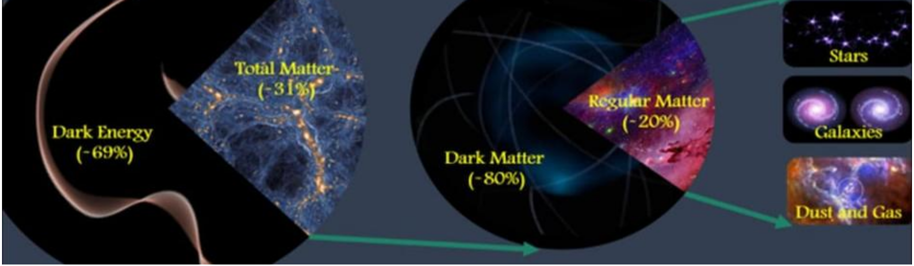


UNIVERSIDADE DE SÃO PAULO
Instituto de Física de São Carlos

cta cherenkov telescope array

SWGO The Southern Wide-field Gamma-ray Observatory

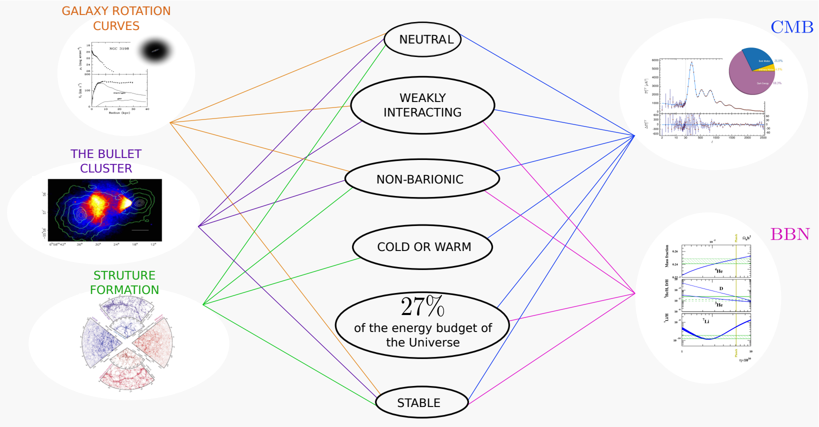
Searching for Secluded Dark Matter with Present and Future TeV Gamma-ray Observatories

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

Aion Viana

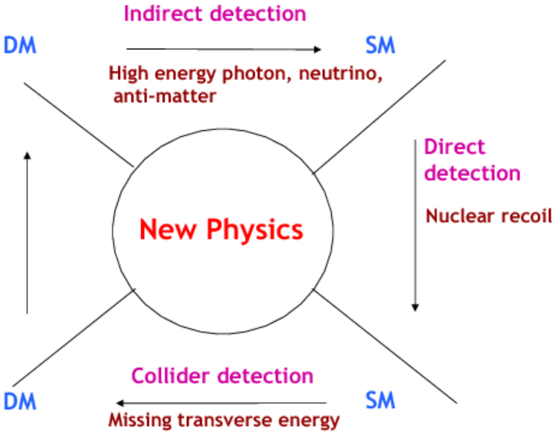
TeVPA, August, 2022

What are the main evidences for the Dark Matter Existence?

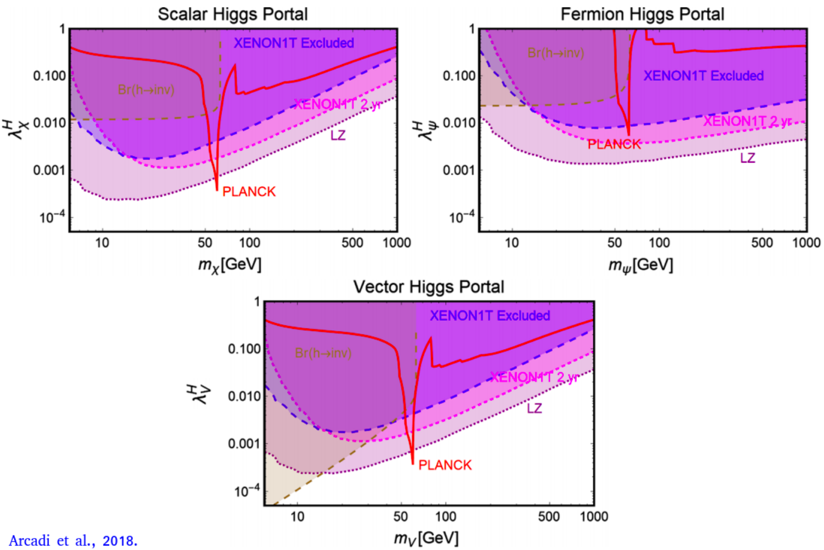


Main candidates: Weakly Interacting Massive Particles $\rightarrow$ WIMPs!

Detection Methods

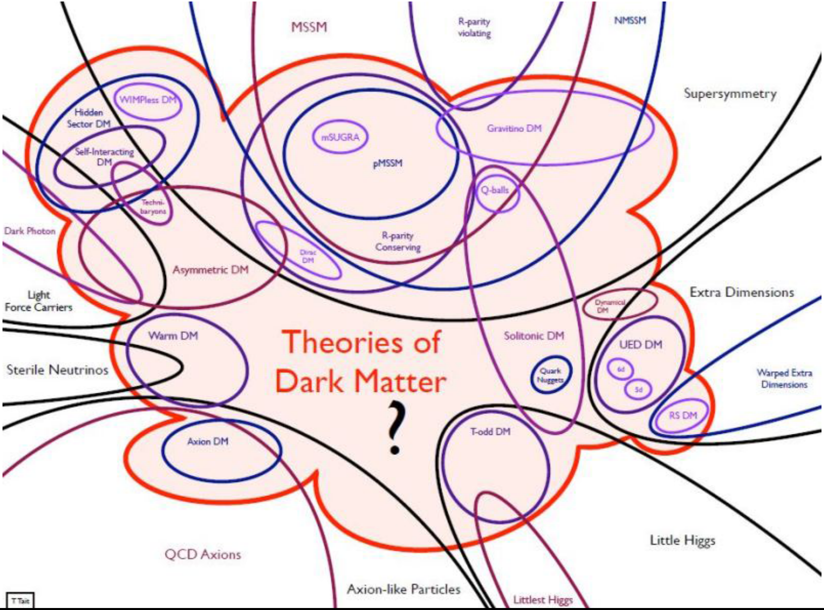


Stringent limits on WIMPs

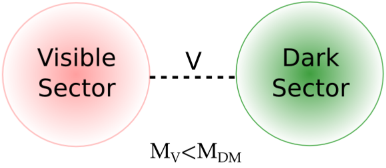


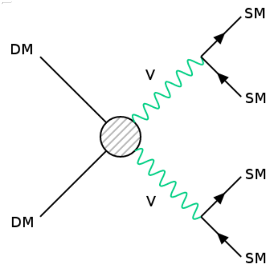
Arcadi et al., 2018.

Alternative scenarios



Secluded Models

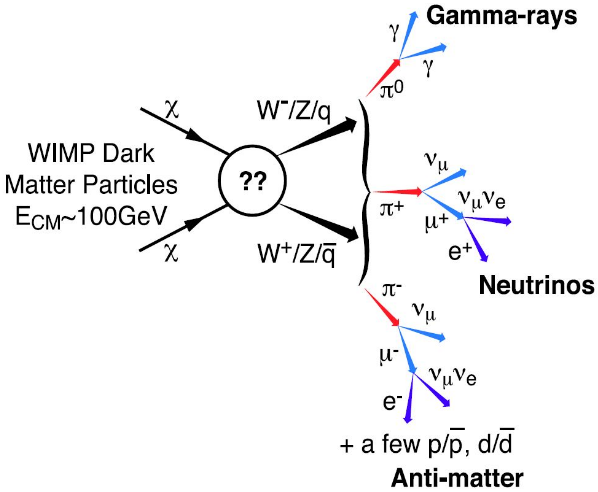




Motivation

- Escape from the stringent limits from direct and collider searches;
- It can be probed by indirect detection experiments;
- We will focus on TeV secluded models;
- Channels: $V \to 4e$, $V \to 4\mu$, $V \to 4\tau$, $V \to 4q$, and $V \to 4b$.

Indirect Detection



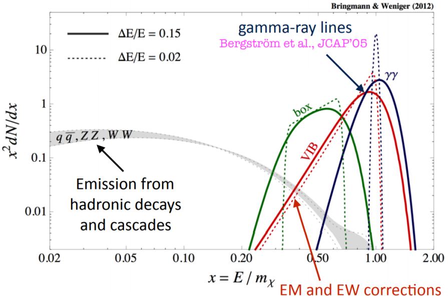
γ-ray Flux

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



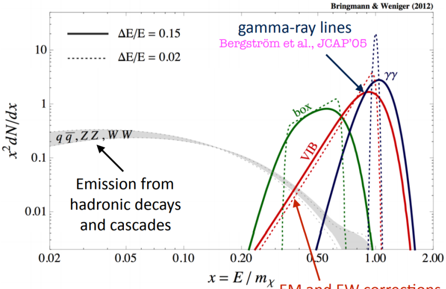
γ-ray Flux

Particle Physics

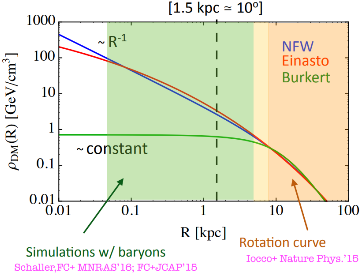
J−Factor

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

Spectral Energy Distribution



Spatial Distribution



Pictures from Calore, 2018.

Gamma-ray spectrum for Secluded TeV I

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

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

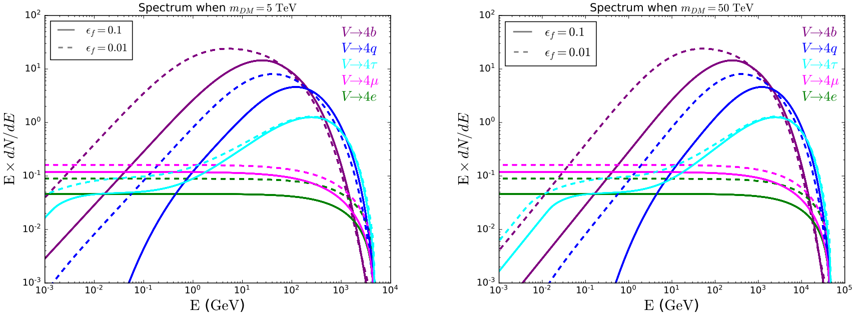
$$t_{1,min} = \frac{2x_1}{E_1^2}\left(1-\sqrt{1-\epsilon_1^2}\right) \quad (2)$$

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

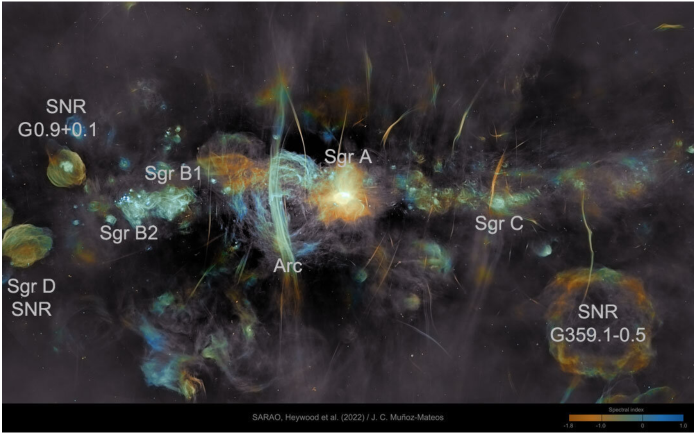
We can also define,

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

Gamma-ray spectrum for Secluded TeV II

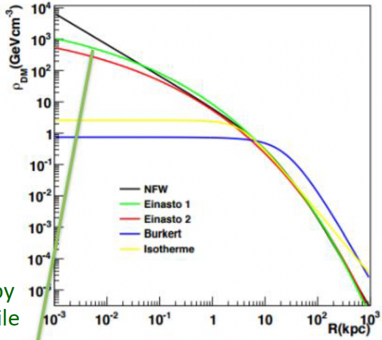


Target: Galactic Center

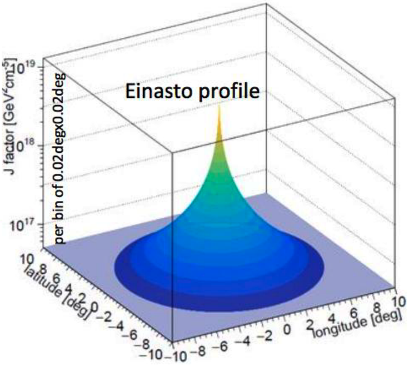


- Proximity (8kpc)
- Region with high (possibly) central DM density: core or cusp?
- High astrophysical background in gamma rays

Dark Matter distribution in the GC



Cuspy profile



$$\rho_{\mathrm{Ein1}}(\mathrm{r}) = \rho_{\mathrm{s}} \exp\left[\frac{-2}{\alpha}\left(\left(\frac{\mathrm{r}}{\mathrm{r_s}}\right)^{\alpha} - 1\right)\right]$$

parametrized with

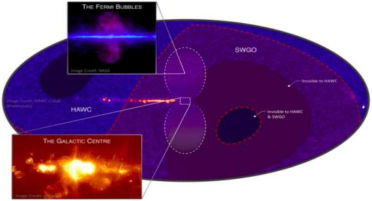
$\alpha = 0.17$

$r_s = 21\ kpc$

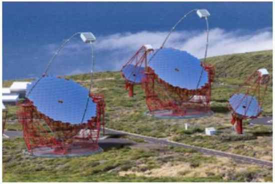
$\rho_s = 0.07\ GeV cm^{-3}$

- Here we assume an Einasto profile (*for comparison with cored see AV et al 2019 arXiv:1906.03353*)
- Morphology helps to discriminate between a DM gamma-ray signal and the residual isotropic hadronic background

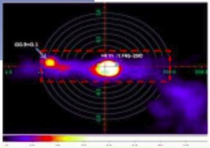
γ-ray Experiments



SWGO:
Energy: 100 GeV - 100 TeV



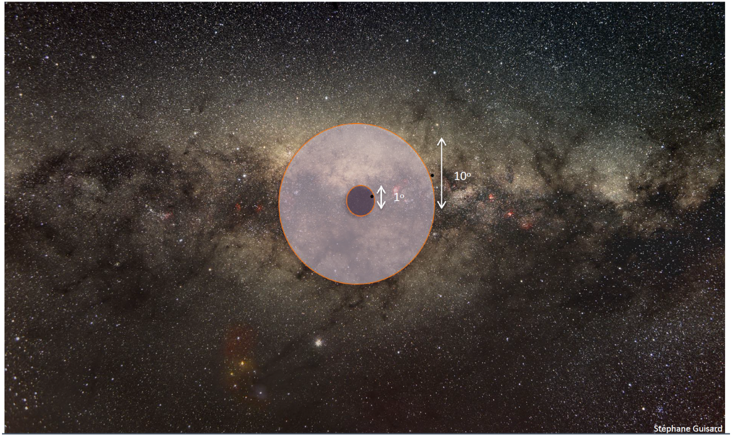
CTA
Energy: 20 GeV - 300 TeV



HESS
Energy: 230 GeV - 30TeV

GC halo: DM annihilation sensitivity

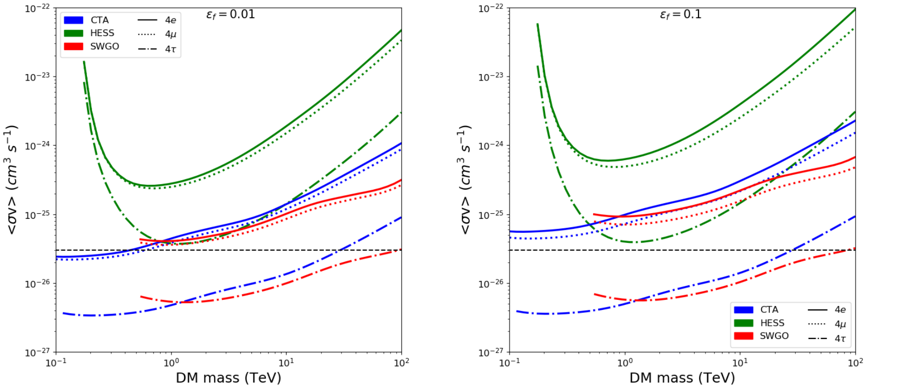
- Search for signal in the inner $r < 1^\circ$ for HESS (254h) and CTA (500h) and $r < 10^\circ$ for SWGO (10 yrs)



GC halo: DM annihilation sensitivity

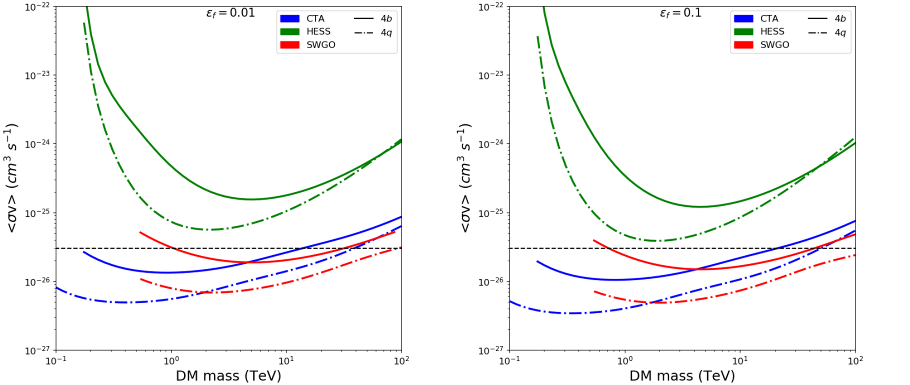
- Search for signal in the inner $r < 1^\circ$ for HESS (254h) and CTA (500h) and $r < 10^\circ$ for SWGO (10 yrs)
- Exclusion of $\pm 0.3^\circ$ band in latitude to avoid strong astrophysical background
- 2D likelihood analysis with spectral and spatial information of signal and background

Annihilation cross-section limits - Leptons



- For $\tau^+\tau^-$: combined (CTA,SWGO) sensitivity smaller than thermal relic cross-section(3×10^{-26} cm^{-3} s^{-1}) for all masses below 100 TeV
- For $\mu^+\mu^-$ and e^+e^-: less contraining and large dependency on ϵ_f

Annihilation cross-section limits - Quarks



- For $q\bar{q}$: combined (CTA,SWGO) sensitivity smaller than thermal relic cross-section for all masses below 100 TeV
- For $b\bar{b}$: combined (CTA,SWGO) sensitivity smaller than thermal relic cross-section for all masses below 20-40 TeV

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 energy range explored in this work.
- Paper under internal review by CTA consortium (soon on ArxiV)

SWGO
The Southern Wide-field Gamma-ray Observatory

Thank you!!

Secluded Models @ TeV γ-ray experiments

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