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Indirect Searches for Secluded Dark Matter

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What are the main evidences for the Dark Matter Existence?

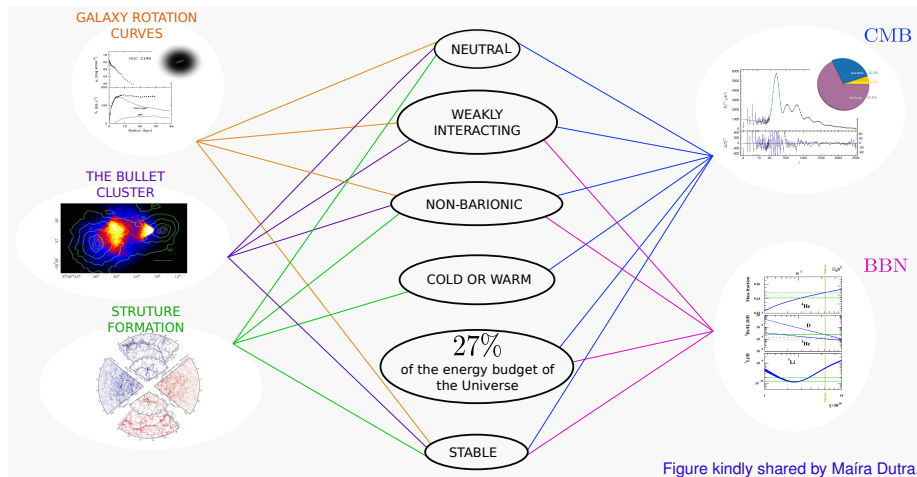
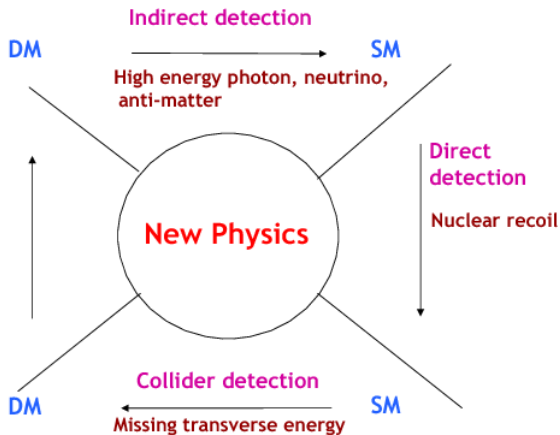


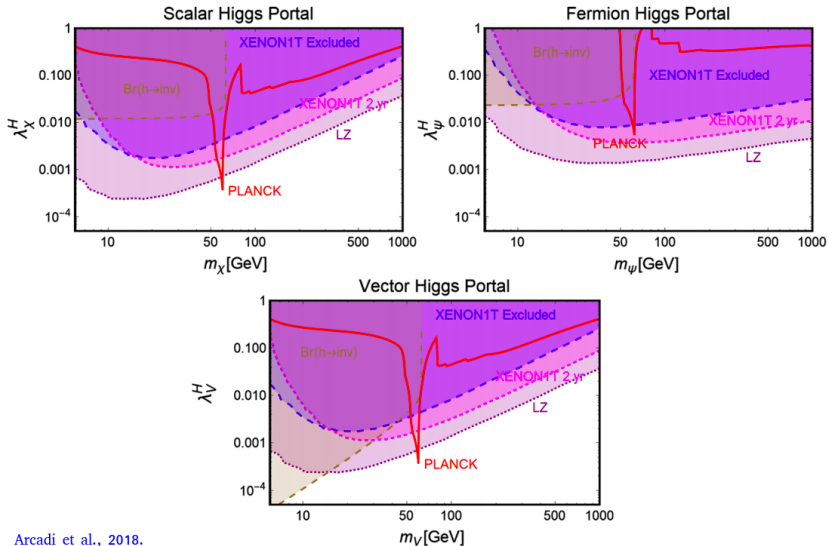
Figure kindly shared by Maira Dutra.

Main candidates: Weakly Interacting Massive Particles → WIMPs!

Detection Methods

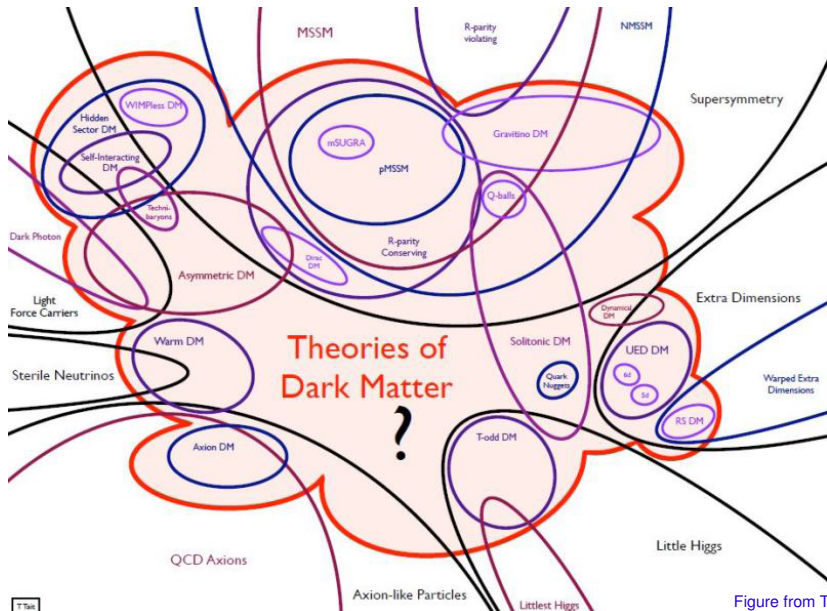


Stringent limits on WIMPs



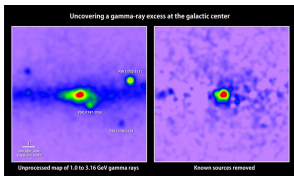
Arcadi et al., 2018.

Alternative scenarios

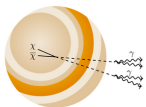


Secluded Models - Motivation

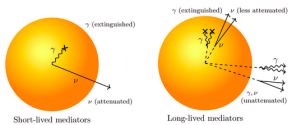
Interesting Indirect Signatures



Picture from: Tim Linden



Picture from: 2104.02068



Picture from: 1703.04629

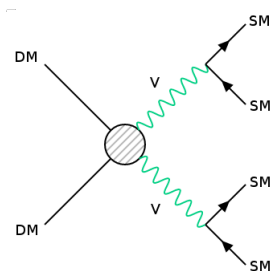
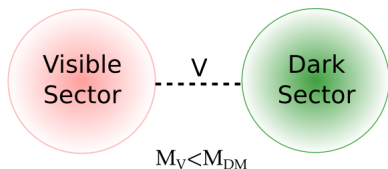
Phenomenologically motivated models

DM Bound State:
2007.13787

SUSY DM:
2003.13744

Leptoquark Portals:
2012.05743

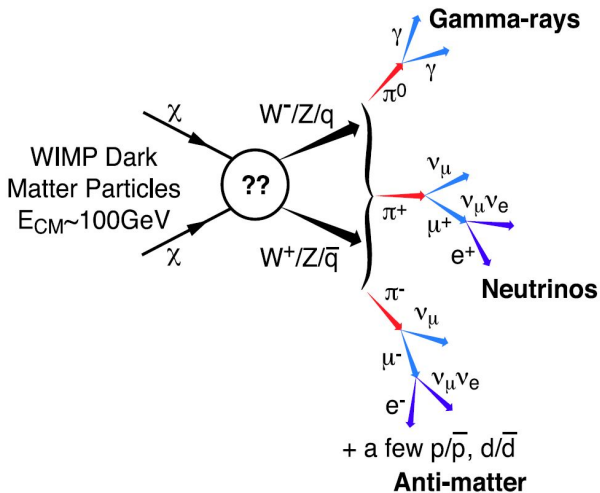
Secluded Models



Characteristics

- Escape from the stringent limits from direct and collider searches;
- It can be probed by indirect detection experiments;
- Model-independent analysis: mediator can be a scalar or a vector.

Indirect Detection



Key Ingredients for Indirect Searches

Target?

- Galactic Center
- Dwarfs
- Galaxy Clusters
- ...

Channel?

- $\bar{b}b$
- $\bar{\tau}\tau$
- $\bar{\mu}\mu$
- ...

DM Distribution?

- NFW
- Einasto
- Burkert
- ...

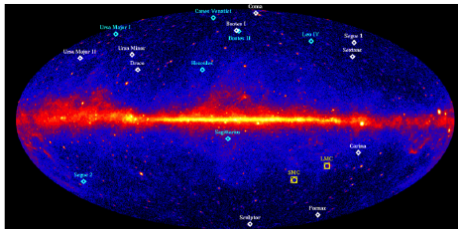
Background?

Final State?

- Gamma-Rays
- Neutrinos
- Charged Particles

Energy?

Key ingredients for this work



TeV Gamma-rays at the Galactic Center (GC)

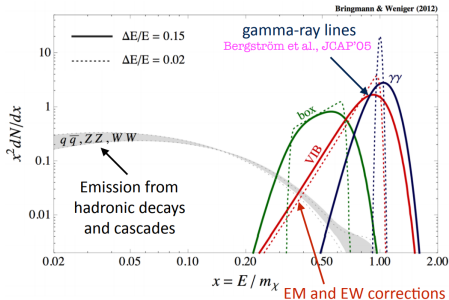
- Central region of the Galaxy: $r < 1^\circ$ for HESS and CTA and $r < 10^\circ$ for SWGO (Excluding $|b| < 0.3^\circ$);
- Region with high DM density, strong background;
- Channels: $V \rightarrow 4e$, $V \rightarrow 4\mu$, $V \rightarrow 4\tau$, $V \rightarrow 4q$, and $V \rightarrow 4b$;
- DM distribution: Einasto profile;
- Limits from H.E.S.S. (current, 254h) and SWGO and CTA (prospects, 10 years and 500h, respectively).

γ -ray Flux

$$\gamma\text{-ray Flux: } \frac{\Phi_\gamma}{dE} = \frac{\langle \sigma v \rangle}{8\pi m_{DM}^2} \frac{dN_\gamma}{dE} \int ds \int d\Omega \rho_{DM}^2$$

Particle Physics J-Factor

Spectral Energy Distribution

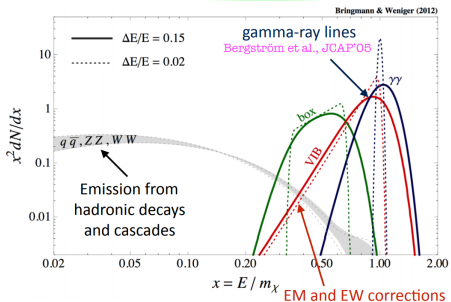


γ -ray Flux

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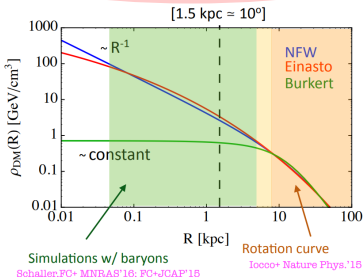
Particle Physics J-Factor

Spectral Energy Distribution



Pictures from Calore, 2018.

Spacial Distribution



Gamma-ray spectrum for Secluded TeV I

$$\frac{dN^\gamma}{dx_1} = 2 \int_{t_{1,\min}}^{t_{1,\max}} \frac{dx_0}{x_0 \sqrt{1 - \epsilon_1^2}} \frac{dN^\gamma}{dx_0} \quad (1)$$

with $\epsilon_1 = m_V/m_{DM}$, and

$$t_{1,\min} = \frac{2x_1}{E_1^2} \left(1 - \sqrt{1 - \epsilon_1^2} \right) \quad (2)$$

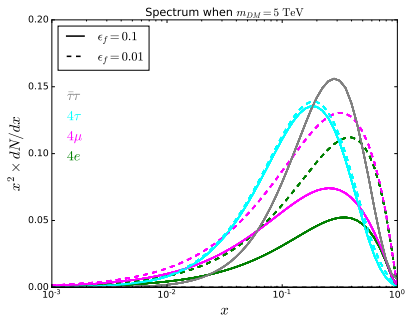
$$t_{1,\max} = \text{Min} \left[1, \frac{2x_1}{E_1^2} \left(1 + \sqrt{1 - \epsilon_1^2} \right) \right] \quad (3)$$

We can also define,

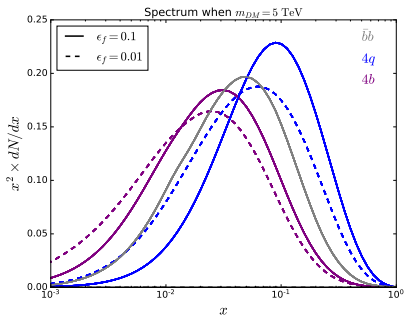
$$\epsilon_f = \frac{2m_f}{m_V}. \quad (4)$$

Gamma-ray spectrum for Secluded TeV II

Leptonic channels



Hadronic channels

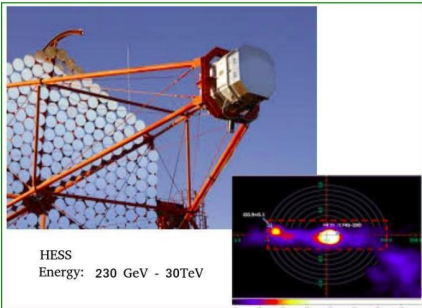


$$\epsilon_f = \frac{2m_f}{m_V}$$

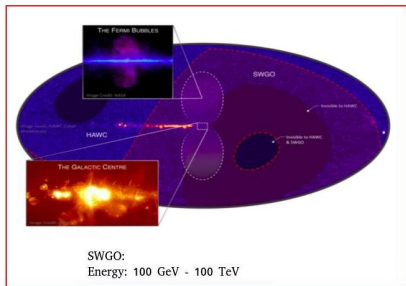
γ -ray Experiments



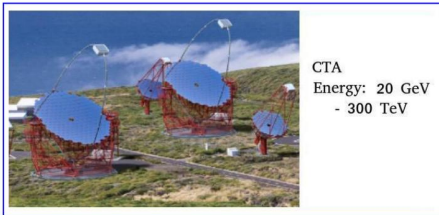
Fermi-LAT:
Energy: 500 MeV - 500 GeV



HESS
Energy: 230 GeV - 30TeV

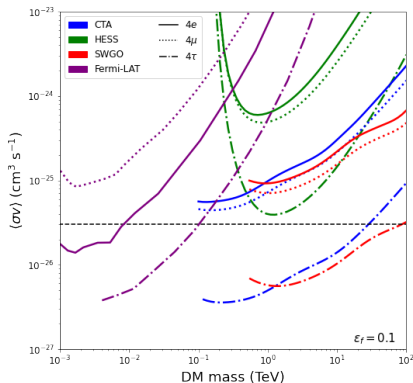
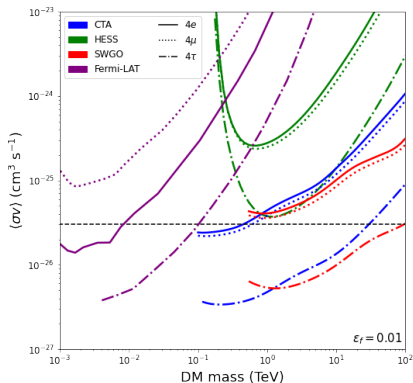


SWGO:
Energy: 100 GeV - 100 TeV



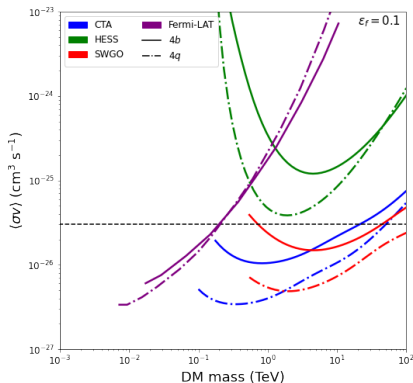
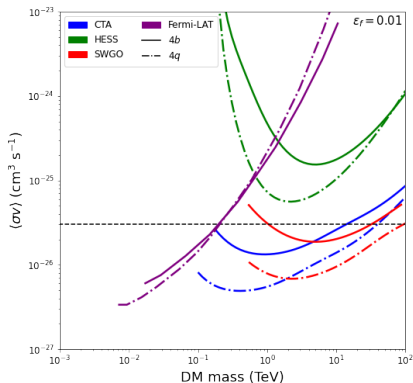
CTA
Energy: 20 GeV
- 300 TeV

Preliminary Results - Leptons



- Limits from Fermi-LAT (current, 7 years), H.E.S.S. (current, 254h) and SWGO and CTA (prospects, 10 years and 500h);
- ON-OFF 2D (energy and space) joint-likelihood method.

Preliminary Results - Quarks



- Limits from Fermi-LAT (current, 7 years), H.E.S.S. (current, 254h) and SWGO and CTA (prospects, 10 years and 500h);
- ON-OFF 2D (energy and space) joint-likelihood method.

Conclusions

- Secluded models are good alternatives to the standard WIMP scenario;
- In this work, we explored the complementarity between three different experiments looking at the Galactic Center: SWGO, HESS and CTA, and the Fermi-LAT looking at dSphs;
- We found stringent limits able to explore the standard WIMP annihilation cross-section, even at the whole range explored in this work.



Thank you!!



Secluded Models @ TeV γ -ray experiments

