

# LIGHT UNFLAVORED MESONS

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

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

$\pi^\pm$

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

Mass  $m = 139.57039 \pm 0.00018$  MeV ( $S = 1.8$ )  
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]

$$F_V = 0.0254 \pm 0.0017$$

$$F_A = 0.0119 \pm 0.0001$$

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

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

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

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

$\pi^+$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	Confidence level	$\frac{p}{\text{MeV}/c}$
$\mu^+ \nu_\mu$	[b] (99.98770 $\pm$ 0.00004) %		30
$\mu^+ \nu_\mu \gamma$	[c] ( 2.00 $\pm$ 0.25 ) $\times 10^{-4}$		30
$e^+ \nu_e$	[b] ( 1.230 $\pm$ 0.004 ) $\times 10^{-4}$		70
$e^+ \nu_e \gamma$	[c] ( 7.39 $\pm$ 0.05 ) $\times 10^{-7}$		70
$e^+ \nu_e \pi^0$	( 1.036 $\pm$ 0.006 ) $\times 10^{-8}$		4
$e^+ \nu_e e^+ e^-$	( 3.2 $\pm$ 0.5 ) $\times 10^{-9}$		70
$e^+ \nu_e \nu \bar{\nu}$	< 5 $\times 10^{-6}$	90%	70

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

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

$\pi^0$

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

Mass  $m = 134.9768 \pm 0.0005$  MeV ( $S = 1.1$ )  
 $m_{\pi^\pm} - m_{\pi^0} = 4.5936 \pm 0.0005$  MeV  
Mean life  $\tau = (8.52 \pm 0.18) \times 10^{-17}$  s ( $S = 1.2$ )  
 $c\tau = 25.5$  nm

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

$\pi^0$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	Scale factor/ Confidence level	$p$ (MeV/c)	
$2\gamma$	$(98.823 \pm 0.034) \%$	S=1.5	67	
$e^+ e^- \gamma$	$(1.174 \pm 0.035) \%$	S=1.5	67	
$\gamma$ positronium	$(1.82 \pm 0.29) \times 10^{-9}$		67	
$e^+ e^+ e^- e^-$	$(3.34 \pm 0.16) \times 10^{-5}$		67	
$e^+ e^-$	$(6.46 \pm 0.33) \times 10^{-8}$		67	
$4\gamma$	$< 2$	$\times 10^{-8}$ CL=90%	67	
$\nu \bar{\nu}$	[e] $< 2.7$	$\times 10^{-7}$ CL=90%	67	
$\nu_e \bar{\nu}_e$	$< 1.7$	$\times 10^{-6}$ CL=90%	67	
$\nu_\mu \bar{\nu}_\mu$	$< 1.6$	$\times 10^{-6}$ CL=90%	67	
$\nu_\tau \bar{\nu}_\tau$	$< 2.1$	$\times 10^{-6}$ CL=90%	67	
$\gamma \nu \bar{\nu}$	$< 1.9$	$\times 10^{-7}$ CL=90%	67	
<b>Charge conjugation (C) or Lepton Family number (LF) violating modes</b>				
$3\gamma$	C	$< 3.1$	$\times 10^{-8}$ CL=90%	67
$\mu^+ e^-$	LF	$< 3.8$	$\times 10^{-10}$ CL=90%	26
$\mu^- e^+$	LF	$< 3.4$	$\times 10^{-9}$ CL=90%	26
$\mu^+ e^- + \mu^- e^+$	LF	$< 3.6$	$\times 10^{-10}$ CL=90%	26

**$\eta$**

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

Mass  $m = 547.862 \pm 0.017$  MeV

Full width  $\Gamma = 1.31 \pm 0.05$  keV

**C-nonconserving decay parameters**

$$\begin{aligned} \pi^+ \pi^- \pi^0 \text{ left-right asymmetry} &= (0.09_{-0.12}^{+0.11}) \times 10^{-2} \\ \pi^+ \pi^- \pi^0 \text{ sextant asymmetry} &= (0.12_{-0.11}^{+0.10}) \times 10^{-2} \\ \pi^+ \pi^- \pi^0 \text{ quadrant asymmetry} &= (-0.09 \pm 0.09) \times 10^{-2} \\ \pi^+ \pi^- \gamma \text{ left-right asymmetry} &= (0.9 \pm 0.4) \times 10^{-2} \\ \pi^+ \pi^- \gamma \beta \text{ (D-wave)} &= -0.02 \pm 0.07 \quad (S = 1.3) \end{aligned}$$

**CP-nonconserving decay parameters**

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

**Other decay parameters**

$$\begin{aligned} \pi^0 \pi^0 \pi^0 \text{ Dalitz plot } \alpha &= -0.0288 \pm 0.0012 \quad (S = 1.1) \\ \text{Parameter } \Lambda \text{ in } \eta \rightarrow \ell^+ \ell^- \gamma \text{ decay} &= 0.716 \pm 0.011 \text{ GeV}/c^2 \end{aligned}$$

$\eta$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	Scale factor/ Confidence level	$p$ (MeV/c)
<b>Neutral modes</b>			
neutral modes	$(72.12 \pm 0.34) \%$	S=1.2	–
$2\gamma$	$(39.41 \pm 0.20) \%$	S=1.1	274
$3\pi^0$	$(32.68 \pm 0.23) \%$	S=1.1	179
$\pi^0 2\gamma$	$(2.56 \pm 0.22) \times 10^{-4}$		257
$2\pi^0 2\gamma$	$< 1.2 \times 10^{-3}$	CL=90%	238
$4\gamma$	$< 2.8 \times 10^{-4}$	CL=90%	274
invisible	$< 1.0 \times 10^{-4}$	CL=90%	–
<b>Charged modes</b>			
charged modes	$(27.89 \pm 0.29) \%$	S=1.2	–
$\pi^+ \pi^- \pi^0$	$(22.92 \pm 0.28) \%$	S=1.2	174
$\pi^+ \pi^- \gamma$	$(4.22 \pm 0.08) \%$	S=1.1	236
$e^+ e^- \gamma$	$(6.9 \pm 0.4) \times 10^{-3}$	S=1.3	274
$\mu^+ \mu^- \gamma$	$(3.1 \pm 0.4) \times 10^{-4}$		253
$e^+ e^-$	$< 7 \times 10^{-7}$	CL=90%	274
$\mu^+ \mu^-$	$(5.8 \pm 0.8) \times 10^{-6}$		253
$2e^+ 2e^-$	$(2.40 \pm 0.22) \times 10^{-5}$		274
$\pi^+ \pi^- e^+ e^- (\gamma)$	$(2.68 \pm 0.11) \times 10^{-4}$		235
$e^+ e^- \mu^+ \mu^-$	$< 1.6 \times 10^{-4}$	CL=90%	253
$2\mu^+ 2\mu^-$	$< 3.6 \times 10^{-4}$	CL=90%	161
$\mu^+ \mu^- \pi^+ \pi^-$	$< 3.6 \times 10^{-4}$	CL=90%	113
$\pi^+ e^- \bar{\nu}_e + \text{c.c.}$	$< 1.7 \times 10^{-4}$	CL=90%	256
$\pi^+ \pi^- 2\gamma$	$< 2.1 \times 10^{-3}$		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
<b>Charge conjugation (C), Parity (P), Charge conjugation <math>\times</math> Parity (CP), or Lepton Family number (LF) violating modes</b>			
$\pi^0 \gamma$	C [f] $< 9$	$\times 10^{-5}$	CL=90% 257
$\pi^+ \pi^-$	P, CP $< 1.3$	$\times 10^{-5}$	CL=90% 236
$2\pi^0$	P, CP $< 3.5$	$\times 10^{-4}$	CL=90% 238
$2\pi^0 \gamma$	C $< 5$	$\times 10^{-4}$	CL=90% 238
$3\pi^0 \gamma$	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 [g] $< 8$	$\times 10^{-6}$	CL=90% 257
$\pi^0 \mu^+ \mu^-$	C [g] $< 5$	$\times 10^{-6}$	CL=90% 210
$\mu^+ e^- + \mu^- e^+$	LF $< 6$	$\times 10^{-6}$	CL=90% 264

**$f_0(500)$**

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

also known as  $\sigma$ ; was  $f_0(600)$

See the review on "Scalar Mesons below 2 GeV."

Mass (T-Matrix Pole  $\sqrt{s}$ ) = (400–550)– $i$ (200–350) MeV

Mass (Breit-Wigner) = (400–550) MeV

Full width (Breit-Wigner) = (400–700) MeV

<b><math>f_0(500)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$\pi\pi$	seen	–
$\gamma\gamma$	seen	–

**$\rho(770)$**

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

See the note in  $\rho(770)$  Particle Listings.

Mass  $m = 775.26 \pm 0.25$  MeV

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

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

<b><math>\rho(770)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	Scale factor/ Confidence level	$p$ (MeV/c)
$\pi\pi$	$\sim 100$	%	363
<b><math>\rho(770)^\pm</math> decays</b>			
$\pi^\pm\gamma$	( $4.5 \pm 0.5$ ) $\times 10^{-4}$	S=2.2	375
$\pi^\pm\eta$	< 6 $\times 10^{-3}$	CL=84%	152
$\pi^\pm\pi^+\pi^-\pi^0$	< 2.0 $\times 10^{-3}$	CL=84%	254
<b><math>\rho(770)^0</math> decays</b>			
$\pi^+\pi^-\gamma$	( $9.9 \pm 1.6$ ) $\times 10^{-3}$		362
$\pi^0\gamma$	( $4.7 \pm 0.6$ ) $\times 10^{-4}$	S=1.4	376
$\eta\gamma$	( $3.00 \pm 0.21$ ) $\times 10^{-4}$		194
$\pi^0\pi^0\gamma$	( $4.5 \pm 0.8$ ) $\times 10^{-5}$		363
$\mu^+\mu^-$	[ $h$ ] ( $4.55 \pm 0.28$ ) $\times 10^{-5}$		373
$e^+e^-$	[ $h$ ] ( $4.72 \pm 0.05$ ) $\times 10^{-5}$		388
$\pi^+\pi^-\pi^0$	( $1.01^{+0.54}_{-0.36} \pm 0.34$ ) $\times 10^{-4}$		323
$\pi^+\pi^-\pi^+\pi^-$	( $1.8 \pm 0.9$ ) $\times 10^{-5}$		251
$\pi^+\pi^-\pi^0\pi^0$	( $1.6 \pm 0.8$ ) $\times 10^{-5}$		257
$\pi^0e^+e^-$	< 1.2 $\times 10^{-5}$	CL=90%	376

**$\omega(782)$**

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

Mass  $m = 782.65 \pm 0.12$  MeV ( $S = 1.9$ )

Full width  $\Gamma = 8.49 \pm 0.08$  MeV

$\Gamma_{ee} = 0.60 \pm 0.02$  keV

<b><math>\omega(782)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	Scale factor/ Confidence level	$\rho$ (MeV/c)
$\pi^+\pi^-\pi^0$	(89.3 $\pm$ 0.6 ) %		327
$\pi^0\gamma$	( 8.40 $\pm$ 0.22) %	S=1.8	380
$\pi^+\pi^-$	( 1.53 $\pm$ 0.06) %		366
neutrals (excluding $\pi^0\gamma$ )	( 7 $\begin{smallmatrix} +7 \\ -4 \end{smallmatrix}$ ) $\times 10^{-3}$	S=1.1	–
$\eta\gamma$	( 4.5 $\pm$ 0.4 ) $\times 10^{-4}$	S=1.1	200
$\pi^0e^+e^-$	( 7.7 $\pm$ 0.6 ) $\times 10^{-4}$		380
$\pi^0\mu^+\mu^-$	( 1.34 $\pm$ 0.18) $\times 10^{-4}$	S=1.5	349
$e^+e^-$	( 7.36 $\pm$ 0.15) $\times 10^{-5}$	S=1.5	391
$\pi^+\pi^-\pi^0\pi^0$	< 2 $\times 10^{-4}$	CL=90%	262
$\pi^+\pi^-\gamma$	< 3.6 $\times 10^{-3}$	CL=95%	366
$\pi^+\pi^-\pi^+\pi^-$	< 1 $\times 10^{-3}$	CL=90%	256
$\pi^0\pi^0\gamma$	( 6.7 $\pm$ 1.1 ) $\times 10^{-5}$		367
$\eta\pi^0\gamma$	< 3.3 $\times 10^{-5}$	CL=90%	162
$\mu^+\mu^-$	( 7.4 $\pm$ 1.8 ) $\times 10^{-5}$		377
$3\gamma$	< 1.9 $\times 10^{-4}$	CL=95%	391
<b>Charge conjugation (C) violating modes</b>			
$\eta\pi^0$	C < 2.2 $\times 10^{-4}$	CL=90%	162
$2\pi^0$	C < 2.2 $\times 10^{-4}$	CL=90%	367
$3\pi^0$	C < 2.3 $\times 10^{-4}$	CL=90%	330
invisible	< 7 $\times 10^{-5}$	CL=90%	–

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

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

Mass  $m = 957.78 \pm 0.06$  MeV

Full width  $\Gamma = 0.188 \pm 0.006$  MeV

<b><math>\eta'(958)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	Confidence level	$\rho$ (MeV/c)
$\pi^+\pi^-\eta$	(42.5 $\pm$ 0.5 ) %		232
$\rho^0\gamma$ (including non-resonant $\pi^+\pi^-\gamma$ )	(29.5 $\pm$ 0.4 ) %		165
$\pi^0\pi^0\eta$	(22.4 $\pm$ 0.5 ) %		239
$\omega\gamma$	( 2.52 $\pm$ 0.07 ) %		159
$\omega e^+e^-$	( 2.0 $\pm$ 0.4 ) $\times 10^{-4}$		159
$\gamma\gamma$	( 2.307 $\pm$ 0.033) %		479

$3\pi^0$		$( 2.50 \pm 0.17 ) \times 10^{-3}$		430
$\mu^+ \mu^- \gamma$		$( 1.13 \pm 0.28 ) \times 10^{-4}$		467
$\pi^+ \pi^- \mu^+ \mu^-$		$< 2.9 \times 10^{-5}$	90%	401
$\pi^+ \pi^- \pi^0$		$( 3.61 \pm 0.17 ) \times 10^{-3}$		428
$(\pi^+ \pi^- \pi^0)$ S-wave		$( 3.8 \pm 0.5 ) \times 10^{-3}$		428
$\pi^\mp \rho^\pm$		$( 7.4 \pm 2.3 ) \times 10^{-4}$		106
$\pi^0 \rho^0$		$< 4$	% 90%	111
$2(\pi^+ \pi^-)$		$( 8.4 \pm 0.9 ) \times 10^{-5}$		372
$\pi^+ \pi^- 2\pi^0$		$( 1.8 \pm 0.4 ) \times 10^{-4}$		376
$2(\pi^+ \pi^-)$ neutrals		$< 1$	% 95%	–
$2(\pi^+ \pi^-) \pi^0$		$< 1.8 \times 10^{-3}$	90%	298
$2(\pi^+ \pi^-) 2\pi^0$		$< 1$	% 95%	197
$3(\pi^+ \pi^-)$		$< 3.1 \times 10^{-5}$	90%	189
$K^\pm \pi^\mp$		$< 4 \times 10^{-5}$	90%	334
$\pi^+ \pi^- e^+ e^-$		$( 2.4 \begin{smallmatrix} +1.3 \\ -1.0 \end{smallmatrix} ) \times 10^{-3}$		458
$\pi^+ e^- \nu_e + \text{c.c.}$		$< 2.1 \times 10^{-4}$	90%	469
$\gamma e^+ e^-$		$( 4.91 \pm 0.27 ) \times 10^{-4}$		479
$\pi^0 \gamma \gamma$		$( 3.20 \pm 0.24 ) \times 10^{-3}$		469
$\pi^0 \gamma \gamma (\text{non resonant})$		$( 6.2 \pm 0.9 ) \times 10^{-4}$		–
$\eta \gamma \gamma$		$< 1.33 \times 10^{-4}$	90%	322
$4\pi^0$		$< 3.2 \times 10^{-4}$	90%	380
$e^+ e^-$		$< 5.6 \times 10^{-9}$	90%	479
invisible		$< 6 \times 10^{-4}$	90%	–

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

$\pi^+ \pi^-$	$P, CP$	$< 1.8 \times 10^{-5}$	90%	458
$\pi^0 \pi^0$	$P, CP$	$< 4 \times 10^{-4}$	90%	459
$\pi^0 e^+ e^-$	$C$ [g]	$< 1.4 \times 10^{-3}$	90%	469
$\eta e^+ e^-$	$C$ [g]	$< 2.4 \times 10^{-3}$	90%	322
$3\gamma$	$C$	$< 1.0 \times 10^{-4}$	90%	479
$\mu^+ \mu^- \pi^0$	$C$ [g]	$< 6.0 \times 10^{-5}$	90%	445
$\mu^+ \mu^- \eta$	$C$ [g]	$< 1.5 \times 10^{-5}$	90%	273
$e\mu$	$LF$	$< 4.7 \times 10^{-4}$	90%	473

**$f_0(980)$**

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

See the review on "Scalar Mesons below 2 GeV."

Mass  $m = 990 \pm 20$  MeV

Full width  $\Gamma = 10$  to 100 MeV

<b><math>f_0(980)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$\pi \pi$	seen	476

$K\bar{K}$	seen	36
$\gamma\gamma$	seen	495

 **$a_0(980)$** 

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

See the review on "Scalar Mesons below 2 GeV."

Mass  $m = 980 \pm 20$  MeV

Full width  $\Gamma = 50$  to 100 MeV

<b><math>a_0(980)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$\eta\pi$	seen	319
$K\bar{K}$	seen	†
$\rho\pi$	not seen	137
$\gamma\gamma$	seen	490

 **$\phi(1020)$** 

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

Mass  $m = 1019.461 \pm 0.016$  MeV

Full width  $\Gamma = 4.249 \pm 0.013$  MeV ( $S = 1.1$ )

<b><math>\phi(1020)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	Scale factor/ Confidence level	$p$ (MeV/c)
$K^+K^-$	(49.2 ± 0.5 ) %	S=1.3	127
$K_L^0 K_S^0$	(34.0 ± 0.4 ) %	S=1.3	110
$\rho\pi + \pi^+\pi^-\pi^0$	(15.24 ± 0.33 ) %	S=1.2	—
$\eta\gamma$	( 1.303 ± 0.025 ) %	S=1.2	363
$\pi^0\gamma$	( 1.30 ± 0.05 ) × 10 <sup>-3</sup>		501
$\ell^+\ell^-$	—		510
$e^+e^-$	( 2.973 ± 0.034 ) × 10 <sup>-4</sup>	S=1.3	510
$\mu^+\mu^-$	( 2.86 ± 0.19 ) × 10 <sup>-4</sup>		499
$\eta e^+e^-$	( 1.08 ± 0.04 ) × 10 <sup>-4</sup>		363
$\pi^+\pi^-$	( 7.3 ± 1.3 ) × 10 <sup>-5</sup>		490
$\omega\pi^0$	( 4.7 ± 0.5 ) × 10 <sup>-5</sup>		172
$\omega\gamma$	< 5 %	CL=84%	209
$\rho\gamma$	< 1.2 × 10 <sup>-5</sup>	CL=90%	215
$\pi^+\pi^-\gamma$	( 4.1 ± 1.3 ) × 10 <sup>-5</sup>		490
$f_0(980)\gamma$	( 3.22 ± 0.19 ) × 10 <sup>-4</sup>	S=1.1	29
$\pi^0\pi^0\gamma$	( 1.12 ± 0.06 ) × 10 <sup>-4</sup>		492
$\pi^+\pi^-\pi^+\pi^-$	( 3.9 <sup>+2.8</sup> / <sub>-2.2</sub> ) × 10 <sup>-6</sup>		410
$\pi^+\pi^+\pi^-\pi^-\pi^0$	< 4.6 × 10 <sup>-6</sup>	CL=90%	342
$\pi^0 e^+ e^-$	( 1.33 <sup>+0.07</sup> / <sub>-0.10</sub> ) × 10 <sup>-5</sup>		501

$\pi^0 \eta \gamma$	$( 7.27 \pm 0.30 ) \times 10^{-5}$	$S=1.5$	346
$a_0(980) \gamma$	$( 7.6 \pm 0.6 ) \times 10^{-5}$		39
$K^0 \bar{K}^0 \gamma$	$< 1.9$	$\times 10^{-8}$ CL=90%	110
$\eta'(958) \gamma$	$( 6.22 \pm 0.21 ) \times 10^{-5}$		60
$\eta \pi^0 \pi^0 \gamma$	$< 2$	$\times 10^{-5}$ CL=90%	293
$\mu^+ \mu^- \gamma$	$( 1.4 \pm 0.5 ) \times 10^{-5}$		499
$\rho \gamma \gamma$	$< 1.2$	$\times 10^{-4}$ CL=90%	215
$\eta \pi^+ \pi^-$	$< 1.8$	$\times 10^{-5}$ CL=90%	288
$\eta \mu^+ \mu^-$	$< 9.4$	$\times 10^{-6}$ CL=90%	321
$\eta U \rightarrow \eta e^+ e^-$	$< 1$	$\times 10^{-6}$ CL=90%	—
invisible	$< 1.7$	$\times 10^{-4}$ CL=90%	—

**Lepton Family number (LF) violating modes**

$e^\pm \mu^\mp$	LF	$< 2$	$\times 10^{-6}$ CL=90%	504
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**$h_1(1170)$**

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

Mass  $m = 1166 \pm 6$  MeV

Full width  $\Gamma = 375 \pm 35$  MeV

<b><math>h_1(1170)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$\rho \pi$	seen	305

**$b_1(1235)$**

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

Mass  $m = 1229.5 \pm 3.2$  MeV ( $S = 1.6$ )

Full width  $\Gamma = 142 \pm 9$  MeV ( $S = 1.2$ )

<b><math>b_1(1235)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	Confidence level	$p$ (MeV/c)
$\omega \pi$	seen		348
	[D/S amplitude ratio = $0.277 \pm 0.027$ ]		
$\pi^\pm \gamma$	$( 1.6 \pm 0.4 ) \times 10^{-3}$		607
$\eta \rho$	seen		†
$\pi^+ \pi^+ \pi^- \pi^0$	$< 50$ %	84%	535
$K^*(892)^\pm K^\mp$	seen		†
$(K\bar{K})^\pm \pi^0$	$< 8$ %	90%	248
$K_S^0 K_L^0 \pi^\pm$	$< 6$ %	90%	235
$K_S^0 K_S^0 \pi^\pm$	$< 2$ %	90%	235
$\phi \pi$	$< 1.5$ %	84%	147



**$a_1(1260)$**  [i]

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

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

<b><math>a_1(1260)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$3\pi$	seen	577
$(\rho\pi)_{S\text{-wave}}, \rho \rightarrow \pi\pi$	seen	353
$(\rho\pi)_{D\text{-wave}}, \rho \rightarrow \pi\pi$	seen	353
$(\rho(1450)\pi)_{S\text{-wave}}, \rho \rightarrow \pi\pi$	seen	†
$(\rho(1450)\pi)_{D\text{-wave}}, \rho \rightarrow \pi\pi$	seen	†
$f_0(500)\pi, f_0 \rightarrow \pi\pi$	seen	—
$f_0(980)\pi, f_0 \rightarrow \pi\pi$	not seen	179
$f_0(1370)\pi, f_0 \rightarrow \pi\pi$	seen	†
$f_2(1270)\pi, f_2 \rightarrow \pi\pi$	seen	†
$\pi^+\pi^-\pi^0$	seen	576
$\pi^0\pi^0\pi^0$	not seen	577
$KK\pi$	seen	250
$K^*(892)K$	seen	†
$\pi\gamma$	seen	608

 **$f_2(1270)$** 

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

Mass  $m = 1275.5 \pm 0.8$  MeVFull width  $\Gamma = 186.7^{+2.2}_{-2.5}$  MeV ( $S = 1.4$ )

<b><math>f_2(1270)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	Scale factor/ Confidence level	$p$ (MeV/c)
$\pi\pi$	$(84.2^{+2.9}_{-0.9})\%$	S=1.1	623
$\pi^+\pi^-\pi^0$	$(7.7^{+1.1}_{-3.2})\%$	S=1.2	563
$K\bar{K}$	$(4.6^{+0.5}_{-0.4})\%$	S=2.7	404
$2\pi^+2\pi^-$	$(2.8 \pm 0.4)\%$	S=1.2	560
$\eta\eta$	$(4.0 \pm 0.8) \times 10^{-3}$	S=2.1	326
$4\pi^0$	$(3.0 \pm 1.0) \times 10^{-3}$		565
$\gamma\gamma$	$(1.42 \pm 0.24) \times 10^{-5}$	S=1.4	638
$\eta\pi\pi$	$< 8 \times 10^{-3}$	CL=95%	478
$K^0K^-\pi^+ + \text{c.c.}$	$< 3.4 \times 10^{-3}$	CL=95%	293
$e^+e^-$	$< 6 \times 10^{-10}$	CL=90%	638

**$f_1(1285)$**

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

Mass  $m = 1281.9 \pm 0.5$  MeV (S = 1.8)

Full width  $\Gamma = 22.7 \pm 1.1$  MeV (S = 1.5)

<b><math>f_1(1285)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	Scale factor/ Confidence level	$p$ (MeV/c)
$4\pi$	$(32.7 \pm 1.9) \%$	S=1.2	568
$\pi^0 \pi^0 \pi^+ \pi^-$	$(21.8 \pm 1.3) \%$	S=1.2	566
$2\pi^+ 2\pi^-$	$(10.9 \pm 0.6) \%$	S=1.2	563
$\rho^0 \pi^+ \pi^-$	$(10.9 \pm 0.6) \%$	S=1.2	336
$\rho^0 \rho^0$	seen		†
$4\pi^0$	$< 7 \times 10^{-4}$	CL=90%	568
$\eta \pi^+ \pi^-$	$(35 \pm 15) \%$		479
$\eta \pi \pi$	$(52.2 \pm 2.0) \%$	S=1.2	482
$a_0(980)\pi$ [ignoring $a_0(980) \rightarrow K \bar{K}$ ]	$(38 \pm 4) \%$		238
$\eta \pi \pi$ [excluding $a_0(980)\pi$ ]	$(14 \pm 4) \%$		482
$K \bar{K} \pi$	$(9.0 \pm 0.4) \%$	S=1.1	308
$K \bar{K}^*(892)$	not seen		†
$\pi^+ \pi^- \pi^0$	$(3.0 \pm 0.9) \times 10^{-3}$		603
$\rho^\pm \pi^\mp$	$< 3.1 \times 10^{-3}$	CL=95%	390
$\gamma \rho^0$	$(6.1 \pm 1.0) \%$	S=1.7	406
$\phi \gamma$	$(7.4 \pm 2.6) \times 10^{-4}$		236
$e^+ e^-$	$< 9.4 \times 10^{-9}$	CL=90%	641

**$\eta(1295)$**

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

See the review on "Pseudoscalar and pseudovector mesons in the 1400 MeV region."

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

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

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

**$\pi(1300)$**

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

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

Full width  $\Gamma = 200$  to 600 MeV

<b><math>\pi(1300)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$\rho\pi$	seen	404
$\pi(\pi\pi)_{S\text{-wave}}$	seen	—

**$a_2(1320)$**

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

Mass  $m = 1316.9 \pm 0.9$  MeV ( $S = 1.9$ )

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

<b><math>a_2(1320)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	Scale factor/ Confidence level	$p$ (MeV/c)
$3\pi$	(70.1 $\pm$ 2.7 ) %	S=1.2	623
$\eta\pi$	(14.5 $\pm$ 1.2 ) %		535
$\omega\pi\pi$	(10.6 $\pm$ 3.2 ) %	S=1.3	364
$K\bar{K}$	( 4.9 $\pm$ 0.8 ) %		436
$\eta'(958)\pi$	( 5.5 $\pm$ 0.9 ) $\times 10^{-3}$		287
$\pi^\pm\gamma$	( 2.91 $\pm$ 0.27 ) $\times 10^{-3}$		651
$\gamma\gamma$	( 9.4 $\pm$ 0.7 ) $\times 10^{-6}$		658
$e^+e^-$	< 5 $\times 10^{-9}$	CL=90%	658

**$f_0(1370)$**

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

See the review on "Scalar Mesons below 2 GeV."

Mass  $m = 1200$  to 1500 MeV

Full width  $\Gamma = 200$  to 500 MeV

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

$a_1(1260)\pi$	seen	35
$\eta\eta$	seen	411
$K\bar{K}$	seen	475
$K\bar{K}n\pi$	not seen	†
$6\pi$	not seen	508
$\omega\omega$	not seen	†
$\gamma\gamma$	seen	685
$e^+e^-$	not seen	685

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

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

See the review on "Non- $q\bar{q}$  Mesons."

Mass  $m = 1354 \pm 25$  MeV (S = 1.8)

Full width  $\Gamma = 330 \pm 35$  MeV

<b><math>\pi_1(1400)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$\eta\pi^0$	seen	557
$\eta\pi^-$	seen	556
$\rho(770)\pi$	not seen	442

**$\eta(1405)$**

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

See the review on "Pseudoscalar and Pseudovector Mesons in the 1400 MeV Region."

Mass  $m = 1408.8 \pm 2.0$  MeV (S = 2.2)

Full width  $\Gamma = 50.1 \pm 2.6$  MeV (S = 1.7)

<b><math>\eta(1405)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	Confidence level	$p$ (MeV/c)
$K\bar{K}\pi$	seen		424
$\eta\pi\pi$	seen		562
$a_0(980)\pi$	seen		345
$\eta(\pi\pi)$ S-wave	seen		—
$f_0(980)\pi^0 \rightarrow \pi^+\pi^-\pi^0$	not seen		—
$f_0(980)\eta$	seen		†
$4\pi$	seen		639
$\rho\rho$	<58 %	99.85%	†
$\rho^0\gamma$	seen		491
$K^*(892)K$	seen		123

**$h_1(1415)$** 

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

was  $h_1(1380)$ 

Mass  $m = 1416 \pm 8$  MeV ( $S = 1.5$ )

Full width  $\Gamma = 90 \pm 15$  MeV

 **$f_1(1420)$** 

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

See the review on "Pseudoscalar and Pseudovector Mesons in the 1400 MeV Region."

Mass  $m = 1426.3 \pm 0.9$  MeV ( $S = 1.1$ )

Full width  $\Gamma = 54.5 \pm 2.6$  MeV

 **$f_1(1420)$  DECAY MODES**

	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$K\bar{K}\pi$	seen	438
$K\bar{K}^*(892) + \text{c.c.}$	seen	163
$\eta\pi\pi$	possibly seen	573
$\phi\gamma$	seen	349

 **$\omega(1420)$  [1]**

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

Mass  $m = 1410 \pm 60$  MeV [1]

Full width  $\Gamma = 290 \pm 190$  MeV [1]

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

	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$\rho\pi$	seen	480
$\omega\pi\pi$	seen	437
$b_1(1235)\pi$	seen	112
$e^+e^-$	seen	705

 **$a_0(1450)$** 

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

See the review on "Scalar Mesons below 2 GeV."

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)
$\pi\eta$	$0.093 \pm 0.020$	627

$\pi \eta'(958)$	$0.033 \pm 0.017$	410
$K \bar{K}$	$0.082 \pm 0.028$	547
$\omega \pi \pi$	<b>DEFINED AS 1</b>	484
$a_0(980) \pi \pi$	seen	342
$\gamma \gamma$	seen	737

**$\rho(1450)$**

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

See the note in  $\rho(1450)$  Particle Listings.

$$\text{Mass } m = 1465 \pm 25 \text{ MeV } [j]$$

$$\text{Full width } \Gamma = 400 \pm 60 \text{ MeV } [j]$$

<b><math>\rho(1450)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$\pi \pi$	seen	720
$\pi^+ \pi^-$	seen	719
$4\pi$	seen	669
$e^+ e^-$	seen	732
$\eta \rho$	seen	311
$a_2(1320) \pi$	not seen	58
$K \bar{K}$	seen	541
$K^+ K^-$	seen	541
$K \bar{K}^*(892) + \text{c.c.}$	possibly seen	229
$\eta \gamma$	seen	630
$f_0(500) \gamma$	not seen	—
$f_0(980) \gamma$	not seen	398
$f_0(1370) \gamma$	not seen	92
$f_2(1270) \gamma$	not seen	177

**$\eta(1475)$**

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

See the review on "Pseudoscalar and Pseudovector Mesons in the 1400 MeV Region."

$$\text{Mass } m = 1475 \pm 4 \text{ MeV } (S = 1.4)$$

$$\text{Full width } \Gamma = 90 \pm 9 \text{ MeV } (S = 1.6)$$

<b><math>\eta(1475)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$K \bar{K} \pi$	seen	477
$K \bar{K}^*(892) + \text{c.c.}$	seen	244
$a_0(980) \pi$	seen	396

$\gamma\gamma$	seen	738
$K_S^0 K_S^0 \eta$	possibly seen	†
$\gamma\phi(1020)$	possibly seen	385

## $f_0(1500)$

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

See the reviews on "Scalar Mesons below 2 GeV" and on "Non- $q\bar{q}$  Mesons".

$$\text{Mass } m = 1506 \pm 6 \text{ MeV} \quad (S = 1.4)$$

$$\text{Full width } \Gamma = 112 \pm 9 \text{ MeV}$$

$f_0(1500)$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	Scale factor	$\rho$ (MeV/c)
$\pi\pi$	(34.5±2.2) %	1.2	741
$\pi^+\pi^-$	seen		740
$2\pi^0$	seen		741
$4\pi$	(48.9±3.3) %	1.2	692
$4\pi^0$	seen		692
$2\pi^+2\pi^-$	seen		687
$2(\pi\pi)_{S\text{-wave}}$	seen		—
$\rho\rho$	seen		†
$\pi(1300)\pi$	seen		145
$a_1(1260)\pi$	seen		219
$\eta\eta$	( 6.0±0.9) %	1.1	517
$\eta\eta'(958)$	( 2.2±0.8) %	1.4	20
$K\bar{K}$	( 8.5±1.0) %	1.1	569
$\gamma\gamma$	not seen		753

## $f_2'(1525)$

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

$$\text{Mass } m = 1517.4 \pm 2.5 \text{ MeV} \quad (S = 2.8)$$

$$\text{Full width } \Gamma = 86 \pm 5 \text{ MeV} \quad (S = 2.2)$$

$f_2'(1525)$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	Scale factor	$\rho$ (MeV/c)
$K\bar{K}$	(87.6±2.2) %	1.1	576
$\eta\eta$	(11.6±2.2) %	1.1	525
$\pi\pi$	( 8.3±1.6) × 10 <sup>-3</sup>		747
$\gamma\gamma$	( 9.5±1.1) × 10 <sup>-7</sup>	1.1	759

**$\pi_1(1600)$** 

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

See the review on "Non- $q\bar{q}$  Mesons" and a note in PDG 06, Journal of Physics **G33** 1 (2006).

$$\text{Mass } m = 1660^{+15}_{-11} \text{ MeV} \quad (S = 1.2)$$

$$\text{Full width } \Gamma = 257 \pm 60 \text{ MeV} \quad (S = 1.9)$$

<b><math>\pi_1(1600)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$\pi\pi\pi$	seen	802
$\rho^0\pi^-$	seen	640
$f_2(1270)\pi^-$	not seen	316
$b_1(1235)\pi$	seen	355
$\eta'(958)\pi^-$	seen	542
$f_1(1285)\pi$	seen	312

 **$a_1(1640)$** 

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

$$\text{Mass } m = 1655 \pm 16 \text{ MeV} \quad (S = 1.2)$$

$$\text{Full width } \Gamma = 254 \pm 40 \text{ MeV} \quad (S = 1.8)$$

<b><math>a_1(1640)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$\pi\pi\pi$	seen	800
$f_2(1270)\pi$	seen	314
$\sigma\pi$	seen	—
$\rho\pi$ <i>S-wave</i>	seen	638
$\rho\pi$ <i>D-wave</i>	seen	638
$\omega\pi\pi$	seen	607
$f_1(1285)\pi$	seen	309
$a_1(1260)\eta$	not seen	†

 **$\eta_2(1645)$** 

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

$$\text{Mass } m = 1617 \pm 5 \text{ MeV}$$

$$\text{Full width } \Gamma = 181 \pm 11 \text{ MeV}$$

<b><math>\eta_2(1645)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$a_2(1320)\pi$	seen	243
$K\bar{K}\pi$	seen	580
$K^*\bar{K}$	seen	404



$\eta\pi^+\pi^-$	seen	685
$a_0(980)\pi$	seen	499
$f_2(1270)\eta$	not seen	†

 **$\omega(1650)$  [n]**

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

 Mass  $m = 1670 \pm 30$  MeV [j]

 Full width  $\Gamma = 315 \pm 35$  MeV [j]

<b><math>\omega(1650)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$\rho\pi$	seen	647
$\omega\pi\pi$	seen	617
$\omega\eta$	seen	500
$e^+e^-$	seen	835
$\pi^0\gamma$	not seen	830

 **$\omega_3(1670)$** 

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

 Mass  $m = 1667 \pm 4$  MeV

 Full width  $\Gamma = 168 \pm 10$  MeV

<b><math>\omega_3(1670)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$\rho\pi$	seen	645
$\omega\pi\pi$	seen	615
$b_1(1235)\pi$	possibly seen	361

 **$\pi_2(1670)$** 

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

 Mass  $m = 1670.6^{+2.9}_{-1.2}$  MeV ( $S = 1.3$ )

 Full width  $\Gamma = 258^{+8}_{-9}$  MeV ( $S = 1.2$ )

<b><math>\pi_2(1670)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	Confidence level	$p$ (MeV/c)
$3\pi$	(95.8±1.4) %		808
$f_2(1270)\pi$	(56.3±3.2) %		327
$\rho\pi$	(31 ±4 ) %		647
$\sigma\pi$	(10 ±4 ) %		—
$\pi(\pi\pi)_{S\text{-wave}}$	( 8.7±3.4) %		—
$\pi^\pm\pi^+\pi^-$	(53 ±4 ) %		806
$K\bar{K}^*(892)+\text{c.c.}$	( 4.2±1.4) %		453
$\omega\rho$	( 2.7±1.1) %		302

$\pi^\pm \gamma$	$(7.0 \pm 1.2) \times 10^{-4}$		829
$\gamma \gamma$	$< 2.8 \times 10^{-7}$	90%	835
$\eta \pi$	$< 5 \%$		739
$\pi^\pm 2\pi^+ 2\pi^-$	$< 5 \%$		735
$\rho(1450)\pi$	$< 3.6 \times 10^{-3}$	97.7%	145
$b_1(1235)\pi$	$< 1.9 \times 10^{-3}$	97.7%	364
$f_1(1285)\pi$	possibly seen		322
$a_2(1320)\pi$	not seen		292

 **$\phi(1680)$** 

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

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

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

<b><math>\phi(1680)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$K \bar{K}^*(892) + \text{c.c.}$	seen	462
$K_S^0 K \pi$	seen	621
$K \bar{K}$	seen	680
$e^+ e^-$	seen	840
$\omega \pi \pi$	not seen	623
$K^+ K^- \pi^+ \pi^-$	seen	544
$\eta \phi$	seen	290
$\eta \gamma$	seen	751

 **$\rho_3(1690)$** 

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

 Mass  $m = 1688.8 \pm 2.1$  MeV

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

<b><math>\rho_3(1690)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	Scale factor	$p$ (MeV/c)
$4\pi$	$(71.1 \pm 1.9) \%$		790
$\pi^\pm \pi^+ \pi^- \pi^0$	$(67 \pm 22) \%$		787
$\omega \pi$	$(16 \pm 6) \%$		655
$\pi \pi$	$(23.6 \pm 1.3) \%$		834
$K \bar{K} \pi$	$(3.8 \pm 1.2) \%$		629
$K \bar{K}$	$(1.58 \pm 0.26) \%$	1.2	685
$\eta \pi^+ \pi^-$	seen		727
$\rho(770)\eta$	seen		520
$\pi \pi \rho$	seen		633
$a_2(1320)\pi$	seen		308
$\rho \rho$	seen		335

**$\rho(1700)$** 

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

See the note in  $\rho(1700)$  Particle Listings.Mass  $m = 1720 \pm 20$  MeV [*j*] ( $\eta\rho^0$  and  $\pi^+\pi^-$  modes)Full width  $\Gamma = 250 \pm 100$  MeV [*j*] ( $\eta\rho^0$  and  $\pi^+\pi^-$  modes)

<b><math>\rho(1700)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$2(\pi^+\pi^-)$	seen	803
$\rho\pi\pi$	seen	653
$\rho^0\pi^+\pi^-$	seen	651
$\rho^\pm\pi^\mp\pi^0$	seen	652
$a_1(1260)\pi$	seen	404
$h_1(1170)\pi$	seen	450
$\pi(1300)\pi$	seen	349
$\rho\rho$	seen	372
$\pi^+\pi^-$	seen	849
$\pi\pi$	seen	849
$K\bar{K}^*(892) + \text{c.c.}$	seen	496
$\eta\rho$	seen	545
$a_2(1320)\pi$	not seen	335
$K\bar{K}$	seen	704
$e^+e^-$	seen	860
$\pi^0\omega$	seen	674
$\pi^0\gamma$	not seen	855

 **$a_2(1700)$** 

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

Mass  $m = 1705 \pm 40$  MeVFull width  $\Gamma = 258 \pm 40$  MeV

<b><math>a_2(1700)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$\eta\pi$	$(3.7 \pm 1.0) \%$	758
$\gamma\gamma$	$(1.16 \pm 0.27) \times 10^{-6}$	852
$\rho\pi$	seen	668
$f_2(1270)\pi$	seen	356
$K\bar{K}$	$(1.9 \pm 1.2) \%$	695
$\omega\pi^-\pi^0$	seen	638
$\omega\rho$	seen	346

**$f_0(1710)$** 

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

See the review on "Non- $q\bar{q}$  Mesons."Mass  $m = 1704 \pm 12$  MeVFull width  $\Gamma = 123 \pm 18$  MeV

<b><math>f_0(1710)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$K\bar{K}$	seen	694
$\eta\eta$	seen	652
$\pi\pi$	seen	841
$\gamma\gamma$	seen	852
$\omega\omega$	seen	337

 **$\pi(1800)$** 

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

Mass  $m = 1810^{+9}_{-11}$  MeV ( $S = 2.2$ )Full width  $\Gamma = 215^{+7}_{-8}$  MeV

<b><math>\pi(1800)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$\pi^+\pi^-\pi^-$	seen	878
$f_0(500)\pi^-$	seen	—
$f_0(980)\pi^-$	seen	624
$f_0(1370)\pi^-$	seen	366
$f_0(1500)\pi^-$	not seen	247
$\rho\pi^-$	not seen	731
$\eta\eta\pi^-$	seen	660
$a_0(980)\eta$	seen	471
$a_2(1320)\eta$	not seen	†
$f_2(1270)\pi$	not seen	441
$f_0(1370)\pi^-$	not seen	366
$f_0(1500)\pi^-$	seen	247
$\eta\eta'(958)\pi^-$	seen	373
$K_0^*(1430)K^-$	seen	†
$K^*(892)K^-$	not seen	568

 **$\phi_3(1850)$** 

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

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

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

 **$\eta_2(1870)$** 

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

Mass  $m = 1842 \pm 8$  MeVFull width  $\Gamma = 225 \pm 14$  MeV

$\eta_2(1870)$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$\gamma\gamma$	seen	921

 **$\pi_2(1880)$** 

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

Mass  $m = 1874_{-5}^{+26}$  MeV ( $S = 1.6$ )Full width  $\Gamma = 237_{-30}^{+33}$  MeV ( $S = 1.2$ ) **$f_2(1950)$** 

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

Mass  $m = 1936 \pm 12$  MeV ( $S = 1.3$ )Full width  $\Gamma = 464 \pm 24$  MeV

$f_2(1950)$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$K^*(892)\bar{K}^*(892)$	seen	377
$\pi^+\pi^-$	seen	958
$\pi^0\pi^0$	seen	959
$4\pi$	seen	921
$\eta\eta$	seen	798
$K\bar{K}$	seen	833
$\gamma\gamma$	seen	968
$p\bar{p}$	seen	238

 **$a_4(1970)$** 

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

was  $a_4(2040)$ Mass  $m = 1967 \pm 16$  MeV ( $S = 2.1$ )Full width  $\Gamma = 324_{-18}^{+15}$  MeV

<b><math>a_4(1970)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$K\bar{K}$	seen	851
$\pi^+\pi^-\pi^0$	seen	959
$\rho\pi$	seen	825
$f_2(1270)\pi$	seen	559
$\omega\pi^-\pi^0$	seen	801
$\omega\rho$	seen	601
$\eta\pi$	seen	902
$\eta'(958)\pi$	seen	743

 **$f_2(2010)$** 

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

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

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

 **$f_4(2050)$** 

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

Mass  $m = 2018 \pm 11$  MeV ( $S = 2.1$ )Full width  $\Gamma = 237 \pm 18$  MeV ( $S = 1.9$ )

<b><math>f_4(2050)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$\omega\omega$	seen	637
$\pi\pi$	$(17.0 \pm 1.5)\%$	1000
$K\bar{K}$	$(6.8^{+3.4}_{-1.8}) \times 10^{-3}$	880
$\eta\eta$	$(2.1 \pm 0.8) \times 10^{-3}$	848
$4\pi^0$	$< 1.2\%$	964
$a_2(1320)\pi$	seen	568

 **$\phi(2170)$** 

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

Mass  $m = 2160 \pm 80$  MeV [j]Full width  $\Gamma = 125 \pm 65$  MeV [j]

<b><math>\phi(2170)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$e^+e^-$	seen	1080

$\phi f_0(980)$	seen	396
$K^+ K^- f_0(980) \rightarrow$	seen	—
$K^+ K^- \pi^+ \pi^-$		
$K^+ K^- f_0(980) \rightarrow K^+ K^- \pi^0 \pi^0$	seen	—
$K^{*0} K^\pm \pi^\mp$	not seen	759
$K^*(892)^0 \bar{K}^*(892)^0$	not seen	609

**$f_2(2300)$**

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

Mass  $m = 2297 \pm 28$  MeV

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

<b><math>f_2(2300)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$\phi\phi$	seen	529
$K\bar{K}$	seen	1037
$\gamma\gamma$	seen	1149

**$f_2(2340)$**

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

Mass  $m = 2345^{+50}_{-40}$  MeV

Full width  $\Gamma = 322^{+70}_{-60}$  MeV

<b><math>f_2(2340)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$\phi\phi$	seen	580
$\eta\eta$	seen	1037

## NOTES

- [a] See the review on “Form Factors for Radiative Pion and Kaon Decays” for definitions and details.
- [b] Measurements of  $\Gamma(e^+ \nu_e)/\Gamma(\mu^+ \nu_\mu)$  always include decays with  $\gamma$ 's, and measurements of  $\Gamma(e^+ \nu_e \gamma)$  and  $\Gamma(\mu^+ \nu_\mu \gamma)$  never include low-energy  $\gamma$ 's. Therefore, since no clean separation is possible, we consider the modes with  $\gamma$ 's to be subreactions of the modes without them, and let  $[\Gamma(e^+ \nu_e) + \Gamma(\mu^+ \nu_\mu)]/\Gamma_{\text{total}} = 100\%$ .
- [c] See the  $\pi^\pm$  Particle Listings for the energy limits used in this measurement; low-energy  $\gamma$ 's are not included.
- [d] Derived from an analysis of neutrino-oscillation experiments.
- [e] Astrophysical and cosmological arguments give limits of order  $10^{-13}$ .
- [f] Forbidden by angular momentum conservation.
- [g] C parity forbids this to occur as a single-photon process.
- [h] The  $\omega\rho$  interference is then due to  $\omega\rho$  mixing only, and is expected to be small. If  $e\mu$  universality holds,  $\Gamma(\rho^0 \rightarrow \mu^+ \mu^-) = \Gamma(\rho^0 \rightarrow e^+ e^-) \times 0.99785$ .
- [i] See the “Note on  $a_1(1260)$ ” in the  $a_1(1260)$  Particle Listings in PDG 06, Journal of Physics **G33** 1 (2006).
- [j] Our estimate. See the Particle Listings for details.
- [k] See the note on “Non- $q\bar{q}$  mesons” in the Particle Listings in PDG 06, Journal of Physics **G33** 1 (2006).
- [l] See also the  $\omega(1650)$ .
- [n] See also the  $\omega(1420)$ .