



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

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.

<u>VALUE (u)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
1.00727646677 ± 0.00000000010	MOHR	08	RVUE 2006 CODATA value
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
1.00727646688 ± 0.00000000013	MOHR	05	RVUE 2002 CODATA value
1.00727646688 ± 0.00000000013	MOHR	99	RVUE 1998 CODATA value
1.007276470 ± 0.000000012	COHEN	87	RVUE 1986 CODATA value

p MASS (MeV)

The mass is known much more precisely in u (atomic mass units) than in MeV. The conversion from u to MeV, $1 u = 931.494028 \pm 0.000023$ MeV/ c^2 (MOHR 08, the 2006 CODATA value), involves the relatively poorly known electronic charge.

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
938.272013 ± 0.000023	MOHR	08	RVUE 2006 CODATA value
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
938.272029 ± 0.000080	MOHR	05	RVUE 2002 CODATA value
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.

<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<2 × 10⁻⁹	90	¹ HORI	06	SPEC $\bar{p}e^-$ He atom
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
<1.0 × 10 ⁻⁸	90	¹ HORI	03	SPEC $\bar{p}e^-$ ⁴ He, $\bar{p}e^-$ ³ He
<6 × 10 ⁻⁸	90	¹ HORI	01	SPEC $\bar{p}e^-$ He atom
<5 × 10 ⁻⁷		² TORII	99	SPEC $\bar{p}e^-$ He atom

¹ HORI 01, HORI 03, and HORI 06 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, HORI 03, and HORI 06 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>
$< 2 \times 10^{-9}$	90	⁵ HORI	06	SPEC $\bar{p}e^-$ He atom
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
$< 1.0 \times 10^{-8}$	90	⁵ HORI	03	SPEC $\bar{p}e^-$ ⁴ He, $\bar{p}e^-$ ³ He
$< 6 \times 10^{-8}$	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, HORI 03, and HORI 06 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, HORI 03, and HORI 06 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>
2.792847356 ± 0.000000023	MOHR 08	RVUE	2006 CODATA value
• • • We do not use the following data for averages, fits, limits, etc. • • •			
2.792847351 ± 0.000000028	MOHR 05	RVUE	2002 CODATA value
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

***p̄* 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	<i>p̄</i> 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 *p̄* 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 ¹⁹⁹Hg 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_p

For a very complete review of the “polarizability of the nucleon and Compton scattering,” see SCHUMACHER 05. His recommended values for the proton are $\alpha_p = (12.0 \pm 0.6) \times 10^{-4} \text{ fm}^3$ and $\beta_p = (1.9 \mp 0.6) \times 10^{-4} \text{ fm}^3$, almost exactly our averages.

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 + γp
11.82 ± 0.98 ^{+0.52} _{-0.98}	¹⁴ BLANPIED 01	LEGS	$p(\vec{\gamma}, \gamma)$, $p(\vec{\gamma}, \pi^0)$, $p(\vec{\gamma}, \pi^+)$
11.9 ± 0.5 ± 1.3	¹⁵ OLMOSDEL... 01	CNTR	γp 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	γp Compton scattering
9.8 ± 0.4 ± 1.1	HALLIN 93	CNTR	γp Compton scattering
10.62 ^{+1.25+1.07} _{-1.19-1.03}	ZIEGER 92	CNTR	γp Compton scattering
10.9 ± 2.2 ± 1.3	¹⁸ FEDERSPIEL 91	CNTR	γp Compton scattering

¹³ BEANE 03 uses effective field theory and low-energy γp and γd Compton-scattering data. It also gets for the isoscalar polarizabilities (see the erratum) $\alpha_N = (13.0 \pm 1.9^{+3.9}_{-1.5}) \times 10^{-4} \text{ fm}^3$ and $\beta_N = (-1.8 \pm 1.9^{+2.1}_{-0.9}) \times 10^{-4} \text{ fm}^3$.

¹⁴ BLANPIED 01 gives $\alpha_p + \beta_p$ and $\alpha_p - \beta_p$. The separate α_p and β_p 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 $\alpha + \beta = (13.8 \pm 0.4) \times 10^{-4} \text{ fm}^3$. 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 $\alpha_p + \beta_p$.
- ¹⁸ FEDERSPIEL 91 obtains for the (static) electric polarizability α_p , defined in terms of the induced electric dipole moment by $\mathbf{D} = 4\pi\epsilon_0\alpha_p\mathbf{E}$, the value $(7.0 \pm 2.2 \pm 1.3) \times 10^{-4} \text{ fm}^3$.

p MAGNETIC POLARIZABILITY β_p

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 $\bar{\alpha}_p$ 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 (see the erratum) $\alpha_N = (13.0 \pm 1.9 ^{+3.9}_{-1.5}) \times 10^{-4} \text{ fm}^3$ and $\beta_N = (-1.8 \pm 1.9 ^{+2.1}_{-0.9}) \times 10^{-4} \text{ fm}^3$.
- ²⁰ BLANPIED 01 gives $\alpha_p + \beta_p$ and $\alpha_p - \beta_p$. The separate α_p and β_p 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 $\alpha_p + \beta_p$.

p CHARGE RADIUS

This is the rms charge radius, $\sqrt{\langle r^2 \rangle}$.

VALUE (fm)	DOCUMENT ID	TECN	COMMENT
0.8768 ± 0.0069	MOHR	08	RVUE 2006 CODATA value

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

0.897 ± 0.018	BLUNDEN	05	SICK 03 + 2γ correction
0.8750 ± 0.0068	MOHR	05	RVUE 2002 CODATA value
0.895 ± 0.010 ± 0.013	SICK	03	$ep \rightarrow ep$ reanalysis
0.830 ± 0.040 ± 0.040	²⁴ ESCHRICH	01	$ep \rightarrow ep$
0.883 ± 0.014	MELNIKOV	00	1S Lamb Shift in H
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
0.865 ± 0.020	MCCORD	91	$ep \rightarrow ep$
0.862 ± 0.012	SIMON	80	$ep \rightarrow ep$
0.880 ± 0.030	BORKOWSKI	74	$ep \rightarrow ep$
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	$ep \rightarrow ep$

²⁴ESCHRICH 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.

<i>LIMIT</i> (years)	<i>PARTICLE</i>	<i>CL%</i>	<i>DOCUMENT ID</i>	<i>TECN</i>	<i>COMMENT</i>
>5.8 × 10²⁹	n	90	²⁵ ARAKI	06	KLND $n \rightarrow$ invisible
>2.1 × 10²⁹	p	90	²⁶ AHMED	04	SNO $p \rightarrow$ invisible
>1.9 × 10 ²⁹	n	90	²⁶ AHMED	04	SNO $n \rightarrow$ invisible
>1.8 × 10 ²⁵	n	90	²⁷ BACK	03	BORX
>1.1 × 10 ²⁶	p	90	²⁷ BACK	03	BORX
>3.5 × 10 ²⁸	p	90	²⁸ ZDESENKO	03	$p \rightarrow$ invisible
>1 × 10 ²⁸	p	90	²⁹ AHMAD	02	SNO $p \rightarrow$ invisible
>4 × 10 ²³	p	95	TRETYAK	01	$d \rightarrow n + ?$
>1.9 × 10 ²⁴	p	90	³⁰ BERNABEI	00B	DAMA
>1.6 × 10 ²⁵	p, n		^{31,32} EVANS	77	
>3 × 10 ²³	p		³² DIX	70	CNTR
>3 × 10 ²³	p, n		^{32,33} FLEROV	58	

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

²⁵ ARAKI 06 looks for signs of de-excitation of the residual nucleus after disappearance of a neutron from the s shell of ¹²C.

²⁶ AHMED 04 looks for γ rays from the de-excitation of a residual ¹⁵O* or ¹⁵N* following the disappearance of a neutron or proton in ¹⁶O.

²⁷ BACK 03 looks for decays of unstable nuclides left after N decays of parent ¹²C, ¹³C, ¹⁶O nuclei. These are “invisible channel” limits.

²⁸ ZDESENKO 03 gets this limit on proton disappearance in deuterium by analyzing SNO data in AHMAD 02.

²⁹ AHMAD 02 (see its footnote 7) looks for neutrons left behind after the disappearance of the proton in deuterons.

- ³⁰ 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.
- ³¹ EVANS 77 looks for the daughter nuclide ^{129}Xe from possible ^{130}Te decays in ancient Te ore samples.
- ³² This mean-life limit has been obtained from a half-life limit by dividing the latter by $\ln(2) = 0.693$.
- ³³ 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.

LIMIT (years)	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$>8 \times 10^5$	90		³⁴ GEER	00D	\bar{p}/p ratio, cosmic rays
>0.28			GABRIELSE	90	TRAP Penning trap
>0.08	90	1	BELL	79	CNTR Storage ring
$>1 \times 10^7$			GOLDEN	79	SPEC \bar{p}/p ratio, cosmic rays
$>3.7 \times 10^{-3}$			BREGMAN	78	CNTR Storage ring
³⁴ GEER 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**, 1173) 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}	$pn \rightarrow$ invisible	> 2.1×10^{-5}	90%
τ_{76}	$pp \rightarrow$ invisible	> 0.00005	90%

\bar{p} DECAY MODES

Mode	Partial mean life (years)	Confidence level
$\tau_{77} \quad \bar{p} \rightarrow e^- \gamma$	$> 7 \times 10^5$	90%
$\tau_{78} \quad \bar{p} \rightarrow \mu^- \gamma$	$> 5 \times 10^4$	90%
$\tau_{79} \quad \bar{p} \rightarrow e^- \pi^0$	$> 4 \times 10^5$	90%
$\tau_{80} \quad \bar{p} \rightarrow \mu^- \pi^0$	$> 5 \times 10^4$	90%
$\tau_{81} \quad \bar{p} \rightarrow e^- \eta$	$> 2 \times 10^4$	90%
$\tau_{82} \quad \bar{p} \rightarrow \mu^- \eta$	$> 8 \times 10^3$	90%
$\tau_{83} \quad \bar{p} \rightarrow e^- K_S^0$	> 900	90%
$\tau_{84} \quad \bar{p} \rightarrow \mu^- K_S^0$	$> 4 \times 10^3$	90%
$\tau_{85} \quad \bar{p} \rightarrow e^- K_L^0$	$> 9 \times 10^3$	90%
$\tau_{86} \quad \bar{p} \rightarrow \mu^- K_L^0$	$> 7 \times 10^3$	90%
$\tau_{87} \quad \bar{p} \rightarrow e^- \gamma \gamma$	$> 2 \times 10^4$	90%
$\tau_{88} \quad \bar{p} \rightarrow \mu^- \gamma \gamma$	$> 2 \times 10^4$	90%
$\tau_{89} \quad \bar{p} \rightarrow e^- \rho$		
$\tau_{90} \quad \bar{p} \rightarrow e^- \omega$	> 200	90%
$\tau_{91} \quad \bar{p} \rightarrow e^- K^*(892)^0$		

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	<i>n</i>	90	3	5	MCGREW 99	IMB3	
>1600	<i>p</i>	90	0	0.1	SHIOZAWA 98	SKAM	
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●							
> 540	<i>p</i>	90	0	0.2	MCGREW 99	IMB3	
> 70	<i>p</i>	90	0	0.5	BERGER 91	FREJ	
> 70	<i>n</i>	90	0	≤ 0.1	BERGER 91	FREJ	
> 550	<i>p</i>	90	0	0.7	³⁵ BECKER-SZ... 90	IMB3	
> 260	<i>p</i>	90	0	<0.04	HIRATA 89C	KAMI	
> 130	<i>n</i>	90	0	<0.2	HIRATA 89C	KAMI	
> 310	<i>p</i>	90	0	0.6	SEIDEL 88	IMB	
> 100	<i>n</i>	90	0	1.6	SEIDEL 88	IMB	
> 1.3	<i>n</i>	90	0		BARTELT 87	SOUD	
> 1.3	<i>p</i>	90	0		BARTELT 87	SOUD	

> 250	<i>p</i>	90	0	0.3	HAINES	86	IMB
> 31	<i>n</i>	90	8	9	HAINES	86	IMB
> 64	<i>p</i>	90	0	<0.4	ARISAKA	85	KAMI
> 26	<i>n</i>	90	0	<0.7	ARISAKA	85	KAMI
> 82	<i>p</i> (free)	90	0	0.2	BLEWITT	85	IMB
> 250	<i>p</i>	90	0	0.2	BLEWITT	85	IMB
> 25	<i>n</i>	90	4	4	PARK	85	IMB
> 15	<i>p, n</i>	90	0		BATTISTONI	84	NUSX
> 0.5	<i>p</i>	90	1	0.3	³⁶ BARTELT	83	SOUD
> 0.5	<i>n</i>	90	1	0.3	³⁶ BARTELT	83	SOUD
> 5.8	<i>p</i>	90	2		³⁷ KRISHNA...	82	KOLR
> 5.8	<i>n</i>	90	2		³⁷ KRISHNA...	82	KOLR
> 0.1	<i>n</i>	90			³⁸ GURR	67	CNTR

³⁵ This BECKER-SZENDY 90 result includes data from SEIDEL 88.

³⁶ Limit based on zero events.

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

³⁸ We have converted half-life to 90% CL mean life.

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

τ_2

<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>
>473	<i>p</i>	90	0	0.6	MCGREW 99	IMB3
>100	<i>n</i>	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

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

τ_3

<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	³⁹ 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		⁴⁰ KRISHNA...	82	KOLR
> 0.3	<i>p</i>	90	2		⁴¹ CHERRY	81	HOME
> 0.1	<i>p</i>	90			⁴² GURR	67	CNTR

³⁹ In 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.

⁴⁰ We have calculated 90% CL limit from 1 confined event.

⁴¹ We have converted 2 possible events to 90% CL limit.

⁴² We have converted half-life to 90% CL mean life.

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

T4

<u>LIMIT</u> <u>(10³⁰ years)</u>	<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	<i>p</i>	90	1	1.7	WALL	00B SOU2
> 44	<i>p</i>	90	0	0.1	BERGER	91 FREJ
>140	<i>p</i>	90	0	<0.04	HIRATA	89C KAMI
>100	<i>p</i>	90	0	0.6	SEIDEL	88 IMB
>200	<i>p</i>	90	5	3.3	HAINES	86 IMB
> 64	<i>p</i>	90	0	<0.8	ARISAKA	85 KAMI
> 64	<i>p</i> (free)	90	5	6.5	BLEWITT	85 IMB
>200	<i>p</i>	90	5	4.7	BLEWITT	85 IMB
> 1.2	<i>p</i>	90	2		⁴³ CHERRY	81 HOME

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

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

T5

<u>LIMIT</u> <u>(10³⁰ years)</u>	<u>PARTICLE</u>	<u>CL%</u>	<u>EVTS</u>	<u>BKGD EST</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
>126	<i>p</i>	90	3	2.8	MCGREW	99 IMB3
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●						
> 89	<i>p</i>	90	0	1.6	WALL	00B SOU2
> 26	<i>p</i>	90	1	0.8	BERGER	91 FREJ
> 69	<i>p</i>	90	1	<0.08	HIRATA	89C KAMI
> 1.3	<i>p</i>	90	0	0.7	PHILLIPS	89 HPW
> 34	<i>p</i>	90	1	1.5	SEIDEL	88 IMB
> 46	<i>p</i>	90	7	6	HAINES	86 IMB
> 26	<i>p</i>	90	1	<0.8	ARISAKA	85 KAMI
> 17	<i>p</i> (free)	90	6	6	BLEWITT	85 IMB
> 46	<i>p</i>	90	7	8	BLEWITT	85 IMB

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

T6

LIMIT (10 ³⁰ years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID	TECN
>158	<i>n</i>	90	0	1.2	MCGREW	99 IMB3
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●						
> 71	<i>n</i>	90	2	3.7	WALL	00B SOU2
> 29	<i>n</i>	90	0	0.9	BERGER	89 FREJ
> 54	<i>n</i>	90	2	0.9	HIRATA	89C KAMI
> 16	<i>n</i>	90	3	2.1	SEIDEL	88 IMB
> 25	<i>n</i>	90	7	6	HAINES	86 IMB
> 30	<i>n</i>	90	0	0.4	KAJITA	86 KAMI
> 18	<i>n</i>	90	4	3	PARK	85 IMB
> 0.6	<i>n</i>	90	2		⁴⁴ CHERRY	81 HOME

⁴⁴We have converted 2 possible events to 90% CL limit.

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

T7

LIMIT (10 ³⁰ years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID	TECN
>217	<i>n</i>	90	4	4.8	MCGREW	99 IMB3
> 75	<i>p</i>	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	⁴⁵ BARTELT	83 SOUD
> 0.5	<i>p</i>	90	1	0.3	⁴⁵ BARTELT	83 SOUD
> 9.8	<i>p</i>	90	1		⁴⁶ KRISHNA...	82 KOLR
> 0.8	<i>p</i>	90	2		⁴⁷ CHERRY	81 HOME

⁴⁵Limit based on zero events.

⁴⁶We have calculated 90% CL limit from 0 confined events.

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

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

T8

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

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

τ_9

<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		⁴⁸ CHERRY	81	HOME
> 0.6	<i>n</i>	90	2		⁴⁸ CHERRY	81	HOME

⁴⁸We 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	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	49 BARTELT	83	SOUD
> 9.8	p	90	1		50 KRISHNA...	82	KOLR
> 2.8	p	90	2		51 CHERRY	81	HOME

⁴⁹ Limit based on zero events.

⁵⁰ We have calculated 90% CL limit from 0 confined events.

⁵¹ We 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	p	90	11	12.1	MCGREW	99 IMB3

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

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

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

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	n	90	12	22.5	MCGREW	99 IMB3

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

> 17	n	90	1	0.7	BERGER	89	FREJ
> 43	n	90	3	2.7	HIRATA	89C	KAMI
> 6	n	90	2	1.3	SEIDEL	88	IMB
> 12	n	90	6	6	HAINES	86	IMB
> 18	n	90	2	2	KAJITA	86	KAMI
> 16	n	90	1	2	PARK	85	IMB
> 2.0	n	90	2		52 CHERRY	81	HOME

⁵² We 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	n	90	35	29.4	MCGREW	99 IMB3
>150	p	90	0	<0.27	HIRATA	89C KAMI

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

> 85	p	90	3	4.9	WALL	00	SOU2
> 31	p	90	23	25.2	MCGREW	99	IMB3
> 60	p	90	0		BERGER	91	FREJ
> 70	p	90	0	1.8	SEIDEL	88	IMB
> 77	p	90	5	4.5	HAINES	86	IMB
> 38	p	90	0	<0.8	ARISAKA	85	KAMI
> 24	p (free)	90	7	8.5	BLEWITT	85	IMB
> 77	p	90	5	4	BLEWITT	85	IMB
> 1.3	p	90	0		ALEKSEEV	81	BAKS
> 1.3	n	90	0		ALEKSEEV	81	BAKS

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

τ_{14}

LIMIT (10^{30} years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID	TECN
>2000	p	90	6	4.7	⁵³ KOBAYASHI 05	SKAM

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

> 120	<i>p</i>	90	1	1.3	WALL	00	SOU2
> 76	<i>p</i>	90	0	0.5	BERGER	91	FREJ

⁵³ We have doubled the $p \rightarrow e^+ K^0$ limit given in KOBAYASHI 05 to obtain this $p \rightarrow e^+ K_S^0$ limit.

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

τ_{15}

LIMIT (10^{30} years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID	TECN	
>51	p	90	2	3.5	WALL	00	SOU2

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

>44	<i>p</i>	90	0	≤ 0.1	BERGER	91	FREJ
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$\tau(N \rightarrow \mu^+ K)$

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	<i>p</i>	90	0		BERGER	91	FREJ
> 3.0	<i>p</i>	90	0	0.7	PHILLIPS	89	HPW
> 19	<i>p</i>	90	3	2.5	SEIDEL	88	IMB
> 1.5	<i>p</i>	90	0		⁵⁴ BARTELT	87	SOUD
> 1.1	<i>n</i>	90	0		BARTELT	87	SOUD
> 40	<i>p</i>	90	7	6	HAINES	86	IMB
> 19	<i>p</i>	90	1	<1.1	ARISAKA	85	KAMI
> 6.7	<i>p</i> (free)	90	11	13	BLEWITT	85	IMB
> 40	<i>p</i>	90	7	8	BLEWITT	85	IMB
> 6	<i>p</i>	90	1		BATTISTONI	84	NUSX
> 0.6	<i>p</i>	90	0		⁵⁵ BARTELT	83	SOUD
> 0.4	<i>n</i>	90	0		⁵⁵ BARTELT	83	SOUD
> 5.8	<i>p</i>	90	2		⁵⁶ KRISHNA...	82	KOLR
> 2.0	<i>p</i>	90	0		CHERRY	81	HOME
> 0.2	<i>n</i>	90			⁵⁷ GURR	67	CNTR

⁵⁴ BARTELT 87 limit applies to $p \rightarrow \mu^+ K_S^0$.

⁵⁵ Limit based on zero events.

⁵⁶ We have calculated 90% CL limit from 1 confined event.

⁵⁷ 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
>2600	p	90	3	3.9	⁵⁸ KOBAYASHI 05	SKAM

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

> 150	<i>p</i>	90	0	<0.8	WALL	00	SOU2
> 64	<i>p</i>	90	0	1.2	BERGER	91	FREJ

⁵⁸ We have doubled the $p \rightarrow \mu^+ K^0$ limit given in KOBAYASHI 05 to obtain this $p \rightarrow \mu^+ K_S^0$ limit.

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

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	<i>p</i>	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	
>2300	p	90	0	1.3	KOBAYASHI	05	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
> 670	<i>p</i>	90			HAYATO	99	SKAM
> 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	⁵⁹ 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	89C	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		⁶⁰ 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		⁶¹ BARTELT	83	SOUD
> 0.1	<i>p</i>	90	0		⁶¹ BARTELT	83	SOUD
> 5.8	<i>p</i>	90	1		⁶² KRISHNA...	82	KOLR
> 0.3	<i>n</i>	90	2		⁶³ CHERRY	81	HOME

⁵⁹This ALLISON 98 limit is with no background subtraction; with subtraction the limit becomes $> 46 \times 10^{30}$ years.

⁶⁰BARTELT 87 limit applies to $n \rightarrow \nu K_S^0$.

⁶¹Limit based on zero events.

⁶²We have calculated 90% CL limit from 1 confined event.

⁶³We have converted 2 possible events to 90% CL limit.

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

T20

<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>
>260	n	90	34	30	⁶⁴ KOBAYASHI 05	SKAM

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

> 51	n	90	16	9.1	WALL	00	SOU2
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⁶⁴We have doubled the $n \rightarrow \nu K^0$ limit given in KOBAYASHI 05 to obtain this $n \rightarrow \nu K_S^0$ limit.

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

T21

<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	p	90	38	52.0	MCGREW	99	IMB3

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

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

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

T22

<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	p	90	7	9.1	MCGREW	99	IMB3
>78	n	90	40	50	MCGREW	99	IMB3

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

>22	n	90	0	2.1	BERGER	89	FREJ
>17	p	90	0	2.4	BERGER	89	FREJ
>20	p	90	5	2.1	HIRATA	89C	KAMI
>21	n	90	4	2.4	HIRATA	89C	KAMI
>10	p	90	7	6	HAINES	86	IMB
> 5	n	90	8	7	HAINES	86	IMB
> 8	p	90	3	2	KAJITA	86	KAMI
> 6	n	90	2	1.6	KAJITA	86	KAMI
> 5.8	p (free)	90	10	16	BLEWITT	85	IMB
> 9.6	p	90	7	6	BLEWITT	85	IMB
> 7	n	90	1	4	PARK	85	IMB
> 2.1	p	90	1		⁶⁵ BATTISTONI	82	NUSX

⁶⁵We 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	p	90	16	23.1	MCGREW 99	IMB3
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●						
>21	p	90	0	2.2	BERGER 91	FREJ

$\tau(p \rightarrow e^+ \pi^0 \pi^0)$ **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	p	90	2	0.8	MCGREW 99	IMB3
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●						
> 38	p	90	1	0.5	BERGER 91	FREJ

$\tau(n \rightarrow e^+ \pi^- \pi^0)$ **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	n	90	38	34.2	MCGREW 99	IMB3
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●						
>32	n	90	1	0.8	BERGER 91	FREJ

$\tau(p \rightarrow \mu^+ \pi^+ \pi^-)$ **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	p	90	25	38.0	MCGREW 99	IMB3
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●						
> 17	p	90	1	2.6	BERGER 91	FREJ
> 3.3	p	90	0	0.7	PHILLIPS 89	HPW

$\tau(p \rightarrow \mu^+ \pi^0 \pi^0)$ **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	p	90	3	1.6	MCGREW 99	IMB3
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●						
> 33	p	90	1	0.9	BERGER 91	FREJ

$\tau(n \rightarrow \mu^+ \pi^- \pi^0)$ **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	n	90	17	20.8	MCGREW 99	IMB3
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●						
>33	n	90	0	1.1	BERGER 91	FREJ

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

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

$\tau(n \rightarrow \mu^- \pi^+ \pi^0)$ **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	n	90	0	0.78	BERGER 91B	FREJ

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

<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>
>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**

<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>
>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**

<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>
>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			⁶⁶ GURR	67	CNTR

⁶⁶ We have converted half-life to 90% CL mean life.

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

<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>
>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			⁶⁷ GURR	67	CNTR

⁶⁷ We have converted half-life to 90% CL mean life.

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

<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>
>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	<i>p</i>	90	1	0.9	MCGREW 99	IMB3
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●						
> 81	<i>p</i>	90	0	0.16	BERGER 91	FREJ
> 5.0	<i>p</i>	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	<i>p</i>	90	152	153.7	MCGREW 99	IMB3
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●						
>11	<i>p</i>	90	11	6.08	BERGER 91B	FREJ

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

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	<i>n</i>	90	5	7.5	MCGREW 99	IMB3
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●						
> 74	<i>n</i>	90	0	< 0.1	BERGER 91B	FREJ
> 45	<i>n</i>	90	5	5	HAINES 86	IMB
> 26	<i>n</i>	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	<i>n</i>	90	25	29.4	MCGREW 99	IMB3
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●						
>47	<i>n</i>	90	0	< 0.1	BERGER 91B	FREJ

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

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	p	90	0	0.3	MCGREW 99	IMB3
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●						
>119	p	90	0	0.2	BERGER 91	FREJ
> 10.5	p	90	0	0.7	PHILLIPS 89	HPW
>190	p	90	1	0.1	HAINES 86	IMB
> 44	p (free)	90	1	0.7	BLEWITT 85	IMB
>190	p	90	1	0.9	BLEWITT 85	IMB
> 2.1	p	90	1		⁶⁸ BATTISTONI 82	NUSX

⁶⁸We 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	p	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	p	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. Such modes could of course be to three (or five) neutrinos, and the limits are stronger, but we do not repeat them here.

<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	n	90	2	2	⁶⁹ SUZUKI 93B	KAMI
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●						
>0.0023	n	90			⁷⁰ GLICENSTEIN 97	KAMI
>0.00003	n	90	11	6.1	⁷¹ BERGER 91B	FREJ
>0.00012	n	90	7	11.2	⁷¹ BERGER 91B	FREJ
>0.0005	n	90	0		LEARNED 79	RVUE

⁶⁹The SUZUKI 93B limit applies to any of $\nu_e \nu_e \bar{\nu}_e$, $\nu_\mu \nu_\mu \bar{\nu}_\mu$, or $\nu_\tau \nu_\tau \bar{\nu}_\tau$.

⁷⁰GLICENSTEIN 97 uses Kamioka data and the idea that the disappearance of the neutron's magnetic moment should produce radiation.

⁷¹The first BERGER 91B limit is for $n \rightarrow \nu_e \nu_e \bar{\nu}_e$, the second is for $n \rightarrow \nu_\mu \nu_\mu \bar{\nu}_\mu$.

$\tau(n \rightarrow 5\nu)$ **T58**

See the note on $\tau(n \rightarrow 3\nu)$ on the previous data block.

<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>
>0.0017	n	90			⁷² GLICENSTEIN 97	KAMI

⁷²GLICENSTEIN 97 uses Kamioka data and the idea that the disappearance of the neutron's magnetic moment should produce radiation.

————— Inclusive modes —————

$\tau(N \rightarrow e^+ \text{ anything})$ **T59**

<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>
>0.6	p, n	90			⁷³ LEARNED	79 RVUE

⁷³ The electron may be primary or secondary.

$\tau(N \rightarrow \mu^+ \text{ anything})$ **T60**

<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>
>12	p, n	90	2		^{74,75} CHERRY	81 HOME
> 1.8	p, n	90			⁷⁵ COWSIK	80 CNTR
> 6	p, n	90			⁷⁵ LEARNED	79 RVUE

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

⁷⁴ We have converted 2 possible events to 90% CL limit.

⁷⁵ The muon may be primary or secondary.

$\tau(N \rightarrow \nu \text{ anything})$ **T61**

Anything = π, ρ, K , etc.

<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>
>0.0002	p, n	90	0		LEARNED	79 RVUE

$\tau(N \rightarrow e^+ \pi^0 \text{ anything})$ **T62**

<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>
>0.6	p, n	90	0		LEARNED	79 RVUE

$\tau(N \rightarrow 2 \text{ bodies, } \nu\text{-free})$ **T63**

<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>
>1.3	p, n	90	0		ALEKSEEV	81 BAKS

————— $\Delta B = 2$ 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.						
<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>
>1.4	90			⁷⁶ ARAKI	06 KLND	$nn \rightarrow$ invisible
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●						
>0.000042	90			⁷⁷ TRETYAK	04 CNTR	
>0.000049	90			⁷⁸ BACK	03 BORX	
>0.000012	90			⁷⁹ BERNABEI	00B DAMA	
>0.000012	90	5	9.7	BERGER	91B FREJ	τ per iron nucleus

- ⁷⁶ ARAKI 06 looks for signs of de-excitation of the residual nucleus after disappearance of two neutrons from the *s* shell of ¹²C.
⁷⁷ TRETAK 04 uses data from an old Homestake-mine radiochemical experiment on limits for invisible decays of ³⁹K to ³⁷Ar.
⁷⁸ BACK 03 looks for decays of unstable nuclides left after *NN* decays of parent ¹²C, ¹³C, ¹⁶O nuclei. These are “invisible channel” limits.
⁷⁹ BERNABEI 00B looks for the decay of a ¹²⁷Xe nucleus following the disappearance of an *nn* pair in the otherwise-stable ¹²⁹Xe nucleus. The limit here applies as well to *nn* → $\nu_\mu \bar{\nu}_\mu$, *nn* → $\nu_\tau \bar{\nu}_\tau$, 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

$\tau(pn \rightarrow \text{invisible})$ **T75**

This violates charge conservation as well as baryon number conservation.

VALUE (10 ³⁰ years)	CL%	DOCUMENT ID	TECN
>0.000021	90	⁸⁰ TRETAK 04	CNTR

- ⁸⁰ TRETAK 04 uses data from an old Homestake-mine radiochemical experiment on limits for invisible decays of ³⁹K to ³⁷Ar.

$\tau(pp \rightarrow \text{invisible})$ **T76**

This violates charge conservation as well as baryon number conservation.

LIMIT (10 ³⁰ years)	CL%	EVTS	BKGD EST	CL%	DOCUMENT ID	TECN
>0.00005				90	⁸¹ BACK 03	BORX

- • • We do not use the following data for averages, fits, limits, etc. • • •
 >0.00000055 90 ⁸² BERNABEI 00B DAMA

- ⁸¹ BACK 03 looks for decays of unstable nuclides left after *NN* decays of parent ¹²C, ¹³C, ¹⁶O nuclei. These are “invisible channel” limits.
⁸² BERNABEI 00B looks for the decay of a ¹²⁷Te nucleus following the disappearance of a *pp* pair in the otherwise-stable ¹²⁹Xe nucleus.

\bar{p} PARTIAL MEAN LIVES

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

$\tau(\bar{p} \rightarrow e^- \gamma)$ **T77**

VALUE (years)	CL%	DOCUMENT ID	TECN	COMMENT
> 7 x 10⁵	90	GEER 00	APEX	8.9 GeV/ <i>c</i> \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

$\tau(\bar{p} \rightarrow \mu^- \gamma)$ **T78**

<u>VALUE (years)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
>5 × 10⁴	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 × 10 ⁴	90	HU 98B	APEX	8.9 GeV/c \bar{p} beam

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

<u>VALUE (years)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
> 4 × 10⁵	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

$\tau(\bar{p} \rightarrow \mu^- \pi^0)$ **T80**

<u>VALUE (years)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
>5 × 10⁴	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 × 10 ⁴	90	HU 98B	APEX	8.9 GeV/c \bar{p} beam

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

<u>VALUE (years)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
> 2 × 10⁴	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

$\tau(\bar{p} \rightarrow \mu^- \eta)$ **T82**

<u>VALUE (years)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
>8 × 10³	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 × 10 ³	90	HU 98B	APEX	8.9 GeV/c \bar{p} beam

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

<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

$\tau(\bar{p} \rightarrow \mu^- K_S^0)$ **T84**

<u>VALUE (years)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
>4 × 10³	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 × 10 ³	90	HU 98B	APEX	8.9 GeV/c \bar{p} beam

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

<u>VALUE (years)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
>9 × 10³	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

$\tau(\bar{p} \rightarrow \mu^- K_L^0)$ **T86**

VALUE (years)	CL%	DOCUMENT ID	TECN	COMMENT
$>7 \times 10^3$	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

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

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

$\tau(\bar{p} \rightarrow \mu^- \gamma \gamma)$ **T88**

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

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

VALUE (years)	CL%	DOCUMENT ID	TECN	COMMENT
>200	90	⁸³ GEER 00	APEX	8.9 GeV/c \bar{p} beam
⁸³ This GEER 00 measurement has been withdrawn; see GEER 00C.				

$\tau(\bar{p} \rightarrow e^- \omega)$ **T90**

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

$\tau(\bar{p} \rightarrow e^- K^*(892)^0)$ **T91**

VALUE (years)	CL%	DOCUMENT ID	TECN	COMMENT
$>1 \times 10^3$	90	⁸⁴ GEER 00	APEX	8.9 GeV/c \bar{p} beam
⁸⁴ This GEER 00 measurement has been withdrawn; see GEER 00C.				

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GEER	00C	PRL 85 3546 (erratum)	S. Geer <i>et al.</i>	(FNAL APEX Collab.)
GEER	00D	APJ 532 648	S.H. Geer, D.C. Kennedy	
MELNIKOV	00	PRL 84 1673	K. Melnikov <i>et al.</i>	(SLAC, KARL)
ROSENFELDR...	00	PL B479 381	R. Rosenfelder	
SENGUPTA	00	PL B484 275	S. Sengupta	
WALL	00	PR D61 072004	D. Wall <i>et al.</i>	(Soudan-2 Collab.)
WALL	00B	PR D62 092003	D. Wall <i>et al.</i>	(Soudan-2 Collab.)
GABRIELSE	99	PRL 82 3198	G. Gabrielse <i>et al.</i>	
HAYATO	99	PRL 83 1529	Y. Hayato <i>et al.</i>	(Super-Kamiokande Collab.)
MCGREW	99	PR D59 052004	C. McGrew <i>et al.</i>	(IMB-3 Collab.)
MOHR	99	JPCRD 28 1713	P.J. Mohr, B.N. Taylor	(NIST)
Also		RMP 72 351	P.J. Mohr, B.N. Taylor	(NIST)
TORII	99	PR A59 223	H.A. Torii <i>et al.</i>	(CERN PS-205 Collab.)
ALLISON	98	PL B427 217	W.W.M. Allison <i>et al.</i>	(Soudan-2 Collab.)
HU	98B	PR D58 111101	M. Hu <i>et al.</i>	(FNAL APEX Collab.)
SHIOZAWA	98	PRL 81 3319	M. Shiozawa <i>et al.</i>	(Super-Kamiokande Collab.)
GLICENSTEIN	97	PL B411 326	J.F. Glicenstein	(SACL)
MERGELL	96	NP A596 367	P. Mergell <i>et al.</i>	(MANZ, BONN)
GABRIELSE	95	PRL 74 3544	G. Gabrielse <i>et al.</i>	(HARV, MANZ, SEOUL)
MACGIBBON	95	PR C52 2097	B.E. MacGibbon <i>et al.</i>	(ILL, SASK, INRM)
GEER	94	PRL 72 1596	S. Geer <i>et al.</i>	(FNAL, UCLA, PSU)
WONG	94	IJMP E3 821	C.W. Wong	(UCLA)
HALLIN	93	PR C48 1497	E.L. Hallin <i>et al.</i>	(SASK, BOST, ILL)
SUZUKI	93B	PL B311 357	Y. Suzuki <i>et al.</i>	(KAMIOKANDE Collab.)
HUGHES	92	PRL 69 578	R.J. Hughes, B.I. Deutch	(LANL, AARH)
ZIEGER	92	PL B278 34	A. Zieger <i>et al.</i>	(MPCM)
Also		PL B281 417 (erratum)	A. Zieger <i>et al.</i>	(MPCM)
BERGER	91	ZPHY C50 385	C. Berger <i>et al.</i>	(FREJUS Collab.)
BERGER	91B	PL B269 227	C. Berger <i>et al.</i>	(FREJUS Collab.)
FEDERSPIEL	91	PRL 67 1511	F.J. Federspiel <i>et al.</i>	(ILL)
MCCORD	91	NIM B56/57 496	M. McCord <i>et al.</i>	
BECKER-SZ...	90	PR D42 2974	R.A. Becker-Szendy <i>et al.</i>	(IMB-3 Collab.)
ERICSON	90	EPL 11 295	T.E.O. Ericson, A. Richter	(CERN, DARM)
GABRIELSE	90	PRL 65 1317	G. Gabrielse <i>et al.</i>	(HARV, MANZ, WASH+)
BERGER	89	NP B313 509	C. Berger <i>et al.</i>	(FREJUS Collab.)
CHO	89	PRL 63 2559	D. Cho, K. Sangster, E.A. Hinds	(YALE)
HIRATA	89C	PL B220 308	K.S. Hirata <i>et al.</i>	(Kamiokande Collab.)
PHILLIPS	89	PL B224 348	T.J. Phillips <i>et al.</i>	(HPW Collab.)
KREISSL	88	ZPHY C37 557	A. Kreissl <i>et al.</i>	(CERN PS176 Collab.)
SEIDEL	88	PRL 61 2522	S. Seidel <i>et al.</i>	(IMB Collab.)
BARTELT	87	PR D36 1990	J.E. Bartelt <i>et al.</i>	(Soudan Collab.)
Also		PR D40 1701 (erratum)	J.E. Bartelt <i>et al.</i>	(Soudan Collab.)
COHEN	87	RMP 59 1121	E.R. Cohen, B.N. Taylor	(RISC, NBS)
HAINES	86	PRL 57 1986	T.J. Haines <i>et al.</i>	(IMB Collab.)
KAJITA	86	JPSJ 55 711	T. Kajita <i>et al.</i>	(Kamiokande Collab.)
ARISAKA	85	JPSJ 54 3213	K. Arisaka <i>et al.</i>	(Kamiokande Collab.)
BLEWITT	85	PRL 55 2114	G.B. Blewitt <i>et al.</i>	(IMB Collab.)
DZUBA	85	PL 154B 93	V.A. Dzuba, V.V. Flambaum, P.G. Silvestrov	(NOVO)
PARK	85	PRL 54 22	H.S. Park <i>et al.</i>	(IMB Collab.)
BATTISTONI	84	PL 133B 454	G. Battistoni <i>et al.</i>	(NUSEX Collab.)
MARINELLI	84	PL 137B 439	M. Marinelli, G. Morpurgo	(GENO)
WILKENING	84	PR A29 425	D.A. Wilkening, N.F. Ramsey, D.J. Larson	(HARV+)
BARTELT	83	PRL 50 651	J.E. Bartelt <i>et al.</i>	(MINN, ANL)
BATTISTONI	82	PL 118B 461	G. Battistoni <i>et al.</i>	(NUSEX Collab.)
KRISHNA...	82	PL 115B 349	M.R. Krishnaswamy <i>et al.</i>	(TATA, OSKC+)
ALEKSEEV	81	JETPL 33 651	E.N. Alekseev <i>et al.</i>	(PNPI)

Translated from ZETFP 33 664.

CHERRY	81	PRL 47 1507	M.L. Cherry <i>et al.</i>	(PENN, BNL)
COWSIK	80	PR D22 2204	R. Cowsik, V.S. Narasimham	(TATA)
SIMON	80	NP A333 381	G.G. Simon <i>et al.</i>	
BELL	79	PL 86B 215	M. Bell <i>et al.</i>	(CERN)
GOLDEN	79	PRL 43 1196	R.L. Golden <i>et al.</i>	(NASA, PSLL)
LEARNED	79	PRL 43 907	J.G. Learned, F. Reines, A. Soni	(UCI)
BREGMAN	78	PL 78B 174	M. Bregman <i>et al.</i>	(CERN)
ROBERTS	78	PR D17 358	B.L. Roberts	(WILL, RHEL)
EVANS	77	SCI 197 989	J.C. Evans Jr., R.I. Steinberg	(BNL, PENN)
HU	75	NP A254 403	E. Hu <i>et al.</i>	(COLU, YALE)
BORKOWSKI	74	NP A222 269	F. Borkowski <i>et al.</i>	
COHEN	73	JPCRD 2 664	E.R. Cohen, B.N. Taylor	(RISC, NBS)
DYLLA	73	PR A7 1224	H.F. Dylla, J.G. King	(MIT)
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)
