

Invisible widths

G.F. Giudice

with A. De Simone and A. Strumia
arXiv:1402.6287

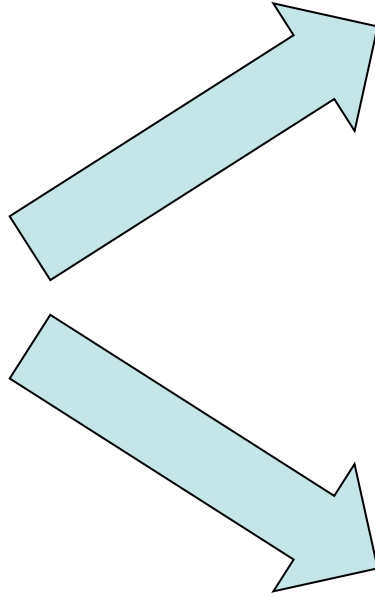


CERN, 19-21 June 2014



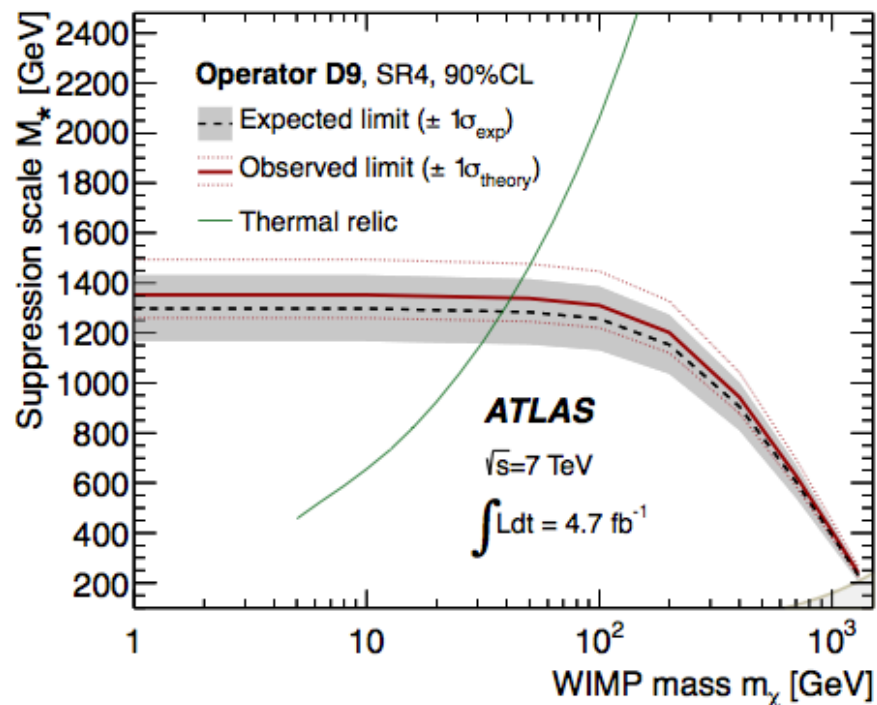
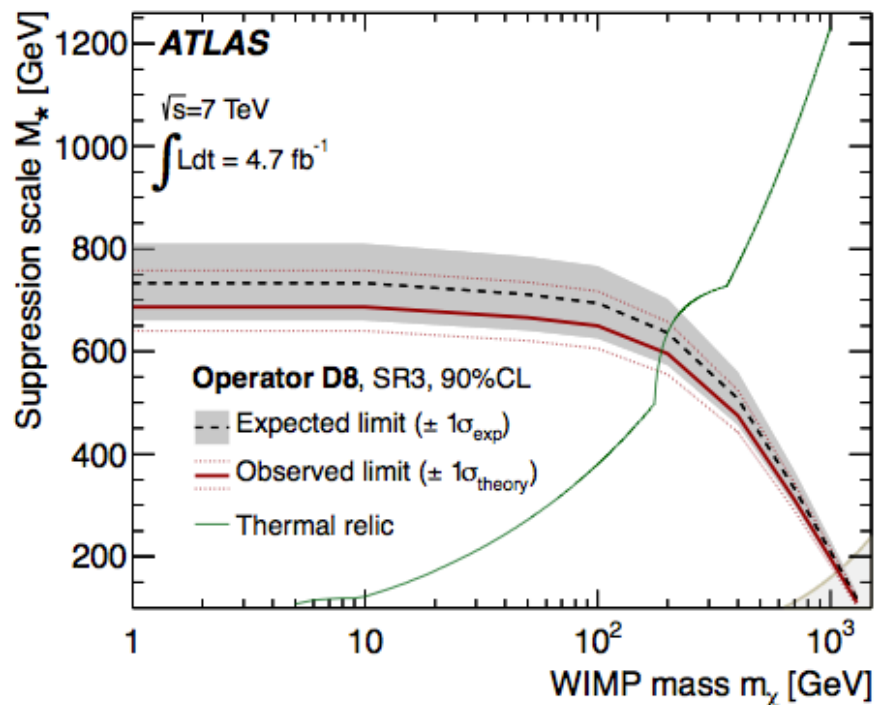
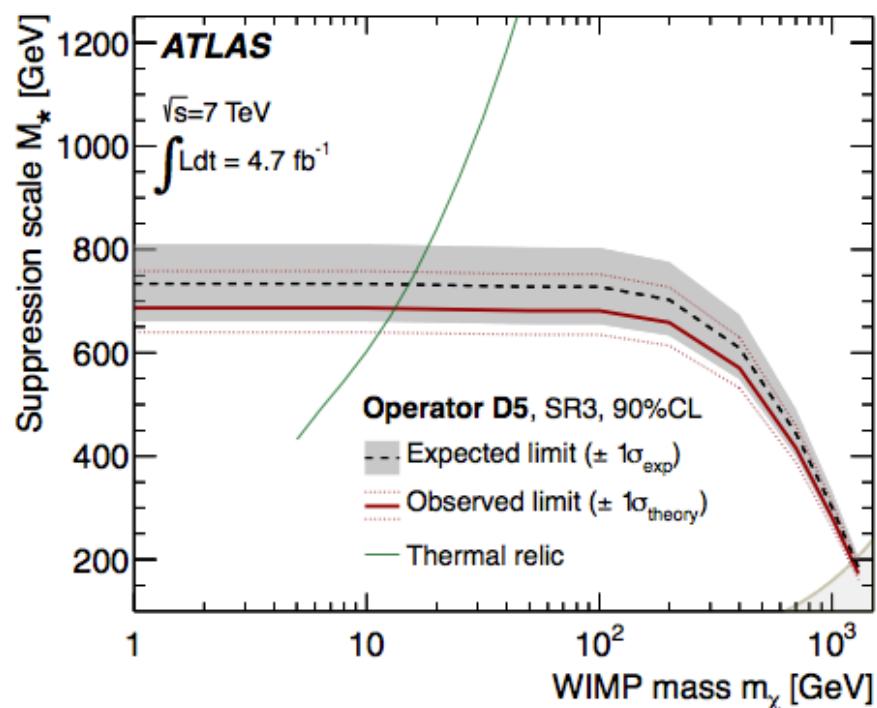
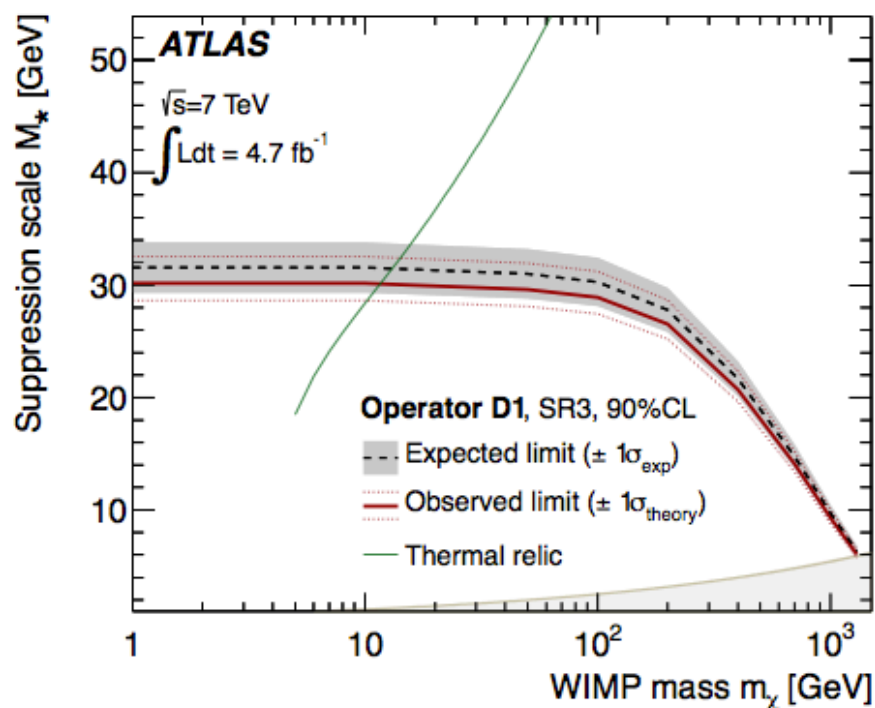
FCC-ee/TLEP physics workshop (TLEP7)

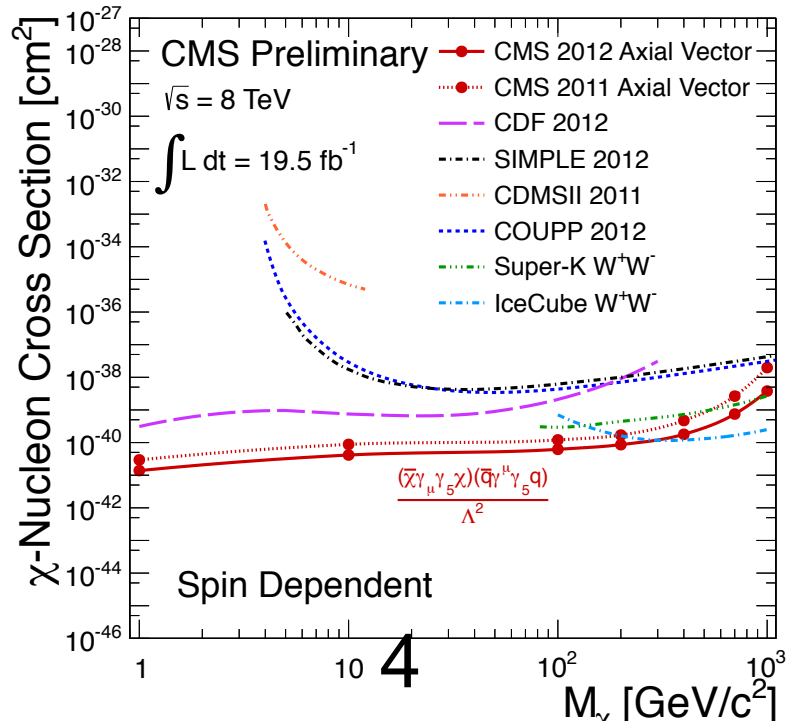
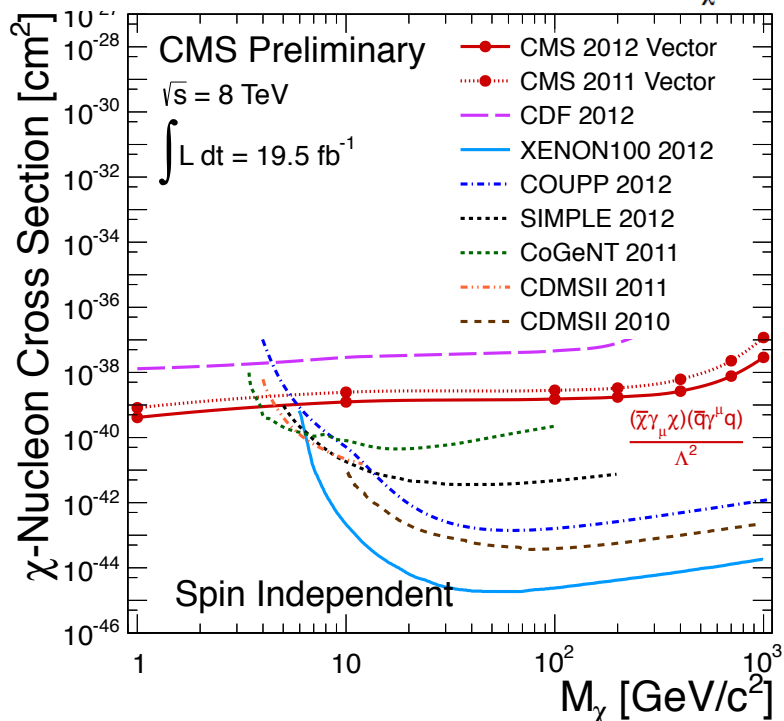
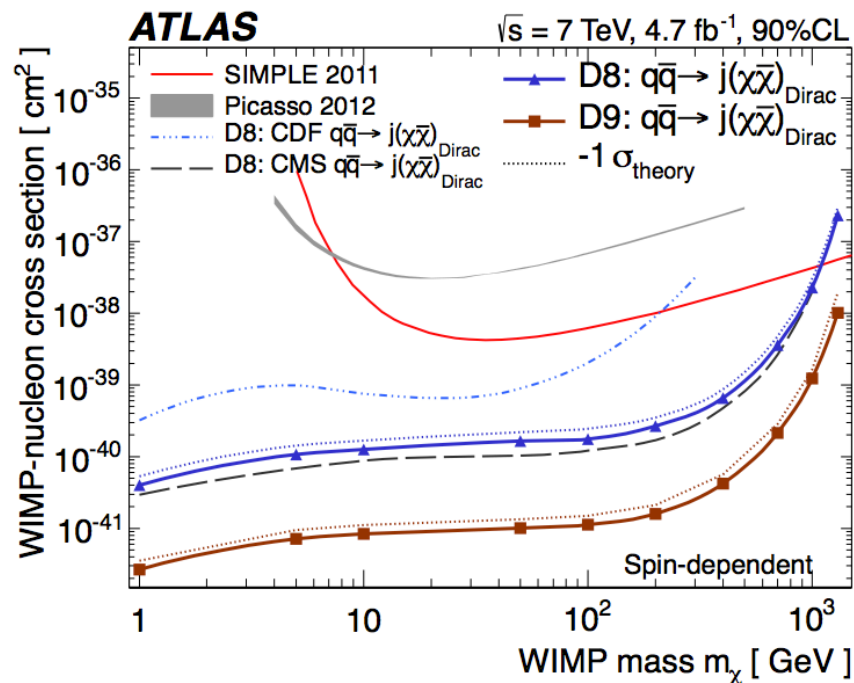
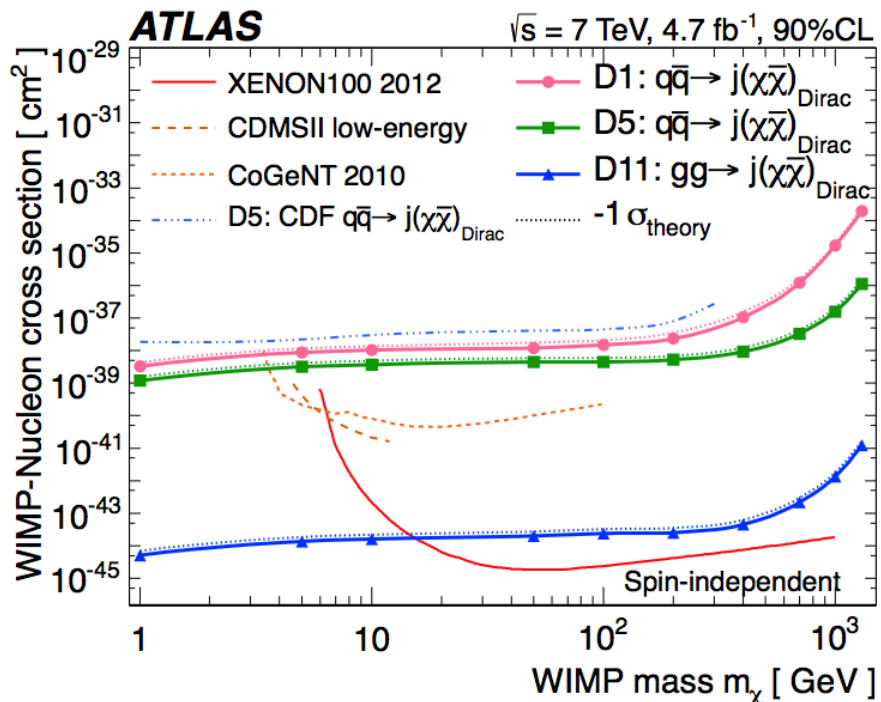
LHC



naturalness

dark matter





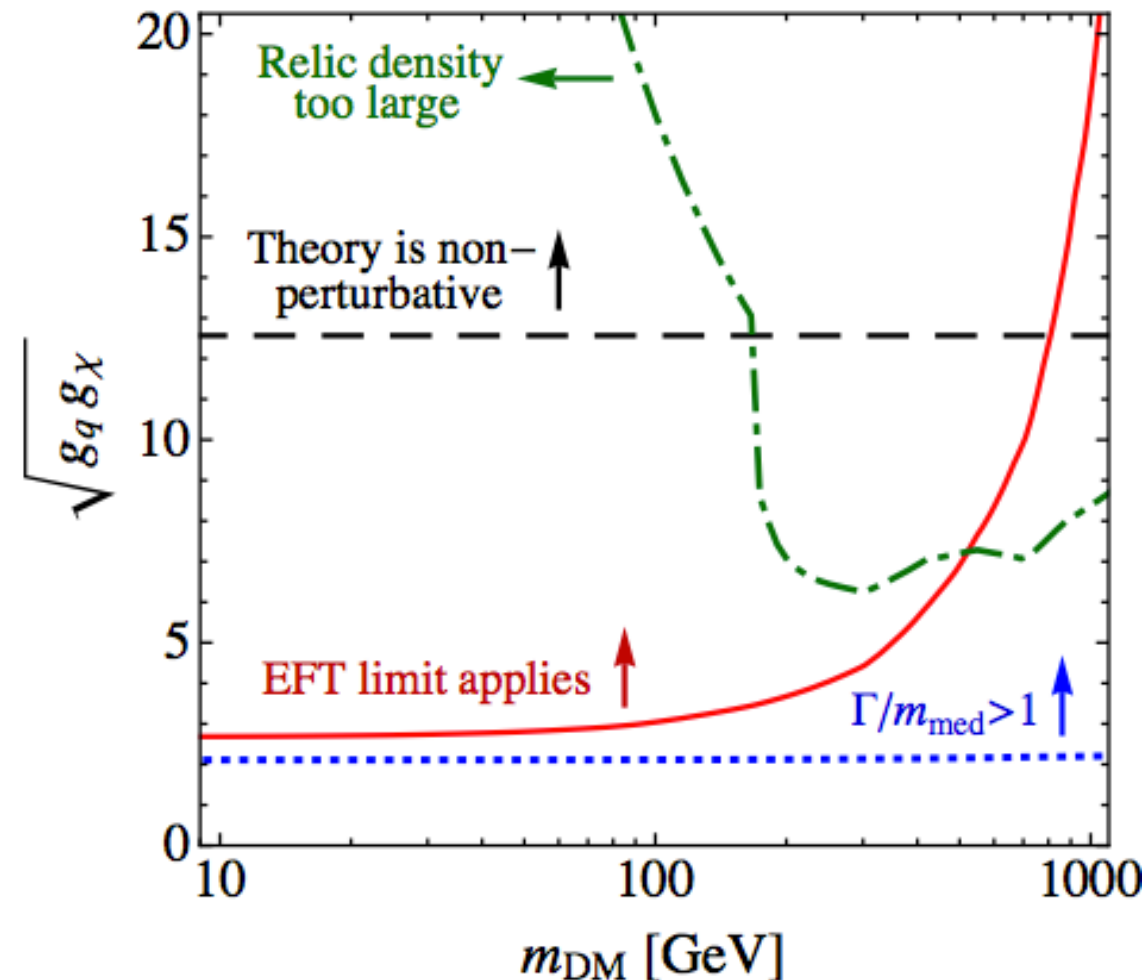
EFT

- Can overestimate LHC signals if $s > M^2$
- Can underestimate LHC signals by missing mediator production

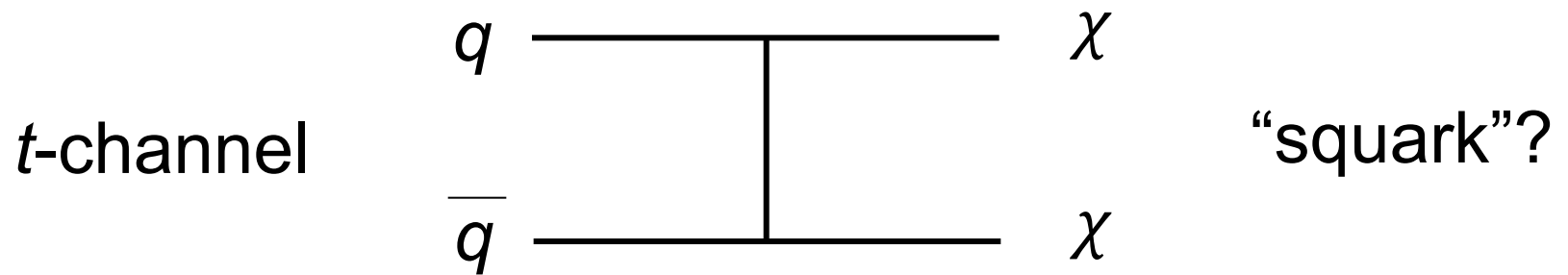
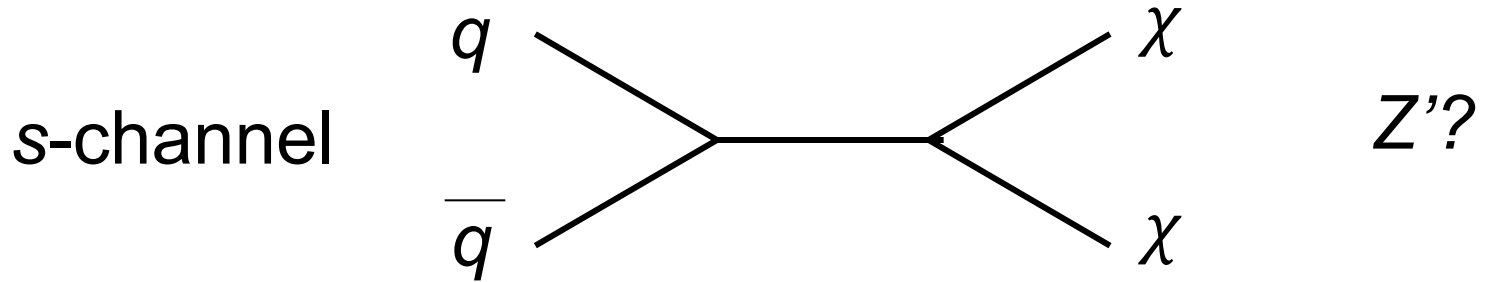
$$\frac{g_q g_\chi}{M^2} \bar{q} q \bar{\chi} \chi$$

EFT often is either not applicable to LHC or corresponds to very special theories

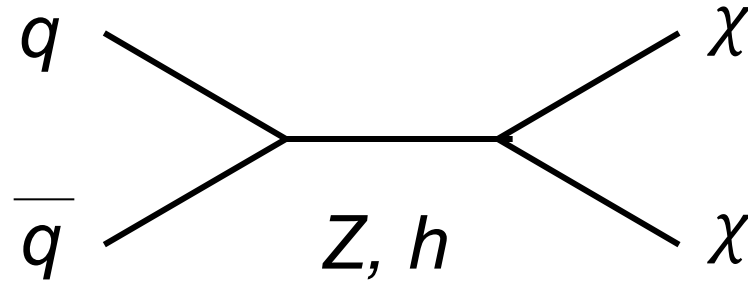
Buchmüller, Dolan, McCabe



SEARCH FOR MEDIATORS



A conservative hypothesis: SM MEDIATORS?



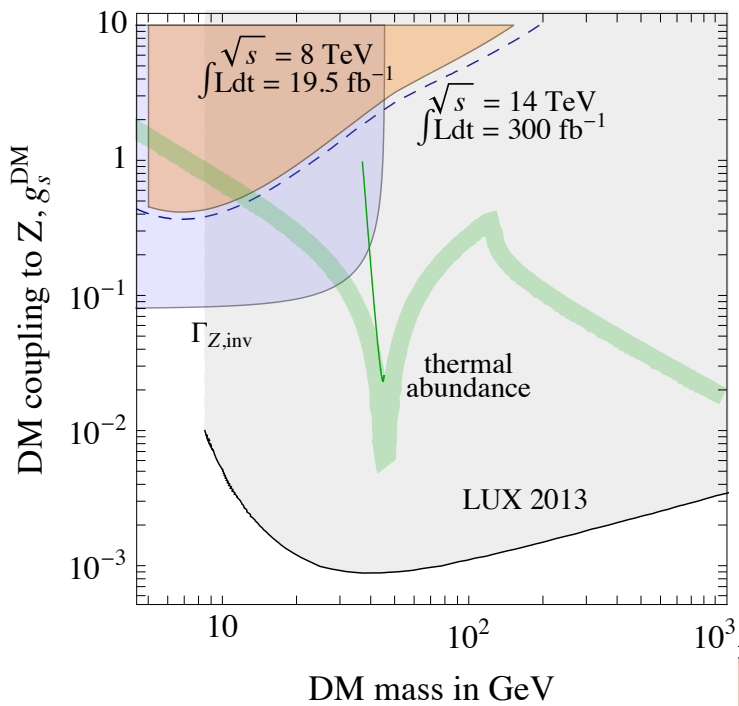
$$\mathcal{L} = -Z_\mu J_Z^\mu, \quad J_\mu^Z = \frac{g_2}{\cos \theta_W} \left[\sum_f [\bar{f} \gamma_\mu (g_V^f + \gamma_5 g_A^f) f] + \sum_s g_s [s^* (i\partial_\mu s) - (i\partial_\mu s^*) s] \right]$$

g_V, g_A, g_s arbitrary couplings (mixing of DM or Z-Z')

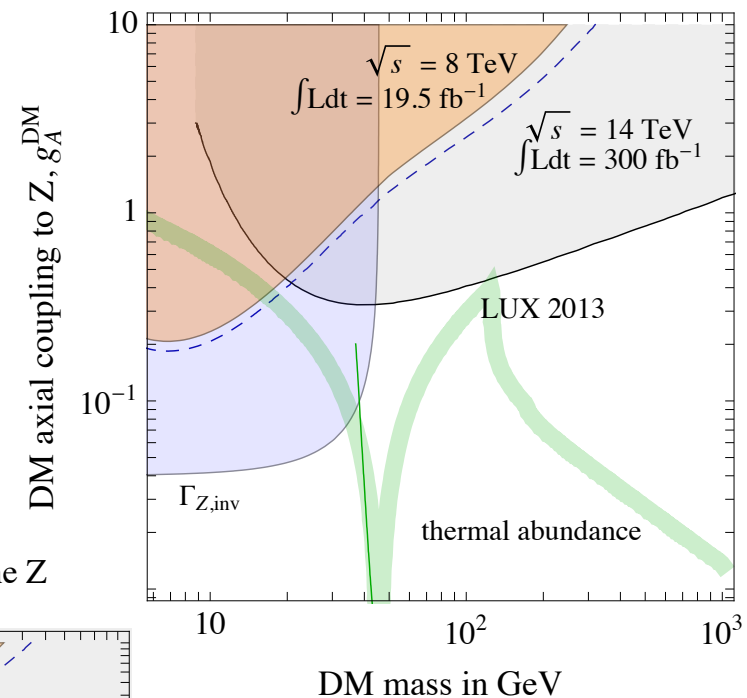
$$\mathcal{L} = -h J_h, \quad J_h = \frac{1}{\sqrt{2}} \left[\sum_f y_f \bar{f} f + \bar{\psi}_{\text{DM}} (y_{\text{DM}} + i y_{\text{DM}}^P \gamma_5) \psi_{\text{DM}} + \frac{\lambda_{\text{DM}} v}{2} s_{\text{DM}}^2 \right]$$

y, y^P, λ arbitrary couplings

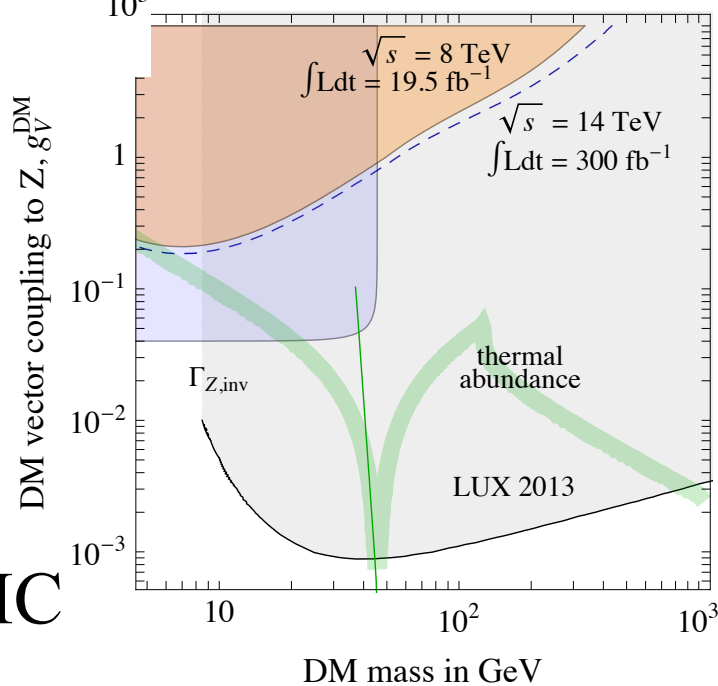
Scalar DM coupled to the Z



Fermion DM coupled to the Z

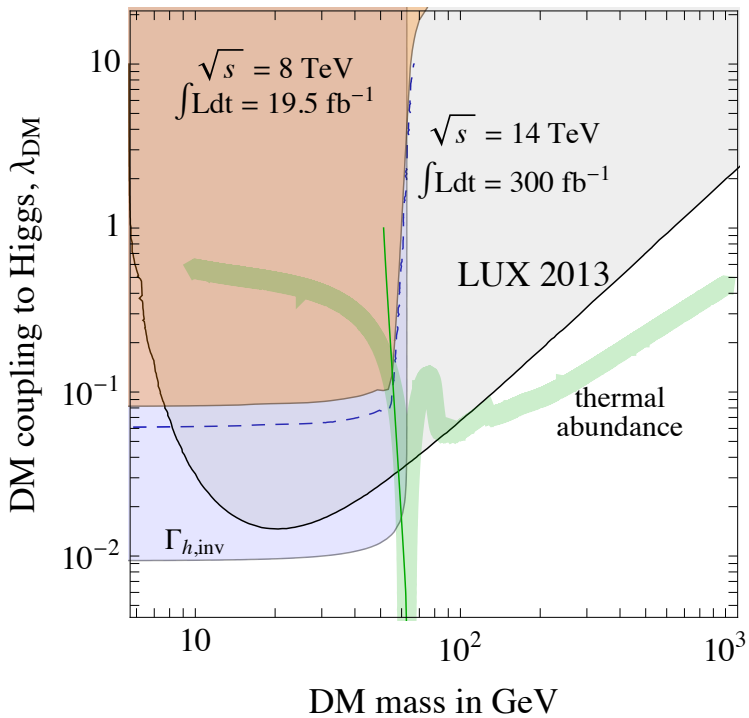


Fermion DM coupled to the Z

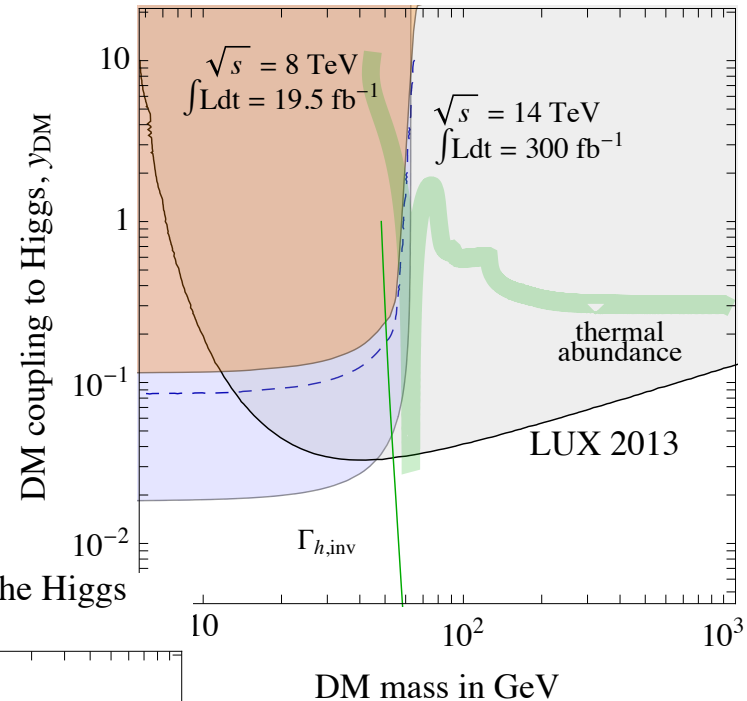


Γ_Z invisible &
direct DM
do better than LHC

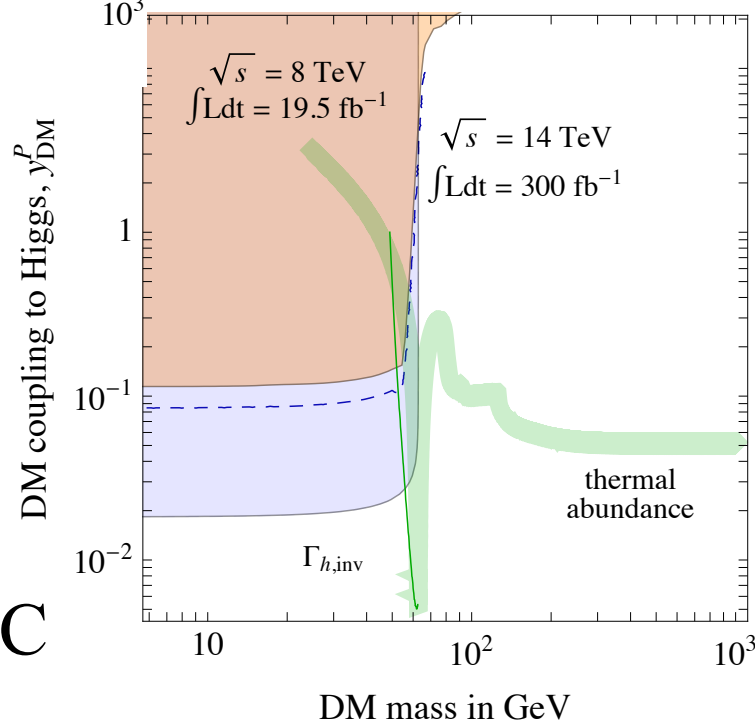
Scalar DM coupled to the Higgs



Fermion DM coupled to the Higgs



Fermion DM coupled to the Higgs



Γ_h invisible &
direct DM
do better than LHC

Γ_Z and Γ_h invisible are the most efficient way to explore SM-mediated DM at colliders

An especially interesting case:

DM freeze-out via decays

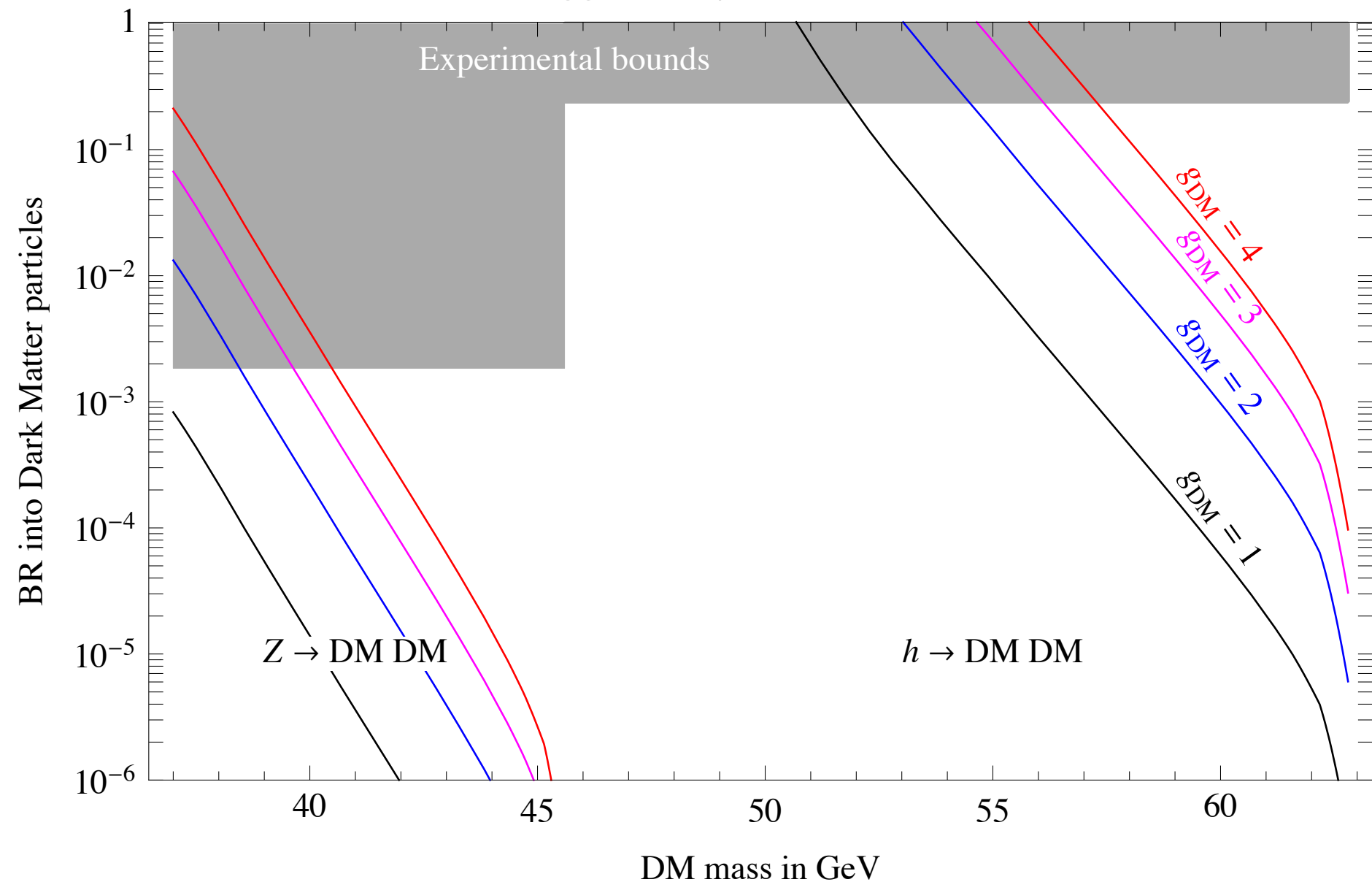
$$\text{If } M_M - 2M_{DM} < \Gamma_M$$

relic abundance determined in terms of M invisible width

$$\frac{\Omega_{DM} h^2}{0.1187} = r \frac{g_{DM}^2 10^{-12} \text{ GeV}}{g_M \Gamma_{M \rightarrow DM}} \left(\frac{M_{DM}}{\text{GeV}} \right)^3 e^{-2z_f \Delta M / M_{DM}}$$

$$\Delta M = M_M - 2M_{DM} \quad z_f \equiv 25$$

Invisible BR suggested by DM thermal relic abundance



CONCLUSIONS

Invisible Z and h widths

- efficient probe of DM (with mass $< m_h/2$)
- best collider option for models with SM mediators
- test of DM freeze-out via decays (invisible BR predicted from thermal relic abundance)