LHC dijet limits on $0\nu\beta\beta$

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Based on:

J.C. Helo, M. Hirsch, Phys.Rev. D 92 073017 (2015)

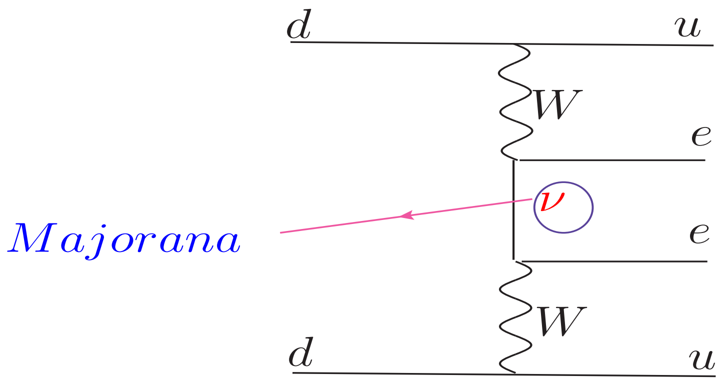
Helo et. al., To appear soon (2016)

Contents

- Lepton number violation

$$(A, Z) \rightarrow (A, Z+2) + 2e^-$$

- Neutrino Mass Mechanism:
  $m_{\beta\beta} < 0.06 - 0.161 eV$ 1605.02889 KamLAND-Zen

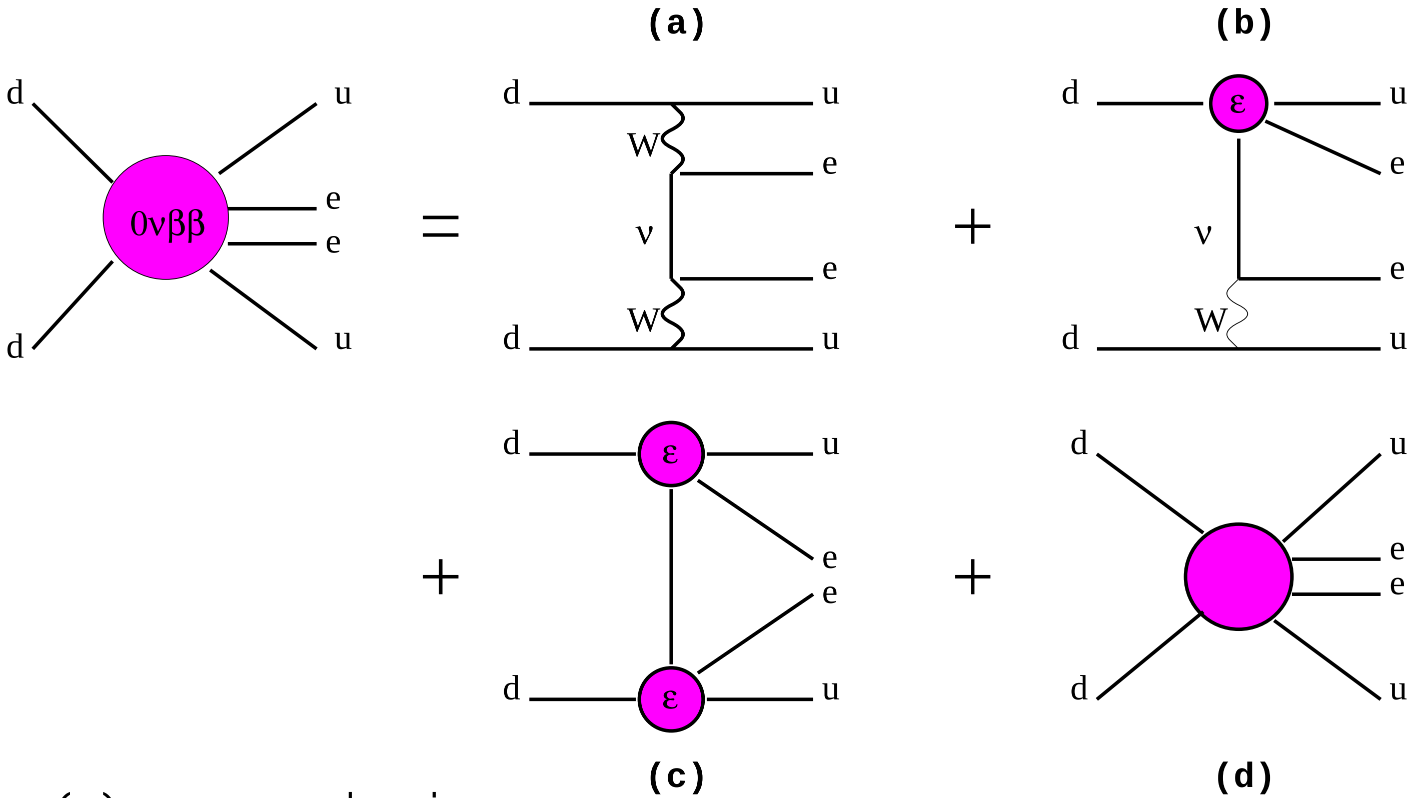


- Sensitive to extensions of SM:
  Left-Right, SUSY RPV, LQ, Sterile neutrinos, Color sextet diquarks, ..etc.
  Deppish et. al. J.Phys. G39, 124007
  Hirsch, AIP Conf. Proc. 1666, 170007 (2015).

- Schether-Valle Theorem: Observation of $0\nu\beta\beta$ implies neutrinos are Majorana Phys. Rev. D. 25 2951 (1982). However it won't be easily interpreted as evidence for any specific model.

Lorentz-invariant description

Graphically:



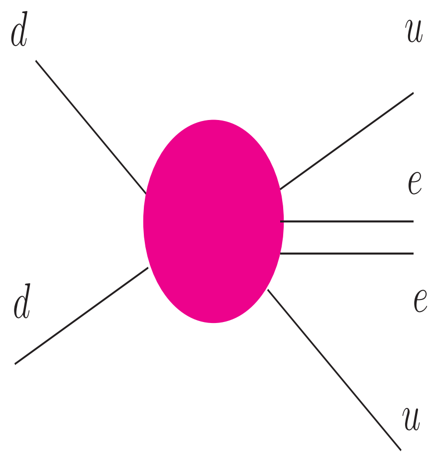
⇒ (a) mass mechanism

⇒ (b) long-range part: H. Päs et al. PLB453 (1999)

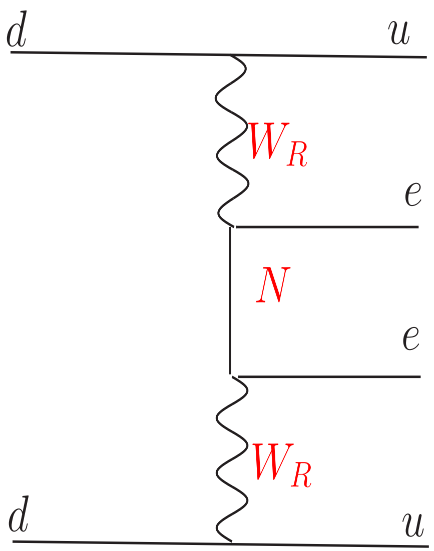
⇒ (d) short-range part: H. Päs et al. PLB498 (2001)

Examples Short range part

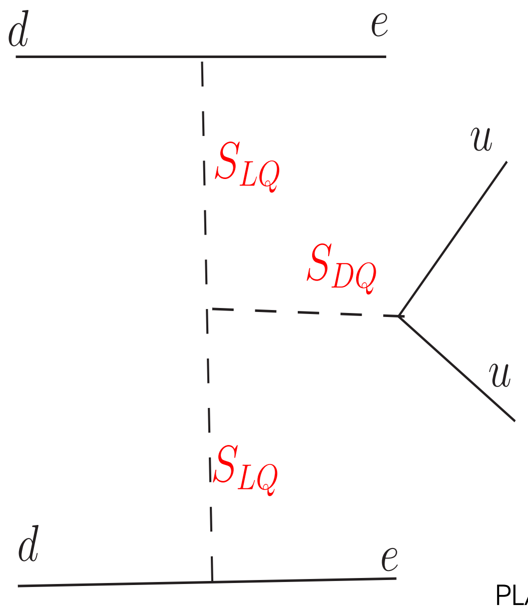
Short range part:



(a) LR symmetric model

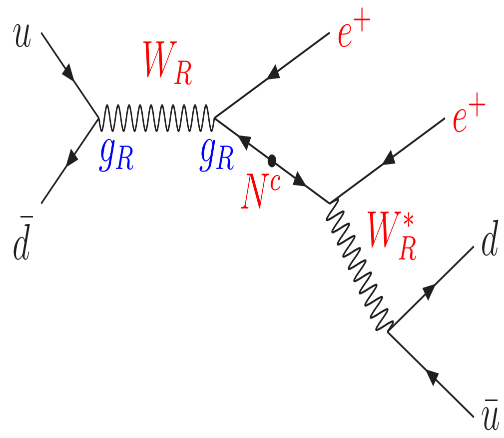


(b) DQ model



Bonnet et al, JHEP03 (2013) 055; arXiv:1212.3045

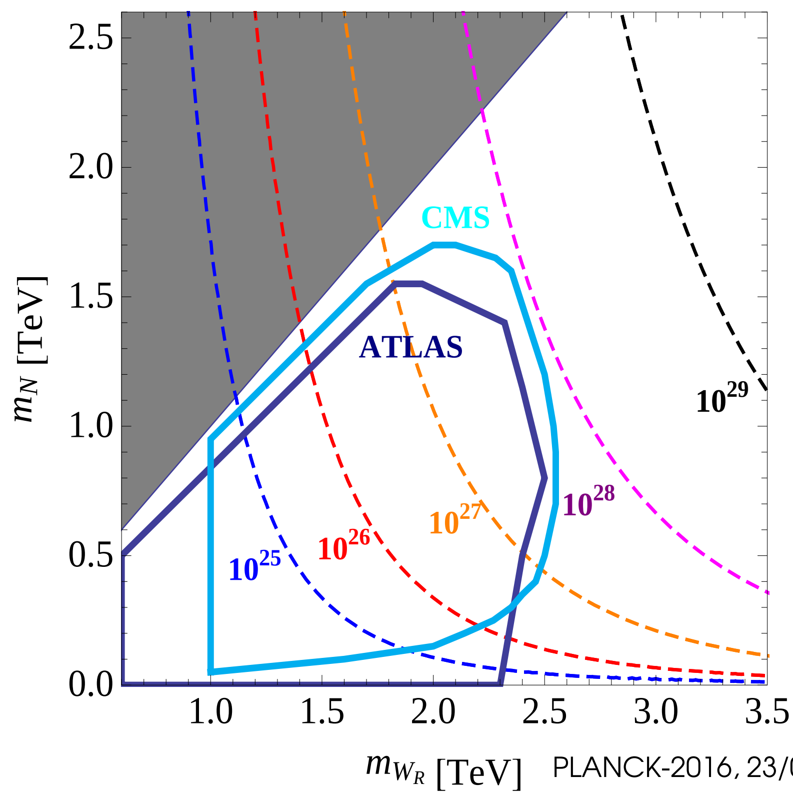
Example: W_R @ LHC



Keung & Senjanovic, 1983
Phys. Rev. Lett. 50, 1427

Signal:

di-lepton + jets, **no** $\not{E}_T$



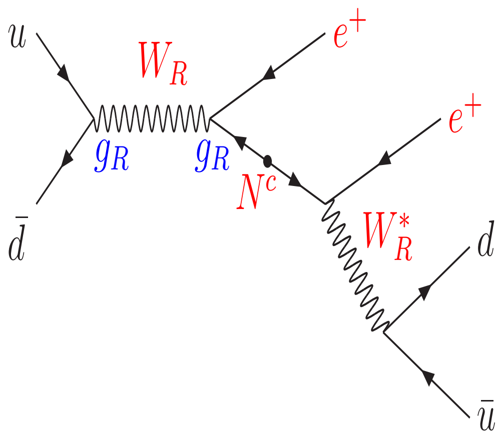
$0\nu\beta\beta : dd \to uue^-e^-$

CMS (and ATLAS) with $\sqrt{s} = 8$ TeV:
Non-observation gives stringent limits on short-range W_R diagrams for $0\nu\beta\beta$ decay.

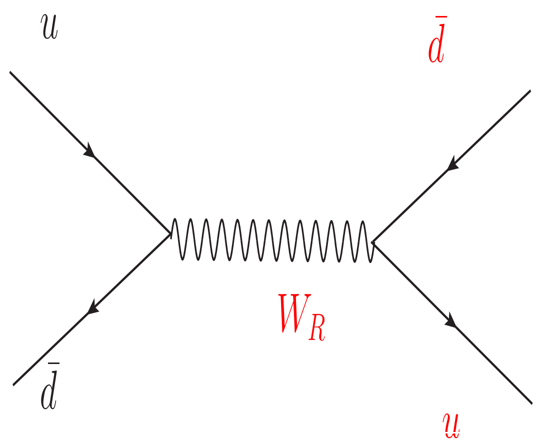
Assumes: $g_R = g_L$!

Example: W_R @ LHC

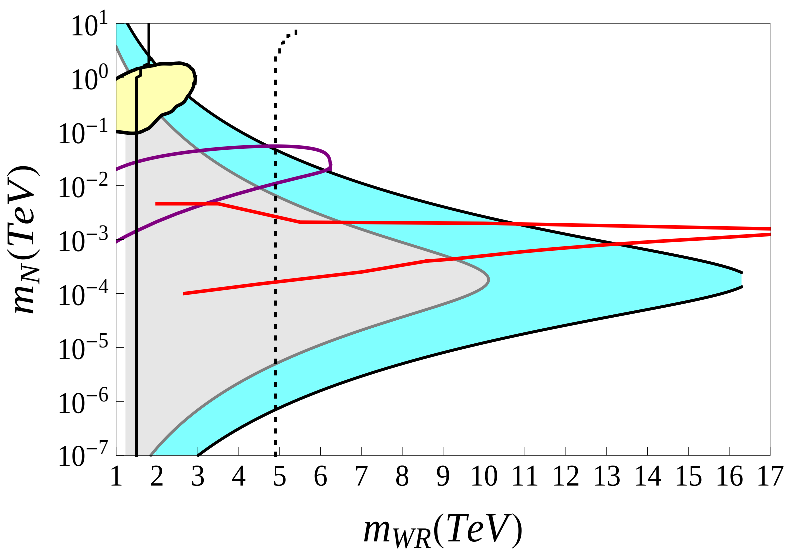
di-lepton + jets, **no** $\not{E}_T$



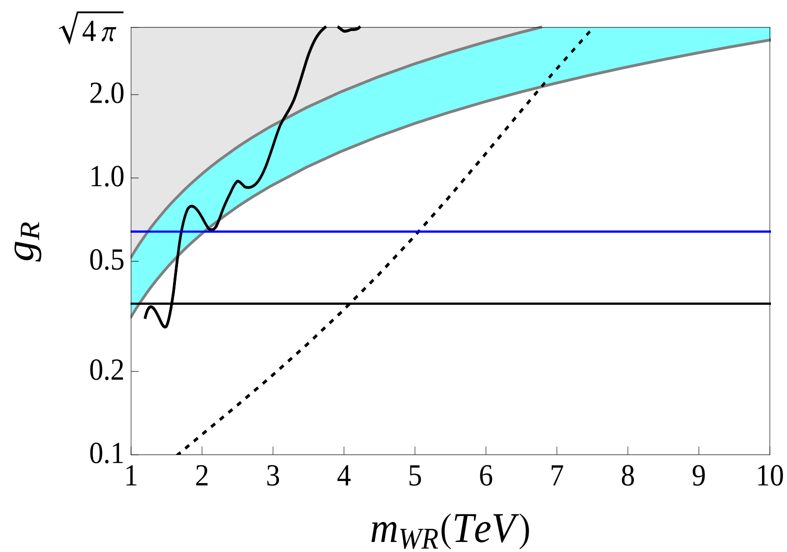
di-jets



$g_R = g_L$



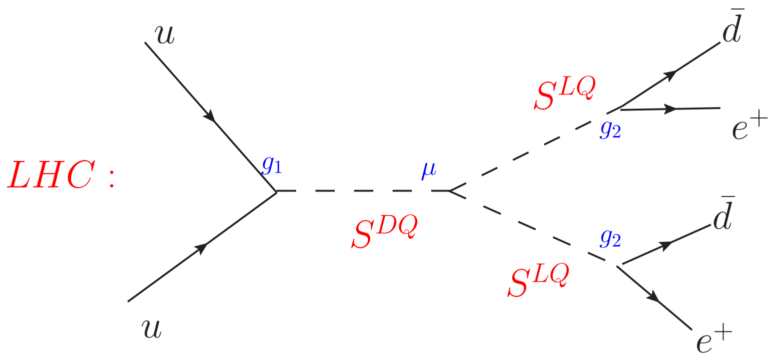
$g_R \neq g_L$



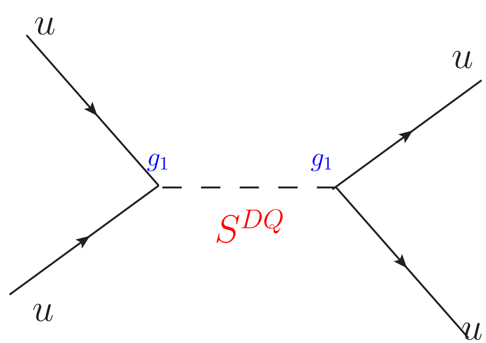
DQ model with LNV

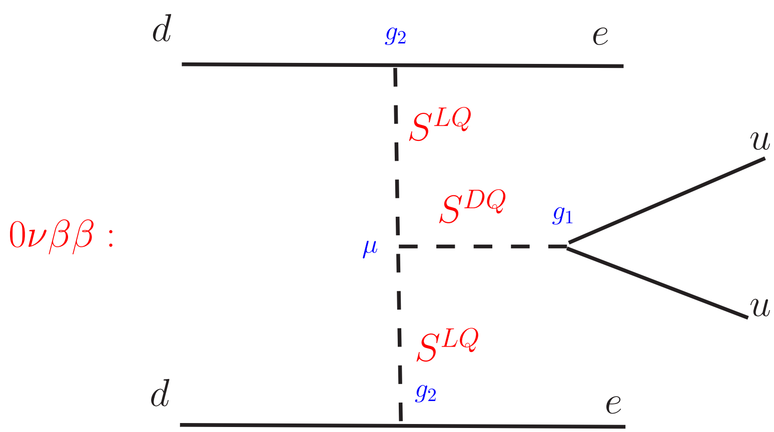
$$\mathcal{L}_{DQLQ} \quad = \quad \mathcal{L}_{SM} + g_1 \bar{Q} \cdot \hat{S}_{DQ} \cdot Q^C + g_2 \bar{L} \cdot S^\dagger_{LQ} d_R + \mu S_{LQ} S_{LQ} S^\dagger_{DQ} + \text{h.c.}$$

di-lepton + jets,



di-jets

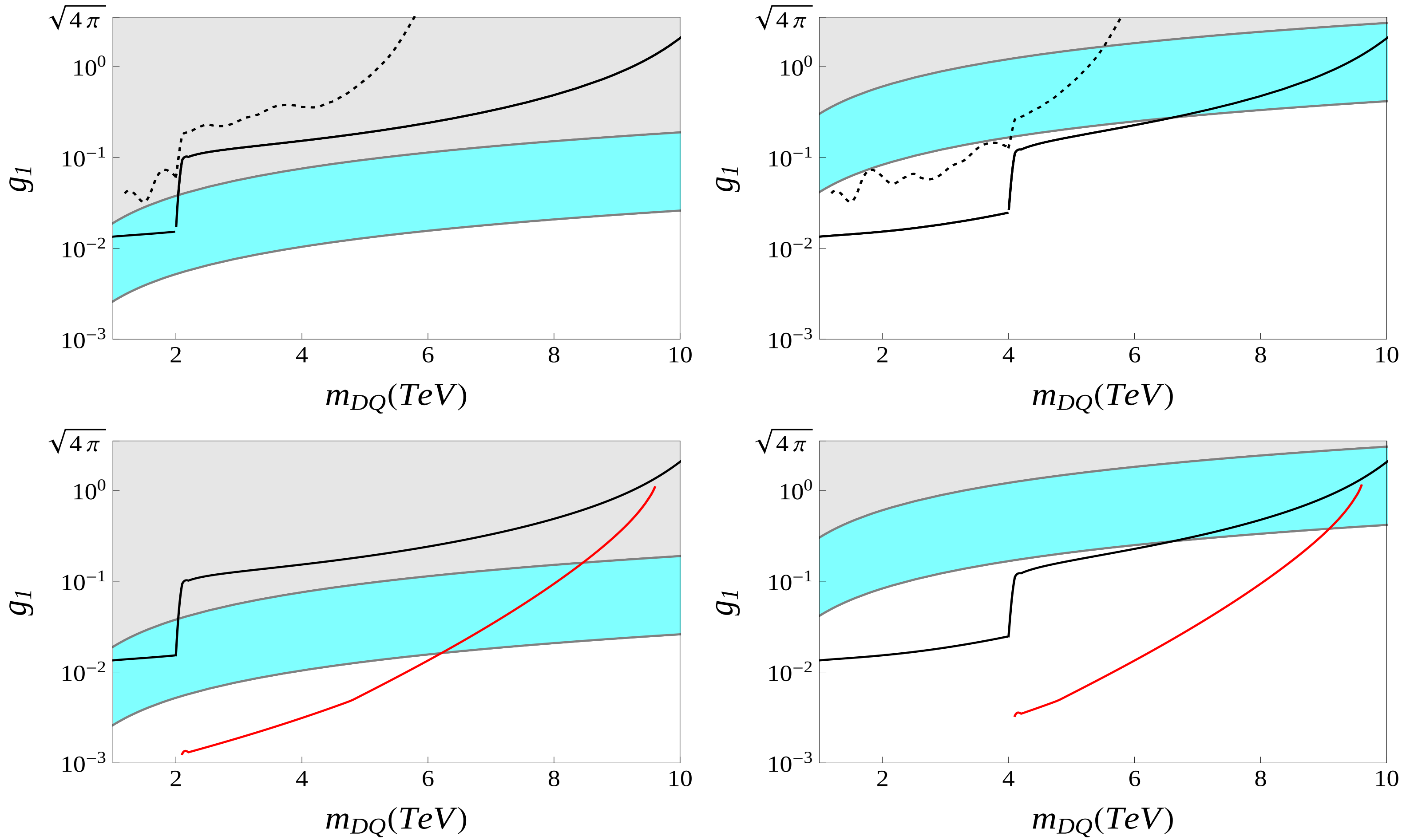




DQ model with LNV

Parameters:

$m_{LQ} = 1TeV, \mu = m_{DQ}, g_2 = 1$ $\qquad$ $m_{LQ} = 2TeV, \mu = m_{DQ}, g_2 = 1$



Dijet limits: 8 TeV 19.7 fb^{-1} (dotted curve), 13 TeV, 300 fb^{-1} (black solid),

Dilepton + jets limits: 13 TeV, 300 fb^{-1} (red solid curve)

Conclusions

⇒ We have discussed how upper limits on dijet cross sections, derived from LHC data, can be used to constrain the short-range part of the $0\nu\beta\beta$ decay amplitude.

⇒ We have concentrated on two example models: (a) minimal left-right symmetry and (b) a diquark model with LNV.

⇒ For both setups, the LHC dijet data provides constraints complementary to those derived from the search for dilepton + jets final state.

⇒ We have also estimated the impact of future LHC data. Current dijet limits provide already interesting constraints on $0\nu\beta\beta$ decay, future limits will rule out measurably half-lives of double beta decay $(T_{1/2} < 10^{27} ys)$, except in some well-defined regions of parameter space.

⇒ We note that, while we have concentrated on two particular example models, similar constraints will apply to any short-range contribution to $0\nu\beta\beta$ decay in which a state coupling to a pair of quarks appears.