Number of Light Neutrino Types

The neutrinos referred to in this section are those of the Standard SU(2)×U(1) Electroweak Model possibly extended to allow nonzero neutrino masses. Light neutrinos are those with $m_\nu < m_Z/2$. The limits are on the number of neutrino families or species, including ν_e, ν_μ, ν_τ

A REVIEW GOES HERE – Check our WWW List of Reviews

Number from $e^+ e^-$ Colliders

Number of Light ν Types

Our evaluation uses the invisible and leptonic widths of the Z boson from our combined fit shown in the Particle Listings for the Z Boson, and the Standard Model value Γ_ν/Γ_ℓ = 1.992 ± 0.003.

VALUE	*DOCUMENT ID*		*TECN*
2.991±0.016 OUR EVALUATION	Combined fit to all LEP data.		
• • • We do not use the following data for averages, fits, limits, etc. • • •			
3.00 ±0.05	[1] LEP	92	RVUE

[1] Simultaneous fits to all measured cross section data from all four LEP experiments.

Number of Light ν Types from Direct Measurement of Invisible Z Width

In the following, the invisible Z width is obtained from studies of single-photon events from the reaction $e^+ e^- \to \nu\overline{\nu}\gamma$. All are obtained from LEP runs in the $E_{\rm cm}^{ee}$ range 88–94 GeV.

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
3.09±0.13 OUR AVERAGE				
3.23±0.16±0.10	AKERS	95C	OPAL	1990–1992 LEP runs
2.68±0.20±0.20	BUSKULIC	93L	ALEP	1990–1991 LEP runs
3.24±0.46±0.22	ADEVA	92	L3	1990 LEP run
3.14±0.24±0.12	ADRIANI	92E	L3	1991 LEP run
• • • We do not use the following data for averages, fits, limits, etc. • • •				
3.1 ±0.6 ±0.1	ADAM	96C	DLPH	$\sqrt{s}$ = 130, 136 GeV

Limits from Astrophysics and Cosmology

Number of Light ν Types

("light" means < about 1 MeV). See also OLIVE 81. For a review of limits based on Nucleosynthesis, Supernovae, and also on terrestial experiments, see DENEGRI 90.

VALUE	DOCUMENT ID		TECN
• • • We do not use the following data for averages, fits, limits, etc. • • •			
< 3.6	[2] OLIVE	95	COSM
< 3.1	OLIVE	95B	COSM
< 3.04	KERNAN	94	COSM
< 3.3	WALKER	91	COSM
< 3.4	OLIVE	90	COSM
< 5.2	ELLIS	86	COSM
< 4	STEIGMAN	86	COSM
< 4	YANG	84	COSM
< 4	YANG	79	COSM
< 7	STEIGMAN	77	COSM
	PEEBLES	71	COSM
<16	[3] SHVARTSMAN	69	COSM
	HOYLE	64	COSM

[2] OLIVE 95 limit assumes the existence of at least three (massless) neutrinos.
[3] SHVARTSMAN 69 limit inferred from his equations.

Number Coupling with Less Than Full Weak Strength

VALUE	DOCUMENT ID		TECN
• • • We do not use the following data for averages, fits, limits, etc. • • •			
<20	[4] OLIVE	81C	COSM
<20	[4] STEIGMAN	79	COSM

[4] Limit varies with strength of coupling. See also WALKER 91.

REFERENCES FOR Limits on Number of Light Neutrino Types

ADAM	96C	PL B380 471	+Adye, Agasi, Ajinenko, Aleksan+	(DELPHI Collab.)
AKERS	95C	ZPHY C65 47	+Alexander, Allison+	(OPAL Collab.)
OLIVE	95	PL B354 357	+Steigman	(MINN, OSU)
OLIVE	95B	APJS 97 49	+Steigman	(MINN, OSU)
KERNAN	94	PRL 72 3309	+Krauss	(CASE)
BUSKULIC	93L	PL B313 520	+De Bonis, Decamp+	(ALEPH Collab.)
ADEVA	92	PL B275 209	+Adriani, Aguilar-Benitez+	(L3 Collab.)
ADRIANI	92E	PL B292 463	+Aguilar-Benitez, Ahlen, Akbari, Alcaraz+	(L3 Collab.)
LEP	92	PL B276 247	+ALEPH, DELPHI, L3, OPAL	(LEP Collabs.)
WALKER	91	APJ 376 51	+Steigman, Schramm, Olive+	(HSCA, OSU, CHIC, MINN)
DENEGRI	90	RMP 62 1	+Sadoulet, Spiro	(CERN, UCB, SACL)
OLIVE	90	PL B236 454	+Schramm, Steigman, Walker	(MINN, CHIC, OSU, HARV)
ELLIS	86	PL 167B 457	+Enqvist, Nanopoulos, Sarkar	(CERN, OXFTP)
STEIGMAN	86	PL B176 33	+Olive, Schramm, Turner	(BART, MINN+)
YANG	84	APJ 281 493	+Turner, Steigman, Schramm, Olive	(CHIC, BART)
OLIVE	81	APJ 246 557	+Schramm, Steigman, Turner, Yang+	(CHIC, BART)
OLIVE	81C	NP B180 497	+Schramm, Steigman	(EFI, BART)
STEIGMAN	79	PRL 43 239	+Olive, Schramm	(BART, EFI)
YANG	79	APJ 227 697	+Schramm, Steigman, Rood	(CHIC, YALE, VIRG)
STEIGMAN	77	PL 66B 202	+Schramm, Gunn	(YALE, CHIC, CIT)
PEEBLES	71	Physical Cosmology Princeton Univ. Press (1971)		(PRIN)
SHVARTSMAN	69	JETPL 9 184 Translated from ZETFP 9 315.		(MOSU)

HOYLE	64	Nature 203 1108	+Tayler	(CAMB)