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, $\sigma(e^+e^- \rightarrow W^+W^-)$, 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 208 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 $qqqq$ and $qq\ell\nu$ 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 = 80.412±0.042 GeV [2]. Errors due uncertainties in LEP energy (17 MeV) and possible effect of color reconnection (CR) and Bose–Einstein (BE) correlations between quarks from different W's are included. The mass difference between $qqqq$ and $qq\ell\nu$

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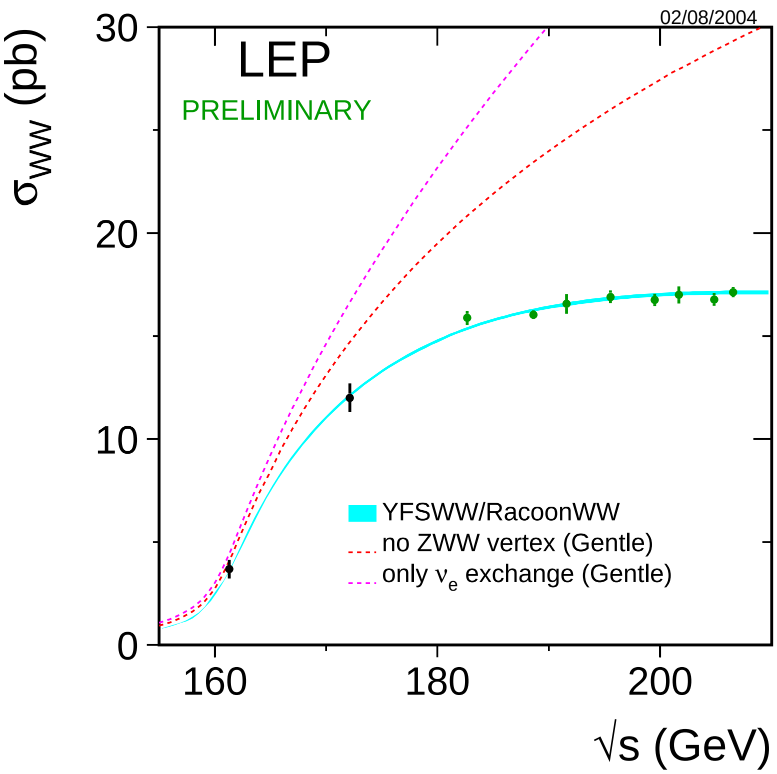

Figure 1: The W–pair cross section as a function of the center–of–mass energy. The data points are the LEP averages. The solid lines are predictions from different models of WW production. For comparison the figure contains also the cross section if the ZWW coupling did not exist (dashed line), or if only the t–channel ν_e exchange diagram existed (dotted-dashed line). (Figure from `http://lepewwg.web.cern.ch/LEPEWWG/lepww/4f/Summer04/wwxsec_ nocouplings_2004.eps`)
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final states (due to possible CR and BE effects) is $+22 \pm 43$ MeV.

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 [2]= 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 an average W mass of 80.426 ± 0.034 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 80.425 ± 0.033 GeV.

The Standard Model prediction from the electroweak fit, using Z-pole data plus $m_{\rm top}$ measurement, gives a W–boson mass of 80.379 ± 0.023 GeV [1].

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, and the SLD Heavy Flavour Group, CERN-PH-EP/2004-069, hep-ex/0412015 (6 December 2004).
2. V.M. Abazov *et al.*, Phys. Rev. **D70**, 092008 (2004).