

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

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

Mass $m = 139.57061 \pm 0.00024$ MeV ($S = 1.6$)
 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 slope parameter $a = 0.10 \pm 0.06$
 $R = 0.059^{+0.009}_{-0.008}$

π^- modes are charge conjugates of the modes below.

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

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] (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

π^0

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

Mass $m = 134.9770 \pm 0.0005$ 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.).

π^0 DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (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

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

Mass $m = 547.862 \pm 0.017$ MeV

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

C-nonconserving decay parameters

$$\pi^+ \pi^- \pi^0 \text{ left-right asymmetry} = (0.09^{+0.11}_{-0.12}) \times 10^{-2}$$

$$\pi^+ \pi^- \pi^0 \text{ sextant asymmetry} = (0.12^{+0.10}_{-0.11}) \times 10^{-2}$$

$$\pi^+ \pi^- \pi^0 \text{ quadrant asymmetry} = (-0.09 \pm 0.09) \times 10^{-2}$$

$$\pi^+ \pi^- \gamma \text{ left-right asymmetry} = (0.9 \pm 0.4) \times 10^{-2}$$

$$\pi^+ \pi^- \gamma \beta \text{ (D-wave)} = -0.02 \pm 0.07 \quad (S = 1.3)$$

CP-nonconserving decay parameters

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

Dalitz plot parameter

$$\pi^0 \pi^0 \pi^0 \quad \alpha = -0.0318 \pm 0.0015$$

$$\text{PARAMETER } \Lambda \text{ IN } \eta \rightarrow \mu^+ \mu^- \gamma \text{ DECAY} = 0.719 \pm 0.014 \text{ GeV}/c^2$$

η DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
Neutral modes			
neutral modes	$(72.12 \pm 0.34) \%$	S=1.2	—
2γ	$(39.41 \pm 0.20) \%$	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
4γ	$< 2.8 \times 10^{-4}$	CL=90%	274
invisible	$< 1.0 \times 10^{-4}$	CL=90%	—
Charged modes			
charged modes	$(28.10 \pm 0.34) \%$	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
$e^+ e^-$	$< 2.3 \times 10^{-6}$	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
Charge conjugation (C), Parity (P), Charge conjugation \times 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
$2\pi^0$	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
3γ	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	$[f] < 4 \times 10^{-5}$	CL=90% 257
$\pi^0 \mu^+ \mu^-$	C	$[f] < 5 \times 10^{-6}$	CL=90% 210
$\mu^+ e^- + \mu^- e^+$	LF	$< 6 \times 10^{-6}$	CL=90% 264

**$f_0(500)$ or σ [g]
was $f_0(600)$**

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

Mass $m = (400\text{--}550)$ MeV

Full width $\Gamma = (400\text{--}700)$ MeV

$f_0(500)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\pi\pi$	dominant	—
$\gamma\gamma$	seen	—

$\rho(770)$ [h]

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

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

$\rho(770)$ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (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%	152
$\pi^\pm\pi^+\pi^-\pi^0$	< 2.0 $\times 10^{-3}$	CL=84%	254

$\rho(770)^0$ decays

$\pi^+\pi^-\gamma$	(9.9 ± 1.6) $\times 10^{-3}$		362
$\pi^0\gamma$	(4.7 ± 0.6) $\times 10^{-4}$	S=1.4	376
$\eta\gamma$	(3.00 ± 0.21) $\times 10^{-4}$		194
$\pi^0\pi^0\gamma$	(4.5 ± 0.8) $\times 10^{-5}$		363
$\mu^+\mu^-$	[i] (4.55 ± 0.28) $\times 10^{-5}$		373
e^+e^-	[j] (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
$\pi^+\pi^-\pi^0\pi^0$	(1.6 ± 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

$\omega(782)$ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
$\pi^+\pi^-\pi^0$	(89.2 \pm 0.7) %		327
$\pi^0\gamma$	(8.40 \pm 0.22) %	S=1.8	380
$\pi^+\pi^-$	(1.53 $^{+0.11}_{-0.13}$) %	S=1.2	366
neutrals (excluding $\pi^0\gamma$)	(7 $^{+7}_{-4}$) $\times 10^{-3}$	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
$\mu^+\mu^-$	(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	< 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

$\eta'(958)$

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

Mass $m = 957.78 \pm 0.06$ MeV

Full width $\Gamma = 0.196 \pm 0.009$ MeV

$\eta'(958)$ DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$\pi^+\pi^-\eta$	(42.6 \pm 0.7) %		232
$\rho^0\gamma$ (including non-resonant $\pi^+\pi^-\gamma$)	(28.9 \pm 0.5) %		165
$\pi^0\pi^0\eta$	(22.8 \pm 0.8) %		239
$\omega\gamma$	(2.62 \pm 0.13) %		159
ωe^+e^-	(2.0 \pm 0.4) $\times 10^{-4}$		159
$\gamma\gamma$	(2.22 \pm 0.08) %		479
$3\pi^0$	(2.54 \pm 0.18) $\times 10^{-3}$		430
$\mu^+\mu^-\gamma$	(1.09 \pm 0.27) $\times 10^{-4}$		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
$2(\pi^+ \pi^-)$	$(8.6 \pm 0.9) \times 10^{-5}$			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
$\pi^+ \pi^- e^+ e^-$	$(2.4^{+1.3}_{-1.0}) \times 10^{-3}$			458
$\pi^+ e^- \nu_e + \text{c.c.}$	< 2.1	$\times 10^{-4}$	90%	469
$\gamma e^+ e^-$	$(4.73 \pm 0.30) \times 10^{-4}$			479
$\pi^0 \gamma \gamma$	< 8	$\times 10^{-4}$	90%	469
$4\pi^0$	< 3.2	$\times 10^{-4}$	90%	380
$e^+ e^-$	< 5.6	$\times 10^{-9}$	90%	479
invisible	< 5	$\times 10^{-4}$	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	< 5	$\times 10^{-4}$	90%	459
$\pi^0 e^+ e^-$	C	$[f] < 1.4$	$\times 10^{-3}$	90%	469
$\eta e^+ e^-$	C	$[f] < 2.4$	$\times 10^{-3}$	90%	322
3γ	C	< 1.1	$\times 10^{-4}$	90%	479
$\mu^+ \mu^- \pi^0$	C	$[f] < 6.0$	$\times 10^{-5}$	90%	445
$\mu^+ \mu^- \eta$	C	$[f] < 1.5$	$\times 10^{-5}$	90%	273
$e\mu$	LF	< 4.7	$\times 10^{-4}$	90%	473

$f_0(980)$ [1]

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

Mass $m = 990 \pm 20$ MeV

Full width $\Gamma = 10$ to 100 MeV

$f_0(980)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\pi\pi$	dominant	476
$K\bar{K}$	seen	36
$\gamma\gamma$	seen	495

$a_0(980)$ [J]

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

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

$\phi(1020)$

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

Mass $m = 1019.460 \pm 0.016$ MeV

Full width $\Gamma = 4.247 \pm 0.016$ MeV ($S = 1.2$)

$\phi(1020)$ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
K^+K^-	(48.9 ± 0.5) %	S=1.1	127
$K_L^0K_S^0$	(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
$\pi^0\gamma$	(1.31 ± 0.05) × 10 ⁻³		501
$\ell^+\ell^-$	—		510
e^+e^-	(2.955 ± 0.029) × 10 ⁻⁴	S=1.1	510
$\mu^+\mu^-$	(2.87 ^{+0.18} _{-0.20}) × 10 ⁻⁴		499
ηe^+e^-	(1.08 ± 0.04) × 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	29
$\pi^0\pi^0\gamma$	(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 × 10 ⁻⁶	CL=90%	342
$\pi^0e^+e^-$	(1.33 ^{+0.07} _{-0.10}) × 10 ⁻⁵		501
$\pi^0\eta\gamma$	(7.27 ± 0.30) × 10 ⁻⁵	S=1.5	346
$a_0(980)\gamma$	(7.6 ± 0.6) × 10 ⁻⁵		39
$K^0\bar{K}^0\gamma$	< 1.9 × 10 ⁻⁸	CL=90%	110
$\eta'(958)\gamma$	(6.25 ± 0.21) × 10 ⁻⁵		60

$\eta\pi^0\pi^0\gamma$	< 2	$\times 10^{-5}$	CL=90%	293
$\mu^+\mu^-\gamma$	(1.4 ± 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%	—

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 $m = 1170 \pm 20$ MeV

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

$h_1(1170)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\rho\pi$	seen	308

$b_1(1235)$

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

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%	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

$a_1(1260)$ ^[k]

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

Mass $m = 1230 \pm 40$ MeV [l]

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	179
$f_0(1370)\pi$	seen	†
$f_2(1270)\pi$	seen	†
$K\bar{K}^*(892) + \text{c.c.}$	seen	†
$\pi\gamma$	seen	608

$f_2(1270)$

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

Mass $m = 1275.5 \pm 0.8$ MeV

Full width $\Gamma = 186.7^{+2.2}_{-2.5}$ MeV ($S = 1.4$)

$f_2(1270)$ DECAY MODES	Fraction (Γ_i/Γ)	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 ($S = 1.5$)

$f_1(1285)$ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
4π	$(33.5^{+2.0}_{-1.8})\%$	S=1.3	568
$\pi^0\pi^0\pi^+\pi^-$	$(22.3^{+1.3}_{-1.2})\%$	S=1.3	566

$2\pi^+ 2\pi^-$	$(11.2_{-0.6}^{+0.7})\%$	S=1.3	563
$\rho^0 \pi^+ \pi^-$	$(11.2_{-0.6}^{+0.7})\%$	S=1.3	336
$4\pi^0$	seen		†
$\eta \pi^+ \pi^-$	$< 7 \times 10^{-4}$	CL=90%	568
$\eta \pi \pi$	$(35 \pm 15)\%$		479
$a_0(980)\pi$ [ignoring $a_0(980) \rightarrow K \bar{K}$]	$(52.0_{-2.1}^{+1.8})\%$	S=1.2	482
$\eta \pi \pi$ [excluding $a_0(980)\pi$]	$(38 \pm 4)\%$		238
$K \bar{K} \pi$	$(14 \pm 4)\%$		482
$K \bar{K}^*(892)$	$(9.1 \pm 0.4)\%$	S=1.1	308
$\pi^+ \pi^- \pi^0$	not seen		†
$\rho^\pm \pi^\mp$	$(3.0 \pm 0.9) \times 10^{-3}$		603
$\gamma \rho^0$	$< 3.1 \times 10^{-3}$	CL=95%	390
$\phi \gamma$	$(5.3 \pm 1.2)\%$	S=2.9	406
	$(7.5 \pm 2.7) \times 10^{-4}$		236

$\eta(1295)$

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

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

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

$\eta(1295)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\eta \pi^+ \pi^-$	seen	487
$a_0(980)\pi$	seen	248
$\eta \pi^0 \pi^0$	seen	490
$\eta(\pi\pi)_{S\text{-wave}}$	seen	—

$\pi(1300)$

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

Mass $m = 1300 \pm 100$ MeV [1]

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 $m = 1318.3^{+0.5}_{-0.6}$ MeV ($S = 1.2$)

Full width $\Gamma = 107 \pm 5$ MeV [1]

$a_2(1320)$ 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
$\eta'(958)\pi$	(5.5 \pm 0.9) $\times 10^{-3}$		288
$\pi^\pm\gamma$	(2.91 \pm 0.27) $\times 10^{-3}$		652
$\gamma\gamma$	(9.4 \pm 0.7) $\times 10^{-6}$		659
e^+e^-	< 5 $\times 10^{-9}$	CL=90%	659

$f_0(1370)$ [1]

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

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	†
$2(\pi\pi)_S$ -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

$\pi_1(1400)$ [*n*]

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

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

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

$\pi_1(1400)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\eta\pi^0$	seen	557
$\eta\pi^-$	seen	556

$\eta(1405)$ [*o*]

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

Mass $m = 1408.8 \pm 1.8$ MeV [*l*] (S = 2.1)

Full width $\Gamma = 51.0 \pm 2.9$ MeV [*l*] (S = 1.8)

$\eta(1405)$ DECAY MODES	Fraction (Γ_i/Γ)	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		—
$f_0(980)\eta$	seen		†
4π	seen		639
$\rho\rho$	<58 %	99.85%	†
$\rho^0\gamma$	seen		491
$K^*(892)K$	seen		123

$f_1(1420)$ [*p*]

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

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

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

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

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

$a_0(1450)$ [j]

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

Mass $m = 1474 \pm 19$ MeV

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

$a_0(1450)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\pi\eta$	0.093 ± 0.020	627
$\pi\eta'(958)$	0.033 ± 0.017	410
$K\bar{K}$	0.082 ± 0.028	547
$\omega\pi\pi$	DEFINED AS 1	484
$a_0(980)\pi\pi$	seen	342
$\gamma\gamma$	seen	737

$\rho(1450)$ [r]

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

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

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

$\rho(1450)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\pi\pi$	seen	720
4π	seen	669
e^+e^-	seen	732
$\eta\rho$	seen	311
$a_2(1320)\pi$	not seen	54
$K\bar{K}$	not 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

$\eta(1475)$ [o]

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

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
$K_S^0 K_S^0 \eta$	possibly seen	†

$f_0(1500)$ [n]

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

Mass $m = 1504 \pm 6$ 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±2.3) %	1.2	740
$\pi^+\pi^-$	seen		739
$2\pi^0$	seen		740
4π	(49.5±3.3) %	1.2	691
$4\pi^0$	seen		691
$2\pi^+2\pi^-$	seen		686
$2(\pi\pi)$ S-wave	seen		—
$\rho\rho$	seen		†
$\pi(1300)\pi$	seen		143
$a_1(1260)\pi$	seen		217
$\eta\eta$	(5.1±0.9) %	1.4	515
$\eta\eta'(958)$	(1.9±0.8) %	1.7	†
$K\bar{K}$	(8.6±1.0) %	1.1	568
$\gamma\gamma$	not seen		752

$f_2'(1525)$

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

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

$f_2'(1525)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K\bar{K}$	(88.7 ±2.2) %	581
$\eta\eta$	(10.4 ±2.2) %	530

$\pi\pi$	$(8.2 \pm 1.5) \times 10^{-3}$	750
$\gamma\gamma$	$(1.10 \pm 0.14) \times 10^{-6}$	763

$\pi_1(1600)$ [η]

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

Mass $m = 1662^{+8}_{-9}$ MeV

Full width $\Gamma = 241 \pm 40$ MeV ($S = 1.4$)

$\pi_1(1600)$ 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	318
$b_1(1235)\pi$	seen	357
$\eta'(958)\pi^-$	seen	543
$f_1(1285)\pi$	seen	314

$\eta_2(1645)$

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

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	†

$\omega(1650)$ [s]

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

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	647
$\omega\pi\pi$	seen	617
$\omega\eta$	seen	500
e^+e^-	seen	835

$\omega_3(1670)$

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

Mass $m = 1667 \pm 4$ MeV

Full width $\Gamma = 168 \pm 10$ MeV [1]

$\omega_3(1670)$ 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

$\pi_2(1670)$

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

Mass $m = 1672.2 \pm 3.0$ MeV [1] ($S = 1.4$)

Full width $\Gamma = 260 \pm 9$ MeV [1] ($S = 1.2$)

$\pi_2(1670)$ 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) %		328
$\rho\pi$	(31 ±4) %		648
$\sigma\pi$	(10.9±3.4) %		–
$\pi(\pi\pi)_{S\text{-wave}}$	(8.7±3.4) %		–
$K\bar{K}^*(892) + \text{c.c.}$	(4.2±1.4) %		455
$\omega\rho$	(2.7±1.1) %		304
$\pi^\pm\gamma$	(7.0±1.1) × 10 ⁻⁴		830
$\gamma\gamma$	< 2.8 × 10 ⁻⁷	90%	836
$\rho(1450)\pi$	< 3.6 × 10 ⁻³	97.7%	147
$b_1(1235)\pi$	< 1.9 × 10 ⁻³	97.7%	365
$f_1(1285)\pi$	possibly seen		323
$a_2(1320)\pi$	not seen		292

$\phi(1680)$

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

Mass $m = 1680 \pm 20$ MeV [1]

Full width $\Gamma = 150 \pm 50$ MeV [1]

$\phi(1680)$ 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
$K^+ K^- \pi^+ \pi^-$	seen	544
$\eta \phi$	seen	290
$\eta \gamma$	seen	751

$\rho_3(1690)$

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

Mass $m = 1688.8 \pm 2.1$ MeV [1]
 Full width $\Gamma = 161 \pm 10$ MeV [1] (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		335

$\rho(1700)$ [r]

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

Mass $m = 1720 \pm 20$ MeV [1] ($\eta \rho^0$ and $\pi^+ \pi^-$ modes)
 Full width $\Gamma = 250 \pm 100$ MeV [1] ($\eta \rho^0$ 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	651
$\rho^\pm \pi^\mp \pi^0$	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

$f_0(1710)$ [t]

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

Mass $m = 1723_{-5}^{+6}$ MeV (S = 1.6)
 Full width $\Gamma = 139 \pm 8$ MeV (S = 1.1)

$f_0(1710)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K \bar{K}$	seen	706
$\eta \eta$	seen	665
$\pi \pi$	seen	851
$\omega \omega$	seen	360

$\pi(1800)$

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

Mass $m = 1812 \pm 12$ 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	879
$f_0(500) \pi^-$	seen	—
$f_0(980) \pi^-$	seen	625
$f_0(1370) \pi^-$	seen	368
$f_0(1500) \pi^-$	not seen	250
$\rho \pi^-$	not seen	732
$\eta \eta \pi^-$	seen	661
$a_0(980) \eta$	seen	473
$a_2(1320) \eta$	not seen	†
$f_2(1270) \pi$	not seen	442
$f_0(1370) \pi^-$	not seen	368
$f_0(1500) \pi^-$	seen	250
$\eta \eta'(958) \pi^-$	seen	375
$K_0^*(1430) K^-$	seen	†
$K^*(892) K^-$	not seen	570

$\phi_3(1850)$

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

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
$\pi^0\pi^0$	seen	963
4π	seen	925
$\eta\eta$	seen	803
$K\bar{K}$	seen	837
$\gamma\gamma$	seen	972
$p\bar{p}$	seen	254

$f_2(2010)$

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

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 $m = 1995^{+10}_{-8}$ MeV (S = 1.1)
 Full width $\Gamma = 257^{+25}_{-23}$ MeV (S = 1.3)

$a_4(2040)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K\bar{K}$	seen	867
$\pi^+\pi^-\pi^0$	seen	973
$\rho\pi$	seen	841
$f_2(1270)\pi$	seen	579
$\omega\pi^-\pi^0$	seen	818
$\omega\rho$	seen	623
$\eta\pi$	seen	917
$\eta'(958)\pi$	seen	760

 $f_4(2050)$

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

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

 $\phi(2170)$

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

Mass $m = 2188 \pm 10$ MeV (S = 1.8)

Full width $\Gamma = 83 \pm 12$ MeV

$\phi(2170)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
e^+e^-	seen	1094
$\phi f_0(980)$	seen	433
$K^+K^-f_0(980) \rightarrow$ $K^+K^-\pi^+\pi^-$	seen	—
$K^+K^-f_0(980) \rightarrow K^+K^-\pi^0\pi^0$	seen	—
$K^{*0}K^\pm\pi^\mp$	not seen	779
$K^*(892)^0\bar{K}^*(892)^0$	not seen	634

$f_2(2300)$

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

Mass $m = 2297 \pm 28$ MeVFull width $\Gamma = 149 \pm 40$ MeV

$f_2(2300)$ DECAY MODES	Fraction (Γ_i/Γ)	ρ (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 $m = 2345^{+50}_{-40}$ MeVFull width $\Gamma = 322^{+70}_{-60}$ MeV

$f_2(2340)$ DECAY MODES	Fraction (Γ_i/Γ)	ρ (MeV/c)
$\phi\phi$	seen	580
$\eta\eta$	seen	1037

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] C parity forbids this to occur as a single-photon process.
- [g] See the “Note on scalar mesons” in the $f_0(500)$ Particle Listings . The interpretation of this entry as a particle is controversial.
- [h] See the “Note on $\rho(770)$ ” in the $\rho(770)$ Particle Listings .

- [i] The $\omega\rho$ interference is then due to $\omega\rho$ mixing only, and is expected to be small. If $e\mu$ universality holds, $\Gamma(\rho^0 \rightarrow \mu^+\mu^-) = \Gamma(\rho^0 \rightarrow e^+e^-) \times 0.99785$.
- [j] See the “Note on scalar mesons” in the $f_0(500)$ Particle Listings .
- [k] See the “Note on $a_1(1260)$ ” in the $a_1(1260)$ Particle Listings in PDG 06, *Journal of Physics* **G33** 1 (2006).
- [l] 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.
- [n] See the “Note on non- $q\bar{q}$ mesons” in the Particle Listings in PDG 06, *Journal of Physics* **G33** 1 (2006).
- [o] See the “Note on the $\eta(1405)$ ” in the $\eta(1405)$ Particle Listings.
- [p] See the “Note on the $f_1(1420)$ ” in the $\eta(1405)$ Particle Listings.
- [q] See also the $\omega(1650)$ Particle Listings.
- [r] See the “Note on the $\rho(1450)$ and the $\rho(1700)$ ” in the $\rho(1700)$ Particle Listings.
- [s] See also the $\omega(1420)$ Particle Listings.
- [t] See the “Note on $f_0(1710)$ ” in the $f_0(1710)$ Particle Listings in 2004 edition of *Review of Particle Physics*.