THE MASS OF THE *W* BOSON

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Till 1995 the production and study of the W boson was the exclusive domain of the $\overline{p}p$ colliders at CERN and FNAL. W production in these 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.

Beginning 1996 the energy of LEP 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, $\sigma(e^+e^- \to W^+W^-)$, have been used to determine the W mass using the predicted dependence of this cross section on M_W (see Fig. 1). 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 has run 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 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 $q\overline{q}\ell\overline{\nu_\ell}$ 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 *preliminary* LEP W mass = 80.388±0.035 GeV [2], 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

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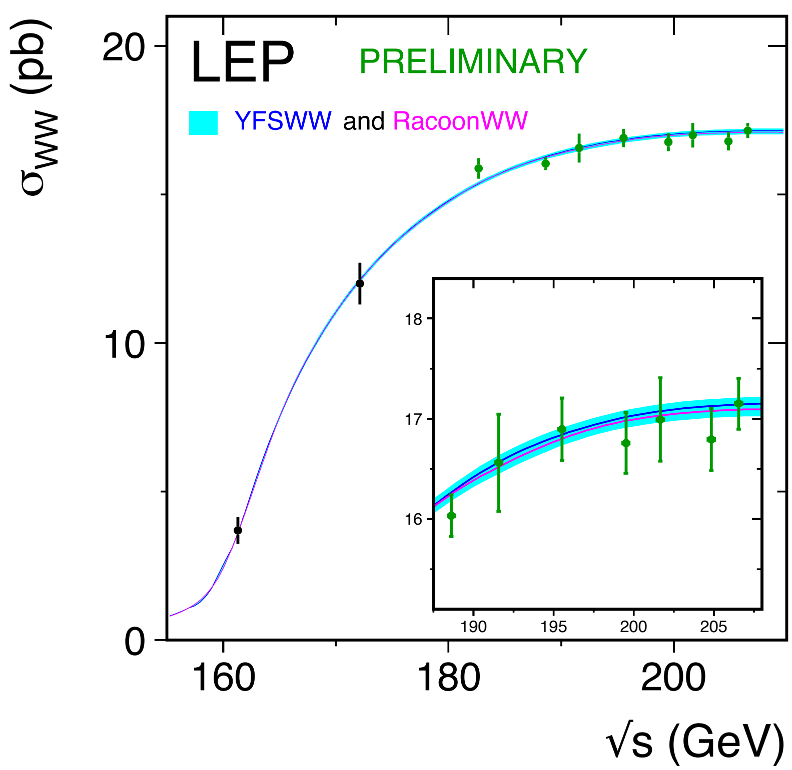

Figure 1: Measurement of the W-pair production cross section as a function of the center–of–mass energy [1], compared to the predictions of RACOONWW [3] and YFSWW [4]. The shaded area represents the uncertainty on the theoretical predictions, estimated to be $\pm 2\%$ for $\sqrt{s} < 170$ GeV and ranging from 0.7 to 0.4% above 170 GeV. See full-color version on color pages at end of book.

(BEC) between quarks from different W's (7 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 -4 ± 44 MeV.

For completeness we give here also the *preliminary* LEP value for the W width: $\Gamma(W) = 2.134 \pm 0.079$ GeV [2].

The two Tevatron experiments have also carried out the exercise of identifying common systematic errors and averaging with CERN UA2 data obtain an average W mass [5]= 80.454±0.059 GeV.

Combining the above W mass values from LEP and hadron colliders, which are based on all published and unpublished results, and assuming no common systematics between them, yields a *preliminary* average W mass of 80.405 ± 0.030 GeV.

Finally a fit to this directly determined W mass together with measurements on the ratio of W to Z mass (M_W/M_Z) and on their mass difference ($M_Z - M_W$) yields a world average W-boson mass of 80.406 ± 0.029 GeV.

The Standard Model prediction from the electroweak fit, using Z-pole data plus $m_{\rm top}$ measurement, gives a W–boson mass of 80.364 ± 0.021 GeV [1,2].

OUR FIT in the listing below is obtained by combining only published LEP and p–$\overline{p}$ Collider results using the same procedure as above.

References

1. The LEP Collaborations: ALEPH, DELPHI, L3, OPAL, the LEP Electroweak Working Group, CERN-PH-EP/2005-051, `hep-ex/0511027` (9 November 2005).
2. A. Venturi, "New (almost final) W mass and width results from LEP", talk given at "Les Rencontres de Physique de la Vallée d'Aoste", La Thuile (Italy), 5–11 March 2006.
3. A. Denner *et al.*, Nucl. Phys. **B587** 67, (2000).
4. S. Jadach *et al.*, Comput. Phys. Comm. **140**, 432 (2001).
5. V.M. Abazov *et al.*, Phys. Rev. **D70**, 092008 (2004).