

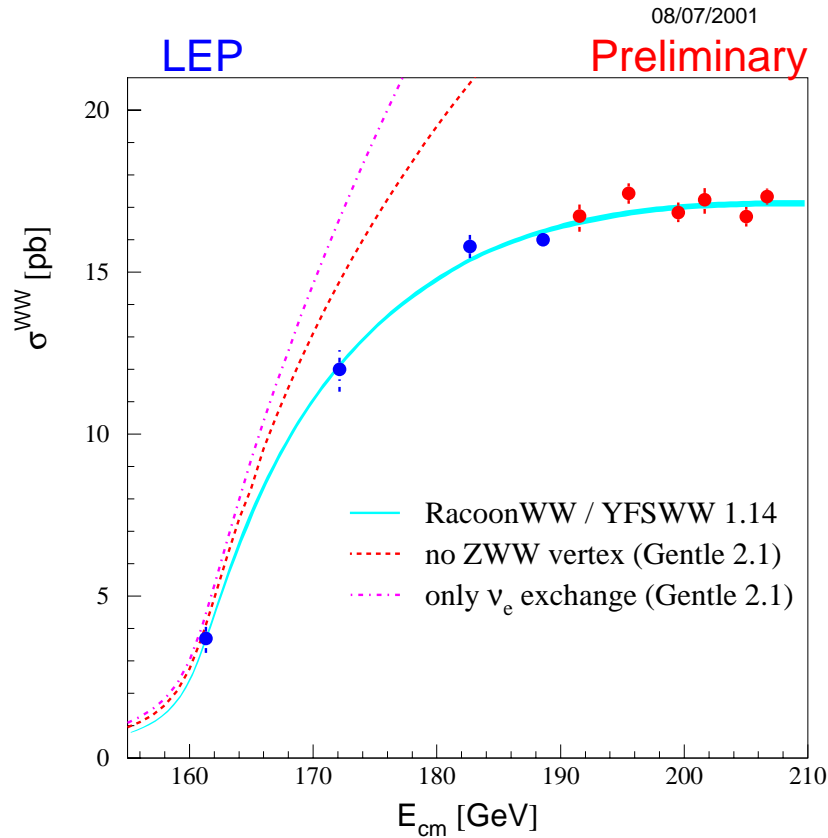
## THE MASS OF THE $W$ BOSON

Revised April 2002 by C. Caso (University of Genova) and A. Gurtu (Tata Institute).

Till 1995 the production and study of the  $W$  boson was the exclusive domain of the  $\bar{p}p$  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  $e^+e^-$  centre 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 =  $80.450 \pm 0.039$  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 (40 MeV and 25 MeV respectively) are included. The mass difference



**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  $\nu_e$  exchange diagram existed (dotted-dashed line). (Figure from [http://lepewwg.web.cern.ch/LEPEWWG/lepww/4f/summer01/s01\\_sww\\_no\\_tgc.eps](http://lepewwg.web.cern.ch/LEPEWWG/lepww/4f/summer01/s01_sww_no_tgc.eps))

between  $qqqq$  and  $qql\nu$  final states (due to possible CR and BE effects) is  $+9 \pm 44$  MeV.

The two Tevatron experiments have also carried out the exercise of identifying common systematic errors (25 MeV) and averaging with CERN UA2 data obtain an average  $W$  mass [2]=  $80.454 \pm 0.060$  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  $80.451 \pm 0.033$  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  $80.448 \pm 0.031$  GeV.

The Standard Model prediction from the electroweak fit, excluding the direct  $W$  mass measurements from LEP and Tevatron, gives a  $W$ -boson mass of  $80.373 \pm 0.023$  GeV [3].

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

## References

1. The LEP Collaborations: ALEPH, DELPHI, L3, OPAL, and the LEP  $W$  Working Group, LEPEWWG/MASS/2001-02, July 11, 2001, accessible at <http://lepewwg.web.cern.ch/LEPEWWG/lepww/mw/Summer01/>.
2. D. Charlton, “Experimental Tests of the Standard Model,” Int. Europhysics Conference on High Energy Physics, July 12–18, 2001 (Budapest, Hungary).
3. The LEP Collaborations: ALEPH, DELPHI, L3, OPAL, the LEP Electroweak Working Group, and the SLD Heavy Flavour and Electroweak Groups, CERN-EP-2001-098, [hep-ex/0112021](http://hep-ex/0112021) (December 2001).