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

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1. MOTIVATION:

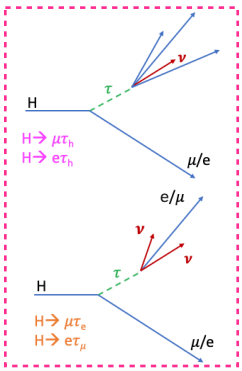
Search for off-diagonal Yukawa couplings that allow Lepton Flavour Violating Higgs Boson decays

LFV decays of the Higgs boson have been searched for in two channels forbidden in the SM: H → $\mu\,\tau$ and H → e τ [1]

2. ANALYSIS STRATEGY

Data set: pp-collisions ($\sqrt{s}$ = 13 TeV) collected in 2016 by CMS detector.

- The studied LFV decays signal contains a **prompt isolated lepton, μ or e**, along with either:
  - an oppositely charged **isolated lepton of different flavour** coming from the τ decay
  - **or** an **hadronically decaying** oppositely charged τ
- The events are then divided into categories: 0 jets, 1 jet, 2 jets.

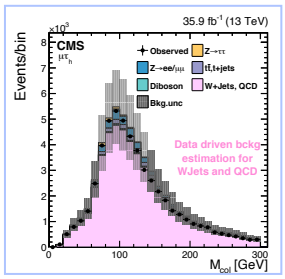


3. HIGGS PRODUCTION MODES AND MAIN BACKGROUNDS

All simulated samples are **weighted** to match the **pileup** distribution observed in data

Higgs production mechanisms → ggH and VBF

1. Z+Jets (Z → $\tau\tau$).
2. Misidentified leptons (W+Jets, QCD).
3. ttbar and single-top quark.
4. Diboson.
5. SM Higgs.

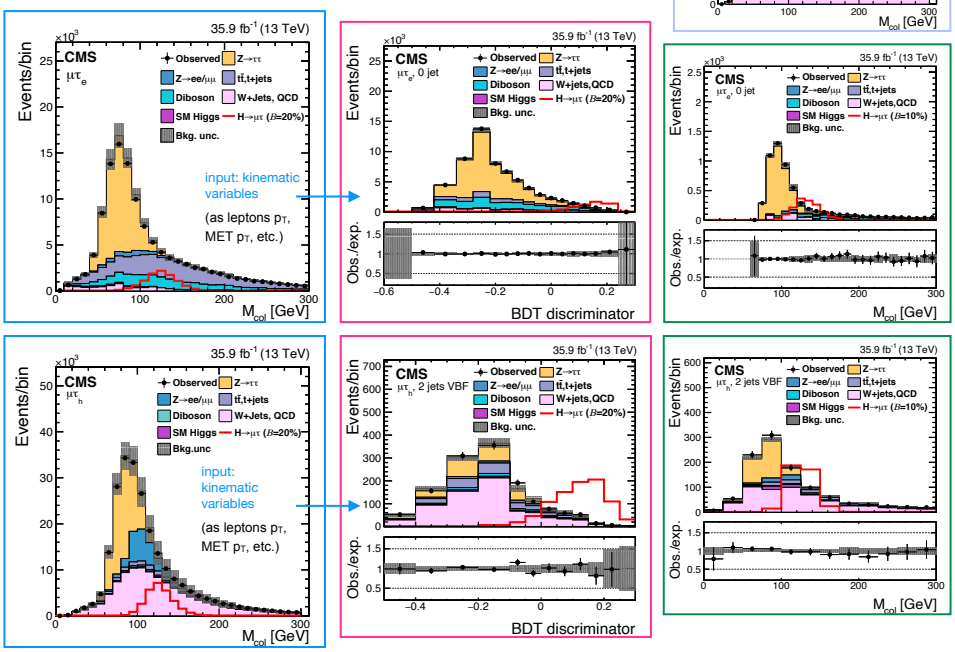


4. Signal extraction

1. **BDT**: A binned likelihood combines all categories to fit the distribution of a BDT discriminator for the signal and the background contributions.
2. **Mcol (cross-check)**: Selection requirements are placed on the kinematic variables and a fit is performed to the M_{col} distribution.

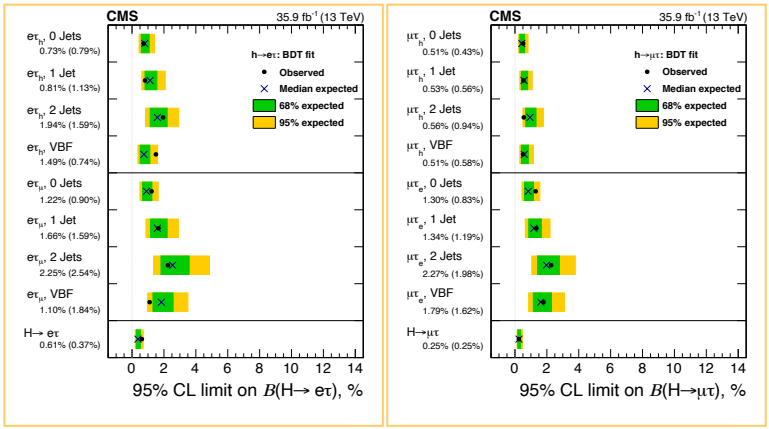
The collinear mass provides an estimate of m_H using the visible decay products of the Higgs boson candidate.

A maximum likelihood fit is performed to derive the expected and observed limits on the BR.



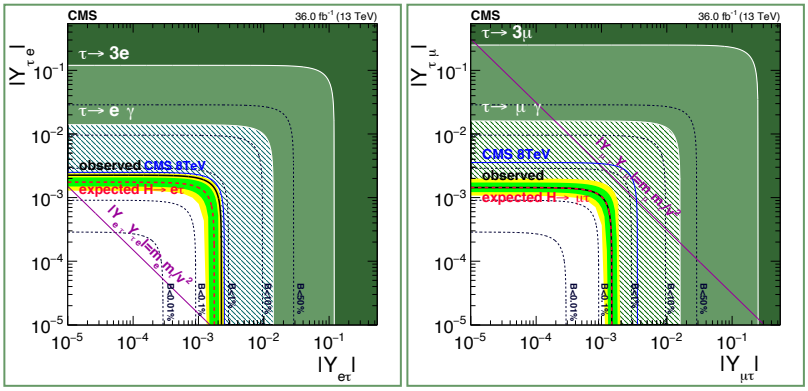
RESULTS

The calculated expected and observed limits on the BR are derived at 95% CL.



The constraints on the studied channels can be interpreted in terms of LFV

	BDT fit	M_{col} fit
$\sqrt{\lvert Y_{\mu\tau}\rvert^2 + \lvert Y_{\tau\mu}\rvert^2}$	$< 1.43 \times 10^{-3}$	$< 2.05 \times 10^{-3}$
$\sqrt{\lvert Y_{e\tau}\rvert^2 + \lvert Y_{\tau e}\rvert^2}$	$< 2.26 \times 10^{-3}$	$< 2.45 \times 10^{-3}$



Conclusions and outlook:

1. No evidence is found for lepton flavour violating Higgs Boson decays:
   BR(H-> τ μ) < 0.25 (0.25) and BR(H-> τ e) < 0.61 (0.37) at 95 % CL
2. The new limits constitute a significant improvement over the previously obtained constraints by CMS.
3. Analysis of the full Run2 data set ongoing.

References:
[1] CMS Collaboration, "Search for lepton flavour violating decays of the Higgs Boson" CMS-HIG-17-001 ; CERN-EP-2017-292; arXiv:1712.07173v3
[2] Sirunyan, A. M. et al. "Combined Measurements of Higgs Boson Couplings in Proton–proton Collisions at $\sqrt{s}$ = 13 TeV" The European Physical Journal C 79.5 (2019):