Cosmic ray constraints on singlino-like dark matter candidates

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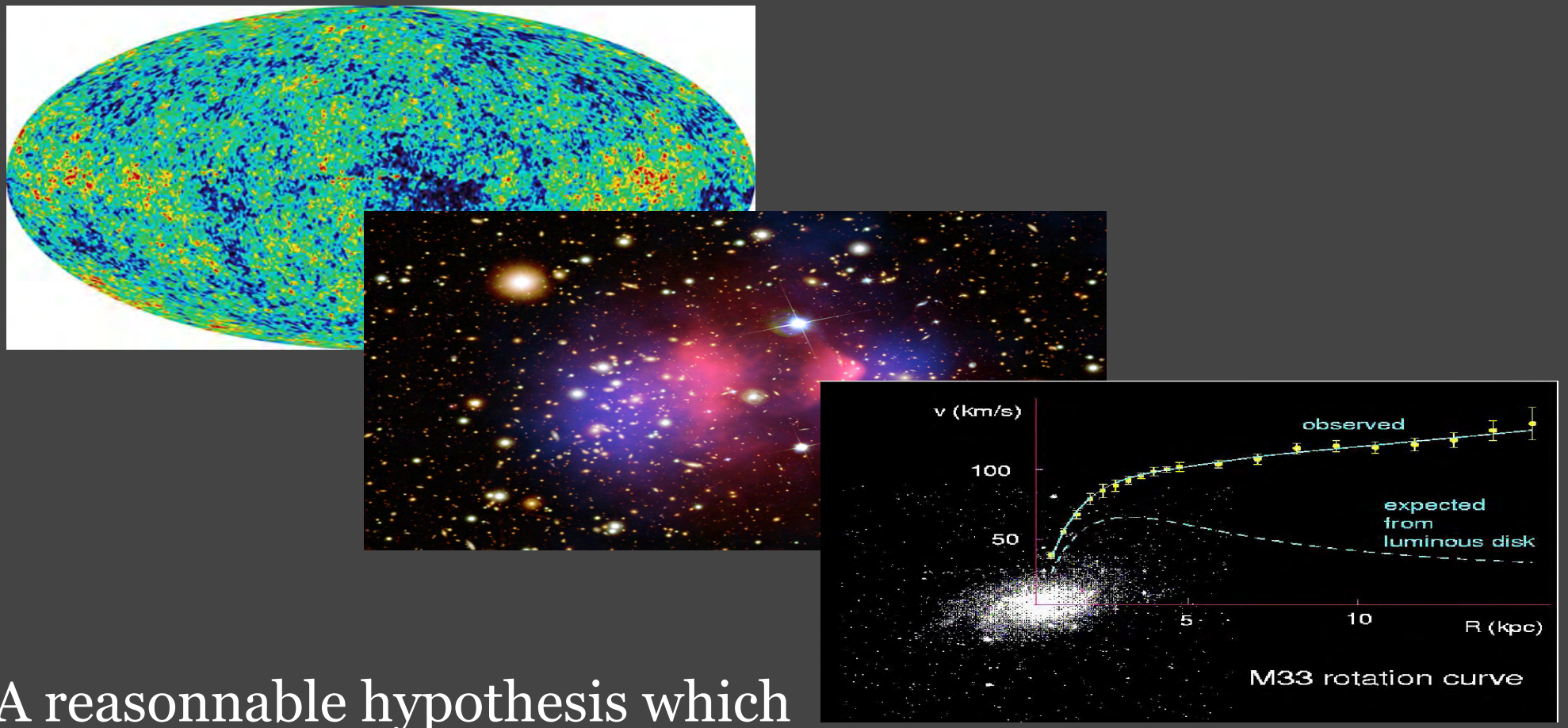
in preparation

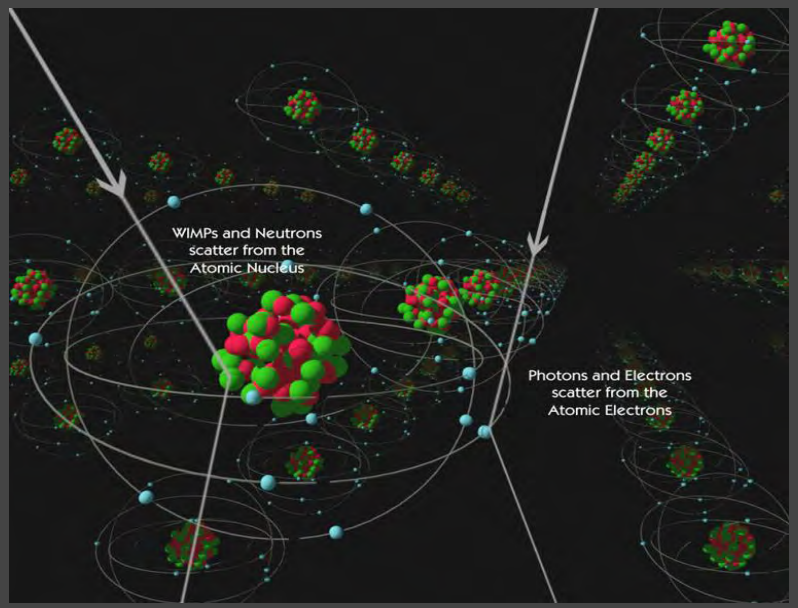
Dark Matter

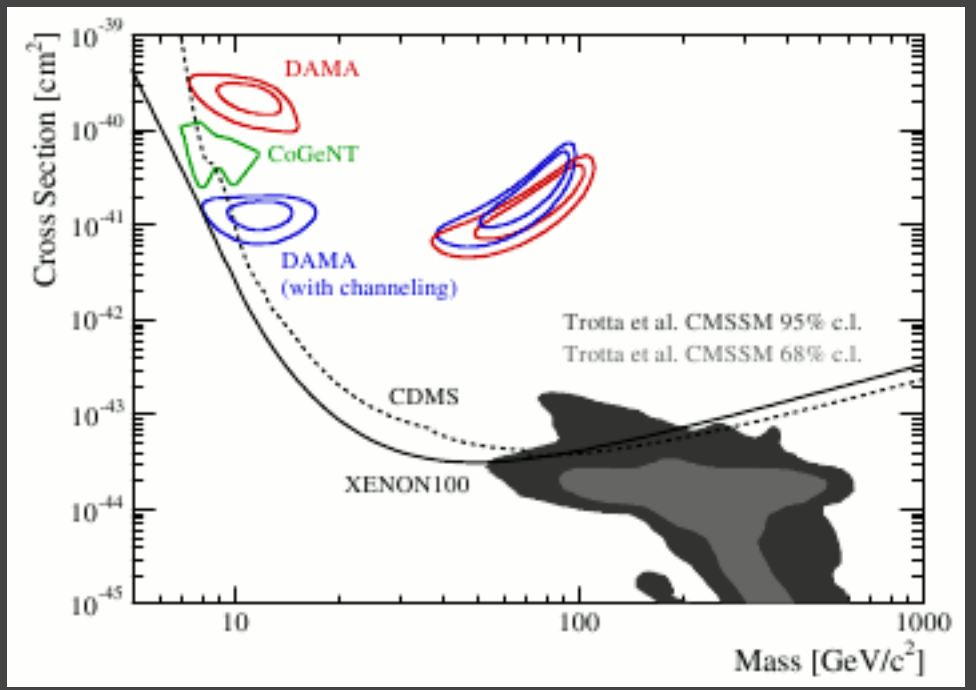


A reasonnable hypothesis which requires a microscopic confirmation

Motivations

Dark matter direct detection experiments results are difficult to explain.
Some of them hint towards a low mass candidate
(3 - 20 GeV)





Xenon experiment : arXiv:1005.0380

See all the other talks of this morning

Timur Delahaye

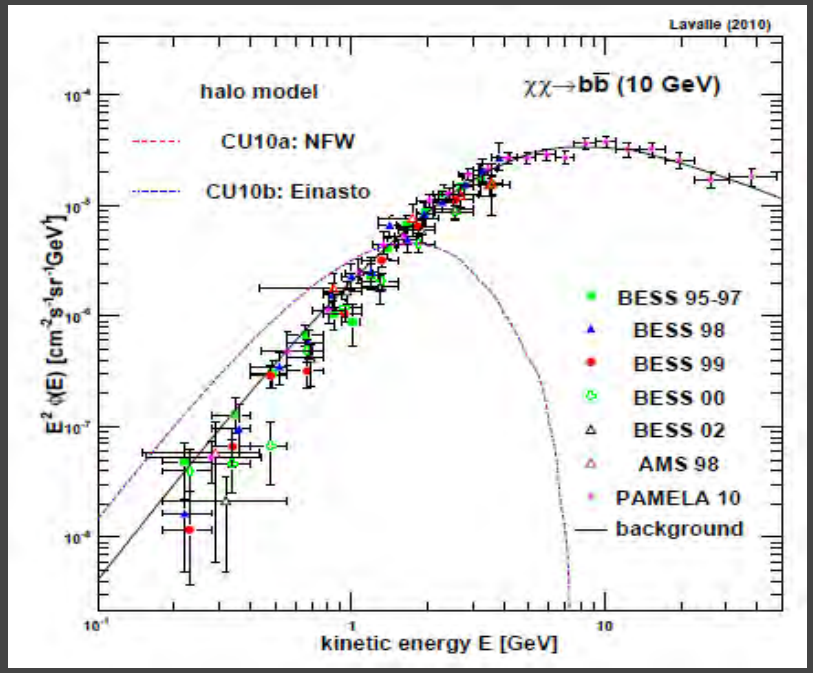
Motivations

Low mass dark matter candidate are difficult to achieve in MSSM

Strong coupling to quarks imply strong cosmic anti-proton production.

But possible:
Fornengo et al (arXiv:1011.4743)

Lavalle (arXiv:1007.5253)



The model

$$\mathcal{L}_{\text{eff}} = -\frac{1}{2}\sum_i \chi\, C_{\chi i}\, \chi\, \phi_i - \frac{1}{2}\sum_{i\le j\le k} \lambda_{ijk}\, \phi_i\, \phi_j\, \phi_k$$

Particle content:
Standard model particles +
a scalar particle h +
a pseudo-scalar particle a +
a dark matter particle χ

} mainly singlets

mainly singlino

See:
Kappl et al, (arxiv:1010.0553)
Gunion et al, (arxiv:1009.2555)
Draper et al (arxiv:1009.3963)

For instance a singlet extension of the MSSM model.

The parameters

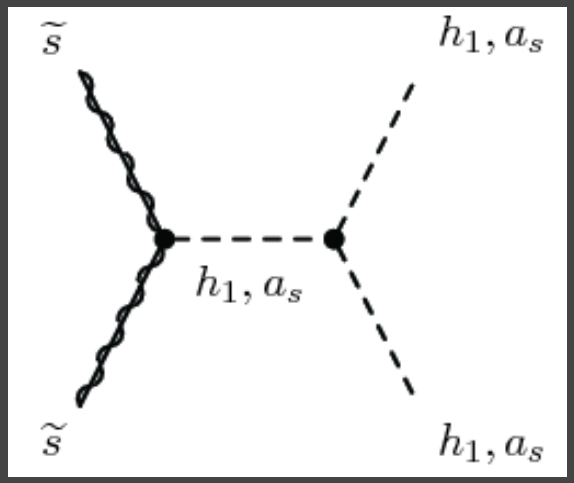
c_h, $\tilde{c_a}$, O, m_a, m_h, m_χ

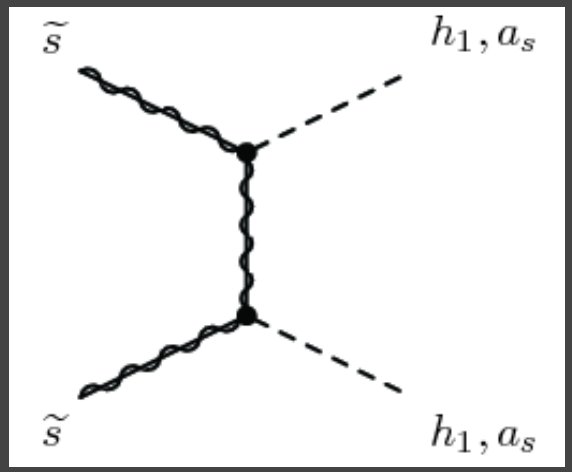
allow to compute the annihilation cross-section

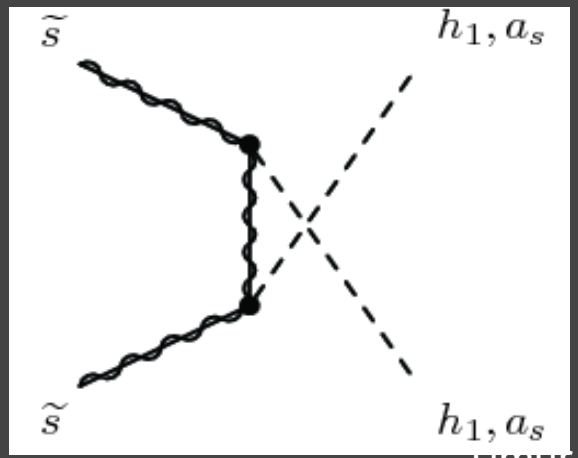
$<\sigma v_{\{\chi+\chi => a + h\}}>(s)$

Relic density

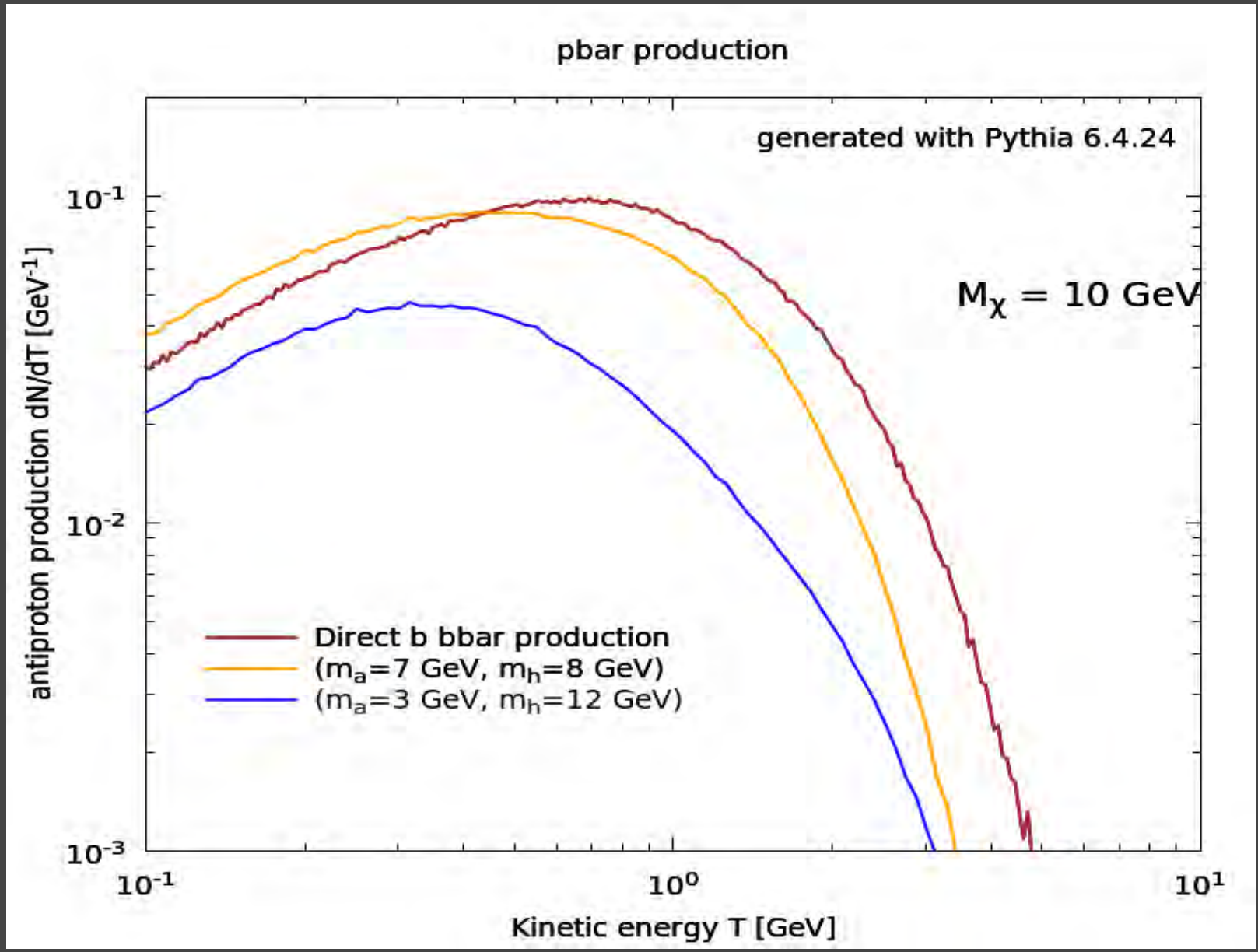
Cosmic ray production (only if $m_a + m_h < 2\, m_\chi$)





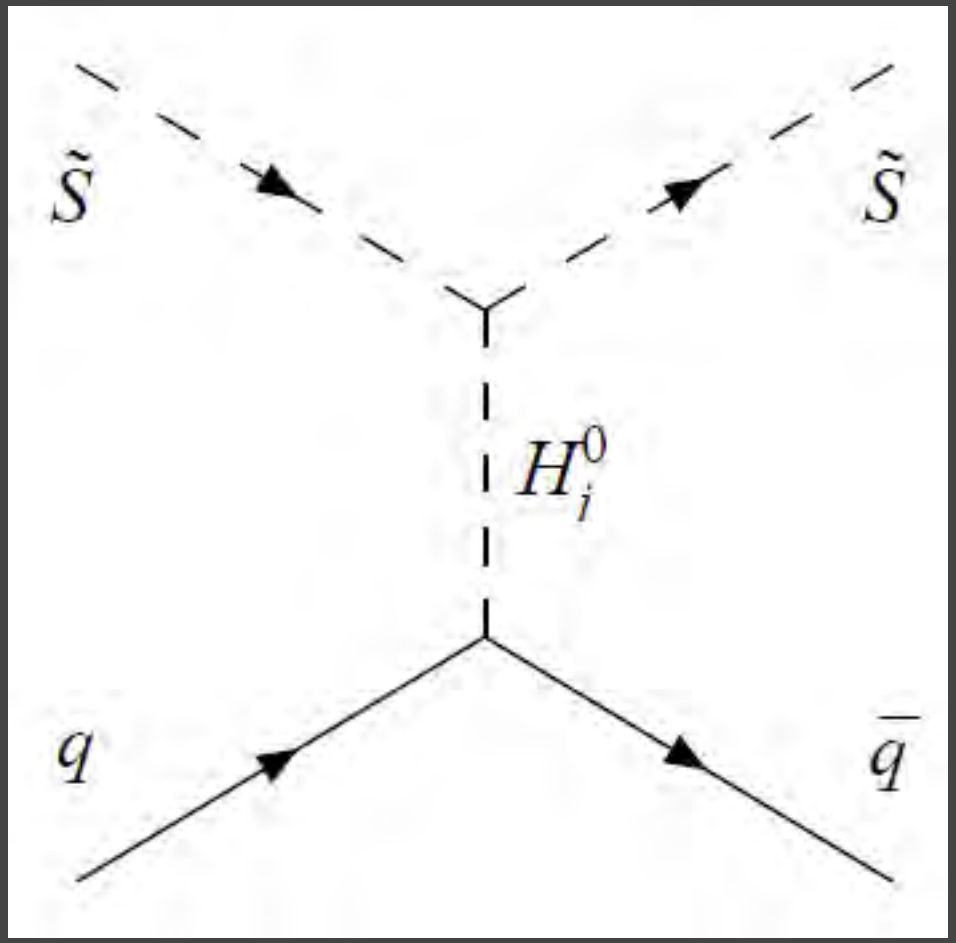


anti-proton production



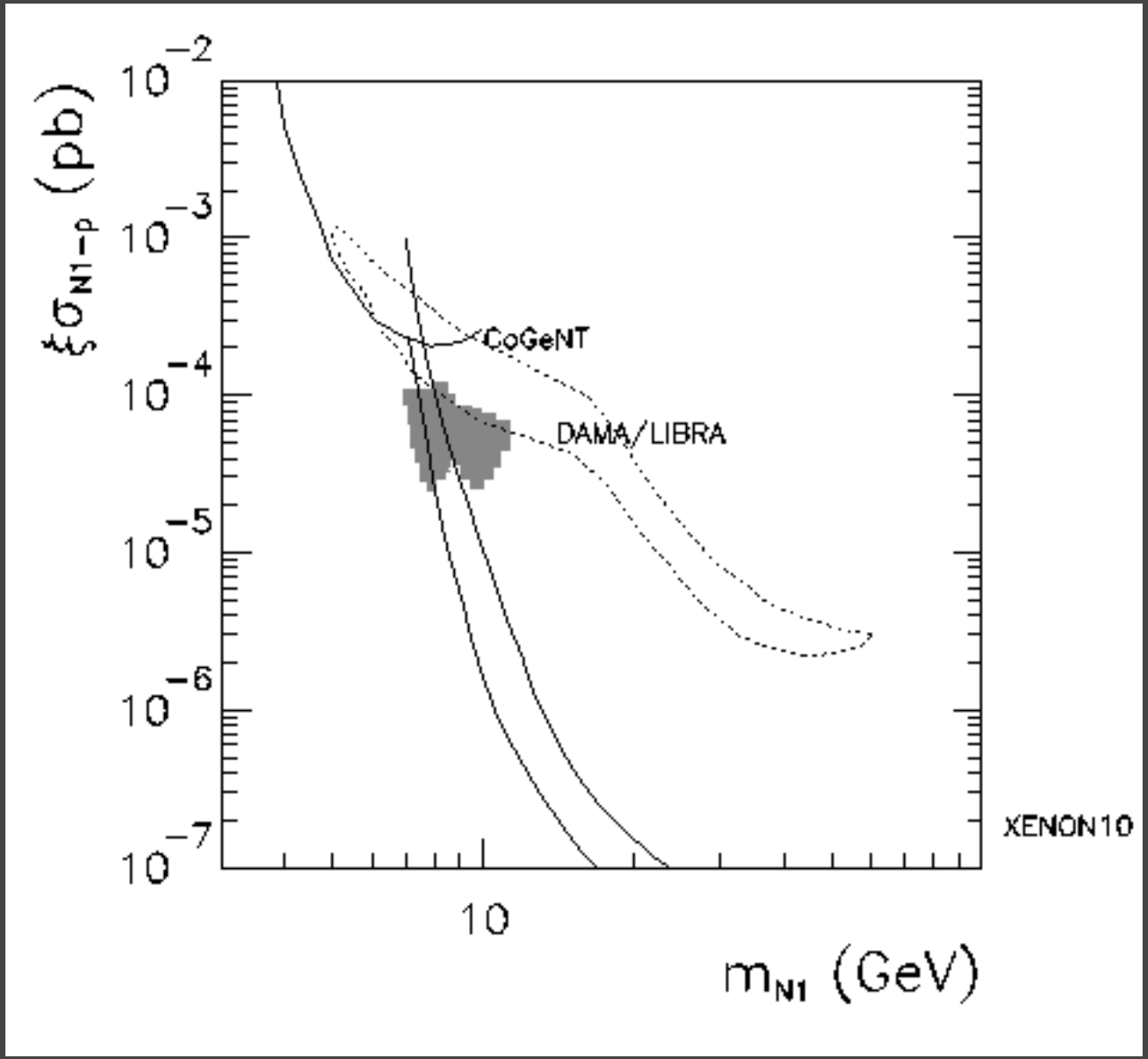
The parameters

& the spin independent nuclear recoil cross-section



Couplings of light Higgs bosons to quarks are suppressed
=> direct detection signal dominated by heavy Higgs exchanges in most of cases
=> m_χ is constrained and hence m_a and m_h

The CoGeNT region

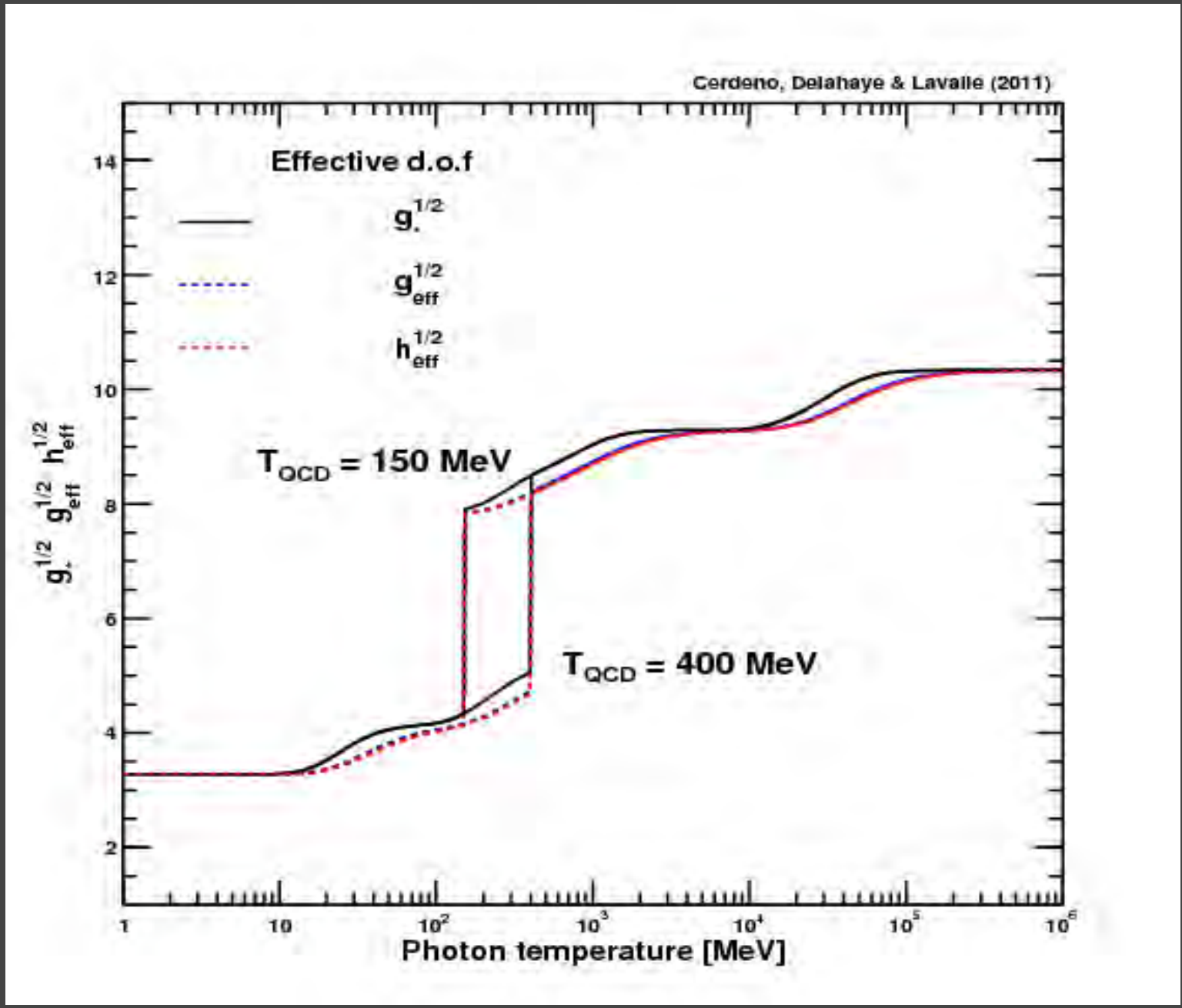


Relic density

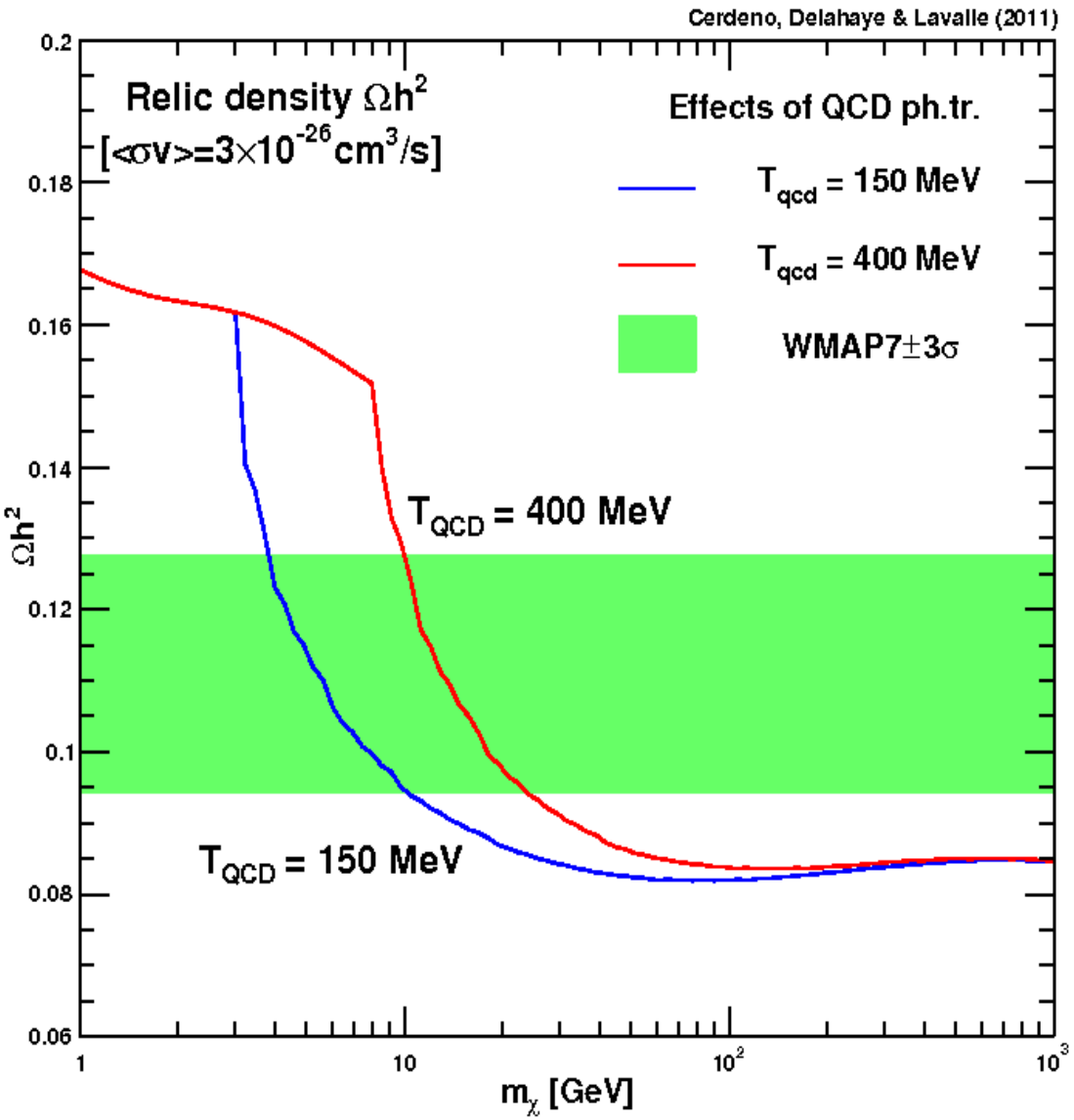
Thermally produced particles are in equilibrium with the photons untill they become non-relativistic. Then they annihilate untill they are so few that the probability of annihilation gets very small. The relic density is then:

$$\Omega h^2 \propto 1 / \sqrt{g_*} \langle \sigma v \rangle$$

Relic density



Relic density

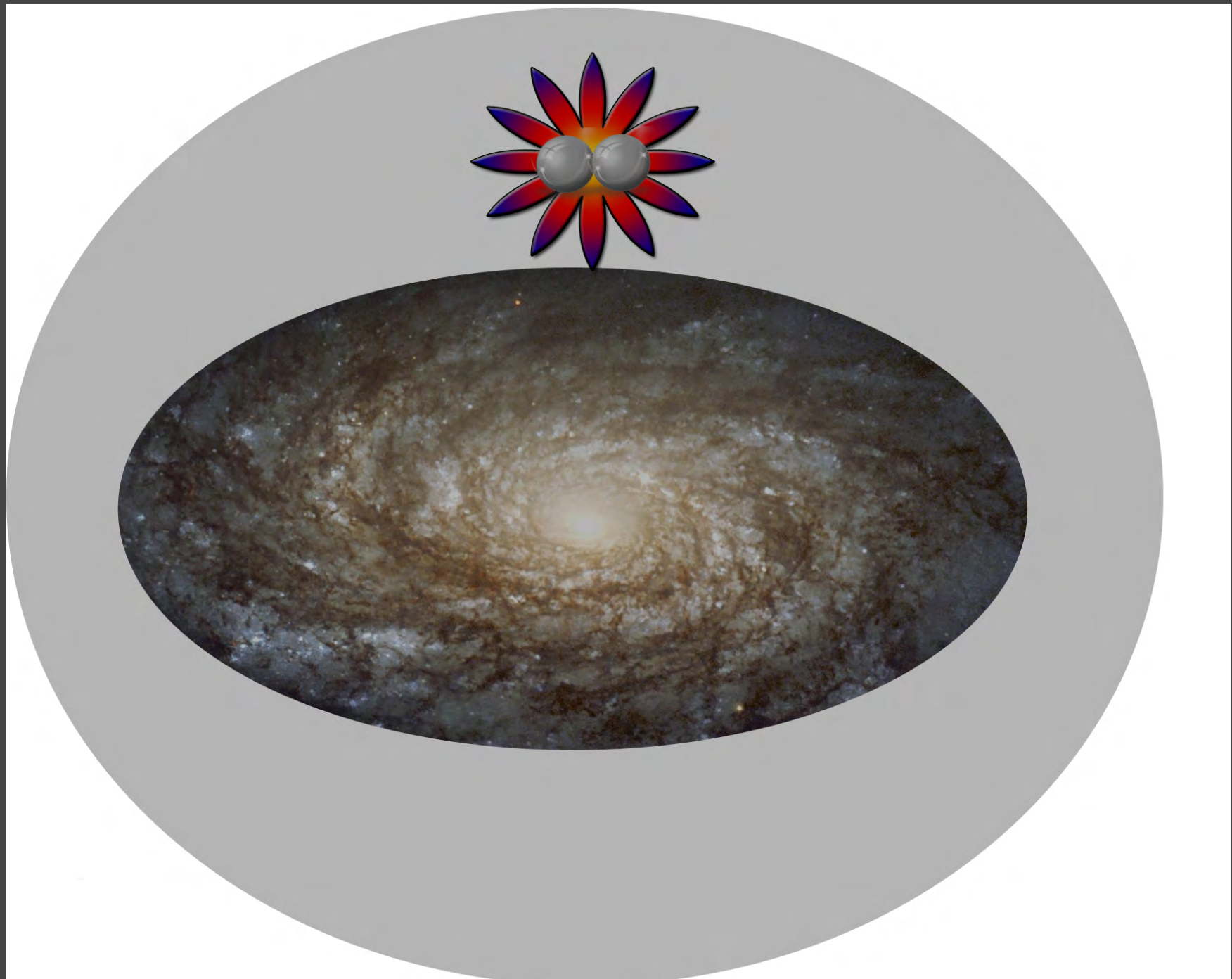


In the case where
$m_a = m_h$ and
$c_h = \tilde{c_a} = O$

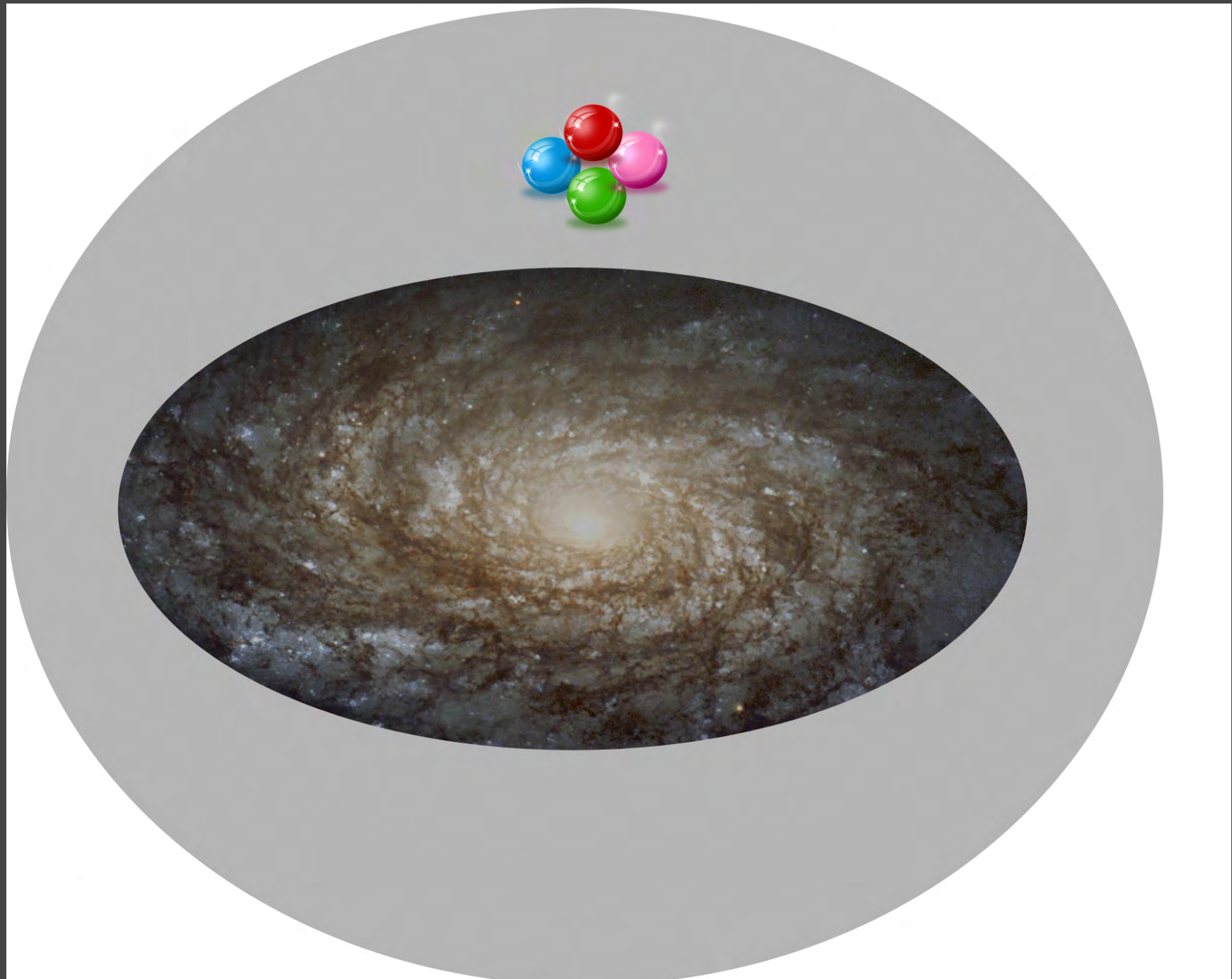
about 90% of the parameter space allowed by CoGeNT is excluded.

Indirect detection

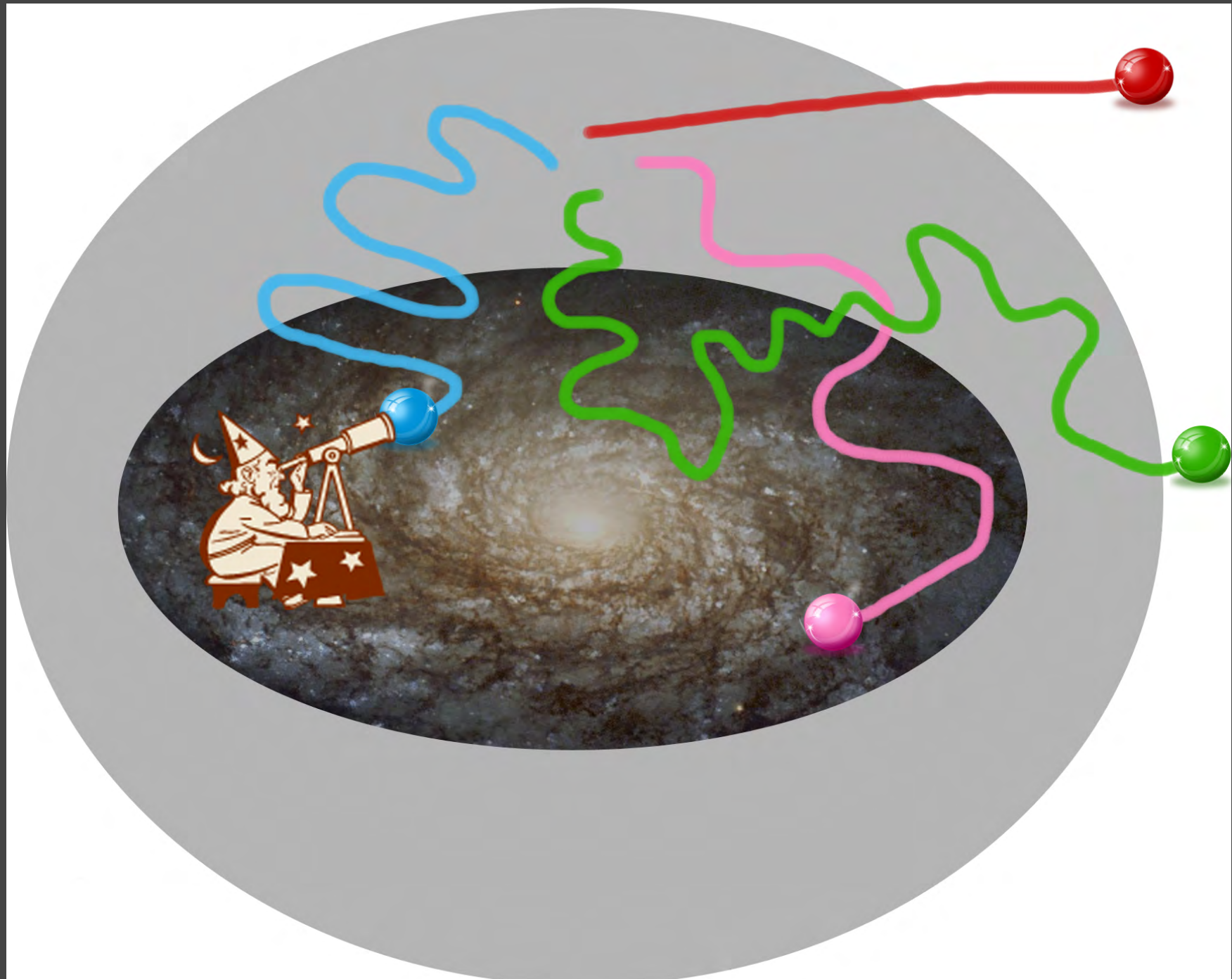
Indirect detection



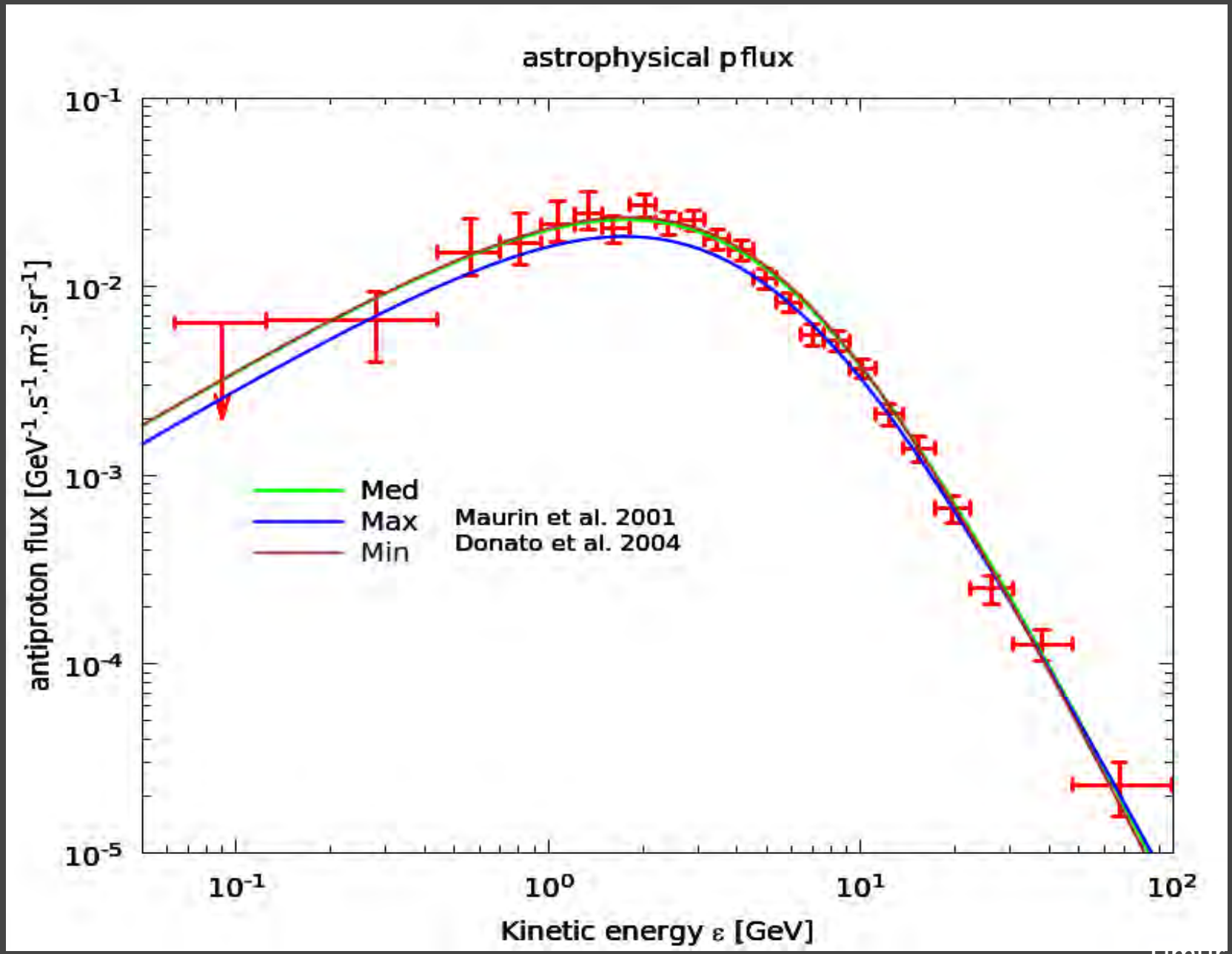
Indirect detection



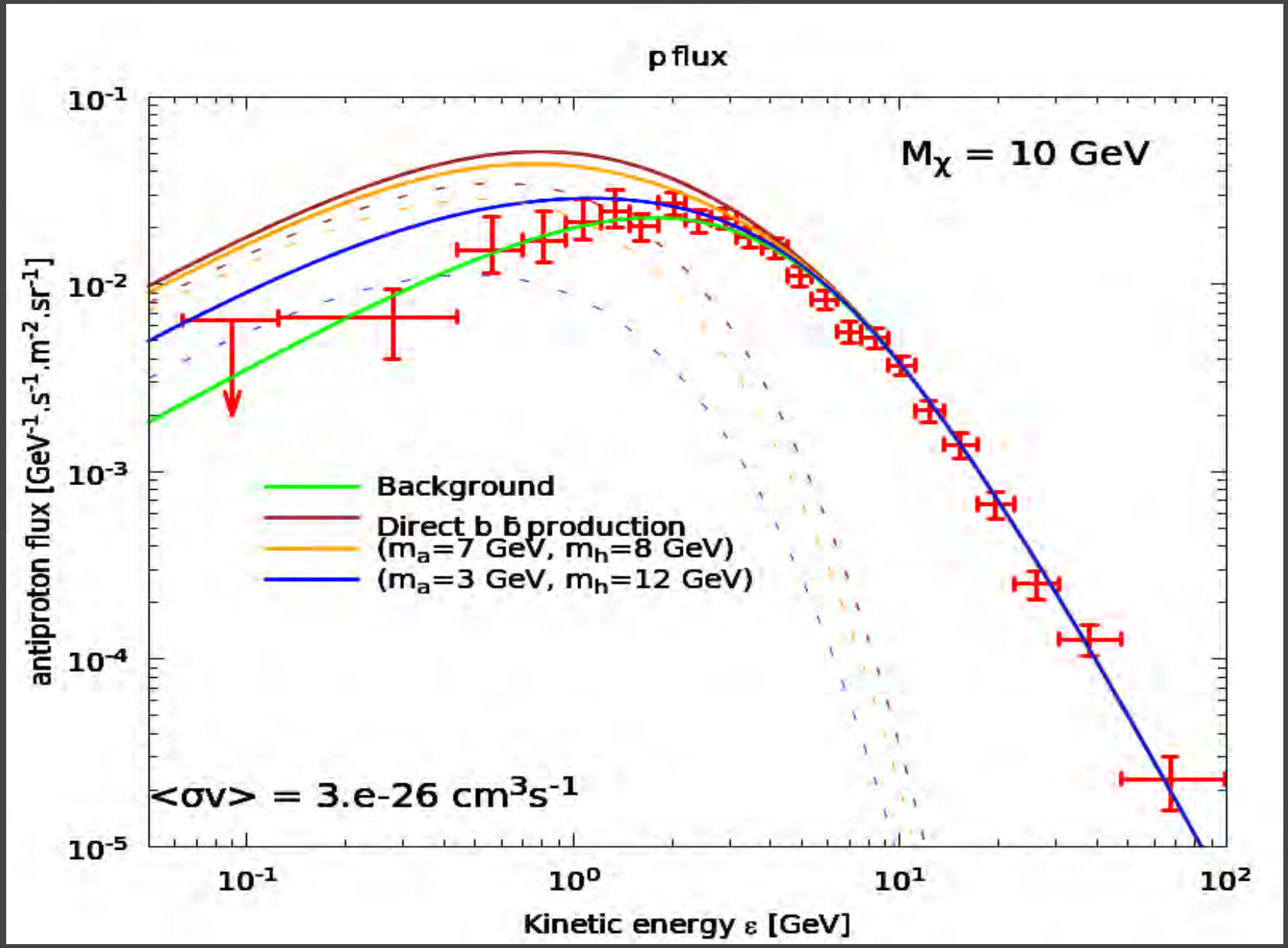
Indirect detection



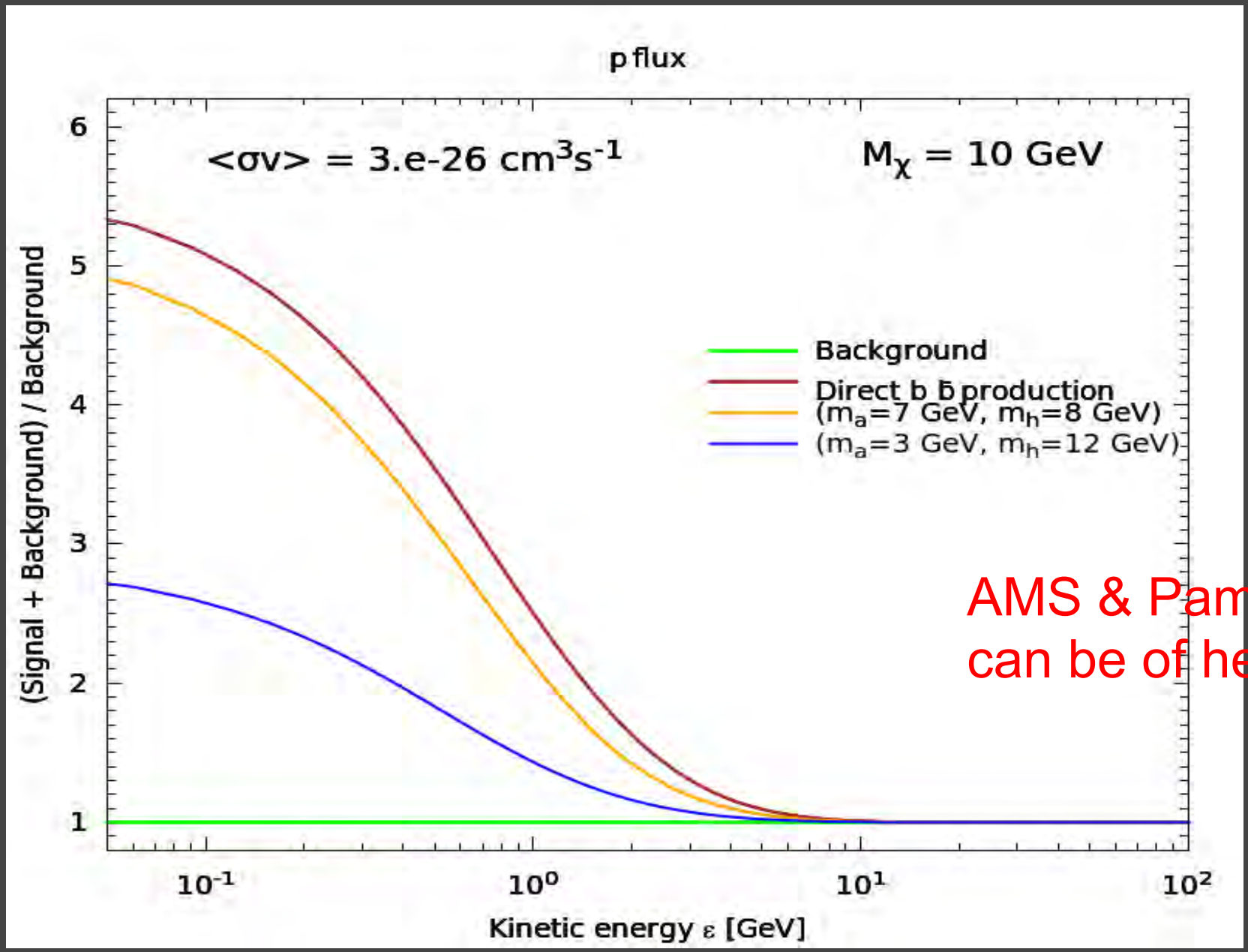
Cosmic anti-protons: background



Cosmic anti-protons: signal



Cosmic anti-protons: (S + B) / B



Conclusions and outlook

Though it is not possible to absolutely dismiss the dark matter interpretation of CoGent and DAMA with indirect detection

some masse ranges of the scalar and pseudo-scalar particles are forbidden by indirect detection.

Relic density is very constraining, even considering the uncertainties.

A more systematic scan of the parameter space is now required. (very soon)