

The decay $H \rightarrow Wb\bar{c}$ as a proof for the flavor changing neutral coupling Htc

G. Tetlalmatzi*, M. A. Pérez* and F. Larios†

*Departamento de Física, CINVESTAV, A. P. 14-740, 07000, México D. F., México

†Departamento de Física Aplicada, CINVESTAV-Merida, A. P. 73, 97310, Mérida, Yucatán, México

Abstract. It is analyzed if the flavor changing neutral coupling (FCNC) Htc can give place to a significant deviation from the Standar Model predictions in the decay channel $H \rightarrow W^+b\bar{c}$, the effect of this coupling in the three W^+ polarization states is studied. The FCNC comes from an effective Lagrangian with dimension six operators which give rise to an extended Yukawa sector non diagonal in the mass fermionic eigenstates.

Keywords: Flavor changing neutral coupling, Polarization.

PACS: 14.65.Ha, 14.80.Bn, 14.80.Cp

INTRODUCTION

The couplings between the Higgs boson and the fermion fields are diagonal in the mass base within the Standar Model Lagrangian, therefore at tree level the Flavor Changing Neutral Coupling FCNC Htc is not allowed and remains highly suppressed when it appears in radiative corrections [2]. Nevertheless in different standard model extensions some processes involving Top-quark FCNCs can be enhanced by several orders of magnitude because of the presence of new fields such as a second Higgs doublet or new fermionic degrees of freedom. That is the case of the decay $t \rightarrow cH$: in the standard model it has a branching ratio between 10^{-13} and 10^{-14} , however in the Two Higgs Doublet Models II and III the results are 10^{-4} and 10^{-3} respectively, in the MSSM its value is 10^{-4} and in models with extra quarks a branching ratio of 10^{-5} is obtained [2]. In this work the effect of the Htc coupling in the decay channel $H \rightarrow W^+b\bar{c}$ is studied making a comparison between the standard model process $H \rightarrow W^+W^{*-} \rightarrow W^+b\bar{c}$ (SM) and the flavor changing channel $H \rightarrow t\bar{c} \rightarrow W^+b\bar{c}$ (FC). The FCNC Htc is introduced following a model independent approach through the effective coupling[1]

$$\mathcal{L} = \bar{t} \left\{ \frac{g}{2\sqrt{2}} \left(h_{tcH} + i\tilde{h}_{tcH}\gamma_5 \right) H \right\} c + h.c. \quad (1)$$

which comes from an extended Yukawa sector with dimension six operators. Here the equality $\tilde{h}_{tcH} = 0$ will be taken in order to avoid CP violation effects, the remaining coupling constant will be written as C_a . The bounds for C_a derived from the experimental information available are very loose hence its value was fixed using the Cheng and Sher Ansatz $C_a = g \frac{\sqrt{m_t m_c}}{2m_W} = 0.060$.

STUDY OF THE CHANNELS $H \rightarrow W^+W^{*-} \rightarrow W^+b\bar{c}$ AND $H \rightarrow t\bar{c} \rightarrow W^+b\bar{c}$ BY W^+ 'S POLARIZATION STATE

The Feynman diagrams for the purely Standar Model (SM) and Flavor Changing (FC) decay channels are given in figure 1. In order to evaluate the effect of the FCNC Htc in the process $H \rightarrow W^+b\bar{c}$, the energy distributions $\frac{d\Gamma_{SM}}{dE_W}$ and $\frac{d\Gamma_{SM+FC}}{dE_W}$ were constructed and compared. Here Γ_{SM} and Γ_{SM+FC} are the decay widths for the Higgs particle into the products $W^+b\bar{c}$: the first one was estimated regarding just the SM process, the second width was obtained combining the SM and FC channels. The calculations were made taking into account the separate contribution of the following $W^{(+)}$ polarization vectors to the Higgs decay width: $\epsilon^{(+)} = -\frac{\epsilon^{(1)}+i\epsilon^{(2)}}{\sqrt{2}}$, $\epsilon^{(-)} = \frac{\epsilon^{(1)}-i\epsilon^{(2)}}{\sqrt{2}}$ and $\epsilon^{(l)} = \epsilon^{(3)}$. The symbols $\epsilon^{(1)}$ and $\epsilon^{(2)}$ represent transverse polarization states and $\epsilon^{(l)}$ refers to the longitudinal polarization vector associated with a spin 1 massive particle. The figure 2 shows the energy distributions $\frac{d\Gamma}{dE_W}$ by W^+ polarization state assuming a Higgs mass of $m_H = 154.4 \text{ GeV}$, this value falls inside the recent experimental bounds and is almost the energy necessary to produce two real W bosons.

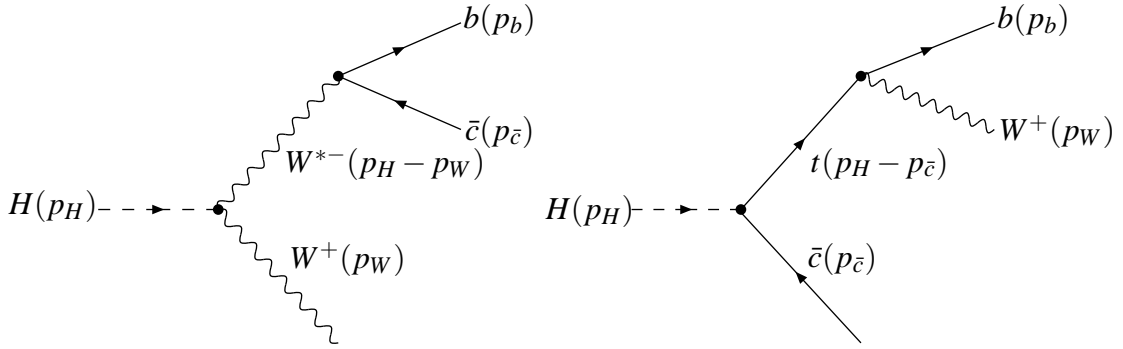


FIGURE 1. Left Standar Model Channel decay $H \rightarrow W^+W^{*-} \rightarrow W^+b\bar{c}$ (SM) and right with flavor changing effect $H \rightarrow t\bar{c} \rightarrow W^+b\bar{c}$.

Finally the ratio $r^{(j)} = \frac{\Gamma^{(j)}(H \rightarrow W^+b\bar{c})}{\Gamma(H \rightarrow W^+b\bar{c})} = \frac{\int \frac{d\Gamma_{SM+FC}^{(j)}}{dE_W} dE_W}{\int \frac{d\Gamma_{SM+FC}}{dE_W} dE_W}$ was evaluated, where

$\frac{d\Gamma_{SM+FC}}{dE_W} = \sum_j \frac{d\Gamma_{SM+FC}^{(j)}}{dE_W}$ with $j = +, -, l$ (more details about the calculations can be found in [3]).

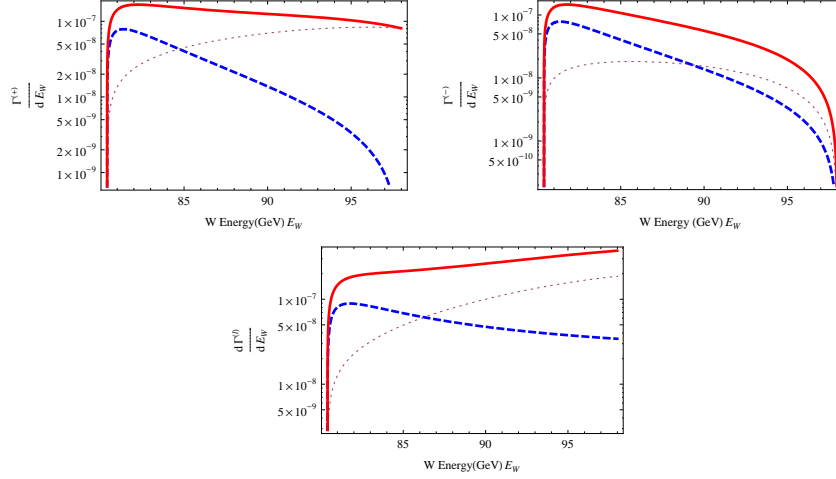


FIGURE 2. Solid curve $\frac{d\Gamma_{SM+FC}}{dE_W}$, dashed curve $\frac{d\Gamma_{SM}}{dE_W}$ and dotted curve $\frac{d\Gamma_{FC}}{dE_W}$ (logarithmic scale).

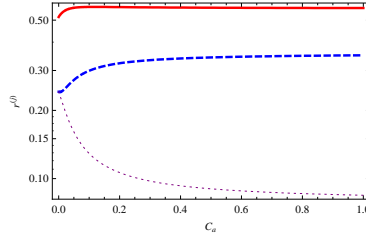


FIGURE 3. Solid curve $r^{(l)}$, dashed curve $r^{(+)}$ and dotted curve $r^{(-)}$ (logarithmic scale).

CONCLUSIONS

The decay channel $H \rightarrow W^+ b \bar{c}$ is enhanced in one order of magnitude due to the FCNC Htc (see figure 2). As the C_a coupling constant is increased the $W^{(+)}$ longitudinal polarization contribution to the Higgs decay width grows from 51.6% to nearly 56.0%, the $\epsilon^{(+)}$ contribution goes from 24.2% to around 35.0%, and the $\epsilon^{(-)}$ contribution value is always lower than 24.2% (see figure 3).

ACKNOWLEDGMENTS

To the organizing committee. This work was supported by CONACYT.

REFERENCES

1. A. Cordero-Cid, M.A. Pérez, G. Tavares-Velasco and J. J. Toscano, *Phys. Rev. D* **70**, 074003 (2004).
2. F. Larios, R. Martínez and M.A. Pérez, *Int. J. Mod. Phys. A* **21**, 17 (2006).
3. Gilberto Tetlalmatzi Xolocotzi, Master Degree Thesis, CINVESTAV; F. Larios, M. A. Pérez and G. Tetlalmatzi, work in progress.