tbW anomalous couplings in the Two-Higgs-Doublet Model

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Plan de la présentation

Introduction

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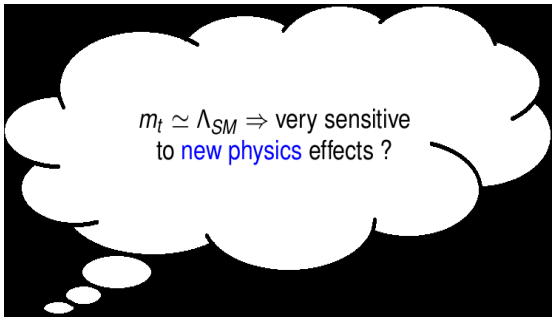

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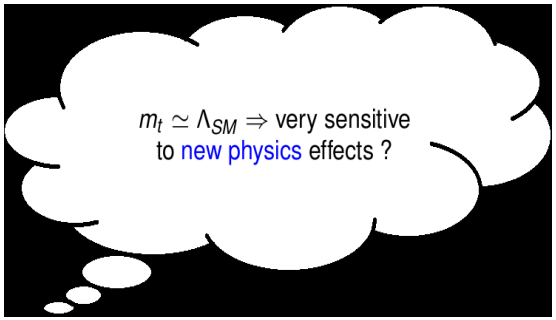

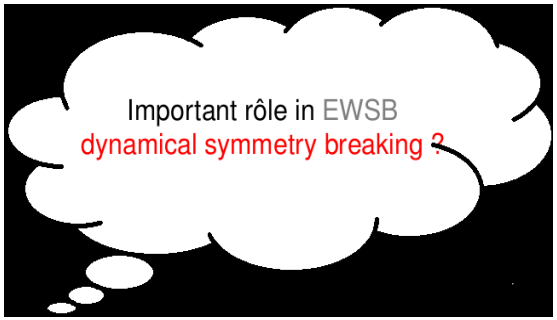

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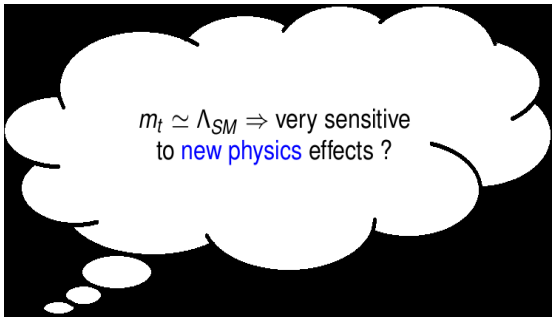

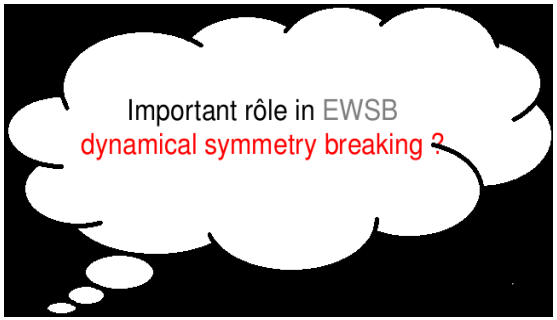

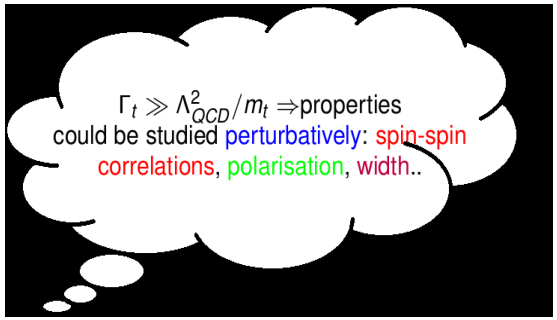

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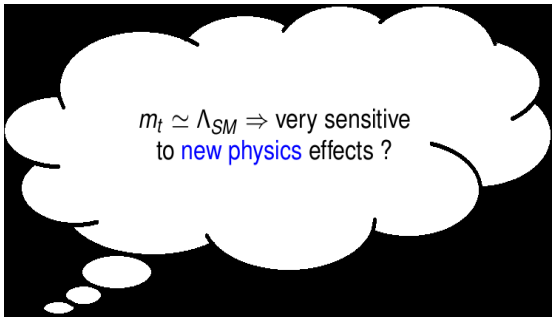

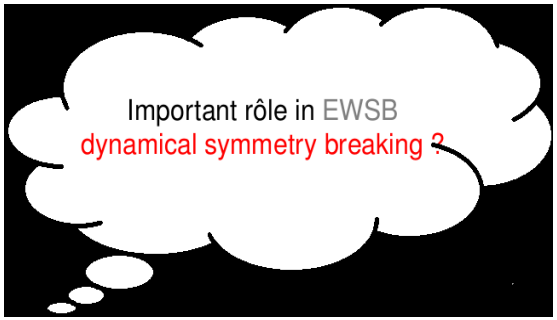

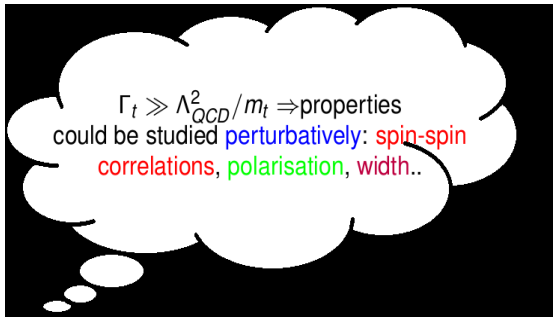

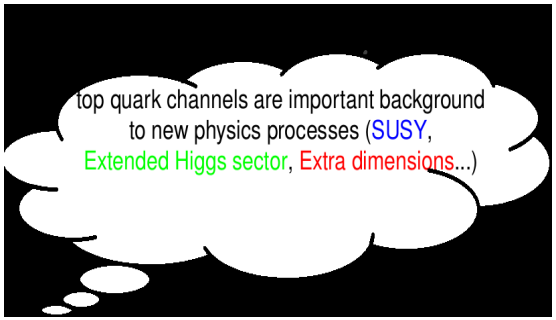

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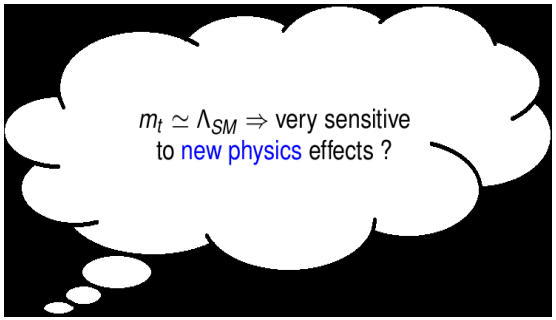

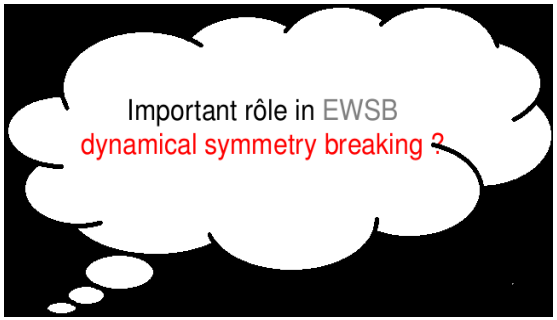

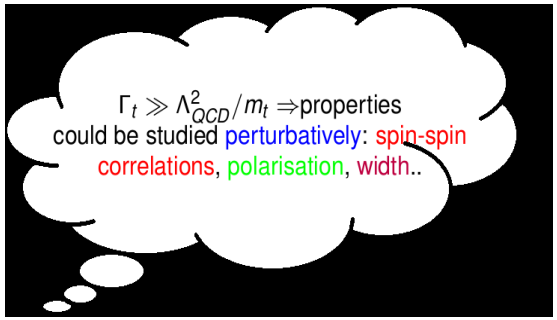

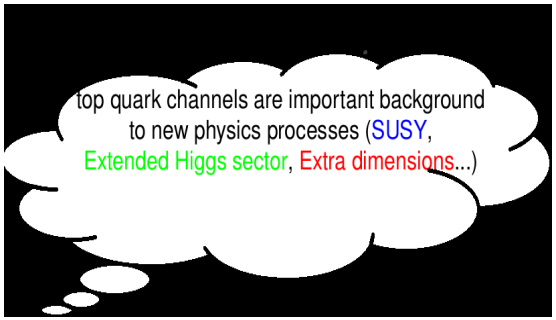

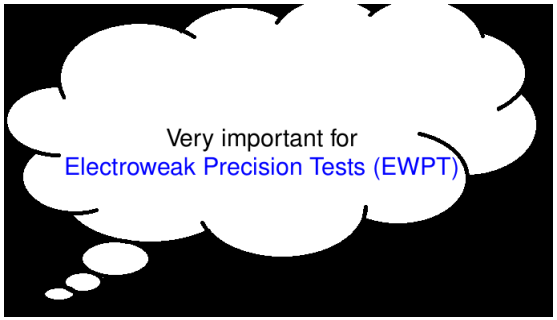

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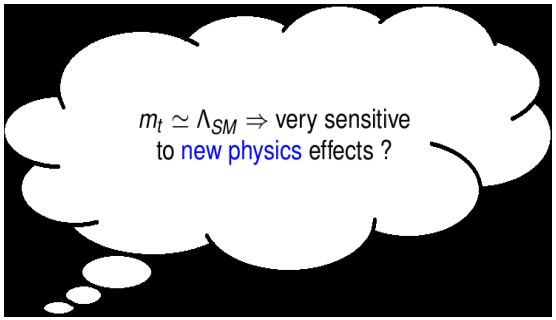

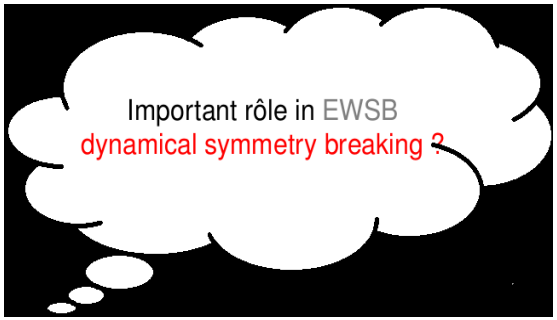

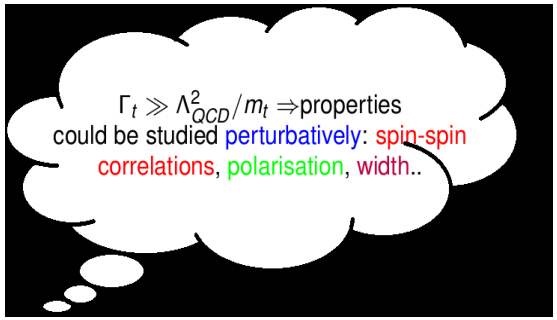

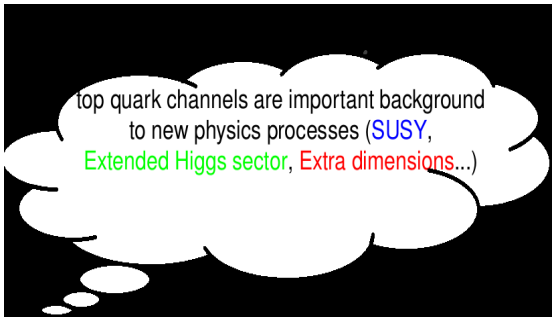

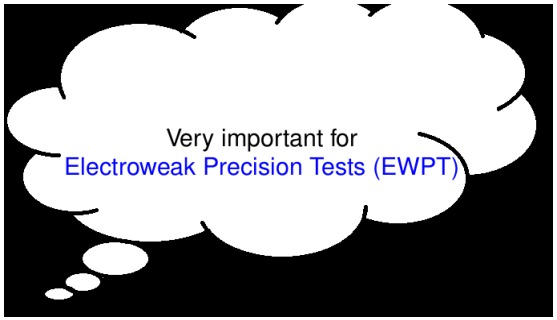

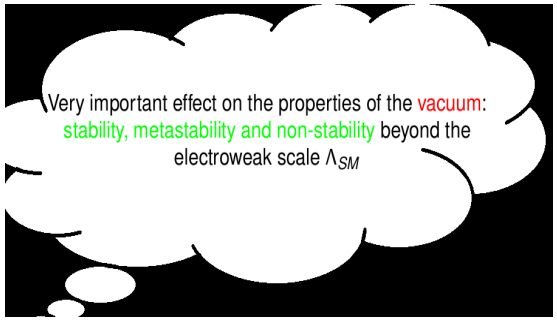

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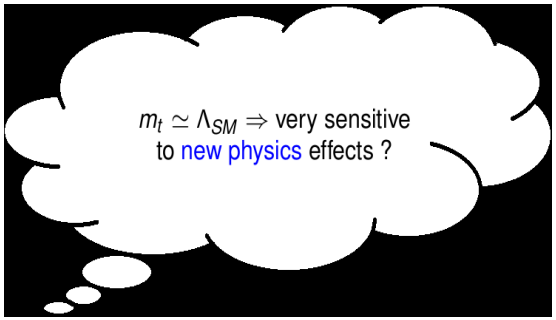

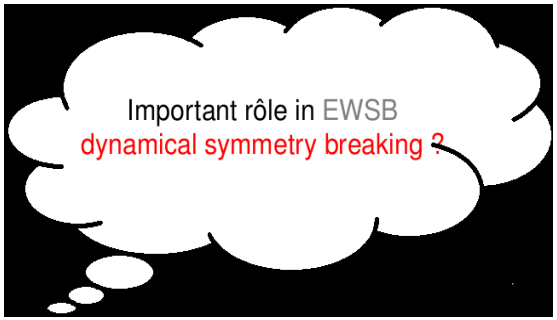

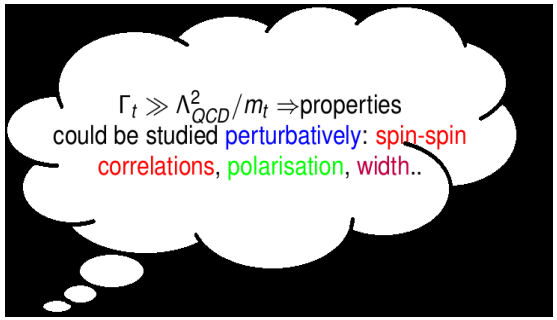

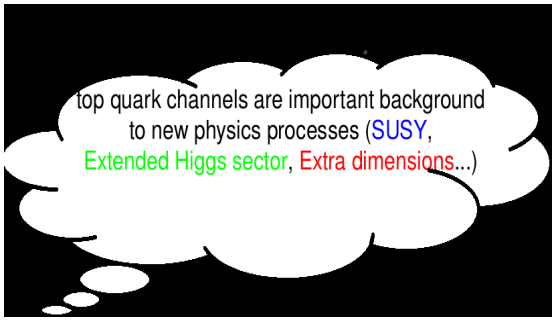

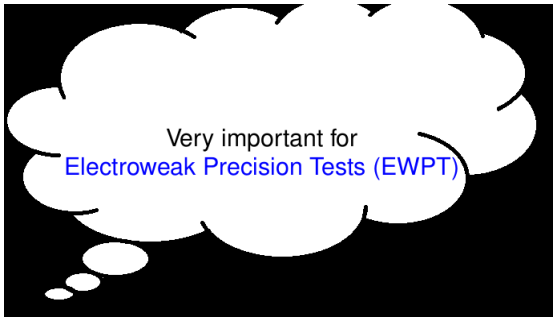

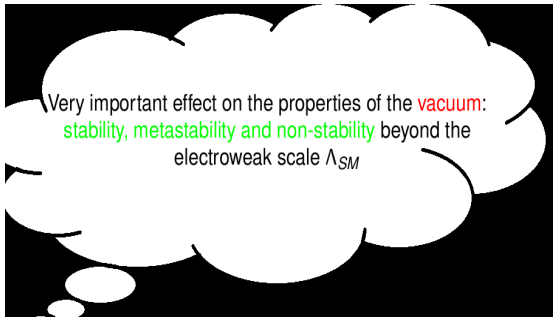

We should know the properties of top quark with a very high precision

Introduction

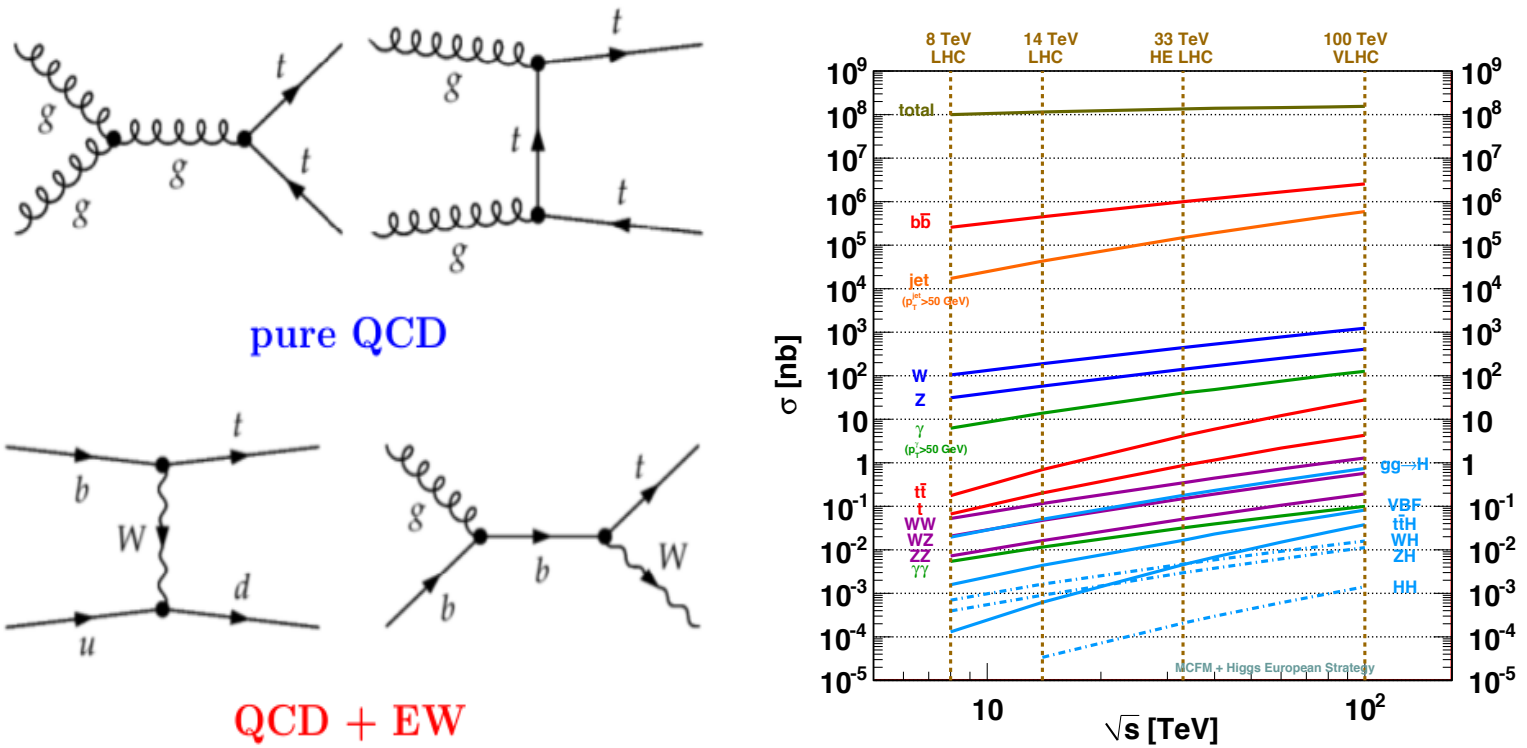

Figure : Examples of Feynman diagrams for Top production at the LHC (left), Cross sections at the LHC @7, 8 TeV and future colliders @33 and 100 TeV (WGR: QCD, arXiv:1310.5189.) (right)

Introduction

Production mode	Cross Section (8 TeV)
s-channel	$\sigma_s = 4.8 \pm 0.8(stat.)^{+1.6}_{-0.3}(syst.)$ pb arXiv:1511.05980v2 [hep-ex]
Wt production	$\sigma_{Wt} = 23.0 \pm 13(stat.)^{+3.2}_{-3.5}(syst.) \pm 1.1(lum.)$ pb arXiv:1510.03752v2 [hep-ex]
t-channel	$\sigma_t = 82.6 \pm 1.2(stat.) \pm 11.4(syst.) \pm 3.1(PDF) \pm 2.3(lum.)$ pb ATLAS-CONF-2014-007
$t\bar{t}$	$\sigma_{t\bar{t}} = 260 \pm 1(stat.)^{+22}_{-23}(syst.) \pm 8(lumi.) \pm 4(beam)$ pb arXiv:1504.04251v3 [hep-ex]
$t\bar{t}(W^{\pm}/Z)$	$\sigma_{t\bar{t}Z} = 176^{+58}_{-52}$ fb, $\sigma_{t\bar{t}W} = 369^{+100}_{-91}$ fb arXiv:1509.05276v2 [hep-ex]

Table : Cross sections @8 TeV measured by the ATLAS collaboration

	$t\bar{t}$	$t\bar{t}t\bar{t}$	$t\bar{t}W^{\pm}$	$t\bar{t}Z^0$	$t\bar{t}W^{\pm}W^{\mp}$	$t\bar{t}W^{\pm}Z$	$t\bar{t}ZZ$
σ(fb)(13 TeV)	810 pb	13.31	644.8	8736	11.84	4.157	2.117
σ(pb)(100 TeV)	3.2×10^4	4.9	16.8	56.3	1.1	0.17	0.16

Table : σ_{t+X} at 13 and 100 TeV arXiv:1507.05640 [hep-ph], arXiv:1511.06495 [hep-ph] @NLO

tbW Anomalous Couplings

- In the SM, at tree level, Top quark couplings to $W^{\pm} + b$ has a $V - A$ structure.
- new physics effects and/or one-loop corrections might induce non-trivial right chiral and tensorial couplings.

$$\mathcal{M}(t \to bW^+) = \frac{-e}{\sqrt{2}s_W}\bar{u}_b\left[(\mathbf{V_L}P_L + \mathbf{V_R}P_R)\gamma^\mu - \frac{i\sigma^{\mu\nu}q_\nu}{M_W}(\mathbf{g_L}P_L + \mathbf{g_R}P_R)\right]u_t\epsilon^*_\mu$$

- In the SM, the corrections at the one-loop order are very small and dominated by the QCD contribution.

Coupling	Value in the SM
g_L	$-(1.247 + 0.002747i) \times 10^{-3}$
g_R	$-(8.6 + 2.05i) \times 10^{-3}$
V_R	$(2.911 + 0.9) \times 10^{-3}$
V_L	$-0.0296 + 0.0119i$

Limits on *tbW* anomalous couplings

Reference	Limit
2σ for LHC simulation ([hep-ph/0605190])	$-0.026 \leq g_R \leq 0.024$, $-0.058 \leq g_L \leq 0.026$
Tevatron ([arXiv:1204.2332 [hep-ex]])	$\lvert V_R\rvert^2 < 0.30, \lvert g_L\rvert^2 < 0.05$ $\lvert g_R\rvert^2 < 0.12$ at 95% CL
$b \to s\gamma$ ([arXiv:0802.1413 [hep-ph]])	$-0.15 \leq \mathrm{Re}(g_R) \leq 0.57$ $-1.3 \times 10^{-3} \leq g_L \leq 4 \times 10^{-4}$ $-7 \times 10^{-4} \leq V_R \leq 2.5 \times 10^{-3}$
CMS best fit (CMS PAS TOP-11-020)	$g_R = 0.070 \pm 0.053(stat.)^{+0.081}_{-0.073}(syst.)$

Table : Constraints on *tbW* anomalous couplings

Anomalous *tbW* couplings in the Two-Higgs-Doublet-Model

- Two Higgs Doublet Model is an extension of the SM where two doublets H_1 and H_2 participate to the mechanism of EWSB. It is an extension like SUSY but without supersymmetric partners.

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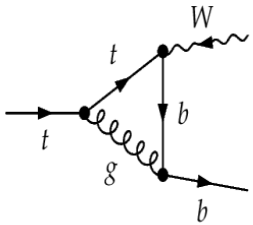
- We calculate the anomalous couplings in the Two-Higgs-Doublet Model type-I and type-II taking into account various theoretical and experimental constraints.
- For numerical analysis, we have defined the ratio $\Delta\mathcal{O}_i$ by :

$$\Delta\mathcal{O}_i = \frac{\mathcal{O}_i^{2HDM} - \mathcal{O}_i^{SM}}{\mathcal{O}_i^{SM}}$$

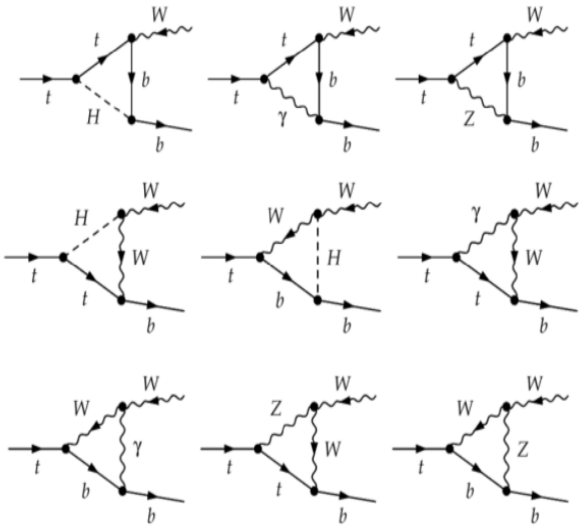
where $\mathcal{O}_i = \mathrm{Re}(g_L), \mathrm{Re}(g_R), \mathrm{Re}(V_R), V_{tb} + \mathrm{Re}(V_L)$.

Warning! $\Delta\mathcal{O}$ gives only the contribution of the extra particles in the THDM

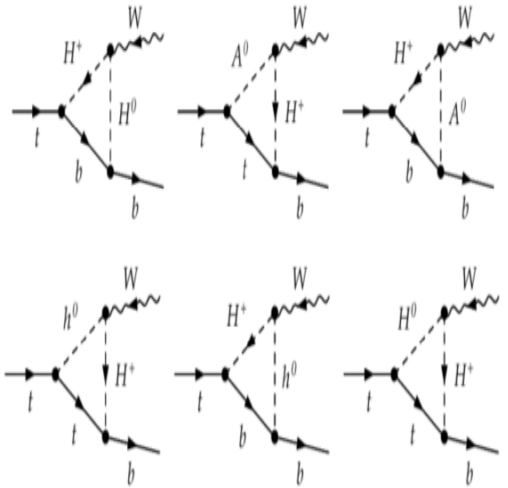
Feynman diagrams



Dominant contribution



Electroweak contribution; only 8 to 10%



contribution of charged Higgs boson, sensitive to $\tan\beta$

Numerical Results : tensorial left coupling g_L

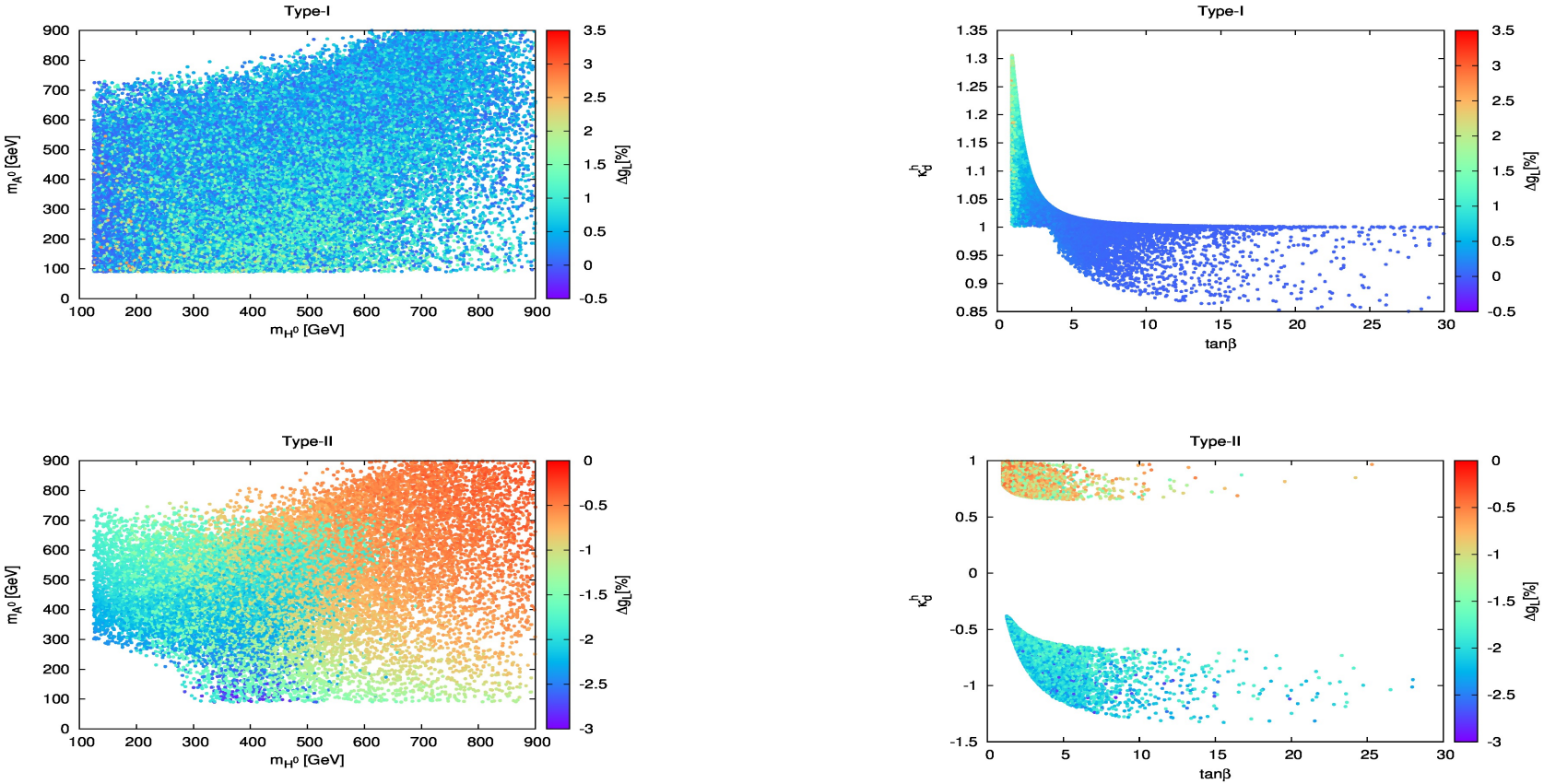


Figure : Relative contribution to the *tbW* left anomalous tensorial coupling g_L in type-I and type-II THDM

Summary

- Calculations of *tbW* anomalous couplings in the THDM has shown no significant deviations from the SM results
- observables related to anomalous *tbW* couplings will receive smaller effects from extra loops.

$\Longrightarrow$ The THDM remains viable as a BSM candidate

- Top quark anomalous couplings might be probed more efficiently in the 2nd LHC run with the accumulation of more data. More observables have to be constructed in order to increase the sensitivity of the LHC to these couplings.

Outlook

- Single top production at the LHC with Lab frame observables could be used a probe of the anomalous *tbW* couplings. collaboration with Abdesslam Arhrib, Fawzi Boudjema and Rohini Godbole (started while I was staying at LAPTh, Annecy-Le-Vieux).
- $t\bar{t}$ spin correlations in $pp \to H^- t \to t\bar{t}b$ production : might be used to probe the THDM (tan β and $m_{H^\pm}$). collaboration with Abdesslam Arhrib.

Numerical Results : tensorial right coupling g_R

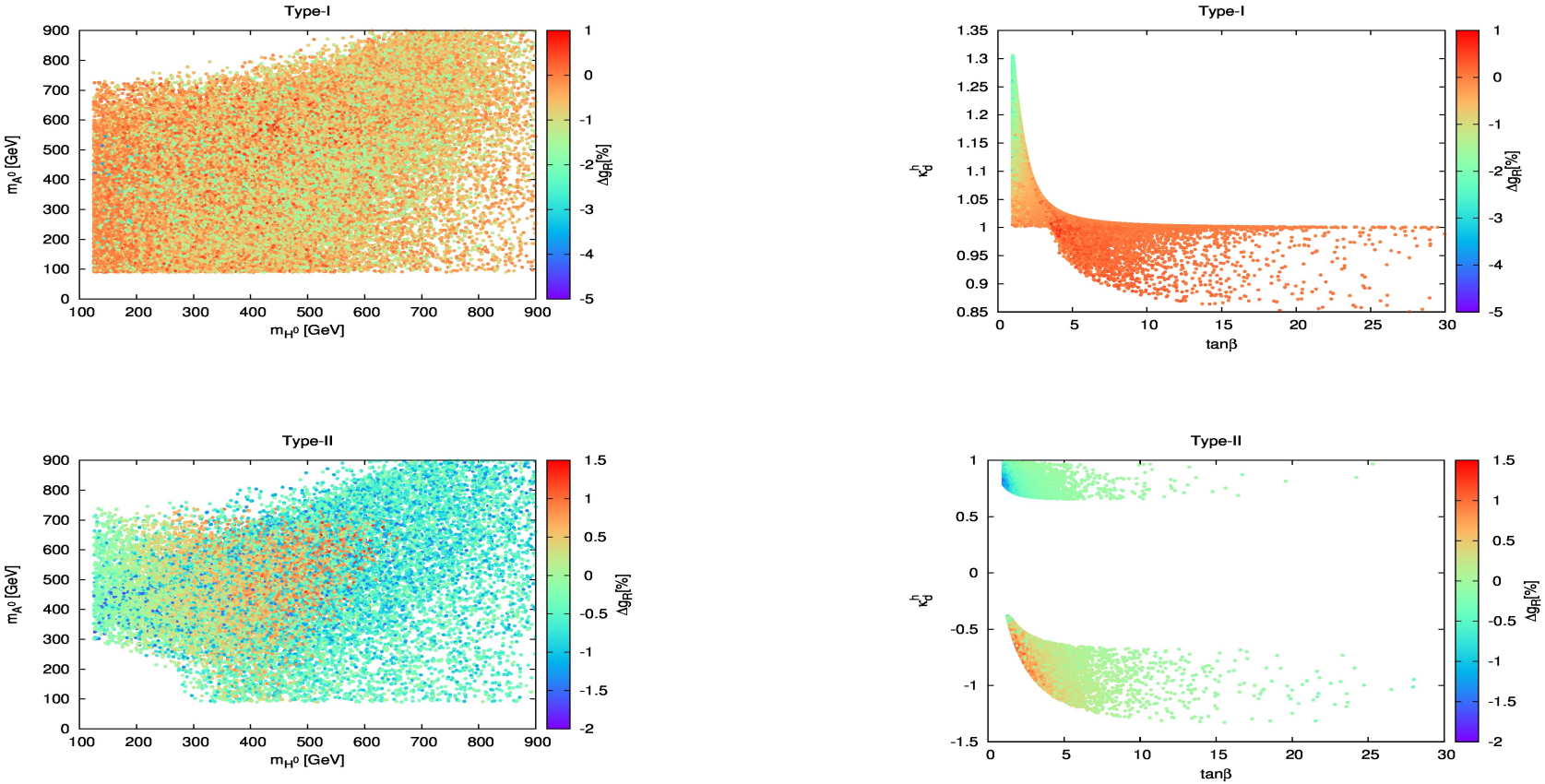


Figure : Relative contribution to the *tbW* right anomalous tensorial coupling g_R in type-I and type-II models

Numerical Results : right chiral coupling V_R

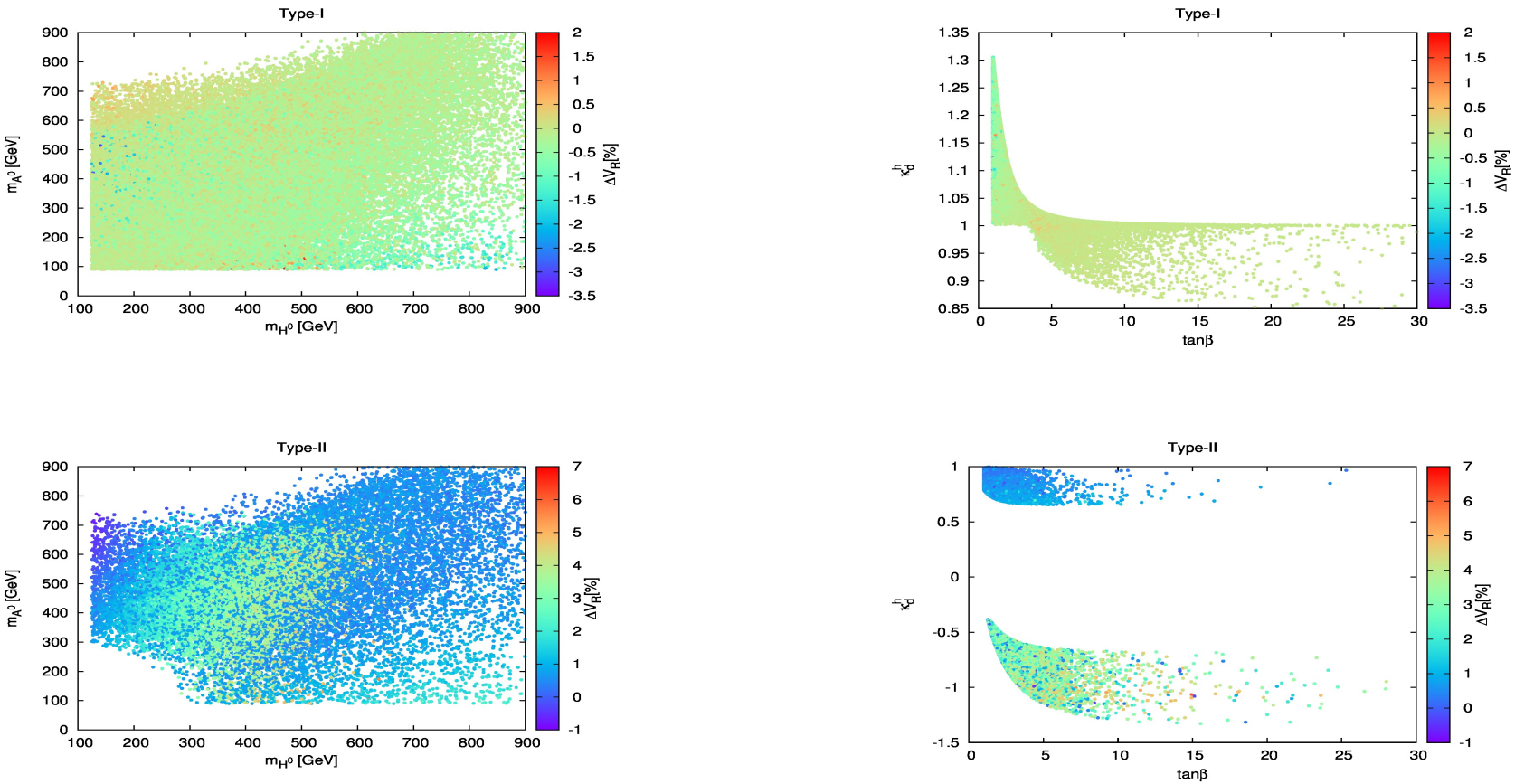
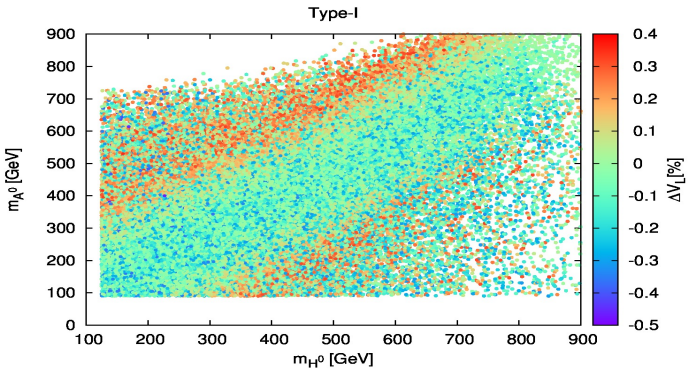
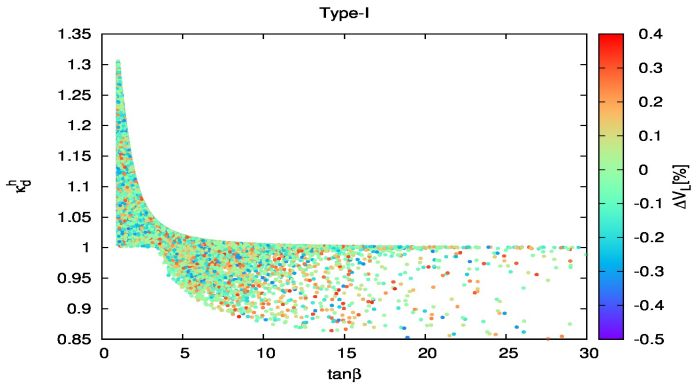
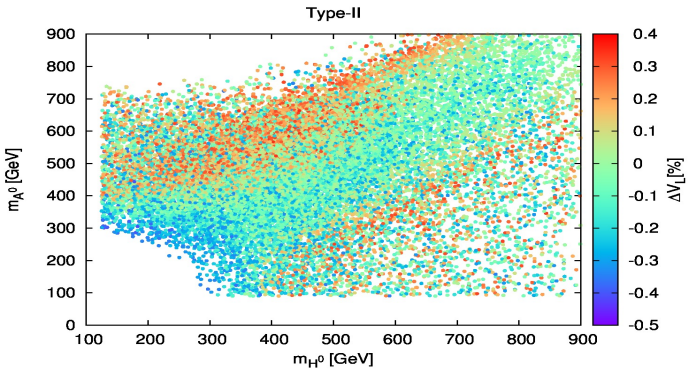


Figure : Relative contribution to the *tbW* right chiral coupling V_R in type-I and type-II

Numerical Results : left chiral coupling V_L







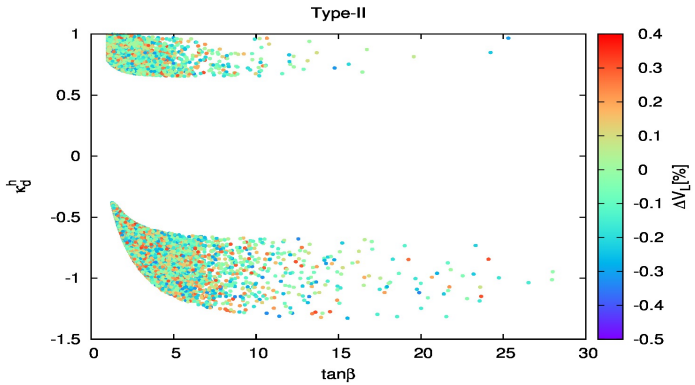


Figure : Relative contribution to the *tbW* left chiral coupling V_L in type-I and type-II