Appendix A

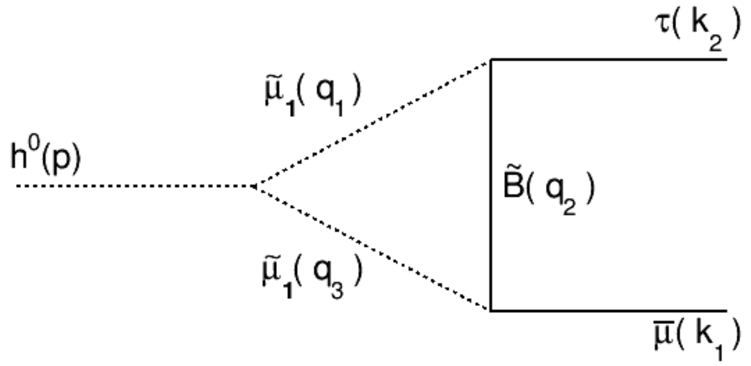
Explicit Calculation of the Amplitudes of $h^0 -> \tau\mu$

Our interest in this appendix is to show the explicit calculation of the different amplitudes of the sixteen possible Feynmann Diagrams with Flavour Violation in MSSM taking our *Ansatz* [11]. The calculation will lead us to a constant wich we call as α_{jk}, the scalar S_{jk} and pseudoscalar$P^{'}_{jk}$ part of the amplitudes. After we know the scalar and pseudoscalar part of each possible Feynman Diagram we proceed to calculate

$$\Gamma(h^0 -> \mu\tau) = \frac{|\alpha_{jk}|^2\rho}{8\pi^2\hbar m^2_{h^0}}\Big\{\big(|S_{jk}|^2 + |P^{'}_{jk}|^2\big)\big(E_\tau E_\mu + \rho^2\big) + \big(|P^{'}_{jk}|^2 - |S_{jk}|^2\big)m_\tau m_\mu\Big\} \tag{A.1}$$

where

$$\begin{aligned} \rho &= \frac{\sqrt{[m^2_{h^0} - (m_\mu + m_\tau)^2][m^2_{h^0} - (m_\mu - m_\tau)^2]}}{2m_{h^0}} \\ m_\tau &= 1.77699\frac{GeV}{c^2} \\ m_\mu &= 0.1056583715\frac{GeV}{c^2} \\ m_{h^0} &= 125\frac{GeV}{c^2} \end{aligned} \tag{A.2}$$



The amplitude is the integration over the momentums of the quantum loop correction.

$$M_{11} = \int \frac{d^4q_1}{(2\pi)^4}\bar{v}_\mu(k_1) * g_{\tilde{B}\tilde{\mu}_1\bar{\mu}} * P_{\tilde{B}}(q_2) * g_{\tilde{B}\tilde{\mu}_1\tau} * u_\tau(k_2) * P_{\tilde{\mu}_1}(q_3) * g_{h^0\tilde{\mu}_1\tilde{\mu}_1} * P_{\tilde{\mu}_1} \tag{A.3}$$

,where $g_{\tilde{B}\tilde{\mu}_1\bar{\mu}}$,$g_{\tilde{B}\tilde{\mu}_1\tau}$,$g_{h^0\tilde{\mu}_1\tilde{\mu}_1}$ represent the interactions and are taken from the respective Lagrangians. $P_{\tilde{B}}$, $P_{\tilde{\mu}_1}$ represent the propagators. In table 4.3 are shown the propagators that are of our interest.
We Substiute the respective propagators, taken from table 4.3

$$M_{11} = \int \frac{d^4q_1}{(2\pi)^4}\bar{v}_\mu(k_1) * g_{\tilde{B}\tilde{\mu}_1\bar{\mu}} * \frac{i(\not{q}_2 + m_{\tilde{B}})}{q_2^2 - m_{\tilde{B}}^2} * g_{\tilde{B}\tilde{\mu}_1\tau} * u_\tau(k_2) * \frac{i}{q_1^2 - m_{\tilde{\mu}_1}^2} * g_{h^0\tilde{\mu}_1\tilde{\mu}_1} * \frac{i}{{q_3}^2 - m_{\tilde{\mu}_1}^2} \tag{A.4}$$

From $\mathcal{L}_{\tilde{B}\tilde{f}f}$ we have that the interaction $g_{\tilde{B}\tilde{\mu}_1\bar{\mu}}$ is

$$g_{\tilde{B}\tilde{\mu}_1\bar{\mu}} = -\frac{gc_\varphi}{4}tan\theta_w[3+\gamma_5] \tag{A.5}$$

Similarly from $\mathcal{L}_{\tilde{B}\tilde{f}f}$, we obtain the following expression

$$g_{\tilde{B}\tilde{\mu}_1\tau} = -\frac{gs_\varphi}{4}tan\theta_w[3+\gamma_5] \tag{A.6}$$

Substituing A.5,A.6 in A.3, we obtain:

$$\begin{aligned} M_{11} &= \int \frac{d^4q_1}{(2\pi)^4}\bar{v}_\mu(k_1) * \frac{gc\varphi}{4}tan\theta_w(3+\gamma_5)\frac{i(\not{q}_2 + m_{\tilde{B}})}{q_2^2 - m_{\tilde{B}}^2}\frac{gs\varphi}{4}tan\theta_w(3+\gamma_5)u_\tau(k_2) * \\ &* \frac{i}{q_1^2 - m_{\tilde{\mu}_1}^2}g_{h^0\tilde{\mu}_1\tilde{\mu}_1}\frac{i}{{q_3}^2 - m_{\tilde{\mu}_1}^2} \\ &= -g_{h^0\tilde{\mu}_1\tilde{\mu}_1}\frac{ig^2s_\varphi c_\varphi}{16}tan^2\theta_w\bar{v}_\mu(k_1)(3+\gamma_5)\frac{\not{q}_2 + m_{\tilde{B}}}{q_2^2 - m_{\tilde{B}}^2}(3+\gamma_5)u_\tau(k_2)\frac{1}{q_1^2 - m_{\tilde{\mu}_1}^2}\frac{1}{{q_3}^2 - m_{\tilde{\mu}_1}^2} \end{aligned} \tag{A.7}$$

Labeling the following expressions as α_{11},N_1 and D_1:

$$\begin{aligned}
\alpha_{11} &= -g_{h^0\tilde{\mu}_1\tilde{\mu}_1}\frac{ig^2 s_\varphi c_\varphi}{16}tan^2\theta_w \\
N_{11} &= \bar{v}_\mu(k_1)(3+\gamma_5)(\not{q}_2 + m_{\tilde{B}})(3+\gamma_5)u_\tau(k_2) \\
D_{11} &= (q_2^2 - m_{\tilde{B}}^2)(q_1^2 - m_{\tilde{\mu}_1}^2)({q_3}^2 - m_{\tilde{\mu}_1}^2)
\end{aligned} \tag{A.8}$$

where $g_{h^0\tilde{\mu}_1\tilde{\mu}_1} = s_\varphi^2(Q_{\tilde{\tau}} + X_{\tilde{\tau}}) + c_\varphi^2(Q_{\tilde{\mu}} + X_{\tilde{\mu}}) - \frac{1}{4}G$

We can express the amplitude as:

$$M_{11} = \alpha_{11}\int \frac{d^4q_1}{(2\pi)^4}\frac{N_{11}}{D_{11}} \tag{A.9}$$

Expanding the products of N_1 and substituing $q_3 = k_1 + k_2 + q_1$, $q_2 = k_2 + q_1$

$$\begin{aligned}
N_{11} &= \bar{v}_\mu(k_1)(3+\gamma_5)(\not{q}_2 + m_{\tilde{B}})(3+\gamma_5)u_\tau(k_2) \\
&= \bar{v}_\mu(k_1)\big\{9(\not{q}_1 + \not{k}_2 + m_{\tilde{B}}) + 3(\not{q}_1 + \not{k}_2 + m_{\tilde{B}})\gamma_5 + \gamma_5(\not{q}_1 + \not{k}_2 + m_{\tilde{B}})3 \\
&+ \gamma_5(\not{q}_1 + \not{k}_2 + m_{\tilde{B}})\gamma_5\big\}u_\tau(k_2)
\end{aligned}$$

We use two properties of the Dirac matrixes

$$\begin{aligned}
\gamma_5^2 &= 1 \\
\gamma_5\gamma^\mu &= -\gamma^\mu\gamma_5
\end{aligned} \tag{A.10}$$

And substituing

$$\not{q}_1 = \gamma^\mu q_{1\mu}, \not{k}_2 = \gamma^\mu k_{2\mu}$$

$$\begin{aligned}
N_{11} &= \bar{v}_\mu(k_1)\big\{9(\gamma^\mu q_{1\mu} + \gamma^\mu k_{2\mu} + m_{\tilde{B}}) + 3(\gamma^\mu q_{1\mu} + \gamma^\mu k_{2\mu} + m_{\tilde{B}})\gamma_5 + \gamma_5(\gamma^\mu q_{1\mu} + \gamma^\mu k_{2\mu} + m_{\tilde{B}})3 \\
&+ \gamma_5(\not{q}_1 + \not{k}_2 + m_{\tilde{B}})\gamma_5\big\}u_\tau(k_2) \\
&= \bar{v}_\mu(k_1)\big\{9(\gamma^\mu q_{1\mu} + \gamma^\mu k_{2\mu} + m_{\tilde{B}}) + 3(-\gamma_5\gamma^\mu q_{1\mu} - \gamma_5\gamma^\mu k_{2\mu} + \gamma_5 m_{\tilde{B}}) \\
&+ 3\gamma_5(\gamma^\mu q_{1\mu} + \gamma^\mu k_{2\mu} + m_{\tilde{B}}) + \gamma_5(-\gamma_5\gamma^\mu q_{1\mu} - \gamma_5\gamma^\mu k_{2\mu} + \gamma_5 m_{\tilde{B}})]\big\}u_\tau(k_2) \\
&= \bar{v}_\mu(k_1)\big\{8\gamma^\mu q_{1\mu} + 8\gamma^\mu k_{2\mu} + 10m_{\tilde{B}} + 6\gamma_5 m_{\tilde{B}}\big\}u_\tau(k_2) \\
&= \bar{v}_\mu(k_1)\big\{8\not{q}_1 + 8\not{k}_2 + 10m_{\tilde{B}} + 6\gamma_5 m_{\tilde{B}}\big\}u_\tau(k_2)
\end{aligned} \tag{A.11}$$

If we substitute the expression above in M_{11} and $q_3 = k_1 + k_2 + q_1$, $q_2 = k_2 + q_1$ in D_{11}

$$\alpha_{11}\int \frac{\bar{v}_\mu(k_1)\big\{8\not{q}_1 + 8\not{k}_2 + 10m_{\tilde{B}} + 6\gamma_5 m_{\tilde{B}}\big\}u_\tau(k_2)}{((k_2+q_1)^2 - m_{\tilde{B}}^2)(q_1^2 - m_{\tilde{\mu}_1}^2)((k_2+k_1+q_1)^2 - m_{\tilde{\mu}_1}^2)} \tag{A.12}$$

We separate the integral, since the integral is a linear operator.

$$
\begin{aligned}
M_{11} &= \alpha_{11}\bar{v}_\mu(k_1)\Big\{8\int d^4q_1 \frac{\not{q}_1}{(2\pi)^4((q_1+k_2)^2-m_{\tilde{B}}^2)(q_1^2-m_{\tilde{\mu}_1}^2)((q_1+k_2+k_1)^2-m_{\tilde{\mu}_1}^2))} \\
&+ 8\not{k}_2\int \frac{d^4q_1}{(2\pi)^4((q_1+k_2)^2-m_{\tilde{B}}^2)(q_1^2-m_{\tilde{\mu}_1}^2)((q_1+k_2+k_1)^2-m_{\tilde{\mu}_1}^2)} \\
&+ 10m_{\tilde{B}}\int \frac{d^4q_1}{(2\pi)^4((q_1+k_2)^2-m_{\tilde{B}}^2)(q_1^2-m_{\tilde{\mu}_1}^2)((q_1+k_2+k_1)^2-m_{\tilde{\mu}_1}{}^2)} \\
&+ 6\gamma_5 m_{\tilde{B}}\int \frac{d^4q_1}{(2\pi)^4((q_1+k_2)^2-m_{\tilde{B}}^2)(q_1^2-m_{\tilde{\mu}_1}^2)((q_1+k_2+k_1)^2-m_{\tilde{\mu}_1}{}^2)}\Big\}u_\tau(k_2)
\end{aligned}
\tag{A.13}
$$

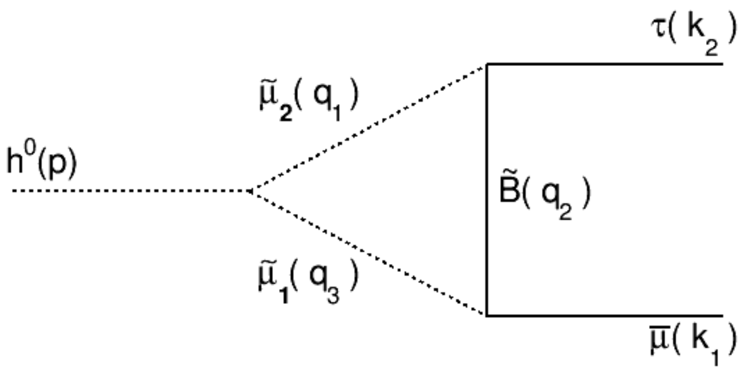
We use the generalized cases in Ec. 4.26 and Ec. 4.38 of the integrals $IC1$ and $IC2$ with $j=1$ and $k=1$.

$$
M_{11} = -8\frac{i\pi^2}{C_{h^0\mu\tau}}\{\mathcal{B}_{11} - F_{c0}C_{11}\} + i\pi^2 F_{c0}\{8\not{k}_2 + 10m_{\tilde{B}} + 6\gamma_5 m_{\tilde{B}}\}
\tag{A.14}
$$

We use the completeness relation that states that $\not{k}_2 u_\tau(k_2) = m_\tau u_\tau(k_2)$

$$
\begin{aligned}
M_{11} &= -8\frac{i\pi^2}{C_{h^0\mu\tau}}\{\mathcal{B}_{11} - F_{C0}[C_{11} + C_{h^0\mu\tau}(m_\tau + \frac{10}{8}m_{\tilde{B}})]\} + 6i\pi^2 F_{c0}\gamma_5 m_{\tilde{B}} \\
&= \bar{v}_\mu(k_1)\alpha_{11}\{S_{11} + P_{11}\}u_\tau(k_2)
\end{aligned}
\tag{A.15}
$$

where we called as $S_{11} = -8\frac{i\pi^2}{C_{h^0\mu\tau}}\{\mathcal{B}_{11} - F_{C0}[C_{11} + C_{h^0\mu\tau}(m_\tau + \frac{10}{8}m_{\tilde{B}})]\}$ and $P_{11} = 6i\pi^2 F_{c0}\gamma_5 m_{\tilde{B}}$ because one is scalar and the second one is pseudoscalar.



We continue with amplitude M_{12}. We calculate it with the following equation.

$$M_{12} = \int \frac{d^4q_1}{(2\pi)^4} \times \bar{v}_\mu(k_1) \times g_{\tilde{B}\tilde{\mu}_1\mu} \times P_{\tilde{B}}(q_2) \times g_{\tilde{B}\tilde{\mu}_2\tau} \times u_\tau(k_2) \times P_{\tilde{\mu}_2}(q_1) \times g_{h^0\tilde{\mu}_1\tilde{\mu}_2} \times P_{\tilde{\mu}_1}(q_3) \tag{A.16}$$

From Table 3.3, we have that

$$g_{\tilde{B}\tilde{\mu}_1\mu} = -\frac{gc_\varphi}{4} tan\theta_w[3+\gamma_5] \tag{A.17}$$
$$g_{\tilde{B}\tilde{\mu}_2\tau} = -\frac{gs_\varphi}{4} tan\theta_w[1+3\gamma_5] \tag{A.18}$$
$$\tag{A.19}$$

And from Table 4.3, we obtain

$$P_{\tilde{B}}(q_2) = \frac{i(\not{q}_2 + m_{\tilde{B}})}{q_2^2 - m_{\tilde{B}}^2} \tag{A.20}$$
$$P_{\tilde{\mu}_2}(q_1) = \frac{i}{q_1^2 - m_{\tilde{\mu}_2}^2} \tag{A.21}$$
$$P_{\tilde{\mu}_1}(q_3) = \frac{i}{q_3^2 - m_{\tilde{\mu}_1}^2} \tag{A.22}$$

Substituing the propagators and two of the three interactions in the integral, we obtain

$$\begin{aligned} M_{12} &= \int \frac{d^4q_1}{(2\pi)^4} \times \bar{v}_\mu(k_1) \times \frac{gc_\varphi}{4} tan\theta_w[3+\gamma_5] \times \frac{i(\not{q}_2 + m_{\tilde{B}})}{q_2^2 - m_{\tilde{B}}^2} \times \\ &\times \frac{gs_\varphi}{4} tan\theta_w[1+3\gamma_5] \times u_\tau(k_2) \times \frac{i}{q_1^2 - m_{\tilde{\mu}_2}^2} \times g_{h^0\tilde{\mu}_1\tilde{\mu}_2} \times \frac{i}{q_3^2 - m_{\tilde{\mu}_1}^2} \\ &= -\int \frac{d^4q_1}{(2\pi)^4} \times \frac{ig_{h^0\tilde{\mu}_1\tilde{\mu}_2} g^2 c_\varphi s_\varphi}{16} tan^2\theta_w \times \bar{v}_\mu(k_1) \times [3+\gamma_5] \times \frac{\not{q}_2 + m_{\tilde{B}}}{q_2^2 - m_{\tilde{B}}^2} \\ &\times [1+3\gamma_5] \times u_\tau(k_2) \times \frac{1}{q_1^2 - m_{\tilde{\mu}_2}^2} \times \frac{1}{q_3^2 - m_{\tilde{\mu}_1}^2} \end{aligned} \tag{A.23}$$

Labeling as α_{12},D_{12} and N_{12} the following expressions:

$$\begin{aligned}\alpha_{12} = -\frac{ig_{h^0\tilde{\mu}_1\tilde{\mu}_2}g^2c_\varphi s_\varphi}{16}tan^2\theta_w\\ D_{12} = [q_2^2 - m_{\tilde{B}}^2][q_1^2 - m_{\tilde{\mu}_2}^2][q_3^2 - m_{\tilde{\mu}_1}^2]\\ N_{12} = \bar{v}_\mu(k_1)[3+\gamma_5][\not{q}_2 + m_{\tilde{B}}][1+3\gamma_5]u_\tau(k_2)\end{aligned} \quad (A.24)$$

We have that:

$$M_{12} = \alpha_{12}\int\frac{d^4q_1}{(2\pi)^4}\frac{N_{12}}{D_{12}} \quad (A.25)$$

Working with N_{12} and leaving it in terms of q_1, using 4.6

$$\begin{aligned}N_{12} &= \bar{v}_\mu(k_1)[3+\gamma_5][\not{q}_2 + m_{\tilde{B}}][1+3\gamma_5]u_\tau(k_2)\\ &= \bar{v}_\mu(k_1)\big\{3(\not{q}_2+m_{\tilde{B}}) + 3(\not{q}_2+m_{\tilde{B}})3\gamma_5 + \gamma_5(\not{q}_2+m_{\tilde{B}}) + \gamma_5(\not{q}_2+m_{\tilde{B}})3\gamma_5\big\}u_\tau(k_2)\\ &= \bar{v}_\mu(k_1)\big\{3(\not{q}_2+m_{\tilde{B}}) + 9\gamma_5(-\not{q}_2+m_{\tilde{B}}) + \gamma_5(\not{q}_2+m_{\tilde{B}}) + 3(-\not{q}_2+m_{\tilde{B}})\big\}u_\tau(k_2)\\ &= \bar{v}_\mu(k_1)\big\{-8\gamma_5\not{q}_2 + 10m_{\tilde{B}}\gamma_5 + 6m_{\tilde{B}}\big\}u_\tau(k_2)\\ &= \bar{v}_\mu(k_1)\big\{-8\gamma_5\not{k}_2 - 8\gamma_5\not{q}_1 + 10m_{\tilde{B}}\gamma_5 + 6m_{\tilde{B}}\big\}u_\tau(k_2)\end{aligned} \quad (A.26)$$

Leaving D_{12} in terms of q_1

$$D_{12} = [(k_2+q_1)^2 - m_{\tilde{B}}^2][q_1^2 - m_{\mu_2}^2][(k_2+k_1+q_1)^2 - m_{\mu_1}^2] \quad (A.27)$$

We substitute N_{12} in M_{12} and we separate the integral

$$\begin{aligned}M_{12} = \alpha_{12}\bar{v}_\mu(k_1)\Bigg\{-8\gamma_5\not{k}_2\int\frac{d^4q_1}{(2\pi)^4}\frac{1}{[(k_2+q_1)^2 - m_{\tilde{B}}^2][q_1^2 - m_{\mu_2}^2][(k_2+k_1+q_1)^2 - m_{\mu_1}^2]}\\ -8\gamma_5\int\frac{d^4q_1}{(2\pi)^4}\frac{\not{q}_1}{[(k_2+q_1)^2 - m_{\tilde{B}}^2][q_1^2 - m_{\mu_2}^2][(k_2+k_1+q_1)^2 - m_{\mu_1}^2]}\\ +10m_{\tilde{B}}\gamma_5\int\frac{d^4q_1}{(2\pi)^4}\frac{1}{[(k_2+q_1)^2 - m_{\tilde{B}}^2][q_1^2 - m_{\mu_2}^2][(k_2+k_1+q_1)^2 - m_{\mu_1}^2]}\\ +6m_{\tilde{B}}\int\frac{d^4q_1}{(2\pi)^4}\frac{1}{[(k_2+q_1)^2 - m_{\tilde{B}}^2][q_1^2 - m_{\mu_2}^2][(k_2+k_1+q_1)^2 - m_{\mu_1}^2]}\Bigg\}u_\tau(k_2)\end{aligned} \quad (A.28)$$

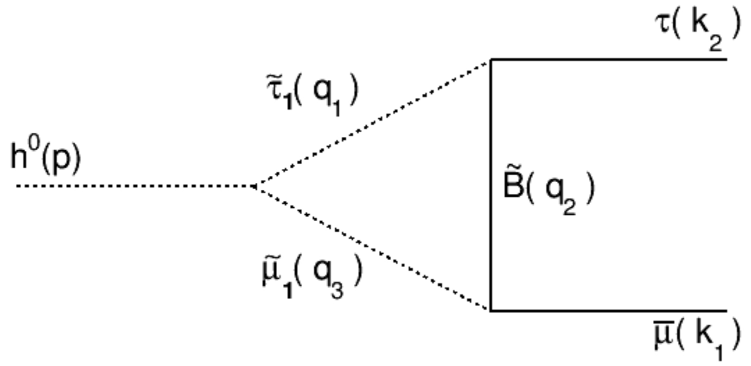
Using the result of the generalized integrals in Ec. 4.26 ,4.38, we obtain

$$\begin{aligned}M_{12} &= \alpha_{12}\bar{v}_\mu(k_1)\Bigg\{-8i\pi^2F_{c0}\gamma_5\not{k}_2 + 8\frac{i\pi^2}{C_{h^0\mu\tau}}\{\mathcal{B}_{12} - F_{c0}C_{12}\}\gamma_5\\ &+ 10i\pi^2m_{\tilde{B}}F_{c0}\gamma_5 + 6im_{\tilde{B}}\pi^2F_{c0}\Bigg\}u_\tau(k_2)\\ &= \alpha_{12}\bar{v}_\mu(k_1)\Bigg\{6im_{\tilde{B}}\pi^2F_{c0} + 8\frac{i\pi^2}{C_{h^0\mu\tau}}\{\mathcal{B}_{12} - F_{c0}(C_{12} + C_{h^0\mu\tau}(m_\tau - \frac{10}{8}m_{\tilde{B}})\}\gamma_5\Bigg\}u_\tau(k_2)\end{aligned} \quad (A.29)$$

where we used the completeness relation $\not{k}_2 u_\tau(k_2) = m_\tau u_\tau(k_2)$ Or separating in the scalar part and pseudoscalar part

$$\begin{aligned} S_{12} &= 6im_{\tilde{B}}\pi^2 F_{c0} \\ P_{12} &= 8\frac{i\pi^2}{C_{h^0\mu\tau}}\{\mathcal{B}_{12} - F_{c0}(C_{12} + C_{h^0\mu\tau}(m_\tau - \frac{10}{8}m_{\tilde{B}}))\}\gamma_5 \end{aligned} \tag{A.30}$$

$$M_{12} = \alpha_{12}\bar{v}_\mu(k_1)\big\{S_{12} + P_{12}\big\}u_\tau(k_2) \tag{A.31}$$



We have that

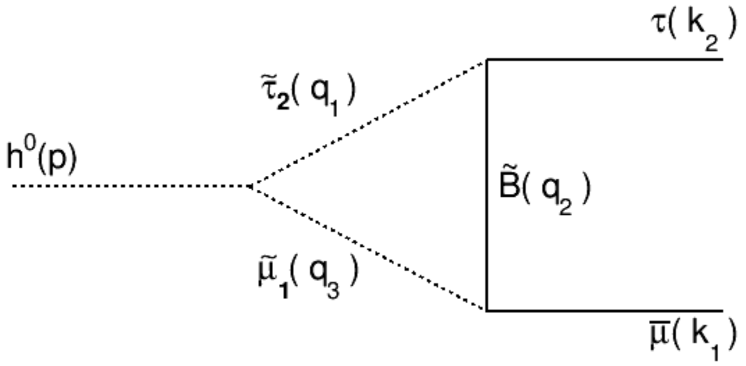
$$M_{13} = \int \frac{d^4 q_1}{(2\pi)^4} \bar{v}_\mu(k_1) * g_{\tilde{B}\tilde{\mu}_1\mu} * P_{\tilde{B}}(q_2) * g_{\tilde{B}\tilde{\tau}_1\tau} * u_\tau(k_2) * P_{\tilde{\tau}_1}(q_1) * g_{h^0\tilde{\mu}_1\tilde{\tau}_1} * P_{\tilde{\mu}_1}(q_3) \tag{A.32}$$

However, from table 3.2 we have that the interaction of higgs h^0,$\tilde{\mu}_1$, $\tilde{\tau}_1$ is zero, since it does not exist in the Lagrangian. Therefore $g_{h^0\tilde{\mu}_1\tilde{\tau}_1} = 0$ and we obtain

$$M_{13} = 0 \tag{A.33}$$

For simplicity it will be written

$$\begin{aligned} \alpha_{13} &= 0 \\ S_{13} &= 0 \\ P_{13} &= 0 \end{aligned} \tag{A.34}$$



We have that the amplitude M_{14} is

$$M_{14} = \int \frac{d^4q_1}{(2\pi)^4} \times \bar{v}_\mu(k_1) \times g_{\tilde{B}\tilde{\mu}_1\mu} \times P_{\tilde{B}}(q_2) \times g_{\tilde{B}\tilde{\tau}_2\tau} \times u_\tau(k_2) \times P_{\tilde{\tau}_2}(q_1) \times g_{h^0\tilde{\mu}_1\tilde{\tau}_2} \times P_{\tilde{\mu}_1}(q_3) \tag{A.35}$$

From Table 3.3, we have that

$$g_{\tilde{B}\tilde{\mu}_1\mu} = -\frac{gc_\varphi}{4} tan\theta_w[3+\gamma_5] \tag{A.36}$$

$$g_{\tilde{B}\tilde{\tau}_2\tau} = -\frac{gc_\varphi}{4} tan\theta_w[3+\gamma_5] \tag{A.37}$$

From Table 4.3, we obtain

$$P_{\tilde{B}}(q_2) = \frac{i(\not{q}_2 + m_{\tilde{B}})}{q_2^2 - m_{\tilde{B}}^2} \tag{A.38}$$

$$P_{\tilde{\tau}_2}(q_1) = \frac{i}{q_1^2 - m_{\tilde{\tau}_2}^2} \tag{A.39}$$

$$P_{\tilde{\mu}_1}(q_3) = \frac{i}{q_3^2 - m_{\tilde{\mu}_1}^2} \tag{A.40}$$

From Table 3.2

$$g_{h^0\tilde{\mu}_1\tau_2} = c_\varphi s_\varphi(Q_{\tilde{\tau}} - Q_{\tilde{\mu}} + X_{\tilde{\tau}} - X_{\tilde{\mu}}) \tag{A.41}$$

Substituing the propagators and the respective interactions, we obtain

$$\begin{aligned} M_{14} &= \int \frac{d^4q_1}{(2\pi)^4} \bar{v}_\mu(k_1) \frac{gc_\varphi}{4} tan\theta_w[3+\gamma_5] \frac{i(\not{q}_2 + m_{\tilde{B}})}{q_2^2 - m_{\tilde{B}}^2} \frac{gc_\varphi}{4} tan\theta_w[3+\gamma_5] u_\tau(k_2) \times \\ &\times \frac{i}{q_1^2 - m_{\tilde{\tau}_2}^2} g_{h^0\tilde{\mu}_1\tilde{\tau}_2} \frac{i}{q_3^2 - m_{\tilde{\mu}_1}^2} \\ &= -\int \frac{d^4q_1}{(2\pi)^4} \frac{i g_{h^0\tilde{\mu}_1\tilde{\tau}_2} g^2 c_\varphi^2}{16} tan^2\theta_w \bar{v}_\mu(k_1)[3+\gamma_5] \frac{\not{q}_2 + m_{\tilde{B}}}{q_2^2 - m_{\tilde{B}}^2}[3+\gamma_5] \times \\ &\times u_\tau(k_2) \frac{1}{q_1^2 - m_{\tilde{\tau}_2}^2} \frac{1}{q_3^2 - m_{\tilde{\mu}_1}^2} \end{aligned} \tag{A.42}$$

Labeling the following expressions as α_{14},N_{14} and D_{14}

$$N_{14} = \bar{v}_\mu(k_1)[3+\gamma_5][\not{q}_2 + m_{\tilde{B}}][3+\gamma_5]u_\tau(k_2)$$
$$\alpha_{14} = -\frac{ig_{h^0\tilde{\mu}_1\tilde{\tau}_2} g^2 c_\varphi^2}{16} tan^2\theta_w$$
$$D_{14} = [q_2^2 - m_{\tilde{B}}^2][q_1^2 - m_{\tilde{\tau}_2}^2][q_3^2 - m_{\tilde{\mu}_1}^2] \quad \text{(A.43)}$$

Therefore, we can rewrite M_{14} as

$$M_{14} = \alpha_{14}\int \frac{d^4q_1}{(2\pi)^4}\frac{N_{14}}{D_{14}} \quad \text{(A.44)}$$

As it can be noticed N_{14} is exactly as N_{11} in A.8.Therefore substituing N_{11} in the expression above

$$\begin{aligned} M_{14} &= \alpha_{14}\bar{v}_\mu(k_1)\Big\{8\int d^4q_1 \frac{\not{q}_1}{(2\pi)^4((q_1+k_2)^2 - m_{\tilde{B}}^2)(q_1^2 - m_{\tilde{\tau}_2}^2)((q_1+k_2+k_1)^2 - m_{\tilde{\mu}_1}^2))} \\ &+ 8\not{k}_2\int \frac{d^4q_1}{(2\pi)^4((q_1+k_2)^2 - m_{\tilde{B}}^2)(q_1^2 - m_{\tilde{\tau}_2}^2)((q_1+k_2+k_1)^2 - m_{\tilde{\mu}_1}^2)} \\ &+ 10m_{\tilde{B}}\int \frac{d^4q_1}{(2\pi)^4((q_1+k_2)^2 - m_{\tilde{B}}^2)(q_1^2 - m_{\tilde{\tau}_2}^2)((q_1+k_2+k_1)^2 - m_{\tilde{\mu_1}^2})} \\ &+ 6\gamma_5 m_{\tilde{B}}\int \frac{d^4q_1}{(2\pi)^4((q_1+k_2)^2 - m_{\tilde{B}}^2)(q_1^2 - m_{\tilde{\tau}_2}^2)((q_1+k_2+k_1)^2 - m_{\tilde{\mu_1}^2})}\Big\}u_\tau(k_2) \end{aligned} \quad \text{(A.45)}$$

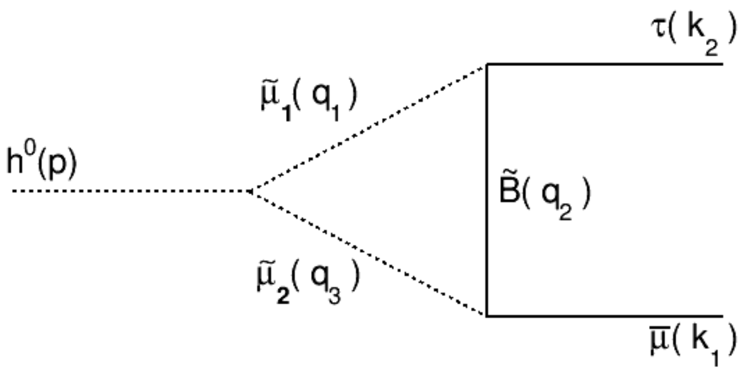
Using the integral generalization in Ec. 4.26 and Ec. 4.38 for this particular case (j=1,k=4)

$$M_{14} = \alpha_{14}\bar{v}_\mu(k_1)\Big\{-8\frac{i\pi^2}{C_{h^0\mu\tau}}\{\mathcal{B}_{14} - F_{c0}C_{14}\} + i\pi^2 F_{c0}\{8\not{k}_2 + 10m_{\tilde{B}} + 6\gamma_5 m_{\tilde{B}}\}\Big\}u_\tau(k_2) \quad \text{(A.46)}$$

We use the completeness relation that states that $\not{k}_2 u_\tau(k_2) = m_\tau u_\tau(k_2)$

$$\begin{aligned} M_{14} &= \alpha_{14}\bar{v}_\mu(k_1)\Big\{-8\frac{i\pi^2}{C_{h^0\mu\tau}}\{\mathcal{B}_{14} - F_{C0}[C_{14} + C_{h^0\mu\tau}(m_\tau + \frac{10}{8}m_{\tilde{B}})]\} + 6i\pi^2 F_{c0}\gamma_5\Big\}u_\tau(k_2) \\ &= \alpha_{14}\bar{v}_\mu(k_1)\{S_{14} + P_{14}\}u_\tau(k_2) \end{aligned} \quad \text{(A.47)}$$

where we separeted the scalar and pseudoscalar part of M_{14} in S_{14} and P_{14}



We follow the same algorithm for calculating the amplitude. The amplitude is represented by M_{21} and is calculated as follows

$$M_{14} = \int \frac{d^4q_1}{(2\pi)^4} \times \bar{v}_\mu(k_1) \times g_{\tilde{B}\tilde{\mu}_2\mu} \times P_{\tilde{B}}(q_2) \times g_{\tilde{B}\tilde{\mu}_1\tau} \times u_\tau(k_2) \times P_{\tilde{\mu}_1}(q_1) \times g_{h^0\tilde{\mu}_1\tilde{\mu}_2} \times P_{\tilde{\mu}_2}(q_3) \tag{A.48}$$

We take the propagators and interactions from tables 4.3,3.3.

$$g_{\tilde{B}\tilde{\mu}_2\mu} = -\frac{gc_\varphi}{4} tan\theta_w[1+3\gamma_5] \tag{A.49}$$
$$g_{\tilde{B}\tilde{\mu}_1\tau} = -\frac{gs_\varphi}{4} tan\theta_w[3+\gamma_5] \tag{A.50}$$
$$P_{\tilde{B}}(q_2) = \frac{i(\not{q}_2 + m_{\tilde{B}})}{q_2^2 - m_{\tilde{B}}^2} \tag{A.51}$$
$$P_{\tilde{\mu}_1}(q_1) = \frac{i}{q_1^2 - m_{\tilde{\mu}_1}^2} \tag{A.52}$$
$$P_{\tilde{\mu}_2}(q_3) = \frac{i}{q_3^2 - m_{\tilde{\mu}_2}^2} \tag{A.53}$$

Therefore we have that

$$\begin{aligned} M_{21} &= \int \frac{d^4q_1}{(2\pi)^4} \bar{v}_\mu(k_1) \frac{gc_\varphi}{4} tan\theta_w[1+3\gamma_5] \frac{i(\not{q}_2 + m_{\tilde{B}})}{q_2^2 - m_{\tilde{B}}^2} \frac{gs_\varphi}{4} tan\theta_w[3+\gamma_5] u_\tau(k_2) \times \\ &\times \frac{i}{q_1^2 - m_{\tilde{\mu}_1}^2} g_{h^0\mu_2\mu_1} \frac{i}{q_3^2 - m_{\tilde{\mu}_2}^2} \\ &= -\int \frac{d^4q_1}{(2\pi)^4} \frac{ig_{h^0\mu_2\mu_1} g^2 c_\varphi s_\varphi}{16} tan^2\theta_w \bar{v}_\mu(k_1)[1+3\gamma_5] \frac{\not{q}_2 + m_{\tilde{B}}}{q_2^2 - m_{\tilde{B}}^2} [3+\gamma_5] u_\tau(k_2) \frac{1}{q_1^2 - m_{\tilde{\mu}_1}^2} \frac{1}{q_3^2 - m_{\tilde{\mu}_2}^2} \end{aligned} \tag{A.54}$$

And as we did in the last cases, we label an expression N_{21},α_{21} and D_{21}

$$\begin{aligned} \alpha_{21} &= -\frac{ig_{h^0\mu_2\mu_1} g^2 c_\varphi s_\varphi}{16} tan^2\theta_w \\ N_{21} &= \bar{v}_\mu(k_1)[1+3\gamma_5][\not{q}_2 + m_{\tilde{B}}][3+\gamma_5] u_\tau(k_2) \\ D_{21} &= [q_2^2 - m_{\tilde{B}}^2][q_1^2 - m_{\tilde{\mu}_1}^2][q_3^2 - m_{\tilde{\mu}_2}^2] \end{aligned} \tag{A.55}$$

Using the expressions above we can express M_{21} as $M_{21}=\alpha_{21}\int\frac{d^4q_1}{(2\pi)^4}\frac{N_{21}}{D_{21}}$
We expand N_{21}. We use the dirac matrix property $\gamma_5\gamma^\mu=-\gamma^\mu\gamma_5$.Also we know that $\not{k}_2=\gamma^\mu k_{2\mu}$, $\not{q}_1=\gamma^\mu q_{1\mu}$

$$\begin{aligned}
N_{21} &= \bar{v}_\mu(k_1)[1+3\gamma_5][\not{q}_2+m_{\tilde{B}}][3+\gamma_5]u_\tau(k_2)\\
&= \bar{v}_\mu(k_1)\{(\not{q}_2+m_{\tilde{B}})3+(\not{q}_2+m_{\tilde{B}})\gamma_5+3\gamma_5(\not{q}_2+m_{\tilde{B}})3+3\gamma_5(\not{q}_2+m_{\tilde{B}})\gamma_5\}u_\tau(k_2)\\
&= \bar{v}_\mu(k_1)\{3(\not{q}_2+m_{\tilde{B}})+\gamma_5(-\not{q}_2+m_{\tilde{B}})+9\gamma_5(\not{q}_2+m_{\tilde{B}})+3(-\not{q}_2+m_{\tilde{B}})\}u_\tau(k_2)\\
&= \bar{v}_\mu(k_1)\{8\gamma_5\not{q}_2+10\gamma_5 m_{\tilde{B}}+6m_{\tilde{B}}\}u_\tau(k_2)\\
&= \bar{v}_\mu(k_1)\{8\gamma_5(\not{q}_1+\not{k}_2)+10\gamma_5 m_{\tilde{B}}+6m_{\tilde{B}}\}u_\tau(k_2)
\end{aligned} \tag{A.56}$$

We substitute N_{21} in M_{21} and substitute $q_3=k_2+k_1+q_1$,$q_2=k_2+q_1$ in D_{21}

$$\begin{aligned}
M_{21} &= \alpha_{21}\bar{v}_\mu(k_1)\Big\{8\gamma_5\int\frac{d^4q_1}{(2\pi)^4}\frac{\not{q}_1}{[(k_2+q_1)^2-m_{\tilde{B}}^2][q_1^2-m_{\tilde{\mu}_1}^2][(k_2+k_1+q_1)^2-m_{\tilde{\mu}_2}^2]}\\
&+ 8\gamma_5\not{k}_2\int\frac{d^4q_1}{(2\pi)^4[(k_2+q_1)^2-m_{\tilde{B}}^2][q_1^2-m_{\tilde{\mu}_1}^2][(k_2+k_1+q_1)^2-m_{\tilde{\mu}_2}^2]}\\
&+ 10\gamma_5 m_{\tilde{B}}\int\frac{d^4q_1}{(2\pi)^4[(k_2+q_1)^2-m_{\tilde{B}}^2][q_1^2-m_{\tilde{\mu}_1}^2][(k_2+k_1+q_1)^2-m_{\tilde{\mu}_2}^2]}\\
&+ 6m_{\tilde{B}}\int\frac{d^4q_1}{(2\pi)^4[(k_2+q_1)^2-m_{\tilde{B}}^2][q_1^2-m_{\tilde{\mu}_1}^2][(k_2+k_1+q_1)^2-m_{\tilde{\mu}_2}^2]}\Big\}u_\tau(k_2)
\end{aligned} \tag{A.57}$$

We use Ec. 4.26 and Ec. 4.38 and substitute the value of the integrals above. For this particular case $j=2$ and $k=1$.

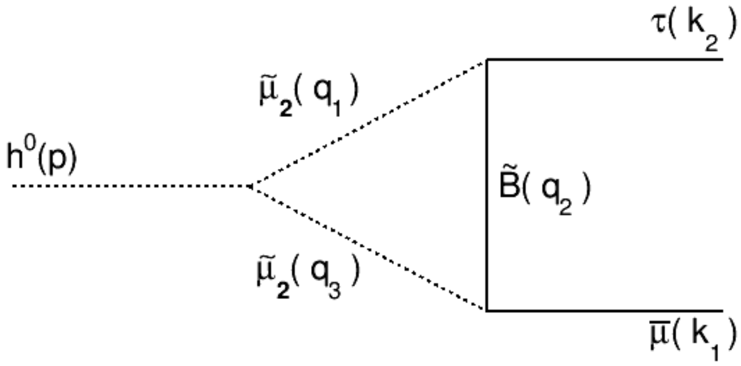
$$\begin{aligned}
M_{21} &= \alpha_{21}\bar{v}_\mu(k_1)\Big\{-8\gamma_5\frac{i\pi^2}{C_{h^0\mu\tau}}\{B_{21}-F_{c0}C_{21}\}+8\gamma_5 m_\tau i\pi^2F_{c0}+10\gamma_5 m_{\tilde{B}}i\pi^2F_{c0}+6i\pi^2m_{\tilde{B}}F_{c0}\Big\}\\
&= \alpha_{21}\bar{v}_\mu(k_1)\Big\{6i\pi^2m_{\tilde{B}}F_{c0}-8\frac{i\pi^2}{C_{h^0\mu\tau}}\{B_{21}-F_{c0}[C_{21}+C_{h^0\mu\tau}(m_\tau+\frac{10}{8}m_{\tilde{B}})]\}\gamma_5\Big\}u_\tau(k_2)
\end{aligned} \tag{A.58}$$

and where we used the completeness relation $\not{k}_2u_\tau(k_2)=m_\tau u_\tau(k_2)$
If we label the scalar and pseudoscalar part

$$S_{21} = 6i\pi^2m_{\tilde{B}}F_{c0} \tag{A.59}$$

$$P_{21} = -8\frac{i\pi^2}{C_{h^0\mu\tau}}\{B_{21}-F_{c0}[C_{21}+C_{h^0\mu\tau}(m_\tau+\frac{10}{8}m_{\tilde{B}})]\}\gamma_5 \tag{A.60}$$

$$M_{21}=\alpha_{21}\bar{v}_\mu(k_1)\{S_{21}+P_{21}\} \tag{A.61}$$



We use equation 4.6, since the momentums are labed in the same way. We have

$$M_{22} = \int \frac{d^4q_1}{(2\pi)^4}\bar{v}_\mu(k_2)g_{\tilde{B}\tilde{\mu}_2\mu} * P_{\tilde{B}}(q_2) * g_{\tilde{B}\tilde{\mu}_2\tau} * u_\tau(k_1)P_{\tilde{\mu_2}}(q_1) * g_{h^0\tilde{\mu}_2\tilde{\mu}_2} * P_{\tilde{\mu_2}}(q_3) \tag{A.62}$$

From the Lagrangian we have

$$g_{\tilde{B}\tilde{\mu}_2\tilde{\mu}} = -\frac{gc_\varphi}{4}tan\theta_w[1+3\gamma_5] \tag{A.63}$$

$$g_{\tilde{B}\tilde{\mu}_2\tau} = -\frac{gs_\varphi}{4}tan\theta_w[1+3\gamma_5] \tag{A.64}$$

Substituing the propagators and the interactions

$$\begin{aligned}
M_{22} &= \int \frac{d^4q_1}{(2\pi)^4}\bar{v}_\mu(k_1)\frac{gc_\varphi}{4}tan\theta_w[1+3\gamma_5] \times \\
&\times \frac{i(\not{q}_2+m_{\tilde{B}})}{q_2^2-m_{\tilde{B}}^2}\frac{gs_\varphi}{4}tan\theta_w[1+3\gamma_5]u_\tau(k_2)\frac{i}{q_1^2-m_{\tilde{\mu_2}}^2}g_{h^0\tilde{\mu}_2\tilde{\mu}_2}\frac{i}{q_3^2-m_{\tilde{\mu_2}}^2} \\
&= -\int \frac{d^4q_1}{(2\pi)^4}\bar{v}_\mu(k_1)\frac{ig_{h^0\tilde{\mu}_2\tilde{\mu}_2}g^2c_\varphi s_\varphi}{16}tan^2\theta_w[1+3\gamma_5] \times \\
&\times \frac{\not{q}_2+m_{\tilde{B}}}{q_2^2-m_{\tilde{B}}^2}[1+3\gamma_5]u_\tau(k_2)\frac{1}{q_1^2-m_{\tilde{\mu_2}}^2}\frac{1}{q_3^2-m_{\tilde{\mu_2}}^2}
\end{aligned} \tag{A.65}$$

Labeling the following expressions as α_{22},D_{22} and N_{22}. We can rewrite M_{22} as $M_{22} = \alpha_{22}\int \frac{d^4q_1}{(2\pi)^4}\frac{N_{22}}{D_{22}}$

$$\begin{aligned}
\alpha_{22} &= -g_{h^0\mu_2\mu_2}\frac{ig^2c_\varphi s\varphi}{16}tan^2\theta_w \\
N_{22} &= \bar{v}_\mu(k_1)(1+3\gamma_5)(\not{q}_2+m_{\tilde{B}})(1+3\gamma_5)u_\tau(k_2) \\
D_{22} &= (q_2^2-m_{\tilde{B}}^2)(q_1^2-m_{\tilde{\mu_2}}^2)(q_3^2-m_{\tilde{\mu_2}}^2)
\end{aligned} \tag{A.66}$$

Expanding the products of N_{22}. Using the properties of gamma matrixes (A.10)

$$\begin{aligned} N_{22} &= \bar{v}_\mu(k_1)(1+3\gamma_5)(\not{q}_2 + m_{\tilde{B}})(1+3\gamma_5)u_\tau(k_2) \\ &= \bar{v}_\mu(k_1)\{(\not{q}_2 + m_{\tilde{B}}) + (\not{q}_2 + m_{\tilde{B}})3\gamma_5 + 3\gamma_5(\not{q}_2 + m_{\tilde{B}}) + 3\gamma_5(\not{q}_2 + m_{\tilde{B}})3\gamma_5\}u_\tau(k_2) \\ &= \bar{v}_\mu(k_1)\{(\not{q}_2 + m_{\tilde{B}}) + 3\gamma_5(-\not{q}_2 + m_{\tilde{B}}) + 3\gamma_5(\not{q}_2 + m_{\tilde{B}}) + 9(-\not{q}_2 + m_{\tilde{B}})\}u_\tau(k_2) \\ &= \bar{v}_\mu(k_1)\{-8\not{q}_2 + 10m_{\tilde{B}} + 6\gamma_5 m_{\tilde{B}}\}u_\tau(k_2) \\ &= \bar{v}_\mu(k_1)\{-8(\not{k}_2 + \not{q}_1) + 10m_{\tilde{B}} + 6\gamma_5 m_{\tilde{B}}\}u_\tau(k_2) \end{aligned} \tag{A.67}$$

We substitude N_{22} in M_{22} and $q_2 = k_2 + q_1$,$q_3 = k_2 + k_1 + q_1$.

$$\begin{aligned} M_{22} = \alpha_{22}\bar{v}_\mu(k_1)\Big\{ -8\not{k}_2 \int & \frac{d^4q_1}{((k_2+q_1)^2 - m_{\tilde{B}}^2)(q_1^2 - m_{\tilde{\mu}_2}^2)((k_2+k_1+q_1)^2 - m_{\tilde{\mu}_2}^2)} \\ -8\int & \frac{d^4q_1 \not{q}_1}{((k_2+q_1)^2 - m_{\tilde{B}}^2)(q_1^2 - m_{\tilde{\mu}_2}^2)((k_2+k_1+q_1)^2 - m_{\tilde{\mu}_2}^2)} \\ +10m_{\tilde{B}}\int & \frac{d^4q_1}{((k_2+q_1)^2 - m_{\tilde{B}}^2)(q_1^2 - m_{\tilde{\mu}_2}^2)((k_2+k_1+q_1)^2 - m_{\tilde{\mu}_2}^2)} \\ +6\gamma_5 m_{\tilde{B}}\int & \frac{d^4q_1}{((k_2+q_1)^2 - m_{\tilde{B}}^2)(q_1^2 - m_{\tilde{\mu}_2}^2)((k_2+k_1+q_1)^2 - m_{\tilde{\mu}_2}^2)}\Big\}u_\tau(k_2) \end{aligned} \tag{A.68}$$

Using the results of the integrals in Ec. 4.38 and Ec.4.26 for this particular case (j=2,k=2)

$$M_{22} = \alpha_{22}\bar{v}_\mu(k_1)\Big\{ -8i\pi^2\not{k}_2 F_{c0} + 8\frac{i\pi^2}{C_{h^0\mu\tau}}\{\mathcal{B}_{22} - F_{c0}C_{22}\} + 10m_{\tilde{B}}i\pi^2F_{c0} + 6\gamma_5 m_{\tilde{B}}i\pi^2F_{c0}\Big\}u_\tau(k_2) \tag{A.69}$$

We use the completeness relation $\not{k}_2 u_\tau(k_2) = m_\tau u_\tau(k_2)$

$$M_{22} = \alpha_{22}\bar{v}_\mu(k_1)\Big\{8\frac{i\pi^2}{C_{h^0\mu\tau}}\{\mathcal{B}_{22} - F_{c0}[C_{22} + C_{h^0\mu\tau}(m_\tau - \frac{10}{8}m_{\tilde{B}})]\} + 6\gamma_5 m_{\tilde{B}}i\pi^2F_{c0}\Big\}u_\tau(k_2) \tag{A.70}$$

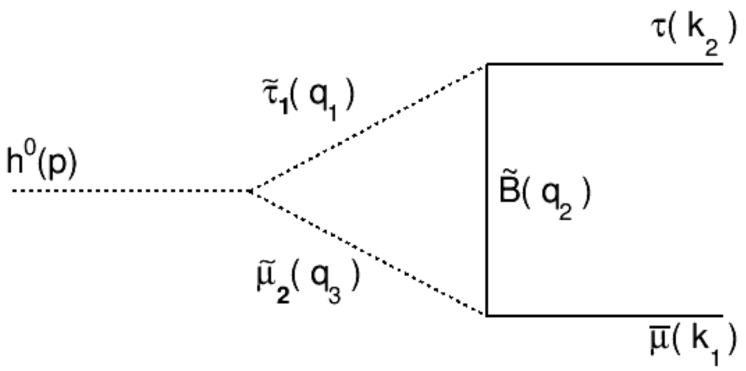
Where the scalar and pseudoscalar parts are

$$S_{22} = 8\frac{i\pi^2}{C_{h^0\mu\tau}}\{\mathcal{B}_{22} - F_{c0}[C_{22} + C_{h^0\mu\tau}(m_\tau - \frac{10}{8}m_{\tilde{B}})]\} \tag{A.71}$$

$$P_{22} = 6\gamma_5 m_{\tilde{B}}i\pi^2F_{c0} \tag{A.72}$$

And

$$M_{22} = \alpha_{22}\bar{v}_\mu(k_1)\{S_{22} + P_{22}\}u_\tau(k_2) \tag{A.73}$$



We calculate M_{23} as

$$M_{23} = \int \frac{d^4q_1}{(2\pi)^4} \bar{v}_\mu(k_1) g_{\tilde{B}\tilde{\mu}_2\mu} * P_{\tilde{B}}(q_2) * g_{\tilde{B}\tilde{\tau}_1\tau} * u_\tau(k_2) P_{\tilde{\tau}_1}(q_1) * g_{h^0\tilde{\mu}_2\tilde{\tau}_1} * P_{\tilde{\mu}_2}(q_3) \tag{A.74}$$

Taking the vertexes and the propagators from tables 3.3,4.3

$$\begin{aligned} g_{\tilde{B}\tilde{\mu}_2\mu} &= -\frac{gc_\varphi}{4} tan\theta_w [1 + 3\gamma_5] \\ g_{\tilde{B}\tilde{\tau}_1\tau} &= -\frac{gc_\varphi}{4} tan\theta_w [1 + 3\gamma_5] \\ P_{\tilde{B}}(q_2) &= \frac{i(\not{q}_2 + m_{\tilde{B}})}{q_2^2 - m_{\tilde{B}}^2} \\ P_{\tilde{\tau}_1}(q_1) &= \frac{i}{q_1^2 - m_{\tilde{\tau}_2}^2} \\ P_{\tilde{\mu}_2}(q_3) &= \frac{i}{q_3^2 - m_{\tilde{\mu}_2}^2} \end{aligned} \tag{A.75}$$

By this way we obtain that the Amplitude M_{23} is

$$\begin{aligned} M_{23} &= \int \frac{d^4q_1}{(2\pi)^4} \bar{v}_\mu(k_1) \frac{gc_\varphi}{4} tan\theta_w [1 + 3\gamma_5] \frac{i(\not{q}_2 + m_{\tilde{B}})}{q_2^2 - m_{\tilde{B}}^2} \frac{gc_\varphi}{4} tan\theta_w [1 + 3\gamma_5] u_\tau(k_2) \times \\ &\times \frac{i}{q_1^2 - m_{\tilde{\tau}_2}^2} g_{h^0\tilde{\mu}_2\tilde{\tau}_1} \frac{i}{q_3^2 - m_{\tilde{\mu}_2}^2} \\ &= -\int \frac{d^4q_1}{(2\pi)^4} \bar{v}_\mu(k_1) \frac{ig_{h^0\tilde{\mu}_2\tilde{\tau}_1} g^2 c_\varphi^2}{16} tan^2\theta_w \bar{v}_\mu(k_1) [1 + 3\gamma_5] \frac{\not{q}_2 + m_{\tilde{B}}}{q_2^2 - m_{\tilde{B}}^2} [1 + 3\gamma_5] u_\tau(k_2) \times \\ &\times \frac{1}{q_1^2 - m_{\tilde{\tau}_2}^2} \frac{1}{q_3^2 - m_{\tilde{\mu}_2}^2} \end{aligned} \tag{A.76}$$

Labeling N_{23},α_{23} and D_{23} as

$$\begin{aligned} N_{23} &= \bar{v}_\mu(k_1)[1+3\gamma_5][\not{q}_2+m_{\tilde{B}}][1+3\gamma_5]u_\tau(k_2) \\ \alpha_{23} &= -\frac{ig_{h^0\tilde{\mu}_2\tilde{\tau}_1}g^2c_\varphi^2}{16}tan^2\theta_w \\ D_{23} &= [q_2^2-m_{\tilde{B}}^2][q_1^2-m_{\tilde{\tau}_2}^2][q_3^2-m_{\tilde{\mu}_2}^2] \end{aligned} \quad (A.77)$$

As it can be noticed in Ec. A.66 that $N_{23}=N_{22}$. Therefore substituing N_{22} in M_{23}

$$\begin{aligned} M_{23} = \alpha_{23}\bar{v}_\mu(k_1)\Big\{ -8\not{k}_2 \int \frac{d^4q_1}{((k_2+q_1)^2-m_{\tilde{B}}^2)(q_1^2-m_{\tilde{\tau}_1}^2)((k_2+k_1+q_1)^2-m_{\tilde{\mu}_2}^2)} \\ -8\int \frac{d^4q_1\not{q}_1}{((k_2+q_1)^2-m_{\tilde{B}}^2)(q_1^2-m_{\tilde{\tau}_1}^2)((k_2+k_1+q_1)^2-m_{\tilde{\mu}_2}^2)} \\ +10m_{\tilde{B}}\int \frac{d^4q_1}{((k_2+q_1)^2-m_{\tilde{B}}^2)(q_1^2-m_{\tilde{\tau}_1}^2)((k_2+k_1+q_1)^2-m_{\tilde{\mu}_2}^2)} \\ +6\gamma_5 m_{\tilde{B}}\int \frac{d^4q_1}{((k_2+q_1)^2-m_{\tilde{B}}^2)(q_1^2-m_{\tilde{\tau}_1}^2)((k_2+k_1+q_1)^2-m_{\tilde{\mu}_2}^2)}\Big\}u_\tau(k_2) \end{aligned} \quad (A.78)$$

Using the results of the integrals in Ec. 4.38 and Ec.4.26 for this particular case (j=2,k=3)

$$M_{23} = \alpha_{23}\bar{v}_\mu(k_1)\Big\{ -8i\pi^2\not{k}_2F_{c0} + 8\frac{i\pi^2}{C_{h^0\mu\tau}}\{\mathcal{B}_{23}-F_{c0}C_{23}\} + 10m_{\tilde{B}}i\pi^2F_{c0} + 6\gamma_5 m_{\tilde{B}}i\pi^2F_{c0}\Big\}u_\tau(k_2) \quad (A.79)$$

We use the completeness relation $\not{k}_2u_\tau(k_2)=m_\tau u_\tau(k_2)$.

$$M_{23} = \alpha_{23}\bar{v}_\mu(k_1)\Big\{8\frac{i\pi^2}{C_{h^0\mu\tau}}\{\mathcal{B}_{23}-F_{c0}[C_{23}+C_{h^0\mu\tau}(m_\tau-\frac{10}{8}m_{\tilde{B}})]\} + 6\gamma_5 m_{\tilde{B}}i\pi^2F_{c0}\Big\}u_\tau(k_2) \quad (A.80)$$

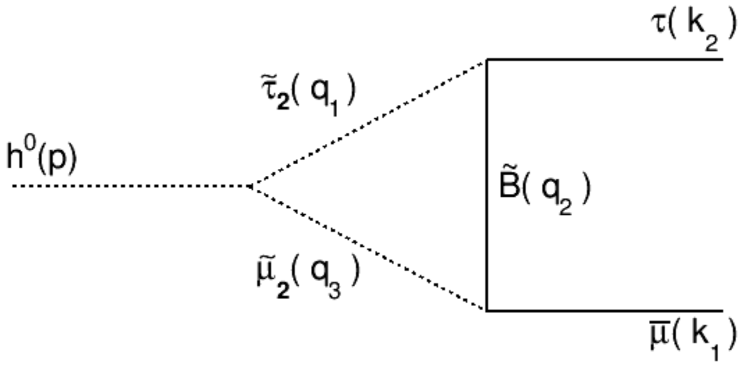
Where the scalar and pseudoscalar parts are

$$S_{23} = 8\frac{i\pi^2}{C_{h^0\mu\tau}}\{\mathcal{B}_{23}-F_{c0}[C_{23}+C_{h^0\mu\tau}(m_\tau-\frac{10}{8}m_{\tilde{B}})]\} \quad (A.81)$$

$$P_{23} = 6\gamma_5 m_{\tilde{B}}i\pi^2F_{c0} \quad (A.82)$$

And

$$M_{23} = \alpha_{23}\bar{v}_\mu(k_1)\{S_{23}+P_{23}\}u_\tau(k_2) \quad (A.83)$$



For M_{24}

$$M_{24} = \int \frac{d^4q_1}{(2\pi)^4} \bar{v}_\mu(k_1) g_{\tilde{B}\tilde{\mu}_2\mu} * P_{\tilde{B}}(q_2) * g_{\tilde{B}\tilde{\tau}_2\tau} * u_\tau(k_2) P_{\tilde{\tau}_2}(q_1) * g_{h^0\tilde{\mu}_2\tilde{\tau}_2} * P_{\tilde{\mu_2}}(q_3) \tag{A.84}$$

However from table 3.2 we have that

$$g_{h^0\mu_2\tau_2} = 0 \tag{A.85}$$

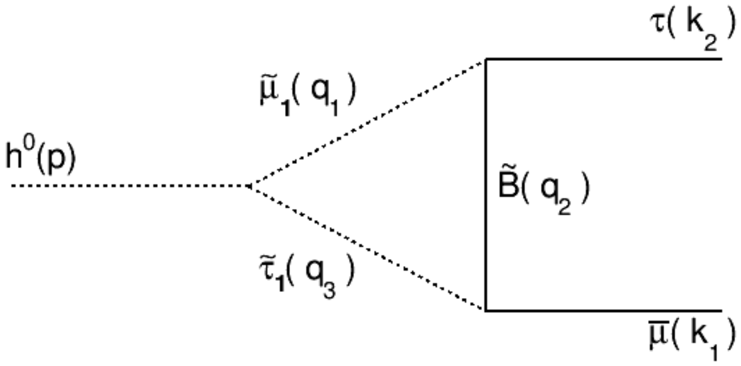
Therefore

$$M_{24} = 0 \tag{A.86}$$

We write the scalar, pseudoscalar and the constant α_{24} as zero for simplicity

$$\begin{aligned} \alpha_{24} &= 0 \\ S_{24} &= 0 \\ P_{24} &= 0 \end{aligned} \tag{A.87}$$

We proceed to calculate the Feynman branching ratio of the following Feynman Diagram.



We have that

$$M_{31} = \int \frac{d^4 q_1}{(2\pi)^4} \bar{v}_\mu(k_1) * g_{\tilde{B}\tilde{\tau}_1\mu} * P_{\tilde{B}}(q_2) * g_{\tilde{B}\tilde{\mu}_1\tau} * u_\tau(k_2) * P_{\tilde{\mu_1}}(q_1) * g_{h^0\tilde{\tau}_1\tilde{\mu}_1} * P_{\tilde{\tau_1}}(q_3) \tag{A.88}$$

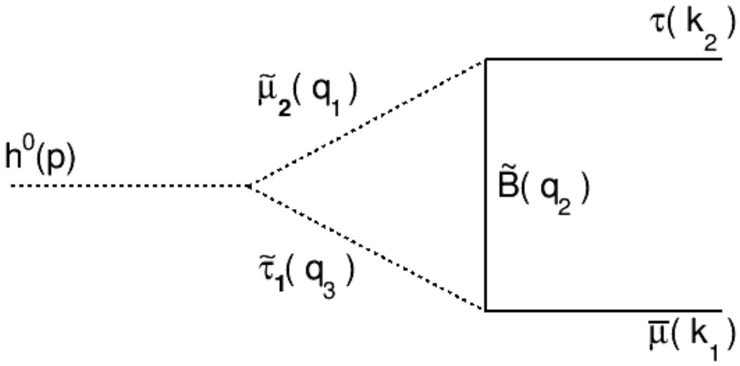
However, from table 3.2 we have that the interaction of higgs h^0,$\tilde{\tau}_1$, $\tilde{\mu}_1$ is zero, since it does not exist in the Lagrangian. Therefore $g_{h^0\tilde{\tau}_1\tilde{\mu}_1} = 0$ and we obtain

$$M_{31} = 0 \tag{A.89}$$

We write the scalar, pseudoscalar and the constant α_{31} as zero for simplicity

$$\begin{aligned} \alpha_{31} &= 0 \\ S_{31} &= 0 \\ P_{31} &= 0 \end{aligned} \tag{A.90}$$

We can take as the fourth option the Feynman Diagram



The Amplitude is

$$M_{32} = \int \frac{d^4q_1}{(2\pi)^4} \bar{v}_\mu(k_1) * g_{\tilde{B}\tilde{\tau}_1\mu} * P_{\tilde{B}}(q_2) * g_{\tilde{B}\tilde{\mu}_2\tau} * u_\tau(k_2) \times \\ \times P_{\tilde{\mu}_2}(q_1) * g_{h^0\tau_1\mu_2} * P_{\tilde{\tau}_1}(q_3) \quad \text{(A.91)}$$

Obtaining $g_{\tilde{B}\tilde{\mu}_2\tau}$, $g_{\tilde{B}\tilde{\tau}_1\mu}$ from table 3.3, we have that:

$$g_{\tilde{B}\tilde{\tau}_1\mu} = \frac{gs_\varphi}{4} tan\theta_w(1+3\gamma_5) \quad \text{(A.92)}$$

$$g_{\tilde{B}\tilde{\mu}_2\tau} = -\frac{gs_\varphi}{4} tan\theta_w(1+3\gamma_5) \quad \text{(A.93)}$$

Substituing the respective propagators and V_1,V_2 in A.94

$$\begin{aligned} M_{32} &= -\int \frac{d^4q_1}{(2\pi)^4} \bar{v}_\mu(k_1) * \frac{gs_\varphi}{4} tan\theta_w(1+3\gamma_5) * \frac{i(\not{q}_2 + m_{\tilde{B}})}{q_2^2 - m_{\tilde{B}}^2} \frac{gs_\varphi}{4} tan\theta_w(1+3\gamma_5) * u_\tau(k_2) \times \\ &\times \frac{i}{q_1^2 - m_{\tilde{\mu}_2}^2} * g_{h^0\tau_1\mu_2} * \frac{i}{q_3^2 - m_{\tilde{\tau}_1}^2} \\ &= \int \frac{d^4q_1}{(2\pi)^4} \bar{v}_\mu(k_1) * \frac{ig_{h^0\tau_1\mu_2} g^2 s_\varphi^2}{16} tan^2\theta_w(1+3\gamma_5) * \frac{\not{q}_2 + m_{\tilde{B}}}{q_2^2 - m_{\tilde{B}}^2}(1+3\gamma_5) * u_\tau(k_2) \times \\ &\times \frac{1}{q_1^2 - m_{\tilde{\mu}_2}^2} * \frac{1}{q_3^2 - m_{\tilde{\tau}_1}^2} \end{aligned} \quad \text{(A.94)}$$

Labeling the following expressions:

$$\begin{aligned} N_{32} &= \bar{v}_\mu(k_1)[1+3\gamma_5][\not{q}_2 + m_{\tilde{B}}][1+3\gamma_5]u_\tau(k_2) \\ \alpha_{32} &= g_{h^0\tau_1\mu_2} \frac{ig^2 s^2\varphi}{16} tan^2\theta_w \\ D_{32} &= [q_2^2 - m_{\tilde{B}}^2]]q_1^2 - m_{\tilde{\mu}_2}^2][q_3^2 - m_{\tilde{\tau}_1}^2] \end{aligned} \quad \text{(A.95)}$$

We can rewrite M_{32} as

$$M_{32} = \alpha_{32} \int \frac{d^4 q_1}{(2\pi)^4} \frac{N_{32}}{D_{32}} \tag{A.96}$$

It can be noticed in Ec. A.66 that $N_{32} = N_{22}$. Therefore substituing N_{22} in M_{32}

$$\begin{aligned} M_{32} = \alpha_{32}\bar{v}_\mu(k_1)\Big\{ -8\not{k}_2 \int \frac{d^4 q_1}{((k_2+q_1)^2 - m_{\tilde{B}}^2)(q_1^2 - m_{\tilde{\mu}_2}^2)((k_2+k_1+q_1)^2 - m_{\tilde{\tau}_1}^2)} \\ -8 \int \frac{d^4 q_1 \not{q}_1}{((k_2+q_1)^2 - m_{\tilde{B}}^2)(q_1^2 - m_{\tilde{\mu}_2}^2)((k_2+k_1+q_1)^2 - m_{\tilde{\tau}_1}^2)} \\ +10 m_{\tilde{B}} \int \frac{d^4 q_1}{((k_2+q_1)^2 - m_{\tilde{B}}^2)(q_1^2 - m_{\tilde{\mu}_2}^2)((k_2+k_1+q_1)^2 - m_{\tilde{\tau}_1}^2)} \\ +6\gamma_5 m_{\tilde{B}} \int \frac{d^4 q_1}{((k_2+q_1)^2 - m_{\tilde{B}}^2)(q_1^2 - m_{\tilde{\mu}_2}^2)((k_2+k_1+q_1)^2 - m_{\tilde{\tau}_1}^2)} \Big\} u_\tau(k_2) \end{aligned} \tag{A.97}$$

Using the results of the integrals in Ec. 4.38 and Ec.4.26 for this particular case (j=3,k=2)

$$M_{32} = \alpha_{32}\bar{v}_\mu(k_1)\Big\{ -8i\pi^2 \not{k}_2 F_{c0} + 8\frac{i\pi^2}{C_{h^0\mu\tau}}\{\mathcal{B}_{32} - F_{c0}C_{32}\} + 10 m_{\tilde{B}} i\pi^2 F_{c0} + 6\gamma_5 m_{\tilde{B}} i\pi^2 F_{c0} \Big\} u_\tau(k_2) \tag{A.98}$$

We use the completeness relation $\not{k}_2 u_\tau(k_2) = m_\tau u_\tau(k_2)$

$$M_{32} = \alpha_{32}\bar{v}_\mu(k_1)\Big\{ 8\frac{i\pi^2}{C_{h^0\mu\tau}}\big\{\mathcal{B}_{32} - F_{c0}[C_{32} + C_{h^0\mu\tau}(m_\tau - \frac{10}{8}m_{\tilde{B}})]\big\} + 6\gamma_5 m_{\tilde{B}} i\pi^2 F_{c0} \Big\} u_\tau(k_2) \tag{A.99}$$

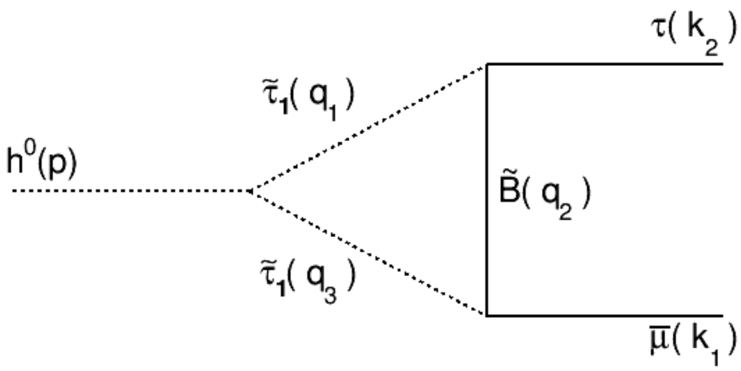
Where the scalar and pseudoscalar parts are

$$S_{32} = 8\frac{i\pi^2}{C_{h^0\mu\tau}}\big\{\mathcal{B}_{32} - F_{c0}[C_{23} + C_{h^0\mu\tau}(m_\tau - \frac{10}{8}m_{\tilde{B}})]\big\} \tag{A.100}$$

$$P_{32} = 6\gamma_5 m_{\tilde{B}} i\pi^2 F_{c0} \tag{A.101}$$

And

$$M_{32} = \alpha_{32}\bar{v}_\mu(k_1)\{S_{32} + P_{32}\}u_\tau(k_2) \tag{A.102}$$



We proceed to make the calculation of the amplitude M_{33}

$$M_{31} = \int \frac{d^4q_1}{(2\pi)^4} \bar{v}_\mu(k_1) * g_{\tilde{B}\tilde{\tau}_1\mu} * P_{\tilde{B}}(q_2) * g_{\tilde{B}\tilde{\tau}_1\tau} * u_\tau(k_2) * P_{\tilde{\tau}_1}(q_1) * g_{h^0\tilde{\tau}_1\tilde{\tau}_1} * P_{\tilde{\tau}_1}(q_3) \tag{A.103}$$

As we have been calculating, we take the propagators and interactions from tables 3.3, 4.3

$$\begin{aligned}
g_{\tilde{B}\tilde{\tau}_1\mu} &= \frac{gs_\varphi}{4} tan\theta_w[1+3\gamma_5] \\
g_{\tilde{B}\tilde{\tau}_1\tau} &= -\frac{gc_\varphi}{4} tan\theta_w[1+3\gamma_5] \\
P_{\tilde{B}}(q_2) &= \frac{i(\not{q}_2 + m_{\tilde{B}})}{q_2^2 - m_{\tilde{B}}^2} \\
P_{\tilde{\tau}_1}(q_1) &= \frac{i}{q_1^2 - m_{\tilde{\tau}_1}^2} \\
P_{\tilde{\tau}_1}(q_3) &= \frac{i}{q_3^2 - m_{\tilde{\tau}_1}^2}
\end{aligned} \tag{A.104}$$

Therefore

$$\begin{aligned}
M_{33} &= -\int \frac{d^4q_1}{(2\pi)^4} \times \bar{v}_\mu(k_1) \times \frac{gs_\varphi}{4} tan\theta_w[1+3\gamma_5] \times \frac{i(\not{q}_2 + m_{\tilde{B}})}{q_2^2 - m_{\tilde{B}}^2} \\
&\times \frac{gc_\varphi}{4} tan\theta_w[1+3\gamma_5] \times u_\tau(k_2) \times \frac{i}{q_1^2 - m_{\tilde{\tau}_1}^2} \times g_{h^0\tilde{\tau}_1\tilde{\tau}_1} \times \frac{i}{q_3^2 - m_{\tilde{\tau}_1}^2} \\
&= \int \frac{d^4q_1}{(2\pi)^4} \bar{v}_\mu(k_1) \frac{ig_{h^0\tilde{\tau}_1\tilde{\tau}_1} g^2 c_\varphi s_\varphi}{16} tan^2\theta_w[1+3\gamma_5] \frac{\not{q}_2 + m_{\tilde{B}}}{q_2^2 - m_{\tilde{B}}^2} [1+3\gamma_5] u_\tau(k_2) \frac{1}{q_1^2 - m_{\tilde{\tau}_1}^2} \frac{1}{q_3^2 - m_{\tilde{\tau}_1}^2}
\end{aligned} \tag{A.105}$$

Labeling N_{33},α_{33} and D_{33} as

$$N_{33} = \bar{v}_\mu(k_1)[1+3\gamma_5][\not{q}_2 + m_{\tilde{B}}][1+3\gamma_5]u_\tau(k_2)$$
$$\alpha_{33} = \frac{ig_{h^0\tilde{\tau}_1\tilde{\tau}_1}g^2 c_\varphi s_\varphi}{16} tan^2\theta_w$$
$$D_{33} = [q_2^2 - m_{\tilde{B}}^2][q_1^2 - m_{\tilde{\tau}_1}^2][q_3^2 - m_{\tilde{\tau}_1}^2] \quad \text{(A.106)}$$

As we can notice,the expression of N_{33} is the same one to N_{22} that we obtained in eq. A.66 Therefore we substitute the expansion of N_{22} in M_{33}. Moreover, we substitute $q_3 = k_2 + k_1 + q_1$,$q_2 = k_2 + q_1$ in D_{33}

$$\begin{aligned} M_{33} = \alpha_{33}\bar{v}_\mu(k_1)\Big\{ -8\not{k}_2 \int \frac{d^4q_1}{((k_2+q_1)^2 - m_{\tilde{B}}^2)(q_1^2 - m_{\tilde{\tau}_1}^2)((k_2+k_1+q_1)^2 - m_{\tilde{\tau}_1}^2)} \\ -8\int \frac{d^4q_1 \not{q}_1}{((k_2+q_1)^2 - m_{\tilde{B}}^2)(q_1^2 - m_{\tilde{\tau}_1}^2)((k_2+k_1+q_1)^2 - m_{\tilde{\tau}_1}^2)} \\ +10m_{\tilde{B}}\int \frac{d^4q_1}{((k_2+q_1)^2 - m_{\tilde{B}}^2)(q_1^2 - m_{\tilde{\tau}_1}^2)((k_2+k_1+q_1)^2 - m_{\tilde{\tau}_1}^2)} \\ +6\gamma_5 m_{\tilde{B}}\int \frac{d^4q_1}{((k_2+q_1)^2 - m_{\tilde{B}}^2)(q_1^2 - m_{\tilde{\tau}_1}^2)((k_2+k_1+q_1)^2 - m_{\tilde{\tau}_1}^2)}\Big\} u_\tau(k_2) \end{aligned} \quad \text{(A.107)}$$

Using the results of the integrals in Ec. 4.38 and Ec.4.26 for this particular case (j=3,k=3)

$$M_{33} = \alpha_{33}\bar{v}_\mu(k_1)\Big\{ -8i\pi^2\not{k}_2 F_{c0} + 8\frac{i\pi^2}{C_{h^0\mu\tau}}\{\mathcal{B}_{33} - F_{c0}C_{33}\} + 10m_{\tilde{B}}i\pi^2 F_{c0} + 6\gamma_5 m_{\tilde{B}} i\pi^2 F_{c0}\Big\} u_\tau(k_2) \quad \text{(A.108)}$$

We use the completeness relation $\not{k}_2 u_\tau(k_2) = m_\tau u_\tau(k_2)$

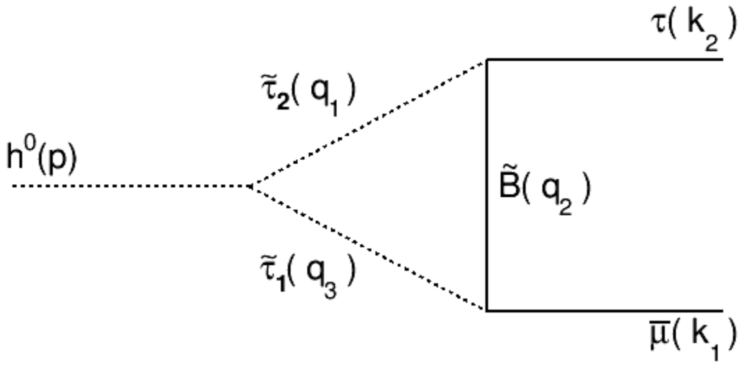
$$M_{33} = \alpha_{33}\bar{v}_\mu(k_1)\Big\{ 8\frac{i\pi^2}{C_{h^0\mu\tau}}\{\mathcal{B}_{33} - F_{c0}[C_{33} + C_{h^0\mu\tau}(m_\tau - \frac{10}{8}m_{\tilde{B}})]\} + 6\gamma_5 m_{\tilde{B}} i\pi^2 F_{c0}\Big\} u_\tau(k_2) \quad \text{(A.109)}$$

Where the scalar and pseudoscalar parts are

$$S_{33} = 8\frac{i\pi^2}{C_{h^0\mu\tau}}\{\mathcal{B}_{33} - F_{c0}[C_{33} + C_{h^0\mu\tau}(m_\tau - \frac{10}{8}m_{\tilde{B}})]\} \quad \text{(A.110)}$$
$$P_{33} = 6\gamma_5 m_{\tilde{B}} i\pi^2 F_{c0} \quad \text{(A.111)}$$

And

$$M_{33} = \alpha_{33}\bar{v}_\mu(k_1)\{S_{33} + P_{33}\}u_\tau(k_2) \quad \text{(A.112)}$$



We know that the propagators and the interactions are the following expressions, since we have extracted them from tables 3.3 and 4.3

$$
\begin{aligned}
g_{\tilde{B}\tilde{\tau}_2\tilde{\tau}_1} &= -\frac{gc_\varphi}{4} tan\theta_w [3+\gamma_5] \\
g_{\tilde{B}\tilde{\tau}_1\mu} &= \frac{gs_\varphi}{4} tan\theta_w [1+3\gamma_5] \\
P_{\tilde{B}}(q_2) &= \frac{i(\not{q}_2 + m_{\tilde{B}})}{q_2^2 - m_{\tilde{B}}^2} \\
P_{\tilde{\tau}_2}(q_1) &= \frac{i}{q_1^2 - m_{\tilde{\tau}_2}^2} \\
P_{\tilde{\tau}_1}(q_3) &= \frac{i}{q_3^2 - m_{\tilde{\tau}_1}^2}
\end{aligned}
\tag{A.113}
$$

And we obtain that

$$
\begin{aligned}
M_{34} &= -\int \frac{d^4q_1}{(2\pi)^4} \bar{v}_\mu(k_1) \frac{gs_\varphi}{4} tan\theta_w [1+3\gamma_5] \frac{i(\not{q}_2 + m_{\tilde{B}})}{q_2^2 - m_{\tilde{B}}^2} \frac{gc_\varphi}{4} tan\theta_w [3+\gamma_5] u_\tau(k_2) \frac{i}{q_1^2 - m_{\tilde{\tau}_2}^2} g_{h^0\tilde{\tau}_2\tilde{\tau}_1} \frac{i}{q_3^2 - m_{\tilde{\tau}_1}^2} \\
&= \int \frac{d^4q_1}{(2\pi)^4} \bar{v}_\mu(k_1) \frac{ig_{h^0\tilde{\tau}_2\tilde{\tau}_1} g^2 c_\varphi s_\varphi}{16} tan^2\theta_w [1+3\gamma_5] \frac{\not{q}_2 + m_{\tilde{B}}}{q_2^2 - m_{\tilde{B}}^2} [3+\gamma_5] u_\tau(k_2) \frac{1}{q_1^2 - m_{\tilde{\tau}_2}^2} \frac{1}{q_3^2 - m_{\tilde{\tau}_1}^2}
\end{aligned}
\tag{A.114}
$$

Labeling N_{34},α_{34} and D_{34} as

$$
\begin{aligned}
N_{34} &= \bar{v}_\mu(k_1)[1+3\gamma_5][\not{q}_2 + m_{\tilde{B}}][3+\gamma_5] u_\tau(k_2) \\
\alpha_{34} &= \frac{ig_{h^0\tilde{\tau}_1\tilde{\tau}_2} g^2 c_\varphi s_\varphi}{16} tan^2\theta_w \\
D_{34} &= [q_2^2 - m_{\tilde{B}}^2][q_1^2 - m_{\tilde{\tau}_2}^2][q_3^2 - m_{\tilde{\tau}_1}^2]
\end{aligned}
\tag{A.115}
$$

We can write M_{34} as $M_{34} = \alpha_{34} \int \frac{d^4q_1}{(2\pi)^4} \frac{N_{34}}{D_{34}}$ As we can notice, the expression of N_{34} is the same one that we obtained in eq. A.55.Therefore substituing Ec.

A.56 in M_{34}, where Ec. A.56is N_{34} expanded.

$$
\begin{aligned}
M_{34} &= \alpha_{34}\bar{v}_\mu(k_1)\Big\{8\gamma_5\int\frac{d^4q_1}{(2\pi)^4}\frac{\not{q}_1}{[(k_2+q_1)^2-m_{\tilde{B}}^2][q_1^2-m_{\tilde{\tau}_2}^2][(k_2+k_1+q_1)^2-m_{\tilde{\tau}_1}^2]} \\
&+ 8\gamma_5\not{k}_1\int\frac{d^4q_1}{(2\pi)^4[(k_2+q_1)^2-m_{\tilde{B}}^2][q_1^2-m_{\tilde{\tau}_2}^2][(k_2+k_1+q_1)^2-m_{\tilde{\tau}_1}^2]} \\
&+ 10\gamma_5 m_{\tilde{B}}\int\frac{d^4q_1}{(2\pi)^4[(k_2+q_1)^2-m_{\tilde{B}}^2][q_1^2-m_{\tilde{\tau}_2}^2][(k_2+k_1+q_1)^2-m_{\tilde{\tau}_1}^2]} \\
&+ 6m_{\tilde{B}}\int\frac{d^4q_1}{(2\pi)^4[(k_2+q_1)^2-m_{\tilde{B}}^2][q_1^2-m_{\tilde{\tau}_2}^2][(k_2+k_1+q_1)^2-m_{\tilde{\tau}_1}^2]}\Big\}u_\tau(k_2)
\end{aligned}
\tag{A.116}
$$

We use Ec. 4.26 and Ec. 4.38 and substitute the value of the integrals above.
For this particular case $j = 3$ and $k = 4$.

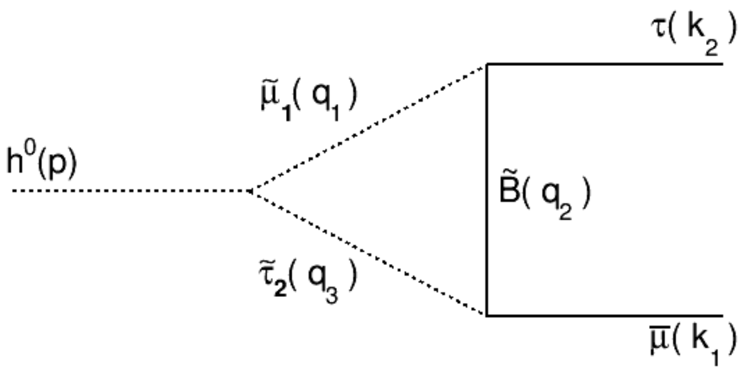
$$
\begin{aligned}
M_{34} &= \alpha_{34}\bar{v}_\mu(k_1)\Big\{-8\gamma_5\frac{i\pi^2}{C_{h^0\mu\tau}}\{B_{34}-F_{c0}C_{34}\}+8\gamma_5 m_\tau i\pi^2F_{c0}+10\gamma_5 m_{\tilde{B}}i\pi^2F_{c0}+6i\pi^2m_{\tilde{B}}F_{c0}\Big\} \\
&= \alpha_{34}\bar{v}_\mu(k_1)\Big\{6i\pi^2m_{\tilde{B}}F_{c0}-8\frac{i\pi^2}{C_{h^0\mu\tau}}\{B_{34}-F_{c0}[C_{34}+C_{h^0\mu\tau}(m_\tau+\frac{10}{8}m_{\tilde{B}})]\}\gamma_5\Big\}u_\tau(k_2)
\end{aligned}
\tag{A.117}
$$

or labeling the scalar and pseudoscalar part

$$
S_{34} = 6i\pi^2m_{\tilde{B}}F_{c0} \tag{A.118}
$$

$$
P_{34} = -8\frac{i\pi^2}{C_{h^0\mu\tau}}\{B_{34}-F_{c0}[C_{34}+C_{h^0\mu\tau}(m_\tau+\frac{10}{8}m_{\tilde{B}})]\}\gamma_5 \tag{A.119}
$$

$$
M_{34} = \alpha_{34}\bar{v}_\mu(k_1)\{S_{34}+P_{34}\} \tag{A.120}
$$



The amplitude M_{41} is calculated as follows

$$M_{41} = \int \frac{d^4q_1}{(2\pi)^4}\bar{v}_\mu(k_1) * g_{\tilde{B}\tilde{\tau}_2\mu} * P_{\tilde{B}}(q_2) * g_{\tilde{B}\tilde{\mu}_1\tau} * u_\tau(k_2) * P_{\tilde{\mu_1}}(q_1) * g_{h^0\tilde{\tau}_2\tilde{\mu}_1} * P_{\tilde{\tau}_2}(q_3) \quad (A.121)$$

If we see table 3.3, we have that

$$\begin{aligned} g_{\tilde{B}\tilde{\tau}_2\mu} &= \frac{gs_\varphi}{4}tan\theta_w[3+\gamma_5] \\ g_{\tilde{B}\tilde{\mu}_1\tilde{\tau}} &= -\frac{gs_\varphi}{4}tan\theta_w[3+\gamma_5] \end{aligned} \quad (A.122)$$

And table 4.3 give us the following expressions

$$P_{\tilde{B}}(q_2) = \frac{i(\not{q}_2 + m_{\tilde{B}})}{q_2^2 - m_{\tilde{B}}^2} \quad (A.123)$$

$$P_{\tilde{\mu}_1}(q_1) = \frac{i}{q_1^2 - m_{\tilde{\mu}_1}^2} \quad (A.124)$$

$$P_{\tilde{\tau}_2}(q_3) = \frac{i}{q_3^2 - m_{\tilde{\tau}_2}^2} \quad (A.125)$$

And we obtain

$$\begin{aligned} M_{41} &= -\int \frac{d^4q_1}{(2\pi)^4}\bar{v}_\mu(k_1)\frac{gs_\varphi}{4}tan\theta_w[3+\gamma_5]\frac{i(\not{q}_2 + m_{\tilde{B}})}{q_2^2 - m_{\tilde{B}}^2}\frac{gs_\varphi}{4}tan\theta_w[3+\gamma_5]u_\tau(k_2)\frac{i}{q_1^2 - m_{\tilde{\mu}_1}^2}g_{h^0\tilde{\tau}_2\tilde{\mu}_1}\frac{i}{q_3^2 - m_{\tilde{\tau}_2}^2} \\ &= \int \frac{d^4q_1}{(2\pi)^4}\bar{v}_\mu(k_1)\frac{ig_{h^0\tilde{\tau}_2\tilde{\mu}_1}g^2s_\varphi^2}{16}tan^2\theta_w[3+\gamma_5]\frac{(\not{q}_2 + m_{\tilde{B}})}{q_2^2 - m_{\tilde{B}}^2}[3+\gamma_5]u_\tau(k_2)\frac{1}{q_1^2 - m_{\tilde{\mu}_1}^2}\frac{1}{q_3^2 - m_{\tilde{\tau}_2}^2} \end{aligned} \quad (A.126)$$

Labeling as N_{41},α_{41} and D_{41} as

$$\begin{aligned} N_{41} &= \bar{v}_\mu(k_1)[3+\gamma_5][\not{q}_2 + m_{\tilde{B}}[[3+\gamma_5]u_\tau(k_2) \\ \alpha_{41} &= -\frac{ig_{h^0\tilde{\tau}_2\tilde{\mu}_1}g^2s_\varphi^2}{16}tan^2\theta_w \\ D_{41} &= [q_2^2 - m_{\tilde{B}}^2][q_1^2 - m_{\tilde{\mu}_1}^2][q_3^2 - m_{\tilde{\tau}_2}^2] \end{aligned} \quad (A.127)$$

With the expressions above we express $M_{41} = \alpha_{41}\int \frac{d^4q_1}{(2\pi)^4}\frac{N_{41}}{D_{41}}$

As it can be noticed N_{41} is exactly as N_{11} in A.8.Therefore substituing N_{11} in M_{41}

$$\begin{aligned}
M_{41} &= \alpha_{41}\bar{v}_\mu(k_1)\Big\{8\int d^4q_1\frac{\not{q}_1}{(2\pi)^4((q_1+k_2)^2-m_{\tilde{B}}^2)(q_1^2-m_{\tilde{\mu}_1}^2)((q_1+k_2+k_1)^2-m_{\tilde{\mu}_1}^2))} \\
&+ 8\not{k}_2\int\frac{d^4q_1}{(2\pi)^4((q_1+k_2)^2-m_{\tilde{B}}^2)(q_1^2-m_{\tilde{\mu}_1}^2)((q_1+k_2+k_1)^2-m_{\tilde{\mu}_1}^2)} \\
&+ 10m_{\tilde{B}}\int\frac{d^4q_1}{(2\pi)^4((q_1+k_2)^2-m_{\tilde{B}}^2)(q_1^2-m_{\tilde{\mu}_1}^2)((q_1+k_2+k_1)^2-m_{\tilde{\mu}_1}{}^2)} \\
&+ 6\gamma_5 m_{\tilde{B}}\int\frac{d^4q_1}{(2\pi)^4((q_1+k_2)^2-m_{\tilde{B}}^2)(q_1^2-m_{\tilde{\mu}_1}^2)((q_1+k_2+k_1)^2-m_{\tilde{\mu}_1}{}^2)}\Big\}u_\tau(k_2)
\end{aligned} \quad (A.128)$$

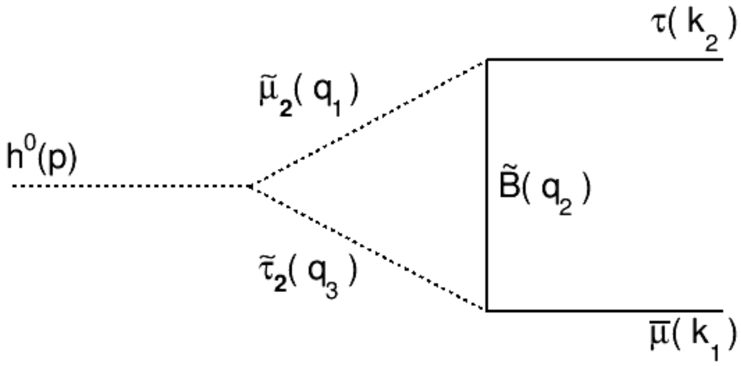
We use the generalized cases in Ec. 4.26 and Ec. 4.38 of the integrals $IC1$ and $IC2$ with $j=4$ and $k=1$.

$$M_{41} = -8\frac{i\pi^2}{C_{h^0\mu\tau}}\{\mathcal{B}_{41}-F_{c0}C_{41}\}+i\pi^2F_{c0}\{8\not{k}_2+10m_{\tilde{B}}+6\gamma_5 m_{\tilde{B}}\} \quad (A.129)$$

We use the completeness relation that states that $\not{k}_2 u_\tau(k_2)=m_\tau u_\tau(k_2)$

$$\begin{aligned}
M_{41} &= -8\frac{i\pi^2}{C_{h^0\mu\tau}}\{\mathcal{B}_{41}-F_{C0}[C_{41}+C_{h^0\mu\tau}(m_\tau+\frac{10}{8}m_{\tilde{B}})]\}+6i\pi^2F_{c0}\gamma_5 \\
&= \bar{v}_\mu(k_1)\alpha_{41}\{S_{41}+P_{41}\}u_\tau(k_2)
\end{aligned} \quad (A.130)$$

where we called as $S_{41}=-8\frac{i\pi^2}{C_{h^0\mu\tau}}\{\mathcal{B}_{41}-F_{C0}[C_{41}+C_{h^0\mu\tau}(m_\tau+\frac{10}{8}m_{\tilde{B}})]\}$ and $P_{41}=6i\pi^2F_{c0}\gamma_5$ because one is scalar and the second one is pseudoscalar.

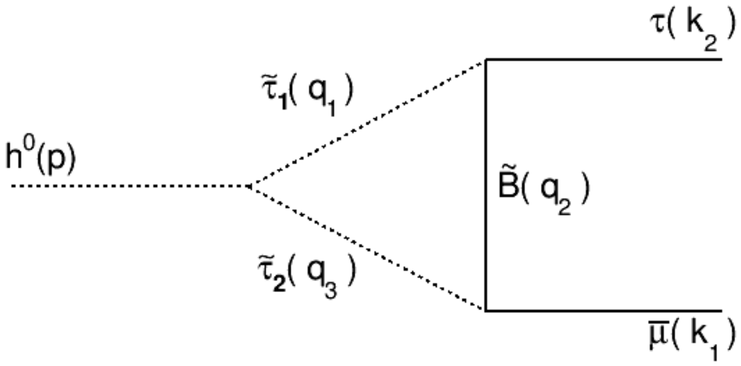


The amplitude M_{41} is calculated as follows

$$M_{42} = \int \frac{d^4q_1}{(2\pi)^4}\bar{v}_\mu(k_1) * g_{\tilde{B}\tilde{\tau}_2\mu} * P_{\tilde{B}}(q_2) * g_{\tilde{B}\tilde{\mu}_2\tau} * u_\tau(k_2) * P_{\tilde{\mu_2}}(q_1) * g_{h^0\tilde{\tau}_2\tilde{\mu}_2} * P_{\tilde{\tau_2}}(q_3) \tag{A.131}$$

However, from table 3.3 we extract that the interaction $g_{\tilde{B}\tau_2\mu_2} = 0$. Therefore

$$\begin{aligned} M_{42} &= 0 \\ \alpha_{42} &= 0 \\ S_{42} &= 0 \\ P_{42} &= 0 \end{aligned} \tag{A.132}$$



In order to calculate the amplitude M_{43}, we use the following expression

$$M_{43} = \int \frac{d^4q_1}{(2\pi)^4} \bar{v}_\mu(k_1) * g_{\tilde{B}\tilde{\tau}_2\mu} * P_{\tilde{B}}(q_2) * g_{\tilde{B}\tilde{\tau}_1\tau} * u_\tau(k_2) * P_{\tilde{\tau}_1}(q_1) * g_{h^0\tilde{\tau}_2\tilde{\tau}_1} * P_{\tilde{\tau}_2}(q_3) \tag{A.133}$$

We obtain the interactions and propagators from tables 3.3 and 4.3.

$$\begin{aligned} g_{\tilde{B}\tilde{\tau}_2\tilde{\mu}} &= \frac{gs_\varphi}{4} tan\theta_w[3+\gamma_5] \\ g_{\tilde{B}\tilde{\tau}_1\tau} &= -\frac{gc_\varphi}{4} tan\theta_w[1+3\gamma_5] \\ P_{\tilde{B}}(q_2) &= \frac{i(\not{q}_2 + m_{\tilde{B}})}{q_2^2 - m_{\tilde{B}}^2} \\ P_{\tilde{\tau}_1}(q_1) &= \frac{i}{q_1^2 - m_{\tilde{\tau}_1}^2} \\ P_{\tilde{\tau}_2}(q_3) &= \frac{i}{q_3^2 - m_{\tilde{\tau}_2}^2} \end{aligned} \tag{A.134}$$

And we obtain that M_{43} is

$$\begin{aligned} M_{43} &= -\int \frac{d^4q_1}{(2\pi)^4} \bar{v}_\mu \frac{gs_\varphi}{4} tan\theta_w[3+\gamma_5] \frac{i(\not{q}_2 + m_{\tilde{B}})}{q_2^2 - m_{\tilde{B}}^2} \frac{gc_\varphi}{4} tan\theta_w[1+3\gamma_5] u_\tau(k_2) \times \\ &\quad \times \frac{i}{q_1^2 - m_{\tilde{\tau}_1}^2} g_{h^0\tilde{\tau}_2\tilde{\tau}_1} \frac{i}{q_3^2 - m_{\tilde{\tau}_2}^2} \\ &= -\int \frac{d^4q_1}{(2\pi)^4} \bar{v}_\mu \frac{i g_{h^0\tilde{\tau}_2\tilde{\tau}_1} g^2 s_\varphi^2}{16} tan^2\theta_w[3+\gamma_5] \frac{\not{q}_2 + m_{\tilde{B}}}{q_2^2 - m_{\tilde{B}}^2} [1+3\gamma_5] u_\tau(k_2) \frac{1}{q_1^2 - m_{\tilde{\tau}_1}^2} \frac{1}{q_3^2 - m_{\tilde{\tau}_2}^2} \end{aligned} \tag{A.135}$$

Labeling as N_{43},α_{43} and D_{43} the following expressions

$$\begin{aligned} N_{43} &= \bar{v}_\mu[3+\gamma_5][\not{q}_2 + m_{\tilde{B}}][1+3\gamma_5]u_\tau(k_2) \\ \alpha_{43} &= -\frac{ig_{h^0\tilde{\tau}_2\tilde{\tau}_1} g^2 s_\varphi^2}{16} tan^2\theta_w \\ D_{43} &= [q_2^2 - m_{\tilde{B}}^2][q_1^2 - m_{\tilde{\tau}_1}^2][q_3^2 - m_{\tilde{\tau}_2}^2] \end{aligned} \tag{A.136}$$

$$\begin{aligned} N_{43} &= \bar{v}_\mu(k_1)[3+\gamma_5][\not{q}_2 + m_{\tilde{B}}][1+3\gamma_5]u_\tau(k_2) \\ &= \bar{v}_\mu(k_1)\big\{3(\not{q}_2 + m_{\tilde{B}}) + 3(\not{q}_2 + m_{\tilde{B}})3\gamma_5 + \gamma_5(\not{q}_2 + m_{\tilde{B}}) + \gamma_5(\not{q}_2 + m_{\tilde{B}})3\gamma_5\big\}u_\tau(k_2) \\ &= \bar{v}_\mu(k_1)\big\{3(\not{q}_2 + m_{\tilde{B}}) + 9\gamma_5(-\not{q}_2 + m_{\tilde{B}}) + \gamma_5(\not{q}_2 + m_{\tilde{B}}) + 3(-\not{q}_2 + m_{\tilde{B}})\big\}u_\tau(k_2) \\ &= \bar{v}_\mu(k_1)\big\{-8\gamma_5\not{q}_2 + 10m_{\tilde{B}}\gamma_5 + 6m_{\tilde{B}}\big\}u_\tau(k_2) \\ &= \bar{v}_\mu(k_1)\big\{-8\gamma_5\not{k}_2 - 8\gamma_5\not{q}_1 + 10m_{\tilde{B}}\gamma_5 + 6m_{\tilde{B}}\big\}u_\tau(k_2) \end{aligned} \tag{A.137}$$

Leaving D_{43} in terms of q_1

$$D_{43} = [(k_2+q_1)^2 - m_{\tilde{B}}^2][q_1^2 - m_{\tau_1}^2][(k_2+k_1+q_1)^2 - m_{\tau_2}^2] \tag{A.138}$$

Substituing Ec. A.137,A.138 in A.25

$$\begin{aligned} M_{43} = \alpha_{12}\bar{v}_\mu(k_1)\Bigg\{ -8\gamma_5\not{k}_2 \int \frac{d^4q_1}{(2\pi)^4}\frac{1}{[(k_2+q_1)^2 - m_{\tilde{B}}^2][q_1^2 - m_{\mu_2}^2][(k_2+k_1+q_1)^2 - m_{\mu_1}^2]} \\ -8\gamma_5 \int \frac{d^4q_1}{(2\pi)^4}\frac{\not{q}_1}{[(k_2+q_1)^2 - m_{\tilde{B}}^2][q_1^2 - m_{\mu_2}^2][(k_2+k_1+q_1)^2 - m_{\mu_1}^2]} \\ +10m_{\tilde{B}}\gamma_5 \int \frac{d^4q_1}{(2\pi)^4}\frac{1}{[(k_2+q_1)^2 - m_{\tilde{B}}^2][q_1^2 - m_{\mu_2}^2][(k_2+k_1+q_1)^2 - m_{\mu_1}^2]} \\ +6m_{\tilde{B}} \int \frac{d^4q_1}{(2\pi)^4}\frac{1}{[(k_2+q_1)^2 - m_{\tilde{B}}^2][q_1^2 - m_{\mu_2}^2][(k_2+k_1+q_1)^2 - m_{\mu_1}^2]}\Bigg\}u_\tau(k_2) \end{aligned} \tag{A.139}$$

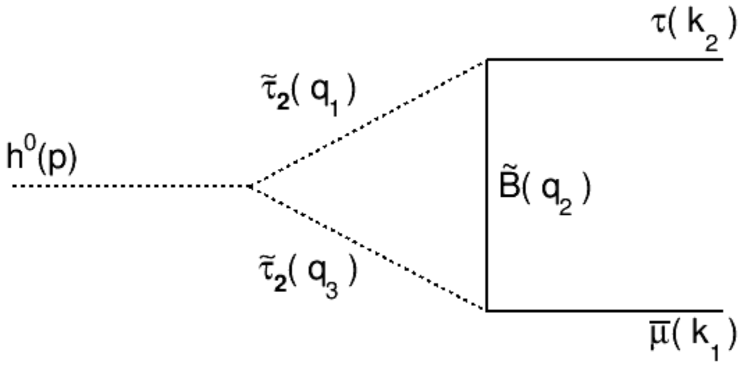
Using the result of the generalized integrals in Ec. 4.26 ,4.38, we obtain

$$\begin{aligned} M_{43} &= \alpha_{12}\bar{v}_\mu(k_1)\Bigg\{-8i\pi^2 F_{c0}\gamma_5\not{k}_2 + 8\frac{i\pi^2}{C_{h^0\mu\tau}}\{\mathcal{B}_{43} - F_{c0}C_{43}\}\gamma_5 \\ &+ 10i\pi^2 m_{\tilde{B}}F_{c0}\gamma_5 + 6im_{\tilde{B}}\pi^2 F_{c0}\Bigg\}u_\tau(k_2) \\ &= \alpha_{43}\bar{v}_\mu(k_1)\Bigg\{6im_{\tilde{B}}\pi^2 F_{c0} + 8\frac{i\pi^2}{C_{h^0\mu\tau}}\{\mathcal{B}_{43} - F_{c0}(C_{43} + C_{h^0\mu\tau}(m_\tau - \frac{10}{8}m_{\tilde{B}})\}\gamma_5\Bigg\}u_\tau(k_2) \end{aligned} \tag{A.140}$$

where we used the completeness relation $\not{k}_2 u_\tau(k_2) = m_\tau u_\tau(k_2)$ Or separating in the scalar part and pseudoscalar part

$$\begin{aligned} S_{43} &= 6im_{\tilde{B}}\pi^2 F_{c0} \\ P_{43} &= 8\frac{i\pi^2}{C_{h^0\mu\tau}}\{\mathcal{B}_{43} - F_{c0}(C_{43} + C_{h^0\mu\tau}(m_\tau - \frac{10}{8}m_{\tilde{B}}))\}\gamma_5 \end{aligned} \tag{A.141}$$

$$M_{43} = \alpha_{43}\bar{v}_\mu(k_1)\big\{S_{43} + P_{43}\big\}u_\tau(k_2) \tag{A.142}$$



In order to calculate the amplitude M_{43}, we use the following expression

$$M_{44} = \int \frac{d^4q_1}{(2\pi)^4} \bar{v}_\mu(k_1) * g_{\tilde{B}\tilde{\tau}_2\mu} * P_{\tilde{B}}(q_2) * g_{\tilde{B}\tilde{\tau}_2\tau} * u_\tau(k_2) * P_{\tilde{\tau}_2}(q_1) * g_{h^0\tilde{\tau}_2\tilde{\tau}_2} * P_{\tilde{\tau}_2}(q_3) \tag{A.143}$$

Obtaining the vertexes and propagators from tables 3.3 ,4.3

$$\begin{aligned}
g_{\tilde{B}\tilde{\tau}_2\tilde{\mu}} &= \frac{gs_\varphi}{4} tan\theta_w[3+\gamma_5] \\
g_{\tilde{B}\tilde{\tau}_2\tau} &= -\frac{gc_\varphi}{4} tan\theta_w[3+\gamma_5] \\
P_{\tilde{B}}(q_2) &= \frac{i(\not{q}_2 + m_{\tilde{B}})}{q_2^2 - m_{\tilde{B}}^2} \\
P_{\tilde{\tau}_2}(q_1) &= \frac{i}{q_1^2 - m_{\tilde{\tau}_2}^2} \\
P_{\tilde{\tau}_2}(q_3) &= \frac{i}{q_3^2 - m_{\tilde{\tau}_2}^2}
\end{aligned} \tag{A.144}$$

Therefore

$$\begin{aligned}
M_{44} &= -\int \frac{d^4q_1}{(2\pi)^4} \bar{v}_\mu(k_1) \frac{gs_\varphi}{4} tan\theta_w[3+\gamma_5] \frac{i(\not{q}_2 + m_{\tilde{B}})}{q_2^2 - m_{\tilde{B}}^2} \frac{gc_\varphi}{4} tan\theta_w[3+\gamma_5] u_\tau(k_2) \times \\
&\times \frac{i}{q_1^2 - m_{\tilde{\tau}_2}^2} g_{h^0\tilde{\tau}_2\tilde{\tau}_2} \frac{i}{q_3^2 - m_{\tilde{\tau}_2}^2} \\
&= \int \frac{d^4q_1}{(2\pi)^4} \bar{v}_\mu(k_1) \frac{ig_{h^0\tilde{\tau}_2\tilde{\tau}_2} g^2 c_\varphi s_\varphi}{16} tan^2\theta_w[3+\gamma_5] \frac{i(\not{q}_2 + m_{\tilde{B}})}{q_2^2 - m_{\tilde{B}}^2} [3+\gamma_5] u_\tau(k_2) \frac{1}{q_1^2 - m_{\tilde{\tau}_2}^2} \frac{1}{q_3^2 - m_{\tilde{\tau}_2}^2}
\end{aligned} \tag{A.145}$$

Labeling N_{44}, α_{44} and D_{44}

$$\begin{aligned}
N_{44} &= \bar{v}_\mu(k_1)[3+\gamma_5][\not{q}_2 + m_{\tilde{B}}][3+\gamma_5] u_\tau(k_2) \\
\alpha_{44} &= -\frac{ig_{h^0\tilde{\tau}_2\tilde{\tau}_2} g^2 c_\varphi s_\varphi}{16} tan^2\theta_w \\
D_{44} &= [q_2^2 - m_{\tilde{B}}^2][q_1^2 - m_{\tilde{\tau}_2}^2][q_3^2 - m_{\tilde{\tau}_2}^2]
\end{aligned} \tag{A.146}$$

With the expressions above we can write M_{44} as $M_{44} = \alpha_{44}\int \frac{d^4_{q_1}}{(2\pi)^4}\frac{N_{44}}{D_{44}}$ As it can be noticed N_{44} is exactly as N_{11} in A.8. Therefore substituing N_{11} in M_{44}

$$\begin{aligned} M_{44} &= \alpha_{44}\bar{v}_\mu(k_1)\Big\{8\int d^4q_1\frac{\not{q}_1}{(2\pi)^4((q_1+k_2)^2-m^2_{\tilde{B}})(q_1^2-m^2_{\tilde{\tau}_2})((q_1+k_2+k_1)^2-m^2_{\tilde{\tau}_2}))} \\ &+ 8\not{k}_2\int\frac{d^4q_1}{(2\pi)^4((q_1+k_2)^2-m^2_{\tilde{B}})(q_1^2-m^2_{\tilde{\tau}_2})((q_1+k_2+k_1)^2-m^2_{\tilde{\tau}_2})} \\ &+ 10m_{\tilde{B}}\int\frac{d^4q_1}{(2\pi)^4((q_1+k_2)^2-m^2_{\tilde{B}})(q_1^2-m^2_{\tilde{\tau}_2})((q_1+k_2+k_1)^2-m^2_{\tilde{\tau}_2})} \\ &+ 6\gamma_5 m_{\tilde{B}}\int\frac{d^4q_1}{(2\pi)^4((q_1+k_2)^2-m^2_{\tilde{B}})(q_1^2-m^2_{\tilde{\tau}_2})((q_1+k_2+k_1)^2-m^2_{\tilde{\tau}_2})}\Big\}u_\tau(k_2) \end{aligned} \tag{A.147}$$

We use the generalized cases in Ec. 4.26 and Ec. 4.38 of the integrals $IC1$ and $IC2$ with $j=1$ and $k=1$.

$$M_{44} = -8\frac{i\pi^2}{C_{h^0\mu\tau}}\{\mathcal{B}_{11}-F_{c0}C_{11}\} + i\pi^2F_{c0}\{8\not{k}_2+10m_{\tilde{B}}+6\gamma_5 m_{\tilde{B}}\} \tag{A.148}$$

We use the completeness relation that states that $\not{k}_2 u_\tau(k_2) = m_\tau u_\tau(k_2)$

$$\begin{aligned} M_{44} &= -8\frac{i\pi^2}{C_{h^0\mu\tau}}\{\mathcal{B}_{44}-F_{C0}[C_{44}+C_{h^0\mu\tau}(m_\tau+\frac{10}{8}m_{\tilde{B}})]\} + 6i\pi^2F_{c0}\gamma_5 \\ &= \bar{v}_\mu(k_1)\alpha_{44}\{S_{44}+P_{44}\}u_\tau(k_2) \end{aligned} \tag{A.149}$$

where we called as $S_{44} = -8\frac{i\pi^2}{C_{h^0\mu\tau}}\{\mathcal{B}_{44}-F_{C0}[C_{44}+C_{h^0\mu\tau}(m_\tau+\frac{10}{8}m_{\tilde{B}})]\}$ and $P_{44} = 6i\pi^2F_{c0}\gamma_5$ because one is scalar and the second one is pseudoscalar.