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

For $I = 1$ (π, b, ρ, a): $u\overline{d}$, $(u\overline{u}-d\overline{d})/\sqrt{2}$, $d\overline{u}$;
for $I = 0$ (η, η', h, h', ω, ϕ, 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]

$F_V = 0.017 \pm 0.008$
$F_A = 0.0116 \pm 0.0016$ (S = 1.3)
$R = 0.059^{+0.009}_{-0.008}$

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

For decay limits to particles which are not established, see the appropriate Search setions (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	p (MeV/c)
$\mu^+\nu_\mu$		[b]	(99.98770 ± 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
$e^+\nu_e\pi^0$			$(1.025 \pm 0.034) \times 10^{-8}$		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

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 setions (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		(98.798 ± 0.032) %	S=1.1	67
$e^+ e^- \gamma$		(1.198 ± 0.032) %	S=1.1	67
γ 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
4γ		$< 2 \times 10^{-8}$	CL=90%	67
$\nu \overline{\nu}$	[e]	$< 8.3 \times 10^{-7}$	CL=90%	67
$\nu_e \overline{\nu}_e$		$< 1.7 \times 10^{-6}$	CL=90%	67
$\nu_\mu \overline{\nu}_\mu$		$< 3.1 \times 10^{-6}$	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				
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	$< 1.72 \times 10^{-8}$	CL=90%	26

η

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

Mass $m = 547.75 \pm 0.12$ MeV [f] (S = 2.6)
Full width $\Gamma = 1.29 \pm 0.07$ 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 $= (0.9 \pm 0.4) \times 10^{-2}$
$\pi^+ \pi^- \gamma$ β (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)

η DECAY MODES		Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
Neutral modes				
neutral modes		(72.0 ± 0.5) %	S=1.3	–
2γ	[g]	(39.43 ± 0.26) %	S=1.2	274
$3\pi^0$		(32.51 ± 0.29) %	S=1.2	179
$\pi^0 2\gamma$		$(7.2 \pm 1.4) \times 10^{-4}$		257
other neutral modes		< 2.8 %	CL=90%	–
Charged modes				
charged modes		(28.0 ± 0.5) %	S=1.3	–
$\pi^+\pi^-\pi^0$		(22.6 ± 0.4) %	S=1.3	174
$\pi^+\pi^-\gamma$		(4.68 ± 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
$\pi^+\pi^-e^+e^-$		$(4.0 {}^{+14.0}_{-2.7}) \times 10^{-4}$	S=5.8	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 $\times$ Parity (CP), or Lepton Family number (LF) violating modes				
$\pi^+\pi^-$	*P,CP*	$< 3.3 \times 10^{-4}$	CL=90%	236
$\pi^0\pi^0$	*P,CP*	$< 4.3 \times 10^{-4}$	CL=90%	238
3γ	*C*	$< 5 \times 10^{-4}$	CL=95%	274
$4\pi^0$	*P,CP*	$< 6.9 \times 10^{-7}$	CL=90%	40
$\pi^0e^+e^-$	*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

$f_0(600)$ [i] or σ

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

Mass m = (400–1200) MeV
Full width Γ = (600–1000) MeV

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

$\rho(770)$ [j]

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

Mass m = 775.8 ± 0.5 MeV
Full width Γ = 150.3 ± 1.6 MeV
Γ_{ee} = 7.02 ± 0.11 keV

$\rho(770)$ DECAY MODES		Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
$\pi\pi$		$\sim$ 100 %		364
$\rho(770)^{\pm}$ 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
$\pi^{0}\gamma$		$(6.0 \pm 1.3) \times 10^{-4}$	S=1.1	376
$\eta\gamma$		$(3.0 \pm 0.4) \times 10^{-4}$	S=1.4	195
$\pi^{0}\pi^{0}\gamma$		$(4.5 \pm 0.8) \times 10^{-5}$		364
$\mu^{+}\mu^{-}$	[k]	$(4.55 \pm 0.28) \times 10^{-5}$		373
$e^{+}e^{-}$	[k]	$(4.67 \pm 0.09) \times 10^{-5}$		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
$\pi^{+}\pi^{-}\pi^{0}\pi^{0}$		$< 4 \times 10^{-5}$	CL=90%	257

$\omega(782)$

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

Mass $m = 782.59 \pm 0.11$ MeV (S = 1.7)
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)
$\pi^+\pi^-\pi^0$		(89.1 ± 0.7) %	S=1.1	327
$\pi^0\gamma$		$(8.92^{+0.28}_{-0.24})$ %	S=1.1	380
$\pi^+\pi^-$		(1.70 ± 0.27) %	S=1.4	366
neutrals (excluding $\pi^0\gamma$)		$(1.4\ ^{+7.0}_{-0.9}) \times 10^{-3}$		–
$\eta\gamma$		$(4.9 \pm 0.5) \times 10^{-4}$		200
$\pi^0 e^+ e^-$		$(5.9 \pm 1.9) \times 10^{-4}$		380
$\pi^0\mu^+\mu^-$		$(9.6 \pm 2.3) \times 10^{-5}$		349
e^+e^-		$(7.14 \pm 0.13) \times 10^{-5}$	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
$\pi^0\pi^0\gamma$		$(6.7 \pm 1.1) \times 10^{-5}$		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 $m = 957.78 \pm 0.14$ MeV
Full width $\Gamma = 0.202 \pm 0.016$ MeV (S = 1.3)

$\eta'(958)$ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
$\pi^+\pi^-\eta$	(44.3 ± 1.5) %	S=1.2	232
$\rho^0\gamma$ (including non-resonant $\pi^+\pi^-\gamma$)	(29.5 ± 1.0) %	S=1.2	165
$\pi^0\pi^0\eta$	(20.9 ± 1.2) %	S=1.2	239
$\omega\gamma$	(3.03 ± 0.31) %		159
$\gamma\gamma$	(2.12 ± 0.14) %	S=1.3	479
$3\pi^0$	$(1.56 \pm 0.26) \times 10^{-3}$		430
$\mu^+\mu^-\gamma$	$(1.04 \pm 0.26) \times 10^{-4}$		467
$\pi^+\pi^-\pi^0$	< 5 %	CL=90%	428

$\pi^0 \rho^0$			$<$ 4	%	CL=90%	110
$\pi^+ \pi^+ \pi^- \pi^-$			$<$ 1	%	CL=90%	372
$\pi^+ \pi^+ \pi^- \pi^-$ neutrals			$<$ 1	%	CL=95%	–
$\pi^+ \pi^+ \pi^- \pi^- \pi^0$			$<$ 1	%	CL=90%	298
6π			$<$ 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
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

$f_0(980)$ [l]

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

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
$K \overline{K}$	seen	†
$\gamma \gamma$	seen	490

$a_0(980)$ [l]

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

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

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

$\phi(1020)$

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

Mass $m = 1019.456 \pm 0.020$ MeV (S = 1.1)
Full width $\Gamma = 4.26 \pm 0.05$ MeV (S = 1.7)

$\phi(1020)$ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
$K^+ K^-$	(49.1 ± 0.6) %	S=1.2	127
$K^0_L K^0_S$	(34.0 ± 0.5) %	S=1.1	110
$\rho\pi + \pi^+\pi^-\pi^0$	(15.4 ± 0.5) %	S=1.3	–
$\eta\gamma$	(1.295 ± 0.025) %	S=1.1	363
$\pi^0\gamma$	$(1.23 \pm 0.10) \times 10^{-3}$		501
e^+e^-	$(2.98 \pm 0.04) \times 10^{-4}$	S=1.1	510
$\mu^+\mu^-$	$(2.85 \pm 0.19) \times 10^{-4}$		499
ηe^+e^-	$(1.15 \pm 0.10) \times 10^{-4}$		363
$\pi^+\pi^-$	$(7.3 \pm 1.3) \times 10^{-5}$		490
$\omega\pi^0$	$(5.2 {}^{+1.3}_{-1.1}) \times 10^{-5}$		172
$\omega\gamma$	< 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
$\pi^+\pi^-\pi^+\pi^-$	$(3.9 {}^{+2.8}_{-2.2}) \times 10^{-6}$		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 (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]			
$\pi^\pm\gamma$	$(1.6\pm0.4)\times10^{-3}$		607
$\eta\rho$	seen		†
$\pi^+\pi^+\pi^-\pi^0$	< 50 %	84%	535
$(K\overline{K})^\pm\pi^0$	< 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

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

$f_2(1270)$

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

Mass $m = 1275.4 \pm 1.2$ MeV
Full width $\Gamma = 185.1^{+3.5}_{-2.6}$ MeV (S = 1.5)

f_2(1270) DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
$\pi\pi$	$(84.8\ ^{+2.5}_{-1.3})$ %	S=1.3	623
$\pi^+\pi^-2\pi^0$	$(7.1\ ^{+1.5}_{-2.7})$ %	S=1.3	563

$K\overline{K}$	(4.6 ± 0.4) %	S=2.7	404
$2\pi^+ 2\pi^-$	(2.8 ± 0.4) %	S=1.2	559
$\eta\eta$	$(4.5 \pm 1.0) \times 10^{-3}$	S=2.4	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

$f_1(1285)$

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

Mass $m = 1281.8 \pm 0.6$ MeV (S = 1.6)
Full width $\Gamma = 24.1 \pm 1.1$ MeV (S = 1.3)

f_1(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 ± 16) %		482
$a_0(980)\pi$ [ignoring $a_0(980) \to K\overline{K}$]	(36 ± 7) %		234
$\eta\pi\pi$ [excluding $a_0(980)\pi$]	(16 ± 7) %		482
$K\overline{K}\pi$	(9.0 ± 0.4) %	S=1.1	308
$K\overline{K}^*(892)$	not seen		†
$\gamma\rho^0$	(5.5 ± 1.3) %	S=2.8	406
$\phi\gamma$	$(7.4 \pm 2.6) \times 10^{-4}$		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	244
$\eta\pi^0\pi^0$	seen	490
$\eta(\pi\pi)_{S\text{-wave}}$	seen	–

$\pi(1300)$

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

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

$a_2(1320)$ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
$\rho\pi$	(70.1 ± 2.7) %	S=1.2	416
$\eta\pi$	(14.5 ± 1.2) %		535
$\omega\pi\pi$	(10.6 ± 3.2) %	S=1.3	366
$K\overline{K}$	(4.9 ± 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]

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

Mass m = 1200 to 1500 MeV
Full width Γ = 200 to 500 MeV

$f_0(1370)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\pi\pi$	seen	–
4π	seen	–
$4\pi^0$	seen	–
$2\pi^+2\pi^-$	seen	–
$\pi^+\pi^-2\pi^0$	seen	–
$\rho\rho$	dominant	–
$2(\pi\pi)_{S\text{-wave}}$	seen	–
$\pi(1300)\pi$	seen	–
$a_1(1260)\pi$	seen	–
$\eta\eta$	seen	–
$K\overline{K}$	seen	–
$\gamma\gamma$	seen	–
e^+e^-	not seen	–

$\pi_1(1400)$ [o]

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

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

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

$\eta(1405)$ [p]
was $\eta(1440)$

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

Mass $m = 1410.3 \pm 2.6$ MeV [n] (S = 2.2)
Full width $\Gamma = 51 \pm 4$ MeV [n] (S = 2.2)

$\eta(1405)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K\overline{K}\pi$	seen	425
$\eta\pi\pi$	seen	563
$a_0(980)\pi$	seen	342

$\eta(\pi\pi)_{S\text{-wave}}$	seen	–
$f_0(980)\eta$	seen	†
4π	seen	639
$K^*(892)K$	seen	127

$f_1(1420)$ [q]

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

Mass $m = 1426.3 \pm 0.9$ 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)
$K\overline{K}\pi$	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 Γ (180–250) MeV

ω(1420) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\rho\pi$	dominant	488
$\omega\pi\pi$	seen	–
$b_1(1235)\pi$	seen	–
e^+e^-	seen	–

$a_0(1450)$ [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 (Γ_i/Γ)	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 $m = 1465 \pm 25$ MeV [n]
Full width $\Gamma = 400 \pm 60$ MeV [n]

$\rho(1450)$ DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$\pi\pi$	seen		720
4π	seen		669
$\omega\pi$	<2.0 %	95%	512
e^+e^-	seen		732
$\eta\rho$	<4 %		310
$a_2(1320)\pi$	not seen		55
$\phi\pi$	<1 %		360
$K\overline{K}$	$<1.6 \times 10^{-3}$	95%	541
$\eta\gamma$	possibly seen		630

$\eta(1475)$ [p]
was $\eta(1440)$

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

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

$\eta(1475)$ DECAY MODES	Fraction (Γ_i/Γ)	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 (Γ_i/Γ)	Scale factor	p (MeV/c)
$\eta\eta'(958)$	(1.9±0.8) %	1.7	34
$\eta\eta$	(5.1±0.9) %	1.4	518
4π	(49.5±3.3) %	1.2	692
$4\pi^0$	seen		692
$2\pi^+2\pi^-$	seen		688

$\pi\pi$	(34.9 ± 2.3) %	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 (Γ_i/Γ)	p (MeV/c)
$K\overline{K}$	$(88.8\ \pm3.1\ )$ %	581
$\eta\eta$	$(10.3\ \pm3.1\ )$ %	530
$\pi\pi$	$(\ 8.2\ \pm1.5\ )\times10^{-3}$	750
$\gamma\gamma$	$(\ 1.11\pm0.14)\times10^{-6}$	763

$\pi_1(1600)$ [o]

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

Mass $m = 1596^{+25}_{-14}$ MeV
Full width $\Gamma = 312^{+64}_{-24}$ MeV (S = 1.1)

$\pi_1(1600)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\pi\pi\pi$	seen	769
$\rho^0\pi^-$	seen	600
$f_2(1270)\pi^-$	not seen	259
$\eta'(958)\pi^-$	seen	497

$\eta_2(1645)$

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

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
$K\overline{K}\pi$	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] was $\omega(1600)$

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

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
$f_2(1270)\pi$	(56.2 ± 3.2) %		329
$\rho\pi$	$(31\ \pm4\ )$ %		648
$\sigma\pi$	(10.9 ± 3.4) %		–
$(\pi\pi)_{S\text{-wave}}$	$(\ 8.7\pm3.4)$ %		–
$K\overline{K}^*(892)+$ c.c.	$(\ 4.2\pm1.4)$ %		455
$\omega\rho$	$(\ 2.7\pm1.1)$ %		303
$\rho(1450)\pi$	$< 3.6 \times 10^{-3}$	97.7%	148
$b_1(1235)\pi$	$< 1.9 \times 10^{-3}$	97.7%	366

$\phi(1680)$

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

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)
$K\overline{K}^*(892)+$ 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 (Γ_i/Γ)	Scale factor	p (MeV/c)
4π	(71.1 ± 1.9) %		790
$\pi^\pm\pi^+\pi^-\pi^0$	(67 ± 22) %		787
$\omega\pi$	(16 ± 6) %		655
$\pi\pi$	(23.6 ± 1.3) %		834
$K\overline{K}\pi$	(3.8 ± 1.2) %		629
$K\overline{K}$	(1.58 ± 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		333

$\rho(1700)$ [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)	p (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	651
$a_1(1260)\pi$	seen	404
$h_1(1170)\pi$	seen	447
$\pi(1300)\pi$	seen	349
$\rho\rho$	seen	371
$\pi^+\pi^-$	seen	849
$\pi\pi$	seen	849
$K\overline{K}^*(892)+$ c.c.	seen	496
$\eta\rho$	seen	544
$a_2(1320)\pi$	not seen	334
$K\overline{K}$	seen	704
e^+e^-	seen	860
$\pi^0\omega$	seen	674

$f_0(1710)$ [u]

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

Mass $m = 1714 \pm 5$ MeV
Full width $\Gamma = 140 \pm 10$ MeV (S = 1.2)

f_0(1710) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K\overline{K}$	seen	701
$\eta\eta$	seen	659
$\pi\pi$	seen	846

$\pi(1800)$

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

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

π(1800) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\pi^+\pi^-\pi^-$	seen	879
$f_0(600)\pi^-$	seen	–
$f_0(980)\pi^-$	seen	631
$f_0(1370)\pi^-$	seen	–
$f_0(1500)\pi^-$	not seen	248
$\rho\pi^-$	not seen	732
$\eta\eta\pi^-$	seen	661
$a_0(980)\eta$	seen	469
$f_0(1500)\pi^-$	seen	248

$\eta\eta'(958)\pi^-$	seen	376
$K_0^*(1430)K^-$	seen	†
$K^*(892)K^-$	not seen	570

$\phi_3(1850)$

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

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)
$K\overline{K}$	seen	785
$K\overline{K}^*(892)+$ c.c.	seen	602

$f_2(1950)$

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

Mass $m = 1945 \pm 13$ MeV (S = 1.6)
Full width $\Gamma = 475 \pm 19$ MeV

$f_2(1950)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K^*(892)\overline{K}^*(892)$	seen	389
$\pi^+\pi^-$	seen	963
4π	seen	925
$\eta\eta$	seen	804
$K\overline{K}$	seen	838
$\gamma\gamma$	seen	973

$f_2(2010)$

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

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	†

$a_4(2040)$

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

Mass $m = 2010 \pm 12$ MeV
Full width $\Gamma = 353 \pm 40$ MeV

a_4(2040) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K\overline{K}$	seen	875
$\pi^+\pi^-\pi^0$	seen	981
$\rho\pi$	seen	849
$f_2(1270)\pi$	seen	590
$\eta\pi^0$	seen	925
$\eta'(958)\pi$	seen	769

$f_4(2050)$

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

Mass $m = 2034 \pm 11$ MeV (S = 1.6)
Full width $\Gamma = 222 \pm 19$ MeV (S = 1.8)

f_4(2050) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\omega\omega$	not seen	650
$\pi\pi$	(17.0 ± 1.5) %	1008
$K\overline{K}$	$(6.8^{+3.4}_{-1.8}) \times 10^{-3}$	889
$\eta\eta$	$(2.1\pm0.8) \times 10^{-3}$	857
$4\pi^0$	< 1.2 %	972
$a_2(1320)\pi$	seen	579

$f_2(2300)$

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

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
$K\overline{K}$	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

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 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 $\pi^\pm$ 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, $\Gamma(\rho^0 \to \mu^+\mu^-) = \Gamma(\rho^0 \to e^+e^-) \times 0.99785$.

[*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 .