Identifying Dark Matter with MeV Gamma-Ray Telescopes

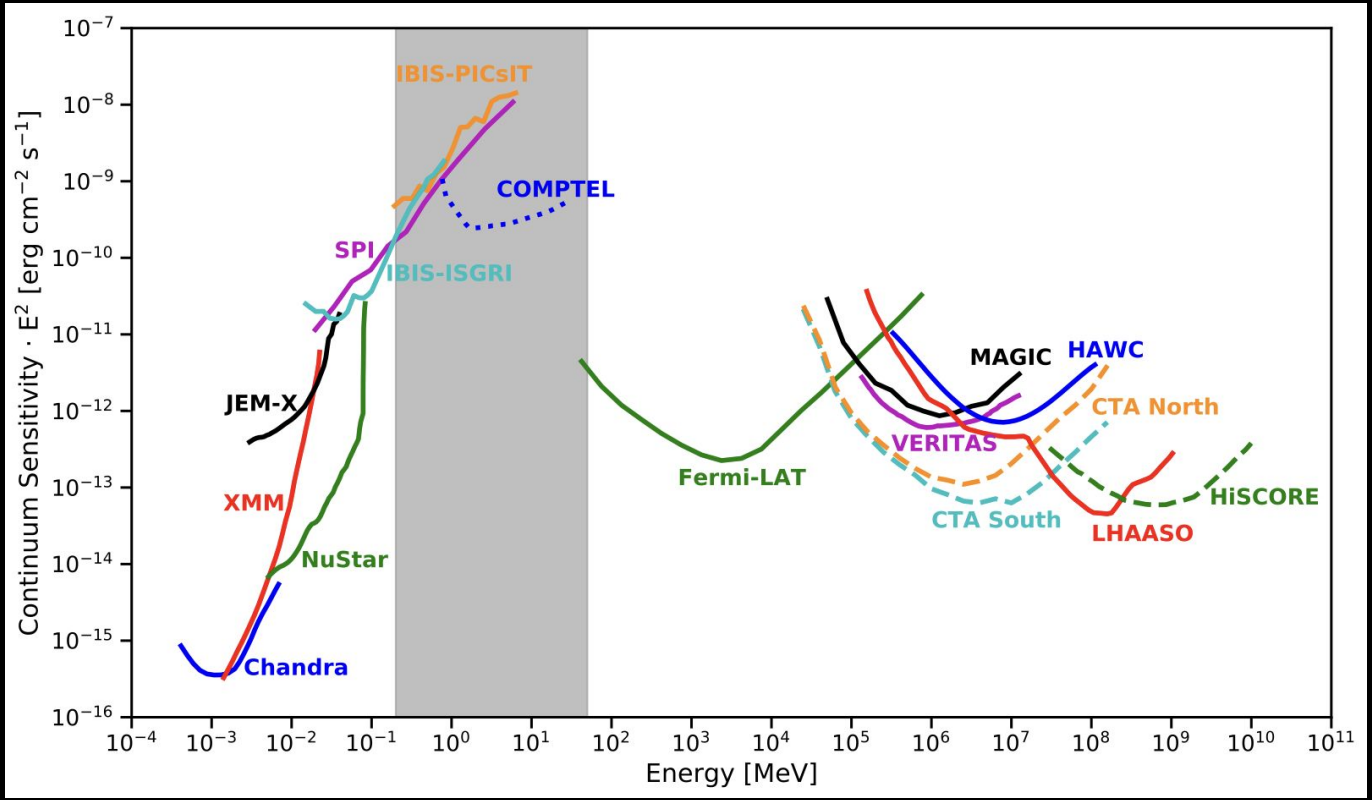
Chris Cappiello

w/ James Dent, Bhaskar Dutta, and Jeremy Padvorac

Light Dark World
Carleton University, July 28, 2026

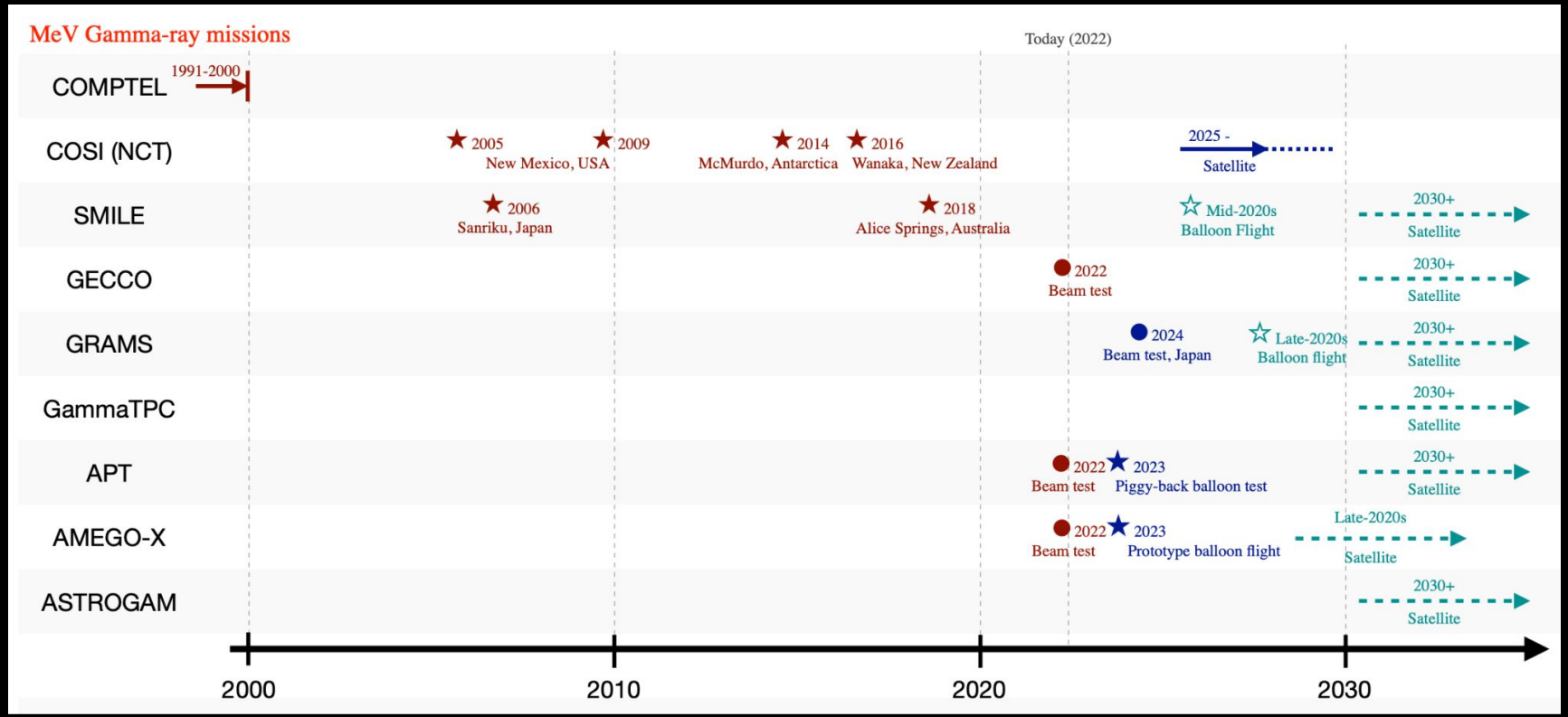
Credit: ESO/S. Brunier

The MeV Gap



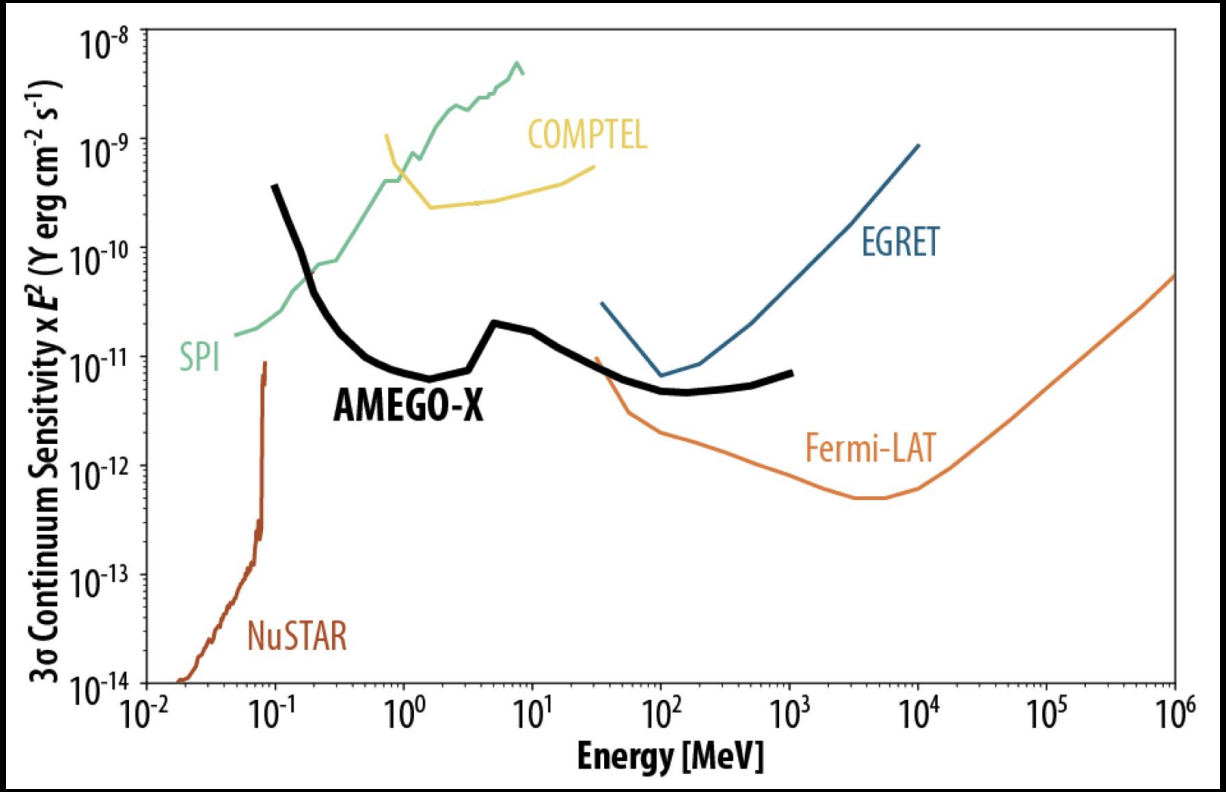
arXiv:2204.01325 (MeVCube)

The MeV Gap



arXiv:2209.07426 (Snowmass 2021)

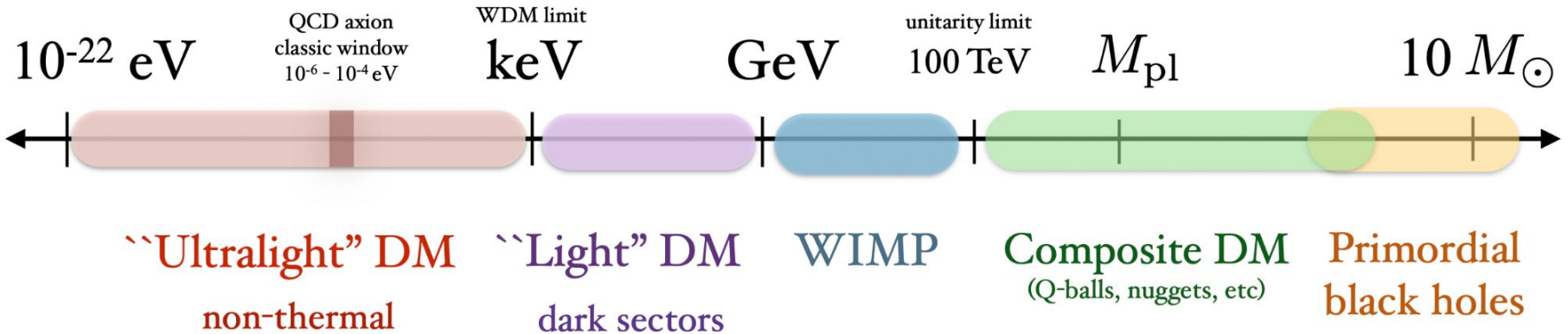
The MeV Gap



arXiv:2208.04990 (AMEGO-X)

Mass scale of dark matter

(not to scale)



Credit: Tongyan Lin

Mass scale of dark matter

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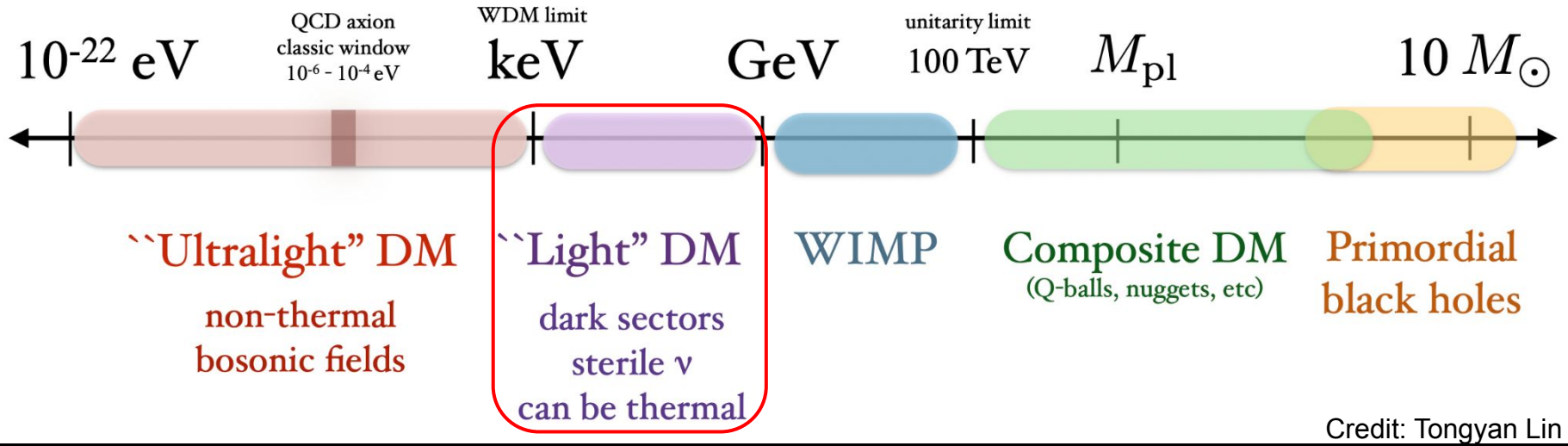

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Mass scale of dark matter

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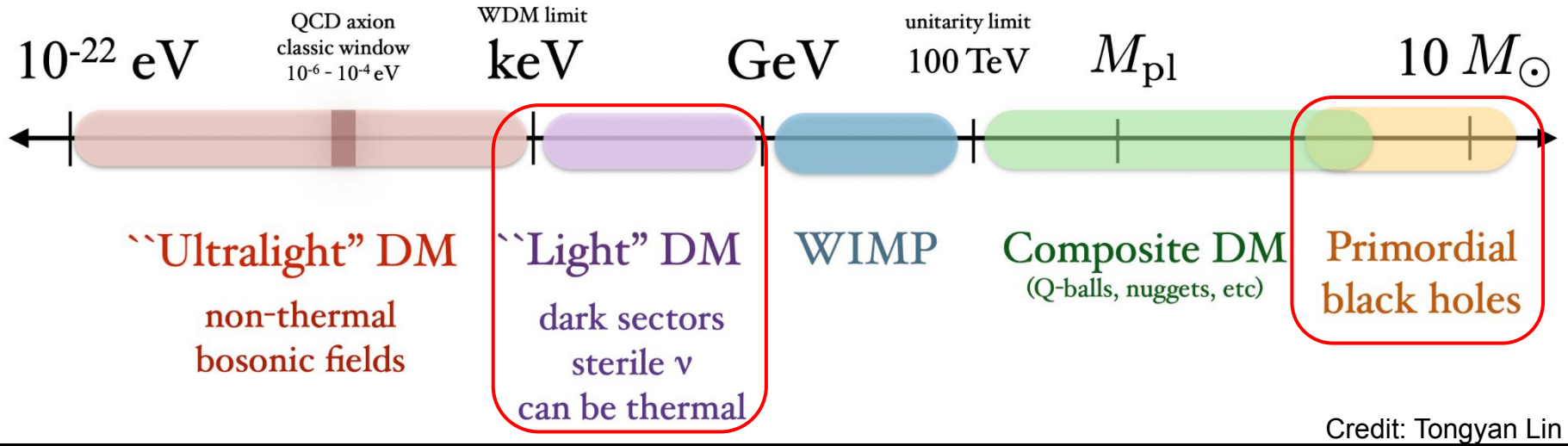
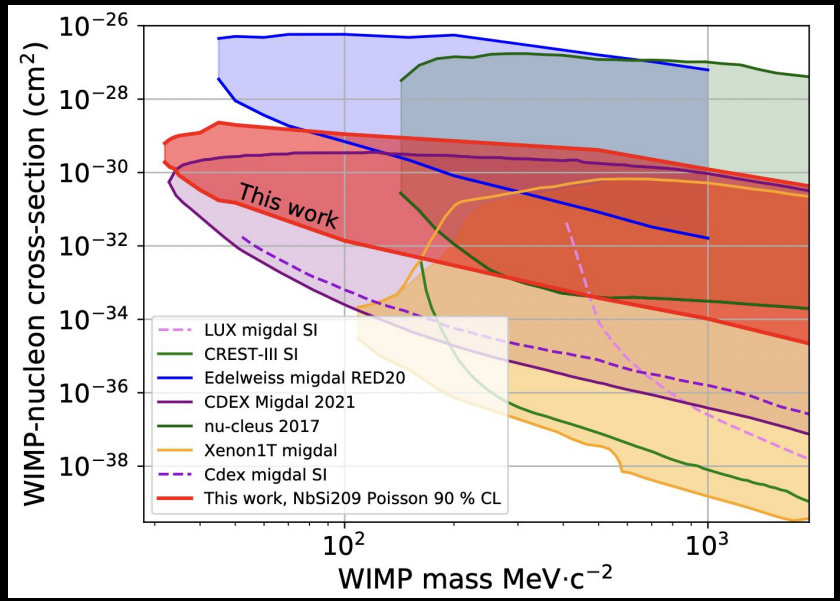
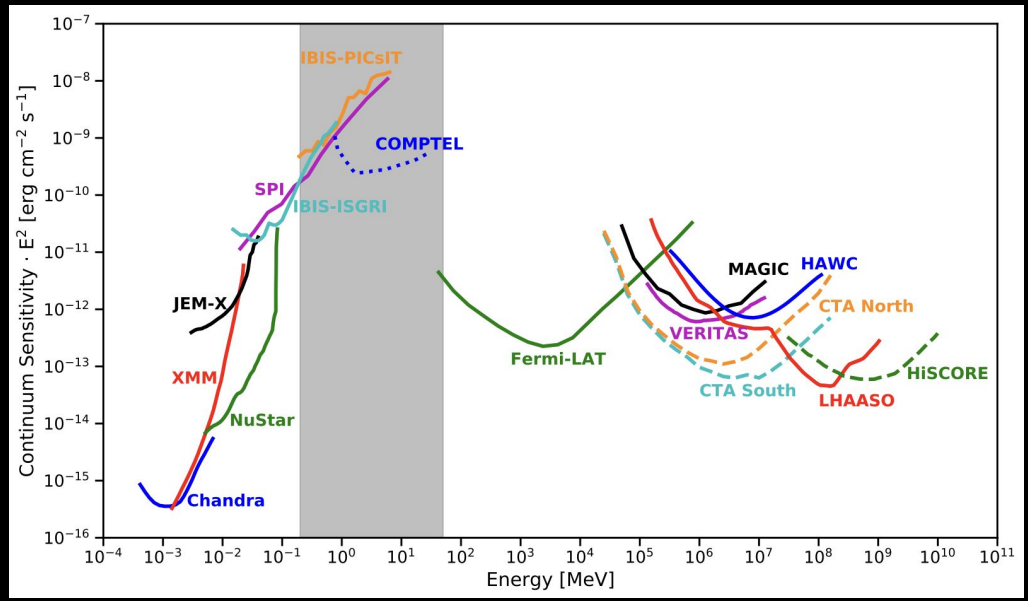


Credit: Tongyan Lin

Sub-GeV Dark Matter

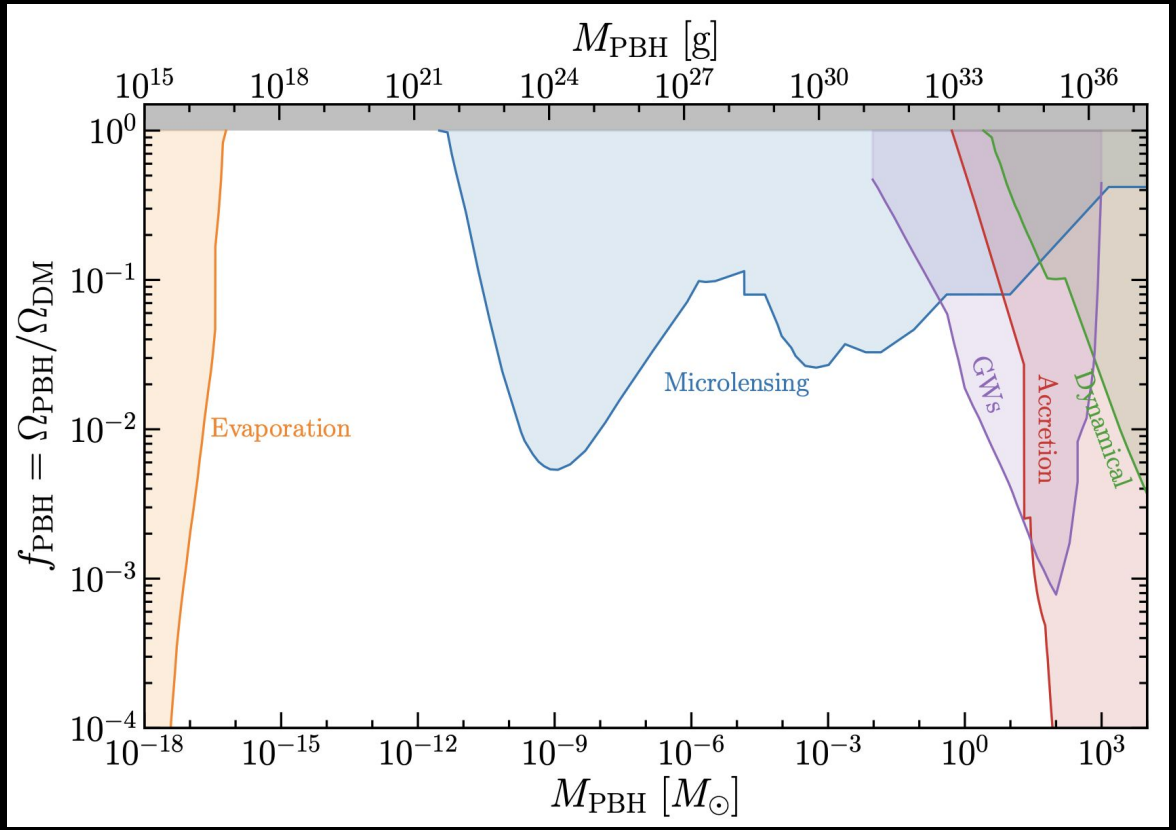


arXiv:2203.03993 (Edelweiss)



arXiv:2204.01325 (MeVCube)

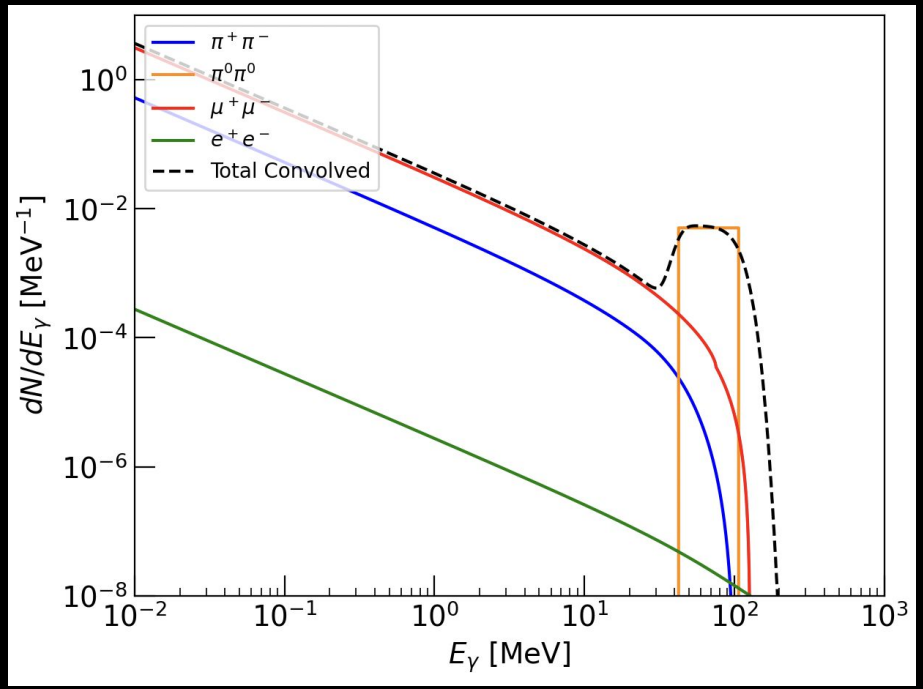
Primordial Black Holes



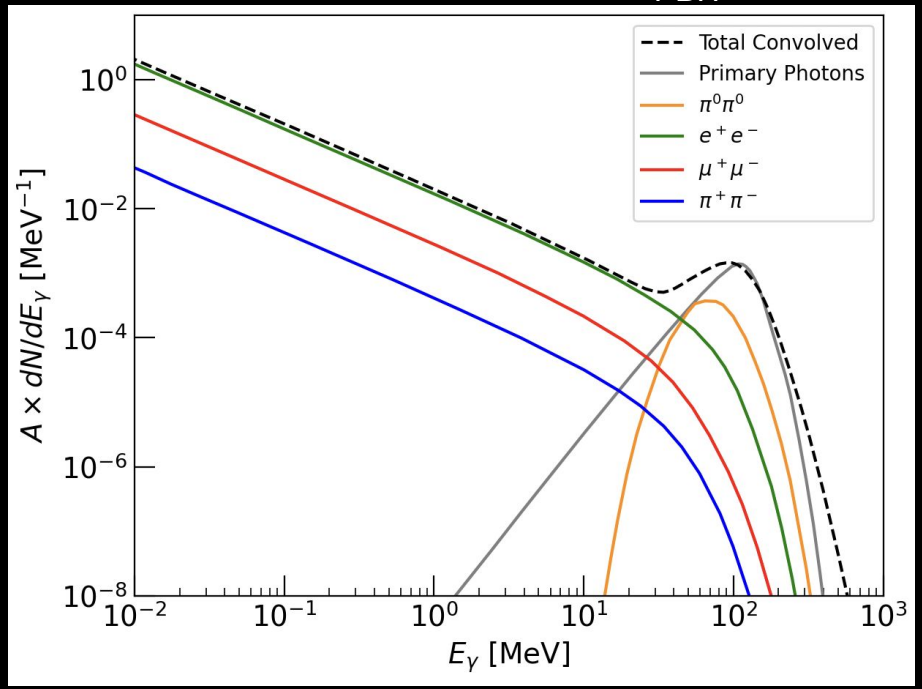
arXiv:2007.10722

Gamma-Ray Spectra

Scalar DM, M = 300 MeV, T = 10^{28} s



PBH DM, M = 5.5 * 10^{14} g, $f_{PBH} < 10^{-9.5}$



Dark Matter Models

Particle Dark Matter

- Scalar w/ couplings equal to Standard Model Yukawas
- Vector (kinetically mixed dark photon)
- For both, assume lifetime = 10^{28} s

Primordial Black Holes

- Monochromatic distribution
- Spin 0, Charge 0
- Fit subject to constraints on f_{PBH}
- Extremal PBHs: work in progress

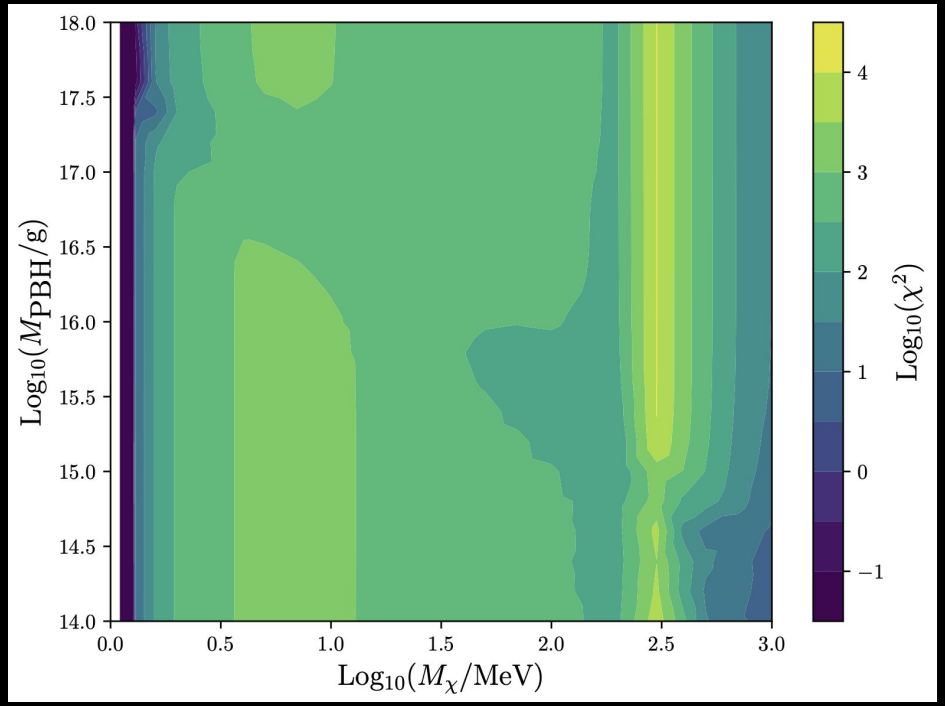
Statistical Analysis

Compare particle dark matter and PBH dark matter spectra

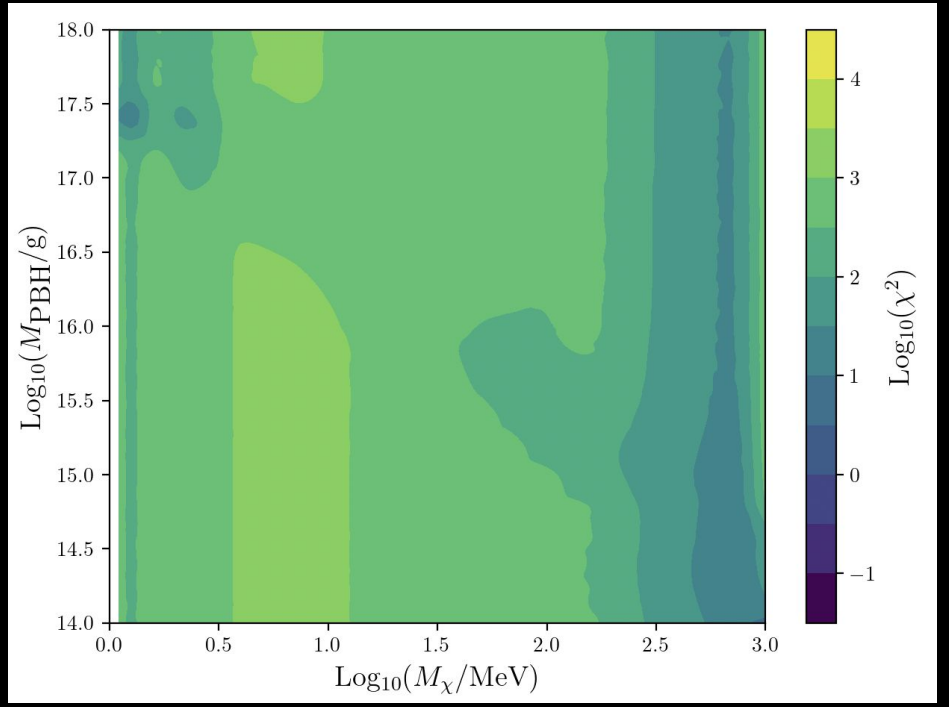
- Generate Asimov dataset for particle dark matter plus background
- Compute delta chi squared between particle dark matter plus background and PBH dark matter plus background
- Determine how well an instrument like AMEGO-X can distinguish these spectra, how much observation time is needed, etc.
- Start by assuming observation time of 10^8 s

PBH Model Fit to Particle DM

Scalar DM



Vector DM



Gamma-Ray Spectra

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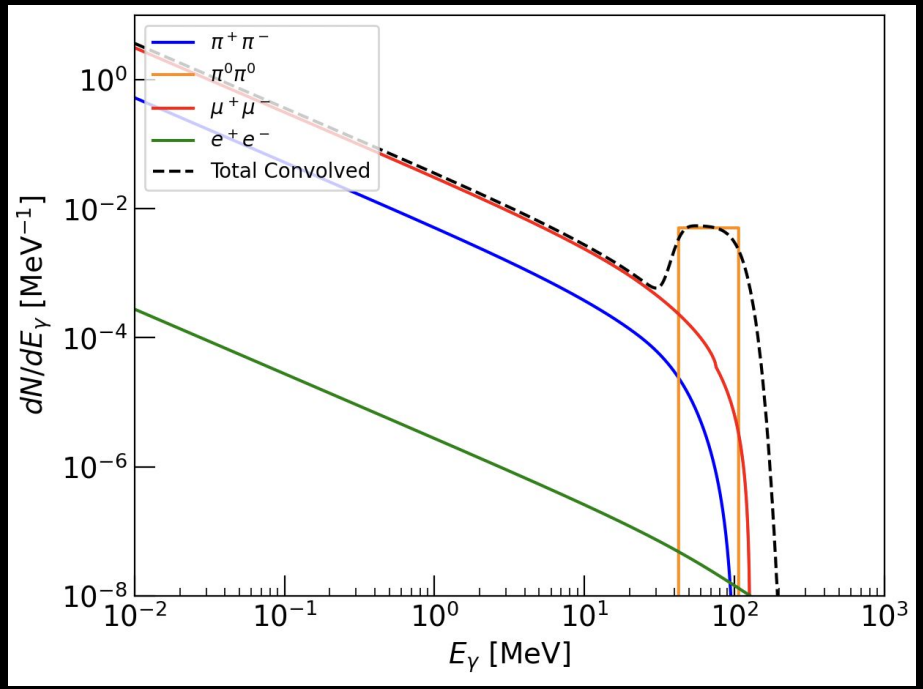

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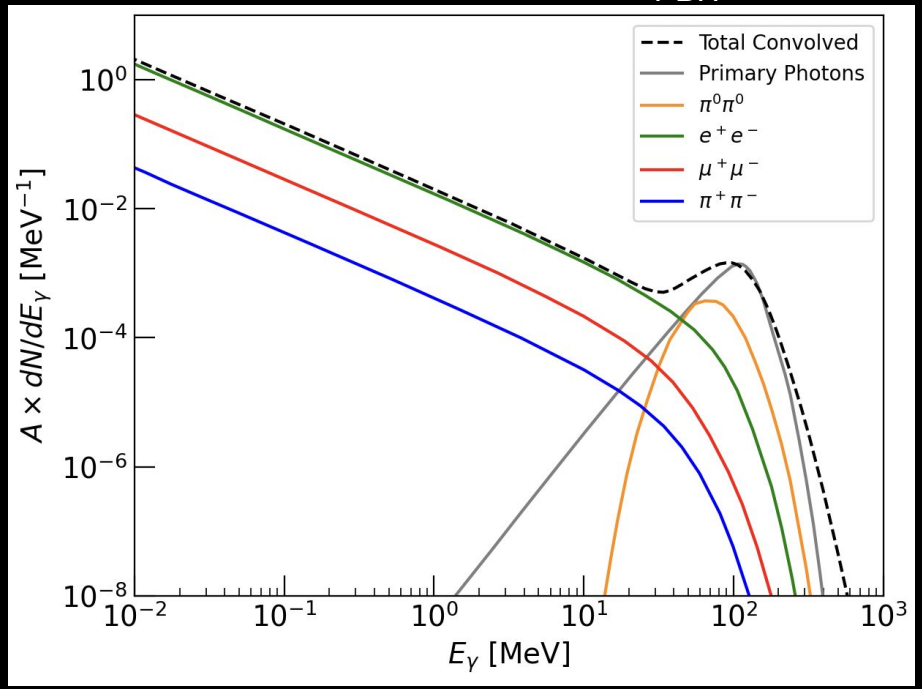
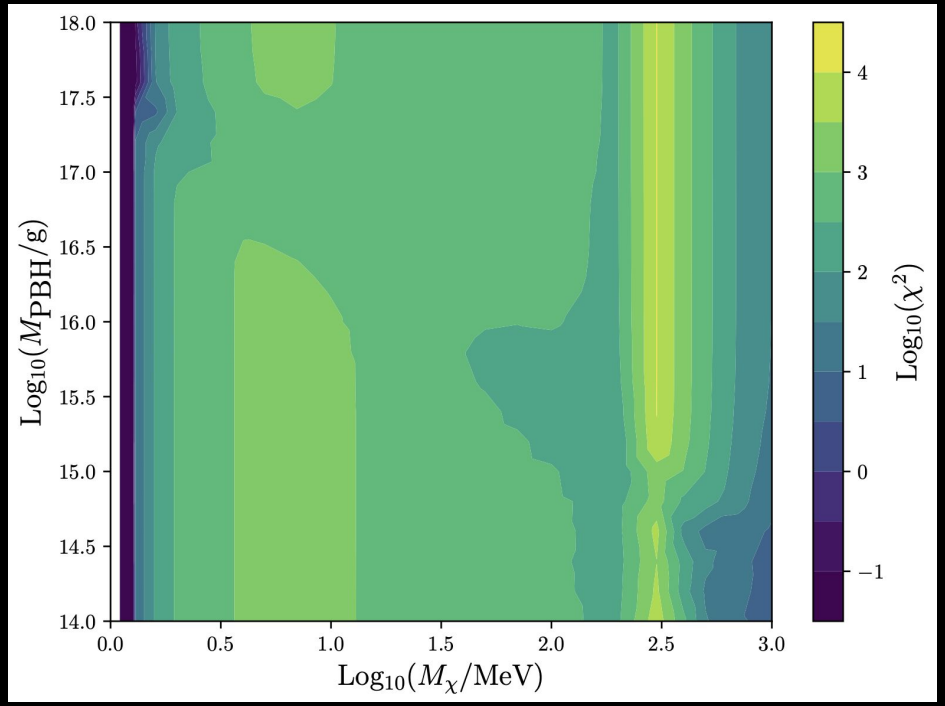
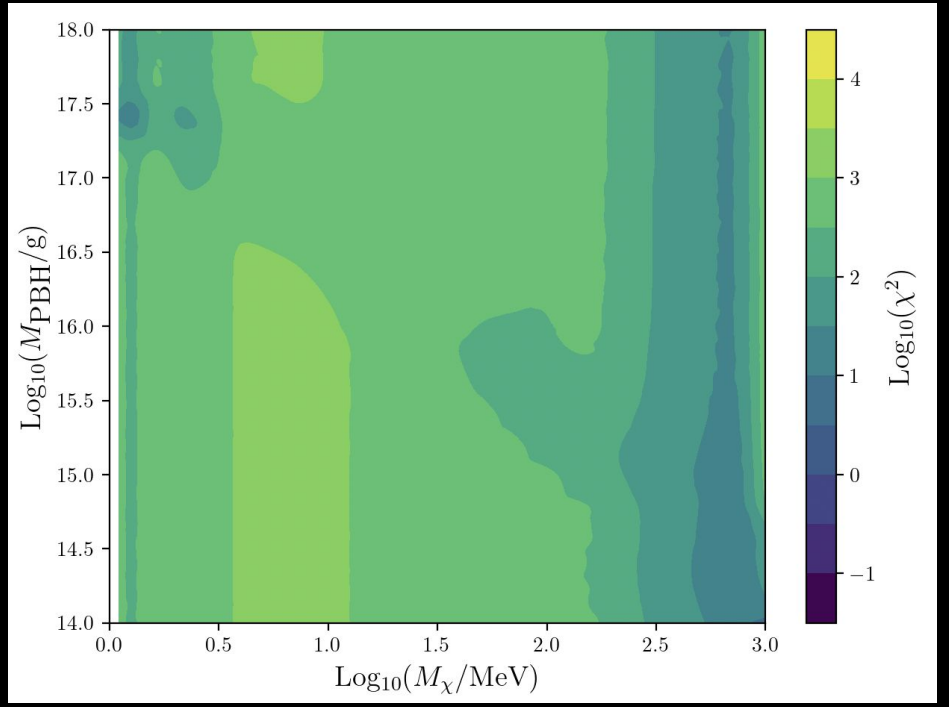


PBH Model Fit to Particle DM

Scalar DM

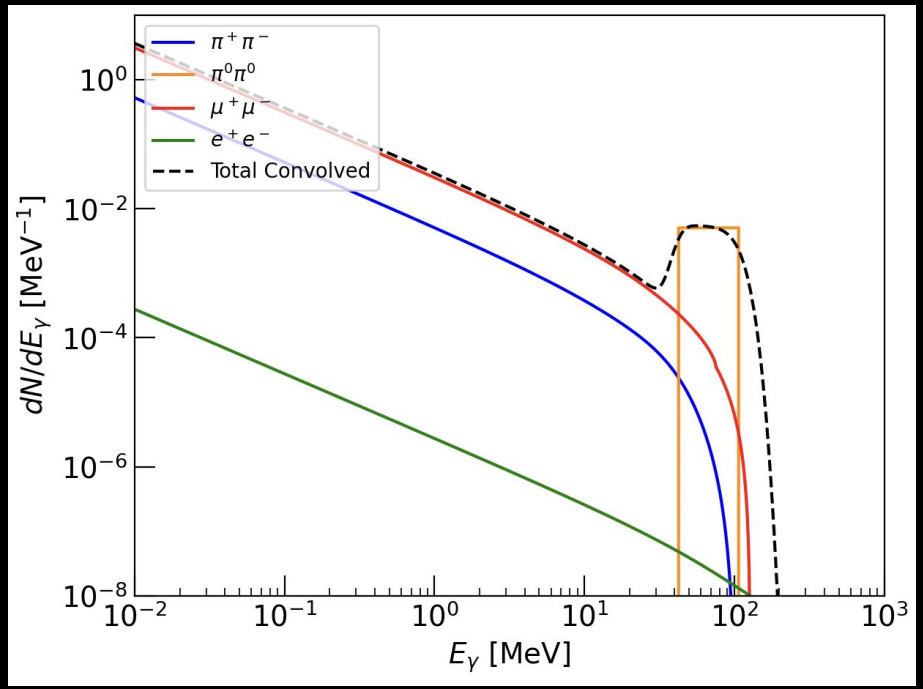


Vector DM

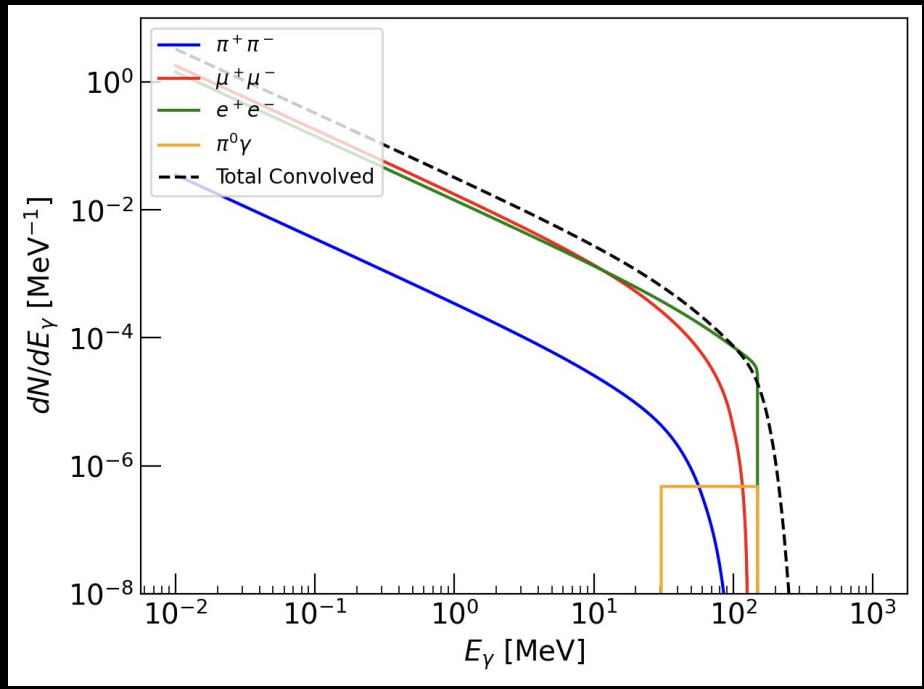


Gamma-Ray Spectra

Scalar DM, M = 300 MeV, T = 10^{28} s

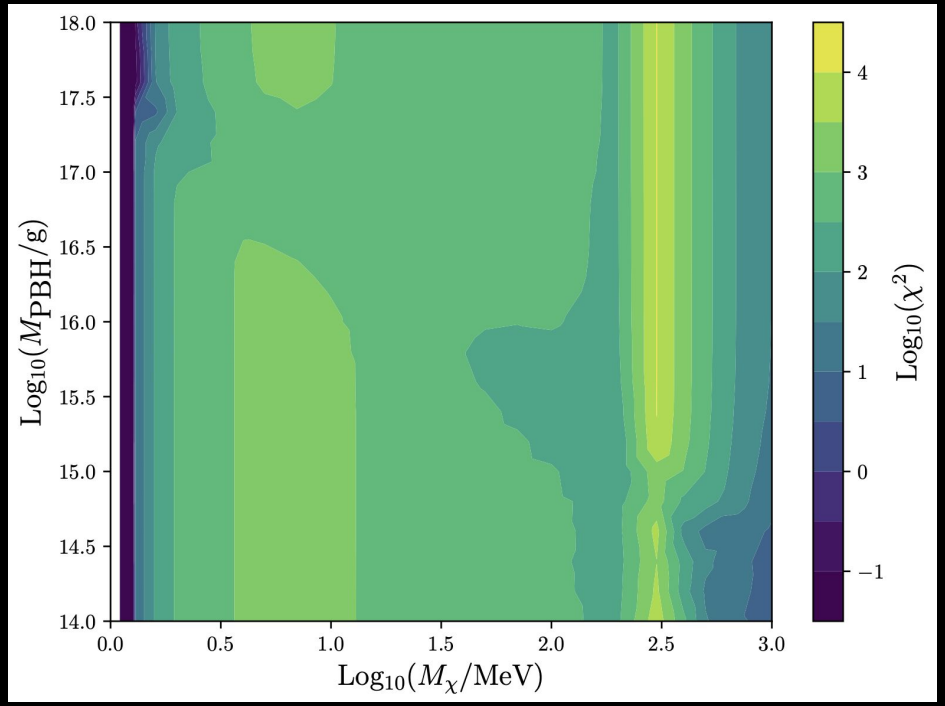


Vector DM, M = 300 MeV, T = 10^{28} s

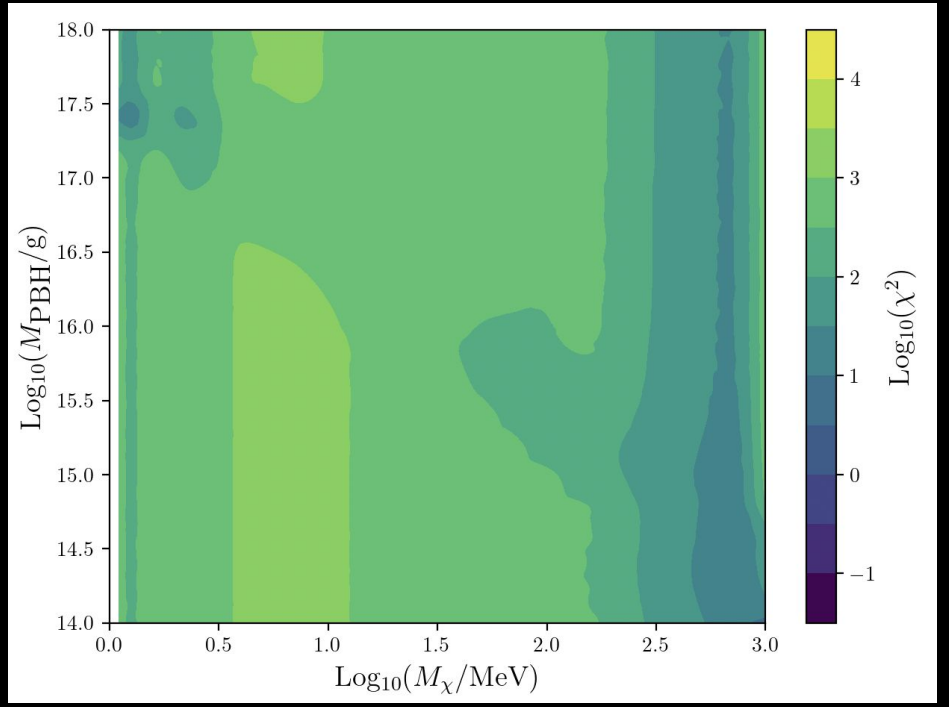


PBH Model Fit to Particle DM

Scalar DM

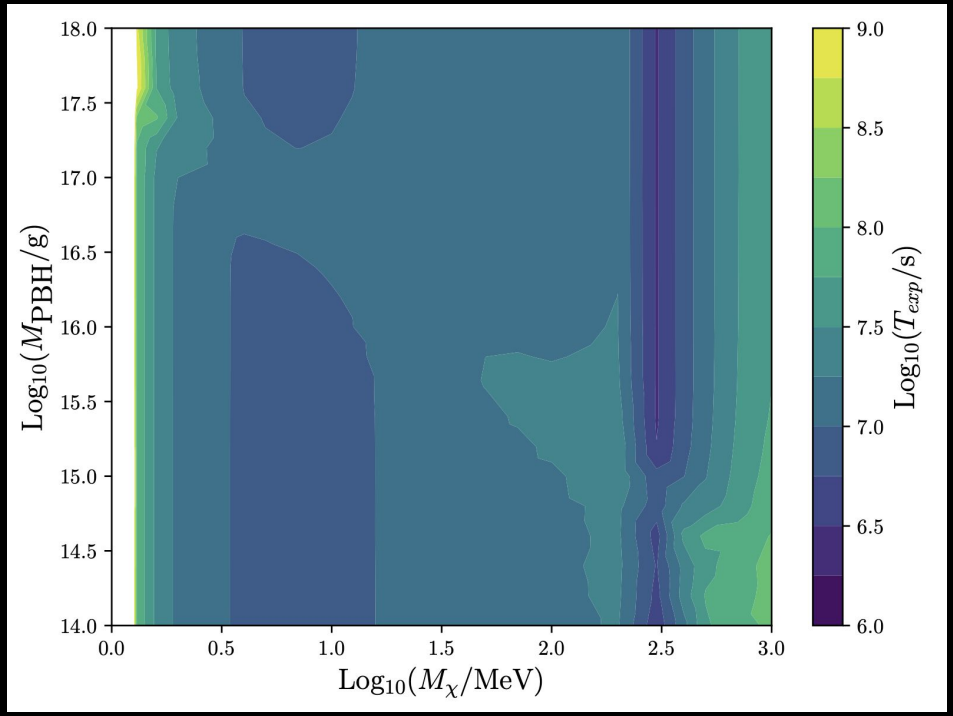


Vector DM



Required Observation Time

Scalar DM



Vector DM