μ

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

μ MASS

The mass is known more precisely in u (atomic mass units) than in MeV (see the footnote to COHEN 87). The conversion from u to MeV, 1 u = 931.49432 ± 0.00028 MeV, involves the relatively poorly known electronic charge.

Where m_μ/m_e was measured, we have used the 1986 CODATA value for m_e = 0.51099906 ± 0.00000015 MeV.

VALUE (MeV)	DOCUMENT ID		TECN	CHG	COMMENT
105.658389±0.000034	[1] COHEN	87	RVUE		1986 CODATA value
• • • We do not use the following data for averages, fits, limits, etc. • • •					
105.65841 ±0.00033	[2] BELTRAMI	86	SPEC	−	Muonic atoms
105.658432±0.000064	[3] KLEMPT	82	CNTR	+	Incl. in MARIAM 82
105.658386±0.000044	[4] MARIAM	82	CNTR	+	
105.65856 ±0.00015	[5] CASPERSON	77	CNTR	+	
105.65836 ±0.00026	[6] CROWE	72	CNTR		
105.65865 ±0.00044	[7] CRANE	71	CNTR		

[1] The mass is known more precisely in u: m = 0.113428913± 0.000000017u. COHEN 87 makes use of the other entries below.

[2] BELTRAMI 86 gives m_μ/m_e = 206.76830(64).

[3] KLEMPT 82 gives m_μ/m_e = 206.76835(11).

[4] MARIAM 82 gives m_μ/m_e = 206.768259(62).

[5] CASPERSON 77 gives m_μ/m_e = 206.76859(29).

[6] CROWE 72 gives m_μ/m_e = 206.7682(5).

[7] CRANE 71 gives m_μ/m_e = 206.76878(85).

μ MEAN LIFE τ

Measurements with an error > 0.001×10^{-6} s have been omitted.

VALUE (10^{-6} s)	DOCUMENT ID		TECN	CHG
2.19703 ±0.00004 OUR AVERAGE				
2.197078±0.000073	BARDIN	84	CNTR	+
2.197025±0.000155	BARDIN	84	CNTR	−
2.19695 ±0.00006	GIOVANETTI	84	CNTR	+
2.19711 ±0.00008	BALANDIN	74	CNTR	+
2.1973 ±0.0003	DUCLOS	73	CNTR	+

$\tau_{\mu^+}/\tau_{\mu^-}$ MEAN LIFE RATIO

A test of *CPT* invariance.

VALUE	DOCUMENT ID		TECN	COMMENT
1.000024±0.000078	BARDIN	84	CNTR	
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1.0008 ±0.0010	BAILEY	79	CNTR	Storage ring
1.000 ±0.001	MEYER	63	CNTR	Mean life μ^+/μ^-

$(\tau_{\mu^+} - \tau_{\mu^-}) / \tau_{\text{average}}$

A test of *CPT* invariance. Calculated from the mean-life ratio, above.

VALUE	DOCUMENT ID
(2±8) × 10^{-5} OUR EVALUATION	

μ MAGNETIC MOMENT ANOMALY

$\mu_\mu/(e\hbar/2m_\mu)-1 = (g_\mu-2)/2$

For reviews of theory and experiments, see HUGHES 85, KINOSHITA 84, COMBLEY 81, FARLEY 79, and CALMET 77.

VALUE (units 10^{-6})	DOCUMENT ID		TECN	CHG	COMMENT
1165.9230±0.0084	COHEN	87	RVUE		1986 CODATA value
• • • We do not use the following data for averages, fits, limits, etc. • • •					
1165.910 ±0.011	[8] BAILEY	79	CNTR	+	Storage ring
1165.937 ±0.012	[8] BAILEY	79	CNTR	−	Storage ring
1165.923 ±0.0085	[8] BAILEY	79	CNTR	±	Storage ring
1165.922 ±0.009	[8] BAILEY	77	CNTR	±	Storage ring
1166.16 ±0.31	BAILEY	68	CNTR	±	Storage rings
1162.0 ±5.0	CHARPAK	62	CNTR	+	

[8] BAILEY 79 is final result. Includes BAILEY 77 data. We use μ/p magnetic moment ratio = 3.1833452 and recalculate the BAILEY 79 values. Third BAILEY 79 result is first two combined.

$(g_{\mu^+} - g_{\mu^-}) / g_{\text{average}}$

A test of CPT invariance.

VALUE (units 10^{-8})	DOCUMENT ID	
−2.6±1.6	BAILEY	79

μ ELECTRIC DIPOLE MOMENT

A nonzero value is forbidden by both T invariance and P invariance.

VALUE (10^{-19} e cm)	DOCUMENT ID		TECN	CHG	COMMENT
3.7±3.4	[9] BAILEY	78	CNTR	±	Storage ring
• • • We do not use the following data for averages, fits, limits, etc. • • •					
8.6±4.5	BAILEY	78	CNTR	+	Storage rings
0.8±4.3	BAILEY	78	CNTR	−	Storage rings

[9] This is the combination of the two BAILEY 78 results given below.

μ/p MAGNETIC MOMENT RATIO

This ratio is used to obtain a precise value of the muon mass. Measurements with an error > 0.00001 have been omitted.

VALUE	DOCUMENT ID		TECN	CHG	COMMENT
3.18334547±0.00000047	[10] COHEN	87	RVUE		1986 CODATA value
• • • We do not use the following data for averages, fits, limits, etc. • • •					
3.1833441 ±0.0000017	KLEMPT	82	CNTR	+	Precession strob
3.1833461 ±0.0000011	MARIAM	82	CNTR	+	HFS splitting
3.1833448 ±0.0000029	CAMANI	78	CNTR	+	See KLEMPT 82
3.1833403 ±0.0000044	CASPERSON	77	CNTR	+	HFS splitting
3.1833402 ±0.0000072	COHEN	73	RVUE		1973 CODATA value
3.1833467 ±0.0000082	CROWE	72	CNTR	+	Precession phase

[10] COHEN 87 (1986 CODATA) value was fitted using their own selection of the following data. Because their value is from a multiparameter fit, correlations with other quantities may be important and one cannot arrive at this result by any average of these data alone.

μ^- DECAY MODES

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

	Mode		Fraction (Γ_i/Γ)	Confidence level
Γ_1	$e^-\overline{\nu}_e\nu_\mu$		$\approx 100\%$	
Γ_2	$e^-\overline{\nu}_e\nu_\mu\gamma$	[a]	$(1.4\pm0.4)\%$	
Γ_3	$e^-\overline{\nu}_e\nu_\mu e^+e^-$	[b]	$(3.4\pm0.4)\times10^{-5}$	

Lepton Family number (LF) violating modes

Γ_4	$e^- \nu_e \overline{\nu}_\mu$	LF	[c] < 1.2	%	90%
Γ_5	$e^- \gamma$	LF	< 4.9	$\times 10^{-11}$	90%
Γ_6	$e^- e^+ e^-$	LF	< 1.0	$\times 10^{-12}$	90%
Γ_7	$e^- 2\gamma$	LF	< 7.2	$\times 10^{-11}$	90%

[a] 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.

[b] See the Full Listings below for the energy limits used in this measurement.

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

μ^- BRANCHING RATIOS

$\Gamma(e^- \overline{\nu}_e \nu_\mu \gamma)/\Gamma_{\text{total}}$ Γ_2/Γ

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.014 ±0.004		CRITTENDEN	61	CNTR	γ KE > 10 MeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
	862	BOGART	67	CNTR	γ KE > 14.5 MeV
0.0033±0.0013		CRITTENDEN	61	CNTR	γ KE > 20 MeV
	27	ASHKIN	59	CNTR	

$\Gamma(e^- \overline{\nu}_e \nu_\mu e^+ e^-)/\Gamma_{\text{total}}$ Γ_3/Γ

VALUE (units 10^{-5})	EVTS	DOCUMENT ID		TECN	CHG	COMMENT
3.4±0.2±0.3	7443	[11] BERTL	85	SPEC	+	SINDRUM
• • • We do not use the following data for averages, fits, limits, etc. • • •						
2.2±1.5	7	[12] CRITTENDEN	61	HLBC	+	$E(e^+ e^-)>10$ MeV
2	1	[13] GUREVICH	60	EMUL	+	
1.5±1.0	3	[14] LEE	59	HBC	+	

[11] BERTL 85 has transverse momentum cut $p_T > 17$ MeV/c. Systematic error was increased by us.

[12] CRITTENDEN 61 count only those decays where total energy of either (e^+, e^-) combination is >10 MeV.

[13] GUREVICH 60 interpret their event as either virtual or real photon conversion. e^+ and e^- energies not measured.

[14] In the three LEE 59 events, the sum of energies E(e^+) + E(e^-) + E(e^+) was 51 MeV, 55 MeV, and 33 MeV.

$\Gamma(e^- \nu_e \overline{\nu}_\mu)/\Gamma_{\text{total}}$ Γ_4/Γ

Forbidden by the additive conservation law for lepton family number. A multiplicative law predicts this branching ratio to be 1/2. For a review see NEMETHY 81.

VALUE	CL%	DOCUMENT ID		TECN	CHG	COMMENT
< 0.012	90	FREEDMAN	93	CNTR	+	ν oscillation search
• • • We do not use the following data for averages, fits, limits, etc. • • •						
< 0.018	90	KRAKAUER	91B	CALO	+	
< 0.05	90	[15] BERGSMA	83	CALO		$\overline{\nu}_\mu e \to \mu^- \overline{\nu}_e$
< 0.09	90	JONKER	80	CALO		See BERGSMA 83
−0.001±0.061		WILLIS	80	CNTR	+	
0.13 ±0.15		BLIETSCHAU	78	HLBC	±	Avg. of 4 values
< 0.25	90	EICHTEN	73	HLBC	+	

[15] BERGSMA 83 gives a limit on the inverse muon decay cross-section ratio $\sigma(\overline{\nu}_\mu e^- \to \mu^- \overline{\nu}_e)/\sigma(\nu_\mu e^- \to \mu^- \nu_e)$, which is essentially equivalent to $\Gamma(e^- \nu_e \overline{\nu}_\mu)/\Gamma_{\text{total}}$ for small values like that quoted.

$\Gamma(e^- \gamma)/\Gamma_{\text{total}}$ Γ_5/Γ

Forbidden by lepton family number conservation.

VALUE (units 10^{-11})	CL%	DOCUMENT ID		TECN	CHG	COMMENT
< 4.9	90	BOLTON	88	CBOX	+	LAMPF
• • • We do not use the following data for averages, fits, limits, etc. • • •						
<100	90	AZUELOS	83	CNTR	+	TRIUMF
< 17	90	KINNISON	82	SPEC	+	LAMPF
<100	90	SCHAAF	80	ELEC	+	SIN

$\Gamma(e^- e^+ e^-)/\Gamma_{total}$ Γ_6/Γ

Forbidden by lepton family number conservation.

VALUE (units 10^{-12})	CL%	DOCUMENT ID		TECN	CHG	COMMENT
< 1.0	90	[16] BELLGARDT	88	SPEC	+	SINDRUM
• • • We do not use the following data for averages, fits, limits, etc. • • •						
< 36	90	BARANOV	91	SPEC	+	ARES
< 35	90	BOLTON	88	CBOX	+	LAMPF
< 2.4	90	[16] BERTL	85	SPEC	+	SINDRUM
<160	90	[16] BERTL	84	SPEC	+	SINDRUM
<130	90	[16] BOLTON	84	CNTR		LAMPF

[16] These experiments assume a constant matrix element.

$\Gamma(e^- 2\gamma)/\Gamma_{total}$ Γ_7/Γ

Forbidden by lepton family number conservation.

VALUE (units 10^{-11})	CL%	DOCUMENT ID		TECN	CHG	COMMENT
< 7.2	90	BOLTON	88	CBOX	+	LAMPF
• • • We do not use the following data for averages, fits, limits, etc. • • •						
< 840	90	[17] AZUELOS	83	CNTR	+	TRIUMF
<5000	90	[18] BOWMAN	78	CNTR		DEPOMMIER 77 data

[17] AZUELOS 83 uses the phase space distribution of BOWMAN 78.
[18] BOWMAN 78 assumes an interaction Lagrangian local on the scale of the inverse μ mass.

LIMIT ON $\mu^- \to e^-$ CONVERSION

Forbidden by lepton family number conservation.

$\sigma(\mu^- {}^{32}S \to e^- {}^{32}S) / \sigma(\mu^- {}^{32}S \to \nu_\mu {}^{32}P^*)$

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
$<7 \times 10^{-11}$	90	BADERT...	80	STRC	SIN
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$<4 \times 10^{-10}$	90	BADERT...	77	STRC	SIN

$\sigma(\mu^- Cu \to e^- Cu) / \sigma(\mu^- Cu \to \text{capture})$

VALUE	CL%	DOCUMENT ID		TECN
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$<1.6 \times 10^{-8}$	90	BRYMAN	72	SPEC

$\sigma(\mu^- Ti \to e^- Ti) / \sigma(\mu^- Ti \to \text{capture})$

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
$<4.3 \times 10^{-12}$	90	[19] DOHMEN	93	SPEC	SINDRUM II
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$<4.6 \times 10^{-12}$	90	AHMAD	88	TPC	TRIUMF
$<1.6 \times 10^{-11}$	90	BRYMAN	85	TPC	TRIUMF

[19] DOHMEN 93 assumes $\mu^- \to e^-$ conversion leaves the nucleus in its ground state, a process enhanced by coherence and expected to dominate.

$\sigma(\mu^- Pb \to e^- Pb) / \sigma(\mu^- Pb \to \text{capture})$

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$<4.9 \times 10^{-10}$	90	AHMAD	88	TPC	TRIUMF

LIMIT ON $\mu^- \to e^+$ CONVERSION

Forbidden by total lepton number conservation.

$\sigma(\mu^- {}^{32}S \to e^+ {}^{32}Si^*) / \sigma(\mu^- {}^{32}S \to \nu_\mu {}^{32}P^*)$

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
$<9 \times 10^{-10}$	90	BADERT...	80	STRC	SIN
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$<1.5 \times 10^{-9}$	90	BADERT...	78	STRC	SIN

$\sigma(\mu^- {}^{127}\mathrm{I} \to e^+ {}^{127}\mathrm{Sb}^*) / \sigma(\mu^- {}^{127}\mathrm{I} \to \text{anything})$

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
$< 3 \times 10^{-10}$	90	[20] ABELA	80	CNTR	Radiochemical tech.

[20] ABELA 80 is upper limit for $\mu^- e^+$ conversion leading to particle-stable states of ^{127}Sb. Limit for total conversion rate is higher by a factor less than 4 (G. Backenstoss, private communication).

$\sigma(\mu^- \mathrm{Cu} \to e^+ \mathrm{Co}) / \sigma(\mu^- \mathrm{Cu} \to \nu_\mu \mathrm{Ni})$

VALUE	CL%	DOCUMENT ID		TECN
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$< 2.6 \times 10^{-8}$	90	BRYMAN	72	SPEC
$< 2.2 \times 10^{-7}$	90	CONFORTO	62	OSPK

$\sigma(\mu^- \mathrm{Ti} \to e^+ \mathrm{Ca}) / \sigma(\mu^- \mathrm{Ti} \to \text{capture})$

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
$< 8.9 \times 10^{-11}$	90	[21] DOHMEN	93	SPEC	SINDRUM II
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$< 4.3 \times 10^{-12}$	90	[22] DOHMEN	93	SPEC	SINDRUM II
$< 1.7 \times 10^{-10}$	90	[23] AHMAD	88	TPC	TRIUMF

[21] This DOHMEN 93 limit assumes a giant resonance excitation of the daughter Ca nucleus (mean energy and width both 20 MeV).

[22] This DOHMEN 93 limit assumes the daughter Ca nucleus is left in the ground state. However, the probability of this is unknown.

[23] Assuming a giant-resonance-excitation model.

LIMIT ON MUONIUM → ANTIMUONIUM CONVERSION

Forbidden by lepton family number conservation.

$R_g \equiv G_C / G_F$

The effective Lagrangian for the $\mu^+ e^- \to \mu^- e^+$ conversion is assumed to be

$$\mathcal{L} = 2^{-1/2}\, G_C\, [\overline{\psi}_\mu \gamma_\lambda\, (1 - \gamma_5)\, \psi_e]\, [\overline{\psi}_\mu \gamma_\lambda\, (1 - \gamma_5)\, \psi_e] + \text{h.c.}$$

The experimental result is then an upper limit on G_C/G_F, where G_F is the Fermi coupling constant.

VALUE	CL%	EVTS	DOCUMENT ID		TECN	CHG	COMMENT
< 0.13	90		GORDEEV	93	SPEC		JINR phasotron
• • • We do not use the following data for averages, fits, limits, etc. • • •							
< 0.14	90	1	[24] GORDEEV	94	SPEC	+	JINR phasotron
< 6.9	90		NI	93	CBOX		LAMPF
< 0.16	90		MATTHIAS	91	SPEC		LAMPF
< 0.29	90		HUBER	90B	CNTR		TRIUMF
< 0.88	90		HUBER	88	CNTR		See HUBER 90B
< 7.5	90		NI	87	CBOX		See NI 93
<20	95		BEER	86	CNTR		TRIUMF
<42	95		MARSHALL	82	CNTR		

[24] GORDEEV 94 quote limits on both $f = G_{M\overline{M}}/G_F$ and on the probability $W_{M\overline{M}} < 5.1 \times 10^{-7}$ (90% CL). Final results are based on the full data set.

MINIREVIEW GOES HERE

μ DECAY PARAMETERS

ρ PARAMETER

$(V-A)$ theory predicts $\rho = 0.75$.

VALUE	EVTS	DOCUMENT ID		TECN	CHG	COMMENT
0.7518±0.0026		DERENZO	69	RVUE		
• • • We do not use the following data for averages, fits, limits, etc. • • •						
0.762 ±0.008	170k	[25] FRYBERGER	68	ASPK	+	25–53 MeV e^+
0.760 ±0.009	280k	[25] SHERWOOD	67	ASPK	+	25–53 MeV e^+
0.7503±0.0026	800k	[25] PEOPLES	66	ASPK	+	20–53 MeV e^+

[25] η constrained = 0. These values incorporated into a two parameter fit to ρ and η by DERENZO 69.

η PARAMETER

($V-A$) theory predicts $\eta = 0$.

VALUE	EVTS	DOCUMENT ID		TECN	CHG	COMMENT
-0.007 ± 0.013 OUR AVERAGE						
-0.007 ± 0.013	5.3M	[26] BURKARD	85B	FIT	+	9–53 MeV e^+
$-0.12\ \pm0.21$	6346	DERENZO	69	HBC	+	1.6–6.8 MeV e^+
• • • We do not use the following data for averages, fits, limits, etc. • • •						
$-0.012\pm0.015\pm0.003$	5.3M	[27] BURKARD	85B	CNTR	+	9–53 MeV e^+
$0.011\pm0.081\pm0.026$	5.3M	BURKARD	85B	CNTR	+	9–53 MeV e^+
$-0.7\ \pm0.5$	170k	[28] FRYBERGER	68	ASPK	+	25–53 MeV e^+
$-0.7\ \pm0.6$	280k	[28] SHERWOOD	67	ASPK	+	25–53 MeV e^+
$0.05\ \pm0.5$	800k	[28] PEOPLES	66	ASPK	+	20–53 MeV e^+
$-2.0\ \pm0.9$	9213	[29] PLANO	60	HBC	+	Whole spectrum

[26] Global fit to all measured parameters. Correlation coefficients are given in BURKARD 85B.
[27] $\alpha = \alpha' = 0$ assumed.
[28] ρ constrained $= 0.75$.
[29] Two parameter fit to ρ and η; PLANO 60 discounts value for η.

δ PARAMETER

($V-A$) theory predicts $\delta = 0.75$.

VALUE	EVTS	DOCUMENT ID		TECN	CHG	COMMENT
$0.7486\pm0.0026\pm0.0028$		[30] BALKE	88	SPEC	+	Surface μ^+'s
• • • We do not use the following data for averages, fits, limits, etc. • • •						
		[31] VOSSLER	69			
$0.752\ \pm0.009$	490k	FRYBERGER	68	ASPK	+	25–53 MeV e^+
$0.782\ \pm0.031$		KRUGER	61			
$0.78\ \pm0.05$	8354	PLANO	60	HBC	+	Whole spectrum

[30] BALKE 88 uses $\rho = 0.752 \pm 0.003$.
[31] VOSSLER 69 has measured the asymmetry below 10 MeV. See comments about radiative corrections in VOSSLER 69.

$|(\xi$ PARAMETER$)\times(\mu$ LONGITUDINAL POLARIZATION$)|$

($V-A$) theory predicts $\xi = 1$, longitudinal polarization $= 1$.

VALUE	EVTS	DOCUMENT ID		TECN	CHG	COMMENT
$1.0027\pm0.0079\pm0.0030$		BELTRAMI	87	CNTR		SIN, π decay in flight
• • • We do not use the following data for averages, fits, limits, etc. • • •						
$1.0013\pm0.0030\pm0.0053$		[32] IMAZATO	92	SPEC	+	$K^+ \to \mu^+ \nu_\mu$
$0.975\ \pm0.015$		AKHMANOV	68	EMUL		140 kG
$0.975\ \pm0.030$	66k	GUREVICH	64	EMUL		See AKHMANOV 68
$0.903\ \pm0.027$		[33] ALI-ZADE	61	EMUL	+	27 kG
$0.93\ \pm0.06$	8354	PLANO	60	HBC	+	8.8 kG
$0.97\ \pm0.05$	9k	BARDON	59	CNTR		Bromoform target

[32] The corresponding 90% confidence limit from IMAZATO 92 is $|\xi P_\mu| > 0.990$. This measurement is of K^+ decay, not π^+ decay, so we do not include it in an average, nor do we yet set up a separate data block for K results.
[33] Depolarization by medium not known sufficiently well.

$\xi \times (\mu$ LONGITUDINAL POLARIZATION$) \times \delta / \rho$

VALUE	CL%	DOCUMENT ID		TECN	CHG	COMMENT
>0.99682	90	[34] JODIDIO	86	SPEC	+	TRIUMF
• • • We do not use the following data for averages, fits, limits, etc. • • •						
>0.9966	90	[35] STOKER	85	SPEC	+	μ-spin rotation
>0.9959	90	CARR	83	SPEC	+	11 kG

[34] JODIDIO 86 includes data from CARR 83 and STOKER 85. The value here is from the erratum.
[35] STOKER 85 find $(\xi P_\mu \delta/\rho) > 0.9955$ and > 0.9966, where the first limit is from new μ spin-rotation data and the second is from combination with CARR 83 data. In $V-A$ theory, $(\delta/\rho) = 1.0$.

ξ' = LONGITUDINAL POLARIZATION OF e^+

($V-A$) theory predicts the longitudinal polarization = ± 1 for $e^\pm$, respectively. We have flipped the sign for e^- so our programs can average.

VALUE	EVTS	DOCUMENT ID		TECN	CHG	COMMENT
1.00 ±0.04 OUR AVERAGE						
0.998±0.045	1M	BURKARD	85	CNTR	+	Bhabha + annihil
0.89 ±0.28	29k	SCHWARTZ	67	OSPK	−	Moller scattering
0.94 ±0.38		BLOOM	64	CNTR	+	Brems. transmiss.
1.04 ±0.18		DUCLOS	64	CNTR	+	Bhabha scattering
1.05 ±0.30		BUHLER	63	CNTR	+	Annihilation

ξ'' PARAMETER

VALUE	EVTS	DOCUMENT ID		TECN	CHG	COMMENT
0.65±0.36	326k	[36] BURKARD	85	CNTR	+	Bhabha + annihil

[36] BURKARD 85 measure $(\xi''\text{-}\xi\xi')/\xi$ and ξ' and set $\xi = 1$.

TRANSVERSE e^+ POLARIZATION IN PLANE OF μ SPIN, e^+ MOMENTUM

VALUE	EVTS	DOCUMENT ID		TECN	CHG	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •						
0.016±0.021±0.01	5.3M	BURKARD	85B	CNTR	+	Annihil 9–53 MeV

TRANSVERSE e^+ POLARIZATION NORMAL TO PLANE OF μ SPIN, e^+ MOMENTUM

Zero if T invariance holds.

VALUE	EVTS	DOCUMENT ID		TECN	CHG	COMMENT
0.007±0.022±0.007	5.3M	BURKARD	85B	CNTR	+	Annihil 9–53 MeV

α/A

VALUE (units 10^{-3})	EVTS	DOCUMENT ID		TECN	CHG	COMMENT
0.4± 4.3		[37] BURKARD	85B	FIT		
• • • We do not use the following data for averages, fits, limits, etc. • • •						
15 ±50 ±14	5.3M	BURKARD	85B	CNTR	+	9–53 MeV e^+

[37] Global fit to all measured parameters. Correlation coefficients are given in BURKARD 85B.

α'/A

Zero if T invariance holds.

VALUE (units 10^{-3})	EVTS	DOCUMENT ID		TECN	CHG	COMMENT
− 0.2± 4.3		[38] BURKARD	85B	FIT		
• • • We do not use the following data for averages, fits, limits, etc. • • •						
−47 ±50 ±14	5.3M	[39] BURKARD	85B	CNTR	+	9–53 MeV e^+

[38] Global fit to all measured parameters. Correlation coefficients are given in BURKARD 85B.
[39] BURKARD 85B measure e^+ polarizations P_{T_1} and P_{T_2} versus e^+ energy.

β/A

VALUE (units 10^{-3})	EVTS	DOCUMENT ID		TECN	CHG	COMMENT
3.9± 6.2		[40] BURKARD	85B	FIT		
• • • We do not use the following data for averages, fits, limits, etc. • • •						
2 ±17 ±6	5.3M	BURKARD	85B	CNTR	+	9–53 MeV e^+

[40] Global fit to all measured parameters. Correlation coefficients are given in BURKARD 85B.

β'/A

Zero if T invariance holds.

VALUE (units 10^{-3})	EVTS	DOCUMENT ID		TECN	CHG	COMMENT
1.5± 6.3		[41] BURKARD	85B	FIT		
• • • We do not use the following data for averages, fits, limits, etc. • • •						
17 ±17 ±6	5.3M	[42] BURKARD	85B	CNTR	+	9–53 MeV e^+

[41] Global fit to all measured parameters. Correlation coefficients are given in BURKARD 85B.
[42] BURKARD 85B measure e^+ polarizations P_{T_1} and P_{T_2} versus e^+ energy.

a/A

This comes from an alternative parameterization to that used in the Summary Table (see the "Note on Muon Decay Parameters" above).

VALUE (units 10^{-3})	CL%	DOCUMENT ID		TECN
• • • We do not use the following data for averages, fits, limits, etc. • • •				
<15.9	90	[43] BURKARD	85B	FIT

[43] Global fit to all measured parameters. Correlation coefficients are given in BURKARD 85B.

a'/A

This comes from an alternative parameterization to that used in the Summary Table (see the "Note on Muon Decay Parameters" above).

VALUE (units 10^{-3})	DOCUMENT ID		TECN
• • • We do not use the following data for averages, fits, limits, etc. • • •			
5.3 ± 4.1	[44] BURKARD	85B	FIT

[44] Global fit to all measured parameters. Correlation coefficients are given in BURKARD 85B.

$(b'+b)/A$

This comes from an alternative parameterization to that used in the Summary Table (see the "Note on Muon Decay Parameters" above).

VALUE (units 10^{-3})	CL%	DOCUMENT ID		TECN
• • • We do not use the following data for averages, fits, limits, etc. • • •				
<1.04	90	[45] BURKARD	85B	FIT

[45] Global fit to all measured parameters. Correlation coefficients are given in BURKARD 85B.

c/A

This comes from an alternative parameterization to that used in the Summary Table (see the "Note on Muon Decay Parameters" above).

VALUE (units 10^{-3})	CL%	DOCUMENT ID		TECN
• • • We do not use the following data for averages, fits, limits, etc. • • •				
<6.4	90	[46] BURKARD	85B	FIT

[46] Global fit to all measured parameters. Correlation coefficients are given in BURKARD 85B.

c'/A

This comes from an alternative parameterization to that used in the Summary Table (see the "Note on Muon Decay Parameters" above).

VALUE (units 10^{-3})	DOCUMENT ID		TECN
• • • We do not use the following data for averages, fits, limits, etc. • • •			
3.5 ± 2.0	[47] BURKARD	85B	FIT

[47] Global fit to all measured parameters. Correlation coefficients are given in BURKARD 85B.

$\overline{\eta}$ PARAMETER

$(V-A)$ theory predicts $\overline{\eta} = 0$. $\overline{\eta}$ affects spectrum of radiative muon decay.

VALUE	DOCUMENT ID		TECN	CHG	COMMENT
0.02 ±0.08 OUR AVERAGE					
-0.014 ± 0.090	EICHENBER...	84	ELEC	+	ρ free
$+0.09 \pm 0.14$	BOGART	67	CNTR	+	
• • • We do not use the following data for averages, fits, limits, etc. • • •					
-0.035 ± 0.098	EICHENBER...	84	ELEC	+	ρ=0.75 assumed

μ REFERENCES

GORDEEV	94	JETPL 59 589	+Kiselev, Aleshin+ (JINR)
		Translated from ZETFP 59 565.	
DOHMEN	93	PL B317 631	+Groth, Heer+ (PSI SINDRUM-II Collab.)
FREEDMAN	93	PR D47 811	+Fujikawa, Napolitano, Nelson+ (LAMPF E645 Collab.)
GORDEEV	93	JETPL 57 270	+Savchenko, Abazov+ (PNPI, JINR)
		Translated from ZETFP 57 262.	
NI	93	PR D48 1976	+Arnold, Chmely+ (LAMPF Crystal-Box Collab.)
IMAZATO	92	PRL 69 877	+Kawashima, Tanaka+ (KEK, INUS, TOKY, TOKMS)
BARANOV	91	SJNP 53 802	+Vanko, Glazov, Evtukhovich+ (JINR)
		Translated from YAF 53 1302.	

KRAKAUER	91B	PL B263 534	+Talaga, Allen, Chen, Doe+	(UMD, UCI, LANL)
MATTHIAS	91	PRL 66 2716	+Ahn+	(YALE, HEIDP, WILL, GSI, VILL, BNL)
Also	91B	PRL 67 932 erratum	Matthias, Ahn+	(YALE, HEIDP, WILL, GSI, VILL, BNL)
HUBER	90B	PR D41 2709	+	(WYOM, VICT, ARIZ, ROCH, TRIU, SFRA, BRCO)
AHMAD	88	PR D38 2102	+Azuelos+	(TRIU, VICT, VPI, BRCO, MONT, CNRC)
Also	87	PRL 59 970	Ahmad+	(TRIU, VPI, VICT, BRCO, MONT, CNRC)
BALKE	88	PR D37 587	+Gidal, Jodidio+	(LBL, UCB, COLO, NWES, TRIU)
BELLGARDT	88	NP B299 1	+Otter, Eichler+	(SINDRUM Collab.)
BOLTON	88	PR D38 2077	+Cooper, Frank, Hallin+	(LANL, STAN, CHIC, TEMP)
Also	86	PRL 56 2461	Bolton, Bowman, Cooper+	(LANL, STAN, CHIC, TEMP)
Also	86	PRL 57 3241	Grosnick, Wright, Bolton+	(CHIC, LANL, STAN, TEMP)
HUBER	88	PRL 61 2189	+Beer+	(WYOM, VICT, ARIZ, ROCH, TRIU, BRCO)
BELTRAMI	87	PL B194 326	+Burkard, Von Dincklage+	(ETH, SIN, MANZ)
COHEN	87	RMP 59 1121	+Taylor	(RISC, NBS)
NI	87	PRL 59 2716	+Arnold, Chmely+	(YALE, LANL, WILL, MISS, HEIDP)
BEER	86	PRL 57 671	+Marshall, Mason+	(VICT, TRIU, WYOM)
BELTRAMI	86	NP A451 679	+Aas, Beer, Dechambrier, Goudsmit+	(ETH, FRIB)
JODIDIO	86	PR D34 1967	+Balke, Carr, Gidal, Shinsky+	(LBL, NWES, TRIU)
Also	88	PR D37 237 erratum	Jodidio, Balke, Carr+	(LBL, NWES, TRIU)
BERTL	85	NP B260 1	+Egli, Eichler+	(SINDRUM Collab.)
BRYMAN	85	PRL 55 465	+	(TRIU, CNRC, BRCO, LANL, CHIC, CARL+)
BURKARD	85	PL 150B 242	+Corriveau, Egger+	(ETH, SIN, MANZ)
BURKARD	85B	PL 160B 343	+Corriveau, Egger+	(ETH, SIN, MANZ)
Also	81B	PR D24 2004	Corriveau, Egger, Fetscher+	(ETH, SIN, MANZ)
Also	83B	PL 129B 260	Corriveau, Egger, Fetscher+	(ETH, SIN, MANZ)
HUGHES	85	CNPP 14 341	+Kinoshita	(YALE, CORN)
STOKER	85	PRL 54 1887	+Balke, Carr, Gidal+	(LBL, NWES, TRIU)
BARDIN	84	PL 137B 135	+Duclos, Magnon+	(SACL, CERN, BGNA, FIRZ)
BERTL	84	PL 140B 299	+Eichler, Felawka+	(SINDRUM Collab.)
BOLTON	84	PRL 53 1415	+Bowman, Carlini+	(LANL, CHIC, STAN, TEMP)
EICHENBER...	84	NP A412 523	Eichenberger, Engfer, VanderSchaff	(ZURI)
GIOVANETTI	84	PR D29 343	+Dey, Eckhause, Hart+	(WILL)
KINOSHITA	84	PRL 52 717	+Nizic, Okamoto	(CORN)
AZUELOS	83	PRL 51 164	+Depommier, Leroy, Martin+	(MONT, TRIU, BRCO)
Also	77	PRL 39 1113	Depommier+	(MONT, BRCO, TRIU, VICT, MELB)
BERGSMA	83	PL 122B 465	+Dorenbosch, Jonker+	(CHARM Collab.)
CARR	83	PRL 51 627	+Gidal, Gobbi, Jodidio, Oram+	(LBL, NWES, TRIU)
KINNISON	82	PR D25 2846	+Anderson, Matis, Wright+	(EFI, STAN, LANL)
Also	79	PRL 42 556	Bowman, Cooper, Hamm+	(LASL, EFI, STAN)
KLEMPT	82	PR D25 652	+Schulze, Wolf, Camani, Gygax+	(MANZ, ETH)
MARIAM	82	PRL 49 993	+Beer, Bolton, Egan, Gardner+	(YALE, HEIDH, BERN)
MARSHALL	82	PR D25 1174	+Warren, Oram, Kiefl	(BRCO)
COMBLEY	81	PRPL 68 93	+Farley, Picasso	(SHEF, RMCS, CERN)
NEMETHY	81	CNPP 10 147	+Hughes	(LBL, YALE)
ABELA	80	PL 95B 318	+Backenstoss, Simons, Wuest+	(BASL, KARLK, KARLE)
BADERT...	80	LNC 28 401	Badertscher, Borer, Czapek, Flueckiger+	(BERN)
Also	82	NP A377 406	Badertscher, Borer, Czapek, Flueckiger+	(BERN)
JONKER	80	PL 93B 203	+Panman, Udo, Allaby+	(CHARM Collab.)
SCHAAF	80	NP A340 249	+Engfer, Povel, Dey+	(ZURI, ETH, SIN)
Also	77	PL 72B 183	Povel, Dey, Walter, Pfeiffer+	(ZURI, ETH, SIN)
WILLIS	80	PRL 44 522	+Hughes+	(YALE, LBL, LASL, SACL, SIN, CNRC+)
Also	80B	PRL 45 1370	Willis+	(YALE, LBL, LASL, SACL, SIN, CNRC+)
BAILEY	79	NP B150 1		(CERN, DARE, MANZ)
FARLEY	79	ARNPS 29 243	+Picasso	(RMCS, CERN)
BADERT...	78	PL 79B 371	Badertscher, Borer, Czapek, Flueckiger+	(BERN)
BAILEY	78	JPG 4 345		(DARE, BERN, SHEF, MANZ, RMCS, CERN, BIRM)
Also	79	NP B150 1	Bailey	(CERN, DARE, MANZ)
BLIETSCHAU	78	NP B133 205	+Deden, Hasert, Krenz+	(Gargamelle Collab.)
BOWMAN	78	PRL 41 442	+Cheng, Li, Matis	(LASL, IAS, CMU, EFI)
CAMANI	78	PL 77B 326	+Gygax, Klempt, Schenck, Schulze+	(ETH, MANZ)
BADERT...	77	PRL 39 1385	Badertscher, Borer, Czapek, Flueckiger+	(BERN)
BAILEY	77	PL 67B 225	+	(CERN Muon Storage Ring Collab.)
Also	77C	PL 68B 191	Bailey+	(CERN, DARE, BERN, SHEF, MANZ+)
Also	75	PL 55B 420	Bailey+	(CERN Muon Storage Ring Collab., BIRM)
CALMET	77	RMP 49 21	+Narison, Perrottet+	(CNRS)
CASPERSON	77	PRL 38 956	+Crane+	(BERN, HEIDH, LASL, WYOM, YALE)
DEPOMMIER	77	PRL 39 1113	+	(MONT, BRCO, TRIU, VICT, MELB)
BALANDIN	74	JETP 40 811	+Grebenyuk, Zinov, Konin, Ponomarev	(JINR)
		Translated from ZETF 67 1631.		
COHEN	73	JPCRD 2 663	+Taylor	(RISC, NBS)
DUCLOS	73	PL 47B 491	+Magnon, Picard	(SACL)
EICHTEN	73	PL 46B 281	+Deden, Hasert, Krenz+	(Gargamelle Collab.)
BRYMAN	72	PRL 28 1469	+Blecher, Gotow, Powers	(VPI)
CROWE	72	PR D5 2145	+Hague, Rothberg, Schenck+	(LBL, WASH)
CRANE	71	PRL 27 474	+Casperson, Crane, Egan, Hughes+	(YALE)
DERENZO	69	PR 181 1854		(EFI)
VOSSLER	69	NC 63A 423		(EFI)
AKHMANOV	68	SJNP 6 230	+Gurevich, Dobretsov, Makarina+	(KIAE)
		Translated from YAF 6 316.		
BAILEY	68	PL 28B 287	+Bartl, VonBochmann, Brown, Farley+	(CERN)
Also	72	NC 9A 369	Bailey, Bartl, VonBochmann, Brown+	(CERN)
FRYBERGER	68	PR 166 1379		(EFI)
BOGART	67	PR 156 1405	+Dicapua, Nemethy, Strelzoff	(COLU)
SCHWARTZ	67	PR 162 1306		(EFI)
SHERWOOD	67	PR 156 1475		(EFI)
PEOPLES	66	Nevis 147 unpub.		(COLU)
BLOOM	64	PL 8 87	+Dick, Feuvrais, Henry, Macq, Spighel	(CERN)
DUCLOS	64	PL 9 62	+Heintze, DeRujula, Soergel	(CERN)
GUREVICH	64	PL 11 185	+Makarina+	(KIAE)
BUHLER	63	PL 7 368	+Cabibbo, Fidecaro, Massam, Muller+	(CERN)
MEYER	63	PR 132 2693	+Anderson, Bleser, Lederman+	(COLU)
CHARPAK	62	PL 1 16	+Farley, Garwin+	(CERN)
CONFORTO	62	NC 26 261	+Conversi, Dilella+	(INFN, ROMA, CERN)
ALI-ZADE	61	JETP 13 313	+Gurevich, Nikolski	
		Translated from ZETF 40 452.		

CRITTENDEN	61	PR 121 1823	+Walker, Ballam	(WISC, MSU)
KRUGER	61	UCRL 9322 unpub.		(LRL)
GUREVICH	60	JETP 10 225 Translated from ZETF 37 318.	+Nikolski, Surkova	(ITEP)
PLANO	60	PR 119 1400		(COLU)
ASHKIN	59	NC 14 1266	+Fazzini, Fidecaro, Lipman, Merrison+	(CERN)
BARDON	59	PRL 2 56	+Berley, Lederman	(COLU)
LEE	59	PRL 3 55	+Samios	(COLU)