

# 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)

<b><math>\eta_c(1S)</math> DECAY MODES</b>	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
$K^*(892)^0 K^- \pi^+ + \text{c.c.}$	(2.0 $\pm$ 0.7 ) %		1276
$K^*(892)\bar{K}^*(892)$	(9.2 $\pm$ 3.4 ) $\times 10^{-3}$		1194
$K^{*0}\bar{K}^{*0}\pi^+\pi^-$	(1.1 $\pm$ 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
$K^*(892)\bar{K} + \text{c.c.}$	< 1.28 %	90%	1308
$f_2(1270)\eta$	< 1.1 %	90%	1143
$\omega\omega$	< 3.1 $\times 10^{-3}$	90%	1268
$\omega\phi$	< 1.7 $\times 10^{-3}$	90%	1183
$f_2(1270)f_2(1270)$	(7.6 $^{+3.0}_{-3.4}$ ) $\times 10^{-3}$		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/ψ(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>J/ψ(1S) DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	Scale factor/ Confidence level	$p$ (MeV/c)
hadrons	(87.7 ± 0.5 ) %		—
virtual $\gamma \rightarrow$ hadrons	(13.50 ± 0.30 ) %		—
$g g g$	(64.1 ± 1.0 ) %		—
$\gamma g g$	( 8.8 ± 0.5 ) %		—
$e^+ e^-$	( 5.94 ± 0.06 ) %		1548
$e^+ e^- \gamma$	[a] ( 8.8 ± 1.4 ) $\times 10^{-3}$		1548
$\mu^+ \mu^-$	( 5.93 ± 0.06 ) %		1545

**Decays involving hadronic resonances**

$\rho \pi$	( 1.69 ± 0.15 ) %	S=2.4	1448
$\rho^0 \pi^0$	( 5.6 ± 0.7 ) $\times 10^{-3}$		1448
$a_2(1320) \rho$	( 1.09 ± 0.22 ) %		1123
$\omega \pi^+ \pi^+ \pi^- \pi^-$	( 8.5 ± 3.4 ) $\times 10^{-3}$		1392
$\omega \pi^+ \pi^- \pi^0$	( 4.0 ± 0.7 ) $\times 10^{-3}$		1418
$\omega \pi^+ \pi^-$	( 8.6 ± 0.7 ) $\times 10^{-3}$	S=1.1	1435
$\omega f_2(1270)$	( 4.3 ± 0.6 ) $\times 10^{-3}$		1142
$K^*(892)^0 \bar{K}^*(892)^0$	( 2.3 ± 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 ± 0.26 ) $\times 10^{-3}$		1003
$K^*(892)^0 \bar{K}_2^*(1430)^0 + c.c.$	( 6.0 ± 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 ± 0.9 ) $\times 10^{-4}$		—
$\omega K^*(892) \bar{K} + c.c.$	( 6.1 ± 0.9 ) $\times 10^{-3}$		1097
$K^+ \bar{K}^*(892)^- + c.c.$	( 5.12 ± 0.30 ) $\times 10^{-3}$		1373
$K^+ \bar{K}^*(892)^- + c.c. \rightarrow$ $K^+ K^- \pi^0$	( 1.97 ± 0.20 ) $\times 10^{-3}$		—
$K^+ \bar{K}^*(892)^- + c.c. \rightarrow$ $K^0 K^\pm \pi^\mp$	( 3.0 ± 0.4 ) $\times 10^{-3}$		—

$K^0 \bar{K}^*(892)^0 + \text{c.c.}$		$( 4.39 \pm 0.31 ) \times 10^{-3}$		1373
$K^0 \bar{K}^*(892)^0 + \text{c.c.} \rightarrow$ $K^0 K^\pm \pi^\mp$		$( 3.2 \pm 0.4 ) \times 10^{-3}$		—
$K_1(1400)^\pm K^\mp$		$( 3.8 \pm 1.4 ) \times 10^{-3}$		1170
$\bar{K}^*(892)^0 K^+ \pi^- + \text{c.c.}$		seen		1343
$\omega \pi^0 \pi^0$		$( 3.4 \pm 0.8 ) \times 10^{-3}$		1436
$b_1(1235)^\pm \pi^\mp$	[b]	$( 3.0 \pm 0.5 ) \times 10^{-3}$		1300
$\omega K^\pm K_S^0 \pi^\mp$	[b]	$( 3.4 \pm 0.5 ) \times 10^{-3}$		1210
$b_1(1235)^0 \pi^0$		$( 2.3 \pm 0.6 ) \times 10^{-3}$		1300
$\eta K^\pm K_S^0 \pi^\mp$	[b]	$( 2.2 \pm 0.4 ) \times 10^{-3}$		1278
$\phi K^*(892) \bar{K} + \text{c.c.}$		$( 2.18 \pm 0.23 ) \times 10^{-3}$		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
$\Sigma(1385)^- \bar{\Sigma}(1385)^+ (\text{or c.c.})$	[b]	$( 1.03 \pm 0.13 ) \times 10^{-3}$		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
$\phi K^\pm K_S^0 \pi^\mp$	[b]	$( 7.2 \pm 0.8 ) \times 10^{-4}$		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
$\Sigma(1385)^- \bar{\Sigma}^+ (\text{or c.c.})$	[b]	$( 3.1 \pm 0.5 ) \times 10^{-4}$		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

$a_2(1320)^\pm \pi^\mp$	[b] < 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
$\eta \phi(2170) \rightarrow$ $\eta K^*(892)^0 \bar{K}^*(892)^0$	< 2.52	$\times 10^{-4}$	CL=90%	—
$\Sigma(1385)^0 \bar{\Lambda}$	< 2	$\times 10^{-4}$	CL=90%	912
$\Delta(1232)^+ \bar{p}$	< 1	$\times 10^{-4}$	CL=90%	1100
$\Theta(1540) \bar{\Theta}(1540) \rightarrow$ $K_S^0 p K^- \bar{n} + \text{c.c.}$	< 1.1	$\times 10^{-5}$	CL=90%	—
$\Theta(1540) K^- \bar{n} \rightarrow K_S^0 p K^- \bar{n}$	< 2.1	$\times 10^{-5}$	CL=90%	—
$\Theta(1540) K_S^0 \bar{p} \rightarrow K_S^0 \bar{p} K^+ n$	< 1.6	$\times 10^{-5}$	CL=90%	—
$\bar{\Theta}(1540) K^+ n \rightarrow K_S^0 \bar{p} K^+ n$	< 5.6	$\times 10^{-5}$	CL=90%	—
$\bar{\Theta}(1540) K_S^0 p \rightarrow K_S^0 p K^- \bar{n}$	< 1.1	$\times 10^{-5}$	CL=90%	—
$\Sigma^0 \bar{\Lambda}$	< 9	$\times 10^{-5}$	CL=90%	1032

### Decays into stable hadrons

$2(\pi^+ \pi^-) \pi^0$	( 5.5 $\pm$ 0.4 ) %		1496
$3(\pi^+ \pi^-) \pi^0$	( 2.9 $\pm$ 0.6 ) %		1433
$\pi^+ \pi^- \pi^0$	( 2.07 $\pm$ 0.12 ) %	S=1.6	1533
$\pi^+ \pi^- \pi^0 K^+ K^-$	( 1.94 $\pm$ 0.15 ) %		1368
$4(\pi^+ \pi^-) \pi^0$	( 9.0 $\pm$ 3.0 ) $\times 10^{-3}$		1345
$\pi^+ \pi^- K^+ K^-$	( 6.6 $\pm$ 0.5 ) $\times 10^{-3}$		1407
$\pi^+ \pi^- K^+ K^- \eta$	( 1.84 $\pm$ 0.28 ) $\times 10^{-3}$		1221
$\pi^0 \pi^0 K^+ K^-$	( 2.45 $\pm$ 0.31 ) $\times 10^{-3}$		1410
$K \bar{K} \pi$	( 6.1 $\pm$ 1.0 ) $\times 10^{-3}$		1442
$2(\pi^+ \pi^-)$	( 3.55 $\pm$ 0.23 ) $\times 10^{-3}$		1517
$3(\pi^+ \pi^-)$	( 4.3 $\pm$ 0.4 ) $\times 10^{-3}$		1466
$2(\pi^+ \pi^- \pi^0)$	( 1.61 $\pm$ 0.21 ) %		1468
$2(\pi^+ \pi^-) \eta$	( 2.29 $\pm$ 0.24 ) $\times 10^{-3}$		1446
$3(\pi^+ \pi^-) \eta$	( 7.2 $\pm$ 1.5 ) $\times 10^{-4}$		1379
$p \bar{p}$	( 2.17 $\pm$ 0.07 ) $\times 10^{-3}$		1232
$p \bar{p} \pi^0$	( 1.19 $\pm$ 0.08 ) $\times 10^{-3}$	S=1.1	1176
$p \bar{p} \pi^+ \pi^-$	( 6.0 $\pm$ 0.5 ) $\times 10^{-3}$	S=1.3	1107
$p \bar{p} \pi^+ \pi^- \pi^0$	[c] ( 2.3 $\pm$ 0.9 ) $\times 10^{-3}$	S=1.9	1033
$p \bar{p} \eta$	( 2.00 $\pm$ 0.12 ) $\times 10^{-3}$		948
$p \bar{p} \rho$	< 3.1 $\times 10^{-4}$	CL=90%	774
$p \bar{p} \omega$	( 1.10 $\pm$ 0.15 ) $\times 10^{-3}$	S=1.3	768
$p \bar{p} \eta'(958)$	( 2.1 $\pm$ 0.4 ) $\times 10^{-4}$		596
$p \bar{p} \phi$	( 4.5 $\pm$ 1.5 ) $\times 10^{-5}$		527
$n \bar{n}$	( 2.2 $\pm$ 0.4 ) $\times 10^{-3}$		1231

$n\bar{n}\pi^+\pi^-$		$( 4 \pm 4 ) \times 10^{-3}$		1106
$\Sigma^+\bar{\Sigma}^-$		$( 1.50 \pm 0.24 ) \times 10^{-3}$		992
$\Sigma^0\bar{\Sigma}^0$		$( 1.29 \pm 0.09 ) \times 10^{-3}$		988
$2(\pi^+\pi^-)K^+K^-$		$( 5.0 \pm 0.5 ) \times 10^{-3}$		1320
$p\bar{n}\pi^-$		$( 2.12 \pm 0.09 ) \times 10^{-3}$		1174
$nN(1440)$		seen		978
$nN(1520)$		seen		924
$nN(1535)$		seen		914
$\Xi^-\bar{\Xi}^+$		$( 8.5 \pm 1.6 ) \times 10^{-4}$	S=1.5	807
$\Lambda\bar{\Lambda}$		$( 1.61 \pm 0.15 ) \times 10^{-3}$	S=2.0	1074
$\Lambda\bar{\Sigma}^-\pi^+$ (or c.c.)	[b]	$( 8.3 \pm 0.7 ) \times 10^{-4}$	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
$\Lambda\bar{\Lambda}\eta$		$( 2.6 \pm 0.7 ) \times 10^{-4}$		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
$\gamma\eta_2(1870) \rightarrow \gamma\eta\pi^+\pi^-$		$( 6.2 \pm 2.4 ) \times 10^{-4}$		—
$\gamma\eta(1405/1475) \rightarrow \gamma K\bar{K}\pi$	[d]	$( 2.8 \pm 0.6 ) \times 10^{-3}$	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
$\gamma f_2(1640) \rightarrow \gamma \omega \omega$	$( 2.8 \pm 1.8 ) \times 10^{-4}$		—
$\gamma f_2(1910) \rightarrow \gamma \omega \omega$	$( 2.0 \pm 1.4 ) \times 10^{-4}$		—
$\gamma f_2(1950) \rightarrow$	$( 7.0 \pm 2.2 ) \times 10^{-4}$		—
$\gamma K^*(892) \bar{K}^*(892)$			
$\gamma K^*(892) \bar{K}^*(892)$	$( 4.0 \pm 1.3 ) \times 10^{-3}$		1266
$\gamma \phi \phi$	$( 4.0 \pm 1.2 ) \times 10^{-4}$	S=2.1	1166
$\gamma \rho \bar{\rho}$	$( 3.8 \pm 1.0 ) \times 10^{-4}$		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
$\gamma X(1835) \rightarrow \gamma \rho \bar{\rho}$	$( 7.5 \begin{smallmatrix} +1.9 \\ -0.9 \end{smallmatrix} ) \times 10^{-5}$		—
$\gamma (K \bar{K} \pi) [J^{PC} = 0^- +]$	$( 7 \pm 4 ) \times 10^{-4}$	S=2.1	1442
$\gamma \pi^0$	$( 3.49 \begin{smallmatrix} +0.33 \\ -0.30 \end{smallmatrix} ) \times 10^{-5}$		1546
$\gamma \rho \bar{\rho} \pi^+ \pi^-$	$< 7.9 \times 10^{-4}$	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
$\gamma f_J(2220) \rightarrow \gamma \pi \pi$	$( 8 \pm 4 ) \times 10^{-5}$		—
$\gamma f_J(2220) \rightarrow \gamma K \bar{K}$	$< 3.6 \times 10^{-5}$		—
$\gamma f_J(2220) \rightarrow \gamma \rho \bar{\rho}$	$( 1.5 \pm 0.8 ) \times 10^{-5}$		—
$\gamma f_0(1500)$	$( 1.01 \pm 0.32 ) \times 10^{-4}$		1183
$\gamma A \rightarrow \gamma \text{invisible}$	$[e] < 6.3 \times 10^{-6}$	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

$D^- \pi^+ + \text{c.c.}$	< 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%	–
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**$\chi_{c0}(1P)$**

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

Mass  $m = 3414.75 \pm 0.31$  MeV

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

<b><math>\chi_{c0}(1P)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	Scale factor/ Confidence level	$p$ (MeV/c)
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**Hadronic decays**

$2(\pi^+ \pi^-)$	(2.26 ± 0.19) %		1679
$\rho^0 \pi^+ \pi^-$	(8.8 ± 2.8) $\times 10^{-3}$		1607
$f_0(980) f_0(980)$	(6.7 ± 2.1) $\times 10^{-4}$		1398
$\pi^+ \pi^- \pi^0 \pi^0$	(3.4 ± 0.4) %		1680
$\rho^+ \pi^- \pi^0 + \text{c.c.}$	(2.9 ± 0.4) %		1607
$4\pi^0$	(3.3 ± 0.4) $\times 10^{-3}$		1681
$\pi^+ \pi^- K^+ K^-$	(1.79 ± 0.15) %		1580
$K_0^*(1430)^0 \bar{K}_0^*(1430)^0 \rightarrow$ $\pi^+ \pi^- K^+ K^-$	(9.9 $^{+4.0}_{-2.9}$ ) $\times 10^{-4}$		–
$K_0^*(1430)^0 \bar{K}_2^*(1430)^0 + \text{c.c.} \rightarrow$ $\pi^+ \pi^- K^+ K^-$	(8.1 $^{+2.0}_{-2.4}$ ) $\times 10^{-4}$		–
$K_1(1270)^+ K^- + \text{c.c.} \rightarrow$ $\pi^+ \pi^- K^+ K^-$	(6.3 ± 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 $^{+1.1}_{-0.9}$ ) $\times 10^{-4}$		1398
$f_0(980) f_0(2200)$	(8.0 $^{+2.0}_{-2.5}$ ) $\times 10^{-4}$		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 $^{+4.0}_{-2.4}$ ) $\times 10^{-4}$		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
$K^*(892)^- K^+ \pi^0 \rightarrow$ $K^+ \pi^- K^0 \pi^0 + \text{c.c.}$	$(4.7 \pm 1.2) \times 10^{-3}$		—
$K_S^0 K_S^0 \pi^+ \pi^-$	$(5.8 \pm 1.1) \times 10^{-3}$		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)
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### Hadronic decays

$3(\pi^+ \pi^-)$	$(5.8 \pm 1.4) \times 10^{-3}$	S=1.2	1683
$2(\pi^+ \pi^-)$	$(7.6 \pm 2.6) \times 10^{-3}$		1728
$\pi^+ \pi^- \pi^0 \pi^0$	$(1.26 \pm 0.17) \%$		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
$K^*(892)^0 K^0 \pi^0 \rightarrow K^+ \pi^- K^0 \pi^0 + \text{c.c.}$	$(2.5 \pm 0.7) \times 10^{-3}$		—
$K^+ K^- \eta \pi^0$	$(1.2 \pm 0.4) \times 10^{-3}$		1523
$\pi^+ \pi^- K_S^0 K_S^0$	$(7.2 \pm 3.1) \times 10^{-4}$		1630
$K^+ K^- \eta$	$(3.3 \pm 1.0) \times 10^{-4}$		1566
$K^0 K^+ \pi^- + \text{c.c.}$	$(7.3 \pm 0.6) \times 10^{-3}$		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
$K_J^*(1430)^0 \bar{K}^0 + \text{c.c.} \rightarrow K_S^0 K^+ \pi^- + \text{c.c.}$	$< 8 \times 10^{-4}$	CL=90%	—
$K_J^*(1430)^+ K^- + \text{c.c.} \rightarrow K_S^0 K^+ \pi^- + \text{c.c.}$	$< 2.3 \times 10^{-3}$	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
$K^+ K^- K_S^0 K_S^0$	$< 5 \times 10^{-4}$	CL=90%	1390
$K^+ K^- K^+ K^-$	$(5.6 \pm 1.2) \times 10^{-4}$		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
$\pi^+ \pi^- p \bar{p}$	$(5.0 \pm 1.9) \times 10^{-4}$		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

<b><math>h_c(1P)</math> DECAY MODES</b>	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

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

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

Mass  $m = 3556.20 \pm 0.09$  MeV

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

<b><math>\chi_{c2}(1P)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	Confidence level ( $\frac{p}{\text{MeV/c}}$ )
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**Hadronic decays**

$2(\pi^+\pi^-)$	( 1.11 $\pm$ 0.11 ) %	1751
$\pi^+\pi^-\pi^0\pi^0$	( 1.99 $\pm$ 0.26 ) %	1752
$\rho^+\pi^-\pi^0 + \text{c.c.}$	( 2.4 $\pm$ 0.4 ) %	1682
$4\pi^0$	( 1.21 $\pm$ 0.17 ) $\times 10^{-3}$	1752
$K^+K^-\pi^0\pi^0$	( 2.2 $\pm$ 0.4 ) $\times 10^{-3}$	1658
$K^+\pi^-K^0\pi^0 + \text{c.c.}$	( 1.50 $\pm$ 0.22 ) %	1657
$\rho^+K^-K^0 + \text{c.c.}$	( 4.5 $\pm$ 1.4 ) $\times 10^{-3}$	1540
$K^*(892)^0K^+\pi^- \rightarrow$ $K^+\pi^-K^0\pi^0 + \text{c.c.}$	( 3.2 $\pm$ 0.9 ) $\times 10^{-3}$	–
$K^*(892)^0K^0\pi^0 \rightarrow$ $K^+\pi^-K^0\pi^0 + \text{c.c.}$	( 4.2 $\pm$ 0.9 ) $\times 10^{-3}$	–
$K^*(892)^-K^+\pi^0 \rightarrow$ $K^+\pi^-K^0\pi^0 + \text{c.c.}$	( 4.1 $\pm$ 0.9 ) $\times 10^{-3}$	–
$K^*(892)^+K^0\pi^- \rightarrow$ $K^+\pi^-K^0\pi^0 + \text{c.c.}$	( 3.2 $\pm$ 0.9 ) $\times 10^{-3}$	–
$K^+K^-\eta\pi^0$	( 1.4 $\pm$ 0.5 ) $\times 10^{-3}$	1549
$\pi^+\pi^-K^+K^-$	( 9.2 $\pm$ 1.1 ) $\times 10^{-3}$	1656
$K^+\bar{K}^*(892)^0\pi^- + \text{c.c.}$	( 2.3 $\pm$ 1.2 ) $\times 10^{-3}$	1602
$K^*(892)^0\bar{K}^*(892)^0$	( 2.5 $\pm$ 0.5 ) $\times 10^{-3}$	1538
$3(\pi^+\pi^-)$	( 8.6 $\pm$ 1.8 ) $\times 10^{-3}$	1707
$\phi\phi$	( 1.48 $\pm$ 0.28 ) $\times 10^{-3}$	1457
$\omega\omega$	( 1.9 $\pm$ 0.6 ) $\times 10^{-3}$	1597
$\pi\pi$	( 2.42 $\pm$ 0.13 ) $\times 10^{-3}$	1773
$\rho^0\pi^+\pi^-$	( 4.0 $\pm$ 1.7 ) $\times 10^{-3}$	1681
$\pi^+\pi^-\eta$	( 5.2 $\pm$ 1.4 ) $\times 10^{-4}$	1724
$\pi^+\pi^-\eta'$	( 5.4 $\pm$ 2.0 ) $\times 10^{-4}$	1636
$\eta\eta$	( 5.9 $\pm$ 0.5 ) $\times 10^{-4}$	1692

$K^+ K^-$	$( 1.09 \pm 0.08 ) \times 10^{-3}$		1708
$K_S^0 K_S^0$	$( 5.8 \pm 0.5 ) \times 10^{-4}$		1707
$\overline{K}^0 K^+ \pi^- + \text{c.c.}$	$( 1.32 \pm 0.20 ) \times 10^{-3}$		1685
$K^+ K^- \pi^0$	$( 3.3 \pm 0.8 ) \times 10^{-4}$		1686
$K^+ K^- \eta$	$< 3.5 \times 10^{-4}$	90%	1592
$\eta \eta'$	$< 6 \times 10^{-5}$	90%	1600
$\eta' \eta'$	$< 1.1 \times 10^{-4}$	90%	1498
$\pi^+ \pi^- K_S^0 K_S^0$	$( 2.4 \pm 0.6 ) \times 10^{-3}$		1655
$K^+ K^- K_S^0 K_S^0$	$< 4 \times 10^{-4}$	90%	1418
$K^+ K^- K^+ K^-$	$( 1.78 \pm 0.22 ) \times 10^{-3}$		1421
$K^+ K^- \phi$	$( 1.55 \pm 0.32 ) \times 10^{-3}$		1468
$K_S^0 K_S^0 p \bar{p}$	$< 7.9 \times 10^{-4}$	90%	1007
$p \bar{p}$	$( 7.2 \pm 0.4 ) \times 10^{-5}$		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
$\pi^+ \pi^- p \bar{p}$	$( 1.32 \pm 0.34 ) \times 10^{-3}$		1410
$\pi^0 \pi^0 p \bar{p}$	$( 8.5 \pm 2.6 ) \times 10^{-4}$		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%	—
$\gamma X \rightarrow \gamma p\bar{p}$	$[f] < 2 \times 10^{-6}$	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

## ψ(3770)

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

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>ψ(3770) 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

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

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

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

### $\psi(4160)$ [g]

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

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
$D^* \bar{D} + \text{c.c.}$	seen		746
$D^*(2007)^0 \bar{D}^0 + \text{c.c.}$	seen		751
$D^*(2010)^+ D^- + \text{c.c.}$	seen		740
$D^* \bar{D}^*$	seen		520
$D^*(2007)^0 \bar{D}^*(2007)^0$	seen		533
$D^*(2010)^+ D^*(2010)^-$	seen		520
$D^0 D^- \pi^+ + \text{c.c.}$ (excl. $D^*(2007)^0 \bar{D}^0 + \text{c.c.},$ $D^*(2010)^+ D^- + \text{c.c.}$ )	not seen		—
$D\bar{D}^* \pi + \text{c.c.}$ (excl. $D^* \bar{D}^*$ )	seen		—
$D^0 D^{*-} \pi^+ + \text{c.c.}$ (excl. $D^*(2010)^+ D^*(2010)^-$ )	not seen		—
$D_s^+ D_s^-$	not seen		661
$D_s^{*+} D_s^- + \text{c.c.}$	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)**

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

$$\text{Mass } m = 4263_{-9}^{+8} \text{ MeV} \quad (S = 1.1)$$

$$\text{Full width } \Gamma = 95 \pm 14 \text{ MeV}$$

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
$D^0 D^- \pi^+ + c.c. (excl.$	not seen	—
$D^*(2007)^0 \bar{D}^{*0} + c.c.,$		
$D^*(2010)^+ D^- + c.c.)$		
$D \bar{D}^* \pi + c.c. (excl. D^* \bar{D}^*)$	seen	723
$D^0 D^{*-} \pi^+ + c.c. (excl.$	not seen	—
$D^*(2010)^+ D^*(2010)^-$		
$D^0 D^*(2010)^- \pi^+ + c.c.$	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

**$\psi(4415)$  [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.

<b><math>\psi(4415)</math> DECAY MODES</b>	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
$D^* \bar{D} + c.c.$	not seen		1064
$D^*(2007)^0 \bar{D}^0 + c.c.$	seen		1067
$D^*(2010)^+ D^- + c.c.$	seen		1059
$D^* \bar{D}^*$	not seen		919
$D^*(2007)^0 \bar{D}^*(2007)^0 + c.c.$	seen		927

$D^*(2010)^+ D^*(2010)^- + \text{c.c.}$	seen			919
$D^0 D^- \pi^+ (\text{excl. } D^*(2007)^0 \bar{D}^0$	$< 2.3$	%	90%	—
$+ \text{c.c.}, D^*(2010)^+ D^- + \text{c.c.}$				
$D \bar{D}_2^*(2460) \rightarrow D^0 D^- \pi^+ + \text{c.c.}$	$(10 \pm 4)$	%		—
$D^0 D^{*-} \pi^+ + \text{c.c.}$	$< 11$	%	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

## NOTES

- [a] For  $E_\gamma > 100$  MeV.
- [b] The value is for the sum of the charge states or particle/antiparticle states indicated.
- [c] Includes  $p\bar{p}\pi^+\pi^-\gamma$  and excludes  $p\bar{p}\eta, p\bar{p}\omega, p\bar{p}\eta'$ .
- [d] See the “Note on the  $\eta(1405)$ ” in the  $\eta(1405)$  Particle Listings.
- [e] For a narrow state  $A$  with mass less than 960 MeV.
- [f] For a narrow resonance in the range  $2.2 < M(X) < 2.8$  GeV.
- [g]  $J^{PC}$  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.