DELPHI Collaboration

DELPHI 2000-169 TALK 19
14 November, 2000

Measurement of the W boson mass and width in DELPHI at LEP

M. Mulders
NIKHEF, Postbus 41882, 1009 DB Amsterdam, The Netherlands

Abstract

A measurement of the W boson mass and width has been performed by the DELPHI collaboration. During the years 1997-1999 DELPHI collected data with an integrated luminosity of 435 pb-1 at center-of-mass energies ranging from 183 to 202 GeV. LEP is currently running at energies up to 208 GeV. The DELPHI analysis and preliminary numbers presented at ICHEP 2000, Osaka, are discussed and an overview is given of improvements in statistical sensitivity and determination of systematic errors to be expected for the final analysis of the total LEP2 data sample.

Talk given on behalf of the DELPHI collaboration at the DPF2000 conference, August 9-12 2000, Columbus, Ohio, United States.

1 Introduction

One of the main goals of the LEP2 program is the direct measurement of the W boson mass. Through its sensitivity to pure electroweak corrections this measurement offers an important consistency check of the Standard Model, and a means to further constrain the prediction of the mass of the Higgs boson.[1] This contribution starts with a short outline of the DELPHI W mass and width measurement and then concentrates on the prospects for a further reduction of the systematic uncertainties that currently dominate the uncertainty on the LEP combined W mass result.

2 Extraction of the W mass and width

Events are selected both in the fully hadronic ($WW \to q\bar{q}q\bar{q}$) and the semileptonic ($WW \to q\bar{q}l\nu$) decay channel. The W mass m_{W} is derived directly from the invariant mass of the decay products. In order to improve the invariant mass determination beyond the detector resolution kinematic fits are performed using the constraints of energy and momentum provided by LEP.

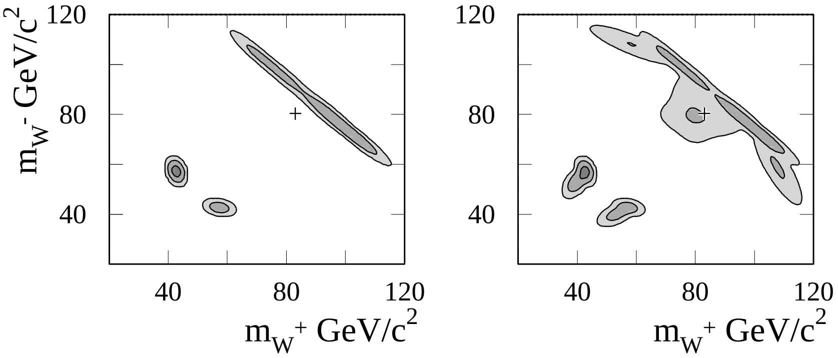

Figure 1: Example of an Ideogram for a simulated 4-jet event, giving the probability from the constrained fit as a function of the W^+ and W^- mass, purely based on the kinematic information in the event. The Ideogram is shown without (left) and with (right) the additional hypothesis of an unseen ISR photon escaping down the beampipe. The first 3 sigma contours are shown and the generated masses of the two W bosons in the event are marked with a cross.

Rather than fitting the overall shape of the reconstructed mass spectrum,[2] DELPHI uses event-by-event likelihood curves as function of m_{W} (or Γ_{W}). For each event a likelihood is constructed by convoluting an experimental resolution function P_{event}, containing all kinematic mass information from the event, with a physics function P_{phys} containing a Breit-Wigner component that defines the m_{W} and Γ_{W} dependence:

$$\mathcal{L}_{\mathrm{event}}(m_{\mathrm{W}}, \Gamma_{\mathrm{W}}) = \int P_{\mathrm{event}}(\vec{m}) \cdot P_{\mathrm{phys}}(\vec{m}, m_{\mathrm{W}}, \Gamma_{\mathrm{W}})\; d\vec{m} \qquad (1)$$

This convolution approach allows to improve the statistical information extracted from each event. In the semileptonic channel a 1-dimensional convolution is used, where the main improvement comes from taking into account the variation from event to event in the mass resolution (due to the presence of the neutrino). In the fully hadronic channel the most important advantage is the ability to take into account the full ambiguity of the event. Here P_{event} is a 2-dimensional function (a so-called 'ideogram', an example of which is depicted in figure 1), taking into account all possible jet pairings and other ambiguities arising from jet clustering and possible presence of initial state photon radiation.[3]

3 Systematic errors

An overview of the uncertainties on the LEP2 combined W mass measurement as quoted at the 2000 summer conferences[4] is shown in table 1.

Uncertainty on m_{W} [MeV/c^2]

		$q\bar{q}l\nu$	$q\bar{q}q\bar{q}$	combined
Source	Fragmentation	26	23	24
	LEP energy scale	17	17	17
	Final State Interference	-	56	15
	Other	14	13	13
	Total Systematic	35	64	36
	Statistical	38	34	30
	Total uncertainty	51	73	47

Table 1: Overview of the errors on the Summer 2000 LEP2 m_{W} combination.

There clearly is hope for a significant reduction of the major systematic error components quoted, as promising work is in progress for each of them. The LEP beam energy scale is being cross-checked by two independent methods, notably the beam spectrometer and a method based on the accelerator synchrotron tune. The understanding of Final State Interactions will benefit from the direct measurements at LEP2 of Bose-Einstein Correlations and Color Reconnection that are still inconclusive but rapidly gaining statistical significance.

Finally, fragmentation modeling accounts for the largest systematic uncertainty quoted, and is therefore subject to elaborate study in the four LEP experiments. Many of these studies are hampered by limited Monte Carlo statistics, however. A promising alternative technique developed by DELPHI that does not have this limitation is the Mixed Lorentz Boosted Z^0 method.[5]

4 Results and Prospects

The uncertainties on the current LEP combined direct measurement of the W mass and width both contain significant systematic and statistical components:

$$m_{\mathrm{W}} = 80.428 \pm 0.030(\mathrm{stat.}) \pm 0.036(\mathrm{syst.})\ \mathrm{GeV/c^2}$$
$$\Gamma_{\mathrm{W}} = 2.12 \pm 0.08(\mathrm{stat.}) \pm 0.07(\mathrm{syst.})\ \mathrm{GeV/c^2}$$

There is still room for a reduction of the statistical error, by adding the 2000 LEP data and by fully exploiting advanced statistical methods like the DELPHI convolution approach.

Also a further reduction of the main systematic errors can be expected, potentially enabling a final LEP W mass measurement with an excellent precision of 30 MeV/c^2 or better.

Acknowledgments

I would like to thank my DELPHI colleagues for their help in the preparation of my talk and of these proceedings.

References

[1] N. Konstantinidis, *proceedings of the DPF2000 conference.*

[2] The ALEPH collaboration, CERN-EP/00-045, submitted to European Physical Journal C.
The L3 collaboration, *Phys. Lett.* B454 (1999) 386.
The OPAL collaboration, CERN-EP/00-099, submitted to Physics Letters.

[3] The DELPHI collaboration, *Phys. Lett.* B462 (1999) 410.
The DELPHI collaboration, DELPHI 2000-144 CONF 443 and 2000-149 CONF 446, contributed papers for ICHEP 2000, Osaka.

[4] LEP ElectroWeak Working Group, LEPEWWG/MASS/2000-01, more information can be found on http://lepewwg.web.cern.ch/LEPEWWG/.
Also available as LEP collaboration public notes: ALEPH 2000-086 PHYSIC 2000-032, DELPHI 2000-165 PHYS 879, L3 Note 2617, OPAL TN-667.

[5] N. Kjær and M. Mulders, DELPHI 2000-51 CONF 366, contributed paper for Moriond 2000, Les Arcs.