Dark Matter In Split Supersymmetry

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Outline

- Split Supersymmetry
- Direct detection
- Indirect detection
- Conclusions

Motivation

- Cosmological Constant Problem
- problems of the MSSM:
    - Higgs mass
    - flavor violation
    - CP
    - proton decay

MSSM problems solved when scalar sparticles are heavy

Split Supersymmetry

M_{GUT} — GUT

M_s — Scalar Superpartners (squarks, sleptons)
heavy Higgs

TeV — Gauginos and Higgsinos
SM particles (including one light Higgs)

Preserves successes of MSSM:
gauge coupling unification and a natural DM candidate

TeV scale necessary for DM relic abundance

Split Supersymmetry

Below the SUSY breaking scale, M_s:

$$\mathcal{L} \supset \tilde{B}(\kappa_1' h^\dagger \tilde{H}_1 + \kappa_2' h \tilde{H}_2) + \tilde{W}^a(\kappa_1 h^\dagger \tau^a \tilde{H}_1 + \kappa_2 \tilde{H}_2 \tau^a h)$$

$$-\frac{1}{2}(M_1 \tilde{B}\tilde{B} + M_2 \tilde{W}\tilde{W} + M_3 \tilde{g}\tilde{g}) - \mu \tilde{H}_1 \tilde{H}_2 - \lambda |h|^4$$

At M_s the couplings obey SUSY relations:

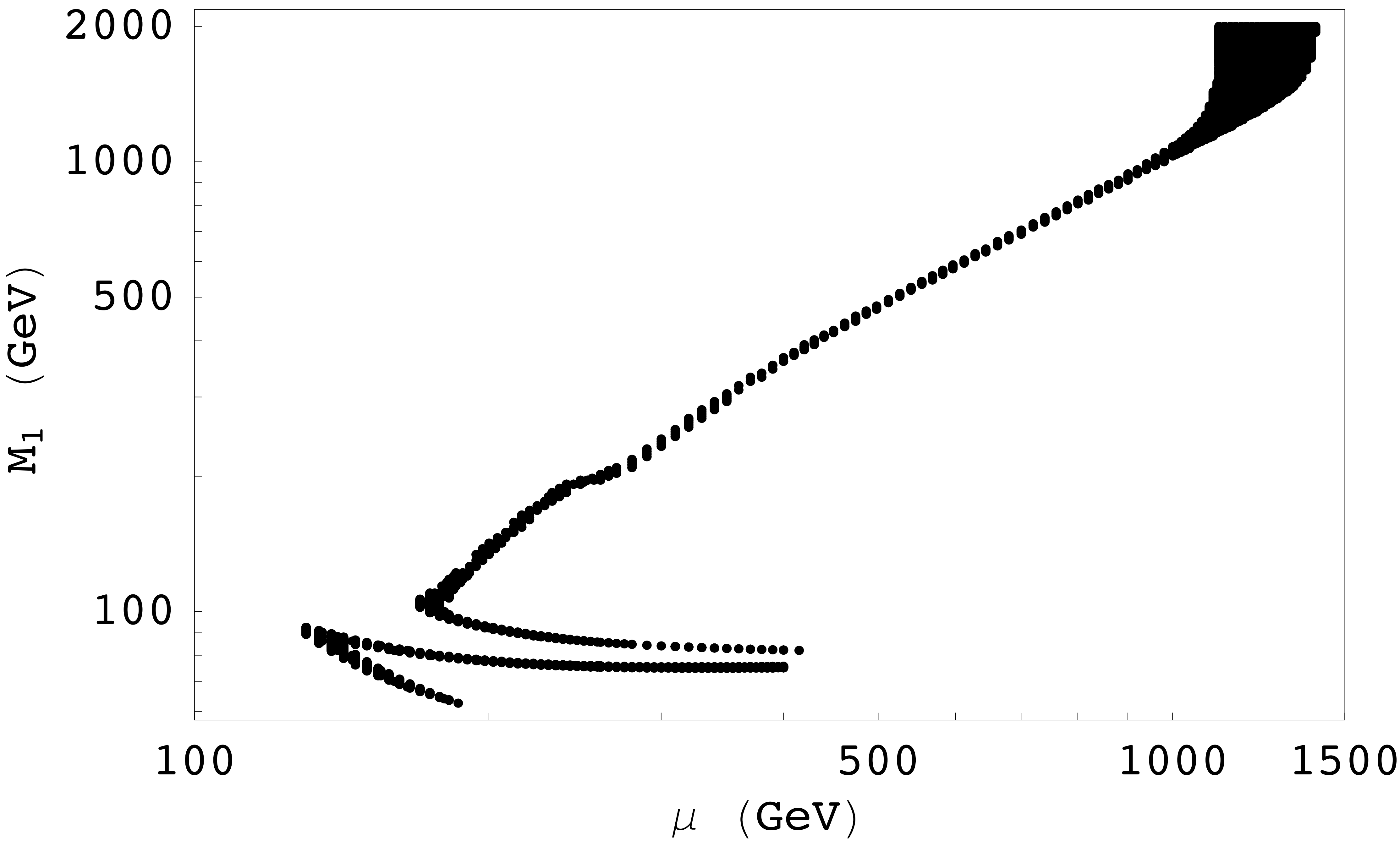
$$\kappa_1' = \sqrt{\frac{3}{10}} g_1 \sin\beta \qquad \kappa_2' = \sqrt{\frac{3}{10}} g_1 \cos\beta$$

$$\lambda = \frac{\frac{3}{5} g_1^2 + g_2^2}{8} \cos^2 2\beta.$$

$$\kappa_1 = \sqrt{2} g_2 \sin\beta \qquad \kappa_2 = \sqrt{2} g_2 \cos\beta$$

Split SUSY models are specified by M_S, $\tan\beta$, μ, M_1, M_2, M_3

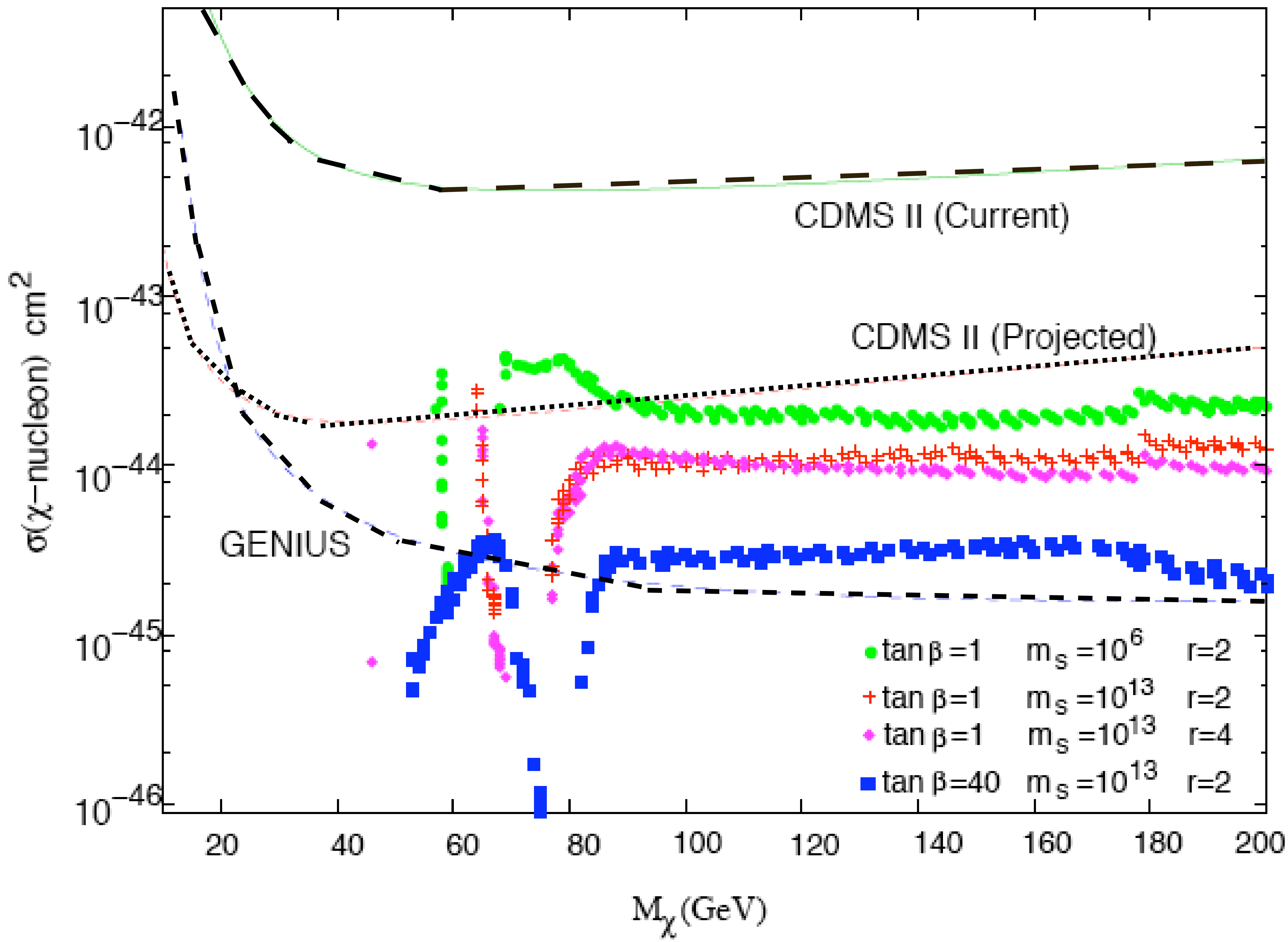
Relic Abundance



$M_s = 10^9$ GeV $\tan\beta = 5$ $M_2 = 2\,M_1$

DM abundance in WMAP allowed range: $0.094 < \Omega h^2 < 0.129$

Direct Detection



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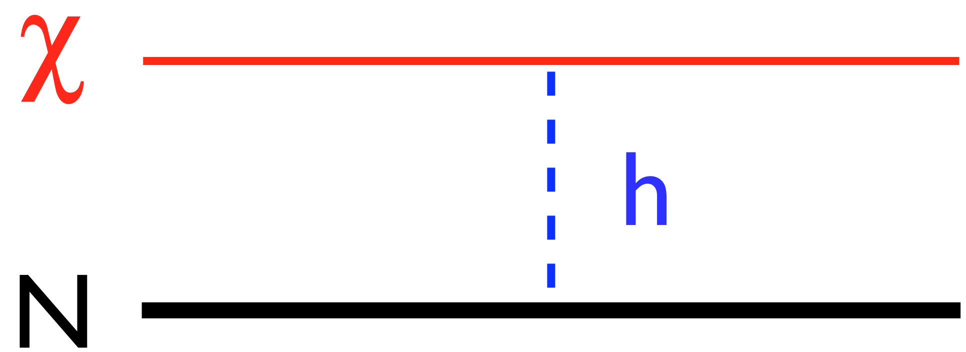
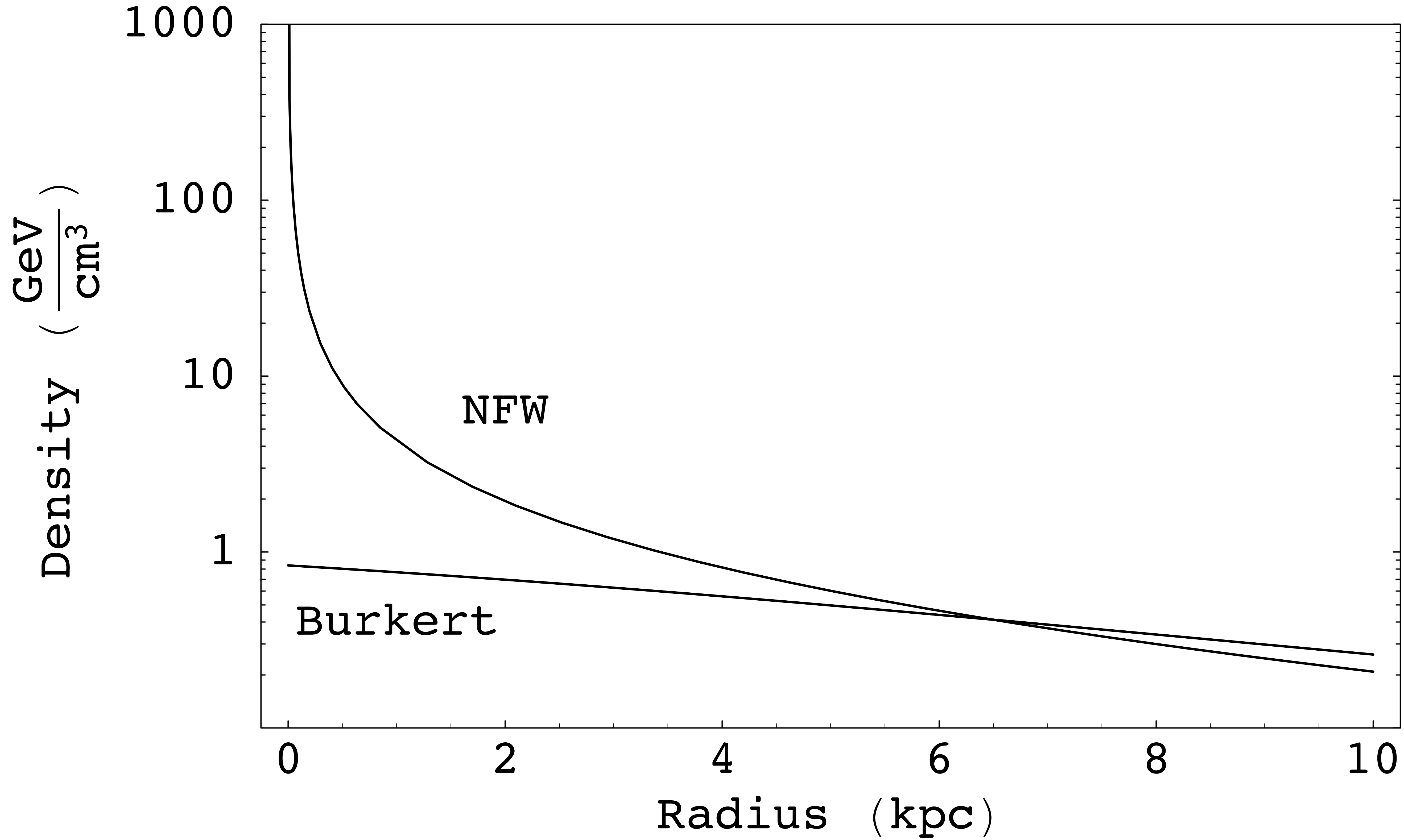
Direct Detection

- much of parameter space observable at next generation detectors
- Spin-independent cross section for LSP-nucleon scattering given by Higgs exchange:

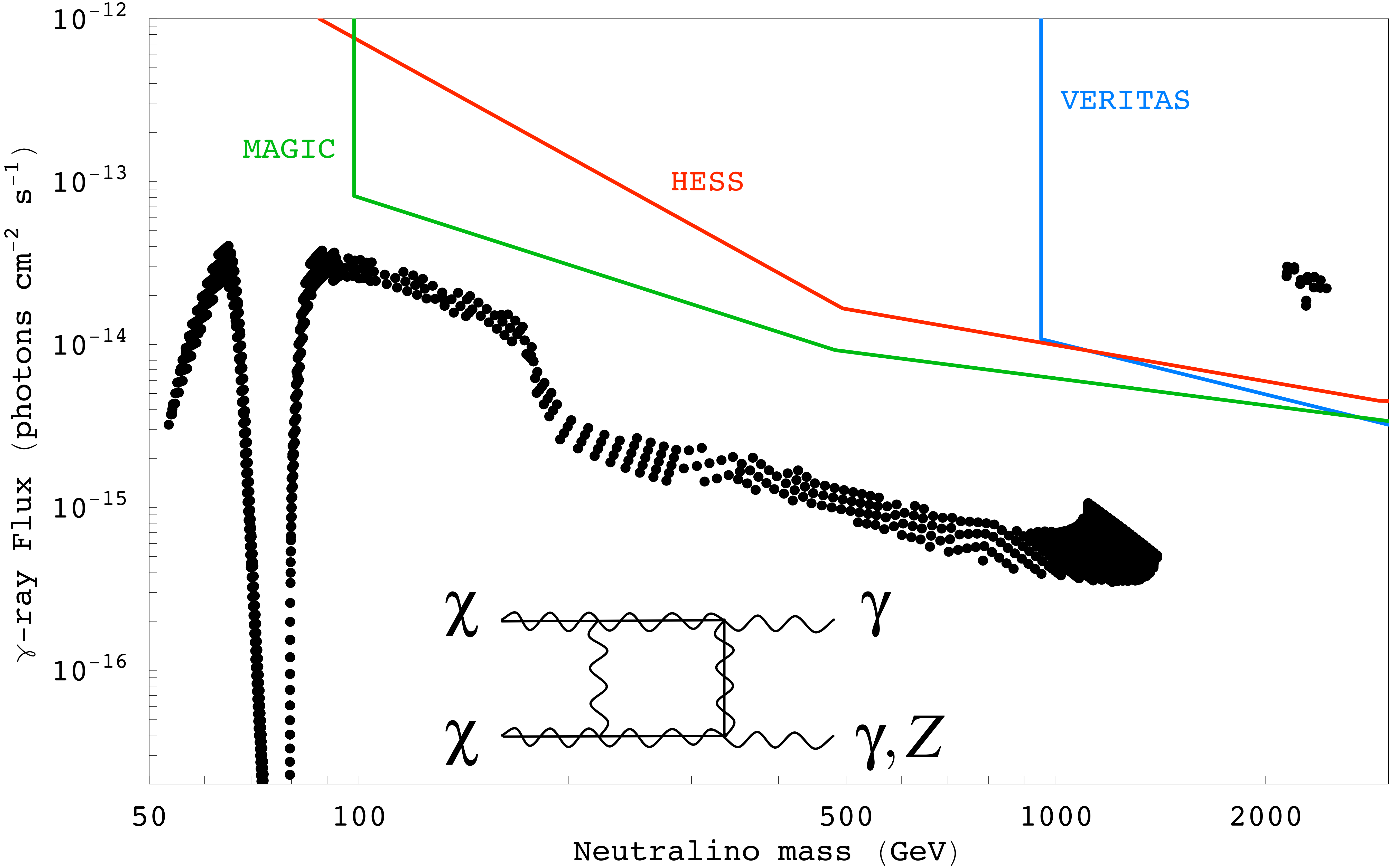


- relies on Higgs-higgsino-gaugino couplings (κ's)
- greatly suppressed for heavy higgsino or wino DM (for which collider tests also challenging)

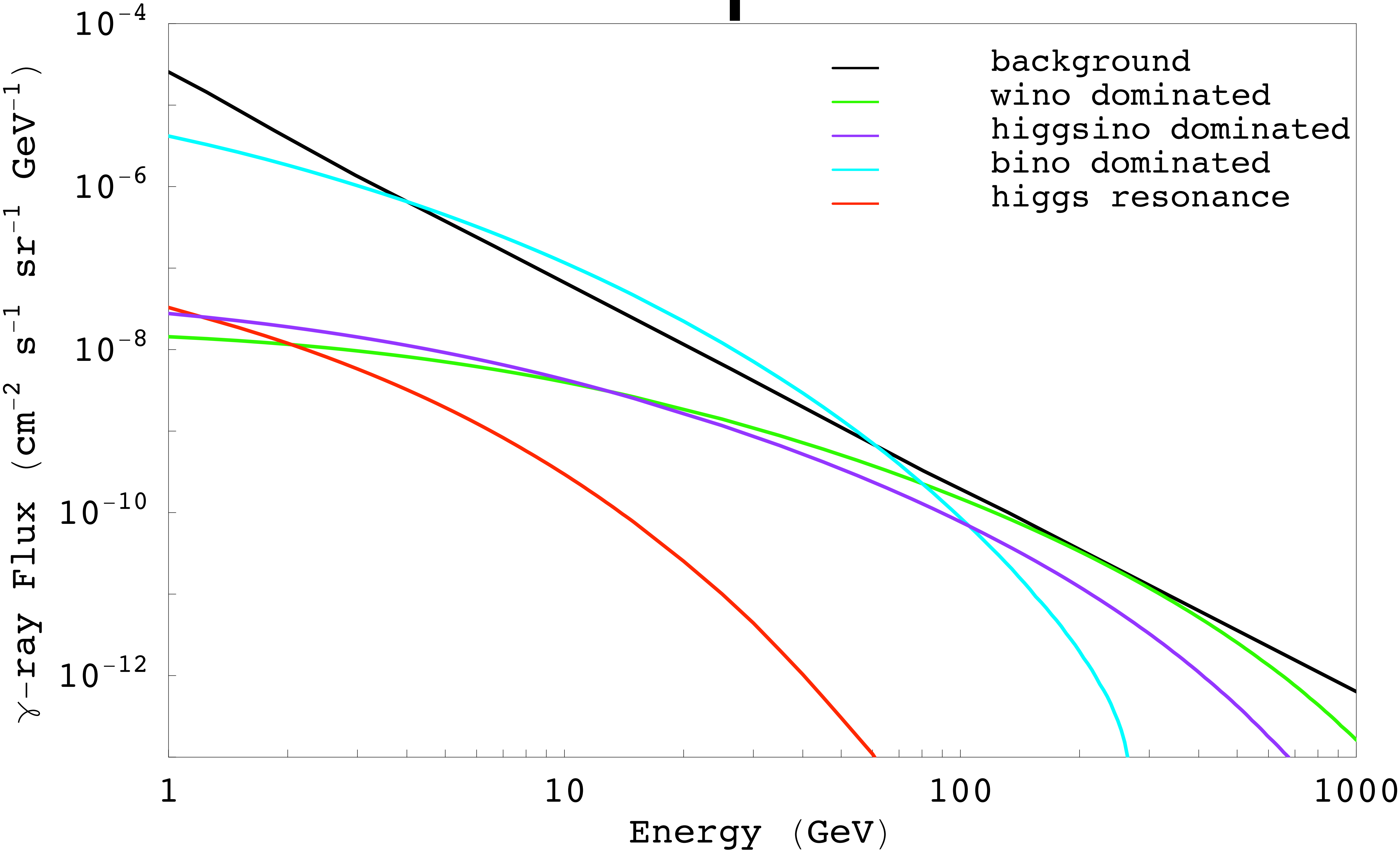
Halo Profile



Photon Lines

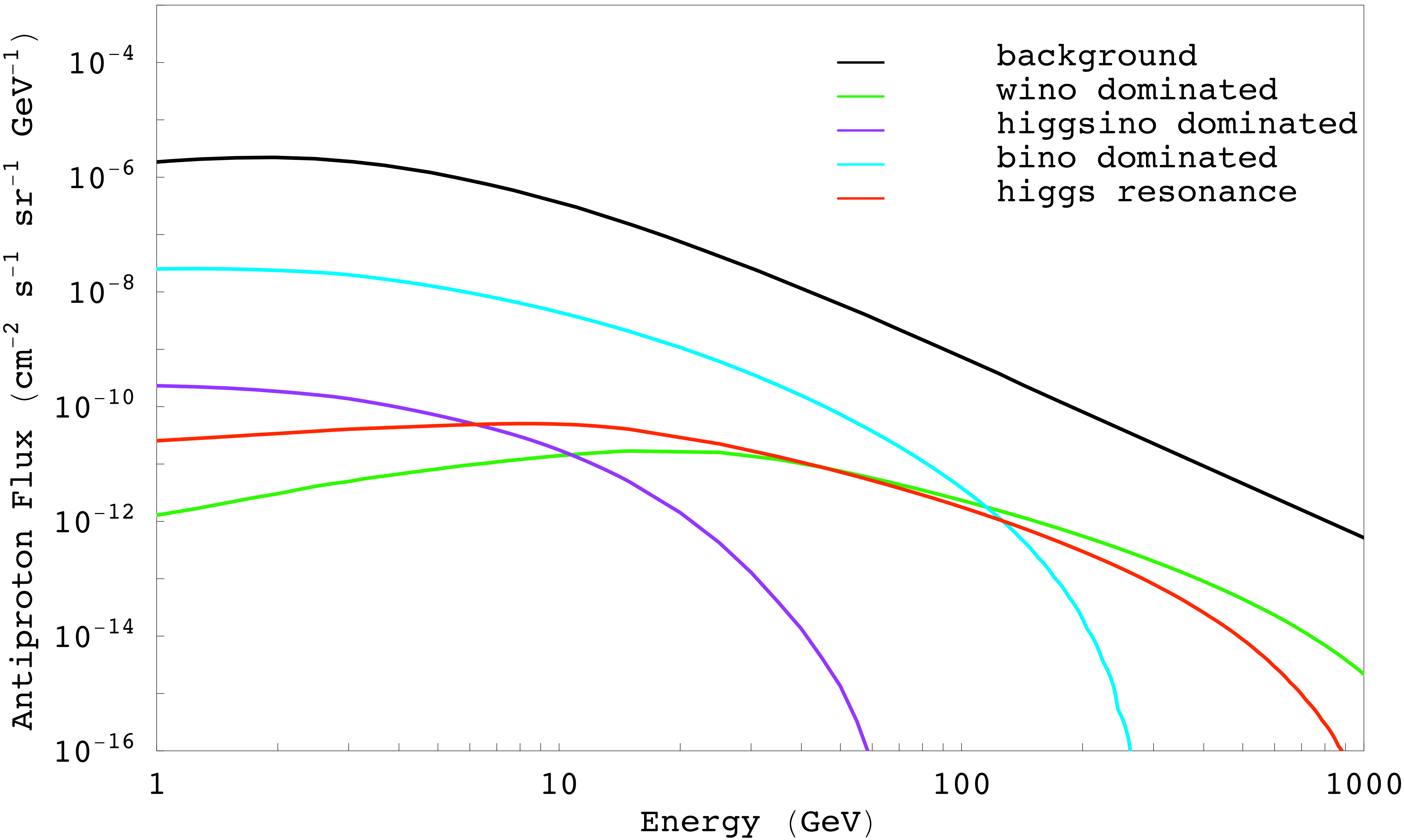


Photon Spectrum



Observable for some cases (requires spike in halo profile)

Antimatter



Unobservable at current or near-future detectors

Conclusions

- Direct detection and collider searches cover much of Split SUSY parameter space
- In challenging areas, annihilation signals could detect the LSP, and even measure its mass