

LIGHT UNFLAVORED MESONS

($S = C = B = 0$)

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

π^\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]

$$F_V = 0.017 \pm 0.008$$

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

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

π^- 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.).

π^+ DECAY MODES	Fraction (Γ_i/Γ)	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] (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
$e^+ \nu_e \nu \bar{\nu}$	< 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

π^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.).

π^0 DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	ρ (MeV/c)
2γ	$(98.823 \pm 0.034) \%$	S=1.5	67
$e^+ e^- \gamma$	$(1.174 \pm 0.035) \%$	S=1.5	67
γ 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
4γ	< 2	$\times 10^{-8}$ CL=90%	67
$\nu \bar{\nu}$	[e] < 2.7	$\times 10^{-7}$ CL=90%	67
$\nu_e \bar{\nu}_e$	< 1.7	$\times 10^{-6}$ CL=90%	67
$\nu_\mu \bar{\nu}_\mu$	< 1.6	$\times 10^{-6}$ CL=90%	67
$\nu_\tau \bar{\nu}_\tau$	< 2.1	$\times 10^{-6}$ CL=90%	67
$\gamma \nu \bar{\nu}$	< 6	$\times 10^{-4}$ CL=90%	67
Charge conjugation (C) or Lepton Family number (LF) violating modes			
3γ	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

η

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

Mass $m = 547.853 \pm 0.024$ MeV [*f*]

Full width $\Gamma = 1.30 \pm 0.07$ keV [*g*]

C-nonconserving decay parameters

- $\pi^+ \pi^- \pi^0$ Left-right asymmetry = $(0.09^{+0.11}_{-0.12}) \times 10^{-2}$
- $\pi^+ \pi^- \pi^0$ Sextant asymmetry = $(0.12^{+0.10}_{-0.11}) \times 10^{-2}$
- $\pi^+ \pi^- \pi^0$ Quadrant asymmetry = $(-0.09 \pm 0.09) \times 10^{-2}$
- $\pi^+ \pi^- \gamma$ Left-right asymmetry = $(0.9 \pm 0.4) \times 10^{-2}$
- $\pi^+ \pi^- \gamma$ β (*D*-wave) = -0.02 ± 0.07 ($S = 1.3$)

Dalitz plot parameter

$$\pi^0 \pi^0 \pi^0 \quad \alpha = -0.031 \pm 0.004$$

η DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
Neutral modes			
neutral modes	(71.89±0.34) %	S=1.2	—
2 γ	[g] (39.30±0.20) %	S=1.1	274
3 π^0	(32.56±0.23) %	S=1.1	179
$\pi^0 2\gamma$	(2.7 ±0.5) × 10 ⁻⁴	S=1.1	257
$\pi^0 \pi^0 \gamma \gamma$	< 1.2 × 10 ⁻³	CL=90%	238
4 γ	< 2.8 × 10 ⁻⁴	CL=90%	274
invisible	< 6 × 10 ⁻⁴	CL=90%	—
Charged modes			
charged modes	(28.08±0.34) %	S=1.2	—
$\pi^+ \pi^- \pi^0$	(22.73±0.28) %	S=1.2	174
$\pi^+ \pi^- \gamma$	(4.60±0.16) %	S=2.1	236
$e^+ e^- \gamma$	(7.0 ±0.7) × 10 ⁻³	S=1.5	274
$\mu^+ \mu^- \gamma$	(3.1 ±0.4) × 10 ⁻⁴		253
$e^+ e^-$	< 2.7 × 10 ⁻⁵	CL=90%	274
$\mu^+ \mu^-$	(5.8 ±0.8) × 10 ⁻⁶		253
$e^+ e^- e^+ e^-$	< 6.9 × 10 ⁻⁵	CL=90%	274
$\pi^+ \pi^- e^+ e^-$	(4.2 ^{+1.5} _{-1.3}) × 10 ⁻⁴		235
$e^+ e^- \mu^+ \mu^-$	< 1.6 × 10 ⁻⁴	CL=90%	253
$\mu^+ \mu^- \mu^+ \mu^-$	< 3.6 × 10 ⁻⁴	CL=90%	161
$\mu^+ \mu^- \pi^+ \pi^-$	< 3.6 × 10 ⁻⁴	CL=90%	113
$\pi^+ \pi^- 2\gamma$	< 2.0 × 10 ⁻³		236
$\pi^+ \pi^- \pi^0 \gamma$	< 5 × 10 ⁻⁴	CL=90%	174
$\pi^0 \mu^+ \mu^- \gamma$	< 3 × 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 × 10 ⁻⁵	CL=90%	257
$\pi^+ \pi^-$	P,CP < 1.3 × 10 ⁻⁵	CL=90%	236
$\pi^0 \pi^0$	P,CP < 3.5 × 10 ⁻⁴	CL=90%	238
$\pi^0 \pi^0 \gamma$	C < 5 × 10 ⁻⁴	CL=90%	238
$\pi^0 \pi^0 \pi^0 \gamma$	C < 6 × 10 ⁻⁵	CL=90%	179
3 γ	C < 1.6 × 10 ⁻⁵	CL=90%	274
4 π^0	P,CP < 6.9 × 10 ⁻⁷	CL=90%	40
$\pi^0 e^+ e^-$	C [h] < 4 × 10 ⁻⁵	CL=90%	257
$\pi^0 \mu^+ \mu^-$	C [h] < 5 × 10 ⁻⁶	CL=90%	210
$\mu^+ e^- + \mu^- e^+$	LF < 6 × 10 ⁻⁶	CL=90%	264

$f_0(600)$ [1]
or σ

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

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

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

$f_0(600)$ DECAY MODES	Fraction (Γ_i/Γ)	ρ (MeV/c)
$\pi\pi$	dominant	—
$\gamma\gamma$	seen	—

$\rho(770)$ [1]

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

Mass $m = 775.49 \pm 0.34$ MeV

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

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

$\rho(770)$ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	ρ (MeV/c)
$\pi\pi$	~ 100	%	363
$\rho(770)^\pm$ decays			
$\pi^\pm\gamma$	(4.5 ± 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 ± 1.6) $\times 10^{-3}$		362
$\pi^0\gamma$	(6.0 ± 0.8) $\times 10^{-4}$		376
$\eta\gamma$	(3.00 ± 0.20) $\times 10^{-4}$		194
$\pi^0\pi^0\gamma$	(4.5 ± 0.8) $\times 10^{-5}$		363
$\mu^+\mu^-$	[k] (4.55 ± 0.28) $\times 10^{-5}$		373
e^+e^-	[k] (4.72 ± 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 ± 0.9) $\times 10^{-5}$		251
$\pi^+\pi^-\pi^0\pi^0$	< 4 $\times 10^{-5}$	CL=90%	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

$\omega(782)$ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	ρ (MeV/c)
$\pi^+ \pi^- \pi^0$	(89.2 \pm 0.7) %		327
$\pi^0 \gamma$	(8.28 \pm 0.28) %	S=2.1	380
$\pi^+ \pi^-$	(1.53 $^{+0.11}_{-0.13}$) %	S=1.2	366
neutrals (excluding $\pi^0 \gamma$)	(8 $^{+8}_{-5}$) $\times 10^{-3}$	S=1.1	—
$\eta \gamma$	(4.6 \pm 0.4) $\times 10^{-4}$	S=1.1	200
$\pi^0 e^+ e^-$	(7.7 \pm 0.6) $\times 10^{-4}$		380
$\pi^0 \mu^+ \mu^-$	(9.6 \pm 2.3) $\times 10^{-5}$		349
$e^+ e^-$	(7.28 \pm 0.14) $\times 10^{-5}$	S=1.3	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
$\pi^0 \pi^0 \gamma$	(6.6 \pm 1.1) $\times 10^{-5}$		367
$\eta \pi^0 \gamma$	< 3.3 $\times 10^{-5}$	CL=90%	162
$\mu^+ \mu^-$	(9.0 \pm 3.1) $\times 10^{-5}$		377
3γ	< 1.9 $\times 10^{-4}$	CL=95%	391
Charge conjugation (C) violating modes			
$\eta \pi^0$	C < 1 $\times 10^{-3}$	CL=90%	162
$3\pi^0$	C < 3 $\times 10^{-4}$	CL=90%	330

$\eta'(958)$

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

Mass $m = 957.78 \pm 0.06$ MeV

Full width $\Gamma = 0.204 \pm 0.015$ MeV (S = 1.2)

c C-violating decay parameter = 0.015 ± 0.018

$\eta'(958)$ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	ρ (MeV/c)
$\pi^+\pi^-\eta$	(44.6 \pm 1.4) %	S=1.2	232
$\rho^0\gamma$ (including non-resonant $\pi^+\pi^-\gamma$)	(29.4 \pm 0.9) %	S=1.1	165
$\pi^0\pi^0\eta$	(20.7 \pm 1.2) %	S=1.2	239
$\omega\gamma$	(3.02 \pm 0.31) %		159
$\gamma\gamma$	(2.10 \pm 0.12) %	S=1.2	479
$3\pi^0$	(1.61 \pm 0.23) $\times 10^{-3}$	S=1.1	430
$\mu^+\mu^-\gamma$	(1.03 \pm 0.26) $\times 10^{-4}$		467
$\pi^+\pi^-\mu^+\mu^-$	< 2.3 $\times 10^{-4}$	CL=90%	401
$\pi^+\pi^-\pi^0$	(3.7 $^{+1.1}_{-1.0}$) $\times 10^{-3}$		428
$\pi^0\rho^0$	< 4 %	CL=90%	111
$2(\pi^+\pi^-)$	< 2.5 $\times 10^{-4}$	CL=90%	372
$\pi^+\pi^-2\pi^0$	< 2.6 $\times 10^{-3}$	CL=90%	376
$2(\pi^+\pi^-)$ neutrals	< 1 %	CL=95%	–
$2(\pi^+\pi^-)\pi^0$	< 1.9 $\times 10^{-3}$	CL=90%	298
$2(\pi^+\pi^-)2\pi^0$	< 1 %	CL=95%	197
$3(\pi^+\pi^-)$	< 5 $\times 10^{-4}$	CL=90%	189
$\pi^+\pi^-e^+e^-$	(2.5 $^{+1.3}_{-1.0}$) $\times 10^{-3}$		458
γe^+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
invisible	< 9 $\times 10^{-4}$	CL=90%	–

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

$\pi^+\pi^-$	P, CP	< 2.9 $\times 10^{-3}$	CL=90%	458
$\pi^0\pi^0$	P, CP	< 9 $\times 10^{-4}$	CL=90%	459
$\pi^0e^+e^-$	C	[h] < 1.4 $\times 10^{-3}$	CL=90%	469
ηe^+e^-	C	[h] < 2.4 $\times 10^{-3}$	CL=90%	322
3γ	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%	273
$e\mu$	LF	< 4.7 $\times 10^{-4}$	CL=90%	473

$f_0(980)$ [1]

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

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

$f_0(980)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\pi\pi$	dominant	471
$K\bar{K}$	seen	†
$\gamma\gamma$	seen	490

$a_0(980)$ [1]

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

Mass $m = 980 \pm 20$ MeV
 Full width $\Gamma = 50$ to 100 MeV

$a_0(980)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\eta\pi$	dominant	319
$K\bar{K}$	seen	†
$\gamma\gamma$	seen	490

$\phi(1020)$

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

Mass $m = 1019.455 \pm 0.020$ MeV ($S = 1.1$)
 Full width $\Gamma = 4.26 \pm 0.04$ MeV ($S = 1.4$)

$\phi(1020)$ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
K^+K^-	(48.9 ± 0.5) %	S=1.1	127
$K_L^0 K_S^0$	(34.2 ± 0.4) %	S=1.1	110
$\rho\pi + \pi^+\pi^-\pi^0$	(15.32 ± 0.32) %	S=1.1	—
$\eta\gamma$	(1.309±0.024) %	S=1.2	363
$\pi^0\gamma$	(1.27 ± 0.06) × 10 ⁻³		501
$\ell^+\ell^-$	—		510
e^+e^-	(2.954±0.030) × 10 ⁻⁴	S=1.1	510
$\mu^+\mu^-$	(2.87 ± 0.19) × 10 ⁻⁴		499
ηe^+e^-	(1.15 ± 0.10) × 10 ⁻⁴		363
$\pi^+\pi^-$	(7.4 ± 1.3) × 10 ⁻⁵		490
$\omega\pi^0$	(4.7 ± 0.5) × 10 ⁻⁵		171
$\omega\gamma$	< 5 %	CL=84%	209
$\rho\gamma$	< 1.2 × 10 ⁻⁵	CL=90%	215
$\pi^+\pi^-\gamma$	(4.1 ± 1.3) × 10 ⁻⁵		490
$f_0(980)\gamma$	(3.22 ± 0.19) × 10 ⁻⁴	S=1.1	39
$\pi^0\pi^0\gamma$	(1.13 ± 0.06) × 10 ⁻⁴		492
$\pi^+\pi^-\pi^+\pi^-$	(4.0 ^{+2.8} _{-2.2}) × 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)	$\times 10^{-5}$		39
$\eta'(958) \gamma$	(6.25 \pm 0.21)	$\times 10^{-5}$		60
$\eta \pi^0 \pi^0 \gamma$	< 2	$\times 10^{-5}$	CL=90%	293
$\mu^+ \mu^- \gamma$	(1.4 \pm 0.5)	$\times 10^{-5}$		499
$\rho \gamma \gamma$	< 1.2	$\times 10^{-4}$	CL=90%	215
$\eta \pi^+ \pi^-$	< 1.8	$\times 10^{-5}$	CL=90%	288
$\eta \mu^+ \mu^-$	< 9.4	$\times 10^{-6}$	CL=90%	321

$h_1(1170)$

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

Mass $m = 1170 \pm 20$ MeV

Full width $\Gamma = 360 \pm 40$ MeV

$h_1(1170)$ DECAY MODES	Fraction (Γ_i/Γ)	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 (Γ_i/Γ)	Confidence level	p (MeV/c)
$\omega \pi$	dominant		348
	[D/S amplitude ratio = 0.277 ± 0.027]		
$\pi^\pm \gamma$	(1.6 \pm 0.4)	$\times 10^{-3}$	607
$\eta \rho$	seen		†
$\pi^+ \pi^+ \pi^- \pi^0$	< 50	%	84%
$(K\bar{K})^\pm \pi^0$	< 8	%	90%
$K_S^0 K_L^0 \pi^\pm$	< 6	%	90%
$K_S^0 K_S^0 \pi^\pm$	< 2	%	90%
$\phi \pi$	< 1.5	%	84%

$a_1(1260)$ ^[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 (Γ_i/Γ)	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	†
$K\bar{K}^*(892)+$ c.c.	seen	†
$\pi\gamma$	seen	608

$f_2(1270)$

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

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

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

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

$f_1(1285)$

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

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

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

f₁(1285) DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
4π	$(33.1^{+2.1}_{-1.8})\%$	S=1.3	568
$\pi^0\pi^0\pi^+\pi^-$	$(22.0^{+1.4}_{-1.2})\%$	S=1.3	566
$2\pi^+2\pi^-$	$(11.0^{+0.7}_{-0.6})\%$	S=1.3	563
$\rho^0\pi^+\pi^-$	$(11.0^{+0.7}_{-0.6})\%$	S=1.3	336
$\rho^0\rho^0$	seen		†
$4\pi^0$	$< 7 \times 10^{-4}$	CL=90%	568
$\eta\pi\pi$	$(52 \pm 16)\%$		482
$a_0(980)\pi$ [ignoring $a_0(980) \rightarrow K\bar{K}$]	$(36 \pm 7)\%$		238
$\eta\pi\pi$ [excluding $a_0(980)\pi$]	$(16 \pm 7)\%$		482
$K\bar{K}\pi$	$(9.0 \pm 0.4)\%$	S=1.1	308
$K\bar{K}^*(892)$	not seen		†
$\gamma\rho^0$	$(5.5 \pm 1.3)\%$	S=2.8	406
$\phi\gamma$	$(7.4 \pm 2.6) \times 10^{-4}$		236

$\eta(1295)$

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

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

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

$\eta(1295)$ DECAY MODES	Fraction (Γ_i/Γ)	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	—

$\pi(1300)$

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

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

Full width $\Gamma = 200$ to 600 MeV

$\pi(1300)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\rho\pi$	seen	404
$\pi(\pi\pi)_{S\text{-wave}}$	seen	—

$a_2(1320)$

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

Mass $m = 1318.3 \pm 0.6$ MeV ($S = 1.2$)

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

$a_2(1320)$ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
3π	(70.1 \pm 2.7) %	S=1.2	624
$\eta\pi$	(14.5 \pm 1.2) %		535
$\omega\pi\pi$	(10.6 \pm 3.2) %	S=1.3	366
$K\bar{K}$	(4.9 \pm 0.8) %		437
$\eta'(958)\pi$	(5.3 \pm 0.9) $\times 10^{-3}$		288
$\pi^\pm\gamma$	(2.68 \pm 0.31) $\times 10^{-3}$		652
$\gamma\gamma$	(9.4 \pm 0.7) $\times 10^{-6}$		659
e^+e^-	< 6 $\times 10^{-9}$	CL=90%	659

$f_0(1370)$ [η]

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

Mass $m = 1200$ to 1500 MeV

Full width $\Gamma = 200$ to 500 MeV

$f_0(1370)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\pi\pi$	seen	672
4π	seen	617
$4\pi^0$	seen	617
$2\pi^+2\pi^-$	seen	612
$\pi^+\pi^-2\pi^0$	seen	615
$\rho\rho$	dominant	†
$2(\pi\pi)_{S\text{-wave}}$	seen	—
$\pi(1300)\pi$	seen	†
$a_1(1260)\pi$	seen	35
$\eta\eta$	seen	411
$K\bar{K}$	seen	475
$K\bar{K}n\pi$	not seen	†
6π	not seen	508

$\omega\omega$	not seen	†
$\gamma\gamma$	seen	685
e^+e^-	not seen	685

$\pi_1(1400)$ [0^-]

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

Mass $m = 1351 \pm 30$ MeV (S = 2.0)

Full width $\Gamma = 313 \pm 40$ MeV

$\pi_1(1400)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\eta\pi^0$	seen	555
$\eta\pi^-$	seen	554

$\eta(1405)$ [0^-]

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

Mass $m = 1409.8 \pm 2.5$ MeV [n] (S = 2.2)

Full width $\Gamma = 51.1 \pm 3.4$ MeV [n] (S = 2.0)

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

$f_1(1420)$ [q]

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

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

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

$f_1(1420)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K \bar{K} \pi$	dominant	438
$K \bar{K}^*(892) + \text{c.c.}$	dominant	163
$\eta \pi \pi$	possibly seen	573
$\phi \gamma$	seen	349

$\omega(1420)$ [r]

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

Mass m (1400–1450) MeV

Full width Γ (180–250) MeV

$\omega(1420)$ DECAY MODES	Fraction (Γ_i/Γ)	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]

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

Mass $m = 1474 \pm 19$ MeV

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

$a_0(1450)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\pi \eta$	seen	627
$\pi \eta'(958)$	seen	410
$K \bar{K}$	seen	547
$\omega \pi \pi$	seen	484
$a_0(980) \pi \pi$	seen	342

$\rho(1450)$ [s]

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

Mass $m = 1465 \pm 25$ MeV [n]

Full width $\Gamma = 400 \pm 60$ MeV [n]

$\rho(1450)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\pi\pi$	seen	720
4π	seen	669
e^+e^-	seen	732
$\eta\rho$	possibly seen	310
$a_2(1320)\pi$	not seen	55
$K\bar{K}$	not seen	541
$K\bar{K}^*(892)+c.c.$	possibly seen	229
$\eta\gamma$	possibly seen	630

$\eta(1475)$ [ρ]

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

Mass $m = 1476 \pm 4$ MeV (S = 1.3)

Full width $\Gamma = 85 \pm 9$ MeV (S = 1.5)

$\eta(1475)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K\bar{K}\pi$	dominant	477
$K\bar{K}^*(892)+c.c.$	seen	245
$a_0(980)\pi$	seen	396
$\gamma\gamma$	seen	738

$f_0(1500)$ [0]

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

Mass $m = 1505 \pm 6$ MeV (S = 1.3)

Full width $\Gamma = 109 \pm 7$ MeV

$f_0(1500)$ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor	p (MeV/c)
$\pi\pi$	$(34.9 \pm 2.3) \%$	1.2	741
$\pi^+\pi^-$	seen		740
$2\pi^0$	seen		741
4π	$(49.5 \pm 3.3) \%$	1.2	691
$4\pi^0$	seen		691
$2\pi^+2\pi^-$	seen		687
$\eta\eta$	$(5.1 \pm 0.9) \%$	1.4	516
$\eta\eta'(958)$	$(1.9 \pm 0.8) \%$	1.7	†
$K\bar{K}$	$(8.6 \pm 1.0) \%$	1.1	568
$\gamma\gamma$	not seen		753

$f'_2(1525)$

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

Mass $m = 1525 \pm 5$ MeV [η]

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

$f'_2(1525)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K\bar{K}$	$(88.7 \pm 2.2) \%$	581
$\eta\eta$	$(10.4 \pm 2.2) \%$	530
$\pi\pi$	$(8.2 \pm 1.5) \times 10^{-3}$	750
$\gamma\gamma$	$(1.11 \pm 0.14) \times 10^{-6}$	763

$\pi_1(1600)$ [ρ]

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

Mass $m = 1662^{+15}_{-11}$ MeV ($S = 1.2$)

Full width $\Gamma = 234 \pm 50$ MeV ($S = 1.7$)

$\pi_1(1600)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\pi\pi\pi$	not seen	803
$\rho^0\pi^-$	not seen	641
$f_2(1270)\pi^-$	not seen	319
$b_1(1235)\pi$	seen	357
$\eta'(958)\pi^-$	seen	543
$f_1(1285)\pi$	seen	315

$\eta_2(1645)$

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

Mass $m = 1617 \pm 5$ MeV

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

$\eta_2(1645)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$a_2(1320)\pi$	seen	242
$K\bar{K}\pi$	seen	580
$K^*\bar{K}$	seen	404
$\eta\pi^+\pi^-$	seen	685
$a_0(980)\pi$	seen	499
$f_2(1270)\eta$	not seen	†

$\omega(1650)$ [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 (Γ_i/Γ)	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 (Γ_i/Γ)	p (MeV/c)
$\rho\pi$	seen	645
$\omega\pi\pi$	seen	615
$b_1(1235)\pi$	possibly seen	361

$\pi_2(1670)$

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

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

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

$\pi_2(1670)$ DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
3π	(95.8±1.4) %		809
$f_2(1270)\pi$	(56.3±3.2) %		329
$\rho\pi$	(31 ±4) %		648
$\sigma\pi$	(10.9±3.4) %		—
$(\pi\pi)_{S\text{-wave}}$	(8.7±3.4) %		—
$K\bar{K}^*(892)+\text{c.c.}$	(4.2±1.4) %		455
$\omega\rho$	(2.7±1.1) %		304
$\gamma\gamma$	< 2.8 × 10 ⁻⁷	90%	836
$\rho(1450)\pi$	< 3.6 × 10 ⁻³	97.7%	148
$b_1(1235)\pi$	< 1.9 × 10 ⁻³	97.7%	366
$f_1(1285)\pi$	possibly seen		323
$a_2(1320)\pi$	not seen		292

$\phi(1680)$

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

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

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

$\phi(1680)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K\bar{K}^*(892)+\text{c.c.}$	dominant	462
$K_S^0 K\pi$	seen	621
$K\bar{K}$	seen	680
e^+e^-	seen	840
$\omega\pi\pi$	not seen	623

$\rho_3(1690)$

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

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 (Γ_i/Γ)	Scale factor	ρ (MeV/c)
4π	(71.1 \pm 1.9) %		790
$\pi^\pm \pi^+ \pi^- \pi^0$	(67 \pm 22) %		787
$\omega \pi$	(16 \pm 6) %		655
$\pi \pi$	(23.6 \pm 1.3) %		834
$K \bar{K} \pi$	(3.8 \pm 1.2) %		629
$K \bar{K}$	(1.58 \pm 0.26) %	1.2	685
$\eta \pi^+ \pi^-$	seen		727
$\rho(770)\eta$	seen		520
$\pi \pi \rho$	seen		633
Excluding 2ρ 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 (Γ_i/Γ)	ρ (MeV/c)
$2(\pi^+ \pi^-)$	large	803
$\rho \pi \pi$	dominant	653
$\rho^0 \pi^+ \pi^-$	large	650
$\rho^\pm \pi^\mp \pi^0$	large	652
$a_1(1260)\pi$	seen	404
$h_1(1170)\pi$	seen	447
$\pi(1300)\pi$	seen	349
$\rho\rho$	seen	372
$\pi^+ \pi^-$	seen	849
$\pi \pi$	seen	849
$K \bar{K}^*(892) + \text{c.c.}$	seen	496
$\eta\rho$	seen	545
$a_2(1320)\pi$	not seen	334
$K \bar{K}$	seen	704
$e^+ e^-$	seen	860
$\pi^0 \omega$	seen	674

$f_0(1710)$ [u]

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

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

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

$f_0(1710)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K\bar{K}$	seen	704
$\eta\eta$	seen	663
$\pi\pi$	seen	849
$\omega\omega$	seen	357

$\pi(1800)$

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

Mass $m = 1816 \pm 14$ MeV ($S = 2.3$)

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

$\pi(1800)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\pi^+\pi^-\pi^-$	seen	881
$f_0(600)\pi^-$	seen	—
$f_0(980)\pi^-$	seen	634
$f_0(1370)\pi^-$	seen	371
$f_0(1500)\pi^-$	not seen	254
$\rho\pi^-$	not seen	735
$\eta\eta\pi^-$	seen	664
$a_0(980)\eta$	seen	477
$a_2(1320)\eta$	not seen	†
$f_2(1270)\pi$	not seen	445
$f_0(1370)\pi^-$	not seen	371
$f_0(1500)\pi^-$	seen	254
$\eta\eta'(958)\pi^-$	seen	380
$K_0^*(1430)K^-$	seen	†
$K^*(892)K^-$	not seen	573

$\phi_3(1850)$

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

Mass $m = 1854 \pm 7$ MeV

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

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

$\pi_2(1880)$

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

Mass $m = 1895 \pm 16$ MeV

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

$f_2(1950)$

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

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

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

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

$f_2(2010)$

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

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

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

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

$a_4(2040)$

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

Mass $m = 2001 \pm 10$ MeV

Full width $\Gamma = 313 \pm 31$ MeV

$a_4(2040)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K\bar{K}$	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

$f_4(2050)$

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

Mass $m = 2018 \pm 11$ MeV (S = 2.1)

Full width $\Gamma = 237 \pm 18$ MeV (S = 1.9)

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

$f_2(2300)$

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

Mass $m = 2297 \pm 28$ MeV

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

$f_2(2300)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\phi\phi$	seen	529
$K\bar{K}$	seen	1037
$\gamma\gamma$	seen	1149

$f_2(2340)$

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

Mass $m = 2339 \pm 60$ MeV

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

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

NOTES

- [a] See the “Note on $\pi^\pm \rightarrow \ell^\pm \nu \gamma$ and $K^\pm \rightarrow \ell^\pm \nu \gamma$ Form Factors” in the π^\pm Particle Listings for definitions and details.
- [b] Measurements of $\Gamma(e^+ \nu_e)/\Gamma(\mu^+ \nu_\mu)$ always include decays with γ 's, and measurements of $\Gamma(e^+ \nu_e \gamma)$ and $\Gamma(\mu^+ \nu_\mu \gamma)$ never include low-energy γ 's. Therefore, since no clean separation is possible, we consider the modes with γ '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 π^\pm Particle Listings for the energy limits used in this measurement; low-energy γ '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 π^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 ± 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 ± 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, $\Gamma(\rho^0 \rightarrow \mu^+ \mu^-) = \Gamma(\rho^0 \rightarrow e^+ e^-) \times 0.99785$.
- [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 in PDG 06, Journal of Physics, G **33** 1 (2006).
- [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- $q\bar{q}$ mesons” in the Particle Listings in PDG 06, Journal of Physics, G **33** 1 (2006).
- [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 in 2004 edition of *Review of Particle Physics*.