Complementarity of Dark Matter Searches at Resonance (arXiv:1406.3288)

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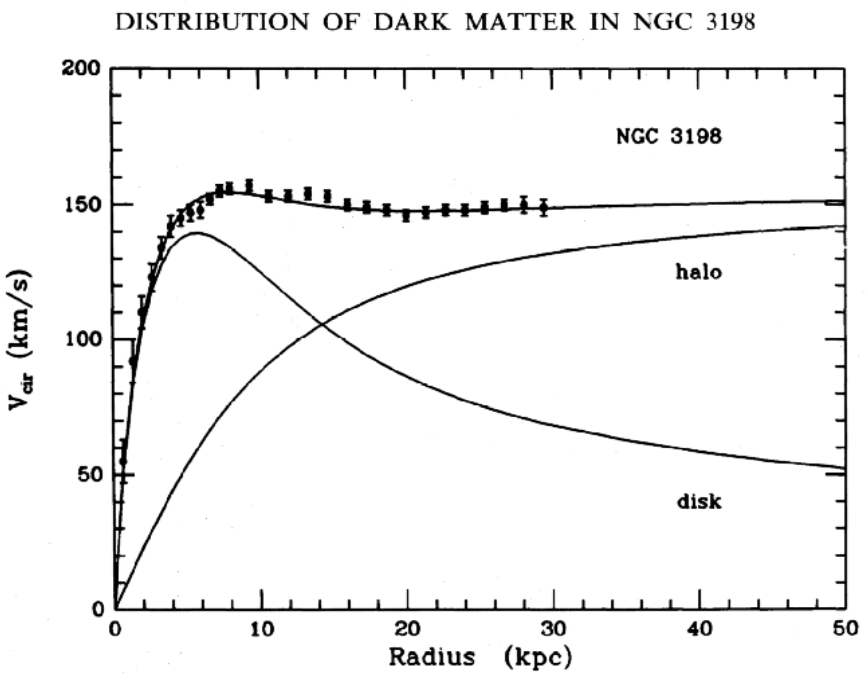
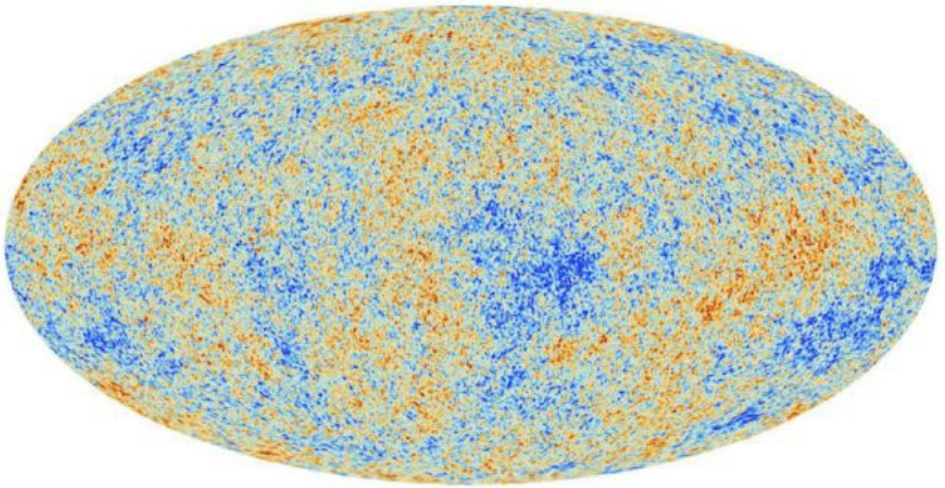
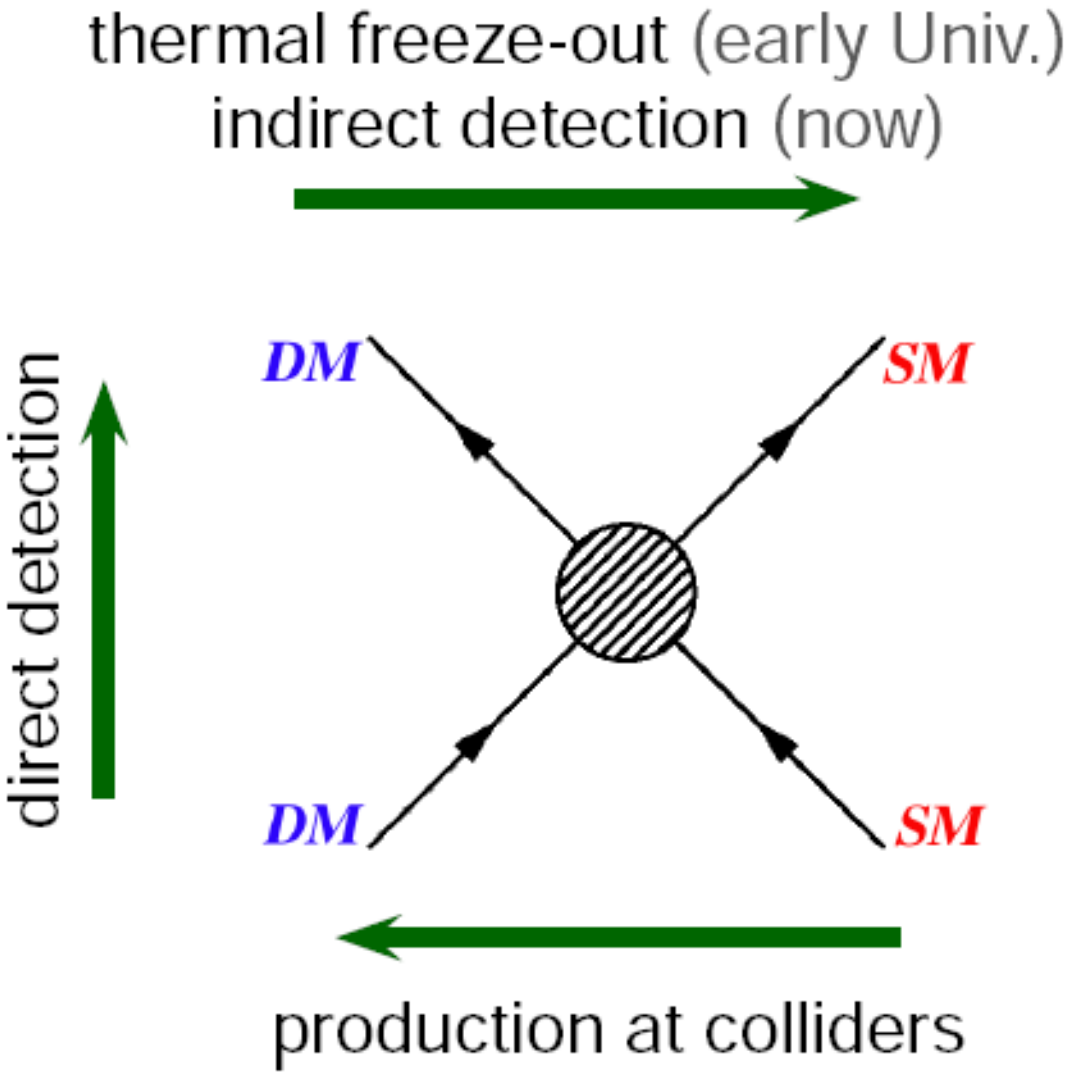
Dark Matter Evidence

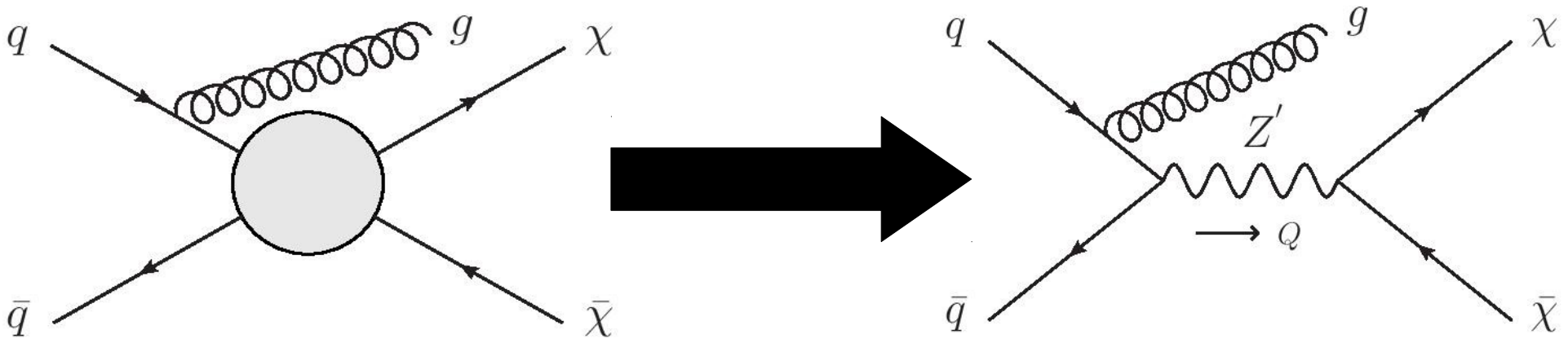




Effective Interaction



Beyond Effective Interactions



Effective Interactions:
2 parameters.
Easier to constrain.
Very good for low energy physics.

Simplified Models:
More than 2 parameters.
More difficult to constrain.
Relationships between parameters can avoid direct detection limits.
Good for higher energy physics.
Open up new search channels.

Simplified Model

$$-\tfrac{1}{4}F'_{\mu\nu}F'^{\mu\nu} + \tfrac{1}{2}m^2_{A'}A'_\mu A'^\mu + \bar{\chi}(\gamma^\mu\partial_\mu - m_\chi)\chi$$
$$+A'_\mu\bar{\chi}\gamma^\mu(g_{\chi V} - g_{\chi A}\gamma^5)\chi + A'_\mu\bar{q}\gamma^\mu(g_{qV} - g_{qA}\gamma^5)q$$

Fermionic DM

Spin-1 Mediator

Leptophobic

Flavour blind coupling to quarks

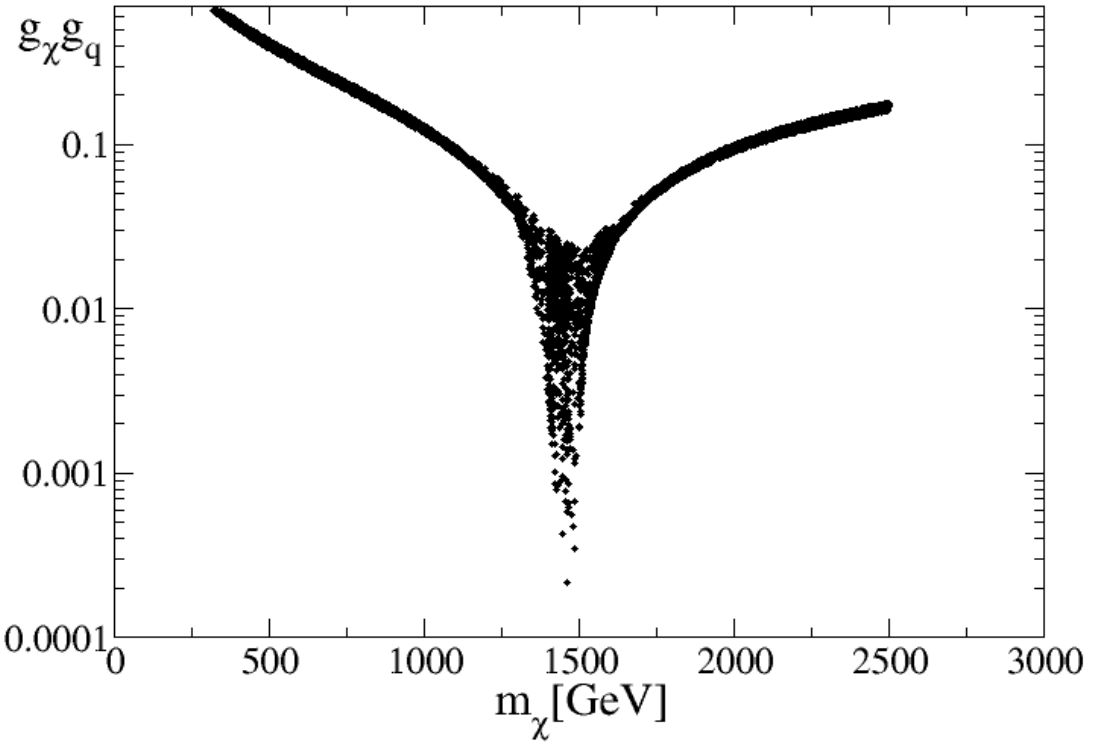
Parameter ranges:

$m_{A'} = 1.5\ \text{TeV}$
$m_\chi < 2.5\ \text{TeV}$
$0 < g_{\chi V}, g_{qV} \leq 3$
$g_{\chi V}, g_{qV} = 0$
$\Gamma_{A'} \leq 0.15 m_{A'}$

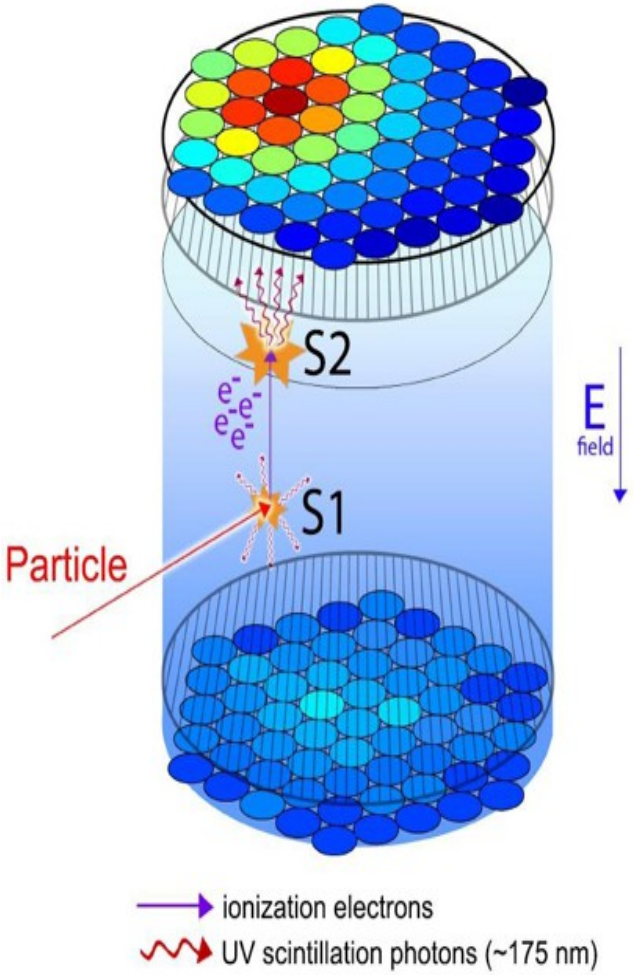
Relic Density

Assume standard freeze out
Calculate using micrOMEGAS
Getting from Planck:

$$\Omega_{DM}h^2 = 0.1198 \pm 0.0026$$



Direct Detection



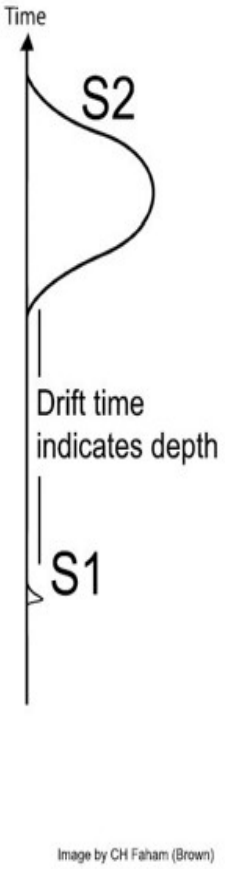
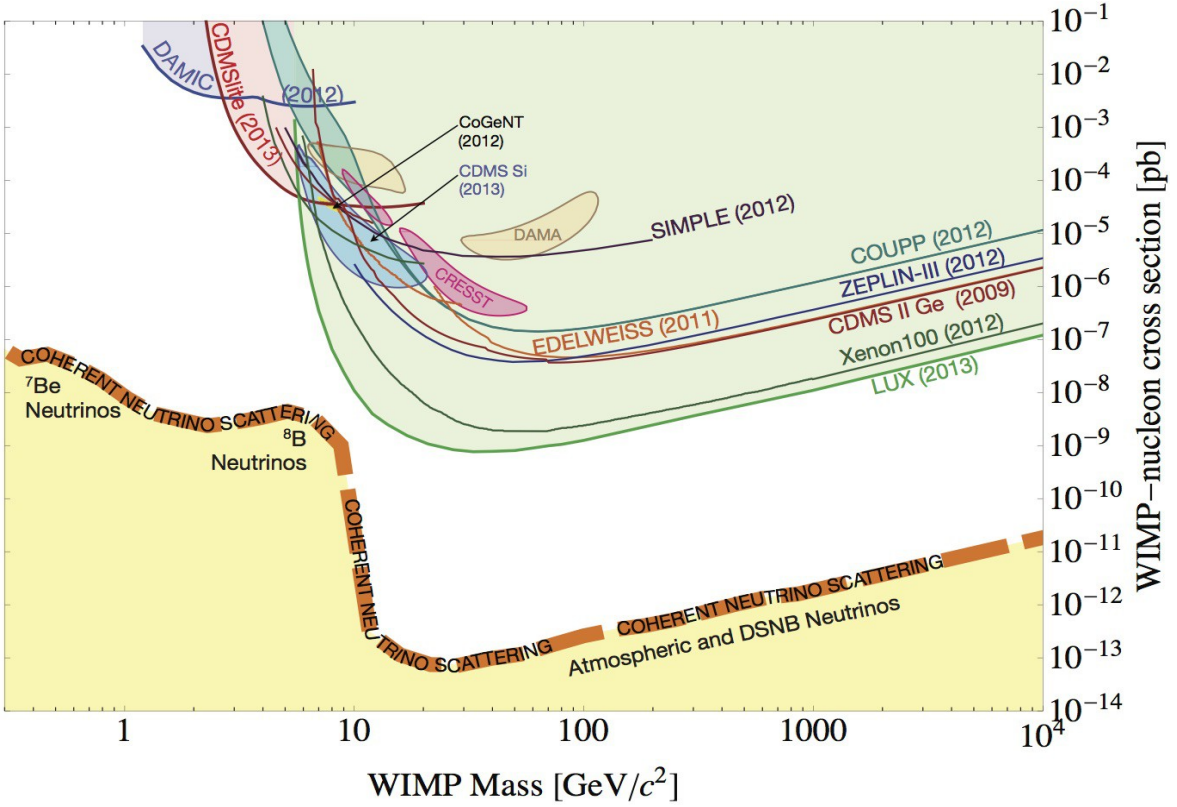
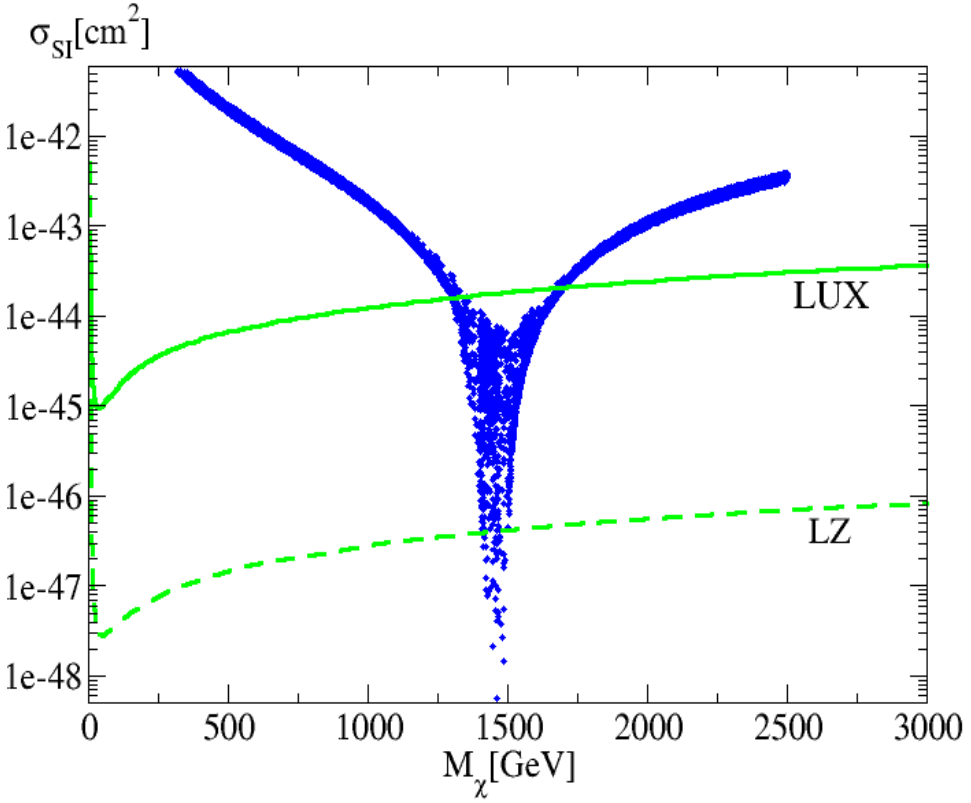


Image by CH Faham (Brown)



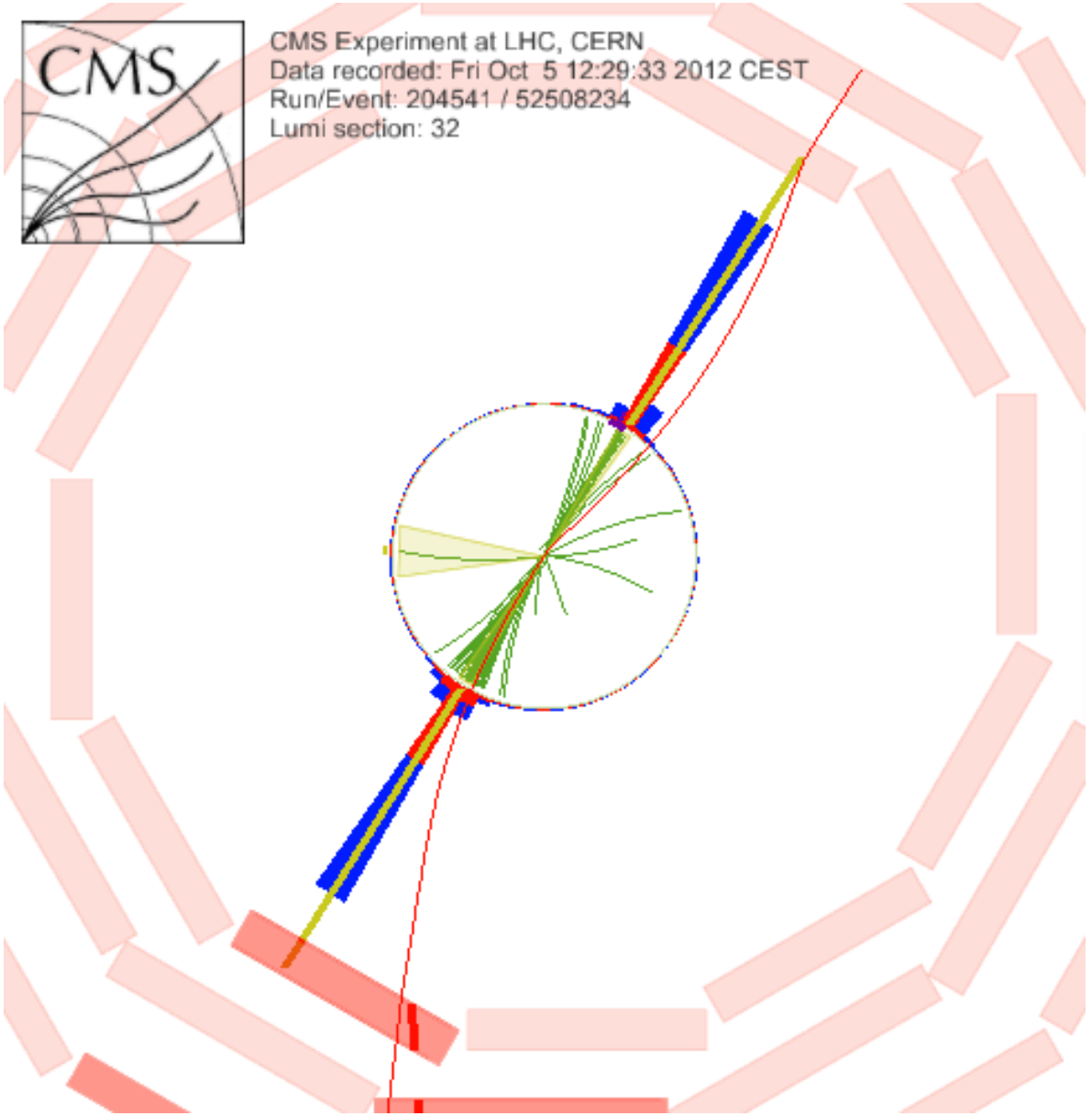
Direct Detection



Characteristic shape due to the couplings falling off to produce the correct relic density when on the s-channel resonance

LUX limits the mass range to between roughly 1.25 and 1.75 TeV

Collider Searches - Dijets



New heavy vector boson

Can possibly be produced on-shell and decay back into quarks

Experiments already looking at this signature

Result can be reinterpreted in the context of simplified models of dark matter

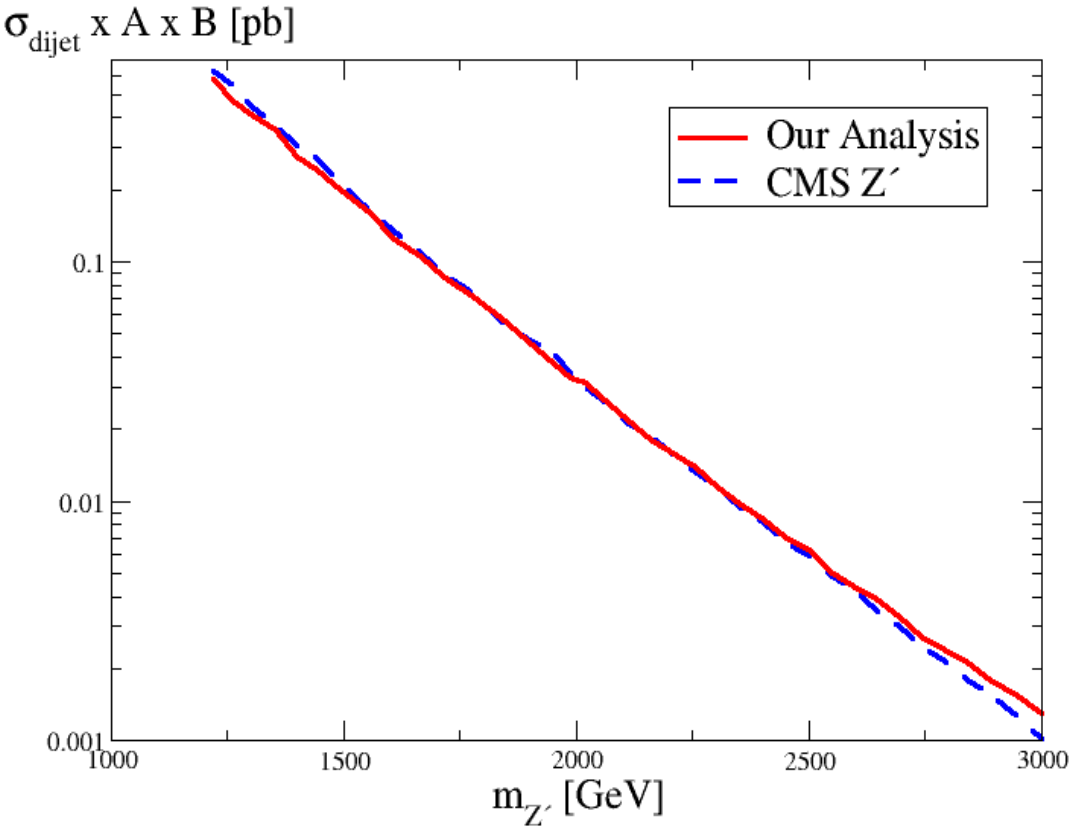
Not possible in the effective operator approach

Collider Searches – Dijet Validation

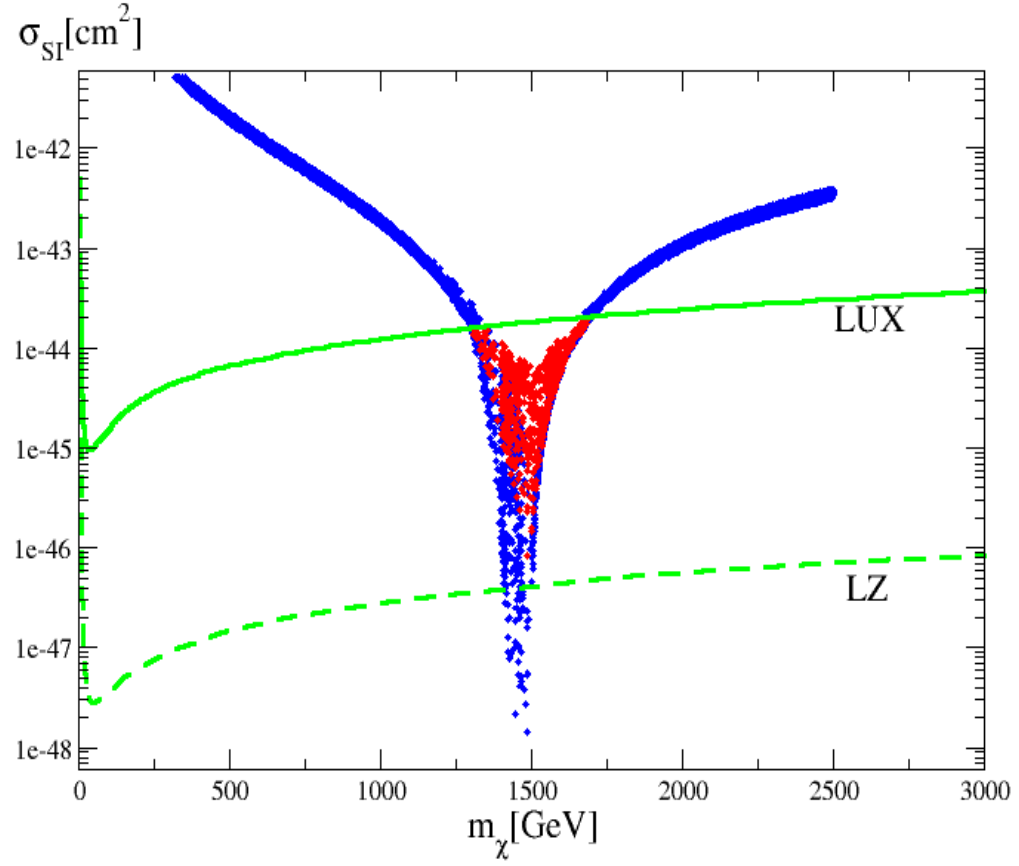
Steps:
Edit the model in Feynrules
Compute the matrix element in MadGraph
Generate and shower the events in pythia
Cluster the jets with FastJet
Apply CMS dijet cuts

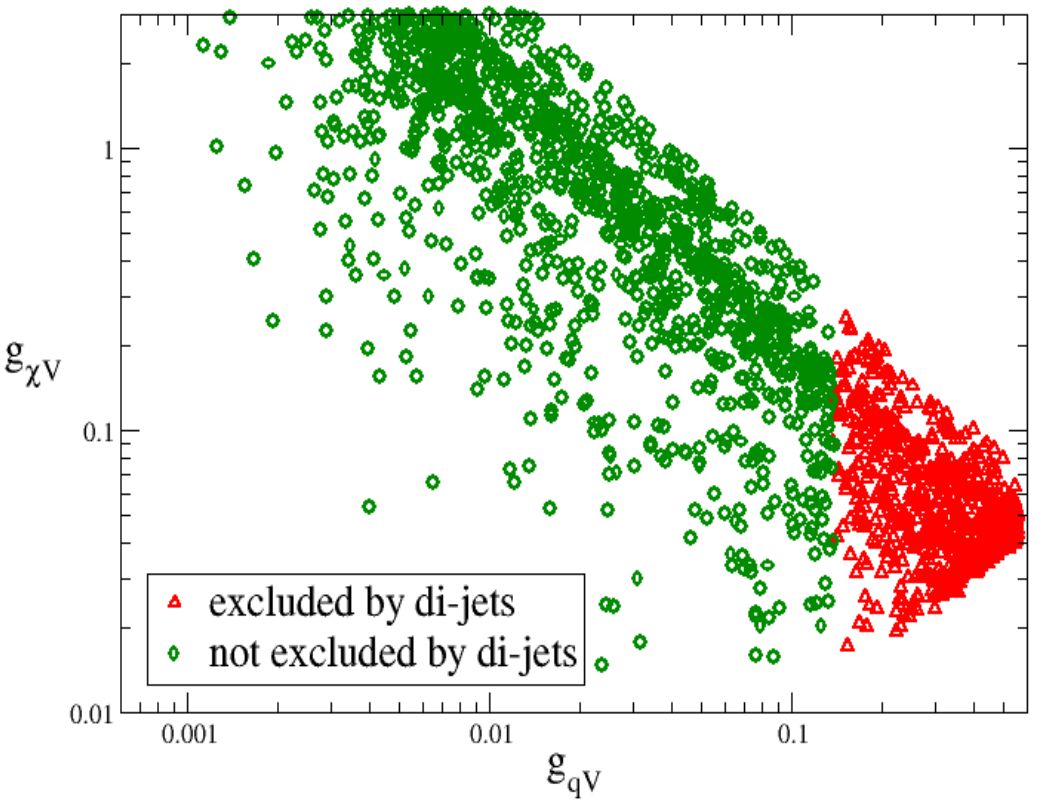
$$p_T > 30 \text{ GeV}$$
$$|\eta| < 2.5$$

$$m_{jj} > 890 \text{ GeV}$$
$$|\eta_{jj}| < 1.3$$



Collider Searches – Dijet Results



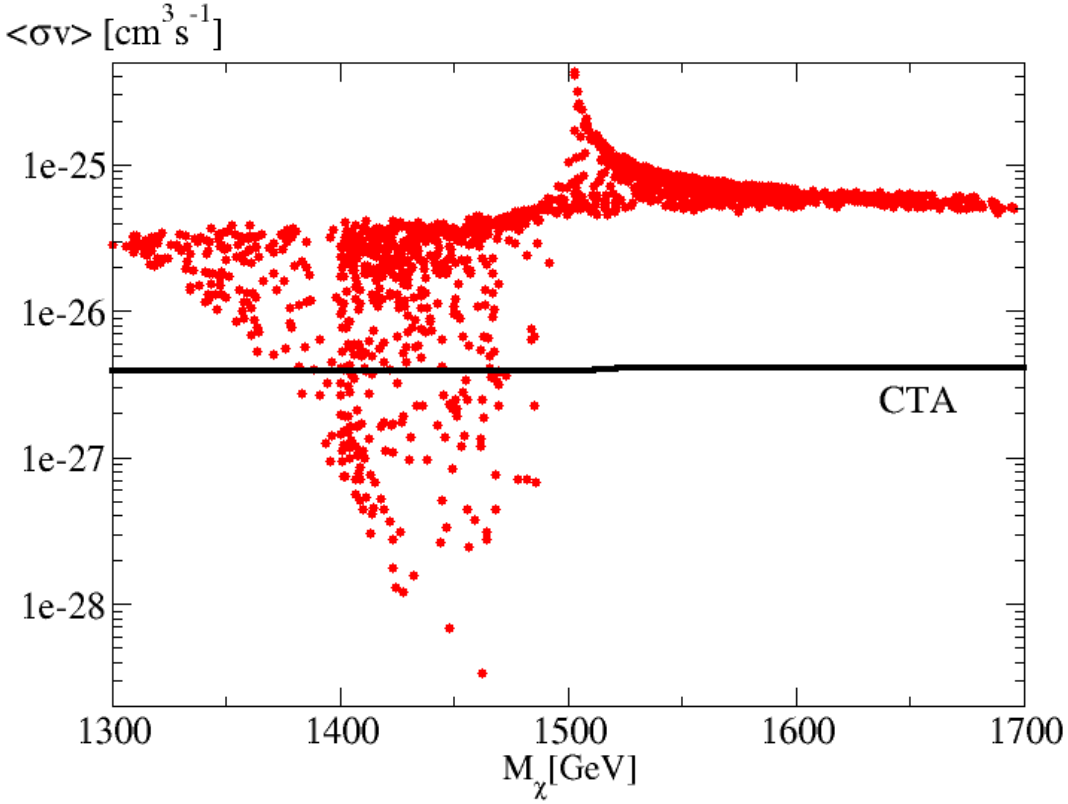


Indirect Detection

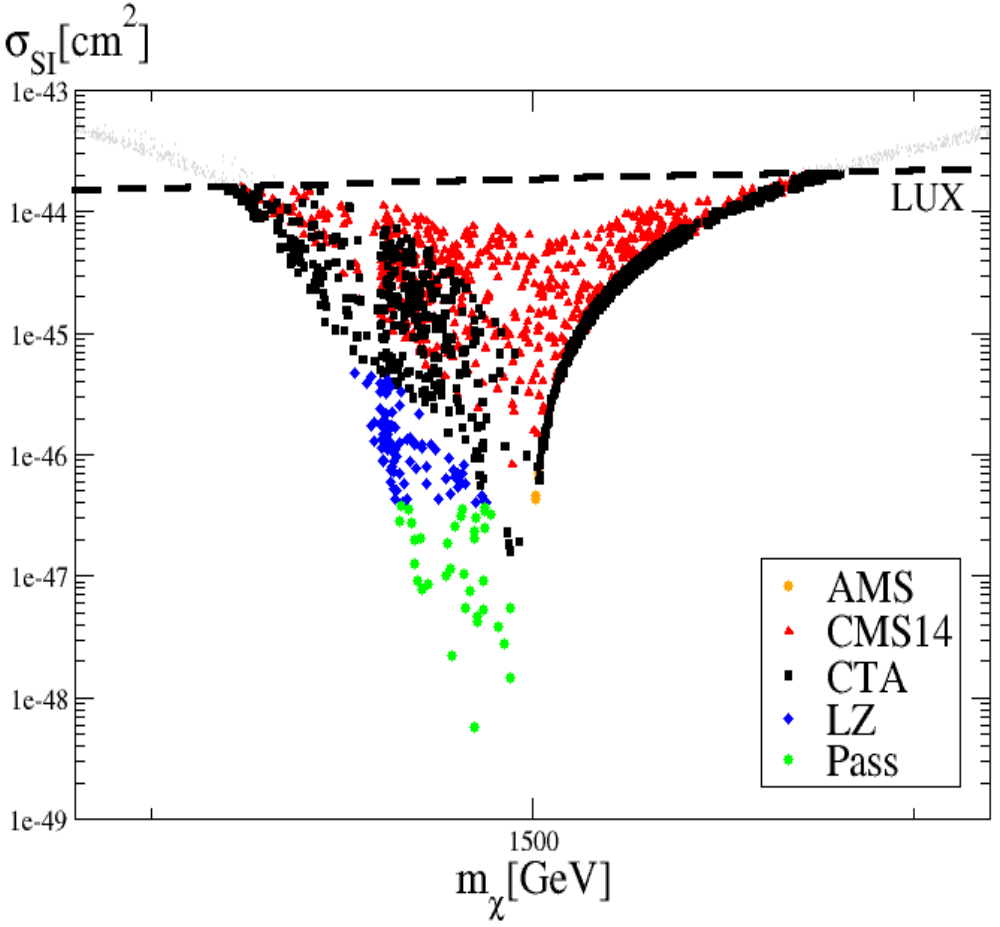
Self annihilation signals in regions of high dark matter density
Dwarf galaxies
Galactic centre

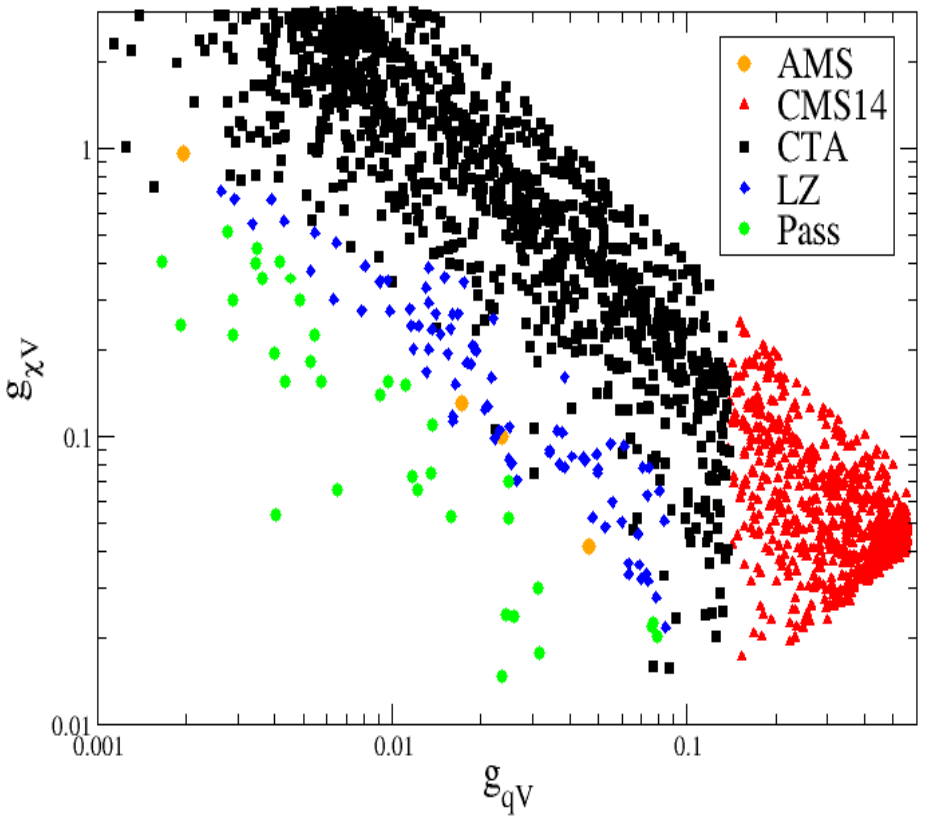
Same process as the relic density with a different energy

Leads to a suppression of the cross section when DM is less than half the mass of the mediator



Combined Limits





Conclusions

Direct detection heavily constrains WIMP models of dark matter

These limits can be avoided in certain kinematic regions of parameter space

To study these simplified models should be used

These models open up new searches and possible constrains

Combining these searches can restrict a large amount of parameters