PROCEEDINGS OF SCIENCE

Higgs search in H→WW decay channels with the CMS detector

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The prospects for the search of the Standard Model Higgs boson in the decay channel H→WW*→lνl'ν' (l or l' = e or mu) with the CMS experiment [1] at the LHC is presented. The analysis relies on a full simulation of the detector response and emphasis is put on explicit strategies for the measurement of experimental and background systematics from data. The discovery reach is presented as a function of the Higgs mass. A new complete strategy is presented for the early searches and for the control of systematics at very low luminosities of O(1 fb^{-1})

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1. Introduction

The channel H→WW*→2l2ν is one of the most promising channels for the SM Higgs discovery, as it has the highest branching ratio (near to 1) in the mass region $m_H \gtrsim 2m_W$. The Higgs production at LHC is dominated by gluon fusion in p-p collisions at a center mass energy of 14 TeV.

2. Signal and Backgrounds

The process H→WW*→lνl'ν' (l or l' = e or μ) is studied for a mass range $m_H \in [120, 200]$ GeV [2]. The signature is characterized by two isolated high transverse momentum leptons with opposite charges, large missing transverse energy due to the undetected neutrinos, no hard jet activity and small separation angle between the two leptons due to spin correlation with the Higgs (a spin 0 particle). The analysis is performed using Monte Carlo generated sample processed by the CMS full simulation.

The main sources of background are the processes $t\bar{t}$,WW,WZ,ZZ,tW,W/Z+jets and Wγ with higher cross sections. WW is an irreducible physics background with exactly the same final state; a handle for this background is the angular separation between the leptons that tends to be large. The other main backgrounds, Z+jets and $t\bar{t}$ are instrumental where either the missing transverse energy or the jets have been mismeasured.

3. Analysis

An event preselection is done to enhanced the Higgs signature. Events are triggered by the single lepton High Level Triggers, and required offline to have two opposite charges isolated leptons with $p_T > 10, 20$ GeV within the acceptance of CMS. Two different analysis techniques have been used: a traditional cut based analysis and a more sophisticated multivariate technique based on neural network (NN) or boosted decision trees (BDT).

The cut based analysis rejects events further by applying a jet veto, requiring no hard jet activity in the events; upper and lower limits on the missing transverse energy and the transverse momenta of the harder and softer lepton; low cut on the separation angle between the two leptons and upper cut on the invariant mass of the two leptons. The final event selection is optimized for each Higgs mass.

The multivariate analysis make use of the kinematic and topology of the event to distinguish between signal and background after vetoing the jets in the event. On top of the variable already studied for the cut based analysis, new variables are added. Using signal and background samples, NM and BDT are trained to give a discriminator distribution which is used in the final event selection. The trainings have been optimized for each Higgs mass to get the full power of these type of analyses.

Different sources of systematic uncertainties have been considered for both techniques. The overall relative error depends on the final state and on the Higgs mass. It is about 11% for the signal and 21% for the background.

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4. Results

With the analysis done, the statistical significance of a possible signal in the presence of background has been evaluated using the estimator 2lnQ = $2\ln(L_{s+b}/L_b)$, where L_{s+b} is the likelihood for the signal-plus-background hypothesis and L_b is the one for the background-only hypothesis. In the Figure 1 the expected significances from both analysis are shown, and Figure 2 shows the 95% confidence level upper limits for each of the Higgs mass considered, where no signal is assumed to be present. Systematic uncertainties have been considered in the results.

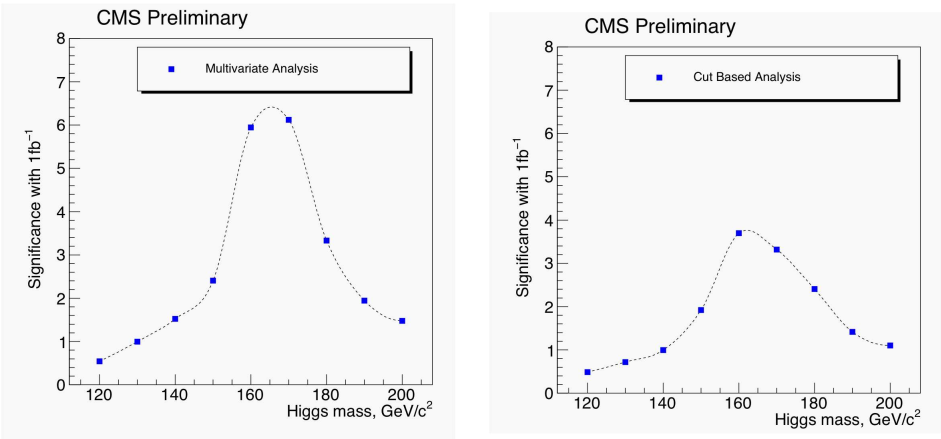

Figure 1: The expected significance of an event excess in assumption of a Higgs boson presence, for the multivariate (left) and for the cut based (right) analysis for an integrated luminosity of 1 fb^{-1}

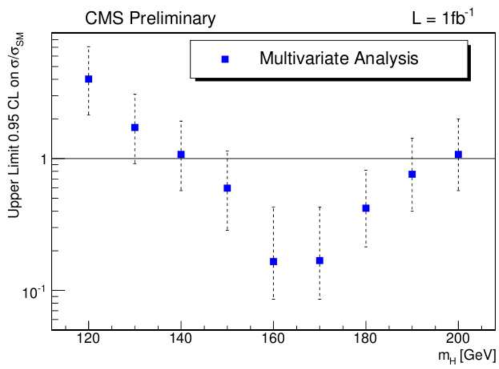

Figure 2: The 95% confidence level upper limits obtained for each of the Higgs mass considered. No signal is assumed to be present

5. Conclusions

Two analysis strategies for the search of SM-like Higgs boson decaying into WW* pairs in the range $m_H \in [120, 200]$ GeV have been presented for the CMS experiment at the LHC accelerator, with a center mass energy of 14 TeV. One is a traditional cut based analysis and the other is a more sophisticated multivariate analysis.

The cut based analysis shows less sensitivity than the multivariate (NN) (see Figure 1). Using such a technique, a SM Higgs could be found at 5σ around $m_H = 160$ GeV, for an integrated luminosity of 1 fb^{-1}. Systematics uncertainties are taken into account in this result.

References

[1] S.Chatrchyan et al, *The CMS experiment at the CERN LHC* 2008 JINST 3 S08004

[2] CMS Collaboration, *Search Strategy for a Standard Model Higgs Boson Decaying to Two W Bosons in the Fully Leptonic Final State*, CMS PAS HIG-08-006