NODE=S004

μ $J = \frac{1}{2}$

μ MASS (atomic mass units u)

NODE=S004AMU

NODE=S004AMU

The muon's mass is obtained from the muon-electron mass ratio as determined from the measurement of Zeeman transition frequencies in muonium ($\mu^+ e^-$ atom). Since the electron's mass is most accurately known in u, the muon's mass is also most accurately known in u. The conversion factor to MeV has approximately the same relative uncertainty as the mass of the muon in u. In this datablock we give the result in u, and in the following datablock in MeV.

NODE=S004AMU

NEW

VALUE (u)	*DOCUMENT ID*		*TECN*	*COMMENT*
0.1134289257±0.0000000025 OUR AVERAGE [0.1134289259 ± 0.0000000025 u OUR 2025 AVERAGE]				
0.1134289257±0.0000000025	MOHR	25	RVUE	2022 CODATA value
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.1134289259±0.0000000025	TIESINGA	21	RVUE	2018 CODATA value
0.1134289257±0.0000000025	MOHR	16	RVUE	2014 CODATA value
0.1134289267±0.0000000029	MOHR	12	RVUE	2010 CODATA value
0.1134289256±0.0000000029	MOHR	08	RVUE	2006 CODATA value
0.1134289264±0.0000000030	MOHR	05	RVUE	2002 CODATA value
0.1134289168±0.0000000034	[1] MOHR	99	RVUE	1998 CODATA value
0.113428913 ±0.000000017	[2] COHEN	87	RVUE	1986 CODATA value

[1] MOHR 99 make use of other 1998 CODATA entries below.

[2] COHEN 87 make use of other 1986 CODATA entries below.

NODE=S004AMU;LINKAGE=M

NODE=S004AMU;LINKAGE=C

μ MASS

NODE=S004M

NODE=S004M

The mass is known more precisely in u (atomic mass units) than in MeV. The conversion is: 1 u = 931.494 103 72(29) MeV/c^2 (2022 CODATA value, MOHR 25). The conversion error contributes significantly to the uncertainty of the masses given below.

NODE=S004M

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*CHG*	*COMMENT*
105.6583755±0.0000023	MOHR	25	RVUE		2022 CODATA value
• • • We do not use the following data for averages, fits, limits, etc. • • •					
105.6583755±0.0000023	TIESINGA	21	RVUE		2018 CODATA value
105.6583745±0.0000024	MOHR	16	RVUE		2014 CODATA value
105.6583715±0.0000035	MOHR	12	RVUE		2010 CODATA value
105.6583668±0.0000038	MOHR	08	RVUE		2006 CODATA value
105.6583692±0.0000094	MOHR	05	RVUE		2002 CODATA value
105.6583568±0.0000052	MOHR	99	RVUE		1998 CODATA value
105.658353 ±0.000016	[1] COHEN	87	RVUE		1986 CODATA value
105.658386 ±0.000044	[2] MARIAM	82	CNTR	+	
105.65836 ±0.00026	[3] CROWE	72	CNTR		
105.65865 ±0.00044	[4] CRANE	71	CNTR		

[1] Converted to MeV using the 1998 CODATA value of the conversion constant, 931.494013 ± 0.000037 MeV/u.

[2] MARIAM 82 give m_μ/m_e = 206.768259(62).

[3] CROWE 72 give m_μ/m_e = 206.7682(5).

[4] CRANE 71 give m_μ/m_e = 206.76878(85).

NODE=S004M;LINKAGE=A1

NODE=S004M;LINKAGE=M

NODE=S004M;LINKAGE=D

NODE=S004M;LINKAGE=C

μ MEAN LIFE τ

NODE=S004T

NODE=S004T

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

NODE=S004T

VALUE (10^{-6} s)	*DOCUMENT ID*		*TECN*	*CHG*	*COMMENT*
2.1969811±0.0000022 OUR AVERAGE					
2.1969803±0.0000021±0.0000007	[1] TISHCHENKO	13	CNTR	+	Surface μ^+ at PSI
2.197083 ±0.000032 ±0.000015	BARCZYK	08	CNTR	+	Muons from π^+ decay at rest
2.197013 ±0.000021 ±0.000011	CHITWOOD	07	CNTR	+	Surface μ^+ at PSI
2.197078 ±0.000073	BARDIN	84	CNTR	+	

2.197025 ±0.000155	BARDIN	84	CNTR	−		OCCUR=2
2.19695 ±0.00006	GIOVANETTI	84	CNTR	+		
2.19711 ±0.00008	BALANDIN	74	CNTR	+		
2.1973 ±0.0003	DUCLOS	73	CNTR	+		

• • • We do not use the following data for averages, fits, limits, etc. • • •

2.1969803±0.0000022	WEBBER	11	CNTR	+	Surface μ^+ at PSI

[1] TISHCHENKO 13 uses 1.6×10^{12} μ^+ events and supersedes WEBBER 11. NODE=S004T;LINKAGE=A

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

NODE=S004DT

A test of *CPT* invariance. NODE=S004DT

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
1.000024±0.000078	BARDIN	84	CNTR	

NODE=S004DT

• • • 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^-

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

NODE=S004DTT

A test of *CPT* invariance. Calculated from the mean-life ratio, above. NODE=S004DTT

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

NODE=S004DTT

μ/p MAGNETIC MOMENT RATIO

NODE=S004MPR

This ratio is used to obtain a precise value of the muon mass and to reduce experimental muon Larmor frequency measurements to the muon magnetic moment anomaly. Measurements with an error $>$ 0.00001 have been omitted. By convention, the minus sign on this ratio is omitted. CODATA values were fitted using their selection of data, plus other data from multiparameter fits. NODE=S004MPR

VALUE	*DOCUMENT ID*		*TECN*	*CHG*	*COMMENT*
3.183345142±0.000000071	TIESINGA	21	RVUE		2018 CODATA value

NODE=S004MPR OCCUR=2

• • • We do not use the following data for averages, fits, limits, etc. • • •

3.183345142±0.000000071	MOHR	16	RVUE		2014 CODATA value
3.183345107±0.000000084	MOHR	12	RVUE		2010 CODATA value
3.183345137±0.000000085	MOHR	08	RVUE		2006 CODATA value
3.183345118±0.000000089	MOHR	05	RVUE		2002 CODATA value
3.18334513 ±0.00000039	LIU	99	CNTR	+	HFS in muonium
3.18334539 ±0.00000010	MOHR	99	RVUE		1998 CODATA value
3.18334547 ±0.00000047	COHEN	87	RVUE		1986 CODATA value
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

See the related review(s):

Muon Anomalous Magnetic Moment

μ MAGNETIC MOMENT ANOMALY

NODE=S004220

The parity-violating decay of muons in a storage ring is observed. The difference frequency ω_a between the muon spin precession and the orbital angular frequency $(e/m_\mu c)\langle B\rangle$ is measured, as is the free proton NMR frequency ω_p, thus determining the ratio $R=\omega_a/\omega_p$. Given the magnetic NODE=S004220 moment ratio $\lambda=\mu_\mu/\mu_p$ (from hyperfine structure in muonium), $(g-2)/2 = R/(\lambda-R)$.

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

NODE=S004MM
NODE=S004MM

VALUE (units 10^{-10})				DOCUMENT ID		TECN	CHG	COMMENT
11659207.2 ±	**1.5**		**OUR AVERAGE**	[(11659205.9 ± 2.2) × 10^{-10} OUR 2025 AVERAGE]				NEW
11659207.15±	**1.45**			[1] AGUILLARD	25	MUG2	±	Combined FNAL and BNL values — OCCUR=2
• • • We do not use the following data for averages, fits, limits, etc. • • •								
11659207.05±	1.48			[2] AGUILLARD	25	MUG2	+	Storage ring
11659205.5 ±	2.4			[3] AGUILLARD	23	MUG2	+	Storage ring
11659205.9 ±	2.2			[4] AGUILLARD	23	MUG2	±	Combined FNAL and BNL values — OCCUR=2
11659204.0 ±	5.4			ABI	21	MUG2	+	Storage ring
11659206.1 ±	4.1			[5] ABI	21	MUG2	±	Combined FNAL and BNL values — OCCUR=2
11659208.0 ±	5.4	±3.3		BENNETT	06	MUG2	±	Average μ^+ and μ^-
11659208 ±	6			BENNETT	04	MUG2	±	Average μ^+ and μ^-
11659214 ±	8	±3		BENNETT	04	MUG2	−	Storage ring — OCCUR=2
11659203 ±	6	±5		BENNETT	04	MUG2	+	Storage ring — OCCUR=3
11659204 ±	7	±5		BENNETT	02	MUG2	+	Storage ring
11659202 ±	14	±6		BROWN	01	MUG2	+	Storage ring
11659191 ±	59			BROWN	00	MUG2	+	
11659100 ±	110			[6] BAILEY	79	CNTR	+	Storage ring
11659360 ±	120			[6] BAILEY	79	CNTR	−	Storage ring — OCCUR=2
11659230 ±	85			[6] BAILEY	79	CNTR	±	Storage ring — OCCUR=3
11620000 ±	5000			CHARPAK	62	CNTR	+	

[1] AGUILLARD 25 combined their value with the previous independent BNL measurement of BENNETT 06. NODE=S004MM;LINKAGE=H

[2] AGUILLARD 25 quote the combined value from all RUNS 1–6 (at 127 ppm precision). For the 2020–2023 data (Runs 4, 5, 6) alone AGUILLARD 25 measure a value of $(11659207.10 \pm 1.62) \times 10^{-10}$ (at precision of 139 ppb). NODE=S004MM;LINKAGE=G

[3] This AGUILLARD 23 value is the combination of all 2018, 2019 and 2020 data, including the ABI 21 value. The new FNAL 2019 and 2020 data alone combined yield $(11659205.7 \pm 2.5) \times 10^{-10}$. NODE=S004MM;LINKAGE=E

[4] AGUILLARD 23 combined their value with the previous independent BNL measurement of BENNETT 06. NODE=S004MM;LINKAGE=F

[5] ABI 21 combined their value with the previous independent BNL measurement of BENNETT 06. ABI 21 also report that the difference of this combination with the standard model value of $(11659181.0 \pm 4.3) \times 10^{-10}$ (AOYAMA 20) has a significance of 4.2 σ. NODE=S004MM;LINKAGE=D

[6] BAILEY 79 values recalculated by HUGHES 99 using the COHEN 87 μ/p magnetic moment. The improved MOHR 99 value does not change the result. NODE=S004MM;LINKAGE=I

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

NODE=S004MMR

A test of *CPT* invariance.

NODE=S004MMR

NODE=S004MMR

VALUE (units 10^{-8})	DOCUMENT ID		TECN
−0.11±0.12	BENNETT	04	MUG2
• • • We do not use the following data for averages, fits, limits, etc. • • •			
−2.6 ±1.6	BAILEY	79	CNTR

μ ELECTRIC DIPOLE MOMENT (d)

NODE=S004EDM

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

NODE=S004EDM

NODE=S004EDM

VALUE (10^{-19} e cm)	CL%	DOCUMENT ID		TECN	CHG	COMMENT	
< 1.8	95	[1] BENNETT	09	MUG2	±	Storage ring	
• • • We do not use the following data for averages, fits, limits, etc. • • •							
< 0.19	90	[2] EMA	22			theory limit	
−0.1 ±1.0		[3] BENNETT	09	MUG2	+	Storage ring	OCCUR=2
−0.1 ±0.7		[4] BENNETT	09	MUG2	−	Storage ring	OCCUR=3
−3.7 ±3.4		[5] BAILEY	78	CNTR	±	Storage ring	
8.6 ±4.5		BAILEY	78	CNTR	+	Storage ring	OCCUR=2
0.8 ±4.3		BAILEY	78	CNTR	−	Storage ring	OCCUR=3

[1] This is the combination of the two BENNETT 09 measurements quoted here separately for μ^+ and μ^-. The result is also presented as a measurement of $(0.0 \pm 0.9) \times 10^{-19} e$ cm. NODE=S004EDM;LINKAGE=BE

[2] EMA 22 determine indirect constraints on $|\mu_{EDM}|$ from EDM measurements performed on heavy atoms and molecules, based on the muon-loop induced light-by-light CP-odd amplitude. NODE=S004EDM;LINKAGE=D

[3] Also reported as the limit of $|d(\mu^+)| < 2.1 \times 10^{-19}$ e cm at 95% CL. NODE=S004EDM;LINKAGE=A

[4] Also reported as the limit of $|d(\mu^-)| < 1.5 \times 10^{-19}$ e cm at 95% CL. NODE=S004EDM;LINKAGE=C

[5] This is the combination of the two BAILEY 78 results quoted here separately for μ^+ and μ^-. BAILEY 78 uses the convention d $= 1/2 \cdot (d_{\mu^+} - d_{\mu^-})$ and reports 3.7 ± 3.4. We convert their result to use the same convention as BENNETT 09. NODE=S004EDM;LINKAGE=B

MUON-ELECTRON CHARGE RATIO ANOMALY $q_{\mu^+}/q_{e^-} + 1$

NODE=S004MEC

NODE=S004MEC

VALUE	DOCUMENT ID		TECN	CHG	COMMENT
$(1.1 \pm 2.1) \times 10^{-9}$	[1] MEYER	00	CNTR	+	1s–2s muonium interval

[1] MEYER 00 measure the 1s–2s muonium interval, and then interpret the result in terms of muon-electron charge ratio q_{μ^+}/q_{e^-}. NODE=S004MEC;LINKAGE=A

μ^- DECAY MODES

NODE=S004235;NODE=S004

μ^+ modes are charge conjugates of the modes below. NODE=S004

	Mode			Fraction (Γ_i/Γ)		Confidence level	
Γ_1	$e^- \overline{\nu}_e \nu_\mu$			$\approx 100\%$			DESIG=1;OUR EVAL;→ UNCHECKED ←
Γ_2	$e^- \overline{\nu}_e \nu_\mu \gamma$		[a]	$(6.0 \pm 0.5) \times 10^{-8}$			DESIG=2
Γ_3	$e^- \overline{\nu}_e \nu_\mu e^+ e^-$		[b]	$(3.4 \pm 0.4) \times 10^{-5}$			DESIG=7

Lepton Family number (*LF*) violating modes

NODE=S004;CLUMP=A

	Mode			Fraction (Γ_i/Γ)		Confidence level	
Γ_4	$e^- \nu_e \overline{\nu}_\mu$	*LF*	[c]	< 1.2	%	90%	DESIG=3
Γ_5	$e^- \gamma$	*LF*		< 1.5	$\times 10^{-13}$	90%	DESIG=4
Γ_6	$e^- e^+ e^-$	*LF*		< 1.0	$\times 10^{-12}$	90%	DESIG=5
Γ_7	$e^- 2\gamma$	*LF*		< 7.2	$\times 10^{-11}$	90%	DESIG=6

[a] 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. LINKAGE=XMD

[b] See the Particle Listings below for the energy limits used in this measurement. LINKAGE=KDM

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

μ^- BRANCHING RATIOS

NODE=S004240

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

NODE=S004R1

NODE=S004R1

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
$(6.03 \pm 0.14 \pm 0.53) \times 10^{-8}$	13k	[1] BALDINI	16A	SPEC	γ KE > 40 MeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
	862	BOGART	67	CNTR	γ KE > 14.5 MeV
$(3.3 \pm 1.3) \times 10^{-3}$		CRITTENDEN	61	CNTR	γ KE > 20 MeV
$(1.4 \pm 0.4) \times 10^{-2}$		CRITTENDEN	61	CNTR	γ KE > 10 MeV
	27	ASHKIN	59	CNTR	

OCCUR=2

[1] BALDINI 16 measurement refers to $\mu^+ \rightarrow e^+ \nu \overline{\nu} \gamma$ decay and requires energy of $e^+ >$ 45 MeV and energy $\gamma > 40$ MeV. NODE=S004R1;LINKAGE=B

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

NODE=S004R6

NODE=S004R6

VALUE (units 10^{-5})	EVTS	DOCUMENT ID		TECN	CHG	COMMENT
$3.4 \pm 0.2 \pm 0.3$	7443	[1] BERTL	85	SPEC	+	SINDRUM
• • • We do not use the following data for averages, fits, limits, etc. • • •						
2.2 ± 1.5	7	[2] CRITTENDEN	61	HLBC	+	$E(e^+ e^-) > 10$ MeV
2	1	[3] GUREVICH	60	EMUL	+	
1.5 ± 1.0	3	[4] LEE	59	HBC	+	

[1] BERTL 85 has transverse momentum cut $p_T > 17$ MeV/c. Systematic error was increased by us. NODE=S004R6;LINKAGE=B

[2] CRITTENDEN 61 count only those decays where total energy of either (e^+, e^-) combination is >10 MeV. NODE=S004R6;LINKAGE=C

[3] GUREVICH 60 interpret their event as either virtual or real photon conversion. e^+ and e^- energies not measured. NODE=S004R6;LINKAGE=G

[4] In the three LEE 59 events, the sum of energies E(e^+) + E(e^-) + E(e^+) was 51 MeV, 55 MeV, and 33 MeV. NODE=S004R6;LINKAGE=L

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

NODE=S004R2

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. NODE=S004R2

NODE=S004R2

VALUE	CL%	DOCUMENT ID		TECN	CHG	COMMENT
< 0.012	90	[1] 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	[2] 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	+	

[1] FREEDMAN 93 limit on $\overline{\nu}_e$ observation is here interpreted as a limit on lepton family number violation. NODE=S004R2;LINKAGE=L

[2] 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. NODE=S004R2;LINKAGE=A

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

NODE=S004R3

Forbidden by lepton family number conservation. NODE=S004R3

NODE=S004R3

VALUE	CL%	DOCUMENT ID		TECN	CHG	COMMENT
< 1.5 × 10^{-13} (CL = 90%) [<3.1 × 10^{-13} (CL = 90%) OUR 2025 BEST LIMIT]						
< 1.5 × 10^{-13}	90	[1] AFANACIEV	25A	SPEC	+	MEG II at PSI
• • • We do not use the following data for averages, fits, limits, etc. • • •						
< 3.1 × 10^{-13}	90	[2] AFANACIEV	24	SPEC	+	MEG II at PSI
< 4.2 × 10^{-13}	90	BALDINI	16	SPEC	+	MEG at PSI
< 5.7 × 10^{-13}	90	ADAM	13B	SPEC	+	MEG at PSI
< 2.4 × 10^{-12}	90	ADAM	11	SPEC	+	MEG at PSI
< 2.8 × 10^{-11}	90	ADAM	10	SPEC	+	MEG at PSI
< 1.2 × 10^{-11}	90	AHMED	02	SPEC	+	MEGA
< 1.2 × 10^{-11}	90	BROOKS	99	SPEC	+	LAMPF
< 4.9 × 10^{-11}	90	BOLTON	88	CBOX	+	LAMPF
<100 × 10^{-11}	90	AZUELOS	83	CNTR	+	TRIUMF
< 17 × 10^{-11}	90	KINNISON	82	SPEC	+	LAMPF
<100 × 10^{-11}	90	SCHAAF	80	ELEC	+	SIN

[1] AFANACIEV 25A is based on all 2021-2022 data and supersedes previous results. A combination of MEG/MEG II would only improve the limit by a few % and thus is not reported separately by AFANACIEV 25A. NODE=S004R3;LINKAGE=C

[2] AFANACIEV 24 reports results using data collected by MEGII in 2021 combined with the limit obtained by the MEG experiment. Supersedes BALDINI 16. NODE=S004R3;LINKAGE=A

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

NODE=S004R4

Forbidden by lepton family number conservation. NODE=S004R4

NODE=S004R4

VALUE (units 10^{-12})	CL%	DOCUMENT ID		TECN	CHG	COMMENT
< 1.0	90	[1] 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	[1] BERTL	85	SPEC	+	SINDRUM
<160	90	[1] BERTL	84	SPEC	+	SINDRUM
<130	90	[1] BOLTON	84	CNTR		LAMPF

[1] These experiments assume a constant matrix element. NODE=S004R4;LINKAGE=K

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

NODE=S004R5

Forbidden by lepton family number conservation.

NODE=S004R5
NODE=S004R5

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. • • •						
< 1	90	[1] BALDINI	20	MEG		PSI
< 840	90	[2] AZUELOS	83	CNTR	+	TRIUMF
<5000	90	[3] BOWMAN	78	CNTR		DEPOMMIER 77 data

[1] BALDINI 20 uses 7.5×10^{14} stopped muons to obtain limits on $\mu \rightarrow eX$ decay mediated by a new light particle X with lifetimes < 40 ps, which decays to $\gamma\gamma$ for X-mass ranges 20–45 MeV. The limit of the order < 10^{-11} at 90% CL is for the mass range 20–30 MeV.
NODE=S004R5;LINKAGE=D

[2] AZUELOS 83 uses the phase space distribution of BOWMAN 78.
NODE=S004R5;LINKAGE=B

[3] BOWMAN 78 assumes an interaction Lagrangian local on the scale of the inverse μ mass.
NODE=S004R5;LINKAGE=A

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

NODE=S004245

Forbidden by lepton family number conservation.

NODE=S004245

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

NODE=S004RE
NODE=S004RE

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 $\rightarrow e^-$ Cu) / $\sigma(\mu^-$ Cu $\rightarrow$ capture)

NODE=S004RF
NODE=S004RF

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 $\rightarrow e^-$ Ti) / $\sigma(\mu^-$ Ti $\rightarrow$ capture)

NODE=S004RG
NODE=S004RG

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
$<4.3 \times 10^{-12}$	90	[1] 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

[1] DOHMEN 93 assumes $\mu^- \rightarrow e^-$ conversion leaves the nucleus in its ground state, a process enhanced by coherence and expected to dominate.
NODE=S004RG;LINKAGE=A

$\sigma(\mu^-$ Pb $\rightarrow e^-$ Pb) / $\sigma(\mu^-$ Pb $\rightarrow$ capture)

NODE=S004RH
NODE=S004RH

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
$<4.6 \times 10^{-11}$	90	HONECKER	96	SPEC	SINDRUM II
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$<4.9 \times 10^{-10}$	90	AHMAD	88	TPC	TRIUMF

$\sigma(\mu^-$ Au $\rightarrow e^-$ Au) / $\sigma(\mu^-$ Au $\rightarrow$ capture)

NODE=S004RA
NODE=S004RA

VALUE	CL%	DOCUMENT ID		TECN	CHG	COMMENT
$<7 \times 10^{-13}$	90	BERTL	06	SPEC	–	SINDRUM II

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

NODE=S004250

Forbidden by total lepton number conservation.

NODE=S004250

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

NODE=S004RP1
NODE=S004RP1

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

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

NODE=S004RP2
NODE=S004RP2

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
$<3 \times 10^{-10}$	90	[1] ABELA	80	CNTR	Radiochemical tech.

[1] 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).
NODE=S004RP2;LINKAGE=A

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

NODE=S004RP3
NODE=S004RP3

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

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

NODE=S004RP4
NODE=S004RP4

VALUE	CL%	EVTS	DOCUMENT ID		TECN	CHG	COMMENT
$<3.6 \times 10^{-11}$	90	1	[1,2] KAULARD	98	SPEC	−	SINDRUM II
• • • We do not use the following data for averages, fits, limits, etc. • • •							
$<1.7 \times 10^{-12}$	90	1	[2,3] KAULARD	98	SPEC	−	SINDRUM II
$<4.3 \times 10^{-12}$	90		[3] DOHMEN	93	SPEC		SINDRUM II
$<8.9 \times 10^{-11}$	90		[1] DOHMEN	93	SPEC		SINDRUM II
$<1.7 \times 10^{-10}$	90		[4] AHMAD	88	TPC		TRIUMF

OCCUR=2
OCCUR=2

[1] This limit assumes a giant resonance excitation of the daughter Ca nucleus (mean energy and width both 20 MeV). NODE=S004RP4;LINKAGE=C2

[2] KAULARD 98 obtained these same limits using the unified classical analysis of FELDMAN 98. NODE=S004RP4;LINKAGE=D

[3] This limit assumes the daughter Ca nucleus is left in the ground state. However, the probability of this is unknown. NODE=S004RP4;LINKAGE=C1

[4] Assuming a giant-resonance-excitation model. NODE=S004RP4;LINKAGE=A

LIMIT ON MUONIUM → ANTIMUONIUM CONVERSION

NODE=S004255

Forbidden by lepton family number conservation.

NODE=S004255

$R_g = G_C \,/\, G_F$

NODE=S004MC
NODE=S004MC

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.

NODE=S004MC

VALUE	CL%	EVTS	DOCUMENT ID		TECN	CHG	COMMENT
$<$ 0.0030	90	1	[1] WILLMANN	99	SPEC	+	μ^+ at 26 GeV/c
• • • We do not use the following data for averages, fits, limits, etc. • • •							
$<$ 0.14	90	1	[2] GORDEEV	97	SPEC	+	JINR phasotron
$<$ 0.018	90	0	[3] ABELA	96	SPEC	+	μ^+ at 24 MeV
$<$ 6.9	90		NI	93	CBOX		LAMPF
$<$ 0.16	90		MATTHIAS	91	SPEC		LAMPF
$<$ 0.29	90		HUBER	90B	CNTR		TRIUMF
$<$20	95		BEER	86	CNTR		TRIUMF
$<$42	95		MARSHALL	82	CNTR		

[1] WILLMANN 99 quote both probability $P_{M\overline{M}} < 8.3 \times 10^{-11}$ at 90%CL in a 0.1 T field and $R_g = G_C/G_F$. NODE=S004MC;LINKAGE=M9

[2] GORDEEV 97 quote limits on both $f = G_{MM}/GF$ and the probability $W_{MM} < 4.7 \times 10^{-7}$ (90% CL). NODE=S004MC;LINKAGE=GG

[3] ABELA 96 quote both probability $P_{M\overline{M}} < 8 \times 10^{-9}$ at 90% CL and $R_g = G_C/G_F$. NODE=S004MC;LINKAGE=C

See the related review(s):

Muon Decay Parameters

μ DECAY PARAMETERS

NODE=S004260

ρ PARAMETER

NODE=S004RHO

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

NODE=S004RHO
NODE=S004RHO

VALUE	EVTS	DOCUMENT ID		TECN	CHG	COMMENT
0.74979±0.00026 OUR AVERAGE						
0.74977±0.00012±0.00023		[1] BAYES	11	TWST	+	Surface μ^+
0.7518 ±0.0026		DERENZO	69	RVUE		
• • • We do not use the following data for averages, fits, limits, etc. • • •						
0.75014±0.00017±0.00045		[2] MACDONALD	08	TWST	+	Surface μ^+
0.75080±0.00032±0.00100	6G	[3] MUSSER	05	TWST	+	Surface μ^+
0.72 ±0.06 ±0.08		AMORUSO	04	ICAR		Liquid Ar TPC
0.762 ±0.008	170k	[4] FRYBERGER	68	ASPK	+	25–53 MeV e^+
0.760 ±0.009	280k	[4] SHERWOOD	67	ASPK	+	25–53 MeV e^+
0.7503 ±0.0026	800k	[4] PEOPLES	66	ASPK	+	20–53 MeV e^+

[1] The quoted systematic error includes a contribution of 0.00013 (added in quadrature) from uncertainties on radiative corrections and on the Michel parameter η.
[2] The quoted systematic error includes a contribution of 0.00011 (added in quadrature) from the dependence on the Michel parameter η.
[3] The quoted systematic error includes a contribution of 0.00023 (added in quadrature) from the dependence on the Michel parameter η.
[4] η constrained = 0. These values incorporated into a two parameter fit to ρ and η by DERENZO 69.

NODE=S004RHO;LINKAGE=BA
NODE=S004RHO;LINKAGE=MA
NODE=S004RHO;LINKAGE=MU
NODE=S004RHO;LINKAGE=C

η PARAMETER

NODE=S004ETA

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

NODE=S004ETA
NODE=S004ETA

VALUE	EVTS	DOCUMENT ID		TECN	CHG	COMMENT	
0.057 ±0.034 OUR AVERAGE							
0.071 ±0.037 ±0.005	30M	DANNEBERG	05	CNTR	+	7–53 MeV e^+	
0.011 ±0.081 ±0.026	5.3M	[1] BURKARD	85B	CNTR	+	9–53 MeV e^+	OCCUR=2
−0.12 ±0.21	6346	DERENZO	69	HBC	+	1.6–6.8 MeV e^+	
• • • We do not use the following data for averages, fits, limits, etc. • • •							
−0.0021±0.0070±0.0010	30M	[2] DANNEBERG	05	CNTR	+	7–53 MeV e^+	OCCUR=2
−0.012 ±0.015 ±0.003	5.3M	[2] BURKARD	85B	CNTR	+	9–53 MeV e^+	
−0.007 ±0.013	5.3M	[3] BURKARD	85B	FIT	+	9–53 MeV e^+	OCCUR=3
−0.7 ±0.5	170k	[4] FRYBERGER	68	ASPK	+	25–53 MeV e^+	
−0.7 ±0.6	280k	[4] SHERWOOD	67	ASPK	+	25–53 MeV e^+	
0.05 ±0.5	800k	[4] PEOPLES	66	ASPK	+	20–53 MeV e^+	
−2.0 ±0.9	9213	[5] PLANO	60	HBC	+	Whole spectrum	

[1] Previously we used the global fit result from BURKARD 85B in OUR AVERAGE, we now only include their actual measurement.
[2] $\alpha = \alpha' = 0$ assumed.
[3] Global fit to all measured parameters. The fit correlation coefficients are given in BURKARD 85B.
[4] ρ constrained = 0.75.
[5] Two parameter fit to ρ and η; PLANO 60 discounts value for η.

NODE=S004ETA;LINKAGE=BU
NODE=S004ETA;LINKAGE=D
NODE=S004ETA;LINKAGE=F
NODE=S004ETA;LINKAGE=C
NODE=S004ETA;LINKAGE=P

δ PARAMETER

NODE=S004DEL

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

NODE=S004DEL
NODE=S004DEL

VALUE	EVTS	DOCUMENT ID		TECN	CHG	COMMENT
0.75047±0.00034 OUR AVERAGE						
0.75049±0.00021±0.00027		[1] BAYES	11	TWST	+	Surface μ^+
0.7486 ±0.0026 ±0.0028		[2] BALKE	88	SPEC	+	Surface μ^+
• • • We do not use the following data for averages, fits, limits, etc. • • •						
0.75067±0.00030±0.00067		MACDONALD	08	TWST	+	Surface μ^+
0.74964±0.00066±0.00112	6G	GAPONENKO	05	TWST	+	Surface μ^+
		[3] VOSSLER	69			
0.752 ±0.009	490k	FRYBERGER	68	ASPK	+	25–53 MeV e^+
0.782 ±0.031		KRUGER	61			
0.78 ±0.05	8354	PLANO	60	HBC	+	Whole spectrum

[1] The quoted systematic error includes a contribution of 0.00006 (added in quadrature) from uncertainties on radiative corrections and on the Michel parameter η.
[2] BALKE 88 uses $\rho = 0.752 \pm 0.003$.
[3] VOSSLER 69 has measured the asymmetry below 10 MeV. See comments about radiative corrections in VOSSLER 69.

NODE=S004DEL;LINKAGE=BA
NODE=S004DEL;LINKAGE=A
NODE=S004DEL;LINKAGE=V

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

NODE=S004XI

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

NODE=S004XI
NODE=S004XI

VALUE	DOCUMENT ID		TECN	CHG	COMMENT
1.0009 $^{+0.0016}_{-0.0007}$ OUR AVERAGE					
1.00084±0.00029$^{+0.00165}_{-0.00063}$	BUENO	11	TWST		Surface μ^+ beam
1.0027 ±0.0079 ±0.0030	BELTRAMI	87	CNTR		SIN, π decay in flight
• • • We do not use the following data for averages, fits, limits, etc. • • •					
1.0003 ±0.0006 ±0.0038	JAMIESON	06	TWST	+	surface μ^+ beam
1.0013 ±0.0030 ±0.0053	[1] IMAZATO	92	SPEC	+	$K^+ \rightarrow \mu^+ \nu_\mu$
0.975 ±0.015	AKHMANOV	68	EMUL		140 kG
0.975 ±0.030	GUREVICH	64	EMUL		See AKHMANOV 68
0.903 ±0.027	[2] ALI-ZADE	61	EMUL	+	27 kG
0.93 ±0.06	PLANO	60	HBC	+	8.8 kG
0.97 ±0.05	BARDON	59	CNTR		Bromoform target

[1] 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.
[2] Depolarization by medium not known sufficiently well.

NODE=S004XI;LINKAGE=B
NODE=S004XI;LINKAGE=A

$\xi \times$ (μ LONGITUDINAL POLARIZATION) $\times$ δ / ρ

NODE=S004XID
NODE=S004XID

VALUE	CL%	DOCUMENT ID		TECN	CHG	COMMENT
1.00179$^{+0.00156}_{-0.00071}$		[1] BAYES	11	TWST	+	Surface μ^+ beam
• • • We do not use the following data for averages, fits, limits, etc. • • •						
>0.99682	90	[2] JODIDIO	86	SPEC	+	TRIUMF
>0.9966	90	[3] STOKER	85	SPEC	+	μ-spin rotation
>0.9959	90	CARR	83	SPEC	+	11 kG

[1] BAYES 11 obtains the limit > 0.99909 (90% CL) with the constraint that $\xi\times$(μ LONGITUDINAL POLARIZATION) $\times\,\delta/\rho\ \leq\ 1.0$. NODE=S004XID;LINKAGE=BA

[2] JODIDIO 86 includes data from CARR 83 and STOKER 85. The value here is from the erratum. NODE=S004XID;LINKAGE=C

[3] 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, $(\delta/\rho) = 1.0$. NODE=S004XID;LINKAGE=S

ξ' = LONGITUDINAL POLARIZATION OF e^+

NODE=S004PL

($V-A$) theory predicts the longitudinal polarization $= \pm1$ for $e^{\pm}$, respectively. We have flipped the sign for e^- so our programs can average.

NODE=S004PL

NODE=S004PL

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

NODE=S004XPP
NODE=S004XPP

VALUE	EVTS	DOCUMENT ID		TECN	CHG	COMMENT
0.98 ±0.04 OUR AVERAGE						
0.981±0.045±0.003	3.87M	PRIEELS	14	CNTR	+	Bhabha + annihil
0.65 ±0.36	326k	[1] BURKARD	85	CNTR	+	Bhabha + annihil

[1] BURKARD 85 measure $(\xi''$-$\xi\xi')/\xi$ and ξ' and set $\xi = 1$. NODE=S004XPP;LINKAGE=B

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

NODE=S004PT1
NODE=S004PT1

VALUE (units 10^{-3})	EVTS	DOCUMENT ID		TECN	CHG	COMMENT
7 ± 8 OUR AVERAGE						
6.3± 7.7± 3.4	30M	DANNEBERG	05	CNTR	+	7–53 MeV e^+
16 ±21 ±10	5.3M	BURKARD	85B	CNTR	+	Annihil 9–53 MeV

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

NODE=S004PT2

Zero if T invariance holds.

NODE=S004PT2
NODE=S004PT2

VALUE (units 10^{-3})	EVTS	DOCUMENT ID		TECN	CHG	COMMENT
−2 ± 8 OUR AVERAGE						
−3.7± 7.7±3.4	30M	DANNEBERG	05	CNTR	+	7–53 MeV e^+
7 ±22 ±7	5.3M	BURKARD	85B	CNTR	+	Annihil 9–53 MeV

α/A

NODE=S004AL
NODE=S004AL

VALUE (units 10^{-3})	EVTS	DOCUMENT ID		TECN	CHG	COMMENT
0.4± 4.3		[1] 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^+

OCCUR=2

[1] Global fit to all measured parameters. Correlation coefficients are given in BURKARD 85B. NODE=S004AL;LINKAGE=F

α'/A

NODE=S004ALP

Zero if T invariance holds.

NODE=S004ALP
NODE=S004ALP

VALUE (units 10^{-3})	EVTS	DOCUMENT ID		TECN	CHG	COMMENT
−10 ±20 OUR AVERAGE						
− 3.4±21.3± 4.9	30M	DANNEBERG	05	CNTR	+	7–53 MeV e^+
−47 ±50 ±14	5.3M	[1] BURKARD	85B	CNTR	+	9–53 MeV e^+
• • • We do not use the following data for averages, fits, limits, etc. • • •						
− 0.2± 4.3		[2] BURKARD	85B	FIT		

OCCUR=2

[1] Previously we used the global fit result from BURKARD 85B in OUR AVERAGE, we now only include their actual measurement. BURKARD 85B measure e^+ polarizations P_{T_1} and P_{T_2} versus e^+ energy. NODE=S004ALP;LINKAGE=C

[2] Global fit to all measured parameters. The fit correlation coefficients are given in BURKARD 85B. NODE=S004ALP;LINKAGE=F

β/A

NODE=S004BT
NODE=S004BT

VALUE (units 10^{-3})	EVTS	DOCUMENT ID		TECN	CHG	COMMENT	
3.9± 6.2		[1] BURKARD	85B	FIT			OCCUR=2
• • • We do not use the following data for averages, fits, limits, etc. • • •							
2 ±17 ±6	5.3M	BURKARD	85B	CNTR	+	9–53 MeV e^+	

[1] Global fit to all measured parameters. The fit correlation coefficients are given in BURKARD 85B. NODE=S004BT;LINKAGE=F

β'/A

NODE=S004BTP

Zero if T invariance holds. NODE=S004BTP

NODE=S004BTP

VALUE (units 10^{-3})	EVTS	DOCUMENT ID		TECN	CHG	COMMENT	
2 ± 7 OUR AVERAGE							
− 0.5± 7.8±1.8	30M	DANNEBERG	05	CNTR	+	7–53 MeV e^+	
17 ±17 ±6	5.3M	[1] BURKARD	85B	CNTR	+	9–53 MeV e^+	
• • • We do not use the following data for averages, fits, limits, etc. • • •							
− 1.3± 3.5±0.6	30M	[2] DANNEBERG	05	CNTR	+	7–53 MeV e^+	OCCUR=2
1.5± 6.3		[3] BURKARD	85B	FIT			OCCUR=2

[1] Previously we used the global fit result from BURKARD 85B in OUR AVERAGE, we now only include their actual measurement. BURKARD 85B measure e^+ polarizations P_{T_1} and P_{T_2} versus e^+ energy. NODE=S004BTP;LINKAGE=C

[2] $\alpha = \alpha' = 0$ assumed. NODE=S004BTP;LINKAGE=DA

[3] Global fit to all measured parameters. The fit correlation coefficients are given in BURKARD 85B. NODE=S004BTP;LINKAGE=F

a/A

NODE=S004SA

This comes from an alternative parameterization to that used in the Summary Table (see the "Note on Muon Decay Parameters" above). NODE=S004SA

NODE=S004SA

VALUE (units 10^{-3})	CL%	DOCUMENT ID		TECN
• • • We do not use the following data for averages, fits, limits, etc. • • •				
<15.9	90	[1] BURKARD	85B	FIT

[1] Global fit to all measured parameters. Correlation coefficients are given in BURKARD 85B. NODE=S004SA;LINKAGE=F

a'/A

NODE=S004SAP

This comes from an alternative parameterization to that used in the Summary Table (see the "Note on Muon Decay Parameters" above). NODE=S004SAP

NODE=S004SAP

VALUE (units 10^{-3})	DOCUMENT ID		TECN
• • • We do not use the following data for averages, fits, limits, etc. • • •			
5.3±4.1	[1] BURKARD	85B	FIT

[1] Global fit to all measured parameters. Correlation coefficients are given in BURKARD 85B. NODE=S004SAP;LINKAGE=F

$(b'+b)/A$

NODE=S004SBP

This comes from an alternative parameterization to that used in the Summary Table (see the "Note on Muon Decay Parameters" above). NODE=S004SBP

NODE=S004SBP

VALUE (units 10^{-3})	CL%	DOCUMENT ID		TECN
• • • We do not use the following data for averages, fits, limits, etc. • • •				
<1.04	90	[1] BURKARD	85B	FIT

[1] Global fit to all measured parameters. Correlation coefficients are given in BURKARD 85B. NODE=S004SBP;LINKAGE=F

c/A

NODE=S004SC

This comes from an alternative parameterization to that used in the Summary Table (see the "Note on Muon Decay Parameters" above). NODE=S004SC

NODE=S004SC

VALUE (units 10^{-3})	CL%	DOCUMENT ID		TECN
• • • We do not use the following data for averages, fits, limits, etc. • • •				
<6.4	90	[1] BURKARD	85B	FIT

[1] Global fit to all measured parameters. Correlation coefficients are given in BURKARD 85B. NODE=S004SC;LINKAGE=F

c'/A NODE=S004SCP

This comes from an alternative parameterization to that used in the Summary Table (see the "Note on Muon Decay Parameters" above). NODE=S004SCP

VALUE (units 10^{-3})	*DOCUMENT ID*		*TECN*	NODE=S004SCP
• • • We do not use the following data for averages, fits, limits, etc. • • •				
3.5±2.0	[1] BURKARD	85B	FIT	

[1] Global fit to all measured parameters. Correlation coefficients are given in BURKARD 85B. NODE=S004SCP;LINKAGE=F

$\overline{\eta}$ PARAMETER NODE=S004ETB

($V-A$) theory predicts $\overline{\eta}=0$. $\overline{\eta}$ affects spectrum of radiative muon decay. NODE=S004ETB

VALUE	*DOCUMENT ID*		*TECN*	*CHG*	*COMMENT*	NODE=S004ETB
0.02 ±0.08 OUR AVERAGE						
−0.014±0.090	EICHENBER...	84	ELEC	+	ρ free	
+0.09 ±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	OCCUR=2

μ REFERENCES NODE=S004

AFANACIEV 25A EPJ C85 1177 K. Afanaciev *et al.* (MEG II Collab.) REFID=63725
Also EPJ C85 1317 (errat.) K. Afanaciev *et al.* (MEG II Collab.) REFID=63776
AGUILLARD 25 PRL 135 101802 D.P. Aguillard *et al.* (Muon g-2 Collab.) REFID=63636
MOHR 25 RMP 97 025002 P.J. Mohr *et al.* (NIST) REFID=63239
AFANACIEV 24 EPJ C84 216 K. Afanaciev *et al.* (MEG II Collab.) REFID=62885
AGUILLARD 23 PRL 131 161802 D.P. Aguillard *et al.* (Muon g-2 Collab.) REFID=62455
EMA 22 PRL 128 131803 Y. Ema, T. Gao, M. Pospelov (DESY, MINN) REFID=61672
ABI 21 PRL 126 141801 B. Abi *et al.* (Muon g-2 Collab.) REFID=61073
TIESINGA 21 RMP 93 025010 E. Tiesinga *et al.* (NIST) REFID=61422
AOYAMA 20 PRPL 887 1 T. Aoyama *et al.* REFID=60830
BALDINI 20 EPJ C80 858 A.M. Baldini *et al.* (MEG Collab.) REFID=60768
BALDINI 16 EPJ C76 434 A.M. Baldini *et al.* (MEG Collab.) REFID=57381
BALDINI 16A EPJ C76 108 A.M. Baldini *et al.* (MEG Collab.) REFID=57438
MOHR 16 RMP 88 035009 P.J. Mohr, D.B. Newell, B.N. Taylor (NIST) REFID=57148
PRIEELS 14 PR D90 112003 R. Prieels *et al.* (LOUV, ETH, PSI+) REFID=56329
ADAM 13B PRL 110 201801 J. Adam *et al.* (MEG Collab.) REFID=55212
TISHCHENKO 13 PR D87 052003 V. Tishchenko *et al.* (MuLan Collab.) REFID=55129
MOHR 12 RMP 84 1527 P.J. Mohr, B.N. Taylor, D.B. Newell (NIST) REFID=53956
ADAM 11 PRL 107 171801 J. Adam *et al.* (MEG Collab.) REFID=53830
BAYES 11 PRL 106 041804 R. Bayes *et al.* (TWIST Collab.) REFID=53717
Also PR D85 092013 A. Hillairet *et al.* (TWIST Collab.) REFID=54408
BUENO 11 PR D84 032005 J.F. Bueno *et al.* (TWIST Collab.) REFID=53721
Also PR D85 039908 (errat.) J.F. Bueno *et al.* (TWIST Collab.) REFID=54395
WEBBER 11 PRL 106 041803 D.M. Webber *et al.* (MuLan Collab.) REFID=53731
Also PRL 106 079901 (errat.) D.M. Webber *et al.* (MuLan Collab.) REFID=53730
ADAM 10 NP B834 1 J. Adam *et al.* (MEG Collab.) REFID=53277
BENNETT 09 PR D80 052008 G.W. Bennett *et al.* (MUG-2 Collab.) REFID=53036
BARCZYK 08 PL B663 172 A. Barczyk *et al.* (FAST Collab.) REFID=52456
MACDONALD 08 PR D78 032010 R.P. MacDonald *et al.* (TWIST Collab.) REFID=52420
MOHR 08 RMP 80 633 P.J. Mohr, B.N. Taylor, D.B. Newell (NIST) REFID=52197
CHITWOOD 07 PRL 99 032001 D.B. Chitwood *et al.* (MULAN Collab.) REFID=51867
BENNETT 06 PR D73 072003 G.W. Bennett *et al.* (MUG-2 Collab.) REFID=51274
BERTL 06 EPJ C47 337 W. Bertl *et al.* (SINDRUM II Collab.) REFID=51391
JAMIESON 06 PR D74 072007 B. Jamieson *et al.* (TWIST Collab.) REFID=51463
DANNEBERG 05 PRL 94 021802 N. Danneberg *et al.* (ETH, JAGL, PSI+) REFID=50481
GAPONENKO 05 PR D71 071101 A. Gaponenko *et al.* (TWIST Collab.) REFID=50626
MOHR 05 RMP 77 1 P.J. Mohr, B.N. Taylor (NIST) REFID=49695
MUSSER 05 PRL 94 101805 J.R. Musser *et al.* (TWIST Collab.) REFID=50584
AMORUSO 04 EPJ C33 233 S. Amoruso *et al.* (ICARUS Collab.) REFID=50138
BENNETT 04 PRL 92 161802 G.W. Bennett *et al.* (Muon g-2 Collab.) REFID=49937
AHMED 02 PR D65 112002 M. Ahmed *et al.* (MEGA Collab.) REFID=48801
BENNETT 02 PRL 89 101804 G.W. Bennett *et al.* (Muon g-2 Collab.) REFID=48759
BROWN 01 PRL 86 2227 H.N. Brown *et al.* (Muon g-2 Collab.) REFID=48092
BROWN 00 PR D62 091101 H.N. Brown *et al.* (BNL/G-2 Collab.) REFID=47813
MEYER 00 PRL 84 1136 V. Meyer *et al.* REFID=47704
BROOKS 99 PRL 83 1521 M.L. Brooks *et al.* (MEGA/LAMPF Collab.) REFID=47053
HUGHES 99 RMP 71 S133 V.W. Hughes, T. Kinoshita REFID=47545
LIU 99 PRL 82 711 W. Liu *et al.* (LAMPF Collab.) REFID=46727
MOHR 99 JPCRD 28 1713 P.J. Mohr, B.N. Taylor (NIST) REFID=47256
Also RMP 72 351 P.J. Mohr, B.N. Taylor (NIST) REFID=47373
WILLMANN 99 PRL 82 49 L. Willmann *et al.* REFID=46547
FELDMAN 98 PR D57 3873 G.J. Feldman, R.D. Cousins REFID=46776
KAULARD 98 PL B422 334 J. Kaulard *et al.* (SINDRUM-II Collab.) REFID=46032
GORDEEV 97 PAN 60 1164 V.A. Gordeev *et al.* (PNPI) REFID=45429
Translated from YAF 60 1291.
ABELA 96 PRL 77 1950 R. Abela *et al.* (PSI, ZURI, HEIDH, TBIL+) REFID=44812
HONECKER 96 PRL 76 200 W. Honecker *et al.* (SINDRUM II Collab.) REFID=44735
DOHMEN 93 PL B317 631 C. Dohmen *et al.* (PSI SINDRUM-II Collab.) REFID=43592
FREEDMAN 93 PR D47 811 S.J. Freedman *et al.* (LAMPF E645 Collab.) REFID=43372
NI 93 PR D48 1976 B. Ni *et al.* (LAMPF Crystal-Box Collab.) REFID=43480
IMAZATO 92 PRL 69 877 J. Imazato *et al.* (KEK, INUS, TOKY+) REFID=42141
BARANOV 91 SJNP 53 802 V.A. Baranov *et al.* (JINR) REFID=41621
Translated from YAF 53 1302.

KRAKAUER	91B	PL B263 534	D.A. Krakauer *et al.*	(UMD, UCI, LANL)	REFID=41569
MATTHIAS	91	PRL 66 2716	B.E. Matthias *et al.*	(YALE, HEIDP, WILL+)	REFID=41482
Also		PRL 67 932 (errat.)	B.E. Matthias *et al.*	(YALE, HEIDP, WILL+)	REFID=41775
HUBER	90B	PR D41 2709	T.M. Huber *et al.*	(WYOM, VICT, ARIZ+)	REFID=41251
AHMAD	88	PR D38 2102	S. Ahmad *et al.*	(TRIU, VICT, VPI, BRCO+)	REFID=40684
Also		PRL 59 970	S. Ahmad *et al.*	(TRIU, VPI, VICT, BRCO+)	REFID=40306
BALKE	88	PR D37 587	B. Balke *et al.*	(LBL, UCB, COLO, NWES+)	REFID=40665
BELLGARDT	88	NP B299 1	U. Bellgardt *et al.*	(SINDRUM Collab.)	REFID=40468
BOLTON	88	PR D38 2077	R.D. Bolton *et al.*	(LANL, STAN, CHIC+)	REFID=40683
Also		PRL 56 2461	R.D. Bolton *et al.*	(LANL, STAN, CHIC+)	REFID=10258
Also		PRL 57 3241	D. Grosnick *et al.*	(CHIC, LANL, STAN+)	REFID=40308
BELTRAMI	87	PL B194 326	I. Beltrami *et al.*	(ETH, SIN, MAINZ)	REFID=40307
COHEN	87	RMP 59 1121	E.R. Cohen, B.N. Taylor	(RISC, NBS)	REFID=11616
BEER	86	PRL 57 671	G.A. Beer *et al.*	(VICT, TRIU, WYOM)	REFID=40470
JODIDIO	86	PR D34 1967	A. Jodidio *et al.*	(LBL, NWES, TRIU)	REFID=40309
Also		PR D37 237 (errat.)	A. Jodidio *et al.*	(LBL, NWES, TRIU)	REFID=40467
BERTL	85	NP B260 1	W. Bertl *et al.*	(SINDRUM Collab.)	REFID=10248
BRYMAN	85	PRL 55 465	D.A. Bryman *et al.*	(TRIU, CNRC, BRCO+)	REFID=10249
BURKARD	85	PL 150B 242	H. Burkhardt *et al.*	(ETH, SIN, MAINZ)	REFID=10250
BURKARD	85B	PL 160B 343	H. Burkhardt *et al.*	(ETH, SIN, MAINZ)	REFID=10251
Also		PR D24 2004	F. Corriveau *et al.*	(ETH, SIN, MAINZ)	REFID=10252
Also		PL 129B 260	F. Corriveau *et al.*	(ETH, SIN, MAINZ)	REFID=10253
STOKER	85	PRL 54 1887	D.P. Stoker *et al.*	(LBL, NWES, TRIU)	REFID=10256
BARDIN	84	PL 137B 135	G. Bardin *et al.*	(SACL, CERN, BGNA, FIRZ)	REFID=10242
BERTL	84	PL 140B 299	W. Bertl *et al.*	(SINDRUM Collab.)	REFID=10243
BOLTON	84	PRL 53 1415	R.D. Bolton *et al.*	(LANL, CHIC, STAN+)	REFID=10244
EICHENBER...	84	NP A412 523	W. Eichenberger, R. Engfer, A. van der Schaff		REFID=10245;ERROR=1
GIOVANETTI	84	PR D29 343	K.L. Giovanetti *et al.*	(WILL)	REFID=10246
AZUELOS	83	PRL 51 164	G. Azuelos *et al.*	(MONT, TRIU, BRCO)	REFID=10237
Also		PRL 39 1113	P. Depommier *et al.*	(MONT, BRCO, TRIU+)	REFID=10238
BERGSMA	83	PL 122B 465	F. Bergsma *et al.*	(CHARM Collab.)	REFID=10239
CARR	83	PRL 51 627	J. Carr *et al.*	(LBL, NWES, TRIU)	REFID=10240
KINNISON	82	PR D25 2846	W.W. Kinnison *et al.*	(EFI, STAN, LANL)	REFID=10232
Also		PRL 42 556	J.D. Bowman *et al.*	(LASL, EFI, STAN)	REFID=10233
KLEMPT	82	PR D25 652	E. Klempt *et al.*	(MAINZ, ETH)	REFID=10234
MARIAM	82	PRL 49 993	F.G. Mariam *et al.*	(YALE, HEIDH, BERN)	REFID=10235
MARSHALL	82	PR D25 1174	G.M. Marshall *et al.*	(BRCO)	REFID=10236
NEMETHY	81	CNPP 10 147	P. Nemethy, V.W. Hughes	(LBL, YALE)	REFID=10231
ABELA	80	PL 95B 318	R. Abela *et al.*	(BASL, KARLK, KARLE)	REFID=10222
BADERT...	80	LNC 28 401	A. Badertscher *et al.*	(BERN)	REFID=10223
Also		NP A377 406	A. Badertscher *et al.*	(BERN)	REFID=10224
JONKER	80	PL 93B 203	M. Jonker *et al.*	(CHARM Collab.)	REFID=10225
SCHAAF	80	NP A340 249	A. van der Schaaf *et al.*	(ZURI, ETH+)	REFID=10226
Also		PL 72B 183	H.P. Povel *et al.*	(ZURI, ETH, SIN)	REFID=10227
WILLIS	80	PRL 44 522	S.E. Willis *et al.*	(YALE, LBL, LASL+)	REFID=10228
Also		PRL 45 1370	S.E. Willis *et al.*	(YALE, LBL, LASL+)	REFID=10229
BAILEY	79	NP B150 1	J.M. Bailey	(CERN, DARE, MAINZ)	REFID=10217
BADERT...	78	PL 79B 371	A. Badertscher *et al.*	(BERN)	REFID=10215
BAILEY	78	JP G4 345	J.M. Bailey	(DARE, BERN, SHEF, MAINZ, RMCS+)	REFID=10216
Also		NP B150 1	J.M. Bailey	(CERN, DARE, MAINZ)	REFID=10217
BLIETSCHAU	78	NP B133 205	J. Blietschau *et al.*	(Gargamelle Collab.)	REFID=10131
BOWMAN	78	PRL 41 442	J.D. Bowman *et al.*	(LASL, IAS, CMU+)	REFID=10219
CAMANI	78	PL 77B 326	M. Camani *et al.*	(ETH, MAINZ)	REFID=10220
BADERT...	77	PRL 39 1385	A. Badertscher *et al.*	(BERN)	REFID=10208
CASPERSON	77	PRL 38 956	D.E. Casperson *et al.*	(BERN, HEIDH, LASL+)	REFID=10214
DEPOMMIER	77	PRL 39 1113	P. Depommier *et al.*	(MONT, BRCO, TRIU+)	REFID=10238
BALANDIN	74	JETP 40 811	M.P. Balandin *et al.*	(JINR)	REFID=10204
		Translated from ZETF 67 1631.			
COHEN	73	JPCRD 2 664	E.R. Cohen, B.N. Taylor	(RISC, NBS)	REFID=10098
DUCLOS	73	PL 47B 491	J. Duclos, A. Magnon, J. Picard	(SACL)	REFID=10202
EICHTEN	73	PL 46B 281	T. Eichten *et al.*	(Gargamelle Collab.)	REFID=10203
BRYMAN	72	PRL 28 1469	D.A. Bryman *et al.*	(VPI)	REFID=10198
CROWE	72	PR D5 2145	K.M. Crowe *et al.*	(LBL, WASH)	REFID=10199
CRANE	71	PRL 27 474	T. Crane *et al.*	(YALE)	REFID=10192
DERENZO	69	PR 181 1854	S.E. Derenzo	(EFI)	REFID=10184
VOSSLER	69	NC 63A 423	C. Vossler	(EFI)	REFID=10189
AKHMANOV	68	SJNP 6 230	V.V. Akhmanov *et al.*	(KIAE)	REFID=10180
		Translated from YAF 6 316.			
FRYBERGER	68	PR 166 1379	D. Fryberger	(EFI)	REFID=10183
BOGART	67	PR 156 1405	E. Bogart *et al.*	(COLU)	REFID=10177
SCHWARTZ	67	PR 162 1306	D.M. Schwartz	(EFI)	REFID=10178
SHERWOOD	67	PR 156 1475	B.A. Sherwood	(EFI)	REFID=10179
PEOPLES	66	Nevis 147 unpub.	J. Peoples	(COLU)	REFID=10176
BLOOM	64	PL 8 87	S. Bloom *et al.*	(CERN)	REFID=10171
DUCLOS	64	PL 9 62	J. Duclos *et al.*	(CERN)	REFID=10172
GUREVICH	64	PL 11 185	I.I. Gurevich *et al.*	(KIAE)	REFID=10173
BUHLER	63	PL 7 368	A. Buhler-Broglin *et al.*	(CERN)	REFID=10162
MEYER	63	PR 132 2693	S.L. Meyer *et al.*	(COLU)	REFID=10169
CHARPAK	62	PL 1 16	G. Charpak *et al.*	(CERN)	REFID=10155
CONFORTO	62	NC 26 261	G. Conforto *et al.*	(INFN, ROMA, CERN)	REFID=10156
ALI-ZADE	61	JETP 13 313	S.A. Ali-Zade, I.I. Gurevich, B.A. Nikolsky		REFID=10150
		Translated from ZETF 40 452.			
CRITTENDEN	61	PR 121 1823	R.R. Crittenden, W.D. Walker, J. Ballam	(WISC+)	REFID=10151
KRUGER	61	UCRL 9322 unpub.	H. Kruger	(LRL)	REFID=10152
GUREVICH	60	JETP 10 225	I.I. Gurevich, B.A. Nikolsky, L.V. Surkova	(ITEP)	REFID=10148
		Translated from ZETF 37 318.			
PLANO	60	PR 119 1400	R.J. Plano	(COLU)	REFID=10149
ASHKIN	59	NC 14 1266	J. Ashkin *et al.*	(CERN)	REFID=10143
BARDON	59	PRL 2 56	M. Bardon, D. Berley, L.M. Lederman	(COLU)	REFID=10144
LEE	59	PRL 3 55	J. Lee, N.P. Samios	(COLU)	REFID=10146