SUMMARY TABLES OF PARTICLE PROPERTIES

Extracted from the Particle Listings of the
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GAUGE AND HIGGS BOSONS

γ

$I(J^{PC}) = 0\Gamma1(1^{--})$

Mass $m < 2 \times 10^{-16}$ eV
Charge $q < 5 \times 10^{-30}$ e
Mean life τ = Stable

g or gluon

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

Mass $m = 0$ [a]
SU(3) color octet

W

$J = 1$

Charge = ±1 e
Mass $m = 80.41 \pm 0.10$ GeV
$m_Z - m_W = 10.78 \pm 0.10$ GeV
$m_{W^+} - m_{W^-} = -0.2 \pm 0.6$ GeV
Full width $\Gamma = 2.06 \pm 0.06$ GeV

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

W^+ DECAY MODES		Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$\ell^+\nu$	[b]	(10.74±0.33) %		–
$e^+\nu$		(10.9 ±0.4) %		40205
$\mu^+\nu$		(10.2 ±0.5) %		40205
$\tau^+\nu$		(11.3 ±0.8) %		40185
hadrons		(67.8 ±1.0) %		–
$\pi^+\gamma$		$< 2.2 \times 10^{-4}$	95%	40205

Z

$J = 1$

Charge = 0
Mass $m = 91.187 \pm 0.007$ GeV [c]
Full width $\Gamma = 2.490 \pm 0.007$ GeV
$\Gamma(\ell^+\ell^-) = 83.83 \pm 0.27$ MeV [b]
Γ(invisible) $= 498.3 \pm 4.2$ MeV [d]
Γ(hadrons) $= 1740.7 \pm 5.9$ MeV
$\Gamma(\mu^+\mu^-)/\Gamma(e^+e^-) = 1.000 \pm 0.005$
$\Gamma(\tau^+\tau^-)/\Gamma(e^+e^-) = 0.998 \pm 0.005$ [e]

Average charged multiplicity

$\langle N_{charged} \rangle = 21.00 \pm 0.13$

Couplings to leptons

$g_V^{\ell} = -0.0377 \pm 0.0007$
$g_A^{\ell} = -0.5008 \pm 0.0008$
$g^{\nu_e} = 0.53 \pm 0.09$
$g^{\nu_\mu} = 0.502 \pm 0.017$

Asymmetry parameters [f]

$A_e = 0.1519 \pm 0.0034$
$A_\mu = 0.102 \pm 0.034$
$A_\tau = 0.143 \pm 0.008$
$A_c = 0.59 \pm 0.19$
$A_b = 0.89 \pm 0.11$

Charge asymmetry (%) at Z pole

$A_{FB}^{(0\ell)} = 1.59 \pm 0.18$
$A_{FB}^{(0u)} = 4.0 \pm 7.3$
$A_{FB}^{(0s)} = 9.9 \pm 3.1$ (S = 1.2)
$A_{FB}^{(0c)} = 7.32 \pm 0.58$
$A_{FB}^{(0b)} = 10.02 \pm 0.28$

Z DECAY MODES		Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
e^+e^-		(3.366±0.008) %		45594
$\mu^+\mu^-$		(3.367±0.013) %		45593
$\tau^+\tau^-$		(3.360±0.015) %		45559
$\ell^+\ell^-$	[b]	(3.366±0.006) %		–
invisible		(20.01 ±0.16) %		–
hadrons		(69.90 ±0.15) %		–
$(u\overline{u}+c\overline{c})/2$		(10.1 ±1.1) %		–
$(d\overline{d}+s\overline{s}+b\overline{b})/3$		(16.6 ±0.6) %		–
$c\overline{c}$		(12.4 ±0.6) %		–
$b\overline{b}$		(15.16 ±0.09) %		–
ggg		$<$ 1.1 %	95%	–
$\pi^0\gamma$		$< 5.2 \times 10^{-5}$	95%	45593
$\eta\gamma$		$< 5.1 \times 10^{-5}$	95%	45592
$\omega\gamma$		$< 6.5 \times 10^{-4}$	95%	45590
$\eta'(958)\gamma$		$< 4.2 \times 10^{-5}$	95%	45588
$\gamma\gamma$		$< 5.2 \times 10^{-5}$	95%	45594
$\gamma\gamma\gamma$		$< 1.0 \times 10^{-5}$	95%	45594
$\pi^\pm W^\mp$	[g]	$< 7 \times 10^{-5}$	95%	10139
$\rho^\pm W^\mp$	[g]	$< 8.3 \times 10^{-5}$	95%	10114
$J/\psi(1S)X$		(3.66 ±0.23) $\times 10^{-3}$		–
$\psi(2S)X$		(1.60 ±0.29) $\times 10^{-3}$		–
$\chi_{c1}(1P)X$		(2.9 ±0.7) $\times 10^{-3}$		–
$\chi_{c2}(1P)X$		$< 3.2 \times 10^{-3}$	90%	–
$\Upsilon(1S)$ X + $\Upsilon(2S)$ X + $\Upsilon(3S)$ X		(1.0 ±0.5) $\times 10^{-4}$		–
$\Upsilon(1S)$X		$< 5.5 \times 10^{-5}$	95%	–
$\Upsilon(2S)$X		$< 1.39 \times 10^{-4}$	95%	–
$\Upsilon(3S)$X		$< 9.4 \times 10^{-5}$	95%	–
$(D^0/\overline{D}^0)$ X		(20.7 ±2.0) %		–
$D^\pm$X		(12.2 ±1.7) %		–
$D^*(2010)^\pm$X	[g]	(11.4 ±1.3) %		–
B_s^0X		seen		–
anomalous γ+ hadrons	[h]	$< 3.2 \times 10^{-3}$	95%	–
$e^+e^-\gamma$	[h]	$< 5.2 \times 10^{-4}$	95%	45594
$\mu^+\mu^-\gamma$	[h]	$< 5.6 \times 10^{-4}$	95%	45593
$\tau^+\tau^-\gamma$	[h]	$< 7.3 \times 10^{-4}$	95%	45559
$\ell^+\ell^-\gamma\gamma$	[i]	$< 6.8 \times 10^{-6}$	95%	–
$q\overline{q}\gamma\gamma$	[i]	$< 5.5 \times 10^{-6}$	95%	–

$\nu\overline{\nu}\gamma\gamma$		[i] <	3.1	$\times 10^{-6}$	95%	45594
$e^{\pm}\mu^{\mp}$	LF	[g] <	1.7	$\times 10^{-6}$	95%	45593
$e^{\pm}\tau^{\mp}$	LF	[g] <	9.8	$\times 10^{-6}$	95%	45576
$\mu^{\pm}\tau^{\mp}$	LF	[g] <	1.2	$\times 10^{-5}$	95%	45576

Higgs Bosons — H^0 and $H^{\pm}$, Searches for

H^0 Mass $m >$ 77.5 GeV, CL = 95%

H^0_1 in Supersymmetric Models ($m_{H^0_1} < m_{H^0_2}$)

Mass $m >$ 62.5 GeV, CL = 95%

A^0 Pseudoscalar Higgs Boson in Supersymmetric Models [j]

Mass $m >$ 62.5 GeV, CL = 95% $\tan\beta > 1$

$H^{\pm}$ Mass $m >$ 54.5 GeV, CL = 95%

See the Particle Listings for a Note giving details of Higgs Bosons.

Heavy Bosons Other Than Higgs Bosons, Searches for

Additional *W* Bosons

W_R — right-handed W
Mass $m >$ 549 GeV
(assuming light right-handed neutrino)
W' with standard couplings decaying to $e\nu$, $\mu\nu$
Mass $m >$ 720 GeV, CL = 95%

Additional *Z* Bosons

Z'_{SM} with standard couplings
Mass $m >$ 690 GeV, CL = 95% ($p\overline{p}$ direct search)
Mass $m >$ 779 GeV, CL = 95% (electroweak fit)
Z_{LR} of SU(2)$_L$×SU(2)$_R$×U(1)
(with $g_L = g_R$)
Mass $m >$ 630 GeV, CL = 95% ($p\overline{p}$ direct search)
Mass $m >$ 389 GeV, CL = 95% (electroweak fit)
Z_χ of SO(10) → SU(5)×U(1)$_\chi$
(coupling constant derived from G.U.T.)
Mass $m >$ 595 GeV, CL = 95% ($p\overline{p}$ direct search)
Mass $m >$ 321 GeV, CL = 95% (electroweak fit)
Z_ψ of E_6 → SO(10)×U(1)$_\psi$
(coupling constant derived from G.U.T.)
Mass $m >$ 590 GeV, CL = 95% ($p\overline{p}$ direct search)
Mass $m >$ 160 GeV, CL = 95% (electroweak fit)
Z_η of E_6 → SU(3)×SU(2)×U(1)×U(1)$_\eta$
(coupling constant derived from G.U.T.);
charges are $Q_\eta = \sqrt{3/8}Q_\chi - \sqrt{5/8}Q_\psi$)
Mass $m >$ 620 GeV, CL = 95% ($p\overline{p}$ direct search)
Mass $m >$ 182 GeV, CL = 95% (electroweak fit)

Scalar Leptoquarks

Mass $m >$ 225 GeV, CL = 95% (1st generation, pair prod.)
Mass $m >$ 237 GeV, CL = 95% (1st gener., single prod.)
Mass $m >$ 119 GeV, CL = 95% (2nd gener., pair prod.)
Mass $m >$ 73 GeV, CL = 95% (2nd gener., single prod.)
Mass $m >$ 99 GeV, CL = 95% (3rd gener., pair prod.)
(See the Particle Listings for assumptions on leptoquark quantum numbers and branching fractions.)

Axions (A^0) and Other Very Light Bosons, Searches for

The standard Peccei-Quinn axion is ruled out. Variants with reduced couplings or much smaller masses are constrained by various data. The Particle Listings in the full *Review* contain a Note discussing axion searches.

The best limit for the half-life of neutrinoless double beta decay with Majoron emission is $> 7.2 \times 10^{24}$ years (CL = 90%).

NOTES

In this Summary Table:

When a quantity has "(S = ...)" to its right, the error on the quantity has been enlarged by the "scale factor" S, defined as $S = \sqrt{\chi^2/(N-1)}$, where N is the number of measurements used in calculating the quantity. We do this when S > 1, which often indicates that the measurements are inconsistent. When S > 1.25, we also show in the Particle Listings an ideogram of the measurements. For more about S, see the Introduction.

A decay momentum p is given for each decay mode. For a 2-body decay, p is the momentum of each decay product in the rest frame of the decaying particle. For a 3-or-more-body decay, p is the largest momentum any of the products can have in this frame.

[a] Theoretical value. A mass as large as a few MeV may not be precluded.
[b] ℓ indicates each type of lepton (e, μ, and τ), not sum over them.
[c] The Z-boson mass listed here corresponds to a Breit-Wigner resonance parameter. It lies approximately 34 MeV above the real part of the position of the pole (in the energy-squared plane) in the Z-boson propagator.
[d] This partial width takes into account Z decays into $\nu\overline{\nu}$ and any other possible undetected modes.
[e] This ratio has not been corrected for the τ mass.
[f] Here $A \equiv 2g_V g_A/(g_V^2 + g_A^2)$.
[g] The value is for the sum of the charge states of particle/antiparticle states indicated.
[h] See the Z Particle Listings for the γ energy range used in this measurement.
[i] For $m_{\gamma\gamma} = (60 \pm 5)$ GeV.
[j] The limits assume no invisible decays.

LEPTON SUMMARY TABLE

LEPTONS

e

$J = \frac{1}{2}$

Mass $m = 0.51099907 \pm 0.00000015$ MeV [a]
$= (5.485799111 \pm 0.000000012) \times 10^{-4}$ u
$(m_{e^+} - m_{e^-})/m < 4 \times 10^{-8}$, CL = 90%
$|q_{e^+} + q_{e^-}|/e < 4 \times 10^{-8}$
Magnetic moment $\mu = 1.001159652193 \pm 0.000000000010\ \mu_B$
$(g_{e^+} - g_{e^-})\ /\ g_{\text{average}} = (-0.5 \pm 2.1) \times 10^{-12}$
Electric dipole moment $d = (0.18 \pm 0.16) \times 10^{-26}$ $e$cm
Mean life $\tau > 4.3 \times 10^{23}$ yr, CL = 68% [b]

μ

$J = \frac{1}{2}$

Mass $m = 105.658389 \pm 0.000034$ MeV [c]
$= 0.113428913 \pm 0.000000017$ u
Mean life $\tau = (2.19703 \pm 0.00004) \times 10^{-6}$ s
$\tau_{\mu^+}/\tau_{\mu^-} = 1.00002 \pm 0.00008$
$c\tau = 658.654$ m
Magnetic moment $\mu = 1.0011659230 \pm 0.0000000084\ e\hbar/2m_\mu$
$(g_{\mu^+} - g_{\mu^-})\ /\ g_{\text{average}} = (-2.6 \pm 1.6) \times 10^{-8}$
Electric dipole moment $d = (3.7 \pm 3.4) \times 10^{-19}$ $e$cm

Decay parameters [d]

$\rho = 0.7518 \pm 0.0026$
$\eta = -0.007 \pm 0.013$
$\delta = 0.749 \pm 0.004$
$\xi P_\mu = 1.003 \pm 0.008$ [e]
$\xi P_\mu \delta/\rho > 0.99682$, CL = 90% [e]
$\xi' = 1.00 \pm 0.04$
$\xi'' = 0.7 \pm 0.4$
$\alpha/A = (0 \pm 4) \times 10^{-3}$
$\alpha'/A = (0 \pm 4) \times 10^{-3}$
$\beta/A = (4 \pm 6) \times 10^{-3}$
$\beta'/A = (2 \pm 6) \times 10^{-3}$
$\overline{\eta} = 0.02 \pm 0.08$

μ^+ modes are charge conjugates of the modes below.

μ^- DECAY MODES		Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$e^- \overline{\nu}_e \nu_\mu$		$\approx 100\%$		53
$e^- \overline{\nu}_e \nu_\mu \gamma$	[f]	(1.4 ± 0.4) %		53
$e^- \overline{\nu}_e \nu_\mu e^+ e^-$	[g]	$(3.4\pm0.4) \times 10^{-5}$		53
Lepton Family number (*LF*) violating modes				
$e^- \nu_e \overline{\nu}_\mu$	*LF* [h]	< 1.2 %	90%	53
$e^- \gamma$	*LF*	$< 4.9 \times 10^{-11}$	90%	53
$e^- e^+ e^-$	*LF*	$< 1.0 \times 10^{-12}$	90%	53
$e^- 2\gamma$	*LF*	$< 7.2 \times 10^{-11}$	90%	53

τ

$J = \frac{1}{2}$

Mass $m = 1777.05^{+0.29}_{-0.26}$ MeV
Mean life $\tau = (290.0 \pm 1.2) \times 10^{-15}$ s
$c\tau = 86.93\ \mu$m
Magnetic moment anomaly > -0.052 and < 0.058, CL = 95%
Electric dipole moment $d > -3.1$ and $< 3.1 \times 10^{-16}$ $e$cm, CL = 95%

Weak dipole moment

$\text{Re}(d^w_\tau) < 0.56 \times 10^{-17}$ $e$cm, CL = 95%
$\text{Im}(d^w_\tau) < 1.5 \times 10^{-17}$ $e$cm, CL = 95%

Weak anomalous magnetic dipole moment

$\text{Re}(\alpha^w_\tau) < 4.5 \times 10^{-3}$, CL = 90%
$\text{Im}(\alpha^w_\tau) < 9.9 \times 10^{-3}$, CL = 90%

Decay parameters

See the τ Particle Listings for a note concerning τ-decay parameters.

$\rho^\tau(e \text{ or } \mu) = 0.748 \pm 0.010$
$\rho^\tau(e) = 0.745 \pm 0.012$
$\rho^\tau(\mu) = 0.741 \pm 0.030$
$\xi^\tau(e \text{ or } \mu) = 1.01 \pm 0.04$
$\xi^\tau(e) = 0.98 \pm 0.05$
$\xi^\tau(\mu) = 1.07 \pm 0.08$
$\eta^\tau(e \text{ or } \mu) = 0.01 \pm 0.07$
$\eta^\tau(\mu) = -0.10 \pm 0.18$
$(\delta\xi)^\tau(e \text{ or } \mu) = 0.749 \pm 0.026$
$(\delta\xi)^\tau(e) = 0.733 \pm 0.033$
$(\delta\xi)^\tau(\mu) = 0.78 \pm 0.05$
$\xi^\tau(\pi) = 0.99 \pm 0.05$
$\xi^\tau(\rho) = 0.996 \pm 0.010$
$\xi^\tau(a_1) = 1.02 \pm 0.04$
$\xi^\tau(\text{all hadronic modes}) = 0.997 \pm 0.009$

τ^+ modes are charge conjugates of the modes below. "$h^\pm$" stands for $\pi^\pm$ or $K^\pm$. "ℓ" stands for e or μ. "Neutral" means neutral hadron whose decay products include γ's and/or π^0's.

τ^- DECAY MODES		Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
Modes with one charged particle				
particle$^- \geq 0$ neutrals $\geq 0K^0_L \nu_\tau$ ("1-prong")		(84.71 ± 0.13) %	S=1.2	–
particle$^- \geq 0$ neutrals $\geq 0K^0 \nu_\tau$		(85.30 ± 0.13) %	S=1.2	–
$\mu^- \overline{\nu}_\mu \nu_\tau$	[f]	(17.37 ± 0.09) %		885
$\mu^- \overline{\nu}_\mu \nu_\tau \gamma$	[g]	$(3.0 \pm 0.6) \times 10^{-3}$		–
$e^- \overline{\nu}_e \nu_\tau$	[f]	(17.81 ± 0.07) %		889
$h^- \geq 0$ neutrals $\geq 0K^0_L \nu_\tau$		(49.52 ± 0.16) %	S=1.2	–
$h^- \geq 0K^0_L \nu_\tau$		(12.32 ± 0.12) %	S=1.5	–
$h^- \nu_\tau$		(11.79 ± 0.12) %	S=1.5	–
$\pi^- \nu_\tau$	[f]	(11.08 ± 0.13) %	S=1.4	883
$K^- \nu_\tau$	[f]	$(7.1 \pm 0.5) \times 10^{-3}$		820
$h^- \geq 1$ neutrals ν_τ		(36.91 ± 0.17) %	S=1.2	–
$h^- \pi^0 \nu_\tau$		(25.84 ± 0.14) %	S=1.1	–
$\pi^- \pi^0 \nu_\tau$	[f]	(25.32 ± 0.15) %	S=1.1	878
$\pi^- \pi^0$ non-$\rho(770) \nu_\tau$		$(3.0 \pm 3.2) \times 10^{-3}$		878
$K^- \pi^0 \nu_\tau$	[f]	$(5.2 \pm 0.5) \times 10^{-3}$		814
$h^- \geq 2\pi^0 \nu_\tau$		(10.79 ± 0.16) %	S=1.2	–
$h^- 2\pi^0 \nu_\tau$		(9.39 ± 0.14) %	S=1.2	–
$h^- 2\pi^0 \nu_\tau (\text{ex.}K^0)$		(9.23 ± 0.14) %	S=1.2	–
$\pi^- 2\pi^0 \nu_\tau (\text{ex.}K^0)$	[f]	(9.15 ± 0.15) %	S=1.2	862
$K^- 2\pi^0 \nu_\tau (\text{ex.}K^0)$	[f]	$(8.0 \pm 2.7) \times 10^{-4}$		796
$h^- \geq 3\pi^0 \nu_\tau$		(1.40 ± 0.11) %	S=1.1	–
$h^- 3\pi^0 \nu_\tau$		(1.23 ± 0.10) %	S=1.1	–
$\pi^- 3\pi^0 \nu_\tau (\text{ex.}K^0)$	[f]	(1.11 ± 0.14) %		836
$K^- 3\pi^0 \nu_\tau (\text{ex.}K^0)$	[f]	$(4.3\ ^{+10.0}_{-\ 2.9}) \times 10^{-4}$		766
$h^- 4\pi^0 \nu_\tau (\text{ex.}K^0)$		$(1.7 \pm 0.6) \times 10^{-3}$		–
$h^- 4\pi^0 \nu_\tau (\text{ex.}K^0,\eta)$	[f]	$(1.1 \pm 0.6) \times 10^{-3}$		–
$K^- \geq 0\pi^0 \geq 0K^0 \nu_\tau$		(1.66 ± 0.10) %		–
$K^- \geq 1 (\pi^0 \text{ or } K^0) \nu_\tau$		$(9.5 \pm 1.0) \times 10^{-3}$		–
Modes with K^0's				
$K^0(\text{particles})^- \nu_\tau$		(1.66 ± 0.09) %	S=1.4	–
$h^- \overline{K}^0 \geq 0$ neutrals $\geq 0K^0_L \nu_\tau$		(1.62 ± 0.09) %	S=1.4	–
$h^- \overline{K}^0 \nu_\tau$		$(9.9 \pm 0.8) \times 10^{-3}$	S=1.5	–
$\pi^- \overline{K}^0 \nu_\tau$	[f]	$(8.3 \pm 0.8) \times 10^{-3}$	S=1.4	812
$\pi^- \overline{K}^0$ (non-$K^*(892)^-$)ν_τ		$< 1.7 \times 10^{-3}$	CL=95%	812
$K^- K^0 \nu_\tau$	[f]	$(1.59\pm 0.24) \times 10^{-3}$		737
$h^- \overline{K}^0 \pi^0 \nu_\tau$		$(5.5\pm 0.5) \times 10^{-3}$		–
$\pi^- \overline{K}^0 \pi^0 \nu_\tau$	[f]	$(3.9 \pm 0.5) \times 10^{-3}$		794
$\overline{K}^0 \rho^- \nu_\tau$		$(1.9 \pm 0.7) \times 10^{-3}$		–
$K^- K^0 \pi^0 \nu_\tau$	[f]	$(1.51\pm 0.29) \times 10^{-3}$		685
$\pi^- \overline{K}^0 \pi^0 \pi^0 \nu_\tau$		$(6 \pm 4) \times 10^{-4}$		–
$K^- K^0 \pi^0 \pi^0 \nu_\tau$		$< 3.9 \times 10^{-4}$	CL=95%	–
$\pi^- K^0 \overline{K}^0 \nu_\tau$	[f]	$(1.21\pm 0.21) \times 10^{-3}$	S=1.2	682

Mode		Fraction	Scale factor / CL	p (MeV/c)
$\pi^- K^0_S K^0_S \nu_\tau$		$(3.0 \pm 0.5) \times 10^{-4}$	S=1.2	–
$\pi^- K^0_S K^0_L \nu_\tau$		$(6.0 \pm 1.0) \times 10^{-4}$	S=1.2	–
$\pi^- K^0_S K^0_S \pi^0 \nu_\tau$		$< 2.0 \times 10^{-4}$	CL=95%	–
$\pi^- K^0_S K^0_L \pi^0 \nu_\tau$		$(3.1 \pm 1.2) \times 10^{-4}$		–
$K^- K^0 \geq 0$ neutrals ν_τ		$(3.1 \pm 0.4) \times 10^{-3}$		–
$K^0 h^+ h^- h^- \geq 0$ neutrals ν_τ		$< 1.7 \times 10^{-3}$	CL=95%	–
$K^0 h^+ h^- h^- \nu_\tau$		$(2.3 \pm 2.0) \times 10^{-4}$		–
Modes with three charged particles				
$h^- h^- h^+ \geq 0$neut. ν_τ ("3-prong")		(15.18 ± 0.13) %	S=1.2	–
$h^- h^- h^+ \geq 0$ neutrals ν_τ (ex. $K^0_S \to \pi^+\pi^-$)		(14.60 ± 0.13) %	S=1.2	–
$\pi^- \pi^+ \pi^- \geq 0$ neutrals ν_τ		(14.60 ± 0.14) %		–
$h^- h^- h^+ \nu_\tau$		(9.96 ± 0.10) %	S=1.1	–
$h^- h^- h^+ \nu_\tau$ (ex.K^0)		(9.62 ± 0.10) %	S=1.1	–
$h^- h^- h^+ \nu_\tau$ (ex.K^0,ω)		(9.57 ± 0.10) %	S=1.1	–
$\pi^- \pi^+ \pi^- \nu_\tau$		(9.56 ± 0.11) %	S=1.1	–
$\pi^- \pi^+ \pi^- \nu_\tau$ (ex.K^0)		(9.52 ± 0.11) %	S=1.1	–
$\pi^- \pi^+ \pi^- \nu_\tau$ (ex.K^0,ω)	[l]	(9.23 ± 0.11) %	S=1.1	–
$h^- h^- h^+ \geq 1$ neutrals ν_τ		(5.18 ± 0.11) %	S=1.2	–
$h^- h^- h^+ \geq 1$ neutrals ν_τ (ex. $K^0_S \to \pi^+\pi^-$)		(4.98 ± 0.11) %	S=1.2	–
$h^- h^- h^+ \pi^0 \nu_\tau$		(4.50 ± 0.09) %	S=1.1	–
$h^- h^- h^+ \pi^0 \nu_\tau$ (ex.K^0)		(4.31 ± 0.09) %	S=1.1	–
$h^- h^- h^+ \pi^0 \nu_\tau$ (ex. K^0, ω)		(2.59 ± 0.09) %		–
$\pi^- \pi^+ \pi^- \pi^0 \nu_\tau$		(4.35 ± 0.10) %		–
$\pi^- \pi^+ \pi^- \pi^0 \nu_\tau$ (ex.K^0)		(4.22 ± 0.10) %		–
$\pi^- \pi^+ \pi^- \pi^0 \nu_\tau$ (ex.K^0,ω)	[l]	(2.49 ± 0.10) %		–
$h^- (\rho\pi)^0 \nu_\tau$		(2.88 ± 0.35) %		–
$(a_1(1260) h)^- \nu_\tau$		< 2.0 %	CL=95%	–
$h^- \rho \pi^0 \nu_\tau$		(1.35 ± 0.20) %		–
$h^- \rho^+ h^- \nu_\tau$		$(4.5 \pm 2.2) \times 10^{-3}$		–
$h^- \rho^- h^+ \nu_\tau$		(1.17 ± 0.23) %		–
$h^- h^- h^+ 2\pi^0 \nu_\tau$		$(5.4 \pm 0.4) \times 10^{-3}$		–
$h^- h^- h^+ 2\pi^0 \nu_\tau$ (ex.K^0)		$(5.3 \pm 0.4) \times 10^{-3}$		–
$h^- h^- h^+ 2\pi^0 \nu_\tau$ (ex.K^0,ω,η)	[l]	$(1.1 \pm 0.4) \times 10^{-3}$		–
$h^- h^- h^+ \geq 3\pi^0 \nu_\tau$	[l]	$(1.4\ ^{+0.9}_{-0.7}) \times 10^{-3}$	S=1.5	–
$h^- h^- h^+ 3\pi^0 \nu_\tau$		$(2.9 \pm 0.8) \times 10^{-4}$		–
$K^- h^+ h^- \geq 0$ neutrals ν_τ		$(5.4 \pm 0.7) \times 10^{-3}$	S=1.1	–
$K^- \pi^+ \pi^- \geq 0$ neutrals ν_τ		$(3.1 \pm 0.6) \times 10^{-3}$	S=1.1	–
$K^- \pi^+ \pi^- \nu_\tau$		$(2.3 \pm 0.4) \times 10^{-3}$		–
$K^- \pi^+ \pi^- \nu_\tau$ (ex.K^0)	[l]	$(1.8 \pm 0.5) \times 10^{-3}$		–
$K^- \pi^+ \pi^- \pi^0 \nu_\tau$		$(8 \pm 4) \times 10^{-4}$		–
$K^- \pi^+ \pi^- \pi^0 \nu_\tau$ (ex.K^0)	[l]	$(2.4\ ^{+4.3}_{-1.6}) \times 10^{-4}$		–
$K^- \pi^+ K^- \geq 0$ neut. ν_τ		$< 9 \times 10^{-4}$	CL=95%	–
$K^- K^+ \pi^- \geq 0$ neut. ν_τ		$(2.3 \pm 0.4) \times 10^{-3}$		–
$K^- K^+ \pi^- \nu_\tau$	[l]	$(1.61 \pm 0.26) \times 10^{-3}$		685
$K^- K^+ \pi^- \pi^0 \nu_\tau$	[l]	$(6.9 \pm 3.0) \times 10^{-4}$		–
$K^- K^+ K^- \geq 0$ neut. ν_τ		$< 2.1 \times 10^{-3}$	CL=95%	–
$K^- K^+ K^- \nu_\tau$		$< 1.9 \times 10^{-4}$	CL=90%	–
$\pi^- K^+ \pi^- \geq 0$ neut. ν_τ		$< 2.5 \times 10^{-3}$	CL=95%	–
$e^- e^- e^+ \overline{\nu}_e \nu_\tau$		$(2.8 \pm 1.5) \times 10^{-5}$		889
$\mu^- e^- e^+ \overline{\nu}_\mu \nu_\tau$		$< 3.6 \times 10^{-5}$	CL=90%	885
Modes with five charged particles				
$3h^- 2h^+ \geq 0$ neutrals ν_τ (ex. $K^0_S \to \pi^-\pi^+$) ("5-prong")		$(9.7 \pm 0.7) \times 10^{-4}$		–
$3h^- 2h^+ \nu_\tau$ (ex.K^0)	[l]	$(7.5 \pm 0.7) \times 10^{-4}$		–
$3h^- 2h^+ \pi^0 \nu_\tau$ (ex.K^0)	[l]	$(2.2 \pm 0.5) \times 10^{-4}$		–
$3h^- 2h^+ 2\pi^0 \nu_\tau$		$< 1.1 \times 10^{-4}$	CL=90%	–
Miscellaneous other allowed modes				
$(5\pi)^- \nu_\tau$		$(7.4 \pm 0.7) \times 10^{-3}$		–
$4h^- 3h^+ \geq 0$ neutrals ν_τ ("7-prong")		$< 2.4 \times 10^{-6}$	CL=90%	–
$K^*(892)^- \geq 0(h^0 \neq K^0_S)\nu_\tau$		(1.94 ± 0.31) %		–
$K^*(892)^- \geq 0$ neutrals ν_τ		(1.33 ± 0.13) %		–
$K^*(892)^- \nu_\tau$		(1.28 ± 0.08) %		665
$K^*(892)^0 K^- \geq 0$ neutrals ν_τ		$(3.2 \pm 1.4) \times 10^{-3}$		–
$K^*(892)^0 K^- \nu_\tau$		$(2.1 \pm 0.4) \times 10^{-3}$		539
$\overline{K}^*(892)^0 \pi^- \geq 0$ neutrals ν_τ		$(3.8 \pm 1.7) \times 10^{-3}$		–
$\overline{K}^*(892)^0 \pi^- \nu_\tau$		$(2.2 \pm 0.5) \times 10^{-3}$		653
$(\overline{K}^*(892)\pi)^- \nu_\tau \to \pi^- \overline{K}^0 \pi^0 \nu_\tau$		$(1.1 \pm 0.5) \times 10^{-3}$		–
$K_1(1270)^- \nu_\tau$		$(4 \pm 4) \times 10^{-3}$		433
$K_1(1400)^- \nu_\tau$		$(8 \pm 4) \times 10^{-3}$		335
$K^*_2(1430)^- \nu_\tau$		$< 3 \times 10^{-3}$	CL=95%	317
$\eta \pi^- \nu_\tau$		$< 1.4 \times 10^{-4}$	CL=95%	798
$\eta \pi^- \pi^0 \nu_\tau$	[l]	$(1.74 \pm 0.24) \times 10^{-3}$		778
$\eta \pi^- \pi^0 \pi^0 \nu_\tau$		$(1.4 \pm 0.7) \times 10^{-4}$		746
$\eta K^- \nu_\tau$		$(2.7 \pm 0.6) \times 10^{-4}$		720
$\eta \pi^+ \pi^- \pi^- \geq 0$ neutrals ν_τ		$< 3 \times 10^{-3}$	CL=90%	–
$\eta \pi^- \pi^+ \pi^- \nu_\tau$		$(3.4 \pm 0.8) \times 10^{-4}$		–
$\eta a_1(1260)^- \nu_\tau \to \eta \pi^- \rho^0 \nu_\tau$		$< 3.9 \times 10^{-4}$	CL=90%	–
$\eta \eta \pi^- \nu_\tau$		$< 1.1 \times 10^{-4}$	CL=95%	637
$\eta \eta \pi^- \pi^0 \nu_\tau$		$< 2.0 \times 10^{-4}$	CL=95%	559
$\eta'(958) \pi^- \nu_\tau$		$< 7.4 \times 10^{-5}$	CL=90%	–
$\eta'(958) \pi^- \pi^0 \nu_\tau$		$< 8.0 \times 10^{-5}$	CL=90%	–
$\phi \pi^- \nu_\tau$		$< 2.0 \times 10^{-4}$	CL=90%	585
$\phi K^- \nu_\tau$		$< 6.7 \times 10^{-5}$	CL=90%	–
$f_1(1285) \pi^- \nu_\tau$		$(5.8 \pm 2.3) \times 10^{-4}$		–
$f_1(1285) \pi^- \nu_\tau \to \eta \pi^- \pi^+ \pi^- \nu_\tau$		$(1.9 \pm 0.7) \times 10^{-4}$		–
$h^- \omega \geq 0$ neutrals ν_τ		(2.36 ± 0.08) %		–
$h^- \omega \nu_\tau$	[l]	(1.93 ± 0.06) %		–
$h^- \omega \pi^0 \nu_\tau$	[l]	$(4.3 \pm 0.5) \times 10^{-3}$		–
$h^- \omega 2\pi^0 \nu_\tau$		$(1.9 \pm 0.8) \times 10^{-4}$		–

Lepton Family number (*LF*), Lepton number (*L*), or Baryon number (*B*) violating modes
(In the modes below, ℓ means a sum over e and μ modes)

L means lepton number violation (*e.g.* $\tau^- \to e^+\pi^-\pi^-$). Following common usage, *LF* means lepton family violation *and not* lepton number violation (*e.g.* $\tau^- \to e^-\pi^+\pi^-$). *B* means baryon number violation.

Mode		Fraction	CL	p (MeV/c)
$e^- \gamma$	LF	$< 2.7 \times 10^{-6}$	CL=90%	888
$\mu^- \gamma$	LF	$< 3.0 \times 10^{-6}$	CL=90%	885
$e^- \pi^0$	LF	$< 3.7 \times 10^{-6}$	CL=90%	883
$\mu^- \pi^0$	LF	$< 4.0 \times 10^{-6}$	CL=90%	880
$e^- K^0$	LF	$< 1.3 \times 10^{-3}$	CL=90%	819
$\mu^- K^0$	LF	$< 1.0 \times 10^{-3}$	CL=90%	815
$e^- \eta$	LF	$< 8.2 \times 10^{-6}$	CL=90%	804
$\mu^- \eta$	LF	$< 9.6 \times 10^{-6}$	CL=90%	800
$e^- \rho^0$	LF	$< 2.0 \times 10^{-6}$	CL=90%	722
$\mu^- \rho^0$	LF	$< 6.3 \times 10^{-6}$	CL=90%	718
$e^- K^*(892)^0$	LF	$< 5.1 \times 10^{-6}$	CL=90%	663
$\mu^- K^*(892)^0$	LF	$< 7.5 \times 10^{-6}$	CL=90%	657
$e^- \overline{K}^*(892)^0$	LF	$< 7.4 \times 10^{-6}$	CL=90%	663
$\mu^- \overline{K}^*(892)^0$	LF	$< 7.5 \times 10^{-6}$	CL=90%	657
$e^- \phi$	LF	$< 6.9 \times 10^{-6}$	CL=90%	596
$\mu^- \phi$	LF	$< 7.0 \times 10^{-6}$	CL=90%	590
$\pi^- \gamma$	L	$< 2.8 \times 10^{-4}$	CL=90%	883
$\pi^- \pi^0$	L	$< 3.7 \times 10^{-4}$	CL=90%	878
$e^- e^+ e^-$	LF	$< 2.9 \times 10^{-6}$	CL=90%	888
$e^- \mu^+ \mu^-$	LF	$< 1.8 \times 10^{-6}$	CL=90%	882
$e^+ \mu^- \mu^-$	LF	$< 1.5 \times 10^{-6}$	CL=90%	882
$\mu^- e^+ e^-$	LF	$< 1.7 \times 10^{-6}$	CL=90%	885
$\mu^+ e^- e^-$	LF	$< 1.5 \times 10^{-6}$	CL=90%	885
$\mu^- \mu^+ \mu^-$	LF	$< 1.9 \times 10^{-6}$	CL=90%	873
$e^- \pi^+ \pi^-$	LF	$< 2.2 \times 10^{-6}$	CL=90%	877
$e^+ \pi^- \pi^-$	L	$< 1.9 \times 10^{-6}$	CL=90%	877
$\mu^- \pi^+ \pi^-$	LF	$< 8.2 \times 10^{-6}$	CL=90%	866
$\mu^+ \pi^- \pi^-$	L	$< 3.4 \times 10^{-6}$	CL=90%	866
$e^- \pi^+ K^-$	LF	$< 6.4 \times 10^{-6}$	CL=90%	814
$e^- \pi^- K^+$	LF	$< 3.8 \times 10^{-6}$	CL=90%	814
$e^+ \pi^- K^-$	L	$< 2.1 \times 10^{-6}$	CL=90%	814
$e^- K^+ K^-$	LF	$< 6.0 \times 10^{-6}$	CL=90%	739
$e^+ K^- K^-$	L	$< 3.8 \times 10^{-6}$	CL=90%	739
$\mu^- \pi^+ K^-$	LF	$< 7.5 \times 10^{-6}$	CL=90%	800
$\mu^- \pi^- K^+$	LF	$< 7.4 \times 10^{-6}$	CL=90%	800
$\mu^+ \pi^- K^-$	L	$< 7.0 \times 10^{-6}$	CL=90%	800
$\mu^- K^+ K^-$	LF	$< 1.5 \times 10^{-5}$	CL=90%	699
$\mu^+ K^- K^-$	L	$< 6.0 \times 10^{-6}$	CL=90%	699
$e^- \pi^0 \pi^0$	LF	$< 6.5 \times 10^{-6}$	CL=90%	878
$\mu^- \pi^0 \pi^0$	LF	$< 1.4 \times 10^{-5}$	CL=90%	867
$e^- \eta \eta$	LF	$< 3.5 \times 10^{-5}$	CL=90%	700
$\mu^- \eta \eta$	LF	$< 6.0 \times 10^{-5}$	CL=90%	654
$e^- \pi^0 \eta$	LF	$< 2.4 \times 10^{-5}$	CL=90%	798
$\mu^- \pi^0 \eta$	LF	$< 2.2 \times 10^{-5}$	CL=90%	784
$\overline{p} \gamma$	L,B	$< 2.9 \times 10^{-4}$	CL=90%	641
$\overline{p} \pi^0$	L,B	$< 6.6 \times 10^{-4}$	CL=90%	632
$\overline{p} \eta$	L,B	$< 1.30 \times 10^{-3}$	CL=90%	476
e^- light boson	LF	$< 2.7 \times 10^{-3}$	CL=95%	–
μ^- light boson	LF	$< 5 \times 10^{-3}$	CL=95%	–

Heavy Charged Lepton Searches

$L^{\pm}$ – charged lepton

Mass $m >$ 80.2 GeV, CL = 95% $m_\nu \approx 0$

$L^{\pm}$ – stable charged heavy lepton

Mass $m >$ 84.2 GeV, CL = 95%

Neutrinos

See the Particle Listings for a Note "Neutrino Mass" giving details of neutrinos, masses, mixing, and the status of experimental searches.

ν_e

$J = \frac{1}{2}$

Mass m: Unexplained effects have resulted in significantly negative m^2 in the new, precise tritium beta decay experiments. It is felt that a real neutrino mass as large as 10–15 eV would cause observable spectral distortions even in the presence of the end-point count excesses.

Mean life/mass, $\tau/m_{\nu_e} > 7 \times 10^9$ s/eV (solar)

Mean life/mass, $\tau/m_{\nu_e} > 300$ s/eV, CL = 90% (reactor)

Magnetic moment $\mu < 1.8 \times 10^{-10}\ \mu_B$, CL = 90%

ν_μ

$J = \frac{1}{2}$

Mass $m <$ 0.17 MeV, CL = 90%

Mean life/mass, $\tau/m_{\nu_\mu} > 15.4$ s/eV, CL = 90%

Magnetic moment $\mu < 7.4 \times 10^{-10}\ \mu_B$, CL = 90%

ν_τ

$J = \frac{1}{2}$

Mass $m <$ 18.2 MeV, CL = 95%

Magnetic moment $\mu < 5.4 \times 10^{-7}\ \mu_B$, CL = 90%

Electric dipole moment $d < 5.2 \times 10^{-17}$ $e$cm, CL = 95%

Number of Light Neutrino Types

(including ν_e, ν_μ, and ν_τ)

Number $N = 2.994 \pm 0.012$ (Standard Model fits to LEP data)

Number $N = 3.07 \pm 0.12$ (Direct measurement of invisible Z width)

Massive Neutrinos and Lepton Mixing, Searches for

For excited leptons, see Compositeness Limits below.

See the Particle Listings for a Note "Neutrino Mass" giving details of neutrinos, masses, mixing, and the status of experimental searches.

While no direct, uncontested evidence for massive neutrinos or lepton mixing has been obtained, suggestive evidence has come from solar neutrino observations, from anomalies in the relative fractions of ν_e and ν_μ observed in energetic cosmic-ray air showers, and possibly from a $\overline{\nu}_e$ appearance experiment at Los Alamos. Sample limits are:

Stable Neutral Heavy Lepton Mass Limits

Mass $m >$ 45.0 GeV, CL = 95% (Dirac)

Mass $m >$ 39.5 GeV, CL = 95% (Majorana)

Neutral Heavy Lepton Mass Limits

Mass $m >$ 69.0 GeV, CL = 95% (Dirac ν_L coupling to e, μ, τ with $|U_{\ell j}|^2 > 10^{-12}$)

Mass $m >$ 58.2 GeV, CL = 95% (Majorana ν_L coupling to e, μ, τ with $|U_{\ell j}|^2 > 10^{-12}$)

Solar Neutrinos

Detectors using gallium ($E_\nu \gtrsim 0.2$ MeV), chlorine ($E_\nu \gtrsim 0.8$ MeV), and Čerenkov effect in water ($E_\nu \gtrsim 7$ MeV) measure significantly lower neutrino rates than are predicted from solar models. The deficit in the solar neutrino flux compared with solar model calculations could be explained by oscillations with $\Delta m^2 \leq 10^{-5}$ eV^2 causing the disappearance of ν_e.

Atmospheric Neutrinos

Underground detectors observing neutrinos produced by cosmic rays in the atmosphere have measured a ν_μ/ν_e ratio much less than expected and also a deficiency of upward going ν_μ compared to downward. This could be explained by oscillations leading to the disappearance of ν_μ with $\Delta m^2 \approx 10^{-3}$ to 10^{-2} eV^2.

ν oscillation: $\overline{\nu}_e \not\to \overline{\nu}_e$ (θ = mixing angle)

$\Delta m^2 < 9 \times 10^{-4}$ eV^2, CL = 90% (if $\sin^2 2\theta = 1$)

$\sin^2 2\theta < 0.02$, CL = 90% (if $\Delta(m^2)$ is large)

ν oscillation: ν_μ ($\overline{\nu}_\mu$) $\to$ ν_e ($\overline{\nu}_e$) (any combination)

$\Delta m^2 < 0.075$ eV^2, CL = 90% (if $\sin^2 2\theta = 1$)

$\sin^2 2\theta < 1.8 \times 10^{-3}$, CL = 90% (if $\Delta(m^2)$ is large)

NOTES

In this Summary Table:

When a quantity has "(S = ...)" to its right, the error on the quantity has been enlarged by the "scale factor" S, defined as $S = \sqrt{\chi^2/(N-1)}$, where N is the number of measurements used in calculating the quantity. We do this when S > 1, which often indicates that the measurements are inconsistent. When S > 1.25, we also show in the Particle Listings an ideogram of the measurements. For more about S, see the Introduction.

A decay momentum p is given for each decay mode. For a 2-body decay, p is the momentum of each decay product in the rest frame of the decaying particle. For a 3-or-more-body decay, p is the largest momentum any of the products can have in this frame.

[a] The uncertainty in the electron mass in unified atomic mass units (u) is ten times smaller than that given by the 1986 CODATA adjustment, quoted in the Table of Physical Constants (Section 1). The conversion to MeV via the factor 931.49432(28) MeV/u is more uncertain because of the electron charge uncertainty. Our value in MeV differs slightly from the 1986 CODATA result.

[b] This is the best "electron disappearance" limit. The best limit for the mode $e^- \to \nu\gamma$ is $> 2.35 \times 10^{25}$ yr (CL=68%).

[c] The muon mass is most precisely known in u (unified atomic mass units). The conversion factor to MeV via the factor 931.49432(28) MeV/u is more uncertain because of the electron charge uncertainty.

[d] See the "Note on Muon Decay Parameters" in the μ Particle Listings for definitions and details.

[e] P_μ is the longitudinal polarization of the muon from pion decay. In standard $V-A$ theory, $P_\mu = 1$ and $\rho = \delta = 3/4$.

[f] This only includes events with the γ energy > 10 MeV. Since the $e^-\overline{\nu}_e\nu_\mu$ and $e^-\overline{\nu}_e\nu_\mu\gamma$ modes cannot be clearly separated, we regard the latter mode as a subset of the former.

[g] See the μ Particle Listings for the energy limits used in this measurement.

[h] A test of additive vs. multiplicative lepton family number conservation.

[i] Basis mode for the τ.

QUARK SUMMARY TABLE

QUARKS

The *u*-, *d*-, and *s*-quark masses are estimates of so-called "current-quark masses," in a mass-independent subtraction scheme such as $\overline{\text{MS}}$ at a scale $\mu \approx 2$ GeV. The *c*- and *b*-quark masses are estimated from charmonium, bottomonium, *D*, and *B* masses. They are the "running" masses in the $\overline{\text{MS}}$ scheme. These can be different from the heavy quark masses obtained in potential models.

u

$I(J^P) = \frac{1}{2}(\frac{1}{2}^+)$

Mass $m = 1.5$ to 5 MeV [a]   Charge $= \frac{2}{3}\ e$ $I_z = +\frac{1}{2}$

$m_u/m_d = 0.20$ to 0.70

d

$I(J^P) = \frac{1}{2}(\frac{1}{2}^+)$

Mass $m = 3$ to 9 MeV [a]   Charge $= -\frac{1}{3}\ e$ $I_z = -\frac{1}{2}$

$m_s/m_d = 17$ to 25

$\overline{m} = (m_u + m_d)/2 = 2$ to 6 MeV

s

$I(J^P) = 0(\frac{1}{2}^+)$

Mass $m = 60$ to 170 MeV [a]   Charge $= -\frac{1}{3}\ e$ Strangeness $= -1$

$(m_s - (m_u + m_d)/2)/(m_d - m_u) = 34$ to 51

c

$I(J^P) = 0(\frac{1}{2}^+)$

Mass $m = 1.1$ to 1.4 GeV   Charge $= \frac{2}{3}\ e$ Charm $= +1$

b

$I(J^P) = 0(\frac{1}{2}^+)$

Mass $m = 4.1$ to 4.4 GeV   Charge $= -\frac{1}{3}\ e$ Bottom $= -1$

t

$I(J^P) = 0(\frac{1}{2}^+)$

Charge $= \frac{2}{3}\ e$ Top $= +1$

Mass $m = 173.8 \pm 5.2$ GeV   (direct observation of top events)

Mass $m = 170 \pm 7\ (+14)$ GeV   (Standard Model electroweak fit, assuming $M_H = M_Z$. Number in parentheses is shift from changing M_H to 300 GeV.

b′ (4^{th} Generation) Quark, Searches for

Mass $m >$ 128 GeV, CL = 95%   ($p\overline{p}$, charged current decays)

Mass $m >$ 46.0 GeV, CL = 95%   (e^+e^-, all decays)

Free Quark Searches

All searches since 1977 have had negative results.

NOTES

[*a*] The ratios m_u/m_d and m_s/m_d are extracted from pion and kaon masses using chiral symmetry. The estimates of *u* and *d* masses are not without controversy and remain under active investigation. Within the literature there are even suggestions that the *u* quark could be essentially massless. The *s*-quark mass is estimated from SU(3) splittings in hadron masses.

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

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

$\pi^\pm$

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

Mass $m = 139.56995 \pm 0.00035$ MeV
Mean life $\tau = (2.6033 \pm 0.0005) \times 10^{-8}$ s (S = 1.2)
$c\tau = 7.8045$ m

$\pi^\pm \to \ell^\pm \nu\gamma$ 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.

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]	(1.24 ±0.25) $\times 10^{-4}$		30
$e^+\nu_e$		[b]	(1.230 ±0.004) $\times 10^{-4}$		70
$e^+\nu_e\gamma$		[c]	(1.61 ±0.23) $\times 10^{-7}$		70
$e^+\nu_e\pi^0$			(1.025 ±0.034) $\times 10^{-8}$		4
$e^+\nu_e e^+ e^-$			(3.2 ±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 $m = 134.9764 \pm 0.0006$ MeV
$m_{\pi^\pm} - m_{\pi^0} = 4.5936 \pm 0.0005$ MeV
Mean life $\tau = (8.4 \pm 0.6) \times 10^{-17}$ s (S = 3.0)
$c\tau = 25.1$ nm

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
γpositronium			(1.82 ±0.29) $\times 10^{-9}$		67
$e^+e^+e^-e^-$			(3.14 ±0.30) $\times 10^{-5}$		67
e^+e^-			(7.5 ±2.0) $\times 10^{-8}$		67
4γ			< 2 $\times 10^{-8}$	CL=90%	67
$\nu\bar{\nu}$		[e]	< 8.3 $\times 10^{-7}$	CL=90%	67
$\nu_e\bar{\nu}_e$			< 1.7 $\times 10^{-6}$	CL=90%	67
$\nu_\mu\bar{\nu}_\mu$			< 3.1 $\times 10^{-6}$	CL=90%	67
$\nu_\tau\bar{\nu}_\tau$			< 2.1 $\times 10^{-6}$	CL=90%	67
Charge conjugation (*C*) or Lepton Family number (*LF*) violating modes					
3γ	C		< 3.1 $\times 10^{-8}$	CL=90%	67
$\mu^+e^- + e^-\mu^+$	LF		< 1.72 $\times 10^{-8}$	CL=90%	26

η

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

Mass $m = 547.30 \pm 0.12$ MeV
Full width $\Gamma = 1.18 \pm 0.11$ keV [f] (S = 1.8)

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) = 0.05 ± 0.06 (S = 1.5)

Dalitz plot parameter

$\pi^0\pi^0\pi^0$ $\alpha = -0.039 \pm 0.015$

η DECAY MODES			Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
Neutral modes					
neutral modes			(71.5 ±0.6) %	S=1.4	–
2γ		[f]	(39.21±0.34) %	S=1.4	274
$3\pi^0$			(32.2 ±0.4) %	S=1.3	178
$\pi^0 2\gamma$			(7.1 ±1.4) $\times 10^{-4}$		257
other neutral modes			< 2.8 %	CL=90%	–
Charged modes					
charged modes			(28.5 ±0.6) %	S=1.4	–
$\pi^+\pi^-\pi^0$			(23.1 ±0.5) %	S=1.4	173
$\pi^+\pi^-\gamma$			(4.77±0.13) %	S=1.3	235
$e^+e^-\gamma$			(4.9 ±1.1) $\times 10^{-3}$		274
$\mu^+\mu^-\gamma$			(3.1 ±0.4) $\times 10^{-4}$		252
e^+e^-			< 7.7 $\times 10^{-5}$	CL=90%	274
$\mu^+\mu^-$			(5.8 ±0.8) $\times 10^{-6}$		252
$\pi^+\pi^-e^+e^-$			(1.3 $^{+1.2}_{-0.8}$) $\times 10^{-3}$		235
$\pi^+\pi^-2\gamma$			< 2.1 $\times 10^{-3}$		235
$\pi^+\pi^-\pi^0\gamma$			< 6 $\times 10^{-4}$	CL=90%	173
$\pi^0\mu^+\mu^-\gamma$			< 3 $\times 10^{-6}$	CL=90%	210
Charge conjugation (*C*)ΓParity (*P*)Γ Charge conjugation × Parity (*CP*)Γor Lepton Family number (*LF*) violating modes					
$\pi^+\pi^-$	PΓCP		< 9 $\times 10^{-4}$	CL=90%	235
3γ	C		< 5 $\times 10^{-4}$	CL=95%	274
$\pi^0e^+e^-$	C	[g]	< 4 $\times 10^{-5}$	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%	263

$f_0(400\text{–}1200)$ [h] or σ

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

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

$f_0(400\text{–}1200)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\pi\pi$	dominant	–
$\gamma\gamma$	seen	–

$\rho(770)$ [l]

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

Mass $m = 770.0 \pm 0.8$ MeV (S = 1.8)
Full width $\Gamma = 150.7 \pm 1.1$ MeV
$\Gamma_{ee} = 6.77 \pm 0.32$ keV

$\rho(770)$ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
$\pi\pi$	~ 100 %		358
$\rho(770)^\pm$ decays			
$\pi^\pm\gamma$	$(4.5 \pm 0.5) \times 10^{-4}$	S=2.2	372
$\pi^\pm\eta$	$< 6 \times 10^{-3}$	CL=84%	146
$\pi^\pm\pi^+\pi^-\pi^0$	$< 2.0 \times 10^{-3}$	CL=84%	249
$\rho(770)^0$ decays			
$\pi^+\pi^-\gamma$	$(9.9 \pm 1.6) \times 10^{-3}$		358
$\pi^0\gamma$	$(6.8 \pm 1.7) \times 10^{-4}$		372
$\eta\gamma$	$(2.4 {}^{+0.8}_{-0.9}) \times 10^{-4}$	S=1.6	189
$\mu^+\mu^-$	[j] $(4.60 \pm 0.28) \times 10^{-5}$		369
e^+e^-	[j] $(4.49 \pm 0.22) \times 10^{-5}$		384
$\pi^+\pi^-\pi^0$	$< 1.2 \times 10^{-4}$	CL=90%	319
$\pi^+\pi^-\pi^+\pi^-$	$< 2 \times 10^{-4}$	CL=90%	246
$\pi^+\pi^-\pi^0\pi^0$	$< 4 \times 10^{-5}$	CL=90%	252

$\omega(782)$

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

Mass $m = 781.94 \pm 0.12$ MeV (S = 1.5)
Full width $\Gamma = 8.41 \pm 0.09$ MeV
$\Gamma_{ee} = 0.60 \pm 0.02$ keV

$\omega(782)$ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
$\pi^+\pi^-\pi^0$	(88.8 ± 0.7) %		327
$\pi^0\gamma$	(8.5 ± 0.5) %		379
$\pi^+\pi^-$	(2.21 ± 0.30) %		365
neutrals (excluding $\pi^0\gamma$)	$(5.3 {}^{+8.7}_{-3.5}) \times 10^{-3}$		–
$\eta\gamma$	$(6.5 \pm 1.0) \times 10^{-4}$		199
$\pi^0 e^+e^-$	$(5.9 \pm 1.9) \times 10^{-4}$		379
$\pi^0\mu^+\mu^-$	$(9.6 \pm 2.3) \times 10^{-5}$		349
e^+e^-	$(7.07 \pm 0.19) \times 10^{-5}$	S=1.1	391
$\pi^+\pi^-\pi^0\pi^0$	< 2 %	CL=90%	261
$\pi^+\pi^-\gamma$	$< 3.6 \times 10^{-3}$	CL=95%	365
$\pi^+\pi^-\pi^+\pi^-$	$< 1 \times 10^{-3}$	CL=90%	256
$\pi^0\pi^0\gamma$	$(7.2 \pm 2.5) \times 10^{-5}$		367
$\mu^+\mu^-$	$< 1.8 \times 10^{-4}$	CL=90%	376
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%	329

$\eta'(958)$

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

Mass $m = 957.78 \pm 0.14$ MeV
Full width $\Gamma = 0.203 \pm 0.016$ MeV (S = 1.3)

$\eta'(958)$ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
$\pi^+\pi^-\eta$	(43.8 ± 1.5) %	S=1.1	232
$\rho^0\gamma$ (including non-resonant $\pi^+\pi^-\gamma$)	(30.2 ± 1.3) %	S=1.1	169
$\pi^0\pi^0\eta$	(20.7 ± 1.3) %	S=1.2	239
$\omega\gamma$	(3.01 ± 0.30) %		160
$\gamma\gamma$	(2.11 ± 0.13) %	S=1.2	479
$3\pi^0$	$(1.54 \pm 0.26) \times 10^{-3}$		430
$\mu^+\mu^-\gamma$	$(1.03 \pm 0.26) \times 10^{-4}$		467
$\pi^+\pi^-\pi^0$	< 5 %	CL=90%	427
$\pi^0\rho^0$	< 4 %	CL=90%	118
$\pi^+\pi^+\pi^-\pi^-$	< 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%	189
$\pi^+\pi^- e^+e^-$	$< 6 \times 10^{-3}$	CL=90%	458
$\pi^0\gamma\gamma$	$< 8 \times 10^{-4}$	CL=90%	469
$4\pi^0$	$< 5 \times 10^{-4}$	CL=90%	379
e^+e^-	$< 2.1 \times 10^{-7}$	CL=90%	479
Charge conjugation (C) or Parity (P) 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 [g] < 1.3 %	CL=90%	469
ηe^+e^-	C [g] < 1.1 %	CL=90%	322
3γ	C $< 1.0 \times 10^{-4}$	CL=90%	479
$\mu^+\mu^-\pi^0$	C [g] $< 6.0 \times 10^{-5}$	CL=90%	445
$\mu^+\mu^-\eta$	C [g] $< 1.5 \times 10^{-5}$	CL=90%	274

$f_0(980)$ [k]

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

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

$f_0(980)$ DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$\pi\pi$	dominant		470
$K\overline{K}$	seen		–
$\gamma\gamma$	$(1.19 \pm 0.33) \times 10^{-5}$		490
e^+e^-	$< 3 \times 10^{-7}$	90%	490

$a_0(980)$ [k]

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

Mass $m = 983.4 \pm 0.9$ MeV
Full width $\Gamma = 50$ to 100 MeV

$a_0(980)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\eta\pi$	dominant	321
$K\overline{K}$	seen	–
$\gamma\gamma$	seen	492

$\phi(1020)$

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

Mass $m = 1019.413 \pm 0.008$ MeV
Full width $\Gamma = 4.43 \pm 0.05$ MeV

$\phi(1020)$ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
K^+K^-	(49.1 ± 0.8) %	S=1.3	127
$K^0_L K^0_S$	(34.1 ± 0.6) %	S=1.2	110
$\rho\pi + \pi^+\pi^-\pi^0$	(15.5 ± 0.7) %	S=1.5	–
$\eta\gamma$	(1.26 ± 0.06) %	S=1.1	363
$\pi^0\gamma$	$(1.31 \pm 0.13) \times 10^{-3}$		501
e^+e^-	$(2.99 \pm 0.08) \times 10^{-4}$	S=1.2	510
$\mu^+\mu^-$	$(2.5 \pm 0.4) \times 10^{-4}$		499
ηe^+e^-	$(1.3 {}^{+0.8}_{-0.6}) \times 10^{-4}$		363
$\pi^+\pi^-$	$(8 {}^{+5}_{-4}) \times 10^{-5}$	S=1.5	490
$\omega\gamma$	< 5 %	CL=84%	210
$\rho\gamma$	$< 7 \times 10^{-4}$	CL=90%	219
$\pi^+\pi^-\gamma$	$< 3 \times 10^{-5}$	CL=90%	490
$f_0(980)\gamma$	$< 1 \times 10^{-4}$	CL=90%	39
$\pi^0\pi^0\gamma$	$< 1 \times 10^{-3}$	CL=90%	492
$\pi^+\pi^-\pi^+\pi^-$	$< 8.7 \times 10^{-4}$	CL=90%	410
$\pi^+\pi^+\pi^-\pi^-\pi^0$	$< 1.5 \times 10^{-4}$	CL=95%	341
$\pi^0 e^+e^-$	$< 1.2 \times 10^{-4}$	CL=90%	501
$\pi^0\eta\gamma$	$< 2.5 \times 10^{-3}$	CL=90%	346
$a_0(980)\gamma$	$< 5 \times 10^{-3}$	CL=90%	36
$\eta'(958)\gamma$	$(1.2 {}^{+0.7}_{-0.5}) \times 10^{-4}$		–
$\mu^+\mu^-\gamma$	$(2.3 \pm 1.0) \times 10^{-5}$		–

$h_1(1170)$

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

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	310

$b_1(1235)$

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

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 $= 0.29 \pm 0.04$]			
$\pi^{\pm}\gamma$	$(1.6 \pm 0.4) \times 10^{-3}$		608
$\eta\rho$	seen		–
$\pi^+\pi^+\pi^-\pi^0$	< 50 %	84%	536
$(K\overline{K})^{\pm}\pi^0$	< 8 %	90%	248
$K^0_S K^0_L \pi^{\pm}$	< 6 %	90%	238
$K^0_S K^0_S \pi^{\pm}$	< 2 %	90%	238
$\phi\pi$	< 1.5 %	84%	146

$a_1(1260)$ [l]

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

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

$a_1(1260)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\rho\pi$	dominant	356
[D/S amplitude ratio $= -0.100 \pm 0.028$]		
$\pi\gamma$	seen	607
$\pi(\pi\pi)_{S\text{-wave}}$	possibly seen	575

$f_2(1270)$

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

Mass $m = 1275.0 \pm 1.2$ MeV
Full width $\Gamma = 185.5^{+3.8}_{-2.7}$ MeV (S = 1.5)

$f_2(1270)$ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
$\pi\pi$	$(84.6 \ ^{+2.5}_{-1.3})$ %	S=1.3	622
$\pi^+\pi^-2\pi^0$	$(7.2 \ ^{+1.5}_{-2.7})$ %	S=1.3	562
$K\overline{K}$	(4.6 ± 0.4) %	S=2.8	403
$2\pi^+2\pi^-$	(2.8 ± 0.4) %	S=1.2	559
$\eta\eta$	$(4.5 \pm 1.0) \times 10^{-3}$	S=2.4	327
$4\pi^0$	$(3.0 \pm 1.0) \times 10^{-3}$		564
$\gamma\gamma$	$(1.32^{+0.17}_{-0.16}) \times 10^{-5}$		637
$\eta\pi\pi$	$< 8 \times 10^{-3}$	CL=95%	475
$K^0 K^- \pi^+ +$ c.c.	$< 3.4 \times 10^{-3}$	CL=95%	293
e^+e^-	$< 9 \times 10^{-9}$	CL=90%	637

$f_1(1285)$

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

Mass $m = 1281.9 \pm 0.6$ MeV (S = 1.7)
Full width $\Gamma = 24.0 \pm 1.2$ MeV (S = 1.4)

$(4\pi = \rho(\pi\pi)_{Pwave})$

$f_1(1285)$ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
4π	(35 ± 4) %	S=1.6	563
$\pi^0\pi^0\pi^+\pi^-$	(23.5 ± 3.0) %	S=1.6	566
$2\pi^+2\pi^-$	(11.7 ± 1.5) %	S=1.6	563
$\rho^0\pi^+\pi^-$	(11.7 ± 1.5) %	S=1.6	340
$4\pi^0$	$< 7 \times 10^{-4}$	CL=90%	568
$\eta\pi\pi$	(50 ± 18) %		479
$a_0(980)\pi$ [ignoring $a_0(980) \to K\overline{K}$]	(34 ± 8) %	S=1.2	234
$\eta\pi\pi$ [excluding $a_0(980)\pi$]	(15 ± 7) %	S=1.1	–
$K\overline{K}\pi$	(9.6 ± 1.2) %	S=1.5	308
$K\overline{K}^*(892)$	not seen		–
$\gamma\rho^0$	(5.4 ± 1.2) %	S=2.3	410
$\phi\gamma$	$(7.9 \pm 3.0) \times 10^{-4}$		236

$\eta(1295)$

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

Mass $m = 1297.0 \pm 2.8$ MeV
Full width $\Gamma = 53 \pm 6$ MeV

$\eta(1295)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\eta\pi^+\pi^-$	seen	488
$a_0(980)\pi$	seen	245
$\eta\pi^0\pi^0$	seen	–
$\eta(\pi\pi)_{S\text{-wave}}$	seen	–

$\pi(1300)$

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

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

$\pi(1300)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\rho\pi$	seen	406
$\pi(\pi\pi)_{S\text{-wave}}$	seen	–

$a_2(1320)$

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

Mass $m = 1318.1 \pm 0.6$ MeV (S = 1.1)
Full width $\Gamma = 107 \pm 5$ MeV [m] ($K^{\pm}K^0_S$ and $\eta\pi$ modes)

$a_2(1320)$ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
$\rho\pi$	(70.1 ± 2.7) %	S=1.2	419
$\eta\pi$	(14.5 ± 1.2) %		535
$\omega\pi\pi$	(10.6 ± 3.2) %	S=1.3	362
$K\overline{K}$	(4.9 ± 0.8) %		437
$\eta'(958)\pi$	$(5.3 \pm 0.9) \times 10^{-3}$		287
$\pi^{\pm}\gamma$	$(2.8 \pm 0.6) \times 10^{-3}$		652
$\gamma\gamma$	$(9.4 \pm 0.7) \times 10^{-6}$		659
$\pi^+\pi^-\pi^-$	< 8 %	CL=90%	621
e^+e^-	$< 2.3 \times 10^{-7}$	CL=90%	659

$f_0(1370)$ [k]

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

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	–
4π	seen	–
$4\pi^0$	seen	–
$2\pi^+2\pi^-$	seen	–
$\pi^+\pi^-2\pi^0$	seen	–
$2(\pi\pi)_{S\text{-wave}}$	seen	–
$\eta\eta$	seen	–
$K\overline{K}$	seen	–
$\gamma\gamma$	seen	–
e^+e^-	not seen	–

$f_1(1420)$ [n]

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

Mass $m = 1426.2 \pm 1.2$ MeV (S = 1.3)
Full width $\Gamma = 55.0 \pm 3.0$ MeV

$f_1(1420)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K\overline{K}\pi$	dominant	439
$K\overline{K}^*(892)+$ c.c.	dominant	155
$\eta\pi\pi$	possibly seen	571

$\omega(1420)$ [o]

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

Mass $m = 1419 \pm 31$ MeV
Full width $\Gamma = 174 \pm 60$ MeV

$\omega(1420)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\rho\pi$	dominant	488

$\eta(1440)$ [p]

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

Mass $m = 1400$ - 1470 MeV [m]
Full width $\Gamma = 50$ - 80 MeV [m]

$\eta(1440)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K\overline{K}\pi$	seen	–
$K\overline{K}^*(892)+$ c.c.	seen	–
$\eta\pi\pi$	seen	–
$a_0(980)\pi$	seen	–
$\eta(\pi\pi)_{S\text{-wave}}$	seen	–
4π	seen	–

$a_0(1450)$

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

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	613
$\pi\eta'(958)$	seen	392
$K\overline{K}$	seen	530

$\rho(1450)$ [q]

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

Mass $m = 1465 \pm 25$ MeV [m]
Full width $\Gamma = 310 \pm 60$ MeV [m]

$\rho(1450)$ DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$\pi\pi$	seen		719
4π	seen		665
$\omega\pi$	<2.0 %	95%	512
e^+e^-	seen		732
$\eta\rho$	<4 %		317
$\phi\pi$	<1 %		358
$K\overline{K}$	$<1.6 \times 10^{-3}$	95%	541

$f_0(1500)$ [r]

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

Mass $m = 1500 \pm 10$ MeV (S = 1.3)
Full width $\Gamma = 112 \pm 10$ MeV

$f_0(1500)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\eta\eta'(958)$	seen	–
$\eta\eta$	seen	513
4π	seen	–
$4\pi^0$	seen	690
$2\pi^+2\pi^-$	seen	686
2π	seen	–
$\pi^+\pi^-$	seen	737
$2\pi^0$	seen	738
$K\overline{K}$	seen	563

$f'_2(1525)$

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

Mass $m = 1525 \pm 5$ MeV [m]
Full width $\Gamma = 76 \pm 10$ MeV [m]

$f'_2(1525)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K\overline{K}$	(88.8 ±3.1) %	581
$\eta\eta$	(10.3 ±3.1) %	531
$\pi\pi$	(8.2 ±1.5) $\times 10^{-3}$	750
$\gamma\gamma$	(1.32±0.21) $\times 10^{-6}$	763

$\omega(1600)$ [s]

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

Mass $m = 1649 \pm 24$ MeV (S = 2.3)
Full width $\Gamma = 220 \pm 35$ MeV (S = 1.6)

$\omega(1600)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\rho\pi$	seen	637
$\omega\pi\pi$	seen	601
e^+e^-	seen	824

$\omega_3(1670)$

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

Mass $m = 1667 \pm 4$ MeV
Full width $\Gamma = 168 \pm 10$ MeV [m]

$\omega_3(1670)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\rho\pi$	seen	647
$\omega\pi\pi$	seen	614
$b_1(1235)\pi$	possibly seen	359

$\pi_2(1670)$

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

Mass $m = 1670 \pm 20$ MeV [m]
Full width $\Gamma = 258 \pm 18$ MeV [m] (S = 1.7)

$\pi_2(1670)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
3π	(95.8±1.4) %	806
$f_2(1270)\pi$	(56.2±3.2) %	325
$\rho\pi$	(31 ±4) %	649
$f_0(1370)\pi$	(8.7±3.4) %	–
$K\overline{K}^*(892)+$ c.c.	(4.2±1.4) %	453

$\phi(1680)$

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

Mass $m = 1680 \pm 20$ MeV [m]
Full width $\Gamma = 150 \pm 50$ MeV [m]

$\phi(1680)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K\overline{K}^*(892)+$ c.c.	dominant	463
$K^0_S K\pi$	seen	620
$K\overline{K}$	seen	681
e^+e^-	seen	840
$\omega\pi\pi$	not seen	622

$\rho_3(1690)$

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

J^P from the 2π and $K\overline{K}$ modes.
Mass $m = 1691 \pm 5$ MeV [m]
Full width $\Gamma = 160 \pm 10$ MeV [m] (S = 1.5)

$\rho_3(1690)$ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor	p (MeV/c)
4π	(71.1 ± 1.9) %		788
$\pi^\pm\pi^+\pi^-\pi^0$	(67 ±22) %		788
$\omega\pi$	(16 ± 6) %		656
$\pi\pi$	(23.6 ± 1.3) %		834
$K\overline{K}\pi$	(3.8 ± 1.2) %		628
$K\overline{K}$	(1.58± 0.26) %	1.2	686
$\eta\pi^+\pi^-$	seen		728

$\rho(1700)$ [q]

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

Mass $m = 1700 \pm 20$ MeV [m] ($\eta\rho^0$ and $\pi^+\pi^-$ modes)
Full width $\Gamma = 240 \pm 60$ MeV [m] ($\eta\rho^0$ and $\pi^+\pi^-$ modes)

$\rho(1700)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\rho\pi\pi$	dominant	640
$2(\pi^+\pi^-)$	large	792
$\rho^0\pi^+\pi^-$	large	640
$\rho^\pm\pi^\mp\pi^0$	large	642
$\pi^+\pi^-$	seen	838
$\pi^-\pi^0$	seen	839
$K\overline{K}{}^*(892)$+ c.c.	seen	479
$\eta\rho$	seen	533
$K\overline{K}$	seen	692
e^+e^-	seen	850
$\pi^0\omega$	seen	662

$f_J(1710)$ [t]

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

Mass $m = 1712 \pm 5$ MeV (S = 1.1)
Full width $\Gamma = 133 \pm 14$ MeV (S = 1.2)

$f_J(1710)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K\overline{K}$	seen	690
$\eta\eta$	seen	648
$\pi\pi$	seen	837

$\pi(1800)$

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

Mass $m = 1801 \pm 13$ MeV (S = 1.9)
Full width $\Gamma = 210 \pm 15$ MeV

$\pi(1800)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\pi^+\pi^-\pi^-$	seen	–
$f_0(980)\pi^-$	seen	623
$f_0(1370)\pi^-$	seen	–
$\rho\pi^-$	not seen	728
$\eta\eta\pi^-$	seen	–
$a_0(980)\eta$	seen	459
$f_0(1500)\pi^-$	seen	240
$\eta\eta'(958)\pi^-$	seen	–
$K_0^*(1430)K^-$	seen	–
$K^*(892)K^-$	not seen	560

$\phi_3(1850)$

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

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

$f_2(2010)$

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

Seen by one group only.
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 $m = 2020 \pm 16$ MeV
Full width $\Gamma = 387 \pm 70$ MeV

$a_4(2040)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K\overline{K}$	seen	892
$\pi^+\pi^-\pi^0$	seen	–
$\eta\pi^0$	seen	941

$f_4(2050)$

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

Mass $m = 2044 \pm 11$ MeV (S = 1.4)
Full width $\Gamma = 208 \pm 13$ MeV (S = 1.2)

$f_4(2050)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\omega\omega$	(26 ±6) %	658
$\pi\pi$	(17.0±1.5) %	1012
$K\overline{K}$	$(6.8^{+3.4}_{-1.8}) \times 10^{-3}$	895
$\eta\eta$	$(2.1\pm0.8) \times 10^{-3}$	863
$4\pi^0$	< 1.2 %	977

$f_2(2300)$

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

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

$f_2(2340)$

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

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

STRANGE MESONS
($S = \pm1$, $C = B = 0$)

$K^+ = u\bar{s}$Γ $K^0 = d\bar{s}$Γ $\overline{K}^0 = \bar{d}s$Γ $K^- = \bar{u}s$Γ similarly for K^*'s

$K^\pm$

$I(J^P) = \frac{1}{2}(0^-)$

Mass $m = 493.677 \pm 0.016$ MeV [u] (S = 2.8)
Mean life $\tau = (1.2386 \pm 0.0024) \times 10^{-8}$ s (S = 2.0)
$c\tau = 3.713$ m

Slope parameter g [v]

(See Particle Listings for quadratic coefficients)

$K^+ \to \pi^+\pi^+\pi^- = -0.2154 \pm 0.0035$ (S = 1.4)
$K^- \to \pi^-\pi^-\pi^+ = -0.217 \pm 0.007$ (S = 2.5)
$K^\pm \to \pi^\pm\pi^0\pi^0 = 0.594 \pm 0.019$ (S = 1.3)

$K^\pm$ decay form factors [a,w]

K^+_{e3} $\lambda_+ = 0.0286 \pm 0.0022$
$K^+_{\mu3}$ $\lambda_+ = 0.032 \pm 0.008$ (S = 1.6)
$K^+_{\mu3}$ $\lambda_0 = 0.006 \pm 0.007$ (S = 1.6)
K^+_{e3} $|f_S/f_+| = 0.084 \pm 0.023$ (S = 1.2)
K^+_{e3} $|f_T/f_+| = 0.38 \pm 0.11$ (S = 1.1)
$K^+_{\mu3}$ $|f_T/f_+| = 0.02 \pm 0.12$
$K^+ \to e^+\nu_e\gamma$ $|F_A + F_V| = 0.148 \pm 0.010$
$K^+ \to \mu^+\nu_\mu\gamma$ $|F_A + F_V| < 0.23$Γ CL = 90%
$K^+ \to e^+\nu_e\gamma$ $|F_A - F_V| < 0.49$
$K^+ \to \mu^+\nu_\mu\gamma$ $|F_A - F_V| = -2.2$ to 0.3

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

K^+ DECAY MODES		Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
$\mu^+\nu_\mu$		(63.51±0.18) %	S=1.3	236
$e^+\nu_e$		(1.55±0.07) × 10^{-5}		247
$\pi^+\pi^0$		(21.16±0.14) %	S=1.1	205
$\pi^+\pi^+\pi^-$		(5.59±0.05) %	S=1.8	125
$\pi^+\pi^0\pi^0$		(1.73±0.04) %	S=1.2	133
$\pi^0\mu^+\nu_\mu$		(3.18±0.08) %	S=1.5	215
Called $K^+_{\mu3}$.				
$\pi^0 e^+\nu_e$		(4.82±0.06) %	S=1.3	228
Called K^+_{e3}.				
$\pi^0\pi^0 e^+\nu_e$		(2.1 ±0.4) × 10^{-5}		206
$\pi^+\pi^- e^+\nu_e$		(3.91±0.17) × 10^{-5}		203
$\pi^+\pi^-\mu^+\nu_\mu$		(1.4 ±0.9) × 10^{-5}		151
$\pi^0\pi^0\pi^0 e^+\nu_e$		< 3.5 × 10^{-6}	CL=90%	135
$\pi^+\gamma\gamma$	[x]	(1.10±0.32) × 10^{-6}		227
$\pi^+ 3\gamma$	[x]	< 1.0 × 10^{-4}	CL=90%	227
$\mu^+\nu_\mu\nu\bar{\nu}$		< 6.0 × 10^{-6}	CL=90%	236
$e^+\nu_e\nu\bar{\nu}$		< 6 × 10^{-5}	CL=90%	247
$\mu^+\nu_\mu e^+e^-$		(1.3 ±0.4) × 10^{-7}		236
$e^+\nu_e e^+e^-$		(3.0 $^{+3.0}_{-1.5}$) × 10^{-8}		247
$\mu^+\nu_\mu\mu^+\mu^-$		< 4.1 × 10^{-7}	CL=90%	185
$\mu^+\nu_\mu\gamma$	[x,y]	(5.50±0.28) × 10^{-3}		236
$\pi^+\pi^0\gamma$	[x,y]	(2.75±0.15) × 10^{-4}		205
$\pi^+\pi^0\gamma$(DE)	[x,z]	(1.8 ±0.4) × 10^{-5}		205
$\pi^+\pi^+\pi^-\gamma$	[x,y]	(1.04±0.31) × 10^{-4}		125
$\pi^+\pi^0\pi^0\gamma$	[x,y]	(7.5 $^{+5.5}_{-3.0}$) × 10^{-6}		133
$\pi^0\mu^+\nu_\mu\gamma$	[x,y]	< 6.1 × 10^{-5}	CL=90%	215
$\pi^0 e^+\nu_e\gamma$	[x,y]	(2.62±0.20) × 10^{-4}		228
$\pi^0 e^+\nu_e\gamma$(SD)	[aa]	< 5.3 × 10^{-5}	CL=90%	228
$\pi^0\pi^0 e^+\nu_e\gamma$		< 5 × 10^{-6}	CL=90%	206

Lepton Family number (LF)Γ Lepton number (L)Γ $\Delta S = \Delta Q$ (SQ) violating modesΓ or $\Delta S = 1$ weak neutral current ($S1$) modes

$\pi^+\pi^+e^-\bar{\nu}_e$	SQ		< 1.2 × 10^{-8}	CL=90%	203
$\pi^+\pi^+\mu^-\bar{\nu}_\mu$	SQ		< 3.0 × 10^{-6}	CL=95%	151
$\pi^+e^+e^-$	$S1$		(2.74±0.23) × 10^{-7}		227
$\pi^+\mu^+\mu^-$	$S1$		(5.0 ±1.0) × 10^{-8}		172
$\pi^+\nu\bar{\nu}$	$S1$		(4.2 $^{+9.7}_{-3.5}$) × 10^{-10}		227
$\mu^-\nu e^+e^+$	LF		< 2.0 × 10^{-8}	CL=90%	236
$\mu^+\nu_e$	LF	[d]	< 4 × 10^{-3}	CL=90%	236
$\pi^+\mu^+e^-$	LF		< 2.1 × 10^{-10}	CL=90%	214
$\pi^+\mu^-e^+$	LF		< 7 × 10^{-9}	CL=90%	214
$\pi^-\mu^+e^+$	L		< 7 × 10^{-9}	CL=90%	214
$\pi^-e^+e^+$	L		< 1.0 × 10^{-8}	CL=90%	227
$\pi^-\mu^+\mu^+$	L	[d]	< 1.5 × 10^{-4}	CL=90%	172
$\mu^+\bar{\nu}_e$	L	[d]	< 3.3 × 10^{-3}	CL=90%	236
$\pi^0e^+\bar{\nu}_e$	L		< 3 × 10^{-3}	CL=90%	228

K^0

$I(J^P) = \frac{1}{2}(0^-)$

50% K_SΓ 50% K_L

Mass $m = 497.672 \pm 0.031$ MeV
$m_{K^0} - m_{K^\pm} = 3.995 \pm 0.034$ MeV (S = 1.1)
$|m_{K^0} - m_{\overline{K}^0}| / m_{\text{average}} < 10^{-18}$ [bb]

K^0_S

$I(J^P) = \frac{1}{2}(0^-)$

Mean life $\tau = (0.8934 \pm 0.0008) \times 10^{-10}$ s
$c\tau = 2.6762$ cm

***CP*-violation parameters** [cc]

$\text{Im}(\eta_{+-0}) = -0.002 \pm 0.008$
$\text{Im}(\eta_{000})^2 < 0.1$Γ CL = 90%

K^0_S DECAY MODES		Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
$\pi^+\pi^-$		(68.61±0.28) %	S=1.2	206
$\pi^0\pi^0$		(31.39±0.28) %	S=1.2	209
$\pi^+\pi^-\gamma$	[y,dd]	(1.78±0.05) × 10^{-3}		206
$\gamma\gamma$		(2.4 ±0.9) × 10^{-6}		249
$\pi^+\pi^-\pi^0$		(3.4 $^{+1.1}_{-0.9}$) × 10^{-7}		133
$3\pi^0$		< 3.7 × 10^{-5}	CL=90%	139
$\pi^\pm e^\mp\nu$	[ee]	(6.70±0.07) × 10^{-4}	S=1.1	229
$\pi^\pm\mu^\mp\nu$	[ee]	(4.69±0.06) × 10^{-4}	S=1.1	216

$\Delta S = 1$ weak neutral current ($S1$) modes

$\mu^+\mu^-$	$S1$	< 3.2 × 10^{-7}	CL=90%	225
e^+e^-	$S1$	< 1.4 × 10^{-7}	CL=90%	249
$\pi^0e^+e^-$	$S1$	< 1.1 × 10^{-6}	CL=90%	231

K^0_L

$I(J^P) = \frac{1}{2}(0^-)$

$m_{K_L} - m_{K_S} = (0.5301 \pm 0.0014) \times 10^{10}\ \hbar\ s^{-1}$
$= (3.489 \pm 0.009) \times 10^{-12}$ MeV
Mean life $\tau = (5.17 \pm 0.04) \times 10^{-8}$ s (S = 1.1)
$c\tau = 15.51$ m

Slope parameter g [v]

(See Particle Listings for quadratic coefficients)

$K^0_L \to \pi^+\pi^-\pi^0 = 0.670 \pm 0.014$ (S = 1.6)

K_L decay form factors [w]

K^0_{e3} $\lambda_+ = 0.0300 \pm 0.0016$ (S = 1.2)
$K^0_{\mu3}$ $\lambda_+ = 0.034 \pm 0.005$ (S = 2.3)
$K^0_{\mu3}$ $\lambda_0 = 0.025 \pm 0.006$ (S = 2.3)
K^0_{e3} $|f_S/f_+| < 0.04$Γ CL = 68%
K^0_{e3} $|f_T/f_+| < 0.23$Γ CL = 68%
$K^0_{\mu3}$ $|f_T/f_+| = 0.12 \pm 0.12$
$K_L \to e^+e^-\gamma$: $\alpha_{K^*} = -0.28 \pm 0.08$

***CP*-violation parameters** [cc]

$\delta = (0.327 \pm 0.012)\%$
$|\eta_{00}| = (2.275 \pm 0.019) \times 10^{-3}$ (S = 1.1)
$|\eta_{+-}| = (2.285 \pm 0.019) \times 10^{-3}$
$|\eta_{00}/\eta_{+-}| = 0.9956 \pm 0.0023$ [ff] (S = 1.8)
$\epsilon'/\epsilon = (1.5 \pm 0.8) \times 10^{-3}$ [ff] (S = 1.8)
$\phi_{+-} = (43.5 \pm 0.6)^\circ$
$\phi_{00} = (43.4 \pm 1.0)^\circ$
$\phi_{00} - \phi_{+-} = (-0.1 \pm 0.8)^\circ$
j for $K^0_L \to \pi^+\pi^-\pi^0 = 0.0011 \pm 0.0008$
$|\eta_{+-\gamma}| = (2.35 \pm 0.07) \times 10^{-3}$
$\phi_{+-\gamma} = (44 \pm 4)^\circ$
$|\epsilon'_{+-\gamma}|/\epsilon < 0.3$ΓCL = 90%

$\Delta S = -\Delta Q$ in $K^0_{\ell 3}$ decay

Re $x = 0.006 \pm 0.018$ (S = 1.3)
Im $x = -0.003 \pm 0.026$ (S = 1.2)

***CPT*-violation parameters**

Re $\Delta = 0.018 \pm 0.020$
Im $\Delta = 0.02 \pm 0.04$

K^0_L DECAY MODES		Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
$3\pi^0$		$(21.12 \pm 0.27)\ \%$	S=1.1	139
$\pi^+\pi^-\pi^0$		$(12.56 \pm 0.20)\ \%$	S=1.7	133
$\pi^\pm\mu^\mp\nu$	[gg]	$(27.17 \pm 0.25)\ \%$	S=1.1	216
Called $K^0_{\mu 3}$.				
$\pi^\pm e^\mp\nu_e$	[gg]	$(38.78 \pm 0.27)\ \%$	S=1.1	229
Called K^0_{e3}.				
2γ		$(5.92 \pm 0.15) \times 10^{-4}$		249
3γ		$< 2.4 \times 10^{-7}$	CL=90%	249
$\pi^0 2\gamma$	[hh]	$(1.70 \pm 0.28) \times 10^{-6}$		231
$\pi^0\pi^\pm e^\mp\nu$	[gg]	$(5.18 \pm 0.29) \times 10^{-5}$		207
$(\pi\mu\text{atom})\nu$		$(1.06 \pm 0.11) \times 10^{-7}$		–
$\pi^\pm e^\mp\nu_e\gamma$	[y,gg,hh]	$(3.62\ ^{+0.26}_{-0.21}) \times 10^{-3}$		229
$\pi^+\pi^-\gamma$	[y,hh]	$(4.61 \pm 0.14) \times 10^{-5}$		206
$\pi^0\pi^0\gamma$		$< 5.6 \times 10^{-6}$		209

Charge conjugation × Parity (*CP*, *CPV*) or Lepton Family number (*LF*) violating modesΓor $\Delta S = 1$ weak neutral current (*S1*) modes

		Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
$\pi^+\pi^-$	*CPV*	$(2.067 \pm 0.035) \times 10^{-3}$	S=1.1	206
$\pi^0\pi^0$	*CPV*	$(9.36 \pm 0.20) \times 10^{-4}$		209
$\mu^+\mu^-$	*S1*	$(7.2 \pm 0.5) \times 10^{-9}$	S=1.4	225
$\mu^+\mu^-\gamma$	*S1*	$(3.25 \pm 0.28) \times 10^{-7}$		225
e^+e^-	*S1*	$< 4.1 \times 10^{-11}$	CL=90%	249
$e^+e^-\gamma$	*S1*	$(9.1 \pm 0.5) \times 10^{-6}$		249
$e^+e^-\gamma\gamma$	*S1* [hh]	$(6.5 \pm 1.2) \times 10^{-7}$		249
$\pi^+\pi^-e^+e^-$	*S1* [hh]	$< 4.6 \times 10^{-7}$	CL=90%	206
$\mu^+\mu^-e^+e^-$	*S1*	$(2.9\ ^{+6.7}_{-2.4}) \times 10^{-9}$		225
$e^+e^-e^+e^-$	*S1*	$(4.1 \pm 0.8) \times 10^{-8}$	S=1.2	249
$\pi^0\mu^+\mu^-$	*CPΓS1* [ii]	$< 5.1 \times 10^{-9}$	CL=90%	177
$\pi^0e^+e^-$	*CPΓS1* [ii]	$< 4.3 \times 10^{-9}$	CL=90%	231
$\pi^0\nu\overline{\nu}$	*CPΓS1* [jj]	$< 5.8 \times 10^{-5}$	CL=90%	231
$e^\pm\mu^\mp$	*LF* [gg]	$< 3.3 \times 10^{-11}$	CL=90%	238
$e^\pm e^\pm\mu^\mp\mu^\mp$	*LF* [gg]	$< 6.1 \times 10^{-9}$	CL=90%	–

$K^*(892)$

$I(J^P) = \frac{1}{2}(1^-)$

$K^*(892)^\pm$ mass $m = 891.66 \pm 0.26$ MeV
$K^*(892)^0$ mass $m = 896.10 \pm 0.28$ MeV (S = 1.4)
$K^*(892)^\pm$ full width $\Gamma = 50.8 \pm 0.9$ MeV
$K^*(892)^0$ full width $\Gamma = 50.5 \pm 0.6$ MeV (S = 1.1)

$K^*(892)$ DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$K\pi$	$\sim 100\ \%$		291
$K^0\gamma$	$(2.30 \pm 0.20) \times 10^{-3}$		310
$K^\pm\gamma$	$(9.9 \pm 0.9) \times 10^{-4}$		309
$K\pi\pi$	$< 7 \times 10^{-4}$	95%	224

$K_1(1270)$

$I(J^P) = \frac{1}{2}(1^+)$

Mass $m = 1273 \pm 7$ MeV [m]
Full width $\Gamma = 90 \pm 20$ MeV [m]

$K_1(1270)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K\rho$	$(42 \pm 6)\ \%$	76
$K^*_0(1430)\pi$	$(28 \pm 4)\ \%$	–
$K^*(892)\pi$	$(16 \pm 5)\ \%$	301
$K\omega$	$(11.0 \pm 2.0)\ \%$	–
$K f_0(1370)$	$(3.0 \pm 2.0)\ \%$	–

$K_1(1400)$

$I(J^P) = \frac{1}{2}(1^+)$

Mass $m = 1402 \pm 7$ MeV
Full width $\Gamma = 174 \pm 13$ MeV (S = 1.6)

$K_1(1400)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K^*(892)\pi$	$(94 \pm 6)\ \%$	401
$K\rho$	$(3.0 \pm 3.0)\ \%$	298
$K f_0(1370)$	$(2.0 \pm 2.0)\ \%$	–
$K\omega$	$(1.0 \pm 1.0)\ \%$	285
$K^*_0(1430)\pi$	not seen	–

$K^*(1410)$

$I(J^P) = \frac{1}{2}(1^-)$

Mass $m = 1414 \pm 15$ MeV (S = 1.3)
Full width $\Gamma = 232 \pm 21$ MeV (S = 1.1)

$K^*(1410)$ DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$K^*(892)\pi$	$> 40\ \%$	95%	408
$K\pi$	$(6.6 \pm 1.3)\ \%$		611
$K\rho$	$< 7\ \%$	95%	309

$K^*_0(1430)$ [kk]

$I(J^P) = \frac{1}{2}(0^+)$

Mass $m = 1429 \pm 6$ MeV
Full width $\Gamma = 287 \pm 23$ MeV

$K^*_0(1430)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K\pi$	$(93 \pm 10)\ \%$	621

$K^*_2(1430)$

$I(J^P) = \frac{1}{2}(2^+)$

$K^*_2(1430)^\pm$ mass $m = 1425.6 \pm 1.5$ MeV (S = 1.1)
$K^*_2(1430)^0$ mass $m = 1432.4 \pm 1.3$ MeV
$K^*_2(1430)^\pm$ full width $\Gamma = 98.5 \pm 2.7$ MeV (S = 1.1)
$K^*_2(1430)^0$ full width $\Gamma = 109 \pm 5$ MeV (S = 1.9)

$K^*_2(1430)$ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
$K\pi$	$(49.9 \pm 1.2)\ \%$		622
$K^*(892)\pi$	$(24.7 \pm 1.5)\ \%$		423
$K^*(892)\pi\pi$	$(13.4 \pm 2.2)\ \%$		375
$K\rho$	$(8.7 \pm 0.8)\ \%$	S=1.2	331
$K\omega$	$(2.9 \pm 0.8)\ \%$		319
$K^+\gamma$	$(2.4 \pm 0.5) \times 10^{-3}$	S=1.1	627
$K\eta$	$(1.5\ ^{+3.4}_{-1.0}) \times 10^{-3}$	S=1.3	492
$K\omega\pi$	$< 7.2 \times 10^{-4}$	CL=95%	110
$K^0\gamma$	$< 9 \times 10^{-4}$	CL=90%	631

$K^*(1680)$ $\quad I(J^P) = \frac{1}{2}(1^-)$

Mass $m = 1717 \pm 27$ MeV (S = 1.4)
Full width $\Gamma = 322 \pm 110$ MeV (S = 4.2)

$K^*(1680)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K\pi$	(38.7 ± 2.5) %	779
$K\rho$	$(31.4^{+4.7}_{-2.1})$ %	571
$K^*(892)\pi$	$(29.9^{+2.2}_{-4.7})$ %	615

$K_2(1770)$ [ll] $\quad I(J^P) = \frac{1}{2}(2^-)$

Mass $m = 1773 \pm 8$ MeV
Full width $\Gamma = 186 \pm 14$ MeV

$K_2(1770)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K\pi\pi$		–
$K_2^*(1430)\pi$	dominant	287
$K^*(892)\pi$	seen	653
$K f_2(1270)$	seen	–
$K\phi$	seen	441
$K\omega$	seen	608

$K_3^*(1780)$ $\quad I(J^P) = \frac{1}{2}(3^-)$

Mass $m = 1776 \pm 7$ MeV (S = 1.1)
Full width $\Gamma = 159 \pm 21$ MeV (S = 1.3)

$K_3^*(1780)$ DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$K\rho$	(31 ± 9) %		612
$K^*(892)\pi$	(20 ± 5) %		651
$K\pi$	(18.8 ± 1.0) %		810
$K\eta$	(30 ± 13) %		715
$K_2^*(1430)\pi$	< 16 %	95%	284

$K_2(1820)$ [mm] $\quad I(J^P) = \frac{1}{2}(2^-)$

Mass $m = 1816 \pm 13$ MeV
Full width $\Gamma = 276 \pm 35$ MeV

$K_2(1820)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K_2^*(1430)\pi$	seen	325
$K^*(892)\pi$	seen	680
$K f_2(1270)$	seen	186
$K\omega$	seen	638

$K_4^*(2045)$ $\quad I(J^P) = \frac{1}{2}(4^+)$

Mass $m = 2045 \pm 9$ MeV (S = 1.1)
Full width $\Gamma = 198 \pm 30$ MeV

$K_4^*(2045)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K\pi$	(9.9 ± 1.2) %	958
$K^*(892)\pi\pi$	(9 ± 5) %	800
$K^*(892)\pi\pi\pi$	(7 ± 5) %	764
$\rho K\pi$	(5.7 ± 3.2) %	742
$\omega K\pi$	(5.0 ± 3.0) %	736
$\phi K\pi$	(2.8 ± 1.4) %	591
$\phi K^*(892)$	(1.4 ± 0.7) %	363

CHARMED MESONS
$(C = \pm1)$

$D^+ = c\overline{d}$Γ $D^0 = c\overline{u}$Γ $\overline{D}^0 = \overline{c}u$Γ $D^- = \overline{c}d$Γ similarly for D^*'s

$D^\pm$ $\quad I(J^P) = \frac{1}{2}(0^-)$

Mass $m = 1869.3 \pm 0.5$ MeV (S = 1.1)
Mean life $\tau = (1.057 \pm 0.015) \times 10^{-12}$ s
$c\tau = 317$ μm

CP-violation decay-rate asymmetries

$A_{CP}(K^+K^-\pi^\pm) = -0.017 \pm 0.027$
$A_{CP}(K^\pm K^{*0}) = -0.02 \pm 0.05$
$A_{CP}(\phi\pi^\pm) = -0.014 \pm 0.033$
$A_{CP}(\pi^+\pi^-\pi^\pm) = -0.02 \pm 0.04$

$D^+ \to \overline{K}^*(892)^0 \ell^+ \nu_\ell$ form factors

$r_2 = 0.72 \pm 0.09$
$r_V = 1.85 \pm 0.12$
$\Gamma_L/\Gamma_T = 1.23 \pm 0.13$
$\Gamma_+/\Gamma_- = 0.16 \pm 0.04$

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

D^+ DECAY MODES		Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
Inclusive modes				
e^+ anything		(17.2 ± 1.9) %		–
K^- anything		(24.2 ± 2.8) %	S=1.4	–
$\overline{K}^0$ anything + K^0 anything		(59 ± 7) %		–
K^+ anything		(5.8 ± 1.4) %		–
η anything	[nn]	< 13 %	CL=90%	–
Leptonic and semileptonic modes				
$\mu^+\nu_\mu$		$< 7.2 \times 10^{-4}$	CL=90%	932
$\overline{K}^0\ell^+\nu_\ell$	[oo]	(6.8 ± 0.8) %		868
$\overline{K}^0 e^+\nu_e$		(6.7 ± 0.9) %		868
$\overline{K}^0\mu^+\nu_\mu$		$(7.0 \ ^{+3.0}_{-2.0})$ %		865
$K^-\pi^+e^+\nu_e$		$(4.1 \ ^{+0.9}_{-0.7})$ %		863
$\overline{K}^*(892)^0 e^+\nu_e$ $\times$ B($\overline{K}^{*0} \to K^-\pi^+$)		(3.2 ± 0.33) %		720
$K^-\pi^+e^+\nu_e$ nonresonant		$< 7 \times 10^{-3}$	CL=90%	863
$K^-\pi^+\mu^+\nu_\mu$		(3.2 ± 0.4) %	S=1.1	851
$\overline{K}^*(892)^0\mu^+\nu_\mu$ $\times$ B($\overline{K}^{*0} \to K^-\pi^+$)		(2.9 ± 0.4) %		715
$K^-\pi^+\mu^+\nu_\mu$ nonresonant		$(2.7 \pm1.1) \times 10^{-3}$		851
$(\overline{K}^*(892)\pi)^0 e^+\nu_e$		< 1.2 %	CL=90%	714
$(\overline{K}\pi\pi)^0 e^+\nu_e$ non-$\overline{K}^*(892)$		$< 9 \times 10^{-3}$	CL=90%	846
$K^-\pi^+\pi^0\mu^+\nu_\mu$		$< 1.4 \times 10^{-3}$	CL=90%	825
$\pi^0\ell^+\nu_\ell$	[pp]	$(3.1 \pm1.5) \times 10^{-3}$		930
Fractions of some of the following modes with resonances have already appeared above as submodes of particular charged-particle modes.				
$\overline{K}^*(892)^0\ell^+\nu_\ell$	[oo]	(4.7 ± 0.4) %		720
$\overline{K}^*(892)^0 e^+\nu_e$		(4.8 ± 0.5) %		720
$\overline{K}^*(892)^0\mu^+\nu_\mu$		(4.4 ± 0.6) %	S=1.1	715
$\rho^0 e^+\nu_e$		$(2.2 \pm0.8) \times 10^{-3}$		776
$\rho^0\mu^+\nu_\mu$		$(2.7 \pm0.7) \times 10^{-3}$		772
$\phi e^+\nu_e$		< 2.09 %	CL=90%	657
$\phi\mu^+\nu_\mu$		< 3.72 %	CL=90%	651
$\eta\ell^+\nu_\ell$		$< 5 \times 10^{-3}$	CL=90%	–
$\eta'(958)\mu^+\nu_\mu$		$< 9 \times 10^{-3}$	CL=90%	684
Hadronic modes with a $\overline{K}$ or $\overline{K}K\overline{K}$				
$\overline{K}^0\pi^+$		(2.89 ± 0.26) %	S=1.1	862
$K^-\pi^+\pi^+$	[qq]	(9.0 ± 0.6) %		845
$\overline{K}^*(892)^0\pi^+$ $\times$ B($\overline{K}^{*0} \to K^-\pi^+$)		(1.27 ± 0.13) %		712
$\overline{K}_0^*(1430)^0\pi^+$ $\times$ B($\overline{K}_0^*(1430)^0 \to K^-\pi^+$)		(2.3 ± 0.3) %		368
$\overline{K}^*(1680)^0\pi^+$ $\times$ B($\overline{K}^*(1680)^0 \to K^-\pi^+$)		$(3.7 \pm0.8) \times 10^{-3}$		65
$K^-\pi^+\pi^+$ nonresonant		(8.5 ± 0.8) %		845
$\overline{K}^0\pi^+\pi^0$	[qq]	(9.7 ± 3.0) %	S=1.1	845

$\overline{K}^0 \rho^+$		(6.6 ± 2.5) %		680
$\overline{K}^*(892)^0 \pi^+$		$(6.3 \pm 0.4) \times 10^{-3}$		712
$\times$ B$(\overline{K}^{*0} \to \overline{K}^0 \pi^0)$				
$\overline{K}^0 \pi^+ \pi^0$ nonresonant		(1.3 ± 1.1) %		845
$K^- \pi^+ \pi^+ \pi^0$	[qq]	(6.4 ± 1.1) %		816
$\overline{K}^*(892)^0 \rho^+$ total		(1.4 ± 0.9) %		423
$\times$ B$(\overline{K}^{*0} \to K^- \pi^+)$				
$\overline{K}_1(1400)^0 \pi^+$		(2.2 ± 0.6) %		390
$\times$ B$(\overline{K}_1(1400)^0 \to K^- \pi^+ \pi^0)$				
$K^- \rho^+ \pi^+$ total		(3.1 ± 1.1) %		616
$K^- \rho^+ \pi^+$ 3-body		(1.1 ± 0.4) %		616
$\overline{K}^*(892)^0 \pi^+ \pi^0$ total		(4.5 ± 0.9) %		687
$\times$ B$(\overline{K}^{*0} \to K^- \pi^+)$				
$\overline{K}^*(892)^0 \pi^+ \pi^0$ 3-body		(2.8 ± 0.9) %		687
$\times$ B$(\overline{K}^{*0} \to K^- \pi^+)$				
$K^*(892)^- \pi^+ \pi^+$ 3-body		$(7 \pm 3) \times 10^{-3}$		688
$\times$ B$(K^{*-} \to K^- \pi^0)$				
$K^- \pi^+ \pi^+ \pi^0$ nonresonant	[rr]	(1.2 ± 0.6) %		816
$\overline{K}^0 \pi^+ \pi^+ \pi^-$	[qq]	(7.0 ± 0.9) %		814
$\overline{K}^0 a_1(1260)^+$		(4.0 ± 0.9) %		328
$\times$ B$(a_1(1260)^+ \to \pi^+ \pi^+ \pi^-)$				
$\overline{K}_1(1400)^0 \pi^+$		(2.2 ± 0.6) %		390
$\times$ B$(\overline{K}_1(1400)^0 \to \overline{K}^0 \pi^+ \pi^-)$				
$K^*(892)^- \pi^+ \pi^+$ 3-body		(1.4 ± 0.6) %		688
$\times$ B$(K^{*-} \to \overline{K}^0 \pi^-)$				
$\overline{K}^0 \rho^0 \pi^+$ total		(4.2 ± 0.9) %		614
$\overline{K}^0 \rho^0 \pi^+$ 3-body		$(5 \pm 5) \times 10^{-3}$		614
$\overline{K}^0 \pi^+ \pi^+ \pi^-$ nonresonant		$(8 \pm 4) \times 10^{-3}$		814
$K^- \pi^+ \pi^+ \pi^+ \pi^-$	[qq]	$(7.2 \pm 1.0) \times 10^{-3}$		772
$\overline{K}^*(892)^0 \pi^+ \pi^+ \pi^-$		$(5.4 \pm 2.3) \times 10^{-3}$		642
$\times$ B$(\overline{K}^{*0} \to K^- \pi^+)$				
$\overline{K}^*(892)^0 \rho^0 \pi^+$		$(1.9 ^{+1.1}_{-1.0}) \times 10^{-3}$		242
$\times$ B$(\overline{K}^{*0} \to K^- \pi^+)$				
$\overline{K}^*(892)^0 \pi^+ \pi^+ \pi^-$ no-ρ		$(2.9 \pm 1.1) \times 10^{-3}$		642
$\times$ B$(\overline{K}^{*0} \to K^- \pi^+)$				
$K^- \rho^0 \pi^+ \pi^+$		$(3.1 \pm 0.9) \times 10^{-3}$		529
$K^- \pi^+ \pi^+ \pi^+ \pi^-$ nonresonant		$< 2.3 \times 10^{-3}$	CL=90%	772
$K^- \pi^+ \pi^+ \pi^0 \pi^0$		$(2.2 ^{+5.0}_{-0.9})$ %		775
$\overline{K}^0 \pi^+ \pi^+ \pi^- \pi^0$		$(5.4 ^{+3.0}_{-1.4})$ %		773
$\overline{K}^0 \pi^+ \pi^+ \pi^+ \pi^- \pi^-$		$(8 \pm 7) \times 10^{-4}$		714
$K^- \pi^+ \pi^+ \pi^+ \pi^- \pi^0$		$(2.0 \pm 1.8) \times 10^{-3}$		718
$\overline{K}^0 \overline{K}^0 K^+$		(1.8 ± 0.8) %		545

Fractions of some of the following modes with resonances have already appeared above as submodes of particular charged-particle modes.

$\overline{K}^0 \rho^+$		(6.6 ± 2.5) %		680
$\overline{K}^0 a_1(1260)^+$		(8.0 ± 1.7) %		328
$\overline{K}^0 a_2(1320)^+$		$< 3 \times 10^{-3}$	CL=90%	199
$\overline{K}^*(892)^0 \pi^+$		(1.90 ± 0.19) %		712
$\overline{K}^*(892)^0 \rho^+$ total	[rr]	(2.1 ± 1.3) %		423
$\overline{K}^*(892)^0 \rho^+$ S-wave	[rr]	(1.6 ± 1.6) %		423
$\overline{K}^*(892)^0 \rho^+$ P-wave		$< 1 \times 10^{-3}$	CL=90%	423
$\overline{K}^*(892)^0 \rho^+$ D-wave		$(10 \pm 7) \times 10^{-3}$		423
$\overline{K}^*(892)^0 \rho^+$ D-wave longitudinal		$< 7 \times 10^{-3}$	CL=90%	423
$\overline{K}_1(1270)^0 \pi^+$		$< 7 \times 10^{-3}$	CL=90%	487
$\overline{K}_1(1400)^0 \pi^+$		(4.9 ± 1.2) %		390
$\overline{K}^*(1410)^0 \pi^+$		$< 7 \times 10^{-3}$	CL=90%	382
$\overline{K}_0^*(1430)^0 \pi^+$		(3.7 ± 0.4) %		368
$\overline{K}^*(1680)^0 \pi^+$		(1.43 ± 0.30) %		65
$\overline{K}^*(892)^0 \pi^+ \pi^0$ total		(6.7 ± 1.4) %		687
$\overline{K}^*(892)^0 \pi^+ \pi^0$ 3-body	[rr]	(4.2 ± 1.4) %		687
$K^*(892)^- \pi^+ \pi^+$ 3-body		(2.0 ± 0.9) %		688
$K^- \rho^+ \pi^+$ total		(3.1 ± 1.1) %		616
$K^- \rho^+ \pi^+$ 3-body		(1.1 ± 0.4) %		616
$\overline{K}^0 \rho^0 \pi^+$ total		(4.2 ± 0.9) %	CL=90%	614
$\overline{K}^0 \rho^0 \pi^+$ 3-body		$(5 \pm 5) \times 10^{-3}$		614
$\overline{K}^0 f_0(980) \pi^+$		$< 5 \times 10^{-3}$	CL=90%	461
$\overline{K}^*(892)^0 \pi^+ \pi^+ \pi^-$		$(8.1 \pm 3.4) \times 10^{-3}$	S=1.7	642
$\overline{K}^*(892)^0 \rho^0 \pi^+$		$(2.9 ^{+1.7}_{-1.5}) \times 10^{-3}$	S=1.8	242
$\overline{K}^*(892)^0 \pi^+ \pi^+ \pi^-$ no-ρ		$(4.3 \pm 1.7) \times 10^{-3}$		642
$K^- \rho^0 \pi^+ \pi^+$		$(3.1 \pm 0.9) \times 10^{-3}$		529

Pionic modes

$\pi^+ \pi^0$		$(2.5 \pm 0.7) \times 10^{-3}$		925
$\pi^+ \pi^+ \pi^-$		$(3.6 \pm 0.4) \times 10^{-3}$		908
$\rho^0 \pi^+$		$(1.05 \pm 0.31) \times 10^{-3}$		769
$\pi^+ \pi^+ \pi^-$ nonresonant		$(2.2 \pm 0.4) \times 10^{-3}$		908
$\pi^+ \pi^+ \pi^- \pi^0$		$(1.9 ^{+1.5}_{-1.2})$ %		882
$\eta \pi^+ \times$ B$(\eta \to \pi^+ \pi^- \pi^0)$		$(1.7 \pm 0.6) \times 10^{-3}$		848
$\omega \pi^+ \times$ B$(\omega \to \pi^+ \pi^- \pi^0)$		$< 6 \times 10^{-3}$	CL=90%	764
$\pi^+ \pi^+ \pi^+ \pi^- \pi^-$		$(2.1 \pm 0.4) \times 10^{-3}$		845
$\pi^+ \pi^+ \pi^+ \pi^- \pi^- \pi^0$		$(2.9 ^{+2.9}_{-2.0}) \times 10^{-3}$		799

Fractions of some of the following modes with resonances have already appeared above as submodes of particular charged-particle modes.

$\eta \pi^+$		$(7.5 \pm 2.5) \times 10^{-3}$		848
$\rho^0 \pi^+$		$(1.05 \pm 0.31) \times 10^{-3}$		769
$\omega \pi^+$		$< 7 \times 10^{-3}$	CL=90%	764
$\eta \rho^+$		< 1.2 %	CL=90%	658
$\eta'(958) \pi^+$		$< 9 \times 10^{-3}$	CL=90%	680
$\eta'(958) \rho^+$		< 1.5 %	CL=90%	355

Hadronic modes with a $K\overline{K}$ pair

$K^+ \overline{K}^0$		$(7.4 \pm 1.0) \times 10^{-3}$		792
$K^+ K^- \pi^+$	[qq]	$(8.8 \pm 0.8) \times 10^{-3}$		744
$\phi \pi^+ \times$ B$(\phi \to K^+ K^-)$		$(3.0 \pm 0.3) \times 10^{-3}$		647
$K^+ \overline{K}^*(892)^0$		$(2.8 \pm 0.4) \times 10^{-3}$		610
$\times$ B$(\overline{K}^{*0} \to K^- \pi^+)$				
$K^+ K^- \pi^+$ nonresonant		$(4.5 \pm 0.9) \times 10^{-3}$		744
$K^0 \overline{K}^0 \pi^+$		—		741
$K^*(892)^+ \overline{K}^0$		(2.1 ± 1.0) %		611
$\times$ B$(K^{*+} \to K^0 \pi^+)$				
$K^+ K^- \pi^+ \pi^0$		—		682
$\phi \pi^+ \pi^0 \times$ B$(\phi \to K^+ K^-)$		(1.1 ± 0.5) %		619
$\phi \rho^+ \times$ B$(\phi \to K^+ K^-)$		$< 7 \times 10^{-3}$	CL=90%	268
$K^+ K^- \pi^+ \pi^0$ non-ϕ		$(1.5 ^{+0.7}_{-0.6})$ %		682
$K^+ \overline{K}^0 \pi^+ \pi^-$		< 2 %	CL=90%	678
$K^0 K^- \pi^+ \pi^+$		(1.0 ± 0.6) %		678
$K^*(892)^+ \overline{K}^*(892)^0$		(1.2 ± 0.5) %		273
$\times$ B$^2(K^{*+} \to K^0 \pi^+)$				
$K^0 K^- \pi^+ \pi^+$ non-$K^{*+} \overline{K}^{*0}$		$< 7.9 \times 10^{-3}$	CL=90%	678
$K^+ K^- \pi^+ \pi^+ \pi^-$		—		600
$\phi \pi^+ \pi^+ \pi^-$		$< 1 \times 10^{-3}$	CL=90%	565
$\times$ B$(\phi \to K^+ K^-)$				
$K^+ K^- \pi^+ \pi^+ \pi^-$ nonresonant		< 3 %	CL=90%	600

Fractions of the following modes with resonances have already appeared above as submodes of particular charged-particle modes.

$\phi \pi^+$		$(6.1 \pm 0.6) \times 10^{-3}$		647
$\phi \pi^+ \pi^0$		(2.3 ± 1.0) %		619
$\phi \rho^+$		< 1.4 %	CL=90%	268
$\phi \pi^+ \pi^+ \pi^-$		$< 2 \times 10^{-3}$	CL=90%	565
$K^+ \overline{K}^*(892)^0$		$(4.2 \pm 0.5) \times 10^{-3}$		610
$K^*(892)^+ \overline{K}^0$		(3.2 ± 1.5) %		611
$K^*(892)^+ \overline{K}^*(892)^0$		(2.6 ± 1.1) %		273

Doubly Cabibbo suppressed (*DC*) modes,
$\Delta C = 1$ weak neutral current (*C1*) modes, or
Lepton Family number (*LF*) or Lepton number (*L*) violating modes

$K^+ \pi^+ \pi^-$	DC		$(6.8 \pm 1.5) \times 10^{-4}$		845
$K^+ \rho^0$	DC		$(2.5 \pm 1.2) \times 10^{-4}$		681
$K^*(892)^0 \pi^+$	DC		$(3.6 \pm 1.6) \times 10^{-4}$		712
$K^+ \pi^+ \pi^-$ nonresonant	DC		$(2.4 \pm 1.2) \times 10^{-4}$		845
$K^+ K^+ K^-$	DC		$< 1.4 \times 10^{-4}$	CL=90%	550
ϕK^+	DC		$< 1.3 \times 10^{-4}$	CL=90%	527
$\pi^+ e^+ e^-$	C1		$< 6.6 \times 10^{-5}$	CL=90%	929
$\pi^+ \mu^+ \mu^-$	C1		$< 1.8 \times 10^{-5}$	CL=90%	917
$\rho^+ \mu^+ \mu^-$	C1		$< 5.6 \times 10^{-4}$	CL=90%	759
$K^+ e^+ e^-$		[ss]	$< 2.0 \times 10^{-4}$	CL=90%	869
$K^+ \mu^+ \mu^-$		[ss]	$< 9.7 \times 10^{-5}$	CL=90%	856
$\pi^+ e^+ \mu^-$	LF		$< 1.1 \times 10^{-4}$	CL=90%	926
$\pi^+ e^- \mu^+$	LF		$< 1.3 \times 10^{-4}$	CL=90%	926
$K^+ e^+ \mu^-$	LF		$< 1.3 \times 10^{-4}$	CL=90%	866

$K^+ e^- \mu^+$	LF	< 1.2 × 10^{-4}	CL=90%	866
$\pi^- e^+ e^+$	L	< 1.1 × 10^{-4}	CL=90%	929
$\pi^- \mu^+ \mu^+$	L	< 8.7 × 10^{-5}	CL=90%	917
$\pi^- e^+ \mu^+$	L	< 1.1 × 10^{-4}	CL=90%	926
$\rho^- \mu^+ \mu^+$	L	< 5.6 × 10^{-4}	CL=90%	759
$K^- e^+ e^+$	L	< 1.2 × 10^{-4}	CL=90%	869
$K^- \mu^+ \mu^+$	L	< 1.2 × 10^{-4}	CL=90%	856
$K^- e^+ \mu^+$	L	< 1.3 × 10^{-4}	CL=90%	866
$K^*(892)^- \mu^+ \mu^+$	L	< 8.5 × 10^{-4}	CL=90%	703

D^0

$I(J^P) = \frac{1}{2}(0^-)$

Mass $m = 1864.6 \pm 0.5$ MeV (S = 1.1)

$m_{D^\pm} - m_{D^0} = 4.76 \pm 0.10$ MeV (S = 1.1)

Mean life $\tau = (0.415 \pm 0.004) \times 10^{-12}$ s

$c\tau = 124.4\ \mu$m

$\left|m_{D_1^0} - m_{D_2^0}\right| < 24 \times 10^{10}\ \hbar\ s^{-1} \Gamma CL = 90\%$ [tt]

$\left|\Gamma_{D_1^0} - \Gamma_{D_2^0}\right| / \Gamma_{D^0} < 0.20 \Gamma CL = 90\%$ [tt]

$\Gamma(K^+ \ell^- \overline{\nu}_\ell \text{ (via } \overline{D}^0)) / \Gamma(K^- \ell^+ \nu_\ell) < 0.005 \Gamma CL = 90\%$

$\frac{\Gamma(K^+\pi^- \text{ or } K^+\pi^-\pi^+\pi^- \text{(via} \overline{D}^0))}{\Gamma(K^-\pi^+ \text{ or } K^-\pi^+\pi^+\pi^-)} < 0.0085 \text{ (or } < 0.0037) \Gamma CL = 90\%$ [uu]

CP-violation decay-rate asymmetries

$A_{CP}(K^+ K^-) = 0.026 \pm 0.035$

$A_{CP}(\pi^+ \pi^-) = -0.05 \pm 0.08$

$A_{CP}(K_S^0 \phi) = -0.03 \pm 0.09$

$A_{CP}(K_S^0 \pi^0) = -0.018 \pm 0.030$

$\overline{D}^0$ modes are charge conjugates of the modes below.

D^0 DECAY MODES		Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
Inclusive modes				
e^+ anything		(6.75±0.29) %		–
μ^+ anything		(6.6 ±0.8) %		–
K^- anything		(53 ±4) %	S=1.3	–
$\overline{K}^0$ anything + K^0 anything		(42 ±5) %		–
K^+ anything		(3.4 $^{+0.6}_{-0.4}$) %		–
η anything	[nn]	< 13 %	CL=90%	–
Semileptonic modes				
$K^- \ell^+ \nu_\ell$	[oo]	(3.50±0.17) %	S=1.3	867
$K^- e^+ \nu_e$		(3.66±0.18) %		867
$K^- \mu^+ \nu_\mu$		(3.23±0.17) %		863
$K^- \pi^0 e^+ \nu_e$		(1.6 $^{+1.3}_{-0.5}$) %		861
$\overline{K}^0 \pi^- e^+ \nu_e$		(2.8 $^{+1.7}_{-0.9}$) %		860
$\overline{K}^*(892)^- e^+ \nu_e$		(1.35±0.22) %		719
× B($K^{*-} \to \overline{K}^0 \pi^-$)				
$K^*(892)^- \ell^+ \nu_\ell$		—		–
$\overline{K}^*(892)^0 \pi^- e^+ \nu_e$		—		708
$K^- \pi^+ \pi^- \mu^+ \nu_\mu$		< 1.2 × 10^{-3}	CL=90%	821
$(\overline{K}^*(892)\pi)^- \mu^+ \nu_\mu$		< 1.4 × 10^{-3}	CL=90%	693
$\pi^- e^+ \nu_e$		(3.7 ±0.6) × 10^{-3}		927

A fraction of the following resonance mode has already appeared above as a submode of a charged-particle mode.

$K^*(892)^- e^+ \nu_e$		(2.02±0.33) %		719
Hadronic modes with a $\overline{K}$ or $\overline{K}K\overline{K}$				
$K^- \pi^+$		(3.85±0.09) %		861
$\overline{K}^0 \pi^0$		(2.12±0.21) %	S=1.1	860
$\overline{K}^0 \pi^+ \pi^-$	[qq]	(5.4 ±0.4) %	S=1.2	842
$\overline{K}^0 \rho^0$		(1.21±0.17) %		676
$\overline{K}^0 f_0(980)$		(3.0 ±0.8) × 10^{-3}		549
× B($f_0 \to \pi^+ \pi^-$)				
$\overline{K}^0 f_2(1270)$		(2.4 ±0.9) × 10^{-3}		263
× B($f_2 \to \pi^+ \pi^-$)				
$\overline{K}^0 f_0(1370)$		(4.3 ±1.3) × 10^{-3}		–
× B($f_0 \to \pi^+ \pi^-$)				
$K^*(892)^- \pi^+$		(3.4 ±0.3) %		711
× B($K^{*-} \to \overline{K}^0 \pi^-$)				
$K_0^*(1430)^- \pi^+$		(6.4 ±1.6) × 10^{-3}		364
× B($K_0^*(1430)^- \to \overline{K}^0 \pi^-$)				
$\overline{K}^0 \pi^+ \pi^-$ nonresonant		(1.47±0.24) %		842
$K^- \pi^+ \pi^0$	[qq]	(13.9 ±0.9) %	S=1.3	844
$K^- \rho^+$		(10.8 ±1.0) %		678
$K^*(892)^- \pi^+$		(1.7 ±0.2) %		711
× B($K^{*-} \to K^- \pi^0$)				
$\overline{K}^*(892)^0 \pi^0$		(2.1 ±0.3) %		709
× B($\overline{K}^{*0} \to K^- \pi^+$)				
$K^- \pi^+ \pi^0$ nonresonant		(6.9 ±2.5) × 10^{-3}		844
$\overline{K}^0 \pi^0 \pi^0$		—		843
$\overline{K}^*(892)^0 \pi^0$		(1.1 ±0.2) %		709
× B($\overline{K}^{*0} \to \overline{K}^0 \pi^0$)				
$\overline{K}^0 \pi^0 \pi^0$ nonresonant		(7.9 ±2.1) × 10^{-3}		843
$K^- \pi^+ \pi^+ \pi^-$	[qq]	(7.6 ±0.4) %	S=1.1	812
$K^- \pi^+ \rho^0$ total		(6.3 ±0.4) %		612
$K^- \pi^+ \rho^0$ 3-body		(4.8 ±2.1) × 10^{-3}		612
$\overline{K}^*(892)^0 \rho^0$		(9.8 ±2.2) × 10^{-3}		418
× B($\overline{K}^{*0} \to K^- \pi^+$)				
$K^- a_1(1260)^+$		(3.6 ±0.6) %		327
× B($a_1(1260)^+ \to \pi^+ \pi^+ \pi^-$)				
$\overline{K}^*(892)^0 \pi^+ \pi^-$ total		(1.5 ±0.4) %		683
× B($\overline{K}^{*0} \to K^- \pi^+$)				
$\overline{K}^*(892)^0 \pi^+ \pi^-$ 3-body		(9.5 ±2.1) × 10^{-3}		683
× B($\overline{K}^{*0} \to K^- \pi^+$)				
$K_1(1270)^- \pi^+$	[rr]	(3.6 ±1.0) × 10^{-3}		483
× B($K_1(1270)^- \to K^- \pi^+ \pi^-$)				
$K^- \pi^+ \pi^+ \pi^-$ nonresonant		(1.76±0.25) %		812
$\overline{K}^0 \pi^+ \pi^- \pi^0$	[qq]	(10.0 ±1.2) %		812
$\overline{K}^0 \eta$ × B($\eta \to \pi^+ \pi^- \pi^0$)		(1.6 ±0.3) × 10^{-3}		772
$\overline{K}^0 \omega$ × B($\omega \to \pi^+ \pi^- \pi^0$)		(1.9 ±0.4) %		670
$K^*(892)^- \rho^+$		(4.1 ±1.6) %		422
× B($K^{*-} \to \overline{K}^0 \pi^-$)				
$\overline{K}^*(892)^0 \rho^0$		(4.9 ±1.1) × 10^{-3}		418
× B($\overline{K}^{*0} \to \overline{K}^0 \pi^0$)				
$K_1(1270)^- \pi^+$	[rr]	(5.1 ±1.4) × 10^{-3}		483
× B($K_1(1270)^- \to \overline{K}^0 \pi^- \pi^0$)				
$\overline{K}^*(892)^0 \pi^+ \pi^-$ 3-body		(4.8 ±1.1) × 10^{-3}		683
× B($\overline{K}^{*0} \to \overline{K}^0 \pi^0$)				
$\overline{K}^0 \pi^+ \pi^- \pi^0$ nonresonant		(2.1 ±2.1) %		812
$K^- \pi^+ \pi^0 \pi^0$		(15 ±5) %		815
$K^- \pi^+ \pi^+ \pi^- \pi^0$		(4.1 ±0.4) %		771
$\overline{K}^*(892)^0 \pi^+ \pi^- \pi^0$		(1.2 ±0.6) %		641
× B($\overline{K}^{*0} \to K^- \pi^+$)				
$\overline{K}^*(892)^0 \eta$		(2.9 ±0.8) × 10^{-3}		580
× B($\overline{K}^{*0} \to K^- \pi^+$)				
× B($\eta \to \pi^+ \pi^- \pi^0$)				
$K^- \pi^+ \omega$ × B($\omega \to \pi^+ \pi^- \pi^0$)		(2.7 ±0.5) %		605
$\overline{K}^*(892)^0 \omega$		(7 ±3) × 10^{-3}		406
× B($\overline{K}^{*0} \to K^- \pi^+$)				
× B($\omega \to \pi^+ \pi^- \pi^0$)				
$\overline{K}^0 \pi^+ \pi^+ \pi^- \pi^-$		(5.8 ±1.6) × 10^{-3}		768
$\overline{K}^0 \pi^+ \pi^- \pi^0 \pi^0 (\pi^0)$		(10.6 $^{+7.3}_{-3.0}$) %		771
$\overline{K}^0 K^+ K^-$		(9.4 ±1.0) × 10^{-3}		544
$\overline{K}^0 \phi$ × B($\phi \to K^+ K^-$)		(4.3 ±0.5) × 10^{-3}		520
$\overline{K}^0 K^+ K^-$ non-ϕ		(5.1 ±0.8) × 10^{-3}		544
$K_S^0 K_S^0 K_S^0$		(8.4 ±1.5) × 10^{-4}		538
$K^+ K^- K^- \pi^+$		(2.1 ±0.5) × 10^{-4}		434
$K^+ K^- \overline{K}^0 \pi^0$		(7.2 $^{+4.8}_{-3.5}$) × 10^{-3}		435

Fractions of many of the following modes with resonances have already appeared above as submodes of particular charged-particle modes. (Modes for which there are only upper limits and $\overline{K}^*(892)\rho$ submodes only appear below.)

$\overline{K}^0 \eta$		(7.1 ±1.0) × 10^{-3}		772
$\overline{K}^0 \rho^0$		(1.21±0.17) %		676
$K^- \rho^+$		(10.8 ±1.0) %	S=1.2	678
$\overline{K}^0 \omega$		(2.1 ±0.4) %		670
$\overline{K}^0 \eta'(958)$		(1.72±0.26) %		565
$\overline{K}^0 f_0(980)$		(5.7 ±1.6) × 10^{-3}		549
$\overline{K}^0 \phi$		(8.6 ±1.0) × 10^{-3}		520
$K^- a_1(1260)^+$		(7.3 ±1.1) %		327
$\overline{K}^0 a_1(1260)^0$		< 1.9 %	CL=90%	322
$\overline{K}^0 f_2(1270)$		(4.2 ±1.5) × 10^{-3}		263
$K^- a_2(1320)^+$		< 2 × 10^{-3}	CL=90%	197
$\overline{K}^0 f_0(1370)$		(7.0 ±2.1) × 10^{-3}		–
$K^*(892)^- \pi^+$		(5.1 ±0.4) %	S=1.2	711
$\overline{K}^*(892)^0 \pi^0$		(3.2 ±0.4) %		709
$\overline{K}^*(892)^0 \pi^+ \pi^-$ total		(2.3 ±0.5) %		683
$\overline{K}^*(892)^0 \pi^+ \pi^-$ 3-body		(1.43±0.32) %		683

Mode		Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
$K^-\pi^+\rho^0$ total		$(6.3\ \pm0.4)\ \%$		612
$K^-\pi^+\rho^0$ 3-body		$(4.8\ \pm2.1)\times10^{-3}$		612
$\overline{K}^*(892)^0\rho^0$		$(1.47\pm0.33)\ \%$		418
$\overline{K}^*(892)^0\rho^0$ transverse		$(1.5\ \pm0.5)\ \%$		418
$\overline{K}^*(892)^0\rho^0$ S-wave		$(2.8\ \pm0.6)\ \%$		418
$\overline{K}^*(892)^0\rho^0$ S-wave long.		$<3\ \times10^{-3}$	CL=90%	418
$\overline{K}^*(892)^0\rho^0$ P-wave		$<3\ \times10^{-3}$	CL=90%	418
$\overline{K}^*(892)^0\rho^0$ D-wave		$(1.9\ \pm0.6)\ \%$		418
$K^*(892)^-\rho^+$		$(6.1\ \pm2.4)\ \%$		422
$K^*(892)^-\rho^+$ longitudinal		$(2.9\ \pm1.2)\ \%$		422
$K^*(892)^-\rho^+$ transverse		$(3.2\ \pm1.8)\ \%$		422
$K^*(892)^-\rho^+$ P-wave		$<1.5\ \%$	CL=90%	422
$K^-\pi^+f_0(980)$		$<1.1\ \%$	CL=90%	459
$\overline{K}^*(892)^0 f_0(980)$		$<7\ \times10^{-3}$	CL=90%	–
$K_1(1270)^-\pi^+$	[rr]	$(1.06\pm0.29)\ \%$		483
$K_1(1400)^-\pi^+$		$<1.2\ \%$	CL=90%	386
$\overline{K}_1(1400)^0\pi^0$		$<3.7\ \%$	CL=90%	387
$K^*(1410)^-\pi^+$		$<1.2\ \%$	CL=90%	378
$K_0^*(1430)^-\pi^+$		$(1.04\pm0.26)\ \%$		364
$K_2^*(1430)^-\pi^+$		$<8\ \times10^{-3}$	CL=90%	367
$\overline{K}_2^*(1430)^0\pi^0$		$<4\ \times10^{-3}$	CL=90%	363
$\overline{K}^*(892)^0\pi^+\pi^-\pi^0$		$(1.8\ \pm0.9)\ \%$		641
$\overline{K}^*(892)^0\eta$		$(1.9\ \pm0.5)\ \%$		580
$K^-\pi^+\omega$		$(3.0\ \pm0.6)\ \%$		605
$\overline{K}^*(892)^0\omega$		$(1.1\ \pm0.5)\ \%$		406
$K^-\pi^+\eta'(958)$		$(7.0\ \pm1.8)\times10^{-3}$		479
$\overline{K}^*(892)^0\eta'(958)$		$<1.1\ \times10^{-3}$	CL=90%	99
Pionic modes				
$\pi^+\pi^-$		$(1.53\pm0.09)\times10^{-3}$		922
$\pi^0\pi^0$		$(8.5\ \pm2.2)\times10^{-4}$		922
$\pi^+\pi^-\pi^0$		$(1.6\ \pm1.1)\ \%$	S=2.7	907
$\pi^+\pi^+\pi^-\pi^-$		$(7.4\ \pm0.6)\times10^{-3}$		879
$\pi^+\pi^+\pi^-\pi^-\pi^0$		$(1.9\ \pm0.4)\ \%$		844
$\pi^+\pi^+\pi^+\pi^-\pi^-\pi^-$		$(4.0\ \pm3.0)\times10^{-4}$		795
Hadronic modes with a $K\overline{K}$ pair				
K^+K^-		$(4.27\pm0.16)\times10^{-3}$		791
$K^0\overline{K}^0$		$(6.5\ \pm1.8)\times10^{-4}$	S=1.2	788
$K^0K^-\pi^+$		$(6.4\ \pm1.0)\times10^{-3}$	S=1.1	739
$\overline{K}^*(892)^0K^0$ $\times$ B($\overline{K}^{*0}\to K^-\pi^+$)		$<1.1\ \times10^{-3}$	CL=90%	605
$K^*(892)^+K^-$ $\times$ B($K^{*+}\to K^0\pi^+$)		$(2.3\ \pm0.5)\times10^{-3}$		610
$K^0K^-\pi^+$ nonresonant		$(2.3\ \pm2.3)\times10^{-3}$		739
$\overline{K}^0K^+\pi^-$		$(5.0\ \pm1.0)\times10^{-3}$		739
$K^*(892)^0\overline{K}^0$ $\times$ B($K^{*0}\to K^+\pi^-$)		$<5\ \times10^{-4}$	CL=90%	605
$K^*(892)^-K^+$ $\times$ B($K^{*-}\to\overline{K}^0\pi^-$)		$(1.2\ \pm0.7)\times10^{-3}$		610
$\overline{K}^0K^+\pi^-$ nonresonant		$(3.9\ ^{+2.3}_{-1.9})\times10^{-3}$		739
$K^+K^-\pi^0$		$(1.3\ \pm0.4)\times10^{-3}$		742
$K_S^0K_S^0\pi^0$		$<5.9\ \times10^{-4}$		739
$K^+K^-\pi^+\pi^-$	[w]	$(2.52\pm0.24)\times10^{-3}$		676
$\phi\pi^+\pi^-$ $\times$ B($\phi\to K^+K^-$)		$(5.3\ \pm1.4)\times10^{-4}$		614
$\phi\rho^0$ $\times$ B($\phi\to K^+K^-$)		$(3.0\ \pm1.6)\times10^{-4}$		260
$K^+K^-\rho^0$ 3-body		$(9.1\ \pm2.3)\times10^{-4}$		309
$K^*(892)^0K^-\pi^+$+c.c. $\times$ B($K^{*0}\to K^+\pi^-$)	[ww]	$<5\ \times10^{-4}$		528
$K^*(892)^0\overline{K}^*(892)^0$ $\times$ B^2($K^{*0}\to K^+\pi^-$)		$(6\ \pm2)\times10^{-4}$		257
$K^+K^-\pi^+\pi^-$ non-ϕ		—		676
$K^+K^-\pi^+\pi^-$ nonresonant		$<8\ \times10^{-4}$	CL=90%	676
$K^0\overline{K}^0\pi^+\pi^-$		$(6.9\ \pm2.7)\times10^{-3}$		673
$K^+K^-\pi^+\pi^-\pi^0$		$(3.1\ \pm2.0)\times10^{-3}$		600

Fractions of most of the following modes with resonances have already appeared above as submodes of particular charged-particle modes.

Mode		Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
$\overline{K}^*(892)^0K^0$		$<1.6\ \times10^{-3}$	CL=90%	605
$K^*(892)^+K^-$		$(3.5\ \pm0.8)\times10^{-3}$		610
$K^*(892)^0\overline{K}^0$		$<8\ \times10^{-4}$	CL=90%	605
$K^*(892)^-K^+$		$(1.8\ \pm1.0)\times10^{-3}$		610
$\phi\pi^0$		$<1.4\ \times10^{-3}$	CL=90%	644
$\phi\eta$		$<2.8\ \times10^{-3}$	CL=90%	489
$\phi\omega$		$<2.1\ \times10^{-3}$	CL=90%	239
$\phi\pi^+\pi^-$		$(1.08\pm0.29)\times10^{-3}$		614
$\phi\rho^0$		$(6\ \pm3)\times10^{-4}$		260
$\phi\pi^+\pi^-$ 3-body		$(7\ \pm5)\times10^{-4}$		614
$K^*(892)^0K^-\pi^+$ + c.c.	[ww]	$<8\ \times10^{-4}$	CL=90%	–
$K^*(892)^0\overline{K}^*(892)^0$		$(1.4\ \pm0.5)\times10^{-3}$		257

Doubly Cabibbo suppressed (DC) modes,
$\Delta C = 2$ forbidden via mixing ($C2M$) modes,
$\Delta C = 1$ weak neutral current ($C1$) modes, or
Lepton Family number (LF) violating modes

Mode			Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
$K^+\ell^-\overline{\nu}_\ell$ (via $\overline{D}^0$)	$C2M$		$<1.7\ \times10^{-4}$	CL=90%	–
$K^+\pi^-$ or $K^+\pi^-\pi^+\pi^-$ (via $\overline{D}^0$)	$C2M$		$<1.0\ \times10^{-3}$	CL=90%	–
$K^+\pi^-$	DC		$(2.8\ \pm0.9)\times10^{-4}$		861
$K^+\pi^-$ (via $\overline{D}^0$)			$<1.9\ \times10^{-4}$	CL=90%	861
$K^+\pi^-\pi^+\pi^-$	DC		$(1.9\ \pm2.7)\times10^{-4}$		812
$K^+\pi^-\pi^+\pi^-$ (via $\overline{D}^0$)			$<4\ \times10^{-4}$	CL=90%	812
μ^- anything (via $\overline{D}^0$)			$<4\ \times10^{-4}$	CL=90%	–
e^+e^-	$C1$		$<1.3\ \times10^{-5}$	CL=90%	932
$\mu^+\mu^-$	$C1$		$<4.1\ \times10^{-6}$	CL=90%	926
$\pi^0e^+e^-$	$C1$		$<4.5\ \times10^{-5}$	CL=90%	927
$\pi^0\mu^+\mu^-$	$C1$		$<1.8\ \times10^{-4}$	CL=90%	915
ηe^+e^-	$C1$		$<1.1\ \times10^{-4}$	CL=90%	852
$\eta\mu^+\mu^-$	$C1$		$<5.3\ \times10^{-4}$	CL=90%	838
$\rho^0e^+e^-$	$C1$		$<1.0\ \times10^{-4}$	CL=90%	773
$\rho^0\mu^+\mu^-$	$C1$		$<2.3\ \times10^{-4}$	CL=90%	756
ωe^+e^-	$C1$		$<1.8\ \times10^{-4}$	CL=90%	768
$\omega\mu^+\mu^-$	$C1$		$<8.3\ \times10^{-4}$	CL=90%	751
ϕe^+e^-	$C1$		$<5.2\ \times10^{-5}$	CL=90%	654
$\phi\mu^+\mu^-$	$C1$		$<4.1\ \times10^{-4}$	CL=90%	631
$\overline{K}^0e^+e^-$		[ss]	$<1.1\ \times10^{-4}$	CL=90%	866
$\overline{K}^0\mu^+\mu^-$		[ss]	$<2.6\ \times10^{-4}$	CL=90%	852
$\overline{K}^*(892)^0e^+e^-$		[ss]	$<1.4\ \times10^{-4}$	CL=90%	717
$\overline{K}^*(892)^0\mu^+\mu^-$		[ss]	$<1.18\ \times10^{-3}$	CL=90%	698
$\pi^+\pi^-\pi^0\mu^+\mu^-$	$C1$		$<8.1\ \times10^{-4}$	CL=90%	863
$\mu^\pm e^\mp$	LF	[gg]	$<1.9\ \times10^{-5}$	CL=90%	929
$\pi^0e^\pm\mu^\mp$	LF	[gg]	$<8.6\ \times10^{-5}$	CL=90%	924
$\eta e^\pm\mu^\mp$	LF	[gg]	$<1.0\ \times10^{-4}$	CL=90%	848
$\rho^0e^\pm\mu^\mp$	LF	[gg]	$<4.9\ \times10^{-5}$	CL=90%	769
$\omega e^\pm\mu^\mp$	LF	[gg]	$<1.2\ \times10^{-4}$	CL=90%	764
$\phi e^\pm\mu^\mp$	LF	[gg]	$<3.4\ \times10^{-5}$	CL=90%	648
$\overline{K}^0e^\pm\mu^\mp$	LF	[gg]	$<1.0\ \times10^{-4}$	CL=90%	862
$\overline{K}^*(892)^0e^\pm\mu^\mp$	LF	[gg]	$<1.0\ \times10^{-4}$	CL=90%	712

$D^*(2007)^0$

$I(J^P) = \frac{1}{2}(1^-)$
I, J, P need confirmation.

Mass $m = 2006.7 \pm 0.5$ MeV (S = 1.1)
$m_{D^{*0}} - m_{D^0} = 142.12 \pm 0.07$ MeV
Full width $\Gamma < 2.1$ MeV, CL = 90%

$\overline{D}^*(2007)^0$ modes are charge conjugates of modes below.

$D^*(2007)^0$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$D^0\pi^0$	$(61.9\pm2.9)\ \%$	43
$D^0\gamma$	$(38.1\pm2.9)\ \%$	137

$D^*(2010)^\pm$

$I(J^P) = \frac{1}{2}(1^-)$
I, J, P need confirmation.

Mass $m = 2010.0 \pm 0.5$ MeV (S = 1.1)
$m_{D^*(2010)^-} - m_{D^-} = 140.64 \pm 0.10$ MeV (S = 1.1)
$m_{D^*(2010)^-} - m_{D^0} = 145.397 \pm 0.030$ MeV
Full width $\Gamma < 0.131$ MeV, CL = 90%

$D^*(2010)^-$ modes are charge conjugates of the modes below.

$D^*(2010)^\pm$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$D^0\pi^+$	$(68.3\pm1.4)\ \%$	39
$D^+\pi^0$	$(30.6\pm2.5)\ \%$	38
$D^+\gamma$	$(1.1^{+2.1}_{-0.7})\ \%$	136

$D_1(2420)^0$

$I(J^P) = \frac{1}{2}(1^+)$
I, J, P need confirmation.

Mass $m = 2422.2 \pm 1.8$ MeV (S = 1.2)
Full width $\Gamma = 18.9^{+4.6}_{-3.5}$ MeV

$\overline{D}_1(2420)^0$ modes are charge conjugates of modes below.

$D_1(2420)^0$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$D^*(2010)^+\pi^-$	seen	355
$D^+\pi^-$	not seen	474

$D_2^*(2460)^0$

$I(J^P) = \frac{1}{2}(2^+)$

$J^P = 2^+$ assignment strongly favored (ALBRECHT 89B).
Mass $m = 2458.9 \pm 2.0$ MeV (S = 1.2)
Full width $\Gamma = 23 \pm 5$ MeV

$\overline{D}_2^*(2460)^0$ modes are charge conjugates of modes below.

$D_2^*(2460)^0$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$D^+\pi^-$	seen	503
$D^*(2010)^+\pi^-$	seen	387

$D_2^*(2460)^\pm$

$I(J^P) = \frac{1}{2}(2^+)$

$J^P = 2^+$ assignment strongly favored (ALBRECHT 89B).
Mass $m = 2459 \pm 4$ MeV (S = 1.7)
$m_{D_2^*(2460)^\pm} - m_{D_2^*(2460)^0} = 0.9 \pm 3.3$ MeV (S = 1.1)
Full width $\Gamma = 25^{+8}_{-7}$ MeV

$D_2^*(2460)^-$ modes are charge conjugates of modes below.

$D_2^*(2460)^\pm$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$D^0\pi^+$	seen	508
$D^{*0}\pi^+$	seen	390

CHARMED, STRANGE MESONS
($C = S = \pm1$)

$D_s^+ = c\overline{s}$, $D_s^- = \overline{c}s$, similarly for D_s^*'s

$D_s^\pm$
was $F^\pm$

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

Mass $m = 1968.5 \pm 0.6$ MeV (S = 1.1)
$m_{D_s^\pm} - m_{D^\pm} = 99.2 \pm 0.5$ MeV (S = 1.1)
Mean life $\tau = (0.467 \pm 0.017) \times 10^{-12}$ s
$c\tau = 140$ μm

D_s^+ form factors

$r_2 = 1.6 \pm 0.4$
$r_V = 1.5 \pm 0.5$
$\Gamma_L/\Gamma_T = 0.72 \pm 0.18$

Branching fractions for modes with a resonance in the final state include all the decay modes of the resonance. D_s^- modes are charge conjugates of the modes below.

D_s^+ DECAY MODES		Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
Inclusive modes				
K^- anything		$(13 {}^{+14}_{-12})$ %		–
$\overline{K}^0$ anything + K^0 anything		(39 ± 28) %		–
K^+ anything		$(20 {}^{+18}_{-14})$ %		–
non-$K\overline{K}$ anything		(64 ± 17) %		–
e^+ anything		$(8 {}^{+6}_{-5})$ %		–
ϕ anything		$(18 {}^{+15}_{-10})$ %		–
Leptonic and semileptonic modes				
$\mu^+\nu_\mu$		$(4.0 {}^{+2.2}_{-2.0}) \times 10^{-3}$	S=1.4	981
$\tau^+\nu_\tau$		(7 ± 4) %		182
$\phi\ell^+\nu_\ell$	[xx]	(2.0 ± 0.5) %		–
$\eta\ell^+\nu_\ell$ + $\eta'(958)\ell^+\nu_\ell$	[xx]	(3.4 ± 1.0) %		–
$\eta\ell^+\nu_\ell$		(2.5 ± 0.7) %		–
$\eta'(958)\ell^+\nu_\ell$		$(8.8 \pm 3.4) \times 10^{-3}$		–
Hadronic modes with a $K\overline{K}$ pair (including from a ϕ)				
$K^+\overline{K}^0$		(3.6 ± 1.1) %		850
$K^+K^-\pi^+$	[qq]	(4.4 ± 1.2) %	S=1.1	805
$\phi\pi^+$	[yy]	(3.6 ± 0.9) %		712
$K^+\overline{K}^*(892)^0$	[yy]	(3.3 ± 0.9) %		682
$f_0(980)\pi^+$	[yy]	(1.8 ± 0.8) %	S=1.3	732
$K^+\overline{K}_0^*(1430)^0$	[yy]	$(7 \pm 4) \times 10^{-3}$		186
$f_J(1710)\pi^+ \to K^+K^-\pi^+$	[zz]	$(1.5 \pm 1.9) \times 10^{-3}$		204
$K^+K^-\pi^+$ nonresonant		$(9 \pm 4) \times 10^{-3}$		805
$K^0\overline{K}^0\pi^+$		—		802
$K^*(892)^+\overline{K}^0$	[yy]	(4.3 ± 1.4) %		683
$K^+K^-\pi^+\pi^0$		—		748
$\phi\pi^+\pi^0$	[yy]	(9 ± 5) %		687
$\phi\rho^+$	[yy]	(6.7 ± 2.3) %		407
$\phi\pi^+\pi^0$ 3-body	[yy]	< 2.6 %	CL=90%	687
$K^+K^-\pi^+\pi^0$ non-ϕ		< 9 %	CL=90%	748
$K^+\overline{K}^0\pi^+\pi^-$		< 2.8 %	CL=90%	744
$K^0K^-\pi^+\pi^+$		(4.3 ± 1.5) %		744
$K^*(892)^+\overline{K}^*(892)^0$	[yy]	(5.8 ± 2.5) %		412
$K^0K^-\pi^+\pi^+$ non-$K^{*+}\overline{K}^{*0}$		< 2.9 %	CL=90%	744
$K^+K^-\pi^+\pi^+\pi^-$		$(8.3 \pm 3.3) \times 10^{-3}$		673
$\phi\pi^+\pi^+\pi^-$	[yy]	(1.18 ± 0.35) %		640
$K^+K^-\pi^+\pi^+\pi^-$ non-ϕ		$(3.0 {}^{+3.0}_{-2.0}) \times 10^{-3}$		673
Hadronic modes without K's				
$\pi^+\pi^+\pi^-$		(1.0 ± 0.4) %	S=1.2	959
$\rho^0\pi^+$		$< 8 \times 10^{-4}$	CL=90%	827
$f_0(980)\pi^+$	[yy]	(1.8 ± 0.8) %	S=1.7	732
$f_2(1270)\pi^+$	[yy]	$(2.3 \pm 1.3) \times 10^{-3}$		559
$f_0(1500)\pi^+ \to \pi^+\pi^-\pi^+$	[aaa]	$(2.8 \pm 1.6) \times 10^{-3}$		391
$\pi^+\pi^+\pi^-$ nonresonant		$< 2.8 \times 10^{-3}$	CL=90%	959
$\pi^+\pi^+\pi^-\pi^0$		< 12 %	CL=90%	935
$\eta\pi^+$	[yy]	(2.0 ± 0.6) %		902

$\omega\pi^+$	[yy]	$(3.1 \pm 1.4) \times 10^{-3}$		822
$\pi^+\pi^+\pi^+\pi^-\pi^-$		$(6.9 \pm 3.0) \times 10^{-3}$		899
$\pi^+\pi^+\pi^-\pi^0\pi^0$		—		902
$\eta\rho^+$	[yy]	(10.3 ± 3.2) %		727
$\eta\pi^+\pi^0$ 3-body	[yy]	< 3.0 %	CL=90%	886
$\pi^+\pi^+\pi^+\pi^-\pi^-\pi^0$		(4.9 ± 3.2) %		856
$\eta'(958)\pi^+$	[yy]	(4.9 ± 1.8) %		743
$\pi^+\pi^+\pi^+\pi^-\pi^-\pi^0\pi^0$		—		803
$\eta'(958)\rho^+$	[yy]	(12 ± 4) %		470
$\eta'(958)\pi^+\pi^0$ 3-body	[yy]	< 3.1 %	CL=90%	720
Modes with one or three K's				
$K^0\pi^+$		$< 8 \times 10^{-3}$	CL=90%	916
$K^+\pi^+\pi^-$		(1.0 ± 0.4) %		900
$K^+\rho^0$		$< 2.9 \times 10^{-3}$	CL=90%	747
$K^*(892)^0\pi^+$	[yy]	$(6.5 \pm 2.8) \times 10^{-3}$		773
$K^+K^+K^-$		$< 6 \times 10^{-4}$	CL=90%	628
ϕK^+	[yy]	$< 5 \times 10^{-4}$	CL=90%	607
$\Delta C = 1$ weak neutral current ($C1$) modes, or Lepton number (L) violating modes				
$\pi^+\mu^+\mu^-$	[ss]	$< 4.3 \times 10^{-4}$	CL=90%	968
$K^+\mu^+\mu^-$	$C1$	$< 5.9 \times 10^{-4}$	CL=90%	909
$K^*(892)^+\mu^+\mu^-$	$C1$	$< 1.4 \times 10^{-3}$	CL=90%	765
$\pi^-\mu^+\mu^+$	L	$< 4.3 \times 10^{-4}$	CL=90%	968
$K^-\mu^+\mu^+$	L	$< 5.9 \times 10^{-4}$	CL=90%	909
$K^*(892)^-\mu^+\mu^+$	L	$< 1.4 \times 10^{-3}$	CL=90%	765

$D_s^{*\pm}$

$I(J^P) = 0(?^?)$

J^P is natural, width and decay modes consistent with 1^-.

Mass $m = 2112.4 \pm 0.7$ MeV (S = 1.1)

$m_{D_s^{*\pm}} - m_{D_s^{\pm}} = 143.8 \pm 0.4$ MeV

Full width $\Gamma < 1.9$ MeV, CL = 90%

D_s^{*-} modes are charge conjugates of the modes below.

D_s^{*+} DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$D_s^+\gamma$	(94.2 ± 2.5) %	139
$D_s^+\pi^0$	(5.8 ± 2.5) %	48

$D_{s1}(2536)^\pm$

$I(J^P) = 0(1^+)$

J, P need confirmation.

Mass $m = 2535.35 \pm 0.34 \pm 0.5$ MeV

Full width $\Gamma < 2.3$ MeV, CL = 90%

$D_{s1}(2536)^-$ modes are charge conjugates of the modes below.

$D_{s1}(2536)^+$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$D^*(2010)^+K^0$	seen	150
$D^*(2007)^0K^+$	seen	169
D^+K^0	not seen	382
D^0K^+	not seen	392
$D_s^{*+}\gamma$	possibly seen	389

$D_{sJ}(2573)^\pm$

$I(J^P) = 0(?^?)$

J^P is natural, width and decay modes consistent with 2^+.

Mass $m = 2573.5 \pm 1.7$ MeV

Full width $\Gamma = 15^{+5}_{-4}$ MeV

$D_{sJ}(2573)^-$ modes are charge conjugates of the modes below.

$D_{sJ}(2573)^+$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
D^0K^+	seen	436
$D^*(2007)^0K^+$	not seen	245

BOTTOM MESONS
$(B = \pm1)$

$B^+ = u\bar{b}$, $B^0 = d\bar{b}$, $\bar{B}^0 = \bar{d}b$, $B^- = \bar{u}b$, similarly for B^*'s

B-particle organization

Many measurements of B decays involve admixtures of B hadrons. Previously we arbitrarily included such admixtures in the $B^\pm$ section, but because of their importance we have created two new sections: "$B^\pm/B^0$ Admixture" for $\Upsilon(4S)$ results and "$B^\pm/B^0/B_s^0/b$-baryon Admixture" for results at higher energies. Most inclusive decay branching fractions are found in the Admixture sections. B^0-$\bar{B}^0$ mixing data are found in the B^0 section, while B_s^0-$\bar{B}_s^0$ mixing data and B-$\bar{B}$ mixing data for a B^0/B_s^0 admixture are found in the B_s^0 section. CP-violation data are found in the B^0 section. b-baryons are found near the end of the Baryon section.

The organization of the B sections is now as follows, where bullets indicate particle sections and brackets indicate reviews.

[Production and Decay of b-flavored Hadrons]

[Semileptonic Decays of B Mesons]

- $B^\pm$
  - mass, mean life
  - branching fractions
- B^0
  - mass, mean life
  - branching fractions
  - polarization in B^0 decay
  - B^0-$\bar{B}^0$ mixing
  - [B^0-$\bar{B}^0$ Mixing and CP Violation in B Decay]
  - CP violation
- $B^\pm$ B^0 Admixtures
  - branching fractions
- $B^\pm/B^0/B_s^0/b$-baryon Admixtures
  - mean life
  - production fractions
  - branching fractions
- B^*
  - mass
- B_s^0
  - mass, mean life
  - branching fractions
  - polarization in B_s^0 decay
  - B_s^0-$\bar{B}_s^0$ mixing
  - B-$\bar{B}$ mixing (admixture of B^0, B_s^0)

At end of Baryon Listings:

- Λ_b
  - mass, mean life
  - branching fractions
- b-baryon Admixture
  - mean life
  - branching fractions

$B^{\pm}$

$I(J^P) = \frac{1}{2}(0^-)$

IΓJΓP need confirmation. Quantum numbers shown are quark-model predictions.

Mass $m_{B^{\pm}} = 5278.9 \pm 1.8$ MeV
Mean life $\tau_{B^{\pm}} = (1.65 \pm 0.04) \times 10^{-12}$ s
$c\tau = 495\ \mu$m

B^- modes are charge conjugates of the modes below. Modes which do not identify the charge state of the B are listed in the $B^{\pm}/B^0$ ADMIXTURE section.

The branching fractions listed below assume 50% $B^0\overline{B}^0$ and 50% B^+B^- production at the $\Upsilon(4S)$. We have attempted to bring older measurements up to date by rescaling their assumed $\Upsilon(4S)$ production ratio to 50:50 and their assumed DΓ D_sΓ D^*Γand ψ branching ratios to current values whenever this would affect our averages and best limits significantly.

Indentation is used to indicate a subchannel of a previous reaction. All resonant subchannels have been corrected for resonance branching fractions to the final state so the sum of the subchannel branching fractions can exceed that of the final state.

B^+ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
Semileptonic and leptonic modes			
$\ell^+\nu_\ell$ anything	[pp] (10.3 ± 0.9) %		–
$\overline{D}^0\ell^+\nu_\ell$	[pp] (1.86 ± 0.33) %		–
$\overline{D}^*(2007)^0\ell^+\nu_\ell$	[pp] (5.3 ± 0.8) %		–
$\pi^0 e^+\nu_e$	$< 2.2 \times 10^{-3}$	CL=90%	2638
$\omega\ell^+\nu_\ell$	[pp] $< 2.1 \times 10^{-4}$	CL=90%	–
$\rho^0\ell^+\nu_\ell$	[pp] $< 2.1 \times 10^{-4}$	CL=90%	–
$e^+\nu_e$	$< 1.5 \times 10^{-5}$	CL=90%	2639
$\mu^+\nu_\mu$	$< 2.1 \times 10^{-5}$	CL=90%	2638
$\tau^+\nu_\tau$	$< 5.7 \times 10^{-4}$	CL=90%	2340
$e^+\nu_e\gamma$	$< 2.0 \times 10^{-4}$	CL=90%	–
$\mu^+\nu_\mu\gamma$	$< 5.2 \times 10^{-5}$	CL=90%	–
DΓ D*Γor D_s modes			
$\overline{D}^0\pi^+$	$(5.3 \pm 0.5) \times 10^{-3}$		2308
$\overline{D}^0\rho^+$	(1.34 ± 0.18) %		2238
$\overline{D}^0\pi^+\pi^+\pi^-$	(1.1 ± 0.4) %		2289
$\overline{D}^0\pi^+\pi^+\pi^-$ nonresonant	$(5 \pm 4) \times 10^{-3}$		2289
$\overline{D}^0\pi^+\rho^0$	$(4.2 \pm 3.0) \times 10^{-3}$		2209
$\overline{D}^0 a_1(1260)^+$	$(5 \pm 4) \times 10^{-3}$		2123
$D^*(2010)^-\pi^+\pi^+$	$(2.1 \pm 0.6) \times 10^{-3}$		2247
$D^-\pi^+\pi^+$	$< 1.4 \times 10^{-3}$	CL=90%	2299
$\overline{D}^*(2007)^0\pi^+$	$(4.6 \pm 0.4) \times 10^{-3}$		2256
$D^*(2010)^+\pi^0$	$< 1.7 \times 10^{-4}$	CL=90%	2254
$\overline{D}^*(2007)^0\rho^+$	(1.55 ± 0.31) %		2183
$\overline{D}^*(2007)^0\pi^+\pi^+\pi^-$	$(9.4 \pm 2.6) \times 10^{-3}$		2236
$\overline{D}^*(2007)^0 a_1(1260)^+$	(1.9 ± 0.5) %		2062
$D^*(2010)^-\pi^+\pi^+\pi^0$	(1.5 ± 0.7) %		2235
$D^*(2010)^-\pi^+\pi^+\pi^+\pi^-$	< 1 %	CL=90%	2217
$\overline{D}_1(2420)^0\pi^+$	$(1.5 \pm 0.6) \times 10^{-3}$	S=1.3	2081
$\overline{D}_1(2420)^0\rho^+$	$< 1.4 \times 10^{-3}$	CL=90%	1997
$\overline{D}_2^*(2460)^0\pi^+$	$< 1.3 \times 10^{-3}$	CL=90%	2064
$\overline{D}_2^*(2460)^0\rho^+$	$< 4.7 \times 10^{-3}$	CL=90%	1979
$\overline{D}^0 D_s^+$	(1.3 ± 0.4) %		1815
$\overline{D}^0 D_s^{*+}$	$(9 \pm 4) \times 10^{-3}$		1734
$\overline{D}^*(2007)^0 D_s^+$	(1.2 ± 0.5) %		1737
$\overline{D}^*(2007)^0 D_s^{*+}$	(2.7 ± 1.0) %		1650
$D_s^+\pi^0$	$< 2.0 \times 10^{-4}$	CL=90%	2270
$D_s^{*+}\pi^0$	$< 3.3 \times 10^{-4}$	CL=90%	2214
$D_s^+\eta$	$< 5 \times 10^{-4}$	CL=90%	2235
$D_s^{*+}\eta$	$< 8 \times 10^{-4}$	CL=90%	2177
$D_s^+\rho^0$	$< 4 \times 10^{-4}$	CL=90%	2198
$D_s^{*+}\rho^0$	$< 5 \times 10^{-4}$	CL=90%	2139
$D_s^+\omega$	$< 5 \times 10^{-4}$	CL=90%	2195
$D_s^{*+}\omega$	$< 7 \times 10^{-4}$	CL=90%	2136
$D_s^+ a_1(1260)^0$	$< 2.2 \times 10^{-3}$	CL=90%	2079
$D_s^{*+} a_1(1260)^0$	$< 1.6 \times 10^{-3}$	CL=90%	2014
$D_s^+\phi$	$< 3.2 \times 10^{-4}$	CL=90%	2141
$D_s^{*+}\phi$	$< 4 \times 10^{-4}$	CL=90%	2079
$D_s^+\overline{K}^0$	$< 1.1 \times 10^{-3}$	CL=90%	2241
$D_s^{*+}\overline{K}^0$	$< 1.1 \times 10^{-3}$	CL=90%	2184
$D_s^+\overline{K}^*(892)^0$	$< 5 \times 10^{-4}$	CL=90%	2171
$D_s^{*+}\overline{K}^*(892)^0$	$< 4 \times 10^{-4}$	CL=90%	2110
$D_s^-\pi^+K^+$	$< 8 \times 10^{-4}$	CL=90%	2222
$D_s^{*-}\pi^+K^+$	$< 1.2 \times 10^{-3}$	CL=90%	2164
$D_s^-\pi^+K^*(892)^+$	$< 6 \times 10^{-3}$	CL=90%	2137
$D_s^{*-}\pi^+K^*(892)^+$	$< 8 \times 10^{-3}$	CL=90%	2075
Charmonium modes			
$J/\psi(1S)K^+$	$(9.9 \pm 1.0) \times 10^{-4}$		1683
$J/\psi(1S)K^+\pi^+\pi^-$	$(1.4 \pm 0.6) \times 10^{-3}$		1612
$J/\psi(1S)K^*(892)^+$	$(1.47 \pm 0.27) \times 10^{-3}$		1571
$J/\psi(1S)\pi^+$	$(5.0 \pm 1.5) \times 10^{-5}$		1727
$J/\psi(1S)\rho^+$	$< 7.7 \times 10^{-4}$	CL=90%	1613
$J/\psi(1S)a_1(1260)^+$	$< 1.2 \times 10^{-3}$	CL=90%	1414
$\psi(2S)K^+$	$(6.9 \pm 3.1) \times 10^{-4}$	S=1.3	1284
$\psi(2S)K^*(892)^+$	$< 3.0 \times 10^{-3}$	CL=90%	1115
$\psi(2S)K^+\pi^+\pi^-$	$(1.9 \pm 1.2) \times 10^{-3}$		909
$\chi_{c1}(1P)K^+$	$(1.0 \pm 0.4) \times 10^{-3}$		1411
$\chi_{c1}(1P)K^*(892)^+$	$< 2.1 \times 10^{-3}$	CL=90%	1265
K or K^* modes			
$K^0\pi^+$	$(2.3 \pm 1.1) \times 10^{-5}$		2614
$K^+\pi^0$	$< 1.6 \times 10^{-5}$	CL=90%	2615
$\eta' K^+$	$(6.5 \pm 1.7) \times 10^{-5}$		2528
$\eta' K^*(892)^+$	$< 1.3 \times 10^{-4}$	CL=90%	2472
ηK^+	$< 1.4 \times 10^{-5}$	CL=90%	2587
$\eta K^*(892)^+$	$< 3.0 \times 10^{-5}$	CL=90%	2534
$K^*(892)^0\pi^+$	$< 4.1 \times 10^{-5}$	CL=90%	2561
$K^*(892)^+\pi^0$	$< 9.9 \times 10^{-5}$	CL=90%	2562
$K^+\pi^-\pi^+$ nonresonant	$< 2.8 \times 10^{-5}$	CL=90%	2609
$K^-\pi^+\pi^+$ nonresonant	$< 5.6 \times 10^{-5}$	CL=90%	–
$K_1(1400)^0\pi^+$	$< 2.6 \times 10^{-3}$	CL=90%	2451
$K_2^*(1430)^0\pi^+$	$< 6.8 \times 10^{-4}$	CL=90%	2443
$K^+\rho^0$	$< 1.9 \times 10^{-5}$	CL=90%	2559
$K^0\rho^+$	$< 4.8 \times 10^{-5}$	CL=90%	2559
$K^*(892)^+\pi^+\pi^-$	$< 1.1 \times 10^{-3}$	CL=90%	2556
$K^*(892)^+\rho^0$	$< 9.0 \times 10^{-4}$	CL=90%	2505
$K_1(1400)^+\rho^0$	$< 7.8 \times 10^{-4}$	CL=90%	2389
$K_2^*(1430)^+\rho^0$	$< 1.5 \times 10^{-3}$	CL=90%	2382
$K^+\overline{K}^0$	$< 2.1 \times 10^{-5}$	CL=90%	2592
$K^+K^-\pi^+$ nonresonant	$< 7.5 \times 10^{-5}$	CL=90%	–
$K^+K^-K^+$	$< 2.0 \times 10^{-4}$	CL=90%	2522
$K^+\phi$	$< 1.2 \times 10^{-5}$	CL=90%	2516
$K^+K^-K^+$ nonresonant	$< 3.8 \times 10^{-5}$	CL=90%	2516
$K^*(892)^+K^+K^-$	$< 1.6 \times 10^{-3}$	CL=90%	2466
$K^*(892)^+\phi$	$< 7.0 \times 10^{-5}$	CL=90%	2460
$K_1(1400)^+\phi$	$< 1.1 \times 10^{-3}$	CL=90%	2339
$K_2^*(1430)^+\phi$	$< 3.4 \times 10^{-3}$	CL=90%	2332
$K^+ f_0(980)$	$< 8 \times 10^{-5}$	CL=90%	2524
$K^*(892)^+\gamma$	$(5.7 \pm 3.3) \times 10^{-5}$		2564
$K_1(1270)^+\gamma$	$< 7.3 \times 10^{-3}$	CL=90%	2486
$K_1(1400)^+\gamma$	$< 2.2 \times 10^{-3}$	CL=90%	2453
$K_2^*(1430)^+\gamma$	$< 1.4 \times 10^{-3}$	CL=90%	2447
$K^*(1680)^+\gamma$	$< 1.9 \times 10^{-3}$	CL=90%	2361
$K_3^*(1780)^+\gamma$	$< 5.5 \times 10^{-3}$	CL=90%	2343
$K_4^*(2045)^+\gamma$	$< 9.9 \times 10^{-3}$	CL=90%	2243
Light unflavored meson modes			
$\pi^+\pi^0$	$< 2.0 \times 10^{-5}$	CL=90%	2636
$\pi^+\pi^+\pi^-$	$< 1.3 \times 10^{-4}$	CL=90%	2630
$\rho^0\pi^+$	$< 4.3 \times 10^{-5}$	CL=90%	2582
$\pi^+ f_0(980)$	$< 1.4 \times 10^{-4}$	CL=90%	2547
$\pi^+ f_2(1270)$	$< 2.4 \times 10^{-4}$	CL=90%	2483
$\pi^+\pi^-\pi^+$ nonresonant	$< 4.1 \times 10^{-5}$	CL=90%	–
$\pi^+\pi^0\pi^0$	$< 8.9 \times 10^{-4}$	CL=90%	2631
$\rho^+\pi^0$	$< 7.7 \times 10^{-5}$	CL=90%	2582
$\pi^+\pi^-\pi^+\pi^0$	$< 4.0 \times 10^{-3}$	CL=90%	2621
$\rho^+\rho^0$	$< 1.0 \times 10^{-3}$	CL=90%	2525
$a_1(1260)^+\pi^0$	$< 1.7 \times 10^{-3}$	CL=90%	2494
$a_1(1260)^0\pi^+$	$< 9.0 \times 10^{-4}$	CL=90%	2494
$\omega\pi^+$	$< 4.0 \times 10^{-4}$	CL=90%	2580

$\eta\pi^+$	$<$ 1.5	$\times 10^{-5}$	CL=90%	2609
$\eta'\pi^+$	$<$ 3.1	$\times 10^{-5}$	CL=90%	2550
$\eta'\rho^+$	$<$ 4.7	$\times 10^{-5}$	CL=90%	2493
$\eta\rho^+$	$<$ 3.2	$\times 10^{-5}$	CL=90%	2554
$\pi^+\pi^+\pi^+\pi^-\pi^-$	$<$ 8.6	$\times 10^{-4}$	CL=90%	2608
$\rho^0 a_1(1260)^+$	$<$ 6.2	$\times 10^{-4}$	CL=90%	2434
$\rho^0 a_2(1320)^+$	$<$ 7.2	$\times 10^{-4}$	CL=90%	2411
$\pi^+\pi^+\pi^+\pi^-\pi^-\pi^0$	$<$ 6.3	$\times 10^{-3}$	CL=90%	2592
$a_1(1260)^+ a_1(1260)^0$	$<$ 1.3	%	CL=90%	2335

Baryon modes

$p\overline{p}\pi^+$	$<$ 1.6	$\times 10^{-4}$	CL=90%	2439
$p\overline{p}\pi^+$ nonresonant	$<$ 5.3	$\times 10^{-5}$	CL=90%	–
$p\overline{p}\pi^+\pi^+\pi^-$	$<$ 5.2	$\times 10^{-4}$	CL=90%	2369
$p\overline{p}K^+$ nonresonant	$<$ 8.9	$\times 10^{-5}$	CL=90%	–
$p\overline{\Lambda}$	$<$ 6	$\times 10^{-5}$	CL=90%	2430
$p\overline{\Lambda}\pi^+\pi^-$	$<$ 2.0	$\times 10^{-4}$	CL=90%	2367
$\overline{\Delta}^0 p$	$<$ 3.8	$\times 10^{-4}$	CL=90%	2402
$\Delta^{++}\overline{p}$	$<$ 1.5	$\times 10^{-4}$	CL=90%	2402
$\Lambda_c^- p\pi^+$	(6.2 ±2.7) $\times 10^{-4}$			–
$\Lambda_c^- p\pi^+\pi^0$	$<$ 3.12	$\times 10^{-3}$	CL=90%	–
$\Lambda_c^- p\pi^+\pi^+\pi^-$	$<$ 1.46	$\times 10^{-3}$	CL=90%	–
$\Lambda_c^- p\pi^+\pi^+\pi^-\pi^0$	$<$ 1.34	%	CL=90%	–

Lepton Family number (*LF*) or Lepton number (*L*) violating modesΓor $\Delta B = 1$ weak neutral current (*B1*) modes

$\pi^+ e^+ e^-$	*B1*	$<$ 3.9	$\times 10^{-3}$	CL=90%	2638
$\pi^+\mu^+\mu^-$	*B1*	$<$ 9.1	$\times 10^{-3}$	CL=90%	2633
$K^+ e^+ e^-$	*B1*	$<$ 6	$\times 10^{-5}$	CL=90%	2616
$K^+\mu^+\mu^-$	*B1*	$<$ 1.0	$\times 10^{-5}$	CL=90%	2612
$K^*(892)^+ e^+ e^-$	*B1*	$<$ 6.9	$\times 10^{-4}$	CL=90%	2564
$K^*(892)^+\mu^+\mu^-$	*B1*	$<$ 1.2	$\times 10^{-3}$	CL=90%	2560
$\pi^+ e^+\mu^-$	*LF*	$<$ 6.4	$\times 10^{-3}$	CL=90%	2637
$\pi^+ e^-\mu^+$	*LF*	$<$ 6.4	$\times 10^{-3}$	CL=90%	2637
$K^+ e^+\mu^-$	*LF*	$<$ 6.4	$\times 10^{-3}$	CL=90%	2615
$K^+ e^-\mu^+$	*LF*	$<$ 6.4	$\times 10^{-3}$	CL=90%	2615
$\pi^- e^+ e^+$	*L*	$<$ 3.9	$\times 10^{-3}$	CL=90%	2638
$\pi^-\mu^+\mu^+$	*L*	$<$ 9.1	$\times 10^{-3}$	CL=90%	2633
$\pi^- e^+\mu^+$	*LF*	$<$ 6.4	$\times 10^{-3}$	CL=90%	2637
$K^- e^+ e^+$	*L*	$<$ 3.9	$\times 10^{-3}$	CL=90%	2616
$K^-\mu^+\mu^+$	*L*	$<$ 9.1	$\times 10^{-3}$	CL=90%	2612
$K^- e^+\mu^+$	*LF*	$<$ 6.4	$\times 10^{-3}$	CL=90%	2615

B^0

$I(J^P) = \frac{1}{2}(0^-)$

*I*Γ*J*Γ*P* need confirmation. Quantum numbers shown are quark-model predictions.

Mass $m_{B^0} = 5279.2 \pm 1.8$ MeV

$m_{B^0} - m_{B^\pm} = 0.35 \pm 0.29$ MeV (S = 1.1)

Mean life $\tau_{B^0} = (1.56 \pm 0.04) \times 10^{-12}$ s

$c\tau = 468\ \mu$m

$\tau_{B^\pm}/\tau_{B^0} = 1.02 \pm 0.04$ (average of direct and inferred)

$\tau_{B^\pm}/\tau_{B^0} = 1.04 \pm 0.04$ (direct measurements)

$\tau_{B^\pm}/\tau_{B^0} = 0.95^{+0.15}_{-0.12}$ (inferred from branching fractions)

B^0-$\overline{B}^0$ mixing parameters

$\chi_d = 0.172 \pm 0.010$

$\Delta m_{B^0} = m_{B^0_H} - m_{B^0_L} = (0.464 \pm 0.018) \times 10^{12}\ \hbar\ s^{-1}$

$x_d = \Delta m_{B^0}/\Gamma_{B^0} = 0.723 \pm 0.032$

***CP* violation parameters**

$|\mathrm{Re}(\epsilon_{B^0})| = 0.002 \pm 0.008$

$\overline{B}^0$ modes are charge conjugates of the modes below. Reactions indicate the weak decay vertex and do not include mixing. Modes which do not identify the charge state of the *B* are listed in the $B^\pm/B^0$ ADMIXTURE section.

The branching fractions listed below assume 50% $B^0\overline{B}^0$ and 50% B^+B^- production at the $\Upsilon(4S)$. We have attempted to bring older measurements up to date by rescaling their assumed $\Upsilon(4S)$ production ratio to 50:50 and their assumed *D*Γ D_sΓ D^*Γand ψ branching ratios to current values whenever this would affect our averages and best limits significantly.

Indentation is used to indicate a subchannel of a previous reaction. All resonant subchannels have been corrected for resonance branching fractions to the final state so the sum of the subchannel branching fractions can exceed that of the final state.

B^0 DECAY MODES		Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
$\ell^+\nu_\ell$ anything	[pp]	(10.5 ± 0.8) %		–
$D^-\ell^+\nu_\ell$	[pp]	(2.00± 0.25) %		–
$D^*(2010)^-\ell^+\nu_\ell$	[pp]	(4.60± 0.27) %		–
$\rho^-\ell^+\nu_\ell$	[pp]	($2.5^{+0.8}_{-1.0}$) $\times 10^{-4}$		–
$\pi^-\ell^+\nu_\ell$		(1.8 ± 0.6) $\times 10^{-4}$		–
Inclusive modes				
K^+ anything		(78 ±80) %		–
DΓD^*Γor D_s modes				
$D^-\pi^+$		(3.0 ± 0.4) $\times 10^{-3}$		2306
$D^-\rho^+$		(7.9 ± 1.4) $\times 10^{-3}$		2236
$\overline{D}^0\pi^+\pi^-$		$<$ 1.6 $\times 10^{-3}$	CL=90%	2301
$D^*(2010)^-\pi^+$		(2.76± 0.21) $\times 10^{-3}$		2254
$D^-\pi^+\pi^+\pi^-$		(8.0 ± 2.5) $\times 10^{-3}$		2287
$(D^-\pi^+\pi^+\pi^-)$ nonresonant		(3.9 ± 1.9) $\times 10^{-3}$		2287
$D^-\pi^+\rho^0$		(1.1 ± 1.0) $\times 10^{-3}$		2207
$D^- a_1(1260)^+$		(6.0 ± 3.3) $\times 10^{-3}$		2121
$D^*(2010)^-\pi^+\pi^0$		(1.5 ± 0.5) %		2247
$D^*(2010)^-\rho^+$		(6.7 ± 3.3) $\times 10^{-3}$		2181
$D^*(2010)^-\pi^+\pi^+\pi^-$		(7.6 ± 1.7) $\times 10^{-3}$	S=1.3	2235
$(D^*(2010)^-\pi^+\pi^+\pi^-)$ non-resonant		(0.0 ± 2.5) $\times 10^{-3}$		2235
$D^*(2010)^-\pi^+\rho^0$		(5.7 ± 3.1) $\times 10^{-3}$		2151
$D^*(2010)^- a_1(1260)^+$		(1.30± 0.27) %		2061
$D^*(2010)^-\pi^+\pi^+\pi^-\pi^0$		(3.4 ± 1.8) %		2218
$\overline{D}_2^*(2460)^-\pi^+$		$<$ 2.2 $\times 10^{-3}$	CL=90%	2064
$\overline{D}_2^*(2460)^-\rho^+$		$<$ 4.9 $\times 10^{-3}$	CL=90%	1979
$D^- D_s^+$		(8.0 ± 3.0) $\times 10^{-3}$		1812
$D^*(2010)^- D_s^+$		(9.6 ± 3.4) $\times 10^{-3}$		1735
$D^- D_s^{*+}$		(1.0 ± 0.5) %		1731
$D^*(2010)^- D_s^{*+}$		(2.0 ± 0.7) %		1649
$D_s^+\pi^-$		$<$ 2.8 $\times 10^{-4}$	CL=90%	2270
$D_s^{*+}\pi^-$		$<$ 5 $\times 10^{-4}$	CL=90%	2214
$D_s^+\rho^-$		$<$ 7 $\times 10^{-4}$	CL=90%	2198
$D_s^{*+}\rho^-$		$<$ 8 $\times 10^{-4}$	CL=90%	2139
$D_s^+ a_1(1260)^-$		$<$ 2.6 $\times 10^{-3}$	CL=90%	2079
$D_s^{*+} a_1(1260)^-$		$<$ 2.2 $\times 10^{-3}$	CL=90%	2014
$D_s^- K^+$		$<$ 2.4 $\times 10^{-4}$	CL=90%	2242
$D_s^{*-} K^+$		$<$ 1.7 $\times 10^{-4}$	CL=90%	2185
$D_s^- K^*(892)^+$		$<$ 9.9 $\times 10^{-4}$	CL=90%	2172
$D_s^{*-} K^*(892)^+$		$<$ 1.1 $\times 10^{-3}$	CL=90%	2112
$D_s^-\pi^+ K^0$		$<$ 5 $\times 10^{-3}$	CL=90%	2221
$D_s^{*-}\pi^+ K^0$		$<$ 3.1 $\times 10^{-3}$	CL=90%	2164
$D_s^-\pi^+ K^*(892)^0$		$<$ 4 $\times 10^{-3}$	CL=90%	2136
$D_s^{*-}\pi^+ K^*(892)^0$		$<$ 2.0 $\times 10^{-3}$	CL=90%	2074
$\overline{D}^0\pi^0$		$<$ 1.2 $\times 10^{-4}$	CL=90%	2308
$\overline{D}^0\rho^0$		$<$ 3.9 $\times 10^{-4}$	CL=90%	2238
$\overline{D}^0\eta$		$<$ 1.3 $\times 10^{-4}$	CL=90%	2274
$\overline{D}^0\eta'$		$<$ 9.4 $\times 10^{-4}$	CL=90%	2198
$\overline{D}^0\omega$		$<$ 5.1 $\times 10^{-4}$	CL=90%	2235
$\overline{D}^*(2007)^0\pi^0$		$<$ 4.4 $\times 10^{-4}$	CL=90%	2256
$\overline{D}^*(2007)^0\rho^0$		$<$ 5.6 $\times 10^{-4}$	CL=90%	2183
$\overline{D}^*(2007)^0\eta$		$<$ 2.6 $\times 10^{-4}$	CL=90%	2220
$\overline{D}^*(2007)^0\eta'$		$<$ 1.4 $\times 10^{-3}$	CL=90%	2141
$\overline{D}^*(2007)^0\omega$		$<$ 7.4 $\times 10^{-4}$	CL=90%	2180
$D^*(2010)^+ D^*(2010)^-$		$<$ 2.2 $\times 10^{-3}$	CL=90%	1711
$D^*(2010)^+ D^-$		$<$ 1.8 $\times 10^{-3}$	CL=90%	1790
$D^+ D^*(2010)^-$		$<$ 1.2 $\times 10^{-3}$	CL=90%	1790
Charmonium modes				
$J/\psi(1S) K^0$		(8.9 ± 1.2) $\times 10^{-4}$		1683
$J/\psi(1S) K^+\pi^-$		(1.1 ± 0.6) $\times 10^{-3}$		1652
$J/\psi(1S) K^*(892)^0$		(1.35± 0.18) $\times 10^{-3}$		1570
$J/\psi(1S)\pi^0$		$<$ 5.8 $\times 10^{-5}$	CL=90%	1728
$J/\psi(1S)\eta$		$<$ 1.2 $\times 10^{-3}$	CL=90%	1672
$J/\psi(1S)\rho^0$		$<$ 2.5 $\times 10^{-4}$	CL=90%	1614

$J/\psi(1S)\omega$		< 2.7	$\times 10^{-4}$	CL=90%	1609
$\psi(2S)K^0$		< 8	$\times 10^{-4}$	CL=90%	1283
$\psi(2S)K^+\pi^-$		< 1	$\times 10^{-3}$	CL=90%	1238
$\psi(2S)K^*(892)^0$		(1.4 ± 0.9)	$\times 10^{-3}$		1113
$\chi_{c1}(1P)K^0$		< 2.7	$\times 10^{-3}$	CL=90%	1411
$\chi_{c1}(1P)K^*(892)^0$		< 2.1	$\times 10^{-3}$	CL=90%	1263
***K* or *K** modes**					
$K^+\pi^-$		($1.5^{+0.5}_{-0.4}$)	$\times 10^{-5}$		2615
$K^0\pi^0$		< 4.1	$\times 10^{-5}$	CL=90%	2614
$\eta' K^0$		($4.7^{+2.8}_{-2.2}$)	$\times 10^{-5}$		2528
$\eta' K^*(892)^0$		< 3.9	$\times 10^{-5}$	CL=90%	2472
$\eta K^*(892)^0$		< 3.0	$\times 10^{-5}$	CL=90%	2534
ηK^0		< 3.3	$\times 10^{-5}$	CL=90%	2593
K^+K^-		< 4.3	$\times 10^{-6}$	CL=90%	2593
$K^0\overline{K}^0$		< 1.7	$\times 10^{-5}$	CL=90%	2592
$K^+\rho^-$		< 3.5	$\times 10^{-5}$	CL=90%	2559
$K^0\rho^0$		< 3.9	$\times 10^{-5}$	CL=90%	2559
$K^0 f_0(980)$		< 3.6	$\times 10^{-4}$	CL=90%	2523
$K^*(892)^+\pi^-$		< 7.2	$\times 10^{-5}$	CL=90%	2562
$K^*(892)^0\pi^0$		< 2.8	$\times 10^{-5}$	CL=90%	2562
$K_2^*(1430)^+\pi^-$		< 2.6	$\times 10^{-3}$	CL=90%	2445
$K^0K^+K^-$		< 1.3	$\times 10^{-3}$	CL=90%	2522
$K^0\phi$		< 8.8	$\times 10^{-5}$	CL=90%	2516
$K^-\pi^+\pi^+\pi^-$	[bbb]	< 2.3	$\times 10^{-4}$	CL=90%	2600
$K^*(892)^0\pi^+\pi^-$		< 1.4	$\times 10^{-3}$	CL=90%	2556
$K^*(892)^0\rho^0$		< 4.6	$\times 10^{-4}$	CL=90%	2504
$K^*(892)^0 f_0(980)$		< 1.7	$\times 10^{-4}$	CL=90%	2467
$K_1(1400)^+\pi^-$		< 1.1	$\times 10^{-3}$	CL=90%	2451
$K^- a_1(1260)^+$	[bbb]	< 2.3	$\times 10^{-4}$	CL=90%	2471
$K^*(892)^0K^+K^-$		< 6.1	$\times 10^{-4}$	CL=90%	2466
$K^*(892)^0\phi$		< 4.3	$\times 10^{-5}$	CL=90%	2459
$K_1(1400)^0\rho^0$		< 3.0	$\times 10^{-3}$	CL=90%	2389
$K_1(1400)^0\phi$		< 5.0	$\times 10^{-3}$	CL=90%	2339
$K_2^*(1430)^0\rho^0$		< 1.1	$\times 10^{-3}$	CL=90%	2380
$K_2^*(1430)^0\phi$		< 1.4	$\times 10^{-3}$	CL=90%	2330
$K^*(892)^0\gamma$		(4.0 ± 1.9)	$\times 10^{-5}$		2564
$K_1(1270)^0\gamma$		< 7.0	$\times 10^{-3}$	CL=90%	2486
$K_1(1400)^0\gamma$		< 4.3	$\times 10^{-3}$	CL=90%	2453
$K_2^*(1430)^0\gamma$		< 4.0	$\times 10^{-4}$	CL=90%	2445
$K^*(1680)^0\gamma$		< 2.0	$\times 10^{-3}$	CL=90%	2361
$K_3^*(1780)^0\gamma$		< 1.0	%	CL=90%	2343
$K_4^*(2045)^0\gamma$		< 4.3	$\times 10^{-3}$	CL=90%	2244
$\phi\phi$		< 3.9	$\times 10^{-5}$	CL=90%	2435
Light unflavored meson modes					
$\pi^+\pi^-$		< 1.5	$\times 10^{-5}$	CL=90%	2636
$\pi^0\pi^0$		< 9.3	$\times 10^{-6}$	CL=90%	2636
$\eta\pi^0$		< 8	$\times 10^{-6}$	CL=90%	2609
$\eta\eta$		< 1.8	$\times 10^{-5}$	CL=90%	2582
$\eta'\pi^0$		< 1.1	$\times 10^{-5}$	CL=90%	2551
$\eta'\eta'$		< 4.7	$\times 10^{-5}$	CL=90%	2460
$\eta'\eta$		< 2.7	$\times 10^{-5}$	CL=90%	2522
$\eta'\rho^0$		< 2.3	$\times 10^{-5}$	CL=90%	2493
$\eta\rho^0$		< 1.3	$\times 10^{-5}$	CL=90%	2554
$\pi^+\pi^-\pi^0$		< 7.2	$\times 10^{-4}$	CL=90%	2631
$\rho^0\pi^0$		< 2.4	$\times 10^{-5}$	CL=90%	2582
$\rho^\mp\pi^\pm$	[gg]	< 8.8	$\times 10^{-5}$	CL=90%	2582
$\pi^+\pi^-\pi^+\pi^-$		< 2.3	$\times 10^{-4}$	CL=90%	2621
$\rho^0\rho^0$		< 2.8	$\times 10^{-4}$	CL=90%	2525
$a_1(1260)^\mp\pi^\pm$	[gg]	< 4.9	$\times 10^{-4}$	CL=90%	2494
$a_2(1320)^\mp\pi^\pm$	[gg]	< 3.0	$\times 10^{-4}$	CL=90%	2473
$\pi^+\pi^-\pi^0\pi^0$		< 3.1	$\times 10^{-3}$	CL=90%	2622
$\rho^+\rho^-$		< 2.2	$\times 10^{-3}$	CL=90%	2525
$a_1(1260)^0\pi^0$		< 1.1	$\times 10^{-3}$	CL=90%	2494
$\omega\pi^0$		< 4.6	$\times 10^{-4}$	CL=90%	2580
$\pi^+\pi^+\pi^-\pi^-\pi^0$		< 9.0	$\times 10^{-3}$	CL=90%	2609
$a_1(1260)^+\rho^-$		< 3.4	$\times 10^{-3}$	CL=90%	2434
$a_1(1260)^0\rho^0$		< 2.4	$\times 10^{-3}$	CL=90%	2434
$\pi^+\pi^+\pi^+\pi^-\pi^-\pi^-$		< 3.0	$\times 10^{-3}$	CL=90%	2592
$a_1(1260)^+a_1(1260)^-$		< 2.8	$\times 10^{-3}$	CL=90%	2336
$\pi^+\pi^+\pi^+\pi^-\pi^-\pi^-\pi^0$		< 1.1	%	CL=90%	2572

Baryon modes					
$p\overline{p}$		< 1.8	$\times 10^{-5}$	CL=90%	2467
$p\overline{p}\pi^+\pi^-$		< 2.5	$\times 10^{-4}$	CL=90%	2406
$p\overline{\Lambda}\pi^-$		< 1.8	$\times 10^{-4}$	CL=90%	2401
$\Delta^0\overline{\Delta}^0$		< 1.5	$\times 10^{-3}$	CL=90%	2334
$\Delta^{++}\Delta^{--}$		< 1.1	$\times 10^{-4}$	CL=90%	2334
$\overline{\Sigma}_c^{--}\Delta^{++}$		< 1.0	$\times 10^{-3}$	CL=90%	1839
$\overline{\Lambda}_c^- p\pi^+\pi^-$		(1.3 ± 0.6)	$\times 10^{-3}$		–
$\overline{\Lambda}_c^- p$		< 2.1	$\times 10^{-4}$	CL=90%	2021
$\overline{\Lambda}_c^- p\pi^0$		< 5.9	$\times 10^{-4}$	CL=90%	–
$\overline{\Lambda}_c^- p\pi^+\pi^-\pi^0$		< 5.07	$\times 10^{-3}$	CL=90%	–
$\overline{\Lambda}_c^- p\pi^+\pi^-\pi^+\pi^-$		< 2.74	$\times 10^{-3}$	CL=90%	–
Lepton Family number (*LF*) violating modesΓor $\Delta B = 1$ weak neutral current (*B1*) modes					
$\gamma\gamma$	*B1*	< 3.9	$\times 10^{-5}$	CL=90%	2640
e^+e^-	*B1*	< 5.9	$\times 10^{-6}$	CL=90%	2640
$\mu^+\mu^-$	*B1*	< 6.8	$\times 10^{-7}$	CL=90%	2637
$K^0e^+e^-$	*B1*	< 3.0	$\times 10^{-4}$	CL=90%	2616
$K^0\mu^+\mu^-$	*B1*	< 3.6	$\times 10^{-4}$	CL=90%	2612
$K^*(892)^0e^+e^-$	*B1*	< 2.9	$\times 10^{-4}$	CL=90%	2564
$K^*(892)^0\mu^+\mu^-$	*B1*	< 2.3	$\times 10^{-5}$	CL=90%	2559
$K^*(892)^0\nu\overline{\nu}$	*B1*	< 1.0	$\times 10^{-3}$	CL=90%	2244
$e^\pm\mu^\mp$	*LF* [gg]	< 5.9	$\times 10^{-6}$	CL=90%	2639
$e^\pm\tau^\mp$	*LF* [gg]	< 5.3	$\times 10^{-4}$	CL=90%	2341
$\mu^\pm\tau^\mp$	*LF* [gg]	< 8.3	$\times 10^{-4}$	CL=90%	2339

$B^\pm/B^0$ ADMIXTURE

The branching fraction measurements are for an admixture of B mesons at the $\Upsilon(4S)$. The values quoted assume that $B(\Upsilon(4S) \to B\overline{B}) = 100\%$.

For inclusive branching fractionsΓ*e.g.*, $B \to D^\pm$ anythingΓthe treatment of multiple D's in the final state must be defined. One possiblity would be to count the number of events with one-or-more D's and divide by the total number of B's. Another possibility would be to count the total number of D's and divide by the total number of B'sΓwhich is the definition of average multiplicity. The two definitions are identical when only one of the specified particles is allowed in the final state. Even though the "one-or-more" definition seems sensibleΓfor practical reasons inclusive branching fractions are almost always measured using the multiplicity definition. For heavy final state particlesΓauthors call their results inclusive branching fractions while for light particles some authors call their results multiplicities. In the B sectionsΓwe list all results as inclusive branching fractionsΓadopting a multiplicity definition. This means that inclusive branching fractions can exceed 100% and that inclusive partial widths can exceed total widthsΓjust as inclusive cross sections can exceed total cross sections.

$\overline{B}$ modes are charge conjugates of the modes below. Reactions indicate the weak decay vertex and do not include mixing.

***B* DECAY MODES**		Fraction (Γ_i/Γ)		Scale factor/ Confidence level	*p* (MeV/*c*)
Semileptonic and leptonic modes					
$B \to e^+\nu_e$ anything	[ccc]	(10.41±0.29)	%	S=1.2	–
$B \to \overline{p}e^+\nu_e$ anything		< 1.6	$\times 10^{-3}$	CL=90%	–
$B \to \mu^+\nu_\mu$ anything	[ccc]	(10.3 ±0.5)	%		–
$B \to \ell^+\nu_\ell$ anything	[pp,ccc]	(10.45±0.21)	%		–
$B \to D^-\ell^+\nu_\ell$ anything	[pp]	(2.7 ±0.8)	%		–
$B \to \overline{D}^0\ell^+\nu_\ell$ anything	[pp]	(7.0 ±1.4)	%		–
$B \to \overline{D}^{**}\ell^+\nu_\ell$	[pp,ddd]	(2.7 ±0.7)	%		–
$B \to \overline{D}_1(2420)\ell^+\nu_\ell$ anything		(7.4 ±1.6)	$\times 10^{-3}$		–
$B \to D\pi\ell^+\nu_\ell$ anything + $D^*\pi\ell^+\nu_\ell$ anything		(2.3 ±0.4)	%		–
$B \to \overline{D}_2^*(2460)\ell^+\nu_\ell$ anything		< 6.5	$\times 10^{-3}$	CL=95%	–
$B \to D^{*-}\pi^+\ell^+\nu_\ell$ anything		(1.00±0.34)	%		–
$B \to D_s^-\ell^+\nu_\ell$ anything	[pp]	< 9	$\times 10^{-3}$	CL=90%	–
$B \to D_s^-\ell^+\nu_\ell K^+$ anything	[pp]	< 6	$\times 10^{-3}$	CL=90%	–
$B \to D_s^-\ell^+\nu_\ell K^0$ anything	[pp]	< 9	$\times 10^{-3}$	CL=90%	–
$B \to K^+\ell^+\nu_\ell$ anything	[pp]	(6.0 ±0.5)	%		–
$B \to K^-\ell^+\nu_\ell$ anything	[pp]	(10 ±4)	$\times 10^{-3}$		–
$B \to K^0/\overline{K}^0\ell^+\nu_\ell$ anything	[pp]	(4.4 ±0.5)	%		–

DΓ D^*Γor D_s modes

$B \to D^{\pm}$anything		(24.1 ±1.9) %		–
$B \to D^0/\overline{D}{}^0$anything		(63.1 ±2.9) %	S=1.1	–
$B \to D^*(2010)^{\pm}$anything		(22.7 ±1.6) %		–
$B \to D^*(2007)^0$anything		(26.0 ±2.7) %		–
$B \to D_s^{\pm}$anything	[gg]	(10.0 ±2.5) %		–
$b \to c\overline{c}s$		(22 ±4) %		–
$B \to D_s D$Γ $D_s^* D$Γ $D_s D^*$Γor $D_s^* D^*$	[gg]	(4.9 ±1.3) %		–
$B \to D^*(2010)\gamma$		< 1.1 × 10^{-3}	CL=90%	–
$B \to D_s^+\pi^-$Γ $D_s^{*+}\pi^-$Γ $D_s^+\rho^-$Γ $D_s^{*+}\rho^-$Γ $D_s^+\pi^0$Γ $D_s^{*+}\pi^0$Γ $D_s^+\eta$Γ $D_s^{*+}\eta$Γ $D_s^+\rho^0$Γ $D_s^{*+}\rho^0$Γ $D_s^+\omega$Γ $D_s^{*+}\omega$	[gg]	< 5 × 10^{-4}	CL=90%	–
$B \to D_{s1}(2536)^+$anything		< 9.5 × 10^{-3}	CL=90%	–

Charmonium modes

$B \to J/\psi(1S)$anything		(1.13±0.06) %		–
$B \to J/\psi(1S)$(direct) anything		(8.0 ±0.8) × 10^{-3}		–
$B \to \psi(2S)$anything		(3.5 ±0.5) × 10^{-3}		–
$B \to \chi_{c1}(1P)$anything		(4.2 ±0.7) × 10^{-3}		–
$B \to \chi_{c1}(1P)$(direct) anything		(3.7 ±0.7) × 10^{-3}		–
$B \to \chi_{c2}(1P)$anything		< 3.8 × 10^{-3}	CL=90%	–
$B \to \eta_c(1S)$anything		< 9 × 10^{-3}	CL=90%	–

K or K^* modes

$B \to K^{\pm}$anything	[gg]	(78.9 ±2.5) %		–
$B \to K^+$anything		(66 ±5) %		–
$B \to K^-$anything		(13 ±4) %		–
$B \to K^0/\overline{K}{}^0$anything	[gg]	(64 ±4) %		–
$B \to K^*(892)^{\pm}$anything		(18 ±6) %		–
$B \to K^*(892)^0/\overline{K}{}^*(892)^0$anything	[gg]	(14.6 ±2.6) %		–
$B \to K_1(1400)\gamma$		< 4.1 × 10^{-4}	CL=90%	–
$B \to K_2^*(1430)\gamma$		< 8.3 × 10^{-4}	CL=90%	–
$B \to K_2(1770)\gamma$		< 1.2 × 10^{-3}	CL=90%	–
$B \to K_3^*(1780)\gamma$		< 3.0 × 10^{-3}	CL=90%	–
$B \to K_4^*(2045)\gamma$		< 1.0 × 10^{-3}	CL=90%	–
$B \to \overline{b} \to \overline{s}\gamma$		(2.3 ±0.7) × 10^{-4}		–
$B \to \overline{b} \to \overline{s}$gluon		< 6.8 %	CL=90%	–

Light unflavored meson modes

$B \to \pi^{\pm}$ anything	[gg,eee]	(359 ±7) %		–
$B \to \eta$ anything		(17.6 ±1.6) %		–
$B \to \rho^0$ anything		(21 ±5) %		–
$B \to \omega$ anything		< 81 %	CL=90%	–
$B \to \phi$ anything		(3.5 ±0.7) %	S=1.8	–

Baryon modes

$B \to \Lambda_c^{\pm}$anything		(6.4 ±1.1) %		–
$B \to \Lambda_c^- e^+$anything		< 3.2 × 10^{-3}	CL=90%	–
$B \to \Lambda_c^- p$anything		(3.6 ±0.7) %		–
$B \to \Lambda_c^- p e^+ \nu_e$		< 1.5 × 10^{-3}	CL=90%	–
$B \to \overline{\Sigma}{}_c^{--}$anything		(4.2 ±2.4) × 10^{-3}		–
$B \to \overline{\Sigma}{}_c^-$anything		< 9.6 × 10^{-3}	CL=90%	–
$B \to \overline{\Sigma}{}_c^0$anything		(4.6 ±2.4) × 10^{-3}		–
$B \to \overline{\Sigma}{}_c^0 N (N = p$ or $n)$		< 1.5 × 10^{-3}	CL=90%	–
$B \to \Xi_c^0$anything × B($\Xi_c^0 \to \Xi^-\pi^+$)		(1.4 ±0.5) × 10^{-4}		–
$B \to \Xi_c^+$anything × B($\Xi_c^+ \to \Xi^-\pi^+\pi^+$)		(4.5 $^{+1.3}_{-1.2}$) × 10^{-4}		–
$B \to p/\overline{p}$anything	[gg]	(8.0 ±0.4) %		–
$B \to p/\overline{p}$(direct) anything	[gg]	(5.5 ±0.5) %		–
$B \to \Lambda/\overline{\Lambda}$anything	[gg]	(4.0 ±0.5) %		–
$B \to \Xi^-/\overline{\Xi}{}^+$anything	[gg]	(2.7 ±0.6) × 10^{-3}		–
$B \to$ baryons anything		(6.8 ±0.6) %		–
$B \to p\overline{p}$anything		(2.47±0.23) %		–
$B \to \Lambda\overline{p}/\overline{\Lambda}p$anything	[gg]	(2.5 ±0.4) %		–
$B \to \Lambda\overline{\Lambda}$anything		< 5 × 10^{-3}	CL=90%	–

Lepton Family number (LF) violating modes or $\Delta B = 1$ weak neutral current ($B1$) modes

$B \to e^+e^-s$	$B1$	< 5.7 × 10^{-5}	CL=90%	–
$B \to \mu^+\mu^-s$	$B1$	< 5.8 × 10^{-5}	CL=90%	–
$B \to e^{\pm}\mu^{\mp}s$	LF	< 2.2 × 10^{-5}	CL=90%	–

$B^{\pm}/B^0/B_s^0/b$-baryon ADMIXTURE

These measurements are for an admixture of bottom particles at high energy (LEPΓ TevatronΓ S$p\overline{p}$S).

Mean life $\tau = (1.564 \pm 0.014) \times 10^{-12}$ s

Mean life $\tau = (1.72 \pm 0.10) \times 10^{-12}$ s Charged b-hadron admixture

Mean life $\tau = (1.58 \pm 0.14) \times 10^{-12}$ s Neutral b-hadron admixture

$\tau_{\text{charged } b\text{–hadron}}/\tau_{\text{neutral } b\text{–hadron}} = 1.09 \pm 0.13$

The branching fraction measurements are for an admixture of B mesons and baryons at energies above the $\Upsilon(4S)$. Only the highest energy results (LEPΓ TevatronΓ S$p\overline{p}$S) are used in the branching fraction averages. The production fractions give our best current estimate of the admixture at LEP.

For inclusive branching fractionsΓ *e.g.*, $B \to D^{\pm}$anythingΓ the treatment of multiple D's in the final state must be defined. One possiblity would be to count the number of events with one-or-more D's and divide by the total number of B's. Another possibility would be to count the total number of D's and divide by the total number of B'sΓ which is the definition of average multiplicity. The two definitions are identical when only one of the specified particles is allowed in the final state. Even though the "one-or-more" definition seems sensibleΓ for practical reasons inclusive branching fractions are almost always measured using the multiplicity definition. For heavy final state particlesΓ authors call their results inclusive branching fractions while for light particles some authors call their results multiplicities. In the B sectionsΓ we list all results as inclusive branching fractionsΓ adopting a multiplicity definition. This means that inclusive branching fractions can exceed 100% and that inclusive partial widths can exceed total widthsΓ just as inclusive cross sections can exceed total cross sections.

The modes below are listed for a $\overline{b}$ initial state. b modes are their charge conjugates. Reactions indicate the weak decay vertex and do not include mixing.

$\overline{b}$ DECAY MODES		Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)

PRODUCTION FRACTIONS

The production fractions for weakly decaying b-hadrons at the Z have been calculated from the best values of mean livesΓ mixing parametersΓ and branching fractions in this edition by the LEP B Oscillation Working Group as described in the note "Production and Decay of b-Flavored Hadrons" in the $B^{\pm}$ Particle Listings. Values assume

B($\overline{b} \to B^+$) = B($\overline{b} \to B^0$)
B($\overline{b} \to B^+$) + B($\overline{b} \to B^0$) +B($\overline{b} \to B_s^0$) + B($b \to \Lambda_b$) = 100 %.

The notation for production fractions varies in the literature (f_{B^0}Γ $f(b \to \overline{B}{}^0)$Γ Br($b \to \overline{B}{}^0$)). We use our own branching fraction notation hereΓ B($\overline{b} \to B^0$).

B^+		(39.7 $^{+1.8}_{-2.2}$) %		–
B^0		(39.7 $^{+1.8}_{-2.2}$) %		–
B_s^0		(10.5 $^{+1.8}_{-1.7}$) %		–
Λ_b		(10.1 $^{+3.9}_{-3.1}$) %		–

DECAY MODES

Semileptonic and leptonic modes

νanything		(23.1 ± 1.5) %		–
$\ell^+\nu_\ell$anything	[pp,ccc]	(10.99± 0.23) %		–
$e^+\nu_e$anything	[ccc]	(10.9 ± 0.5) %		–
$\mu^+\nu_\mu$anything	[ccc]	(10.8 ± 0.5) %		–
$D^-\ell^+\nu_\ell$anything	[pp]	(2.02± 0.29) %		–
$\overline{D}{}^0\ell^+\nu_\ell$anything	[pp]	(6.5 ± 0.6) %		–
$D^{*-}\ell^+\nu_\ell$anything	[pp]	(2.76± 0.29) %		–
$\overline{D}{}_j^0\ell^+\nu_\ell$anything	[pp,fff]	seen		–
$D_j^-\ell^+\nu_\ell$anything	[pp,fff]	seen		–
$\overline{D}{}_2^*(2460)^0\ell^+\nu_\ell$anything		seen		–
$D_2^*(2460)^-\ell^+\nu_\ell$anything		seen		–
$\tau^+\nu_\tau$anything		(2.6 ± 0.4) %		–
$\overline{c} \to \ell^-\overline{\nu}_\ell$anything	[pp]	(7.8 ± 0.6) %		–

Charmed meson and baryon modes				
$\overline{D}^0$ anything		(60.1 ± 3.2) %		–
D^- anything		(23.7 ± 2.3) %		–
$\overline{D}_s$ anything		(18 ± 5) %		–
Λ_c anything		(9.7 ± 2.9) %		–
$\overline{c}/c$ anything	[eee]	(117 ± 4) %		–
Charmonium modes				
$J/\psi(1S)$ anything		(1.16 ± 0.10) %		–
$\psi(2S)$ anything		(4.8 ± 2.4) $\times 10^{-3}$		–
$\chi_{c1}(1P)$ anything		(1.8 ± 0.5) %		–
***K* or *K** modes**				
$\overline{s}\gamma$		< 5.4 $\times 10^{-4}$	90%	–
$K^\pm$ anything		(88 ±19) %		–
K^0_S anything		(29.0 ± 2.9) %		–
Pion modes				
π^0 anything	[eee]	(278 ±60) %		–
Baryon modes				
$p/\overline{p}$ anything		(14 ± 6) %		–
Other modes				
charged anything	[eee]	(497 ± 7) %		–
hadron$^+$ hadron$^-$		($1.7\ ^{+\,1.0}_{-\,0.7}$) $\times 10^{-5}$		–
charmless		(7 ±21) $\times 10^{-3}$		–
Baryon modes				
$\Lambda/\overline{\Lambda}$ anything		(5.9 ± 0.6) %		–
$\Delta B = 1$ weak neutral current (*B1*) modes				
$\mu^+\mu^-$ anything	*B1*	< 3.2 $\times 10^{-4}$	90%	–

B^* $\qquad I(J^P) = \frac{1}{2}(1^-)$

IΓ JΓ P need confirmation. Quantum numbers shown are quark-model predictions.

Mass $m_{B^*} = 5324.9 \pm 1.8$ MeV

$m_{B^*} - m_B = 45.78 \pm 0.35$ MeV

B^* DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$B\gamma$	dominant	46

BOTTOM, STRANGE MESONS
($B = \pm1$, $S = \mp1$)

$B^0_s = s\overline{b}$Γ $\overline{B}^0_s = \overline{s}b$Γ similarly for B^*_s's

B^0_s $\qquad I(J^P) = 0(0^-)$

IΓ JΓ P need confirmation. Quantum numbers shown are quark-model predictions.

Mass $m_{B^0_s} = 5369.3 \pm 2.0$ MeV

Mean life $\tau = (1.54 \pm 0.07) \times 10^{-12}$ s

$c\tau = 462\ \mu$m

B^0_s-$\overline{B}^0_s$ mixing parameters

χ_B at high energy $= f_d\chi_d + f_s\chi_s = 0.118 \pm 0.006$

$\Delta m_{B^0_s} = m_{B^0_{sH}} - m_{B^0_{sL}} > 9.1 \times 10^{12}\ \hbar\ s^{-1}$ΓCL = 95%

$x_s = \Delta m_{B^0_s}/\Gamma_{B^0_s} > 14.0$ΓCL = 95%

$\chi_s > 0.4975$ΓCL = 95%

These branching fractions all scale with B($\overline{b} \to B^0_s$)Γ the LEP B^0_s production fraction. The first four were evaluated using B($\overline{b} \to B^0_s$) = $(10.5^{+1.8}_{-1.7})$% and the rest assume B($\overline{b} \to B^0_s$) = 12%.

The branching fraction B($B^0_s \to D^-_s \ell^+ \nu_\ell$ anything) is not a pure measurement since the measured product branching fraction B($\overline{b} \to B^0_s$) × B($B^0_s \to D^-_s \ell^+ \nu_\ell$ anything) was used to determine B($\overline{b} \to B^0_s$)Γ as described in the note on "Production and Decay of b-Flavored Hadrons."

B^0_s DECAY MODES		Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
D^-_s anything		(92 ±33) %		–
$D^-_s \ell^+ \nu_\ell$ anything	[ggg]	(8.1 ± 2.5) %		–
$D^-_s \pi^+$		< 13 %		2321
$J/\psi(1S)\phi$		(9.3 ± 3.3) $\times 10^{-4}$		1590
$J/\psi(1S)\pi^0$		< 1.2 $\times 10^{-3}$	90%	1788
$J/\psi(1S)\eta$		< 3.8 $\times 10^{-3}$	90%	1735
$\psi(2S)\phi$		seen		1122
$\pi^+\pi^-$		< 1.7 $\times 10^{-4}$	90%	1122
$\pi^0\pi^0$		< 2.1 $\times 10^{-4}$	90%	2861
$\eta\pi^0$		< 1.0 $\times 10^{-3}$	90%	2655
$\eta\eta$		< 1.5 $\times 10^{-3}$	90%	2628
π^+K^-		< 2.1 $\times 10^{-4}$	90%	2660
K^+K^-		< 5.9 $\times 10^{-5}$	90%	2639
$p\overline{p}$		< 5.9 $\times 10^{-5}$	90%	2515
$\gamma\gamma$		< 1.48 $\times 10^{-4}$	90%	2685
$\phi\gamma$		< 7 $\times 10^{-4}$	90%	2588
Lepton Family number (*LF*) violating modes or $\Delta B = 1$ weak neutral current (*B1*) modes				
$\mu^+\mu^-$	*B1*	< 2.0 $\times 10^{-6}$	90%	2682
e^+e^-	*B1*	< 5.4 $\times 10^{-5}$	90%	2864
$e^\pm\mu^\mp$	*LF* [gg]	< 4.1 $\times 10^{-5}$	90%	2864
$\phi\nu\overline{\nu}$	*B1*	< 5.4 $\times 10^{-3}$	90%	–

$c\overline{c}$ MESONS

$\eta_c(1S)$

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

Mass $m = 2979.8 \pm 2.1$ MeV (S = 2.1)
Full width $\Gamma = 13.2^{+3.8}_{-3.2}$ MeV

$\eta_c(1S)$ DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
Decays involving hadronic resonances			
$\eta'(958)\pi\pi$	(4.1 ± 1.7) %		1319
$\rho\rho$	(2.6 ± 0.9) %		1275
$K^*(892)^0 K^- \pi^+ +$ c.c.	(2.0 ± 0.7) %		1273
$K^*(892)\overline{K}^*(892)$	$(8.5 \pm 3.1) \times 10^{-3}$		1193
$\phi\phi$	$(7.1 \pm 2.8) \times 10^{-3}$		1086
$a_0(980)\pi$	< 2 %	90%	1323
$a_2(1320)\pi$	< 2 %	90%	1193
$K^*(892)\overline{K} +$ c.c.	< 1.28 %	90%	1307
$f_2(1270)\eta$	< 1.1 %	90%	1142
$\omega\omega$	$< 3.1 \times 10^{-3}$	90%	1268
Decays into stable hadrons			
$K\overline{K}\pi$	(5.5 ± 1.7) %		1378
$\eta\pi\pi$	(4.9 ± 1.8) %		1425
$\pi^+\pi^-K^+K^-$	$(2.0 ^{+0.7}_{-0.6})$ %		1342
$2(K^+K^-)$	(2.1 ± 1.2) %		1053
$2(\pi^+\pi^-)$	(1.2 ± 0.4) %		1457
$p\overline{p}$	$(1.2 \pm 0.4) \times 10^{-3}$		1157
$K\overline{K}\eta$	< 3.1 %	90%	1262
$\pi^+\pi^-p\overline{p}$	< 1.2 %	90%	1023
$\Lambda\overline{\Lambda}$	$< 2 \times 10^{-3}$	90%	987
Radiative decays			
$\gamma\gamma$	$(3.0 \pm 1.2) \times 10^{-4}$		1489

$J/\psi(1S)$

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

Mass $m = 3096.88 \pm 0.04$ MeV
Full width $\Gamma = 87 \pm 5$ keV
$\Gamma_{ee} = 5.26 \pm 0.37$ keV (Assuming $\Gamma_{ee} = \Gamma_{\mu\mu}$)

$J/\psi(1S)$ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
hadrons	(87.7 ± 0.5) %		–
virtual$\gamma \to$ hadrons	(17.0 ± 2.0) %		–
e^+e^-	(6.02 ± 0.19) %		1548
$\mu^+\mu^-$	(6.01 ± 0.19) %		1545
Decays involving hadronic resonances			
$\rho\pi$	(1.27 ± 0.09) %		1449
$\rho^0\pi^0$	$(4.2 \pm 0.5) \times 10^{-3}$		1449
$a_2(1320)\rho$	(1.09 ± 0.22) %		1125
$\omega\pi^+\pi^+\pi^-\pi^-$	$(8.5 \pm 3.4) \times 10^{-3}$		1392
$\omega\pi^+\pi^-$	$(7.2 \pm 1.0) \times 10^{-3}$		1435
$\omega f_2(1270)$	$(4.3 \pm 0.6) \times 10^{-3}$		1143
$K^*(892)^0\overline{K}^*_2(1430)^0 +$ c.c.	$(6.7 \pm 2.6) \times 10^{-3}$		1005
$\omega K^*(892)\overline{K} +$ c.c.	$(5.3 \pm 2.0) \times 10^{-3}$		1098
$K^+\overline{K}^*(892)^- +$ c.c.	$(5.0 \pm 0.4) \times 10^{-3}$		1373
$K^0\overline{K}^*(892)^0 +$ c.c.	$(4.2 \pm 0.4) \times 10^{-3}$		1371
$\omega\pi^0\pi^0$	$(3.4 \pm 0.8) \times 10^{-3}$		1436
$b_1(1235)^\pm\pi^\mp$ [gg]	$(3.0 \pm 0.5) \times 10^{-3}$		1299
$\omega K^\pm K^0_S\pi^\mp$ [gg]	$(3.0 \pm 0.7) \times 10^{-3}$		1210
$b_1(1235)^0\pi^0$	$(2.3 \pm 0.6) \times 10^{-3}$		1299
$\phi K^*(892)\overline{K} +$ c.c.	$(2.04 \pm 0.28) \times 10^{-3}$		969
$\omega K\overline{K}$	$(1.9 \pm 0.4) \times 10^{-3}$		1268
$\omega f_J(1710) \to \omega K\overline{K}$	$(4.8 \pm 1.1) \times 10^{-4}$		878
$\phi 2(\pi^+\pi^-)$	$(1.60 \pm 0.32) \times 10^{-3}$		1318
$\Delta(1232)^{++}\overline{p}\pi^-$	$(1.6 \pm 0.5) \times 10^{-3}$		1030
$\omega\eta$	$(1.58 \pm 0.16) \times 10^{-3}$		1394
$\phi K\overline{K}$	$(1.48 \pm 0.22) \times 10^{-3}$		1179
$\phi f_J(1710) \to \phi K\overline{K}$	$(3.6 \pm 0.6) \times 10^{-4}$		875
$p\overline{p}\omega$	$(1.30 \pm 0.25) \times 10^{-3}$	S=1.3	769
$\Delta(1232)^{++}\overline{\Delta}(1232)^{--}$	$(1.10 \pm 0.29) \times 10^{-3}$		938
$\Sigma(1385)^-\overline{\Sigma}(1385)^+$ (or c.c.) [gg]	$(1.03 \pm 0.13) \times 10^{-3}$		692
$p\overline{p}\eta'(958)$	$(9 \pm 4) \times 10^{-4}$	S=1.7	596
$\phi f'_2(1525)$	$(8 \pm 4) \times 10^{-4}$	S=2.7	871
$\phi\pi^+\pi^-$	$(8.0 \pm 1.2) \times 10^{-4}$		1365
$\phi K^\pm K^0_S\pi^\mp$ [gg]	$(7.2 \pm 0.9) \times 10^{-4}$		1114
$\omega f_1(1420)$	$(6.8 \pm 2.4) \times 10^{-4}$		1062
$\phi\eta$	$(6.5 \pm 0.7) \times 10^{-4}$		1320
$\Xi(1530)^-\overline{\Xi}^+$	$(5.9 \pm 1.5) \times 10^{-4}$		597
$pK^-\overline{\Sigma}(1385)^0$	$(5.1 \pm 3.2) \times 10^{-4}$		645
$\omega\pi^0$	$(4.2 \pm 0.6) \times 10^{-4}$	S=1.4	1447
$\phi\eta'(958)$	$(3.3 \pm 0.4) \times 10^{-4}$		1192
$\phi f_0(980)$	$(3.2 \pm 0.9) \times 10^{-4}$	S=1.9	1182
$\Xi(1530)^0\overline{\Xi}^0$	$(3.2 \pm 1.4) \times 10^{-4}$		608
$\Sigma(1385)^-\overline{\Sigma}^+$ (or c.c.) [gg]	$(3.1 \pm 0.5) \times 10^{-4}$		857
$\phi f_1(1285)$	$(2.6 \pm 0.5) \times 10^{-4}$	S=1.1	1032
$\rho\eta$	$(1.93 \pm 0.23) \times 10^{-4}$		1398
$\omega\eta'(958)$	$(1.67 \pm 0.25) \times 10^{-4}$		1279
$\omega f_0(980)$	$(1.4 \pm 0.5) \times 10^{-4}$		1271
$\rho\eta'(958)$	$(1.05 \pm 0.18) \times 10^{-4}$		1283
$p\overline{p}\phi$	$(4.5 \pm 1.5) \times 10^{-5}$		527
$a_2(1320)^\pm\pi^\mp$ [gg]	$< 4.3 \times 10^{-3}$	CL=90%	1263
$K\overline{K}^*_2(1430) +$ c.c.	$< 4.0 \times 10^{-3}$	CL=90%	1159
$K^*_2(1430)^0\overline{K}^*_2(1430)^0$	$< 2.9 \times 10^{-3}$	CL=90%	588
$K^*(892)^0\overline{K}^*(892)^0$	$< 5 \times 10^{-4}$	CL=90%	1263
$\phi f_2(1270)$	$< 3.7 \times 10^{-4}$	CL=90%	1036
$p\overline{p}\rho$	$< 3.1 \times 10^{-4}$	CL=90%	779
$\phi\eta(1440) \to \phi\eta\pi\pi$	$< 2.5 \times 10^{-4}$	CL=90%	946
$\omega f'_2(1525)$	$< 2.2 \times 10^{-4}$	CL=90%	1003
$\Sigma(1385)^0\overline{\Lambda}$	$< 2 \times 10^{-4}$	CL=90%	911
$\Delta(1232)^+\overline{p}$	$< 1 \times 10^{-4}$	CL=90%	1100
$\Sigma^0\overline{\Lambda}$	$< 9 \times 10^{-5}$	CL=90%	1032
$\phi\pi^0$	$< 6.8 \times 10^{-6}$	CL=90%	1377
Decays into stable hadrons			
$2(\pi^+\pi^-)\pi^0$	(3.37 ± 0.26) %		1496
$3(\pi^+\pi^-)\pi^0$	(2.9 ± 0.6) %		1433
$\pi^+\pi^-\pi^0$	(1.50 ± 0.20) %		1533
$\pi^+\pi^-\pi^0K^+K^-$	(1.20 ± 0.30) %		1368
$4(\pi^+\pi^-)\pi^0$	$(9.0 \pm 3.0) \times 10^{-3}$		1345
$\pi^+\pi^-K^+K^-$	$(7.2 \pm 2.3) \times 10^{-3}$		1407
$K\overline{K}\pi$	$(6.1 \pm 1.0) \times 10^{-3}$		1440
$p\overline{p}\pi^+\pi^-$	$(6.0 \pm 0.5) \times 10^{-3}$	S=1.3	1107
$2(\pi^+\pi^-)$	$(4.0 \pm 1.0) \times 10^{-3}$		1517
$3(\pi^+\pi^-)$	$(4.0 \pm 2.0) \times 10^{-3}$		1466
$n\overline{n}\pi^+\pi^-$	$(4 \pm 4) \times 10^{-3}$		1106
$\Sigma^0\overline{\Sigma}^0$	$(1.27 \pm 0.17) \times 10^{-3}$		992
$2(\pi^+\pi^-)K^+K^-$	$(3.1 \pm 1.3) \times 10^{-3}$		1320
$p\overline{p}\pi^+\pi^-\pi^0$ [hhh]	$(2.3 \pm 0.9) \times 10^{-3}$	S=1.9	1033
$p\overline{p}$	$(2.14 \pm 0.10) \times 10^{-3}$		1232
$p\overline{p}\eta$	$(2.09 \pm 0.18) \times 10^{-3}$		948
$p\overline{n}\pi^-$	$(2.00 \pm 0.10) \times 10^{-3}$		1174
$n\overline{n}$	$(1.9 \pm 0.5) \times 10^{-3}$		1231
$\Xi\overline{\Xi}$	$(1.8 \pm 0.4) \times 10^{-3}$	S=1.8	818
$\Lambda\overline{\Lambda}$	$(1.35 \pm 0.14) \times 10^{-3}$	S=1.2	1074
$p\overline{p}\pi^0$	$(1.09 \pm 0.09) \times 10^{-3}$		1176
$\Lambda\overline{\Sigma}^-\pi^+$ (or c.c.) [gg]	$(1.06 \pm 0.12) \times 10^{-3}$		945
$pK^-\overline{\Lambda}$	$(8.9 \pm 1.6) \times 10^{-4}$		876
$2(K^+K^-)$	$(7.0 \pm 3.0) \times 10^{-4}$		1131
$pK^-\overline{\Sigma}^0$	$(2.9 \pm 0.8) \times 10^{-4}$		820
K^+K^-	$(2.37 \pm 0.31) \times 10^{-4}$		1468
$\Lambda\overline{\Lambda}\pi^0$	$(2.2 \pm 0.7) \times 10^{-4}$		998
$\pi^+\pi^-$	$(1.47 \pm 0.23) \times 10^{-4}$		1542
$K^0_SK^0_L$	$(1.08 \pm 0.14) \times 10^{-4}$		1466
$\Lambda\overline{\Sigma} +$ c.c.	$< 1.5 \times 10^{-4}$	CL=90%	1032
$K^0_SK^0_S$	$< 5.2 \times 10^{-6}$	CL=90%	1466
Radiative decays			
$\gamma\eta_c(1S)$	(1.3 ± 0.4) %		116
$\gamma\pi^+\pi^-2\pi^0$	$(8.3 \pm 3.1) \times 10^{-3}$		1518
$\gamma\eta\pi\pi$	$(6.1 \pm 1.0) \times 10^{-3}$		1487
$\gamma\eta(1440) \to \gamma K\overline{K}\pi$ [p]	$(9.1 \pm 1.8) \times 10^{-4}$		1223
$\gamma\eta(1440) \to \gamma\gamma\rho^0$	$(6.4 \pm 1.4) \times 10^{-5}$		1223
$\gamma\eta(1440) \to \gamma\eta\pi^+\pi^-$	$(3.4 \pm 0.7) \times 10^{-4}$		–
$\gamma\rho\rho$	$(4.5 \pm 0.8) \times 10^{-3}$		1343
$\gamma\eta'(958)$	$(4.31 \pm 0.30) \times 10^{-3}$		1400
$\gamma 2\pi^+2\pi^-$	$(2.8 \pm 0.5) \times 10^{-3}$	S=1.9	1517
$\gamma f_4(2050)$	$(2.7 \pm 0.7) \times 10^{-3}$		874
$\gamma\omega\omega$	$(1.59 \pm 0.33) \times 10^{-3}$		1337
$\gamma\eta(1440) \to \gamma\rho^0\rho^0$	$(1.7 \pm 0.4) \times 10^{-3}$	S=1.3	1223
$\gamma f_2(1270)$	$(1.38 \pm 0.14) \times 10^{-3}$		1286
$\gamma f_J(1710) \to \gamma K\overline{K}$	$(8.5 ^{+1.2}_{-0.9}) \times 10^{-4}$	S=1.2	1075

$\gamma\eta$	$(8.6 \pm 0.8) \times 10^{-4}$		1500
$\gamma f_1(1420) \to \gamma K \overline{K} \pi$	$(8.3 \pm 1.5) \times 10^{-4}$		1220
$\gamma f_1(1285)$	$(6.5 \pm 1.0) \times 10^{-4}$		1283
$\gamma f'_2(1525)$	$(4.7 {}^{+0.7}_{-0.5}) \times 10^{-4}$		1173
$\gamma\phi\phi$	$(4.0 \pm 1.2) \times 10^{-4}$	S=2.1	1166
$\gamma p \overline{p}$	$(3.8 \pm 1.0) \times 10^{-4}$		1232
$\gamma\eta(2225)$	$(2.9 \pm 0.6) \times 10^{-4}$		834
$\gamma\eta(1760) \to \gamma\rho^0\rho^0$	$(1.3 \pm 0.9) \times 10^{-4}$		1048
$\gamma\pi^0$	$(3.9 \pm 1.3) \times 10^{-5}$		1546
$\gamma p \overline{p} \pi^+ \pi^-$	$< 7.9 \times 10^{-4}$	CL=90%	1107
$\gamma\gamma$	$< 5 \times 10^{-4}$	CL=90%	1548
$\gamma\Lambda\overline{\Lambda}$	$< 1.3 \times 10^{-4}$	CL=90%	1074
3γ	$< 5.5 \times 10^{-5}$	CL=90%	1548
$\gamma f_J(2220)$	$> 2.50 \times 10^{-3}$	CL=99.9%	–
$\gamma f_0(1500)$	$(5.7 \pm 0.8) \times 10^{-4}$		1184
$\gamma e^+ e^-$	$(8.8 \pm 1.4) \times 10^{-3}$		–

$\chi_{c0}(1P)$

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

Mass $m = 3417.3 \pm 2.8$ MeV
Full width $\Gamma = 14 \pm 5$ MeV

$\chi_{c0}(1P)$ DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
Hadronic decays			
$2(\pi^+\pi^-)$	(3.7 ± 0.7) %		1679
$\pi^+\pi^- K^+ K^-$	(3.0 ± 0.7) %		1580
$\rho^0 \pi^+ \pi^-$	(1.6 ± 0.5) %		1608
$3(\pi^+\pi^-)$	(1.5 ± 0.5) %		1633
$K^+ \overline{K}^*(892)^0 \pi^- +$ c.c.	(1.2 ± 0.4) %		1522
$\pi^+\pi^-$	$(7.5 \pm 2.1) \times 10^{-3}$		1702
$K^+ K^-$	$(7.1 \pm 2.4) \times 10^{-3}$		1635
$\pi^+\pi^- p \overline{p}$	$(5.0 \pm 2.0) \times 10^{-3}$		1320
$p \overline{p}$	$< 9.0 \times 10^{-4}$	90%	1427
Radiative decays			
$\gamma J/\psi(1S)$	$(6.6 \pm 1.8) \times 10^{-3}$		303
$\gamma\gamma$	$< 5 \times 10^{-4}$	95%	1708

$\chi_{c1}(1P)$

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

Mass $m = 3510.53 \pm 0.12$ MeV
Full width $\Gamma = 0.88 \pm 0.14$ MeV

$\chi_{c1}(1P)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
Hadronic decays		
$3(\pi^+\pi^-)$	(2.2 ± 0.8) %	1683
$2(\pi^+\pi^-)$	(1.6 ± 0.5) %	1727
$\pi^+\pi^- K^+ K^-$	$(9 \pm 4) \times 10^{-3}$	1632
$\rho^0 \pi^+ \pi^-$	$(3.9 \pm 3.5) \times 10^{-3}$	1659
$K^+ \overline{K}^*(892)^0 \pi^- +$ c.c.	$(3.2 \pm 2.1) \times 10^{-3}$	1576
$\pi^+\pi^- p \overline{p}$	$(1.4 \pm 0.9) \times 10^{-3}$	1381
$p \overline{p}$	$(8.6 \pm 1.2) \times 10^{-5}$	1483
$\pi^+\pi^- + K^+ K^-$	$< 2.1 \times 10^{-3}$	–
Radiative decays		
$\gamma J/\psi(1S)$	(27.3 ± 1.6) %	389

$\chi_{c2}(1P)$

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

Mass $m = 3556.17 \pm 0.13$ MeV
Full width $\Gamma = 2.00 \pm 0.18$ MeV

$\chi_{c2}(1P)$ DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
Hadronic decays			
$2(\pi^+\pi^-)$	(2.2 ± 0.5) %		1751
$\pi^+\pi^- K^+ K^-$	(1.9 ± 0.5) %		1656
$3(\pi^+\pi^-)$	(1.2 ± 0.8) %		1707
$\rho^0 \pi^+ \pi^-$	$(7 \pm 4) \times 10^{-3}$		1683
$K^+ \overline{K}^*(892)^0 \pi^- +$ c.c.	$(4.8 \pm 2.8) \times 10^{-3}$		1601
$\pi^+\pi^- p \overline{p}$	$(3.3 \pm 1.3) \times 10^{-3}$		1410
$\pi^+\pi^-$	$(1.9 \pm 1.0) \times 10^{-3}$		1773
$K^+ K^-$	$(1.5 \pm 1.1) \times 10^{-3}$		1708
$p \overline{p}$	$(10.0 \pm 1.0) \times 10^{-5}$		1510
$J/\psi(1S) \pi^+ \pi^- \pi^0$	< 1.5 %	90%	185
Radiative decays			
$\gamma J/\psi(1S)$	(13.5 ± 1.1) %		430
$\gamma\gamma$	$(1.6 \pm 0.5) \times 10^{-4}$		1778

$\psi(2S)$

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

Mass $m = 3686.00 \pm 0.09$ MeV
Full width $\Gamma = 277 \pm 31$ keV (S = 1.1)
$\Gamma_{ee} = 2.14 \pm 0.21$ keV (Assuming $\Gamma_{ee} = \Gamma_{\mu\mu}$)

$\psi(2S)$ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
hadrons	(98.10 ± 0.30) %		–
virtual$\gamma \to$ hadrons	(2.9 ± 0.4) %		–
$e^+ e^-$	$(8.5 \pm 0.7) \times 10^{-3}$		1843
$\mu^+ \mu^-$	$(7.7 \pm 1.7) \times 10^{-3}$		1840
Decays into $J/\psi(1S)$ and anything			
$J/\psi(1S)$anything	(54.2 ± 3.0) %		–
$J/\psi(1S)$neutrals	(22.8 ± 1.7) %		–
$J/\psi(1S) \pi^+ \pi^-$	(30.2 ± 1.9) %		477
$J/\psi(1S) \pi^0 \pi^0$	(17.9 ± 1.8) %		481
$J/\psi(1S) \eta$	(2.7 ± 0.4) %	S=1.7	200
$J/\psi(1S) \pi^0$	$(9.7 \pm 2.1) \times 10^{-4}$		527
$J/\psi(1S) \mu^+ \mu^-$	$(10.0 \pm 3.3) \times 10^{-3}$		–
Hadronic decays			
$3(\pi^+\pi^-)\pi^0$	$(3.5 \pm 1.6) \times 10^{-3}$		1746
$2(\pi^+\pi^-)\pi^0$	$(3.0 \pm 0.8) \times 10^{-3}$		1799
$\pi^+\pi^- K^+ K^-$	$(1.6 \pm 0.4) \times 10^{-3}$		1726
$\pi^+\pi^- p \overline{p}$	$(8.0 \pm 2.0) \times 10^{-4}$		1491
$K^+ \overline{K}^*(892)^0 \pi^- +$ c.c.	$(6.7 \pm 2.5) \times 10^{-4}$		1673
$2(\pi^+\pi^-)$	$(4.5 \pm 1.0) \times 10^{-4}$		1817
$\rho^0 \pi^+ \pi^-$	$(4.2 \pm 1.5) \times 10^{-4}$		1751
$\overline{p} p$	$(1.9 \pm 0.5) \times 10^{-4}$		1586
$3(\pi^+\pi^-)$	$(1.5 \pm 1.0) \times 10^{-4}$		1774
$\overline{p} p \pi^0$	$(1.4 \pm 0.5) \times 10^{-4}$		1543
$K^+ K^-$	$(1.0 \pm 0.7) \times 10^{-4}$		1776
$\pi^+\pi^-\pi^0$	$(9 \pm 5) \times 10^{-5}$		1830
$\rho\pi$	$< 8.3 \times 10^{-5}$	CL=90%	1760
$\pi^+\pi^-$	$(8 \pm 5) \times 10^{-5}$		1838
$\Lambda\overline{\Lambda}$	$< 4 \times 10^{-4}$	CL=90%	1467
$\Xi^- \overline{\Xi}^+$	$< 2 \times 10^{-4}$	CL=90%	1285
$K^+ K^- \pi^0$	$< 2.96 \times 10^{-5}$	CL=90%	1754
$K^+ \overline{K}^*(892)^- +$ c.c.	$< 5.4 \times 10^{-5}$	CL=90%	1698
Radiative decays			
$\gamma\chi_{c0}(1P)$	(9.3 ± 0.9) %		261
$\gamma\chi_{c1}(1P)$	(8.7 ± 0.8) %		171
$\gamma\chi_{c2}(1P)$	(7.8 ± 0.8) %		127
$\gamma\eta_c(1S)$	$(2.8 \pm 0.6) \times 10^{-3}$		639
$\gamma\eta'(958)$	$< 1.1 \times 10^{-3}$	CL=90%	1719
$\gamma\gamma$	$< 1.6 \times 10^{-4}$	CL=90%	1843
$\gamma\eta(1440) \to \gamma K \overline{K} \pi$	$< 1.2 \times 10^{-4}$	CL=90%	1569

$\psi(3770)$

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

Mass $m = 3769.9 \pm 2.5$ MeV (S = 1.8)
Full width $\Gamma = 23.6 \pm 2.7$ MeV (S = 1.1)
$\Gamma_{ee} = 0.26 \pm 0.04$ keV (S = 1.2)

$\psi(3770)$ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor	p (MeV/c)
$D\overline{D}$	dominant		242
$e^+ e^-$	$(1.12 \pm 0.17) \times 10^{-5}$	1.2	1885

$\psi(4040)$ [iii]

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

Mass $m = 4040 \pm 10$ MeV
Full width $\Gamma = 52 \pm 10$ MeV
$\Gamma_{ee} = 0.75 \pm 0.15$ keV

$\psi(4040)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$e^+ e^-$	$(1.4 \pm 0.4) \times 10^{-5}$	2020
$D^0 \overline{D}^0$	seen	777
$D^*(2007)^0 \overline{D}^0 +$ c.c.	seen	578
$D^*(2007)^0 \overline{D}^*(2007)^0$	seen	232

$\psi(4160)$ [iii]

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

Mass $m = 4159 \pm 20$ MeV
Full width $\Gamma = 78 \pm 20$ MeV
$\Gamma_{ee} = 0.77 \pm 0.23$ keV

$\psi(4160)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
e^+e^-	$(10\pm4)\times10^{-6}$	2079

$\psi(4415)$ [iii]

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

Mass $m = 4415 \pm 6$ MeV
Full width $\Gamma = 43 \pm 15$ MeV (S = 1.8)
$\Gamma_{ee} = 0.47 \pm 0.10$ keV

$\psi(4415)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
hadrons	dominant	–
e^+e^-	$(1.1\pm0.4)\times10^{-5}$	2207

$b\overline{b}$ MESONS

$\Upsilon(1S)$

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

Mass $m = 9460.37 \pm 0.21$ MeV (S = 2.7)
Full width $\Gamma = 52.5 \pm 1.8$ keV
$\Gamma_{ee} = 1.32 \pm 0.05$ keV

$\Upsilon(1S)$ DECAY MODES	Fraction (Γ_i/Γ)		Scale factor/ Confidence level	p (MeV/c)
$\tau^+\tau^-$	$(2.67^{+0.14}_{-0.16})$ %			4384
e^+e^-	(2.52 ± 0.17) %			4730
$\mu^+\mu^-$	(2.48 ± 0.07) %		S=1.1	4729
Hadronic decays				
$J/\psi(1S)$anything	$(1.1\ \pm0.4\ )$	$\times10^{-3}$		4223
$\rho\pi$	<2	$\times10^{-4}$	CL=90%	4698
$\pi^+\pi^-$	<5	$\times10^{-4}$	CL=90%	4728
K^+K^-	<5	$\times10^{-4}$	CL=90%	4704
$p\overline{p}$	<5	$\times10^{-4}$	CL=90%	4636
Radiative decays				
$\gamma 2h^+2h^-$	$(7.0\ \pm1.5\ )$	$\times10^{-4}$		4720
$\gamma 3h^+3h^-$	$(5.4\ \pm2.0\ )$	$\times10^{-4}$		4703
$\gamma 4h^+4h^-$	$(7.4\ \pm3.5\ )$	$\times10^{-4}$		4679
$\gamma\pi^+\pi^-K^+K^-$	$(2.9\ \pm0.9\ )$	$\times10^{-4}$		4686
$\gamma 2\pi^+2\pi^-$	$(2.5\ \pm0.9\ )$	$\times10^{-4}$		4720
$\gamma 3\pi^+3\pi^-$	$(2.5\ \pm1.2\ )$	$\times10^{-4}$		4703
$\gamma 2\pi^+2\pi^-K^+K^-$	$(2.4\ \pm1.2\ )$	$\times10^{-4}$		4658
$\gamma\pi^+\pi^-p\overline{p}$	$(1.5\ \pm0.6\ )$	$\times10^{-4}$		4604
$\gamma 2\pi^+2\pi^-p\overline{p}$	$(4\ \ \pm6\ \ )$	$\times10^{-5}$		4563
$\gamma 2K^+2K^-$	$(2.0\ \pm2.0\ )$	$\times10^{-5}$		4601
$\gamma\eta'(958)$	<1.3	$\times10^{-3}$	CL=90%	4682
$\gamma\eta$	<3.5	$\times10^{-4}$	CL=90%	4714
$\gamma f'_2(1525)$	<1.4	$\times10^{-4}$	CL=90%	4607
$\gamma f_2(1270)$	<1.3	$\times10^{-4}$	CL=90%	4644
$\gamma\eta(1440)$	<8.2	$\times10^{-5}$	CL=90%	4624
$\gamma f_J(1710) \to \gamma K\overline{K}$	<2.6	$\times10^{-4}$	CL=90%	4576
$\gamma f_0(2200) \to \gamma K^+K^-$	<2	$\times10^{-4}$	CL=90%	4475
$\gamma f_J(2220) \to \gamma K^+K^-$	<1.5	$\times10^{-5}$	CL=90%	4469
$\gamma\eta(2225) \to \gamma\phi\phi$	<3	$\times10^{-3}$	CL=90%	4469
γX	<3	$\times10^{-5}$	CL=90%	–
X = pseudoscalar with $m<7.2$ GeV)				
$\gamma X\overline{X}$	<1	$\times10^{-3}$	CL=90%	–
$X\overline{X}$ = vectors with $m<3.1$ GeV)				

$\chi_{b0}(1P)$ [jjj]

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

Mass $m = 9859.8 \pm 1.3$ MeV

$\chi_{b0}(1P)$ DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$\gamma\,\Upsilon(1S)$	<6 %	90%	391

$\chi_{b1}(1P)$ [jjj]

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

Mass $m = 9891.9 \pm 0.7$ MeV

$\chi_{b1}(1P)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\gamma\,\Upsilon(1S)$	(35 ± 8) %	422

$\chi_{b2}(1P)$ [jjj]

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

Mass $m = 9913.2 \pm 0.6$ MeV

$\chi_{b2}(1P)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\gamma\,\Upsilon(1S)$	(22 ± 4) %	443

$\Upsilon(2S)$

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

Mass $m = 10.02330 \pm 0.00031$ GeV
Full width $\Gamma = 44 \pm 7$ keV
$\Gamma_{ee} = 0.520 \pm 0.032$ keV

$\Upsilon(2S)$ DECAY MODES	Fraction (Γ_i/Γ)		Confidence level	p (MeV/c)
$\Upsilon(1S)\pi^+\pi^-$	$(18.5\ \pm0.8\ )$ %			475
$\Upsilon(1S)\pi^0\pi^0$	$(\ 8.8\ \pm1.1\ )$ %			480
$\tau^+\tau^-$	$(\ 1.7\ \pm1.6\ )$ %			4686
$\mu^+\mu^-$	$(\ 1.31\pm0.21)$ %			5011
e^+e^-	$(\ 1.18\pm0.20)$ %			5012
$\Upsilon(1S)\pi^0$	$<\ 8$	$\times10^{-3}$	90%	531
$\Upsilon(1S)\eta$	$<\ 2$	$\times10^{-3}$	90%	127
$J/\psi(1S)$anything	$<\ 6$	$\times10^{-3}$	90%	4533
Radiative decays				
$\gamma\chi_{b1}(1P)$	$(\ 6.7\ \pm0.9\ )$ %			131
$\gamma\chi_{b2}(1P)$	$(\ 6.6\ \pm0.9\ )$ %			110
$\gamma\chi_{b0}(1P)$	$(\ 4.3\ \pm1.0\ )$ %			162
$\gamma f_J(1710)$	$<\ 5.9$	$\times10^{-4}$	90%	4866
$\gamma f'_2(1525)$	$<\ 5.3$	$\times10^{-4}$	90%	4896
$\gamma f_2(1270)$	$<\ 2.41$	$\times10^{-4}$	90%	4931

$\chi_{b0}(2P)$ [jjj]

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

Mass $m = 10.2321 \pm 0.0006$ GeV

$\chi_{b0}(2P)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\gamma\,\Upsilon(2S)$	(4.6 ± 2.1) %	210
$\gamma\,\Upsilon(1S)$	$(9\ \ \pm6\ \ )\times10^{-3}$	746

$\chi_{b1}(2P)$ [jjj]

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

Mass $m = 10.2552 \pm 0.0005$ GeV
$m_{\chi_{b1}(2P)} - m_{\chi_{b0}(2P)} = 23.5 \pm 1.0$ MeV

$\chi_{b1}(2P)$ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor	p (MeV/c)
$\gamma\,\Upsilon(2S)$	$(21\ \ \pm4\ \ )$ %	1.5	229
$\gamma\,\Upsilon(1S)$	$(\ 8.5\pm1.3)$ %	1.3	764

$\chi_{b2}(2P)$ [jjj]

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

Mass $m = 10.2685 \pm 0.0004$ GeV
$m_{\chi_{b2}(2P)} - m_{\chi_{b1}(2P)} = 13.5 \pm 0.6$ MeV

$\chi_{b2}(2P)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\gamma\,\Upsilon(2S)$	(16.2 ± 2.4) %	242
$\gamma\,\Upsilon(1S)$	$(\ 7.1\pm1.0)$ %	776

$\Upsilon(3S)$

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

Mass $m = 10.3553 \pm 0.0005$ GeV
Full width $\Gamma = 26.3 \pm 3.5$ keV

$\Upsilon(3S)$ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
$\Upsilon(2S)$anything	(10.6 ±0.8) %		296
$\Upsilon(2S)\pi^+\pi^-$	(2.8 ±0.6) %	S=2.2	177
$\Upsilon(2S)\pi^0\pi^0$	(2.00±0.32) %		190
$\Upsilon(2S)\gamma\gamma$	(5.0 ±0.7) %		327
$\Upsilon(1S)\pi^+\pi^-$	(4.48±0.21) %		814
$\Upsilon(1S)\pi^0\pi^0$	(2.06±0.28) %		816
$\Upsilon(1S)\eta$	< 2.2 × 10^{-3}	CL=90%	–
$\mu^+\mu^-$	(1.81±0.17) %		5177
e^+e^-	seen		5177
Radiative decays			
$\gamma\chi_{b2}(2P)$	(11.4 ±0.8) %	S=1.3	87
$\gamma\chi_{b1}(2P)$	(11.3 ±0.6) %		100
$\gamma\chi_{b0}(2P)$	(5.4 ±0.6) %	S=1.1	123

$\Upsilon(4S)$ or $\Upsilon(10580)$

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

Mass $m = 10.5800 \pm 0.0035$ GeV
Full width $\Gamma = 10 \pm 4$ MeV
$\Gamma_{ee} = 0.248 \pm 0.031$ keV (S = 1.3)

$\Upsilon(4S)$ DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$B\overline{B}$	> 96 %	95%	–
non-$B\overline{B}$	< 4 %	95%	–
e^+e^-	(2.8±0.7) × 10^{-5}		5290
$J/\psi(3097)$anything	(2.2±0.7) × 10^{-3}		–
D^{*+}anything + c.c.	< 7.4 %	90%	5099
ϕanything	< 2.3 × 10^{-3}	90%	5240
$\Upsilon(1S)$anything	< 4 × 10^{-3}	90%	1053

$\Upsilon(10860)$

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

Mass $m = 10.865 \pm 0.008$ GeV (S = 1.1)
Full width $\Gamma = 110 \pm 13$ MeV
$\Gamma_{ee} = 0.31 \pm 0.07$ keV (S = 1.3)

$\Upsilon(10860)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
e^+e^-	(2.8±0.7) × 10^{-6}	5432

$\Upsilon(11020)$

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

Mass $m = 11.019 \pm 0.008$ GeV
Full width $\Gamma = 79 \pm 16$ MeV
$\Gamma_{ee} = 0.130 \pm 0.030$ keV

$\Upsilon(11020)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
e^+e^-	(1.6±0.5) × 10^{-6}	5509

NOTES

In this Summary Table:

When a quantity has "(S = ...)" to its right, the error on the quantity has been enlarged by the "scale factor" S, defined as S $= \sqrt{\chi^2/(N-1)}$, where N is the number of measurements used in calculating the quantity. We do this when S > 1, which often indicates that the measurements are inconsistent. When S > 1.25, we also show in the Particle Listings an ideogram of the measurements. For more about S, see the Introduction.

A decay momentum p is given for each decay mode. For a 2-body decay, p is the momentum of each decay product in the rest frame of the decaying particle. For a 3-or-more-body decay, p is the largest momentum any of the products can have in this frame.

[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 $[\Gamma(e^+\nu_e) + \Gamma(\mu^+\nu_\mu)]/\Gamma_{total} = 100\%$.

[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] See the "Note on the Decay Width $\Gamma(\eta \to \gamma\gamma)$" in our 1994 edition, Phys. Rev. **D50**, 1 August 1994, Part I, p. 1451.

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

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

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

[j] The e^+e^- branching fraction is from $e^+e^- \to \pi^+\pi^-$ experiments only. The $\omega\rho$ interference is then due to $\omega\rho$ mixing only, and is expected to be small. If $e\mu$ universality holds, $\Gamma(\rho^0 \to \mu^+\mu^-) = \Gamma(\rho^0 \to e^+e^-) \times 0.99785$.

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

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

[m] 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 the $f_1(1420)$" in the $\eta(1440)$ Particle Listings.

[o] See also the $\omega(1600)$ Particle Listings.

[p] See the "Note on the $\eta(1440)$" in the $\eta(1440)$ Particle Listings.

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

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

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

[t] See the "Note on $f_J(1710)$" in the $f_J(1710)$ Particle Listings .

[u] See the note in the $K^\pm$ Particle Listings.

[v] The definition of the slope parameter g of the $K \to 3\pi$ Dalitz plot is as follows (see also "Note on Dalitz Plot Parameters for $K \to 3\pi$ Decays" in the $K^\pm$ Particle Listings):

$$|M|^2 = 1 + g(s_3 - s_0)/m_{\pi^-}^2 + \cdots .$$

[*w*] For more details and definitions of parameters see the Particle Listings.

[*x*] See the $K^{\pm}$ Particle Listings for the energy limits used in this measurement.

[*y*] Most of this radiative mode, the low-momentum γ part, is also included in the parent mode listed without γ's.

[*z*] Direct-emission branching fraction.

[*aa*] Structure-dependent part.

[*bb*] Derived from measured values of ϕ_{+-}, ϕ_{00}, $|\eta|$, $|m_{K^0_L} - m_{K^0_S}|$, and $\tau_{K^0_S}$, as described in the introduction to "Tests of Conservation Laws."

[*cc*] The *CP*-violation parameters are defined as follows (see also "Note on *CP* Violation in $K_S \to 3\pi$" and "Note on *CP* Violation in K^0_L Decay" in the Particle Listings):

$$\eta_{+-} = |\eta_{+-}|e^{i\phi_{+-}} = \frac{A(K^0_L \to \pi^+\pi^-)}{A(K^0_S \to \pi^+\pi^-)} = \epsilon + \epsilon'$$

$$\eta_{00} = |\eta_{00}|e^{i\phi_{00}} = \frac{A(K^0_L \to \pi^0\pi^0)}{A(K^0_S \to \pi^0\pi^0)} = \epsilon - 2\epsilon'$$

$$\delta = \frac{\Gamma(K^0_L \to \pi^-\ell^+\nu) - \Gamma(K^0_L \to \pi^+\ell^-\nu)}{\Gamma(K^0_L \to \pi^-\ell^+\nu) + \Gamma(K^0_L \to \pi^+\ell^-\nu)},$$

$$\mathrm{Im}(\eta_{+-0})^2 = \frac{\Gamma(K^0_S \to \pi^+\pi^-\pi^0)^{CP\ \mathrm{viol.}}}{\Gamma(K^0_L \to \pi^+\pi^-\pi^0)},$$

$$\mathrm{Im}(\eta_{000})^2 = \frac{\Gamma(K^0_S \to \pi^0\pi^0\pi^0)}{\Gamma(K^0_L \to \pi^0\pi^0\pi^0)} .$$

where for the last two relations *CPT* is assumed valid, *i.e.*, $\mathrm{Re}(\eta_{+-0}) \simeq 0$ and $\mathrm{Re}(\eta_{000}) \simeq 0$.

[*dd*] See the K^0_S Particle Listings for the energy limits used in this measurement.

[*ee*] Calculated from K^0_L semileptonic rates and the K^0_S lifetime assuming $\Delta S = \Delta Q$.

[*ff*] ϵ'/ϵ is derived from $|\eta_{00}/\eta_{+-}|$ measurements using theoretical input on phases.

[*gg*] The value is for the sum of the charge states of particle/antiparticle states indicated.

[*hh*] See the K^0_L Particle Listings for the energy limits used in this measurement.

[*ii*] Allowed by higher-order electroweak interactions.

[*jj*] Violates *CP* in leading order. Test of direct *CP* violation since the indirect *CP*-violating and *CP*-conserving contributions are expected to be suppressed.

[*kk*] See the "Note on $f_0(1370)$" in the $f_0(1370)$ Particle Listings and in the 1994 edition.

[*ll*] See the note in the $L(1770)$ Particle Listings in Reviews of Modern Physics **56** No. 2 Pt. II (1984), p. S200. See also the "Note on $K_2(1770)$ and the $K_2(1820)$" in the $K_2(1770)$ Particle Listings .

[*mm*] See the "Note on $K_2(1770)$ and the $K_2(1820)$" in the $K_2(1770)$ Particle Listings .

[*nn*] This is a weighted average of $D^{\pm}$ (44%) and D^0 (56%) branching fractions. See "D^+ and $D^0 \to$ (η anything) / (total D^+ and D^0)" under "D^+ Branching Ratios" in the Particle Listings.

[*oo*] This value averages the e^+ and μ^+ branching fractions, after making a small phase-space adjustment to the μ^+ fraction to be able to use it as an e^+ fraction; hence our ℓ^+ here is really an e^+.

[*pp*] An ℓ indicates an e or a μ mode, not a sum over these modes.

[*qq*] The branching fraction for this mode may differ from the sum of the submodes that contribute to it, due to interference effects. See the relevant papers in the Particle Listings.

[*rr*] The two experiments measuring this fraction are in serious disagreement. See the Particle Listings.

[*ss*] This mode is not a useful test for a ΔC=1 weak neutral current because both quarks must change flavor in this decay.

[*tt*] The D^0_1-D^0_2 limits are inferred from the D^0-$\overline{D}^0$ mixing ratio $\Gamma(K^+\ell^-\overline{\nu}_\ell(\text{via } \overline{D}^0))$ / $\Gamma(K^-\ell^+\nu_\ell)$.

[*uu*] The larger limit (from E791) allows interference between the doubly Cabibbo-suppressed and mixing amplitudes; the smaller limit (from E691) doesn't. See the papers for details.

[*vv*] The experiments on the division of this charge mode amongst its submodes disagree, and the submode branching fractions here add up to considerably more than the charged-mode fraction.

[*ww*] However, these upper limits are in serious disagreement with values obtained in another experiment.

[*xx*] For now, we average together measurements of the $X e^+\nu_e$ and $X\mu^+\nu_\mu$ branching fractions. This is the *average*, not the *sum*.

[*yy*] This branching fraction includes all the decay modes of the final-state resonance.

[*zz*] This value includes only K^+K^- decays of the $f_J(1710)$, because branching fractions of this resonance are not known.

[*aaa*] This value includes only $\pi^+\pi^-$ decays of the $f_0(1500)$, because branching fractions of this resonance are not known.

[*bbb*] B^0 and B^0_s contributions not separated. Limit is on weighted average of the two decay rates.

[*ccc*] These values are model dependent. See 'Note on Semileptonic Decays' in the B^+ Particle Listings.

[*ddd*] D^{**} stands for the sum of the $D(1\,^1P_1)$, $D(1\,^3P_0)$, $D(1\,^3P_1)$, $D(1\,^3P_2)$, $D(2\,^1S_0)$, and $D(2\,^1S_1)$ resonances.

[*eee*] Inclusive branching fractions have a multiplicity definition and can be greater than 100%.

[*fff*] D_j represents an unresolved mixture of pseudoscalar and tensor D^{**} (*P*-wave) states.

[*ggg*] Not a pure measurement. See note at head of B^0_s Decay Modes.

[*hhh*] Includes $p\overline{p}\pi^+\pi^-\gamma$ and excludes $p\overline{p}\eta$, $p\overline{p}\omega$, $p\overline{p}\eta'$.

[*iii*] J^{PC} known by production in e^+e^- via single photon annihilation. I^G is not known; interpretation of this state as a single resonance is unclear because of the expectation of substantial threshold effects in this energy region.

[*jjj*] Spectroscopic labeling for these states is theoretical, pending experimental information.

See also the table of suggested $q\overline{q}$ quark-model assignments in the Quark Model section.

- • Indicates particles that appear in the preceding Meson Summary Table. We do not regard the other entries as being established.
- † Indicates that the value of J given is preferred, but needs confirmation.

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

	$I^G(J^{PC})$		$I^G(J^{PC})$
• $\pi^\pm$	$1^-(0^-)$	$X(1650)$	$0^+(?^{?-})$
• π^0	$1^-(0^{-+})$	• $\omega_3(1670)$	$0^-(3^{--})$
• η	$0^+(0^{-+})$	• $\pi_2(1670)$	$1^-(2^{-+})$
• $f_0(400\text{–}1200)$	$0^+(0^{++})$	• $\phi(1680)$	$0^-(1^{--})$
• $\rho(770)$	$1^+(1^{--})$	• $\rho_3(1690)$	$1^+(3^{--})$
• $\omega(782)$	$0^-(1^{--})$	• $\rho(1700)$	$1^+(1^{--})$
• $\eta'(958)$	$0^+(0^{-+})$	• $f_J(1710)$	$0^+(\text{even}^{++})$
• $f_0(980)$	$0^+(0^{++})$	$\eta(1760)$	$0^+(0^{-+})$
• $a_0(980)$	$1^-(0^{++})$	$X(1775)$	$1^-(?^{-+})$
• $\phi(1020)$	$0^-(1^{--})$	• $\pi(1800)$	$1^-(0^{-+})$
• $h_1(1170)$	$0^-(1^{+-})$	$f_2(1810)$	$0^+(2^{++})$
• $b_1(1235)$	$1^+(1^{+-})$	• $\phi_3(1850)$	$0^-(3^{--})$
• $a_1(1260)$	$1^-(1^{++})$	$\eta_2(1870)$	$0^+(2^{-+})$
• $f_2(1270)$	$0^+(2^{++})$	$X(1910)$	$0^+(?^{?+})$
• $f_1(1285)$	$0^+(1^{++})$	$f_2(1950)$	$0^+(2^{++})$
• $\eta(1295)$	$0^+(0^{-+})$	$X(2000)$	$1^-(?^{?+})$
• $\pi(1300)$	$1^-(0^{-+})$	• $f_2(2010)$	$0^+(2^{++})$
• $a_2(1320)$	$1^-(2^{++})$	$f_0(2020)$	$0^+(0^{++})$
• $f_0(1370)$	$0^+(0^{++})$	• $a_4(2040)$	$1^-(4^{++})$
$h_1(1380)$	$?^-(1^{+-})$	• $f_4(2050)$	$0^+(4^{++})$
$\hat{\rho}(1405)$	$1^-(1^{-+})$	$f_0(2060)$	$0^+(0^{++})$
• $f_1(1420)$	$0^+(1^{++})$	$\pi_2(2100)$	$1^-(2^{-+})$
• $\omega(1420)$	$0^-(1^{--})$	$f_2(2150)$	$0^+(2^{++})$
$f_2(1430)$	$0^+(2^{++})$	$\rho(2150)$	$1^+(1^{--})$
• $\eta(1440)$	$0^+(0^{-+})$	$f_0(2200)$	$0^+(0^{++})$
• $a_0(1450)$	$1^-(0^{++})$	$f_J(2220)$	$0^+(2^{++}$ or $4^{++})$
• $\rho(1450)$	$1^+(1^{--})$		
• $f_0(1500)$	$0^+(0^{++})$	$\eta(2225)$	$0^+(0^{-+})$
$f_1(1510)$	$0^+(1^{++})$	$\rho_3(2250)$	$1^+(3^{--})$
• $f_2'(1525)$	$0^+(2^{++})$	• $f_2(2300)$	$0^+(2^{++})$
$f_2(1565)$	$0^+(2^{++})$	$f_4(2300)$	$0^+(4^{++})$
• $\omega(1600)$	$0^-(1^{--})$	• $f_2(2340)$	$0^+(2^{++})$
$X(1600)$	$2^+(2^{++})$	$\rho_5(2350)$	$1^+(5^{--})$
$f_2(1640)$	$0^+(2^{++})$	$a_6(2450)$	$1^-(6^{++})$
$\eta_2(1645)$	$0^+(2^{-+})$	$f_6(2510)$	$0^+(6^{++})$
		$X(3250)$	$?^?(?^{??})$

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

$e^+e^-(1100\text{–}2200)$	$?^?(1^{--})$
$\overline{N}N(1100\text{–}3600)$	
$X(1900\text{–}3600)$	

STRANGE ($S = \pm1$, $C = B = 0$)

	$I(J^P)$
• $K^\pm$	$1/2(0^-)$
• K^0	$1/2(0^-)$
• K^0_S	$1/2(0^-)$
• K^0_L	$1/2(0^-)$
• $K^*(892)$	$1/2(1^-)$
• $K_1(1270)$	$1/2(1^+)$
• $K_1(1400)$	$1/2(1^+)$
• $K^*(1410)$	$1/2(1^-)$
• $K^*_0(1430)$	$1/2(0^+)$
• $K^*_2(1430)$	$1/2(2^+)$
$K(1460)$	$1/2(0^-)$
$K_2(1580)$	$1/2(2^-)$
$K_1(1650)$	$1/2(1^+)$
• $K^*(1680)$	$1/2(1^-)$
• $K_2(1770)$	$1/2(2^-)$
• $K^*_3(1780)$	$1/2(3^-)$
• $K_2(1820)$	$1/2(2^-)$
$K(1830)$	$1/2(0^-)$
$K^*_0(1950)$	$1/2(0^+)$
$K^*_2(1980)$	$1/2(2^+)$
• $K^*_4(2045)$	$1/2(4^+)$
$K_2(2250)$	$1/2(2^-)$
$K_3(2320)$	$1/2(3^+)$
$K^*_5(2380)$	$1/2(5^-)$
$K_4(2500)$	$1/2(4^-)$
$K(3100)$	$?^?(?^{??})$

CHARMED ($C = \pm1$)

• $D^\pm$	$1/2(0^-)$
• D^0	$1/2(0^-)$
• $D^*(2007)^0$	$1/2(1^-)$
• $D^*(2010)^\pm$	$1/2(1^-)$
• $D_1(2420)^0$	$1/2(1^+)$
$D_1(2420)^\pm$	$1/2(?^?)$
• $D^*_2(2460)^0$	$1/2(2^+)$
• $D^*_2(2460)^+$	$1/2(2^+)$

CHARMED, STRANGE ($C = S = \pm1$)

• $D^\pm_s$	$0(0^-)$
• $D^{*\pm}_s$	$0(?^?)$
• $D_{s1}(2536)^\pm$	$0(1^+)$
• $D_{sJ}(2573)^\pm$	$0(?^?)$

BOTTOM ($B = \pm1$)

• $B^\pm$	$1/2(0^-)$
• B^0	$1/2(0^-)$
• B^*	$1/2(1^-)$
$B^*_J(5732)$	$?(?^?)$

BOTTOM, STRANGE ($B = \pm1$, $S = \mp1$)

	$I^G(J^{PC})$
• B^0_s	$0(0^-)$
B^*_s	$0(1^-)$
$B^*_{sJ}(5850)$	$?(?^?)$

BOTTOM, CHARMED ($B = C = \pm1$)

$B^\pm_c$	$0(0^-)$

$c\overline{c}$

• $\eta_c(1S)$	$0^+(0^{-+})$
• $J/\psi(1S)$	$0^-(1^{--})$
• $\chi_{c0}(1P)$	$0^+(0^{++})$
• $\chi_{c1}(1P)$	$0^+(1^{++})$
$h_c(1P)$	$?^?(?^{??})$
• $\chi_{c2}(1P)$	$0^+(2^{++})$
$\eta_c(2S)$	$?^?(?^{?+})$
• $\psi(2S)$	$0^-(1^{--})$
• $\psi(3770)$	$?^?(1^{--})$
• $\psi(4040)$	$?^?(1^{--})$
• $\psi(4160)$	$?^?(1^{--})$
• $\psi(4415)$	$?^?(1^{--})$

$b\overline{b}$

• $\Upsilon(1S)$	$0^-(1^{--})$
• $\chi_{b0}(1P)$	$0^+(0^{++})$
• $\chi_{b1}(1P)$	$0^+(1^{++})$
• $\chi_{b2}(1P)$	$0^+(2^{++})$
• $\Upsilon(2S)$	$0^-(1^{--})$
• $\chi_{b0}(2P)$	$0^+(0^{++})$
• $\chi_{b1}(2P)$	$0^+(1^{++})$
• $\chi_{b2}(2P)$	$0^+(2^{++})$
• $\Upsilon(3S)$	$0^-(1^{--})$
• $\Upsilon(4S)$	$?^?(1^{--})$
• $\Upsilon(10860)$	$?^?(1^{--})$
• $\Upsilon(11020)$	$?^?(1^{--})$

NON-$q\overline{q}$ CANDIDATES

Non-$q\overline{q}$ Candidates

BARYON SUMMARY TABLE

This short table gives the name, the quantum numbers (where known), and the status of baryons in the Review. Only the baryons with 3- or 4-star status are included in the main Baryon Summary Table. Due to insufficient data or uncertain interpretation, the other entries in the short table are not established as baryons. The names with masses are of baryons that decay strongly. See our 1986 edition (Physics Letters **170B**) for listings of evidence for Z baryons (KN resonances).

p	P_{11}	****	$\Delta(1232)$	P_{33}	****	Λ	P_{01}	****	Σ^+	P_{11}	****	Ξ^0	P_{11}	****
n	P_{11}	****	$\Delta(1600)$	P_{33}	***	$\Lambda(1405)$	S_{01}	****	Σ^0	P_{11}	****	Ξ^-	P_{11}	****
$N(1440)$	P_{11}	****	$\Delta(1620)$	S_{31}	****	$\Lambda(1520)$	D_{03}	****	Σ^-	P_{11}	****	$\Xi(1530)$	P_{13}	****
$N(1520)$	D_{13}	****	$\Delta(1700)$	D_{33}	****	$\Lambda(1600)$	P_{01}	***	$\Sigma(1385)$	P_{13}	****	$\Xi(1620)$		*
$N(1535)$	S_{11}	****	$\Delta(1750)$	P_{31}	*	$\Lambda(1670)$	S_{01}	****	$\Sigma(1480)$		*	$\Xi(1690)$		***
$N(1650)$	S_{11}	****	$\Delta(1900)$	S_{31}	**	$\Lambda(1690)$	D_{03}	****	$\Sigma(1560)$		**	$\Xi(1820)$	D_{13}	***
$N(1675)$	D_{15}	****	$\Delta(1905)$	F_{35}	****	$\Lambda(1800)$	S_{01}	***	$\Sigma(1580)$	D_{13}	**	$\Xi(1950)$		***
$N(1680)$	F_{15}	****	$\Delta(1910)$	P_{31}	****	$\Lambda(1810)$	P_{01}	***	$\Sigma(1620)$	S_{11}	**	$\Xi(2030)$		***
$N(1700)$	D_{13}	***	$\Delta(1920)$	P_{33}	***	$\Lambda(1820)$	F_{05}	****	$\Sigma(1660)$	P_{11}	***	$\Xi(2120)$		*
$N(1710)$	P_{11}	***	$\Delta(1930)$	D_{35}	***	$\Lambda(1830)$	D_{05}	****	$\Sigma(1670)$	D_{13}	****	$\Xi(2250)$		**
$N(1720)$	P_{13}	****	$\Delta(1940)$	D_{33}	*	$\Lambda(1890)$	P_{03}	****	$\Sigma(1690)$		**	$\Xi(2370)$		**
$N(1900)$	P_{13}	**	$\Delta(1950)$	F_{37}	****	$\Lambda(2000)$		*	$\Sigma(1750)$	S_{11}	***	$\Xi(2500)$		*
$N(1990)$	F_{17}	**	$\Delta(2000)$	F_{35}	**	$\Lambda(2020)$	F_{07}	*	$\Sigma(1770)$	P_{11}	*			
$N(2000)$	F_{15}	**	$\Delta(2150)$	S_{31}	*	$\Lambda(2100)$	G_{07}	****	$\Sigma(1775)$	D_{15}	****	Ω^-		****
$N(2080)$	D_{13}	**	$\Delta(2200)$	G_{37}	*	$\Lambda(2110)$	F_{05}	***	$\Sigma(1840)$	P_{13}	*	$\Omega(2250)^-$		***
$N(2090)$	S_{11}	*	$\Delta(2300)$	H_{39}	**	$\Lambda(2325)$	D_{03}	*	$\Sigma(1880)$	P_{11}	**	$\Omega(2380)^-$		**
$N(2100)$	P_{11}	*	$\Delta(2350)$	D_{35}	*	$\Lambda(2350)$	H_{09}	***	$\Sigma(1915)$	F_{15}	****	$\Omega(2470)^-$		**
$N(2190)$	G_{17}	****	$\Delta(2390)$	F_{37}	*	$\Lambda(2585)$		**	$\Sigma(1940)$	D_{13}	***			
$N(2200)$	D_{15}	**	$\Delta(2400)$	G_{39}	**				$\Sigma(2000)$	S_{11}	*	Λ_c^+		****
$N(2220)$	H_{19}	****	$\Delta(2420)$	$H_{3,11}$	****				$\Sigma(2030)$	F_{17}	****	$\Lambda_c(2593)^+$		***
$N(2250)$	G_{19}	****	$\Delta(2750)$	$I_{3,13}$	**				$\Sigma(2070)$	F_{15}	*	$\Lambda_c(2625)^+$		***
$N(2600)$	$I_{1,11}$	***	$\Delta(2950)$	$K_{3,15}$	**				$\Sigma(2080)$	P_{13}	**	$\Sigma_c(2455)$		****
$N(2700)$	$K_{1,13}$	**							$\Sigma(2100)$	G_{17}	*	$\Sigma_c(2520)$		***
									$\Sigma(2250)$		***	Ξ_c^+		***
									$\Sigma(2455)$		**	Ξ_c^0		***
									$\Sigma(2620)$		**	$\Xi_c(2645)$		***
									$\Sigma(3000)$		*	Ω_c^0		***
									$\Sigma(3170)$		*			
												Λ_b^0		***
												Ξ_b^0, Ξ_b^-		*

**** Existence is certain, and properties are at least fairly well explored.

*** Existence ranges from very likely to certain, but further confirmation is desirable and/or quantum numbers, branching fractions, etc. are not well determined.

** Evidence of existence is only fair.

* Evidence of existence is poor.

N BARYONS
($S = 0$, $I = 1/2$)

$p\Gamma N^+ = uud$; $n\Gamma N^0 = udd$

p

$I(J^P) = \frac{1}{2}(\frac{1}{2}^+)$

Mass $m = 938.27231 \pm 0.00028$ MeV [a]
$= 1.007276470 \pm 0.000000012$ u
$\left|\frac{q_{\overline{p}}}{m_{\overline{p}}}\right|/(\frac{q_p}{m_p}) = 1.0000000015 \pm 0.0000000011$
$\left|q_p + q_{\overline{p}}\right|/e < 2 \times 10^{-5}$
$\left|q_p + q_e\right|/e < 1.0 \times 10^{-21}$ [b]
Magnetic moment $\mu = 2.79284739 \pm 0.00000006\ \mu_N$
Electric dipole moment $d = (-4 \pm 6) \times 10^{-23}$ $e$cm
Electric polarizability $\overline{\alpha} = (12.1 \pm 0.9) \times 10^{-4}$ fm^3
Magnetic polarizability $\overline{\beta} = (2.1 \pm 0.9) \times 10^{-4}$ fm^3
Mean life $\tau > 1.6 \times 10^{25}$ years (independent of mode)
$> 10^{31}$ to 5×10^{32} years [c] (mode dependent)

BelowΓfor *N* decaysΓ*p* and *n* distinguish proton and neutron partial lifetimes. See also the "Note on Nucleon Decay" in our 1994 edition (Phys. Rev. **D50**Γ1673) for a short review.

The "partial mean life" limits tabulated here are the limits on τ/B_iΓwhere τ is the total mean life and B_i is the branching fraction for the mode in question.

p DECAY MODES	Partial mean life (10^{30} years)	Confidence level	*p* (MeV/*c*)
Antilepton + meson			
$N \to e^+\pi$	> 130 (n)Γ> 550 (p)	90%	459
$N \to \mu^+\pi$	> 100 (n)Γ> 270 (p)	90%	453
$N \to \nu\pi$	> 100 (n)Γ> 25 (p)	90%	459
$p \to e^+\eta$	> 140	90%	309
$p \to \mu^+\eta$	> 69	90%	296
$n \to \nu\eta$	> 54	90%	310
$N \to e^+\rho$	> 58 (n)Γ> 75 (p)	90%	153
$N \to \mu^+\rho$	> 23 (n)Γ> 110 (p)	90%	119
$N \to \nu\rho$	> 19 (n)Γ> 27 (p)	90%	153
$p \to e^+\omega$	> 45	90%	142
$p \to \mu^+\omega$	> 57	90%	104
$n \to \nu\omega$	> 43	90%	144
$N \to e^+K$	> 1.3 (n)Γ> 150 (p)	90%	337
$p \to e^+K^0_S$	> 76	90%	337
$p \to e^+K^0_L$	> 44	90%	337
$N \to \mu^+K$	> 1.1 (n)Γ> 120 (p)	90%	326
$p \to \mu^+K^0_S$	> 64	90%	326
$p \to \mu^+K^0_L$	> 44	90%	326
$N \to \nu K$	> 86 (n)Γ> 100 (p)	90%	339
$p \to e^+K^*(892)^0$	> 52	90%	45
$N \to \nu K^*(892)$	> 22 (n)Γ> 20 (p)	90%	45
Antilepton + mesons			
$p \to e^+\pi^+\pi^-$	> 21	90%	448
$p \to e^+\pi^0\pi^0$	> 38	90%	449
$n \to e^+\pi^-\pi^0$	> 32	90%	449
$p \to \mu^+\pi^+\pi^-$	> 17	90%	425
$p \to \mu^+\pi^0\pi^0$	> 33	90%	427
$n \to \mu^+\pi^-\pi^0$	> 33	90%	427
$n \to e^+K^0\pi^-$	> 18	90%	319
Lepton + meson			
$n \to e^-\pi^+$	> 65	90%	459
$n \to \mu^-\pi^+$	> 49	90%	453
$n \to e^-\rho^+$	> 62	90%	154
$n \to \mu^-\rho^+$	> 7	90%	120
$n \to e^-K^+$	> 32	90%	340
$n \to \mu^-K^+$	> 57	90%	330
Lepton + mesons			
$p \to e^-\pi^+\pi^+$	> 30	90%	448
$n \to e^-\pi^+\pi^0$	> 29	90%	449
$p \to \mu^-\pi^+\pi^+$	> 17	90%	425
$n \to \mu^-\pi^+\pi^0$	> 34	90%	427
$p \to e^-\pi^+K^+$	> 20	90%	320
$p \to \mu^-\pi^+K^+$	> 5	90%	279
Antilepton + photon(s)			
$p \to e^+\gamma$	> 460	90%	469
$p \to \mu^+\gamma$	> 380	90%	463
$n \to \nu\gamma$	> 24	90%	470
$p \to e^+\gamma\gamma$	> 100	90%	469
Three (or more) leptons			
$p \to e^+e^+e^-$	> 510	90%	469
$p \to e^+\mu^+\mu^-$	> 81	90%	457
$p \to e^+\nu\nu$	> 11	90%	469
$n \to e^+e^-\nu$	> 74	90%	470
$n \to \mu^+e^-\nu$	> 47	90%	464
$n \to \mu^+\mu^-\nu$	> 42	90%	458
$p \to \mu^+e^+e^-$	> 91	90%	464
$p \to \mu^+\mu^+\mu^-$	> 190	90%	439
$p \to \mu^+\nu\nu$	> 21	90%	463
$p \to e^-\mu^+\mu^+$	> 6	90%	457
$n \to 3\nu$	> 0.0005	90%	470
Inclusive modes			
$N \to e^+$anything	> 0.6 (nΓp)	90%	–
$N \to \mu^+$anything	> 12 (nΓp)	90%	–
$N \to e^+\pi^0$anything	> 0.6 (nΓp)	90%	–
$\Delta B = 2$ dinucleon modes			
The following are lifetime limits per iron nucleus.			
$pp \to \pi^+\pi^+$	> 0.7	90%	–
$pn \to \pi^+\pi^0$	> 2	90%	–
$nn \to \pi^+\pi^-$	> 0.7	90%	–
$nn \to \pi^0\pi^0$	> 3.4	90%	–
$pp \to e^+e^+$	> 5.8	90%	–
$pp \to e^+\mu^+$	> 3.6	90%	–
$pp \to \mu^+\mu^+$	> 1.7	90%	–
$pn \to e^+\overline{\nu}$	> 2.8	90%	–
$pn \to \mu^+\overline{\nu}$	> 1.6	90%	–
$nn \to \nu_e\overline{\nu}_e$	> 0.000012	90%	–
$nn \to \nu_\mu\overline{\nu}_\mu$	> 0.000006	90%	–

$\overline{p}$ DECAY MODES

$\overline{p}$ DECAY MODES	Partial mean life (years)	Confidence level	*p* (MeV/*c*)
$\overline{p} \to e^-\gamma$	> 1848	95%	469
$\overline{p} \to e^-\pi^0$	> 554	95%	459
$\overline{p} \to e^-\eta$	> 171	95%	309
$\overline{p} \to e^-K^0_S$	> 29	95%	337
$\overline{p} \to e^-K^0_L$	> 9	95%	337

n

$I(J^P) = \frac{1}{2}(\frac{1}{2}^+)$

Mass $m = 939.56563 \pm 0.00028$ MeV [a]
$= 1.008664904 \pm 0.000000014$ u
$m_n - m_p = 1.293318 \pm 0.000009$ MeV
$= 0.001388434 \pm 0.000000009$ u
Mean life $\tau = 886.7 \pm 1.9$ s (S = 1.2)
$c\tau = 2.658 \times 10^8$ km
Magnetic moment $\mu = -1.9130428 \pm 0.0000005\ \mu_N$
Electric dipole moment $d < 0.97 \times 10^{-25}$ $e$cmΓCL = 90%
Electric polarizability $\alpha = (0.98^{+0.19}_{-0.23}) \times 10^{-3}$ fm^3 (S = 1.1)
Charge $q = (-0.4 \pm 1.1) \times 10^{-21}$ e
Mean $n\overline{n}$-oscillation time $> 1.2 \times 10^8$ sΓCL = 90% [d] (bound n)
$> 0.86 \times 10^8$ sΓCL = 90% (free n)

Decay parameters [e]

$pe^-\overline{\nu}_e$	$g_A/g_V = -1.2670 \pm 0.0035$ (S = 1.9)
"	$A = -0.1162 \pm 0.0013$ (S = 1.8)
"	$B = 0.990 \pm 0.008$
"	$a = -0.102 \pm 0.005$
"	$\phi_{AV} = (180.07 \pm 0.18)^\circ$ [f]
"	$D = (-0.5 \pm 1.4) \times 10^{-3}$

n DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	*p* (MeV/*c*)
$pe^-\overline{\nu}_e$	100 %		1.19
Charge conservation (Q) violating mode			
$p\nu_e\overline{\nu}_e$	Q $< 8 \times 10^{-27}$	68%	1.29

$N(1440)\ P_{11}$

$I(J^P) = \frac{1}{2}(\frac{1}{2}^+)$

Breit-Wigner mass = 1430 to 1470 (≈ 1440) MeV
Breit-Wigner full width = 250 to 450 (≈ 350) MeV
$p_{\text{beam}} = 0.61$ GeV/c $\quad 4\pi\bar{\lambda}^2 = 31.0$ mb
Re(pole position) = 1345 to 1385 (≈ 1365) MeV
−2Im(pole position) = 160 to 260 (≈ 210) MeV

N(1440) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	60–70 %	397
$N\pi\pi$	30–40 %	342
$\Delta\pi$	20–30 %	143
$N\rho$	<8 %	†
$N(\pi\pi)^{I=0}_{S\text{-wave}}$	5–10 %	–
$p\gamma$	0.035–0.048 %	414
$p\gamma$Γhelicity=1/2	0.035–0.048 %	414
$n\gamma$	0.009–0.032 %	413
$n\gamma$Γhelicity=1/2	0.009–0.032 %	413

$N(1520)\ D_{13}$

$I(J^P) = \frac{1}{2}(\frac{3}{2}^-)$

Breit-Wigner mass = 1515 to 1530 (≈ 1520) MeV
Breit-Wigner full width = 110 to 135 (≈ 120) MeV
$p_{\text{beam}} = 0.74$ GeV/c $\quad 4\pi\bar{\lambda}^2 = 23.5$ mb
Re(pole position) = 1505 to 1515 (≈ 1510) MeV
−2Im(pole position) = 110 to 120 (≈ 115) MeV

N(1520) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	50–60 %	456
$N\pi\pi$	40–50 %	410
$\Delta\pi$	15–25 %	228
$N\rho$	15–25 %	†
$N(\pi\pi)^{I=0}_{S\text{-wave}}$	<8 %	–
$p\gamma$	0.46–0.56 %	470
$p\gamma$Γhelicity=1/2	0.001–0.034 %	470
$p\gamma$Γhelicity=3/2	0.44–0.53 %	470
$n\gamma$	0.30–0.53 %	470
$n\gamma$Γhelicity=1/2	0.04–0.10 %	470
$n\gamma$Γhelicity=3/2	0.25–0.45 %	470

$N(1535)\ S_{11}$

$I(J^P) = \frac{1}{2}(\frac{1}{2}^-)$

Breit-Wigner mass = 1520 to 1555 (≈ 1535) MeV
Breit-Wigner full width = 100 to 250 (≈ 150) MeV
$p_{\text{beam}} = 0.76$ GeV/c $\quad 4\pi\bar{\lambda}^2 = 22.5$ mb
Re(pole position) = 1495 to 1515 (≈ 1505) MeV
−2Im(pole position) = 90 to 250 (≈ 170) MeV

N(1535) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	35–55 %	467
$N\eta$	30–55 %	182
$N\pi\pi$	1–10 %	422
$\Delta\pi$	<1 %	242
$N\rho$	<4 %	†
$N(\pi\pi)^{I=0}_{S\text{-wave}}$	<3 %	–
$N(1440)\pi$	<7 %	†
$p\gamma$	0.15–0.35 %	481
$p\gamma$Γhelicity=1/2	0.15–0.35 %	481
$n\gamma$	0.004–0.29 %	480
$n\gamma$Γhelicity=1/2	0.004–0.29 %	480

$N(1650)\ S_{11}$

$I(J^P) = \frac{1}{2}(\frac{1}{2}^-)$

Breit-Wigner mass = 1640 to 1680 (≈ 1650) MeV
Breit-Wigner full width = 145 to 190 (≈ 150) MeV
$p_{\text{beam}} = 0.96$ GeV/c $\quad 4\pi\bar{\lambda}^2 = 16.4$ mb
Re(pole position) = 1640 to 1680 (≈ 1660) MeV
−2Im(pole position) = 150 to 170 (≈ 160) MeV

N(1650) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	55–90 %	547
$N\eta$	3–10 %	346
ΛK	3–11 %	161
$N\pi\pi$	10–20 %	511
$\Delta\pi$	1–7 %	344
$N\rho$	4–12 %	†
$N(\pi\pi)^{I=0}_{S\text{-wave}}$	<4 %	–
$N(1440)\pi$	<5 %	147
$p\gamma$	0.04–0.18 %	558
$p\gamma$Γhelicity=1/2	0.04–0.18 %	558
$n\gamma$	0.003–0.17 %	557
$n\gamma$Γhelicity=1/2	0.003–0.17 %	557

$N(1675)\ D_{15}$

$I(J^P) = \frac{1}{2}(\frac{5}{2}^-)$

Breit-Wigner mass = 1670 to 1685 (≈ 1675) MeV
Breit-Wigner full width = 140 to 180 (≈ 150) MeV
$p_{\text{beam}} = 1.01$ GeV/c $\quad 4\pi\bar{\lambda}^2 = 15.4$ mb
Re(pole position) = 1655 to 1665 (≈ 1660) MeV
−2Im(pole position) = 125 to 155 (≈ 140) MeV

N(1675) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	40–50 %	563
ΛK	<1 %	209
$N\pi\pi$	50–60 %	529
$\Delta\pi$	50–60 %	364
$N\rho$	< 1–3 %	†
$p\gamma$	0.004–0.023 %	575
$p\gamma$Γhelicity=1/2	0.0–0.015 %	575
$p\gamma$Γhelicity=3/2	0.0–0.011 %	575
$n\gamma$	0.02–0.12 %	574
$n\gamma$Γhelicity=1/2	0.006–0.046 %	574
$n\gamma$Γhelicity=3/2	0.01–0.08 %	574

$N(1680)\ F_{15}$

$I(J^P) = \frac{1}{2}(\frac{5}{2}^+)$

Breit-Wigner mass = 1675 to 1690 (≈ 1680) MeV
Breit-Wigner full width = 120 to 140 (≈ 130) MeV
$p_{\text{beam}} = 1.01$ GeV/c $\quad 4\pi\bar{\lambda}^2 = 15.2$ mb
Re(pole position) = 1665 to 1675 (≈ 1670) MeV
−2Im(pole position) = 105 to 135 (≈ 120) MeV

N(1680) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	60–70 %	567
$N\pi\pi$	30–40 %	532
$\Delta\pi$	5–15 %	369
$N\rho$	3–15 %	†
$N(\pi\pi)^{I=0}_{S\text{-wave}}$	5–20 %	–
$p\gamma$	0.21–0.32 %	578
$p\gamma$Γhelicity=1/2	0.001–0.011 %	578
$p\gamma$Γhelicity=3/2	0.20–0.32 %	578
$n\gamma$	0.021–0.046 %	577
$n\gamma$Γhelicity=1/2	0.004–0.029 %	577
$n\gamma$Γhelicity=3/2	0.01–0.024 %	577

$N(1700)\ D_{13}$

$I(J^P) = \frac{1}{2}(\frac{3}{2}^-)$

Breit-Wigner mass = 1650 to 1750 (≈ 1700) MeV
Breit-Wigner full width = 50 to 150 (≈ 100) MeV
p_{beam} = 1.05 GeV/c $4\pi\lambda\!\!\!^{-2}$ = 14.5 mb
Re(pole position) = 1630 to 1730 (≈ 1680) MeV
−2Im(pole position) = 50 to 150 (≈ 100) MeV

N(1700) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	5–15 %	580
ΛK	<3 %	250
$N\pi\pi$	85–95 %	547
$N\rho$	<35 %	†
$p\gamma$	0.01–0.05 %	591
$p\gamma$Γhelicity=1/2	0.0–0.024 %	591
$p\gamma$Γhelicity=3/2	0.002–0.026 %	591
$n\gamma$	0.01–0.13 %	590
$n\gamma$Γhelicity=1/2	0.0–0.09 %	590
$n\gamma$Γhelicity=3/2	0.01–0.05 %	590

$N(1710)\ P_{11}$

$I(J^P) = \frac{1}{2}(\frac{1}{2}^+)$

Breit-Wigner mass = 1680 to 1740 (≈ 1710) MeV
Breit-Wigner full width = 50 to 250 (≈ 100) MeV
p_{beam} = 1.07 GeV/c $4\pi\lambda\!\!\!^{-2}$ = 14.2 mb
Re(pole position) = 1670 to 1770 (≈ 1720) MeV
−2Im(pole position) = 80 to 380 (≈ 230) MeV

N(1710) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	10–20 %	587
ΛK	5–25 %	264
$N\pi\pi$	40–90 %	554
$\Delta\pi$	15–40 %	393
$N\rho$	5–25 %	48
$N(\pi\pi)^{I=0}_{S\text{-wave}}$	10–40 %	–
$p\gamma$	0.002–0.05%	598
$p\gamma$Γhelicity=1/2	0.002–0.05%	598
$n\gamma$	0.0–0.02%	597
$n\gamma$Γhelicity=1/2	0.0–0.02%	597

$N(1720)\ P_{13}$

$I(J^P) = \frac{1}{2}(\frac{3}{2}^+)$

Breit-Wigner mass = 1650 to 1750 (≈ 1720) MeV
Breit-Wigner full width = 100 to 200 (≈ 150) MeV
p_{beam} = 1.09 GeV/c $4\pi\lambda\!\!\!^{-2}$ = 13.9 mb
Re(pole position) = 1650 to 1750 (≈ 1700) MeV
−2Im(pole position) = 110 to 390 (≈ 250) MeV

N(1720) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	10–20 %	594
ΛK	1–15 %	278
$N\pi\pi$	>70 %	561
$N\rho$	70–85 %	104
$p\gamma$	0.003–0.10 %	604
$p\gamma$Γhelicity=1/2	0.003–0.08 %	604
$p\gamma$Γhelicity=3/2	0.001–0.03 %	604
$n\gamma$	0.002–0.39 %	603
$n\gamma$Γhelicity=1/2	0.0–0.002 %	603
$n\gamma$Γhelicity=3/2	0.001–0.39 %	603

$N(2190)\ G_{17}$

$I(J^P) = \frac{1}{2}(\frac{7}{2}^-)$

Breit-Wigner mass = 2100 to 2200 (≈ 2190) MeV
Breit-Wigner full width = 350 to 550 (≈ 450) MeV
p_{beam} = 2.07 GeV/c $4\pi\lambda\!\!\!^{-2}$ = 6.21 mb
Re(pole position) = 1950 to 2150 (≈ 2050) MeV
−2Im(pole position) = 350 to 550 (≈ 450) MeV

N(2190) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	10–20 %	888

$N(2220)\ H_{19}$

$I(J^P) = \frac{1}{2}(\frac{9}{2}^+)$

Breit-Wigner mass = 2180 to 2310 (≈ 2220) MeV
Breit-Wigner full width = 320 to 550 (≈ 400) MeV
p_{beam} = 2.14 GeV/c $4\pi\lambda\!\!\!^{-2}$ = 5.97 mb
Re(pole position) = 2100 to 2240 (≈ 2170) MeV
−2Im(pole position) = 370 to 570 (≈ 470) MeV

N(2220) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	10–20 %	905

$N(2250)\ G_{19}$

$I(J^P) = \frac{1}{2}(\frac{9}{2}^-)$

Breit-Wigner mass = 2170 to 2310 (≈ 2250) MeV
Breit-Wigner full width = 290 to 470 (≈ 400) MeV
p_{beam} = 2.21 GeV/c $4\pi\lambda\!\!\!^{-2}$ = 5.74 mb
Re(pole position) = 2080 to 2200 (≈ 2140) MeV
−2Im(pole position) = 280 to 680 (≈ 480) MeV

N(2250) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	5–15 %	923

$N(2600)\ I_{1,11}$

$I(J^P) = \frac{1}{2}(\frac{11}{2}^-)$

Breit-Wigner mass = 2550 to 2750 (≈ 2600) MeV
Breit-Wigner full width = 500 to 800 (≈ 650) MeV
p_{beam} = 3.12 GeV/c $4\pi\lambda\!\!\!^{-2}$ = 3.86 mb

N(2600) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	5–10 %	1126

Δ BARYONS
($S = 0$, $I = 3/2$)

$\Delta^{++} = uuu$Γ $\Delta^{+} = uud$Γ $\Delta^{0} = udd$Γ $\Delta^{-} = ddd$

$\Delta(1232)\ P_{33}$

$I(J^P) = \frac{3}{2}(\frac{3}{2}^+)$

Breit-Wigner mass (mixed charges) = 1230 to 1234 (≈ 1232) MeV
Breit-Wigner full width (mixed charges) = 115 to 125 (≈ 120) MeV
p_{beam} = 0.30 GeV/c $4\pi\lambda\!\!\!^{-2}$ = 94.8 mb
Re(pole position) = 1209 to 1211 (≈ 1210) MeV
−2Im(pole position) = 98 to 102 (≈ 100) MeV

Δ(1232) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	>99 %	227
$N\gamma$	0.52–0.60 %	259
$N\gamma$Γhelicity=1/2	0.11–0.13 %	259
$N\gamma$Γhelicity=3/2	0.41–0.47 %	259

$\Delta(1600)\ P_{33}$

$I(J^P) = \frac{3}{2}(\frac{3}{2}^+)$

Breit-Wigner mass = 1550 to 1700 (≈ 1600) MeV
Breit-Wigner full width = 250 to 450 (≈ 350) MeV
p_{beam} = 0.87 GeV/c $4\pi\lambda\!\!\!^{-2}$ = 18.6 mb
Re(pole position) = 1500 to 1700 (≈ 1600) MeV
−2Im(pole position) = 200 to 400 (≈ 300) MeV

Δ(1600) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	10–25 %	512
$N\pi\pi$	75–90 %	473
$\Delta\pi$	40–70 %	301
$N\rho$	<25 %	†
$N(1440)\pi$	10–35 %	74
$N\gamma$	0.001–0.02 %	525
$N\gamma$Γhelicity=1/2	0.0–0.02 %	525
$N\gamma$Γhelicity=3/2	0.001–0.005 %	525

$\Delta(1620)\ S_{31}$ $I(J^P) = \frac{3}{2}(\frac{1}{2}^-)$

Breit-Wigner mass = 1615 to 1675 (≈ 1620) MeV
Breit-Wigner full width = 120 to 180 (≈ 150) MeV
$p_{\text{beam}} = 0.91$ GeV/c $4\pi\lambda^2 = 17.7$ mb
Re(pole position) = 1580 to 1620 (≈ 1600) MeV
−2Im(pole position) = 100 to 130 (≈ 115) MeV

Δ(1620) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	20–30 %	526
$N\pi\pi$	70–80 %	488
$\Delta\pi$	30–60 %	318
$N\rho$	7–25 %	†
$N\gamma$	0.004–0.044 %	538
$N\gamma$, helicity=1/2	0.004–0.044 %	538

$\Delta(1700)\ D_{33}$ $I(J^P) = \frac{3}{2}(\frac{3}{2}^-)$

Breit-Wigner mass = 1670 to 1770 (≈ 1700) MeV
Breit-Wigner full width = 200 to 400 (≈ 300) MeV
$p_{\text{beam}} = 1.05$ GeV/c $4\pi\lambda^2 = 14.5$ mb
Re(pole position) = 1620 to 1700 (≈ 1660) MeV
−2Im(pole position) = 150 to 250 (≈ 200) MeV

Δ(1700) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	10–20 %	580
$N\pi\pi$	80–90 %	547
$\Delta\pi$	30–60 %	385
$N\rho$	30–55 %	†
$N\gamma$	0.12–0.26 %	591
$N\gamma$, helicity=1/2	0.08–0.16 %	591
$N\gamma$, helicity=3/2	0.025–0.12 %	591

$\Delta(1905)\ F_{35}$ $I(J^P) = \frac{3}{2}(\frac{5}{2}^+)$

Breit-Wigner mass = 1870 to 1920 (≈ 1905) MeV
Breit-Wigner full width = 280 to 440 (≈ 350) MeV
$p_{\text{beam}} = 1.45$ GeV/c $4\pi\lambda^2 = 9.62$ mb
Re(pole position) = 1800 to 1860 (≈ 1830) MeV
−2Im(pole position) = 230 to 330 (≈ 280) MeV

Δ(1905) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	5–15 %	713
$N\pi\pi$	85–95 %	687
$\Delta\pi$	<25 %	542
$N\rho$	>60 %	421
$N\gamma$	0.01–0.03 %	721
$N\gamma$, helicity=1/2	0.0–0.1 %	721
$N\gamma$, helicity=3/2	0.004–0.03 %	721

$\Delta(1910)\ P_{31}$ $I(J^P) = \frac{3}{2}(\frac{1}{2}^+)$

Breit-Wigner mass = 1870 to 1920 (≈ 1910) MeV
Breit-Wigner full width = 190 to 270 (≈ 250) MeV
$p_{\text{beam}} = 1.46$ GeV/c $4\pi\lambda^2 = 9.54$ mb
Re(pole position) = 1830 to 1880 (≈ 1855) MeV
−2Im(pole position) = 200 to 500 (≈ 350) MeV

Δ(1910) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	15–30 %	716
$N\gamma$	0.0–0.2 %	725
$N\gamma$, helicity=1/2	0.0–0.2 %	725

$\Delta(1920)\ P_{33}$ $I(J^P) = \frac{3}{2}(\frac{3}{2}^+)$

Breit-Wigner mass = 1900 to 1970 (≈ 1920) MeV
Breit-Wigner full width = 150 to 300 (≈ 200) MeV
$p_{\text{beam}} = 1.48$ GeV/c $4\pi\lambda^2 = 9.37$ mb
Re(pole position) = 1850 to 1950 (≈ 1900) MeV
−2Im(pole position) = 200 to 400 (≈ 300) MeV

Δ(1920) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	5–20 %	722

$\Delta(1930)\ D_{35}$ $I(J^P) = \frac{3}{2}(\frac{5}{2}^-)$

Breit-Wigner mass = 1920 to 1970 (≈ 1930) MeV
Breit-Wigner full width = 250 to 450 (≈ 350) MeV
$p_{\text{beam}} = 1.50$ GeV/c $4\pi\lambda^2 = 9.21$ mb
Re(pole position) = 1840 to 1940 (≈ 1890) MeV
−2Im(pole position) = 200 to 300 (≈ 250) MeV

Δ(1930) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	10–20 %	729
$N\gamma$	0.0–0.02 %	737
$N\gamma$, helicity=1/2	0.0–0.01 %	737
$N\gamma$, helicity=3/2	0.0–0.01 %	737

$\Delta(1950)\ F_{37}$ $I(J^P) = \frac{3}{2}(\frac{7}{2}^+)$

Breit-Wigner mass = 1940 to 1960 (≈ 1950) MeV
Breit-Wigner full width = 290 to 350 (≈ 300) MeV
$p_{\text{beam}} = 1.54$ GeV/c $4\pi\lambda^2 = 8.91$ mb
Re(pole position) = 1880 to 1890 (≈ 1885) MeV
−2Im(pole position) = 210 to 270 (≈ 240) MeV

Δ(1950) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	35–40 %	741
$N\pi\pi$		716
$\Delta\pi$	20–30 %	574
$N\rho$	<10 %	469
$N\gamma$	0.08–0.13 %	749
$N\gamma$, helicity=1/2	0.03–0.055 %	749
$N\gamma$, helicity=3/2	0.05–0.075 %	749

$\Delta(2420)\ H_{3,11}$ $I(J^P) = \frac{3}{2}(\frac{11}{2}^+)$

Breit-Wigner mass = 2300 to 2500 (≈ 2420) MeV
Breit-Wigner full width = 300 to 500 (≈ 400) MeV
$p_{\text{beam}} = 2.64$ GeV/c $4\pi\lambda^2 = 4.68$ mb
Re(pole position) = 2260 to 2400 (≈ 2330) MeV
−2Im(pole position) = 350 to 750 (≈ 550) MeV

Δ(2420) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	5–15 %	1023

Λ BARYONS
$(S = -1, I = 0)$

$\Lambda^0 = uds$

Λ

$I(J^P) = 0(\frac{1}{2}^+)$

Mass $m = 1115.683 \pm 0.006$ MeV
Mean life $\tau = (2.632 \pm 0.020) \times 10^{-10}$ s (S = 1.6)
$c\tau = 7.89$ cm
Magnetic moment $\mu = -0.613 \pm 0.004$ μ_N
Electric dipole moment $d < 1.5 \times 10^{-16}$ $e$cmΓCL = 95%

Decay parameters

$p\pi^-$	$\alpha_- = 0.642 \pm 0.013$
"	$\phi_- = (-6.5 \pm 3.5)°$
"	$\gamma_- = 0.76$ [g]
"	$\Delta_- = (8 \pm 4)°$ [g]
$n\pi^0$	$\alpha_0 = +0.65 \pm 0.05$
$pe^-\overline{\nu}_e$	$g_A/g_V = -0.718 \pm 0.015$ [e]

Λ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$p\pi^-$	(63.9 ± 0.5) %	101
$n\pi^0$	(35.8 ± 0.5) %	104
$n\gamma$	$(1.75 \pm 0.15) \times 10^{-3}$	162
$p\pi^-\gamma$	[h] $(8.4 \pm 1.4) \times 10^{-4}$	101
$pe^-\overline{\nu}_e$	$(8.32 \pm 0.14) \times 10^{-4}$	163
$p\mu^-\overline{\nu}_\mu$	$(1.57 \pm 0.35) \times 10^{-4}$	131

$\Lambda(1405)$ S_{01}

$I(J^P) = 0(\frac{1}{2}^-)$

Mass $m = 1407 \pm 4$ MeV
Full width $\Gamma = 50.0 \pm 2.0$ MeV
Below $\overline{K}N$ threshold

$\Lambda(1405)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\Sigma\pi$	100 %	152

$\Lambda(1520)$ D_{03}

$I(J^P) = 0(\frac{3}{2}^-)$

Mass $m = 1519.5 \pm 1.0$ MeV [i]
Full width $\Gamma = 15.6 \pm 1.0$ MeV [i]
$p_{\text{beam}} = 0.39$ GeV/c $4\pi\lambda\!\!\!^{-2} = 82.8$ mb

$\Lambda(1520)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\overline{K}$	45 ± 1%	244
$\Sigma\pi$	42 ± 1%	267
$\Lambda\pi\pi$	10 ± 1%	252
$\Sigma\pi\pi$	0.9 ± 0.1%	152
$\Lambda\gamma$	0.8 ± 0.2%	351

$\Lambda(1600)$ P_{01}

$I(J^P) = 0(\frac{1}{2}^+)$

Mass $m = 1560$ to 1700 (≈ 1600) MeV
Full width $\Gamma = 50$ to 250 (≈ 150) MeV
$p_{\text{beam}} = 0.58$ GeV/c $4\pi\lambda\!\!\!^{-2} = 41.6$ mb

$\Lambda(1600)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\overline{K}$	15–30 %	343
$\Sigma\pi$	10–60 %	336

$\Lambda(1670)$ S_{01}

$I(J^P) = 0(\frac{1}{2}^-)$

Mass $m = 1660$ to 1680 (≈ 1670) MeV
Full width $\Gamma = 25$ to 50 (≈ 35) MeV
$p_{\text{beam}} = 0.74$ GeV/c $4\pi\lambda\!\!\!^{-2} = 28.5$ mb

$\Lambda(1670)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\overline{K}$	15–25 %	414
$\Sigma\pi$	20–60 %	393
$\Lambda\eta$	15–35 %	64

$\Lambda(1690)$ D_{03}

$I(J^P) = 0(\frac{3}{2}^-)$

Mass $m = 1685$ to 1695 (≈ 1690) MeV
Full width $\Gamma = 50$ to 70 (≈ 60) MeV
$p_{\text{beam}} = 0.78$ GeV/c $4\pi\lambda\!\!\!^{-2} = 26.1$ mb

$\Lambda(1690)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\overline{K}$	20–30 %	433
$\Sigma\pi$	20–40 %	409
$\Lambda\pi\pi$	~ 25 %	415
$\Sigma\pi\pi$	~ 20 %	350

$\Lambda(1800)$ S_{01}

$I(J^P) = 0(\frac{1}{2}^-)$

Mass $m = 1720$ to 1850 (≈ 1800) MeV
Full width $\Gamma = 200$ to 400 (≈ 300) MeV
$p_{\text{beam}} = 1.01$ GeV/c $4\pi\lambda\!\!\!^{-2} = 17.5$ mb

$\Lambda(1800)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\overline{K}$	25–40 %	528
$\Sigma\pi$	seen	493
$\Sigma(1385)\pi$	seen	345
$N\overline{K}^*(892)$	seen	†

$\Lambda(1810)$ P_{01}

$I(J^P) = 0(\frac{1}{2}^+)$

Mass $m = 1750$ to 1850 (≈ 1810) MeV
Full width $\Gamma = 50$ to 250 (≈ 150) MeV
$p_{\text{beam}} = 1.04$ GeV/c $4\pi\lambda\!\!\!^{-2} = 17.0$ mb

$\Lambda(1810)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\overline{K}$	20–50 %	537
$\Sigma\pi$	10–40 %	501
$\Sigma(1385)\pi$	seen	356
$N\overline{K}^*(892)$	30–60 %	†

$\Lambda(1820)$ F_{05}

$I(J^P) = 0(\frac{5}{2}^+)$

Mass $m = 1815$ to 1825 (≈ 1820) MeV
Full width $\Gamma = 70$ to 90 (≈ 80) MeV
$p_{\text{beam}} = 1.06$ GeV/c $4\pi\lambda\!\!\!^{-2} = 16.5$ mb

$\Lambda(1820)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\overline{K}$	55–65 %	545
$\Sigma\pi$	8–14 %	508
$\Sigma(1385)\pi$	5–10 %	362

$\Lambda(1830)$ D_{05}

$I(J^P) = 0(\frac{5}{2}^-)$

Mass $m = 1810$ to 1830 (≈ 1830) MeV
Full width $\Gamma = 60$ to 110 (≈ 95) MeV
$p_{\text{beam}} = 1.08$ GeV/c $4\pi\lambda\!\!\!^{-2} = 16.0$ mb

$\Lambda(1830)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\overline{K}$	3–10 %	553
$\Sigma\pi$	35–75 %	515
$\Sigma(1385)\pi$	>15 %	371

$\Lambda(1890)\ P_{03}$

$I(J^P) = 0(\frac{3}{2}^+)$

Mass $m = 1850$ to 1910 (≈ 1890) MeV
Full width $\Gamma = 60$ to 200 (≈ 100) MeV
$p_{\rm beam} = 1.21$ GeV/c $4\pi\lambda\!\!\!^-{}^2 = 13.6$ mb

$\Lambda(1890)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\overline{K}$	20–35 %	599
$\Sigma\pi$	3–10 %	559
$\Sigma(1385)\pi$	seen	420
$N\overline{K}^*(892)$	seen	233

$\Lambda(2100)\ G_{07}$

$I(J^P) = 0(\frac{7}{2}^-)$

Mass $m = 2090$ to 2110 (≈ 2100) MeV
Full width $\Gamma = 100$ to 250 (≈ 200) MeV
$p_{\rm beam} = 1.68$ GeV/c $4\pi\lambda\!\!\!^-{}^2 = 8.68$ mb

$\Lambda(2100)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\overline{K}$	25–35 %	751
$\Sigma\pi$	$\sim$ 5 %	704
$\Lambda\eta$	<3 %	617
ΞK	<3 %	483
$\Lambda\omega$	<8 %	443
$N\overline{K}^*(892)$	10–20 %	514

$\Lambda(2110)\ F_{05}$

$I(J^P) = 0(\frac{5}{2}^+)$

Mass $m = 2090$ to 2140 (≈ 2110) MeV
Full width $\Gamma = 150$ to 250 (≈ 200) MeV
$p_{\rm beam} = 1.70$ GeV/c $4\pi\lambda\!\!\!^-{}^2 = 8.53$ mb

$\Lambda(2110)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\overline{K}$	5–25 %	757
$\Sigma\pi$	10–40 %	711
$\Lambda\omega$	seen	455
$\Sigma(1385)\pi$	seen	589
$N\overline{K}^*(892)$	10–60 %	524

$\Lambda(2350)\ H_{09}$

$I(J^P) = 0(\frac{9}{2}^+)$

Mass $m = 2340$ to 2370 (≈ 2350) MeV
Full width $\Gamma = 100$ to 250 (≈ 150) MeV
$p_{\rm beam} = 2.29$ GeV/c $4\pi\lambda\!\!\!^-{}^2 = 5.85$ mb

$\Lambda(2350)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\overline{K}$	$\sim$ 12 %	915
$\Sigma\pi$	$\sim$ 10 %	867

Σ BARYONS
$(S = -1, I = 1)$

$\Sigma^+ = uus,\ \Sigma^0 = uds,\ \Sigma^- = dds$

Σ^+

$I(J^P) = 1(\frac{1}{2}^+)$

Mass $m = 1189.37 \pm 0.07$ MeV (S = 2.2)
Mean life $\tau = (0.799 \pm 0.004) \times 10^{-10}$ s
$c\tau = 2.396$ cm
Magnetic moment $\mu = 2.458 \pm 0.010\ \mu_N$ (S = 2.1)
$\Gamma(\Sigma^+ \to n\ell^+\nu)/\Gamma(\Sigma^- \to n\ell^-\overline{\nu}) < 0.043$

Decay parameters

$p\pi^0$	$\alpha_0 = -0.980^{+0.017}_{-0.015}$
"	$\phi_0 = (36 \pm 34)^\circ$
"	$\gamma_0 = 0.16$ [g]
"	$\Delta_0 = (187 \pm 6)^\circ$ [g]
$n\pi^+$	$\alpha_+ = 0.068 \pm 0.013$
"	$\phi_+ = (167 \pm 20)^\circ$ (S = 1.1)
"	$\gamma_+ = -0.97$ [g]
"	$\Delta_+ = (-73^{+133}_{-10})^\circ$ [g]
$p\gamma$	$\alpha_\gamma = -0.76 \pm 0.08$

Σ^+ DECAY MODES		Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$p\pi^0$		(51.57 ± 0.30) %		189
$n\pi^+$		(48.31 ± 0.30) %		185
$p\gamma$		$(1.23\pm0.05) \times 10^{-3}$		225
$n\pi^+\gamma$	[h]	$(4.5\ \pm0.5\ ) \times 10^{-4}$		185
$\Lambda e^+\nu_e$		$(2.0\ \pm0.5\ ) \times 10^{-5}$		71
$\Delta S = \Delta Q$ (SQ) violating modes or $\Delta S = 1$ weak neutral current ($S1$) modes				
$ne^+\nu_e$	SQ	$< 5 \times 10^{-6}$	90%	224
$n\mu^+\nu_\mu$	SQ	$< 3.0 \times 10^{-5}$	90%	202
pe^+e^-	$S1$	$< 7 \times 10^{-6}$		225

Σ^0

$I(J^P) = 1(\frac{1}{2}^+)$

Mass $m = 1192.642 \pm 0.024$ MeV
$m_{\Sigma^-} - m_{\Sigma^0} = 4.807 \pm 0.035$ MeV (S = 1.1)
$m_{\Sigma^0} - m_\Lambda = 76.959 \pm 0.023$ MeV
Mean life $\tau = (7.4 \pm 0.7) \times 10^{-20}$ s
$c\tau = 2.22 \times 10^{-11}$ m
Transition magnetic moment $|\mu_{\Sigma\Lambda}| = 1.61 \pm 0.08\ \mu_N$

Σ^0 DECAY MODES		Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$\Lambda\gamma$		100 %		74
$\Lambda\gamma\gamma$		< 3 %	90%	74
Λe^+e^-	[i]	5×10^{-3}		74

Σ^-

$I(J^P) = 1(\frac{1}{2}^+)$

Mass $m = 1197.449 \pm 0.030$ MeV (S = 1.2)
$m_{\Sigma^-} - m_{\Sigma^+} = 8.08 \pm 0.08$ MeV (S = 1.9)
$m_{\Sigma^-} - m_{\Lambda} = 81.766 \pm 0.030$ MeV (S = 1.2)
Mean life $\tau = (1.479 \pm 0.011) \times 10^{-10}$ s (S = 1.3)
$c\tau = 4.434$ cm
Magnetic moment $\mu = -1.160 \pm 0.025\ \mu_N$ (S = 1.7)

Decay parameters

$n\pi^-$	$\alpha_- = -0.068 \pm 0.008$
"	$\phi_- = (10 \pm 15)^\circ$
"	$\gamma_- = 0.98$ [g]
"	$\Delta_- = (249^{+12}_{-120})^\circ$ [g]
$ne^-\overline{\nu}_e$	$g_A/g_V = 0.340 \pm 0.017$ [e]
"	$f_2(0)/f_1(0) = 0.97 \pm 0.14$
"	$D = 0.11 \pm 0.10$
$\Lambda e^-\overline{\nu}_e$	$g_V/g_A = 0.01 \pm 0.10$ [e] (S = 1.5)
"	$g_{WM}/g_A = 2.4 \pm 1.7$ [e]

Σ^- DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$n\pi^-$	(99.848 ± 0.005) %	193
$n\pi^-\gamma$	[h] $(4.6 \pm 0.6) \times 10^{-4}$	193
$ne^-\overline{\nu}_e$	$(1.017 \pm 0.034) \times 10^{-3}$	230
$n\mu^-\overline{\nu}_\mu$	$(4.5 \pm 0.4) \times 10^{-4}$	210
$\Lambda e^-\overline{\nu}_e$	$(5.73 \pm 0.27) \times 10^{-5}$	79

$\Sigma(1385)\ P_{13}$

$I(J^P) = 1(\frac{3}{2}^+)$

$\Sigma(1385)^+$ mass $m = 1382.8 \pm 0.4$ MeV (S = 2.0)
$\Sigma(1385)^0$ mass $m = 1383.7 \pm 1.0$ MeV (S = 1.4)
$\Sigma(1385)^-$ mass $m = 1387.2 \pm 0.5$ MeV (S = 2.2)
$\Sigma(1385)^+$ full width $\Gamma = 35.8 \pm 0.8$ MeV
$\Sigma(1385)^0$ full width $\Gamma = 36 \pm 5$ MeV
$\Sigma(1385)^-$ full width $\Gamma = 39.4 \pm 2.1$ MeV (S = 1.7)
Below $\overline{K}N$ threshold

$\Sigma(1385)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\Lambda\pi$	88 ± 2 %	208
$\Sigma\pi$	12 ± 2 %	127

$\Sigma(1660)\ P_{11}$

$I(J^P) = 1(\frac{1}{2}^+)$

Mass $m = 1630$ to 1690 (≈ 1660) MeV
Full width $\Gamma = 40$ to 200 (≈ 100) MeV
$p_{beam} = 0.72$ GeV/c $4\pi\lambda\!\!\!^{-2} = 29.9$ mb

$\Sigma(1660)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\overline{K}$	10–30 %	405
$\Lambda\pi$	seen	439
$\Sigma\pi$	seen	385

$\Sigma(1670)\ D_{13}$

$I(J^P) = 1(\frac{3}{2}^-)$

Mass $m = 1665$ to 1685 (≈ 1670) MeV
Full width $\Gamma = 40$ to 80 (≈ 60) MeV
$p_{beam} = 0.74$ GeV/c $4\pi\lambda\!\!\!^{-2} = 28.5$ mb

$\Sigma(1670)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\overline{K}$	7–13 %	414
$\Lambda\pi$	5–15 %	447
$\Sigma\pi$	30–60 %	393

$\Sigma(1750)\ S_{11}$

$I(J^P) = 1(\frac{1}{2}^-)$

Mass $m = 1730$ to 1800 (≈ 1750) MeV
Full width $\Gamma = 60$ to 160 (≈ 90) MeV
$p_{beam} = 0.91$ GeV/c $4\pi\lambda\!\!\!^{-2} = 20.7$ mb

$\Sigma(1750)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\overline{K}$	10–40 %	486
$\Lambda\pi$	seen	507
$\Sigma\pi$	<8 %	455
$\Sigma\eta$	15–55 %	81

$\Sigma(1775)\ D_{15}$

$I(J^P) = 1(\frac{5}{2}^-)$

Mass $m = 1770$ to 1780 (≈ 1775) MeV
Full width $\Gamma = 105$ to 135 (≈ 120) MeV
$p_{beam} = 0.96$ GeV/c $4\pi\lambda\!\!\!^{-2} = 19.0$ mb

$\Sigma(1775)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\overline{K}$	37–43%	508
$\Lambda\pi$	14–20%	525
$\Sigma\pi$	2–5%	474
$\Sigma(1385)\pi$	8–12%	324
$\Lambda(1520)\pi$	17–23%	198

$\Sigma(1915)\ F_{15}$

$I(J^P) = 1(\frac{5}{2}^+)$

Mass $m = 1900$ to 1935 (≈ 1915) MeV
Full width $\Gamma = 80$ to 160 (≈ 120) MeV
$p_{beam} = 1.26$ GeV/c $4\pi\lambda\!\!\!^{-2} = 12.8$ mb

$\Sigma(1915)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\overline{K}$	5–15 %	618
$\Lambda\pi$	seen	622
$\Sigma\pi$	seen	577
$\Sigma(1385)\pi$	<5 %	440

$\Sigma(1940)\ D_{13}$

$I(J^P) = 1(\frac{3}{2}^-)$

Mass $m = 1900$ to 1950 (≈ 1940) MeV
Full width $\Gamma = 150$ to 300 (≈ 220) MeV
$p_{beam} = 1.32$ GeV/c $4\pi\lambda\!\!\!^{-2} = 12.1$ mb

$\Sigma(1940)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\overline{K}$	<20 %	637
$\Lambda\pi$	seen	639
$\Sigma\pi$	seen	594
$\Sigma(1385)\pi$	seen	460
$\Lambda(1520)\pi$	seen	354
$\Delta(1232)\overline{K}$	seen	410
$N\overline{K}^*(892)$	seen	320

$\Sigma(2030)\ F_{17}$

$I(J^P) = 1(\frac{7}{2}^+)$

Mass $m = 2025$ to 2040 (≈ 2030) MeV
Full width $\Gamma = 150$ to 200 (≈ 180) MeV
$p_{beam} = 1.52$ GeV/c $4\pi\lambda\!\!\!^{-2} = 9.93$ mb

$\Sigma(2030)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\overline{K}$	17–23 %	702
$\Lambda\pi$	17–23 %	700
$\Sigma\pi$	5–10 %	657
ΞK	<2 %	412
$\Sigma(1385)\pi$	5–15 %	529
$\Lambda(1520)\pi$	10–20 %	430
$\Delta(1232)\overline{K}$	10–20 %	498
$N\overline{K}^*(892)$	<5 %	438

Σ(2250)

$I(J^P) = 1(?^?)$

Mass $m = 2210$ to 2280 (≈ 2250) MeV
Full width $\Gamma = 60$ to 150 (≈ 100) MeV
$p_{\text{beam}} = 2.04$ GeV/c $\quad 4\pi\lambda\!\!\!^{-2} = 6.76$ mb

Σ(2250) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\overline{K}$	<10 %	851
$\Lambda\pi$	seen	842
$\Sigma\pi$	seen	803

Ξ BARYONS (S = −2, I = 1/2)

$\Xi^0 = uss$, $\Xi^- = dss$

Ξ^0

$I(J^P) = \frac{1}{2}(\frac{1}{2}^+)$

P is not yet measured; + is the quark model prediction.

Mass $m = 1314.9 \pm 0.6$ MeV
$m_{\Xi^-} - m_{\Xi^0} = 6.4 \pm 0.6$ MeV
Mean life $\tau = (2.90 \pm 0.09) \times 10^{-10}$ s
$c\tau = 8.71$ cm
Magnetic moment $\mu = -1.250 \pm 0.014\ \mu_N$

Decay parameters

$\Lambda\pi^0$	$\alpha = -0.411 \pm 0.022$ (S = 2.1)
"	$\phi = (21 \pm 12)°$
"	$\gamma = 0.85$ [g]
"	$\Delta = (218^{+12}_{-19})°$ [g]
$\Lambda\gamma$	$\alpha = 0.4 \pm 0.4$
$\Sigma^0\gamma$	$\alpha = 0.20 \pm 0.32$

Ξ^0 DECAY MODES		Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$\Lambda\pi^0$		(99.54±0.05) %		135
$\Lambda\gamma$		(1.06±0.16) × 10^{-3}		184
$\Sigma^0\gamma$		(3.5 ±0.4) × 10^{-3}		117
$\Sigma^+ e^- \overline{\nu}_e$		< 1.1 × 10^{-3}	90%	120
$\Sigma^+ \mu^- \overline{\nu}_\mu$		< 1.1 × 10^{-3}	90%	64
ΔS = ΔQ (SQ) violating modes or ΔS = 2 forbidden (S2) modes				
$\Sigma^- e^+ \nu_e$	SQ	< 9 × 10^{-4}	90%	112
$\Sigma^- \mu^+ \nu_\mu$	SQ	< 9 × 10^{-4}	90%	49
$p\pi^-$	S2	< 4 × 10^{-5}	90%	299
$p e^- \overline{\nu}_e$	S2	< 1.3 × 10^{-3}		323
$p \mu^- \overline{\nu}_\mu$	S2	< 1.3 × 10^{-3}		309

Ξ^-

$I(J^P) = \frac{1}{2}(\frac{1}{2}^+)$

P is not yet measured; + is the quark model prediction.

Mass $m = 1321.32 \pm 0.13$ MeV
Mean life $\tau = (1.639 \pm 0.015) \times 10^{-10}$ s
$c\tau = 4.91$ cm
Magnetic moment $\mu = -0.6507 \pm 0.0025\ \mu_N$

Decay parameters

$\Lambda\pi^-$	$\alpha = -0.456 \pm 0.014$ (S = 1.8)
"	$\phi = (4 \pm 4)°$
"	$\gamma = 0.89$ [g]
"	$\Delta = (188 \pm 8)°$ [g]
$\Lambda e^- \overline{\nu}_e$	$g_A/g_V = -0.25 \pm 0.05$ [e]

Ξ^- DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$\Lambda\pi^-$	(99.887±0.035) %		139
$\Sigma^-\gamma$	(1.27 ±0.23) × 10^{-4}		118
$\Lambda e^- \overline{\nu}_e$	(5.63 ±0.31) × 10^{-4}		190
$\Lambda \mu^- \overline{\nu}_\mu$	(3.5 $^{+3.5}_{-2.2}$) × 10^{-4}		163
$\Sigma^0 e^- \overline{\nu}_e$	(8.7 ±1.7) × 10^{-5}		122
$\Sigma^0 \mu^- \overline{\nu}_\mu$	< 8 × 10^{-4}	90%	70
$\Xi^0 e^- \overline{\nu}_e$	< 2.3 × 10^{-3}	90%	6

ΔS = 2 forbidden (S2) modes

$n\pi^-$	S2	< 1.9 × 10^{-5}	90%	303
$n e^- \overline{\nu}_e$	S2	< 3.2 × 10^{-3}	90%	327
$n \mu^- \overline{\nu}_\mu$	S2	< 1.5 %	90%	314
$p\pi^-\pi^-$	S2	< 4 × 10^{-4}	90%	223
$p\pi^- e^- \overline{\nu}_e$	S2	< 4 × 10^{-4}	90%	304
$p\pi^- \mu^- \overline{\nu}_\mu$	S2	< 4 × 10^{-4}	90%	250
$p\mu^-\mu^-$	L	< 4 × 10^{-4}	90%	272

Ξ(1530) P_{13}

$I(J^P) = \frac{1}{2}(\frac{3}{2}^+)$

$\Xi(1530)^0$ mass $m = 1531.80 \pm 0.32$ MeV (S = 1.3)
$\Xi(1530)^-$ mass $m = 1535.0 \pm 0.6$ MeV
$\Xi(1530)^0$ full width $\Gamma = 9.1 \pm 0.5$ MeV
$\Xi(1530)^-$ full width $\Gamma = 9.9^{+1.7}_{-1.9}$ MeV

Ξ(1530) DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$\Xi\pi$	100 %		152
$\Xi\gamma$	<4 %	90%	200

Ξ(1690)

$I(J^P) = \frac{1}{2}(?^?)$

Mass $m = 1690 \pm 10$ MeV [l]
Full width $\Gamma < 50$ MeV

Ξ(1690) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\Lambda\overline{K}$	seen	240
$\Sigma\overline{K}$	seen	51
$\Xi^-\pi^+\pi^-$	possibly seen	214

Ξ(1820) D_{13}

$I(J^P) = \frac{1}{2}(\frac{3}{2}^-)$

Mass $m = 1823 \pm 5$ MeV [l]
Full width $\Gamma = 24^{+15}_{-10}$ MeV [l]

Ξ(1820) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\Lambda\overline{K}$	large	400
$\Sigma\overline{K}$	small	320
$\Xi\pi$	small	413
$\Xi(1530)\pi$	small	234

Ξ(1950)

$I(J^P) = \frac{1}{2}(?^?)$

Mass $m = 1950 \pm 15$ MeV [l]
Full width $\Gamma = 60 \pm 20$ MeV [l]

Ξ(1950) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\Lambda\overline{K}$	seen	522
$\Sigma\overline{K}$	possibly seen	460
$\Xi\pi$	seen	518

Ξ(2030)

$I(J^P) = \frac{1}{2}(\geq \frac{5}{2}^?)$

Mass $m = 2025 \pm 5$ MeV [l]
Full width $\Gamma = 20^{+15}_{-5}$ MeV [l]

Ξ(2030) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\Lambda\overline{K}$	~ 20 %	589
$\Sigma\overline{K}$	~ 80 %	533
$\Xi\pi$	small	573
$\Xi(1530)\pi$	small	421
$\Lambda\overline{K}\pi$	small	501
$\Sigma\overline{K}\pi$	small	430

Ω BARYONS
$(S=-3, I=0)$

$\Omega^- = sss$

Ω^-

$I(J^P) = 0(\frac{3}{2}^+)$

J^P is not yet measured; $\frac{3}{2}^+$ is the quark model prediction.

Mass $m = 1672.45 \pm 0.29$ MeV
Mean life $\tau = (0.822 \pm 0.012) \times 10^{-10}$ s
$c\tau = 2.46$ cm
Magnetic moment $\mu = -2.02 \pm 0.05\ \mu_N$

Decay parameters

ΛK^-	$\alpha = -0.026 \pm 0.026$
$\Xi^0 \pi^-$	$\alpha = 0.09 \pm 0.14$
$\Xi^- \pi^0$	$\alpha = 0.05 \pm 0.21$

Ω^- DECAY MODES		Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
ΛK^-		(67.8 ± 0.7) %		211
$\Xi^0 \pi^-$		(23.6 ± 0.7) %		294
$\Xi^- \pi^0$		(8.6 ± 0.4) %		290
$\Xi^- \pi^+ \pi^-$		$(4.3^{+3.4}_{-1.3}) \times 10^{-4}$		190
$\Xi(1530)^0 \pi^-$		$(6.4^{+5.1}_{-2.0}) \times 10^{-4}$		17
$\Xi^0 e^- \overline{\nu}_e$		$(5.6 \pm 2.8) \times 10^{-3}$		319
$\Xi^- \gamma$		$< 4.6 \times 10^{-4}$	90%	314
$\Delta S = 2$ forbidden ($S2$) modes				
$\Lambda \pi^-$	$S2$	$< 1.9 \times 10^{-4}$	90%	449

$\Omega(2250)^-$

$I(J^P) = 0(?^?)$

Mass $m = 2252 \pm 9$ MeV
Full width $\Gamma = 55 \pm 18$ MeV

$\Omega(2250)^-$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\Xi^- \pi^+ K^-$	seen	531
$\Xi(1530)^0 K^-$	seen	437

CHARMED BARYONS
$(C=+1)$

$\Lambda_c^+ = udc$Γ $\Sigma_c^{++} = uuc$Γ $\Sigma_c^+ = udc$Γ $\Sigma_c^0 = ddc$Γ
$\Xi_c^+ = usc$Γ $\Xi_c^0 = dsc$Γ $\Omega_c^0 = ssc$

Λ_c^+

$I(J^P) = 0(\frac{1}{2}^+)$

J not confirmed; $\frac{1}{2}$ is the quark model prediction.

Mass $m = 2284.9 \pm 0.6$ MeV
Mean life $\tau = (0.206 \pm 0.012) \times 10^{-12}$ s
$c\tau = 61.8\ \mu$m

Decay asymmetry parameters

$\Lambda \pi^+$	$\alpha = -0.98 \pm 0.19$
$\Sigma^+ \pi^0$	$\alpha = -0.45 \pm 0.32$
$\Lambda \ell^+ \nu_\ell$	$\alpha = -0.82^{+0.11}_{-0.07}$

Nearly all branching fractions of the Λ_c^+ are measured relative to the $pK^-\pi^+$ modeΓ butthere are no model-independent measurements of this branching fraction. We explain how we arrive at our value of $B(\Lambda_c^+ \to pK^-\pi^+)$ in a Note at the beginning of the branching-ratio measurementsΓ in the Listings. When this branching fraction is eventually well determinedΓ all the other branching fractions will slide up or down proportionally as the true value differs from the value we use here.

Λ_c^+ DECAY MODES		Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
Hadronic modes with a p and one $\overline{K}$				
$p\overline{K}^0$		(2.5 ± 0.7) %		872
$pK^-\pi^+$	[k]	(5.0 ± 1.3) %		822
$p\overline{K}^*(892)^0$	[l]	(1.8 ± 0.6) %		681
$\Delta(1232)^{++}K^-$		$(8 \pm 5) \times 10^{-3}$		709
$\Lambda(1520)\pi^+$	[l]	$(4.5 ^{+2.5}_{-2.1}) \times 10^{-3}$		626
$pK^-\pi^+$ nonresonant		(2.8 ± 0.9) %		822
$p\overline{K}^0\eta$		(1.3 ± 0.4) %		567
$p\overline{K}^0\pi^+\pi^-$		(2.4 ± 1.1) %		753
$pK^-\pi^+\pi^0$		seen		758
$pK^*(892)^-\pi^+$	[l]	(1.1 ± 0.6) %		579
$p(K^-\pi^+)_{\text{nonresonant}}\pi^0$		(3.6 ± 1.2) %		758
$\Delta(1232)\overline{K}^*(892)$		seen		416
$pK^-\pi^+\pi^+\pi^-$		$(1.1 \pm 0.8) \times 10^{-3}$		670
$pK^-\pi^+\pi^0\pi^0$		$(8 \pm 4) \times 10^{-3}$		676
$pK^-\pi^+\pi^0\pi^0\pi^0$		$(5.0 \pm 3.4) \times 10^{-3}$		573
Hadronic modes with a p and zero or two K's				
$p\pi^+\pi^-$		$(3.5 \pm 2.0) \times 10^{-3}$		926
$pf_0(980)$	[l]	$(2.8 \pm 1.9) \times 10^{-3}$		621
$p\pi^+\pi^+\pi^-\pi^-$		$(1.8 \pm 1.2) \times 10^{-3}$		851
pK^+K^-		$(2.3 \pm 0.9) \times 10^{-3}$		615
$p\phi$	[l]	$(1.2 \pm 0.5) \times 10^{-3}$		589
Hadronic modes with a hyperon				
$\Lambda\pi^+$		$(9.0 \pm 2.8) \times 10^{-3}$		863
$\Lambda\pi^+\pi^0$		(3.6 ± 1.3) %		843
$\Lambda\rho^+$		< 5 %	CL=95%	638
$\Lambda\pi^+\pi^+\pi^-$		(3.3 ± 1.0) %		806
$\Lambda\pi^+\eta$		(1.7 ± 0.6) %		690
$\Sigma(1385)^+\eta$	[l]	$(8.5 \pm 3.3) \times 10^{-3}$		569
$\Lambda K^+\overline{K}^0$		$(6.0 \pm 2.1) \times 10^{-3}$		441
$\Sigma^0\pi^+$		$(9.9 \pm 3.2) \times 10^{-3}$		824
$\Sigma^+\pi^0$		(1.00 ± 0.34) %		826
$\Sigma^+\eta$		$(5.5 \pm 2.3) \times 10^{-3}$		712
$\Sigma^+\pi^+\pi^-$		(3.4 ± 1.0) %		803
$\Sigma^+\rho^0$		< 1.4 %	CL=95%	578
$\Sigma^-\pi^+\pi^+$		(1.8 ± 0.8) %		798
$\Sigma^0\pi^+\pi^0$		(1.8 ± 0.8) %		802
$\Sigma^0\pi^+\pi^+\pi^-$		(1.1 ± 0.4) %		762
$\Sigma^+\pi^+\pi^-\pi^0$		—		766
$\Sigma^+\omega$	[l]	(2.7 ± 1.0) %		568
$\Sigma^+\pi^+\pi^+\pi^-\pi^-$		$(3.0 ^{+4.1}_{-2.1}) \times 10^{-3}$		707
$\Sigma^+K^+K^-$		$(3.5 \pm 1.2) \times 10^{-3}$		346
$\Sigma^+\phi$	[l]	$(3.5 \pm 1.7) \times 10^{-3}$		292
$\Sigma^+K^+\pi^-$		$(7 ^{+6}_{-4}) \times 10^{-3}$		668
Ξ^0K^+		$(3.9 \pm 1.4) \times 10^{-3}$		652
$\Xi^-K^+\pi^+$		$(4.9 \pm 1.7) \times 10^{-3}$		564
$\Xi(1530)^0K^+$	[l]	$(2.6 \pm 1.0) \times 10^{-3}$		471
Semileptonic modes				
$\Lambda\ell^+\nu_\ell$	[m]	(2.0 ± 0.6) %		–
$\Lambda e^+\nu_e$		(2.1 ± 0.6) %		–
$\Lambda\mu^+\nu_\mu$		(2.0 ± 0.7) %		–
e^+ anything		(4.5 ± 1.7) %		–
pe^+ anything		(1.8 ± 0.9) %		–
Λe^+ anything		—		–
$\Lambda\mu^+$ anything		—		–
$\Lambda\ell^+\nu_\ell$ anything		—		–
Inclusive modes				
p anything		(50 ± 16) %		–
p anything (no Λ)		(12 ± 19) %		–
p hadrons		—		–
n anything		(50 ± 16) %		–
n anything (no Λ)		(29 ± 17) %		–
Λ anything		(35 ± 11) %	S=1.4	–
$\Sigma^\pm$ anything	[n]	(10 ± 5) %		–

$\Delta C = 1$ weak neutral current ($C1$) modes, or Lepton number (L) violating modes

$p\mu^+\mu^-$	$C1$	< 3.4	$\times 10^{-4}$ CL=90%	936
$\Sigma^-\mu^+\mu^+$	L	< 7.0	$\times 10^{-4}$ CL=90%	811

$\Lambda_c(2593)^+$

$I(J^P) = 0(\frac{1}{2}^-)$

The spin-parity follows from the fact that $\Sigma_c(2455)\pi$ decays, with little available phase space, are dominant.

Mass $m = 2593.9 \pm 0.8$ MeV
$m - m_{\Lambda_c^+} = 308.9 \pm 0.6$ MeV (S = 1.1)
Full width $\Gamma = 3.6^{+2.0}_{-1.3}$ MeV

$\Lambda_c^+\pi\pi$ and its submode $\Sigma_c(2455)\pi$ — the latter just barely — are the only strong decays allowed to an excited Λ_c^+ having this mass; and the $\Lambda_c^+\pi^+\pi^-$ mode seems to be largely via $\Sigma_c^{++}\pi^-$ or $\Sigma_c^0\pi^+$.

$\Lambda_c(2593)^+$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\Lambda_c^+\pi^+\pi^-$	[o] ≈ 67 %	124
$\Sigma_c(2455)^{++}\pi^-$	24 ± 7 %	17
$\Sigma_c(2455)^0\pi^+$	24 ± 7 %	23
$\Lambda_c^+\pi^+\pi^-$ 3-body	18 ± 10 %	124
$\Lambda_c^+\pi^0$	not seen	261
$\Lambda_c^+\gamma$	not seen	290

$\Lambda_c(2625)^+$

$I(J^P) = 0(?^?)$

J^P is expected to be $3/2^-$.

Mass $m = 2626.6 \pm 0.8$ MeV (S = 1.2)
$m - m_{\Lambda_c^+} = 341.7 \pm 0.6$ MeV (S = 1.6)
Full width $\Gamma < 1.9$ MeV, CL = 90%

$\Lambda_c^+\pi\pi$ and its submode $\Sigma(2455)\pi$ are the only strong decays allowed to an excited Λ_c^+ having this mass.

$\Lambda_c(2625)^+$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\Lambda_c^+\pi^+\pi^-$	seen	184
$\Sigma_c(2455)^{++}\pi^-$	small	100
$\Sigma_c(2455)^0\pi^+$	small	101
$\Lambda_c^+\pi^+\pi^-$ 3-body	large	184
$\Lambda_c^+\pi^0$	not seen	293
$\Lambda_c^+\gamma$	not seen	319

$\Sigma_c(2455)$

$I(J^P) = 1(\frac{1}{2}^+)$

J^P not confirmed; $\frac{1}{2}^+$ is the quark model prediction.

$\Sigma_c(2455)^{++}$ mass $m = 2452.8 \pm 0.6$ MeV
$\Sigma_c(2455)^+$ mass $m = 2453.6 \pm 0.9$ MeV
$\Sigma_c(2455)^0$ mass $m = 2452.2 \pm 0.6$ MeV
$m_{\Sigma_c^{++}} - m_{\Lambda_c^+} = 167.87 \pm 0.19$ MeV
$m_{\Sigma_c^+} - m_{\Lambda_c^+} = 168.7 \pm 0.6$ MeV
$m_{\Sigma_c^0} - m_{\Lambda_c^+} = 167.30 \pm 0.20$ MeV
$m_{\Sigma_c^{++}} - m_{\Sigma_c^0} = 0.57 \pm 0.23$ MeV
$m_{\Sigma_c^+} - m_{\Sigma_c^0} = 1.4 \pm 0.6$ MeV

$\Lambda_c^+\pi$ is the only strong decay allowed to a Σ_c having this mass.

$\Sigma_c(2455)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\Lambda_c^+\pi$	≈ 100 %	90

$\Sigma_c(2520)$

$I(J^P) = 1(?^?)$

$\Sigma_c(2520)^{++}$ mass $m = 2519.4 \pm 1.5$ MeV
$\Sigma_c(2520)^0$ mass $m = 2517.5 \pm 1.4$ MeV
$m_{\Sigma_c(2520)^{++}} - m_{\Lambda_c^+} = 234.5 \pm 1.4$ MeV
$m_{\Sigma_c(2520)^0} - m_{\Lambda_c^+} = 232.6 \pm 1.3$ MeV
$m_{\Sigma_c(2520)^{++}} - m_{\Sigma_c(2520)^0} = 1.9 \pm 1.9$ MeV
$\Sigma_c(2520)^{++}$ full width $\Gamma = 18 \pm 5$ MeV
$\Sigma_c(2520)^0$ full width $\Gamma = 13 \pm 5$ MeV

Ξ_c^+

$I(J^P) = \frac{1}{2}(\frac{1}{2}^+)$

$I(J^P)$ not confirmed; $\frac{1}{2}(\frac{1}{2}^+)$ is the quark model prediction.

Mass $m = 2465.6 \pm 1.4$ MeV
Mean life $\tau = (0.35^{+0.07}_{-0.04}) \times 10^{-12}$ s
$c\tau = 106$ μm

Ξ_c^+ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\Lambda K^-\pi^+\pi^+$	seen	784
$\Lambda \overline{K}^*(892)^0\pi^+$	not seen	601
$\Sigma(1385)^+K^-\pi^+$	not seen	676
$\Sigma^+K^-\pi^+$	seen	808
$\Sigma^+\overline{K}^*(892)^0$	seen	653
$\Sigma^0K^-\pi^+\pi^+$	seen	733
$\Xi^0\pi^+$	seen	875
$\Xi^-\pi^+\pi^+$	seen	850
$\Xi(1530)^0\pi^+$	not seen	748
$\Xi^0\pi^+\pi^0$	seen	854
$\Xi^0\pi^+\pi^+\pi^-$	seen	817
$\Xi^0e^+\nu_e$	seen	882

Ξ_c^0

$I(J^P) = \frac{1}{2}(\frac{1}{2}^+)$

$I(J^P)$ not confirmed; $\frac{1}{2}(\frac{1}{2}^+)$ is the quark model prediction.

Mass $m = 2470.3 \pm 1.8$ MeV (S = 1.3)
$m_{\Xi_c^0} - m_{\Xi_c^+} = 4.7 \pm 2.1$ MeV (S = 1.2)
Mean life $\tau = (0.098^{+0.023}_{-0.015}) \times 10^{-12}$ s
$c\tau = 29$ μm

Ξ_c^0 DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\Lambda\overline{K}^0$	seen	864
$\Xi^-\pi^+$	seen	875
$\Xi^-\pi^+\pi^+\pi^-$	seen	816
$pK^-\overline{K}^*(892)^0$	seen	406
Ω^-K^+	seen	522
$\Xi^-e^+\nu_e$	seen	882
$\Xi^-\ell^+$ anything	seen	–

$\Xi_c(2645)$

$I(J^P) = ?(?^?)$

$\Xi_c(2645)^+$ mass $m = 2644.6 \pm 2.1$ MeV (S = 1.2)
$\Xi_c(2645)^0$ mass $m = 2643.8 \pm 1.8$ MeV
$m_{\Xi_c(2645)^+} - m_{\Xi_c^0} = 174.3 \pm 1.1$ MeV
$m_{\Xi_c(2645)^0} - m_{\Xi_c^+} = 178.2 \pm 1.1$ MeV
$\Xi_c(2645)^+$ full width $\Gamma < 3.1$ MeV, CL = 90%
$\Xi_c(2645)^0$ full width $\Gamma < 5.5$ MeV, CL = 90%

$\Xi_c\pi$ is the only strong decay allowed to a Ξ_c resonance having this mass.

$\Xi_c(2645)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\Xi_c^0\pi^+$	seen	101
$\Xi_c^+\pi^-$	seen	107

Ω_c^0

$I(J^P) = 0(\frac{1}{2}^+)$

$I(J^P)$ not confirmed; $0(\frac{1}{2}^+)$ is the quark model prediction.

Mass $m = 2704 \pm 4$ MeV (S = 1.8)
Mean life $\tau = (0.064 \pm 0.020) \times 10^{-12}$ s
$c\tau = 19\ \mu$m

Ω_c^0 DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\Sigma^+ K^- K^- \pi^+$	seen	697
$\Xi^- K^- \pi^+ \pi^+$	seen	838
$\Omega^- \pi^+$	seen	827
$\Omega^- \pi^- \pi^+ \pi^+$	seen	759

BOTTOM BARYONS
($B = -1$)

$\Lambda_b^0 = udb$Γ $\Xi_b^0 = usb$Γ $\Xi_b^- = dsb$

Λ_b^0

$I(J^P) = 0(\frac{1}{2}^+)$

$I(J^P)$ not yet measured; $0(\frac{1}{2}^+)$ is the quark model prediction.

Mass $m = 5624 \pm 9$ MeV (S = 1.8)
Mean life $\tau = (1.24 \pm 0.08) \times 10^{-12}$ s
$c\tau = 372\ \mu$m

These branching fractions are actually an average over weakly decaying b-baryons weighted by their production rates in Z decay (or high-energy $p\overline{p}$)Γbranching ratiosΓand detection efficiencies. They scale with the LEP Λ_b production fraction B($b \to \Lambda_b$) and are evaluated for our value B($b \to \Lambda_b$) = $(10.1^{+3.9}_{-3.1})$%.

The branching fractions B(b-baryon $\to \Lambda \ell^- \overline{\nu}_\ell$anything) and B($\Lambda_b^0 \to \Lambda_c^+ \ell^- \overline{\nu}_\ell$anything) are not pure measurements because the underlying measured products of these with B($b \to \Lambda_b$) were used to determine B($b \to \Lambda_b$)Γas described in the note "Production and Decay of b-Flavored Hadrons."

Λ_b^0 DECAY MODES		Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$J/\psi(1S)\Lambda$		$(4.7 \pm 2.8) \times 10^{-4}$		1744
$\Lambda_c^+ \pi^-$		seen		2345
$\Lambda_c^+ a_1(1260)^-$		seen		2156
$\Lambda_c^+ \ell^- \overline{\nu}_\ell$anything	[p]	$(9.0^{+3.1}_{-3.8})$ %		–
$p\pi^-$		$< 5.0 \times 10^{-5}$	90%	2732
pK^-		$< 5.0 \times 10^{-5}$	90%	2711

b-baryon ADMIXTURE (Λ_b, Ξ_b, Σ_b, Ω_b)

Mean life $\tau = (1.20 \pm 0.07) \times 10^{-12}$ s

These branching fractions are actually an average over weakly decaying b-baryons weighted by their production rates in Z decay (or high-energy $p\overline{p}$)Γbranching ratiosΓand detection efficiencies. They scale with the LEP Λ_b production fraction B($b \to \Lambda_b$) and are evaluated for our value B($b \to \Lambda_b$) = $(10.1^{+3.9}_{-3.1})$%.

The branching fractions B(b-baryon $\to \Lambda \ell^- \overline{\nu}_\ell$anything) and B($\Lambda_b^0 \to \Lambda_c^+ \ell^- \overline{\nu}_\ell$anything) are not pure measurements because the underlying measured products of these with B($b \to \Lambda_b$) were used to determine B($b \to \Lambda_b$)Γas described in the note "Production and Decay of b-Flavored Hadrons."

b-baryon ADMIXTURE (Λ_bΓΞ_bΓΣ_bΓΩ_b)	Fraction (Γ_i/Γ)	p (MeV/c)
$p\mu^- \overline{\nu}$anything	(4.9 ± 2.4) %	–
$\Lambda \ell^- \overline{\nu}_\ell$anything	$(3.1^{+1.0}_{-1.2})$ %	–
$\Lambda/\overline{\Lambda}$anything	(35^{+12}_{-14}) %	–
$\Xi^- \ell^- \overline{\nu}_\ell$anything	$(5.5^{+2.0}_{-2.4}) \times 10^{-3}$	–

NOTES

This Summary Table only includes established baryons. The Particle Listings include evidence for other baryons. The massesΓwidthsΓand branching fractions for the resonances in this Table are Breit-Wigner parametersΓbut pole positions are also given for most of the N and Δ resonances.

For most of the resonancesΓthe parameters come from various partial-wave analyses of more or less the same sets of dataΓand it is not appropriate to treat the results of the analyses as independent or to average them together. FurthermoreΓthe systematic errors on the results are not well understood. ThusΓwe usually only give ranges for the parameters. We then also give a best guess for the mass (as part of the name of the resonance) and for the width. The *Note on N and Δ Resonances* and the *Note on Λ and Σ Resonances* in the Particle Listings review the partial-wave analyses.

When a quantity has "(S = ...)" to its rightΓthe error on the quantity has been enlarged by the "scale factor" SΓdefined as $S = \sqrt{\chi^2/(N-1)}$Γwhere N is the number of measurements used in calculating the quantity. We do this when $S > 1$Γwhich often indicates that the measurements are inconsistent. When $S > 1.25$Γwe also show in the Particle Listings an ideogram of the measurements. For more about SΓsee the Introduction.

A decay momentum p is given for each decay mode. For a 2-body decayΓp is the momentum of each decay product in the rest frame of the decaying particle. For a 3-or-more-body decayΓp is the largest momentum any of the products can have in this frame. For any resonanceΓthe *nominal* mass is used in calculating p. A dagger ("†") in this column indicates that the mode is forbidden when the nominal masses of resonances are usedΓbut is in fact allowed due to the nonzero widths of the resonances.

[a] The masses of the p and n are most precisely known in u (unified atomic mass units). The conversion factor to MeVΓ1 u = 931.49432 ± 0.00028 MeVΓis less well known than are the masses in u.

[b] The limit is from neutrality-of-matter experiments; it assumes $q_n = q_p + q_e$. See also the charge of the neutron.

[c] The first limit is geochemical and independent of decay mode. The second entryΓa range of limitsΓassumes the dominant decay modes are among those investigated. For antiprotons the best limitΓinferred from the observation of cosmic ray $\overline{p}$'s is $\tau_{\overline{p}} > 10^7$ yrΓthe cosmic-ray storage timeΓbut this limit depends on a number of assumptions. The best direct observation of stored antiprotons gives $\tau_{\overline{p}}/\mathrm{B}(\overline{p} \to e^-\gamma) > 1848$ yr.

[d] There is some controversy about whether nuclear physics and model dependence complicate the analysis for bound neutrons (from which the best limit comes). The second limit here is from reactor experiments with free neutrons.

[e] The parameters g_AΓg_VΓand g_{WM} for semileptonic modes are defined by $\overline{B}_f[\gamma_\lambda(g_V + g_A\gamma_5) + i(g_{WM}/m_{B_i})\ \sigma_{\lambda\nu}\ q^\nu]B_i$Γand ϕ_{AV} is defined by $g_A/g_V = |g_A/g_V|e^{i\phi_{AV}}$. See the "Note on Baryon Decay Parameters" in the neutron Particle Listings.

[f] Time-reversal invariance requires this to be 0° or 180°.

[g] The decay parameters γ and Δ are calculated from α and ϕ using

$$\gamma = \sqrt{1-\alpha^2}\ \cos\phi\ \Gamma \qquad \tan\Delta = -\frac{1}{\alpha}\ \sqrt{1-\alpha^2}\ \sin\phi\ .$$

See the "Note on Baryon Decay Parameters" in the neutron Particle Listings.

[h] See the Particle Listings for the pion momentum range used in this measurement.

[i] The error given here is only an educated guess. It is larger than the error on the weighted average of the published values.

[j] A theoretical value using QED.

[k] See the "Note on Λ_c^+ Branching Fractions" in the Branching Fractions of the Λ_c^+ Particle Listings.

[l] This branching fraction includes all the decay modes of the final-state resonance.

[m] An ℓ indicates an e or a μ modeΓnot a sum over these modes.

[n] The value is for the sum of the charge states of particle/antiparticle states indicated.

[o] Assuming isospin conservationΓso that the other third is $\Lambda_c^+ \pi^0 \pi^0$.

[p] Not a pure measurement. See note at head of Λ_b^0 Decay Modes.

MONOPOLES, SUPERSYMMETRY, COMPOSITENESS, etc., SEARCHES FOR

Magnetic Monopole Searches

Isolated supermassive monopole candidate events have not been confirmed. The most sensitive experiments obtain negative results.

Best cosmic-ray supermassive monopole flux limit:

$< 1.0 \times 10^{-15}$ cm^{-2}sr^{-1}s^{-1} for $1.1 \times 10^{-4} < \beta < 0.1$

Supersymmetric Particle Searches

Limits are based on the Minimal Supersymmetric Standard Model.

Assumptions include: 1) $\widetilde{\chi}_1^0$ (or $\widetilde{\gamma}$) is lightest supersymmetric particle; 2) R-parity is conserved; 3) All scalar quarks (except $\widetilde{t}_L$ and $\widetilde{t}_R$) are degenerate in mass, and $m_{\widetilde{q}_R} = m_{\widetilde{q}_L}$. 4) Limits for selectrons and smuons refer to the $\widetilde{\ell}_R$ states.

See the Particle Listings for a Note giving details of supersymmetry.

$\widetilde{\chi}_i^0$ — neutralinos (mixtures of $\widetilde{\gamma}$, $\widetilde{Z}^0$, and $\widetilde{H}_i^0$)

Mass $m_{\widetilde{\chi}_1^0}$ $>$ 10.9 GeV, CL = 95%

Mass $m_{\widetilde{\chi}_2^0}$ $>$ 45.3 GeV, CL = 95% [tanβ >1]

Mass $m_{\widetilde{\chi}_3^0}$ $>$ 75.8 GeV, CL = 95% [tanβ >1]

Mass $m_{\widetilde{\chi}_4^0}$ $>$ 127 GeV, CL = 95% [tanβ >3]

$\widetilde{\chi}_i^\pm$ — charginos (mixtures of $\widetilde{W}^\pm$ and $\widetilde{H}_i^\pm$)

Mass $m_{\widetilde{\chi}_1^\pm}$ $>$ 65.7 GeV, CL = 95% [$m_{\widetilde{\chi}_1^\pm} - m_{\widetilde{\chi}_1^0} \geq 2$ GeV]

Mass $m_{\widetilde{\chi}_2^\pm}$ $>$ 99 GeV, CL = 95% [GUT relations assumed]

$\widetilde{\nu}$ — scalar neutrino (sneutrino)

Mass $m >$ 37.1 GeV, CL = 95% [one flavor]

Mass $m >$ 43.1 GeV, CL = 95% [three degenerate flavors]

$\widetilde{e}$ — scalar electron (selectron)

Mass $m >$ 58 GeV, CL = 95% [$m_{\widetilde{e}_R} - m_{\widetilde{\chi}_1^0} \geq 4$ GeV]

$\widetilde{\mu}$ — scalar muon (smuon)

Mass $m >$ 55.6 GeV, CL = 95% [$m_{\widetilde{\mu}_R} - m_{\widetilde{\chi}_1^0} \geq 4$ GeV]

$\widetilde{\tau}$ — scalar tau (stau)

Mass $m >$ 45 GeV, CL = 95% [if $m_{\widetilde{\chi}_1^0} < 38$ GeV]

$\widetilde{q}$ — scalar quark (squark)

These limits include the effects of cascade decays, evaluated assuming a fixed value of the parameters μ and tanβ. The limits are weakly sensitive to these parameters over much of parameter space. Limits assume GUT relations between gaugino masses and the gauge coupling; in particular that for $|\mu|$ not small, $m_{\widetilde{\chi}_1^0} \approx m_{\widetilde{g}}/6$.

Mass $m >$ 176 GeV, CL = 95% [any $m_{\widetilde{g}} <$300 GeV, $\mu = -250$ GeV, tan$\beta = 2$]

Mass $m >$ 224 GeV, CL = 95% [$m_{\widetilde{g}} \leq m_{\widetilde{q}}$, $\mu = -400$ GeV, tan$\beta = 4$]

$\widetilde{g}$ — gluino

There is some controversy on whether gluinos in a low-mass window ($1 \lesssim m_{\widetilde{g}} \lesssim 5$ GeV) are excluded or not. See the Supersymmetry Listings for details.

The limits summarised here refere to the high-mass region ($m_{\widetilde{g}} \gtrsim 5$ GeV), and include the effects of cascade decays, evaluated assuming a fixed value of the parameters μ and tanβ. The limits are weakly sensitive to these parameters over much of parameter space. Limits assume GUT relations between gaugino masses and the gauge coupling; in particular that for $|\mu|$ not small, $m_{\widetilde{\chi}_1^0} \approx m_{\widetilde{g}}/6$.

Mass $m >$ 173 GeV, CL = 95% [any $m_{\widetilde{q}}$, $\mu = -200$ GeV, tan$\beta = 2$]

Mass $m >$ 212 GeV, CL = 95% [$m_{\widetilde{g}} \geq m_{\widetilde{q}}$, $\mu = -250$ GeV, tan$\beta = 2$]

Quark and Lepton Compositeness, Searches for

Scale Limits Λ for Contact Interactions (the lowest dimensional interactions with four fermions)

If the Lagrangian has the form

$$\pm \frac{g^2}{2\Lambda^2} \overline{\psi}_L \gamma_\mu \psi_L \overline{\psi}_L \gamma^\mu \psi_L$$

(with $g^2/4\pi$ set equal to 1), then we define $\Lambda \equiv \Lambda^\pm_{LL}$. For the full definitions and for other forms, see the Note in the Listings on Searches for Quark and Lepton Compositeness in the full *Review* and the original literature.

$\Lambda^+_{LL}(eeee)$ $>$ 2.4 TeV, CL = 95%

$\Lambda^-_{LL}(eeee)$ $>$ 3.6 TeV, CL = 95%

$\Lambda^+_{LL}(ee\mu\mu)$ $>$ 2.6 TeV, CL = 95%

$\Lambda^-_{LL}(ee\mu\mu)$ $>$ 2.9 TeV, CL = 95%

$\Lambda^+_{LL}(ee\tau\tau)$ $>$ 1.9 TeV, CL = 95%

$\Lambda^-_{LL}(ee\tau\tau)$ $>$ 3.0 TeV, CL = 95%

$\Lambda^+_{LL}(\ell\ell\ell\ell)$ $>$ 3.5 TeV, CL = 95%

$\Lambda^-_{LL}(\ell\ell\ell\ell)$ $>$ 3.8 TeV, CL = 95%

$\Lambda^+_{LL}(eeqq)$ $>$ 2.5 TeV, CL = 95%

$\Lambda^-_{LL}(eeqq)$ $>$ 3.7 TeV, CL = 95%

$\Lambda^+_{LL}(eebb)$ $>$ 3.1 TeV, CL = 95%

$\Lambda^-_{LL}(eebb)$ $>$ 2.9 TeV, CL = 95%

$\Lambda^+_{LL}(\mu\mu qq)$ $>$ 2.9 TeV, CL = 95%

$\Lambda^-_{LL}(\mu\mu qq)$ $>$ 4.2 TeV, CL = 95%

$\Lambda^\pm_{LR}(\nu_\mu \nu_e \mu e)$ $>$ 3.1 TeV, CL = 90%

$\Lambda^\pm_{LL}(qqqq)$ $>$ 1.6 TeV, CL = 95%

Excited Leptons

The limits from $\ell^{*+}\ell^{*-}$ do not depend on λ (where λ is the $\ell\ell^*$ transition coupling). The λ-dependent limits assume chiral coupling, except for the third limit for e^* which is for nonchiral coupling. For chiral coupling, this limit corresponds to $\lambda_\gamma = \sqrt{2}$.

$e^{*\pm}$ — excited electron

Mass $m >$ 85.0 GeV, CL = 95% (from $e^{*+}e^{*-}$)

Mass $m >$ 91 GeV, CL = 95% (if $\lambda_Z > 1$)

Mass $m >$ 194 GeV, CL = 95% (if $\lambda_\gamma = 1$)

$\mu^{*\pm}$ — excited muon

Mass $m >$ 85.3 GeV, CL = 95% (from $\mu^{*+}\mu^{*-}$)

Mass $m >$ 91 GeV, CL = 95% (if $\lambda_Z > 1$)

$\tau^{*\pm}$ — excited tau

Mass $m >$ 84.6 GeV, CL = 95% (from $\tau^{*+}\tau^{*-}$)

Mass $m >$ 90 GeV, CL = 95% (if $\lambda_Z > 0.18$)

ν^* — excited neutrino

Mass $m >$ 84.9 GeV, CL = 95% (from $\nu^*\overline{\nu}^*$)

Mass $m >$ 91 GeV, CL = 95% (if $\lambda_Z > 1$)

Mass $m =$ none 40–96 GeV, CL = 95% (from $ep \rightarrow \nu^* X$)

q^* — excited quark

Mass $m >$ 45.6 GeV, CL = 95% (from $q^*\overline{q}^*$)

Mass $m >$ 88 GeV, CL = 95% (if $\lambda_Z > 1$)

Mass $m >$ 570 GeV, CL = 95% ($p\overline{p} \rightarrow q^* X$)

Color Sextet and Octet Particles

Color Sextet Quarks (q_6)

Mass $m >$ 84 GeV, CL = 95% (Stable q_6)

Color Octet Charged Leptons (ℓ_8)

Mass $m >$ 86 GeV, CL = 95% (Stable ℓ_8)

Color Octet Neutrinos (ν_8)

Mass $m >$ 110 GeV, CL = 90% ($\nu_8 \rightarrow \nu g$)

TESTS OF CONSERVATION LAWS

Revised by L. Wolfenstein and T.G. TrippeΓMay 1998.

In keeping with the current interest in tests of conservation lawsΓ we collect together a Table of experimental limits on all weak and electromagnetic decaysΓmass differencesΓand momentsΓand on a few reactionsΓwhose observation would violate conservation laws. The Table is given only in the full *Review of Particle Physics*Γnot in the Particle Physics Booklet. For the benefit of Booklet readersΓwe include the best limits from the Table in the following text. Limits in this text are for CL=90% unless otherwise specified. The Table is in two parts: "Discrete Space-Time SymmetriesΓ" *i.e.*ΓCΓPΓTΓCPΓand CPT; and "Number Conservation LawsΓ" *i.e.*ΓleptonΓbaryonΓhadronic flavorΓand charge conservation. The references for these data can be found in the the Particle Listings in the *Review*. A discussion of these tests follows.

CPT INVARIANCE

General principles of relativistic field theory require invariance under the combined transformation CPT. The simplest tests of CPT invariance are the equality of the masses and lifetimes of a particle and its antiparticle. The best test comes from the limit on the mass difference between K^0 and $\overline{K}^0$. Any such difference contributes to the CP-violating parameter ϵ. Assuming CPT invarianceΓϕ_ϵΓthe phase of ϵ should be very close to 44°. (See the "Note on CP Violation in K^0_L Decay" in the Particle Listings.) In contrastΓif the entire source of CP violation in K^0 decays were a $K^0 - \overline{K}^0$ mass differenceΓϕ_ϵ would be $44° + 90°$. Assuming that there is no other source of CPT violation than this mass differenceΓit is possible to deduce that [1]

$$m_{\overline{K}^0} - m_{K^0} \approx \frac{2(m_{K^0_L} - m_{K^0_S})\,|\eta|\,(\frac{2}{3}\phi_{+-} + \frac{1}{3}\phi_{00} - \phi_0)}{\sin\phi_0} ,$$

where $\phi_0 = 43.5°$ with an uncertainty of less than 0.1°. Using our best values of the CP-violation parametersΓwe get $|(m_{\overline{K}^0} - m_{K^0})/m_{K^0}| \leq 10^{-18}$. Limits can also be placed on specific CPT-violating decay amplitudes. Given the small value of $(1 - |\eta_{00}/\eta_{+-}|)$Γthe value of $\phi_{00} - \phi_{+-}$ provides a measure of CPT violation in $K^0_L \to 2\pi$ decay. Results from CERN [1] and Fermilab [2] indicate no CPT-violating effect.

CP AND T INVARIANCE

Given CPT invarianceΓCP violation and T violation are equivalent. So far the only evidence for CP or T violation comes from the measurements of η_{+-}Γη_{00}Γand the semileptonic decay charge asymmetry for K_LΓ*e.g.*Γ$|\eta_{+-}| = |A(K^0_L \to \pi^+\pi^-)/A(K^0_S \to \pi^+\pi^-)| = (2.285 \pm 0.019) \times 10^{-3}$ and $[\Gamma(K^0_L \to \pi^-e^+\nu) - \Gamma(K^0_L \to \pi^+e^-\overline{\nu})]/[\text{sum}] = (0.333 \pm 0.014)\%$. Other searches for CP or T violation divide into (a) those that involve weak interactions or parity violationΓand (b) those that involve processes otherwise allowed by the strong or electromagnetic interactions. In class (a) the most sensitive are probably the searches for an electric dipole moment of the neutronΓmeasured to be $< 1.0 \times 10^{-25}$ e cmΓand the electron $(-0.18 \pm 0.16) \times 10^{-26}$ e cm. A nonzero value requires both P and T violation. Class (b) includes the search for C violation in η decayΓbelieved to be an electromagnetic processΓ*e.g.*Γas measured by $\Gamma(\eta \to \mu^+\mu^-\pi^0)/\Gamma(\eta \to \text{all}) < 5 \times 10^{-6}$Γand searches for T violation in a number of nuclear and electromagnetic reactions.

CONSERVATION OF LEPTON NUMBERS

Present experimental evidence and the standard electroweak theory are consistent with the absolute conservation of three separate lepton numbers: electron number L_eΓmuon number L_μΓand tau number L_τ. Searches for violations are of the following types:

a) $\Delta L = 2$ for one type of lepton. The best limit comes from the search for neutrinoless double beta decay $(Z, A) \to (Z + 2, A) + e^- + e^-$. The best laboratory limit is $t_{1/2} > 1.1 \times 10^{25}$ yr (CL=90%) for ^{76}Ge.

b) Conversion of one lepton type to another. For purely leptonic processesΓthe best limits are on $\mu \to e\gamma$ and $\mu \to 3e$Γmeasured as $\Gamma(\mu \to e\gamma)/\Gamma(\mu \to \text{all}) < 5 \times 10^{-11}$ and $\Gamma(\mu \to 3e)/\Gamma(\mu \to \text{all}) < 1.0 \times 10^{-12}$. For semileptonic processesΓthe best limit comes from the coherent conversion process in a muonic atomΓ$\mu^- + (Z, A) \to e^- + (Z, A)$Γmeasured as $\Gamma(\mu^-\text{Ti} \to e^-\text{Ti})/\Gamma(\mu^-\text{Ti} \to \text{all}) < 4 \times 10^{-12}$. Of special interest is the case in which the hadronic flavor also changesΓas in $K_L \to e\mu$ and $K^+ \to \pi^+e^-\mu^+$Γmeasured as $\Gamma(K_L \to e\mu)/\Gamma(K_L \to \text{all}) < 3.3 \times 10^{-11}$ and $\Gamma(K^+ \to \pi^+e^-\mu^+)/\Gamma(K^+ \to \text{all}) < 2.1 \times 10^{-10}$. Limits on the conversion of τ into e or μ are found in τ decay and are much less stringent than those for $\mu \to e$ conversionΓ*e.g.*Γ$\Gamma(\tau \to \mu\gamma)/\Gamma(\tau \to \text{all}) < 3.0 \times 10^{-6}$ and $\Gamma(\tau \to e\gamma)/\Gamma(\tau \to \text{all}) < 2.7 \times 10^{-6}$.

c) Conversion of one type of lepton into another type of antilepton. The case most studied is $\mu^- + (Z, A) \to e^+ + (Z - 2, A)$Γthe strongest limit being $\Gamma(\mu^-\text{Ti} \to e^+\text{Ca})/\Gamma(\mu^-\text{Ti} \to \text{all}) < 9 \times 10^{-11}$.

d) Relation to neutrino mass. If neutrinos have massΓthen it is expected even in the standard electroweak theory that the lepton numbers are not separately conservedΓas a consequence of lepton mixing analogous to Cabibbo quark mixing. HoweverΓin this case lepton-number-violating processes such as $\mu \to e\gamma$ are expected to have extremely small probability. For small neutrino massesΓthe lepton-number violation would be observed first in neutrino oscillationsΓwhich have been the subject of extensive experimental searches. For exampleΓsearches for $\overline{\nu}_e$ disappearanceΓwhich we label as $\overline{\nu}_e \not\to \overline{\nu}_e$Γgive measured limits $\Delta(m^2) < 9 \times 10^{-4}$ eV^2 for $\sin^2(2\theta) = 1$Γand $\sin^2(2\theta) < 0.02$ for large $\Delta(m^2)$Γwhere θ is the neutrino mixing angle. Possible evidence for mixing has come from two sources. The deficit in the solar neutrino flux compared with solar model calculations could be explained by oscillations with $\Delta(m^2) \leq 10^{-5}$ eV^2 causing the disappearance of ν_e. In addition underground detectors observing neutrinos produced by cosmic rays in the atmosphere have measured a ν_μ/ν_e ratio much less than expected and also a deficiency of upward going ν_μ compared to downward. This could be explained by oscillations leading to the disappearance of ν_μ with $\Delta(m^2)$ of the order 10^{-2}–10^{-3} eV^2.

CONSERVATION OF HADRONIC FLAVORS

In strong and electromagnetic interactionsΓ hadronic flavor is conservedΓ *i.e.* the conversion of a quark of one flavor (d, u, s, c, b, t) into a quark of another flavor is forbidden. In the Standard ModelΓthe weak interactions violate these conservation laws in a manner described by the Cabibbo-Kobayashi-Maskawa mixing (see the section "Cabibbo-Kobayashi-Maskawa Mixing Matrix"). The way in which these conservation laws are violated is tested as follows:

a) $\Delta S = \Delta Q$ rule. In the semileptonic decay of strange particlesΓthe strangeness change equals the change in charge of the hadrons. Tests come from limits on decay rates such as

$\Gamma(\Sigma^+ \to ne^+\nu)/\Gamma(\Sigma^+ \to \text{all}) < 5\times10^{-6}$Γand from a detailed analysis of $K_L \to \pi e \nu$Γwhich yields the parameter xΓmeasured to be (Re xΓIm x) $= (0.006 \pm 0.018$Γ$-0.003 \pm 0.026)$. Corresponding rules are $\Delta C = \Delta Q$ and $\Delta B = \Delta Q$.

b) Change of flavor by two units. In the Standard Model this occurs only in second-order weak interactions. The classic example is $\Delta S = 2$ via $K^0 - \overline{K}^0$ mixingΓwhich is directly measured by $m(K_S) - m(K_L) = (3.489 \pm 0.009)\times10^{-12}$ MeV. There is now evidence for $B^0 - \overline{B}^0$ mixing ($\Delta B = 2$)Γwith the corresponding mass difference between the eigenstates $(m_{B^0_H} - m_{B^0_L})$ $= (0.723 \pm 0.032)\Gamma_{B^0} = (3.05 \pm 0.12)\times10^{-10}$ MeVΓand for B^0_s–$\overline{B}^0_s$ mixingΓwith $(m_{B^0_{sH}} - m_{B^0_{sL}}) > 14\Gamma_{B^0_s}$ or $> 6\times10^{-9}$ MeV (CL=95%). No evidence exists for $D^0 - \overline{D}^0$ mixingΓwhich is expected to be much smaller in the Standard Model.

c) Flavor-changing neutral currents. In the Standard Model the neutral-current interactions do not change flavor. The low rate $\Gamma(K_L \to \mu^+\mu^-)/\Gamma(K_L \to \text{all}) = (7.2 \pm 0.5)\times10^{-9}$ puts limits on such interactions; the nonzero value for this rate is attributed to a combination of the weak and electromagnetic interactions. The best test should come from $K^+ \to \pi^+\nu\overline{\nu}$Γwhich occurs in the Standard Model only as a second-order weak process with a branching fraction of (1 to 8)$\times10^{-10}$. Observation of one event has been reported [4]Γyielding $\Gamma(K^+ \to \pi^+\nu\overline{\nu})/\Gamma(K^+ \to \text{all}) = (4.2^{+9.7}_{-3.5})\times10^{-10}$. Limits for charm-changing or bottom-changing neutral currents are much less stringent: $\Gamma(D^0 \to \mu^+\mu^-)/\Gamma(D^0 \to \text{all}) < 4\times10^{-6}$ and $\Gamma(B^0 \to \mu^+\mu^-)/\Gamma(B^0 \to \text{all}) < 7\times10^{-7}$. One cannot isolate flavor-changing neutral current (FCNC) effects in non leptonic decays. For exampleΓthe FCNC transition $s \to d + (\overline{u} + u)$ is equivalent to the charged-current transition $s \to u + (\overline{u} + d)$. Tests for FCNC are therefore limited to hadron decays into lepton pairs. Such decays are expected only in second-order in the electroweak coupling in the Standard Model.

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TESTS OF DISCRETE SPACE-TIME SYMMETRIES

CHARGE CONJUGATION (*C*) INVARIANCE

$\Gamma(\pi^0 \to 3\gamma)/\Gamma_{total}$		$<3.1\times10^{-8}$ΓCL = 90%
η *C*-nonconserving decay parameters		
$\pi^+\pi^-\pi^0$ left-right asymmetry parameter		$(0.09 \pm 0.17)\times10^{-2}$
$\pi^+\pi^-\pi^0$ sextant asymmetry parameter		$(0.18 \pm 0.16)\times10^{-2}$
$\pi^+\pi^-\pi^0$ quadrant asymmetry parameter		$(-0.17 \pm 0.17)\times10^{-2}$
$\pi^+\pi^-\gamma$ left-right asymmetry parameter		$(0.9 \pm 0.4)\times10^{-2}$
$\pi^+\pi^-\gamma$ parameter β (*D*-wave)		0.05 ± 0.06 (S = 1.5)
$\Gamma(\eta \to 3\gamma)/\Gamma_{total}$		$<5\times10^{-4}$ΓCL = 95%
$\Gamma(\eta \to \pi^0 e^+e^-)/\Gamma_{total}$	[*a*]	$<4\times10^{-5}$ΓCL = 90%
$\Gamma(\eta \to \pi^0 \mu^+\mu^-)/\Gamma_{total}$	[*a*]	$<5\times10^{-6}$ΓCL = 90%
$\Gamma(\omega(782) \to \eta\pi^0)/\Gamma_{total}$		$<1\times10^{-3}$ΓCL = 90%
$\Gamma(\omega(782) \to 3\pi^0)/\Gamma_{total}$		$<3\times10^{-4}$ΓCL = 90%
$\Gamma(\eta'(958) \to \pi^0 e^+e^-)/\Gamma_{total}$	[*a*]	$<1.3\times10^{-2}$ΓCL = 90%
$\Gamma(\eta'(958) \to \eta e^+e^-)/\Gamma_{total}$	[*a*]	$<1.1\times10^{-2}$ΓCL = 90%
$\Gamma(\eta'(958) \to 3\gamma)/\Gamma_{total}$		$<1.0\times10^{-4}$ΓCL = 90%
$\Gamma(\eta'(958) \to \mu^+\mu^-\pi^0)/\Gamma_{total}$	[*a*]	$<6.0\times10^{-5}$ΓCL = 90%
$\Gamma(\eta'(958) \to \mu^+\mu^-\eta)/\Gamma_{total}$	[*a*]	$<1.5\times10^{-5}$ΓCL = 90%

Limits are given at the 90% confidence levelΓwhile errors are given as ±1 standard deviation.

PARITY (*P*) INVARIANCE

e electric dipole moment	$(0.18 \pm 0.16)\times10^{-26}$ *e*cm
μ electric dipole moment	$(3.7 \pm 3.4)\times10^{-19}$ *e*cm
τ electric dipole moment (d_τ)	> -3.1 and $< 3.1\times10^{-16}$ *e*cmΓ CL = 95%
$\Gamma(\eta \to \pi^+\pi^-)/\Gamma_{total}$	$<9\times10^{-4}$ΓCL = 90%
$\Gamma(\eta'(958) \to \pi^+\pi^-)/\Gamma_{total}$	$<2\times10^{-2}$ΓCL = 90%
$\Gamma(\eta'(958) \to \pi^0\pi^0)/\Gamma_{total}$	$<9\times10^{-4}$ΓCL = 90%
p electric dipole moment	$(-4 \pm 6)\times10^{-23}$ *e*cm
n electric dipole moment	$<0.97\times10^{-25}$ *e*cmΓCL = 90%
Λ electric dipole moment	$<1.5\times10^{-16}$ *e*cmΓCL = 95%

TIME REVERSAL (*T*) INVARIANCE

Limits on *e*, μ, τ, *p*, *n*, and Λ electric dipole moments under Parity Invariance above are also tests of Time Reversal Invariance.

μ decay parameters		
transverse e^+ polarization normal to plane of μ spinΓe^+ momentum		0.007 ± 0.023
α'/A		$(0 \pm 4)\times10^{-3}$
β'/A		$(2 \pm 6)\times10^{-3}$
τ electric dipole moment (d_τ)		> -3.1 and $< 3.1\times10^{-16}$ *e*cmΓ CL = 95%
Im(ξ) in $K^\pm_{\mu3}$ decay (from transverse μ pol.)		-0.017 ± 0.025
Im(ξ) in $K^0_{\mu3}$ decay (from transverse μ pol.)		-0.007 ± 0.026
$n \to pe^-\nu$ decay parameters		
ϕ_{AV}Γphase of g_A relative to g_V	[*b*]	$(180.07 \pm 0.18)^\circ$
triple correlation coefficient *D*		$(-0.5 \pm 1.4)\times10^{-3}$
triple correlation coefficient *D* for $\Sigma^- \to ne^-\overline{\nu}_e$		0.11 ± 0.10

CP INVARIANCE

Re(d^W_τ)		$<0.56\times10^{-17}$ *e*cmΓCL = 95%
Im(d^W_τ)		$<1.5\times10^{-17}$ *e*cmΓCL = 95%
$\Gamma(\eta \to \pi^+\pi^-)/\Gamma_{total}$		$<9\times10^{-4}$ΓCL = 90%
$\Gamma(\eta'(958) \to \pi^+\pi^-)/\Gamma_{total}$		$<2\times10^{-2}$ΓCL = 90%
$\Gamma(\eta'(958) \to \pi^0\pi^0)/\Gamma_{total}$		$<9\times10^{-4}$ΓCL = 90%
$K^\pm \to \pi^\pm\pi^+\pi^-$ rate difference/average		(0.07 ± 0.12)%
$K^\pm \to \pi^\pm\pi^0\pi^0$ rate difference/average		(0.0 ± 0.6)%
$K^\pm \to \pi^\pm\pi^0\gamma$ rate difference/average		(0.9 ± 3.3)%
$(g_{\tau^+} - g_{\tau^-}) / (g_{\tau^+} + g_{\tau^-})$ for $K^\pm \to \pi^\pm\pi^+\pi^-$		(-0.7 ± 0.5)%
CP-violation parameters in K^0_S decay		
$\text{Im}(\eta_{+-0}) = \text{Im}(A(K^0_S \to \pi^+\pi^-\pi^0$Γ *CP*-violating) / $A(K^0_L \to \pi^+\pi^-\pi^0))$		-0.002 ± 0.008
$\text{Im}(\eta_{000})^2 = \Gamma(K^0_S \to 3\pi^0) / \Gamma(K^0_L \to 3\pi^0)$		<0.1ΓCL = 90%
charge asymmetry *j* for $K^0_L \to \pi^+\pi^-\pi^0$		0.0011 ± 0.0008
$\lvert\epsilon'_{+-\gamma}\rvert/\epsilon$ for $K^0_L \to \pi^+\pi^-\gamma$		<0.3ΓCL = 90%
$\Gamma(K^0_L \to \pi^0\mu^+\mu^-)/\Gamma_{total}$	[*c*]	$<5.1\times10^{-9}$ΓCL = 90%
$\Gamma(K^0_L \to \pi^0 e^+e^-)/\Gamma_{total}$	[*c*]	$<4.3\times10^{-9}$ΓCL = 90%
$\Gamma(K^0_L \to \pi^0\nu\overline{\nu})/\Gamma_{total}$	[*d*]	$<5.8\times10^{-5}$ΓCL = 90%
$A_{CP}(K^+K^-\pi^\pm)$ in $D^\pm \to K^+K^-\pi^\pm$		-0.017 ± 0.027
$A_{CP}(K^\pm K^{*0})$ in $D^+ \to K^+\overline{K}^{*0}$ and $D^- \to K^-K^{*0}$		-0.02 ± 0.05
$A_{CP}(\phi\pi^\pm)$ in $D^\pm \to \phi\pi^\pm$		-0.014 ± 0.033
$A_{CP}(\pi^+\pi^-\pi^\pm)$ in $D^\pm \to \pi^+\pi^-\pi^\pm$		-0.02 ± 0.04
$A_{CP}(K^+K^-)$ in D^0Γ$\overline{D}^0 \to K^+K^-$		0.026 ± 0.035
$A_{CP}(\pi^+\pi^-)$ in D^0Γ$\overline{D}^0 \to \pi^+\pi^-$		-0.05 ± 0.08
$A_{CP}(K^0_S\phi)$ in D^0Γ$\overline{D}^0 \to K^0_S\phi$		-0.03 ± 0.09
$A_{CP}(K^0_S\pi^0)$ in D^0Γ$\overline{D}^0 \to K^0_S\pi^0$		-0.018 ± 0.030
$\lvert\text{Re}(\epsilon_{B^0})\rvert$		0.002 ± 0.008
$[\alpha_-(\Lambda) + \alpha_+(\overline{\Lambda})] / [\alpha_-(\Lambda) - \alpha_+(\overline{\Lambda})]$		-0.03 ± 0.06

CP VIOLATION OBSERVED

K^0_L branching ratios		
charge asymmetry in $K^0_{\ell 3}$ decays		
$\delta(\mu) = [\Gamma(\pi^-\mu^+\nu_\mu) - \Gamma(\pi^+\mu^-\overline{\nu}_\mu)]$/sum		$(0.304 \pm 0.025)\%$
$\delta(e) = [\Gamma(\pi^-e^+\nu_e) - \Gamma(\pi^+e^-\overline{\nu}_e)]$/sum		$(0.333 \pm 0.014)\%$
parameters for $K^0_L \rightarrow 2\pi$ decay		
$\lvert\eta_{00}\rvert = \lvert A(K^0_L \rightarrow 2\pi^0) / A(K^0_S \rightarrow 2\pi^0)\rvert$		$(2.275 \pm 0.019) \times 10^{-3}$ (S = 1.1)
$\lvert\eta_{+-}\rvert = \lvert A(K^0_L \rightarrow \pi^+\pi^-) / A(K^0_S \rightarrow \pi^+\pi^-)\rvert$		$(2.285 \pm 0.019) \times 10^{-3}$
$\epsilon'/\epsilon \approx \mathrm{Re}(\epsilon'/\epsilon) = (1-\lvert\eta_{00}/\eta_{+-}\rvert)/3$	[e]	$(1.5 \pm 0.8) \times 10^{-3}$ (S = 1.8)
ϕ_{+-}Γphase of η_{+-}		$(43.5 \pm 0.6)^\circ$
ϕ_{00}Γphase of η_{00}		$(43.4 \pm 1.0)^\circ$
parameters for $K^0_L \rightarrow \pi^+\pi^-\gamma$ decay		
$\lvert\eta_{+-\gamma}\rvert = \lvert A(K^0_L \rightarrow \pi^+\pi^-\gamma$Γ*CP* violating$)/A(K^0_S \rightarrow \pi^+\pi^-\gamma)\rvert$		$(2.35 \pm 0.07) \times 10^{-3}$
$\phi_{+-\gamma}$ = phase of $\eta_{+-\gamma}$		$(44 \pm 4)^\circ$
$\Gamma(K^0_L \rightarrow \pi^+\pi^-)/\Gamma_{total}$		$(2.067 \pm 0.035) \times 10^{-3}$ (S = 1.1)
$\Gamma(K^0_L \rightarrow \pi^0\pi^0)/\Gamma_{total}$		$(9.36 \pm 0.20) \times 10^{-4}$

CPT INVARIANCE

$(m_{W^+} - m_{W^-}) / m_{average}$		-0.002 ± 0.007
$(m_{e^+} - m_{e^-}) / m_{average}$		$<4 \times 10^{-8}$ΓCL = 90%
$\lvert q_{e^+} + q_{e^-}\rvert/e$		$<2 \times 10^{-18}$
$(g_{e^+} - g_{e^-}) / g_{average}$		$(-0.5 \pm 2.1) \times 10^{-12}$
$(\tau_{\mu^+} - \tau_{\mu^-}) / \tau_{average}$		$(2 \pm 8) \times 10^{-5}$
$(g_{\mu^+} - g_{\mu^-}) / g_{average}$		$(-2.6 \pm 1.6) \times 10^{-8}$
$(m_{\pi^+} - m_{\pi^-}) / m_{average}$		$(2 \pm 5) \times 10^{-4}$
$(\tau_{\pi^+} - \tau_{\pi^-}) / \tau_{average}$		$(6 \pm 7) \times 10^{-4}$
$(m_{K^+} - m_{K^-}) / m_{average}$		$(-0.6 \pm 1.8) \times 10^{-4}$
$(\tau_{K^+} - \tau_{K^-}) / \tau_{average}$		$(0.11 \pm 0.09)\%$ (S = 1.2)
$K^\pm \rightarrow \mu^\pm\nu_\mu$ rate difference/average		$(-0.5 \pm 0.4)\%$
$K^\pm \rightarrow \pi^\pm\pi^0$ rate difference/average	[f]	$(0.8 \pm 1.2)\%$
$\lvert m_{K^0} - m_{\overline{K}^0}\rvert / m_{average}$	[g]	$<10^{-18}$
phase difference $\phi_{00} - \phi_{+-}$		$(-0.1 \pm 0.8)^\circ$
CPT-violation parameters in K^0 decay		
real part of Δ		0.018 ± 0.020
imaginary part of Δ		0.02 ± 0.04
$(\lvert\frac{q_p}{m_p}\rvert - \lvert\frac{q_{\overline{p}}}{m_{\overline{p}}}\rvert)/\lvert\frac{q}{m}\rvert_{average}$		$(1.5 \pm 1.1) \times 10^{-9}$
$\lvert q_p + q_{\overline{p}}\rvert/e$		$<2 \times 10^{-5}$
$(\mu_p + \mu_{\overline{p}}) / \lvert\mu\rvert_{average}$		$(-2.6 \pm 2.9) \times 10^{-3}$
$(m_n - m_{\overline{n}}) / m_{average}$		$(9 \pm 5) \times 10^{-5}$
$(m_\Lambda - m_{\overline{\Lambda}}) / m_\Lambda$		$(-1.0 \pm 0.9) \times 10^{-5}$
$(\tau_\Lambda - \tau_{\overline{\Lambda}}) / \tau_{average}$		0.04 ± 0.09
$(\mu_{\Sigma^+} + \mu_{\overline{\Sigma}^-}) / \lvert\mu\rvert_{average}$		0.014 ± 0.015
$(m_{\Xi^-} - m_{\overline{\Xi}^+}) / m_{average}$		$(1.1 \pm 2.7) \times 10^{-4}$
$(\tau_{\Xi^-} - \tau_{\overline{\Xi}^+}) / \tau_{average}$		0.02 ± 0.18
$(m_{\Omega^-} - m_{\overline{\Omega}^+}) / m_{average}$		$(0 \pm 5) \times 10^{-4}$

Limits are given at the 90% confidence levelΓwhile errors are given as ±1 standard deviation.

TESTS OF NUMBER CONSERVATION LAWS

LEPTON FAMILY NUMBER

Lepton family number conservation means separate conservation of each of L_e, L_μ, L_τ.

$\Gamma(Z \rightarrow e^\pm\mu^\mp)/\Gamma_{total}$	[h]	$<1.7 \times 10^{-6}$ΓCL = 95%
$\Gamma(Z \rightarrow e^\pm\tau^\mp)/\Gamma_{total}$	[h]	$<9.8 \times 10^{-6}$ΓCL = 95%
$\Gamma(Z \rightarrow \mu^\pm\tau^\mp)/\Gamma_{total}$	[h]	$<1.2 \times 10^{-5}$ΓCL = 95%
limit on $\mu^- \rightarrow e^-$ conversion		
$\sigma(\mu^-\,{}^{32}S \rightarrow e^-\,{}^{32}S) / \sigma(\mu^-\,{}^{32}S \rightarrow \nu_\mu\,{}^{32}P^*)$		$<7 \times 10^{-11}$ΓCL = 90%
$\sigma(\mu^-\,\mathrm{Ti} \rightarrow e^-\,\mathrm{Ti}) / \sigma(\mu^-\,\mathrm{Ti} \rightarrow$ capture$)$		$<4.3 \times 10^{-12}$ΓCL = 90%
$\sigma(\mu^-\,\mathrm{Pb} \rightarrow e^-\,\mathrm{Pb}) / \sigma(\mu^-\,\mathrm{Pb} \rightarrow$ capture$)$		$<4.6 \times 10^{-11}$ΓCL = 90%
limit on muonium → antimuonium conversion $R_g = G_C / G_F$		<0.018ΓCL = 90%
$\Gamma(\mu^- \rightarrow e^-\nu_e\overline{\nu}_\mu)/\Gamma_{total}$	[i]	$<1.2 \times 10^{-2}$ΓCL = 90%
$\Gamma(\mu^- \rightarrow e^-\gamma)/\Gamma_{total}$		$<4.9 \times 10^{-11}$ΓCL = 90%
$\Gamma(\mu^- \rightarrow e^-e^+e^-)/\Gamma_{total}$		$<1.0 \times 10^{-12}$ΓCL = 90%
$\Gamma(\mu^- \rightarrow e^-2\gamma)/\Gamma_{total}$		$<7.2 \times 10^{-11}$ΓCL = 90%
$\Gamma(\tau^- \rightarrow e^-\gamma)/\Gamma_{total}$		$<2.7 \times 10^{-6}$ΓCL = 90%
$\Gamma(\tau^- \rightarrow \mu^-\gamma)/\Gamma_{total}$		$<3.0 \times 10^{-6}$ΓCL = 90%
$\Gamma(\tau^- \rightarrow e^-\pi^0)/\Gamma_{total}$		$<3.7 \times 10^{-6}$ΓCL = 90%
$\Gamma(\tau^- \rightarrow \mu^-\pi^0)/\Gamma_{total}$		$<4.0 \times 10^{-6}$ΓCL = 90%
$\Gamma(\tau^- \rightarrow e^-K^0)/\Gamma_{total}$		$<1.3 \times 10^{-3}$ΓCL = 90%
$\Gamma(\tau^- \rightarrow \mu^-K^0)/\Gamma_{total}$		$<1.0 \times 10^{-3}$ΓCL = 90%
$\Gamma(\tau^- \rightarrow e^-\eta)/\Gamma_{total}$		$<8.2 \times 10^{-6}$ΓCL = 90%
$\Gamma(\tau^- \rightarrow \mu^-\eta)/\Gamma_{total}$		$<9.6 \times 10^{-6}$ΓCL = 90%
$\Gamma(\tau^- \rightarrow e^-\rho^0)/\Gamma_{total}$		$<2.0 \times 10^{-6}$ΓCL = 90%
$\Gamma(\tau^- \rightarrow \mu^-\rho^0)/\Gamma_{total}$		$<6.3 \times 10^{-6}$ΓCL = 90%
$\Gamma(\tau^- \rightarrow e^-K^*(892)^0)/\Gamma_{total}$		$<5.1 \times 10^{-6}$ΓCL = 90%
$\Gamma(\tau^- \rightarrow \mu^-K^*(892)^0)/\Gamma_{total}$		$<7.5 \times 10^{-6}$ΓCL = 90%
$\Gamma(\tau^- \rightarrow e^-\overline{K}^*(892)^0)/\Gamma_{total}$		$<7.4 \times 10^{-6}$ΓCL = 90%
$\Gamma(\tau^- \rightarrow \mu^-\overline{K}^*(892)^0)/\Gamma_{total}$		$<7.5 \times 10^{-6}$ΓCL = 90%
$\Gamma(\tau^- \rightarrow e^-\phi)/\Gamma_{total}$		$<6.9 \times 10^{-6}$ΓCL = 90%
$\Gamma(\tau^- \rightarrow \mu^-\phi)/\Gamma_{total}$		$<7.0 \times 10^{-6}$ΓCL = 90%
$\Gamma(\tau^- \rightarrow e^-e^+e^-)/\Gamma_{total}$		$<2.9 \times 10^{-6}$ΓCL = 90%
$\Gamma(\tau^- \rightarrow e^-\mu^+\mu^-)/\Gamma_{total}$		$<1.8 \times 10^{-6}$ΓCL = 90%
$\Gamma(\tau^- \rightarrow e^+\mu^-\mu^-)/\Gamma_{total}$		$<1.5 \times 10^{-6}$ΓCL = 90%
$\Gamma(\tau^- \rightarrow \mu^-e^+e^-)/\Gamma_{total}$		$<1.7 \times 10^{-6}$ΓCL = 90%
$\Gamma(\tau^- \rightarrow \mu^+e^-e^-)/\Gamma_{total}$		$<1.5 \times 10^{-6}$ΓCL = 90%
$\Gamma(\tau^- \rightarrow \mu^-\mu^+\mu^-)/\Gamma_{total}$		$<1.9 \times 10^{-6}$ΓCL = 90%
$\Gamma(\tau^- \rightarrow e^-\pi^+\pi^-)/\Gamma_{total}$		$<2.2 \times 10^{-6}$ΓCL = 90%
$\Gamma(\tau^- \rightarrow \mu^-\pi^+\pi^-)/\Gamma_{total}$		$<8.2 \times 10^{-6}$ΓCL = 90%
$\Gamma(\tau^- \rightarrow e^-\pi^+K^-)/\Gamma_{total}$		$<6.4 \times 10^{-6}$ΓCL = 90%
$\Gamma(\tau^- \rightarrow e^-\pi^-K^+)/\Gamma_{total}$		$<3.8 \times 10^{-6}$ΓCL = 90%
$\Gamma(\tau^- \rightarrow e^-K^+K^-)/\Gamma_{total}$		$<6.0 \times 10^{-6}$ΓCL = 90%
$\Gamma(\tau^- \rightarrow \mu^-\pi^+K^-)/\Gamma_{total}$		$<7.5 \times 10^{-6}$ΓCL = 90%
$\Gamma(\tau^- \rightarrow \mu^-\pi^-K^+)/\Gamma_{total}$		$<7.4 \times 10^{-6}$ΓCL = 90%
$\Gamma(\tau^- \rightarrow \mu^-K^+K^-)/\Gamma_{total}$		$<1.5 \times 10^{-5}$ΓCL = 90%
$\Gamma(\tau^- \rightarrow e^-\pi^0\pi^0)/\Gamma_{total}$		$<6.5 \times 10^{-6}$ΓCL = 90%
$\Gamma(\tau^- \rightarrow \mu^-\pi^0\pi^0)/\Gamma_{total}$		$<1.4 \times 10^{-5}$ΓCL = 90%
$\Gamma(\tau^- \rightarrow e^-\eta\eta)/\Gamma_{total}$		$<3.5 \times 10^{-5}$ΓCL = 90%
$\Gamma(\tau^- \rightarrow \mu^-\eta\eta)/\Gamma_{total}$		$<6.0 \times 10^{-5}$ΓCL = 90%
$\Gamma(\tau^- \rightarrow e^-\pi^0\eta)/\Gamma_{total}$		$<2.4 \times 10^{-5}$ΓCL = 90%
$\Gamma(\tau^- \rightarrow \mu^-\pi^0\eta)/\Gamma_{total}$		$<2.2 \times 10^{-5}$ΓCL = 90%
$\Gamma(\tau^- \rightarrow e^-$ light boson$)/\Gamma_{total}$		$<2.7 \times 10^{-3}$ΓCL = 95%
$\Gamma(\tau^- \rightarrow \mu^-$ light boson$)/\Gamma_{total}$		$<5 \times 10^{-3}$ΓCL = 95%

ν oscillations. (For other lepton mixing effects in particle decaysΓsee the Particle Listings.)

$\overline{\nu}_e \not\rightarrow \overline{\nu}_e$	
$\Delta(m^2)$ for $\sin^2(2\theta) = 1$	$<9 \times 10^{-4}$ eV^{2}ΓCL = 90%
$\sin^2(2\theta)$ for "Large" $\Delta(m^2)$	<0.02ΓCL = 90%
$\nu_e \rightarrow \nu_\tau$	
$\Delta(m^2)$ for $\sin^2(2\theta) = 1$	<9 eV^{2}ΓCL = 90%
$\sin^2(2\theta)$ for "Large" $\Delta(m^2)$	<0.25ΓCL = 90%
$\overline{\nu}_e \rightarrow \overline{\nu}_\tau$	
$\sin^2(2\theta)$ for "Large" $\Delta(m^2)$	<0.7ΓCL = 90%
$\nu_\mu \rightarrow \nu_e$	

$\Delta(m^2)$ for $\sin^2(2\theta) = 1$		<0.09 eV^{2}ΓCL = 90%
$\sin^2(2\theta)$ for "Large" $\Delta(m^2)$		$<3.0 \times 10^{-3}$ΓCL = 90%
$\overline{\nu}_\mu \to \overline{\nu}_e$		
$\Delta(m^2)$ for $\sin^2(2\theta) = 1$		<0.14 eV^{2}ΓCL = 90%
$\sin^2(2\theta)$ for "Large" $\Delta(m^2)$		<0.004ΓCL = 95%
$\nu_\mu(\overline{\nu}_\mu) \to \nu_e(\overline{\nu}_e)$		
$\Delta(m^2)$ for $\sin^2(2\theta) = 1$		<0.075 eV^{2}ΓCL = 90%
$\sin^2(2\theta)$ for "Large" $\Delta(m^2)$		$<1.8 \times 10^{-3}$ΓCL = 90%
$\nu_\mu \to \nu_\tau$		
$\Delta(m^2)$ for $\sin^2(2\theta) = 1$		<0.9 eV^{2}ΓCL = 90%
$\sin^2(2\theta)$ for "Large" $\Delta(m^2)$		<0.004ΓCL = 90%
$\overline{\nu}_\mu \to \overline{\nu}_\tau$		
$\Delta(m^2)$ for $\sin^2(2\theta) = 1$		<2.2 eV^{2}ΓCL = 90%
$\sin^2(2\theta)$ for "Large" $\Delta(m^2)$		$<4.4 \times 10^{-2}$ΓCL = 90%
$\nu_\mu(\overline{\nu}_\mu) \to \nu_\tau(\overline{\nu}_\tau)$		
$\Delta(m^2)$ for $\sin^2(2\theta) = 1$		<1.5 eV^{2}ΓCL = 90%
$\sin^2(2\theta)$ for "Large" $\Delta(m^2)$		$<8 \times 10^{-3}$ΓCL = 90%
$\nu_e \not\to \nu_e$		
$\Delta(m^2)$ for $\sin^2(2\theta) = 1$		<0.17 eV^{2}ΓCL = 90%
$\sin^2(2\theta)$ for "Large" $\Delta(m^2)$		$<7 \times 10^{-2}$ΓCL = 90%
$\nu_\mu \not\to \nu_\mu$		
$\Delta(m^2)$ for $\sin^2(2\theta) = 1$		<0.23 or >1500 eV^2
$\sin^2(2\theta)$ for $\Delta(m^2) = 100$eV^2	[j]	<0.02ΓCL = 90%
$\overline{\nu}_\mu \not\to \overline{\nu}_\mu$		
$\Delta(m^2)$ for $\sin^2(2\theta) = 1$		<7 or >1200 eV^2
$\sin^2(2\theta)$ for 190 eV^2 $< \Delta(m^2) <$ 320 eV^2	[k]	<0.02ΓCL = 90%
$\Gamma(\pi^+ \to \mu^+\nu_e)/\Gamma_{total}$	[l]	$<8.0 \times 10^{-3}$ΓCL = 90%
$\Gamma(\pi^+ \to \mu^- e^+ e^+ \nu)/\Gamma_{total}$		$<1.6 \times 10^{-6}$ΓCL = 90%
$\Gamma(\pi^0 \to \mu^+ e^- + e^- \mu^+)/\Gamma_{total}$		$<1.72 \times 10^{-8}$ΓCL = 90%
$\Gamma(\eta \to \mu^+ e^- + \mu^- e^+)/\Gamma_{total}$		$<6 \times 10^{-6}$ΓCL = 90%
$\Gamma(K^+ \to \mu^- \nu e^+ e^+)/\Gamma_{total}$		$<2.0 \times 10^{-8}$ΓCL = 90%
$\Gamma(K^+ \to \mu^+\nu_e)/\Gamma_{total}$	[l]	$<4 \times 10^{-3}$ΓCL = 90%
$\Gamma(K^+ \to \pi^+\mu^+e^-)/\Gamma_{total}$		$<2.1 \times 10^{-10}$ΓCL = 90%
$\Gamma(K^+ \to \pi^+\mu^-e^+)/\Gamma_{total}$		$<7 \times 10^{-9}$ΓCL = 90%
$\Gamma(K^0_L \to e^\pm\mu^\mp)/\Gamma_{total}$	[h]	$<3.3 \times 10^{-11}$ΓCL = 90%
$\Gamma(K^0_L \to e^\pm e^\pm \mu^\mp \mu^\mp)/\Gamma_{total}$	[h]	$<6.1 \times 10^{-9}$ΓCL = 90%
$\Gamma(D^+ \to \pi^+ e^+ \mu^-)/\Gamma_{total}$		$<1.1 \times 10^{-4}$ΓCL = 90%
$\Gamma(D^+ \to \pi^+ e^- \mu^+)/\Gamma_{total}$		$<1.3 \times 10^{-4}$ΓCL = 90%
$\Gamma(D^+ \to K^+ e^+ \mu^-)/\Gamma_{total}$		$<1.3 \times 10^{-4}$ΓCL = 90%
$\Gamma(D^+ \to K^+ e^- \mu^+)/\Gamma_{total}$		$<1.2 \times 10^{-4}$ΓCL = 90%
$\Gamma(D^0 \to \mu^\pm e^\mp)/\Gamma_{total}$	[h]	$<1.9 \times 10^{-5}$ΓCL = 90%
$\Gamma(D^0 \to \pi^0 e^\pm \mu^\mp)/\Gamma_{total}$	[h]	$<8.6 \times 10^{-5}$ΓCL = 90%
$\Gamma(D^0 \to \eta e^\pm \mu^\mp)/\Gamma_{total}$	[h]	$<1.0 \times 10^{-4}$ΓCL = 90%
$\Gamma(D^0 \to \rho^0 e^\pm \mu^\mp)/\Gamma_{total}$	[h]	$<4.9 \times 10^{-5}$ΓCL = 90%
$\Gamma(D^0 \to \omega e^\pm \mu^\mp)/\Gamma_{total}$	[h]	$<1.2 \times 10^{-4}$ΓCL = 90%
$\Gamma(D^0 \to \phi e^\pm \mu^\mp)/\Gamma_{total}$	[h]	$<3.4 \times 10^{-5}$ΓCL = 90%
$\Gamma(D^0 \to \overline{K}^0 e^\pm \mu^\mp)/\Gamma_{total}$	[h]	$<1.0 \times 10^{-4}$ΓCL = 90%
$\Gamma(D^0 \to \overline{K}^*(892)^0 e^\pm \mu^\mp)/\Gamma_{total}$	[h]	$<1.0 \times 10^{-4}$ΓCL = 90%
$\Gamma(B^+ \to \pi^+ e^+ \mu^-)/\Gamma_{total}$		$<6.4 \times 10^{-3}$ΓCL = 90%
$\Gamma(B^+ \to \pi^+ e^- \mu^+)/\Gamma_{total}$		$<6.4 \times 10^{-3}$ΓCL = 90%
$\Gamma(B^+ \to K^+ e^+ \mu^-)/\Gamma_{total}$		$<6.4 \times 10^{-3}$ΓCL = 90%
$\Gamma(B^+ \to K^+ e^- \mu^+)/\Gamma_{total}$		$<6.4 \times 10^{-3}$ΓCL = 90%
$\Gamma(B^+ \to \pi^- e^+ \mu^+)/\Gamma_{total}$		$<6.4 \times 10^{-3}$ΓCL = 90%
$\Gamma(B^+ \to K^- e^+ \mu^+)/\Gamma_{total}$		$<6.4 \times 10^{-3}$ΓCL = 90%
$\Gamma(B^0 \to e^\pm \mu^\mp)/\Gamma_{total}$	[h]	$<5.9 \times 10^{-6}$ΓCL = 90%
$\Gamma(B^0 \to e^\pm \tau^\mp)/\Gamma_{total}$	[h]	$<5.3 \times 10^{-4}$ΓCL = 90%
$\Gamma(B^0 \to \mu^\pm \tau^\mp)/\Gamma_{total}$	[h]	$<8.3 \times 10^{-4}$ΓCL = 90%
$\Gamma(B \to e^\pm \mu^\mp s)/\Gamma_{total}$		$<2.2 \times 10^{-5}$ΓCL = 90%
$\Gamma(B^0_s \to e^\pm \mu^\mp)/\Gamma_{total}$	[h]	$<4.1 \times 10^{-5}$ΓCL = 90%

Limits are given at the 90% confidence levelΓwhile errors are given as ±1 standard deviation.

TOTAL LEPTON NUMBER

Violation of total lepton number conservation also implies violation of lepton family number conservation.

limit on $\mu^- \to e^+$ conversion		
$\sigma(\mu^- {}^{32}\text{S} \to e^+ {}^{32}\text{Si}^*)$ / $\sigma(\mu^- {}^{32}\text{S} \to \nu_\mu {}^{32}\text{P}^*)$		$<9 \times 10^{-10}$ΓCL = 90%
$\sigma(\mu^- {}^{127}\text{I} \to e^+ {}^{127}\text{Sb}^*)$ / $\sigma(\mu^- {}^{127}\text{I} \to$ anything)		$<3 \times 10^{-10}$ΓCL = 90%
$\sigma(\mu^-\text{Ti} \to e^+\text{Ca})$ / $\sigma(\mu^-\text{Ti} \to$ capture)		$<8.9 \times 10^{-11}$ΓCL = 90%
$\Gamma(\tau^- \to \pi^-\gamma)/\Gamma_{total}$		$<2.8 \times 10^{-4}$ΓCL = 90%
$\Gamma(\tau^- \to \pi^-\pi^0)/\Gamma_{total}$		$<3.7 \times 10^{-4}$ΓCL = 90%
$\Gamma(\tau^- \to e^+\pi^-\pi^-)/\Gamma_{total}$		$<1.9 \times 10^{-6}$ΓCL = 90%
$\Gamma(\tau^- \to \mu^+\pi^-\pi^-)/\Gamma_{total}$		$<3.4 \times 10^{-6}$ΓCL = 90%
$\Gamma(\tau^- \to e^+\pi^-K^-)/\Gamma_{total}$		$<2.1 \times 10^{-6}$ΓCL = 90%
$\Gamma(\tau^- \to e^+K^-K^-)/\Gamma_{total}$		$<3.8 \times 10^{-6}$ΓCL = 90%
$\Gamma(\tau^- \to \mu^+\pi^-K^-)/\Gamma_{total}$		$<7.0 \times 10^{-6}$ΓCL = 90%
$\Gamma(\tau^- \to \mu^+K^-K^-)/\Gamma_{total}$		$<6.0 \times 10^{-6}$ΓCL = 90%
$\Gamma(\tau^- \to \overline{p}\gamma)/\Gamma_{total}$		$<2.9 \times 10^{-4}$ΓCL = 90%
$\Gamma(\tau^- \to \overline{p}\pi^0)/\Gamma_{total}$		$<6.6 \times 10^{-4}$ΓCL = 90%
$\Gamma(\tau^- \to \overline{p}\eta)/\Gamma_{total}$		$<1.30 \times 10^{-3}$ΓCL = 90%
$\nu_e \to (\overline{\nu}_e)_L$		
$\alpha\Delta(m^2)$ for $\sin^2(2\theta) = 1$		<0.14 eV^{2}ΓCL = 90%
$\alpha^2\sin^2(2\theta)$ for "Large" $\Delta(m^2)$		<0.032ΓCL = 90%
$\nu_\mu \to (\overline{\nu}_e)_L$		
$\alpha\Delta(m^2)$ for $\sin^2(2\theta) = 1$		<0.16 eV^{2}ΓCL = 90%
$\alpha^2\sin^2(2\theta)$ for "Large" $\Delta(m^2)$		<0.001ΓCL = 90%
$\Gamma(\pi^+ \to \mu^+\overline{\nu}_e)/\Gamma_{total}$	[l]	$<1.5 \times 10^{-3}$ΓCL = 90%
$\Gamma(K^+ \to \pi^-\mu^+e^+)/\Gamma_{total}$		$<7 \times 10^{-9}$ΓCL = 90%
$\Gamma(K^+ \to \pi^-e^+e^+)/\Gamma_{total}$		$<1.0 \times 10^{-8}$ΓCL = 90%
$\Gamma(K^+ \to \pi^-\mu^+\mu^+)/\Gamma_{total}$	[l]	$<1.5 \times 10^{-4}$ΓCL = 90%
$\Gamma(K^+ \to \mu^+\overline{\nu}_e)/\Gamma_{total}$	[l]	$<3.3 \times 10^{-3}$ΓCL = 90%
$\Gamma(K^+ \to \pi^0e^+\overline{\nu}_e)/\Gamma_{total}$		$<3 \times 10^{-3}$ΓCL = 90%
$\Gamma(D^+ \to \pi^-e^+e^+)/\Gamma_{total}$		$<1.1 \times 10^{-4}$ΓCL = 90%
$\Gamma(D^+ \to \pi^-\mu^+\mu^+)/\Gamma_{total}$		$<8.7 \times 10^{-5}$ΓCL = 90%
$\Gamma(D^+ \to \pi^-e^+\mu^+)/\Gamma_{total}$		$<1.1 \times 10^{-4}$ΓCL = 90%
$\Gamma(D^+ \to \rho^-\mu^+\mu^+)/\Gamma_{total}$		$<5.6 \times 10^{-4}$ΓCL = 90%
$\Gamma(D^+ \to K^-e^+e^+)/\Gamma_{total}$		$<1.2 \times 10^{-4}$ΓCL = 90%
$\Gamma(D^+ \to K^-\mu^+\mu^+)/\Gamma_{total}$		$<1.2 \times 10^{-4}$ΓCL = 90%
$\Gamma(D^+ \to K^-e^+\mu^+)/\Gamma_{total}$		$<1.3 \times 10^{-4}$ΓCL = 90%
$\Gamma(D^+ \to K^*(892)^-\mu^+\mu^+)/\Gamma_{total}$		$<8.5 \times 10^{-4}$ΓCL = 90%
$\Gamma(D^+_s \to \pi^-\mu^+\mu^+)/\Gamma_{total}$		$<4.3 \times 10^{-4}$ΓCL = 90%
$\Gamma(D^+_s \to K^-\mu^+\mu^+)/\Gamma_{total}$		$<5.9 \times 10^{-4}$ΓCL = 90%
$\Gamma(D^+_s \to K^*(892)^-\mu^+\mu^+)/\Gamma_{total}$		$<1.4 \times 10^{-3}$ΓCL = 90%
$\Gamma(B^+ \to \pi^-e^+e^+)/\Gamma_{total}$		$<3.9 \times 10^{-3}$ΓCL = 90%
$\Gamma(B^+ \to \pi^-\mu^+\mu^+)/\Gamma_{total}$		$<9.1 \times 10^{-3}$ΓCL = 90%
$\Gamma(B^+ \to K^-e^+e^+)/\Gamma_{total}$		$<3.9 \times 10^{-3}$ΓCL = 90%
$\Gamma(B^+ \to K^-\mu^+\mu^+)/\Gamma_{total}$		$<9.1 \times 10^{-3}$ΓCL = 90%
$\Gamma(\Xi^- \to p\mu^-\mu^-)/\Gamma_{total}$		$<4 \times 10^{-4}$ΓCL = 90%
$\Gamma(\Lambda^+_c \to \Sigma^-\mu^+\mu^+)/\Gamma_{total}$		$<7.0 \times 10^{-4}$ΓCL = 90%

BARYON NUMBER

$\Gamma(\tau^- \to \overline{p}\gamma)/\Gamma_{total}$		$<2.9 \times 10^{-4}$ΓCL = 90%
$\Gamma(\tau^- \to \overline{p}\pi^0)/\Gamma_{total}$		$<6.6 \times 10^{-4}$ΓCL = 90%
$\Gamma(\tau^- \to \overline{p}\eta)/\Gamma_{total}$		$<1.30 \times 10^{-3}$ΓCL = 90%
p mean life		$>1.6 \times 10^{25}$ years

A few examples of proton or bound neutron decay follow. For limits on many other nucleon decay channelsΓsee the Baryon Summary Table.

$\tau(N \to e^+\pi)$		> 130 (n)Γ> 550 (p) $\times 10^{30}$ yearsΓ CL = 90%
$\tau(N \to \mu^+\pi)$		> 100 (n)Γ> 270 (p) $\times 10^{30}$ yearsΓ CL = 90%
$\tau(N \to e^+K)$		> 1.3 (n)Γ> 150 (p) $\times 10^{30}$ yearsΓ CL = 90%
$\tau(N \to \mu^+K)$		> 1.1 (n)Γ> 120 (p) $\times 10^{30}$ yearsΓ CL = 90%
limit on $n\overline{n}$ oscillations (bound n)	[m]	$>1.2 \times 10^8$ sΓCL = 90%
limit on $n\overline{n}$ oscillations (free n)		$>0.86 \times 10^8$ sΓCL = 90%

ELECTRIC CHARGE (Q)

e mean life / branching fraction	[n]	$>4.3 \times 10^{23}$ yrΓCL = 68%
$\Gamma(n \to p \nu_e \overline{\nu}_e)/\Gamma_{total}$		$<8 \times 10^{-27}$ΓCL = 68%

$\Delta S = \Delta Q$ RULE

Allowed in second-order weak interactions.

$\Gamma(K^+ \to \pi^+ \pi^+ e^- \overline{\nu}_e)/\Gamma_{total}$	$<1.2 \times 10^{-8}$ΓCL = 90%
$\Gamma(K^+ \to \pi^+ \pi^+ \mu^- \overline{\nu}_\mu)/\Gamma_{total}$	$<3.0 \times 10^{-6}$ΓCL = 95%
$x = A(\overline{K}^0 \to \pi^- \ell^+ \nu)/A(K^0 \to \pi^- \ell^+ \nu) = A(\Delta S{=}-\Delta Q)/A(\Delta S{=}\Delta Q)$	
real part of x	0.006 ± 0.018 (S = 1.3)
imaginary part of x	-0.003 ± 0.026 (S = 1.2)
$\Gamma(\Sigma^+ \to n \ell^+ \nu)/\Gamma(\Sigma^- \to n \ell^- \overline{\nu})$	<0.043
$\Gamma(\Sigma^+ \to n e^+ \nu_e)/\Gamma_{total}$	$<5 \times 10^{-6}$ΓCL = 90%
$\Gamma(\Sigma^+ \to n \mu^+ \nu_\mu)/\Gamma_{total}$	$<3.0 \times 10^{-5}$ΓCL = 90%
$\Gamma(\Xi^0 \to \Sigma^- e^+ \nu_e)/\Gamma_{total}$	$<9 \times 10^{-4}$ΓCL = 90%
$\Gamma(\Xi^0 \to \Sigma^- \mu^+ \nu_\mu)/\Gamma_{total}$	$<9 \times 10^{-4}$ΓCL = 90%

$\Delta S = 2$ FORBIDDEN

Allowed in second-order weak interactions.

$\Gamma(\Xi^0 \to p \pi^-)/\Gamma_{total}$	$<4 \times 10^{-5}$ΓCL = 90%
$\Gamma(\Xi^0 \to p e^- \overline{\nu}_e)/\Gamma_{total}$	$<1.3 \times 10^{-3}$
$\Gamma(\Xi^0 \to p \mu^- \overline{\nu}_\mu)/\Gamma_{total}$	$<1.3 \times 10^{-3}$
$\Gamma(\Xi^- \to n \pi^-)/\Gamma_{total}$	$<1.9 \times 10^{-5}$ΓCL = 90%
$\Gamma(\Xi^- \to n e^- \overline{\nu}_e)/\Gamma_{total}$	$<3.2 \times 10^{-3}$ΓCL = 90%
$\Gamma(\Xi^- \to n \mu^- \overline{\nu}_\mu)/\Gamma_{total}$	$<1.5 \times 10^{-2}$ΓCL = 90%
$\Gamma(\Xi^- \to p \pi^- \pi^-)/\Gamma_{total}$	$<4 \times 10^{-4}$ΓCL = 90%
$\Gamma(\Xi^- \to p \pi^- e^- \overline{\nu}_e)/\Gamma_{total}$	$<4 \times 10^{-4}$ΓCL = 90%
$\Gamma(\Xi^- \to p \pi^- \mu^- \overline{\nu}_\mu)/\Gamma_{total}$	$<4 \times 10^{-4}$ΓCL = 90%
$\Gamma(\Omega^- \to \Lambda \pi^-)/\Gamma_{total}$	$<1.9 \times 10^{-4}$ΓCL = 90%

$\Delta S = 2$ VIA MIXING

Allowed in second-order weak interactions, e.g. mixing.

$m_{K_L^0} - m_{K_S^0}$	$(0.5301 \pm 0.0014) \times 10^{10}\ \hbar\ s^{-1}$
$m_{K_L^0} - m_{K_S^0}$	$(3.489 \pm 0.009) \times 10^{-12}$ MeV

$\Delta C = 2$ VIA MIXING

Allowed in second-order weak interactions, e.g. mixing.

$\lvert m_{D_1^0} - m_{D_2^0} \rvert$	[o]	$<24 \times 10^{10}\ \hbar\ s^{-1}$ΓCL = 90%
$\lvert \Gamma_{D_1^0} - \Gamma_{D_2^0} \rvert / \Gamma_{D^0}$ mean life difference/average	[o]	<0.20ΓCL = 90%
$\Gamma(K^+ \ell^- \overline{\nu}_\ell (\text{via } \overline{D}^0))/\Gamma(K^- \ell^+ \nu_\ell)$		<0.005ΓCL = 90%
$\Gamma(K^+ \pi^- \text{ or } K^+ \pi^- \pi^+ \pi^- (\text{via } \overline{D}^0))/\Gamma(K^- \pi^+ \text{ or } K^- \pi^+ \pi^+ \pi^-)$	[p]	< 0.0085 (or < 0.0037)ΓCL = 90%
$\Gamma(D^0 \to K^+ \ell^- \overline{\nu}_\ell (\text{via } \overline{D}^0))/\Gamma_{total}$		$<1.7 \times 10^{-4}$ΓCL = 90%
$\Gamma(D^0 \to K^+ \pi^- \text{ or } K^+ \pi^- \pi^+ \pi^- (\text{via } \overline{D}^0))/\Gamma_{total}$		$<1.0 \times 10^{-3}$ΓCL = 90%

$\Delta B = 2$ VIA MIXING

Allowed in second-order weak interactions, e.g. mixing.

χ_d	0.172 ± 0.010
$\Delta m_{B^0} = m_{B_H^0} - m_{B_L^0}$	$(0.464 \pm 0.018) \times 10^{12}\ \hbar\ s^{-1}$
$x_d = \Delta m_{B^0}/\Gamma_{B^0}$	0.723 ± 0.032
χ_B at high energy	0.118 ± 0.006
$\Delta m_{B_s^0} = m_{B_{sH}^0} - m_{B_{sL}^0}$	$>9.1 \times 10^{12}\ \hbar\ s^{-1}$ΓCL = 95%
$x_s = \Delta m_{B_s^0}/\Gamma_{B_s^0}$	>14.0ΓCL = 95%
χ_s	>0.4975ΓCL = 95%

$\Delta S = 1$ WEAK NEUTRAL CURRENT FORBIDDEN

Allowed by higher-order electroweak interactions.

$\Gamma(K^+ \to \pi^+ e^+ e^-)/\Gamma_{total}$		$(2.74 \pm 0.23) \times 10^{-7}$
$\Gamma(K^+ \to \pi^+ \mu^+ \mu^-)/\Gamma_{total}$		$(5.0 \pm 1.0) \times 10^{-8}$
$\Gamma(K^+ \to \pi^+ \nu \overline{\nu})/\Gamma_{total}$		$(4.2^{+9.7}_{-3.5}) \times 10^{-10}$
$\Gamma(K_S^0 \to \mu^+ \mu^-)/\Gamma_{total}$		$<3.2 \times 10^{-7}$ΓCL = 90%
$\Gamma(K_S^0 \to e^+ e^-)/\Gamma_{total}$		$<1.4 \times 10^{-7}$ΓCL = 90%
$\Gamma(K_S^0 \to \pi^0 e^+ e^-)/\Gamma_{total}$		$<1.1 \times 10^{-6}$ΓCL = 90%
$\Gamma(K_L^0 \to \mu^+ \mu^-)/\Gamma_{total}$		$(7.2 \pm 0.5) \times 10^{-9}$ (S = 1.4)
$\Gamma(K_L^0 \to \mu^+ \mu^- \gamma)/\Gamma_{total}$		$(3.25 \pm 0.28) \times 10^{-7}$
$\Gamma(K_L^0 \to e^+ e^-)/\Gamma_{total}$		$<4.1 \times 10^{-11}$ΓCL = 90%
$\Gamma(K_L^0 \to e^+ e^- \gamma)/\Gamma_{total}$		$(9.1 \pm 0.5) \times 10^{-6}$
$\Gamma(K_L^0 \to e^+ e^- \gamma \gamma)/\Gamma_{total}$	[q]	$(6.5 \pm 1.2) \times 10^{-7}$
$\Gamma(K_L^0 \to \pi^+ \pi^- e^+ e^-)/\Gamma_{total}$	[q]	$<4.6 \times 10^{-7}$ΓCL = 90%
$\Gamma(K_L^0 \to \mu^+ \mu^- e^+ e^-)/\Gamma_{total}$		$(2.9^{+6.7}_{-2.4}) \times 10^{-9}$
$\Gamma(K_L^0 \to e^+ e^- e^+ e^-)/\Gamma_{total}$		$(4.1 \pm 0.8) \times 10^{-8}$ (S = 1.2)
$\Gamma(K_L^0 \to \pi^0 \mu^+ \mu^-)/\Gamma_{total}$		$<5.1 \times 10^{-9}$ΓCL = 90%
$\Gamma(K_L^0 \to \pi^0 e^+ e^-)/\Gamma_{total}$		$<4.3 \times 10^{-9}$ΓCL = 90%
$\Gamma(K_L^0 \to \pi^0 \nu \overline{\nu})/\Gamma_{total}$		$<5.8 \times 10^{-5}$ΓCL = 90%
$\Gamma(\Sigma^+ \to p e^+ e^-)/\Gamma_{total}$		$<7 \times 10^{-6}$

$\Delta C = 1$ WEAK NEUTRAL CURRENT FORBIDDEN

Allowed by higher-order electroweak interactions.

$\Gamma(D^+ \to \pi^+ e^+ e^-)/\Gamma_{total}$	$<6.6 \times 10^{-5}$ΓCL = 90%
$\Gamma(D^+ \to \pi^+ \mu^+ \mu^-)/\Gamma_{total}$	$<1.8 \times 10^{-5}$ΓCL = 90%
$\Gamma(D^+ \to \rho^+ \mu^+ \mu^-)/\Gamma_{total}$	$<5.6 \times 10^{-4}$ΓCL = 90%
$\Gamma(D^0 \to e^+ e^-)/\Gamma_{total}$	$<1.3 \times 10^{-5}$ΓCL = 90%
$\Gamma(D^0 \to \mu^+ \mu^-)/\Gamma_{total}$	$<4.1 \times 10^{-6}$ΓCL = 90%
$\Gamma(D^0 \to \pi^0 e^+ e^-)/\Gamma_{total}$	$<4.5 \times 10^{-5}$ΓCL = 90%
$\Gamma(D^0 \to \pi^0 \mu^+ \mu^-)/\Gamma_{total}$	$<1.8 \times 10^{-4}$ΓCL = 90%
$\Gamma(D^0 \to \eta e^+ e^-)/\Gamma_{total}$	$<1.1 \times 10^{-4}$ΓCL = 90%
$\Gamma(D^0 \to \eta \mu^+ \mu^-)/\Gamma_{total}$	$<5.3 \times 10^{-4}$ΓCL = 90%
$\Gamma(D^0 \to \rho^0 e^+ e^-)/\Gamma_{total}$	$<1.0 \times 10^{-4}$ΓCL = 90%
$\Gamma(D^0 \to \rho^0 \mu^+ \mu^-)/\Gamma_{total}$	$<2.3 \times 10^{-4}$ΓCL = 90%
$\Gamma(D^0 \to \omega e^+ e^-)/\Gamma_{total}$	$<1.8 \times 10^{-4}$ΓCL = 90%
$\Gamma(D^0 \to \omega \mu^+ \mu^-)/\Gamma_{total}$	$<8.3 \times 10^{-4}$ΓCL = 90%
$\Gamma(D^0 \to \phi e^+ e^-)/\Gamma_{total}$	$<5.2 \times 10^{-5}$ΓCL = 90%
$\Gamma(D^0 \to \phi \mu^+ \mu^-)/\Gamma_{total}$	$<4.1 \times 10^{-4}$ΓCL = 90%
$\Gamma(D^0 \to \pi^+ \pi^- \pi^0 \mu^+ \mu^-)/\Gamma_{total}$	$<8.1 \times 10^{-4}$ΓCL = 90%
$\Gamma(D_s^+ \to K^+ \mu^+ \mu^-)/\Gamma_{total}$	$<5.9 \times 10^{-4}$ΓCL = 90%
$\Gamma(D_s^+ \to K^*(892)^+ \mu^+ \mu^-)/\Gamma_{total}$	$<1.4 \times 10^{-3}$ΓCL = 90%
$\Gamma(\Lambda_c^+ \to p \mu^+ \mu^-)/\Gamma_{total}$	$<3.4 \times 10^{-4}$ΓCL = 90%

Limits are given at the 90% confidence levelΓwhile errors are given as ± 1 standard deviation.

$\Delta B = 1$ WEAK NEUTRAL CURRENT FORBIDDEN

Allowed by higher-order electroweak interactions.

$\Gamma(B^+ \rightarrow \pi^+ e^+ e^-)/\Gamma_{total}$	$<3.9 \times 10^{-3}$ΓCL = 90%
$\Gamma(B^+ \rightarrow \pi^+ \mu^+ \mu^-)/\Gamma_{total}$	$<9.1 \times 10^{-3}$ΓCL = 90%
$\Gamma(B^+ \rightarrow K^+ e^+ e^-)/\Gamma_{total}$	$<6 \times 10^{-5}$ΓCL = 90%
$\Gamma(B^+ \rightarrow K^+ \mu^+ \mu^-)/\Gamma_{total}$	$<1.0 \times 10^{-5}$ΓCL = 90%
$\Gamma(B^+ \rightarrow K^*(892)^+ e^+ e^-)/\Gamma_{total}$	$<6.9 \times 10^{-4}$ΓCL = 90%
$\Gamma(B^+ \rightarrow K^*(892)^+ \mu^+ \mu^-)/\Gamma_{total}$	$<1.2 \times 10^{-3}$ΓCL = 90%
$\Gamma(B^0 \rightarrow \gamma\gamma)/\Gamma_{total}$	$<3.9 \times 10^{-5}$ΓCL = 90%
$\Gamma(B^0 \rightarrow e^+ e^-)/\Gamma_{total}$	$<5.9 \times 10^{-6}$ΓCL = 90%
$\Gamma(B^0 \rightarrow \mu^+ \mu^-)/\Gamma_{total}$	$<6.8 \times 10^{-7}$ΓCL = 90%
$\Gamma(B^0 \rightarrow K^0 e^+ e^-)/\Gamma_{total}$	$<3.0 \times 10^{-4}$ΓCL = 90%
$\Gamma(B^0 \rightarrow K^0 \mu^+ \mu^-)/\Gamma_{total}$	$<3.6 \times 10^{-4}$ΓCL = 90%
$\Gamma(B^0 \rightarrow K^*(892)^0 e^+ e^-)/\Gamma_{total}$	$<2.9 \times 10^{-4}$ΓCL = 90%
$\Gamma(B^0 \rightarrow K^*(892)^0 \mu^+ \mu^-)/\Gamma_{total}$	$<2.3 \times 10^{-5}$ΓCL = 90%
$\Gamma(B^0 \rightarrow K^*(892)^0 \nu\overline{\nu})/\Gamma_{total}$	$<1.0 \times 10^{-3}$ΓCL = 90%
$\Gamma(B \rightarrow e^+ e^- s)/\Gamma_{total}$	$<5.7 \times 10^{-5}$ΓCL = 90%
$\Gamma(B \rightarrow \mu^+ \mu^- s)/\Gamma_{total}$	$<5.8 \times 10^{-5}$ΓCL = 90%
$\Gamma(\overline{b} \rightarrow \mu^+ \mu^-$ anything$)/\Gamma_{total}$	$<3.2 \times 10^{-4}$ΓCL = 90%
$\Gamma(B^0_s \rightarrow \mu^+ \mu^-)/\Gamma_{total}$	$<2.0 \times 10^{-6}$ΓCL = 90%
$\Gamma(B^0_s \rightarrow e^+ e^-)/\Gamma_{total}$	$<5.4 \times 10^{-5}$ΓCL = 90%
$\Gamma(B^0_s \rightarrow \phi\nu\overline{\nu})/\Gamma_{total}$	$<5.4 \times 10^{-3}$ΓCL = 90%

Limits are given at the 90% confidence levelΓwhile errors are given as ± 1 standard deviation.

NOTES

In this Summary Table:

When a quantity has "(S = ...)" to its rightΓthe error on the quantity has been enlarged by the "scale factor" SΓdefined as $S = \sqrt{\chi^2/(N-1)}$Γwhere N is the number of measurements used in calculating the quantity. We do this when $S > 1$Γwhich often indicates that the measurements are inconsistent. When $S > 1.25$Γwe also show in the Particle Listings an ideogram of the measurements. For more about SΓsee the Introduction.

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

[*b*] Time-reversal invariance requires this to be 0° or 180°.

[*c*] Allowed by higher-order electroweak interactions.

[*d*] Violates *CP* in leading order. Test of direct *CP* violation since the indirect *CP*-violating and *CP*-conserving contributions are expected to be suppressed.

[*e*] ϵ'/ϵ is derived from $\left|\eta_{00}/\eta_{+-}\right|$ measurements using theoretical input on phases.

[*f*] Neglecting photon channels. SeeΓ*e.g.*ΓA. Pais and S.B. TreimanΓPhys. Rev. **D12**Γ2744 (1975).

[*g*] Derived from measured values of ϕ_{+-}Γϕ_{00}Γ$|\eta|$Γ$\left|m_{K^0_L} - m_{K^0_S}\right|$Γand $\tau_{K^0_S}$Γas described in the introduction to "Tests of Conservation Laws."

[*h*] The value is for the sum of the charge states of particle/antiparticle states indicated.

[*i*] A test of additive vs. multiplicative lepton family number conservation.

[*j*] $\Delta(m^2) = 100$ eV^2.

[*k*] 190 eV^2 $< \Delta(m^2) <$ 320 eV^2.

[*l*] Derived from an analysis of neutrino-oscillation experiments.

[*m*] There is some controversy about whether nuclear physics and model dependence complicate the analysis for bound neutrons (from which the best limit comes). The second limit here is from reactor experiments with free neutrons.

[*n*] This is the best "electron disappearance" limit. The best limit for the mode $e^- \rightarrow \nu\gamma$ is $> 2.35 \times 10^{25}$ yr (CL=68%).

[*o*] The D^0_1-D^0_2 limits are inferred from the D^0-$\overline{D}^0$ mixing ratio $\Gamma(K^+ \ell^- \overline{\nu}_\ell$(via $\overline{D}^0$)) / $\Gamma(K^- \ell^+ \nu_\ell)$.

[*p*] The larger limit (from E791) allows interference between the doubly Cabibbo-suppressed and mixing amplitudes; the smaller limit (from E691) doesn't. See the papers for details.

[*q*] See the K^0_L Particle Listings for the energy limits used in this measurement.