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Search for a neutral MSSM Higgs boson decaying into a pair of tau leptons at 13 TeV with the CMS experiment

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Abstract

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Search for a Neutral MSSM Higgs Boson Decaying into a Pair of Tau Leptons at 13 TeV with the CMS Experiment

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A search for a neutral Higgs boson decaying into a pair of tau leptons is presented. The analysis is performed with proton-proton collision data collected with the CMS experiment in 2015 using 2.3 fb^{-1} of integrated luminosity. Results are interpreted within the context of the minimal supersymmetric extension to the standard model. Exclusion limits in the m_A - tanβ plane are presented.

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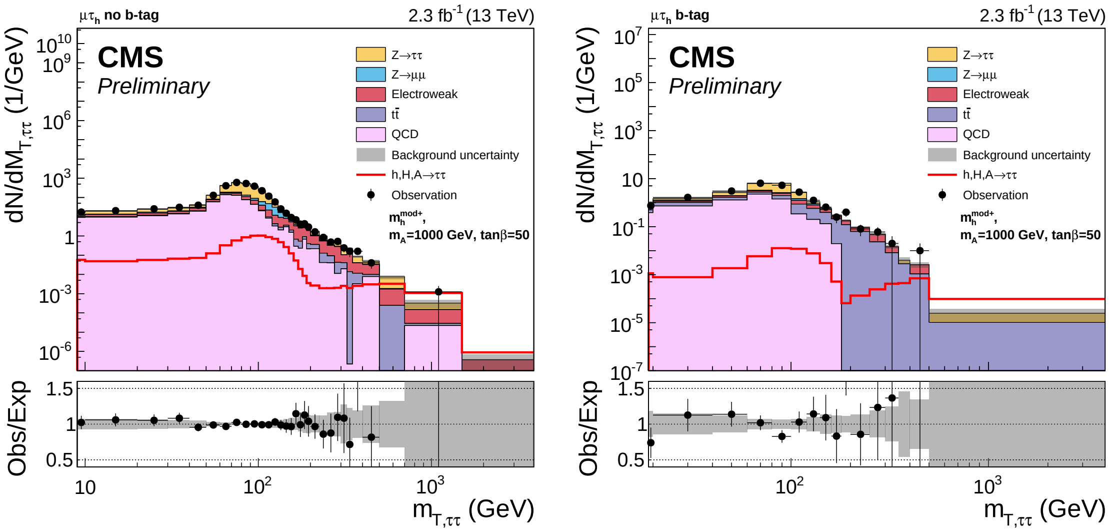
1. Introduction

The standard model (SM) predicts one scalar Higgs boson. In 2012, one neutral boson was discovered at the Large Hadron Collider with a mass of 125.09 $\pm$ 0.21(stat.) $\pm$ 0.11(syst.) GeV [1]. Along with the SM, there are several theories beyond the SM that predict extended Higgs sectors. The minimal supersymmetric standard model (MSSM) [2] is one of the simplest extension of the SM. The MSSM Higgs boson sector has two Higgs doublets that lead to five Higgs particles; two are charged Higgs bosons $H^{\pm}$ and remaining three are neutral Higgs boson (ϕ = h,H A). The pseudoscalar Higgs boson mass m_A and the ratio tanβ of the vacuum expectation values of two the doublets are two free parameters that characterize the MSSM at tree level. There are two main Higgs production process and their relative importance depends on the value of tanβ. For low and medium tanβ gluon-gluon fusion process dominates, while for high tanβ the production associated with b quarks is dominant. The MSSM Higgs sector is defined by various benchmark scenarios such as m_h^{mod+} and hMSSM scenarios [3].

A search for a MSSM neutral Higgs boson decaying into pair of τ leptons is performed using early Run 2 data collected with the CMS experiment at the LHC. During this 2015 run period, data was recorded with 2.3 fb^{-1} integrated luminosity at the center of mass energy of 13 TeV. The analysis is performed for four final states of the tau decays, viz. eμ, eτ_h, $\mu\tau_h$, and $\tau_h\tau_h$, where the hadronic τ decay is represented as τ_h.

2. H/A $\rightarrow \tau\tau$

For the neutral Higgs searches, simulated Monte Carlo (MC) samples are generated for various ranges of signal masses (m_ϕ = 90 - 3200 GeV). MC samples for background events include the Drell-Yan Z/γ^*+jets, W+jets, diboson (WW,WZ, ZZ), $t\bar{t}$, and single top processes.

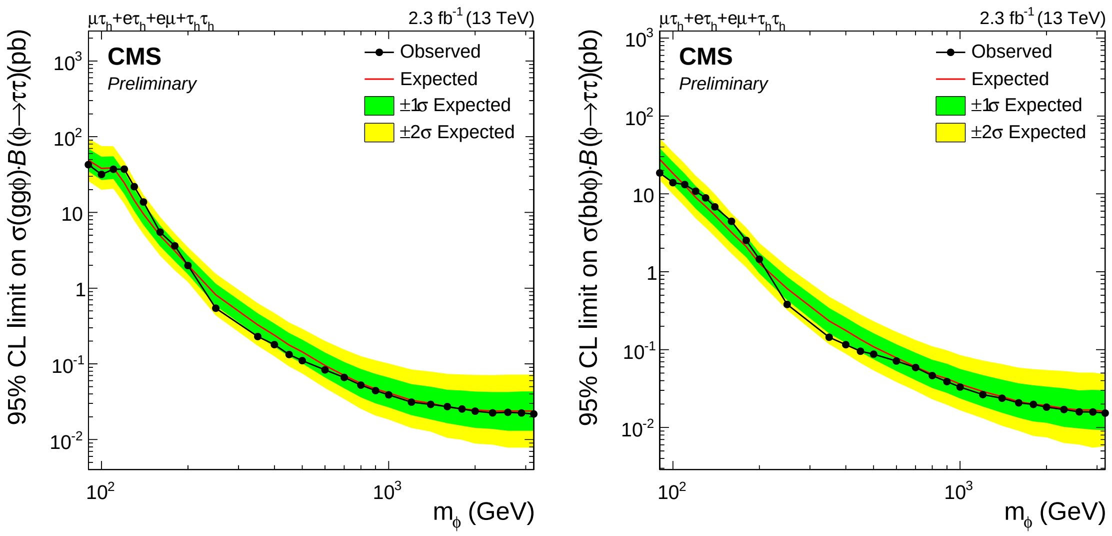


(a) no b-tag category (b) b-tag category

Figure 1: Post fit plots of transverse mass distribution of the $\mu\tau_h$ channel.

All particle objects such as muons, electrons, photons, charged and neutral hadrons are reconstructed using a particle-flow (PF) event reconstruction algorithm by gathering information coming from all the sub-detectors of the CMS. Events above the trigger threshold are selected by applying offline p_T and η cuts [4] within the geometric acceptance in all four channels of the τ decay. To focus on one or the other production mode, the analysis is performed in two complementary event categories: one requiring b-tagged jets and the other vetoing such b-tagged jets. For gluon-gluon production, no b-tagged events are selected, i.e. all events have exactly 0 b-jet. To target b-associated production, selected events have at least one b-tag jet with $p_T > 20$GeV and $|\eta| < 2.4$. In addition, for $e\mu$, $e\tau_h$, $\mu\tau_h$ these jets must pass the "medium" working point criteria [4] of the combined secondary vertex (CSV) discriminator and the "loose" working point for $\tau_h\tau_h$ channel to increase the event statistics in this b-tagged category. Backgrounds for all channels are estimated from MC samples and with data driven corrections. Some backgrounds such as QCD and W+jets are estimated using control regions in data. Finally, normalization and shape uncertainties are applied to the simulated MC samples.

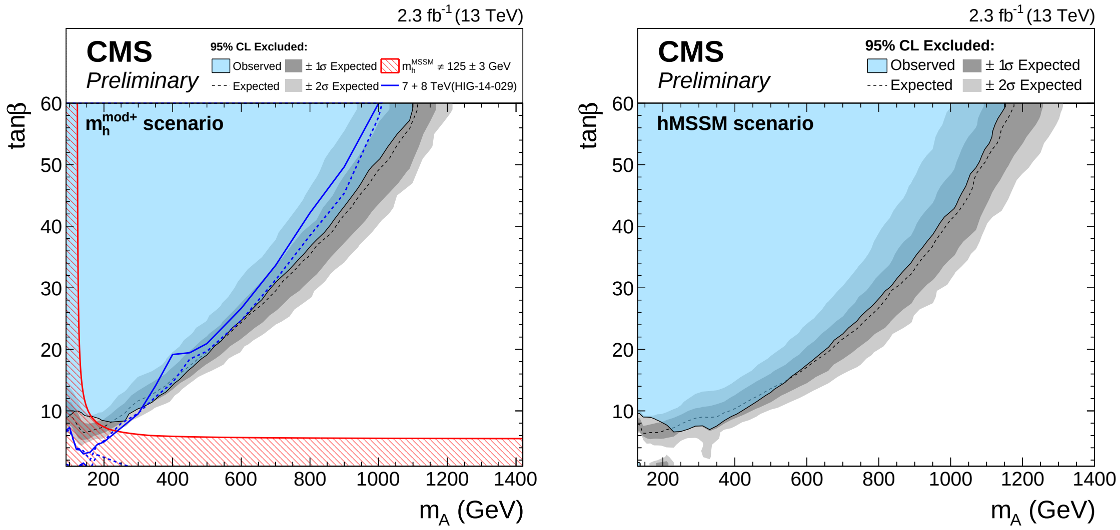
Using a secondary vertex (SV) fit algorithm [5], the transverse invariant mass of the di-τ pair is computed. This reconstructed transverse mass is then fitted using a binned maximum likelihood fit in all four channels in the no b-tag and b-tag categories (Figure 1).



(a) gluon-gluon fusion production ($gg\phi$) (b) $b\bar{b}$ associated production ($bb\phi$)

Figure 2: Expected and observed limits on the $\sigma(gg\phi)\cdot B(\phi\to\tau\tau)$ (left) and $\sigma(bb\phi)\cdot B(\phi\to\tau\tau)$ (right)

The fit to the mass distributions are used to set model-independent upper limits on the cross sections time the branching ratios for both gluon-gluon and b-associated Higgs production. Figure 2 shows the 95% CL upper limit on $\sigma\cdot$ B for the combination of all channels in both categories. Finally m_h^{mod+} and hMSSM scenarios are used to set the model dependent exclusion limits as shown in Figure 3. Comparing the observed and expected exclusion limits obtained from Run 1 analysis (blue line in Figure 3(a)), Run 2 analysis with 13TeV shows larger exclusion from $m_A = \sim 300$GeV and better sensitivity from $m_A = \sim 600$GeV although having much smaller dataset.



(a) m_h^{mod+} (b) hMSSM

Figure 3: Model-dependent exclusion limits combining all channels in m$_A$ - tanβ plane, for m_h^{mode+} scenario (left) and the hMSSM (right). In the left figure, In a) the blue lines indicate the expected (dashed) and observed (solid) exclusions obtained from the most recent Run 1 CMS search for $\phi \to \tau\tau$, and the red shaded area indicates the region where neither of the two scalar Higgs bosons in the model have a mass compatible with 125 ± 3 GeV. [4].

3. Conclusion

No evidence for excessive signal events has been found for a neutral MSSM Higgs boson decaying into a $\tau\tau$ pair in a dataset corresponding to an integrated luminosity of 2.3 fb^{-1} at 13 TeV center-of-mass energy using $\mu\tau_h$, $e\tau_h$, $\tau_h\tau_h$, and $e\mu$ final states. Exclusion limits are set on the production cross section times branching fraction of the gluon-gluon fusion and b-associated production modes. For two MSSM benchmark scenarios, the exclusion limits are set as a function of m$_A$ and tanβ.

References

[1] ATLAS and CMS Collaboration, *"Measurement of Higgs boson production and decay rates and constraints on its couplings from a combined ATLAS and CMS analysis of the LHC pp collision data $\sqrt{s}$ = 7 and 8 TeV"*, ATLAS-CONF-2015-044, CMS-PAS-HIG-15-002, CERN, Geneva, Sep, 2015.

[2] P. Fayet, *"Supergauge invariant extension of the Higgs mechanism and a model for the electron and its neutrino", Nucl. Phys. B* **90** (1975) 104, doi:10.1016/0550-3213(75)90636-7.

[3] E. Bagnaschi et al., *"Benchmark scenarios for low tan beta in the MSSM"*, Cross Section Working Group Public Note 2015/002, 2015.

[4] CMS Collaboration, *"Search for a neutral MSSM Higgs boson decaying into $\tau\tau$ at 13 TeV"*, CMS-PAS-HIG-16-006, CERN (2016).

[5] CMS Collaboration, *"Search for neutral MSSM Higgs bosons decaying into a pair of tau leptons in pp collisions", JHEP* **10** (2014) 160, doi:10.1007/JHEP10(2014)160, arXiv:1408.3316.