125 Gev Higgs decays into γγ, Zγ and rare top quark decay in generic Two Higgs Doublet Model

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Abstract

Models of electroweak symmetry breaking with extended Higgs sectors are theoretically well motivated. In this study, we investigate the phenomenology of the new Yukawa couplings in generic two-Higgs-doublet models. We find that a heavy charged Higgs together with $\alpha, \tan\beta\sim O(1)$, type-II and III could enhance the two-photon production cross section; however, with large $\tan\beta$ scenario, only type-III could match the LHC data. Additionally, we study the implications of LHC data on the production cross sections for the channel $h\to Z\gamma$ and branching ratio for $t\to c h$ decay.

†Motivation -2HDM-

- Tree-level flavour changing neutral currents (FCNC's) due to non diagonal Yukawa interactions .
- New sources of CP violation in scalar-scalar interactions .
- An increase in the scalar spectrum with one charged and three neutral scalar .

The scalar potential can be written as :

$$V(\Phi_1,\Phi_2) = m_{11}^2(\Phi_1^\dagger\Phi_1) + m_{22}^2(\Phi_2^\dagger\Phi_2) - (m_{12}^2(\Phi_1^\dagger\Phi_2) + h.c) + \frac{\lambda_1}{2}(\Phi_1^\dagger\Phi_1)^2 + \frac{\lambda_2}{2}(\Phi_2^\dagger\Phi_2)^2 + \lambda_3(\Phi_1^\dagger\Phi_1)(\Phi_2^\dagger\Phi_2) + \lambda_4(\Phi_1^\dagger\Phi_2)(\Phi_1^\dagger\Phi_1) + (\frac{\lambda_5}{2}(\Phi_1^\dagger\Phi_2)^2 + h.c) + \{(\lambda_6(\Phi_1^\dagger\Phi_1) + \lambda_7(\Phi_2^\dagger\Phi_2))(\Phi_1^\dagger\Phi_2) + h.c\}$$

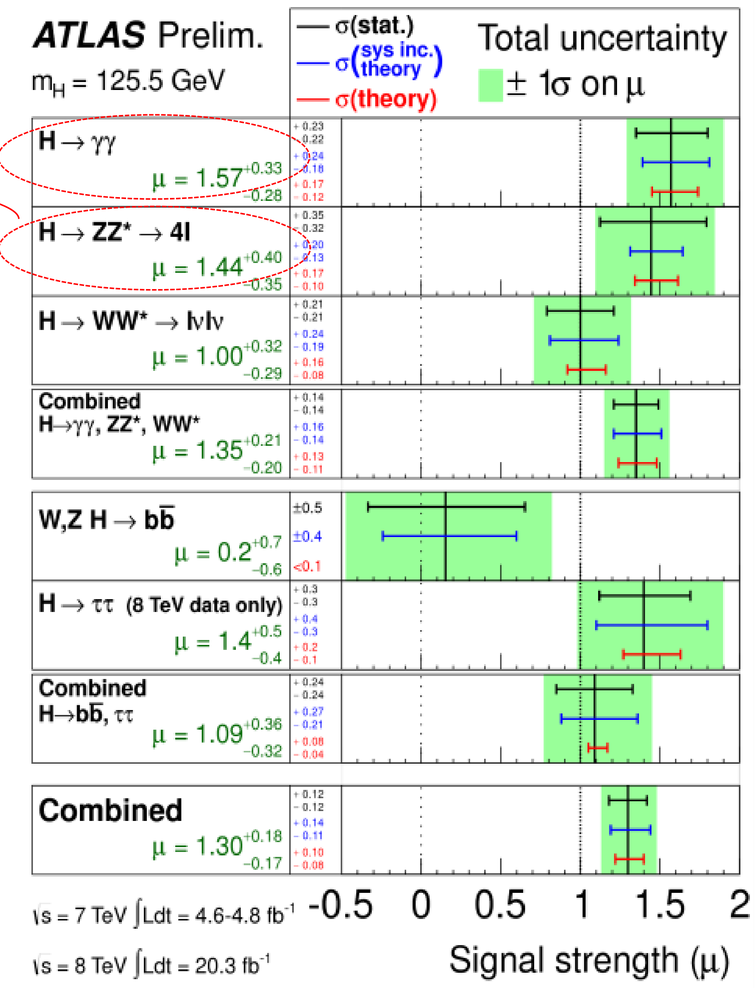
The lightest higgs coupling to fermions are written as :

$$\mathcal{L}_Y^h = \bar{u}_i\left(\frac{\cos\alpha}{\sin\beta}\frac{m_{u_i}}{v}\delta_{ij} - \frac{\cos(\alpha-\beta)}{\sqrt{2}\sin\beta}X_{ij}^u\right)u_j h + \bar{d}_i\left(-\frac{\sin\alpha}{\cos\beta}\frac{m_{d_i}}{v}\delta_{ij} + \frac{\cos(\alpha-\beta)}{\sqrt{2}\cos\beta}X_{ij}^d\right)d_j h\,,$$

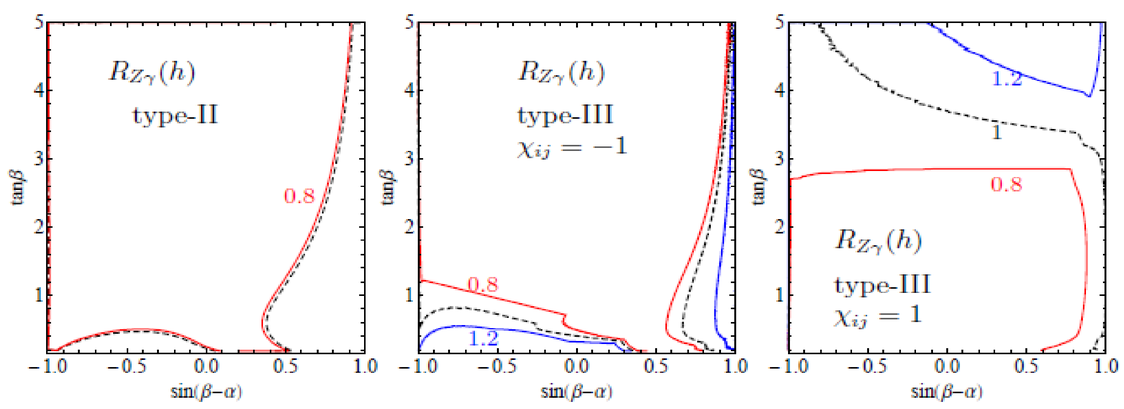
The overall signal strength for diphoton at ATLAS may be explained by one of Standard model's extensions like **Two-Higgs-Doublet Models**† (2HDMs) .

So , in order to study the new physics effects on the LHC measurements for some specific XY finale state, we define the quatntities R_{XY}

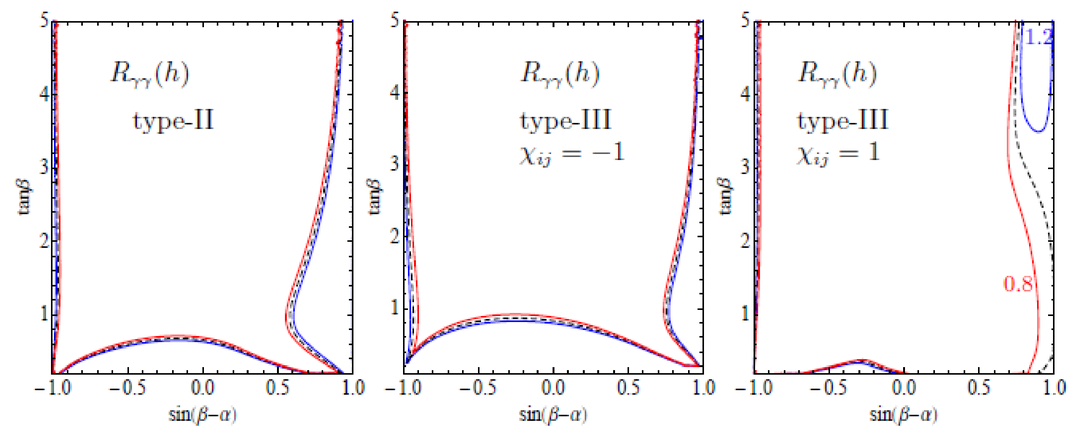
$$R_{XY} = \frac{\sigma(pp\to h)B(h\to XY)}{\sigma(pp\to h)_{SM}B(h\to XY)_{SM}}$$



Numerical Results



The $R_{Z\gamma}(h)$ for mh = 125 GeV in the type-II (left panel), type-III with χ_i = -1 (middel panel) and type-III with χ_i = 1 (right panel). The contour lines are 0.8 (red), 1 (dashed) and 1.2 (blue).

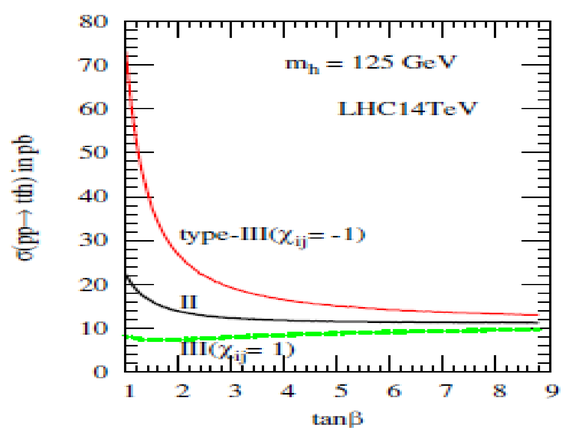


The $R_{\gamma\gamma}(h)$ for mh = 125 GeV in the type-II (left panel), type-III with χ_i = -1 (middel panel) and type-III with χ_i = 1 (right panel). The contour lines are 0.8 (red), 1 (dashed) and 1.2 (blue).

If $R_{z\gamma}(h)$requires to be between 1 and 2, then type-II is almost excluded. Both type-III with χ_{ij} = 1 provides a wider allowed parameter space especially type-III with χ_{ij} = -1 in the region where sin(β-α) is negative .

The new fermion couplings in type-II and type-III could enhance $R_{\gamma\gamma}$. Type-III could fit the data for both χ_{ij} at different region of sin(β-α) and provides a wider allowed parameter space .

As we already know, flavor changing neutral currents (FCNCs) can be induced at tree level in type-III model, so if a large BR for $t \to c\,h$ is measured, the type-III model could be the best extension of the SM .



Production cross section of $pp \to t\bar{t}\,h$ at the LO as a function of tan β in the general THDM where mH = 200 GeV, mH±= 480 GeV, mA0 = 420 GeV and mh = 125 GeV are chosen .

Conclusion:

✓The phenomenologies of the three types of yukawa interactions are completly different from each other.

✓ The differences between the types of the yukawa interactions largely affect the production and the decay of the Higgs boson.

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