LEPTONS

e

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

Mass $m = 0.51099907 \pm 0.00000015$ MeV [a]
$= (5.48579903 \pm 0.00000013) \times 10^{-4}$ u
$(m_{e^+} - m_{e^-})/m < 4 \times 10^{-8}$, CL = 90%
$\left|q_{e^+} + q_{e^-}\right|/e < 4 \times 10^{-8}$
Magnetic moment $\mu = 1.001159652193 \pm 0.000000000010\ \mu_B$
$(g_{e^+} - g_{e^-})\ /\ g_{\text{average}} = (-0.5 \pm 2.1) \times 10^{-12}$
Electric dipole moment $d = (-0.3 \pm 0.8) \times 10^{-26}\ e\,$cm
Mean life $\tau > 4.3 \times 10^{23}$ yr, CL = 68% [b]

μ

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

Mass $m = 105.658389 \pm 0.000034$ MeV [c]
$= 0.113428913 \pm 0.000000017$ u
Mean life $\tau = (2.19703 \pm 0.00004) \times 10^{-6}$ s
$\tau_{\mu^+}/\tau_{\mu^-} = 1.00002 \pm 0.00008$
$c\tau = 658.654$ m
Magnetic moment $\mu = 1.001165923 \pm 0.000000008\ e\hbar/2m_\mu$
$(g_{\mu^+} - g_{\mu^-})\ /\ g_{\text{average}} = (-2.6 \pm 1.6) \times 10^{-8}$
Electric dipole moment $d = (3.7 \pm 3.4) \times 10^{-19}\ e\,$cm

Decay parameters [d]

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

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

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

τ

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

Mass $m = 1777.00^{+0.30}_{-0.27}$ MeV
Mean life $\tau = (291.0 \pm 1.5) \times 10^{-15}$ s
$c\tau = 87.2\ \mu$m
Electric dipole moment $d < 5 \times 10^{-17}$ $e$cm, CL = 95%

Weak dipole moment

$\mathrm{Re}(d^w_\tau) < 7.8 \times 10^{-18}$ $e$cm, CL = 95%
$\mathrm{Im}(d^w_\tau) < 4.5 \times 10^{-17}$ $e$cm, CL = 95%

Decay parameters

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

$\rho^\tau(e \text{ or } \mu) = 0.742 \pm 0.027$
$\rho^\tau(e) = 0.736 \pm 0.028$
$\rho^\tau(\mu) = 0.74 \pm 0.04$
$\xi^\tau(e \text{ or } \mu) = 1.03 \pm 0.12$
$\xi^\tau(e) = 1.03 \pm 0.25$
$\xi^\tau(\mu) = 1.23 \pm 0.24$
$\eta^\tau(e \text{ or } \mu) = -0.01 \pm 0.14$
$\eta^\tau(\mu) = -0.24 \pm 0.29$
$(\delta\xi)^\tau(e \text{ or } \mu) = 0.76 \pm 0.11$ (S = 1.3)
$(\delta\xi)^\tau(e) = 1.11 \pm 0.18$
$(\delta\xi)^\tau(\mu) = 0.71 \pm 0.15$
$\xi^\tau(\pi) = 0.99 \pm 0.06$
$\xi^\tau(\rho) = 1.04 \pm 0.07$
$\xi^\tau(a_1) = 1.01 \pm 0.04$
$\xi^\tau(\text{all hadronic modes}) = 1.011 \pm 0.027$

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

τ^- **DECAY MODES**		Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
Modes with one charged particle				
particle$^-$ ≥ 0 neutrals $\geq 0 K^0_L \nu_\tau$ ("1-prong")		(84.96 ± 0.14) %	S=1.3	–
particle$^-$ ≥ 0 neutrals $\geq 0 K^0 \nu_\tau$		(85.53 ± 0.14) %	S=1.3	–
$\mu^- \overline{\nu}_\mu \nu_\tau$	[i]	(17.35 ± 0.10) %		885
$\mu^- \overline{\nu}_\mu \nu_\tau \gamma$ ($E_\gamma > 37$ MeV)		$(2.3 \pm 1.0) \times 10^{-3}$		–
$e^- \overline{\nu}_e \nu_\tau$	[i]	(17.83 ± 0.08) %		888
$h^- \geq 0$ neutrals $\geq 0 K^0_L \nu_\tau$		(49.78 ± 0.17) %	S=1.2	–
$h^- \geq 0 K^0_L \nu_\tau$		(12.51 ± 0.13) %	S=1.1	–
$h^- \nu_\tau$		(12.03 ± 0.14) %	S=1.1	–
$\pi^- \nu_\tau$	[i]	(11.31 ± 0.15) %	S=1.1	883
$K^- \nu_\tau$	[i]	$(7.1 \pm 0.5) \times 10^{-3}$		820
$h^- \geq 1 \pi^0 \nu_\tau$		(36.97 ± 0.18) %	S=1.1	–
$h^- \pi^0 \nu_\tau$		(25.76 ± 0.15) %	S=1.1	–
$\pi^- \pi^0 \nu_\tau$	[i]	(25.24 ± 0.16) %	S=1.1	878
$\pi^- \pi^0$ non-$\rho(770) \nu_\tau$		$(3.0 \pm 3.2) \times 10^{-3}$		878
$K^- \pi^0 \nu_\tau$	[i]	$(5.2 \pm 0.5) \times 10^{-3}$		814
$h^- \geq 2\pi^0 \nu_\tau$		(10.95 ± 0.16) %	S=1.1	–
$h^- 2\pi^0 \nu_\tau$		(9.50 ± 0.14) %	S=1.1	–
$h^- 2\pi^0 \nu_\tau (\text{ex.}K^0)$		(9.35 ± 0.14) %	S=1.1	–
$\pi^- 2\pi^0 \nu_\tau (\text{ex.}K^0)$	[i]	(9.27 ± 0.14) %	S=1.1	862
$K^- 2\pi^0 \nu_\tau (\text{ex.}K^0)$	[i]	$(8.1 \pm 2.7) \times 10^{-4}$		796
$h^- \geq 3\pi^0 \nu_\tau$		(1.46 ± 0.11) %	S=1.1	–
$h^- 3\pi^0 \nu_\tau$		(1.28 ± 0.10) %		–
$\pi^- 3\pi^0 \nu_\tau (\text{ex.}K^0)$	[i]	(1.14 ± 0.14) %		836
$K^- 3\pi^0 \nu_\tau (\text{ex.}K^0)$	[i]	$(5.0 {}^{+10.0}_{-3.3}) \times 10^{-4}$		766
$h^- 4\pi^0 \nu_\tau (\text{ex.}K^0)$		$(1.8 \pm 0.6) \times 10^{-3}$		–
$h^- 4\pi^0 \nu_\tau (\text{ex.}K^0,\eta)$	[i]	$(1.2 \pm 0.6) \times 10^{-3}$		–
$K^- \geq 1$ (π^0 or K^0) ν_τ		$(9.4 \pm 1.0) \times 10^{-3}$		–

Modes with K^0's				
$h^- \overline{K}^0 \geq 0$ neutrals $\geq 0 K_L^0 \nu_\tau$		(1.54 ± 0.10) %	S=1.3	–
$h^- \overline{K}^0 \nu_\tau$		$(9.2 \pm 0.8) \times 10^{-3}$	S=1.3	–
$\pi^- \overline{K}^0 \nu_\tau$	[i]	$(7.7 \pm 0.8) \times 10^{-3}$	S=1.3	812
$\pi^- \overline{K}^0$ (non-$K^*(892)^-$) ν_τ		$< 1.7 \times 10^{-3}$	CL=95%	812
$K^- K^0 \nu_\tau$	[i]	$(1.55 \pm 0.28) \times 10^{-3}$		737
$h^- \overline{K}^0 \pi^0 \nu_\tau$		$(5.5 \pm 0.5) \times 10^{-3}$		–
$\pi^- \overline{K}^0 \pi^0 \nu_\tau$	[i]	$(4.1 \pm 0.6) \times 10^{-3}$		794
$K^- K^0 \pi^0 \nu_\tau$	[i]	$(1.38 \pm 0.32) \times 10^{-3}$		685
$h^- K_S^0 K_S^0 \nu_\tau$		$(2.5 \pm 0.6) \times 10^{-4}$		–
$\pi^- K^0 \overline{K}^0 \nu_\tau$	[i]	$(1.01 \pm 0.23) \times 10^{-3}$		682
$K^- K^0 \geq 0$ neutrals ν_τ		$(2.9 \pm 0.4) \times 10^{-3}$		–
$K^- \geq 0\pi^0 \geq 0 K^0 \nu_\tau$		(1.65 ± 0.10) %		–
K^0 (particles)$^-$ ν_τ		(1.58 ± 0.10) %	S=1.2	–
$K^0 h^+ h^- h^- \geq 0$ neut. ν_τ		$< 1.7 \times 10^{-3}$	CL=95%	–
Modes with three charged particles				
$h^- h^- h^+ \geq 0$neut. ν_τ ("3-prong")		(14.91 ± 0.14) %	S=1.3	–
$h^- h^- h^+ \geq 0$ neutrals ν_τ (ex. $K_S^0 \to \pi^+ \pi^-$)		(14.36 ± 0.14) %	S=1.3	–
$\pi^- \pi^+ \pi^- \geq 0$ neutrals ν_τ		(14.09 ± 0.31) %		–
$h^- h^- h^+ \nu_\tau$		(9.80 ± 0.10) %	S=1.1	–
$h^- h^- h^+ \nu_\tau$ (ex.K^0)		(9.48 ± 0.10) %	S=1.1	–
$h^- h^- h^+ \nu_\tau$ (ex.K^0,ω)	[i]	(9.44 ± 0.10) %	S=1.1	–
$h^- h^- h^+ \geq 1$ neutrals ν_τ		(5.08 ± 0.11) %	S=1.2	–
$h^- h^- h^+ \geq 1$ neutrals ν_τ (ex. $K_S^0 \to \pi^+ \pi^-$)		(4.88 ± 0.11) %	S=1.2	–
$h^- h^- h^+ \pi^0 \nu_\tau$		(4.44 ± 0.09) %	S=1.1	–
$h^- h^- h^+ \pi^0 \nu_\tau$ (ex.K^0)		(4.25 ± 0.09) %	S=1.1	–
$h^- h^- h^+ \pi^0 \nu_\tau$ (ex. K^0, ω)	[i]	(2.55 ± 0.09) %		–
$h^- (\rho\pi)^0 \nu_\tau$		(2.84 ± 0.34) %		–
$(a_1(1260) h)^- \nu_\tau$		< 2.0 %	CL=95%	–
$h^- \rho \pi^0 \nu_\tau$		(1.33 ± 0.20) %		–
$h^- \rho^+ h^- \nu_\tau$		$(4.4 \pm 2.2) \times 10^{-3}$		–
$h^- \rho^- h^+ \nu_\tau$		(1.15 ± 0.23) %		–
$h^- h^- h^+ 2\pi^0 \nu_\tau$		$(5.2 \pm 0.5) \times 10^{-3}$		–
$h^- h^- h^+ 2\pi^0 \nu_\tau$ (ex.K^0)		$(5.1 \pm 0.5) \times 10^{-3}$		–
$h^- h^- h^+ 2\pi^0 \nu_\tau$ (ex.K^0,ω,η)	[i]	$(1.0 \pm 0.4) \times 10^{-3}$		–

$h^- h^- h^+ \geq 3\pi^0 \nu_\tau$	[*i*]	$(1.1 \pm 0.6) \times 10^{-3}$		–
$K^- h^+ h^- \geq 0$ neutrals ν_τ		$< 6 \times 10^{-3}$	CL=90%	–
$K^- \pi^+ \pi^- \geq 0$ neut. ν_τ		$(3.9 {}^{+1.9}_{-1.6}) \times 10^{-3}$	S=1.5	–
$K^- \pi^+ K^- \geq 0$ neut. ν_τ		$< 9 \times 10^{-4}$	CL=95%	–
$K^- K^+ \pi^- \geq 0$ neut. ν_τ		$(1.5 {}^{+0.9}_{-0.8}) \times 10^{-3}$		–
$K^- K^+ \pi^- \nu_\tau$		$(2.2 {}^{+1.8}_{-1.2}) \times 10^{-3}$		685
$\phi \pi^- \nu_\tau$		$< 3.5 \times 10^{-4}$	CL=90%	585
$K^- K^+ K^- \geq 0$ neut. ν_τ		$< 2.1 \times 10^{-3}$	CL=95%	–
$\pi^- K^+ \pi^- \geq 0$ neut. ν_τ		$< 2.5 \times 10^{-3}$	CL=95%	–
$e^- e^- e^+ \overline{\nu}_e \nu_\tau$		$(2.8 \pm 1.5) \times 10^{-5}$		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. $K^0_S \to \pi^- \pi^+$) ("5-prong")		$(9.7 \pm 0.7) \times 10^{-4}$		–
$3h^- 2h^+ \nu_\tau$ (ex.K^0)	[*i*]	$(7.5 \pm 0.7) \times 10^{-4}$		–
$3h^- 2h^+ \pi^0 \nu_\tau$ (ex.K^0)	[*i*]	$(2.2 \pm 0.5) \times 10^{-4}$		–
$3h^- 2h^+ 2\pi^0 \nu_\tau$		$< 1.1 \times 10^{-4}$	CL=90%	–
Miscellaneous other allowed modes				
$(5\pi)^- \nu_\tau$		$(3.3 \pm 0.7) \times 10^{-3}$		–
$4h^- 3h^+ \geq 0$ neutrals ν_τ ("7-prong")		$< 1.9 \times 10^{-4}$	CL=90%	–
$K^*(892)^- \geq 0(h^0 \neq K^0_S) \nu_\tau$		(1.94 ± 0.31) %		–
$K^*(892)^- \geq 0$ neutrals ν_τ		(1.33 ± 0.13) %		–
$K^*(892)^- \nu_\tau$		(1.28 ± 0.08) %		665
$K^*(892)^0 K^- \geq 0$ neutrals ν_τ		$(3.2 \pm 1.4) \times 10^{-3}$		–
$K^*(892)^0 K^- \nu_\tau$		$(2.0 \pm 0.6) \times 10^{-3}$		539
$\overline{K}^*(892)^0 \pi^- \geq 0$ neutrals ν_τ		$(3.8 \pm 1.7) \times 10^{-3}$		–
$\overline{K}^*(892)^0 \pi^- \nu_\tau$		$(2.5 \pm 1.1) \times 10^{-3}$		653
$K_1(1270)^- \nu_\tau$		$(4 \pm 4) \times 10^{-3}$		433
$K_1(1400)^- \nu_\tau$		$(8 \pm 4) \times 10^{-3}$		335
$K^*_2(1430)^- \nu_\tau$		$< 3 \times 10^{-3}$	CL=95%	317
$\eta \pi^- \nu_\tau$		$< 1.4 \times 10^{-4}$	CL=95%	798
$\eta \pi^- \pi^0 \nu_\tau$	[*i*]	$(1.71 \pm 0.28) \times 10^{-3}$		778
$\eta \pi^- \pi^0 \pi^0 \nu_\tau$		$< 4.3 \times 10^{-4}$	CL=95%	746
$\eta K^- \nu_\tau$		$(2.6 \pm 0.7) \times 10^{-4}$		720

$\eta \pi^+ \pi^- \pi^- \geq 0$ neutrals ν_τ		< 3	$\times 10^{-3}$	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
$h^- \omega \geq 0$ neutrals ν_τ		(2.32 ± 0.11)	%		–
$h^- \omega \nu_\tau$	[*i*]	(1.91 ± 0.09)	%		–
$h^- \omega \pi^0 \nu_\tau$	[*i*]	(4.1 ± 0.6)	$\times 10^{-3}$		–

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

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

$e^-\gamma$	*LF*	<	1.1	$\times 10^{-4}$	CL=90%	888
$\mu^-\gamma$	*LF*	<	4.2	$\times 10^{-6}$	CL=90%	885
$e^-\pi^0$	*LF*	<	1.4	$\times 10^{-4}$	CL=90%	883
$\mu^-\pi^0$	*LF*	<	4.4	$\times 10^{-5}$	CL=90%	880
e^-K^0	*LF*	<	1.3	$\times 10^{-3}$	CL=90%	819
μ^-K^0	*LF*	<	1.0	$\times 10^{-3}$	CL=90%	815
$e^-\eta$	*LF*	<	6.3	$\times 10^{-5}$	CL=90%	804
$\mu^-\eta$	*LF*	<	7.3	$\times 10^{-5}$	CL=90%	800
$e^-\rho^0$	*LF*	<	4.2	$\times 10^{-6}$	CL=90%	722
$\mu^-\rho^0$	*LF*	<	5.7	$\times 10^{-6}$	CL=90%	718
$e^-K^*(892)^0$	*LF*	<	6.3	$\times 10^{-6}$	CL=90%	663
$\mu^-K^*(892)^0$	*LF*	<	9.4	$\times 10^{-6}$	CL=90%	657
$\pi^-\gamma$	*L*	<	2.8	$\times 10^{-4}$	CL=90%	883
$\pi^-\pi^0$	*L*	<	3.7	$\times 10^{-4}$	CL=90%	878
$e^-e^+e^-$	*LF*	<	3.3	$\times 10^{-6}$	CL=90%	888
$e^-\mu^+\mu^-$	*LF*	<	3.6	$\times 10^{-6}$	CL=90%	882
$e^+\mu^-\mu^-$	*LF*	<	3.5	$\times 10^{-6}$	CL=90%	882
$\mu^-e^+e^-$	*LF*	<	3.4	$\times 10^{-6}$	CL=90%	885
$\mu^+e^-e^-$	*L*	<	3.4	$\times 10^{-6}$	CL=90%	885
$\mu^-\mu^+\mu^-$	*LF*	<	1.9	$\times 10^{-6}$	CL=90%	873
$e^-\pi^+\pi^-$	*LF*	<	4.4	$\times 10^{-6}$	CL=90%	877
$e^+\pi^-\pi^-$	*L*	<	4.4	$\times 10^{-6}$	CL=90%	877
$\mu^-\pi^+\pi^-$	*LF*	<	7.4	$\times 10^{-6}$	CL=90%	866
$\mu^+\pi^-\pi^-$	*L*	<	6.9	$\times 10^{-6}$	CL=90%	866
$e^-\pi^+K^-$	*LF*	<	7.7	$\times 10^{-6}$	CL=90%	813
$e^-\pi^-K^+$	*LF*	<	4.6	$\times 10^{-6}$	CL=90%	813
$e^+\pi^-K^-$	*L*	<	4.5	$\times 10^{-6}$	CL=90%	813
$\mu^-\pi^+K^-$	*LF*	<	8.7	$\times 10^{-6}$	CL=90%	800
$\mu^-\pi^-K^+$	*LF*	<	1.5	$\times 10^{-5}$	CL=90%	800
$\mu^+\pi^-K^-$	*L*	<	2.0	$\times 10^{-5}$	CL=90%	800
$\overline{p}\gamma$	*L,B*	<	2.9	$\times 10^{-4}$	CL=90%	641
$\overline{p}\pi^0$	*L,B*	<	6.6	$\times 10^{-4}$	CL=90%	632
$\overline{p}\eta$	*L,B*	<	1.30	$\times 10^{-3}$	CL=90%	475
$e^-\overline{K}^*(892)^0$	*LF*	<	1.1	$\times 10^{-5}$	CL=90%	663
$\mu^-\overline{K}^*(892)^0$	*LF*	<	8.7	$\times 10^{-6}$	CL=90%	657
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 $m >$ 42.7 GeV, CL = 95% $m_{\nu} \approx 0$

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

Mass $m >$ 42.8 GeV, CL = 95%

Neutrinos

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

ν_e

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

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

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

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

ν_μ

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

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

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

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

ν_τ

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

Mass $m <$ 24 MeV, CL = 95%

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

Number of Light Neutrino Types

(including ν_e, ν_μ, and ν_τ)

Number $N = 2.991 \pm 0.016$ (Standard Model fits to LEP data)

Number $N = 3.09 \pm 0.13$ (Direct measurement of invisible Z width)

Massive Neutrinos and Lepton Mixing, Searches for

For excited leptons, see Compositeness Limits below.

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

No direct, uncontested evidence for massive neutrinos or lepton mixing has been obtained. Sample limits are:

Stable Neutral Heavy Lepton Mass Limits

Mass $m >$ 45.0 GeV, CL = 95% (Dirac)
Mass $m >$ 39.5 GeV, CL = 95% (Majorana)

Neutral Heavy Lepton Mass Limits

Mass $m >$ 19.6 GeV, CL = 95% (all $|U_{\ell j}|^2$) (Dirac)
Mass $m >$ 45.7 GeV or $m < 25$, CL = 95% ($|U_{\ell j}|^2 > 10^{-13}$ (Dirac)

ν oscillation: $\overline{\nu}_e \not\to \overline{\nu}_e$

$\Delta(m^2) < 0.0075$ eV^2, CL = 90% (if $\sin^2 2\theta = 1$)
$\sin^2 2\theta < 0.02$, CL = 90% (if $\Delta(m^2)$ is large)

ν oscillation: $\nu_\mu \to \nu_e$ (θ = mixing angle)

$\Delta(m^2) < 0.09$ eV^2, CL = 90% (if $\sin^2 2\theta = 1$)
$\sin^2 2\theta < 2.5 \times 10^{-3}$, CL = 90% (if $\Delta(m^2)$ is large)

NOTES

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

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

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

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

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

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

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

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

[*i*] Basis mode for the τ.