4 \pm 0.6) \times 10^{-4}$		436

### Pionic modes

$\pi^+ \pi^0$		$(1.19 \pm 0.06) \times 10^{-3}$		925
$2\pi^+ \pi^-$		$(3.18 \pm 0.18) \times 10^{-3}$		908
$\rho^0 \pi^+$		$(8.1 \pm 1.5) \times 10^{-4}$		767
$\pi^+ (\pi^+ \pi^-)_{S\text{-wave}}$		$(1.78 \pm 0.16) \times 10^{-3}$		908
$\sigma \pi^+$ , $\sigma \rightarrow \pi^+ \pi^-$		$(1.34 \pm 0.12) \times 10^{-3}$		–
$f_0(980) \pi^+$ ,		$(1.52 \pm 0.33) \times 10^{-4}$		669
$f_0(980) \rightarrow \pi^+ \pi^-$				
$f_0(1370) \pi^+$ ,		$(8 \pm 4) \times 10^{-5}$		–
$f_0(1370) \rightarrow \pi^+ \pi^-$				
$f_2(1270) \pi^+$ ,		$(4.9 \pm 0.9) \times 10^{-4}$		485
$f_2(1270) \rightarrow \pi^+ \pi^-$				
$\rho(1450)^0 \pi^+$ ,	< 8	$\times 10^{-5}$	CL=95%	338
$\rho(1450)^0 \rightarrow \pi^+ \pi^-$				
$f_0(1500) \pi^+$ ,		$(1.1 \pm 0.4) \times 10^{-4}$		–
$f_0(1500) \rightarrow \pi^+ \pi^-$				
$f_0(1710) \pi^+$ ,	< 5	$\times 10^{-5}$	CL=95%	–
$f_0(1710) \rightarrow \pi^+ \pi^-$				
$f_0(1790) \pi^+$ ,	< 6	$\times 10^{-5}$	CL=95%	–
$f_0(1790) \rightarrow \pi^+ \pi^-$				
$(\pi^+ \pi^+)_{S\text{-wave}} \pi^-$	< 1.2	$\times 10^{-4}$	CL=95%	908
$2\pi^+ \pi^-$ nonresonant	< 1.1	$\times 10^{-4}$	CL=95%	908
$\pi^+ 2\pi^0$		$(4.6 \pm 0.4) \times 10^{-3}$		910
$2\pi^+ \pi^- \pi^0$		$(1.13 \pm 0.08) \%$		883
$\eta \pi^+$ , $\eta \rightarrow \pi^+ \pi^- \pi^0$		$(7.8 \pm 0.5) \times 10^{-4}$		848
$\omega \pi^+$ , $\omega \rightarrow \pi^+ \pi^- \pi^0$	< 3	$\times 10^{-4}$	CL=90%	763
$3\pi^+ 2\pi^-$		$(1.61 \pm 0.16) \times 10^{-3}$		845

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

$\eta\pi^+$	$(3.53 \pm 0.21) \times 10^{-3}$		848
$\eta\pi^+\pi^0$	$(1.38 \pm 0.35) \times 10^{-3}$		830
$\omega\pi^+$	$< 3.4 \times 10^{-4}$	CL=90%	764
$\eta'(958)\pi^+$	$(4.67 \pm 0.29) \times 10^{-3}$		680
$\eta'(958)\pi^+\pi^0$	$(1.6 \pm 0.5) \times 10^{-3}$		654

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

$K^+K_S^0$	$(2.83 \pm 0.16) \times 10^{-3}$	S=2.2	793
$K^+K^-\pi^+$	[pp] $(9.54 \pm 0.26) \times 10^{-3}$	S=1.1	744
$\phi\pi^+, \phi \rightarrow K^+K^-$	$(2.65^{+0.08}_{-0.09}) \times 10^{-3}$		647
$K^+\bar{K}^*(892)^0, \bar{K}^*(892)^0 \rightarrow K^-\pi^+$	$(2.45^{+0.09}_{-0.14}) \times 10^{-3}$		613
$K^+\bar{K}_0^*(1430)^0, \bar{K}_0^*(1430)^0 \rightarrow K^-\pi^+$	$(1.79 \pm 0.34) \times 10^{-3}$		—
$K^+\bar{K}_2^*(1430)^0, \bar{K}_2^* \rightarrow K^-\pi^+$	$(1.6^{+1.2}_{-0.8}) \times 10^{-4}$		—
$K^+\bar{K}_0^*(800), \bar{K}_0^* \rightarrow K^-\pi^+$	$(6.7^{+3.4}_{-2.1}) \times 10^{-4}$		—
$a_0(1450)^0\pi^+, a_0^0 \rightarrow K^+K^-$	$(4.4^{+7.0}_{-1.8}) \times 10^{-4}$		—
$\phi(1680)\pi^+, \phi \rightarrow K^+K^-$	$(4.9^{+4.0}_{-1.9}) \times 10^{-5}$		—
$K^+K^-\pi^+$ nonresonant	not seen		744
$K^+K_S^0\pi^+\pi^-$	$(1.75 \pm 0.18) \times 10^{-3}$		678
$K_S^0K^-2\pi^+$	$(2.40 \pm 0.18) \times 10^{-3}$		678
$K^+K^-2\pi^+\pi^-$	$(2.2 \pm 1.2) \times 10^{-4}$		600

A few poorly measured branching fractions:

$\phi\pi^+\pi^0$	$(2.3 \pm 1.0) \%$		619
$\phi\rho^+$	$< 1.5 \%$	CL=90%	259
$K^+K^-\pi^+\pi^0$ non- $\phi$	$(1.5^{+0.7}_{-0.6}) \%$		682
$K^*(892)^+K_S^0$	$(1.6 \pm 0.7) \%$		611

### Doubly Cabibbo-suppressed modes

$K^+\pi^0$	$(1.83 \pm 0.26) \times 10^{-4}$	S=1.4	864
$K^+\eta$	$< 1.4 \times 10^{-4}$	CL=90%	776
$K^+\eta'(958)$	$< 1.8 \times 10^{-4}$	CL=90%	571
$K^+\pi^+\pi^-$	$(5.27 \pm 0.23) \times 10^{-4}$		846
$K^+\rho^0$	$(2.0 \pm 0.5) \times 10^{-4}$		679

$K^*(892)^0 \pi^+, K^*(892)^0 \rightarrow K^+ \pi^-$	$(2.5 \pm 0.4) \times 10^{-4}$	714
$K^+ f_0(980), f_0(980) \rightarrow \pi^+ \pi^-$	$(4.7 \pm 2.8) \times 10^{-5}$	—
$K_2^*(1430)^0 \pi^+, K_2^*(1430)^0 \rightarrow K^+ \pi^-$	$(4.2 \pm 2.8) \times 10^{-5}$	—
$K^+ \pi^+ \pi^-$ nonresonant	not seen	846
$2K^+ K^-$	$(8.7 \pm 2.0) \times 10^{-5}$	550

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

$\pi^+ e^+ e^-$	C1	$< 5.9 \times 10^{-6}$	CL=90%	930
$\pi^+ \phi, \phi \rightarrow e^+ e^-$	[tt]	$(1.7^{+1.4}_{-0.9}) \times 10^{-6}$		—
$\pi^+ \mu^+ \mu^-$	C1	$< 3.9 \times 10^{-6}$	CL=90%	917
$\pi^+ \phi, \phi \rightarrow \mu^+ \mu^-$	[tt]	$(1.8 \pm 0.8) \times 10^{-6}$		—
$\rho^+ \mu^+ \mu^-$	C1	$< 5.6 \times 10^{-4}$	CL=90%	757
$K^+ e^+ e^-$	[uu]	$< 3.0 \times 10^{-6}$	CL=90%	870
$K^+ \mu^+ \mu^-$	[uu]	$< 9.2 \times 10^{-6}$	CL=90%	856
$\pi^+ e^\pm \mu^\mp$	LF	[ee] $< 3.4 \times 10^{-5}$	CL=90%	927
$K^+ e^\pm \mu^\mp$	LF	[ee] $< 6.8 \times 10^{-5}$	CL=90%	866
$\pi^- 2e^+$	L	$< 1.1 \times 10^{-6}$	CL=90%	930
$\pi^- 2\mu^+$	L	$< 4.8 \times 10^{-6}$	CL=90%	917
$\pi^- e^+ \mu^+$	L	$< 5.0 \times 10^{-5}$	CL=90%	927
$\rho^- 2\mu^+$	L	$< 5.6 \times 10^{-4}$	CL=90%	757
$K^- 2e^+$	L	$< 3.5 \times 10^{-6}$	CL=90%	870
$K^- 2\mu^+$	L	$< 1.3 \times 10^{-5}$	CL=90%	856
$K^- e^+ \mu^+$	L	$< 1.3 \times 10^{-4}$	CL=90%	866
$K^*(892)^- 2\mu^+$	L	$< 8.5 \times 10^{-4}$	CL=90%	703

**$D^0$**

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

Mass  $m = 1864.80 \pm 0.14$  MeV

$m_{D^\pm} - m_{D^0} = 4.77 \pm 0.10$  MeV (S = 1.1)

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

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

$|m_{D_1^0} - m_{D_2^0}| = (2.39^{+0.59}_{-0.63}) \times 10^{10} \hbar \text{ s}^{-1} [\text{vv}]$

$(\Gamma_{D_1^0} - \Gamma_{D_2^0})/\Gamma = 2y = (1.66 \pm 0.32) \times 10^{-2} [\text{vv}]$

$|q/p| = 0.86^{+0.18}_{-0.15}$

$A_\Gamma = (1.4 \pm 2.7) \times 10^{-3}$

$K^+ \pi^-$  relative strong phase:  $\cos \delta = 1.03^{+0.32}_{-0.18}$

$K^- \pi^+ \pi^0$  coherence factor  $R_{K\pi\pi^0} = 0.78^{+0.11}_{-0.25}$

$K^- \pi^+ \pi^0$  average relative strong phase  $\delta^{K\pi\pi^0} = (239^{+32}_{-28})^\circ$



$$K^- \pi^- 2\pi^+ \text{ coherence factor } R_{K3\pi} = 0.36_{-0.30}^{+0.24}$$

$$K^- \pi^- 2\pi^+ \text{ average relative strong phase } \delta^{K3\pi} = (118_{-50}^{+60})^\circ$$

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

$$A_{CP}(K^+ K^-) = (-0.17 \pm 0.31)\% \quad (S = 1.3)$$

$$A_{CP}(2K_S^0) = (-23 \pm 19)\%$$

$$A_{CP}(\pi^+ \pi^-) = (0.2 \pm 0.4)\%$$

$$A_{CP}(2\pi^0) = (0 \pm 5)\%$$

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

$$A_{CP}(\rho(770)^+ \pi^- \rightarrow \pi^+ \pi^- \pi^0) = (1.2 \pm 0.9)\%$$

$$A_{CP}(\rho(770)^0 \pi^0 \rightarrow \pi^+ \pi^- \pi^0) = (-3.1 \pm 3.0)\%$$

$$A_{CP}(\rho(770)^- \pi^+ \rightarrow \pi^+ \pi^- \pi^0) = (-1.0 \pm 1.7)\%$$

$$A_{CP}(\rho(1450)^+ \pi^- \rightarrow \pi^+ \pi^- \pi^0) = (0 \pm 70)\%$$

$$A_{CP}(\rho(1450)^0 \pi^0 \rightarrow \pi^+ \pi^- \pi^0) = (-17 \pm 40)\%$$

$$A_{CP}(\rho(1450)^- \pi^+ \rightarrow \pi^+ \pi^- \pi^0) = (6 \pm 9)\%$$

$$A_{CP}(\rho(1700)^+ \pi^- \rightarrow \pi^+ \pi^- \pi^0) = (-5 \pm 14)\%$$

$$A_{CP}(\rho(1700)^0 \pi^0 \rightarrow \pi^+ \pi^- \pi^0) = (13 \pm 9)\%$$

$$A_{CP}(\rho(1700)^- \pi^+ \rightarrow \pi^+ \pi^- \pi^0) = (8 \pm 11)\%$$

$$A_{CP}(f_0(980) \pi^0 \rightarrow \pi^+ \pi^- \pi^0) = (0 \pm 35)\%$$

$$A_{CP}(f_0(1370) \pi^0 \rightarrow \pi^+ \pi^- \pi^0) = (25 \pm 18)\%$$

$$A_{CP}(f_0(1500) \pi^0 \rightarrow \pi^+ \pi^- \pi^0) = (0 \pm 18)\%$$

$$A_{CP}(f_0(1710) \pi^0 \rightarrow \pi^+ \pi^- \pi^0) = (0 \pm 24)\%$$

$$A_{CP}(f_2(1270) \pi^0 \rightarrow \pi^+ \pi^- \pi^0) = (-4 \pm 6)\%$$

$$A_{CP}(\sigma(400) \pi^0 \rightarrow \pi^+ \pi^- \pi^0) = (6 \pm 8)\%$$

$$A_{CP}(\text{nonresonant } \pi^+ \pi^- \pi^0) = (-13 \pm 23)\%$$

$$A_{CP}(K^+ K^- \pi^0) = (-1.0 \pm 1.7)\%$$

$$A_{CP}(K^*(892)^+ K^- \rightarrow K^+ K^- \pi^0) = (-0.9 \pm 1.3)\%$$

$$A_{CP}(K^*(1410)^+ K^- \rightarrow K^+ K^- \pi^0) = (-21 \pm 24)\%$$

$$A_{CP}((K^+ \pi^0)_{S\text{-wave}} K^- \rightarrow K^+ K^- \pi^0) = (7 \pm 15)\%$$

$$A_{CP}(\phi(1020) \pi^0 \rightarrow K^+ K^- \pi^0) = (1.1 \pm 2.2)\%$$

$$A_{CP}(f_0(980) \pi^0 \rightarrow K^+ K^- \pi^0) = (-3 \pm 19)\%$$

$$A_{CP}(a_0(980)^0 \pi^0 \rightarrow K^+ K^- \pi^0) = (-5 \pm 16)\%$$

$$A_{CP}(f_2'(1525) \pi^0 \rightarrow K^+ K^- \pi^0) = (0 \pm 160)\%$$

$$A_{CP}(K^*(892)^- K^+ \rightarrow K^+ K^- \pi^0) = (-5 \pm 4)\%$$

$$A_{CP}(K^*(1410)^- K^+ \rightarrow K^+ K^- \pi^0) = (-17 \pm 29)\%$$

$$A_{CP}((K^- \pi^0)_{S\text{-wave}} K^+ \rightarrow K^+ K^- \pi^0) = (-7 \pm 40)\%$$

$$A_{CP}(K_S^0 \phi) = (-3 \pm 9)\%$$

$$A_{CP}(K_S^0 \pi^0) = (0.1 \pm 1.3)\%$$

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

$$A_{CP}(K^+ \pi^-) = (2.2 \pm 3.2)\%$$

$$A_{CP}(K^- \pi^+ \pi^0) = (0.2 \pm 0.9)\%$$

$$A_{CP}(K^+ \pi^- \pi^0) = (0 \pm 5)\%$$

$$\begin{aligned}
 A_{CP}(K_S^0 \pi^+ \pi^-) &= (-0.9^{+2.6}_{-6.0})\% \\
 A_{CP}(K^*(892)^- \pi^+ \rightarrow K_S^0 \pi^+ \pi^-) &< 3.5 \times 10^{-4}, \text{ CL} = 95\% \\
 A_{CP}(K^*(892)^+ \pi^- \rightarrow K_S^0 \pi^+ \pi^-) &< 7.8 \times 10^{-4}, \text{ CL} = 95\% \\
 A_{CP}(\bar{K}^0 \rho^0 \rightarrow K_S^0 \pi^+ \pi^-) &< 4.8 \times 10^{-4}, \text{ CL} = 95\% \\
 A_{CP}(\bar{K}^0 \omega \rightarrow K_S^0 \pi^+ \pi^-) &< 9.2 \times 10^{-4}, \text{ CL} = 95\% \\
 A_{CP}(\bar{K}^0 f_0(980) \rightarrow K_S^0 \pi^+ \pi^-) &< 6.8 \times 10^{-4}, \text{ CL} = 95\% \\
 A_{CP}(\bar{K}^0 f_2(1270) \rightarrow K_S^0 \pi^+ \pi^-) &< 13.5 \times 10^{-4}, \text{ CL} = 95\% \\
 A_{CP}(\bar{K}^0 f_0(1370) \rightarrow K_S^0 \pi^+ \pi^-) &< 25.5 \times 10^{-4}, \text{ CL} = 95\% \\
 A_{CP}(K_0^*(1430)^- \pi^+ \rightarrow K_S^0 \pi^+ \pi^-) &< 9.0 \times 10^{-4}, \text{ CL} = 95\% \\
 A_{CP}(K_2^*(1430)^- \pi^+ \rightarrow K_S^0 \pi^+ \pi^-) &< 6.5 \times 10^{-4}, \text{ CL} = 95\% \\
 A_{CP}(K^*(1680)^- \pi^+ \rightarrow K_S^0 \pi^+ \pi^-) &< 28.4 \times 10^{-4}, \text{ CL} = 95\% \\
 A_{CP}(K^- \pi^+ \pi^+ \pi^-) &= (0.7 \pm 1.0)\% \\
 A_{CP}(K^+ \pi^- \pi^+ \pi^-) &= (-2 \pm 4)\% \\
 A_{CP}(K^+ K^- \pi^+ \pi^-) &= (-8 \pm 7)\%
 \end{aligned}$$

### T-violation decay-rate asymmetry

$$A_T(K^+ K^- \pi^+ \pi^-) = (1 \pm 7) \times 10^{-3} [{}^{\infty}]$$

### CPT-violation decay-rate asymmetry

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

### Form factors

$$\begin{aligned}
 r_V &\equiv V(0)/A_1(0) \text{ in } D^0 \rightarrow K^*(892)^- \ell^+ \nu_\ell = 1.7 \pm 0.8 \\
 r_2 &\equiv A_2(0)/A_1(0) \text{ in } D^0 \rightarrow K^*(892)^- \ell^+ \nu_\ell = 0.9 \pm 0.4 \\
 f_+(0) |V_{cs}| &\text{ in } D^0 \rightarrow K^- \ell^+ \nu_\ell = 0.726 \pm 0.009 \\
 r_1 &\equiv a_1/a_0 \text{ in } D^0 \rightarrow K^- \ell^+ \nu_\ell = -2.65 \pm 0.35 \\
 r_2 &\equiv a_1/a_0 \text{ in } D^0 \rightarrow K^- \ell^+ \nu_\ell = 13 \pm 9 \\
 f_+(0) |V_{cd}| &\text{ in } D^0 \rightarrow \pi^- \ell^+ \nu_\ell = 0.152 \pm 0.005 \\
 r_1 &\equiv a_1/a_0 \text{ in } D^0 \rightarrow \pi^- \ell^+ \nu_\ell = -2.8 \pm 0.5 \\
 r_2 &\equiv a_1/a_0 \text{ in } D^0 \rightarrow \pi^- \ell^+ \nu_\ell = 6 \pm 3.0
 \end{aligned}$$

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

<b><math>D^0</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	Scale factor/ Confidence level	$p$ (MeV/c)
<b>Topological modes</b>			
0-prongs	[ww] (17 ± 6 ) %		—
2-prongs	(69 ± 6 ) %		—
4-prongs	[xx] (14.3 ± 0.5 ) %		—
6-prongs	[yy] ( 6.4 ± 1.3 ) × 10 <sup>-4</sup>		—
<b>Inclusive modes</b>			
$e^+$ anything	[zz] ( 6.49 ± 0.11 ) %		—
$\mu^+$ anything	( 6.7 ± 0.6 ) %		—
$K^-$ anything	(54.7 ± 2.8 ) %	S=1.3	—
$\bar{K}^0$ anything + $K^0$ anything	(47 ± 4 ) %		—
$K^+$ anything	( 3.4 ± 0.4 ) %		—
$K^*(892)^-$ anything	(15 ± 9 ) %		—
$\bar{K}^*(892)^0$ anything	( 9 ± 4 ) %		—
$K^*(892)^+$ anything	< 3.6 %	CL=90%	—
$K^*(892)^0$ anything	( 2.8 ± 1.3 ) %		—
$\eta$ anything	( 9.5 ± 0.9 ) %		—
$\eta'$ anything	( 2.48 ± 0.27 ) %		—
$\phi$ anything	( 1.05 ± 0.11 ) %		—
<b>Semileptonic modes</b>			
$K^- e^+ \nu_e$	( 3.55 ± 0.04 ) %	S=1.1	867
$K^- \mu^+ \nu_\mu$	( 3.30 ± 0.13 ) %		864
$K^*(892)^- e^+ \nu_e$	( 2.16 ± 0.16 ) %		719
$K^*(892)^- \mu^+ \nu_\mu$	( 1.90 ± 0.23 ) %		714
$K^- \pi^0 e^+ \nu_e$	( 1.6 <sup>+1.3</sup> <sub>-0.5</sub> ) %		861
$\bar{K}^0 \pi^- e^+ \nu_e$	( 2.7 <sup>+0.9</sup> <sub>-0.7</sub> ) %		860
$K^- \pi^+ \pi^- e^+ \nu_e$	( 2.8 <sup>+1.4</sup> <sub>-1.1</sub> ) × 10 <sup>-4</sup>		843
$K_1(1270)^- e^+ \nu_e$	( 7.6 <sup>+4.0</sup> <sub>-3.1</sub> ) × 10 <sup>-4</sup>		498
$K^- \pi^+ \pi^- \mu^+ \nu_\mu$	< 1.2 × 10 <sup>-3</sup>	CL=90%	821
$(\bar{K}^*(892)\pi)^- \mu^+ \nu_\mu$	< 1.4 × 10 <sup>-3</sup>	CL=90%	692
$\pi^- e^+ \nu_e$	( 2.89 ± 0.08 ) × 10 <sup>-3</sup>	S=1.1	927
$\pi^- \mu^+ \nu_\mu$	( 2.37 ± 0.24 ) × 10 <sup>-3</sup>		924
$\rho^- e^+ \nu_e$	( 1.9 ± 0.4 ) × 10 <sup>-3</sup>		771

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

$K^- \pi^+$	( 3.87 ± 0.05 ) %	S=1.2	861
$K_S^0 \pi^0$	( 1.19 ± 0.05 ) %	S=1.3	860
$K_L^0 \pi^0$	(10.0 ± 0.7 ) × 10 <sup>-3</sup>		860
$K_S^0 \pi^+ \pi^-$	[pp] ( 2.81 ± 0.15 ) %	S=1.1	842
$K_S^0 \rho^0$	( 6.3 $\begin{smallmatrix} + 0.6 \\ - 0.7 \end{smallmatrix}$ ) × 10 <sup>-3</sup>		674
$K_S^0 \omega, \omega \rightarrow \pi^+ \pi^-$	( 2.0 ± 0.6 ) × 10 <sup>-4</sup>		670
$K_S^0 (\pi^+ \pi^-)_{S\text{-wave}}$	( 3.3 ± 0.8 ) × 10 <sup>-3</sup>		842
$K_S^0 f_0(980),$ $f_0(980) \rightarrow \pi^+ \pi^-$	( 1.21 $\begin{smallmatrix} + 0.40 \\ - 0.23 \end{smallmatrix}$ ) × 10 <sup>-3</sup>		549
$K_S^0 f_0(1370),$ $f_0(1370) \rightarrow \pi^+ \pi^-$	( 2.8 $\begin{smallmatrix} + 0.9 \\ - 1.3 \end{smallmatrix}$ ) × 10 <sup>-3</sup>		†
$K_S^0 f_2(1270),$ $f_2(1270) \rightarrow \pi^+ \pi^-$	( 9 $\begin{smallmatrix} + 10 \\ - 6 \end{smallmatrix}$ ) × 10 <sup>-5</sup>		262
$K^*(892)^- \pi^+,$ $K^*(892)^- \rightarrow K_S^0 \pi^-$	( 1.65 $\begin{smallmatrix} + 0.13 \\ - 0.16 \end{smallmatrix}$ ) %		711
$K_0^*(1430)^- \pi^+,$ $K_0^*(1430)^- \rightarrow K_S^0 \pi^-$	( 2.69 $\begin{smallmatrix} + 0.40 \\ - 0.31 \end{smallmatrix}$ ) × 10 <sup>-3</sup>		378
$K_2^*(1430)^- \pi^+,$ $K_2^*(1430)^- \rightarrow K_S^0 \pi^-$	( 3.4 $\begin{smallmatrix} + 1.9 \\ - 1.0 \end{smallmatrix}$ ) × 10 <sup>-4</sup>		367
$K^*(1680)^- \pi^+,$ $K^*(1680)^- \rightarrow K_S^0 \pi^-$	( 4 ± 4 ) × 10 <sup>-4</sup>		46
$K^*(892)^+ \pi^-,$ $K^*(892)^+ \rightarrow K_S^0 \pi^+$	[aaa] ( 1.13 $\begin{smallmatrix} + 0.60 \\ - 0.34 \end{smallmatrix}$ ) × 10 <sup>-4</sup>		711
$K_0^*(1430)^+ \pi^-,$ $K_0^*(1430)^+ \rightarrow K_S^0 \pi^+$	[aaa] < 1.4 × 10 <sup>-5</sup> CL=95%		-
$K_2^*(1430)^+ \pi^-,$ $K_2^*(1430)^+ \rightarrow K_S^0 \pi^+$	[aaa] < 3.4 × 10 <sup>-5</sup> CL=95%		-
$K_S^0 \pi^+ \pi^-$ nonresonant	( 2.5 $\begin{smallmatrix} + 6.0 \\ - 1.6 \end{smallmatrix}$ ) × 10 <sup>-4</sup>		842
$K^- \pi^+ \pi^0$	[pp] (13.9 ± 0.5 ) %	S=1.7	844
$K^- \rho^+$	(10.8 ± 0.7 ) %		675
$K^- \rho(1700)^+,$ $\rho(1700)^+ \rightarrow \pi^+ \pi^0$	( 7.9 ± 1.7 ) × 10 <sup>-3</sup>		†
$K^*(892)^- \pi^+,$ $K^*(892)^- \rightarrow K^- \pi^0$	( 2.21 $\begin{smallmatrix} + 0.40 \\ - 0.19 \end{smallmatrix}$ ) %		711
$\bar{K}^*(892)^0 \pi^0,$ $\bar{K}^*(892)^0 \rightarrow K^- \pi^+$	( 1.88 ± 0.23 ) %		711
$K_0^*(1430)^- \pi^+,$ $K_0^*(1430)^- \rightarrow K^- \pi^0$	( 4.6 ± 2.1 ) × 10 <sup>-3</sup>		378

$\bar{K}_0^*(1430)^0 \pi^0,$	$( 5.7 \pm 5.0 ) \times 10^{-3}$		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	$( 1.11 \pm 0.50 ) \%$		844
$K_S^0 2\pi^0$	$( 8.3 \pm 0.6 ) \times 10^{-3}$		843
$\bar{K}^*(892)^0 \pi^0,$	$( 6.6 \pm 1.8 ) \times 10^{-3}$		711
$\bar{K}^*(892)^0 \rightarrow K_S^0 \pi^0$			
$K_S^0 2\pi^0$ nonresonant	$( 4.4 \pm 1.1 ) \times 10^{-3}$		843
$K^- 2\pi^+ \pi^-$	[ <i>pp</i> ] $( 8.07 \pm 0.21 ) \%$	S=1.4	813
$K^- \pi^+ \rho^0$ total	$( 6.74 \pm 0.33 ) \%$		609
$K^- \pi^+ \rho^0$ 3-body	$( 5.1 \pm 2.3 ) \times 10^{-3}$		609
$\bar{K}^*(892)^0 \rho^0,$	$( 1.05 \pm 0.23 ) \%$		416
$\bar{K}^*(892)^0 \rightarrow K^- \pi^+$			
$K^- a_1(1260)^+,$	$( 3.6 \pm 0.6 ) \%$		327
$a_1(1260)^+ \rightarrow 2\pi^+ \pi^-$			
$\bar{K}^*(892)^0 \pi^+ \pi^-$ total,	$( 1.6 \pm 0.4 ) \%$		685
$\bar{K}^*(892)^0 \rightarrow K^- \pi^+$			
$\bar{K}^*(892)^0 \pi^+ \pi^-$ 3-body,	$( 9.9 \pm 2.3 ) \times 10^{-3}$		685
$\bar{K}^*(892)^0 \rightarrow K^- \pi^+$			
$K_1(1270)^- \pi^+,$	[ <i>bbb</i> ] $( 2.9 \pm 0.3 ) \times 10^{-3}$		484
$K_1(1270)^- \rightarrow K^- \pi^+ \pi^-$			
$K^- 2\pi^+ \pi^-$ nonresonant	$( 1.88 \pm 0.26 ) \%$		813
$K_S^0 \pi^+ \pi^- \pi^0$	[ <i>ccc</i> ] $( 5.2 \pm 0.6 ) \%$		813
$K_S^0 \eta, \eta \rightarrow \pi^+ \pi^- \pi^0$	$( 1.02 \pm 0.09 ) \times 10^{-3}$		772
$K_S^0 \omega, \omega \rightarrow \pi^+ \pi^- \pi^0$	$( 9.9 \pm 0.5 ) \times 10^{-3}$		670
$K^- 2\pi^+ \pi^- \pi^0$	$( 4.2 \pm 0.4 ) \%$		771
$\bar{K}^*(892)^0 \pi^+ \pi^- \pi^0,$	$( 1.3 \pm 0.6 ) \%$		643
$\bar{K}^*(892)^0 \rightarrow K^- \pi^+$			
$K^- \pi^+ \omega, \omega \rightarrow \pi^+ \pi^- \pi^0$	$( 2.7 \pm 0.5 ) \%$		605
$\bar{K}^*(892)^0 \omega,$	$( 6.5 \pm 3.0 ) \times 10^{-3}$		410
$\bar{K}^*(892)^0 \rightarrow K^- \pi^+,$			
$\omega \rightarrow \pi^+ \pi^- \pi^0$			
$K_S^0 \eta \pi^0$	$( 5.5 \pm 1.1 ) \times 10^{-3}$		721
$K_S^0 a_0(980), a_0(980) \rightarrow \eta \pi^0$	$( 6.5 \pm 2.0 ) \times 10^{-3}$		–
$\bar{K}^*(892)^0 \eta,$	$( 1.6 \pm 0.5 ) \times 10^{-3}$		–
$\bar{K}^*(892)^0 \rightarrow K_S^0 \pi^0$			
$K_S^0 2\pi^+ 2\pi^-$	$( 2.67 \pm 0.28 ) \times 10^{-3}$		768
$K_S^0 \rho^0 \pi^+ \pi^-,$ no $K^*(892)^-$	$( 1.1 \pm 0.7 ) \times 10^{-3}$		–

$K^*(892)^- 2\pi^+ \pi^-$ ,	$( 5 \pm 8 ) \times 10^{-4}$	642
$K^*(892)^- \rightarrow K_S^0 \pi^-$ ,		
no $\rho^0$		
$K^*(892)^- \rho^0 \pi^+$ ,	$( 1.6 \pm 0.6 ) \times 10^{-3}$	230
$K^*(892)^- \rightarrow K_S^0 \pi^-$		
$K_S^0 2\pi^+ 2\pi^-$ nonresonant	$< 1.2 \times 10^{-3}$ CL=90%	768
$K^- 3\pi^+ 2\pi^-$	$( 2.2 \pm 0.6 ) \times 10^{-4}$	713

Fractions of 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.)

$K_S^0 \eta$	$( 4.5 \pm 0.4 ) \times 10^{-3}$ S=1.5	772
$K_S^0 \omega$	$( 1.11 \pm 0.06 ) \%$	670
$K_S^0 \eta'(958)$	$( 9.4 \pm 0.5 ) \times 10^{-3}$	565
$K^- a_1(1260)^+$	$( 7.8 \pm 1.1 ) \%$	327
$K^- a_2(1320)^+$	$< 2 \times 10^{-3}$ CL=90%	198
$\bar{K}^*(892)^0 \pi^+ \pi^-$ total	$( 2.4 \pm 0.5 ) \%$	685
$\bar{K}^*(892)^0 \pi^+ \pi^-$ 3-body	$( 1.48 \pm 0.34 ) \%$	685
$\bar{K}^*(892)^0 \rho^0$	$( 1.57 \pm 0.34 ) \%$	417
$\bar{K}^*(892)^0 \rho^0$ transverse	$( 1.7 \pm 0.6 ) \%$	417
$\bar{K}^*(892)^0 \rho^0$ S-wave	$( 3.0 \pm 0.6 ) \%$	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	$( 2.1 \pm 0.6 ) \%$	417
$K_1(1270)^- \pi^+$	[bbb] $( 1.6 \pm 0.8 ) \%$	484
$K_1(1400)^- \pi^+$	$< 1.2 \%$ CL=90%	386
$\bar{K}^*(892)^0 \pi^+ \pi^- \pi^0$	$( 1.9 \pm 0.9 ) \%$	643
$K^- \pi^+ \omega$	$( 3.0 \pm 0.6 ) \%$	605
$\bar{K}^*(892)^0 \omega$	$( 1.1 \pm 0.5 ) \%$	410
$K^- \pi^+ \eta'(958)$	$( 7.5 \pm 1.9 ) \times 10^{-3}$	479
$\bar{K}^*(892)^0 \eta'(958)$	$< 1.1 \times 10^{-3}$ CL=90%	119

### Hadronic modes with three $K$ 's

$K_S^0 K^+ K^-$	$( 4.45 \pm 0.28 ) \times 10^{-3}$	544
$K_S^0 a_0(980)^0, a_0^0 \rightarrow K^+ K^-$	$( 3.0 \pm 0.4 ) \times 10^{-3}$	—
$K^- a_0(980)^+, a_0^+ \rightarrow K^+ K_S^0$	$( 6.0 \pm 1.8 ) \times 10^{-4}$	—
$K^+ a_0(980)^-, a_0^- \rightarrow K^- K_S^0$	$< 1.1 \times 10^{-4}$ CL=95%	—
$K_S^0 f_0(980), f_0 \rightarrow K^+ K^-$	$< 9 \times 10^{-5}$ CL=95%	—
$K_S^0 \phi, \phi \rightarrow K^+ K^-$	$( 2.04 \pm 0.14 ) \times 10^{-3}$	520
$K_S^0 f_0(1370), f_0 \rightarrow K^+ K^-$	$( 1.7 \pm 1.1 ) \times 10^{-4}$	—
$3K_S^0$	$( 9.1 \pm 1.3 ) \times 10^{-4}$	539

$K^+ 2K^- \pi^+$	$( 2.21 \pm 0.31 ) \times 10^{-4}$	434
$K^+ K^- \bar{K}^*(892)^0,$	$( 4.4 \pm 1.7 ) \times 10^{-5}$	†
$\bar{K}^*(892)^0 \rightarrow K^- \pi^+$		
$K^- \pi^+ \phi, \phi \rightarrow K^+ K^-$	$( 4.0 \pm 1.7 ) \times 10^{-5}$	422
$\phi \bar{K}^*(892)^0,$	$( 1.06 \pm 0.20 ) \times 10^{-4}$	†
$\phi \rightarrow K^+ K^-,$		
$\bar{K}^*(892)^0 \rightarrow K^- \pi^+$		
$K^+ 2K^- \pi^+$ nonresonant	$( 3.3 \pm 1.5 ) \times 10^{-5}$	434
$2K_S^0 K^\pm \pi^\mp$	$( 6.0 \pm 1.3 ) \times 10^{-4}$	427

### Pionic modes

$\pi^+ \pi^-$	$( 1.400 \pm 0.026 ) \times 10^{-3}$	S=1.1	922
$2\pi^0$	$( 8.0 \pm 0.5 ) \times 10^{-4}$		923
$\pi^+ \pi^- \pi^0$	$( 1.43 \pm 0.06 ) \%$	S=1.9	907
$\rho^+ \pi^-$	$( 9.8 \pm 0.4 ) \times 10^{-3}$		764
$\rho^0 \pi^0$	$( 3.72 \pm 0.22 ) \times 10^{-3}$		764
$\rho^- \pi^+$	$( 4.96 \pm 0.24 ) \times 10^{-3}$		764
$\rho(1450)^+ \pi^-, \rho(1450)^+ \rightarrow$	$( 1.6 \pm 2.0 ) \times 10^{-5}$		–
$\pi^+ \pi^0$			
$\rho(1450)^0 \pi^0, \rho(1450)^0 \rightarrow$	$( 4.3 \pm 1.9 ) \times 10^{-5}$		–
$\pi^+ \pi^-$			
$\rho(1450)^- \pi^+, \rho(1450)^- \rightarrow$	$( 2.6 \pm 0.4 ) \times 10^{-4}$		–
$\pi^- \pi^0$			
$\rho(1700)^+ \pi^-, \rho(1700)^+ \rightarrow$	$( 5.9 \pm 1.4 ) \times 10^{-4}$		–
$\pi^+ \pi^0$			
$\rho(1700)^0 \pi^0, \rho(1700)^0 \rightarrow$	$( 7.2 \pm 1.7 ) \times 10^{-4}$		–
$\pi^+ \pi^-$			
$\rho(1700)^- \pi^+, \rho(1700)^- \rightarrow$	$( 4.6 \pm 1.1 ) \times 10^{-4}$		–
$\pi^- \pi^0$			
$f_0(980) \pi^0, f_0(980) \rightarrow$	$( 3.6 \pm 0.8 ) \times 10^{-5}$		–
$\pi^+ \pi^-$			
$f_0(600) \pi^0, f_0(600) \rightarrow$	$( 1.17 \pm 0.21 ) \times 10^{-4}$		–
$\pi^+ \pi^-$			
$f_0(1370) \pi^0, f_0(1370) \rightarrow$	$( 5.3 \pm 2.0 ) \times 10^{-5}$		–
$\pi^+ \pi^-$			
$f_0(1500) \pi^0, f_0(1500) \rightarrow$	$( 5.6 \pm 1.5 ) \times 10^{-5}$		–
$\pi^+ \pi^-$			
$f_0(1710) \pi^0, f_0(1710) \rightarrow$	$( 4.4 \pm 1.5 ) \times 10^{-5}$		–
$\pi^+ \pi^-$			
$f_2(1270) \pi^0, f_2(1270) \rightarrow$	$( 1.89 \pm 0.20 ) \times 10^{-4}$		–
$\pi^+ \pi^- \pi^0$ nonresonant	$( 1.20 \pm 0.35 ) \times 10^{-4}$		907
$3\pi^0$	$< 3.5 \times 10^{-4}$	CL=90%	908
$2\pi^+ 2\pi^-$	$( 7.42 \pm 0.21 ) \times 10^{-3}$	S=1.1	880
$a_1(1260)^+ \pi^-, a_1^+ \rightarrow$	$( 4.45 \pm 0.31 ) \times 10^{-3}$		–
$2\pi^+ \pi^-$ total			

$a_1(1260)^+ \pi^- , a_1^+ \rightarrow$ $\rho^0 \pi^+$ S-wave	$( 3.21 \pm 0.25 ) \times 10^{-3}$	—
$a_1(1260)^+ \pi^- , a_1^+ \rightarrow$ $\rho^0 \pi^+$ D-wave	$( 1.9 \pm 0.5 ) \times 10^{-4}$	—
$a_1(1260)^+ \pi^- , a_1^+ \rightarrow$ $\sigma \pi^+$	$( 6.2 \pm 0.7 ) \times 10^{-4}$	—
$2\rho^0$ total	$( 1.82 \pm 0.13 ) \times 10^{-3}$	518
$2\rho^0$ , parallel helicities	$( 8.2 \pm 3.2 ) \times 10^{-5}$	—
$2\rho^0$ , perpendicular helicities	$( 4.7 \pm 0.6 ) \times 10^{-4}$	—
$2\rho^0$ , longitudinal helicities	$( 1.25 \pm 0.10 ) \times 10^{-3}$	—
Resonant $(\pi^+ \pi^-) \pi^+ \pi^-$	$( 1.48 \pm 0.12 ) \times 10^{-3}$	—
3-body total		
$\sigma \pi^+ \pi^-$	$( 6.1 \pm 0.9 ) \times 10^{-4}$	—
$f_0(980) \pi^+ \pi^- , f_0 \rightarrow$ $\pi^+ \pi^-$	$( 1.8 \pm 0.5 ) \times 10^{-4}$	—
$f_2(1270) \pi^+ \pi^- , f_2 \rightarrow$ $\pi^+ \pi^-$	$( 3.6 \pm 0.6 ) \times 10^{-4}$	—
$\pi^+ \pi^- 2\pi^0$	$(10.0 \pm 0.9 ) \times 10^{-3}$	882
$\eta \pi^0$	[ddd] $( 6.8 \pm 0.7 ) \times 10^{-4}$	846
$\omega \pi^0$	[ddd] $< 2.6 \times 10^{-4}$ CL=90%	761
$2\pi^+ 2\pi^- \pi^0$	$( 4.1 \pm 0.5 ) \times 10^{-3}$	844
$\eta \pi^+ \pi^-$	[ddd] $( 1.09 \pm 0.16 ) \times 10^{-3}$	827
$\omega \pi^+ \pi^-$	[ddd] $( 1.6 \pm 0.5 ) \times 10^{-3}$	738
$3\pi^+ 3\pi^-$	$( 4.2 \pm 1.2 ) \times 10^{-4}$	795
$\eta'(958) \pi^0$	$( 8.9 \pm 1.4 ) \times 10^{-4}$	678
$\eta'(958) \pi^+ \pi^-$	$( 4.5 \pm 1.7 ) \times 10^{-4}$	650
$2\eta$	$( 1.67 \pm 0.20 ) \times 10^{-3}$	754
$\eta \eta'(958)$	$( 1.05 \pm 0.26 ) \times 10^{-3}$	537

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

$K^+ K^-$	$( 3.96 \pm 0.08 ) \times 10^{-3}$ S=1.4	791
$2K_S^0$	$( 1.73 \pm 0.29 ) \times 10^{-4}$ S=1.7	789
$K_S^0 K^- \pi^+$	$( 3.3 \pm 0.5 ) \times 10^{-3}$ S=1.1	739
$\bar{K}^*(892)^0 K_S^0 ,$ $\bar{K}^*(892)^0 \rightarrow K^- \pi^+$	$< 5 \times 10^{-4}$ CL=90%	608
$K_S^0 K^+ \pi^-$	$( 2.6 \pm 0.5 ) \times 10^{-3}$	739
$K^*(892)^0 K_S^0 ,$ $K^*(892)^0 \rightarrow K^+ \pi^-$	$< 2.8 \times 10^{-4}$ CL=90%	608
$K^+ K^- \pi^0$	$( 3.28 \pm 0.14 ) \times 10^{-3}$	743
$K^*(892)^+ K^- ,$ $K^*(892)^+ \rightarrow K^+ \pi^0$	$( 1.46 \pm 0.07 ) \times 10^{-3}$	—
$K^*(892)^- K^+ ,$ $K^*(892)^- \rightarrow K^- \pi^0$	$( 5.2 \pm 0.4 ) \times 10^{-4}$	—
$(K^+ \pi^0)_{S-wave} K^-$	$( 2.33 \pm 0.17 ) \times 10^{-3}$	743



$(K^- \pi^0)_{S\text{-wave}} K^+$		$( 1.3 \pm 0.4 ) \times 10^{-4}$	743
$f_0(980) \pi^0, f_0 \rightarrow K^+ K^-$		$( 3.4 \pm 0.6 ) \times 10^{-4}$	—
$\phi \pi^0, \phi \rightarrow K^+ K^-$		$( 6.4 \pm 0.4 ) \times 10^{-4}$	—
$2K_S^0 \pi^0$		$< 5.9 \times 10^{-4}$	740
$K^+ K^- \pi^+ \pi^-$	[eee]	$( 2.42 \pm 0.12 ) \times 10^{-3}$	677
$\phi \pi^+ \pi^-$ 3-body, $\phi \rightarrow$ $K^+ K^-$		$( 2.4 \pm 2.4 ) \times 10^{-5}$	614
$\phi \rho^0, \phi \rightarrow K^+ K^-$		$( 7.0 \pm 0.6 ) \times 10^{-4}$	250
$K^+ K^- \rho^0$ 3-body		$( 5 \pm 7 ) \times 10^{-5}$	302
$f_0(980) \pi^+ \pi^-, f_0 \rightarrow K^+ K^-$		$( 3.6 \pm 0.9 ) \times 10^{-4}$	—
$K^*(892)^0 K^\mp \pi^\pm$ 3-body, [fff]		$( 2.7 \pm 0.6 ) \times 10^{-4}$	531
$K^{*0} \rightarrow K^\pm \pi^\mp$			
$K^*(892)^0 \bar{K}^*(892)^0, K^{*0} \rightarrow$ $K^\pm \pi^\mp$		$( 7 \pm 5 ) \times 10^{-5}$	272
$K_1(1270)^\pm K^\mp,$		$( 8.0 \pm 1.8 ) \times 10^{-4}$	—
$K_1(1270)^\pm \rightarrow K^\pm \pi^+ \pi^-$			
$K_1(1400)^\pm K^\mp,$		$( 5.3 \pm 1.2 ) \times 10^{-4}$	—
$K_1(1400)^\pm \rightarrow K^\pm \pi^+ \pi^-$			
$2K_S^0 \pi^+ \pi^-$		$( 1.22 \pm 0.23 ) \times 10^{-3}$	673
$K_S^0 K^- 2\pi^+ \pi^-$		$< 1.4 \times 10^{-4}$ CL=90%	595
$K^+ K^- \pi^+ \pi^- \pi^0$		$( 3.1 \pm 2.0 ) \times 10^{-3}$	600

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

$\phi \eta$		$( 1.4 \pm 0.5 ) \times 10^{-4}$	489
$\phi \omega$		$< 2.1 \times 10^{-3}$ CL=90%	238

### Radiative modes

$\rho^0 \gamma$		$< 2.4 \times 10^{-4}$ CL=90%	771
$\omega \gamma$		$< 2.4 \times 10^{-4}$ CL=90%	768
$\phi \gamma$		$( 2.69 \pm 0.35 ) \times 10^{-5}$	654
$\bar{K}^*(892)^0 \gamma$		$( 3.27 \pm 0.34 ) \times 10^{-4}$	719

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

$K^+ \ell^- \bar{\nu}_\ell$ via $\bar{D}^0$		$< 2.2 \times 10^{-5}$ CL=90%	—
$K^+$ or $K^*(892)^+$ $e^- \bar{\nu}_e$ via $\bar{D}^0$		$< 6 \times 10^{-5}$ CL=90%	—
$K^+ \pi^-$	DC	$( 1.47 \pm 0.07 ) \times 10^{-4}$ S=2.8	861
$K^+ \pi^-$ via DCS		$( 1.31 \pm 0.08 ) \times 10^{-4}$	—
$K^+ \pi^-$ via $\bar{D}^0$		$< 1.5 \times 10^{-5}$ CL=95%	861
$K_S^0 \pi^+ \pi^-$ in $D^0 \rightarrow \bar{D}^0$		$< 1.8 \times 10^{-4}$ CL=95%	—
$K^*(892)^+ \pi^-,$	DC	$( 1.13 \pm_{-0.34}^{0.60} ) \times 10^{-4}$	711
$K^*(892)^+ \rightarrow K_S^0 \pi^+$			
$K_0^*(1430)^+ \pi^-,$	DC	$< 1.4 \times 10^{-5}$	—
$K_0^*(1430)^+ \rightarrow K_S^0 \pi^+$			

$K_2^*(1430)^+ \pi^-$ ,	<i>DC</i>	< 3.4	$\times 10^{-5}$	—
$K_2^*(1430)^+ \rightarrow K_S^0 \pi^+$				
$K^+ \pi^- \pi^0$	<i>DC</i>	( 3.04 ± 0.17 )	$\times 10^{-4}$	844
$K^+ \pi^- \pi^0$ via $\bar{D}^0$		( 7.3 ± 0.5 )	$\times 10^{-4}$	—
$K^+ \pi^+ 2\pi^-$	<i>DC</i>	( 2.61 $\begin{smallmatrix} + \\ - \end{smallmatrix}$ 0.21 / 0.19 )	$\times 10^{-4}$	813
$K^+ \pi^+ 2\pi^-$ via $\bar{D}^0$		< 4	$\times 10^{-4}$ CL=90%	812
$\mu^-$ anything via $\bar{D}^0$		< 4	$\times 10^{-4}$ CL=90%	—

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

$\gamma\gamma$	<i>C1</i>	< 2.6	$\times 10^{-5}$ CL=90%	932
$e^+ e^-$	<i>C1</i>	< 7.9	$\times 10^{-8}$ CL=90%	932
$\mu^+ \mu^-$	<i>C1</i>	< 1.4	$\times 10^{-7}$ CL=90%	926
$\pi^0 e^+ e^-$	<i>C1</i>	< 4.5	$\times 10^{-5}$ CL=90%	928
$\pi^0 \mu^+ \mu^-$	<i>C1</i>	< 1.8	$\times 10^{-4}$ CL=90%	915
$\eta e^+ e^-$	<i>C1</i>	< 1.1	$\times 10^{-4}$ CL=90%	852
$\eta \mu^+ \mu^-$	<i>C1</i>	< 5.3	$\times 10^{-4}$ CL=90%	838
$\pi^+ \pi^- e^+ e^-$	<i>C1</i>	< 3.73	$\times 10^{-4}$ CL=90%	922
$\rho^0 e^+ e^-$	<i>C1</i>	< 1.0	$\times 10^{-4}$ CL=90%	771
$\pi^+ \pi^- \mu^+ \mu^-$	<i>C1</i>	< 3.0	$\times 10^{-5}$ CL=90%	894
$\rho^0 \mu^+ \mu^-$	<i>C1</i>	< 2.2	$\times 10^{-5}$ CL=90%	754
$\omega e^+ e^-$	<i>C1</i>	< 1.8	$\times 10^{-4}$ CL=90%	768
$\omega \mu^+ \mu^-$	<i>C1</i>	< 8.3	$\times 10^{-4}$ CL=90%	751
$K^- K^+ e^+ e^-$	<i>C1</i>	< 3.15	$\times 10^{-4}$ CL=90%	791
$\phi e^+ e^-$	<i>C1</i>	< 5.2	$\times 10^{-5}$ CL=90%	654
$K^- K^+ \mu^+ \mu^-$	<i>C1</i>	< 3.3	$\times 10^{-5}$ CL=90%	710
$\phi \mu^+ \mu^-$	<i>C1</i>	< 3.1	$\times 10^{-5}$ CL=90%	631
$\bar{K}^0 e^+ e^-$		[ <i>uu</i> ] < 1.1	$\times 10^{-4}$ CL=90%	866
$\bar{K}^0 \mu^+ \mu^-$		[ <i>uu</i> ] < 2.6	$\times 10^{-4}$ CL=90%	852
$K^- \pi^+ e^+ e^-$	<i>C1</i>	< 3.85	$\times 10^{-4}$ CL=90%	861
$\bar{K}^*(892)^0 e^+ e^-$		[ <i>uu</i> ] < 4.7	$\times 10^{-5}$ CL=90%	719
$K^- \pi^+ \mu^+ \mu^-$	<i>C1</i>	< 3.59	$\times 10^{-4}$ CL=90%	829
$\bar{K}^*(892)^0 \mu^+ \mu^-$		[ <i>uu</i> ] < 2.4	$\times 10^{-5}$ CL=90%	700
$\pi^+ \pi^- \pi^0 \mu^+ \mu^-$	<i>C1</i>	< 8.1	$\times 10^{-4}$ CL=90%	863
$\mu^\pm e^\mp$	<i>LF</i>	[ <i>ee</i> ] < 2.6	$\times 10^{-7}$ CL=90%	929
$\pi^0 e^\pm \mu^\mp$	<i>LF</i>	[ <i>ee</i> ] < 8.6	$\times 10^{-5}$ CL=90%	924
$\eta e^\pm \mu^\mp$	<i>LF</i>	[ <i>ee</i> ] < 1.0	$\times 10^{-4}$ CL=90%	848
$\pi^+ \pi^- e^\pm \mu^\mp$	<i>LF</i>	[ <i>ee</i> ] < 1.5	$\times 10^{-5}$ CL=90%	911
$\rho^0 e^\pm \mu^\mp$	<i>LF</i>	[ <i>ee</i> ] < 4.9	$\times 10^{-5}$ CL=90%	767
$\omega e^\pm \mu^\mp$	<i>LF</i>	[ <i>ee</i> ] < 1.2	$\times 10^{-4}$ CL=90%	764
$K^- K^+ e^\pm \mu^\mp$	<i>LF</i>	[ <i>ee</i> ] < 1.8	$\times 10^{-4}$ CL=90%	754
$\phi e^\pm \mu^\mp$	<i>LF</i>	[ <i>ee</i> ] < 3.4	$\times 10^{-5}$ CL=90%	648
$\bar{K}^0 e^\pm \mu^\mp$	<i>LF</i>	[ <i>ee</i> ] < 1.0	$\times 10^{-4}$ CL=90%	863

$K^- \pi^+ e^\pm \mu^\mp$	$LF$	$[ee] < 5.53$	$\times 10^{-4} \text{CL}=90\%$	848
$\bar{K}^*(892)^0 e^\pm \mu^\mp$	$LF$	$[ee] < 8.3$	$\times 10^{-5} \text{CL}=90\%$	714
$2\pi^- 2e^+ + \text{c.c.}$	$L$	$< 1.12$	$\times 10^{-4} \text{CL}=90\%$	922
$2\pi^- 2\mu^+ + \text{c.c.}$	$L$	$< 2.9$	$\times 10^{-5} \text{CL}=90\%$	894
$K^- \pi^- 2e^+ + \text{c.c.}$	$L$	$< 2.06$	$\times 10^{-4} \text{CL}=90\%$	861
$K^- \pi^- 2\mu^+ + \text{c.c.}$	$L$	$< 3.9$	$\times 10^{-4} \text{CL}=90\%$	829
$2K^- 2e^+ + \text{c.c.}$	$L$	$< 1.52$	$\times 10^{-4} \text{CL}=90\%$	791
$2K^- 2\mu^+ + \text{c.c.}$	$L$	$< 9.4$	$\times 10^{-5} \text{CL}=90\%$	710
$\pi^- \pi^- e^+ \mu^+ + \text{c.c.}$	$L$	$< 7.9$	$\times 10^{-5} \text{CL}=90\%$	911
$K^- \pi^- e^+ \mu^+ + \text{c.c.}$	$L$	$< 2.18$	$\times 10^{-4} \text{CL}=90\%$	848
$2K^- e^+ \mu^+ + \text{c.c.}$	$L$	$< 5.7$	$\times 10^{-5} \text{CL}=90\%$	754
$pe^-$	$L, B$	$[ggg] < 1.0$	$\times 10^{-5} \text{CL}=90\%$	696
$\bar{p}e^+$	$L, B$	$[hhh] < 1.1$	$\times 10^{-5} \text{CL}=90\%$	696

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

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

$I, J, P$  need confirmation.

Mass  $m = 2006.93 \pm 0.16$  MeV

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

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

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

<b><math>D^*(2007)^0</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (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.

Mass  $m = 2010.22 \pm 0.14$  MeV

$m_{D^*(2010)^+} - m_{D^+} = 140.66 \pm 0.10$  MeV ( $S = 1.1$ )

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

Full width  $\Gamma = 96 \pm 22$  keV

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

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

**$D_0^*(2400)^0$**

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

Mass  $m = 2318 \pm 29$  MeV (S = 1.7)

Full width  $\Gamma = 267 \pm 40$  MeV

$D_0^*(2400)^0$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$D^+ \pi^-$	seen	385

**$D_1(2420)^0$**

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

$I$  needs confirmation.

Mass  $m = 2421.3 \pm 0.6$  MeV (S = 1.2)

$m_{D_1^0} - m_{D^{*+}} = 411.0 \pm 0.6$  (S = 1.2)

Full width  $\Gamma = 27.1 \pm 2.7$  MeV (S = 2.4)

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

$D_1(2420)^0$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$D^*(2010)^+ \pi^-$	seen	354
$D^0 \pi^+ \pi^-$	seen	425
$D^+ \pi^-$	not seen	473
$D^{*0} \pi^+ \pi^-$	not seen	279

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

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

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

Mass  $m = 2462.6 \pm 0.7$  MeV (S = 1.3)

$m_{D_2^{*0}} - m_{D^+} = 593.0 \pm 0.7$  MeV (S = 1.3)

$m_{D_2^0} - m_{D^{*+}} = 452.4 \pm 0.7$  MeV (S = 1.3)

Full width  $\Gamma = 49.0 \pm 1.4$  MeV (S = 1.7)

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

$D_2^*(2460)^0$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$D^+ \pi^-$	seen	507
$D^*(2010)^+ \pi^-$	seen	391
$D^0 \pi^+ \pi^-$	not seen	463
$D^{*0} \pi^+ \pi^-$	not seen	326

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

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

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

$$\text{Mass } m = 2464.4 \pm 1.9 \text{ MeV} \quad (S = 1.9)$$

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

$$\text{Full width } \Gamma = 37 \pm 6 \text{ MeV} \quad (S = 1.4)$$

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

$D_2^*(2460)^\pm$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$D^0 \pi^+$	seen	512
$D^{*0} \pi^+$	seen	395
$D^+ \pi^+ \pi^-$	not seen	461
$D^{*+} \pi^+ \pi^-$	not seen	325

## CHARMED, STRANGE MESONS ( $C = S = \pm 1$ )

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

**$D_s^\pm$**

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

$$\text{Mass } m = 1968.45 \pm 0.33 \text{ MeV} \quad (S = 1.3)$$

$$m_{D_s^\pm} - m_{D^\pm} = 98.88 \pm 0.30 \text{ MeV} \quad (S = 1.4)$$

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

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

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

$$\begin{aligned}
 A_{CP}(\mu^\pm \nu) &= (5 \pm 6)\% \\
 A_{CP}(K^\pm K_S^0) &= (0.3 \pm 0.4)\% \\
 A_{CP}(K^+ K^- \pi^\pm) &= (0.3 \pm 1.4)\% \\
 A_{CP}(K^+ K^- \pi^\pm \pi^0) &= (-6 \pm 4)\% \\
 A_{CP}(K_S^0 K^\mp 2\pi^\pm) &= (-1 \pm 4)\% \\
 A_{CP}(\pi^+ \pi^- \pi^\pm) &= (2 \pm 5)\% \\
 A_{CP}(\pi^\pm \eta) &= (-4.6 \pm 2.9)\% \\
 A_{CP}(\pi^\pm \eta') &= (-6.1 \pm 3.0)\% \\
 A_{CP}(K^\pm \pi^0) &= (-27 \pm 24)\% \\
 A_{CP}(K_S^0 \pi^\pm) &= (6.6 \pm 3.3)\% \quad (S = 1.4) \\
 A_{CP}(K^\pm \pi^+ \pi^-) &= (11 \pm 7)\% \\
 A_{CP}(K^\pm \eta) &= (9 \pm 15)\% \\
 A_{CP}(K^\pm \eta'(958)) &= (6 \pm 19)\%
 \end{aligned}$$

### **T-violating decay-rate asymmetry**

$$A_T(K_S^0 K^\pm \pi^+ \pi^-) = -0.04 \pm 0.07 [{}^\infty]$$

### **$D_s^+ \rightarrow \phi \ell^+ \nu_\ell$ form factors**

$$\begin{aligned}
 r_2 &= 0.84 \pm 0.11 \quad (S = 2.4) \\
 r_\nu &= 1.80 \pm 0.08 \\
 \Gamma_L/\Gamma_T &= 0.72 \pm 0.18
 \end{aligned}$$

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

$D_S^+$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	Scale factor/ Confidence level	$\rho$ (MeV/c)
<b>Inclusive modes</b>			
$e^+$ semileptonic	[iii] ( 6.5 $\pm$ 0.4 ) %		—
$\pi^+$ anything	(119.3 $\pm$ 1.4 ) %		—
$\pi^-$ anything	( 43.2 $\pm$ 0.9 ) %		—
$\pi^0$ anything	(123 $\pm$ 7 ) %		—
$K^-$ anything	( 18.7 $\pm$ 0.5 ) %		—
$K^+$ anything	( 28.9 $\pm$ 0.7 ) %		—
$K_S^0$ anything	( 19.0 $\pm$ 1.1 ) %		—
$\eta$ anything	[jjj] ( 29.9 $\pm$ 2.8 ) %		—
$\omega$ anything	( 6.1 $\pm$ 1.4 ) %		—
$\eta'$ anything	[kkk] ( 11.7 $\pm$ 1.8 ) %		—
$f_0(980)$ anything, $f_0 \rightarrow \pi^+ \pi^-$	< 1.3 %	CL=90%	—
$\phi$ anything	( 15.7 $\pm$ 1.0 ) %		—
$K^+ K^-$ anything	( 15.8 $\pm$ 0.7 ) %		—
$K_S^0 K^+$ anything	( 5.8 $\pm$ 0.5 ) %		—
$K_S^0 K^-$ anything	( 1.9 $\pm$ 0.4 ) %		—
$2K_S^0$ anything	( 1.70 $\pm$ 0.32 ) %		—
$2K^+$ anything	< 2.6 $\times 10^{-3}$	CL=90%	—
$2K^-$ anything	< 6 $\times 10^{-4}$	CL=90%	—
<b>Leptonic and semileptonic modes</b>			
$e^+ \nu_e$	< 1.2 $\times 10^{-4}$	CL=90%	984
$\mu^+ \nu_\mu$	( 5.90 $\pm$ 0.33 ) $\times 10^{-3}$		981
$\tau^+ \nu_\tau$	( 5.43 $\pm$ 0.31 ) %		182
$K^+ K^- e^+ \nu_e$	—		851
$\phi e^+ \nu_e$	[lll] ( 2.49 $\pm$ 0.14 ) %		720
$\eta e^+ \nu_e + \eta'(958) e^+ \nu_e$	[lll] ( 3.66 $\pm$ 0.37 ) %		—
$\eta e^+ \nu_e$	[lll] ( 2.67 $\pm$ 0.29 ) %	S=1.1	908
$\eta'(958) e^+ \nu_e$	[lll] ( 9.9 $\pm$ 2.3 ) $\times 10^{-3}$		751
$K^0 e^+ \nu_e$	( 3.7 $\pm$ 1.0 ) $\times 10^{-3}$		921
$K^*(892)^0 e^+ \nu_e$	[lll] ( 1.8 $\pm$ 0.7 ) $\times 10^{-3}$		782
$f_0(980) e^+ \nu_e, f_0 \rightarrow \pi^+ \pi^-$	( 2.00 $\pm$ 0.32 ) $\times 10^{-3}$		—
<b>Hadronic modes with a <math>K\bar{K}</math> pair</b>			
$K^+ K_S^0$	( 1.48 $\pm$ 0.08 ) %		850
$K^+ K^- \pi^+$	[pp] ( 5.49 $\pm$ 0.27 ) %		805
$\phi \pi^+$	[lll,mmm] ( 4.5 $\pm$ 0.4 ) %		712
$\phi \pi^+, \phi \rightarrow K^+ K^-$	[mmm] ( 2.32 $\pm$ 0.14 ) %		712

$K^+ \bar{K}^*(892)^0, \bar{K}^{*0} \rightarrow$	( 2.60 ± 0.15 ) %	416
$K^- \pi^+$		
$f_0(980) \pi^+, f_0 \rightarrow K^+ K^-$	( 1.55 ± 0.16 ) %	732
$f_0(1370) \pi^+, f_0 \rightarrow K^+ K^-$	( 2.4 ± 0.4 ) × 10 <sup>-3</sup>	—
$f_0(1710) \pi^+, f_0 \rightarrow K^+ K^-$	( 1.87 ± 0.33 ) × 10 <sup>-3</sup>	198
$K^+ \bar{K}_0^*(1430)^0, \bar{K}_0^* \rightarrow$	( 2.1 ± 0.4 ) × 10 <sup>-3</sup>	218
$K^- \pi^+$		
$K^0 \bar{K}_0^0 \pi^+$	—	802
$K^*(892)^+ \bar{K}^0$	[III] ( 5.4 ± 1.2 ) %	683
$K^+ K^- \pi^+ \pi^0$	( 5.6 ± 0.5 ) %	748
$\phi \rho^+$	[III] ( 8.4 <sup>+1.9</sup> <sub>-2.3</sub> ) %	401
$K_S^0 K^- 2\pi^+$	( 1.64 ± 0.12 ) %	744
$K^*(892)^+ \bar{K}^*(892)^0$	[III] ( 7.2 ± 2.6 ) %	417
$K^+ K_S^0 \pi^+ \pi^-$	( 9.6 ± 1.3 ) × 10 <sup>-3</sup>	744
$K^+ K^- 2\pi^+ \pi^-$	( 8.8 ± 1.6 ) × 10 <sup>-3</sup>	673
$\phi 2\pi^+ \pi^-$	[III] ( 1.21 ± 0.16 ) %	640
$K^+ K^- \rho^0 \pi^+ \text{non-}\phi$	< 2.6 × 10 <sup>-4</sup> CL=90%	249
$\phi \rho^0 \pi^+, \phi \rightarrow K^+ K^-$	( 6.6 ± 1.3 ) × 10 <sup>-3</sup>	181
$\phi a_1(1260)^+, \phi \rightarrow$	( 7.5 ± 1.3 ) × 10 <sup>-3</sup>	†
$K^+ K^-, a_1^+ \rightarrow \rho^0 \pi^+$		
$K^+ K^- 2\pi^+ \pi^- \text{nonresonant}$	( 9 ± 7 ) × 10 <sup>-4</sup>	673
$2K_S^0 2\pi^+ \pi^-$	( 8.3 ± 3.5 ) × 10 <sup>-4</sup>	669

### Hadronic modes without $K$ 's

$\pi^+ \pi^0$	< 3.4 × 10 <sup>-4</sup> CL=90%	975
$2\pi^+ \pi^-$	( 1.10 ± 0.06 ) %	959
$\rho^0 \pi^+$	( 2.0 ± 1.2 ) × 10 <sup>-4</sup>	825
$\pi^+ (\pi^+ \pi^-)_{S\text{-wave}}$	[nnn] ( 9.2 ± 0.6 ) × 10 <sup>-3</sup>	959
$f_2(1270) \pi^+, f_2 \rightarrow \pi^+ \pi^-$	( 1.11 ± 0.20 ) × 10 <sup>-3</sup>	559
$\rho(1450)^0 \pi^+, \rho^0 \rightarrow \pi^+ \pi^-$	( 3.0 ± 2.0 ) × 10 <sup>-4</sup>	421
$\pi^+ 2\pi^0$	( 6.5 ± 1.3 ) × 10 <sup>-3</sup>	961
$2\pi^+ \pi^- \pi^0$	—	935
$\eta \pi^+$	[III] ( 1.83 ± 0.15 ) %	902
$\omega \pi^+$	[III] ( 2.5 ± 0.7 ) × 10 <sup>-3</sup>	822
$3\pi^+ 2\pi^-$	( 8.0 ± 0.9 ) × 10 <sup>-3</sup>	899
$2\pi^+ \pi^- 2\pi^0$	—	902
$\eta \rho^+$	[III] ( 8.9 ± 0.8 ) %	724
$\eta \pi^+ \pi^0 3\text{-body}$	[III] < 5 % CL=90%	886
$\omega \pi^+ \pi^0$	[III] ( 2.8 ± 0.7 ) %	802
$3\pi^+ 2\pi^- \pi^0$	( 4.9 ± 3.2 ) %	856
$\omega 2\pi^+ \pi^-$	[III] ( 1.6 ± 0.5 ) %	766
$\eta'(958) \pi^+$	[kkk, III] ( 3.94 ± 0.33 ) %	743
$3\pi^+ 2\pi^- 2\pi^0$	—	803



$\omega\eta\pi^+$	[ $lll$ ] < 2.13 %	CL=90%	654
$\eta'(958)\rho^+$	[ $kkk, lll$ ] ( 12.5 $\pm$ 2.2 ) %		465
$\eta'(958)\pi^+\pi^0$ 3-body	[ $lll$ ] < 1.8 %	CL=90%	720

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

$K^+\pi^0$	( 6.2 $\pm$ 2.1 ) $\times 10^{-4}$		917
$K_S^0\pi^+$	( 1.21 $\pm$ 0.08 ) $\times 10^{-3}$		916
$K^+\eta$	[ $lll$ ] ( 1.75 $\pm$ 0.35 ) $\times 10^{-3}$		835
$K^+\omega$	[ $lll$ ] < 2.4 $\times 10^{-3}$	CL=90%	741
$K^+\eta'(958)$	[ $lll$ ] ( 1.8 $\pm$ 0.6 ) $\times 10^{-3}$		646
$K^+\pi^+\pi^-$	( 6.9 $\pm$ 0.5 ) $\times 10^{-3}$		900
$K^+\rho^0$	( 2.7 $\pm$ 0.5 ) $\times 10^{-3}$		745
$K^+\rho(1450)^0, \rho^0 \rightarrow \pi^+\pi^-$	( 7.3 $\pm$ 2.6 ) $\times 10^{-4}$		—
$K^*(892)^0\pi^+, K^{*0} \rightarrow$	( 1.50 $\pm$ 0.26 ) $\times 10^{-3}$		775
$K^+\pi^-$			
$K^*(1410)^0\pi^+, K^{*0} \rightarrow$	( 1.30 $\pm$ 0.31 ) $\times 10^{-3}$		—
$K^+\pi^-$			
$K^*(1430)^0\pi^+, K^{*0} \rightarrow$	( 5 $\pm$ 4 ) $\times 10^{-4}$		—
$K^+\pi^-$			
$K^+\pi^+\pi^-$ nonresonant	( 1.1 $\pm$ 0.4 ) $\times 10^{-3}$		900
$K^0\pi^+\pi^0$	( 1.00 $\pm$ 0.18 ) %		900
$K_S^0 2\pi^+\pi^-$	( 2.9 $\pm$ 1.1 ) $\times 10^{-3}$		870
$K^+\omega\pi^0$	[ $lll$ ] < 8.2 $\times 10^{-3}$	CL=90%	684
$K^+\omega\pi^+\pi^-$	[ $lll$ ] < 5.4 $\times 10^{-3}$	CL=90%	603
$K^+\omega\eta$	[ $lll$ ] < 7.9 $\times 10^{-3}$	CL=90%	367
$2K^+K^-$	( 4.9 $\pm$ 1.7 ) $\times 10^{-4}$		628
$\phi K^+$	[ $lll$ ] < 6 $\times 10^{-4}$	CL=90%	607

**Doubly Cabibbo-suppressed modes**

$2K^+\pi^-$	( 1.29 $\pm$ 0.18 ) $\times 10^{-4}$		805
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**Baryon-antibaryon mode**

$p\bar{n}$	( 1.3 $\pm$ 0.4 ) $\times 10^{-3}$		295
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**$\Delta C = 1$  weak neutral current (C1) modes,  
Lepton family number (LF), or  
Lepton number (L) violating modes**

$\pi^+ e^+ e^-$	[ $uu$ ] < 2.2 $\times 10^{-5}$	CL=90%	979
$\pi^+ \phi, \phi \rightarrow e^+ e^-$	[ $tt$ ] ( 6 $\frac{+8}{-4}$ ) $\times 10^{-6}$		—

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

$\pi^+ \mu^+ \mu^-$	[ $uu$ ] < 2.6 $\times 10^{-5}$	CL=90%	968
$K^+ e^+ e^-$	C1 < 5.2 $\times 10^{-5}$	CL=90%	922
$K^+ \mu^+ \mu^-$	C1 < 3.6 $\times 10^{-5}$	CL=90%	909

$K^*(892)^+ \mu^+ \mu^-$	CI	< 1.4	$\times 10^{-3}$	CL=90%	765
$\pi^+ e^\pm \mu^\mp$	LF [ee]	< 6.1	$\times 10^{-4}$	CL=90%	976
$K^+ e^\pm \mu^\mp$	LF [ee]	< 6.3	$\times 10^{-4}$	CL=90%	919
$\pi^- 2e^+$	L	< 1.8	$\times 10^{-5}$	CL=90%	979
$\pi^- 2\mu^+$	L	< 2.9	$\times 10^{-5}$	CL=90%	968
$\pi^- e^+ \mu^+$	L	< 7.3	$\times 10^{-4}$	CL=90%	976
$K^- 2e^+$	L	< 1.7	$\times 10^{-5}$	CL=90%	922
$K^- 2\mu^+$	L	< 1.3	$\times 10^{-5}$	CL=90%	909
$K^- e^+ \mu^+$	L	< 6.8	$\times 10^{-4}$	CL=90%	919
$K^*(892)^- 2\mu^+$	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  $1^-$ .

$$\text{Mass } m = 2112.3 \pm 0.5 \text{ MeV} \quad (S = 1.1)$$

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

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

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

<b><math>D_s^{*+}</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$D_s^+ \gamma$	(94.2±0.7) %	139
$D_s^+ \pi^0$	( 5.8±0.7) %	48

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

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

$J, P$  need confirmation.

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

$$\text{Mass } m = 2317.8 \pm 0.6 \text{ MeV} \quad (S = 1.1)$$

$$m_{D_{s0}^*(2317)^\pm} - m_{D_s^\pm} = 349.3 \pm 0.6 \text{ MeV} \quad (S = 1.1)$$

$$\text{Full width } \Gamma < 3.8 \text{ MeV, CL} = 95\%$$

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

$D_{s0}^*(2317)^\pm$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$D_s^+ \pi^0$	seen	298
$D_s^+ \pi^0 \pi^0$	not seen	205

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

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

Mass  $m = 2459.5 \pm 0.6$  MeV (S = 1.1)

$m_{D_{s1}(2460)^\pm} - m_{D_s^{*\pm}} = 347.3 \pm 0.8$  MeV (S = 1.2)

$m_{D_{s1}(2460)^\pm} - m_{D_s^\pm} = 491.1 \pm 0.7$  MeV (S = 1.1)

Full width  $\Gamma < 3.5$  MeV, CL = 95%

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

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

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

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

$J, P$  need confirmation.

Mass  $m = 2535.28 \pm 0.20$  MeV

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

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

$D_{s1}(2536)^+$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$D^*(2010)^+ K^0$	seen	149
$D^*(2007)^0 K^+$	seen	168
$D^+ K^0$	not seen	382
$D^0 K^+$	not seen	391
$D_s^{*+} \gamma$	possibly seen	388
$D_s^+ \pi^+ \pi^-$	seen	437

### $D_{s2}^*(2573)$

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

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

$$\text{Mass } m = 2572.6 \pm 0.9 \text{ MeV}$$

$$\text{Full width } \Gamma = 20 \pm 5 \text{ MeV} \quad (S = 1.3)$$

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

$D_{s2}^*(2573)^+$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$D^0 K^+$	seen	435
$D^*(2007)^0 K^+$	not seen	244

## BOTTOM MESONS ( $B = \pm 1$ )

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

### $B$ -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  $\chi_b$  at high energy are found in the Admixture sections.

$B^0-\bar{B}^0$  mixing data are found in the  $B^0$  section, while  $B_s^0-\bar{B}_s^0$  mixing data and  $B-\bar{B}$  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,  $CP$  violation, branching fractions
- $B^0$   
mass, mean life,  $B^0-\bar{B}^0$  mixing,  $CP$  violation, branching fractions
- $B^\pm B^0$  Admixtures  
 $CP$  violation, branching fractions
- $B^\pm/B^0/B_s^0/b$ -baryon Admixtures  
mean life, production fractions, branching fractions
- $B^*$   
mass
- $B_1(5721)^0$   
mass
- $B_2^*(5747)^0$   
mass
- $B_s^0$   
mass, mean life,  $B_s^0-\bar{B}_s^0$  mixing,  $CP$  violation, branching fractions
- $B_s^*$   
mass
- $B_{s1}(5830)^0$   
mass
- $B_{s2}^8(5840)^0$   
mass
- $B_c^\pm$   
mass, mean life, branching fractions

At the end of Baryon Listings:

- $\Lambda_b$   
mass, mean life, branching fractions
- $\Sigma_b$   
mass
- $\Sigma_b^*$   
mass
- $\Xi_b^0, \Xi_b^-$   
mass, mean life, branching fractions
- $\Omega_b^-$   
mass, 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.

$$\begin{aligned} \text{Mass } m_{B^\pm} &= 5279.17 \pm 0.29 \text{ MeV} \\ \text{Mean life } \tau_{B^\pm} &= (1.641 \pm 0.008) \times 10^{-12} \text{ s} \\ c\tau &= 492.0 \text{ } \mu\text{m} \end{aligned}$$

**CP violation**

$$\begin{aligned} A_{CP}(B^+ \rightarrow J/\psi(1S)K^+) &= (1 \pm 7) \times 10^{-3} \quad (S = 1.8) \\ A_{CP}(B^+ \rightarrow J/\psi(1S)\pi^+) &= 0.01 \pm 0.07 \quad (S = 1.3) \\ A_{CP}(B^+ \rightarrow J/\psi\rho^+) &= -0.11 \pm 0.14 \\ A_{CP}(B^+ \rightarrow J/\psi K^*(892)^+) &= -0.048 \pm 0.033 \\ A_{CP}(B^+ \rightarrow \eta_c K^+) &= -0.16 \pm 0.08 \\ A_{CP}(B^+ \rightarrow \psi(2S)\pi^+) &= 0.02 \pm 0.09 \\ A_{CP}(B^+ \rightarrow \psi(2S)K^+) &= -0.025 \pm 0.024 \\ A_{CP}(B^+ \rightarrow \psi(2S)K^*(892)^+) &= 0.08 \pm 0.21 \\ A_{CP}(B^+ \rightarrow \chi_{c1}(1P)\pi^+) &= 0.07 \pm 0.18 \\ A_{CP}(B^+ \rightarrow \chi_{c0}K^+) &= -0.11 \pm 0.12 \\ A_{CP}(B^+ \rightarrow \chi_{c1}K^+) &= -0.009 \pm 0.033 \\ A_{CP}(B^+ \rightarrow \chi_{c1}K^*(892)^+) &= 0.5 \pm 0.5 \\ A_{CP}(B^+ \rightarrow \overline{D}^0\pi^+) &= -0.008 \pm 0.008 \\ A_{CP}(B^+ \rightarrow D_{CP(+1)}\pi^+) &= 0.035 \pm 0.024 \\ A_{CP}(B^+ \rightarrow D_{CP(-1)}\pi^+) &= 0.017 \pm 0.026 \\ A_{CP}(B^+ \rightarrow \overline{D}^0K^+) &= 0.07 \pm 0.04 \end{aligned}$$

$$\begin{aligned}
 r_B(B^+ \rightarrow D^0 K^+) &= 0.113^{+0.024}_{-0.021} \\
 \delta_B(B^+ \rightarrow D^0 K^+) &= 125 \pm 16 \text{ degrees} \\
 r_B(B^+ \rightarrow DK^{*+}) &= 0.34 \pm 0.09 \quad (S = 1.3) \\
 \delta_B(B^+ \rightarrow DK^{*+}) &= 157 \pm 70 \text{ degrees} \quad (S = 2.0) \\
 A_{CP}(B^+ \rightarrow [K^- \pi^+]_D K^+) &= -0.9 \pm 0.5 \\
 A_{CP}(B^+ \rightarrow [K^- \pi^+]_{\overline{D}} K^*(892)^+) &= -0.3 \pm 0.5 \\
 A_{CP}(B^+ \rightarrow [K^- \pi^+]_D \pi^+) &= 0.03 \pm 0.17 \\
 A_{CP}(B^+ \rightarrow [K^- \pi^+]_{(D\pi)} \pi^+) &= -0.09 \pm 0.27 \\
 A_{CP}(B^+ \rightarrow [K^- \pi^+]_{(D\gamma)} \pi^+) &= -0.7 \pm 0.6 \\
 A_{CP}(B^+ \rightarrow [K^- \pi^+]_{(D\pi)} K^+) &= 0.8 \pm 0.4 \\
 A_{CP}(B^+ \rightarrow [K^- \pi^+]_{(D\gamma)} K^+) &= 0.4 \pm 1.0 \\
 A_{CP}(B^+ \rightarrow [\pi^+ \pi^- \pi^0]_D K^+) &= -0.02 \pm 0.15 \\
 \mathbf{A_{CP}(B^+ \rightarrow D_{CP(+1)} K^+)} &= 0.24 \pm 0.06 \quad (S = 1.1) \\
 A_{CP}(B^+ \rightarrow D_{CP(-1)} K^+) &= -0.10 \pm 0.07 \\
 A_{CP}(B^+ \rightarrow \overline{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^+) &= -0.07 \pm 0.04 \\
 r_B^*(B^+ \rightarrow D^{*0} K^+) &= 0.123^{+0.026}_{-0.029} \\
 \delta_B^*(B^+ \rightarrow D^{*0} K^+) &= 300 \pm 30 \text{ degrees} \quad (S = 1.7) \\
 A_{CP}(B^+ \rightarrow D_{CP(+1)}^{*0} K^+) &= -0.12 \pm 0.08 \\
 A_{CP}(B^+ \rightarrow D_{CP(-1)}^* K^+) &= 0.07 \pm 0.10 \\
 A_{CP}(B^+ \rightarrow D_{CP(+1)} K^*(892)^+) &= 0.09 \pm 0.14 \\
 A_{CP}(B^+ \rightarrow D_{CP(-1)} K^*(892)^+) &= -0.23 \pm 0.22 \\
 A_{CP}(B^+ \rightarrow D^{*+} \overline{D}^{*0}) &= -0.15 \pm 0.11 \\
 A_{CP}(B^+ \rightarrow D^{*+} \overline{D}^0) &= -0.06 \pm 0.13 \\
 A_{CP}(B^+ \rightarrow D^+ \overline{D}^{*0}) &= 0.13 \pm 0.18 \\
 A_{CP}(B^+ \rightarrow D^+ \overline{D}^0) &= -0.03 \pm 0.07 \\
 A_{CP}(B^+ \rightarrow K_S^0 \pi^+) &= 0.009 \pm 0.029 \quad (S = 1.2) \\
 A_{CP}(B^+ \rightarrow K^+ \pi^0) &= 0.051 \pm 0.025 \\
 A_{CP}(B^+ \rightarrow \eta' K^+) &= 0.013 \pm 0.017 \\
 A_{CP}(B^+ \rightarrow \eta' K^*(892)^+) &= -0.26 \pm 0.27 \\
 A_{CP}(B^+ \rightarrow \eta' K_0^*(1430)^+) &= 0.06 \pm 0.20 \\
 A_{CP}(B^+ \rightarrow \eta' K_2^*(1430)^+) &= 0.15 \pm 0.13 \\
 \mathbf{A_{CP}(B^+ \rightarrow \eta K^+)} &= -0.37 \pm 0.09 \\
 A_{CP}(B^+ \rightarrow \eta K^*(892)^+) &= 0.02 \pm 0.06 \\
 A_{CP}(B^+ \rightarrow \eta K_0^*(1430)^+) &= 0.05 \pm 0.13 \\
 A_{CP}(B^+ \rightarrow \eta K_2^*(1430)^+) &= -0.45 \pm 0.30 \\
 A_{CP}(B^+ \rightarrow \omega K^+) &= 0.02 \pm 0.05
 \end{aligned}$$

$$\begin{aligned}
 A_{CP}(B^+ \rightarrow \omega K^{*+}) &= 0.29 \pm 0.35 \\
 A_{CP}(B^+ \rightarrow \omega(K\pi)_0^{*+}) &= -0.10 \pm 0.09 \\
 A_{CP}(B^+ \rightarrow \omega K_2^*(1430)^+) &= 0.14 \pm 0.15 \\
 A_{CP}(B^+ \rightarrow K^{*0}\pi^+) &= -0.04 \pm 0.09 \quad (S = 2.1) \\
 A_{CP}(B^+ \rightarrow K^*(892)^+\pi^0) &= 0.04 \pm 0.29 \\
 A_{CP}(B^+ \rightarrow K^+\pi^-\pi^+) &= 0.038 \pm 0.022 \\
 A_{CP}(B^+ \rightarrow f_0(980)K^+) &= -0.10^{+0.05}_{-0.04} \\
 \mathbf{A_{CP}(B^+ \rightarrow f_2(1270)K^+)} &= -0.68^{+0.19}_{-0.17} \\
 A_{CP}(B^+ \rightarrow f_X(1300)K^+) &= 0.28 \pm 0.30 \\
 \mathbf{A_{CP}(B^+ \rightarrow \rho^0 K^+)} &= 0.37 \pm 0.10 \\
 A_{CP}(B^+ \rightarrow K_0^*(1430)^0\pi^+) &= 0.055 \pm 0.033 \\
 A_{CP}(B^+ \rightarrow K_2^*(1430)^0\pi^+) &= 0.05^{+0.29}_{-0.24} \\
 A_{CP}(B^+ \rightarrow K^0\rho^+) &= -0.12 \pm 0.17 \\
 A_{CP}(B^+ \rightarrow K^{*+}\pi^+\pi^-) &= 0.07 \pm 0.08 \\
 A_{CP}(B^+ \rightarrow \rho^0 K^*(892)^+) &= 0.31 \pm 0.13 \\
 A_{CP}(B^+ \rightarrow K^*(892)^+ f_0(980)) &= -0.15 \pm 0.12 \\
 A_{CP}(B^+ \rightarrow a_1^+ K^0) &= 0.12 \pm 0.11 \\
 A_{CP}(B^+ \rightarrow b_1^+ K^0) &= -0.03 \pm 0.15 \\
 A_{CP}(B^+ \rightarrow K^*(892)^0\rho^+) &= -0.01 \pm 0.16 \\
 A_{CP}(B^+ \rightarrow b_1^0 K^+) &= -0.46 \pm 0.20 \\
 A_{CP}(B^+ \rightarrow K^0 K^+) &= 0.12 \pm 0.18 \\
 A_{CP}(B^+ \rightarrow K^+ K_S^0 K_S^0) &= -0.04 \pm 0.11 \\
 A_{CP}(B^+ \rightarrow K^+ K^- \pi^+) &= 0.00 \pm 0.10 \\
 A_{CP}(B^+ \rightarrow K^+ K^- K^+) &= -0.017 \pm 0.030 \\
 A_{CP}(B^+ \rightarrow \phi K^+) &= -0.01 \pm 0.06 \\
 A_{CP}(B^+ \rightarrow X_0(1550)K^+) &= -0.04 \pm 0.07 \\
 A_{CP}(B^+ \rightarrow K^{*+} K^+ K^-) &= 0.11 \pm 0.09 \\
 A_{CP}(B^+ \rightarrow \phi K^*(892)^+) &= -0.01 \pm 0.08 \\
 A_{CP}(B^+ \rightarrow \phi(K\pi)_0^{*+}) &= 0.04 \pm 0.16 \\
 A_{CP}(B^+ \rightarrow \phi K_1(1270)^+) &= 0.15 \pm 0.20 \\
 A_{CP}(B^+ \rightarrow \phi K_2^*(1430)^+) &= -0.23 \pm 0.20 \\
 A_{CP}(B^+ \rightarrow K^*(892)^+\gamma) &= 0.018 \pm 0.029 \\
 A_{CP}(B^+ \rightarrow \eta K^+\gamma) &= -0.12 \pm 0.07 \\
 A_{CP}(B^+ \rightarrow \phi K^+\gamma) &= -0.26 \pm 0.15 \\
 A_{CP}(B^+ \rightarrow \rho^+\gamma) &= -0.11 \pm 0.33 \\
 A_{CP}(B^+ \rightarrow \pi^+\pi^0) &= 0.06 \pm 0.05 \\
 A_{CP}(B^+ \rightarrow \pi^+\pi^-\pi^+) &= 0.03 \pm 0.06 \\
 A_{CP}(B^+ \rightarrow \rho^0\pi^+) &= 0.18^{+0.09}_{-0.17} \\
 A_{CP}(B^+ \rightarrow f_2(1270)\pi^+) &= 0.41 \pm 0.30 \\
 A_{CP}(B^+ \rightarrow \rho^0(1450)\pi^+) &= -0.1^{+0.4}_{-0.5} \\
 \mathbf{A_{CP}(B^+ \rightarrow f_0(1370)\pi^+)} &= 0.72 \pm 0.22
 \end{aligned}$$



$$\begin{aligned}
 A_{CP}(B^+ \rightarrow \pi^+ \pi^- \pi^+ \text{ nonresonant}) &= -0.14^{+0.23}_{-0.16} \\
 A_{CP}(B^+ \rightarrow \rho^+ \pi^0) &= 0.02 \pm 0.11 \\
 A_{CP}(B^+ \rightarrow \rho^+ \rho^0) &= -0.05 \pm 0.05 \\
 A_{CP}(B^+ \rightarrow \omega \pi^+) &= -0.04 \pm 0.06 \\
 A_{CP}(B^+ \rightarrow \omega \rho^+) &= -0.20 \pm 0.09 \\
 A_{CP}(B^+ \rightarrow \eta \pi^+) &= -0.13 \pm 0.10 \quad (S = 1.5) \\
 A_{CP}(B^+ \rightarrow \eta \rho^+) &= 0.11 \pm 0.11 \\
 A_{CP}(B^+ \rightarrow \eta' \pi^+) &= 0.06 \pm 0.16 \\
 A_{CP}(B^+ \rightarrow \eta' \rho^+) &= 0.26 \pm 0.17 \\
 A_{CP}(B^+ \rightarrow b_1^0 \pi^+) &= 0.05 \pm 0.16 \\
 A_{CP}(B^+ \rightarrow \rho \bar{p} \pi^+) &= 0.00 \pm 0.04 \\
 A_{CP}(B^+ \rightarrow \rho \bar{p} K^+) &= -0.16 \pm 0.07 \\
 A_{CP}(B^+ \rightarrow \rho \bar{p} K^*(892)^+) &= 0.21 \pm 0.16 \quad (S = 1.4) \\
 A_{CP}(B^+ \rightarrow \rho \bar{\Lambda} \gamma) &= 0.17 \pm 0.17 \\
 A_{CP}(B^+ \rightarrow \rho \bar{\Lambda} \pi^0) &= 0.01 \pm 0.17 \\
 A_{CP}(B^+ \rightarrow K^+ \ell^+ \ell^-) &= -0.01 \pm 0.09 \quad (S = 1.1) \\
 A_{CP}(B^+ \rightarrow K^+ e^+ e^-) &= 0.14 \pm 0.14 \\
 A_{CP}(B^+ \rightarrow K^+ \mu^+ \mu^-) &= -0.05 \pm 0.13 \\
 A_{CP}(B^+ \rightarrow K^{*+} \ell^+ \ell^-) &= -0.09 \pm 0.14 \\
 A_{CP}(B^+ \rightarrow K^* e^+ e^-) &= -0.14 \pm 0.23 \\
 A_{CP}(B^+ \rightarrow K^* \mu^+ \mu^-) &= -0.12 \pm 0.24 \\
 \gamma(B^+ \rightarrow D^{(*)} K^{(*)+}) &= (73 \pm 10)^\circ
 \end{aligned}$$

$B^-$  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  $\psi$  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><math>B^+</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	Scale factor/ Confidence level (MeV/c)	$p$
<b>Semileptonic and leptonic modes</b>			
$l^+ \nu_l$ anything	[ooo] ( 10.99 ± 0.28 ) %		—
$e^+ \nu_e X_c$	( 10.8 ± 0.4 ) %		—
$D l^+ \nu_l$ anything	( 9.8 ± 0.7 ) %		—
$\bar{D}^0 l^+ \nu_l$	[ooo] ( 2.23 ± 0.11 ) %		2310
$\bar{D}^0 \tau^+ \nu_\tau$	( 7.7 ± 2.5 ) × 10 <sup>-3</sup>		1911
$\bar{D}^*(2007)^0 l^+ \nu_l$	[ooo] ( 5.68 ± 0.19 ) %		2258
$\bar{D}^*(2007)^0 \tau^+ \nu_\tau$	( 2.1 ± 0.4 ) %		1839
$D^- \pi^+ l^+ \nu_l$	( 4.2 ± 0.5 ) × 10 <sup>-3</sup>		2306
$\bar{D}_0^*(2420)^0 l^+ \nu_l \times$ B( $\bar{D}_0^{*0} \rightarrow D^- \pi^+$ )	( 2.5 ± 0.5 ) × 10 <sup>-3</sup>		—
$\bar{D}_2^*(2460)^0 l^+ \nu_l \times$ B( $\bar{D}_2^{*0} \rightarrow D^- \pi^+$ )	( 1.53 ± 0.16 ) × 10 <sup>-3</sup>		2065
$D^{(*)} n \pi l^+ \nu_l$ (n ≥ 1)	( 1.86 ± 0.26 ) %		—
$D^{*-} \pi^+ l^+ \nu_l$	( 6.1 ± 0.6 ) × 10 <sup>-3</sup>		2254
$\bar{D}_1(2420)^0 l^+ \nu_l \times$ B( $\bar{D}_1^0 \rightarrow$ $D^{*-} \pi^+$ )	( 3.03 ± 0.20 ) × 10 <sup>-3</sup>		2084
$\bar{D}'_1(2430)^0 l^+ \nu_l \times$ B( $\bar{D}'_1^0 \rightarrow D^{*-} \pi^+$ )	( 2.7 ± 0.6 ) × 10 <sup>-3</sup>		—
$\bar{D}_2^*(2460)^0 l^+ \nu_l \times$ B( $\bar{D}_2^{*0} \rightarrow D^{*-} \pi^+$ )	( 1.01 ± 0.24 ) × 10 <sup>-3</sup>	S=2.0	2065
$\pi^0 l^+ \nu_l$	( 7.7 ± 1.2 ) × 10 <sup>-5</sup>		2638
$\eta l^+ \nu_l$	( 3.9 ± 0.8 ) × 10 <sup>-5</sup>	S=1.3	2611
$\eta' l^+ \nu_l$	( 2.3 ± 0.8 ) × 10 <sup>-5</sup>		2553
$\omega l^+ \nu_l$	[ooo] ( 1.15 ± 0.17 ) × 10 <sup>-4</sup>		2582
$\rho^0 l^+ \nu_l$	[ooo] ( 1.07 ± 0.13 ) × 10 <sup>-4</sup>		2583
$p \bar{p} e^+ \nu_e$	< 5.2 × 10 <sup>-3</sup>	CL=90%	2467
$e^+ \nu_e$	< 1.9 × 10 <sup>-6</sup>	CL=90%	2640
$\mu^+ \nu_\mu$	< 1.0 × 10 <sup>-6</sup>	CL=90%	2639
$\tau^+ \nu_\tau$	( 1.65 ± 0.34 ) × 10 <sup>-4</sup>		2341
$l^+ \nu_l \gamma$	< 1.56 × 10 <sup>-5</sup>	CL=90%	2640
$e^+ \nu_e \gamma$	< 1.7 × 10 <sup>-5</sup>	CL=90%	2640
$\mu^+ \nu_\mu \gamma$	< 2.4 × 10 <sup>-5</sup>	CL=90%	2639
<b>Inclusive modes</b>			
$D^0 X$	( 8.6 ± 0.7 ) %		—
$\bar{D}^0 X$	( 79 ± 4 ) %		—
$D^+ X$	( 2.5 ± 0.5 ) %		—
$D^- X$	( 9.9 ± 1.2 ) %		—

$D_s^+ X$	( 7.9 $\begin{smallmatrix} +1.4 \\ -1.3 \end{smallmatrix}$ ) %	—
$D_s^- X$	( 1.10 $\begin{smallmatrix} +0.40 \\ -0.32 \end{smallmatrix}$ ) %	—
$\Lambda_c^+ X$	( 2.1 $\begin{smallmatrix} +0.9 \\ -0.6 \end{smallmatrix}$ ) %	—
$\bar{\Lambda}_c^- X$	( 2.8 $\begin{smallmatrix} +1.1 \\ -0.9 \end{smallmatrix}$ ) %	—
$\bar{c} X$	( 97 $\pm 4$ ) %	—
$c X$	( 23.4 $\begin{smallmatrix} +2.2 \\ -1.8 \end{smallmatrix}$ ) %	—
$\bar{c} c X$	(120 $\pm 6$ ) %	—

**$D, D^*,$  or  $D_s$  modes**

$\bar{D}^0 \pi^+$	( 4.84 $\pm 0.15$ ) $\times 10^{-3}$	2308
$D_{CP(+1)} \pi^+$	[ $\rho\rho\rho$ ] ( 2.5 $\pm 0.4$ ) $\times 10^{-3}$	—
$D_{CP(-1)} \pi^+$	[ $\rho\rho\rho$ ] ( 2.0 $\pm 0.4$ ) $\times 10^{-3}$	—
$\bar{D}^0 \rho^+$	( 1.34 $\pm 0.18$ ) %	2237
$\bar{D}^0 K^+$	( 3.68 $\pm 0.33$ ) $\times 10^{-4}$	2280
$D_{CP(+1)} K^+$	[ $\rho\rho\rho$ ] ( 2.20 $\pm 0.26$ ) $\times 10^{-4}$	—
$D_{CP(-1)} K^+$	[ $\rho\rho\rho$ ] ( 1.98 $\pm 0.24$ ) $\times 10^{-4}$	—
$[K^- \pi^+]_D K^+$	[ $qqq$ ] < 2.8 $\times 10^{-7}$	CL=90% —
$[K^+ \pi^-]_D K^+$	[ $qqq$ ] < 2.5 $\times 10^{-5}$	CL=90% —
$[K^- \pi^+]_D \pi^+$	[ $qqq$ ] ( 6.3 $\pm 1.1$ ) $\times 10^{-7}$	—
$[K^+ \pi^-]_D \pi^+$	( 1.9 $\pm 0.5$ ) $\times 10^{-4}$	—
$[\pi^+ \pi^- \pi^0]_D K^-$	( 4.6 $\pm 0.9$ ) $\times 10^{-6}$	—
$\bar{D}^0 K^*(892)^+$	( 5.3 $\pm 0.4$ ) $\times 10^{-4}$	2213
$D_{CP(-1)} K^*(892)^+$	[ $\rho\rho\rho$ ] ( 2.7 $\pm 0.8$ ) $\times 10^{-4}$	—
$D_{CP(+1)} K^*(892)^+$	[ $\rho\rho\rho$ ] ( 5.8 $\pm 1.1$ ) $\times 10^{-4}$	—
$\bar{D}^0 K^+ \bar{K}^0$	( 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
$D^- \pi^+ \pi^+$	( 1.07 $\pm 0.05$ ) $\times 10^{-3}$	2299
$D^+ K^0$	< 2.9 $\times 10^{-6}$	CL=90% 2278
$D^+ K^{*0}$	< 3.0 $\times 10^{-6}$	CL=90% 2211
$\bar{D}^*(2007)^0 \pi^+$	( 5.19 $\pm 0.26$ ) $\times 10^{-3}$	2256
$\bar{D}_{CP(+1)}^{*0} \pi^+$	[ $rrr$ ] ( 2.9 $\pm 0.7$ ) $\times 10^{-3}$	—
$D_{CP(-1)}^{*0} \pi^+$	[ $rrr$ ] ( 2.6 $\pm 1.0$ ) $\times 10^{-3}$	—
$\bar{D}^*(2007)^0 \omega \pi^+$	( 4.5 $\pm 1.2$ ) $\times 10^{-3}$	2149
$\bar{D}^*(2007)^0 \rho^+$	( 9.8 $\pm 1.7$ ) $\times 10^{-3}$	2181

$\bar{D}^*(2007)^0 K^+$	( 4.21 ± 0.35 ) × 10 <sup>-4</sup>		2227
$\bar{D}_{CP(+1)}^{*0} K^+$	[rrr] ( 2.8 ± 0.4 ) × 10 <sup>-4</sup>		–
$\bar{D}_{CP(-1)}^{*0} K^+$	[rrr] ( 2.32 ± 0.33 ) × 10 <sup>-4</sup>		–
$\bar{D}^*(2007)^0 K^*(892)^+$	( 8.1 ± 1.4 ) × 10 <sup>-4</sup>		2156
$\bar{D}^*(2007)^0 K^+ \bar{K}^0$	< 1.06 × 10 <sup>-3</sup>	CL=90%	2132
$\bar{D}^*(2007)^0 K^+ K^*(892)^0$	( 1.5 ± 0.4 ) × 10 <sup>-3</sup>		2008
$\bar{D}^*(2007)^0 \pi^+ \pi^+ \pi^-$	( 1.03 ± 0.12 ) %		2236
$\bar{D}^*(2007)^0 a_1(1260)^+$	( 1.9 ± 0.5 ) %		2062
$\bar{D}^*(2007)^0 \pi^- \pi^+ \pi^+ \pi^0$	( 1.8 ± 0.4 ) %		2219
$\bar{D}^{*0} 3\pi^+ 2\pi^-$	( 5.7 ± 1.2 ) × 10 <sup>-3</sup>		2196
$D^*(2010)^+ \pi^0$	< 3.6 × 10 <sup>-6</sup>		2255
$D^*(2010)^+ K^0$	< 9.0 × 10 <sup>-6</sup>	CL=90%	2225
$D^*(2010)^- \pi^+ \pi^+ \pi^0$	( 1.5 ± 0.7 ) %		2235
$D^*(2010)^- \pi^+ \pi^+ \pi^+ \pi^-$	( 2.6 ± 0.4 ) × 10 <sup>-3</sup>		2217
$\bar{D}^{*0} \pi^+$	[sss] ( 5.9 ± 1.3 ) × 10 <sup>-3</sup>		–
$\bar{D}_1^*(2420)^0 \pi^+$	( 1.5 ± 0.6 ) × 10 <sup>-3</sup>	S=1.3	2082
$\bar{D}_1(2420)^0 \pi^+ \times B(\bar{D}_1^0 \rightarrow \bar{D}^0 \pi^+ \pi^-)$	( 1.8 <sup>+0.5</sup> <sub>-0.6</sub> ) × 10 <sup>-4</sup>		2082
$\bar{D}_2^*(2462)^0 \pi^+$	( 3.5 ± 0.4 ) × 10 <sup>-4</sup>		–
$\times B(\bar{D}_2^*(2462)^0 \rightarrow D^- \pi^+)$			
$\bar{D}_0^*(2400)^0 \pi^+$	( 6.4 ± 1.4 ) × 10 <sup>-4</sup>		2128
$\times B(\bar{D}_0^*(2400)^0 \rightarrow D^- \pi^+)$			
$\bar{D}_1(2421)^0 \pi^+$	( 6.8 ± 1.5 ) × 10 <sup>-4</sup>		–
$\times B(\bar{D}_1(2421)^0 \rightarrow D^{*-} \pi^+)$			
$\bar{D}_2^*(2462)^0 \pi^+$	( 1.8 ± 0.5 ) × 10 <sup>-4</sup>		–
$\times B(\bar{D}_2^*(2462)^0 \rightarrow D^{*-} \pi^+)$			
$\bar{D}'_1(2427)^0 \pi^+$	( 5.0 ± 1.2 ) × 10 <sup>-4</sup>		–
$\times B(\bar{D}'_1(2427)^0 \rightarrow D^{*-} \pi^+)$			
$\bar{D}_1(2420)^0 \pi^+ \times B(\bar{D}_1^0 \rightarrow \bar{D}^{*0} \pi^+ \pi^-)$	< 6 × 10 <sup>-6</sup>	CL=90%	2082
$\bar{D}_1^*(2420)^0 \rho^+$	< 1.4 × 10 <sup>-3</sup>	CL=90%	1996
$\bar{D}_2^*(2460)^0 \pi^+$	< 1.3 × 10 <sup>-3</sup>	CL=90%	2062
$\bar{D}_2^*(2460)^0 \pi^+ \times B(\bar{D}_2^{*0} \rightarrow \bar{D}^{*0} \pi^+ \pi^-)$	< 2.2 × 10 <sup>-5</sup>	CL=90%	2062
$\bar{D}_2^*(2460)^0 \rho^+$	< 4.7 × 10 <sup>-3</sup>	CL=90%	1975
$\bar{D}^0 D_s^+$	( 10.0 ± 1.7 ) × 10 <sup>-3</sup>		1815
$D_{s0}(2317)^+ \bar{D}^0 \times B(D_{s0}(2317)^+ \rightarrow D_s^+ \pi^0)$	( 7.3 <sup>+2.2</sup> <sub>-1.7</sub> ) × 10 <sup>-4</sup>		1605
$D_{s0}(2317)^+ \bar{D}^0 \times B(D_{s0}(2317)^+ \rightarrow D_s^{*+} \gamma)$	< 7.6 × 10 <sup>-4</sup>	CL=90%	1605

$D_{s0}(2317)^+ \bar{D}^*(2007)^0 \times$ $B(D_{s0}(2317)^+ \rightarrow D_s^+ \pi^0)$	( 9 ±7 ) × 10 <sup>-4</sup>		1511
$D_{sJ}(2457)^+ \bar{D}^0$	( 3.1 <sup>+1.0</sup> <sub>-0.9</sub> ) × 10 <sup>-3</sup>		—
$D_{sJ}(2457)^+ \bar{D}^0 \times$ $B(D_{sJ}(2457)^+ \rightarrow D_s^+ \gamma)$	( 4.6 <sup>+1.3</sup> <sub>-1.1</sub> ) × 10 <sup>-4</sup>		—
$D_{sJ}(2457)^+ \bar{D}^0 \times$ $B(D_{sJ}(2457)^+ \rightarrow$ $D_s^+ \pi^+ \pi^-)$	< 2.2	× 10 <sup>-4</sup>	CL=90% —
$D_{sJ}(2457)^+ \bar{D}^0 \times$ $B(D_{sJ}(2457)^+ \rightarrow D_s^+ \pi^0)$	< 2.7	× 10 <sup>-4</sup>	CL=90% —
$D_{sJ}(2457)^+ \bar{D}^0 \times$ $B(D_{sJ}(2457)^+ \rightarrow D_s^{*+} \gamma)$	< 9.8	× 10 <sup>-4</sup>	CL=90% —
$D_{sJ}(2457)^+ \bar{D}^*(2007)^0$	( 1.20 ±0.30 ) %		—
$D_{sJ}(2457)^+ \bar{D}^*(2007)^0 \times$ $B(D_{sJ}(2457)^+ \rightarrow D_s^+ \gamma)$	( 1.4 <sup>+0.7</sup> <sub>-0.6</sub> ) × 10 <sup>-3</sup>		—
$\bar{D}^0 D_{s1}(2536)^+ \times$ $B(D_{s1}(2536)^+ \rightarrow$ $D^*(2007)^0 K^+)$	( 2.2 ±0.7 ) × 10 <sup>-4</sup>		1447
$\bar{D}^*(2007)^0 D_{s1}(2536)^+ \times$ $B(D_{s1}(2536)^+ \rightarrow$ $D^*(2007)^0 K^+)$	( 5.5 ±1.6 ) × 10 <sup>-4</sup>		1338
$\bar{D}^0 D_{s1}(2536)^+ \times$ $B(D_{s1}(2536)^+ \rightarrow D^{*+} K^0)$	( 2.3 ±1.1 ) × 10 <sup>-4</sup>		1447
$\bar{D}^0 D_{sJ}(2700)^+ \times$ $B(D_{sJ}(2700)^+ \rightarrow D^0 K^+)$	( 1.13 <sup>+0.26</sup> <sub>-0.40</sub> ) × 10 <sup>-3</sup>		—
$\bar{D}^{*0} D_{s1}(2536)^+ \times$ $B(D_{s1}(2536)^+ \rightarrow D^{*+} K^0)$	( 3.9 ±2.6 ) × 10 <sup>-4</sup>		1338
$\bar{D}^{*0} D_{sJ}(2573)^+ \times$ $B(D_{sJ}(2573)^+ \rightarrow D^0 K^+)$	< 2	× 10 <sup>-4</sup>	CL=90% 1306
$\bar{D}^*(2007)^0 D_{sJ}(2573)^+ \times$ $B(D_{sJ}(2573)^+ \rightarrow D^0 K^+)$	< 5	× 10 <sup>-4</sup>	CL=90% 1306
$\bar{D}^0 D_s^{*+}$	( 7.6 ±1.6 ) × 10 <sup>-3</sup>		1734
$\bar{D}^*(2007)^0 D_s^+$	( 8.2 ±1.7 ) × 10 <sup>-3</sup>		1737
$\bar{D}^*(2007)^0 D_s^{*+}$	( 1.71 ±0.24 ) %		1651
$D_s^{(*)+} \bar{D}^{*0}$	( 2.7 ±1.2 ) %		—
$\bar{D}^*(2007)^0 D^*(2010)^+$	( 8.1 ±1.7 ) × 10 <sup>-4</sup>		1713
$\bar{D}^0 D^*(2010)^+ +$ $\bar{D}^*(2007)^0 D^+$	< 1.30	%	CL=90% 1792
$\bar{D}^0 D^*(2010)^+$	( 3.9 ±0.5 ) × 10 <sup>-4</sup>		1792
$\bar{D}^0 D^+$	( 3.8 ±0.4 ) × 10 <sup>-4</sup>		1866
$\bar{D}^0 D^+ K^0$	( 1.55 ±0.21 ) × 10 <sup>-3</sup>		1571

$D^+ \bar{D}^*(2007)^0$	$( 6.3 \pm 1.7 ) \times 10^{-4}$		1791
$\bar{D}^*(2007)^0 D^+ K^0$	$( 2.1 \pm 0.5 ) \times 10^{-3}$		1474
$\bar{D}^0 \bar{D}^*(2010)^+ K^0$	$( 3.8 \pm 0.4 ) \times 10^{-3}$		1476
$\bar{D}^*(2007)^0 D^*(2010)^+ K^0$	$( 9.2 \pm 1.2 ) \times 10^{-3}$		1362
$\bar{D}^0 D^0 K^+$	$( 1.45 \pm 0.33 ) \times 10^{-3}$	S=2.6	1577
$\bar{D}^*(2007)^0 D^0 K^+$	$( 2.26 \pm 0.23 ) \times 10^{-3}$		1481
$\bar{D}^0 D^*(2007)^0 K^+$	$( 6.3 \pm 0.5 ) \times 10^{-3}$		1481
$\bar{D}^*(2007)^0 D^*(2007)^0 K^+$	$( 1.12 \pm 0.13 ) \%$		1368
$D^- D^+ K^+$	$( 2.2 \pm 0.7 ) \times 10^{-4}$		1570
$D^- D^*(2010)^+ K^+$	$( 6.3 \pm 1.1 ) \times 10^{-4}$		1475
$D^*(2010)^- D^+ K^+$	$( 6.0 \pm 1.3 ) \times 10^{-4}$		1475
$D^*(2010)^- D^*(2010)^+ K^+$	$( 1.32 \pm 0.18 ) \times 10^{-3}$		1363
$(\bar{D} + \bar{D}^*)(D + D^*)K$	$( 4.05 \pm 0.30 ) \%$		–
$D_s^+ \pi^0$	$( 1.6 \pm 0.5 ) \times 10^{-5}$		2270
$D_s^{*+} \pi^0$	$< 2.6$	$\times 10^{-4}$ CL=90%	2215
$D_s^+ \eta$	$< 4$	$\times 10^{-4}$ CL=90%	2235
$D_s^{*+} \eta$	$< 6$	$\times 10^{-4}$ CL=90%	2178
$D_s^+ \rho^0$	$< 3.0$	$\times 10^{-4}$ 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%	2014
$D_s^+ \phi$	$< 1.9$	$\times 10^{-6}$ CL=90%	2141
$D_s^{*+} \phi$	$< 1.2$	$\times 10^{-5}$ CL=90%	2079
$D_s^+ \bar{K}^0$	$< 8$	$\times 10^{-4}$ CL=90%	2241
$D_s^{*+} \bar{K}^0$	$< 9$	$\times 10^{-4}$ CL=90%	2184
$D_s^+ \bar{K}^*(892)^0$	$< 4$	$\times 10^{-4}$ CL=90%	2172
$D_s^{*+} \bar{K}^*(892)^0$	$< 3.5$	$\times 10^{-4}$ CL=90%	2112
$D_s^- \pi^+ K^+$	$( 1.80 \pm 0.22 ) \times 10^{-4}$		2222
$D_s^{*-} \pi^+ K^+$	$( 1.45 \pm 0.24 ) \times 10^{-4}$		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
$D_s^- K^+ K^+$	$( 1.1 \pm 0.4 ) \times 10^{-5}$		2149
$D_s^{*-} K^+ K^+$	$< 1.5$	$\times 10^{-5}$ CL=90%	2088

### Charmonium modes

$\eta_c K^+$	$( 9.1 \pm 1.3 ) \times 10^{-4}$		1753
$\eta_c K^*(892)^+$	$( 1.2 \begin{smallmatrix} +0.7 \\ -0.6 \end{smallmatrix} ) \times 10^{-3}$		1648
$\eta_c(2S) K^+$	$( 3.4 \pm 1.8 ) \times 10^{-4}$		1320
$J/\psi(1S) K^+$	$( 1.013 \pm 0.034 ) \times 10^{-3}$		1683

$J/\psi(1S)K^+\pi^+\pi^-$	( 8.1 ±1.3 ) × 10 <sup>-4</sup>	S=2.5	1612
$h_c(1P)K^+ \times B(h_c(1P) \rightarrow J/\psi\pi^+\pi^-)$	< 3.4 × 10 <sup>-6</sup>	CL=90%	1401
$X(3872)K^+$	< 3.2 × 10 <sup>-4</sup>	CL=90%	1141
$X(3872)K^+ \times B(X \rightarrow J/\psi\pi^+\pi^-)$	( 9.5 ±1.9 ) × 10 <sup>-6</sup>	S=1.3	1141
$X(3872)K^+ \times B(X \rightarrow J/\psi\gamma)$	( 2.8 ±0.8 ) × 10 <sup>-6</sup>		1141
$X(3872)K^*(892)^+ \times B(X \rightarrow J/\psi\gamma)$	< 4.8 × 10 <sup>-6</sup>	CL=90%	939
$X(3872)K^+ \times B(X \rightarrow \psi(2S)\gamma)$	( 9.5 ±2.8 ) × 10 <sup>-6</sup>		1141
$X(3872)K^*(892)^+ \times B(X \rightarrow \psi(2S)\gamma)$	< 2.8 × 10 <sup>-5</sup>	CL=90%	939
$X(3872)K^+ \times B(X \rightarrow D^0\bar{D}^0)$	< 6.0 × 10 <sup>-5</sup>	CL=90%	1141
$X(3872)K^+ \times B(X \rightarrow D^+D^-)$	< 4.0 × 10 <sup>-5</sup>	CL=90%	1141
$X(3872)K^+ \times B(X \rightarrow D^0\bar{D}^0\pi^0)$	( 1.0 ±0.4 ) × 10 <sup>-4</sup>		1141
$X(3872)K^+ \times B(X \rightarrow \bar{D}^{*0}D^0)$	( 8.5 ±2.6 ) × 10 <sup>-5</sup>	S=1.4	1141
$X(3872)K^+ \times B(X(3872) \rightarrow J/\psi(1S)\eta)$	< 7.7 × 10 <sup>-6</sup>	CL=90%	1141
$X(3872)^+K^0 \times B(X(3872)^+ \rightarrow [ttt]J/\psi(1S)\pi^+\pi^0)$	< 2.2 × 10 <sup>-5</sup>	CL=90%	–
$X(4430)^+K^0 \times B(X^+ \rightarrow J/\psi\pi^+)$	< 1.5 × 10 <sup>-5</sup>	CL=95%	–
$X(4430)^+K^0 \times B(X^+ \rightarrow \psi(2S)\pi^+)$	< 4.7 × 10 <sup>-5</sup>	CL=95%	–
$X(4260)^0K^+ \times B(X^0 \rightarrow J/\psi\pi^+\pi^-)$	< 2.9 × 10 <sup>-5</sup>	CL=95%	–
$X(3915)^0K^+ \times B(X^0 \rightarrow J/\psi\gamma)$	< 1.4 × 10 <sup>-5</sup>	CL=90%	–
$Z(3930)^0K^+ \times B(Z^0 \rightarrow J/\psi\gamma)$	< 2.5 × 10 <sup>-6</sup>	CL=90%	–
$J/\psi(1S)K^*(892)^+$	( 1.43 ±0.08 ) × 10 <sup>-3</sup>		1571
$J/\psi(1S)K(1270)^+$	( 1.8 ±0.5 ) × 10 <sup>-3</sup>		1390
$J/\psi(1S)K(1400)^+$	< 5 × 10 <sup>-4</sup>	CL=90%	1308
$J/\psi(1S)\eta K^+$	( 1.08 ±0.33 ) × 10 <sup>-4</sup>		1510
$J/\psi(1S)\eta' K^+$	< 8.8 × 10 <sup>-5</sup>	CL=90%	1273
$J/\psi(1S)\phi K^+$	( 5.2 ±1.7 ) × 10 <sup>-5</sup>	S=1.2	1227
$J/\psi(1S)\omega K^+$	( 3.20 <sup>+0.60</sup> / <sub>-0.32</sub> ) × 10 <sup>-4</sup>		1388
$X(3872)K^+ \times B(X \rightarrow J/\psi\omega)$	( 6.0 ±2.2 ) × 10 <sup>-6</sup>		1141

$X(3915)K^+ \times B(X \rightarrow J/\psi\omega)$	$( 3.0 \begin{smallmatrix} +0.9 \\ -0.7 \end{smallmatrix} ) \times 10^{-5}$		1104
$J/\psi(1S)\pi^+$	$( 4.9 \pm 0.4 ) \times 10^{-5}$	S=1.2	1727
$J/\psi(1S)\rho^+$	$( 5.0 \pm 0.8 ) \times 10^{-5}$		1611
$J/\psi(1S)\pi^+\pi^0$ nonresonant	$< 7.3 \times 10^{-6}$	CL=90%	1717
$J/\psi(1S)a_1(1260)^+$	$< 1.2 \times 10^{-3}$	CL=90%	1415
$J/\psi(1S)p\bar{\Lambda}$	$( 1.18 \pm 0.31 ) \times 10^{-5}$		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%	870
$J/\psi(1S)\bar{D}^0\pi^+$	$< 2.5 \times 10^{-5}$	CL=90%	665
$\psi(2S)\pi^+$	$( 2.55 \pm 0.29 ) \times 10^{-5}$		1347
$\psi(2S)K^+$	$( 6.39 \pm 0.33 ) \times 10^{-4}$		1284
$\psi(2S)K^*(892)^+$	$( 6.1 \pm 1.2 ) \times 10^{-4}$		1115
$\psi(2S)K^+\pi^+\pi^-$	$( 4.3 \pm 0.5 ) \times 10^{-4}$		1178
$\psi(3770)K^+$	$( 4.9 \pm 1.3 ) \times 10^{-4}$		1218
$\psi(3770)K^+ \times B(\psi \rightarrow D^0\bar{D}^0)$	$( 1.6 \pm 0.4 ) \times 10^{-4}$	S=1.1	1218
$\psi(3770)K^+ \times B(\psi \rightarrow D^+D^-)$	$( 9.4 \pm 3.5 ) \times 10^{-5}$		1218
$\chi_{c0}\pi^+ \times B(\chi_{c0} \rightarrow \pi^+\pi^-)$	$< 1 \times 10^{-7}$	CL=90%	1531
$\chi_{c0}(1P)K^+$	$( 1.32 \begin{smallmatrix} +0.19 \\ -0.16 \end{smallmatrix} ) \times 10^{-4}$		1478
$\chi_{c0}K^*(892)^+$	$< 2.1 \times 10^{-4}$	CL=90%	1341
$\chi_{c2}\pi^+ \times B(\chi_{c2} \rightarrow \pi^+\pi^-)$	$< 1 \times 10^{-7}$	CL=90%	1437
$\chi_{c2}K^+$	$< 1.8 \times 10^{-5}$	CL=90%	1379
$\chi_{c2}K^*(892)^+$	$< 1.2 \times 10^{-4}$	CL=90%	1227
$\chi_{c1}(1P)\pi^+$	$( 2.0 \pm 0.4 ) \times 10^{-5}$		1468
$\chi_{c1}(1P)K^+$	$( 4.6 \pm 0.4 ) \times 10^{-4}$	S=1.6	1412
$\chi_{c1}(1P)K^*(892)^+$	$( 3.0 \pm 0.6 ) \times 10^{-4}$	S=1.1	1265
$h_c(1P)K^+$	$< 3.8 \times 10^{-5}$		1401

### K or K\* modes

$K^0\pi^+$	$( 2.31 \pm 0.10 ) \times 10^{-5}$		2614
$K^+\pi^0$	$( 1.29 \pm 0.06 ) \times 10^{-5}$		2615
$\eta'K^+$	$( 7.06 \pm 0.25 ) \times 10^{-5}$		2528
$\eta'K^*(892)^+$	$( 4.8 \begin{smallmatrix} +1.8 \\ -1.6 \end{smallmatrix} ) \times 10^{-6}$		2472
$\eta'K_0^*(1430)^+$	$( 5.2 \pm 2.1 ) \times 10^{-6}$		—
$\eta'K_2^*(1430)^+$	$( 2.8 \pm 0.5 ) \times 10^{-5}$		2346
$\eta K^+$	$( 2.33 \begin{smallmatrix} +0.33 \\ -0.29 \end{smallmatrix} ) \times 10^{-6}$	S=1.4	2588
$\eta K^*(892)^+$	$( 1.93 \pm 0.16 ) \times 10^{-5}$		2534
$\eta K_0^*(1430)^+$	$( 1.8 \pm 0.4 ) \times 10^{-5}$		—
$\eta K_2^*(1430)^+$	$( 9.1 \pm 3.0 ) \times 10^{-6}$		2414
$\eta(1295)K^+ \times B(\eta(1295) \rightarrow \eta\pi\pi)$	$( 2.9 \begin{smallmatrix} +0.8 \\ -0.7 \end{smallmatrix} ) \times 10^{-6}$		2455



$\eta(1405) K^+ \times B(\eta(1405) \rightarrow \eta \pi \pi)$	< 1.3	$\times 10^{-6}$	CL=90%	2425
$\eta(1405) K^+ \times B(\eta(1405) \rightarrow K^* K)$	< 1.2	$\times 10^{-6}$	CL=90%	2425
$\eta(1475) K^+ \times B(\eta(1475) \rightarrow K^* K)$	( 1.38 $\begin{smallmatrix} +0.21 \\ -0.18 \end{smallmatrix}$ )	$\times 10^{-5}$		2406
$f_1(1285) K^+$	< 2.0	$\times 10^{-6}$	CL=90%	2458
$f_1(1420) K^+ \times B(f_1(1420) \rightarrow \eta \pi \pi)$	< 2.9	$\times 10^{-6}$	CL=90%	2420
$f_1(1420) K^+ \times B(f_1(1420) \rightarrow K^* K)$	< 4.1	$\times 10^{-6}$	CL=90%	2420
$\phi(1680) K^+ \times B(\phi(1680) \rightarrow K^* K)$	< 3.4	$\times 10^{-6}$	CL=90%	2344
$\omega K^+$	( 6.7 $\pm 0.8$ )	$\times 10^{-6}$	S=1.8	2557
$\omega K^*(892)^+$	< 7.4	$\times 10^{-6}$	CL=90%	2503
$\omega (K\pi)_0^{*+}$	( 2.8 $\pm 0.4$ )	$\times 10^{-5}$		–
$\omega K_0^*(1430)^+$	( 2.4 $\pm 0.5$ )	$\times 10^{-5}$		–
$\omega K_2^*(1430)^+$	( 2.1 $\pm 0.4$ )	$\times 10^{-5}$		2380
$a_0(980)^+ K^0 \times B(a_0(980)^+ \rightarrow \eta \pi^+)$	< 3.9	$\times 10^{-6}$	CL=90%	–
$a_0(980)^0 K^+ \times B(a_0(980)^0 \rightarrow \eta \pi^0)$	< 2.5	$\times 10^{-6}$	CL=90%	–
$K^*(892)^0 \pi^+$	( 1.01 $\pm 0.09$ )	$\times 10^{-5}$		2562
$K^*(892)^+ \pi^0$	( 6.9 $\pm 2.4$ )	$\times 10^{-6}$		2562
$K^+ \pi^- \pi^+$	( 5.10 $\pm 0.29$ )	$\times 10^{-5}$		2609
$K^+ \pi^- \pi^+$ nonresonant	( 1.63 $\begin{smallmatrix} +0.21 \\ -0.15 \end{smallmatrix}$ )	$\times 10^{-5}$		2609
$\omega(782) K^+$	( 6 $\pm 9$ )	$\times 10^{-6}$		2557
$K^+ f_0(980) \times B(f_0(980) \rightarrow \pi^+ \pi^-)$	( 9.4 $\begin{smallmatrix} +1.0 \\ -1.2 \end{smallmatrix}$ )	$\times 10^{-6}$		2524
$f_2(1270)^0 K^+$	( 1.07 $\pm 0.27$ )	$\times 10^{-6}$		–
$f_0(1370)^0 K^+ \times B(f_0(1370)^0 \rightarrow \pi^+ \pi^-)$	< 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%	–
$K^+ f_X(1300) \times B(f_X \rightarrow \pi^+ \pi^-)$	( 7 $\pm 5$ )	$\times 10^{-7}$		–
$f_0(1500) K^+ \times B(f_0(1500) \rightarrow \pi^+ \pi^-)$	< 4.4	$\times 10^{-6}$	CL=90%	2398
$f_2'(1525) K^+ \times B(f_2'(1525) \rightarrow \pi^+ \pi^-)$	< 3.4	$\times 10^{-6}$	CL=90%	2392
$K^+ \rho^0$	( 3.7 $\pm 0.5$ )	$\times 10^{-6}$		2559
$K_0^*(1430)^0 \pi^+$	( 4.5 $\begin{smallmatrix} +0.9 \\ -0.7 \end{smallmatrix}$ )	$\times 10^{-5}$	S=1.5	2445

$K_2^*(1430)^0 \pi^+$	( 5.6 $\begin{smallmatrix} +2.2 \\ -1.5 \end{smallmatrix}$ ) $\times 10^{-6}$		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
$K^- \pi^+ \pi^+$	< 9.5 $\times 10^{-7}$	CL=90%	2609
$K^- \pi^+ \pi^+$ nonresonant	< 5.6 $\times 10^{-5}$	CL=90%	2609
$K_1(1270)^0 \pi^+$	< 4.0 $\times 10^{-5}$	CL=90%	2484
$K_1(1400)^0 \pi^+$	< 3.9 $\times 10^{-5}$	CL=90%	2451
$K^0 \pi^+ \pi^0$	< 6.6 $\times 10^{-5}$	CL=90%	2609
$K^0 \rho^+$	( 8.0 $\pm 1.5$ ) $\times 10^{-6}$		2558
$K^*(892)^+ \pi^+ \pi^-$	( 7.5 $\pm 1.0$ ) $\times 10^{-5}$		2556
$K^*(892)^+ \rho^0$	( 4.6 $\pm 1.1$ ) $\times 10^{-6}$		2504
$K^*(892)^+ f_0(980)$	( 4.2 $\pm 0.7$ ) $\times 10^{-6}$		2468
$a_1^+ K^0$	( 3.5 $\pm 0.7$ ) $\times 10^{-5}$		—
$b_1^+ K^0 \times B(b_1^+ \rightarrow \omega \pi^+)$	( 9.6 $\pm 1.9$ ) $\times 10^{-6}$		—
$K^*(892)^0 \rho^+$	( 9.2 $\pm 1.5$ ) $\times 10^{-6}$		2504
$K_1(1400)^+ \rho^0$	< 7.8 $\times 10^{-4}$	CL=90%	2387
$K_2^*(1430)^+ \rho^0$	< 1.5 $\times 10^{-3}$	CL=90%	2381
$b_1^0 K^+ \times B(b_1^0 \rightarrow \omega \pi^0)$	( 9.1 $\pm 2.0$ ) $\times 10^{-6}$		—
$b_1^+ K^{*0} \times B(b_1^+ \rightarrow \omega \pi^+)$	< 5.9 $\times 10^{-6}$	CL=90%	—
$b_1^0 K^{*+} \times B(b_1^0 \rightarrow \omega \pi^0)$	< 6.7 $\times 10^{-6}$	CL=90%	—
$K^+ \bar{K}^0$	( 1.36 $\pm 0.27$ ) $\times 10^{-6}$		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
$K_S^0 K_S^0 \pi^+$	< 5.1 $\times 10^{-7}$	CL=90%	2577
$K^+ K^- \pi^+$	( 5.0 $\pm 0.7$ ) $\times 10^{-6}$		2578
$K^+ K^- \pi^+$ nonresonant	< 7.5 $\times 10^{-5}$	CL=90%	2578
$K^+ \bar{K}^*(892)^0$	< 1.1 $\times 10^{-6}$	CL=90%	2540
$K^+ \bar{K}_0^*(1430)^0$	< 2.2 $\times 10^{-6}$	CL=90%	2421
$K^+ K^+ \pi^-$	< 1.6 $\times 10^{-7}$	CL=90%	2578
$K^+ K^+ \pi^-$ nonresonant	< 8.79 $\times 10^{-5}$	CL=90%	2578
$K^{*+} \pi^+ K^-$	< 1.18 $\times 10^{-5}$	CL=90%	2524
$K^*(892)^+ K^*(892)^0$	( 1.2 $\pm 0.5$ ) $\times 10^{-6}$		2484
$K^{*+} K^+ \pi^-$	< 6.1 $\times 10^{-6}$	CL=90%	2524
$K^+ K^- K^+$	( 3.37 $\pm 0.22$ ) $\times 10^{-5}$	S=1.4	2522
$K^+ \phi$	( 8.3 $\pm 0.7$ ) $\times 10^{-6}$		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
$X_0(1550) K^+ \times B(X_0(1550) \rightarrow K^+ K^-)$	( 4.3 $\pm 0.7$ ) $\times 10^{-6}$		—

$\phi(1680)K^+ \times B(\phi(1680) \rightarrow K^+K^-)$	< 8	$\times 10^{-7}$	CL=90%	2344
$f_0(1710)K^+ \times B(f_0(1710) \rightarrow K^+K^-)$	( 1.7 $\pm$ 1.0 )	$\times 10^{-6}$		2331
$K^+K^-K^+$ nonresonant	( 2.8 $^{+0.9}_{-1.6}$ )	$\times 10^{-5}$	S=3.3	2522
$K^*(892)^+K^+K^-$	( 3.6 $\pm$ 0.5 )	$\times 10^{-5}$		2466
$K^*(892)^+\phi$	( 10.0 $\pm$ 2.0 )	$\times 10^{-6}$	S=1.7	2460
$\phi(K\pi)_0^{*+}$	( 8.3 $\pm$ 1.6 )	$\times 10^{-6}$		—
$\phi K_1(1270)^+$	( 6.1 $\pm$ 1.9 )	$\times 10^{-6}$		2375
$\phi K_1(1400)^+$	< 3.2	$\times 10^{-6}$	CL=90%	2339
$\phi K^*(1410)^+$	< 4.3	$\times 10^{-6}$	CL=90%	—
$\phi K_0^*(1430)^+$	( 7.0 $\pm$ 1.6 )	$\times 10^{-6}$		—
$\phi K_2^*(1430)^+$	( 8.4 $\pm$ 2.1 )	$\times 10^{-6}$		2332
$\phi K_2^*(1770)^+$	< 1.50	$\times 10^{-5}$	CL=90%	—
$\phi K_2^*(1820)^+$	< 1.63	$\times 10^{-5}$	CL=90%	—
$a_1^+K^{*0}$	< 3.6	$\times 10^{-6}$	CL=90%	—
$K^+\phi\phi$	( 4.9 $^{+2.4}_{-2.2}$ )	$\times 10^{-6}$	S=2.9	2306
$\eta'\eta'K^+$	< 2.5	$\times 10^{-5}$	CL=90%	2338
$\omega\phi K^+$	< 1.9	$\times 10^{-6}$	CL=90%	2374
$X(1812)K^+ \times B(X \rightarrow \omega\phi)$	< 3.2	$\times 10^{-7}$	CL=90%	—
$K^*(892)^+\gamma$	( 4.21 $\pm$ 0.18 )	$\times 10^{-5}$		2564
$K_1(1270)^+\gamma$	( 4.3 $\pm$ 1.3 )	$\times 10^{-5}$		2486
$\eta K^+\gamma$	( 7.9 $\pm$ 0.9 )	$\times 10^{-6}$		2588
$\eta'K^+\gamma$	( 2.9 $^{+1.0}_{-0.9}$ )	$\times 10^{-6}$		2528
$\phi K^+\gamma$	( 3.5 $\pm$ 0.6 )	$\times 10^{-6}$		2516
$K^+\pi^-\pi^+\gamma$	( 2.76 $\pm$ 0.22 )	$\times 10^{-5}$	S=1.2	2609
$K^*(892)^0\pi^+\gamma$	( 2.0 $^{+0.7}_{-0.6}$ )	$\times 10^{-5}$		2562
$K^+\rho^0\gamma$	< 2.0	$\times 10^{-5}$	CL=90%	2559
$K^+\pi^-\pi^+\gamma$ nonresonant	< 9.2	$\times 10^{-6}$	CL=90%	2609
$K^0\pi^+\pi^0\gamma$	( 4.6 $\pm$ 0.5 )	$\times 10^{-5}$		2609
$K_1(1400)^+\gamma$	< 1.5	$\times 10^{-5}$	CL=90%	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%	2244

### Light unflavored meson modes

$\rho^+\gamma$	( 9.8 $\pm$ 2.5 )	$\times 10^{-7}$		2583
$\pi^+\pi^0$	( 5.7 $\pm$ 0.5 )	$\times 10^{-6}$	S=1.4	2636
$\pi^+\pi^+\pi^-$	( 1.52 $\pm$ 0.14 )	$\times 10^{-5}$		2630
$\rho^0\pi^+$	( 8.3 $\pm$ 1.2 )	$\times 10^{-6}$		2581

$\pi^+ f_0(980) \times B(f_0(980) \rightarrow \pi^+ \pi^-)$	< 1.5	$\times 10^{-6}$	CL=90%	2547
$\pi^+ f_2(1270)$	( 1.6	$\begin{matrix} +0.7 \\ -0.4 \end{matrix}$ )	$\times 10^{-6}$	2484
$\rho(1450)^0 \pi^+ \times B(\rho^0 \rightarrow \pi^+ \pi^-)$	( 1.4	$\begin{matrix} +0.6 \\ -0.9 \end{matrix}$ )	$\times 10^{-6}$	2434
$f_0(1370) \pi^+ \times B(f_0(1370) \rightarrow \pi^+ \pi^-)$	< 4.0	$\times 10^{-6}$	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	( 5.3	$\begin{matrix} +1.5 \\ -1.1 \end{matrix}$ )	$\times 10^{-6}$	2630
$\pi^+ \pi^0 \pi^0$	< 8.9	$\times 10^{-4}$	CL=90%	2631
$\rho^+ \pi^0$	( 1.09	$\pm 0.14$ )	$\times 10^{-5}$	2581
$\pi^+ \pi^- \pi^+ \pi^0$	< 4.0	$\times 10^{-3}$	CL=90%	2621
$\rho^+ \rho^0$	( 2.40	$\pm 0.19$ )	$\times 10^{-5}$	2523
$\rho^+ f_0(980) \times B(f_0(980) \rightarrow \pi^+ \pi^-)$	< 2.0	$\times 10^{-6}$	CL=90%	2488
$a_1(1260)^+ \pi^0$	( 2.6	$\pm 0.7$ )	$\times 10^{-5}$	2494
$a_1(1260)^0 \pi^+$	( 2.0	$\pm 0.6$ )	$\times 10^{-5}$	2494
$\omega \pi^+$	( 6.9	$\pm 0.5$ )	$\times 10^{-6}$	2580
$\omega \rho^+$	( 1.59	$\pm 0.21$ )	$\times 10^{-5}$	2522
$\eta \pi^+$	( 4.07	$\pm 0.32$ )	$\times 10^{-6}$	2609
$\eta \rho^+$	( 7.0	$\pm 2.9$ )	$\times 10^{-6}$	S=2.8 2553
$\eta' \pi^+$	( 2.7	$\pm 0.9$ )	$\times 10^{-6}$	S=1.9 2551
$\eta' \rho^+$	( 9.7	$\pm 2.2$ )	$\times 10^{-6}$	2492
$\phi \pi^+$	< 2.4	$\times 10^{-7}$	CL=90%	2539
$\phi \rho^+$	< 3.0	$\times 10^{-6}$	CL=90%	2480
$a_0(980)^0 \pi^+ \times B(a_0(980)^0 \rightarrow \eta \pi^0)$	< 5.8	$\times 10^{-6}$	CL=90%	—
$a_0(980)^+ \pi^0 \times B(a_0^+ \rightarrow \eta \pi^+)$	< 1.4	$\times 10^{-6}$	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
$b_1^0 \pi^+ \times B(b_1^0 \rightarrow \omega \pi^0)$	( 6.7	$\pm 2.0$ )	$\times 10^{-6}$	—
$b_1^+ \pi^0 \times B(b_1^+ \rightarrow \omega \pi^+)$	< 3.3	$\times 10^{-6}$	CL=90%	—
$\pi^+ \pi^+ \pi^+ \pi^- \pi^- \pi^0$	< 6.3	$\times 10^{-3}$	CL=90%	2592
$b_1^+ \rho^0 \times B(b_1^+ \rightarrow \omega \pi^+)$	< 5.2	$\times 10^{-6}$	CL=90%	—
$a_1(1260)^+ a_1(1260)^0$	< 1.3	%	CL=90%	2335
$b_1^0 \rho^+ \times B(b_1^0 \rightarrow \omega \pi^0)$	< 3.3	$\times 10^{-6}$	CL=90%	—

### Charged particle ( $h^\pm$ ) modes

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

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

### Baryon modes

$p\bar{p}\pi^+$	( 1.62 $\pm 0.20$ ) $\times 10^{-6}$	2439
$p\bar{p}\pi^+$ nonresonant	< 5.3 $\times 10^{-5}$	CL=90% 2439
$p\bar{p}K^+$	( 5.9 $\pm 0.5$ ) $\times 10^{-6}$	S=1.5 2348
$\Theta(1710)^{++}\bar{p} \times$ B( $\Theta(1710)^{++} \rightarrow pK^+$ )	[uuu] < 9.1 $\times 10^{-8}$	CL=90% -
$f_J(2220)K^+ \times$ B( $f_J(2220) \rightarrow$ $p\bar{p}$ )	[uuu] < 4.1 $\times 10^{-7}$	CL=90% 2135
$p\bar{\Lambda}(1520)$	< 1.5 $\times 10^{-6}$	CL=90% 2322
$p\bar{p}K^+$ nonresonant	< 8.9 $\times 10^{-5}$	CL=90% 2348
$p\bar{p}K^*(892)^+$	( 3.6 $^{+0.8}_{-0.7}$ ) $\times 10^{-6}$	2215
$f_J(2220)K^{*+} \times$ B( $f_J(2220) \rightarrow$ $p\bar{p}$ )	< 7.7 $\times 10^{-7}$	CL=90% 2059
$p\bar{\Lambda}$	< 3.2 $\times 10^{-7}$	CL=90% 2430
$p\bar{\Lambda}\gamma$	( 2.4 $^{+0.5}_{-0.4}$ ) $\times 10^{-6}$	2430
$p\bar{\Lambda}\pi^0$	( 3.0 $^{+0.7}_{-0.6}$ ) $\times 10^{-6}$	2402
$p\bar{\Sigma}^-(1385)^0$	< 4.7 $\times 10^{-7}$	CL=90% 2362
$\Delta^+\bar{\Lambda}$	< 8.2 $\times 10^{-7}$	CL=90% -
$p\bar{\Sigma}^-\gamma$	< 4.6 $\times 10^{-6}$	CL=90% 2413
$p\bar{\Lambda}\pi^+\pi^-$	( 5.9 $\pm 1.1$ ) $\times 10^{-6}$	2367
$p\bar{\Lambda}\rho^0$	( 4.8 $\pm 0.9$ ) $\times 10^{-6}$	2214
$p\bar{\Lambda}f_2(1270)$	( 2.0 $\pm 0.8$ ) $\times 10^{-6}$	2026
$\Lambda\bar{\Lambda}\pi^+$	< 9.4 $\times 10^{-7}$	CL=90% 2358
$\Lambda\bar{\Lambda}K^+$	( 3.4 $\pm 0.6$ ) $\times 10^{-6}$	2251
$\Lambda\bar{\Lambda}K^{*+}$	( 2.2 $^{+1.2}_{-0.9}$ ) $\times 10^{-6}$	2098
$\bar{\Delta}^0\rho$	< 1.38 $\times 10^{-6}$	CL=90% 2402
$\Delta^{++}\bar{p}$	< 1.4 $\times 10^{-7}$	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
$\bar{\Lambda}_c^-p\pi^+$	( 2.8 $\pm 0.8$ ) $\times 10^{-4}$	1980
$\bar{\Lambda}_c^- \Delta(1232)^{++}$	< 1.9 $\times 10^{-5}$	CL=90% 1928
$\bar{\Lambda}_c^- \Delta_X(1600)^{++}$	( 5.9 $\pm 1.9$ ) $\times 10^{-5}$	-
$\bar{\Lambda}_c^- \Delta_X(2420)^{++}$	( 4.7 $\pm 1.6$ ) $\times 10^{-5}$	-
$(\bar{\Lambda}_c^- \rho)_s \pi^+$	[vvv] ( 3.9 $\pm 1.3$ ) $\times 10^{-5}$	-

$\overline{\Sigma}_c(2520)^0 p$	< 2.6	$\times 10^{-6}$	CL=90%	1904
$\overline{\Sigma}_c(2800)^0 p$	( 3.3 $\pm$ 1.3 )	$\times 10^{-5}$		–
$\overline{\Lambda}_c^- p \pi^+ \pi^0$	( 1.8 $\pm$ 0.6 )	$\times 10^{-3}$		1935
$\overline{\Lambda}_c^- p \pi^+ \pi^+ \pi^-$	( 2.2 $\pm$ 0.7 )	$\times 10^{-3}$		1880
$\overline{\Lambda}_c^- p \pi^+ \pi^+ \pi^- \pi^0$	< 1.34	%	CL=90%	1822
$\Lambda_c^+ \Lambda_c^- K^+$	( 8.7 $\pm$ 3.5 )	$\times 10^{-4}$		–
$\overline{\Sigma}_c(2455)^0 p$	( 3.5 $\pm$ 1.0 )	$\times 10^{-5}$		1938
$\overline{\Sigma}_c(2455)^0 p \pi^0$	( 4.4 $\pm$ 1.8 )	$\times 10^{-4}$		1896
$\overline{\Sigma}_c(2455)^0 p \pi^- \pi^+$	( 4.4 $\pm$ 1.7 )	$\times 10^{-4}$		1845
$\overline{\Sigma}_c(2455)^{--} p \pi^+ \pi^+$	( 2.8 $\pm$ 1.2 )	$\times 10^{-4}$		1845
$\overline{\Lambda}_c(2593)^- / \overline{\Lambda}_c(2625)^- p \pi^+$	< 1.9	$\times 10^{-4}$	CL=90%	–
$\Xi_c^0 \Lambda_c^+ \times B(\Xi_c^0 \rightarrow \Xi^+ \pi^-)$	( 3.0 $\pm$ 1.1 )	$\times 10^{-5}$		1144
$\Xi_c^0 \Lambda_c^+ \times B(\Xi_c^0 \rightarrow \Lambda K^+ \pi^-)$	( 2.6 $\pm$ 1.1 )	$\times 10^{-5}$	S=1.1	1144

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

$\pi^+ \ell^+ \ell^-$	B1	< 4.9	$\times 10^{-8}$	CL=90%	2638
$\pi^+ e^+ e^-$	B1	< 8.0	$\times 10^{-8}$	CL=90%	2638
$\pi^+ \mu^+ \mu^-$	B1	< 6.9	$\times 10^{-8}$	CL=90%	2634
$\pi^+ \nu \bar{\nu}$	B1	< 1.0	$\times 10^{-4}$	CL=90%	2638
$K^+ \ell^+ \ell^-$	B1 [ooo]	( 5.1 $\pm$ 0.5 )	$\times 10^{-7}$		2617
$K^+ e^+ e^-$	B1	( 5.5 $\pm$ 0.7 )	$\times 10^{-7}$		2617
$K^+ \mu^+ \mu^-$	B1	( 5.2 $\pm$ 0.7 )	$\times 10^{-7}$		2612
$K^+ \bar{\nu} \nu$	B1	< 1.3	$\times 10^{-5}$	CL=90%	2617
$\rho^+ \nu \bar{\nu}$	B1	< 1.5	$\times 10^{-4}$	CL=90%	2583
$K^*(892)^+ \ell^+ \ell^-$	B1 [ooo]	( 1.29 $\pm$ 0.21 )	$\times 10^{-6}$		2564
$K^*(892)^+ e^+ e^-$	B1	( 1.55 $^{+0.40}_{-0.31}$ )	$\times 10^{-6}$		2564
$K^*(892)^+ \mu^+ \mu^-$	B1	( 1.16 $^{+0.31}_{-0.27}$ )	$\times 10^{-6}$		2560
$K^*(892)^+ \nu \bar{\nu}$	B1	< 8	$\times 10^{-5}$	CL=90%	2564
$\pi^+ e^+ \mu^-$	LF	< 6.4	$\times 10^{-3}$	CL=90%	2637
$\pi^+ e^- \mu^+$	LF	< 6.4	$\times 10^{-3}$	CL=90%	2637
$\pi^+ e^\pm \mu^\mp$	LF	< 1.7	$\times 10^{-7}$	CL=90%	2637
$K^+ e^+ \mu^-$	LF	< 9.1	$\times 10^{-8}$	CL=90%	2615
$K^+ e^- \mu^+$	LF	< 1.3	$\times 10^{-7}$	CL=90%	2615
$K^+ e^\pm \mu^\mp$	LF	< 9.1	$\times 10^{-8}$	CL=90%	2615
$K^+ \mu^\pm \tau^\mp$	LF	< 7.7	$\times 10^{-5}$	CL=90%	2298
$K^*(892)^+ e^+ \mu^-$	LF	< 1.3	$\times 10^{-6}$	CL=90%	2563
$K^*(892)^+ e^- \mu^+$	LF	< 9.9	$\times 10^{-7}$	CL=90%	2563
$K^*(892)^+ e^\pm \mu^\mp$	LF	< 1.4	$\times 10^{-7}$	CL=90%	2563
$\pi^- e^+ e^+$	L	< 1.6	$\times 10^{-6}$	CL=90%	2638
$\pi^- \mu^+ \mu^+$	L	< 1.4	$\times 10^{-6}$	CL=90%	2634
$\pi^- e^+ \mu^+$	L	< 1.3	$\times 10^{-6}$	CL=90%	2637

$\rho^- e^+ e^+$	$L$	$< 2.6$	$\times 10^{-6}$	CL=90%	2583
$\rho^- \mu^+ \mu^+$	$L$	$< 5.0$	$\times 10^{-6}$	CL=90%	2578
$\rho^- e^+ \mu^+$	$L$	$< 3.3$	$\times 10^{-6}$	CL=90%	2582
$K^- e^+ e^+$	$L$	$< 1.0$	$\times 10^{-6}$	CL=90%	2617
$K^- \mu^+ \mu^+$	$L$	$< 1.8$	$\times 10^{-6}$	CL=90%	2612
$K^- e^+ \mu^+$	$L$	$< 2.0$	$\times 10^{-6}$	CL=90%	2615
$K^*(892)^- e^+ e^+$	$L$	$< 2.8$	$\times 10^{-6}$	CL=90%	2564
$K^*(892)^- \mu^+ \mu^+$	$L$	$< 8.3$	$\times 10^{-6}$	CL=90%	2560
$K^*(892)^- e^+ \mu^+$	$L$	$< 4.4$	$\times 10^{-6}$	CL=90%	2563

**$B^0$**

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

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

$$\text{Mass } m_{B^0} = 5279.50 \pm 0.30 \text{ MeV}$$

$$m_{B^0} - m_{B^\pm} = 0.33 \pm 0.06 \text{ MeV}$$

$$\text{Mean life } \tau_{B^0} = (1.519 \pm 0.007) \times 10^{-12} \text{ s}$$

$$c\tau = 455.4 \text{ } \mu\text{m}$$

$$\tau_{B^+}/\tau_{B^0} = 1.079 \pm 0.007 \quad (\text{direct measurements})$$

### $B^0$ - $\bar{B}^0$ mixing parameters

$$\chi_d = 0.1863 \pm 0.0023$$

$$\begin{aligned} \Delta m_{B^0} = m_{B_H^0} - m_{B_L^0} &= (0.507 \pm 0.004) \times 10^{12} \text{ } \hbar \text{ s}^{-1} \\ &= (3.337 \pm 0.033) \times 10^{-10} \text{ MeV} \end{aligned}$$

$$x_d = \Delta m_{B^0}/\Gamma_{B^0} = 0.771 \pm 0.008$$

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

$$\Delta\Gamma \text{ Re}(z) = -0.007 \pm 0.004$$

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

$$\text{Im}(z) = -0.015 \pm 0.008$$

**CP violation parameters**

$$\begin{aligned}
\text{Re}(\epsilon_{B^0})/(1+|\epsilon_{B^0}|^2) &= (-0.1 \pm 1.4) \times 10^{-3} \\
A_{T/CP} &= 0.005 \pm 0.018 \\
A_{CP}(B^0 \rightarrow D^*(2010)^+ D^-) &= 0.02 \pm 0.04 \\
\mathbf{A_{CP}(B^0 \rightarrow K^+ \pi^-)} &= -0.098 \pm 0.013 \\
A_{CP}(B^0 \rightarrow \eta' K^*(892)^0) &= 0.02 \pm 0.23 \\
A_{CP}(B^0 \rightarrow \eta' K_0^*(1430)^0) &= -0.19 \pm 0.17 \\
A_{CP}(B^0 \rightarrow \eta' K_2^*(1430)^0) &= 0.14 \pm 0.18 \\
\mathbf{A_{CP}(B^0 \rightarrow \eta K^*(892)^0)} &= 0.19 \pm 0.05 \\
A_{CP}(B^0 \rightarrow \eta K_0^*(1430)^0) &= 0.06 \pm 0.13 \\
A_{CP}(B^0 \rightarrow \eta K_2^*(1430)^0) &= -0.07 \pm 0.19 \\
A_{CP}(B^0 \rightarrow b_1 K^+) &= -0.07 \pm 0.12 \\
A_{CP}(B^0 \rightarrow \omega K^{*0}) &= 0.45 \pm 0.25 \\
A_{CP}(B^0 \rightarrow \omega (K\pi)_0^{*0}) &= -0.07 \pm 0.09 \\
A_{CP}(B^0 \rightarrow \omega K_2^*(1430)^0) &= -0.37 \pm 0.17 \\
A_{CP}(B^0 \rightarrow K^0 K^0) &= -0.6 \pm 0.7 \\
A_{CP}(B^0 \rightarrow K^+ \pi^- \pi^0) &= (0+6) \times 10^{-2} \\
A_{CP}(B^0 \rightarrow \rho^- K^+) &= 0.15 \pm 0.13 \\
A_{CP}(B^0 \rightarrow K^+ \pi^- \pi^0 \text{ nonresonant}) &= 0.23^{+0.22}_{-0.29} \\
A_{CP}(B^0 \rightarrow (K\pi)_0^{*0} \pi^0) &= -0.22 \pm 0.32 \\
A_{CP}(B^0 \rightarrow K^{*0} \pi^0) &= -0.09^{+0.23}_{-0.26} \\
A_{CP}(B^0 \rightarrow K^*(892)^+ \pi^-) &= -0.19 \pm 0.07 \\
A_{CP}(B^0 \rightarrow (K\pi)_0^{*+} \pi^-) &= 0.10 \pm 0.07 \\
A_{CP}(B^0 \rightarrow K^0 \pi^+ \pi^-) &= -0.01 \pm 0.05 \\
A_{CP}(B^0 \rightarrow K^*(892)^0 \pi^+ \pi^-) &= 0.07 \pm 0.05 \\
A_{CP}(B^0 \rightarrow K^*(892)^0 \rho^0) &= 0.09 \pm 0.19 \\
A_{CP}(B^0 \rightarrow K^{*0} f_0(980)) &= -0.17 \pm 0.28 \\
A_{CP}(B^0 \rightarrow a_1^- K^+) &= -0.16 \pm 0.12 \\
A_{CP}(B^0 \rightarrow K^*(892)^0 K^+ K^-) &= 0.01 \pm 0.05 \\
A_{CP}(B^0 \rightarrow K^*(892)^0 \phi) &= 0.01 \pm 0.05 \\
A_{CP}(B^0 \rightarrow K^*(892)^0 K^- \pi^+) &= 0.2 \pm 0.4 \\
A_{CP}(B^0 \rightarrow \phi (K\pi)_0^{*0}) &= 0.20 \pm 0.15 \\
A_{CP}(B^0 \rightarrow \phi K_2^*(1430)^0) &= -0.08 \pm 0.13 \\
A_{CP}(B^0 \rightarrow K^*(892)^0 \gamma) &= -0.016 \pm 0.023 \\
A_{CP}(B^0 \rightarrow K^*(1430) \gamma) &= -0.08 \pm 0.15 \\
A_{CP}(B^0 \rightarrow \rho^+ \pi^-) &= 0.08 \pm 0.12 \quad (S = 2.0) \\
A_{CP}(B^0 \rightarrow \rho^- \pi^+) &= -0.16 \pm 0.23 \quad (S = 1.7) \\
A_{CP}(B^0 \rightarrow a_1(1260)^\pm \pi^\mp) &= -0.07 \pm 0.07 \\
A_{CP}(B^0 \rightarrow b_1 \pi^+) &= -0.05 \pm 0.10 \\
A_{CP}(B^0 \rightarrow \rho \bar{\rho} K^*(892)^0) &= 0.05 \pm 0.12
\end{aligned}$$



$$\begin{aligned}
 A_{CP}(B^0 \rightarrow p\bar{\Lambda}\pi^-) &= 0.04 \pm 0.07 \\
 A_{CP}(B^0 \rightarrow K^{*0}\ell^+\ell^-) &= -0.05 \pm 0.10 \\
 A_{CP}(B^0 \rightarrow K^{*0}e^+e^-) &= -0.21 \pm 0.19 \\
 A_{CP}(B^0 \rightarrow K^{*0}\mu^+\mu^-) &= 0.00 \pm 0.15 \\
 C_{D^{*-}D^+}(B^0 \rightarrow D^*(2010)^-D^+) &= 0.07 \pm 0.14 \\
 \mathbf{S_{D^{*-}D^+}(B^0 \rightarrow D^*(2010)^-D^+)} &= -0.78 \pm 0.21 \\
 C_{D^{*+}D^-}(B^0 \rightarrow D^*(2010)^+D^-) &= -0.09 \pm 0.22 \quad (S = 1.6) \\
 \mathbf{S_{D^{*+}D^-}(B^0 \rightarrow D^*(2010)^+D^-)} &= -0.61 \pm 0.19 \\
 C_{D^{*+}D^{*-}}(B^0 \rightarrow D^{*+}D^{*-}) &= -0.01 \pm 0.09 \quad (S = 1.2) \\
 \mathbf{S_{D^{*+}D^{*-}}(B^0 \rightarrow D^{*+}D^{*-})} &= -0.76 \pm 0.14 \\
 C_+(B^0 \rightarrow D^{*+}D^{*-}) &= 0.00 \pm 0.12 \\
 \mathbf{S_+(B^0 \rightarrow D^{*+}D^{*-})} &= -0.76 \pm 0.16 \\
 C_-(B^0 \rightarrow D^{*+}D^{*-}) &= 0.4 \pm 0.5 \\
 S_-(B^0 \rightarrow D^{*+}D^{*-}) &= -1.8 \pm 0.7 \\
 C(B^0 \rightarrow D^*(2010)^+D^*(2010)^-K_S^0) &= 0.01 \pm 0.29 \\
 S(B^0 \rightarrow D^*(2010)^+D^*(2010)^-K_S^0) &= 0.1 \pm 0.4 \\
 C_{D^+D^-}(B^0 \rightarrow D^+D^-) &= -0.5 \pm 0.4 \quad (S = 2.5) \\
 \mathbf{S_{D^+D^-}(B^0 \rightarrow D^+D^-)} &= -0.87 \pm 0.26 \\
 C_{J/\psi(1S)\pi^0}(B^0 \rightarrow J/\psi(1S)\pi^0) &= -0.13 \pm 0.13 \\
 \mathbf{S_{J/\psi(1S)\pi^0}(B^0 \rightarrow J/\psi(1S)\pi^0)} &= -0.94 \pm 0.29 \quad (S = 1.9) \\
 C_{D_{CP}^{(*)}h^0}(B^0 \rightarrow D_{CP}^{(*)}h^0) &= -0.23 \pm 0.16 \\
 S_{D_{CP}^{(*)}h^0}(B^0 \rightarrow D_{CP}^{(*)}h^0) &= -0.56 \pm 0.24 \\
 C_{K_S^0\pi^0}(B^0 \rightarrow K^0\pi^0) &= 0.00 \pm 0.13 \quad (S = 1.4) \\
 \mathbf{S_{K_S^0\pi^0}(B^0 \rightarrow K^0\pi^0)} &= 0.58 \pm 0.17 \\
 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_{\eta'K^0}(B^0 \rightarrow \eta'K^0) &= -0.05 \pm 0.05 \\
 \mathbf{S_{\eta'K^0}(B^0 \rightarrow \eta'K^0)} &= 0.60 \pm 0.07 \\
 C_{\omega K_S^0}(B^0 \rightarrow \omega K_S^0) &= -0.30 \pm 0.28 \quad (S = 1.6) \\
 S_{\omega K_S^0}(B^0 \rightarrow \omega K_S^0) &= 0.43 \pm 0.24 \\
 C(B^0 \rightarrow K_S^0\pi^0\pi^0) &= 0.2 \pm 0.5 \\
 S(B^0 \rightarrow K_S^0\pi^0\pi^0) &= 0.7 \pm 0.7 \\
 C_{\rho^0 K_S^0}(B^0 \rightarrow \rho^0 K_S^0) &= -0.04 \pm 0.20 \\
 S_{\rho^0 K_S^0}(B^0 \rightarrow \rho^0 K_S^0) &= 0.50^{+0.17}_{-0.21} \\
 C_{f_0 K_S^0}(B^0 \rightarrow f_0(980)K_S^0) &= 0.14 \pm 0.17 \\
 S_{f_0 K_S^0}(B^0 \rightarrow f_0(980)K_S^0) &= -0.73^{+0.27}_{-0.09} \quad (S = 1.6)
 \end{aligned}$$

$$\begin{aligned}
 S_{f_2 K_S^0} (B^0 \rightarrow f_2(1270) K_S^0) &= -0.5 \pm 0.5 \\
 C_{f_2 K_S^0} (B^0 \rightarrow f_2(1270) K_S^0) &= 0.3 \pm 0.4 \\
 S_{f_x K_S^0} (B^0 \rightarrow f_x(1300) K_S^0) &= -0.2 \pm 0.5 \\
 C_{f_x K_S^0} (B^0 \rightarrow f_x(1300) K_S^0) &= 0.13 \pm 0.35 \\
 S_{K^0 \pi^+ \pi^-} (B^0 \rightarrow K^0 \pi^+ \pi^- \text{ nonresonant}) &= -0.01 \pm 0.33 \\
 C_{K^0 \pi^+ \pi^-} (B^0 \rightarrow K^0 \pi^+ \pi^- \text{ nonresonant}) &= 0.01 \pm 0.26 \\
 C_{K_S^0 K_S^0} (B^0 \rightarrow K_S^0 K_S^0) &= 0.0 \pm 0.4 \quad (S = 1.4) \\
 S_{K_S^0 K_S^0} (B^0 \rightarrow K_S^0 K_S^0) &= -0.8 \pm 0.5 \\
 C_{K^+ K^- K_S^0} (B^0 \rightarrow K^+ K^- K_S^0 \text{ nonresonant}) &= 0.09 \pm 0.09 \\
 \mathbf{S_{K^+ K^- K_S^0} (B^0 \rightarrow K^+ K^- K_S^0 \text{ nonresonant})} &= -0.74^{+0.12}_{-0.10} \\
 C_{K^+ K^- K_S^0} (B^0 \rightarrow K^+ K^- K_S^0 \text{ inclusive}) &= 0.01 \pm 0.09 \\
 \mathbf{S_{K^+ K^- K_S^0} (B^0 \rightarrow K^+ K^- K_S^0 \text{ inclusive})} &= -0.65 \pm 0.12 \\
 C_{\phi K_S^0} (B^0 \rightarrow \phi K_S^0) &= 0.03 \pm 0.14 \\
 S_{\phi K_S^0} (B^0 \rightarrow \phi K_S^0) &= 0.39 \pm 0.17 \\
 C_{K_S K_S K_S} (B^0 \rightarrow K_S K_S K_S) &= -0.15 \pm 0.16 \quad (S = 1.1) \\
 S_{K_S K_S K_S} (B^0 \rightarrow K_S K_S K_S) &= -0.4 \pm 0.5 \quad (S = 2.5) \\
 C_{K_S^0 \pi^0 \gamma} (B^0 \rightarrow K_S^0 \pi^0 \gamma) &= 0.36 \pm 0.33 \\
 S_{K_S^0 \pi^0 \gamma} (B^0 \rightarrow K_S^0 \pi^0 \gamma) &= -0.8 \pm 0.6 \\
 C_{K^{*0} \gamma} (B^0 \rightarrow K^{*0} \gamma) &= -0.04 \pm 0.16 \quad (S = 1.2) \\
 S_{K^{*0} \gamma} (B^0 \rightarrow K^{*0} \gamma) &= -0.15 \pm 0.22 \\
 C_{\eta K^0 \gamma} (B^0 \rightarrow \eta K^0 \gamma) &= -0.3 \pm 0.4 \\
 S_{\eta K^0 \gamma} (B^0 \rightarrow \eta K^0 \gamma) &= -0.2 \pm 0.5 \\
 C(B^0 \rightarrow K_S^0 \rho^0 \gamma) &= -0.05 \pm 0.19 \\
 S(B^0 \rightarrow K_S^0 \rho^0 \gamma) &= 0.11 \pm 0.34 \\
 C(B^0 \rightarrow \rho^0 \gamma) &= 0.4 \pm 0.5 \\
 S(B^0 \rightarrow \rho^0 \gamma) &= -0.8 \pm 0.7 \\
 C_{\pi \pi} (B^0 \rightarrow \pi^+ \pi^-) &= -0.38 \pm 0.17 \quad (S = 2.6) \\
 \mathbf{S_{\pi \pi} (B^0 \rightarrow \pi^+ \pi^-)} &= -0.61 \pm 0.08 \\
 C_{\pi^0 \pi^0} (B^0 \rightarrow \pi^0 \pi^0) &= -0.48 \pm 0.30 \\
 C_{\rho \pi} (B^0 \rightarrow \rho^+ \pi^-) &= 0.01 \pm 0.14 \quad (S = 1.9) \\
 S_{\rho \pi} (B^0 \rightarrow \rho^+ \pi^-) &= 0.01 \pm 0.09 \\
 \mathbf{\Delta C_{\rho \pi} (B^0 \rightarrow \rho^+ \pi^-)} &= 0.37 \pm 0.08 \\
 \mathbf{\Delta S_{\rho \pi} (B^0 \rightarrow \rho^+ \pi^-)} &= -0.05 \pm 0.10 \\
 C_{\rho^0 \pi^0} (B^0 \rightarrow \rho^0 \pi^0) &= 0.3 \pm 0.4 \\
 S_{\rho^0 \pi^0} (B^0 \rightarrow \rho^0 \pi^0) &= 0.1 \pm 0.4
 \end{aligned}$$

$$\begin{aligned}
 C_{a_1\pi}(B^0 \rightarrow a_1(1260)^+\pi^-) &= -0.10 \pm 0.17 \\
 S_{a_1\pi}(B^0 \rightarrow a_1(1260)^+\pi^-) &= 0.37 \pm 0.22 \\
 \Delta C_{a_1\pi}(B^0 \rightarrow a_1(1260)^+\pi^-) &= 0.26 \pm 0.17 \\
 \Delta S_{a_1\pi}(B^0 \rightarrow a_1(1260)^+\pi^-) &= -0.14 \pm 0.22 \\
 C(B^0 \rightarrow b_1^- K^+) &= -0.22 \pm 0.24 \\
 \Delta C(B^0 \rightarrow b_1^- \pi^+) &= -1.04 \pm 0.24 \\
 C_{\rho^0\rho^0}(B^0 \rightarrow \rho^0\rho^0) &= 0.2 \pm 0.9 \\
 S_{\rho^0\rho^0}(B^0 \rightarrow \rho^0\rho^0) &= 0.3 \pm 0.7 \\
 C_{\rho\rho}(B^0 \rightarrow \rho^+\rho^-) &= -0.05 \pm 0.13 \\
 S_{\rho\rho}(B^0 \rightarrow \rho^+\rho^-) &= -0.06 \pm 0.17 \\
 |\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_{-0.9}^{+0.7} \quad (S = 1.6) \\
 \cos 2\beta(B^0 \rightarrow [K_S^0 \pi^+ \pi^-]_{D^{(*)}} h^0) &= 1.0_{-0.7}^{+0.6} \quad (S = 1.8) \\
 (S_+ + S_-)/2(B^0 \rightarrow D^{*-}\pi^+) &= -0.037 \pm 0.012 \\
 (S_- - S_+)/2(B^0 \rightarrow D^{*-}\pi^+) &= -0.006 \pm 0.016 \\
 (S_+ + S_-)/2(B^0 \rightarrow D^-\pi^+) &= -0.046 \pm 0.023 \\
 (S_- - S_+)/2(B^0 \rightarrow D^-\pi^+) &= -0.022 \pm 0.021 \\
 (S_+ + S_-)/2(B^0 \rightarrow D^-\rho^+) &= -0.024 \pm 0.032 \\
 (S_- - S_+)/2(B^0 \rightarrow D^-\rho^+) &= -0.10 \pm 0.06 \\
 C_{\eta_c K_S^0}(B^0 \rightarrow \eta_c K_S^0) &= 0.08 \pm 0.13 \\
 S_{\eta_c K_S^0}(B^0 \rightarrow \eta_c K_S^0) &= 0.93 \pm 0.17 \\
 C_{c\bar{c}K^{(*)0}}(B^0 \rightarrow c\bar{c}K^{(*)0}) &= 0.004 \pm 0.019 \\
 \sin(2\beta) &= 0.673 \pm 0.023 \\
 C_{J/\psi(nS)K^0}(B^0 \rightarrow J/\psi(nS)K^0) &= (0.1 \pm 2.0) \times 10^{-2} \\
 S_{J/\psi(nS)K^0}(B^0 \rightarrow J/\psi(nS)K^0) &= 0.668 \pm 0.024 \\
 C_{J/\psi K^{*0}}(B^0 \rightarrow J/\psi K^{*0}) &= 0.03 \pm 0.10 \\
 S_{J/\psi K^{*0}}(B^0 \rightarrow J/\psi K^{*0}) &= 0.60 \pm 0.25 \\
 C_{\chi_{c0} K_S^0}(B^0 \rightarrow \chi_{c0} K_S^0) &= -0.3_{-0.4}^{+0.5} \\
 S_{\chi_{c0} K_S^0}(B^0 \rightarrow \chi_{c0} K_S^0) &= -0.7 \pm 0.5 \\
 C_{\chi_{c1} K_S^0}(B^0 \rightarrow \chi_{c1} K_S^0) &= 0.13 \pm 0.11 \\
 S_{\chi_{c1} K_S^0}(B^0 \rightarrow \chi_{c1} K_S^0) &= 0.61 \pm 0.16 \\
 \sin(2\beta_{\text{eff}})(B^0 \rightarrow \phi K^0) &= 0.22 \pm 0.30 \\
 \sin(2\beta_{\text{eff}})(B^0 \rightarrow \phi K_0^*(1430)^0) &= 0.97_{-0.52}^{+0.03} \\
 \sin(2\beta_{\text{eff}})(B^0 \rightarrow K^+ K^- K_S^0) &= 0.77_{-0.12}^{+0.13} \\
 \sin(2\beta_{\text{eff}})(B^0 \rightarrow [K_S^0 \pi^+ \pi^-]_{D^{(*)}} h^0) &= 0.45 \pm 0.28 \\
 |\lambda|(B^0 \rightarrow [K_S^0 \pi^+ \pi^-]_{D^{(*)}} h^0) &= 1.01 \pm 0.08 \\
 |\sin(2\beta + \gamma)| &> 0.40, \text{ CL} = 90\% \\
 2\beta + \gamma &= (83 \pm 60)^\circ \\
 \gamma(B^0 \rightarrow D^0 K^{*0}) &= (162 \pm 60)^\circ \\
 \alpha &= (90 \pm 5)^\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  $\psi$  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><math>B^0</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	Scale factor/ Confidence level	$p$ (MeV/c)
$\ell^+ \nu_\ell$ anything	[000] ( 10.33 ± 0.28 ) %		—
$e^+ \nu_e X_c$	( 10.1 ± 0.4 ) %		—
$D \ell^+ \nu_\ell$ anything	( 9.4 ± 0.9 ) %		—
$D^- \ell^+ \nu_\ell$	[000] ( 2.17 ± 0.12 ) %		2309
$D^- \tau^+ \nu_\tau$	( 1.1 ± 0.4 ) %		1909
$D^*(2010)^- \ell^+ \nu_\ell$	[000] ( 5.05 ± 0.12 ) %		2257
$D^*(2010)^- \tau^+ \nu_\tau$	( 1.5 ± 0.5 ) %	S=1.4	1837
$\bar{D}^0 \pi^- \ell^+ \nu_\ell$	( 4.3 ± 0.6 ) × 10 <sup>-3</sup>		2308
$D_0^*(2400)^- \ell^+ \nu_\ell \times$ B( $D_0^{*-} \rightarrow \bar{D}^0 \pi^-$ )	( 3.0 ± 1.2 ) × 10 <sup>-3</sup>	S=1.8	—
$D_2^*(2460)^- \ell^+ \nu_\ell \times$ B( $D_2^{*-} \rightarrow \bar{D}^0 \pi^-$ )	( 1.21 ± 0.33 ) × 10 <sup>-3</sup>	S=1.8	2065
$\bar{D}^{(*)} n \pi \ell^+ \nu_\ell$ (n ≥ 1)	( 2.3 ± 0.5 ) %		—
$\bar{D}^{*0} \pi^- \ell^+ \nu_\ell$	( 4.9 ± 0.8 ) × 10 <sup>-3</sup>		2256
$D_1(2420)^- \ell^+ \nu_\ell \times$ B( $D_1^- \rightarrow \bar{D}^{*0} \pi^-$ )	( 2.80 ± 0.28 ) × 10 <sup>-3</sup>		—
$D_1'(2430)^- \ell^+ \nu_\ell \times$ B( $D_1'^- \rightarrow \bar{D}^{*0} \pi^-$ )	( 3.1 ± 0.9 ) × 10 <sup>-3</sup>		—
$D_2^*(2460)^- \ell^+ \nu_\ell \times$ B( $D_2^{*-} \rightarrow \bar{D}^{*0} \pi^-$ )	( 6.8 ± 1.2 ) × 10 <sup>-4</sup>		2065
$\rho^- \ell^+ \nu_\ell$	[000] ( 2.07 ± 0.34 ) × 10 <sup>-4</sup>	S=1.4	2583
$\pi^- \ell^+ \nu_\ell$	[000] ( 1.42 ± 0.06 ) × 10 <sup>-4</sup>		2638

### Inclusive modes

$K^\pm$ anything	( 78 ± 8 ) %		—
$D^0 X$	( 8.1 ± 1.5 ) %		—
$\overline{D}^0 X$	( 47.4 ± 2.8 ) %		—
$D^+ X$	< 3.9 %	CL=90%	—
$D^- X$	( 36.9 ± 3.3 ) %		—
$D_s^+ X$	( 10.3 $\begin{smallmatrix} + 2.1 \\ - 1.8 \end{smallmatrix}$ ) %		—
$D_s^- X$	< 2.6 %	CL=90%	—
$\Lambda_c^+ X$	< 3.1 %	CL=90%	—
$\overline{\Lambda}_c^- X$	( 5.0 $\begin{smallmatrix} + 2.1 \\ - 1.5 \end{smallmatrix}$ ) %		—
$\overline{c} X$	( 95 ± 5 ) %		—
$c X$	( 24.6 ± 3.1 ) %		—
$\overline{c} c X$	(119 ± 6 ) %		—

### $D, D^*$ , or $D_s$ modes

$D^- \pi^+$	( 2.68 ± 0.13 ) × 10 <sup>-3</sup>		2306
$D^- \rho^+$	( 7.8 ± 1.3 ) × 10 <sup>-3</sup>		2235
$D^- K^0 \pi^+$	( 4.9 ± 0.9 ) × 10 <sup>-4</sup>		2259
$D^- K^*(892)^+$	( 4.5 ± 0.7 ) × 10 <sup>-4</sup>		2211
$D^- \omega \pi^+$	( 2.8 ± 0.6 ) × 10 <sup>-3</sup>		2204
$D^- K^+$	( 2.0 ± 0.6 ) × 10 <sup>-4</sup>		2279
$D^- K^+ \overline{K}^0$	< 3.1 × 10 <sup>-4</sup>	CL=90%	2188
$D^- K^+ \overline{K}^*(892)^0$	( 8.8 ± 1.9 ) × 10 <sup>-4</sup>		2070
$\overline{D}^0 \pi^+ \pi^-$	( 8.4 ± 0.9 ) × 10 <sup>-4</sup>		2301
$D^*(2010)^- \pi^+$	( 2.76 ± 0.13 ) × 10 <sup>-3</sup>		2255
$D^- \pi^+ \pi^+ \pi^-$	( 8.0 ± 2.5 ) × 10 <sup>-3</sup>		2287
( $D^- \pi^+ \pi^+ \pi^-$ ) nonresonant	( 3.9 ± 1.9 ) × 10 <sup>-3</sup>		2287
$D^- \pi^+ \rho^0$	( 1.1 ± 1.0 ) × 10 <sup>-3</sup>		2206
$D^- a_1(1260)^+$	( 6.0 ± 3.3 ) × 10 <sup>-3</sup>		2121
$D^*(2010)^- \pi^+ \pi^0$	( 1.5 ± 0.5 ) %		2247
$D^*(2010)^- \rho^+$	( 6.8 ± 0.9 ) × 10 <sup>-3</sup>		2180
$D^*(2010)^- K^+$	( 2.14 ± 0.16 ) × 10 <sup>-4</sup>		2226
$D^*(2010)^- K^0 \pi^+$	( 3.0 ± 0.8 ) × 10 <sup>-4</sup>		2205
$D^*(2010)^- K^*(892)^+$	( 3.3 ± 0.6 ) × 10 <sup>-4</sup>		2155
$D^*(2010)^- K^+ \overline{K}^0$	< 4.7 × 10 <sup>-4</sup>	CL=90%	2131
$D^*(2010)^- K^+ \overline{K}^*(892)^0$	( 1.29 ± 0.33 ) × 10 <sup>-3</sup>		2007
$D^*(2010)^- \pi^+ \pi^+ \pi^-$	( 7.0 ± 0.8 ) × 10 <sup>-3</sup>	S=1.3	2235
( $D^*(2010)^- \pi^+ \pi^+ \pi^-$ ) non-resonant	( 0.0 ± 2.5 ) × 10 <sup>-3</sup>		2235
$D^*(2010)^- \pi^+ \rho^0$	( 5.7 ± 3.2 ) × 10 <sup>-3</sup>		2150
$D^*(2010)^- a_1(1260)^+$	( 1.30 ± 0.27 ) %		2061
$D^*(2010)^- \pi^+ \pi^+ \pi^- \pi^0$	( 1.76 ± 0.27 ) %		2218
$D^*- 3\pi^+ 2\pi^-$	( 4.7 ± 0.9 ) × 10 <sup>-3</sup>		2195

$\bar{D}^*(2010)^- \omega \pi^+$	( $2.89 \pm 0.30$ ) $\times 10^{-3}$	2148
$D_1(2430)^0 \omega \times$ $B(D_1(2430)^0 \rightarrow$ $D^{*-} \pi^+)$	( $4.1 \pm 1.6$ ) $\times 10^{-4}$	1992
$\bar{D}^{*-} \pi^+$	[sss] ( $2.1 \pm 1.0$ ) $\times 10^{-3}$	—
$D_1(2420)^- \pi^+ \times B(D_1^- \rightarrow$ $D^- \pi^+ \pi^-)$	( $8.9 \pm 2.3$ $- 3.5$ ) $\times 10^{-5}$	—
$D_1(2420)^- \pi^+ \times B(D_1^- \rightarrow$ $D^{*-} \pi^+ \pi^-)$	< 3.3 $\times 10^{-5}$ CL=90%	—
$\bar{D}_2^*(2460)^- \pi^+ \times$ $B(D_2^*(2460)^- \rightarrow D^0 \pi^-)$	( $2.15 \pm 0.35$ ) $\times 10^{-4}$	2062
$\bar{D}_0^*(2400)^- \pi^+ \times$ $B(D_0^*(2400)^- \rightarrow D^0 \pi^-)$	( $6.0 \pm 3.0$ ) $\times 10^{-5}$	2090
$D_2^*(2460)^- \pi^+ \times B((D_2^*)^- \rightarrow$ $D^{*-} \pi^+ \pi^-)$	< 2.4 $\times 10^{-5}$ CL=90%	—
$\bar{D}_2^*(2460)^- \rho^+$	< 4.9 $\times 10^{-3}$ CL=90%	1975
$D^0 \bar{D}^0$	< 4.3 $\times 10^{-5}$ CL=90%	1868
$D^{*0} \bar{D}^0$	< 2.9 $\times 10^{-4}$ CL=90%	1794
$D^- D^+$	( $2.11 \pm 0.31$ ) $\times 10^{-4}$ S=1.2	1864
$D^- D_s^+$	( $7.2 \pm 0.8$ ) $\times 10^{-3}$	1812
$D^*(2010)^- D_s^+$	( $8.0 \pm 1.1$ ) $\times 10^{-3}$	1735
$D^- D_s^{*+}$	( $7.4 \pm 1.6$ ) $\times 10^{-3}$	1731
$D^*(2010)^- D_s^{*+}$	( $1.77 \pm 0.14$ ) %	1649
$D_{s0}(2317)^- K^+ \times$ $B(D_{s0}(2317)^- \rightarrow D_s^- \pi^0)$	( $4.2 \pm 1.4$ ) $\times 10^{-5}$	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%	—
$D_s^- D_s^+$	< 3.6 $\times 10^{-5}$ 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%	1583
$D_{s0}(2317)^+ D^- \times$ $B(D_{s0}(2317)^+ \rightarrow D_s^+ \pi^0)$	( $9.7 \pm 4.0$ $- 3.3$ ) $\times 10^{-4}$ S=1.5	1602
$D_{s0}(2317)^+ D^- \times$ $B(D_{s0}(2317)^+ \rightarrow D_s^{*+} \gamma)$	< 9.5 $\times 10^{-4}$ CL=90%	—
$D_{s0}(2317)^+ D^*(2010)^- \times$ $B(D_{s0}(2317)^+ \rightarrow D_s^+ \pi^0)$	( $1.5 \pm 0.6$ ) $\times 10^{-3}$	1509

$D_{sJ}(2457)^+ D^-$	$( 3.5 \pm 1.1 ) \times 10^{-3}$	—
$D_{sJ}(2457)^+ D^- \times$ $B(D_{sJ}(2457)^+ \rightarrow D_s^+ \gamma)$	$( 6.5 \begin{smallmatrix} + 1.7 \\ - 1.4 \end{smallmatrix} ) \times 10^{-4}$	—
$D_{sJ}(2457)^+ D^- \times$ $B(D_{sJ}(2457)^+ \rightarrow D_s^{*+} \gamma)$	$< 6.0 \times 10^{-4}$ 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%	—
$D^*(2010)^- D_{sJ}(2457)^+$	$( 9.3 \pm 2.2 ) \times 10^{-3}$	—
$D_{sJ}(2457)^+ D^*(2010) \times$ $B(D_{sJ}(2457)^+ \rightarrow D_s^+ \gamma)$	$( 2.3 \begin{smallmatrix} + 0.9 \\ - 0.7 \end{smallmatrix} ) \times 10^{-3}$	—
$D^- D_{s1}(2536)^+ \times$ $B(D_{s1}(2536)^+ \rightarrow D^{*0} K^+)$	$( 1.7 \pm 0.6 ) \times 10^{-4}$	1444
$D^*(2010)^- D_{s1}(2536)^+ \times$ $B(D_{s1}(2536)^+ \rightarrow D^{*0} K^+)$	$( 3.3 \pm 1.1 ) \times 10^{-4}$	1336
$D^- D_{s1}(2536)^+ \times$ $B(D_{s1}(2536)^+ \rightarrow D^{*+} K^0)$	$( 2.6 \pm 1.1 ) \times 10^{-4}$	1444
$D^{*-} D_{s1}(2536)^+ \times$ $B(D_{s1}(2536)^+ \rightarrow D^{*+} K^0)$	$( 5.0 \pm 1.7 ) \times 10^{-4}$	1336
$D^- D_{sJ}(2573)^+ \times$ $B(D_{sJ}(2573)^+ \rightarrow D^0 K^+)$	$< 1 \times 10^{-4}$ CL=90%	1414
$D^*(2010)^- D_{sJ}(2573)^+ \times$ $B(D_{sJ}(2573)^+ \rightarrow D^0 K^+)$	$< 2 \times 10^{-4}$ CL=90%	1303
$D^+ \pi^-$	$( 4.6 \pm 0.4 ) \times 10^{-5}$	2306
$D_s^+ \pi^-$	$( 2.16 \pm 0.26 ) \times 10^{-5}$	2270
$D_s^{*+} \pi^-$	$( 2.1 \pm 0.4 ) \times 10^{-5}$ S=1.4	2215
$D_s^+ \rho^-$	$< 2.4 \times 10^{-5}$ CL=90%	2197
$D_s^{*+} \rho^-$	$( 4.1 \pm 1.3 ) \times 10^{-5}$	2138
$D_s^+ a_0^-$	$< 1.9 \times 10^{-5}$ CL=90%	—
$D_s^{*+} a_0^-$	$< 3.6 \times 10^{-5}$ CL=90%	—
$D_s^+ a_1(1260)^-$	$< 2.1 \times 10^{-3}$ CL=90%	2080
$D_s^{*+} a_1(1260)^-$	$< 1.7 \times 10^{-3}$ CL=90%	2015
$D_s^+ a_2^-$	$< 1.9 \times 10^{-4}$ CL=90%	—
$D_s^{*+} a_2^-$	$< 2.0 \times 10^{-4}$ CL=90%	—
$D_s^- K^+$	$( 2.2 \pm 0.5 ) \times 10^{-5}$ S=1.8	2242
$D_s^{*-} K^+$	$( 2.19 \pm 0.30 ) \times 10^{-5}$	2185
$D_s^- K^*(892)^+$	$( 3.5 \pm 1.0 ) \times 10^{-5}$	2172
$D_s^{*-} K^*(892)^+$	$( 3.2 \begin{smallmatrix} + 1.5 \\ - 1.3 \end{smallmatrix} ) \times 10^{-5}$	2112

$D_s^- \pi^+ K^0$	( 1.10 ± 0.33 ) × 10 <sup>-4</sup>		2222
$D_s^{*-} \pi^+ K^0$	< 1.10	× 10 <sup>-4</sup> CL=90%	2164
$D_s^- \pi^+ K^*(892)^0$	< 3.0	× 10 <sup>-3</sup> CL=90%	2138
$D_s^{*-} \pi^+ K^*(892)^0$	< 1.6	× 10 <sup>-3</sup> CL=90%	2076
$\overline{D}^0 K^0$	( 5.2 ± 0.7 ) × 10 <sup>-5</sup>		2280
$\overline{D}^0 K^+ \pi^-$	( 8.8 ± 1.7 ) × 10 <sup>-5</sup>		2261
$\overline{D}^0 K^*(892)^0$	( 4.2 ± 0.6 ) × 10 <sup>-5</sup>		2213
$D_2^*(2460)^- K^+ \times$ $B(D_2^*(2460)^- \rightarrow \overline{D}^0 \pi^-)$	( 1.8 ± 0.5 ) × 10 <sup>-5</sup>		2028
$\overline{D}^0 K^+ \pi^-$ non-resonant	< 3.7	× 10 <sup>-5</sup> CL=90%	—
$\overline{D}^0 \pi^0$	( 2.61 ± 0.24 ) × 10 <sup>-4</sup>		2308
$\overline{D}^0 \rho^0$	( 3.2 ± 0.5 ) × 10 <sup>-4</sup>		2237
$\overline{D}^0 f_2$	( 1.2 ± 0.4 ) × 10 <sup>-4</sup>		—
$\overline{D}^0 \eta$	( 2.02 ± 0.35 ) × 10 <sup>-4</sup>	S=1.6	2274
$\overline{D}^0 \eta'$	( 1.25 ± 0.23 ) × 10 <sup>-4</sup>	S=1.1	2198
$\overline{D}^0 \omega$	( 2.59 ± 0.30 ) × 10 <sup>-4</sup>		2235
$D^0 \phi$	< 1.16	× 10 <sup>-5</sup> CL=90%	2182
$D^0 K^+ \pi^-$	( 6 ± 4 ) × 10 <sup>-6</sup>		2261
$D^0 K^*(892)^0$	< 1.1	× 10 <sup>-5</sup> CL=90%	2213
$\overline{D}^{*0} \gamma$	< 2.5	× 10 <sup>-5</sup> CL=90%	2258
$\overline{D}^*(2007)^0 \pi^0$	( 1.7 ± 0.4 ) × 10 <sup>-4</sup>	S=1.5	2256
$\overline{D}^*(2007)^0 \rho^0$	< 5.1	× 10 <sup>-4</sup> CL=90%	2182
$\overline{D}^*(2007)^0 \eta$	( 2.0 ± 0.5 ) × 10 <sup>-4</sup>		2220
$\overline{D}^*(2007)^0 \eta'$	( 1.23 ± 0.35 ) × 10 <sup>-4</sup>		2141
$\overline{D}^*(2007)^0 \pi^+ \pi^-$	( 6.2 ± 2.2 ) × 10 <sup>-4</sup>		2248
$\overline{D}^*(2007)^0 K^0$	( 3.6 ± 1.2 ) × 10 <sup>-5</sup>		2227
$\overline{D}^*(2007)^0 K^*(892)^0$	< 6.9	× 10 <sup>-5</sup> CL=90%	2157
$D^*(2007)^0 K^*(892)^0$	< 4.0	× 10 <sup>-5</sup> CL=90%	2157
$D^*(2007)^0 \pi^+ \pi^+ \pi^- \pi^-$	( 2.7 ± 0.5 ) × 10 <sup>-3</sup>		2219
$D^*(2010)^+ D^*(2010)^-$	( 8.2 ± 0.9 ) × 10 <sup>-4</sup>		1711
$\overline{D}^*(2007)^0 \omega$	( 3.3 ± 0.7 ) × 10 <sup>-4</sup>		2180
$D^*(2010)^+ D^-$	( 6.1 ± 1.5 ) × 10 <sup>-4</sup>	S=1.6	1790
$D^*(2007)^0 \overline{D}^*(2007)^0$	< 9	× 10 <sup>-5</sup> CL=90%	1715
$D^- D^0 K^+$	( 1.07 ± 0.11 ) × 10 <sup>-3</sup>		1574
$D^- D^*(2007)^0 K^+$	( 3.5 ± 0.4 ) × 10 <sup>-3</sup>		1478
$D^*(2010)^- D^0 K^+$	( 2.47 ± 0.21 ) × 10 <sup>-3</sup>		1479
$D^*(2010)^- D^*(2007)^0 K^+$	( 1.06 ± 0.09 ) %		1366
$D^- D^+ K^0$	( 7.5 ± 1.7 ) × 10 <sup>-4</sup>		1568
$D^*(2010)^- D^+ K^0 +$ $D^- D^*(2010)^+ K^0$	( 6.4 ± 0.5 ) × 10 <sup>-3</sup>		1473
$D^*(2010)^- D^*(2010)^+ K^0$	( 8.1 ± 0.7 ) × 10 <sup>-3</sup>		1360
$D^{*-} D_{s1}(2536)^+ \times$ $B(D_{s1}(2536)^+ \rightarrow$ $D^{*+} K^0)$	( 8.0 ± 2.4 ) × 10 <sup>-4</sup>		1336



$\bar{D}^0 D^0 K^0$	$( 2.7 \pm 1.1 ) \times 10^{-4}$	1574
$\bar{D}^0 D^*(2007)^0 K^0 +$ $\bar{D}^*(2007)^0 D^0 K^0$	$( 1.1 \pm 0.5 ) \times 10^{-3}$	1478
$\bar{D}^*(2007)^0 D^*(2007)^0 K^0$	$( 2.4 \pm 0.9 ) \times 10^{-3}$	1365
$(\bar{D} + \bar{D}^*)(D + D^*)K$	$( 3.68 \pm 0.26 ) \%$	—

### Charmonium modes

$\eta_c K^0$	$( 8.9 \pm 1.6 ) \times 10^{-4}$	1753
$\eta_c K^*(892)^0$	$( 6.1 \pm 1.0 ) \times 10^{-4}$	1648
$\eta_c(2S) K^{*0}$	$< 3.9 \times 10^{-4}$	CL=90% 1159
$h_c(1P) K^{*0}$	$< 4 \times 10^{-4}$	CL=90% 1253
$J/\psi(1S) K^0$	$( 8.71 \pm 0.32 ) \times 10^{-4}$	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
$J/\psi(1S) \eta' K_S^0$	$< 2.5 \times 10^{-5}$	CL=90% 1271
$J/\psi(1S) \phi K^0$	$( 9.4 \pm 2.6 ) \times 10^{-5}$	1224
$J/\psi(1S) \omega K^0$	$( 2.3 \pm 0.4 ) \times 10^{-4}$	1386
$X(3872) K^0 \times B(X \rightarrow$ $J/\psi \omega)$	$( 6.0 \pm 3.2 ) \times 10^{-6}$	1140
$X(3915) K^0 \times B(X \rightarrow$ $J/\psi \omega)$	$( 2.1 \pm 0.9 ) \times 10^{-5}$	1103
$J/\psi(1S) K(1270)^0$	$( 1.3 \pm 0.5 ) \times 10^{-3}$	1390
$J/\psi(1S) \pi^0$	$( 1.76 \pm 0.16 ) \times 10^{-5}$	S=1.1 1728
$J/\psi(1S) \eta$	$( 9.5 \pm 1.9 ) \times 10^{-6}$	1672
$J/\psi(1S) \pi^+ \pi^-$	$( 4.6 \pm 0.9 ) \times 10^{-5}$	1716
$J/\psi(1S) \pi^+ \pi^-$ nonresonant	$< 1.2 \times 10^{-5}$	CL=90% 1716
$J/\psi(1S) f_2$	$< 4.6 \times 10^{-6}$	CL=90% —
$J/\psi(1S) \rho^0$	$( 2.7 \pm 0.4 ) \times 10^{-5}$	1612
$J/\psi(1S) \omega$	$< 2.7 \times 10^{-4}$	CL=90% 1609
$J/\psi(1S) \phi$	$< 9.4 \times 10^{-7}$	CL=90% 1520
$J/\psi(1S) \eta'(958)$	$< 6.3 \times 10^{-5}$	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% —
$X(3872)^- K^+ \times$ $B(X(3872)^- \rightarrow$ $J/\psi(1S) \pi^- \pi^0)$	$[ttt] < 5.4 \times 10^{-6}$	CL=90% —
$X(3872) K^0 \times B(X \rightarrow$ $J/\psi \pi^+ \pi^-)$	$< 6.0 \times 10^{-6}$	CL=90% 1140
$X(3872) K^0 \times B(X \rightarrow J/\psi \gamma)$	$< 4.9 \times 10^{-6}$	CL=90% 1140
$X(3872) K^*(892)^0 \times B(X \rightarrow$ $J/\psi \gamma)$	$< 2.8 \times 10^{-6}$	CL=90% 940

$X(3872)K^0 \times B(X \rightarrow \psi(2S)\gamma)$	$< 1.9 \times 10^{-5}$	CL=90%	1140
$X(3872)K^*(892)^0 \times B(X \rightarrow \psi(2S)\gamma)$	$< 4.4 \times 10^{-6}$	CL=90%	940
$X(3872)K^0 \times B(X \rightarrow D^0\bar{D}^0\pi^0)$	$(1.7 \pm 0.8) \times 10^{-4}$		1140
$X(3872)K^0 \times B(X \rightarrow \bar{D}^{*0}D^0)$	$(1.2 \pm 0.4) \times 10^{-4}$		1140
$X(4430)^\pm K^\mp \times B(X^\pm \rightarrow \psi(2S)\pi^\pm)$	$(3.2 \begin{smallmatrix} +6.0 \\ -1.8 \end{smallmatrix}) \times 10^{-5}$		621
$X(4430)^\pm K^\mp \times B(X^\pm \rightarrow J/\psi\pi^\pm)$	$< 4 \times 10^{-6}$	CL=95%	621
$J/\psi(1S)p\bar{p}$	$< 8.3 \times 10^{-7}$	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
$\psi(2S)K^0$	$(6.2 \pm 0.5) \times 10^{-4}$		1283
$\psi(3770)K^0 \times B(\psi \rightarrow \bar{D}^0D^0)$	$< 1.23 \times 10^{-4}$	CL=90%	1217
$\psi(3770)K^0 \times B(\psi \rightarrow D^-D^+)$	$< 1.88 \times 10^{-4}$	CL=90%	1217
$\psi(2S)K^+\pi^-$	$(5.7 \pm 0.4) \times 10^{-4}$		1238
$\psi(2S)K^*(892)^0$	$(6.1 \pm 0.5) \times 10^{-4}$	S=1.1	1116
$\chi_{c0}(1P)K^0$	$(1.4 \begin{smallmatrix} +0.6 \\ -0.5 \end{smallmatrix}) \times 10^{-4}$		1477
$\chi_{c0}K^*(892)^0$	$(1.7 \pm 0.4) \times 10^{-4}$		1341
$\chi_{c2}K^0$	$< 2.6 \times 10^{-5}$	CL=90%	1378
$\chi_{c2}K^*(892)^0$	$(6.6 \pm 1.9) \times 10^{-5}$		1228
$\chi_{c1}(1P)\pi^0$	$(1.12 \pm 0.28) \times 10^{-5}$		1468
$\chi_{c1}(1P)K^0$	$(3.90 \pm 0.33) \times 10^{-4}$		1411
$\chi_{c1}(1P)K^-\pi^+$	$(3.8 \pm 0.4) \times 10^{-4}$		1371
$\chi_{c1}(1P)K^*(892)^0$	$(2.22 \begin{smallmatrix} +0.40 \\ -0.31 \end{smallmatrix}) \times 10^{-4}$	S=1.6	1265
$X(4051)^+K^- \times B(X^+ \rightarrow \chi_{c1}\pi^+)$	$(3.0 \begin{smallmatrix} +4.0 \\ -1.8 \end{smallmatrix}) \times 10^{-5}$		—
$X(4248)^+K^- \times B(X^+ \rightarrow \chi_{c1}\pi^+)$	$(4.0 \begin{smallmatrix} +20.0 \\ -1.0 \end{smallmatrix}) \times 10^{-5}$		—

### **K or K\* modes**

$K^+\pi^-$	$(1.94 \pm 0.06) \times 10^{-5}$		2615
$K^0\pi^0$	$(9.5 \pm 0.8) \times 10^{-6}$	S=1.3	2615
$\eta'K^0$	$(6.6 \pm 0.4) \times 10^{-5}$	S=1.4	2528
$\eta'K^*(892)^0$	$(3.1 \pm 0.9) \times 10^{-6}$		2472
$\eta'K_0^*(1430)^0$	$(6.3 \pm 1.6) \times 10^{-6}$		2346
$\eta'K_2^*(1430)^0$	$(1.37 \pm 0.32) \times 10^{-5}$		2346
$\eta K^0$	$(1.1 \pm 0.4) \times 10^{-6}$		2587
$\eta K^*(892)^0$	$(1.59 \pm 0.10) \times 10^{-5}$		2534
$\eta K_0^*(1430)^0$	$(1.10 \pm 0.22) \times 10^{-5}$		2414

$\eta K_2^*(1430)^0$	$( 9.6 \pm 2.1 ) \times 10^{-6}$		2414
$\omega K^0$	$( 5.0 \pm 0.6 ) \times 10^{-6}$		2557
$a_0(980)^0 K^0 \times B(a_0(980)^0 \rightarrow \eta \pi^0)$	$< 7.8 \times 10^{-6}$	CL=90%	—
$b_1^0 K^0 \times B(b_1^0 \rightarrow \omega \pi^0)$	$< 7.8 \times 10^{-6}$	CL=90%	—
$a_0(980)^\pm K^\mp \times B(a_0(980)^\pm \rightarrow \eta \pi^\pm)$	$< 1.9 \times 10^{-6}$	CL=90%	—
$b_1^- K^+ \times B(b_1^- \rightarrow \omega \pi^-)$	$( 7.4 \pm 1.4 ) \times 10^{-6}$		—
$b_1^0 K^{*0} \times B(b_1^0 \rightarrow \omega \pi^0)$	$< 8.0 \times 10^{-6}$	CL=90%	—
$b_1^- K^{*+} \times B(b_1^- \rightarrow \omega \pi^-)$	$< 5.0 \times 10^{-6}$	CL=90%	—
$a_0(1450)^\pm K^\mp \times B(a_0(1450)^\pm \rightarrow \eta \pi^\pm)$	$< 3.1 \times 10^{-6}$	CL=90%	—
$K_S^0 X^0$ (Familon)	$< 5.3 \times 10^{-5}$	CL=90%	—
$\omega K^*(892)^0$	$( 2.0 \pm 0.5 ) \times 10^{-6}$		2503
$\omega (K\pi)_0^{*0}$	$( 1.84 \pm 0.25 ) \times 10^{-5}$		—
$\omega K_0^*(1430)^0$	$( 1.60 \pm 0.34 ) \times 10^{-5}$		2380
$\omega K_2^*(1430)^0$	$( 1.01 \pm 0.23 ) \times 10^{-5}$		2380
$\omega K^+ \pi^-$ nonresonant	$( 5.1 \pm 1.0 ) \times 10^{-6}$		2542
$K^+ \pi^- \pi^0$	$( 3.59_{-0.24}^{+0.28} ) \times 10^{-5}$		2609
$K^+ \rho^-$	$( 8.4_{-2.2}^{+1.6} ) \times 10^{-6}$	S=1.6	2559
$K^+ \rho(1450)^-$	$< 2.1 \times 10^{-6}$	CL=90%	—
$K^+ \rho(1700)^-$	$< 1.1 \times 10^{-6}$	CL=90%	—
$(K^+ \pi^- \pi^0)$ non-resonant	$( 4.4 \pm 1.0 ) \times 10^{-6}$		—
$(K\pi)_0^{*+} \pi^- \times B((K\pi)_0^{*+} \rightarrow K^+ \pi^0)$	$( 9.4 \pm 2.5 ) \times 10^{-6}$		—
$(K\pi)_0^{*0} \pi^0 \times B((K\pi)_0^{*0} \rightarrow K^+ \pi^-)$	$( 8.7 \pm 2.9 ) \times 10^{-6}$		—
$K_2^*(1430)^0 \pi^0$	$< 4.0 \times 10^{-6}$	CL=90%	2445
$K^*(1680)^0 \pi^0$	$< 7.5 \times 10^{-6}$	CL=90%	2358
$K_x^{*0} \pi^0$	[www] $( 6.1 \pm 1.6 ) \times 10^{-6}$		—
$K^0 \pi^+ \pi^-$ charmless	$( 4.96 \pm 0.20 ) \times 10^{-5}$		2609
$K^0 \pi^+ \pi^-$ non-resonant	$( 1.47_{-0.26}^{+0.40} ) \times 10^{-5}$	S=2.1	—
$K^0 \rho^0$	$( 4.7 \pm 0.6 ) \times 10^{-6}$		2558
$K^*(892)^+ \pi^-$	$( 9.4_{-1.2}^{+1.3} ) \times 10^{-6}$	S=1.5	2562
$K_0^*(1430)^+ \pi^-$	$( 3.3 \pm 0.7 ) \times 10^{-5}$	S=2.0	—
$K_x^{*+} \pi^-$	[www] $( 5.1 \pm 1.6 ) \times 10^{-6}$		—
$K^*(1410)^+ \pi^- \times B(K^*(1410)^+ \rightarrow K^0 \pi^+)$	$< 3.8 \times 10^{-6}$	CL=90%	—
$f_0(980) K^0 \times B(f_0(980) \rightarrow \pi^+ \pi^-)$	$( 7.0 \pm 0.9 ) \times 10^{-6}$		2524

$f_2(1270)K^0$	$( 2.7 \pm 1.3 ) \times 10^{-6}$	2459
$f_x(1300)K^0 \times B(f_x \rightarrow \pi^+\pi^-)$	$( 1.8 \pm 0.7 ) \times 10^{-6}$	—
$K^*(892)^0\pi^0$	$( 3.6 \pm 0.8 ) \times 10^{-6}$	2563
$K_2^*(1430)^+\pi^-$	$< 6 \times 10^{-6}$ CL=90%	2445
$K^*(1680)^+\pi^-$	$< 1.0 \times 10^{-5}$ CL=90%	2358
$K^+\pi^-\pi^+\pi^-$	[xxx] $< 2.3 \times 10^{-4}$ CL=90%	2600
$\rho^0 K^+\pi^-$	$( 2.8 \pm 0.7 ) \times 10^{-6}$	2543
$f_0(980)K^+\pi^-$	$( 1.4 \pm 0.5 ) \times 10^{-6}$	2508
$K^+\pi^-\pi^+\pi^-$ nonresonant	$< 2.1 \times 10^{-6}$ CL=90%	2600
$K^*(892)^0\pi^+\pi^-$	$( 5.5 \pm 0.5 ) \times 10^{-5}$	2557
$K^*(892)^0\rho^0$	$( 3.4 \pm 1.7 ) \times 10^{-6}$ S=1.8	2504
$K^*(892)^0 f_0(980)$	$< 2.2 \times 10^{-6}$ CL=90%	2468
$K_1(1270)^+\pi^-$	$< 3.0 \times 10^{-5}$ CL=90%	2484
$K_1(1400)^+\pi^-$	$< 2.7 \times 10^{-5}$ CL=90%	2451
$a_1(1260)^-K^+$	[xxx] $( 1.6 \pm 0.4 ) \times 10^{-5}$	2471
$K^*(892)^+\rho^-$	$< 1.20 \times 10^{-5}$ CL=90%	2504
$K_1(1400)^0\rho^0$	$< 3.0 \times 10^{-3}$ CL=90%	2388
$K^+K^-$	$< 4.1 \times 10^{-7}$ CL=90%	2593
$K^0\bar{K}^0$	$( 9.6 \pm 2.0 ) \times 10^{-7}$	2592
$K^0K^-\pi^+$	$( 6.4 \pm 1.2 ) \times 10^{-6}$	2578
$\bar{K}^{*0}K^0 + K^{*0}\bar{K}^0$	$< 1.9 \times 10^{-6}$	—
$K^+K^-\pi^0$	$< 1.9 \times 10^{-5}$ CL=90%	2579
$K_S^0 K_S^0 \pi^0$	$< 9 \times 10^{-7}$ CL=90%	2578
$K_S^0 K_S^0 \eta$	$< 1.0 \times 10^{-6}$ CL=90%	2515
$K_S^0 K_S^0 \eta'$	$< 2.0 \times 10^{-6}$ CL=90%	2452
$K^0 K^+ K^-$	$( 2.47 \pm 0.23 ) \times 10^{-5}$	2522
$K^0 \phi$	$( 8.6 \pm 1.3 ) \times 10^{-6}$	2516
$K_S^0 K_S^0 K_S^0$	$( 6.2 \pm 1.2 ) \times 10^{-6}$ S=1.3	2521
$K_S^0 K_S^0 K_L^0$	$< 1.6 \times 10^{-5}$ CL=90%	2521
$K^*(892)^0 K^+ K^-$	$( 2.75 \pm 0.26 ) \times 10^{-5}$	2466
$K^*(892)^0 \phi$	$( 9.8 \pm 0.6 ) \times 10^{-6}$	2460
$K^+ K^- \pi^+ \pi^-$ nonresonant	$< 7.17 \times 10^{-5}$ CL=90%	2559
$K^*(892)^0 K^- \pi^+$	$( 4.5 \pm 1.3 ) \times 10^{-6}$	2524
$K^*(892)^0 \bar{K}^*(892)^0$	$( 8 \pm 5 ) \times 10^{-7}$ S=2.2	2485
$K^+ K^+ \pi^- \pi^-$ nonresonant	$< 6.0 \times 10^{-6}$ CL=90%	2559
$K^*(892)^0 K^+ \pi^-$	$< 2.2 \times 10^{-6}$ CL=90%	2524
$K^*(892)^0 K^*(892)^0$	$< 2 \times 10^{-7}$ CL=90%	2485
$K^*(892)^+ K^*(892)^-$	$< 2.0 \times 10^{-6}$ CL=90%	2485
$K_1(1400)^0 \phi$	$< 5.0 \times 10^{-3}$ CL=90%	2339

$\phi(K\pi)_0^{*0}$	( 4.3 ± 0.7 ) × 10 <sup>-6</sup>	—
$\phi(K\pi)_0^{*0} (1.60 < m_{K\pi} < 2.15) [yyy]$	< 1.7 × 10 <sup>-6</sup> CL=90%	—
$K_0^*(1430)^0 K^- \pi^+$	< 3.18 × 10 <sup>-5</sup> CL=90%	2403
$K_0^*(1430)^0 \bar{K}^*(892)^0$	< 3.3 × 10 <sup>-6</sup> CL=90%	2360
$K_0^*(1430)^0 \bar{K}_0^*(1430)^0$	< 8.4 × 10 <sup>-6</sup> CL=90%	2222
$K_0^*(1430)^0 \phi$	( 3.9 ± 0.8 ) × 10 <sup>-6</sup>	2333
$K_0^*(1430)^0 K^*(892)^0$	< 1.7 × 10 <sup>-6</sup> CL=90%	2360
$K_0^*(1430)^0 K_0^*(1430)^0$	< 4.7 × 10 <sup>-6</sup> CL=90%	2222
$K^*(1680)^0 \phi$	< 3.5 × 10 <sup>-6</sup> CL=90%	2238
$K^*(1780)^0 \phi$	< 2.7 × 10 <sup>-6</sup> CL=90%	—
$K^*(2045)^0 \phi$	< 1.53 × 10 <sup>-5</sup> CL=90%	—
$K_2^*(1430)^0 \rho^0$	< 1.1 × 10 <sup>-3</sup> CL=90%	2381
$K_2^*(1430)^0 \phi$	( 7.5 ± 1.0 ) × 10 <sup>-6</sup>	2333
$K^0 \phi \phi$	( 4.1 $\begin{smallmatrix} + \\ - \end{smallmatrix}$ $\begin{smallmatrix} 1.7 \\ 1.5 \end{smallmatrix}$ ) × 10 <sup>-6</sup>	2305
$\eta' \eta' K^0$	< 3.1 × 10 <sup>-5</sup> CL=90%	2337
$\eta K^0 \gamma$	( 7.6 ± 1.8 ) × 10 <sup>-6</sup>	2587
$\eta' K^0 \gamma$	< 6.4 × 10 <sup>-6</sup> CL=90%	2528
$K^0 \phi \gamma$	< 2.7 × 10 <sup>-6</sup> CL=90%	2516
$K^+ \pi^- \gamma$	( 4.6 ± 1.4 ) × 10 <sup>-6</sup>	2615
$K^*(892)^0 \gamma$	( 4.33 ± 0.15 ) × 10 <sup>-5</sup>	2564
$K^*(1410) \gamma$	< 1.3 × 10 <sup>-4</sup> CL=90%	2450
$K^+ \pi^- \gamma$ nonresonant	< 2.6 × 10 <sup>-6</sup> CL=90%	2615
$K^*(892)^0 X(214) \times B(X \rightarrow [zzz])$	< 2.26 × 10 <sup>-8</sup> CL=90%	—
$\mu^+ \mu^-$		
$K^0 \pi^+ \pi^- \gamma$	( 1.95 ± 0.22 ) × 10 <sup>-5</sup>	2609
$K^+ \pi^- \pi^0 \gamma$	( 4.1 ± 0.4 ) × 10 <sup>-5</sup>	2609
$K_1(1270)^0 \gamma$	< 5.8 × 10 <sup>-5</sup> CL=90%	2486
$K_1(1400)^0 \gamma$	< 1.2 × 10 <sup>-5</sup> CL=90%	2453
$K_2^*(1430)^0 \gamma$	( 1.24 ± 0.24 ) × 10 <sup>-5</sup>	2447
$K^*(1680)^0 \gamma$	< 2.0 × 10 <sup>-3</sup> CL=90%	2361
$K_3^*(1780)^0 \gamma$	< 8.3 × 10 <sup>-5</sup> CL=90%	2341
$K_4^*(2045)^0 \gamma$	< 4.3 × 10 <sup>-3</sup> CL=90%	2244

### Light unflavored meson modes

$\rho^0 \gamma$	( 8.6 ± 1.5 ) × 10 <sup>-7</sup>	2583
$\rho^0 X(214) \times B(X \rightarrow \mu^+ \mu^-) [zzz]$	< 1.73 × 10 <sup>-8</sup> CL=90%	—
$\omega \gamma$	( 4.4 $\begin{smallmatrix} + \\ - \end{smallmatrix}$ $\begin{smallmatrix} 1.8 \\ 1.6 \end{smallmatrix}$ ) × 10 <sup>-7</sup>	2582
$\phi \gamma$	< 8.5 × 10 <sup>-7</sup> CL=90%	2541
$\pi^+ \pi^-$	( 5.13 ± 0.24 ) × 10 <sup>-6</sup>	2636
$\pi^0 \pi^0$	( 1.62 ± 0.31 ) × 10 <sup>-6</sup> S=1.3	2636
$\eta \pi^0$	< 1.5 × 10 <sup>-6</sup> CL=90%	2610
$\eta \eta$	< 1.0 × 10 <sup>-6</sup> CL=90%	2582

$\eta' \pi^0$	( 1.2 $\pm$ 0.6 ) $\times 10^{-6}$	S=1.7	2551
$\eta' \eta'$	< 1.7	$\times 10^{-6}$ CL=90%	2460
$\eta' \eta$	< 1.2	$\times 10^{-6}$ CL=90%	2522
$\eta' \rho^0$	< 1.3	$\times 10^{-6}$ CL=90%	2492
$\eta' f_0(980) \times B(f_0(980) \rightarrow \pi^+ \pi^-)$	< 9	$\times 10^{-7}$ CL=90%	2455
$\eta \rho^0$	< 1.5	$\times 10^{-6}$ CL=90%	2553
$\eta f_0(980) \times B(f_0(980) \rightarrow \pi^+ \pi^-)$	< 4	$\times 10^{-7}$ CL=90%	2518
$\omega \eta$	( 9.4 $\pm$ 4.0 $\pm$ 3.1 ) $\times 10^{-7}$		2552
$\omega \eta'$	( 1.0 $\pm$ 0.5 $\pm$ 0.4 ) $\times 10^{-6}$		2491
$\omega \rho^0$	< 1.6	$\times 10^{-6}$ CL=90%	2522
$\omega f_0(980) \times B(f_0(980) \rightarrow \pi^+ \pi^-)$	< 1.5	$\times 10^{-6}$ CL=90%	2487
$\omega \omega$	< 4.0	$\times 10^{-6}$ CL=90%	2521
$\phi \pi^0$	< 2.8	$\times 10^{-7}$ CL=90%	2539
$\phi \eta$	< 5	$\times 10^{-7}$ CL=90%	2511
$\phi \eta'$	< 5	$\times 10^{-7}$ CL=90%	2447
$\phi \rho^0$	< 3.3	$\times 10^{-7}$ CL=90%	2480
$\phi f_0(980) \times B(f_0 \rightarrow \pi^+ \pi^-)$	< 3.8	$\times 10^{-7}$ CL=90%	2443
$\phi \omega$	< 1.2	$\times 10^{-6}$ CL=90%	2479
$\phi \phi$	< 2	$\times 10^{-7}$ CL=90%	2435
$a_0(980)^\pm \pi^\mp \times B(a_0(980)^\pm \rightarrow \eta \pi^\pm)$	< 3.1	$\times 10^{-6}$ CL=90%	–
$a_0(1450)^\pm \pi^\mp \times B(a_0(1450)^\pm \rightarrow \eta \pi^\pm)$	< 2.3	$\times 10^{-6}$ CL=90%	–
$\pi^+ \pi^- \pi^0$	< 7.2	$\times 10^{-4}$ CL=90%	2631
$\rho^0 \pi^0$	( 2.0 $\pm$ 0.5 ) $\times 10^{-6}$		2581
$\rho^\mp \pi^\pm$	[ee] ( 2.30 $\pm$ 0.23 ) $\times 10^{-5}$		2581
$\pi^+ \pi^- \pi^+ \pi^-$	< 1.93	$\times 10^{-5}$ CL=90%	2621
$\rho^0 \pi^+ \pi^-$	< 8.8	$\times 10^{-6}$ CL=90%	2575
$\rho^0 \rho^0$	( 7.3 $\pm$ 2.8 ) $\times 10^{-7}$		2523
$f_0(980) \pi^+ \pi^-$	< 3.8	$\times 10^{-6}$ CL=90%	2541
$\rho^0 f_0(980) \times B(f_0(980) \rightarrow \pi^+ \pi^-)$	< 3	$\times 10^{-7}$ CL=90%	2488
$f_0(980) f_0(980) \times B^2(f_0(980) \rightarrow \pi^+ \pi^-)$	< 1	$\times 10^{-7}$ CL=90%	2451
$f_0(980) f_0(980) \times B(f_0 \rightarrow \pi^+ \pi^-) \times B(f_0 \rightarrow K^+ K^-)$	< 2.3	$\times 10^{-7}$ CL=90%	2451
$a_1(1260)^\mp \pi^\pm$	[ee] ( 3.3 $\pm$ 0.5 ) $\times 10^{-5}$		2494
$a_2(1320)^\mp \pi^\pm$	[ee] < 3.0	$\times 10^{-4}$ CL=90%	2473
$\pi^+ \pi^- \pi^0 \pi^0$	< 3.1	$\times 10^{-3}$ CL=90%	2622
$\rho^+ \rho^-$	( 2.42 $\pm$ 0.31 ) $\times 10^{-5}$		2523

$a_1(1260)^0 \pi^0$	< 1.1	$\times 10^{-3}$	CL=90%	2495
$\omega \pi^0$	< 5	$\times 10^{-7}$	CL=90%	2580
$\pi^+ \pi^+ \pi^- \pi^- \pi^0$	< 9.0	$\times 10^{-3}$	CL=90%	2609
$a_1(1260)^+ \rho^-$	< 6.1	$\times 10^{-5}$	CL=90%	2433
$a_1(1260)^0 \rho^0$	< 2.4	$\times 10^{-3}$	CL=90%	2433
$b_1^\mp \pi^\pm \times B(b_1^\mp \rightarrow \omega \pi^\mp)$	( 1.09 ± 0.15 )	$\times 10^{-5}$		—
$b_1^0 \pi^0 \times B(b_1^0 \rightarrow \omega \pi^0)$	< 1.9	$\times 10^{-6}$	CL=90%	—
$b_1^- \rho^+ \times B(b_1^- \rightarrow \omega \pi^-)$	< 1.4	$\times 10^{-6}$	CL=90%	—
$b_1^0 \rho^0 \times B(b_1^0 \rightarrow \omega \pi^0)$	< 3.4	$\times 10^{-6}$	CL=90%	—
$\pi^+ \pi^+ \pi^+ \pi^- \pi^- \pi^-$	< 3.0	$\times 10^{-3}$	CL=90%	2592
$a_1(1260)^+ a_1(1260)^- \times$ $B^2(a_1^+ \rightarrow 2\pi^+ \pi^-)$	( 1.18 ± 0.31 )	$\times 10^{-5}$		2336
$\pi^+ \pi^+ \pi^+ \pi^- \pi^- \pi^- \pi^0$	< 1.1	%	CL=90%	2572

### Baryon modes

$p \bar{p}$	< 1.1	$\times 10^{-7}$	CL=90%	2467
$p \bar{p} \pi^+ \pi^-$	< 2.5	$\times 10^{-4}$	CL=90%	2406
$p \bar{p} K^0$	( 2.66 ± 0.32 )	$\times 10^{-6}$		2347
$\Theta(1540)^+ \bar{p} \times$ $B(\Theta(1540)^+ \rightarrow p K_S^0)$	[aaaa] < 5	$\times 10^{-8}$	CL=90%	2318
$f_J(2220) K^0 \times B(f_J(2220) \rightarrow$ $p \bar{p})$	< 4.5	$\times 10^{-7}$	CL=90%	2135
$p \bar{p} K^*(892)^0$	( 1.24 $^{+0.28}$ $_{-0.25}$ )	$\times 10^{-6}$		2215
$f_J(2220) K_0^* \times B(f_J(2220) \rightarrow$ $p \bar{p})$	< 1.5	$\times 10^{-7}$	CL=90%	—
$p \bar{\Lambda} \pi^-$	( 3.14 ± 0.29 )	$\times 10^{-6}$		2401
$p \bar{\Sigma}^-(1385)^-$	< 2.6	$\times 10^{-7}$	CL=90%	2363
$\Delta^0 \bar{\Lambda}$	< 9.3	$\times 10^{-7}$	CL=90%	2364
$p \bar{\Lambda} K^-$	< 8.2	$\times 10^{-7}$	CL=90%	2308
$p \bar{\Sigma}^0 \pi^-$	< 3.8	$\times 10^{-6}$	CL=90%	2383
$\bar{\Lambda} \Lambda$	< 3.2	$\times 10^{-7}$	CL=90%	2392
$\bar{\Lambda} \Lambda K^0$	( 4.8 $^{+1.0}$ $_{-0.9}$ )	$\times 10^{-6}$		2250
$\bar{\Lambda} \Lambda K^{*0}$	( 2.5 $^{+0.9}$ $_{-0.8}$ )	$\times 10^{-6}$		2098
$\bar{\Lambda} \Lambda D^0$	( 1.1 $^{+0.6}$ $_{-0.5}$ )	$\times 10^{-5}$		1661
$\Delta^0 \bar{\Delta}^0$	< 1.5	$\times 10^{-3}$	CL=90%	2335
$\Delta^{++} \bar{\Delta}^{--}$	< 1.1	$\times 10^{-4}$	CL=90%	2335
$\bar{D}^0 p \bar{p}$	( 1.14 ± 0.09 )	$\times 10^{-4}$		1862
$D_s^- \bar{\Lambda} p$	( 2.8 ± 0.9 )	$\times 10^{-5}$		1710
$\bar{D}^*(2007)^0 p \bar{p}$	( 1.03 ± 0.13 )	$\times 10^{-4}$		1788
$D^*(2010)^- p \bar{n}$	( 1.4 ± 0.4 )	$\times 10^{-3}$		1785
$D^- p \bar{p} \pi^+$	( 3.38 ± 0.32 )	$\times 10^{-4}$		1786

$D^*(2010)^- p \bar{p} \pi^+$		$( 5.0 \pm 0.5 ) \times 10^{-4}$		1707
$\Theta_c \bar{p} \pi^+ \times B(\Theta_c \rightarrow D^- p)$		$< 9 \times 10^{-6}$	CL=90%	—
$\Theta_c \bar{p} \pi^+ \times B(\Theta_c \rightarrow D^{*-} p)$		$< 1.4 \times 10^{-5}$	CL=90%	—
$\bar{\Sigma}_c^{--} \Delta^{++}$		$< 1.0 \times 10^{-3}$	CL=90%	1839
$\bar{\Lambda}_c^- p \pi^+ \pi^-$		$( 1.3 \pm 0.4 ) \times 10^{-3}$		1934
$\bar{\Lambda}_c^- p$		$( 2.0 \pm 0.4 ) \times 10^{-5}$		2021
$\bar{\Lambda}_c^- p \pi^0$		$( 1.9 \pm 0.5 ) \times 10^{-4}$		1982
$\Sigma_c(2455)^- p$		$< 3.0 \times 10^{-5}$		—
$\bar{\Lambda}_c^- p \pi^+ \pi^- \pi^0$		$< 5.07 \times 10^{-3}$	CL=90%	1882
$\bar{\Lambda}_c^- p \pi^+ \pi^- \pi^+ \pi^-$		$< 2.74 \times 10^{-3}$	CL=90%	1821
$\bar{\Lambda}_c^- p \pi^+ \pi^-$		$( 1.12 \pm 0.32 ) \times 10^{-3}$		1934
$\bar{\Lambda}_c^- p \pi^+ \pi^-$ (nonresonant)		$( 6.4 \pm 1.9 ) \times 10^{-4}$		1934
$\bar{\Sigma}_c(2520)^{--} p \pi^+$		$( 1.2 \pm 0.4 ) \times 10^{-4}$		1860
$\bar{\Sigma}_c(2520)^0 p \pi^-$		$< 3.8 \times 10^{-5}$	CL=90%	1860
$\bar{\Sigma}_c(2455)^0 p \pi^-$		$( 1.5 \pm 0.5 ) \times 10^{-4}$		1895
$\bar{\Sigma}_c(2455)^0 N^0 \times B(N^0 \rightarrow p \pi^-)$		$( 8.0 \pm 2.9 ) \times 10^{-5}$		—
$\bar{\Sigma}_c(2455)^{--} p \pi^+$		$( 2.2 \pm 0.7 ) \times 10^{-4}$		1895
$\Lambda_c^- p K^+ \pi^-$		$( 4.3 \pm 1.4 ) \times 10^{-5}$		—
$\bar{\Sigma}_c(2455)^{--} p K^+ \times B(\bar{\Sigma}_c^{--} \rightarrow \bar{\Lambda}_c^- \pi^-)$		$( 1.1 \pm 0.4 ) \times 10^{-5}$		1754
$\Lambda_c^- p K^*(892)^0$		$< 2.42 \times 10^{-5}$	CL=90%	—
$\bar{\Lambda}_c^- \Lambda_c^+$		$< 6.2 \times 10^{-5}$	CL=90%	1319
$\bar{\Lambda}_c(2593)^- / \bar{\Lambda}_c(2625)^- p$		$< 1.1 \times 10^{-4}$	CL=90%	—
$\Xi_c^- \Lambda_c^+ \times B(\Xi_c^- \rightarrow \Xi^+ \pi^- \pi^-)$		$( 2.2 \pm 2.3 ) \times 10^{-5}$	S=1.9	1147
$\Lambda_c^+ \Lambda_c^- K^0$		$( 5.4 \pm 3.2 ) \times 10^{-4}$		—

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

$\gamma \gamma$	B1	$< 3.3 \times 10^{-7}$	CL=90%	2640
$e^+ e^-$	B1	$< 8.3 \times 10^{-8}$	CL=90%	2640
$e^+ e^- \gamma$	B1	$< 1.2 \times 10^{-7}$	CL=90%	2640
$\mu^+ \mu^-$	B1	$< 1.5 \times 10^{-8}$	CL=90%	2638
$\mu^+ \mu^- \gamma$	B1	$< 1.6 \times 10^{-7}$	CL=90%	2638
$\tau^+ \tau^-$	B1	$< 4.1 \times 10^{-3}$	CL=90%	1952
$\pi^0 \ell^+ \ell^-$	B1	$< 1.2 \times 10^{-7}$	CL=90%	2638
$\pi^0 e^+ e^-$	B1	$< 1.4 \times 10^{-7}$	CL=90%	2638
$\pi^0 \mu^+ \mu^-$	B1	$< 1.8 \times 10^{-7}$	CL=90%	2634
$\pi^0 \nu \bar{\nu}$	B1	$< 2.2 \times 10^{-4}$	CL=90%	2638
$K^0 \ell^+ \ell^-$	B1 [ooo]	$( 3.1 \begin{smallmatrix} + 0.8 \\ - 0.7 \end{smallmatrix} ) \times 10^{-7}$		2616
$K^0 e^+ e^-$	B1	$( 1.6 \begin{smallmatrix} + 1.0 \\ - 0.8 \end{smallmatrix} ) \times 10^{-7}$		2616



$K^0 \mu^+ \mu^-$	<i>B1</i>	$( 4.5 \begin{smallmatrix} + \\ - \end{smallmatrix} \begin{smallmatrix} 1.2 \\ 1.0 \end{smallmatrix} ) \times 10^{-7}$		2612
$K^0 \nu \bar{\nu}$	<i>B1</i>	$< 5.6$	$\times 10^{-5}$ CL=90%	2616
$\rho^0 \nu \bar{\nu}$	<i>B1</i>	$< 4.4$	$\times 10^{-4}$ CL=90%	2583
$K^*(892)^0 \ell^+ \ell^-$	<i>B1</i> [ooo]	$( 9.9 \begin{smallmatrix} + \\ - \end{smallmatrix} \begin{smallmatrix} 1.2 \\ 1.1 \end{smallmatrix} ) \times 10^{-7}$		2564
$K^*(892)^0 e^+ e^-$	<i>B1</i>	$( 1.03 \begin{smallmatrix} + \\ - \end{smallmatrix} \begin{smallmatrix} 0.19 \\ 0.17 \end{smallmatrix} ) \times 10^{-6}$		2564
$K^*(892)^0 \mu^+ \mu^-$	<i>B1</i>	$( 1.05 \begin{smallmatrix} + \\ - \end{smallmatrix} \begin{smallmatrix} 0.16 \\ 0.13 \end{smallmatrix} ) \times 10^{-6}$		2560
$K^*(892)^0 \nu \bar{\nu}$	<i>B1</i>	$< 1.2$	$\times 10^{-4}$ CL=90%	2564
$\phi \nu \bar{\nu}$	<i>B1</i>	$< 5.8$	$\times 10^{-5}$ CL=90%	2541
$e^\pm \mu^\mp$	<i>LF</i> [ee]	$< 6.4$	$\times 10^{-8}$ CL=90%	2639
$\pi^0 e^\pm \mu^\mp$	<i>LF</i>	$< 1.4$	$\times 10^{-7}$ CL=90%	2637
$K^0 e^\pm \mu^\mp$	<i>LF</i>	$< 2.7$	$\times 10^{-7}$ CL=90%	2615
$K^*(892)^0 e^+ \mu^-$	<i>LF</i>	$< 5.3$	$\times 10^{-7}$ CL=90%	2563
$K^*(892)^0 e^- \mu^+$	<i>LF</i>	$< 3.4$	$\times 10^{-7}$ CL=90%	2563
$K^*(892)^0 e^\pm \mu^\mp$	<i>LF</i>	$< 5.8$	$\times 10^{-7}$ CL=90%	2563
$e^\pm \tau^\mp$	<i>LF</i> [ee]	$< 2.8$	$\times 10^{-5}$ CL=90%	2341
$\mu^\pm \tau^\mp$	<i>LF</i> [ee]	$< 2.2$	$\times 10^{-5}$ CL=90%	2339
invisible	<i>B1</i>	$< 2.2$	$\times 10^{-4}$ CL=90%	—
$\nu \bar{\nu} \gamma$	<i>B1</i>	$< 4.7$	$\times 10^{-5}$ CL=90%	2640

## B<sup>±</sup>/B<sup>0</sup> ADMIXTURE

### CP violation

$$\begin{aligned}
 A_{CP}(B \rightarrow K^*(892)\gamma) &= -0.003 \pm 0.017 \\
 A_{CP}(b \rightarrow s\gamma) &= -0.008 \pm 0.029 \\
 A_{CP}(b \rightarrow (s+d)\gamma) &= -0.09 \pm 0.07 \\
 A_{CP}(B \rightarrow X_s \ell^+ \ell^-) &= -0.22 \pm 0.26 \\
 A_{CP}(B \rightarrow K^* e^+ e^-) &= -0.18 \pm 0.15 \\
 A_{CP}(B \rightarrow K^* \mu^+ \mu^-) &= -0.03 \pm 0.13 \\
 A_{CP}(B \rightarrow K^* \ell^+ \ell^-) &= -0.07 \pm 0.08 \\
 A_{CP}(B \rightarrow \eta \text{anything}) &= -0.13 \begin{smallmatrix} +0.04 \\ -0.05 \end{smallmatrix}
 \end{aligned}$$

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 treatment of multiple  $D$ 's in the final state must be defined. One possibility would be to count the number of events with one-or-more  $D$ 's and divide by the total number of  $B$ 's. Another possibility would be to count the total number of  $D$ 's and divide by the total number of  $B$ 's, which is the definition of average multiplicity. The two definitions are identical if only one  $D$  is allowed in the final state. Even though the "one-or-more" definition seems sensible, for practical reasons inclusive branching fractions are almost always measured using the multiplicity definition. For heavy final state particles, authors call their results inclusive branching fractions while for light particles some authors call their results multiplicities. In the  $B$  sections, we list all results as inclusive branching fractions, adopting a multiplicity definition. This means that inclusive branching fractions can exceed 100% and that inclusive partial widths can exceed total widths, just as inclusive cross sections can exceed total cross section.

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

<b>B DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	Scale factor/ Confidence level(MeV/c)	$p$
<b>Semileptonic and leptonic modes</b>			
$e^+ \nu_e$ anything	[bbbb] ( 10.76 $\pm$ 0.14 ) %		—
$\bar{p} e^+ \nu_e$ anything	< 5.9 $\times 10^{-4}$	CL=90%	—
$\mu^+ \nu_\mu$ anything	[bbbb] ( 10.76 $\pm$ 0.14 ) %		—
$l^+ \nu_l$ anything	[ooo,bbbb] ( 10.76 $\pm$ 0.14 ) %		—
$D^- l^+ \nu_l$ anything	[ooo] ( 2.8 $\pm$ 0.9 ) %		—
$\bar{D}^0 l^+ \nu_l$ anything	[ooo] ( 7.2 $\pm$ 1.5 ) %		—
$\bar{D} l \nu_l$	( 2.40 $\pm$ 0.12 ) %		2310
$D \tau^+ \nu_\tau$	( 8.6 $\pm$ 2.7 ) $\times 10^{-3}$		1911
$D^{*-} l^+ \nu_l$ anything	[cccc] ( 6.7 $\pm$ 1.3 ) $\times 10^{-3}$		—
$D^* \tau^+ \nu_\tau$	( 1.62 $\pm$ 0.33 ) %		1837
$\bar{D}^{*+} l^+ \nu_l$	[ooo,dddd] ( 2.7 $\pm$ 0.7 ) %		—
$\bar{D}_1(2420) l^+ \nu_l$ anything	( 3.8 $\pm$ 1.3 ) $\times 10^{-3}$	S=2.4	—
$D \pi l^+ \nu_l$ anything + $D^* \pi l^+ \nu_l$ anything	( 2.6 $\pm$ 0.5 ) %	S=1.5	—
$D \pi l^+ \nu_l$ anything	( 1.5 $\pm$ 0.6 ) %		—
$D^* \pi l^+ \nu_l$ anything	( 1.9 $\pm$ 0.4 ) %		—
$\bar{D}_2^*(2460) l^+ \nu_l$ anything	( 4.4 $\pm$ 1.6 ) $\times 10^{-3}$		—
$D^{*-} \pi^+ l^+ \nu_l$ anything	( 1.00 $\pm$ 0.34 ) %		—
$D_s^- l^+ \nu_l$ anything	[ooo] < 7 $\times 10^{-3}$	CL=90%	—
$D_s^- l^+ \nu_l K^+$ anything	[ooo] < 5 $\times 10^{-3}$	CL=90%	—
$D_s^- l^+ \nu_l K^0$ anything	[ooo] < 7 $\times 10^{-3}$	CL=90%	—
$l^+ \nu_l$ charm	( 10.55 $\pm$ 0.14 ) %		—

$X_u \ell^+ \nu_\ell$	( 2.10 ± 0.32 ) × 10 <sup>-3</sup>	—
$\pi \ell \nu_\ell$	( 1.35 ± 0.10 ) × 10 <sup>-4</sup>	2638
$K^+ \ell^+ \nu_\ell$ anything	[ooo] ( 6.2 ± 0.5 ) %	—
$K^- \ell^+ \nu_\ell$ anything	[ooo] ( 10 ± 4 ) × 10 <sup>-3</sup>	—
$K^0 / \bar{K}^0 \ell^+ \nu_\ell$ anything	[ooo] ( 4.6 ± 0.5 ) %	—

### D, D\*, or D<sub>s</sub> modes

$D^\pm$ anything	( 23.7 ± 1.3 ) %	—
$D^0 / \bar{D}^0$ anything	( 62.8 ± 2.9 ) %	S=1.3 —
$D^*(2010)^\pm$ anything	( 22.5 ± 1.5 ) %	—
$D^*(2007)^0$ anything	( 26.0 ± 2.7 ) %	—
$D_s^\pm$ anything	[ee] ( 8.3 ± 0.8 ) %	—
$D_s^{*\pm}$ anything	( 6.3 ± 1.0 ) %	—
$D_s^{*\pm} \bar{D}^*$	( 3.4 ± 0.6 ) %	—
$D^{(*)} \bar{D}^{(*)} K^0 + D^{(*)} \bar{D}^{(*)} K^\pm$	[ee,eeee] ( 7.1 + - 1.7 ) %	—
$b \rightarrow c \bar{c} s$	( 22 ± 4 ) %	—
$D_s^{(*)} \bar{D}^{(*)}$	[ee,eeee] ( 3.9 ± 0.4 ) %	—
$D^* D^*(2010)^\pm$	[ee] < 5.9 × 10 <sup>-3</sup>	CL=90% 1711
$DD^*(2010)^\pm + D^* D^\pm$	[ee] < 5.5 × 10 <sup>-3</sup>	CL=90% —
$DD^\pm$	[ee] < 3.1 × 10 <sup>-3</sup>	CL=90% 1866
$D_s^{(*)\pm} \bar{D}^{(*)} X(n\pi^\pm)$	[ee,eeee] ( 9 + - 5/4 ) %	—
$D^*(2010)\gamma$	< 1.1 × 10 <sup>-3</sup>	CL=90% 2257
$D_s^+ \pi^-, D_s^{*+} \pi^-, D_s^+ \rho^-, D_s^{*+} \rho^-, D_s^+ \pi^0, D_s^{*+} \pi^0, D_s^+ \eta, D_s^{*+} \eta, D_s^+ \rho^0, D_s^{*+} \rho^0, D_s^+ \omega, D_s^{*+} \omega$	[ee] < 4 × 10 <sup>-4</sup>	CL=90% —
$D_{s1}(2536)^+$ anything	< 9.5 × 10 <sup>-3</sup>	CL=90% —

### Charmonium modes

$J/\psi(1S)$ anything	( 1.094 ± 0.032 ) %	S=1.1 —
$J/\psi(1S)$ (direct) anything	( 7.8 ± 0.4 ) × 10 <sup>-3</sup>	S=1.1 —
$\psi(2S)$ anything	( 3.07 ± 0.21 ) × 10 <sup>-3</sup>	—
$\chi_{c1}(1P)$ anything	( 3.86 ± 0.27 ) × 10 <sup>-3</sup>	—
$\chi_{c1}(1P)$ (direct) anything	( 3.22 ± 0.25 ) × 10 <sup>-3</sup>	—
$\chi_{c2}(1P)$ anything	( 1.3 ± 0.4 ) × 10 <sup>-3</sup>	S=1.9 —
$\chi_{c2}(1P)$ (direct) anything	( 1.65 ± 0.31 ) × 10 <sup>-3</sup>	—
$\eta_c(1S)$ anything	< 9 × 10 <sup>-3</sup>	CL=90% —
$K X(3872) \times B(X \rightarrow D^0 \bar{D}^0 \pi^0)$	( 1.2 ± 0.4 ) × 10 <sup>-4</sup>	1141

$K X(3872) \times B(X \rightarrow D^{*0} D^0)$	$( 8.0 \pm 2.2 ) \times 10^{-5}$		1141
$K X(3940) \times B(X \rightarrow D^{*0} D^0)$	$< 6.7$	$\times 10^{-5}$	CL=90% 1084
$K X(3915) \times B(X \rightarrow \omega J/\psi) [ffff]$	$( 7.1 \pm 3.4 ) \times 10^{-5}$		1104

**K or K\* modes**

$K^\pm$ anything	[ee] $( 78.9 \pm 2.5 ) \%$		—
$K^+$ anything	$( 66 \pm 5 ) \%$		—
$K^-$ anything	$( 13 \pm 4 ) \%$		—
$K^0/\bar{K}^0$ anything	[ee] $( 64 \pm 4 ) \%$		—
$K^*(892)^\pm$ anything	$( 18 \pm 6 ) \%$		—
$K^*(892)^0/\bar{K}^*(892)^0$ anything	[ee] $( 14.6 \pm 2.6 ) \%$		—
$K^*(892)\gamma$	$( 4.2 \pm 0.6 ) \times 10^{-5}$		2564
$\eta K \gamma$	$( 8.5 \begin{smallmatrix} + 1.8 \\ - 1.6 \end{smallmatrix} ) \times 10^{-6}$		2588
$K_1(1400)\gamma$	$< 1.27$	$\times 10^{-4}$	CL=90% 2453
$K_2^*(1430)\gamma$	$( 1.7 \begin{smallmatrix} + 0.6 \\ - 0.5 \end{smallmatrix} ) \times 10^{-5}$		2447
$K_2(1770)\gamma$	$< 1.2$	$\times 10^{-3}$	CL=90% 2342
$K_3^*(1780)\gamma$	$< 3.7$	$\times 10^{-5}$	CL=90% 2341
$K_4^*(2045)\gamma$	$< 1.0$	$\times 10^{-3}$	CL=90% 2244
$K \eta'(958)$	$( 8.3 \pm 1.1 ) \times 10^{-5}$		2528
$K^*(892)\eta'(958)$	$( 4.1 \pm 1.1 ) \times 10^{-6}$		2472
$K \eta$	$< 5.2$	$\times 10^{-6}$	CL=90% 2588
$K^*(892)\eta$	$( 1.8 \pm 0.5 ) \times 10^{-5}$		2534
$K \phi \phi$	$( 2.3 \pm 0.9 ) \times 10^{-6}$		2306
$\bar{b} \rightarrow \bar{s} \gamma$	$( 3.08 \pm 0.25 ) \times 10^{-4}$	S=1.3	—
$\bar{b} \rightarrow \bar{d} \gamma$	$( 9.2 \pm 3.0 ) \times 10^{-6}$		—
$\bar{b} \rightarrow \bar{s} \text{gluon}$	$< 6.8$	%	CL=90% —
$\eta$ anything	$( 2.6 \begin{smallmatrix} + 0.5 \\ - 0.8 \end{smallmatrix} ) \times 10^{-4}$		—
$\eta'$ anything	$( 4.2 \pm 0.9 ) \times 10^{-4}$		—
$K^+$ gluon (charmless)	$< 1.87$	$\times 10^{-4}$	CL=90% —
$K^0$ gluon (charmless)	$< 2.94$	$\times 10^{-4}$	CL=90% —

**Light unflavored meson modes**

$\rho \gamma$	$( 1.39 \pm 0.25 ) \times 10^{-6}$	S=1.2	2583
$\rho/\omega \gamma$	$( 1.30 \pm 0.23 ) \times 10^{-6}$	S=1.2	—
$\pi^\pm$ anything	[ee,gggg] $( 358 \pm 7 ) \%$		—
$\pi^0$ anything	$( 235 \pm 11 ) \%$		—
$\eta$ anything	$( 17.6 \pm 1.6 ) \%$		—
$\rho^0$ anything	$( 21 \pm 5 ) \%$		—
$\omega$ anything	$< 81$	%	CL=90% —

$\phi$ anything	( 3.43 $\pm$ 0.12 ) %			—
$\phi K^*(892)$	< 2.2	$\times 10^{-5}$	CL=90%	2460
$\pi^+$ gluon (charmless)	( 3.7 $\pm$ 0.8 )	$\times 10^{-4}$		—

### Baryon modes

$\Lambda_c^+ / \bar{\Lambda}_c^-$ anything	( 4.5 $\pm$ 1.2 ) %			—
$\bar{\Lambda}_c^- e^+$ anything	< 2.3	$\times 10^{-3}$	CL=90%	—
$\bar{\Lambda}_c^- p$ anything	( 2.6 $\pm$ 0.8 ) %			—
$\bar{\Lambda}_c^- p e^+ \nu_e$	< 1.0	$\times 10^{-3}$	CL=90%	2021
$\bar{\Sigma}_c^{--}$ anything	( 4.2 $\pm$ 2.4 )	$\times 10^{-3}$		—
$\bar{\Sigma}_c^-$ anything	< 9.6	$\times 10^{-3}$	CL=90%	—
$\bar{\Sigma}_c^0$ anything	( 4.6 $\pm$ 2.4 )	$\times 10^{-3}$		—
$\bar{\Sigma}_c^0 N (N = p \text{ or } n)$	< 1.5	$\times 10^{-3}$	CL=90%	1938
$\Xi_c^0$ anything	( 1.93 $\pm$ 0.30 )	$\times 10^{-4}$	S=1.1	—
$\times B(\Xi_c^0 \rightarrow \Xi^- \pi^+)$				
$\Xi_c^+$ anything	( 4.5 $\pm$ 1.3 )	$\times 10^{-4}$		—
$\times B(\Xi_c^+ \rightarrow \Xi^- \pi^+ \pi^+)$				
$p / \bar{p}$ anything	[ee] ( 8.0 $\pm$ 0.4 ) %			—
$p / \bar{p}$ (direct) anything	[ee] ( 5.5 $\pm$ 0.5 ) %			—
$\Lambda / \bar{\Lambda}$ anything	[ee] ( 4.0 $\pm$ 0.5 ) %			—
$\Xi^- / \Xi^+$ anything	[ee] ( 2.7 $\pm$ 0.6 )	$\times 10^{-3}$		—
baryons anything	( 6.8 $\pm$ 0.6 ) %			—
$p \bar{p}$ anything	( 2.47 $\pm$ 0.23 ) %			—
$\Lambda \bar{p} / \bar{\Lambda} p$ anything	[ee] ( 2.5 $\pm$ 0.4 ) %			—
$\Lambda \bar{\Lambda}$ anything	< 5	$\times 10^{-3}$	CL=90%	—

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

$s e^+ e^-$	B1	( 4.7 $\pm$ 1.3 )	$\times 10^{-6}$		—
$s \mu^+ \mu^-$	B1	( 4.3 $\pm$ 1.2 )	$\times 10^{-6}$		—
$s l^+ l^-$	B1 [ooo]	( 4.5 $\pm$ 1.0 )	$\times 10^{-6}$		—
$\pi l^+ l^-$		< 6.2	$\times 10^{-8}$	CL=90%	2638
$K e^+ e^-$	B1	( 4.4 $\pm$ 0.6 )	$\times 10^{-7}$		2617
$K^*(892) e^+ e^-$	B1	( 1.19 $\pm$ 0.20 )	$\times 10^{-6}$	S=1.2	2564
$K \mu^+ \mu^-$	B1	( 4.8 $\pm$ 0.6 )	$\times 10^{-7}$		2612
$K^*(892) \mu^+ \mu^-$	B1	( 1.15 $\pm$ 0.15 )	$\times 10^{-6}$		2560
$K l^+ l^-$	B1	( 4.5 $\pm$ 0.4 )	$\times 10^{-7}$		2617
$K^*(892) l^+ l^-$	B1	( 1.08 $\pm$ 0.11 )	$\times 10^{-6}$		2564
$K \nu \bar{\nu}$		< 1.4	$\times 10^{-5}$	CL=90%	2617
$K^* \nu \bar{\nu}$		< 8	$\times 10^{-5}$	CL=90%	—
$s e^\pm \mu^\mp$	LF [ee]	< 2.2	$\times 10^{-5}$	CL=90%	—
$\pi e^\pm \mu^\mp$	LF	< 9.2	$\times 10^{-8}$	CL=90%	2637

$\rho e^\pm \mu^\mp$	LF	< 3.2	$\times 10^{-6}$	CL=90%	2582
$K e^\pm \mu^\mp$	LF	< 3.8	$\times 10^{-8}$	CL=90%	2616
$K^*(892) e^\pm \mu^\mp$	LF	< 5.1	$\times 10^{-7}$	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,  $S\bar{p}\bar{p}S$ ).

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

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

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

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

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

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,  $S\bar{p}\bar{p}S$ ) 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.*,  $B \rightarrow D^\pm$  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 ( $\Gamma_i/\Gamma$ )	Scale factor/ Confidence level	$p$ (MeV/c)
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### 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. The production fractions in  $b$ -hadronic  $Z$  decay or  $p\bar{p}$  collisions at the Tevatron are also listed at the end of the section. Values assume

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

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

The correlation coefficients between production fractions are also reported:

$$\text{cor}(B_s^0, b\text{-baryon}) = -0.067$$

$$\text{cor}(B_s^0, B^\pm=B^0) = -0.476$$

$$\text{cor}(b\text{-baryon}, B^\pm=B^0) = -0.846.$$

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,  $\text{B}(\bar{b} \rightarrow B^0)$ .

Note these production fractions are  $b$ -hadronization fractions, not the conventional branching fractions of  $b$ -quark to a  $B$ -hadron, which may have considerable dependence on the initial and final state kinematic and production environment.

$B^+$	( 40.3 ± 1.1 ) %	—
$B^0$	( 40.3 ± 1.1 ) %	—
$B_s^0$	( 11.0 ± 1.2 ) %	—
$b$ -baryon	( 8.3 ± 2.0 ) %	—
$B_c$	—	—

## DECAY MODES

### Semileptonic and leptonic modes

$\nu$ anything	( 23.1 ± 1.5 ) %	—
$\ell^+ \nu_\ell$ anything	[ooo] ( 10.69 ± 0.22 ) %	—
$e^+ \nu_e$ anything	( 10.86 ± 0.35 ) %	—
$\mu^+ \nu_\mu$ anything	( 10.95 <sup>+</sup> <sub>-</sub> 0.29 / 0.25 ) %	—
$D^- \ell^+ \nu_\ell$ anything	[ooo] ( 2.27 ± 0.35 ) %	S=1.7 —
$D^- \pi^+ \ell^+ \nu_\ell$ anything	( 4.9 ± 1.9 ) × 10 <sup>-3</sup>	—
$D^- \pi^- \ell^+ \nu_\ell$ anything	( 2.6 ± 1.6 ) × 10 <sup>-3</sup>	—
$\bar{D}^0 \ell^+ \nu_\ell$ anything	[ooo] ( 6.85 ± 0.35 ) %	—
$\bar{D}^0 \pi^- \ell^+ \nu_\ell$ anything	( 1.07 ± 0.27 ) %	—
$\bar{D}^0 \pi^+ \ell^+ \nu_\ell$ anything	( 2.3 ± 1.6 ) × 10 <sup>-3</sup>	—
$D^{*-} \ell^+ \nu_\ell$ anything	[ooo] ( 2.75 ± 0.19 ) %	—
$D^{*-} \pi^- \ell^+ \nu_\ell$ anything	( 6 ± 7 ) × 10 <sup>-4</sup>	—
$D^{*-} \pi^+ \ell^+ \nu_\ell$ anything	( 4.8 ± 1.0 ) × 10 <sup>-3</sup>	—
$\bar{D}_j^0 \ell^+ \nu_\ell$ anything × [ooo,hhhh]	( 2.6 ± 0.9 ) × 10 <sup>-3</sup>	—
$\text{B}(\bar{D}_j^0 \rightarrow D^{*+} \pi^-)$		
$D_j^- \ell^+ \nu_\ell$ anything × [ooo,hhhh]	( 7.0 ± 2.3 ) × 10 <sup>-3</sup>	—
$\text{B}(D_j^- \rightarrow D^0 \pi^-)$		
$\bar{D}_2^*(2460)^0 \ell^+ \nu_\ell$ anything	< 1.4 × 10 <sup>-3</sup>	CL=90% —
× $\text{B}(\bar{D}_2^*(2460)^0 \rightarrow D^{*-} \pi^+)$		
$D_2^*(2460)^- \ell^+ \nu_\ell$ anything	( 4.2 <sup>+</sup> <sub>-</sub> 1.5 / 1.8 ) × 10 <sup>-3</sup>	—
× $\text{B}(D_2^*(2460)^- \rightarrow D^0 \pi^-)$		
$\bar{D}_2^*(2460)^0 \ell^+ \nu_\ell$ anything	( 1.6 ± 0.8 ) × 10 <sup>-3</sup>	—
× $\text{B}(\bar{D}_2^*(2460)^0 \rightarrow D^- \pi^+)$		

charmless $\ell\bar{\nu}_\ell$	[ <i>ooo</i> ]	( 1.7 ± 0.5 ) × 10 <sup>-3</sup>	—
$\tau^+ \nu_\tau$ anything		( 2.41 ± 0.23 ) %	—
$D^{*-} \tau \nu_\tau$ anything		( 9 ± 4 ) × 10 <sup>-3</sup>	—
$\bar{c} \rightarrow \ell^- \bar{\nu}_\ell$ anything	[ <i>ooo</i> ]	( 8.02 ± 0.19 ) %	—
$c \rightarrow \ell^+ \nu$ anything		( 1.6 $\begin{smallmatrix} + \\ - \end{smallmatrix}$ 0.4 / 0.5 ) %	—

### Charmed meson and baryon modes

$\bar{D}^0$ anything		( 59.8 ± 2.9 ) %	—
$D^0 D_s^\pm$ anything	[ <i>ee</i> ]	( 9.1 $\begin{smallmatrix} + \\ - \end{smallmatrix}$ 4.0 / 2.8 ) %	—
$D^\mp D_s^\pm$ anything	[ <i>ee</i> ]	( 4.0 $\begin{smallmatrix} + \\ - \end{smallmatrix}$ 2.3 / 1.8 ) %	—
$\bar{D}^0 D^0$ anything	[ <i>ee</i> ]	( 5.1 $\begin{smallmatrix} + \\ - \end{smallmatrix}$ 2.0 / 1.8 ) %	—
$D^0 D^\pm$ anything	[ <i>ee</i> ]	( 2.7 $\begin{smallmatrix} + \\ - \end{smallmatrix}$ 1.8 / 1.6 ) %	—
$D^\pm D^\mp$ anything	[ <i>ee</i> ]	< 9 × 10 <sup>-3</sup> CL=90%	—
$D^-$ anything		( 23.3 ± 1.7 ) %	—
$D^*(2010)^+$ anything		( 17.3 ± 2.0 ) %	—
$D_1(2420)^0$ anything		( 5.0 ± 1.5 ) %	—
$D^*(2010)^\mp D_s^\pm$ anything	[ <i>ee</i> ]	( 3.3 $\begin{smallmatrix} + \\ - \end{smallmatrix}$ 1.6 / 1.3 ) %	—
$D^0 D^*(2010)^\pm$ anything	[ <i>ee</i> ]	( 3.0 $\begin{smallmatrix} + \\ - \end{smallmatrix}$ 1.1 / 0.9 ) %	—
$D^*(2010)^\pm D^\mp$ anything	[ <i>ee</i> ]	( 2.5 $\begin{smallmatrix} + \\ - \end{smallmatrix}$ 1.2 / 1.0 ) %	—
$D^*(2010)^\pm D^*(2010)^\mp$ anything	[ <i>ee</i> ]	( 1.2 ± 0.4 ) %	—
$\bar{D} D$ anything		( 10 $\begin{smallmatrix} + \\ - \end{smallmatrix}$ 11 / 10 ) %	—
$D_2^*(2460)^0$ anything		( 4.7 ± 2.7 ) %	—
$D_s^-$ anything		( 14.7 ± 2.1 ) %	—
$D_s^+$ anything		( 10.1 ± 3.1 ) %	—
$\Lambda_c^+$ anything		( 9.7 ± 2.9 ) %	—
$\bar{c}/c$ anything	[ <i>gggg</i> ]	(116.2 ± 3.2) %	—

### Charmonium modes

$J/\psi(1S)$ anything		( 1.16 ± 0.10 ) %	—
$\psi(2S)$ anything		( 4.8 ± 2.4 ) × 10 <sup>-3</sup>	—
$\chi_{c1}(1P)$ anything		( 1.4 ± 0.4 ) %	—

### K or K\* modes

$\bar{s}\gamma$		( 3.1 ± 1.1 ) × 10 <sup>-4</sup>	—
$\bar{s}\bar{\nu}\nu$	<	6.4 × 10 <sup>-4</sup> CL=90%	—
$K^\pm$ anything		( 74 ± 6 ) %	—
$K_S^0$ anything		( 29.0 ± 2.9 ) %	—



<b>Pion modes</b>			
$\pi^\pm$ anything		(397 $\pm$ 21 ) %	—
$\pi^0$ anything	[gggg]	(278 $\pm$ 60 ) %	—
$\phi$ anything		( 2.82 $\pm$ 0.23 ) %	—
<b>Baryon modes</b>			
$p/\bar{p}$ anything		( 13.1 $\pm$ 1.1 ) %	—
<b>Other modes</b>			
charged anything	[gggg]	(497 $\pm$ 7 ) %	—
hadron <sup>+</sup> hadron <sup>-</sup>		( 1.7 $\pm$ 1.0 / $-$ 0.7 ) $\times 10^{-5}$	—
charmless		( 7 $\pm$ 21 ) $\times 10^{-3}$	—
<b>Baryon modes</b>			
$\Lambda/\bar{\Lambda}$ anything		( 5.9 $\pm$ 0.6 ) %	—
$b$ -baryon anything		( 10.2 $\pm$ 2.8 ) %	—
<b><math>\Delta B = 1</math> weak neutral current (<math>B1</math>) modes</b>			
$\mu^+ \mu^-$ 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.

$$\text{Mass } m_{B^*} = 5325.1 \pm 0.5 \text{ MeV}$$

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

<b><math>B^*</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$B\gamma$	dominant	45

**$B_1(5721)^0$**

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

$I, J, P$  need confirmation.

$$B_1(5721)^0 \text{ MASS} = 5723.4 \pm 2.0 \text{ MeV} \quad (S = 1.1)$$

$$m_{B_1^0} - m_{B^+} = 444.3 \pm 2.0 \text{ MeV} \quad (S = 1.1)$$

$B_1(5721)^0$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$B^{*+} \pi^-$	dominant	—

**$B_2^*(5747)^0$**

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

$I, J, P$  need confirmation.

$$B_2^*(5747)^0 \text{ MASS} = 5743 \pm 5 \text{ MeV} \quad (S = 2.8)$$

$$\text{Full width } \Gamma = 23_{-11}^{+5} \text{ MeV}$$

$$m_{B_2^{*0}} - m_{B_1^0} = 19 \pm 6 \text{ MeV} \quad (S = 3.0)$$

$B_2^*(5747)^0$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$B^+ \pi^-$	dominant	424
$B^{*+} \pi^-$	dominant	—

## 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.

$$\text{Mass } m_{B_s^0} = 5366.3 \pm 0.6 \text{ MeV} \quad (S = 1.1)$$

$$\text{Mean life } \tau = (1.472_{-0.026}^{+0.024}) \times 10^{-12} \text{ s}$$

$$c\tau = 441 \mu\text{m}$$

$$\begin{aligned} \Delta\Gamma_{B_s^0} &= \Gamma_{B_{sL}^0} - \Gamma_{B_{sH}^0} = (0.062_{-0.037}^{+0.034}) \times 10^{12} \text{ s}^{-1} \\ &= 18.6_{-11.1}^{+10.2} \mu\text{m} \end{aligned}$$

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

$$\begin{aligned} \Delta m_{B_s^0} &= m_{B_{sH}^0} - m_{B_{sL}^0} = (17.77 \pm 0.12) \times 10^{12} \hbar \text{ s}^{-1} \\ &= (117.0 \pm 0.8) \times 10^{-10} \text{ MeV} \end{aligned}$$

$$x_s = \Delta m_{B_s^0} / \Gamma_{B_s^0} = 26.2 \pm 0.5$$

$$\chi_s = 0.49927 \pm 0.00003$$

### CP violation parameters in $B_s^0$

$$\text{Re}(\epsilon_{B_s^0}) / (1 + |\epsilon_{B_s^0}|^2) = (-2.9 \pm 1.5) \times 10^{-3}$$

$$\text{CP Violation phase } \beta_s = 0.46_{-0.12}^{+0.08} \text{ or } 1.15_{-0.10}^{+0.08}$$

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  $B(\bar{b} \rightarrow B_s^0) = (10.7 \pm 1.2)\%$  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 ( $\Gamma_i/\Gamma$ )	Confidence level	$P$ (MeV/c)
$D_s^-$ anything	(93 ± 25 ) %		–
$D_s^- \ell^+ \nu_\ell$ anything	[iiii] ( 7.9 ± 2.4 ) %		–
$D_{s1}(2536)^- \mu^+ \nu_\mu$ , $D_{s1}^- \rightarrow D^{*-} K_S^0$	( 2.4 ± 0.7 ) $\times 10^{-3}$		–
$D_s^- \pi^+$	( 3.2 ± 0.5 ) $\times 10^{-3}$		2320
$D_s^- \rho^+$	( 7.4 ± 1.8 ) $\times 10^{-3}$		2248
$D_s^- \pi^+ \pi^+ \pi^-$	( 8.4 ± 3.3 ) $\times 10^{-3}$		2301
$D_s^\mp K^\pm$	( 3.0 ± 0.7 ) $\times 10^{-4}$		2292
$D_s^+ D_s^-$	( 1.04 $\begin{smallmatrix} + 0.29 \\ - 0.26 \end{smallmatrix}$ ) %		1823
$D_s^{*-} \pi^+$	( 2.1 ± 0.6 ) $\times 10^{-3}$		2265
$D_s^{*-} \rho^+$	( 1.03 ± 0.27 ) %		2190
$D_s^{*+} D_s^- + D_s^{*-} D_s^+$	( 2.8 ± 1.0 ) %		1742
$D_s^{*+} D_s^{*-}$	( 3.1 ± 1.4 ) %		1655
$D_s^{(*)+} D_s^{(*)-}$	( 4.5 ± 1.4 ) %		–
$J/\psi(1S) \phi$	( 1.4 ± 0.5 ) $\times 10^{-3}$		1587
$J/\psi(1S) \pi^0$	< 1.2 $\times 10^{-3}$	90%	1786
$J/\psi(1S) \eta$	< 3.8 $\times 10^{-3}$	90%	1733
$J/\psi(1S) K^0$	( 3.5 ± 0.8 ) $\times 10^{-5}$		1743
$J/\psi(1S) K^{*0}$	( 8 ± 4 ) $\times 10^{-5}$		–
$J/\psi(1S) f_0(980), f_0 \rightarrow \pi^+ \pi^-$	( 1.29 $\begin{smallmatrix} + 0.40 \\ - 0.28 \end{smallmatrix}$ ) $\times 10^{-4}$		–

$J/\psi(1S) f_0(1370), f_0 \rightarrow \pi^+ \pi^-$		$( 3.4 \pm 1.4 ) \times 10^{-5}$		—
$\psi(2S) \phi$		$( 7.1 \pm 2.8 ) \times 10^{-4}$		1119
$\pi^+ \pi^-$		$< 1.2 \times 10^{-6}$	90%	2680
$\pi^0 \pi^0$		$< 2.1 \times 10^{-4}$	90%	2680
$\eta \pi^0$		$< 1.0 \times 10^{-3}$	90%	2653
$\eta \eta$		$< 1.5 \times 10^{-3}$	90%	2627
$\rho^0 \rho^0$		$< 3.20 \times 10^{-4}$	90%	2569
$\phi \rho^0$		$< 6.17 \times 10^{-4}$	90%	2526
$\phi \phi$		$( 1.4 \pm 0.8 ) \times 10^{-5}$		2482
$\pi^+ K^-$		$( 5.0 \pm 1.0 ) \times 10^{-6}$		2659
$K^+ K^-$		$( 3.5 \pm 0.7 ) \times 10^{-5}$		2637
$K^0 \bar{K}^0$		$< 6.6 \times 10^{-5}$	90%	2637
$\bar{K}^*(892)^0 \rho^0$		$< 7.67 \times 10^{-4}$	90%	2550
$\bar{K}^*(892)^0 K^*(892)^0$		$< 1.681 \times 10^{-3}$	90%	2531
$\phi K^*(892)^0$		$< 1.013 \times 10^{-3}$	90%	2507
$p \bar{p}$		$< 5.9 \times 10^{-5}$	90%	2514
$\gamma \gamma$	<i>B1</i>	$< 8.7 \times 10^{-6}$	90%	2683
$\phi \gamma$		$( 5.7 \pm_{-1.9}^{2.2} ) \times 10^{-5}$		2586

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

$\mu^+ \mu^-$	<i>B1</i>	$< 4.2 \times 10^{-8}$	90%	2681
$e^+ e^-$	<i>B1</i>	$< 2.8 \times 10^{-7}$	90%	2683
$e^\pm \mu^\mp$	<i>LF</i> [ee]	$< 2.0 \times 10^{-7}$	90%	2682
$\phi(1020) \mu^+ \mu^-$	<i>B1</i>	$< 3.2 \times 10^{-6}$	90%	2582
$\phi \nu \bar{\nu}$	<i>B1</i>	$< 5.4 \times 10^{-3}$	90%	2586

**$B_s^*$**

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

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

$$\text{Mass } m = 5415.4 \pm 1.4 \text{ MeV } (S = 2.5)$$

$$m_{B_s^*} - m_{B_s} = 49.0 \pm 1.5 \text{ MeV } (S = 2.0)$$

$B_s^*$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$B_s \gamma$	dominant	—

**$B_{s1}(5830)^0$**

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

$I, J, P$  need confirmation.

Mass  $m = 5829.4 \pm 0.7$  MeV

$$m_{B_{s1}^0} - m_{B^{*+}} = 504.41 \pm 0.25$$
 MeV

$B_{s1}(5830)^0$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$B^{*+} K^-$	dominant	—

**$B_{s2}^*(5840)^0$**

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

$I, J, P$  need confirmation.

Mass  $m = 5839.7 \pm 0.6$  MeV

$$m_{B_{s2}^{*0}} - m_{B_{s1}^0} = 10.5 \pm 0.6$$
 MeV

$B_{s2}^*(5840)^0$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$B^+ K^-$	dominant	252

## 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.

Mass  $m = 6.277 \pm 0.006$  GeV ( $S = 1.6$ )

Mean life  $\tau = (0.453 \pm 0.041) \times 10^{-12}$  s

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

$B_c^+$ DECAY MODES $\times B(\bar{b} \rightarrow B_c)$	Fraction ( $\Gamma_i/\Gamma$ )	Confidence level	$P$ (MeV/c)
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The following quantities are not pure branching ratios; rather the fraction  $\Gamma_i/\Gamma \times B(\bar{b} \rightarrow B_c)$ .

$J/\psi(1S)\ell^+\nu_\ell$ anything	$(5.2_{-2.1}^{+2.4}) \times 10^{-5}$		—
$J/\psi(1S)\pi^+$	$< 8.2 \times 10^{-5}$	90%	2372
$J/\psi(1S)\pi^+\pi^+\pi^-$	$< 5.7 \times 10^{-4}$	90%	2352
$J/\psi(1S)a_1(1260)$	$< 1.2 \times 10^{-3}$	90%	2171
$D^*(2010)^+\bar{D}^0$	$< 6.2 \times 10^{-3}$	90%	2468

## c $\bar{c}$ MESONS

**$\eta_c(1S)$**

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

Mass  $m = 2980.3 \pm 1.2$  MeV (S = 1.6)

Full width  $\Gamma = 28.6 \pm 2.2$  MeV (S = 2.0)

$\eta_c(1S)$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	Confidence level	$P$ (MeV/c)
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### Decays involving hadronic resonances

$\eta'(958)\pi\pi$	$(4.1 \pm 1.7) \%$		1321
$\rho\rho$	$(2.0 \pm 0.7) \%$		1272
$K^*(892)^0 K^- \pi^+ + c.c.$	$(2.0 \pm 0.7) \%$		1276
$K^*(892)\bar{K}^*(892)$	$(9.2 \pm 3.4) \times 10^{-3}$		1194
$K^{*0}\bar{K}^{*0}\pi^+\pi^-$	$(1.1 \pm 0.5) \%$		1071
$\phi K^+ K^-$	$(2.9 \pm 1.4) \times 10^{-3}$		1102
$\phi\phi$	$(2.7 \pm 0.9) \times 10^{-3}$		1087
$\phi 2(\pi^+\pi^-)$	$< 3.5 \times 10^{-3}$	90%	1249
$a_0(980)\pi$	$< 2 \%$	90%	1325
$a_2(1320)\pi$	$< 2 \%$	90%	1194
$K^*(892)\bar{K} + c.c.$	$< 1.28 \%$	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
$f_2(1270)f_2(1270)$	$(7.6_{-3.4}^{+3.0}) \times 10^{-3}$		771
$f_2(1270)f_2'(1525)$	$(2.7 \pm 1.5) \%$		509

### 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
$K^+ K^- 2(\pi^+ \pi^-)$	$(7.1 \pm 2.9) \times 10^{-3}$		1252
$2(K^+ K^-)$	$(1.6 \pm 0.7) \times 10^{-3}$		1053
$2(\pi^+ \pi^-)$	$(1.20 \pm 0.30) \%$		1457
$3(\pi^+ \pi^-)$	$(1.5 \pm 0.5) \%$		1405
$p \bar{p}$	$(1.3 \pm 0.4) \times 10^{-3}$		1158
$\Lambda \bar{\Lambda}$	$(1.04 \pm 0.31) \times 10^{-3}$		988
$K \bar{K} \eta$	$< 3.1 \%$	90%	1263
$\pi^+ \pi^- p \bar{p}$	$< 1.2 \%$	90%	1024

### Radiative decays

$\gamma \gamma$	$(6.3 \pm 2.9) \times 10^{-5}$		1490
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### Charge conjugation (C), Parity (P), Lepton family number (LF) violating modes

$\pi^+ \pi^-$	$P, CP < 6$	$\times 10^{-4}$	90%	1484
$\pi^0 \pi^0$	$P, CP < 4$	$\times 10^{-4}$	90%	1484
$K^+ K^-$	$P, CP < 6$	$\times 10^{-4}$	90%	1406
$K_S^0 K_S^0$	$P, CP < 3.1$	$\times 10^{-4}$	90%	1405

**$J/\psi(1S)$**

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

Mass  $m = 3096.916 \pm 0.011$  MeV

Full width  $\Gamma = 92.9 \pm 2.8$  keV (S = 1.1)

$\Gamma_{ee} = 5.55 \pm 0.14 \pm 0.02$  keV

<b><math>J/\psi(1S)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	Scale factor/ Confidence level	$\rho$ (MeV/c)
hadrons	(87.7 $\pm$ 0.5 ) %		—
virtual $\gamma \rightarrow$ hadrons	(13.50 $\pm$ 0.30 ) %		—
$g g g$	(64.1 $\pm$ 1.0 ) %		—
$\gamma g g$	( 8.8 $\pm$ 0.5 ) %		—
$e^+ e^-$	( 5.94 $\pm$ 0.06 ) %		1548
$e^+ e^- \gamma$	[ <i>jjj</i> ] ( 8.8 $\pm$ 1.4 ) $\times 10^{-3}$		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
$\omega\pi^+\pi^-$	( 8.6 $\pm$ 0.7 ) $\times 10^{-3}$	S=1.1	1435
$\omega f_2(1270)$	( 4.3 $\pm$ 0.6 ) $\times 10^{-3}$		1142
$K^*(892)^0\bar{K}^*(892)^0$	( 2.3 $\pm$ 0.7 ) $\times 10^{-4}$		1266
$K^*(892)^\pm\bar{K}^*(892)^\mp$	( 1.00 $^{+0.22}_{-0.40}$ ) $\times 10^{-3}$		1266
$K^*(892)^\pm\bar{K}^*(800)^\mp$	( 1.1 $^{+1.0}_{-0.6}$ ) $\times 10^{-3}$		—
$\eta K^*(892)^0\bar{K}^*(892)^0$	( 1.15 $\pm$ 0.26 ) $\times 10^{-3}$		1003
$K^*(892)^0\bar{K}_2^*(1430)^0 + c.c.$	( 6.0 $\pm$ 0.6 ) $\times 10^{-3}$		1012
$K^*(892)^0\bar{K}_2^*(1770)^0 + c.c. \rightarrow$ $K^*(892)^0 K^- \pi^+ + c.c.$	( 6.9 $\pm$ 0.9 ) $\times 10^{-4}$		—
$\omega K^*(892)\bar{K} + c.c.$	( 6.1 $\pm$ 0.9 ) $\times 10^{-3}$		1097
$K^+\bar{K}^*(892)^- + c.c.$	( 5.12 $\pm$ 0.30 ) $\times 10^{-3}$		1373
$K^+\bar{K}^*(892)^- + c.c. \rightarrow$ $K^+ K^- \pi^0$	( 1.97 $\pm$ 0.20 ) $\times 10^{-3}$		—
$K^+\bar{K}^*(892)^- + c.c. \rightarrow$ $K^0 K^\pm \pi^\mp$	( 3.0 $\pm$ 0.4 ) $\times 10^{-3}$		—
$K^0\bar{K}^*(892)^0 + c.c.$	( 4.39 $\pm$ 0.31 ) $\times 10^{-3}$		1373
$K^0\bar{K}^*(892)^0 + c.c. \rightarrow$ $K^0 K^\pm \pi^\mp$	( 3.2 $\pm$ 0.4 ) $\times 10^{-3}$		—
$K_1(1400)^\pm K^\mp$	( 3.8 $\pm$ 1.4 ) $\times 10^{-3}$		1170
$\bar{K}^*(892)^0 K^+ \pi^- + c.c.$	seen		1343
$\omega\pi^0\pi^0$	( 3.4 $\pm$ 0.8 ) $\times 10^{-3}$		1436
$b_1(1235)^\pm\pi^\mp$	[ <i>ee</i> ] ( 3.0 $\pm$ 0.5 ) $\times 10^{-3}$		1300
$\omega K^\pm K_S^0 \pi^\mp$	[ <i>ee</i> ] ( 3.4 $\pm$ 0.5 ) $\times 10^{-3}$		1210
$b_1(1235)^0\pi^0$	( 2.3 $\pm$ 0.6 ) $\times 10^{-3}$		1300
$\eta K^\pm K_S^0 \pi^\mp$	[ <i>ee</i> ] ( 2.2 $\pm$ 0.4 ) $\times 10^{-3}$		1278
$\phi K^*(892)\bar{K} + c.c.$	( 2.18 $\pm$ 0.23 ) $\times 10^{-3}$		969
$\omega K\bar{K}$	( 1.6 $\pm$ 0.5 ) $\times 10^{-4}$		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
$\phi f_2(1270)$		$( 7.2 \pm 1.3 ) \times 10^{-4}$		1036
$\Delta(1232)^{++} \bar{\Delta}(1232)^{--}$		$( 1.10 \pm 0.29 ) \times 10^{-3}$		938
$\Sigma(1385)^- \bar{\Sigma}(1385)^+ \text{ (or c.c.)}$	[ee]	$( 1.03 \pm 0.13 ) \times 10^{-3}$		697
$\phi f_2'(1525)$		$( 8 \pm 4 ) \times 10^{-4}$	S=2.7	871
$\phi \pi^+ \pi^-$		$( 8.7 \pm 0.8 ) \times 10^{-4}$		1365
$\phi \pi^0 \pi^0$		$( 5.6 \pm 1.6 ) \times 10^{-4}$		1366
$\phi K^\pm K_S^0 \pi^\mp$	[ee]	$( 7.2 \pm 0.8 ) \times 10^{-4}$		1114
$\omega f_1(1420)$		$( 6.8 \pm 2.4 ) \times 10^{-4}$		1062
$\phi \eta$		$( 7.5 \pm 0.8 ) \times 10^{-4}$	S=1.5	1320
$\Xi^0 \Xi^0$		$( 1.20 \pm 0.24 ) \times 10^{-3}$		818
$\Xi(1530)^- \Xi^+$		$( 5.9 \pm 1.5 ) \times 10^{-4}$		600
$\rho K^- \bar{\Sigma}(1385)^0$		$( 5.1 \pm 3.2 ) \times 10^{-4}$		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
$\phi f_0(980) \rightarrow \phi \pi^+ \pi^-$		$( 2.2 \pm 0.4 ) \times 10^{-4}$		—
$\phi f_0(980) \rightarrow \phi \pi^0 \pi^0$		$( 1.7 \pm 0.7 ) \times 10^{-4}$		—
$\eta \phi f_0(980) \rightarrow \eta \phi \pi^+ \pi^-$		$( 3.2 \pm 1.0 ) \times 10^{-4}$		—
$\Xi(1530)^0 \Xi^0$		$( 3.2 \pm 1.4 ) \times 10^{-4}$		608
$\Sigma(1385)^- \bar{\Sigma}^+ \text{ (or c.c.)}$	[ee]	$( 3.1 \pm 0.5 ) \times 10^{-4}$		855
$\phi f_1(1285)$		$( 2.6 \pm 0.5 ) \times 10^{-4}$	S=1.1	1032
$\eta \pi^+ \pi^-$		$( 4.0 \pm 1.7 ) \times 10^{-4}$		1487
$\rho \eta$		$( 1.93 \pm 0.23 ) \times 10^{-4}$		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
$a_2(1320)^\pm \pi^\mp$	[ee]	$< 4.3 \times 10^{-3}$	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
$\phi \pi^0$		$< 6.4 \times 10^{-6}$	CL=90%	1377
$\phi \eta(1405) \rightarrow \phi \eta \pi \pi$		$< 2.5 \times 10^{-4}$	CL=90%	946
$\omega f_2'(1525)$		$< 2.2 \times 10^{-4}$	CL=90%	1003
$\eta \phi(2170) \rightarrow$		$< 2.52 \times 10^{-4}$	CL=90%	—
$\eta K^*(892)^0 \bar{K}^*(892)^0$				
$\Sigma(1385)^0 \bar{\Lambda}$		$< 2 \times 10^{-4}$	CL=90%	912
$\Delta(1232)^+ \bar{p}$		$< 1 \times 10^{-4}$	CL=90%	1100

$\Theta(1540)\bar{\Theta}(1540) \rightarrow$	$< 1.1$	$\times 10^{-5}$	CL=90%	—
$K_S^0 p K^- \bar{n} + \text{c.c.}$				
$\Theta(1540) K^- \bar{n} \rightarrow K_S^0 p K^- \bar{n}$	$< 2.1$	$\times 10^{-5}$	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

### Decays into stable hadrons

$2(\pi^+ \pi^-) \pi^0$	( 5.5 ± 0.4 ) %			1496
$3(\pi^+ \pi^-) \pi^0$	( 2.9 ± 0.6 ) %			1433
$\pi^+ \pi^- \pi^0$	( 2.07 ± 0.12 ) %		S=1.6	1533
$\pi^+ \pi^- \pi^0 K^+ K^-$	( 1.94 ± 0.15 ) %			1368
$4(\pi^+ \pi^-) \pi^0$	( 9.0 ± 3.0 ) $\times 10^{-3}$			1345
$\pi^+ \pi^- K^+ K^-$	( 6.6 ± 0.5 ) $\times 10^{-3}$			1407
$\pi^+ \pi^- K^+ K^- \eta$	( 1.84 ± 0.28 ) $\times 10^{-3}$			1221
$\pi^0 \pi^0 K^+ K^-$	( 2.45 ± 0.31 ) $\times 10^{-3}$			1410
$K \bar{K} \pi$	( 6.1 ± 1.0 ) $\times 10^{-3}$			1442
$2(\pi^+ \pi^-)$	( 3.55 ± 0.23 ) $\times 10^{-3}$			1517
$3(\pi^+ \pi^-)$	( 4.3 ± 0.4 ) $\times 10^{-3}$			1466
$2(\pi^+ \pi^- \pi^0)$	( 1.61 ± 0.21 ) %			1468
$2(\pi^+ \pi^-) \eta$	( 2.29 ± 0.24 ) $\times 10^{-3}$			1446
$3(\pi^+ \pi^-) \eta$	( 7.2 ± 1.5 ) $\times 10^{-4}$			1379
$p \bar{p}$	( 2.17 ± 0.07 ) $\times 10^{-3}$			1232
$p \bar{p} \pi^0$	( 1.19 ± 0.08 ) $\times 10^{-3}$		S=1.1	1176
$p \bar{p} \pi^+ \pi^-$	( 6.0 ± 0.5 ) $\times 10^{-3}$		S=1.3	1107
$p \bar{p} \pi^+ \pi^- \pi^0$	[kkkk] ( 2.3 ± 0.9 ) $\times 10^{-3}$		S=1.9	1033
$p \bar{p} \eta$	( 2.00 ± 0.12 ) $\times 10^{-3}$			948
$p \bar{p} \rho$	$< 3.1$	$\times 10^{-4}$	CL=90%	774
$p \bar{p} \omega$	( 1.10 ± 0.15 ) $\times 10^{-3}$		S=1.3	768
$p \bar{p} \eta'(958)$	( 2.1 ± 0.4 ) $\times 10^{-4}$			596
$p \bar{p} \phi$	( 4.5 ± 1.5 ) $\times 10^{-5}$			527
$n \bar{n}$	( 2.2 ± 0.4 ) $\times 10^{-3}$			1231
$n \bar{n} \pi^+ \pi^-$	( 4 ± 4 ) $\times 10^{-3}$			1106
$\Sigma^+ \bar{\Sigma}^-$	( 1.50 ± 0.24 ) $\times 10^{-3}$			992
$\Sigma^0 \bar{\Sigma}^0$	( 1.29 ± 0.09 ) $\times 10^{-3}$			988
$2(\pi^+ \pi^-) K^+ K^-$	( 5.0 ± 0.5 ) $\times 10^{-3}$			1320
$p \bar{n} \pi^-$	( 2.12 ± 0.09 ) $\times 10^{-3}$			1174
$n N(1440)$	seen			978
$n N(1520)$	seen			924
$n N(1535)$	seen			914
$\Xi^- \bar{\Xi}^+$	( 8.5 ± 1.6 ) $\times 10^{-4}$		S=1.5	807
$\Lambda \bar{\Lambda}$	( 1.61 ± 0.15 ) $\times 10^{-3}$		S=2.0	1074
$\Lambda \bar{\Sigma}^- \pi^+$ (or c.c.)	[ee] ( 8.3 ± 0.7 ) $\times 10^{-4}$		S=1.2	950

$pK^-\bar{\Lambda}$	$( 8.9 \pm 1.6 ) \times 10^{-4}$		876
$2(K^+K^-)$	$( 7.6 \pm 0.9 ) \times 10^{-4}$		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
$K_S^0K_L^0$	$( 1.46 \pm 0.26 ) \times 10^{-4}$	S=2.7	1466
$\Lambda\Lambda\eta$	$( 2.6 \pm 0.7 ) \times 10^{-4}$		672
$\Lambda\bar{\Lambda}\pi^0$	$< 6.4$	$\times 10^{-5}$ CL=90%	998
$\bar{\Lambda}nK_S^0 + \text{c.c.}$	$( 6.5 \pm 1.1 ) \times 10^{-4}$		872
$\pi^+\pi^-$	$( 1.47 \pm 0.23 ) \times 10^{-4}$		1542
$\Lambda\bar{\Sigma} + \text{c.c.}$	$< 1.5$	$\times 10^{-4}$ CL=90%	1034
$K_S^0K_S^0$	$< 1$	$\times 10^{-6}$ CL=95%	1466

### Radiative decays

$3\gamma$	$( 1.2 \pm 0.4 ) \times 10^{-5}$		1548
$4\gamma$	$< 9$	$\times 10^{-6}$ CL=90%	1548
$5\gamma$	$< 1.5$	$\times 10^{-5}$ CL=90%	1548
$\gamma\eta_c(1S)$	$( 1.7 \pm 0.4 ) \%$	S=1.6	114
$\gamma\eta_c(1S) \rightarrow 3\gamma$	$( 1.2 \begin{smallmatrix} +2.7 \\ -1.1 \end{smallmatrix} ) \times 10^{-6}$		—
$\gamma\pi^+\pi^-2\pi^0$	$( 8.3 \pm 3.1 ) \times 10^{-3}$		1518
$\gamma\eta\pi\pi$	$( 6.1 \pm 1.0 ) \times 10^{-3}$		1487
$\gamma\eta_2(1870) \rightarrow \gamma\eta\pi^+\pi^-$	$( 6.2 \pm 2.4 ) \times 10^{-4}$		—
$\gamma\eta(1405/1475) \rightarrow \gamma K\bar{K}\pi$	[ $\eta$ ] $( 2.8 \pm 0.6 ) \times 10^{-3}$	S=1.6	1223
$\gamma\eta(1405/1475) \rightarrow \gamma\gamma\rho^0$	$( 7.8 \pm 2.0 ) \times 10^{-5}$	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
$\gamma\rho\omega$	$< 5.4$	$\times 10^{-4}$ CL=90%	1338
$\gamma\rho\phi$	$< 8.8$	$\times 10^{-5}$ CL=90%	1258
$\gamma\eta'(958)$	$( 5.16 \pm 0.15 ) \times 10^{-3}$	S=1.1	1400
$\gamma 2\pi^+2\pi^-$	$( 2.8 \pm 0.5 ) \times 10^{-3}$	S=1.9	1517
$\gamma f_2(1270) f_2(1270)$	$( 9.5 \pm 1.7 ) \times 10^{-4}$		879
$\gamma f_2(1270) f_2(1270)$ (non resonant)	$( 8.2 \pm 1.9 ) \times 10^{-4}$		—
$\gamma K^+K^-\pi^+\pi^-$	$( 2.1 \pm 0.6 ) \times 10^{-3}$		1407
$\gamma f_4(2050)$	$( 2.7 \pm 0.7 ) \times 10^{-3}$		891
$\gamma\omega\omega$	$( 1.61 \pm 0.33 ) \times 10^{-3}$		1336
$\gamma\eta(1405/1475) \rightarrow \gamma\rho^0\rho^0$	$( 1.7 \pm 0.4 ) \times 10^{-3}$	S=1.3	1223
$\gamma f_2(1270)$	$( 1.43 \pm 0.11 ) \times 10^{-3}$		1286
$\gamma f_0(1710) \rightarrow \gamma K\bar{K}$	$( 8.5 \begin{smallmatrix} +1.2 \\ -0.9 \end{smallmatrix} ) \times 10^{-4}$	S=1.2	1075
$\gamma f_0(1710) \rightarrow \gamma\pi\pi$	$( 4.0 \pm 1.0 ) \times 10^{-4}$		—
$\gamma f_0(1710) \rightarrow \gamma\omega\omega$	$( 3.1 \pm 1.0 ) \times 10^{-4}$		—
$\gamma\eta$	$( 1.104 \pm 0.034 ) \times 10^{-3}$		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
$\gamma f_1(1510) \rightarrow \gamma \eta \pi^+ \pi^-$	$( 4.5 \pm 1.2 ) \times 10^{-4}$		—
$\gamma f_2'(1525)$	$( 4.5 \begin{smallmatrix} +0.7 \\ -0.4 \end{smallmatrix} ) \times 10^{-4}$		1173
$\gamma f_2(1640) \rightarrow \gamma \omega \omega$	$( 2.8 \pm 1.8 ) \times 10^{-4}$		—
$\gamma f_2(1910) \rightarrow \gamma \omega \omega$	$( 2.0 \pm 1.4 ) \times 10^{-4}$		—
$\gamma f_2(1950) \rightarrow$ $\gamma K^*(892) \bar{K}^*(892)$	$( 7.0 \pm 2.2 ) \times 10^{-4}$		—
$\gamma K^*(892) \bar{K}^*(892)$	$( 4.0 \pm 1.3 ) \times 10^{-3}$		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
$\gamma \eta(2225)$	$( 3.3 \pm 0.5 ) \times 10^{-4}$		749
$\gamma \eta(1760) \rightarrow \gamma \rho^0 \rho^0$	$( 1.3 \pm 0.9 ) \times 10^{-4}$		1048
$\gamma \eta(1760) \rightarrow \gamma \omega \omega$	$( 1.98 \pm 0.33 ) \times 10^{-3}$		—
$\gamma X(1835) \rightarrow \gamma \pi^+ \pi^- \eta'$	$( 2.6 \pm 0.4 ) \times 10^{-4}$		1006
$\gamma X(1835) \rightarrow \gamma p \bar{p}$	$( 7.5 \begin{smallmatrix} +1.9 \\ -0.9 \end{smallmatrix} ) \times 10^{-5}$		—
$\gamma (K \bar{K} \pi) [J^{PC} = 0^{-+}]$	$( 7 \pm 4 ) \times 10^{-4}$	S=2.1	1442
$\gamma \pi^0$	$( 3.49 \begin{smallmatrix} +0.33 \\ -0.30 \end{smallmatrix} ) \times 10^{-5}$		1546
$\gamma p \bar{p} \pi^+ \pi^-$	$< 7.9 \times 10^{-4}$	CL=90%	1107
$\gamma \Lambda \bar{\Lambda}$	$< 1.3 \times 10^{-4}$	CL=90%	1074
$\gamma f_J(2220)$	$> 2.50 \times 10^{-3}$	CL=99.9%	745
$\gamma f_J(2220) \rightarrow \gamma \pi \pi$	$( 8 \pm 4 ) \times 10^{-5}$		—
$\gamma f_J(2220) \rightarrow \gamma K \bar{K}$	$< 3.6 \times 10^{-5}$		—
$\gamma f_J(2220) \rightarrow \gamma p \bar{p}$	$( 1.5 \pm 0.8 ) \times 10^{-5}$		—
$\gamma f_0(1500)$	$( 1.01 \pm 0.32 ) \times 10^{-4}$		1183
$\gamma A \rightarrow \gamma \text{invisible}$	$[////] < 6.3 \times 10^{-6}$	CL=90%	—

### Weak decays

$D^- e^+ \nu_e + \text{c.c.}$	$< 1.2 \times 10^{-5}$	CL=90%	984
$\bar{D}^0 e^+ e^- + \text{c.c.}$	$< 1.1 \times 10^{-5}$	CL=90%	987
$D_s^- e^+ \nu_e + \text{c.c.}$	$< 3.6 \times 10^{-5}$	CL=90%	923
$D_s^- \pi^+ + \text{c.c.}$	$< 7.5 \times 10^{-5}$	CL=90%	977
$\bar{D}^0 \bar{K}^0 + \text{c.c.}$	$< 1.7 \times 10^{-4}$	CL=90%	898
$D_s^- \pi^+ + \text{c.c.}$	$< 1.3 \times 10^{-4}$	CL=90%	915

### Charge conjugation (C), Parity (P), Lepton Family number (LF) violating modes

$\gamma \gamma$	C	$< 5 \times 10^{-6}$	CL=90%	1548
$e^\pm \mu^\mp$	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

### Other decays

invisible  $< 7 \times 10^{-4}$  CL=90% -

**$\chi_{c0}(1P)$**

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

Mass  $m = 3414.75 \pm 0.31$  MeV

Full width  $\Gamma = 10.4 \pm 0.6$  MeV

$\chi_{c0}(1P)$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	Scale factor/ Confidence level	$\rho$ (MeV/c)
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#### Hadronic decays

$2(\pi^+\pi^-)$	$(2.26 \pm 0.19) \%$		1679
$\rho^0\pi^+\pi^-$	$(8.8 \pm 2.8) \times 10^{-3}$		1607
$f_0(980)f_0(980)$	$(6.7 \pm 2.1) \times 10^{-4}$		1398
$\pi^+\pi^-\pi^0\pi^0$	$(3.4 \pm 0.4) \%$		1680
$\rho^+\pi^-\pi^0 + \text{c.c.}$	$(2.9 \pm 0.4) \%$		1607
$4\pi^0$	$(3.3 \pm 0.4) \times 10^{-3}$		1681
$\pi^+\pi^-K^+K^-$	$(1.79 \pm 0.15) \%$		1580
$K_0^*(1430)^0\bar{K}_0^*(1430)^0 \rightarrow \pi^+\pi^-K^+K^-$	$(9.9 \begin{smallmatrix} +4.0 \\ -2.9 \end{smallmatrix}) \times 10^{-4}$		-
$K_0^*(1430)^0\bar{K}_2^*(1430)^0 + \text{c.c.} \rightarrow \pi^+\pi^-K^+K^-$	$(8.1 \begin{smallmatrix} +2.0 \\ -2.4 \end{smallmatrix}) \times 10^{-4}$		-
$K_1(1270)^+K^- + \text{c.c.} \rightarrow \pi^+\pi^-K^+K^-$	$(6.3 \pm 1.9) \times 10^{-3}$		-
$K_1(1400)^+K^- + \text{c.c.} \rightarrow \pi^+\pi^-K^+K^-$	$< 2.7 \times 10^{-3}$	CL=90%	-
$f_0(980)f_0(980)$	$(1.6 \begin{smallmatrix} +1.1 \\ -0.9 \end{smallmatrix}) \times 10^{-4}$		1398
$f_0(980)f_0(2200)$	$(8.0 \begin{smallmatrix} +2.0 \\ -2.5 \end{smallmatrix}) \times 10^{-4}$		595
$f_0(1370)f_0(1370)$	$< 2.8 \times 10^{-4}$	CL=90%	1019
$f_0(1370)f_0(1500)$	$< 1.7 \times 10^{-4}$	CL=90%	920
$f_0(1370)f_0(1710)$	$(6.8 \begin{smallmatrix} +4.0 \\ -2.4 \end{smallmatrix}) \times 10^{-4}$		723
$f_0(1500)f_0(1370)$	$< 1.3 \times 10^{-4}$	CL=90%	920
$f_0(1500)f_0(1500)$	$< 5 \times 10^{-5}$	CL=90%	805
$f_0(1500)f_0(1710)$	$< 7 \times 10^{-5}$	CL=90%	559
$K^+K^-\pi^0\pi^0$	$(5.6 \pm 0.9) \times 10^{-3}$		1582
$K^+\pi^-K^0\pi^0 + \text{c.c.}$	$(2.52 \pm 0.34) \%$		1581
$\rho^+K^-K^0 + \text{c.c.}$	$(1.22 \pm 0.21) \%$		1458
$K^*(892)^-K^+\pi^0 \rightarrow K^+\pi^-K^0\pi^0 + \text{c.c.}$	$(4.7 \pm 1.2) \times 10^{-3}$		-
$K_S^0K_S^0\pi^+\pi^-$	$(5.8 \pm 1.1) \times 10^{-3}$		1579
$K^+K^-\eta\pi^0$	$(3.0 \pm 0.7) \times 10^{-3}$		1468
$3(\pi^+\pi^-)$	$(1.20 \pm 0.18) \%$		1633

$K^+ \bar{K}^*(892)^0 \pi^- + \text{c.c.}$	$(7.3 \pm 1.6) \times 10^{-3}$		1523
$K^*(892)^0 \bar{K}^*(892)^0$	$(1.7 \pm 0.6) \times 10^{-3}$		1456
$\pi \pi$	$(8.5 \pm 0.4) \times 10^{-3}$		1702
$\pi^0 \eta$	$< 1.8 \times 10^{-4}$		1661
$\pi^0 \eta'$	$< 1.1 \times 10^{-3}$		1570
$\eta \eta$	$(3.03 \pm 0.21) \times 10^{-3}$		1617
$\eta \eta'$	$< 2.4 \times 10^{-4}$	CL=90%	1521
$\eta' \eta'$	$(2.02 \pm 0.22) \times 10^{-3}$		1413
$\omega \omega$	$(2.2 \pm 0.7) \times 10^{-3}$		1517
$K^+ K^-$	$(6.06 \pm 0.35) \times 10^{-3}$		1634
$K_S^0 K_S^0$	$(3.15 \pm 0.18) \times 10^{-3}$		1633
$\pi^+ \pi^- \eta$	$< 2.0 \times 10^{-4}$	CL=90%	1651
$\pi^+ \pi^- \eta'$	$< 4 \times 10^{-4}$	CL=90%	1560
$\bar{K}^0 K^+ \pi^- + \text{c.c.}$	$< 1.0 \times 10^{-4}$	CL=90%	1610
$K^+ K^- \pi^0$	$< 6 \times 10^{-5}$	CL=90%	1611
$K^+ K^- \eta$	$< 2.3 \times 10^{-4}$	CL=90%	1512
$K^+ K^- K_S^0 K_S^0$	$(1.4 \pm 0.5) \times 10^{-3}$		1331
$K^+ K^- K^+ K^-$	$(2.79 \pm 0.29) \times 10^{-3}$		1333
$K^+ K^- \phi$	$(9.8 \pm 2.5) \times 10^{-4}$		1381
$\phi \phi$	$(9.1 \pm 1.9) \times 10^{-4}$		1370
$p \bar{p}$	$(2.23 \pm 0.13) \times 10^{-4}$		1426
$p \bar{p} \pi^0$	$(7.0 \pm 0.7) \times 10^{-4}$	S=1.2	1379
$p \bar{p} \eta$	$(3.6 \pm 0.4) \times 10^{-4}$		1187
$p \bar{p} \omega$	$(5.3 \pm 0.6) \times 10^{-4}$		1043
$\pi^+ \pi^- p \bar{p}$	$(2.1 \pm 0.7) \times 10^{-3}$	S=1.4	1320
$\pi^0 \pi^0 p \bar{p}$	$(1.05 \pm 0.28) \times 10^{-3}$		1324
$K_S^0 K_S^0 p \bar{p}$	$< 8.8 \times 10^{-4}$	CL=90%	884
$p \bar{n} \pi^-$	$(1.14 \pm 0.31) \times 10^{-3}$		1376
$\Lambda \bar{\Lambda}$	$(3.3 \pm 0.4) \times 10^{-4}$		1292
$\Lambda \bar{\Lambda} \pi^+ \pi^-$	$< 4.0 \times 10^{-3}$	CL=90%	1153
$K^+ \bar{p} \Lambda + \text{c.c.}$	$(1.02 \pm 0.19) \times 10^{-3}$		1132
$\Sigma^0 \bar{\Sigma}^0$	$(4.2 \pm 0.7) \times 10^{-4}$		1222
$\Sigma^+ \bar{\Sigma}^-$	$(3.1 \pm 0.7) \times 10^{-4}$		1225
$\Xi^0 \bar{\Xi}^0$	$(3.2 \pm 0.8) \times 10^{-4}$		1089
$\Xi^- \bar{\Xi}^+$	$(4.9 \pm 0.7) \times 10^{-4}$		1081

### Radiative decays

$\gamma J/\psi(1S)$	$(1.17 \pm 0.08) \%$		303
$\gamma \rho^0$	$< 9 \times 10^{-6}$	CL=90%	1619
$\gamma \omega$	$< 8 \times 10^{-6}$	CL=90%	1618
$\gamma \phi$	$< 6 \times 10^{-6}$	CL=90%	1555
$\gamma \gamma$	$(2.23 \pm 0.17) \times 10^{-4}$		1707

**$\chi_{c1}(1P)$**

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

Mass  $m = 3510.66 \pm 0.07$  MeV (S = 1.5)

Full width  $\Gamma = 0.86 \pm 0.05$  MeV

$\chi_{c1}(1P)$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	Scale factor/ Confidence level	$p$ (MeV/c)
<b>Hadronic decays</b>			
$3(\pi^+\pi^-)$	$(5.8 \pm 1.4) \times 10^{-3}$	S=1.2	1683
$2(\pi^+\pi^-)$	$(7.6 \pm 2.6) \times 10^{-3}$		1728
$\pi^+\pi^-\pi^0\pi^0$	$(1.26 \pm 0.17) \%$		1729
$\rho^+\pi^-\pi^0 + \text{c.c.}$	$(1.53 \pm 0.26) \%$		1658
$\rho^0\pi^+\pi^-$	$(3.9 \pm 3.5) \times 10^{-3}$		1657
$4\pi^0$	$(5.7 \pm 0.8) \times 10^{-4}$		1729
$\pi^+\pi^-K^+K^-$	$(4.5 \pm 1.0) \times 10^{-3}$		1632
$K^+K^-\pi^0\pi^0$	$(1.18 \pm 0.29) \times 10^{-3}$		1634
$K^+\pi^-K^0\pi^0 + \text{c.c.}$	$(9.0 \pm 1.5) \times 10^{-3}$		1632
$\rho^+K^-K^0 + \text{c.c.}$	$(5.3 \pm 1.3) \times 10^{-3}$		1514
$K^*(892)^0K^0\pi^0 \rightarrow$ $K^+\pi^-K^0\pi^0 + \text{c.c.}$	$(2.5 \pm 0.7) \times 10^{-3}$		—
$K^+K^-\eta\pi^0$	$(1.2 \pm 0.4) \times 10^{-3}$		1523
$\pi^+\pi^-K_S^0K_S^0$	$(7.2 \pm 3.1) \times 10^{-4}$		1630
$K^+K^-\eta$	$(3.3 \pm 1.0) \times 10^{-4}$		1566
$K^0K^+\pi^- + \text{c.c.}$	$(7.3 \pm 0.6) \times 10^{-3}$		1661
$K^*(892)^0\bar{K}^0 + \text{c.c.}$	$(1.0 \pm 0.4) \times 10^{-3}$		1602
$K^*(892)^+K^- + \text{c.c.}$	$(1.5 \pm 0.7) \times 10^{-3}$		1602
$K_J^*(1430)^0\bar{K}^0 + \text{c.c.} \rightarrow$ $K_S^0K^+\pi^- + \text{c.c.}$	$< 8 \times 10^{-4}$	CL=90%	—
$K_J^*(1430)^+K^- + \text{c.c.} \rightarrow$ $K_S^0K^+\pi^- + \text{c.c.}$	$< 2.3 \times 10^{-3}$	CL=90%	—
$K^+K^-\pi^0$	$(1.91 \pm 0.26) \times 10^{-3}$		1662
$\eta\pi^+\pi^-$	$(5.0 \pm 0.5) \times 10^{-3}$		1701
$a_0(980)^+\pi^- + \text{c.c.} \rightarrow \eta\pi^+\pi^-$	$(1.9 \pm 0.7) \times 10^{-3}$		—
$f_2(1270)\eta$	$(2.8 \pm 0.8) \times 10^{-3}$		1468
$\pi^+\pi^-\eta'$	$(2.4 \pm 0.5) \times 10^{-3}$		1612
$K^+\bar{K}^*(892)^0\pi^- + \text{c.c.}$	$(3.2 \pm 2.1) \times 10^{-3}$		1577
$K^*(892)^0\bar{K}^*(892)^0$	$(1.5 \pm 0.4) \times 10^{-3}$		1512
$K^+K^-\bar{K}_S^0K_S^0$	$< 5 \times 10^{-4}$	CL=90%	1390
$K^+K^-\bar{K}^+K^-$	$(5.6 \pm 1.2) \times 10^{-4}$		1393
$K^+K^-\phi$	$(4.3 \pm 1.6) \times 10^{-4}$		1440
$p\bar{p}$	$(7.3 \pm 0.4) \times 10^{-5}$		1484
$p\bar{p}\pi^0$	$(1.64 \pm 0.20) \times 10^{-4}$		1438
$p\bar{p}\eta$	$(1.53 \pm 0.26) \times 10^{-4}$		1254

$p\bar{p}\omega$	$(2.24 \pm 0.33) \times 10^{-4}$		1117
$\pi^+\pi^-\rho\bar{\rho}$	$(5.0 \pm 1.9) \times 10^{-4}$		1381
$K_S^0 K_S^0 p\bar{p}$	$< 4.5 \times 10^{-4}$	CL=90%	968
$\Lambda\bar{\Lambda}$	$(1.18 \pm 0.19) \times 10^{-4}$		1355
$\Lambda\bar{\Lambda}\pi^+\pi^-$	$< 1.5 \times 10^{-3}$	CL=90%	1223
$K^+\bar{p}\Lambda$	$(3.2 \pm 1.0) \times 10^{-4}$		1203
$\Sigma^0\bar{\Sigma}^0$	$< 4 \times 10^{-5}$	CL=90%	1288
$\Sigma^+\bar{\Sigma}^-$	$< 6 \times 10^{-5}$	CL=90%	1291
$\Xi^0\bar{\Xi}^0$	$< 6 \times 10^{-5}$	CL=90%	1163
$\Xi^-\bar{\Xi}^+$	$(8.4 \pm 2.3) \times 10^{-5}$		1155
$\pi^+\pi^- + K^+K^-$	$< 2.1 \times 10^{-3}$		—
$K_S^0 K_S^0$	$< 6 \times 10^{-5}$	CL=90%	1683

### Radiative decays

$\gamma J/\psi(1S)$	$(34.4 \pm 1.5) \%$		389
$\gamma\rho^0$	$(2.29 \pm 0.27) \times 10^{-4}$		1670
$\gamma\omega$	$(7.8 \pm 1.8) \times 10^{-5}$		1668
$\gamma\phi$	$< 2.4 \times 10^{-5}$	CL=90%	1607

## $h_c(1P)$

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

Mass  $m = 3525.41 \pm 0.16$  MeV (S = 1.2)

Full width  $\Gamma < 1$  MeV

$h_c(1P)$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$J/\psi(1S)\pi\pi$	not seen	312
$\eta_c(1S)\gamma$	$(53 \pm 7) \%$	503
$\pi^+\pi^-\pi^0$	$< 2.3 \times 10^{-3}$	1749
$2\pi^+2\pi^-\pi^0$	$(2.2^{+0.9}_{-0.8}) \%$	1716
$3\pi^+3\pi^-\pi^0$	$< 3.0 \%$	1661

## $\chi_{c2}(1P)$

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

Mass  $m = 3556.20 \pm 0.09$  MeV

Full width  $\Gamma = 1.97 \pm 0.11$  MeV



$\chi_{c2}(1P)$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	Confidence level	$\rho$ (MeV/c)
<b>Hadronic decays</b>			
$2(\pi^+\pi^-)$	( 1.11±0.11 ) %		1751
$\pi^+\pi^-\pi^0\pi^0$	( 1.99±0.26 ) %		1752
$\rho^+\pi^-\pi^0 + \text{c.c.}$	( 2.4 ±0.4 ) %		1682
$4\pi^0$	( 1.21±0.17 ) × 10 <sup>-3</sup>		1752
$K^+K^-\pi^0\pi^0$	( 2.2 ±0.4 ) × 10 <sup>-3</sup>		1658
$K^+\pi^-K^0\pi^0 + \text{c.c.}$	( 1.50±0.22 ) %		1657
$\rho^+K^-K^0 + \text{c.c.}$	( 4.5 ±1.4 ) × 10 <sup>-3</sup>		1540
$K^*(892)^0K^+\pi^- \rightarrow$ $K^+\pi^-K^0\pi^0 + \text{c.c.}$	( 3.2 ±0.9 ) × 10 <sup>-3</sup>		—
$K^*(892)^0K^0\pi^0 \rightarrow$ $K^+\pi^-K^0\pi^0 + \text{c.c.}$	( 4.2 ±0.9 ) × 10 <sup>-3</sup>		—
$K^*(892)^-K^+\pi^0 \rightarrow$ $K^+\pi^-K^0\pi^0 + \text{c.c.}$	( 4.1 ±0.9 ) × 10 <sup>-3</sup>		—
$K^*(892)^+K^0\pi^- \rightarrow$ $K^+\pi^-K^0\pi^0 + \text{c.c.}$	( 3.2 ±0.9 ) × 10 <sup>-3</sup>		—
$K^+K^-\eta\pi^0$	( 1.4 ±0.5 ) × 10 <sup>-3</sup>		1549
$\pi^+\pi^-K^+K^-$	( 9.2 ±1.1 ) × 10 <sup>-3</sup>		1656
$K^+\bar{K}^*(892)^0\pi^- + \text{c.c.}$	( 2.3 ±1.2 ) × 10 <sup>-3</sup>		1602
$K^*(892)^0\bar{K}^*(892)^0$	( 2.5 ±0.5 ) × 10 <sup>-3</sup>		1538
$3(\pi^+\pi^-)$	( 8.6 ±1.8 ) × 10 <sup>-3</sup>		1707
$\phi\phi$	( 1.48±0.28 ) × 10 <sup>-3</sup>		1457
$\omega\omega$	( 1.9 ±0.6 ) × 10 <sup>-3</sup>		1597
$\pi\pi$	( 2.42±0.13 ) × 10 <sup>-3</sup>		1773
$\rho^0\pi^+\pi^-$	( 4.0 ±1.7 ) × 10 <sup>-3</sup>		1681
$\pi^+\pi^-\eta$	( 5.2 ±1.4 ) × 10 <sup>-4</sup>		1724
$\pi^+\pi^-\eta'$	( 5.4 ±2.0 ) × 10 <sup>-4</sup>		1636
$\eta\eta$	( 5.9 ±0.5 ) × 10 <sup>-4</sup>		1692
$K^+K^-$	( 1.09±0.08 ) × 10 <sup>-3</sup>		1708
$K_S^0K_S^0$	( 5.8 ±0.5 ) × 10 <sup>-4</sup>		1707
$\bar{K}^0K^+\pi^- + \text{c.c.}$	( 1.32±0.20 ) × 10 <sup>-3</sup>		1685
$K^+K^-\pi^0$	( 3.3 ±0.8 ) × 10 <sup>-4</sup>		1686
$K^+K^-\eta$	< 3.5 × 10 <sup>-4</sup>	90%	1592
$\eta\eta'$	< 6 × 10 <sup>-5</sup>	90%	1600
$\eta'\eta'$	< 1.1 × 10 <sup>-4</sup>	90%	1498
$\pi^+\pi^-K_S^0K_S^0$	( 2.4 ±0.6 ) × 10 <sup>-3</sup>		1655
$K^+K^-K_S^0K_S^0$	< 4 × 10 <sup>-4</sup>	90%	1418
$K^+K^-K^+K^-$	( 1.78±0.22 ) × 10 <sup>-3</sup>		1421
$K^+K^-\phi$	( 1.55±0.32 ) × 10 <sup>-3</sup>		1468
$K_S^0K_S^0p\bar{p}$	< 7.9 × 10 <sup>-4</sup>	90%	1007
$p\bar{p}$	( 7.2 ±0.4 ) × 10 <sup>-5</sup>		1510

$p\bar{p}\pi^0$	$( 5.1 \pm 0.5 ) \times 10^{-4}$		1465
$p\bar{p}\eta$	$( 1.90 \pm 0.28 ) \times 10^{-4}$		1285
$p\bar{p}\omega$	$( 3.9 \pm 0.5 ) \times 10^{-4}$		1152
$\pi^+\pi^-\rho\bar{p}$	$( 1.32 \pm 0.34 ) \times 10^{-3}$		1410
$\pi^0\pi^0\rho\bar{p}$	$( 8.5 \pm 2.6 ) \times 10^{-4}$		1414
$p\bar{n}\pi^-$	$( 1.1 \pm 0.4 ) \times 10^{-3}$		1463
$\Lambda\bar{\Lambda}$	$( 1.86 \pm 0.27 ) \times 10^{-4}$		1385
$\Lambda\bar{\Lambda}\pi^+\pi^-$	$< 3.5 \times 10^{-3}$	90%	1255
$K^+\bar{p}\Lambda + \text{c.c.}$	$( 9.1 \pm 1.8 ) \times 10^{-4}$		1236
$\Sigma^0\bar{\Sigma}^0$	$< 8 \times 10^{-5}$	90%	1319
$\Sigma^+\bar{\Sigma}^-$	$< 7 \times 10^{-5}$	90%	1322
$\Xi^0\bar{\Xi}^0$	$< 1.1 \times 10^{-4}$	90%	1197
$\Xi^-\bar{\Xi}^+$	$( 1.55 \pm 0.35 ) \times 10^{-4}$		1189
$J/\psi(1S)\pi^+\pi^-\pi^0$	$< 1.5 \%$	90%	185

### Radiative decays

$\gamma J/\psi(1S)$	$(19.5 \pm 0.8) \%$		430
$\gamma\rho^0$	$< 5 \times 10^{-5}$	90%	1694
$\gamma\omega$	$< 6 \times 10^{-6}$	90%	1692
$\gamma\phi$	$< 1.2 \times 10^{-5}$	90%	1632
$\gamma\gamma$	$( 2.56 \pm 0.16 ) \times 10^{-4}$		1778

**$\eta_c(2S)$**

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

Quantum numbers are quark model predictions.

Mass  $m = 3637 \pm 4$  MeV ( $S = 1.7$ )

Full width  $\Gamma = 14 \pm 7$  MeV

$\eta_c(2S)$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	Confidence level	$\rho$ (MeV/c)
hadrons	not seen		—
$K\bar{K}\pi$	$(1.9 \pm 1.2) \%$		1729
$2\pi^+ 2\pi^-$	not seen		1792
$3\pi^+ 3\pi^-$	not seen		1749
$K^+ K^- \pi^+ \pi^-$	not seen		1700
$K^+ K^- \pi^+ \pi^- \pi^0$	not seen		1667
$K^+ K^- 2\pi^+ 2\pi^-$	not seen		1627
$K_S^0 K^- 2\pi^+ \pi^- + \text{c.c.}$	not seen		1666
$2K^+ 2K^-$	not seen		1470
$p\bar{p}$	not seen		1558
$\gamma\gamma$	$< 5 \times 10^{-4}$	90%	1819
$\pi^+ \pi^- \eta$	not seen		1766
$\pi^+ \pi^- \eta'$	not seen		1680
$K^+ K^- \eta$	not seen		1637
$\pi^+ \pi^- \eta_c(1S)$	not seen		541

## $\psi(2S)$

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

Mass  $m = 3686.09 \pm 0.04$  MeV (S = 1.6)

Full width  $\Gamma = 304 \pm 9$  keV

$\Gamma_{ee} = 2.35 \pm 0.04$  keV

$\psi(2S)$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	Scale factor/ Confidence level	$\rho$ (MeV/c)
hadrons	$(97.85 \pm 0.13) \%$		—
virtual $\gamma \rightarrow$ hadrons	$(1.73 \pm 0.14) \%$	S=1.5	—
$ggg$	$(10.6 \pm 1.6) \%$		—
$\gamma gg$	$(1.03 \pm 0.29) \%$		—
light hadrons	$(15.4 \pm 1.5) \%$		—
$e^+ e^-$	$(7.73 \pm 0.17) \times 10^{-3}$		1843
$\mu^+ \mu^-$	$(7.7 \pm 0.8) \times 10^{-3}$		1840
$\tau^+ \tau^-$	$(3.0 \pm 0.4) \times 10^{-3}$		490

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

$J/\psi(1S)$ anything	$(59.5 \pm 0.8) \%$		—
$J/\psi(1S)$ neutrals	$(24.6 \pm 0.4) \%$		—
$J/\psi(1S) \pi^+ \pi^-$	$(33.6 \pm 0.4) \%$		477
$J/\psi(1S) \pi^0 \pi^0$	$(17.76 \pm 0.34) \%$		481
$J/\psi(1S) \eta$	$(3.28 \pm 0.07) \%$		199
$J/\psi(1S) \pi^0$	$(1.30 \pm 0.10) \times 10^{-3}$	S=1.4	528

### Hadronic decays

$\pi^0 h_c(1P)$	$( 8.4 \pm 1.6 ) \times 10^{-4}$		85
$3(\pi^+ \pi^-) \pi^0$	$( 3.5 \pm 1.6 ) \times 10^{-3}$		1746
$2(\pi^+ \pi^-) \pi^0$	$( 2.9 \pm 1.0 ) \times 10^{-3}$	S=4.6	1799
$\rho a_2(1320)$	$( 2.6 \pm 0.9 ) \times 10^{-4}$		1500
$p \bar{p}$	$( 2.76 \pm 0.12 ) \times 10^{-4}$		1586
$\Delta^{++} \bar{\Delta}^{--}$	$( 1.28 \pm 0.35 ) \times 10^{-4}$		1371
$\Lambda \bar{\Lambda} \pi^0$	$< 1.2 \times 10^{-4}$	CL=90%	1412
$\Lambda \bar{\Lambda} \eta$	$< 4.9 \times 10^{-5}$	CL=90%	1197
$\Lambda \bar{p} K^+$	$( 1.00 \pm 0.14 ) \times 10^{-4}$		1327
$\Lambda \bar{p} K^+ \pi^+ \pi^-$	$( 1.8 \pm 0.4 ) \times 10^{-4}$		1167
$\Lambda \bar{\Lambda} \pi^+ \pi^-$	$( 2.8 \pm 0.6 ) \times 10^{-4}$		1346
$\Lambda \bar{\Lambda}$	$( 2.8 \pm 0.5 ) \times 10^{-4}$	S=2.6	1467
$\Sigma^+ \bar{\Sigma}^-$	$( 2.6 \pm 0.8 ) \times 10^{-4}$		1408
$\Sigma^0 \bar{\Sigma}^0$	$( 2.2 \pm 0.4 ) \times 10^{-4}$	S=1.5	1405
$\Sigma(1385)^+ \bar{\Sigma}(1385)^-$	$( 1.1 \pm 0.4 ) \times 10^{-4}$		1218
$\Xi^- \bar{\Xi}^+$	$( 1.8 \pm 0.6 ) \times 10^{-4}$	S=2.8	1284
$\Xi^0 \bar{\Xi}^0$	$( 2.8 \pm 0.9 ) \times 10^{-4}$		1291
$\Xi(1530)^0 \bar{\Xi}(1530)^0$	$< 8.1 \times 10^{-5}$	CL=90%	1025
$\Omega^- \bar{\Omega}^+$	$< 7.3 \times 10^{-5}$	CL=90%	774
$\pi^0 p \bar{p}$	$( 1.50 \pm 0.08 ) \times 10^{-4}$	S=1.1	1543
$N_1^*(1440) \bar{p} \rightarrow \pi^0 p \bar{p}$	$( 8.1 \pm 0.8 ) \times 10^{-5}$		—
$\pi^0 f_0(2100) \rightarrow \pi^0 p \bar{p}$	$( 1.1 \pm 0.4 ) \times 10^{-5}$		—
$\eta p \bar{p}$	$( 5.7 \pm 0.6 ) \times 10^{-5}$		1373
$\eta f_0(2100) \rightarrow \eta p \bar{p}$	$( 1.2 \pm 0.4 ) \times 10^{-5}$		—
$N^*(1535) \bar{p} \rightarrow \eta p \bar{p}$	$( 4.4 \pm 0.7 ) \times 10^{-5}$		—
$\omega p \bar{p}$	$( 6.9 \pm 2.1 ) \times 10^{-5}$		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
$p \bar{n} \pi^-$ or c.c.	$( 2.48 \pm 0.17 ) \times 10^{-4}$		—
$p \bar{n} \pi^- \pi^0$	$( 3.2 \pm 0.7 ) \times 10^{-4}$		1492
$2(\pi^+ \pi^- \pi^0)$	$( 4.8 \pm 1.5 ) \times 10^{-3}$		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
$2(\pi^+ \pi^-) \eta$	$( 1.2 \pm 0.6 ) \times 10^{-3}$		1758
$\eta' \pi^+ \pi^- \pi^0$	$( 4.5 \pm 2.1 ) \times 10^{-4}$		1692
$\omega \pi^+ \pi^-$	$( 7.3 \pm 1.2 ) \times 10^{-4}$	S=2.1	1748
$b_1^\pm \pi^\mp$	$( 4.0 \pm 0.6 ) \times 10^{-4}$	S=1.1	1635
$b_1^0 \pi^0$	$( 2.4 \pm 0.6 ) \times 10^{-4}$		—
$\omega f_2(1270)$	$( 2.2 \pm 0.4 ) \times 10^{-4}$		1515
$\pi^+ \pi^- K^+ K^-$	$( 7.5 \pm 0.9 ) \times 10^{-4}$	S=1.9	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
$K^+ K^- \pi^+ \pi^- \eta$	$( 1.3 \pm 0.7 ) \times 10^{-3}$		1574

$K^+ K^- 2(\pi^+ \pi^-) \pi^0$	$(1.00 \pm 0.31) \times 10^{-3}$		1611
$K^+ K^- 2(\pi^+ \pi^-)$	$(1.9 \pm 0.9) \times 10^{-3}$		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
$\rho^0 \rho \bar{\rho}$	$(5.0 \pm 2.2) \times 10^{-5}$		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
$K^+ K^- \pi^+ \pi^- \pi^0$	$(1.26 \pm 0.09) \times 10^{-3}$		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
$\rho \bar{\rho} \pi^+ \pi^- \pi^0$	$(7.3 \pm 0.7) \times 10^{-4}$		1435
$K^+ K^-$	$(6.3 \pm 0.7) \times 10^{-5}$		1776
$K_S^0 K_L^0$	$(5.4 \pm 0.5) \times 10^{-5}$		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
$K^+ \bar{K}^*(892)^- + \text{c.c.}$	$(1.7 \pm_{-0.7}^{+0.8}) \times 10^{-5}$		1698
$K^*(892)^0 \bar{K}^0 + \text{c.c.}$	$(1.09 \pm 0.20) \times 10^{-4}$		1697
$\phi \pi^+ \pi^-$	$(1.17 \pm 0.29) \times 10^{-4}$	S=1.7	1690
$\phi f_0(980) \rightarrow \pi^+ \pi^-$	$(6.8 \pm 2.5) \times 10^{-5}$	S=1.1	—
$2(K^+ K^-)$	$(6.0 \pm 1.4) \times 10^{-5}$		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
$\phi \eta$	$(2.8 \pm_{-0.8}^{+1.0}) \times 10^{-5}$		1654
$\phi \eta'$	$(3.1 \pm 1.6) \times 10^{-5}$		1555
$\omega \eta'$	$(3.2 \pm_{-2.1}^{+2.5}) \times 10^{-5}$		1623
$\omega \pi^0$	$(2.1 \pm 0.6) \times 10^{-5}$		1757
$\rho \eta'$	$(1.9 \pm_{-1.2}^{+1.7}) \times 10^{-5}$		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

$\eta_c \pi^+ \pi^- \pi^0$	$< 1.0 \times 10^{-3}$	CL=90%	—
$p\bar{p}K^+K^-$	$(2.7 \pm 0.7) \times 10^{-5}$		1118
$\Lambda n K_S^0 + \text{c.c.}$	$(8.1 \pm 1.8) \times 10^{-5}$		1324
$\phi f_2'(1525)$	$(4.4 \pm 1.6) \times 10^{-5}$		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

$\gamma \chi_{c0}(1P)$	$(9.68 \pm 0.31) \%$		261
$\gamma \chi_{c1}(1P)$	$(9.2 \pm 0.4) \%$		171
$\gamma \chi_{c2}(1P)$	$(8.75 \pm 0.35) \%$		128
$\gamma \eta_c(1S)$	$(3.4 \pm 0.5) \times 10^{-3}$	S=1.3	638
$\gamma \eta_c(2S)$	$< 8 \times 10^{-4}$	CL=90%	48
$\gamma \pi^0$	$(1.6 \pm 0.4) \times 10^{-6}$		1841
$\gamma \eta'(958)$	$(1.23 \pm 0.06) \times 10^{-4}$		1719
$\gamma f_2(1270)$	$(2.1 \pm 0.4) \times 10^{-4}$		1622
$\gamma f_0(1710) \rightarrow \gamma \pi \pi$	$(3.0 \pm 1.3) \times 10^{-5}$		—
$\gamma f_0(1710) \rightarrow \gamma K \bar{K}$	$(6.0 \pm 1.6) \times 10^{-5}$		—
$\gamma \gamma$	$< 1.4 \times 10^{-4}$	CL=90%	1843
$\gamma \eta$	$(1.4 \pm 0.5) \times 10^{-6}$		1802
$\gamma \eta \pi^+ \pi^-$	$(8.7 \pm 2.1) \times 10^{-4}$		1791
$\gamma \eta(1405) \rightarrow \gamma K \bar{K} \pi$	$< 9 \times 10^{-5}$	CL=90%	1569
$\gamma \eta(1405) \rightarrow \eta \pi^+ \pi^-$	$(3.6 \pm 2.5) \times 10^{-5}$		—
$\gamma \eta(1475) \rightarrow K \bar{K} \pi$	$< 1.4 \times 10^{-4}$	CL=90%	—
$\gamma \eta(1475) \rightarrow \eta \pi^+ \pi^-$	$< 8.8 \times 10^{-5}$	CL=90%	—
$\gamma 2(\pi^+ \pi^-)$	$(4.0 \pm 0.6) \times 10^{-4}$		1817
$\gamma K^{*0} K^+ \pi^- + \text{c.c.}$	$(3.7 \pm 0.9) \times 10^{-4}$		1674
$\gamma K^{*0} \bar{K}^{*0}$	$(2.4 \pm 0.7) \times 10^{-4}$		1613
$\gamma K_S^0 K^+ \pi^- + \text{c.c.}$	$(2.6 \pm 0.5) \times 10^{-4}$		1753
$\gamma K^+ K^- \pi^+ \pi^-$	$(1.9 \pm 0.5) \times 10^{-4}$		1726
$\gamma p\bar{p}$	$(3.9 \pm 0.5) \times 10^{-5}$	S=2.0	1586
$\gamma f_2(1950) \rightarrow \gamma p\bar{p}$	$(1.20 \pm 0.22) \times 10^{-5}$		—
$\gamma f_2(2150) \rightarrow \gamma p\bar{p}$	$(7.2 \pm 1.8) \times 10^{-6}$		—
$\gamma X(1835) \rightarrow \gamma p\bar{p}$	$< 1.6 \times 10^{-6}$	CL=90%	—
$\gamma X \rightarrow \gamma p\bar{p}$	$[mmmm] < 2 \times 10^{-6}$	CL=90%	—
$\gamma \pi^+ \pi^- p\bar{p}$	$(2.8 \pm 1.4) \times 10^{-5}$		1491

$\gamma 2(\pi^+ \pi^-) K^+ K^-$	< 2.2	$\times 10^{-4}$	CL=90%	1654
$\gamma 3(\pi^+ \pi^-)$	< 1.7	$\times 10^{-4}$	CL=90%	1774
$\gamma K^+ K^- K^+ K^-$	< 4	$\times 10^{-5}$	CL=90%	1499

## $\psi(3770)$

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

Mass  $m = 3772.92 \pm 0.35$  MeV (S = 1.1)

Full width  $\Gamma = 27.3 \pm 1.0$  MeV

$\Gamma_{ee} = 0.265 \pm 0.018$  keV (S = 1.3)

In addition to the dominant decay mode to  $D\bar{D}$ ,  $\psi(3770)$  was found to decay into the final states containing the  $J/\psi$  (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).

<b><math>\psi(3770)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	Scale factor/ Confidence level	$p$ (MeV/c)
$D\bar{D}$	(93 $^{+8}_{-9}$ ) %	S=2.0	285
$D^0\bar{D}^0$	(52 $\pm 5$ ) %	S=2.0	285
$D^+D^-$	(41 $\pm 4$ ) %	S=2.0	252
$J/\psi\pi^+\pi^-$	(1.93 $\pm 0.28$ ) $\times 10^{-3}$		560
$J/\psi\pi^0\pi^0$	(8.0 $\pm 3.0$ ) $\times 10^{-4}$		564
$J/\psi\eta$	(9 $\pm 4$ ) $\times 10^{-4}$		359
$J/\psi\pi^0$	< 2.8 $\times 10^{-4}$	CL=90%	603
$e^+e^-$	(9.7 $\pm 0.7$ ) $\times 10^{-6}$	S=1.2	1886

### Decays to light hadrons

$b_1(1235)\pi$	< 1.4	$\times 10^{-5}$	CL=90%	1683
$\phi\eta'$	< 7	$\times 10^{-4}$	CL=90%	1606
$\omega\eta'$	< 4	$\times 10^{-4}$	CL=90%	1672
$\rho^0\eta'$	< 6	$\times 10^{-4}$	CL=90%	1674
$\phi\eta$	(3.1 $\pm 0.7$ ) $\times 10^{-4}$			1703
$\omega\eta$	< 1.4	$\times 10^{-5}$	CL=90%	1762
$\rho^0\eta$	< 5	$\times 10^{-4}$	CL=90%	1763
$\phi\pi^0$	< 3	$\times 10^{-5}$	CL=90%	1746
$\omega\pi^0$	< 6	$\times 10^{-4}$	CL=90%	1803
$\pi^+\pi^-\pi^0$	< 5	$\times 10^{-6}$	CL=90%	1874
$\rho\pi$	< 5	$\times 10^{-6}$	CL=90%	1804
$K^*(892)^+K^- + c.c.$	< 1.4	$\times 10^{-5}$	CL=90%	1745
$K^*(892)^0\bar{K}^0 + c.c.$	< 1.2	$\times 10^{-3}$	CL=90%	1744
$K_S^0 K_L^0$	< 1.2	$\times 10^{-5}$	CL=90%	1820
$2(\pi^+\pi^-)$	< 1.12	$\times 10^{-3}$	CL=90%	1861
$2(\pi^+\pi^-)\pi^0$	< 1.06	$\times 10^{-3}$	CL=90%	1843
$2(\pi^+\pi^-\pi^0)$	< 5.85	%	CL=90%	1821

$\omega\pi^+\pi^-$	< 6.0	$\times 10^{-4}$	CL=90%	1794
$3(\pi^+\pi^-)$	< 9.1	$\times 10^{-3}$		1819
$3(\pi^+\pi^-)\pi^0$	< 1.37	%		1792
$3(\pi^+\pi^-)2\pi^0$	< 11.74	%	CL=90%	1759
$\eta\pi^+\pi^-$	< 1.24	$\times 10^{-3}$	CL=90%	1836
$\pi^+\pi^-2\pi^0$	< 8.9	$\times 10^{-3}$	CL=90%	1862
$\rho^0\pi^+\pi^-$	< 6.9	$\times 10^{-3}$	CL=90%	1796
$\eta3\pi$	< 1.34	$\times 10^{-3}$	CL=90%	1824
$\eta2(\pi^+\pi^-)$	< 2.43	%		1804
$\eta\rho^0\pi^+\pi^-$	< 1.45	%	CL=90%	1708
$\eta'3\pi$	< 2.44	$\times 10^{-3}$	CL=90%	1740
$K^+K^-\pi^+\pi^-$	< 9.0	$\times 10^{-4}$	CL=90%	1772
$\phi\pi^+\pi^-$	< 4.1	$\times 10^{-4}$	CL=90%	1737
$K^+K^-2\pi^0$	< 4.2	$\times 10^{-3}$	CL=90%	1774
$4(\pi^+\pi^-)$	< 1.67	%	CL=90%	1757
$4(\pi^+\pi^-)\pi^0$	< 3.06	%	CL=90%	1720
$\phi f_0(980)$	< 4.5	$\times 10^{-4}$	CL=90%	1600
$K^+K^-\pi^+\pi^-\pi^0$	< 2.36	$\times 10^{-3}$	CL=90%	1741
$K^+K^-\rho^0\pi^0$	< 8	$\times 10^{-4}$	CL=90%	1624
$K^+K^-\rho^+\pi^-$	< 1.46	%	CL=90%	1622
$\omega K^+K^-$	< 3.4	$\times 10^{-4}$	CL=90%	1664
$\phi\pi^+\pi^-\pi^0$	< 3.8	$\times 10^{-3}$	CL=90%	1722
$K^{*0}K^-\pi^+\pi^0 + \text{c.c.}$	< 1.62	%	CL=90%	1693
$K^{*+}K^-\pi^+\pi^- + \text{c.c.}$	< 3.23	%	CL=90%	1692
$K^+K^-\pi^+\pi^-2\pi^0$	< 2.67	%	CL=90%	1705
$K^+K^-2(\pi^+\pi^-)$	< 1.03	%	CL=90%	1702
$K^+K^-2(\pi^+\pi^-)\pi^0$	< 3.60	%	CL=90%	1660
$\eta K^+K^-$	< 4.1	$\times 10^{-4}$	CL=90%	1711
$\eta K^+K^-\pi^+\pi^-$	< 1.24	%	CL=90%	1624
$\rho^0 K^+K^-$	< 5.0	$\times 10^{-3}$	CL=90%	1665
$2(K^+K^-)$	< 6.0	$\times 10^{-4}$	CL=90%	1551
$\phi K^+K^-$	< 7.5	$\times 10^{-4}$	CL=90%	1597
$2(K^+K^-)\pi^0$	< 2.9	$\times 10^{-4}$	CL=90%	1493
$2(K^+K^-)\pi^+\pi^-$	< 3.2	$\times 10^{-3}$	CL=90%	1425
$K_S^0 K^-\pi^+$	< 3.2	$\times 10^{-3}$	CL=90%	1799
$K_S^0 K^-\pi^+\pi^0$	< 1.33	%	CL=90%	1773
$K_S^0 K^-\rho^+$	< 6.6	$\times 10^{-3}$	CL=90%	1664
$K_S^0 K^-\pi^+\pi^-$	< 8.7	$\times 10^{-3}$	CL=90%	1739
$K_S^0 K^-\pi^+\rho^0$	< 1.6	%	CL=90%	1621
$K_S^0 K^-\pi^+\eta$	< 1.3	%	CL=90%	1669
$K_S^0 K^-\pi^+\pi^-\pi^0$	< 4.18	%	CL=90%	1703
$K_S^0 K^-\pi^+\pi^-\eta$	< 4.8	%	CL=90%	1570
$K_S^0 K^-\pi^+2(\pi^+\pi^-)$	< 1.22	%	CL=90%	1658



$K_S^0 K^- \pi^+ 2\pi^0$	< 2.65	%	CL=90%	1741
$K_S^0 K^- K^+ K^- \pi^+$	< 4.9	$\times 10^{-3}$	CL=90%	1490
$K_S^0 K^- K^+ K^- \pi^+ \pi^0$	< 3.0	%	CL=90%	1427
$K_S^0 K^- K^+ K^- \pi^+ \eta$	< 2.2	%	CL=90%	1214
$K^{*0} K^- \pi^+ + \text{c.c.}$	< 9.7	$\times 10^{-3}$	CL=90%	1721
$\rho \bar{\rho} \pi^0$	< 1.2	$\times 10^{-3}$		1595
$\rho \bar{\rho} \pi^+ \pi^-$	< 5.8	$\times 10^{-4}$	CL=90%	1544
$\Lambda \bar{\Lambda}$	< 1.2	$\times 10^{-4}$	CL=90%	1521
$\rho \bar{\rho} \pi^+ \pi^- \pi^0$	< 1.85	$\times 10^{-3}$	CL=90%	1490
$\omega \rho \bar{\rho}$	< 2.9	$\times 10^{-4}$	CL=90%	1309
$\Lambda \bar{\Lambda} \pi^0$	< 1.2	$\times 10^{-3}$	CL=90%	1468
$\rho \bar{\rho} 2(\pi^+ \pi^-)$	< 2.6	$\times 10^{-3}$	CL=90%	1425
$\eta \rho \bar{\rho}$	< 5.4	$\times 10^{-4}$	CL=90%	1430
$\eta \rho \bar{\rho} \pi^+ \pi^-$	< 3.3	$\times 10^{-3}$	CL=90%	1284
$\rho^0 \rho \bar{\rho}$	< 1.7	$\times 10^{-3}$	CL=90%	1313
$\rho \bar{\rho} K^+ K^-$	< 3.2	$\times 10^{-4}$	CL=90%	1185
$\eta \rho \bar{\rho} K^+ K^-$	< 6.9	$\times 10^{-3}$	CL=90%	736
$\pi^0 \rho \bar{\rho} K^+ K^-$	< 1.2	$\times 10^{-3}$	CL=90%	1093
$\phi \rho \bar{\rho}$	< 1.3	$\times 10^{-4}$	CL=90%	1178
$\Lambda \bar{\Lambda} \pi^+ \pi^-$	< 2.5	$\times 10^{-4}$	CL=90%	1404
$\Lambda \bar{\rho} K^+$	< 2.8	$\times 10^{-4}$	CL=90%	1387
$\Lambda \bar{\rho} K^+ \pi^+ \pi^-$	< 6.3	$\times 10^{-4}$	CL=90%	1234

### Radiative decays

$\gamma \chi_{c2}$	< 9	$\times 10^{-4}$	CL=90%	210
$\gamma \chi_{c1}$	( 2.9 $\pm$ 0.6 )	$\times 10^{-3}$		253
$\gamma \chi_{c0}$	( 7.3 $\pm$ 0.9 )	$\times 10^{-3}$		341
$\gamma \eta'$	< 1.8	$\times 10^{-4}$	CL=90%	1765
$\gamma \eta$	< 1.5	$\times 10^{-4}$	CL=90%	1847
$\gamma \pi^0$	< 2	$\times 10^{-4}$	CL=90%	1884

**X(3872)**

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

Quantum numbers not established.

$$\text{Mass } m = 3871.57 \pm 0.25 \text{ MeV} \quad (S = 1.1)$$

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

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

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

<b>X(3872) DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$\pi^+ \pi^- J/\psi(1S)$	>2.6 %	650
$\omega J/\psi(1S)$	>1.9 %	†
$D^0 \bar{D}^0 \pi^0$	> $3.2 \times 10^{-3}$	116
$\bar{D}^{*0} D^0$	> $5 \times 10^{-3}$	†
$\gamma J/\psi$	> $9 \times 10^{-3}$	697
$\gamma \psi(2S)$	>3.0 %	181

### $\chi_{c2}(2P)$

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

Mass  $m = 3927.2 \pm 2.6$  MeV

Full width  $\Gamma = 24 \pm 6$  MeV

### $\psi(4040)$ $[nnnn]$

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

Mass  $m = 4039 \pm 1$  MeV

Full width  $\Gamma = 80 \pm 10$  MeV

$\Gamma_{ee} = 0.86 \pm 0.07$  keV

Due to the complexity of the  $c\bar{c}$  threshold region, in this listing, “seen” (“not seen”) means that a cross section for the mode in question has been measured at effective  $\sqrt{s}$  near this particle’s central mass value, more (less) than  $2\sigma$  above zero, without regard to any peaking behavior in  $\sqrt{s}$  or absence thereof. See mode listing(s) for details and references.

<b><math>\psi(4040)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	Confidence level	$p$ (MeV/c)
$e^+ e^-$	$(1.07 \pm 0.16) \times 10^{-5}$		2019
$D \bar{D}$	seen		775
$D^0 \bar{D}^0$	seen		775
$D^+ D^-$	seen		764
$D^* \bar{D} + \text{c.c.}$	seen		569
$D^*(2007)^0 \bar{D}^0 + \text{c.c.}$	seen		575
$D^*(2010)^+ D^- + \text{c.c.}$	seen		561
$D^* \bar{D}^*$	seen		193
$D^*(2007)^0 \bar{D}^*(2007)^0$	seen		225
$D^*(2010)^+ D^*(2010)^-$	seen		193
$D^0 D^- \pi^+ + \text{c.c.}$ (excl. $D^*(2007)^0 \bar{D}^0 + \text{c.c.}$ , $D^*(2010)^+ D^- + \text{c.c.}$ )	not seen		—
$D \bar{D}^* \pi$ (excl. $D^* \bar{D}^*$ )	not seen		—
$D^0 \bar{D}^{*-} \pi^+ + \text{c.c.}$ (excl. $D^*(2010)^+ D^*(2010)^-$ )	seen		—

$D_s^+ D_s^-$	seen			451
$J/\psi \pi^+ \pi^-$	$< 4$	$\times 10^{-3}$	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

### $\psi(4160)$ $[nnnn]$

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

Mass  $m = 4153 \pm 3$  MeV

Full width  $\Gamma = 103 \pm 8$  MeV

$\Gamma_{ee} = 0.83 \pm 0.07$  keV

Due to the complexity of the  $c\bar{c}$  threshold region, in this listing, “seen” (“not seen”) means that a cross section for the mode in question has been measured at effective  $\sqrt{s}$  near this particle’s central mass value, more (less) than  $2\sigma$  above zero, without regard to any peaking behavior in  $\sqrt{s}$  or absence thereof. See mode listing(s) for details and references.

$\psi(4160)$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	Confidence level	$P$ (MeV/c)
$e^+ e^-$	$(8.1 \pm 0.9) \times 10^{-6}$		2076
$D\bar{D}$	seen		913
$D^0 \bar{D}^0$	seen		913
$D^+ D^-$	seen		904
$D^* \bar{D} + c.c.$	seen		746
$D^*(2007)^0 \bar{D}^0 + c.c.$	seen		751
$D^*(2010)^+ D^- + c.c.$	seen		740
$D^* \bar{D}^*$	seen		520
$D^*(2007)^0 \bar{D}^*(2007)^0$	seen		533
$D^*(2010)^+ D^*(2010)^-$	seen		520
$D^0 D^- \pi^+ + c.c.$ (excl. $D^*(2007)^0 \bar{D}^0 + c.c.$ , $D^*(2010)^+ D^- + c.c.$ )	not seen		—
$D\bar{D}^* \pi + c.c.$ (excl. $D^* \bar{D}^*$ )	seen		—
$D^0 D^{*-} \pi^+ + c.c.$ (excl. $D^*(2010)^+ D^*(2010)^-$ )	not seen		—
$D_s^+ D_s^-$	not seen		661
$D_s^{*+} D_s^- + c.c.$	seen		385

$J/\psi \pi^+ \pi^-$	< 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

**X(4260)**

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

Mass  $m = 4263_{-9}^{+8}$  MeV (S = 1.1)

Full width  $\Gamma = 95 \pm 14$  MeV

Due to the complexity of the  $c\bar{c}$  threshold region, in this listing, “seen” (“not seen”) means that a cross section for the mode in question has been measured at effective  $\sqrt{s}$  near this particle’s central mass value, more (less) than  $2\sigma$  above zero, without regard to any peaking behavior in  $\sqrt{s}$  or absence thereof. See mode listing(s) for details and references.

<b>X(4260) DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$J/\psi \pi^+ \pi^-$	seen	976
$J/\psi \pi^0 \pi^0$	seen	978
$J/\psi K^+ K^-$	seen	530
$J/\psi \eta$	not seen	886
$J/\psi \pi^0$	not seen	999
$J/\psi \eta'$	not seen	569
$J/\psi \pi^+ \pi^- \pi^0$	not seen	939
$J/\psi \eta \eta$	not seen	339
$\psi(2S) \pi^+ \pi^-$	not seen	470
$\psi(2S) \eta$	not seen	167
$\chi_{c0} \omega$	not seen	292
$\chi_{c1} \gamma$	not seen	686
$\chi_{c2} \gamma$	not seen	648
$\chi_{c1} \pi^+ \pi^- \pi^0$	not seen	571
$\chi_{c2} \pi^+ \pi^- \pi^0$	not seen	524
$\phi \pi^+ \pi^-$	not seen	1999
$\phi f_0(980) \rightarrow \phi \pi^+ \pi^-$	not seen	—
$D\bar{D}$	not seen	1032

$D^0 \bar{D}^0$	seen	1032
$D^+ D^-$	seen	1023
$D^* \bar{D} + c.c.$	seen	887
$D^*(2007)^0 \bar{D}^0 + c.c.$	seen	—
$D^*(2010)^+ D^- + c.c.$	seen	—
$D^* \bar{D}^*$	not seen	708
$D^*(2007)^0 \bar{D}^*(2007)^0$	seen	717
$D^*(2010)^+ D^*(2010)^-$	seen	708
$D^0 D^- \pi^+ + c.c.$ (excl. $D^*(2007)^0 \bar{D}^{*0} + c.c.,$ $D^*(2010)^+ D^- + c.c.)$	not seen	—
$D \bar{D}^* \pi + c.c.$ (excl. $D^* \bar{D}^*$ )	seen	723
$D^0 D^{*-} \pi^+ + c.c.$ (excl. $D^*(2010)^+ D^*(2010)^-$ )	not seen	—
$D^0 D^*(2010)^- \pi^+ + c.c.$	not seen	716
$D^* \bar{D}^* \pi$	seen	475
$D_s^+ D_s^-$	seen	817
$D_s^{*+} D_s^- + c.c.$	seen	615
$D_s^{*+} D_s^{*-}$	seen	284
$p \bar{p}$	not seen	1914
$K_S^0 K^\pm \pi^\mp$	not seen	2054
$K^+ K^- \pi^0$	not seen	2055

**$\psi(4415)$**   $[nnnn]$

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

Mass  $m = 4421 \pm 4$  MeV

Full width  $\Gamma = 62 \pm 20$  MeV

$\Gamma_{ee} = 0.58 \pm 0.07$  keV

Due to the complexity of the  $c\bar{c}$  threshold region, in this listing, “seen” (“not seen”) means that a cross section for the mode in question has been measured at effective  $\sqrt{s}$  near this particle’s central mass value, more (less) than  $2\sigma$  above zero, without regard to any peaking behavior in  $\sqrt{s}$  or absence thereof. See mode listing(s) for details and references.

$\psi(4415)$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	Confidence level	$P$ (MeV/c)
$D\bar{D}$	not seen		1187
$D^0\bar{D}^0$	seen		1187
$D^+D^-$	seen		1179
$D^*\bar{D} + \text{c.c.}$	not seen		1064
$D^*(2007)^0\bar{D}^0 + \text{c.c.}$	seen		1067
$D^*(2010)^+D^- + \text{c.c.}$	seen		1059
$D^*\bar{D}^*$	not seen		919
$D^*(2007)^0\bar{D}^*(2007)^0 + \text{c.c.}$	seen		927
$D^*(2010)^+D^*(2010)^- + \text{c.c.}$	seen		919
$D^0D^-\pi^+$ (excl. $D^*(2007)^0\bar{D}^0$ +c.c., $D^*(2010)^+D^- + \text{c.c.}$ )	< 2.3 %	90%	—
$D\bar{D}_2^*(2460) \rightarrow D^0D^-\pi^+ + \text{c.c.}$	(10 $\pm$ 4 ) %		—
$D^0D^*\pi^+ + \text{c.c.}$	< 11 %	90%	926
$D_s^+D_s^-$	not seen		1006
$D_s^{*+}D_s^- + \text{c.c.}$	seen		—
$D_s^{*+}D_s^{*-}$	not seen		652
$e^+e^-$	( 9.4 $\pm$ 3.2 ) $\times 10^{-6}$		2210

## $b\bar{b}$ MESONS

$\Upsilon(1S)$

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

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

<b><math>\Upsilon(1S)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	Confidence level	$p$ (MeV/c)
$\tau^+ \tau^-$	( 2.50±0.07 ) %		4384
$e^+ e^-$	( 2.48±0.07 ) %		4730
$\mu^+ \mu^-$	( 2.48±0.05 ) %		4729
<b>Hadronic decays</b>			
$g g g$	(81.7 ±0.7 ) %		—
$\gamma g g$	( 2.21±0.22 ) %		—
$\eta'(958)$ anything	( 2.94±0.24 ) %		—
$J/\psi(1S)$ anything	( 6.5 ±0.7 ) × 10 <sup>-4</sup>		4223
$\chi_{c0}$ anything	< 5 × 10 <sup>-3</sup>	90%	—
$\chi_{c1}$ anything	( 2.3 ±0.7 ) × 10 <sup>-4</sup>		—
$\chi_{c2}$ anything	( 3.4 ±1.0 ) × 10 <sup>-4</sup>		—
$\psi(2S)$ anything	( 2.7 ±0.9 ) × 10 <sup>-4</sup>		—
$\rho\pi$	< 2 × 10 <sup>-4</sup>	90%	4697
$\pi^+ \pi^-$	< 5 × 10 <sup>-4</sup>	90%	4728
$K^+ K^-$	< 5 × 10 <sup>-4</sup>	90%	4704
$p\bar{p}$	< 5 × 10 <sup>-4</sup>	90%	4636
$\pi^0 \pi^+ \pi^-$	< 1.84 × 10 <sup>-5</sup>	90%	4725
$D^*(2010)^\pm$ anything	( 2.52±0.20 ) %		—
$\bar{d}$ anything	( 2.86±0.28 ) × 10 <sup>-5</sup>		—
<b>Radiative decays</b>			
$\gamma \pi^+ \pi^-$	( 6.3 ±1.8 ) × 10 <sup>-5</sup>		4728
$\gamma \pi^0 \pi^0$	( 1.7 ±0.7 ) × 10 <sup>-5</sup>		4728
$\gamma \pi^0 \eta$	< 2.4 × 10 <sup>-6</sup>	90%	4713
$\gamma K^+ K^-$	[oooo] ( 1.14±0.13 ) × 10 <sup>-5</sup>		4704
$\gamma p\bar{p}$	[pppp] < 6 × 10 <sup>-6</sup>	90%	4636
$\gamma 2h^+ 2h^-$	( 7.0 ±1.5 ) × 10 <sup>-4</sup>		4720
$\gamma 3h^+ 3h^-$	( 5.4 ±2.0 ) × 10 <sup>-4</sup>		4703
$\gamma 4h^+ 4h^-$	( 7.4 ±3.5 ) × 10 <sup>-4</sup>		4679
$\gamma \pi^+ \pi^- K^+ K^-$	( 2.9 ±0.9 ) × 10 <sup>-4</sup>		4686
$\gamma 2\pi^+ 2\pi^-$	( 2.5 ±0.9 ) × 10 <sup>-4</sup>		4720
$\gamma 3\pi^+ 3\pi^-$	( 2.5 ±1.2 ) × 10 <sup>-4</sup>		4703
$\gamma 2\pi^+ 2\pi^- K^+ K^-$	( 2.4 ±1.2 ) × 10 <sup>-4</sup>		4658
$\gamma \pi^+ \pi^- p\bar{p}$	( 1.5 ±0.6 ) × 10 <sup>-4</sup>		4604
$\gamma 2\pi^+ 2\pi^- p\bar{p}$	( 4 ±6 ) × 10 <sup>-5</sup>		4563
$\gamma 2K^+ 2K^-$	( 2.0 ±2.0 ) × 10 <sup>-5</sup>		4601
$\gamma \eta'(958)$	< 1.9 × 10 <sup>-6</sup>	90%	4682
$\gamma \eta$	< 1.0 × 10 <sup>-6</sup>	90%	4714
$\gamma f_0(980)$	< 3 × 10 <sup>-5</sup>	90%	4679
$\gamma f_2'(1525)$	( 3.7 <sup>+1.2</sup> / <sub>-1.1</sub> ) × 10 <sup>-5</sup>		4607
$\gamma f_2(1270)$	( 1.01±0.09 ) × 10 <sup>-4</sup>		4644

$\gamma\eta(1405)$	$< 8.2$	$\times 10^{-5}$	90%	4625
$\gamma f_0(1500)$	$< 1.5$	$\times 10^{-5}$	90%	4610
$\gamma f_0(1710)$	$< 2.6$	$\times 10^{-4}$	90%	4574
$\gamma f_0(1710) \rightarrow \gamma K^+ K^-$	$< 7$	$\times 10^{-6}$	90%	—
$\gamma f_0(1710) \rightarrow \gamma \pi^0 \pi^0$	$< 1.4$	$\times 10^{-6}$	90%	—
$\gamma f_0(1710) \rightarrow \gamma \eta \eta$	$< 1.8$	$\times 10^{-6}$	90%	—
$\gamma f_4(2050)$	$< 5.3$	$\times 10^{-5}$	90%	4515
$\gamma f_0(2200) \rightarrow \gamma K^+ K^-$	$< 2$	$\times 10^{-4}$	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
$\gamma \eta_c(1S)$	$< 5.7$	$\times 10^{-5}$	90%	4261
$\gamma \chi_{c0}$	$< 6.5$	$\times 10^{-4}$	90%	4114
$\gamma \chi_{c1}$	$< 2.3$	$\times 10^{-5}$	90%	4079
$\gamma \chi_{c2}$	$< 7.6$	$\times 10^{-6}$	90%	4062
$\gamma X(3872) \rightarrow \pi^+ \pi^- J/\psi$	$< 1.6$	$\times 10^{-6}$	90%	—
$\gamma X(3872) \rightarrow \pi^+ \pi^- \pi^0 J/\psi$	$< 2.8$	$\times 10^{-6}$	90%	—
$\gamma X(3915) \rightarrow \omega J/\psi$	$< 3.0$	$\times 10^{-6}$	90%	—
$\gamma X(4140) \rightarrow \phi J/\psi$	$< 2.2$	$\times 10^{-6}$	90%	—
$\gamma X$	[qqqq] $< 3$	$\times 10^{-5}$	90%	—
$\gamma X \bar{X}$	[rrrr] $< 1$	$\times 10^{-3}$	90%	—
$\gamma X \rightarrow \gamma + \geq 4$ prongs	[ssss] $< 1.78$	$\times 10^{-4}$	95%	—
$\gamma a_1^0 \rightarrow \gamma \mu^+ \mu^-$	[tttt] $< 9$	$\times 10^{-6}$	90%	—
$\gamma a_1^0 \rightarrow \gamma \tau^+ \tau^-$	[oooo] $< 5.0$	$\times 10^{-5}$	90%	—
<b>Lepton Family number (LF) violating modes</b>				
$\mu^\pm \tau^\mp$	LF $< 6.0$	$\times 10^{-6}$	95%	4563
<b>Other decays</b>				
invisible	$< 3.0$	$\times 10^{-4}$	90%	—



**$\chi_{b0}(1P)$**  [uuuu]

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

$J$  needs confirmation.

$$\text{Mass } m = 9859.44 \pm 0.42 \pm 0.31 \text{ MeV}$$

<b><math>\chi_{b0}(1P)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	Confidence level	$P$ (MeV/c)
$\gamma \Upsilon(1S)$	< 6 %	90%	391
$D^0 X$	< 10.4 %	90%	—
$\pi^+ \pi^- K^+ K^- \pi^0$	< 1.6 $\times 10^{-4}$	90%	4875
$2\pi^+ \pi^- K^- K_S^0$	< 5 $\times 10^{-5}$	90%	4875
$2\pi^+ \pi^- K^- K_S^0 2\pi^0$	< 5 $\times 10^{-4}$	90%	4846
$2\pi^+ 2\pi^- 2\pi^0$	< 2.1 $\times 10^{-4}$	90%	4905
$2\pi^+ 2\pi^- K^+ K^-$	( $1.1 \pm 0.6$ ) $\times 10^{-4}$		4861
$2\pi^+ 2\pi^- K^+ K^- \pi^0$	< 2.7 $\times 10^{-4}$	90%	4846
$2\pi^+ 2\pi^- K^+ K^- 2\pi^0$	< 5 $\times 10^{-4}$	90%	4828
$3\pi^+ 2\pi^- K^- K_S^0 \pi^0$	< 1.6 $\times 10^{-4}$	90%	4827
$3\pi^+ 3\pi^-$	< 8 $\times 10^{-5}$	90%	4904
$3\pi^+ 3\pi^- 2\pi^0$	< 6 $\times 10^{-4}$	90%	4881
$3\pi^+ 3\pi^- K^+ K^-$	( $2.4 \pm 1.2$ ) $\times 10^{-4}$		4827
$3\pi^+ 3\pi^- K^+ K^- \pi^0$	< 1.0 $\times 10^{-3}$	90%	4808
$4\pi^+ 4\pi^-$	< 8 $\times 10^{-5}$	90%	4880
$4\pi^+ 4\pi^- 2\pi^0$	< 2.1 $\times 10^{-3}$	90%	4850

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

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

$J$  needs confirmation.

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

<b><math>\chi_{b1}(1P)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	Confidence level	$P$ (MeV/c)
$\gamma \Upsilon(1S)$	( $35 \pm 8$ ) %		423
$D^0 X$	( $12.6 \pm 2.2$ ) %		—
$\pi^+ \pi^- K^+ K^- \pi^0$	( $2.0 \pm 0.6$ ) $\times 10^{-4}$		4892
$2\pi^+ \pi^- K^- K_S^0$	( $1.3 \pm 0.5$ ) $\times 10^{-4}$		4892
$2\pi^+ \pi^- K^- K_S^0 2\pi^0$	< 6 $\times 10^{-4}$	90%	4863
$2\pi^+ 2\pi^- 2\pi^0$	( $8.0 \pm 2.5$ ) $\times 10^{-4}$		4921
$2\pi^+ 2\pi^- K^+ K^-$	( $1.5 \pm 0.5$ ) $\times 10^{-4}$		4878
$2\pi^+ 2\pi^- K^+ K^- \pi^0$	( $3.5 \pm 1.2$ ) $\times 10^{-4}$		4863
$2\pi^+ 2\pi^- K^+ K^- 2\pi^0$	( $8.6 \pm 3.2$ ) $\times 10^{-4}$		4845
$3\pi^+ 2\pi^- K^- K_S^0 \pi^0$	( $9.3 \pm 3.3$ ) $\times 10^{-4}$		4844
$3\pi^+ 3\pi^-$	( $1.9 \pm 0.6$ ) $\times 10^{-4}$		4921
$3\pi^+ 3\pi^- 2\pi^0$	( $1.7 \pm 0.5$ ) $\times 10^{-3}$		4898

$3\pi^+ 3\pi^- K^+ K^-$	$(2.6 \pm 0.8) \times 10^{-4}$	4844
$3\pi^+ 3\pi^- K^+ K^- \pi^0$	$(7.5 \pm 2.6) \times 10^{-4}$	4825
$4\pi^+ 4\pi^-$	$(2.6 \pm 0.9) \times 10^{-4}$	4897
$4\pi^+ 4\pi^- 2\pi^0$	$(1.4 \pm 0.6) \times 10^{-3}$	4867

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

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

*J* needs confirmation.

Mass  $m = 9912.21 \pm 0.26 \pm 0.31$  MeV

<b><math>\chi_{b2}(1P)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	Confidence level	$\rho$ (MeV/c)
$\gamma \Upsilon(1S)$	$(22 \pm 4) \%$		442
$D^0 X$	$< 7.9 \%$	90%	—
$\pi^+ \pi^- K^+ K^- \pi^0$	$(8 \pm 5) \times 10^{-5}$		4902
$2\pi^+ \pi^- K^- K_S^0$	$< 1.0 \times 10^{-4}$	90%	4901
$2\pi^+ \pi^- K^- K_S^0 2\pi^0$	$(5.3 \pm 2.4) \times 10^{-4}$		4873
$2\pi^+ 2\pi^- 2\pi^0$	$(3.5 \pm 1.4) \times 10^{-4}$		4931
$2\pi^+ 2\pi^- K^+ K^-$	$(1.1 \pm 0.4) \times 10^{-4}$		4888
$2\pi^+ 2\pi^- K^+ K^- \pi^0$	$(2.1 \pm 0.9) \times 10^{-4}$		4872
$2\pi^+ 2\pi^- K^+ K^- 2\pi^0$	$(3.9 \pm 1.8) \times 10^{-4}$		4855
$3\pi^+ 2\pi^- K^- K_S^0 \pi^0$	$< 5 \times 10^{-4}$	90%	4854
$3\pi^+ 3\pi^-$	$(7.0 \pm 3.1) \times 10^{-5}$		4931
$3\pi^+ 3\pi^- 2\pi^0$	$(1.0 \pm 0.4) \times 10^{-3}$		4908
$3\pi^+ 3\pi^- K^+ K^-$	$< 8 \times 10^{-5}$	90%	4854
$3\pi^+ 3\pi^- K^+ K^- \pi^0$	$(3.6 \pm 1.5) \times 10^{-4}$		4835
$4\pi^+ 4\pi^-$	$(8 \pm 4) \times 10^{-5}$		4907
$4\pi^+ 4\pi^- 2\pi^0$	$(1.8 \pm 0.7) \times 10^{-3}$		4877

**$\Upsilon(2S)$**

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

Mass  $m = 10.02326 \pm 0.00031$  GeV

Full width  $\Gamma = 31.98 \pm 2.63$  keV

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

<b><math>\Upsilon(2S)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	Scale factor/ Confidence level	$p$ (MeV/c)
$\Upsilon(1S)\pi^+\pi^-$	(18.1 $\pm$ 0.4 ) %		475
$\Upsilon(1S)\pi^0\pi^0$	( 8.6 $\pm$ 0.4 ) %		480
$\tau^+\tau^-$	( 2.00 $\pm$ 0.21 ) %		4686
$\mu^+\mu^-$	( 1.93 $\pm$ 0.17 ) %	S=2.2	5011
$e^+e^-$	( 1.91 $\pm$ 0.16 ) %		5012
$\Upsilon(1S)\pi^0$	< 1.8	$\times 10^{-4}$ CL=90%	531
$\Upsilon(1S)\eta$	( 2.1 $^{+0.8}_{-0.7}$ ) $\times 10^{-4}$		126
$J/\psi(1S)$ anything	< 6	$\times 10^{-3}$ CL=90%	4533
$\bar{d}$ anything	( 3.4 $\pm$ 0.6 ) $\times 10^{-5}$		–
hadrons	(94 $\pm$ 11 ) %		–
$ggg$	(58.8 $\pm$ 1.2 ) %		–
$\gamma gg$	( 1.87 $\pm$ 0.28 ) %		–

### Radiative decays

$\gamma\chi_{b1}(1P)$	( 6.9 $\pm$ 0.4 ) %		130
$\gamma\chi_{b2}(1P)$	( 7.15 $\pm$ 0.35 ) %		110
$\gamma\chi_{b0}(1P)$	( 3.8 $\pm$ 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%	4931
$\gamma\eta_b(1S)$	( 3.9 $\pm$ 1.5 ) $\times 10^{-4}$		612
$\gamma X \rightarrow \gamma + \geq 4$ prongs	[ $\nu\nu\nu\nu$ ] < 1.95	$\times 10^{-4}$ CL=95%	–

### Lepton Family number (LF) violating modes

$e^\pm\tau^\mp$	LF	< 3.2	$\times 10^{-6}$ CL=90%	4854
$\mu^\pm\tau^\mp$	LF	< 3.3	$\times 10^{-6}$ CL=90%	4854

**$\Upsilon(1D)$**

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

$$\text{Mass } m = 10163.7 \pm 1.4 \text{ MeV} \quad (S = 1.7)$$

<b><math>\Upsilon(1D)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$\gamma\gamma\Upsilon(1S)$	seen	679

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

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

$J$  needs confirmation.

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

<b><math>\chi_{b0}(2P)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	Confidence level	$P$ (MeV/c)
$\gamma \Upsilon(2S)$	$(4.6 \pm 2.1) \%$		207
$\gamma \Upsilon(1S)$	$(9 \pm 6) \times 10^{-3}$		743
$D^0 X$	$< 8.2 \%$	90%	—
$\pi^+ \pi^- K^+ K^- \pi^0$	$< 3.4 \times 10^{-5}$	90%	5064
$2\pi^+ \pi^- K^- K_S^0$	$< 5 \times 10^{-5}$	90%	5063
$2\pi^+ \pi^- K^- K_S^0 2\pi^0$	$< 2.2 \times 10^{-4}$	90%	5036
$2\pi^+ 2\pi^- 2\pi^0$	$< 2.4 \times 10^{-4}$	90%	5092
$2\pi^+ 2\pi^- K^+ K^-$	$< 1.5 \times 10^{-4}$	90%	5050
$2\pi^+ 2\pi^- K^+ K^- \pi^0$	$< 2.2 \times 10^{-4}$	90%	5035
$2\pi^+ 2\pi^- K^+ K^- 2\pi^0$	$< 1.1 \times 10^{-3}$	90%	5019
$3\pi^+ 2\pi^- K^- K_S^0 \pi^0$	$< 7 \times 10^{-4}$	90%	5018
$3\pi^+ 3\pi^-$	$< 7 \times 10^{-5}$	90%	5091
$3\pi^+ 3\pi^- 2\pi^0$	$< 1.2 \times 10^{-3}$	90%	5070
$3\pi^+ 3\pi^- K^+ K^-$	$< 1.5 \times 10^{-4}$	90%	5017
$3\pi^+ 3\pi^- K^+ K^- \pi^0$	$< 7 \times 10^{-4}$	90%	4999
$4\pi^+ 4\pi^-$	$< 1.7 \times 10^{-4}$	90%	5069
$4\pi^+ 4\pi^- 2\pi^0$	$< 6 \times 10^{-4}$	90%	5039

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

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

$J$  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 ( $\Gamma_i/\Gamma$ )	Scale factor	$\rho$ (MeV/c)
$\omega \Upsilon(1S)$	$(1.63^{+0.40}_{-0.34})\%$		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
$D^0 X$	$(8.8 \pm 1.7)\%$		—
$\pi^+ \pi^- K^+ K^- \pi^0$	$(3.1 \pm 1.0) \times 10^{-4}$		5075
$2\pi^+ \pi^- K^- K_S^0$	$(1.1 \pm 0.5) \times 10^{-4}$		5075
$2\pi^+ \pi^- K^- K_S^0 2\pi^0$	$(7.7 \pm 3.2) \times 10^{-4}$		5047
$2\pi^+ 2\pi^- 2\pi^0$	$(5.9 \pm 2.0) \times 10^{-4}$		5104
$2\pi^+ 2\pi^- K^+ K^-$	$(10 \pm 4) \times 10^{-5}$		5062
$2\pi^+ 2\pi^- K^+ K^- \pi^0$	$(5.5 \pm 1.8) \times 10^{-4}$		5047
$2\pi^+ 2\pi^- K^+ K^- 2\pi^0$	$(10 \pm 4) \times 10^{-4}$		5030
$3\pi^+ 2\pi^- K^- K_S^0 \pi^0$	$(6.7 \pm 2.6) \times 10^{-4}$		5029
$3\pi^+ 3\pi^-$	$(1.2 \pm 0.4) \times 10^{-4}$		5103
$3\pi^+ 3\pi^- 2\pi^0$	$(1.2 \pm 0.4) \times 10^{-3}$		5081
$3\pi^+ 3\pi^- K^+ K^-$	$(2.0 \pm 0.8) \times 10^{-4}$		5029
$3\pi^+ 3\pi^- K^+ K^- \pi^0$	$(6.1 \pm 2.2) \times 10^{-4}$		5011
$4\pi^+ 4\pi^-$	$(1.7 \pm 0.6) \times 10^{-4}$		5080
$4\pi^+ 4\pi^- 2\pi^0$	$(1.9 \pm 0.7) \times 10^{-3}$		5051

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

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

$J$  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 ( $\Gamma_i/\Gamma$ )	Confidence level	$p$ (MeV/c)
$\omega \Upsilon(1S)$	( 1.10 <sup>+0.34</sup> <sub>-0.30</sub> ) %		194
$\gamma \Upsilon(2S)$	( 16.2 ± 2.4 ) %		242
$\gamma \Upsilon(1S)$	( 7.1 ± 1.0 ) %		777
$\pi\pi \chi_{b2}(1P)$	( 6.0 ± 2.1 ) × 10 <sup>-3</sup>		229
$D^0 X$	< 2.4 %	90%	—
$\pi^+ \pi^- K^+ K^- \pi^0$	< 1.1 × 10 <sup>-4</sup>	90%	5082
$2\pi^+ \pi^- K^- K_S^0$	< 9 × 10 <sup>-5</sup>	90%	5082
$2\pi^+ \pi^- K^- K_S^0 2\pi^0$	< 7 × 10 <sup>-4</sup>	90%	5054
$2\pi^+ 2\pi^- 2\pi^0$	( 3.9 ± 1.6 ) × 10 <sup>-4</sup>		5110
$2\pi^+ 2\pi^- K^+ K^-$	( 9 ± 4 ) × 10 <sup>-5</sup>		5068
$2\pi^+ 2\pi^- K^+ K^- \pi^0$	( 2.4 ± 1.1 ) × 10 <sup>-4</sup>		5054
$2\pi^+ 2\pi^- K^+ K^- 2\pi^0$	( 4.7 ± 2.3 ) × 10 <sup>-4</sup>		5037
$3\pi^+ 2\pi^- K^- K_S^0 \pi^0$	< 4 × 10 <sup>-4</sup>	90%	5036
$3\pi^+ 3\pi^-$	( 9 ± 4 ) × 10 <sup>-5</sup>		5110
$3\pi^+ 3\pi^- 2\pi^0$	( 1.2 ± 0.4 ) × 10 <sup>-3</sup>		5088
$3\pi^+ 3\pi^- K^+ K^-$	( 1.4 ± 0.7 ) × 10 <sup>-4</sup>		5036
$3\pi^+ 3\pi^- K^+ K^- \pi^0$	( 4.2 ± 1.7 ) × 10 <sup>-4</sup>		5017
$4\pi^+ 4\pi^-$	( 9 ± 5 ) × 10 <sup>-5</sup>		5087
$4\pi^+ 4\pi^- 2\pi^0$	( 1.3 ± 0.5 ) × 10 <sup>-3</sup>		5058

**$\Upsilon(3S)$**

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

Mass  $m = 10.3552 \pm 0.0005$  GeV

Full width  $\Gamma = 20.32 \pm 1.85$  keV

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

<b><math>\Upsilon(3S)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	Scale factor/ Confidence level	$p$ (MeV/c)
$\Upsilon(2S)$ anything	(10.6 $\pm$ 0.8 ) %		296
$\Upsilon(2S)\pi^+\pi^-$	( 2.45 $\pm$ 0.23) %	S=1.1	177
$\Upsilon(2S)\pi^0\pi^0$	( 1.85 $\pm$ 0.14) %		190
$\Upsilon(2S)\gamma\gamma$	( 5.0 $\pm$ 0.7 ) %		327
$\Upsilon(2S)\pi^0$	< 5.1 $\times 10^{-4}$	CL=90%	298
$\Upsilon(1S)\pi^+\pi^-$	( 4.40 $\pm$ 0.10) %		813
$\Upsilon(1S)\pi^0\pi^0$	( 2.20 $\pm$ 0.13) %		816
$\Upsilon(1S)\eta$	< 1.8 $\times 10^{-4}$	CL=90%	677
$\Upsilon(1S)\pi^0$	< 7 $\times 10^{-5}$	CL=90%	846
$\tau^+\tau^-$	( 2.29 $\pm$ 0.30) %		4863
$\mu^+\mu^-$	( 2.18 $\pm$ 0.21) %	S=2.1	5177
$e^+e^-$	seen		5178
$ggg$	(35.7 $\pm$ 2.6 ) %		–
$\gamma gg$	( 9.7 $\pm$ 1.8 ) $\times 10^{-3}$		–

**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
$\gamma\chi_{b2}(1P)$	< 1.9 %	CL=90%	434
$\gamma\chi_{b1}(1P)$	< 1.7 $\times 10^{-3}$	CL=90%	452
$\gamma\chi_{b0}(1P)$	( 3.0 $\pm$ 1.1 ) $\times 10^{-3}$		484
$\gamma\eta_b(2S)$	< 6.2 $\times 10^{-4}$	CL=90%	–
$\gamma\eta_b(1S)$	( 5.1 $\pm$ 0.7 ) $\times 10^{-4}$		919
$\gamma X \rightarrow \gamma + \geq 4$ prongs	[wwww] < 2.2 $\times 10^{-4}$	CL=95%	–
$\gamma a_1^0 \rightarrow \gamma\tau^+\tau^-$	[xxxx] < 1.6 $\times 10^{-4}$	CL=90%	–

**Lepton Family number (LF) violating modes**

$e^\pm\tau^\mp$	LF	< 4.2 $\times 10^{-6}$	CL=90%	5025
$\mu^\pm\tau^\mp$	LF	< 3.1 $\times 10^{-6}$	CL=90%	5025

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

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

Mass  $m = 10.5794 \pm 0.0012$  GeV

Full width  $\Gamma = 20.5 \pm 2.5$  MeV

$\Gamma_{ee} = 0.272 \pm 0.029$  keV (S = 1.5)

$\Upsilon(4S)$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	Confidence level	$\rho$ (MeV/c)
$B\bar{B}$	> 96 %	95%	328
$B^+B^-$	(51.6 $\pm$ 0.6 ) %		334
$D_s^+$ anything + c.c.	(17.8 $\pm$ 2.6 ) %		—
$B^0\bar{B}^0$	(48.4 $\pm$ 0.6 ) %		328
$J/\psi K_S^0 (J/\psi, \eta_c) K_S^0$	< 4 $\times 10^{-7}$	90%	—
non- $B\bar{B}$	< 4 %	95%	—
$e^+e^-$	( 1.57 $\pm$ 0.08 ) $\times 10^{-5}$		5290
$\rho^+\rho^-$	< 5.7 $\times 10^{-6}$	90%	5233
$J/\psi(1S)$ anything	< 1.9 $\times 10^{-4}$	95%	—
$D^{*+}$ anything + c.c.	< 7.4 %	90%	5099
$\phi$ anything	( 7.1 $\pm$ 0.6 ) %		5240
$\phi\eta$	< 1.8 $\times 10^{-6}$	90%	5226
$\phi\eta'$	< 4.3 $\times 10^{-6}$	90%	5196
$\rho\eta$	< 1.3 $\times 10^{-6}$	90%	5247
$\rho\eta'$	< 2.5 $\times 10^{-6}$	90%	5217
$\Upsilon(1S)$ anything	< 4 $\times 10^{-3}$	90%	1053
$\Upsilon(1S)\pi^+\pi^-$	( 8.1 $\pm$ 0.6 ) $\times 10^{-5}$		1026
$\Upsilon(1S)\eta$	( 1.96 $\pm$ 0.11 ) $\times 10^{-4}$		924
$\Upsilon(2S)\pi^+\pi^-$	( 8.6 $\pm$ 1.3 ) $\times 10^{-5}$		468
$\bar{d}$ anything	< 1.3 $\times 10^{-5}$	90%	—

**$\Upsilon(10860)$**

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

Mass  $m = 10876 \pm 11$  MeV

Full width  $\Gamma = 55 \pm 28$  MeV

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



$\Upsilon(10860)$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	Confidence level	$p$ (MeV/c)
$e^+ e^-$	$( 5.6 \pm 3.1 ) \times 10^{-6}$		5438
$B\bar{B}X$	$( 71 \pm 6 )\%$		—
$B\bar{B}$	$( 5.5 \pm 1.0 )\%$		1303
$B\bar{B}^* + \text{c.c.}$	$( 13.7 \pm 1.6 )\%$		—
$B^*\bar{B}^*$	$( 38.1 \pm 3.4 )\%$		1102
$B\bar{B}^{(*)}\pi$	$< 19.7$	90%	991
$B\bar{B}\pi$	$( 0.0 \pm 1.2 )\%$		991
$B^*\bar{B}\pi + B\bar{B}^*\pi$	$( 7.3 \pm 2.3 )\%$		—
$B^*\bar{B}^*\pi$	$( 1.0 \pm 1.4 )\%$		701
$B\bar{B}\pi\pi$	$< 8.9$	90%	505
$B_s^{(*)}\bar{B}_s^{(*)}$	$( 19.3 \pm 2.9 )\%$		880
$B_s\bar{B}_s$	$( 5 \pm 5 ) \times 10^{-3}$		880
$B_s\bar{B}_s^* + \text{c.c.}$	$( 1.4 \pm 0.6 )\%$		—
$B_s^*\bar{B}_s^*$	$( 17.4 \pm 2.7 )\%$		496
$\Upsilon(1S)\pi^+\pi^-$	$( 5.3 \pm 0.6 ) \times 10^{-3}$		1297
$\Upsilon(2S)\pi^+\pi^-$	$( 7.8 \pm 1.3 ) \times 10^{-3}$		774
$\Upsilon(3S)\pi^+\pi^-$	$( 4.8^{+1.9}_{-1.7} ) \times 10^{-3}$		429
$\Upsilon(1S)K^+K^-$	$( 6.1 \pm 1.8 ) \times 10^{-4}$		947

### Inclusive Decays.

These decay modes are submodes of one or more of the decay modes above.

$\phi$ anything	$( 13.8^{+2.4}_{-1.7} )\%$	—
$D^0$ anything + c.c.	$(108 \pm 8 )\%$	—
$D_s$ anything + c.c.	$( 46 \pm 6 )\%$	—
$J/\psi$ anything	$( 2.06 \pm 0.21 )\%$	—
$B^0$ anything + c.c.	$( 77 \pm 8 )\%$	—
$B^+$ anything + c.c.	$( 72 \pm 6 )\%$	—

**$\Upsilon(11020)$**

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

$$\text{Mass } m = 11.019 \pm 0.008 \text{ GeV}$$

$$\text{Full width } \Gamma = 79 \pm 16 \text{ MeV}$$

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

$\Upsilon(11020)$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (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  $\pi^\pm$  Particle Listings for definitions and details.
- [b] Measurements of  $\Gamma(e^+ \nu_e)/\Gamma(\mu^+ \nu_\mu)$  always include decays with  $\gamma$ 's, and measurements of  $\Gamma(e^+ \nu_e \gamma)$  and  $\Gamma(\mu^+ \nu_\mu \gamma)$  never include low-energy  $\gamma$ 's. Therefore, since no clean separation is possible, we consider the modes with  $\gamma$ '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  $\pi^\pm$  Particle Listings for the energy limits used in this measurement; low-energy  $\gamma$ '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  $\pi^0$  Particle Listings.
- [f] C parity forbids this to occur as a single-photon process.
- [g] See the “Note on scalar mesons” in the  $f_0(1370)$  Particle Listings . The interpretation of this entry as a particle is controversial.
- [h] See the “Note on  $\rho(770)$ ” in the  $\rho(770)$  Particle Listings .
- [i] The  $\omega\rho$  interference is then due to  $\omega\rho$  mixing only, and is expected to be small. If  $e\mu$  universality holds,  $\Gamma(\rho^0 \rightarrow \mu^+ \mu^-) = \Gamma(\rho^0 \rightarrow e^+ e^-) \times 0.99785$ .
- [j] See the “Note on scalar mesons” in the  $f_0(1370)$  Particle Listings .
- [k] See the “Note on  $a_1(1260)$ ” in the  $a_1(1260)$  Particle Listings in PDG 06, Journal of Physics, G **33** 1 (2006).
- [l] 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.
- [m] See the “Note on non- $q\bar{q}$  mesons” in the Particle Listings in PDG 06, Journal of Physics, G **33** 1 (2006).
- [n] See the “Note on the  $\eta(1405)$ ” in the  $\eta(1405)$  Particle Listings.
- [o] See the “Note on the  $f_1(1420)$ ” in the  $\eta(1405)$  Particle Listings.
- [p] See also the  $\omega(1650)$  Particle Listings.
- [q] See the “Note on the  $\rho(1450)$  and the  $\rho(1700)$ ” in the  $\rho(1700)$  Particle Listings.
- [r] See also the  $\omega(1420)$  Particle Listings.
- [s] See the “Note on  $f_0(1710)$ ” in the  $f_0(1710)$  Particle Listings in 2004 edition of *Review of Particle Physics*.
- [t] See the note in the  $K^\pm$  Particle Listings.

[u] 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):

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

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

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

[x] Most of this radiative mode, the low-momentum  $\gamma$  part, is also included in the parent mode listed without  $\gamma$ 's.

[y] Structure-dependent part.

[z] Direct-emission branching fraction.

[aa] Violates angular-momentum conservation.

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

[cc] 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  $\text{Re}(\eta_{000}) \simeq 0$ .

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

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

[ff]  $\text{Re}(\epsilon'/\epsilon) = \epsilon'/\epsilon$  to a very good approximation provided the phases satisfy  $CPT$  invariance.

- [*gg*] This mode includes gammas from inner bremsstrahlung but not the direct emission mode  $K_L^0 \rightarrow \pi^+ \pi^- \gamma$ (DE).
- [*hh*] See the  $K_L^0$  Particle Listings for the energy limits used in this measurement.
- [*ii*] Allowed by higher-order electroweak interactions.
- [*jj*] Violates  $CP$  in leading order. Test of direct  $CP$  violation since the indirect  $CP$ -violating and  $CP$ -conserving contributions are expected to be suppressed.
- [*kk*] See the “Note on  $f_0(1370)$ ” in the  $f_0(1370)$  Particle Listings and in the 1994 edition.
- [*ll*] See the note in the  $L(1770)$  Particle Listings in Reviews of Modern Physics **56** S1 (1984), p. S200. See also the “Note on  $K_2(1770)$  and the  $K_2(1820)$ ” in the  $K_2(1770)$  Particle Listings .
- [*mm*] See the “Note on  $K_2(1770)$  and the  $K_2(1820)$ ” in the  $K_2(1770)$  Particle Listings .
- [*nn*] This result applies to  $Z^0 \rightarrow c\bar{c}$  decays only. Here  $\ell^+$  is an average (not a sum) of  $e^+$  and  $\mu^+$  decays.
- [*oo*] See the Particle Listings for the (complicated) definition of this quantity.
- [*pp*] 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.
- [*qq*] These subfractions of the  $K^- 2\pi^+$  mode are uncertain: see the Particle Listings.
- [*rr*] Submodes of the  $D^+ \rightarrow K^- 2\pi^+ \pi^0$  and  $K_S^0 2\pi^+ \pi^-$  modes were studied by ANJOS 92C and COFFMAN 92B, but with at most 142 events for the first mode and 229 for the second – not enough for precise results. With nothing new for 18 years, we refer to our 2008 edition, Physics Letters **B667** 1 (2008), for those results.
- [*ss*] The unseen decay modes of the resonances are included.
- [*tt*] This is *not* a test for the  $\Delta C=1$  weak neutral current, but leads to the  $\pi^+ \ell^+ \ell^-$  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*] We are leaving the  $D^0$  mixing numbers unchanged from the 2010 Review, awaiting a comprehensive re-analysis by the Heavy Flavor Averaging Group. This would include as-yet-unpublished results from CLEO. Note, however, that there are in the Listings new measurements of the  $D_1^0$ - $D_2^0$  mass and width differences from BABAR.
- [*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  $K^- 2\pi^+ \pi^-$ ,  $K^- 2\pi^+ \pi^- \pi^0$ ,  $\bar{K}^0 2\pi^+ 2\pi^-$ ,  $K^+ 2K^- \pi^+$ ,  $2\pi^+ 2\pi^-$ ,  $2\pi^+ 2\pi^- \pi^0$ ,  $K^+ K^- \pi^+ \pi^-$ , and  $K^+ K^- \pi^+ \pi^- \pi^0$ , branching fractions.
- [yy] This is the sum of our  $K^- 3\pi^+ 2\pi^-$  and  $3\pi^+ 3\pi^-$  branching fractions.
- [zz] 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  $6.20 \pm 0.17$  %.
- [aaa] This is a doubly Cabibbo-suppressed mode.
- [bbb] The two experiments measuring this fraction are in serious disagreement. See the Particle Listings.
- [ccc] Submodes of the  $D^0 \rightarrow K_S^0 \pi^+ \pi^- \pi^0$  mode with a  $K^*$  and/or  $\rho$  were studied by COFFMAN 92B, but with only 140 events. With nothing new for 18 years, we refer to our 2008 edition, Physics Letters **B667** 1 (2008), for those results.
- [ddd] This branching fraction includes all the decay modes of the resonance in the final state.
- [eee] The experiments on the division of this charge mode amongst its submodes disagree, and the submode branching fractions here add up to considerably more than the charged-mode fraction.
- [fff] However, these upper limits are in serious disagreement with values obtained in another experiment.
- [ggg] This limit is for either  $D^0$  or  $\bar{D}^0$  to  $p e^-$ .
- [hhh] This limit is for either  $D^0$  or  $\bar{D}^0$  to  $\bar{p} e^+$ .
- [iii] This is the purely  $e^+$  semileptonic branching fraction: the  $e^+$  fraction from  $\tau^+$  decays has been subtracted off. The sum of our (non- $\tau$ )  $e^+$  exclusive fractions — an  $e^+ \nu_e$  with an  $\eta$ ,  $\eta'$ ,  $\phi$ ,  $K^0$ ,  $K^{*0}$ , or  $f_0(980)$  — is  $6.9 \pm 0.4$  %
- [jjj] This fraction includes  $\eta$  from  $\eta'$  decays.
- [kkk] Two times (to include  $\mu$  decays) the  $\eta' e^+ \nu_e$  branching fraction, plus the  $\eta' \pi^+$ ,  $\eta' \rho^+$ , and  $\eta' K^+$  fractions, is  $(18.6 \pm 2.3)\%$ , which considerably exceeds the inclusive  $\eta'$  fraction of  $(11.7 \pm 1.8)\%$ . Our best guess is that the  $\eta' \rho^+$  fraction,  $(12.5 \pm 2.2)\%$ , is too large.
- [lll] This branching fraction includes all the decay modes of the final-state resonance.
- [mmm] We decouple the  $D_s^+ \rightarrow \phi \pi^+$  branching fraction obtained from mass projections (and used to get some of the other branching fractions) from the  $D_s^+ \rightarrow \phi \pi^+$ ,  $\phi \rightarrow K^+ K^-$  branching fraction obtained from the Dalitz-plot analysis of  $D_s^+ \rightarrow K^+ K^- \pi^+$ . That is, the ratio of these two branching fractions is not exactly the  $\phi \rightarrow K^+ K^-$  branching fraction 0.491.

- [*nnn*] This comes from a model-independent and a  $K$ -matrix parametrization of the  $\pi^+\pi^-$   $S$ -wave and is a sum over several  $f_0$  mesons.
- [*ooo*] An  $\ell$  indicates an  $e$  or a  $\mu$  mode, not a sum over these modes.
- [*ppp*] An  $CP(\pm 1)$  indicates the  $CP=+1$  and  $CP=-1$  eigenstates of the  $D^0-\bar{D}^0$  system.
- [*qqq*]  $D$  denotes  $D^0$  or  $\bar{D}^0$ .
- [*rrr*]  $D_{CP+}^{*0}$  decays into  $D^0\pi^0$  with the  $D^0$  reconstructed in  $CP$ -even eigenstates  $K^+K^-$  and  $\pi^+\pi^-$ .
- [*sss*]  $\bar{D}^{**}$  represents an excited state with mass  $2.2 < M < 2.8$  GeV/ $c^2$ .
- [*ttt*]  $X(3872)^+$  is a hypothetical charged partner of the  $X(3872)$ .
- [*uuu*]  $\Theta(1710)^{++}$  is a possible narrow pentaquark state and  $G(2220)$  is a possible glueball resonance.
- [*vvv*]  $(\bar{\Lambda}_c^- p)_s$  denotes a low-mass enhancement near 3.35 GeV/ $c^2$ .
- [*www*] Stands for the possible candidates of  $K^*(1410)$ ,  $K_0^*(1430)$  and  $K_2^*(1430)$ .
- [*xxx*]  $B^0$  and  $B_s^0$  contributions not separated. Limit is on weighted average of the two decay rates.
- [*yyy*] This decay refers to the coherent sum of resonant and nonresonant  $J^P = 0^+ K\pi$  components with  $1.60 < m_{K\pi} < 2.15$  GeV/ $c^2$ .
- [*zzz*]  $X(214)$  is a hypothetical particle of mass 214 MeV/ $c^2$  reported by the HyperCP experiment, Physical Review Letters **94** 021801 (2005)
- [*aaaa*]  $\Theta(1540)^+$  denotes a possible narrow pentaquark state.
- [*bbbb*] These values are model dependent.
- [*cccc*] Here “anything” means at least one particle observed.
- [*dddd*]  $D^{**}$  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.
- [*eeee*]  $D^{(*)}\bar{D}^{(*)}$  stands for the sum of  $D^*\bar{D}^*$ ,  $D^*\bar{D}$ ,  $D\bar{D}^*$ , and  $D\bar{D}$ .
- [*ffff*]  $X(3915)$  denotes a near-threshold enhancement in the  $\omega J/\psi$  mass spectrum.
- [*gggg*] Inclusive branching fractions have a multiplicity definition and can be greater than 100%.
- [*hhhh*]  $D_J$  represents an unresolved mixture of pseudoscalar and tensor  $D^{**}$  ( $P$ -wave) states.
- [*iiii*] Not a pure measurement. See note at head of  $B_s^0$  Decay Modes.
- [*jjjj*] For  $E_\gamma > 100$  MeV.
- [*kkkk*] Includes  $p\bar{p}\pi^+\pi^-\gamma$  and excludes  $p\bar{p}\eta$ ,  $p\bar{p}\omega$ ,  $p\bar{p}\eta'$ .
- [*llll*] For a narrow state  $A$  with mass less than 960 MeV.
- [*mmmm*] For a narrow resonance in the range  $2.2 < M(X) < 2.8$  GeV.

[*nnnn*] $J^{PC}$  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.

[*oooo*]  $2m_\tau < M(\tau^+\tau^-) < 7500$  MeV.

[*pppp*]  $2 < m_{K^+K^-} < 3$  GeV.

[*qqqq*] $X$  = pseudoscalar with  $m < 7.2$  GeV

[*rrrr*]  $X\bar{X}$  = vectors with  $m < 3.1$  GeV

[*ssss*]  $1.5$  GeV  $< m_X < 5.0$  GeV

[*tttt*]  $201 < M(\mu^+\mu^-) < 3565$  MeV.

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

[*vvvv*]  $1.5$  GeV  $< m_X < 5.0$  GeV

[*wwww*]  $1.5$  GeV  $< m_X < 5.0$  GeV

[*xxxx*] For  $m_{\tau^+\tau^-}$  in the ranges 4.03–9.52 and 9.61–10.10 GeV.