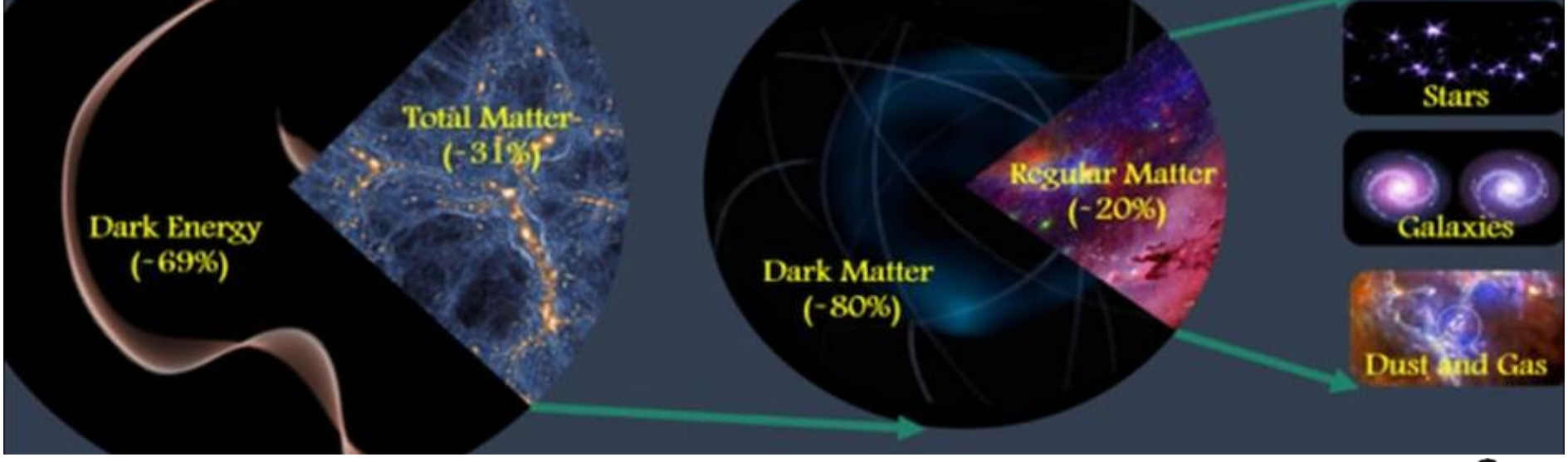


UNIVERSIDADE DE SÃO PAULO
Instituto de Física de São Carlos

MOCa 2021

Indirect Searches for Secluded Dark Matter

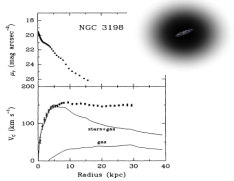
Fortes, G.; Queiroz, F.; Siqueira, C.; Viana, A.

Clarissa Siqueira

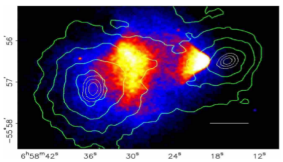
June, 2021

What are the main evidences for the Dark Matter Existence?

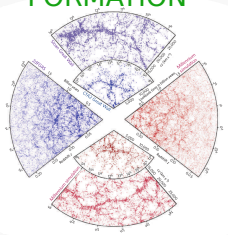
GALAXY ROTATION CURVES



THE BULLET CLUSTER



STRUTURE FORMATION



NEUTRAL

WEAKLY INTERACTING

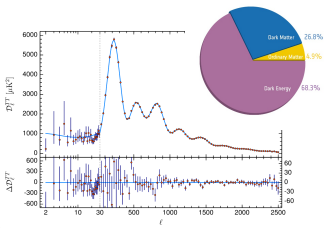
NON-BARIONIC

COLD OR WARM

27% of the energy budget of the Universe

STABLE

CMB



BBN

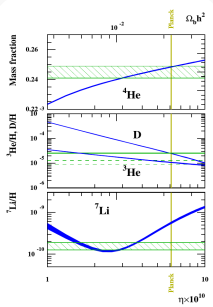
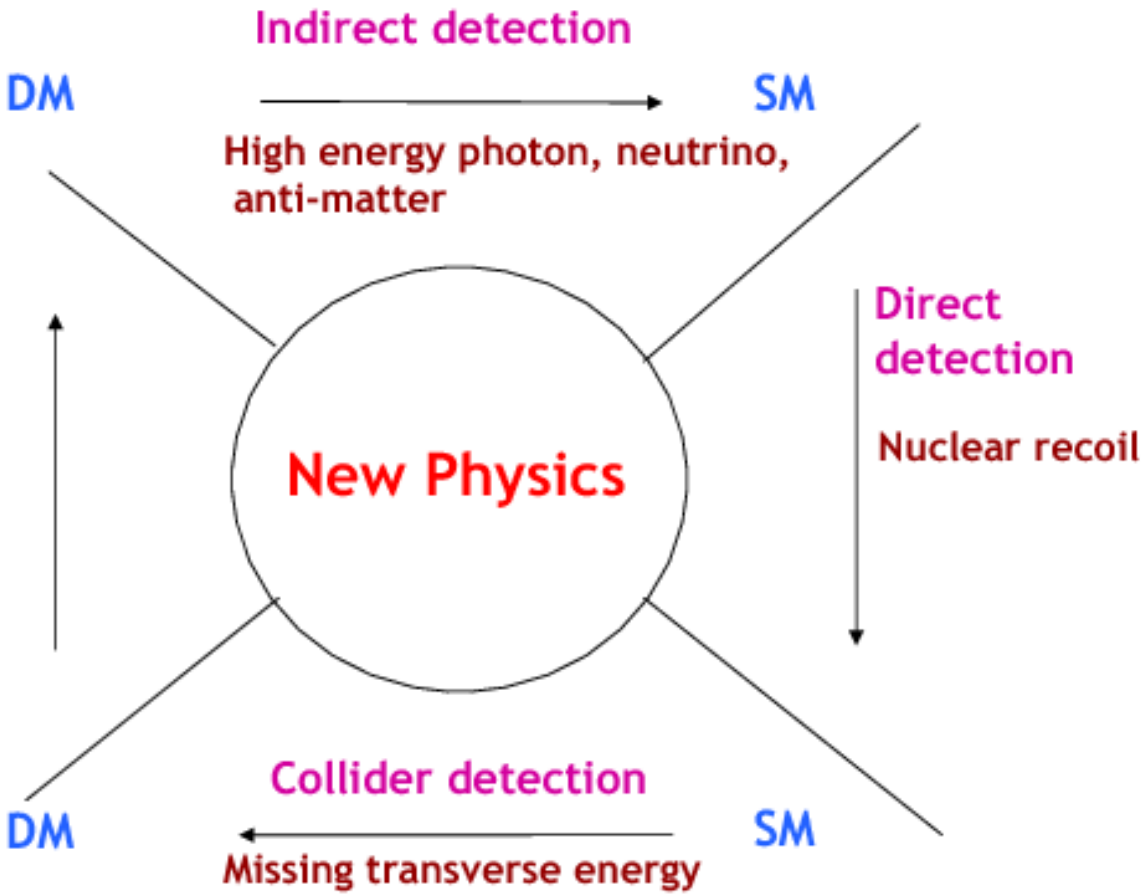


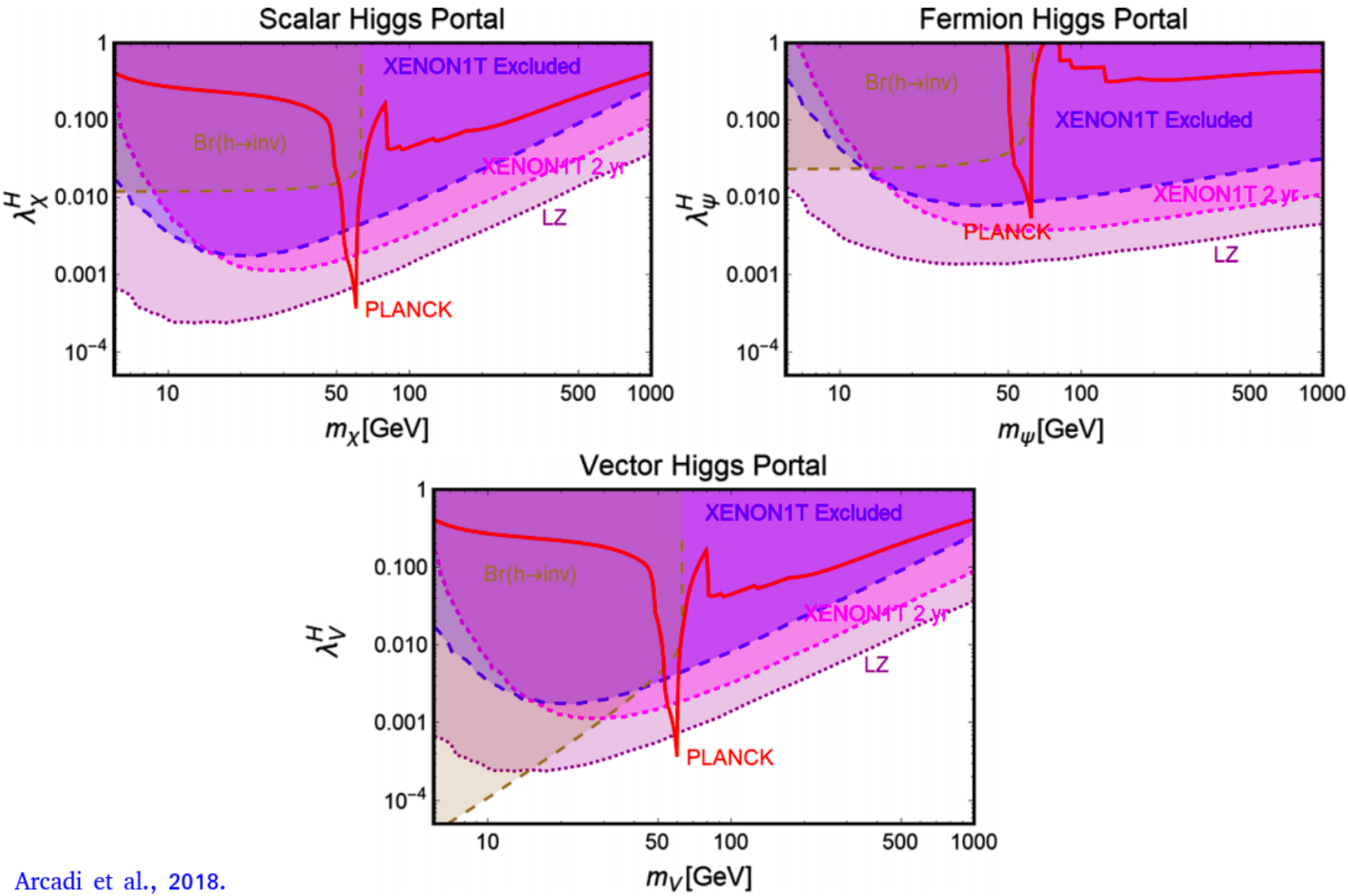
Figure kindly shared by Maíra Dutra.

Main candidates: Weakly Interacting Massive Particles $\rightarrow$ WIMPs!

Detection Methods



Stringent limits on WIMPs



Arcadi et al., 2018.

Alternative scenarios

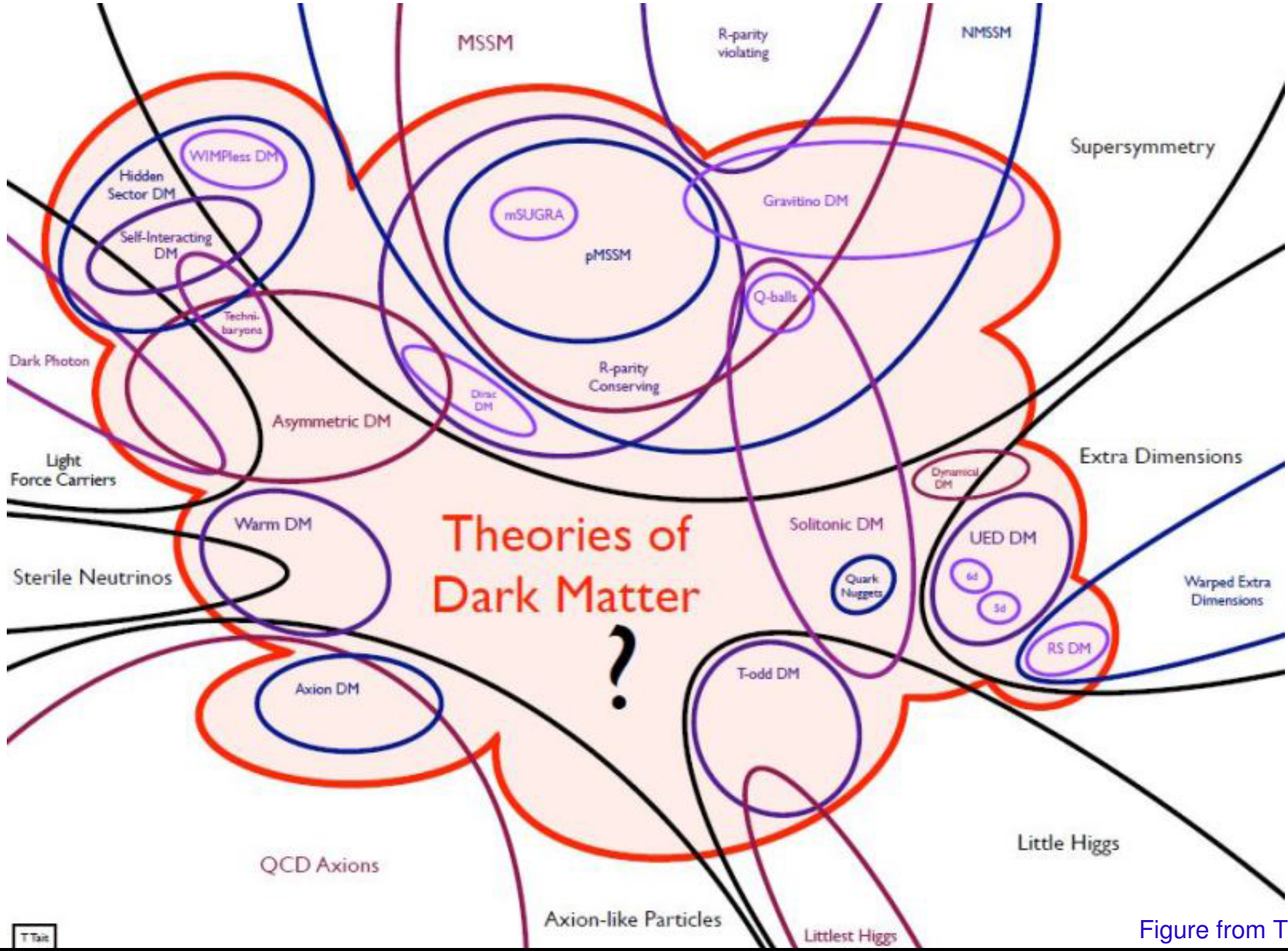
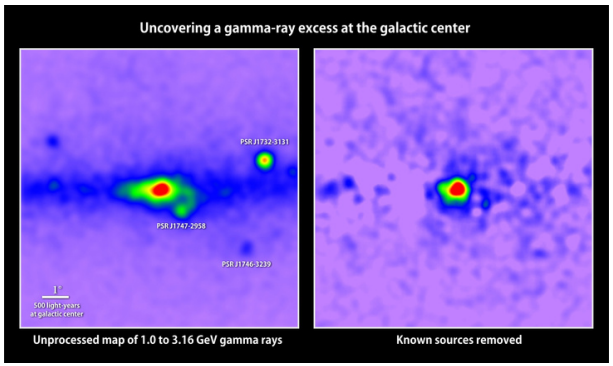


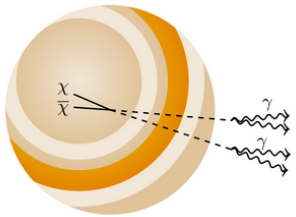
Figure from Tim Tait.

Secluded Models - Motivation

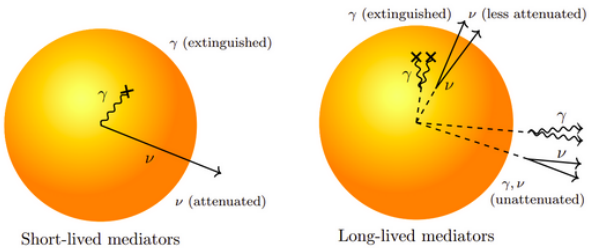
Interesting Indirect Signatures



Picture from: Tim Linden



Picture from: 2104.02068



Picture from: 1703.04629

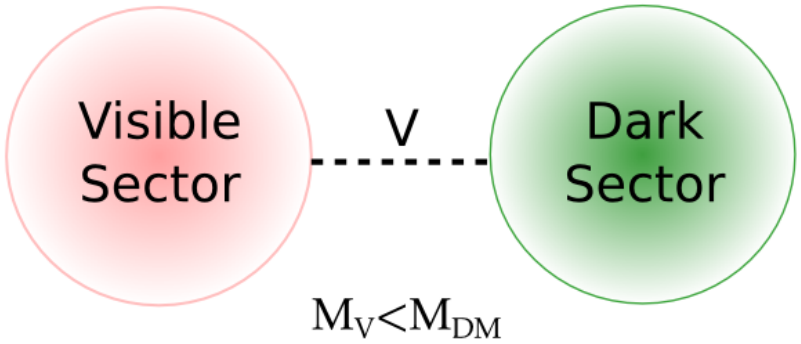
Phenomenologically motivated models

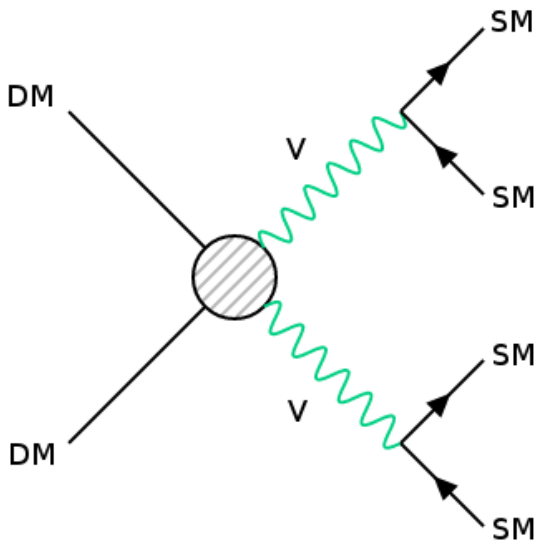
DM Bound State: 2007.13787

SUSY DM: 2003.13744

Leptoquark Portals: 2012.05743

Secluded Models

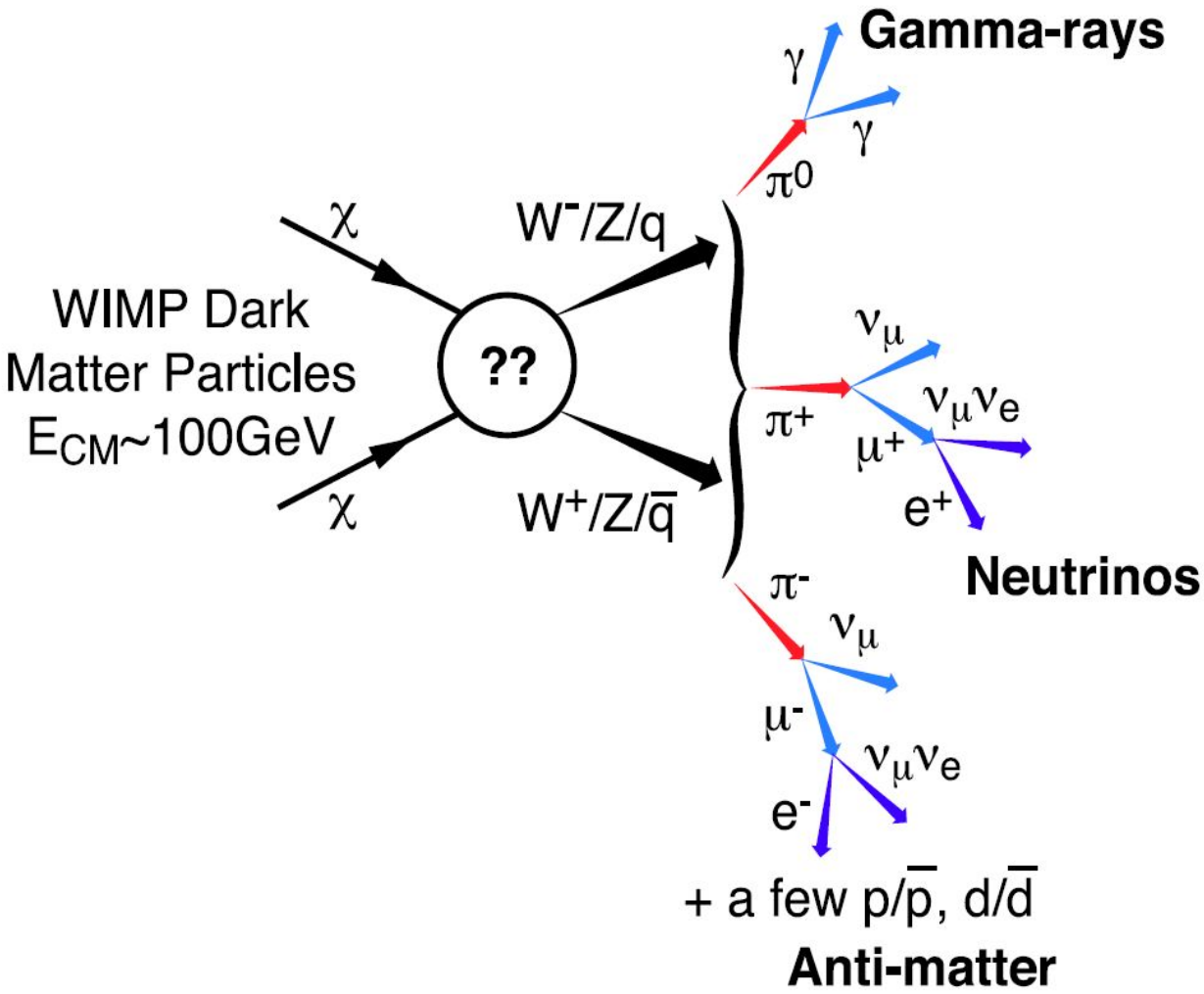




Characteristics

- 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
- Burket
- ...

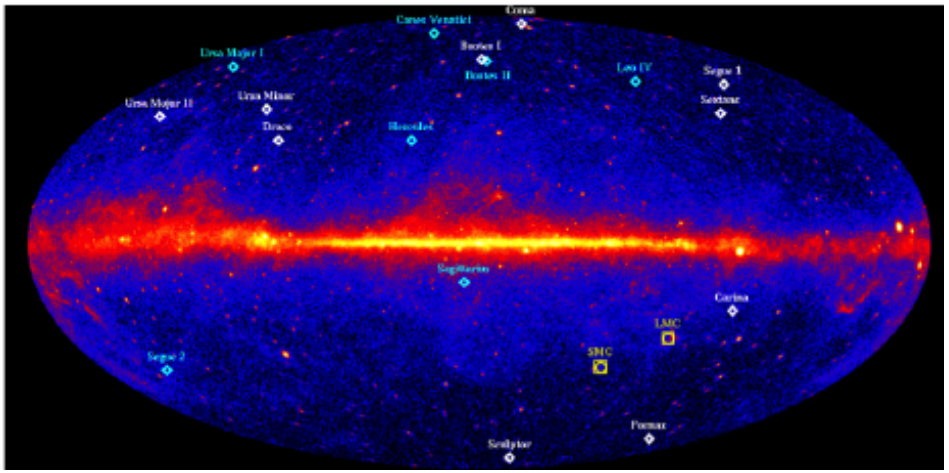
Final State?

- Gamma-Rays
- Neutrinos
- Charged Particles

Background?

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: $V \to 4e$, $V \to 4\mu$, $V \to 4\tau$, $V \to 4q$, and $V \to 4b$;
- DM distribution: Einasto profile;
- Limits from H.E.S.S. (current, 254h) and SWGO and CTA (prospects, 10 years and 500h, respectively).

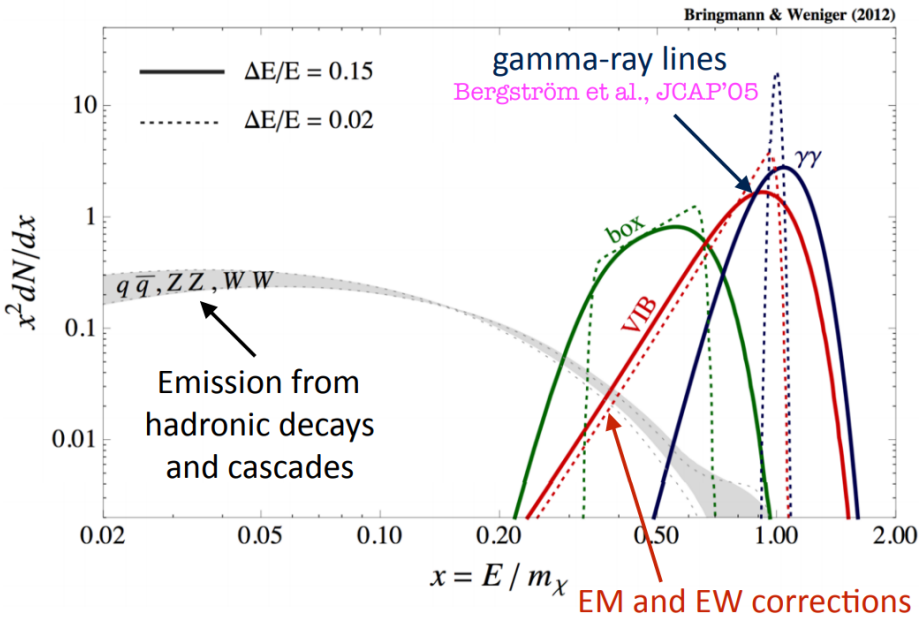
γ-ray Flux

Particle Physics

J−Factor

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

Spectral Energy Distribution



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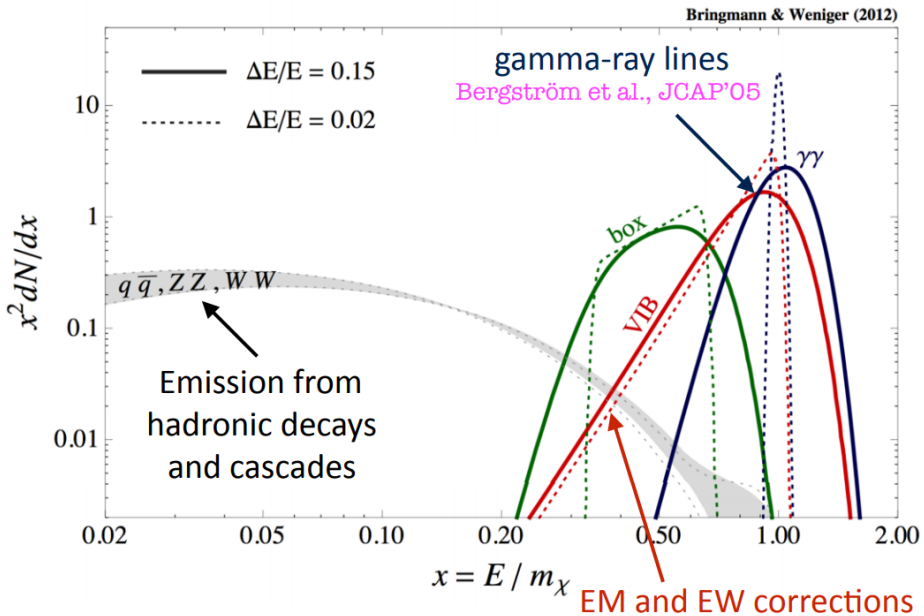
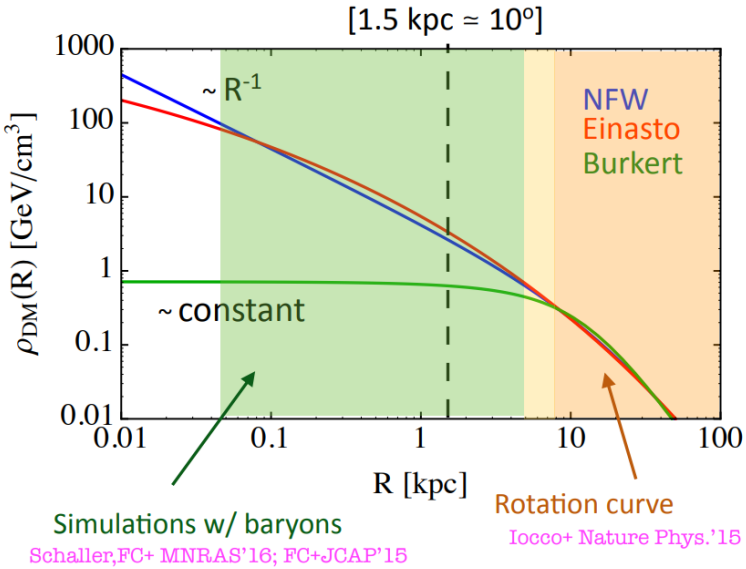
Spectral Energy Distribution



Spacial Distribution



Pictures from Calore, 2018.

Gamma-ray spectrum for Secluded TeV I

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

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

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

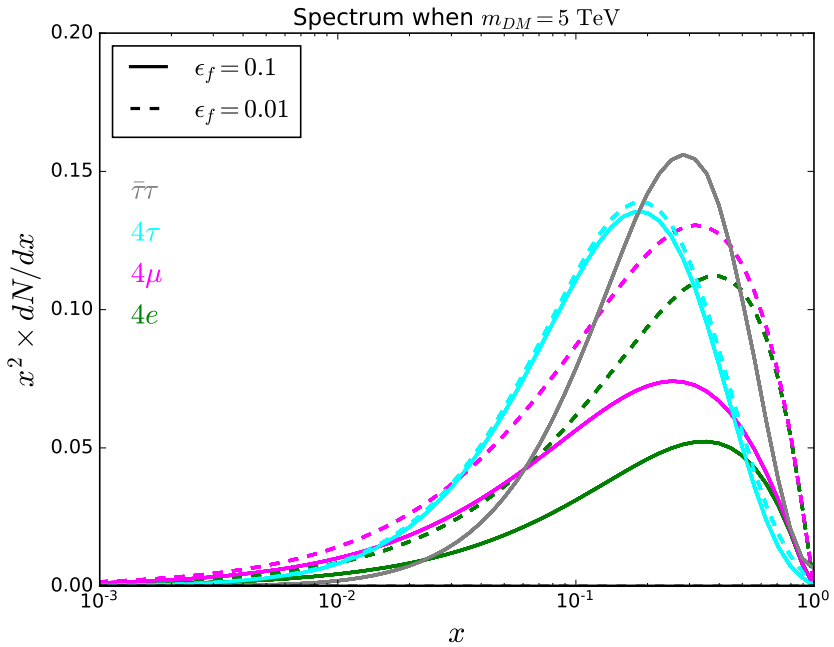
$$t_{1,max} = Min\left[1, \frac{2x_1}{E_1^2}\left(1+\sqrt{1-\epsilon_1^2}\right)\right] \tag{3}$$

We can also define,

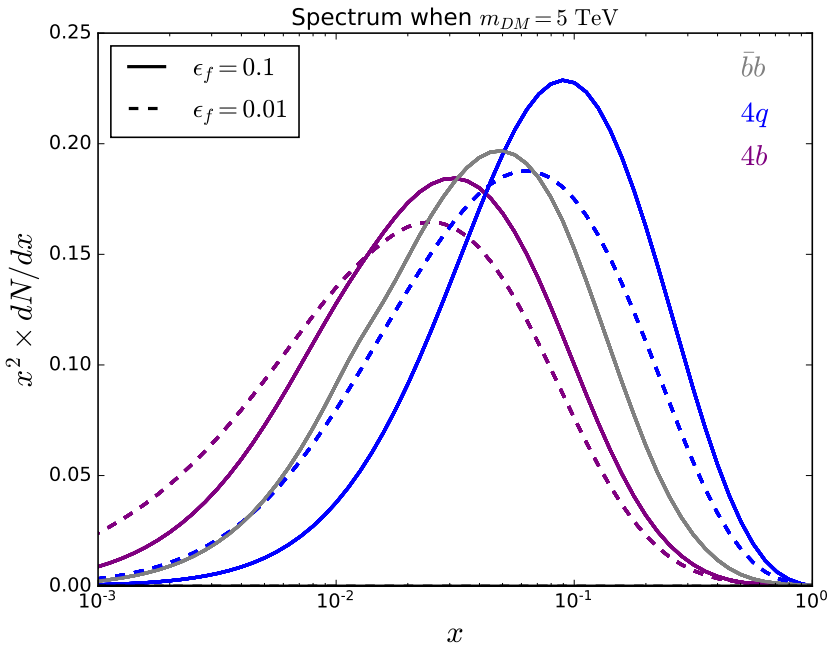
$$\epsilon_f = \frac{2m_f}{m_V}. \tag{4}$$

Gamma-ray spectrum for Secluded TeV II

Leptonic channels

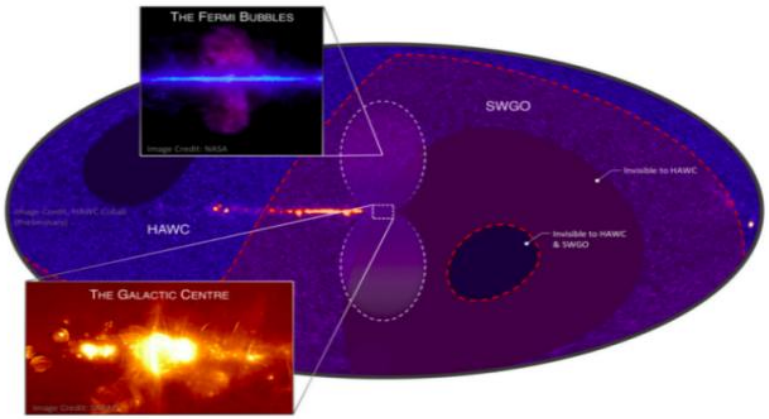


Hadronic channels

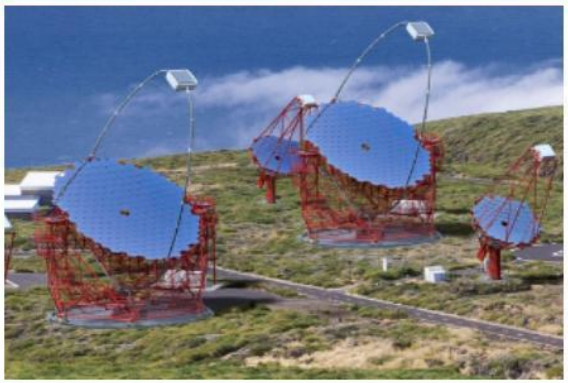


$$\epsilon_f = \frac{2m_f}{m_V}$$

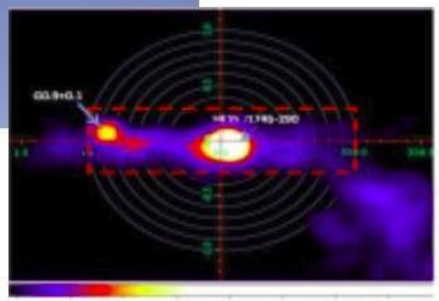
γ-ray Experiments



SWGO:
Energy: 100 GeV - 100 TeV

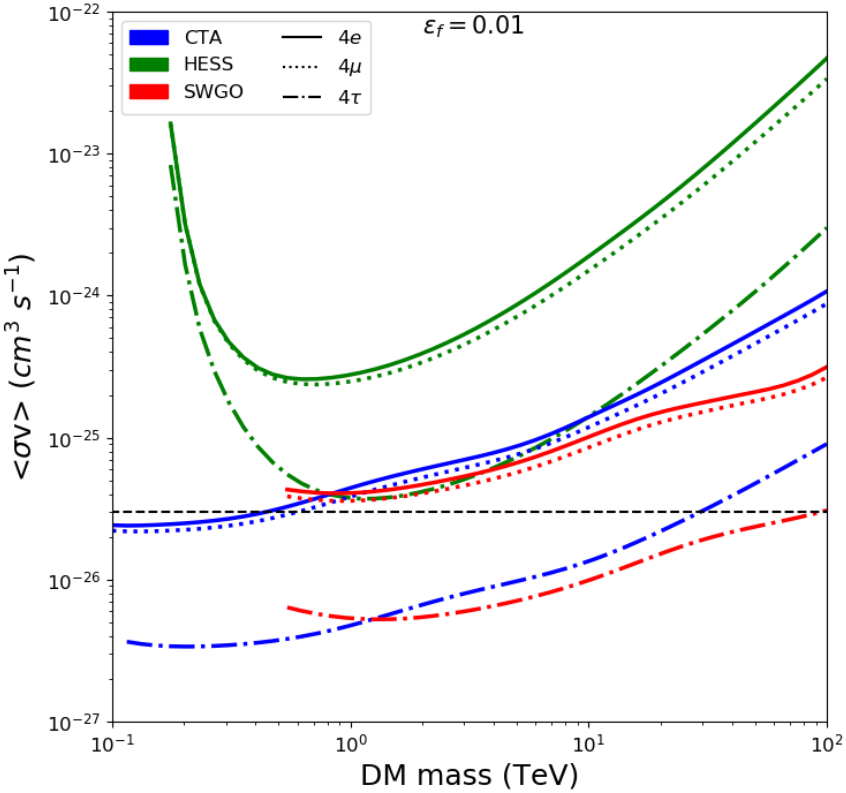


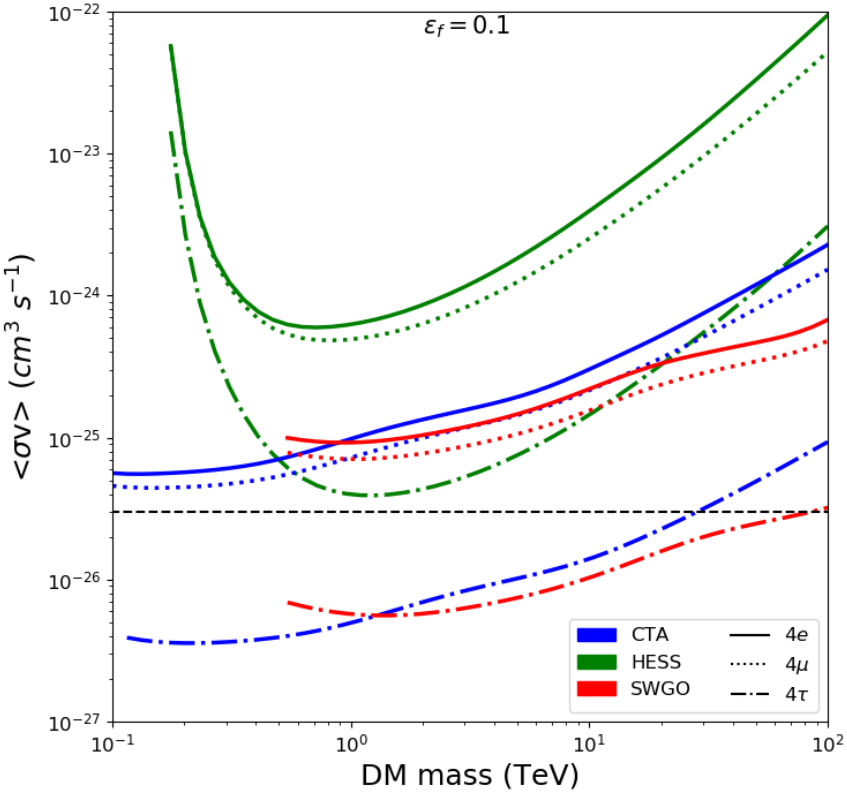
CTA
Energy: 20 GeV - 300 TeV



HESS
Energy: 230 GeV - 30TeV

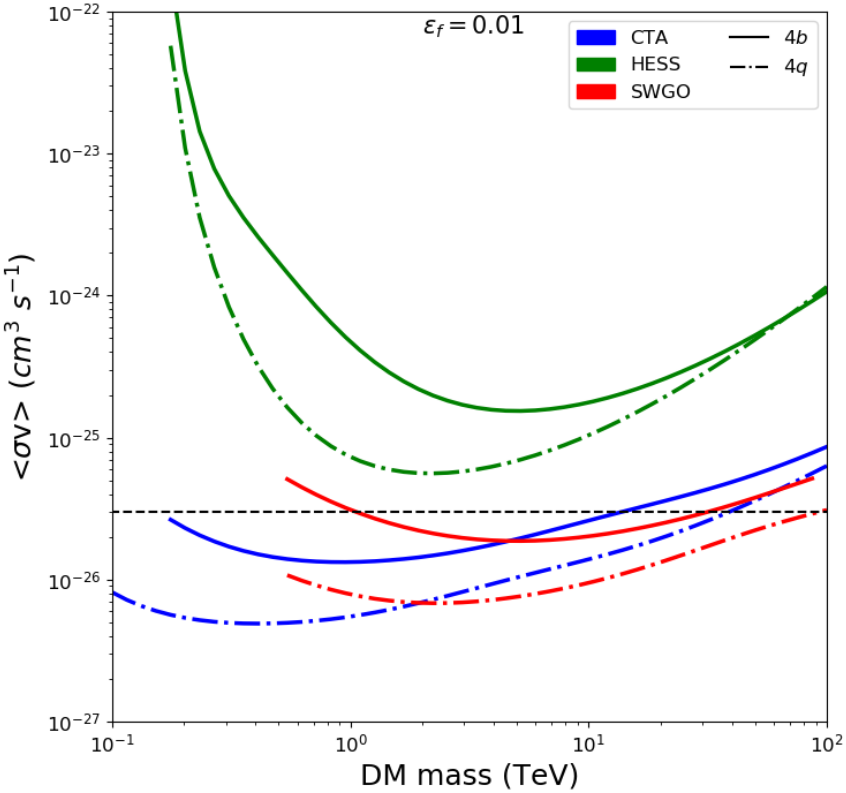
Preliminary Results - Leptons

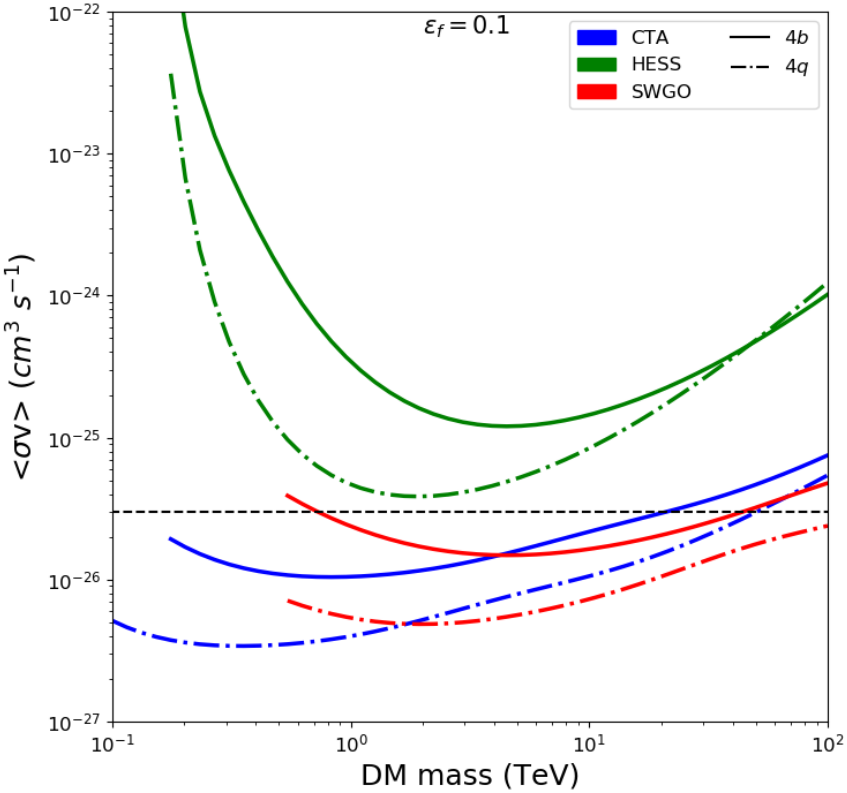




- Limits from H.E.S.S. (current, 254h) and SWGO and CTA (prospects, 10 years and 500h, respectively);
- ON-OFF 2D (energy and space) joint-likelihood method.

Preliminary Results - Quarks





- Limits from H.E.S.S. (current, 254h) and SWGO and CTA (prospects, 10 years and 500h, respectively);
- 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 complimentarity between three different experiments looking at the Galactic Center: SWGO, HESS and CTA;
- We found stringent limits able to explore the standard WIMP annihilation cross-section, even at the whole range explored in this work.

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Thank you!!

Secluded Models @ TeV γ-ray experiments

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