LEPTONS

e

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

Mass $m = (548.579909044 \pm 0.000000010) \times 10^{-6}$ u
Mass $m = 0.51099895069 \pm 0.00000000016$ 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 anomaly
$(g-2)/2 = (1159.65218062 \pm 0.00000012) \times 10^{-6}$
$(g_{e^+} - g_{e^-}) / g_{\text{average}} = (-0.5 \pm 2.1) \times 10^{-12}$
Electric dipole moment $d < 0.041 \times 10^{-28}$ e cm, CL = 90%
Mean life $\tau > 6.6 \times 10^{28}$ yr, CL = 90% [a]

μ

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

Mass $m = 0.1134289257 \pm 0.0000000025$ u
Mass $m = 105.6583755 \pm 0.0000023$ MeV
Mean life $\tau = (2.1969811 \pm 0.0000022) \times 10^{-6}$ s
$\tau_{\mu^+}/\tau_{\mu^-} = 1.00002 \pm 0.00008$
$c\tau = 658.6384$ m
Magnetic moment anomaly $(g-2)/2 = (11659207.2 \pm 1.5) \times 10^{-10}$
$(g_{\mu^+} - g_{\mu^-}) / g_{\text{average}} = (-0.11 \pm 0.12) \times 10^{-8}$
Electric dipole moment $\left|\text{d}\right| < 1.8 \times 10^{-19}$ e cm, CL = 95%

Decay parameters [b]

$\rho = 0.74979 \pm 0.00026$
$\eta = 0.057 \pm 0.034$
$\delta = 0.75047 \pm 0.00034$
$\xi P_\mu = 1.0009^{+0.0016}_{-0.0007}$ [c]
$\xi P_\mu \delta/\rho = 1.0018^{+0.0016}_{-0.0007}$ [c]
$\xi' = 1.00 \pm 0.04$
$\xi'' = 0.98 \pm 0.04$
$\alpha/\text{A} = (0 \pm 4) \times 10^{-3}$
$\alpha'/\text{A} = (-10 \pm 20) \times 10^{-3}$
$\beta/\text{A} = (4 \pm 6) \times 10^{-3}$
$\beta'/\text{A} = (2 \pm 7) \times 10^{-3}$
$\overline{\eta} = 0.02 \pm 0.08$

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] $(6.0 \pm 0.5) \times 10^{-8}$		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	$< 1.5 \times 10^{-13}$	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 $m = 1776.93 \pm 0.09$ MeV
$(m_{\tau^+} - m_{\tau^-})/m_{\text{average}} < 2.8 \times 10^{-4}$, CL = 90%
Mean life $\tau = (290.3 \pm 0.5) \times 10^{-15}$ s
$c\tau = 87.03$ μm
Magnetic moment anomaly $= -0.0024$ to 0.0047, CL = 95%
$\text{Re}(d_\tau) = -0.185$ to 0.061×10^{-16} e cm, CL = 95%
$\text{Im}(d_\tau) = -0.103$ to 0.023×10^{-16} e cm, CL = 95%

Weak dipole moment

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

Weak anomalous magnetic dipole moment

$\text{Re}(\alpha_\tau^w) < 1.1 \times 10^{-3}$, CL = 95%
$\text{Im}(\alpha_\tau^w) < 2.7 \times 10^{-3}$, CL = 95%
$\tau^\pm \to \pi^\pm K_S^0 \nu_\tau$ (RATE DIFFERENCE) / (RATE SUM) = $(-0.36 \pm 0.25)\%$

Decay parameters

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

$\rho(e \text{ or } \mu) = 0.745 \pm 0.008$
$\rho(e) = 0.747 \pm 0.010$
$\rho(\mu) = 0.763 \pm 0.020$
$\xi(e \text{ or } \mu) = 0.985 \pm 0.030$
$\xi(e) = 0.994 \pm 0.040$
$\xi(\mu) = 1.030 \pm 0.059$
$\eta(e \text{ or } \mu) = 0.013 \pm 0.020$
$\eta(\mu) = 0.094 \pm 0.073$

$(\delta\xi)(e \text{ or } \mu) = 0.746 \pm 0.021$
$(\delta\xi)(e) = 0.734 \pm 0.028$
$(\delta\xi)(\mu) = 0.778 \pm 0.037$
$\xi(\pi) = 0.993 \pm 0.022$
$\xi(\rho) = 0.994 \pm 0.008$
$\xi(a_1) = 1.001 \pm 0.027$
$\xi(\text{all hadronic modes}) = 0.995 \pm 0.007$
$\xi'(\mu) = 0.2 \pm 1.0$
$\overline{\eta}(\mu) = -1.3 \pm 1.7$
$(\xi\kappa)(e \text{ or } \mu) = 0.5 \pm 0.4$
$(\xi\kappa)(e) = -0.4 \pm 1.2$
$(\xi\kappa)(\mu) = 0.8 \pm 0.6$

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$^- \geq 0$ neutrals $\geq 0 K^0 \nu_\tau$ ("1-prong")		(85.24 ± 0.06) %		–
particle$^- \geq 0$ neutrals $\geq 0 K_L^0 \nu_\tau$		(84.58 ± 0.06) %		–
$\mu^- \overline{\nu}_\mu \nu_\tau$	[g]	(17.37 ± 0.04) %		885
$\mu^- \overline{\nu}_\mu \nu_\tau \gamma$	[e]	(3.67 ± 0.08) × 10^{-3}		885
$e^- \overline{\nu}_e \nu_\tau$	[g]	(17.85 ± 0.04) %		888
$e^- \overline{\nu}_e \nu_\tau \gamma$	[e]	(1.83 ± 0.05) %		888
$h^- \geq 0 K_L^0 \nu_\tau$		(12.03 ± 0.05) %		883
$h^- \nu_\tau$		(11.51 ± 0.05) %		883
$\pi^- \nu_\tau$	[g]	(10.82 ± 0.05) %		883
$K^- \nu_\tau$	[g]	(6.97 ± 0.10) × 10^{-3}		820
$h^- \geq 1$ neutrals ν_τ		(37.00 ± 0.09) %		–
$h^- \geq 1 \pi^0 \nu_\tau$ (ex.K^0)		(36.50 ± 0.09) %		–
$h^- \pi^0 \nu_\tau$		(25.93 ± 0.09) %		878
$\pi^- \pi^0 \nu_\tau$	[g]	(25.49 ± 0.09) %		878
$\pi^- \pi^0$ non-$\rho(770) \nu_\tau$		(3.0 ± 3.2) × 10^{-3}		878
$K^- \pi^0 \nu_\tau$	[g]	(4.33 ± 0.15) × 10^{-3}		814
$h^- \geq 2 \pi^0 \nu_\tau$		(10.81 ± 0.09) %		–
$h^- 2\pi^0 \nu_\tau$		(9.48 ± 0.10) %		862
$h^- 2\pi^0 \nu_\tau$ (ex.K^0)		(9.32 ± 0.10) %		862
$\pi^- 2\pi^0 \nu_\tau$ (ex.K^0)	[g]	(9.26 ± 0.10) %		862
$\pi^- 2\pi^0 \nu_\tau$ (ex.K^0), scalar		< 9	× 10^{-3} CL=95%	862
$\pi^- 2\pi^0 \nu_\tau$ (ex.K^0), vector		< 7	× 10^{-3} CL=95%	862

$K^-2\pi^0\nu_\tau$(ex.K^0)	[g]	(6.5 ± 2.2) × 10^{-4}		796
$h^- \geq 3\pi^0\nu_\tau$		(1.34 ± 0.07) %		–
$h^- \geq 3\pi^0\nu_\tau$(ex. K^0)		(1.26 ± 0.07) %		–
$h^-3\pi^0\nu_\tau$		(1.18 ± 0.07) %		836
$\pi^-3\pi^0\nu_\tau$(ex.K^0)	[g]	(1.04 ± 0.07) %		836
$K^-3\pi^0\nu_\tau$(ex.K^0, η)	[g]	(4.8 ± 2.1) × 10^{-4}		766
$h^-4\pi^0\nu_\tau$(ex.K^0)		(1.6 ± 0.4) × 10^{-3}		800
$h^-4\pi^0\nu_\tau$(ex.K^0,η)	[g]	(1.1 ± 0.4) × 10^{-3}		800
$a_1(1260)\nu_\tau \rightarrow \pi^-\gamma\nu_\tau$		(4.0 ± 1.5) × 10^{-4}		–
$K^- \geq 0\pi^0 \geq 0K^0 \geq 0\gamma\ \nu_\tau$		(1.552± 0.029) %		820
$K^- \geq 1$ (π^0 or K^0 or γ) ν_τ		(8.59 ± 0.28) × 10^{-3}		–

Modes with K^0's

K^0_S(particles)$^-\nu_\tau$		(9.43 ± 0.28) × 10^{-3}		–
$h^-\overline{K}^0\nu_\tau$		(9.87 ± 0.14) × 10^{-3}		812
$\pi^-\overline{K}^0\nu_\tau$	[g]	(8.38 ± 0.14) × 10^{-3}		812
$\pi^-\overline{K}^0$ (non-$K^*(892)^-$)ν_τ		(5.4 ± 2.1) × 10^{-4}		812
$K^-K^0\nu_\tau$	[g]	(1.486± 0.034) × 10^{-3}		737
$K^-K^0 \geq 0\pi^0\nu_\tau$		(2.99 ± 0.07) × 10^{-3}		737
$h^-\overline{K}^0\pi^0\nu_\tau$		(5.32 ± 0.13) × 10^{-3}		794
$\pi^-\overline{K}^0\pi^0\nu_\tau$	[g]	(3.82 ± 0.13) × 10^{-3}		794
$\overline{K}^0\rho^-\nu_\tau$		(2.2 ± 0.5) × 10^{-3}		612
$K^-K^0\pi^0\nu_\tau$	[g]	(1.50 ± 0.07) × 10^{-3}		685
$\pi^-\overline{K}^0 \geq 1\pi^0\nu_\tau$		(4.08 ± 0.25) × 10^{-3}		–
$\pi^-\overline{K}^0\pi^0\pi^0\nu_\tau$(ex.$K^0$)	[g]	(2.6 ± 2.3) × 10^{-4}		763
$K^-K^0\pi^0\pi^0\nu_\tau$		< 1.6 × 10^{-4}	CL=95%	619
$\pi^-K^0\overline{K}^0\nu_\tau$		(1.55 ± 0.24) × 10^{-3}		682
$\pi^-K^0_SK^0_S\nu_\tau$	[g]	(2.35 ± 0.06) × 10^{-4}		682
$\pi^-K^0_SK^0_L\nu_\tau$	[g]	(1.08 ± 0.24) × 10^{-3}		682
$\pi^-K^0_LK^0_L\nu_\tau$		(2.35 ± 0.06) × 10^{-4}		682
$\pi^-K^0\overline{K}^0\pi^0\nu_\tau$		(3.6 ± 1.2) × 10^{-4}		614
$\pi^-K^0_SK^0_S\pi^0\nu_\tau$	[g]	(1.82 ± 0.21) × 10^{-5}		614
$K^{*-}K^0\pi^0\nu_\tau \rightarrow \pi^-K^0_SK^0_S\pi^0\nu_\tau$		(1.08 ± 0.21) × 10^{-5}		–
$f_1(1285)\pi^-\nu_\tau \rightarrow \pi^-K^0_SK^0_S\pi^0\nu_\tau$		(6.8 ± 1.5) × 10^{-6}		–
$f_1(1420)\pi^-\nu_\tau \rightarrow \pi^-K^0_SK^0_S\pi^0\nu_\tau$		(2.4 ± 0.8) × 10^{-6}		–
$\pi^-K^0_SK^0_L\pi^0\nu_\tau$	[g]	(3.2 ± 1.2) × 10^{-4}		614
$\pi^-K^0_LK^0_L\pi^0\nu_\tau$		(1.82 ± 0.21) × 10^{-5}		614
$K^-K^0_SK^0_S\nu_\tau$		< 6.3 × 10^{-7}	CL=90%	466
$K^-K^0_SK^0_S\pi^0\nu_\tau$		< 4.0 × 10^{-7}	CL=90%	337

$K^0 h^+ h^- h^- \geq 0$ neutrals ν_τ		< 1.7	$\times 10^{-3}$	CL=95%	760
$K^0 h^+ h^- h^- \nu_\tau$	[g]	$(2.5 \pm 2.0) \times 10^{-4}$			760

Modes with three charged particles

$h^- h^- h^+ \geq 0$ neutrals $\geq 0 K^0_L \nu_\tau$		(15.20 ± 0.06) %			861
$h^- h^- h^+ \geq 0$ neutrals ν_τ (ex. $K^0_S \to \pi^+\pi^-$) ("3-prong")		(14.55 ± 0.06) %			861
$h^- h^- h^+ \nu_\tau$		(9.80 ± 0.05) %			861
$h^- h^- h^+ \nu_\tau$(ex.K^0)		(9.45 ± 0.05) %			861
$h^- h^- h^+ \nu_\tau$(ex.K^0,ω)		(9.42 ± 0.05) %			861
$\pi^-\pi^+\pi^-\nu_\tau$		(9.31 ± 0.05) %			861
$\pi^-\pi^+\pi^-\nu_\tau$(ex.K^0)		(9.02 ± 0.05) %			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]	(8.99 ± 0.05) %			861
$h^- h^- h^+ \geq 1$ neutrals ν_τ		(5.29 ± 0.05) %			–
$h^- h^- h^+ \geq 1 \pi^0 \nu_\tau$(ex. K^0)		(5.09 ± 0.05) %			–
$h^- h^- h^+ \pi^0 \nu_\tau$		(4.76 ± 0.05) %			834
$h^- h^- h^+ \pi^0 \nu_\tau$(ex.$K^0$)		(4.57 ± 0.05) %			834
$h^- h^- h^+ \pi^0 \nu_\tau$(ex. K^0, ω)		(2.79 ± 0.07) %			834
$\pi^-\pi^+\pi^-\pi^0\nu_\tau$		(4.62 ± 0.05) %			834
$\pi^-\pi^+\pi^-\pi^0\nu_\tau$(ex.$K^0$)		(4.49 ± 0.05) %			834
$\pi^-\pi^+\pi^-\pi^0\nu_\tau$(ex.$K^0$,$\omega$)	[g]	(2.74 ± 0.07) %			834
$h^- h^- h^+ \geq 2\pi^0 \nu_\tau$(ex. K^0)		(5.17 ± 0.31) $\times 10^{-3}$			–
$h^- h^- h^+ 2\pi^0 \nu_\tau$		(5.05 ± 0.31) $\times 10^{-3}$			797
$h^- h^- h^+ 2\pi^0 \nu_\tau$(ex.$K^0$)		(4.95 ± 0.31) $\times 10^{-3}$			797
$h^- h^- h^+ 2\pi^0 \nu_\tau$(ex.$K^0$,$\omega$,$\eta$)	[g]	(10 ± 4) $\times 10^{-4}$			797
$h^- h^- h^+ 3\pi^0 \nu_\tau$		(2.13 ± 0.30) $\times 10^{-4}$			749
$2\pi^-\pi^+ 3\pi^0 \nu_\tau$(ex.$K^0$)		(1.94 ± 0.30) $\times 10^{-4}$			749
$2\pi^-\pi^+ 3\pi^0 \nu_\tau$(ex.$K^0$, η, $f_1(1285)$)		(1.7 ± 0.4) $\times 10^{-4}$			–
$2\pi^-\pi^+ 3\pi^0 \nu_\tau$(ex.$K^0$, η, ω, $f_1(1285)$)	[g]	(1.4 ± 2.7) $\times 10^{-5}$			–
$K^- h^+ h^- \geq 0$ neutrals ν_τ		(6.29 ± 0.14) $\times 10^{-3}$			794
$K^- h^+ \pi^- \nu_\tau$(ex.K^0)		(4.37 ± 0.07) $\times 10^{-3}$			794
$K^- h^+ \pi^- \pi^0 \nu_\tau$(ex.$K^0$)		(8.6 ± 1.2) $\times 10^{-4}$			763
$K^-\pi^+\pi^- \geq 0$ neutrals ν_τ		(4.77 ± 0.14) $\times 10^{-3}$			794
$K^-\pi^+\pi^- \geq 0\pi^0\nu_\tau$(ex.$K^0$)		(3.73 ± 0.13) $\times 10^{-3}$			794
$K^-\pi^+\pi^-\nu_\tau$		(3.45 ± 0.07) $\times 10^{-3}$			794
$K^-\pi^+\pi^-\nu_\tau$(ex.K^0)		(2.93 ± 0.07) $\times 10^{-3}$			794
$K^-\pi^+\pi^-\nu_\tau$(ex.K^0,ω)	[g]	(2.93 ± 0.07) $\times 10^{-3}$			794

$K^-\rho^0\nu_\tau \rightarrow K^-\pi^+\pi^-\nu_\tau$		(1.4 ± 0.5) × 10^{-3}		–
$K^-\pi^+\pi^-\pi^0\nu_\tau$		(1.31 ± 0.12) × 10^{-3}		763
$K^-\pi^+\pi^-\pi^0\nu_\tau$(ex.$K^0$)		(8.0 ± 1.2) × 10^{-4}		763
$K^-\pi^+\pi^-\pi^0\nu_\tau$(ex.$K^0$,$\eta$)		(7.6 ± 1.2) × 10^{-4}		763
$K^-\pi^+\pi^-\pi^0\nu_\tau$(ex.$K^0$,$\omega$)		(3.7 ± 0.9) × 10^{-4}		763
$K^-\pi^+\pi^-\pi^0\nu_\tau$(ex.$K^0$,$\omega$,$\eta$)	[g]	(3.9 ± 1.4) × 10^{-4}		763
$K^-\pi^+K^-\geq 0$ neut. ν_τ		< 9	× 10^{-4} CL=95%	685
$K^-K^+\pi^-\geq 0$ neut. ν_τ		(1.496 ± 0.033) × 10^{-3}		685
$K^-K^+\pi^-\nu_\tau$	[g]	(1.435 ± 0.027) × 10^{-3}		685
$K^-K^+\pi^-\pi^0\nu_\tau$	[g]	(6.1 ± 1.8) × 10^{-5}		618
$K^-K^+K^-\nu_\tau$		(2.2 ± 0.8) × 10^{-5}	S=5.4	472
$K^-K^+K^-\nu_\tau$(ex. ϕ)		< 2.5	× 10^{-6} CL=90%	–
$K^-K^+K^-\pi^0\nu_\tau$		< 4.8	× 10^{-6} CL=90%	346
$\pi^-K^+\pi^-\geq 0$ neut. ν_τ		< 2.5	× 10^{-3} CL=95%	794
$e^-e^-e^+\overline{\nu}_e\nu_\tau$		(2.8 ± 1.5) × 10^{-5}		888
$\mu^-e^-e^+\overline{\nu}_\mu\nu_\tau$		< 3.2	× 10^{-5} CL=90%	885
$\pi^-e^-e^+\nu_\tau$		seen		883
$\pi^-\mu^-\mu^+\nu_\tau$		< 1.14	× 10^{-5} CL=90%	870

Modes with five charged particles

$3h^-2h^+\geq 0$ neutrals ν_τ (ex. $K^0_S\rightarrow\pi^-\pi^+$) ("5-prong")		(9.9 ± 0.4) × 10^{-4}		794
$3h^-2h^+\nu_\tau$(ex.K^0)		(8.29 ± 0.31) × 10^{-4}		794
$3\pi^-2\pi^+\nu_\tau$(ex.K^0, ω)		(8.27 ± 0.31) × 10^{-4}		794
$3\pi^-2\pi^+\nu_\tau$(ex.K^0, ω, $f_1(1285)$)	[g]	(7.75 ± 0.30) × 10^{-4}		–
$K^-2\pi^-2\pi^+\nu_\tau$(ex.K^0)	[g]	(6 ±12) × 10^{-7}		716
$K^+3\pi^-\pi^+\nu_\tau$		< 5.0	× 10^{-6} CL=90%	716
$K^+K^-2\pi^-\pi^+\nu_\tau$		< 4.5	× 10^{-7} CL=90%	528
$3h^-2h^+\pi^0\nu_\tau$(ex.K^0)		(1.65 ± 0.11) × 10^{-4}		746
$3\pi^-2\pi^+\pi^0\nu_\tau$(ex.$K^0$)		(1.64 ± 0.11) × 10^{-4}		746
$3\pi^-2\pi^+\pi^0\nu_\tau$(ex.$K^0$, η, $f_1(1285)$)		(1.11 ± 0.10) × 10^{-4}		–
$3\pi^-2\pi^+\pi^0\nu_\tau$(ex.$K^0$, η, ω, $f_1(1285)$)	[g]	(3.8 ± 0.9) × 10^{-5}		–
$K^-2\pi^-2\pi^+\pi^0\nu_\tau$(ex.$K^0$)	[g]	(1.1 ± 0.6) × 10^{-6}		657
$K^+3\pi^-\pi^+\pi^0\nu_\tau$		< 8	× 10^{-7} CL=90%	657
$3h^-2h^+2\pi^0\nu_\tau$		< 3.4	× 10^{-6} CL=90%	687

Miscellaneous other allowed modes

$(5\pi)^-\nu_\tau$		(7.8 ± 0.5) × 10^{-3}		800
$4h^-3h^+\geq 0$ neutrals ν_τ ("7-prong")		< 3.0	× 10^{-7} CL=90%	682

$4h^-3h^+\nu_\tau$		$<$	4.3		$\times 10^{-7}$	CL=90%	682
$4h^-3h^+\pi^0\nu_\tau$		$<$	2.5		$\times 10^{-7}$	CL=90%	612
$X^-(S{=}-1)\nu_\tau$		(	2.92	± 0.04)	%		–
$K^*(892)^-\ \geq$ 0 neutrals $\geq$ $0K^0_L\nu_\tau$		(	1.42	± 0.18)	%	S=1.4	665
$K^*(892)^-\nu_\tau$		(	1.20	± 0.07)	%	S=1.8	665
$K^*(892)^-\nu_\tau \rightarrow \pi^-\overline{K}^0\nu_\tau$		(	7.82	± 0.26)	$\times 10^{-3}$		–
$K^*(892)^0K^-\geq 0$ neutrals ν_τ		(	3.2	± 1.4)	$\times 10^{-3}$		542
$K^*(892)^0K^-\nu_\tau$		(	2.1	± 0.4)	$\times 10^{-3}$		542
$\overline{K}^*(892)^0\pi^-\geq 0$ neutrals ν_τ		(	3.8	± 1.7)	$\times 10^{-3}$		655
$\overline{K}^*(892)^0\pi^-\nu_\tau$		(	2.2	± 0.5)	$\times 10^{-3}$		655
$(\overline{K}^*(892)\pi)^-\nu_\tau \rightarrow \pi^-\overline{K}^0\pi^0\nu_\tau$		(	1.0	± 0.4)	$\times 10^{-3}$		–
$K_1(1270)^-\nu_\tau$		(	4.7	± 1.1)	$\times 10^{-3}$		445
$K_1(1400)^-\nu_\tau$		(	1.7	± 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%	317
$K^*_2(1430)^-\nu_\tau$		$<$	3		$\times 10^{-3}$	CL=95%	315
$\eta\pi^-\nu_\tau$		$<$	9.9		$\times 10^{-5}$	CL=95%	797
$\eta\pi^-\pi^0\nu_\tau$	[g]	(	1.39	± 0.07)	$\times 10^{-3}$		778
$\eta\pi^-\pi^0\pi^0\nu_\tau$	[g]	(	1.9	± 0.4)	$\times 10^{-4}$		746
$\eta K^-\nu_\tau$	[g]	(	1.55	± 0.08)	$\times 10^{-4}$		720
$\eta K^*(892)^-\nu_\tau$		(	1.38	± 0.15)	$\times 10^{-4}$		511
$\eta K^-\pi^0\nu_\tau$	[g]	(	4.8	± 1.2)	$\times 10^{-5}$		665
$\eta K^-\pi^0$(non-$K^*(892)$)ν_τ		$<$	3.5		$\times 10^{-5}$	CL=90%	–
$\eta\overline{K}^0\pi^-\nu_\tau$	[g]	(	9.4	± 1.5)	$\times 10^{-5}$		661
$\eta\overline{K}^0\pi^-\pi^0\nu_\tau$		$<$	5.0		$\times 10^{-5}$	CL=90%	590
$\eta K^-K^0\nu_\tau$		$<$	9.0		$\times 10^{-6}$	CL=90%	430
$\eta\pi^+\pi^-\pi^-\geq 0$ neutrals ν_τ		$<$	3		$\times 10^{-3}$	CL=90%	744
$\eta\pi^-\pi^+\pi^-\nu_\tau$(ex.$K^0$)	[g]	(	2.20	± 0.13)	$\times 10^{-4}$		744
$\eta\pi^-\pi^+\pi^-\nu_\tau$(ex.$K^0$,$f_1(1285)$)		(	9.9	± 1.6)	$\times 10^{-5}$		–
$\eta a_1(1260)^-\nu_\tau \rightarrow \eta\pi^-\rho^0\nu_\tau$		$<$	3.9		$\times 10^{-4}$	CL=90%	–
$\eta\eta\pi^-\nu_\tau$		$<$	7.4		$\times 10^{-6}$	CL=90%	637
$\eta\eta\pi^-\pi^0\nu_\tau$		$<$	2.0		$\times 10^{-4}$	CL=95%	559
$\eta\eta K^-\nu_\tau$		$<$	3.0		$\times 10^{-6}$	CL=90%	382
$\eta'(958)\pi^-\nu_\tau$		$<$	4.0		$\times 10^{-6}$	CL=90%	620
$\eta'(958)\pi^-\pi^0\nu_\tau$		$<$	1.2		$\times 10^{-5}$	CL=90%	591
$\eta'(958)K^-\nu_\tau$		$<$	2.4		$\times 10^{-6}$	CL=90%	495
$\phi\pi^-\nu_\tau$		(	3.4	± 0.6)	$\times 10^{-5}$		585
$\phi K^-\nu_\tau$	[g]	(	4.4	± 1.6)	$\times 10^{-5}$		445
$f_1(1285)\pi^-\nu_\tau$		(	3.9	± 0.5)	$\times 10^{-4}$	S=1.9	408
$f_1(1285)\pi^-\nu_\tau \rightarrow \eta\pi^-\pi^+\pi^-\nu_\tau$		(	1.18	± 0.07)	$\times 10^{-4}$	S=1.3	–

$f_1(1285)\pi^-\nu_\tau \rightarrow 3\pi^-2\pi^+\nu_\tau$	[g]	(5.2 ± 0.4) $\times 10^{-5}$		–
$\pi(1300)^-\nu_\tau \rightarrow (\rho\pi)^-\nu_\tau \rightarrow (3\pi)^-\nu_\tau$		< 1.0	$\times 10^{-4}$ CL=90%	–
$\pi(1300)^-\nu_\tau \rightarrow ((\pi\pi)_{S-\text{wave}}\,\pi)^-\nu_\tau \rightarrow (3\pi)^-\nu_\tau$		< 1.9	$\times 10^{-4}$ CL=90%	–
$h^-\omega \geq 0$ neutrals ν_τ		(2.40 ± 0.08) %		708
$h^-\omega\nu_\tau$		(1.99 ± 0.06) %		708
$\pi^-\omega\nu_\tau$	[g]	(1.95 ± 0.06) %		708
$K^-\omega\nu_\tau$	[g]	(4.1 ± 0.9) $\times 10^{-4}$		610
$h^-\omega\pi^0\nu_\tau$	[g]	(4.1 ± 0.4) $\times 10^{-3}$		684
$h^-\omega 2\pi^0\nu_\tau$		(1.4 ± 0.5) $\times 10^{-4}$		644
$\pi^-\omega 2\pi^0\nu_\tau$	[g]	(7.2 ± 1.6) $\times 10^{-5}$		644
$h^-2\omega\nu_\tau$		< 5.4	$\times 10^{-7}$ CL=90%	250
$2h^-h^+\omega\nu_\tau$		(1.20 ± 0.22) $\times 10^{-4}$		641
$2\pi^-\pi^+\omega\nu_\tau$(ex.$K^0$)	[g]	(8.4 ± 0.6) $\times 10^{-5}$		641

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

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

$e^-\gamma$	*LF*	< 3.3	$\times 10^{-8}$ CL=90%	888
$e^-\gamma\gamma$	*LF*	< 2.5	$\times 10^{-4}$ CL=90%	888
$\mu^-\gamma$	*LF*	< 4.2	$\times 10^{-8}$ CL=90%	885
$\mu^-\gamma\gamma$	*LF*	< 5.8	$\times 10^{-4}$ CL=90%	885
$e^-\pi^0$	*LF*	< 8.0	$\times 10^{-8}$ CL=90%	883
$\mu^-\pi^0$	*LF*	< 1.1	$\times 10^{-7}$ CL=90%	880
$e^-K^0_S$	*LF*	< 8	$\times 10^{-9}$ CL=90%	819
$\mu^-K^0_S$	*LF*	< 1.2	$\times 10^{-8}$ CL=90%	815
$e^-\eta$	*LF*	< 9.2	$\times 10^{-8}$ CL=90%	804
$\mu^-\eta$	*LF*	< 6.5	$\times 10^{-8}$ CL=90%	800
$e^-\rho^0$	*LF*	< 2.2	$\times 10^{-8}$ CL=90%	719
$\mu^-\rho^0$	*LF*	< 1.7	$\times 10^{-8}$ CL=90%	715
$e^-\omega$	*LF*	< 2.4	$\times 10^{-8}$ CL=90%	716
$\mu^-\omega$	*LF*	< 3.9	$\times 10^{-8}$ CL=90%	711
$e^-K^*(892)^0$	*LF*	< 1.9	$\times 10^{-8}$ CL=90%	665
$\mu^-K^*(892)^0$	*LF*	< 2.9	$\times 10^{-8}$ CL=90%	659
$e^-\overline{K}^*(892)^0$	*LF*	< 1.7	$\times 10^{-8}$ CL=90%	665
$\mu^-\overline{K}^*(892)^0$	*LF*	< 4.3	$\times 10^{-8}$ CL=90%	659
$e^-\eta'(958)$	*LF*	< 1.6	$\times 10^{-7}$ CL=90%	630
$\mu^-\eta'(958)$	*LF*	< 1.3	$\times 10^{-7}$ CL=90%	625
$e^-f_0(980) \rightarrow e^-\pi^+\pi^-$	*LF*	< 3.2	$\times 10^{-8}$ CL=90%	–

$\mu^- f_0(980) \rightarrow \mu^- \pi^+ \pi^-$	LF	$<$	3.4	$\times 10^{-8}$ CL=90%	–
$e^- \phi$	LF	$<$	2.0	$\times 10^{-8}$ CL=90%	596
$\mu^- \phi$	LF	$<$	2.3	$\times 10^{-8}$ CL=90%	590
$e^- e^+ e^-$	LF	$<$	2.5	$\times 10^{-8}$ CL=90%	888
$e^- \mu^+ \mu^-$	LF	$<$	2.4	$\times 10^{-8}$ CL=90%	882
$e^+ \mu^- \mu^-$	LF	$<$	1.3	$\times 10^{-8}$ CL=90%	882
$\mu^- e^+ e^-$	LF	$<$	1.6	$\times 10^{-8}$ CL=90%	885
$\mu^+ e^- e^-$	LF	$<$	1.5	$\times 10^{-8}$ CL=90%	885
$\mu^- \mu^+ \mu^-$	LF	$<$	1.9	$\times 10^{-8}$ CL=90%	873
$e^- \pi^+ \pi^-$	LF	$<$	2.3	$\times 10^{-8}$ CL=90%	877
$e^+ \pi^- \pi^-$	L	$<$	2.0	$\times 10^{-8}$ CL=90%	877
$\mu^- \pi^+ \pi^-$	LF	$<$	2.1	$\times 10^{-8}$ CL=90%	866
$\mu^+ \pi^- \pi^-$	L	$<$	3.9	$\times 10^{-8}$ CL=90%	866
$e^- \pi^+ K^-$	LF	$<$	3.7	$\times 10^{-8}$ CL=90%	813
$e^- \pi^- K^+$	LF	$<$	3.1	$\times 10^{-8}$ CL=90%	813
$e^+ \pi^- K^-$	L	$<$	3.2	$\times 10^{-8}$ CL=90%	813
$e^- K^0_S K^0_S$	LF	$<$	7.1	$\times 10^{-8}$ CL=90%	736
$e^- K^+ K^-$	LF	$<$	3.4	$\times 10^{-8}$ CL=90%	739
$e^+ K^- K^-$	L	$<$	3.3	$\times 10^{-8}$ CL=90%	739
$\mu^- \pi^+ K^-$	LF	$<$	8.6	$\times 10^{-8}$ CL=90%	800
$\mu^- \pi^- K^+$	LF	$<$	4.5	$\times 10^{-8}$ CL=90%	800
$\mu^+ \pi^- K^-$	L	$<$	4.8	$\times 10^{-8}$ CL=90%	800
$\mu^- K^0_S K^0_S$	LF	$<$	8.0	$\times 10^{-8}$ CL=90%	696
$\mu^- K^+ K^-$	LF	$<$	4.4	$\times 10^{-8}$ CL=90%	699
$\mu^+ K^- K^-$	L	$<$	4.7	$\times 10^{-8}$ 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%	653
$e^- \pi^0 \eta$	LF	$<$	2.4	$\times 10^{-5}$ CL=90%	798
$\mu^- \pi^0 \eta$	LF	$<$	2.2	$\times 10^{-5}$ CL=90%	784
$p e^- e^-$	L,B	$<$	3.0	$\times 10^{-8}$ CL=90%	641
$\overline{p} e^+ e^-$	L,B	$<$	3.0	$\times 10^{-8}$ CL=90%	641
$\overline{p} e^+ \mu^-$	L,B	$<$	2.0	$\times 10^{-8}$ CL=90%	635
$\overline{p} e^- \mu^+$	L,B	$<$	1.8	$\times 10^{-8}$ CL=90%	635
$p \mu^- \mu^-$	L,B	$<$	4.0	$\times 10^{-8}$ CL=90%	618
$\overline{p} \mu^+ \mu^-$	L,B	$<$	1.8	$\times 10^{-8}$ CL=90%	618
$\overline{p} \gamma$	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
$\Lambda \pi^-$	L,B	$<$	4.7	$\times 10^{-8}$ CL=90%	525
$\overline{\Lambda} \pi^-$	L,B	$<$	4.3	$\times 10^{-8}$ CL=90%	525

e^- light boson	*LF*	<	4.5	$\times 10^{-4}$ CL=90%	–
μ^- light boson	*LF*	<	2.8	$\times 10^{-4}$ CL=90%	–

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%

Neutrino Properties

See the note on "Neutrino properties listings" in the Particle Listings.

Mass $m <$ 0.45 eV, CL = 90% (tritium decay)
Mean life/mass, $\tau/m >$ 300 s/eV, CL = 90% (reactor)
Mean life/mass, $\tau/m > 7 \times 10^9$ s/eV (solar)
Mean life/mass, $\tau/m >$ 15.4 s/eV, CL = 90% (accelerator)
Magnetic moment $\mu < 0.064 \times 10^{-10}\ \mu_B$, CL = 90% (solar + radiochemical)

Number of Neutrino Types

Number $N = 2.996 \pm 0.007$ (Standard Model fits to LEP-SLC data)
Number $N = 2.92 \pm 0.05$ (S = 1.2) (Direct measurement of invisible Z width)

Neutrino Mixing

The following values are obtained through data analyses based on the 3-neutrino mixing scheme described in the review "Neutrino Masses, Mixing, and Oscillations."

$\sin^2(\theta_{12}) = 0.307 \pm 0.012$
$\Delta m^2_{21} = (7.60 \pm 0.17) \times 10^{-5}$ eV^2
$\sin^2(\theta_{23}) = 0.523^{+0.031}_{-0.027}$ (S = 1.3) (Inverted order)
$\sin^2(\theta_{23}) = 0.533 \pm 0.018$ (Normal order)

$\Delta m^2_{32} = (-2.52 \pm 0.04) \times 10^{-3}$ eV^2 (S = 1.3) (Inverted order)
$\Delta m^2_{32} = (2.445 \pm 0.023) \times 10^{-3}$ eV^2 (Normal order)
$\sin^2(\theta_{13}) = (2.17 \pm 0.07) \times 10^{-2}$ (S = 1.4)
δ, *CP* violating phase $= 1.21^{+0.19}_{-0.17}\ \pi$ rad (S = 1.2)
$\langle \Delta m^2_{21} - \Delta \overline{m}^2_{21} \rangle < 1.1 \times 10^{-4}$ eV^2, CL = 99.7%
$\langle \Delta m^2_{32} - \Delta \overline{m}^2_{32} \rangle = (-0.12 \pm 0.25) \times 10^{-3}$ eV^2

NOTES

[*a*] This is the best limit for the mode $e^- \to \nu\gamma$.

[*b*] See the review on "Muon Decay Parameters" for definitions and details.

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

[*d*] This only includes events with energy of $e > 45$ MeV and energy of $\gamma > 40$ 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.