PRELIMINARY RESULTS OF THE STANDARD MODEL HIGGS BOSON SEARCH AT LEP2 IN 2000

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A search for the Standard Model Higgs boson is performed using the data collected by the four LEP experiments at center-of-mass energies between 202 GeV and 209 GeV. An average luminosity of 140 pb^{-1} per experiment has been analyzed. A 2.6 σ excess is observed in the LEP-wide combination for a Higgs boson mass hypothesis of around 114 GeV. All results are preliminary.

1 Introduction

The Standard Model has succesfully described properties of interactions between fundamental particles up to the electroweak scale. There is still one particle predicted by the theory yet to be discovered: the Higgs boson. Since its mass cannot be predicted by the Standard Model alone, all possible masses must be investigated. Consistency of the Standard Model parameters prefers a low-mass Higgs with mass around 100 GeV. A Higgs mass below 107.9 GeV has already been excluded at 95% confidence level by previous LEP-wide analyses[2].

2 Higgs production and decay

At interaction energies available at LEP, the most dominant mechanism of Higgs production is called "Higgs-strahlung" ($e^+e^- \rightarrow Z^* \rightarrow hZ$), where the electron-positron annihilation produces an off-shell Z boson which then radiates a Higgs boson.

The Higgs boson, once produced, immediately decays into other particles. The main decay modes available to the Higgs at LEP energies are b-quark decay ($h \rightarrow b\bar{b}$), $\sim$ 80% of all decays, and τ-lepton decay ($h \rightarrow \tau\bar{\tau}$), $\sim$ 12% of all decays. With the combination of the Z boson decay modes, the following four decay channels are analyzed, covering more than 90% of the total branching ratio.

- four-jet channel, when the Z boson decays into quarks ($hZ \rightarrow b\bar{b}q\bar{q}$). The branching ratio is $\sim$ 60%.
- missing energy channel, when the Z boson decays into neutrino pairs

($hZ \to b\bar{b}\nu\bar{\nu}$). The branching ratio is $\sim 20\%$.

- lepton channel, when the Z boson decays into e^+e^- or $\mu^+\mu^-$ pairs ($hZ \to b\bar{b}l^+l^-$). The branching ration is $\sim 3\%$ respectively.
- τ channel, with Z boson decays into $\tau^+\tau^-$ pairs ($hZ \to b\bar{b}\tau^+\tau^-$), the branching ratio is $\sim 3\%$) or; because of the similar topology, the Higgs boson deacays into $\tau^+\tau^-$ pairs and while the Z boson decays into quark pairs ($hZ \to \tau^+\tau^- q\bar{q}$), the branching ratio is $\sim 6\%$.

3 Analysis

The main aim of the analysis is to reduce Higgs-like Standard Model backgrounds while retaining any possible Higgs signals. After neural network or cut based selections are performed, the most discriminating variables are combined to form the "final discriminant" which is a function of the Higgs mass hypothesis.

Figure 1 shows the LEP-wide (ALEPH, DELPHI, L3 and OPAL - "ADLO") final discriminant variable constructed for the Higgs mass hypothesis of 115 GeV. In the upper plot, the white area is the background, the shaded area is the Higgs signal and the dots are the observed data. The horizontal scale is the logarithm base 10 of the signal to background ratio. Note the three right-most events with high signal over background ratios.

The lower two plots show the integral of the upper plot from right to left. The solid line is background only; the dashed line is signal plus background. Observed data, indicated by dots, is more consistent with the signal plus background line.

An alternate way of determining whether a set of data is more consistent with background rather than with signal plus background is to calculate the *log likelihood ratio*. The final variable is treated with Poisson statistics on a bin-by-bin basis. The log likelihood ratio is then given by:

$$\ln Q = -S_{tot} + \sum_i n_i \ln(1 + \frac{S_i}{B_i}) \qquad (1)$$

where n_i is the number of observed events in the i-th bin with S_i expected signal events and B_i expected background events.

The log likelihood plot is shown in Figure 2. The upper dashed line is the background only hypothesis (n_i is the background expectation), the lower dotted line is the signal plus background hypothesis (n_i is signal plus background expectation). The solid line is the observed data. The shaded

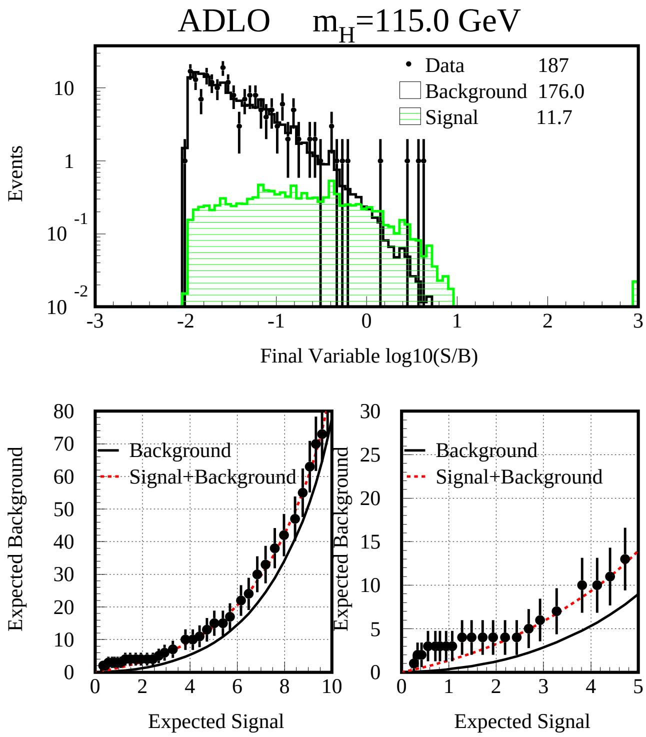

Figure 1. The final discriminant variable for the Higgs mass hypothesis of 115 GeV.

region closest to the upper dashed line represents the area which is less than 1 sigma away from background. The wider shaded region is 2 sigma away.

The data stays roughly at the 2 sigma border until about 114.5 GeV when it dips to 2.6 sigma off the background expectation. This dip is due mostly to Higgs-like four-jet events seen by ALEPH and DELPHI.

4 Conclusion

With present statistics, Higgs observation cannot be confirmed or ruled out. The LEP running has been extended until November 2 which will increase

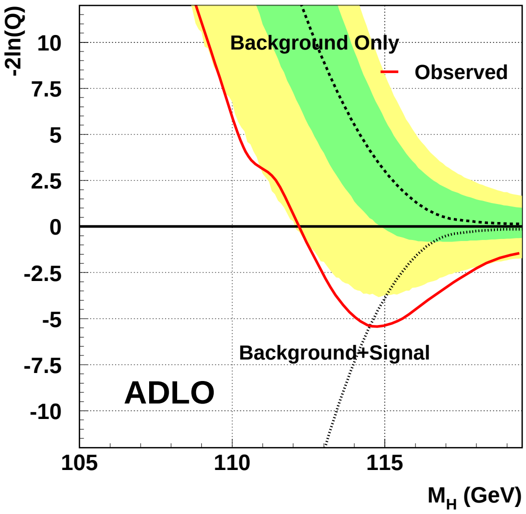

Figure 2. Log Likelihood curve for LEP-wide data.

statistics. New data could possibly exclude Higgs mass up to 114 GeV at 95% confidence level or increase the LEP-wide excess to 3 sigma. The results will be updated after the end of 2000 LEP running. The results presented here are preliminary.

References

1. L3 Collaboration, "Search for the Standard Model Higgs Boson in e^+e^- interactions at $\sqrt{s} = 189$ GeV", *Physics Letters B*, **461**, 376 (1999).
2. The LEP Collaborations, ALEPH, DELPHI, L3, OPAL, the LEP Electroweak Working Group for Higgs boson searches, "Searches for Higgs bosons: Preliminary combined results using LEP data collected at energies up to 202 GeV", No submission to Editors, CERN-EP-2000-055; 25 April 2000, L3 preprint 209.
3. Chris Tully, "Status LEP-wide Higgs Searches", Special LEPC 5 September 2000