Primordial Black Holes as Silver Bullets for WIMPS
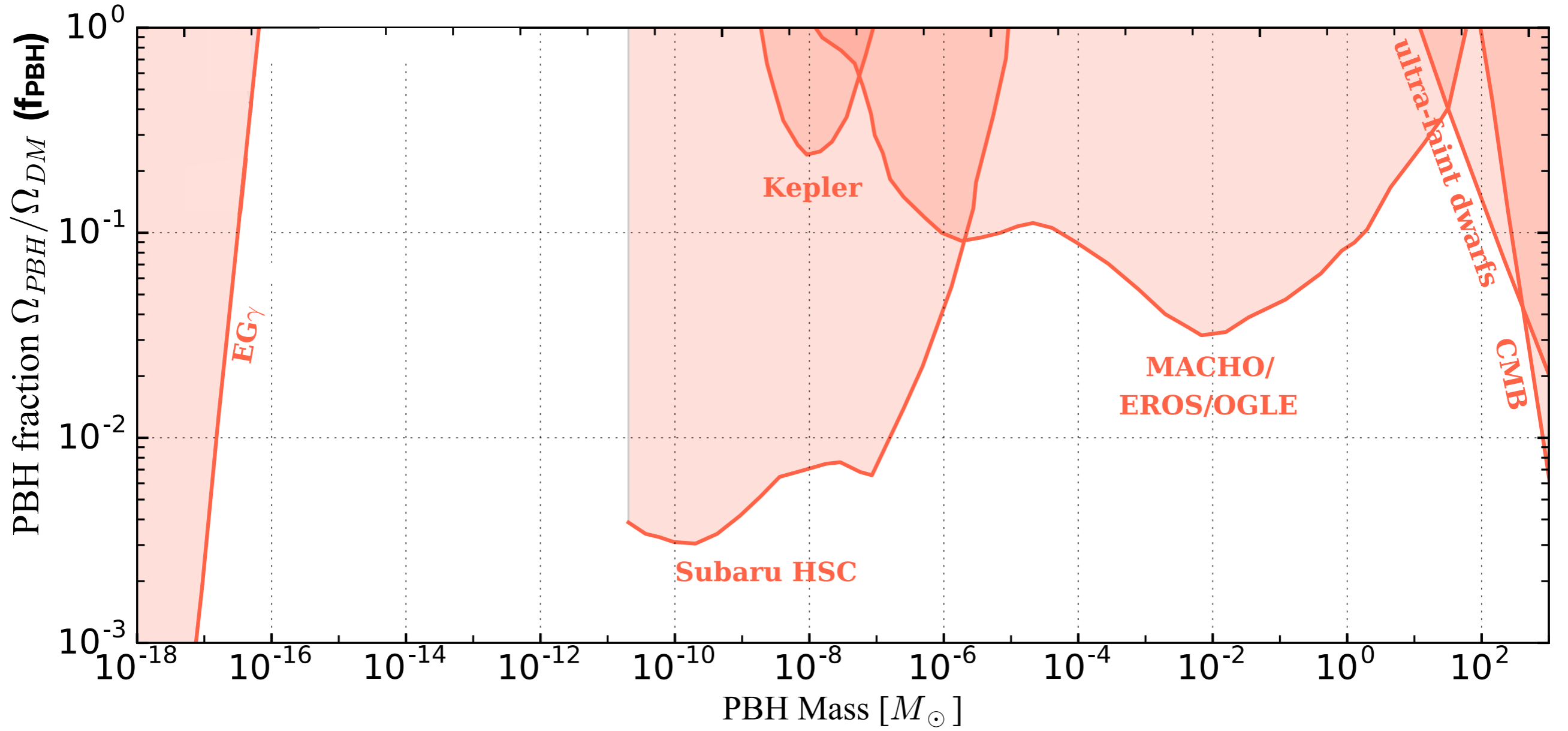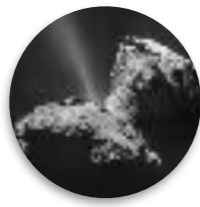
arXiv:1905.01238

Adam Coogan

With Gianfranco Bertone, Daniele Gaggero,
Bradley Kavanagh, Christoph Weniger

TeVPA, 3 December 2019

UNIVERSITY OF AMSTERDAM

GRAPPA
GRavitation AstroParticle Physics Amsterdam

PBH fraction Ω_{PBH}/Ω_{DM} (f$_{\mathbf{PBH}}$) vs *PBH Mass [$M_\odot$]*

$M_\odot$ axis (red): 10, 10^{-11}, 10^{-9}, 10^{-7}, 10^{-5}, 10^{-3}, 10^{-1}, 10^1

g axis (green): 10^{22}, 10^{24}, 10^{26}, 10^{28}, 10^{30}, 10^{32}, 10^{34}, 10^{3}

eV axis (blue): 10^{51}, 10^{53}, 10^{55}, 10^{57}, 10^{59}, 10^{61}, 10^{63}, 10^{65}, 10^{67}, 10

Subaru HSC

x-axis: 10^{-18}, 10^{-16}, 10^{-14}, 10^{-12}, 10^{-10}, 10^{-8}, 10^{-6}, 10^{-4}, 10^{-2}, 10^0, 10^2

y-axis: 10^0, 10^{-1}, 10^{-2}, 10^{-3}

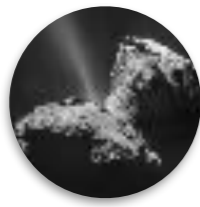Zel'dovich & Novikov (1967), Hawking (1971), Carr & Hawking (1974), Carr (1975)
Fig. adapted from arXiv:1807.11495
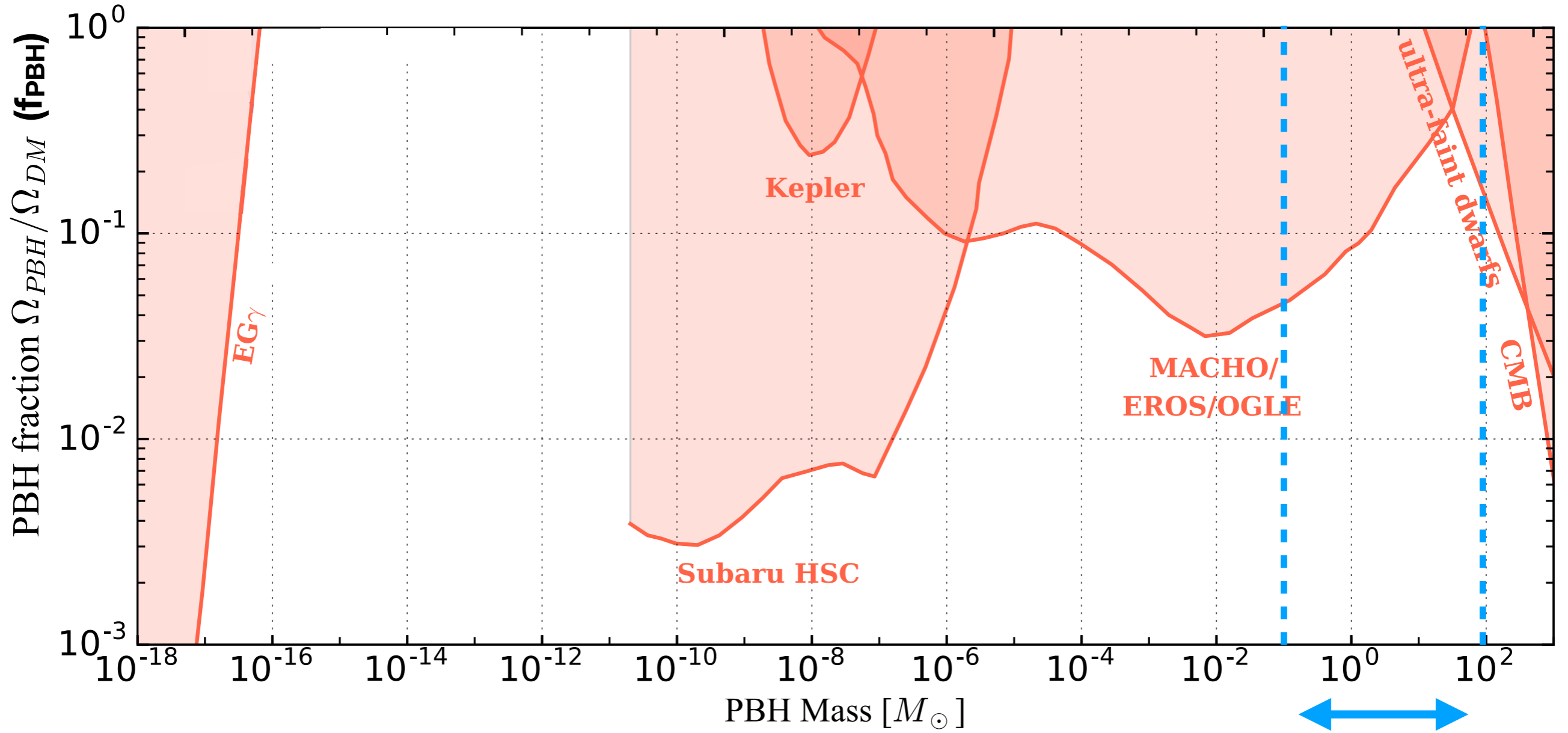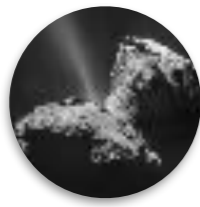
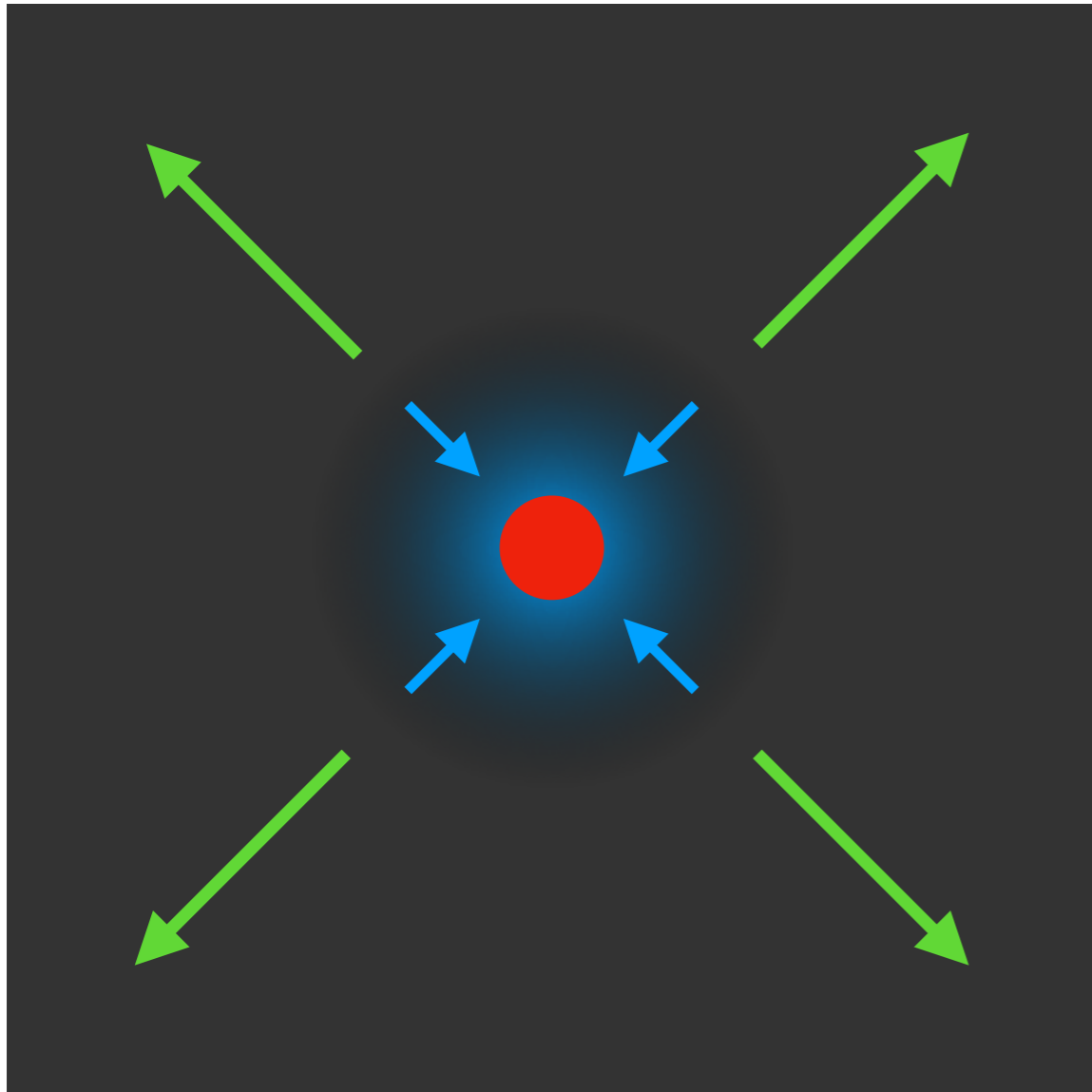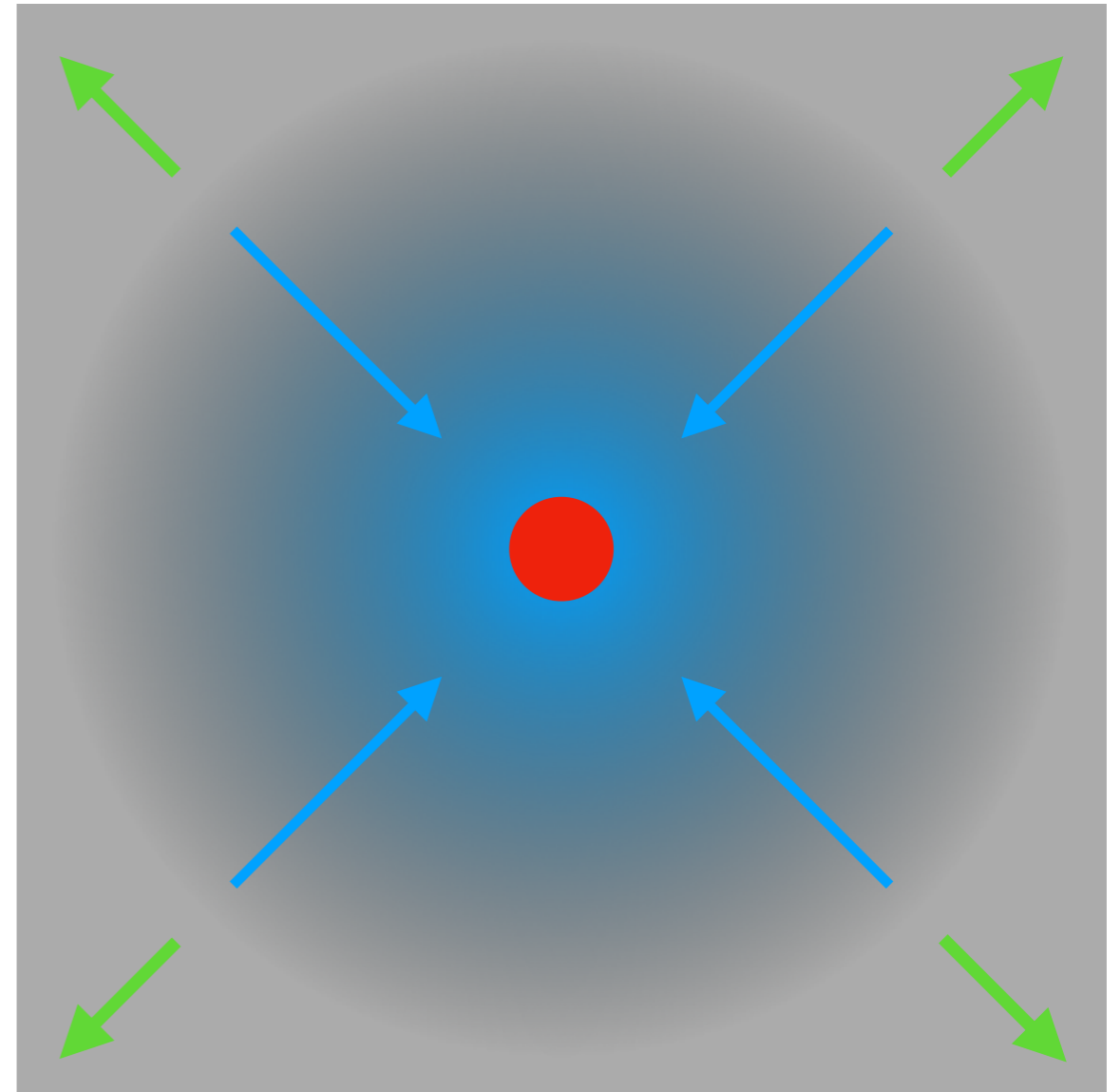Zel'dovich & Novikov (1967), Hawking (1971), Carr & Hawking (1974), Carr (1975)
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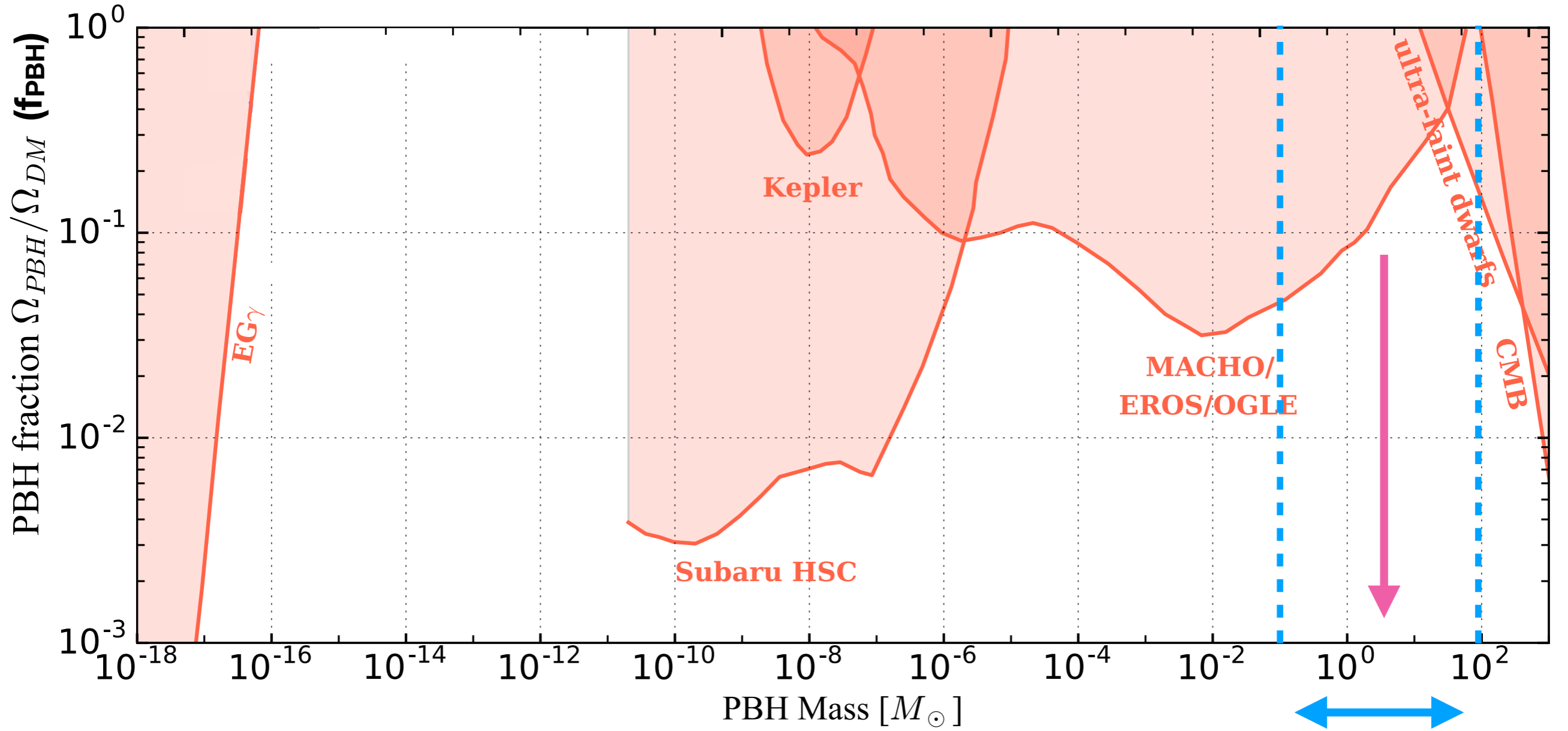
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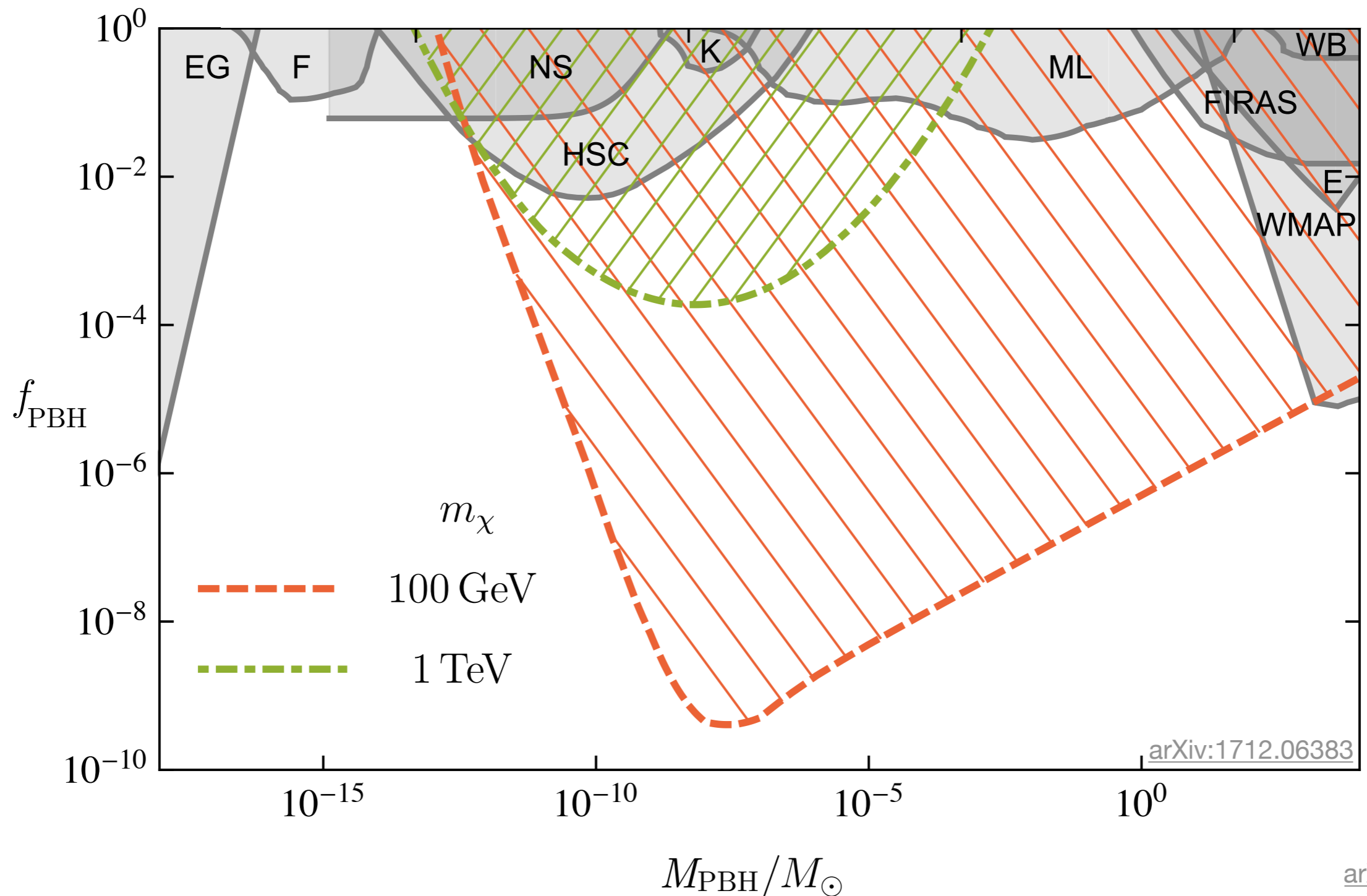
Primordial black holes accumulate WIMP halos

High redshift

Low redshift

Thermal WIMP ⇒ PBH constraint

arXiv:1712.06383

arXiv:1003.3466,
arXiv:1607.00612,
arXiv:1901.08528

PBH detection ⟹ WIMP constraint

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1. Detection scenario: M_{PBH}, N_{PBH}

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2. Infer **PBH abundance** f_{PBH}

PBH detection ⇒ WIMP constraint

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2. Infer **PBH abundance** f_{PBH}

3. For **WIMP model**, constrain $\langle \sigma v \rangle$ with γ-ray observations

1. Detection scenarios

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- *LIGO O3* detects $\mathbf{M_{PBH} = 0.5\ M_{\odot}}$ merger

arXiv:1709.06576,
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p(f$_{PBH}$|N$_{PBH}$): depends on $\int dz$ (merger rate) $\times$ (sensitivity)

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Compute p(f$_{PBH}$|N$_{PBH}$) with Monte Carlo simulation
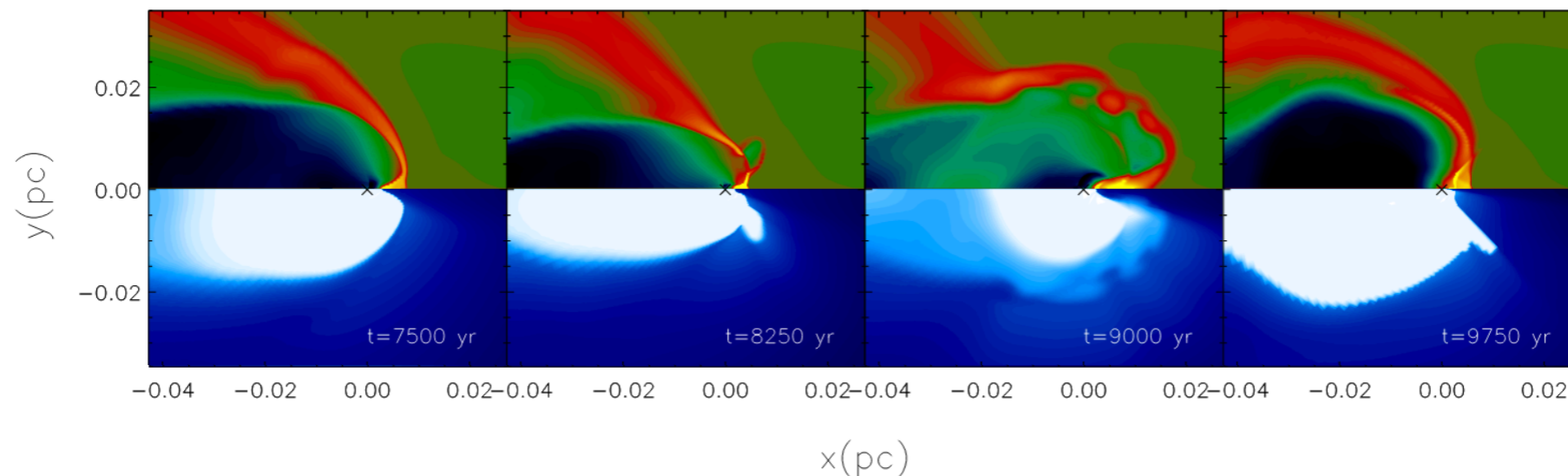
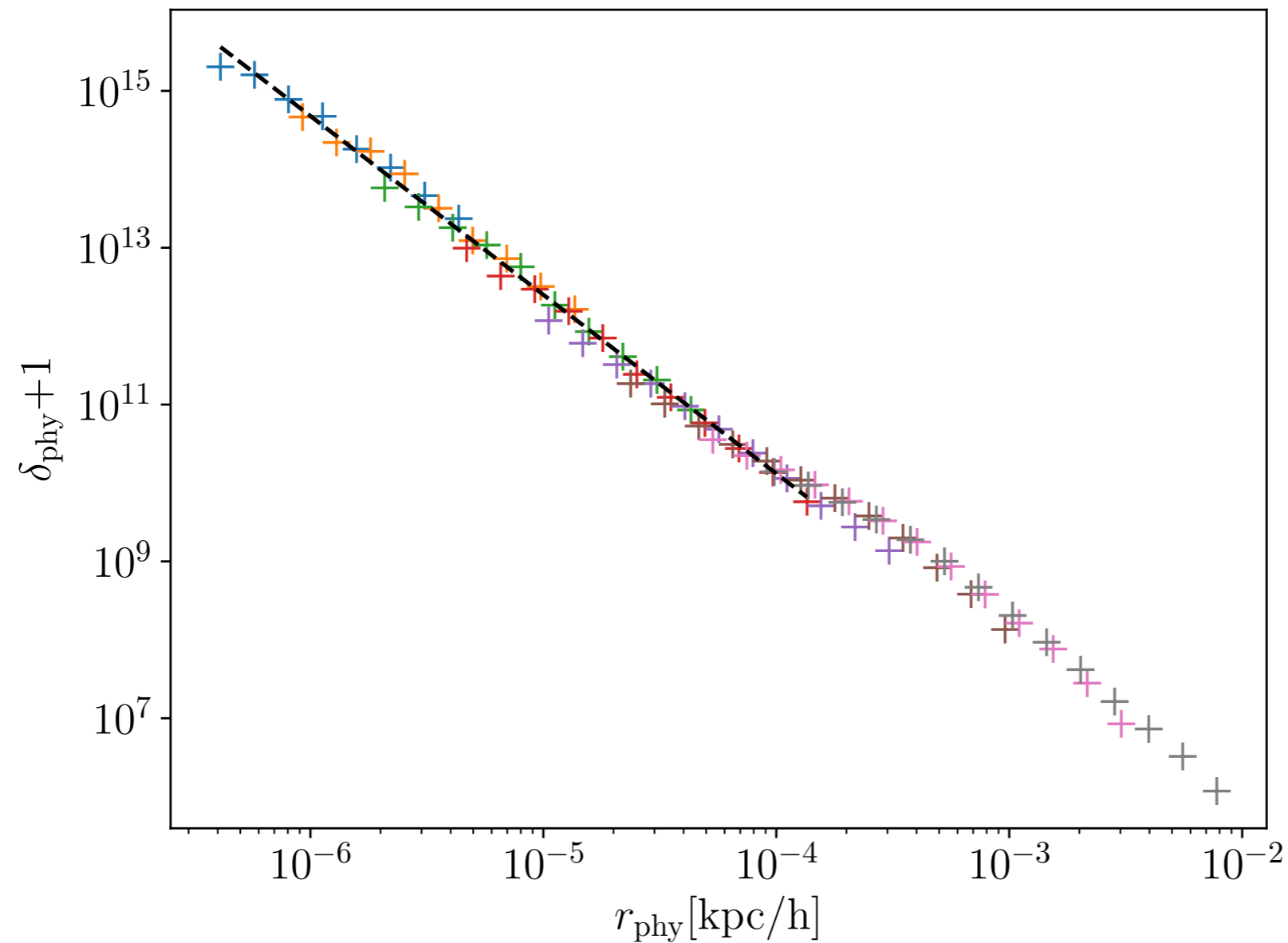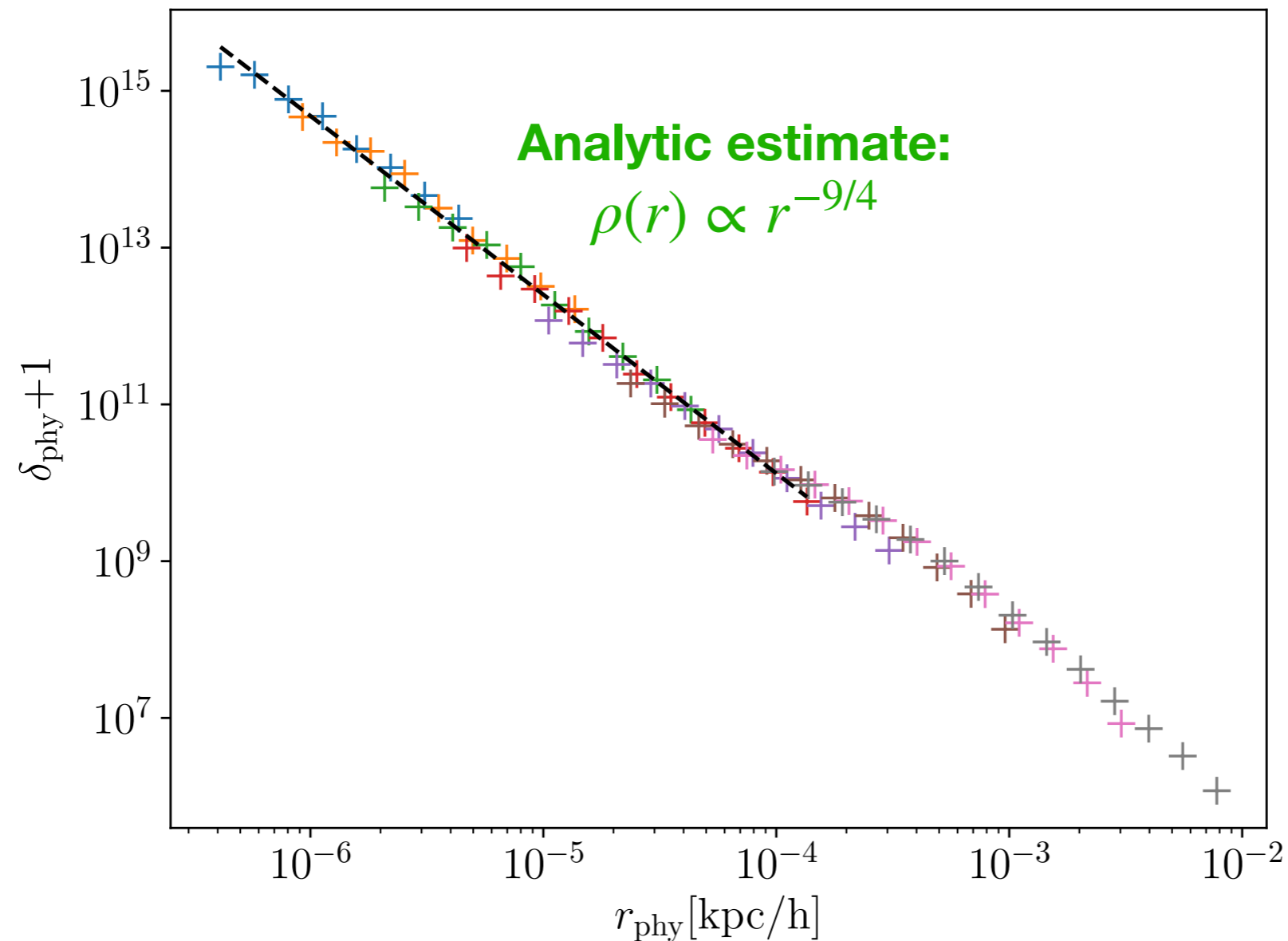# 2. Detection → abundance
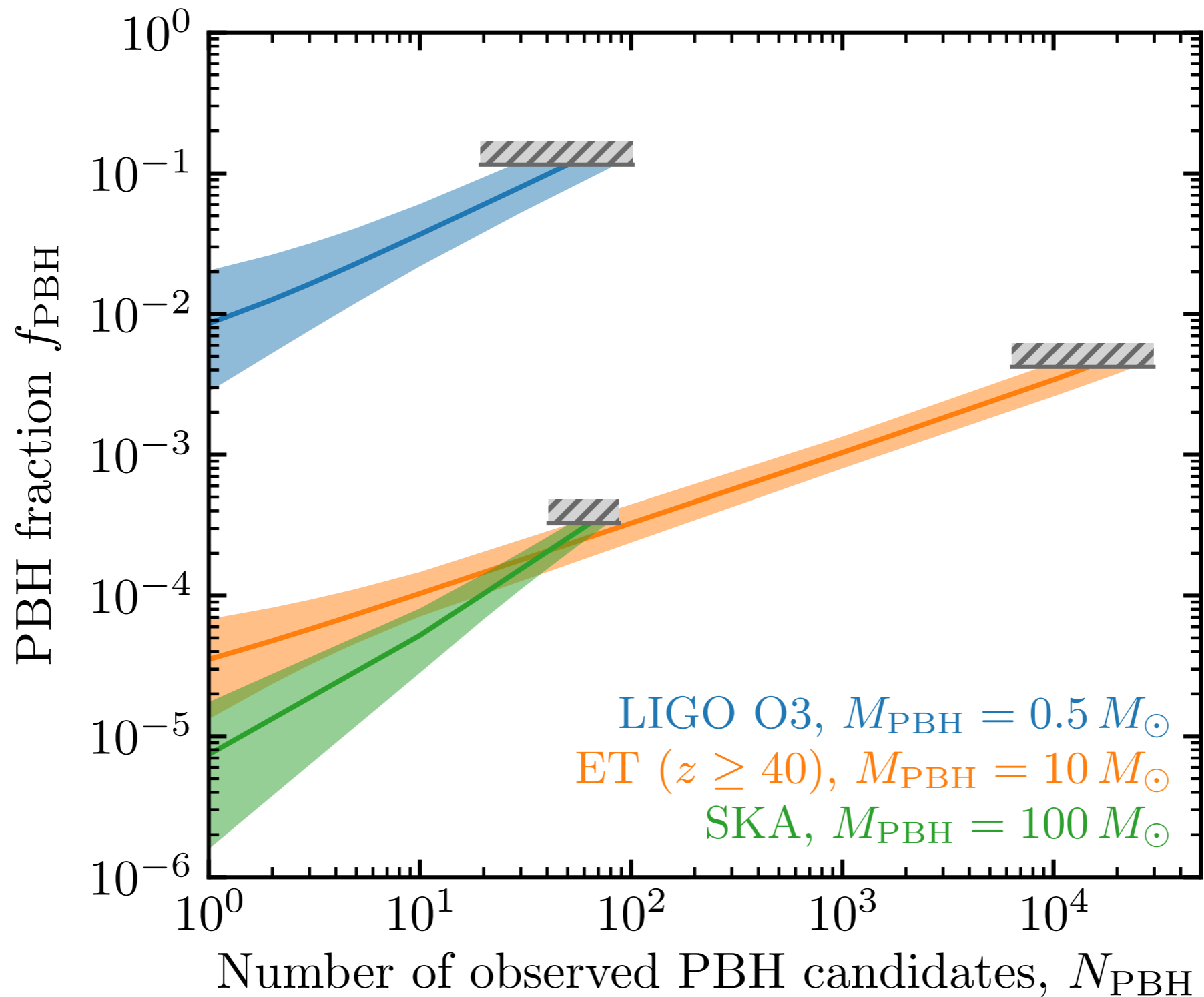
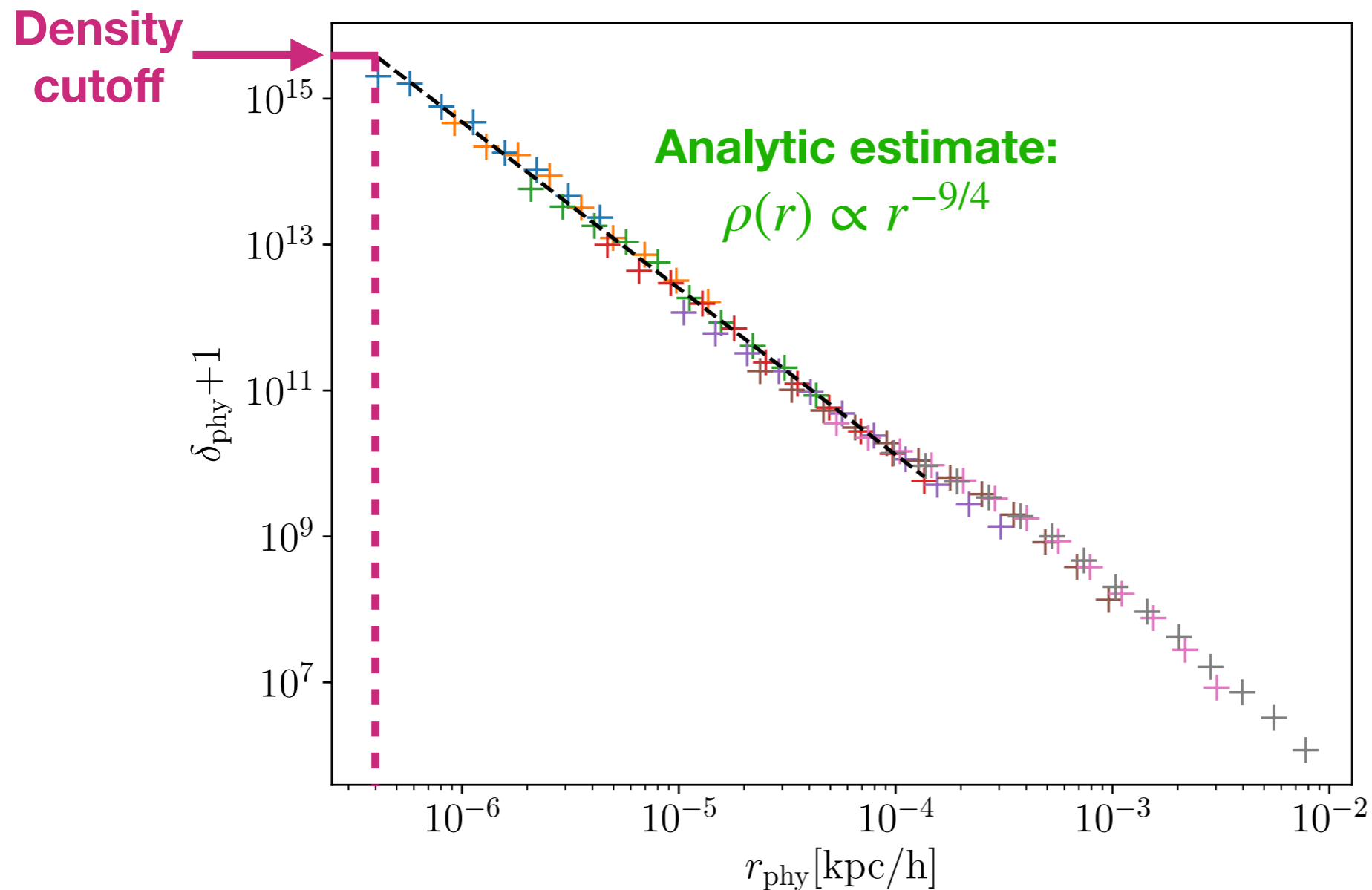# 3. Ann. rate around PBH

WIMP halo around 30 M$_\odot$ PBH

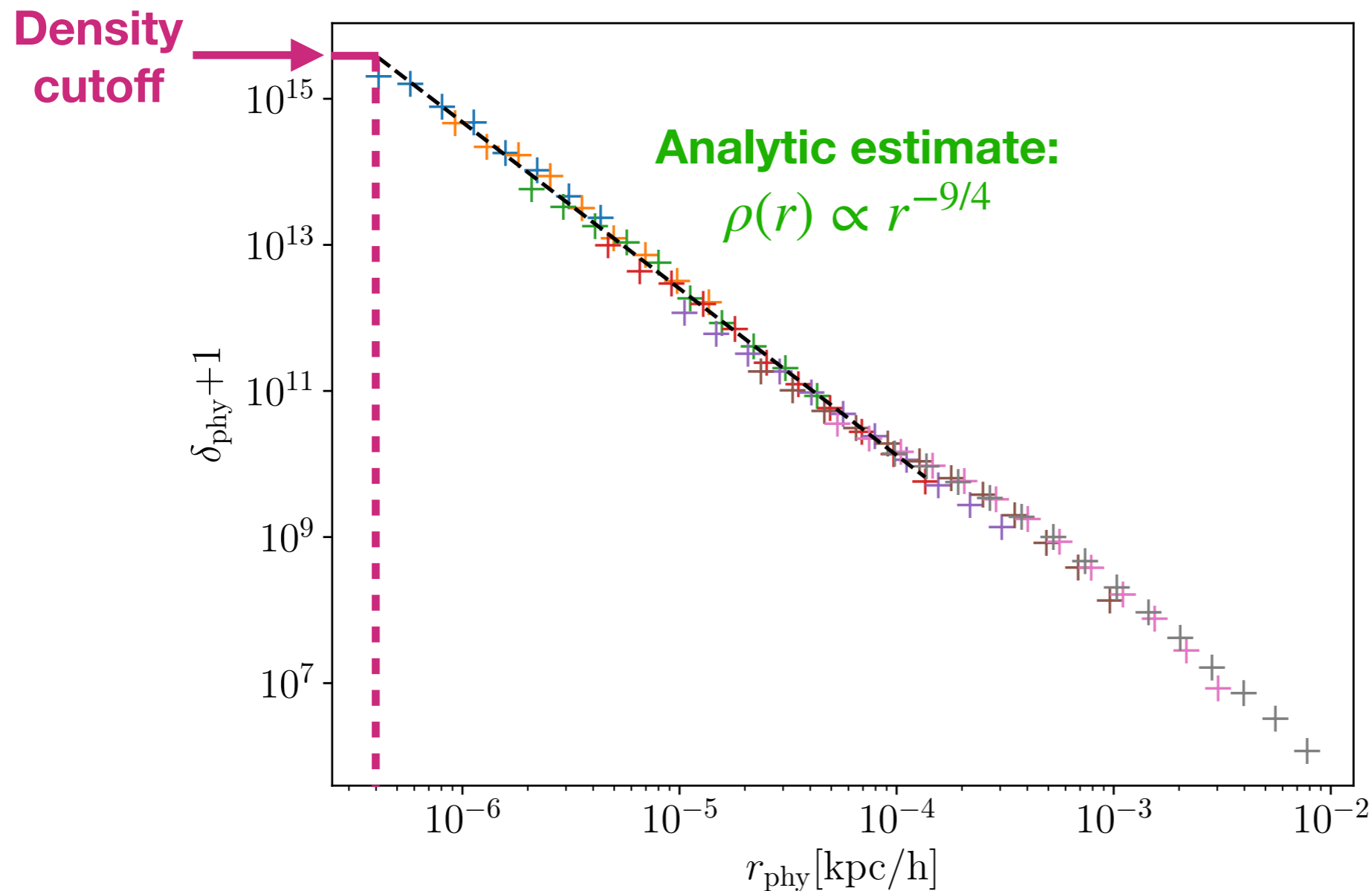# 3. Ann. rate around PBH

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$$\rho(r) \propto r^{-9/4}$$

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Can now compute gamma-ray flux from PBH's halo

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Constraint: PBH halos as γ-ray *galactic point sources*

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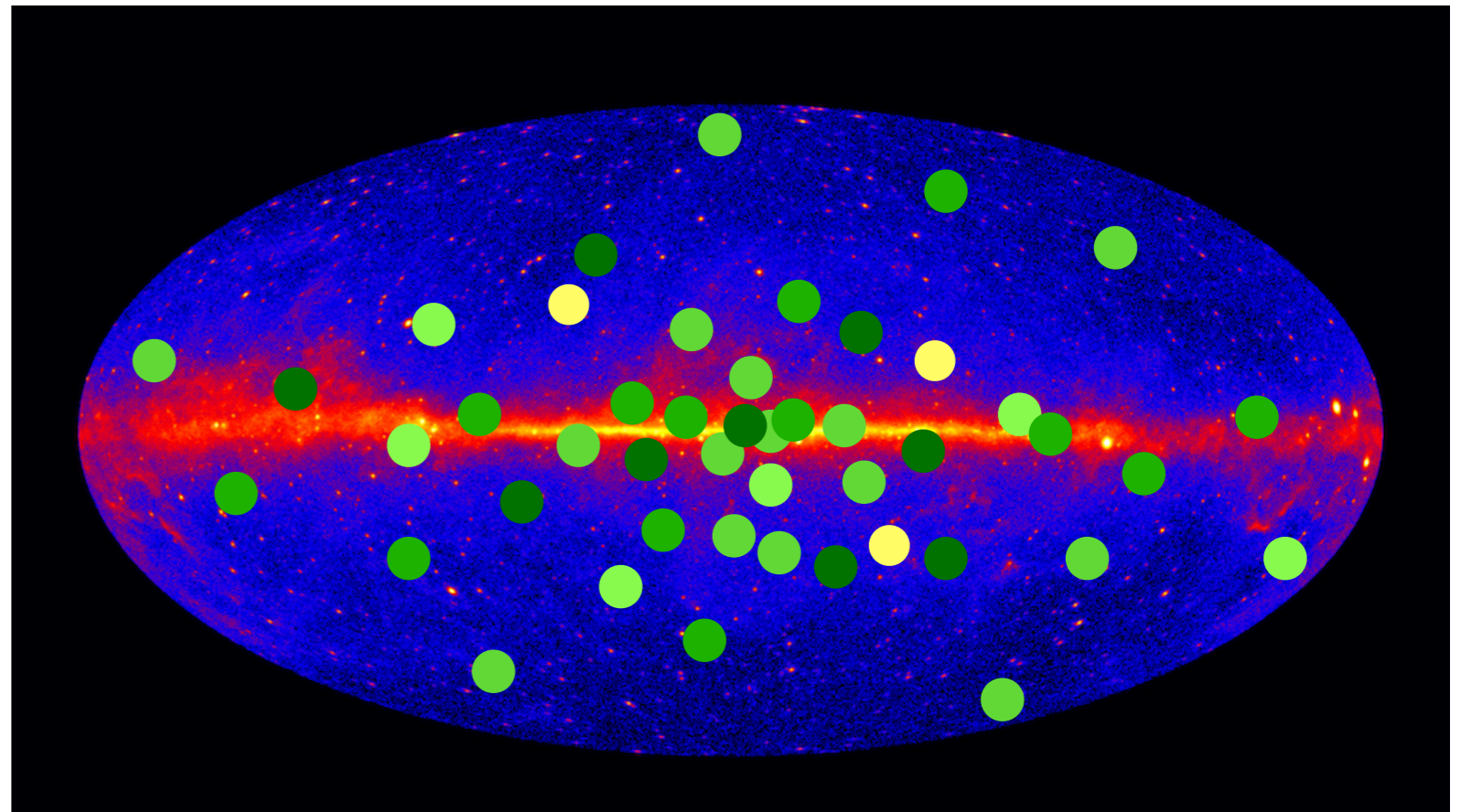
Monte Carlo procedure

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Monte Carlo procedure

1. Place PBHs in Milky Way

Fermi/NASA

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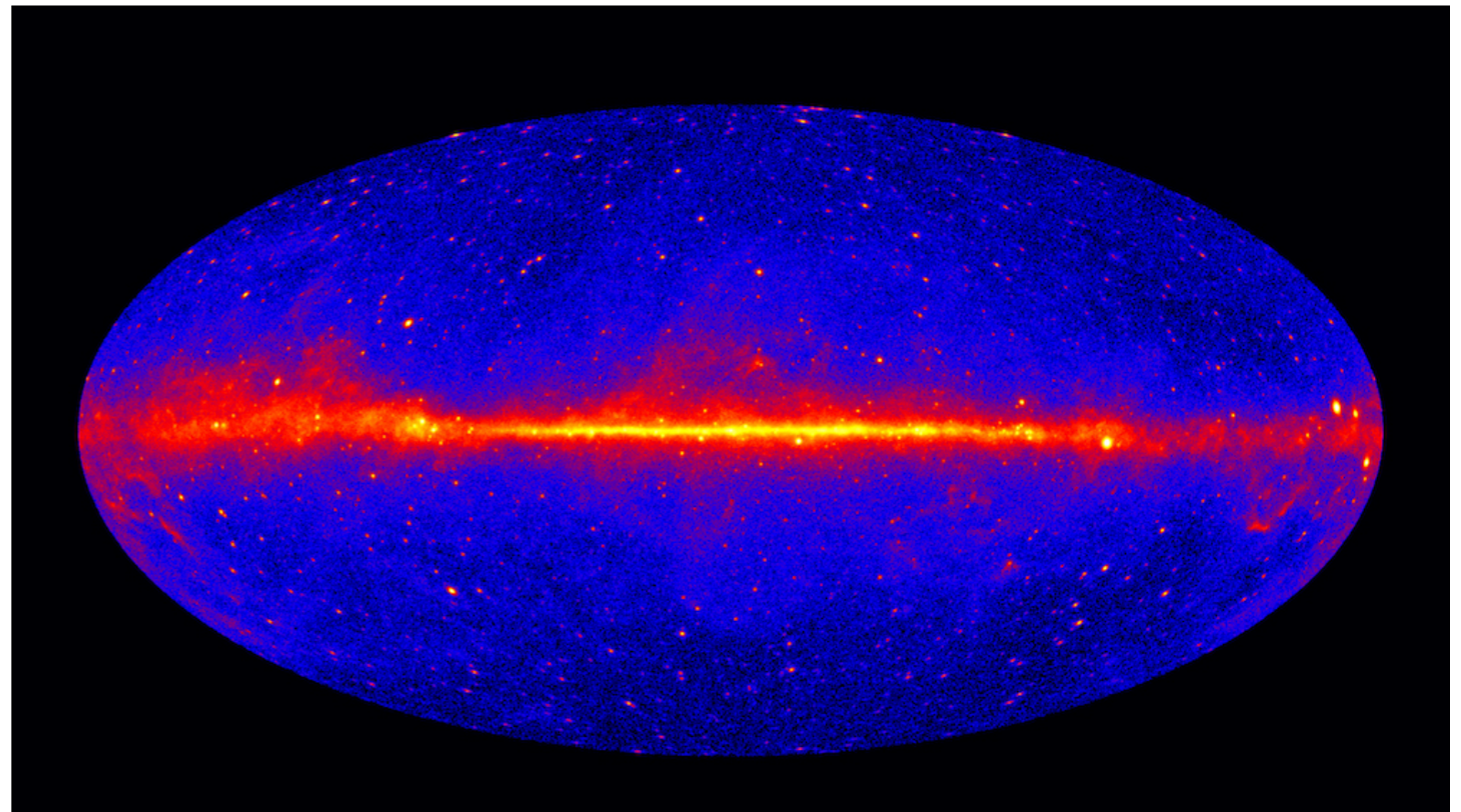
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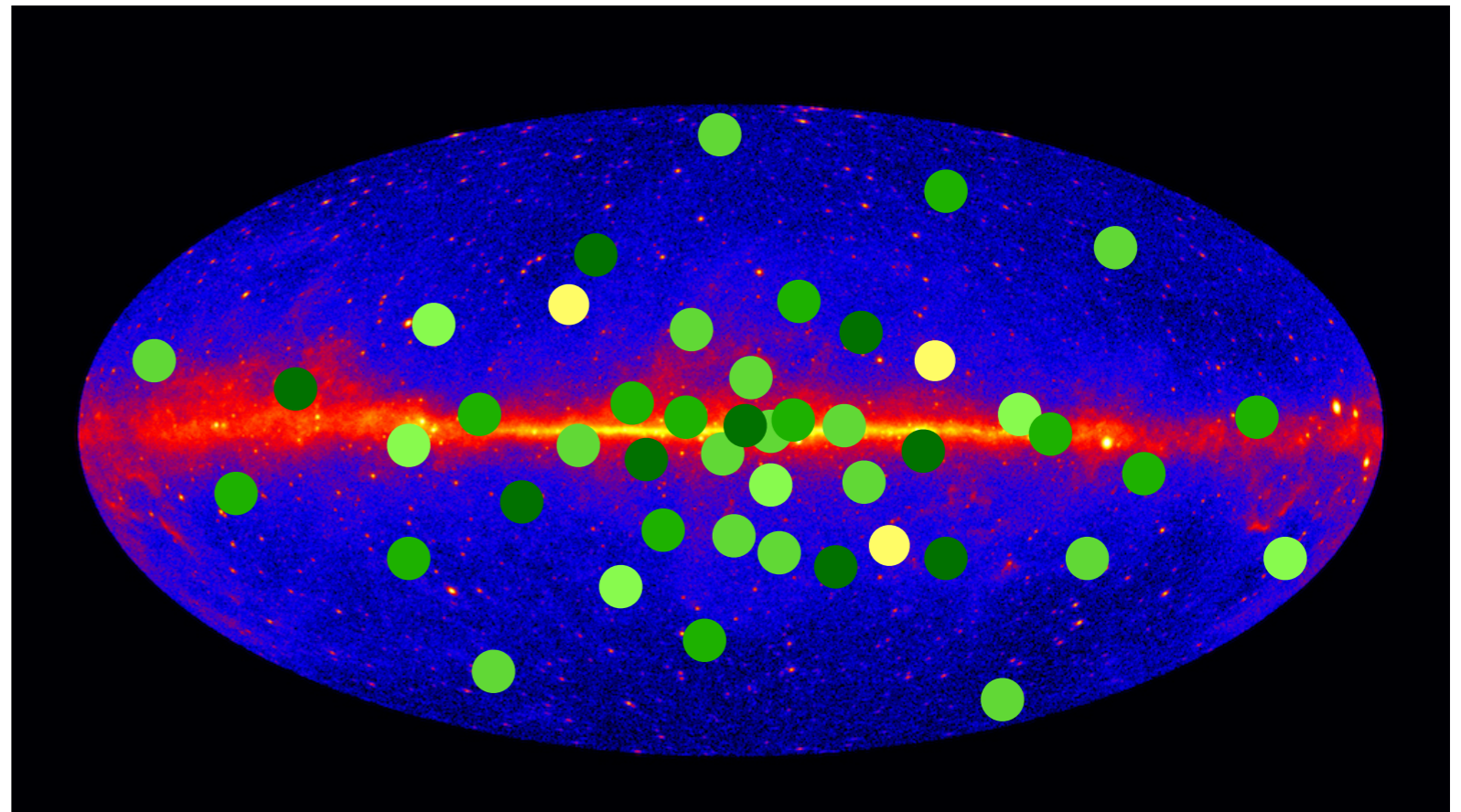

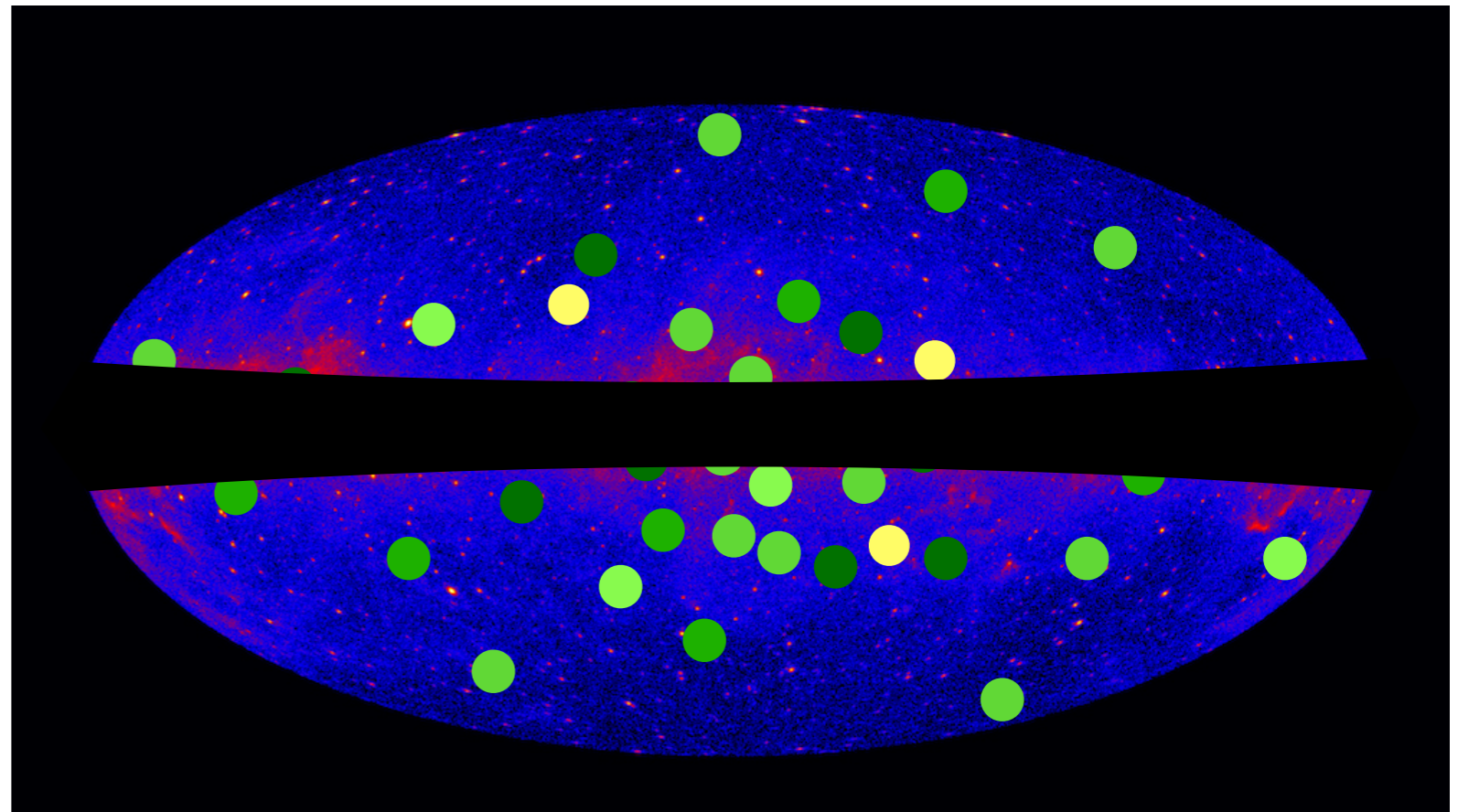Fermi/NASA

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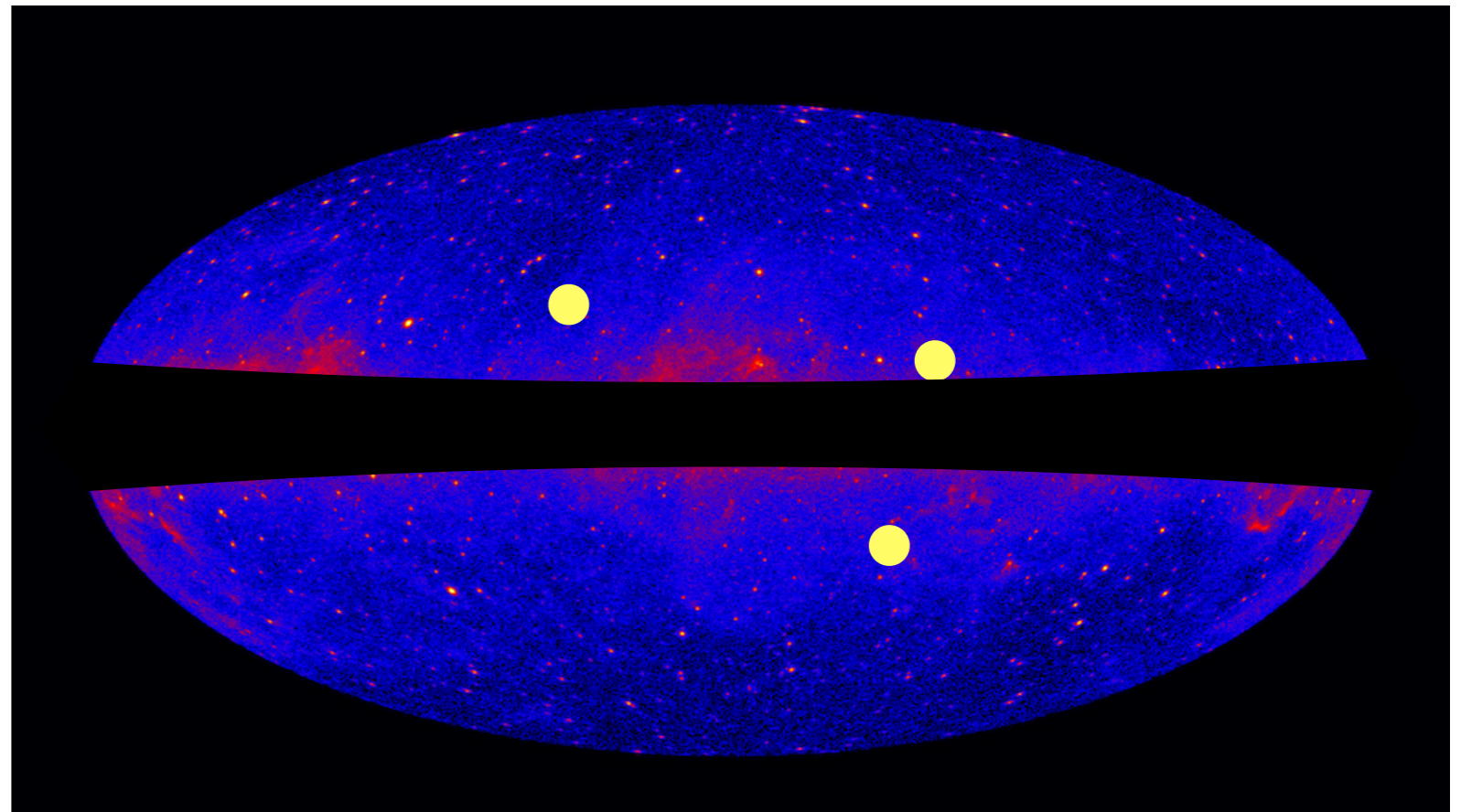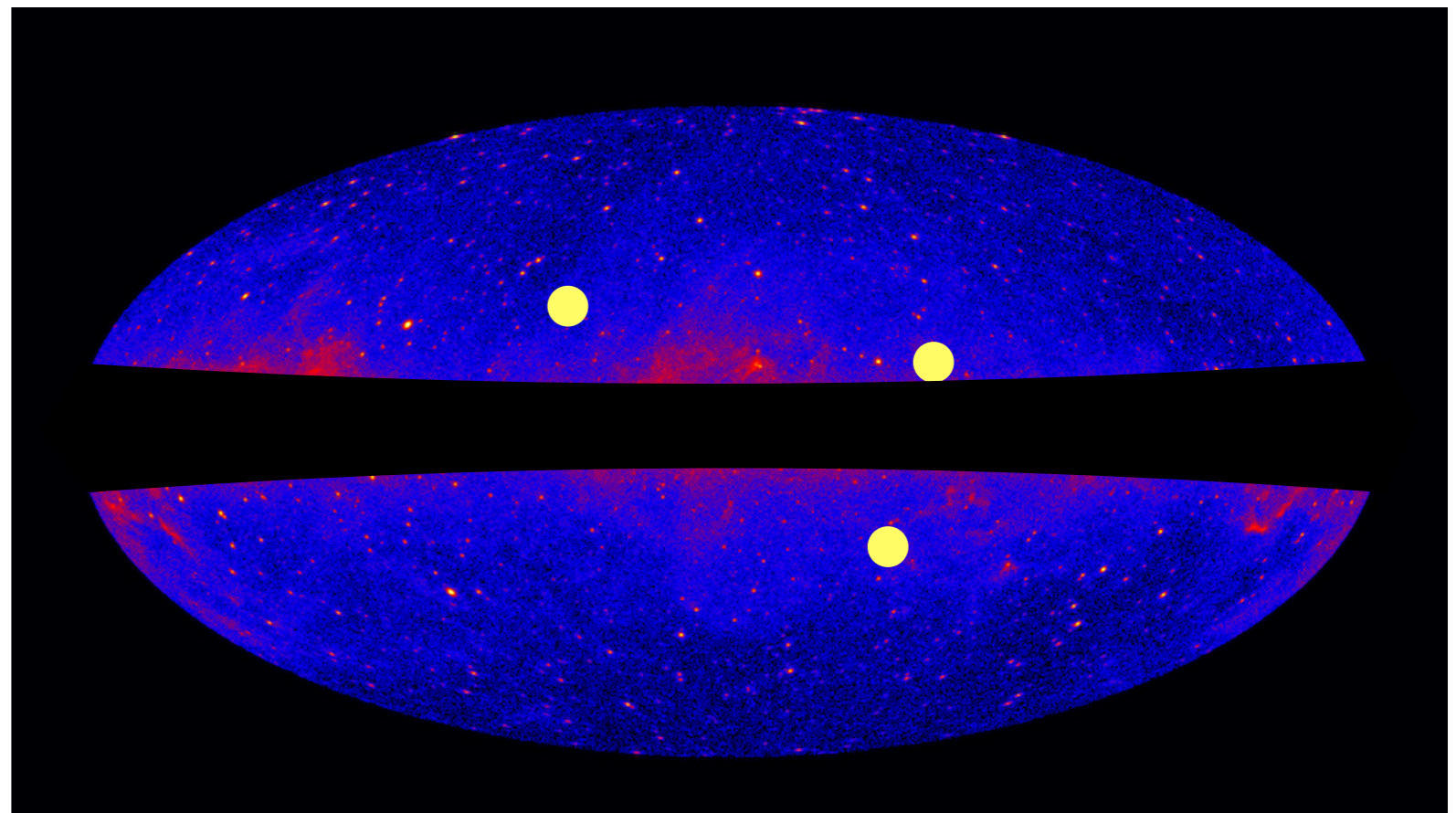3. **Limit:** require $N_{p.s.} < 19$

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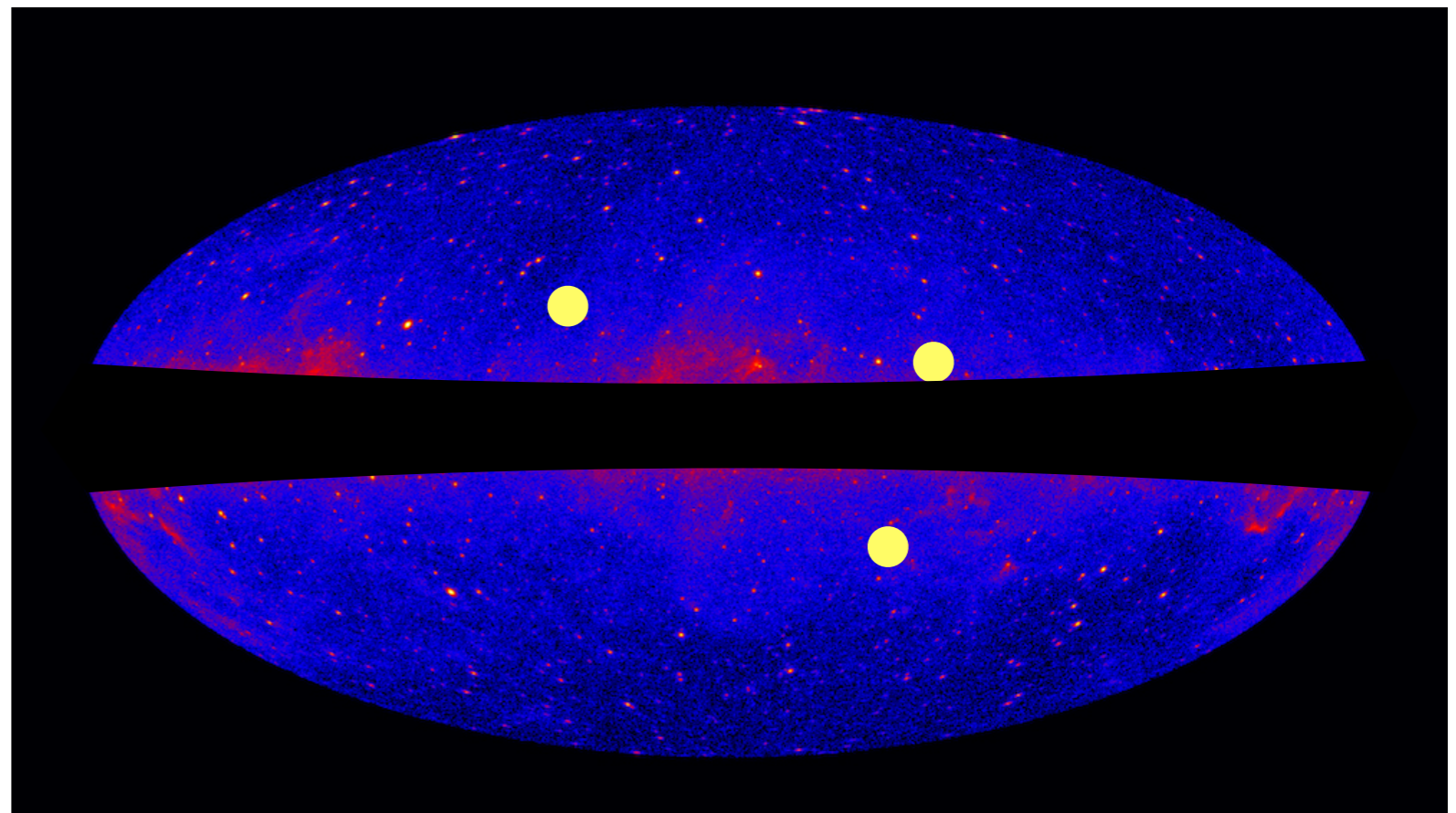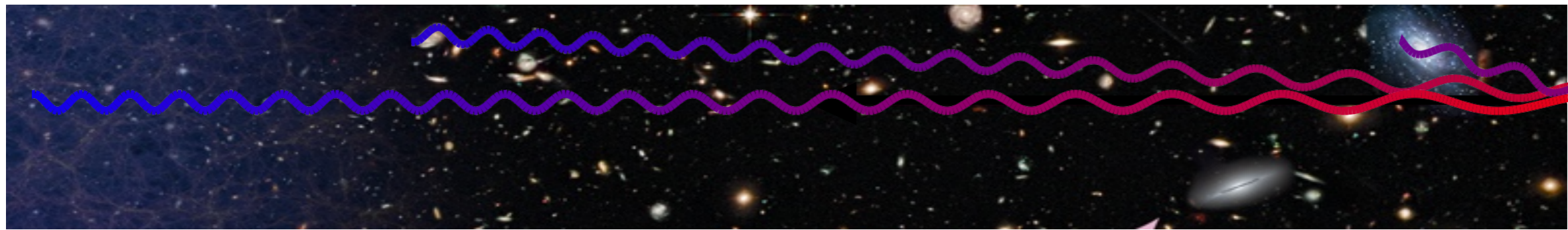3. **Limit:** require $N_{p.s.} < 19$

Number of 3FGL unassociated sources compatible with DM annihilation

Fermi/NASA

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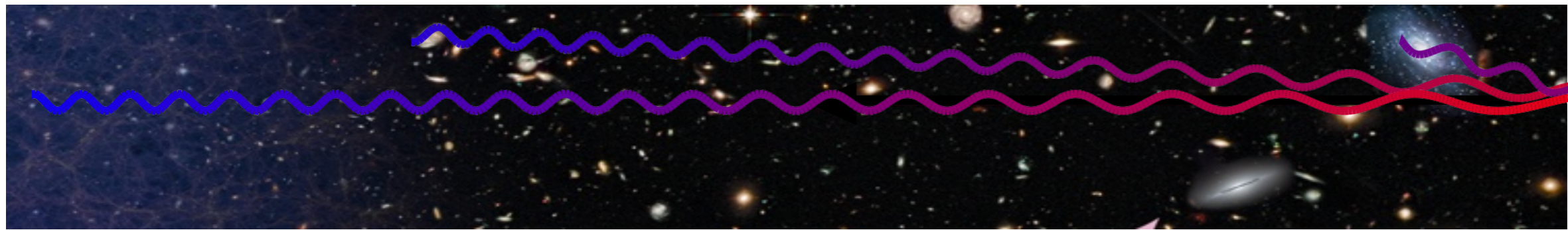

UCO/Lick Observatory

NASA

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UCO/Lick Observatory
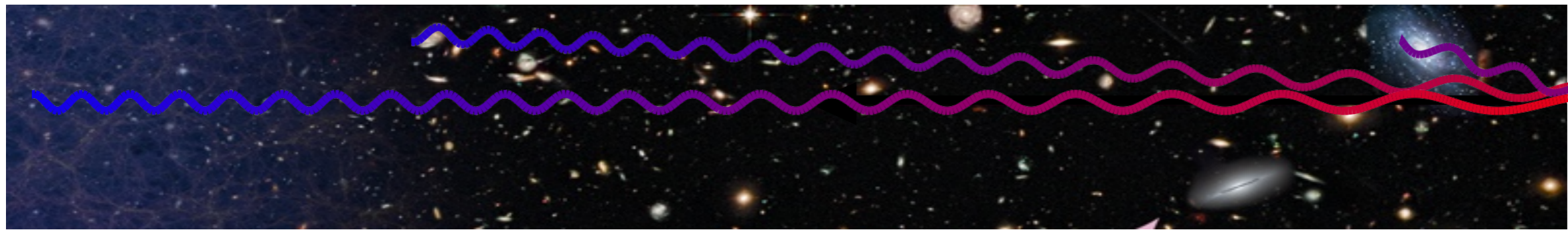
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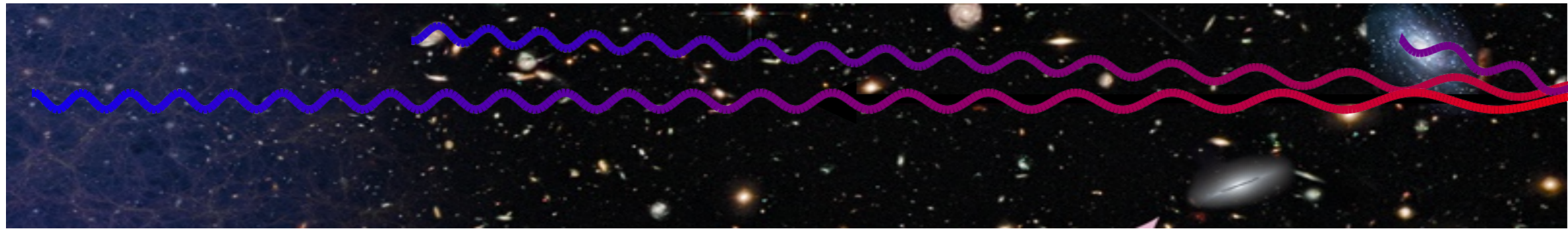
UCO/Lick Observatory

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Ingredients: *Ann. rate* in PBH halo   *Cosmological* PBH density

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UCO/Lick Observatory

NASA

Ingredients: *Ann. rate* in PBH halo   *Cosmological* PBH density   Attenuation   Redshifting

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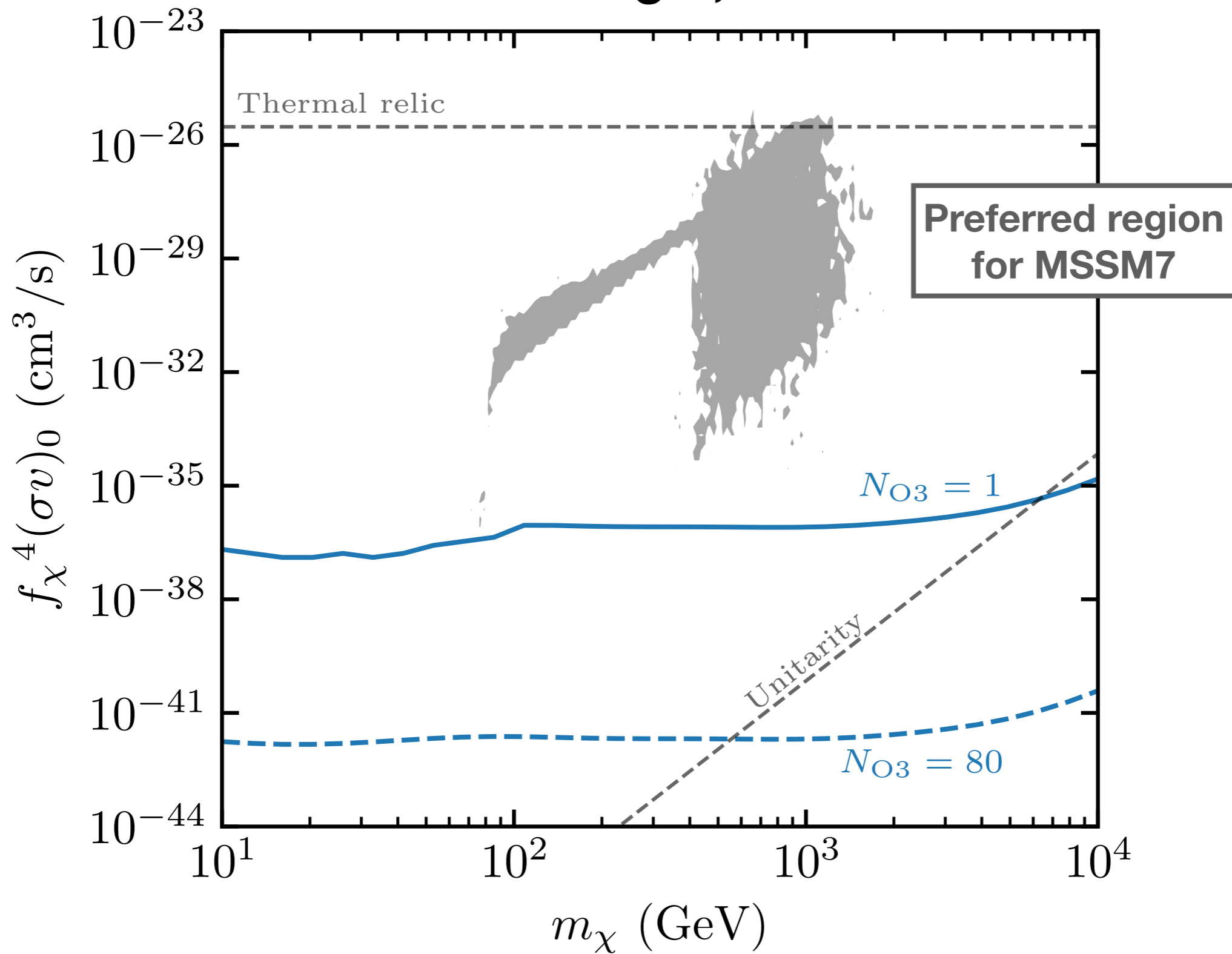**Limit:** for each bin, require $\phi \lesssim \phi_{\mathrm{obs}} + 3\,\Delta\phi_{\mathrm{obs}}$

Robust constraint with few assumptions

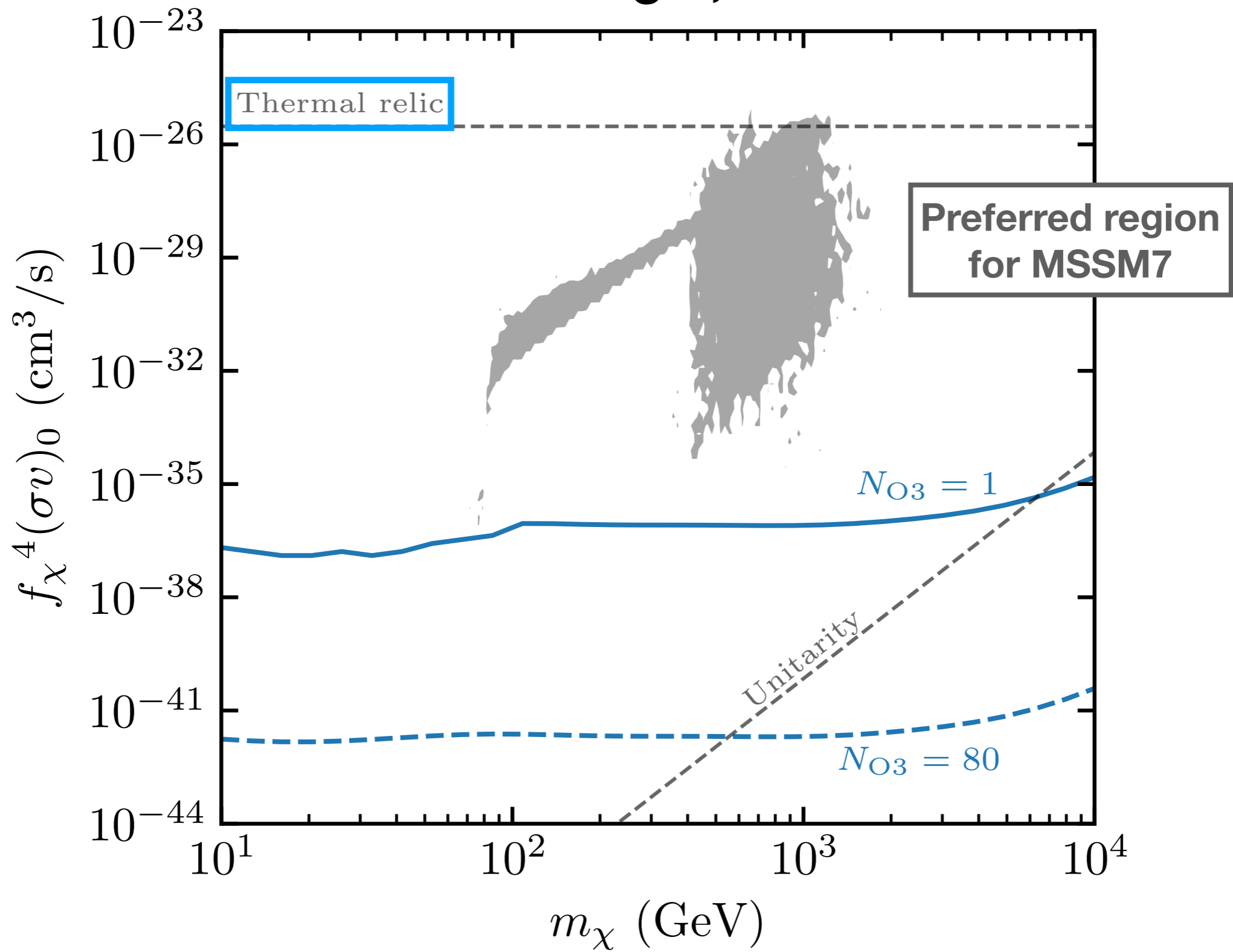# PBH detection $\Rightarrow$ WIMP constraint

0.5 M$_\odot$ merger, LIGO O3

Thermal relic

Preferred region for MSSM7

$N_{O3} = 1$

Unitarity

$N_{O3} = 80$

$f_\chi{}^4 (\sigma v)_0 \; (\mathrm{cm}^3/\mathrm{s})$

m_χ (GeV)

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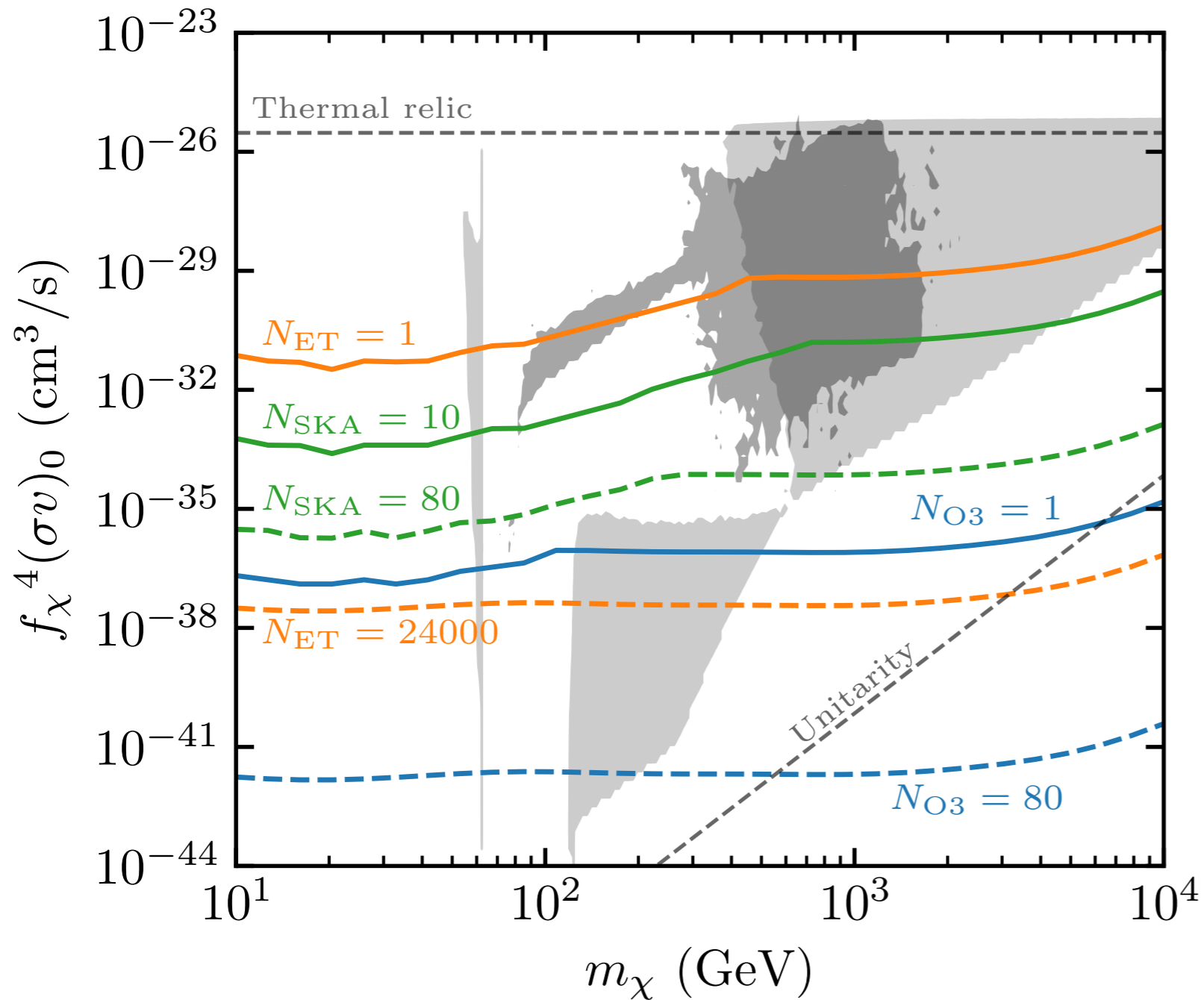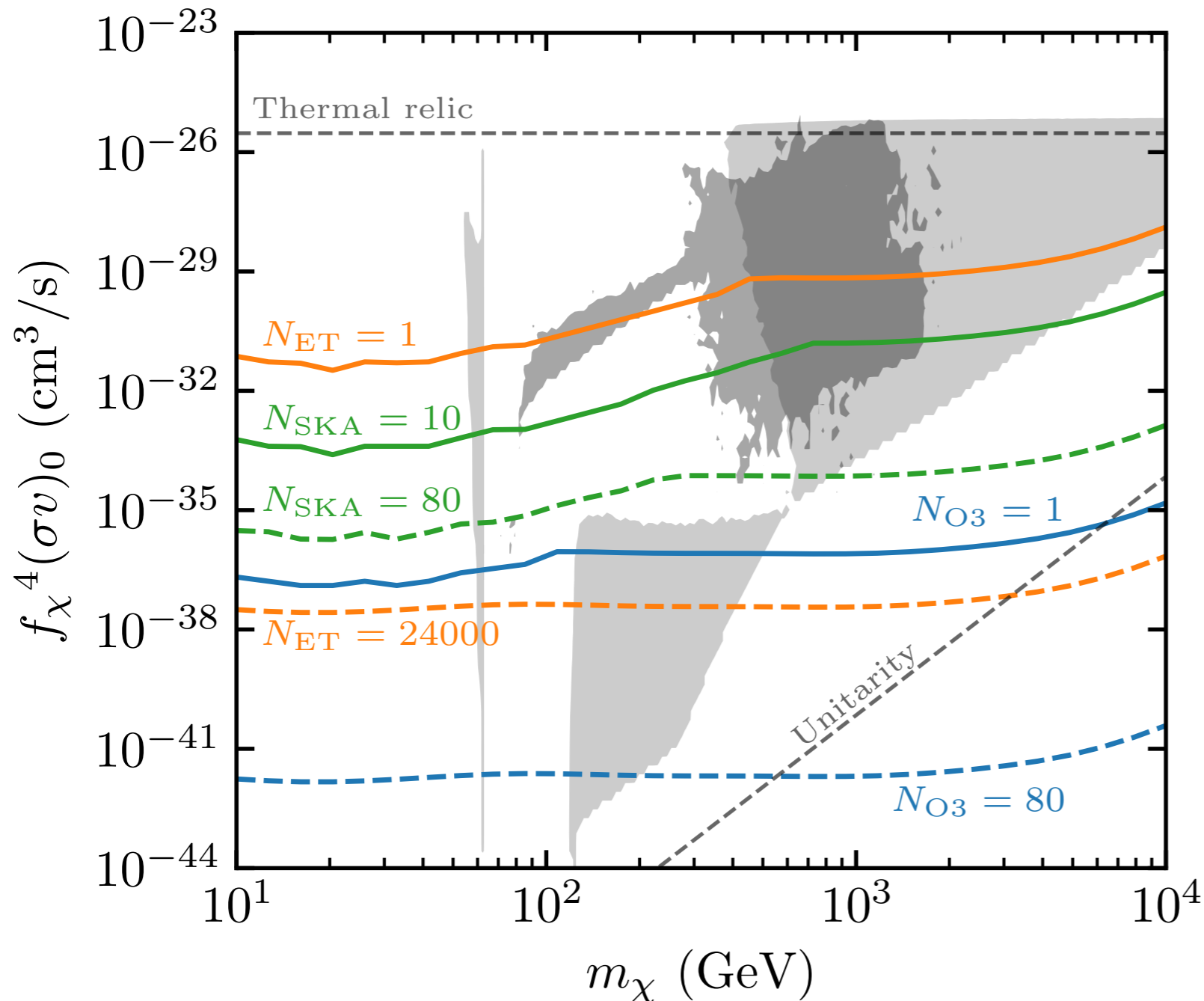
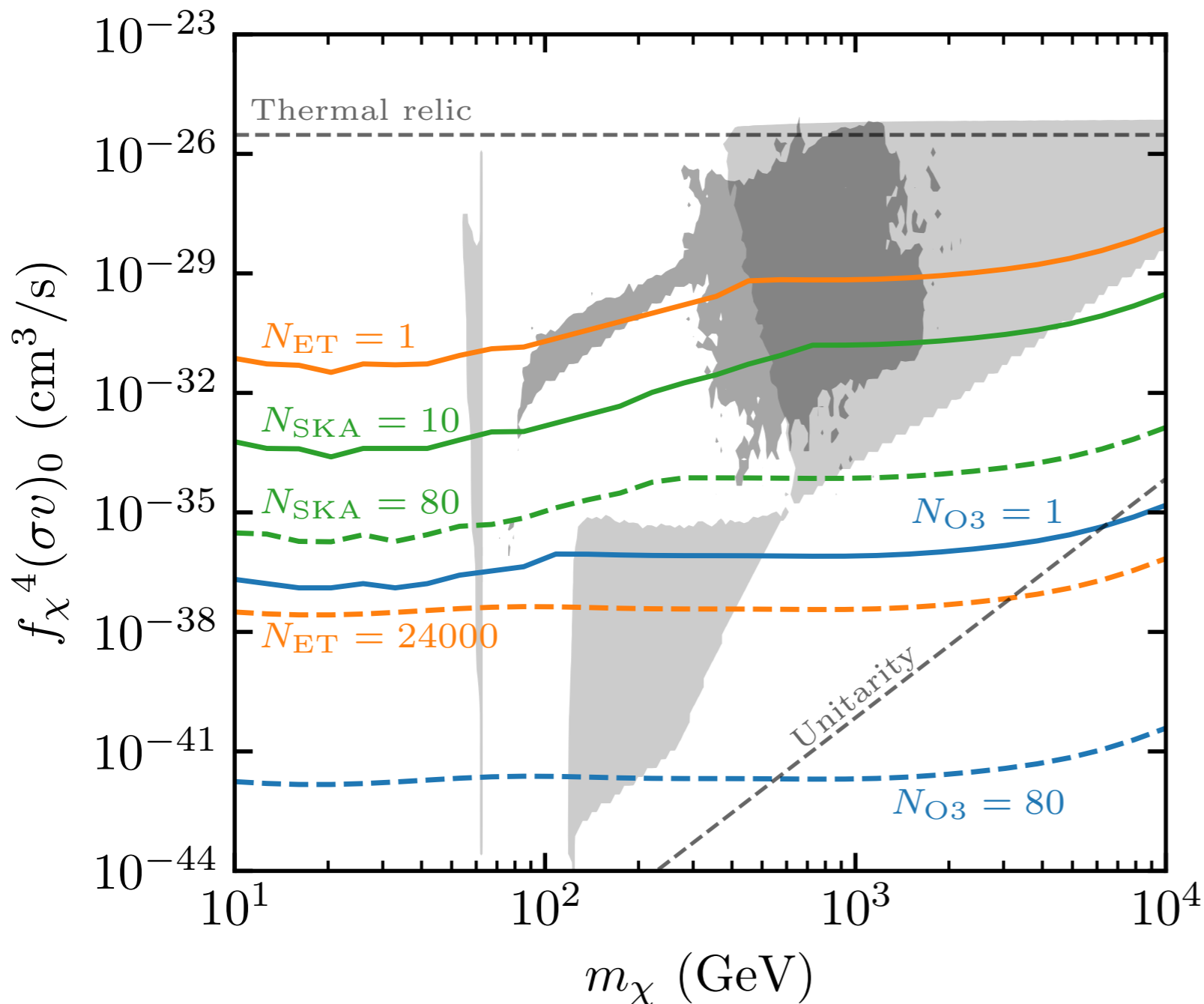# Conclusion

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Thank you!