Primordial Black Holes as Silver Bullets for WIMPS

arXiv:1905.01238

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GRAPPA

GRavitation AstroParticle Physics Amsterdam

Primordial black holes accumulate dark matter halos

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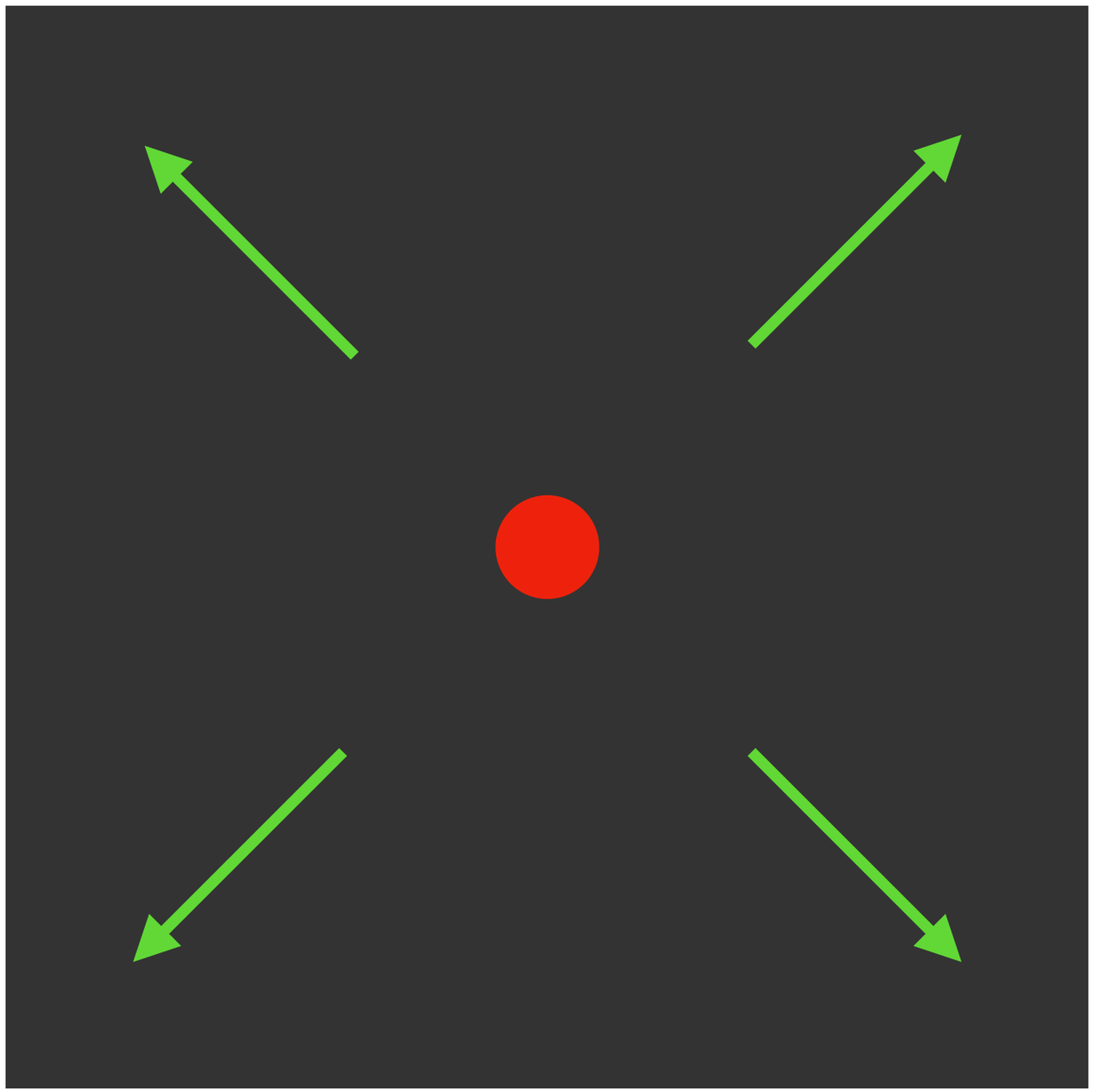
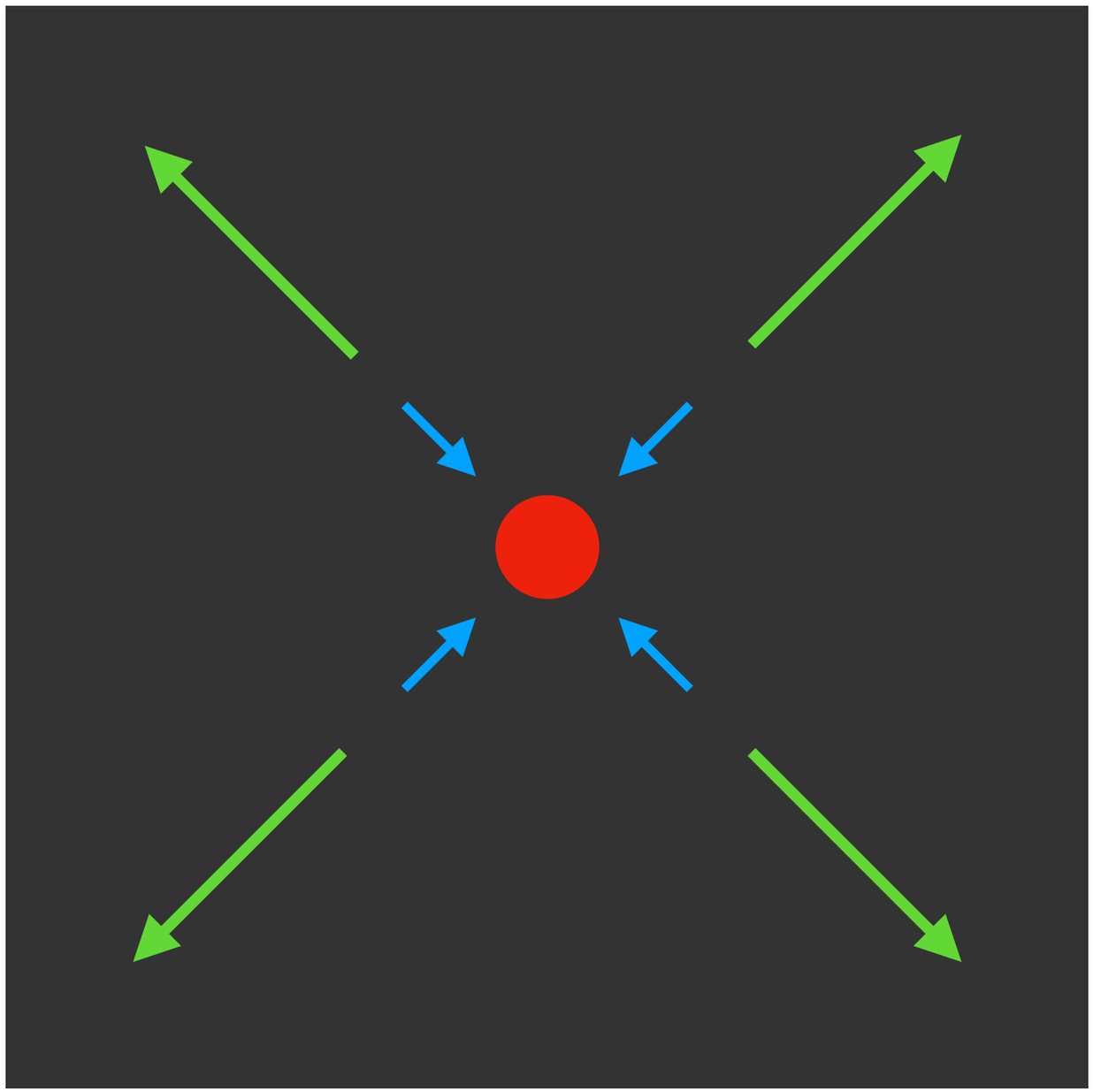


High redshift

Primordial black holes accumulate dark matter halos



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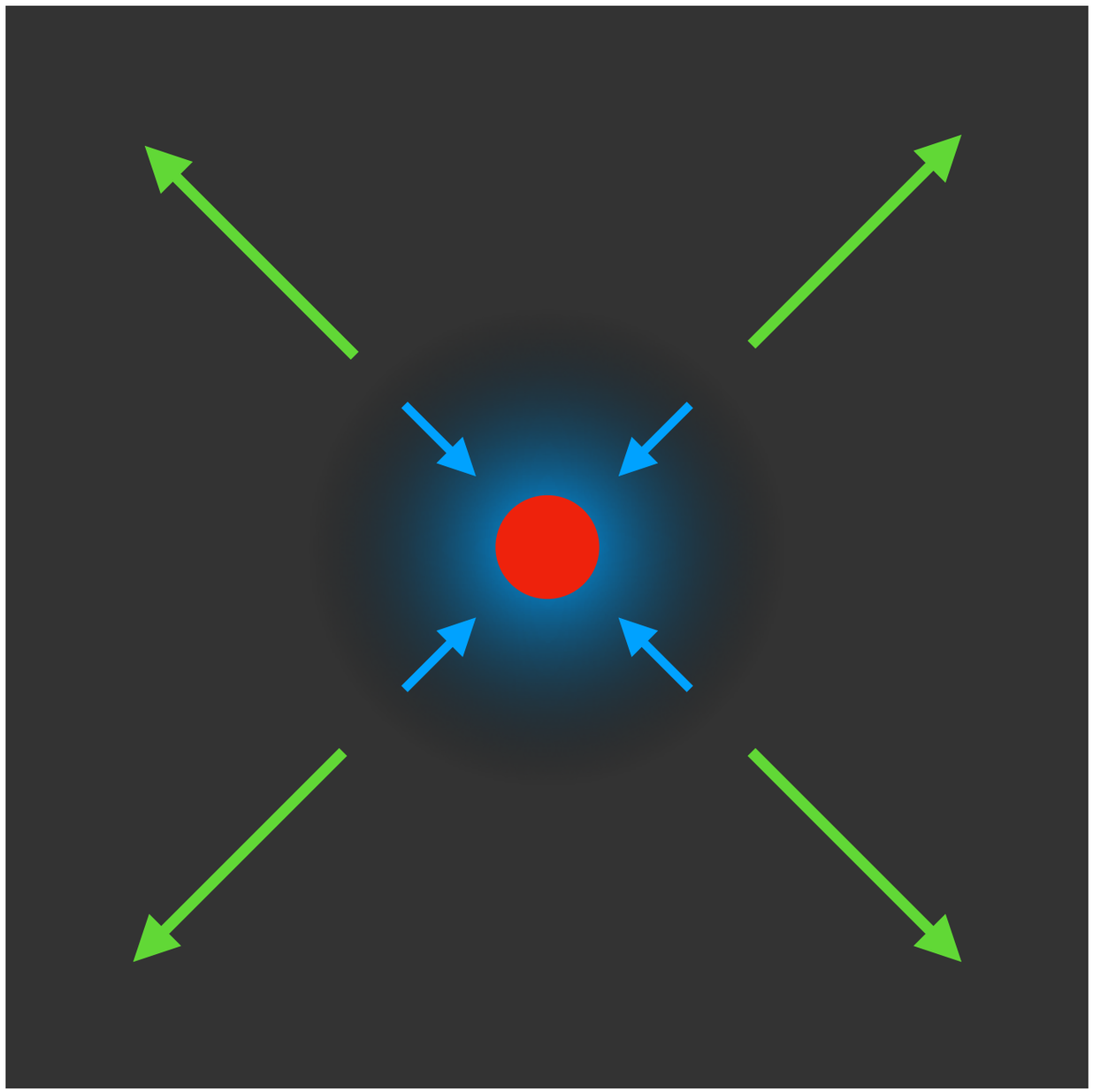

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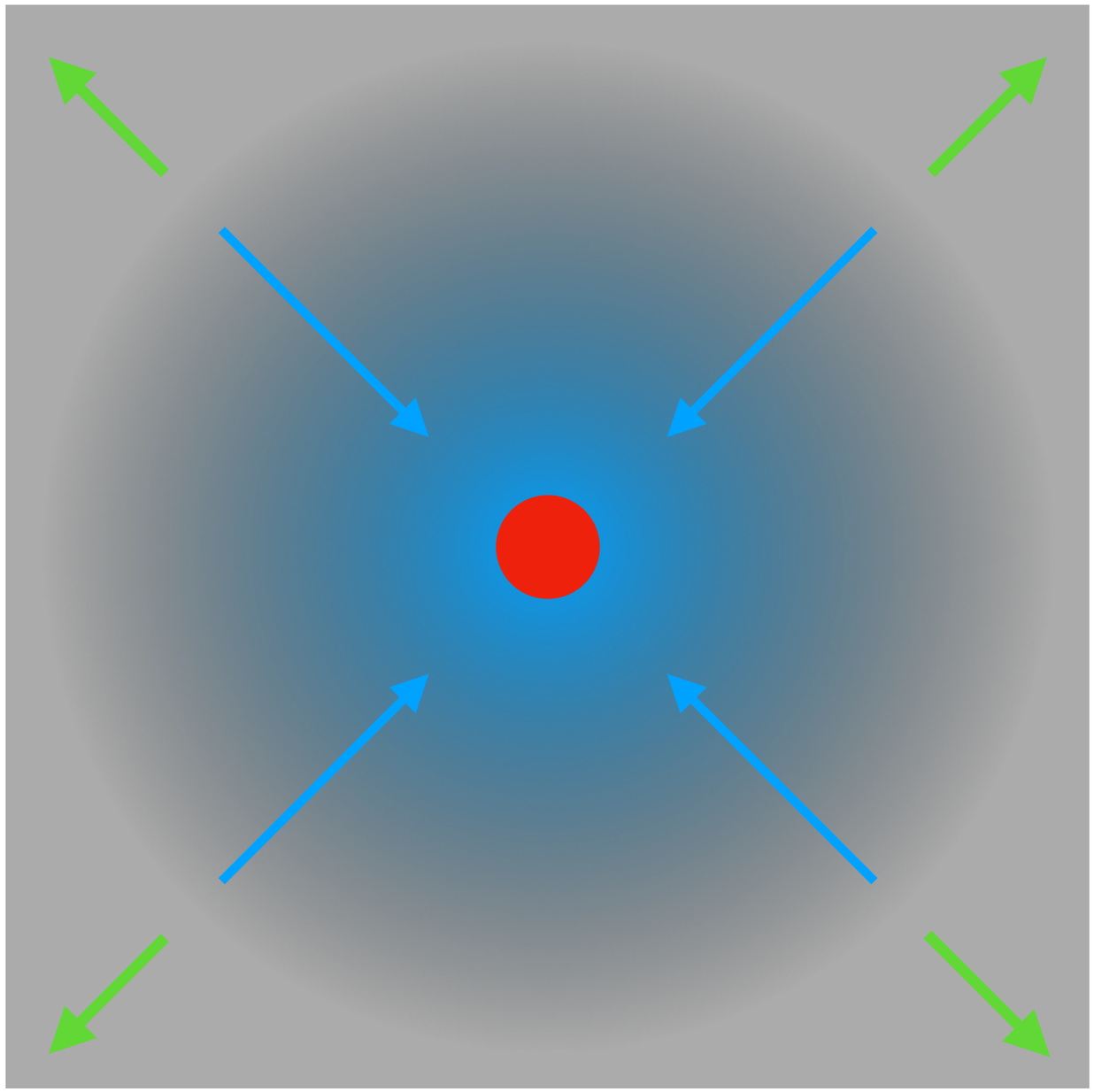
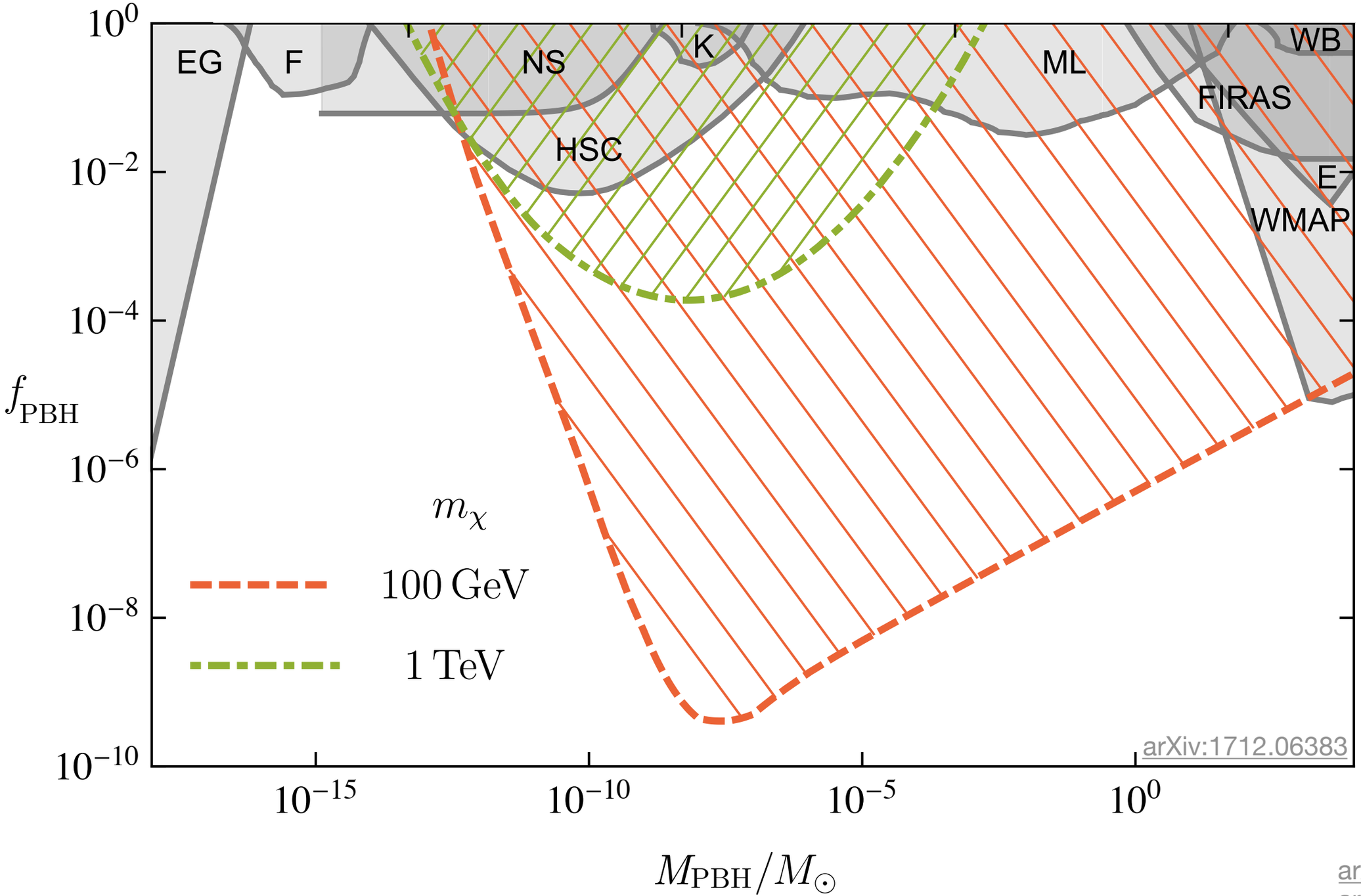


Low redshift

Thermal WIMP ⇒ PBH constraint



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}**

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

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$p(f_{PBH}|N_{PBH})$: depends on $\int dz\ (\text{merger rate}) \times (\text{sensitivity})$

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arXiv:1812.07967

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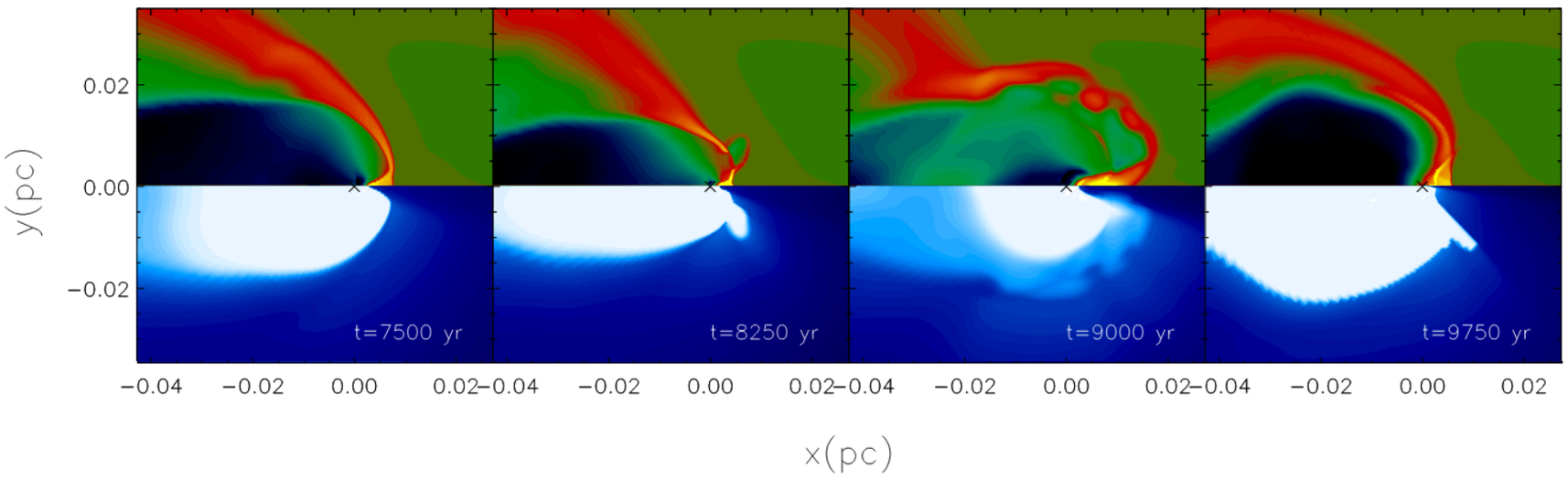

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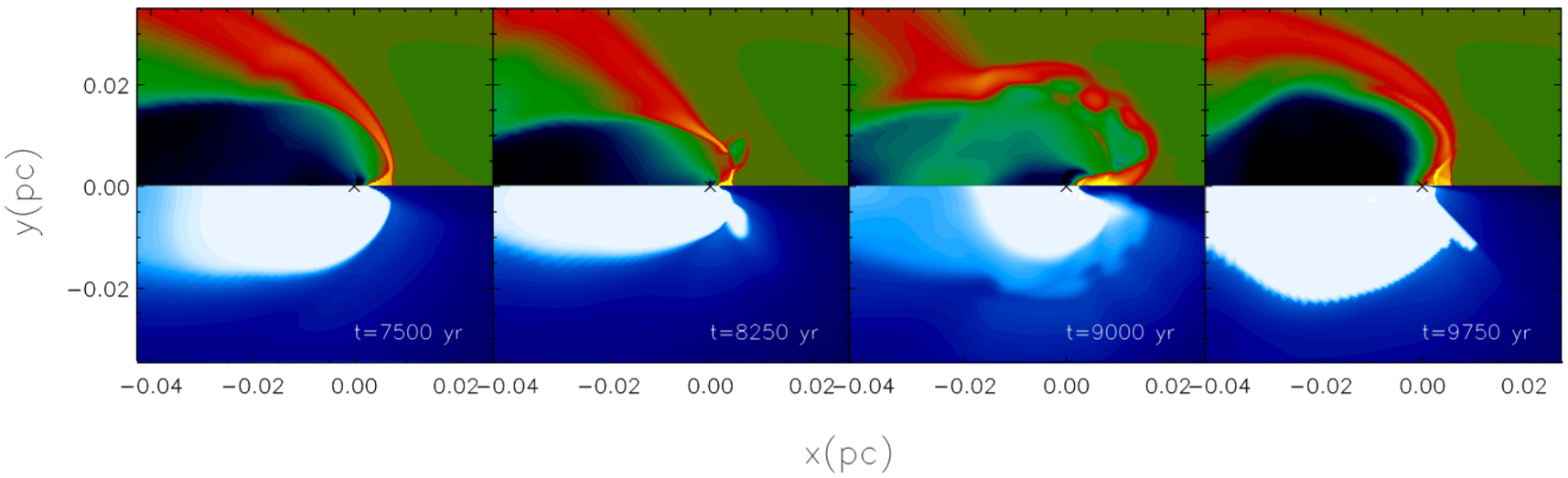
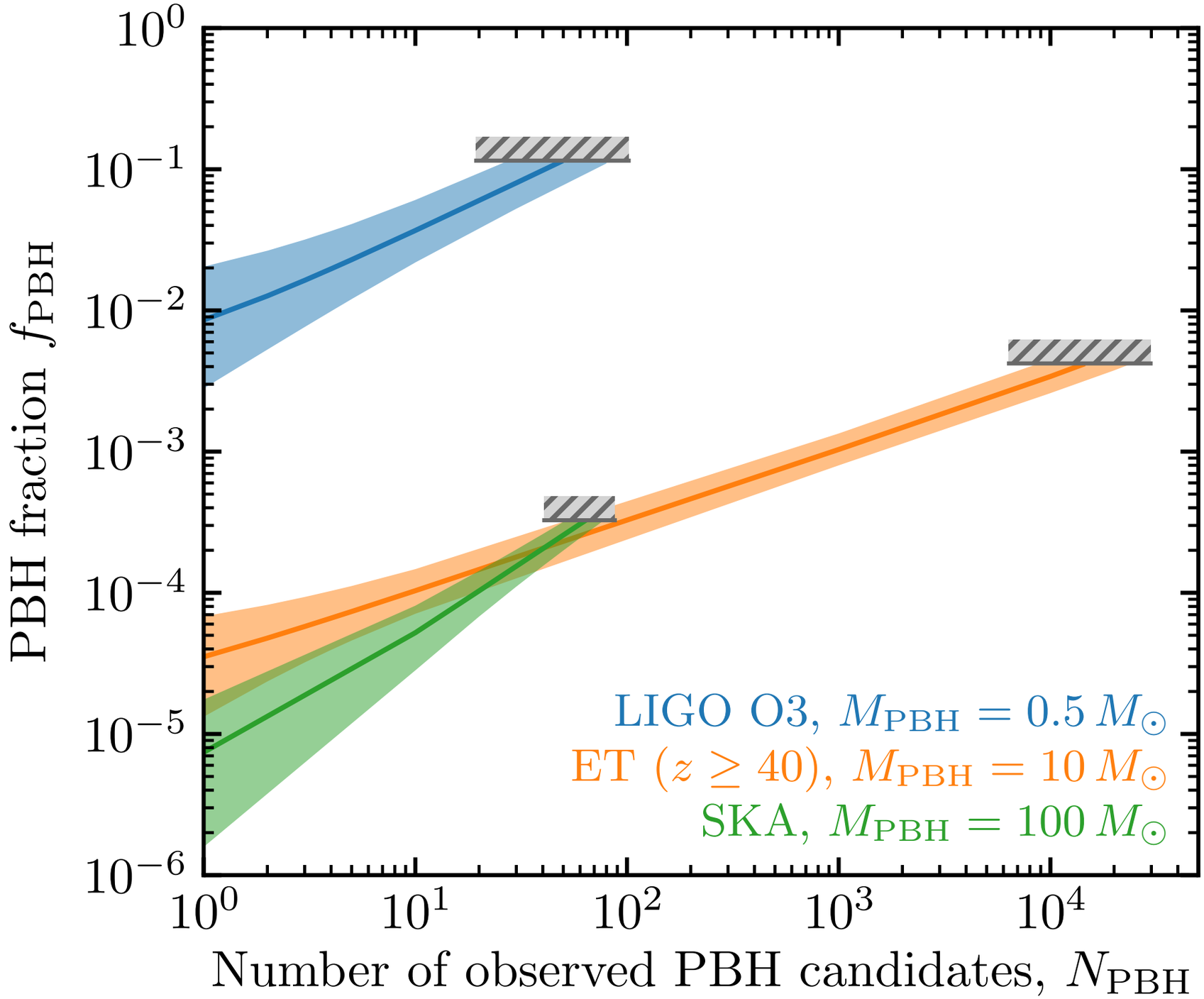


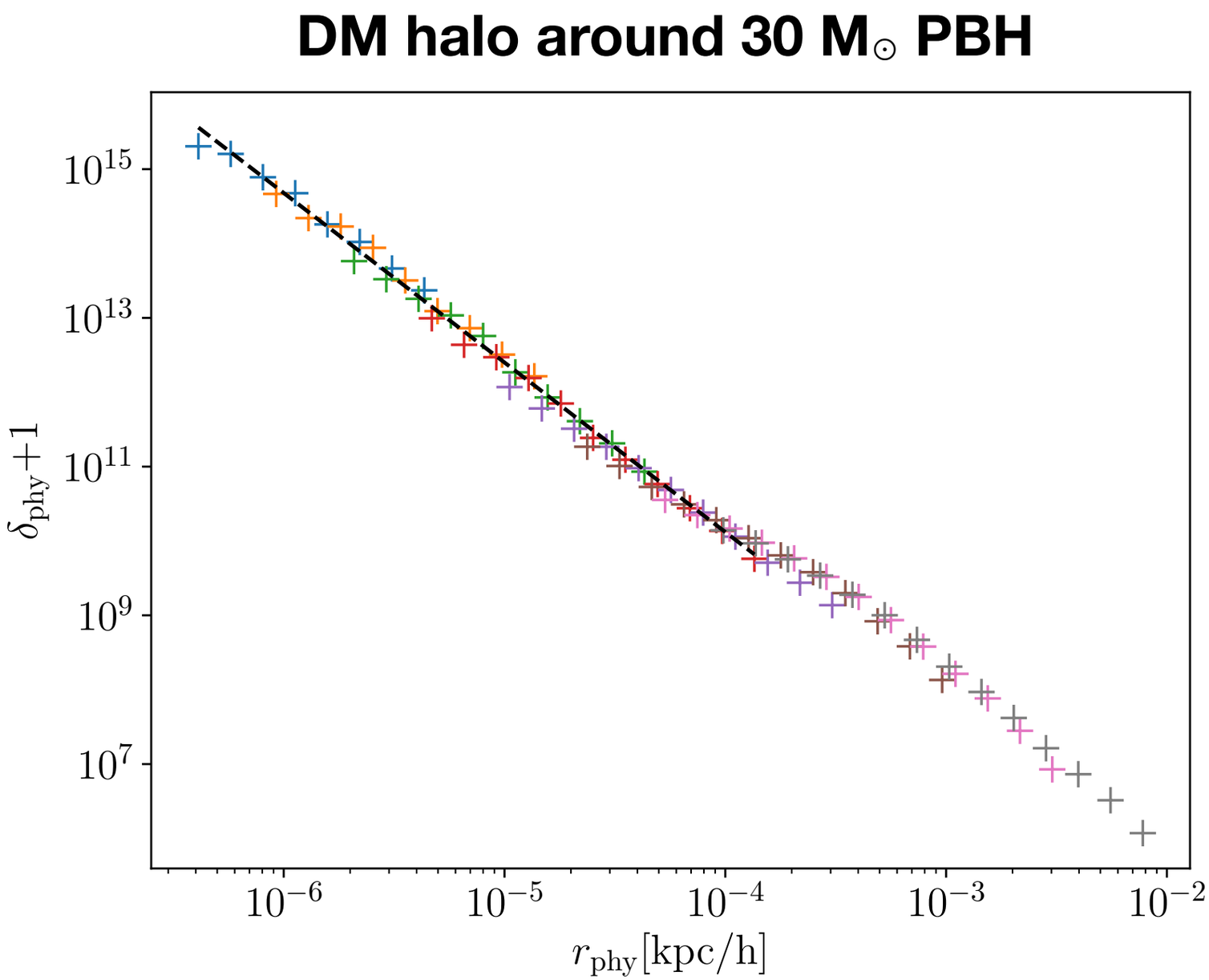
Compute $p(f_{PBH}|N_{PBH})$ with Monte Carlo simulation

arXiv:1812.07967

2. Detection → abundance



3. Ann. rate around PBH



arXiv:1901.08528

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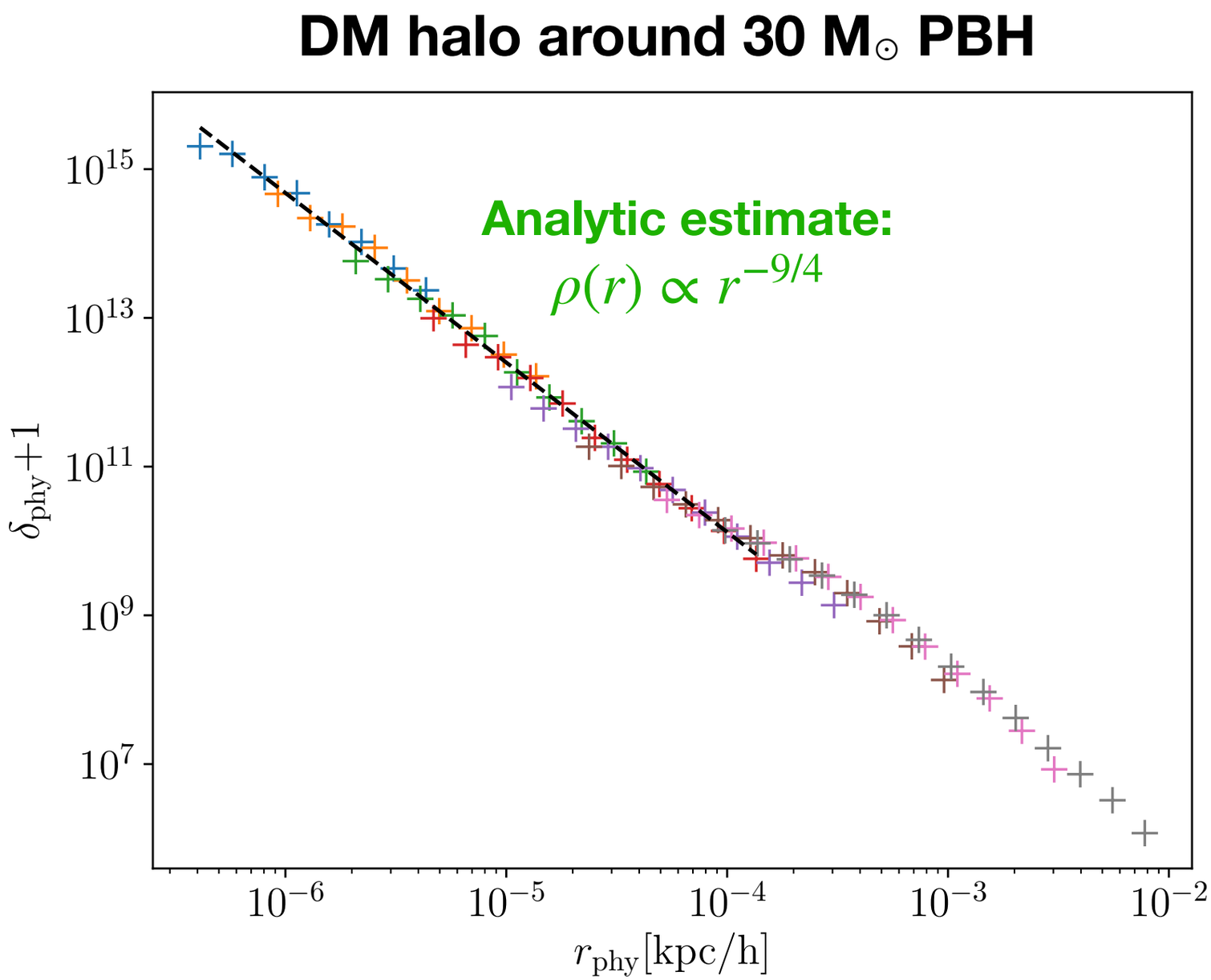

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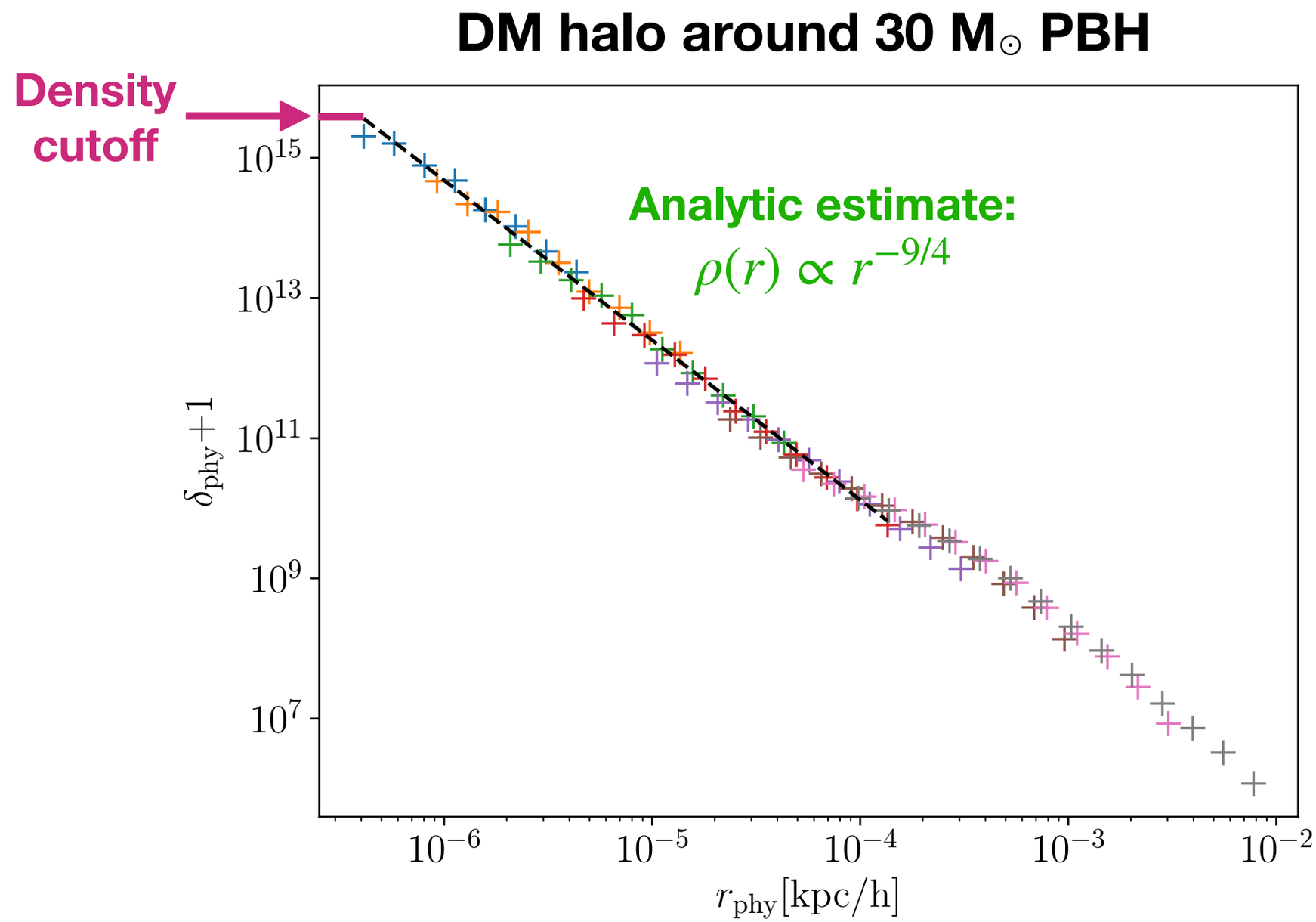

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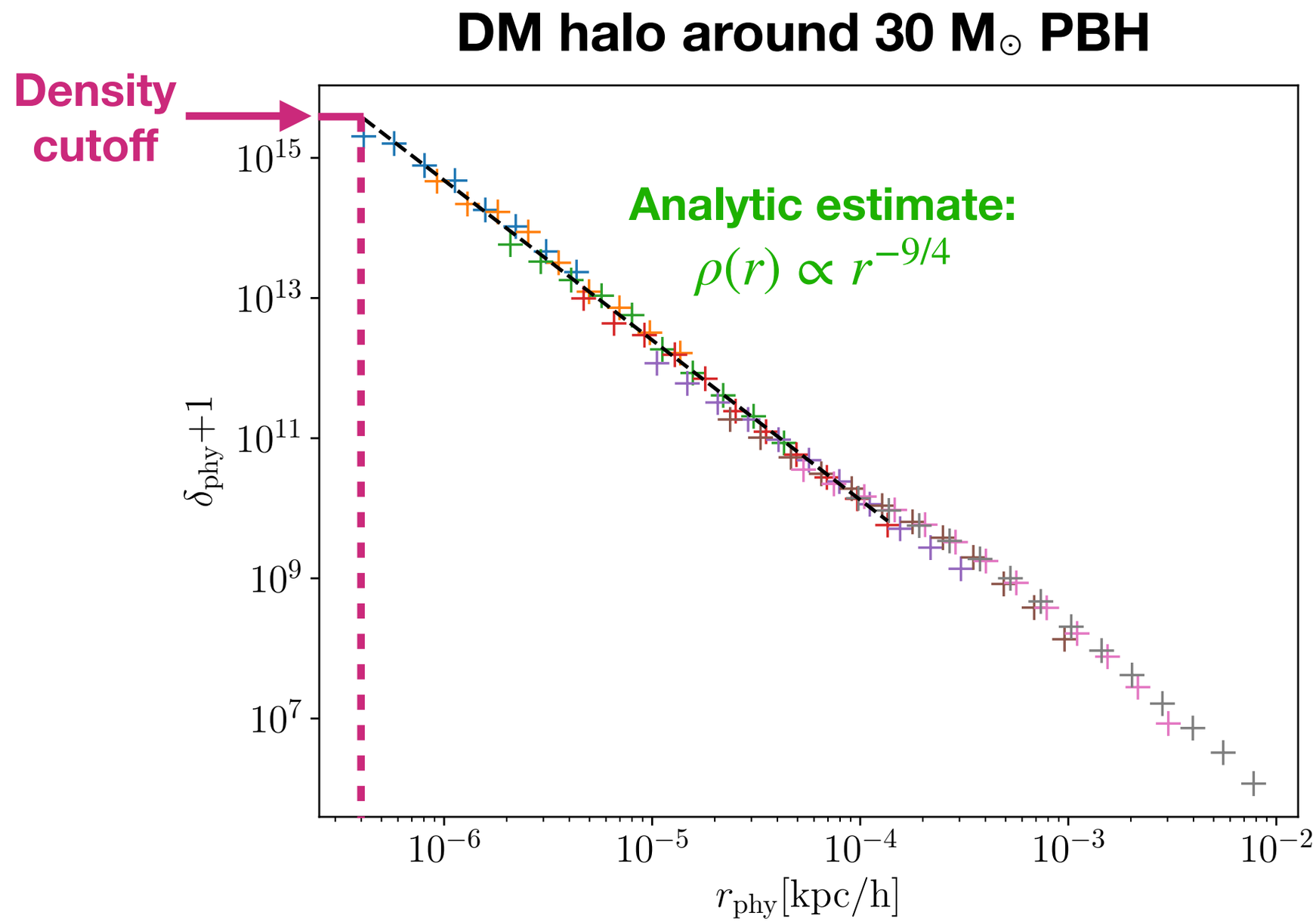

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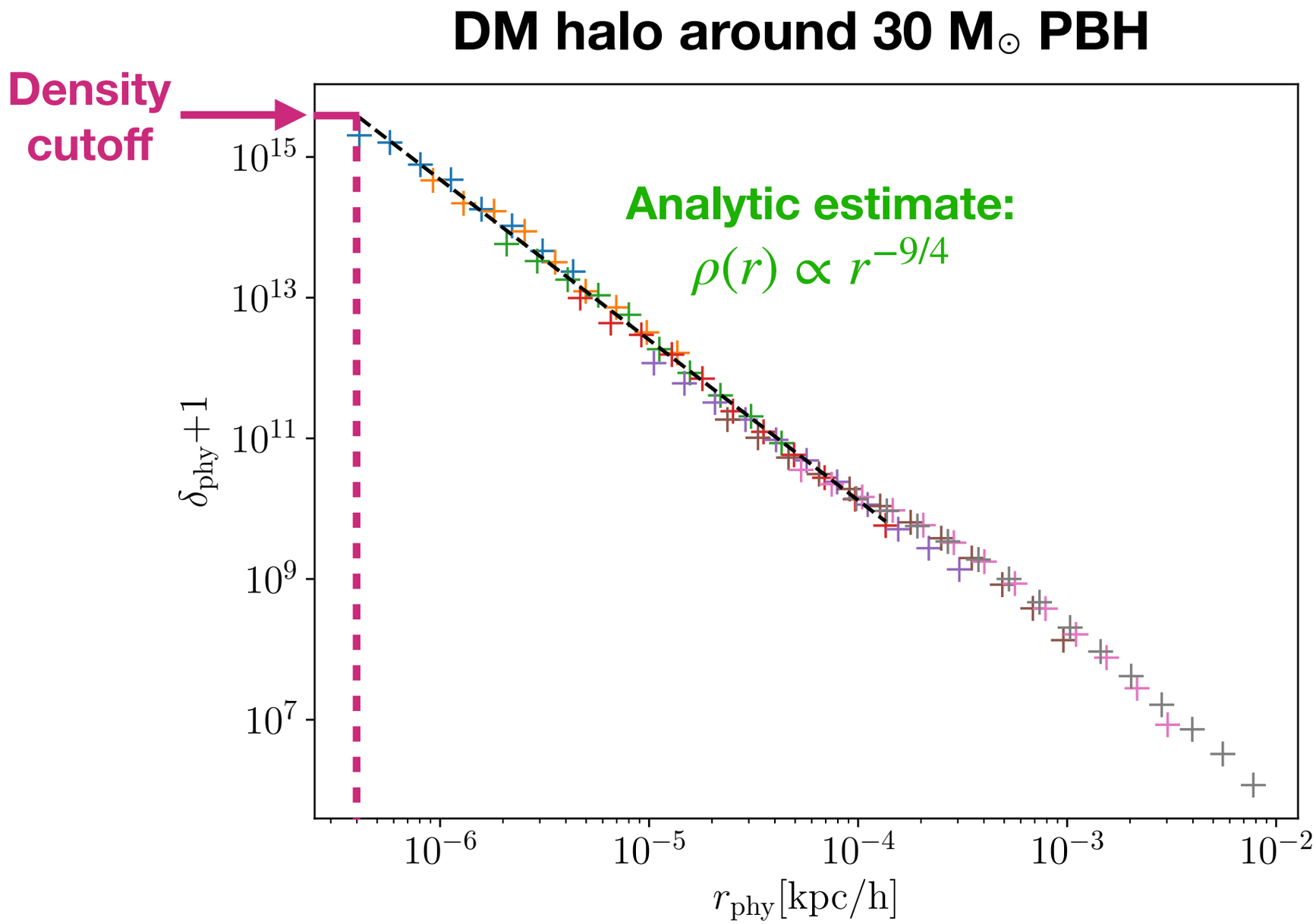

Stellar/tidal disruptions?
Negligible!

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3. Point source γ-ray limits

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

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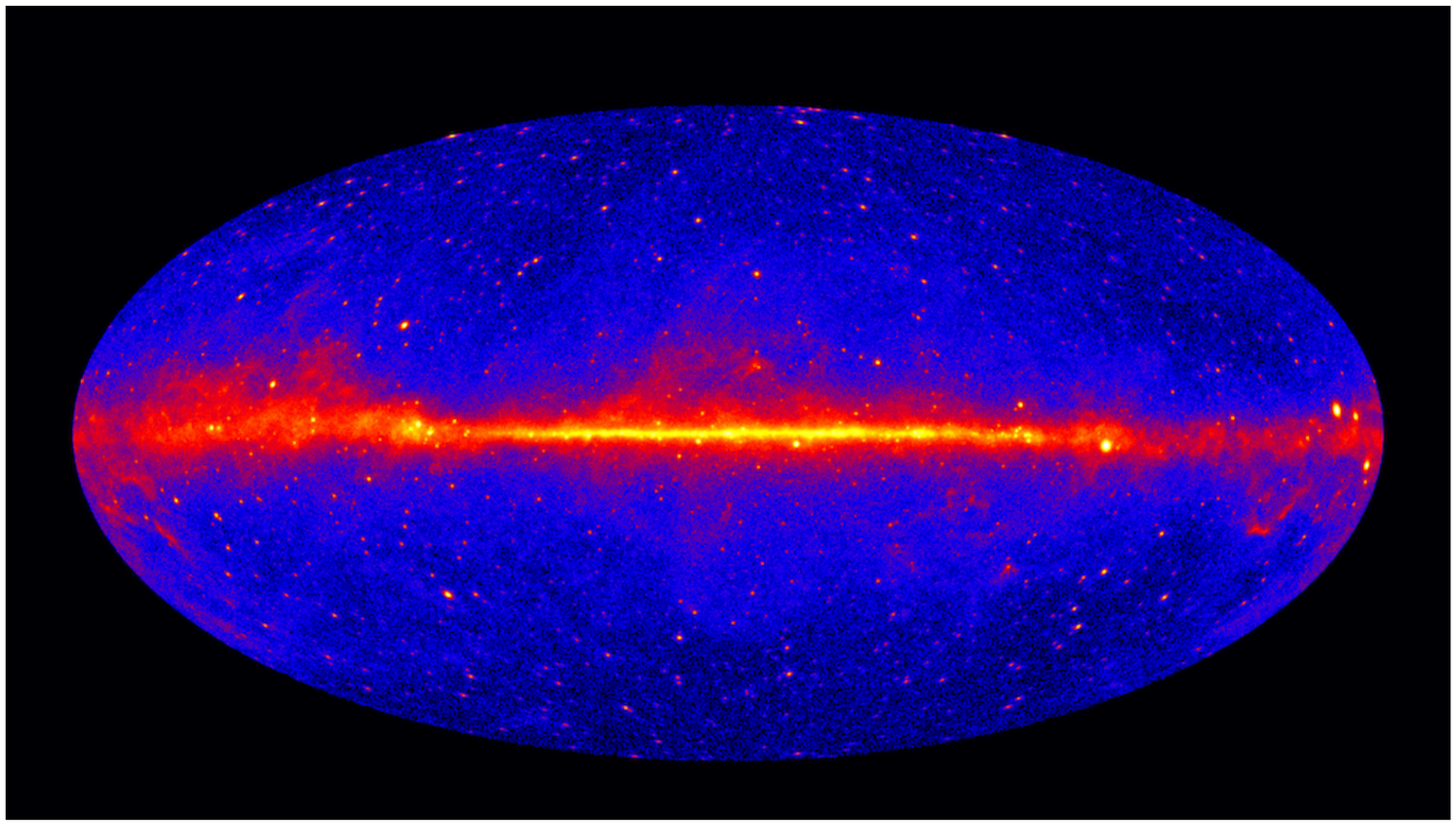

Fermi/NASA

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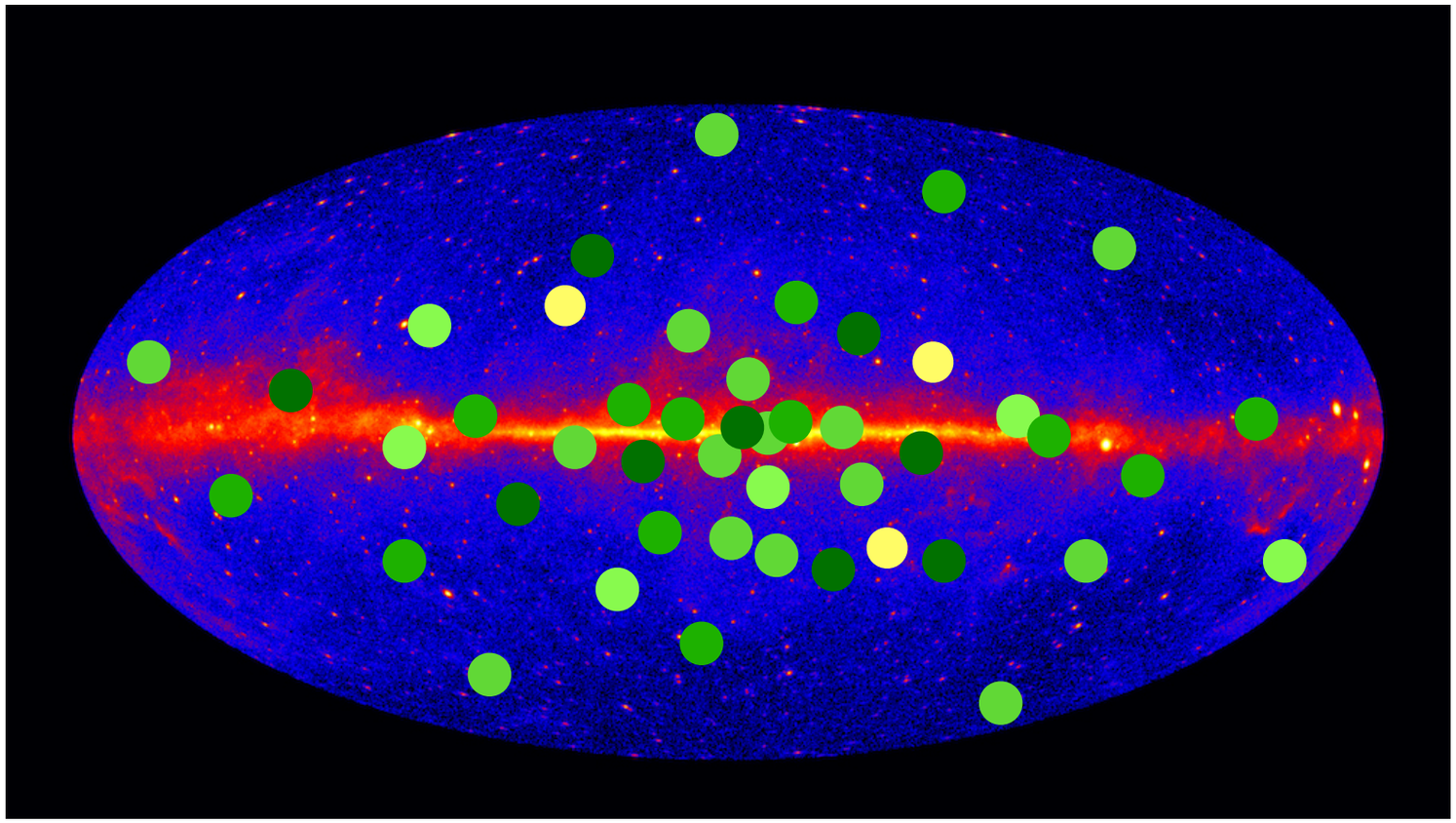

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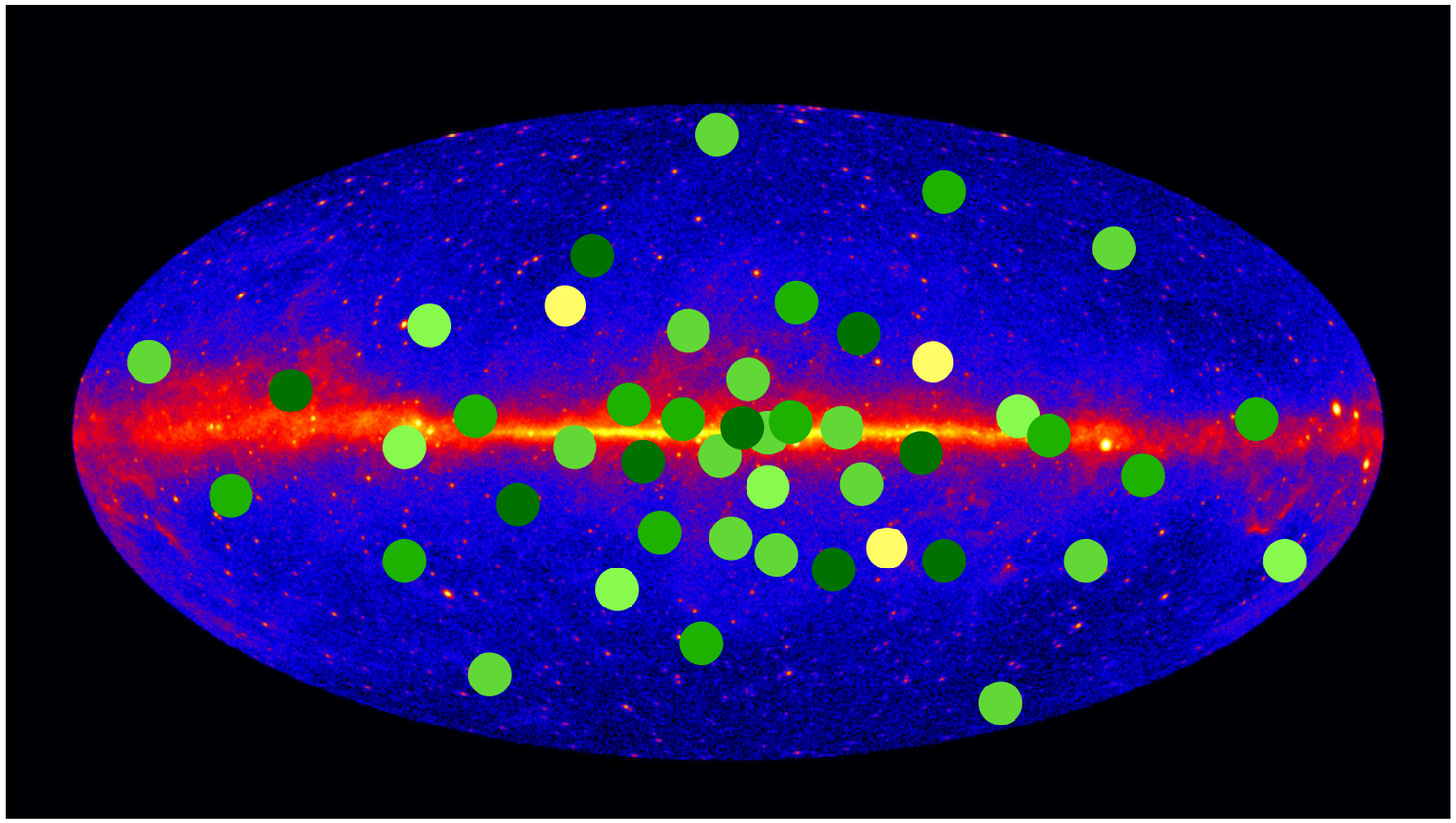

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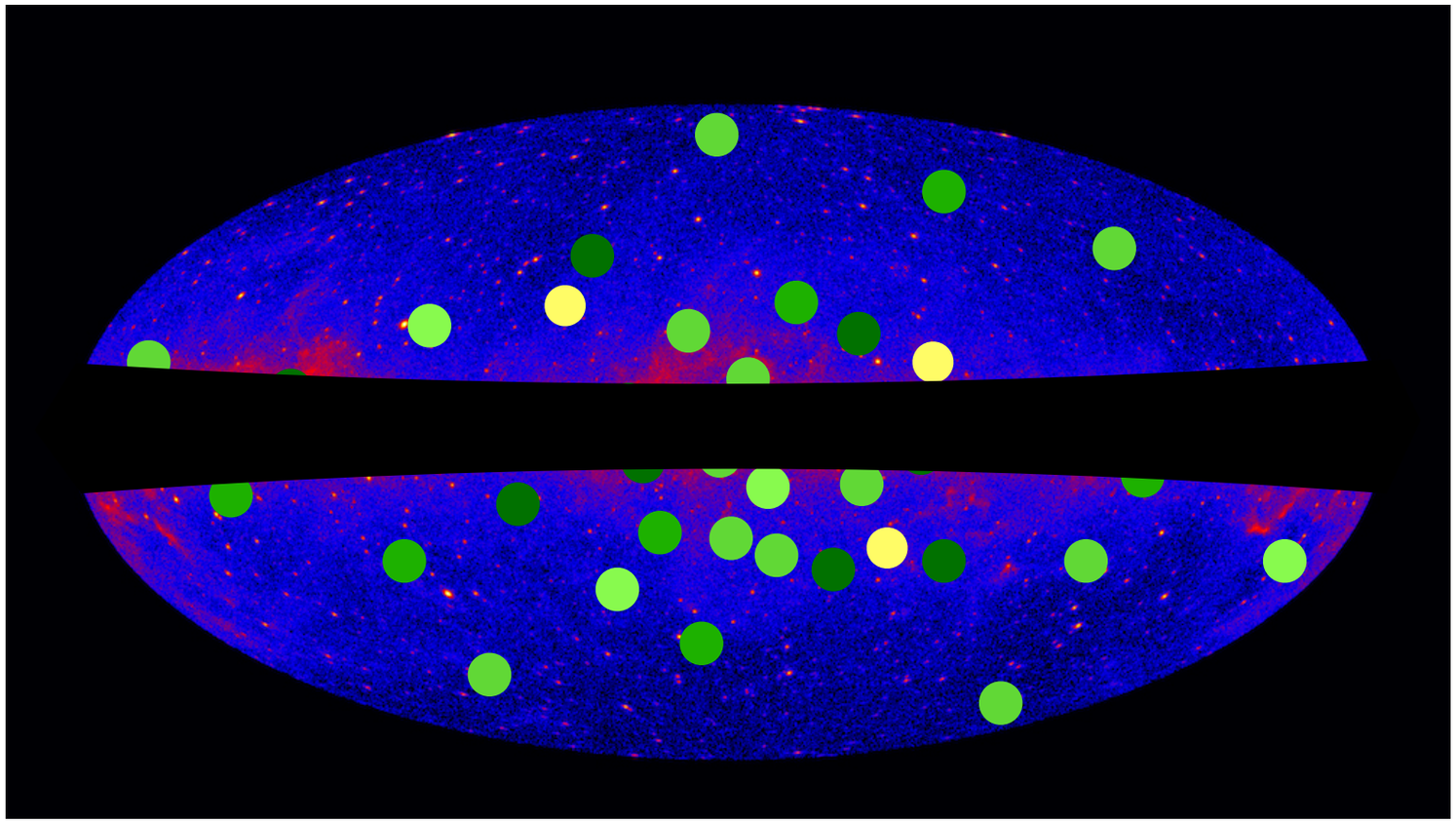

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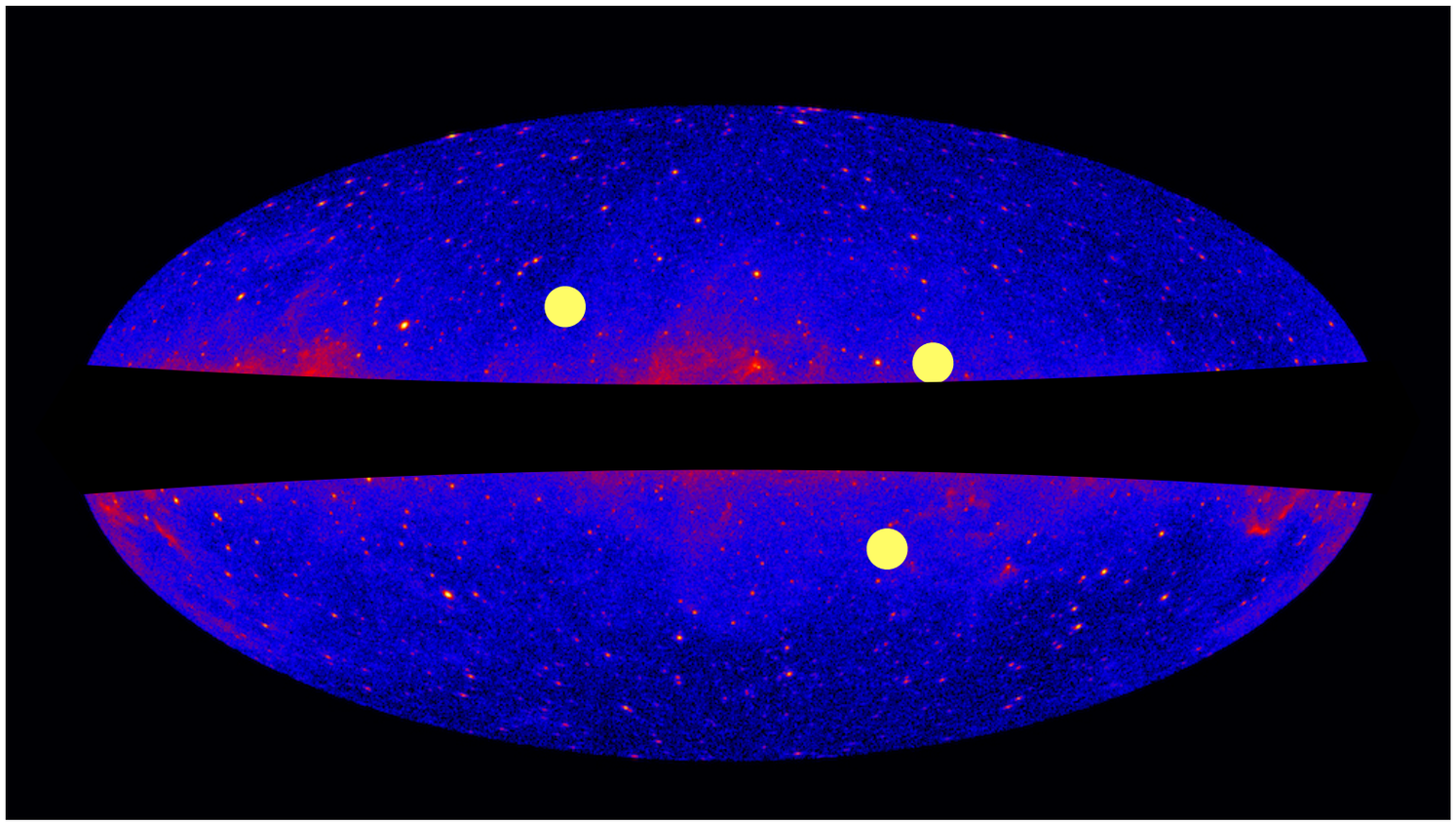

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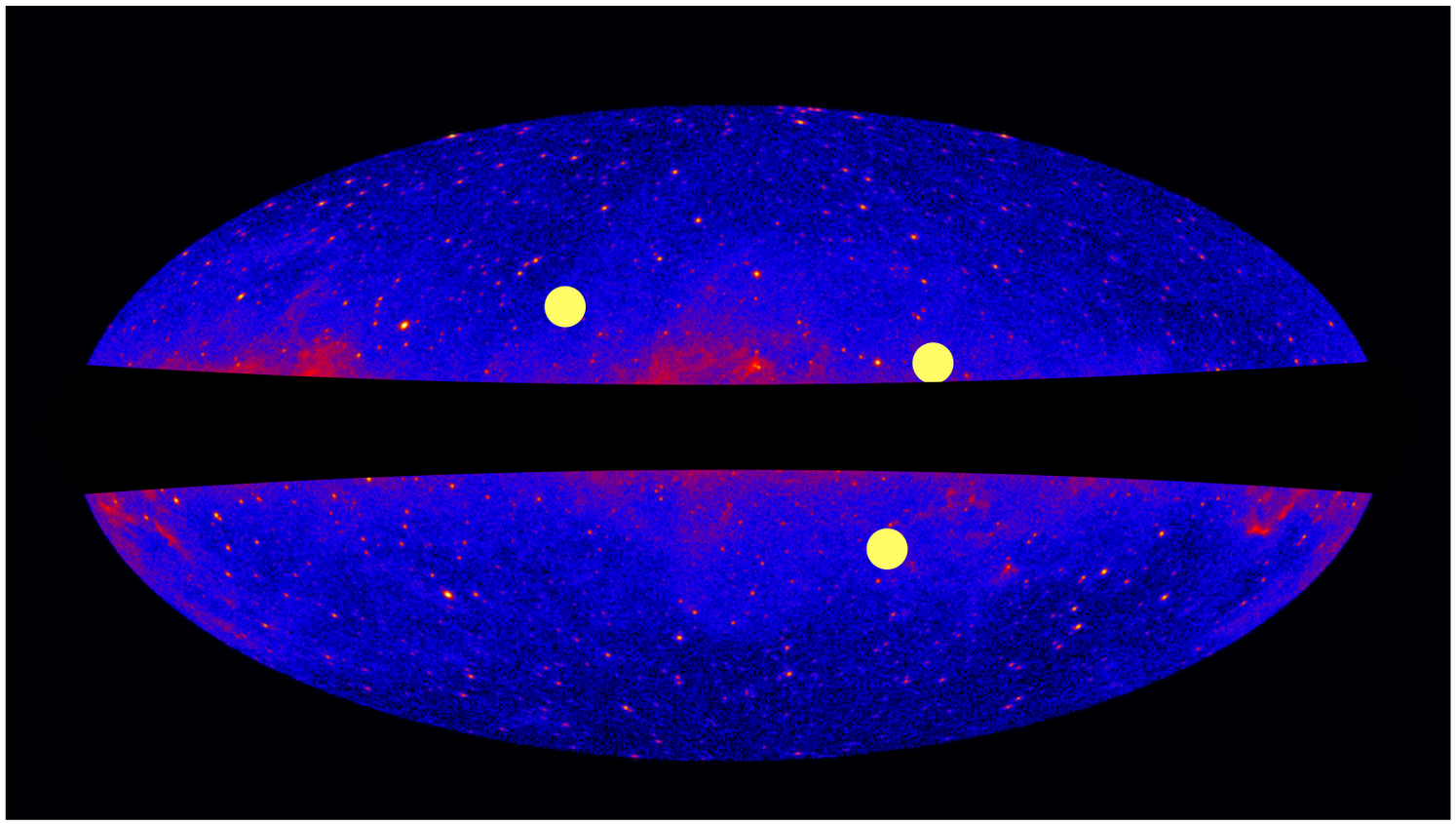

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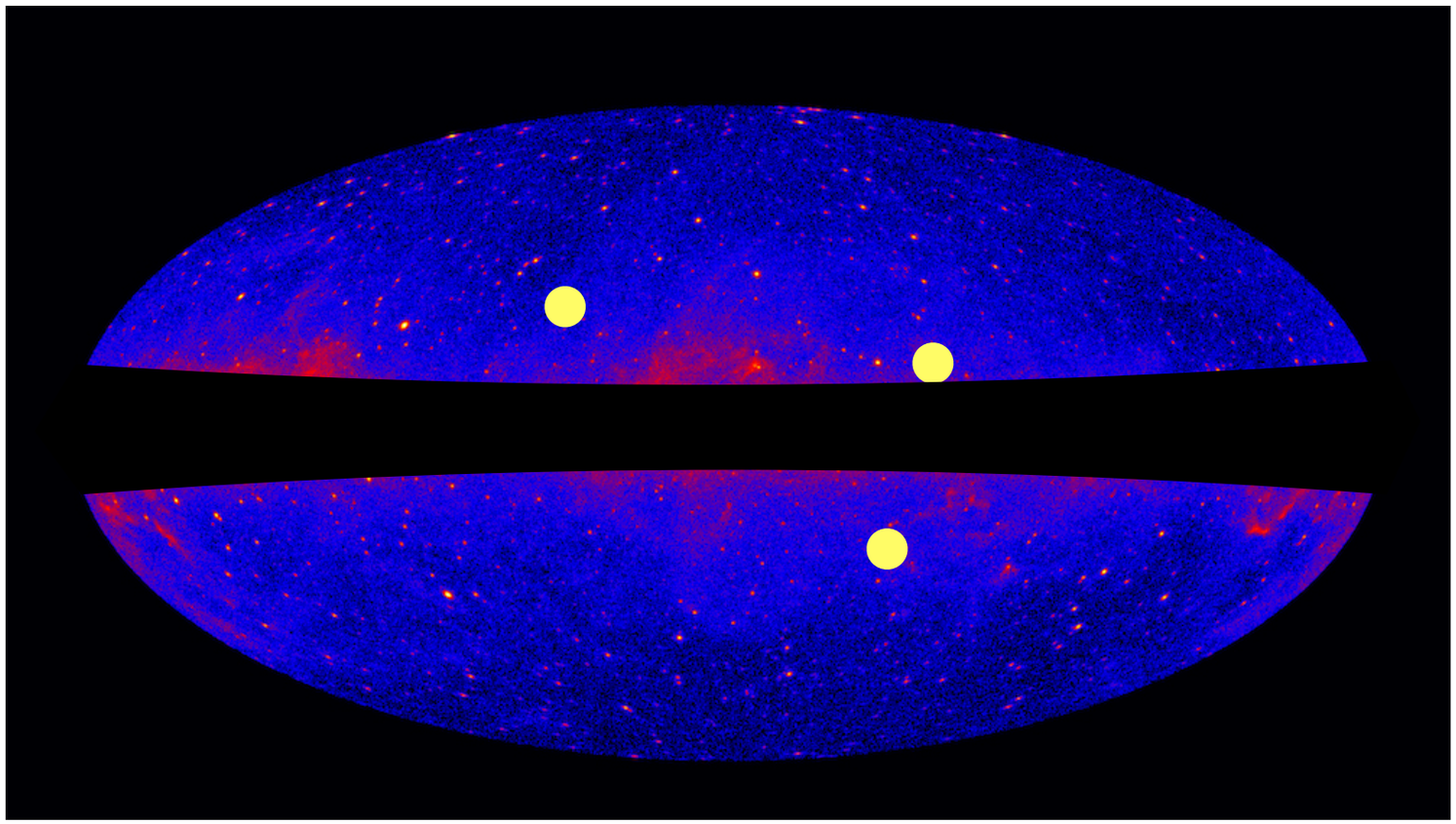

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Number of 3FGL unassociated sources compatible with DM annihilation

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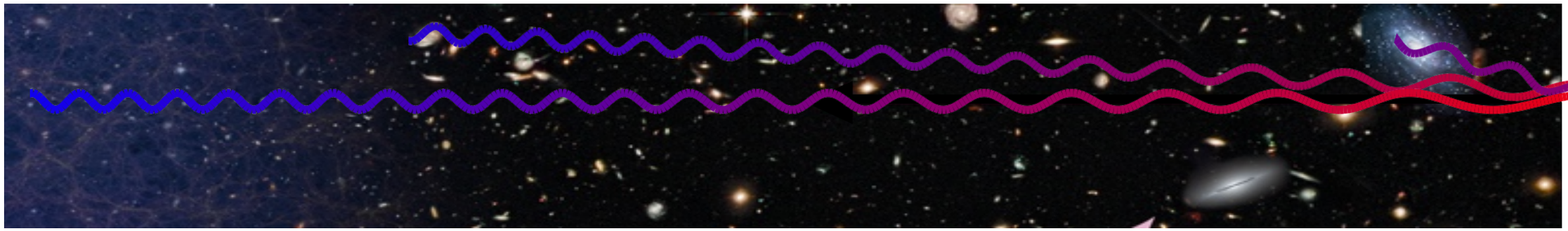

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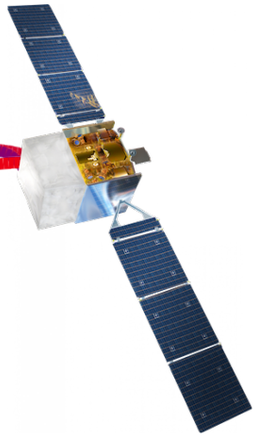

NASA

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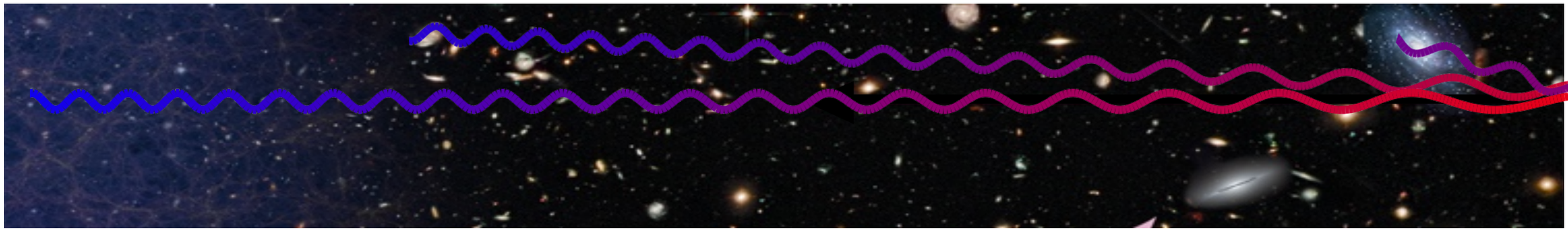

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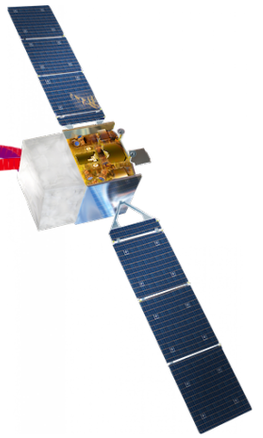

NASA

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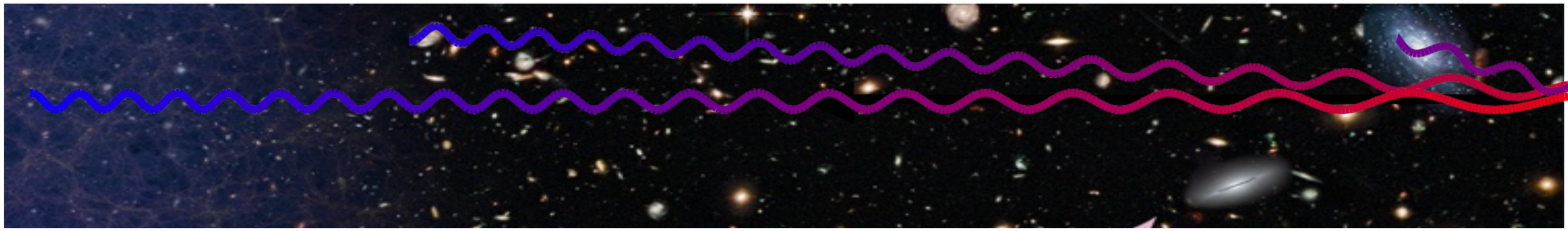

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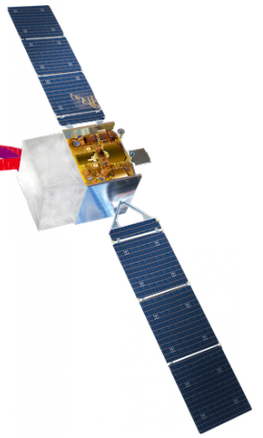

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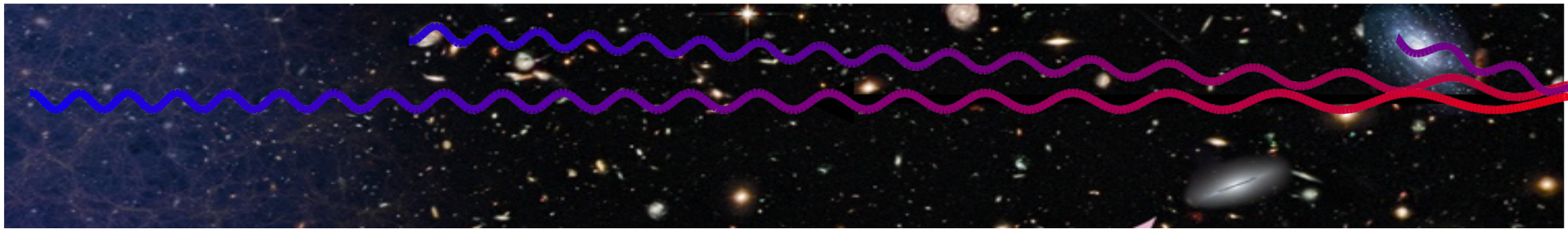

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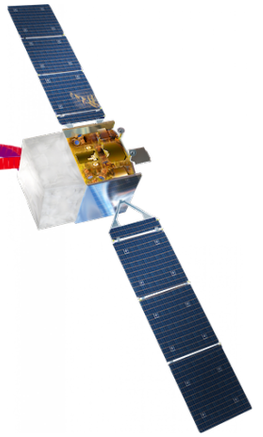

NASA

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Ann. rate in PBH halo

Cosmological PBH density

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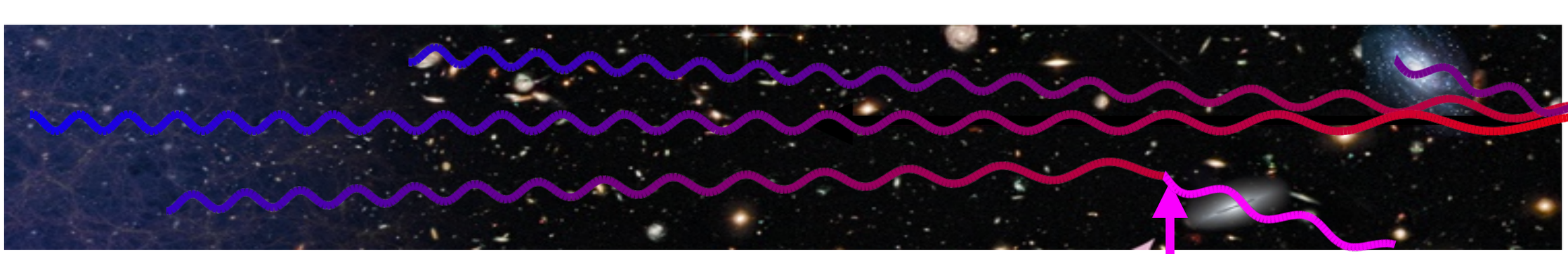

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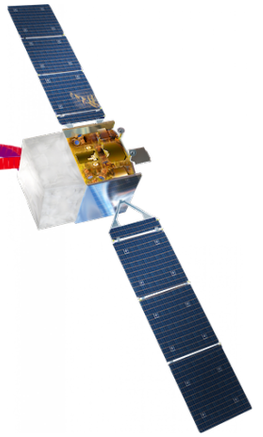

NASA

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Cosmological PBH density

Attenuation

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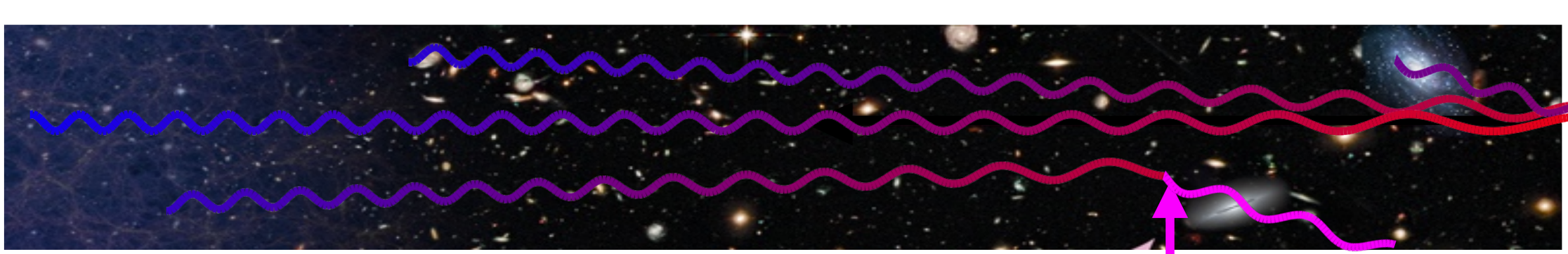

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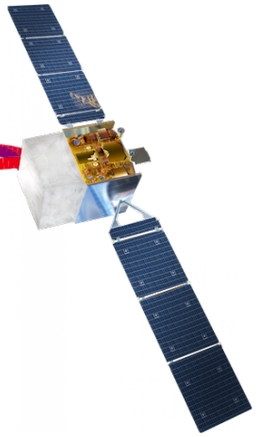

NASA

Ingredients:

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Redshifting

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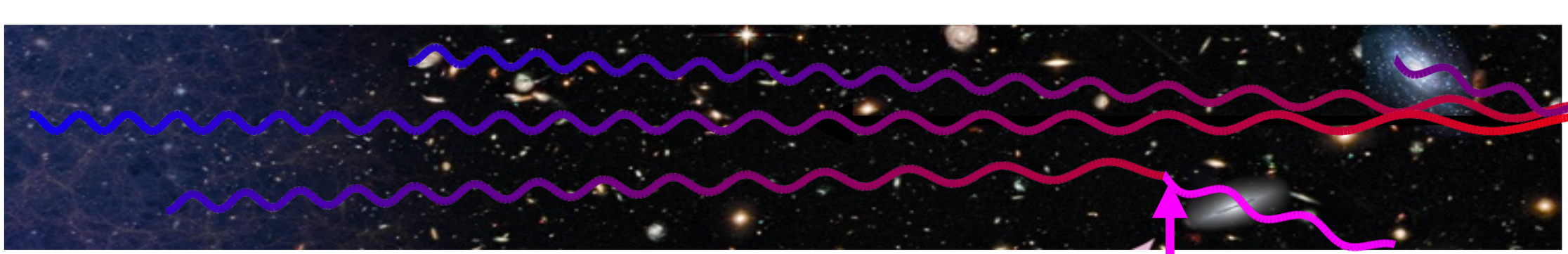

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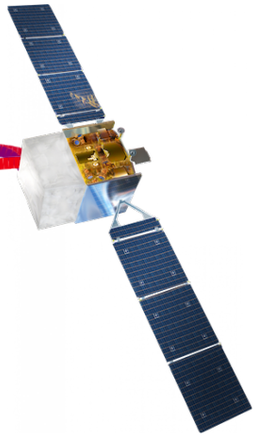

NASA

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

Limit: for each bin, require $\phi^{\rm ex} \lesssim \phi^{\rm ex}_{\rm Fermi} + 3\,\Delta\phi^{\rm ex}_{\rm Fermi}$

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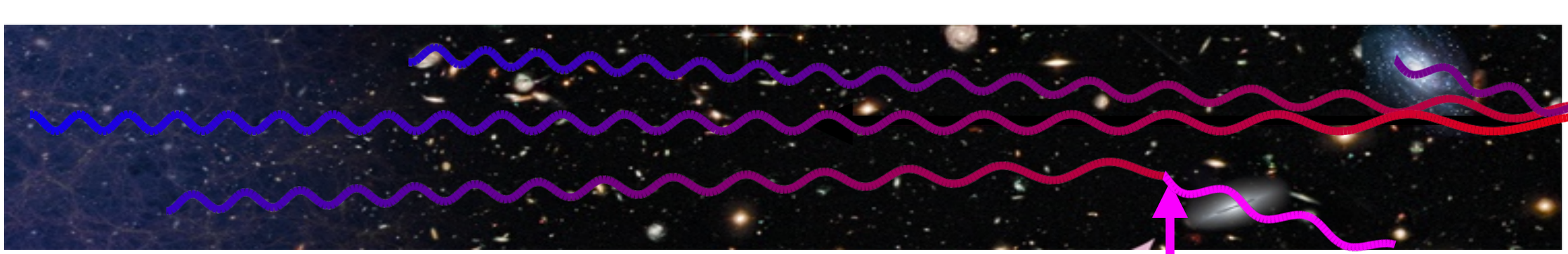

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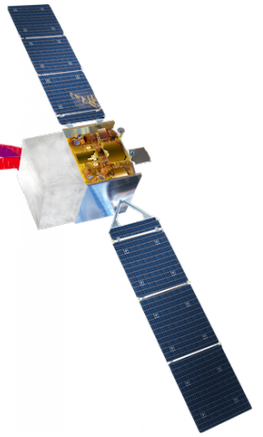

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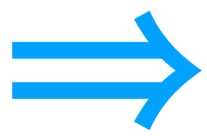
Robust constraint with few assumptions

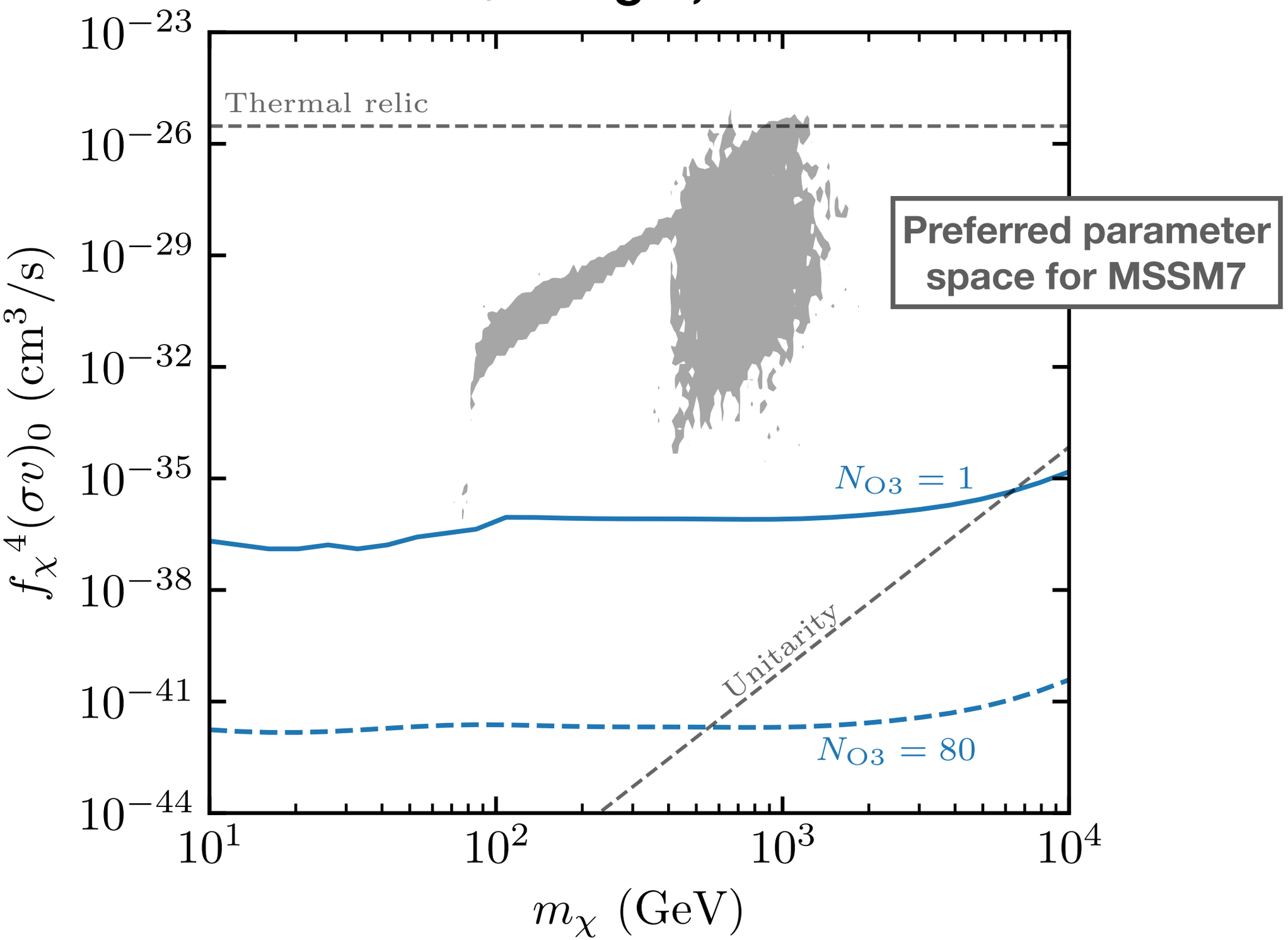
PBH

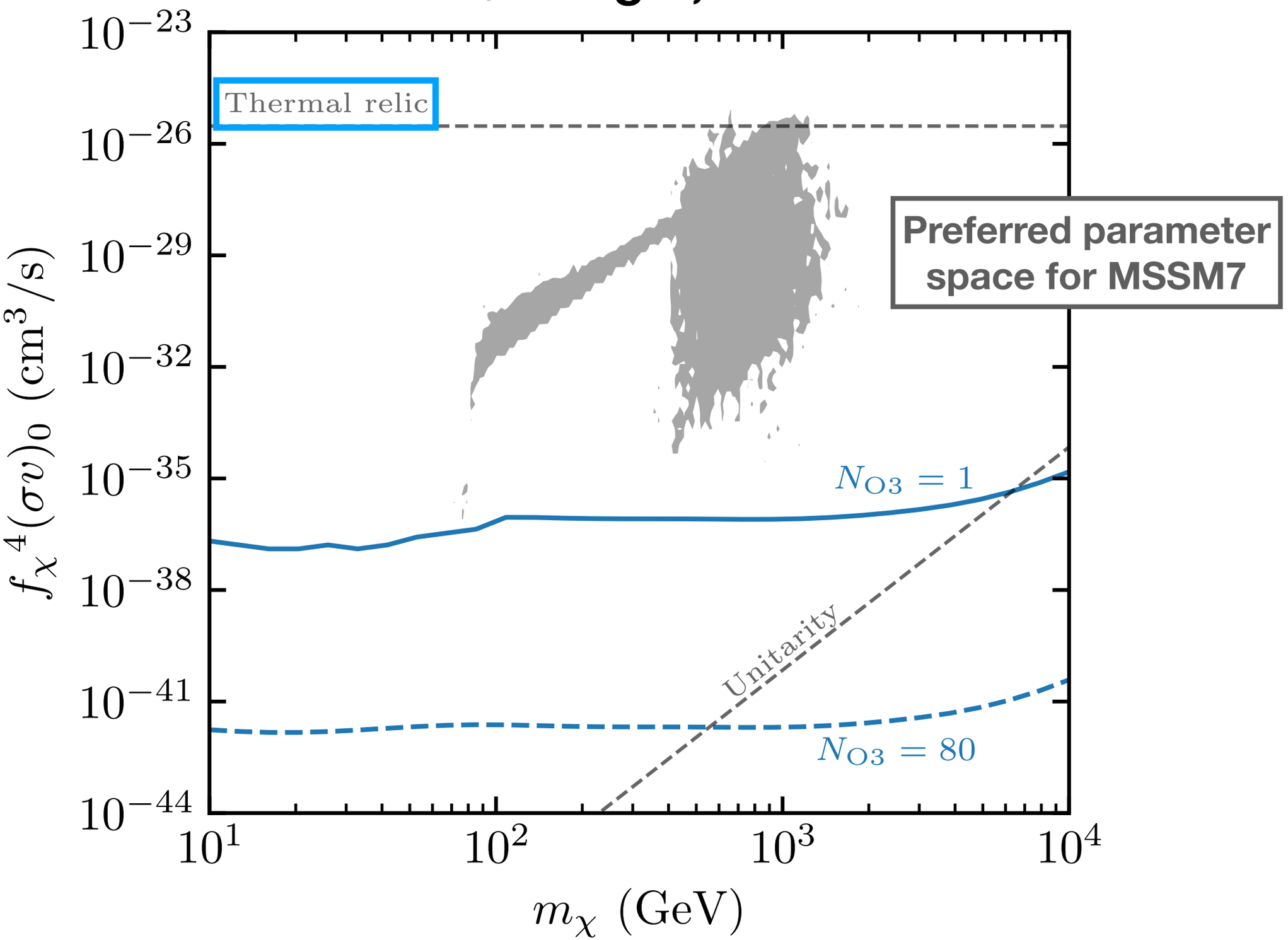
detection



WIMP

constraint


0.5 M⊙ merger, LIGO O3
Thermal relic
Preferred parameter space for MSSM7
$N_{O3} = 1$
Unitarity
$N_{O3} = 80$
10^{-23}
10^{-26}
10^{-29}
10^{-32}
10^{-35}
10^{-38}
10^{-41}
10^{-44}
10^{1}
10^{2}
10^{3}
10^{4}
$f_\chi{}^4 (\sigma v)_0 \ (\mathrm{cm}^3/\mathrm{s})$
m_χ (GeV)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10^{-29}
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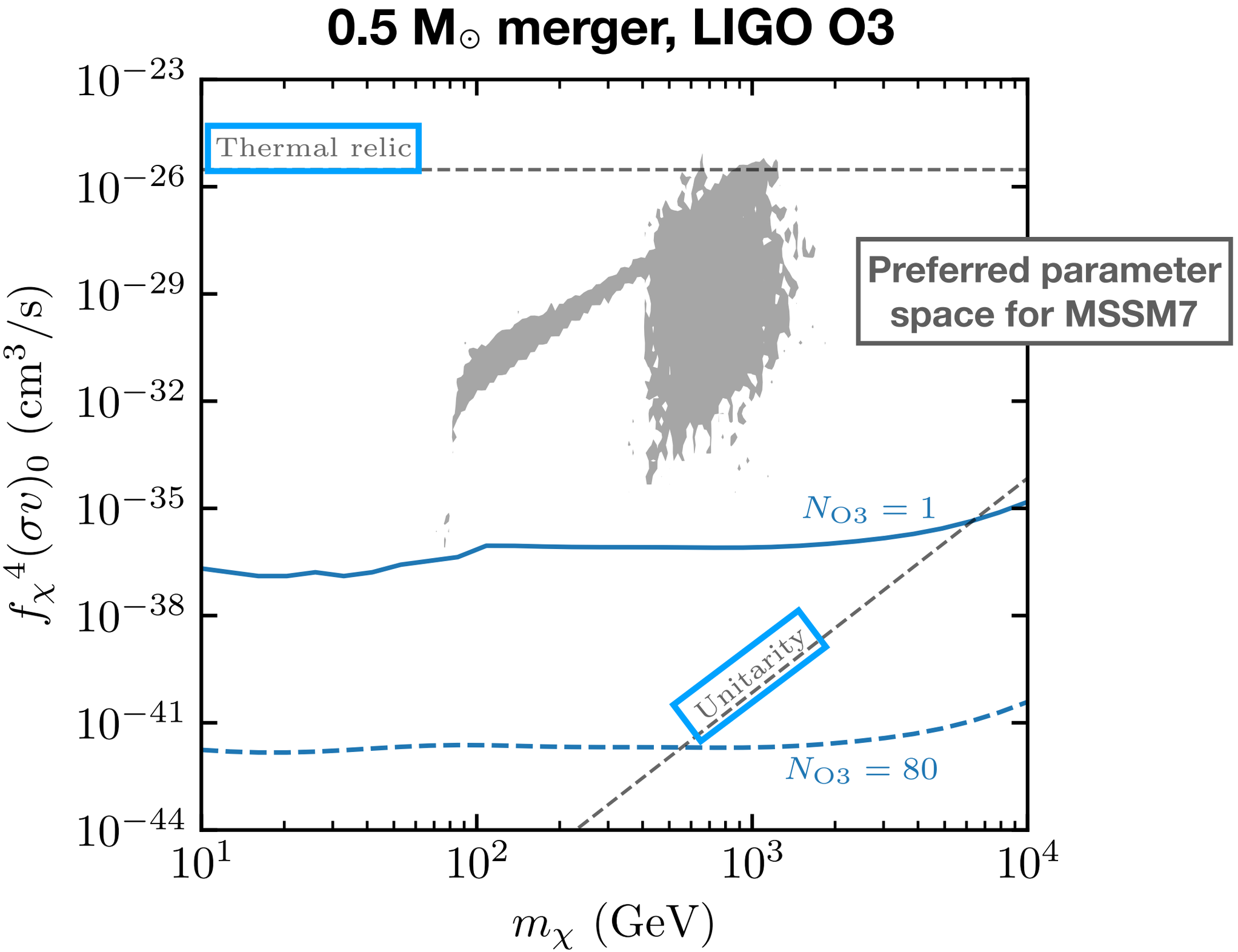
10^{-38}
10^{-41}
10^{-44}
10^1
10^2
10^3
10^4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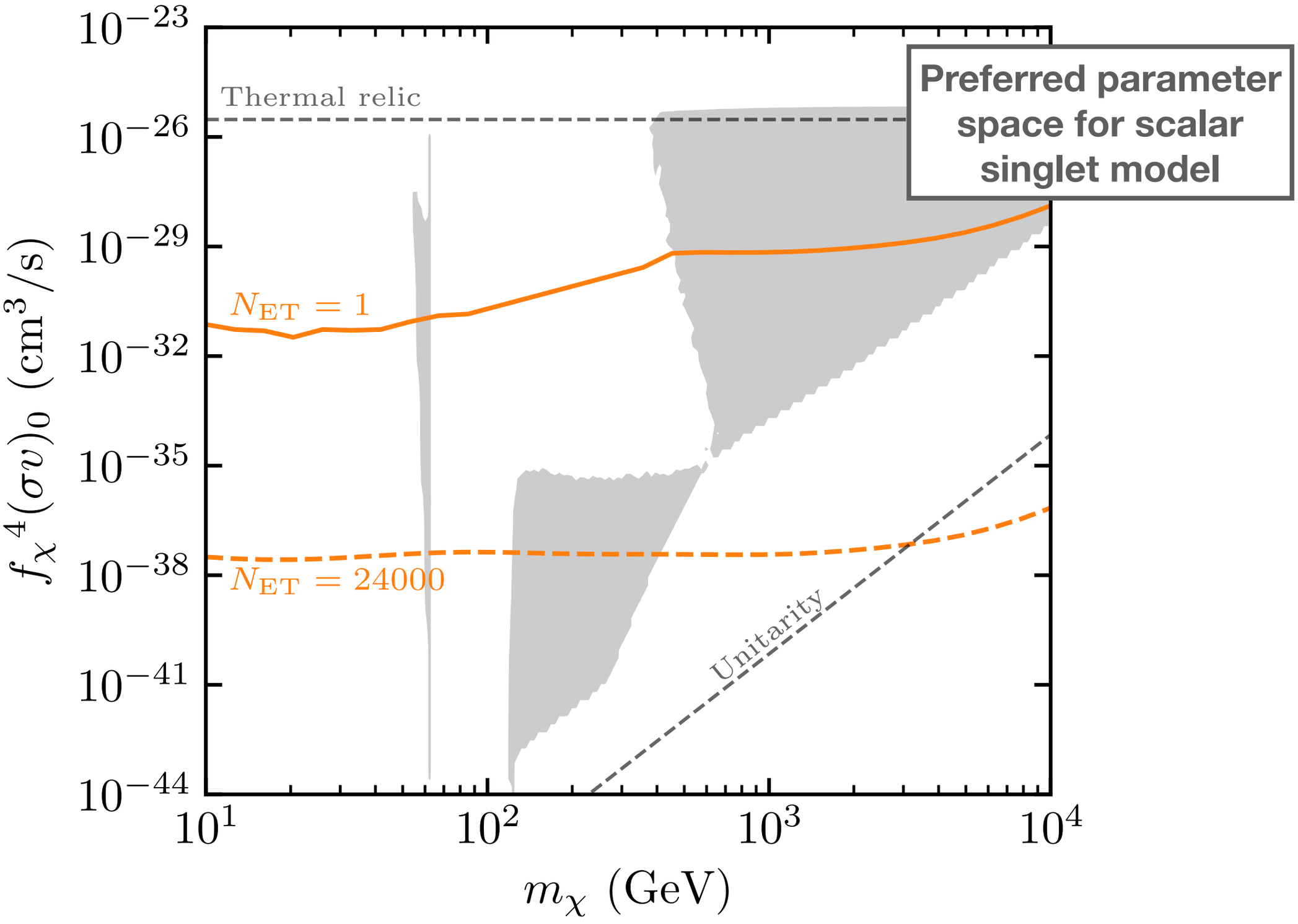
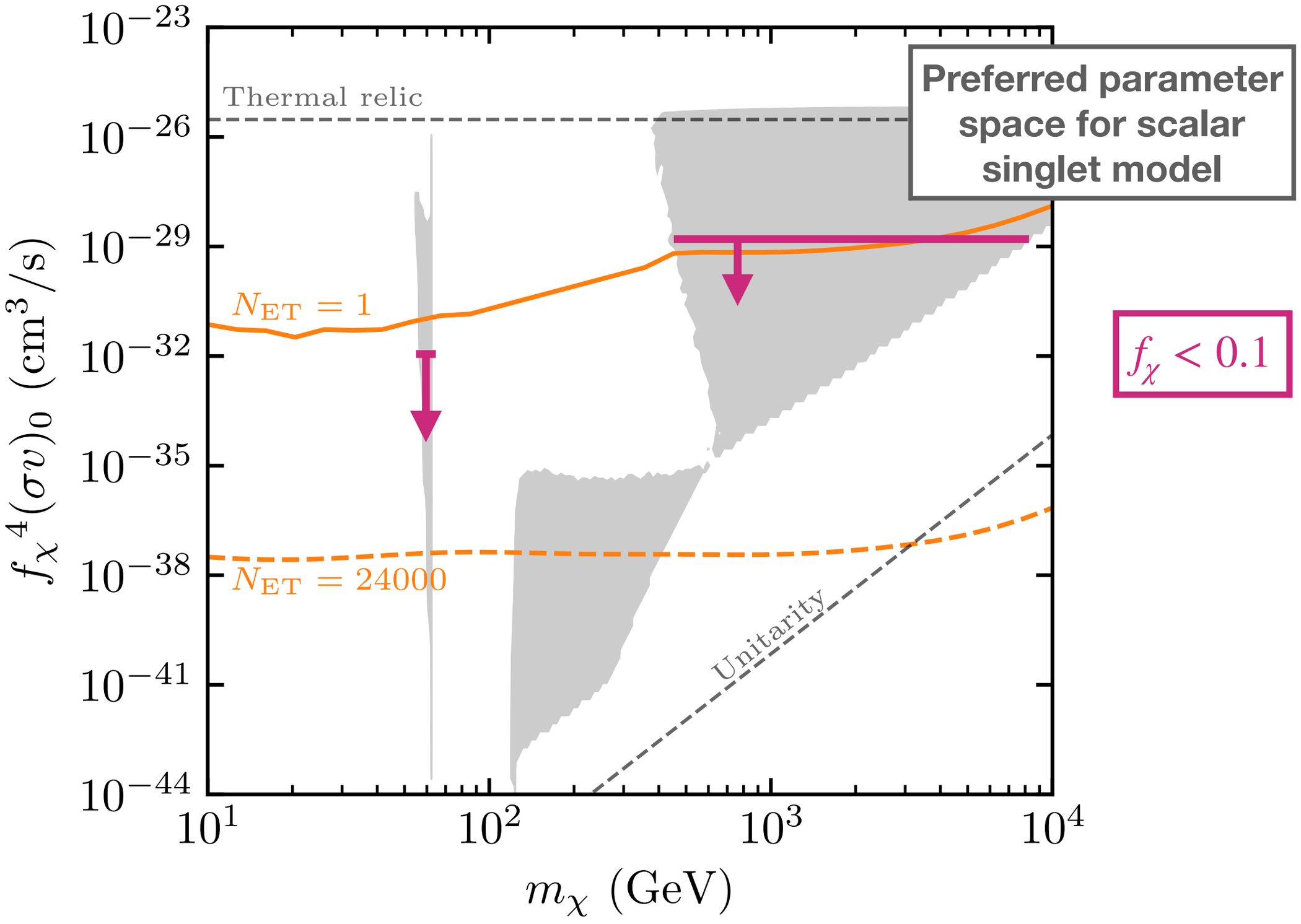
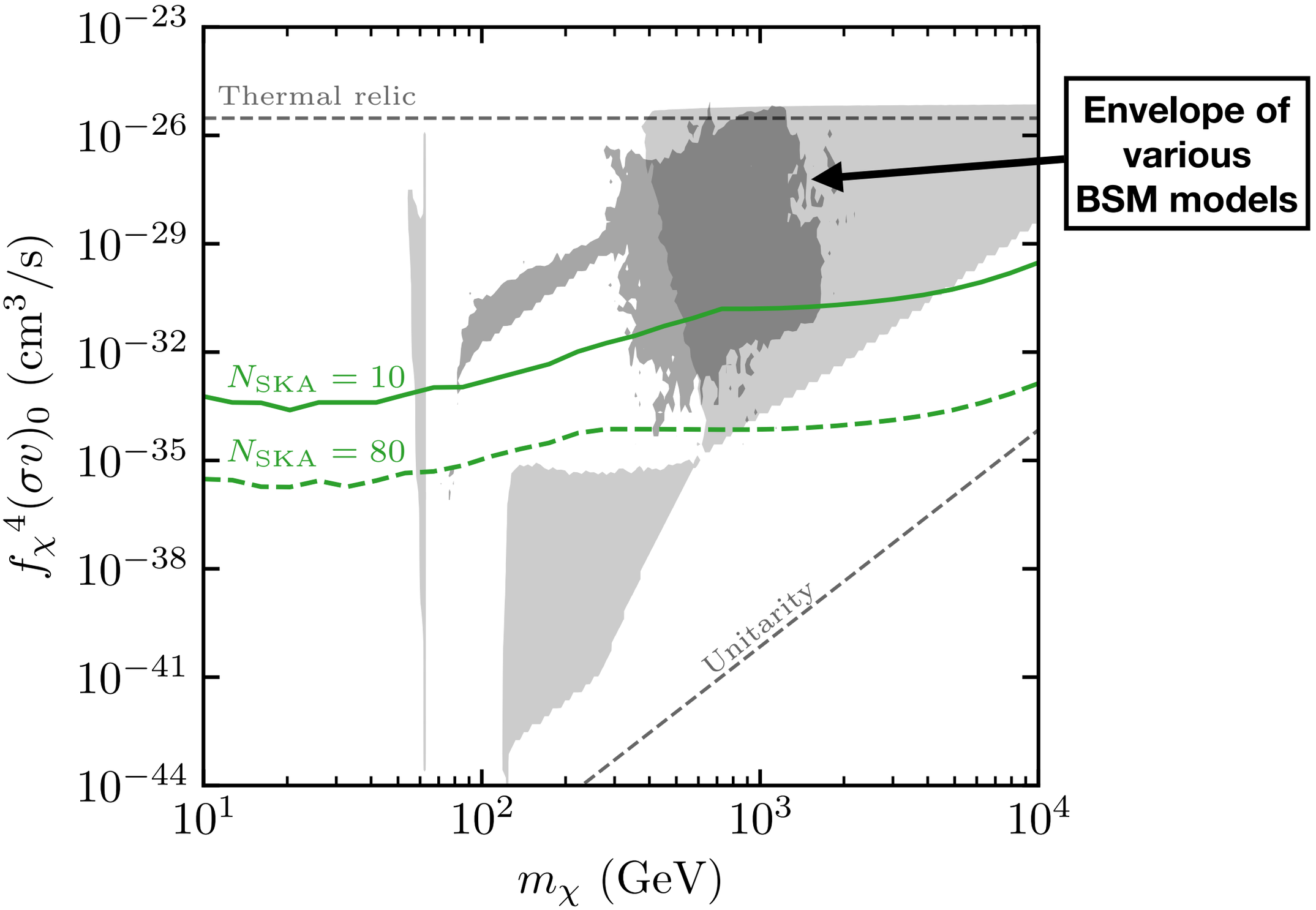
10^3
10^4


10 M⊙ z≥40 merger, Einstein Telescope
Preferred parameter space for scalar singlet model
Thermal relic
$N_{\rm ET} = 1$
$N_{\rm ET} = 24000$
Unitarity
$f_\chi^4 (\sigma v)_0$ (cm^3/s)
m_χ (GeV)
10^{-23}
10^{-26}
10^{-29}
10^{-32}
10^{-35}
10^{-38}
10^{-41}
10^{-44}
10^1
10^2
10^3
10^4

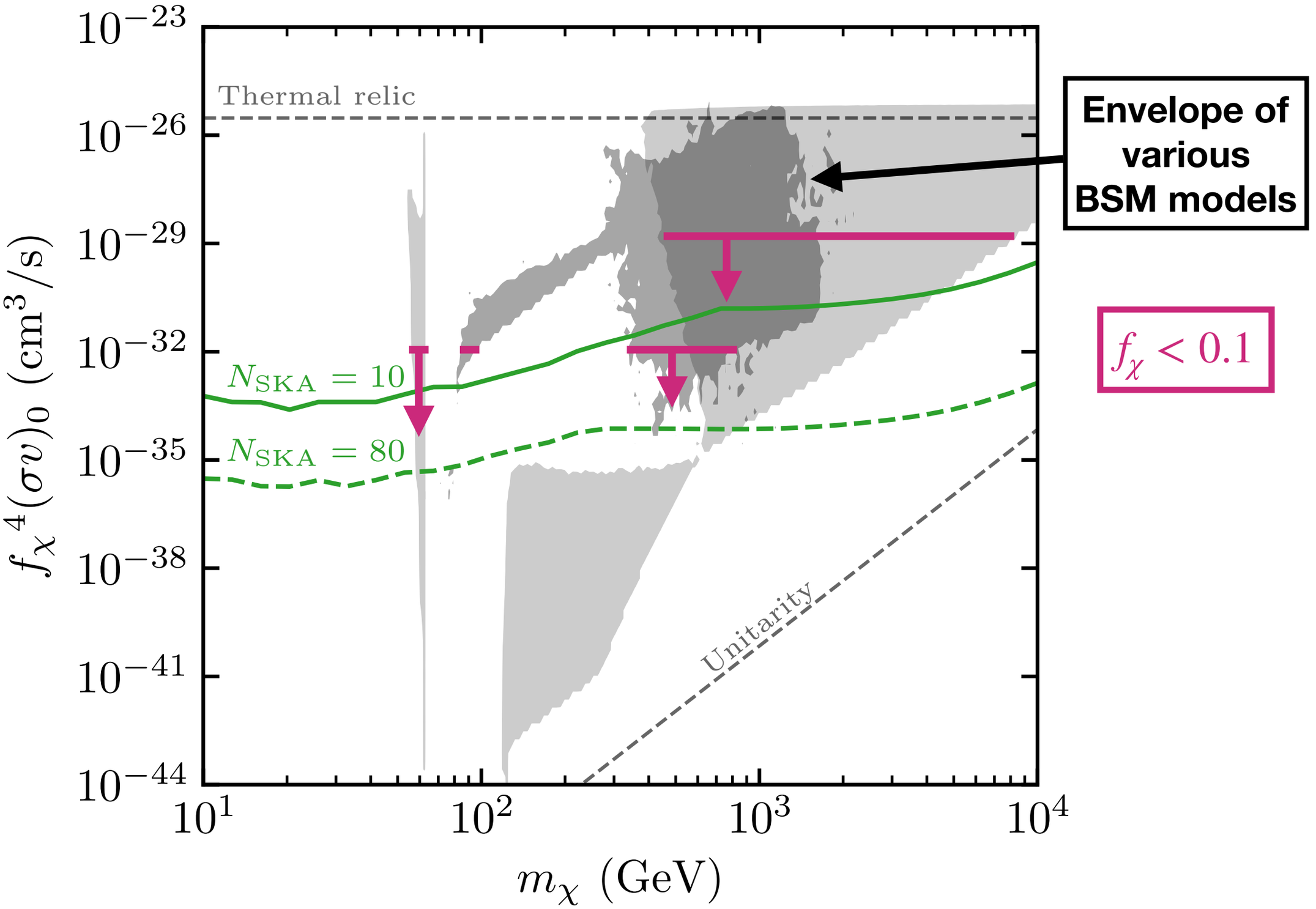
10 $M_\odot$ z≥40 merger, Einstein Telescope



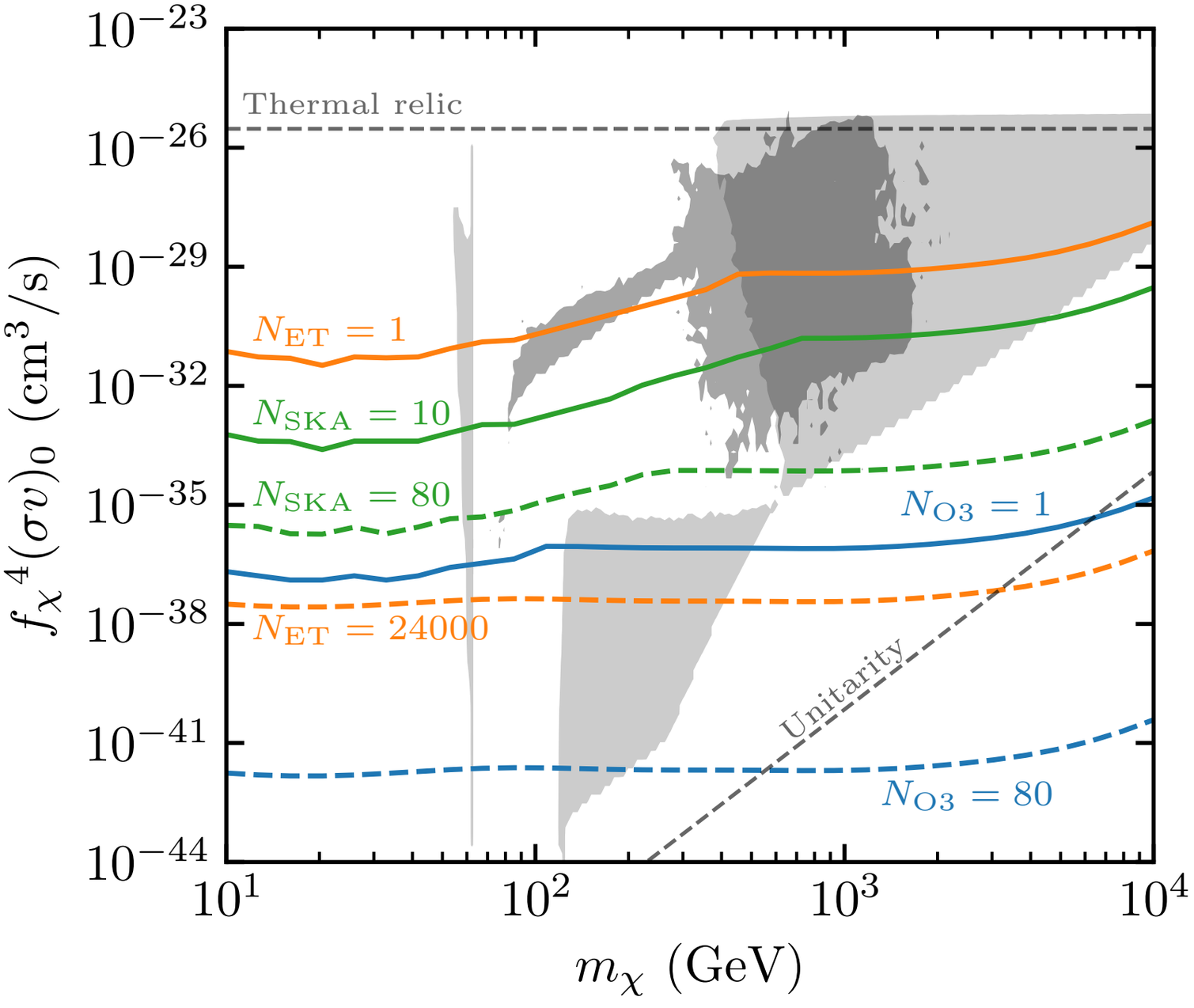
100 $M_\odot$, radio detections at SKA



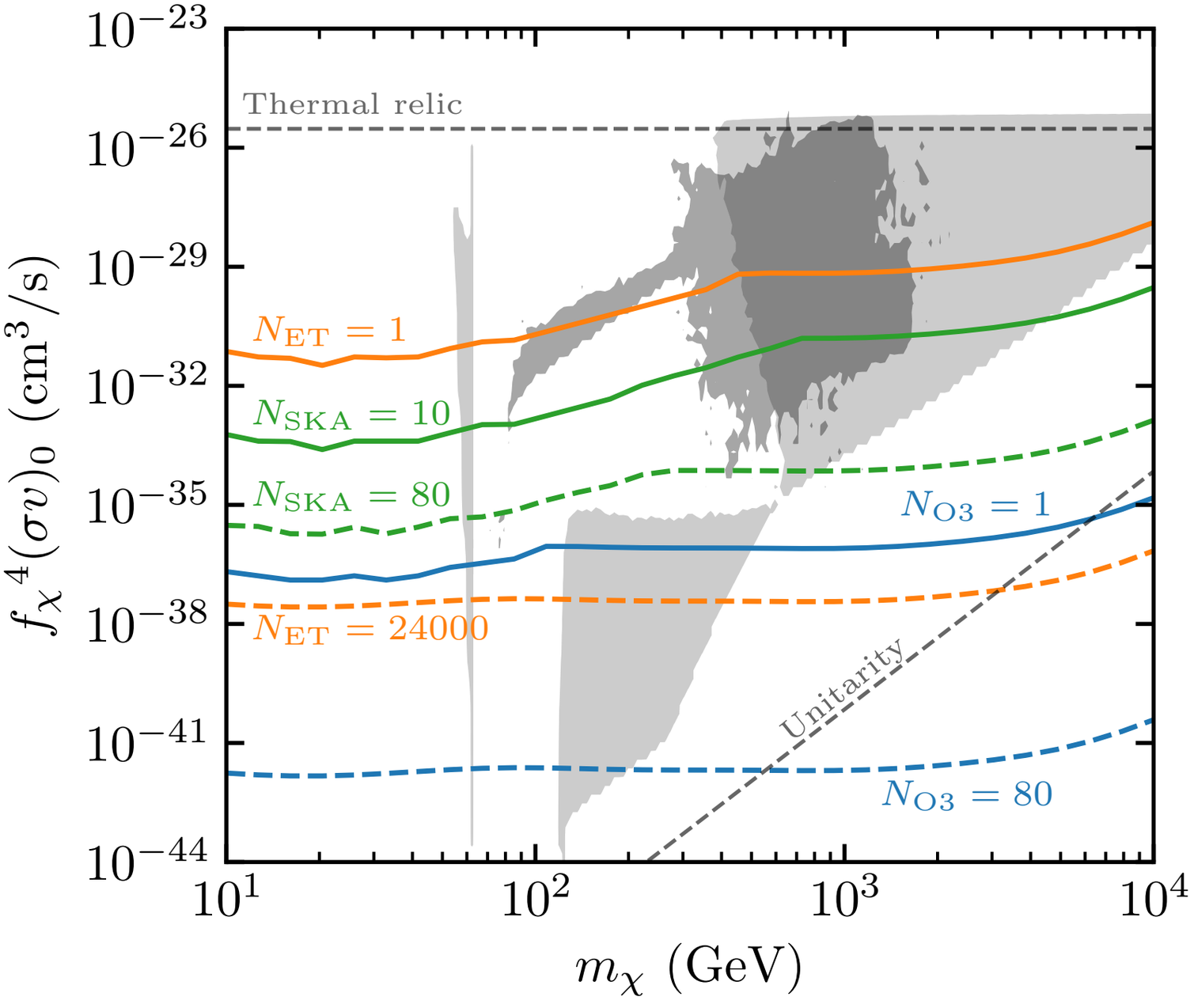
100 $M_\odot$, radio detections at SKA



Conclusion

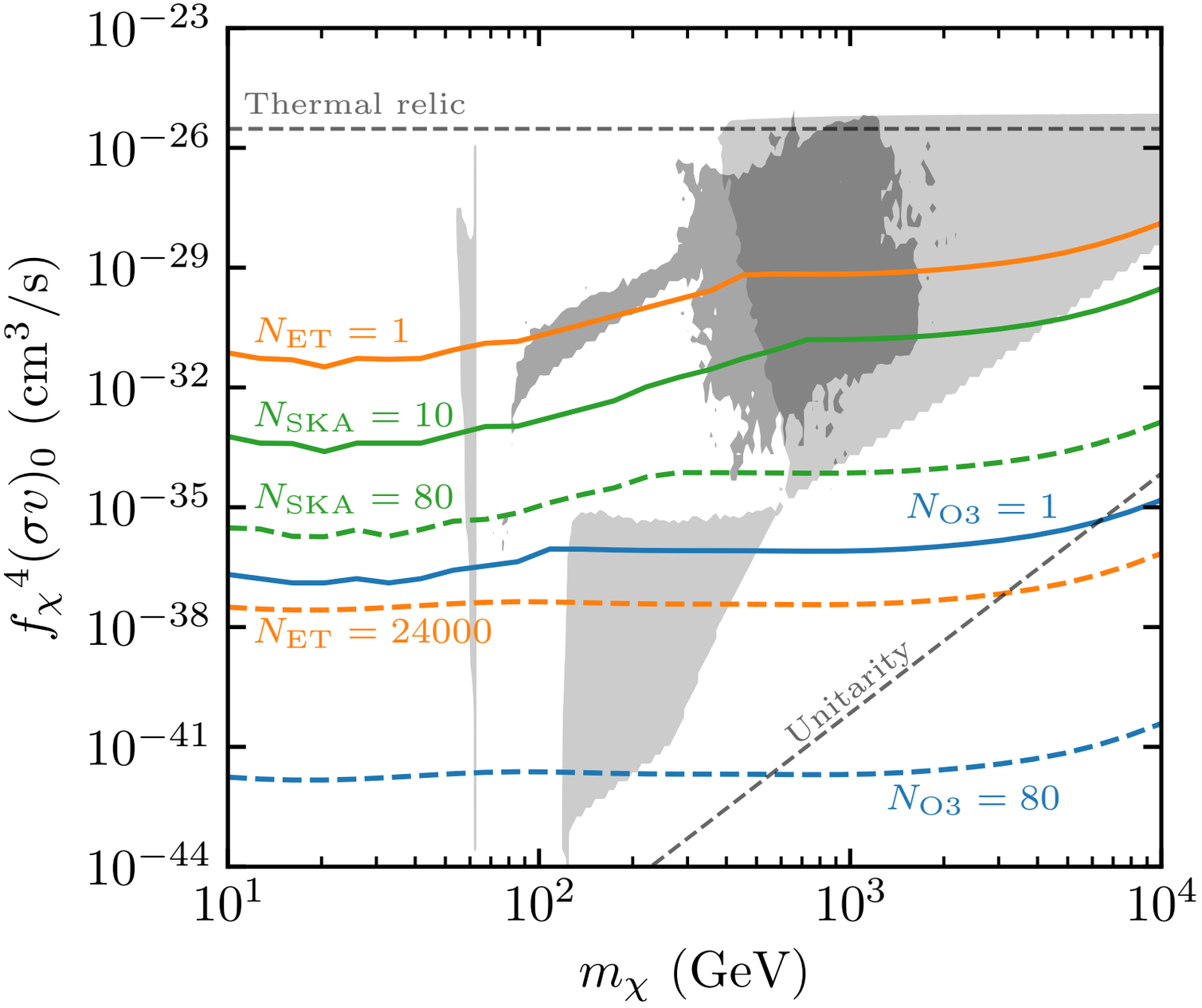

Thermal relic
$N_{\rm ET} = 1$
$N_{\rm SKA} = 10$
$N_{\rm SKA} = 80$
$N_{\rm O3} = 1$
$N_{\rm ET} = 24000$
Unitarity
$N_{\rm O3} = 80$
$f_\chi^4 (\sigma v)_0$ (cm^3/s)
m_χ (GeV)
10^{-23}
10^{-26}
10^{-29}
10^{-32}
10^{-35}
10^{-38}
10^{-41}
10^{-44}
10^1
10^2
10^3
10^4

Conclusion



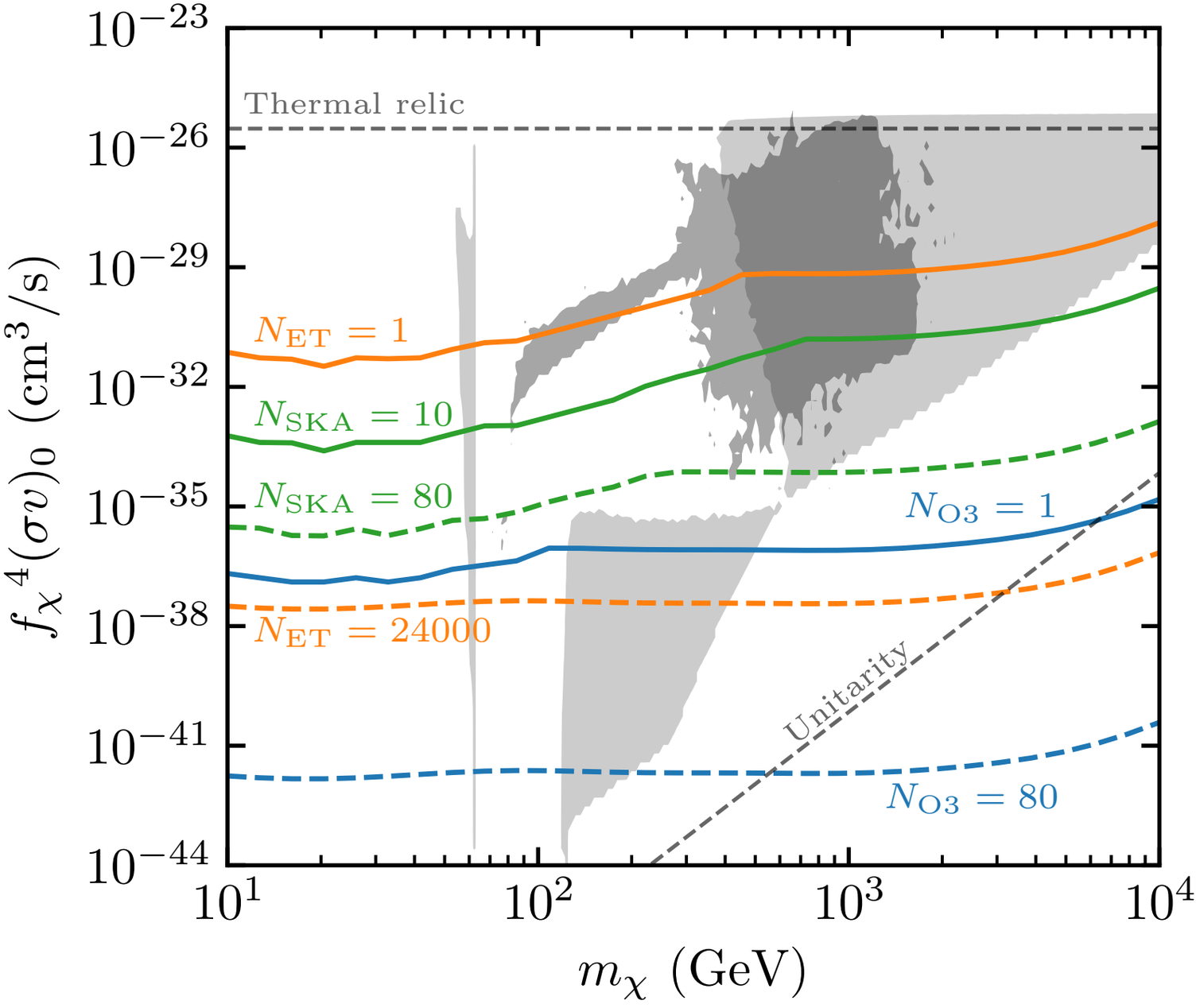
- Even **one** PBH detection would rule out standard thermal WIMPs

Conclusion



- Even **one** PBH detection would rule out standard thermal WIMPs
- Also constrains *any* BSM model with a WIMP, **even if it's under-abundant**

Conclusion



- Even **one** PBH detection would rule out standard thermal WIMPs
- Also constrains *any* BSM model with a WIMP, **even if it's under-abundant**

Thank you!