p

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

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p MASS

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

VALUE (MeV)	*DOCUMENT ID*	*TECN*	*COMMENT*
938.27231±0.00028	[1] COHEN 87	RVUE	1986 CODATA value
• • • We do not use the following data for averages, fits, limits, etc. • • •			
938.2796 ±0.0027	COHEN 73	RVUE	1973 CODATA value

[1] The mass is known much more precisely in u: $m = 1.007276470 \pm 0.000000012$ u.

$\overline{p}$ MASS

See, however, the next entry in the Listings, which establishes the $\overline{p}$ mass much more precisely.

VALUE (MeV)	*DOCUMENT ID*	*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •			
938.30 ±0.13	ROBERTS 78	CNTR	
938.229±0.049	ROBERSON 77	CNTR	
938.179±0.058	HU 75	CNTR	Exotic atoms
938.3 ±0.5	BAMBERGER 70	CNTR	

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

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*
1.0000000015±0.0000000011	[2] GABRIELSE 95	TRAP	Penning trap
• • • We do not use the following data for averages, fits, limits, etc. • • •			
1.000000023 ±0.000000042	[3] GABRIELSE 90	TRAP	Penning trap

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

[3] 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. We use the CODATA values of the masses (they come from an overall fit to a variety of data on the fundamental constants) and don't try to take into account more recent measurements involving the masses.

$(|\frac{q_{\overline{p}}}{m_{\overline{p}}}|-\frac{q_p}{m_p})/|\frac{q}{m}|_{\text{average}}$

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

VALUE	*DOCUMENT ID*
$(1.5\pm1.1)\times10^{-9}$ OUR EVALUATION	

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

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	*DOCUMENT ID*		*TECN*
$<2\times10^{-5}$	[4] HUGHES	92	RVUE

[4] 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*
$<1.0\times10^{-21}$	[5] DYLLA	73	Neutrality of SF_6
• • • We do not use the following data for averages, fits, limits, etc. • • •			
$<0.8\times10^{-21}$	MARINELLI	84	Magnetic levitation

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

p MAGNETIC MOMENT

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

VALUE (μ_N)	*DOCUMENT ID*		*TECN*	*COMMENT*
$2.792847386\pm0.000000063$	COHEN	87	RVUE	1986 CODATA value
• • • We do not use the following data for averages, fits, limits, etc. • • •				
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

$(\mu_p + \mu_{\overline{p}}) / |\mu|_{\text{average}}$

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	

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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		[6] WILKENING	84		
900 $\pm$1400		[7] WILKENING	84		
700 $\pm$ 900	1G	HARRISON	69	MBR	Molecular beam

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

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

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

VALUE (10^{-4} fm^3)	*DOCUMENT ID*		*TECN*	*COMMENT*
12.1 $\pm$0.8 $\pm$0.5	[8] MACGIBBON	95	RVUE	global average
• • • We do not use the following data for averages, fits, limits, etc. • • •				
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	[9] FEDERSPIEL	91	CNTR	γp Compton scattering

[8] 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.

[9] 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 $(7.0\pm2.2\pm1.3)\times10^{-4}$ fm^3.

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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.

VALUE (10^{-4} fm^3)	*DOCUMENT ID*		*TECN*	*COMMENT*
2.1 $\pm$0.8 $\pm$0.5	[10] MACGIBBON	95	RVUE	global average

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

1.7 ± 0.6 ± 0.9	MACGIBBON	95	CNTR	γp Compton scattering
4.4 ± 0.4 ± 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 ± 2.2 ± 1.3	FEDERSPIEL	91	CNTR	γp Compton scattering

[10] 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.

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*	*DOCUMENT ID*		*TECN*
>1.6 × 10^{25}	***p*, *n***	[11,12] EVANS	77	
• • • We do not use the following data for averages, fits, limits, etc. • • •				
>3 × 10^{23}	*p*	[12] DIX	70	CNTR
>3 × 10^{23}	*p*, *n*	[12,13] FLEROV	58	

[11] Mean lifetime of nucleons in ^{130}Te nuclei.
[12] Converted to mean life by dividing half-life by ln(2) = 0.693.
[13] Mean lifetime of nucleons in ^{232}Th nuclei.

$\overline{p}$ MEAN LIFE

The best limit by far, that of GOLDEN 79, relies, however, on a number of astrophysical assumptions. The other limits come from direct observations of stored antiprotons. See also "$\overline{p}$ Partial Mean Lives" after "*p* Partial Mean Lives," below.

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

p DECAY MODES

Below, for *N* decays, *p* and *n* distinguish proton and neutron partial lifetimes. See also 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.

Mode	Partial mean life (10^{30} years)	Confidence level

Antilepton + meson

τ_1	$N \to e^+ \pi$	$>$ 130 (n), $>$ 550 (p)	90%
τ_2	$N \to \mu^+ \pi$	$>$ 100 (n), $>$ 270 (p)	90%
τ_3	$N \to \nu \pi$	$>$ 100 (n), $>$ 25 (p)	90%
τ_4	$p \to e^+ \eta$	$>$ 140	90%
τ_5	$p \to \mu^+ \eta$	$>$ 69	90%
τ_6	$n \to \nu \eta$	$>$ 54	90%
τ_7	$N \to e^+ \rho$	$>$ 58 (n), $>$ 75 (p)	90%
τ_8	$N \to \mu^+ \rho$	$>$ 23 (n), $>$ 110 (p)	90%
τ_9	$N \to \nu \rho$	$>$ 19 (n), $>$ 27 (p)	90%
τ_{10}	$p \to e^+ \omega$	$>$ 45	90%
τ_{11}	$p \to \mu^+ \omega$	$>$ 57	90%
τ_{12}	$n \to \nu \omega$	$>$ 43	90%
τ_{13}	$N \to e^+ K$	$>$ 1.3 (n), $>$ 150 (p)	90%
τ_{14}	$p \to e^+ K^0_S$	$>$ 76	90%
τ_{15}	$p \to e^+ K^0_L$	$>$ 44	90%
τ_{16}	$N \to \mu^+ K$	$>$ 1.1 (n), $>$ 120 (p)	90%
τ_{17}	$p \to \mu^+ K^0_S$	$>$ 64	90%
τ_{18}	$p \to \mu^+ K^0_L$	$>$ 44	90%
τ_{19}	$N \to \nu K$	$>$ 86 (n), $>$ 100 (p)	90%
τ_{20}	$p \to e^+ K^*(892)^0$	$>$ 52	90%
τ_{21}	$N \to \nu K^*(892)$	$>$ 22 (n), $>$ 20 (p)	90%

Antilepton + mesons

τ_{22}	$p \to e^+ \pi^+ \pi^-$	$>$ 21	90%
τ_{23}	$p \to e^+ \pi^0 \pi^0$	$>$ 38	90%
τ_{24}	$n \to e^+ \pi^- \pi^0$	$>$ 32	90%
τ_{25}	$p \to \mu^+ \pi^+ \pi^-$	$>$ 17	90%
τ_{26}	$p \to \mu^+ \pi^0 \pi^0$	$>$ 33	90%
τ_{27}	$n \to \mu^+ \pi^- \pi^0$	$>$ 33	90%
τ_{28}	$n \to e^+ K^0 \pi^-$	$>$ 18	90%

Lepton + meson

τ_{29}	$n \to e^- \pi^+$	$>$ 65	90%
τ_{30}	$n \to \mu^- \pi^+$	$>$ 49	90%
τ_{31}	$n \to e^- \rho^+$	$>$ 62	90%
τ_{32}	$n \to \mu^- \rho^+$	$>$ 7	90%
τ_{33}	$n \to e^- K^+$	$>$ 32	90%
τ_{34}	$n \to \mu^- K^+$	$>$ 57	90%

Lepton + mesons

τ_{35}	$p \to e^- \pi^+ \pi^+$	> 30	90%
τ_{36}	$n \to e^- \pi^+ \pi^0$	> 29	90%
τ_{37}	$p \to \mu^- \pi^+ \pi^+$	> 17	90%
τ_{38}	$n \to \mu^- \pi^+ \pi^0$	> 34	90%
τ_{39}	$p \to e^- \pi^+ K^+$	> 20	90%
τ_{40}	$p \to \mu^- \pi^+ K^+$	> 5	90%

Antilepton + photon(s)

τ_{41}	$p \to e^+ \gamma$	> 460	90%
τ_{42}	$p \to \mu^+ \gamma$	> 380	90%
τ_{43}	$n \to \nu \gamma$	> 24	90%
τ_{44}	$p \to e^+ \gamma \gamma$	> 100	90%

Three (or more) leptons

τ_{45}	$p \to e^+ e^+ e^-$	> 510	90%
τ_{46}	$p \to e^+ \mu^+ \mu^-$	> 81	90%
τ_{47}	$p \to e^+ \nu \nu$	> 11	90%
τ_{48}	$n \to e^+ e^- \nu$	> 74	90%
τ_{49}	$n \to \mu^+ e^- \nu$	> 47	90%
τ_{50}	$n \to \mu^+ \mu^- \nu$	> 42	90%
τ_{51}	$p \to \mu^+ e^+ e^-$	> 91	90%
τ_{52}	$p \to \mu^+ \mu^+ \mu^-$	> 190	90%
τ_{53}	$p \to \mu^+ \nu \nu$	> 21	90%
τ_{54}	$p \to e^- \mu^+ \mu^+$	> 6	90%
τ_{55}	$n \to 3\nu$	> 0.0005	90%
τ_{56}	$n \to 5\nu$		

Inclusive modes

τ_{57}	$N \to e^+$ anything	> 0.6 (n, p)	90%
τ_{58}	$N \to \mu^+$ anything	> 12 (n, p)	90%
τ_{59}	$N \to \nu$ anything		
τ_{60}	$N \to e^+ \pi^0$ anything	> 0.6 (n, p)	90%
τ_{61}	$N \to$ 2 bodies, ν-free		

$\Delta B = 2$ dinucleon modes

The following are lifetime limits per iron nucleus.

τ_{62}	$p p \to \pi^+ \pi^+$	> 0.7	90%
τ_{63}	$p n \to \pi^+ \pi^0$	> 2	90%
τ_{64}	$n n \to \pi^+ \pi^-$	> 0.7	90%
τ_{65}	$n n \to \pi^0 \pi^0$	> 3.4	90%
τ_{66}	$p p \to e^+ e^+$	> 5.8	90%

τ_{67}	$pp \rightarrow e^+\mu^+$	> 3.6	90%
τ_{68}	$pp \rightarrow \mu^+\mu^+$	> 1.7	90%
τ_{69}	$pn \rightarrow e^+\overline{\nu}$	> 2.8	90%
τ_{70}	$pn \rightarrow \mu^+\overline{\nu}$	> 1.6	90%
τ_{71}	$nn \rightarrow \nu_e\overline{\nu}_e$	> 0.000012	90%
τ_{72}	$nn \rightarrow \nu_\mu\overline{\nu}_\mu$	> 0.000006	90%

$\overline{p}$ DECAY MODES

	Mode	Partial mean life (years)	Confidence level
τ_{73}	$\overline{p} \rightarrow e^-\gamma$	> 1848	95%
τ_{74}	$\overline{p} \rightarrow e^-\pi^0$	> 554	95%
τ_{75}	$\overline{p} \rightarrow e^-\eta$	> 171	95%
τ_{76}	$\overline{p} \rightarrow e^-K^0_S$	> 29	95%
τ_{77}	$\overline{p} \rightarrow e^-K^0_L$	> 9	95%

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.

$\tau(N \rightarrow e^+\pi)$ τ_1

LIMIT (10^{30} years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID		TECN
>550	***p***	**90**	**0**	**0.7**	[14] BECKER-SZ...	90	IMB3
>130	***n***	**90**	**0**	**<0.2**	HIRATA	89C	KAMI
• • • We do not use the following data for averages, fits, limits, etc. • • •							
> 70	*p*	90	0	0.5	BERGER	91	FREJ
> 70	*n*	90	0	≤ 0.1	BERGER	91	FREJ
>260	*p*	90	0	<0.04	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	[15] BARTELT	83	SOUD
> 0.5	*n*	90	1	0.3	[15] BARTELT	83	SOUD
> 5.8	*p*	90	2		[16] KRISHNA...	82	KOLR
> 5.8	*n*	90	2		[16] KRISHNA...	82	KOLR
> 0.1	*n*	90			[17] GURR	67	CNTR

[14] This BECKER-SZENDY 90 result includes data from SEIDEL 88.
[15] Limit based on zero events.
[16] We have calculated 90% CL limit from 1 confined event.
[17] 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	***n***	**90**	**0**	**<0.2**	HIRATA	89C	KAMI
>270	***p***	**90**	**0**	**0.5**	SEIDEL	88	IMB
• • • We do not use the following data for averages, fits, limits, etc. • • •							
> 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
> 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	***p***	**90**	**32**	**32.8**	HIRATA	89C	KAMI
>100	***n***	**90**	**1**	**3**	HIRATA	89C	KAMI
• • • We do not use the following data for averages, fits, limits, etc. • • •							
> 13	*n*	90	1	1.2	BERGER	89	FREJ
> 10	*p*	90	11	14	BERGER	89	FREJ
> 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		[18] KRISHNA...	82	KOLR
> 0.3	*p*	90	2		[19] CHERRY	81	HOME
> 0.1	*p*	90			[20] GURR	67	CNTR

[18] We have calculated 90% CL limit from 1 confined event.
[19] We have converted 2 possible events to 90% CL limit.
[20] 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*
>140	***p***	**90**	**0**	**<0.04**	HIRATA	89C	KAMI
• • • We do not use the following data for averages, fits, limits, etc. • • •							
> 44	*p*	90	0	0.1	BERGER	91	FREJ
>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		[21] CHERRY	81	HOME

[21] 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*
>69	***p***	**90**	**1**	**<0.08**	HIRATA	89C	KAMI
• • • We do not use the following data for averages, fits, limits, etc. • • •							
>26	*p*	90	1	0.8	BERGER	91	FREJ
> 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*
>54	***n***	**90**	**2**	**0.9**	HIRATA	89C	KAMI
• • • We do not use the following data for averages, fits, limits, etc. • • •							
>29	*n*	90	0	0.9	BERGER	89	FREJ
>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		[22] CHERRY	81	HOME

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

$\tau(N \to e^+ \rho)$ τ_7

LIMIT (10^{30} years)	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*		*TECN*
>75	***p***	**90**	**2**	**2.7**	HIRATA	89C	KAMI
>58	***n***	**90**	**0**	**1.9**	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
>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	[23] BARTELT	83	SOUD
> 0.5	*p*	90	1	0.3	[23] BARTELT	83	SOUD
> 9.8	*p*	90	1		[24] KRISHNA...	82	KOLR
> 0.8	*p*	90	2		[25] CHERRY	81	HOME

[23] Limit based on zero events.
[24] We have calculated 90% CL limit from 0 confined events.
[25] We have converted 2 possible events to 90% CL limit.

$\tau(N \to \mu^+ \rho)$ τ_8

LIMIT (10^{30} years)	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*		*TECN*
>110	***p***	**90**	**0**	**1.7**	HIRATA	89C	KAMI
> 23	***n***	**90**	**1**	**1.8**	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
> 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*
>27	***p***	**90**	**5**	**1.5**	HIRATA	89C	KAMI
>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
>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		[26] CHERRY	81	HOME
> 0.6	*n*	90	2		[26] CHERRY	81	HOME

[26] 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
>45	***p***	**90**	**2**	**1.45**	HIRATA	89C	KAMI

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

>17	*p*	90	0	1.1	BERGER	91	FREJ
>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	[27] BARTELT	83	SOUD
> 9.8	*p*	90	1		[28] KRISHNA...	82	KOLR
> 2.8	*p*	90	2		[29] CHERRY	81	HOME

[27] Limit based on zero events.
[28] We have calculated 90% CL limit from 0 confined events.
[29] 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
>57	***p***	**90**	**2**	**1.9**	HIRATA	89C	KAMI

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

>11	*p*	90	0	1.0	BERGER	91	FREJ
> 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

$\tau(n \rightarrow \nu\omega)$ τ_{12}

LIMIT (10^{30} years)	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*		*TECN*
>43	***n***	**90**	**3**	**2.7**	HIRATA	89C	KAMI

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

LIMIT (10^{30} years)	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*		*TECN*
>17	*n*	90	1	0.7	BERGER	89	FREJ
> 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		[30] CHERRY	81	HOME

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

$\tau(N \rightarrow e^+ K)$ τ_{13}

LIMIT (10^{30} years)	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*		*TECN*
>150	***p***	**90**	**0**	**<0.27**	HIRATA	89C	KAMI
> 1.3	***n***	**90**	**0**		ALEKSEEV	81	BAKS

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

LIMIT (10^{30} years)	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*		*TECN*
> 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

$\tau(p \rightarrow e^+ K^0_S)$ τ_{14}

LIMIT (10^{30} years)	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*		*TECN*
>76	***p***	**90**	**0**	**0.5**	BERGER	91	FREJ

$\tau(p \rightarrow e^+ K^0_L)$ τ_{15}

LIMIT (10^{30} years)	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*		*TECN*
>44	***p***	**90**	**0**	**$\leq$ 0.1**	BERGER	91	FREJ

$\tau(N \rightarrow \mu^+ K)$ τ_{16}

LIMIT (10^{30} years)	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*		*TECN*
>120	***p***	**90**	**1**	**0.4**	HIRATA	89C	KAMI
> 1.1	***n***	**90**	**0**		BARTELT	87	SOUD

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

LIMIT (10^{30} years)	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*		*TECN*
> 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		[31] 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		[32] BARTELT	83	SOUD
>0.4	n	90	0		[32] BARTELT	83	SOUD
>5.8	p	90	2		[33] KRISHNA...	82	KOLR
>2.0	p	90	0		CHERRY	81	HOME
>0.2	n	90			[34] GURR	67	CNTR

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

[32] Limit based on zero events.

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

[34] 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*
>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*
>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*
>100	**p**	**90**	**9**	**7.3**	HIRATA	89C	KAMI
> 86	**n**	**90**	**0**	**2.4**	HIRATA	89C	KAMI

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

>15	n	90	1	1.8	BERGER	89	FREJ
>15	p	90	1	1.8	BERGER	89	FREJ
>0.28	p	90	0	0.7	PHILLIPS	89	HPW
>0.3	p	90	0		BARTELT	87	SOUD
>0.75	n	90	0		[35] 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		[36] BARTELT	83	SOUD
>0.1	p	90	0		[36] BARTELT	83	SOUD
>5.8	p	90	1		[37] KRISHNA...	82	KOLR
>0.3	n	90	2		[38] CHERRY	81	HOME

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

[36] Limit based on zero events.

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

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

$\tau(p \to e^+ K^*(892)^0)$ τ_{20}

LIMIT (10^{30} years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID		TECN
>52	***p***	**90**	**2**	**1.55**	HIRATA	89C	KAMI
• • • We do not use the following data for averages, fits, limits, etc. • • •							
>10	*p*	90	0	0.8	BERGER	91	FREJ
>10	*p*	90	1	<1	ARISAKA	85	KAMI

$\tau(N \to \nu K^*(892))$ τ_{21}

LIMIT (10^{30} years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID		TECN
>22	***n***	**90**	**0**	**2.1**	BERGER	89	FREJ
>20	***p***	**90**	**5**	**2.1**	HIRATA	89C	KAMI
• • • We do not use the following data for averages, fits, limits, etc. • • •							
>17	*p*	90	0	2.4	BERGER	89	FREJ
>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		[39] BATTISTONI	82	NUSX

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

$\tau(p \to e^+ \pi^+ \pi^-)$ τ_{22}

LIMIT (10^{30} years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID		TECN
>21	***p***	**90**	**0**	**2.2**	BERGER	91	FREJ

$\tau(p \to e^+ \pi^0 \pi^0)$ τ_{23}

LIMIT (10^{30} years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID		TECN
>38	***p***	**90**	**1**	**0.5**	BERGER	91	FREJ

$\tau(n \to e^+ \pi^- \pi^0)$ τ_{24}

LIMIT (10^{30} years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID		TECN
>32	***n***	**90**	**1**	**0.8**	BERGER	91	FREJ

$\tau(p \to \mu^+ \pi^+ \pi^-)$ τ_{25}

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

$\tau(p \rightarrow \mu^+ \pi^0 \pi^0)$ τ_{26}

LIMIT (10^{30} years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID	TECN
>33	***p***	**90**	**1**	**0.9**	BERGER 91	FREJ

$\tau(n \rightarrow \mu^+ \pi^- \pi^0)$ τ_{27}

LIMIT (10^{30} years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID	TECN
>33	***n***	**90**	**0**	**1.1**	BERGER 91	FREJ

$\tau(n \rightarrow e^+ K^0 \pi^-)$ τ_{28}

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

$\tau(n \rightarrow e^- \pi^+)$ τ_{29}

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

$\tau(n \rightarrow \mu^- \pi^+)$ τ_{30}

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

$\tau(n \rightarrow e^- \rho^+)$ τ_{31}

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_{32}

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. • • •						
>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_{33}

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. • • •						
> 0.23	*n*	90	0	0.7	PHILLIPS 89	HPW

$\tau(n \rightarrow \mu^- K^+)$ τ_{34}

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. • • •						
> 4.7	*n*	90	0	0.7	PHILLIPS 89	HPW

$\tau(p \rightarrow e^- \pi^+ \pi^+)$ τ_{35}

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. • • •						
> 2.0	*p*	90	0	0.7	PHILLIPS 89	HPW

$\tau(n \rightarrow e^- \pi^+ \pi^0)$ τ_{36}

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_{37}

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. • • •						
> 7.8	*p*	90	0	0.7	PHILLIPS 89	HPW

$\tau(n \rightarrow \mu^- \pi^+ \pi^0)$ τ_{38}

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

$\tau(p \rightarrow e^- \pi^+ K^+)$ τ_{39}

LIMIT (10^{30} years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID	TECN
>20	***p***	**90**	**3**	**2.50**	BERGER 91B	FREJ

$\tau(p \rightarrow \mu^- \pi^+ K^+)$ τ_{40}

LIMIT (10^{30} years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID	TECN
>5	***p***	**90**	**2**	**0.78**	BERGER 91B	FREJ

$\tau(p \to e^+ \gamma)$ τ_{41}

LIMIT (10^{30} years)	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*		*TECN*
>460	***p***	**90**	**0**	**0.6**	SEIDEL	88	IMB
• • • We do not use the following data for averages, fits, limits, etc. • • •							
>133	*p*	90	0	0.3	BERGER	91	FREJ
>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			[40] GURR	67	CNTR

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

$\tau(p \to \mu^+ \gamma)$ τ_{42}

LIMIT (10^{30} years)	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*		*TECN*
>380	***p***	**90**	**0**	**0.5**	SEIDEL	88	IMB
• • • We do not use the following data for averages, fits, limits, etc. • • •							
>155	*p*	90	0	0.1	BERGER	91	FREJ
> 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			[41] GURR	67	CNTR

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

$\tau(n \to \nu \gamma)$ τ_{43}

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

$\tau(p \to e^+ \gamma \gamma)$ τ_{44}

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

$\tau(p \to e^+ e^+ e^-)$ τ_{45}

LIMIT (10^{30} years)	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*		*TECN*
>510	***p***	**90**	**0**	**0.3**	HAINES	86	IMB
• • • We do not use the following data for averages, fits, limits, etc. • • •							
>147	*p*	90	0	0.1	BERGER	91	FREJ
> 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_{46}

LIMIT (10^{30} years)	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*		*TECN*
>81	**p**	**90**	**0**	**0.16**	BERGER	91	FREJ

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

> 5.0	p	90	0	0.7	PHILLIPS	89	HPW

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

LIMIT (10^{30} years)	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*		*TECN*
>11	**p**	**90**	**11**	**6.08**	BERGER	91B	FREJ

$\tau(n \rightarrow e^+ e^- \nu)$ τ_{48}

LIMIT (10^{30} years)	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*		*TECN*
>74	**n**	**90**	**0**	**< 0.1**	BERGER	91B	FREJ

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

>45	n	90	5	5	HAINES	86	IMB
>26	n	90	4	3	PARK	85	IMB

$\tau(n \rightarrow \mu^+ e^- \nu)$ τ_{49}

LIMIT (10^{30} years)	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*		*TECN*
>47	**n**	**90**	**0**	**< 0.1**	BERGER	91B	FREJ

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

LIMIT (10^{30} years)	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*		*TECN*
>42	**n**	**90**	**0**	**1.4**	BERGER	91B	FREJ

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

> 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

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

LIMIT (10^{30} years)	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*		*TECN*
>91	**p**	**90**	**0**	**≤ 0.1**	BERGER	91	FREJ

$\tau(p \rightarrow \mu^+ \mu^+ \mu^-)$ τ_{52}

LIMIT (10^{30} years)	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*		*TECN*
>190	**p**	**90**	**1**	**0.1**	HAINES	86	IMB

• • • 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
> 44	p (free)	90	1	0.7	BLEWITT	85	IMB
>190	p	90	1	0.9	BLEWITT	85	IMB
> 2.1	p	90	1		[42] BATTISTONI	82	NUSX

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

$\tau(p \to \mu^+ \nu\nu)$ τ_{53}

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_{54}

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_{55}

LIMIT (10^{30} years)	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*		*TECN*
>0.00049	***n***	**90**	**2**	**2**	[43] SUZUKI	93B	KAMI
• • • We do not use the following data for averages, fits, limits, etc. • • •							
>0.0023	*n*	90			[44] GLICENSTEIN	97	KAMI
>0.00003	*n*	90	11	6.1	[45] BERGER	91B	FREJ
>0.00012	*n*	90	7	11.2	[45] BERGER	91B	FREJ
>0.0005	*n*	90	0		LEARNED	79	RVUE

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

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

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

$\tau(n \to 5\nu)$ τ_{56}

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			[46] GLICENSTEIN	97	KAMI

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

$\tau(N \to e^+$ anything$)$ τ_{57}

LIMIT (10^{30} years)	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*		*TECN*
>0.6	***p*, *n***	**90**			[47] LEARNED	79	RVUE

[47] The electron may be primary or secondary.

$\tau(N \to \mu^+$ anything$)$ τ_{58}

LIMIT (10^{30} years)	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*		*TECN*
>12	***p*, *n***	**90**	**2**		[48,49] CHERRY	81	HOME
• • • We do not use the following data for averages, fits, limits, etc. • • •							
> 1.8	*p*, *n*	90			[49] COWSIK	80	CNTR
> 6	*p*, *n*	90			[49] LEARNED	79	RVUE

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

[49] The muon may be primary or secondary.

$\tau(N \to \nu\,\text{anything})$ τ_{59}

Anything = π, ρ, K, etc.

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

LIMIT (10^{30} years)	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*	*TECN*
>0.0002	p, n	90	0		LEARNED 79	RVUE

$\tau(N \to e^+ \pi^0\,\text{anything})$ τ_{60}

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

$\tau(N \to 2\text{ bodies}, \nu\text{-free})$ τ_{61}

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

LIMIT (10^{30} years)	*PARTICLE*	*CL%*	*EVTS*	*BKGD EST*	*DOCUMENT ID*	*TECN*
>1.3	p, n	90	0		ALEKSEEV 81	BAKS

$\tau(pp \to \pi^+ \pi^+)$ τ_{62}

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_{63}

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_{64}

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_{65}

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_{66}

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_{67}

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_{68}

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_{69}

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_{70}

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_{71}

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

$\tau(nn \to \nu_\mu\overline{\nu}_\mu)$ τ_{72}

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

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$\overline{p}$ PARTIAL MEAN LIVES

The "partial mean life" limits tabulated here are the limits on $\overline{\tau}/\mathrm{B}_i$, 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_{73}

VALUE (years)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
>1848	95	GEER	94	CALO	8.9 GeV/c $\overline{p}$ beam

$\tau(\overline{p} \to e^-\pi^0)$ τ_{74}

VALUE (years)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
>554	95	GEER	94	CALO	8.9 GeV/c $\overline{p}$ beam

$\tau(\overline{p} \to e^-\eta)$ τ_{75}

VALUE (years)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
>171	95	GEER	94	CALO	8.9 GeV/c $\overline{p}$ beam

$\tau(\overline{p} \to e^-K^0_S)$ τ_{76}

VALUE (years)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
>29	95	GEER	94	CALO	8.9 GeV/c $\overline{p}$ beam

$\tau(\overline{p} \to e^-K^0_L)$ τ_{77}

VALUE (years)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
>9	95	GEER	94	CALO	8.9 GeV/c $\overline{p}$ beam

p REFERENCES

GLICENSTEIN	97	PL B411 326	J.F. Glicenstein	(SACL)
GABRIELSE	95	PRL 74 3544	+Phillips, Quint+	(HARV, MANZ, SEOUL)
MACGIBBON	95	PR C52 2097	+Garino, Lucas, Nathan+	(ILL, SASK, INRM)
GEER	94	PRL 72 1596	+Marriner, Ray+	(FNAL, UCLA, PSU)
HALLIN	93	PR C48 1497	+Amendt, Bergstrom+	(SASK, BOST, ILL)
SUZUKI	93B	PL B311 357	+Fukuda, Hirata, Inoue+	(KAMIOKANDE Collab.)
HUGHES	92	PRL 69 578	+Deutch	(LANL, AARH)
ZIEGER	92	PL B278 34	+Van de Vyver, Christmann, DeGraeve+	(MPCM)
Also	92B	PL B281 417 (erratum)	Zieger, ..., Van den Abeele, Ziegler	(MPCM)
BERGER	91	ZPHY C50 385	+Froehlich, Moench, Nisius+	(FREJUS Collab.)
BERGER	91B	PL B269 227	+Froehlich, Moench, Nisius+	(FREJUS Collab.)
FEDERSPIEL	91	PRL 67 1511	+Eisenstein, Lucas, MacGibbon+	(ILL)
BECKER-SZ...	90	PR D42 2974	Becker-Szendy, Bratton, Cady, Casper+	(IMB-3 Collab.)
ERICSON	90	EPL 11 295	+Richter	(CERN, DARM)
GABRIELSE	90	PRL 65 1317	+Fei, Orozco, Tjoelker+	(HARV, MANZ, WASH, IBS)
BERGER	89	NP B313 509	+Froehlich, Moench+	(FREJUS Collab.)
CHO	89	PRL 63 2559	+Sangster, Hinds	(YALE)
HIRATA	89C	PL B220 308	+Kajita, Kifune, Kihara+	(Kamiokande Collab.)
PHILLIPS	89	PL B224 348	+Matthews, Aprile, Cline+	(HPW Collab.)
KREISSL	88	ZPHY C37 557	+Hancock, Koch, Koehler, Poth+	(CERN PS176 Collab.)
SEIDEL	88	PRL 61 2522	+Bionta, Blewitt, Bratton+	(IMB Collab.)
BARTELT	87	PR D36 1990	+Courant, Heller+	(Soudan Collab.)
Also	89	PR D40 1701 erratum	Bartelt, Courant, Heller+	(Soudan Collab.)
COHEN	87	RMP 59 1121	+Taylor	(RISC, NBS)
HAINES	86	PRL 57 1986	+Bionta, Blewitt, Bratton, Casper+	(IMB Collab.)
KAJITA	86	JPSJ 55 711	+Arisaka, Koshiba, Nakahata+	(Kamiokande Collab.)
ARISAKA	85	JPSJ 54 3213	+Kajita, Koshiba, Nakahata+	(Kamiokande Collab.)
BLEWITT	85	PRL 55 2114	+LoSecco, Bionta, Bratton+	(IMB Collab.)
DZUBA	85	PL 154B 93	+Flambaum, Silvestrov	(NOVO)
PARK	85	PRL 54 22	+Blewitt, Cortez, Foster+	(IMB Collab.)
BATTISTONI	84	PL 133B 454	+Bellotti, Bologna, Campana+	(NUSEX Collab.)
MARINELLI	84	PL 137B 439	+Morpurgo	(GENO)
WILKENING	84	PR A29 425	+Ramsey, Larson	(HARV, VIRG)
BARTELT	83	PRL 50 651	+Courant, Heller, Joyce, Marshak+	(MINN, ANL)
BATTISTONI	82	PL 118B 461	+Bellotti, Bologna, Campana+	(NUSEX Collab.)
KRISHNA...	82	PL 115B 349	Krishnaswamy, Menon+	(TATA, OSKC, INUS)
ALEKSEEV	81	JETPL 33 651 Translated from ZETFP 33 664.	+Bakatanov, Butkevich, Voevodskii+	(PNPI)
CHERRY	81	PRL 47 1507	+Deakyne, Lande, Lee, Steinberg+	(PENN, BNL)
COWSIK	80	PR D22 2204	+Narasimhan	(TATA)
BELL	79	PL 86B 215	+Calvetti, Carron, Chaney, Cittolin+	(CERN)
GOLDEN	79	PRL 43 1196	+Horan, Mauger, Badhwar, Lacy+	(NASA, PSLL)
LEARNED	79	PRL 43 907	+Reines, Soni	(UCI)
BREGMAN	78	PL 78B 174	+Calvetti, Carron, Cittolin, Hauer, Herr+	(CERN)
ROBERTS	78	PR D17 358		(WILL, RHEL)
EVANS	77	Science 197 989	+Steinberg	(BNL, PENN)
ROBERSON	77	PR C16 1945	+King, Kunselman+	(WYOM, CIT, CMU, VPI, WILL)
HU	75	NP A254 403	+Asano, Chen, Cheng, Dugan+	(COLU, YALE)
COHEN	73	JPCRD 2 663	+Taylor	(RISC, NBS)
DYLLA	73	PR A7 1224	+King	(MIT)
BAMBERGER	70	PL 33B 233	+Lynen, Piekarz+	(MPIH, CERN, KARL)
DIX	70	Thesis Case		(CASE)
HARRISON	69	PRL 22 1263	+Sandars, Wright	(OXF)
GURR	67	PR 158 1321	+Kropp, Reines, Meyer	(CASE, WITW)
FLEROV	58	DOKL 3 79	+Klochkov, Skobkin, Terentev	(ASCI)