ELECTROWEAK RESULTS FROM LEP

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Recent results from all four LEP experiments on tests of electroweak aspects of the Standard Model are presented briefly.

1 Introduction

Results presented here consist of data taken by the four LEP experiments at energies up to 209 GeV. Some of the results are still preliminary; most are reviewed in the report of the LEP Combined Results Working Group [1].

2 Fermion-pair and two photon production

A comparison of the measured cross-sections with the predictions of the Standard Model has been made. The agreement is good for both lepton pairs and for hadrons although the hadron production tantalisingly lies 1.8σ above the SM prediction. Physics beyond the Standard Model would show up as deviations of the data from the SM predictions. Two photon production, from the reaction e^+e^- to $\gamma\gamma(\gamma)$, is a pure QED proces at tree level. The detection of acolinear $\gamma\gamma$ pairs would constitute a signature of new physics. No such new effects have been observed.

3 WW and ZZ production

The WW data comprise three categories of events, all detected with high efficiency and containing low backgrounds. The first category, purely leptonic ($WW \rightarrow \ell\nu_\ell\ell\nu_\ell$), consists of two charged leptons with their corresponding neutrinos. With their two missing neutrinos, these events are underconstrained kinematically and so have limited impact on measurements of the W mass.

The second class, $WW \to q\bar{q}\ell\nu_\ell$, comprises two well separated hadronic jets, one charged lepton and its corresponding neutrino. The missing neutrino can be reconstructed via energy-momentum conservation. The final category, $WW \to q\bar{q}q\bar{q}$, consists of events with four well separated jets. Although kinematically well constrained, there is a basic ambiguity as to which pair of jets correspond to a given W. Decays of the W into all lepton flavours have been measured; results show agreement with lepton universality. The combined branching ratio, $W \to \ell\nu_\ell$, is $(10.69 \pm 0.09)\%$ in good agreement with the naive expectation from flavour counting, of 1/9. The WW cross-section, combining data from all LEP experiments, is shown in Fig.1. The data, taken at energies from the WW threshold up to 209 GeV, show excellent agreement with the Standard Model; the existence of the ZWW vertex is seen to be essential. Single W production imposes additional constraints on the γWW vertex. The corresponding charged Triple Gauge Couplings (TGCs) are measured.

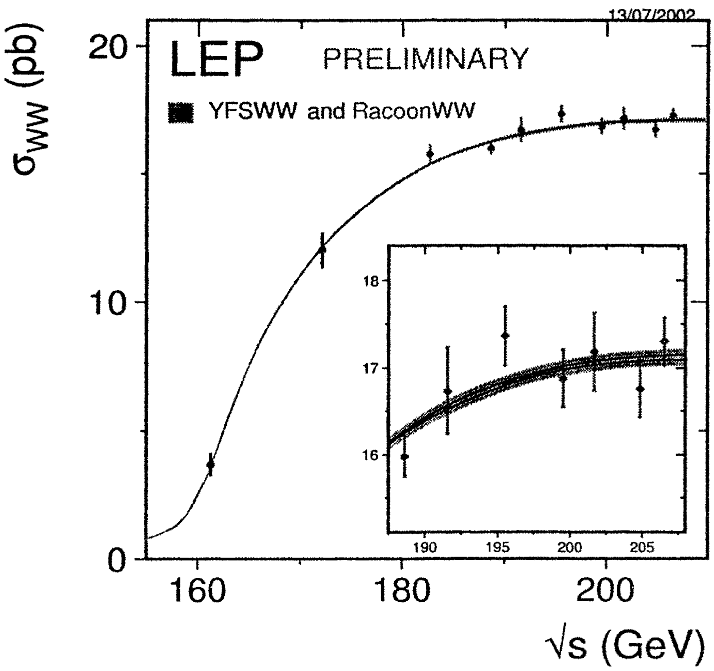

Figure 1: Measurements of the W pair production cross-section compared to the predictions of YFSWW [1] and RACOONWW [1].

Although ZZ production is approximately a factor 100 lower than for WW, sufficient ZZ events have been detected to make a meaningful comparison with the expectations of the Standard Model. Fig.2 shows that the agreement is good. ZZ production can proceed via t channel electron exchange or via *s* channel processes which involve neutral triple gauge couplings.

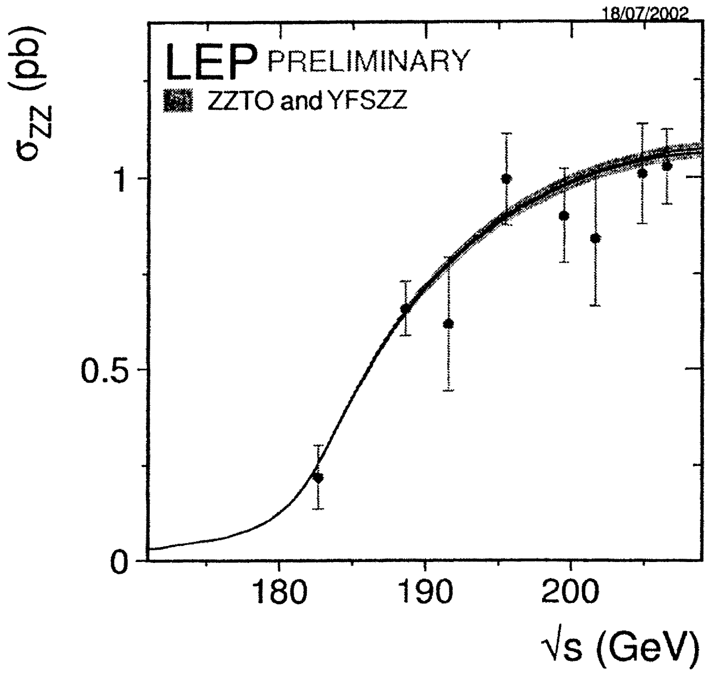

Figure 2: Measurements of the Z pair production cross-section compared to the predictions of YFSZZ [1] and ZZTO [1].

All LEP experiments have provided data on charged and neutral Triple Gauge Couplings as well as on Quartic Gauge Couplings (associated with the $ZZ\gamma\gamma$ vertex). No significant deviations from the predictions of the Standard Model have been found for any of the electroweak couplings studied.

The W mass can also be constructed directly from the lepton momenta and the jet momenta and energies. A kinematic fit is made over all quantities while the total energy and momentum are constrained to be equal to those of the colliding e^+e^- beams. Systematic uncertainties common to all WW decays are those concerning hadronisation ($\sim$ 18MeV) and LEP energy ($\sim$ 17MeV). In the $q\bar{q}q\bar{q}$ channel, there are two systematic error contributions (correlated between experiments) which are the subject of major study. When the two Ws decay hadronically, they may not hadronise independently as they decay well within 1 fermi. QCD final state interactions may occur: Colour Reconnection (CR) in the hadronic shower phase and Bose-Einstein (BE) correlations in the formation of hadrons. The difference, $\Delta M_W(q\bar{q}q\bar{q} - q\bar{q}\ell\nu) = +22 \pm 43$ MeV, indicates that there is no significant bias although errors are large. Current errors of 95MeV for CR and 35MeV for BE reduce the statistical impact of the $q\bar{q}q\bar{q}$ events to the W mass measurement to 10%. The resulting combined W mass from direct reconstruction, $M_W = (80.412 \pm 0.029(stat) \pm 0.031(syst))$GeV, is in very good agreement with other direct W mass measurements from hadron colliders. In the final result, the LEP W mass uncertainty is expected to fall from the current $\sim$ 42MeV to $\sim$ 35MeV.

4 Global electroweak tests

Data from LEP, SLD and the Tevatron are combined, including results from νN scattering and atomic parity violation. In Fig.3, the W mass is plotted against the top mass for both direct measurements (from LEP2 and the Tevatron) and indirect estimations from electroweak fits. The two values agree well, the direct and indirect W masses differing only by $\sim 1\sigma$. The good agreement shows the essential correctness of the Standard Model at 1 loop level.

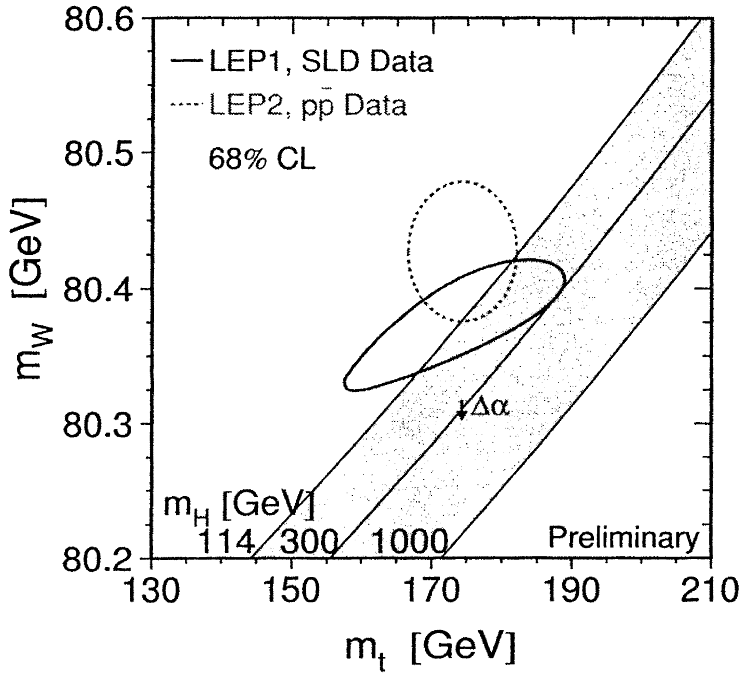

Figure 3: A comparison of direct (dotted contour) and indirect (solid line) measurements of the masses of the W boson and the top quark.

Fig.4 illustrates the power of each type of electroweak measurement in constraining the Higgs mass. For example, we see that σ^0_{had} and A_b provide little constraint while $A_\ell(SLD)$ and $A^{0,b}_{fb}$ depend sensitively on the Higgs mass and so their values limit tightly the possible range of M_H. The combined electroweak data [2] constrain the Higgs mass to the range, $M_H < 211$GeV, while direct

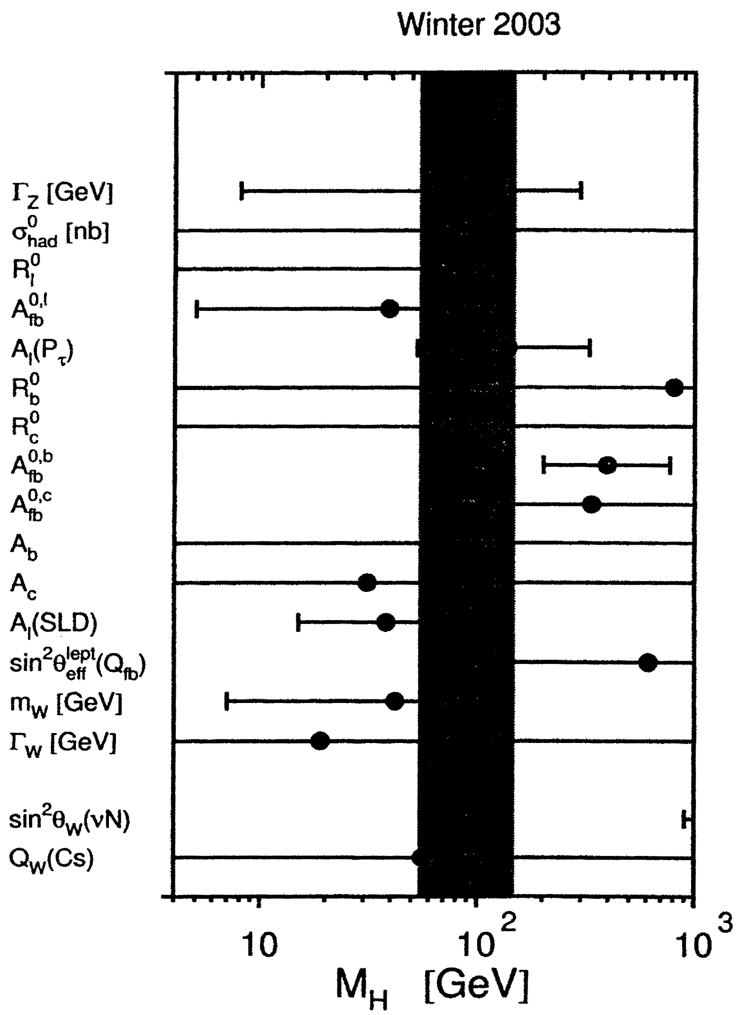

Figure 4: Sensitivity of the prediction of Higgs mass to the various electroweak measurements.

searches have imposed the limit, $M_H > 114.4GeV$ (both limits at 95%CL). There seems a clear preference for a relatively light Higgs boson.

Acknowledgements

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References

[1] The LEP Electroweak Working Group, CERN-EP/2002-091; hep-ex/0212036.

[2] A. Mehta, contribution to this conference.