UAE Tangier Node

Presented by Abdesslam Arhrib

"Non minimal Higgs": 1st RISE meeting; 6-8th December 2015

University of Warsaw

Tangier node

Faculty members:

- Abdesslam Arhrib (Tangier)
- Rachid Benbrik (Marrakesh)
- Mohamed Chabab (Marrakesh)

PhD students:

- Jaouad El-Falaki and Adil Jueid (Tangier)
- Souad Semlali and El Batoul (Marrakesh)

Post-doctoral:

- Larbi Rahili (Marrakesh)

Radiative corrections; unitarity constraint and BFB, QCD, extended Higgs models, MSSM, Tools for loop calculations.

Secondments

- El Falaki (Tangier) $\rightarrow$ Aveiro/Lisboa (November'15)
- A.Arhrib (Tangier) $\rightarrow$ Lisboa January'16(2 weeks)
- R. Benbrik (Marrakesh) $\rightarrow$ Soton (January'16)
- M. Chabab (Marrakesh) $\rightarrow$ Lisboa (multiHiggs'16)
- ??? (Tangier) $\rightarrow$ Lisboa (multiHiggs'16)
- ??? (Tangier) $\rightarrow$ Lisboa (ChargedHiggs'16)

Recent activities

1. “Radiative corrections to the Triple Higgs Coupling in the nert Higgs Doublet Model,” A. A, R. Benbrik, J. El Falaki and A. Jueid.

- Corrections to hhh could be extremely large.
- If the invisible decay $h \to HH$ is open, the constraints from DM could reduce these corrections, but they can still be of the order of 100% for heavy $H^{\pm}$ or A^0.
- loop-corrections to $e^+e^- \to Zhh$ through hhh one loop coupling are also large

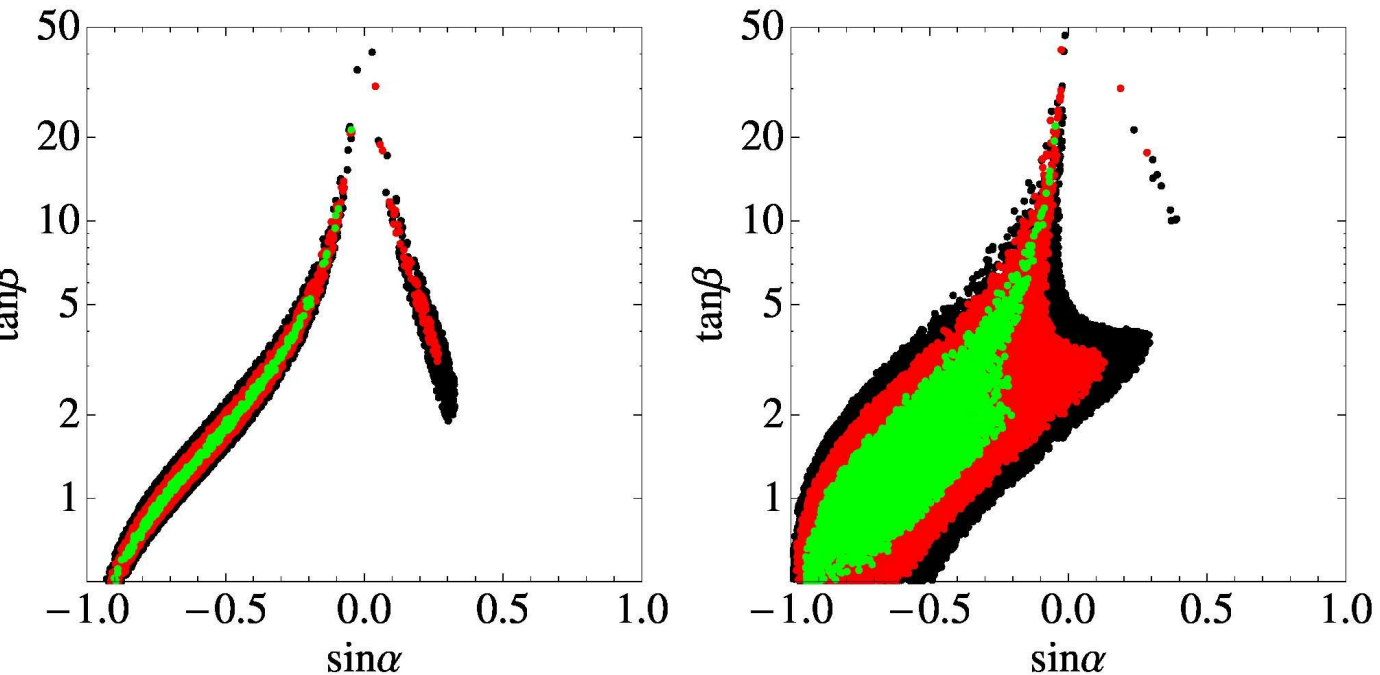
Recent activities (cont.)

2. "Type II Seesaw Higgsology and LEP/LHC constraints,"
A.A, R. Benbrik, G. Moultaka and L. Rahili, arXiv:1411.5645
Degenerate Higgs bosons decays to $\gamma\gamma$ and $Z\gamma$ in the type II seesaw Model,"
M. Chabab, M. Capdequi. Peyranère and L. Rahili. (Phys. Rev. D **90**, 035026 (2014))

- We study both: h is SM-like and H is SM-like.
- In the case where H is SM-like: We study the constraints on these light CP-even (h0) and CP-odd (A0) states from LEP exclusion limits and LHC constraints.
- If h and H are degenerate, we show that the LHC data can be interpreted within a delineated region controlled by λ_1 and λ_4 coupling which favours a light $H^{\pm\pm}$.
- Correlation between $h \to \gamma\gamma$ and $h \to \gamma Z$.

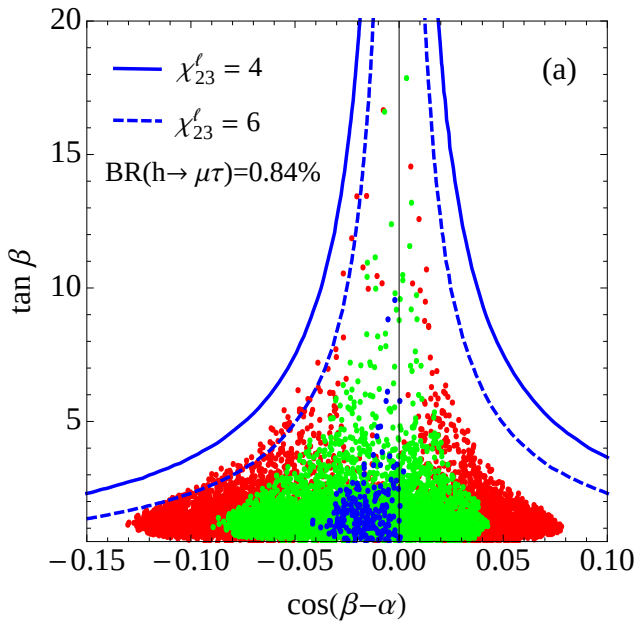
Recent activities (cont.)

3. "Two-Higgs-Doublet type-II and -III models and $t \to ch$ at the LHC,";
A. Arhrib, R. Benbrik, C. H. Chen, M. Gomez-Bock and S. Semlali, arXiv:1508.06490.
$h, Z \to \ell_i \bar{\ell}_j$, Δa_μ, $\tau \to (3\mu, \mu\gamma)$ in generic two-Higgs-doublet models,"
R. Benbrik, C. H. Chen and T. Nomura, arXiv:1511.08544 [hep-ph].



The allowed regions in $(\sin\alpha, \tan\beta)$, left: 2HDM-II, right 2HDM-III. The errors for χ-square fit are 99.7% CL (black), 95.5% CL (red) and 68% CL (green).

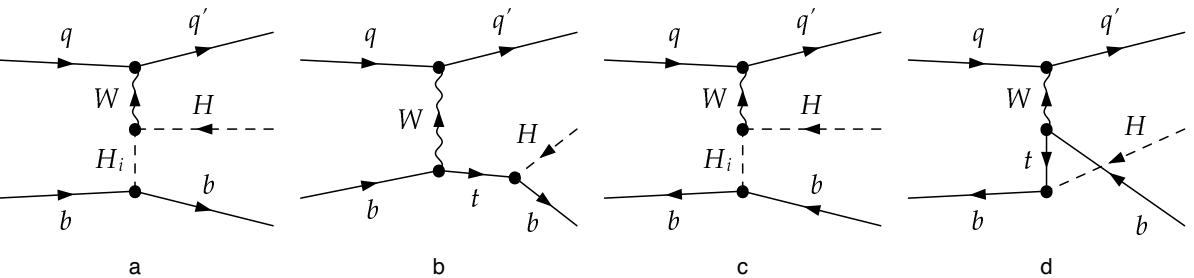
Confrontig $h \to \tau\mu$ and $(g-2)_\mu$ with Higg data



Contours plots of $h \to \tau\mu$ in $(\tan\beta, \cos(\beta-\alpha))$ plan .

Recent activities (cont.)

4. “Enhanced Charged Higgs Production through
$W^{\pm}$-Higgs Fusion,”
A. Arhrib, K. Cheung, J. S. Lee and C. T. Lu,
arXiv:1509.00978 [hep-ph].



Ongoing activities

1. “Naturalness in Type II Seesaw and implications for Physical scalars”
   M. Chabab, M. C. Peyranère and L. Rahili.

- We show from naturalness considerations that the Veltman condition is modified by virtue of the additional scalar charged states of Higgs Triplet Model (HTM).

- We analyse the naturalness condition effects to the masses of heavy Higgs bosons H^0, A^0, $H^{\pm}$ and $H^{\pm\pm}$, providing a drastic reduction of the ranges of variation of $m_{H^{\pm}}$ and $m_{H^{\pm\pm}}$ with an upper bounds at 288 GeV and 351 GeV respectively, while predicting an almost mass degeneracy for the neutral Higgs, about 207 GeV.

Ongoing activities(cont.)

2. Anomalous tbW couplings in 2HDM

- New physics might induce non-trivial tensorial couplings.

$$\mathcal{L} = \frac{ig}{\sqrt{2}}\bar{u}_b(p_b)\left[(V_L P_L + V_R P_R)\gamma^\mu - \frac{\sigma^{\mu\nu}q_\nu}{M_W}(g_L P_L + g_R P_R)\right] u_t(p_t)\epsilon^*_\mu($$

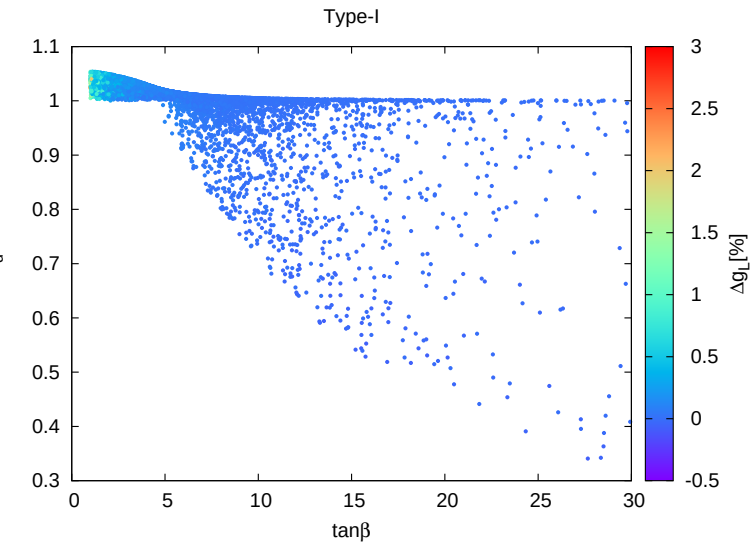
- In SM, the effects are dominated by QCD corrections.

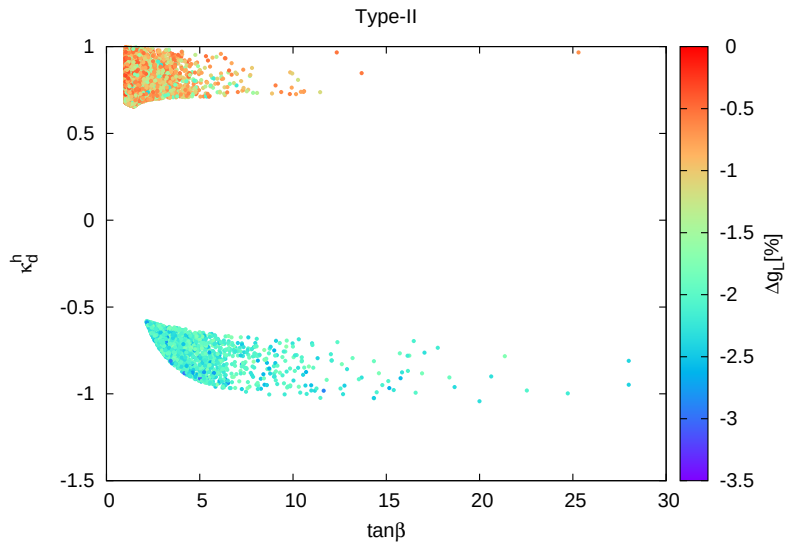
$$g_L = -(1.247 + 0.002747i)10^{-3}\ ,\ g_R = -(8.6 + 2.05i)10^{-3}$$
$$V_L = -0.0296 + 0.0119i \quad , \quad V_R = (2.911 + 0.9) \times 10^{-3}$$

- We evaluate $\Delta\mathcal{O}_i$ with LHC constraints

$$\Delta\mathcal{O}_i = \frac{\mathcal{O}_i^{2HDM} - \mathcal{O}_i^{SM}}{\mathcal{O}_i^{SM}} \quad , \ \mathcal{O}_i = \mathrm{Re}(g_L), \mathrm{Re}(g_R), \mathrm{Re}(V_R), V_{tb} + \mathrm{Re}(V_L)$$

preliminary Results





Relative contribution to the tbW tensorial coupling g_L in type-I (left) and type-II THDM (right)

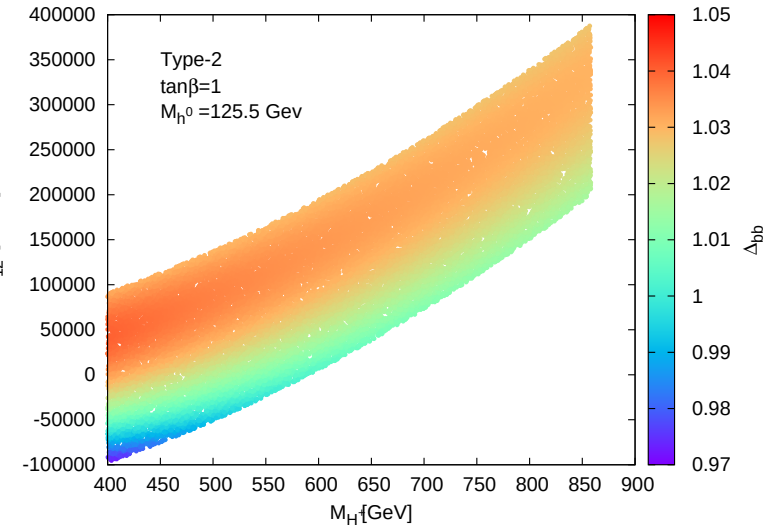
Ongoing activities (cont.)

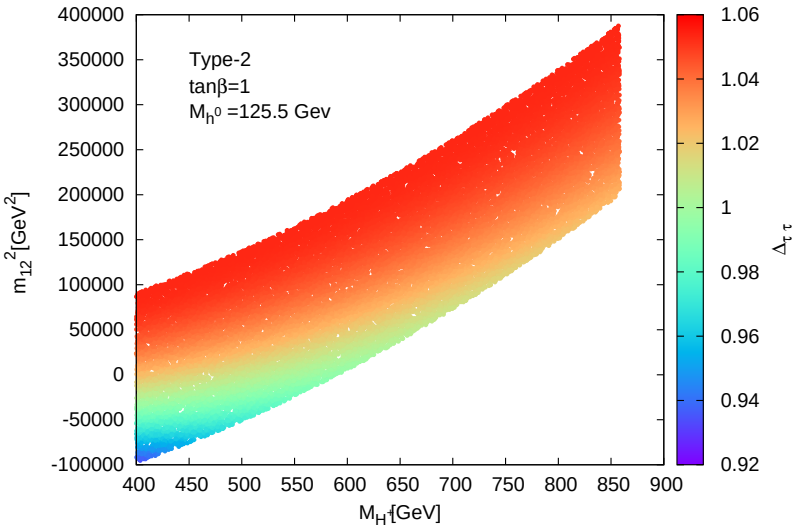
3. Radiative corrections to $h \to b\bar{b}$ and $h \to \tau^+\tau^-$ in 2HDM.

- We use on-shell scheme for determination of the counterterms,

- The field renormalization constants for the two Higgs doublets are determined in the $\overline{MS}$ scheme.

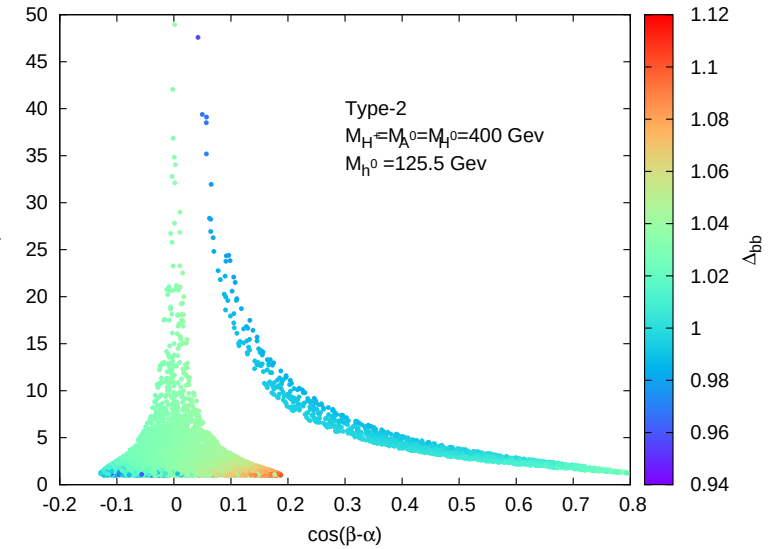
Preliminary, Decoupling limit $\cos(\beta - \alpha) = 0$

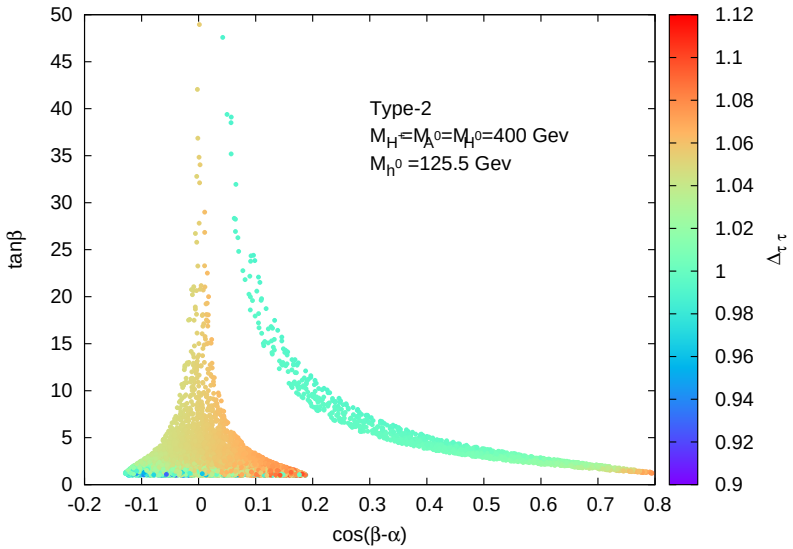




Left) $\Delta_{bb}(\%)$, (right) $\Delta_{\tau^+\tau^-}(\%)$ in the plane (M_{H^+}, m_{12}^2) in 2HDM2

Preliminary, $(\cos(\beta-\alpha), \tan\beta)$





Left) $\Delta_{bb}(\%)$, (right) $\Delta_{\tau^-\tau^-}(\%)$ in the plane $(\cos(\beta-\alpha), \tan\beta)$ in 2HDM2

Yukawa Lagrangian

$$
\begin{aligned}
\mathcal{L}_Y \;=\;& \bar{u}_{Li}\left(\frac{\cos\alpha}{\sin\beta}\frac{m_{u_i}}{v}\delta_{ij} - \frac{\cos(\beta-\alpha)}{\sqrt{2}\sin\beta}X^u_{ij}\right)u_{Rj}h \\
+\;& \bar{d}_{Li}\left(-\frac{\sin\alpha}{\cos\beta}\frac{m_{d_i}}{v}\delta_{ij} + \frac{\cos(\beta-\alpha)}{\sqrt{2}\cos\beta}X^d_{ij}\right)d_{Rj}h \\
+\;& \bar{u}_{Li}\left(\frac{\sin\alpha}{\sin\beta}\frac{m_{u_i}}{v}\delta_{ij} + \frac{\sin(\beta-\alpha)}{\sqrt{2}\sin\beta}X^u_{ij}\right)u_{Rj}H \\
+\;& \bar{d}_{Li}\left(\frac{\cos\alpha}{\cos\beta}\frac{m_{d_i}}{v}\delta_{ij} - \frac{\sin(\beta-\alpha)}{\sqrt{2}\cos\beta}X^d_{ij}\right)d_{Rj}H \\
-\;& i\bar{u}_{Li}\left(\frac{1}{\tan\beta}\frac{m_{u_i}}{v}\delta_{ij} - \frac{X^u_{ij}}{\sqrt{2}\sin\beta}\right)u_{Rj}A \\
+\;& i\bar{d}_{Li}\left(-\tan\beta\frac{m_{d_i}}{v}\delta_{ij} + \frac{X^d_{ij}}{\sqrt{2}\cos\beta}\right)d_{Rj}A + \text{h.c}\,,
\end{aligned}
$$