

General extensions of the Standard Model with new quarks

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Setting

Effective theory

- Fields: SM fields + Q
- Symmetry: SM gauge group
- Operator dimension: up to 5

Restriction

Q has linear interactions $\bar{Q}\mathcal{O}_{\text{SM}}$. Relevant for:

- Single production
- Decay
- Tree-level matching

Representations

With dimension-4 couplings

U	D	Q_7	Q_1	Q_5	T_2	T_1
$1_{2/3}$	$1_{-1/3}$	$2_{7/6}$	$2_{1/6}$	$2_{-5/6}$	$3_{2/3}$	$3_{-1/3}$

With dimension-5 couplings

T_5	T_4	F_7	F_1	F_5
$3_{5/3}$	$3_{-2/3}$	$4_{7/6}$	$4_{1/6}$	$4_{-5/6}$

Interactions

Linear:

$$\bar{Q}q\phi, \bar{Q}q\phi\phi, \bar{Q}\not{D}\phi q, \bar{Q}\sigma^{\mu\nu}qF_{\mu\nu}.$$

Quadratic:

$$\bar{Q}Q\phi, \bar{Q}\sigma^{\mu\nu}QF_{\mu\nu}.$$

Charge eigenstates

X'	X	T	B	Y	Y'
$8/3$	$5/3$	$2/3$	$-1/3$	$-4/3$	$-7/3$

Example: $F_7 = (X', X, T, B)^T$

Mixing

$$T \leftrightarrow t, B \leftrightarrow b$$

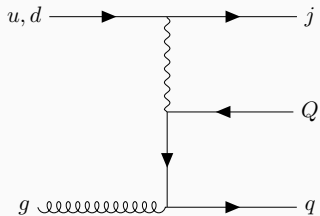
$$\text{EWPT} \implies \theta \lesssim 0.04\text{--}0.18$$

Only dimension-5 couplings:

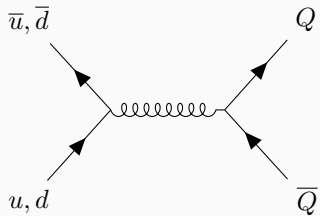
$$\theta \sim \frac{v^2}{\Lambda M} \sim \frac{(246 \text{ GeV})^2}{(2 \text{ TeV})(1 \text{ TeV})} = 5 \cdot 10^{-3}.$$

Production

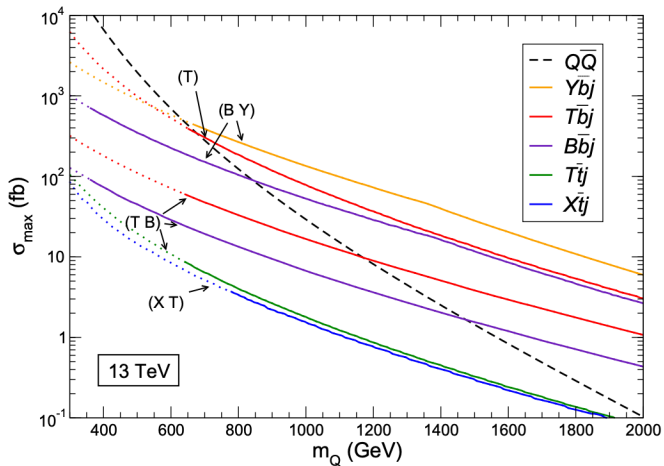
Single



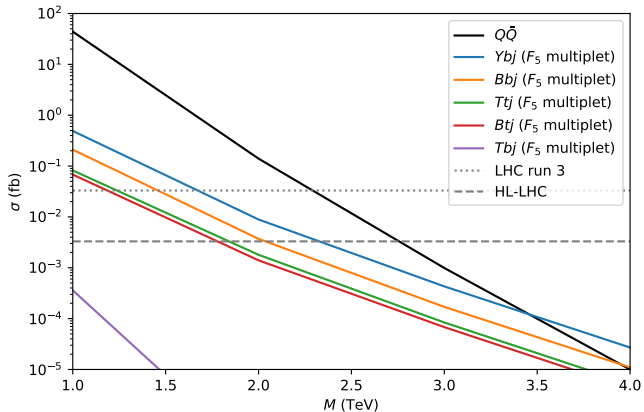
Pair



Aguilar-Saavedra, Benbrik, Heinemeyer, Pérez-Victoria
(1306.0572):

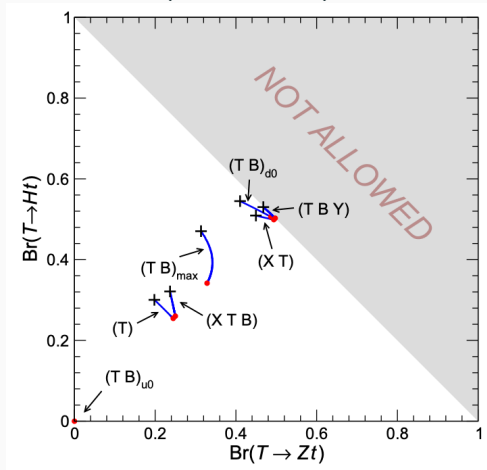


JCC, Pérez-Victoria (preliminary):



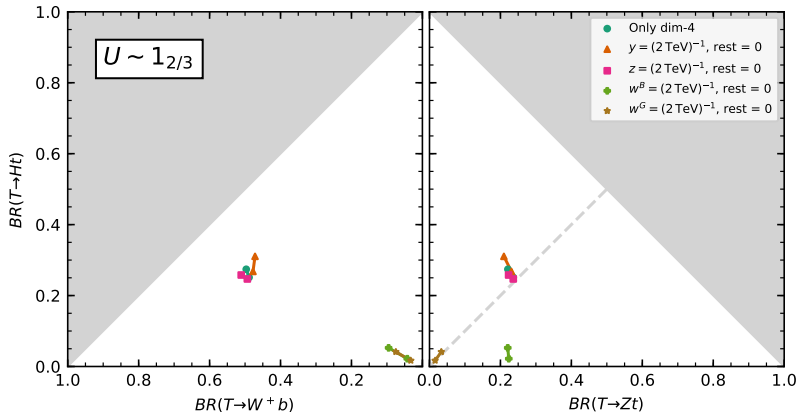
Decay

Aguilar-Saavedra, Benbrik, Heinemeyer, Pérez-Victoria
(1306.0572):



$$BR(Q \rightarrow Hq) + BR(Q \rightarrow Zq) + BR(Q \rightarrow W^\pm q') = 1$$

JCC, Pérez-Victoria (preliminary):

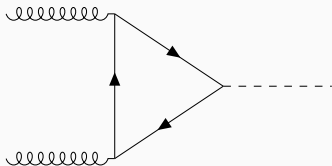


$$BR(Q \rightarrow Hq) + BR(Q \rightarrow Zq) + BR(Q \rightarrow W^\pm q') \leq 1$$

Indirect effects

t , b physics modified by mixing with T , B

Higgs physics:



Summary

12 possible irreps for new quarks with dimension-5 interactions:

Quarks with dimension-4 couplings

Dimension-5 gives small corrections

Quarks without dimension-4 couplings

- Automatically satisfy EWPT and other indirect limits
- Only pair production (unless $\mathcal{L} \supset \bar{Q}qG$)
- New decay channels