W/Z MASS RATIO

The fit uses the W and Z mass, mass difference, and mass ratio measurements.

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
0.8798±0.0028 OUR FIT				
0.8813±0.0036±0.0019	156	[11] ALITTI 92B	UA2	$E_{\rm cm}^{p\overline{p}}$= 630 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.8831±0.0048±0.0026		[11] ALITTI 90B	UA2	$E_{\rm cm}^{p\overline{p}}$= 546,630 GeV

[11] Scale error cancels in this ratio.

$m_Z - m_W$

The fit uses the W and Z mass, mass difference, and mass ratio measurements.

VALUE (GeV)	DOCUMENT ID	TECN	COMMENT
10.96±0.26 OUR FIT			
10.4 ±1.4 ±0.8	ALBAJAR 89	UA1	$E_{\rm cm}^{p\overline{p}}$= 546,630 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •			
11.3 ±1.3 ±0.9	ANSARI 87	UA2	$E_{\rm cm}^{p\overline{p}}$= 546,630 GeV

$m_{W^+} - m_{W^-}$

VALUE (GeV)	EVTS	DOCUMENT ID	TECN	COMMENT
−0.19±0.58	1722	ABE 90G	CDF	$E_{\rm cm}^{p\overline{p}}$= 1800 GeV

W WIDTH

The widths labelled "extracted value" are obtained by measuring $R = \sigma(W \rightarrow e\nu)/\sigma(Z \rightarrow e^+e^-)$ which is equal to $[\sigma(W)/\sigma(Z)]$ $[\Gamma(W \rightarrow e\nu)/\Gamma(Z \rightarrow ee)]$ $\Gamma(Z)/\Gamma(W)$. The bracketed quantities can be calculated with plausible reliability. $\Gamma(W)$ is then extracted by using a value of $\Gamma(Z)$ measured at LEP. The Standard Model prediction is 2.067 ± 0.021 (ROSNER 94).

VALUE (GeV)	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
2.08 ±0.07 OUR AVERAGE					
2.063±0.061±0.060			[12] ABE 94B	CDF	Extracted value
2.10 $^{+0.14}_{-0.13}$ ±0.09		3559	[13] ALITTI 92	UA2	Extracted value
2.18 $^{+0.26}_{-0.24}$ ±0.04			[14] ALBAJAR 91	UA1	Extracted value
• • • We do not use the following data for averages, fits, limits, etc. • • •					
2.16 ±0.17			[15] ABE 92I	CDF	Repl. by ABE 94B
2.12 ±0.20			[16] ABE 90	CDF	Repl. by ABE 92I
2.30 ±0.19 ±0.06			[17] ALITTI 90C	UA2	Extracted value
<5.4	90	149	[18] ALBAJAR 89	UA1	$E_{\rm cm}^{p\overline{p}}$= 546,630 GeV
2.8 $^{+1.4}_{-1.5}$ ±1.3		149	[18] ALBAJAR 89	UA1	$E_{\rm cm}^{p\overline{p}}$= 546,630 GeV
<7	90	251	ANSARI 87	UA2	$E_{\rm cm}^{p\overline{p}}$= 546,630 GeV
<7	90	119	APPEL 86	UA2	$E_{\rm cm}^{p\overline{p}}$= 546,630 GeV
<6.5	90	86	[19] ARNISON 86	UA1	Repl. by ALBAJAR 89
<7	90	27	ARNISON 83D	UA1	Repl. by ARNISON 86

[12] ABE 94B measured $R = 10.90 \pm 0.32 \pm 0.29$. The values of $\sigma(Z)$ and $\sigma(W)$ come from $O(\alpha_s^2)$ calculations using $m_W = 80.24 \pm 0.10$ GeV, and $m_Z = 91.188 \pm 0.007$ GeV along with the corresponding value of $\sin^2\theta_W = 0.2325 \pm 0.005$. They use $\sigma(W)/\sigma(Z) = 3.33 \pm 0.03$, $\Gamma(Z) = 2.492 \pm 0.007$ GeV, and $\Gamma(W \rightarrow e\nu_e)/\Gamma(Z \rightarrow e^+e^-) = 2.710 \pm 0.018$.

[13] ALITTI 92 measured $R = 10.4^{+0.7}_{-0.6} \pm 0.3$. The values of $\sigma(Z)$ and $\sigma(W)$ come from $O(\alpha_s^2)$ calculations using $m_W = 80.14 \pm 0.27$ GeV, and $m_Z = 91.175 \pm 0.021$ GeV along with the corresponding value of $\sin^2\theta_W = 0.2274$. They use $\sigma(W)/\sigma(Z) = 3.26 \pm 0.07 \pm 0.05$ and $\Gamma(Z) = 2.487 \pm 0.010$ GeV.

[14] ALBAJAR 91 measured $R = 9.5^{+1.1}_{-1.0}$ (stat. + syst.). $\sigma(W)/\sigma(Z)$ is calculated in QCD at the parton level using $m_W = 80.18 \pm 0.28$ GeV and $m_Z = 91.172 \pm 0.031$ GeV along with $\sin^2\theta_W = 0.2322 \pm 0.0014$. They use $\sigma(W)/\sigma(Z) = 3.23 \pm 0.05$ and $\Gamma(Z) = 2.498 \pm 0.020$ GeV.

[15] ABE 92I report $1216 \pm 38^{+27}_{-31}$ $W \rightarrow \mu\nu$ and $106 \pm 10^{+0.2}_{-1}$ $Z \rightarrow \mu^+\mu^-$ events which are combined with 2426 $W \rightarrow e\nu$ events of ABE 91C to derive the ratio σ_W B$(W \rightarrow \ell\nu)/\sigma_Z$ B$(Z \rightarrow \ell^+\ell^-)$= 10.0 ± 0.6 ± 0.4. Finally the value of $\Gamma(Z)$ measured by LEP 92 is used to extract $\Gamma(W)$.

[16] ABE 90 extract $\Gamma(W) = 2.19 \pm 0.20$ by using the value $\Gamma(Z) = 2.57 \pm 0.07$ GeV. However, in ABE 91C they update their analysis with a new LEP value $\Gamma(Z) = 2.496 \pm 0.016$; the value $\Gamma(W) = 2.12 \pm 0.20$ above reflects this update. They measured $R = 10.2 \pm 0.8 \pm 0.4$, assumed $\sin^2\theta_W = 0.229 \pm 0.007$, and took predicted values $\sigma(W)/\sigma(Z) = 3.23 \pm 0.03$ and $\Gamma(W \rightarrow e\nu)/\Gamma(Z \rightarrow ee) = 2.70 \pm 0.02$. This yields $\Gamma(W)/\Gamma(Z) = 0.85 \pm 0.08$. The quoted error for $\Gamma(W)$ includes systematic uncertainties. $E_{\rm cm}^{p\overline{p}} = 1800$ GeV.

[17] ALITTI 90C used the same technique as described for ABE 90. They measured $R = 9.38^{+0.82}_{-0.72} \pm 0.25$, obtained $\Gamma(W)/\Gamma(Z) = 0.902 \pm 0.074 \pm 0.024$. Using $\Gamma(Z) = 2.546 \pm 0.032$ GeV, they obtained the $\Gamma(W)$ value quoted above and the limits $\Gamma(W) < 2.56$ (2.64) GeV at the 90% (95%) CL. $E_{\rm cm}^{p\overline{p}} = 546{,}630$ GeV.

[18] ALBAJAR 89 result is from a total sample of 299 $W \rightarrow e\nu$ events.

[19] If systematic error is neglected, result is $2.7^{+1.4}_{-1.5}$ GeV. This is enhanced subsample of 172 total events.

W ANOMALOUS MAGNETIC MOMENT ($\Delta\kappa$)

The full magnetic moment is given by $\mu_W = e(1+\kappa+\lambda)/2m_W$. In the Standard Model, at tree level, $\kappa = 1$ and $\lambda = 0$. Some papers have defined $\Delta\kappa = 1-\kappa$ and assume that $\lambda = 0$. Note that the electric quadrupole moment is given by $-e(\kappa-\lambda)/m_W^2$. A description of the parameterization of these moments and additional references can be found in HAGIWARA 87 and BAUR 88. The parameter Λ appearing in the theoretical limits below is a regularization cutoff which roughly corresponds to the energy scale where the structure of the W boson becomes manifest.

VALUE ($e/2m_W$)	DOCUMENT ID	TECN
• • • We do not use the following data for averages, fits, limits, etc. • • •		
	[20] ALITTI 92C	UA2
	[21] SAMUEL 92	THEO
	[22] SAMUEL 91	THEO
	[23] GRIFOLS 88	THEO
	[24] GROTCH 87	THEO
	[25] VANDERBIJ 87	THEO
	[26] GRAU 85	THEO
	[27] SUZUKI 85	THEO
	[28] HERZOG 84	THEO

[20] ALITTI 92C measure $\kappa = 1^{+2.6}_{-2.2}$ and $\lambda = 0^{+1.7}_{-1.8}$ in $p\overline{p} \rightarrow e\nu\gamma + X$ at $\sqrt{s} = 630$ GeV. At 95%CL they report $-3.5 < \kappa < 5.9$ and $-3.6 < \lambda < 3.5$.

[21] SAMUEL 92 use preliminary CDF and UA2 data and find $-2.4 < \kappa < 3.7$ at 96%CL and $-3.1 < \kappa < 4.2$ at 95%CL respectively. They use data for $W\gamma$ production and radiative W decay.

[22] SAMUEL 91 use preliminary CDF data for $p\overline{p} \rightarrow W\gamma X$ to obtain $-11.3 \leq \Delta\kappa \leq 10.9$. Note that their $\kappa = 1-\Delta\kappa$.

[23] GRIFOLS 88 uses deviation from ρ parameter to set limit $\Delta\kappa \lesssim 65\ (M_W^2/\Lambda^2)$.

[24] GROTCH 87 finds the limit $-37 < \Delta\kappa < 73.5$ (90% CL) from the experimental limits on $e^+e^- \rightarrow \nu\overline{\nu}\gamma$ assuming three neutrino generations and $-19.5 < \Delta\kappa < 56$ for four generations. Note their $\Delta\kappa$ has the opposite sign as our definition.

[25] VANDERBIJ 87 uses existing limits to the photon structure to obtain $|\Delta\kappa| < 33$ (m_W/Λ). In addition VANDERBIJ 87 discusses problems with using the ρ parameter of the Standard Model to determine $\Delta\kappa$.

[26] GRAU 85 uses the muon anomaly to derive a coupled limit on the anomalous magnetic dipole and electric quadrupole (λ) moments $1.05 > \Delta\kappa \ln(\Lambda/m_W) + \lambda/2 > -2.77$. In the Standard Model $\lambda = 0$.

[27] SUZUKI 85 uses partial-wave unitarity at high energies to obtain $|\Delta\kappa| \lesssim 190$ $(m_W/\Lambda)^2$. From the anomalous magnetic moment of the muon, SUZUKI 85 obtains $|\Delta\kappa| \lesssim 2.2/\ln(\Lambda/m_W)$. Finally SUZUKI 85 uses deviations from the ρ parameter and obtains a very qualitative, order-of-magnitude limit $|\Delta\kappa| \lesssim 150\ (m_W/\Lambda)^4$ if $|\Delta\kappa| \ll 1$.

[28] HERZOG 84 consider the contribution of W-boson to muon magnetic moment including anomalous coupling of $WW\gamma$. Obtain a limit $-1 < \Delta\kappa < 3$ for $\Lambda \gtrsim 1$ TeV.

W^+ DECAY MODES

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

	Mode	Fraction (Γ_i/Γ)	Confidence level
Γ_1	$\ell^+\nu$	[a] (10.8±0.4) %	
Γ_2	$e^+\nu$	(10.8±0.4) %	
Γ_3	$\mu^+\nu$	(10.6±0.7) %	
Γ_4	$\tau^+\nu$	(10.8±1.0) %	
Γ_5	hadrons	(67.8±1.5) %	
Γ_6	$\pi^+\gamma$	< 5 × 10^{-4}	95%

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

CONSTRAINED FIT INFORMATION

An overall fit to 4 branching ratios uses 7 measurements and one constraint to determine 4 parameters. The overall fit has a χ^2 = 1.1 for 4 degrees of freedom.

The following *off-diagonal* array elements are the correlation coefficients $\left\langle\delta x_i \delta x_j\right\rangle/(\delta x_i \cdot \delta x_j)$, in percent, from the fit to the branching fractions, $x_i \equiv \Gamma_i/\Gamma_{\rm total}$. The fit constrains the x_i whose labels appear in this array to sum to one.

x_3	34		
x_4	43	15	
x_5	−70	−64	−82
	x_2	x_3	x_4