Search for Galactic dark matter subhalos in the VHE regime.

Moritz Hütten, DESY Zeuthen

HAP Dark Matter workshop Karlsruhe, Sept. 23, 2015

RADUIERTEN KOLLEG
Masse-Spektrum-Symmetrie

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DESY

Reminder: Indirect dark matter targets

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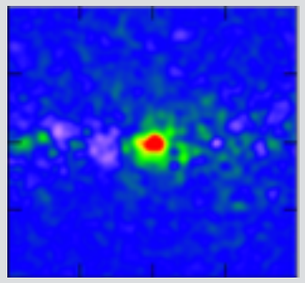
- Galactic center and vicinity



1402.6703

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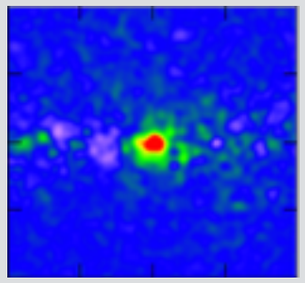

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- remote galaxies & galaxy clusters

Abell 1689

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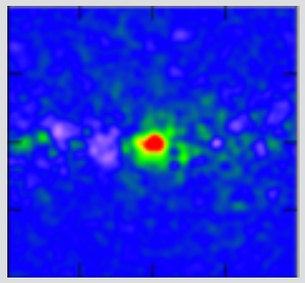

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Sculptor
dwarf galaxy

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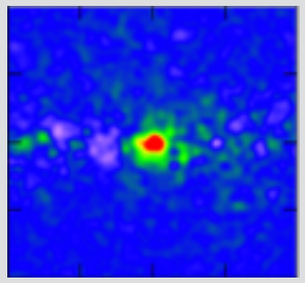

1402.6703

- remote galaxies & galaxy clusters

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- **Dark Galactic subhalos**
  - **individually seen as point sources?**
  - **small-scale anisotropies in the diffuse gamma-ray background?**

Galactic dark matter subhalos

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What is the **systematic uncertainty** on the expected γ-ray brightness of the subhalos?

Galactic dark matter subhalos

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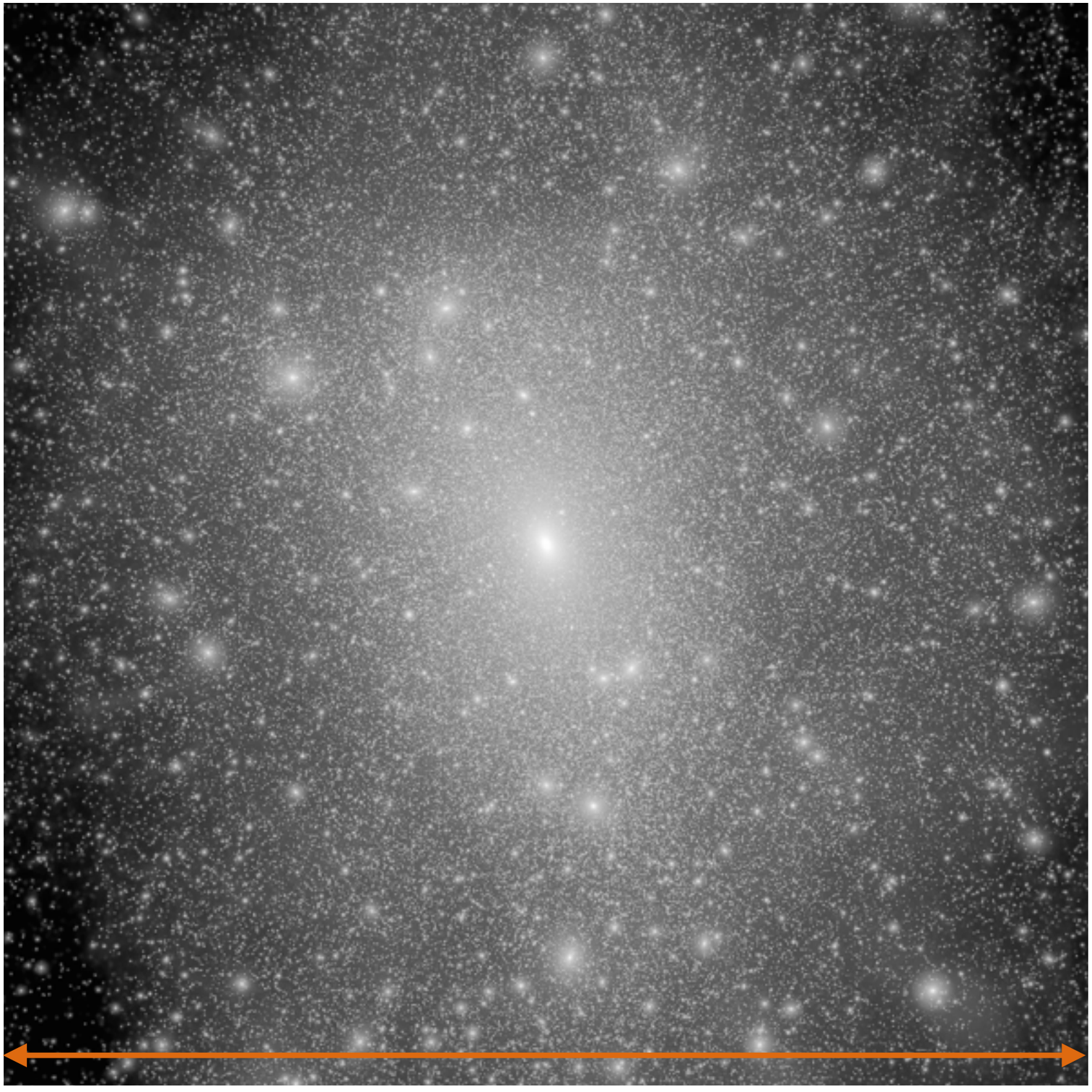
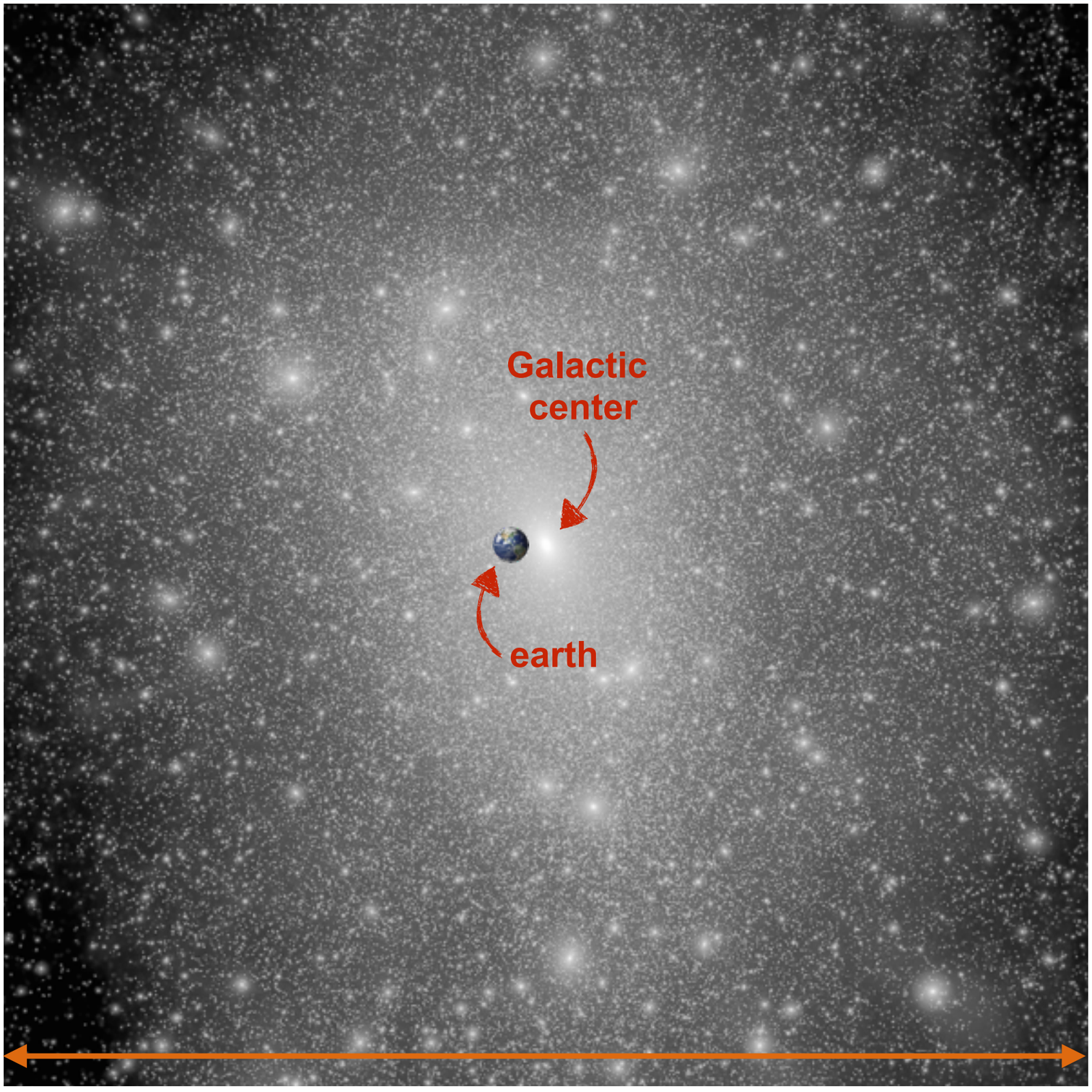
Dark matter in the Milky Way



800 kpc

Aquarius simulations
(Springel et al. 2008)

Dark matter in the Milky Way



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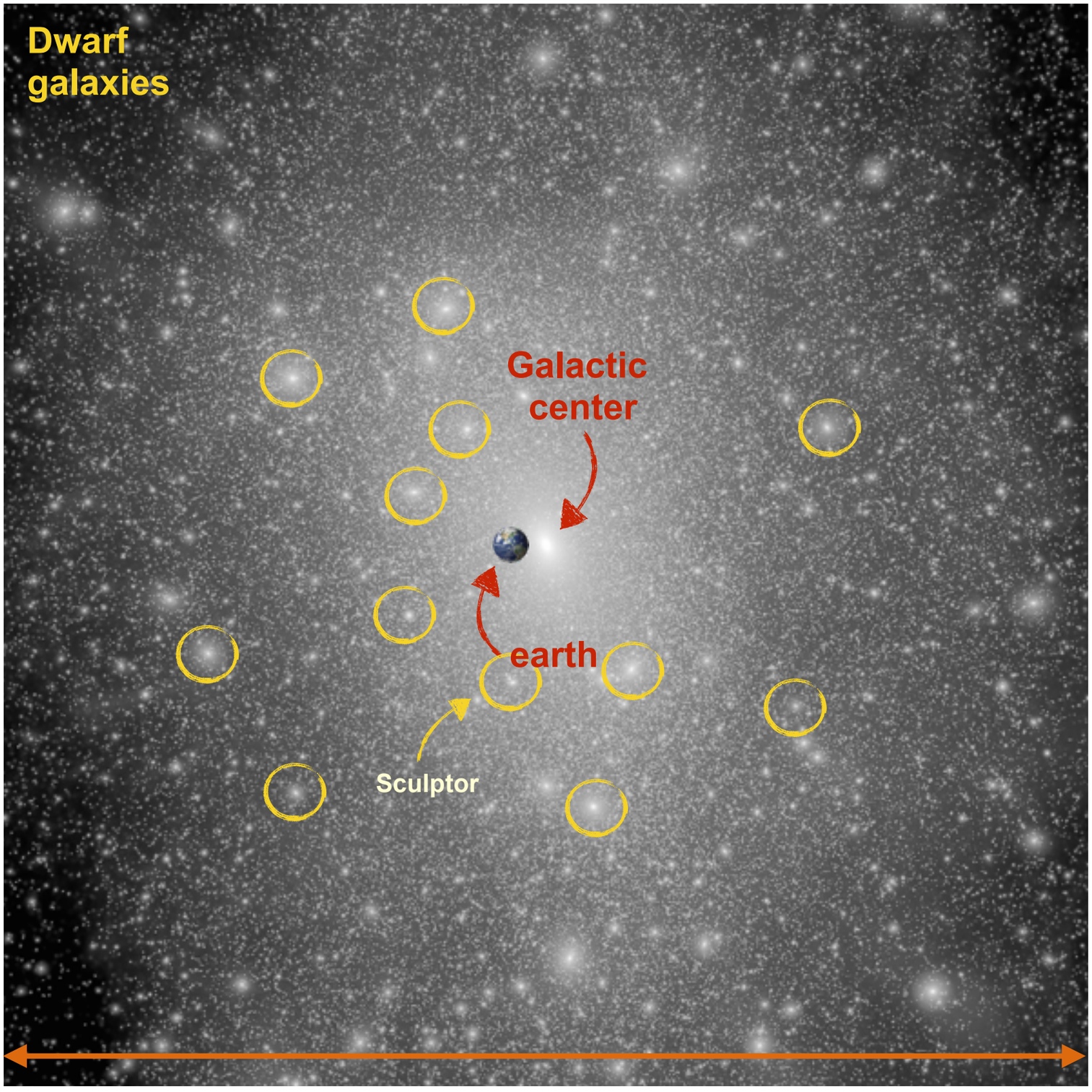

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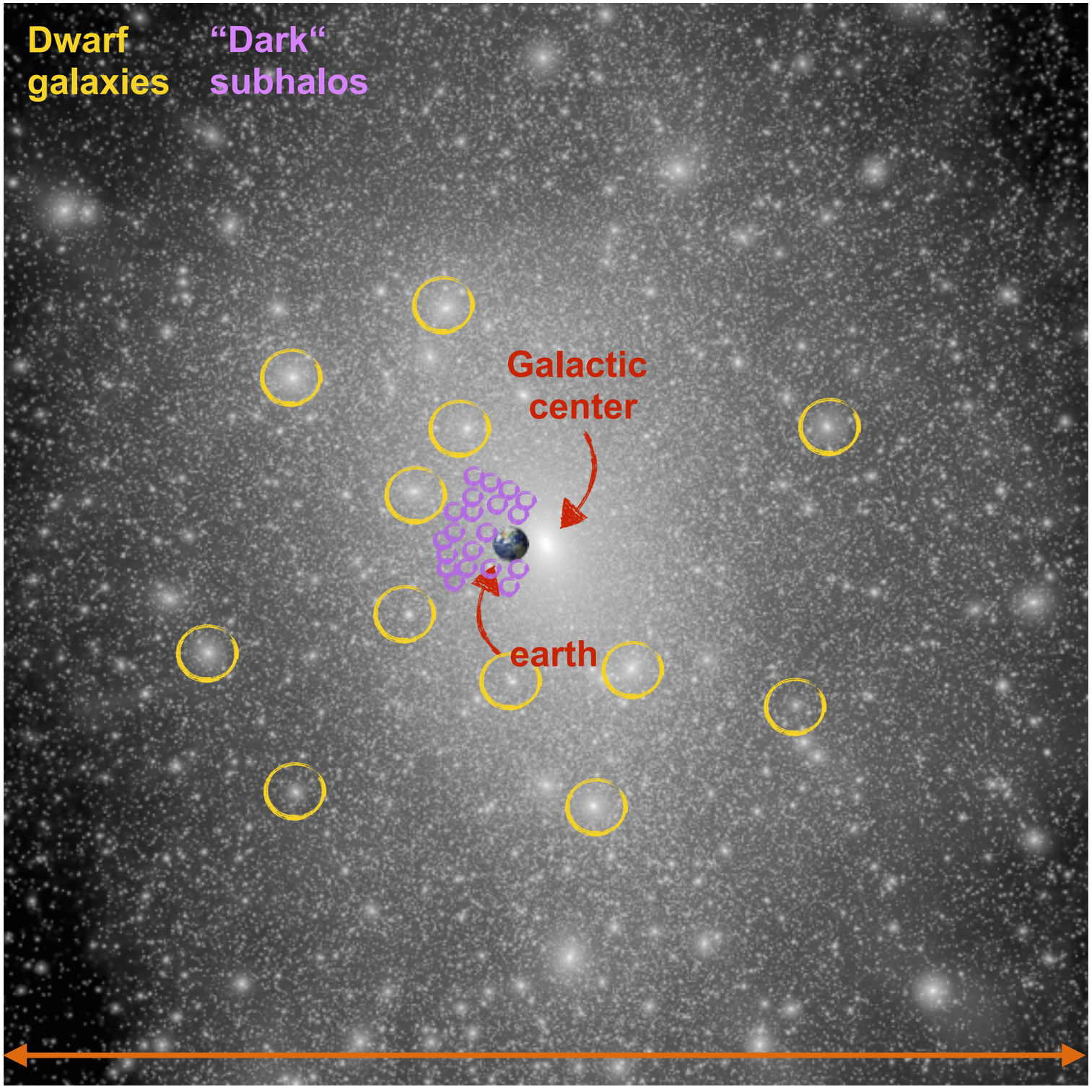

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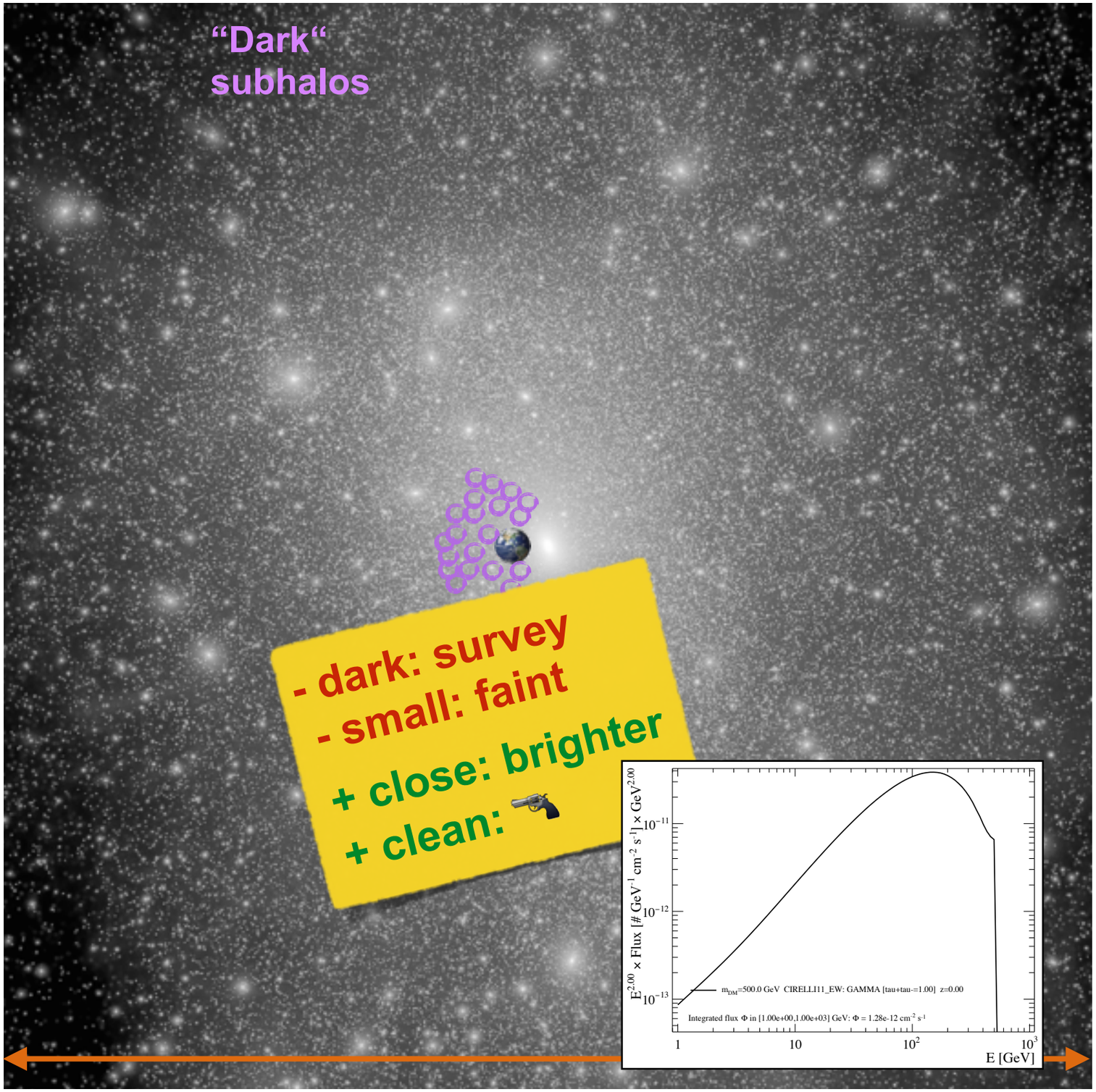

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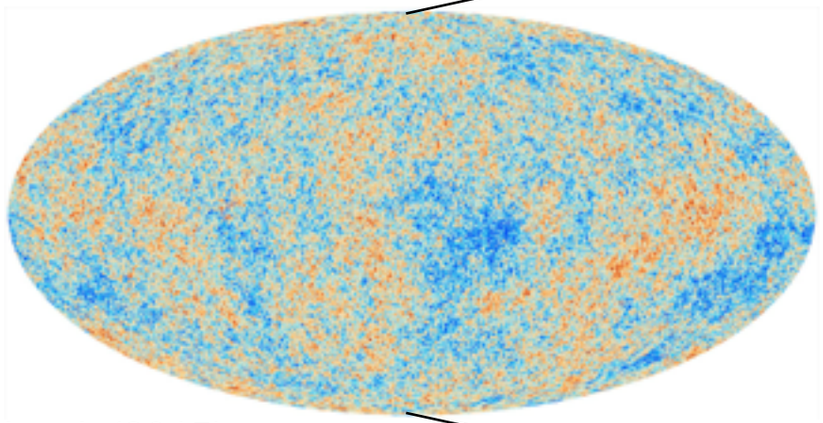
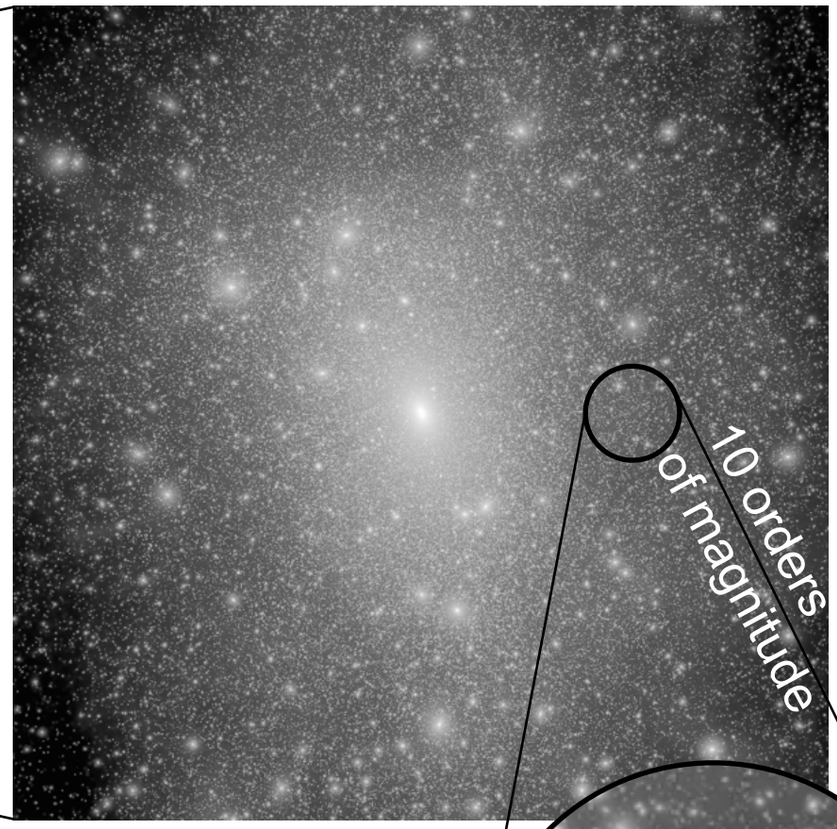
Galactic dark matter subhalos: What do we know?

Knowledge of subhalo density based on simulation and extrapolation:

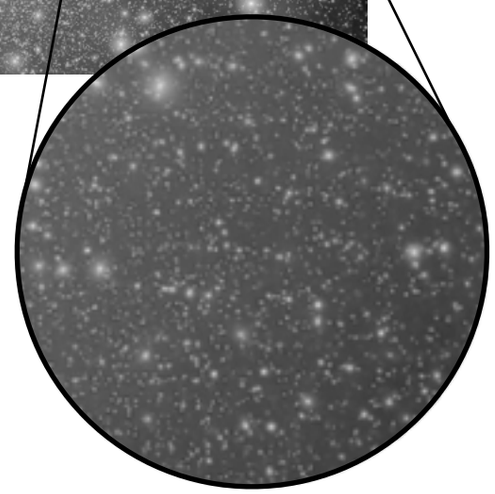


Planck (2015)

13 billion years, ΛCDM



10 orders of magnitude



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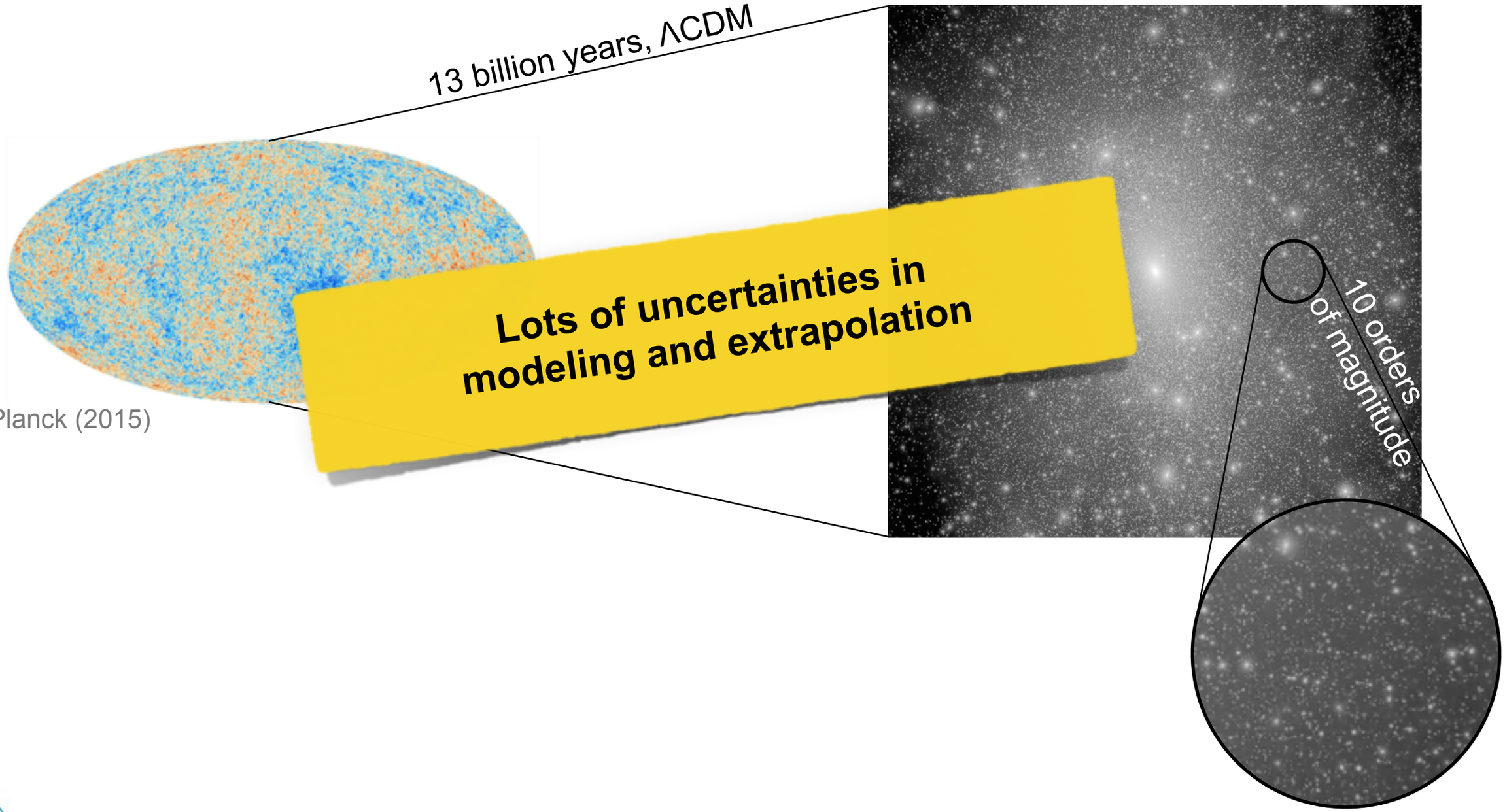

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Galactic dark matter subhalos: What do we know?

Picked four crucial modeling parameters to study systematic uncertainty

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clumpy (1506.07628): A code for γ-ray signals from dark matter substructures

→ versatile tool to study parametrized N-body results

Model uncertainties of subhalo density distribution

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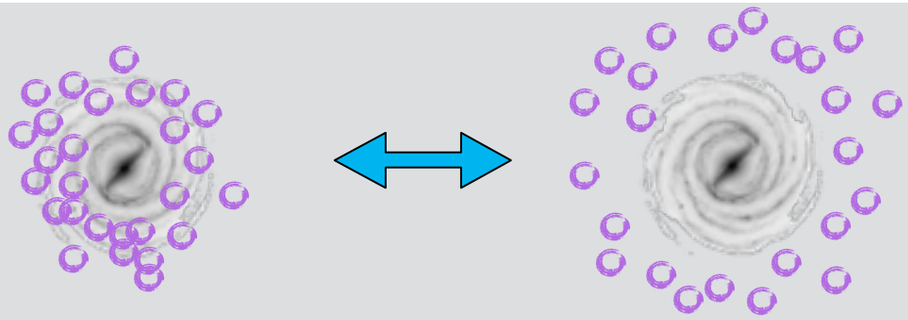
> Distribution of subhalos in the host halo:

Madau (2008) vs. Springel (2008)



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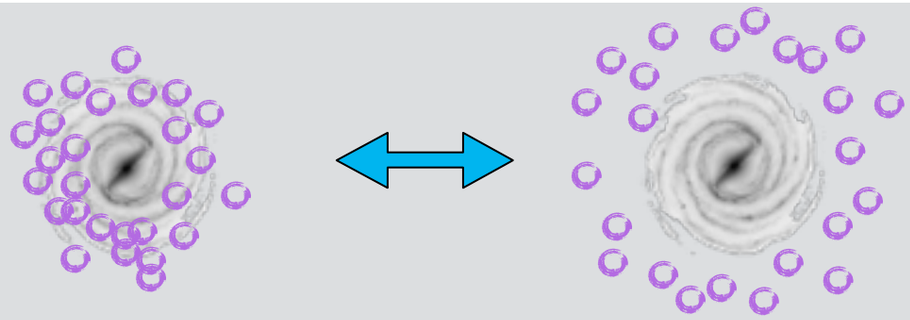

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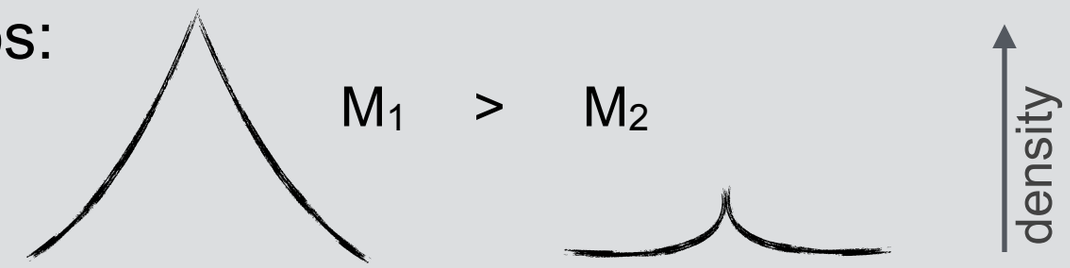
  Sanchez-Conde (2014) vs. Bullock (2001)



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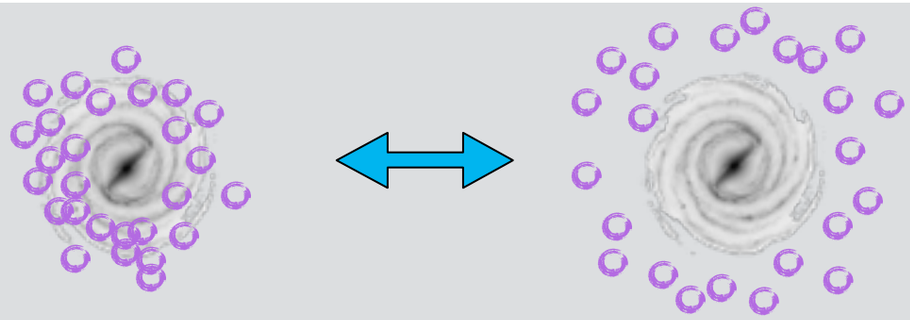

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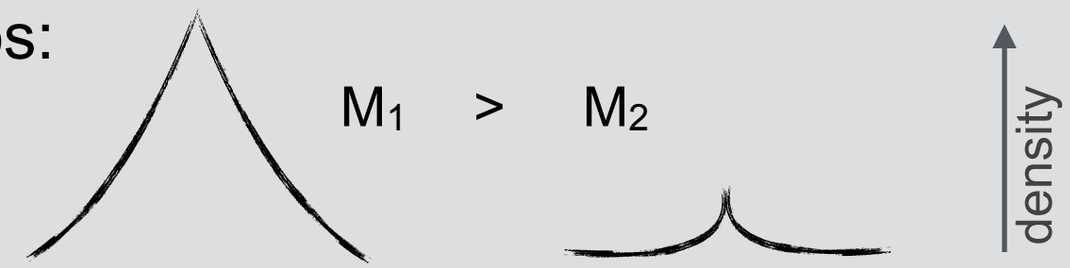

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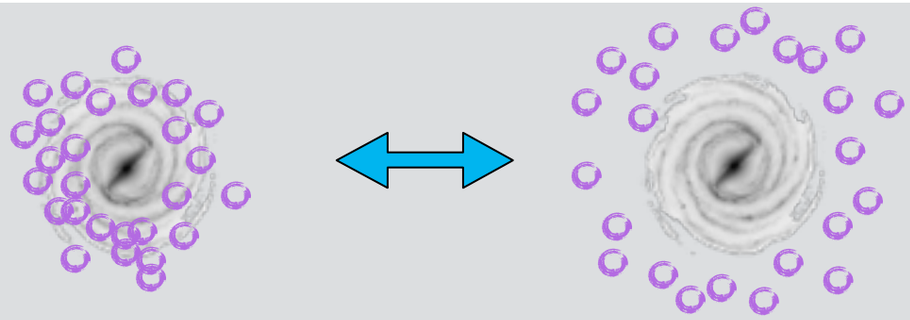

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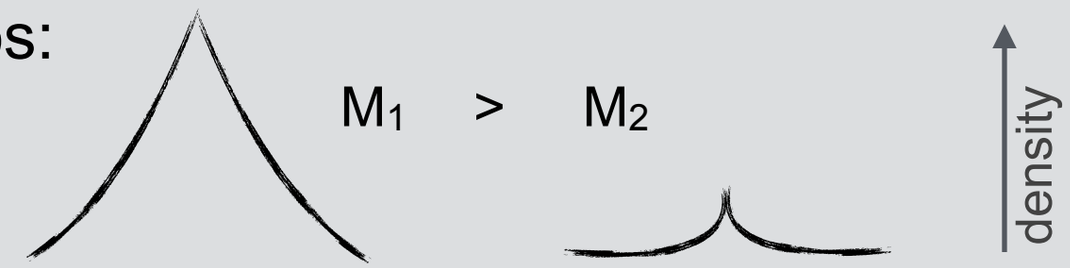

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> Mass distribution dN/dM:

Aquarius $\frac{\mathrm{d}N}{\mathrm{d}M} \sim M^{-1.9}$ ⟺ $\frac{\mathrm{d}N}{\mathrm{d}M} \sim M^{-2.0}$ Via Lactea

Gamma-ray flux from DM annihilation

$$\frac{\mathrm{d}\Phi_\gamma^{\mathrm{ann.}}}{\mathrm{d}E_\gamma} = \frac{1}{4\pi}\frac{\langle\sigma v\rangle}{2{m_\chi}^2}\cdot\sum_i^{\mathrm{chann.}} b_i\,\frac{\mathrm{d}N_\gamma^i}{\mathrm{d}E_\gamma}\cdot\int_{\Delta\Omega}\int_{l.o.s.}\rho^2_{\mathrm{DM}}[r(l,\Omega)]\,\mathrm{d}l\,\mathrm{d}\Omega$$

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Region of interest (ROI)

Galactic center

Galactic plane

equatorial coord.

10^{19}

10^{18}

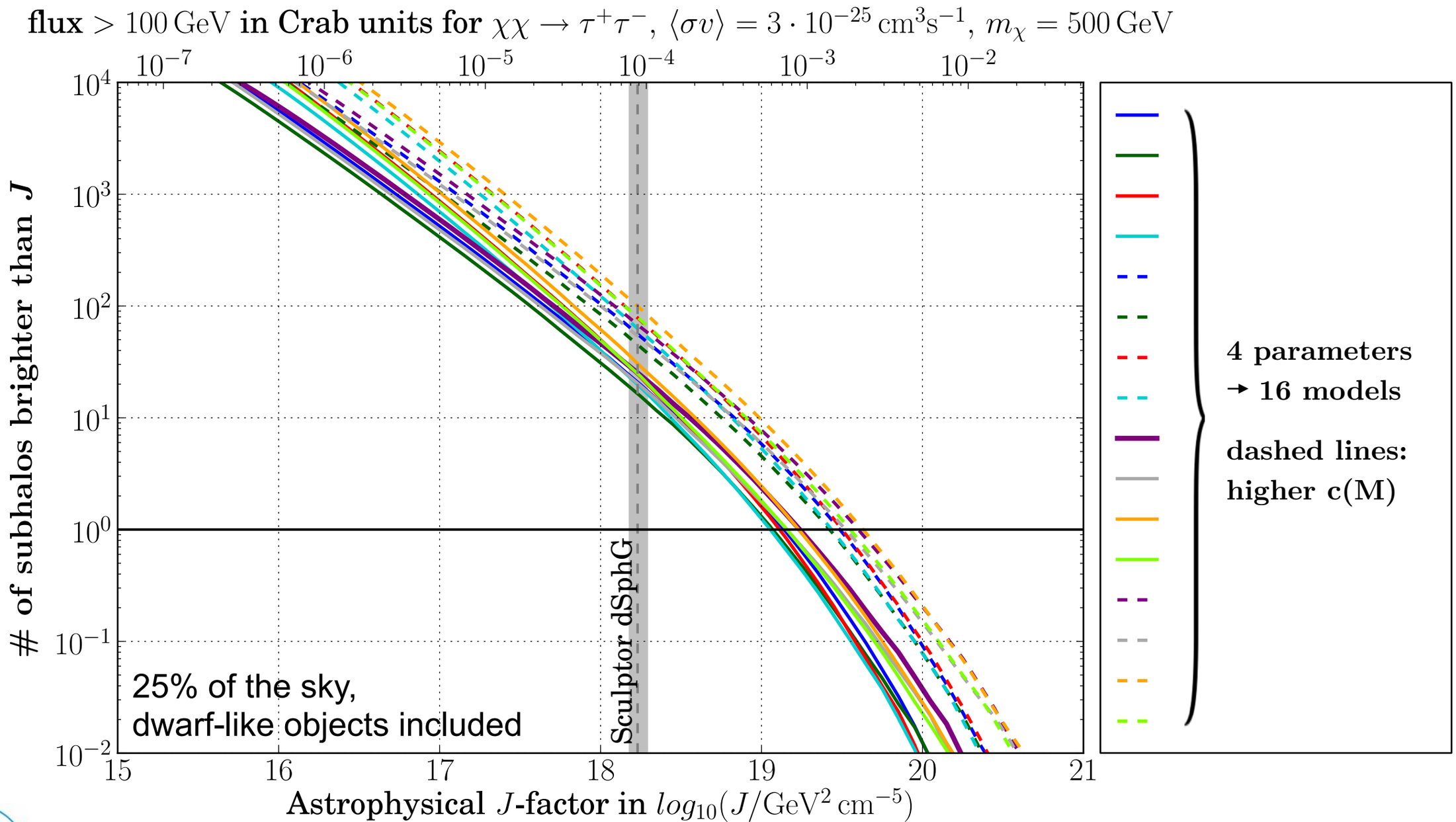
10^{17}

$[\mathrm{GeV}^5\,\mathrm{cm}^{-2}]$

(map made with `clumpy`)

DM subhalo source count distribution: annihilation

Number of subhalos brighter than a given flux/ *J*-factor:



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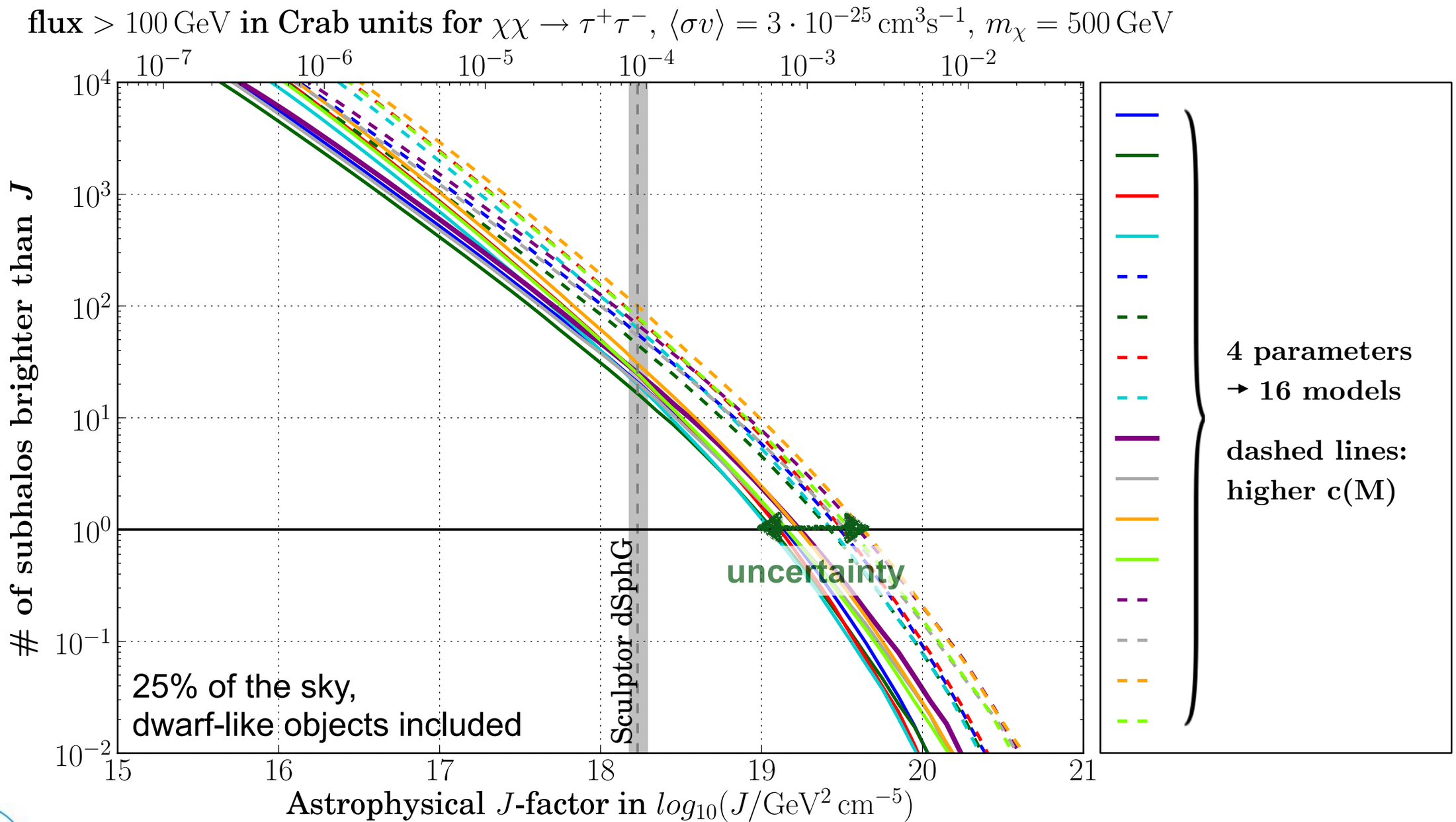

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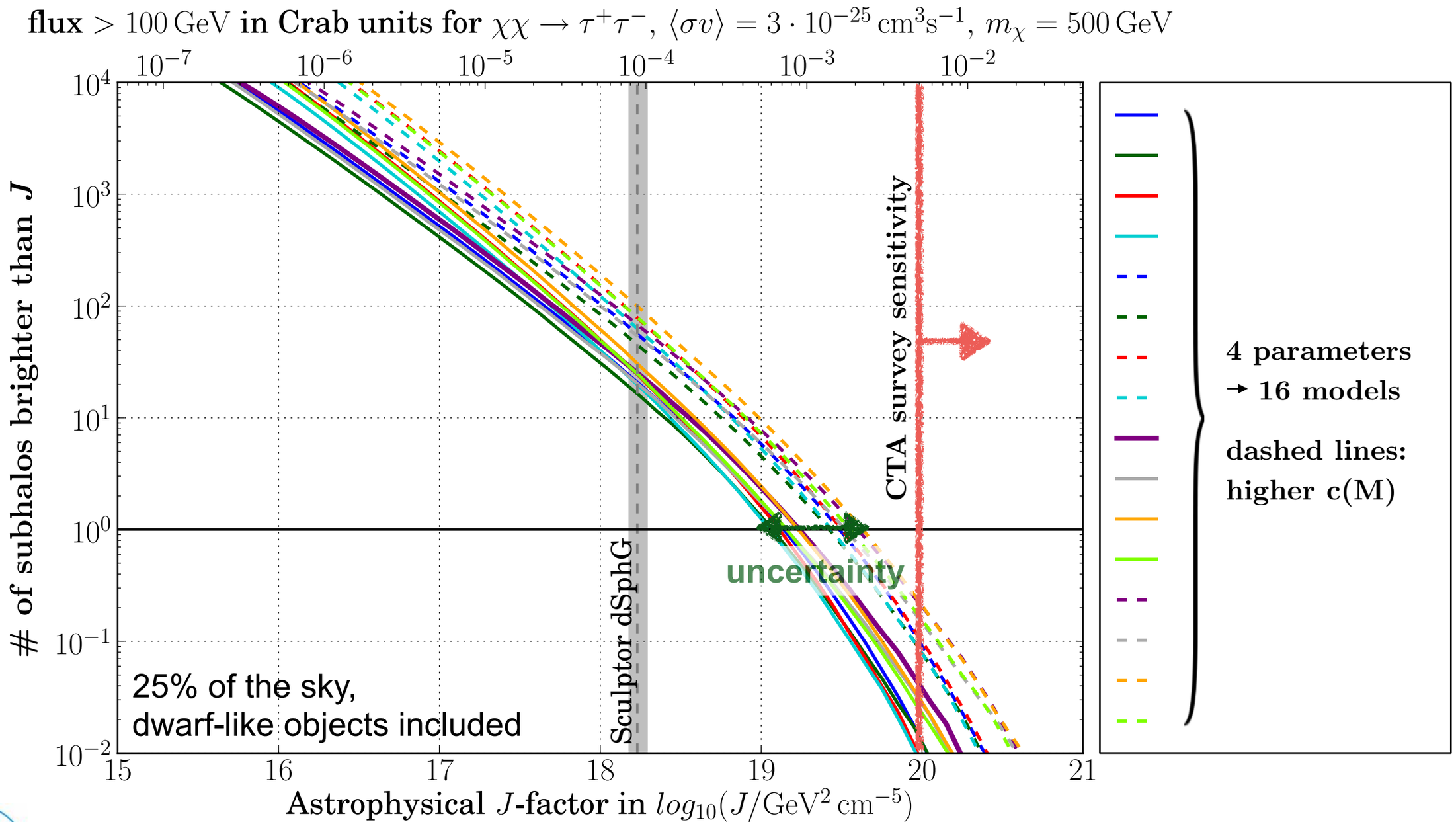

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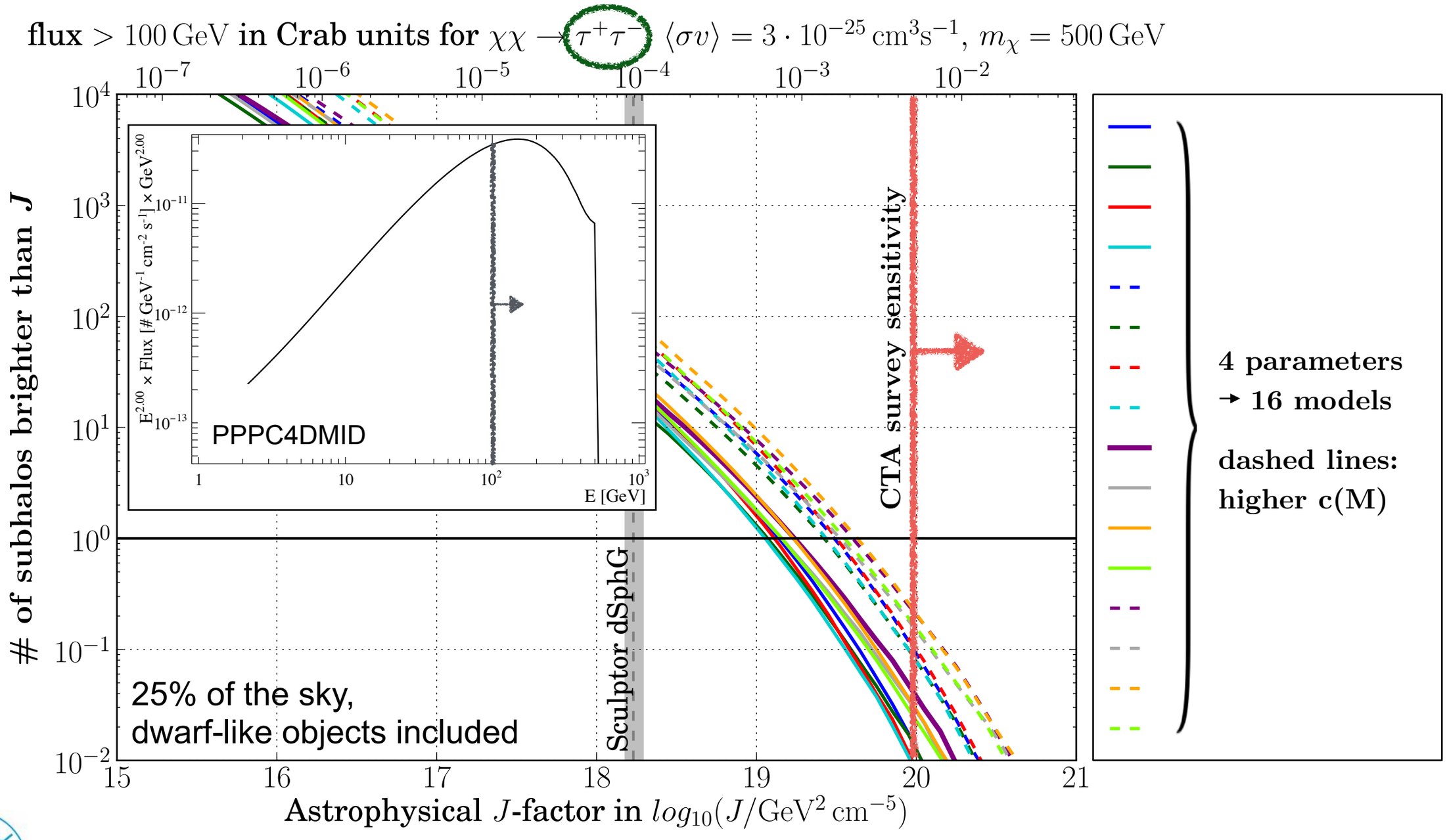

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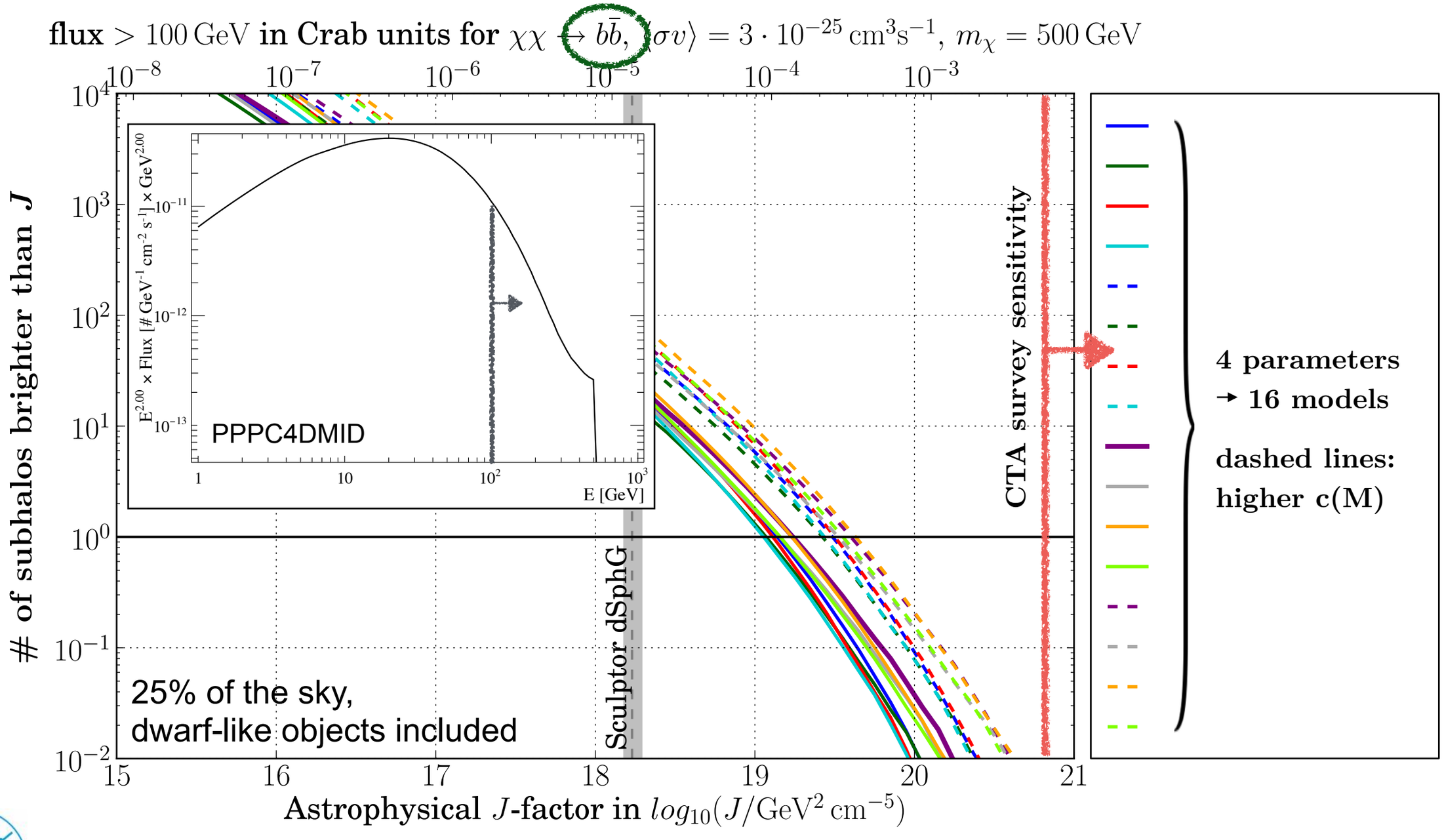


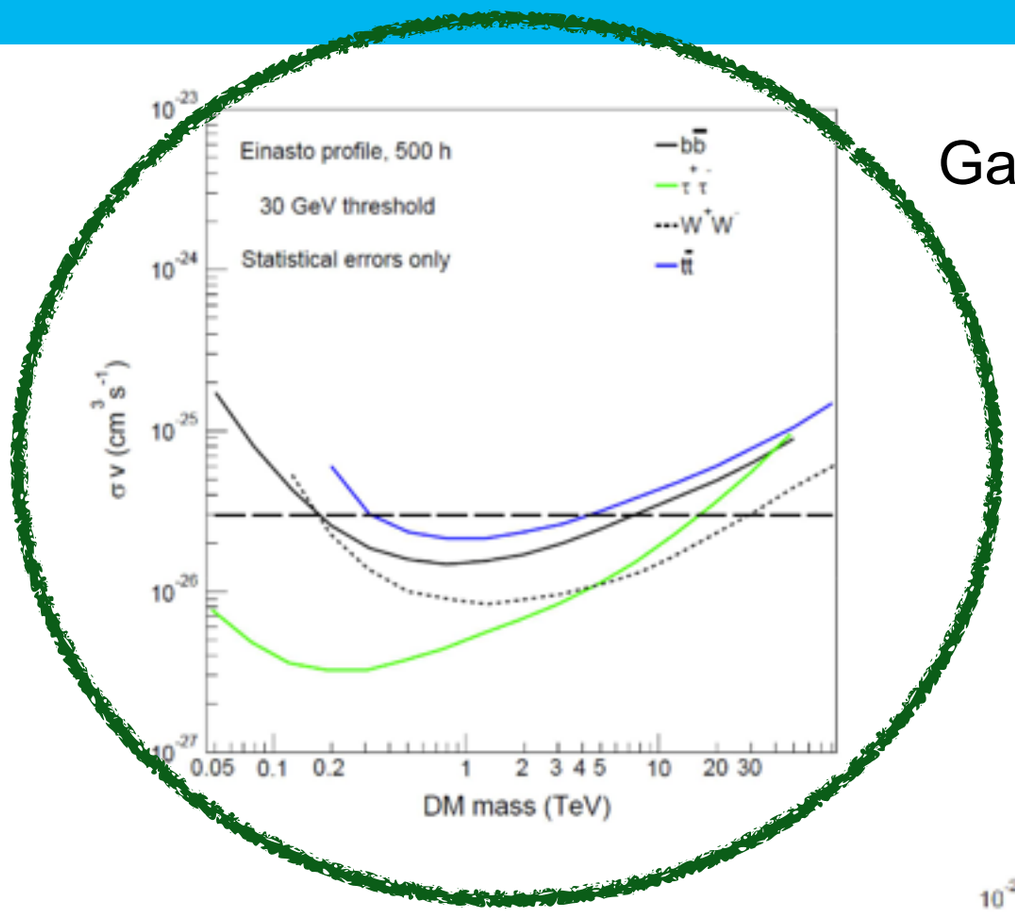
Conclusions

- dark matter subhalos:
  - would be a **clean** dark matter target
  - systematic uncertainties different from other targets
  - probe CDM vs. WDM scenario

- But even within ΛCDM paradigm:
  - → **Difficult to individually detect even for CTA**
  - → **High systematic uncertainty about flux level**

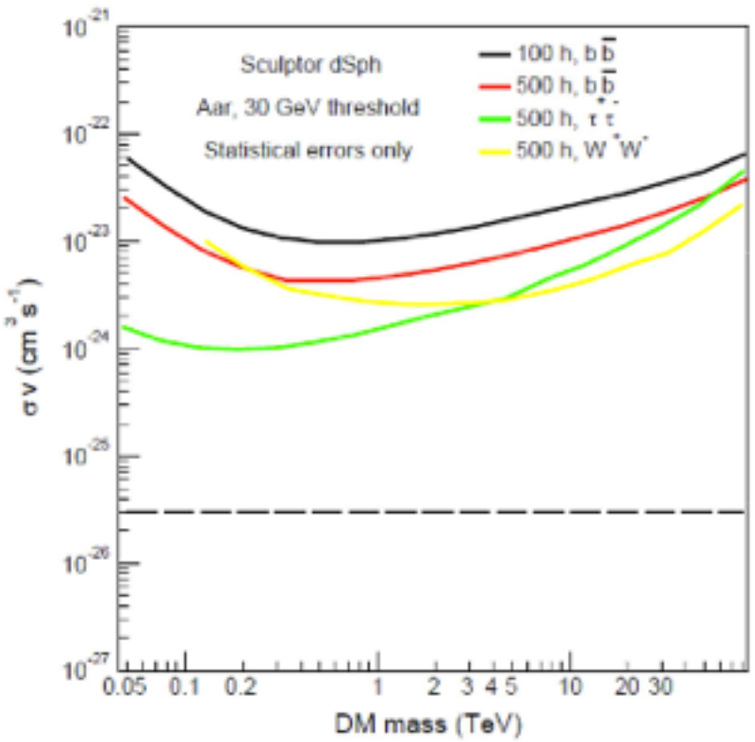
- anisotropy analysis: ongoing study

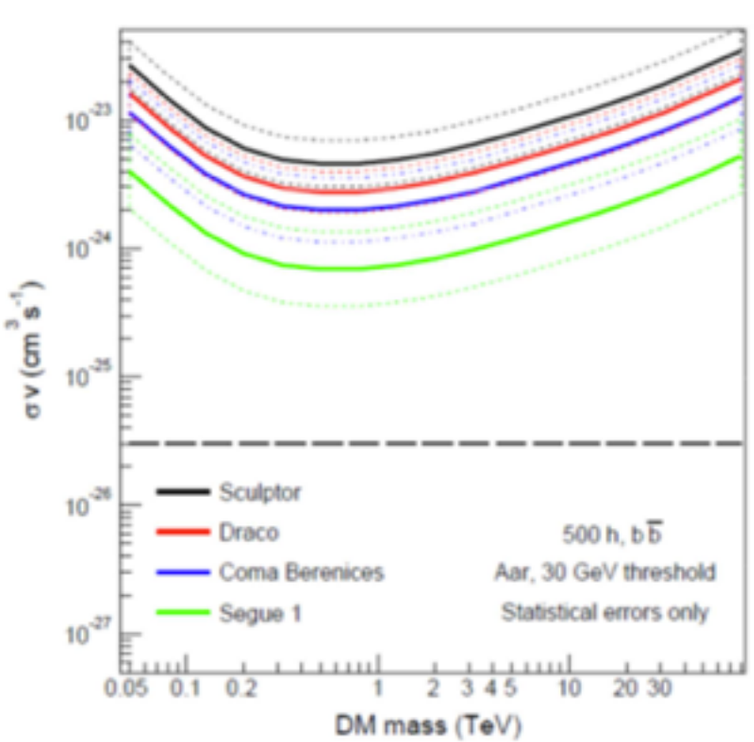
BACKUP: Prospects for the CTA Dark Matter program



Galactic center

all figures from
J. Carr et al (2015)
1508.06128



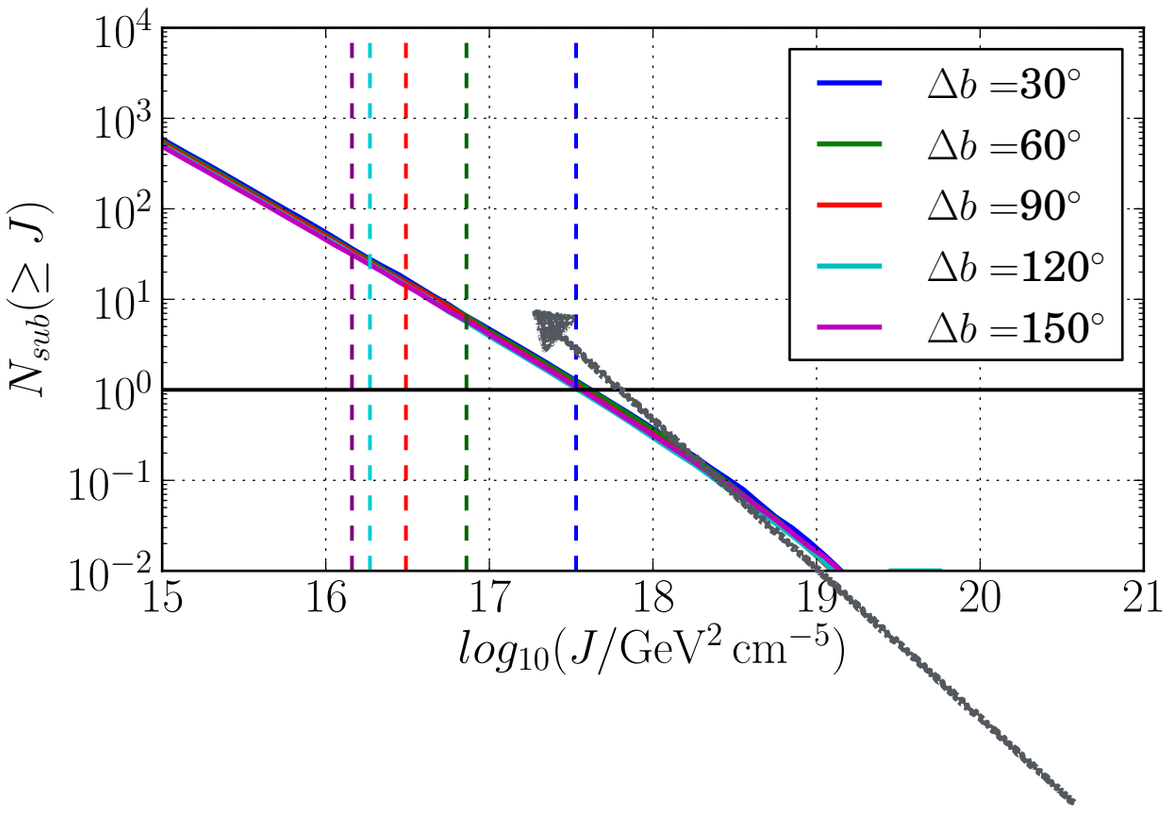


dwarf galaxies

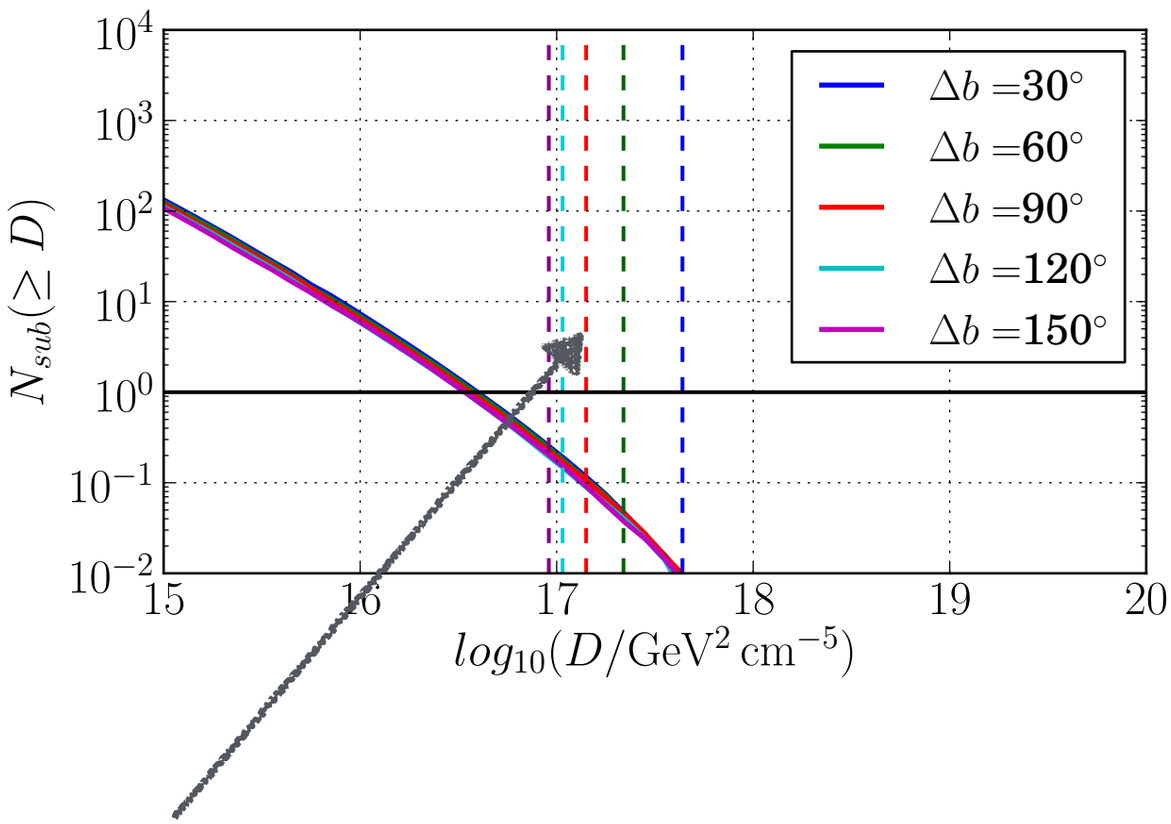
BACKUP: subhalos vs. DM background

- Field of view with diameter = 10°

annihilation



decay



dark matter background emission

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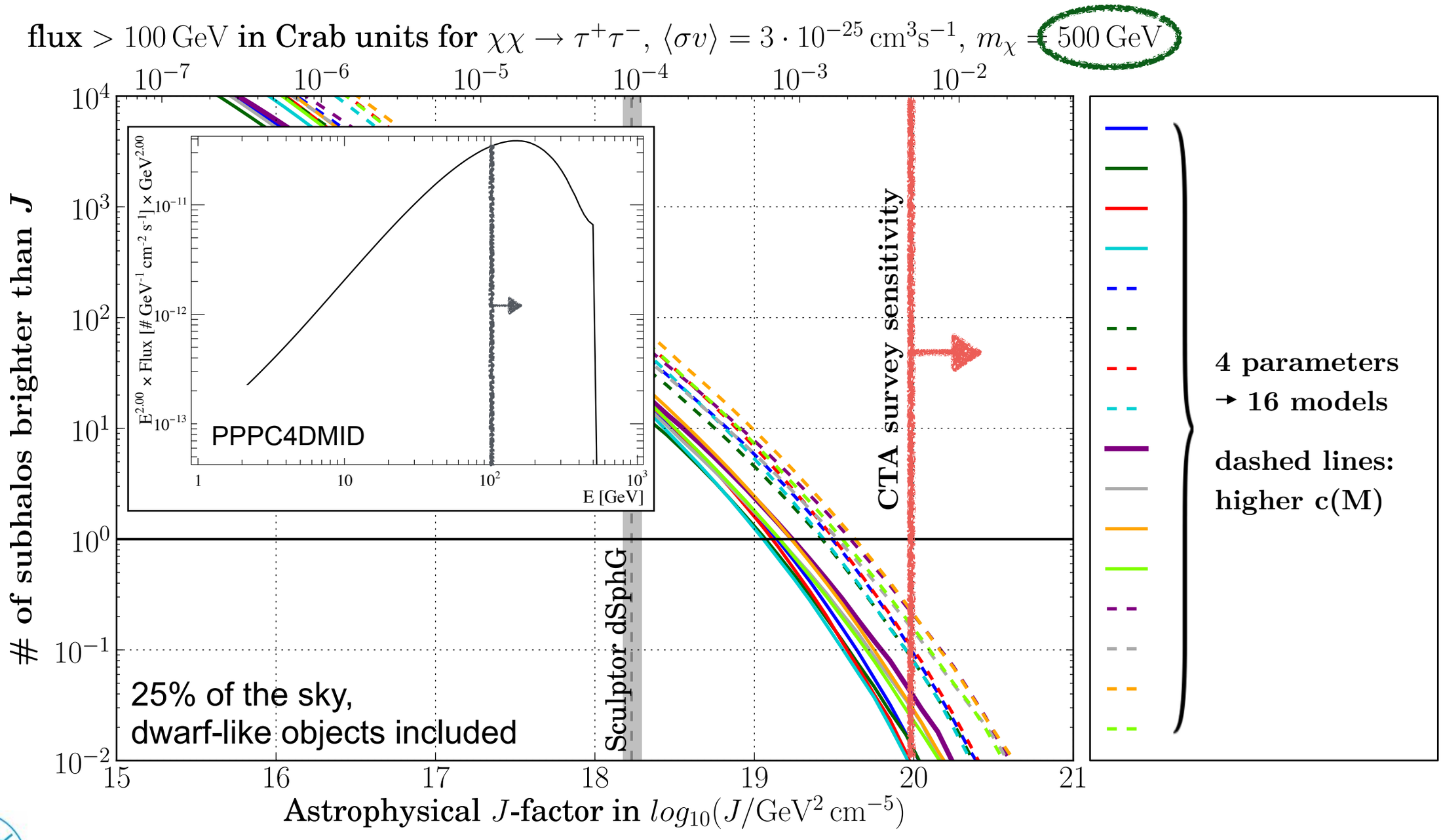

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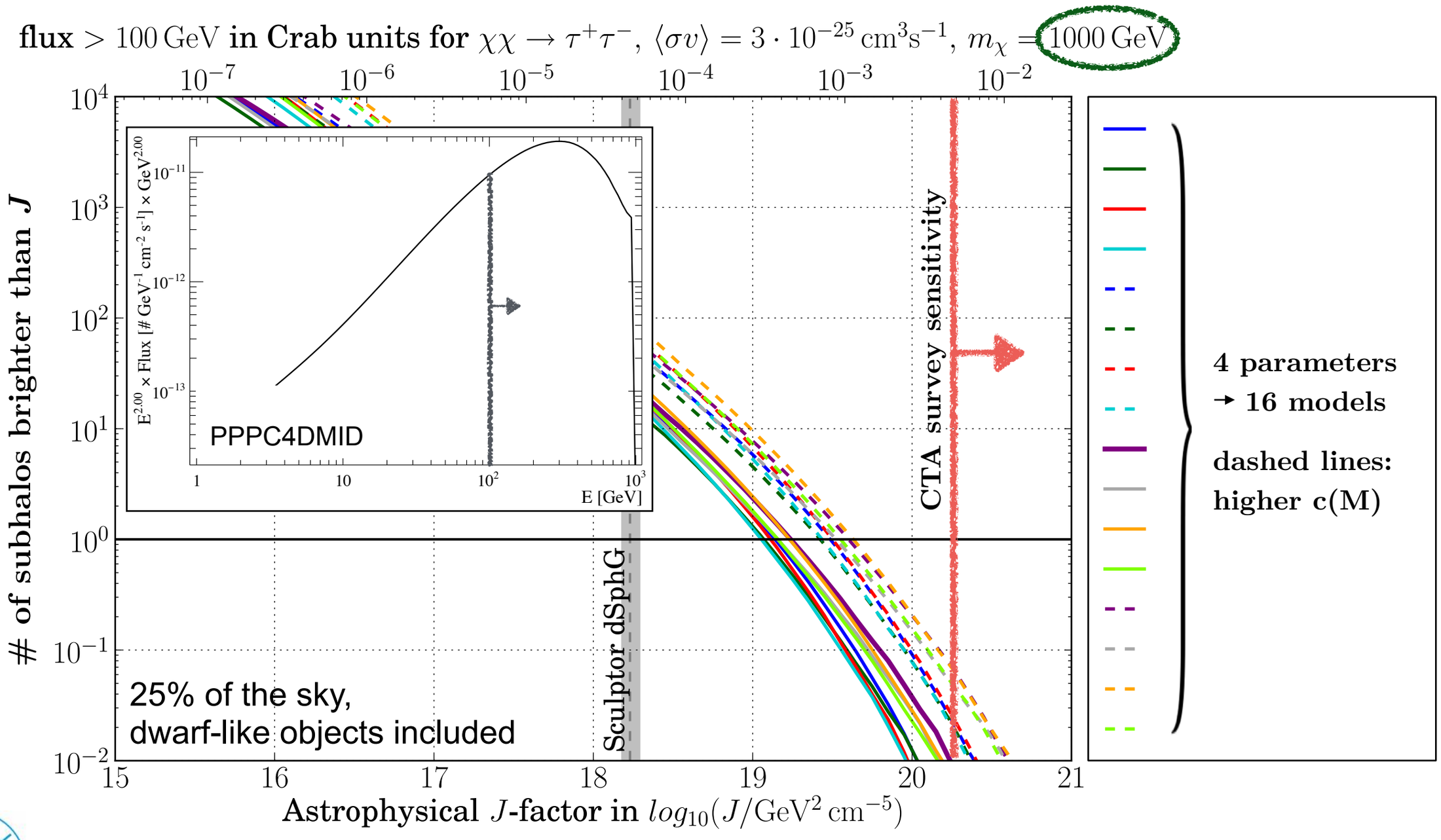

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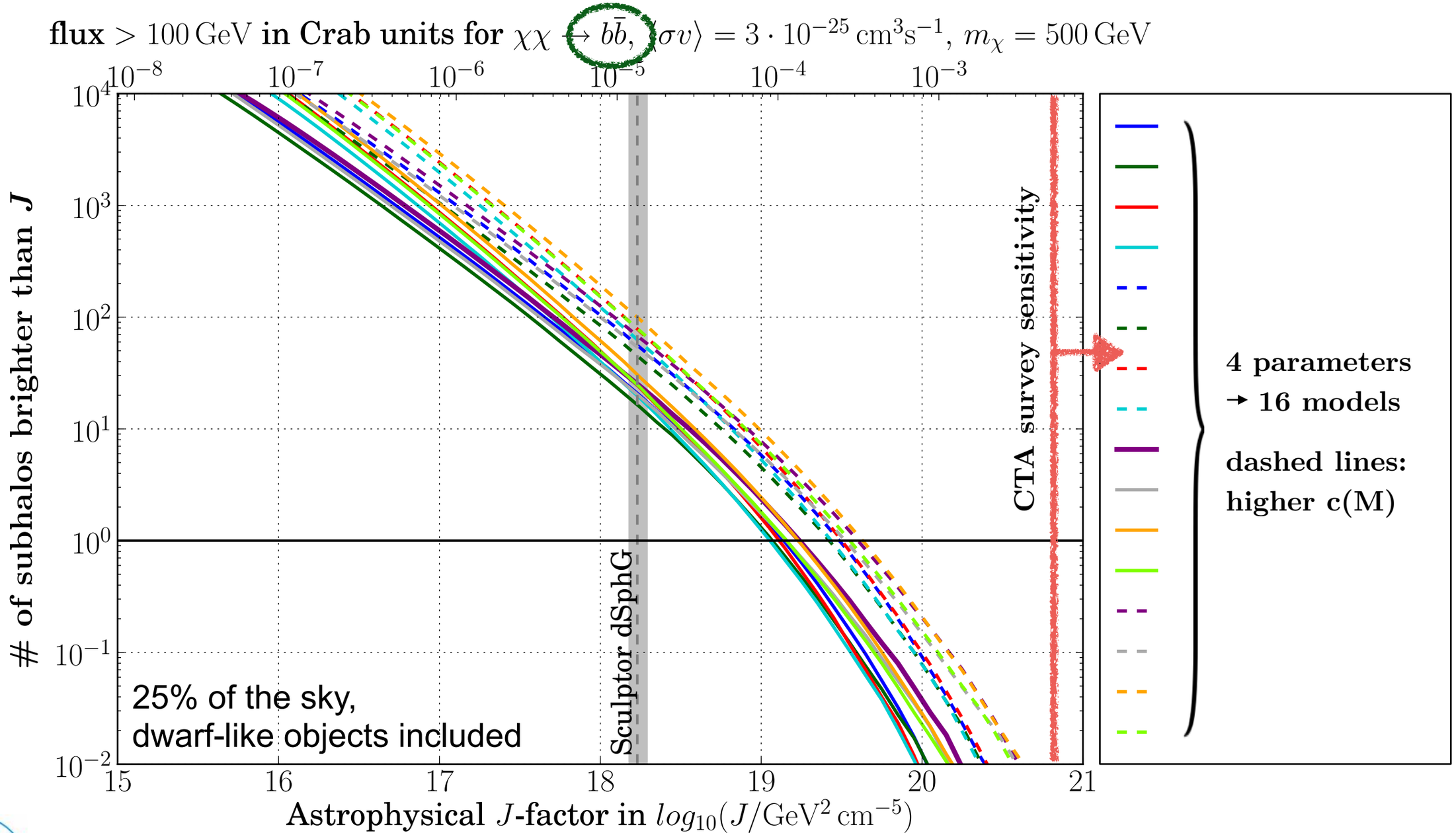

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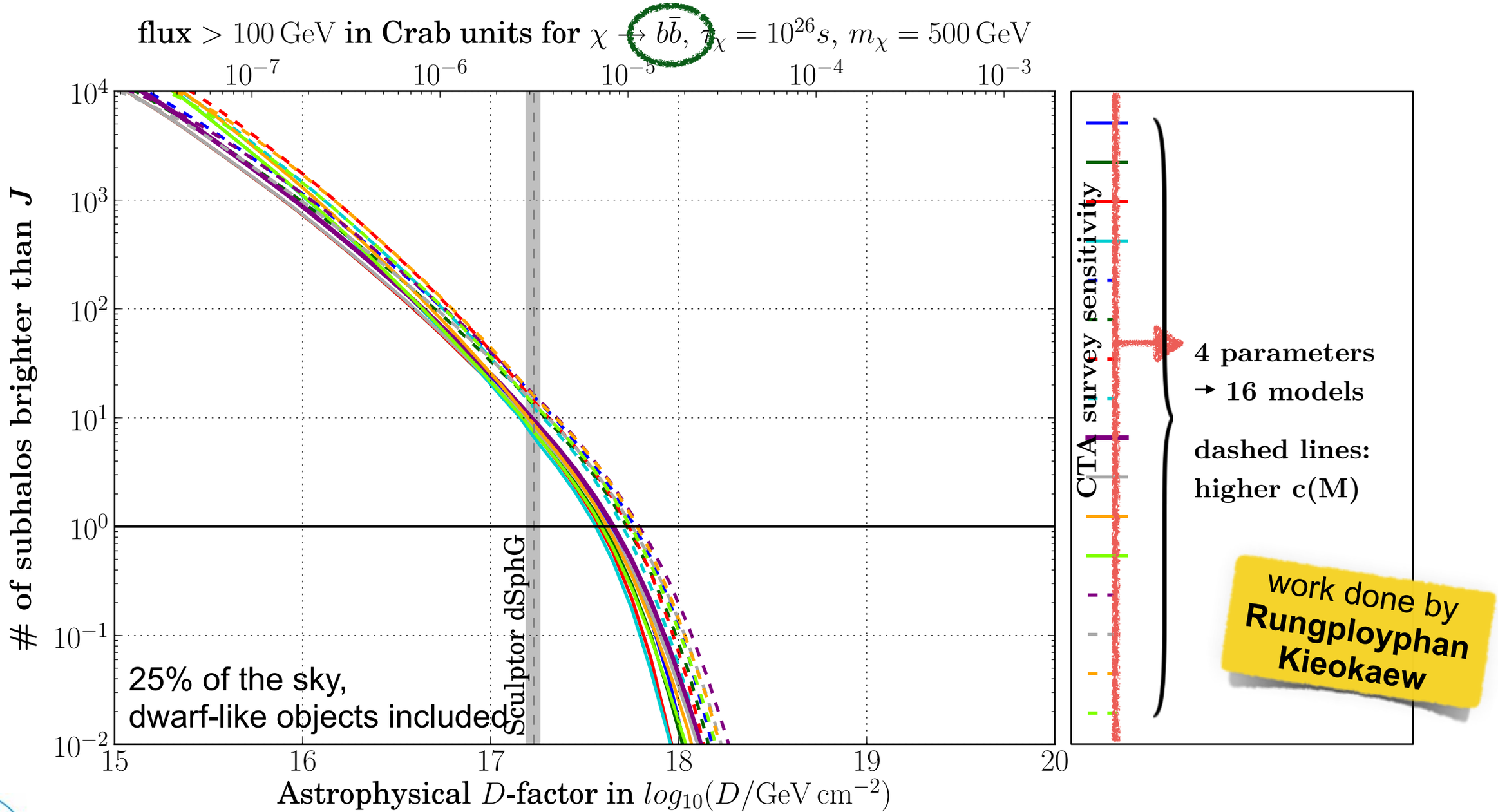
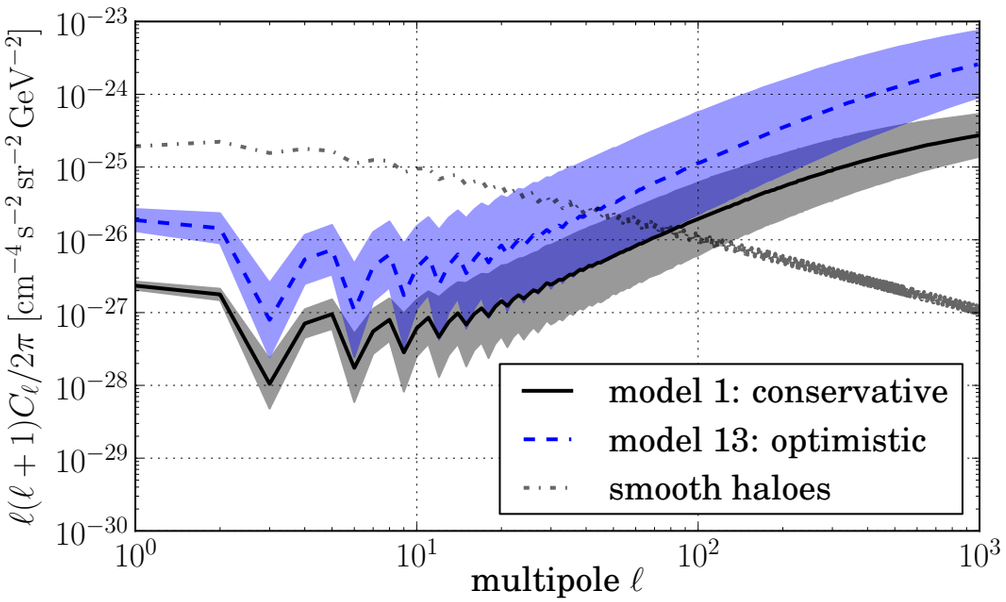


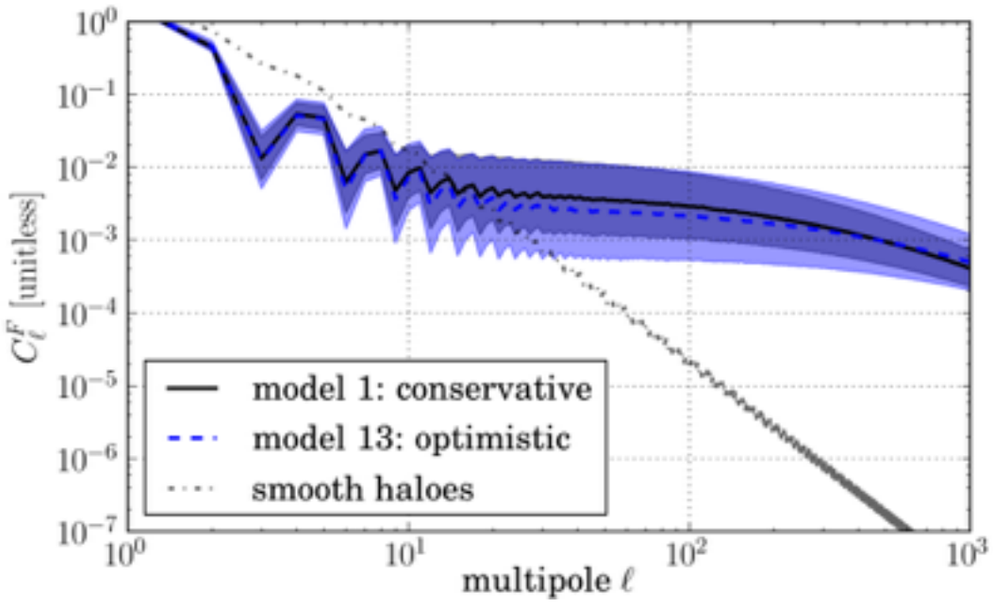
BACKUP: DM subhalo gamma-ray fluctuation

- Imprint of subhalos on **fluctuations of the isotropic gamma ray background**:
  - low intensity, but high relative fluctuation of the signal:

intensity angular power spectrum



fluctuation angular power spectrum



- Unresolved blazars: $C_\ell^F \approx 10^{-5}$ (higher intensity, but lower fluctuation)

(Ackermann 2012, Ripken 2014)