The Determination of the W Boson Mass

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The electroweak standard model predicts relations between the mass of the W boson and other electroweak observables. At lowest order the W boson mass can be calculated as a function of the Z boson mass, the finestructure constant α and the Fermi constant G_F. Loop corrections introduce additional dependencies on the mass of the top quark and Higgs boson. The direct measurements of M_W and m_T are compared in fig. 1 with the prediction of the standard model (the different lines correspond to different higgs masses) and to a fit of the standard model to all electroweek data excluding the direct measurements. The comparison of the direct measurement with the predictions is an important test of the standard model at the level of quantum corrections.

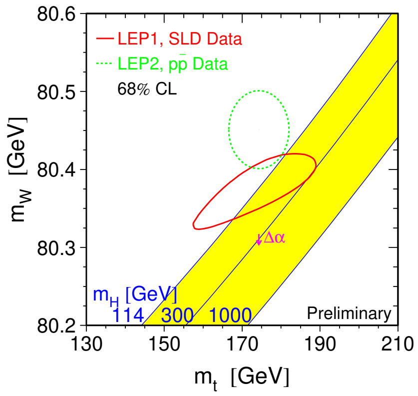

Fig. 1: Comparison of the direkt measurment of the W boson and top quark mass with the standartmodel prediction and a fit to the electroweek precion data.

Since 1995 LEP operated at center of mass energies above the W pair production thresholds. The decay of the W pairs lead to three distinctive signatures. In 47 % both W decay hadronicly (hadronic decays) producing a total of 4 jets. In 43 % of the cases one W decays hadronically and the other leptonically (semileptonic decays) giving two jets, a charged lepton and an unobserved neutrino. In 10% of the events both W decay leptonically.

We extented our analysis of semileptonic W decays [1] to the full data set measured with the OPAL detector. The result for the W mass for the 1999 and 2000 data is:

$$M_W = 80.575 \pm 0.079 \pm 0.052$$

The first error is statistical and the second on systematic. Studies of a simultaneous determination of the mass and width in this channel and on extending the method to a two dimensional convolution fit are described elsewhere in this report [2]

We finalized the mass determination from fully leptonic W decays [3]. Due to the two missing neutrinos a full mass reconstruction is not possible in this channel. The mass can however be extracted from distributions sensitive to it. The analysis is based on the momentum spectrum of the leptons and the pseudo mass which is the mass one gets from an event reconstruction assuming that both neutrinos are in the same plane as the charged leptons. The edge of the pseudo mass distribution depends on the W boson mass. It has been used for the first time in the mass determination. Figure 2 shows the data and a fit to it where the shape of the fit function has been taken from Monte Carlo predictions.

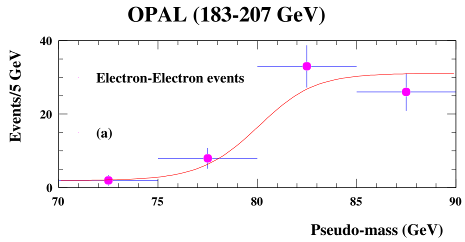

Fig. 2: Pseudo mass distribution.

The correlation between the mass determination from the lepton momentum and the pseudo mass is only 11 %. For the current analysis the statistical error is about a factor 10 larger than in the other channels. But for future high statistic experiments the channel might become very interesting since it dose not suffer from systematic uncertainties due to the hadronisation of quarks. In addition it has a smaller error due to uncertainties on the beam energy which might be one of the dominant errors in future experiments.

The study of systematic uncertainties is a major aspect of the ongoing W mass determination. In the hadronic channel the systematic error is dominated by the uncertainty of possible color reconnection effects between the two W bosons which are described elsewhere in this report [4]. The uncertainties on the fragmentation of quarks into hadrons forming the jets used to determine the W mass is the source of another important systematic error. This error is estimated by comparing different models which have been optimized in order to describe the Z^0 data. One important aspect which can affect the reconstructed mass is the fraction of produced baryons. In the jet reconstruction all tracks from charged particles are assumed to have the π mass. This leads to a bias in the measured jet mass which depends on this fraction and influences the reconstructed W mass.

References

[1] B. Bußmann *et al.*, Annual report 2000, p. 20
[2] F Vollmer *et al.*, this report, p.36
[3] The OPAL Collaboration, G. Abbiendi *et al.*, Measurement of the Mass of the W boson in e+e- Collisons using Fully Leptonic Channel, CERN-EP-2002-022, Submitted to Eur.Phys.J.C.
[4] R. Ströhmer *et al.*, this report, p.**??**