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LEP WW cross-sections and W mass for '98 winter conferences

Preliminary

The LEP Electroweak W Mass Working Group•

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}.

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 15.90 ± 0.41 pb, with a χ^2 per degree of freedom of 1.8/3; the common error amounts to 0.20 pb.

Experiment	Cross-section (pb)
ALEPH	15.51 ± 0.71
DELPHI	16.01 ± 0.83
L3	16.66 ± 0.73
OPAL	15.52 ± 0.71
Combined	15.90 ± 0.41

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

From individual channels cross-section values measured by the four experiments (at all centre of mass energies), 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.

	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	10.7 ± 0.9 ± 0.2	10.3 ± 0.9 ± 0.2	9.2 ± 1.2 ± 0.3	69.5 ± 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	10.97 ± 0.49	10.33 ± 0.47	9.99 ± 0.61	68.61 ± 0.78

Table 2: Summary of W branching ratios.

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$B(W \to \tau\nu)$ is 25% anti-correlated with the other two leptonic branching ratios, $B(W \to e\nu)$ and $B(W \to \mu\nu)$ are +1.6% correlated. Under the assumption of lepton universality, the measured hadronic W decay branching ratio is 68.61 ± 0.78%.

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}[6], and $\alpha_s(M_Z^2) = 0.118 \pm 0.003$[6], the result is:

$$|V_{cs}| = 1.03 \pm 0.04.$$

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 jets in W decays. Details are given in [7-9].

The W mass values determined by each of the four experiments, from semi-leptonic and hadronic WW decays 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 3-top), is 80.22 ± 0.11 ± 0.03 GeV, the first error includes statistics and systematics, the latter corresponding to the uncertainty on the LEP beam energy[5]. The total common error is 0.05 GeV, the χ^2 per degree of freedom is 1.8/3.

The combined W mass value from the fully hadronic channel (table 3-middle) is 80.36 ± 0.10 ± 0.10 (FSI) ± 0.03 (LEP) GeV, the χ^2 per degree of freedom is 3.8/3. Conservatively an error of 100 MeV has been assigned to final state interactions (Bose-Einstein and Color Reconnection effects). The total common error amounts to 0.11 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-bottom), as the treatment of error correlations is better controlled by each experiment. The averaged W mass value is 80.30 ± 0.08 ± 0.05 (FSI) ± 0.03 (LEP) GeV, the χ^2 per degree of freedom is 0.3/3 and the total common error amounts to 0.07 GeV.

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 $M_W^{leptonic} = 80.27 \pm 0.10 \pm 0.03$ (LEP) GeV, from the hadronic channel, the W mass is measured to be $M_W^{hadronic} = 80.40 \pm 0.10 \pm 0.10$ (FSI) ± 0.03 (LEP) 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 $M_W = 80.34 \pm 0.07 \pm 0.05$ (FSI) ± 0.03 (LEP) GeV.

This W mass measurement from direct reconstruction is combined with the W mass determination from the WW cross-section at threshold (80.40 ± 0.22 GeV), yielding M_W = 80.35 ± 0.09 GeV.

References:

[1] ALEPH Collaboration, ALEPH note 98-020 CONF-98-010.
[2] DELPHI Collaboration, DELPHI note 98-27 CONF 123.
[3] L3 Collaboration, L3 note 2236.
[4] OPAL Collaboration, OPAL Physics Note PN331.
[5] LEP Energy Calibration Working Group, LEP Energy Note 98/01.
[6] R.M. Barnett et al., Review of particles properties, Phys. Rev. D54 (1996) 1.
[7] ALEPH Collaboration, ALEPH note 98-011 CONF-98-001.
[8] DELPHI Collaboration, DELPHI note 97-114 CONF 96.
[9]] L3 Collaboration, L3 note 2232.

Semi-leptonic channel

	M_W (GeV)	Statistical Error	Uncorrelated Systematic	Correlated Systematic	FSI	LEP Energy	Total Error
ALEPH	80.16	0.20	0.07	0.03		0.03	0.22
DELPHI	80.50	0.26	0.06	0.02		0.03	0.27
L3	80.03	0.24	0.05	0.04		0.03	0.25
OPAL	80.25	0.18	0.06	0.04		0.03	0.20
COMBINED	80.22	0.11		0.03	0.00	0.03	0.12

Hadronic channel

	M_W (GeV)	Statistical Error	Uncorrelated Systematic	Correlated Systematic	FSI	LEP Energy	Total Error
ALEPH	80.45	0.18	0.04	0.04	0.10	0.03	0.22
DELPHI	80.02	0.20	0.03	0.03	0.10	0.03	0.23
L3	80.51	0.21	0.07	0.04	0.10	0.03	0.25
OPAL	80.48	0.23	0.05	0.06	0.10	0.03	0.26
COMBINED	80.36	0.10		0.04	0.10	0.03	0.15

Combined channel

	M_W (GeV)	Statistical Error	Uncorrelated Systematic	Correlated Systematic	FSI	LEP Energy	Total Error
ALEPH	80.30	0.13	0.06	0.03	0.05	0.03	0.16
DELPHI	80.23	0.16	0.03	0.02	0.06	0.03	0.18
L3	80.32	0.16	0.05	0.04	0.06	0.03	0.19
OPAL	80.34	0.14	0.04	0.03	0.05	0.03	0.15
COMBINED	80.30	0.08		0.03	0.05	0.03	0.10

Table 3: Details of W mass measurements at 183 GeV from the four LEP experiments in the semi-leptonic channel (top), the hadronic channel (middle) and the combined M_W (bottom).

Experiment	Semi-leptonic channel M_W (GeV)	Hadronic channel M_W (GeV)	Combined M_W (GeV)
ALEPH	80.20 ± 0.20	80.57 ± 0.21	80.38 ± 0.15
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	80.27 ± 0.11	80.40 ± 0.15	80.34 ± 0.10

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.