



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

p MASS (atomic mass units u)

The mass is known much more precisely in u (atomic mass units) than in MeV. See the next data block.

VALUE (u)	DOCUMENT ID	TECN	COMMENT
$1.00727646688 \pm 0.00000000013$	MOHR	04	RVUE 2002 CODATA value
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
$1.00727646688 \pm 0.00000000013$	MOHR	99	RVUE 1998 CODATA value
$1.007276470 \pm 0.000000012$	COHEN	87	RVUE 1986 CODATA value

p MASS (MeV)

The mass is known much more precisely in u (atomic mass units) than in MeV. The conversion from u to MeV, $1 u = 931.494043 \pm 0.000080$ MeV/ c^2 (MOHR 04, the 2002 CODATA value), involves the relatively poorly known electronic charge.

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
938.272029 ± 0.000080	MOHR	04	RVUE 2002 CODATA value
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
938.271998 ± 0.000038	MOHR	99	RVUE 1998 CODATA value
938.27231 ± 0.00028	COHEN	87	RVUE 1986 CODATA value
938.2796 ± 0.0027	COHEN	73	RVUE 1973 CODATA value

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

A test of CPT invariance. Note that the comparison of the \bar{p} and p charge-to-mass ratio, given in the next data block, is much better determined.

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$< 1.0 \times 10^{-8}$	90	¹ HORI	03	SPEC $\bar{p}e^-$ ^4He and $\bar{p}e^-$ ^3He
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
$< 6 \times 10^{-8}$	90	¹ HORI	01	SPEC $\bar{p}e^-$ He atom
$< 5 \times 10^{-7}$		² TORII	99	SPEC $\bar{p}e^-$ He atom

¹ HORI 01 and HORI 03 use the more-precisely-known constraint on the \bar{p} charge-to-mass ratio of GABRIELSE 99 (see below) to get their results. Their results are not independent of the HORI 01 and HORI 03 values for $|q_p + q_{\bar{p}}|/e$, below.

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

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

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 \bar{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 \bar{p} 's.

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
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 $M(\bar{p})/M(p) = 0.999\,999\,9985$ (11) (G. Gabrielse, private communication).			
⁴ GABRIELSE 90 also measures $m_{\bar{p}}/m_{e^-} = 1836.152660 \pm 0.000083$ 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 .			

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

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

<u>VALUE</u>	<u>DOCUMENT ID</u>
$(-9 \pm 9) \times 10^{-11}$ OUR EVALUATION	

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

A test of *CPT* invariance. Note that the comparison of the \bar{p} and p charge-to-mass ratios given above is much better determined. See also a similar test involving the electron.

<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
$< 1.0 \times 10^{-8}$	90	⁵ HORI	03 SPEC	$\bar{p}e^-$ ⁴ He and $\bar{p}e^-$ ³ He
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
$< 6 \times 10^{-8}$	90	⁵ HORI	01 SPEC	$\bar{p}e^-$ He atom
$< 5 \times 10^{-7}$		⁶ TORII	99 SPEC	$\bar{p}e^-$ He atom
$< 2 \times 10^{-5}$		⁷ HUGHES	92 RVUE	
⁵ HORI 01 and HORI 03 use the more-precisely-known constraint on the \bar{p} charge-to-mass ratio of GABRIELSE 99 (see above) to get their results. Their results are not independent of the HORI 01 and HORI 03 values for $ m_p - m_{\bar{p}} /m_p$, above.				
⁶ TORII 99 uses the more-precisely-known constraint on the \bar{p} charge-to-mass ratio of GABRIELSE 95 (see above) to get this result. This is not independent of the TORII 99 value for $ m_p - m_{\bar{p}} /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.

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>COMMENT</u>
<1.0 × 10⁻²¹	⁸ DYLLA 73	Neutrality of SF ₆
• • • We do not use the following data for averages, fits, limits, etc. • • •		
<3.2 × 10 ⁻²⁰	⁹ SENGUPTA 00	binary pulsar
<0.8 × 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 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.

<u>VALUE (μ_N)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
2.792847351 ± 0.000000028	MOHR	04	RVUE 2002 CODATA value
• • • We do not use the following data for averages, fits, limits, etc. • • •			
2.792847337 ± 0.000000029	MOHR	99	RVUE 1998 CODATA value
2.792847386 ± 0.000000063	COHEN	87	RVUE 1986 CODATA value
2.7928456 ± 0.0000011	COHEN	73	RVUE 1973 CODATA value

\bar{p} MAGNETIC MOMENT

A few early results have been omitted.

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

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

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

<u>VALUE</u>	<u>DOCUMENT ID</u>
(−2.6 ± 2.9) × 10⁻³ OUR EVALUATION	

ρ ELECTRIC DIPOLE MOMENT

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

VALUE (10^{-23} ecm)	EVTS	DOCUMENT ID	TECN	COMMENT
< 0.54		¹⁰ DMITRIEV 03		Uses ¹⁹⁹ Hg atom EDM
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
– 3.7 ± 6.3		CHO 89	NMR	TI F molecules
< 400		DZUBA 85	THEO	Uses ¹²⁹ Xe moment
130 ± 200		¹¹ WILKENING 84		
900 ± 1400		¹² WILKENING 84		
700 ± 900	1G	HARRISON 69	MBR	Molecular beam
¹⁰ DMITRIEV 03 calculates this limit from the limit on the electric dipole moment of the ¹⁹⁹ Hg atom.				
¹¹ This WILKENING 84 value includes a finite-size effect and a magnetic effect.				
¹² This WILKENING 84 value is more cautious than the other and excludes the finite-size effect, which relies on uncertain nuclear integrals.				

ρ ELECTRIC POLARIZABILITY α_ρ

VALUE (10^{-4} fm ³)	DOCUMENT ID	TECN	COMMENT
12.0 ± 0.6 OUR AVERAGE			
12.1 ± 1.1 ± 0.5	¹³ BEANE 03		EFT + $\gamma\rho$
11.82 ± 0.98 ^{+0.52} _{-0.98}	¹⁴ BLANPIED 01	LEGS	$\rho(\vec{\gamma}, \gamma)$, $\rho(\vec{\gamma}, \pi^0)$, $\rho(\vec{\gamma}, \pi^+)$
11.9 ± 0.5 ± 1.3	¹⁵ OLMOSDEL... 01	CNTR	$\gamma\rho$ Compton scattering
12.1 ± 0.8 ± 0.5	¹⁶ MACGIBBON 95	RVUE	global average
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
11.7 ± 0.8 ± 0.7	¹⁷ BARANOV 01	RVUE	Global average
12.5 ± 0.6 ± 0.9	MACGIBBON 95	CNTR	$\gamma\rho$ Compton scattering
9.8 ± 0.4 ± 1.1	HALLIN 93	CNTR	$\gamma\rho$ Compton scattering
10.62 ^{+1.25+1.07} _{-1.19-1.03}	ZIEGER 92	CNTR	$\gamma\rho$ Compton scattering
10.9 ± 2.2 ± 1.3	¹⁸ FEDERSPIEL 91	CNTR	$\gamma\rho$ Compton scattering
¹³ BEANE 03 uses effective field theory and low-energy $\gamma\rho$ and γd Compton-scattering data. It also gets for the isoscalar polarizabilities $\alpha_N = (9.0 \pm 1.5^{+3.6}_{-0.8}) \times 10^{-4}$ fm ³ and $\beta_N = (1.7 \pm 1.5^{+1.4}_{-0.6}) \times 10^{-4}$ fm ³ .			
¹⁴ BLANPIED 01 gives $\alpha_\rho + \beta_\rho$ and $\alpha_\rho - \beta_\rho$. The separate α_ρ and β_ρ are provided to us by A. Sandorfi. The first error above is statistics plus systematics; the second is from the model.			
¹⁵ This OLMOSDELEON 01 result uses the TAPS data alone, and does not use the (re-evaluated) sum-rule constraint that $\alpha + \beta = (13.8 \pm 0.4) \times 10^{-4}$ fm ³ . See the paper for a discussion.			
¹⁶ 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.			
¹⁷ 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 $\alpha_\rho + \beta_\rho$.			
¹⁸ FEDERSPIEL 91 obtains for the (static) electric polarizability α_ρ , defined in terms of the induced electric dipole moment by $\mathbf{D} = 4\pi\epsilon_0\alpha_\rho\mathbf{E}$, the value $(7.0 \pm 2.2 \pm 1.3) \times 10^{-4}$ fm ³ .			

ρ MAGNETIC POLARIZABILITY β_ρ

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

VALUE (10^{-4} fm^3)	DOCUMENT ID	TECN	COMMENT
1.9 ± 0.5 OUR AVERAGE			
3.4 ± 1.1 ± 0.1	¹⁹ BEANE	03	EFT + γp
1.43 ± 0.98 ^{+0.52} _{-0.98}	²⁰ BLANPIED	01	LEGS $p(\vec{\gamma}, \gamma)$, $p(\vec{\gamma}, \pi^0)$, $p(\vec{\gamma}, \pi^+)$
1.2 ± 0.7 ± 0.5	²¹ OLMOSDEL...	01	CNTR γp Compton scattering
2.1 ± 0.8 ± 0.5	²² MACGIBBON	95	RVUE global average
• • • We do not use the following data for averages, fits, limits, etc. • • •			
2.3 ± 0.9 ± 0.7	²³ BARANOV	01	RVUE Global average
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+1.03} _{-1.25-1.07}	ZIEGER	92	CNTR γp Compton scattering
3.3 ± 2.2 ± 1.3	FEDERSPIEL	91	CNTR γp Compton scattering
¹⁹ BEANE 03 uses effective field theory and low-energy γp and γd Compton-scattering data. It also gets for the isoscalar polarizabilities $\alpha_N = (9.0 \pm 1.5+3.6-0.8) \times 10^{-4} \text{ fm}^3$ and $\beta_N = (1.7 \pm 1.5+1.4-0.6) \times 10^{-4} \text{ fm}^3$.			
²⁰ BLANPIED 01 gives $\alpha_\rho + \beta_\rho$ and $\alpha_\rho - \beta_\rho$. The separate α_ρ and β_ρ are provided to us by A. Sandorfi. The first error above is statistics plus systematics; the second is from the model.			
²¹ This OLMOSDELEON 01 result uses the TAPS data alone, and does not use the (re-evaluated) sum-rule constraint that $\alpha + \beta = (13.8 \pm 0.4) \times 10^{-4} \text{ fm}^3$. See the paper for a discussion.			
²² 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.			
²³ 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 $\alpha_\rho + \beta_\rho$.			

ρ CHARGE RADIUS

VALUE (fm)	DOCUMENT ID	COMMENT
0.870 ± 0.008 OUR AVERAGE		
0.830 ± 0.040 ± 0.040	²⁴ ESCHRICH	01 $ep \rightarrow ep$
0.883 ± 0.014	MELNIKOV	00 1S Lamb Shift in H
0.865 ± 0.020	MCCORD	91 $ep \rightarrow ep$
0.862 ± 0.012	SIMON	80 $ep \rightarrow ep$
0.880 ± 0.030	BORKOWSKI	74 $ep \rightarrow ep$
• • • We do not use the following data for averages, fits, limits, etc. • • •		
0.880 ± 0.015	ROSENFELDR.	00 ep + Coul. corrections
0.847 ± 0.008	MERGELL	96 ep + disp. relations
0.877 ± 0.024	WONG	94 reanalysis of Mainz ep data
0.810 ± 0.020	AKIMOV	72 $ep \rightarrow ep$
0.800 ± 0.025	FREREJACQ...	66 $ep \rightarrow ep$ (CH_2 tgt.)
0.805 ± 0.011	HAND	63 $ep \rightarrow ep$

²⁴ ESCHRICH 01 actually gives $\langle r^2 \rangle = (0.69 \pm 0.06 \pm 0.06) \text{ fm}^2$.

p MEAN LIFE

A test of baryon conservation. See the “ p Partial Mean Lives” section below for limits for identified final states. The limits here are to “anything” or are for “disappearance” modes of a bound proton (p) or (n). See also the 3ν modes in the “Partial Mean Lives” section. Table 1 of BACK 03 is a nice summary.

<u>LIMIT</u> (years)	<u>PARTICLE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
$>2.1 \times 10^{29}$	p	90	²⁵ AHMED	04 SNO	$p \rightarrow$ invisible
$>1.9 \times 10^{29}$	n	90	²⁵ AHMED	04 SNO	$n \rightarrow$ invisible
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●					
$>1.8 \times 10^{25}$	n	90	²⁶ BACK	03 BORX	
$>1.1 \times 10^{26}$	p	90	²⁶ BACK	03 BORX	
$>3.5 \times 10^{28}$	p	90	²⁷ ZDESENKO	03	$p \rightarrow$ invisible
$>1 \times 10^{28}$	p	90	²⁸ AHMAD	02 SNO	$p \rightarrow$ invisible
$>4 \times 10^{23}$	p	95	TRETYAK	01	$d \rightarrow n + ?$
$>1.9 \times 10^{24}$	p	90	²⁹ BERNABEI	00B DAMA	
$>1.6 \times 10^{25}$	p, n		^{30,31} EVANS	77	
$>3 \times 10^{23}$	p		³¹ DIX	70 CNTR	
$>3 \times 10^{23}$	p, n		^{31,32} FLEROV	58	

²⁵ AHMED 04 looks for γ rays from the de-excitation of a residual $^{15}\text{O}^*$ or $^{15}\text{N}^*$ following the disappearance of a neutron or proton in ^{16}O .

²⁶ BACK 03 looks for decays of unstable nuclides left after N decays of parent ^{12}C , ^{13}C , ^{16}O nuclei. These are “invisible channel” limits.

²⁷ ZDESENKO 03 gets this limit on proton disappearance in deuterium by analyzing SNO data in AHMAD 02.

²⁸ AHMAD 02 (see its footnote 7) looks for neutrons left behind after the disappearance of the proton in deuterons.

²⁹ BERNABEI 00B looks for the decay of a $^{128}_{53}\text{I}$ nucleus following the disappearance of a proton in the otherwise-stable $^{129}_{54}\text{Xe}$ nucleus.

³⁰ EVANS 77 looks for the daughter nuclide ^{129}Xe from possible ^{130}Te decays in ancient Te ore samples.

³¹ This mean-life limit has been obtained from a half-life limit by dividing the latter by $\ln(2) = 0.693$.

³² FLEROV 58 looks for the spontaneous fission of a ^{232}Th nucleus after the disappearance of one of its nucleons.

\bar{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 “ \bar{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 $\bar{p} \rightarrow e^- \gamma$. We advance only the exclusive-mode limits to our Summary Tables.

<u>LIMIT</u> (years)	<u>CL%</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
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● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●

>8 × 10 ⁵	90		³³ GEER	00D	\bar{p}/p ratio, cosmic rays
>0.28			GABRIELSE	90 TRAP	Penning trap
>0.08	90	1	BELL	79 CNTR	Storage ring
>1 × 10 ⁷			GOLDEN	79 SPEC	\bar{p}/p ratio, cosmic rays
>3.7 × 10 ⁻³			BREGMAN	78 CNTR	Storage ring

³³GEER 00D uses agreement between a model of galactic \bar{p} production and propagation and the observed \bar{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 $N \rightarrow e^+ \pi$	> 158 (n), > 1600 (p)	90%
τ_2 $N \rightarrow \mu^+ \pi$	> 100 (n), > 473 (p)	90%
τ_3 $N \rightarrow \nu \pi$	> 112 (n), > 25 (p)	90%
τ_4 $p \rightarrow e^+ \eta$	> 313	90%
τ_5 $p \rightarrow \mu^+ \eta$	> 126	90%
τ_6 $n \rightarrow \nu \eta$	> 158	90%
τ_7 $N \rightarrow e^+ \rho$	> 217 (n), > 75 (p)	90%
τ_8 $N \rightarrow \mu^+ \rho$	> 228 (n), > 110 (p)	90%
τ_9 $N \rightarrow \nu \rho$	> 19 (n), > 162 (p)	90%
τ_{10} $p \rightarrow e^+ \omega$	> 107	90%
τ_{11} $p \rightarrow \mu^+ \omega$	> 117	90%
τ_{12} $n \rightarrow \nu \omega$	> 108	90%
τ_{13} $N \rightarrow e^+ K$	> 17 (n), > 150 (p)	90%
τ_{14} $p \rightarrow e^+ K_S^0$	> 120	90%
τ_{15} $p \rightarrow e^+ K_L^0$	> 51	90%
τ_{16} $N \rightarrow \mu^+ K$	> 26 (n), > 120 (p)	90%
τ_{17} $p \rightarrow \mu^+ K_S^0$	> 150	90%
τ_{18} $p \rightarrow \mu^+ K_L^0$	> 83	90%
τ_{19} $N \rightarrow \nu K$	> 86 (n), > 670 (p)	90%
τ_{20} $n \rightarrow \nu K_S^0$	> 51	90%
τ_{21} $p \rightarrow e^+ K^*(892)^0$	> 84	90%
τ_{22} $N \rightarrow \nu K^*(892)$	> 78 (n), > 51 (p)	90%

Antilepton + mesons

τ_{23}	$p \rightarrow e^+ \pi^+ \pi^-$	> 82	90%
τ_{24}	$p \rightarrow e^+ \pi^0 \pi^0$	> 147	90%
τ_{25}	$n \rightarrow e^+ \pi^- \pi^0$	> 52	90%
τ_{26}	$p \rightarrow \mu^+ \pi^+ \pi^-$	> 133	90%
τ_{27}	$p \rightarrow \mu^+ \pi^0 \pi^0$	> 101	90%
τ_{28}	$n \rightarrow \mu^+ \pi^- \pi^0$	> 74	90%
τ_{29}	$n \rightarrow e^+ K^0 \pi^-$	> 18	90%

Lepton + meson

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

Lepton + mesons

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

Antilepton + photon(s)

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

Three (or more) leptons

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

Inclusive modes

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

$\Delta B = 2$ dinucleon modes

The following are lifetime limits per iron nucleus.

τ_{64}	$pp \rightarrow \pi^+ \pi^+$	> 0.7	90%
τ_{65}	$pn \rightarrow \pi^+ \pi^0$	> 2	90%
τ_{66}	$nn \rightarrow \pi^+ \pi^-$	> 0.7	90%
τ_{67}	$nn \rightarrow \pi^0 \pi^0$	> 3.4	90%
τ_{68}	$pp \rightarrow e^+ e^+$	> 5.8	90%
τ_{69}	$pp \rightarrow e^+ \mu^+$	> 3.6	90%
τ_{70}	$pp \rightarrow \mu^+ \mu^+$	> 1.7	90%
τ_{71}	$pn \rightarrow e^+ \bar{\nu}$	> 2.8	90%
τ_{72}	$pn \rightarrow \mu^+ \bar{\nu}$	> 1.6	90%
τ_{73}	$nn \rightarrow \nu_e \bar{\nu}_e$	> 0.000049	90%
τ_{74}	$nn \rightarrow \nu_\mu \bar{\nu}_\mu$		
τ_{75}	$pp \rightarrow$ neutrinos	> 0.00005	90%

\bar{p} DECAY MODES

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

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 ————

$\tau(N \rightarrow e^+ \pi)$

τ_1

<i>LIMIT</i> (10^{30} years)	<i>PARTICLE</i>	<i>CL%</i>	<i>EVTS</i>	<i>BKGD EST</i>	<i>DOCUMENT ID</i>	<i>TECN</i>
> 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. • • •

> 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	³⁴ 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	³⁵ BARTELT	83 SOUD
> 0.5	n	90	1	0.3	³⁵ BARTELT	83 SOUD
> 5.8	p	90	2		³⁶ KRISHNA...	82 KOLR
> 5.8	n	90	2		³⁶ KRISHNA...	82 KOLR
> 0.1	n	90			³⁷ GURR	67 CNTR

³⁴ This BECKER-SZENDY 90 result includes data from SEIDEL 88.

³⁵ Limit based on zero events.

³⁶ We have calculated 90% CL limit from 1 confined event.

³⁷ We have converted half-life to 90% CL mean life.

$\tau(N \rightarrow \mu^+ \pi)$

τ_2

<i>LIMIT</i> (10^{30} years)	<i>PARTICLE</i>	<i>CL%</i>	<i>EVTS</i>	<i>BKGD EST</i>	<i>DOCUMENT ID</i>	<i>TECN</i>
>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	<i>n</i>	90	1	1.9	MCGREW	99	IMB3
> 81	<i>p</i>	90	0	0.2	BERGER	91	FREJ
> 35	<i>n</i>	90	1	1.0	BERGER	91	FREJ
>230	<i>p</i>	90	0	<0.07	HIRATA	89C	KAMI
>270	<i>p</i>	90	0	0.5	SEIDEL	88	IMB
> 63	<i>n</i>	90	0	0.5	SEIDEL	88	IMB
> 76	<i>p</i>	90	2	1	HAINES	86	IMB
> 23	<i>n</i>	90	8	7	HAINES	86	IMB
> 46	<i>p</i>	90	0	<0.7	ARISAKA	85	KAMI
> 20	<i>n</i>	90	0	<0.4	ARISAKA	85	KAMI
> 59	<i>p</i> (free)	90	0	0.2	BLEWITT	85	IMB
>100	<i>p</i>	90	1	0.4	BLEWITT	85	IMB
> 38	<i>n</i>	90	1	4	PARK	85	IMB
> 10	<i>p, n</i>	90	0		BATTISTONI	84	NUSX
> 1.3	<i>p, n</i>	90	0		ALEKSEEV	81	BAKS

$\tau(N \rightarrow \nu\pi)$

T3

<u>LIMIT</u> (10^{30} years)	<u>PARTICLE</u>	<u>CL%</u>	<u>EVTS</u>	<u>BKGD EST</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
> 16	<i>p</i>	90	6	6.7	WALL	00B SOU2
>112	<i>n</i>	90	6	6.6	MCGREW	99 IMB3

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

> 39	<i>n</i>	90	4	3.8	WALL	00B	SOU2
> 10	<i>p</i>	90	15	20.3	MCGREW	99	IMB3
> 13	<i>n</i>	90	1	1.2	BERGER	89	FREJ
> 10	<i>p</i>	90	11	14	BERGER	89	FREJ
> 25	<i>p</i>	90	32	32.8	³⁸ HIRATA	89C	KAMI
>100	<i>n</i>	90	1	3	HIRATA	89C	KAMI
> 6	<i>n</i>	90	73	60	HAINES	86	IMB
> 2	<i>p</i>	90	16	13	KAJITA	86	KAMI
> 40	<i>n</i>	90	0	1	KAJITA	86	KAMI
> 7	<i>n</i>	90	28	19	PARK	85	IMB
> 7	<i>n</i>	90	0		BATTISTONI	84	NUSX
> 2	<i>p</i>	90	≤ 3		BATTISTONI	84	NUSX
> 5.8	<i>p</i>	90	1		³⁹ KRISHNA...	82	KOLR
> 0.3	<i>p</i>	90	2		⁴⁰ CHERRY	81	HOME
> 0.1	<i>p</i>	90			⁴¹ GURR	67	CNTR

³⁸In estimating the background, this HIRATA 89C limit (as opposed to the later limits of WALL 00B and MCGREW 99) does not take into account present understanding that the flux of ν_μ originating in the upper atmosphere is depleted. Doing so would reduce the background and thus also would reduce the limit here.

³⁹We have calculated 90% CL limit from 1 confined event.

⁴⁰We have converted 2 possible events to 90% CL limit.

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

$\tau(p \rightarrow e^+\eta)$

T4

<u>LIMIT</u> (10^{30} years)	<u>PARTICLE</u>	<u>CL%</u>	<u>EVTS</u>	<u>BKGD EST</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
>313	<i>p</i>	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		⁴² CHERRY	81	HOME

⁴²We have converted 2 possible events to 90% CL limit.

$\tau(p \rightarrow \mu^+ \eta)$

T5

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

$\tau(n \rightarrow \nu \eta)$

T6

<u>LIMIT</u> (10^{30} years)	<u>PARTICLE</u>	<u>CL%</u>	<u>EVTS</u>	<u>BKGD EST</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
>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		⁴³ CHERRY	81	HOME

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

$\tau(N \rightarrow e^+ \rho)$

T7

<u>LIMIT</u> (10^{30} years)	<u>PARTICLE</u>	<u>CL%</u>	<u>EVTS</u>	<u>BKGD EST</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
>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	<i>p</i>	90	0	2.2	BERGER	91	FREJ
> 41	<i>n</i>	90	0	1.4	BERGER	91	FREJ
> 58	<i>n</i>	90	0	1.9	HIRATA	89C	KAMI
> 38	<i>n</i>	90	2	4.1	SEIDEL	88	IMB
> 1.2	<i>p</i>	90	0		BARTELT	87	SOUD
> 1.5	<i>n</i>	90	0		BARTELT	87	SOUD
> 17	<i>p</i>	90	7	7	HAINES	86	IMB
> 14	<i>n</i>	90	9	4	HAINES	86	IMB
> 12	<i>p</i>	90	0	<1.2	ARISAKA	85	KAMI
> 6	<i>n</i>	90	2	<1	ARISAKA	85	KAMI
> 6.7	<i>p</i> (free)	90	6	6	BLEWITT	85	IMB
> 17	<i>p</i>	90	7	7	BLEWITT	85	IMB
> 12	<i>n</i>	90	4	2	PARK	85	IMB
> 0.6	<i>n</i>	90	1	0.3	⁴⁴ BARTELT	83	SOUD
> 0.5	<i>p</i>	90	1	0.3	⁴⁴ BARTELT	83	SOUD
> 9.8	<i>p</i>	90	1		⁴⁵ KRISHNA...	82	KOLR
> 0.8	<i>p</i>	90	2		⁴⁶ CHERRY	81	HOME

⁴⁴ Limit based on zero events.

⁴⁵ We have calculated 90% CL limit from 0 confined events.

⁴⁶ We have converted 2 possible events to 90% CL limit.

$\tau(N \rightarrow \mu^+ \rho)$

T8

<u>LIMIT</u> (10^{30} years)	<u>PARTICLE</u>	<u>CL%</u>	<u>EVTS</u>	<u>BKGD EST</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
>228	<i>n</i>	90	3	9.5	MCGREW	99 IMB3
>110	<i>p</i>	90	0	1.7	HIRATA	89C KAMI

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

> 12	<i>p</i>	90	0	0.5	BERGER	91	FREJ
> 22	<i>n</i>	90	0	1.1	BERGER	91	FREJ
> 23	<i>n</i>	90	1	1.8	HIRATA	89C	KAMI
> 4.3	<i>p</i>	90	0	0.7	PHILLIPS	89	HPW
> 30	<i>p</i>	90	0	0.5	SEIDEL	88	IMB
> 11	<i>n</i>	90	1	1.1	SEIDEL	88	IMB
> 16	<i>p</i>	90	4	4.5	HAINES	86	IMB
> 7	<i>n</i>	90	6	5	HAINES	86	IMB
> 12	<i>p</i>	90	0	<0.7	ARISAKA	85	KAMI
> 5	<i>n</i>	90	1	<1.2	ARISAKA	85	KAMI
> 5.5	<i>p</i> (free)	90	4	5	BLEWITT	85	IMB
> 16	<i>p</i>	90	4	5	BLEWITT	85	IMB
> 9	<i>n</i>	90	1	2	PARK	85	IMB

$\tau(N \rightarrow \nu \rho)$

T9

<u>LIMIT</u> (10^{30} years)	<u>PARTICLE</u>	<u>CL%</u>	<u>EVTS</u>	<u>BKGD EST</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
>162	<i>p</i>	90	18	21.7	MCGREW	99 IMB3
> 19	<i>n</i>	90	0	0.5	SEIDEL	88 IMB

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

> 9	<i>n</i>	90	4	2.4	BERGER	89	FREJ
> 24	<i>p</i>	90	0	0.9	BERGER	89	FREJ
> 27	<i>p</i>	90	5	1.5	HIRATA	89C	KAMI
> 13	<i>n</i>	90	4	3.6	HIRATA	89C	KAMI
> 13	<i>p</i>	90	1	1.1	SEIDEL	88	IMB
> 8	<i>p</i>	90	6	5	HAINES	86	IMB
> 2	<i>n</i>	90	15	10	HAINES	86	IMB
> 11	<i>p</i>	90	2	1	KAJITA	86	KAMI
> 4	<i>n</i>	90	2	2	KAJITA	86	KAMI
> 4.1	<i>p</i> (free)	90	6	7	BLEWITT	85	IMB
> 8.4	<i>p</i>	90	6	5	BLEWITT	85	IMB
> 2	<i>n</i>	90	7	3	PARK	85	IMB
> 0.9	<i>p</i>	90	2		⁴⁷ CHERRY	81	HOME
> 0.6	<i>n</i>	90	2		⁴⁷ CHERRY	81	HOME

⁴⁷We have converted 2 possible events to 90% CL limit.

$\tau(p \rightarrow e^+ \omega)$

τ_{10}

<u>LIMIT</u> (10^{30} years)	<u>PARTICLE</u>	<u>CL%</u>	<u>EVTS</u>	<u>BKGD EST</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
>107	<i>p</i>	90	7	10.8	MCGREW	99 IMB3

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

> 17	<i>p</i>	90	0	1.1	BERGER	91	FREJ
> 45	<i>p</i>	90	2	1.45	HIRATA	89C	KAMI
> 26	<i>p</i>	90	1	1.0	SEIDEL	88	IMB
> 1.5	<i>p</i>	90	0		BARTELT	87	SOUD
> 37	<i>p</i>	90	6	5.3	HAINES	86	IMB
> 25	<i>p</i>	90	1	<1.4	ARISAKA	85	KAMI
> 12	<i>p</i> (free)	90	6	7.5	BLEWITT	85	IMB
> 37	<i>p</i>	90	6	5.7	BLEWITT	85	IMB
> 0.6	<i>p</i>	90	1	0.3	⁴⁸ BARTELT	83	SOUD
> 9.8	<i>p</i>	90	1		⁴⁹ KRISHNA...	82	KOLR
> 2.8	<i>p</i>	90	2		⁵⁰ CHERRY	81	HOME

⁴⁸Limit based on zero events.

⁴⁹We have calculated 90% CL limit from 0 confined events.

⁵⁰We have converted 2 possible events to 90% CL limit.

$\tau(p \rightarrow \mu^+ \omega)$

τ_{11}

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

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

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

$\tau(n \rightarrow \nu \omega)$

τ_{12}

<u>LIMIT</u> (10^{30} years)	<u>PARTICLE</u>	<u>CL%</u>	<u>EVTS</u>	<u>BKGD EST</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
>108	<i>n</i>	90	12	22.5	MCGREW	99 IMB3
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●						
> 17	<i>n</i>	90	1	0.7	BERGER	89 FREJ
> 43	<i>n</i>	90	3	2.7	HIRATA	89C KAMI
> 6	<i>n</i>	90	2	1.3	SEIDEL	88 IMB
> 12	<i>n</i>	90	6	6	HAINES	86 IMB
> 18	<i>n</i>	90	2	2	KAJITA	86 KAMI
> 16	<i>n</i>	90	1	2	PARK	85 IMB
> 2.0	<i>n</i>	90	2		⁵¹ CHERRY	81 HOME

⁵¹We have converted 2 possible events to 90% CL limit.

$\tau(N \rightarrow e^+ K)$

τ_{13}

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

$\tau(p \rightarrow e^+ K_S^0)$

τ_{14}

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

$\tau(p \rightarrow e^+ K_L^0)$

τ_{15}

<u>LIMIT</u> (10^{30} years)	<u>PARTICLE</u>	<u>CL%</u>	<u>EVTS</u>	<u>BKGD EST</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
>51	<i>p</i>	90	2	3.5	WALL	00 SOU2
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●						
>44	<i>p</i>	90	0	≤ 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	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		52 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		53 BARTELT	83 SOUD
> 0.4	n	90	0		53 BARTELT	83 SOUD
> 5.8	p	90	2		54 KRISHNA...	82 KOLR
> 2.0	p	90	0		CHERRY	81 HOME
> 0.2	n	90			55 GURR	67 CNTR

⁵² BARTELT 87 limit applies to $p \rightarrow \mu^+ K_S^0$.

⁵³ Limit based on zero events.

⁵⁴ We have calculated 90% CL limit from 1 confined event.

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

$\tau(p \rightarrow \mu^+ K_S^0)$

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
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$\tau(p \rightarrow \mu^+ K_L^0)$

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
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$\tau(N \rightarrow \nu K)$

τ_{19}

LIMIT (10^{30} years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID	TECN
>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	<i>n</i>	90	16	9.1	WALL	00	SOU2
>151	<i>p</i>	90	15	21.4	MCGREW	99	IMB3
> 30	<i>n</i>	90	34	34.1	MCGREW	99	IMB3
> 43	<i>p</i>	90	1	1.54	⁵⁶ ALLISON	98	SOU2
> 15	<i>n</i>	90	1	1.8	BERGER	89	FREJ
> 15	<i>p</i>	90	1	1.8	BERGER	89	FREJ
>100	<i>p</i>	90	9	7.3	HIRATA	89 ^C	KAMI
> 0.28	<i>p</i>	90	0	0.7	PHILLIPS	89	HPW
> 0.3	<i>p</i>	90	0		BARTELT	87	SOUD
> 0.75	<i>n</i>	90	0		⁵⁷ BARTELT	87	SOUD
> 10	<i>p</i>	90	6	5	HAINES	86	IMB
> 15	<i>n</i>	90	3	5	HAINES	86	IMB
> 28	<i>p</i>	90	3	3	KAJITA	86	KAMI
> 32	<i>n</i>	90	0	1.4	KAJITA	86	KAMI
> 1.8	<i>p</i> (free)	90	6	11	BLEWITT	85	IMB
> 9.6	<i>p</i>	90	6	5	BLEWITT	85	IMB
> 10	<i>n</i>	90	2	2	PARK	85	IMB
> 5	<i>n</i>	90	0		BATTISTONI	84	NUSX
> 2	<i>p</i>	90	0		BATTISTONI	84	NUSX
> 0.3	<i>n</i>	90	0		⁵⁸ BARTELT	83	SOUD
> 0.1	<i>p</i>	90	0		⁵⁸ BARTELT	83	SOUD
> 5.8	<i>p</i>	90	1		⁵⁹ KRISHNA...	82	KOLR
> 0.3	<i>n</i>	90	2		⁶⁰ CHERRY	81	HOME

⁵⁶ This ALLISON 98 limit is with no background subtraction; with subtraction the limit becomes $> 46 \times 10^{30}$ years.

⁵⁷ BARTELT 87 limit applies to $n \rightarrow \nu K_S^0$.

⁵⁸ Limit based on zero events.

⁵⁹ We have calculated 90% CL limit from 1 confined event.

⁶⁰ We have converted 2 possible events to 90% CL limit.

$\tau(n \rightarrow \nu K_S^0)$

τ_{20}

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

$\tau(p \rightarrow e^+ K^*(892)^0)$

τ_{21}

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

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

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

$\tau(N \rightarrow \nu K^*(892))$

τ_{22}

<u>LIMIT</u> (10^{30} years)	<u>PARTICLE</u>	<u>CL%</u>	<u>EVTS</u>	<u>BKGD EST</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
>51	<i>p</i>	90	7	9.1	MCGREW	99 IMB3
>78	<i>n</i>	90	40	50	MCGREW	99 IMB3

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

>22	<i>n</i>	90	0	2.1	BERGER	89	FREJ
>17	<i>p</i>	90	0	2.4	BERGER	89	FREJ
>20	<i>p</i>	90	5	2.1	HIRATA	89C	KAMI
>21	<i>n</i>	90	4	2.4	HIRATA	89C	KAMI
>10	<i>p</i>	90	7	6	HAINES	86	IMB
> 5	<i>n</i>	90	8	7	HAINES	86	IMB
> 8	<i>p</i>	90	3	2	KAJITA	86	KAMI
> 6	<i>n</i>	90	2	1.6	KAJITA	86	KAMI
> 5.8	<i>p</i> (free)	90	10	16	BLEWITT	85	IMB
> 9.6	<i>p</i>	90	7	6	BLEWITT	85	IMB
> 7	<i>n</i>	90	1	4	PARK	85	IMB
> 2.1	<i>p</i>	90	1		⁶¹ BATTISTONI	82	NUSX

⁶¹We have converted 1 possible event to 90% CL limit.

————— Antilepton + mesons —————

$\tau(p \rightarrow e^+ \pi^+ \pi^-)$

T23

<u>LIMIT</u> (10 ³⁰ years)	<u>PARTICLE</u>	<u>CL%</u>	<u>EVTS</u>	<u>BKGD EST</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
>82	<i>p</i>	90	16	23.1	MCGREW	99 IMB3

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

>21	<i>p</i>	90	0	2.2	BERGER	91	FREJ
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$\tau(p \rightarrow e^+ \pi^0 \pi^0)$

T24

<u>LIMIT</u> (10 ³⁰ years)	<u>PARTICLE</u>	<u>CL%</u>	<u>EVTS</u>	<u>BKGD EST</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
>147	<i>p</i>	90	2	0.8	MCGREW	99 IMB3

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

> 38	<i>p</i>	90	1	0.5	BERGER	91	FREJ
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$\tau(n \rightarrow e^+ \pi^- \pi^0)$

T25

<u>LIMIT</u> (10 ³⁰ years)	<u>PARTICLE</u>	<u>CL%</u>	<u>EVTS</u>	<u>BKGD EST</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
>52	<i>n</i>	90	38	34.2	MCGREW	99 IMB3

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

>32	<i>n</i>	90	1	0.8	BERGER	91	FREJ
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$\tau(p \rightarrow \mu^+ \pi^+ \pi^-)$

T26

<u>LIMIT</u> (10 ³⁰ years)	<u>PARTICLE</u>	<u>CL%</u>	<u>EVTS</u>	<u>BKGD EST</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
>133	<i>p</i>	90	25	38.0	MCGREW	99 IMB3

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

> 17	<i>p</i>	90	1	2.6	BERGER	91	FREJ
> 3.3	<i>p</i>	90	0	0.7	PHILLIPS	89	HPW

$\tau(p \rightarrow \mu^+ \pi^0 \pi^0)$ **T27**

<u>LIMIT</u> (10^{30} years)	<u>PARTICLE</u>	<u>CL%</u>	<u>EVTS</u>	<u>BKGD EST</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
>101	<i>p</i>	90	3	1.6	MCGREW	99 IMB3
• • • We do not use the following data for averages, fits, limits, etc. • • •						
> 33	<i>p</i>	90	1	0.9	BERGER	91 FREJ

$\tau(n \rightarrow \mu^+ \pi^- \pi^0)$ **T28**

<u>LIMIT</u> (10^{30} years)	<u>PARTICLE</u>	<u>CL%</u>	<u>EVTS</u>	<u>BKGD EST</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
>74	<i>n</i>	90	17	20.8	MCGREW	99 IMB3
• • • We do not use the following data for averages, fits, limits, etc. • • •						
>33	<i>n</i>	90	0	1.1	BERGER	91 FREJ

$\tau(n \rightarrow e^+ K^0 \pi^-)$ **T29**

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

————— **Lepton + meson** —————

$\tau(n \rightarrow e^- \pi^+)$ **T30**

<u>LIMIT</u> (10^{30} years)	<u>PARTICLE</u>	<u>CL%</u>	<u>EVTS</u>	<u>BKGD EST</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
>65	<i>n</i>	90	0	1.6	SEIDEL	88 IMB
• • • We do not use the following data for averages, fits, limits, etc. • • •						
>55	<i>n</i>	90	0	1.09	BERGER	91B FREJ
>16	<i>n</i>	90	9	7	HAINES	86 IMB
>25	<i>n</i>	90	2	4	PARK	85 IMB

$\tau(n \rightarrow \mu^- \pi^+)$ **T31**

<u>LIMIT</u> (10^{30} years)	<u>PARTICLE</u>	<u>CL%</u>	<u>EVTS</u>	<u>BKGD EST</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
>49	<i>n</i>	90	0	0.5	SEIDEL	88 IMB
• • • We do not use the following data for averages, fits, limits, etc. • • •						
>33	<i>n</i>	90	0	1.40	BERGER	91B FREJ
> 2.7	<i>n</i>	90	0	0.7	PHILLIPS	89 HPW
>25	<i>n</i>	90	7	6	HAINES	86 IMB
>27	<i>n</i>	90	2	3	PARK	85 IMB

$\tau(n \rightarrow e^- \rho^+)$ **T32**

<u>LIMIT</u> (10^{30} years)	<u>PARTICLE</u>	<u>CL%</u>	<u>EVTS</u>	<u>BKGD EST</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
>62	<i>n</i>	90	2	4.1	SEIDEL	88 IMB
• • • We do not use the following data for averages, fits, limits, etc. • • •						
>12	<i>n</i>	90	13	6	HAINES	86 IMB
>12	<i>n</i>	90	5	3	PARK	85 IMB

$\tau(n \rightarrow \mu^- \rho^+)$ T33

<u>LIMIT</u> (10^{30} years)	<u>PARTICLE</u>	<u>CL%</u>	<u>EVTS</u>	<u>BKGD EST</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
>7	<i>n</i>	90	1	1.1	SEIDEL	88 IMB
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●						
>2.6	<i>n</i>	90	0	0.7	PHILLIPS	89 HPW
>9	<i>n</i>	90	7	5	HAINES	86 IMB
>9	<i>n</i>	90	2	2	PARK	85 IMB

$\tau(n \rightarrow e^- K^+)$ T34

<u>LIMIT</u> (10^{30} years)	<u>PARTICLE</u>	<u>CL%</u>	<u>EVTS</u>	<u>BKGD EST</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
>32	<i>n</i>	90	3	2.96	BERGER	91B FREJ
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●						
> 0.23	<i>n</i>	90	0	0.7	PHILLIPS	89 HPW

$\tau(n \rightarrow \mu^- K^+)$ T35

<u>LIMIT</u> (10^{30} years)	<u>PARTICLE</u>	<u>CL%</u>	<u>EVTS</u>	<u>BKGD EST</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
>57	<i>n</i>	90	0	2.18	BERGER	91B FREJ
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●						
> 4.7	<i>n</i>	90	0	0.7	PHILLIPS	89 HPW

————— **Lepton + mesons** —————

$\tau(p \rightarrow e^- \pi^+ \pi^+)$ T36

<u>LIMIT</u> (10^{30} years)	<u>PARTICLE</u>	<u>CL%</u>	<u>EVTS</u>	<u>BKGD EST</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
>30	<i>p</i>	90	1	2.50	BERGER	91B FREJ
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●						
> 2.0	<i>p</i>	90	0	0.7	PHILLIPS	89 HPW

$\tau(n \rightarrow e^- \pi^+ \pi^0)$ T37

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

$\tau(p \rightarrow \mu^- \pi^+ \pi^+)$ T38

<u>LIMIT</u> (10^{30} years)	<u>PARTICLE</u>	<u>CL%</u>	<u>EVTS</u>	<u>BKGD EST</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
>17	<i>p</i>	90	1	1.72	BERGER	91B FREJ
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●						
> 7.8	<i>p</i>	90	0	0.7	PHILLIPS	89 HPW

$\tau(n \rightarrow \mu^- \pi^+ \pi^0)$ T39

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

$\tau(p \rightarrow e^- \pi^+ K^+)$ **T40**

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

$\tau(p \rightarrow \mu^- \pi^+ K^+)$ **T41**

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) —————

$\tau(p \rightarrow e^+ \gamma)$ **T42**

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			⁶² GURR	67 CNTR

⁶²We have converted half-life to 90% CL mean life.

$\tau(p \rightarrow \mu^+ \gamma)$ **T43**

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			⁶³ GURR	67 CNTR

⁶³We have converted half-life to 90% CL mean life.

$\tau(n \rightarrow \nu \gamma)$ **T44**

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

$\tau(p \rightarrow e^+ \gamma \gamma)$ T45

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

$\tau(n \rightarrow \nu \gamma \gamma)$ T46

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

————— **Three (or more) leptons** —————

$\tau(p \rightarrow e^+ e^+ e^-)$ T47

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

$\tau(p \rightarrow e^+ \mu^+ \mu^-)$ T48

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

$\tau(p \rightarrow e^+ \nu \nu)$ T49

<u>LIMIT</u> (10^{30} years)	<u>PARTICLE</u>	<u>CL%</u>	<u>EVTS</u>	<u>BKGD EST</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
>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
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$\tau(n \rightarrow e^+ e^- \nu)$ T50

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

$\tau(n \rightarrow \mu^+ e^- \nu)$ T51

<u>LIMIT</u> (10^{30} years)	<u>PARTICLE</u>	<u>CL%</u>	<u>EVTS</u>	<u>BKGD EST</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
>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
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$\tau(n \rightarrow \mu^+ \mu^- \nu)$

T52

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

$\tau(p \rightarrow \mu^+ e^+ e^-)$

T53

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

$\tau(p \rightarrow \mu^+ \mu^+ \mu^-)$

T54

<u>LIMIT</u> (10^{30} years)	<u>PARTICLE</u>	<u>CL%</u>	<u>EVTS</u>	<u>BKGD EST</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
>675	<i>p</i>	90	0	0.3	MCGREW	99 IMB3
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●						
>119	<i>p</i>	90	0	0.2	BERGER	91 FREJ
> 10.5	<i>p</i>	90	0	0.7	PHILLIPS	89 HPW
>190	<i>p</i>	90	1	0.1	HAINES	86 IMB
> 44	<i>p</i> (free)	90	1	0.7	BLEWITT	85 IMB
>190	<i>p</i>	90	1	0.9	BLEWITT	85 IMB
> 2.1	<i>p</i>	90	1		⁶⁴ BATTISTONI	82 NUSX

⁶⁴We have converted 1 possible event to 90% CL limit.

$\tau(p \rightarrow \mu^+ \nu \nu)$

T55

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

$\tau(p \rightarrow e^- \mu^+ \mu^+)$

T56

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

$\tau(n \rightarrow 3\nu)$

T57

See also the "to anything" and "disappearance" limits for bound nucleons in the "p Mean Life" data block just in front of the list of possible *p* decay modes.

<u>LIMIT</u> (10^{30} years)	<u>PARTICLE</u>	<u>CL%</u>	<u>EVTS</u>	<u>BKGD EST</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
>0.00049	<i>n</i>	90	2	2	⁶⁵ SUZUKI	93B KAMI
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●						
>0.0023	<i>n</i>	90			⁶⁶ GLICENSTEIN	97 KAMI
>0.00003	<i>n</i>	90	11	6.1	⁶⁷ BERGER	91B FREJ
>0.00012	<i>n</i>	90	7	11.2	⁶⁷ BERGER	91B FREJ
>0.0005	<i>n</i>	90	0		LEARNED	79 RVUE

————— $\Delta B = 2$ dinucleon modes —————

$\tau(pp \rightarrow \pi^+ \pi^+)$ **T64**

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

$\tau(pn \rightarrow \pi^+ \pi^0)$ **T65**

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

$\tau(nn \rightarrow \pi^+ \pi^-)$ **T66**

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

$\tau(nn \rightarrow \pi^0 \pi^0)$ **T67**

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

$\tau(pp \rightarrow e^+ e^+)$ **T68**

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

$\tau(pp \rightarrow e^+ \mu^+)$ **T69**

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

$\tau(pp \rightarrow \mu^+ \mu^+)$ **T70**

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

$\tau(pn \rightarrow e^+ \bar{\nu})$ **T71**

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

$\tau(pn \rightarrow \mu^+ \bar{\nu})$ **T72**

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

$\tau(nn \rightarrow \nu_e \bar{\nu}_e)$

T73

We include "invisible" modes here.

LIMIT (10 ³⁰ years)	CL%	EVTS	BKGD EST	CL%	DOCUMENT ID	TECN	COMMENT
>0.000049				90	⁷² BACK	03	BORX

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

>0.000012	90				⁷³ BERNABEI	00B	DAMA
>0.000012	90	5	9.7		BERGER	91B	FREJ τ per iron nucleus

⁷² BACK 03 looks for decays of unstable nuclides left after NN decays of parent ¹²C, ¹³C, ¹⁶O nuclei. These are "invisible channel" limits.
⁷³ BERNABEI 00B looks for the decay of a ¹²⁷₅₄Xe nucleus following the disappearance of an nn pair in the otherwise-stable ¹²⁹₅₄Xe nucleus. The limit here applies as well to $nn \rightarrow \nu_\mu \bar{\nu}_\mu$, $nn \rightarrow \nu_\tau \bar{\nu}_\tau$, or any "disappearance" mode.

$\tau(nn \rightarrow \nu_\mu \bar{\nu}_\mu)$

T74

LIMIT (10 ³⁰ years)	CL%	EVTS	BKGD EST	DOCUMENT ID	TECN	COMMENT
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• • • We do not use the following data for averages, fits, limits, etc. • • •

>0.000006	90	4	4.4	BERGER	91B	FREJ τ per iron nucleus
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$\tau(pp \rightarrow \text{neutrinos})$

T75

We include "invisible" modes here.

LIMIT (10 ³⁰ years)	CL%	EVTS	BKGD EST	CL%	DOCUMENT ID	TECN	COMMENT
>0.00005				90	⁷⁴ BACK	03	BORX

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

>0.0000055	90				⁷⁵ BERNABEI	00B	DAMA
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⁷⁴ BACK 03 looks for decays of unstable nuclides left after NN decays of parent ¹²C, ¹³C, ¹⁶O nuclei. These are "invisible channel" limits.
⁷⁵ BERNABEI 00B looks for the decay of a ¹²⁷₅₂Te nucleus following the disappearance of a pp pair in the otherwise-stable ¹²⁹₅₄Xe nucleus. Note that the decay doesn't conserve charge as well as baryon number.

\bar{p} PARTIAL MEAN LIVES

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

$\tau(\bar{p} \rightarrow e^- \gamma)$

T76

VALUE (years)	CL%	DOCUMENT ID	TECN	COMMENT
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> **7×10^5** 90 GEER 00 APEX 8.9 GeV/c \bar{p} beam

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

>1848	95	GEER	94	CALO 8.9 GeV/c \bar{p} beam
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$\tau(\bar{p} \rightarrow \mu^- \gamma)$

T77

VALUE (years)	CL%	DOCUMENT ID	TECN	COMMENT
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> **5×10^4** 90 GEER 00 APEX 8.9 GeV/c \bar{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 \bar{p} beam
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$\tau(\bar{p} \rightarrow e^- \pi^0)$ **T78**

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

$\tau(\bar{p} \rightarrow \mu^- \pi^0)$ **T79**

<u>VALUE (years)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
$> 5 \times 10^4$	90	GEER	00 APEX	8.9 GeV/c \bar{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 \bar{p} beam

$\tau(\bar{p} \rightarrow e^- \eta)$ **T80**

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

$\tau(\bar{p} \rightarrow \mu^- \eta)$ **T81**

<u>VALUE (years)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
$> 8 \times 10^3$	90	GEER	00 APEX	8.9 GeV/c \bar{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 \bar{p} beam

$\tau(\bar{p} \rightarrow e^- K_S^0)$ **T82**

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

$\tau(\bar{p} \rightarrow \mu^- K_S^0)$ **T83**

<u>VALUE (years)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
$> 4 \times 10^3$	90	GEER	00 APEX	8.9 GeV/c \bar{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 \bar{p} beam

$\tau(\bar{p} \rightarrow e^- K_L^0)$ **T84**

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

$\tau(\bar{p} \rightarrow \mu^- K_L^0)$ **T85**

<u>VALUE (years)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
$> 7 \times 10^3$	90	GEER	00 APEX	8.9 GeV/c \bar{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 \bar{p} beam

$\tau(\bar{p} \rightarrow e^- \gamma \gamma)$ **T86**

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

$\tau(\bar{p} \rightarrow \mu^- \gamma \gamma)$ **T87**

VALUE (years)	CL%	DOCUMENT ID	TECN	COMMENT
$>2 \times 10^4$	90	GEER	00	APEX 8.9 GeV/c \bar{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 \bar{p} beam
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$\tau(\bar{p} \rightarrow e^- \rho)$ **T88**

VALUE (years)	CL%	DOCUMENT ID	TECN	COMMENT
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• • • We do not use the following data for averages, fits, limits, etc. • • •

>200	90	⁷⁶ GEER	00	APEX 8.9 GeV/c \bar{p} beam
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⁷⁶ This GEER 00 measurement has been withdrawn; see GEER 00C.

$\tau(\bar{p} \rightarrow e^- \omega)$ **T89**

VALUE (years)	CL%	DOCUMENT ID	TECN	COMMENT
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>200	90	GEER	00	APEX 8.9 GeV/c \bar{p} beam
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$\tau(\bar{p} \rightarrow e^- K^*(892)^0)$ **T90**

VALUE (years)	CL%	DOCUMENT ID	TECN	COMMENT
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• • • We do not use the following data for averages, fits, limits, etc. • • •

$>1 \times 10^3$	90	⁷⁷ GEER	00	APEX 8.9 GeV/c \bar{p} beam
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⁷⁷ This GEER 00 measurement has been withdrawn; see GEER 00C.

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AKIMOV	72	JETP 35 651	Yu.K. Akimov <i>et al.</i>	(YERE)
		Translated from ZETF 62 1231.		
DIX	70	Thesis Case	F.W. Dix	(CASE)
HARRISON	69	PRL 22 1263	G.E. Harrison, P.G.H. Sandars, S.J. Wright	(OXF)
GURR	67	PR 158 1321	H.S. Gurr <i>et al.</i>	(CASE, WITW)
FREREJACQ...	66	PR 141 1308	D. Frerejacque <i>et al.</i>	
HAND	63	RMP 35 335	L.N. hand <i>et al.</i>	
FLEROV	58	DOKL 3 79	G.N. Flerov <i>et al.</i>	(ASCI)