



The Compact Muon Solenoid Experiment
Conference Report

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Ricerca del bosone di Higgs leggero, SM o MSSM, nei canali $b\bar{b}$ e $\tau\tau$ in CMS a LHC

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Abstract

Il canale di decadimento più probabile per un bosone di Higgs leggero ($m_H \lesssim 135$ GeV) del modello standard H è $H \rightarrow b\bar{b}$; tuttavia il segnale compete con un fondo estremamente più copioso dovuto soprattutto a processi multijet (QCD).

La comunicazione punta a riassumere lo stato dell'arte delle analisi sviluppate sul campione di dati pari ad una luminosità integrata $\int L = 4.7 \text{ fb}^{-1}$, raccolto dai rivelatori dell'esperimento CMS nel periodo del 2011 in cui a LHC sono avvenute collisioni protone-protone con energia nel centro di massa $\sqrt{s} = 7$ TeV.

Il bosone di Higgs del modello standard H, prodotto in associazione ad un bosone vettore V, è studiato nei cinque seguenti canali: $W(\mu\nu)H$, $W(e\nu)H$, $Z(\mu\mu)H$, $Z(ee)H$, $Z(\nu\nu)H$, dove in tutti i casi $H \rightarrow b\bar{b}$. Saranno poste in risalto analogie e differenze tra i modi di decadimento negli ambiti di trigger, di valutazione dei fondi e di scelta dei tagli, per giungere poi al limite globale posto sulla sezione d'urto di produzione HV.

La ricerca di H leggero è condotta anche per mezzo del decadimento $H \rightarrow \tau\tau$, includendo i casi in cui ci siano due jets in avanti da produzione di H per fusione tra bosoni vettori, o dove la coppia di leptoni τ ha un elevato impulso trasverso. Lo stato finale $\tau\tau$ contribuisce altresì alla ricerca di un bosone di Higgs neutro (h) del modello supersimmetrico minimale (MSSM), negli eventi in cui sia prodotto in associazione con due b quark jets. Saranno presentati i risultati ricavati per $H(h) \rightarrow \tau\tau$.

In linea con l'esposizione legata ai risultati di analisi che coinvolgono stati finali con b quark jets e per confronto con $h \rightarrow \tau\tau$, sarà presentato il punto sulla ricerca di $(h, H, A) \rightarrow b\bar{b}$, dove h, H ed A sono gli stati scalari e pseudoscalare neutri previsti da MSSM.

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Low mass Higgs boson searches in $b\bar{b}$ or $\tau\tau$ channels at CMS

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Summary. — The most probable decay for a light Higgs Boson Standard Model ($m_H < 135$ GeV) is $H \rightarrow b\bar{b}$; the signal competes with background mostly due to multijet processes (QCD). The poster summarizes the analysis status with data sample corresponding to an integrated luminosity of about 4.7 fb^{-1} , collected in 2011 by Compact Muon Solenoid experiment during Large Hadron Collider proton - proton collisions at a centre of mass energy $\sqrt{s} = 7$ TeV. The Standard Model Higgs H, produced in association with a vector boson V, is studied in five different final states, where $H \rightarrow b\bar{b}$ and the vector boson decays to charged leptons (e, μ) and neutrinos. The poster shows the resulting global limit on production cross section of Higgs boson and weak bosons, $pp \rightarrow VH + X$. The poster also includes information on recent light Higgs boson searches studying the $H \rightarrow \tau\tau$ decay. Such a final state is also important in the context of MSSM neutral Higgs boson searches.

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1. – CMS detector and event display

The Compact Muon Solenoid (CMS) is a multipurpose experiment installed at the Large Hadron Collider (LHC). The CMS apparatus is composed of a silicon pixel and strip tracker, surrounded by a homogeneous crystal electromagnetic calorimeter and a brass-scintillator hadronic calorimeter. Outside the calorimeter, a superconducting solenoid provides a field of 3.8 T. Outside are located three types of muon detectors embedded in the steel return yoke: drift tubes, resistive plate chambers, and cathode strip chambers.

2. – Trigger, event selections, final states, analyses strategies, backgrounds

In the search channels for associated WH production [1, 2] the trigger paths include several single-lepton triggers with tight lepton identification, calorimeter and tracker isolation requirements applied to maintain an acceptable trigger rate. Isolated lepton thresholds in transverse momentum p_T are in the range (17, 40) GeV in all cases. The event selection exploits the predicted signal topology: the azimuthal angle between the reconstructed vector boson direction and the dijet system, $\Delta\phi(V, H)$ is larger than 3

radians. The two b-tagged jets are required to be boosted, with a combined transverse momentum threshold in the range of (100,150) GeV. The b-tag algorithm used is the Combined Secondary Vertex (CSV), where the highest- p_T jet is required to have $CSV > 0.89$, and the second jet $CSV > 0.40$. In the $H \rightarrow \tau\tau$ search the triggers used to select the events are also based on the presence of electron and/or muon trigger objects, but they require in addition calorimeter deposits consistent with those expected from hadronic τ decays. Both analyses use Particle Flow (PF) objects: the PF methods employ information from all CMS sub-detectors to construct particle and jet candidates.

There are five channels for $H \rightarrow b\bar{b}$ analysis: $W(\mu\nu)H$, $W(e\nu)H$, $Z(\mu\mu)H$, $Z(ee)H$, $Z(\nu\nu)H$. All final states include the decay products of H in $b\bar{b}$. The Higgs boson is reconstructed from two central PF b-tagged jets, and is searched with a cut-and-count strategy in the dijet mass distribution. A parallel analysis technique implements Boosted Decision Tree (BDT) to discriminate the signal from backgrounds. $H \rightarrow \tau\tau$ searches include three final states: $\tau_\mu\tau_h$, $\tau_e\tau_h$, $\tau_e\tau_\mu$. A binned maximum likelihood fit on the visible invariant mass of the τ pair is used to search for the signal. For the SM search Higgs events are divided in different categories according to kinematic characteristics: vector boson fusion, boosted, and 0/1 jet categories. For MSSM Higgs searches there are two categories: CSV-tagged and untagged events. For both analyses, the main backgrounds arise from QCD multi-jet and $t\bar{t}$ production.

3. – Results

The predicted number of events in the signal regions of the M(jj) and BDT analyses are determined with the mix of data-driven estimates based on the control regions, and with direct expectations from simulation for those backgrounds for which scale factors were not explicitly derived from control regions. The final signal and background estimates in both sets of analyses, including all uncertainties are calculated and plotted. The $H \rightarrow \tau\tau$ analysis produces the distributions of the τ pair mass $m_{\tau\tau}$ summed over the three search channels, for each category, compared with the background prediction. No significant signal is observed in any channel, and preliminary 95 % CL upper limits on the SM Higgs production cross section in the VH modes with $H \rightarrow b\bar{b}$ are obtained for a dataset corresponding to an integrated luminosity of 4.7 fb^{-1} . The results of the all channels in the BDT and M(jj) analyses are combined separately to produce limits on SM Higgs production in the $b\bar{b}$ channel for the assumed masses in range (110, 135) GeV. At $m_H = 115 \text{ GeV}$, the expected (observed) upper limit is 3.1 (5.2) times the standard model cross section. In the MSSM case the observed τ pair mass spectrum reveals no evidence for neutral Higgs boson production; an upper bound on the product of Higgs boson cross section and τ pair branching fraction is derived as a function of m_A . These results, interpreted in the MSSM parameter space of $\tan(\beta)$ versus m_A , in the m_h^{max} scenario, exclude a previously unexplored region reaching as low as $\tan(\beta) = 7.8$ at $m_A = 160 \text{ GeV}$.

REFERENCES

- [1] CMS COLLABORATION, "Search for Neutral Higgs Bosons Decaying to τ Pairs in pp Collisions at $\sqrt{s} = 7 \text{ TeV}$ ", Phys.Lett. **B712** (2012) 68, doi:10.1016/j.physletb.2012.05.028, arXiv: 1202.4083.
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