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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 ($m_H < 135\,\text{GeV}$) is $H \to b\bar{b}$; 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 $4.7\,\text{fb}^{-1}$, collected in 2011 by the Compact Muon Solenoid experiment during the Large Hadron Collider proton-proton collisions at a centre of mass energy $\sqrt{s} = 7\,\text{TeV}$. The Standard Model Higgs H, produced in association with a vector boson V, is studied in five different final states, where $H \to b\bar{b}$ 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, $pp \to VH + X$. The poster also includes information on recent light Higgs boson searches studying the $H \to \tau\tau$ 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 employs 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 recontructed 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 into 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 $4.7\,\text{fb}^{-1}$. 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, *Phys. Lett. B*, **712** (2012) 68, doi:10.1016/j.physletb.2012.05.028, arXiv: 1202.4083.

[2] CMS Collaboration, *Phys. Lett. B*, **710** (2012) 284, doi:10.1016/j.physletb.2012.02.085, arXiv: 1202.4195.