Probing Extra Fermions with Higgs Ratios

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Projected Uncertainties for Higgs Decay Ratios

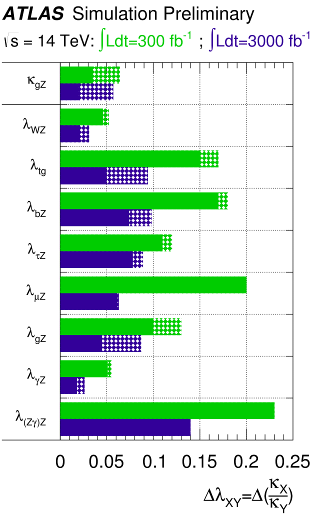


Figure: ATLAS Collaboration, ATL-PHYS-PUB-2014-016.

Higgs Decay Ratios at the HL-LHC: $D_{\gamma\gamma}$

In Higgs physics at the (HL-)LHC, production channels are the main source of theoretical uncertainty $\rightarrow$ a promising way of diminishing this error is to consider ratios of Higgs production times decay rates [1208.3436]. A well-motivated example is:

$$D_{\gamma\gamma} \equiv \frac{\sigma(pp \rightarrow H \rightarrow \gamma\gamma)}{\sigma(pp \rightarrow H \rightarrow ZZ^{*})} \simeq \frac{\Gamma(H \rightarrow \gamma\gamma)}{\Gamma(H \rightarrow ZZ^{*})}.$$

- $H \rightarrow \gamma\gamma$ and $H \rightarrow ZZ^{*}$ precisely measured;
- $D_{\gamma\gamma}$ sensitive especially to VLQs with high electric charge;
- Challenge $\rightarrow$ in such ratios, the same kinematical cuts should be applied when measuring the two processes $\Rightarrow$ in this ideal case, the production cross section cancels (as well as the Higgs total width)! In what follows, we will assume that this indeed happens.

VLQ Mass Reach Through $D_{\gamma\gamma}$

To get an idea of the power of $D_{\gamma\gamma}$ for indirect detection of VLQs, we will focus on simplified, generic VLQ models.

- We consider 2 VLQ multiplets that mix between themselves, with one of them significantly heavier than the other;
- Set their mixing with SM quarks to 0.

We assume (rather optimistically) that the experimental error at the HL-LHC will be:

$$\frac{\Delta D_{\gamma\gamma}}{D_{\gamma\gamma}} = 1\%,$$

at 68% C.L., with the experimental central value of $D_{\gamma\gamma}$ taken to be equal to its SM value at LO.

VLQ Mass Reach Through $D_{\gamma\gamma}$: Numerical Results

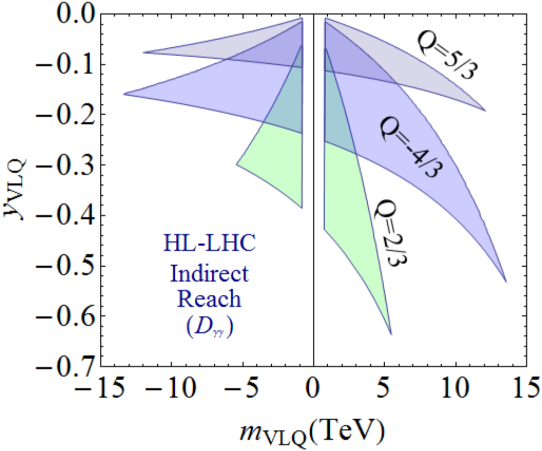


Figure: Mass (m_{VLQ}) vs mass basis Yukawa coupling (y_{VLQ}) of the lighter VL quark.

VLQ Mass Reach Through D_{bb}

What about bottom-like VLQs? A good way to search indirectly for them is to consider the ratio:

$$D_{bb} \equiv \frac{\sigma(pp \to VH \to Vb\bar{b})}{\sigma(pp \to VH \to VZZ^*)} \simeq \frac{\Gamma(H \to b\bar{b})}{\Gamma(H \to ZZ^*)}.$$

Again, we study a generic model where only one bottom-like VLQ singlet mixes with the SM-like b quark. We assume that, at 68% C.L., the HL-LHC experimental error will be:

$$\frac{\Delta D_{bb}}{D_{bb}} = 5\%,$$

with the experimental central value taken equal to its SM value at LO.

VLQ Mass Reach Through D_{bb}: Numerical Results

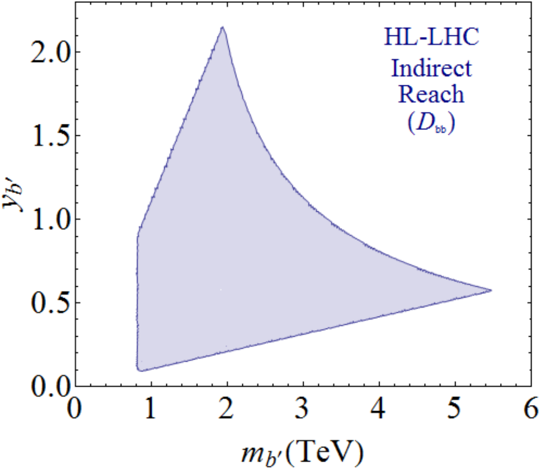
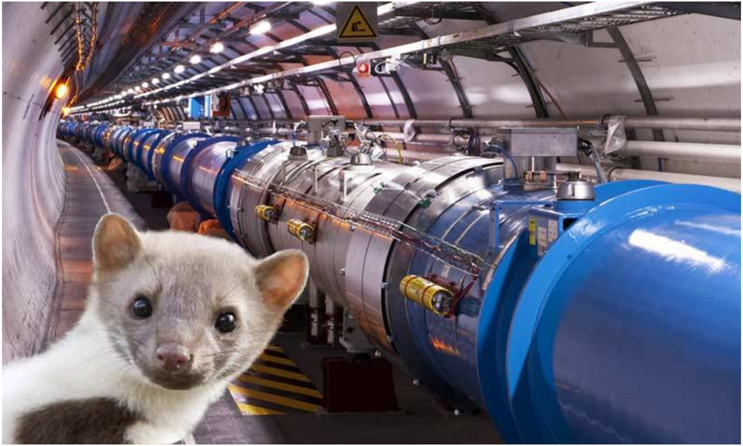


Figure: Mass vs mass basis Yukawa coupling of the b' VLQ.

Conclusions

- By considering ratios of Higgs production times decay rates, we showed that top and bottom VL partners with masses up to 5 TeV and more exotic VLQs with masses in the 10 TeV range can be indirectly probed at the HL-LHC.
- Interesting to note $\rightarrow$ complementarity between $D_{\gamma\gamma}$, which probes VLQs with $Q \geq 2/3$, and D_{bb}, which probes bottom-like VLQs.
- This is to be compared with the mass reach through direct searches, which is estimated to be around $1.5 - 2$ TeV [1307.7135].



Thank you for your attention !