# LEP

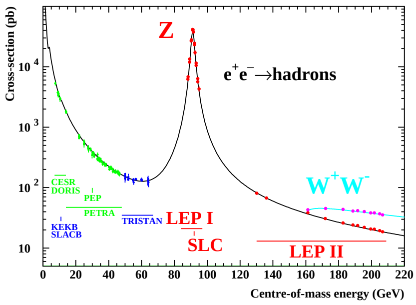
# Teilchenphysik in Deutschland

## Status und Perspektiven

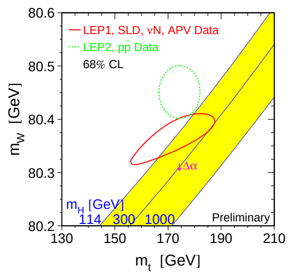
**The LEP $e^+e^-$ collider ran at centre-of-mass energies around the Z mass from 1989 to 1995 (LEP1). From 1995 to 2000 (LEP2), the energy was gradually increased, crossing the W-pair production threshold in 1996, and reaching 208 GeV in 2000. Each of the four experiments, ALEPH, DELPHI, L3 and OPAL, observed around 5 million Z and 10000 W-pair events.**

## Z lineshape and LEP2 cross sections

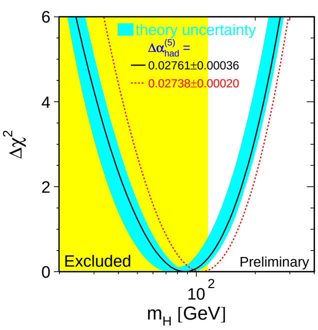
The cross section as a function of centre-of-mass energy in the region of the Z mass allows both the Z mass and width to be measured to a precision of 2 MeV. The lineshape data constrain the number of light neutrinos to be $N_\nu = 2.9841 \pm 0.0083$.



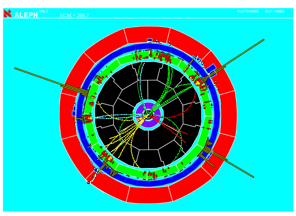

## Combined Electroweak results

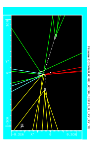



The direct W and top quark mass measurements are compared to the predictions from electroweak fits to LEP1 and SLD data and from the Standard Model (yellow).



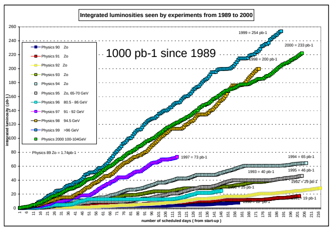

The chisquared curve from a fit to all electroweak data as a function of Higgs mass. The limit from direct searches is also indicated. The electroweak data prefer a low Higgs mass.



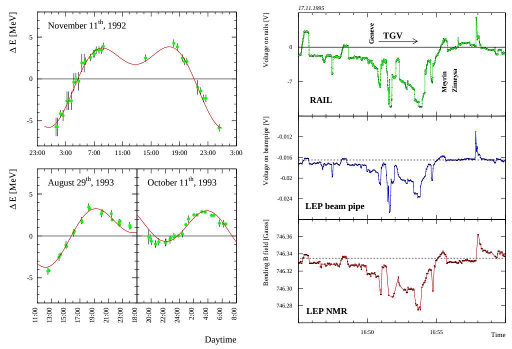


ALEPH 4-jet Higgs candidate. Secondary b decay vertices can be seen by zooming in on tracks inside the beam pipe.

## The LEP collider



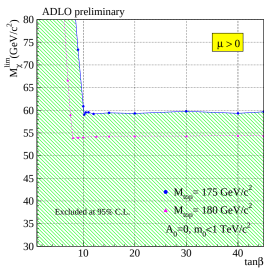

The luminosity delivered over the years of LEP running (top). The machine was pushed to deliver the highest possible beam energies while continuing to deliver high luminosity. The Z lineshape and W mass measurements rely on a precise calibration of the LEP beam energy, taking into account systematic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



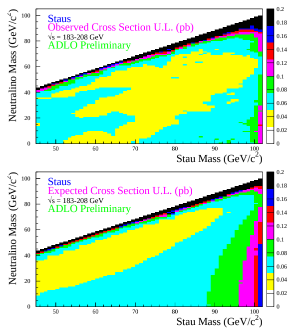

## SUSY

LEP is sensitive to many possible new phenomena, including SUSY. The signals are varied, with combinations of leptons, jets and/or missing energy in many topologies. Some SUSY particles would be produced with a very large cross-section in $e^+e^-$ annihilation with sufficient centre-of-mass energy.

The mass limit for the lightest neutralino depends on the value of tanβ and other assumptions. In mSUGRA, an absolute lower limit of about 60 GeV can be set for a top mass of 175 GeV, which has implications for neutralino cold dark matter.

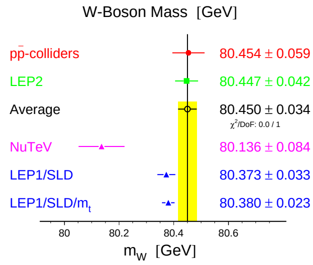



The observed and expected cross-section limits for stau production.



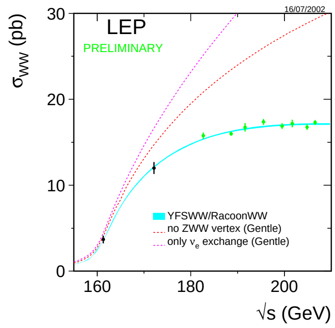

## W mass

The most precise measurement of the W mass from LEP2 comes from directly reconstructing the W bosons from the final state particles. The preliminary combined LEP uncertainty on the W mass is 42 MeV. The final W mass will be available after the calibration of the LEP beam energy is finalised.



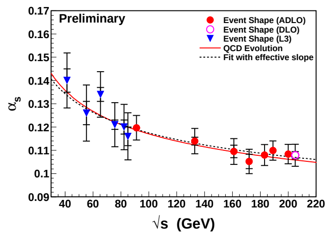

## W-pair cross section

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




## QCD

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




## Standard Model Higgs boson search

A small number of very clean Higgs candidate events ($e^+e^- \rightarrow ZH$) caused excitement at LEP in 2000. With the latest analyses and the full dataset, a Higgs boson with mass below 114.4 GeV is excluded at 95%CL. The likelihood ratio $Q(m_H) = (L(s+b))/(L(b))$ (plotted as -2lnQ) shows that the combined LEP data are more consistent with a Higgs boson of mass 115.3 GeV than with background only. However the significance of the deviation from background expectation, $(1 - CL_b)$ is $8 \times 10^{-2}$, only about 1.7σ. The relative probabilities of signal+background and background only can be seen in the plot on the right.