Evasive maneuvers for a sequential fourth generation to circumvent the Higgs data

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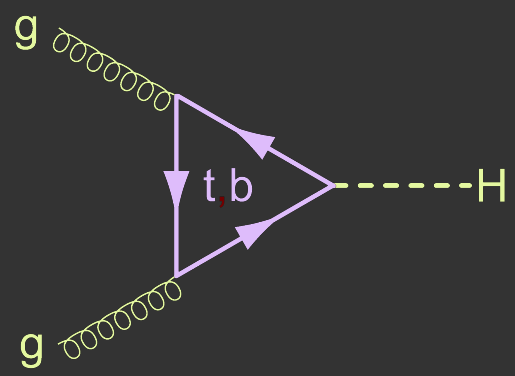
♣ Sources : arXiv:1707.03000 (PRD)

♣ Collaborators : A. Kundu and I. Saha

Why evasive maneuver?



- Higgs coupling modification factors relative to the SM:

$$\kappa_x = \frac{g_{xxh}}{(g_{xxh})_{\mathrm{SM}}} .$$

- The modification factor for the $gg \to h$ production

$$R_{gg} = \frac{\left| \kappa_t F_{1/2}(\tau_t) + \frac{-4}{3} \sum_{f=t',b'} \kappa_f F_{1/2}(\tau_f) \right|^2}{\left| F_{1/2}(\tau_t) \right|^2} \approx 9$$

when $\kappa_t = \kappa_{t'} = \kappa_{b'} = 1$ in the SM-like limit.

Consequences

arXiv.org > hep-ph > arXiv:1204.1252

High Energy Physics - Phenomenology

Sealing the fate of a fourth generation of fermions

Abdelhak Djouadi, Alexander Lenz

arXiv.org > hep-ph > arXiv:1312.0474

High Energy Physics - Phenomenology

The rise and fall of the fourth quark-lepton generation

M.I.Vysotsky

arXiv.org > hep-ph > arXiv:1204.1975

High Energy Physics - Phenomenology

Implications of Higgs Searches on the Four Generation Standard Model

Eric Kuflik, Yosef Nir, Tomer Volansky

The maneuver

- NP contribution to $gg \to h$ is proportional to $\kappa_{gg} = (\kappa_{t'} + \kappa_{b'})$.
- Wrong sign limit:

$$\begin{aligned} \kappa_V &= 1 && (V = W, Z) \\ \kappa_u &= 1 && (\text{for up type quarks}) \\ \kappa_d &= -1 && (\text{for down type quarks and charged leptons}) \,. \end{aligned}$$

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- The NP contribution to $h \to \gamma\gamma$

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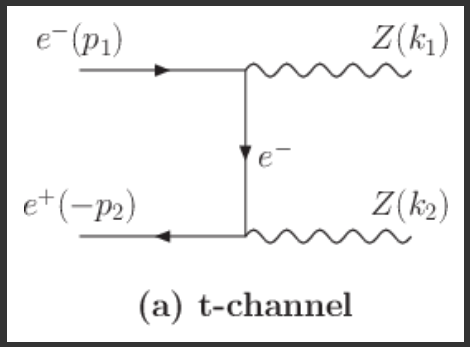
- The NP contribution to $h \to Z\gamma$

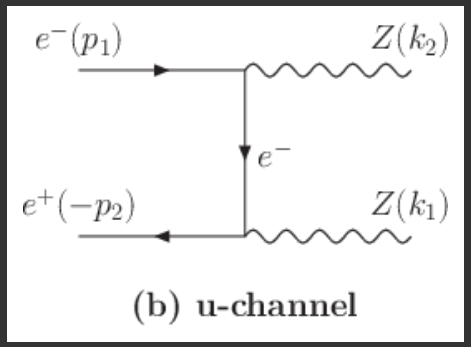
$$\kappa_{Z\gamma} = \sum_{f=t',b',\tau'} Q_f\, T_3^f\, N_c^f\, \kappa_f = 0\,.$$

Implementation

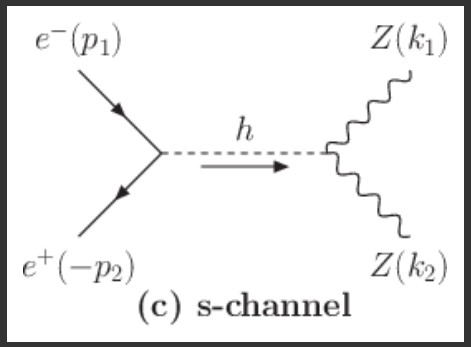
- Not possible in the SM with only one scalar doublet.



(a) t-channel



(b) u-channel



(c) s-channel

Implementation

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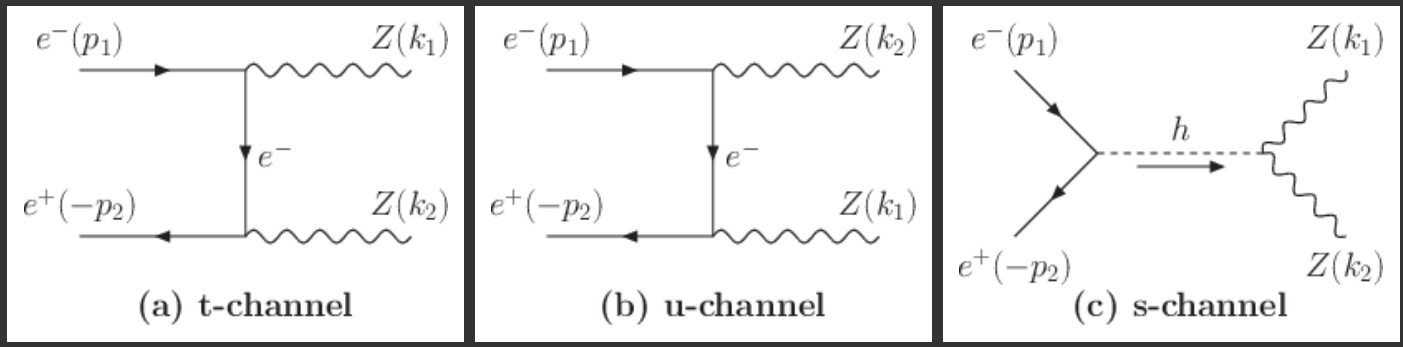


- Type II 2HDM:

$$\begin{aligned} \kappa_V &= \sin(\beta-\alpha)\,, \quad (V=W,Z) \\ \kappa_u &= \sin(\beta-\alpha)+\cot\beta\cos(\beta-\alpha)\,, \quad \text{(up quarks)} \\ \kappa_d &= \sin(\beta-\alpha)-\tan\beta\cos(\beta-\alpha)\,. \quad \text{(down quarks and charged leptons)} \end{aligned}$$

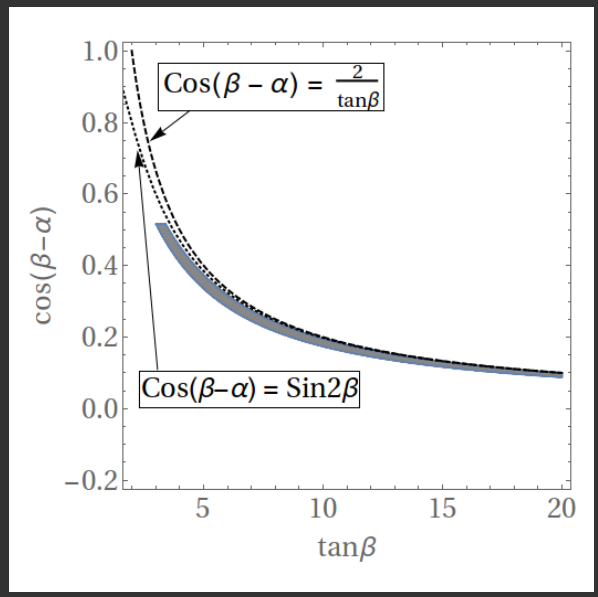
- Wrong sign is achieved by

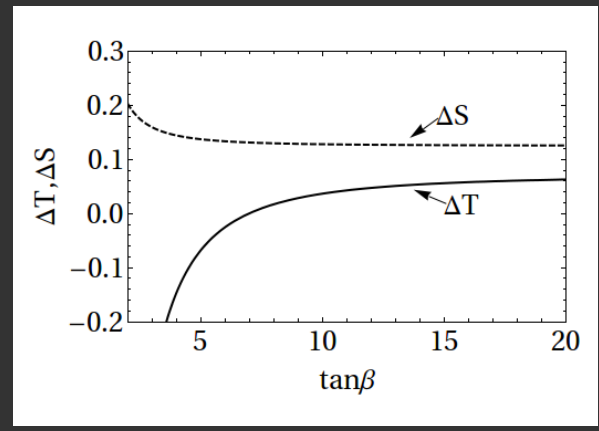
$$\cos(\beta-\alpha)=\frac{2}{\tan\beta}\,, \quad \text{with, } \tan\beta \gg 2\,.$$

Results

Benchmark:

$$m_{t'} = 550\,\text{GeV}\,,\ m_{b'} = 510\,\text{GeV}\,,\ m_{\tau'} = 400\,\text{GeV}\,,\ m_{\nu'} = 200\,\text{GeV}\,,$$
$$m_H = 400\,\text{GeV}\,,\ m_A = 810\,\text{GeV}\,,\ m_{H+} = 600\,\text{GeV}\,.$$





Caveat emptor

- Direct searches at the LHC? Sometimes relies on assumptions about V_{i4} and/or V_{4i}. (1205.0575).
- What about perturbative unitarity once LHC pushes too far?
- What about vacuum stability? More scalars?

Conclusion

- A sequential fourth generation of fermions faces constraints from many different considerations.
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THANK YOU !