SUMMARY TABLES OF PARTICLE PROPERTIES

Extracted from the Particle Listings of the
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GAUGE AND HIGGS BOSONS

γ

$I(J^{PC}) = 0,1(1^{--})$

Mass $m < 6 \times 10^{-17}$ eV
Charge $q < 5 \times 10^{-30}$ e
Mean life τ = Stable

g
or gluon

$I(J^{P}) = 0(1^{-})$

Mass $m = 0$ [a]
SU(3) color octet

W

$J = 1$

Charge $= \pm 1$ e
Mass $m = 80.403 \pm 0.029$ GeV
$m_Z - m_W = 10.785 \pm 0.029$ GeV
$m_{W^+} - m_{W^-} = -0.2 \pm 0.6$ GeV
Full width $\Gamma = 2.141 \pm 0.041$ GeV
$\langle N_{\pi^\pm} \rangle = 15.70 \pm 0.35$
$\langle N_{K^\pm} \rangle = 2.20 \pm 0.19$
$\langle N_p \rangle = 0.92 \pm 0.14$
$\langle N_{\text{charged}} \rangle = 19.41 \pm 0.15$

W^- modes are charge conjugates of the modes below.

W^+ DECAY MODES		Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$\ell^+\nu$	[b]	(10.80 ± 0.09) %		–
$e^+\nu$		(10.75 ± 0.13) %		40201
$\mu^+\nu$		(10.57 ± 0.15) %		40201
$\tau^+\nu$		(11.25 ± 0.20) %		40182
hadrons		(67.60 ± 0.27) %		–
$\pi^+\gamma$		$< 8 \times 10^{-5}$	95%	40201
$D_s^+\gamma$		$< 1.3 \times 10^{-3}$	95%	40177
cX		(33.4 ± 2.6) %		–
$c\overline{s}$		$(31\ ^{+13}_{-11})$ %		–
invisible	[c]	(1.4 ± 2.8) %		–

Z

$J = 1$

Charge = 0
Mass $m = 91.1876 \pm 0.0021$ GeV [d]
Full width $\Gamma = 2.4952 \pm 0.0023$ GeV
$\Gamma(\ell^+\ell^-) = 83.984 \pm 0.086$ MeV [b]
$\Gamma(\text{invisible}) = 499.0 \pm 1.5$ MeV [e]
$\Gamma(\text{hadrons}) = 1744.4 \pm 2.0$ MeV
$\Gamma(\mu^+\mu^-)/\Gamma(e^+e^-) = 1.0009 \pm 0.0028$
$\Gamma(\tau^+\tau^-)/\Gamma(e^+e^-) = 1.0019 \pm 0.0032$ [f]

Average charged multiplicity

$\langle N_{charged} \rangle = 20.76 \pm 0.16$ (S = 2.1)

Couplings to leptons

$g_V^\ell = -0.03783 \pm 0.00041$
$g_A^\ell = -0.50123 \pm 0.00026$
$g^{\nu_e} = 0.53 \pm 0.09$
$g^{\nu_\mu} = 0.502 \pm 0.017$

Asymmetry parameters [g]

$A_e = 0.1515 \pm 0.0019$
$A_\mu = 0.142 \pm 0.015$
$A_\tau = 0.143 \pm 0.004$
$A_s = 0.90 \pm 0.09$
$A_c = 0.670 \pm 0.027$
$A_b = 0.923 \pm 0.020$

Charge asymmetry (%) at Z pole

$A_{FB}^{(0\ell)} = 1.71 \pm 0.10$
$A_{FB}^{(0u)} = 4 \pm 7$
$A_{FB}^{(0s)} = 9.8 \pm 1.1$
$A_{FB}^{(0c)} = 7.07 \pm 0.35$
$A_{FB}^{(0b)} = 9.92 \pm 0.16$

Z DECAY MODES		Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
e^+e^-		(3.363 ±0.004) %		45594
$\mu^+\mu^-$		(3.366 ±0.007) %		45594
$\tau^+\tau^-$		(3.370 ±0.008) %		45559
$\ell^+\ell^-$	[b]	(3.3658±0.0023) %		–
invisible		(20.00 ±0.06) %		–
hadrons		(69.91 ±0.06) %		–
$(u\overline{u}+c\overline{c})/2$		(11.6 ±0.6) %		–
$(d\overline{d}+s\overline{s}+b\overline{b})/3$		(15.6 ±0.4) %		–
$c\overline{c}$		(12.03 ±0.21) %		–
$b\overline{b}$		(15.12 ±0.05) %		–
$b\overline{b}b\overline{b}$		(3.6 ±1.3) $\times 10^{-4}$		–
ggg		< 1.1 %	CL=95%	–
$\pi^0\gamma$		$< 5.2 \times 10^{-5}$	CL=95%	45594
$\eta\gamma$		$< 5.1 \times 10^{-5}$	CL=95%	45592
$\omega\gamma$		$< 6.5 \times 10^{-4}$	CL=95%	45590
$\eta'(958)\gamma$		$< 4.2 \times 10^{-5}$	CL=95%	45589
$\gamma\gamma$		$< 5.2 \times 10^{-5}$	CL=95%	45594
$\gamma\gamma\gamma$		$< 1.0 \times 10^{-5}$	CL=95%	45594
$\pi^\pm W^\mp$	[h]	$< 7 \times 10^{-5}$	CL=95%	10146
$\rho^\pm W^\mp$	[h]	$< 8.3 \times 10^{-5}$	CL=95%	10120
$J/\psi(1S)$X		$(3.51\ ^{+0.23}_{-0.25}) \times 10^{-3}$	S=1.1	–
$\psi(2S)$X		(1.60 ±0.29) $\times 10^{-3}$		–
$\chi_{c1}(1P)$X		(2.9 ±0.7) $\times 10^{-3}$		–
$\chi_{c2}(1P)$X		$< 3.2 \times 10^{-3}$	CL=90%	–

Gauge & Higgs Boson Summary Table

$\Upsilon(1S)$ X + $\Upsilon(2S)$ X + $\Upsilon(3S)$ X			(1.0 ±0.5) × 10^{-4}			–
$\Upsilon(1S)$ X			< 4.4	× 10^{-5}	CL=95%	–
$\Upsilon(2S)$ X			< 1.39	× 10^{-4}	CL=95%	–
$\Upsilon(3S)$ X			< 9.4	× 10^{-5}	CL=95%	–
(D^0 / $\overline{D}^0$) X			(20.7 ±2.0) %			–
$D^{\pm}$ X			(12.2 ±1.7) %			–
$D^*(2010)^{\pm}$ X		[h]	(11.4 ±1.3) %			–
$D_{s1}(2536)^{\pm}$ X			(3.6 ±0.8) × 10^{-3}			–
$D_{sJ}(2573)^{\pm}$ X			(5.8 ±2.2) × 10^{-3}			–
$D^{*\prime}(2629)^{\pm}$ X			searched for			–
B^+ X			(6.12 ±0.15) %			–
B_s^0 X			(1.57 ±0.13) %			–
B_c^+ X			searched for			–
Λ_c^+ X			(1.54 ±0.33) %			–
b-baryon X			(1.51 ±0.26) %			–
anomalous γ + hadrons		[i]	< 3.2	× 10^{-3}	CL=95%	–
$e^+e^-\gamma$		[i]	< 5.2	× 10^{-4}	CL=95%	45594
$\mu^+\mu^-\gamma$		[i]	< 5.6	× 10^{-4}	CL=95%	45594
$\tau^+\tau^-\gamma$		[i]	< 7.3	× 10^{-4}	CL=95%	45559
$\ell^+\ell^-\gamma\gamma$		[j]	< 6.8	× 10^{-6}	CL=95%	–
$q\overline{q}\gamma\gamma$		[j]	< 5.5	× 10^{-6}	CL=95%	–
$\nu\overline{\nu}\gamma\gamma$		[j]	< 3.1	× 10^{-6}	CL=95%	45594
$e^{\pm}\mu^{\mp}$	LF	[h]	< 1.7	× 10^{-6}	CL=95%	45594
$e^{\pm}\tau^{\mp}$	LF	[h]	< 9.8	× 10^{-6}	CL=95%	45576
$\mu^{\pm}\tau^{\mp}$	LF	[h]	< 1.2	× 10^{-5}	CL=95%	45576
pe	L,B		< 1.8	× 10^{-6}	CL=95%	45589
$p\mu$	L,B		< 1.8	× 10^{-6}	CL=95%	45589

Higgs Bosons — H^0 and $H^{\pm}$, Searches for

H^0 Mass $m >$ 114.4 GeV, CL = 95%

H_1^0 in Supersymmetric Models ($m_{H_1^0} < m_{H_2^0}$)

Mass $m >$ 89.8 GeV, CL = 95%

A^0 Pseudoscalar Higgs Boson in Supersymmetric Models [k]

Mass $m >$ 90.4 GeV, CL = 95% $\tan\beta > 0.4$

$H^{\pm}$ Mass $m >$ 79.3 GeV, CL = 95%

See the Particle Listings for a Note giving details of Higgs Bosons.

Heavy Bosons Other Than Higgs Bosons, Searches for

Additional W Bosons

W' with standard couplings decaying to $e\nu$, $\mu\nu$

Mass $m >$ 800 GeV, CL = 95%

W_R — right-handed W

Mass $m >$ 715 GeV, CL = 90% (electroweak fit)

Additional Z Bosons

Z'_{SM} with standard couplings

Mass $m >$ 825 GeV, CL = 95% ($p\overline{p}$ direct search)

Mass $m >$ 1500 GeV, CL = 95% (electroweak fit)

Z_{LR} of $SU(2)_L \times SU(2)_R \times U(1)$ (with $g_L = g_R$)

Mass $m >$ 630 GeV, CL = 95% ($p\overline{p}$ direct search)

Mass $m >$ 860 GeV, CL = 95% (electroweak fit)

Z_χ of $SO(10) \rightarrow SU(5) \times U(1)_\chi$ (with $g_\chi = e/\cos\theta_W$)

Mass $m >$ 690 GeV, CL = 95% ($p\overline{p}$ direct search)

Mass $m >$ 781 GeV, CL = 95% (electroweak fit)

Z_ψ of $E_6 \rightarrow SO(10) \times U(1)_\psi$ (with $g_\psi = e/\cos\theta_W$)

Mass $m >$ 675 GeV, CL = 95% ($p\overline{p}$ direct search)

Mass $m >$ 366 GeV, CL = 95% (electroweak fit)

Z_η of $E_6 \rightarrow SU(3) \times SU(2) \times U(1) \times U(1)_\eta$ (with $g_\eta = e/\cos\theta_W$)

Mass $m >$ 720 GeV, CL = 95% ($p\overline{p}$ direct search)

Mass $m >$ 619 GeV, CL = 95% (electroweak fit)

Scalar Leptoquarks

Mass $m >$ 256 GeV, CL = 95% (1st generation, pair prod.)

Mass $m >$ 298 GeV, CL = 95% (1st gener., single prod.)

Mass $m >$ 202 GeV, CL = 95% (2nd gener., pair prod.)

Mass $m >$ 73 GeV, CL = 95% (2nd gener., single prod.)

Mass $m >$ 148 GeV, CL = 95% (3rd gener., pair prod.)

(See the Particle Listings for assumptions on leptoquark quantum numbers and branching fractions.)

Axions (A^0) and Other Very Light Bosons, Searches for

The standard Peccei-Quinn axion is ruled out. Variants with reduced couplings or much smaller masses are constrained by various data. The Particle Listings in the full *Review* contain a Note discussing axion searches.

The best limit for the half-life of neutrinoless double beta decay with Majoron emission is $> 7.2 \times 10^{24}$ years (CL = 90%).

NOTES

In this Summary Table:

When a quantity has "(S = ...)" to its right, the error on the quantity has been enlarged by the "scale factor" S, defined as $S = \sqrt{\chi^2/(N-1)}$, where N is the number of measurements used in calculating the quantity. We do this when $S > 1$, which often indicates that the measurements are inconsistent. When $S > 1.25$, we also show in the Particle Listings an ideogram of the measurements. For more about S, see the Introduction.

A decay momentum p is given for each decay mode. For a 2-body decay, p is the momentum of each decay product in the rest frame of the decaying particle. For a 3-or-more-body decay, p is the largest momentum any of the products can have in this frame.

[a] Theoretical value. A mass as large as a few MeV may not be precluded.

[b] ℓ indicates each type of lepton (e, μ, and τ), not sum over them.

[c] This represents the width for the decay of the W boson into a charged particle with momentum below detectability, p< 200 MeV.

[d] The Z-boson mass listed here corresponds to a Breit-Wigner resonance parameter. It lies approximately 34 MeV above the real part of the position of the pole (in the energy-squared plane) in the Z-boson propagator.

[e] This partial width takes into account Z decays into $\nu\overline{\nu}$ and any other possible undetected modes.

[f] This ratio has not been corrected for the τ mass.

[g] Here $A \equiv 2g_V g_A/(g_V^2+g_A^2)$.

[h] The value is for the sum of the charge states or particle/antiparticle states indicated.

[i] See the Z Particle Listings for the γ energy range used in this measurement.

[j] For $m_{\gamma\gamma} = (60 \pm 5)$ GeV.

[k] The limits assume no invisible decays.