PROCEEDINGS OF SCIENCE

Search for lepton flavour violating decays of the Higgs boson with Run II data

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A search for Lepton Flavor Violating (LFV) decays of the Higgs boson to a muon and a tau lepton, and an electron and a tau lepton is presented. The data set used to perform the search has a total luminosity of 35.9 fb^{-1} of proton-proton collisions collected by the CMS detector in 2016, at a center-of-mass energy of 13 TeV. Good agreement with the standard model background expectation is obtained and we set the observed (expected) upper limits on the LFV branching fractions of the Higgs boson to be B(H→$\mu\tau$) < 0.25% (0.25%) and B(H→eτ) < 0.61% (0.37%) at 95% confidence level (CL).

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1. Introduction

The Standard Model (SM) Higgs boson was discovered in 2012 [1] [2]. Since then, the CMS Collaboration [3] joined the search for beyond the SM properties using this particle. The constraints on the BSM branching fraction derived from the measured couplings of the Higgs boson and the SM predictions still allows for a significant contribution from exotic decays. One possibility would be the decay of the Higgs boson into a pair of different flavor leptons. The Lepton Flavor Violating (LFV) decays have been searched for in two channels forbidden in the SM: H→$\mu\tau$ and H→eτ [4].

2. Analysis strategy

The search uses the 2016 data set corresponding to an integrated luminosity of 35.9 fb^{-1} of pp collisions collected by the CMS detector, at a centre-of-mass energy of 13 TeV. The topology of the LFV decays signal contains a prompt isolated lepton, μ or e, along with an oppositely charged τ decaying leptonically or hadronically. In order to perform a better identification of these topologies, we divide the events into categories depending on the number of jets. These categories allow us to separate the different Higgs production mechanisms (gluon-gluon fusion and vector-boson-fusion) and to distinguish signal from the backgrounds. The dominant backgrounds arise from Drell-Yan, W+jets and QCD, $t\bar{t}$ and single-top quark, dibosons, and SM Higgs production.

The division of the events into categories, along with a loose selection in terms of kinematic variables (such as the leptons p_T) constitutes our starting point to extract the signal. An example of a distribution of events after the preselection cuts is shown in the first plot of Figure 1. This distribution corresponds to the collinear mass computed between the two leptons in the final state. By applying tighter kinematic cuts (including the MET p_T and $\Delta\phi$ between the leptons in the final state), we obtain a purer selection. The signal extraction is based on a fit to the collinear mass distribution which is presented in the central plot from Figure 1 for the 2 jets VBF enhanced category of the $\mu\tau_h$ channel.

However, a more powerful strategy can be used in order to extract the signal. Considering the initial loose selection, we train a boosted decision tree (BDT) with kinematic variables as inputs. The BDT technique exploits the correlation between variables and the results are significantly improved by performing the signal extraction through a fit to the BDT discriminator output. We can see an example of a BDT discriminator distribution on the right plot of Figure 1 for the 2 jets VBF enhanced category of the $\mu\tau_h$ channel.

3. Results

After performing the maximum likelihood fits, good agreement is found with the SM background prediction and we extract 95% CL upper limits on the branching ratio for each channel. Figure 2 (left and center) shows the summary of the expected and observed limits for the different categories discussed. We set the observed (expected) upper limits on the LFV branching fractions of the Higgs boson to be: B(H→$\mu\tau$) < 0.25% (0.25%) and B(H→eτ) < 0.61% (0.37%) at 95% confidence level. The constrains on branching ratios can be interpreted in terms of non-diagonal Yukawa couplings, as shown in Figure 2 (right).

In conclusion, this analysis finds no evidence for Lepton Flavour Violation in Higgs boson decays and improves significatively the previous limits obtained by CMS. Further and related studies are ongoing for the Full Run II of the LHC.

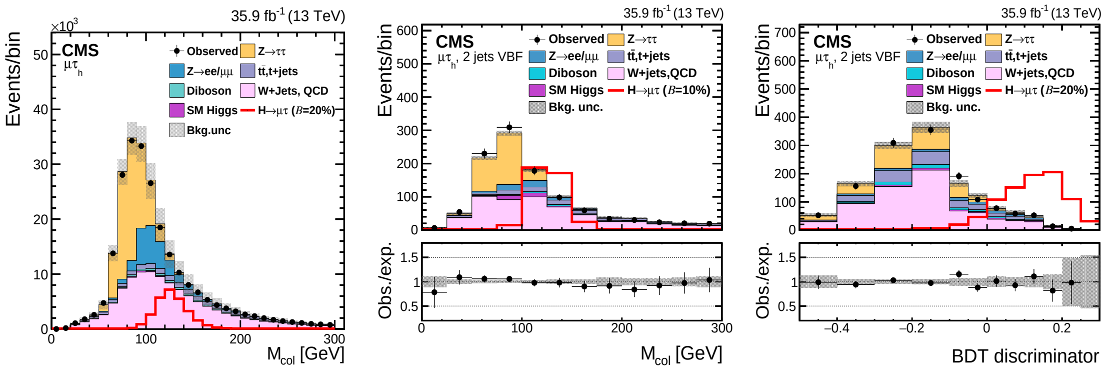

Figure 1: Left: Example of a distribution of an input variable for the BDT fit analysis. Center: M_{col} distribution for the $\mu\tau_h$ channel for the M_{col} fit. Right: BDT discriminator distribution for the $\mu\tau_h$ channel for the BDT fit. The Data/MC agreement appears below the second and third plot. Figures taken from [4].

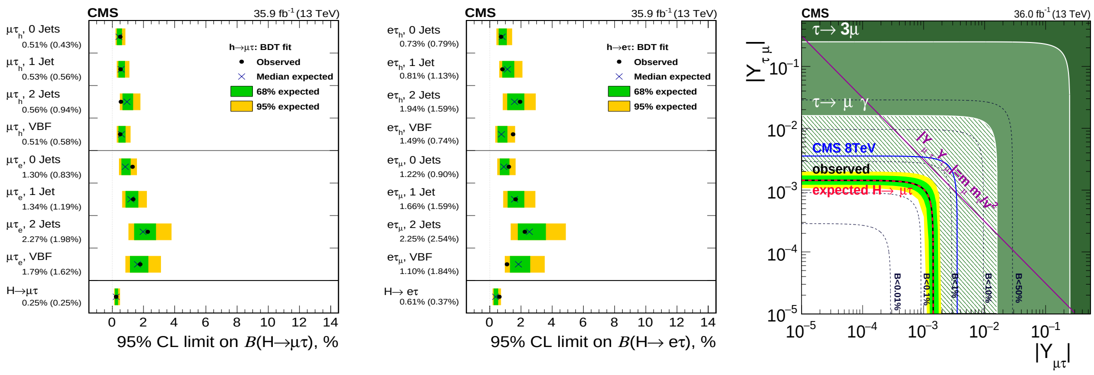

Figure 2: Left and center: Observed and expected upper limits on the the branching fractions for each individual category and combined for $\mu\tau$ and $e\tau$ channels, respectively. Right: Example of constraints on Yukawa couplings for the $\mu\tau$ channel. The plots are taken from Reference [4].

References

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