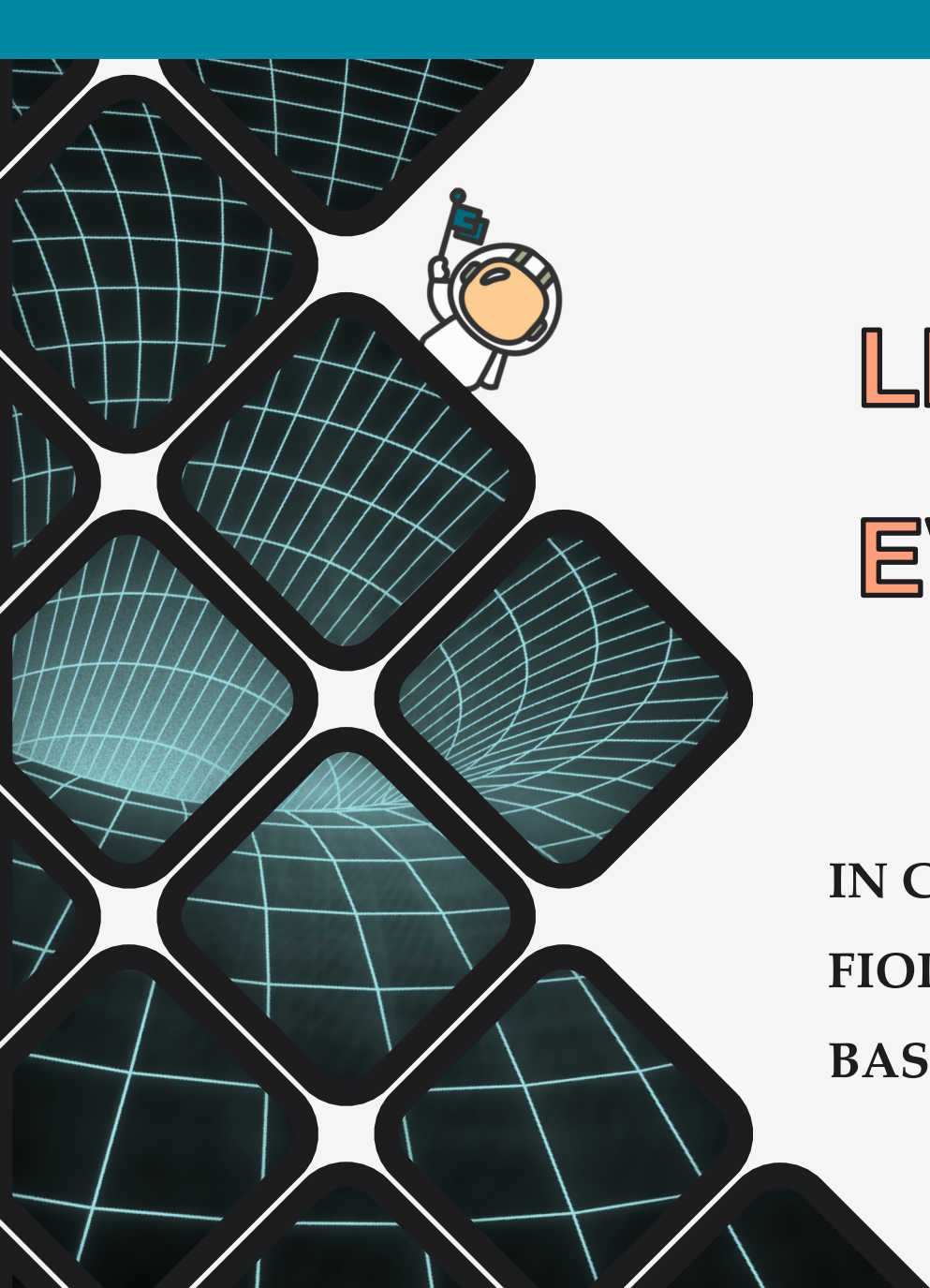




DIRECT DETECTION OF LIGHT DARK MATTER FROM EVAPORATING PRIMORDIAL BLACK HOLES

IN COLLABORATION WITH: M. CHIANESE, D. F. G.

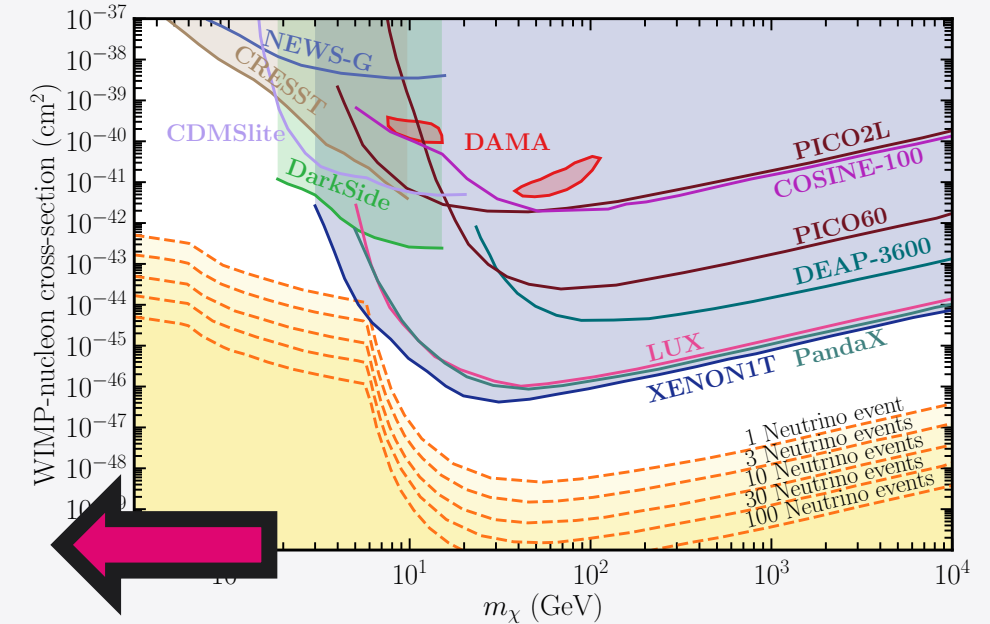
FIORILLO, N. SAVIANO

BASED ON:

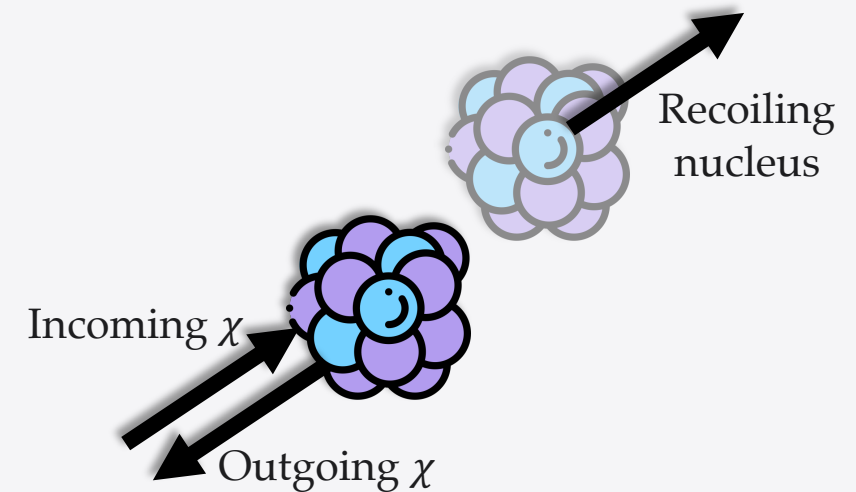
PHYSICAL REVIEW D 105 (2022) 2, L021302

PHYSICAL REVIEW D 105 (2022) 10, 103024

MAIN IDEA



SUB-GEV DARK MATTER!

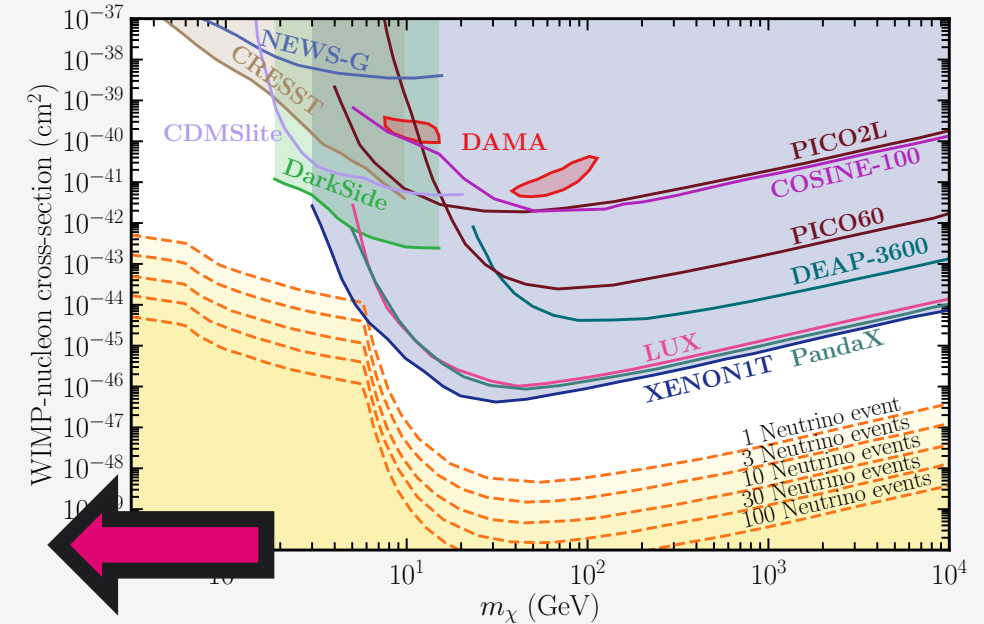


MAIN IDEA

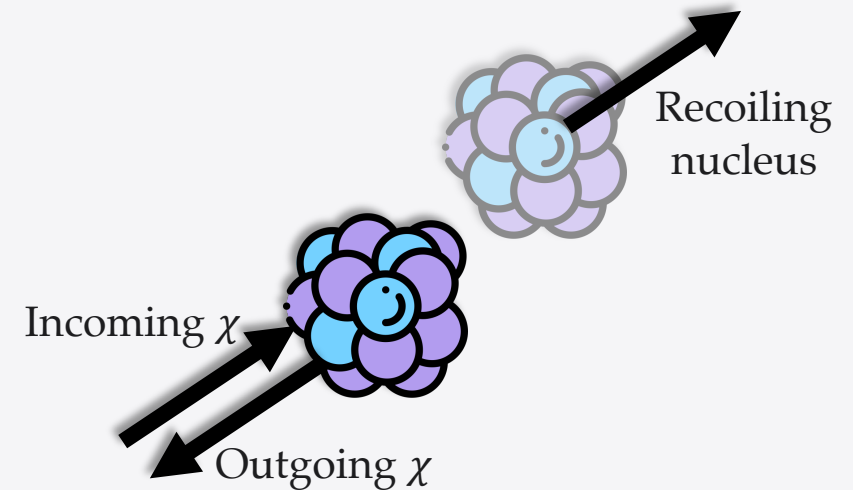


Light Dark Matter endowed with high kinetic energies can produce observable signals!!

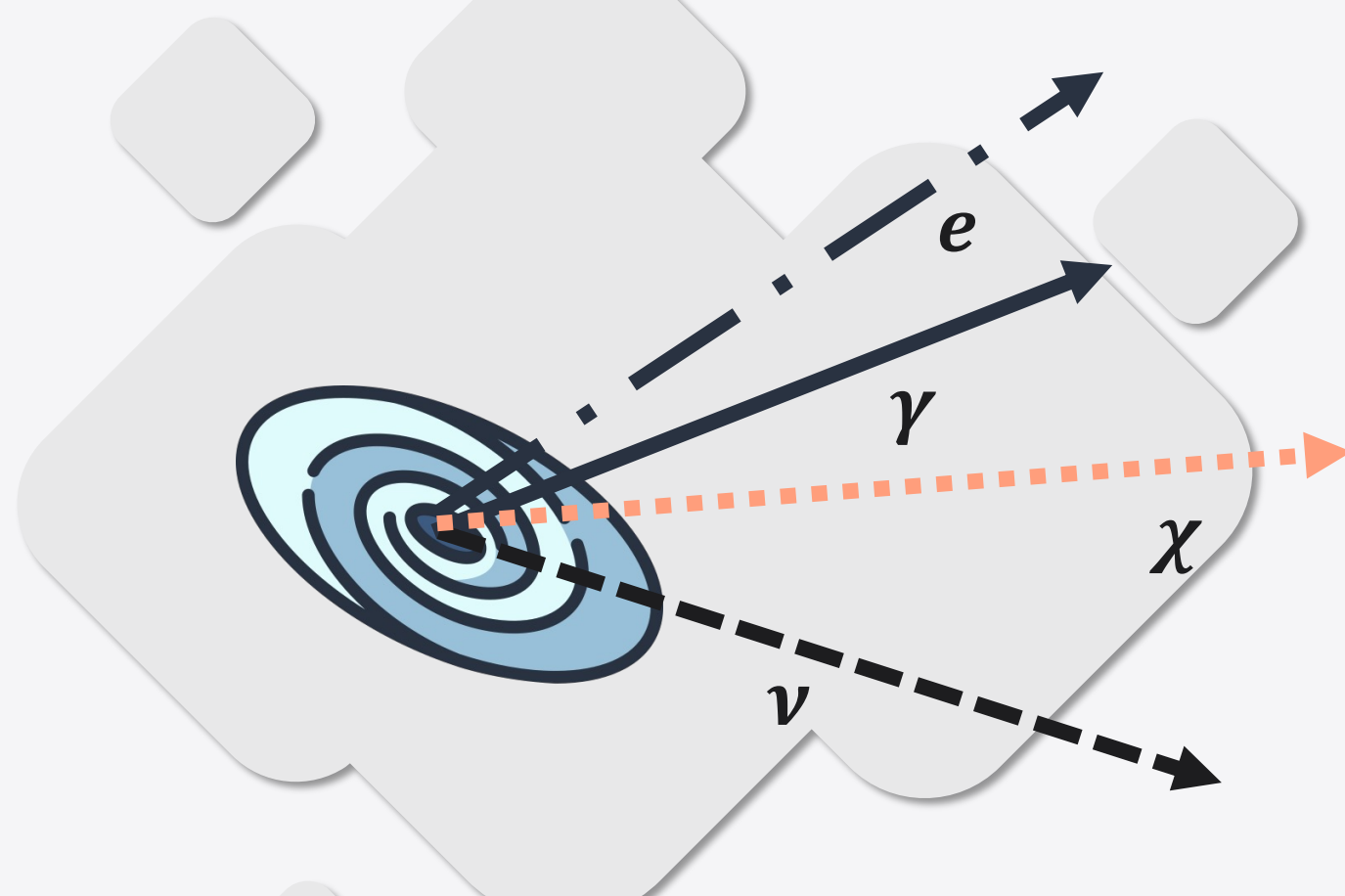
K. Agashe et al, JCAP 10, 062 (2014)
G. F. Giudice et al, PLB 780, 543-552 (2018)



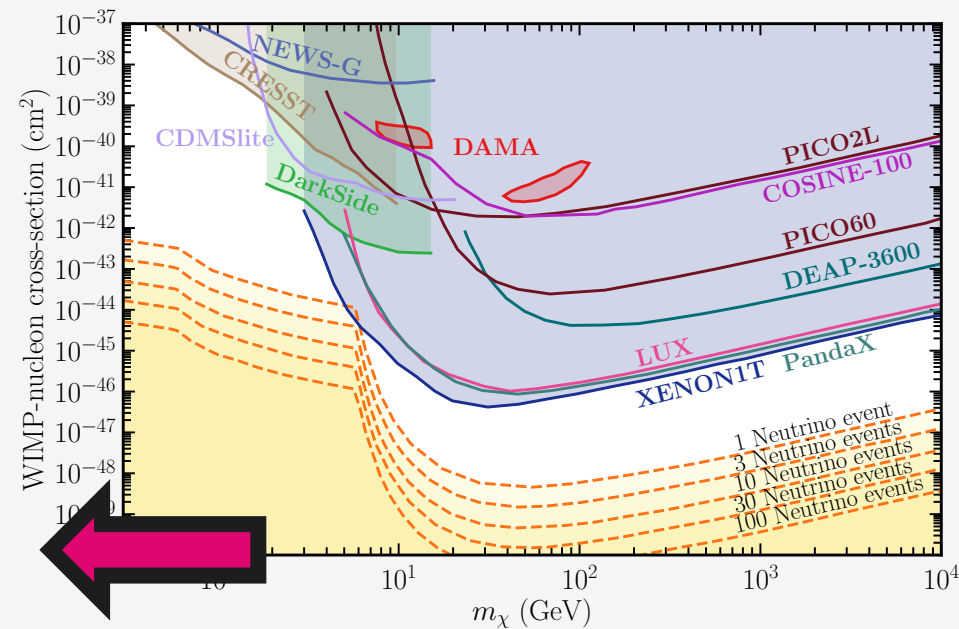
SUB-GEV DARK MATTER!



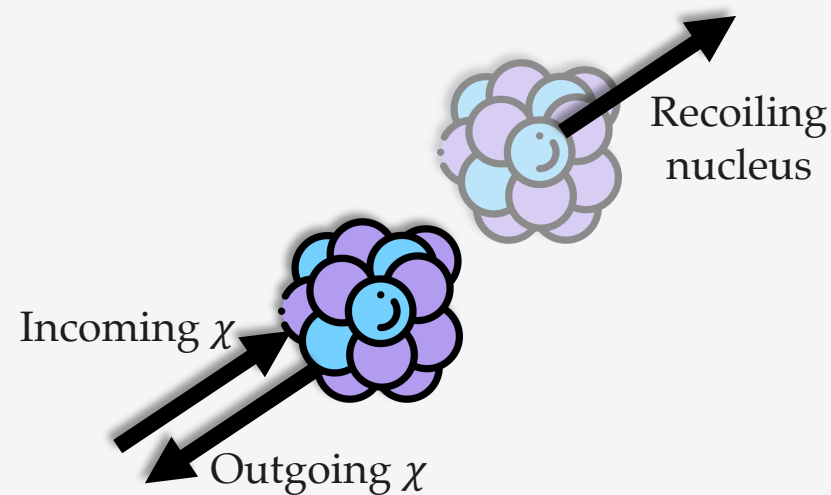
MAIN IDEA



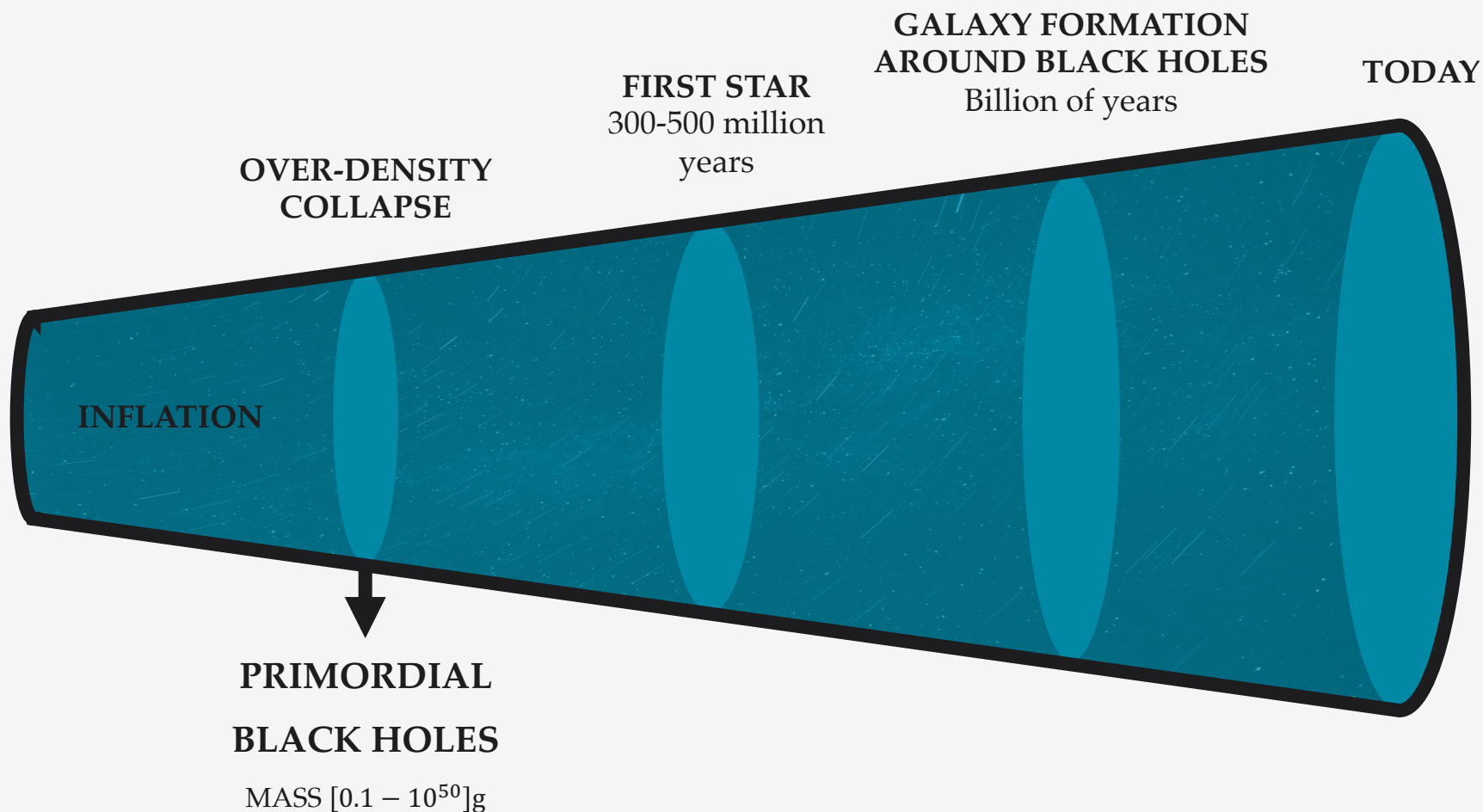
**PRIMORDIAL BLACK HOLES ARE A
SOURCE OF BOOSTED SUB-GEV DARK
MATTER!**



SUB-GEV DARK MATTER!



PRIMORDIAL BLACK HOLES



S. W. Hawking, *Commun.Math.Phys.* 43 (1975) 199-220

B. J. Carr, *Astrophys.J.* 201 (1975) 1-19

J. Auffinger, arXiv: 2206.02672

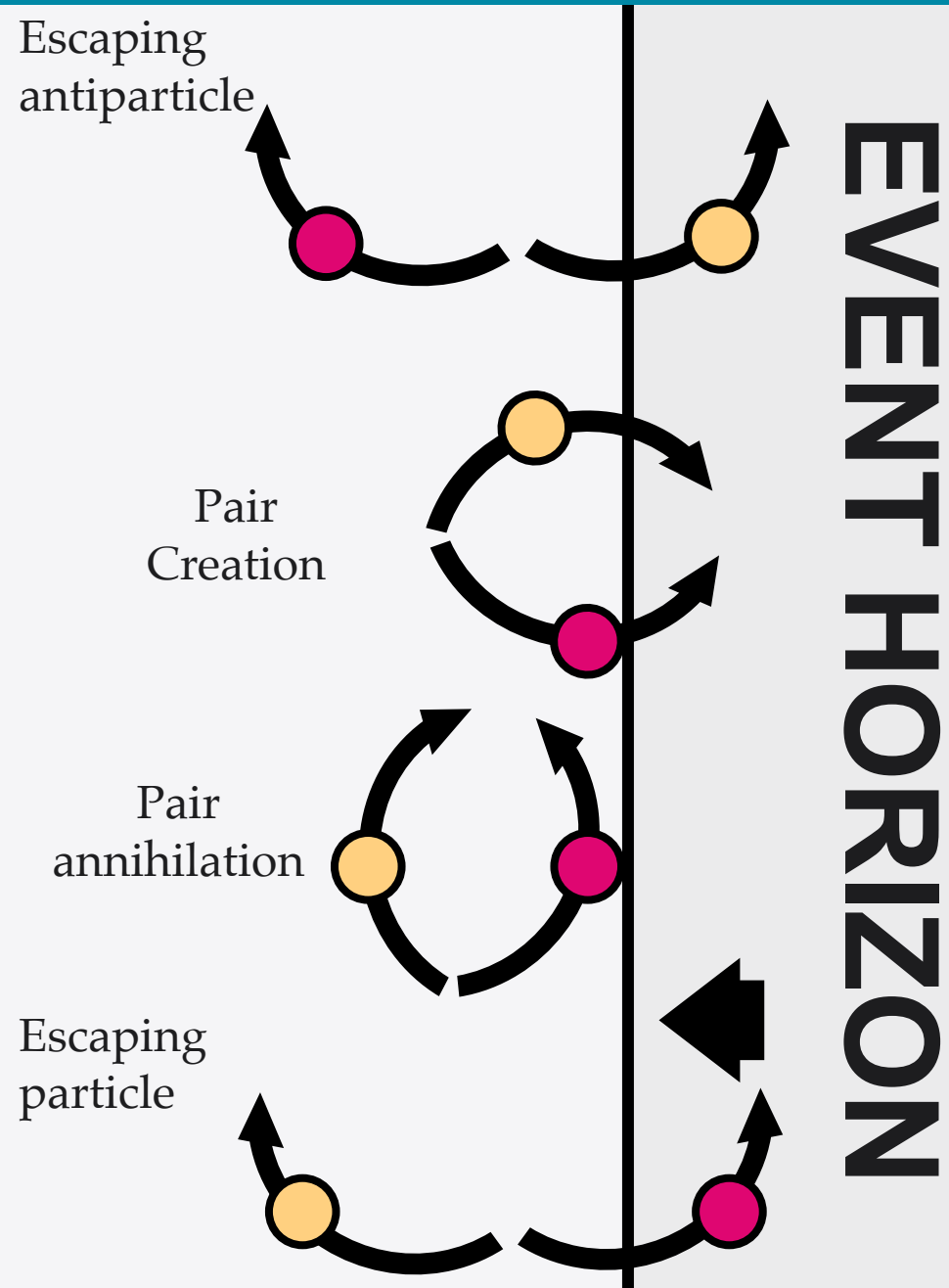
HAWKING RADIATION

Quantum Vacuum fluctuation: empty space is a medium in which particle and antiparticle pairs appear and disappear

$$E_p + E_{\bar{p}} = 0$$

What happens near the event horizon of a Black Hole?

S. W. Hawking, CMP 87 (1983) 577
G.W. Gibbons and S. W. Hawking, PRD 15 (1977)
H. J. Trashen, arXiv gr-qc/0010055



HAWKING RADIATION

Particle's degrees of freedom

Grey-body factor

$$\frac{dN}{dt dE_\chi} = \frac{g_\chi}{2\pi} \frac{\Gamma^\chi(E_\chi, T_{PBH})}{\exp(E_\chi/T_{PBH}) - (-1)^{2s_\chi}}$$

PBH temperature ($\propto 1/M_{PBH}$)

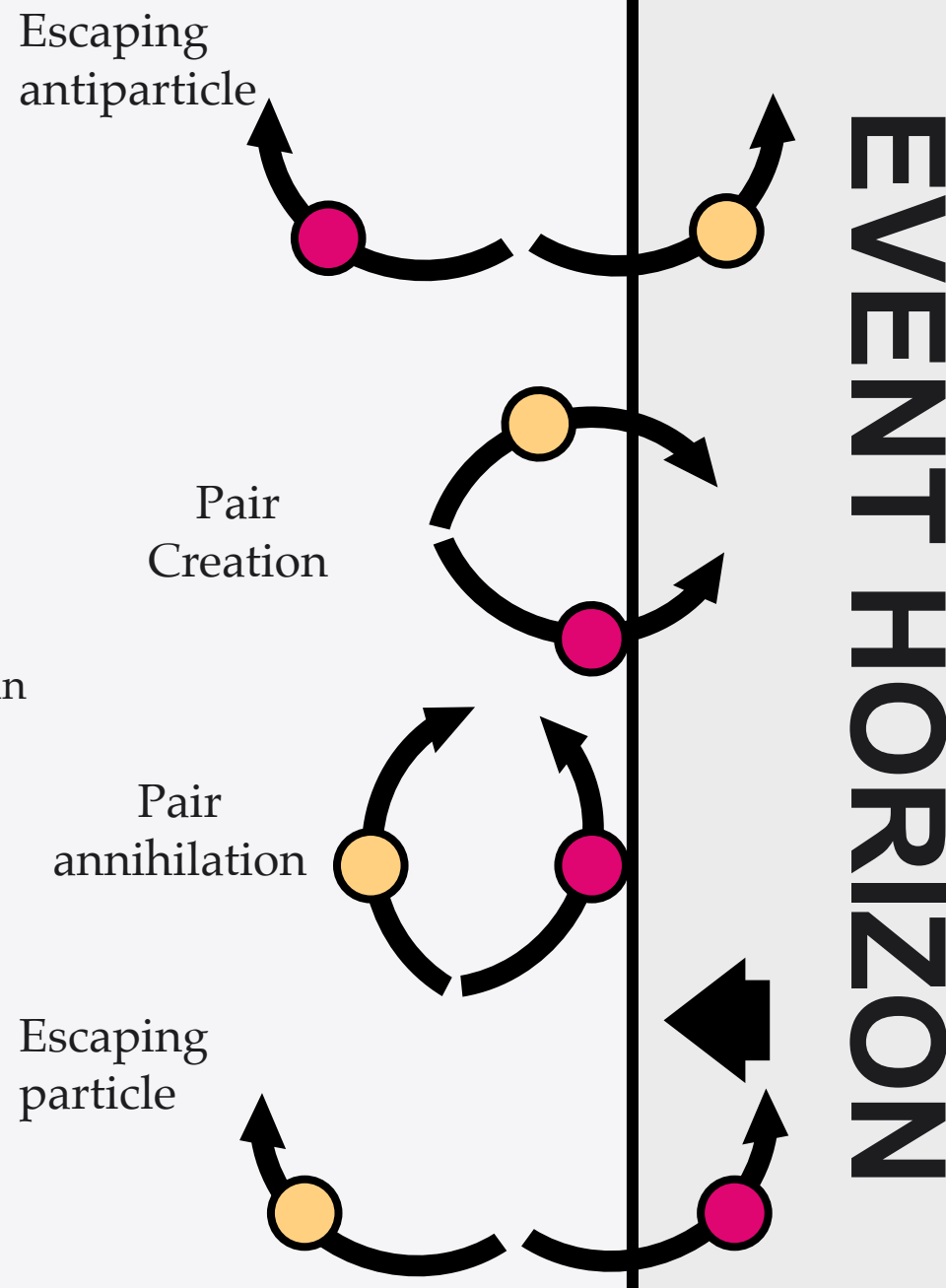
χ Spin

BLACKHAWK (A. Arbey and J. Auffinger, Eur.Phys.J.C 79 (2019), A. Arbey and J. Auffinger, Eur.Phys.J.C 81 (2021), J. Auffinger, Eur.Phys.J.C 82 (2022))

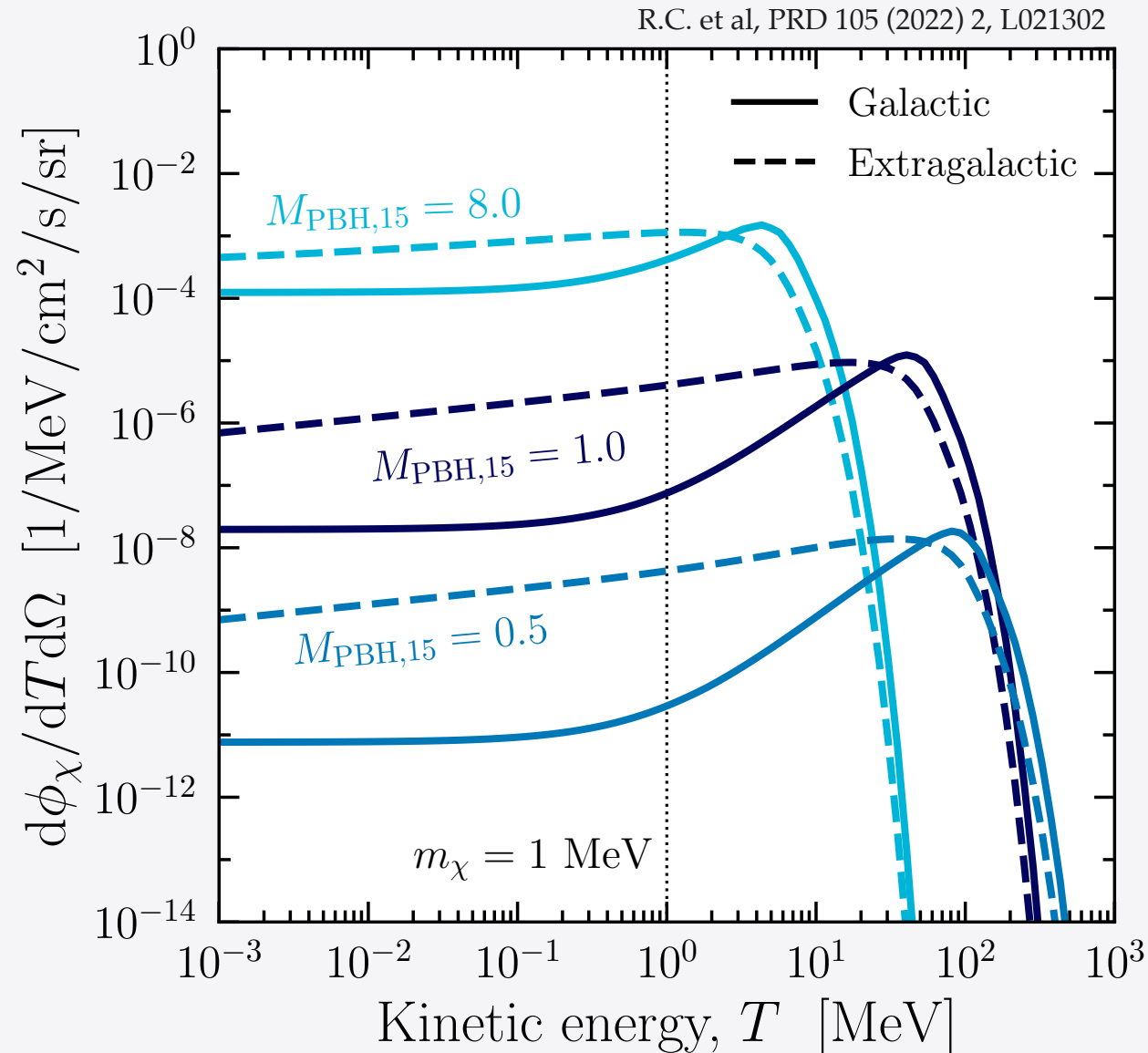
S. W. Hawking, CMP 87 (1983) 577

G.W. Gibbons and S. W. Hawking, PRD 15 (1977)

H. J. Trashen, arXiv gr-qc/0010055



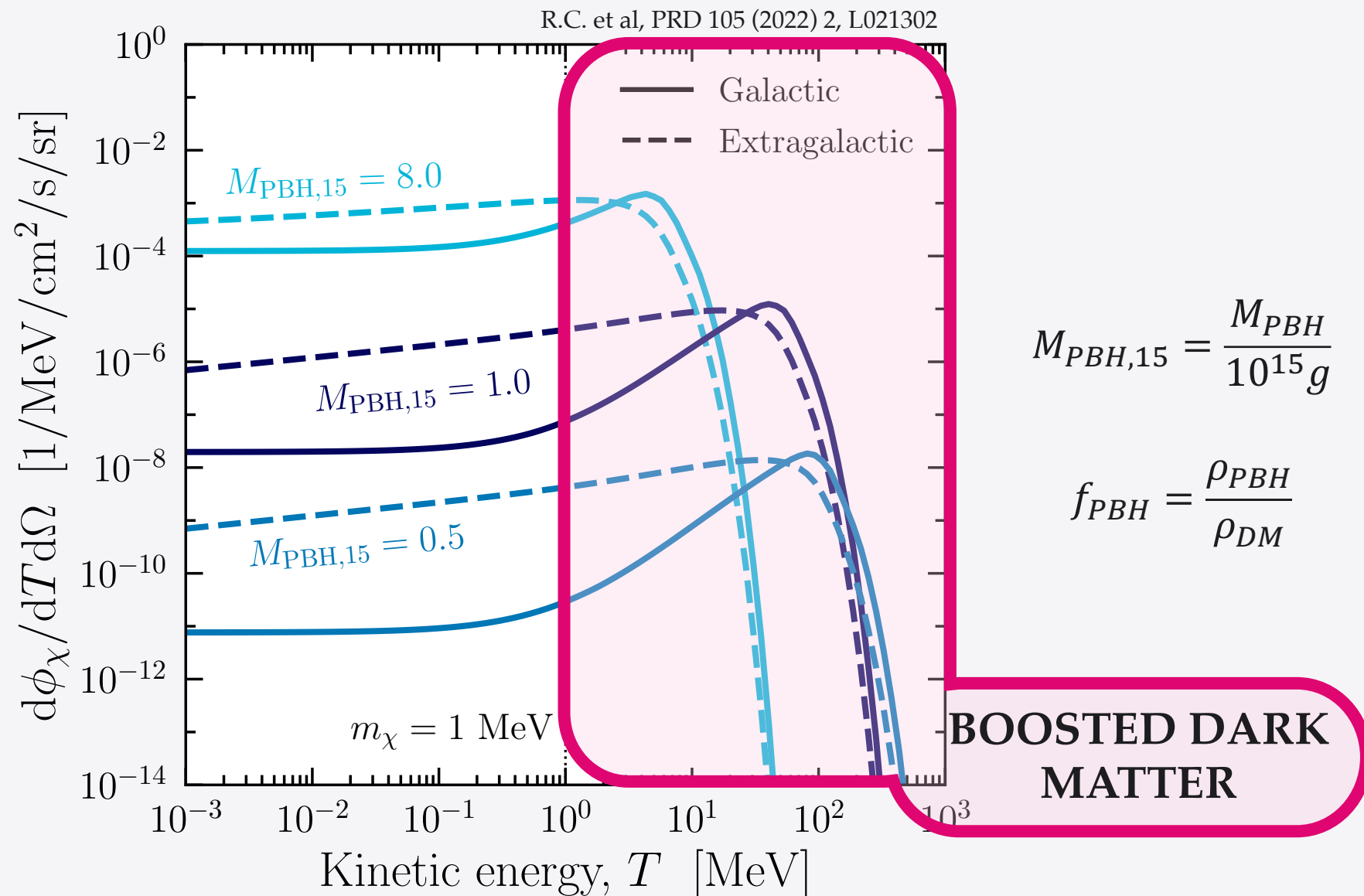
DARK MATTER FLUX FROM PBHS



$$M_{PBH,15} = \frac{M_{PBH}}{10^{15} g}$$

$$f_{PBH} = \frac{\rho_{PBH}}{\rho_{DM}}$$

DARK MATTER FLUX FROM PBHS



EVENT RATE

The differential event rate (number of events per ton year) per Xenon recoil energy E_r can be obtained as

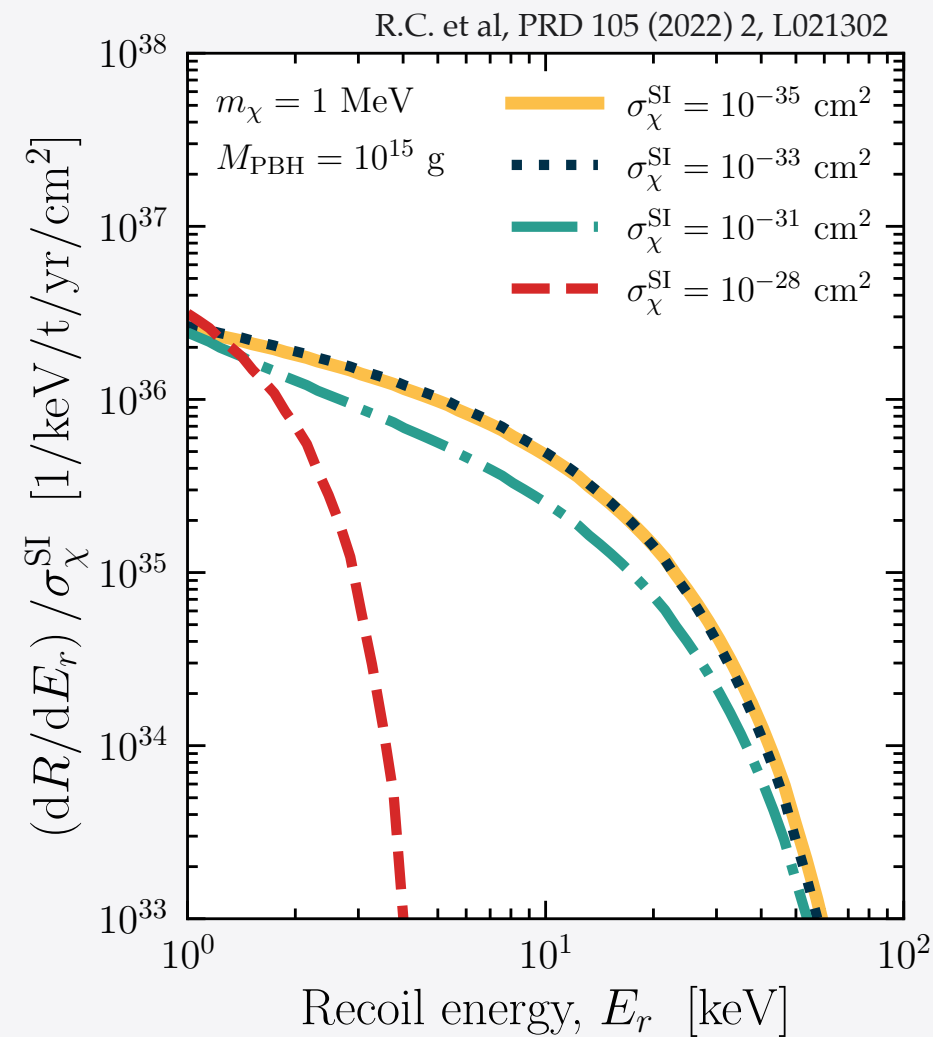
$$\frac{dR}{dE_r} = \sigma_{\chi\text{Xe}} N_{\text{Xe}} \int dT_d d\Omega \frac{d\phi_{\chi}^d}{dT_d d\Omega} \frac{\Theta(E_r^{\max} - E_r)}{E_r^{\max}}$$

$E_r^{\max} = \frac{T_d + 2m_{\chi}T_d}{T_d + (m_{\chi} + m_{\text{Xe}})^2/(2m_{\text{Xe}})}$

Attenuated Dark Matter flux (pointing to $d\phi_{\chi}^d$)
 Propagation effects (pointing to $E_r^{\max}$)

Propagation effects are relevant for cross-sections $\gtrsim 10^{-31} \text{cm}^2$

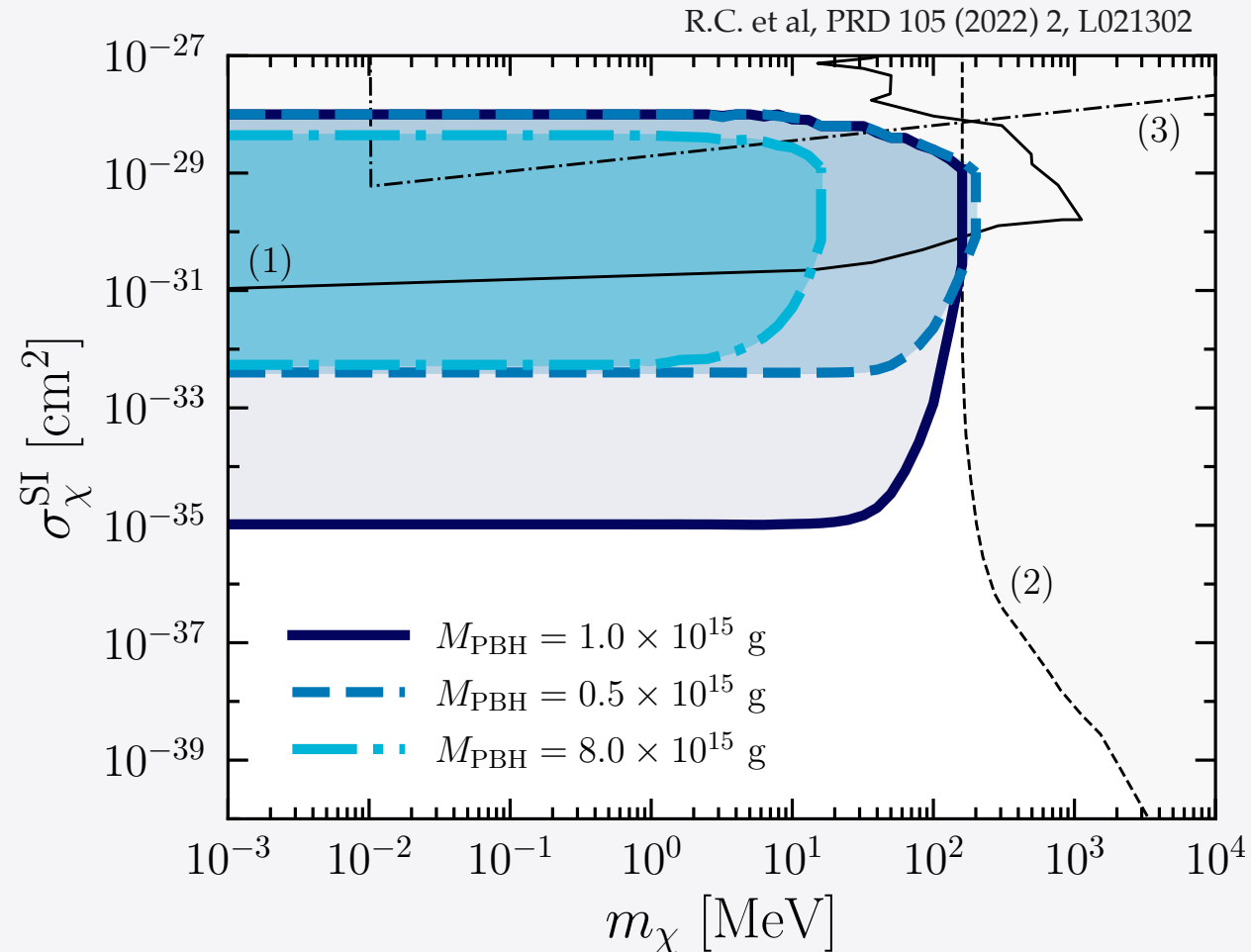
$$\frac{dR}{dE_r} \propto f_{\text{PBH}} \sigma_{\chi}^{\text{SI}} \quad \text{if } \sigma_{\chi\text{Xe}} < 10^{-31} \text{cm}^2$$



CONSTRAINTS

We obtained constraints on the σ_{χ}^{SI} from the non observation of excess in XENON1T for $E_r \in [4.9 - 40.9]\text{keV}$

- (1) Cosmic Rays up-scatterings (T. Bringmann and M. Pospelov, PRL 2019; Christopher Cappiello and John F. Beacom, PRD 2019);
- (2) CRESST experiment (G. Angloher et al, EPJC 2017; A. H. Abdelhameed et al, PRD 2019);
- (3) Cosmology (V. Gluscevic and K. K. Boddy, PRL 2018; W. L. Xu et al, PRD 2018; T. R. Slatyer and C. L. Wu, PRD 2018; E. O. Nadler et al, AJL 2019).

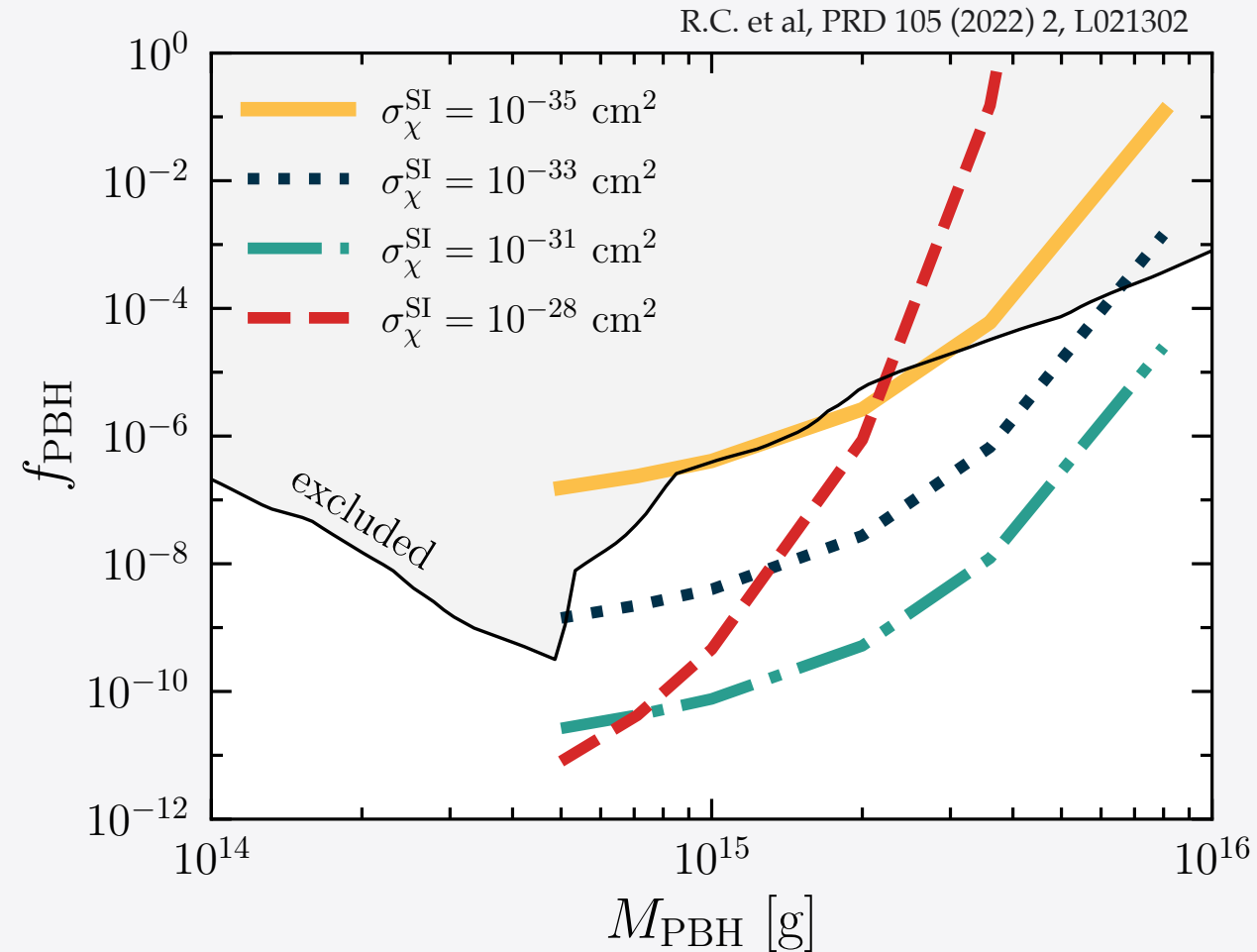


CONSTRAINTS

Assuming the existence of χ , we constraint
Primordial Black Holes abundance.

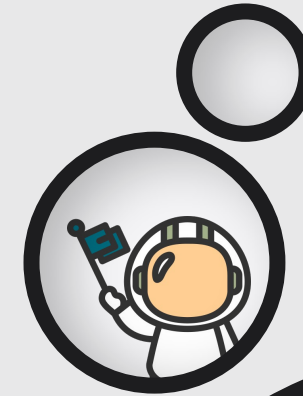
$$f_{PBH} = \frac{\rho_{PBH}}{\rho_{DM}}$$

Grey region: B. Carr et al, Rept.Prog.Phys. 84 21) 11, 116902



CONCLUSIONS & OUTLOOKS

- ★ **Primordial Black Holes as a source of Boosted light Dark Matter**
- ★ We limit $\sigma_{\chi X e}^{SI}$ assuming Primordial Black Holes existence
- ★ We constrain Primordial Black Holes abundance assuming χ existence

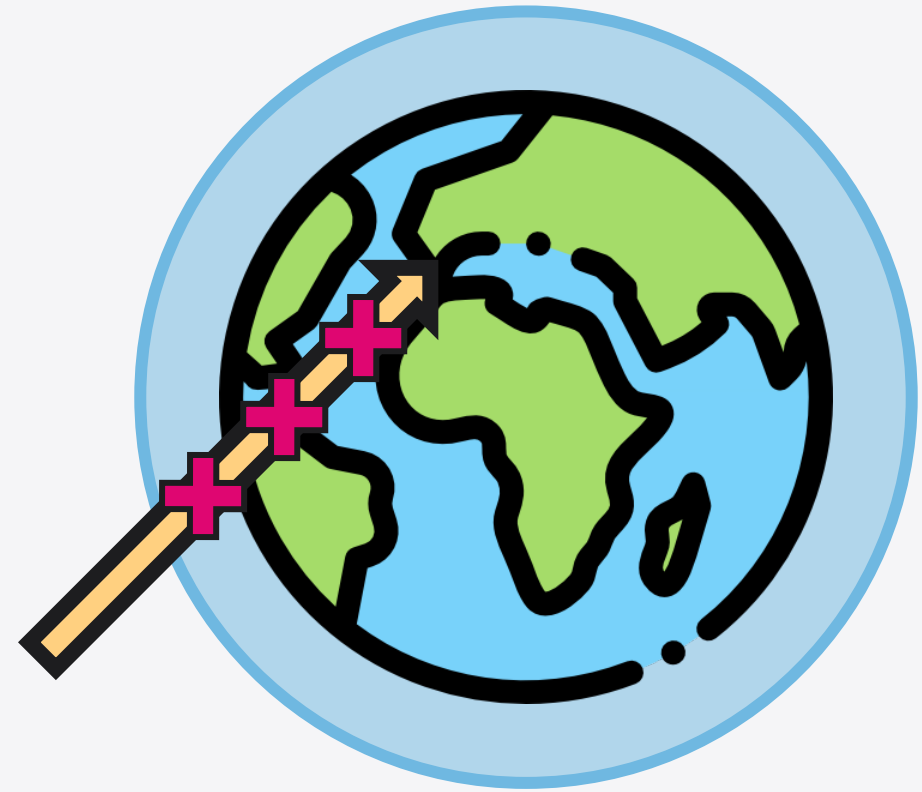
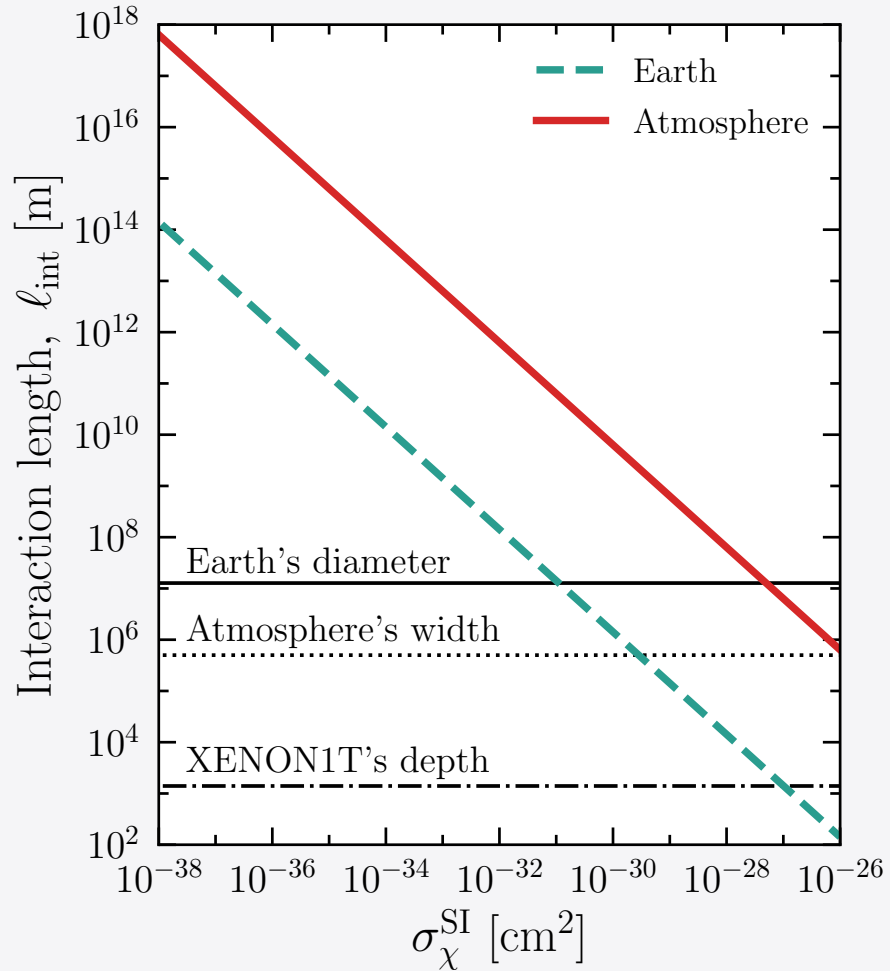


*Thank you for
your attention!*

BACKUP SLIDES

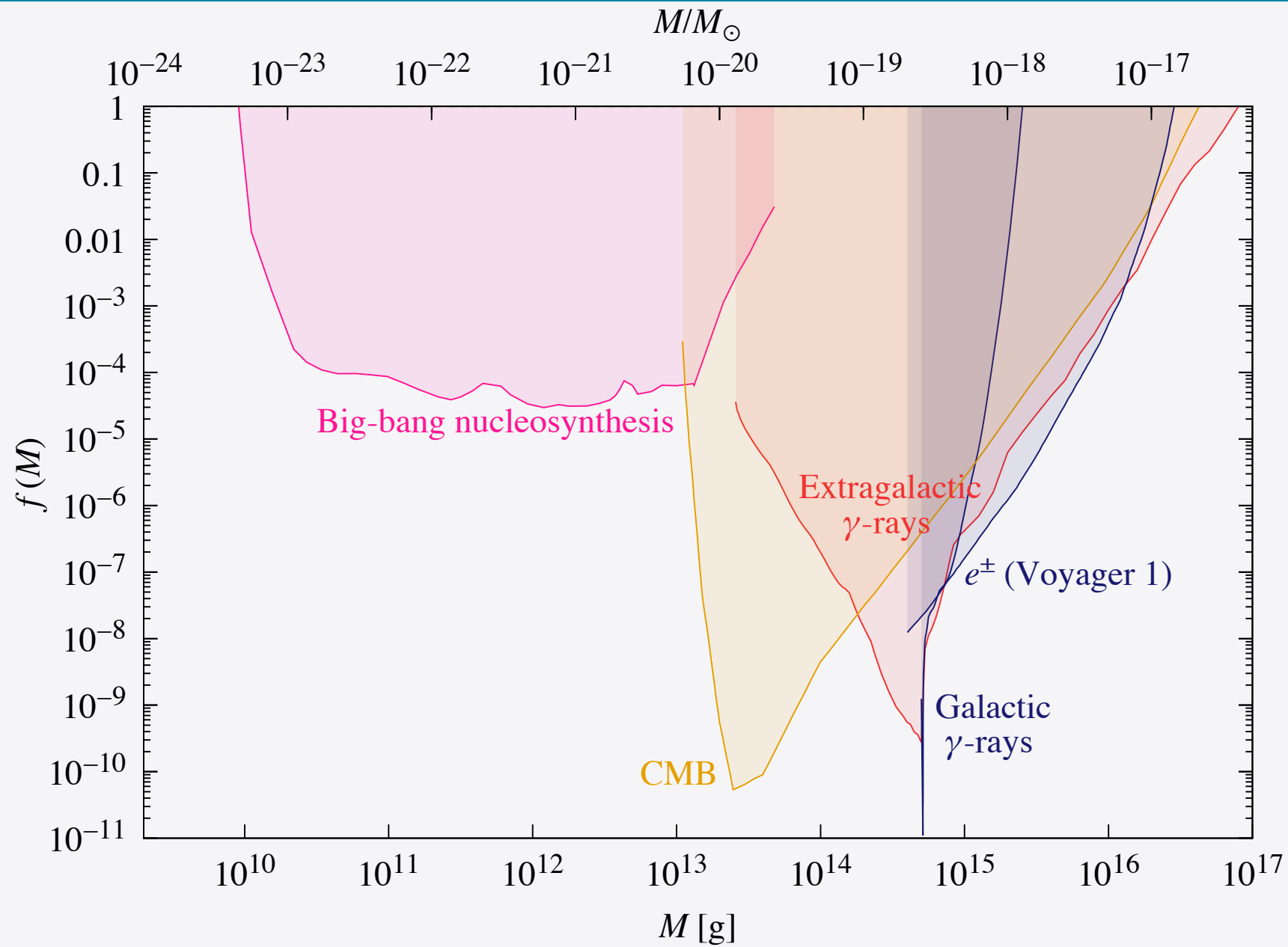
FLUX ATTENUATION

We analytically account for the energy loss of DM particles in the ballistic-trajectory approximation.



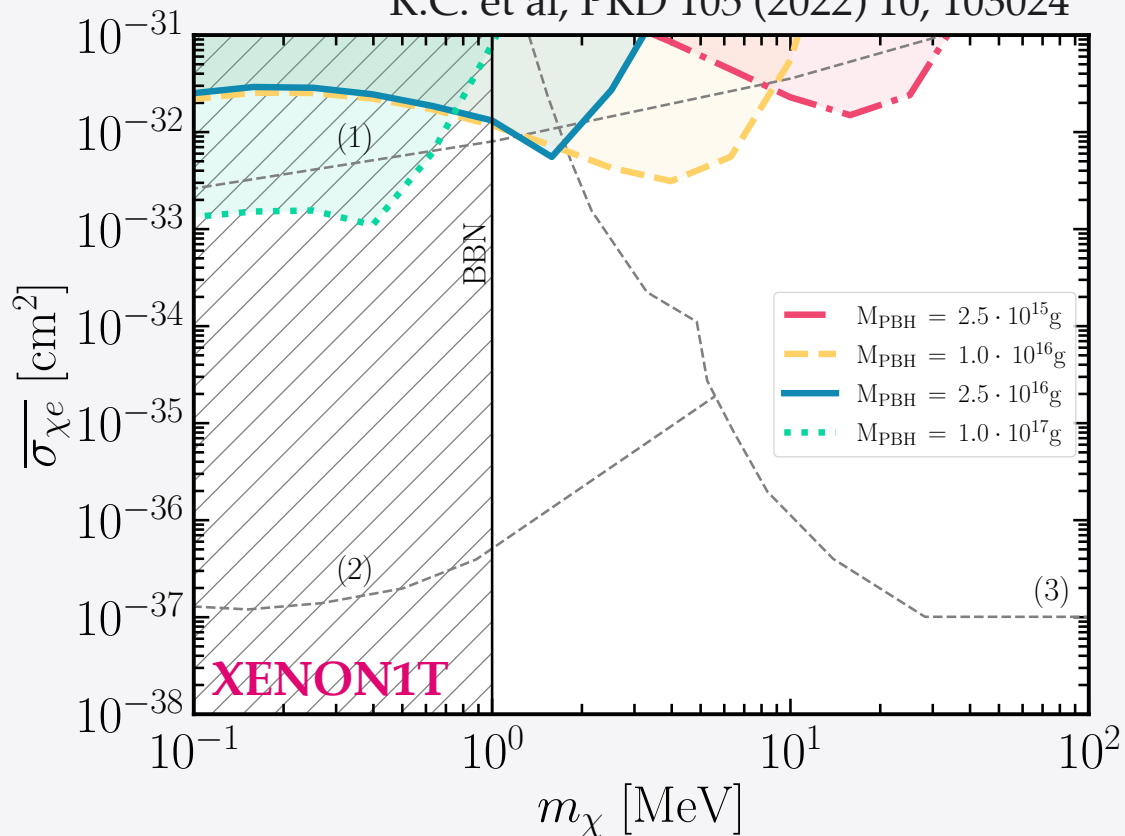
G. D. Starkman et al, PRD (1990)
G. D. Mack et al, PRD (2007)
B. J. Kavanagh et al, JCAP (2017)

T. Emken, C. Kouvaris, PRD (2018)
T. Bringmann and M. Pospelov, PRL (2019)



$e - \chi$ INTERACTION

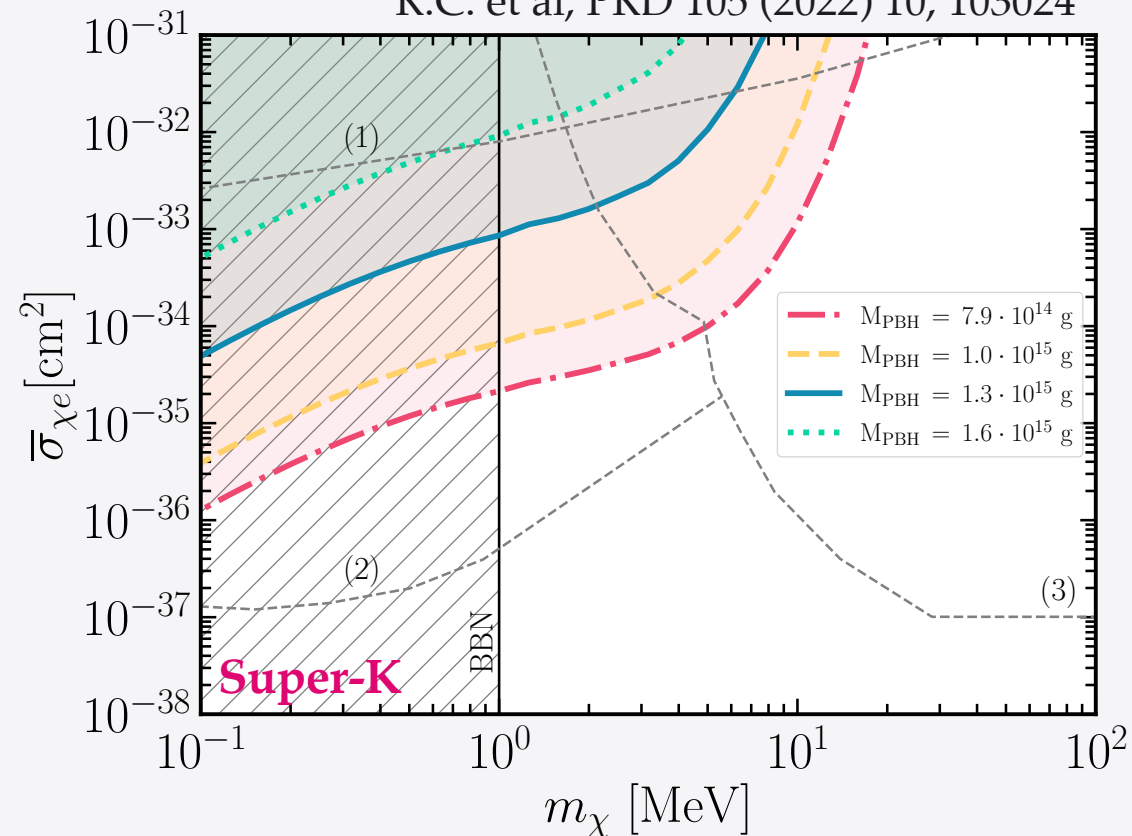
R.C. et al, PRD 105 (2022) 10, 103024



(1) boosted dark matter from cosmic-ray up-scatterings (C. Cappiello and J. Beacom, PRD 2019)

(2) Solar reflection with XENON1T (H. An et al, PRL 2018)

R.C. et al, PRD 105 (2022) 10, 103024



(3) combined constraints from direct detection experiments (C. Cappiello and J. Beacom, PRD 2019)

BBN: Big Bang Nucleosynthesis constraints (B. Henning and H. Murayama, arXiv:1205.647)