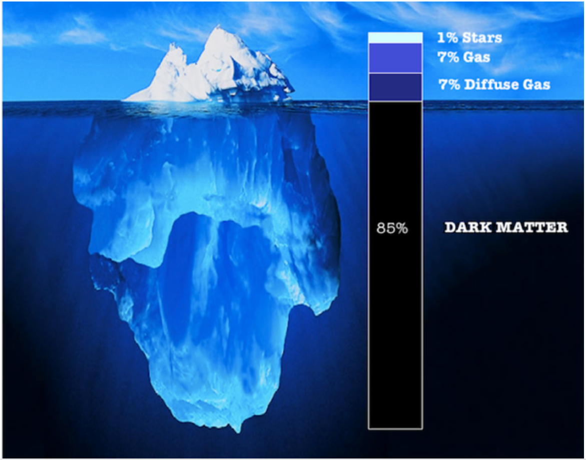
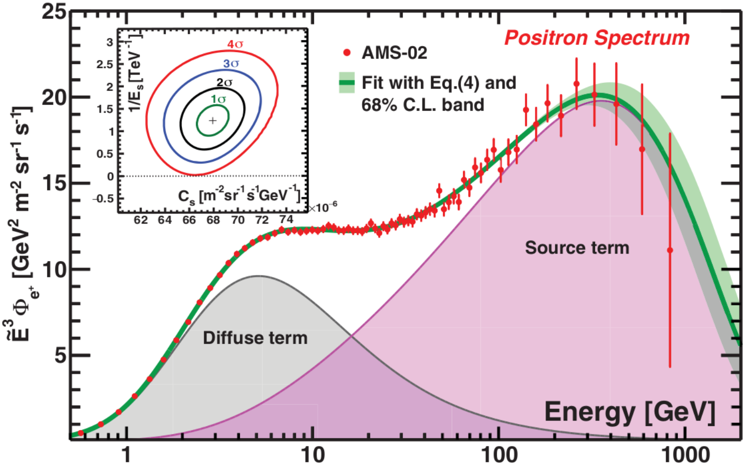
An evidence of dark matter decay at AMS-02?

based on arXiv:1903.07638, S. Profumo, F. Queiroz, C. Siqueira
and, in preparation with J. Silk, F. Queiroz, C. Siqueira



Motivation - Results AMS-02

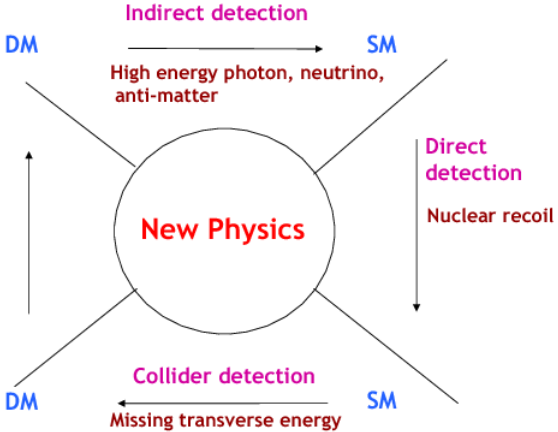


Aguilar *et al.*, 2019

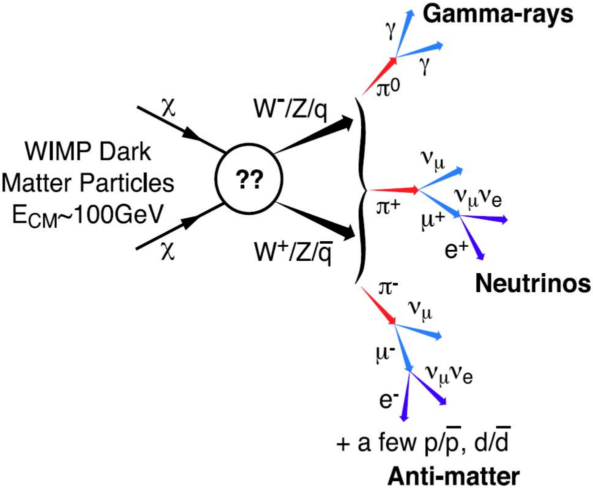
Several works trying to explain the data

- Pulsars: B1055-52 (Fang *et al.*, 2019), Milisecond (Bykov *et al.*, 2019)
- Annihilating or decaying DM (Geng *et al.*,2019)

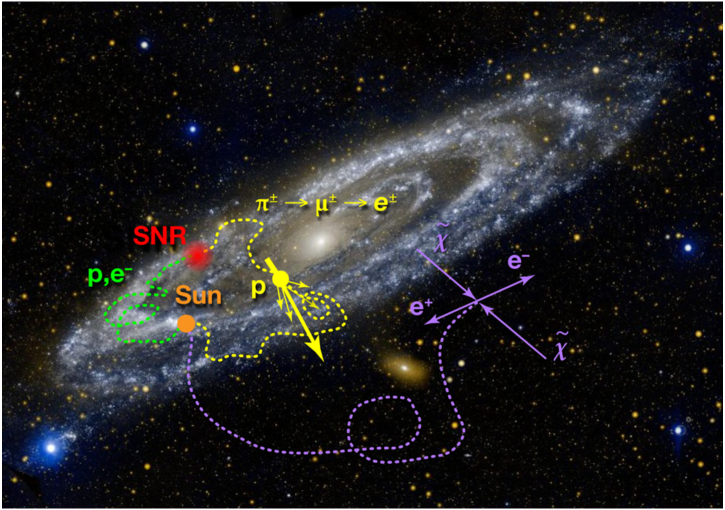
DM Particle - Detection Methods



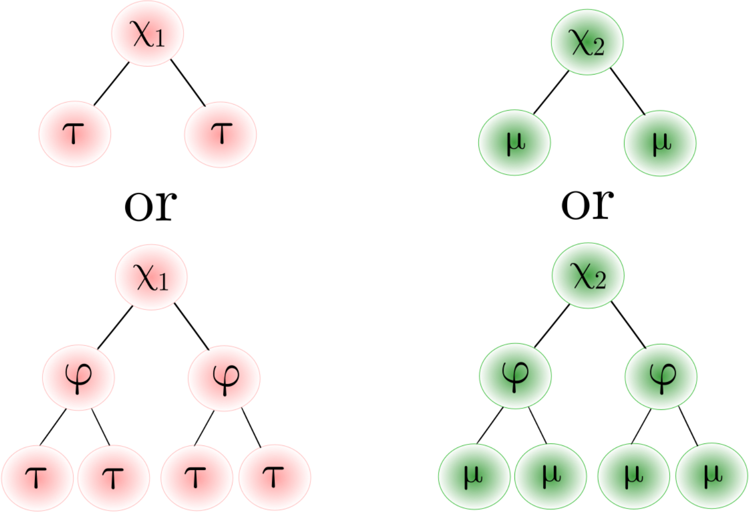
DM Indirect Searches



Propagation trough the Galaxy



Two-component DM Interpretation



The positron flux

The total expected flux:

$$\Phi_{pred}(E) = \Phi_{\chi}^{e^+}(E) + \Phi_{back}^{e^+}(E) \quad (1)$$

with,

$$\Phi_{\chi}^{e^+}(E) = \Phi_{\chi_1}^{e^+}(E) + \Phi_{\chi_2}^{e^+}(E) \quad (2)$$

The positron flux

- Background flux:

$$\Phi^{e^+}_{back}(E) = c_d \frac{E^2}{\hat{E}^2} \left(\frac{\hat{E}}{E_1} \right)^{\gamma_d} \tag{3}$$

We adopt $c_d = 6.9 \times 10^{-2} (\mathrm{m}^2\,\mathrm{sr}\,\mathrm{s}\,\mathrm{GeV})^{-1}$, $\gamma_d = -3.98$, and $\hat{E}(E) = E + \varphi_{e^+}$ with $\varphi_{e^+} = 1.10$ GeV.

  - Include interaction between cosmic rays and the gas in the intergalactic medium;
  - takes into account effects of solar modulation.

The positron flux

- DM flux:

$$\Phi_\chi^{e^+}(E) = \frac{1}{4\pi\, b(E)} \frac{\rho_\odot}{m_\chi} \Gamma \times$$

$$\times \int_E^{m_\chi/2} dE_s \sum_f BR_f \frac{dN_f^{e^+}}{dE}(E_s) \; \mathcal{I}(E, E_s) \quad (4)$$

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The positron flux

Syncroton; ICS

DM mass; decay rate

- DM flux:

$$\Phi_{\chi}^{e^+}(E) = \frac{1}{4\pi\, b(E)} \frac{\rho_{\odot}}{m_{\chi}} \Gamma \times$$

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Spectrum at production

Halo function (NFW profile)

The positron flux

Syncroton; ICS

DM mass; decay rate

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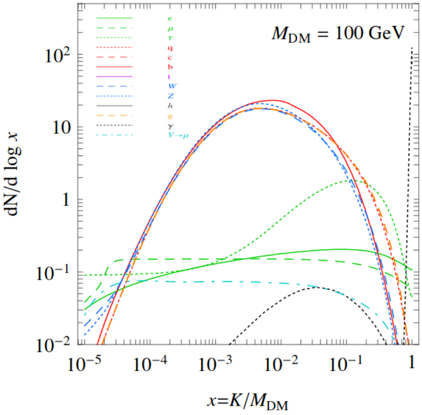
Spectrum at production

Halo function (NFW profile)

Energy spectrum



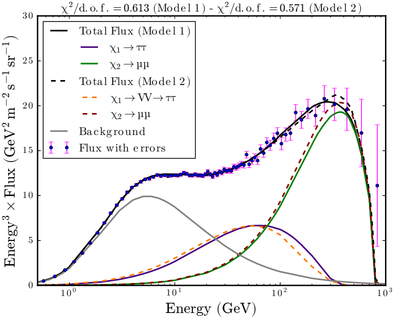
Cirelli, 2010.

Compatibility with $\gamma-$ray data

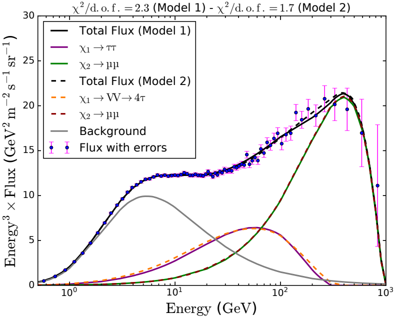
- Strong limits from $\gamma-$rays: Dwarf Spheroidal galaxies (Fermi-LAT) and the Galactic Center (H.E.S.S.).

Results

MED propagation

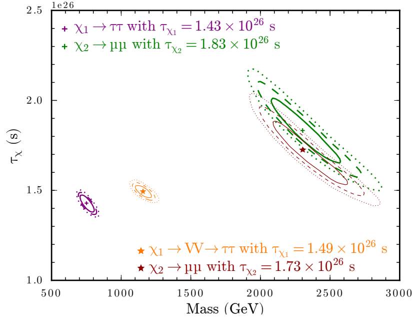


MAX propagation

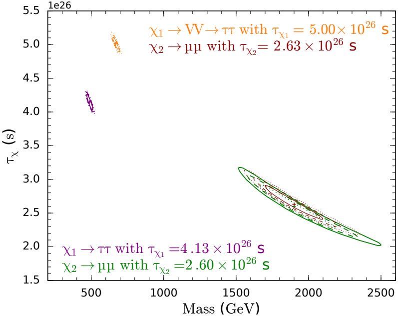


Results

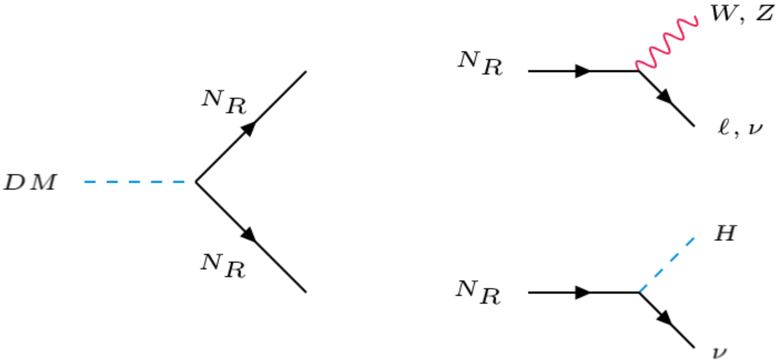
MED propagation



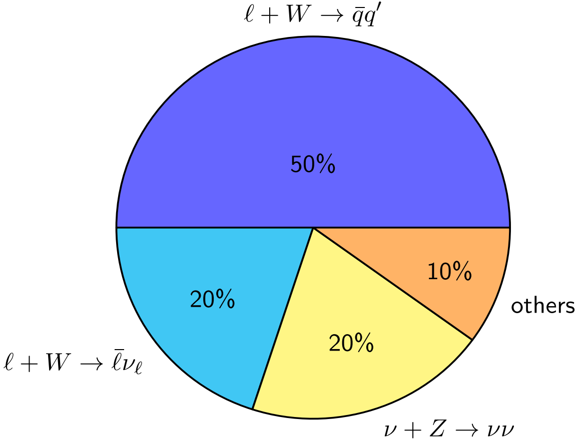
MAX propagation



Cheking other possibilities



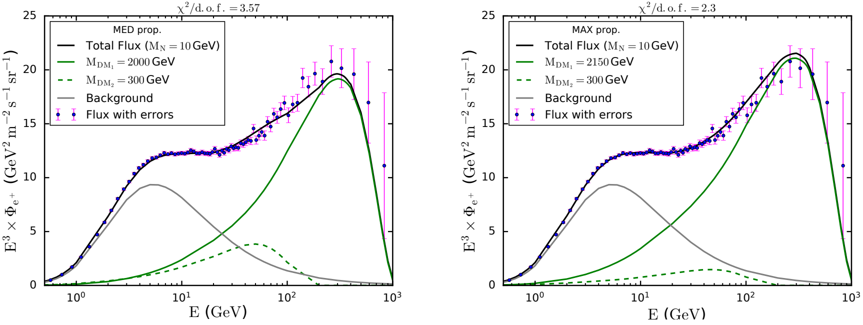
Branching ratio



Results - RHN

$$M_N = 10 \text{ GeV}$$

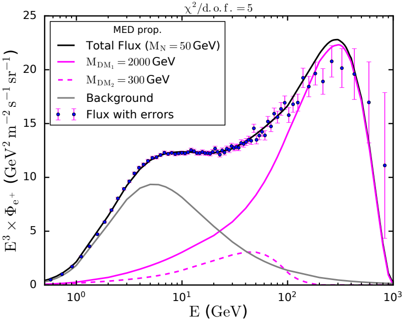
MED propagation | MAX propagation



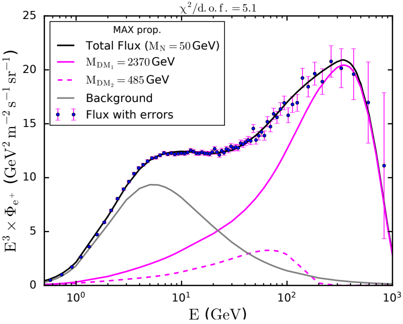
Results - RHN

$$M_N = 50 \text{ GeV}$$

MED propagation



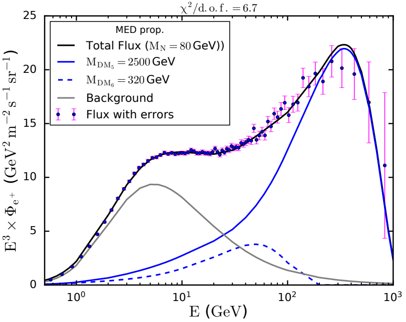
MAX propagation



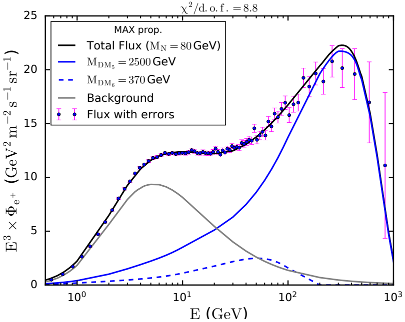
Results - RHN

$$M_N = 80\ \text{GeV}$$

MED propagation

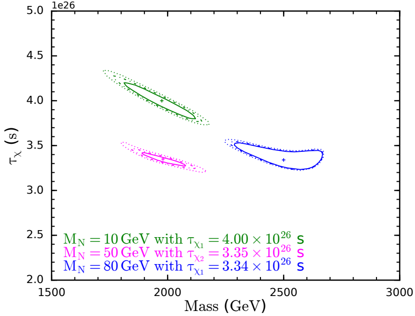


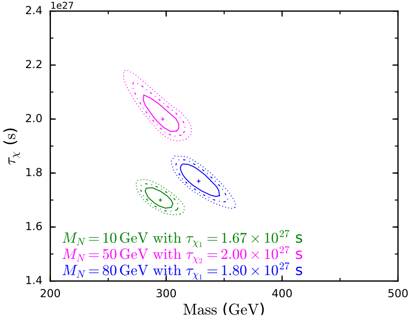
MAX propagation



Results - RHN

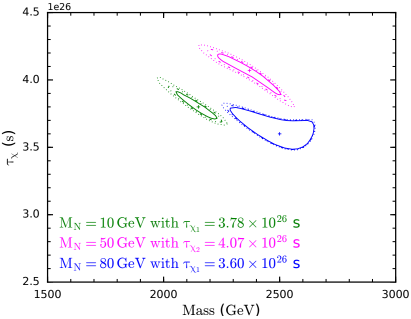
MED propagation

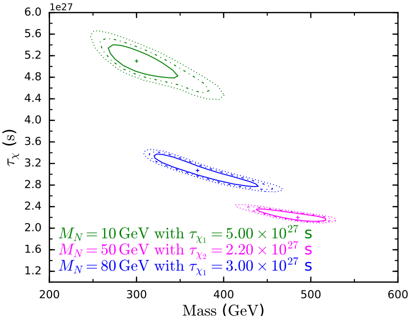




Results - RHN

MAX propagation

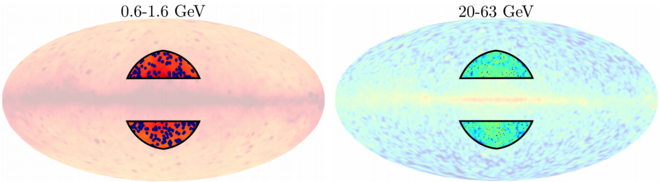




Gamma-ray data

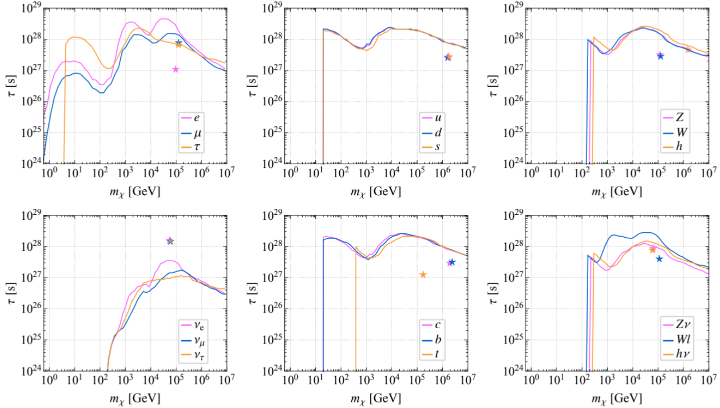
Gamma-ray Flux

$$\frac{\Phi_\gamma}{d\Omega dE} = \frac{r_\odot}{4\pi}\frac{\rho_\odot}{M_{DM}} J \sum_f \frac{dN_\gamma^f}{dE}, \qquad J = \int_{l.o.s.} \frac{ds}{r_\odot}\frac{\rho(r(s,\theta))}{\rho_\odot}$$



Cohen *et al.*, 2016.

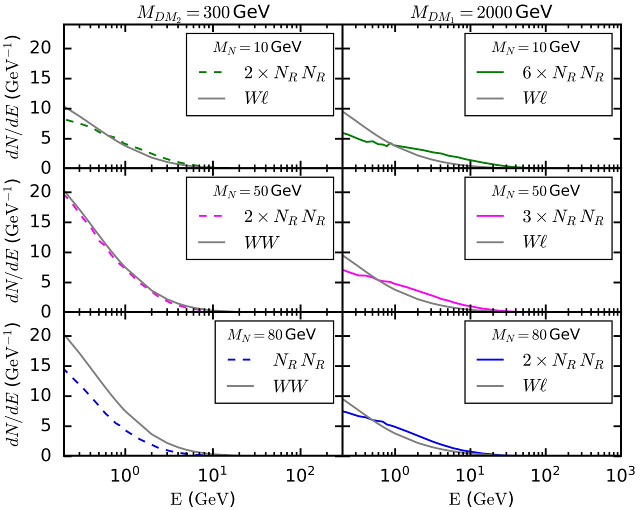
Gamma-ray data - Fermi-LAT



Cohen *et al.*, 2016.

Comparing the dN/dE

$$\frac{\Phi_\gamma}{d\Omega dE} \propto \frac{dN_\gamma^f}{dE}$$



Comparing the Limits

M_N (GeV)	M_{DM} (GeV)	Γ_{pred} (s)	Γ_{lim} (s) (rescaled)
10	300	5.0×10^{27}	1.2×10^{27}
10	2000	3.6×10^{26}	3.0×10^{27}
50	300	2.2×10^{27}	1.2×10^{27}
50	2000	4.1×10^{26}	6.0×10^{27}
80	300	3.0×10^{27}	4.8×10^{27}
80	2000	3.6×10^{26}	9.0×10^{27}

Table: Comparison between the stronger limits rescaled and our predictions.

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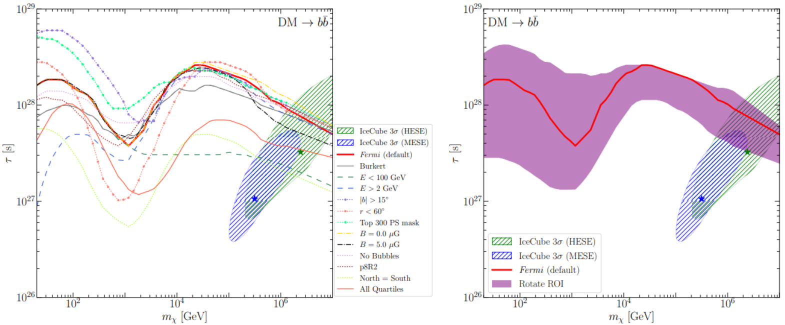
Uncertainties in $\gamma-$ray Limits



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Conclusions

- The positron excess observed by AMS-02 remains unexplained;
- In this talk we showed different scenarios where two-component DM can provide a good fit to the data;
- We include several different approaches, including direct decay into SM particles and secluded scenarios;
- The comparison with $\gamma-$ray data provides a really trick scenario, however we have several systematic uncertainties which can alleviate the limits.

Thank You!