# Direct DM versus mediator searches at 100 TeV

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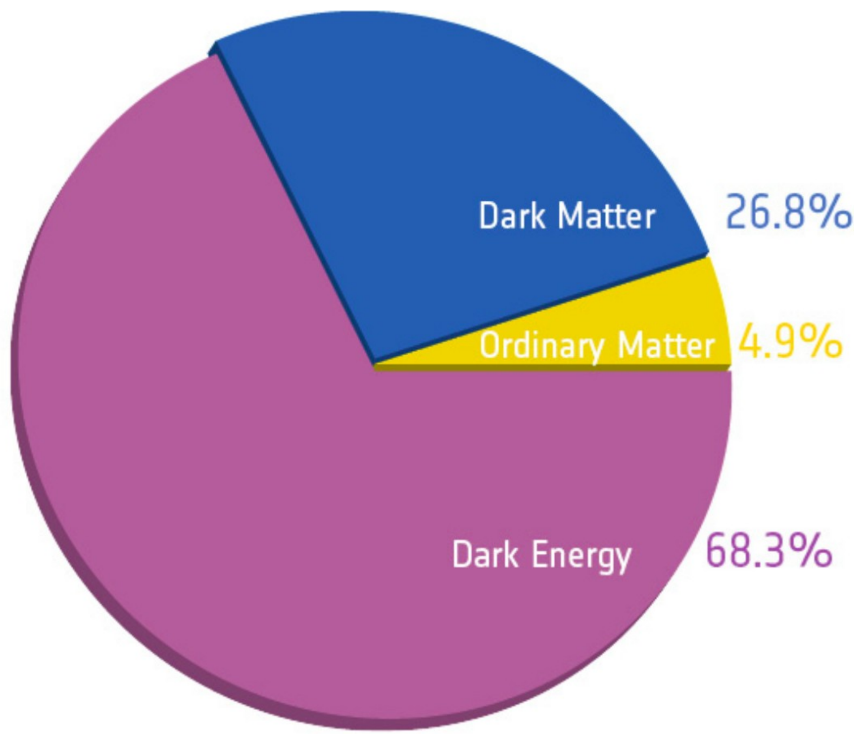
in collaboration with **F. Kahlhoefer, M. McCullough, G. Nardini** and **K. Schmidt-Hoberg.** Based on *1606.00947* and *1503.05916* .

The SM is very strong, but it cannot accommodate all experimental observations

**Planck scale**

valid up to

**TeV scale**



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~ 100 TeV

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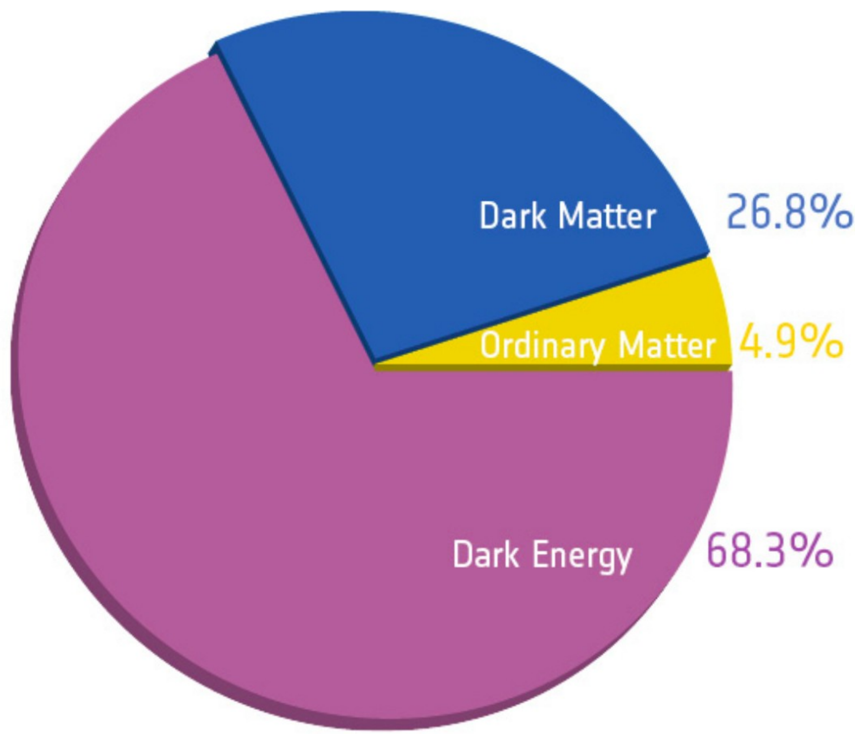

A WIMP is a good candidate: sterile neutrinos, hidden photons, scalar singlets, minimal DM, ...

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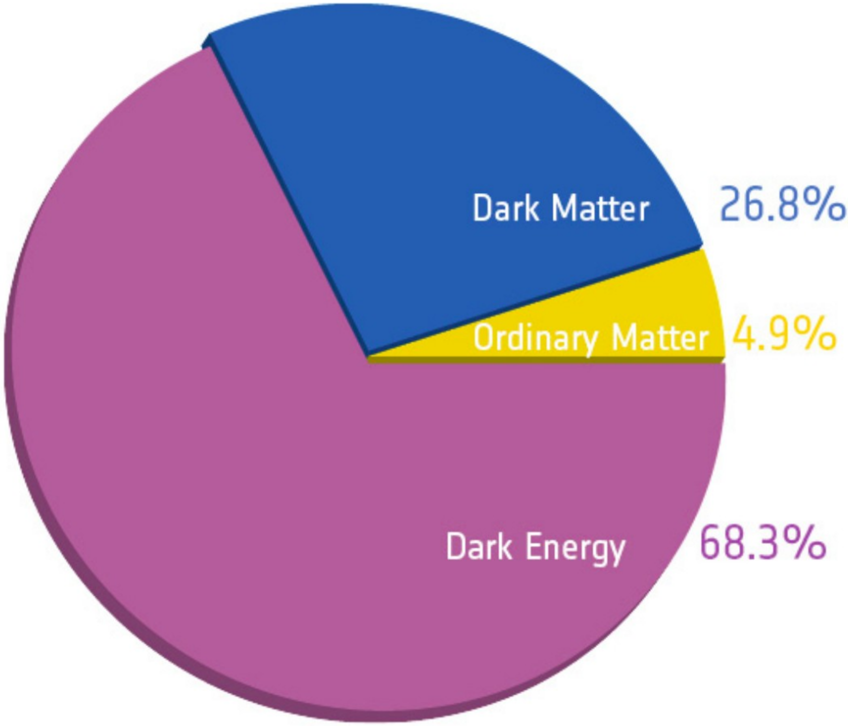

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Provide a richer phenomenology. Interplay between searches for DM and for the mediator itself. Let us consider the Lagrangian

$$\mathcal{L} \sim -g_q \sum_q Z'^{\mu}\ \bar{q}\gamma_\mu q - \frac{g_{DM}}{2} Z'^{\mu}\ \bar{\chi}\gamma_\mu\gamma^5\chi$$

Avoid constraints from: EWPD, dilepton and DM direct searches, (which would rule out most of the parameter space)

In a gauge-invariant version of this Lagrangian *[1510.02110]*:

- The SM Higgs is **not charged** under the new U(1)'

$$q_H = q_{q_L} - q_{u_R} = q_{d_R} - q_{q_L} = q_{e_R} - q_{\ell_L}$$

- Leptons can naturally decouple from the mediator
- Tree-level Z-Z' mass mixing absent (kinetic mixing small)
- Direct-detection cross section velocity suppressed

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In other words, we focus on a typical case that the 100 TeV collider will have to tackle if no DM detection arises in next years

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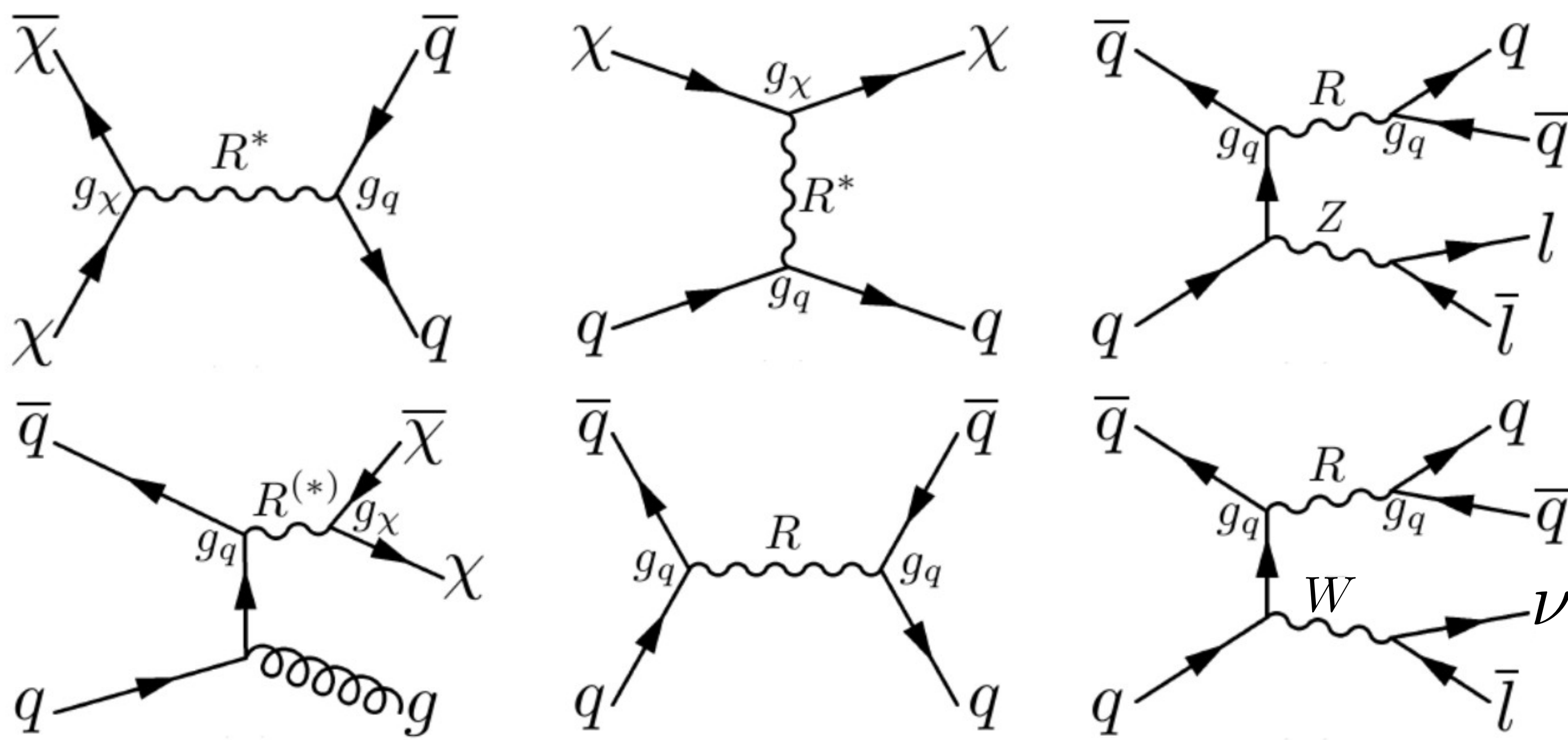
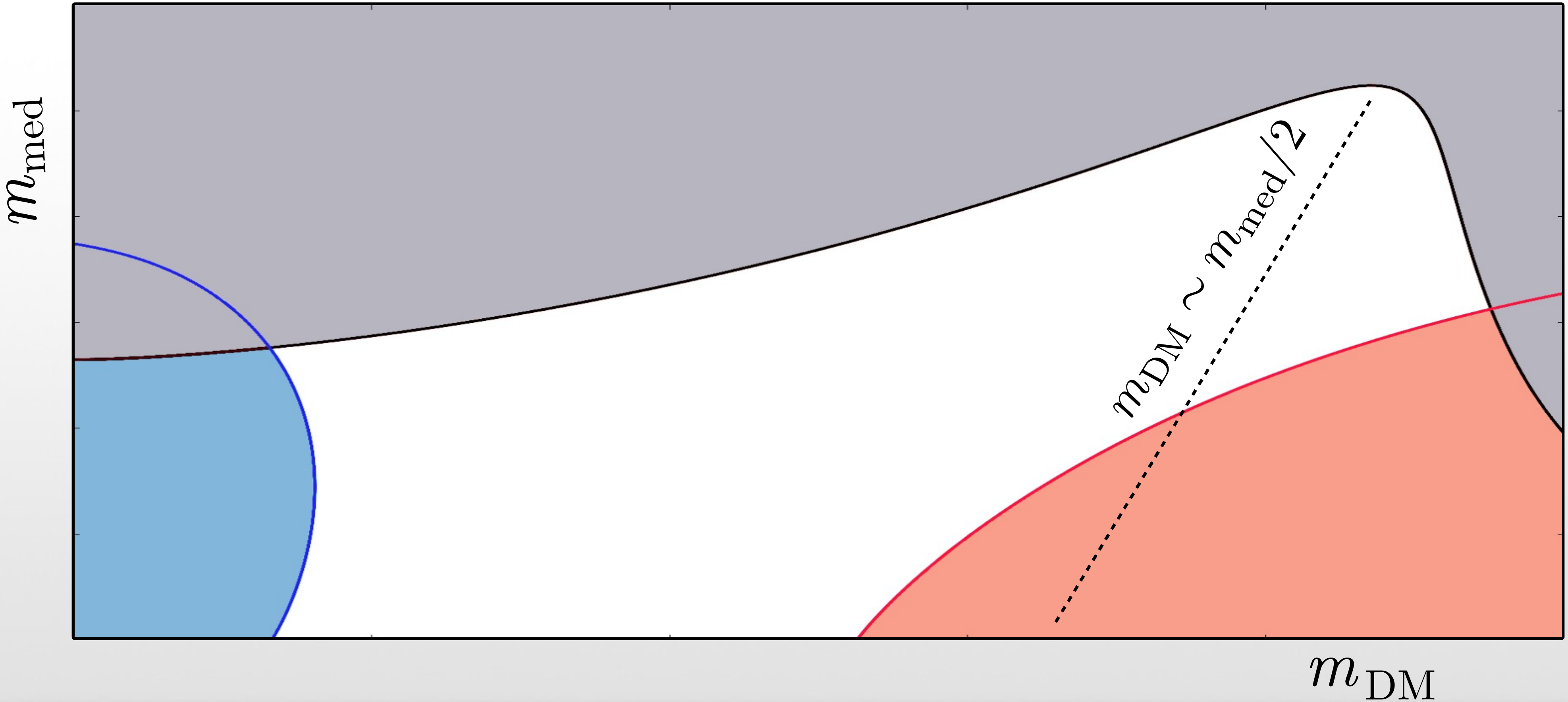
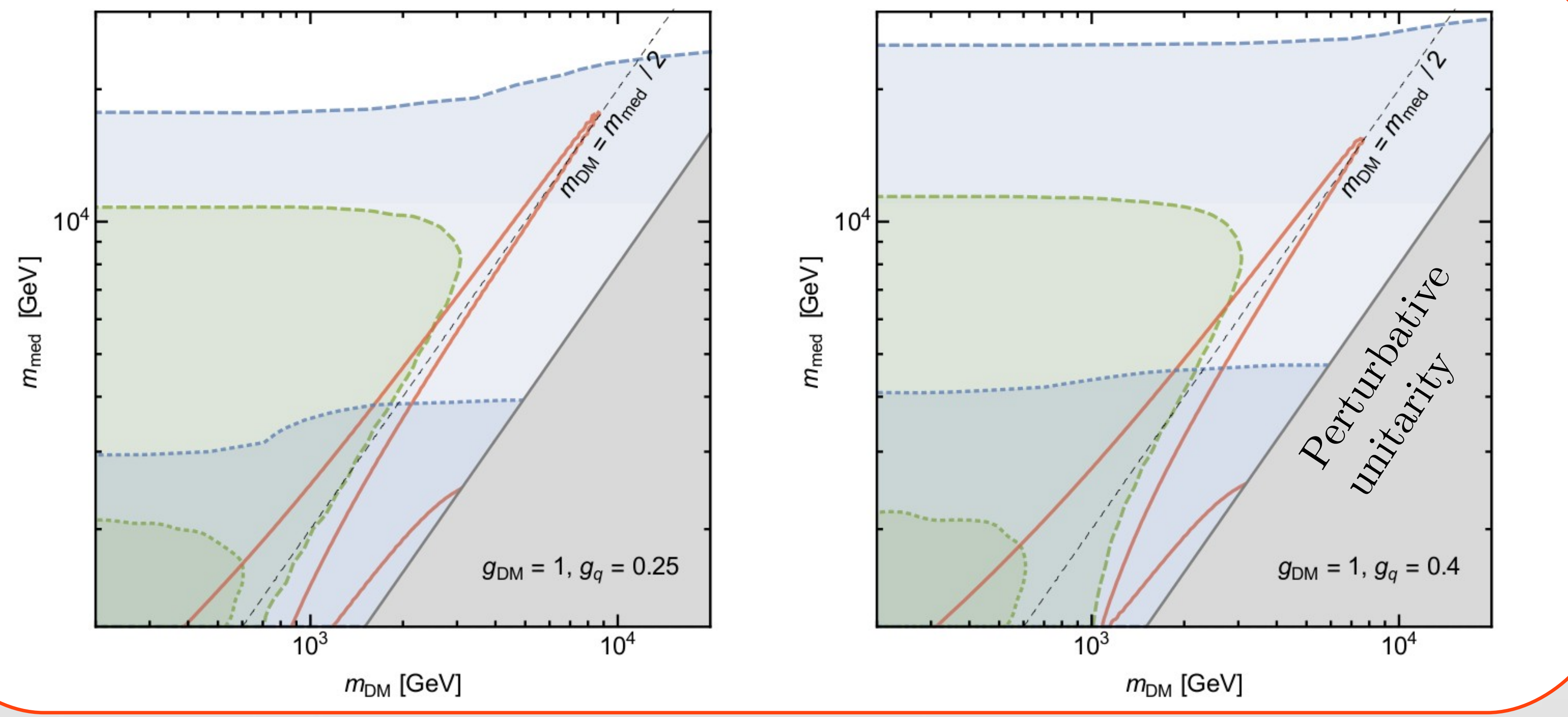


## Complementarity between different searches:
relic density, monojet searches and dijet searches

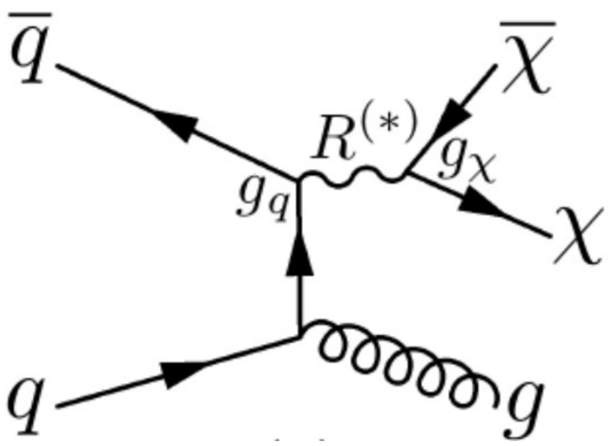


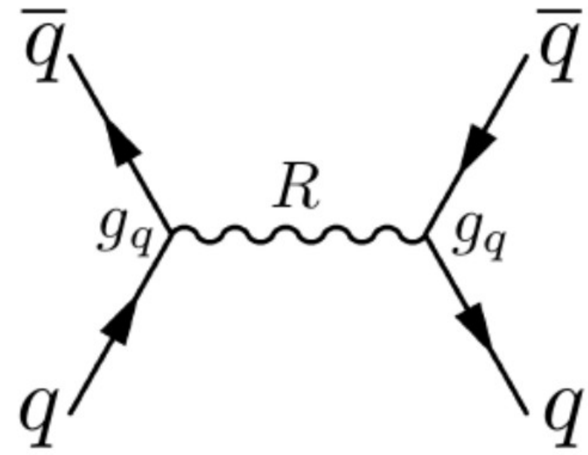
A real example: we consider the relic density bound, dijet and monojet bounds, at 14 TeV and 100 TeV



# Monojet and dijet searches
(luminosity assumed $10\ \mathrm{ab}^{-1}$ )

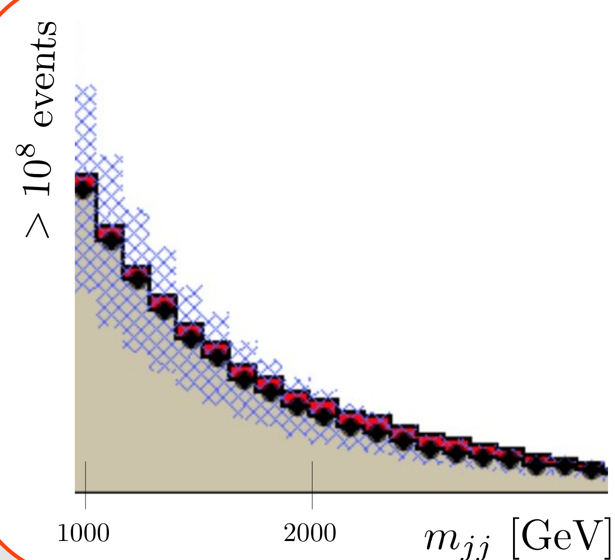
Analysis strategy suggested in *[1503.02931]*: $\not{E}_T > 2.6$ TeV , main background $pp \to j + Z(\to \overline{\nu}\nu)$ . Dijet background extracted from *[1308.1077]* . *CLs* analysis of the shape of $m_{jj}$ .

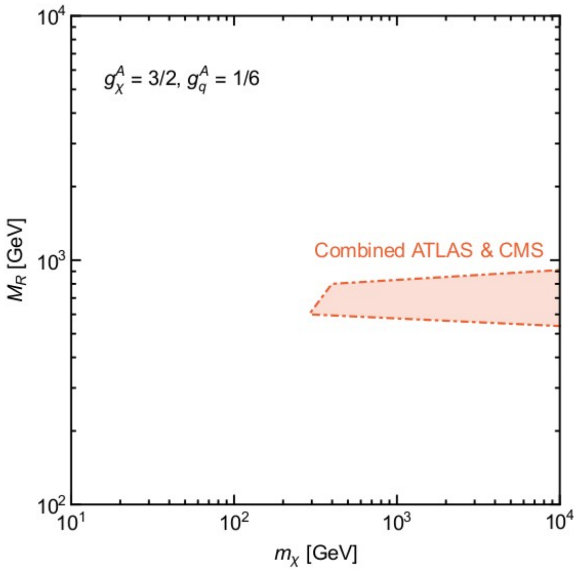


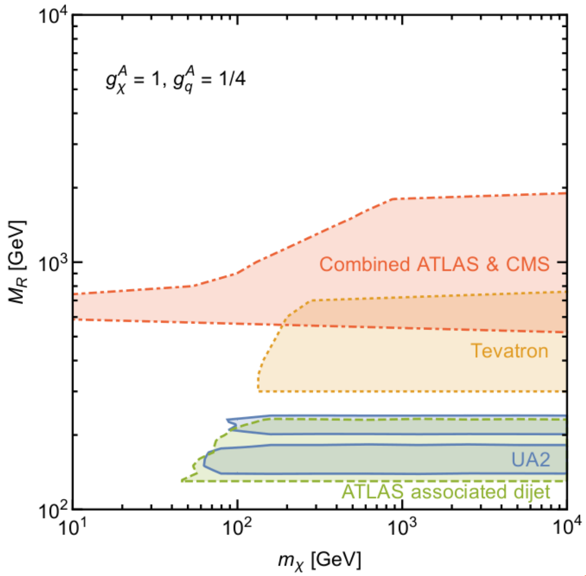



# Dijet searches: the large coupling regime

If $g$ is very large, the mediator becomes very broad. The resonance can be still bounded, but systematics play a major role

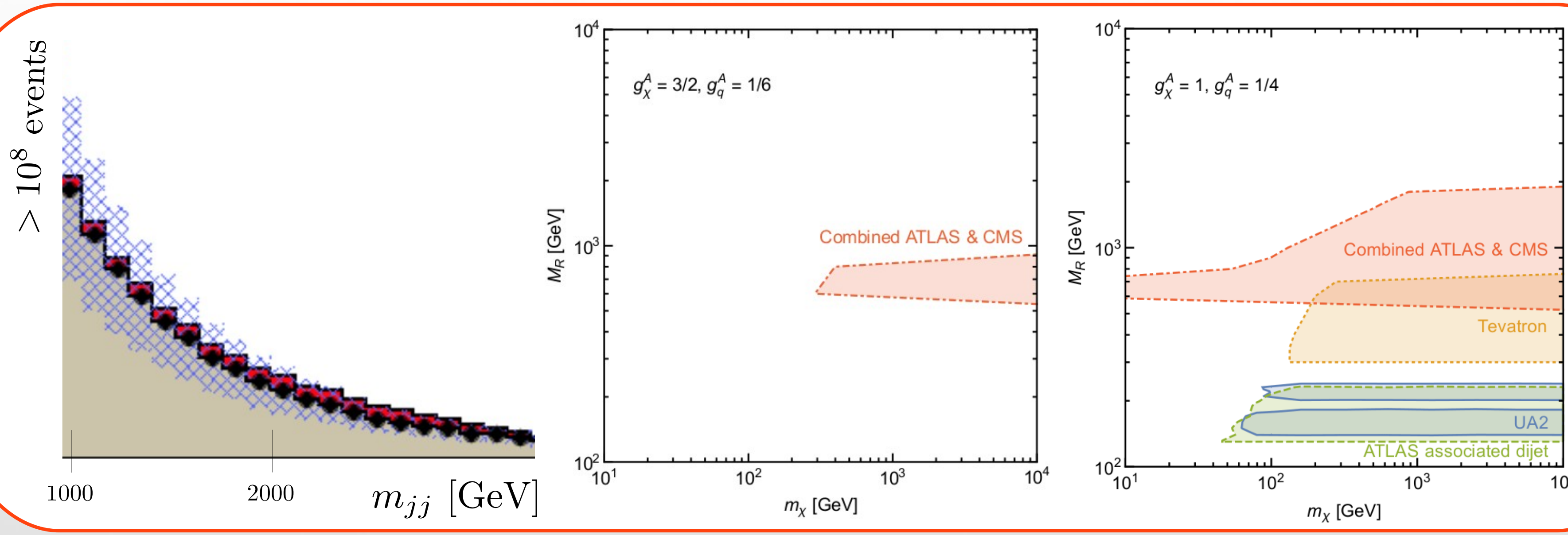


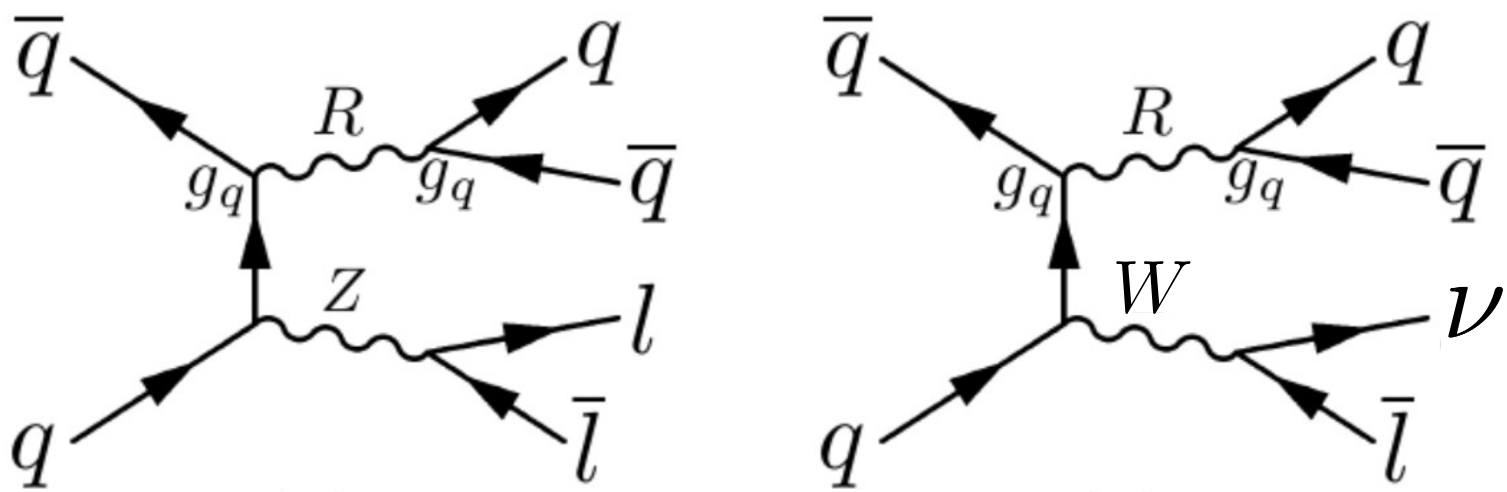
# Dijet searches: the small mass region

Small coupling: small signal. Large coupling: broad signal. Not to mention the hard task of collecting events at small invariant masses



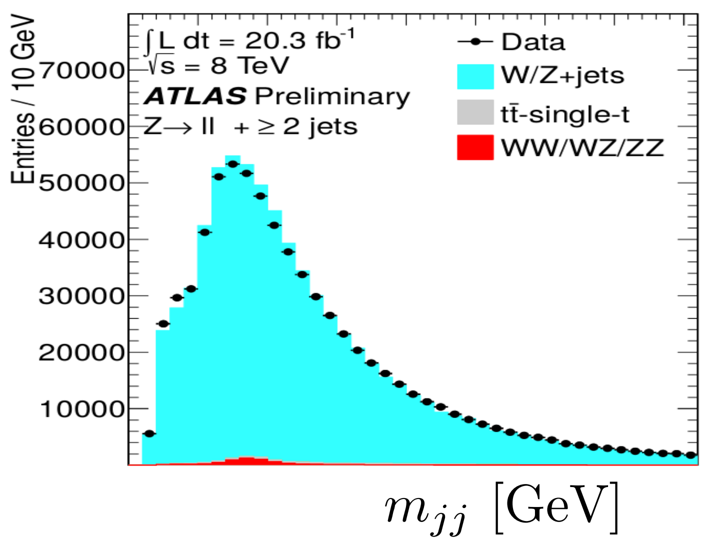
# Dijet searches: the small mass region

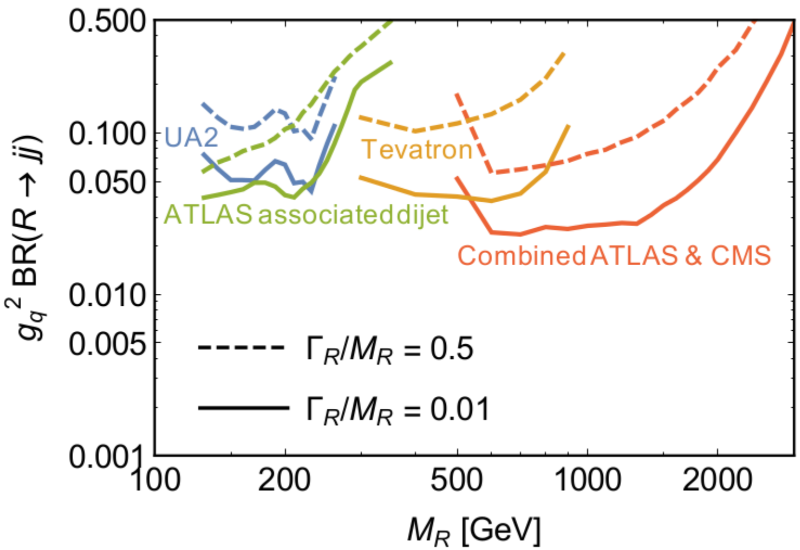
Considering new processes in which the DM is produced in association with other SM particles might help covering this region



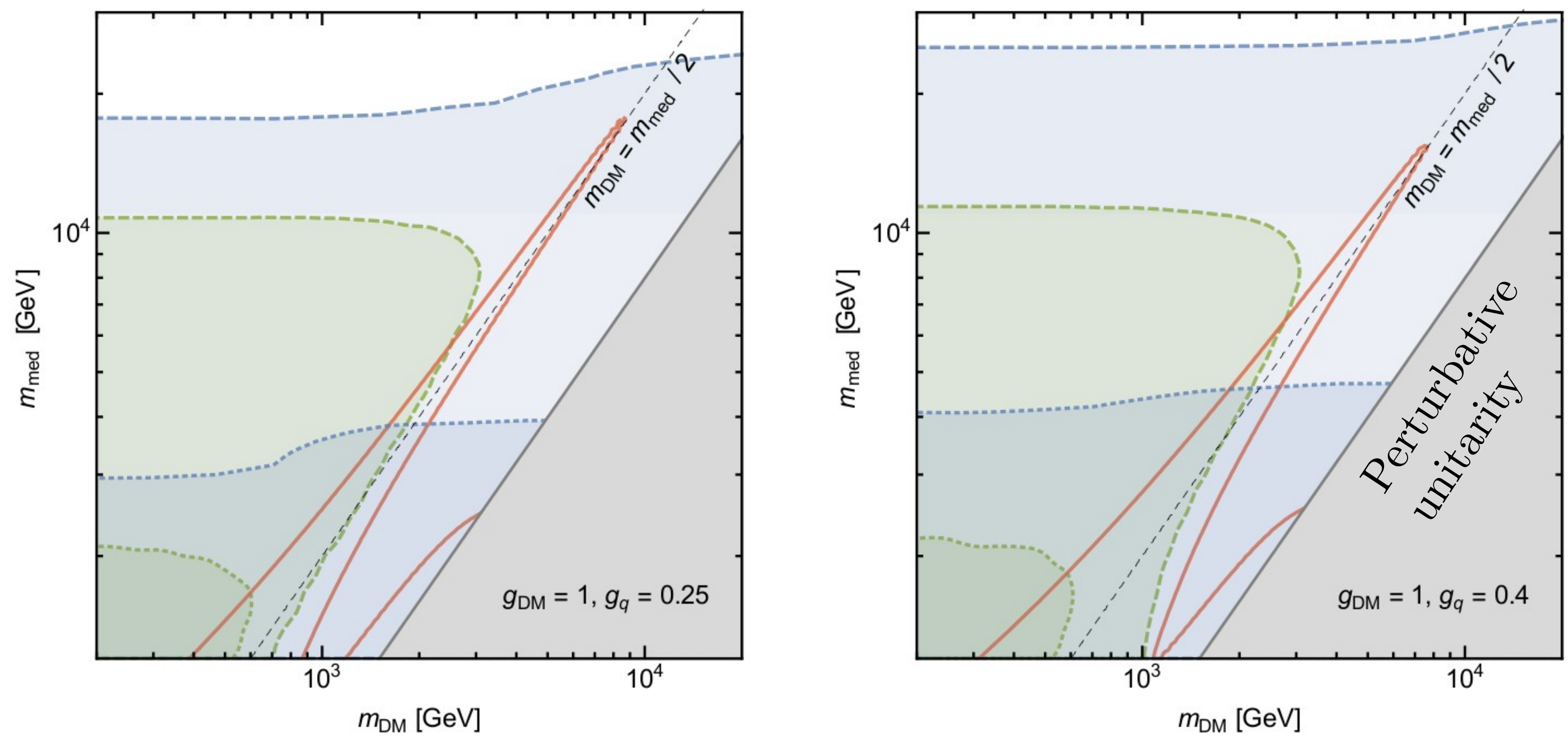
# Dijet searches: the small mass region

This is apparently the case at the LHC: $130 \leq m_{jj} \leq 300$ GeV *[ATLAS-CONF-2013-074]* (but this note has not been published)



## The tuned region: small couplings and $m_{\rm DM} \sim m_{\rm med}/2$ (large mediator masses are compatible)



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Because the DM is Majorana (its couplings are purely axial),
$\sigma v \sim \cancelto{0}{a} + bv^2$, where $b$ is given by the expression

$$b \sim \frac{g_{\mathrm{DM}}^2 \; g_q^2 \; m_{\mathrm{DM}}^2}{(m_{\mathrm{med}}^2 - 4m_{\mathrm{DM}}^2)^2 + (\Gamma_{\mathrm{med}} m_{\mathrm{med}})^2}$$

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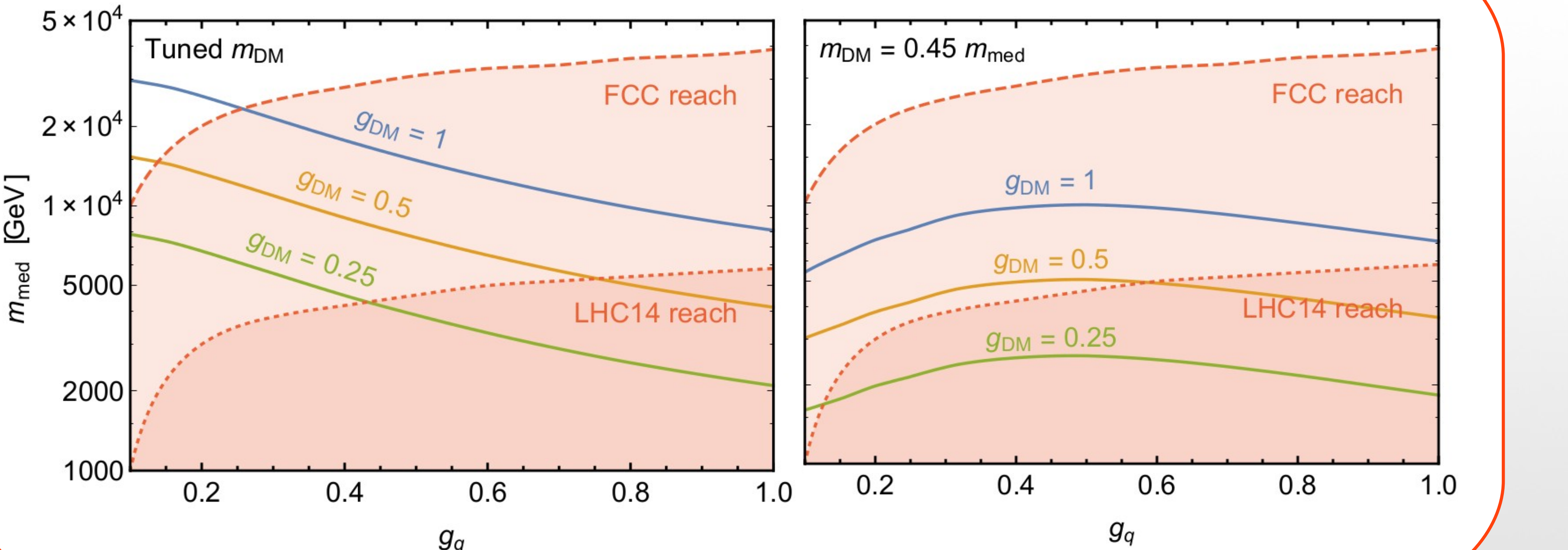

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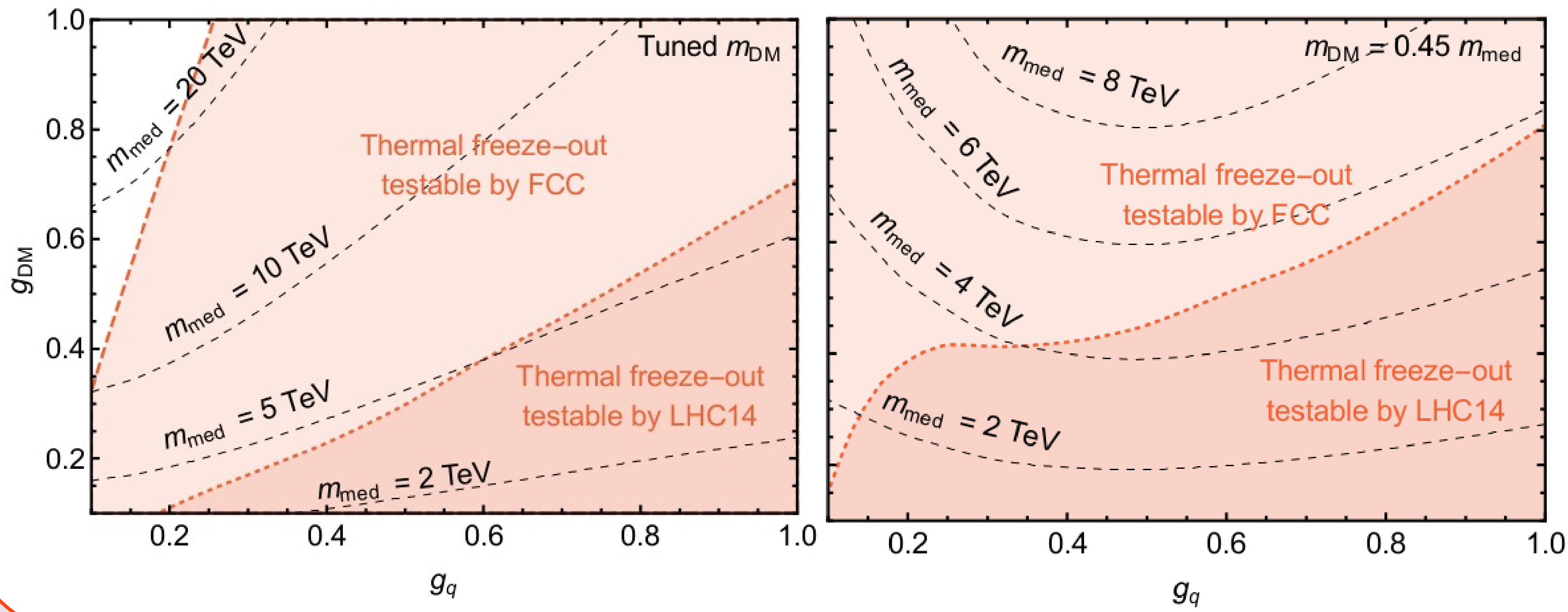

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Thank you for your attention!