Global scans of combined EFT operators

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Paper in preparation with...

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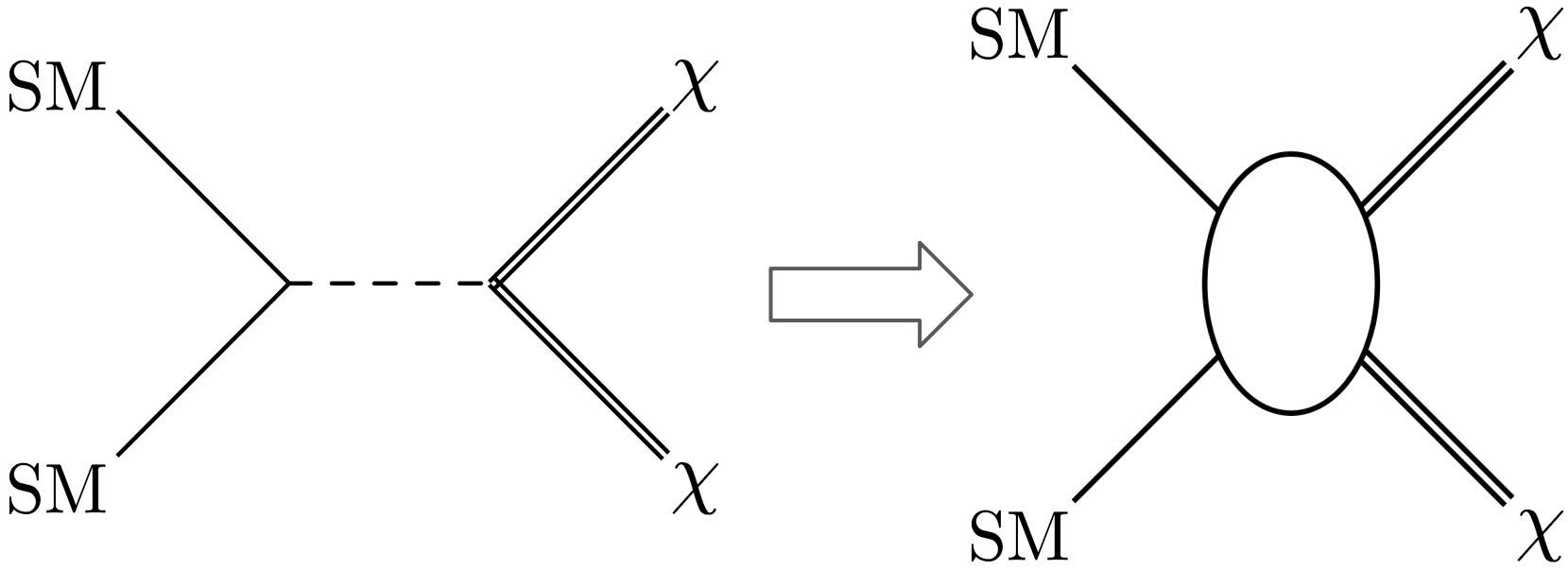
EFT? - Effective field theory



DM-parton EFT operators

Real scalar DM operators		
Label	Usual definition	Our definition
R1	$\frac{m_q}{2M^2}\,\chi^2\bar{q}q$	$\lambda_1\, m_q\chi^2\bar{q}q$
R2	$i\frac{m_q}{2M^2}\,\chi^2\bar{q}\gamma^5 q$	$\lambda_2\, i m_q\chi^2\bar{q}\gamma^5 q$
R3	$\frac{\alpha_s}{4M^2}\,\chi^2 G_{\mu\nu}G^{\mu\nu}$	$\lambda_3\,\chi^2 G_{\mu\nu}G^{\mu\nu}$
R4	$i\frac{\alpha_s}{4M^2}\,\chi^2 G_{\mu\nu}\tilde{G}^{\mu\nu}$	$\lambda_4\, i\chi^2 G_{\mu\nu}\tilde{G}^{\mu\nu}$

Goodman et al. arXiv:1008.1783

Complex scalar DM operators		
Label	Usual definition	Our definition
C1	$\frac{m_q}{M^2}\,\chi^\dagger\chi\bar{q}q$	$\lambda_1\, m_q\chi^\dagger\chi\bar{q}q$
C2	$i\frac{m_q}{M^2}\,\chi^\dagger\chi\bar{q}\gamma^5 q$	$\lambda_2\, i m_q\chi^\dagger\chi\bar{q}\gamma^5 q$
C3	$\frac{1}{M^2}\,\chi^\dagger\partial_\mu\chi\bar{q}\gamma^\mu q$	$\lambda_3\,\chi^\dagger\partial_\mu\chi\bar{q}\gamma^\mu q$
C4	$\frac{1}{M^2}\,\chi^\dagger\partial_\mu\chi\bar{q}\gamma^\mu\gamma^5 q$	$\lambda_4\,\chi^\dagger\partial_\mu\chi\bar{q}\gamma^\mu\gamma^5 q$
C5	$\frac{\alpha_s}{8M^2}\,\chi^\dagger\chi G_{\mu\nu}G^{\mu\nu}$	$\lambda_5\,\chi^\dagger\chi G_{\mu\nu}G^{\mu\nu}$
C6	$i\frac{\alpha_s}{8M^2}\,\chi^\dagger\chi G_{\mu\nu}\tilde{G}^{\mu\nu}$	$\lambda_6\, i\chi^\dagger\chi G_{\mu\nu}\tilde{G}^{\mu\nu}$

Our idea – combine all operators

If the EFT operators span the theory space then

scan all EFT op ⇨ scans the theory space.

$$\mathcal{L} \supset \sum_i \lambda_i \mathcal{O}_i$$

ASSUMES two separate scales; DM mass and mediator mass.

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Parameters not fully independent!

$$M > 2m_\chi, \quad g_1 g_2 \leq (4\pi)^2, \quad \lambda_i = k_i \frac{g_1 g_2}{M^2}$$

$$\Rightarrow \lambda_i \leq \frac{k_i \pi^2}{4m_\chi^2}$$

Bayesian scanning with MultiNEST

Our hammer: SuperBayeS ⇨ EFTBayeS

Highly efficient at scanning the posterior distribution. Needs likelihood implementations.

Log priors: $m_\chi \in [1, 1000]\,\mathrm{GeV}, \quad \left|\frac{4m_\chi^2}{k_i \pi^2}\lambda_i\right| \in [10^{-20}, 1]$

Data and likelihood

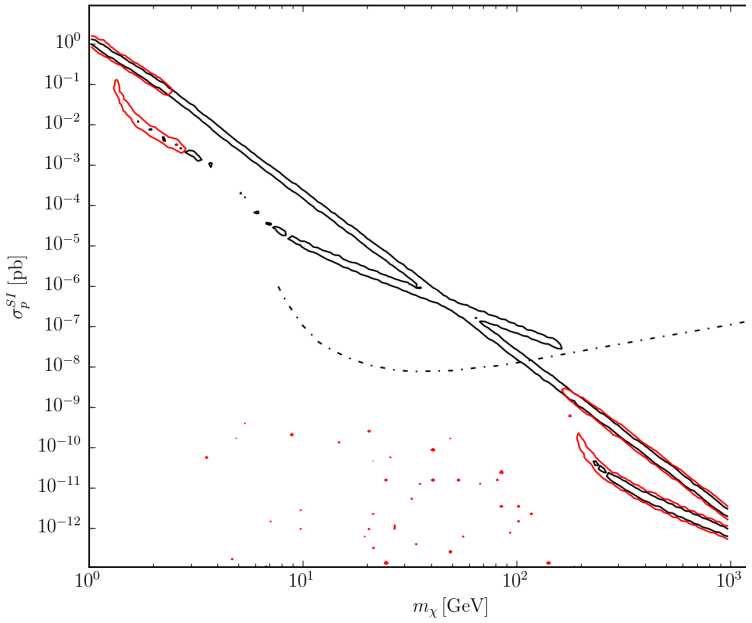
Relic density measurement from Planck (arxiv:1502.01589) using simple normal distribution.

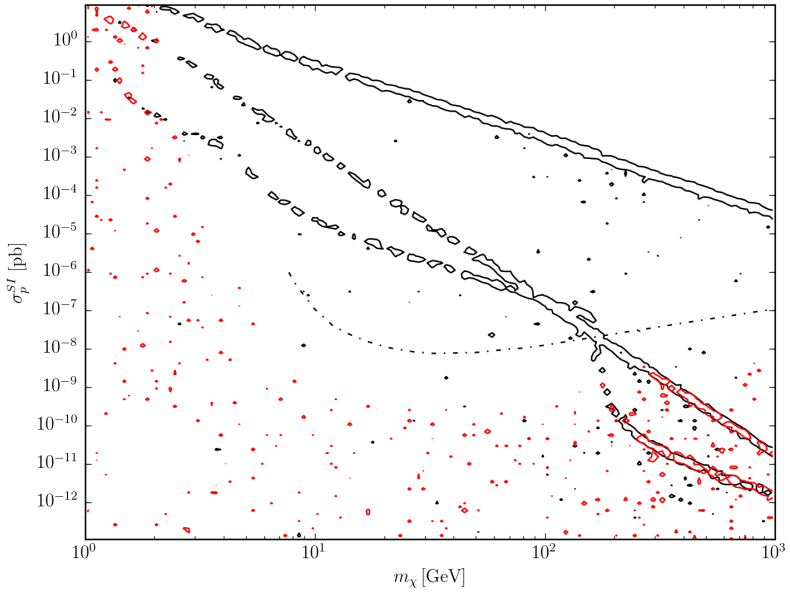
LUX limits on spin independent cross-section (arxiv:1310.8214), using LUXCalc code by Savage et al. (arxiv:1502.02667)

Galactic Centre Excess as measured by Fermi-LAT using likelihood implementation by Calore & Weniger (arxiv:1409.0042)

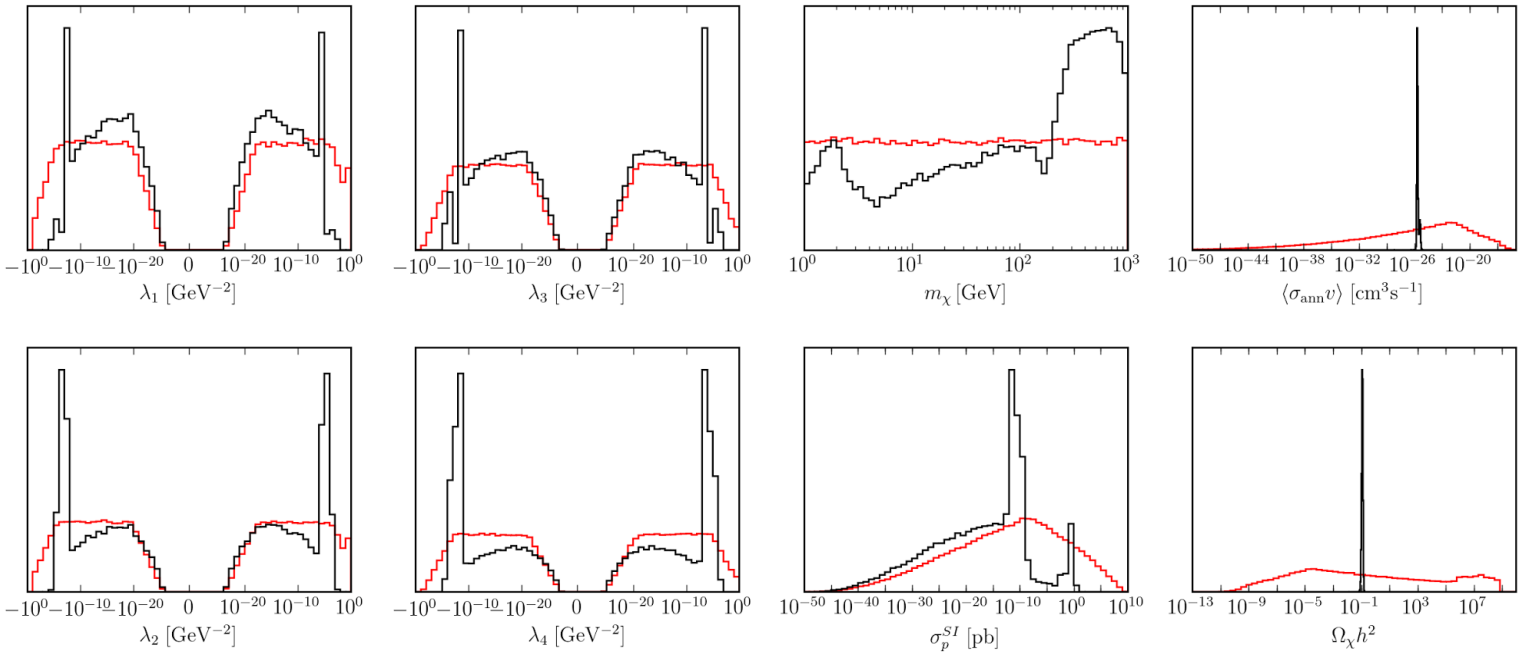
Results

Relic density and LUX



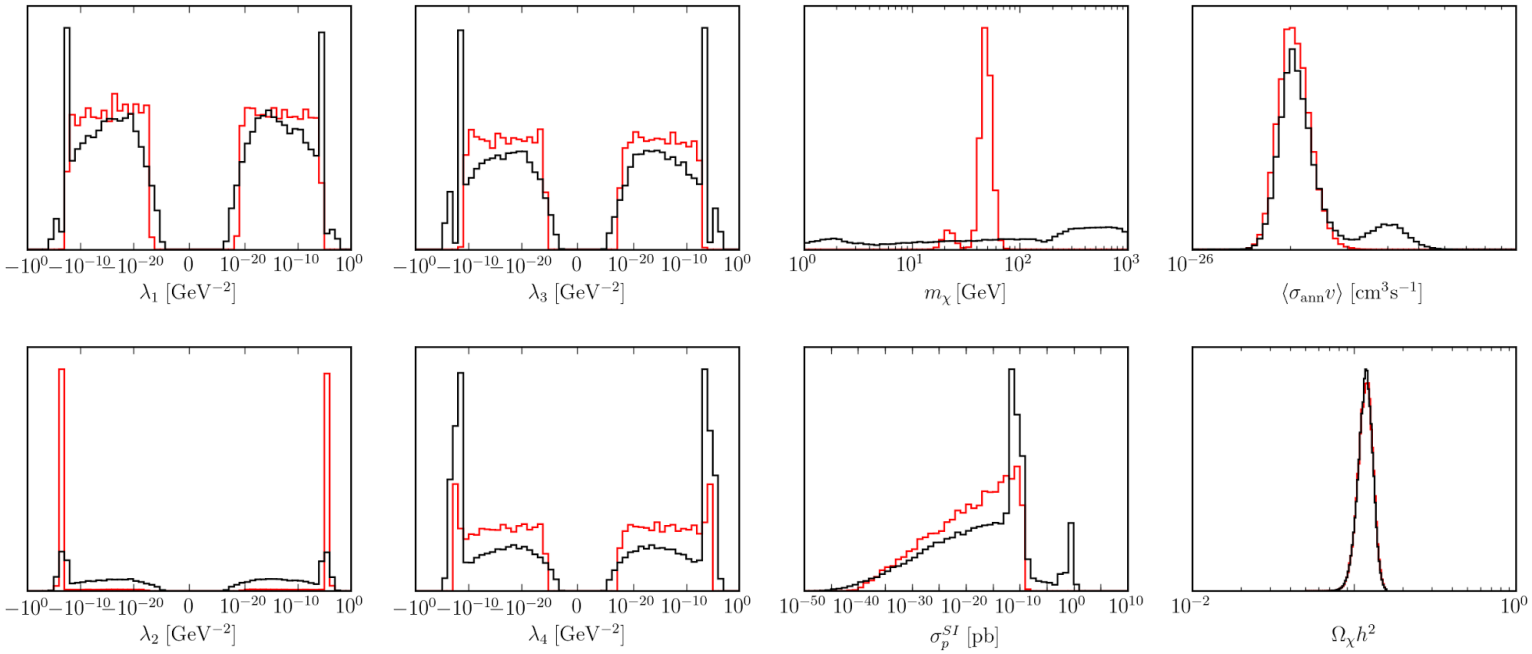


Real scalar DM



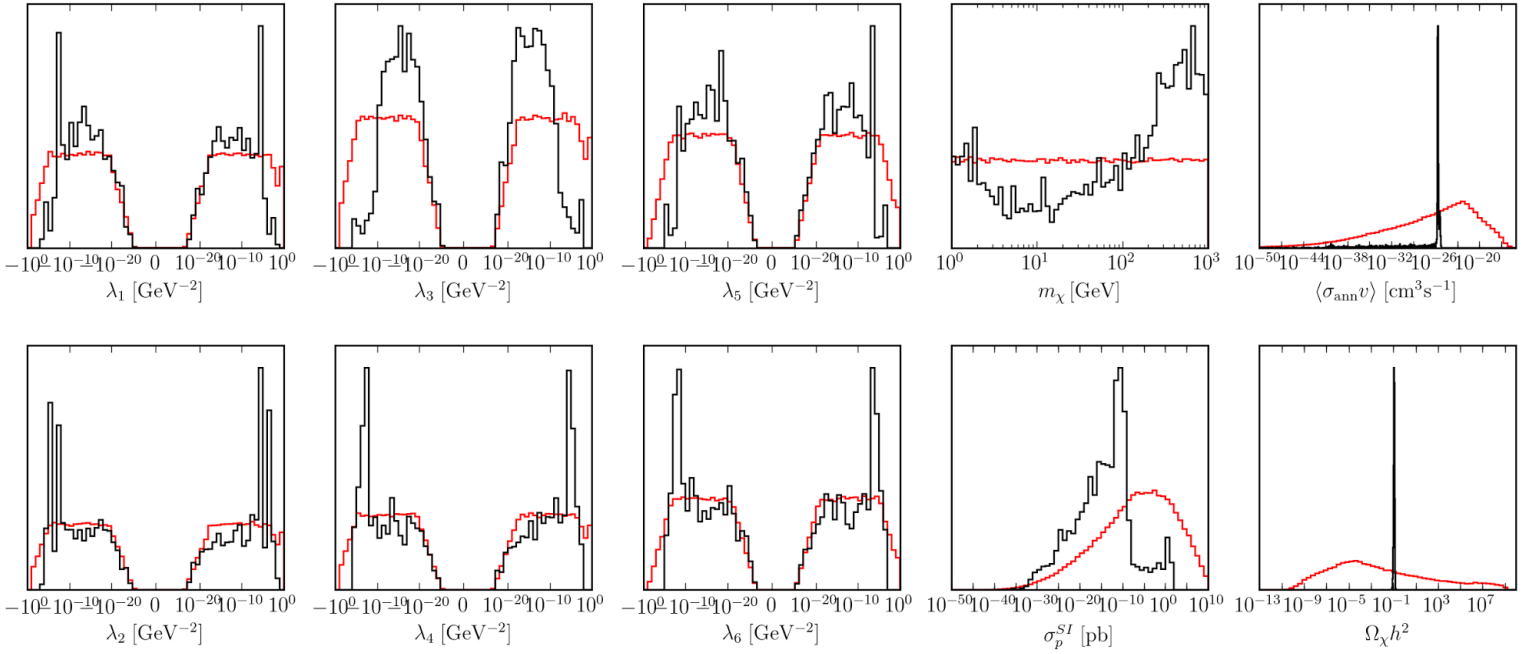
Prior, Relic Density + LUX

Real scalar DM



Relic Density + LUX, + Galactic Centre Excess

Complex scalar DM



Prior, Relic Density + LUX

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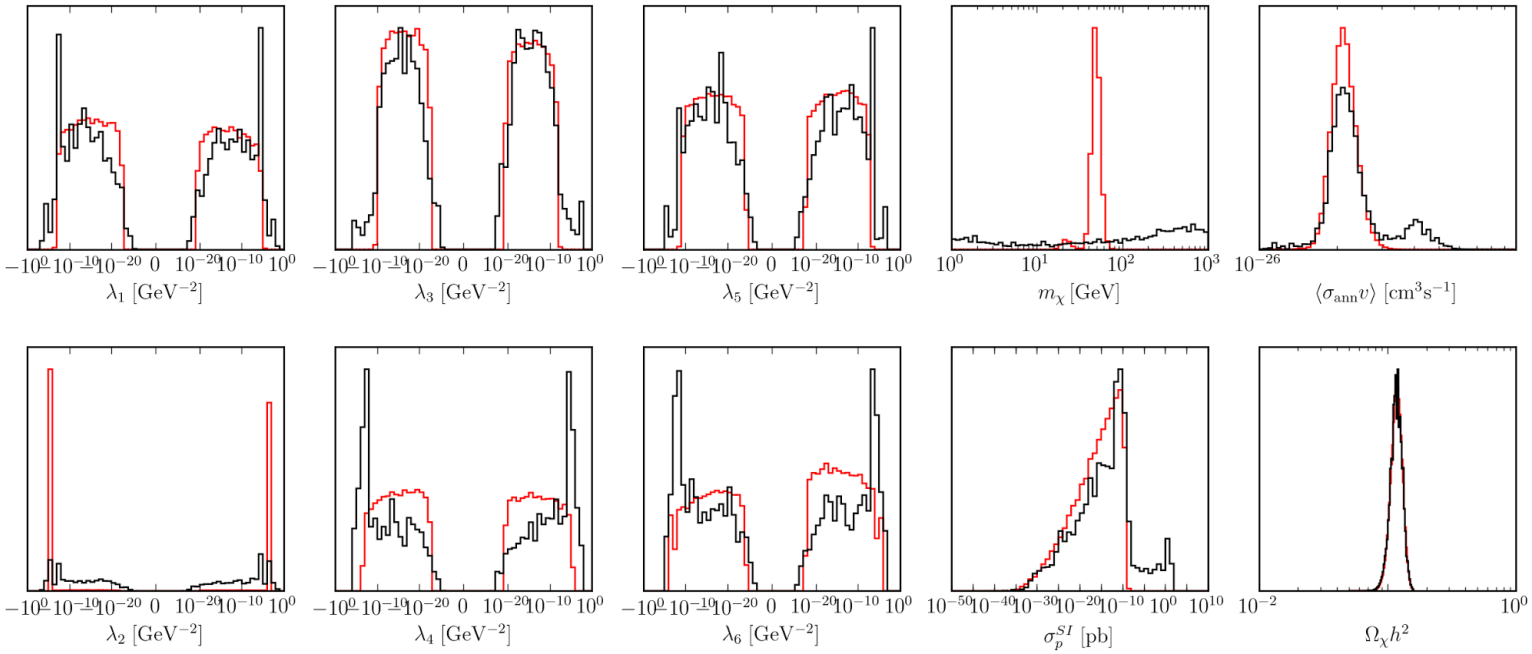

Relic Density + LUX, + Galactic Centre Excess

Concluding remarks

Using effective likelihood driven scanning algorithms allows for combining multiple experimental results coherently.

EFTBayeS - reasonably model independent.

Thank you for listening.

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