# LIGHT UNFLAVORED MESONS
# $(S = C = B = 0)$

For $I = 1$ $(\pi, b, \rho, a)$:  $u\overline{d}$, $(u\overline{u} - d\overline{d})/\sqrt{2}$, $d\overline{u}$;

for $I = 0$ $(\eta, \eta', h, h', \omega, \phi, f, f')$:  $c_1(u\overline{u} + d\overline{d}) + c_2(s\overline{s})$

## $\pi^{\pm}$

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

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)

$c\tau = 7.8045$ m

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

$F_V = 0.017 \pm 0.008$

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

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

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

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

| $\pi^+$ 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] | $( 1.61$ | $\pm 0.23$ $) \times 10^{-7}$ | | 70 |
| $e^+ \nu_e \pi^0$ | | | | $( 1.036$ | $\pm 0.006$ $) \times 10^{-8}$ | | 4 |
| $e^+ \nu_e e^+ e^-$ | | | | $( 3.2$ | $\pm 0.5$ $) \times 10^{-9}$ | | 70 |
| $e^+ \nu_e \nu \overline{\nu}$ | | | | $< 5$ | $\times 10^{-6}$ | 90% | 70 |
| **Lepton Family number (*LF*) or Lepton number (*L*) violating modes** | | | | | | | |
| $\mu^+ \overline{\nu}_e$ | $L$ | [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)

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

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

$c\tau = 25.1$ 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/$c$) |
|---|---|---|---|---|
| $2\gamma$ | | $(98.798 \pm 0.032)$ % | S=1.1 | 67 |
| $e^+ e^- \gamma$ | | $(1.198 \pm 0.032)$ % | S=1.1 | 67 |
| $\gamma$ positronium | | $(1.82 \pm 0.29) \times 10^{-9}$ | | 67 |
| $e^+ e^+ e^- e^-$ | | $(3.14 \pm 0.30) \times 10^{-5}$ | | 67 |
| $e^+ e^-$ | | $(6.2 \pm 0.5) \times 10^{-8}$ | | 67 |
| $4\gamma$ | | $< 2$ | $\times 10^{-8}$ CL=90% | 67 |
| $\nu\overline{\nu}$ | | [e] $< 2.7$ | $\times 10^{-7}$ CL=90% | 67 |
| $\nu_e \overline{\nu}_e$ | | $< 1.7$ | $\times 10^{-6}$ CL=90% | 67 |
| $\nu_\mu \overline{\nu}_\mu$ | | $< 1.6$ | $\times 10^{-6}$ CL=90% | 67 |
| $\nu_\tau \overline{\nu}_\tau$ | | $< 2.1$ | $\times 10^{-6}$ CL=90% | 67 |
| $\gamma\nu\overline{\nu}$ | | $< 6$ | $\times 10^{-4}$ CL=90% | 67 |

**Charge conjugation ($C$) or Lepton Family number ($LF$) violating modes**

| | | | | |
|---|---|---|---|---|
| $3\gamma$ | $C$ | $< 3.1$ | $\times 10^{-8}$ 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 |
| $\mu^+ e^- + \mu^- e^+$ | $LF$ | $< 1.72$ | $\times 10^{-8}$ CL=90% | 26 |

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$$\boxed{\eta} \qquad I^G(J^{PC}) = 0^+(0^{-+})$$

Mass $m = 547.51 \pm 0.18$ MeV [f]  (S = 5.8)
Full width $\Gamma = 1.30 \pm 0.07$ keV [g]

**$C$-nonconserving decay parameters**

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

**Dalitz plot parameter**

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

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

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### $f_0(600)$ [i] or $\sigma$

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

Mass $m = (400\text{–}1200)$ MeV
Full width $\Gamma = (600\text{–}1000)$ MeV

| $f_0(600)$ DECAY MODES | Fraction $(\Gamma_i/\Gamma)$ | $p$ (MeV/c) |
|---|---|---|
| $\pi\pi$ | dominant | − |
| $\gamma\gamma$ | seen | − |

## $\rho(770)$ [j]    $I^G(J^{PC}) = 1^+(1^{--})$

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

| $\rho(770)$ DECAY MODES | Fraction $(\Gamma_i/\Gamma)$ | | Scale factor/ Confidence level | $p$ (MeV/c) |
|---|---|---|---|---|
| $\pi\pi$ | $\sim$ 100 | % | | 363 |
| **$\rho(770)^\pm$ decays** | | | | |
| $\pi^\pm\gamma$ | ( 4.5 $\pm$0.5 | ) $\times 10^{-4}$ | S=2.2 | 375 |
| $\pi^\pm\eta$ | < 6 | $\times 10^{-3}$ | CL=84% | 153 |
| $\pi^\pm\pi^+\pi^-\pi^0$ | < 2.0 | $\times 10^{-3}$ | CL=84% | 254 |
| **$\rho(770)^0$ decays** | | | | |
| $\pi^+\pi^-\gamma$ | ( 9.9 $\pm$1.6 | ) $\times 10^{-3}$ | | 362 |
| $\pi^0\gamma$ | ( 6.0 $\pm$0.8 | ) $\times 10^{-4}$ | | 376 |
| $\eta\gamma$ | ( 2.95$\pm$0.30 | ) $\times 10^{-4}$ | S=1.2 | 194 |
| $\pi^0\pi^0\gamma$ | ( 4.5 $\pm$0.8 | ) $\times 10^{-5}$ | | 363 |
| $\mu^+\mu^-$ [k] | ( 4.55$\pm$0.28 | ) $\times 10^{-5}$ | | 373 |
| $e^+e^-$ [k] | ( 4.70$\pm$0.08 | ) $\times 10^{-5}$ | | 388 |
| $\pi^+\pi^-\pi^0$ | ( $1.01^{+0.54}_{-0.36}\pm0.34$) $\times 10^{-4}$ | | | 323 |
| $\pi^+\pi^-\pi^+\pi^-$ | ( 1.8 $\pm$0.9 | ) $\times 10^{-5}$ | | 251 |
| $\pi^+\pi^-\pi^0\pi^0$ | < 4 | $\times 10^{-5}$ | CL=90% | 257 |

## $\omega(782)$    $I^G(J^{PC}) = 0^-(1^{--})$

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

| $\omega(782)$ DECAY MODES | Fraction $(\Gamma_i/\Gamma)$ | Scale factor/ Confidence level | $p$ (MeV/$c$) |
|---|---|---|---|
| $\pi^+\pi^-\pi^0$ | $(89.1 \pm 0.7 )\%$ | S=1.1 | 327 |
| $\pi^0\gamma$ | $( 8.90^{+0.27}_{-0.23})\%$ | S=1.1 | 380 |
| $\pi^+\pi^-$ | $( 1.70\pm0.27)\%$ | S=1.4 | 366 |
| neutrals (excluding $\pi^0\gamma$) | $( 1.6^{+7.4}_{-1.1} )\times 10^{-3}$ | | – |
| $\eta\gamma$ | $( 4.9 \pm0.5 )\times 10^{-4}$ | | 200 |
| $\pi^0 e^+ e^-$ | $( 7.7 \pm0.9 )\times 10^{-4}$ | S=1.1 | 380 |
| $\pi^0 \mu^+ \mu^-$ | $( 9.6 \pm2.3 )\times 10^{-5}$ | | 349 |
| $e^+ e^-$ | $( 7.18\pm0.12)\times 10^{-5}$ | S=1.1 | 391 |
| $\pi^+\pi^-\pi^0\pi^0$ | $< 2 \%$ | CL=90% | 262 |
| $\pi^+\pi^-\gamma$ | $< 3.6 \times 10^{-3}$ | CL=95% | 366 |
| $\pi^+\pi^-\pi^+\pi^-$ | $< 1 \times 10^{-3}$ | CL=90% | 256 |
| $\pi^0\pi^0\gamma$ | $( 6.7 \pm1.1 )\times 10^{-5}$ | | 367 |
| $\eta\pi^0\gamma$ | $< 3.3 \times 10^{-5}$ | CL=90% | 163 |
| $\mu^+\mu^-$ | $( 9.0 \pm3.1 )\times 10^{-5}$ | | 377 |
| $3\gamma$ | $< 1.9 \times 10^{-4}$ | CL=95% | 391 |

### Charge conjugation ($C$) violating modes

| | | Fraction $(\Gamma_i/\Gamma)$ | Scale factor/ Confidence level | $p$ (MeV/$c$) |
|---|---|---|---|---|
| $\eta\pi^0$ | $C$ | $< 1 \times 10^{-3}$ | CL=90% | 163 |
| $3\pi^0$ | $C$ | $< 3 \times 10^{-4}$ | CL=90% | 330 |

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## $\eta'(958)$

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

Mass $m = 957.78 \pm 0.14$ MeV

Full width $\Gamma = 0.203 \pm 0.016$ MeV   (S = 1.3)

| $\eta'(958)$ DECAY MODES | Fraction $(\Gamma_i/\Gamma)$ | Scale factor/ Confidence level | $p$ (MeV/$c$) |
|---|---|---|---|
| $\pi^+\pi^-\eta$ | $(44.5 \pm1.4 )\%$ | S=1.1 | 232 |
| $\rho^0\gamma$ (including non-resonant $\pi^+\pi^-\gamma$) | $(29.4 \pm0.9 )\%$ | S=1.1 | 165 |
| $\pi^0\pi^0\eta$ | $(20.8 \pm1.2 )\%$ | S=1.2 | 239 |
| $\omega\gamma$ | $( 3.03\pm0.31)\%$ | | 159 |
| $\gamma\gamma$ | $( 2.12\pm0.14)\%$ | S=1.3 | 479 |
| $3\pi^0$ | $( 1.55\pm0.26)\times 10^{-3}$ | | 430 |
| $\mu^+\mu^-\gamma$ | $( 1.04\pm0.26)\times 10^{-4}$ | | 467 |
| $\pi^+\pi^-\pi^0$ | $< 5 \%$ | CL=90% | 428 |
| $\pi^0\rho^0$ | $< 4 \%$ | CL=90% | 111 |
| $\pi^+\pi^+\pi^-\pi^-$ | $< 1 \%$ | CL=90% | 372 |
| $\pi^+\pi^+\pi^-\pi^-$ neutrals | $< 1 \%$ | CL=95% | – |

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

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

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

## $f_0(980)$ [I]    $I^G(J^{PC}) = 0^+(0^{++})$

Mass $m = 980 \pm 10$ MeV
Full width $\Gamma = 40$ to $100$ MeV

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

## $a_0(980)$ [I]    $I^G(J^{PC}) = 1^-(0^{++})$

Mass $m = 984.7 \pm 1.2$ MeV    (S = 1.5)
Full width $\Gamma = 50$ to $100$ MeV

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

## $\phi(1020)$    $I^G(J^{PC}) = 0^-(1^{--})$

Mass $m = 1019.460 \pm 0.019$ MeV
Full width $\Gamma = 4.26 \pm 0.05$ MeV    (S = 1.7)

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

## $h_1(1170)$

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

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

| $h_1(1170)$ DECAY MODES | 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)

| $b_1(1235)$ DECAY MODES | Fraction ($\Gamma_i/\Gamma$) | Confidence level | $p$ (MeV/$c$) |
|---|---|---|---|
| $\omega\pi$ | dominant | | 348 |
| $[D/S$ amplitude ratio $= 0.277 \pm 0.027]$ | | | |
| $\pi^{\pm}\gamma$ | ( $1.6\pm0.4$ ) $\times 10^{-3}$ | | 607 |
| $\eta\rho$ | seen | | † |
| $\pi^+\pi^+\pi^-\pi^0$ | < 50 % | 84% | 535 |
| $(K\overline{K})^{\pm}\pi^0$ | < 8 % | 90% | 248 |
| $K^0_S K^0_L \pi^{\pm}$ | < 6 % | 90% | 235 |
| $K^0_S K^0_S \pi^{\pm}$ | < 2 % | 90% | 235 |
| $\phi\pi$ | < 1.5 % | 84% | 147 |

## $a_1(1260)$ [m]     $I^G(J^{PC}) = 1^-(1^{++})$

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

| $a_1(1260)$ DECAY MODES | 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 | † |
| $K\overline{K}^*(892)+$ c.c. | seen | † |
| $\pi\gamma$ | seen | 608 |

## $f_2(1270)$     $I^G(J^{PC}) = 0^+(2^{++})$

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

| $f_2(1270)$ DECAY MODES | Fraction ($\Gamma_i/\Gamma$) | Scale factor/ Confidence level | $p$ (MeV/$c$) |
|---|---|---|---|
| $\pi\pi$ | (84.7 $^{+2.5}_{-1.2}$ ) % | S=1.2 | 623 |
| $\pi^+\pi^- 2\pi^0$ | ( 7.1 $^{+1.4}_{-2.7}$ ) % | S=1.3 | 563 |
| $K\overline{K}$ | ( 4.6 $\pm0.4$ ) % | S=2.7 | 404 |
| $2\pi^+ 2\pi^-$ | ( 2.8 $\pm0.4$ ) % | S=1.2 | 559 |
| $\eta\eta$ | ( 4.0 $\pm0.8$ ) $\times 10^{-3}$ | S=2.1 | 327 |

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

## $f_1(1285)$  $\quad I^G(J^{PC}) = 0^+(1^{++})$

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

| $f_1(1285)$ DECAY MODES | Fraction $(\Gamma_i/\Gamma)$ | Scale factor/ Confidence level | $p$ (MeV/c) |
|---|---|---|---|
| $4\pi$ | $(33.1^{+2.1}_{-1.8})$ % | S=1.3 | 568 |
| $\quad \pi^0\pi^0\pi^+\pi^-$ | $(22.0^{+1.4}_{-1.2})$ % | S=1.3 | 566 |
| $\quad 2\pi^+ 2\pi^-$ | $(11.0^{+0.7}_{-0.6})$ % | S=1.3 | 563 |
| $\quad\quad \rho^0\pi^+\pi^-$ | $(11.0^{+0.7}_{-0.6})$ % | S=1.3 | 336 |
| $\quad\quad \rho^0\rho^0$ | seen | | † |
| $4\pi^0$ | $< 7 \times 10^{-4}$ | CL=90% | 568 |
| $\eta\pi\pi$ | $(52 \pm 16)$ % | | 482 |
| $\quad a_0(980)\pi$ [ignoring $a_0(980) \to K\overline{K}$] | $(36 \pm 7)$ % | | 234 |
| $\quad \eta\pi\pi$ [excluding $a_0(980)\pi$] | $(16 \pm 7)$ % | | 482 |
| $K\overline{K}\pi$ | $(9.0 \pm 0.4)$ % | S=1.1 | 308 |
| $\quad K\overline{K}^*(892)$ | 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 |

## $\eta(1295)$  $\quad I^G(J^{PC}) = 0^+(0^{-+})$

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 | 244 |
| $\eta\pi^0\pi^0$ | seen | 490 |
| $\eta(\pi\pi)_{S\text{-wave}}$ | seen | – |

## $\pi(1300)$ $\qquad I^G(J^{PC}) = 1^-(0^{-+})$

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

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

## $a_2(1320)$ $\qquad I^G(J^{PC}) = 1^-(2^{++})$

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

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

## $f_0(1370)$ [l] $\qquad I^G(J^{PC}) = 0^+(0^{++})$

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

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

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

## $\pi_1(1400)$ [o] $\qquad\qquad I^G(J^{PC}) = 1^-(1^{-+})$

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

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

## $\eta(1405)$ [p] $\qquad\qquad I^G(J^{PC}) = 0^+(0^{-+})$

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

| $\eta(1405)$ DECAY MODES | Fraction $(\Gamma_i/\Gamma)$ | Confidence level | $p$ (MeV/$c$) |
|---|---|---|---|
| $K\overline{K}\pi$ | seen | | 425 |
| $\eta\pi\pi$ | seen | | 563 |
| $\quad a_0(980)\pi$ | seen | | 342 |
| $\quad \eta(\pi\pi)_{S\text{-wave}}$ | seen | | – |
| $f_0(980)\eta$ | seen | | † |
| $4\pi$ | seen | | 639 |
| $\quad \rho\rho$ | <58 % | 99.85% | † |
| $K^*(892)K$ | seen | | 125 |

## $f_1(1420)$ [q] $\qquad\qquad I^G(J^{PC}) = 0^+(1^{++})$

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

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

## $\omega(1420)$ [r]  $I^G(J^{PC}) = 0^-(1^{--})$

Mass $m$ (1400–1450) MeV
Full width $\Gamma$ (180–250) MeV

| $\omega(1420)$ DECAY MODES | 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 |

## $a_0(1450)$ [l]  $I^G(J^{PC}) = 1^-(0^{++})$

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

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

## $\rho(1450)$ [s]  $I^G(J^{PC}) = 1^+(1^{--})$

Mass $m = 1459 \pm 11$ MeV [n]   (S = 3.4)
Full width $\Gamma = 171 \pm 50$ MeV [n]   (S = 4.9)

| $\rho(1450)$ DECAY MODES | Fraction ($\Gamma_i/\Gamma$) | Confidence level | $p$ (MeV/c) |
|---|---|---|---|
| $\pi\pi$ | seen | | 717 |
| $4\pi$ | seen | | 666 |
| $\omega\pi$ | $<2.0\,\%$ | 95% | 508 |
| $e^+e^-$ | seen | | 730 |
| $\eta\rho$ | $<4\ \,\%$ | | 304 |
| $a_2(1320)\pi$ | not seen | | 39 |
| $\phi\pi$ | $<1\ \,\%$ | | 355 |
| $K\overline{K}$ | $<1.6\times10^{-3}$ | 95% | 537 |
| $\eta\gamma$ | possibly seen | | 627 |

## $\eta(1475)$ [p]     $I^G(J^{PC}) = 0^+(0^{-+})$

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

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

## $f_0(1500)$ [o]     $I^G(J^{PC}) = 0^+(0^{++})$

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

| $f_0(1500)$ DECAY MODES | Fraction ($\Gamma_i/\Gamma$) | Scale factor | $p$ (MeV/c) |
|---|---|---|---|
| $\eta\eta'(958)$ | $(\ 1.9\pm0.8)\,\%$ | 1.7 | 37 |
| $\eta\eta$ | $(\ 5.1\pm0.9)\,\%$ | 1.4 | 518 |
| $4\pi$ | $(49.5\pm3.3)\,\%$ | 1.2 | 692 |
| $4\pi^0$ | seen | | 692 |
| $2\pi^+2\pi^-$ | seen | | 688 |
| $\pi\pi$ | $(34.9\pm2.3)\,\%$ | 1.2 | 741 |
| $\pi^+\pi^-$ | seen | | 741 |
| $2\pi^0$ | seen | | 741 |
| $K\overline{K}$ | $(\ 8.6\pm1.0)\,\%$ | 1.1 | 569 |
| $\gamma\gamma$ | not seen | | 754 |

## $f_2'(1525)$   $I^G(J^{PC}) = 0^+(2^{++})$

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

| $f_2'(1525)$ DECAY MODES | Fraction ($\Gamma_i/\Gamma$) | $p$ (MeV/$c$) |
|---|---|---|
| $K\overline{K}$ | $(88.8 \pm 3.1)$ % | 581 |
| $\eta\eta$ | $(10.3 \pm 3.1)$ % | 531 |
| $\pi\pi$ | $(8.2 \pm 1.5) \times 10^{-3}$ | 750 |
| $\gamma\gamma$ | $(1.11 \pm 0.14) \times 10^{-6}$ | 763 |

## $\pi_1(1600)$ [o]   $I^G(J^{PC}) = 1^-(1^{-+})$

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

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

## $\eta_2(1645)$   $I^G(J^{PC}) = 0^+(2^{-+})$

Mass $m = 1617 \pm 5$ 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 |
| $K\overline{K}\pi$ | seen | 580 |
| $K^*\overline{K}$ | seen | 404 |
| $\eta\pi^+\pi^-$ | seen | 685 |
| $a_0(980)\pi$ | seen | 496 |
| $f_2(1270)\eta$ | not seen | † |

## $\omega(1650)$ [t]   $I^G(J^{PC}) = 0^-(1^{--})$

Mass $m = 1670 \pm 30$ 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 |

## $\omega_3(1670)$

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

Mass $m = 1667 \pm 4$ MeV

Full width $\Gamma = 168 \pm 10$ MeV [n]

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

## $\pi_2(1670)$

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

Mass $m = 1672.4 \pm 3.2$ MeV [n]    (S = 1.4)

Full width $\Gamma = 259 \pm 9$ MeV [n]    (S = 1.3)

| $\pi_2(1670)$ DECAY MODES | Fraction $(\Gamma_i/\Gamma)$ | Confidence level | $p$ (MeV/$c$) |
|---|---|---|---|
| $3\pi$ | $(95.8\pm1.4)$ % | | 809 |
| $\quad f_2(1270)\pi$ | $(56.2\pm3.2)$ % | | 329 |
| $\quad \rho\pi$ | $(31 \pm4\ )$ % | | 648 |
| $\quad \sigma\pi$ | $(10.9\pm3.4)$ % | | – |
| $\quad (\pi\pi)_{S\text{-wave}}$ | $(\ 8.7\pm3.4)$ % | | – |
| $K\overline{K}^*(892)+$ c.c. | $(\ 4.2\pm1.4)$ % | | 455 |
| $\omega\rho$ | $(\ 2.7\pm1.1)$ % | | 304 |
| $\rho(1450)\pi$ | $<\ 3.6\ \ \times 10^{-3}$ | 97.7% | 154 |
| $b_1(1235)\pi$ | $<\ 1.9\ \ \times 10^{-3}$ | 97.7% | 366 |
| $\quad f_1(1285)\pi$ | possibly seen | | 323 |
| $\quad a_2(1320)\pi$ | not seen | | 292 |

## $\phi(1680)$

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

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

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

**$\phi(1680)$ DECAY MODES**

| $\phi(1680)$ DECAY MODES | Fraction ($\Gamma_i/\Gamma$) | $p$ (MeV/c) |
|---|---|---|
| $K\overline{K}^*(892)+$ c.c. | dominant | 462 |
| $K^0_S K\pi$ | seen | 621 |
| $K\overline{K}$ | seen | 680 |
| $e^+e^-$ | seen | 840 |
| $\omega\pi\pi$ | not seen | 623 |

## $\rho_3(1690)$    $I^G(J^{PC}) = 1^+(3^{--})$

Mass $m = 1688.8 \pm 2.1$ MeV [n]
Full width $\Gamma = 161 \pm 10$ MeV [n]  (S = 1.5)

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

## $\rho(1700)$ [s]    $I^G(J^{PC}) = 1^+(1^{--})$

Mass $m = 1720 \pm 20$ MeV [n]  ($\eta\rho^0$ and $\pi^+\pi^-$ modes)
Full width $\Gamma = 250 \pm 100$ MeV [n]  ($\eta\rho^0$ and $\pi^+\pi^-$ modes)

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

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

## $f_0(1710)$ [u] $\qquad\qquad I^G(J^{PC}) = 0^+(0^{++})$

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

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

## $\pi(1800)$ $\qquad\qquad I^G(J^{PC}) = 1^-(0^{-+})$

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

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

## $\phi_3(1850)$ $\qquad I^G(J^{PC}) = 0^-(3^{--})$

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

| $\phi_3(1850)$ DECAY MODES | Fraction $(\Gamma_i/\Gamma)$ | $p$ (MeV/$c$) |
|---|---|---|
| $K\overline{K}$ | seen | 785 |
| $K\overline{K}{}^*(892)+$ c.c. | seen | 602 |

## $f_2(1950)$ $\qquad I^G(J^{PC}) = 0^+(2^{++})$

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

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

## $f_2(2010)$ $\qquad I^G(J^{PC}) = 0^+(2^{++})$

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 | † |

## $a_4(2040)$ $\qquad I^G(J^{PC}) = 1^-(4^{++})$

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

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

## $f_4(2050)$ $\quad\quad I^G(J^{PC}) = 0^+(4^{++})$

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

| $f_4(2050)$ DECAY MODES | Fraction ($\Gamma_i/\Gamma$) | $p$ (MeV/$c$) |
|---|:---:|---:|
| $\omega\omega$ | not seen | 642 |
| $\pi\pi$ | $(17.0\pm1.5)$ % | 1003 |
| $K\overline{K}$ | $(6.8^{+3.4}_{-1.8}) \times 10^{-3}$ | 884 |
| $\eta\eta$ | $(2.1\pm0.8) \times 10^{-3}$ | 852 |
| $4\pi^0$ | < 1.2    % | 967 |
| $a_2(1320)\pi$ | seen | 572 |

## $f_2(2300)$ $\quad\quad I^G(J^{PC}) = 0^+(2^{++})$

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 |
| $K\overline{K}$ | seen | 1037 |
| $\gamma\gamma$ | seen | 1149 |

## $f_2(2340)$ $\quad\quad I^G(J^{PC}) = 0^+(2^{++})$

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 |

## NOTES

[a] See the "Note on $\pi^{\pm} \to \ell^{\pm}\nu\gamma$ and $K^{\pm} \to \ell^{\pm}\nu\gamma$ 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 $[\Gamma(e^{+}\nu_e) + \Gamma(\mu^{+}\nu_{\mu})]/\Gamma_{total} = 100\%$.

[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] Due to a new measurement in the average, this is 0.45 MeV larger than the mass we gave in our 2002 edition, $547.30 \pm 0.12$ MeV.

[g] Due to removing an old measurement from the average, this is 0.11 keV larger than the width we gave in our 2002 edition, $1.18 \pm 0.11$ keV. See the $\Gamma(2\gamma)$ data block in the Data Listings.

[h] $C$ parity forbids this to occur as a single-photon process.

[i] See the "Note on scalar mesons" in the $f_0$(1370) Particle Listings . The interpretation of this entry as a particle is controversial.

[j] See the "Note on $\rho$(770)" in the $\rho$(770) Particle Listings .

[k] The $\omega\rho$ interference is then due to $\omega\rho$ mixing only, and is expected to be small. If $e\mu$ universality holds, $\Gamma(\rho^0 \to \mu^{+}\mu^{-}) = \Gamma(\rho^0 \to e^{+}e^{-}) \times 0.99785$.

[l] See the "Note on scalar mesons" in the $f_0$(1370) Particle Listings .

[m] See the "Note on $a_1$(1260)" in the $a_1$(1260) Particle Listings .

[n] This is only an educated guess; the error given is larger than the error on the average of the published values. See the Particle Listings for details.

[o] See the "Note on non-$q\overline{q}$ mesons" in the Particle Listings (see the index for the page number).

[p] See the "Note on the $\eta$(1405)" in the $\eta$(1405) Particle Listings.

[q] See the "Note on the $f_1$(1420)" in the $\eta$(1405) Particle Listings.

[r] See also the $\omega$(1650) Particle Listings.

[s] See the "Note on the $\rho(1450)$ and the $\rho(1700)$" in the $\rho(1700)$ Particle Listings.

[t] See also the $\omega(1420)$ Particle Listings.

[u] See the "Note on $f_0(1710)$" in the $f_0(1710)$ Particle Listings .