HOW ROBUST IS THE RESULT OF THE STANDARD MODEL HIGGS BOSON SEARCH AT LEP? [a]

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An excess of signal-like events above the expected background, corresponding to approximately three standard deviations, was observed in the search for the standard model Higgs boson at LEP in 2000. This excess is consistent with the existence of a Higgs boson with mass 115 GeV/c^2. Relevant consistency and robustness checks, which further support the signal interpretation, are presented.

The outstanding run of LEP in 2000 at centre-of-mass energies up to 209 GeV allowed the standard model Higgs boson search sensitivity to exceed three standard deviations (σ) up to a mass of 115 GeV/c^2. Amazingly enough, an excess of 2.9σ was observed [1] around this sensitivity limit. Not only is this global excess in quantitative agreement with the signal prediction, but its characteristics are also qualitatively consistent with those expected from a 115 GeV/c^2 Higgs boson. More explicitly, the distributions of the events among the experiments [1,2,3,4], among the decay channels [1], as a function of time, and as a function of signal purity [1] all match the signal hypothesis [5] with a global probability 33 times larger than the background only hypothesis. Many consistency checks were performed in order to exclude that this observation would result from a systematic bias of the search. Two relevant examples are given here.

In the first check, a combination of the searches with the 500 pb^{-1} of data taken at centre-of-mass energies ranging from 189 to 206 GeV is compared to what it would have been had the excess observed above 206 GeV been due to systematic bias close to the kinematic threshold. The estimators, for both cases, are displayed in Fig. 1-a [6] as a function of the distance to threshold $(m_{\mathrm{H}} + m_{\mathrm{Z}} - \sqrt{s})$. This result largely excludes the possibility of a systematic effect arising in the mass reconstruction.

The second check is aimed at further illustrating the robustness of the mass reconstruction algorithm in the four jets channel in ALEPH [7]. A control sample is selected with the kinematical and topological criteria of the ALEPH "Cuts" stream [1] analysis, but with the requirement that none of the jets be tagged as b-quark jets [7]. This control sample, mostly free of signal events due to the anti-b-tag criterion, contains mainly WW events with kinematic similarities with the signal. The reconstructed mass spectrum for the aforementioned control sample is shown in Fig. 1-b. The peak in the reconstructed mass spectrum around $m_{\mathrm{rec}} \approx 2 \times m_{\mathrm{W}} - m_{\mathrm{Z}}$ corresponds to events where the jet pairing is correctly assigned to each W boson. The broader peak at higher reconstructed masses is due to events with the wrong choice of pairing. The good agreement over the full reconstructed mass spectrum illustrates the robustness of the mass reconstruction procedure in the experiment and the channel where the excess is most present (the fact that most of the excess is seen in this particular channel is expected in the hypothesis of a signal).

In view of its consistency in all regards and its robustness, the evidence for a signal is as strong as could be expected from the amount of data collected at centre-of-mass energies above 206 GeV. Besides, these hints are also consistent with the indirect constraints on the mass of the standard model Higgs boson from precision electroweak measurements [8].

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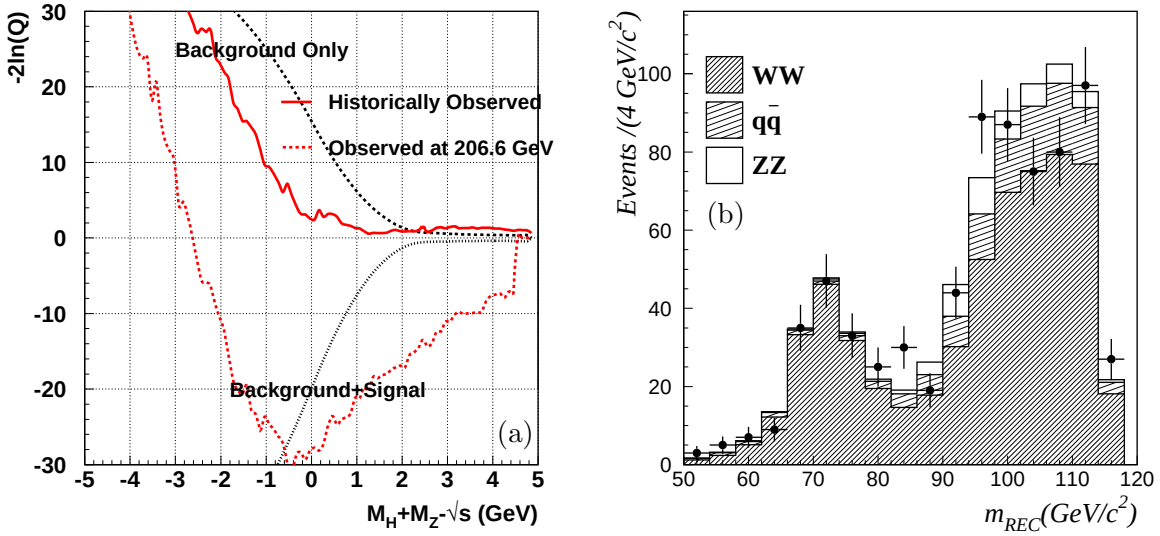

Figure 1: (a) Observed estimators for the combination of all experiments and all data with $\sqrt{s}$ <206.5 GeV (full curve) and what it would have been had the excess observed above $\sqrt{s}$ >206.5 GeV been seen at all centre-of-mass energies (dashed curve) as a function of the distance of the Higgs boson mass hypothesis to the threshold. The expectation in absence and presence (dotted curves) of signal are also shown. (b) Distribution of the reconstructed mass for anti-b-tagged events selected by the ALEPH four jet "Cuts" stream analysis.

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References

1. P. Teixeira Dias, *"Observation of an excess in the ALEPH search for the standard model Higgs boson, LEP combined results"*, these proceedings.
2. I. Nakamura, *"The Standard Model Higgs in OPAL"*, these proceedings.
3. P. Morettini, *"Higgs searches in DELPHI"*, these proceedings.
4. L3 Collaboration, *"Higgs candidates in e+ e- interactions at s**(1/2) = 206.6-GeV"*, Phys. Lett. B **495**, 18 (2000).
5. LEP Higgs Working Group, *Standard Model Higgs Boson at LEP: Results with the 2000 data, Request for running in 2001*, http://alephwww.cern.ch/~janot/LEPCO/lephwg.ps
6. LEP Higgs Working Group, *FAQ (and their answers)*, http://alephwww.cern.ch/~janot/LEPCO/qanda.ps
7. ALEPH Collaboration, *"Observation of an excess in the search for the standard model Higgs boson at ALEPH"*, Phys. Lett. B **495**, 1 (2000).
8. E. Tournefier, *"Electroweak results and fit to the standard model"*, these proceedings.