SUMMARY TABLES OF PARTICLE PROPERTIES

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GAUGE AND HIGGS BOSONS

γ

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

Mass $m < 6 \times 10^{-17}$ 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 $m = 80.425 \pm 0.038$ GeV
$m_Z - m_W = 10.763 \pm 0.038$ GeV
$m_{W^+} - m_{W^-} = -0.2 \pm 0.6$ GeV
Full width $\Gamma = 2.124 \pm 0.041$ GeV
$\langle N_{\pi^\pm} \rangle = 15.70 \pm 0.35$
$\langle N_{K^\pm} \rangle = 2.20 \pm 0.19$
$\langle N_p \rangle = 0.92 \pm 0.14$
$\langle N_{\text{charged}} \rangle = 19.41 \pm 0.15$

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

W^+ DECAY MODES		Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$\ell^+ \nu$	[b]	(10.68 ± 0.12) %		–
$e^+ \nu$		(10.72 ± 0.16) %		40212
$\mu^+ \nu$		(10.57 ± 0.22) %		40212
$\tau^+ \nu$		(10.74 ± 0.27) %		40193
hadrons		(67.96 ± 0.35) %		–
$\pi^+ \gamma$		$< 8 \times 10^{-5}$	95%	40212
$D_s^+ \gamma$		$< 1.3 \times 10^{-3}$	95%	40188
cX		(33.6 ± 2.7) %		–
$c\overline{s}$		$(31 ^{+13}_{-11})$ %		–
invisible	[c]	(1.4 ± 2.8) %		–

Z

$J = 1$

Charge = 0
Mass $m = 91.1876 \pm 0.0021$ GeV [d]
Full width $\Gamma = 2.4952 \pm 0.0023$ GeV
$\Gamma(\ell^+\ell^-) = 83.984 \pm 0.086$ MeV [b]
$\Gamma(\text{invisible}) = 499.0 \pm 1.5$ MeV [e]
$\Gamma(\text{hadrons}) = 1744.4 \pm 2.0$ MeV
$\Gamma(\mu^+\mu^-)/\Gamma(e^+e^-) = 1.0009 \pm 0.0028$
$\Gamma(\tau^+\tau^-)/\Gamma(e^+e^-) = 1.0019 \pm 0.0032$ [f]

Average charged multiplicity

$\langle N_{charged} \rangle = 21.07 \pm 0.11$

Couplings to leptons

$g_V^\ell = -0.03783 \pm 0.00041$
$g_A^\ell = -0.50123 \pm 0.00026$
$g^{\nu_e} = 0.53 \pm 0.09$
$g^{\nu_\mu} = 0.502 \pm 0.017$

Asymmetry parameters [g]

$A_e = 0.1515 \pm 0.0019$
$A_\mu = 0.142 \pm 0.015$
$A_\tau = 0.143 \pm 0.004$
$A_s = 0.90 \pm 0.09$
$A_c = 0.666 \pm 0.036$
$A_b = 0.926 \pm 0.024$

Charge asymmetry (%) at Z pole

$A_{FB}^{(0\ell)} = 1.71 \pm 0.10$
$A_{FB}^{(0u)} = 4 \pm 7$
$A_{FB}^{(0s)} = 9.8 \pm 1.1$
$A_{FB}^{(0c)} = 7.04 \pm 0.36$
$A_{FB}^{(0b)} = 10.01 \pm 0.17$

Z DECAY MODES		Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
e^+e^-		(3.363 ± 0.004) %		45594
$\mu^+\mu^-$		(3.366 ± 0.007) %		45594
$\tau^+\tau^-$		(3.370 ± 0.008) %		45559
$\ell^+\ell^-$	[b]	(3.3658 ± 0.0023) %		–
invisible		(20.00 ± 0.06) %		–
hadrons		(69.91 ± 0.06) %		–
$(u\overline{u}+c\overline{c})/2$		(10.1 ± 1.1) %		–
$(d\overline{d}+s\overline{s}+b\overline{b})/3$		(16.6 ± 0.6) %		–
$c\overline{c}$		(11.81 ± 0.33) %		–
$b\overline{b}$		(15.13 ± 0.05) %		–
$b\overline{b}b\overline{b}$		$(3.6 \pm 1.3) \times 10^{-4}$		–
ggg		< 1.1 %	CL=95%	–
$\pi^0\gamma$		$< 5.2 \times 10^{-5}$	CL=95%	45594
$\eta\gamma$		$< 5.1 \times 10^{-5}$	CL=95%	45592
$\omega\gamma$		$< 6.5 \times 10^{-4}$	CL=95%	45590
$\eta'(958)\gamma$		$< 4.2 \times 10^{-5}$	CL=95%	45589
$\gamma\gamma$		$< 5.2 \times 10^{-5}$	CL=95%	45594
$\gamma\gamma\gamma$		$< 1.0 \times 10^{-5}$	CL=95%	45594
$\pi^\pm W^\mp$	[h]	$< 7 \times 10^{-5}$	CL=95%	10127
$\rho^\pm W^\mp$	[h]	$< 8.3 \times 10^{-5}$	CL=95%	10101
$J/\psi(1S)X$		$(3.51 ^{+0.23}_{-0.25}) \times 10^{-3}$	S=1.1	–
$\psi(2S)X$		$(1.60 \pm 0.29) \times 10^{-3}$		–
$\chi_{c1}(1P)X$		$(2.9 \pm 0.7) \times 10^{-3}$		–

$\chi_{c2}(1P)$X		< 3.2	$\times 10^{-3}$ CL=90%	–
$\Upsilon(1S)$ X + $\Upsilon(2S)$ X + $\Upsilon(3S)$ X		(1.0 $\pm$0.5) $\times 10^{-4}$		–
$\Upsilon(1S)$X		< 4.4	$\times 10^{-5}$ CL=95%	–
$\Upsilon(2S)$X		< 1.39	$\times 10^{-4}$ CL=95%	–
$\Upsilon(3S)$X		< 9.4	$\times 10^{-5}$ CL=95%	–
$(D^0\,/\,\overline{D}^0)$ X		(20.7 $\pm$2.0) %		–
$D^\pm$X		(12.2 $\pm$1.7) %		–
$D^*(2010)^\pm$X	[h]	(11.4 $\pm$1.3) %		–
$D_{s1}(2536)^\pm$X		(3.6 $\pm$0.8) $\times 10^{-3}$		–
$D_{sJ}(2573)^\pm$X		(5.8 $\pm$2.2) $\times 10^{-3}$		–
$D^{*\prime}(2629)^\pm$X		searched for		–
B^0_sX		seen		–
B^+_cX		searched for		–
anomalous γ+ hadrons	[i]	< 3.2	$\times 10^{-3}$ CL=95%	–
$e^+e^-\gamma$	[i]	< 5.2	$\times 10^{-4}$ CL=95%	45594
$\mu^+\mu^-\gamma$	[i]	< 5.6	$\times 10^{-4}$ CL=95%	45594
$\tau^+\tau^-\gamma$	[i]	< 7.3	$\times 10^{-4}$ CL=95%	45559
$\ell^+\ell^-\gamma\gamma$	[j]	< 6.8	$\times 10^{-6}$ CL=95%	–
$q\overline{q}\gamma\gamma$	[j]	< 5.5	$\times 10^{-6}$ CL=95%	–
$\nu\overline{\nu}\gamma\gamma$	[j]	< 3.1	$\times 10^{-6}$ CL=95%	45594
$e^\pm\mu^\mp$	*LF* [h]	< 1.7	$\times 10^{-6}$ CL=95%	45594
$e^\pm\tau^\mp$	*LF* [h]	< 9.8	$\times 10^{-6}$ CL=95%	45576
$\mu^\pm\tau^\mp$	*LF* [h]	< 1.2	$\times 10^{-5}$ CL=95%	45576
$p\,e$	*L,B*	< 1.8	$\times 10^{-6}$ CL=95%	45589
$p\,\mu$	*L,B*	< 1.8	$\times 10^{-6}$ CL=95%	45589

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

H^0 Mass $m >$ 114.4 GeV, CL = 95%

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

Mass $m >$ 89.8 GeV, CL = 95%

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

Mass $m >$ 90.4 GeV, CL = 95% $\tan\beta > 1$

$H^\pm$ Mass $m >$ 79.3 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' with standard couplings decaying to $e\nu$, $\mu\nu$

Mass $m >$ 786 GeV, CL = 95%

W_R — right-handed W

Mass $m >$ 715 GeV, CL = 90% (electroweak fit)

Additional *Z* Bosons

Z'_{SM} with standard couplings

Mass $m >$ 690 GeV, CL = 95% ($p\overline{p}$ direct search)
Mass $m >$ 1500 GeV, CL = 95% (electroweak fit)

Z_{LR} of SU(2)$_L\times$SU(2)$_R\times$U(1) (with $g_L = g_R$)

Mass $m >$ 630 GeV, CL = 95% ($p\overline{p}$ direct search)
Mass $m >$ 860 GeV, CL = 95% (electroweak fit)

Z_χ of SO(10) $\to$ SU(5)$\times$U(1)$_\chi$ (with $g_\chi = e/\cos\theta_W$)

Mass $m >$ 595 GeV, CL = 95% ($p\overline{p}$ direct search)
Mass $m >$ 680 GeV, CL = 95% (electroweak fit)

Z_ψ of E_6 $\to$ SO(10)$\times$U(1)$_\psi$ (with $g_\psi = e/\cos\theta_W$)

Mass $m >$ 590 GeV, CL = 95% ($p\overline{p}$ direct search)
Mass $m >$ 350 GeV, CL = 95% (electroweak fit)

Z_η of E_6 $\to$ SU(3)$\times$SU(2)$\times$U(1)$\times$U(1)$_\eta$ (with $g_\eta = e/\cos\theta_W$)

Mass $m >$ 620 GeV, CL = 95% ($p\overline{p}$ direct search)
Mass $m >$ 619 GeV, CL = 95% (electroweak fit)

Scalar Leptoquarks

Mass $m >$ 242 GeV, CL = 95% (1st generation, pair prod.)
Mass $m >$ 298 GeV, CL = 95% (1st gener., single prod.)
Mass $m >$ 202 GeV, CL = 95% (2nd gener., pair prod.)
Mass $m >$ 73 GeV, CL = 95% (2nd gener., single prod.)
Mass $m >$ 148 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] This represents the width for the decay of the W boson into a charged particle with momentum below detectability, p< 200 MeV.

[d] 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.

[e] This partial width takes into account Z decays into $\nu\overline{\nu}$ and any other possible undetected modes.

[f] This ratio has not been corrected for the τ mass.

[g] Here $A \equiv 2g_V g_A/(g_V^2 + g_A^2)$.

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

[i] See the Z Particle Listings for the γ energy range used in this measurement.

[j] For $m_{\gamma\gamma} = (60 \pm 5)$ GeV.

[k] The limits assume no invisible decays.

LEPTONS

e

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

Mass $m = (548.57990945 \pm 0.00000024) \times 10^{-6}$ u
Mass $m = 0.51099892 \pm 0.00000004$ MeV
$\left|m_{e^+} - m_{e^-}\right|/m < 8 \times 10^{-9}$, CL = 90%
$\left|q_{e^+} + q_{e^-}\right|/e < 4 \times 10^{-8}$
Magnetic moment $\mu = 1.001159652187 \pm 0.000000000004\ \mu_B$
$(g_{e^+} - g_{e^-})\ /\ g_{\text{average}} = (-0.5 \pm 2.1) \times 10^{-12}$
Electric dipole moment $d = (0.07 \pm 0.07) \times 10^{-26}$ e cm
Mean life $\tau > 4.6 \times 10^{26}$ yr, CL = 90% [a]

μ

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

Mass $m = 0.1134289264 \pm 0.0000000030$ u
Mass $m = 105.658369 \pm 0.000009$ MeV
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 $\mu = 1.0011659160 \pm 0.0000000006\ e\hbar/2m_\mu$
$(g_{\mu^+} - g_{\mu^-})\ /\ g_{\text{average}} = (-2.6 \pm 1.6) \times 10^{-8}$
Electric dipole moment $d = (3.7 \pm 3.4) \times 10^{-19}$ e cm

Decay parameters [b]

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

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
$e^- \overline{\nu}_e \nu_\mu \gamma$		[d] (1.4 ± 0.4) %			53
$e^- \overline{\nu}_e \nu_\mu e^+ e^-$		[e] $(3.4 \pm 0.4) \times 10^{-5}$			53
Lepton Family number (*LF*) violating modes					
$e^- \nu_e \overline{\nu}_\mu$	*LF*	[f] < 1.2	%	90%	53
$e^- \gamma$	*LF*	< 1.2	$\times 10^{-11}$	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 $m = 1776.99^{+0.29}_{-0.26}$ MeV
$(m_{\tau^+} - m_{\tau^-})/m_{\text{average}} < 3.0 \times 10^{-3}$, CL = 90%
Mean life $\tau = (290.6 \pm 1.1) \times 10^{-15}$ s
$c\tau = 87.11\ \mu$m
Magnetic moment anomaly > -0.052 and < 0.058, CL = 95%
$\text{Re}(d_\tau) = -0.22$ to 0.45×10^{-16} e cm, CL = 95%
$\text{Im}(d_\tau) = -0.25$ to 0.008×10^{-16} e cm, CL = 95%

Weak dipole moment

$\text{Re}(d^w_\tau) < 0.50 \times 10^{-17}$ e cm, CL = 95%
$\text{Im}(d^w_\tau) < 1.1 \times 10^{-17}$ e cm, CL = 95%

Weak anomalous magnetic dipole moment

$\text{Re}(\alpha^w_\tau) < 1.1 \times 10^{-3}$, CL = 95%
$\text{Im}(\alpha^w_\tau) < 2.7 \times 10^{-3}$, CL = 95%

Decay parameters

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

$\rho^\tau(e \text{ or } \mu) = 0.745 \pm 0.008$
$\rho^\tau(e) = 0.747 \pm 0.010$
$\rho^\tau(\mu) = 0.763 \pm 0.020$
$\xi^\tau(e \text{ or } \mu) = 0.985 \pm 0.030$
$\xi^\tau(e) = 0.994 \pm 0.040$
$\xi^\tau(\mu) = 1.030 \pm 0.059$
$\eta^\tau(e \text{ or } \mu) = 0.013 \pm 0.020$
$\eta^\tau(\mu) = 0.094 \pm 0.073$
$(\delta\xi)^\tau(e \text{ or } \mu) = 0.746 \pm 0.021$
$(\delta\xi)^\tau(e) = 0.734 \pm 0.028$
$(\delta\xi)^\tau(\mu) = 0.778 \pm 0.037$
$\xi^\tau(\pi) = 0.993 \pm 0.022$
$\xi^\tau(\rho) = 0.994 \pm 0.008$
$\xi^\tau(a_1) = 1.001 \pm 0.027$
$\xi^\tau(\text{all hadronic modes}) = 0.995 \pm 0.007$

τ^+ modes are charge conjugates of the modes below. "$h^\pm$" stands for $\pi^\pm$ or $K^\pm$. "ℓ" stands for e or μ. "Neutrals" stands for 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$^-$ ≥ 0 neutrals $\geq 0 K^0 \nu_\tau$ ("1-prong")		(85.35 ± 0.07) %	S=1.1	–
particle$^-$ ≥ 0 neutrals $\geq 0 K^0_L \nu_\tau$		(84.72 ± 0.07) %	S=1.1	–
$\mu^- \overline{\nu}_\mu \nu_\tau$	[g]	(17.36 ± 0.06) %		885
$\mu^- \overline{\nu}_\mu \nu_\tau \gamma$	[e]	$(3.6 \pm 0.4) \times 10^{-3}$		885
$e^- \overline{\nu}_e \nu_\tau$	[g]	(17.84 ± 0.06) %		888
$e^- \overline{\nu}_e \nu_\tau \gamma$	[e]	(1.75 ± 0.18) %		888
$h^- \geq 0 K^0_L\ \nu_\tau$		(12.30 ± 0.11) %	S=1.4	883
$h^- \nu_\tau$		(11.75 ± 0.11) %	S=1.4	883
$\pi^- \nu_\tau$	[g]	(11.06 ± 0.11) %	S=1.4	883
$K^- \nu_\tau$	[g]	$(6.86 \pm 0.23) \times 10^{-3}$		820
$h^- \geq 1$ neutrals ν_τ		(36.92 ± 0.14) %	S=1.1	–
$h^- \pi^0 \nu_\tau$		(25.87 ± 0.13) %	S=1.1	878
$\pi^- \pi^0 \nu_\tau$	[g]	(25.42 ± 0.14) %	S=1.1	878
$\pi^- \pi^0$ non-$\rho(770)\nu_\tau$		$(3.0 \pm 3.2) \times 10^{-3}$		878
$K^- \pi^0 \nu_\tau$	[g]	$(4.50 \pm 0.30) \times 10^{-3}$		814
$h^- \geq 2\pi^0 \nu_\tau$		(10.77 ± 0.15) %	S=1.1	–
$h^- 2\pi^0 \nu_\tau$		(9.39 ± 0.14) %	S=1.1	862
$h^- 2\pi^0 \nu_\tau (\text{ex.} K^0)$		(9.23 ± 0.14) %	S=1.1	862
$\pi^- 2\pi^0 \nu_\tau (\text{ex.} K^0)$	[g]	(9.17 ± 0.14) %	S=1.1	862
$\pi^- 2\pi^0 \nu_\tau (\text{ex.} K^0)$, scalar		$< 9 \times 10^{-3}$	CL=95%	862
$\pi^- 2\pi^0 \nu_\tau (\text{ex.} K^0)$, vector		$< 7 \times 10^{-3}$	CL=95%	862
$K^- 2\pi^0 \nu_\tau (\text{ex.} K^0)$	[g]	$(5.8 \pm 2.3) \times 10^{-4}$		796
$h^- \geq 3\pi^0 \nu_\tau$		(1.37 ± 0.11) %	S=1.1	–
$h^- 3\pi^0 \nu_\tau$		(1.21 ± 0.10) %		836
$\pi^- 3\pi^0 \nu_\tau (\text{ex.} K^0)$	[g]	(1.08 ± 0.10) %		836
$K^- 3\pi^0 \nu_\tau (\text{ex.} K^0, \eta)$	[g]	$(3.8^{+2.2}_{-2.0}) \times 10^{-4}$		766
$h^- 4\pi^0 \nu_\tau (\text{ex.} K^0)$		$(1.6 \pm 0.6) \times 10^{-3}$		800
$h^- 4\pi^0 \nu_\tau (\text{ex.} K^0, \eta)$	[g]	$(1.0^{+0.6}_{-0.5}) \times 10^{-3}$		800
$K^- \geq 0\pi^0\ \geq 0 K^0\ \geq 0\gamma\ \nu_\tau$		(1.56 ± 0.04) %		820
$K^- \geq 1\ (\pi^0 \text{ or } K^0 \text{ or } \gamma)\ \nu_\tau$		$(8.74 \pm 0.35) \times 10^{-3}$		–

Mode		Fraction	Scale / CL	p (MeV/c)
Modes with K^0's				
K_S^0 (particles)$^- \nu_\tau$		$(9.2 \pm 0.4) \times 10^{-3}$	S=1.1	–
$h^- \overline{K}^0 \nu_\tau$		(1.05 ± 0.04) %	S=1.1	812
$\pi^- \overline{K}^0 \nu_\tau$	[g]	$(8.9 \pm 0.4) \times 10^{-3}$	S=1.1	812
$\pi^- \overline{K}^0$ (non-$K^*(892)^-$)ν_τ		$< 1.7 \times 10^{-3}$	CL=95%	812
$K^- K^0 \nu_\tau$	[g]	$(1.54 \pm 0.16) \times 10^{-3}$		737
$K^- K^0 \geq 0\pi^0 \nu_\tau$		$(3.09 \pm 0.24) \times 10^{-3}$		737
$h^- \overline{K}^0 \pi^0 \nu_\tau$		$(5.2 \pm 0.4) \times 10^{-3}$		794
$\pi^- \overline{K}^0 \pi^0 \nu_\tau$	[g]	$(3.7 \pm 0.4) \times 10^{-3}$		794
$\overline{K}^0 \rho^- \nu_\tau$		$(2.2 \pm 0.5) \times 10^{-3}$		612
$K^- K^0 \pi^0 \nu_\tau$	[g]	$(1.55 \pm 0.20) \times 10^{-3}$		685
$\pi^- \overline{K}^0 \geq 1\pi^0 \nu_\tau$		$(3.2 \pm 1.0) \times 10^{-3}$		–
$\pi^- \overline{K}^0 \pi^0 \pi^0 \nu_\tau$		$(2.6 \pm 2.4) \times 10^{-4}$		763
$K^- K^0 \pi^0 \pi^0 \nu_\tau$		$< 1.6 \times 10^{-4}$	CL=95%	619
$\pi^- K^0 \overline{K}^0 \nu_\tau$		$(1.59 \pm 0.29) \times 10^{-3}$	S=1.1	682
$\pi^- K_S^0 K_S^0 \nu_\tau$	[g]	$(2.4 \pm 0.5) \times 10^{-4}$		682
$\pi^- K_S^0 K_L^0 \nu_\tau$	[g]	$(1.10 \pm 0.28) \times 10^{-3}$	S=1.1	682
$\pi^- K^0 \overline{K}^0 \pi^0 \nu_\tau$		$(3.1 \pm 2.3) \times 10^{-4}$		614
$\pi^- K_S^0 K_S^0 \pi^0 \nu_\tau$		$< 2.0 \times 10^{-4}$	CL=95%	614
$\pi^- K_S^0 K_L^0 \pi^0 \nu_\tau$		$(3.1 \pm 1.2) \times 10^{-4}$		614
$K^0 h^+ h^- h^- \geq 0$ neutrals ν_τ		$< 1.7 \times 10^{-3}$	CL=95%	760
$K^0 h^+ h^- h^- \nu_\tau$		$(2.3 \pm 2.0) \times 10^{-4}$		760
Modes with three charged particles				
$h^- h^- h^+ \geq 0$ neutrals $\geq 0 K_L^0 \nu_\tau$		(15.19 ± 0.07) %	S=1.1	861
$h^- h^- h^+ \geq 0$ neutrals ν_τ (ex. $K_S^0 \to \pi^+\pi^-$) ("3-prong")		(14.57 ± 0.07) %	S=1.1	861
$h^- h^- h^+ \nu_\tau$		(10.01 ± 0.09) %	S=1.2	861
$h^- h^- h^+ \nu_\tau$ (ex.K^0)		(9.65 ± 0.09) %	S=1.2	861
$h^- h^- h^+ \nu_\tau$ (ex.K^0,ω)		(9.60 ± 0.09) %	S=1.2	861
$\pi^- \pi^+ \pi^- \nu_\tau$		(9.47 ± 0.10) %	S=1.2	861
$\pi^- \pi^+ \pi^- \nu_\tau$ (ex.K^0)		(9.16 ± 0.10) %	S=1.2	861
$\pi^- \pi^+ \pi^- \nu_\tau$ (ex.K^0), non-axial vector		< 2.4 %	CL=95%	861
$\pi^- \pi^+ \pi^- \nu_\tau$ (ex.K^0,ω)	[g]	(9.12 ± 0.10) %	S=1.2	861
$h^- h^- h^+ \geq 1$ neutrals ν_τ		(5.19 ± 0.10) %	S=1.3	–
$h^- h^- h^+ \geq 1$ neutrals ν_τ (ex. $K_S^0 \to \pi^+\pi^-$)		(4.92 ± 0.09) %	S=1.3	–
$h^- h^- h^+ \pi^0 \nu_\tau$		(4.53 ± 0.09) %	S=1.3	834
$h^- h^- h^+ \pi^0 \nu_\tau$ (ex.K^0)		(4.35 ± 0.09) %	S=1.3	834
$h^- h^- h^+ \pi^0 \nu_\tau$ (ex. K^0, ω)		(2.62 ± 0.09) %	S=1.2	834
$\pi^- \pi^+ \pi^- \pi^0 \nu_\tau$		(4.37 ± 0.09) %	S=1.3	834
$\pi^- \pi^+ \pi^- \pi^0 \nu_\tau$ (ex.K^0)		(4.25 ± 0.09) %	S=1.3	834
$\pi^- \pi^+ \pi^- \pi^0 \nu_\tau$ (ex.K^0,ω)	[g]	(2.51 ± 0.09) %	S=1.2	834
$h^- h^- h^+ 2\pi^0 \nu_\tau$		$(5.5 \pm 0.4) \times 10^{-3}$		797
$h^- h^- h^+ 2\pi^0 \nu_\tau$ (ex.K^0)		$(5.4 \pm 0.4) \times 10^{-3}$		797
$h^- h^- h^+ 2\pi^0 \nu_\tau$ (ex.K^0,ω,η)	[g]	$(1.1 \pm 0.4) \times 10^{-3}$		797
$h^- h^- h^+ 3\pi^0 \nu_\tau$	[g]	$(2.3 \pm 0.8) \times 10^{-4}$	S=1.5	749
$K^- h^+ h^- \geq 0$ neutrals ν_τ		$(6.9 \pm 0.4) \times 10^{-3}$	S=1.3	794
$K^- h^+ \pi^- \nu_\tau$ (ex.K^0)		$(4.8 \pm 0.4) \times 10^{-3}$	S=1.5	794
$K^- h^+ \pi^- \pi^0 \nu_\tau$ (ex.K^0)		$(1.07 \pm 0.22) \times 10^{-3}$		763
$K^- \pi^+ \pi^- \geq 0$ neutrals ν_τ		$(5.0 \pm 0.4) \times 10^{-3}$	S=1.3	794
$K^- \pi^+ \pi^- \geq 0\pi^0 \nu_\tau$ (ex.K^0)		$(3.9 \pm 0.4) \times 10^{-3}$	S=1.3	794
$K^- \pi^+ \pi^- \nu_\tau$		$(3.8 \pm 0.4) \times 10^{-3}$	S=1.6	794
$K^- \pi^+ \pi^- \nu_\tau$ (ex.K^0)	[g]	$(3.3 \pm 0.4) \times 10^{-3}$	S=1.6	794
$K^- \rho^0 \nu_\tau \to K^- \pi^+ \pi^- \nu_\tau$		$(1.6 \pm 0.6) \times 10^{-3}$		–
$K^- \pi^+ \pi^- \pi^0 \nu_\tau$		$(1.18 \pm 0.25) \times 10^{-3}$		763
$K^- \pi^+ \pi^- \pi^0 \nu_\tau$ (ex.K^0)		$(6.5 \pm 2.4) \times 10^{-4}$		763
$K^- \pi^+ \pi^- \pi^0 \nu_\tau$ (ex.K^0,η)	[g]	$(5.9 \pm 2.4) \times 10^{-4}$		763
$K^- \pi^+ K^- \geq 0$ neut. ν_τ		$< 9 \times 10^{-4}$	CL=95%	685
$K^- K^+ \pi^- \geq 0$ neut. ν_τ		$(1.97 \pm 0.18) \times 10^{-3}$	S=1.1	685
$K^- K^+ \pi^- \nu_\tau$	[g]	$(1.55 \pm 0.07) \times 10^{-3}$		685
$K^- K^+ \pi^- \pi^0 \nu_\tau$	[g]	$(4.2 \pm 1.6) \times 10^{-4}$	S=1.1	618
$K^- K^+ K^- \geq 0$ neut. ν_τ		$< 2.1 \times 10^{-3}$	CL=95%	472
$K^- K^+ K^- \nu_\tau$		$< 3.7 \times 10^{-5}$	CL=90%	472
$\pi^- K^+ \pi^- \geq 0$ neut. ν_τ		$< 2.5 \times 10^{-3}$	CL=95%	794
$e^- e^- e^+ \overline{\nu}_e \nu_\tau$		$(2.8 \pm 1.5) \times 10^{-5}$		888
$\mu^- e^- e^+ \overline{\nu}_\mu \nu_\tau$		$< 3.6 \times 10^{-5}$	CL=90%	885
Modes with five charged particles				
$3h^- 2h^+ \geq 0$ neutrals ν_τ (ex. $K_S^0 \to \pi^-\pi^+$) ("5-prong")		$(1.00 \pm 0.06) \times 10^{-3}$		794
$3h^- 2h^+ \nu_\tau$ (ex.K^0)	[g]	$(8.2 \pm 0.6) \times 10^{-4}$		794
$3h^- 2h^+ \pi^0 \nu_\tau$ (ex.K^0)	[g]	$(1.81 \pm 0.27) \times 10^{-4}$		746
$3h^- 2h^+ 2\pi^0 \nu_\tau$		$< 1.1 \times 10^{-4}$	CL=90%	687
Miscellaneous other allowed modes				
$(5\pi)^- \nu_\tau$		$(8.0 \pm 0.7) \times 10^{-3}$		800
$4h^- 3h^+ \geq 0$ neutrals ν_τ ("7-prong")		$< 2.4 \times 10^{-6}$	CL=90%	683
$X^-(S{=}-1)\nu_\tau$		(2.91 ± 0.08) %	S=1.1	–
$K^*(892)^- \geq 0$ neutrals $\geq 0K_L^0 \nu_\tau$		(1.42 ± 0.18) %	S=1.4	665
$K^*(892)^- \nu_\tau$		(1.29 ± 0.05) %		665
$K^*(892)^0 K^- \geq 0$ neutrals ν_τ		$(3.2 \pm 1.4) \times 10^{-3}$		542
$K^*(892)^0 K^- \nu_\tau$		$(2.1 \pm 0.4) \times 10^{-3}$		542
$\overline{K}^*(892)^0 \pi^- \geq 0$ neutrals ν_τ		$(3.8 \pm 1.7) \times 10^{-3}$		656
$\overline{K}^*(892)^0 \pi^- \nu_\tau$		$(2.2 \pm 0.5) \times 10^{-3}$		656
$(\overline{K}^*(892)\pi)^- \nu_\tau \to \pi^- \overline{K}^0 \pi^0 \nu_\tau$		$(1.0 \pm 0.4) \times 10^{-3}$		–
$K_1(1270)^- \nu_\tau$		$(4.7 \pm 1.1) \times 10^{-3}$		433
$K_1(1400)^- \nu_\tau$		$(1.7 \pm 2.6) \times 10^{-3}$	S=1.7	335
$K^*(1410)^- \nu_\tau$		$(1.5\ ^{+1.4}_{-1.0}) \times 10^{-3}$		326
$K_0^*(1430)^- \nu_\tau$		$< 5 \times 10^{-4}$	CL=95%	328
$K_2^*(1430)^- \nu_\tau$		$< 3 \times 10^{-3}$	CL=95%	317
$\eta \pi^- \nu_\tau$		$< 1.4 \times 10^{-4}$	CL=95%	797
$\eta \pi^- \pi^0 \nu_\tau$	[g]	$(1.74 \pm 0.24) \times 10^{-3}$		778
$\eta \pi^- \pi^0 \pi^0 \nu_\tau$		$(1.5 \pm 0.5) \times 10^{-4}$		746
$\eta K^- \nu_\tau$	[g]	$(2.7 \pm 0.6) \times 10^{-4}$		720
$\eta K^*(892)^- \nu_\tau$		$(2.9 \pm 0.9) \times 10^{-4}$		511
$\eta K^- \pi^0 \nu_\tau$		$(1.8 \pm 0.9) \times 10^{-4}$		665
$\eta \overline{K}^0 \pi^- \nu_\tau$		$(2.2 \pm 0.7) \times 10^{-4}$		661
$\eta \pi^+ \pi^- \pi^- \geq 0$ neutrals ν_τ		$< 3 \times 10^{-3}$	CL=90%	744
$\eta \pi^- \pi^+ \pi^- \nu_\tau$		$(2.3 \pm 0.5) \times 10^{-4}$		744
$\eta a_1(1260)^- \nu_\tau \to \eta \pi^- \rho^0 \nu_\tau$		$< 3.9 \times 10^{-4}$	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%	620
$\eta'(958) \pi^- \pi^0 \nu_\tau$		$< 8.0 \times 10^{-5}$	CL=90%	591
$\phi \pi^- \nu_\tau$		$< 2.0 \times 10^{-4}$	CL=90%	585
$\phi K^- \nu_\tau$		$< 6.7 \times 10^{-5}$	CL=90%	445
$f_1(1285) \pi^- \nu_\tau$		$(5.8 \pm 2.3) \times 10^{-4}$		408
$f_1(1285) \pi^- \nu_\tau \to \eta \pi^- \pi^+ \pi^- \nu_\tau$		$(1.3 \pm 0.4) \times 10^{-4}$		–
$\pi(1300)^- \nu_\tau \to (\rho\pi)^- \nu_\tau \to (3\pi)^- \nu_\tau$		$< 1.0 \times 10^{-4}$	CL=90%	–
$\pi(1300)^- \nu_\tau \to ((\pi\pi)_{S-\text{wave}} \pi)^- \nu_\tau \to (3\pi)^- \nu_\tau$		$< 1.9 \times 10^{-4}$	CL=90%	–
$h^- \omega \geq 0$ neutrals ν_τ		(2.38 ± 0.08) %		708
$h^- \omega \nu_\tau$	[g]	(1.94 ± 0.07) %		708
$h^- \omega \pi^0 \nu_\tau$	[g]	$(4.4 \pm 0.5) \times 10^{-3}$		684
$h^- \omega 2\pi^0 \nu_\tau$		$(1.4 \pm 0.5) \times 10^{-4}$		644
$2h^- h^+ \omega \nu_\tau$		$(1.20 \pm 0.22) \times 10^{-4}$		641

Lepton Family number (LF), Lepton number (L), or Baryon number (B) violating 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.

$e^-\gamma$	LF	$<$ 2.7	$\times 10^{-6}$	CL=90%	888
$\mu^-\gamma$	LF	$<$ 1.1	$\times 10^{-6}$	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
$e^-K^0_S$	LF	$<$ 9.1	$\times 10^{-7}$	CL=90%	819
$\mu^-K^0_S$	LF	$<$ 9.5	$\times 10^{-7}$	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%	719
$\mu^-\rho^0$	LF	$<$ 6.3	$\times 10^{-6}$	CL=90%	715
$e^-K^*(892)^0$	LF	$<$ 5.1	$\times 10^{-6}$	CL=90%	665
$\mu^-K^*(892)^0$	LF	$<$ 7.5	$\times 10^{-6}$	CL=90%	660
$e^-\overline{K}^*(892)^0$	LF	$<$ 7.4	$\times 10^{-6}$	CL=90%	665
$\mu^-\overline{K}^*(892)^0$	LF	$<$ 7.5	$\times 10^{-6}$	CL=90%	660
$e^-\phi$	LF	$<$ 6.9	$\times 10^{-6}$	CL=90%	596
$\mu^-\phi$	LF	$<$ 7.0	$\times 10^{-6}$	CL=90%	590
$e^-e^+e^-$	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%	813
$e^-\pi^-K^+$	LF	$<$ 3.8	$\times 10^{-6}$	CL=90%	813
$e^+\pi^-K^-$	L	$<$ 2.1	$\times 10^{-6}$	CL=90%	813
$e^-K^0_SK^0_S$	LF	$<$ 2.2	$\times 10^{-6}$	CL=90%	736
$e^-K^+K^-$	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
$\mu^-K^0_SK^0_S$	LF	$<$ 3.4	$\times 10^{-6}$	CL=90%	696
$\mu^-K^+K^-$	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%	699
$\mu^-\eta\eta$	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	$<$ 3.5	$\times 10^{-6}$	CL=90%	641
$\overline{p}\pi^0$	L,B	$<$ 1.5	$\times 10^{-5}$	CL=90%	632
$\overline{p}2\pi^0$	L,B	$<$ 3.3	$\times 10^{-5}$	CL=90%	604
$\overline{p}\eta$	L,B	$<$ 8.9	$\times 10^{-6}$	CL=90%	475
$\overline{p}\pi^0\eta$	L,B	$<$ 2.7	$\times 10^{-5}$	CL=90%	360
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 $m >$ 100.8 GeV, CL = 95% [h] Decay to νW.

$L^\pm$ – stable charged heavy lepton

Mass $m >$ 102.6 GeV, CL = 95%

ν_e

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

The following results are obtained using neutrinos associated with e^+ or e^-. See the Note on "Electron, muon, and tau neutrino listings" in the Particle Listings.

Mass $m <$ 3 eV Interpretation of tritium beta decay experiments is complicated by anomalies near the endpoint, and the limits are not without ambiguity.
Mean life/mass, τ/m_ν $>$ 7×10^9 s/eV [i] (solar)
Mean life/mass, τ/m_ν $>$ 300 s/eV, CL = 90% [i] (reactor)
Magnetic moment μ $<$ 1.0×10^{-10} μ_B, CL = 90%

ν_μ

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

The following results are obtained using neutrinos associated with μ^+ or μ^-. See the Note on "Electron, muon, and tau neutrino listings" in the Particle Listings.

Mass $m <$ 0.19 MeV, CL = 90%
Mean life/mass, τ/m_ν $>$ 15.4 s/eV, CL = 90%
Magnetic moment μ $<$ 6.8×10^{-10} μ_B, CL = 90%

ν_τ

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

The following results are obtained using neutrinos associated with τ^+ or τ^-. See the Note on "Electron, muon, and tau neutrino listings" in the Particle Listings.

Mass $m <$ 18.2 MeV, CL = 95%
Magnetic moment μ $<$ 3.9×10^{-7} μ_B, CL = 90%
Electric dipole moment $d <$ 5.2×10^{-17} $e$cm, CL = 95%

Number of Neutrino Types and Sum of Neutrino Masses

Number $N = 2.994 \pm 0.012$ (Standard Model fits to LEP data)
Number $N = 2.92 \pm 0.07$ (Direct measurement of invisible Z width)

Neutrino Mixing

There is now compelling evidence that neutrinos have nonzero mass from the observation of neutrino flavor change, both from the study of atmospheric neutrino fluxes by SuperKamiokande, and from the study of solar neutrino cross sections by SNO (charged and neutral currents) and SuperKamiokande (elastic scattering). The flavor change observed in solar neutrinos has been confirmed by the KamLAND experiment using reactor antineutrinos.

Solar Neutrinos

Detectors using gallium ($E_\nu \gtrsim 0.2$ MeV), chlorine ($E_\nu \gtrsim 0.8$ MeV), and Cherenkov effect in water ($E_\nu \gtrsim 5$ MeV) measure significantly lower neutrino rates than are predicted from solar models. From the determination by SNO of the ^{8}B solar neutrino flux via elastic scattering, charged-current process interactions, and neutral-current interactions, one can determine the flux of non-ν_e active neutrinos to be $\phi(\nu_{\mu\tau}) = (3.41^{+0.66}_{-0.64}) \times 10^6$ cm^{-2} s^{-1}, providing a 5.3 σ evidence for neutrino flavor change. A global analysis of the solar neutrino data, including the KamLAND results that confirm the effect using reactor antineutrinos, favors large mixing angles and $\Delta(m^2) \simeq$ (6–9) $\times 10^{-5}$ eV^2. See the Note "Solar Neutrinos" in the Listings and the review "Neutrino Mass, Mixing, and Flavor Change."

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 can be explained by oscillations leading to the disappearance of ν_μ with $\Delta m^2 \approx$ (1–3) $\times 10^{-3}$ eV^2 and almost full mixing between ν_μ and ν_τ. The effect has been confirmed by the K2K experiment using accelerator neutrinos. See the review "Neutrino Mass, Mixing, and Flavor Change."

Heavy Neutral Leptons, Searches for

For excited leptons, see Compositeness Limits below.

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 $m >$ 90.3 GeV, CL = 95%
(Dirac ν_L coupling to e, μ, τ; conservative case(τ))
Mass $m >$ 80.5 GeV, CL = 95%
(Majorana ν_L coupling to e, μ, τ; conservative case(τ))

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] This is the best limit for the mode $e^- \to \nu\gamma$. The best limit for "electron disappearance" is 6.4×10^{24} yr.

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

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

[d] 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.

[e] See the relevant Particle Listings for the energy limits used in this measurement.

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

[g] Basis mode for the τ.

[h] $L^\pm$ mass limit depends on decay assumptions; see the Full Listings.

[i] Limit assumes radiative decay of neutrino.

QUARKS

The u-, d-, and s-quark masses are estimates of so-called "current-quark masses," in a mass-independent subtraction scheme such as $\overline{\mathrm{MS}}$ at a scale $\mu \approx 2$ GeV. The c- and b-quark masses are the "running" masses in the $\overline{\mathrm{MS}}$ scheme. For the b-quark we also quote the 1S mass. 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 4 MeV [a]   Charge $= \frac{2}{3}\,e$ $I_z = +\frac{1}{2}$

$m_u/m_d = 0.3$ to 0.7

d

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

Mass $m = 4$ to 8 MeV [a]   Charge $= -\frac{1}{3}\,e$ $I_z = -\frac{1}{2}$

$m_s/m_d = 17$ to 22

$\overline{m} = (m_u+m_d)/2 = 3.0$ to 5.5 MeV

s

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

Mass $m = 80$ to 130 MeV [a]   Charge $= -\frac{1}{3}\,e$ Strangeness $= -1$

$(m_s - (m_u + m_d)/2)/(m_d - m_u) = 30$ to 50

c

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

Mass $m = 1.15$ to 1.35 GeV   Charge $= \frac{2}{3}\,e$ Charm $= +1$

b

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

Charge $= -\frac{1}{3}\,e$ Bottom $= -1$

Mass $m = 4.1$ to 4.4 GeV   ($\overline{\mathrm{MS}}$ mass)

Mass $m = 4.6$ to 4.9 GeV   (1S mass)

t

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

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

Mass $m = 174.3 \pm 5.1$ GeV   (direct observation of top events)

Mass $m = 178.1^{+10.4}_{-\ 8.3}$ GeV   (Standard Model electroweak fit)

t DECAY MODES		Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$W\,q\,(q = b,\,s,\,d)$				–
$W\,b$				–
$\ell\,\nu_\ell$ anything	[b,c]	(9.4 ± 2.4) %		–
$\tau\,\nu_\tau\,b$				–
$\gamma\,q\,(q{=}u,c)$	[d]	$< 5.9 \times 10^{-3}$	95%	–
$\Delta T = 1$ weak neutral current ($T1$) modes				
$Z\,q\,(q{=}u,c)$	$T1$ [e]	< 13.7 %	95%	–

b' (4[th] Generation) Quark, Searches for

Mass $m >$ 190 GeV, CL = 95%   ($p\overline{p}$, quasi-stable b')

Mass $m >$ 199 GeV, CL = 95%   ($p\overline{p}$, neutral-current decays)

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.

[b] ℓ means e or μ decay mode, not the sum over them.

[c] Assumes lepton universality and W-decay acceptance.

[d] This limit is for $\Gamma(t \to \gamma q)/\Gamma(t \to W b)$.

[e] This limit is for $\Gamma(t \to Z q)/\Gamma(t \to W b)$.

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

For $I = 1$ (π, b, ρ, a): $u\overline{d}$, $(u\overline{u} - d\overline{d})/\sqrt{2}$, $d\overline{u}$;
for $I = 0$ (η, η', h, h', ω, ϕ, f, f'): $c_1(u\overline{u} + d\overline{d}) + c_2(s\overline{s})$

$\pi^{\pm}$

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

Mass $m = 139.57018 \pm 0.00035$ MeV (S = 1.2)
Mean life $\tau = (2.6033 \pm 0.0005) \times 10^{-8}$ s (S = 1.2)
$c\tau = 7.8045$ m

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

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

π^+ DECAY MODES			Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$\mu^+\nu_\mu$		[b]	(99.98770±0.00004) %		30
$\mu^+\nu_\mu\gamma$		[c]	(2.00 ±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
$e^+\nu_e\nu\overline{\nu}$			< 5 $\times 10^{-6}$	90%	70
Lepton Family number (*LF*) or Lepton number (*L*) violating modes					
$\mu^+\overline{\nu}_e$	*L*	[d]	< 1.5 $\times 10^{-3}$	90%	30
$\mu^+\nu_e$	*LF*	[d]	< 8.0 $\times 10^{-3}$	90%	30
$\mu^- e^+ e^+ \nu$	*LF*		< 1.6 $\times 10^{-6}$	90%	30

π^0

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

Mass $m = 134.9766 \pm 0.0006$ MeV (S = 1.1)
$m_{\pi^\pm} - m_{\pi^0} = 4.5936 \pm 0.0005$ MeV
Mean life $\tau = (8.4 \pm 0.6) \times 10^{-17}$ s (S = 3.0)
$c\tau = 25.1$ nm

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

π^0 DECAY MODES			Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
2γ			(98.798±0.032) %	S=1.1	67
$e^+e^-\gamma$			(1.198±0.032) %	S=1.1	67
γ positronium			(1.82 ±0.29) $\times 10^{-9}$		67
$e^+e^+e^-e^-$			(3.14 ±0.30) $\times 10^{-5}$		67
e^+e^-			(6.2 ±0.5) $\times 10^{-8}$		67
4γ			< 2 $\times 10^{-8}$	CL=90%	67
$\nu\overline{\nu}$		[e]	< 8.3 $\times 10^{-7}$	CL=90%	67
$\nu_e\overline{\nu}_e$			< 1.7 $\times 10^{-6}$	CL=90%	67
$\nu_\mu\overline{\nu}_\mu$			< 3.1 $\times 10^{-6}$	CL=90%	67
$\nu_\tau\overline{\nu}_\tau$			< 2.1 $\times 10^{-6}$	CL=90%	67
$\gamma\nu\overline{\nu}$			< 6 $\times 10^{-4}$	CL=90%	67
Charge conjugation (*C*) or Lepton Family number (*LF*) violating modes					
3γ	*C*		< 3.1 $\times 10^{-8}$	CL=90%	67
μ^+e^-	*LF*		< 3.8 $\times 10^{-10}$	CL=90%	26
μ^-e^+	*LF*		< 3.4 $\times 10^{-9}$	CL=90%	26
$\mu^+e^- + \mu^-e^+$	*LF*		< 1.72 $\times 10^{-8}$	CL=90%	26

η

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

Mass $m = 547.75 \pm 0.12$ MeV [f] (S = 2.6)
Full width $\Gamma = 1.29 \pm 0.07$ keV [g]

C-nonconserving decay parameters

$\pi^+\pi^-\pi^0$ Left-right asymmetry $= (0.09 \pm 0.17) \times 10^{-2}$
$\pi^+\pi^-\pi^0$ Sextant asymmetry $= (0.18 \pm 0.16) \times 10^{-2}$
$\pi^+\pi^-\pi^0$ Quadrant asymmetry $= (-0.17 \pm 0.17) \times 10^{-2}$
$\pi^+\pi^-\gamma$ Left-right asymmetry $= (0.9 \pm 0.4) \times 10^{-2}$
$\pi^+\pi^-\gamma$ β (D-wave) $= -0.02 \pm 0.07$ (S = 1.3)

Dalitz plot parameter

$\pi^0\pi^0\pi^0$ $\alpha = -0.031 \pm 0.004$ (S = 1.1)

η DECAY MODES			Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
Neutral modes					
neutral modes			(72.0 ± 0.5) %	S=1.3	–
2γ		[g]	(39.43± 0.26) %	S=1.2	274
$3\pi^0$			(32.51± 0.29) %	S=1.2	179
$\pi^0 2\gamma$			(7.2 ± 1.4) $\times 10^{-4}$		257
other neutral modes			< 2.8 %	CL=90%	–
Charged modes					
charged modes			(28.0 ± 0.5) %	S=1.3	–
$\pi^+\pi^-\pi^0$			(22.6 ± 0.4) %	S=1.3	174
$\pi^+\pi^-\gamma$			(4.68± 0.11) %	S=1.2	236
$e^+e^-\gamma$			(6.0 ± 0.8) $\times 10^{-3}$	S=1.4	274
$\mu^+\mu^-\gamma$			(3.1 ± 0.4) $\times 10^{-4}$		253
e^+e^-			< 7.7 $\times 10^{-5}$	CL=90%	274
$\mu^+\mu^-$			(5.8 ± 0.8) $\times 10^{-6}$		253
$e^+e^-e^+e^-$			< 6.9 $\times 10^{-5}$	CL=90%	274
$\pi^+\pi^-e^+e^-$			($4.0^{+14.0}_{-2.7}$) $\times 10^{-4}$	S=5.8	235
$\pi^+\pi^-2\gamma$			< 2.0 $\times 10^{-3}$		236
$\pi^+\pi^-\pi^0\gamma$			< 5 $\times 10^{-4}$	CL=90%	174
$\pi^0\mu^+\mu^-\gamma$			< 3 $\times 10^{-6}$	CL=90%	210
Charge conjugation (*C*), Parity (*P*), Charge conjugation × Parity (*CP*), or Lepton Family number (*LF*) violating modes					
$\pi^+\pi^-$	*P,CP*		< 3.3 $\times 10^{-4}$	CL=90%	236
$\pi^0\pi^0$	*P,CP*		< 4.3 $\times 10^{-4}$	CL=90%	238
3γ	*C*		< 5 $\times 10^{-4}$	CL=95%	274
$4\pi^0$	*P,CP*		< 6.9 $\times 10^{-7}$	CL=90%	40
$\pi^0e^+e^-$	*C*	[h]	< 4 $\times 10^{-5}$	CL=90%	257
$\pi^0\mu^+\mu^-$	*C*	[h]	< 5 $\times 10^{-6}$	CL=90%	210
$\mu^+e^- + \mu^-e^+$	*LF*		< 6 $\times 10^{-6}$	CL=90%	264

$f_0(600)$ [i] or σ

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

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

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

$\rho(770)$ [j]

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

Mass $m = 775.8 \pm 0.5$ MeV
Full width $\Gamma = 150.3 \pm 1.6$ MeV
$\Gamma_{ee} = 7.02 \pm 0.11$ keV

$\rho(770)$ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
$\pi\pi$	$\sim$ 100 %		364
$\rho(770)^{\pm}$ decays			
$\pi^{\pm}\gamma$	$(4.5 \pm 0.5) \times 10^{-4}$	S=2.2	375
$\pi^{\pm}\eta$	$< 6 \times 10^{-3}$	CL=84%	153
$\pi^{\pm}\pi^+\pi^-\pi^0$	$< 2.0 \times 10^{-3}$	CL=84%	254
$\rho(770)^0$ decays			
$\pi^+\pi^-\gamma$	$(9.9 \pm 1.6) \times 10^{-3}$		362
$\pi^0\gamma$	$(6.0 \pm 1.3) \times 10^{-4}$	S=1.1	376
$\eta\gamma$	$(3.0 \pm 0.4) \times 10^{-4}$	S=1.4	195
$\pi^0\pi^0\gamma$	$(4.5 \pm 0.8) \times 10^{-5}$		364
$\mu^+\mu^-$ [k]	$(4.55 \pm 0.28) \times 10^{-5}$		373
e^+e^- [k]	$(4.67 \pm 0.09) \times 10^{-5}$		388
$\pi^+\pi^-\pi^0$	$(1.01^{+0.54}_{-0.36} \pm 0.34) \times 10^{-4}$		323
$\pi^+\pi^-\pi^+\pi^-$	$(1.8 \pm 0.9) \times 10^{-5}$		251
$\pi^+\pi^-\pi^0\pi^0$	$< 4 \times 10^{-5}$	CL=90%	257

$\omega(782)$

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

Mass $m = 782.59 \pm 0.11$ MeV (S = 1.7)
Full width $\Gamma = 8.49 \pm 0.08$ MeV
$\Gamma_{ee} = 0.60 \pm 0.02$ keV

$\omega(782)$ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
$\pi^+\pi^-\pi^0$	(89.1 ± 0.7) %	S=1.1	327
$\pi^0\gamma$	$(8.92^{+0.28}_{-0.24})$ %	S=1.1	380
$\pi^+\pi^-$	(1.70 ± 0.27) %	S=1.4	366
neutrals (excluding $\pi^0\gamma$)	$(1.4\ ^{+7.0}_{-0.9}) \times 10^{-3}$		–
$\eta\gamma$	$(4.9 \pm 0.5) \times 10^{-4}$		200
$\pi^0 e^+e^-$	$(5.9 \pm 1.9) \times 10^{-4}$		380
$\pi^0\mu^+\mu^-$	$(9.6 \pm 2.3) \times 10^{-5}$		349
e^+e^-	$(7.14 \pm 0.13) \times 10^{-5}$	S=1.1	391
$\pi^+\pi^-\pi^0\pi^0$	< 2 %	CL=90%	262
$\pi^+\pi^-\gamma$	$< 3.6 \times 10^{-3}$	CL=95%	366
$\pi^+\pi^-\pi^+\pi^-$	$< 1 \times 10^{-3}$	CL=90%	256
$\pi^0\pi^0\gamma$	$(6.7 \pm 1.1) \times 10^{-5}$		367
$\eta\pi^0\gamma$	$< 3.3 \times 10^{-5}$	CL=90%	162
$\mu^+\mu^-$	$(9.0 \pm 3.1) \times 10^{-5}$		377
3γ	$< 1.9 \times 10^{-4}$	CL=95%	391
Charge conjugation (C) violating modes			
$\eta\pi^0$ C	$< 1 \times 10^{-3}$	CL=90%	162
$3\pi^0$ C	$< 3 \times 10^{-4}$	CL=90%	330

$\eta'(958)$

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

Mass $m = 957.78 \pm 0.14$ MeV
Full width $\Gamma = 0.202 \pm 0.016$ MeV (S = 1.3)

$\eta'(958)$ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
$\pi^+\pi^-\eta$	(44.3 ± 1.5) %	S=1.2	232
$\rho^0\gamma$ (including non-resonant $\pi^+\pi^-\gamma$)	(29.5 ± 1.0) %	S=1.2	165
$\pi^0\pi^0\eta$	(20.9 ± 1.2) %	S=1.2	239
$\omega\gamma$	(3.03 ± 0.31) %		159
$\gamma\gamma$	(2.12 ± 0.14) %	S=1.3	479
$3\pi^0$	$(1.56 \pm 0.26) \times 10^{-3}$		430
$\mu^+\mu^-\gamma$	$(1.04 \pm 0.26) \times 10^{-4}$		467
$\pi^+\pi^-\pi^0$	< 5 %	CL=90%	428
$\pi^0\rho^0$	< 4 %	CL=90%	110
$\pi^+\pi^+\pi^-\pi^-$	< 1 %	CL=90%	372
$\pi^+\pi^+\pi^-\pi^-$ neutrals	< 1 %	CL=95%	–
$\pi^+\pi^+\pi^-\pi^-\pi^0$	< 1 %	CL=90%	298
6π	< 1 %	CL=90%	211
$\pi^+\pi^-e^+e^-$	$< 6 \times 10^{-3}$	CL=90%	458
γe^+e^-	$< 9 \times 10^{-4}$	CL=90%	479
$\pi^0\gamma\gamma$	$< 8 \times 10^{-4}$	CL=90%	469
$4\pi^0$	$< 5 \times 10^{-4}$	CL=90%	380
e^+e^-	$< 2.1 \times 10^{-7}$	CL=90%	479
Charge conjugation (C), Parity (P), Lepton family number (LF) violating modes			
$\pi^+\pi^-$ P,CP	< 2 %	CL=90%	458
$\pi^0\pi^0$ P,CP	$< 9 \times 10^{-4}$	CL=90%	459
$\pi^0 e^+e^-$ C [h]	$< 1.4 \times 10^{-3}$	CL=90%	469
ηe^+e^- C [h]	$< 2.4 \times 10^{-3}$	CL=90%	322
3γ C	$< 1.0 \times 10^{-4}$	CL=90%	479
$\mu^+\mu^-\pi^0$ C [h]	$< 6.0 \times 10^{-5}$	CL=90%	445
$\mu^+\mu^-\eta$ C [h]	$< 1.5 \times 10^{-5}$	CL=90%	273
$e\mu$ LF	$< 4.7 \times 10^{-4}$	CL=90%	473

$f_0(980)$ [l]

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

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

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

$a_0(980)$ [l]

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

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

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

$\phi(1020)$

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

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

$\phi(1020)$ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
K^+K^-	(49.1 ± 0.6) %	S=1.2	127
$K^0_L K^0_S$	(34.0 ± 0.5) %	S=1.1	110
$\rho\pi + \pi^+\pi^-\pi^0$	(15.4 ± 0.5) %	S=1.3	–
$\eta\gamma$	(1.295 ± 0.025) %	S=1.1	363
$\pi^0\gamma$	$(1.23 \pm 0.10) \times 10^{-3}$		501
e^+e^-	$(2.98 \pm 0.04) \times 10^{-4}$	S=1.1	510
$\mu^+\mu^-$	$(2.85 \pm 0.19) \times 10^{-4}$		499
ηe^+e^-	$(1.15 \pm 0.10) \times 10^{-4}$		363
$\pi^+\pi^-$	$(7.3 \pm 1.3) \times 10^{-5}$		490
$\omega\pi^0$	$(5.2\ ^{+1.3}_{-1.1}) \times 10^{-5}$		172
$\omega\gamma$	< 5 %	CL=84%	209
$\rho\gamma$	$< 1.2 \times 10^{-5}$	CL=90%	215
$\pi^+\pi^-\gamma$	$(4.1 \pm 1.3) \times 10^{-5}$		490
$f_0(980)\gamma$	$(4.40 \pm 0.21) \times 10^{-4}$		39
$\pi^0\pi^0\gamma$	$(1.09 \pm 0.06) \times 10^{-4}$		492
$\pi^+\pi^-\pi^+\pi^-$	$(3.9\ ^{+2.8}_{-2.2}) \times 10^{-6}$		410
$\pi^+\pi^+\pi^-\pi^-\pi^0$	$< 4.6 \times 10^{-6}$	CL=90%	342
$\pi^0 e^+e^-$	$(1.12 \pm 0.28) \times 10^{-5}$		501
$\pi^0\eta\gamma$	$(8.3 \pm 0.5) \times 10^{-5}$		346
$a_0(980)\gamma$	$(7.6 \pm 0.6) \times 10^{-5}$		34
$\eta'(958)\gamma$	$(6.2 \pm 0.7) \times 10^{-5}$	S=1.1	60
$\eta\pi^0\pi^0\gamma$	$< 2 \times 10^{-5}$	CL=90%	293
$\mu^+\mu^-\gamma$	$(1.4 \pm 0.5) \times 10^{-5}$		499
$\rho\gamma\gamma$	$< 5 \times 10^{-4}$	CL=90%	215
$\eta\pi^+\pi^-$	$< 1.8 \times 10^{-5}$	CL=90%	288
$\eta\mu^+\mu^-$	$< 9.4 \times 10^{-6}$	CL=90%	321

$h_1(1170)$

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

Mass $m = 1170 \pm 20$ MeV
Full width $\Gamma = 360 \pm 40$ MeV

h_1(1170) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\rho\pi$	seen	307

$b_1(1235)$

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

Mass $m = 1229.5 \pm 3.2$ MeV (S = 1.6)
Full width $\Gamma = 142 \pm 9$ MeV (S = 1.2)

b_1(1235) DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$\omega\pi$	dominant		348
[D/S amplitude ratio = 0.277 ± 0.027]			
$\pi^\pm\gamma$	$(1.6\pm0.4) \times 10^{-3}$		607
$\eta\rho$	seen		†
$\pi^+\pi^+\pi^-\pi^0$	< 50 %	84%	535
$(K\overline{K})^\pm\pi^0$	< 8 %	90%	248
$K^0_S K^0_L \pi^\pm$	< 6 %	90%	235
$K^0_S K^0_S \pi^\pm$	< 2 %	90%	235
$\phi\pi$	< 1.5 %	84%	147

$a_1(1260)$ [m]

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

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

a_1(1260) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$(\rho\pi)_{S-\text{wave}}$	seen	353
$(\rho\pi)_{D-\text{wave}}$	seen	353
$(\rho(1450)\pi)_{S-\text{wave}}$	seen	†
$(\rho(1450)\pi)_{D-\text{wave}}$	seen	†
$\sigma\pi$	seen	–
$f_0(980)\pi$	not seen	189
$f_0(1370)\pi$	seen	–
$f_2(1270)\pi$	seen	†
$K\overline{K}^*(892)$ + c.c.	seen	†
$\pi\gamma$	seen	608

$f_2(1270)$

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

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

f_2(1270) DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
$\pi\pi$	$(84.8\ ^{+2.5}_{-1.3})$ %	S=1.3	623
$\pi^+\pi^-2\pi^0$	$(7.1\ ^{+1.5}_{-2.7})$ %	S=1.3	563
$K\overline{K}$	(4.6 ± 0.4) %	S=2.7	404
$2\pi^+2\pi^-$	(2.8 ± 0.4) %	S=1.2	559
$\eta\eta$	$(4.5 \pm1.0) \times 10^{-3}$	S=2.4	327
$4\pi^0$	$(3.0 \pm1.0) \times 10^{-3}$		565
$\gamma\gamma$	$(1.41\pm0.13) \times 10^{-5}$		638
$\eta\pi\pi$	$< 8 \times 10^{-3}$	CL=95%	478
$K^0K^-\pi^+$ + c.c.	$< 3.4 \times 10^{-3}$	CL=95%	293
e^+e^-	$< 6 \times 10^{-10}$	CL=90%	638

$f_1(1285)$

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

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

f_1(1285) DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
4π	$(33.1\ ^{+\ 2.1}_{-\ 1.8})$ %	S=1.3	568
$\pi^0\pi^0\pi^+\pi^-$	$(22.0\ ^{+\ 1.4}_{-\ 1.2})$ %	S=1.3	566
$2\pi^+2\pi^-$	$(11.0\ ^{+\ 0.7}_{-\ 0.6})$ %	S=1.3	563
$\rho^0\pi^+\pi^-$	$(11.0\ ^{+\ 0.7}_{-\ 0.6})$ %	S=1.3	336
$\rho^0\rho^0$	seen		†
$4\pi^0$	$< 7 \times 10^{-4}$	CL=90%	568
$\eta\pi\pi$	(52 ± 16) %		482
$a_0(980)\pi$ [ignoring $a_0(980) \to K\overline{K}$]	(36 ± 7) %		234
$\eta\pi\pi$ [excluding $a_0(980)\pi$]	(16 ± 7) %		482
$K\overline{K}\pi$	(9.0 ± 0.4) %	S=1.1	308
$K\overline{K}^*(892)$	not seen		†
$\gamma\rho^0$	(5.5 ± 1.3) %	S=2.8	406
$\phi\gamma$	$(7.4\pm 2.6) \times 10^{-4}$		236

$\eta(1295)$

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

Mass $m = 1294 \pm 4$ MeV (S = 1.6)
Full width $\Gamma = 55 \pm 5$ MeV

η(1295) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\eta\pi^+\pi^-$	seen	487
$a_0(980)\pi$	seen	244
$\eta\pi^0\pi^0$	seen	490
$\eta(\pi\pi)_{S\text{-wave}}$	seen	–

$\pi(1300)$

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

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

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

$a_2(1320)$

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

Mass $m = 1318.3 \pm 0.6$ MeV (S = 1.2)
Full width $\Gamma = 107 \pm 5$ MeV [n]

a_2(1320) DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
$\rho\pi$	(70.1 ± 2.7) %	S=1.2	416
$\eta\pi$	(14.5 ± 1.2) %		535
$\omega\pi\pi$	(10.6 ± 3.2) %	S=1.3	366
$K\overline{K}$	(4.9 ± 0.8) %		437
$\eta'(958)\pi$	$(5.3 \pm0.9) \times 10^{-3}$		288
$\pi^\pm\gamma$	$(2.68\pm0.31) \times 10^{-3}$		652
$\gamma\gamma$	$(9.4 \pm0.7) \times 10^{-6}$		659
$\pi^+\pi^-\pi^-$	< 8 %	CL=90%	621
e^+e^-	$< 6 \times 10^{-9}$	CL=90%	659

$f_0(1370)$ [l]

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

Mass $m = 1200$ to 1500 MeV
Full width $\Gamma = 200$ 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	–
$\rho\rho$	dominant	–
$2(\pi\pi)_{S\text{-wave}}$	seen	–
$\pi(1300)\pi$	seen	–
$a_1(1260)\pi$	seen	–
$\eta\eta$	seen	–
$K\overline{K}$	seen	–
$\gamma\gamma$	seen	–
e^+e^-	not seen	–

$\pi_1(1400)$ [o]

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

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

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

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

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

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

$\eta(1405)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K\overline{K}\pi$	seen	425
$\eta\pi\pi$	seen	563
$a_0(980)\pi$	seen	342
$\eta(\pi\pi)_{S\text{-wave}}$	seen	–
$f_0(980)\eta$	seen	†
4π	seen	639
$K^*(892)K$	seen	127

$f_1(1420)$ [q]

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

Mass $m = 1426.3 \pm 0.9$ MeV (S = 1.1)
Full width $\Gamma = 54.9 \pm 2.6$ MeV

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

$\omega(1420)$ [r]

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

Mass m (1400–1450) MeV
Full width Γ (180–250) MeV

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

$a_0(1450)$ [l]

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

Mass $m = 1474 \pm 19$ MeV
Full width $\Gamma = 265 \pm 13$ MeV

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

$\rho(1450)$ [s]

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

Mass $m = 1465 \pm 25$ MeV [n]
Full width $\Gamma = 400 \pm 60$ MeV [n]

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

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

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

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

$\eta(1475)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K\overline{K}\pi$	dominant	477
$K\overline{K}^*(892)+$ c.c.	seen	245
$a_0(980)\pi$	seen	393
$\gamma\gamma$	seen	738

$f_0(1500)$ [o]

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

Mass $m = 1507 \pm 5$ MeV (S = 1.2)
Full width $\Gamma = 109 \pm 7$ MeV

$f_0(1500)$ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor	p (MeV/c)
$\eta\eta'(958)$	(1.9±0.8) %	1.7	34
$\eta\eta$	(5.1±0.9) %	1.4	518
4π	(49.5±3.3) %	1.2	692
$4\pi^0$	seen		692
$2\pi^+2\pi^-$	seen		688
$\pi\pi$	(34.9±2.3) %	1.2	741
$\pi^+\pi^-$	seen		741
$2\pi^0$	seen		741
$K\overline{K}$	(8.6±1.0) %	1.1	569
$\gamma\gamma$	not seen		754

$f_2'(1525)$

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

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

$f_2'(1525)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K\overline{K}$	(88.8 ±3.1) %	581
$\eta\eta$	(10.3 ±3.1) %	530
$\pi\pi$	(8.2 ±1.5) $\times 10^{-3}$	750
$\gamma\gamma$	(1.11±0.14) $\times 10^{-6}$	763

$\pi_1(1600)$ [o]

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

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

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

$\eta_2(1645)$

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

Mass $m = 1617 \pm 5$ MeV
Full width $\Gamma = 181 \pm 11$ MeV

$\eta_2(1645)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$a_2(1320)\pi$	seen	242
$K\overline{K}\pi$	seen	580
$K^*\overline{K}$	seen	404
$\eta\pi^+\pi^-$	seen	685
$a_0(980)\pi$	seen	496
$f_2(1270)\eta$	not seen	†

$\omega(1650)$ [t] was $\omega(1600)$

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

Mass $m = 1670 \pm 30$ MeV
Full width $\Gamma = 315 \pm 35$ MeV

$\omega(1650)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\rho\pi$	seen	646
$\omega\pi\pi$	seen	617
$\omega\eta$	seen	500
e^+e^-	seen	835

$\omega_3(1670)$

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

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

$\omega_3(1670)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\rho\pi$	seen	645
$\omega\pi\pi$	seen	615
$b_1(1235)\pi$	possibly seen	361

$\pi_2(1670)$

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

Mass $m = 1672.4 \pm 3.2$ MeV [n] (S = 1.4)
Full width $\Gamma = 259 \pm 9$ MeV [n] (S = 1.3)

$\pi_2(1670)$ DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
3π	(95.8 ± 1.4) %		809
$f_2(1270)\pi$	(56.2 ± 3.2) %		329
$\rho\pi$	(31 ± 4) %		648
$\sigma\pi$	(10.9 ± 3.4) %		–
$(\pi\pi)_{S\text{-wave}}$	(8.7 ± 3.4) %		–
$K\overline{K}{}^*(892)$+ c.c.	(4.2 ± 1.4) %		455
$\omega\rho$	(2.7 ± 1.1) %		303
$\rho(1450)\pi$	$< 3.6 \times 10^{-3}$	97.7%	148
$b_1(1235)\pi$	$< 1.9 \times 10^{-3}$	97.7%	366

$\phi(1680)$

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

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

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

$\rho_3(1690)$

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

Mass $m = 1688.8 \pm 2.1$ MeV [n]
Full width $\Gamma = 161 \pm 10$ MeV [n] (S = 1.5)

$\rho_3(1690)$ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor	p (MeV/c)
4π	(71.1 ± 1.9) %		790
$\pi^\pm\pi^+\pi^-\pi^0$	(67 ± 22) %		787
$\omega\pi$	(16 ± 6) %		655
$\pi\pi$	(23.6 ± 1.3) %		834
$K\overline{K}\pi$	(3.8 ± 1.2) %		629
$K\overline{K}$	(1.58 ± 0.26) %	1.2	685
$\eta\pi^+\pi^-$	seen		727
$\rho(770)\eta$	seen		520
$\pi\pi\rho$	seen		633
Excluding 2ρ and $a_2(1320)\pi$.			
$a_2(1320)\pi$	seen		307
$\rho\rho$	seen		333

$\rho(1700)$ [s]

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

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

$\rho(1700)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$2(\pi^+\pi^-)$	large	803
$\rho\pi\pi$	dominant	653
$\rho^0\pi^+\pi^-$	large	650
$\rho^\pm\pi^\mp\pi^0$	large	651
$a_1(1260)\pi$	seen	404
$h_1(1170)\pi$	seen	447
$\pi(1300)\pi$	seen	349
$\rho\rho$	seen	371
$\pi^+\pi^-$	seen	849
$\pi\pi$	seen	849
$K\overline{K}{}^*(892)$+ c.c.	seen	496
$\eta\rho$	seen	544
$a_2(1320)\pi$	not seen	334
$K\overline{K}$	seen	704
e^+e^-	seen	860
$\pi^0\omega$	seen	674

$f_0(1710)$ [u]

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

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

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

$\pi(1800)$

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

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

$\pi(1800)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\pi^+\pi^-\pi^-$	seen	879
$f_0(600)\pi^-$	seen	–
$f_0(980)\pi^-$	seen	631
$f_0(1370)\pi^-$	seen	–
$f_0(1500)\pi^-$	not seen	248
$\rho\pi^-$	not seen	732
$\eta\eta\pi^-$	seen	661
$a_0(980)\eta$	seen	469
$f_0(1500)\pi^-$	seen	248
$\eta\eta'(958)\pi^-$	seen	376
$K^*_0(1430)K^-$	seen	†
$K^*(892)K^-$	not seen	570

$\phi_3(1850)$

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

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

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

$f_2(1950)$

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

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

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

$f_2(2010)$

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

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

$f_2(2010)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\phi\phi$	seen	†

$a_4(2040)$

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

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

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

$f_4(2050)$

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

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

$f_4(2050)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\omega\omega$	not seen	650
$\pi\pi$	(17.0 ± 1.5) %	1008
$K\overline{K}$	$(6.8^{+3.4}_{-1.8}) \times 10^{-3}$	889
$\eta\eta$	$(2.1 \pm 0.8) \times 10^{-3}$	857
$4\pi^0$	< 1.2 %	972
$a_2(1320)\pi$	seen	579

$f_2(2300)$

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

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

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

$f_2(2340)$

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

Mass $m = 2339 \pm 60$ MeV
Full width $\Gamma = 319^{+80}_{-70}$ MeV

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

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

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

$K^\pm$

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

Mass $m = 493.677 \pm 0.016$ MeV [v] (S = 2.8)
Mean life $\tau = (1.2384 \pm 0.0024) \times 10^{-8}$ s (S = 2.0)
$c\tau = 3.713$ m

Slope parameter g [w]

(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)
$K^\pm \to \pi^\pm\pi^0\pi^0 = 0.638 \pm 0.020$ (S = 2.5)

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

Assuming μ-e universality

$\lambda_+(K^+_{\mu3}) = \lambda_+(K^+_{e3}) = (2.78 \pm 0.07) \times 10^{-2}$ (S = 1.5)
$\lambda_0(K^+_{\mu3}) = (1.77 \pm 0.16) \times 10^{-2}$ (S = 1.5)

Not assuming μ-e universality

$\lambda_+(K^+_{e3}) = (2.77 \pm 0.05) \times 10^{-2}$
$\lambda_+(K^+_{\mu3}) = (2.84 \pm 0.27) \times 10^{-2}$ (S = 1.8)
$\lambda_0(K^+_{\mu3}) = (1.74 \pm 0.22) \times 10^{-2}$ (S = 1.8)

K^+_{e3} $|f_S/f_+| = (-0.3^{+0.8}_{-0.7}) \times 10^{-2}$
K^+_{e3} $|f_T/f_+| = (-1.2 \pm 2.3) \times 10^{-2}$
$K^+_{\mu3}$ $|f_S/f_+| = (0.2 \pm 0.6) \times 10^{-2}$
$K^+_{\mu3}$ $|f_T/f_+| = (-0.1 \pm 0.7) \times 10^{-2}$
$K^+ \to e^+\nu_e\gamma$ $|F_A + F_V| = 0.148 \pm 0.010$
$K^+ \to \mu^+\nu_\mu\gamma$ $|F_A + F_V| = 0.165 \pm 0.013$
$K^+ \to e^+\nu_e\gamma$ $|F_A - F_V| < 0.49$
$K^+ \to \mu^+\nu_\mu\gamma$ $|F_A - F_V| = -0.24$ to 0.04, CL = 90%

Charge Radius

$\langle r \rangle = 0.560 \pm 0.031$ fm

***CP* violation parameters**

$\Delta(K^\pm_{\pi\mu\mu}) = -0.02 \pm 0.12$

***T* violation parameters**

$K^+ \to \pi^0\mu^+\nu_\mu$ $P_T = (-4 \pm 5) \times 10^{-3}$
$K^+ \to \mu^+\nu_\mu\gamma$ $P_T = (-0.6 \pm 1.9) \times 10^{-2}$
$K^+ \to \pi^0\mu^+\nu_\mu$ $\mathrm{Im}(\xi) = -0.014 \pm 0.014$

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

K^+ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
Leptonic and semileptonic modes			
$e^+\nu_e$	$(1.55 \pm 0.07) \times 10^{-5}$		247
$\mu^+\nu_\mu$	(63.43 ± 0.17) %	S=1.2	236
$\pi^0 e^+\nu_e$	(4.87 ± 0.06) %	S=1.2	228
Called K^+_{e3}.			
$\pi^0\mu^+\nu_\mu$	(3.27 ± 0.06) %	S=1.2	215
Called $K^+_{\mu3}$.			
$\pi^0\pi^0 e^+\nu_e$	$(2.1 \pm 0.4) \times 10^{-5}$		206
$\pi^+\pi^- e^+\nu_e$	$(4.08 \pm 0.09) \times 10^{-5}$		203
$\pi^+\pi^-\mu^+\nu_\mu$	$(1.4 \pm 0.9) \times 10^{-5}$		151
$\pi^0\pi^0\pi^0 e^+\nu_e$	$< 3.5 \times 10^{-6}$	CL=90%	135
Hadronic modes			
$\pi^+\pi^0$	(21.13 ± 0.14) %	S=1.1	205
$\pi^+\pi^0\pi^0$	(1.73 ± 0.04) %	S=1.2	133
$\pi^+\pi^+\pi^-$	(5.576 ± 0.031) %	S=1.1	125
Leptonic and semileptonic modes with photons			
$\mu^+\nu_\mu\gamma$	[y,z] $(5.50 \pm 0.28) \times 10^{-3}$		236
$\pi^0 e^+\nu_e\gamma$	[y,z] $(2.65 \pm 0.20) \times 10^{-4}$		228
$\pi^0 e^+\nu_e\gamma$(SD)	[aa] $< 5.3 \times 10^{-5}$	CL=90%	228
$\pi^0\mu^+\nu_\mu\gamma$	[y,z] $< 6.1 \times 10^{-5}$	CL=90%	215
$\pi^0\pi^0 e^+\nu_e\gamma$	$< 5 \times 10^{-6}$	CL=90%	206

Hadronic modes with photons					
$\pi^+\pi^0\gamma$		[y,z]	$(2.75 \pm 0.15) \times 10^{-4}$		205
$\pi^+\pi^0\gamma$(DE)		[z,bb]	$(4.4 \pm 0.8) \times 10^{-6}$		205
$\pi^+\pi^0\pi^0\gamma$		[y,z]	$(7.4 \ ^{+5.5}_{-2.9}) \times 10^{-6}$		133
$\pi^+\pi^+\pi^-\gamma$		[y,z]	$(1.04 \pm 0.31) \times 10^{-4}$		125
$\pi^+\gamma\gamma$		[z]	$(1.10 \pm 0.32) \times 10^{-6}$		227
$\pi^+ 3\gamma$		[z]	$< 1.0 \times 10^{-4}$	CL=90%	227
Leptonic modes with $\ell\overline{\ell}$ pairs					
$e^+\nu_e\nu\overline{\nu}$			$< 6 \times 10^{-5}$	CL=90%	247
$\mu^+\nu_\mu\nu\overline{\nu}$			$< 6.0 \times 10^{-6}$	CL=90%	236
$e^+\nu_e e^+ e^-$			$(2.48 \pm 0.20) \times 10^{-8}$		247
$\mu^+\nu_\mu e^+ e^-$			$(7.06 \pm 0.31) \times 10^{-8}$		236
$e^+\nu_e\mu^+\mu^-$			$< 5 \times 10^{-7}$	CL=90%	223
$\mu^+\nu_\mu\mu^+\mu^-$			$< 4.1 \times 10^{-7}$	CL=90%	185
Lepton Family number (*LF*), Lepton number (*L*), $\Delta S = \Delta Q$ (*SQ*) violating modes, or $\Delta S = 1$ weak neutral current (*S1*) modes					
$\pi^+\pi^+ e^-\overline{\nu}_e$	*SQ*		$< 1.2 \times 10^{-8}$	CL=90%	203
$\pi^+\pi^+\mu^-\overline{\nu}_\mu$	*SQ*		$< 3.0 \times 10^{-6}$	CL=95%	151
$\pi^+ e^+ e^-$	*S1*		$(2.88 \pm 0.13) \times 10^{-7}$		227
$\pi^+\mu^+\mu^-$	*S1*		$(8.1 \pm 1.4) \times 10^{-8}$	S=2.7	172
$\pi^+\nu\overline{\nu}$	*S1*		$(1.6 \ ^{+1.8}_{-0.8}) \times 10^{-10}$		227
$\pi^+\pi^0\nu\overline{\nu}$	*S1*		$< 4.3 \times 10^{-5}$	CL=90%	205
$\mu^-\nu e^+ e^+$	*LF*		$< 2.0 \times 10^{-8}$	CL=90%	236
$\mu^+\nu_e$	*LF*	[d]	$< 4 \times 10^{-3}$	CL=90%	236
$\pi^+\mu^+ e^-$	*LF*		$< 2.8 \times 10^{-11}$	CL=90%	214
$\pi^+\mu^- e^+$	*LF*		$< 5.2 \times 10^{-10}$	CL=90%	214
$\pi^-\mu^+ e^+$	*L*		$< 5.0 \times 10^{-10}$	CL=90%	214
$\pi^- e^+ e^+$	*L*		$< 6.4 \times 10^{-10}$	CL=90%	227
$\pi^-\mu^+\mu^+$	*L*	[d]	$< 3.0 \times 10^{-9}$	CL=90%	172
$\mu^+\overline{\nu}_e$	*L*	[d]	$< 3.3 \times 10^{-3}$	CL=90%	236
$\pi^0 e^+\overline{\nu}_e$	*L*		$< 3 \times 10^{-3}$	CL=90%	228
$\pi^+\gamma$		[cc]	$< 3.6 \times 10^{-7}$	CL=90%	227

K^0

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

50% K_S, 50% K_L

Mass $m = 497.648 \pm 0.022$ MeV

$m_{K^0} - m_{K^\pm} = 3.972 \pm 0.027$ MeV (S = 1.2)

Mean Square Charge Radius

$\langle r^2 \rangle = -0.076 \pm 0.018$ fm^2 (S = 1.1)

***T*-violation parameters in K^0-$\overline{K}^0$ mixing** [x]

Asymmetry A_T in K^0-$\overline{K}^0$ mixing $= (6.6 \pm 1.6) \times 10^{-3}$

***CPT*-violation parameters** [x]

Re $\delta = (2.9 \pm 2.7) \times 10^{-4}$

Im $\delta = (0.02 \pm 0.05) \times 10^{-3}$

$\left| m_{K^0} - m_{\overline{K}^0} \right| / m_{\text{average}} < 10^{-18}$, CL = 90% [dd]

$(\Gamma_{K^0} - \Gamma_{\overline{K}^0})/m_{\text{average}} = (8 \pm 8) \times 10^{-18}$

K^0_S

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

Mean life $\tau = (0.8953 \pm 0.0006) \times 10^{-10}$ s (S = 1.4) Assuming *CPT*

Mean life $\tau = (0.8958 \pm 0.0006) \times 10^{-10}$ s (S = 1.2) Not assuming *CPT*

$c\tau = 2.6842$ cm Assuming *CPT*

***CP*-violation parameters** [ee]

$\text{Im}(\eta_{+-0}) = -0.002 \pm 0.009$

$\text{Im}(\eta_{000}) = -0.05 \pm 0.13$

CP asymmetry *A* in $\pi^+\pi^- e^+ e^- = (-1 \pm 4)\%$

K^0_S DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
Hadronic modes			
$\pi^0\pi^0$	(31.05 ± 0.14) %	S=1.1	209
$\pi^+\pi^-$	(68.95 ± 0.14) %	S=1.1	206
$\pi^+\pi^-\pi^0$	$(3.2 \ ^{+1.2}_{-1.0}) \times 10^{-7}$		133

Modes with photons or $\ell\overline{\ell}$ pairs					
$\pi^+\pi^-\gamma$		[y,ff]	$(1.79 \pm 0.05) \times 10^{-3}$		206
$\pi^+\pi^- e^+ e^-$			$(4.69 \pm 0.30) \times 10^{-5}$		206
$\pi^0\gamma\gamma$		[ff]	$(4.9 \pm 1.8) \times 10^{-8}$		231
$\gamma\gamma$			$(2.80 \pm 0.07) \times 10^{-6}$		249
Semileptonic modes					
$\pi^\pm e^\mp \nu_e$		[gg]	$(6.9 \pm 0.4) \times 10^{-4}$		229
***CP* violating (*CP*) and $\Delta S = 1$ weak neutral current (*S1*) modes**					
$3\pi^0$	*CP*		$< 1.4 \times 10^{-5}$	CL=90%	139
$\mu^+\mu^-$	*S1*		$< 3.2 \times 10^{-7}$	CL=90%	225
$e^+ e^-$	*S1*		$< 1.4 \times 10^{-7}$	CL=90%	249
$\pi^0 e^+ e^-$	*S1*	[ff]	$(3.0 \ ^{+1.5}_{-1.2}) \times 10^{-9}$		231

K^0_L

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

$m_{K_L} - m_{K_S}$

$= (0.5292 \pm 0.0010) \times 10^{10}\ \hbar\ \text{s}^{-1}$ (S = 1.2) Assuming *CPT*

$= (3.483 \pm 0.006) \times 10^{-12}$ MeV Assuming *CPT*

$= (0.5290 \pm 0.0016) \times 10^{10}\ \hbar\ \text{s}^{-1}$ (S = 1.2) Not assuming *CPT*

Mean life $\tau = (5.18 \pm 0.04) \times 10^{-8}$ s (S = 1.1)

$c\tau = 15.51$ m

Slope parameter *g* [w]

(See Particle Listings for quadratic coefficients)

$K^0_L \to \pi^+\pi^-\pi^0 = 0.678 \pm 0.008$ (S = 1.5)

K_L decay form factors [x]

Assuming μ-e universality

$\lambda_+(K^0_{\mu 3}) = \lambda_+(K^0_{e3}) = 0.0300 \pm 0.0020$ (S = 2.0)

$\lambda_0(K^0_{\mu 3}) = 0.030 \pm 0.005$ (S = 2.0)

Not assuming μ-e universality

$\lambda_+(K^0_{e3}) = 0.0291 \pm 0.0018$ (S = 1.5)

$\lambda_+(K^0_{\mu 3}) = 0.033 \pm 0.005$ (S = 2.3)

$\lambda_0(K^0_{\mu 3}) = 0.027 \pm 0.006$ (S = 2.3)

K^0_{e3} $\left| f_S/f_+ \right| < 0.04$, CL = 68%

K^0_{e3} $\left| f_T/f_+ \right| < 0.23$, CL = 68%

$K^0_{\mu 3}$ $\left| f_T/f_+ \right| = 0.12 \pm 0.12$

$K_L \to e^+ e^- \gamma$: $\alpha_{K^*} = -0.33 \pm 0.05$

$K_L \to \mu^+\mu^-\gamma$: $\alpha_{K^*} = -0.158 \pm 0.027$

$K_L \to e^+ e^- e^+ e^-$: $\alpha^{\text{eff}}_{K^*} = -0.14 \pm 0.22$

$K_L \to \pi^+\pi^- e^+ e^-$: $a_1/a_2 = -0.734 \pm 0.022$ GeV^2

$K_L \to \pi^0 2\gamma$: $a_V = -0.54 \pm 0.12$ (S = 2.8)

***CP*-violation parameters** [ee]

$\delta_L = (0.327 \pm 0.012)\%$

$\left| \eta_{00} \right| = (2.276 \pm 0.014) \times 10^{-3}$

$\left| \eta_{+-} \right| = (2.288 \pm 0.014) \times 10^{-3}$

$\left| \epsilon \right| = (2.284 \pm 0.014) \times 10^{-3}$

$\left| \eta_{00}/\eta_{+-} \right| = 0.9950 \pm 0.0008$ [hh] (S = 1.6)

$\text{Re}(\epsilon'/\epsilon) = (1.67 \pm 0.26) \times 10^{-3}$ [hh] (S = 1.6)

Assuming *CPT*

$\phi_{+-} = (43.52 \pm 0.06)^\circ$ (S = 1.3)

$\phi_{00} = (43.50 \pm 0.06)^\circ$ (S = 1.3)

$\phi_\epsilon = \phi_{\text{SW}} = (43.51 \pm 0.05)^\circ$ (S = 1.2)

Not assuming CPT

$\phi_{+-} = (43.4 \pm 0.7)^\circ$ (S = 1.3)

$\phi_{00} = (43.7 \pm 0.8)^\circ$ (S = 1.2)

$\phi_{\epsilon} = (43.5 \pm 0.7)^\circ$ (S = 1.3)

CP asymmetry A in $K^0_L \to \pi^+\pi^-e^+e^- = (13.8 \pm 2.2)\%$

β_{CP} from $K^0_L \to e^+e^-e^+e^- = -0.23 \pm 0.09$

γ_{CP} from $K^0_L \to e^+e^-e^+e^- = -0.09 \pm 0.09$

j for $K^0_L \to \pi^+\pi^-\pi^0 = 0.0012 \pm 0.0008$

f for $K^0_L \to \pi^+\pi^-\pi^0 = 0.004 \pm 0.006$

$|\eta_{+-\gamma}| = (2.35 \pm 0.07) \times 10^{-3}$

$\phi_{+-\gamma} = (44 \pm 4)^\circ$

$|\epsilon'_{+-\gamma}|/\epsilon < 0.3$, CL = 90%

T-violation parameters

$\text{Im}(\xi)$ in $K^0_{\mu 3} = -0.007 \pm 0.026$

CPT invariance tests

$\phi_{00} - \phi_{+-} = (0.2 \pm 0.4)^\circ$

$\text{Re}(\frac{2}{3}\eta_{+-} + \frac{1}{3}\eta_{00}) - \frac{\delta_L}{2} = (-3 \pm 35) \times 10^{-6}$

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

$\text{Re}\, x = -0.002 \pm 0.006$

$\text{Im}\, x = 0.0012 \pm 0.0021$

K^0_L DECAY MODES		Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
Semileptonic modes				
$\pi^\pm e^\mp \nu_e$ Called K^0_{e3}.	[gg]	(38.81 ±0.27) %	S=1.1	229
$\pi^\pm \mu^\mp \nu_\mu$ Called $K^0_{\mu 3}$.	[gg]	(27.19 ±0.25) %	S=1.1	216
$(\pi\mu\,\text{atom})\nu$		(1.06 ±0.11) $\times 10^{-7}$		188
$\pi^0\pi^\pm e^\mp \nu$	[gg]	(5.18 ±0.29) $\times 10^{-5}$		207
Hadronic modes, including Charge conjugation×Parity Violating (CPV) modes				
$3\pi^0$		(21.05 ±0.23) %	S=1.1	139
$\pi^+\pi^-\pi^0$		(12.59 ±0.19) %	S=1.6	133
$\pi^+\pi^-$	CPV	(2.090±0.025) $\times 10^{-3}$	S=1.1	206
$\pi^0\pi^0$	CPV	(9.32 ±0.12) $\times 10^{-4}$	S=1.1	209
Semileptonic modes with photons				
$\pi^\pm e^\mp \nu_e \gamma$	[y,gg,ii]	(3.53 ±0.06) $\times 10^{-3}$		229
$\pi^\pm \mu^\mp \nu_\mu \gamma$		(5.7 $^{+0.6}_{-0.7}$) $\times 10^{-4}$		216
Hadronic modes with photons or $\ell\bar{\ell}$ pairs				
$\pi^0\pi^0\gamma$		< 5.6 $\times 10^{-6}$		209
$\pi^+\pi^-\gamma$	[y,ii]	(4.39 ±0.12) $\times 10^{-5}$	S=1.8	206
$\pi^0 2\gamma$	[ii]	(1.41 ±0.12) $\times 10^{-6}$	S=2.8	231
$\pi^0\gamma e^+e^-$		(2.3 ±0.4) $\times 10^{-8}$		231
Other modes with photons or $\ell\bar{\ell}$ pairs				
2γ		(5.90 ±0.07) $\times 10^{-4}$	S=1.1	249
3γ		< 2.4 $\times 10^{-7}$	CL=90%	249
$e^+e^-\gamma$		(10.0 ±0.5) $\times 10^{-6}$	S=1.5	249
$\mu^+\mu^-\gamma$		(3.59 ±0.11) $\times 10^{-7}$	S=1.3	225
$e^+e^-\gamma\gamma$	[ii]	(5.95 ±0.33) $\times 10^{-7}$		249
$\mu^+\mu^-\gamma\gamma$	[ii]	(1.0 $^{+0.8}_{-0.6}$) $\times 10^{-8}$		225
Charge conjugation × Parity (CP) or Lepton Family number (LF) violating modes, or $\Delta S = 1$ weak neutral current ($S1$) modes				
$\mu^+\mu^-$	$S1$	(7.27 ±0.14) $\times 10^{-9}$		225
e^+e^-	$S1$	(9 $^{+6}_{-4}$) $\times 10^{-12}$		249
$\pi^+\pi^-e^+e^-$	$S1$ [ii]	(3.11 ±0.19) $\times 10^{-7}$		206
$\pi^0\pi^0e^+e^-$	$S1$	< 6.6 $\times 10^{-9}$	CL=90%	209
$\mu^+\mu^-e^+e^-$	$S1$	(2.69 ±0.27) $\times 10^{-9}$		225
$e^+e^-e^+e^-$	$S1$	(3.75 ±0.27) $\times 10^{-8}$		249
$\pi^0\mu^+\mu^-$	$CP,S1$ [jj]	< 3.8 $\times 10^{-10}$	CL=90%	177
$\pi^0 e^+e^-$	$CP,S1$ [jj]	< 5.1 $\times 10^{-10}$	CL=90%	231
$\pi^0\nu\bar{\nu}$	$CP,S1$ [kk]	< 5.9 $\times 10^{-7}$	CL=90%	231
$e^\pm\mu^\mp$	LF	< 4.7 $\times 10^{-12}$	CL=90%	238
$e^\pm e^\pm \mu^\mp \mu^\mp$	LF [gg]	< 4.12 $\times 10^{-11}$	CL=90%	225
$\pi^0\mu^\pm e^\mp$	LF [gg]	< 6.2 $\times 10^{-9}$	CL=90%	217

$K^*(892)$

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

$K^*(892)^\pm$ mass $m = 891.66 \pm 0.26$ MeV

$K^*(892)^0$ mass $m = 896.10 \pm 0.27$ MeV (S = 1.4)

$K^*(892)^\pm$ full width $\Gamma = 50.8 \pm 0.9$ MeV

$K^*(892)^0$ full width $\Gamma = 50.7 \pm 0.6$ MeV (S = 1.1)

$K^*(892)$ DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$K\pi$	~ 100 %		289
$K^0\gamma$	(2.30±0.20) $\times 10^{-3}$		307
$K^\pm\gamma$	(9.9 ±0.9) $\times 10^{-4}$		309
$K\pi\pi$	< 7 $\times 10^{-4}$	95%	223

$K_1(1270)$

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

Mass $m = 1273 \pm 7$ MeV [n]

Full width $\Gamma = 90 \pm 20$ MeV [n]

$K_1(1270)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K\rho$	(42 ±6) %	43
$K^*_0(1430)\pi$	(28 ±4) %	†
$K^*(892)\pi$	(16 ±5) %	302
$K\omega$	(11.0±2.0) %	†
$K f_0(1370)$	(3.0±2.0) %	–
γK^0	seen	539

$K_1(1400)$

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

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 ±6) %	402
$K\rho$	(3.0±3.0) %	292
$K f_0(1370)$	(2.0±2.0) %	–
$K\omega$	(1.0±1.0) %	284
$K^*_0(1430)\pi$	not seen	†
γK^0	seen	613

$K^*(1410)$

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

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%	410
$K\pi$	(6.6±1.3) %		612
$K\rho$	< 7 %	95%	305
γK^0	seen		619

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

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

Mass $m = 1412 \pm 6$ MeV

Full width $\Gamma = 294 \pm 23$ MeV

$K^*_0(1430)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K\pi$	(93±10) %	611

$K^*_2(1430)$

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

$K^*_2(1430)^\pm$ 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±1.2) %		619
$K^*(892)\pi$	(24.7±1.5) %		419
$K^*(892)\pi\pi$	(13.4±2.2) %		372
$K\rho$	(8.7±0.8) %	S=1.2	318

$K\omega$	(2.9 ± 0.8) %		311
$K^+\gamma$	$(2.4\pm0.5)\times10^{-3}$	S=1.1	627
$K\eta$	$(1.5^{+3.4}_{-1.0})\times10^{-3}$	S=1.3	486
$K\omega\pi$	$< 7.2 \times10^{-4}$	CL=95%	100
$K^0\gamma$	$< 9 \times10^{-4}$	CL=90%	626

$K^*(1680)$

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

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) %	781
$K\rho$	$(31.4^{+4.7}_{-2.1})$ %	570
$K^*(892)\pi$	$(29.9^{+2.2}_{-4.7})$ %	618

$K_2(1770)$ [mm]

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

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)
$K\pi\pi$		794
$K_2^*(1430)\pi$	dominant	288
$K^*(892)\pi$	seen	654
$K f_2(1270)$	seen	53
$K\phi$	seen	441
$K\omega$	seen	607

$K_3^*(1780)$

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

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) %		613
$K^*(892)\pi$	(20 ± 5) %		656
$K\pi$	(18.8 ± 1.0) %		813
$K\eta$	(30 ± 13) %		719
$K_2^*(1430)\pi$	< 16 %	95%	291

$K_2(1820)$ [nn]

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

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	327
$K^*(892)\pi$	seen	681
$K f_2(1270)$	seen	185
$K\omega$	seen	638

$K_4^*(2045)$

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

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) %	802
$K^*(892)\pi\pi\pi$	(7 ± 5) %	768
$\rho K\pi$	(5.7 ± 3.2) %	741
$\omega K\pi$	(5.0 ± 3.0) %	738
$\phi K\pi$	(2.8 ± 1.4) %	594
$\phi K^*(892)$	(1.4 ± 0.7) %	363

CHARMED MESONS
$(C = \pm1)$

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

$D^\pm$

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

Mass $m = 1869.4 \pm 0.5$ MeV (S = 1.1)
Mean life $\tau = (1040 \pm 7)\times10^{-15}$ s
$c\tau = 311.8$ μm

c-quark decays

$\Gamma(c \to \ell^+ \text{anything})/\Gamma(c \to \text{anything}) = 0.096 \pm 0.004$ [oo]
$\Gamma(c \to D^*(2010)^+ \text{anything})/\Gamma(c \to \text{anything}) = 0.255 \pm 0.017$

CP-violation decay-rate asymmetries

$A_{CP}(K^0_S\pi^\pm) = -0.016 \pm 0.017$
$A_{CP}(K^0_S K^\pm) = 0.07 \pm 0.06$
$A_{CP}(K^+K^-\pi^\pm) = 0.002 \pm 0.011$
$A_{CP}(K^\pm K^{*0}) = -0.02 \pm 0.05$
$A_{CP}(\phi\pi^\pm) = -0.014 \pm 0.033$
$A_{CP}(\pi^+\pi^-\pi^\pm) = -0.02 \pm 0.04$

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

$r_v = 1.62 \pm 0.08$ (S = 1.5)
$r_2 = 0.83 \pm 0.05$
$r_3 = 0.0 \pm 0.4$
$\Gamma_L/\Gamma_T = 1.13 \pm 0.08$
$\Gamma_+/\Gamma_- = 0.22 \pm 0.06$ (S = 1.6)

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		(27.5 ± 2.4) %		–
$\overline{K}^0$ anything + K^0 anything		(61 ± 8) %		–
K^+ anything		(5.5 ± 1.6) %		–
η anything	[pp]	< 13 %	CL=90%	–
ϕ anything		< 1.8 %	CL=90%	–
ϕe^+ anything		< 1.6 %	CL=90%	–
Leptonic and semileptonic modes				
$\mu^+\nu_\mu$		$(8 {}^{+17}_{-5})\times10^{-4}$		932
$\overline{K}^0\ell^+\nu_\ell$	[qq]	(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
$K^-\pi^+e^+\nu_e$		$(4.5 {}^{+1.0}_{-0.8})$ %	S=1.1	863
$\overline{K}^*(892)^0 e^+\nu_e \times B(\overline{K}^*(892)^0 \to K^-\pi^+)$		(3.7 ± 0.5) %		722
$K^-\pi^+e^+\nu_e$ nonresonant		$< 7 \times10^{-3}$	CL=90%	863
$K^-\pi^+\mu^+\nu_\mu$		(4.00 ± 0.32) %		851
$\overline{K}^*(892)^0\mu^+\nu_\mu \times B(\overline{K}^*(892)^0 \to K^-\pi^+)$		(3.7 ± 0.3) %		717
$K^-\pi^+\mu^+\nu_\mu$ nonresonant		$(3.3 \pm 1.3)\times10^{-3}$		851
$(\overline{K}^*(892)\pi)^0 e^+\nu_e$		< 1.2 %	CL=90%	712
$(\overline{K}\pi\pi)^0 e^+\nu_e$ non-$\overline{K}^*(892)$		$< 9 \times10^{-3}$	CL=90%	846
$K^-\pi^+\pi^0\mu^+\nu_\mu$		$< 1.7 \times10^{-3}$	CL=90%	825
$\pi^0\ell^+\nu_\ell$	[rr]	$(3.1 \pm 1.5)\times10^{-3}$		930
Fractions of some of the following modes with resonances have already appeared above as submodes of particular charged-particle modes.				
$\overline{K}^*(892)^0\ell^+\nu_\ell$	[qq]	(5.73 ± 0.35) %		722
$\overline{K}^*(892)^0 e^+\nu_e$		(5.5 ± 0.7) %	S=1.4	722
$\overline{K}^*(892)^0\mu^+\nu_\mu$		(5.5 ± 0.4) %		717
$\overline{K}_1(1270)^0\mu^+\nu_\mu$		< 4 %	CL=95%	493
$\overline{K}_2^*(1430)^0\mu^+\nu_\mu$		< 1.0 %	CL=95%	380
$\rho^0 e^+\nu_e$		$(2.5 \pm 1.0)\times10^{-3}$		774
$\rho^0\mu^+\nu_\mu$		$(3.4 \pm 0.8)\times10^{-3}$		769
$\phi e^+\nu_e$		< 2.09 %	CL=90%	657
$\phi\mu^+\nu_\mu$		< 3.72 %	CL=90%	651
$\eta\ell^+\nu_\ell$		$< 5 \times10^{-3}$	CL=90%	854
$\eta'(958)\mu^+\nu_\mu$		< 1.1 %	CL=90%	684

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

$\overline{K}^0\pi^+$		(2.82 ± 0.19) %		862
$K^-\pi^+\pi^+$	[ss]	(9.2 ± 0.6) %		845
$\overline{K}^*(892)^0\pi^+$ × B($\overline{K}^*(892)^0 \to K^-\pi^+$)		(1.30 ± 0.13) %		714
$\overline{K}_0^*(1430)^0\pi^+$ × B($\overline{K}_0^*(1430)^0 \to K^-\pi^+$)		(2.3 ± 0.3) %		382
$\overline{K}^*(1680)^0\pi^+$ × B($\overline{K}^*(1680)^0 \to K^-\pi^+$)		(3.8 ± 0.8) × 10^{-3}		58
$K^-\pi^+\pi^+$ nonresonant		(8.8 ± 0.9) %		845
$\overline{K}^0\pi^+\pi^0$	[ss]	(9.7 ± 3.0) %	S=1.1	845
$\overline{K}^0\rho^+$		(6.6 ± 2.5) %		677
$\overline{K}^*(892)^0\pi^+$ × B($\overline{K}^*(892)^0 \to \overline{K}^0\pi^0$)		(6.5 ± 0.6) × 10^{-3}		714
$\overline{K}^0\pi^+\pi^0$ nonresonant		(1.3 ± 1.1) %		845
$K^-\pi^+\pi^+\pi^0$	[ss]	(6.5 ± 1.1) %		816
$\overline{K}^*(892)^0\rho^+$ total × B($\overline{K}^*(892)^0 \to K^-\pi^+$)		(1.4 ± 0.9) %		422
$\overline{K}_1(1400)^0\pi^+$ × B($\overline{K}_1(1400)^0 \to K^-\pi^+\pi^0$)		(2.2 ± 0.6) %		390
$K^-\rho^+\pi^+$ total		(3.1 ± 1.1) %		612
$K^-\rho^+\pi^+$ 3-body		(1.1 ± 0.4) %		612
$\overline{K}^*(892)^0\pi^+\pi^0$ total × B($\overline{K}^*(892)^0 \to K^-\pi^+$)		(4.5 ± 0.9) %		690
$\overline{K}^*(892)^0\pi^+\pi^0$ 3-body × B($\overline{K}^*(892)^0 \to K^-\pi^+$)		(2.9 ± 0.9) %		690
$K^*(892)^-\pi^+\pi^+$ 3-body × B($K^*(892)^- \to K^-\pi^0$)		(7 ± 3) × 10^{-3}		688
$K^-\pi^+\pi^+\pi^0$ nonresonant	[tt]	(1.2 ± 0.6) %		816
$\overline{K}^0\pi^+\pi^+\pi^-$	[ss]	(7.1 ± 1.0) %		814
$\overline{K}^0 a_1(1260)^+$ × B($a_1(1260)^+ \to \pi^+\pi^+\pi^-$)		(4.0 ± 0.9) %		328
$\overline{K}_1(1400)^0\pi^+$ × B($\overline{K}_1(1400)^0 \to \overline{K}^0\pi^+\pi^-$)		(2.2 ± 0.6) %		390
$K^*(892)^-\pi^+\pi^+$ 3-body × B($K^*(892)^- \to \overline{K}^0\pi^-$)		(1.4 ± 0.6) %		688
$\overline{K}^0\rho^0\pi^+$ total		(4.3 ± 0.9) %		610
$\overline{K}^0\rho^0\pi^+$ 3-body		(5 ± 5) × 10^{-3}		610
$\overline{K}^0\pi^+\pi^+\pi^-$ nonresonant		(9 ± 4) × 10^{-3}		814
$K^-3\pi^+\pi^-$	[ss]	(6.2 ± 0.8) × 10^{-3}	S=1.3	772
$\overline{K}^*(892)^0\pi^+\pi^+\pi^-$ × B($\overline{K}^*(892)^0 \to K^-\pi^+$)		(2.1 ± 0.8) × 10^{-3}		645
$\overline{K}^*(892)^0\rho^0\pi^+$ × B($\overline{K}^*(892)^0 \to K^-\pi^+$)		(2.0 ± 0.5) × 10^{-3}		239
$\overline{K}^*(892)^0\pi^+\pi^+\pi^-$ no-ρ × B($\overline{K}^*(892)^0 \to K^-\pi^+$)		(2.9 ± 1.1) × 10^{-3}		645
$K^-\rho^0\pi^+\pi^+$		(1.94 ± 0.35) × 10^{-3}	S=1.1	524
$K^-3\pi^+\pi^-$ nonresonant		(4.3 ± 3.2) × 10^{-4}		772
$\overline{K}^0\overline{K}^0K^+$		(1.8 ± 0.8) %		545
$K^+K^-\overline{K}^0\pi^+$		(5.5 ± 1.4) × 10^{-4}		435

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) %		677
$\overline{K}^0 a_1(1260)^+$		(8.2 ± 1.7) %		328
$\overline{K}^0 a_2(1320)^+$		< 3 × 10^{-3}	CL=90%	199
$\overline{K}^*(892)^0\pi^+$		(1.95 ± 0.19) %		714
$\overline{K}^*(892)^0\rho^+$ total	[tt]	(2.1 ± 1.4) %		422
$\overline{K}^*(892)^0\rho^+$ S-wave	[tt]	(1.7 ± 1.6) %		422
$\overline{K}^*(892)^0\rho^+$ P-wave		< 1 × 10^{-3}	CL=90%	422
$\overline{K}^*(892)^0\rho^+$ D-wave		(10 ± 7) × 10^{-3}		422
$\overline{K}^*(892)^0\rho^+$ D-wave longitudinal		< 7 × 10^{-3}	CL=90%	422
$\overline{K}_1(1270)^0\pi^+$		< 7 × 10^{-3}	CL=90%	487
$\overline{K}_1(1400)^0\pi^+$		(5.0 ± 1.3) %		390
$\overline{K}_0^*(1430)^0\pi^+$		(3.8 ± 0.4) %		382
$\overline{K}^*(1680)^0\pi^+$		(1.47 ± 0.31) %		58
$\overline{K}^*(892)^0\pi^+\pi^0$ total		(6.8 ± 1.4) %		690
$\overline{K}^*(892)^0\pi^+\pi^0$ 3-body	[tt]	(4.3 ± 1.4) %		690
$K^*(892)^-\pi^+\pi^+$ total		—		688
$K^*(892)^-\pi^+\pi^+$ 3-body		(2.1 ± 0.9) %		688
$K^-\rho^+\pi^+$ total		(3.1 ± 1.1) %		612
$K^-\rho^+\pi^+$ 3-body		(1.1 ± 0.4) %		612
$\overline{K}^0\rho^0\pi^+$ total		(4.3 ± 0.9) %	CL=90%	610
$\overline{K}^0\rho^0\pi^+$ 3-body		(5 ± 5) × 10^{-3}		610
$\overline{K}^*(892)^0\pi^+\pi^+\pi^-$		(3.2 ± 1.2) × 10^{-3}	S=2.0	645
$\overline{K}^*(892)^0\rho^0\pi^+$		(3.0 ± 0.7) × 10^{-3}	S=1.3	239
$\overline{K}^*(892)^0\pi^+\pi^+\pi^-$ no-ρ		(4.4 ± 1.7) × 10^{-3}		645
$K^-\rho^0\pi^+\pi^+$		(1.94 ± 0.35) × 10^{-3}		524
$\overline{K}^*(892)^0 a_1(1260)^+$		(9.1 ± 1.9) × 10^{-3}		†

Pionic modes

$\pi^+\pi^0$		(2.6 ± 0.7) × 10^{-3}		925
$\pi^+\pi^+\pi^-$		(3.1 ± 0.4) × 10^{-3}		908
$\sigma\pi^+$		(2.2 ± 0.5) × 10^{-3}		–
$\rho^0\pi^+$		(1.05 ± 0.18) × 10^{-3}		766
$f_0(980)\pi^+$ × B($f_0 \to \pi^+\pi^-$)	[uu]	(1.9 ± 0.5) × 10^{-4}		669
$f_2(1270)\pi^+$ × B($f_2 \to \pi^+\pi^-$)		(6.1 ± 1.1) × 10^{-4}		485
$\pi^+\pi^+\pi^-$ nonresonant		(2.4 ± 2.1) × 10^{-4}		908
$\pi^+\pi^+\pi^-\pi^0$		—		883
$\eta\pi^+$ × B($\eta \to \pi^+\pi^-\pi^0$)		(6.8 ± 1.4) × 10^{-4}		848
$\omega\pi^+$ × B($\omega \to \pi^+\pi^-\pi^0$)		< 6 × 10^{-3}	CL=90%	763
$3\pi^+2\pi^-$		(1.82 ± 0.25) × 10^{-3}	S=1.2	845

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

$\eta\pi^+$		(3.0 ± 0.6) × 10^{-3}		848
$\rho^0\pi^+$		(1.05 ± 0.18) × 10^{-3}		766
$\omega\pi^+$		< 7 × 10^{-3}	CL=90%	763
$\eta\rho^+$		< 7 × 10^{-3}	CL=90%	655
$\eta'(958)\pi^+$		(5.1 ± 1.0) × 10^{-3}		680
$\eta'(958)\rho^+$		< 5 × 10^{-3}	CL=90%	348
$f_2(1270)\pi^+$		(1.08 ± 0.20) × 10^{-3}		485

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

$K^+\overline{K}^0$		(5.9 ± 0.6) × 10^{-3}	S=1.2	792
$K^+K^-\pi^+$	[ss]	(8.9 ± 0.8) × 10^{-3}		744
$\phi\pi^+$ × B($\phi \to K^+K^-$)		(3.1 ± 0.3) × 10^{-3}		647
$K^+\overline{K}^*(892)^0$ × B($\overline{K}^{*0} \to K^-\pi^+$)		(2.9 ± 0.4) × 10^{-3}		613
$K^+K^-\pi^+$ nonresonant		(4.6 ± 0.9) × 10^{-3}		744
$K^0\overline{K}^0\pi^+$		—		741
$K^*(892)^+\overline{K}^0$ × B($K^{*+} \to K^0\pi^+$)		(2.1 ± 0.9) %		611
$K^+K^-\pi^+\pi^0$		—		682
$\phi\pi^+\pi^0$ × B($\phi \to K^+K^-$)		(1.1 ± 0.5) %		619
$\phi\rho^+$ × B($\phi \to K^+K^-$)		< 7 × 10^{-3}	CL=90%	258
$K^+K^-\pi^+\pi^0$ non-ϕ		(1.5 $^{+0.7}_{-0.6}$) %		682
$K^+\overline{K}^0\pi^+\pi^-$		(4.0 ± 0.7) × 10^{-3}		678
$K^0K^-\pi^+\pi^+$		(5.5 ± 0.8) × 10^{-3}		678
$K^*(892)^+\overline{K}^*(892)^0$ × $B^2(K^*(892)^+ \to K^0\pi^+)$		(1.2 ± 0.5) %		280
$K^0K^-\pi^+\pi^+$ (non-$K^{*+}\overline{K}^{*0}$)		< 7.9 × 10^{-3}	CL=90%	678
$K^+K^-\pi^+\pi^+\pi^-$		(2.5 ± 1.3) × 10^{-4}		600

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

$\phi\pi^+$		(6.2 ± 0.6) × 10^{-3}		647
$\phi\pi^+\pi^0$		(2.3 ± 1.0) %		619
$\phi\rho^+$		< 1.5 %	CL=90%	258
$K^+\overline{K}^*(892)^0$		(4.3 ± 0.6) × 10^{-3}		613
$K^*(892)^+\overline{K}^0$		(3.1 ± 1.4) %		611
$K^*(892)^+\overline{K}^*(892)^0$		(2.6 ± 1.1) %		280

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		(7.0 ± 1.5) × 10^{-4}		845
$K^+\rho^0$	DC		(2.6 ± 1.2) × 10^{-4}		678
$K^*(892)^0\pi^+$	DC	[vv]	(3.7 ± 1.7) × 10^{-4}		714
$K^+\pi^+\pi^-$ nonresonant	DC		(2.5 ± 1.2) × 10^{-4}		845
$K^+K^+K^-$	DC		(8.7 ± 2.1) × 10^{-5}		550
ϕK^+	DC	[vv]	< 1.3 × 10^{-4}	CL=90%	527
$\pi^+e^+e^-$	C1		< 5.2 × 10^{-5}	CL=90%	929
$\pi^+\mu^+\mu^-$	C1		< 8.8 × 10^{-6}	CL=90%	917
$\rho^+\mu^+\mu^-$	C1		< 5.6 × 10^{-4}	CL=90%	757
$K^+e^+e^-$		[ww]	< 2.0 × 10^{-4}	CL=90%	870
$K^+\mu^+\mu^-$		[ww]	< 9.2 × 10^{-6}	CL=90%	856
$\pi^+e^\pm\mu^\mp$	LF	[gg]	< 3.4 × 10^{-5}	CL=90%	926
$K^+e^\pm\mu^\mp$	LF	[gg]	< 6.8 × 10^{-5}	CL=90%	866
$\pi^-e^+e^+$	L		< 9.6 × 10^{-5}	CL=90%	929
$\pi^-\mu^+\mu^+$	L		< 4.8 × 10^{-6}	CL=90%	917

$\pi^- e^+ \mu^+$	L	< 5.0	$\times 10^{-5}$	CL=90%	926
$\rho^- \mu^+ \mu^+$	L	< 5.6	$\times 10^{-4}$	CL=90%	757
$K^- e^+ e^+$	L	< 1.2	$\times 10^{-4}$	CL=90%	870
$K^- \mu^+ \mu^+$	L	< 1.3	$\times 10^{-5}$	CL=90%	856
$K^- e^+ \mu^+$	L	< 1.3	$\times 10^{-4}$	CL=90%	866
$K^*(892)^- \mu^+ \mu^+$	L	< 8.5	$\times 10^{-4}$	CL=90%	703

D^0

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

Mass $m = 1864.6 \pm 0.5$ MeV (S = 1.1)
$m_{D^\pm} - m_{D^0} = 4.78 \pm 0.10$ MeV (S = 1.1)
Mean life $\tau = (410.3 \pm 1.5) \times 10^{-15}$ s
$c\tau = 123.0\ \mu$m
$\left|m_{D_1^0} - m_{D_2^0}\right| < 7 \times 10^{10}\ \hbar\ \text{s}^{-1}$, CL = 95% [xx]
$(\Gamma_{D_1^0} - \Gamma_{D_2^0})/\Gamma = 2y = 0.016 \pm 0.010$
$\Gamma(K^+ \ell^- \overline{\nu}_\ell\ (\text{via}\ \overline{D}^0))/\Gamma(K^- \ell^+ \nu_\ell) < 0.005$, CL = 90%
$\Gamma(K^+ \pi^-\ (\text{via}\ \overline{D}^0))/\Gamma(K^- \pi^+) < 4.1 \times 10^{-4}$, CL = 95%

CP-violation decay-rate asymmetries

$A_{CP}(K^+ K^-) = 0.005 \pm 0.016$
$A_{CP}(K_S^0 K_S^0) = -0.23 \pm 0.19$
$A_{CP}(\pi^+ \pi^-) = 0.021 \pm 0.026$
$A_{CP}(\pi^0 \pi^0) = 0.00 \pm 0.05$
$A_{CP}(K_S^0 \phi) = -0.03 \pm 0.09$
$A_{CP}(K_S^0 \pi^0) = 0.001 \pm 0.013$
$A_{CP}(K^\pm \pi^\mp) = 0.08 \pm 0.09$
$A_{CP}(K^\mp \pi^\pm \pi^0) = -0.03 \pm 0.09$
$A_{CP}(K^\pm \pi^\mp \pi^0) = 0.09^{+0.25}_{-0.22}$

CPT-violation decay-rate asymmetry

$A_{CPT}(K^\mp \pi^\pm) = 0.008 \pm 0.008$

$\overline{D}^0$ 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	[yy]	(6.87 ± 0.28) %		–
μ^+ anything		(6.5 ± 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	[pp]	< 13 %	CL=90%	–
ϕ anything		(1.7 ± 0.8) %		–
Semileptonic modes				
$K^- \ell^+ \nu_\ell$	[qq]	(3.43 ± 0.14) %	S=1.2	867
$K^- e^+ \nu_e$		(3.58 ± 0.18) %	S=1.1	867
$K^- \mu^+ \nu_\mu$		(3.19 ± 0.17) %		864
$K^- \pi^0 e^+ \nu_e$		$(1.1\ ^{+0.8}_{-0.6})$ %	S=1.6	861
$\overline{K}^0 \pi^- e^+ \nu_e$		(1.8 ± 0.8) %	S=1.6	860
$\overline{K}^*(892)^- e^+ \nu_e$ $\times$ B$(K^*(892)^- \to \overline{K}^0 \pi^-)$		(1.43 ± 0.23) %		719
$K^- \pi^+ \pi^- \mu^+ \nu_\mu$		$< 1.2 \times 10^{-3}$	CL=90%	821
$(\overline{K}^*(892)\pi)^- \mu^+ \nu_\mu$		$< 1.4 \times 10^{-3}$	CL=90%	692
$\pi^- e^+ \nu_e$		$(3.6 \pm 0.6) \times 10^{-3}$		927
A fraction of the following resonance mode has already appeared above as a submode of a charged-particle mode.				
$K^*(892)^- e^+ \nu_e$		(2.15 ± 0.35) %		719
Hadronic modes with a $\overline{K}$ or $\overline{K}K\overline{K}$				
$K^- \pi^+$		(3.80 ± 0.09) %		861
$\overline{K}^0 \pi^0$		(2.30 ± 0.22) %		860
$\overline{K}^0 \pi^+ \pi^-$	[ss]	(5.97 ± 0.35) %	S=1.1	842
$\overline{K}^0 \rho^0$		$(1.55\ ^{+0.12}_{-0.16})$ %		673
$\overline{K}^0 \omega$ $\times$ B$(\omega \to \pi^+ \pi^-)$		$(3.9 \pm 0.9) \times 10^{-4}$		670
$\overline{K}^0 f_0(980)$ $\times$ B$(f_0(980) \to \pi^+ \pi^-)$		$(2.8\ ^{+0.6}_{-0.4}) \times 10^{-3}$		549
$\overline{K}^0 f_2(1270)$ $\times$ B$(f_2(1270) \to \pi^+ \pi^-)$		$(2.6\ ^{+2.3}_{-1.4}) \times 10^{-4}$		262
$\overline{K}^0 f_0(1370)$ $\times$ B$(f_0(1370) \to \pi^+ \pi^-)$		$(5.1\ ^{+1.2}_{-1.3}) \times 10^{-3}$		–
$K^*(892)^- \pi^+$ $\times$ B$(K^*(892)^- \to \overline{K}^0 \pi^-)$		(3.9 ± 0.3) %		711
$K_0^*(1430)^- \pi^+$ $\times$ B$(K_0^*(1430)^- \to \overline{K}^0 \pi^-)$		$(6.1\ ^{+1.2}_{-0.8}) \times 10^{-3}$		378
$K_2^*(1430)^- \pi^+$ $\times$ B$(K_2^*(1430)^- \to \overline{K}^0 \pi^-)$		$(1.0\ ^{+0.7}_{-0.4}) \times 10^{-3}$		367
$K^*(1680)^- \pi^+$ $\times$ B$(K^*(1680)^- \to \overline{K}^0 \pi^-)$		$(2.1\ ^{+1.0}_{-0.9}) \times 10^{-3}$		46
$K^*(892)^+ \pi^-$ $\times$ B$(K^*(892)^+ \to K^0 \pi^+)$		$(2.0\ ^{+2.6}_{-0.9}) \times 10^{-4}$		711
$\overline{K}^0 \pi^+ \pi^-$ nonresonant		$(5.4\ ^{+12.0}_{-3.4}) \times 10^{-4}$		842
$K^- \pi^+ \pi^0$	[ss]	(13.0 ± 0.8) %	S=1.3	844
$K^- \rho^+$		(10.1 ± 0.8) %		675
$K^- \rho(1700)^+$ $\times$ B$(\rho(1700)^+ \to \pi^+ \pi^0)$		$(7.4 \pm 1.6) \times 10^{-3}$		†
$K^*(892)^- \pi^+$ $\times$ B$(K^*(892)^- \to K^- \pi^0)$		(1.97 ± 0.13) %		711
$\overline{K}^*(892)^0 \pi^0$ $\times$ B$(\overline{K}^*(892)^0 \to K^- \pi^+)$		(1.87 ± 0.27) %		711
$K_0^*(1430)^- \pi^+$ $\times$ B$(K_0^*(1430)^- \to K^- \pi^0)$		$(3.0\ ^{+0.6}_{-0.4}) \times 10^{-3}$		378
$\overline{K}_0^*(1430)^0 \pi^0$ $\times$ B$(\overline{K}_0^*(1430)^0 \to K^- \pi^+)$		$(5.3\ ^{+4.2}_{-1.4}) \times 10^{-3}$		379
$K^*(1680)^- \pi^+$ $\times$ B$(K^*(1680)^- \to K^- \pi^0)$		$(1.1 \pm 0.5) \times 10^{-3}$		46
$K^- \pi^+ \pi^0$ nonresonant		$(1.04\ ^{+0.50}_{-0.19})$ %		844
$\overline{K}^0 \pi^0 \pi^0$		—		843
$\overline{K}^*(892)^0 \pi^0$ $\times$ B$(\overline{K}^*(892)^0 \to \overline{K}^0 \pi^0)$		$(9.3 \pm 1.3) \times 10^{-3}$		711
$\overline{K}^0 \pi^0 \pi^0$ nonresonant		$(8.5 \pm 2.2) \times 10^{-3}$		843
$K^- \pi^+ \pi^+ \pi^-$	[ss]	(7.46 ± 0.31) %		812
$K^- \pi^+ \rho^0$ total		(6.2 ± 0.4) %		609
$K^- \pi^+ \rho^0$ 3-body		$(4.7 \pm 2.1) \times 10^{-3}$		609
$\overline{K}^*(892)^0 \rho^0$ $\times$ B$(\overline{K}^*(892)^0 \to K^- \pi^+)$		$(9.7 \pm 2.1) \times 10^{-3}$		416
$K^- a_1(1260)^+$ $\times$ B$(a_1(1260)^+ \to \pi^+ \pi^+ \pi^-)$		(3.6 ± 0.6) %		327
$\overline{K}^*(892)^0 \pi^+ \pi^-$ total $\times$ B$(\overline{K}^*(892)^0 \to K^- \pi^+)$		(1.5 ± 0.4) %		685
$\overline{K}^*(892)^0 \pi^+ \pi^-$ 3-body $\times$ B$(\overline{K}^*(892)^0 \to K^- \pi^+)$		$(9.5 \pm 2.1) \times 10^{-3}$		685
$K_1(1270)^- \pi^+$ $\times$ B$(K_1(1270)^- \to K^- \pi^+ \pi^-)$	[tt]	$(2.9 \pm 0.3) \times 10^{-3}$		484
$K^- \pi^+ \pi^+ \pi^-$ nonresonant		(1.74 ± 0.25) %		812
$\overline{K}^0 \pi^+ \pi^- \pi^0$	[ss]	(10.9 ± 1.3) %		812
$\overline{K}^0 \eta$ $\times$ B$(\eta \to \pi^+ \pi^- \pi^0)$		$(1.74 \pm 0.25) \times 10^{-3}$		772
$\overline{K}^0 \omega$ $\times$ B$(\omega \to \pi^+ \pi^- \pi^0)$		(2.1 ± 0.4) %		670
$K^*(892)^- \rho^+$ $\times$ B$(K^*(892)^- \to \overline{K}^0 \pi^-)$		(4.4 ± 1.7) %		416
$\overline{K}^*(892)^0 \rho^0$ $\times$ B$(\overline{K}^*(892)^0 \to \overline{K}^0 \pi^0)$		$(4.8 \pm 1.1) \times 10^{-3}$		416
$K_1(1270)^- \pi^+$ $\times$ B$(K_1(1270)^- \to \overline{K}^0 \pi^- \pi^0)$	[tt]	$(4.5 \pm 1.2) \times 10^{-3}$		484
$\overline{K}^*(892)^0 \pi^+ \pi^-$ 3-body $\times$ B$(\overline{K}^*(892)^0 \to \overline{K}^0 \pi^0)$		$(4.7 \pm 1.0) \times 10^{-3}$		685
$\overline{K}^0 \pi^+ \pi^- \pi^0$ nonresonant		(2.3 ± 2.3) %		812
$K^- \pi^+ \pi^+ \pi^- \pi^0$		(4.0 ± 0.4) %		771
$\overline{K}^*(892)^0 \pi^+ \pi^- \pi^0$ $\times$ B$(\overline{K}^*(892)^0 \to K^- \pi^+)$		(1.2 ± 0.6) %		643
$\overline{K}^*(892)^0 \eta$ $\times$ B$(\overline{K}^*(892)^0 \to K^- \pi^+)$ $\times$ B$(\eta \to \pi^+ \pi^- \pi^0)$		$(2.7 \pm 0.6) \times 10^{-3}$		582
$K^- \pi^+ \omega$ $\times$ B$(\omega \to \pi^+ \pi^- \pi^0)$		(2.7 ± 0.5) %		605
$\overline{K}^*(892)^0 \omega$ $\times$ B$(\overline{K}^*(892)^0 \to K^- \pi^+)$ $\times$ B$(\omega \to \pi^+ \pi^- \pi^0)$		$(6.5 \pm 2.4) \times 10^{-3}$		410
$\overline{K}^0 \pi^+ \pi^+ \pi^- \pi^-$		$(6.4 \pm 1.8) \times 10^{-3}$		768
$\overline{K}^0 K^+ K^-$		(1.03 ± 0.10) %		544
$\overline{K}^0 \phi$ $\times$ B$(\phi \to K^+ K^-)$		$(4.7 \pm 0.6) \times 10^{-3}$		520
$\overline{K}^0 K^+ K^-$ non-ϕ		$(5.6 \pm 0.9) \times 10^{-3}$		544
$K_S^0 K_S^0 K_S^0$		$(9.2 \pm 1.6) \times 10^{-4}$		538
$K^+ K^- K^- \pi^+$		$(2.04 \pm 0.30) \times 10^{-4}$		434
$K^+ K^- \overline{K}^*(892)^0$ $\times$ B$(\overline{K}^*(892)^0 \to K^- \pi^+)$		$(4.1 \pm 1.7) \times 10^{-5}$		†

Mode		Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
$K^-\pi^+\phi \times$ B($\phi \to K^+K^-$)		$(3.8 \pm 1.6) \times 10^{-5}$		422
$\phi\overline{K}^*(892)^0$ $\times$ B($\phi \to K^+K^-$) $\times$ B($\overline{K}^*(892)^0 \to K^-\pi^+$)		$(1.0 \pm 0.2) \times 10^{-4}$		†
$K^+K^-K^-\pi^+$ nonresonant		$(3.1 \pm 1.4) \times 10^{-5}$		434

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.)

Mode		Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
$\overline{K}^0\eta$		$(7.7 \pm 1.1) \times 10^{-3}$		772
$\overline{K}^0\rho^0$		$(1.55^{+0.12}_{-0.16})$ %		673
$K^-\rho^+$		(10.1 ± 0.8) %	S=1.2	675
$\overline{K}^0\omega$		(2.3 ± 0.4) %		670
$\overline{K}^0\eta'(958)$		(1.88 ± 0.28) %		565
$\overline{K}^0\phi$		$(9.4 \pm 1.1) \times 10^{-3}$		520
$K^-a_1(1260)^+$		(7.2 ± 1.1) %		327
$\overline{K}^0a_1(1260)^0$		< 1.9 %	CL=90%	323
$\overline{K}^0f_2(1270)$		$(4.7^{+4.1}_{-2.4}) \times 10^{-4}$		262
$K^-a_2(1320)^+$		$< 2 \times 10^{-3}$	CL=90%	197
$K^*(892)^-\pi^+$		(5.9 ± 0.4) %	S=1.1	711
$\overline{K}^*(892)^0\pi^0$		(2.8 ± 0.4) %	S=1.1	711
$\overline{K}^*(892)^0\pi^+\pi^-$ total		(2.2 ± 0.5) %		685
$\overline{K}^*(892)^0\pi^+\pi^-$ 3-body		(1.42 ± 0.31) %		685
$K^-\pi^+\rho^0$ total		(6.2 ± 0.4) %		609
$K^-\pi^+\rho^0$ 3-body		$(4.7 \pm 2.1) \times 10^{-3}$		609
$\overline{K}^*(892)^0\rho^0$		(1.45 ± 0.32) %		416
$\overline{K}^*(892)^0\rho^0$ transverse		(1.5 ± 0.5) %		416
$\overline{K}^*(892)^0\rho^0$ *S*-wave		(2.8 ± 0.6) %		416
$\overline{K}^*(892)^0\rho^0$ *S*-wave long.		$< 3 \times 10^{-3}$	CL=90%	416
$\overline{K}^*(892)^0\rho^0$ *P*-wave		$< 3 \times 10^{-3}$	CL=90%	416
$\overline{K}^*(892)^0\rho^0$ *D*-wave		(1.9 ± 0.6) %		416
$K^*(892)^-\rho^+$		(6.6 ± 2.6) %		416
$K^*(892)^-\rho^+$ longitudinal		(3.2 ± 1.3) %		416
$K^*(892)^-\rho^+$ transverse		(3.4 ± 2.0) %		416
$K^*(892)^-\rho^+$ *P*-wave		< 1.5 %	CL=90%	416
$K_1(1270)^-\pi^+$	[tt]	(1.14 ± 0.31) %		484
$K_1(1400)^-\pi^+$		< 1.2 %	CL=90%	386
$\overline{K}_1(1400)^0\pi^0$		< 3.7 %	CL=90%	387
$K_0^*(1430)^-\pi^+$		$(9.8^{+2.0}_{-1.3}) \times 10^{-3}$		378
$\overline{K}_0^*(1430)^0\pi^0$		$(8.6^{+6.8}_{-2.3}) \times 10^{-3}$		379
$K_2^*(1430)^-\pi^+$		$(2.0^{+1.3}_{-0.7}) \times 10^{-3}$		367
$\overline{K}_2^*(1430)^0\pi^0$		$< 3.3 \times 10^{-3}$	CL=90%	368
$K^*(1680)^-\pi^+$		$(8.2^{+3.9}_{-3.5}) \times 10^{-3}$	S=1.2	46
$\overline{K}^*(892)^0\pi^+\pi^-\pi^0$		(1.8 ± 0.9) %		643
$\overline{K}^*(892)^0\eta$		(1.8 ± 0.4) %		582
$K^-\pi^+\omega$		(3.0 ± 0.6) %		605
$\overline{K}^*(892)^0\omega$		(1.1 ± 0.4) %		410
$K^-\pi^+\eta'(958)$		$(6.9 \pm 1.8) \times 10^{-3}$		479
$\overline{K}^*(892)^0\eta'(958)$		$< 1.0 \times 10^{-3}$	CL=90%	119
$K^-\pi^+\phi$		$(7.6 \pm 3.1) \times 10^{-5}$		422
$K^+K^-\overline{K}^*(892)^0$		$(6.1 \pm 2.5) \times 10^{-5}$		†
$\phi\overline{K}^*(892)^0$		$(3.0 \pm 0.6) \times 10^{-4}$		†

Pionic modes

Mode		Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
$\pi^+\pi^-$		$(1.38 \pm 0.05) \times 10^{-3}$		922
$\pi^0\pi^0$		$(8.4 \pm 2.2) \times 10^{-4}$		922
$\pi^+\pi^-\pi^0$		(1.1 ± 0.4) %		907
$\pi^+\pi^+\pi^-\pi^-$		$(7.3 \pm 0.5) \times 10^{-3}$		880

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

Mode		Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
K^+K^-		$(3.89^{+0.12}_{-0.15}) \times 10^{-3}$	S=1.2	791
$K^0\overline{K}^0$		$(7.1 \pm 1.9) \times 10^{-4}$	S=1.2	788
$K^0K^-\pi^+$		$(6.9 \pm 1.0) \times 10^{-3}$		739
$\overline{K}^*(892)^0K^0$ $\times$ B($\overline{K}^{*0} \to K^-\pi^+$)		$< 1.1 \times 10^{-3}$	CL=90%	608
$K^*(892)^+K^-$ $\times$ B($K^{*+} \to K^0\pi^+$)		$(2.5 \pm 0.5) \times 10^{-3}$		610
$K^0K^-\pi^+$ nonresonant		$(2.3 \pm 2.3) \times 10^{-3}$		739
$\overline{K}^0K^+\pi^-$		$(5.3 \pm 1.0) \times 10^{-3}$		739
$K^*(892)^0\overline{K}^0$ $\times$ B($K^{*0} \to K^+\pi^-$)		$< 6 \times 10^{-4}$	CL=90%	608
$K^*(892)^-K^+$ $\times$ B($K^{*-} \to \overline{K}^0\pi^-$)		$(1.3 \pm 0.7) \times 10^{-3}$		610
$\overline{K}^0K^+\pi^-$ nonresonant		$(3.8^{+2.3}_{-1.9}) \times 10^{-3}$		739
$K^+K^-\pi^0$		$(1.24 \pm 0.35) \times 10^{-3}$		743
$K_S^0K_S^0\pi^0$		$< 5.9 \times 10^{-4}$		740
$K^+K^-\pi^+\pi^-$	[zz]	$(2.49 \pm 0.23) \times 10^{-3}$		677
$\phi\pi^+\pi^- \times$ B($\phi \to K^+K^-$)		$(5.3 \pm 1.4) \times 10^{-4}$		614
$\phi\rho^0 \times$ B($\phi \to K^+K^-$)		$(2.9 \pm 1.5) \times 10^{-4}$		250
$K^+K^-\rho^0$ 3-body		$(9.0 \pm 2.3) \times 10^{-4}$		301
$K^*(892)^0K^-\pi^+$ + c.c. $\times$ B($K^{*0} \to K^+\pi^-$)	[aaa]	$< 5 \times 10^{-4}$		531
$K^*(892)^0\overline{K}^*(892)^0$ $\times$ B^2($K^{*0} \to K^+\pi^-$)		$(6 \pm 2) \times 10^{-4}$		272
$K^+K^-\pi^+\pi^-$ nonresonant		$< 8 \times 10^{-4}$	CL=90%	677
$K^0\overline{K}^0\pi^+\pi^-$		$(7.5 \pm 2.9) \times 10^{-3}$		673
$K^+K^-\pi^+\pi^-\pi^0$		$(3.1 \pm 2.0) \times 10^{-3}$		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)
$\overline{K}^*(892)^0K^0$		$< 1.7 \times 10^{-3}$	CL=90%	608
$K^*(892)^+K^-$		$(3.8 \pm 0.8) \times 10^{-3}$		610
$K^*(892)^0\overline{K}^0$		$< 9 \times 10^{-4}$	CL=90%	608
$K^*(892)^-K^+$		$(2.0 \pm 1.1) \times 10^{-3}$		610
$\phi\pi^0$		$(7.5 \pm 0.5) \times 10^{-4}$		645
$\phi\eta$		$(1.4 \pm 0.5) \times 10^{-4}$		489
$\phi\omega$		$< 2.1 \times 10^{-3}$	CL=90%	238
$\phi\pi^+\pi^-$		$(1.06 \pm 0.28) \times 10^{-3}$		614
$\phi\rho^0$		$(5.7 \pm 3.0) \times 10^{-4}$		250
$\phi\pi^+\pi^-$ 3-body		$(7 \pm 5) \times 10^{-4}$		614
$K^*(892)^0K^-\pi^+$ + c.c.	[aaa]	$< 7 \times 10^{-4}$	CL=90%	531
$K^*(892)^0\overline{K}^*(892)^0$		$(1.4 \pm 0.5) \times 10^{-3}$		272

Radiative modes

Mode		Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
$\rho^0\gamma$		$< 2.4 \times 10^{-4}$	CL=90%	771
$\omega\gamma$		$< 2.4 \times 10^{-4}$	CL=90%	768
$\phi\gamma$		$(2.5^{+0.7}_{-0.6}) \times 10^{-5}$		654
$\overline{K}^*(892)^0\gamma$		$< 7.6 \times 10^{-4}$	CL=90%	719

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

Mode			Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$K^+\ell^-\overline{\nu}_\ell$ (via $\overline{D}^0$)	C2M		$< 1.7 \times 10^{-4}$	CL=90%	–
$K^+\pi^-$	DC		$(1.38 \pm 0.11) \times 10^{-4}$		861
$K^+\pi^-$ (via $\overline{D}^0$)	C2M		$< 1.6 \times 10^{-5}$	CL=95%	861
$K^*(892)^+\pi^-$			$(3.0^{+3.8}_{-1.3}) \times 10^{-4}$		711
$K^+\pi^-\pi^0$			$(5.6 \pm 1.7) \times 10^{-4}$		844
$K^+\pi^-\pi^+\pi^-$	DC		$(3.1 \pm 1.0) \times 10^{-4}$		812
$K^+\pi^-\pi^+\pi^-$ (via $\overline{D}^0$)	C2M		$< 4 \times 10^{-4}$	CL=90%	812
$K^+\pi^-$ or $K^+\pi^-\pi^+\pi^-$ (via $\overline{D}^0$)			$< 1.0 \times 10^{-3}$	CL=90%	–
μ^- anything (via $\overline{D}^0$)	C2M		$< 4 \times 10^{-4}$	CL=90%	–
$\gamma\gamma$	C1		$< 2.8 \times 10^{-5}$	CL=90%	932
e^+e^-	C1		$< 6.2 \times 10^{-6}$	CL=90%	932
$\mu^+\mu^-$	C1		$< 4.1 \times 10^{-6}$	CL=90%	926
$\pi^0e^+e^-$	C1		$< 4.5 \times 10^{-5}$	CL=90%	927
$\pi^0\mu^+\mu^-$	C1		$< 1.8 \times 10^{-4}$	CL=90%	915
ηe^+e^-	C1		$< 1.1 \times 10^{-4}$	CL=90%	852
$\eta\mu^+\mu^-$	C1		$< 5.3 \times 10^{-4}$	CL=90%	838
$\pi^+\pi^-e^+e^-$	C1		$< 3.73 \times 10^{-4}$	CL=90%	922
$\rho^0e^+e^-$	C1		$< 1.0 \times 10^{-4}$	CL=90%	771
$\pi^+\pi^-\mu^+\mu^-$	C1		$< 3.0 \times 10^{-5}$	CL=90%	894
$\rho^0\mu^+\mu^-$	C1		$< 2.2 \times 10^{-5}$	CL=90%	754
ωe^+e^-	C1		$< 1.8 \times 10^{-4}$	CL=90%	768
$\omega\mu^+\mu^-$	C1		$< 8.3 \times 10^{-4}$	CL=90%	751
$K^-K^+e^+e^-$	C1		$< 3.15 \times 10^{-4}$	CL=90%	791
ϕe^+e^-	C1		$< 5.2 \times 10^{-5}$	CL=90%	654
$K^-K^+\mu^+\mu^-$	C1		$< 3.3 \times 10^{-5}$	CL=90%	710
$\phi\mu^+\mu^-$	C1		$< 3.1 \times 10^{-5}$	CL=90%	631
$\overline{K}^0e^+e^-$		[ww]	$< 1.1 \times 10^{-4}$	CL=90%	866
$\overline{K}^0\mu^+\mu^-$		[ww]	$< 2.6 \times 10^{-4}$	CL=90%	852
$K^-\pi^+e^+e^-$	C1		$< 3.85 \times 10^{-4}$	CL=90%	861
$\overline{K}^*(892)^0e^+e^-$		[ww]	$< 4.7 \times 10^{-5}$	CL=90%	719
$K^-\pi^+\mu^+\mu^-$	C1		$< 3.59 \times 10^{-4}$	CL=90%	829
$\overline{K}^*(892)^0\mu^+\mu^-$		[ww]	$< 2.4 \times 10^{-5}$	CL=90%	700
$\pi^+\pi^-\pi^0\mu^+\mu^-$	C1		$< 8.1 \times 10^{-4}$	CL=90%	863
$\mu^{\pm}e^{\mp}$	LF	[gg]	$< 8.1 \times 10^{-6}$	CL=90%	929

$\pi^0 e^\pm \mu^\mp$	LF	[gg]	$<$ 8.6	$\times 10^{-5}$	CL=90%	924
$\eta e^\pm \mu^\mp$	LF	[gg]	$<$ 1.0	$\times 10^{-4}$	CL=90%	848
$\pi^+\pi^- e^\pm \mu^\mp$	LF	[gg]	$<$ 1.5	$\times 10^{-5}$	CL=90%	911
$\rho^0 e^\pm \mu^\mp$	LF	[gg]	$<$ 4.9	$\times 10^{-5}$	CL=90%	767
$\omega e^\pm \mu^\mp$	LF	[gg]	$<$ 1.2	$\times 10^{-4}$	CL=90%	764
$K^- K^+ e^\pm \mu^\mp$	LF	[gg]	$<$ 1.8	$\times 10^{-4}$	CL=90%	754
$\phi e^\pm \mu^\mp$	LF	[gg]	$<$ 3.4	$\times 10^{-5}$	CL=90%	648
$\overline{K}^0 e^\pm \mu^\mp$	LF	[gg]	$<$ 1.0	$\times 10^{-4}$	CL=90%	862
$K^-\pi^+ e^\pm \mu^\mp$	LF	[gg]	$<$ 5.53	$\times 10^{-4}$	CL=90%	848
$\overline{K}^*(892)^0 e^\pm \mu^\mp$	LF	[gg]	$<$ 8.3	$\times 10^{-5}$	CL=90%	714
$\pi^-\pi^- e^+ e^+$ + c.c.	L		$<$ 1.12	$\times 10^{-4}$	CL=90%	922
$\pi^-\pi^- \mu^+ \mu^+$ + c.c.	L		$<$ 2.9	$\times 10^{-5}$	CL=90%	894
$K^-\pi^- e^+ e^+$ + c.c.	L		$<$ 2.06	$\times 10^{-4}$	CL=90%	861
$K^-\pi^- \mu^+ \mu^+$ + c.c.	L		$<$ 3.9	$\times 10^{-4}$	CL=90%	829
$K^- K^- e^+ e^+$ + c.c.	L		$<$ 1.52	$\times 10^{-4}$	CL=90%	791
$K^- K^- \mu^+ \mu^+$ + c.c.	L		$<$ 9.4	$\times 10^{-5}$	CL=90%	710
$\pi^-\pi^- e^+ \mu^+$ + c.c.	L		$<$ 7.9	$\times 10^{-5}$	CL=90%	911
$K^-\pi^- e^+ \mu^+$ + c.c.	L		$<$ 2.18	$\times 10^{-4}$	CL=90%	848
$K^- K^- e^+ \mu^+$ + c.c.	L		$<$ 5.7	$\times 10^{-5}$	CL=90%	754

$D^*(2007)^0$

$I(J^P) = \frac{1}{2}(1^-)$
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±2.9) %	43
$D^0\gamma$	(38.1±2.9) %	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)
$m_{D^*(2010)^+} - m_{D^0} = 145.421 \pm 0.010$ MeV (S = 1.1)
Full width $\Gamma = 96 \pm 22$ keV

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

$D^*(2010)^\pm$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$D^0\pi^+$	(67.7±0.5) %	39
$D^+\pi^0$	(30.7±0.5) %	38
$D^+\gamma$	(1.6±0.4) %	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.

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	504
$D^*(2010)^+\pi^-$	seen	387

$D_2^*(2460)^\pm$

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

$J^P = 2^+$ assignment strongly favored.

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	507
$D^{*0}\pi^+$	seen	390

CHARMED, STRANGE MESONS ($C = S = \pm 1$)

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

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

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

Mass $m = 1968.3 \pm 0.5$ MeV (S = 1.2)
$m_{D_s^\pm} - m_{D^\pm} = 98.87 \pm 0.31$ MeV (S = 1.4)
Mean life $\tau = (490 \pm 9) \times 10^{-15}$ s (S = 1.1)
$c\tau = 147.0$ μm

D_s^+ form factors

$r_2 = 1.60 \pm 0.24$
$r_V = 1.92 \pm 0.32$
$\Gamma_L/\Gamma_T = 0.72 \pm 0.18$

Unless otherwise noted, the 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				
$\mu^+\nu_\mu$		(5.0 ± 1.9) $\times 10^{-3}$	S=1.3	981
$\tau^+\nu_\tau$		(6.4 ± 1.5) %		182
$\phi \ell^+\nu_\ell$	[bbb]	(2.0 ± 0.5) %		720
$\eta \ell^+\nu_\ell$ + $\eta'(958)\ell^+\nu_\ell$	[bbb]	(3.4 ± 1.0) %		–
$\eta \ell^+\nu_\ell$	[bbb]	(2.5 ± 0.7) %		908
$\eta'(958)\ell^+\nu_\ell$	[bbb]	(8.9 ± 3.3) $\times 10^{-3}$		751
Hadronic modes with a $K\overline{K}$ pair (including from a ϕ)				
$K^+\overline{K}^0$		(3.6 ± 1.1) %		850
$K^+K^-\pi^+$	[ss]	(4.4 ± 1.2) %		805
$\phi\pi^+$	[ccc]	(3.6 ± 0.9) %		712
$K^+\overline{K}^*(892)^0$	[ccc]	(3.3 ± 0.9) %		685
$f_0(980)\pi^+$ $\times$ B($f_0 \to K^+K^-$)	[ddd]	(4.9 ± 2.3) $\times 10^{-3}$		732
$K^+\overline{K}_0^*(1430)^0$	[ccc]	(7 ± 4) $\times 10^{-3}$		218
$K^+K^-\pi^+$ nonresonant		(9 ± 4) $\times 10^{-3}$		805
$K^0\overline{K}^0\pi^+$		—		802
$K^*(892)^+\overline{K}^0$	[ccc]	(4.3 ± 1.4) %		683
$K^+K^-\pi^+\pi^0$		—		748
$\phi\pi^+\pi^0$	[ccc]	(9 ± 5) %		686
$\phi\rho^+$	[ccc]	(6.7 ± 2.3) %		400
$\phi\pi^+\pi^0$ 3-body	[ccc]	$<$ 2.6 %	CL=90%	686
$K^+K^-\pi^+\pi^0$ non-ϕ		$<$ 9 %	CL=90%	748

$K^+ \overline{K}^0 \pi^+ \pi^-$		(2.5 ± 0.9) %		744
$K^0 K^- \pi^+ \pi^+$		(4.3 ± 1.5) %		744
$K^*(892)^+ \overline{K}^*(892)^0$	[ccc]	(5.8 ± 2.5) %		416
$K^0 K^- \pi^+ \pi^+$ (non-$K^{*+}\overline{K}^{*0}$)		< 2.9 %	CL=90%	744
$K^+ K^- \pi^+ \pi^+ \pi^-$		(7.1 ± 2.2) $\times 10^{-3}$		673
$\phi \pi^+ \pi^+ \pi^-$	[ccc]	(9.7 ± 2.6) $\times 10^{-3}$		640
$K^+ K^- \rho^0 \pi^+$ non-ϕ		< 2.1 $\times 10^{-4}$	CL=90%	248
$\phi \rho^0 \pi^+$	[ccc]	(1.06 ± 0.35) %		180
$\phi a_1(1260)^+$	[ccc]	(2.5 ± 0.8) %		†
$K^+ K^- \pi^+ \pi^+ \pi^-$ nonresonant		(7 ± 6) $\times 10^{-4}$		673
Hadronic modes without K's				
$\pi^+ \pi^+ \pi^-$		(1.01 ± 0.28) %	S=1.1	959
$\rho^0 \pi^+$		< 7 $\times 10^{-4}$	CL=90%	824
$f_0(980) \pi^+$ $\times$ B($f_0 \to \pi^+ \pi^-$)	[uu]	(5.7 ± 1.7) $\times 10^{-3}$		732
$f_2(1270) \pi^+$	[ccc]	(3.5 ± 1.2) $\times 10^{-3}$		559
$f_0(1370) \pi^+$ $\times$ B($f_0 \to \pi^+ \pi^-$)	[uu]	(3.3 ± 1.2) $\times 10^{-3}$		493
$\rho(1450)^0 \pi^+$ $\times$ B($\rho^0 \to \pi^+ \pi^-$)	[uu]	(4.4 ± 2.5) $\times 10^{-4}$		421
$\pi^+ \pi^+ \pi^-$ nonresonant		(5 $^{+22}_{-5}$) $\times 10^{-5}$		959
$\pi^+ \pi^+ \pi^- \pi^0$		< 12 %	CL=90%	935
$\eta \pi^+$	[ccc]	(1.7 ± 0.5) %		902
$\omega \pi^+$	[ccc]	(2.8 ± 1.1) $\times 10^{-3}$		822
$3\pi^+ 2\pi^-$		(6.5 ± 1.8) $\times 10^{-3}$		899
$\pi^+ \pi^+ \pi^- \pi^0 \pi^0$		—		902
$\eta \rho^+$	[ccc]	(10.8 ± 3.1) %		723
$\eta \pi^+ \pi^0$ 3-body	[ccc]	< 4 %	CL=90%	885
$3\pi^+ 2\pi^- \pi^0$		(4.9 ± 3.2) %		856
$\eta'(958) \pi^+$	[ccc]	(3.9 ± 1.0) %		743
$3\pi^+ 2\pi^- 2\pi^0$		—		803
$\eta'(958) \rho^+$	[ccc]	(10.1 ± 2.8) %		464
$\eta'(958) \pi^+ \pi^0$ 3-body	[ccc]	< 1.4 %	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%	744
$K^*(892)^0 \pi^+$	[ccc]	(6.5 ± 2.8) $\times 10^{-3}$		775
$K^+ K^+ K^-$		(4.0 ± 1.7) $\times 10^{-4}$		627
ϕK^+	[ccc]	< 5 $\times 10^{-4}$	CL=90%	607
$\Delta C = 1$ weak neutral current ($C1$) modes, Lepton family number (LF), or Lepton number (L) violating modes				
$\pi^+ e^+ e^-$	[ww]	< 2.7 $\times 10^{-4}$	CL=90%	979
$\pi^+ \mu^+ \mu^-$	[ww]	< 2.6 $\times 10^{-5}$	CL=90%	968
$K^+ e^+ e^-$	C1	< 1.6 $\times 10^{-3}$	CL=90%	922
$K^+ \mu^+ \mu^-$	C1	< 3.6 $\times 10^{-5}$	CL=90%	909
$K^*(892)^+ \mu^+ \mu^-$	C1	< 1.4 $\times 10^{-3}$	CL=90%	765
$\pi^+ e^\pm \mu^\mp$	LF [gg]	< 6.1 $\times 10^{-4}$	CL=90%	976
$K^+ e^\pm \mu^\mp$	LF [gg]	< 6.3 $\times 10^{-4}$	CL=90%	919
$\pi^- e^+ e^+$	L	< 6.9 $\times 10^{-4}$	CL=90%	979
$\pi^- \mu^+ \mu^+$	L	< 2.9 $\times 10^{-5}$	CL=90%	968
$\pi^- e^+ \mu^+$	L	< 7.3 $\times 10^{-4}$	CL=90%	976
$K^- e^+ e^+$	L	< 6.3 $\times 10^{-4}$	CL=90%	922
$K^- \mu^+ \mu^+$	L	< 1.3 $\times 10^{-5}$	CL=90%	909
$K^- e^+ \mu^+$	L	< 6.8 $\times 10^{-4}$	CL=90%	919
$K^*(892)^- \mu^+ \mu^+$	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 $m = 2112.1 \pm 0.7$ 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

$D_{sJ}^*(2317)^\pm$

$I(J^P) = 0(0^+)$
J, P need confirmation.

J^P is natural, low mass consistent with 0^+.

Mass $m = 2317.4 \pm 0.9$ MeV (S = 1.1)

$m_{D_{sJ}^*(2317)^\pm} - m_{D_s^\pm} = 349.2 \pm 0.7$ MeV

Full width $\Gamma < 4.6$ MeV, CL = 90%

$D_{sJ}(2460)^\pm$

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

Mass $m = 2459.3 \pm 1.3$ MeV (S = 1.3)

$m_{D_{sJ}^*(2460)^\pm} - m_{D_s^{*\pm}} = 347.2 \pm 1.2$ MeV (S = 1.3)

$m_{D_{sJ}^*(2460)^\pm} - m_{D_s^\pm} = 491.0 \pm 1.2$ MeV (S = 1.3)

Full width $\Gamma < 5.5$ MeV, CL = 90%

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

$I(J^P) = 0(1^+)$
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
$D^*(2007)^0 K^+$	seen	168
$D^+ K^0$	not seen	382
$D^0 K^+$	not seen	392
$D_s^{*+} \gamma$	possibly seen	388

$D_{s2}(2573)^\pm$

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

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

Mass $m = 2572.4 \pm 1.5$ MeV

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

$D_{s2}(2573)^-$ modes are charge conjugates of the modes below.

$D_{s2}(2573)^+$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$D^0 K^+$	seen	435
$D^*(2007)^0 K^+$	not seen	244

BOTTOM MESONS
($B = \pm1$)

$B^+ = u\overline{b}$, $B^0 = d\overline{b}$, $\overline{B}^0 = \overline{d}\,b$, $B^- = \overline{u}\,b$, 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 "$B^\pm/B^0/B^0_s/b$-baryon Admixture" for results at higher energies. Most inclusive decay branching fractions and χ_b at high energy are found in the Admixture sections. B^0-$\overline{B}^0$ mixing data are found in the B^0 section, while B^0_s-$\overline{B}^0_s$ mixing data and B-$\overline{B}$ mixing data for a B^0/B^0_s admixture are found in the B^0_s section. CP-violation data are found in the $B^\pm$, B^0, and $B^\pm$ B^0 Admixture sections. 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.

- $B^\pm$
  mass, mean life, branching fractions CP violation
- B^0
  mass, mean life, branching fractions
  polarization in B^0 decay, B^0-$\overline{B}^0$ mixing, CP violation
- $B^\pm$ B^0 Admixtures
  branching fractions, CP violation
- $B^\pm/B^0/B^0_s/b$-baryon Admixtures
  mean life, production fractions, branching fractions
  χ_b at high energy, V_{cb} measurements
- B^*
  mass
- B^0_s
  mass, mean life, branching fractions
  polarization in B^0_s decay, B^0_s-$\overline{B}^0_s$ mixing
- $B^\pm_c$
  mass, mean life, branching fractions

At end of Baryon Listings:

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

$B^\pm$

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

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

Mass $m_{B^\pm} = 5279.0 \pm 0.5$ MeV
Mean life $\tau_{B^\pm} = (1.671 \pm 0.018) \times 10^{-12}$ s
$c\tau = 501$ μm

CP violation

$A_{CP}(B^+ \to J/\psi(1S)K^+) = -0.007 \pm 0.019$
$A_{CP}(B^+ \to J/\psi(1S)\pi^+) = -0.01 \pm 0.13$
$A_{CP}(B^+ \to \psi(2S)K^+) = -0.037 \pm 0.025$
$A_{CP}(B^+ \to \overline{D}^0 K^+) = 0.04 \pm 0.07$
$A_{CP}(B^+ \to D_{CP(+1)}K^+) = 0.06 \pm 0.19$
$A_{CP}(B^+ \to D_{CP(-1)}K^+) = -0.19 \pm 0.18$
$A_{CP}(B^+ \to \pi^+\pi^0) = 0.05 \pm 0.15$
$A_{CP}(B^+ \to K^+\pi^0) = -0.10 \pm 0.08$
$A_{CP}(B^+ \to K^0_S\pi^+) = 0.03 \pm 0.08$ (S = 1.1)
$A_{CP}(B^+ \to \pi^+\pi^-\pi^+) = -0.39 \pm 0.35$
$A_{CP}(B^+ \to \rho^+\rho^0) = -0.09 \pm 0.16$
$A_{CP}(B^+ \to K^+\pi^-\pi^+) = 0.01 \pm 0.08$
$A_{CP}(B^+ \to K^+K^-K^+) = 0.02 \pm 0.08$
$A_{CP}(B^+ \to K^+\eta') = 0.009 \pm 0.035$
$A_{CP}(B^+ \to \omega\pi^+) = -0.21 \pm 0.19$
$A_{CP}(B^+ \to \omega K^+) = -0.21 \pm 0.28$
$A_{CP}(B^+ \to \phi K^+) = 0.03 \pm 0.07$
$A_{CP}(B^+ \to \phi K^*(892)^+) = 0.09 \pm 0.15$
$A_{CP}(B^+ \to \rho^0 K^*(892)^+) = 0.20 \pm 0.31$

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 D, D_s, D^*, and 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.

For inclusive branching fractions, *e.g.*, $B \to D^\pm$ anything, the values usually are multiplicities, not branching fractions. They can be greater than one.

B^+ DECAY MODES		Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
Semileptonic and leptonic modes				
$\ell^+\nu_\ell$ anything	[rr]	(10.2 ± 0.9) %		–
$\overline{D}^0\ell^+\nu_\ell$	[rr]	(2.15 ± 0.22) %		2310
$\overline{D}^*(2007)^0\ell^+\nu_\ell$	[rr]	(6.5 ± 0.5) %		2258
$\overline{D}_1(2420)^0\ell^+\nu_\ell$		$(5.6 \pm 1.6) \times 10^{-3}$		2084
$\overline{D}^*_2(2460)^0\ell^+\nu_\ell$		$< 8 \times 10^{-3}$	CL=90%	2067
$\pi^0 e^+\nu_e$		$(9.0 \pm 2.8) \times 10^{-5}$		2638
$\eta\ell^+\nu_\ell$		$(8 \pm 4) \times 10^{-5}$		2611
$\omega\ell^+\nu_\ell$	[rr]	$< 2.1 \times 10^{-4}$	CL=90%	2582
$\rho^0\ell^+\nu_\ell$	[rr]	$(1.34^{+0.32}_{-0.35}) \times 10^{-4}$		2583
$p\overline{p}e^+\nu_e$		$< 5.2 \times 10^{-3}$	CL=90%	2467
$e^+\nu_e$		$< 1.5 \times 10^{-5}$	CL=90%	2640
$\mu^+\nu_\mu$		$< 2.1 \times 10^{-5}$	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%	2640
$\mu^+\nu_\mu\gamma$		$< 5.2 \times 10^{-5}$	CL=90%	2638
***D*, *D**, or *D*$_s$ modes**				
$\overline{D}^0\pi^+$		$(4.98 \pm 0.29) \times 10^{-3}$		2308
$\overline{D}^0\rho^+$		(1.34 ± 0.18) %		2236
$\overline{D}^0 K^+$		$(3.7 \pm 0.6) \times 10^{-4}$	S=1.1	2280
$\overline{D}^0 K^*(892)^+$		$(6.1 \pm 2.3) \times 10^{-4}$		2213
$\overline{D}^0 K^+\overline{K}^0$		$(5.5 \pm 1.6) \times 10^{-4}$		2189
$\overline{D}^0 K^+\overline{K}^*(892)^0$		$(7.5 \pm 1.7) \times 10^{-4}$		2071
$\overline{D}^0\pi^+\pi^+\pi^-$		(1.1 ± 0.4) %		2289
$\overline{D}^0\pi^+\pi^+\pi^-$ nonresonant		$(5 \pm 4) \times 10^{-3}$		2289
$\overline{D}^0\pi^+\rho^0$		$(4.2 \pm 3.0) \times 10^{-3}$		2207
$\overline{D}^0 a_1(1260)^+$		$(5 \pm 4) \times 10^{-3}$		2123
$\overline{D}^0\omega\pi^+$		$(4.1 \pm 0.9) \times 10^{-3}$		2206
$D^*(2010)^-\pi^+\pi^+$		$(2.1 \pm 0.6) \times 10^{-3}$		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
$\overline{D}^*(2007)^0\omega\pi^+$		$(4.5 \pm 1.2) \times 10^{-3}$		2149
$\overline{D}^*(2007)^0\rho^+$		$(9.8 \pm 1.7) \times 10^{-3}$		2181
$\overline{D}^*(2007)^0 K^+$		$(3.6 \pm 1.0) \times 10^{-4}$		2227
$\overline{D}^*(2007)^0 K^*(892)^+$		$(7.2 \pm 3.4) \times 10^{-4}$		2156

Mode	Fraction	Scale factor / Confidence level	p (MeV/c)
$\overline{D}^*(2007)^0 K^+ \overline{K}^0$	$< 1.06 \times 10^{-3}$	CL=90%	2132
$\overline{D}^*(2007)^0 K^+ K^*(892)^0$	$(1.5 \pm 0.4) \times 10^{-3}$		2008
$\overline{D}^*(2007)^0 \pi^+ \pi^+ \pi^-$	$(9.4 \pm 2.6) \times 10^{-3}$		2236
$\overline{D}^*(2007)^0 a_1(1260)^+$	(1.9 ± 0.5) %		2062
$\overline{D}^*(2007)^0 \pi^- \pi^+ \pi^+ \pi^0$	(1.8 ± 0.4) %		2219
$D^*(2010)^+ \pi^0$	$< 1.7 \times 10^{-4}$	CL=90%	2255
$\overline{D}^*(2010)^+ K^0$	$< 9.5 \times 10^{-5}$	CL=90%	2225
$D^*(2010)^- \pi^+ \pi^+ \pi^0$	(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%	1995
$\overline{D}_2^*(2460)^0 \pi^+$	$< 1.3 \times 10^{-3}$	CL=90%	2064
$\overline{D}_2^*(2460)^0 \rho^+$	$< 4.7 \times 10^{-3}$	CL=90%	1977
$\overline{D}^0 D_s^+$	(1.3 ± 0.4) %		1815
$\overline{D}^0 D_{sJ}(2317)^+$	seen		1605
$\overline{D}^0 D_{sJ}(2457)^+$	seen		–
$\overline{D}^0 D_{sJ}(2536)^+$	not seen		1447
$\overline{D}^*(2007)^0 D_{sJ}(2536)^+$	not seen		1338
$\overline{D}^0 D_{sJ}(2573)^+$	not seen		1417
$\overline{D}^*(2007)^0 D_{sJ}(2573)^+$	not seen		1306
$\overline{D}^0 D_s^{*+}$	$(9 \pm 4) \times 10^{-3}$		1734
$\overline{D}^*(2007)^0 D_s^+$	(1.2 ± 0.5) %		1737
$\overline{D}^*(2007)^0 D_s^{*+}$	(2.7 ± 1.0) %		1651
$D_s^{(*)+} \overline{D}^{**0}$	(2.7 ± 1.2) %		–
$\overline{D}^*(2007)^0 D^*(2010)^+$	< 1.1 %	CL=90%	1713
$\overline{D}^0 D^*(2010)^+ + \overline{D}^*(2007)^0 D^+$	< 1.3 %	CL=90%	1792
$\overline{D}^0 D^+$	$< 6.7 \times 10^{-3}$	CL=90%	1866
$\overline{D}^0 D^+ K^0$	$< 2.8 \times 10^{-3}$	CL=90%	1571
$\overline{D}^*(2007)^0 D^+ K^0$	$< 6.1 \times 10^{-3}$	CL=90%	1475
$\overline{D}^0 \overline{D}^*(2010)^+ K^0$	$(5.2 \pm 1.2) \times 10^{-3}$		1476
$\overline{D}^*(2007)^0 D^*(2010)^+ K^0$	$(7.8 \pm 2.6) \times 10^{-3}$		1362
$\overline{D}^0 D^0 K^+$	$(1.9 \pm 0.4) \times 10^{-3}$		1577
$\overline{D}^*(2010)^0 D^0 K^+$	$< 3.8 \times 10^{-3}$	CL=90%	–
$\overline{D}^0 D^*(2007)^0 K^+$	$(4.7 \pm 1.0) \times 10^{-3}$		1481
$\overline{D}^*(2007)^0 D^*(2007)^0 K^+$	$(5.3 \pm 1.6) \times 10^{-3}$		1368
$D^- D^+ K^+$	$< 4 \times 10^{-4}$	CL=90%	1571
$D^- D^*(2010)^+ K^+$	$< 7 \times 10^{-4}$	CL=90%	1475
$D^*(2010)^- D^+ K^+$	$(1.5 \pm 0.4) \times 10^{-3}$		1475
$D^*(2010)^- D^*(2010)^+ K^+$	$< 1.8 \times 10^{-3}$	CL=90%	1363
$(\overline{D}+\overline{D}^*)(D+D^*)K$	(3.5 ± 0.6) %		–
$D_s^+ \pi^0$	$< 2.0 \times 10^{-4}$	CL=90%	2270
$D_s^{*+} \pi^0$	$< 3.3 \times 10^{-4}$	CL=90%	2215
$D_s^+ \eta$	$< 5 \times 10^{-4}$	CL=90%	2235
$D_s^{*+} \eta$	$< 8 \times 10^{-4}$	CL=90%	2178
$D_s^+ \rho^0$	$< 4 \times 10^{-4}$	CL=90%	2197
$D_s^{*+} \rho^0$	$< 5 \times 10^{-4}$	CL=90%	2138
$D_s^+ \omega$	$< 5 \times 10^{-4}$	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%	2172
$D_s^{*+} \overline{K}^*(892)^0$	$< 4 \times 10^{-4}$	CL=90%	2112
$D_s^- \pi^+ K^+$	$< 8 \times 10^{-4}$	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%	2138
$D_s^{*-} \pi^+ K^*(892)^+$	$< 8 \times 10^{-3}$	CL=90%	2076

Charmonium modes

Mode	Fraction	Scale factor / Confidence level	p (MeV/c)
$\eta_c K^+$	$(9.0 \pm 2.7) \times 10^{-4}$		1754
$J/\psi(1S) K^+$	$(1.00 \pm 0.04) \times 10^{-3}$		1683
$J/\psi(1S) K^+ \pi^+ \pi^-$	$(7.7 \pm 2.0) \times 10^{-4}$		1612
$X(3872) K^+$	seen		–
$J/\psi(1S) K^*(892)^+$	$(1.35 \pm 0.10) \times 10^{-3}$		1571
$J/\psi(1S) K(1270)^+$	$(1.8 \pm 0.5) \times 10^{-3}$		1390
$J/\psi(1S) K(1400)^+$	$< 5 \times 10^{-4}$	CL=90%	1308
$J/\psi(1S) \phi K^+$	$(5.2 \pm 1.7) \times 10^{-5}$	S=1.2	1227
$J/\psi(1S) \pi^+$	$(4.0 \pm 0.5) \times 10^{-5}$		1727
$J/\psi(1S) \rho^+$	$< 7.7 \times 10^{-4}$	CL=90%	1611
$J/\psi(1S) a_1(1260)^+$	$< 1.2 \times 10^{-3}$	CL=90%	1414
$J/\psi(1S) p \overline{\Lambda}$	$(1.2 {}^{+0.9}_{-0.6}) \times 10^{-5}$		567
$\psi(2S) K^+$	$(6.8 \pm 0.4) \times 10^{-4}$		1284
$\psi(2S) K^*(892)^+$	$(9.2 \pm 2.2) \times 10^{-4}$		1115
$\psi(2S) K^+ \pi^+ \pi^-$	$(1.9 \pm 1.2) \times 10^{-3}$		1178
$\chi_{c0}(1P) K^+$	$(6.0 {}^{+2.4}_{-2.1}) \times 10^{-4}$		1478
$\chi_{c1}(1P) K^+$	$(6.8 \pm 1.2) \times 10^{-4}$		1411
$\chi_{c1}(1P) K^*(892)^+$	$< 2.1 \times 10^{-3}$	CL=90%	1265

***K* or *K** modes**

Mode	Fraction	Scale factor / Confidence level	p (MeV/c)
$K^0 \pi^+$	$(1.88 \pm 0.21) \times 10^{-5}$		2614
$K^+ \pi^0$	$(1.29 \pm 0.12) \times 10^{-5}$		2615
$\eta' K^+$	$(7.8 \pm 0.5) \times 10^{-5}$		2528
$\eta' K^*(892)^+$	$< 3.5 \times 10^{-5}$	CL=90%	2472
ηK^+	$< 6.9 \times 10^{-6}$	CL=90%	2588
$\eta K^*(892)^+$	$(2.6 {}^{+1.0}_{-0.9}) \times 10^{-5}$		2534
ωK^+	$(9.2 {}^{+2.8}_{-2.5}) \times 10^{-6}$		2557
$\omega K^*(892)^+$	$< 8.7 \times 10^{-5}$	CL=90%	2503
$K^*(892)^0 \pi^+$	$(1.9 {}^{+0.6}_{-0.8}) \times 10^{-5}$		2562
$K^*(892)^+ \pi^0$	$< 3.1 \times 10^{-5}$	CL=90%	2562
$K^+ \pi^- \pi^+$	$(5.7 \pm 0.4) \times 10^{-5}$		2609
$K^+ \pi^- \pi^+$ nonresonant	$< 2.8 \times 10^{-5}$	CL=90%	2609
$K^+ \rho^0$	$< 1.2 \times 10^{-5}$	CL=90%	2558
$K_2^*(1430)^0 \pi^+$	$< 6.8 \times 10^{-4}$	CL=90%	2445
$K^- \pi^+ \pi^+$	$< 1.8 \times 10^{-6}$	CL=90%	2609
$K^- \pi^+ \pi^+$ nonresonant	$< 5.6 \times 10^{-5}$	CL=90%	2609
$K_1(1400)^0 \pi^+$	$< 2.6 \times 10^{-3}$	CL=90%	2451
$K^0 \pi^+ \pi^0$	$< 6.6 \times 10^{-5}$	CL=90%	2609
$K^0 \rho^+$	$< 4.8 \times 10^{-5}$	CL=90%	2558
$K^*(892)^+ \pi^+ \pi^-$	$< 1.1 \times 10^{-3}$	CL=90%	2556
$K^*(892)^+ \rho^0$	$(1.1 \pm 0.4) \times 10^{-5}$		2504
$K^*(892)^+ K^*(892)^0$	$< 7.1 \times 10^{-5}$	CL=90%	2484
$K_1(1400)^+ \rho^0$	$< 7.8 \times 10^{-4}$	CL=90%	2387
$K_2^*(1430)^+ \rho^0$	$< 1.5 \times 10^{-3}$	CL=90%	2381
$K^+ \overline{K}^0$	$< 2.0 \times 10^{-6}$	CL=90%	2593
$\overline{K}^0 K^+ \pi^0$	$< 2.4 \times 10^{-5}$	CL=90%	2578
$K^+ K_S^0 K_S^0$	$(1.34 \pm 0.24) \times 10^{-5}$		2521
$K_S^0 K_S^0 \pi^+$	$< 3.2 \times 10^{-6}$	CL=90%	2577
$K^+ K^- \pi^+$	$< 6.3 \times 10^{-6}$	CL=90%	2578
$K^+ K^- \pi^+$ nonresonant	$< 7.5 \times 10^{-5}$	CL=90%	2578
$K^+ K^+ \pi^-$	$< 1.3 \times 10^{-6}$	CL=90%	2578
$K^+ K^+ \pi^-$ nonresonant	$< 8.79 \times 10^{-5}$	CL=90%	2578
$K^+ K^*(892)^0$	$< 5.3 \times 10^{-6}$	CL=90%	2540
$K^+ K^- K^+$	$(3.08 \pm 0.21) \times 10^{-5}$		2522
$K^+ \phi$	$(9.3 \pm 1.0) \times 10^{-6}$	S=1.3	2516
$K^+ K^- K^+$ nonresonant	$< 3.8 \times 10^{-5}$	CL=90%	2522
$K^*(892)^+ K^+ K^-$	$< 1.6 \times 10^{-3}$	CL=90%	2466
$K^*(892)^+ \phi$	$(9.6 \pm 3.0) \times 10^{-6}$	S=1.9	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
$K^+ \phi \phi$	$(2.6 {}^{+1.1}_{-0.9}) \times 10^{-6}$		2306
$K^*(892)^+ \gamma$	$(3.8 \pm 0.5) \times 10^{-5}$		2564
$K_1(1270)^+ \gamma$	$< 9.9 \times 10^{-5}$	CL=90%	2486
$\phi K^+ \gamma$	$(3.4 \pm 1.0) \times 10^{-6}$		2516
$K^+ \pi^- \pi^+ \gamma$	$(2.4 {}^{+0.6}_{-0.5}) \times 10^{-5}$		2609
$K^*(892)^0 \pi^+ \gamma$	$(2.0 {}^{+0.7}_{-0.6}) \times 10^{-5}$		2562
$K^+ \rho^0 \gamma$	$< 2.0 \times 10^{-5}$	CL=90%	2558
$K^+ \pi^- \pi^+ \gamma$ nonresonant	$< 9.2 \times 10^{-6}$	CL=90%	2609
$K_1(1400)^+ \gamma$	$< 5.0 \times 10^{-5}$	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%	2360
$K_3^*(1780)^+ \gamma$	$< 5.5 \times 10^{-3}$	CL=90%	2341
$K_4^*(2045)^+ \gamma$	$< 9.9 \times 10^{-3}$	CL=90%	2243

Light unflavored meson modes

Mode	Fraction	Scale factor / Confidence level	p (MeV/c)
$\rho^+ \gamma$	$< 2.1 \times 10^{-6}$	CL=90%	2583
$\pi^+ \pi^0$	$(5.6 {}^{+0.9}_{-1.1}) \times 10^{-6}$		2636
$\pi^+ \pi^+ \pi^-$	$(1.1 \pm 0.4) \times 10^{-5}$		2630
$\rho^0 \pi^+$	$(8.6 \pm 2.0) \times 10^{-6}$		2581
$\pi^+ f_0(980)$	$< 1.4 \times 10^{-4}$	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%	2630

$\pi^+\pi^0\pi^0$		$<$ 8.9	$\times 10^{-4}$	CL=90%	2631
$\quad\rho^+\pi^0$		$<$ 4.3	$\times 10^{-5}$	CL=90%	2581
$\pi^+\pi^-\pi^+\pi^0$		$<$ 4.0	$\times 10^{-3}$	CL=90%	2621
$\quad\rho^+\rho^0$		(2.6 $\pm$0.6)	$\times 10^{-5}$		2523
$\quad a_1(1260)^+\pi^0$		$<$ 1.7	$\times 10^{-3}$	CL=90%	2494
$\quad a_1(1260)^0\pi^+$		$<$ 9.0	$\times 10^{-4}$	CL=90%	2494
$\omega\pi^+$		(6.4 $^{+1.8}_{-1.6}$)	$\times 10^{-6}$	S=1.3	2580
$\omega\rho^+$		$<$ 6.1	$\times 10^{-5}$	CL=90%	2522
$\eta\pi^+$		$<$ 5.7	$\times 10^{-6}$	CL=90%	2609
$\eta'\pi^+$		$<$ 7.0	$\times 10^{-6}$	CL=90%	2551
$\eta'\rho^+$		$<$ 3.3	$\times 10^{-5}$	CL=90%	2492
$\eta\rho^+$		$<$ 1.5	$\times 10^{-5}$	CL=90%	2553
$\phi\pi^+$		$<$ 4.1	$\times 10^{-7}$	CL=90%	2539
$\phi\rho^+$		$<$ 1.6	$\times 10^{-5}$		2480
$\pi^+\pi^+\pi^+\pi^-\pi^-$		$<$ 8.6	$\times 10^{-4}$	CL=90%	2608
$\quad\rho^0 a_1(1260)^+$		$<$ 6.2	$\times 10^{-4}$	CL=90%	2433
$\quad\rho^0 a_2(1320)^+$		$<$ 7.2	$\times 10^{-4}$	CL=90%	2410
$\pi^+\pi^+\pi^+\pi^-\pi^-\pi^0$		$<$ 6.3	$\times 10^{-3}$	CL=90%	2592
$\quad a_1(1260)^+ a_1(1260)^0$		$<$ 1.3	%	CL=90%	2335

Charged particle ($h^\pm$) modes

$h^\pm = K^\pm$ or $\pi^\pm$

$h^+\pi^0$		(1.6 $^{+0.7}_{-0.6}$)	$\times 10^{-5}$		2636
ωh^+		(1.38$^{+0.27}_{-0.24}$)	$\times 10^{-5}$		2580
h^+X^0 (Familon)		$<$ 4.9	$\times 10^{-5}$	CL=90%	–

Baryon modes

$p\overline{p}\pi^+$		$<$ 3.7	$\times 10^{-6}$	CL=90%	2439
$\quad p\overline{p}\pi^+$ nonresonant		$<$ 5.3	$\times 10^{-5}$	CL=90%	2439
$p\overline{p}\pi^+\pi^+\pi^-$		$<$ 5.2	$\times 10^{-4}$	CL=90%	2369
$p\overline{p}K^+$		(4.3 $^{+1.2}_{-1.0}$)	$\times 10^{-6}$		2348
$\quad p\overline{p}K^+$ nonresonant		$<$ 8.9	$\times 10^{-5}$	CL=90%	2348
$p\overline{\Lambda}$		$<$ 1.5	$\times 10^{-6}$	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
$D^+ p\overline{p}$		$<$ 1.5	$\times 10^{-5}$	CL=90%	1860
$D^*(2010)^+ p\overline{p}$		$<$ 1.5	$\times 10^{-5}$	CL=90%	1786
$\overline{\Lambda}_c^- p\pi^+$		(2.1 $\pm$0.7)	$\times 10^{-4}$		1981
$\overline{\Lambda}_c^- p\pi^+\pi^0$		(1.8 $\pm$0.6)	$\times 10^{-3}$		1936
$\overline{\Lambda}_c^- p\pi^+\pi^+\pi^-$		(2.3 $\pm$0.7)	$\times 10^{-3}$		1881
$\overline{\Lambda}_c^- p\pi^+\pi^+\pi^-\pi^0$		$<$ 1.34	%	CL=90%	1823
$\overline{\Sigma}_c(2455)^0 p$		$<$ 8	$\times 10^{-5}$	CL=90%	1939
$\overline{\Sigma}_c(2520)^0 p$		$<$ 4.6	$\times 10^{-5}$	CL=90%	1905
$\overline{\Sigma}_c(2455)^0 p\pi^0$		(4.4 $\pm$1.8)	$\times 10^{-4}$		1897
$\overline{\Sigma}_c(2455)^0 p\pi^-\pi^+$		(4.4 $\pm$1.7)	$\times 10^{-4}$		1845
$\overline{\Sigma}_c(2455)^{--} p\pi^+\pi^+$		(2.8 $\pm$1.2)	$\times 10^{-4}$		1845
$\overline{\Lambda}_c(2593)^- / \overline{\Lambda}_c(2625)^- p\pi^+$		$<$ 1.9	$\times 10^{-4}$	CL=90%	–

Lepton Family number (LF) or Lepton number (L) violating modes, or $\Delta B = 1$ 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
$K^+e^+e^-$	$B1$		(6.3 $^{+1.9}_{-1.7}$)	$\times 10^{-7}$		2616
$K^+\mu^+\mu^-$	$B1$		(4.5 $^{+1.4}_{-1.2}$)	$\times 10^{-7}$		2612
$K^+\ell^+\ell^-$	$B1$	[rr]	(5.3 $\pm$1.1)	$\times 10^{-7}$		2616
$K^+\overline{\nu}\nu$	$B1$		$<$ 2.4	$\times 10^{-4}$	CL=90%	2616
$K^*(892)^+e^+e^-$	$B1$		$<$ 4.6	$\times 10^{-6}$	CL=90%	2564
$K^*(892)^+\mu^+\mu^-$	$B1$		$<$ 2.2	$\times 10^{-6}$	CL=90%	2560
$K^*(892)^+\ell^+\ell$	$B1$	[rr]	$<$ 2.2	$\times 10^{-6}$	CL=90%	2564
$\pi^+e^+\mu^-$	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		$<$ 8	$\times 10^{-7}$	CL=90%	2615
$K^+e^-\mu^+$	LF		$<$ 6.4	$\times 10^{-3}$	CL=90%	2615
$K^*(892)^+e^\pm\mu^\mp$	LF		$<$ 7.9	$\times 10^{-6}$	CL=90%	2563
$\pi^-e^+e^+$	L		$<$ 1.6	$\times 10^{-6}$	CL=90%	2638
$\pi^-\mu^+\mu^+$	L		$<$ 1.4	$\times 10^{-6}$	CL=90%	2633
$\pi^-e^+\mu^+$	L		$<$ 1.3	$\times 10^{-6}$	CL=90%	2637
$\rho^-e^+e^+$	L		$<$ 2.6	$\times 10^{-6}$	CL=90%	2583
$\rho^-\mu^+\mu^+$	L		$<$ 5.0	$\times 10^{-6}$	CL=90%	2578
$\rho^-e^+\mu^+$	LF		$<$ 3.3	$\times 10^{-6}$	CL=90%	2581
$K^-e^+e^+$	L		$<$ 1.0	$\times 10^{-6}$	CL=90%	2616
$K^-\mu^+\mu^+$	L		$<$ 1.8	$\times 10^{-6}$	CL=90%	2612
$K^-e^+\mu^+$	L		$<$ 2.0	$\times 10^{-6}$	CL=90%	2615
$K^*(892)^-e^+e^+$	L		$<$ 2.8	$\times 10^{-6}$	CL=90%	2564
$K^*(892)^-\mu^+\mu^+$	L		$<$ 8.3	$\times 10^{-6}$	CL=90%	2560
$K^*(892)^-e^+\mu^+$	LF		$<$ 4.4	$\times 10^{-6}$	CL=90%	2563

B^0

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

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

Mass $m_{B^0} = 5279.4 \pm 0.5$ MeV
$m_{B^0} - m_{B^\pm} = 0.33 \pm 0.28$ MeV (S = 1.1)
Mean life $\tau_{B^0} = (1.536 \pm 0.014) \times 10^{-12}$ s
$c\tau = 460\ \mu$m
$\tau_{B^+}/\tau_{B^0} = 1.086 \pm 0.017$ (direct measurements)

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

$\chi_d = 0.186 \pm 0.004$
$\Delta m_{B^0} = m_{B^0_H} - m_{B^0_L} = (0.502 \pm 0.007) \times 10^{12}\ \hbar\ s^{-1}$
$= (3.304 \pm 0.046) \times 10^{-10}$ MeV
$x_d = \Delta m_{B^0}/\Gamma_{B^0} = 0.771 \pm 0.012$

CP violation parameters

$\text{Re}(\epsilon_{B^0})/(1+|\epsilon_{B^0}|^2) = (0.5 \pm 3.1) \times 10^{-3}$
$A_{T/CP} = 0.005 \pm 0.018$
$A_{CP}\ (B^0 \to K^+\pi^-) = -0.09 \pm 0.04$
$A_{CP}(B^0 \to \rho^+\pi^-) = -0.18 \pm 0.09$
$A_{CP}(B^0 \to \rho^+K^-) = 0.28 \pm 0.19$
$A_{CP}(B^0 \to K^*(892)^+\pi^-) = 0.26 \pm 0.35$
$A_{CP}(B^0 \to K^*(892)^0\phi) = 0.05 \pm 0.10$
$A_{CP}(B^0 \to D^*(2010)^+D^-) = -0.03 \pm 0.12$
$C_{\pi\pi}\ (B^0 \to \pi^+\pi^-) = -0.51 \pm 0.23$ (S = 1.2)
$S_{\pi\pi}\ (B^0 \to \pi^+\pi^-) = -0.5 \pm 0.6$ (S = 2.3)
$C_{\rho\pi}\ (B^0 \to \rho^+\pi^-) = 0.36 \pm 0.18$
$S_{\rho\pi}\ (B^0 \to \rho^+\pi^-) = 0.19 \pm 0.24$
$C_{\eta'(958)K}\ (B^0 \to \eta'(958)K^0_S) = 0.04 \pm 0.13$
$S_{\eta'(958)K}\ (B^0 \to \eta'(958)K^0_S) = 0.27 \pm 0.21$
$C_{\phi K^0_S}\ (B^0 \to \phi K^0_S) = 0.15 \pm 0.30$
$S_{\phi K^0_S}\ (B^0 \to \phi K^0_S) = -1.0 \pm 0.5$
$C_{K^+K^-K^0_S}\ (B^0 \to K^+K^-K^0_S) = 0.17 \pm 0.16$
$S_{K^+K^-K^0_S}\ (B^0 \to K^+K^-K^0_S) = -0.51 \pm 0.26$
$C_{D^*(2010)^-D^+}\ (B^0 \to D^*(2010)^-D^+) = -0.2 \pm 0.4$
$S_{D^*(2010)^-D^+}\ (B^0 \to D^*(2010)^-D^+) = -0.2 \pm 0.7$
$C_{D^*(2010)^+D^-}\ (B^0 \to D^*(2010)^+D^-) = -0.5 \pm 0.4$
$S_{D^*(2010)^+D^-}\ (B^0 \to D^*(2010)^+D^-) = -0.8 \pm 0.8$
$C_{J/\psi(1S)\pi^0}\ (B^0 \to J/\psi(1S)\pi^0) = 0.4 \pm 0.4$
$S_{J/\psi(1S)\pi^0}\ (B^0 \to J/\psi(1S)\pi^0) = 0.1 \pm 0.5$
$\Delta C_{\rho\pi}\ (B^0 \to \rho^+\pi^-) = 0.28 \pm 0.19$
$\Delta S_{\rho\pi}\ (B^0 \to \rho^+\pi^-) = 0.15 \pm 0.25$
$|\lambda|\ (B^0 \to c\overline{c}K^0) = 0.949 \pm 0.045$
$|\lambda|\ (B^0 \to D^{*+}D^{*-}) = 0.75 \pm 0.19$
$\text{Im}(\lambda)\ (B^0 \to D^{*+}D^{*-}) = 0.05 \pm 0.31$
$\sin(2\beta) = 0.731 \pm 0.056$

$\overline{B}^0$ 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, D_s, D^*, and 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.

For inclusive branching fractions, *e.g.*, $B \to D^\pm$ anything, the values usually are multiplicities, not branching fractions. They can be greater than one.

B^0 DECAY MODES		Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
$\ell^+ \nu_\ell$ anything	[rr]	(10.5 ± 0.8) %		–
$D^- \ell^+ \nu_\ell$	[rr]	(2.14 ± 0.20) %		2309
$D^*(2010)^- \ell^+ \nu_\ell$	[rr]	(5.44 ± 0.23) %		2257
$\rho^- \ell^+ \nu_\ell$	[rr]	$(2.6 \pm 0.7) \times 10^{-4}$		2583
$\pi^- \ell^+ \nu_\ell$	[rr]	$(1.33 \pm 0.22) \times 10^{-4}$		2638
Inclusive modes				
K^+ anything		(78 ± 8) %		–
D, D^*, or D_s modes				
$D^- \pi^+$		$(2.76 \pm 0.25) \times 10^{-3}$		2306
$D^- \rho^+$		$(7.7 \pm 1.3) \times 10^{-3}$		2235
$D^- K^*(892)^+$		$(3.7 \pm 1.8) \times 10^{-4}$		2211
$D^- \omega \pi^+$		$(2.8 \pm 0.6) \times 10^{-3}$		2204
$D^- K^+$		$(2.0 \pm 0.6) \times 10^{-4}$		2279
$D^- K^+ \overline{K}^0$		$< 3.1 \times 10^{-4}$	CL=90%	2188
$D^- K^+ \overline{K}^*(892)^0$		$(8.8 \pm 1.9) \times 10^{-4}$		2070
$\overline{D}^0 \pi^0$		$(2.7 \pm 0.8) \times 10^{-4}$		2308
$\overline{D}^0 \pi^+ \pi^-$		$(8.0 \pm 1.6) \times 10^{-4}$		2301
$D^*(2010)^- \pi^+$		$(2.76 \pm 0.21) \times 10^{-3}$		2255
$D^- \pi^+ \pi^+ \pi^-$		$(8.0 \pm 2.5) \times 10^{-3}$		2287
$(D^- \pi^+ \pi^+ \pi^-)$ nonresonant		$(3.9 \pm 1.9) \times 10^{-3}$		2287
$D^- \pi^+ \rho^0$		$(1.1 \pm 1.0) \times 10^{-3}$		2206
$D^- a_1(1260)^+$		$(6.0 \pm 3.3) \times 10^{-3}$		2121
$D^*(2010)^- \pi^+ \pi^0$		(1.5 ± 0.5) %		2247
$D^*(2010)^- \rho^+$		$(6.8 \pm 0.9) \times 10^{-3}$		2180
$D^*(2010)^- K^+$		$(2.0 \pm 0.5) \times 10^{-4}$		2226
$D^*(2010)^- K^*(892)^+$		$(3.8 \pm 1.5) \times 10^{-4}$		2155
$D^*(2010)^- K^+ \overline{K}^0$		$< 4.7 \times 10^{-4}$	CL=90%	2131
$D^*(2010)^- K^+ \overline{K}^*(892)^0$		$(1.29 \pm 0.33) \times 10^{-3}$		2007
$D^*(2010)^- \pi^+ \pi^+ \pi^-$		$(7.6 \pm 1.8) \times 10^{-3}$	S=1.4	2235
$(D^*(2010)^- \pi^+ \pi^+ \pi^-)$ non-resonant		$(0.0 \pm 2.5) \times 10^{-3}$		2235
$D^*(2010)^- \pi^+ \rho^0$		$(5.7 \pm 3.2) \times 10^{-3}$		2150
$D^*(2010)^- a_1(1260)^+$		(1.30 ± 0.27) %		2061
$D^*(2010)^- \pi^+ \pi^+ \pi^- \pi^0$		(1.76 ± 0.27) %		2218
$D^*(2010)^+ \pi^+ \pi^- \pi^- \pi^0$		(1.8 ± 0.7) %		2218
$D^*(2010)^- p \overline{p} \pi^+$		$(6.5 \pm 1.6) \times 10^{-4}$		1707
$D^*(2010)^- p \overline{n}$		$(1.5 \pm 0.4) \times 10^{-3}$		1785
$\overline{D}^*(2010)^- \omega \pi^+$		$(2.9 \pm 0.5) \times 10^{-3}$		2148
$\overline{D}_2^*(2460)^- \pi^+$		$< 2.2 \times 10^{-3}$	CL=90%	2064
$\overline{D}_2^*(2460)^- \rho^+$		$< 4.9 \times 10^{-3}$	CL=90%	1977
$D^- D^+$		$< 9.4 \times 10^{-4}$	CL=90%	1864
$D^- D_s^+$		$(8.0 \pm 3.0) \times 10^{-3}$		1812
$D^*(2010)^- D_s^+$		(1.07 ± 0.29) %		1735
$D^- D_s^{*+}$		(1.0 ± 0.5) %		1732
$D^*(2010)^- D_s^{*+}$		(1.9 ± 0.5) %		1649
$D^- D_{sJ}(2317)^+$		seen		1602
$D^- D_{sJ}(2457)^+$		seen		–
$D^- D_{sJ}(2536)^+$		not seen		1444
$D^*(2010)^- D_{sJ}(2536)^+$		not seen		1336
$D^- D_{sJ}(2573)^+$		not seen		1414
$D^*(2010)^- D_{sJ}(2573)^+$		not seen		1303
$D_s^+ \pi^-$		$(2.7 \pm 1.0) \times 10^{-5}$		2270
$D_s^{*+} \pi^-$		$< 4.1 \times 10^{-5}$	CL=90%	2215
$D_s^+ \rho^-$		$< 7 \times 10^{-4}$	CL=90%	2197
$D_s^{*+} \rho^-$		$< 8 \times 10^{-4}$	CL=90%	2138
$D_s^+ a_1(1260)^-$		$< 2.6 \times 10^{-3}$	CL=90%	2080
$D_s^{*+} a_1(1260)^-$		$< 2.2 \times 10^{-3}$	CL=90%	2015
$D_s^- K^+$		$(3.8 \pm 1.3) \times 10^{-5}$		2242
$D_s^{*-} K^+$		$< 2.5 \times 10^{-5}$	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%	2222
$D_s^{*-} \pi^+ K^0$		$< 3.1 \times 10^{-3}$	CL=90%	2164
$D_s^- \pi^+ K^*(892)^0$		$< 4 \times 10^{-3}$	CL=90%	2138
$D_s^{*-} \pi^+ K^*(892)^0$		$< 2.0 \times 10^{-3}$	CL=90%	2076
$\overline{D}^0 K^0$		$(5.0 \pm 1.4) \times 10^{-5}$		2280
$\overline{D}^0 K^*(892)^0$		$(4.8 \pm 1.2) \times 10^{-5}$		2213
$\overline{D}^0 \pi^0$		$(2.91 \pm 0.28) \times 10^{-4}$		2308
$\overline{D}^0 \rho^0$		$(2.9 \pm 1.1) \times 10^{-4}$		2237
$\overline{D}^0 \eta$		$(2.2 \pm 0.5) \times 10^{-4}$	S=1.6	2274
$\overline{D}^0 \eta'$		$(1.7 \pm 0.4) \times 10^{-4}$		2198
$\overline{D}^0 \omega$		$(2.5 \pm 0.6) \times 10^{-4}$	S=1.5	2235
$D^0 K^*(892)^0$		$< 1.8 \times 10^{-5}$	CL=90%	2213
$\overline{D}^{*0} \gamma$		$< 5.0 \times 10^{-5}$	CL=90%	2258
$\overline{D}^*(2007)^0 \pi^0$		$(2.7 \pm 0.5) \times 10^{-4}$		2256
$\overline{D}^*(2007)^0 \rho^0$		$< 5.1 \times 10^{-4}$	CL=90%	2181
$\overline{D}^*(2007)^0 \eta$		$(2.6 \pm 0.6) \times 10^{-4}$		2220
$\overline{D}^*(2007)^0 \eta'$		$< 2.6 \times 10^{-4}$	CL=90%	2141
$\overline{D}^*(2007)^0 \pi^+ \pi^-$		$(6.2 \pm 2.2) \times 10^{-4}$		2248
$\overline{D}^*(2007)^0 K^0$		$< 6.6 \times 10^{-5}$	CL=90%	2227
$\overline{D}^*(2007)^0 K^*(892)^0$		$< 6.9 \times 10^{-5}$	CL=90%	2157
$D^*(2007)^0 K^*(892)^0$		$< 4.0 \times 10^{-5}$	CL=90%	2157
$D^*(2007)^0 \pi^+ \pi^+ \pi^- \pi^-$		$(3.0 \pm 0.9) \times 10^{-3}$		2219
$D^*(2010)^+ D^*(2010)^-$		$(8.7 \pm 1.8) \times 10^{-4}$		1711
$\overline{D}^*(2007)^0 \omega$		$(4.2 \pm 1.1) \times 10^{-4}$		2180
$D^*(2010)^+ D^-$		$< 6.3 \times 10^{-4}$	CL=90%	1790
$D^*(2010)^- D^+ +$ $D^*(2010)^+ D^-$		$(9.3 \pm 1.5) \times 10^{-4}$		1790
$D^*(2007)^0 \overline{D}^*(2007)^0$		< 2.7 %	CL=90%	1715
$D^- D^0 K^+$		$(1.7 \pm 0.4) \times 10^{-3}$		1574
$D^- D^*(2007)^0 K^+$		$(4.6 \pm 1.0) \times 10^{-3}$		1478
$D^*(2010)^- D^0 K^+$		$(3.1 ^{+0.6}_{-0.5}) \times 10^{-3}$		1479
$D^*(2010)^- D^*(2007)^0 K^+$		(1.18 ± 0.20) %		1366
$D^- D^+ K^0$		$< 1.7 \times 10^{-3}$	CL=90%	1568
$D^*(2010)^- D^+ K^0 +$ $D^- D^*(2010)^+ K^0$		$(6.5 \pm 1.6) \times 10^{-3}$		1473
$D^*(2010)^- D^*(2010)^+ K^0$		$(8.8 \pm 1.9) \times 10^{-3}$		1360
$\overline{D}^0 D^0 K^0$		$< 1.4 \times 10^{-3}$	CL=90%	1575
$\overline{D}^0 D^*(2007)^0 K^0 +$ $\overline{D}^*(2007)^0 D^0 K^0$		$< 3.7 \times 10^{-3}$	CL=90%	1478
$\overline{D}^*(2007)^0 D^*(2007)^0 K^0$		$< 6.6 \times 10^{-3}$	CL=90%	1365
$(\overline{D}+\overline{D}^*)(D+D^*)K$		(4.3 ± 0.7) %		–
Charmonium modes				
$\eta_c K^0$		$(1.2 \pm 0.4) \times 10^{-3}$		1753
$\eta_c K^*(892)^0$		$(1.6 \pm 0.7) \times 10^{-3}$		1648
$J/\psi(1S) K^0$		$(8.5 \pm 0.5) \times 10^{-4}$		1683
$J/\psi(1S) K^+ \pi^-$		$(1.2 \pm 0.6) \times 10^{-3}$		1652
$J/\psi(1S) K^*(892)^0$		$(1.31 \pm 0.07) \times 10^{-3}$		1571
$J/\psi(1S) \phi K^0$		$(9.4 \pm 2.6) \times 10^{-5}$		1224
$J/\psi(1S) K(1270)^0$		$(1.3 \pm 0.5) \times 10^{-3}$		1390
$J/\psi(1S) \pi^0$		$(2.2 \pm 0.4) \times 10^{-5}$		1728
$J/\psi(1S) \eta$		$< 2.7 \times 10^{-5}$	CL=90%	1672
$J/\psi(1S) \pi^+ \pi^-$		$(4.6 \pm 0.9) \times 10^{-5}$		1716
$J/\psi(1S) \rho^0$		$(1.6 \pm 0.7) \times 10^{-5}$		1611
$J/\psi(1S) \omega$		$< 2.7 \times 10^{-4}$	CL=90%	1609
$J/\psi(1S) \phi$		$< 9.2 \times 10^{-6}$	CL=90%	1519
$J/\psi(1S) \eta'(958)$		$< 6.3 \times 10^{-5}$	CL=90%	1546
$J/\psi(1S) K^0 \pi^+ \pi^-$		$(1.0 \pm 0.4) \times 10^{-3}$		1611
$J/\psi(1S) K^0 \rho^0$		$(5.4 \pm 3.0) \times 10^{-4}$		1390
$J/\psi(1S) K^*(892)^+ \pi^-$		$(8 \pm 4) \times 10^{-4}$		1514
$J/\psi(1S) K^*(892)^0 \pi^+ \pi^-$		$(6.6 \pm 2.2) \times 10^{-4}$		1447
$J/\psi(1S) p \overline{p}$		$< 1.9 \times 10^{-6}$	CL=90%	862
$\psi(2S) K^0$		$(6.2 \pm 0.7) \times 10^{-4}$		1283
$\psi(2S) K^+ \pi^-$		$< 1 \times 10^{-3}$	CL=90%	1238
$\psi(2S) K^*(892)^0$		$(8.0 \pm 1.3) \times 10^{-4}$		1116
$\chi_{c0}(1P) K^0$		$< 5.0 \times 10^{-4}$	CL=90%	1477
$\chi_{c1}(1P) K^0$		$(4.0 ^{+1.2}_{-1.0}) \times 10^{-4}$		1411
$\chi_{c1}(1P) K^*(892)^0$		$(4.1 \pm 1.5) \times 10^{-4}$		1265
K or K^* modes				
$K^+ \pi^-$		$(1.85 \pm 0.11) \times 10^{-5}$	S=1.2	2615
$K^0 \pi^0$		$(9.5 ^{+2.1}_{-1.9}) \times 10^{-6}$		2614
$\eta' K^0$		$(6.3 \pm 0.7) \times 10^{-5}$	S=1.1	2528
$\eta' K^*(892)^0$		$< 2.4 \times 10^{-5}$	CL=90%	2472
$\eta K^*(892)^0$		$(1.4 ^{+0.6}_{-0.5}) \times 10^{-5}$		2534
ηK^0		$< 9.3 \times 10^{-6}$	CL=90%	2587
ωK^0		$< 1.3 \times 10^{-5}$	CL=90%	2557
$K_S^0 X^0$ (Familon)		$< 5.3 \times 10^{-5}$	CL=90%	–
$\omega K^*(892)^0$		$< 2.3 \times 10^{-5}$	CL=90%	2503
$K^0 \overline{K}^0$		$< 3.3 \times 10^{-6}$	CL=90%	2592
$K_S^0 K_S^0 K_S^0$		$(4.2 ^{+1.8}_{-1.5}) \times 10^{-6}$		2521
$K^+ \pi^- \pi^0$		$< 4.0 \times 10^{-5}$	CL=90%	2609
$K^+ \rho^-$		$(7.3 \pm 1.8) \times 10^{-6}$		2559
$K^0 \pi^+ \pi^-$		$(4.7 \pm 0.7) \times 10^{-5}$		2609

$K^0 \rho^0$		$< 3.9 \times 10^{-5}$	CL=90%	2558
$K^0 f_0(980)$		$< 3.6 \times 10^{-4}$	CL=90%	2524
$K^*(892)^+ \pi^-$		$(1.6 {}^{+0.6}_{-0.5}) \times 10^{-5}$		2562
$K^*(892)^0 \pi^0$		$< 3.6 \times 10^{-6}$	CL=90%	2563
$K_2^*(1430)^+ \pi^-$		$< 1.8 \times 10^{-5}$	CL=90%	2445
$K^0 K^- \pi^+$		$< 2.1 \times 10^{-5}$	CL=90%	2578
$K^+ K^- \pi^0$		$< 1.9 \times 10^{-5}$	CL=90%	2579
$K^0 K^+ K^-$		$(2.8 \pm 0.5) \times 10^{-5}$		2522
$K^0 \phi$		$(8.6 {}^{+1.3}_{-1.1}) \times 10^{-6}$		2516
$K^- \pi^+ \pi^+ \pi^-$	[eee]	$< 2.3 \times 10^{-4}$	CL=90%	2600
$K^*(892)^0 \pi^+ \pi^-$		$< 1.4 \times 10^{-3}$	CL=90%	2557
$K^*(892)^0 \rho^0$		$< 3.4 \times 10^{-5}$	CL=90%	2504
$K^*(892)^0 f_0(980)$		$< 1.7 \times 10^{-4}$	CL=90%	2468
$K_1(1400)^+ \pi^-$		$< 1.1 \times 10^{-3}$	CL=90%	2451
$K^- a_1(1260)^+$	[eee]	$< 2.3 \times 10^{-4}$	CL=90%	2471
$K^*(892)^0 K^+ K^-$		$< 6.1 \times 10^{-4}$	CL=90%	2466
$K^*(892)^0 \phi$		$(1.07 \pm 0.11) \times 10^{-5}$		2460
$\overline{K}^*(892)^0 K^*(892)^0$		$< 2.2 \times 10^{-5}$	CL=90%	2485
$K^*(892)^0 K^*(892)^0$		$< 3.7 \times 10^{-5}$	CL=90%	2485
$K^*(892)^+ K^*(892)^-$		$< 1.41 \times 10^{-4}$	CL=90%	2485
$K_1(1400)^0 \rho^0$		$< 3.0 \times 10^{-3}$	CL=90%	2388
$K_1(1400)^0 \phi$		$< 5.0 \times 10^{-3}$	CL=90%	2339
$K_2^*(1430)^0 \rho^0$		$< 1.1 \times 10^{-3}$	CL=90%	2381
$K_2^*(1430)^0 \phi$		$< 1.4 \times 10^{-3}$	CL=90%	2333
$K^*(892)^0 \gamma$		$(4.3 \pm 0.4) \times 10^{-5}$		2564
$K^0 \phi \gamma$		$< 8.3 \times 10^{-6}$	CL=90%	2516
$K^+ \pi^- \gamma$		$(4.6 \pm 1.4) \times 10^{-6}$		2615
$K^*(1410) \gamma$		$< 1.3 \times 10^{-4}$	CL=90%	2450
$K^+ \pi^- \gamma$ nonresonant		$< 2.6 \times 10^{-6}$	CL=90%	2615
$K_1(1270)^0 \gamma$		$< 7.0 \times 10^{-3}$	CL=90%	2486
$K_1(1400)^0 \gamma$		$< 4.3 \times 10^{-3}$	CL=90%	2453
$K_2^*(1430)^0 \gamma$		$(1.3 \pm 0.5) \times 10^{-5}$		2447
$K^*(1680)^0 \gamma$		$< 2.0 \times 10^{-3}$	CL=90%	2360
$K_3^*(1780)^0 \gamma$		< 1.0 %	CL=90%	2341
$K_4^*(2045)^0 \gamma$		$< 4.3 \times 10^{-3}$	CL=90%	2244

Light unflavored meson modes

$\rho^0 \gamma$		$< 1.2 \times 10^{-6}$	CL=90%	2583
$\omega \gamma$		$< 1.0 \times 10^{-6}$	CL=90%	2582
$\phi \gamma$		$< 3.3 \times 10^{-6}$	CL=90%	2541
$\pi^+ \pi^-$		$(4.8 \pm 0.5) \times 10^{-6}$		2636
$\pi^0 \pi^0$		$(1.9 \pm 0.5) \times 10^{-6}$		2636
$\eta \pi^0$		$< 2.9 \times 10^{-6}$	CL=90%	2610
$\eta \eta$		$< 1.8 \times 10^{-5}$	CL=90%	2582
$\eta' \pi^0$		$< 5.7 \times 10^{-6}$	CL=90%	2551
$\eta' \eta'$		$< 4.7 \times 10^{-5}$	CL=90%	2460
$\eta' \eta$		$< 2.7 \times 10^{-5}$	CL=90%	2522
$\eta' \rho^0$		$< 1.2 \times 10^{-5}$	CL=90%	2492
$\eta \rho^0$		$< 1.0 \times 10^{-5}$	CL=90%	2553
$\omega \eta$		$< 1.2 \times 10^{-5}$	CL=90%	2552
$\omega \eta'$		$< 6.0 \times 10^{-5}$	CL=90%	2491
$\omega \rho^0$		$< 1.1 \times 10^{-5}$	CL=90%	2522
$\omega \omega$		$< 1.9 \times 10^{-5}$	CL=90%	2521
$\phi \pi^0$		$< 5 \times 10^{-6}$	CL=90%	2539
$\phi \eta$		$< 9 \times 10^{-6}$	CL=90%	2511
$\phi \eta'$		$< 3.1 \times 10^{-5}$	CL=90%	2447
$\phi \rho^0$		$< 1.3 \times 10^{-5}$	CL=90%	2480
$\phi \omega$		$< 2.1 \times 10^{-5}$	CL=90%	2479
$\phi \phi$		$< 1.2 \times 10^{-5}$	CL=90%	2435
$\pi^+ \pi^- \pi^0$		$< 7.2 \times 10^{-4}$	CL=90%	2631
$\rho^0 \pi^0$		$< 5.3 \times 10^{-6}$	CL=90%	2581
$\rho^\mp \pi^\pm$	[gg]	$(2.28 \pm 0.25) \times 10^{-5}$		2581
$\pi^+ \pi^- \pi^+ \pi^-$		$< 2.3 \times 10^{-4}$	CL=90%	2621
$\rho^0 \rho^0$		$< 2.1 \times 10^{-6}$	CL=90%	2523
$a_1(1260)^\mp \pi^\pm$	[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%	2523
$a_1(1260)^0 \pi^0$		$< 1.1 \times 10^{-3}$	CL=90%	2494
$\omega \pi^0$		$< 3 \times 10^{-6}$	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%	2433
$a_1(1260)^0 \rho^0$		$< 2.4 \times 10^{-3}$	CL=90%	2433
$\pi^+ \pi^+ \pi^+ \pi^- \pi^- \pi^-$		$< 3.0 \times 10^{-3}$	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

$p \overline{p}$		$< 1.2 \times 10^{-6}$	CL=90%	2467
$p \overline{p} \pi^+ \pi^-$		$< 2.5 \times 10^{-4}$	CL=90%	2406
$p \overline{p} K^0$		$< 7.2 \times 10^{-6}$	CL=90%	2347
$p \overline{\Lambda} \pi^-$		$(4.0 {}^{+1.1}_{-1.0}) \times 10^{-6}$		2401
$p \overline{\Lambda} K^-$		$< 8.2 \times 10^{-7}$	CL=90%	2308
$p \overline{\Sigma}^0 \pi^-$		$< 3.8 \times 10^{-6}$	CL=90%	2383
$\overline{\Lambda} \Lambda$		$< 1.0 \times 10^{-6}$	CL=90%	2392
$\Delta^0 \overline{\Delta}^0$		$< 1.5 \times 10^{-3}$	CL=90%	2335
$\Delta^{++} \overline{\Delta}^{--}$		$< 1.1 \times 10^{-4}$	CL=90%	2335
$\overline{D}^0 p \overline{p}$		$(1.18 \pm 0.22) \times 10^{-4}$		1862
$\overline{D}^*(2007)^0 p \overline{p}$		$(1.2 \pm 0.4) \times 10^{-4}$		1788
$\overline{\Sigma}_c^{--} \Delta^{++}$		$< 1.0 \times 10^{-3}$	CL=90%	1840
$\overline{\Lambda}_c^- p \pi^+ \pi^-$		$(1.3 \pm 0.4) \times 10^{-3}$		1934
$\overline{\Lambda}_c^- p$		$(2.2 \pm 0.8) \times 10^{-5}$		2021
$\overline{\Lambda}_c^- p \pi^0$		$< 5.9 \times 10^{-4}$	CL=90%	1982
$\overline{\Lambda}_c^- p \pi^+ \pi^- \pi^0$		$< 5.07 \times 10^{-3}$	CL=90%	1883
$\overline{\Lambda}_c^- p \pi^+ \pi^- \pi^+ \pi^-$		$< 2.74 \times 10^{-3}$	CL=90%	1821
$\overline{\Sigma}_c(2520)^{--} p \pi^+$		$(1.6 \pm 0.7) \times 10^{-4}$		1861
$\overline{\Sigma}_c(2520)^0 p \pi^-$		$< 1.21 \times 10^{-4}$	CL=90%	1861
$\overline{\Sigma}_c(2455)^0 p \pi^-$		$(10 \pm 8) \times 10^{-5}$	S=1.7	1896
$\overline{\Sigma}_c(2455)^{--} p \pi^+$		$(2.8 \pm 0.9) \times 10^{-4}$		1896
$\overline{\Lambda}_c(2593)^- / \overline{\Lambda}_c(2625)^- p$		$< 1.1 \times 10^{-4}$	CL=90%	–

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

$\gamma \gamma$	B1		$< 1.7 \times 10^{-6}$	CL=90%	2640
$e^+ e^-$	B1		$< 1.9 \times 10^{-7}$	CL=90%	2640
$\mu^+ \mu^-$	B1		$< 1.6 \times 10^{-7}$	CL=90%	2638
$K^0 e^+ e^-$	B1		$< 5.4 \times 10^{-7}$	CL=90%	2616
$K^0 \mu^+ \mu^-$	B1		$(5.6 {}^{+2.9}_{-2.4}) \times 10^{-7}$		2612
$K^0 \ell^+ \ell^-$	B1	[rr]	$< 6.8 \times 10^{-7}$	CL=90%	2616
$K^*(892)^0 e^+ e^-$	B1		$< 2.4 \times 10^{-6}$	CL=90%	2564
$K^*(892)^0 \mu^+ \mu^-$	B1		$(1.3 \pm 0.4) \times 10^{-6}$		2560
$K^*(892)^0 \nu \overline{\nu}$	B1		$< 1.0 \times 10^{-3}$	CL=90%	2564
$K^*(892)^0 \ell^+ \ell^-$	B1	[rr]	$(1.17 \pm 0.30) \times 10^{-6}$		2564
$e^\pm \mu^\mp$	LF	[gg]	$< 1.7 \times 10^{-7}$	CL=90%	2639
$K^0 e^\pm \mu^\mp$	LF		$< 4.0 \times 10^{-6}$	CL=90%	2615
$K^*(892)^0 e^\pm \mu^\mp$	LF		$< 3.4 \times 10^{-6}$	CL=90%	2563
$e^\pm \tau^\mp$	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

CP violation

$A_{CP}(B \rightarrow K^*(892)\gamma) = -0.01 \pm 0.07$

$A_{CP}(B \rightarrow s\gamma) = -0.08 \pm 0.11$

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

For inclusive branching fractions, *e.g.*, $B \rightarrow D^\pm$ anything, the values usually are multiplicities, not branching fractions. They can be greater than one.

$\overline{B}$ 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				
$B \rightarrow e^+ \nu_e$ anything	[fff]	(10.73 ± 0.28) %		–
$B \rightarrow \overline{p} e^+ \nu_e$ anything		$< 5.9 \times 10^{-4}$	CL=90%	–
$B \rightarrow \ell^+ \nu_\ell$ anything	[rr,fff]	(10.73 ± 0.28) %		–
$B \rightarrow D^- \ell^+ \nu_\ell$ anything	[rr]	(2.8 ± 0.9) %		–
$B \rightarrow \overline{D}^0 \ell^+ \nu_\ell$ anything	[rr]	(7.2 ± 1.5) %		–
$B \rightarrow \overline{D}^{**} \ell^+ \nu_\ell$	[rr,ggg]	(2.7 ± 0.7) %		–
$B \rightarrow \overline{D}_1(2420) \ell^+ \nu_\ell$ anything		$(7.4 \pm 1.6) \times 10^{-3}$		–
$B \rightarrow D \pi \ell^+ \nu_\ell$ anything + $D^* \pi \ell^+ \nu_\ell$ anything		(2.6 ± 0.5) %	S=1.5	–
$B \rightarrow D \pi \ell^+ \nu_\ell$ anything		(1.5 ± 0.6) %		–
$B \rightarrow D^* \pi \ell^+ \nu_\ell$ anything		(1.9 ± 0.4) %		–
$B \rightarrow \overline{D}_2^*(2460) \ell^+ \nu_\ell$ anything		$< 6.5 \times 10^{-3}$	CL=95%	–

Mode		Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
$B \to D^{*-}\pi^+\ell^+\nu_\ell$ anything		(1.00 ± 0.34) %		–
$B \to D_s^-\ell^+\nu_\ell$ anything	[rr]	< 9 $\times 10^{-3}$	CL=90%	–
$B \to D_s^-\ell^+\nu_\ell K^+$ anything	[rr]	< 6 $\times 10^{-3}$	CL=90%	–
$B \to D_s^-\ell^+\nu_\ell K^0$ anything	[rr]	< 9 $\times 10^{-3}$	CL=90%	–
$B \to K^+\ell^+\nu_\ell$ anything	[rr]	(6.2 ± 0.6) %		–
$B \to K^-\ell^+\nu_\ell$ anything	[rr]	(10 ± 4) $\times 10^{-3}$		–
$B \to K^0/\overline{K}^0\ell^+\nu_\ell$ anything	[rr]	(4.5 ± 0.5) %		–
D, D^*, or D_s modes				
$B \to D^{\pm}$ anything		(23.5 ± 1.9) %		–
$B \to D^0/\overline{D}^0$ anything		(64.0 ± 3.0) %	S=1.1	–
$B \to D^*(2010)^{\pm}$ anything		(22.5 ± 1.5) %		–
$B \to D^*(2007)^0$ anything		(26.0 ± 2.7) %		–
$B \to D_s^{\pm}$ anything	[gg]	(10.5 ± 2.6) %		–
$B \to D_s^{*\pm}$ anything		(7.9 ± 2.2) %		–
$B \to D_s^{*\pm}\overline{D}^{(*)}$		(4.2 ± 1.2) %		–
$B \to \overline{D}D_{sJ}(2317)$		seen		1605
$B \to \overline{D}D_{sJ}(2457)$		seen		–
$B \to D^{(*)}\overline{D}^{(*)}K^0 + D^{(*)}\overline{D}^{(*)}K^{\pm}$	[gg,hhh]	(7.1 $^{+2.7}_{-1.7}$) %		–
$b \to c\overline{c}s$		(22 ± 4) %		–
$B \to D_s^{(*)}\overline{D}^{(*)}$	[gg,hhh]	(4.9 ± 1.2) %		–
$B \to D^*D^*(2010)^{\pm}$	[gg]	< 5.9 $\times 10^{-3}$	CL=90%	1711
$B \to DD^*(2010)^{\pm} + D^*D^{\pm}$	[gg]	< 5.5 $\times 10^{-3}$	CL=90%	–
$B \to DD^{\pm}$	[gg]	< 3.1 $\times 10^{-3}$	CL=90%	1866
$B \to D_s^{(*)\pm}\overline{D}^{(*)}X(n\pi^{\pm})$	[gg,hhh]	(9 $^{+5}_{-4}$) %		–
$B \to D^*(2010)\gamma$		< 1.1 $\times 10^{-3}$	CL=90%	2257
$B \to D_s^+\pi^-$, $D_s^{*+}\pi^-$, $D_s^+\rho^-$, $D_s^{*+}\rho^-$, $D_s^+\pi^0$, $D_s^{*+}\pi^0$, $D_s^+\eta$, $D_s^{*+}\eta$, $D_s^+\rho^0$, $D_s^{*+}\rho^0$, $D_s^+\omega$, $D_s^{*+}\omega$	[gg]	< 5 $\times 10^{-4}$	CL=90%	–
$B \to D_{s1}(2536)^+$ anything		< 9.5 $\times 10^{-3}$	CL=90%	–
Charmonium modes				
$B \to J/\psi(1S)$ anything		(1.094 ± 0.032) %	S=1.1	–
$B \to J/\psi(1S)$(direct) anything		(7.8 ± 0.4) $\times 10^{-3}$	S=1.1	–
$B \to \psi(2S)$ anything		(3.07 ± 0.21) $\times 10^{-3}$		–
$B \to \chi_{c1}(1P)$ anything		(3.86 ± 0.27) $\times 10^{-3}$		–
$B \to \chi_{c1}(1P)$ (direct) anything		(3.34 ± 0.28) $\times 10^{-3}$		–
$B \to \chi_{c2}(1P)$ anything		(1.3 ± 0.4) $\times 10^{-3}$	S=1.9	–
$B \to \chi_{c2}(1P)$ (direct) anything		(1.65 ± 0.31) $\times 10^{-3}$		–
$B \to \eta_c(1S)$ anything		< 9 $\times 10^{-3}$	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) %		–
$B \to K^*(892)\gamma$		(4.2 ± 0.6) $\times 10^{-5}$		2564
$B \to K_1(1400)\gamma$		< 1.27 $\times 10^{-4}$	CL=90%	2453
$B \to K_2^*(1430)\gamma$		(1.7 $^{+0.6}_{-0.5}$) $\times 10^{-5}$		2447
$B \to K_2(1770)\gamma$		< 1.2 $\times 10^{-3}$	CL=90%	2342
$B \to K_3^*(1780)\gamma$		< 3.0 $\times 10^{-3}$	CL=90%	2341
$B \to K_4^*(2045)\gamma$		< 1.0 $\times 10^{-3}$	CL=90%	2244
$B \to K\eta'(958)$		(8.3 ± 1.1) $\times 10^{-5}$		2528
$B \to K^*(892)\eta'(958)$		< 2.2 $\times 10^{-5}$	CL=90%	2472
$B \to K\eta$		< 5.2 $\times 10^{-6}$	CL=90%	2588
$B \to K^*(892)\eta$		(1.8 ± 0.5) $\times 10^{-5}$		2534
$B \to K\phi\phi$		(2.3 ± 0.9) $\times 10^{-6}$		2306
$B \to \overline{b} \to \overline{s}\gamma$		(3.3 ± 0.4) $\times 10^{-4}$		–
$B \to \overline{b} \to \overline{s}$ gluon		< 6.8 %	CL=90%	–
$B \to \eta$ anything		< 4.4 $\times 10^{-4}$	CL=90%	–
$B \to \eta'$ anything		(4.6 ± 1.3) $\times 10^{-4}$		–
Light unflavored meson modes				
$B \to \rho\gamma$		< 1.9 $\times 10^{-6}$	CL=90%	2583
$B \to \pi^{\pm}$ anything	[gg,iii]	(358 ± 7) %		–
$B \to \pi^0$ anything		(235 ±11) %		–
$B \to \eta$ 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	–
$B \to \phi K^*(892)$		< 2.2 $\times 10^{-5}$	CL=90%	2460
Baryon modes				
$B \to \Lambda_c^+ / \overline{\Lambda}_c^-$ anything		(6.4 ± 1.1) %		–
$B \to \overline{\Lambda}_c^- e^+$ anything		< 3.2 $\times 10^{-3}$	CL=90%	–
$B \to \overline{\Lambda}_c^- p$ anything		(3.6 ± 0.7) %		–
$B \to \overline{\Lambda}_c^- p e^+\nu_e$		< 1.5 $\times 10^{-3}$	CL=90%	2021
$B \to \overline{\Sigma}_c^{--}$ anything		(4.2 ± 2.4) $\times 10^{-3}$		–
$B \to \overline{\Sigma}_c^-$ anything		< 9.6 $\times 10^{-3}$	CL=90%	–
$B \to \overline{\Sigma}_c^0$ anything		(4.6 ± 2.4) $\times 10^{-3}$		–
$B \to \overline{\Sigma}_c^0 N (N = p$ or $n)$		< 1.5 $\times 10^{-3}$	CL=90%	1939
$B \to \Xi_c^0$ anything $\times$ B($\Xi_c^0 \to \Xi^-\pi^+$)		(1.4 ± 0.5) $\times 10^{-4}$		–
$B \to \Xi_c^+$ anything $\times$ B($\Xi_c^+ \to \Xi^-\pi^+\pi^+$)		(4.5 $^{+1.3}_{-1.2}$) $\times 10^{-4}$		–
$B \to p/\overline{p}$ 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) $\times 10^{-3}$		–
$B \to$ 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 $\times 10^{-3}$	CL=90%	–
Lepton Family number (LF) violating modes or $\Delta B = 1$ weak neutral current ($B1$) modes				
$B \to se^+e^-$	$B1$	(5.0 ± 2.6) $\times 10^{-6}$		–
$B \to s\mu^+\mu^-$	$B1$	(7.9 $^{+3.0}_{-2.6}$) $\times 10^{-6}$		–
$B \to s\ell^+\ell^-$	$B1$ [rr]	(6.1 $^{+2.0}_{-1.8}$) $\times 10^{-6}$		–
$B \to Ke^+e^-$	$B1$	(4.8 $^{+1.5}_{-1.3}$) $\times 10^{-7}$		2617
$B \to K^*(892)e^+e^-$	$B1$	(1.5 ± 0.5) $\times 10^{-6}$		2564
$B \to K\mu^+\mu^-$	$B1$	(4.8 ± 1.2) $\times 10^{-7}$		2612
$B \to K^*(892)\mu^+\mu^-$	$B1$	(1.17 $^{+0.37}_{-0.33}$) $\times 10^{-6}$		2560
$B \to K\ell^+\ell^-$	$B1$	(5.4 ± 0.8) $\times 10^{-7}$		2617
$B \to K^*(892)\ell^+\ell^-$	$B1$	(1.05 ± 0.20) $\times 10^{-6}$		2564
$B \to e^{\pm}\mu^{\mp}s$	LF [gg]	< 2.2 $\times 10^{-5}$	CL=90%	–
$B \to \pi e^{\pm}\mu^{\mp}$	LF	< 1.6 $\times 10^{-6}$	CL=90%	2637
$B \to \rho e^{\pm}\mu^{\mp}$	LF	< 3.2 $\times 10^{-6}$	CL=90%	2582
$B \to Ke^{\pm}\mu^{\mp}$	LF	< 1.6 $\times 10^{-6}$	CL=90%	2616
$B \to K^*(892)e^{\pm}\mu^{\mp}$	LF	< 6.2 $\times 10^{-6}$	CL=90%	2563

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

These measurements are for an admixture of bottom particles at high energy (LEP, Tevatron, $Sp\overline{p}S$).

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

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

$|\Delta\tau_b|/\tau_{b,\overline{b}} = -0.001 \pm 0.014$

The branching fraction measurements are for an admixture of B mesons and baryons at energies above the $\Upsilon(4S)$. Only the highest energy results (LEP, Tevatron, $Sp\overline{p}S$) are used in the branching fraction averages. In the following, we assume that the production fractions are the same at the LEP and at the Tevatron.

For inclusive branching fractions, *e.g.*, $B \to D^{\pm}$ anything, the values usually are multiplicities, not branching fractions. They can be greater than one.

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)	Scale factor/ Confidence level	p (MeV/c)

PRODUCTION FRACTIONS

The production fractions for weakly decaying b-hadrons at high energy have been calculated from the best values of mean lives, mixing parameters, and branching fractions in this edition by the Heavy Flavor Averaging Group (HFAG) as described in the note "B^0-$\overline{B}^0$ Mixing" in the B^0 Particle Listings. Values assume

$$B(\overline{b} \rightarrow B^+) = B(\overline{b} \rightarrow B^0)$$
$$B(\overline{b} \rightarrow B^+) + B(\overline{b} \rightarrow B^0) + B(\overline{b} \rightarrow B^0_s) + B(b \rightarrow b\text{-baryon}) = 100\ \%.$$

The notation for production fractions varies in the literature (f_d, d_{B^0}, $f(b \rightarrow \overline{B}^0)$, $\mathrm{Br}(b \rightarrow \overline{B}^0)$). We use our own branching fraction notation here, $B(\overline{b} \rightarrow B^0)$.

B^+		(39.7 ± 1.0) %		–
B^0		(39.7 ± 1.0) %		–
B^0_s		(10.7 ± 1.1) %		–
b-baryon		(9.9 ± 1.7) %		–
B_c		—		–

DECAY MODES

Semileptonic and leptonic modes				
ν anything		(23.1 ± 1.5) %		–
$\ell^+ \nu_\ell$ anything	[rr]	(10.68 ± 0.22) %		–
$e^+ \nu_e$ anything		(10.86 ± 0.35) %		–
$\mu^+ \nu_\mu$ anything		($10.95^{+0.29}_{-0.25}$) %		–
$D^- \ell^+ \nu_\ell$ anything	[rr]	(2.3 ± 0.4) %	S=1.7	–
$D^- \pi^+ \ell^+ \nu_\ell$ anything		(4.9 ± 1.9) $\times 10^{-3}$		–
$D^- \pi^- \ell^+ \nu_\ell$ anything		(2.6 ± 1.6) $\times 10^{-3}$		–
$\overline{D}^0 \ell^+ \nu_\ell$ anything	[rr]	(6.90 ± 0.35) %		–
$\overline{D}^0 \pi^- \ell^+ \nu_\ell$ anything		(1.07 ± 0.27) %		–
$\overline{D}^0 \pi^+ \ell^+ \nu_\ell$ anything		(2.3 ± 1.6) $\times 10^{-3}$		–
$D^{*-} \ell^+ \nu_\ell$ anything	[rr]	(2.75 ± 0.19) %		–
$D^{*-} \pi^+ \ell^+ \nu_\ell$ anything		(4.8 ± 1.0) $\times 10^{-3}$		–
$D^{*-} \pi^- \ell^+ \nu_\ell$ anything		(6 ± 7) $\times 10^{-4}$		–
$D^-_j \ell^+ \nu_\ell$ anything	[rr,jjj]	seen		–
$D^*_2(2460)^- \ell^+ \nu_\ell$ anything		seen		–
charmless $\ell \overline{\nu}_\ell$	[rr]	(1.7 ± 0.5) $\times 10^{-3}$		–
$\tau^+ \nu_\tau$ anything		(2.48 ± 0.26) %		–
$D^{*-} \tau \nu_\tau$ anything		(9 ± 4) $\times 10^{-3}$		–
$\overline{c} \rightarrow \ell^- \overline{\nu}_\ell$ anything	[rr]	(8.0 ± 0.4) %		–
$c \rightarrow \ell^+ \nu$ anything		($1.6^{+0.4}_{-0.5}$) %		–
Charmed meson and baryon modes				
$\overline{D}^0$ anything		(61.0 ± 3.2) %		–
$D^0 D^\pm_s$ anything	[gg]	($9.1^{+3.9}_{-2.8}$) %		–
$D^\mp D^\pm_s$ anything	[gg]	($4.0^{+2.3}_{-1.8}$) %		–
$\overline{D}^0 D^0$ anything	[gg]	($5.1^{+2.0}_{-1.8}$) %		–
$D^0 D^\pm$ anything	[gg]	($2.7^{+1.8}_{-1.6}$) %		–
$D^\pm D^\mp$ anything	[gg]	< 9 $\times 10^{-3}$	CL=90%	–
D^- anything		(23.1 ± 2.2) %		–
$D^*(2010)^+$ anything		(17.3 ± 2.0) %		–
$D_1(2420)^0$ anything		(5.0 ± 1.5) %		–
$D^*(2010)^\mp D^\pm_s$ anything	[gg]	($3.3^{+1.6}_{-1.3}$) %		–
$D^0 D^*(2010)^\pm$ anything	[gg]	($3.0^{+1.1}_{-0.9}$) %		–
$D^*(2010)^\pm D^\mp$ anything	[gg]	($2.5^{+1.2}_{-1.0}$) %		–
$D^*(2010)^\pm D^*(2010)^\mp$ anything	[gg]	(1.2 ± 0.4) %		–
$D^*_2(2460)^0$ anything		(4.7 ± 2.7) %		–
D^-_s anything		(18 ± 5) %		–
D^+_s anything		(10.1 ± 3.1) %		–
Λ^+_c anything		(9.7 ± 2.9) %		–
$\overline{c}/c$ anything	[iii]	(116.6 ± 3.3) %		–
Charmonium modes				
$J/\psi(1S)$ anything		(1.16 ± 0.10) %		–
$\psi(2S)$ anything		(4.8 ± 2.4) $\times 10^{-3}$		–
$\chi_{c1}(1P)$ anything		(1.5 ± 0.5) %		–
***K* or *K** modes**				
$\overline{s}\gamma$		(3.1 ± 1.1) $\times 10^{-4}$		–
$\overline{s}\overline{\nu}\nu$		< 6.4 $\times 10^{-4}$	CL=90%	–
$K^\pm$ anything		(74 ± 6) %		–
K^0_S anything		(29.0 ± 2.9) %		–
Pion modes				
$\pi^\pm$ anything		(397 ±21) %		–
π^0 anything	[iii]	(278 ±60) %		–
ϕ anything		(2.82 ± 0.23) %		–
Baryon modes				
$p/\overline{p}$ anything		(13.1 ± 1.1) %		–
Other modes				
charged anything	[iii]	(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) %		–
b-baryon anything		(10.2 ± 2.8) %		–
$\Delta B = 1$ weak neutral current ($B1$) modes				
$\mu^+ \mu^-$ anything	$B1$	< 3.2 $\times 10^{-4}$	CL=90%	–

B^*

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

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

Mass $m_{B^*} = 5325.0 \pm 0.6$ MeV

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

B^* DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$B\gamma$	dominant	45

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

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

B^0_s

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

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

Mass $m_{B^0_s} = 5369.6 \pm 2.4$ MeV

Mean life $\tau = (1.461 \pm 0.057) \times 10^{-12}$ s

$c\tau = 438\ \mu$m

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

$\Delta m_{B^0_s} = m_{B^0_{sH}} - m_{B^0_{sL}} > 14.4 \times 10^{12}\ \hbar\ s^{-1}$, CL = 95%

$> 94.8 \times 10^{-10}$ MeV, CL = 95%

$x_s = \Delta m_{B^0_s}/\Gamma_{B^0_s} > 20.6$, CL = 95%

$\chi_s > 0.49883$, CL = 95%

These branching fractions all scale with $B(\overline{b} \rightarrow B^0_s)$, the LEP B^0_s production fraction. The first four were evaluated using $B(\overline{b} \rightarrow B^0_s) = (10.7 \pm 1.4)\%$ and the rest assume $B(\overline{b} \rightarrow B^0_s) = 12\%$.

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

For inclusive branching fractions, *e.g.*, $B \rightarrow D^\pm$ anything, the values usually are multiplicities, not branching fractions. They can be greater than one.

B^0_s DECAY MODES		Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
D^-_s anything		(94 ±30) %		–
$D^-_s \ell^+ \nu_\ell$ anything	[kkk]	(7.9 ± 2.4) %		–
$D^-_s \pi^+$		< 13 %		2322
$D_s{}^{(*)+} D_s{}^{(*)-}$		(23^{+21}_{-13}) %		–
$J/\psi(1S)\phi$		(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		1123
$\pi^+\pi^-$		< 1.7 $\times 10^{-4}$	90%	2681

$\pi^0 \pi^0$	$< 2.1 \times 10^{-4}$	90%	2681
$\eta \pi^0$	$< 1.0 \times 10^{-3}$	90%	2655
$\eta \eta$	$< 1.5 \times 10^{-3}$	90%	2628
$\rho^0 \rho^0$	$< 3.20 \times 10^{-4}$	90%	2570
$\phi \rho^0$	$< 6.17 \times 10^{-4}$	90%	2528
$\phi \phi$	$< 1.183 \times 10^{-3}$	90%	2484
$\pi^+ K^-$	$< 2.1 \times 10^{-4}$	90%	2660
$K^+ K^-$	$< 5.9 \times 10^{-5}$	90%	2639
$\overline{K}^*(892)^0 \rho^0$	$< 7.67 \times 10^{-4}$	90%	2551
$\overline{K}^*(892)^0 K^*(892)^0$	$< 1.681 \times 10^{-3}$	90%	2532
$\phi K^*(892)^0$	$< 1.013 \times 10^{-3}$	90%	2508
$p \overline{p}$	$< 5.9 \times 10^{-5}$	90%	2516
$\gamma \gamma$	$< 1.48 \times 10^{-4}$	90%	2685
$\phi \gamma$	$< 1.2 \times 10^{-4}$	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%	2683
$e^+ e^-$	*B1*	$< 5.4 \times 10^{-5}$	90%	2685
$e^\pm \mu^\mp$	*LF*	[gg] $< 6.1 \times 10^{-6}$	90%	2684
$\phi(1020) \mu^+ \mu^-$	*B1*	$< 4.7 \times 10^{-5}$	90%	2584
$\phi \nu \overline{\nu}$	*B1*	$< 5.4 \times 10^{-3}$	90%	2588

BOTTOM, CHARMED MESONS ($B = C = \pm 1$)

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

$B_c^\pm$

$I(J^P) = 0(0^-)$
I, *J*, *P* need confirmation.

Quantum numbers shown are quark-model predicitions.

Mass $m = 6.4 \pm 0.4$ GeV
Mean life $\tau = (0.46^{+0.18}_{-0.16}) \times 10^{-12}$ s

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

B_c^+ DECAY MODES × B($\overline{b} \to B_c$)	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)

The following quantities are not pure branching ratios; rather the fraction $\Gamma_i/\Gamma \times$ B($\overline{b} \to B_c$).

$J/\psi(1S) \ell^+ \nu_\ell$ anything	$(5.2^{+2.4}_{-2.1}) \times 10^{-5}$		–
$J/\psi(1S) \pi^+$	$< 8.2 \times 10^{-5}$	90%	2448
$J/\psi(1S) \pi^+ \pi^+ \pi^-$	$< 5.7 \times 10^{-4}$	90%	2429
$J/\psi(1S)\, a_1(1260)$	$< 1.2 \times 10^{-3}$	90%	2255
$D^*(2010)^+ \overline{D}^0$	$< 6.2 \times 10^{-3}$	90%	2546

$c\overline{c}$ MESONS

$\eta_c(1S)$

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

Mass $m = 2979.6 \pm 1.2$ MeV (S = 1.7)
Full width $\Gamma = 17.3^{+2.7}_{-2.5}$ MeV (S = 1.1)

$\eta_c(1S)$ DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
Decays involving hadronic resonances			
$\eta'(958) \pi \pi$	(4.1 ±1.7) %		1321
$\rho \rho$	(2.6 ±0.9) %		1272
$K^*(892)^0 K^- \pi^+$ + c.c.	(2.0 ±0.7) %		1275
$K^*(892) \overline{K}^*(892)$	(8.5 ±3.1) $\times 10^{-3}$		1194
$\phi K^+ K^-$	(2.9 ±1.4) $\times 10^{-3}$		1101
$\phi \phi$	(2.6 ±0.9) $\times 10^{-3}$		1086
$a_0(980) \pi$	< 2 %	90%	1323
$a_2(1320) \pi$	< 2 %	90%	1194
$K^*(892) \overline{K}$ + c.c.	< 1.28 %	90%	1307
$f_2(1270) \eta$	< 1.1 %	90%	1143
$\omega \omega$	$< 3.1 \times 10^{-3}$	90%	1268
Decays into stable hadrons			
$K \overline{K} \pi$	(5.7 ±1.6) %		1379
$\eta \pi \pi$	(4.9 ±1.8) %		1426
$\pi^+ \pi^- K^+ K^-$	(1.5 ±0.6) %		1343
$2(K^+ K^-)$	(1.5 ±0.7) $\times 10^{-3}$		1053
$2(\pi^+ \pi^-)$	(1.20±0.30) %		1457
$p \overline{p}$	(1.3 ±0.4) $\times 10^{-3}$		1157
$K \overline{K} \eta$	< 3.1 %	90%	1263
$\pi^+ \pi^- p \overline{p}$	< 1.2 %	90%	1024
$\Lambda \overline{\Lambda}$	$< 2 \times 10^{-3}$	90%	987
Radiative decays			
$\gamma \gamma$	(4.3 ±1.5) $\times 10^{-4}$		1490

$J/\psi(1S)$

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

Mass $m = 3096.916 \pm 0.011$ MeV
Full width $\Gamma = 91.0 \pm 3.2$ keV
$\Gamma_{ee} = 5.40 \pm 0.15 \pm 0.07$ keV

$J/\psi(1S)$ 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) %		–
$e^+ e^-$		(5.93±0.10) %		1548
$\mu^+ \mu^-$		(5.88±0.10) %		1545
Decays involving hadronic resonances				
$\rho \pi$		(1.27±0.09) %		1448
$\rho^0 \pi^0$		(4.2 ±0.5) $\times 10^{-3}$		1448
$a_2(1320) \rho$		(1.09±0.22) %		1123
$\omega \pi^+ \pi^+ \pi^- \pi^-$		(8.5 ±3.4) $\times 10^{-3}$		1392
$\omega \pi^+ \pi^-$		(7.2 ±1.0) $\times 10^{-3}$		1435
$\omega f_2(1270)$		(4.3 ±0.6) $\times 10^{-3}$		1142
$K^*(892)^0 \overline{K}_2^*(1430)^0$ + c.c.		(6.7 ±2.6) $\times 10^{-3}$		1012
$\omega K^*(892) \overline{K}$ + c.c.		(5.3 ±2.0) $\times 10^{-3}$		1097
$K^+ \overline{K}^*(892)^-$ + c.c.		(5.0 ±0.4) $\times 10^{-3}$		1373
$K^0 \overline{K}^*(892)^0$ + c.c.		(4.2 ±0.4) $\times 10^{-3}$		1373
$K_1(1400)^\pm K^\mp$		(3.8 ±1.4) $\times 10^{-3}$		1171
$\omega \pi^0 \pi^0$		(3.4 ±0.8) $\times 10^{-3}$		1436
$b_1(1235)^\pm \pi^\mp$	[gg]	(3.0 ±0.5) $\times 10^{-3}$		1300
$\omega K^\pm K_S^0 \pi^\mp$	[gg]	(2.9 ±0.7) $\times 10^{-3}$		1210
$b_1(1235)^0 \pi^0$		(2.3 ±0.6) $\times 10^{-3}$		1300
$\phi K^*(892) \overline{K}$ + c.c.		(2.04±0.28) $\times 10^{-3}$		969
$\omega K \overline{K}$		(1.9 ±0.4) $\times 10^{-3}$		1268
$\omega f_0(1710) \to \omega K \overline{K}$		(4.8 ±1.1) $\times 10^{-4}$		878
$\phi 2(\pi^+ \pi^-)$		(1.60±0.32) $\times 10^{-3}$		1318
$\Delta(1232)^{++} \overline{p} \pi^-$		(1.6 ±0.5) $\times 10^{-3}$		1030
$\omega \eta$		(1.58±0.16) $\times 10^{-3}$		1394
$\phi K \overline{K}$		(1.54±0.21) $\times 10^{-3}$		1179
$\phi f_0(1710) \to \phi K \overline{K}$		(3.6 ±0.6) $\times 10^{-4}$		875
$p \overline{p} \omega$		(1.30±0.25) $\times 10^{-3}$	S=1.3	768
$\Delta(1232)^{++} \overline{\Delta}(1232)^{--}$		(1.10±0.29) $\times 10^{-3}$		938
$\Sigma(1385)^- \overline{\Sigma}(1385)^+$ (or c.c.)	[gg]	(1.03±0.13) $\times 10^{-3}$		697
$p \overline{p} \eta'(958)$		(9 ±4) $\times 10^{-4}$	S=1.7	596
$\phi f_2'(1525)$		(8 ±4) $\times 10^{-4}$	S=2.7	871
$\phi \pi^+ \pi^-$		(8.0 ±1.2) $\times 10^{-4}$		1365
$\phi K^\pm K_S^0 \pi^\mp$	[gg]	(7.2 ±0.9) $\times 10^{-4}$		1114
$\omega f_1(1420)$		(6.8 ±2.4) $\times 10^{-4}$		1062
$\phi \eta$		(6.5 ±0.7) $\times 10^{-4}$		1320
$\Xi(1530)^- \overline{\Xi}^+$		(5.9 ±1.5) $\times 10^{-4}$		601
$p K^- \overline{\Sigma}(1385)^0$		(5.1 ±3.2) $\times 10^{-4}$		646
$\omega \pi^0$		(4.2 ±0.6) $\times 10^{-4}$	S=1.4	1446
$\phi \eta'(958)$		(3.3 ±0.4) $\times 10^{-4}$		1192
$\phi f_0(980)$		(3.2 ±0.9) $\times 10^{-4}$	S=1.9	1182
$\Xi(1530)^0 \overline{\Xi}^0$		(3.2 ±1.4) $\times 10^{-4}$		608
$\Sigma(1385)^- \overline{\Sigma}^+$ (or c.c.)	[gg]	(3.1 ±0.5) $\times 10^{-4}$		855
$\phi f_1(1285)$		(2.6 ±0.5) $\times 10^{-4}$	S=1.1	1032
$\rho \eta$		(1.93±0.23) $\times 10^{-4}$		1396
$\omega \eta'(958)$		(1.67±0.25) $\times 10^{-4}$		1279
$\omega f_0(980)$		(1.4 ±0.5) $\times 10^{-4}$		1271
$\rho \eta'(958)$		(1.05±0.18) $\times 10^{-4}$		1281
$p \overline{p} \phi$		(4.5 ±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
$K_1(1270)^\pm K^\mp$		$< 3.0 \times 10^{-3}$	CL=90%	1231
$K_2^*(1430)^0 \overline{K}_2^*(1430)^0$		$< 2.9 \times 10^{-3}$	CL=90%	604

$K^*(892)^0\overline{K}^*(892)^0$		$< 5 \times 10^{-4}$	CL=90%	1266
$\phi f_2(1270)$		$< 3.7 \times 10^{-4}$	CL=90%	1036
$p\overline{p}\rho$		$< 3.1 \times 10^{-4}$	CL=90%	774
$\phi\eta(1405) \to \phi\eta\pi\pi$		$< 2.5 \times 10^{-4}$	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%	912
$\Delta(1232)^+\overline{p}$		$< 1 \times 10^{-4}$	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
$4(\pi^+\pi^-)\pi^0$		$(9.0 \pm3.0) \times 10^{-3}$		1345
$\pi^+\pi^-K^+K^-$		$(7.2 \pm2.3) \times 10^{-3}$		1407
$K\overline{K}\pi$		$(6.1 \pm1.0) \times 10^{-3}$		1442
$p\overline{p}\pi^+\pi^-$		$(6.0 \pm0.5) \times 10^{-3}$	S=1.3	1107
$2(\pi^+\pi^-)$		$(4.0 \pm1.0) \times 10^{-3}$		1517
$3(\pi^+\pi^-)$		$(4.0 \pm2.0) \times 10^{-3}$		1466
$n\overline{n}\pi^+\pi^-$		$(4 \pm4) \times 10^{-3}$		1106
$\Sigma^0\overline{\Sigma}^0$		$(1.27\pm0.17) \times 10^{-3}$		988
$2(\pi^+\pi^-)K^+K^-$		$(3.1 \pm1.3) \times 10^{-3}$		1320
$p\overline{p}\pi^+\pi^-\pi^0$	[*lll*]	$(2.3 \pm0.9) \times 10^{-3}$	S=1.9	1033
$p\overline{p}$		$(2.12\pm0.10) \times 10^{-3}$		1232
$p\overline{p}\eta$		$(2.09\pm0.18) \times 10^{-3}$		948
$p\overline{n}\pi^-$		$(2.00\pm0.10) \times 10^{-3}$		1174
$n\overline{n}$		$(2.2 \pm0.4) \times 10^{-3}$		1231
$\Xi\overline{\Xi}$		$(1.8 \pm0.4) \times 10^{-3}$	S=1.8	818
$\Lambda\overline{\Lambda}$		$(1.30\pm0.12) \times 10^{-3}$	S=1.1	1074
$p\overline{p}\pi^0$		$(1.09\pm0.09) \times 10^{-3}$		1176
$\Lambda\overline{\Sigma}^-\pi^+$ (or c.c.)	[*gg*]	$(1.06\pm0.12) \times 10^{-3}$		950
$pK^-\overline{\Lambda}$		$(8.9 \pm1.6) \times 10^{-4}$		876
$2(K^+K^-)$		$(9.2 \pm3.3) \times 10^{-4}$	S=1.3	1131
$pK^-\overline{\Sigma}^0$		$(2.9 \pm0.8) \times 10^{-4}$		819
K^+K^-		$(2.37\pm0.31) \times 10^{-4}$		1468
$K^0_SK^0_L$		$(1.46\pm0.26) \times 10^{-4}$	S=2.7	1466
$\Lambda\overline{\Lambda}\pi^0$		$(2.2 \pm0.6) \times 10^{-4}$		998
$\pi^+\pi^-$		$(1.47\pm0.23) \times 10^{-4}$		1542
$\Lambda\overline{\Sigma}$ + c.c.		$< 1.5 \times 10^{-4}$	CL=90%	1034
$K^0_SK^0_S$		$< 5.2 \times 10^{-6}$	CL=90%	1466

Radiative decays

$\gamma\eta_c(1S)$		(1.3 ± 0.4) %		115
$\gamma\pi^+\pi^-2\pi^0$		$(8.3 \pm3.1) \times 10^{-3}$		1518
$\gamma\eta\pi\pi$		$(6.1 \pm1.0) \times 10^{-3}$		1487
$\gamma\eta(1405/1475) \to \gamma K\overline{K}\pi$	[*p*]	$(2.8 \pm0.6) \times 10^{-3}$	S=1.6	1223
$\gamma\eta(1405/1475) \to \gamma\gamma\rho^0$		$(6.4 \pm1.4) \times 10^{-5}$		1223
$\gamma\eta(1405/1475) \to \gamma\eta\pi^+\pi^-$		$(3.0 \pm0.5) \times 10^{-4}$		–
$\gamma\rho\rho$		$(4.5 \pm0.8) \times 10^{-3}$		1340
$\gamma\eta_2(1870) \to \gamma\pi^+\pi^-$		$(6.2 \pm2.4) \times 10^{-4}$		–
$\gamma\eta'(958)$		$(4.31\pm0.30) \times 10^{-3}$		1400
$\gamma 2\pi^+2\pi^-$		$(2.8 \pm0.5) \times 10^{-3}$	S=1.9	1517
$\gamma K^+K^-\pi^+\pi^-$		$(2.1 \pm0.6) \times 10^{-3}$		1407
$\gamma f_4(2050)$		$(2.7 \pm0.7) \times 10^{-3}$		880
$\gamma\omega\omega$		$(1.59\pm0.33) \times 10^{-3}$		1336
$\gamma\eta(1405/1475) \to \gamma\rho^0\rho^0$		$(1.7 \pm0.4) \times 10^{-3}$	S=1.3	1223
$\gamma f_2(1270)$		$(1.38\pm0.14) \times 10^{-3}$		1286
$\gamma f_0(1710) \to \gamma K\overline{K}$		$(8.5 {}^{+1.2}_{-0.9}) \times 10^{-4}$	S=1.2	1075
$\gamma\eta$		$(8.6 \pm0.8) \times 10^{-4}$		1500
$\gamma f_1(1420) \to \gamma K\overline{K}\pi$		$(7.9 \pm1.3) \times 10^{-4}$		1220
$\gamma f_1(1285)$		$(6.1 \pm0.8) \times 10^{-4}$		1283
$\gamma f_1(1510) \to \gamma\eta\pi^+\pi^-$		$(4.5 \pm1.2) \times 10^{-4}$		–
$\gamma f'_2(1525)$		$(4.5 {}^{+0.7}_{-0.4}) \times 10^{-4}$		1173
$\gamma f_2(1950) \to \gamma K^*(892)\overline{K}^*(892)$		$(7.0 \pm2.2) \times 10^{-4}$		–
$\gamma K^*(892)\overline{K}^*(892)$		$(4.0 \pm1.3) \times 10^{-3}$		1266
$\gamma\phi\phi$		$(4.0 \pm1.2) \times 10^{-4}$	S=2.1	1166
$\gamma p\overline{p}$		$(3.8 \pm1.0) \times 10^{-4}$		1232
$\gamma\eta(2225)$		$(2.9 \pm0.6) \times 10^{-4}$		752
$\gamma\eta(1760) \to \gamma\rho^0\rho^0$		$(1.3 \pm0.9) \times 10^{-4}$		1048
$\gamma(K\overline{K}\pi)_{J^{PC}=0-+}$		$(7 \pm4) \times 10^{-4}$	S=2.1	1442
$\gamma\pi^0$		$(3.9 \pm1.3) \times 10^{-5}$		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%	745
$\gamma f_J(2220) \to \gamma\pi\pi$		$(8 \pm4) \times 10^{-5}$		–
$\gamma f_J(2220) \to \gamma K\overline{K}$		$(8.1 \pm3.0) \times 10^{-5}$		–
$\gamma f_J(2220) \to \gamma p\overline{p}$		$(1.5 \pm0.8) \times 10^{-5}$		–
$\gamma f_0(1500)$		$>(5.7 \pm0.8) \times 10^{-4}$		1182
γe^+e^-		$(8.8 \pm1.4) \times 10^{-3}$		1548

Lepton Family number (*LF*) violating modes

$e^\pm\mu^\mp$	*LF*	$< 1.1 \times 10^{-6}$	CL=90%	1547

$\chi_{c0}(1P)$

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

Mass $m = 3415.19 \pm 0.34$ MeV
Full width $\Gamma = 10.1 \pm 0.8$ MeV

$\chi_{c0}(1P)$ DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
Hadronic decays			
$2(\pi^+\pi^-)$	(2.58 ± 0.31) %		1679
$\pi^+\pi^-K^+K^-$	(2.1 ± 0.5) %		1581
$\rho^0\pi^+\pi^-$	(1.6 ± 0.5) %		1607
$3(\pi^+\pi^-)$	(1.27 ± 0.22) %		1633
$K^+\overline{K}^*(892)^0\pi^-$ + c.c.	(1.2 ± 0.4) %		1524
K^+K^-	$(6.0 \pm0.9) \times 10^{-3}$		1635
$\pi\pi$	$(7.4 \pm0.8) \times 10^{-3}$		1702
$\eta\eta$	$(2.1 \pm1.1) \times 10^{-3}$		1617
$K^+K^-K^+K^-$	$(2.3 \pm0.5) \times 10^{-3}$		1334
$K^0_SK^0_S$	$(2.1 \pm0.6) \times 10^{-3}$		1633
$\pi^+\pi^-p\overline{p}$	$(2.2 \pm0.8) \times 10^{-3}$		1320
$\phi\phi$	$(1.0 \pm0.6) \times 10^{-3}$		1370
$p\overline{p}$	$(2.24\pm0.27) \times 10^{-4}$		1427
$\Lambda\overline{\Lambda}$	$(4.7 \pm1.6) \times 10^{-4}$		1293
$K^0_SK^+\pi^-$ + c.c.	$< 8 \times 10^{-4}$	90%	1610
Radiative decays			
$\gamma J/\psi(1S)$	(1.18 ± 0.14) %		303
$\gamma\gamma$	$(2.6 \pm0.5) \times 10^{-4}$		1708

$\chi_{c1}(1P)$

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

Mass $m = 3510.59 \pm 0.10$ MeV (S = 1.1)
Full width $\Gamma = 0.91 \pm 0.13$ MeV

$\chi_{c1}(1P)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
Hadronic decays		
$3(\pi^+\pi^-)$	$(6.2\pm1.6) \times 10^{-3}$	1683
$2(\pi^+\pi^-)$	$(8.2\pm2.9) \times 10^{-3}$	1727
$\pi^+\pi^-K^+K^-$	$(4.9\pm1.1) \times 10^{-3}$	1632
$\rho^0\pi^+\pi^-$	$(3.9\pm3.5) \times 10^{-3}$	1657
$K^+\overline{K}^*(892)^0\pi^-$ + c.c.	$(3.2\pm2.1) \times 10^{-3}$	1577
$K^0_SK^+\pi^-$ + c.c.	$(2.5\pm0.7) \times 10^{-3}$	1660
$\pi^+\pi^-p\overline{p}$	$(5.3\pm2.1) \times 10^{-4}$	1381
$K^+K^-K^+K^-$	$(4.2\pm1.9) \times 10^{-4}$	1393
$p\overline{p}$	$(7.2\pm1.3) \times 10^{-5}$	1483
$\Lambda\overline{\Lambda}$	$(2.6\pm1.2) \times 10^{-4}$	1355
$\pi^+\pi^-$ + K^+K^-	$< 2.1 \times 10^{-3}$	–
Radiative decays		
$\gamma J/\psi(1S)$	(31.6 ± 3.3) %	389

$\chi_{c2}(1P)$

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

Mass $m = 3556.26 \pm 0.11$ MeV
Full width $\Gamma = 2.11 \pm 0.16$ MeV

$\chi_{c2}(1P)$ DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
Hadronic decays			
$2(\pi^+\pi^-)$	(1.48 ± 0.21) %		1751
$\pi^+\pi^-K^+K^-$	(1.24 ± 0.33) %		1656
$3(\pi^+\pi^-)$	(1.07 ± 0.24) %		1707
$\rho^0\pi^+\pi^-$	$(7 \pm4) \times 10^{-3}$		1681
$K^+\overline{K}^*(892)^0\pi^-$ + c.c.	$(4.8 \pm2.8) \times 10^{-3}$		1602
$\phi\phi$	$(2.4 \pm0.9) \times 10^{-3}$		1457
$\pi^+\pi^-$	$(1.77\pm0.27) \times 10^{-3}$		1773

$\pi^0\pi^0$	$(1.1 \pm 0.7) \times 10^{-3}$		1773
$\eta\eta$	$< 1.5 \times 10^{-3}$	90%	1692
$K^+K^-K^+K^-$	$(1.8 \pm 0.5) \times 10^{-3}$		1421
$\pi^+\pi^-p\overline{p}$	$(1.7 \pm 0.4) \times 10^{-3}$		1410
K^+K^-	$(9.4 \pm 2.1) \times 10^{-4}$		1708
$K^0_S K^0_S$	$(7.2 \pm 2.7) \times 10^{-4}$		1707
$p\overline{p}$	$(6.8 \pm 0.7) \times 10^{-5}$		1510
$\Lambda\overline{\Lambda}$	$(3.4 \pm 1.7) \times 10^{-4}$		1385
$J/\psi(1S)\pi^+\pi^-\pi^0$	< 1.5 %	90%	186
$K^0_S K^+\pi^-$ + c.c.	$< 1.3 \times 10^{-3}$	90%	1685
Radiative decays			
$\gamma J/\psi(1S)$	(20.2 ± 1.7) %		430
$\gamma\gamma$	$(2.46 \pm 0.23) \times 10^{-4}$		1778

$\psi(2S)$

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

Mass $m = 3686.093 \pm 0.034$ MeV (S = 1.4)
Full width $\Gamma = 281 \pm 17$ keV
$\Gamma_{ee} = 2.12 \pm 0.12$ keV

$\psi(2S)$ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
hadrons	(97.85 ± 0.13) %		–
virtual$\gamma \to$ hadrons	(2.16 ± 0.35) %	S=2.1	–
e^+e^-	$(7.55 \pm 0.31) \times 10^{-3}$		1843
$\mu^+\mu^-$	$(7.3 \pm 0.8) \times 10^{-3}$		1840
$\tau^+\tau^-$	$(2.8 \pm 0.7) \times 10^{-3}$		489
Decays into $J/\psi(1S)$ and anything			
$J/\psi(1S)$anything	(57.6 ± 2.0) %		–
$J/\psi(1S)$neutrals	(24.6 ± 1.2) %		–
$J/\psi(1S)\pi^+\pi^-$	(31.7 ± 1.1) %		477
$J/\psi(1S)\pi^0\pi^0$	(18.8 ± 1.2) %		481
$J/\psi(1S)\eta$	(3.16 ± 0.22) %		199
$J/\psi(1S)\pi^0$	$(9.6 \pm 2.1) \times 10^{-4}$		528
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
$\rho a_2(1320)$	$< 2.3 \times 10^{-4}$	CL=90%	1500
$\omega\pi^+\pi^-$	$(4.8 \pm 0.9) \times 10^{-4}$		1748
$b_1^\pm\pi^\mp$	$(3.2 \pm 0.8) \times 10^{-4}$		1635
$\omega f_2(1270)$	$< 1.5 \times 10^{-4}$	CL=90%	1515
$\pi^+\pi^-K^+K^-$	$(1.6 \pm 0.4) \times 10^{-3}$		1726
$K^*(892)\overline{K}{}^*_2(1430)^0$	$< 1.2 \times 10^{-4}$	CL=90%	1418
$K_1(1270)^\pm K^\mp$	$(1.00 \pm 0.28) \times 10^{-3}$		1581
$\pi^+\pi^-p\overline{p}$	$(8.0 \pm 2.0) \times 10^{-4}$		1491
$K^+\overline{K}{}^*(892)^0\pi^-$ + c.c.	$(6.7 \pm 2.5) \times 10^{-4}$		1674
$2(\pi^+\pi^-)$	$(4.5 \pm 1.0) \times 10^{-4}$		1817
$\rho^0\pi^+\pi^-$	$(4.2 \pm 1.5) \times 10^{-4}$		1750
ωK^+K^-	$(1.5 \pm 0.4) \times 10^{-4}$		1614
$\omega p\overline{p}$	$(8.0 \pm 3.2) \times 10^{-5}$		1247
$\overline{p}p$	$(2.07 \pm 0.31) \times 10^{-4}$		1586
$\Lambda\overline{\Lambda}$	$(1.81 \pm 0.34) \times 10^{-4}$		1467
$3(\pi^+\pi^-)$	$(1.5 \pm 1.0) \times 10^{-4}$		1774
$\overline{p}p\pi^0$	$(1.4 \pm 0.5) \times 10^{-4}$		1543
$\Delta^{++}\overline{\Delta}{}^{--}$	$(1.28 \pm 0.35) \times 10^{-4}$		1371
$\Sigma^0\overline{\Sigma}{}^0$	$(1.2 \pm 0.6) \times 10^{-4}$		1405
$\Sigma^{*+}\overline{\Sigma}{}^{*-}$	$(1.1 \pm 0.4) \times 10^{-4}$		1218
K^+K^-	$(1.0 \pm 0.7) \times 10^{-4}$		1776
$K^0_S K^0_L$	$(5.2 \pm 0.7) \times 10^{-5}$		1775
$\pi^+\pi^-\pi^0$	$(8 \pm 5) \times 10^{-5}$		1830
$\rho\pi$	$< 8.3 \times 10^{-5}$	CL=90%	1759
$\pi^+\pi^-$	$(8 \pm 5) \times 10^{-5}$		1838
$\Xi^-\overline{\Xi}{}^+$	$(9.4 \pm 3.1) \times 10^{-5}$		1285
$K_1(1400)^\pm K^\mp$	$< 3.1 \times 10^{-4}$	CL=90%	1532
$\Xi^{*0}\overline{\Xi}{}^{*0}$	$< 8.1 \times 10^{-5}$	CL=90%	1025
$\Omega^-\overline{\Omega}{}^+$	$< 7.3 \times 10^{-5}$	CL=90%	774
$K^+K^-\pi^0$	$< 2.96 \times 10^{-5}$	CL=90%	1754
$K^+\overline{K}{}^*(892)^-$ + c.c.	$< 5.4 \times 10^{-5}$	CL=90%	1698
$\phi\pi^+\pi^-$	$(1.50 \pm 0.28) \times 10^{-4}$		1690
$\phi f_0(980) \to \pi^+\pi^-$	$(6.0 \pm 2.2) \times 10^{-5}$		–
ϕK^+K^-	$(6.0 \pm 2.2) \times 10^{-5}$		1546
$\phi p\overline{p}$	$< 2.6 \times 10^{-5}$	CL=90%	1109
$\phi f'_2(1525)$	$< 4.5 \times 10^{-5}$	CL=90%	1321
Radiative decays			
$\gamma\chi_{c0}(1P)$	(8.6 ± 0.7) %		261
$\gamma\chi_{c1}(1P)$	(8.4 ± 0.8) %		171
$\gamma\chi_{c2}(1P)$	(6.4 ± 0.6) %		128
$\gamma\eta_c(1S)$	$(2.8 \pm 0.6) \times 10^{-3}$		639
$\gamma\eta'(958)$	$(1.5 \pm 0.4) \times 10^{-4}$		1719
$\gamma f_2(1270)$	$(2.1 \pm 0.4) \times 10^{-4}$		1622
$\gamma f_0(1710) \to \gamma\pi\pi$	$(3.0 \pm 1.3) \times 10^{-5}$		–
$\gamma f_0(1710) \to \gamma K\overline{K}$	$(6.0 \pm 1.6) \times 10^{-5}$		–
$\gamma\gamma$	$< 1.5 \times 10^{-4}$	CL=90%	1843
$\gamma\eta$	$< 9 \times 10^{-5}$	CL=90%	1802
$\gamma\eta(1405) \to \gamma K\overline{K}\pi$	$< 1.2 \times 10^{-4}$	CL=90%	1569

$\psi(3770)$

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

Mass $m = 3770.0 \pm 2.4$ 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		276
e^+e^-	$(1.12 \pm 0.17) \times 10^{-5}$	1.2	1885

$\psi(4040)$ [mmm]

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

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	577
$D^*(2007)^0\overline{D}{}^*(2007)^0$	seen	231

$\psi(4160)$ [mmm]

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

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^-	$(10 \pm 4) \times 10^{-6}$	2080

$\psi(4415)$ [mmm]

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

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^-	$(1.1 \pm 0.4) \times 10^{-5}$	2207

$b\overline{b}$ MESONS

$\Upsilon(1S)$

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

Mass $m = 9460.30 \pm 0.26$ MeV (S = 3.3)
Full width $\Gamma = 53.0 \pm 1.5$ keV
$\Gamma_{ee} = 1.314 \pm 0.029$ keV

$\Upsilon(1S)$ DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$\tau^+\tau^-$	$(2.67^{+0.14}_{-0.16})$ %		4384
e^+e^-	(2.38 ± 0.11) %		4730
$\mu^+\mu^-$	(2.48 ± 0.06) %		4729

Hadronic decays			
$\eta'(958)$ anything	(2.8 ± 0.4) %		–
$J/\psi(1S)$ anything	$(1.1 \pm 0.4) \times 10^{-3}$		4223
$\rho\pi$	$< 2 \times 10^{-4}$	90%	4697
$\pi^+\pi^-$	$< 5 \times 10^{-4}$	90%	4728
K^+K^-	$< 5 \times 10^{-4}$	90%	4704
$p\overline{p}$	$< 5 \times 10^{-4}$	90%	4636
$\pi^0\pi^+\pi^-$	$< 1.84 \times 10^{-5}$	90%	4725
Radiative decays			
$\gamma\pi^+\pi^-$	$(6.3 \pm 1.8) \times 10^{-5}$		4728
$\gamma\pi^0\pi^0$	$(1.7 \pm 0.7) \times 10^{-5}$		4728
$\gamma 2h^+ 2h^-$	$(7.0 \pm 1.5) \times 10^{-4}$		4720
$\gamma 3h^+ 3h^-$	$(5.4 \pm 2.0) \times 10^{-4}$		4703
$\gamma 4h^+ 4h^-$	$(7.4 \pm 3.5) \times 10^{-4}$		4679
$\gamma\pi^+\pi^- K^+K^-$	$(2.9 \pm 0.9) \times 10^{-4}$		4686
$\gamma 2\pi^+ 2\pi^-$	$(2.5 \pm 0.9) \times 10^{-4}$		4720
$\gamma 3\pi^+ 3\pi^-$	$(2.5 \pm 1.2) \times 10^{-4}$		4703
$\gamma 2\pi^+ 2\pi^- K^+K^-$	$(2.4 \pm 1.2) \times 10^{-4}$		4658
$\gamma\pi^+\pi^- p\overline{p}$	$(1.5 \pm 0.6) \times 10^{-4}$		4604
$\gamma 2\pi^+ 2\pi^- p\overline{p}$	$(4 \pm 6) \times 10^{-5}$		4563
$\gamma 2K^+ 2K^-$	$(2.0 \pm 2.0) \times 10^{-5}$		4601
$\gamma\eta'(958)$	$< 1.6 \times 10^{-5}$	90%	4682
$\gamma\eta$	$< 2.1 \times 10^{-5}$	90%	4714
$\gamma f'_2(1525)$	$< 1.4 \times 10^{-4}$	90%	4607
$\gamma f_2(1270)$	$(8 \pm 4) \times 10^{-5}$		4644
$\gamma\eta(1405)$	$< 8.2 \times 10^{-5}$	90%	4625
$\gamma f_0(1710) \to \gamma K\overline{K}$	$< 2.6 \times 10^{-4}$	90%	4576
$\gamma f_0(2200) \to \gamma K^+K^-$	$< 2 \times 10^{-4}$	90%	4475
$\gamma f_J(2220) \to \gamma K^+K^-$	$< 1.5 \times 10^{-5}$	90%	4469
$\gamma f_J(2220) \to \gamma\pi^+\pi^-$	$< 1.2 \times 10^{-5}$	90%	–
$\gamma f_J(2220) \to \gamma p\overline{p}$	$< 1.6 \times 10^{-5}$	90%	–
$\gamma\eta(2225) \to \gamma\phi\phi$	$< 3 \times 10^{-3}$	90%	4469
γX (X = pseudoscalar with $m <$ 7.2 GeV)	$< 3 \times 10^{-5}$	90%	–
$\gamma X\overline{X}$ ($X\overline{X}$ = vectors with $m <$ 3.1 GeV)	$< 1 \times 10^{-3}$	90%	–

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

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

Mass $m = 9859.9 \pm 1.0$ MeV

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

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

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

Mass $m = 9892.7 \pm 0.6$ MeV (S = 1.1)

$\chi_{b1}(1P)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\gamma\Upsilon(1S)$	(35 ± 8) %	423

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

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

Mass $m = 9912.6 \pm 0.5$ MeV (S = 1.1)

$\chi_{b2}(1P)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\gamma\Upsilon(1S)$	(22 ± 4) %	442

$\Upsilon(2S)$

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

Mass $m = 10.02326 \pm 0.00031$ GeV
Full width $\Gamma = 43 \pm 6$ keV
$\Gamma_{ee} = 0.576 \pm 0.024$ keV

$\Upsilon(2S)$ DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$\Upsilon(1S)\pi^+\pi^-$	(18.8 ± 0.6) %		475
$\Upsilon(1S)\pi^0\pi^0$	(9.0 ± 0.8) %		480
$\tau^+\tau^-$	(1.7 ± 1.6) %		4686
$\mu^+\mu^-$	(1.31 ± 0.21) %		5011
e^+e^-	(1.34 ± 0.20) %		5012
$\Upsilon(1S)\pi^0$	$< 1.1 \times 10^{-3}$	90%	531
$\Upsilon(1S)\eta$	$< 2 \times 10^{-3}$	90%	126
$J/\psi(1S)$ anything	$< 6 \times 10^{-3}$	90%	4533
Radiative decays			
$\gamma\chi_{b1}(1P)$	(6.8 ± 0.7) %		130
$\gamma\chi_{b2}(1P)$	(7.0 ± 0.6) %		110
$\gamma\chi_{b0}(1P)$	(3.8 ± 0.6) %		162
$\gamma f_0(1710)$	$< 5.9 \times 10^{-4}$	90%	4865
$\gamma f'_2(1525)$	$< 5.3 \times 10^{-4}$	90%	4896
$\gamma f_2(1270)$	$< 2.41 \times 10^{-4}$	90%	4930

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

$I^G(J^{PC}) = 0^+(0^{++})$
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) %	207
$\gamma\Upsilon(1S)$	$(9 \pm 6) \times 10^{-3}$	743

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

$I^G(J^{PC}) = 0^+(1^{++})$
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 ± 4) %	1.5	229
$\gamma\Upsilon(1S)$	(8.5 ± 1.3) %	1.3	764

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

$I^G(J^{PC}) = 0^+(2^{++})$
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 ± 1.0) %	776

$\Upsilon(3S)$

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

Mass $m = 10.3552 \pm 0.0005$ GeV
Full width $\Gamma = 26.3 \pm 3.4$ 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) %		813
$\Upsilon(1S)\pi^0\pi^0$	(2.06 ± 0.28) %		816
$\Upsilon(1S)\eta$	$< 2.2 \times 10^{-3}$	CL=90%	677
$\mu^+\mu^-$	(1.81 ± 0.17) %		5177
e^+e^-	seen		5178
Radiative decays			
$\gamma\chi_{b2}(2P)$	(11.4 ± 0.8) %	S=1.3	86
$\gamma\chi_{b1}(2P)$	(11.3 ± 0.6) %		100
$\gamma\chi_{b0}(2P)$	(5.4 ± 0.6) %	S=1.1	122

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

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

Mass $m = 10.5800 \pm 0.0035$ GeV
Full width $\Gamma = 20 \pm 4$ 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%	335
non-$B\overline{B}$	< 4 %	95%	–
e^+e^-	$(2.8 \pm 0.7) \times 10^{-5}$		5290
$J/\psi(1S)$ anything	$< 1.9 \times 10^{-4}$	95%	–

D^{*+} anything + c.c.	< 7.4	%	90%	5099
ϕanything	< 2.3	$\times 10^{-3}$	90%	5240
$\Upsilon(1S)$ anything	< 4	$\times 10^{-3}$	90%	1053
$\Upsilon(1S)\pi^+\pi^-$	< 1.2	$\times 10^{-4}$	90%	1027
$\Upsilon(2S)\pi^+\pi^-$	< 3.9	$\times 10^{-4}$	90%	469

Υ(10860)

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

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)

Υ(10860) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
e^+e^-	$(2.8\pm0.7) \times 10^{-6}$	5432

Υ(11020)

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

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

Υ(11020) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
e^+e^-	$(1.6\pm0.5) \times 10^{-6}$	5510

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

[c] See the $\pi^\pm$ Particle Listings for the energy limits used in this measurement; low-energy γ's are not included.

[d] Derived from an analysis of neutrino-oscillation experiments.

[e] Astrophysical and cosmological arguments give limits of order 10^{-13}; see the π^0 Particle Listings.

[f] Due to a new measurement in the average, this is 0.45 MeV larger than the mass we gave in our 2002 edition, 547.30 ± 0.12 MeV.

[g] Due to removing an old measurement from the average, this is 0.11 keV larger than the width we gave in our 2002 edition, 1.18 ± 0.11 keV. See the $\Gamma(2\gamma)$ data block in the Data Listings.

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

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

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

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

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

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

[n] This is only an educated guess; the error given is larger than the error on the average of the published values. See the Particle Listings for details.

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

[p] See the "Note on the $\eta(1405)$" in the $\eta(1405)$ Particle Listings.

[q] See the "Note on the $f_1(1420)$" in the $\eta(1405)$ Particle Listings.

[r] See also the $\omega(1650)$ Particle Listings.

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

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

[u] See the "Note on $f_0(1710)$" in the $f_0(1710)$ Particle Listings .

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

[w] 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):

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

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

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

[z] See the $K^\pm$ Particle Listings for the energy limits used in this measurement.

[aa] Structure-dependent part.

[bb] Direct-emission branching fraction.

[cc] Violates angular-momentum conservation.

[dd] 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."

[ee] 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):

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

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

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

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

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

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

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

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

[hh] $\text{Re}(\epsilon'/\epsilon) = \epsilon'/\epsilon$ to a very good approximation provided the phases satisfy CPT invariance.

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

[jj] Allowed by higher-order electroweak interactions.

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

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

[mm] 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 .

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

[oo] This result applies to $Z^0 \to c\overline{c}$ decays only. Here ℓ^+ is an average (not a sum) of e^+ and μ^+ decays.

[pp] 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.

[qq] 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^+.

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

[*ss*] 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.

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

[*uu*] This value includes only $\pi^+\pi^-$ decays of the intermediate resonance, because branching fractions of this resonance are not known.

[*vv*] Unseen decay modes of the resonance are included.

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

[*xx*] This $D^0_1 - D^0_2$ limit is inferred from the D^0-$\overline{D}^0$ mixing ratio $\Gamma(K^+\pi^-$ (via $\overline{D}^0$)) / $\Gamma(K^-\pi^+)$ near the end of the D^0 Listings.

[*yy*] The exclusive e^+ modes $K^-e^+\nu_e$, $K^-\pi^0e^+\nu_e$, $\overline{K}^0\pi^-e^+\nu_e$ and $\pi^-e^+\nu_e$ are constrained to equal this (well-measured) inclusive fraction.

[*zz*] 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.

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

[*bbb*] 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*.

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

[*ddd*] This value includes only K^+K^- decays of the intermediate resonance, because branching fractions of this resonance are not known.

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

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

[*ggg*] 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.

[*hhh*] $D^{(*)}\overline{D}^{(*)}$ stands for the sum of $D^*\overline{D}^*$, $D^*\overline{D}$, $D\overline{D}^*$, and $D\overline{D}$.

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

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

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

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

[*mmm*] 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.

[*nnn*] 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 ($S = C = B = 0$)

	$I^G(J^{PC})$
• $\pi^{\pm}$	$1^-(0^-)$
• π^0	$1^-(0^{-+})$
• η	$0^+(0^{-+})$
• $f_0(600)$	$0^+(0^{++})$
• $\rho(770)$	$1^+(1^{--})$
• $\omega(782)$	$0^-(1^{--})$
• $\eta'(958)$	$0^+(0^{-+})$
• $f_0(980)$	$0^+(0^{++})$
• $a_0(980)$	$1^-(0^{++})$
• $\phi(1020)$	$0^-(1^{--})$
• $h_1(1170)$	$0^-(1^{+-})$
• $b_1(1235)$	$1^+(1^{+-})$
• $a_1(1260)$	$1^-(1^{++})$
• $f_2(1270)$	$0^+(2^{++})$
• $f_1(1285)$	$0^+(1^{++})$
• $\eta(1295)$	$0^+(0^{-+})$
• $\pi(1300)$	$1^-(0^{-+})$
• $a_2(1320)$	$1^-(2^{++})$
• $f_0(1370)$	$0^+(0^{++})$
$h_1(1380)$	$?^-(1^{+-})$
• $\pi_1(1400)$	$1^-(1^{-+})$
• $\eta(1405)$	$0^+(0^{-+})$
• $f_1(1420)$	$0^+(1^{++})$
• $\omega(1420)$	$0^-(1^{--})$
$f_2(1430)$	$0^+(2^{++})$
• $a_0(1450)$	$1^-(0^{++})$
• $\rho(1450)$	$1^+(1^{--})$
• $\rho(1450)$	$0^+(0^{-+})$
• $f_0(1500)$	$0^+(0^{++})$
$f_1(1510)$	$0^+(1^{++})$
• $f_2'(1525)$	$0^+(2^{++})$
$f_2(1565)$	$0^+(2^{++})$
$h_1(1595)$	$0^-(1^{+-})$
• $\pi_1(1600)$	$1^-(1^{-+})$
$a_1(1640)$	$1^-(1^{++})$
$f_2(1640)$	$0^+(2^{++})$
• $\eta_2(1645)$	$0^+(2^{-+})$
• $\omega(1650)$	$0^-(1^{--})$
• $\omega_3(1670)$	$0^-(3^{--})$

	$I^G(J^{PC})$
• $\pi_2(1670)$	$1^-(2^{-+})$
• $\phi(1680)$	$0^-(1^{--})$
• $\rho_3(1690)$	$1^+(3^{--})$
• $\rho(1700)$	$1^+(1^{--})$
$a_2(1700)$	$1^-(2^{++})$
• $f_0(1710)$	$0^+(0^{++})$
$\eta(1760)$	$0^+(0^{-+})$
• $\pi(1800)$	$1^-(0^{-+})$
$f_2(1810)$	$0^+(2^{++})$
• $\phi_3(1850)$	$0^-(3^{--})$
$\eta_2(1870)$	$0^+(2^{-+})$
$\rho(1900)$	$1^+(1^{--})$
$f_2(1910)$	$0^+(2^{++})$
• $f_2(1950)$	$0^+(2^{++})$
$\rho_3(1990)$	$1^+(3^{--})$
• $f_2(2010)$	$0^+(2^{++})$
$f_0(2020)$	$0^+(0^{++})$
• $a_4(2040)$	$1^-(4^{++})$
• $f_4(2050)$	$0^+(4^{++})$
$\pi_2(2100)$	$1^-(2^{-+})$
$f_0(2100)$	$0^+(0^{++})$
$f_2(2150)$	$0^+(2^{++})$
$\rho(2150)$	$1^+(1^{--})$
$f_0(2200)$	$0^+(0^{++})$
$f_J(2220)$	$0^+(2^{++}$ or $4^{++})$
$\eta(2225)$	$0^+(0^{-+})$
$\rho_3(2250)$	$1^+(3^{--})$
• $f_2(2300)$	$0^+(2^{++})$
$f_4(2300)$	$0^+(4^{++})$
• $f_2(2340)$	$0^+(2^{++})$
$\rho_5(2350)$	$1^+(5^{--})$
$a_6(2450)$	$1^-(6^{++})$
$f_6(2510)$	$0^+(6^{++})$

OTHER LIGHT

Further States

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	$1/2(0^-)$
$K^*_0(800)$	$1/2(0^+)$
• $K^*(892)$	$1/2(1^-)$
• $K_1(1270)$	$1/2(1^+)$
• $K_1(1400)$	$1/2(1^+)$
• $K^*(1410)$	$1/2(1^-)$
• $K^*_0(1430)$	$1/2(0^+)$
• $K^*_2(1430)$	$1/2(2^+)$
$K(1460)$	$1/2(0^-)$
$K_2(1580)$	$1/2(2^-)$
$K(1630)$	$1/2(?^?)$
$K_1(1650)$	$1/2(1^+)$
• $K^*(1680)$	$1/2(1^-)$
• $K_2(1770)$	$1/2(2^-)$
• $K^*_3(1780)$	$1/2(3^-)$
• $K_2(1820)$	$1/2(2^-)$
$K(1830)$	$1/2(0^-)$
$K^*_0(1950)$	$1/2(0^+)$
$K^*_2(1980)$	$1/2(2^+)$
• $K^*_4(2045)$	$1/2(4^+)$
$K_2(2250)$	$1/2(2^-)$
$K_3(2320)$	$1/2(3^+)$
$K^*_5(2380)$	$1/2(5^-)$
$K_4(2500)$	$1/2(4^-)$
$K(3100)$	$?^?(?^{??})$

CHARMED ($C = \pm1$)

• $D^{\pm}$	$1/2(0^-)$
• D^0	$1/2(0^-)$
• $D^*(2007)^0$	$1/2(1^-)$
• $D^*(2010)^{\pm}$	$1/2(1^-)$
• $D_1(2420)^0$	$1/2(1^+)$
$D_1(2420)^{\pm}$	$1/2(?^?)$
• $D^*_2(2460)^0$	$1/2(2^+)$
• $D^*_2(2460)^{\pm}$	$1/2(2^+)$
$D^*(2640)^{\pm}$	$1/2(?^?)$

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

• $D^{\pm}_s$	$0(0^-)$
• $D^{*\pm}_s$	$0(?^?)$
• $D^*_{sJ}(2317)^{\pm}$	$0(0^+)$
• $D_{sJ}(2460)^{\pm}$	$0(1^+)$
• $D_{s1}(2536)^{\pm}$	$0(1^+)$
• $D_{s2}(2573)^{\pm}$	$0(?^?)$

BOTTOM ($B = \pm1$)

	$I^G(J^{PC})$
• $B^{\pm}$	$1/2(0^-)$
• B^0	$1/2(0^-)$
• $B^{\pm}/B^0$ ADMIXTURE	
• $B^{\pm}/B^0/B^0_s/b$-baryon ADMIXTURE	
V_{cb} and V_{ub} CKM Matrix Elements	
• B^*	$1/2(1^-)$
$B^*_J(5732)$	$?(?^?)$

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

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

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

• $B^{\pm}_c$	$0(0^-)$

$c\overline{c}$

• $\eta_c(1S)$	$0^+(0^{-+})$
• $J/\psi(1S)$	$0^-(1^{--})$
• $\chi_{c0}(1P)$	$0^+(0^{++})$
• $\chi_{c1}(1P)$	$0^+(1^{++})$
$h_c(1P)$	$?^?(?^{??})$
• $\chi_{c2}(1P)$	$0^+(2^{++})$
$\eta_c(2S)$	$0^+(0^{-+})$
• $\psi(2S)$	$0^-(1^{--})$
• $\psi(3770)$	$0^-(1^{--})$
$\psi(3836)$	$0^-(2^{--})$
$X(3872)$	$?^?(?^?)$
• $\psi(4040)$	$0^-(1^{--})$
• $\psi(4160)$	$0^-(1^{--})$
• $\psi(4415)$	$0^-(1^{--})$

$b\overline{b}$

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

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. For N, Δ, and Ξ resonances, the partial wave is indicated by the symbol $L_{2I,2J}$, where L is the orbital angular momuntum (S, P, D, ...), I is the isospin, and J is the total angular momentum. For Λ and Σ resonances, the symbol is $L_{I,2J}$.

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}	**	$\Lambda_c(2765)^+$		*
$N(2700)$	$K_{1,13}$	**							$\Sigma(2100)$	G_{17}	*	$\Lambda_c(2880)^+$		**
			$\Theta(1540)^+$		***				$\Sigma(2250)$		***	$\Sigma_c(2455)$		****
			$\Phi(1860)$		*				$\Sigma(2455)$		**	$\Sigma_c(2520)$		***
									$\Sigma(2620)$		**	Ξ_c^+		***
									$\Sigma(3000)$		*	Ξ_c^0		***
									$\Sigma(3170)$		*	$\Xi_c'^+$		***
												$\Xi_c'^0$		***
												$\Xi_c(2645)$		***
												$\Xi_c(2790)$		***
												$\Xi_c(2815)$		***
												Ω_c^0		***
												Ξ_{cc}^+		*
												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, $N^+ = uud$; n, $N^0 = udd$

p

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

Mass $m = 1.00727646688 \pm 0.00000000013$ u
Mass $m = 938.27203 \pm 0.00008$ MeV [a]
$\left|m_p - m_{\overline{p}}\right|/m_p < 1.0 \times 10^{-8}$, CL = 90% [b]
$\left|\frac{q_{\overline{p}}}{m_{\overline{p}}}\right|/(\frac{q_p}{m_p}) = 0.99999999991 \pm 0.00000000009$
$\left|q_p + q_{\overline{p}}\right|/e < 1.0 \times 10^{-8}$, CL = 90% [b]
$\left|q_p + q_e\right|/e < 1.0 \times 10^{-21}$ [c]
Magnetic moment $\mu = 2.792847351 \pm 0.000000028\ \mu_N$
$(\mu_p + \mu_{\overline{p}}) / \mu_p = (-2.6 \pm 2.9) \times 10^{-3}$
Electric dipole moment $d < 0.54 \times 10^{-23}$ e cm
Electric polarizability $\alpha = (12.0 \pm 0.6) \times 10^{-4}$ fm^3
Magnetic polarizability $\beta = (1.9 \pm 0.5) \times 10^{-4}$ fm^3
Charge radius $= 0.870 \pm 0.008$ fm
Mean life $\tau > 2.1 \times 10^{29}$ years, CL = 90% ($p \rightarrow$ invisible mode)
Mean life $\tau > 10^{31}$ to 10^{33} years [d] (mode dependent)

See the "Note on Nucleon Decay" in our 1994 edition (Phys. Rev. **D50**, 1673) for a short review.

The "partial mean life" limits tabulated here are the limits on τ/B_i, where τ is the total mean life and B_i is the branching fraction for the mode in question. For N decays, p and n indicate proton and neutron partial lifetimes.

p DECAY MODES	Partial mean life (10^{30} years)	Confidence level	p (MeV/c)
	Antilepton + meson		
$N \rightarrow e^+\pi$	> 158 (n), > 1600 (p)	90%	459
$N \rightarrow \mu^+\pi$	> 100 (n), > 473 (p)	90%	453
$N \rightarrow \nu\pi$	> 112 (n), > 25 (p)	90%	459
$p \rightarrow e^+\eta$	> 313	90%	309
$p \rightarrow \mu^+\eta$	> 126	90%	297
$n \rightarrow \nu\eta$	> 158	90%	310
$N \rightarrow e^+\rho$	> 217 (n), > 75 (p)	90%	148
$N \rightarrow \mu^+\rho$	> 228 (n), > 110 (p)	90%	113
$N \rightarrow \nu\rho$	> 19 (n), > 162 (p)	90%	148
$p \rightarrow e^+\omega$	> 107	90%	143
$p \rightarrow \mu^+\omega$	> 117	90%	105
$n \rightarrow \nu\omega$	> 108	90%	144
$N \rightarrow e^+K$	> 17 (n), > 150 (p)	90%	339
$p \rightarrow e^+K^0_S$	> 120	90%	337
$p \rightarrow e^+K^0_L$	> 51	90%	337
$N \rightarrow \mu^+K$	> 26 (n), > 120 (p)	90%	329
$p \rightarrow \mu^+K^0_S$	> 150	90%	326
$p \rightarrow \mu^+K^0_L$	> 83	90%	326
$N \rightarrow \nu K$	> 86 (n), > 670 (p)	90%	339
$n \rightarrow \nu K^0_S$	> 51	90%	338
$p \rightarrow e^+K^*(892)^0$	> 84	90%	45
$N \rightarrow \nu K^*(892)$	> 78 (n), > 51 (p)	90%	45
	Antilepton + mesons		
$p \rightarrow e^+\pi^+\pi^-$	> 82	90%	448
$p \rightarrow e^+\pi^0\pi^0$	> 147	90%	449
$n \rightarrow e^+\pi^-\pi^0$	> 52	90%	449
$p \rightarrow \mu^+\pi^+\pi^-$	> 133	90%	425
$p \rightarrow \mu^+\pi^0\pi^0$	> 101	90%	427
$n \rightarrow \mu^+\pi^-\pi^0$	> 74	90%	427
$n \rightarrow e^+K^0\pi^-$	> 18	90%	319
	Lepton + meson		
$n \rightarrow e^-\pi^+$	> 65	90%	459
$n \rightarrow \mu^-\pi^+$	> 49	90%	453
$n \rightarrow e^-\rho^+$	> 62	90%	149
$n \rightarrow \mu^-\rho^+$	> 7	90%	114
$n \rightarrow e^-K^+$	> 32	90%	340
$n \rightarrow \mu^-K^+$	> 57	90%	330
	Lepton + mesons		
$p \rightarrow e^-\pi^+\pi^+$	> 30	90%	448
$n \rightarrow e^-\pi^+\pi^0$	> 29	90%	449
$p \rightarrow \mu^-\pi^+\pi^+$	> 17	90%	425
$n \rightarrow \mu^-\pi^+\pi^0$	> 34	90%	427
$p \rightarrow e^-\pi^+K^+$	> 75	90%	320
$p \rightarrow \mu^-\pi^+K^+$	> 245	90%	279
	Antilepton + photon(s)		
$p \rightarrow e^+\gamma$	> 670	90%	469
$p \rightarrow \mu^+\gamma$	> 478	90%	463
$n \rightarrow \nu\gamma$	> 28	90%	470
$p \rightarrow e^+\gamma\gamma$	> 100	90%	469
$n \rightarrow \nu\gamma\gamma$	> 219	90%	470
	Three (or more) leptons		
$p \rightarrow e^+e^+e^-$	> 793	90%	469
$p \rightarrow e^+\mu^+\mu^-$	> 359	90%	457
$p \rightarrow e^+\nu\nu$	> 17	90%	469
$n \rightarrow e^+e^-\nu$	> 257	90%	470
$n \rightarrow \mu^+e^-\nu$	> 83	90%	464
$n \rightarrow \mu^+\mu^-\nu$	> 79	90%	458
$p \rightarrow \mu^+e^+e^-$	> 529	90%	463
$p \rightarrow \mu^+\mu^+\mu^-$	> 675	90%	439
$p \rightarrow \mu^+\nu\nu$	> 21	90%	463
$p \rightarrow e^-\mu^+\mu^+$	> 6	90%	457
$n \rightarrow 3\nu$	> 0.0005	90%	470
	Inclusive modes		
$N \rightarrow e^+$ anything	> 0.6 (n, p)	90%	–
$N \rightarrow \mu^+$ anything	> 12 (n, p)	90%	–
$N \rightarrow e^+\pi^0$ anything	> 0.6 (n, p)	90%	–
	$\Delta B = 2$ dinucleon modes		
	The following are lifetime limits per iron nucleus.		
$pp \rightarrow \pi^+\pi^+$	> 0.7	90%	–
$pn \rightarrow \pi^+\pi^0$	> 2	90%	–
$nn \rightarrow \pi^+\pi^-$	> 0.7	90%	–
$nn \rightarrow \pi^0\pi^0$	> 3.4	90%	–
$pp \rightarrow e^+e^+$	> 5.8	90%	–
$pp \rightarrow e^+\mu^+$	> 3.6	90%	–
$pp \rightarrow \mu^+\mu^+$	> 1.7	90%	–
$pn \rightarrow e^+\overline{\nu}$	> 2.8	90%	–
$pn \rightarrow \mu^+\overline{\nu}$	> 1.6	90%	–
$nn \rightarrow \nu_e\overline{\nu}_e$	> 0.000049	90%	–
$pp \rightarrow$ neutrinos	> 0.00005	90%	–

$\overline{p}$ DECAY MODES

$\overline{p}$ DECAY MODES	Partial mean life (years)	Confidence level	p (MeV/c)
$\overline{p} \rightarrow e^-\gamma$	$> 7 \times 10^5$	90%	469
$\overline{p} \rightarrow \mu^-\gamma$	$> 5 \times 10^4$	90%	463
$\overline{p} \rightarrow e^-\pi^0$	$> 4 \times 10^5$	90%	459
$\overline{p} \rightarrow \mu^-\pi^0$	$> 5 \times 10^4$	90%	453
$\overline{p} \rightarrow e^-\eta$	$> 2 \times 10^4$	90%	309
$\overline{p} \rightarrow \mu^-\eta$	$> 8 \times 10^3$	90%	297
$\overline{p} \rightarrow e^-K^0_S$	> 900	90%	337
$\overline{p} \rightarrow \mu^-K^0_S$	$> 4 \times 10^3$	90%	326
$\overline{p} \rightarrow e^-K^0_L$	$> 9 \times 10^3$	90%	337
$\overline{p} \rightarrow \mu^-K^0_L$	$> 7 \times 10^3$	90%	326
$\overline{p} \rightarrow e^-\gamma\gamma$	$> 2 \times 10^4$	90%	469
$\overline{p} \rightarrow \mu^-\gamma\gamma$	$> 2 \times 10^4$	90%	463
$\overline{p} \rightarrow e^-\omega$	> 200	90%	143

n

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

Mass $m = 1.0086649156 \pm 0.0000000006$ u
Mass $m = 939.56536 \pm 0.00008$ MeV [a]
$m_n - m_p = 1.2933317 \pm 0.0000005$ MeV
$= 0.0013884487 \pm 0.0000000006$ u
Mean life $\tau = 885.7 \pm 0.8$ s
$c\tau = 2.655 \times 10^8$ km
Magnetic moment $\mu = -1.9130427 \pm 0.0000005\ \mu_N$
Electric dipole moment $d < 0.63 \times 10^{-25}$ e cm, CL = 90%
Mean-square charge radius $\langle r_n^2 \rangle = -0.1161 \pm 0.0022$ fm^2 (S = 1.3)
Electric polarizability $\alpha = (11.6 \pm 1.5) \times 10^{-4}$ fm^3
Magnetic polarizability $\beta = (3.7 \pm 2.0) \times 10^{-4}$ fm^3
Charge $q = (-0.4 \pm 1.1) \times 10^{-21}$ e
Mean $n\overline{n}$-oscillation time $> 8.6 \times 10^7$ s, CL = 90% (free n)
Mean $n\overline{n}$-oscillation time $> 1.3 \times 10^8$ s, CL = 90% [e] (bound n)

Decay parameters [f]

$p e^- \overline{\nu}_e$	$\lambda \equiv g_A / g_V = -1.2695 \pm 0.0029$ (S = 2.0)
"	$A = -0.1173 \pm 0.0013$ (S = 2.3)
"	$B = 0.983 \pm 0.004$
"	$a = -0.103 \pm 0.004$
"	$\phi_{AV} = (180.08 \pm 0.10)^\circ$ [g]
"	$D = (-0.6 \pm 1.0) \times 10^{-3}$

***n* DECAY MODES**		Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$p e^- \overline{\nu}_e$		100 %		1
$p e^- \overline{\nu}_e \gamma$	[h]	$< 6.9 \times 10^{-3}$	90%	1
Charge conservation (*Q*) violating mode				
$p \nu_e \overline{\nu}_e$	Q	$< 8 \times 10^{-27}$	68%	1

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
$p_{beam} = 0.61$ GeV/c $4\pi\lambda\!\!\!^{-2} = 31.0$ 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 %	398
$N\pi\pi$	30–40 %	347
$\Delta\pi$	20–30 %	147
$N\rho$	<8 %	†
$N(\pi\pi)^{I=0}_{S\text{-wave}}$	5–10 %	–
$p\gamma$	0.035–0.048 %	414
$p\gamma$, helicity=1/2	0.035–0.048 %	414
$n\gamma$	0.009–0.032 %	413
$n\gamma$, helicity=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
$p_{beam} = 0.74$ GeV/c $4\pi\lambda\!\!\!^{-2} = 23.5$ 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 %	457
$N\eta$	$(2.3\pm0.4) \times 10^{-3}$	154
$N\pi\pi$	40–50 %	414
$\Delta\pi$	15–25 %	230
$N\rho$	15–25 %	†
$N(\pi\pi)^{I=0}_{S\text{-wave}}$	<8 %	–
$p\gamma$	0.46–0.56 %	470
$p\gamma$, helicity=1/2	0.001–0.034 %	470
$p\gamma$, helicity=3/2	0.44–0.53 %	470
$n\gamma$	0.30–0.53 %	470
$n\gamma$, helicity=1/2	0.04–0.10 %	470
$n\gamma$, helicity=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 200 (≈ 150) MeV
$p_{beam} = 0.76$ GeV/c $4\pi\lambda\!\!\!^{-2} = 22.5$ 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 %	468
$N\eta$	30–55 %	186
$N\pi\pi$	1–10 %	426
$\Delta\pi$	<1 %	244
$N\rho$	<4 %	†
$N(\pi\pi)^{I=0}_{S\text{-wave}}$	<3 %	–
$N(1440)\pi$	<7 %	†
$p\gamma$	0.15–0.35 %	481
$p\gamma$, helicity=1/2	0.15–0.35 %	481
$n\gamma$	0.004–0.29 %	480
$n\gamma$, helicity=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
$p_{beam} = 0.96$ GeV/c $4\pi\lambda\!\!\!^{-2} = 16.4$ 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 %	348
ΛK	3–11 %	169
$N\pi\pi$	10–20 %	514
$\Delta\pi$	1–7 %	345
$N\rho$	4–12 %	†
$N(\pi\pi)^{I=0}_{S\text{-wave}}$	<4 %	–
$N(1440)\pi$	<5 %	150
$p\gamma$	0.04–0.18 %	558
$p\gamma$, helicity=1/2	0.04–0.18 %	558
$n\gamma$	0.003–0.17 %	557
$n\gamma$, helicity=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
$p_{beam} = 1.01$ GeV/c $4\pi\lambda\!\!\!^{-2} = 15.4$ 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 %	564
$N\eta$	(0.0 ± 1.0) %	376
ΛK	<1 %	216
$N\pi\pi$	50–60 %	532
$\Delta\pi$	50–60 %	366
$N\rho$	< 1–3 %	†
$p\gamma$	0.004–0.023 %	575
$p\gamma$, helicity=1/2	0.0–0.015 %	575
$p\gamma$, helicity=3/2	0.0–0.011 %	575
$n\gamma$	0.02–0.12 %	574
$n\gamma$, helicity=1/2	0.006–0.046 %	574
$n\gamma$, helicity=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_{beam} = 1.01 GeV/c $4\pi\lambda\!\!\!^{-2}$ = 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 %	568
$N\eta$	(0.0±1.0) %	381
$N\pi\pi$	30–40 %	535
$\Delta\pi$	5–15 %	370
$N\rho$	3–15 %	†
$N(\pi\pi)^{I=0}_{S\text{-wave}}$	5–20 %	–
$p\gamma$	0.21–0.32 %	578
$p\gamma$, helicity=1/2	0.001–0.011 %	578
$p\gamma$, helicity=3/2	0.20–0.32 %	578
$n\gamma$	0.021–0.046 %	577
$n\gamma$, helicity=1/2	0.004–0.029 %	577
$n\gamma$, helicity=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 %	581
$N\eta$	(0.0±1.0) %	402
ΛK	<3 %	255
$N\pi\pi$	85–95 %	550
$N\rho$	<35 %	†
$p\gamma$	0.01–0.05 %	591
$p\gamma$, helicity=1/2	0.0–0.024 %	591
$p\gamma$, helicity=3/2	0.002–0.026 %	591
$n\gamma$	0.01–0.13 %	590
$n\gamma$, helicity=1/2	0.0–0.09 %	590
$n\gamma$, helicity=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 %	588
$N\eta$	(6.2±1.0) %	412
$N\omega$	(13.0±2.0) %	†
ΛK	5–25 %	269
$N\pi\pi$	40–90 %	557
$\Delta\pi$	15–40 %	394
$N\rho$	5–25 %	†
$N(\pi\pi)^{I=0}_{S\text{-wave}}$	10–40 %	–
$p\gamma$	0.002–0.05%	598
$p\gamma$, helicity=1/2	0.002–0.05%	598
$n\gamma$	0.0–0.02%	597
$n\gamma$, helicity=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
$N\eta$	(4.0±1.0) %	422
ΛK	1–15 %	283
$N\pi\pi$	>70 %	564
$N\rho$	70–85 %	71
$p\gamma$	0.003–0.10 %	604
$p\gamma$, helicity=1/2	0.003–0.08 %	604
$p\gamma$, helicity=3/2	0.001–0.03 %	604
$n\gamma$	0.002–0.39 %	603
$n\gamma$, helicity=1/2	0.0–0.002 %	603
$n\gamma$, helicity=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
$N\eta$	(0.0±1.0) %	791

$N(2220)\ H_{19}$

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

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 %	906

$N(2250)\ G_{19}$

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

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 %	924

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

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

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)

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

Δ(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 %	229
$N\gamma$	0.52–0.60 %	259
$N\gamma$, helicity=1/2	0.11–0.13 %	259
$N\gamma$, helicity=3/2	0.41–0.47 %	259

Δ(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 %	513
$N\pi\pi$	75–90 %	477
$\Delta\pi$	40–70 %	303
$N\rho$	<25 %	†
$N(1440)\pi$	10–35 %	82
$N\gamma$	0.001–0.02 %	525
$N\gamma$, helicity=1/2	0.0–0.02 %	525
$N\gamma$, helicity=3/2	0.001–0.005 %	525

Δ(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
$p_{beam} = 0.91$ 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 %	527
$N\pi\pi$	70–80 %	492
$\Delta\pi$	30–60 %	320
$N\rho$	7–25 %	†
$N\gamma$	0.004–0.044 %	538
$N\gamma$, helicity=1/2	0.004–0.044 %	538

Δ(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
$p_{beam} = 1.05$ 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 %	581
$N\pi\pi$	80–90 %	550
$\Delta\pi$	30–60 %	386
$N\rho$	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

Δ(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
$p_{beam} = 1.45$ 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 %	714
$N\pi\pi$	85–95 %	690
$\Delta\pi$	<25 %	542
$N\rho$	>60 %	414
$N\gamma$	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

Δ(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
$p_{beam} = 1.46$ 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 %	717
$N\gamma$	0.0–0.2 %	725
$N\gamma$, helicity=1/2	0.0–0.2 %	725

Δ(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
$p_{beam} = 1.48$ 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 %	723
ΣK	(2.10±0.30) %	431

Δ(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
$p_{beam} = 1.50$ 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

Δ(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
$p_{beam} = 1.54$ 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 %	742
$N\pi\pi$		719
$\Delta\pi$	20–30 %	575
$N\rho$	<10 %	463
$N\gamma$	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_{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

EXOTIC BARYONS

Minimum quark content: $\Theta^+ = uudd\overline{s}$, $\Phi^{--} = ssdd\overline{u}$, $\Phi^+ = ssuu\overline{d}$.

$\Theta(1540)^+$

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

It is difficult to deny a place in the Summary Tables for a state that six experiments claim to have seen. Nevertheless, we believe it reasonable to have some reservations about the existence of this state on the basis of the present evidence.

Mass m = 1539.2 ± 1.6 MeV
Full width Γ = 0.90 ± 0.30 MeV

NK is the only strong decay mode allowed for a strangeness S=+1 resonance of this mass.

$\Theta(1540)^+$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
KN	100%	270

Λ BARYONS $(S=-1, I=0)$

$\Lambda^0 = uds$

Λ

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

Mass m = 1115.683 ± 0.006 MeV
$(m_\Lambda - m_{\overline{\Lambda}}) / m_\Lambda = (-0.1 \pm 1.1) \times 10^{-5}$ (S = 1.6)
Mean life $\tau = (2.632 \pm 0.020) \times 10^{-10}$ s (S = 1.6)
$c\tau$ = 7.89 cm
Magnetic moment $\mu = -0.613 \pm 0.004\ \mu_N$
Electric dipole moment $d < 1.5 \times 10^{-16}$ $e$cm, CL = 95%

Decay parameters

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

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±0.15) × 10^{-3}	162
$p\pi^-\gamma$	[j] (8.4 ±1.4) × 10^{-4}	101
$pe^-\overline{\nu}_e$	(8.32±0.14) × 10^{-4}	163
$p\mu^-\overline{\nu}_\mu$	(1.57±0.35) × 10^{-4}	131

$\Lambda(1405)$ S_{01}

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

Mass m = 1406 ± 4 MeV
Full width Γ = 50.0 ± 2.0 MeV
Below $\overline{K}N$ threshold

Λ(1405) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\Sigma\pi$	100 %	157

$\Lambda(1520)$ D_{03}

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

Mass m = 1519.5 ± 1.0 MeV [k]
Full width Γ = 15.6 ± 1.0 MeV [k]
p_{beam} = 0.39 GeV/c $4\pi\lambda^2$ = 82.8 mb

Λ(1520) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\overline{K}$	45 ± 1%	243
$\Sigma\pi$	42 ± 1%	268
$\Lambda\pi\pi$	10 ± 1%	259
$\Sigma\pi\pi$	0.9 ± 0.1%	169
$\Lambda\gamma$	0.8 ± 0.2%	350

$\Lambda(1600)$ P_{01}

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

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

Λ(1600) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\overline{K}$	15–30 %	343
$\Sigma\pi$	10–60 %	338

$\Lambda(1670)$ S_{01}

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

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

Λ(1670) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\overline{K}$	20–30 %	414
$\Sigma\pi$	25–55 %	394
$\Lambda\eta$	10–25 %	70

$\Lambda(1690)$ D_{03}

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

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

Λ(1690) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\overline{K}$	20–30 %	433
$\Sigma\pi$	20–40 %	410
$\Lambda\pi\pi$	~ 25 %	419
$\Sigma\pi\pi$	~ 20 %	358

$\Lambda(1800)$ S_{01}

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

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

Λ(1800) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\overline{K}$	25–40 %	528
$\Sigma\pi$	seen	494
$\Sigma(1385)\pi$	seen	349
$N\overline{K}^*(892)$	seen	†

$\Lambda(1810)$ P_{01}

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

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

Λ(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	357
$N\overline{K}^*(892)$	30–60 %	†

$\Lambda(1820)$ F_{05}

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

Mass m = 1815 to 1825 ($\approx$ 1820) MeV
Full width Γ = 70 to 90 ($\approx$ 80) MeV
p_{beam} = 1.06 GeV/c $\quad 4\pi\bar{\lambda}^2$ = 16.5 mb

Λ(1820) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\overline{K}$	55–65 %	545
$\Sigma\pi$	8–14 %	509
$\Sigma(1385)\pi$	5–10 %	366

$\Lambda(1830)$ D_{05}

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

Mass m = 1810 to 1830 ($\approx$ 1830) MeV
Full width Γ = 60 to 110 ($\approx$ 95) MeV
p_{beam} = 1.08 GeV/c $\quad 4\pi\bar{\lambda}^2$ = 16.0 mb

Λ(1830) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\overline{K}$	3–10 %	553
$\Sigma\pi$	35–75 %	516
$\Sigma(1385)\pi$	>15 %	374

$\Lambda(1890)$ P_{03}

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

Mass m = 1850 to 1910 ($\approx$ 1890) MeV
Full width Γ = 60 to 200 ($\approx$ 100) MeV
p_{beam} = 1.21 GeV/c $\quad 4\pi\bar{\lambda}^2$ = 13.6 mb

Λ(1890) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\overline{K}$	20–35 %	599
$\Sigma\pi$	3–10 %	560
$\Sigma(1385)\pi$	seen	423
$N\overline{K}^*(892)$	seen	236

$\Lambda(2100)$ G_{07}

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

Mass m = 2090 to 2110 ($\approx$ 2100) MeV
Full width Γ = 100 to 250 ($\approx$ 200) MeV
p_{beam} = 1.68 GeV/c $\quad 4\pi\bar{\lambda}^2$ = 8.68 mb

Λ(2100) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\overline{K}$	25–35 %	751
$\Sigma\pi$	$\sim$ 5 %	705
$\Lambda\eta$	<3 %	617
ΞK	<3 %	491
$\Lambda\omega$	<8 %	443
$N\overline{K}^*(892)$	10–20 %	515

$\Lambda(2110)$ F_{05}

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

Mass m = 2090 to 2140 ($\approx$ 2110) MeV
Full width Γ = 150 to 250 ($\approx$ 200) MeV
p_{beam} = 1.70 GeV/c $\quad 4\pi\bar{\lambda}^2$ = 8.53 mb

Λ(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	591
$N\overline{K}^*(892)$	10–60 %	525

$\Lambda(2350)$ H_{09}

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

Mass m = 2340 to 2370 ($\approx$ 2350) MeV
Full width Γ = 100 to 250 ($\approx$ 150) MeV
p_{beam} = 2.29 GeV/c $\quad 4\pi\bar{\lambda}^2$ = 5.85 mb

Λ(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 τ = (0.8018 $\pm$ 0.0026) $\times 10^{-10}$ s
$c\tau$ = 2.404 cm
$(\tau_{\Sigma^+} - \tau_{\overline{\Sigma}^-}) / \tau_{\Sigma^+} = (-0.6 \pm 1.2) \times 10^{-3}$
Magnetic moment μ = 2.458 $\pm$ 0.010 μ_N (S = 2.1)
$\Gamma(\Sigma^+ \rightarrow n\ell^+\nu)/\Gamma(\Sigma^- \rightarrow n\ell^-\overline{\nu}) < 0.043$

Decay parameters

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

Σ^+ DECAY MODES		Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$p\pi^0$		(51.57$\pm$0.30) %		189
$n\pi^+$		(48.31$\pm$0.30) %		185
$p\gamma$		(1.23$\pm$0.05) $\times 10^{-3}$		225
$n\pi^+\gamma$	[j]	(4.5 $\pm$0.5) $\times 10^{-4}$		185
$\Lambda e^+\nu_e$		(2.0 $\pm$0.5) $\times 10^{-5}$		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 τ = (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 μ_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^-	[l]	5 $\times 10^{-3}$		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 τ = (1.479 $\pm$ 0.011) $\times 10^{-10}$ s (S = 1.3)
$c\tau$ = 4.434 cm
Magnetic moment μ = -1.160 ± 0.025 μ_N (S = 1.7)
Σ^- charge radius = 0.78 $\pm$ 0.10 fm

Decay parameters

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

Σ^- DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$n\pi^-$	(99.848 ± 0.005) %	193
$n\pi^-\gamma$	[j] $(4.6 \pm 0.6) \times 10^{-4}$	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 %	129

$\Sigma(1660)$ P_{11}

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

Mass $m = 1630$ to 1690 (≈ 1660) MeV
Full width $\Gamma = 40$ to 200 (≈ 100) MeV
$p_{\text{beam}} = 0.72$ 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	440
$\Sigma\pi$	seen	387

$\Sigma(1670)$ D_{13}

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

Mass $m = 1665$ to 1685 (≈ 1670) MeV
Full width $\Gamma = 40$ to 80 (≈ 60) MeV
$p_{\text{beam}} = 0.74$ 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 %	448
$\Sigma\pi$	30–60 %	394

$\Sigma(1750)$ S_{11}

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

Mass $m = 1730$ to 1800 (≈ 1750) MeV
Full width $\Gamma = 60$ to 160 (≈ 90) MeV
$p_{\text{beam}} = 0.91$ 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 %	456
$\Sigma\eta$	15–55 %	99

$\Sigma(1775)$ D_{15}

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

Mass $m = 1770$ to 1780 (≈ 1775) MeV
Full width $\Gamma = 105$ to 135 (≈ 120) MeV
$p_{\text{beam}} = 0.96$ 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%	475
$\Sigma(1385)\pi$	8–12%	327
$\Lambda(1520)\pi$	17–23%	201

$\Sigma(1915)$ F_{15}

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

Mass $m = 1900$ to 1935 (≈ 1915) MeV
Full width $\Gamma = 80$ to 160 (≈ 120) MeV
$p_{\text{beam}} = 1.26$ 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	623
$\Sigma\pi$	seen	577
$\Sigma(1385)\pi$	<5 %	443

$\Sigma(1940)$ D_{13}

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

Mass $m = 1900$ to 1950 (≈ 1940) MeV
Full width $\Gamma = 150$ to 300 (≈ 220) MeV
$p_{\text{beam}} = 1.32$ 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	640
$\Sigma\pi$	seen	595
$\Sigma(1385)\pi$	seen	463
$\Lambda(1520)\pi$	seen	355
$\Delta(1232)\overline{K}$	seen	410
$N\overline{K}^*(892)$	seen	322

$\Sigma(2030)$ F_{17}

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

Mass $m = 2025$ to 2040 (≈ 2030) MeV
Full width $\Gamma = 150$ to 200 (≈ 180) MeV
$p_{\text{beam}} = 1.52$ 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 %	422
$\Sigma(1385)\pi$	5–15 %	532
$\Lambda(1520)\pi$	10–20 %	430
$\Delta(1232)\overline{K}$	10–20 %	498
$N\overline{K}^*(892)$	<5 %	439

$\Sigma(2250)$

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

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

$\Sigma(2250)$ 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 $m = 1314.83 \pm 0.20$ MeV
$m_{\Xi^-} - m_{\Xi^0} = 6.48 \pm 0.24$ 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)
"	$\phi = (21 \pm 12)^\circ$
"	$\gamma = 0.85$ [i]
"	$\Delta = (218^{+12}_{-19})^\circ$ [i]
$\Lambda\gamma$	$\alpha = -0.4 \pm 0.4$
$\Sigma^0\gamma$	$\alpha = -0.63 \pm 0.09$
$\Sigma^+ e^- \overline{\nu}_e$	$g_1(0)/f_1(0) = 1.32^{+0.22}_{-0.18}$
$\Sigma^+ e^- \overline{\nu}_e$	$f_2(0)/f_1(0) = 2.0 \pm 1.3$

Ξ^0 DECAY MODES		Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
$\Lambda\pi^0$		(99.522 ± 0.032) %	S=1.7	135
$\Lambda\gamma$		$(1.18 \pm 0.30) \times 10^{-3}$	S=2.0	184
$\Sigma^0\gamma$		$(3.33 \pm 0.10) \times 10^{-3}$		117
$\Sigma^+ e^- \overline{\nu}_e$		$(2.7 \pm 0.4) \times 10^{-4}$		119
$\Sigma^+ \mu^- \overline{\nu}_\mu$		$< 1.1 \times 10^{-3}$	CL=90%	64
$\Delta S = \Delta Q$ (SQ) violating modes or $\Delta S = 2$ forbidden ($S2$) modes				
$\Sigma^- e^+ \nu_e$	SQ	$< 9 \times 10^{-4}$	CL=90%	112
$\Sigma^- \mu^+ \nu_\mu$	SQ	$< 9 \times 10^{-4}$	CL=90%	49
$p\pi^-$	$S2$	$< 4 \times 10^{-5}$	CL=90%	299
$p e^- \overline{\nu}_e$	$S2$	$< 1.3 \times 10^{-3}$		323
$p \mu^- \overline{\nu}_\mu$	$S2$	$< 1.3 \times 10^{-3}$		309

Ξ^-

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

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

Mass $m = 1321.31 \pm 0.13$ 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

$\Lambda\pi^-$ $\alpha = -0.458 \pm 0.012$ (S = 1.8)

$[\alpha(\Xi^-)\alpha_-(\Lambda) - \alpha(\overline{\Xi}^+)\alpha_+(\overline{\Lambda})]/[\alpha(\Xi^-)\alpha_-(\Lambda) + \alpha(\overline{\Xi}^+)\alpha_+(\overline{\Lambda})]$
$= 0.012 \pm 0.014$

"	$\phi = (-0.4 \pm 2.3)^\circ$
"	$\gamma = 0.89$ [i]
"	$\Delta = (179 \pm 4)^\circ$ [i]
$\Lambda e^- \overline{\nu}_e$	$g_A/g_V = -0.25 \pm 0.05$ [f]

Ξ^- DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$\Lambda\pi^-$	(99.887 ± 0.035) %		139
$\Sigma^-\gamma$	$(1.27 \pm 0.23) \times 10^{-4}$		118
$\Lambda e^- \overline{\nu}_e$	$(5.63 \pm 0.31) \times 10^{-4}$		190
$\Lambda \mu^- \overline{\nu}_\mu$	$(3.5\ ^{+3.5}_{-2.2}) \times 10^{-4}$		163
$\Sigma^0 e^- \overline{\nu}_e$	$(8.7 \pm 1.7) \times 10^{-5}$		122
$\Sigma^0 \mu^- \overline{\nu}_\mu$	$< 8 \times 10^{-4}$	90%	70
$\Xi^0 e^- \overline{\nu}_e$	$< 2.3 \times 10^{-3}$	90%	6

$\Delta S = 2$ forbidden ($S2$) modes

$n\pi^-$	$S2$	$< 1.9 \times 10^{-5}$	90%	303
$n e^- \overline{\nu}_e$	$S2$	$< 3.2 \times 10^{-3}$	90%	327
$n \mu^- \overline{\nu}_\mu$	$S2$	< 1.5 %	90%	313
$p\pi^-\pi^-$	$S2$	$< 4 \times 10^{-4}$	90%	223
$p\pi^- e^- \overline{\nu}_e$	$S2$	$< 4 \times 10^{-4}$	90%	304
$p\pi^- \mu^- \overline{\nu}_\mu$	$S2$	$< 4 \times 10^{-4}$	90%	250
$p\mu^-\mu^-$	L	$< 4 \times 10^{-4}$	90%	272

$\Xi(1530)\ P_{13}$

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

$\Xi(1530)^0$ 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

$\Xi(1530)$ DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$\Xi\pi$	100 %		158
$\Xi\gamma$	<4 %	90%	202

$\Xi(1690)$

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

Mass $m = 1690 \pm 10$ MeV [k]
Full width $\Gamma < 30$ MeV

$\Xi(1690)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\Lambda\overline{K}$	seen	240
$\Sigma\overline{K}$	seen	70
$\Xi\pi$	seen	311
$\Xi^-\pi^+\pi^-$	possibly seen	214

$\Xi(1820)\ D_{13}$

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

Mass $m = 1823 \pm 5$ MeV [k]
Full width $\Gamma = 24^{+15}_{-10}$ MeV [k]

$\Xi(1820)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\Lambda\overline{K}$	large	402
$\Sigma\overline{K}$	small	324
$\Xi\pi$	small	421
$\Xi(1530)\pi$	small	237

$\Xi(1950)$

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

Mass $m = 1950 \pm 15$ MeV [k]
Full width $\Gamma = 60 \pm 20$ MeV [k]

$\Xi(1950)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\Lambda\overline{K}$	seen	522
$\Sigma\overline{K}$	possibly seen	460
$\Xi\pi$	seen	519

$\Xi(2030)$

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

Mass $m = 2025 \pm 5$ MeV [k]
Full width $\Gamma = 20^{+15}_{-5}$ MeV [k]

$\Xi(2030)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\Lambda\overline{K}$	~ 20 %	585
$\Sigma\overline{K}$	~ 80 %	529
$\Xi\pi$	small	574
$\Xi(1530)\pi$	small	416
$\Lambda\overline{K}\pi$	small	499
$\Sigma\overline{K}\pi$	small	428

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
$(m_{\Omega^-} - m_{\overline{\Omega}^+}) \ / \ m_{\Omega^-} = (-1 \pm 8) \times 10^{-5}$
Mean life $\tau = (0.821 \pm 0.011) \times 10^{-10}$ s
$c\tau = 2.461$ cm
$(\tau_{\Omega^-} - \tau_{\overline{\Omega}^+}) \ / \ \tau_{\Omega^-} = -0.002 \pm 0.040$
Magnetic moment $\mu = -2.02 \pm 0.05 \ \mu_N$

Decay parameters

ΛK^- $\quad \alpha = -0.026 \pm 0.023$
$\frac{1}{2}[\alpha(\Lambda K^-)+\alpha(\overline{\Lambda}K^+)] = -0.004 \pm 0.040$
$\Xi^0 \pi^-$ $\quad \alpha = 0.09 \pm 0.14$
$\Xi^- \pi^0$ $\quad \alpha = 0.05 \pm 0.21$

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
$\Xi^- \pi^0$		$(\ 8.6 \pm 0.4)$ %		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	532
$\Xi(1530)^0 K^-$	seen	437

CHARMED BARYONS
$(C=+1)$

$\Lambda_c^+ = udc$, $\Sigma_c^{++} = uuc$, $\Sigma_c^+ = udc$, $\Sigma_c^0 = ddc$,
$\Xi_c^+ = usc$, $\Xi_c^0 = dsc$, $\Omega_c^0 = ssc$

Λ_c^+

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

J is not well measured; $\frac{1}{2}$ is the quark-model prediction.

Mass $m = 2284.9 \pm 0.6$ MeV
Mean life $\tau = (200 \pm 6) \times 10^{-15}$ s (S = 1.6)
$c\tau = 59.9 \ \mu$m

Decay asymmetry parameters

$\Lambda \pi^+$ $\quad \alpha = -0.98 \pm 0.19$
$\Sigma^+ \pi^0$ $\quad \alpha = -0.45 \pm 0.32$
$\Lambda \ell^+ \nu_\ell$ $\quad \alpha = -0.82^{+0.11}_{-0.07}$

Nearly all branching fractions of the Λ_c^+ are measured relative to the $pK^-\pi^+$ mode, but there 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 measurements in the Listings. When this branching fraction is eventually well determined, 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: $S = -1$ final states				
$p\overline{K}^0$		$(\ 2.3 \pm 0.6)$ %		872
$pK^-\pi^+$	[m]	$(\ 5.0 \pm 1.3)$ %		822
$p\overline{K}^*(892)^0$	[n]	$(\ 1.6 \pm 0.5)$ %		684
$\Delta(1232)^{++}K^-$		$(\ 8.6 \pm 3.0) \times 10^{-3}$		709
$\Lambda(1520)\pi^+$	[n]	$(\ 5.9 \pm 2.1) \times 10^{-3}$		626
$pK^-\pi^+$ nonresonant		$(\ 2.8 \pm 0.8)$ %		822
$p\overline{K}^0\pi^0$		$(\ 3.3 \pm 1.0)$ %		822
$p\overline{K}^0\eta$		$(\ 1.2 \pm 0.4)$ %		566
$p\overline{K}^0\pi^+\pi^-$		$(\ 2.6 \pm 0.7)$ %		753
$pK^-\pi^+\pi^0$		$(\ 3.4 \pm 1.0)$ %		758
$pK^*(892)^-\pi^+$	[n]	$(\ 1.1 \pm 0.5)$ %		579
$p(K^-\pi^+)_{\text{nonresonant}}\pi^0$		$(\ 3.6 \pm 1.2)$ %		758
$\Delta(1232)\overline{K}^*(892)$		seen		417
$pK^-\pi^+\pi^+\pi^-$		$(\ 1.1 \pm 0.8) \times 10^{-3}$		670
$pK^-\pi^+\pi^0\pi^0$		$(\ 8 \pm 4) \times 10^{-3}$		676
Hadronic modes with a p: $S = 0$ final states				
$p\pi^+\pi^-$		$(\ 3.5 \pm 2.0) \times 10^{-3}$		926
$pf_0(980)$	[n]	$(\ 2.8 \pm 1.9) \times 10^{-3}$		621
$p\pi^+\pi^+\pi^-\pi^-$		$(\ 1.8 \pm 1.2) \times 10^{-3}$		851
pK^+K^-		$(\ 7.7 \pm 3.5) \times 10^{-4}$		615
$p\phi$	[n]	$(\ 8.2 \pm 2.7) \times 10^{-4}$		589
pK^+K^- non-ϕ		$(\ 3.5 \pm 1.7) \times 10^{-4}$		615
Hadronic modes with a hyperon: $S = -1$ final states				
$\Lambda\pi^+$		$(\ 9.0 \pm 2.8) \times 10^{-3}$		863
$\Lambda\pi^+\pi^0$		$(\ 3.6 \pm 1.3)$ %		843
$\Lambda\rho^+$		< 5 %	CL=95%	634
$\Lambda\pi^+\pi^+\pi^-$		$(\ 3.3 \pm 1.0)$ %		806
$\Lambda\pi^+\pi^+\pi^-\pi^0$ total		$(\ 1.8 \pm 0.8)$ %		756
$\Lambda\pi^+\eta$		$(\ 1.8 \pm 0.6)$ %		689
$\Sigma(1385)^+\eta$	[n]	$(\ 8.5 \pm 3.3) \times 10^{-3}$		569
$\Lambda\pi^+\omega$	[n]	$(\ 1.2 \pm 0.5)$ %		515
$\Lambda\pi^+\pi^+\pi^-\pi^0$, no η or ω		$< 7 \times 10^{-3}$	CL=90%	756
$\Lambda K^+\overline{K}^0$		$(\ 6.0 \pm 2.1) \times 10^{-3}$		441
$\Xi(1690)^0K^+$, $\Xi(1690)^0 \to \Lambda\overline{K}^0$		$(\ 1.6 \pm 0.8) \times 10^{-3}$		286
$\Sigma^0\pi^+$		$(\ 9.9 \pm 3.2) \times 10^{-3}$		824
$\Sigma^+\pi^0$		$(\ 1.00 \pm 0.34)$ %		826
$\Sigma^+\eta$		$(\ 5.5 \pm 2.3) \times 10^{-3}$		712
$\Sigma^+\pi^+\pi^-$		$(\ 3.6 \pm 1.0)$ %		803
$\Sigma^+\rho^0$		< 1.4 %	CL=95%	573
$\Sigma^-\pi^+\pi^+$		$(\ 1.9 \pm 0.8)$ %		798
$\Sigma^0\pi^+\pi^0$		$(\ 1.8 \pm 0.8)$ %		802
$\Sigma^0\pi^+\pi^+\pi^-$		$(\ 1.1 \pm 0.4)$ %		762
$\Sigma^+\pi^+\pi^-\pi^0$		—		766
$\Sigma^+\omega$	[n]	$(\ 2.7 \pm 1.0)$ %		568
$\Sigma^+K^+K^-$		$(\ 2.8 \pm 0.8) \times 10^{-3}$		346
$\Sigma^+\phi$	[n]	$(\ 3.2 \pm 1.0) \times 10^{-3}$		292
$\Xi(1690)^0K^+$, $\Xi(1690)^0 \to \Sigma^+K^-$		$(\ 8.2 \pm 3.1) \times 10^{-4}$		286
$\Sigma^+K^+K^-$ nonresonant		$< 7 \times 10^{-4}$	CL=90%	346
Ξ^0K^+		$(\ 3.9 \pm 1.4) \times 10^{-3}$		652
$\Xi^-K^+\pi^+$		$(\ 4.9 \pm 1.7) \times 10^{-3}$		564
$\Xi(1530)^0K^+$	[n]	$(\ 2.6 \pm 1.0) \times 10^{-3}$		471
Hadronic modes with a hyperon: $S = 0$ final states				
ΛK^+		$(\ 6.7 \pm 2.5) \times 10^{-4}$		780
Σ^0K^+		$(\ 5.6 \pm 2.4) \times 10^{-4}$		734
$\Sigma^+K^+\pi^-$		$(\ 1.7 \pm 0.7) \times 10^{-3}$		668
$\Sigma^+K^*(892)^0$	[n]	$(\ 2.8 \pm 1.1) \times 10^{-3}$		468
$\Sigma^-K^+\pi^+$		$< 1.0 \times 10^{-3}$	CL=90%	662
Semileptonic modes				
$\Lambda\ell^+\nu_\ell$	[o]	$(\ 2.0 \pm 0.6)$ %		870
$\Lambda e^+\nu_e$		$(\ 2.1 \pm 0.6)$ %		870
$\Lambda\mu^+\nu_\mu$		$(\ 2.0 \pm 0.7)$ %		866
Inclusive modes				
e^+ anything		$(\ 4.5 \pm 1.7)$ %		–
pe^+ anything		$(\ 1.8 \pm 0.9)$ %		–
p anything		(50 ± 16) %		–
p anything (no Λ)		(12 ± 19) %		–
n anything		(50 ± 16) %		–
n anything (no Λ)		(29 ± 17) %		–
Λ anything		(35 ± 11) %	S=1.4	–
$\Sigma^\pm$ anything	[p]	(10 ± 5) %		–
3prongs		(24 ± 8) %		–

$\Delta C = 1$ 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. This assumes that $J^P = 1/2^+$ for the $\Sigma_c(2455)$.

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 submode seems to dominate.

$\Lambda_c(2593)^+$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\Lambda_c^+\pi^+\pi^-$	[q] ≈ 67 %	124
$\Sigma_c(2455)^{++}\pi^-$	24 ± 7 %	28
$\Sigma_c(2455)^0\pi^+$	24 ± 7 %	28
$\Lambda_c^+\pi^+\pi^-$ 3-body	18 ± 10 %	124
$\Lambda_c^+\pi^0$	[r] not seen	261
$\Lambda_c^+\gamma$	not seen	291

$\Lambda_c(2625)^+$

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

J^P has not been measured; $\frac{3}{2}^-$ is the quark-model prediction.

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)	Confidence level	p (MeV/c)
$\Lambda_c^+\pi^+\pi^-$	[q] ≈ 67%		184
$\Sigma_c(2455)^{++}\pi^-$	<5	90%	102
$\Sigma_c(2455)^0\pi^+$	<5	90%	102
$\Lambda_c^+\pi^+\pi^-$ 3-body	large		184
$\Lambda_c^+\pi^0$	[r] not seen		293
$\Lambda_c^+\gamma$	not seen		319

$\Sigma_c(2455)$

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

J^P has not been measured; $\frac{1}{2}^+$ is the quark-model prediction.

$\Sigma_c(2455)^{++}$ mass $m = 2452.5 \pm 0.6$ MeV
$\Sigma_c(2455)^+$ mass $m = 2451.3 \pm 0.7$ MeV
$\Sigma_c(2455)^0$ mass $m = 2452.2 \pm 0.6$ MeV
$m_{\Sigma_c^{++}} - m_{\Lambda_c^+} = 167.58 \pm 0.12$ MeV
$m_{\Sigma_c^+} - m_{\Lambda_c^+} = 166.4 \pm 0.4$ MeV
$m_{\Sigma_c^0} - m_{\Lambda_c^+} = 167.32 \pm 0.12$ MeV
$m_{\Sigma_c^{++}} - m_{\Sigma_c^0} = 0.26 \pm 0.11$ MeV
$m_{\Sigma_c^+} - m_{\Sigma_c^0} = -0.9 \pm 0.4$ MeV
$\Sigma_c(2455)^{++}$ full width $\Gamma = 2.23 \pm 0.30$ MeV
$\Sigma_c(2455)^+$ full width $\Gamma < 4.6$ MeV, CL = 90%
$\Sigma_c(2455)^0$ full width $\Gamma = 2.2 \pm 0.4$ MeV (S = 1.4)

$\Lambda_c^+\pi$ 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 %	94

$\Sigma_c(2520)$

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

J^P has not been measured; $\frac{3}{2}^+$ is the quark-model prediction.

$\Sigma_c(2520)^{++}$ mass $m = 2519.4 \pm 1.5$ MeV
$\Sigma_c(2520)^+$ mass $m = 2515.9 \pm 2.4$ 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
$m_{\Sigma_c(2520)^+} - m_{\Lambda_c^+} = 231.0 \pm 2.3$ MeV
$m_{\Sigma_c(2520)^0} - m_{\Lambda_c^+} = 232.6 \pm 1.3$ MeV
$m_{\Sigma_c(2520)^{++}} - m_{\Sigma_c(2520)^0} = 1.9 \pm 1.7$ MeV
$\Sigma_c(2520)^{++}$ full width $\Gamma = 18 \pm 5$ MeV
$\Sigma_c(2520)^+$ full width $\Gamma < 17$ MeV, CL = 90%
$\Sigma_c(2520)^0$ full width $\Gamma = 13 \pm 5$ MeV

$\Lambda_c^+\pi$ is the only strong decay allowed to a Σ_c having this mass.

$\Sigma_c(2520)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\Lambda_c^+\pi$	≈ 100 %	180

Ξ_c^+

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

J^P has not been measured; $\frac{1}{2}^+$ is the quark-model prediction.

Mass $m = 2466.3 \pm 1.4$ MeV
Mean life $\tau = (442 \pm 26) \times 10^{-15}$ s (S = 1.3)
$c\tau = 132$ μm

Ξ_c^+ DECAY MODES		Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
No absolute branching fractions have been measured. The following are branching *ratios* relative to $\Xi^-\pi^+\pi^+$.				
Cabibbo-favored ($S = -2$) decays				
$\Lambda\overline{K}^0\pi^+$		—		851
$\Sigma(1385)^+\overline{K}^0$	[n,s]	1.0 ± 0.5		745
$\Lambda K^-\pi^+\pi^+$	[s]	0.34 ± 0.12		785
$\Lambda\overline{K}^*(892)^0\pi^+$	[n,s]	<0.2	90%	607
$\Sigma(1385)^+K^-\pi^+$	[n,s]	<0.3	90%	677
$\Sigma^+K^-\pi^+$	[s]	0.94 ± 0.11		809
$\Sigma^+\overline{K}^*(892)^0$	[n,s]	0.81 ± 0.15		657
$\Sigma^0K^-\pi^+\pi^+$	[s]	0.29 ± 0.16		734
$\Xi^0\pi^+$	[s]	0.55 ± 0.16		876
$\Xi^-\pi^+\pi^+$	[s]	DEFINED AS 1		850
$\Xi(1530)^0\pi^+$	[n,s]	<0.1	90%	748
$\Xi^0\pi^+\pi^0$	[s]	2.34 ± 0.68		855
$\Xi^0\pi^+\pi^+\pi^-$	[s]	1.74 ± 0.50		817
$\Xi^0e^+\nu_e$	[s]	$2.3^{+0.7}_{-0.9}$		883
$\Omega^-K^+\pi^+$	[s]	0.07 ± 0.04		397
Cabibbo-suppressed decays				
$pK^-\pi^+$	[s]	0.21 ± 0.03		943
$p\overline{K}^*(892)^0$	[n,s]	0.12 ± 0.02		827
$\Sigma^+K^+K^-$	[s]	0.15 ± 0.07		578
$\Sigma^+\phi$	[n,s]	<0.11	90%	547
$\Xi(1690)^0K^+$ $\times$B($\Xi(1690)^0 \to \Sigma^+K^-$)	[s]	<0.05	90%	501

Ξ_c^0

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

J^P has not been measured; $\frac{1}{2}^+$ is the quark-model prediction.

Mass $m = 2471.8 \pm 1.4$ MeV
$m_{\Xi_c^0} - m_{\Xi_c^+} = 5.5 \pm 1.8$ MeV
Mean life $\tau = (112^{+13}_{-10}) \times 10^{-15}$ s
$c\tau = 33.6\ \mu$m

Decay asymmetry parameters

$\Xi^- \pi^+$ $\alpha = -0.6 \pm 0.4$

Ξ_c^0 DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\Lambda \overline{K}^0$	seen	907
$\Lambda \overline{K}^0 \pi^+ \pi^-$	seen	788
$\Lambda K^- \pi^+ \pi^+ \pi^-$	seen	704
$\Xi^- \pi^+$	seen	876
$\Xi^- \pi^+ \pi^+ \pi^-$	seen	817
$p K^- \overline{K}^*(892)^0$	seen	414
$\Omega^- K^+$	seen	523
$\Xi^- e^+ \nu_e$	seen	883
$\Xi^- \ell^+$ anything	seen	–

$\Xi_c'^+$

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

J^P has not been measured; $\frac{1}{2}^+$ is the quark-model prediction.

Mass $m = 2574.1 \pm 3.3$ MeV
$m_{\Xi_c'^+} - m_{\Xi_c^+} = 107.8 \pm 3.0$ MeV

The $\Xi_c'^+$–Ξ_c^+ mass difference is too small for any strong decay to occur.

$\Xi_c'^+$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\Xi_c^+ \gamma$	seen	106

$\Xi_c'^0$

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

J^P has not been measured; $\frac{1}{2}^+$ is the quark-model prediction.

Mass $m = 2578.8 \pm 3.2$ MeV
$m_{\Xi_c'^0} - m_{\Xi_c^0} = 107.0 \pm 2.9$ MeV

The $\Xi_c'^0 - \Xi_c^0$ mass difference is too small for any strong decay to occur.

$\Xi_c'^0$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\Xi_c^0 \gamma$	seen	105

$\Xi_c(2645)$

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

J^P has not been measured; $\frac{3}{2}^+$ is the quark-model prediction.

$\Xi_c(2645)^+$ mass $m = 2647.4 \pm 2.0$ MeV (S = 1.2)
$\Xi_c(2645)^0$ mass $m = 2644.5 \pm 1.8$ MeV
$m_{\Xi_c(2645)^+} - m_{\Xi_c^0} = 175.6 \pm 1.4$ MeV (S = 1.7)
$m_{\Xi_c(2645)^0} - m_{\Xi_c^+} = 178.2 \pm 1.1$ 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	98
$\Xi_c^+ \pi^-$	seen	107

$\Xi_c(2790)$

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

J^P has not been measured; $\frac{1}{2}^-$ is the quark-model prediction.

$\Xi_c(2790)^+$ mass $= 2790.0 \pm 3.5$ MeV
$\Xi_c(2790)^0$ mass $= 2790 \pm 4$ MeV
$m_{\Xi_c(2790)^+} - m_{\Xi_c^0} = 318.2 \pm 3.2$ MeV
$m_{\Xi_c(2790)^0} - m_{\Xi_c^+} = 324.0 \pm 3.3$ MeV
$\Xi_c(2790)^+$ width < 15 MeV, CL = 90%
$\Xi_c(2790)^0$ width < 12 MeV, CL = 90%

$\Xi_c(2790)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\Xi_c' \pi$	seen	162

$\Xi_c(2815)$

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

J^P has not been measured; $\frac{3}{2}^-$ is the quark-model prediction.

$\Xi_c(2815)^+$ mass $m = 2814.9 \pm 1.8$ MeV
$\Xi_c(2815)^0$ mass $m = 2819.0 \pm 2.5$ MeV
$m_{\Xi_c(2815)^+} - m_{\Xi_c^+} = 348.6 \pm 1.2$ MeV
$m_{\Xi_c(2815)^0} - m_{\Xi_c^0} = 347.2 \pm 2.1$ MeV
$\Xi_c(2815)^+$ full width $\Gamma < 3.5$ MeV, CL = 90%
$\Xi_c(2815)^0$ full width $\Gamma < 6.5$ MeV, CL = 90%

The $\Xi_c \pi\pi$ modes are consistent with being entirely via $\Xi_c(2645)\pi$.

$\Xi_c(2815)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\Xi_c^+ \pi^+ \pi^-$	seen	196
$\Xi_c^0 \pi^+ \pi^-$	seen	187

Ω_c^0

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

J^P has not been measured; $\frac{1}{2}^+$ is the quark-model prediction.

Mass $m = 2697.5 \pm 2.6$ MeV (S = 1.2)
Mean life $\tau = (69 \pm 12) \times 10^{-15}$ s
$c\tau = 21\ \mu$m

No absolute branching fractions have been measured.

Ω_c^0 DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\Sigma^+ K^- K^- \pi^+$	seen	691
$\Xi^0 K^- \pi^+$	seen	903
$\Xi^- K^- \pi^+ \pi^+$	seen	832
$\Omega^- e^+ \nu_e$	seen	830
$\Omega^- \pi^+$	seen	822
$\Omega^- \pi^+ \pi^0$	seen	798
$\Omega^- \pi^- \pi^+ \pi^+$	seen	754

BOTTOM BARYONS
($B = -1$)

$\Lambda_b^0 = udb$, $\Xi_b^0 = usb$, $\Xi_b^- = dsb$

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 $\tau = (1.229 \pm 0.080) \times 10^{-12}$ s

$c\tau = 368$ μm

These branching fractions are actually an average over weakly decaying b-baryons weighted by their production rates in Z decay (or high-energy $p\overline{p}$), branching ratios, and detection efficiencies. They scale with the LEP b-baryon production fraction B($b \to$ b-baryon) and are evaluated for our value B($b \to$ b-baryon) = (9.9 ± 1.7)%.

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($b \to$ b-baryon) were used to determine B($b \to$ b-baryon), as 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	[t]	(9.2 ± 2.1) %		–
$p\pi^-$		$< 5.0 \times 10^{-5}$	90%	2732
pK^-		$< 5.0 \times 10^{-5}$	90%	2711
$\Lambda\gamma$		$< 1.3 \times 10^{-3}$	90%	2701

b-baryon ADMIXTURE (Λ_b, Ξ_b, Σ_b, Ω_b)

Mean life $\tau = (1.208 \pm 0.051) \times 10^{-12}$ s

These branching fractions are actually an average over weakly decaying b-baryons weighted by their production rates in Z decay (or high-energy $p\overline{p}$), branching ratios, and detection efficiencies. They scale with the LEP b-baryon production fraction B($b \to$ b-baryon) and are evaluated for our value B($b \to$ b-baryon) = (9.9 ± 1.7)%.

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($b \to$ b-baryon) were used to determine B($b \to$ b-baryon), as described in the note "Production and Decay of b-Flavored Hadrons."

b-baryon ADMIXTURE DECAY MODES (Λ_b,Ξ_b,Σ_b,Ω_b)	Fraction (Γ_i/Γ)	p (MeV/c)
$p\mu^- \overline{\nu}$ anything	$(4.9^{+2.1}_{-1.8})$ %	–
$p\ell\overline{\nu}_\ell$ anything	(4.8 ± 1.1) %	–
p anything	(60 ± 20) %	–
$\Lambda\ell^- \overline{\nu}_\ell$ anything	(3.2 ± 0.6) %	–
$\Lambda/\overline{\Lambda}$ anything	(33 ± 7) %	–
$\Xi^- \ell^- \overline{\nu}_\ell$ anything	$(5.6 \pm 1.5) \times 10^{-3}$	–

NOTES

This Summary Table only includes established baryons. The Particle Listings include evidence for other baryons. The masses, widths, and branching fractions for the resonances in this Table are Breit-Wigner parameters, but pole positions are also given for most of the N and Δ resonances.

For most of the resonances, the parameters come from various partial-wave analyses of more or less the same sets of data, and it is not appropriate to treat the results of the analyses as independent or to average them together. Furthermore, the systematic errors on the results are not well understood. Thus, we 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 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. For any resonance, the *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 used, but 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 MeV, 1 u = 931.494043 ± 0.000080 MeV, is less well known than are the masses in u.

[b] These two results are not independent, and both use the more precise measurement of $|q_{\overline{p}}/m_{\overline{p}}|/(q_p/m_p)$.

[c] The limit is from neutrality-of-matter experiments; it assumes $q_n = q_p + q_e$. See also the charge of the neutron.

[d] The first limit is for $p \to$ anything or "disappearance" modes of a bound proton. The second entry, a rough range of limits, assumes the dominant decay modes are among those investigated. For antiprotons the best limit, inferred from the observation of cosmic ray $\overline{p}$'s is $\tau_{\overline{p}} > 10^7$ yr, the cosmic-ray storage time, but this limit depends on a number of assumptions. The best direct observation of stored antiprotons gives $\tau_{\overline{p}}/B(\overline{p} \to e^-\gamma) > 7 \times 10^5$ yr.

[e] There is some controversy about whether nuclear physics and model dependence complicate the analysis for bound neutrons (from which the best limit comes). The first limit here is from reactor experiments with free neutrons.

[f] The parameters g_A, g_V, and g_{WM} for semileptonic modes are defined by $\overline{B}_f[\gamma_\lambda(g_V + g_A\gamma_5) + i(g_{WM}/m_{B_i})\,\sigma_{\lambda\nu}\,q^\nu]B_i$, and 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.

[g] Time-reversal invariance requires this to be 0° or 180°.

[h] This limit is for γ energies between 35 and 100 keV.

[i] The decay parameters γ and Δ are calculated from α and ϕ using

$$\gamma = \sqrt{1-\alpha^2}\,\cos\phi\,, \qquad \tan\Delta = -\frac{1}{\alpha}\,\sqrt{1-\alpha^2}\,\sin\phi\,.$$

See the "Note on Baryon Decay Parameters" in the neutron Particle Listings.

[j] See the Listings for the pion momentum range used in this measurement.

[k] The error given here is only an educated guess. It is larger than the error on the weighted average of the published values.

[l] A theoretical value using QED.

[m] See the note on "Λ_c^+ Branching Fractions" in the Λ_c^+ Particle Listings.

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

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

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

[q] Assuming isospin conservation, so that the other third is $\Lambda_c^+\pi^0\pi^0$.

[r] A test that the isospin is indeed 0, so that the particle is indeed a Λ_c^+.

[s] No absolute branching fractions have been measured. The following are branching *ratios* relative to $\Xi^-\pi^+\pi^+$.

[t] Not a pure measurement. See note at head of Λ_b^0 Decay Modes.

SEARCHES FOR MONOPOLES, SUPERSYMMETRY, TECHNICOLOR, COMPOSITENESS, EXTRA DIMENSIONS, etc.

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) $\widetilde{\chi}^0_1$ (or $\widetilde{\gamma}$) is lightest supersymmetric particle; 2) R-parity is conserved; 3) With the exception of $\widetilde{t}$ and $\widetilde{b}$, all scalar quarks are assumed to be degenerate in mass and $m_{\widetilde{q}_R} = m_{\widetilde{q}_L}$. 4) Limits for sleptons refer to the $\widetilde{\ell}_R$ states.

See the Particle Listings for a Note giving details of supersymmetry.

$\widetilde{\chi}^0_i$ — neutralinos (mixtures of $\widetilde{\gamma}$, $\widetilde{Z}^0$, and $\widetilde{H}^0_i$)

Mass $m_{\widetilde{\chi}^0_1}$ > 46 GeV, CL = 95% [all tanβ, all Δm_0, all m_0]

Mass $m_{\widetilde{\chi}^0_2}$ > 62.4 GeV, CL = 95%
[1<tanβ <40, all m_0, all $m_{\widetilde{\chi}^0_2} - m_{\widetilde{\chi}^0_1}$]

Mass $m_{\widetilde{\chi}^0_3}$ > 99.9 GeV, CL = 95%
[1<tanβ <40, all m_0, all $m_{\widetilde{\chi}^0_2} - m_{\widetilde{\chi}^0_1}$]

$\widetilde{\chi}^\pm_i$ — charginos (mixtures of $\widetilde{W}^\pm$ and $\widetilde{H}^\pm_i$)

Mass $m_{\widetilde{\chi}^\pm_1}$ > 94 GeV, CL = 95%
[tanβ < 40, $m_{\widetilde{\chi}^\pm_1} - m_{\widetilde{\chi}^0_1}$ > 3 GeV, all m_0]

$\widetilde{e}$ — scalar electron (selectron)

Mass m > 73 GeV, CL = 95% [all $m_{\widetilde{e}_R} - m_{\widetilde{\chi}^0_1}$]

$\widetilde{\mu}$ — scalar muon (smuon)

Mass m > 94 GeV, CL = 95%
[$1 \leq$ tan$\beta \leq 40$, $m_{\widetilde{\mu}_R} - m_{\widetilde{\chi}^0_1}$ > 10 GeV]

$\widetilde{\tau}$ — scalar tau (stau)

Mass m > 81.9 GeV, CL = 95%
[$m_{\widetilde{\tau}_R} - m_{\widetilde{\chi}^0_1}$ >15 GeV, all θ_τ]

$\widetilde{q}$ — 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.

Mass m > 250 GeV, CL = 95% [tanβ = 2, μ <0, A = 0]

$\widetilde{b}$ — scalar bottom (sbottom)

Mass m > 89 GeV, CL = 95% [$m_{\widetilde{b}_1} - m_{\widetilde{\chi}^0_1}$ >8 GeV, all θ_b]

$\widetilde{t}$ — scalar top (stop)

Mass m > 95.7 GeV, CL = 95%
[$\widetilde{t} \to c\widetilde{\chi}^0_1$, all θ_t, $m_{\widetilde{t}} - m_{\widetilde{\chi}^0_1}$ >10 GeV]

$\widetilde{g}$ — gluino

The limits summarised here refer 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,

Mass m > 195 GeV, CL = 95% [any $m_{\widetilde{q}}$]

Mass m > 300 GeV, CL = 95% [$m_{\widetilde{q}} = m_{\widetilde{g}}$]

Technicolor

Searches for a color-octet techni-ρ constrain its mass to be greater than 260 to 480 GeV, depending on allowed decay channels. Similar bounds exist on the color-octet techni-ω.

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.

$\Lambda^+_{LL}(eeee)$	> 8.3 TeV, CL = 95%
$\Lambda^-_{LL}(eeee)$	> 10.3 TeV, CL = 95%
$\Lambda^+_{LL}(ee\mu\mu)$	> 8.5 TeV, CL = 95%
$\Lambda^-_{LL}(ee\mu\mu)$	> 6.3 TeV, CL = 95%
$\Lambda^+_{LL}(ee\tau\tau)$	> 5.4 TeV, CL = 95%
$\Lambda^-_{LL}(ee\tau\tau)$	> 6.5 TeV, CL = 95%
$\Lambda^+_{LL}(\ell\ell\ell\ell)$	> 9.0 TeV, CL = 95%
$\Lambda^-_{LL}(\ell\ell\ell\ell)$	> 7.8 TeV, CL = 95%
$\Lambda^+_{LL}(eeuu)$	> 23.3 TeV, CL = 95%
$\Lambda^-_{LL}(eeuu)$	> 12.5 TeV, CL = 95%
$\Lambda^+_{LL}(eedd)$	> 11.1 TeV, CL = 95%
$\Lambda^-_{LL}(eedd)$	> 26.4 TeV, CL = 95%
$\Lambda^+_{LL}(eecc)$	> 1.0 TeV, CL = 95%
$\Lambda^-_{LL}(eecc)$	> 2.1 TeV, CL = 95%
$\Lambda^+_{LL}(eebb)$	> 5.6 TeV, CL = 95%
$\Lambda^-_{LL}(eebb)$	> 4.9 TeV, CL = 95%
$\Lambda^+_{LL}(\mu\mu qq)$	> 2.9 TeV, CL = 95%
$\Lambda^-_{LL}(\mu\mu qq)$	> 4.2 TeV, CL = 95%
$\Lambda(\ell\nu\ell\nu)$	> 3.10 TeV, CL = 90%
$\Lambda(e\nu qq)$	> 2.81 TeV, CL = 95%
$\Lambda^+_{LL}(qqqq)$	> 2.7 TeV, CL = 95%
$\Lambda^-_{LL}(qqqq)$	> 2.4 TeV, CL = 95%
$\Lambda^+_{LL}(\nu\nu qq)$	> 5.0 TeV, CL = 95%
$\Lambda^-_{LL}(\nu\nu qq)$	> 5.4 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.

$e^{*\pm}$ — excited electron

Mass $m >$ 103.2 GeV, CL = 95% (from $e^* e^*$)
Mass $m >$ 255 GeV, CL = 95% (from $e e^*$)
Mass $m >$ 310 GeV, CL = 95% (if $\lambda_\gamma = 1$)

$\mu^{*\pm}$ — excited muon

Mass $m >$ 103.2 GeV, CL = 95% (from $\mu^* \mu^*$)
Mass $m >$ 190 GeV, CL = 95% (from $\mu \mu^*$)

$\tau^{*\pm}$ — excited tau

Mass $m >$ 103.2 GeV, CL = 95% (from $\tau^* \tau^*$)
Mass $m >$ 185 GeV, CL = 95% (from $\tau \tau^*$)

ν^* — excited neutrino

Mass $m >$ 102.6 GeV, CL = 95% (from $\nu^* \nu^*$)
Mass $m >$ 190 GeV, CL = 95% (from $\nu \nu^*$)

q^* — excited quark

Mass $m >$ 45.6 GeV, CL = 95% (from $q^* q^*$)
Mass $m >$ 570, none 580–760 GeV, CL = 95% (from 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% ($\nu_8 \rightarrow \nu g$)

Extra Dimensions

Please refer to the Extra Dimensions section of the full *Review* for a discussion of the model-dependence of these bounds, and further constraints.

Constraints on the fundamental gravity scale

$M_H >$ 1.1 TeV, CL = 95% (dim-8 operators; $p\overline{p} \rightarrow e^+e^-, \gamma\gamma$)
$M_D >$ 1.1 TeV, CL = 95% ($e^+e^- \rightarrow G\gamma$; 2-flat dimensions)
$M_D >$ 3–1000 TeV (astrophys. and cosmology; 2-flat dimensions; limits depend on technique and assumptions)

Constraints on the radius of the extra dimensions, for the case of two-flat dimensions of equal radii

$r <$ 90–660 nm (astrophysics; limits depend on technique and assumptions)
$r <$ 0.22 mm, CL = 95% (direct tests of Newton's law; cited in Extra Dimensions review)

TESTS OF CONSERVATION LAWS

Updated February 2004 by L. Wolfenstein and T.G. Trippe.

In keeping with the current interest in tests of conservation laws, we collect together a Table of experimental limits on all weak and electromagnetic decays, mass differences, and moments, and on a few reactions, whose observation would violate conservation laws. The Table is given only in the full *Review of Particle Physics*, not in the Particle Physics Booklet. For the benefit of Booklet readers, we 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 Symmetries," *i.e.*, C, P, T, CP, and CPT; and "Number Conservation Laws," *i.e.*, lepton, baryon, hadronic flavor, and 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 invariance, ϕ_ϵ, the phase of ϵ should be very close to 44°. (See the review "CP Violation in K_L decay" in this edition.) In contrast, if the entire source of CP violation in K^0 decays were a $K^0 - \overline{K}^0$ mass difference, ϕ_ϵ would be $44° + 90°$.

Assuming that there is no other source of CPT violation than this mass difference, it is possible to deduce that[1]

$$m_{\overline{K}^0} - m_{K^0} \approx \frac{2(m_{K_L^0} - m_{K_S^0})\,|\eta|\,(\frac{2}{3}\phi_{+-} + \frac{1}{3}\phi_{00} - \phi_{\rm SW})}{\sin\phi_{\rm SW}} ,$$

where $\phi_{\rm SW} = (43.51 \pm 0.05)°$, the superweak angle. Using our best values of the CP-violation parameters, we get $|(m_{\overline{K}^0} - m_{K^0})/m_{K^0}| \leq 10^{-18}$ at CL=95%. Limits can also be placed on specific CPT-violating decay amplitudes. Given the small value of $(1 - |\eta_{00}/\eta_{+-}|)$, the value of $\phi_{00} - \phi_{+-}$ provides a measure of CPT violation in $K_L^0 \to 2\pi$ decay. Results from CERN[1] and Fermilab[2] indicate no CPT-violating effect.

CP AND T INVARIANCE

Given CPT invariance, CP violation and T violation are equivalent. The original evidence for CP violation came from the measurement of $|\eta_{+-}| = |A(K_L^0 \to \pi^+\pi^-)/A(K_S^0 \to \pi^+\pi^-)| = (2.288 \pm 0.014) \times 10^{-3}$. This could be explained in terms of K^0–$\overline{K}^0$ mixing, which also leads to the asymmetry $[\Gamma(K_L^0 \to \pi^- e^+ \nu) - \Gamma(K_L^0 \to \pi^+ e^- \overline{\nu})]/[\text{sum}] = (0.333 \pm 0.014)\%$. Evidence for CP violation in the kaon decay amplitide comes from the measurement of $(1 - |\eta_{00}/\eta_{+-}|)/3 = Re(\epsilon'/\epsilon) = (1.67 \pm 0.26) \times 10^{-3}$. In the Standard Model much larger CP-violating effects are expected. The first of these, which is associated with B–$\overline{B}$ mixing, is the parameter $sin(2\beta)$ now measured quite accurately to be 0.731 ± 0.056. A number of other CP-violating observables are being measured in B decays and preliminary results are available. Direct tests of T violation are much more difficult; a measurement by CPLEAR of the difference between the oscillation probabilities of K^0 to $\overline{K^0}$ and $\overline{K^0}$ to K^0 is related to T violation [3]. Other searches for CP or T violation involve effects that are expected to be unobservable in the Standard Model. The most sensitive are probably the searches for an electric dipole moment of the neutron, measured to be $< 6 \times 10^{-26}$ e cm, and the electron $(0.07 \pm 0.07) \times 10^{-26}$ e cm. A nonzero value requires both P and T violation.

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_e, muon number L_μ, and tau number L_τ, except for the effect of neutrino mixing associated with neutrino masses. Searches for violations are of the following types:

a) $\Delta L = 2$ for one type of charged 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 $t_{1/2} > 1.9 \times 10^{25}$ yr (CL=90%) for ^{76}Ge.

b) Conversion of one charged-lepton type to another. For purely leptonic processes, the best limits are on $\mu \to e\gamma$ and $\mu \to 3e$, measured as $\Gamma(\mu \to e\gamma)/\Gamma(\mu \to \text{all}) < 1.2 \times 10^{-11}$ and $\Gamma(\mu \to 3e)/\Gamma(\mu \to \text{all}) < 1.0 \times 10^{-12}$. For semileptonic processes, the best limit comes from the coherent conversion process in a muonic atom, $\mu^- + (Z, A) \to e^- + (Z, A)$, measured 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 changes, as in $K_L \to e\mu$ and $K^+ \to \pi^+ e^- \mu^+$, measured as $\Gamma(K_L \to e\mu)/\Gamma(K_L \to \text{all}) < 4.7 \times 10^{-12}$ and $\Gamma(K^+ \to \pi^+ e^- \mu^+)/\Gamma(K^+ \to \text{all}) < 2.8 \times 10^{-11}$. Limits on the conversion of τ into e or μ are found in τ decay and are much less stringent than those for $\mu \to e$ conversion, *e.g.*, $\Gamma(\tau \to \mu\gamma)/\Gamma(\tau \to \text{all}) < 1.1 \times 10^{-6}$ and $\Gamma(\tau \to e\gamma)/\Gamma(\tau \to \text{all}) < 2.7 \times 10^{-6}$.

c) Conversion of one type of charged lepton into another type of charged antilepton. The case most studied is $\mu^- + (Z, A) \to e^+ + (Z - 2, A)$, the strongest limit being $\Gamma(\mu^- \text{Ti} \to e^+ \text{Ca})/\Gamma(\mu^- \text{Ti} \to \text{all}) < 3.6 \times 10^{-11}$.

d) Neutrino oscillations. If neutrinos have mass, then it is expected even in the standard electroweak theory that the lepton numbers are not separately conserved, as a consequence of lepton mixing analogous to Cabibbo quark mixing. However, if the only source of lepton-number violation is the mixing of low-mass neutrinos then processes such as $\mu \to e\gamma$ are expected to have extremely small unobservable probabilities. For small neutrino masses, the lepton-number violation would be observed first in neutrino oscillations, which have been the subject of extensive experimental searches. Strong evidence for neutrino mixing has come from atmospheric and solar neutrinos. The SNO experiment has detected the total flux of neutrinos from the sun measured via neutral current interactions and found it greater than the flux of ν_e. This confirms previous indications of a deficit of ν_e and can be explained by oscillations with $\Delta(m^2) = (7.1^{+1.2}_{-0.6}) \times 10^{-5}$ eV^2. Evidence for such oscillations for reactor $\overline{\nu}$ has been found by the KAMLAND detector. In addition, underground detectors observing neutrinos produced by cosmic rays in the atmosphere have found a factor of 2 deficiency of upward going ν_μ compared to downward. This provides compelling evidence for ν_μ disappearance, for which the most probable explanation is $\nu_\mu \to \nu_\tau$ oscillations with nearly maximal mixing and $\Delta(m^2)$ of the order 0.0013–0.0030 eV^2.

CONSERVATION OF HADRONIC FLAVORS

In strong and electromagnetic interactions, hadronic flavor is conserved, *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 Model, the 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 strangeness-changing semileptonic decay of strange particles, the strangeness change equals the change in charge of the hadrons. Tests come from limits on decay rates such as $\Gamma(\Sigma^+ \to n e^+ \nu)/\Gamma(\Sigma^+ \to \text{all}) < 5 \times 10^{-6}$, and from a detailed analysis of $K_L \to \pi e \nu$, which yields the parameter x, measured to be $(\text{Re}\,x, \text{Im}\,x) = (-0.002 \pm 0.006, 0.0012 \pm 0.0021)$. 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 $K^0 - \overline{K}^0$ mixing, which is directly measured by $m(K_L) - m(K_S) = (3.483 \pm 0.006) \times 10^{-12}$ MeV. There is now evidence for $B^0 - \overline{B}^0$ mixing ($\Delta B = 2$), with the corresponding mass difference between the eigenstates $(m_{B^0_H} - m_{B^0_L}) = (0.751 \pm 0.012)\Gamma_{B^0} = (3.304 \pm 0.045) \times 10^{-10}$ MeV, and for B^0_s–$\overline{B}^0_s$ mixing, with $(m_{B^0_{sH}} - m_{B^0_{sL}}) > 20.6\,\Gamma_{B^0_s}$ or $> 9 \times 10^{-9}$ MeV (CL=95%). For $D^0 - \overline{D}^0$ mixing $m_{D^0_H} - m_{D^0_L} < 5 \times 10^{-11}$ MeV. All results are consistent with the second-order calculations in the Standard Model.

(c) Flavor-changing neutral currents. In the Standard Model the neutral-current interactions do not change flavor. The low rate $\Gamma(K_L \to \mu^+\mu^-)/\Gamma(K_L \to \text{all}) = (7.23 \pm 0.14) \times 10^{-9}$ 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 $K^+ \to \pi^+ \nu \overline{\nu}$, which occurs in the Standard Model only as a second-order weak process with a branching fraction of $(0.4 \text{ to } 1.2) \times 10^{-10}$. Recent results, including observation of two events, yields $\Gamma(K^+ \to \pi^+ \nu \overline{\nu})/\Gamma(K^+ \to \text{all}) = (1.6^{+1.8}_{-0.8}) \times 10^{-10}$[4]. Limits for charm-changing or bottom-changing neutral currents are much less stringent: $\Gamma(D^0 \to \mu^+\mu^-)/\Gamma(D^0 \to \text{all}) < 4 \times 10^{-6}$ and $\Gamma(B^0 \to \mu^+\mu^-)/\Gamma(B^0 \to \text{all}) < 1.6 \times 10^{-7}$. One cannot isolate flavor-changing neutral current (FCNC) effects in non leptonic decays. For example, the 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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Unless otherwise stated, limits are given at the 90% confidence level, while errors are given as ±1 standard deviation.

TESTS OF DISCRETE SPACE-TIME SYMMETRIES

CHARGE CONJUGATION (C) INVARIANCE

$\Gamma(\pi^0 \to 3\gamma)/\Gamma_{total}$		$<3.1 \times 10^{-8}$, CL = 90%
η C-nonconserving decay parameters		
$\pi^+\pi^-\pi^0$ left-right asymmetry parameter		$(0.09 \pm 0.17) \times 10^{-2}$
$\pi^+\pi^-\pi^0$ sextant asymmetry parameter		$(0.18 \pm 0.16) \times 10^{-2}$
$\pi^+\pi^-\pi^0$ quadrant asymmetry parameter		$(-0.17 \pm 0.17) \times 10^{-2}$
$\pi^+\pi^-\gamma$ left-right asymmetry parameter		$(0.9 \pm 0.4) \times 10^{-2}$
$\pi^+\pi^-\gamma$ parameter β (D-wave)		-0.02 ± 0.07 (S = 1.3)
$\Gamma(\eta \to 3\gamma)/\Gamma_{total}$		$<5 \times 10^{-4}$, CL = 95%
$\Gamma(\eta \to \pi^0 e^+ e^-)/\Gamma_{total}$	[a]	$<4 \times 10^{-5}$, CL = 90%
$\Gamma(\eta \to \pi^0 \mu^+ \mu^-)/\Gamma_{total}$	[a]	$<5 \times 10^{-6}$, CL = 90%
$\Gamma(\omega(782) \to \eta\pi^0)/\Gamma_{total}$		$<1 \times 10^{-3}$, CL = 90%
$\Gamma(\omega(782) \to 3\pi^0)/\Gamma_{total}$		$<3 \times 10^{-4}$, CL = 90%
$\Gamma(\eta'(958) \to \pi^0 e^+ e^-)/\Gamma_{total}$	[a]	$<1.4 \times 10^{-3}$, CL = 90%
$\Gamma(\eta'(958) \to \eta e^+ e^-)/\Gamma_{total}$	[a]	$<2.4 \times 10^{-3}$, CL = 90%
$\Gamma(\eta'(958) \to 3\gamma)/\Gamma_{total}$		$<1.0 \times 10^{-4}$, CL = 90%
$\Gamma(\eta'(958) \to \mu^+\mu^-\pi^0)/\Gamma_{total}$	[a]	$<6.0 \times 10^{-5}$, CL = 90%
$\Gamma(\eta'(958) \to \mu^+\mu^-\eta)/\Gamma_{total}$	[a]	$<1.5 \times 10^{-5}$, CL = 90%

PARITY (P) INVARIANCE

e electric dipole moment	$(0.07 \pm 0.07) \times 10^{-26}$ $e$cm
μ electric dipole moment	$(3.7 \pm 3.4) \times 10^{-19}$ $e$cm
Re(d_τ)	-0.22 to 0.45×10^{-16} $e$cm, CL = 95%
$\Gamma(\eta \to \pi^+\pi^-)/\Gamma_{total}$	$<3.3 \times 10^{-4}$, CL = 90%
$\Gamma(\eta \to \pi^0\pi^0)/\Gamma_{total}$	$<4.3 \times 10^{-4}$, CL = 90%
$\Gamma(\eta \to 4\pi^0)/\Gamma_{total}$	$<6.9 \times 10^{-7}$, CL = 90%
$\Gamma(\eta'(958) \to \pi^+\pi^-)/\Gamma_{total}$	$<2 \times 10^{-2}$, CL = 90%
$\Gamma(\eta'(958) \to \pi^0\pi^0)/\Gamma_{total}$	$<9 \times 10^{-4}$, CL = 90%
p electric dipole moment	$<0.54 \times 10^{-23}$ $e$cm
n electric dipole moment	$<0.63 \times 10^{-25}$ $e$cm, CL = 90%
Λ electric dipole moment	$<1.5 \times 10^{-16}$ $e$cm, CL = 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 spin, e^+ momentum		0.007 ± 0.023
α'/A		$(0 \pm 4) \times 10^{-3}$
β'/A		$(2 \pm 6) \times 10^{-3}$
P_T in $K^+ \to \pi^0 \mu^+ \nu_\mu$		$(-4 \pm 5) \times 10^{-3}$
P_T in $K^+ \to \mu^+ \nu_\mu \gamma$		$(-0.6 \pm 1.9) \times 10^{-2}$
Im(ξ) in $K^+ \to \pi^0 \mu^+ \nu_\mu$ decay (from transverse μ pol.)		-0.014 ± 0.014
asymmetry A_T in K^0-$\overline{K}^0$ mixing		$(6.6 \pm 1.6) \times 10^{-3}$
Im(ξ) in $K^0_{\mu 3}$ decay (from transverse μ pol.)		-0.007 ± 0.026
$n \to p e^- \overline{\nu}_e$ decay parameters		
ϕ_{AV}, phase of g_A relative to g_V	[b]	$(180.08 \pm 0.10)°$
triple correlation coefficient D		$(-0.6 \pm 1.0) \times 10^{-3}$
triple correlation coefficient D for $\Sigma^- \to n e^- \overline{\nu}_e$		0.11 ± 0.10

CP INVARIANCE

$\text{Re}(d_\tau^W)$	$<0.50\times10^{-17}$ $e$cm, CL = 95%
$\text{Im}(d_\tau^W)$	$<1.1\times10^{-17}$ $e$cm, CL = 95%
$\Gamma(\eta\to\pi^+\pi^-)/\Gamma_{\text{total}}$	$<3.3\times10^{-4}$, CL = 90%
$\Gamma(\eta\to\pi^0\pi^0)/\Gamma_{\text{total}}$	$<4.3\times10^{-4}$, CL = 90%
$\Gamma(\eta\to4\pi^0)/\Gamma_{\text{total}}$	$<6.9\times10^{-7}$, CL = 90%
$\Gamma(\eta'(958)\to\pi^+\pi^-)/\Gamma_{\text{total}}$	$<2\times10^{-2}$, CL = 90%
$\Gamma(\eta'(958)\to\pi^0\pi^0)/\Gamma_{\text{total}}$	$<9\times10^{-4}$, CL = 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)%
$\Delta(K^\pm_{\pi\mu\mu})=\frac{\Gamma(K^+_{\pi\mu\mu})-\Gamma(K^-_{\pi\mu\mu})}{\Gamma(K^+_{\pi\mu\mu})+\Gamma(K^-_{\pi\mu\mu})}$	-0.02 ± 0.12
$\text{Im}(\eta_{+-0})=\text{Im}(\text{A}(K^0_S\to\pi^+\pi^-\pi^0$, CP-violating) / $\text{A}(K^0_L\to\pi^+\pi^-\pi^0))$	-0.002 ± 0.009
$\text{Im}(\eta_{000})=\text{Im}(A(K^0_S\to\pi^0\pi^0\pi^0)/A(K^0_L\to\pi^0\pi^0\pi^0))$	-0.05 ± 0.13
CP asymmetry A in $K^0_S\to\pi^+\pi^-e^+e^-$	(-1 ± 4)%
$\Gamma(K^0_S\to3\pi^0)/\Gamma_{\text{total}}$	$<1.4\times10^{-5}$, CL = 90%
linear coefficient j for $K^0_L\to\pi^+\pi^-\pi^0$	0.0012 ± 0.0008
quadratic coefficient f for $K^0_L\to\pi^+\pi^-\pi^0$	0.004 ± 0.006
$\lvert\epsilon'_{+-\gamma}\rvert/\epsilon$ for $K^0_L\to\pi^+\pi^-\gamma$	<0.3, CL = 90%
$\Gamma(K^0_L\to\pi^0\mu^+\mu^-)/\Gamma_{\text{total}}$	[c] $<3.8\times10^{-10}$, CL = 90%
$\Gamma(K^0_L\to\pi^0e^+e^-)/\Gamma_{\text{total}}$	[c] $<5.1\times10^{-10}$, CL = 90%
$\Gamma(K^0_L\to\pi^0\nu\overline{\nu})/\Gamma_{\text{total}}$	[d] $<5.9\times10^{-7}$, CL = 90%
$A_{CP}(K^0_S\pi^\pm)$ in $D^\pm\to K^0_S\pi^\pm$	-0.016 ± 0.017
$A_{CP}(K^0_SK^\pm)$ in $D^\pm\to K^0_SK^\pm$	0.07 ± 0.06
$A_{CP}(K^+K^-\pi^\pm)$ in $D^\pm\to K^+K^-\pi^\pm$	0.002 ± 0.011
$A_{CP}(K^\pm K^{*0})$ in $D^+\to K^+\overline{K}^{*0}$, $D^-\to K^-K^{*0}$	-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^0, $\overline{D}^0\to K^+K^-$	0.005 ± 0.016
$A_{CP}(K^0_SK^0_S)$ in D^0, $\overline{D}^0\to K^0_SK^0_S$	-0.23 ± 0.19
$A_{CP}(\pi^+\pi^-)$ in D^0, $\overline{D}^0\to\pi^+\pi^-$	0.021 ± 0.026
$A_{CP}(\pi^0\pi^0)$ in D^0, $\overline{D}^0\to\pi^0\pi^0$	0.00 ± 0.05
$A_{CP}(K^0_S\phi)$ in D^0, $\overline{D}^0\to K^0_S\phi$	-0.03 ± 0.09
$A_{CP}(K^0_S\pi^0)$ in D^0, $\overline{D}^0\to K^0_S\pi^0$	0.001 ± 0.013
$A_{CP}(K^\pm\pi^\mp)$ in $D^0\to K^+\pi^-$, $\overline{D}^0\to K^-\pi^+$	0.08 ± 0.09
$A_{CP}(K^\mp\pi^\pm\pi^0)$ in $D^0\to K^-\pi^+\pi^0$, $\overline{D}^0\to K^+\pi^-\pi^0$	-0.03 ± 0.09
$A_{CP}(K^\pm\pi^\mp\pi^0)$ in $D^0\to K^+\pi^-\pi^0$, $\overline{D}^0\to K^-\pi^+\pi^0$	$0.09^{+0.25}_{-0.22}$
$A_{CP}(B^+\to J/\psi(1S)K^+)$	-0.007 ± 0.019
$A_{CP}(B^+\to J/\psi(1S)\pi^+)$	-0.01 ± 0.13
$A_{CP}(B^+\to\psi(2S)K^+)$	-0.037 ± 0.025
$A_{CP}(B^+\to\overline{D}^0K^+)$	0.04 ± 0.07
$A_{CP}(B^+\to D_{CP(+1)}K^+)$	0.06 ± 0.19
$A_{CP}(B^+\to D_{CP(-1)}K^+)$	-0.19 ± 0.18
$A_{CP}(B^+\to\pi^+\pi^0)$	0.05 ± 0.15
$A_{CP}(B^+\to K^+\pi^0)$	-0.10 ± 0.08
$A_{CP}(B^+\to K^0_S\pi^+)$	0.03 ± 0.08 (S = 1.1)
$A_{CP}(B^+\to\pi^+\pi^-\pi^+)$	-0.39 ± 0.35
$A_{CP}(B^+\to\rho^+\rho^0)$	-0.09 ± 0.16
$A_{CP}(B^+\to K^+\pi^-\pi^+)$	0.01 ± 0.08
$A_{CP}(B^+\to K^+K^-K^+)$	0.02 ± 0.08
$A_{CP}(B^+\to K^+\eta')$	0.009 ± 0.035
$A_{CP}(B^+\to\omega\pi^+)$	-0.21 ± 0.19
$A_{CP}(B^+\to\omega K^+)$	-0.21 ± 0.28
$A_{CP}(B^+\to\phi K^+)$	0.03 ± 0.07
$A_{CP}(B^+\to\phi K^*(892)^+)$	0.09 ± 0.15
$A_{CP}(B^+\to\rho^0K^*(892)^+)$	0.20 ± 0.31
$\text{Re}(\epsilon_{B^0})/(1+\lvert\epsilon_{B^0}\rvert^2)$	$(0.5\pm3.1)\times10^{-3}$
$A_{T/CP}$	0.005 ± 0.018
$A_{CP}\,(B^0\to K^+\pi^-)$	-0.09 ± 0.04
$A_{CP}(B^0\to\rho^+\pi^-)$	-0.18 ± 0.09
$A_{CP}(B^0\to\rho^+K^-)$	0.28 ± 0.19
$A_{CP}(B^0\to K^*(892)^+\pi^-)$	0.26 ± 0.35
$A_{CP}(B^0\to K^*(892)^0\phi)$	0.05 ± 0.10
$A_{CP}(B^0\to D^*(2010)^+D^-)$	-0.03 ± 0.12
$C_{\pi\pi}\,(B^0\to\pi^+\pi^-)$	-0.51 ± 0.23 (S = 1.2)
$S_{\pi\pi}\,(B^0\to\pi^+\pi^-)$	-0.5 ± 0.6 (S = 2.3)
$C_{\rho\pi}\,(B^0\to\rho^+\pi^-)$	0.36 ± 0.18
$S_{\rho\pi}\,(B^0\to\rho^+\pi^-)$	0.19 ± 0.24
$C_{\eta'(958)K}\,(B^0\to\eta'(958)K^0_S)$	0.04 ± 0.13
$S_{\eta'(958)K}\,(B^0\to\eta'(958)K^0_S)$	0.27 ± 0.21
$C_{\phi K^0_S}\,(B^0\to\phi K^0_S)$	0.15 ± 0.30
$S_{\phi K^0_S}\,(B^0\to\phi K^0_S)$	-1.0 ± 0.5
$C_{K^+K^-K^0_S}\,(B^0\to K^+K^-K^0_S)$	0.17 ± 0.16
$S_{K^+K^-K^0_S}\,(B^0\to K^+K^-K^0_S)$	-0.51 ± 0.26
$C_{D^*(2010)^-D^+}\,(B^0\to D^*(2010)^-D^+)$	-0.2 ± 0.4
$S_{D^*(2010)^-D^+}\,(B^0\to D^*(2010)^-D^+)$	-0.2 ± 0.7
$C_{D^*(2010)^+D^-}\,(B^0\to D^*(2010)^+D^-)$	-0.5 ± 0.4
$S_{D^*(2010)^+D^-}\,(B^0\to D^*(2010)^+D^-)$	-0.8 ± 0.8
$C_{J/\psi(1S)\pi^0}\,(B^0\to J/\psi(1S)\pi^0)$	0.4 ± 0.4
$S_{J/\psi(1S)\pi^0}\,(B^0\to J/\psi(1S)\pi^0)$	0.1 ± 0.5
$\Delta C_{\rho\pi}\,(B^0\to\rho^+\pi^-)$	0.28 ± 0.19
$\Delta S_{\rho\pi}\,(B^0\to\rho^+\pi^-)$	0.15 ± 0.25
$\lvert\lambda\rvert\,(B^0\to c\overline{c}K^0)$	0.949 ± 0.045
$\lvert\lambda\rvert\,(B^0\to D^{*+}D^{*-})$	0.75 ± 0.19
$\text{Im}(\lambda)\,(B^0\to D^{*+}D^{*-})$	0.05 ± 0.31
$A_{CP}(B\to K^*(892)\gamma)$	-0.01 ± 0.07
$A_{CP}(B\to s\gamma)$	-0.08 ± 0.11
$[\alpha_-(\Lambda)+\alpha_+(\overline{\Lambda})]\,/\,[\alpha_-(\Lambda)-\alpha_+(\overline{\Lambda})]$	0.012 ± 0.021
$\frac{[\alpha(\Xi^-)\alpha_-(\Lambda)-\alpha(\overline{\Xi}^+)\alpha_+(\overline{\Lambda})]}{[\alpha(\Xi^-)\alpha_-(\Lambda)+\alpha(\overline{\Xi}^+)\alpha_+(\overline{\Lambda})]}$	0.012 ± 0.014
$[\alpha(\Omega^-\to\Lambda K^-)+\alpha(\overline{\Omega}^+\to\overline{\Lambda}K^+)]/2$	-0.004 ± 0.040

CP VIOLATION OBSERVED

charge asymmetry in $K^0_{\ell3}$ decays	
δ_L = weighted average of $\delta_L(\mu)$ and $\delta_L(e)$	(0.327 ± 0.012)%
$\delta_L(\mu)=[\Gamma(\pi^-\mu^+\nu_\mu)-\Gamma(\pi^+\mu^-\overline{\nu}_\mu)]/\text{sum}$	(0.304 ± 0.025)%
$\delta_L(e)=[\Gamma(\pi^-e^+\nu_e)-\Gamma(\pi^+e^-\overline{\nu}_e)]/\text{sum}$	(0.333 ± 0.014)%
parameters for $K^0_L\to2\pi$ decay	
$\lvert\eta_{00}\rvert=\lvert\text{A}(K^0_L\to2\pi^0)\,/\,\text{A}(K^0_S\to2\pi^0)\rvert$	$(2.276\pm0.014)\times10^{-3}$
$\lvert\eta_{+-}\rvert=\lvert\text{A}(K^0_L\to\pi^+\pi^-)\,/\,\text{A}(K^0_S\to\pi^+\pi^-)\rvert$	$(2.288\pm0.014)\times10^{-3}$
$\lvert\epsilon\rvert=(2\lvert\eta_{+-}\rvert+\lvert\eta_{00}\rvert)/3$	$(2.284\pm0.014)\times10^{-3}$
$\lvert\eta_{00}/\eta_{+-}\rvert$	[e] 0.9950 ± 0.0008 (S = 1.6)
$\text{Re}(\epsilon'/\epsilon)=(1-\lvert\eta_{00}/\eta_{+-}\rvert)/3$	[e] $(1.67\pm0.26)\times10^{-3}$ (S = 1.6)
Assuming *CPT*	
ϕ_{+-}, phase of η_{+-}	$(43.52\pm0.06)^\circ$ (S = 1.3)
ϕ_{00}, phase of η_{00}	$(43.50\pm0.06)^\circ$ (S = 1.3)
$\phi_\epsilon=(2\phi_{+-}+\phi_{00})/3$	$(43.51\pm0.05)^\circ$ (S = 1.2)
Not assuming *CPT*	
ϕ_{+-}, phase of η_{+-}	$(43.4\pm0.7)^\circ$ (S = 1.3)
ϕ_{00}, phase of η_{00}	$(43.7\pm0.8)^\circ$ (S = 1.2)
$\phi_\epsilon=(2\phi_{+-}+\phi_{00})/3$	$(43.5\pm0.7)^\circ$ (S = 1.3)
CP asymmetry A in $K^0_L\to\pi^+\pi^-e^+e^-$	(13.8 ± 2.2)%
β_{CP} from $K^0_L\to e^+e^-e^+e^-$	-0.23 ± 0.09
γ_{CP} from $K^0_L\to e^+e^-e^+e^-$	-0.09 ± 0.09
parameters for $K^0_L\to\pi^+\pi^-\gamma$ decay	
$\lvert\eta_{+-\gamma}\rvert=\lvert\text{A}(K^0_L\to\pi^+\pi^-\gamma$, CP violating$)/\text{A}(K^0_S\to\pi^+\pi^-\gamma)\rvert$	$(2.35\pm0.07)\times10^{-3}$
$\phi_{+-\gamma}$ = phase of $\eta_{+-\gamma}$	$(44\pm4)^\circ$
$\Gamma(K^0_L\to\pi^+\pi^-)/\Gamma_{\text{total}}$	$(2.090\pm0.025)\times10^{-3}$ (S = 1.1)

Unless otherwise stated, limits are given at the 90% confidence level, while errors are given as ±1 standard deviation.

$\Gamma(K^0_L \rightarrow \pi^0\pi^0)/\Gamma_{total}$	$(9.32 \pm 0.12) \times 10^{-4}$ (S = 1.1)
Parameters for $B^0 \rightarrow J/\psi K^0_S$	
$\sin(2\beta)$	0.731 ± 0.056

CPT INVARIANCE

$(m_{W^+} - m_{W^-})\ /\ m_{average}$	-0.002 ± 0.007
$(m_{e^+} - m_{e^-})\ /\ m_{average}$	$<8 \times 10^{-9}$, CL = 90%
$\lvert q_{e^+} + q_{e^-}\rvert/e$	$<4 \times 10^{-8}$
$(g_{e^+} - g_{e^-})\ /\ g_{average}$	$(-0.5 \pm 2.1) \times 10^{-12}$
$(\tau_{\mu^+} - \tau_{\mu^-})\ /\ \tau_{average}$	$(2 \pm 8) \times 10^{-5}$
$(g_{\mu^+} - g_{\mu^-})\ /\ g_{average}$	$(-2.6 \pm 1.6) \times 10^{-8}$
$(m_{\pi^+} - m_{\pi^-})\ /\ m_{average}$	$(2 \pm 5) \times 10^{-4}$
$(\tau_{\pi^+} - \tau_{\pi^-})\ /\ \tau_{average}$	$(6 \pm 7) \times 10^{-4}$
$(m_{K^+} - m_{K^-})\ /\ m_{average}$	$(-0.6 \pm 1.8) \times 10^{-4}$
$(\tau_{K^+} - \tau_{K^-})\ /\ \tau_{average}$	$(0.11 \pm 0.09)\%$ (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] $(0.8 \pm 1.2)\%$
δ in $K^0 - \overline{K}^0$ mixing	
real part of δ	$(2.9 \pm 2.7) \times 10^{-4}$
imaginary part of δ	$(0.02 \pm 0.05) \times 10^{-3}$
$\lvert m_{K^0} - m_{\overline{K}^0}\rvert\ /\ m_{average}$	[g] $<10^{-18}$, CL = 90%
$(\Gamma_{K^0} - \Gamma_{\overline{K}^0})/m_{average}$	$(8 \pm 8) \times 10^{-18}$
phase difference $\phi_{00} - \phi_{+-}$	$(0.2 \pm 0.4)^\circ$
$\mathrm{Re}(\frac{2}{3}\eta_{+-} + \frac{1}{3}\eta_{00}) - \frac{\delta_L}{2}$	$(-3 \pm 35) \times 10^{-6}$
$A_{CPT}(K^\mp\pi^\pm)$ in $D^0 \rightarrow K^-\pi^+$, $\overline{D}^0 \rightarrow K^+\pi^-$	0.008 ± 0.008
$\lvert m_p - m_{\overline{p}}\rvert/m_p$	[h] $<1.0 \times 10^{-8}$, CL = 90%
$(\lvert\frac{q_{\overline{p}}}{m_{\overline{p}}}\rvert - \frac{q_p}{m_p})/\frac{q_p}{m_p}$	$(-9 \pm 9) \times 10^{-11}$
$\lvert q_p + q_{\overline{p}}\rvert/e$	[h] $<1.0 \times 10^{-8}$, CL = 90%
$(\mu_p + \mu_{\overline{p}})\ /\ \mu_p$	$(-2.6 \pm 2.9) \times 10^{-3}$
$(m_n - m_{\overline{n}})/\ m_n$	$(9 \pm 5) \times 10^{-5}$
$(m_\Lambda - m_{\overline{\Lambda}})\ /\ m_\Lambda$	$(-0.1 \pm 1.1) \times 10^{-5}$ (S = 1.6)
$(\tau_\Lambda - \tau_{\overline{\Lambda}})\ /\ \tau_\Lambda$	-0.001 ± 0.009
$(\tau_{\Sigma^+} - \tau_{\overline{\Sigma}^-})\ /\ \tau_{\Sigma^+}$	$(-0.6 \pm 1.2) \times 10^{-3}$
$(\mu_{\Sigma^+} + \mu_{\overline{\Sigma}^-})\ /\ \mu_{\Sigma^+}$	0.014 ± 0.015
$(m_{\Xi^-} - m_{\overline{\Xi}^+})\ /\ m_{\Xi^-}$	$(1.1 \pm 2.7) \times 10^{-4}$
$(\tau_{\Xi^-} - \tau_{\overline{\Xi}^+})\ /\ \tau_{\Xi^-}$	0.02 ± 0.18
$(\mu_{\Xi^-} + \mu_{\overline{\Xi}^+})\ /\ \lvert\mu_{\Xi^-}\rvert$	$+0.01 \pm 0.05$
$(m_{\Omega^-} - m_{\overline{\Omega}^+})\ /\ m_{\Omega^-}$	$(-1 \pm 8) \times 10^{-5}$
$(\tau_{\Omega^-} - \tau_{\overline{\Omega}^+})\ /\ \tau_{\Omega^-}$	-0.002 ± 0.040

TESTS OF NUMBER CONSERVATION LAWS

LEPTON FAMILY NUMBER

Lepton family number conservation means separate conservation of each of L_e, L_μ, L_τ.

$\Gamma(Z \rightarrow e^\pm\mu^\mp)/\Gamma_{total}$	[i] $<1.7 \times 10^{-6}$, CL = 95%
$\Gamma(Z \rightarrow e^\pm\tau^\mp)/\Gamma_{total}$	[i] $<9.8 \times 10^{-6}$, CL = 95%
$\Gamma(Z \rightarrow \mu^\pm\tau^\mp)/\Gamma_{total}$	[i] $<1.2 \times 10^{-5}$, CL = 95%
limit on $\mu^- \rightarrow e^-$ conversion	
$\sigma(\mu^-\,^{32}\mathrm{S} \rightarrow e^-\,^{32}\mathrm{S})\ /\ \sigma(\mu^-\,^{32}\mathrm{S} \rightarrow \nu_\mu\,^{32}\mathrm{P}^*)$	$<7 \times 10^{-11}$, CL = 90%
$\sigma(\mu^-\,\mathrm{Ti} \rightarrow e^-\,\mathrm{Ti})\ /\ \sigma(\mu^-\,\mathrm{Ti} \rightarrow \text{capture})$	$<4.3 \times 10^{-12}$, CL = 90%
$\sigma(\mu^-\,\mathrm{Pb} \rightarrow e^-\,\mathrm{Pb})\ /\ \sigma(\mu^-\,\mathrm{Pb} \rightarrow \text{capture})$	$<4.6 \times 10^{-11}$, CL = 90%
limit on muonium $\rightarrow$ antimuonium conversion $R_g = G_C\ /\ G_F$	<0.0030, CL = 90%
$\Gamma(\mu^- \rightarrow e^-\nu_e\overline{\nu}_\mu)/\Gamma_{total}$	[j] $<1.2 \times 10^{-2}$, CL = 90%
$\Gamma(\mu^- \rightarrow e^-\gamma)/\Gamma_{total}$	$<1.2 \times 10^{-11}$, CL = 90%
$\Gamma(\mu^- \rightarrow e^-e^+e^-)/\Gamma_{total}$	$<1.0 \times 10^{-12}$, CL = 90%
$\Gamma(\mu^- \rightarrow e^-2\gamma)/\Gamma_{total}$	$<7.2 \times 10^{-11}$, CL = 90%

Unless otherwise stated, limits are given at the 90% confidence level, while errors are given as ±1 standard deviation.

$\Gamma(\tau^- \rightarrow e^-\gamma)/\Gamma_{total}$	$<2.7 \times 10^{-6}$, CL = 90%
$\Gamma(\tau^- \rightarrow \mu^-\gamma)/\Gamma_{total}$	$<1.1 \times 10^{-6}$, CL = 90%
$\Gamma(\tau^- \rightarrow e^-\pi^0)/\Gamma_{total}$	$<3.7 \times 10^{-6}$, CL = 90%
$\Gamma(\tau^- \rightarrow \mu^-\pi^0)/\Gamma_{total}$	$<4.0 \times 10^{-6}$, CL = 90%
$\Gamma(\tau^- \rightarrow e^-K^0_S)/\Gamma_{total}$	$<9.1 \times 10^{-7}$, CL = 90%
$\Gamma(\tau^- \rightarrow \mu^-K^0_S)/\Gamma_{total}$	$<9.5 \times 10^{-7}$, CL = 90%
$\Gamma(\tau^- \rightarrow e^-\eta)/\Gamma_{total}$	$<8.2 \times 10^{-6}$, CL = 90%
$\Gamma(\tau^- \rightarrow \mu^-\eta)/\Gamma_{total}$	$<9.6 \times 10^{-6}$, CL = 90%
$\Gamma(\tau^- \rightarrow e^-\rho^0)/\Gamma_{total}$	$<2.0 \times 10^{-6}$, CL = 90%
$\Gamma(\tau^- \rightarrow \mu^-\rho^0)/\Gamma_{total}$	$<6.3 \times 10^{-6}$, CL = 90%
$\Gamma(\tau^- \rightarrow e^-K^*(892)^0)/\Gamma_{total}$	$<5.1 \times 10^{-6}$, CL = 90%
$\Gamma(\tau^- \rightarrow \mu^-K^*(892)^0)/\Gamma_{total}$	$<7.5 \times 10^{-6}$, CL = 90%
$\Gamma(\tau^- \rightarrow e^-\overline{K}^*(892)^0)/\Gamma_{total}$	$<7.4 \times 10^{-6}$, CL = 90%
$\Gamma(\tau^- \rightarrow \mu^-\overline{K}^*(892)^0)/\Gamma_{total}$	$<7.5 \times 10^{-6}$, CL = 90%
$\Gamma(\tau^- \rightarrow e^-\phi)/\Gamma_{total}$	$<6.9 \times 10^{-6}$, CL = 90%
$\Gamma(\tau^- \rightarrow \mu^-\phi)/\Gamma_{total}$	$<7.0 \times 10^{-6}$, CL = 90%
$\Gamma(\tau^- \rightarrow e^-e^+e^-)/\Gamma_{total}$	$<2.9 \times 10^{-6}$, CL = 90%
$\Gamma(\tau^- \rightarrow e^-\mu^+\mu^-)/\Gamma_{total}$	$<1.8 \times 10^{-6}$, CL = 90%
$\Gamma(\tau^- \rightarrow e^+\mu^-\mu^-)/\Gamma_{total}$	$<1.5 \times 10^{-6}$, CL = 90%
$\Gamma(\tau^- \rightarrow \mu^-e^+e^-)/\Gamma_{total}$	$<1.7 \times 10^{-6}$, CL = 90%
$\Gamma(\tau^- \rightarrow \mu^+e^-e^-)/\Gamma_{total}$	$<1.5 \times 10^{-6}$, CL = 90%
$\Gamma(\tau^- \rightarrow \mu^-\mu^+\mu^-)/\Gamma_{total}$	$<1.9 \times 10^{-6}$, CL = 90%
$\Gamma(\tau^- \rightarrow e^-\pi^+\pi^-)/\Gamma_{total}$	$<2.2 \times 10^{-6}$, CL = 90%
$\Gamma(\tau^- \rightarrow \mu^-\pi^+\pi^-)/\Gamma_{total}$	$<8.2 \times 10^{-6}$, CL = 90%
$\Gamma(\tau^- \rightarrow e^-\pi^+K^-)/\Gamma_{total}$	$<6.4 \times 10^{-6}$, CL = 90%
$\Gamma(\tau^- \rightarrow e^-\pi^-K^+)/\Gamma_{total}$	$<3.8 \times 10^{-6}$, CL = 90%
$\Gamma(\tau^- \rightarrow e^-K^0_SK^0_S)/\Gamma_{total}$	$<2.2 \times 10^{-6}$, CL = 90%
$\Gamma(\tau^- \rightarrow e^-K^+K^-)/\Gamma_{total}$	$<6.0 \times 10^{-6}$, CL = 90%
$\Gamma(\tau^- \rightarrow \mu^-\pi^+K^-)/\Gamma_{total}$	$<7.5 \times 10^{-6}$, CL = 90%
$\Gamma(\tau^- \rightarrow \mu^-\pi^-K^+)/\Gamma_{total}$	$<7.4 \times 10^{-6}$, CL = 90%
$\Gamma(\tau^- \rightarrow \mu^-K^0_SK^0_S)/\Gamma_{total}$	$<3.4 \times 10^{-6}$, CL = 90%
$\Gamma(\tau^- \rightarrow \mu^-K^+K^-)/\Gamma_{total}$	$<1.5 \times 10^{-5}$, CL = 90%
$\Gamma(\tau^- \rightarrow e^-\pi^0\pi^0)/\Gamma_{total}$	$<6.5 \times 10^{-6}$, CL = 90%
$\Gamma(\tau^- \rightarrow \mu^-\pi^0\pi^0)/\Gamma_{total}$	$<1.4 \times 10^{-5}$, CL = 90%
$\Gamma(\tau^- \rightarrow e^-\eta\eta)/\Gamma_{total}$	$<3.5 \times 10^{-5}$, CL = 90%
$\Gamma(\tau^- \rightarrow \mu^-\eta\eta)/\Gamma_{total}$	$<6.0 \times 10^{-5}$, CL = 90%
$\Gamma(\tau^- \rightarrow e^-\pi^0\eta)/\Gamma_{total}$	$<2.4 \times 10^{-5}$, CL = 90%
$\Gamma(\tau^- \rightarrow \mu^-\pi^0\eta)/\Gamma_{total}$	$<2.2 \times 10^{-5}$, CL = 90%
$\Gamma(\tau^- \rightarrow e^-\text{light boson})/\Gamma_{total}$	$<2.7 \times 10^{-3}$, CL = 95%
$\Gamma(\tau^- \rightarrow \mu^-\text{light boson})/\Gamma_{total}$	$<5 \times 10^{-3}$, CL = 95%

LEPTON FAMILY NUMBER VIOLATION IN NEUTRINOS

Solar Neutrinos

$\theta_\odot = 32.5^\circ\,^{+2.4^\circ}_{-2.3^\circ}$

$\Delta m^2_\odot = \left(7.1^{+1.2}_{-0.6}\right) \times 10^{-5}\ \mathrm{eV}^2$

Atmospheric Neutrinos

$36^\circ < \theta_{atm} < 54^\circ$, CL = 90%

$1.3 \times 10^{-3}\ \mathrm{eV}^2 < \Delta m^2_{atm} < 3.0 \times 10^{-3}\ \mathrm{eV}^2$, CL = 90%

$\Gamma(\pi^+ \rightarrow \mu^+\nu_e)/\Gamma_{total}$	[k] $<8.0 \times 10^{-3}$, CL = 90%
$\Gamma(\pi^+ \rightarrow \mu^-e^+e^+\nu)/\Gamma_{total}$	$<1.6 \times 10^{-6}$, CL = 90%
$\Gamma(\pi^0 \rightarrow \mu^+e^-)/\Gamma_{total}$	$<3.8 \times 10^{-10}$, CL = 90%
$\Gamma(\pi^0 \rightarrow \mu^-e^+)/\Gamma_{total}$	$<3.4 \times 10^{-9}$, CL = 90%
$\Gamma(\pi^0 \rightarrow \mu^+e^- + \mu^-e^+)/\Gamma_{total}$	$<1.72 \times 10^{-8}$, CL = 90%
$\Gamma(\eta \rightarrow \mu^+e^- + \mu^-e^+)/\Gamma_{total}$	$<6 \times 10^{-6}$, CL = 90%
$\Gamma(\eta'(958) \rightarrow e\mu)/\Gamma_{total}$	$<4.7 \times 10^{-4}$, CL = 90%
$\Gamma(K^+ \rightarrow \mu^-\nu e^+e^+)/\Gamma_{total}$	$<2.0 \times 10^{-8}$, CL = 90%
$\Gamma(K^+ \rightarrow \mu^+\nu_e)/\Gamma_{total}$	[k] $<4 \times 10^{-3}$, CL = 90%
$\Gamma(K^+ \rightarrow \pi^+\mu^+e^-)/\Gamma_{total}$	$<2.8 \times 10^{-11}$, CL = 90%
$\Gamma(K^+ \rightarrow \pi^+\mu^-e^+)/\Gamma_{total}$	$<5.2 \times 10^{-10}$, CL = 90%
$\Gamma(K^0_L \rightarrow e^\pm\mu^\mp)/\Gamma_{total}$	[i] $<4.7 \times 10^{-12}$, CL = 90%
$\Gamma(K^0_L \rightarrow e^\pm e^\pm\mu^\mp\mu^\mp)/\Gamma_{total}$	[i] $<4.12 \times 10^{-11}$, CL = 90%
$\Gamma(K^0_L \rightarrow \pi^0\mu^\pm e^\mp)/\Gamma_{total}$	[i] $<6.2 \times 10^{-9}$, CL = 90%
$\Gamma(D^+ \rightarrow \pi^+e^\pm\mu^\mp)/\Gamma_{total}$	[i] $<3.4 \times 10^{-5}$, CL = 90%
$\Gamma(D^+ \rightarrow K^+e^\pm\mu^\mp)/\Gamma_{total}$	[i] $<6.8 \times 10^{-5}$, CL = 90%
$\Gamma(D^0 \rightarrow \mu^\pm e^\mp)/\Gamma_{total}$	[i] $<8.1 \times 10^{-6}$, CL = 90%
$\Gamma(D^0 \rightarrow \pi^0e^\pm\mu^\mp)/\Gamma_{total}$	[i] $<8.6 \times 10^{-5}$, CL = 90%
$\Gamma(D^0 \rightarrow \eta e^\pm\mu^\mp)/\Gamma_{total}$	[i] $<1.0 \times 10^{-4}$, CL = 90%
$\Gamma(D^0 \rightarrow \pi^+\pi^-e^\pm\mu^\mp)/\Gamma_{total}$	[i] $<1.5 \times 10^{-5}$, CL = 90%
$\Gamma(D^0 \rightarrow \rho^0e^\pm\mu^\mp)/\Gamma_{total}$	[i] $<4.9 \times 10^{-5}$, CL = 90%
$\Gamma(D^0 \rightarrow \omega e^\pm\mu^\mp)/\Gamma_{total}$	[i] $<1.2 \times 10^{-4}$, CL = 90%
$\Gamma(D^0 \rightarrow K^-K^+e^\pm\mu^\mp)/\Gamma_{total}$	[i] $<1.8 \times 10^{-4}$, CL = 90%
$\Gamma(D^0 \rightarrow \phi e^\pm\mu^\mp)/\Gamma_{total}$	[i] $<3.4 \times 10^{-5}$, CL = 90%

$\Gamma(D^0 \to \overline{K}^0 e^\pm \mu^\mp)/\Gamma_{total}$	[i]	$<1.0 \times 10^{-4}$, CL = 90%
$\Gamma(D^0 \to K^- \pi^+ e^\pm \mu^\mp)/\Gamma_{total}$	[i]	$<5.53 \times 10^{-4}$, CL = 90%
$\Gamma(D^0 \to \overline{K}^*(892)^0 e^\pm \mu^\mp)/\Gamma_{total}$	[i]	$<8.3 \times 10^{-5}$, CL = 90%
$\Gamma(D_s^+ \to \pi^+ e^\pm \mu^\mp)/\Gamma_{total}$	[i]	$<6.1 \times 10^{-4}$, CL = 90%
$\Gamma(D_s^+ \to K^+ e^\pm \mu^\mp)/\Gamma_{total}$	[i]	$<6.3 \times 10^{-4}$, CL = 90%
$\Gamma(B^+ \to \pi^+ e^+ \mu^-)/\Gamma_{total}$		$<6.4 \times 10^{-3}$, CL = 90%
$\Gamma(B^+ \to \pi^+ e^- \mu^+)/\Gamma_{total}$		$<6.4 \times 10^{-3}$, CL = 90%
$\Gamma(B^+ \to K^+ e^+ \mu^-)/\Gamma_{total}$		$<8 \times 10^{-7}$, CL = 90%
$\Gamma(B^+ \to K^+ e^- \mu^+)/\Gamma_{total}$		$<6.4 \times 10^{-3}$, CL = 90%
$\Gamma(B^+ \to K^*(892)^+ e^\pm \mu^\mp)/\Gamma_{total}$		$<7.9 \times 10^{-6}$, CL = 90%
$\Gamma(B^+ \to \rho^- e^+ \mu^+)/\Gamma_{total}$		$<3.3 \times 10^{-6}$, CL = 90%
$\Gamma(B^+ \to K^*(892)^- e^+ \mu^+)/\Gamma_{total}$		$<4.4 \times 10^{-6}$, CL = 90%
$\Gamma(B^0 \to e^\pm \mu^\mp)/\Gamma_{total}$	[i]	$<1.7 \times 10^{-7}$, CL = 90%
$\Gamma(B^0 \to K^0 e^\pm \mu^\mp)/\Gamma_{total}$		$<4.0 \times 10^{-6}$, CL = 90%
$\Gamma(B^0 \to K^*(892)^0 e^\pm \mu^\mp)/\Gamma_{total}$		$<3.4 \times 10^{-6}$, CL = 90%
$\Gamma(B^0 \to e^\pm \tau^\mp)/\Gamma_{total}$	[i]	$<5.3 \times 10^{-4}$, CL = 90%
$\Gamma(B^0 \to \mu^\pm \tau^\mp)/\Gamma_{total}$	[i]	$<8.3 \times 10^{-4}$, CL = 90%
$\Gamma(B \to e^\pm \mu^\mp s)/\Gamma_{total}$	[i]	$<2.2 \times 10^{-5}$, CL = 90%
$\Gamma(B \to \pi e^\pm \mu^\mp)/\Gamma_{total}$		$<1.6 \times 10^{-6}$, CL = 90%
$\Gamma(B \to \rho e^\pm \mu^\mp)/\Gamma_{total}$		$<3.2 \times 10^{-6}$, CL = 90%
$\Gamma(B \to K e^\pm \mu^\mp)/\Gamma_{total}$		$<1.6 \times 10^{-6}$, CL = 90%
$\Gamma(B \to K^*(892) e^\pm \mu^\mp)/\Gamma_{total}$		$<6.2 \times 10^{-6}$, CL = 90%
$\Gamma(B_s^0 \to e^\pm \mu^\mp)/\Gamma_{total}$	[i]	$<6.1 \times 10^{-6}$, CL = 90%
$\Gamma(J/\psi(1S) \to e^\pm \mu^\mp)/\Gamma_{total}$		$<1.1 \times 10^{-6}$, CL = 90%

TOTAL LEPTON NUMBER

Violation of total lepton number conservation also implies violation of lepton family number conservation.

$\Gamma(Z \to p e)/\Gamma_{total}$		$<1.8 \times 10^{-6}$, CL = 95%
$\Gamma(Z \to p \mu)/\Gamma_{total}$		$<1.8 \times 10^{-6}$, CL = 95%
limit on $\mu^- \to e^+$ conversion		
$\sigma(\mu^- {}^{32}\mathrm{S} \to e^+ {}^{32}\mathrm{Si}^*)$ / $\sigma(\mu^- {}^{32}\mathrm{S} \to \nu_\mu {}^{32}\mathrm{P}^*)$		$<9 \times 10^{-10}$, CL = 90%
$\sigma(\mu^- {}^{127}\mathrm{I} \to e^+ {}^{127}\mathrm{Sb}^*)$ / $\sigma(\mu^- {}^{127}\mathrm{I} \to$ anything)		$<3 \times 10^{-10}$, CL = 90%
$\sigma(\mu^- \mathrm{Ti} \to e^+ \mathrm{Ca})$ / $\sigma(\mu^- \mathrm{Ti} \to$ capture)		$<3.6 \times 10^{-11}$, CL = 90%
$\Gamma(\tau^- \to e^+ \pi^- \pi^-)/\Gamma_{total}$		$<1.9 \times 10^{-6}$, CL = 90%
$\Gamma(\tau^- \to \mu^+ \pi^- \pi^-)/\Gamma_{total}$		$<3.4 \times 10^{-6}$, CL = 90%
$\Gamma(\tau^- \to e^+ \pi^- K^-)/\Gamma_{total}$		$<2.1 \times 10^{-6}$, CL = 90%
$\Gamma(\tau^- \to e^+ K^- K^-)/\Gamma_{total}$		$<3.8 \times 10^{-6}$, CL = 90%
$\Gamma(\tau^- \to \mu^+ \pi^- K^-)/\Gamma_{total}$		$<7.0 \times 10^{-6}$, CL = 90%
$\Gamma(\tau^- \to \mu^+ K^- K^-)/\Gamma_{total}$		$<6.0 \times 10^{-6}$, CL = 90%
$\Gamma(\tau^- \to \overline{p}\gamma)/\Gamma_{total}$		$<3.5 \times 10^{-6}$, CL = 90%
$\Gamma(\tau^- \to \overline{p}\pi^0)/\Gamma_{total}$		$<1.5 \times 10^{-5}$, CL = 90%
$\Gamma(\tau^- \to \overline{p}2\pi^0)/\Gamma_{total}$		$<3.3 \times 10^{-5}$, CL = 90%
$\Gamma(\tau^- \to \overline{p}\eta)/\Gamma_{total}$		$<8.9 \times 10^{-6}$, CL = 90%
$\Gamma(\tau^- \to \overline{p}\pi^0\eta)/\Gamma_{total}$		$<2.7 \times 10^{-5}$, CL = 90%
$t_{1/2}({}^{76}\mathrm{Ge} \to {}^{76}\mathrm{Se} + 2\,e^-)$		$>1.9 \times 10^{25}$ yr, CL = 90%
$\Gamma(\pi^+ \to \mu^+ \overline{\nu}_e)/\Gamma_{total}$	[k]	$<1.5 \times 10^{-3}$, CL = 90%
$\Gamma(K^+ \to \pi^- \mu^+ e^+)/\Gamma_{total}$		$<5.0 \times 10^{-10}$, CL = 90%
$\Gamma(K^+ \to \pi^- e^+ e^+)/\Gamma_{total}$		$<6.4 \times 10^{-10}$, CL = 90%
$\Gamma(K^+ \to \pi^- \mu^+ \mu^+)/\Gamma_{total}$	[k]	$<3.0 \times 10^{-9}$, CL = 90%
$\Gamma(K^+ \to \mu^+ \overline{\nu}_e)/\Gamma_{total}$	[k]	$<3.3 \times 10^{-3}$, CL = 90%
$\Gamma(K^+ \to \pi^0 e^+ \overline{\nu}_e)/\Gamma_{total}$		$<3 \times 10^{-3}$, CL = 90%
$\Gamma(D^+ \to \pi^- e^+ e^+)/\Gamma_{total}$		$<9.6 \times 10^{-5}$, CL = 90%
$\Gamma(D^+ \to \pi^- \mu^+ \mu^+)/\Gamma_{total}$		$<4.8 \times 10^{-6}$, CL = 90%
$\Gamma(D^+ \to \pi^- e^+ \mu^+)/\Gamma_{total}$		$<5.0 \times 10^{-5}$, CL = 90%
$\Gamma(D^+ \to \rho^- \mu^+ \mu^+)/\Gamma_{total}$		$<5.6 \times 10^{-4}$, CL = 90%
$\Gamma(D^+ \to K^- e^+ e^+)/\Gamma_{total}$		$<1.2 \times 10^{-4}$, CL = 90%
$\Gamma(D^+ \to K^- \mu^+ \mu^+)/\Gamma_{total}$		$<1.3 \times 10^{-5}$, CL = 90%
$\Gamma(D^+ \to K^- e^+ \mu^+)/\Gamma_{total}$		$<1.3 \times 10^{-4}$, CL = 90%
$\Gamma(D^+ \to K^*(892)^- \mu^+ \mu^+)/\Gamma_{total}$		$<8.5 \times 10^{-4}$, CL = 90%
$\Gamma(D^0 \to \pi^- \pi^- e^+ e^+ + \mathrm{c.c.})/\Gamma_{total}$		$<1.12 \times 10^{-4}$, CL = 90%
$\Gamma(D^0 \to \pi^- \pi^- \mu^+ \mu^+ + \mathrm{c.c.})/\Gamma_{total}$		$<2.9 \times 10^{-5}$, CL = 90%
$\Gamma(D^0 \to K^- \pi^- e^+ e^+ + \mathrm{c.c.})/\Gamma_{total}$		$<2.06 \times 10^{-4}$, CL = 90%
$\Gamma(D^0 \to K^- \pi^- \mu^+ \mu^+ + \mathrm{c.c.})/\Gamma_{total}$		$<3.9 \times 10^{-4}$, CL = 90%
$\Gamma(D^0 \to K^- K^- e^+ e^+ + \mathrm{c.c.})/\Gamma_{total}$		$<1.52 \times 10^{-4}$, CL = 90%
$\Gamma(D^0 \to K^- K^- \mu^+ \mu^+ + \mathrm{c.c.})/\Gamma_{total}$		$<9.4 \times 10^{-5}$, CL = 90%
$\Gamma(D^0 \to \pi^- \pi^- e^+ \mu^+ + \mathrm{c.c.})/\Gamma_{total}$		$<7.9 \times 10^{-5}$, CL = 90%
$\Gamma(D^0 \to K^- \pi^- e^+ \mu^+ + \mathrm{c.c.})/\Gamma_{total}$		$<2.18 \times 10^{-4}$, CL = 90%
$\Gamma(D^0 \to K^- K^- e^+ \mu^+ + \mathrm{c.c.})/\Gamma_{total}$		$<5.7 \times 10^{-5}$, CL = 90%
$\Gamma(D_s^+ \to \pi^- e^+ e^+)/\Gamma_{total}$		$<6.9 \times 10^{-4}$, CL = 90%
$\Gamma(D_s^+ \to \pi^- \mu^+ \mu^+)/\Gamma_{total}$		$<2.9 \times 10^{-5}$, CL = 90%
$\Gamma(D_s^+ \to \pi^- e^+ \mu^+)/\Gamma_{total}$		$<7.3 \times 10^{-4}$, CL = 90%
$\Gamma(D_s^+ \to K^- e^+ e^+)/\Gamma_{total}$		$<6.3 \times 10^{-4}$, CL = 90%
$\Gamma(D_s^+ \to K^- \mu^+ \mu^+)/\Gamma_{total}$		$<1.3 \times 10^{-5}$, CL = 90%
$\Gamma(D_s^+ \to K^- e^+ \mu^+)/\Gamma_{total}$		$<6.8 \times 10^{-4}$, CL = 90%
$\Gamma(D_s^+ \to K^*(892)^- \mu^+ \mu^+)/\Gamma_{total}$		$<1.4 \times 10^{-3}$, CL = 90%
$\Gamma(B^+ \to \pi^- e^+ e^+)/\Gamma_{total}$		$<1.6 \times 10^{-6}$, CL = 90%
$\Gamma(B^+ \to \pi^- \mu^+ \mu^+)/\Gamma_{total}$		$<1.4 \times 10^{-6}$, CL = 90%
$\Gamma(B^+ \to \pi^- e^+ \mu^+)/\Gamma_{total}$		$<1.3 \times 10^{-6}$, CL = 90%
$\Gamma(B^+ \to \rho^- e^+ e^+)/\Gamma_{total}$		$<2.6 \times 10^{-6}$, CL = 90%
$\Gamma(B^+ \to \rho^- \mu^+ \mu^+)/\Gamma_{total}$		$<5.0 \times 10^{-6}$, CL = 90%
$\Gamma(B^+ \to K^- e^+ e^+)/\Gamma_{total}$		$<1.0 \times 10^{-6}$, CL = 90%
$\Gamma(B^+ \to K^- \mu^+ \mu^+)/\Gamma_{total}$		$<1.8 \times 10^{-6}$, CL = 90%
$\Gamma(B^+ \to K^- e^+ \mu^+)/\Gamma_{total}$		$<2.0 \times 10^{-6}$, CL = 90%
$\Gamma(B^+ \to K^*(892)^- e^+ e^+)/\Gamma_{total}$		$<2.8 \times 10^{-6}$, CL = 90%
$\Gamma(B^+ \to K^*(892)^- \mu^+ \mu^+)/\Gamma_{total}$		$<8.3 \times 10^{-6}$, CL = 90%
$\Gamma(\Xi^- \to p \mu^- \mu^-)/\Gamma_{total}$		$<4 \times 10^{-4}$, CL = 90%
$\Gamma(\Lambda_c^+ \to \Sigma^- \mu^+ \mu^+)/\Gamma_{total}$		$<7.0 \times 10^{-4}$, CL = 90%

BARYON NUMBER

$\Gamma(Z \to p e)/\Gamma_{total}$		$<1.8 \times 10^{-6}$, CL = 95%
$\Gamma(Z \to p \mu)/\Gamma_{total}$		$<1.8 \times 10^{-6}$, CL = 95%
$\Gamma(\tau^- \to \overline{p}\gamma)/\Gamma_{total}$		$<3.5 \times 10^{-6}$, CL = 90%
$\Gamma(\tau^- \to \overline{p}\pi^0)/\Gamma_{total}$		$<1.5 \times 10^{-5}$, CL = 90%
$\Gamma(\tau^- \to \overline{p}2\pi^0)/\Gamma_{total}$		$<3.3 \times 10^{-5}$, CL = 90%
$\Gamma(\tau^- \to \overline{p}\eta)/\Gamma_{total}$		$<8.9 \times 10^{-6}$, CL = 90%
$\Gamma(\tau^- \to \overline{p}\pi^0\eta)/\Gamma_{total}$		$<2.7 \times 10^{-5}$, CL = 90%
p mean life		$>2.1 \times 10^{29}$ years, CL = 90%

A few examples of proton or bound neutron decay follow. For limits on many other nucleon decay channels, see the Baryon Summary Table.

$\tau(N \to e^+ \pi)$		> 158 (n), > 1600 (p) $\times 10^{30}$ years, CL = 90%
$\tau(N \to \mu^+ \pi)$		> 100 (n), > 473 (p) $\times 10^{30}$ years, CL = 90%
$\tau(N \to e^+ K)$		> 17 (n), > 150 (p) $\times 10^{30}$ years, CL = 90%
$\tau(N \to \mu^+ K)$		> 26 (n), > 120 (p) $\times 10^{30}$ years, CL = 90%
limit on $n\overline{n}$ oscillations (free n)		$>0.86 \times 10^{8}$ s, CL = 90%
limit on $n\overline{n}$ oscillations (bound n)	[l]	$>1.2 \times 10^{8}$ s, CL = 90%

ELECTRIC CHARGE (Q)

$e \to \nu_e \gamma$ and astrophysical limits	[m]	$>4.6 \times 10^{26}$ yr, CL = 90%
$\Gamma(n \to p \nu_e \overline{\nu}_e)/\Gamma_{total}$		$<8 \times 10^{-27}$, CL = 68%

$\Delta S = \Delta Q$ RULE

Violations allowed in second-order weak interactions.

$\Gamma(K^+ \to \pi^+ \pi^+ e^- \overline{\nu}_e)/\Gamma_{total}$		$<1.2 \times 10^{-8}$, CL = 90%
$\Gamma(K^+ \to \pi^+ \pi^+ \mu^- \overline{\nu}_\mu)/\Gamma_{total}$		$<3.0 \times 10^{-6}$, CL = 95%

$x = \mathrm{A}(\overline{K}^0 \to \pi^- \ell^+ \nu)/\mathrm{A}(K^0 \to \pi^- \ell^+ \nu) = \mathrm{A}(\Delta S{=}-\Delta Q)/\mathrm{A}(\Delta S{=}\Delta Q)$

real part of x		-0.002 ± 0.006
imaginary part of x		0.0012 ± 0.0021
$\Gamma(\Sigma^+ \to n \ell^+ \nu)/\Gamma(\Sigma^- \to n \ell^- \overline{\nu})$		<0.043
$\Gamma(\Sigma^+ \to n e^+ \nu_e)/\Gamma_{total}$		$<5 \times 10^{-6}$, CL = 90%
$\Gamma(\Sigma^+ \to n \mu^+ \nu_\mu)/\Gamma_{total}$		$<3.0 \times 10^{-5}$, CL = 90%
$\Gamma(\Xi^0 \to \Sigma^- e^+ \nu_e)/\Gamma_{total}$		$<9 \times 10^{-4}$, CL = 90%
$\Gamma(\Xi^0 \to \Sigma^- \mu^+ \nu_\mu)/\Gamma_{total}$		$<9 \times 10^{-4}$, CL = 90%

Unless otherwise stated, limits are given at the 90% confidence level, while errors are given as ± 1 standard deviation.

$\Delta S = 2$ FORBIDDEN

Allowed in second-order weak interactions.

$\Gamma(\Xi^0 \to p\pi^-)/\Gamma_{total}$		$<4 \times 10^{-5}$, CL = 90%
$\Gamma(\Xi^0 \to pe^-\overline{\nu}_e)/\Gamma_{total}$		$<1.3 \times 10^{-3}$
$\Gamma(\Xi^0 \to p\mu^-\overline{\nu}_\mu)/\Gamma_{total}$		$<1.3 \times 10^{-3}$
$\Gamma(\Xi^- \to n\pi^-)/\Gamma_{total}$		$<1.9 \times 10^{-5}$, CL = 90%
$\Gamma(\Xi^- \to ne^-\overline{\nu}_e)/\Gamma_{total}$		$<3.2 \times 10^{-3}$, CL = 90%
$\Gamma(\Xi^- \to n\mu^-\overline{\nu}_\mu)/\Gamma_{total}$		$<1.5 \times 10^{-2}$, CL = 90%
$\Gamma(\Xi^- \to p\pi^-\pi^-)/\Gamma_{total}$		$<4 \times 10^{-4}$, CL = 90%
$\Gamma(\Xi^- \to p\pi^-e^-\overline{\nu}_e)/\Gamma_{total}$		$<4 \times 10^{-4}$, CL = 90%
$\Gamma(\Xi^- \to p\pi^-\mu^-\overline{\nu}_\mu)/\Gamma_{total}$		$<4 \times 10^{-4}$, CL = 90%
$\Gamma(\Omega^- \to \Lambda\pi^-)/\Gamma_{total}$		$<1.9 \times 10^{-4}$, CL = 90%

$\Delta S = 2$ VIA MIXING

Allowed in second-order weak interactions, e.g. mixing.

$m_{K^0_L} - m_{K^0_S}$		$(0.5292 \pm 0.0010) \times 10^{10}\ \hbar\ s^{-1}$ (S = 1.2)
$m_{K^0_L} - m_{K^0_S}$		$(3.483 \pm 0.006) \times 10^{-12}$ MeV

$\Delta C = 2$ VIA MIXING

Allowed in second-order weak interactions, e.g. mixing.

$\lvert m_{D^0_1} - m_{D^0_2} \rvert$	[n]	$<7 \times 10^{10}\ \hbar\ s^{-1}$, CL = 95%
$(\Gamma_{D^0_1} - \Gamma_{D^0_2})/\Gamma = 2y$		0.016 ± 0.010
$\Gamma(D^0 \to K^+\ell^-\overline{\nu}_\ell\,(\text{via } \overline{D}^0))/\Gamma_{total}$		$<1.7 \times 10^{-4}$, CL = 90%
$\Gamma(D^0 \to K^+\pi^-\,(\text{via } \overline{D}^0))/\Gamma_{total}$		$<1.6 \times 10^{-5}$, CL = 95%
$\Gamma(D^0 \to K^+\pi^-\pi^+\pi^-\,(\text{via } \overline{D}^0))/\Gamma_{total}$		$<4 \times 10^{-4}$, CL = 90%
$\Gamma(D^0 \to \mu^-\,\text{anything}\,(\text{via } \overline{D}^0))/\Gamma_{total}$		$<4 \times 10^{-4}$, CL = 90%

$\Delta B = 2$ VIA MIXING

Allowed in second-order weak interactions, e.g. mixing.

χ_d		0.186 ± 0.004
$\Delta m_{B^0} = m_{B^0_H} - m_{B^0_L}$		$(0.502 \pm 0.007) \times 10^{12}\ \hbar\ s^{-1}$
$x_d = \Delta m_{B^0}/\Gamma_{B^0}$		0.771 ± 0.012
$\Delta m_{B^0_s} = m_{B^0_{sH}} - m_{B^0_{sL}}$		$>14.4 \times 10^{12}\ \hbar\ s^{-1}$, CL = 95%
$x_s = \Delta m_{B^0_s}/\Gamma_{B^0_s}$		>20.6, CL = 95%
χ_s		>0.49883, CL = 95%

$\Delta S = 1$ WEAK NEUTRAL CURRENT FORBIDDEN

Allowed by higher-order electroweak interactions.

$\Gamma(K^+ \to \pi^+e^+e^-)/\Gamma_{total}$		$(2.88 \pm 0.13) \times 10^{-7}$
$\Gamma(K^+ \to \pi^+\mu^+\mu^-)/\Gamma_{total}$		$(8.1 \pm 1.4) \times 10^{-8}$ (S = 2.7)
$\Gamma(K^+ \to \pi^+\nu\overline{\nu})/\Gamma_{total}$		$(1.6^{+1.8}_{-0.8}) \times 10^{-10}$
$\Gamma(K^+ \to \pi^+\pi^0\nu\overline{\nu})/\Gamma_{total}$		$<4.3 \times 10^{-5}$, CL = 90%
$\Gamma(K^0_S \to \mu^+\mu^-)/\Gamma_{total}$		$<3.2 \times 10^{-7}$, CL = 90%
$\Gamma(K^0_S \to e^+e^-)/\Gamma_{total}$		$<1.4 \times 10^{-7}$, CL = 90%
$\Gamma(K^0_S \to \pi^0e^+e^-)/\Gamma_{total}$	[o]	$(3.0^{+1.5}_{-1.2}) \times 10^{-9}$
$\Gamma(K^0_L \to \mu^+\mu^-)/\Gamma_{total}$		$(7.27 \pm 0.14) \times 10^{-9}$
$\Gamma(K^0_L \to e^+e^-)/\Gamma_{total}$		$(9^{+6}_{-4}) \times 10^{-12}$
$\Gamma(K^0_L \to \pi^+\pi^-e^+e^-)/\Gamma_{total}$	[p]	$(3.11 \pm 0.19) \times 10^{-7}$
$\Gamma(K^0_L \to \pi^0\pi^0e^+e^-)/\Gamma_{total}$		$<6.6 \times 10^{-9}$, CL = 90%
$\Gamma(K^0_L \to \mu^+\mu^-e^+e^-)/\Gamma_{total}$		$(2.69 \pm 0.27) \times 10^{-9}$
$\Gamma(K^0_L \to e^+e^-e^+e^-)/\Gamma_{total}$		$(3.75 \pm 0.27) \times 10^{-8}$
$\Gamma(K^0_L \to \pi^0\mu^+\mu^-)/\Gamma_{total}$		$<3.8 \times 10^{-10}$, CL = 90%
$\Gamma(K^0_L \to \pi^0e^+e^-)/\Gamma_{total}$		$<5.1 \times 10^{-10}$, CL = 90%
$\Gamma(K^0_L \to \pi^0\nu\overline{\nu})/\Gamma_{total}$		$<5.9 \times 10^{-7}$, CL = 90%
$\Gamma(\Sigma^+ \to pe^+e^-)/\Gamma_{total}$		$<7 \times 10^{-6}$

Unless otherwise stated, limits are given at the 90% confidence level, while errors are given as ± 1 standard deviation.

$\Delta C = 1$ WEAK NEUTRAL CURRENT FORBIDDEN

Allowed by higher-order electroweak interactions.

$\Gamma(D^+ \to \pi^+e^+e^-)/\Gamma_{total}$		$<5.2 \times 10^{-5}$, CL = 90%
$\Gamma(D^+ \to \pi^+\mu^+\mu^-)/\Gamma_{total}$		$<8.8 \times 10^{-6}$, CL = 90%
$\Gamma(D^+ \to \rho^+\mu^+\mu^-)/\Gamma_{total}$		$<5.6 \times 10^{-4}$, CL = 90%
$\Gamma(D^0 \to \gamma\gamma)/\Gamma_{total}$		$<2.8 \times 10^{-5}$, CL = 90%
$\Gamma(D^0 \to e^+e^-)/\Gamma_{total}$		$<6.2 \times 10^{-6}$, CL = 90%
$\Gamma(D^0 \to \mu^+\mu^-)/\Gamma_{total}$		$<4.1 \times 10^{-6}$, CL = 90%
$\Gamma(D^0 \to \pi^0e^+e^-)/\Gamma_{total}$		$<4.5 \times 10^{-5}$, CL = 90%
$\Gamma(D^0 \to \pi^0\mu^+\mu^-)/\Gamma_{total}$		$<1.8 \times 10^{-4}$, CL = 90%
$\Gamma(D^0 \to \eta e^+e^-)/\Gamma_{total}$		$<1.1 \times 10^{-4}$, CL = 90%
$\Gamma(D^0 \to \eta\mu^+\mu^-)/\Gamma_{total}$		$<5.3 \times 10^{-4}$, CL = 90%
$\Gamma(D^0 \to \pi^+\pi^-e^+e^-)/\Gamma_{total}$		$<3.73 \times 10^{-4}$, CL = 90%
$\Gamma(D^0 \to \rho^0e^+e^-)/\Gamma_{total}$		$<1.0 \times 10^{-4}$, CL = 90%
$\Gamma(D^0 \to \pi^+\pi^-\mu^+\mu^-)/\Gamma_{total}$		$<3.0 \times 10^{-5}$, CL = 90%
$\Gamma(D^0 \to \rho^0\mu^+\mu^-)/\Gamma_{total}$		$<2.2 \times 10^{-5}$, CL = 90%
$\Gamma(D^0 \to \omega e^+e^-)/\Gamma_{total}$		$<1.8 \times 10^{-4}$, CL = 90%
$\Gamma(D^0 \to \omega\mu^+\mu^-)/\Gamma_{total}$		$<8.3 \times 10^{-4}$, CL = 90%
$\Gamma(D^0 \to K^-K^+e^+e^-)/\Gamma_{total}$		$<3.15 \times 10^{-4}$, CL = 90%
$\Gamma(D^0 \to \phi e^+e^-)/\Gamma_{total}$		$<5.2 \times 10^{-5}$, CL = 90%
$\Gamma(D^0 \to K^-K^+\mu^+\mu^-)/\Gamma_{total}$		$<3.3 \times 10^{-5}$, CL = 90%
$\Gamma(D^0 \to \phi\mu^+\mu^-)/\Gamma_{total}$		$<3.1 \times 10^{-5}$, CL = 90%
$\Gamma(D^0 \to K^-\pi^+e^+e^-)/\Gamma_{total}$		$<3.85 \times 10^{-4}$, CL = 90%
$\Gamma(D^0 \to K^-\pi^+\mu^+\mu^-)/\Gamma_{total}$		$<3.59 \times 10^{-4}$, CL = 90%
$\Gamma(D^0 \to \pi^+\pi^-\pi^0\mu^+\mu^-)/\Gamma_{total}$		$<8.1 \times 10^{-4}$, CL = 90%
$\Gamma(D^+_s \to K^+e^+e^-)/\Gamma_{total}$		$<1.6 \times 10^{-3}$, CL = 90%
$\Gamma(D^+_s \to K^+\mu^+\mu^-)/\Gamma_{total}$		$<3.6 \times 10^{-5}$, CL = 90%
$\Gamma(D^+_s \to K^*(892)^+\mu^+\mu^-)/\Gamma_{total}$		$<1.4 \times 10^{-3}$, CL = 90%
$\Gamma(\Lambda^+_c \to p\mu^+\mu^-)/\Gamma_{total}$		$<3.4 \times 10^{-4}$, CL = 90%

$\Delta B = 1$ WEAK NEUTRAL CURRENT FORBIDDEN

Allowed by higher-order electroweak interactions.

$\Gamma(B^+ \to \pi^+e^+e^-)/\Gamma_{total}$		$<3.9 \times 10^{-3}$, CL = 90%
$\Gamma(B^+ \to \pi^+\mu^+\mu^-)/\Gamma_{total}$		$<9.1 \times 10^{-3}$, CL = 90%
$\Gamma(B^+ \to K^+e^+e^-)/\Gamma_{total}$		$(6.3^{+1.9}_{-1.7}) \times 10^{-7}$
$\Gamma(B^+ \to K^+\mu^+\mu^-)/\Gamma_{total}$		$(4.5^{+1.4}_{-1.2}) \times 10^{-7}$
$\Gamma(B^+ \to K^+\ell^+\ell^-)/\Gamma_{total}$	[q]	$(5.3 \pm 1.1) \times 10^{-7}$
$\Gamma(B^+ \to K^+\overline{\nu}\nu)/\Gamma_{total}$		$<2.4 \times 10^{-4}$, CL = 90%
$\Gamma(B^+ \to K^*(892)^+e^+e^-)/\Gamma_{total}$		$<4.6 \times 10^{-6}$, CL = 90%
$\Gamma(B^+ \to K^*(892)^+\mu^+\mu^-)/\Gamma_{total}$		$<2.2 \times 10^{-6}$, CL = 90%
$\Gamma(B^+ \to K^*(892)^+\ell^+\ell)/\Gamma_{total}$	[q]	$<2.2 \times 10^{-6}$, CL = 90%
$\Gamma(B^0 \to \gamma\gamma)/\Gamma_{total}$		$<1.7 \times 10^{-6}$, CL = 90%
$\Gamma(B^0 \to e^+e^-)/\Gamma_{total}$		$<1.9 \times 10^{-7}$, CL = 90%
$\Gamma(B^0 \to \mu^+\mu^-)/\Gamma_{total}$		$<1.6 \times 10^{-7}$, CL = 90%
$\Gamma(B^0 \to K^0e^+e^-)/\Gamma_{total}$		$<5.4 \times 10^{-7}$, CL = 90%
$\Gamma(B^0 \to K^0\mu^+\mu^-)/\Gamma_{total}$		$(5.6^{+2.9}_{-2.4}) \times 10^{-7}$
$\Gamma(B^0 \to K^0\ell^+\ell^-)/\Gamma_{total}$	[q]	$<6.8 \times 10^{-7}$, CL = 90%
$\Gamma(B^0 \to K^*(892)^0e^+e^-)/\Gamma_{total}$		$<2.4 \times 10^{-6}$, CL = 90%
$\Gamma(B^0 \to K^*(892)^0\mu^+\mu^-)/\Gamma_{total}$		$(1.3 \pm 0.4) \times 10^{-6}$
$\Gamma(B^0 \to K^*(892)^0\nu\overline{\nu})/\Gamma_{total}$		$<1.0 \times 10^{-3}$, CL = 90%
$\Gamma(B^0 \to K^*(892)^0\ell^+\ell^-)/\Gamma_{total}$	[q]	$(1.17 \pm 0.30) \times 10^{-6}$
$\Gamma(B \to se^+e^-)/\Gamma_{total}$		$(5.0 \pm 2.6) \times 10^{-6}$
$\Gamma(B \to s\mu^+\mu^-)/\Gamma_{total}$		$(7.9^{+3.0}_{-2.6}) \times 10^{-6}$
$\Gamma(B \to s\ell^+\ell^-)/\Gamma_{total}$	[q]	$(6.1^{+2.0}_{-1.8}) \times 10^{-6}$
$\Gamma(B \to Ke^+e^-)/\Gamma_{total}$		$(4.8^{+1.5}_{-1.3}) \times 10^{-7}$
$\Gamma(B \to K^*(892)e^+e^-)/\Gamma_{total}$		$(1.5 \pm 0.5) \times 10^{-6}$
$\Gamma(B \to K\mu^+\mu^-)/\Gamma_{total}$		$(4.8 \pm 1.2) \times 10^{-7}$
$\Gamma(B \to K^*(892)\mu^+\mu^-)/\Gamma_{total}$		$(1.17^{+0.37}_{-0.33}) \times 10^{-6}$
$\Gamma(B \to K\ell^+\ell^-)/\Gamma_{total}$		$(5.4 \pm 0.8) \times 10^{-7}$
$\Gamma(B \to K^*(892)\ell^+\ell^-)/\Gamma_{total}$		$(1.05 \pm 0.20) \times 10^{-6}$
$\Gamma(\overline{b} \to \mu^+\mu^-\,\text{anything})/\Gamma_{total}$		$<3.2 \times 10^{-4}$, CL = 90%
$\Gamma(B^0_s \to \mu^+\mu^-)/\Gamma_{total}$		$<2.0 \times 10^{-6}$, CL = 90%
$\Gamma(B^0_s \to e^+e^-)/\Gamma_{total}$		$<5.4 \times 10^{-5}$, CL = 90%
$\Gamma(B^0_s \to \phi(1020)\mu^+\mu^-)/\Gamma_{total}$		$<4.7 \times 10^{-5}$, CL = 90%
$\Gamma(B^0_s \to \phi\nu\overline{\nu})/\Gamma_{total}$		$<5.4 \times 10^{-3}$, CL = 90%

$\Delta T = 1$ WEAK NEUTRAL CURRENT FORBIDDEN

Allowed by higher-order electroweak interactions.

$\Gamma(t \to Zq(q{=}u,c))/\Gamma_{\text{total}}$	[r]	$<13.7 \times 10^{-2}$, CL = 95%

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] *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] $\text{Re}(\epsilon'/\epsilon) = \epsilon'/\epsilon$ to a very good approximation provided the phases satisfy *CPT* invariance.

[f] Neglecting photon channels. See, *e.g.*, A. Pais and S.B. Treiman, Phys. Rev. **D12**, 2744 (1975).

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

[h] These two results are not independent, and both use the more precise measurement of $|q_{\overline{p}}/m_{\overline{p}}|/(q_p/m_p)$.

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

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

[k] Derived from an analysis of neutrino-oscillation experiments.

[l] There is some controversy about whether nuclear physics and model dependence complicate the analysis for bound neutrons (from which the best limit comes). The first limit here is from reactor experiments with free neutrons.

[m] This is the best limit for the mode $e^- \to \nu\gamma$. The best limit for "electron disappearance" is 6.4×10^{24} yr.

[n] This $D_1^0 - D_2^0$ limit is inferred from the D^0-$\overline{D}^0$ mixing ratio $\Gamma(K^+\pi^-$ (via $\overline{D}^0$)) / $\Gamma(K^-\pi^+)$ near the end of the D^0 Listings.

[o] See the K_S^0 Particle Listings for the energy limits used in this measurement.

[p] See the K_L^0 Particle Listings for the energy limits used in this measurement.

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

[r] This limit is for $\Gamma(t \to Zq)/\Gamma(t \to Wb)$.

Unless otherwise stated, limits are given at the 90% confidence level, while errors are given as ±1 standard deviation.