# $c\overline{c}$ MESONS

## $\eta_c(1S)$

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

Mass $m = 2979.8 \pm 1.8$ MeV (S = 1.9)
Full width $\Gamma = 13.2^{+3.8}_{-3.2}$ MeV

| $\eta_c(1S)$ DECAY MODES | Fraction ($\Gamma_i/\Gamma$) | Confidence level | $p$ (MeV/$c$) |
|---|---|---|---|
| **Decays involving hadronic resonances** | | | |
| $\eta'(958)\pi\pi$ | (4.1 $\pm$1.7) % | | 1319 |
| $\rho\rho$ | (2.6 $\pm$0.9) % | | 1275 |
| $K^*(892)^0 K^-\pi^+$ + c.c. | (2.0 $\pm$0.7) % | | 1273 |
| $K^*(892)\overline{K}^*(892)$ | (8.5 $\pm$3.1) $\times 10^{-3}$ | | 1193 |
| $\phi\phi$ | (7.1 $\pm$2.8) $\times 10^{-3}$ | | 1086 |
| $a_0(980)\pi$ | $< 2$ % | 90% | 1323 |
| $a_2(1320)\pi$ | $< 2$ % | 90% | 1193 |
| $K^*(892)\overline{K}$ + c.c. | $< 1.28$ % | 90% | 1307 |
| $f_2(1270)\eta$ | $< 1.1$ % | 90% | 1142 |
| $\omega\omega$ | $< 3.1$ $\times 10^{-3}$ | 90% | 1268 |
| **Decays into stable hadrons** | | | |
| $K\overline{K}\pi$ | (5.5 $\pm$1.7) % | | 1378 |
| $\eta\pi\pi$ | (4.9 $\pm$1.8) % | | 1425 |
| $\pi^+\pi^- K^+K^-$ | (2.0 $^{+0.7}_{-0.6}$) % | | 1342 |
| $2(K^+K^-)$ | (2.1 $\pm$1.2) % | | 1053 |
| $2(\pi^+\pi^-)$ | (1.2 $\pm$0.4) % | | 1457 |
| $p\overline{p}$ | (1.2 $\pm$0.4) $\times 10^{-3}$ | | 1157 |
| $K\overline{K}\eta$ | $< 3.1$ % | 90% | 1262 |
| $\pi^+\pi^- p\overline{p}$ | $< 1.2$ % | 90% | 1023 |
| $\Lambda\overline{\Lambda}$ | $< 2$ $\times 10^{-3}$ | 90% | 987 |
| **Radiative decays** | | | |
| $\gamma\gamma$ | (3.0 $\pm$1.2) $\times 10^{-4}$ | | 1489 |

# $J/\psi(1S)$

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

Mass $m = 3096.87 \pm 0.04$ MeV
Full width $\Gamma = 87 \pm 5$ keV
$\Gamma_{ee} = 5.26 \pm 0.37$ keV

| $J/\psi(1S)$ DECAY MODES | | Fraction ($\Gamma_i/\Gamma$) | Scale factor/ Confidence level | $p$ (MeV/$c$) |
|---|---|---|---|---|
| hadrons | | (87.7 ±0.5 ) % | | – |
| virtual $\gamma \rightarrow$ hadrons | | (17.0 ±2.0 ) % | | – |
| $e^+ e^-$ | | ( 5.93±0.10) % | | 1548 |
| $\mu^+ \mu^-$ | | ( 5.88±0.10) % | | 1545 |
| **Decays involving hadronic resonances** | | | | |
| $\rho\pi$ | | ( 1.27±0.09) % | | 1449 |
| $\rho^0 \pi^0$ | | ( 4.2 ±0.5 ) $\times 10^{-3}$ | | 1449 |
| $a_2(1320)\rho$ | | ( 1.09±0.22) % | | 1125 |
| $\omega\pi^+\pi^+\pi^-\pi^-$ | | ( 8.5 ±3.4 ) $\times 10^{-3}$ | | 1392 |
| $\omega\pi^+\pi^-$ | | ( 7.2 ±1.0 ) $\times 10^{-3}$ | | 1435 |
| $\omega f_2(1270)$ | | ( 4.3 ±0.6 ) $\times 10^{-3}$ | | 1143 |
| $K^*(892)^0 \overline{K}{}^*_2(1430)^0$ + c.c. | | ( 6.7 ±2.6 ) $\times 10^{-3}$ | | 1005 |
| $\omega K^*(892)\overline{K}$ + c.c. | | ( 5.3 ±2.0 ) $\times 10^{-3}$ | | 1098 |
| $K^+ \overline{K}{}^*(892)^-$ + c.c. | | ( 5.0 ±0.4 ) $\times 10^{-3}$ | | 1373 |
| $K^0 \overline{K}{}^*(892)^0$ + c.c. | | ( 4.2 ±0.4 ) $\times 10^{-3}$ | | 1371 |
| $K_1(1400)^\pm K^\mp$ | | ( 3.8 ±1.4 ) $\times 10^{-3}$ | | – |
| $\omega\pi^0\pi^0$ | | ( 3.4 ±0.8 ) $\times 10^{-3}$ | | 1436 |
| $b_1(1235)^\pm \pi^\mp$ | [ee] | ( 3.0 ±0.5 ) $\times 10^{-3}$ | | 1299 |
| $\omega K^\pm K^0_S \pi^\mp$ | [ee] | ( 2.9 ±0.7 ) $\times 10^{-3}$ | | 1210 |
| $b_1(1235)^0 \pi^0$ | | ( 2.3 ±0.6 ) $\times 10^{-3}$ | | 1299 |
| $\phi K^*(892)\overline{K}$ + c.c. | | ( 2.04±0.28) $\times 10^{-3}$ | | 969 |
| $\omega K \overline{K}$ | | ( 1.9 ±0.4 ) $\times 10^{-3}$ | | 1268 |
| $\omega f_0(1710) \rightarrow \omega K \overline{K}$ | | ( 4.8 ±1.1 ) $\times 10^{-4}$ | | 878 |
| $\phi 2(\pi^+\pi^-)$ | | ( 1.60±0.32) $\times 10^{-3}$ | | 1318 |
| $\Delta(1232)^{++}\overline{p}\pi^-$ | | ( 1.6 ±0.5 ) $\times 10^{-3}$ | | 1030 |
| $\omega\eta$ | | ( 1.58±0.16) $\times 10^{-3}$ | | 1394 |
| $\phi K \overline{K}$ | | ( 1.48±0.22) $\times 10^{-3}$ | | 1179 |
| $\phi f_0(1710) \rightarrow \phi K \overline{K}$ | | ( 3.6 ±0.6 ) $\times 10^{-4}$ | | 875 |
| $p\overline{p}\omega$ | | ( 1.30±0.25) $\times 10^{-3}$ | S=1.3 | 769 |
| $\Delta(1232)^{++}\overline{\Delta}(1232)^{--}$ | | ( 1.10±0.29) $\times 10^{-3}$ | | 938 |
| $\Sigma(1385)^-\overline{\Sigma}(1385)^+$ (or c.c.) | [ee] | ( 1.03±0.13) $\times 10^{-3}$ | | 692 |
| $p\overline{p}\eta'(958)$ | | ( 9 ±4 ) $\times 10^{-4}$ | S=1.7 | 596 |
| $\phi f'_2(1525)$ | | ( 8 ±4 ) $\times 10^{-4}$ | S=2.7 | 871 |
| $\phi\pi^+\pi^-$ | | ( 8.0 ±1.2 ) $\times 10^{-4}$ | | 1365 |

| | | | | | |
|---|---|---|---|---|---|
| $\phi K^{\pm} K_S^0 \pi^{\mp}$ | [ee] | ( 7.2 ±0.9 ) | $\times 10^{-4}$ | | 1114 |
| $\omega f_1(1420)$ | | ( 6.8 ±2.4 ) | $\times 10^{-4}$ | | 1062 |
| $\phi\eta$ | | ( 6.5 ±0.7 ) | $\times 10^{-4}$ | | 1320 |
| $\Xi(1530)^- \overline{\Xi}^+$ | | ( 5.9 ±1.5 ) | $\times 10^{-4}$ | | 597 |
| $p K^- \overline{\Sigma}(1385)^0$ | | ( 5.1 ±3.2 ) | $\times 10^{-4}$ | | 645 |
| $\omega\pi^0$ | | ( 4.2 ±0.6 ) | $\times 10^{-4}$ | S=1.4 | 1447 |
| $\phi\eta'(958)$ | | ( 3.3 ±0.4 ) | $\times 10^{-4}$ | | 1192 |
| $\phi f_0(980)$ | | ( 3.2 ±0.9 ) | $\times 10^{-4}$ | S=1.9 | 1182 |
| $\Xi(1530)^0 \overline{\Xi}^0$ | | ( 3.2 ±1.4 ) | $\times 10^{-4}$ | | 608 |
| $\Sigma(1385)^- \overline{\Sigma}^+$ (or c.c.) | [ee] | ( 3.1 ±0.5 ) | $\times 10^{-4}$ | | 857 |
| $\phi f_1(1285)$ | | ( 2.6 ±0.5 ) | $\times 10^{-4}$ | S=1.1 | 1032 |
| $\rho\eta$ | | ( 1.93±0.23) | $\times 10^{-4}$ | | 1398 |
| $\omega\eta'(958)$ | | ( 1.67±0.25) | $\times 10^{-4}$ | | 1279 |
| $\omega f_0(980)$ | | ( 1.4 ±0.5 ) | $\times 10^{-4}$ | | 1271 |
| $\rho\eta'(958)$ | | ( 1.05±0.18) | $\times 10^{-4}$ | | 1283 |
| $p\overline{p}\phi$ | | ( 4.5 ±1.5 ) | $\times 10^{-5}$ | | 527 |
| $a_2(1320)^{\pm}\pi^{\mp}$ | [ee] | < 4.3 | $\times 10^{-3}$ | CL=90% | 1263 |
| $K\overline{K}_2^*(1430)+$ c.c. | | < 4.0 | $\times 10^{-3}$ | CL=90% | 1159 |
| $K_1(1270)^{\pm} K^{\mp}$ | | < 3.0 | $\times 10^{-3}$ | CL=90% | – |
| $K_2^*(1430)^0 \overline{K}_2^*(1430)^0$ | | < 2.9 | $\times 10^{-3}$ | CL=90% | 588 |
| $K^*(892)^0 \overline{K}^*(892)^0$ | | < 5 | $\times 10^{-4}$ | CL=90% | 1263 |
| $\phi f_2(1270)$ | | < 3.7 | $\times 10^{-4}$ | CL=90% | 1036 |
| $p\overline{p}\rho$ | | < 3.1 | $\times 10^{-4}$ | CL=90% | 779 |
| $\phi\eta(1440) \rightarrow \phi\eta\pi\pi$ | | < 2.5 | $\times 10^{-4}$ | CL=90% | 946 |
| $\omega f_2'(1525)$ | | < 2.2 | $\times 10^{-4}$ | CL=90% | 1003 |
| $\Sigma(1385)^0 \overline{\Lambda}$ | | < 2 | $\times 10^{-4}$ | CL=90% | 911 |
| $\Delta(1232)^+ \overline{p}$ | | < 1 | $\times 10^{-4}$ | CL=90% | 1100 |
| $\Sigma^0 \overline{\Lambda}$ | | < 9 | $\times 10^{-5}$ | CL=90% | 1032 |
| $\phi\pi^0$ | | < 6.8 | $\times 10^{-6}$ | CL=90% | 1377 |

## Decays into stable hadrons

| | | | | | |
|---|---|---|---|---|---|
| $2(\pi^+\pi^-)\pi^0$ | | ( 3.37±0.26) % | | | 1496 |
| $3(\pi^+\pi^-)\pi^0$ | | ( 2.9 ±0.6 ) % | | | 1433 |
| $\pi^+\pi^-\pi^0$ | | ( 1.50±0.20) % | | | 1533 |
| $\pi^+\pi^-\pi^0 K^+ K^-$ | | ( 1.20±0.30) % | | | 1368 |
| $4(\pi^+\pi^-)\pi^0$ | | ( 9.0 ±3.0 ) | $\times 10^{-3}$ | | 1345 |
| $\pi^+\pi^- K^+ K^-$ | | ( 7.2 ±2.3 ) | $\times 10^{-3}$ | | 1407 |
| $K\overline{K}\pi$ | | ( 6.1 ±1.0 ) | $\times 10^{-3}$ | | 1440 |
| $p\overline{p}\pi^+\pi^-$ | | ( 6.0 ±0.5 ) | $\times 10^{-3}$ | S=1.3 | 1107 |
| $2(\pi^+\pi^-)$ | | ( 4.0 ±1.0 ) | $\times 10^{-3}$ | | 1517 |
| $3(\pi^+\pi^-)$ | | ( 4.0 ±2.0 ) | $\times 10^{-3}$ | | 1466 |
| $n\overline{n}\pi^+\pi^-$ | | ( 4 ±4 ) | $\times 10^{-3}$ | | 1106 |
| $\Sigma^0 \overline{\Sigma}^0$ | | ( 1.27±0.17) | $\times 10^{-3}$ | | 992 |
| $2(\pi^+\pi^-) K^+ K^-$ | | ( 3.1 ±1.3 ) | $\times 10^{-3}$ | | 1320 |

| | | | | |
|---|---|---|---|---|
| $p\overline{p}\pi^+\pi^-\pi^0$ | [*iii*] | $( 2.3 \pm 0.9 ) \times 10^{-3}$ | S=1.9 | 1033 |
| $p\overline{p}$ | | $( 2.12 \pm 0.10) \times 10^{-3}$ | | 1232 |
| $p\overline{p}\eta$ | | $( 2.09 \pm 0.18) \times 10^{-3}$ | | 948 |
| $p\overline{n}\pi^-$ | | $( 2.00 \pm 0.10) \times 10^{-3}$ | | 1174 |
| $n\overline{n}$ | | $( 2.2 \pm 0.4 ) \times 10^{-3}$ | | 1231 |
| $\Xi\overline{\Xi}$ | | $( 1.8 \pm 0.4 ) \times 10^{-3}$ | S=1.8 | 818 |
| $\Lambda\overline{\Lambda}$ | | $( 1.30 \pm 0.12) \times 10^{-3}$ | S=1.1 | 1074 |
| $p\overline{p}\pi^0$ | | $( 1.09 \pm 0.09) \times 10^{-3}$ | | 1176 |
| $\Lambda\overline{\Sigma}^-\pi^+$ (or c.c.) | [*ee*] | $( 1.06 \pm 0.12) \times 10^{-3}$ | | 945 |
| $pK^-\overline{\Lambda}$ | | $( 8.9 \pm 1.6 ) \times 10^{-4}$ | | 876 |
| $2(K^+K^-)$ | | $( 7.0 \pm 3.0 ) \times 10^{-4}$ | | 1131 |
| $pK^-\overline{\Sigma}^0$ | | $( 2.9 \pm 0.8 ) \times 10^{-4}$ | | 820 |
| $K^+K^-$ | | $( 2.37 \pm 0.31) \times 10^{-4}$ | | 1468 |
| $\Lambda\overline{\Lambda}\pi^0$ | | $( 2.2 \pm 0.6 ) \times 10^{-4}$ | | 998 |
| $\pi^+\pi^-$ | | $( 1.47 \pm 0.23) \times 10^{-4}$ | | 1542 |
| $K^0_S K^0_L$ | | $( 1.08 \pm 0.14) \times 10^{-4}$ | | 1466 |
| $\Lambda\overline{\Sigma} +$ c.c. | | $< 1.5 \times 10^{-4}$ | CL=90% | 1032 |
| $K^0_S K^0_S$ | | $< 5.2 \times 10^{-6}$ | CL=90% | 1466 |

**Radiative decays**

| | | | | |
|---|---|---|---|---|
| $\gamma\eta_c(1S)$ | | $( 1.3 \pm 0.4 )$ % | | 116 |
| $\gamma\pi^+\pi^-2\pi^0$ | | $( 8.3 \pm 3.1 ) \times 10^{-3}$ | | 1518 |
| $\gamma\eta\pi\pi$ | | $( 6.1 \pm 1.0 ) \times 10^{-3}$ | | 1487 |
| $\gamma\eta(1440) \to \gamma K\overline{K}\pi$ | [*p*] | $( 9.1 \pm 1.8 ) \times 10^{-4}$ | | 1223 |
| $\gamma\eta(1440) \to \gamma\gamma\rho^0$ | | $( 6.4 \pm 1.4 ) \times 10^{-5}$ | | 1223 |
| $\gamma\eta(1440) \to \gamma\eta\pi^+\pi^-$ | | $( 3.0 \pm 0.5 ) \times 10^{-4}$ | | – |
| $\gamma\rho\rho$ | | $( 4.5 \pm 0.8 ) \times 10^{-3}$ | | 1343 |
| $\gamma\eta_2(1870) \to \gamma\pi^+\pi^-$ | | $( 6.2 \pm 2.4 ) \times 10^{-4}$ | | – |
| $\gamma\eta'(958)$ | | $( 4.31 \pm 0.30) \times 10^{-3}$ | | 1400 |
| $\gamma 2\pi^+2\pi^-$ | | $( 2.8 \pm 0.5 ) \times 10^{-3}$ | S=1.9 | 1517 |
| $\gamma K^+K^-\pi^+\pi^-$ | | $( 2.1 \pm 0.6 ) \times 10^{-3}$ | | – |
| $\gamma f_4(2050)$ | | $( 2.7 \pm 0.7 ) \times 10^{-3}$ | | 874 |
| $\gamma\omega\omega$ | | $( 1.59 \pm 0.33) \times 10^{-3}$ | | 1337 |
| $\gamma\eta(1440) \to \gamma\rho^0\rho^0$ | | $( 1.7 \pm 0.4 ) \times 10^{-3}$ | S=1.3 | 1223 |
| $\gamma f_2(1270)$ | | $( 1.38 \pm 0.14) \times 10^{-3}$ | | 1286 |
| $\gamma f_0(1710) \to \gamma K\overline{K}$ | | $( 8.5 \ ^{+1.2}_{-0.9} ) \times 10^{-4}$ | S=1.2 | 1075 |
| $\gamma\eta$ | | $( 8.6 \pm 0.8 ) \times 10^{-4}$ | | 1500 |
| $\gamma f_1(1420) \to \gamma K\overline{K}\pi$ | | $( 8.3 \pm 1.5 ) \times 10^{-4}$ | | 1220 |
| $\gamma f_1(1285)$ | | $( 6.1 \pm 0.9 ) \times 10^{-4}$ | | 1283 |
| $\gamma f_1(1510) \to \gamma\eta\pi^+\pi^-$ | | $( 4.5 \pm 1.2 ) \times 10^{-4}$ | | – |
| $\gamma f'_2(1525)$ | | $( 4.7 \ ^{+0.7}_{-0.5} ) \times 10^{-4}$ | | 1173 |

| | | | |
|---|---|---|---|
| $\gamma f_2(1950) \rightarrow \gamma K^*(892)\overline{K}^*(892)$ | $( 7.0 \pm 2.2 ) \times 10^{-4}$ | | – |
| $\gamma K^*(892)\overline{K}^*(892)$ | $( 4.0 \pm 1.3 ) \times 10^{-3}$ | | – |
| $\gamma\phi\phi$ | $( 4.0 \pm 1.2 ) \times 10^{-4}$ | S=2.1 | 1166 |
| $\gamma p\overline{p}$ | $( 3.8 \pm 1.0 ) \times 10^{-4}$ | | 1232 |
| $\gamma\eta(2225)$ | $( 2.9 \pm 0.6 ) \times 10^{-4}$ | | 834 |
| $\gamma\eta(1760) \rightarrow \gamma\rho^0\rho^0$ | $( 1.3 \pm 0.9 ) \times 10^{-4}$ | | 1048 |
| $\gamma\pi^0$ | $( 3.9 \pm 1.3 ) \times 10^{-5}$ | | 1546 |
| $\gamma p\overline{p}\pi^+\pi^-$ | $< 7.9 \times 10^{-4}$ | CL=90% | 1107 |
| $\gamma\gamma$ | $< 5 \times 10^{-4}$ | CL=90% | 1548 |
| $\gamma\Lambda\overline{\Lambda}$ | $< 1.3 \times 10^{-4}$ | CL=90% | 1074 |
| $3\gamma$ | $< 5.5 \times 10^{-5}$ | CL=90% | 1548 |
| $\gamma f_J(2220)$ | $> 2.50 \times 10^{-3}$ | CL=99.9% | – |
| $\gamma f_J(2220) \rightarrow \gamma\pi\pi$ | $( 8 \pm 4 ) \times 10^{-5}$ | | – |
| $\gamma f_J(2220) \rightarrow \gamma K\overline{K}$ | $( 8.1 \pm 3.0 ) \times 10^{-5}$ | | – |
| $\gamma f_J(2220) \rightarrow \gamma p\overline{p}$ | $( 1.5 \pm 0.8 ) \times 10^{-5}$ | | – |
| $\gamma f_0(1500)$ | $< ( 5.7 \pm 0.8 ) \times 10^{-4}$ | | 1184 |
| $\gamma e^+ e^-$ | $( 8.8 \pm 1.4 ) \times 10^{-3}$ | | – |

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

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

Mass $m = 3415.0 \pm 0.8$ MeV
Full width $\Gamma = 14.9^{+2.6}_{-2.3}$ MeV

| $\chi_{c0}(1P)$ DECAY MODES | Fraction ($\Gamma_i/\Gamma$) | Scale factor/ Confidence level | $p$ (MeV/$c$) |
|---|---|---|---|
| **Hadronic decays** | | | |
| $2(\pi^+\pi^-)$ | $(2.0 \pm 0.9)$ % | S=2.7 | 1679 |
| $\pi^+\pi^- K^+ K^-$ | $(1.8 \pm 0.6)$ % | S=1.9 | 1580 |
| $\rho^0\pi^+\pi^-$ | $(1.6 \pm 0.5)$ % | | 1608 |
| $3(\pi^+\pi^-)$ | $(1.24 \pm 0.22)$ % | | 1633 |
| $K^+\overline{K}^*(892)^0\pi^- +$ c.c. | $(1.2 \pm 0.4)$ % | | 1522 |
| $\pi^+\pi^-$ | $(5.0 \pm 0.7) \times 10^{-3}$ | | 1702 |
| $K^+ K^-$ | $(5.9 \pm 0.9) \times 10^{-3}$ | | 1635 |
| $\pi^+\pi^- p\overline{p}$ | $(1.8 \pm 0.9) \times 10^{-3}$ | S=1.6 | 1320 |
| $K^+ K^- K^+ K^-$ | $(2.1 \pm 0.5) \times 10^{-3}$ | | – |
| $K^0_S K^0_S$ | $(2.0 \pm 0.6) \times 10^{-3}$ | | – |
| $\phi\phi$ | $(9 \pm 5) \times 10^{-4}$ | | – |
| $K^0_S K^+\pi^- +$ c.c. | $< 7.1 \times 10^{-4}$ | CL=90% | – |
| $p\overline{p}$ | $(2.2 \pm 1.3) \times 10^{-4}$ | S=2.1 | 1427 |

**Radiative decays**

| | | |
|---|---|---|
| $\gamma J/\psi(1S)$ | $(6.6\ \pm1.8\ )\times10^{-3}$ | 303 |
| $\gamma\gamma$ | $(2.7\ \pm1.9\ )\times10^{-4}$ | 1708 |

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

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

Mass $m = 3510.51 \pm 0.12$ MeV
Full width $\Gamma = 0.88 \pm 0.14$ MeV

| $\chi_{c1}(1P)$ DECAY MODES | Fraction ($\Gamma_i/\Gamma$) | Scale factor | $p$ (MeV/$c$) |
|---|---|---|---|
| **Hadronic decays** | | | |
| $3(\pi^+\pi^-)$ | $(\ 6.3\pm1.4)\times10^{-3}$ | | 1683 |
| $2(\pi^+\pi^-)$ | $(\ 5.6\pm2.6)\times10^{-3}$ | 2.2 | 1727 |
| $\pi^+\pi^-K^+K^-$ | $(\ 4.9\pm1.2)\times10^{-3}$ | 1.1 | 1632 |
| $\rho^0\pi^+\pi^-$ | $(\ 3.9\pm3.5)\times10^{-3}$ | | 1659 |
| $K^+\overline{K}^*(892)^0\pi^- +$ c.c. | $(\ 3.2\pm2.1)\times10^{-3}$ | | 1576 |
| $K^0_S K^+\pi^-$ | $(\ 2.5\pm0.8)\times10^{-3}$ | | – |
| $\pi^+\pi^- p\overline{p}$ | $(\ 5.4\pm2.1)\times10^{-4}$ | | 1381 |
| $K^+K^-K^+K^-$ | $(\ 4.2\pm1.9)\times10^{-4}$ | | – |
| $p\overline{p}$ | $(\ 8.2\pm1.3)\times10^{-5}$ | 1.2 | 1483 |
| $\pi^+\pi^- +\ K^+K^-$ | $<\ 2.1\ \times10^{-3}$ | | – |
| **Radiative decays** | | | |
| $\gamma J/\psi(1S)$ | $(27.3\pm1.6)$ % | | 389 |

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

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

Mass $m = 3556.18 \pm 0.13$ MeV
Full width $\Gamma = 2.00 \pm 0.18$ MeV

| $\chi_{c2}(1P)$ DECAY MODES | Fraction ($\Gamma_i/\Gamma$) | Scale factor/ Confidence level | $p$ (MeV/$c$) |
|---|---|---|---|
| **Hadronic decays** | | | |
| $2(\pi^+\pi^-)$ | $(\ 1.2\ \pm0.5\ )$ % | S=2.2 | 1751 |
| $\pi^+\pi^-K^+K^-$ | $(10\ \ \pm4\ \ )\times10^{-3}$ | S=2.0 | 1656 |
| $3(\pi^+\pi^-)$ | $(\ 9.2\ \pm2.2\ )\times10^{-3}$ | | 1707 |
| $\rho^0\pi^+\pi^-$ | $(\ 7\ \ \pm4\ \ )\times10^{-3}$ | | 1683 |
| $K^+\overline{K}^*(892)^0\pi^- +$ c.c. | $(\ 4.8\ \pm2.8\ )\times10^{-3}$ | | 1601 |
| $\pi^+\pi^- p\overline{p}$ | $(\ 1.4\ \pm0.6\ )\times10^{-3}$ | S=1.5 | 1410 |
| $\phi\phi$ | $(\ 2.0\ \pm0.8\ )\times10^{-3}$ | | – |

| | | | | |
|---|---|---|---|---|
| $\pi^+\pi^-$ | ( 1.52±0.25) | $\times 10^{-3}$ | | 1773 |
| $K^+K^-$ | ( 8.1 ±1.9 ) | $\times 10^{-4}$ | | 1708 |
| $K^+K^-K^+K^-$ | ( 1.5 ±0.4 ) | $\times 10^{-3}$ | | – |
| $K^0_S K^0_S$ | ( 6.1 ±2.3 ) | $\times 10^{-4}$ | | – |
| $p\overline{p}$ | ( 9.8 ±1.0 ) | $\times 10^{-5}$ | | 1510 |
| $J/\psi(1S)\pi^+\pi^-\pi^0$ | < 1.5 | % | CL=90% | 185 |
| $K^0_S K^+\pi^-$ + c.c. | < 1.06 | $\times 10^{-3}$ | CL=90% | – |

**Radiative decays**

| | | | | |
|---|---|---|---|---|
| $\gamma J/\psi(1S)$ | (13.5 ±1.1 ) | % | | 430 |
| $\gamma\gamma$ | ( 1.6 ±0.5 ) | $\times 10^{-4}$ | | 1778 |

## $\psi(2S)$

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

Mass $m = 3685.96 \pm 0.09$ MeV
Full width $\Gamma = 277 \pm 31$ keV (S = 1.1)
$\Gamma_{ee} = 2.12 \pm 0.18$ keV

| $\psi(2S)$ DECAY MODES | Fraction ($\Gamma_i/\Gamma$) | | Scale factor/ Confidence level | $p$ (MeV/$c$) |
|---|---|---|---|---|
| hadrons | (98.10±0.30) | % | | – |
| virtual $\gamma \rightarrow$ hadrons | ( 2.9 ±0.4 ) | % | | – |
| $e^+e^-$ | ( 8.8 ±1.3 ) | $\times 10^{-3}$ | | 1843 |
| $\mu^+\mu^-$ | ( 1.03±0.35) | % | | 1840 |

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

| | | | | |
|---|---|---|---|---|
| $J/\psi(1S)$ anything | (55 ±5 ) | % | | – |
| $J/\psi(1S)$ neutrals | (23.1 ±2.3 ) | % | | – |
| $J/\psi(1S)\pi^+\pi^-$ | (31.0 ±2.8 ) | % | | 477 |
| $J/\psi(1S)\pi^0\pi^0$ | (18.2 ±2.3 ) | % | | 481 |
| $J/\psi(1S)\eta$ | ( 2.7 ±0.4 ) | % | S=1.6 | 200 |
| $J/\psi(1S)\pi^0$ | ( 9.7 ±2.1 ) | $\times 10^{-4}$ | | 527 |

**Hadronic decays**

| | | | | |
|---|---|---|---|---|
| $3(\pi^+\pi^-)\pi^0$ | ( 3.5 ±1.6 ) | $\times 10^{-3}$ | | 1746 |
| $2(\pi^+\pi^-)\pi^0$ | ( 3.0 ±0.8 ) | $\times 10^{-3}$ | | 1799 |
| $\omega f_2(1270)$ | < 1.7 | $\times 10^{-4}$ | CL=90% | – |
| $\rho a_2(1320)$ | < 2.3 | $\times 10^{-4}$ | CL=90% | – |
| $\pi^+\pi^-K^+K^-$ | ( 1.6 ±0.4 ) | $\times 10^{-3}$ | | 1726 |
| $K^*(892)\overline{K}^*_2(1430)^0$ | < 1.2 | $\times 10^{-4}$ | CL=90% | – |
| $K_1(1270)^\pm K^\mp$ | ( 1.00±0.28) | $\times 10^{-3}$ | | – |
| $\pi^+\pi^- p\overline{p}$ | ( 8.0 ±2.0 ) | $\times 10^{-4}$ | | 1491 |
| $K^+\overline{K}^*(892)^0\pi^-$ + c.c. | ( 6.7 ±2.5 ) | $\times 10^{-4}$ | | 1673 |
| $b_1^\pm\pi^\mp$ | ( 5.2 ±1.3 ) | $\times 10^{-4}$ | | – |
| $2(\pi^+\pi^-)$ | ( 4.5 ±1.0 ) | $\times 10^{-4}$ | | 1817 |

| | | | | |
|---|---|---|---|---|
| $\rho^0\pi^+\pi^-$ | ( 4.2 ±1.5 ) × $10^{-4}$ | | | 1751 |
| $\overline{p}p$ | ( 1.9 ±0.5 ) × $10^{-4}$ | | | 1586 |
| $3(\pi^+\pi^-)$ | ( 1.5 ±1.0 ) × $10^{-4}$ | | | 1774 |
| $\overline{p}p\pi^0$ | ( 1.4 ±0.5 ) × $10^{-4}$ | | | 1543 |
| $K^+K^-$ | ( 1.0 ±0.7 ) × $10^{-4}$ | | | 1776 |
| $\pi^+\pi^-\pi^0$ | ( 8 ±5 ) × $10^{-5}$ | | | 1830 |
| $\rho\pi$ | < 8.3 | × $10^{-5}$ | CL=90% | 1760 |
| $\pi^+\pi^-$ | ( 8 ±5 ) × $10^{-5}$ | | | 1838 |
| $\Lambda\overline{\Lambda}$ | < 4 | × $10^{-4}$ | CL=90% | 1467 |
| $K_1(1400)^\pm K^\mp$ | < 3.1 | × $10^{-4}$ | CL=90% | – |
| $\Xi^-\overline{\Xi}^+$ | < 2 | × $10^{-4}$ | CL=90% | 1285 |
| $K^+K^-\pi^0$ | < 2.96 | × $10^{-5}$ | CL=90% | 1754 |
| $K^+\overline{K}^*(892)^-$ + c.c. | < 5.4 | × $10^{-5}$ | CL=90% | 1698 |
| $\phi f_2'(1525)$ | < 4.5 | × $10^{-5}$ | CL=90% | – |

**Radiative decays**

| | | | | |
|---|---|---|---|---|
| $\gamma\chi_{c0}(1P)$ | ( 9.3 ±0.9 ) % | | | 261 |
| $\gamma\chi_{c1}(1P)$ | ( 8.7 ±0.8 ) % | | | 171 |
| $\gamma\chi_{c2}(1P)$ | ( 7.8 ±0.8 ) % | | | 127 |
| $\gamma\eta_c(1S)$ | ( 2.8 ±0.6 ) × $10^{-3}$ | | | 639 |
| $\gamma\eta'(958)$ | ( 1.5 ±0.4 ) × $10^{-4}$ | | | 1719 |
| $\gamma\eta$ | < 9 | × $10^{-5}$ | CL=90% | 1802 |
| $\gamma\gamma$ | < 1.6 | × $10^{-4}$ | CL=90% | 1843 |
| $\gamma\eta(1440) \rightarrow \gamma K\overline{K}\pi$ | < 1.2 | × $10^{-4}$ | CL=90% | 1569 |

## $\psi(3770)$

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

Mass $m$ = 3769.9 ± 2.5 MeV (S = 1.8)
Full width $\Gamma$ = 23.6 ± 2.7 MeV (S = 1.1)
$\Gamma_{ee}$ = 0.26 ± 0.04 keV (S = 1.2)

| $\psi(3770)$ DECAY MODES | Fraction ($\Gamma_i/\Gamma$) | Scale factor | $p$ (MeV/$c$) |
|---|---|---|---|
| $D\overline{D}$ | dominant | | 242 |
| $e^+e^-$ | (1.12±0.17) × $10^{-5}$ | 1.2 | 1885 |

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

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

Mass $m = 4040 \pm 10$ MeV
Full width $\Gamma = 52 \pm 10$ MeV
$\Gamma_{ee} = 0.75 \pm 0.15$ keV

| $\psi(4040)$ DECAY MODES | Fraction ($\Gamma_i/\Gamma$) | $p$ (MeV/$c$) |
|---|---|---|
| $e^+ e^-$ | $(1.4 \pm 0.4) \times 10^{-5}$ | 2020 |
| $D^0 \overline{D}^0$ | seen | 777 |
| $D^*(2007)^0 \overline{D}^0 +$ c.c. | seen | 578 |
| $D^*(2007)^0 \overline{D}^*(2007)^0$ | seen | 232 |

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

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

Mass $m = 4159 \pm 20$ MeV
Full width $\Gamma = 78 \pm 20$ MeV
$\Gamma_{ee} = 0.77 \pm 0.23$ keV

| $\psi(4160)$ DECAY MODES | Fraction ($\Gamma_i/\Gamma$) | $p$ (MeV/$c$) |
|---|---|---|
| $e^+ e^-$ | $(10 \pm 4) \times 10^{-6}$ | 2079 |

## $\psi(4415)$ [iii]

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

Mass $m = 4415 \pm 6$ MeV
Full width $\Gamma = 43 \pm 15$ MeV (S = 1.8)
$\Gamma_{ee} = 0.47 \pm 0.10$ keV

| $\psi(4415)$ DECAY MODES | Fraction ($\Gamma_i/\Gamma$) | $p$ (MeV/$c$) |
|---|---|---|
| hadrons | dominant | – |
| $e^+ e^-$ | $(1.1 \pm 0.4) \times 10^{-5}$ | 2207 |