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Standard Higgs boson search in the H→WW→2l2ν decay channel with the CMS detector

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The search for the standard model Higgs boson in the H→WW→2l2n channel with the CMS detector using 5.1 fb^{-1} from the 2011 dataset and 19.5 fb^{-1} from the 2012 dataset is described. The most important backgrounds in this analysis are estimated using data driven methods. The results are optimized for different categories regarding the number of jets and the lepton flavour. In order to improve the sensitivity a 2D template based fit using kinematic variables is used in the most sensitive categories. Spin and parity studies have also been performed in this channel.

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1. Introduction

Among all the pieces of the Standard Model (SM), the origin of the mass of the elementary particles has a potential solution. By adding only one doublet of complex scalar fields, the mass of the SM elementary fermions and bosons can be explained, after spontaneous electroweak symmetry breaking of the originally massless Lagrangian [1],[2],[3]. This minimal approach could be confirmed if the remnant of such a breaking, the Higgs boson, is observed with the couplings and properties predicted by the SM.

The ATLAS and CMS collaborations presented the discovery of a new boson at a mass around 125 GeV/c^2, with properties compatible with the SM Higgs boson, being the excess more significant in the $\gamma\gamma$ and ZZ decay modes. In what follows, the search for the SM Higgs boson with the CMS detector in the H→WW*→2l2ν channel using 5.1 fb^{-1} of 7TeV data and 19.5 fb^{-1} of 8 TeV data is presented. A detailed description of the CMS detector can be found in [4].

2. The H→WW process

The H→WW* process is particularly sensitive for Higgs boson searches in the intermediate mass range (120-200 GeV/c^2) and has a comparable sensitivity in the low Higgs mass region as the diphoton channel. The final signature includes two isolated high p_T leptons (e and μ) with opposite sign and a large transverse momentum due to the undetected neutrinos.

The main background is the irreducible WW continuum. The reducible backgrounds include the Drell-Yan, tt, W+jets and the production of the other dibosons. Since it is not possible to reconstruct a mass resonance for this channel, the proper understanding and control of the backgrounds is the key point of the analysis.

3. The event selection

Events with two opposite sign leptons with a p_T greater than 10, 20 GeV/c respectively are selected. The events are classified in three different categories depending on the number of high p_T jets in the final state. For each category the events are also split in same flavour (μμ and ee) and different flavour (eμ and μe). The selection is divided in two steps: a first one selecting the WW like events and rejecting mainly Z and top background (WW selection level) and a second step where, in order to achieve the best separation of the Higgs signal from the backgrounds, two different approaches are used: a "cut and count" method and a 2D fit (final selection level).

3.1 The WW selection level

Each of the different categories of the analysis presents a set of optimized cuts in order to reduce the main backgrounds.

- The top background is reduced by appling two different kind of btagging: a life time based and a soft muon based.
- The Drell-Yan background is rejected by cutting on the missing E_T variable and vetoing the Z invariant mass window for the same flavour events.

- The W+jets and QCD events are rejected by requiring the leptons to be well isolated and fulfill some tight quality criteria. The transverse momentum of the dilepton system must be larger than 30 GeV/c.
- The W+γ* and other di-boson backgrounds are reduced rejecting events with more than 2 leptons and applying a cut on $m_{ll} < 12$ GeV/c^2 to get rid of the low mass resonances.

The main backgrounds (WW, W+jets, Drell-Yan, top and W+γ*) are estimated using data driven methods, extrapolating the yields from a control region in data. The total uncertainty associated to the background estimations in the H→WW*→2l2ν signal region is about 15% and it is dominated by the statistical uncertainty in the observed number of events in the background control regions.

3.2 The final selection level

For the same flavour categories, in order to improve the signal over background, some cuts are applied on the main kinematic variables as the p_T of the leptons, the invariant mass and the azimuthal angle between the two leptons. The values for these cuts are optimized as a function of the Higgs mass.

3.2.1 The 2D fit

The opposite flavour categories are the most sensitive ones. For these events a 2D fit in the plane (m_T,m_{ll}) is performed. m_T is the transverse mass calculated from the dilepton momentum and the missing transverse energy. These variables are chosen because of their great discriminating power, especially in the low mass region.

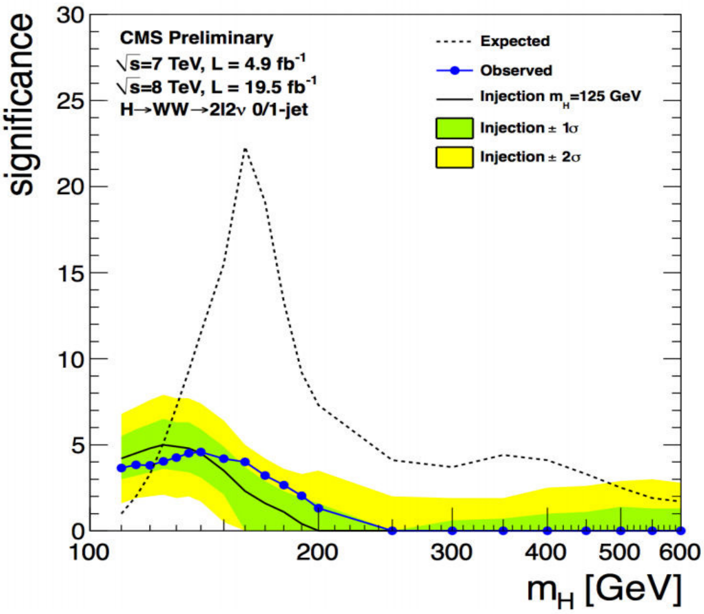

Figure 1. Expected and observed significance for the full 2011 and 2012 datasets. Dashed line is the expected significance and blue line is the observed for each Higgs boson mass hypothesis. The solid line with the colored error bands is the expected significance for a signal injection at 125 GeV/c^2

4. Results

The Higgs boson search in the H→WW* →2l2ν decay channel is presented using 2011 and 2012 data collected by the CMS detector at the LHC. An excess is found in the region of $m_H \approx 125$ GeV/c^2. The significance of this excess is found to be 4.0σ with respect to the background only hypothesis, while 5.1σ are expected according to the Standard Model prediction. Significance as a function of the Higgs boson mass hypothesis is shown in figure 1. The SM Higgs boson is excluded in the mass range 128-600 GeV/c^2 at 95% confidence level.

The present analysis only considers the separation between the Standard Model Higgs hypothesis (0^+) and a minimaly coupled spin 2 resonance at 125 GeV/c^2 (2^+). The data slightly favors the SM Higgs hypothesis of J^P=0^+ over the alternate hypothesis with J^P=2^+ and minimal couplings to the WW pair.

References

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