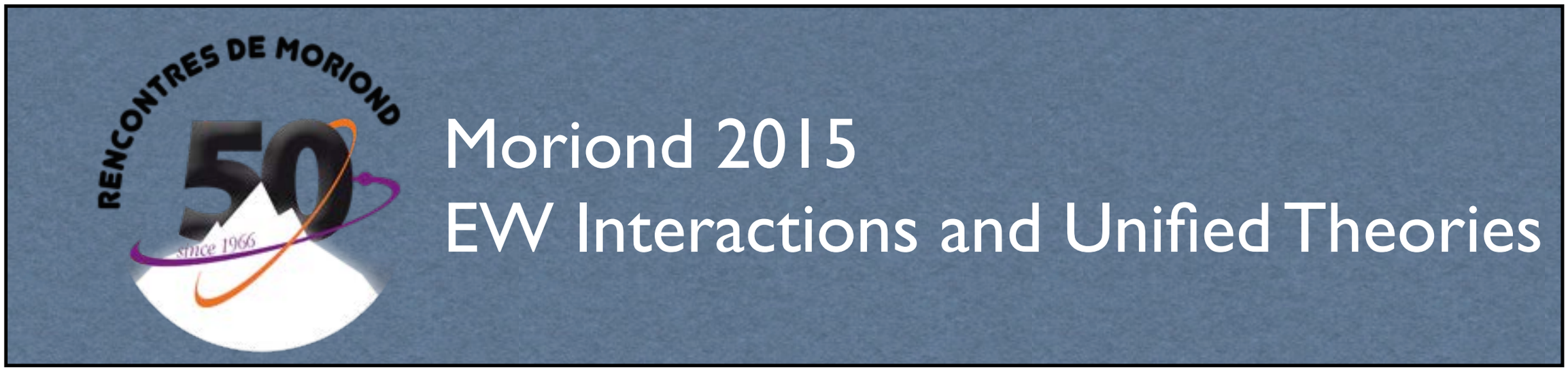


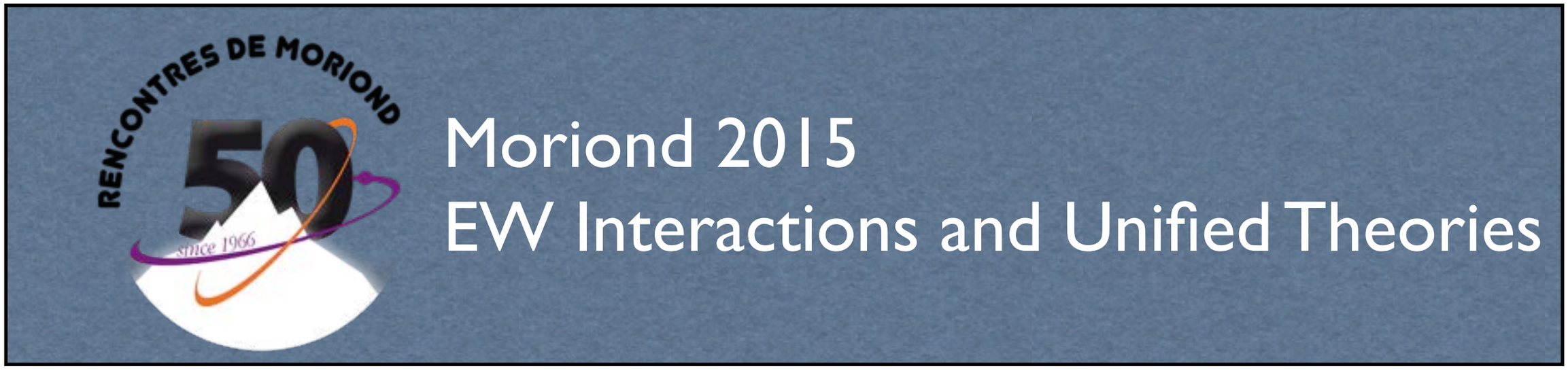
Invisible Z' and dark matter

LHC vs LUX constraints

BRYAN ZALDIVAR

UNIVERSITÉ LIBRE DE BRUXELLES

18/mar/2015



New Complementarities in Simplified Models of Dark Matter

BRYAN ZALDIVAR

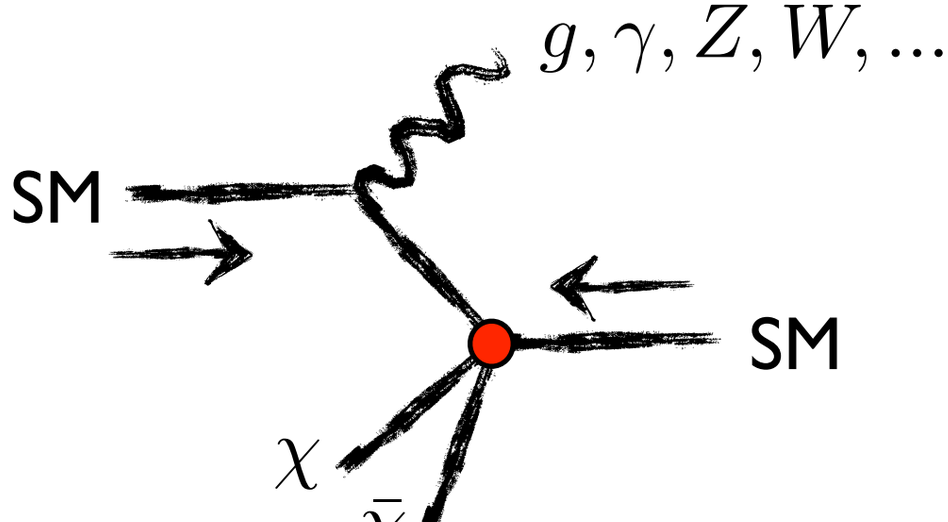
UNIVERSITÉ LIBRE DE BRUXELLES

18/mar/2015

Effective Field Theory Approach

Specific searches for DM@LHC:
mono-signals + ETmiss, in the EFT framework

e.g. $\frac{1}{\Lambda^2}(\bar{\chi}\Gamma^\mu\chi)(\bar{f}\Gamma_\mu f)$



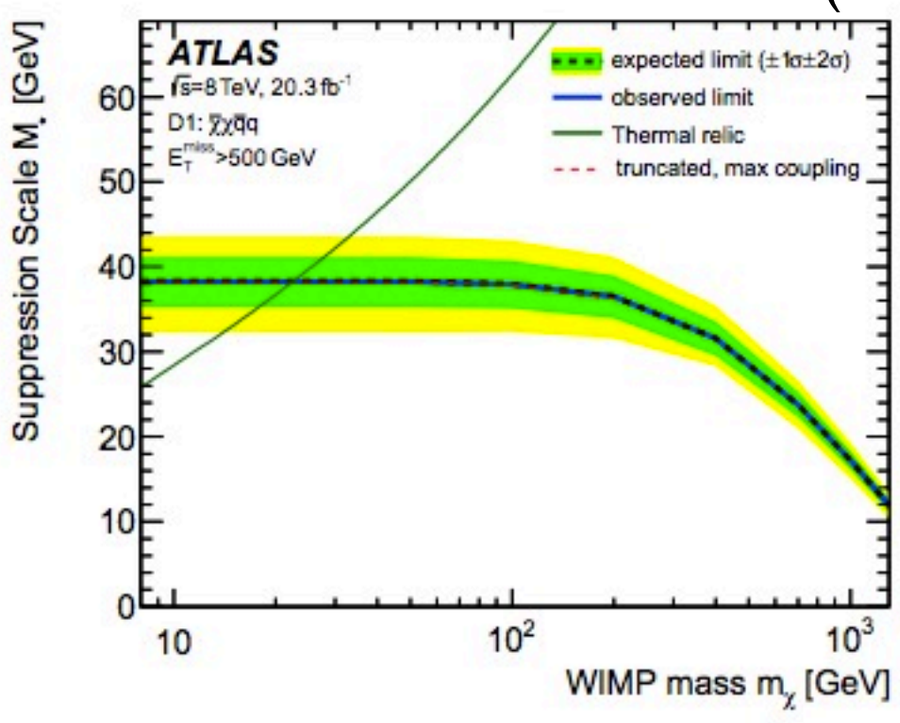
- watch out the validity:

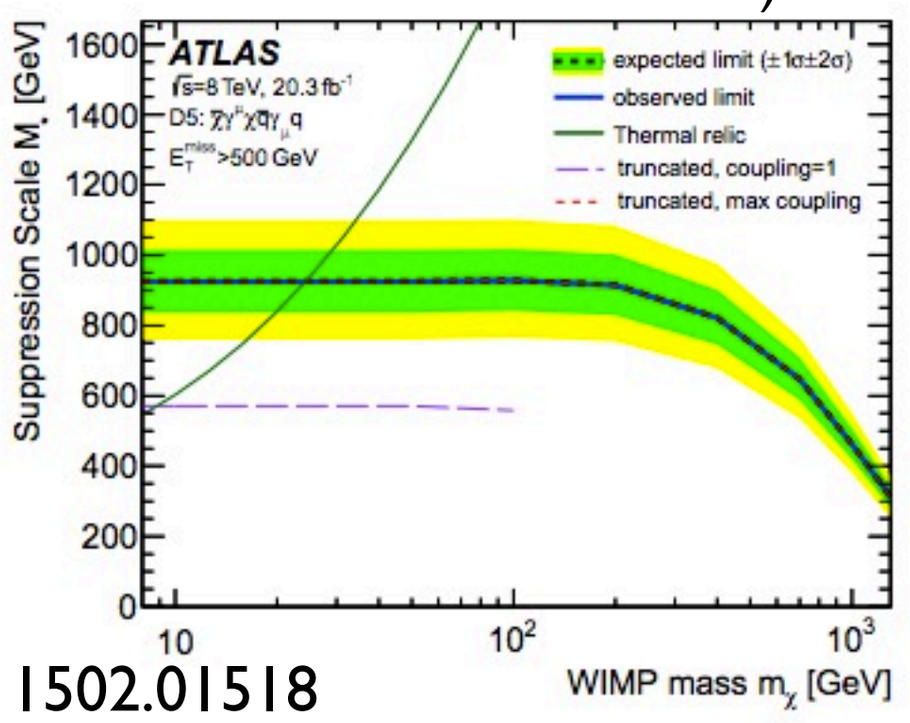
$$M \gg Q_{\rm tr} \gg 2m_\chi$$

$$M = \Lambda\sqrt{g_1 g_2}$$

[Riotto et al, 1307.2253]
[Buchmueller et al, 1308.6799]
....

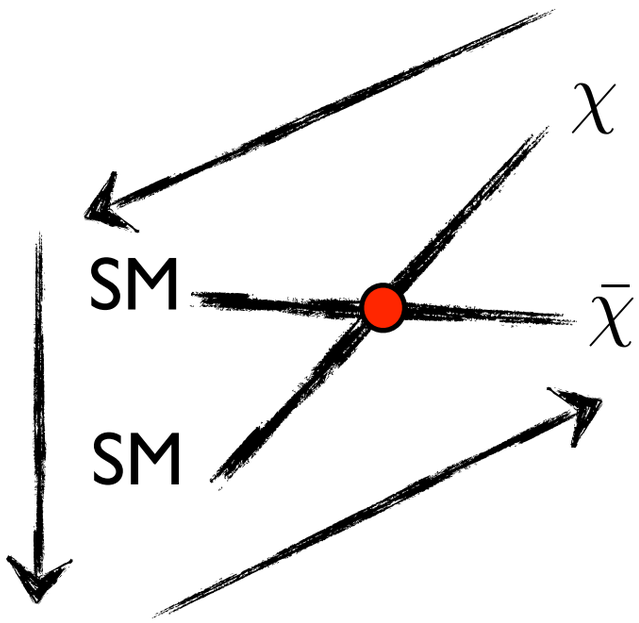
(See talks of Caterina and Deborah)

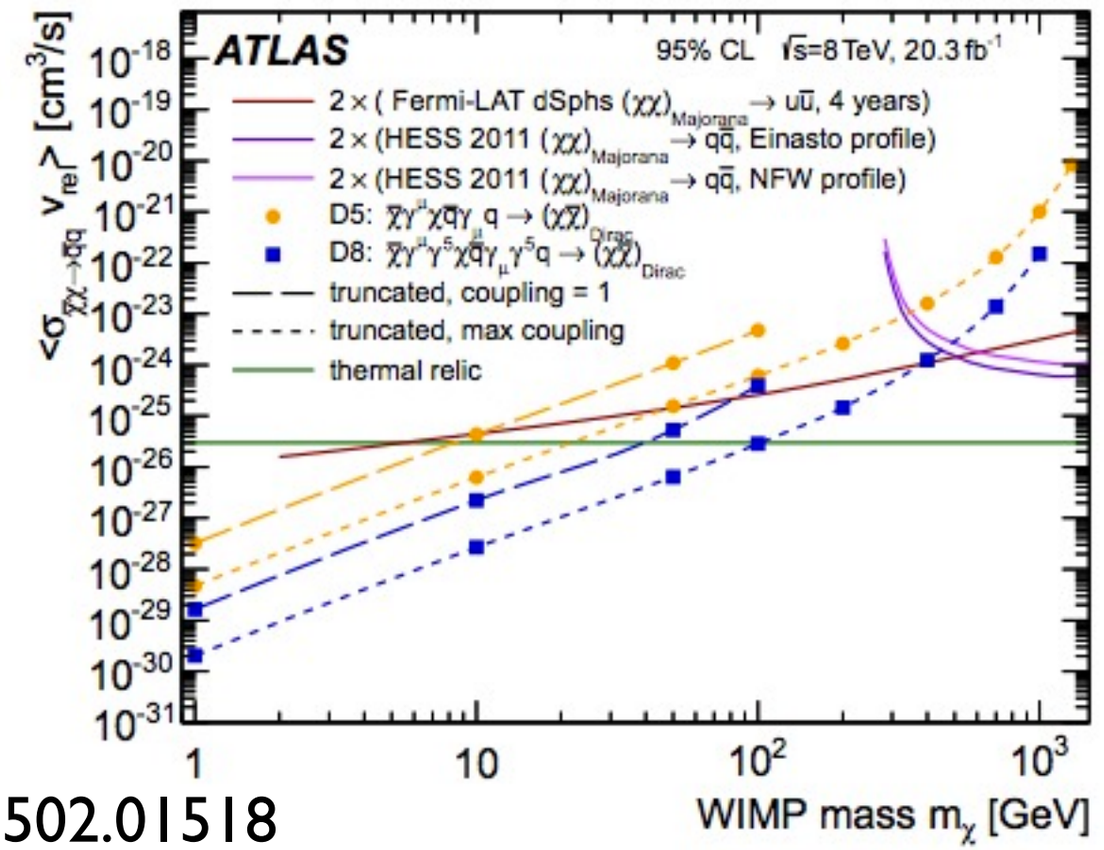




1502.01518

Complementarity between strategies(I)





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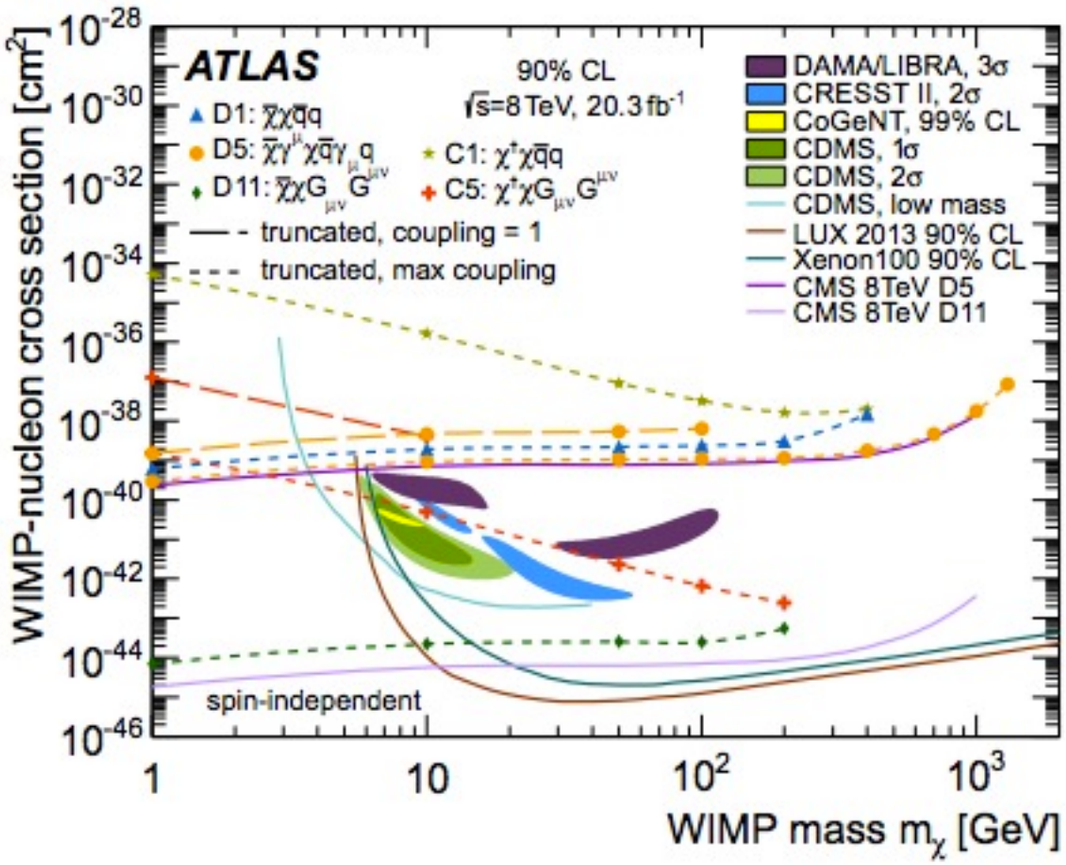
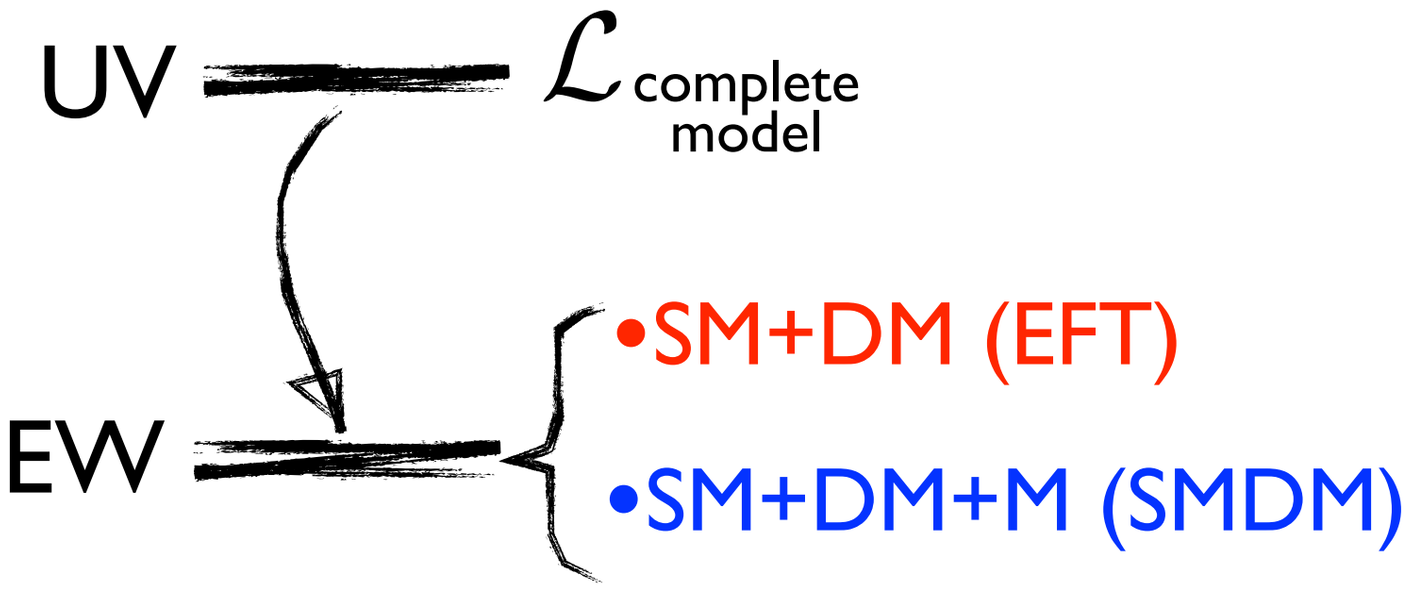


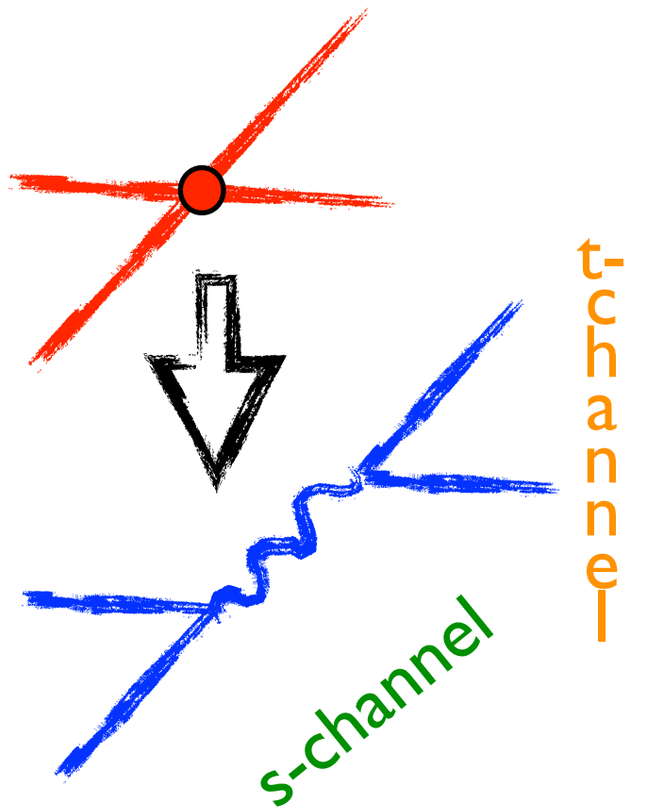
But what if M can be produced on-shell?

Simplified models

Simplified Models for Dark Matter

- The dynamics of the mediator M is now relevant





- $\lambda_f V_\mu \bar{f} \gamma^\mu f + \lambda_\chi V_\mu \bar{\chi} \gamma^\mu \chi$
- $\lambda_f \phi \bar{f} f + \lambda_\chi \phi \bar{\chi} \chi$
- $\lambda \phi \bar{f} \chi$

Λ, m_χ

$M, m_\chi, \lambda_f, \lambda_\chi$

- 4 parameters
- reasonable simulation

- full validity in all kinematical regions

Simulation feasibility vs. Model building

how realistic is to assume universal couplings to all quarks?

Simulation feasibility vs. Model building

how realistic is to assume universal couplings to all quarks?

- 3-4 params., universal couplings

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- More than, say, 10 params.

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Simulation feasibility vs. Model building

how realistic is to assume universal couplings to all quarks?

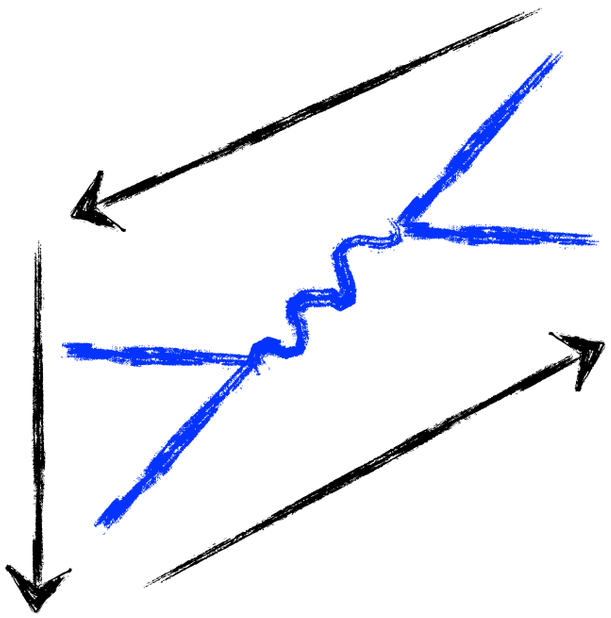
- 3-4 params., universal couplings

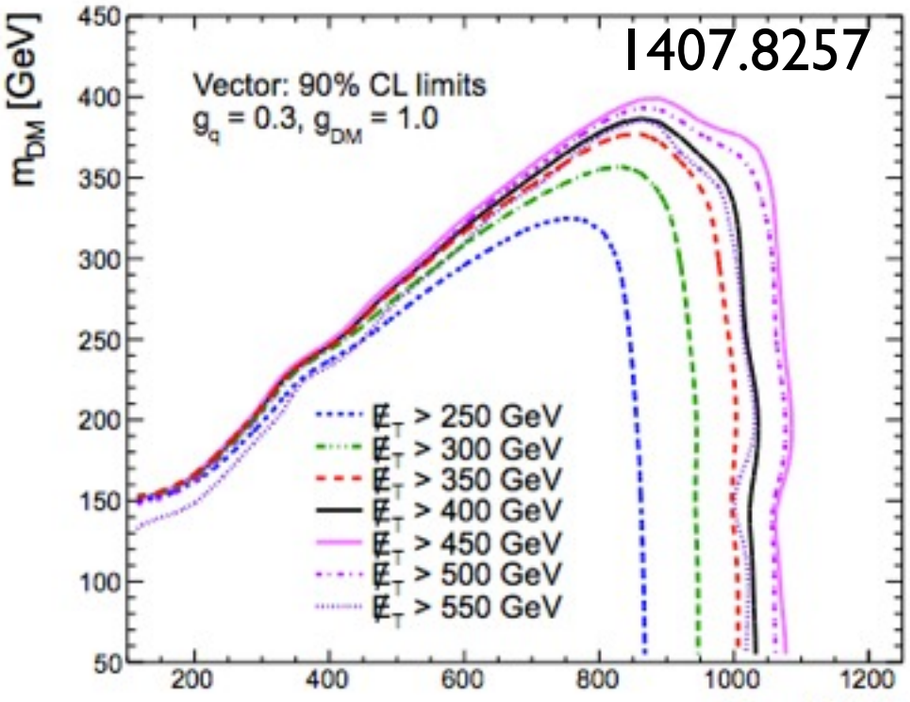
- More than, say, 10 params.

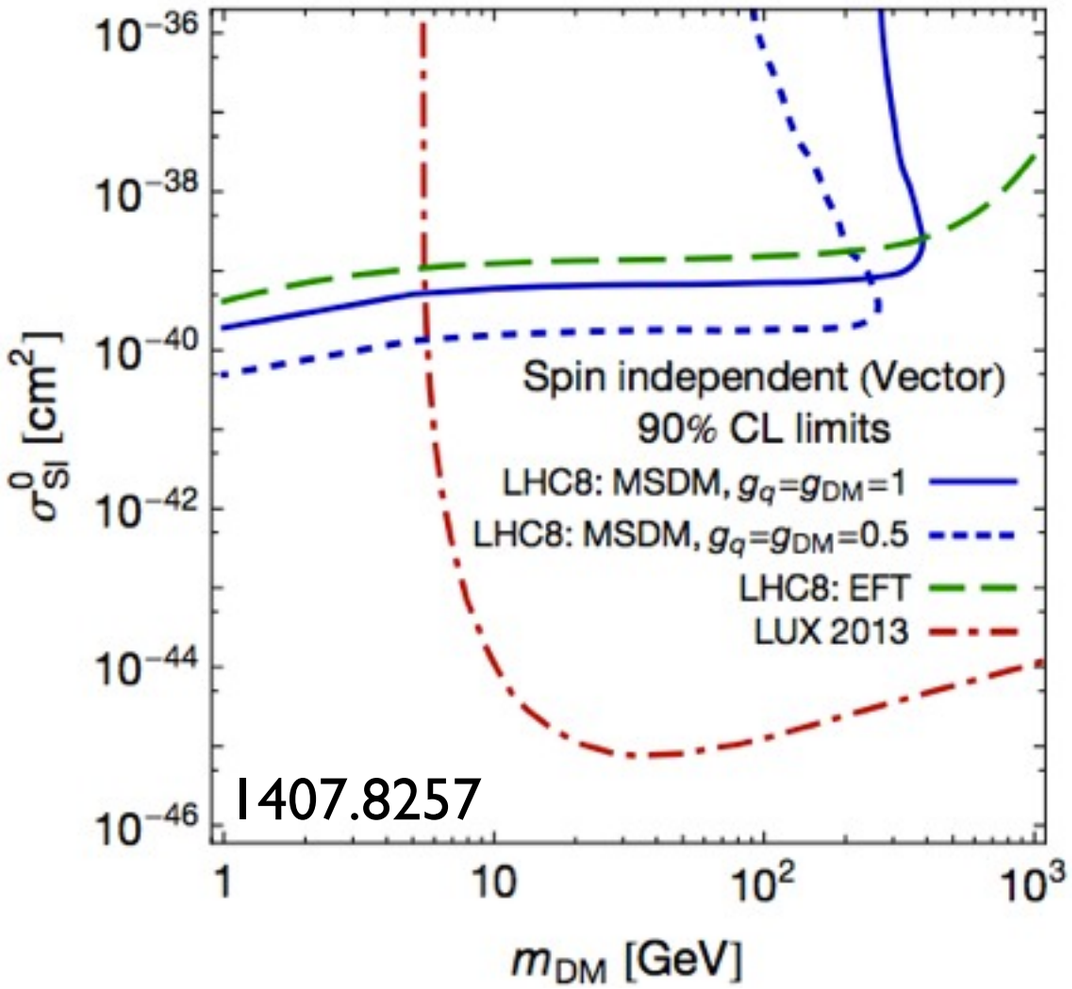
- ???

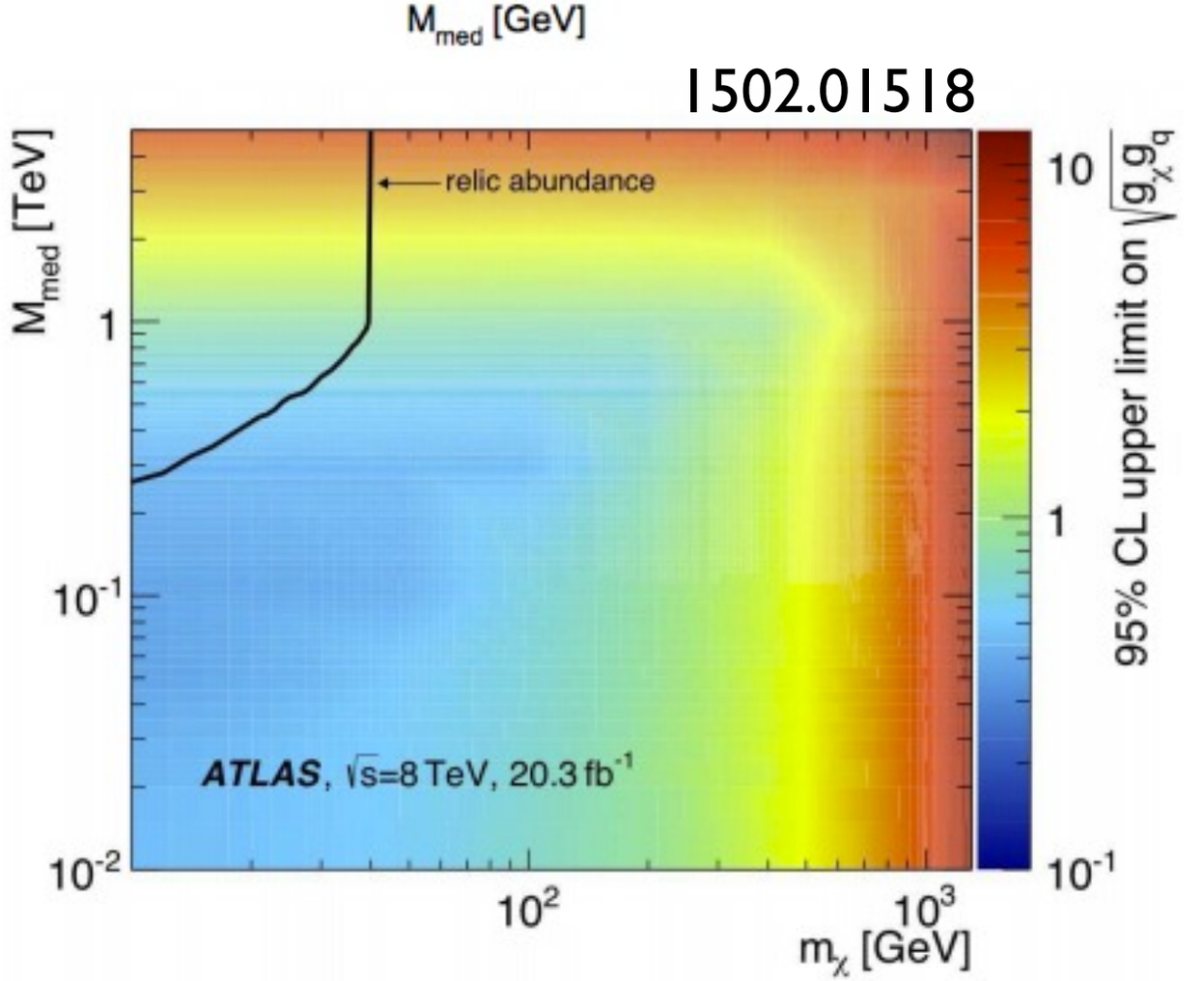
e.g. fixed hierarchy, Higgs-like, or Z-textures, etc.

Complementarity between strategies(II)







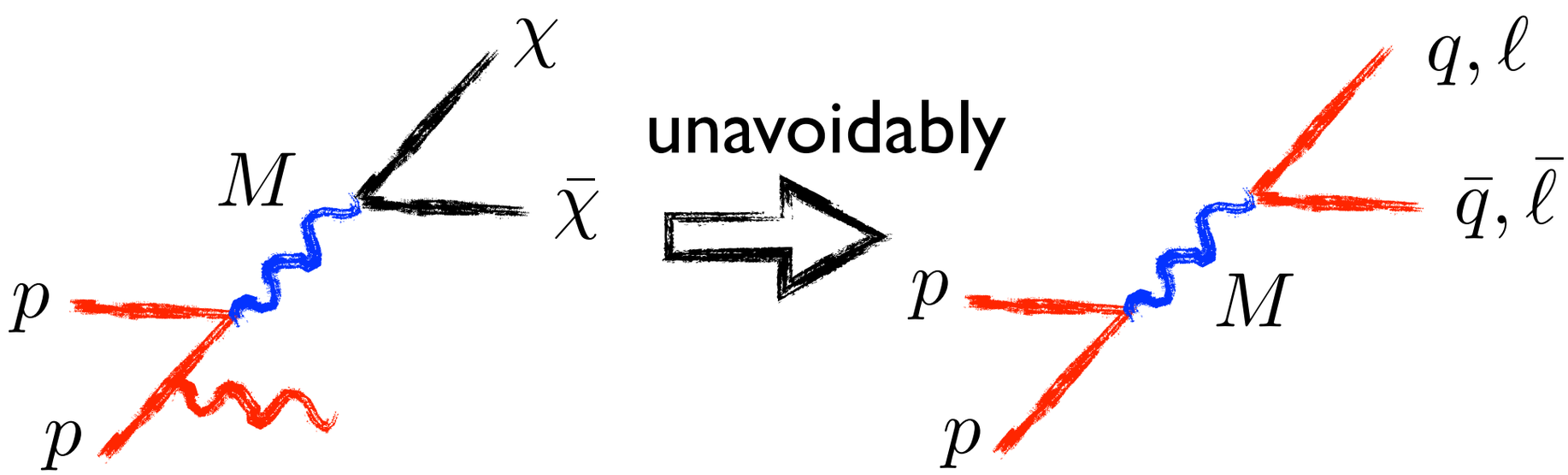


A Bonus Complementarity

$$\lambda_f \phi \bar{f} f + \lambda_\chi \phi \bar{\chi} \chi$$

$$\lambda_f V_\mu \bar{f} \gamma^\mu f + \lambda_\chi V_\mu \bar{\chi} \gamma^\mu \chi$$

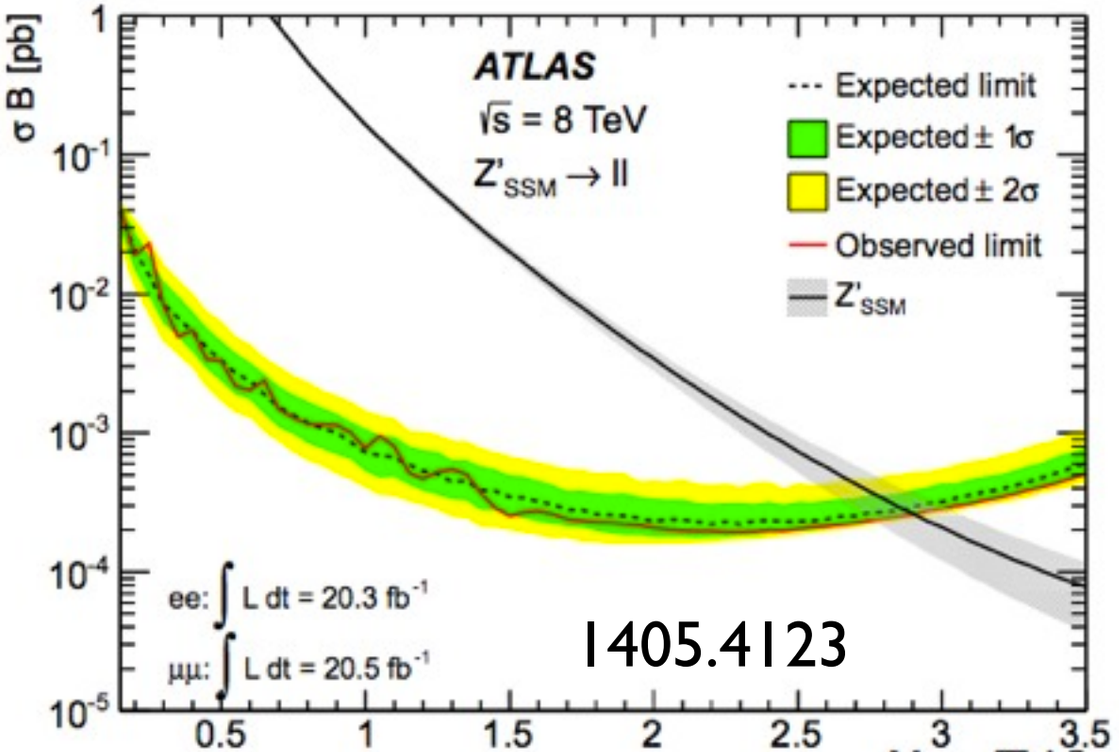
$$\lambda_f V_\mu \bar{f} \gamma^\mu \gamma^5 f + \lambda_\chi V_\mu \bar{\chi} \gamma^\mu \gamma^5 \chi$$

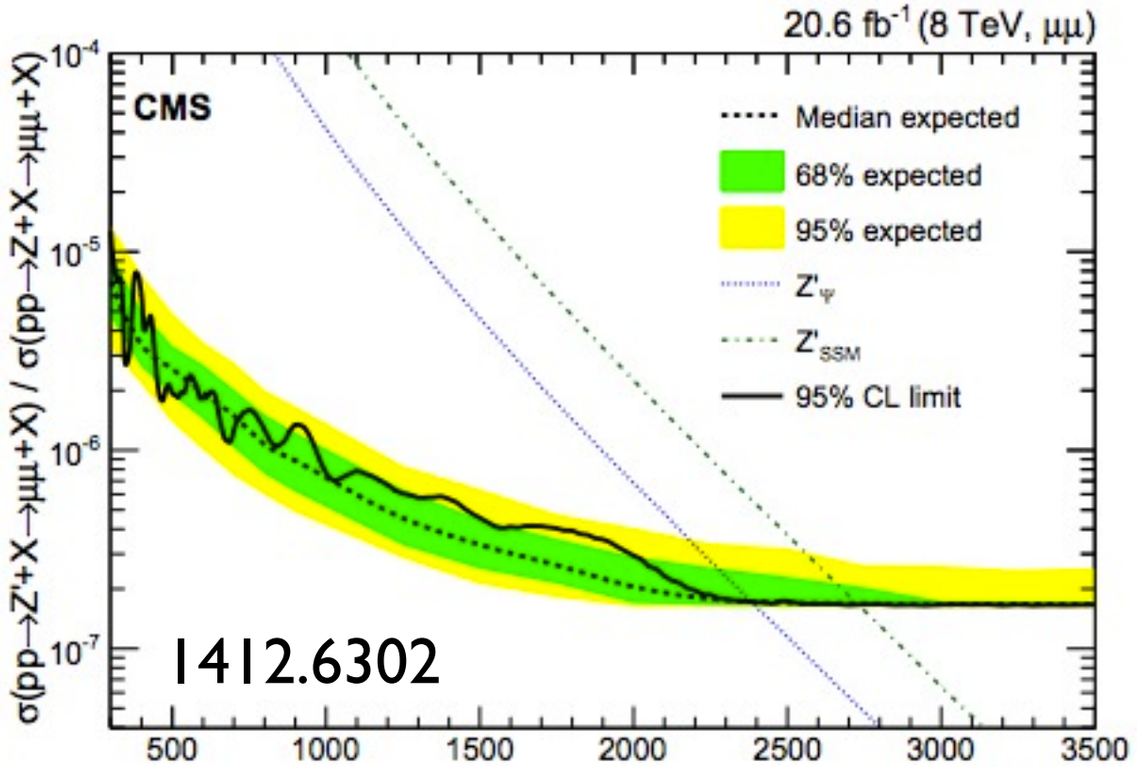


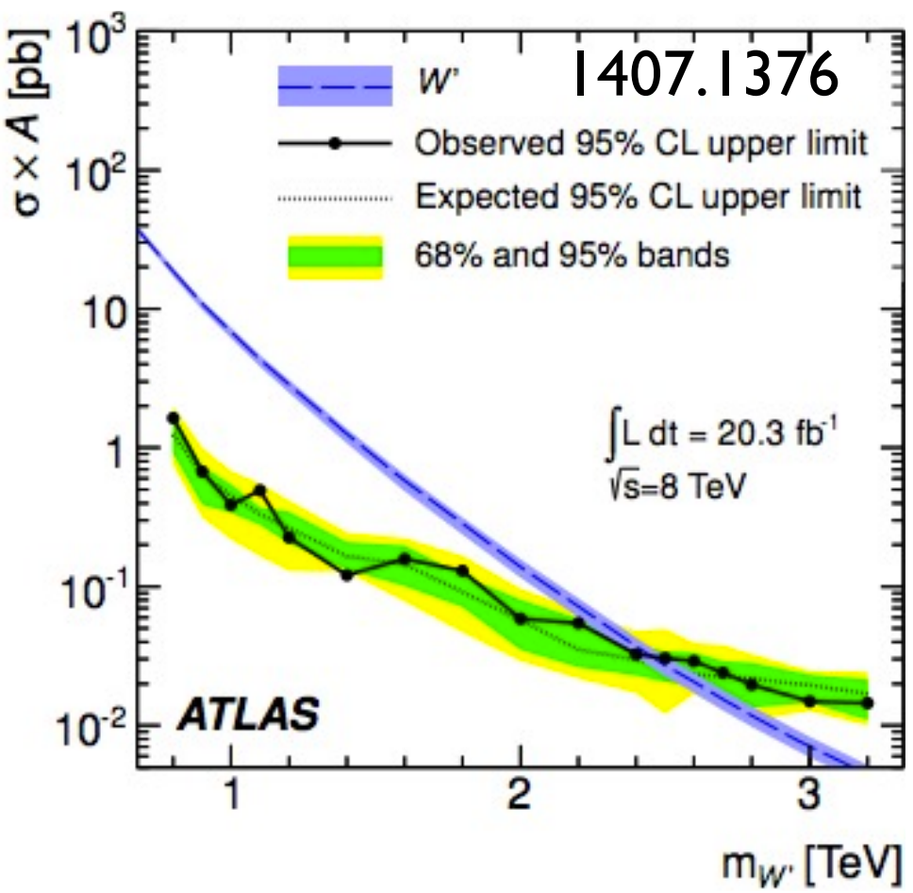
Pure visible signals (e.g. dijets or dileptons) are modified

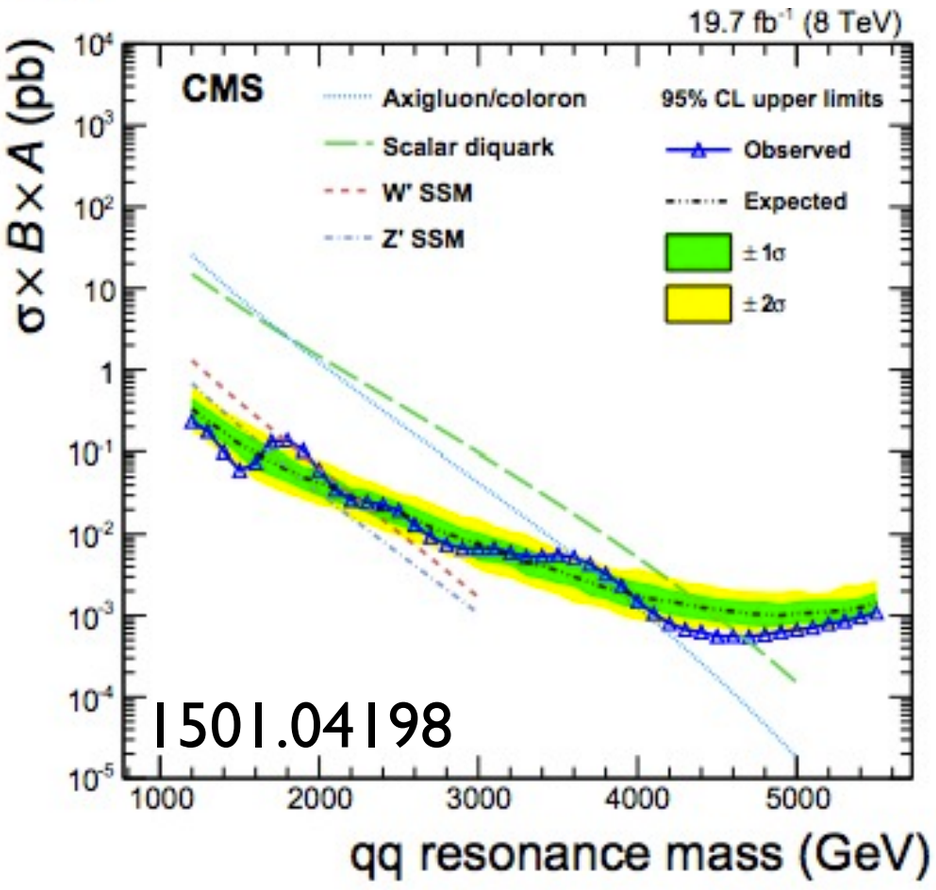
Generic feature of s-channel models

Resonant Di-signals







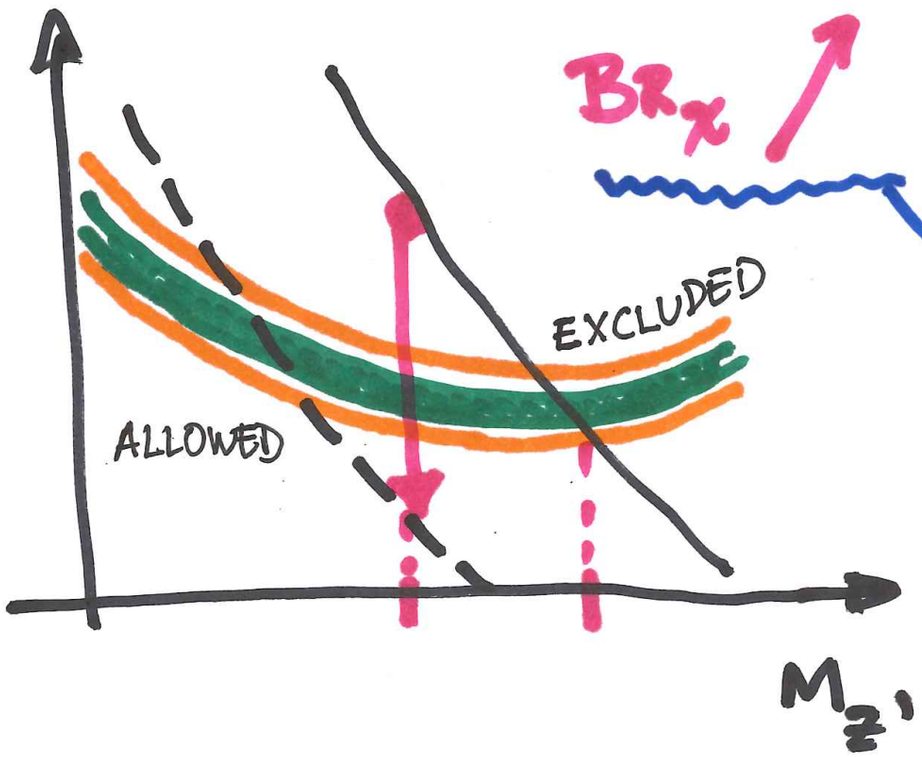


Assumption:
Pure visible mediator decays

ADDING INVISIBLE BRANCHING

$$\sigma(q\bar{q}\to Z'\to \bar{l}l) \approx \frac{g_D^4}{12\pi}\left(|V_q|^2+|A_q|^2\right)\left(|V_l|^2+|A_l|^2\right) \times \left(\frac{s}{(s-M_{Z'}^2)^2+\Gamma_{Z'}^2 M_{Z'}^2}\right)$$

$$\frac{M_{Z'}}{\Gamma_{Z'}}\pi\delta(s-M_{Z'}^2) = \frac{M_{Z'}}{\Gamma_{Z'}^{SM}}(1-Br_\chi)\pi\delta(s-M_{Z'}^2)$$

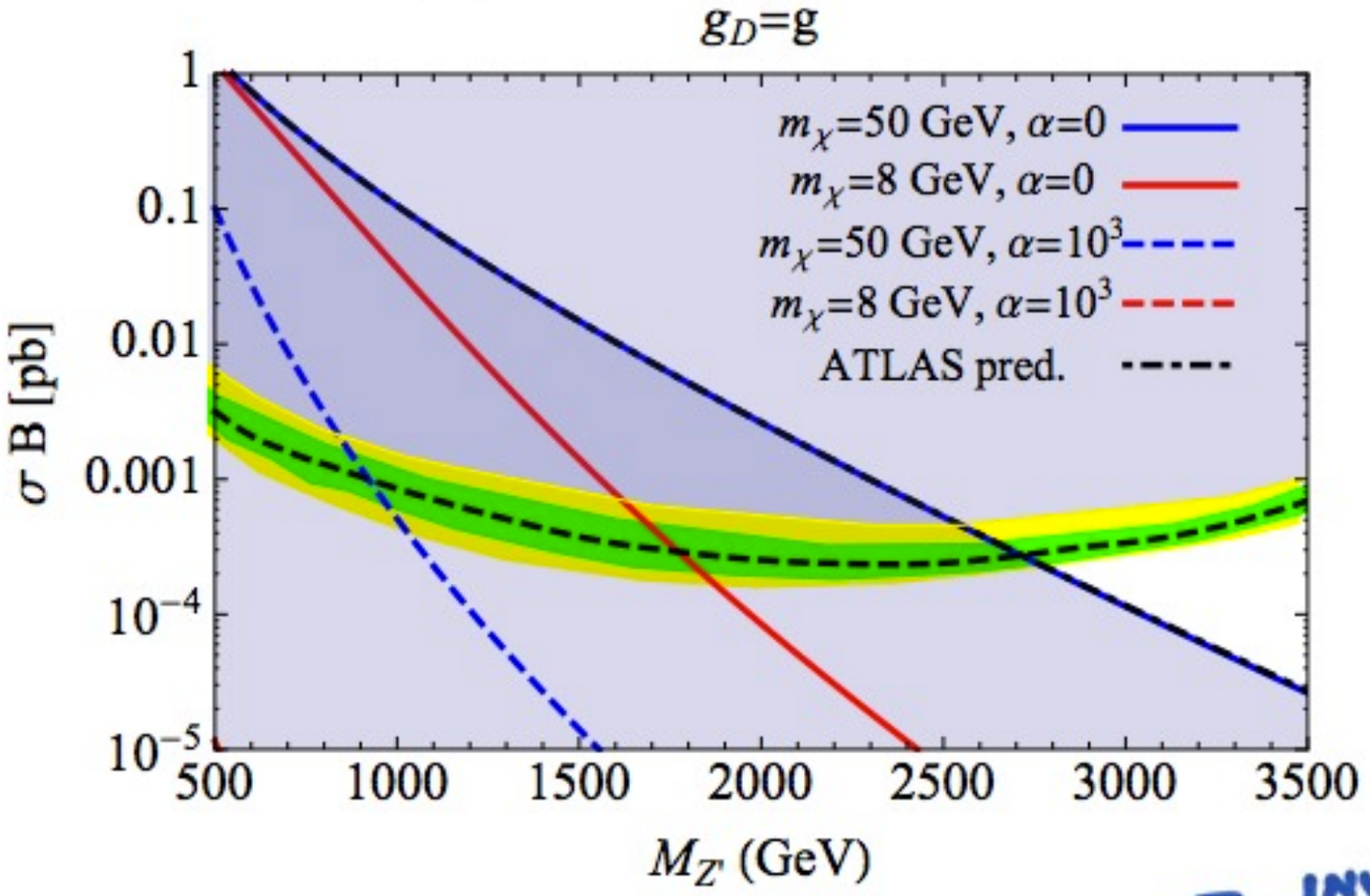


CANNOT INCREASE ARBITRARILY :

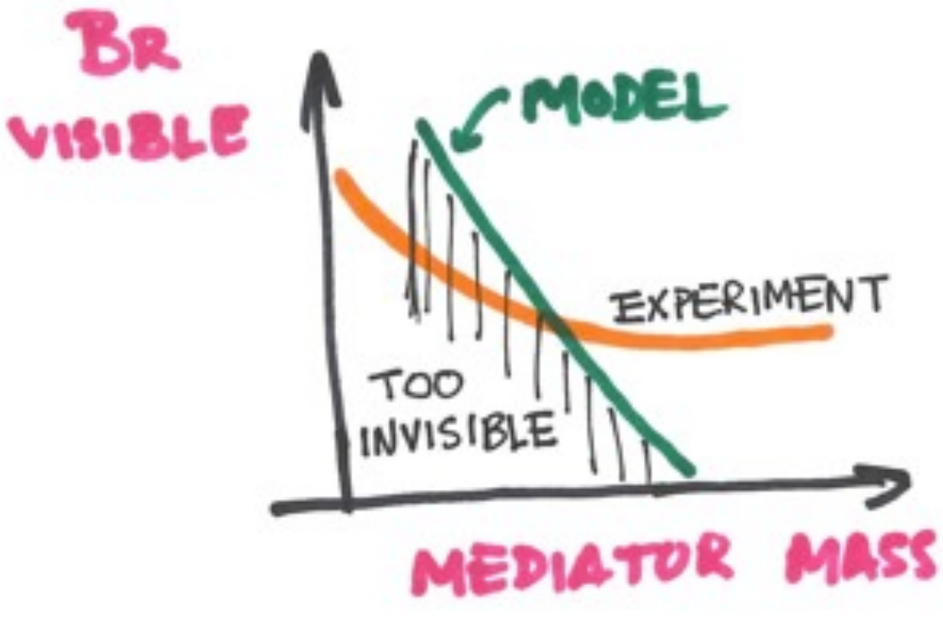
DIRECT DETECTION !

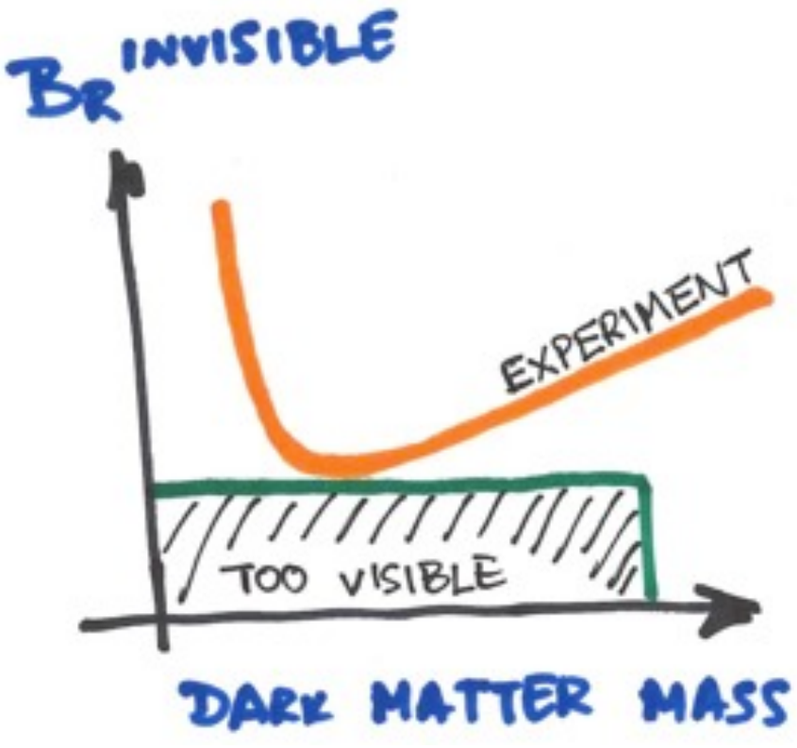
Di-signal vs. Direct Detection

Arcadi, Mambrini, Tytgat, BZ, 1401.0221 (see also: Profumo et al, 1312.5281)

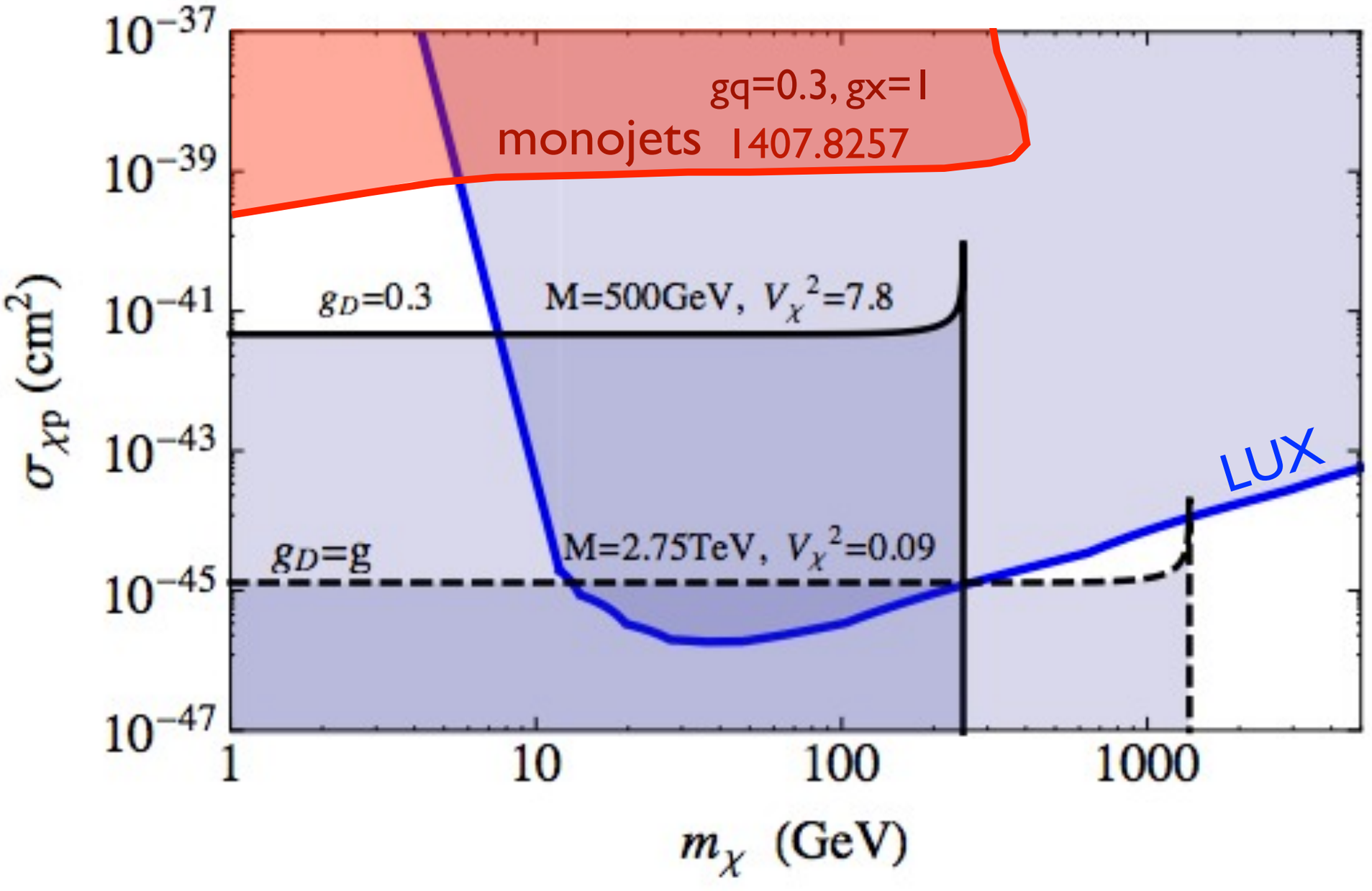


- Relax di-signal bound by increasing BRinv
- BRinv bounded by Direct Detection
- Direct Detection bound depends on DM mass



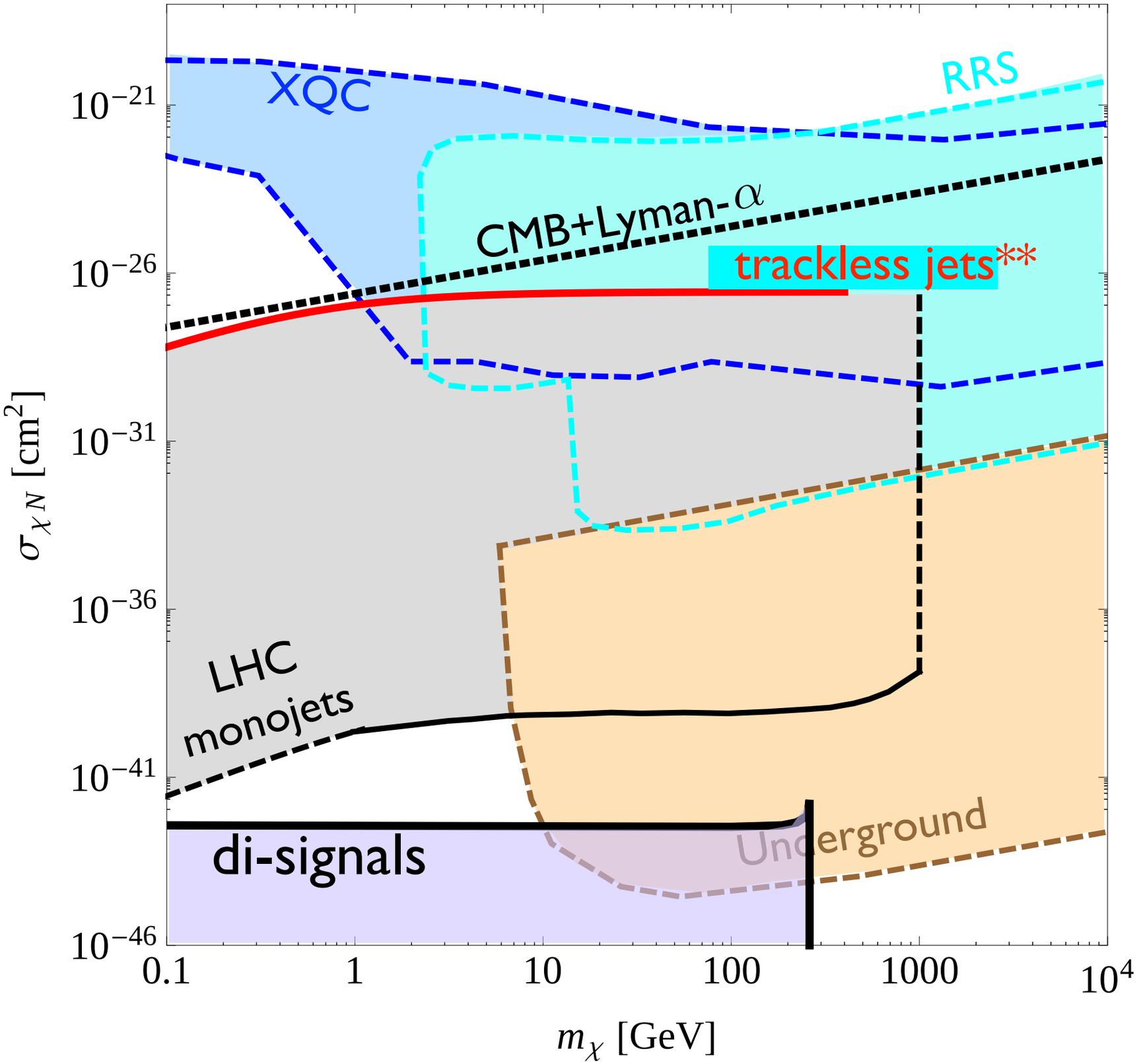


Di-signals vs. Direct Detection vs. Mono-signals



Arcadi, Mambrini, Tytgat, BZ, 1401.0221

Fun plot :-)



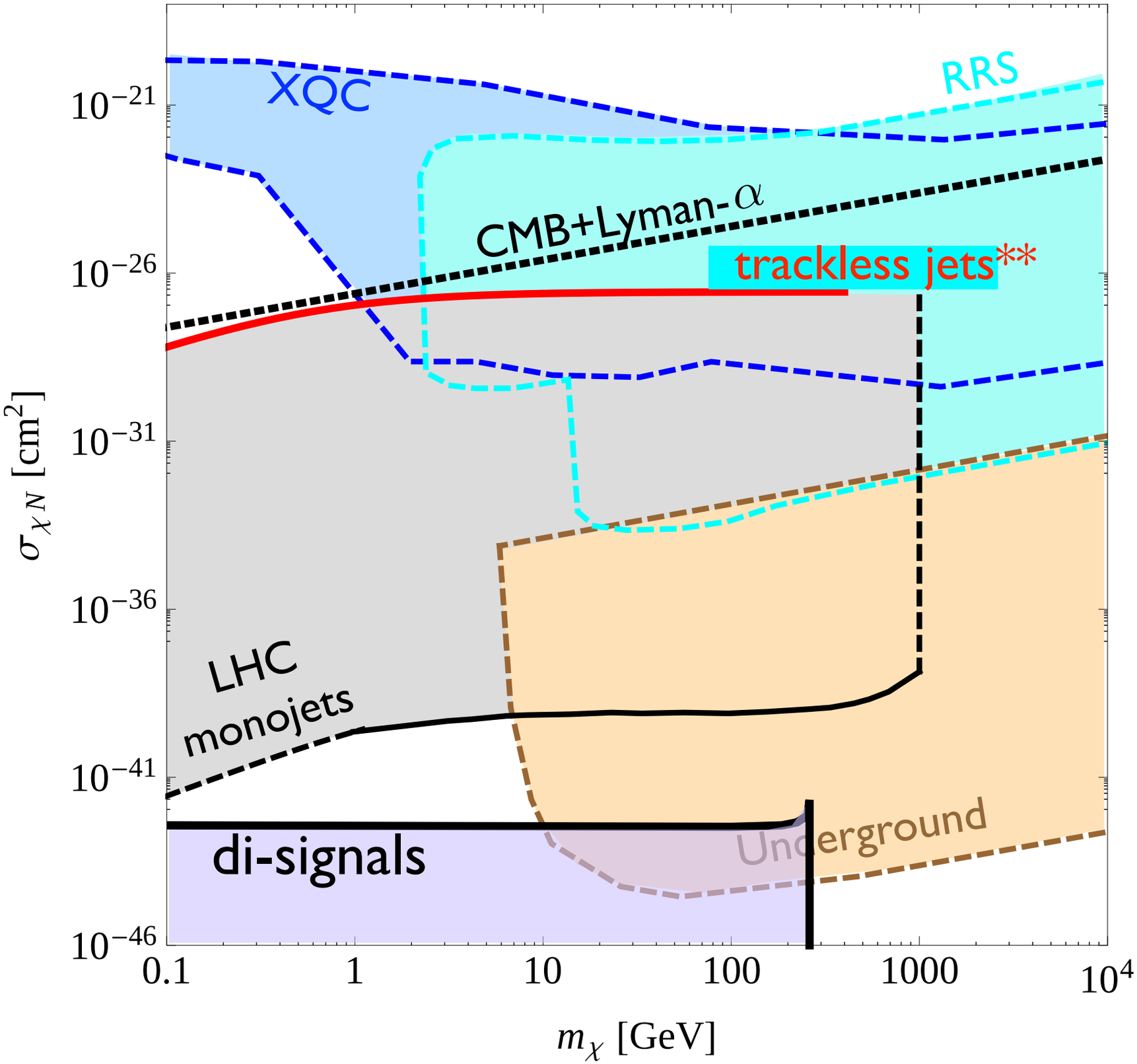
**Daci, De Bruyn, Lowette, Tytgat, BZ, 1503.05505

Conclusions

- DM@LHC more active than ever!
- EFT better understood now, Simplified Models should be the right framework to analyse new, incoming data
- Should join efforts to find a set up optimising the happiness of both experimentalists and theorists
- Simplified Models (s-channels) naturally lead to the analysis of pure visible signals, to complement ETmiss signals
- Visible signals put robust lower bounds on Direct Detection cross sections. Complementarity is enhanced.

gracias!

Fun plot :-)



**Daci, De Bruyn, Lowette, Tytgat, BZ, 1503.05505

BCKP

g_D=g

Arcadi, Mambrini, Tytgat, BZ, 1401.0221