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p

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

p MASS (atomic mass units u)

The mass is known much more precisely in u (atomic mass units) than in MeV. The conversion from u to MeV, 1 u = 931.494013±0.000037 MeV/c^2 (MOHR 99, the 1998 CODATA value), involves the relatively poorly known electronic charge.

VALUE (u)	*DOCUMENT ID*		*TECN*	*COMMENT*
1.00727646688±0.00000000013	MOHR	99	RVUE	1998 CODATA value
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1.007276470 ±0.000000012	COHEN	87	RVUE	1986 CODATA value

p MASS (MeV)

The mass is known much more precisely in u (atomic mass units) than in MeV; see the previous data block. The conversion from u to MeV, 1 u = 931.494013±0.000037 MeV/c^2 (MOHR 99, the 1998 CODATA value), involves the relatively poorly known electronic charge.

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
938.271998±0.000038	MOHR	99	RVUE	1998 CODATA value
• • • We do not use the following data for averages, fits, limits, etc. • • •				
938.27231 ±0.00028	COHEN	87	RVUE	1986 CODATA value
938.2796 ±0.0027	COHEN	73	RVUE	1973 CODATA value

$|m_p - m_{\overline{p}}|/m_p$

A test of *CPT* invariance. Note that the $\overline{p}/p$ charge-to-mass ratio, given below, is much better determined.

VALUE	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
$<6 \times 10^{-8}$	90	[1] HORI	01	SPEC	$\overline{p}e^-$He atom
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$<5 \times 10^{-7}$		[2] TORII	99	SPEC	$\overline{p}e^-$He atom

[1] HORI 01 uses the more-precisely-known constraint on the $\overline{p}$ charge-to-mass ratio of GABRIELSE 99 (see below) to get this result. This is not independent of the HORI 01 value for $|q_p + q_{\overline{p}}|/e$, below.

[2] TORII 99 uses the more-precisely-known constraint on the $\overline{p}$ charge-to-mass ratio of GABRIELSE 95 (see below) to get this result. This is not independent of the TORII 99 value for $|q_p + q_{\overline{p}}|/e$, below.

$\overline{p}/p$ CHARGE-TO-MASS RATIO, $\left|\frac{q_{\overline{p}}}{m_{\overline{p}}}\right|/(\frac{q_p}{m_p})$

A test of *CPT* invariance. Listed here are measurements involving the *inertial* masses. For a discussion of what may be inferred about the ratio of $\overline{p}$ and p *gravitational* masses, see ERICSON 90; they obtain an upper bound of 10^{-6}–10^{-7} for violation of the equivalence principle for $\overline{p}$'s.

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
0.99999999991±0.00000000009	GABRIELSE	99	TRAP	Penning trap
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1.0000000015 ±0.0000000011	[3] GABRIELSE	95	TRAP	Penning trap
1.000000023 ±0.000000042	[4] GABRIELSE	90	TRAP	Penning trap

[3] Equation (2) of GABRIELSE 95 should read $M(\overline{p})/M(p) = 0.999\,999\,99\underline{8}5\,(11)$ (G. Gabrielse, private communication).

[4] GABRIELSE 90 also measures $m_{\overline{p}}/m_{e^-} = 1836.152660 \pm 0.000083$ and $m_p/m_{e^-} = 1836.152680 \pm 0.000088$. Both are completely consistent with the 1986 CODATA (COHEN 87) value for m_p/m_{e^-} of 1836.152701 ± 0.000037.

$(\left|\frac{q_{\overline{p}}}{m_{\overline{p}}}\right|-\frac{q_p}{m_p})/\frac{q_p}{m_p}$

A test of *CPT* invariance. Taken from the $\overline{p}/p$ charge-to-mass ratio, above.

VALUE	*DOCUMENT ID*
$(-9\pm9)\times10^{-11}$ OUR EVALUATION	

$\left|q_p + q_{\overline{p}}\right|/e$

A test of *CPT* invariance. Note that the $\overline{p}/p$ charge-to-mass ratio, given above, is much better determined. See also a similar test involving the electron.

VALUE	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
$<6\times10^{-8}$	90	[5] HORI	01	SPEC	$\overline{p}e^-$He atom
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$<5\times10^{-7}$		[6] TORII	99	SPEC	$\overline{p}e^-$He atom
$<2\times10^{-5}$		[7] HUGHES	92	RVUE	

[5] HORI 01 uses the more-precisely-known constraint on the $\overline{p}$ charge-to-mass ratio of GABRIELSE 99 (see above) to get this result. This is not independent of the HORI 01 value for $\left|m_p - m_{\overline{p}}\right|/m_p$, above.

[6] TORII 99 uses the more-precisely-known constraint on the $\overline{p}$ charge-to-mass ratio of GABRIELSE 95 (see above) to get this result. This is not independent of the TORII 99 value for $\left|m_p - m_{\overline{p}}\right|/m_p$, above.

[7] HUGHES 92 uses recent measurements of Rydberg-energy and cyclotron-frequency ratios.

$|q_p + q_e|/e$

See DYLLA 73 for a summary of experiments on the neutrality of matter.
See also "*n* CHARGE" in the neutron Listings.

VALUE	*DOCUMENT ID*		*COMMENT*
$<1.0 \times 10^{-21}$	[8] DYLLA	73	Neutrality of SF_6
• • • We do not use the following data for averages, fits, limits, etc. • • •			
$<3.2 \times 10^{-20}$	[9] SENGUPTA	00	binary pulsar
$<0.8 \times 10^{-21}$	MARINELLI	84	Magnetic levitation

[8] Assumes that $q_n = q_p + q_e$.

[9] SENGUPTA 00 uses the difference between the observed rate of of rotational energy loss by the binary pulsar PSR B1913+16 and the rate predicted by general relativity to set this limit. See the paper for assumptions.

p MAGNETIC MOMENT

See the "Note on Baryon Magnetic Moments" in the *Λ* Listings.

VALUE (μ_N)	*DOCUMENT ID*		*TECN*	*COMMENT*
2.792847337±0.000000029	MOHR	99	RVUE	1998 CODATA value
• • • We do not use the following data for averages, fits, limits, etc. • • •				
2.792847386±0.000000063	COHEN	87	RVUE	1986 CODATA value
2.7928456 ±0.0000011	COHEN	73	RVUE	1973 CODATA value

$\overline{p}$ MAGNETIC MOMENT

A few early results have been omitted.

VALUE (μ_N)	*DOCUMENT ID*		*TECN*	*COMMENT*
−2.800 ±0.008 OUR AVERAGE				
−2.8005±0.0090	KREISSL	88	CNTR	$\overline{p}\,{}^{208}$Pb 11→ 10 X-ray
−2.817 ±0.048	ROBERTS	78	CNTR	
−2.791 ±0.021	HU	75	CNTR	Exotic atoms

$(\mu_p + \mu_{\overline{p}}) / \mu_p$

A test of *CPT* invariance. Calculated from the *p* and $\overline{p}$ magnetic moments, above.

VALUE	*DOCUMENT ID*
$(-2.6\pm2.9) \times 10^{-3}$ OUR EVALUATION	

p ELECTRIC DIPOLE MOMENT

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

VALUE (10^{-23} *e*cm)	*EVTS*	*DOCUMENT ID*	*TECN*	*COMMENT*
$-$ 3.7 $\pm$ 6.3		CHO 89	NMR	Tl F molecules
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$<$ 400		DZUBA 85	THEO	Uses ^{129}Xe moment
130 $\pm$ 200		[10] WILKENING 84		
900 $\pm$1400		[11] WILKENING 84		
700 $\pm$ 900	1G	HARRISON 69	MBR	Molecular beam

[10] This WILKENING 84 value includes a finite-size effect and a magnetic effect.

[11] This WILKENING 84 value is more cautious than the other and excludes the finite-size effect, which relies on uncertain nuclear integrals.

p ELECTRIC POLARIZABILITY $\overline{\alpha}_p$

In the 2004 *Review*, we will probably switch to listing measurements of $\overline{\alpha}_p + \overline{\beta}_p$ and $\overline{\alpha}_p - \overline{\beta}_p$ instead of $\overline{\alpha}_p$ and $\overline{\beta}_p$ separately.

VALUE (10^{-4} fm^3)	*DOCUMENT ID*	*TECN*	*COMMENT*
12.0 $\pm$0.7 OUR AVERAGE			
$11.82 \pm 0.98 {}^{+0.52}_{-0.98}$	[12] BLANPIED 01	LEGS	$p(\vec{\gamma},\gamma)$, $p(\vec{\gamma},\pi^0)$, $p(\vec{\gamma},\pi^+)$
11.9 $\pm$0.5 $\pm$1.3	[13] OLMOSDEL... 01	CNTR	γp Compton scattering
12.1 $\pm$0.8 $\pm$0.5	[14] MACGIBBON 95	RVUE	global average
• • • We do not use the following data for averages, fits, limits, etc. • • •			
11.7 $\pm$0.8 $\pm$0.7	[15] BARANOV 01	RVUE	Global average
12.5 $\pm$0.6 $\pm$0.9	MACGIBBON 95	CNTR	γp Compton scattering
9.8 $\pm$0.4 $\pm$1.1	HALLIN 93	CNTR	γp Compton scattering
$10.62 {}^{+1.25}_{-1.19} {}^{+1.07}_{-1.03}$	ZIEGER 92	CNTR	γp Compton scattering
10.9 $\pm$2.2 $\pm$1.3	[16] FEDERSPIEL 91	CNTR	γp Compton scattering

[12] BLANPIED 01 gives $\overline{\alpha}_p + \overline{\beta}_p$ and $\overline{\alpha}_p - \overline{\beta}_p$. The separate $\overline{\alpha}_p$ and $\overline{\beta}_p$ are provided to us by A. Sandorfi. The first error above is statistics plus systematics; the second is from the model.

[13] This OLMOSDELEON 01 result uses the TAPS data alone, and does not use the (re-evaluated) sum-rule constraint that $\overline{\alpha}+\overline{\beta}= (13.8 \pm 0.4) \times 10^{-4}$ fm^3. See the paper for a discussion.

[14] MACGIBBON 95 combine the results of ZIEGER 92, FEDERSPIEL 91, and their own experiment to get a "global average" in which model errors and systematic errors are treated in a consistent way. See MACGIBBON 95 for a discussion.

[15] BARANOV 01 combines the results of 10 experiments from 1958 through 1995 to get a global average that takes into account both systematic and model errors and does not use the theoretical constraint on the sum $\alpha_p + \beta_p$.

[16] FEDERSPIEL 91 obtains for the (static) electric polarizablity α_p, defined in terms of the induced electric dipole moment by $\mathbf{D} = 4\pi\epsilon_0\alpha_p\mathbf{E}$, the value $(7.0 \pm 2.2 \pm 1.3) \times 10^{-4}$ fm^3.

p MAGNETIC POLARIZABILITY $\overline{\beta}_p$

The electric and magnetic polarizabilities are subject to a dispersion sum-rule constraint $\overline{\alpha} + \overline{\beta} = (14.2 \pm 0.5) \times 10^{-4}$ fm^3. Errors here are anticorrelated with those on $\overline{\alpha}_p$ due to this constraint.

In the 2004 *Review*, we will probably switch to listing measurements of $\overline{\alpha}_p + \overline{\beta}_p$ and $\overline{\alpha}_p - \overline{\beta}_p$ instead of $\overline{\alpha}_p$ and $\overline{\beta}_p$ separately.

VALUE (10^{-4} fm^3)	*DOCUMENT ID*		*TECN*	*COMMENT*
1.6 ±0.6 OUR AVERAGE				
$1.43 \pm 0.98^{+0.52}_{-0.98}$	[17] BLANPIED	01	LEGS	$p(\vec{\gamma},\gamma)$, $p(\vec{\gamma},\pi^0)$, $p(\vec{\gamma},\pi^+)$
$1.2 \pm 0.7 \pm 0.5$	[18] OLMOSDEL...	01	CNTR	γp Compton scattering
$2.1 \pm 0.8 \pm 0.5$	[19] MACGIBBON	95	RVUE	global average
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$2.3 \pm 0.9 \pm 0.7$	[20] BARANOV	01	RVUE	Global average
$1.7 \pm 0.6 \pm 0.9$	MACGIBBON	95	CNTR	γp Compton scattering
$4.4 \pm 0.4 \pm 1.1$	HALLIN	93	CNTR	γp Compton scattering
$3.58^{+1.19}_{-1.25}{}^{+1.03}_{-1.07}$	ZIEGER	92	CNTR	γp Compton scattering
$3.3 \pm 2.2 \pm 1.3$	FEDERSPIEL	91	CNTR	γp Compton scattering

[17] BLANPIED 01 gives $\overline{\alpha}_p + \overline{\beta}_p$ and $\overline{\alpha}_p - \overline{\beta}_p$. The separate $\overline{\alpha}_p$ and $\overline{\beta}_p$ are provided to us by A. Sandorfi. The first error above is statistics plus systematics; the second is from the model.

[18] This OLMOSDELEON 01 result uses the TAPS data alone, and does not use the (re-evaluated) sum-rule constraint that $\overline{\alpha}+\overline{\beta}= (13.8 \pm 0.4) \times 10^{-4}$ fm^3. See the paper for a discussion.

[19] MACGIBBON 95 combine the results of ZIEGER 92, FEDERSPIEL 91, and their own experiment to get a "global average" in which model errors and systematic errors are treated in a consistent way. See MACGIBBON 95 for a discussion.

[20] BARANOV 01 combines the results of 10 experiments from 1958 through 1995 to get a global average that takes into account both systematic and model errors and does not use the theoretical constraint on the sum $\alpha_p + \beta_p$.

p CHARGE RADIUS

VALUE (fm)	*DOCUMENT ID*		*COMMENT*
0.870±0.008 OUR AVERAGE			
$0.830 \pm 0.040 \pm 0.040$	[21] ESCHRICH	01	$e p \rightarrow e p$
0.883 ± 0.014	MELNIKOV	00	1S Lamb Shift in H
0.865 ± 0.020	MCCORD	91	$e p \rightarrow e p$
0.862 ± 0.012	SIMON	80	$e p \rightarrow e p$
0.880 ± 0.030	BORKOWSKI	74	$e p \rightarrow e p$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
0.880 ± 0.015	ROSENFELDR...	00	$e p$ + Coul. corrections
0.847 ± 0.008	MERGELL	96	$e p$ + disp. relations
0.877 ± 0.024	WONG	94	reanalysis of Mainz $e p$ data
0.810 ± 0.020	AKIMOV	72	$e p \rightarrow e p$
0.800 ± 0.025	FREREJACQ...	66	$e p \rightarrow e p$ (CH_2 tgt.)
0.805 ± 0.011	HAND	63	$e p \rightarrow e p$

[21] ESCHRICH 01 actually gives $\langle r^2 \rangle = (0.69 \pm 0.06 \pm 0.06)$ fm^2.

p MEAN LIFE

A test of baryon conservation. See the "*p* Partial Mean Lives" section below for limits that depend on decay modes. *p* = proton, *n* = bound neutron.

LIMIT (years)	*PARTICLE*	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
$>1.6 \times 10^{25}$	***p, n***		[22,23] EVANS	77		
• • • We do not use the following data for averages, fits, limits, etc. • • •						
$>4 \times 10^{23}$	*p*	95	TRETYAK	01		$d \to n + ?$
$>1.9 \times 10^{24}$	*p*	90	[24] BERNABEI	00B	DAMA	
$>3 \times 10^{23}$	*p*		[23] DIX	70	CNTR	
$>3 \times 10^{23}$	*p, n*		[23,25] FLEROV	58		

[22] Mean lifetime of nucleons in ^{130}Te nuclei.

[23] Converted to mean life by dividing half-life by ln(2) = 0.693.

[24] BERNABEI 00B looks for the decay of a $^{128}_{53}$I nucleus following the disappearance of a proton in the otherwise-stable $^{129}_{54}$Xe nucleus. The *p* decay is to neutrinos or to "nothing," and thus doesn't conserve charge as well as baryon number.

[25] Mean lifetime of nucleons in ^{232}Th nuclei.

$\overline{p}$ MEAN LIFE

Of the two astrophysical limits here, that of GEER 00D involves considerably more refinements in its modeling. The other limits come from direct observations of stored antiprotons. See also "$\overline{p}$ Partial Mean Lives" after "*p* Partial Mean Lives," below, for exclusive-mode limits. The best (lifetime/branching fraction) limit there is 7×10^5 years, for $\overline{p} \to e^- \gamma$. We advance only the exclusive-mode limits to our Summary Tables.

LIMIT (years)	*CL%*	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •						
$>8 \times 10^5$	90		[26] GEER	00D		$\overline{p}/p$ ratio, cosmic rays
>0.28			GABRIELSE	90	TRAP	Penning trap
>0.08	90	1	BELL	79	CNTR	Storage ring
$>1 \times 10^7$			GOLDEN	79	SPEC	$\overline{p}/p$ ratio, cosmic rays
$>3.7 \times 10^{-3}$			BREGMAN	78	CNTR	Storage ring

[26] GEER 00D uses agreement between a model of galactic $\overline{p}$ production and propagation and the observed $\overline{p}/p$ cosmic-ray spectrum to set this limit.

p DECAY MODES

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

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

	Mode	Partial mean life (10^{30} years)	Confidence level
	Antilepton + meson		
τ_1	$N \to e^+\pi$	> 158 (n), > 1600 (p)	90%
τ_2	$N \to \mu^+\pi$	> 100 (n), > 473 (p)	90%
τ_3	$N \to \nu\pi$	> 112 (n), > 25 (p)	90%
τ_4	$p \to e^+\eta$	> 313	90%
τ_5	$p \to \mu^+\eta$	> 126	90%
τ_6	$n \to \nu\eta$	> 158	90%
τ_7	$N \to e^+\rho$	> 217 (n), > 75 (p)	90%
τ_8	$N \to \mu^+\rho$	> 228 (n), > 110 (p)	90%
τ_9	$N \to \nu\rho$	> 19 (n), > 162 (p)	90%
τ_{10}	$p \to e^+\omega$	> 107	90%
τ_{11}	$p \to \mu^+\omega$	> 117	90%
τ_{12}	$n \to \nu\omega$	> 108	90%
τ_{13}	$N \to e^+K$	> 17 (n), > 150 (p)	90%
τ_{14}	$p \to e^+K^0_S$	> 120	90%
τ_{15}	$p \to e^+K^0_L$	> 51	90%
τ_{16}	$N \to \mu^+K$	> 26 (n), > 120 (p)	90%
τ_{17}	$p \to \mu^+K^0_S$	> 150	90%
τ_{18}	$p \to \mu^+K^0_L$	> 83	90%
τ_{19}	$N \to \nu K$	> 86 (n), > 670 (p)	90%
τ_{20}	$n \to \nu K^0_S$	> 51	90%
τ_{21}	$p \to e^+K^*(892)^0$	> 84	90%
τ_{22}	$N \to \nu K^*(892)$	> 78 (n), > 51 (p)	90%
	Antilepton + mesons		
τ_{23}	$p \to e^+\pi^+\pi^-$	> 82	90%
τ_{24}	$p \to e^+\pi^0\pi^0$	> 147	90%
τ_{25}	$n \to e^+\pi^-\pi^0$	> 52	90%
τ_{26}	$p \to \mu^+\pi^+\pi^-$	> 133	90%
τ_{27}	$p \to \mu^+\pi^0\pi^0$	> 101	90%
τ_{28}	$n \to \mu^+\pi^-\pi^0$	> 74	90%
τ_{29}	$n \to e^+K^0\pi^-$	> 18	90%

Lepton + meson

τ_{30}	$n \to e^- \pi^+$	> 65	90%
τ_{31}	$n \to \mu^- \pi^+$	> 49	90%
τ_{32}	$n \to e^- \rho^+$	> 62	90%
τ_{33}	$n \to \mu^- \rho^+$	> 7	90%
τ_{34}	$n \to e^- K^+$	> 32	90%
τ_{35}	$n \to \mu^- K^+$	> 57	90%

Lepton + mesons

τ_{36}	$p \to e^- \pi^+ \pi^+$	> 30	90%
τ_{37}	$n \to e^- \pi^+ \pi^0$	> 29	90%
τ_{38}	$p \to \mu^- \pi^+ \pi^+$	> 17	90%
τ_{39}	$n \to \mu^- \pi^+ \pi^0$	> 34	90%
τ_{40}	$p \to e^- \pi^+ K^+$	> 75	90%
τ_{41}	$p \to \mu^- \pi^+ K^+$	> 245	90%

Antilepton + photon(s)

τ_{42}	$p \to e^+ \gamma$	> 670	90%
τ_{43}	$p \to \mu^+ \gamma$	> 478	90%
τ_{44}	$n \to \nu \gamma$	> 28	90%
τ_{45}	$p \to e^+ \gamma \gamma$	> 100	90%
τ_{46}	$n \to \nu \gamma \gamma$	> 219	90%

Three (or more) leptons

τ_{47}	$p \to e^+ e^+ e^-$	> 793	90%
τ_{48}	$p \to e^+ \mu^+ \mu^-$	> 359	90%
τ_{49}	$p \to e^+ \nu \nu$	> 17	90%
τ_{50}	$n \to e^+ e^- \nu$	> 257	90%
τ_{51}	$n \to \mu^+ e^- \nu$	> 83	90%
τ_{52}	$n \to \mu^+ \mu^- \nu$	> 79	90%
τ_{53}	$p \to \mu^+ e^+ e^-$	> 529	90%
τ_{54}	$p \to \mu^+ \mu^+ \mu^-$	> 675	90%
τ_{55}	$p \to \mu^+ \nu \nu$	> 21	90%
τ_{56}	$p \to e^- \mu^+ \mu^+$	> 6	90%
τ_{57}	$n \to 3\nu$	> 0.0005	90%
τ_{58}	$n \to 5\nu$	—	

Inclusive modes

τ_{59}	$N \to e^+$ anything	> 0.6 (n, p)	90%
τ_{60}	$N \to \mu^+$ anything	> 12 (n, p)	90%
τ_{61}	$N \to \nu$ anything	—	
τ_{62}	$N \to e^+ \pi^0$ anything	> 0.6 (n, p)	90%
τ_{63}	$N \to$ 2 bodies, ν-free	—	

$\Delta B = 2$ dinucleon modes

The following are lifetime limits per iron nucleus.

τ_{64}	$p p \to \pi^+ \pi^+$	> 0.7	90%
τ_{65}	$p n \to \pi^+ \pi^0$	> 2	90%
τ_{66}	$n n \to \pi^+ \pi^-$	> 0.7	90%
τ_{67}	$n n \to \pi^0 \pi^0$	> 3.4	90%
τ_{68}	$p p \to e^+ e^+$	> 5.8	90%
τ_{69}	$p p \to e^+ \mu^+$	> 3.6	90%
τ_{70}	$p p \to \mu^+ \mu^+$	> 1.7	90%
τ_{71}	$p n \to e^+ \overline{\nu}$	> 2.8	90%
τ_{72}	$p n \to \mu^+ \overline{\nu}$	> 1.6	90%
τ_{73}	$n n \to \nu_e \overline{\nu}_e$	> 0.000012	90%
τ_{74}	$n n \to \nu_\mu \overline{\nu}_\mu$	> 0.000006	90%
τ_{75}	$p p \to$ neutrinos	> 0.00000055	90%

$\overline{p}$ DECAY MODES

	Mode	Partial mean life (years)	Confidence level
τ_{76}	$\overline{p} \to e^- \gamma$	$> 7 \times 10^5$	90%
τ_{77}	$\overline{p} \to \mu^- \gamma$	$> 5 \times 10^4$	90%
τ_{78}	$\overline{p} \to e^- \pi^0$	$> 4 \times 10^5$	90%
τ_{79}	$\overline{p} \to \mu^- \pi^0$	$> 5 \times 10^4$	90%
τ_{80}	$\overline{p} \to e^- \eta$	$> 2 \times 10^4$	90%
τ_{81}	$\overline{p} \to \mu^- \eta$	$> 8 \times 10^3$	90%
τ_{82}	$\overline{p} \to e^- K^0_S$	> 900	90%
τ_{83}	$\overline{p} \to \mu^- K^0_S$	$> 4 \times 10^3$	90%
τ_{84}	$\overline{p} \to e^- K^0_L$	$> 9 \times 10^3$	90%
τ_{85}	$\overline{p} \to \mu^- K^0_L$	$> 7 \times 10^3$	90%
τ_{86}	$\overline{p} \to e^- \gamma\gamma$	$> 2 \times 10^4$	90%
τ_{87}	$\overline{p} \to \mu^- \gamma\gamma$	$> 2 \times 10^4$	90%
τ_{88}	$\overline{p} \to e^- \rho$	—	
τ_{89}	$\overline{p} \to e^- \omega$	> 200	90%
τ_{90}	$\overline{p} \to e^- K^*(892)^0$	—	

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p PARTIAL MEAN LIVES

The "partial mean life" limits tabulated here are the limits on τ/B_i, where τ is the total mean life for the proton and B_i is the branching fraction for the mode in question.

Decaying particle: p = proton, n = bound neutron. The same event may appear under more than one partial decay mode. Background estimates may be accurate to a factor of two.

Antilepton + meson

$\tau(N \to e^+\pi)$ τ_1

LIMIT (10^{30} years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID		TECN
>1600	[$>158 \times 10^{30}$ years OUR 2002 BEST LIMIT]						
> 158	***n***	**90**	**3**	**5**	MCGREW	99	IMB3
>1600	***p***	**90**	**0**	**0.1**	SHIOZAWA	98	SKAM

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

LIMIT (10^{30} years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID		TECN
> 540	*p*	90	0	0.2	MCGREW	99	IMB3
> 70	*p*	90	0	0.5	BERGER	91	FREJ
> 70	*n*	90	0	≤ 0.1	BERGER	91	FREJ
> 550	*p*	90	0	0.7	[27] BECKER-SZ...	90	IMB3
> 260	*p*	90	0	<0.04	HIRATA	89C	KAMI
> 130	*n*	90	0	<0.2	HIRATA	89C	KAMI
> 310	*p*	90	0	0.6	SEIDEL	88	IMB
> 100	*n*	90	0	1.6	SEIDEL	88	IMB
> 1.3	*n*	90	0		BARTELT	87	SOUD
> 1.3	*p*	90	0		BARTELT	87	SOUD
> 250	*p*	90	0	0.3	HAINES	86	IMB
> 31	*n*	90	8	9	HAINES	86	IMB
> 64	*p*	90	0	<0.4	ARISAKA	85	KAMI
> 26	*n*	90	0	<0.7	ARISAKA	85	KAMI
> 82	*p* (free)	90	0	0.2	BLEWITT	85	IMB
> 250	*p*	90	0	0.2	BLEWITT	85	IMB
> 25	*n*	90	4	4	PARK	85	IMB
> 15	*p*, *n*	90	0		BATTISTONI	84	NUSX
> 0.5	*p*	90	1	0.3	[28] BARTELT	83	SOUD
> 0.5	*n*	90	1	0.3	[28] BARTELT	83	SOUD
> 5.8	*p*	90	2		[29] KRISHNA...	82	KOLR
> 5.8	*n*	90	2		[29] KRISHNA...	82	KOLR
> 0.1	*n*	90			[30] GURR	67	CNTR

[27] This BECKER-SZENDY 90 result includes data from SEIDEL 88.
[28] Limit based on zero events.
[29] We have calculated 90% CL limit from 1 confined event.
[30] We have converted half-life to 90% CL mean life.

$\tau(N \to \mu^+ \pi)$ τ_2

LIMIT (10^{30} years)	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*		*TECN*
>100	[>473 × 10^{30} years OUR 2002 BEST LIMIT]						
>473	***p***	**90**	**0**	**0.6**	MCGREW	99	IMB3
>100	***n***	**90**	**0**	**<0.2**	HIRATA	89C	KAMI
• • • We do not use the following data for averages, fits, limits, etc. • • •							
> 90	*n*	90	1	1.9	MCGREW	99	IMB3
> 81	*p*	90	0	0.2	BERGER	91	FREJ
> 35	*n*	90	1	1.0	BERGER	91	FREJ
>230	*p*	90	0	<0.07	HIRATA	89C	KAMI
>270	*p*	90	0	0.5	SEIDEL	88	IMB
> 63	*n*	90	0	0.5	SEIDEL	88	IMB
> 76	*p*	90	2	1	HAINES	86	IMB
> 23	*n*	90	8	7	HAINES	86	IMB
> 46	*p*	90	0	<0.7	ARISAKA	85	KAMI
> 20	*n*	90	0	<0.4	ARISAKA	85	KAMI
> 59	*p* (free)	90	0	0.2	BLEWITT	85	IMB
>100	*p*	90	1	0.4	BLEWITT	85	IMB
> 38	*n*	90	1	4	PARK	85	IMB
> 10	*p*, *n*	90	0		BATTISTONI	84	NUSX
> 1.3	*p*, *n*	90	0		ALEKSEEV	81	BAKS

$\tau(N \to \nu \pi)$ τ_3

LIMIT (10^{30} years)	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*		*TECN*
> 25	[>112 × 10^{30} years OUR 2002 BEST LIMIT]						
>112	***n***	**90**	**6**	**6.6**	MCGREW	99	IMB3
> 25	***p***	**90**	**32**	**32.8**	HIRATA	89C	KAMI
• • • We do not use the following data for averages, fits, limits, etc. • • •							
> 16	*p*	90	6	6.7	WALL	00B	SOU2
> 39	*n*	90	4	3.8	WALL	00B	SOU2
> 10	*p*	90	15	20.3	MCGREW	99	IMB3
> 13	*n*	90	1	1.2	BERGER	89	FREJ
> 10	*p*	90	11	14	BERGER	89	FREJ
>100	*n*	90	1	3	HIRATA	89C	KAMI
> 6	*n*	90	73	60	HAINES	86	IMB
> 2	*p*	90	16	13	KAJITA	86	KAMI
> 40	*n*	90	0	1	KAJITA	86	KAMI
> 7	*n*	90	28	19	PARK	85	IMB
> 7	*n*	90	0		BATTISTONI	84	NUSX
> 2	*p*	90	≤ 3		BATTISTONI	84	NUSX
> 5.8	*p*	90	1		[31] KRISHNA...	82	KOLR
> 0.3	*p*	90	2		[32] CHERRY	81	HOME
> 0.1	*p*	90			[33] GURR	67	CNTR

[31] We have calculated 90% CL limit from 1 confined event.

[32] We have converted 2 possible events to 90% CL limit.

[33] We have converted half-life to 90% CL mean life.

$\tau(p \to e^+\eta)$ τ_4

LIMIT (10^{30} years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID		TECN
>313	***p***	**90**	**0**	**0.2**	MCGREW	99	IMB3
• • • We do not use the following data for averages, fits, limits, etc. • • •							
> 81	*p*	90	1	1.7	WALL	00B	SOU2
> 44	*p*	90	0	0.1	BERGER	91	FREJ
>140	*p*	90	0	<0.04	HIRATA	89C	KAMI
>100	*p*	90	0	0.6	SEIDEL	88	IMB
>200	*p*	90	5	3.3	HAINES	86	IMB
> 64	*p*	90	0	<0.8	ARISAKA	85	KAMI
> 64	*p* (free)	90	5	6.5	BLEWITT	85	IMB
>200	*p*	90	5	4.7	BLEWITT	85	IMB
> 1.2	*p*	90	2		[34] CHERRY	81	HOME

[34] We have converted 2 possible events to 90% CL limit.

$\tau(p \to \mu^+\eta)$ τ_5

LIMIT (10^{30} years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID		TECN
>126	***p***	**90**	**3**	**2.8**	MCGREW	99	IMB3
• • • We do not use the following data for averages, fits, limits, etc. • • •							
> 89	*p*	90	0	1.6	WALL	00B	SOU2
> 26	*p*	90	1	0.8	BERGER	91	FREJ
> 69	*p*	90	1	<0.08	HIRATA	89C	KAMI
> 1.3	*p*	90	0	0.7	PHILLIPS	89	HPW
> 34	*p*	90	1	1.5	SEIDEL	88	IMB
> 46	*p*	90	7	6	HAINES	86	IMB
> 26	*p*	90	1	<0.8	ARISAKA	85	KAMI
> 17	*p* (free)	90	6	6	BLEWITT	85	IMB
> 46	*p*	90	7	8	BLEWITT	85	IMB

$\tau(n \to \nu\eta)$ τ_6

LIMIT (10^{30} years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID		TECN
>158	***n***	**90**	**0**	**1.2**	MCGREW	99	IMB3
• • • We do not use the following data for averages, fits, limits, etc. • • •							
> 71	*n*	90	2	3.7	WALL	00B	SOU2
> 29	*n*	90	0	0.9	BERGER	89	FREJ
> 54	*n*	90	2	0.9	HIRATA	89C	KAMI
> 16	*n*	90	3	2.1	SEIDEL	88	IMB
> 25	*n*	90	7	6	HAINES	86	IMB
> 30	*n*	90	0	0.4	KAJITA	86	KAMI
> 18	*n*	90	4	3	PARK	85	IMB
> 0.6	*n*	90	2		[35] CHERRY	81	HOME

[35] We have converted 2 possible events to 90% CL limit.

$\tau(N \rightarrow e^+ \rho)$ τ_7

LIMIT *(10^{30} years)*	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*		*TECN*
> 75	[$>217 \times 10^{30}$ years OUR 2002 BEST LIMIT]						
>217	***n***	**90**	**4**	**4.8**	MCGREW	99	IMB3
> 75	***p***	**90**	**2**	**2.7**	HIRATA	89C	KAMI
• • • We do not use the following data for averages, fits, limits, etc. • • •							
> 29	*p*	90	0	2.2	BERGER	91	FREJ
> 41	*n*	90	0	1.4	BERGER	91	FREJ
> 58	*n*	90	0	1.9	HIRATA	89C	KAMI
> 38	*n*	90	2	4.1	SEIDEL	88	IMB
> 1.2	*p*	90	0		BARTELT	87	SOUD
> 1.5	*n*	90	0		BARTELT	87	SOUD
> 17	*p*	90	7	7	HAINES	86	IMB
> 14	*n*	90	9	4	HAINES	86	IMB
> 12	*p*	90	0	<1.2	ARISAKA	85	KAMI
> 6	*n*	90	2	<1	ARISAKA	85	KAMI
> 6.7	*p* (free)	90	6	6	BLEWITT	85	IMB
> 17	*p*	90	7	7	BLEWITT	85	IMB
> 12	*n*	90	4	2	PARK	85	IMB
> 0.6	*n*	90	1	0.3	[36] BARTELT	83	SOUD
> 0.5	*p*	90	1	0.3	[36] BARTELT	83	SOUD
> 9.8	*p*	90	1		[37] KRISHNA...	82	KOLR
> 0.8	*p*	90	2		[38] CHERRY	81	HOME

[36] Limit based on zero events.

[37] We have calculated 90% CL limit from 0 confined events.

[38] We have converted 2 possible events to 90% CL limit.

$\tau(N \rightarrow \mu^+ \rho)$ τ_8

LIMIT *(10^{30} years)*	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*		*TECN*
>110	[$>228 \times 10^{30}$ years OUR 2002 BEST LIMIT]						
>228	***n***	**90**	**3**	**9.5**	MCGREW	99	IMB3
>110	***p***	**90**	**0**	**1.7**	HIRATA	89C	KAMI
• • • We do not use the following data for averages, fits, limits, etc. • • •							
> 12	*p*	90	0	0.5	BERGER	91	FREJ
> 22	*n*	90	0	1.1	BERGER	91	FREJ
> 23	*n*	90	1	1.8	HIRATA	89C	KAMI
> 4.3	*p*	90	0	0.7	PHILLIPS	89	HPW
> 30	*p*	90	0	0.5	SEIDEL	88	IMB
> 11	*n*	90	1	1.1	SEIDEL	88	IMB
> 16	*p*	90	4	4.5	HAINES	86	IMB
> 7	*n*	90	6	5	HAINES	86	IMB
> 12	*p*	90	0	<0.7	ARISAKA	85	KAMI
> 5	*n*	90	1	<1.2	ARISAKA	85	KAMI
> 5.5	*p* (free)	90	4	5	BLEWITT	85	IMB
> 16	*p*	90	4	5	BLEWITT	85	IMB
> 9	*n*	90	1	2	PARK	85	IMB

$\tau(N \to \nu\rho)$ τ_9

LIMIT *(10^{30} years)*	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*		*TECN*
> 19	[$>162 \times 10^{30}$ years OUR 2002 BEST LIMIT]						
>162	***p***	**90**	**18**	**21.7**	MCGREW	99	IMB3
> 19	***n***	**90**	**0**	**0.5**	SEIDEL	88	IMB
• • • We do not use the following data for averages, fits, limits, etc. • • •							
> 9	*n*	90	4	2.4	BERGER	89	FREJ
> 24	*p*	90	0	0.9	BERGER	89	FREJ
> 27	*p*	90	5	1.5	HIRATA	89C	KAMI
> 13	*n*	90	4	3.6	HIRATA	89C	KAMI
> 13	*p*	90	1	1.1	SEIDEL	88	IMB
> 8	*p*	90	6	5	HAINES	86	IMB
> 2	*n*	90	15	10	HAINES	86	IMB
> 11	*p*	90	2	1	KAJITA	86	KAMI
> 4	*n*	90	2	2	KAJITA	86	KAMI
> 4.1	*p* (free)	90	6	7	BLEWITT	85	IMB
> 8.4	*p*	90	6	5	BLEWITT	85	IMB
> 2	*n*	90	7	3	PARK	85	IMB
> 0.9	*p*	90	2		[39] CHERRY	81	HOME
> 0.6	*n*	90	2		[39] CHERRY	81	HOME

[39] We have converted 2 possible events to 90% CL limit.

$\tau(p \to e^+\omega)$ τ_{10}

LIMIT *(10^{30} years)*	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*		*TECN*
>107	***p***	**90**	**7**	**10.8**	MCGREW	99	IMB3
• • • We do not use the following data for averages, fits, limits, etc. • • •							
> 17	*p*	90	0	1.1	BERGER	91	FREJ
> 45	*p*	90	2	1.45	HIRATA	89C	KAMI
> 26	*p*	90	1	1.0	SEIDEL	88	IMB
> 1.5	*p*	90	0		BARTELT	87	SOUD
> 37	*p*	90	6	5.3	HAINES	86	IMB
> 25	*p*	90	1	<1.4	ARISAKA	85	KAMI
> 12	*p* (free)	90	6	7.5	BLEWITT	85	IMB
> 37	*p*	90	6	5.7	BLEWITT	85	IMB
> 0.6	*p*	90	1	0.3	[40] BARTELT	83	SOUD
> 9.8	*p*	90	1		[41] KRISHNA...	82	KOLR
> 2.8	*p*	90	2		[42] CHERRY	81	HOME

[40] Limit based on zero events.
[41] We have calculated 90% CL limit from 0 confined events.
[42] We have converted 2 possible events to 90% CL limit.

$\tau(p \to \mu^+\omega)$ τ_{11}

LIMIT *(10^{30} years)*	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*		*TECN*
>117	***p***	**90**	**11**	**12.1**	MCGREW	99	IMB3

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

> 11	p	90	0	1.0	BERGER	91	FREJ
> 57	p	90	2	1.9	HIRATA	89C	KAMI
> 4.4	p	90	0	0.7	PHILLIPS	89	HPW
> 10	p	90	2	1.3	SEIDEL	88	IMB
> 23	p	90	2	1	HAINES	86	IMB
> 6.5	p (free)	90	9	8.7	BLEWITT	85	IMB
> 23	p	90	8	7	BLEWITT	85	IMB

$\tau(n \to \nu\omega)$ τ_{12}

LIMIT (10^{30} years)	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*		*TECN*
>108	**n**	**90**	**12**	**22.5**	MCGREW	99	IMB3
• • • We do not use the following data for averages, fits, limits, etc. • • •							
> 17	n	90	1	0.7	BERGER	89	FREJ
> 43	n	90	3	2.7	HIRATA	89C	KAMI
> 6	n	90	2	1.3	SEIDEL	88	IMB
> 12	n	90	6	6	HAINES	86	IMB
> 18	n	90	2	2	KAJITA	86	KAMI
> 16	n	90	1	2	PARK	85	IMB
> 2.0	n	90	2		[43] CHERRY	81	HOME

[43] We have converted 2 possible events to 90% CL limit.

$\tau(N \to e^+ K)$ τ_{13}

LIMIT (10^{30} years)	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*		*TECN*
>150	[>17 × 10^{30} years OUR 2002 BEST LIMIT]						
> 17	**n**	**90**	**35**	**29.4**	MCGREW	99	IMB3
>150	**p**	**90**	**0**	**<0.27**	HIRATA	89C	KAMI
• • • We do not use the following data for averages, fits, limits, etc. • • •							
> 85	p	90	3	4.9	WALL	00	SOU2
> 31	p	90	23	25.2	MCGREW	99	IMB3
> 60	p	90	0		BERGER	91	FREJ
> 70	p	90	0	1.8	SEIDEL	88	IMB
> 77	p	90	5	4.5	HAINES	86	IMB
> 38	p	90	0	<0.8	ARISAKA	85	KAMI
> 24	p (free)	90	7	8.5	BLEWITT	85	IMB
> 77	p	90	5	4	BLEWITT	85	IMB
> 1.3	p	90	0		ALEKSEEV	81	BAKS
> 1.3	n	90	0		ALEKSEEV	81	BAKS

$\tau(p \to e^+ K^0_S)$ τ_{14}

LIMIT (10^{30} years)	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*		*TECN*
>120	**p**	**90**	**1**	**1.3**	WALL	00	SOU2
• • • We do not use the following data for averages, fits, limits, etc. • • •							
> 76	p	90	0	0.5	BERGER	91	FREJ

$\tau(p \to e^+ K^0_L)$ τ_{15}

LIMIT (10^{30} years)	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*		*TECN*
>51	***p***	**90**	**2**	**3.5**	WALL	00	SOU2
• • • We do not use the following data for averages, fits, limits, etc. • • •							
>44	*p*	90	0	≤ 0.1	BERGER	91	FREJ

$\tau(N \to \mu^+ K)$ τ_{16}

LIMIT (10^{30} years)	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*		*TECN*
>120	***p***	**90**	**0**	**<1.2**	WALL	00	SOU2
>120	***p***	**90**	**4**	**7.2**	MCGREW	99	IMB3
> 26	***n***	**90**	**20**	**28.4**	MCGREW	99	IMB3
>120	***p***	**90**	**1**	**0.4**	HIRATA	89C	KAMI
• • • We do not use the following data for averages, fits, limits, etc. • • •							
> 54	*p*	90	0		BERGER	91	FREJ
> 3.0	*p*	90	0	0.7	PHILLIPS	89	HPW
> 19	*p*	90	3	2.5	SEIDEL	88	IMB
> 1.5	*p*	90	0		[44] BARTELT	87	SOUD
> 1.1	*n*	90	0		BARTELT	87	SOUD
> 40	*p*	90	7	6	HAINES	86	IMB
> 19	*p*	90	1	<1.1	ARISAKA	85	KAMI
> 6.7	*p* (free)	90	11	13	BLEWITT	85	IMB
> 40	*p*	90	7	8	BLEWITT	85	IMB
> 6	*p*	90	1		BATTISTONI	84	NUSX
> 0.6	*p*	90	0		[45] BARTELT	83	SOUD
> 0.4	*n*	90	0		[45] BARTELT	83	SOUD
> 5.8	*p*	90	2		[46] KRISHNA...	82	KOLR
> 2.0	*p*	90	0		CHERRY	81	HOME
> 0.2	*n*	90			[47] GURR	67	CNTR

[44] BARTELT 87 limit applies to $p \to \mu^+ K^0_S$.

[45] Limit based on zero events.

[46] We have calculated 90% CL limit from 1 confined event.

[47] We have converted half-life to 90% CL mean life.

$\tau(p \to \mu^+ K^0_S)$ τ_{17}

LIMIT (10^{30} years)	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*		*TECN*
>150	***p***	**90**	**0**	**<0.8**	WALL	00	SOU2
• • • We do not use the following data for averages, fits, limits, etc. • • •							
> 64	*p*	90	0	1.2	BERGER	91	FREJ

$\tau(p \to \mu^+ K^0_L)$ τ_{18}

LIMIT (10^{30} years)	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*		*TECN*
>83	***p***	**90**	**0**	**0.4**	WALL	00	SOU2
• • • We do not use the following data for averages, fits, limits, etc. • • •							
>44	*p*	90	0	≤ 0.1	BERGER	91	FREJ

$\tau(N \to \nu K)$ τ_{19}

LIMIT *(10^{30} years)*	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*		*TECN*
> 86	[>670 × 10^{30} years OUR 2002 BEST LIMIT]						
>670	***p***	**90**			HAYATO	99	SKAM
> 86	***n***	**90**	**0**	**2.4**	HIRATA	89C	KAMI

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

> 26	*n*	90	16	9.1	WALL	00	SOU2
>151	*p*	90	15	21.4	MCGREW	99	IMB3
> 30	*n*	90	34	34.1	MCGREW	99	IMB3
> 43	*p*	90	1	1.54	[48] ALLISON	98	SOU2
> 15	*n*	90	1	1.8	BERGER	89	FREJ
> 15	*p*	90	1	1.8	BERGER	89	FREJ
>100	*p*	90	9	7.3	HIRATA	89C	KAMI
> 0.28	*p*	90	0	0.7	PHILLIPS	89	HPW
> 0.3	*p*	90	0		BARTELT	87	SOUD
> 0.75	*n*	90	0		[49] BARTELT	87	SOUD
> 10	*p*	90	6	5	HAINES	86	IMB
> 15	*n*	90	3	5	HAINES	86	IMB
> 28	*p*	90	3	3	KAJITA	86	KAMI
> 32	*n*	90	0	1.4	KAJITA	86	KAMI
> 1.8	*p* (free)	90	6	11	BLEWITT	85	IMB
> 9.6	*p*	90	6	5	BLEWITT	85	IMB
> 10	*n*	90	2	2	PARK	85	IMB
> 5	*n*	90	0		BATTISTONI	84	NUSX
> 2	*p*	90	0		BATTISTONI	84	NUSX
> 0.3	*n*	90	0		[50] BARTELT	83	SOUD
> 0.1	*p*	90	0		[50] BARTELT	83	SOUD
> 5.8	*p*	90	1		[51] KRISHNA...	82	KOLR
> 0.3	*n*	90	2		[52] CHERRY	81	HOME

[48] This ALLISON 98 limit is with no background subtraction; with subtraction the limit becomes > 46 × 10^{30} years.

[49] BARTELT 87 limit applies to $n \to \nu K^0_S$.

[50] Limit based on zero events.

[51] We have calculated 90% CL limit from 1 confined event.

[52] We have converted 2 possible events to 90% CL limit.

$\tau(n \to \nu K^0_S)$ τ_{20}

LIMIT *(10^{30} years)*	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*		*TECN*
>51	***n***	**90**	**16**	**9.1**	WALL	00	SOU2

$\tau(p \to e^+ K^*(892)^0)$ τ_{21}

LIMIT *(10^{30} years)*	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*		*TECN*
>84	***p***	**90**	**38**	**52.0**	MCGREW	99	IMB3

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

>10	*p*	90	0	0.8	BERGER	91	FREJ
>52	*p*	90	2	1.55	HIRATA	89C	KAMI
>10	*p*	90	1	<1	ARISAKA	85	KAMI

$\tau(N \rightarrow \nu K^*(892))$ τ_{22}

LIMIT (10^{30} years)	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*		*TECN*
>51	**p**	**90**	**7**	**9.1**	MCGREW	99	IMB3
>78	**n**	**90**	**40**	**50**	MCGREW	99	IMB3
• • • We do not use the following data for averages, fits, limits, etc. • • •							
>22	*n*	90	0	2.1	BERGER	89	FREJ
>17	*p*	90	0	2.4	BERGER	89	FREJ
>20	*p*	90	5	2.1	HIRATA	89C	KAMI
>21	*n*	90	4	2.4	HIRATA	89C	KAMI
>10	*p*	90	7	6	HAINES	86	IMB
> 5	*n*	90	8	7	HAINES	86	IMB
> 8	*p*	90	3	2	KAJITA	86	KAMI
> 6	*n*	90	2	1.6	KAJITA	86	KAMI
> 5.8	*p* (free)	90	10	16	BLEWITT	85	IMB
> 9.6	*p*	90	7	6	BLEWITT	85	IMB
> 7	*n*	90	1	4	PARK	85	IMB
> 2.1	*p*	90	1		[53] BATTISTONI	82	NUSX

[53] We have converted 1 possible event to 90% CL limit.

Antilepton + mesons

$\tau(p \rightarrow e^+ \pi^+ \pi^-)$ τ_{23}

LIMIT (10^{30} years)	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*		*TECN*
>82	**p**	**90**	**16**	**23.1**	MCGREW	99	IMB3
• • • We do not use the following data for averages, fits, limits, etc. • • •							
>21	*p*	90	0	2.2	BERGER	91	FREJ

$\tau(p \rightarrow e^+ \pi^0 \pi^0)$ τ_{24}

LIMIT (10^{30} years)	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*		*TECN*
>147	**p**	**90**	**2**	**0.8**	MCGREW	99	IMB3
• • • We do not use the following data for averages, fits, limits, etc. • • •							
> 38	*p*	90	1	0.5	BERGER	91	FREJ

$\tau(n \rightarrow e^+ \pi^- \pi^0)$ τ_{25}

LIMIT (10^{30} years)	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*		*TECN*
>52	**n**	**90**	**38**	**34.2**	MCGREW	99	IMB3
• • • We do not use the following data for averages, fits, limits, etc. • • •							
>32	*n*	90	1	0.8	BERGER	91	FREJ

$\tau(p \rightarrow \mu^+ \pi^+ \pi^-)$ τ_{26}

LIMIT (10^{30} years)	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*		*TECN*
>133	**p**	**90**	**25**	**38.0**	MCGREW	99	IMB3
• • • We do not use the following data for averages, fits, limits, etc. • • •							
> 17	*p*	90	1	2.6	BERGER	91	FREJ
> 3.3	*p*	90	0	0.7	PHILLIPS	89	HPW

$\tau(p \to \mu^+ \pi^0 \pi^0)$ τ_{27}

LIMIT (10^{30} years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID	TECN
>101	***p***	**90**	**3**	**1.6**	MCGREW 99	IMB3

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

$>$ 33	*p*	90	1	0.9	BERGER 91	FREJ

$\tau(n \to \mu^+ \pi^- \pi^0)$ τ_{28}

LIMIT (10^{30} years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID	TECN
>74	***n***	**90**	**17**	**20.8**	MCGREW 99	IMB3

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

$>$33	*n*	90	0	1.1	BERGER 91	FREJ

$\tau(n \to e^+ K^0 \pi^-)$ τ_{29}

LIMIT (10^{30} years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID	TECN
>18	***n***	**90**	**1**	**0.2**	BERGER 91	FREJ

Lepton + meson

$\tau(n \to e^- \pi^+)$ τ_{30}

LIMIT (10^{30} years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID	TECN
>65	***n***	**90**	**0**	**1.6**	SEIDEL 88	IMB

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

$>$55	*n*	90	0	1.09	BERGER 91B	FREJ
$>$16	*n*	90	9	7	HAINES 86	IMB
$>$25	*n*	90	2	4	PARK 85	IMB

$\tau(n \to \mu^- \pi^+)$ τ_{31}

LIMIT (10^{30} years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID	TECN
>49	***n***	**90**	**0**	**0.5**	SEIDEL 88	IMB

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

$>$33	*n*	90	0	1.40	BERGER 91B	FREJ
$>$ 2.7	*n*	90	0	0.7	PHILLIPS 89	HPW
$>$25	*n*	90	7	6	HAINES 86	IMB
$>$27	*n*	90	2	3	PARK 85	IMB

$\tau(n \to e^- \rho^+)$ τ_{32}

LIMIT (10^{30} years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID	TECN
>62	***n***	**90**	**2**	**4.1**	SEIDEL 88	IMB

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

$>$12	*n*	90	13	6	HAINES 86	IMB
$>$12	*n*	90	5	3	PARK 85	IMB

$\tau(n \rightarrow \mu^- \rho^+)$ τ_{33}

LIMIT (10^{30} years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID		TECN
>7	***n***	**90**	**1**	**1.1**	SEIDEL	88	IMB

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

LIMIT (10^{30} years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID		TECN
>2.6	*n*	90	0	0.7	PHILLIPS	89	HPW
>9	*n*	90	7	5	HAINES	86	IMB
>9	*n*	90	2	2	PARK	85	IMB

$\tau(n \rightarrow e^- K^+)$ τ_{34}

LIMIT (10^{30} years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID		TECN
>32	***n***	**90**	**3**	**2.96**	BERGER	91B	FREJ

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

LIMIT (10^{30} years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID		TECN
> 0.23	*n*	90	0	0.7	PHILLIPS	89	HPW

$\tau(n \rightarrow \mu^- K^+)$ τ_{35}

LIMIT (10^{30} years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID		TECN
>57	***n***	**90**	**0**	**2.18**	BERGER	91B	FREJ

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

LIMIT (10^{30} years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID		TECN
> 4.7	*n*	90	0	0.7	PHILLIPS	89	HPW

Lepton + mesons

$\tau(p \rightarrow e^- \pi^+ \pi^+)$ τ_{36}

LIMIT (10^{30} years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID		TECN
>30	***p***	**90**	**1**	**2.50**	BERGER	91B	FREJ

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

LIMIT (10^{30} years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID		TECN
> 2.0	*p*	90	0	0.7	PHILLIPS	89	HPW

$\tau(n \rightarrow e^- \pi^+ \pi^0)$ τ_{37}

LIMIT (10^{30} years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID		TECN
>29	***n***	**90**	**1**	**0.78**	BERGER	91B	FREJ

$\tau(p \rightarrow \mu^- \pi^+ \pi^+)$ τ_{38}

LIMIT (10^{30} years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID		TECN
>17	***p***	**90**	**1**	**1.72**	BERGER	91B	FREJ

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

LIMIT (10^{30} years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID		TECN
> 7.8	*p*	90	0	0.7	PHILLIPS	89	HPW

$\tau(n \rightarrow \mu^- \pi^+ \pi^0)$ τ_{39}

LIMIT (10^{30} years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID		TECN
>34	***n***	**90**	**0**	**0.78**	BERGER	91B	FREJ

$\tau(p \to e^- \pi^+ K^+)$ τ_{40}

LIMIT (10^{30} years)	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*		*TECN*
>75	***p***	**90**	**81**	**127.2**	MCGREW	99	IMB3
• • • We do not use the following data for averages, fits, limits, etc. • • •							
>20	*p*	90	3	2.50	BERGER	91B	FREJ

$\tau(p \to \mu^- \pi^+ K^+)$ τ_{41}

LIMIT (10^{30} years)	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*		*TECN*
>245	***p***	**90**	**3**	**4.0**	MCGREW	99	IMB3
• • • We do not use the following data for averages, fits, limits, etc. • • •							
> 5	*p*	90	2	0.78	BERGER	91B	FREJ

Antilepton + photon(s)

$\tau(p \to e^+ \gamma)$ τ_{42}

LIMIT (10^{30} years)	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*		*TECN*
>670	***p***	**90**	**0**	**0.1**	MCGREW	99	IMB3
• • • We do not use the following data for averages, fits, limits, etc. • • •							
>133	*p*	90	0	0.3	BERGER	91	FREJ
>460	*p*	90	0	0.6	SEIDEL	88	IMB
>360	*p*	90	0	0.3	HAINES	86	IMB
> 87	*p* (free)	90	0	0.2	BLEWITT	85	IMB
>360	*p*	90	0	0.2	BLEWITT	85	IMB
> 0.1	*p*	90			[54] GURR	67	CNTR

[54] We have converted half-life to 90% CL mean life.

$\tau(p \to \mu^+ \gamma)$ τ_{43}

LIMIT (10^{30} years)	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*		*TECN*
>478	***p***	**90**	**0**	**0.1**	MCGREW	99	IMB3
• • • We do not use the following data for averages, fits, limits, etc. • • •							
>155	*p*	90	0	0.1	BERGER	91	FREJ
>380	*p*	90	0	0.5	SEIDEL	88	IMB
> 97	*p*	90	3	2	HAINES	86	IMB
> 61	*p* (free)	90	0	0.2	BLEWITT	85	IMB
>280	*p*	90	0	0.6	BLEWITT	85	IMB
> 0.3	*p*	90			[55] GURR	67	CNTR

[55] We have converted half-life to 90% CL mean life.

$\tau(n \to \nu \gamma)$ τ_{44}

LIMIT (10^{30} years)	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*		*TECN*
>28	***n***	**90**	**163**	**144.7**	MCGREW	99	IMB3
• • • We do not use the following data for averages, fits, limits, etc. • • •							
>24	*n*	90	10	6.86	BERGER	91B	FREJ
> 9	*n*	90	73	60	HAINES	86	IMB
>11	*n*	90	28	19	PARK	85	IMB

$\tau(p \rightarrow e^+\gamma\gamma)$ τ_{45}

LIMIT (10^{30} years)	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*		*TECN*
>100	***p***	**90**	**1**	**0.8**	BERGER	91	FREJ

$\tau(n \rightarrow \nu\gamma\gamma)$ τ_{46}

LIMIT (10^{30} years)	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*		*TECN*
>219	***n***	**90**	**5**	**7.5**	MCGREW	99	IMB3

Three (or more) leptons

$\tau(p \rightarrow e^+e^+e^-)$ τ_{47}

LIMIT (10^{30} years)	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*		*TECN*
>793	***p***	**90**	**0**	**0.5**	MCGREW	99	IMB3
• • • We do not use the following data for averages, fits, limits, etc. • • •							
>147	*p*	90	0	0.1	BERGER	91	FREJ
>510	*p*	90	0	0.3	HAINES	86	IMB
> 89	*p* (free)	90	0	0.5	BLEWITT	85	IMB
>510	*p*	90	0	0.7	BLEWITT	85	IMB

$\tau(p \rightarrow e^+\mu^+\mu^-)$ τ_{48}

LIMIT (10^{30} years)	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*		*TECN*
>359	***p***	**90**	**1**	**0.9**	MCGREW	99	IMB3
• • • We do not use the following data for averages, fits, limits, etc. • • •							
> 81	*p*	90	0	0.16	BERGER	91	FREJ
> 5.0	*p*	90	0	0.7	PHILLIPS	89	HPW

$\tau(p \rightarrow e^+\nu\nu)$ τ_{49}

LIMIT (10^{30} years)	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*		*TECN*
>17	***p***	**90**	**152**	**153.7**	MCGREW	99	IMB3
• • • We do not use the following data for averages, fits, limits, etc. • • •							
>11	*p*	90	11	6.08	BERGER	91B	FREJ

$\tau(n \rightarrow e^+e^-\nu)$ τ_{50}

LIMIT (10^{30} years)	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*		*TECN*
>257	***n***	**90**	**5**	**7.5**	MCGREW	99	IMB3
• • • We do not use the following data for averages, fits, limits, etc. • • •							
> 74	*n*	90	0	< 0.1	BERGER	91B	FREJ
> 45	*n*	90	5	5	HAINES	86	IMB
> 26	*n*	90	4	3	PARK	85	IMB

$\tau(n \rightarrow \mu^+e^-\nu)$ τ_{51}

LIMIT (10^{30} years)	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*		*TECN*
>83	***n***	**90**	**25**	**29.4**	MCGREW	99	IMB3
• • • We do not use the following data for averages, fits, limits, etc. • • •							
>47	*n*	90	0	< 0.1	BERGER	91B	FREJ

$\tau(n \to \mu^+ \mu^- \nu)$ τ_{52}

LIMIT (10^{30} years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID		TECN
>79	***n***	**90**	**100**	**145**	MCGREW	99	IMB3
• • • We do not use the following data for averages, fits, limits, etc. • • •							
>42	*n*	90	0	1.4	BERGER	91B	FREJ
> 5.1	*n*	90	0	0.7	PHILLIPS	89	HPW
>16	*n*	90	14	7	HAINES	86	IMB
>19	*n*	90	4	7	PARK	85	IMB

$\tau(p \to \mu^+ e^+ e^-)$ τ_{53}

LIMIT (10^{30} years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID		TECN
>529	***p***	**90**	**0**	**1.0**	MCGREW	99	IMB3
• • • We do not use the following data for averages, fits, limits, etc. • • •							
> 91	*p*	90	0	≤ 0.1	BERGER	91	FREJ

$\tau(p \to \mu^+ \mu^+ \mu^-)$ τ_{54}

LIMIT (10^{30} years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID		TECN
>675	***p***	**90**	**0**	**0.3**	MCGREW	99	IMB3
• • • We do not use the following data for averages, fits, limits, etc. • • •							
>119	*p*	90	0	0.2	BERGER	91	FREJ
> 10.5	*p*	90	0	0.7	PHILLIPS	89	HPW
>190	*p*	90	1	0.1	HAINES	86	IMB
> 44	*p* (free)	90	1	0.7	BLEWITT	85	IMB
>190	*p*	90	1	0.9	BLEWITT	85	IMB
> 2.1	*p*	90	1		[56] BATTISTONI	82	NUSX

[56] We have converted 1 possible event to 90% CL limit.

$\tau(p \to \mu^+ \nu \nu)$ τ_{55}

LIMIT (10^{30} years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID		TECN
>21	***p***	**90**	**7**	**11.23**	BERGER	91B	FREJ

$\tau(p \to e^- \mu^+ \mu^+)$ τ_{56}

LIMIT (10^{30} years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID		TECN
>6.0	***p***	**90**	**0**	**0.7**	PHILLIPS	89	HPW

$\tau(n \to 3\nu)$ τ_{57}

LIMIT (10^{30} years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID		TECN
>0.00049	***n***	**90**	**2**	**2**	[57] SUZUKI	93B	KAMI
• • • We do not use the following data for averages, fits, limits, etc. • • •							
>0.0023	*n*	90			[58] GLICENSTEIN	97	KAMI
>0.00003	*n*	90	11	6.1	[59] BERGER	91B	FREJ
>0.00012	*n*	90	7	11.2	[59] BERGER	91B	FREJ
>0.0005	*n*	90	0		LEARNED	79	RVUE

[57] The SUZUKI 93B limit applies to any of $\nu_e \nu_e \overline{\nu}_e$, $\nu_\mu \nu_\mu \overline{\nu}_\mu$, or $\nu_\tau \nu_\tau \overline{\nu}_\tau$.

[58] GLICENSTEIN 97 uses Kamioka data and the idea that the disappearance of the neutron's magnetic moment should produce radiation.

[59] The first BERGER 91B limit is for $n \rightarrow \nu_e \nu_e \overline{\nu}_e$, the second is for $n \rightarrow \nu_\mu \nu_\mu \overline{\nu}_\mu$.

$\tau(n \rightarrow 5\nu)$ τ_{58}

LIMIT (10^{30} years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID		TECN
• • • We do not use the following data for averages, fits, limits, etc. • • •							
>0.0017	n	90			[60] GLICENSTEIN	97	KAMI

[60] GLICENSTEIN 97 uses Kamioka data and the idea that the disappearance of the neutron's magnetic moment should produce radiation.

Inclusive modes

$\tau(N \rightarrow e^+ \text{anything})$ τ_{59}

LIMIT (10^{30} years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID		TECN
>0.6	**p, n**	**90**			[61] LEARNED	79	RVUE

[61] The electron may be primary or secondary.

$\tau(N \rightarrow \mu^+ \text{anything})$ τ_{60}

LIMIT (10^{30} years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID		TECN
>12	**p, n**	**90**	**2**		[62,63] CHERRY	81	HOME
• • • We do not use the following data for averages, fits, limits, etc. • • •							
$>$ 1.8	p, n	90			[63] COWSIK	80	CNTR
$>$ 6	p, n	90			[63] LEARNED	79	RVUE

[62] We have converted 2 possible events to 90% CL limit.

[63] The muon may be primary or secondary.

$\tau(N \rightarrow \nu \text{anything})$ τ_{61}

Anything = π, ρ, K, etc.

LIMIT (10^{30} years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID		TECN
• • • We do not use the following data for averages, fits, limits, etc. • • •							
>0.0002	p, n	90	0		LEARNED	79	RVUE

$\tau(N \rightarrow e^+ \pi^0 \text{anything})$ τ_{62}

LIMIT (10^{30} years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID		TECN
>0.6	**p, n**	**90**	**0**		LEARNED	79	RVUE

$\tau(N \rightarrow 2 \text{ bodies}, \nu\text{-free})$ τ_{63}

LIMIT (10^{30} years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID		TECN
• • • We do not use the following data for averages, fits, limits, etc. • • •							
>1.3	p, n	90	0		ALEKSEEV	81	BAKS

$\Delta B = 2$ dinucleon modes

$\tau(pp \to \pi^+\pi^+)$ τ_{64}

LIMIT (10^{30} years)	CL%	EVTS	BKGD EST	DOCUMENT ID		TECN	COMMENT
>0.7	**90**	**4**	**2.34**	BERGER	91B	FREJ	τ per iron nucleus

$\tau(pn \to \pi^+\pi^0)$ τ_{65}

LIMIT (10^{30} years)	CL%	EVTS	BKGD EST	DOCUMENT ID		TECN	COMMENT
>2.0	**90**	**0**	**0.31**	BERGER	91B	FREJ	τ per iron nucleus

$\tau(nn \to \pi^+\pi^-)$ τ_{66}

LIMIT (10^{30} years)	CL%	EVTS	BKGD EST	DOCUMENT ID		TECN	COMMENT
>0.7	**90**	**4**	**2.18**	BERGER	91B	FREJ	τ per iron nucleus

$\tau(nn \to \pi^0\pi^0)$ τ_{67}

LIMIT (10^{30} years)	CL%	EVTS	BKGD EST	DOCUMENT ID		TECN	COMMENT
>3.4	**90**	**0**	**0.78**	BERGER	91B	FREJ	τ per iron nucleus

$\tau(pp \to e^+e^+)$ τ_{68}

LIMIT (10^{30} years)	CL%	EVTS	BKGD EST	DOCUMENT ID		TECN	COMMENT
>5.8	**90**	**0**	**<0.1**	BERGER	91B	FREJ	τ per iron nucleus

$\tau(pp \to e^+\mu^+)$ τ_{69}

LIMIT (10^{30} years)	CL%	EVTS	BKGD EST	DOCUMENT ID		TECN	COMMENT
>3.6	**90**	**0**	**<0.1**	BERGER	91B	FREJ	τ per iron nucleus

$\tau(pp \to \mu^+\mu^+)$ τ_{70}

LIMIT (10^{30} years)	CL%	EVTS	BKGD EST	DOCUMENT ID		TECN	COMMENT
>1.7	**90**	**0**	**0.62**	BERGER	91B	FREJ	τ per iron nucleus

$\tau(pn \to e^+\overline{\nu})$ τ_{71}

LIMIT (10^{30} years)	CL%	EVTS	BKGD EST	DOCUMENT ID		TECN	COMMENT
>2.8	**90**	**5**	**9.67**	BERGER	91B	FREJ	τ per iron nucleus

$\tau(pn \to \mu^+\overline{\nu})$ τ_{72}

LIMIT (10^{30} years)	CL%	EVTS	BKGD EST	DOCUMENT ID		TECN	COMMENT
>1.6	**90**	**4**	**4.37**	BERGER	91B	FREJ	τ per iron nucleus

$\tau(nn \to \nu_e \overline{\nu}_e)$ τ_{73}

LIMIT (10^{30} years)	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*	*TECN*	*COMMENT*
>0.000012	**90**			[64] BERNABEI 00B	DAMA	
>0.000012	**90**	**5**	**9.7**	BERGER 91B	FREJ	τ per iron nucleus

[64] BERNABEI 00B looks for the decay of a $^{127}_{54}$Xe nucleus following the disappearance of an nn pair in the otherwise-stable $^{129}_{54}$Xe nucleus. The limit here applies as well to $nn \to \nu_\mu \overline{\nu}_\mu$, $nn \to \nu_\tau \overline{\nu}_\tau$, or any "disappearance" mode.

$\tau(nn \to \nu_\mu \overline{\nu}_\mu)$ τ_{74}

LIMIT (10^{30} years)	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*	*TECN*	*COMMENT*
>0.000006	**90**	**4**	**4.4**	BERGER 91B	FREJ	τ per iron nucleus

$\tau(pp \to$ neutrinos$)$ τ_{75}

LIMIT (10^{30} years)	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*	*TECN*
>0.00000055	**90**			[65] BERNABEI 00B	DAMA

[65] BERNABEI 00B looks for the decay of a $^{127}_{52}$Te nucleus following the disappearance of a pp pair in the otherwise-stable $^{129}_{54}$Xe nucleus. Note that the decay doesn't conserve charge as well as baryon number.

$\overline{p}$ PARTIAL MEAN LIVES

The "partial mean life" limits tabulated here are the limits on $\overline{\tau}/B_i$, where $\overline{\tau}$ is the total mean life for the antiproton and B_i is the branching fraction for the mode in question.

$\tau(\overline{p} \to e^- \gamma)$ τ_{76}

VALUE (years)	*CL%*	*DOCUMENT ID*	*TECN*	*COMMENT*
$> 7 \times 10^5$	90	GEER 00	APEX	8.9 GeV/c $\overline{p}$ beam
• • • We do not use the following data for averages, fits, limits, etc. • • •				
>1848	95	GEER 94	CALO	8.9 GeV/c $\overline{p}$ beam

$\tau(\overline{p} \to \mu^- \gamma)$ τ_{77}

VALUE (years)	*CL%*	*DOCUMENT ID*	*TECN*	*COMMENT*
$>5 \times 10^4$	90	GEER 00	APEX	8.9 GeV/c $\overline{p}$ beam
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$>5.0 \times 10^4$	90	HU 98B	APEX	8.9 GeV/c $\overline{p}$ beam

$\tau(\overline{p} \to e^- \pi^0)$ τ_{78}

VALUE (years)	*CL%*	*DOCUMENT ID*	*TECN*	*COMMENT*
$> 4 \times 10^5$	90	GEER 00	APEX	8.9 GeV/c $\overline{p}$ beam
• • • We do not use the following data for averages, fits, limits, etc. • • •				
>554	95	GEER 94	CALO	8.9 GeV/c $\overline{p}$ beam

$\tau(\overline{p} \rightarrow \mu^- \pi^0)$ τ_{79}

VALUE (years)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
$>5 \times 10^4$	90	GEER	00	APEX	8.9 GeV/c $\overline{p}$ beam
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$>4.8 \times 10^4$	90	HU	98B	APEX	8.9 GeV/c $\overline{p}$ beam

$\tau(\overline{p} \rightarrow e^- \eta)$ τ_{80}

VALUE (years)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
$> 2 \times 10^4$	90	GEER	00	APEX	8.9 GeV/c $\overline{p}$ beam
• • • We do not use the following data for averages, fits, limits, etc. • • •					
>171	95	GEER	94	CALO	8.9 GeV/c $\overline{p}$ beam

$\tau(\overline{p} \rightarrow \mu^- \eta)$ τ_{81}

VALUE (years)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
$>8 \times 10^3$	90	GEER	00	APEX	8.9 GeV/c $\overline{p}$ beam
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$>7.9 \times 10^3$	90	HU	98B	APEX	8.9 GeV/c $\overline{p}$ beam

$\tau(\overline{p} \rightarrow e^- K^0_S)$ τ_{82}

VALUE (years)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
>900	90	GEER	00	APEX	8.9 GeV/c $\overline{p}$ beam
• • • We do not use the following data for averages, fits, limits, etc. • • •					
> 29	95	GEER	94	CALO	8.9 GeV/c $\overline{p}$ beam

$\tau(\overline{p} \rightarrow \mu^- K^0_S)$ τ_{83}

VALUE (years)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
$>4 \times 10^3$	90	GEER	00	APEX	8.9 GeV/c $\overline{p}$ beam
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$>4.3 \times 10^3$	90	HU	98B	APEX	8.9 GeV/c $\overline{p}$ beam

$\tau(\overline{p} \rightarrow e^- K^0_L)$ τ_{84}

VALUE (years)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
$>9 \times 10^3$	90	GEER	00	APEX	8.9 GeV/c $\overline{p}$ beam
• • • We do not use the following data for averages, fits, limits, etc. • • •					
>9	95	GEER	94	CALO	8.9 GeV/c $\overline{p}$ beam

$\tau(\overline{p} \rightarrow \mu^- K^0_L)$ τ_{85}

VALUE (years)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
$>7 \times 10^3$	90	GEER	00	APEX	8.9 GeV/c $\overline{p}$ beam
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$>6.5 \times 10^3$	90	HU	98B	APEX	8.9 GeV/c $\overline{p}$ beam

$\tau(\overline{p} \rightarrow e^- \gamma\gamma)$ τ_{86}

VALUE (years)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
$>2 \times 10^4$	90	GEER	00	APEX	8.9 GeV/c $\overline{p}$ beam

$\tau(\overline{p}\to\mu^-\gamma\gamma)$ τ_{87}

VALUE (years)	*CL%*	*DOCUMENT ID*	*TECN*	*COMMENT*
$>2 \times 10^4$	90	GEER 00	APEX	8.9 GeV/c $\overline{p}$ beam
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$>2.3 \times 10^4$	90	HU 98B	APEX	8.9 GeV/c $\overline{p}$ beam

$\tau(\overline{p}\to e^-\rho)$ τ_{88}

VALUE (years)	*CL%*	*DOCUMENT ID*	*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •				
>200	90	[66] GEER 00	APEX	8.9 GeV/c $\overline{p}$ beam

[66] This GEER 00 measurement has been withdrawn; see GEER 00C.

$\tau(\overline{p}\to e^-\omega)$ τ_{89}

VALUE (years)	*CL%*	*DOCUMENT ID*	*TECN*	*COMMENT*
>200	90	GEER 00	APEX	8.9 GeV/c $\overline{p}$ beam

$\tau(\overline{p}\to e^-K^*(892)^0)$ τ_{90}

VALUE (years)	*CL%*	*DOCUMENT ID*	*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$>1 \times 10^3$	90	[67] GEER 00	APEX	8.9 GeV/c $\overline{p}$ beam

[67] This GEER 00 measurement has been withdrawn; see GEER 00C.

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