LEPEWWG/MW/98-02
29/09/98

LEP WW cross-section and W mass for '98 Summer conferences

Preliminary

The LEP Electroweak W Mass Working Group•

New preliminary results compared to **Moriond** '98 will appear in ***italic*** through the note.

The four LEP experiments have determined preliminary values of the W mass and the total WW cross-section using data taken at centre of mass energies ranging from 181 to 184 GeV. Each experiment has collected about 55 pb^{-1}.

In addition, all experiments have measured very preliminary WW production cross-section at 189 GeV for an average luminosity of about 36 pb^{-1}.

WW cross-section at 183 GeV

Table 1 summarises the cross section values, assuming standard model decay branching ratios for the W decay, obtained by ALEPH[1], DELPHI[2], L3***[3]*** and OPAL[4]. In the averaging procedure, the QCD component of the systematic errors has been taken as a correlated systematic between experiments. The average is ***15.86 ± 0.40*** pb, with a χ^2 per degree of freedom of 1.4/3; the common error amounts to 0.18 pb.

Experiment	Cross-section (pb)
ALEPH	15.51 ± 0.71
DELPHI	16.01 ± 0.83
L3	***16.53 ± 0.73***
OPAL	15.52 ± 0.71
Combined	***15.86 ± 0.40***

*Table 1: WW cross-section (**at 183 GeV**) from the four LEP experiments and combined value.*

W decay branching ratios

From individual channels cross-section values measured by the four experiments (at all centre of mass energies up to 183 GeV), the W decay branching ratios have been determined, with and without lepton universality assumption (table 2). Correlated errors between the individual channels have been taken into account.

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	Lepton Non-Universality			Lepton Universality
Experiment	$W \to e\nu$ (%)	$W \to \mu\nu$ (%)	$W \to \tau\nu$ (%)	$W \to$ hadrons (%)
ALEPH	11.2 ± 0.8 ± 0.3	9.9 ± 0.8 ± 0.2	9.7 ± 1.0 ± 0.3	69.0 ± 1.2 ± 0.6
DELPHI	9.9 ± 1.1 ± 0.5	11.4 ± 1.1 ± 0.5	11.2 ± 1.7 ± 0.7	67.5 ± 1.5 ± 0.9
L3	***10.5 ± 0.9 ± 0.2***	***10.2 ± 0.9 ± 0.2***	***9.0 ± 1.2 ± 0.3***	***70.1 ± 1.3 ± 0.4***
OPAL	11.7 ± 0.9 ± 0.3	10.1 ± 0.8 ± 0.3	10.3 ± 1.0 ± 0.3	67.9 ± 1.2 ± 0.6
Combined	***10.92 ± 0.49***	***10.29 ± 0.47***	***9.95 ± 0.60***	***68.79 ± 0.77***

Table 2: Summary of W branching ratios derived from WW cross-section measurements up to 183 GeV centre of mass energy.

B($W \to \tau\nu$) is 25% anti-correlated with the other two leptonic branching ratios, B($W \to e\nu$) and B($W \to \mu\nu$) are +***1.0***% correlated. Under the assumption of lepton universality, the measured hadronic W decay branching ratio is ***68.79 ± 0.77***%.

Within the Standard Model the branching fractions of the W boson depend on the six elements V_{qq} of the Cabibbo-Kobayashi-Maskawa quark-mixing matrix (V_{CKM}) not involving the top quark. In terms of these V_{qq} the branching fraction of leptonic W decays is given by

$$1/B(W \to leptons) = 3\ \left\{1 + \left[1 + \alpha_s(M_W^2)/\pi\right]\ \sum V_{ij}^2\right\}$$

where α_s is the strong coupling constant. Since V_{ud} is known much more precisely than V_{cs}, it is most useful to determine the latter. Using the current world-average values and errors of the other matrix elements not assuming the unitarity of V_{CKM}[5], and $\alpha_s(M_Z^2) = 0.118 \pm 0.003$[5], the result is:

$$|V_{cs}| = 1.04 \pm 0.04.$$

The error includes the errors on α_s and the other V_{qq} but is dominated by the statistical error on the W branching fractions.

The element V_{cs} is also determined by counting charm and strange jets in W decays. Details are given in [6-9].

W mass measurement

The W mass values determined by each of the four experiments [10-13], from semi-leptonic and hadronic WW decays at 183 GeV have been combined separately (table 3). Systematic uncertainties arising from ISR and fragmentation effects have been considered as correlated between experiments.

The combined W mass value, derived from the semi-leptonic channels (table 4), ***is 80.28 ± 0.11 ± 0.02*** GeV, the first error includes statistics and systematics, the latter corresponding to the uncertainty on the LEP beam energy [***14***]. The total common error is 0.04 GeV, the χ^2 per degree of freedom is 1.8/3.

The combined W mass value from the fully hadronic channel (table 3) is ***80.34 ± 0.11 ± 0.09 (FSI) ± 0.02 (LEP)*** GeV, the χ^2 per degree of freedom is 3.6/3. ALEPH quotes a 56 MeV error on the W mass due to Final State Interactions (Bose-Einstein and Color Reconnection effects), while the other three experiments assign 100 MeV systematic error for that effect. Conservatively a common systematic error of 90 MeV has been assigned in performing the average. The total common error amounts to 0.10 GeV.

The W masses from direct reconstruction of semi-leptonic and hadronic final states have been derived from the individual experiment mass combination (table 3), as the treatment of error correlations is better controlled by each experiment. The averaged W mass value is ***80.32 ± 0.08 ± 0.05 (FSI) ± 0.02 (LEP)*** GeV, the χ^2 per degree of freedom is 0.5/3 and the total common error amounts to 0.06 GeV.

Experiment	Semi-leptonic channel M_W (GeV)	Hadronic channel M_W (GeV)	Combined M_W (GeV)
ALEPH	***80.34 ± 0.19***	***80.41 ± 0.19***	***80.37 ± 0.14***
DELPHI	80.50 ± 0.27	80.02 ± 0.23	80.23 ± 0.18
L3	80.03 ± 0.25	80.51 ± 0.25	80.32 ± 0.18
OPAL	80.25 ± 0.20	80.48 ± 0.26	80.34 ± 0.15
Combined	***80.28 ± 0.12***	***80.34 ± 0.14***	***80.32 ± 0.10***

Table 3: Summary of W mass measurements by direct reconstruction ***(183 GeV****) from the four LEP experiments in i) the semi-leptonic channel, ii) the hadronic channel and iii) the combined M_W. The last row is the combination of the four measurements for the different channels. The errors include statistics and systematics.*

Earlier direct mass reconstruction (172 GeV) results have been combined by each experiments with the 183 GeV result, for semi-leptonic and hadronic channels. The same method has been used to combine the four experiment measurements; results are summarised in table 4.

The combined four-experiment W mass value in the semi-leptonic channel is $M_W^{leptonic}$ = ***80.31± 0.11 ± 0.02 (LEP)*** GeV (the χ^2 per degree of freedom is 1.6/3, the total common error amoints to 0.04 GeV), from the hadronic channel, the W mass is measured to be $M_W^{hadronic}$ = ***80.39 ± 0.10 ± 0.09 (FSI) ± 0.02 (LEP)*** GeV (the χ^2 per degree of freedom is 5.6/3, the total common error amoints to 0.10 GeV). At the current level of accuracy, there is no significant difference between the W mass determined in the fully hadronic and semi-leptonic channel. The combined mass value from all channels is M_W = ***80.36 ± 0.08 ± 0.05 (FSI) ± 0.02 (LEP)*** GeV (the χ^2 per degree of freedom is 1.1/3, the total common error amoints to 0.06 GeV).

This W mass measurement from direct reconstruction (at 172 and 183 GeV) is combined with the W mass determination from the WW cross-section at threshold (80.40 ± 0.22 GeV), yielding ***M_W = 80.37 ± 0.09 GeV.***

Experiment	Semi-leptonic channel M_W (GeV)	Hadronic channel M_W (GeV)	Combined M_W (GeV)
ALEPH	***80.34 ± 0.18***	***80.53 ± 0.18***	***80.44 ± 0.13***
DELPHI	80.50 ± 0.24	80.01 ± 0.22	80.24 ± 0.17
L3	80.09 ± 0.24	80.59 ± 0.23	80.40 ± 0.18
OPAL	80.29 ± 0.19	80.40 ± 0.24	80.34 ± 0.15
Combined	***80.31 ± 0.11***	***80.39 ± 0.14***	***80.36 ± 0.09***

Table 4: Summary of W mass measurements by direct reconstruction ***(172 and 183 GeV****) from the four LEP experiments in i) the semi-leptonic channel, ii) the hadronic channel and iii) the combined M_W. The last row is the combination of the four measurements for the different channels. The errors include statistics and systematics.*

WW cross-section at 189 GeV

All experiments have measured very preliminary WW production cross-sections at 189 GeV (table 5) for an average luminosity of 36 pb^{-1}. The average is 15.24 ± 0.57 pb, with a χ^2 per degree of freedom of 1.3/3; the conservative common error amounts to 0.40 pb.

Experiment	Cross-section (pb)
ALEPH	14.74 ± 0.85
DELPHI	16.00 ± 0.96
L3	15.44 ± 0.95
OPAL	15.04 ± 0.87
Combined	15.24 ± 0.57

*Table 5: WW cross-section (**at 189 GeV**) from the four LEP experiments and combined value.*

References:

[1] ALEPH Collaboration, ALEPH note 98-020 CONF-98-010.
[2] DELPHI Collaboration, DELPHI note 98-80 CONF 148.
[3] L3 Collaboration, L3 note 2276.
[4] OPAL Collaboration, OPAL Physics Note PN354.
[5] R.M. Barnett et al., Review of particles properties, Phys. Rev. D54 (1996) 1.
[6] ALEPH Collaboration, ALEPH note 98-011 CONF-98-001.
[7] DELPHI Collaboration, DELPHI note 98-107 CONF 174.
[8] L3 Collaboration, L3 note 2232.
[9] OPAL Collaboration, OPAL Physics Note PN355.
[10] ALEPH Collaboration, ALEPH note 98-060 CONF-98-031
[11] DELPHI Collaboration, DELPHI note 98-85 CONF 153.
[12] L3 Collaboration, L3 note 2277.
[13] OPAL Collaboration, OPAL Physics Note PN331.
[14] LEP Energy Calibration Working Group, contribution to ICHEP98 Abstract 352. LEP Energy note 98/02.