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Higgs searches via WW decay channel using CMS detector

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Abstract

We will present a summary of results obtained from the study of Standard Model Higgs boson decay-ing to a pair of W bosons using the CMS detector.

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Higgs searches via WW decay channel using the CMS detector

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Keywords: Standard Model, Higgs boson

1 Introduction

During the year 2012, the CMS [1] and ATLAS experiments at the LHC reported the discovery of a new boson with a mass near 125 GeV and having production and decay rates, spin, parity and coupling strengths consistent with those expected for the Standard Model (SM) Higgs boson within uncertainties [2,3]. The SM Higgs boson is a neutral scalar particle predicted to arise from the Higgs field and is responsible for the electroweak symmetry breaking. At the LHC, the Higgs boson can be produced in several ways: gluon-gluon fusion, vector boson fusion, in association with a W/Z boson or a top quark pair.

This article reports the the latest measurement on SM Higgs boson produced via gluon-gluon fusion mode and decaying to a pair of W bosons, at a center of mass energy of 13 TeV. The analyzed data corresponds to an integrated luminosity of 2.3 fb^{-1} collected during proton-proton collisions at the CMS detector [4]. The leptonic decay of W^+W^- is studied into an oppositely charged electron-muon ($e\mu$) pair with missing transverse energy (E_T^{Miss}) (coming from neutrinos), and in association with either zero or one jet. The major background contribution arises from the non-resonant WW production and top quark events ($t\bar{t}$ and single top quark), followed by other processes such as Drell-Yan, W+jets and electroweak productions.

2 Analysis strategy

The events are triggered using the single or double lepton triggers. Offline event selection criteria demands the presence of exactly one electron and one muon with opposite charges and a minimum p_T of 10 (13) GeV for the muon (electron) candidate. The two well identified and isolated leptons must originate from the

primary vertex of the event and leading lepton should have a p_T greater than 20 GeV. The invariant mass of the two leptons (m_{ll}) is required to be greater than 12 GeV. Background processes involving multiple bosons and hence more than two leptons in the final state are suppressed using an additional lepton veto which rejects the events having three or more identified and isolated leptons with $p_T > 10$ GeV in the final state. To suppress the background arising from the Drell–Yan process, E_T^{Miss} of the event is required to be greater than 20 GeV. The di-lepton transverse momentum (p_T^{ll}) is required to be greater than 30 GeV to further reduce the contributions from Drell–Yan and the non-prompt lepton backgrounds. The contribution from top quark processes is reduced by requesting that no jets with $p_T > 20$ GeV are recognized to originate from the hadronization of a b quark.

Events are categorized according to different jet multiplicities, counting jets with $p_T > 30$ GeV. The zero jet (0-jet) category is dominated by the non-resonant WW background, while in the one jet (1-jet) category receives similar contributions from non-resonant WW and top quark events. To disentangle another important background, W+jets, where one jet is misidentified as a lepton, the 0-jet and 1-jet categories are further split according to the flavour of highest p_T lepton in the event: $e\mu$ and μe .

To extract the Higgs boson signal, the same strategy as in the Run-I analysis [5] is followed. Due to the presence of neutrinos, the Higgs boson invariant mass could not be reconstructed but the expected kinematics of the Higgs boson production and decay could be explored. Given the spin 0 nature of the SM Higgs, the two charged leptons are emitted close to each other. Also, the invariant mass of the two leptons in the signal is relatively small as compared to the one expected for a lepton pair arising from other background processes. The Higgs transverse mass $m_T^H = \sqrt{2p_T^{ll}E_T^{\text{Miss}}(1 - \cos \Delta\phi(ll, E_T^{\text{Miss}}))}$, where $\Delta\phi(ll, E_T^{\text{Miss}})$ is the azimuthal angle between the di-lepton system and the E_T^{Miss} , could be used to disentangle signal from background events. An analysis based on bi-dimensional templates of m_{ll} versus m_T^H is performed to extract the Higgs signal. Background shapes and normalizations are estimated from the data, wherever possible. The non-prompt lepton background contribution is estimated from the data by measuring the lepton misidentification rates in a background enriched control sample of events, and extrapolating its contribution from this control region to the signal phase space. A low m_T^H phase space control region is defined to extract the normalization of Drell–Yan process, and events with at least one b-tagged jet for the top quark events.

3 Results

The final binned fit is performed using template histograms for signal and background processes obtained after all aforementioned selection criteria are applied. The signal and background templates, as well as the distribution observed in the data, are shown in Figure 1 for the 0-jet and 1-jet, μe and $e\mu$ categories. Combining the four categories the observed (expected) significance is 0.7σ (2.0σ)

for a SM Higgs boson with a mass of 125 GeV. The corresponding best fit signal strength, $\sigma/\sigma_{\text{SM}}$, which is the ratio of the measured $H \rightarrow WW$ signal yield to the expectation for the SM Higgs boson, is 0.3 ± 0.5 .

Fig. 1. Bi-dimensional distributions of the m_{ll} and m_T^H templates in the 0-jet (top) and 1-jet (bottom) and μe (left) and $e\mu$ (right) categories at the level of WW selection. The bi-dimensional templates ranges are $10 < m_{ll} < 110$ GeV and $0 < m_T^H < 200$ GeV with 5 bins in m_{ll} and 10 bins in m_T^H . The distributions are unrolled to one dimensional histograms such that that identical values of m_T^H are in adjacent bins [4].

References

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