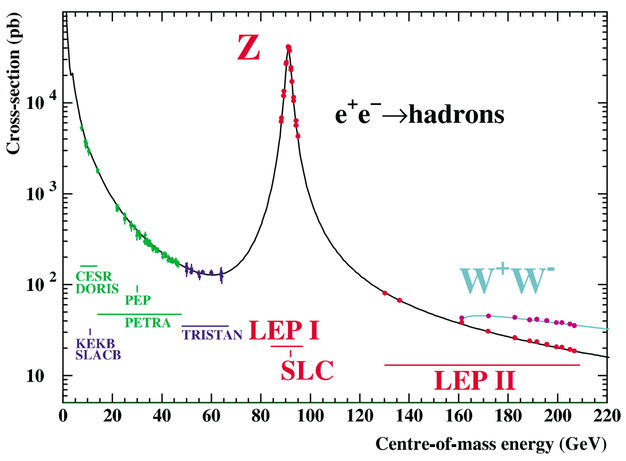
LEP Electroweak & QCD

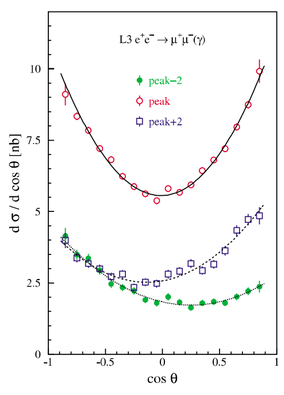
The LEP collider ran at centre-of-mass energies around the Z mass from 1989 to 1995 (LEP1). From 1995 to 2000 (LEP2), the energy was gradually increased, crossing the W-pair production threshold in 1996, and reaching 208 GeV in 2000. Each of the four experiments, ALEPH, DELPHI, L3 and OPAL, observed around 4.5 million Z and 12 thousand W-pair events.

Z lineshape and LEP2 crossing sections

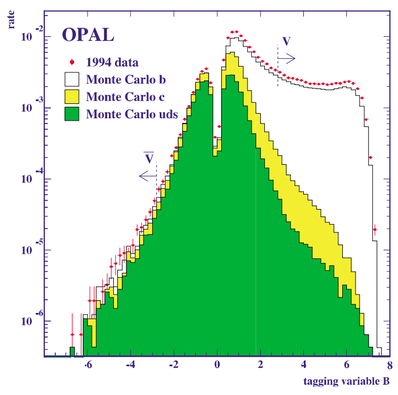
The cross section as a function of centre-of-mass energy in the region of the Z mass allows both the Z mass and width to be measured to a precision of 2 MeV. The lineshape data constrain the number of light neutrinos to be $N_\nu = 2.9841 \pm 0.0083$.



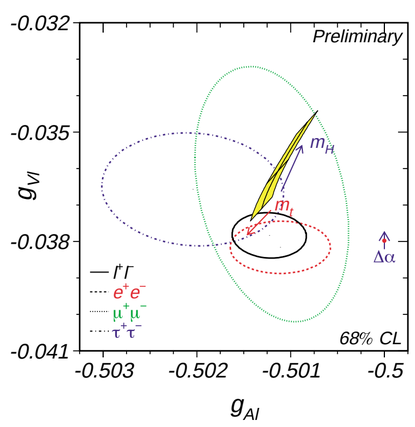
The forward-backward asymmetries of lepton pairs and of tagged heavy quark flavour final states, together with the cross-sections, allow precise measurements of Z couplings to fermions, g_V and g_A.



The forward-backward asymmetry is visible in these differential distributions.

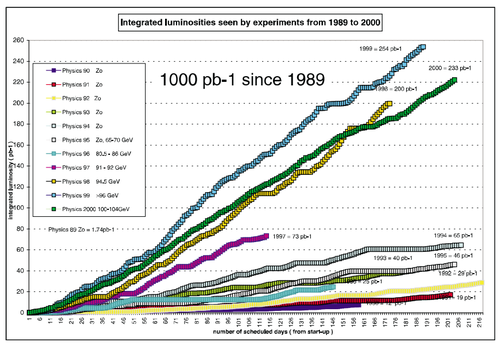


Several tagging variables can be combined to select b-events with high purity.

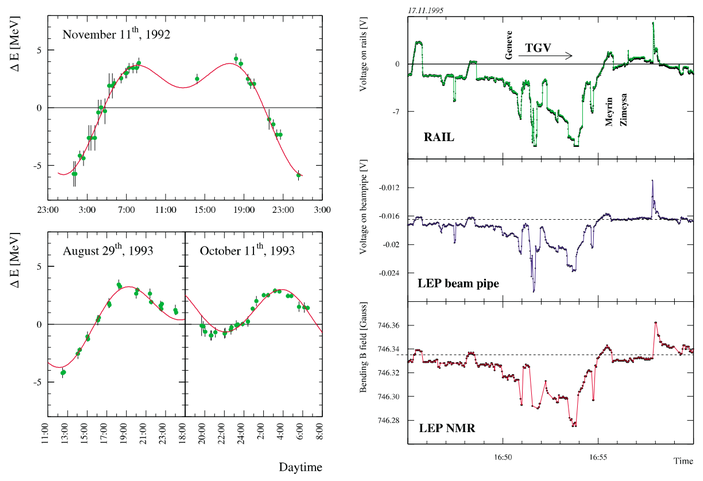


The couplings for different leptons are consistent with lepton universality, and show sensitivity to radiative corrections involving top-quark and Higgs boson loops.

The LEP collider



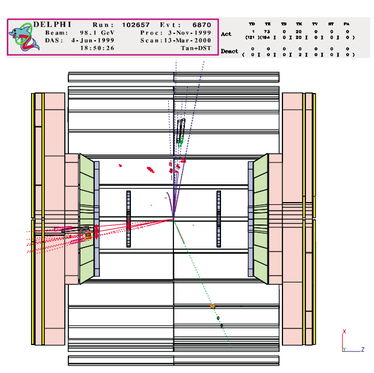
The luminosity delivered over the years of LEP running. The machine was pushed to deliver the highest possible beam energies while continuing to deliver high luminosity. The Z lineshape and W mass measurements rely on a precise calibration of the LEP beam energy, taking into account systematic effects including Earth Tides and leakage of electric current from nearby railway lines.

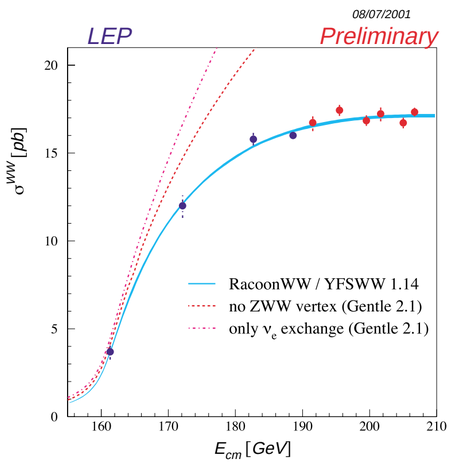


W-pair cross section

The energy dependence of W-pair production cross-section is also a sensitive test of the electroweak gauge structure.

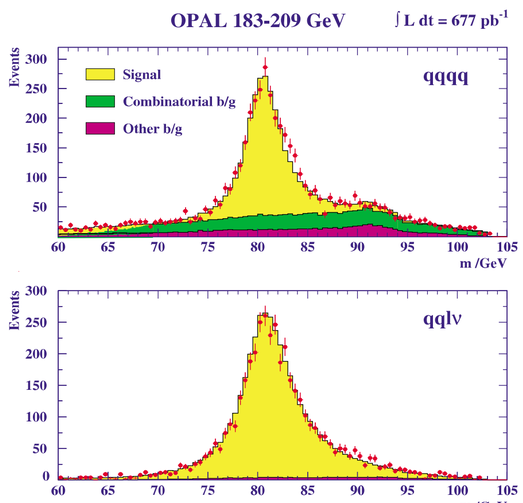
DELPHI $e^+e^- \to W^+W^- \to q\bar{q}\mu\nu$ event





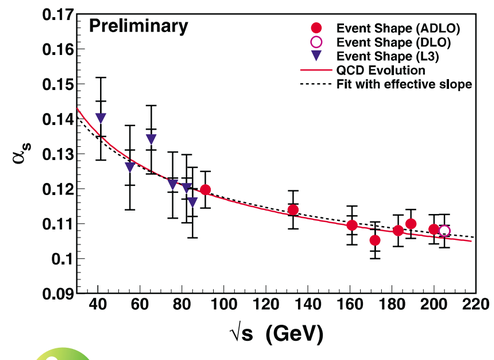
W mass

The most precise measurement of the W mass from LEP2 comes from directly reconstructing the W bosons from the final state particles. This example shows a fit for the W signal (yellow) and the backgrounds as a function of reconstructed mass. The combined LEP uncertainty on the W mass is 39 MeV.



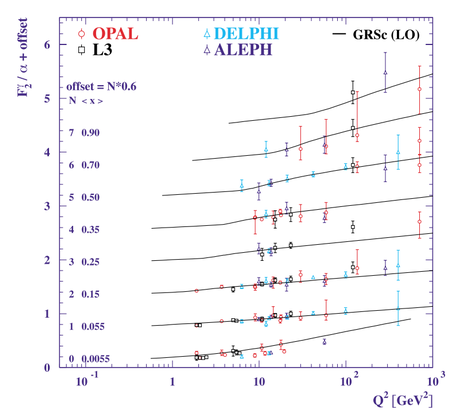
QCD

QCD studies at LEP1 and LEP2 have confirmed the running of α_s over an extended energy range.

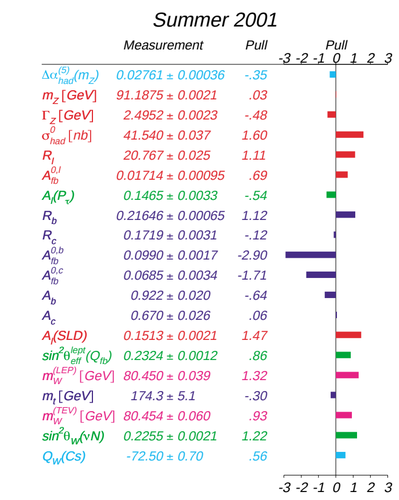


Photon structure

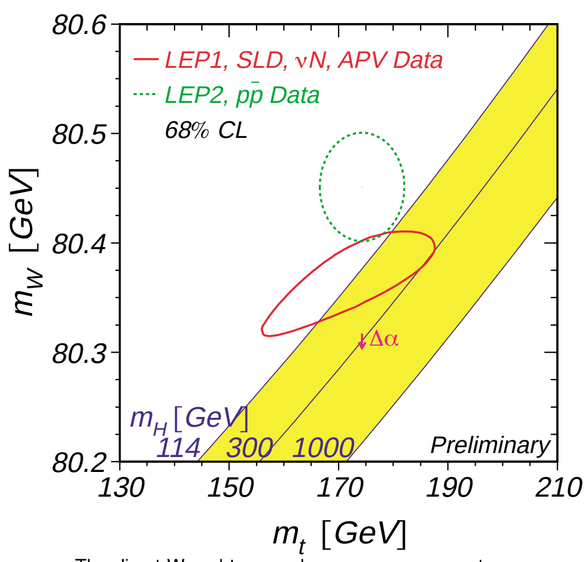
The hadronic structure of the photon is investigated using data from LEP1 and LEP2. F_2^γ shows positive scaling violations as a function of Q^2 for all values of x.



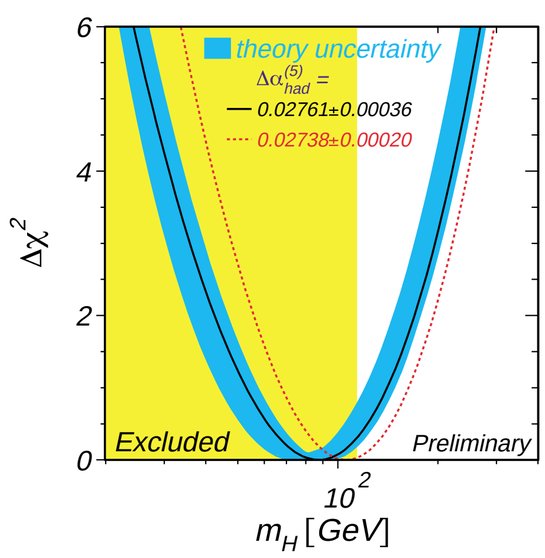
Combined electroweak results



A huge variety of electroweak measurements from LEP and elsewhere are consistent with the Standard Model. The largest discrepancy is in the heavy flavour sector, from the forward-backward asymmetry of b-quarks.



The direct W and top quark mass measurements are compared to the predictions from electroweak fits to LEP1 and SLD data and from the Standard Model (yellow).



The chisquared curve from a fit to all electroweak data as a function of Higgs mass. The limit from direct searches is also indicated. The electroweak data prefer a low Higgs mass.

LEP

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