

Gamma-ray constraints on mixed PBH-WIMPs scenario

Théo Paré

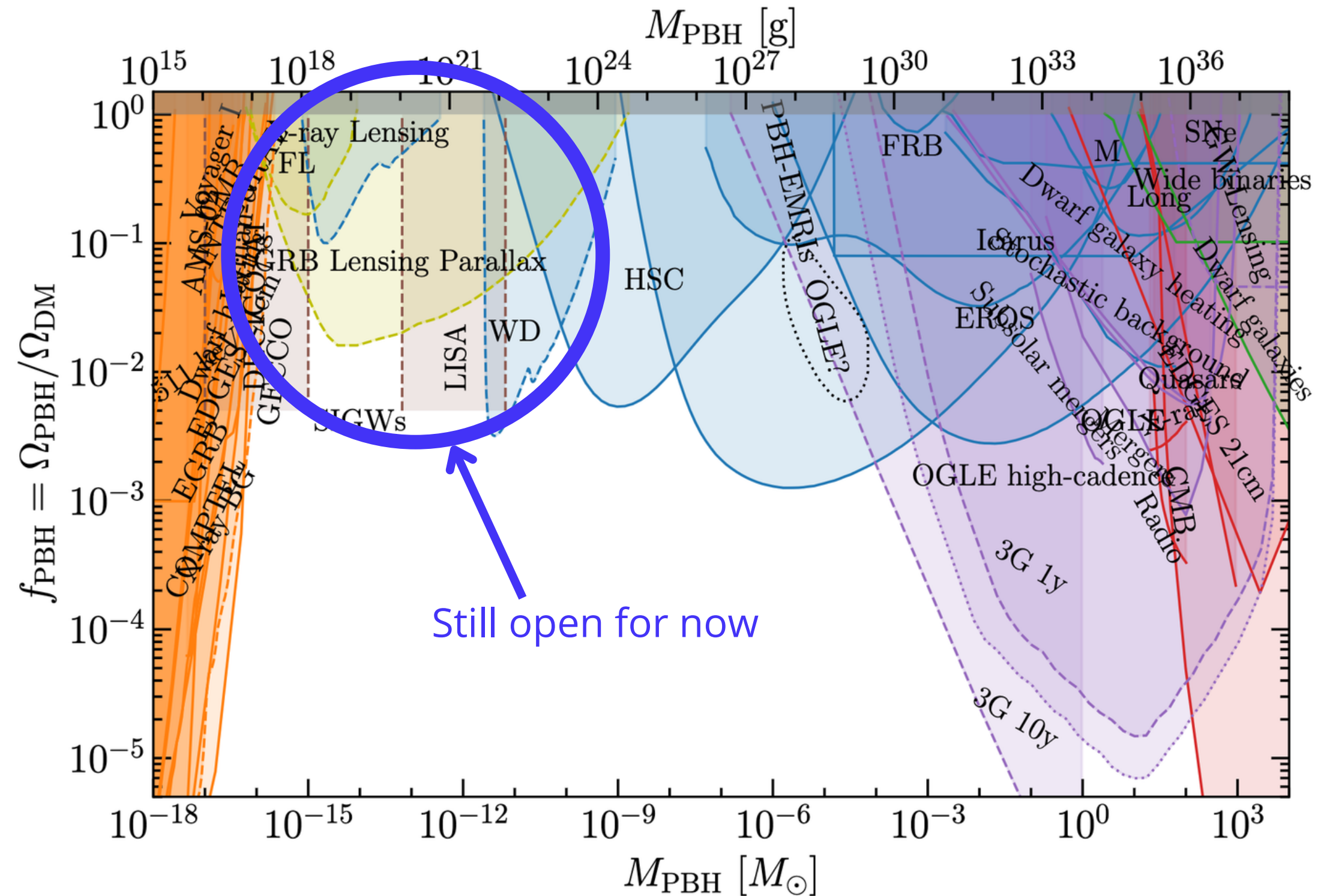
with

Julien Laval & Pierre Salati

Motivations

Pure PBH dark matter is close to
be totally ruled out
→ Subfraction of DM in PBH
possible

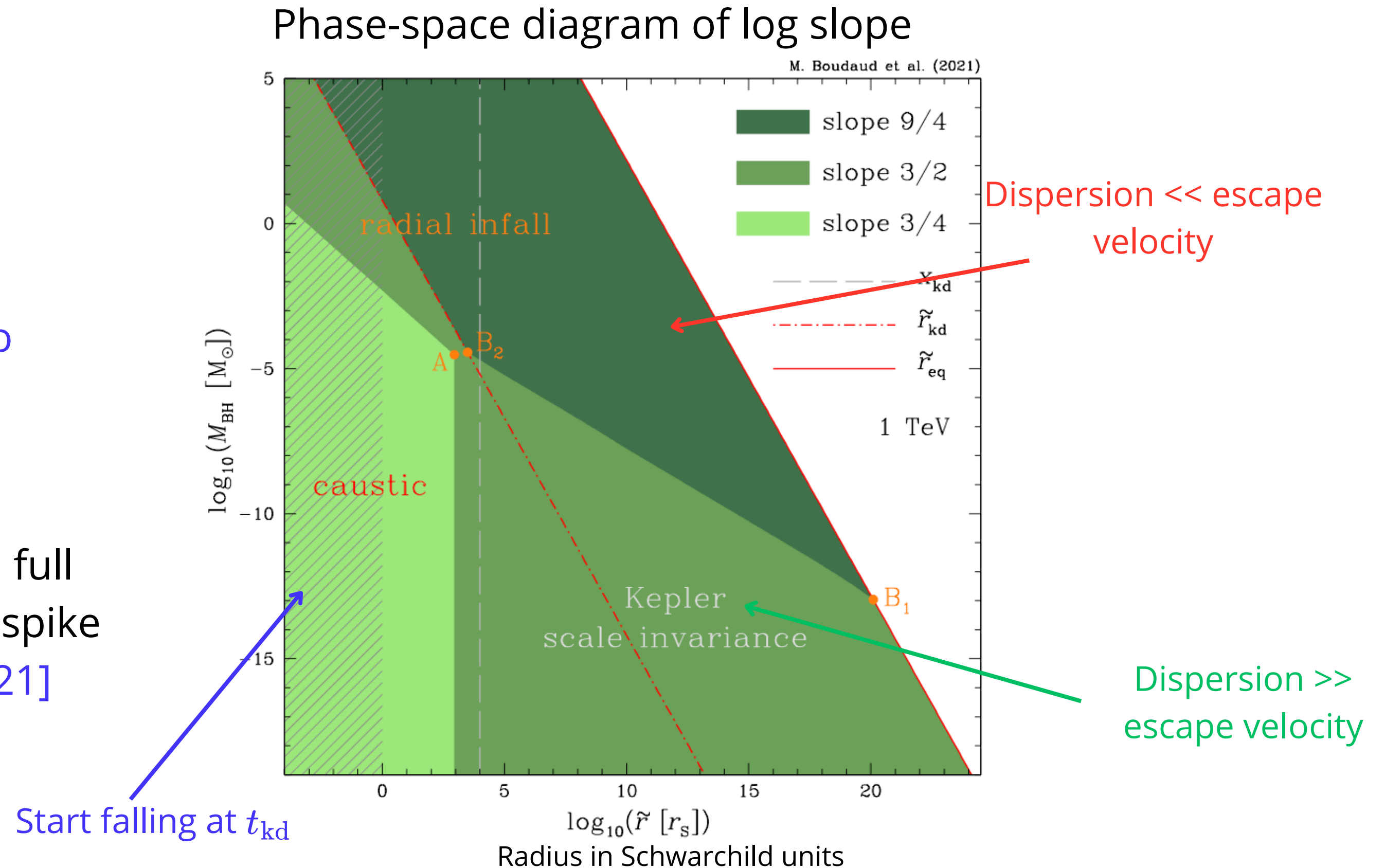
**What are the consequences on
other DM candidates ?**



DM spike density profile

Already explored in previous studies see
[Mack+ '05-08][Lacki & Beacom 2010][Eroshenko 2016]

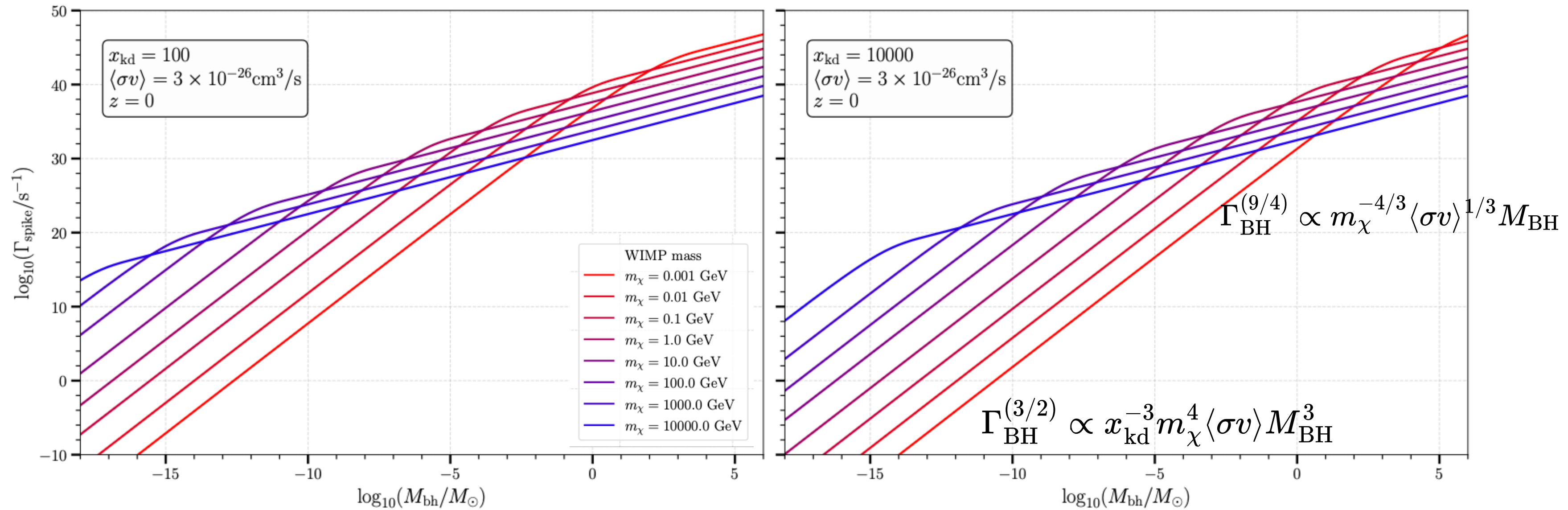
Improved calculations and full analytical understanding of spike formation [Boudaud+ 2021]



Annihilating DM

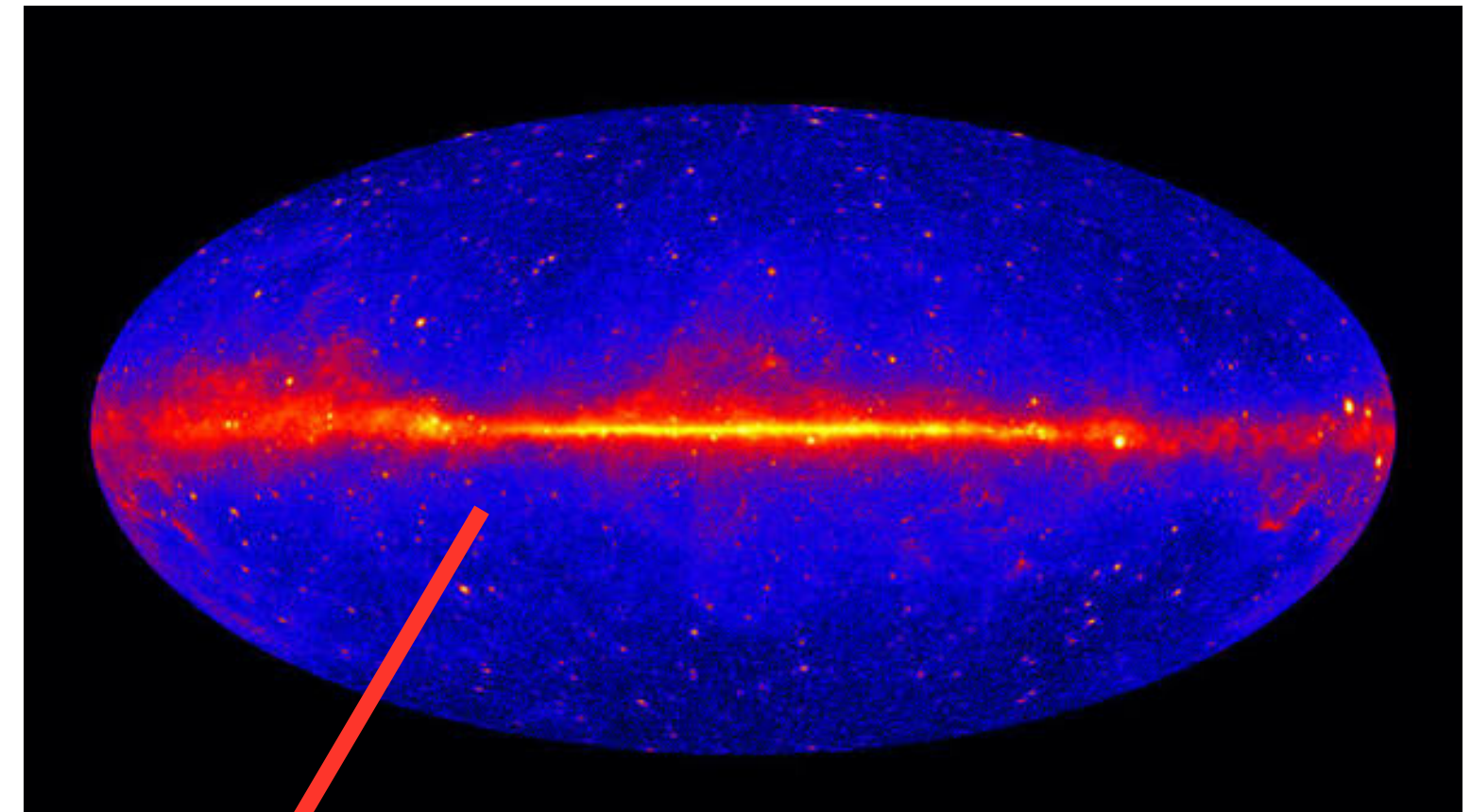
$$\Gamma_{\text{spike}}(t) \simeq \frac{2\pi K_\gamma}{3} \langle \sigma v \rangle \left(\frac{\rho_{\text{max}}(t)}{m_\chi} \right)^2 R_S^3(r_\gamma^c(t))^3$$

→ 5 total parameters : $M_{\text{BH}}, f_{\text{BH}}, m_\chi, x_{\text{kd}}, \langle \sigma v \rangle$

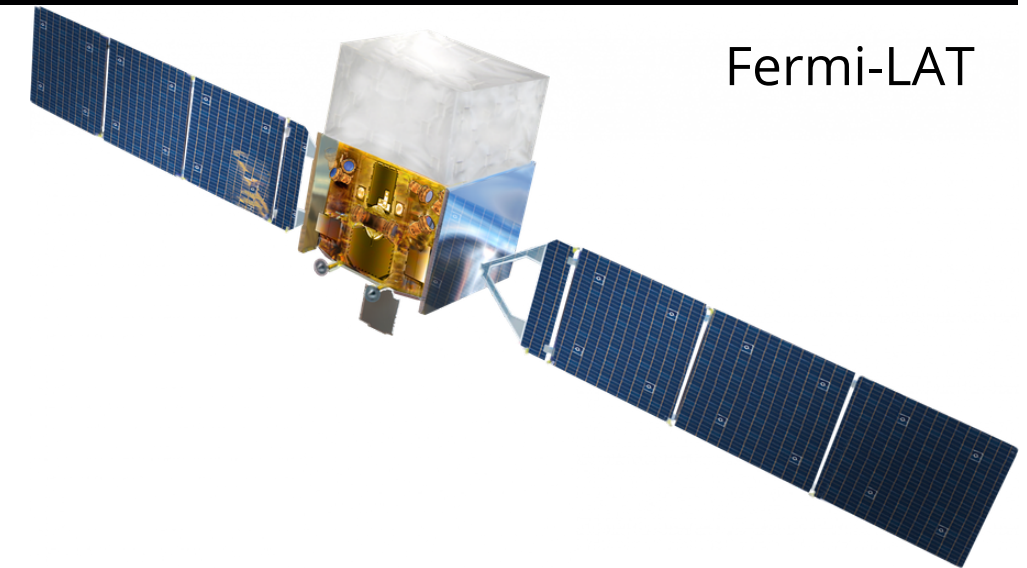


Observables

- PBH spike as point sources inside the galactic halo
- PBH spike contribution to the isotropic gamma-ray background



Fermi-LAT



Point-source

Brightest unassociated gamma-ray source
from Fermi catalog :

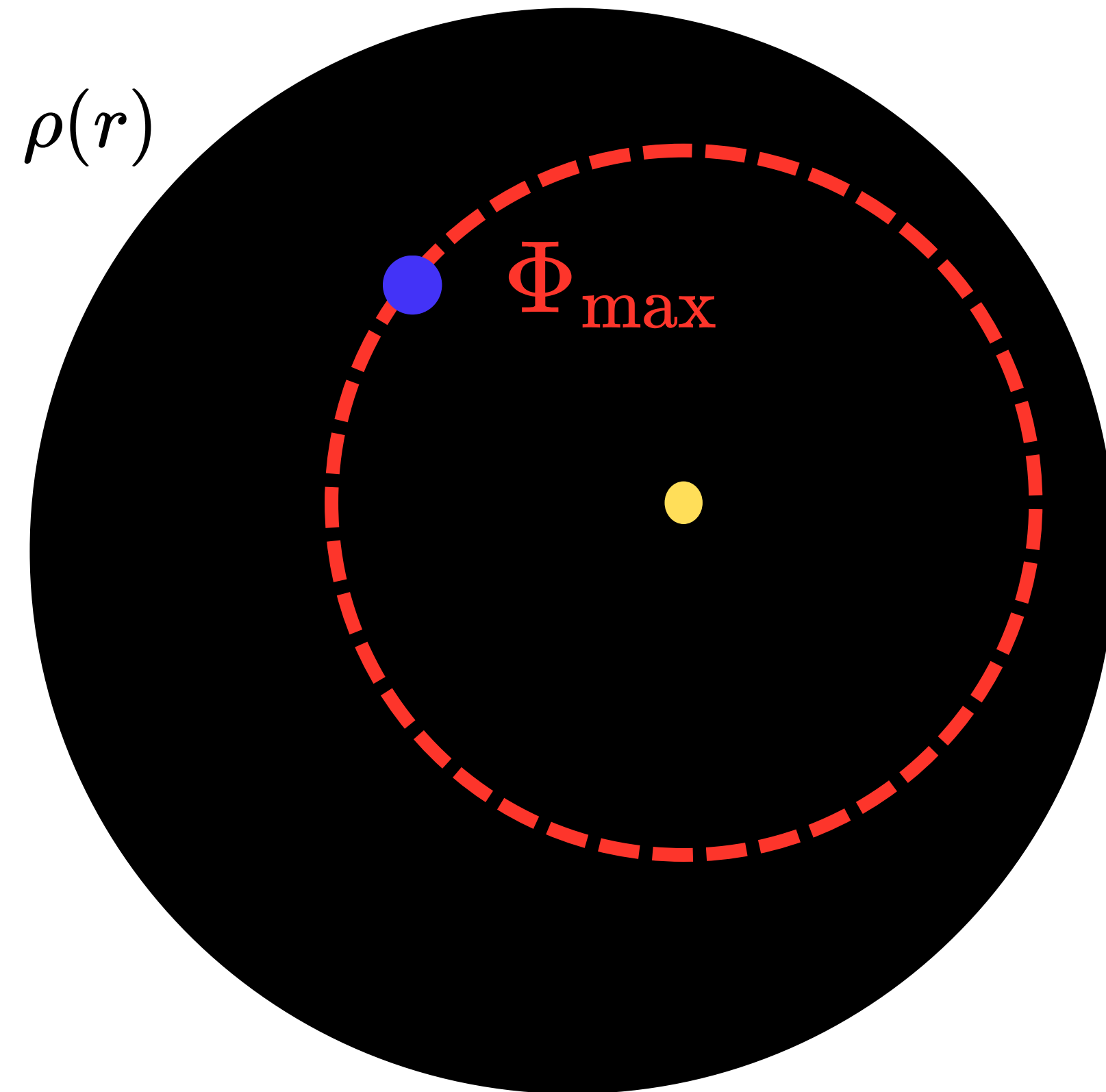
$$\Phi_{\text{max}} = 4.30 \times 10^{-8} \text{ photons cm}^{-2} \text{ s}^{-1}$$

Assuming PBH distribution follows DM density profiles

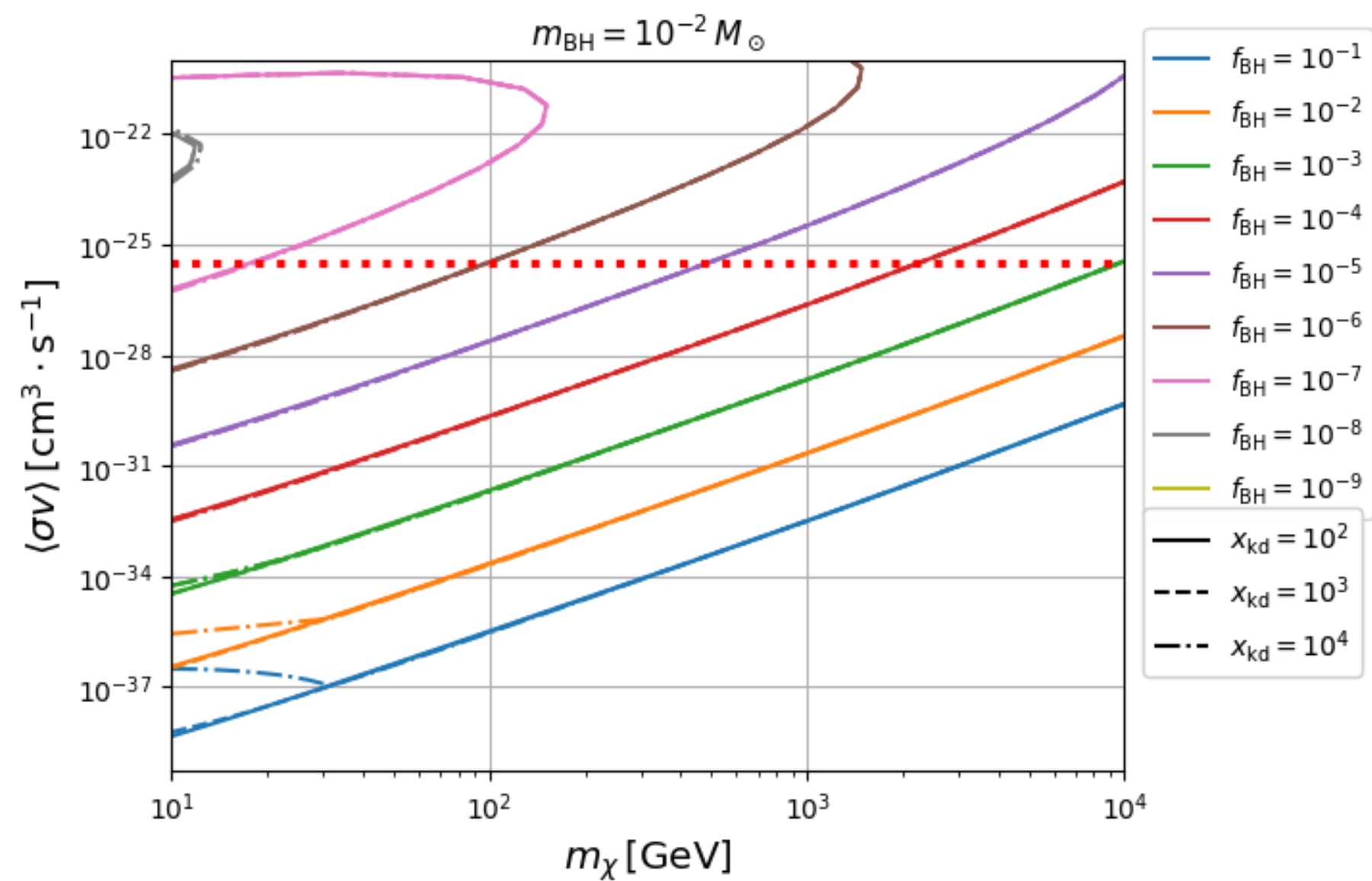
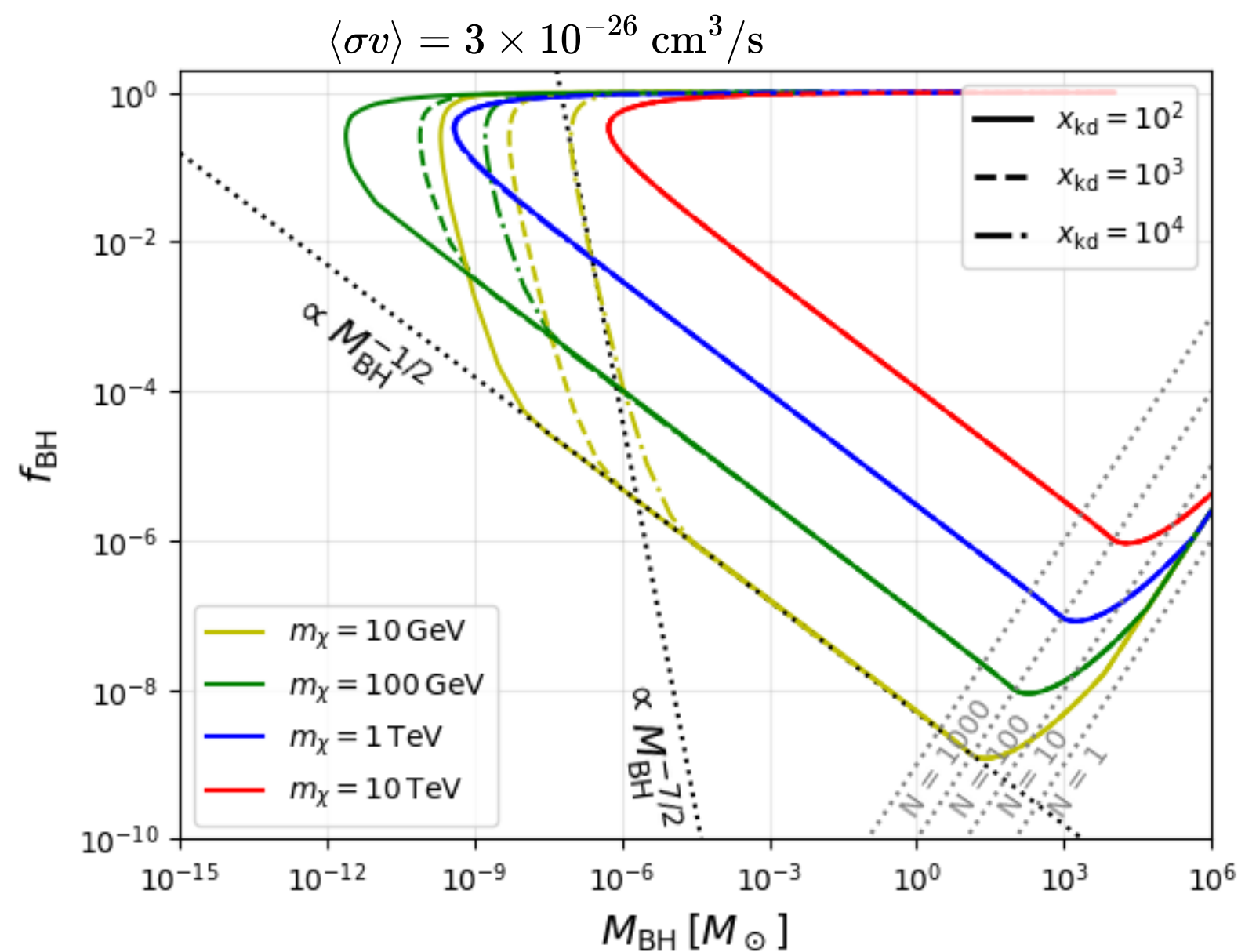
$$P(\Phi > \Phi_{\text{max}}) = M_{\text{sphere}} / M_{\text{MW}}$$

+ Poisson fluctuations on the number of PBHs:

$$P(\text{at least 1}) = 1 - e^{-\bar{N}P(\Phi > \Phi_{\text{max}})}$$



Point-source

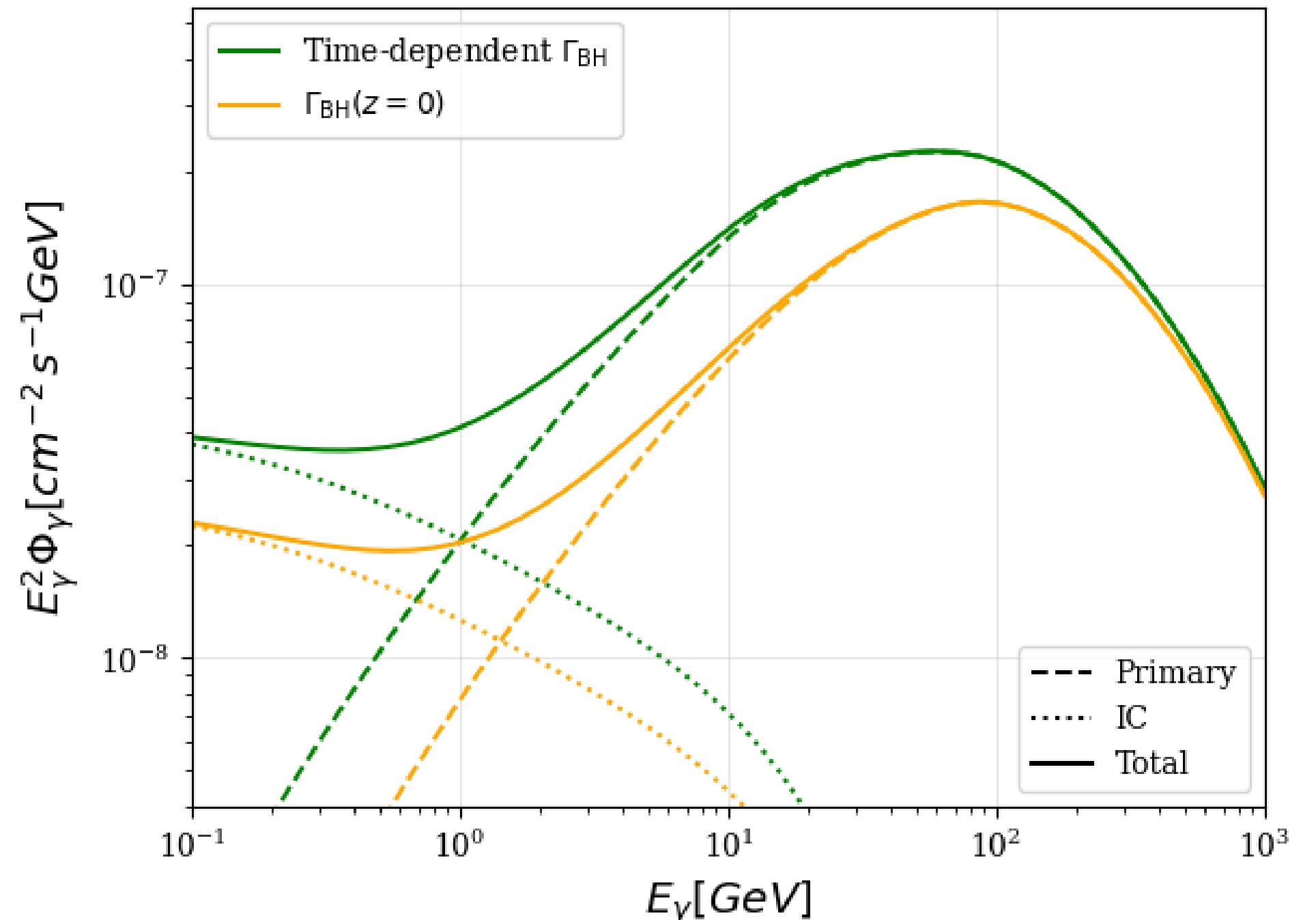


Isotropic background

Each PBH is effectively a large
decaying DM particle

→ Analogy with decaying DM
analysis [Blanco & Hooper 2019]

**Problem : ignores redshift
dependance of Γ**

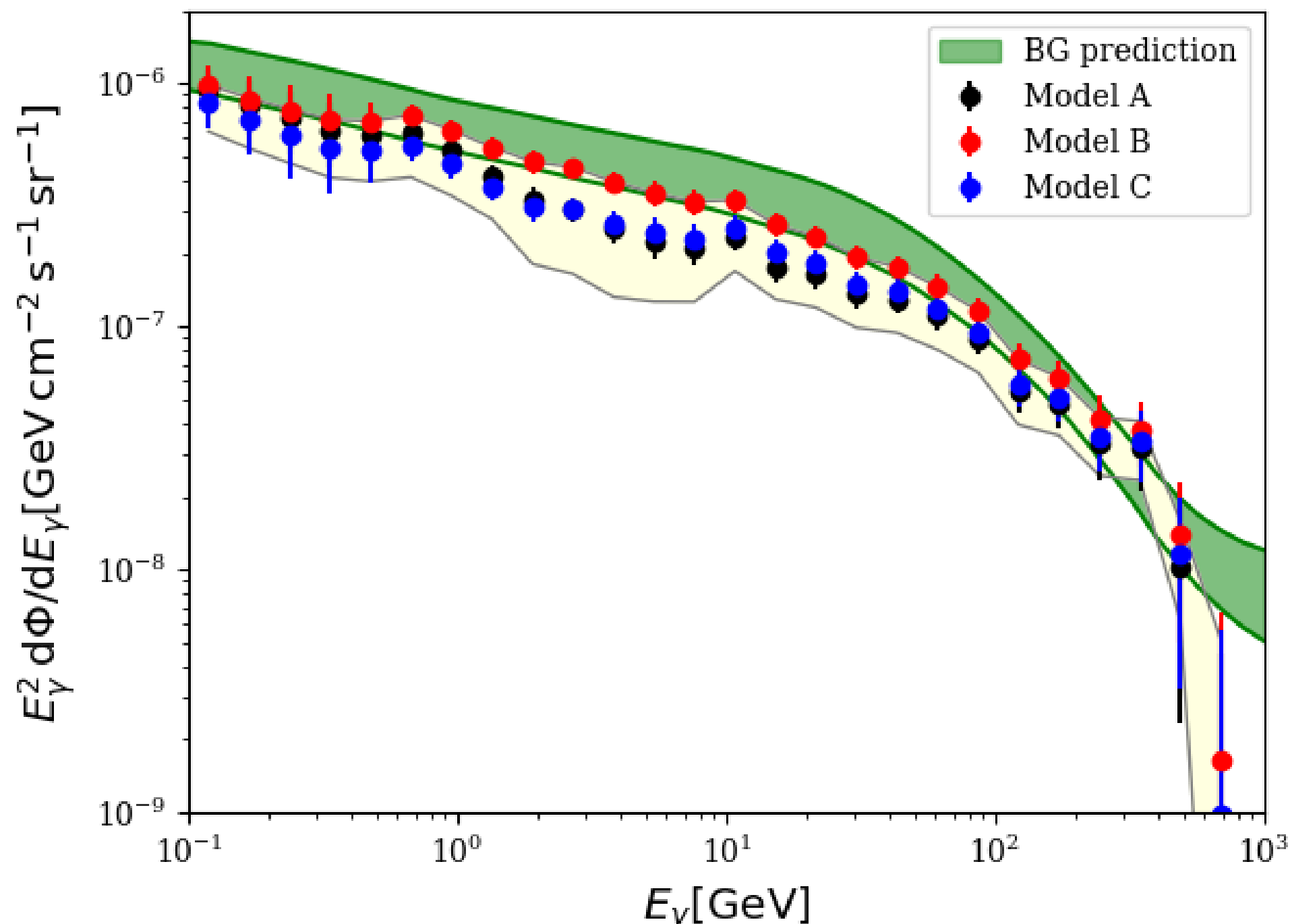


$$M_{\text{BH}} = 10^{-8} M_\odot \quad m_\chi = 1 \text{ TeV}$$

Isotropic background

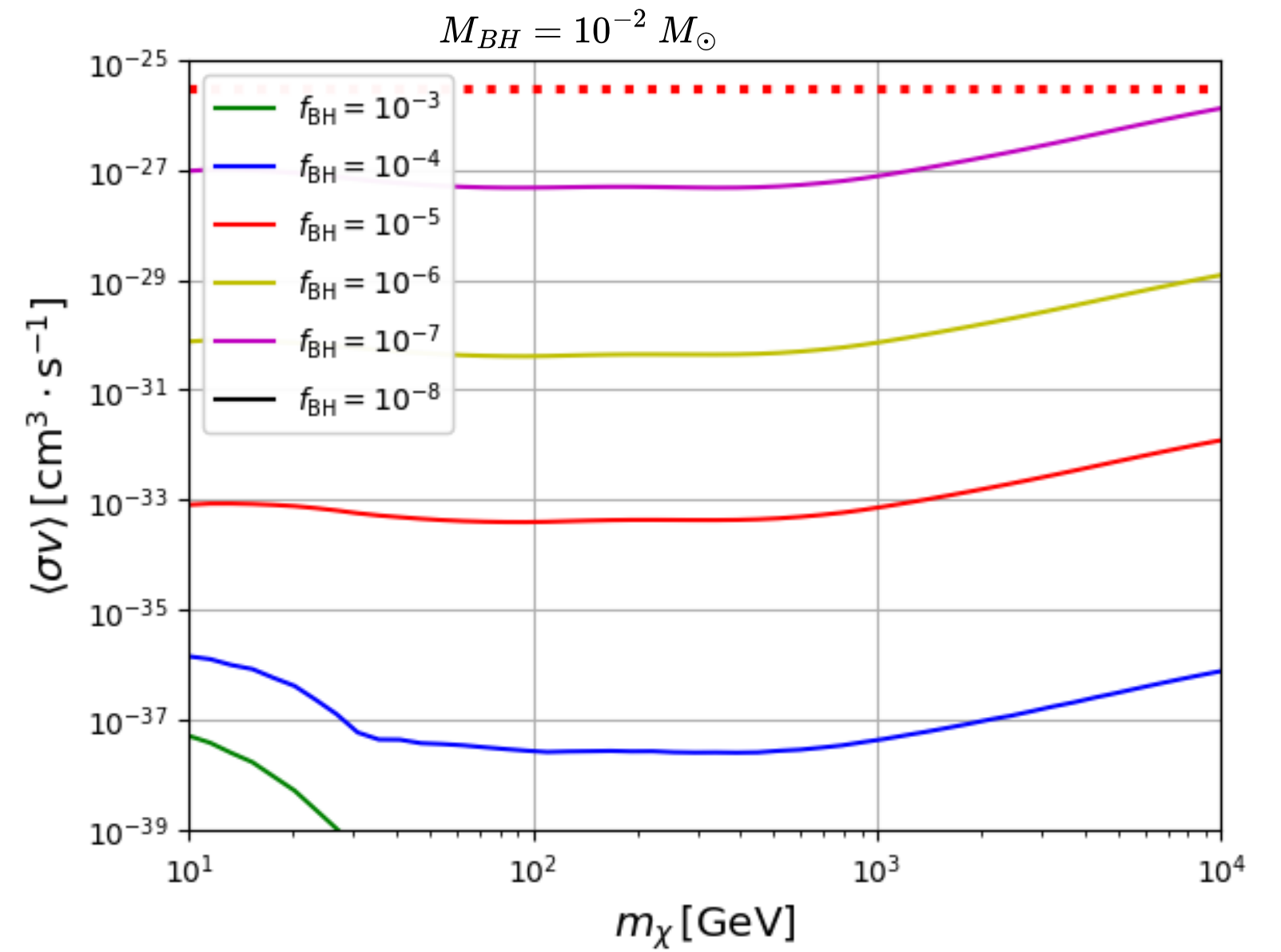
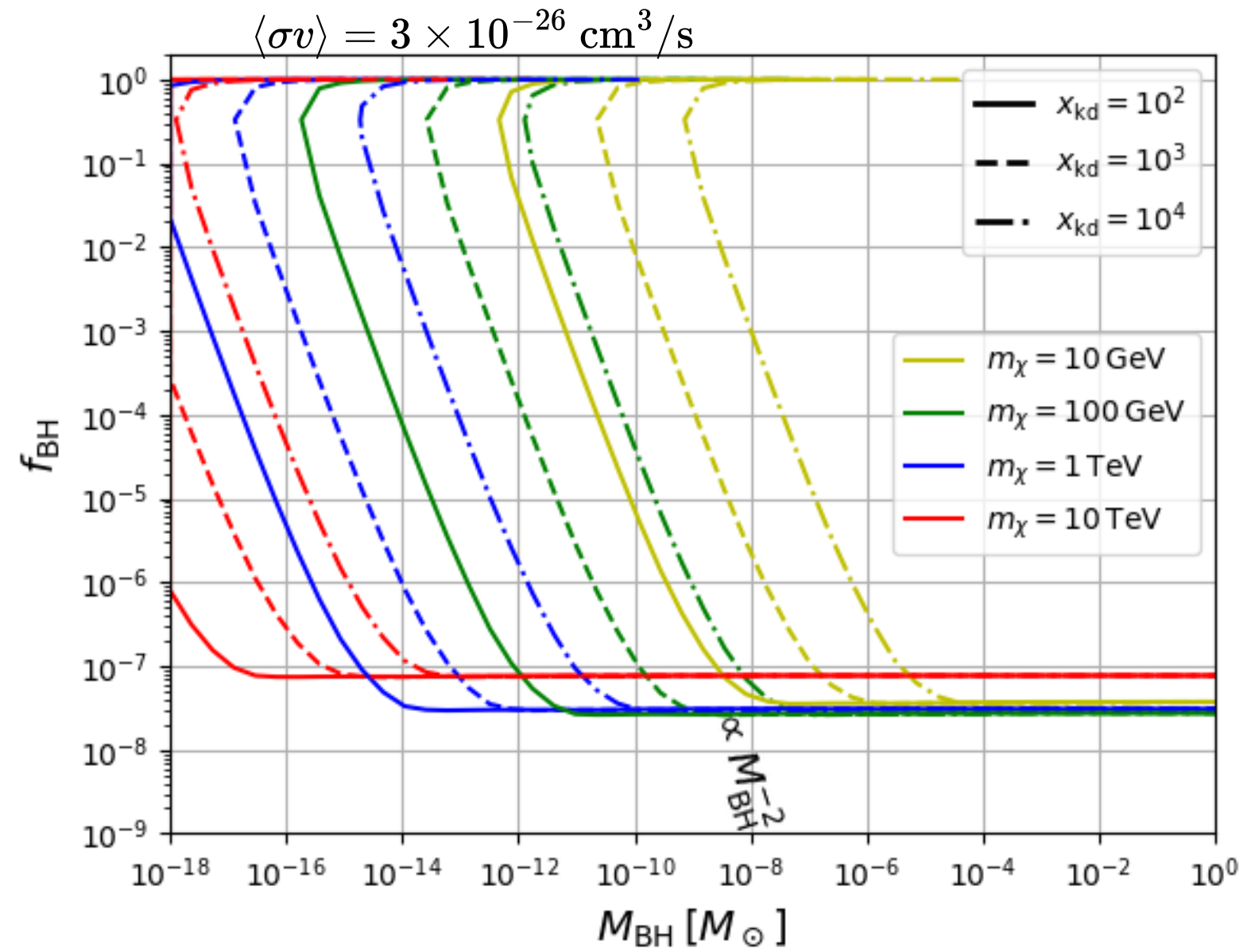
- Same background prediction as [\[Blanco & Hooper 2019\]](#)
- Annihilation spectra from CosmiXs [\[Arina+ 2025\]](#)
- Optical depth from [\[Saldana-Lopez+ 2021\]](#)
- Exact redshift dependence of the signal

**Very little room for extra components
→ very strong constraints**

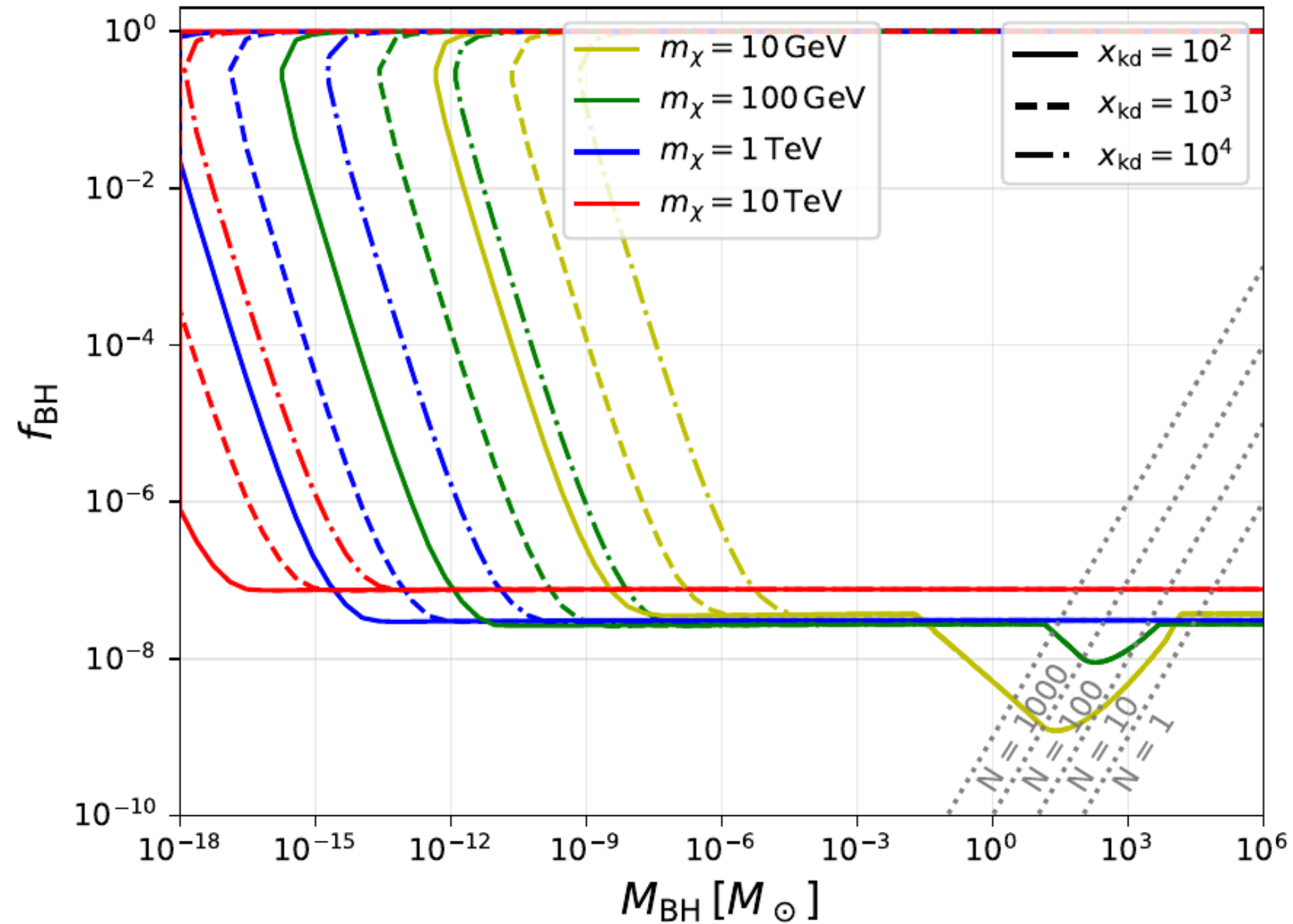


Isotropic gamma-ray background from Fermi Collab. (2015)

Isotropic background



Combined constraints



IGRB is stronger in general but dependent on astro BG prediction

Conclusion and prospects

- Good understanding of the constraints and transitions between different regimes
- f_{BH} is constrained down to $10^{-7} - 10^{-8}$ for both observables
- $\rightarrow$ PBH and WIMPs are mutually exclusive

Prospects :

- Constraints from diffuse emission within the galactic halo
- spike destruction
- PBH mass function
- Other observables ?



Thank you