Inspired by the recent measurement of the $h \rightarrow \mu \tau$ decays by the CMS collaboration at the LHC, we study the lepton flavour-violating (LFV) $B_s \rightarrow \mu \tau$ decays in the general two Higgs doublet model. Those LFV interactions could accommodate the present deviation of the muon anomalous magnetic moment and also predict the LFV $\tau$ decay processes such as $\tau \rightarrow \mu \mu \mu$ and $\tau \rightarrow \mu \gamma$. We find that the $B_s \rightarrow \mu \tau$ decay rates should be sizable with above experimental conditions in the framework of our model. These processes are expected to be observed at the colliders such as LHCb and Belle-II in the future.
I. INTRODUCTION

The discovery of a Higgs boson [1, 2] has opened a new era of particle physics. Henceforth we have to explore the properties of this new boson in detail and try to understand the whole structure of the Higgs sector. Recently the CMS collaboration has reported a slight excess of an exotic decay mode of the Higgs boson into the $\mu\tau$ final states [3]. The best fit value of the branching ratio is $\text{Br}(h \to \mu\tau) = (0.84^{+0.35}_{-0.37})\%$ which shows a 2.4-$\sigma$ deviation from the null result predicted in the standard model (SM). The measurement of the ATLAS collaboration also shows a deviation but still less significance than the CMS result, $\text{Br}(h \to \mu\tau) = (0.77 \pm 0.62)\%$ [4]. The combined result is given by

$$\text{Br}(h \to \mu\tau) = (0.82^{+0.33}_{-0.33})\%$$

and presents an upper limit to be 1.39 % at 95% C.L.

Since $h \to \mu\tau$ decays are the lepton flavour-violating (LFV) processes and forbidden in the SM, the excess could be a direct evidence of the new physics (NP) beyond the SM if it will be confirmed with more data in the future. Lots of expectation value (VEV) and is responsible for the electroweak symmetry breaking [8, 12]. After an appropriate model we consider the general extension of the SM with 2 Higgs doublets as a solution of the LFV Higgs decays. The h
direct evidence of the new physics (NP) beyond the SM if it will be confirmed with more data in the future. Lots of

Thus we focus on the scalar $\mu - \tau$ couplings and neglect other LFV interactions in this paper.

The new scalar $\mu - \tau$ interactions provide various phenomenological implications. First they generically contribute to the muon anomalous magnetic moment, $(g - 2)_\mu$. The precise measurement of $(g - 2)_\mu$ has been one of the most sensitive probe of the NP and still shows unexplained deviation from the SM prediction more than 3-$\sigma$ at present [7]. The scalar LFV interactions are helpful to accommodate the deviation [8, 9]. On the other hand, the LFV $\tau$ decays are also predicted with the scalar FCNC, while they are absent in the SM. Thus the present experimental limits of $(g - 2)_\mu$ and the LFV $\tau$ decays provide stringent constraints on the model.

Here we consider the LFV $B_s \to \mu\tau$ decays in the general two Higgs doublet model (2HDM). The rare $B$ decay modes involving the FCNC are very good testing ground to find hints for NP and have been studied in various channels. For instance, the $B_s \to \mu^- \mu^+$ decays have been in the spotlight to explore the large supersymmetry contribution with scalar exchanges. Recently the branching ratio of $B_s \to \mu^- \mu^+$ mode is measured by the LHCb and the CMS to be $\text{Br}(B_s \to \mu^- \mu^+) = (3.1 \pm 0.7) \times 10^{-9}$ [10, 11] which agrees with the SM prediction. We note that $\text{Br}(h \to \mu^- \mu^+)$ is of order 10%, two order higher than the best fit value of $\text{Br}(h \to \mu\tau)$. Assuming the SM Higgs mediated process is dominated in $B_s \to \mu\tau$ decays, the ratios of $B_s \to \mu\tau$ to $B_s \to \mu\mu$ decays are comparable with those of $\text{Br}(h \to \mu\tau)$ to $\text{Br}(h \to \mu\mu)$. Then we estimate the branching ratio of $B_s \to \mu\tau$ to be of order $10^{-11}$ and it is hard to be measured in the near future. If there are additional contributions to $B_s \to \mu\tau$ decays, however, its branching ratio might be large enough to be observed while $\text{Br}(B_s \to \mu\mu)$ being kept to be within the present measurement 1234. We explore the possibility of such enhancement including the other scalar contributions in the general 2HDM framework.

The paper is organized as follows. We briefly describe the lepton flavour-violation in the general two Higgs doublet model (2HDM). In Sec. II we consider the muon anomalous magnetic moment $(g - 2)_\mu$ and the LFV $\tau$ decay processes in this model. In Sec. IV the $B_s \to \mu\tau$ decays are studied under the experimental constraints discussed in the previous sections. Section V is devoted to conclusions.

II. LFV IN THE GENERAL 2HDM

We can choose a basis for the two Higgs doublets $\hat{H}$ and $\hat{H}$ where only one Higgs doublet $\hat{H}$ gets a vacuum expectation value (VEV) and is responsible for the electroweak symmetry breaking [8, 12]. After an appropriate rotation of leptons such that the neutral components of $\hat{F}$ has flavour-diagonal couplings, the relevant Lagrangian for Yukawa interactions of leptons and d-type quarks reads

$$\mathcal{L} = \frac{\sqrt{2}}{v} \left( m_e \bar{e}_L e_R + m_\mu \bar{\mu}_L \mu_R + m_\tau \bar{\tau}_L \tau_R \right) H^0 + h_{ij}^l \bar{l}_L l_R \phi^0$$

$$+ \frac{\sqrt{2}}{v} \left( m_d \bar{d}_L d_R + m_s \bar{s}_L s_R + m_b \bar{b}_L b_R \right) H^0 + h_{ij}^d \bar{d}_L d_R \phi^0$$

(2)

where the neutral components consist of

$$H^0 = \frac{1}{\sqrt{2}} \left( v + H_+ + iG^0 \right) ,$$
with the scalars $H_s$ and $\phi_s$, Goldstone mode $G^0$, and the pseudoscalar $\phi_p$. Assuming that the CP is conserved in the Higgs sector, the physical states of CP-even scalars, $h$ and $H$ are defined through the mixing

$$
\begin{pmatrix}
\phi_s \\
H_s
\end{pmatrix} = \begin{pmatrix}
\cos \theta & -\sin \theta \\
\sin \theta & \cos \theta
\end{pmatrix} \begin{pmatrix}
H \\
h
\end{pmatrix},
$$

and the CP-odd scalar $A = \phi_p$.

The SM-like Higgs boson $h$ decays into the LFV final states through the small mixing $\sin \theta$. The decay width is given by

$$
\Gamma(h \rightarrow \mu \tau) = \frac{m_h \sin^2 \theta}{16\pi} \left(|h_{\mu\tau}|^2 + |h_{\tau\mu}|^2\right),
$$

and the corresponding branching fraction given by $\text{Br}(h \rightarrow \mu \tau) = \Gamma(h \rightarrow \mu \tau)/(\Gamma_{SM} + \Gamma(h \rightarrow \mu \tau))$. From now on the Yukawa couplings are assumed to be real and $h_{\mu\tau} = h_{\tau\mu}$ for simplicity. Thus we obtain the relation for the combined parameter $h_{\mu\tau} \sin \theta$,

$$
h_{\mu\tau}^2 \sin^2 \theta = \frac{8\pi}{m_h \Gamma_{SM}} \frac{\text{Br}(h \rightarrow \mu \tau)}{1 - \text{Br}(h \rightarrow \mu \tau)} \approx 0.68 \times 10^{-5} \left(\frac{\text{Br}(h \rightarrow \mu \tau)}{0.82\%}\right).
$$

Two curves in the Fig. 1 depicts the equation (6) at 95 % C.L. on the plane of the mixing angle $\sin \theta$ and the LFV coupling $h_{\mu\tau}$. The region between two curves denotes the allowed values by the $h \rightarrow \mu \tau$ branching ratio measurements. We see that the mixing angle might be large if $h_{\mu\tau}$ is small enough as shown in the plot.

### III. LFV CONSTRAINTS

#### A. LFV contributions on $\Delta a_\mu$

The LFV scalar interactions also induce new contributions to the muon anomalous magnetic moment, $(g-2)_\mu$. Still the experimental data of $(g-2)_\mu$ shows a deviation more than 3-$\sigma$ from the SM prediction as,

$$
\Delta a_\mu \equiv a_\mu^{\exp} - a_\mu^{SM} = (288 \pm 63 \pm 49) \times 10^{-11},
$$
where the first error is experimental and the second theoretical. The LFV scalar interaction is one of the good candidates to cure this disagreement of \((g - 2)_\mu\) between theory and experiments. The leading contribution to the \((g - 2)_\mu\) are given by

\[
\Delta a_\mu = \frac{g_\mu^2}{16\pi^2} m_\mu m_\tau \left[ \sin^2 \theta \left( \log \frac{m_\tau^2}{m_h^2} - \frac{3}{2} \right) + \cos^2 \theta \left( \log \frac{m_H^2}{m_\tau^2} - \frac{3}{2} \right) - \frac{1}{m_A^2} \left( \log \frac{m_\tau^2}{m_A^2} - \frac{3}{2} \right) \right],
\]

in the general 2HD model. We note that the SM Higgs contribution of the first term in Eq. (8) \(\sim 4.4 \times 10^{-12}\) with the value of Eq. (6), which could not explain the deviation and additional contribution of \(H\) are inevitable to accommodate \(\Delta a_\mu\) in this model. If the FCNC Yukawa couplings \(y_{ij}\) are small enough, \(H\) and \(A\) might be lighter than the SM Higgs boson \(h\) in this general model. However we avoid unnatural fine tuning and assume the conservative condition \(m_H, m_A \geq m_h\) in this analysis.

We scan the model parameters \((\sin \theta, h_{\mu\tau}, m_H, m_A)\) with the constraints given in the previous section. The red dots and green dots in the Fig. 1 are allowed values of \(\sin \theta\) and \(h_{\mu\tau}\) by \(\Delta a_\mu\) data at 95\% C. L.. The large mixing angle regions are excluded and \(|\sin \theta| < 0.16\). Note that the negative contribution of \(A\) cancels the \(H\) and \(h\) contributions in Eq. (8) and large LFV coupling \(h_{\mu\tau} \sim 0.1\) is still allowed.

### B. LFV \(\tau\) decays

The Higgs FCNC couplings lead to the various LFV decay processes, which do not exist in the SM. In this letter, we focus only on the scalar-\(\mu - \tau\) coupling and the relevant LFV decays are \(\tau \to \mu \gamma\) and \(\tau \to \mu \mu \mu\). The strong experimental limits are given by \(\text{Br}(\tau \to \mu \gamma) < 4.4 \times 10^{-8}\) and \(\text{Br}(\tau \to \mu \mu \mu) < 2.1 \times 10^{-8}\) \([7]\).

We write the effective lagrangian for electromagnetic penguin operators as

\[
\mathcal{L}_{\text{eff}} = C_L \mathcal{O}_L + C_R \mathcal{O}_R + \text{H.c.}
\]

(9)

where the operators are given by

\[
\mathcal{O}_{L,R} = \frac{e}{8\pi^2} m_\tau (\bar{\mu} \sigma^{\mu\nu} P_L \tau) F_{\mu\nu}
\]

(10)

and the leading contributions to the one-loop and two-loop Wilson coefficients by \([14]\)

\[
C^{(1)}_{L,R} \approx \frac{1}{4m_h^2} m_\tau \cos \theta \left( \log \frac{m_h^2}{m_\tau^2} - \frac{4}{3} \right)
\]

\[
C^{(2)}_{L,R} \approx 0.055 h_{\mu\tau} \frac{1}{(125 \text{GeV})^2}
\]

(11)

Note that the one-loop contributions involve the \(\tau\) internal line diagrams and the two-loop contributions come from the Barr-Zee type diagrams. The branching ratio for \(\tau \to \mu \gamma\) decay is

\[
\text{Br}(\tau \to \mu \gamma) = \tau_{\tau} \frac{\alpha m_\tau^5}{64\pi^3} \left( |C_L|^2 + |C_R|^2 \right),
\]

(12)

where \(\tau_{\tau}\) is the tau lifetime.

Due to the Higgs LFV coupling, the \(\tau \to \mu \mu \mu\) decay is obtained at tree level through the Higgs mediated diagram. The branching ratio for \(\tau \to \mu \mu \mu\) decay is given by

\[
\text{Br}(\tau \to \mu \mu \mu) = \tau_{\tau} \frac{m_\mu^5}{3072\pi^4} h_{\mu\tau}^2 \left( \frac{\sin \theta}{m_h^2} y_{h\mu\mu} - \frac{\cos \theta}{m_H^2} y_{H\mu\mu} \right)^2 + \left| \frac{1}{m_A^2} y_{A\mu\mu} \right|^2
\]

(13)

where the lepton flavour conserving Higgs couplings are

\[
y_{h\mu\mu} = \frac{m_\mu}{v} \cos \theta - \frac{h_{\mu\mu}}{\sqrt{2}} \sin \theta,
\]

\[
y_{H\mu\mu} = \frac{m_\mu}{v} \sin \theta + \frac{h_{\mu\mu}}{\sqrt{2}} \cos \theta,
\]

\[
y_{A\mu\mu} = \frac{h_{\mu\mu}}{\sqrt{2}},
\]

(14)
FIG. 2. Allowed masses of H with respect to $h_{\mu\tau}$ by $h \rightarrow \mu\tau$ decays, $(g - 2)_\mu$, $\tau \rightarrow \mu\gamma$, and $\tau \rightarrow \mu\mu\mu$ decays.

where the new flavour conserving coupling $h_{\mu\mu}$ is assumed to be the same order of the ordinary Yukawa coupling $\sim m_\mu/v$ here.

The red dots in the Fig. 1 denotes the allowed values of $\sin \theta$ and $h_{\mu\tau}$ by the additional constraints of the absence of $\tau \rightarrow \mu\gamma$ and $\tau \rightarrow \mu\mu\mu$ decays at 95 % C. L.. We see that the limit of LFV $\tau \rightarrow \mu\gamma$ decay directly leads to the upper bound on $h_{\mu\tau} \sim 0.06$ at this confidence level.

We show the masses of extra neutral scalars H and A in Fig. 2 and 3 with the allowed values of $\sin \theta$ and $h_{\mu\tau}$. Since the sizable H contribution is required to accommodate $\Delta a_\mu$ data, the H mass is upper bounded depending upon $h_{\mu\tau}$ and has the absolute upper bound $\sim 420$ GeV as shown in Fig. 2. No limits are attributed to the A mass. Moreover allowed is the parameter region where both of the H and A are very light simultaneously since the negative contribution of A cancels the H contribution in $\Delta a_\mu$ calculation.
IV. LFV $B_s \rightarrow \mu \tau$ DECAYS

Study of the $B_s$ phenomenology has been performed at the Tevatron and becomes animated at the LHCb. The $B_s$ meson provides good probes to the NP since it involves relatively large FCNC interactions.

The relevant terms of the effective Hamiltonian for $B_s$ decays contributing to the LFV decays of $B_s$ mesons are

$$\mathcal{H}_{\text{eff}} = -\frac{G_F^2 M_W^2}{\pi^2} V_{tb} V_{ts} (C_{10} \mathcal{O}_{10} + C_S \mathcal{O}_S + C_P \mathcal{O}_P) + \text{H.c.}, \quad (15)$$

where the operators are given by

$$\mathcal{O}_{10} = (\bar{b}_R \gamma^\mu s_L)(\bar{\mu} \gamma^\nu s_L),$$

$$\mathcal{O}_S = m_b (\bar{b}_R \gamma^\nu s_L)(\bar{\mu} \gamma^\mu),$$

$$\mathcal{O}_P = m_b (\bar{b}_R \gamma^\nu s_L)(\bar{\mu} \gamma^\mu). \quad (16)$$

The Wilson coefficients are obtained from the $h$, $H$, and $A$ exchange diagrams in this model,

$$C_S = -\frac{\pi^2}{2 G_F M_W (V_{tb} V_{ts})} h_{bs} h_{\mu\tau} \left( \frac{\sin^2 \theta + \cos^2 \theta}{m_h^2} \right),$$

$$C_P = -\frac{\pi^2}{2 G_F M_W (V_{tb} V_{ts})} h_{bs} h_{\mu\tau} \left( \frac{1}{m_A^2} \right). \quad (17)$$

We also assume that $h_{bs} = h_{sb}$ and is real for simplicity. Then the branching ratio of $B_s$ mesons are given by

$$\text{Br}(B_s \rightarrow \mu \tau) = \frac{G_F M_W^4}{8 \pi^5} |V_{tb} V_{ts}|^2 M_B^5 f_B^2 \tau_B \left( \frac{m_b + m_s}{m_B} \right)^2 \times \left[ 1 - \frac{(m_B + m_s)^2}{M_B^2} \right] \left[ 1 - \frac{(m_B - m_s)^2}{M_B^2} \right] \left| C_S \right|^2 \left( 1 - \frac{(m_B - m_s)^2}{M_B^2} \right) |C_P|^2. \quad (18)$$

The quark sector FCNC coupling $h_{bs}$ is constrained by the $B$ physics data. We consider the $B_s - \bar{B}_s$ mixing as a constraint for $h_{bs}$. The present measurement of the mass difference $\Delta M_s$ is

$$\Delta M_s = 17.756 \pm 0.021 \quad (19)$$

in $10^{12} \text{ s}^{-1}$. The $\Delta M_s$ in the general 2HDM reads

$$\Delta M_s = \Delta M^{SM}_s + 2 h_{bs}^2 \left[ \frac{\sin^2 \theta}{m_h^2} \Delta_h + \frac{\cos^2 \theta}{m_H^2} \Delta_H - \frac{1}{m_A^2} \Delta_A \right], \quad (20)$$

where

$$\Delta_S = \sum_{i=1,2} (C_{S_{i1}}^{\text{LL}}(\mu) \langle O_{i1}^{\text{LL}}(\mu) \rangle + C_{S_{i1}}^{\text{RR}}(\mu) \langle O_{i1}^{\text{RR}}(\mu) \rangle + C_{S_{i2}}^{\text{LR}}(\mu) \langle O_{i2}^{\text{LR}}(\mu) \rangle), \quad (21)$$

with $S = h, H, A$. The Wilson coefficients up to $O(\alpha_s)$ are

$$C_{S_{11}}^{\text{LL}}(\mu) = C_{S_{11}}^{\text{RR}}(\mu) = 1 + \frac{\alpha_s}{4\pi} \left( -3 \log \frac{m_Z^2}{\mu^2} + \frac{9}{2} \right),$$

$$C_{S_{22}}^{\text{LL}}(\mu) = C_{S_{22}}^{\text{RR}}(\mu) = \frac{\alpha_s}{4\pi} \left( -\frac{1}{12} \log \frac{m_X^2}{\mu^2} + \frac{1}{8} \right),$$

$$C_{S_{12}}^{\text{LR}}(\mu) = -\frac{3\alpha_s}{2\pi}, \quad C_{S_{22}}^{\text{LR}}(\mu) = 1 - \frac{\alpha_s}{4\pi}. \quad (22)$$

and the matrix elements estimated to be

$$\langle O_{1^{\text{LL}}}^{\text{LL}}(1 \text{ TeV}) \rangle = -0.17, \quad \langle O_{2^{\text{LL}}}^{\text{LL}}(1 \text{ TeV}) \rangle = -0.33,$$

$$\langle O_{1^{\text{LR}}}^{\text{LR}}(1 \text{ TeV}) \rangle = -0.37, \quad \langle O_{2^{\text{LR}}}^{\text{LR}}(1 \text{ TeV}) \rangle = 0.51,$$

$$\langle O_{1^{\text{LL}}}(m_t) \rangle = -0.14, \quad \langle O_{2^{\text{LL}}}(m_t) \rangle = -0.29,$$

$$\langle O_{1^{\text{LR}}}(m_t) \rangle = -0.30, \quad \langle O_{2^{\text{LR}}}(m_t) \rangle = 0.40. \quad (23)$$
FIG. 4. Branching ratios of $B_s \rightarrow \mu \tau$ decays with respect to $m_H$ which explain $h \rightarrow \mu \tau$ decays and allowed by $(g-2)_\mu$, $\tau \rightarrow \mu \gamma$, and $\tau \rightarrow \mu \mu \mu$ decays.

in $(\text{GeV})^3$. We note that $C_i^{SLL} = C_i^{SRR}$, $\langle O_i^{SLL} \rangle = \langle O_i^{SRR} \rangle$. The mass scale is taken to be $\mu = m_t(m_t)$ if $m_{H,A} < 1$ TeV and $\mu = 1$ TeV elsewhere.

Figure 4 show the predictions of the branching ratio $\text{Br}(B_s \rightarrow \mu \tau)$ with respect to $m_H$ with allowed values of parameters given in the previous plots. We find that the decay rates are substantial and even there exists a lower limit of the branching ratio, $\sim 3.5 \times 10^{-8}$. These sizable $B_s \rightarrow \mu \tau$ decay rates are caused by the $H$ exchange contribution. Contributions of the CP-odd scalar $A$ also plays a role for these decay channels since it cancels the $H$ contribution in $\Delta a_\mu$ but constructive in the $B_s$ decay rates.

Observation of the LFV $B_s \rightarrow \mu \tau$ decays is a very clear evidence of the NP, independent of the $h \rightarrow \mu \tau$ decays. The detection of $\tau$ is still challenging at the LHC, but the LHCb collaboration has reported the search results of $B_s \rightarrow \tau^+ \tau^-$ and $B_d \rightarrow \tau^+ \tau^-$ with the $\tau$ reconstruction through the 3 prong decay $\tau^- \rightarrow \pi^- \pi^+ \pi^- \nu_\tau$ [10]. Therefore we expect that it will be possible to observe $B_s \rightarrow \mu \tau$ decays in the future by achieving an improvement of the $\tau$ identification and more data sample in the experiment.

V. CONCLUDING REMARKS

Inspired by the recent measurements of LFV $h \rightarrow \mu \tau$ decays, we suggest an forbidden LFV $B_s$ decays into $\mu \tau$ final states as a new signature of the LFV scalar interactions in the general 2HDM. In order to accommodate the $\Delta a_\mu$ with the scalar FCNC in this model, sizable contributions of additional scalars other than the SM Higgs boson are required. We find that the scalar FCNC contributions to $\Delta a_\mu$ also induce large contribution to $B_s \rightarrow \mu \tau$ decays and the considerable decay rates are possible. We show that the branching ratio is larger than $\mathcal{O}(10^{-8})$ and even could be of order $\sim 10^{-5}$. Such a large decay rate is possible to be measured at the LHCb if $\tau$ detection is improved.

The scalar FCNC couplings in the quark sector, $h_{bs}$ are also essential to $B_s \rightarrow \mu \tau$ decays and constrained by the $B_s - B_s$ mixing data. The $bs$ FCNC couplings also lead to the NP contribution to $B_s \rightarrow \mu^- \mu^+$ decays in general, of which recent measurement agrees with the SM prediction. However our assumption of real $h_{bs} = h_{sb}$ makes NP contributions proportional to $h_{bs}$ and $h_{sb}$ cancel each other and thus we consider no limits from $B_s \rightarrow \mu^- \mu^+$ decays in this work.

The CMS and ATLAS results on $h \rightarrow \mu \tau$ have assumed that the background is of the SM only and $m_b = 125$ GeV. The present signal strengths of the SM Higgs boson have errors of order $\mathcal{O}(10 \%)$ [8]. Thus they are not affected by the new decay channel to $\mu \tau$ of order 1 % branching fraction. The mixing of $h$ and $H$ alters the SM Higgs couplings by the factor $\cos \theta$ in our model and also the signal strengths by $\cos^2 \theta$. Since $|\sin \theta| < 0.07$, it is safe to assume the SM background-only hypothesis. Finally we consider the new scalar productions at the LHC. In our analysis, the new scalar $H$ is not so heavy and even less than 200 GeV, which is enough to be produced at the LHC. However its ordinary Yukawa couplings are suppressed by $\sin \theta$ and the additional $h_{i,j}$ couplings is assumed to be small. Therefore
we do not worry about the LHC search bound on the new scalar bosons.

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[1] G. Aad et al., ATLAS Collaboration, Observation of a new particle in the search for the Standard Model Higgs boson with the ATLAS detector at the LHC, Phys. Lett. B 716, 1 (2012), DOI: 10.1016/j.physletb.2012.08.020, arXiv:1207.7213 [hep-ex].

[2] S. Chatrchyan et al., CMS Collaboration, Observation of a new boson at a mass of 125 GeV with the CMS experiment at the LHC, Phys. Lett. B 716, 30 (2012), DOI: 10.1016/j.physletb.2012.08.021, arXiv:1207.7235 [hep-ex].

[3] V. Khachatryan et al., CMS Collaboration, Search for lepton-flavour-violating decays of the Higgs boson, Phys. Lett. B 749, 337 (2015), DOI: 10.1016/j.physletb.2015.07.053, arXiv:1502.07400 [hep-ex].

[4] G. Aad et al., ATLAS Collaboration, Search for lepton-flavour-violating $H \rightarrow \mu\tau$ decays of the Higgs boson with the ATLAS detector, JHEP 1511, 211 (2015), DOI: 10.1007/JHEP11(2015)211, arXiv:1508.03372 [hep-ex].

[5] S. Baek and J. Tandean, Flavor-Changing Higgs Decays in Grand Unification with Minimal Flavor Violation, Phys. J. C 76, 673 (2016), DOI: 10.1140/epjc/s10052-016-4486-x, arXiv:1604.08935 [hep-ph].

[6] V. Khachatryan et al., CMS Collaboration, Search for lepton-flavour-violating $H \rightarrow e\mu$ decays of the Higgs boson with the CMS detector, JHEP 1511, 211 (2015), DOI: 10.1007/JHEP11(2015)211, arXiv:1508.03372 [hep-ex].

[7] S. Chatrchyan, V. Khachatryan et al., Observations of lepton-flavour-violating decays of the Higgs boson in diphoton and dijet final states, Phys. Rev. D 93, 055021 (2016), DOI: 10.1103/PhysRevD.93.055021, arXiv:1601.03973 [hep-ph].

[8] X.-F. Han, Lepton Flavor Violating Decays of Neutral Higgses in Extended Mirror Fermion Model, Nucl. Phys. B 910, 293 (2016), DOI: 10.1016/j.nuclphysb.2016.07.009, arXiv:1602.00680 [hep-ph].

[9] C.-H. Chen and T. Nomura, Bounds on LFV Higgs decays in a vector-like lepton model and searching for doubly charged leptons at the LHC, Phys. J. C 76, 353 (2016), DOI: 10.1140/epjc/s10052-016-4197-3, arXiv:1602.07519 [hep-ph].

[10] M. Sher and K. Thrasher, Flavor Changing Leptonic Decays of Heavy Higgs Bosons, Phys. Rev. D 93, no. 5, 055021 (2016), DOI: 10.1103/PhysRevD.93.055021, arXiv:1601.03973 [hep-ph].

[11] J. Heeck, M. Holthausen, W. Rodejohann, and Y. Shimizu, Higgs $\rightarrow \mu\tau$ in Abelian and non-Abelian flavor symmetry models, Nucl. Phys. B 896, 281 (2015), DOI: 10.1016/j.nuclphysb.2015.04.025, arXiv:1412.3671 [hep-ph].

[12] D. Aristizabal Sierra and A. Vicente, Explaining the CMS Higgs flavor violating decay excess, Phys. Rev. D 91, no. 11, 115004 (2015), DOI: 10.1103/PhysRevD.91.115004, arXiv:1511.08544 [hep-ph].

[13] A. Crivellin, G. D’Ambrosio, and J. Heeck (Brussels U.), Addressing the LHC flavor anomalies with horizontal gauge symmetries, Phys. Rev. D 91, no. 7, 075066 (2015), DOI: 10.1103/PhysRevD.91.075066, e-Print: arXiv:1503.03477 [hep-ph].

[14] A. Crivellin, G. D’Ambrosio, J. Heeck, Explaining $h \rightarrow \mu^+\tau^-\mu^-$, $B \rightarrow K\mu^+\mu^-$, and $B \rightarrow K\mu^+\mu^-/B \rightarrow K\tau^+\tau^-$ in a two-Higgs-doublet model with gauged $L_\mu - L_\tau$ symmetry, Phys. Rev. Lett. 114, 151801 (2015), DOI: 10.1103/PhysRevLett.114.151801, arXiv:1501.00993 [hep-ph].

[15] J. Heeck, M. Holthausen, W. Rodejohann, and Y. Shimizu, Higgs $\rightarrow \mu\tau$ in Abelian and non-Abelian flavor symmetry models, Nucl. Phys. B 896, 281 (2015), DOI: 10.1016/j.nuclphysb.2015.04.025, arXiv:1412.3671 [hep-ph].

[16] A. Crivellin, G. D’Ambrosio, J. Heeck, Explaining $h \rightarrow \mu^+\tau^-\mu^-$, $B \rightarrow K\mu^+\mu^-$, and $B \rightarrow K\mu^+\mu^-/B \rightarrow K\tau^+\tau^-$ in a two-Higgs-doublet model with gauged $L_\mu - L_\tau$ symmetry, Phys. Rev. Lett. 114, 151801 (2015), DOI: 10.1103/PhysRevLett.114.151801, arXiv:1501.00993 [hep-ph].

[17] C. Patrignani et al. (Particle Data Group), Chin. Phys. C 40, 100001 (2016).

[18] S. Nie and M. Sher, Anomalous magnetic moment of the muon and the Higgs-mediated flavor changing neutral currents, Phys. Rev. D 58, 097701 (1998), DOI: 10.1103/PhysRevD.58.097701, arXiv:hep-ph/9805379.
[9] S. K. Kang and K. Y. Lee, *Implications of the muon anomalous magnetic moment and Higgs-mediated flavor changing neutral currents*, Phys. Lett. B 521, 61 (2001), DOI: 10.1016/S0370-2693(01)01173-X, hep-ph/0103064.

[10] R. Aaij et al., LHCb Collaboration, *Measurement of the $B^0 \to \mu^+\mu^-$ branching fraction and search for $B^0 \to \mu^+\mu^-$ decays at the LHCb experiment*, Phys. Rev. Lett. 111, 101805 (2013), DOI: 10.1103/PhysRevLett.111.101805, arXiv:1307.5024 [hep-ex].

[11] S. Chatrchyan et al., CMS Collaboration, *Measurement of the $B_{s} \to \mu^+\mu^-$ branching fraction and search for $B^0 \to \mu^+\mu^-$ decays with the CMS Experiment*, Phys. Rev. Lett. 111, 101804 (2013), DOI: 10.1103/PhysRevLett.111.101804, arXiv:1307.5025 [hep-ex].

[12] S. Davidson and H. E. Haber, *Basis-independent methods for the two-Higgs-doublet model*, Phys. Rev. D 72, 035004 (2005), Erratum: Phys. Rev. D 72, 099902 (2005), DOI: 10.1103/PhysRevD.72.035004, 10.1103/PhysRevD.72.099902, hep-ph/0504050.

[13] A. J. Buras, F. De Fazio, J. Girrbach, R. Knesjens, and M. Nagai, *The Anatomy of Neutral Scalars with FCNCs in the Flavour Precision Era*, JHEP 1306, 111 (2013), DOI: 10.1007/JHEP06(2013)111, arXiv:1303.3723 [hep-ph].

[14] R. Harnik, J. Kopp, and J. Zupan, *Flavor violating Higgs decays*, JHEP 1303, 026 (2013), DOI: 10.1007/JHEP03(2013)026, arXiv:1209.1397 [hep-ph].

[15] D. Boubaa, A. Datta, M. Duraisamy, and S. Khalil, *Predictions for $B \to \tau\bar{\mu} + \mu\tau$*, Int. J. Mod. Phys. A 28, 1350153 (2013), DOI: 10.1142/S0217751X13501534, arXiv:1211.5168 [hep-ph].

A. Dedes, J. Ellis and M. Raidal, *Higgs-mediated $B^{0}_{s,d} \to \mu\tau, e\tau$ and $\tau \to 3\mu, e\mu\mu$ decays in supersymmetric seesaw models*, Phys. Lett. B 549, 159 (2002), DOI: 10.1016/S0370-2693(02)02900-3, hep-ph/0209207.

[16] R. Aaij et al., LHCb Collaboration, *Search for the decays $B^{0}_{s} \to \tau^{+}\tau^{-}$ and $B^{0} \to \tau^{+}\tau^{-}$*, arXiv:1703.02508 [hep-ex].