Higgs to tau muon in a MSSM flavor extended model

XV Mexican Workshop on Particles and Fields

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Overview

1. Motivation of the Research
   - Experimental Motivation

2. FV Standard Model

3. MSSM

4. Ansatz for FV in MSSM

5. Calculations with the Ansatz

6. Conclusions
Reports of Flavour Violation in CMS and ATLAS

**CMS**
2014/07/05
Standard deviation of the Branching Ratio $BR(h^0 \rightarrow \tau\mu)$: 3.0 $\sigma$ of the Standard Model Prediction
Experimental Branching Ratio: $(0.89^{+0.4}_{-0.37}) \times 10^{-2}$

2015/08/21
Standard deviation of the Branching Ratio $BR(h^0 \rightarrow \tau\mu)$: 2.4 $\sigma$ of the Standard Model Prediction
Experimental Branching Ratio: $(0.84^{+0.39}_{-0.37}) \times 10^{-2}$

**ATLAS**
Upper limit $BR(h^0 \rightarrow \tau\mu) < 1.87 \times 10^{-2}$
The Standard Model

The Model explains three of the fundamental forces of Nature (weak, strong and electromagnetic). It is used in all experimental calculations.

\[ \mathcal{L} = -\frac{1}{4} F_{\mu\nu} F^{\mu\nu} + i \bar{\Psi} \mathcal{D} \Psi + h.c. + \Psi_i Y_{ij} \Psi_j \phi + h.c. + |D_\mu \phi|^2 - V(\phi) \]  

where \(-\frac{1}{4} F_{\mu\nu} F^{\mu\nu}\) represents the electromagnetic interaction, \(i \bar{\Psi} \mathcal{D} \Psi + h.c.\) represents the interaction of fermionic fields, \(\Psi_i Y_{ij} \Psi_j \phi + h.c.\) represents the interaction of the bosonic field with the fermionic field, \(|D_\mu \phi|^2\) represents the interaction of the Higgs field with the fermionic field and \(V(\phi)\) is the Higgs Potential.
Transformations from bosonic fields to fermionic fields and vice versa.

\[ \delta \phi = \epsilon \psi, \delta \phi^* = \epsilon^\dagger \psi^\dagger \]  

\[ \delta S = \int d^4x \delta L = 0 \]  

where \( \epsilon \) is an infinitesimal, anticommuting, two-component Weyl fermion object parameterizing the supersymmetry transformation.
Minimum number of Higgs doublets for Supersymmetrize the Standard Model.

1) It can explain Dark Matter

2) Radiative Higgs boson mass correction quadratic divergences vanish. $m_H$ receives enormous quantum corrections from the virtual effects of every particle that couples, directly or indirectly, to the Higgs field

3) It could be considered that it extends the Standard Model naturally. (Requiring the SUSY transformation)

4) It could join gravity (super-gravity)
Within the MSSM, this soft Lagrangian includes the following terms

\[ \mathcal{L}_{\text{soft}} = \mathcal{L}_{\text{sfermion}}^{\text{mass}} + \mathcal{L}_{\text{bino}}^{\text{mass}} + \mathcal{L}_{\text{wino}}^{\text{mass}} + \mathcal{L}_{\text{gluino}}^{\text{mass}} + \mathcal{L}_{\text{Higgsino}} + \mathcal{L}_{h^0 \tilde{l}_j \tilde{l}_k} \] (4)

In order to establish the free parameters of the model coming from this Lagrangian, we write down the form of the slepton masses and the Higgs- slepton-slepton couplings, the first and last term of eq. 4, which are given as

\[ \mathcal{L}_{\tilde{l} \text{ soft}} = -m^2_{\tilde{E}_{jk}} \tilde{E}_j \tilde{E}_k^\dagger - m^2_{\tilde{L}_{j,k}} \tilde{L}_j^\dagger \tilde{L}_k - (A_{e,j,k} \tilde{E}_j \tilde{L}_k H_1 + h.c) \] (5)
In principle, any scalar with the same quantum numbers could mix through the soft SUSY parameters. This general mixing includes the parity superpartners fermionic labels, and leads us to a sfermion mass matrix given as a squared $6 \times 6$ matrix, which can be written as a block matrix as

$$
\mathbf{\tilde{M}}^2 = \begin{pmatrix}
M_{LL}^2 & M_{LR}^2 \\
M_{LR}^2 & M_{RR}^2
\end{pmatrix}
$$

(6)

where

$$
M_{LL}^2 = m_L^2 + M_i^{(0)2} + \frac{1}{2} \cos 2\beta (2m_W^2 - m_Z^2)I_{3\times3},
$$

(7)

$$
M_{RR}^2 = M_E^2 + M_i^{(0)2} - \cos 2\beta \sin^2 \theta_W m_Z^2 I_{3\times3},
$$

(8)

$$
M_{LR}^2 = \frac{A_i \nu \cos \beta}{\sqrt{2}} - M_i^{(0)} \mu \tan \beta.
$$

(9)

where $M_i^{(0)}$ is the lepton mass matrix.
MSSM extended in Flavour Ansatz

Current data mainly suppress the Flavour mixing associated with the first two slepton families, but allow considerable mixing between the second and third slepton families. Thus, our proposal includes dominant terms that mix the second and third families, as follows

\[ A_{LO} = A'_L = \begin{pmatrix} 0 & 0 & 0 \\ 0 & w & z \\ 0 & y & 1 \end{pmatrix} A_0, \]  

(10)

The dominant terms give a $4 \times 4$ decoupled block mass matrix, in the basis $\tilde{e}_L, \tilde{e}_R, \tilde{\mu}_L, \tilde{\mu}_R, \tilde{\tau}_L, \tilde{\tau}_R$, as

\[ \mathbf{M}^2_{\tilde{l}} = \begin{pmatrix} \tilde{m}_0^2 & 0 & 0 & 0 & 0 & 0 \\ 0 & \tilde{m}_0^2 & X_\tau & 0 & A_z \\ 0 & 0 & \tilde{m}_0^2 & A_y & 0 \\ 0 & 0 & 0 & A_y & \tilde{m}_0^2 & X_\mu \\ 0 & 0 & A_z & 0 & X_\mu & \tilde{m}_0^2 \end{pmatrix}, \]  

(11)

with $X_3 = \frac{1}{\sqrt{2}} A_0 v \cos \beta - \mu m_\tau \tan \beta$ and $X_2 = A_w - \mu m_\mu \tan \beta$. Where $\mu$ is the $SU(2) - invariant$ coupling of two different Higgs superfield doublets, $A_0$ is the trilinear coupling scale and $\tan \beta = \frac{v_2}{v_1}$ is the ratio of the two vacuum expectation values coming from the two neutral Higgs fields, these three are MSSM parameters.
In order to obtain the physical slepton eigenstates, we diagonalize the $4 \times 4$ mass sub-matrix given in (11). For simplicity we consider that $z = y$, which represent that the mixtures $\tilde{\mu}_L \tilde{\tau}_R$ and $\tilde{\mu}_R \tilde{\tau}_L$ are of the same order. The rotation will be performed to this part using an hermitian matrix $Z_I$, such that

$$Z_I^\dagger M_I^2 Z_I = \tilde{M}_{Diag}^2,$$

(12) where

$$M_I^2 = \begin{pmatrix} m_0^2 & X_\tau & 0 & A_y \\ X_\tau & m_0^2 & A_y & 0 \\ 0 & A_y & m_0^2 & X_\mu \\ A_y & 0 & X_\mu & m_0^2 \end{pmatrix}.$$

(13)

| $A_z$ | $\frac{1}{\sqrt{2}} z A_0 v \cos \beta$ |
| $A_y$ | $\frac{1}{\sqrt{2}} y A_0 v \cos \beta$ |
| $A_w$ | $\frac{1}{\sqrt{2}} w A_0 v \cos \beta$ |

Table : Explicit terms of the sfermion mass matrix ansatz.
Masses to the supersymmetric particles

Having new general physical non-degenerate slepton masses

\[
\begin{align*}
    m^2_{\tilde{\mu}_1} &= \frac{1}{2} (2\tilde{m}_0^2 + X_\tau + X_\mu - R) \\
    m^2_{\tilde{\mu}_2} &= \frac{1}{2} (2\tilde{m}_0^2 - X_\tau - X_\mu + R) \\
    m^2_{\tilde{\tau}_1} &= \frac{1}{2} (2\tilde{m}_0^2 - X_\tau - X_\mu - R) \\
    m^2_{\tilde{\tau}_2} &= \frac{1}{2} (2\tilde{m}_0^2 + X_\tau + X_\mu + R)
\end{align*}
\]  

(14)

where \( R = \sqrt{4A_y^2 + (X_\tau - X_\mu)^2} \), \( X_\tau = \frac{1}{\sqrt{2}} A_0 v \cos(\beta) - \mu_{\text{susy}} m_\tau \), \( X_\mu = A_0 v \cos(\beta) - \mu_{\text{susy}} m_\mu \tan(\beta) \)
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MSSM

Flavour Violation

\[
\begin{pmatrix}
\tilde{e}_L \\
\tilde{\mu}_L \\
\tilde{\tau}_L \\
\tilde{e}_R \\
\tilde{\mu}_R \\
\tilde{\tau}_R
\end{pmatrix} = \frac{1}{\sqrt{2}}
\begin{pmatrix}
1 & 0 & 0 & 0 & 0 & 0 \\
0 & -\sin \frac{\varphi}{2} & -\cos \frac{\varphi}{2} & 0 & \sin \frac{\varphi}{2} & \cos \frac{\varphi}{2} \\
0 & \cos \frac{\varphi}{2} & -\sin \frac{\varphi}{2} & 0 & -\cos \frac{\varphi}{2} & \sin \frac{\varphi}{2} \\
0 & 0 & 0 & 1 & 0 & 0 \\
0 & -\sin \frac{\varphi}{2} & \cos \frac{\varphi}{2} & 0 & -\sin \frac{\varphi}{2} & \cos \frac{\varphi}{2} \\
0 & \cos \frac{\varphi}{2} & \sin \frac{\varphi}{2} & 0 & \cos \frac{\varphi}{2} & \sin \frac{\varphi}{2}
\end{pmatrix}
\begin{pmatrix}
\tilde{e}_1 \\
\tilde{\ell}_1 \\
\tilde{\ell}_2 \\
\tilde{\ell}_3 \\
\tilde{\ell}_4
\end{pmatrix}
\]

where

\[
\sin \varphi = \frac{2A_y}{\sqrt{4A_y^2 + (X_2 - X_3)^2}},
\]

\[
\cos \varphi = \frac{(X_2 - X_3)}{\sqrt{4A_y^2 + (X_2 - X_3)^2}}
\]
The Supersymmetric Lagrangian which models the interaction of the Higgs boson with the $\tilde{\mu}_j, \tilde{\tau}_j$, where $j = 1, 2$ is given by

$$
\mathcal{L}_{h0\tilde{f}\tilde{f}} = [Q_\mu + G(-\frac{1}{2} + s^2_w)]\tilde{\mu}_L^*\tilde{\mu}_L h^0 + [Q_\mu - Gs^2_w]\tilde{\mu}_R^*\tilde{\mu}_R h^0 - H_\mu [\tilde{\mu}_L^*\tilde{\mu}_R h^0 + \tilde{\mu}_R^*\tilde{\mu}_L h^0] \\
+ [Q_\tau + G(-\frac{1}{2} + s^2_w)]\tilde{\tau}_L^*\tilde{\tau}_L h^0 + [Q_\tau - Gs^2_w]\tilde{\tau}_R^*\tilde{\tau}_R h^0 - H_\tau [\tilde{\tau}_L^*\tilde{\tau}_R h^0 + \tilde{\tau}_R^*\tilde{\tau}_L h^0]
$$

where

$$
Q_{\mu,\tau} = \frac{g_{m_{\mu,\tau}}}{M_w \cos\beta} s\alpha, \quad G = g_z M_z s(\alpha + \beta), \quad H_{\mu,\tau} = \frac{g_{m_{\mu,\tau}}}{2M_w \cos\beta} (A_{\mu,\tau} s\alpha - \mu_{\text{susy}} \cos\alpha)
$$

The Lagrangian that modelates the interaction of $\tilde{B}\tilde{f}\tilde{f}$ is, where $\tilde{f} = \tilde{\mu}, \tilde{\tau}$

$$
\mathcal{L}_{\tilde{B}0\tilde{f}\tilde{f}} = -\frac{g}{\sqrt{2}} \tilde{B}^0 \left\{ [-\tan\theta_w P_L] \tilde{\mu}_L^* \tilde{\mu} + [2\tan\theta_w P_R] \tilde{\mu}_R^* \tilde{\mu} + [-\tan\theta_w P_L] \tilde{\tau}_L^* \tilde{\tau} + [2\tan\theta_w P_R] \tilde{\tau}_R^* \tilde{\tau} \right\}
$$
We calculate the branching ratio of the decay with one loop correction. The Branching Ratio will be given by the sum of the different contributions of the possible Feynman diagrams, with one loop quantum correction.

\[
\mathcal{BR}(h^0 \rightarrow \tau \mu) = \frac{\Gamma(h^0 \rightarrow \mu \tau)}{\Gamma_{\text{tot}}} \tag{19}
\]

where

\[
\Gamma(h^0 \rightarrow \mu \tau) = \sum_{j,k} \left\{ \frac{1}{8\pi\hbar m_h^0} \int_{(m_\tau + m_\mu)c^2} \left| M_{jk} \right|^2 \frac{\delta(m_{h^0} c - \frac{E_T}{c})}{E_T} dE_T \right\} \tag{20}
\]

Figure: Generalized Decay of \(h^0 \rightarrow \tau \mu\), where \(\mu_1, \mu_2, \tau_1, \tau_2\) are the s-leptons
Lagrangian $h^0\tilde{f}\tilde{f}$ with the Matrix Ansatz

\[
\mathcal{L}_{h^0\tilde{f}\tilde{f}} = \begin{align*}
&\{s_\varphi^2(Q_\tau + H_\tau) + c_\varphi^2(Q_\mu + H_\mu) - \frac{1}{4}G\}h^0\tilde{\mu}_1\tilde{\mu}_1 \\
&+ \{s_\varphi^2(Q_\tau - H_\tau) + c_\varphi^2(Q_\mu - H_\mu) - \frac{1}{4}G\}h^0\tilde{\mu}_2\tilde{\mu}_2 \\
&+ \{s_\varphi^2(Q_\mu - H_\mu) + c_\varphi^2(Q_\tau - H_\tau) - \frac{1}{4}G\}h^0\tilde{\tau}_1\tilde{\tau}_1 \\
&+ \{s_\varphi^2(Q_\mu + H_\mu) + c_\varphi^2(Q_\tau + H_\tau) - \frac{1}{4}G\}h^0\tilde{\tau}_2\tilde{\tau}_2 \\
&+ \frac{1}{4}G(1 - 4s_w^2)h^0\tilde{\mu}_1\tilde{\mu}_2 + c_\varphi s_\varphi(Q_\tau - Q_\mu + H_\tau - H_\mu)h^0\tilde{\mu}_1\tilde{\tau}_2 \\
&+ \frac{1}{4}G(1 - 4s_w^2)h^0\tilde{\mu}_2\tilde{\mu}_1 \\
&+ c_\varphi s_\varphi(Q_\tau - Q_\mu + H_\mu - H_\tau)h^0\tilde{\mu}_2\tilde{\tau}_1 \\
&+ c_\varphi s_\varphi(Q_\tau - Q_\mu + H_\mu - H_\tau)h^0\tilde{\tau}_1\tilde{\mu}_2 + \frac{1}{4}G(1 - 4s_w^2)h^0\tilde{\tau}_1\tilde{\tau}_2 \\
&+ c_\varphi s_\varphi(Q_\tau - Q_\mu + H_\tau - H_\mu)h^0\tilde{\tau}_2\tilde{\mu}_1 \\
&+ \frac{1}{4}G(1 - 4s_w^2)h^0\tilde{\tau}_2\tilde{\tau}_1 \\
\end{align*}
\]
Lagrangian \( \tilde{B}\tilde{f}\tilde{f} \) with the Matrix Ansatz

\[
\mathcal{L}_{\tilde{B}\tilde{f}\tilde{f}} = \frac{g}{4} \tilde{B}\tan \theta_W \left\{ \begin{array}{l}
c_{\varphi}(3 + \gamma_5)\tilde{\mu}_1 \mu \\
+ s_{\varphi}(3 + \gamma_5)\tilde{\mu}_1 \tau \\
+ c_{\varphi}(1 + 3\gamma_5)\tilde{\mu}_2 \mu \\
+ s_{\varphi}(1 + 3\gamma_5)\tilde{\mu}_2 \tau \\
- s_{\varphi}(1 + 3\gamma_5)\tilde{\tau}_1 \mu \\
+ c_{\varphi}(1 + 3\gamma_5)\tilde{\tau}_1 \tau \\
- s_{\varphi}(3 + \gamma_5)\tilde{\tau}_2 \mu \\
+ c_{\varphi}(3 + \gamma_5)\tilde{\tau}_2 \tau \end{array} \right\}
\]
\[ |M_{jk}|^2 = |\alpha_{jk}|^2 \left\{ \left( \frac{|S_{jk}|^2}{c^2} + \frac{|P'_{jk}|^2}{c^2} \right) \left( E_\tau E_\mu + \rho^2 \right) + \left( |P'_{jk}|^2 - |S_{jk}|^2 \right) m_\tau m_\mu \right\} \]

(22)

We have that

\[ \Gamma(h^0 \rightarrow \mu \tau) = \sum_{jk} \frac{1}{8\pi \hbar m_{h^0}} \int_{(m_\tau + m_\mu)c^2} |M_{jk}|^2 \frac{\delta(m_{h^0}c - \frac{E_T}{c})\rho}{E_T} dE_T \]

(23)

Substituting \( |M|^2 \), we obtain.

\[ \Gamma(h^0 \rightarrow \mu \tau) = \sum_{jk} \frac{c}{8\pi^2 \hbar m_{h^0}} |\alpha_{jk}|^2 \left\{ \left( \frac{|S_{jk}|^2}{c^2} + \frac{|P'_{jk}|^2}{c^2} \right) \left( E_\tau E_\mu + \rho^2 \right) \right. \\
+ \left( |P'_{jk}|^2 - |S_{jk}|^2 \right) m_\tau m_\mu \right\} \int_{(m_\tau + m_\mu)c^2} \frac{\delta(E_T - m_{h^0}c^2)\rho}{E_T} dE_T \]

(24)

\[ \Gamma(h^0 \rightarrow \mu \tau) = \sum_{jk} \frac{|\alpha_{jk}|^2 \rho}{8\pi^2 m_{h^0}^2} \left\{ \left( |S_{jk}|^2 + |P'_{jk}|^2 \right) \left( E_\tau E_\mu + \rho^2 \right) + \left( |P'_{jk}|^2 - |S_{jk}|^2 \right) m_\tau m_\mu \right\} \]
### $S_{jk}$ and $P_{jk}$ terms

<table>
<thead>
<tr>
<th>$\tilde{t}\tilde{t}$</th>
<th>$S_{jk}$</th>
<th>$P_{jk}$</th>
</tr>
</thead>
<tbody>
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<td>$\tilde{\mu}\tilde{\mu}$</td>
<td>$-8 \frac{i\pi^2}{C_{h^1 \mu \tau}} {B_{jk} - F_{c0}[C_{jk} + C_{h^1 \mu \tau}(\frac{10}{8}m_{\tilde{B}} + m_{\tau})]}$</td>
<td>$6i\pi^2 m_{\tilde{B}} F_{c0} \gamma_5$</td>
</tr>
<tr>
<td>$\tilde{\mu}\tilde{\tau}$</td>
<td>$6i\pi^2 m_{\tilde{B}} F_{c0}$</td>
<td>$8 \frac{i\pi^2}{C_{h^1 \mu \tau}} {B_{jk} - F_{c0}[C_{jk} + C_{h^1 \mu \tau}(m_{\tau} - \frac{10}{8}m_{\tilde{B}})]} \gamma_5$</td>
</tr>
<tr>
<td>$\tilde{\mu}\tilde{\tau}$</td>
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**Table:** It is shown the Scalar and Pseudoscalar parts of $M_{jk}$. 
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**Ansatz for FV in MSSM**

**Calculations with the Ansatz**

**Conclusions**

**α_{jk} Couplings**

<table>
<thead>
<tr>
<th>$\tilde{f} ; \tilde{f}$</th>
<th>$\alpha_{jk}$</th>
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<tbody>
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<td>$\tilde{\mu}_1 \tilde{\mu}_1$</td>
<td>$-g_{h0}^0 \tilde{\mu}_1 \tilde{\mu}<em>1 \frac{ig^2 s_c c</em>\phi}{16} \tan^2 \theta_w$</td>
</tr>
<tr>
<td>$\tilde{\mu}_1 \tilde{\mu}_2$</td>
<td>$-ig_{h0}^0 \tilde{\mu}<em>1 \tilde{\mu}<em>2 \frac{g^2 c</em>\phi s</em>\phi}{16} \tan^2 \theta_w$</td>
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<tr>
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<td>$\tilde{\mu}_2 \tilde{\mu}_1$</td>
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<tr>
<td>$\tilde{\tau}_2 \tilde{\tau}_2$</td>
<td>$-ig_{h0}^0 \tilde{\tau}<em>2 \tilde{\tau}<em>2 \frac{g^2 c</em>\phi s</em>\phi}{16} \tan^2 \theta_w$</td>
</tr>
</tbody>
</table>

**Table : $\alpha_{jk}$**
Higgs to tau muon in a MSSM flavor extended model

XV Mexican Workshop on Particles and Fields
Rafael Espinosa Castañeda
Thesis Advisor: PhD. Melina Gómez Bock

Motivation of the Research
Experimental Motivation
FV Standard Model
MSSM
Ansatz for FV in

\( g_{\tilde{f}\tilde{f}f} \) Couplings

<table>
<thead>
<tr>
<th>( g_{\tilde{f}\tilde{f}f} )</th>
<th>( \tilde{\mu}_1 )</th>
<th>( \tilde{\mu}_2 )</th>
<th>( \tilde{\tau}_1 )</th>
<th>( \tilde{\tau}_2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \tilde{\mu}_1 )</td>
<td>( s_\nu^2(Q_\tau + H_\tau) + c_\nu^2(Q_\mu + H_\mu) - \frac{1}{4} G )</td>
<td>( \frac{1}{4} G(1 - 4s_\nu^2) )</td>
<td>0</td>
<td>( c_\nu s_\nu(Q_\tau - Q_\mu + H_\tau - H_\mu) )</td>
</tr>
<tr>
<td>( \tilde{\mu}_2 )</td>
<td>( \frac{1}{4} G(1 - 4s_\nu^2) )</td>
<td>( s_\nu^2(Q_\tau - H_\tau) + c_\nu^2(Q_\mu - H_\mu) - \frac{1}{4} G )</td>
<td>( c_\nu s_\nu(Q_\tau - Q_\mu + H_\mu - H_\tau) )</td>
<td>0</td>
</tr>
<tr>
<td>( \tilde{\tau}_1 )</td>
<td>0</td>
<td>( c_\nu s_\nu(Q_\tau - Q_\mu + H_\mu - H_\tau) )</td>
<td>( s_\nu^2(Q_\mu - H_\mu) + c_\nu^2(Q_\tau - H_\tau) - \frac{1}{4} G )</td>
<td>( \frac{1}{4} G(1 - 4s_\nu^2) )</td>
</tr>
<tr>
<td>( \tilde{\tau}_2 )</td>
<td>( c_\nu s_\nu(Q_\tau - Q_\mu + H_\tau - H_\mu) )</td>
<td>0</td>
<td>( \frac{1}{4} G(1 - 4s_\nu^2) )</td>
<td>( s_\nu^2(Q_\mu + H_\mu) + c_\nu^2(Q_\tau + H_\tau) - \frac{1}{4} G )</td>
</tr>
</tbody>
</table>

**Table:** Expressions of the respective interactions of the Higgs boson \( h^0 \) with the s-fermions
\[ B_{jk} = m_{h_0}^2 m_{\mu} [B_{0hjk} - B_{0mbj}] + m_{h_0}^2 m_{\tau} [B_{0hjk} - B_{0tbk}] \]
\[ - m_{\mu}^3 [B_{0hjk} - B_{0mbj}] - m_{\tau}^3 [B_{0hjk} - B_{0tbk}] + m_{\mu} m_{\tau}^2 [B_{0hjk} + B_{0mbj} - 2B_{0tbk}] \]
\[ + m_{\tau} m_{\mu}^2 [B_{0hjk} - 2B_{0mbj} + B_{0tbk}] \]  

(26)

\[ B_{0tbk} = B_{0}(m_{\tau}^2, m_B^2, m_{f_k}^2) \]
\[ B_{0hjk} = B_{0}(m_{h_0}^2, m_{f_j}^2, m_{f_k}^2) \]
\[ B_{0mbj} = B_{0}(m_{\mu}^2, m_B^2, m_{f_j}^2) \]

\[ F_{c0} = C_{0}(m_{h_0}^2, m_{\mu}^2, m_{\tau}^2, m_{f_k}^2, m_{f_j}^2, m_B^2) \]  

(27)

where \[ i\pi^2 F_{C0} = \int \frac{d^4 q_1}{(2\pi)^4 ((q_1 + k_2)^2 - m_B^2)(q_1^2 - m_{f_k}^2)((q_1 + k_2 + k_1)^2 - m_{f_j}^2))} \]

And in general the substraction in terms function B0 where

\[ \Lambda_{i,j} = \sqrt{[m_{i,j}^2 - (m_1^2 + m_2^2)]^2 - 4m_1^2 m_2^2} \]

\[ B0(m_i^2, m_1^2, m_2^2) - B0(m_j^2, m_1^2, m_2^2) = (m_1^2 - m_2^2) \frac{m_i^2 - m_j^2}{m_i^2 m_j^2} \ln\left[ \frac{m_1}{m_1} \right] \]
\[ + \frac{\Lambda_j}{m_j^2} \{ \ln[2m_1 m_2] - \ln[m_1^2 + m_2^2 - m_j^2 + \Lambda_j] \} \]
Figure: Plot Branching Ratio and $m_0$ varying. All the values of $A_0, \mu_{susy}, \tan(\beta), m_b$ are varied.
Results

Figure: Plot Branching Ratio and $\mu_{susy}$. All the values of $A_0, m_0, \tan(\beta), m_b$ are variated.
Results

Figure: Plot Branching Ratio and $\tan(\beta)$. All the values of $A_0, m_0, \mu_{\text{susy}}, m_b$ are varied.
Figure: Plot Branching Ratio and $A_0$. All the values of $\tan(\beta), m_0, \mu_{\text{susy}}, m_b$ are varied.
Figure: Plot Branching Ratio and $mb$. All the values of $\tan(\beta), m_0, \mu_{susy}, A_0$ are varied.
Conclusions

1) The Ansatz proposed of the mixing third and second family within MSSM can predict the Branching Ratio given by the experiment CMS.

2) The range of the free parameters for solving the range of Branching Ratio given by CMS would be

- $400 \lesssim m_0 \lesssim 3800$ [GeV]
- $(600[GeV] < \mu_{susy} \lesssim 1150[GeV]) \cup (1350[GeV] \lesssim \mu_{susy} < 5000[GeV])$
- Restricted for $\tan(\beta) > 48$
- No trilinear restriction (A0)
- No bino mass restriction (mb)

3) We need to overlap with other processes to find more restrictions to our free parameters. Specifically with $BR(\tau \rightarrow \mu \mu \gamma)$
We give special thanks to UNAM PAPIIT IN111115, Red FAE Conacyt and Conacyt 132059 that supported financially this work.