SM Higgs Searches for $H \to WW^{(*)} \to l^+\nu l^-\bar{\nu}$ with a Mass between 150-190 GeV at LHC

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For Higgs-boson masses close to 170 GeV, the signal significance in the $H \to ZZ^{(*)} \to 4l$ channel is reduced, due to the suppression of this channel as the WW decay mode opens up [1]. For $m_H = 170$ GeV, the $H \to WW^{(*)} \to l^+\nu l^-\bar{\nu}$ branching ratio is approximately 100 times larger than that of the $H \to ZZ^{(*)} \to 4l$ channel. In the case of $H \to WW^{(*)} \to l^+\nu l^-\bar{\nu}$ decays, however, it is not possible to reconstruct the Higgs-boson mass peak. Instead, an excess of events with two isolated leptons accompanied by missing transverse energy above the level expected from background processes may be observed showing the presence of a Higgs-boson signal.

Based on the method suggested in [2], the potential for a discovery of the Higgs boson in the $H \to WW^{(*)} \to l^+\nu l^-\bar{\nu}$ decay mode has been investigated for Higgs-boson masses in the range between 150 and 190 GeV. The analysis presented here is based on a fast detector simulation for final states containing electrons and muons. The signal cross section times leptonic branching ratio for the $H \to WW^{(*)} \to l^+\nu l^-\bar{\nu}$ decay is found to be between 0.61 and 0.80 pb over the mass range considered. Decays into τ-leptons, where the τ-leptons decay leptonically into electrons or muons have been taken into account in the analysis.

Since no mass peak can be reconstructed, the uncertainties on the background prediction cannot be neglected in the determination of the signal significance. There are many background contributions, the most important ones are the WW continuum, which is irreducible, and the reducible $t\bar{t}$ and Wt production.

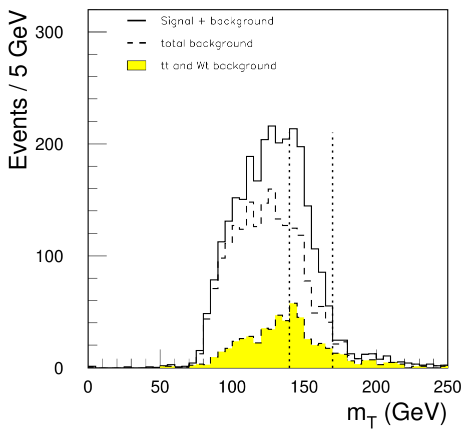

Fig. 1: Transverse mass distribution for the summed $H \to WW^{(*)} \to l^+\nu l^-\bar{\nu}$ signal ($m_H = 170$ GeV) and total background, for an integrated luminosity of 30 fb^{-1}. The distribution for the background alone is also shown separately. The shaded histogram represents the contributions from the Wt and $t\bar{t}$ background. The dashed lines indicate the selected signal region.

The distribution of the transverse mass is shown in fig.1 for the sum of signal and background and for the background alone. The contribution from single top production and from $t\bar{t}$ production is also shown separately by the shaded histogram. The result is shown for $m_H = 170$ GeV and for an integrated luminosity of 30 fb^{-1}. Since there is no mass peak reconstructed, evidence for a Higgs-boson signal has to be deduced from an excess of events in a defined region of transverse mass. This region is indicated by the two dotted lines. The acceptance regions does not cover the full region of excess, because the signal significance in this channel depends critically on the absolute knowledge of the various backgrounds. The cuts applied can be relaxed to some extent and a normalisation between the Monte Carlo prediction and the data can then be performed in regions, where only a small fraction of the signal is expected. To evaluate the significance, it has been assumed that such a normalisation can be performed to an overall accuracy of $\pm 5\%$, i.e. that the summed WW^*, $t\bar{t}$, and Wt background is known with a systematic uncertainty of $\pm 5\%$. This uncertainty is larger than the statistical uncertainty of the background. Taking this into account, the signal significance estimated for an integrated luminosity of 30 fb^{-1} is above 5σ (see fig.2) for $\sim 150 < m_H < 190$ GeV [3].

Finally, it is important to note that also constraints on the Higgs-boson mass can be extracted from the transverse mass distribution. A sensitivity to the Higgs-boson mass is obtained from the upper edge of the distribution. The experimental resolution on the missing transverse energy defines the shape of this upper edge. Systematic uncertainties have not been studied yet, but the Higgs-boson mass can hopefully be constrained to better than ± 5 GeV in this channel.

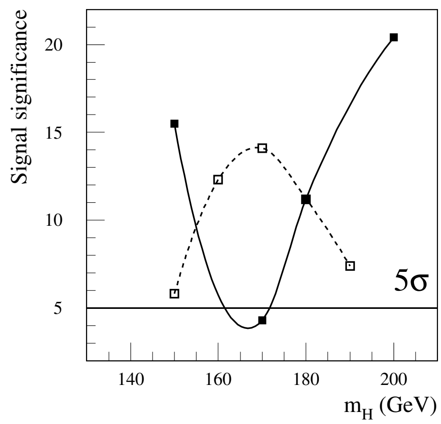

Fig. 2: Sensitivity for the discovery of a Standard Model Higgs boson in the mass range between 150 - 190 GeV assuming an integrated luminosity of 30 fb^{-1}. The dashed line indicate the $H \to WW^{(*)} \to l^+\nu l^-\bar{\nu}$ channel, the solid line the $H \to ZZ^{(*)} \to 4l$ channel.

References

[1] The ATLAS Collaboration, ATLAS Detector and Physics Performance Technical Design Report, CERN/LHCC/99-15, 1999
[2] M. Dittmar, H. Dreiner, Phys.Rev. **D55** (1997) 167
[3] T. Trefzger, K. Jakobs, ATLAS-PHYS-NO 99-031, 1999