The impact of dimension-five operators on top-philic scalar DM

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Based on recent work

in collaboration with Alan Cornell, Aldo Deandrea, Benjamin Fuks, Thomas Flacke

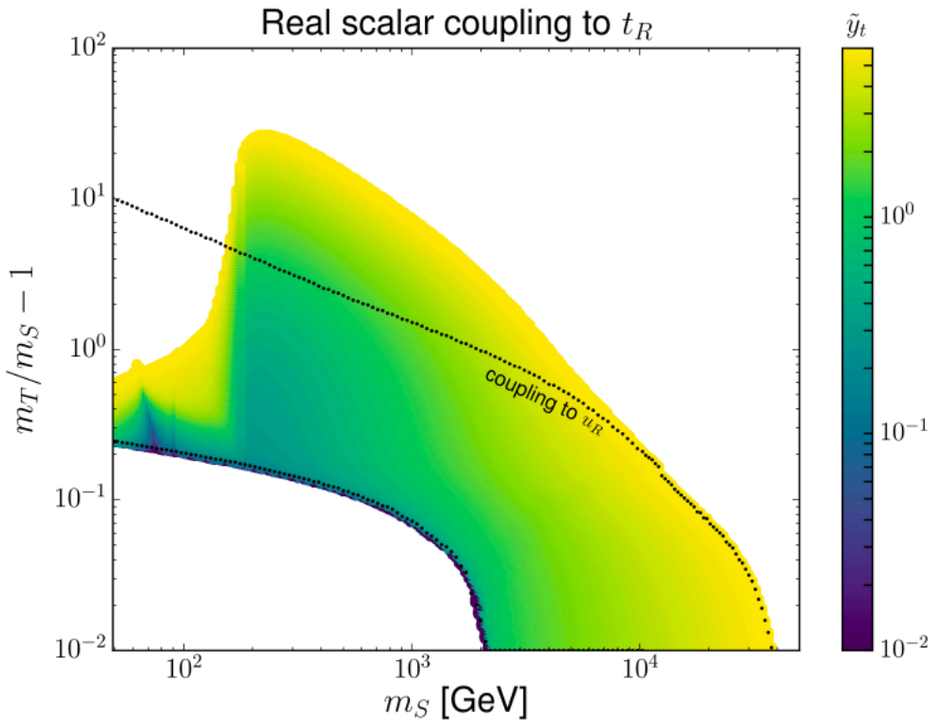
Top LHC France

6 April 2021

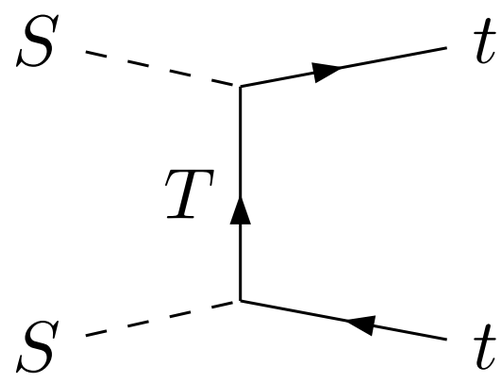
Heavy top-philic DM with a t-channel mediator

Extension of 1804.05068 (Colucci, Fuks, Giacchino, Lopez Honorez, Tytgat, Vandecasteele)

- Featuring S, T both heavy, NLO is NB



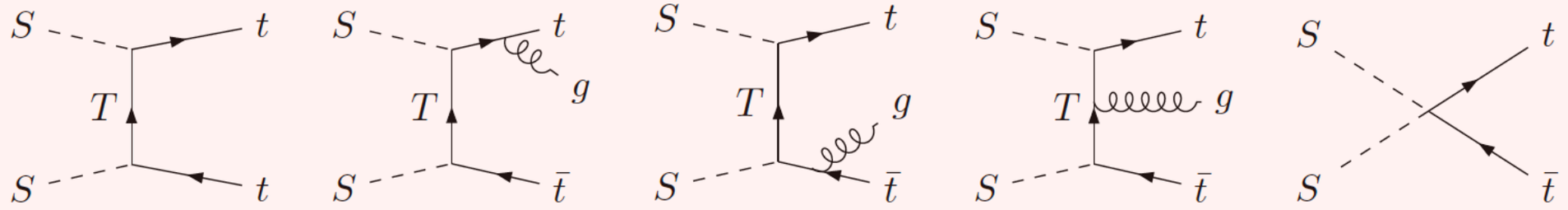
$$\sigma v_{t\bar{t}}|_{\mathrm{NLO}} \approx \begin{cases} \sigma v_{t\bar{t}} & m_S < 300\,\mathrm{GeV}, \\ \sigma v_{t\bar{t}g}|_{m_t=0} + \sigma v_{t\bar{t}} & m_S > 300\,\mathrm{GeV}. \end{cases}$$

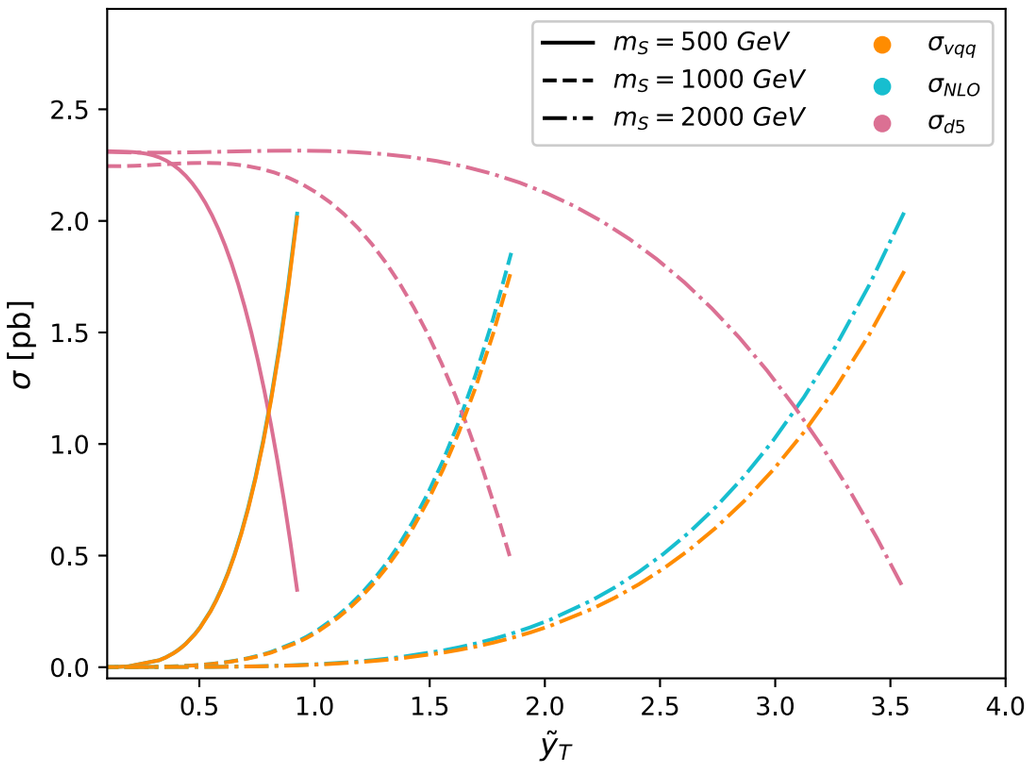


- Could S, T emerge as heavy resonances in a CH model?
- Addition of generic dim-5 operator with $\mathcal{O}(1)$ Wilson coefficient
- Paper available online in April

Our setup

$$\mathcal{L} = i\bar{T}\not{D}T - m_T\bar{T}T + \frac{1}{2}\partial_\mu S\partial^\mu S - \frac{1}{2}m_S^2 S^2 + \left[\tilde{y}_t S\bar{T}P_R t + h.c.\right] + \frac{1}{2}\lambda S^2\phi^\dagger\phi + \frac{C}{\Lambda}SSt\bar{t}$$





$$200 \text{ GeV} \lesssim m_S \lesssim 3 \text{ TeV}$$

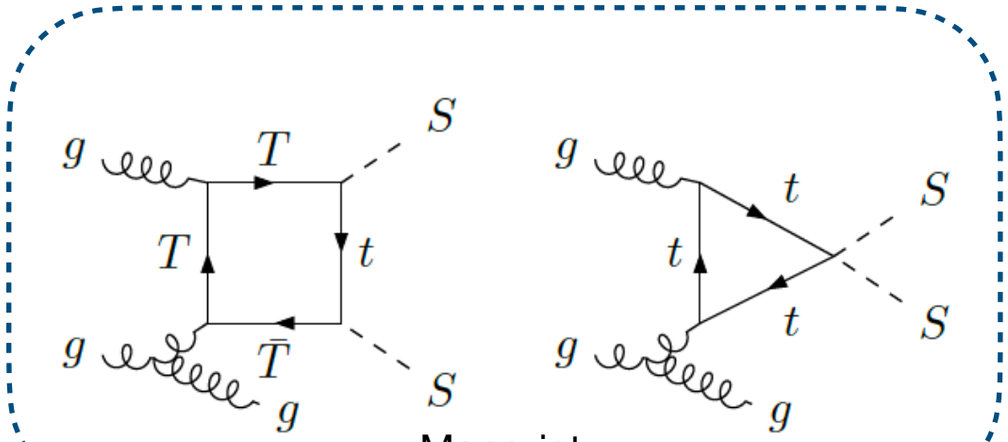
$$m_S < m_T$$

$SS \to tt$ dominates + avoids threshold effects

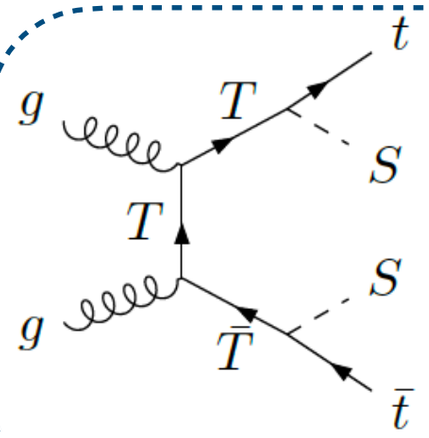
Collider: $pp \to t\bar{t}SS$

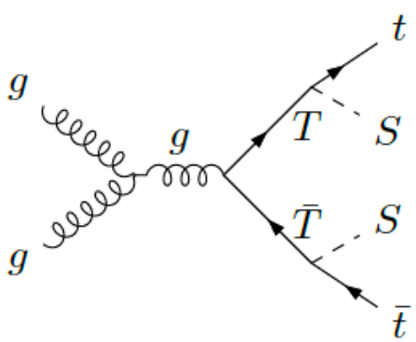
Recasting previous ATLAS and CMS analyses using MadAnalysis5

Collider signatures $(pp \to t\bar{t} + \not{E}_T)$ can be probed using existing DM searches focusing on the mono-jet / multi-jet / ttbar + MET signatures

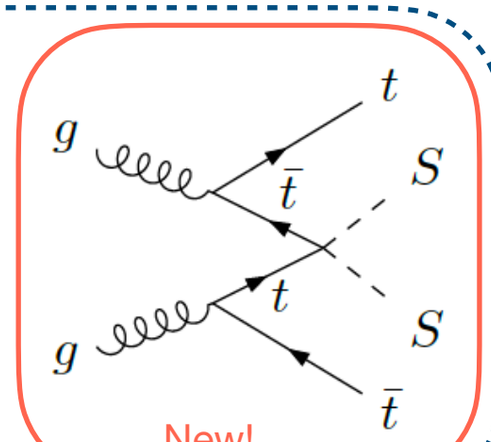


Mono-jet





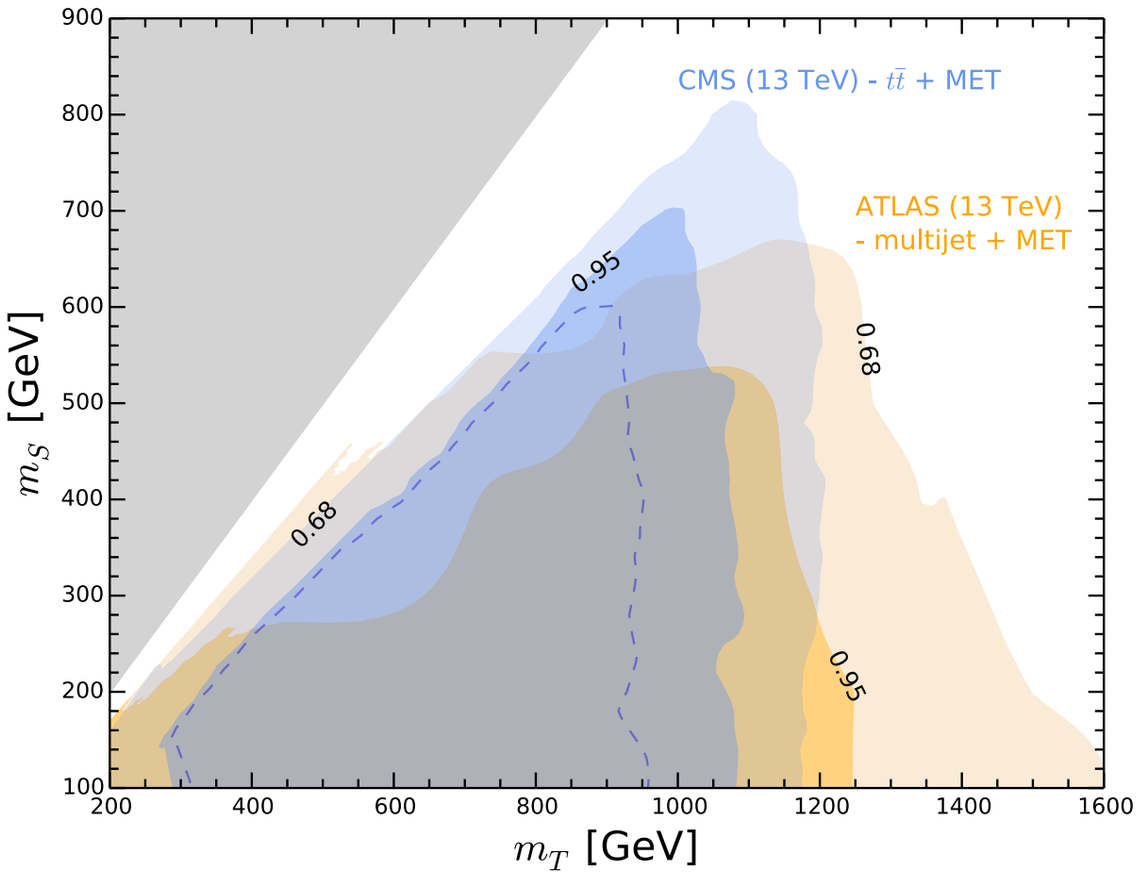
ttSS

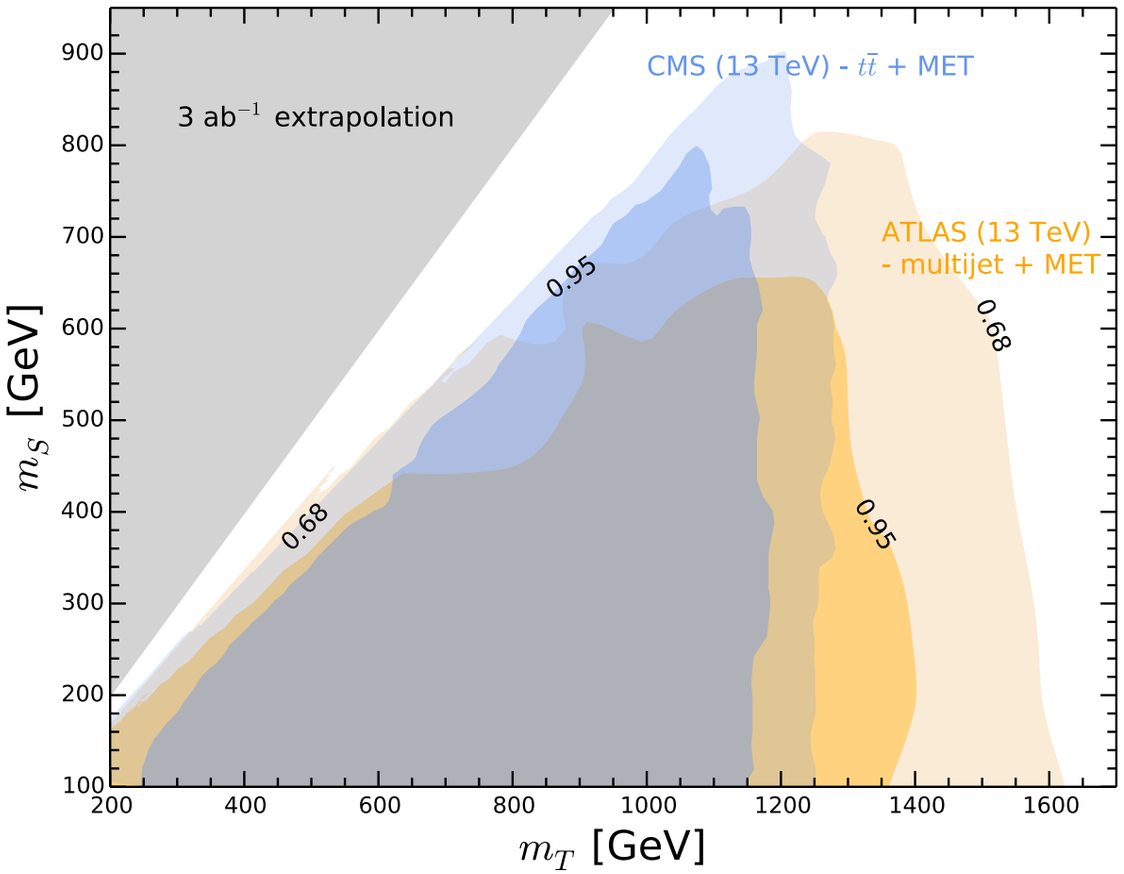


$$\sigma_{t\bar{t}SS}(M_T, M_S) = \sigma^0_{t\bar{t}SS}(M_T, M_S) + \frac{C}{\Lambda}\hat{\sigma}^{\text{int}}_{t\bar{t}SS}(M_T, M_S) + \frac{C^2}{\Lambda^2}\hat{\sigma}^{\text{dim5}}_{t\bar{t}SS}(M_S)$$

Collider: Madanalysis5 recasting

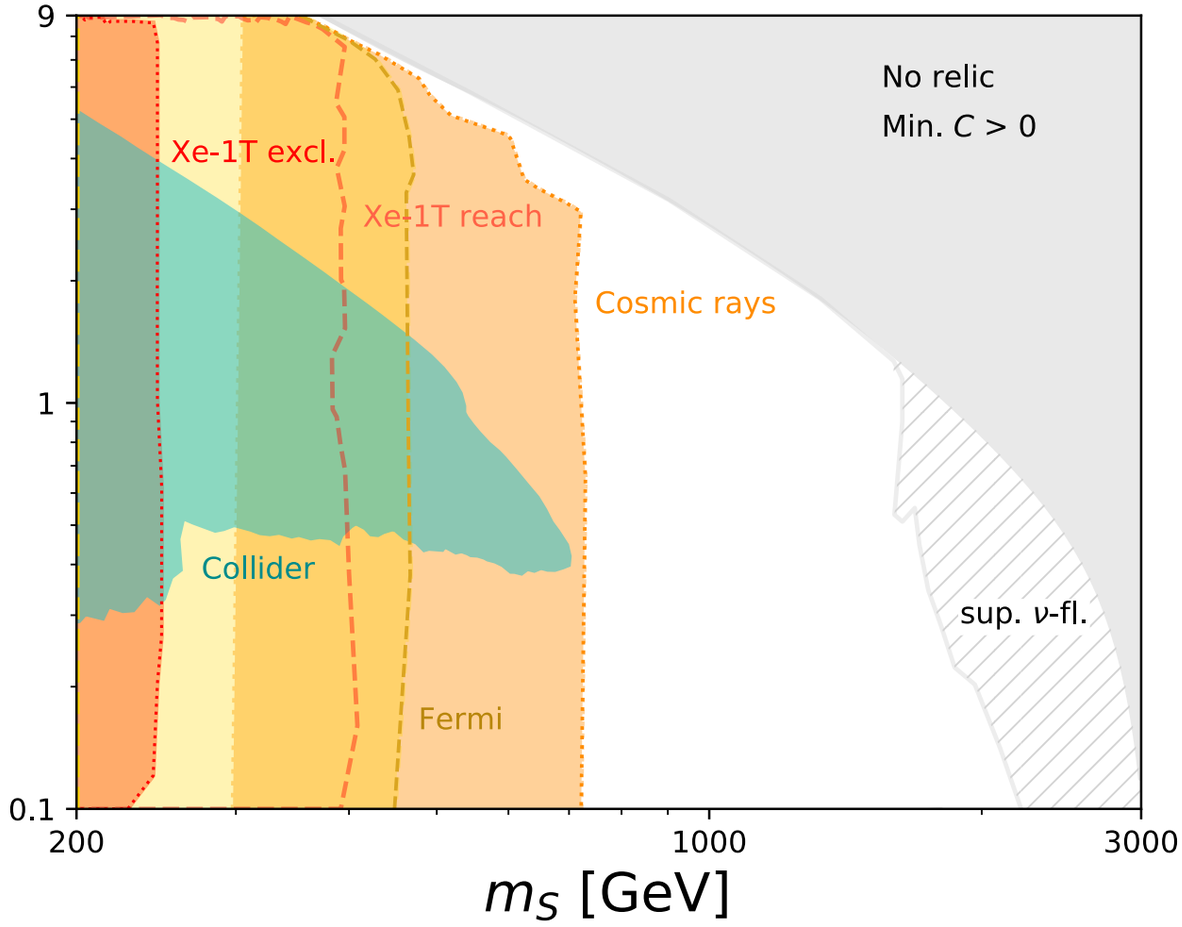
- Multi-jet: ATLAS_CONF_2019_040 (≥ 2 hard jets + $\overrightarrow{p}_T^{\text{miss}}$, 139 fb^{-1})
- ttbar + MET: CMS_SUS_17_001 ($\ell^+\ell^-$ + $\overrightarrow{p}_T^{\text{miss}}$, 35.9 fb^{-1})
- Additional operator yields no significant modification



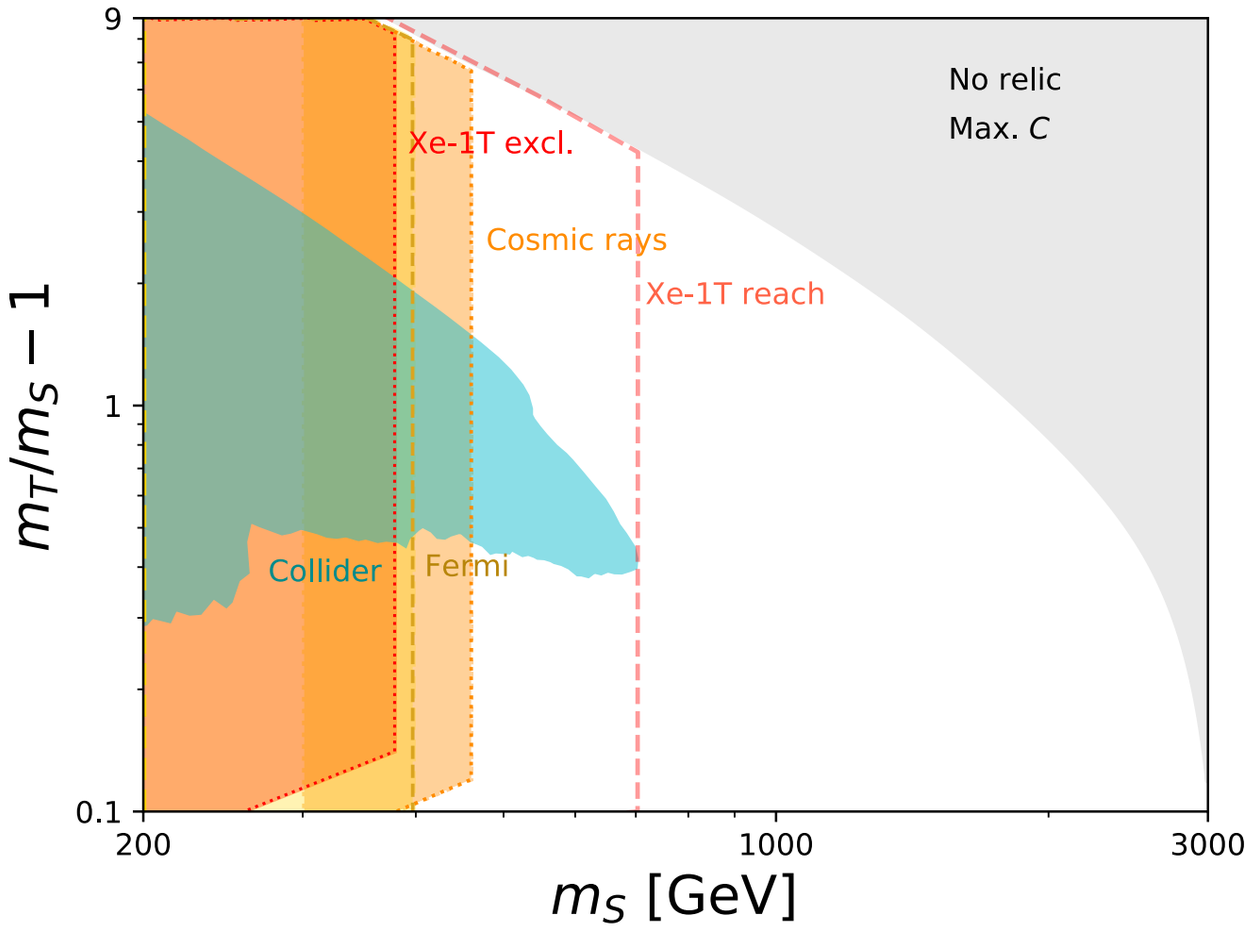


Re scaling: see 1910.11418 (Araz, Frank, Fuks)

Exclusions



- Complementarity of collider constraints with astrophysical ones (more affected by the contact term)

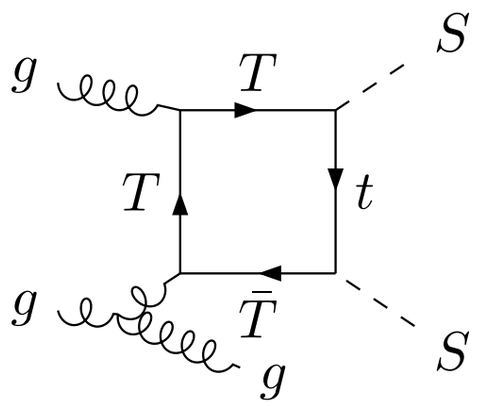


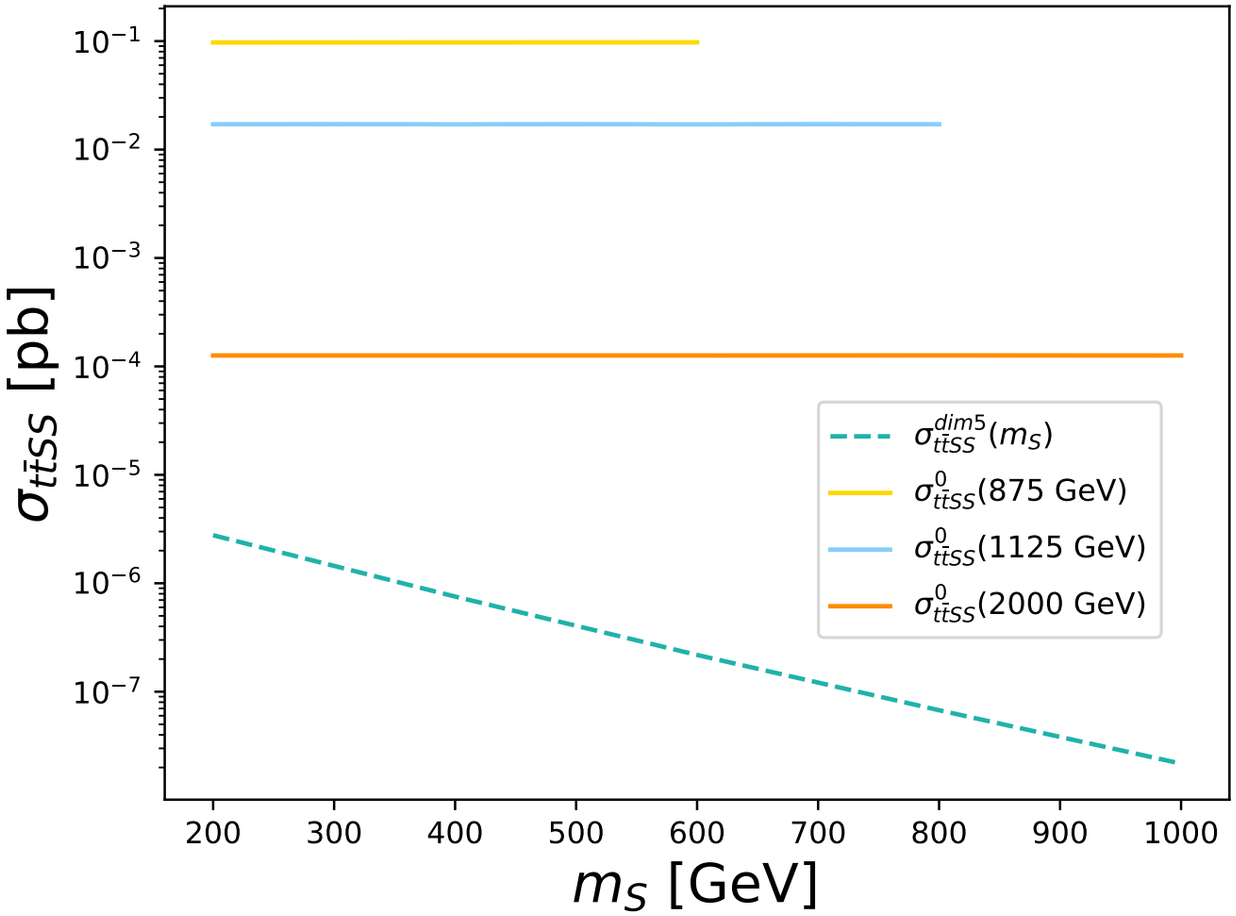
- LHC bounds due to extrapolation to full Run-2
- Larger luminosities hold even more potential
- Wilson coefficient dep. on underlying theory, but collider immune

BACKUP

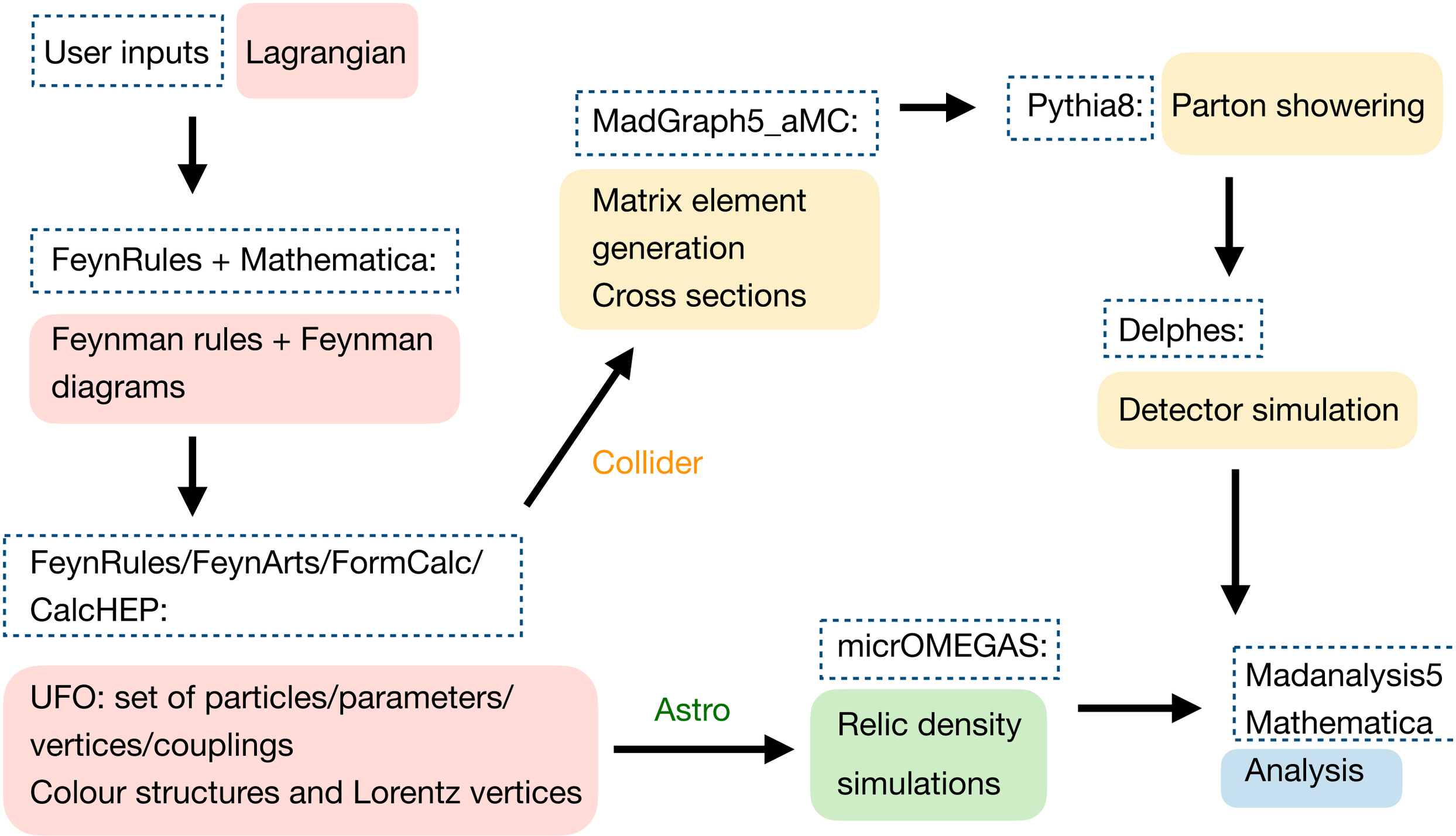
Collider: Madanalysis5 recasting

- Mono-jet: ATLAS_EXOT_2016_27 (energetic jet and large missing momentum, 36.1 fb^{-1})
- Shown previously to have minimal contribution.





Simulation ecosystem



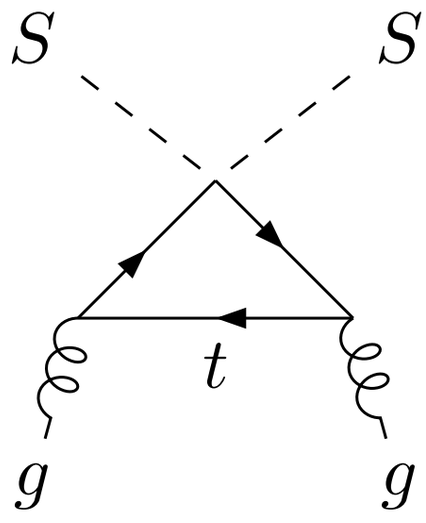
Direct detection

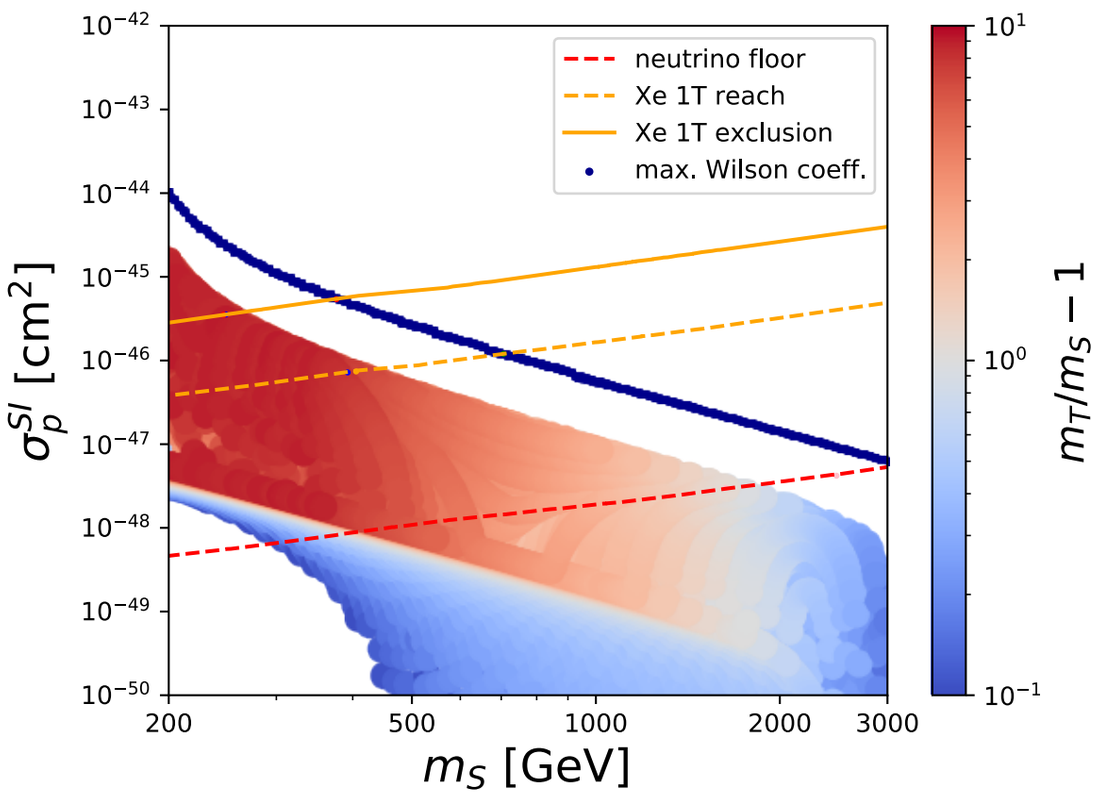
Scattering off atomic nuclei: DM gluon interactions

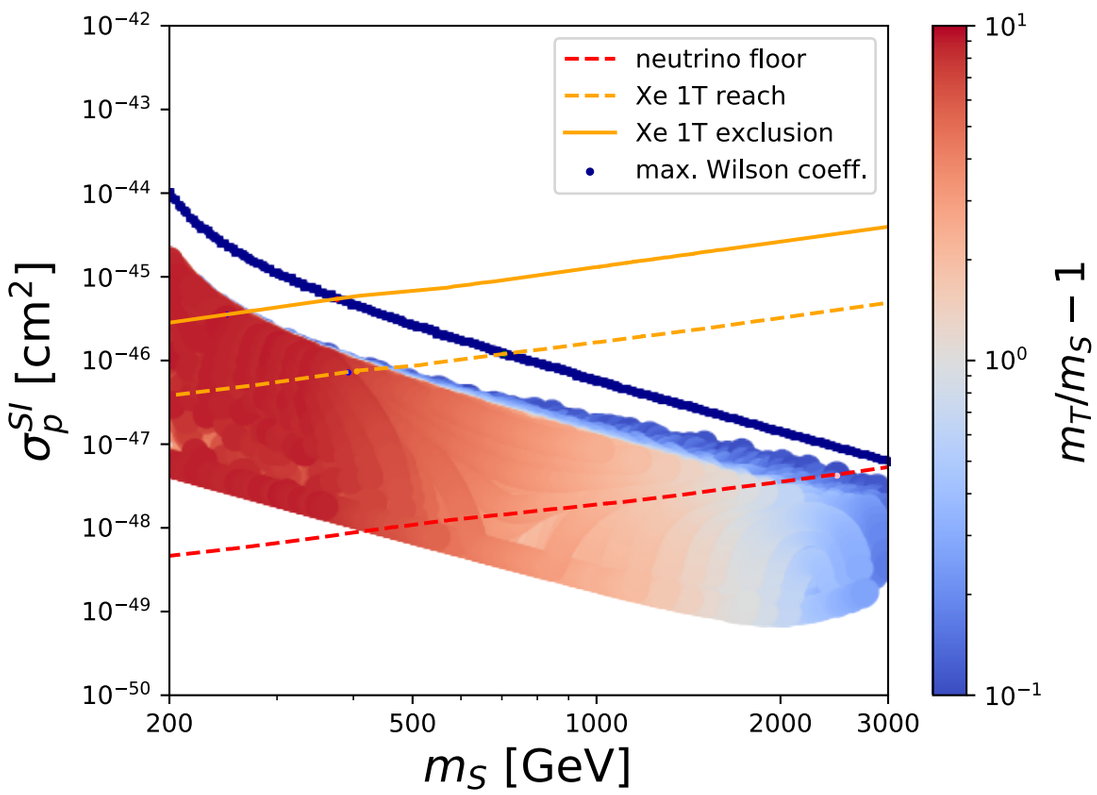
Examine several key points: max C, min pos C, min neg C

Gap would be filled by all C

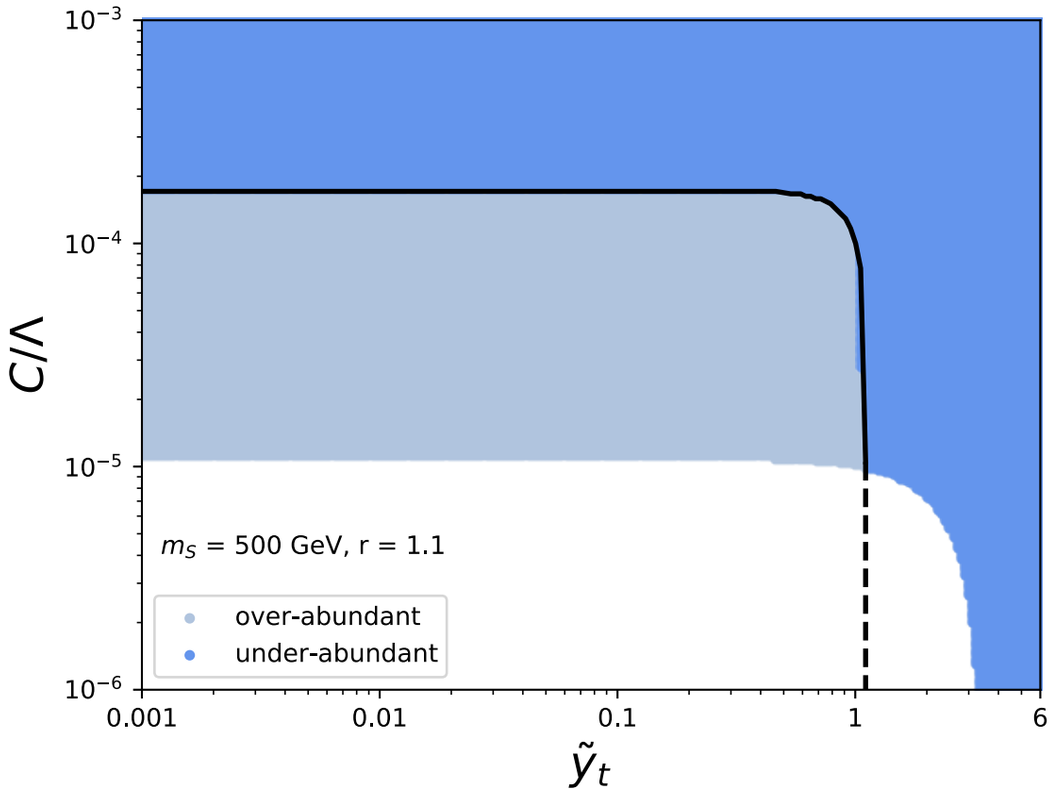
$$\mathscr{L} = C_S^g \mathcal{O}_S^g = C_S^g \frac{\alpha_s}{\pi} S^2 G^{\mu\nu} G_{\mu\nu}$$

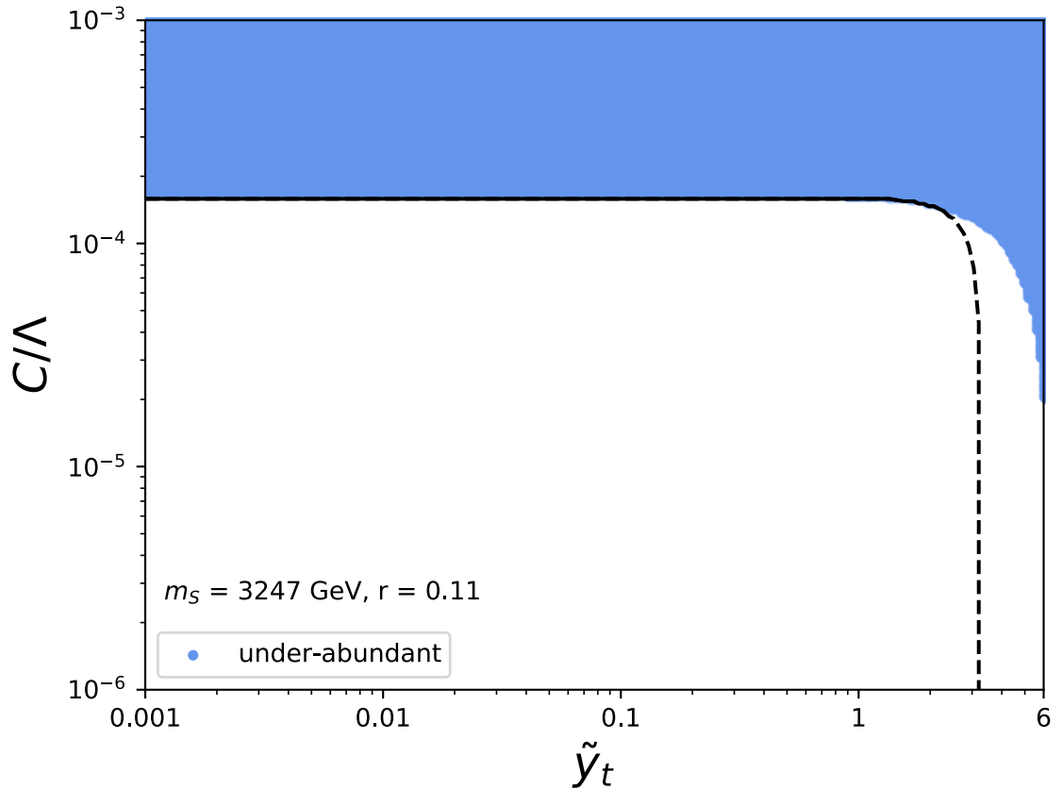




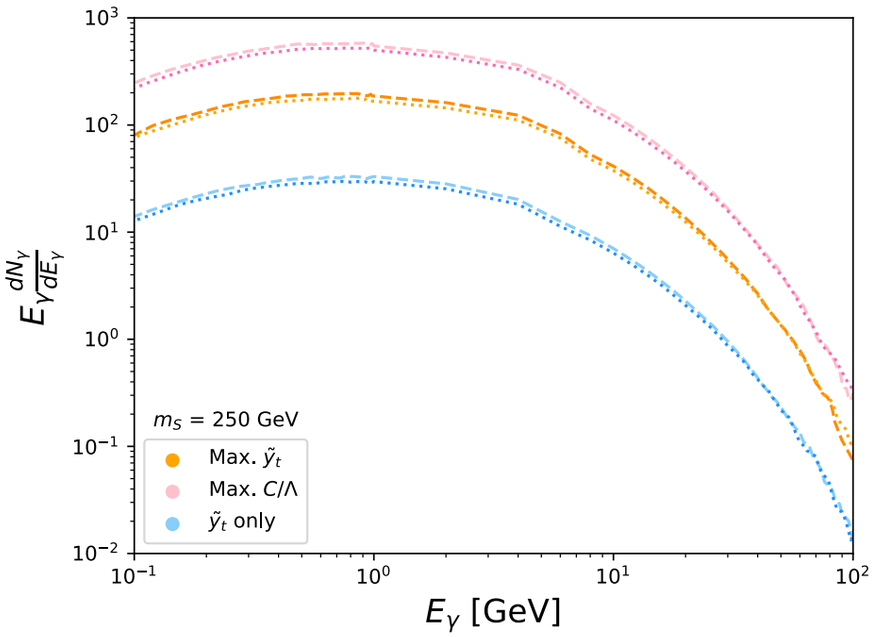


Direct detection





Indirect detection



$$\sigma v_{t\bar{t}} = \sigma v_{b\bar{b}} \frac{N_\gamma^{b\bar{b}}}{N_\gamma^{t\bar{t}}}$$

In indirect detection of DM, experiments aim to measure the annihilation or decays of the WIMPS via the SM particles produced during these processes