THE MASS AND WIDTH OF THE *W* BOSON

Revised March 2008 by C. Caso (University of Genova), M. W. Grünewald (University College Dublin and University Ghent), and A. Gurtu (Tata Institute).

The W mass and width definition used here corresponds to a Breit-Wigner with mass-dependent width.

Until 1995, the production and study of the W boson was the exclusive domain of the $\overline{p}p$ colliders at CERN and Fermilab. W production at hadron colliders is tagged by a high p_T lepton from W decay. Owing to unknown parton–parton effective energy and missing energy in the longitudinal direction, the experiments reconstruct only the transverse mass of the W, and derive the W mass from comparing the transverse mass distribution with Monte Carlo predictions as a function of M_W. These analyses use the electron and muon decay modes.

Beginning in 1996, the energy of the LEP accelerator increased to above 161 GeV, the threshold for W–pair production. A precise knowledge of the e^+e^- center-of-mass energy enables one to reconstruct the W mass, even if one of them decays leptonically. At LEP two methods have been used to obtain the W mass. In the first method the measured W–pair production cross sections, $\sigma(e^+e^- \rightarrow W^+W^-)$, have been used to determine the W mass using the predicted dependence of this cross section on M_W. At 161 GeV, which is just above the W–pair production threshold, this dependence is a much more sensitive function of the W mass than at the higher energies (172 to 209 GeV) at which LEP ran during 1996–2000. In the second method, which is used at the higher energies, the W mass has been determined by directly reconstructing the W and its invariant mass from its decay products.

Each LEP experiment has combined their own mass values properly taking into account the common systematic errors. In order to compute the LEP average W mass, each experiment has provided its measured W mass for the $q\overline{q}q\overline{q}$ and $q\overline{q}\ell\overline{\nu_\ell}$, $\ell = e, \mu, \tau$ channels at each center-of-mass energy, along with a detailed break-up of errors (statistical and uncorrelated, partially correlated and fully correlated systematics [1]) . These have been properly combined to obtain a LEP W mass of

$M_W = 80.376 \pm 0.033$ GeV, which includes W mass determination from W-pair producton cross section variation at threshold. Errors due to uncertainties in LEP energy (9 MeV), and possible effect of color reconnection (CR) and Bose–Einstein correlations (BEC) between quarks from different W's (8 MeV) are included. The mass difference between $q\overline{q}q\overline{q}$ and $q\overline{q}\ell\overline{\nu_\ell}$ final states (due to possible CR and BEC effects) is -12 ± 45 MeV. In a similar manner, the width results obtained at LEP have been combined, resulting in $\Gamma_W = 2.196 \pm 0.083$ GeV [1].

The two Tevatron experiments have also carried out the exercise of identifying common systematic errors and obtain an average W mass of $M_W = 80.430 \pm 0.040$ GeV and a preliminary W width of $\Gamma_W = 2.049 \pm 0.058$ GeV [2].

The LEP and Tevatron results on mass and width, which are based on all published and preliminary results available, are compared in Fig. 1 and Fig. 2. Combining these results, assuming no common systematics between the LEP and Tevatron measurements, yields an average W mass of $M_W = 80.398 \pm 0.025$ GeV and a preliminary W width of $\Gamma_W = 2.097 \pm 0.046$ GeV.

The Standard Model prediction from the electroweak fit, using Z–pole data plus $m_{\rm top}$ measurement, gives a W–boson mass of $M_W = 80.360 \pm 0.020$ GeV and a W–boson width of $\Gamma_W = 2.091 \pm 0.002$ GeV [3].

OUR FIT in the listing below is obtained by combining only published LEP and Tevatron results using the same procedure as above.

References

1. The LEP Collaborations: ALEPH, DELPHI, L3, OPAL, the LEP Electroweak Working Group, CERN-PH-EP/2006-042, `hep-ex/0612034` (14 December 2006).
2. The Tevatron Electroweak Working Group, for the CDF and DØ Collaborations: *Combination of CDF and DØ Results on the W Boson Mass and Width*, March 2008 (unpublished).
3. The LEP Collaborations: ALEPH, DELPHI, L3, OPAL, the LEP Electroweak Working Group, CERN-PH-EP/2007-039, `arXiv:0712.0929 [hep-ex]` (6 December 2007).

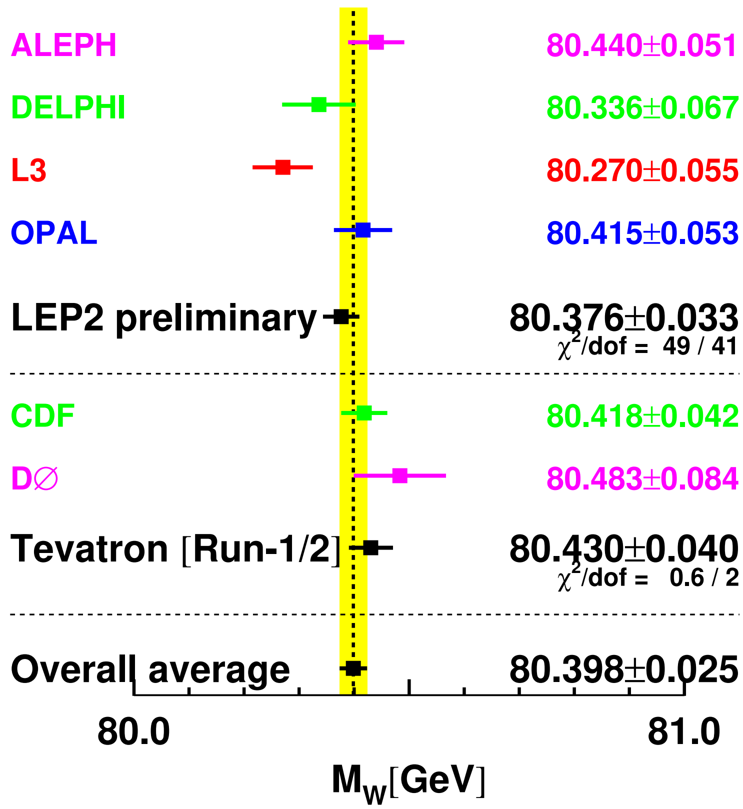

Figure 1: Measurements of the W-boson mass by the LEP and Tevatron experiments.

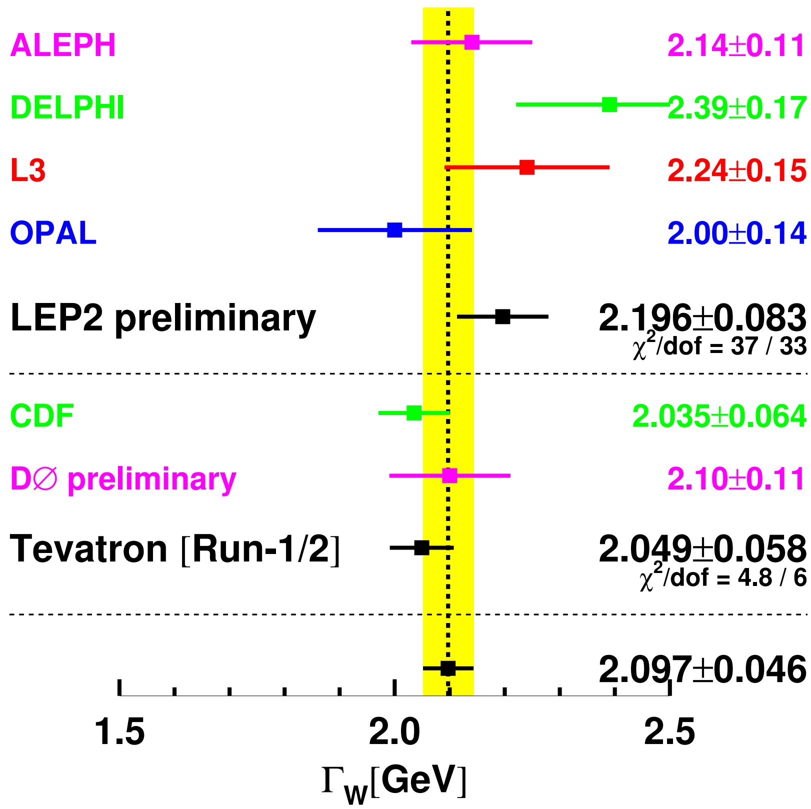

Figure 2: Measurements of the W-boson width by the LEP and Tevatron experiments.