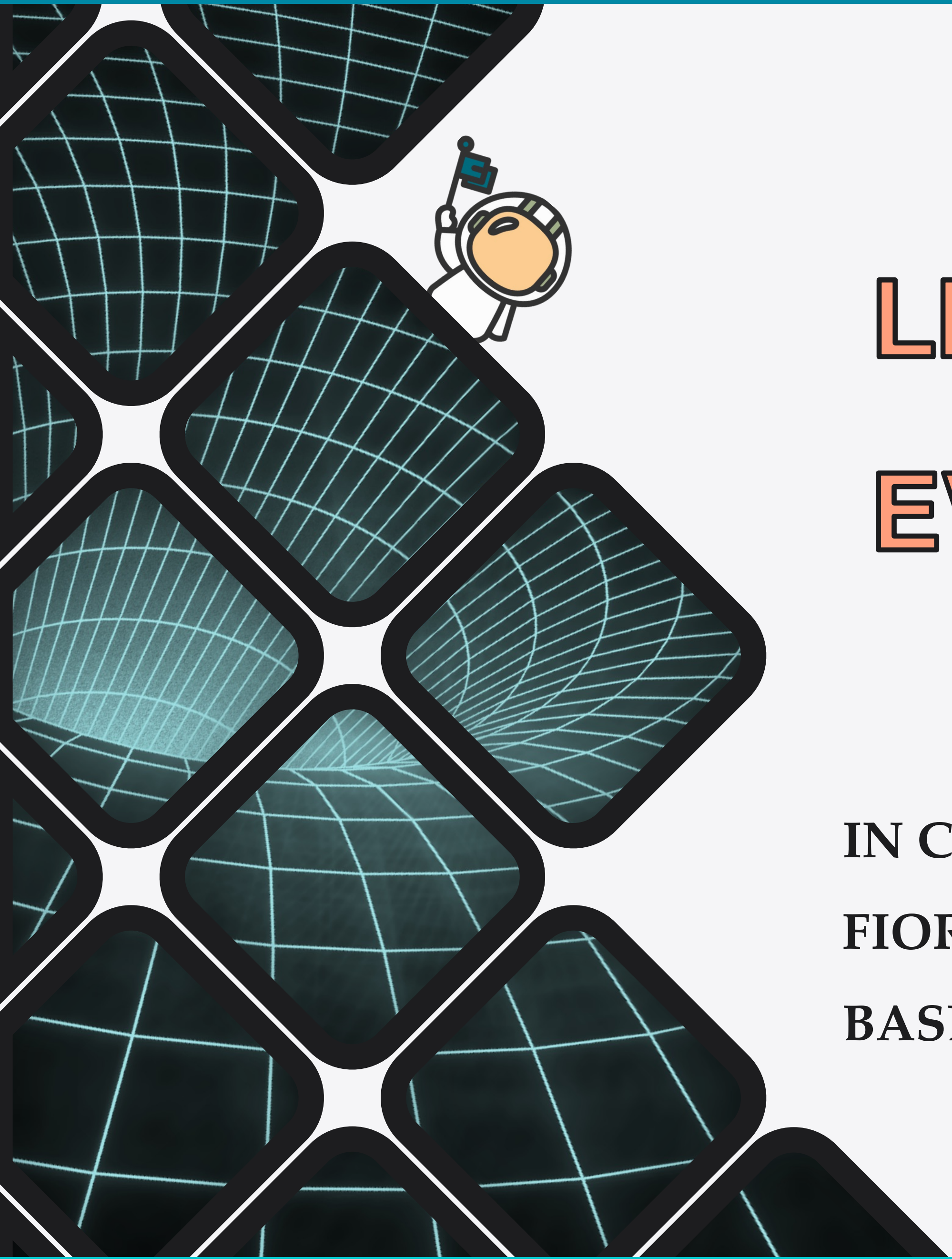


DIRECT DETECTION OF LIGHT DARK MATTER FROM EVAPORATING PRIMORDIAL BLACK HOLES

IN COLLABORATION WITH: M. CHIANESE, D. F. G. FIORILLO, N. SAVIANO

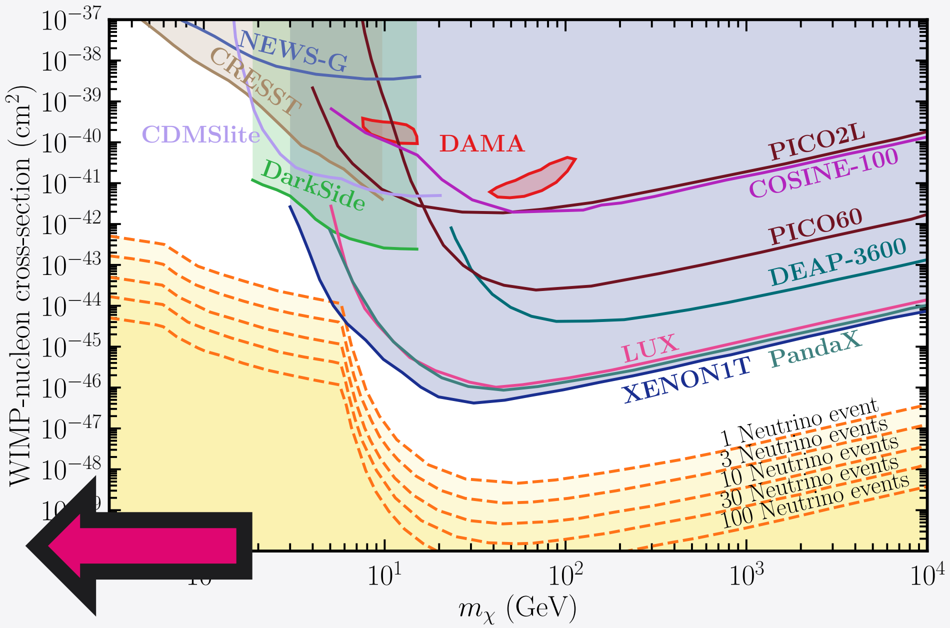
BASED ON:

PHYSICAL REVIEW D 105 (2022) 2, L021302

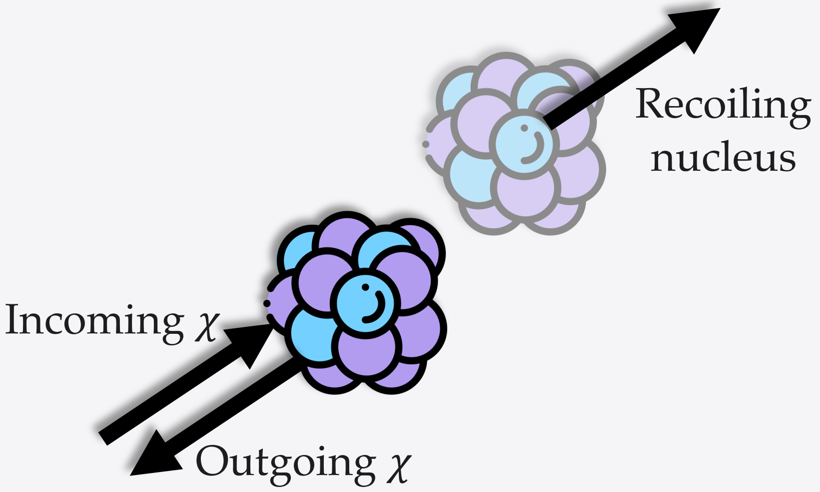
PHYSICAL REVIEW D 105 (2022) 10, 103024

rcalabrese@na.infn.it

MAIN IDEA

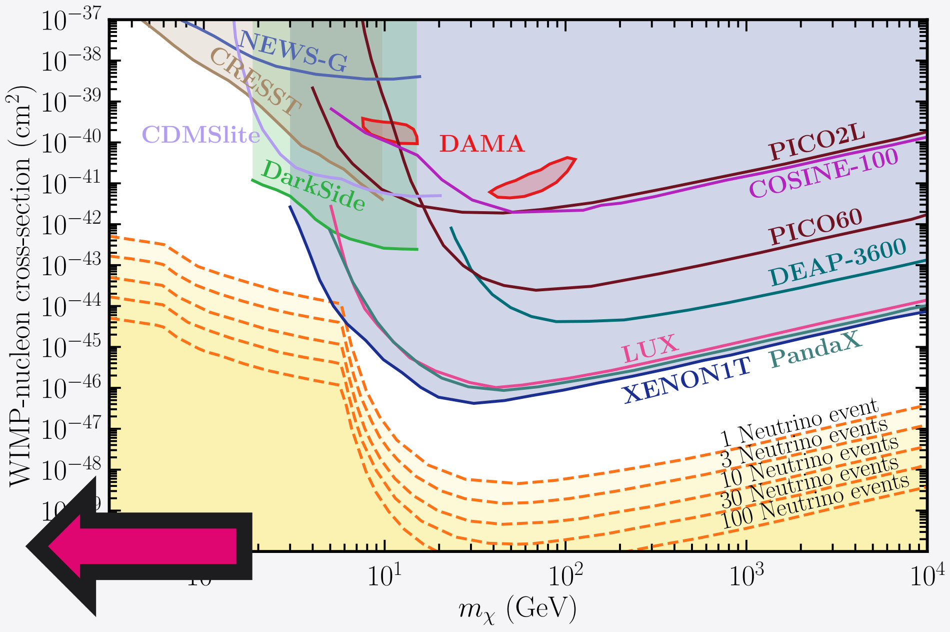


SUB-GEV DARK MATTER!

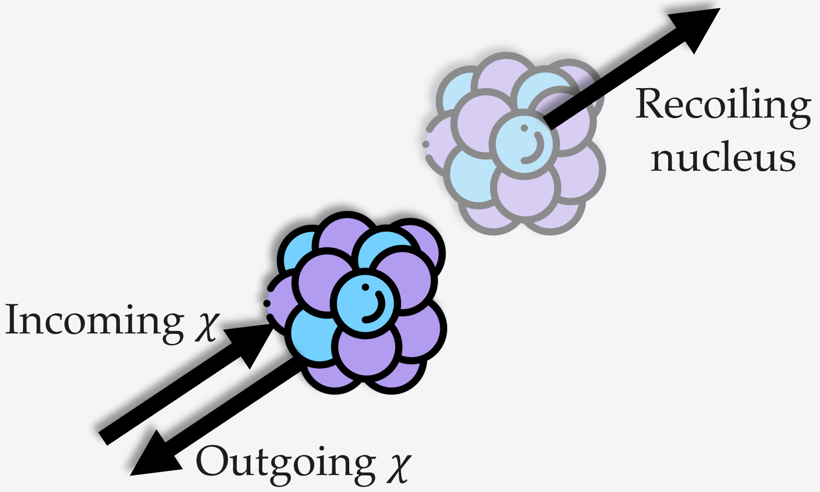


MAIN IDEA

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

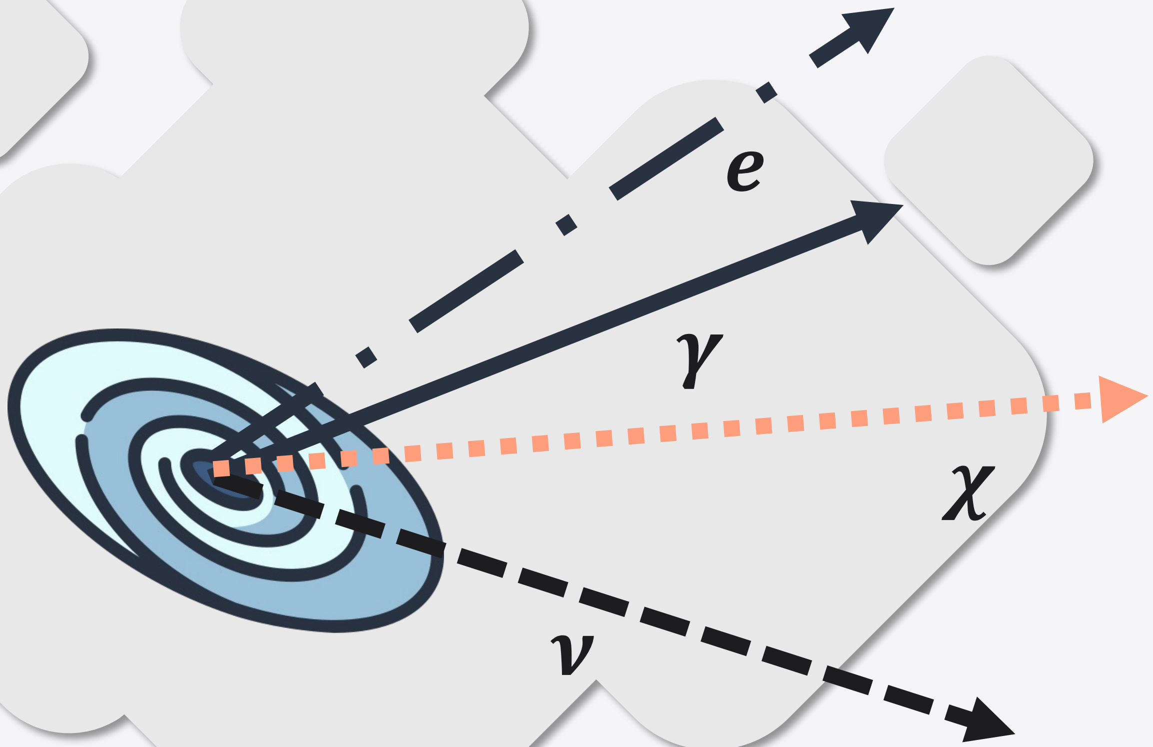


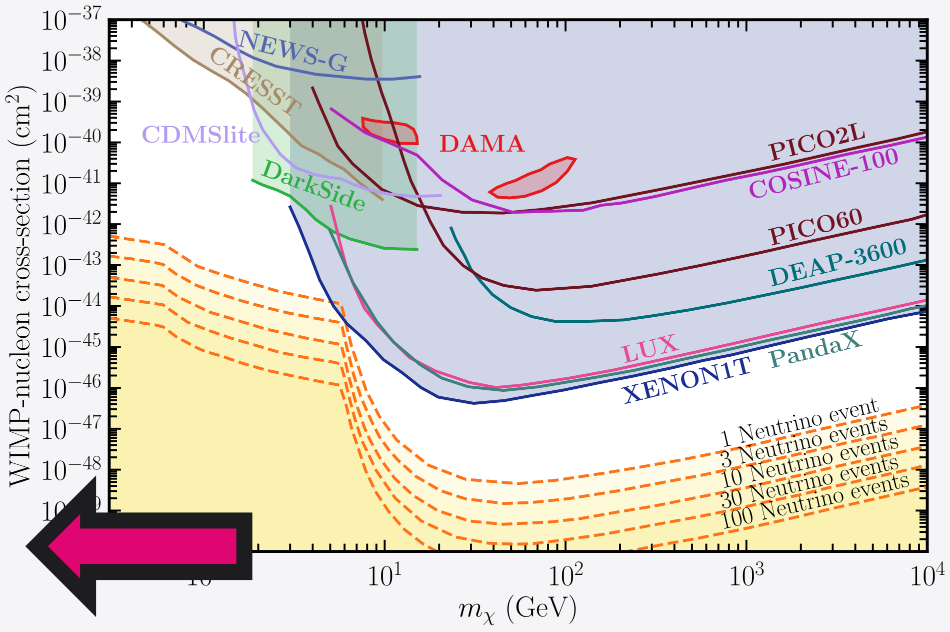
SUB-GEV DARK MATTER!



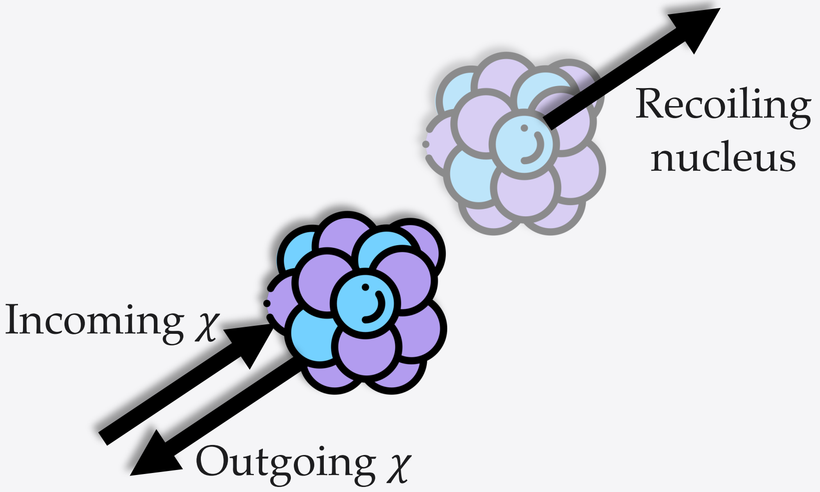
K. Agashe et al, JCAP 10, 062 (2014)
G. F. Giudice et al, PLB 780, 543-552 (2018)

MAIN IDEA



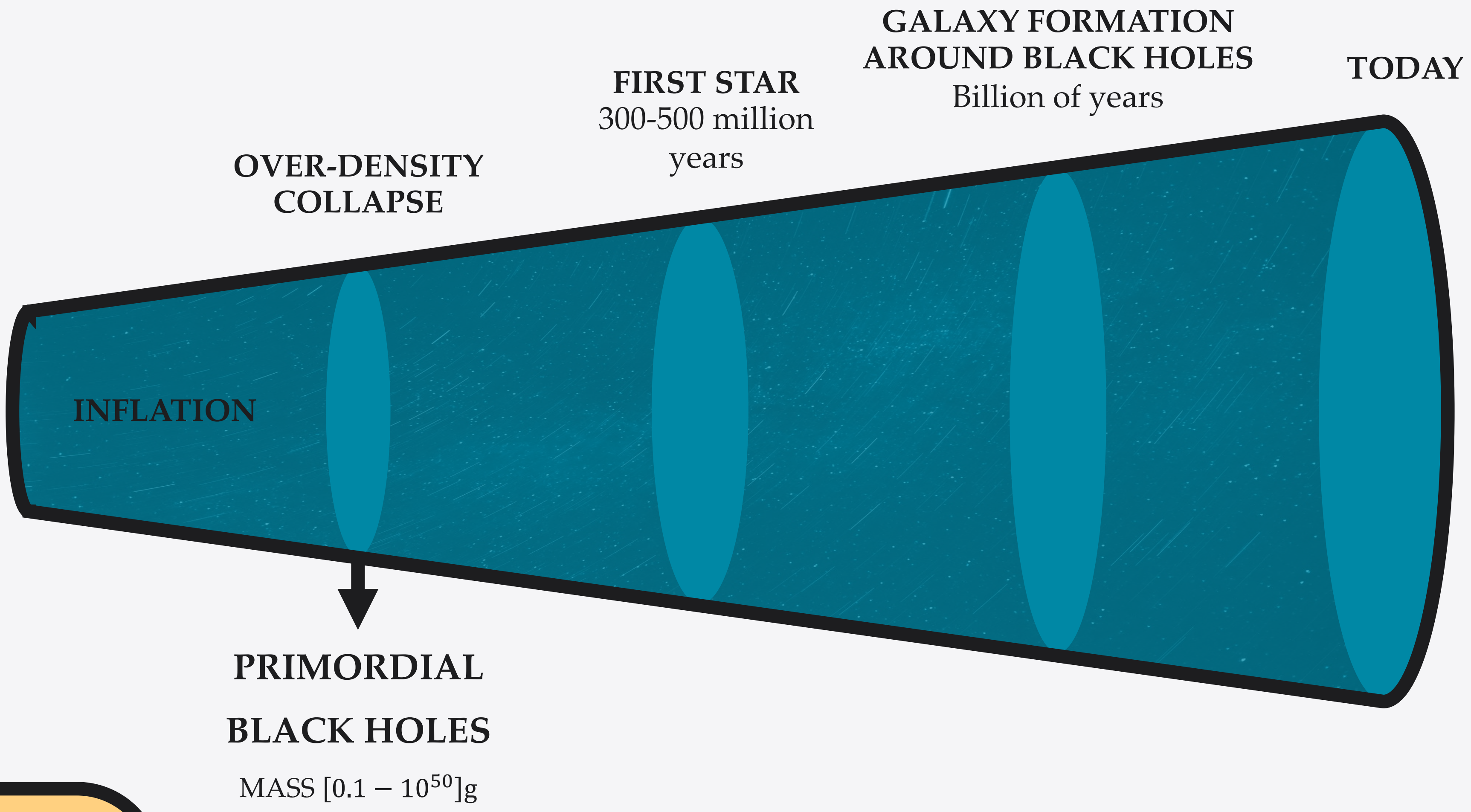


SUB-GEV DARK MATTER!



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

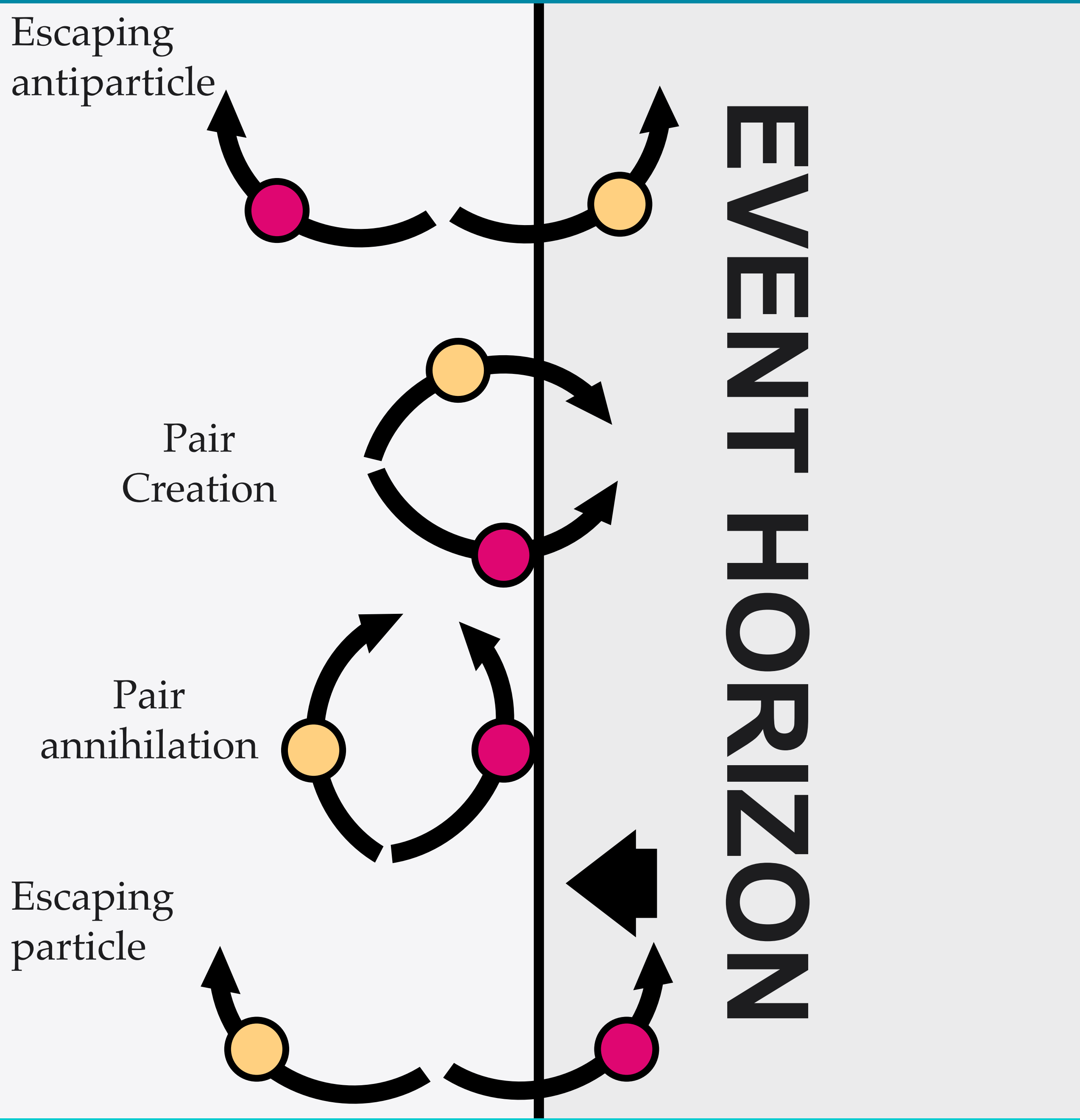
PRIMORDIAL BLACK HOLES



See also P. D. Serpico Talk!!!

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

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

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

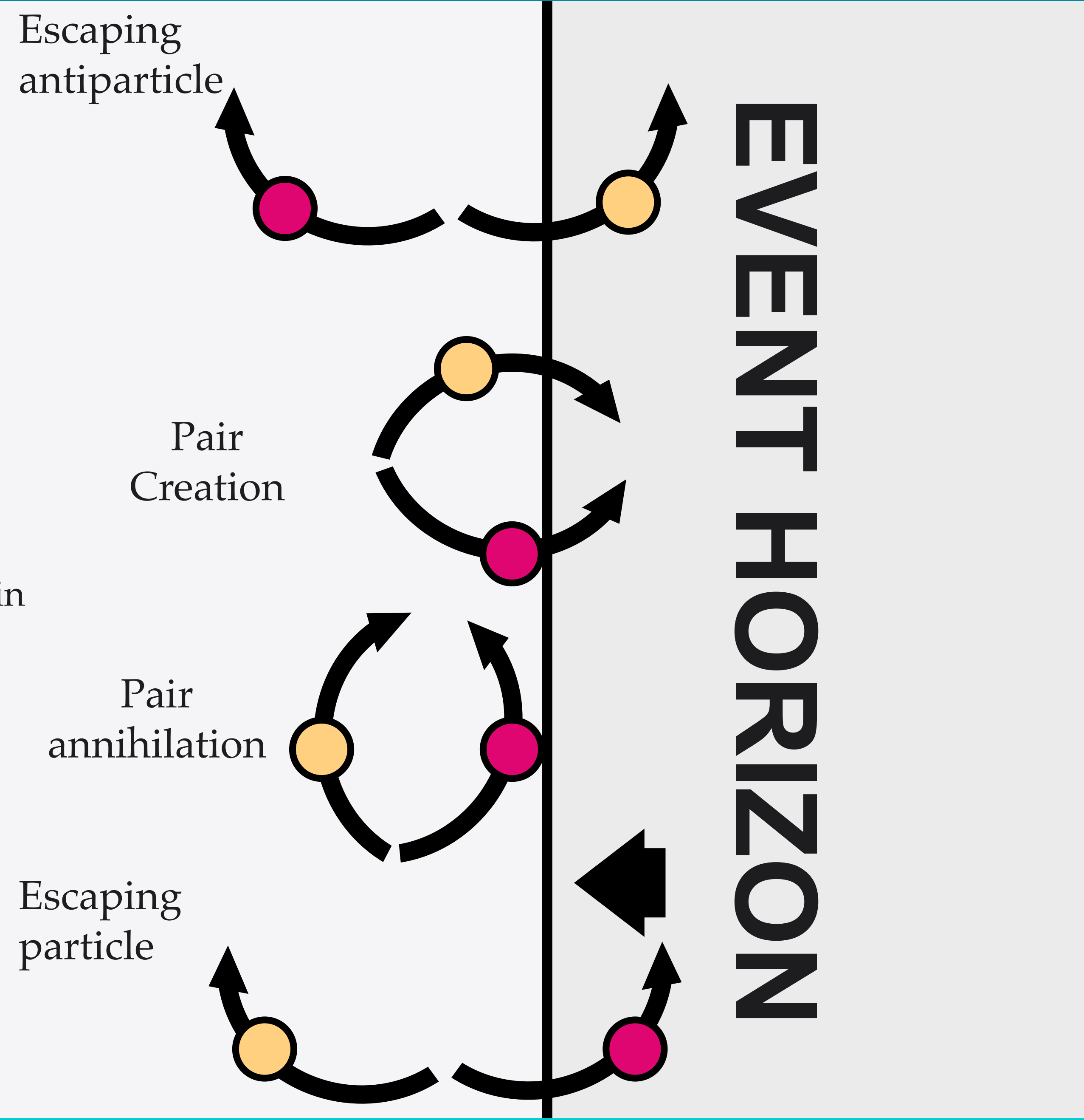
Particle's degrees of freedom

Grey-body factor

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

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

χ Spin

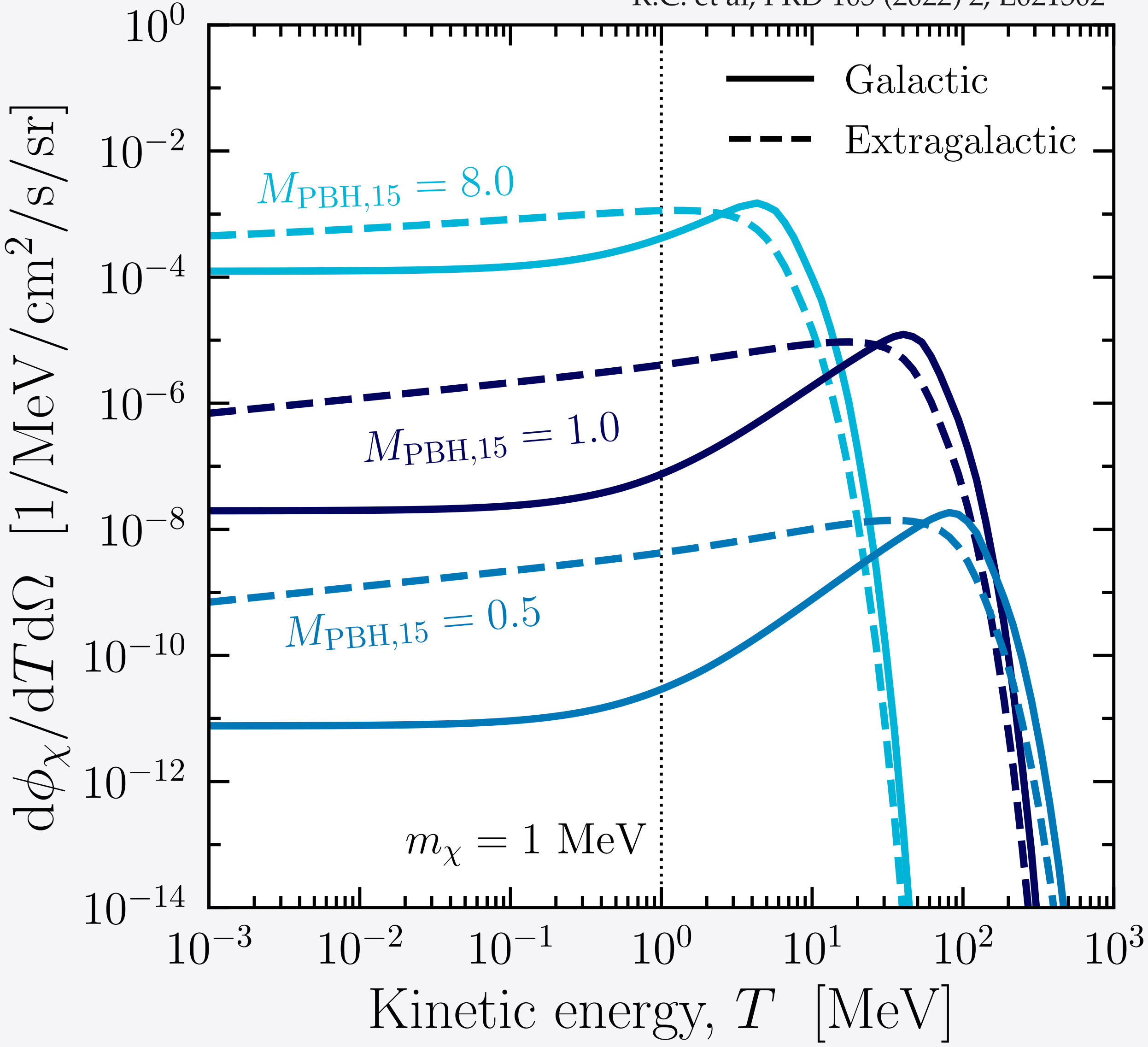


BLACKHAWK (A. Arbey and J. Auffinger, Eur.Phys.J.C 79 (2019), A. Arbey and J. Auffinger, Eur.Phys.J.C 81 (2021) ,J. Auffinger, Eur.Phys.J.C 82 (2022))

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

R.C. et al, PRD 105 (2022) 2, L021302

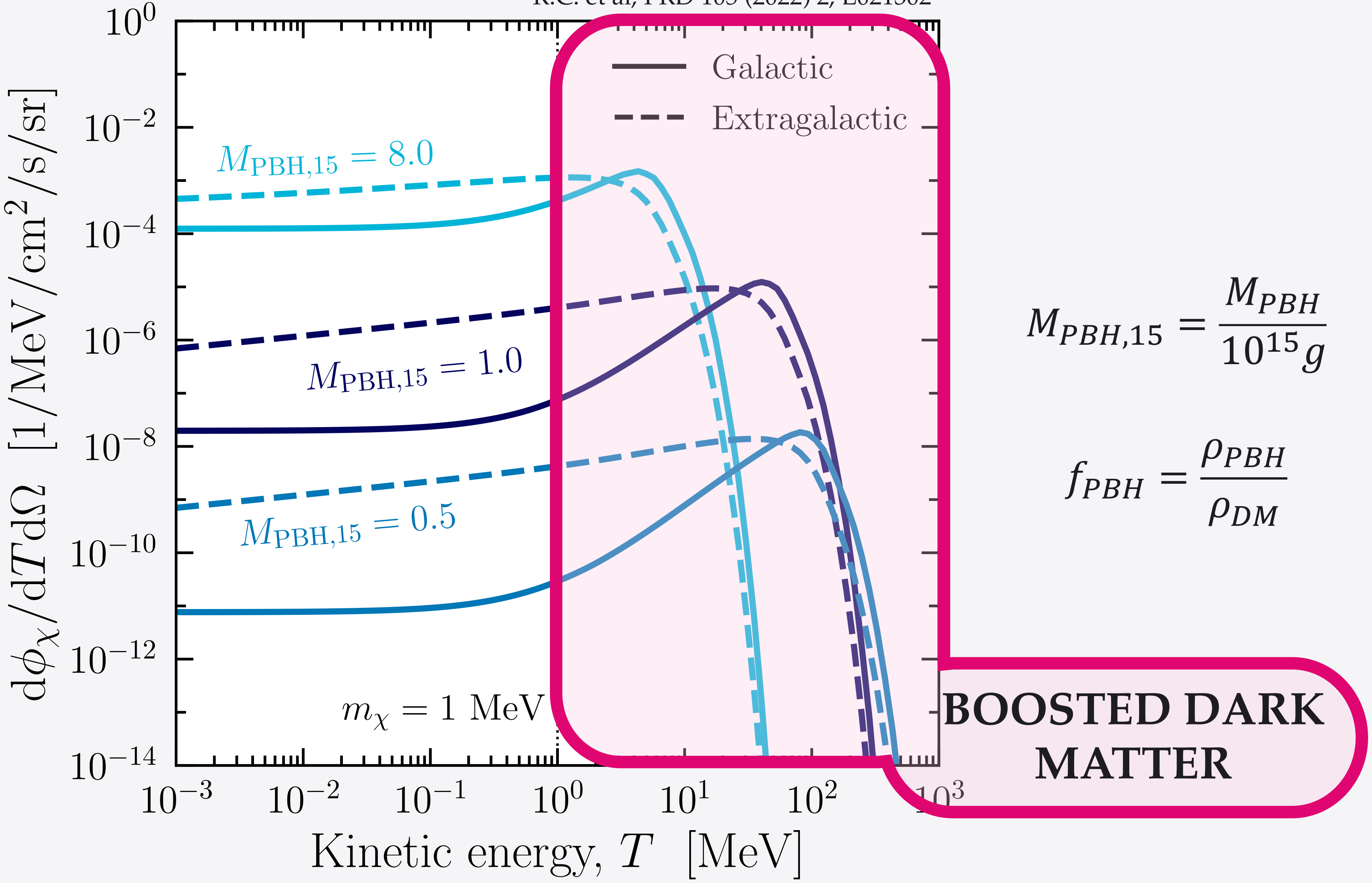


$$M_{PBH,15} = \frac{M_{PBH}}{10^{15} g}$$

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

DARK MATTER FLUX FROM PBHS

R.C. et al, PRD 105 (2022) 2, L021302



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

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

EVENT RATE

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

Attenuated Dark Matter flux

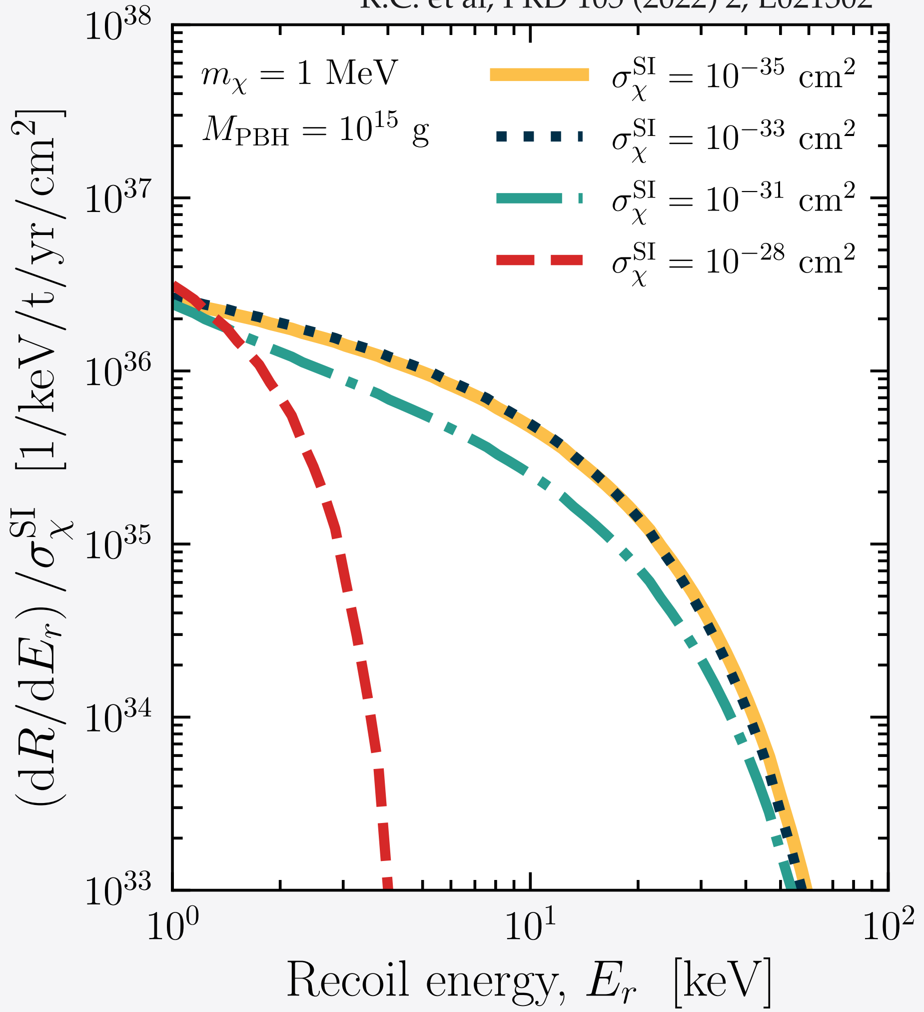
$$\frac{dR}{dE_r} = \sigma_{\chi Xe} N_{Xe} \int dT_d \, d\Omega \, \frac{d\phi_\chi^d}{dT_d d\Omega} \frac{\Theta(E_r^{max} - E_r)}{E_r^{max}}$$

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

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

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

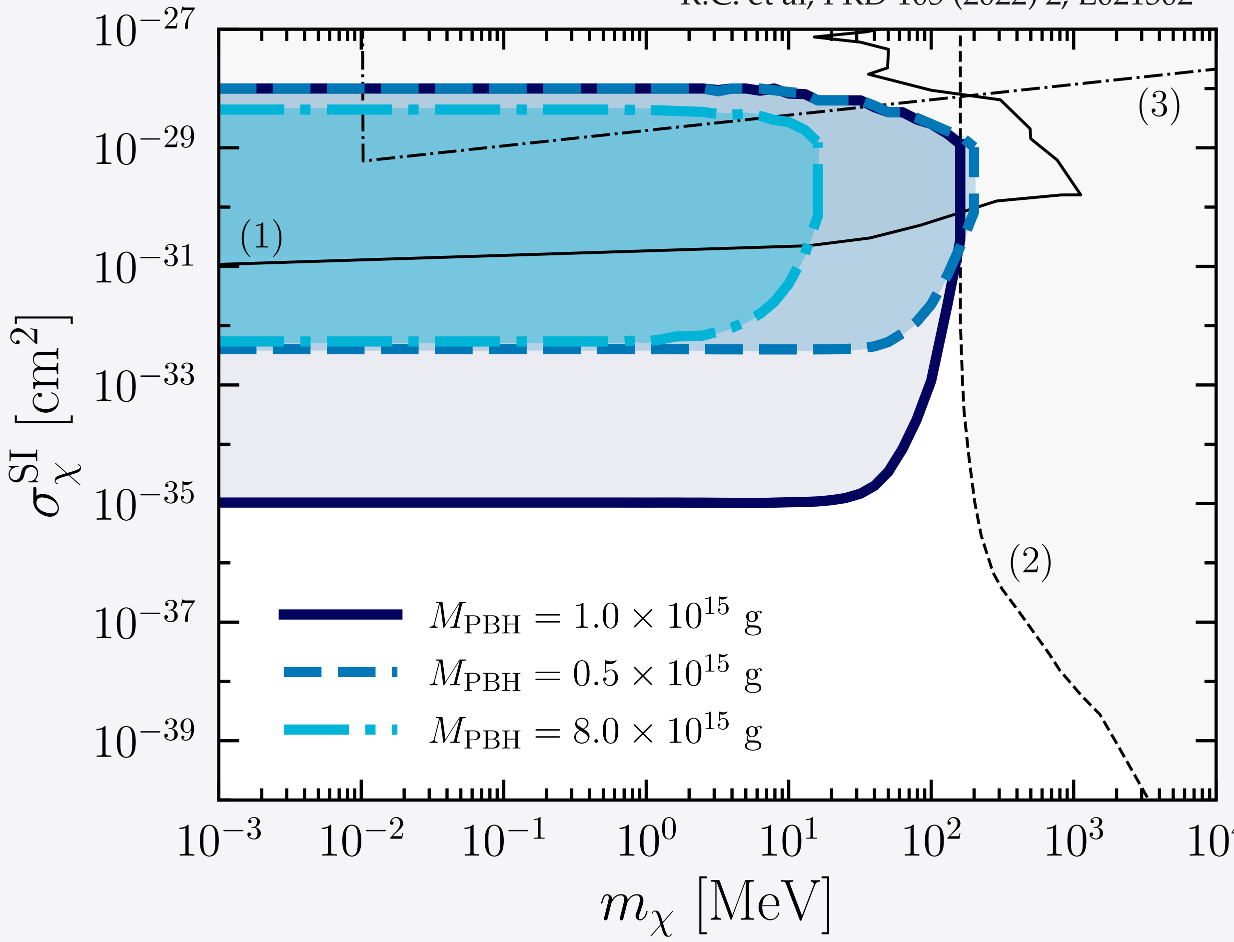
R.C. et al, PRD 105 (2022) 2, L021302



CONSTRAINTS

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

R.C. et al, PRD 105 (2022) 2, L021302



(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).

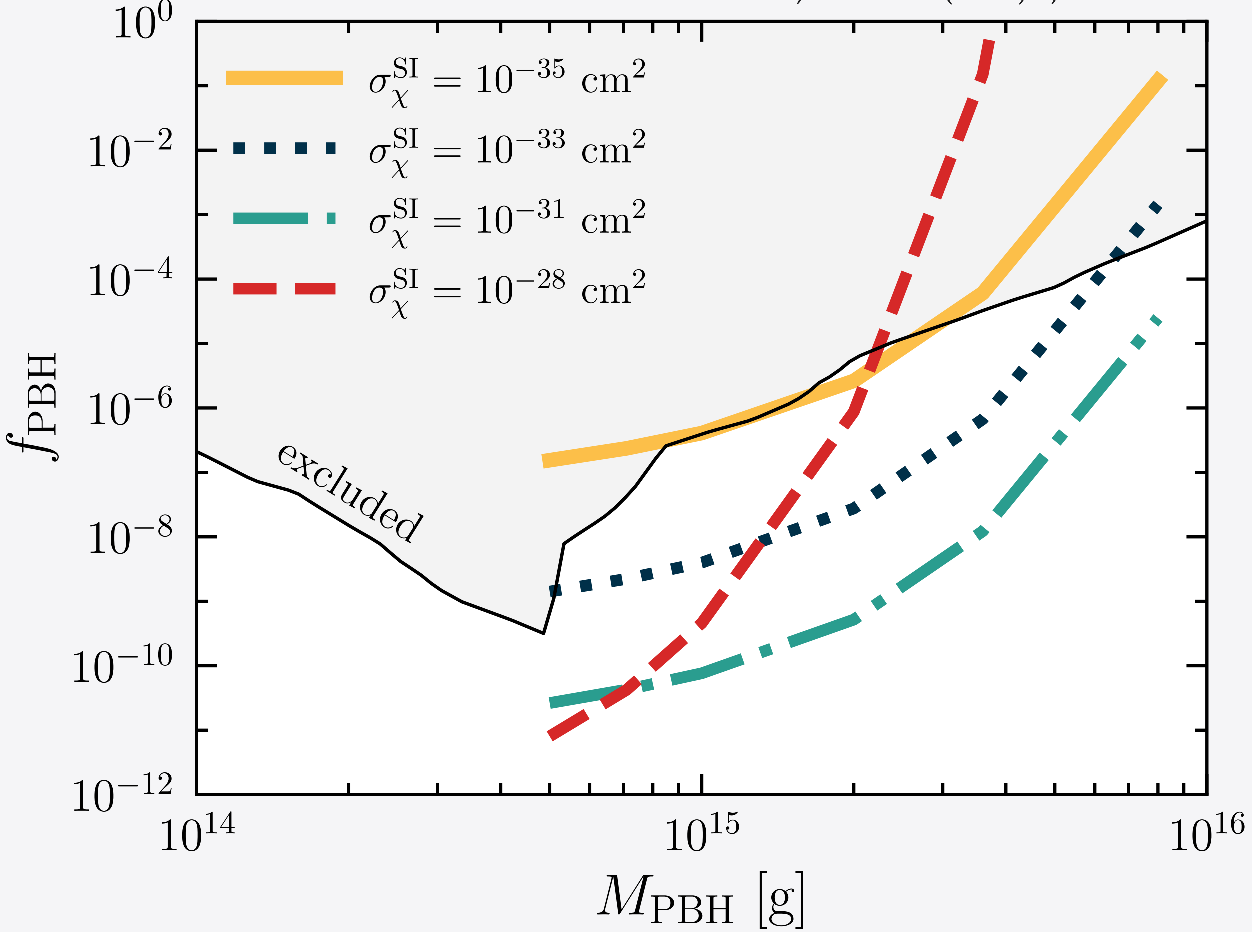
CONSTRAINTS

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

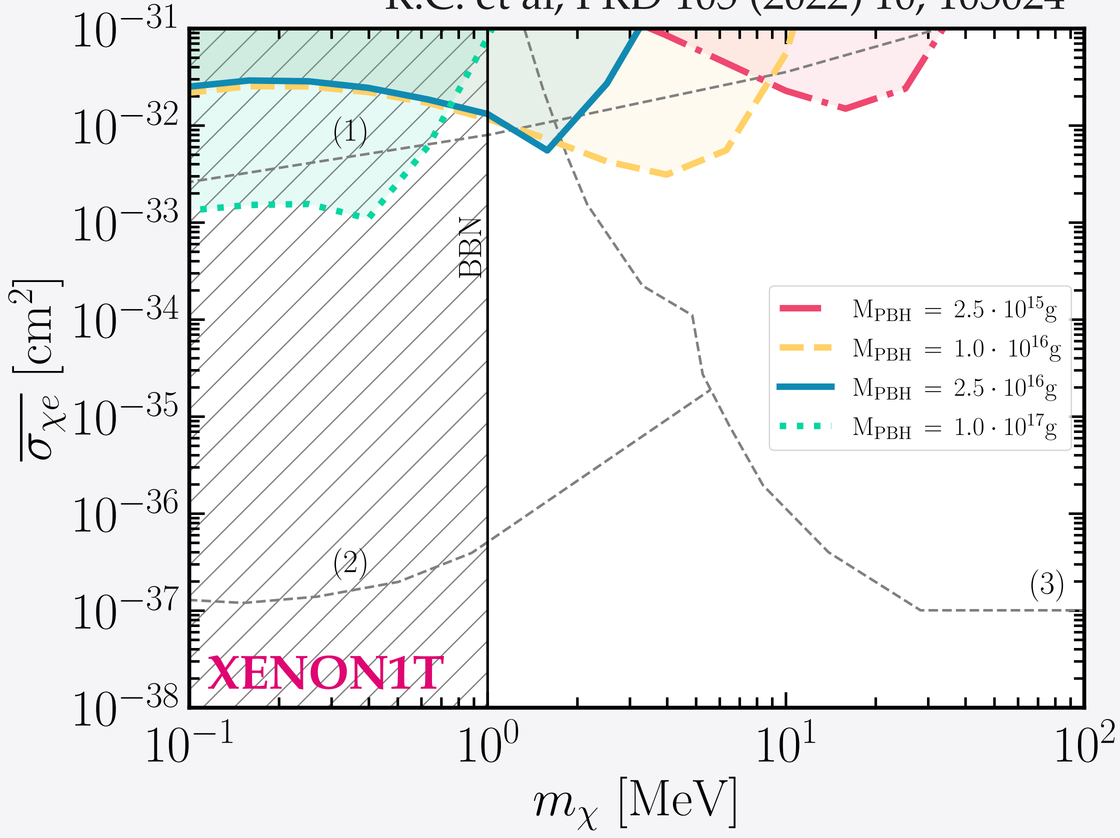
$$f_{PBH} = \frac{\rho_{PBH}}{\rho_{DM}}$$

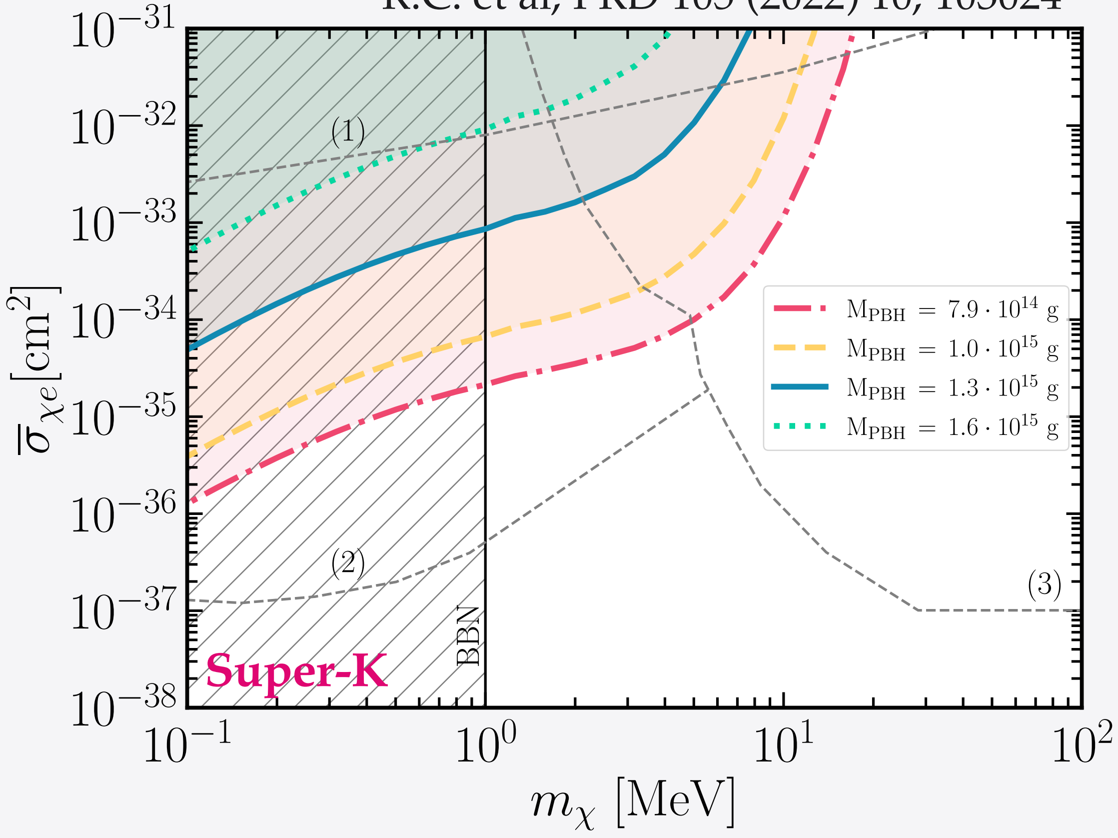
Grey region: B. Carr et al, Rept.Prog.Phys. 84 21) 11, 116902

R.C. et al, PRD 105 (2022) 2, L021302



$e - \chi$ INTERACTION





(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)

(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)

CONCLUSIONS & OUTLOOKS

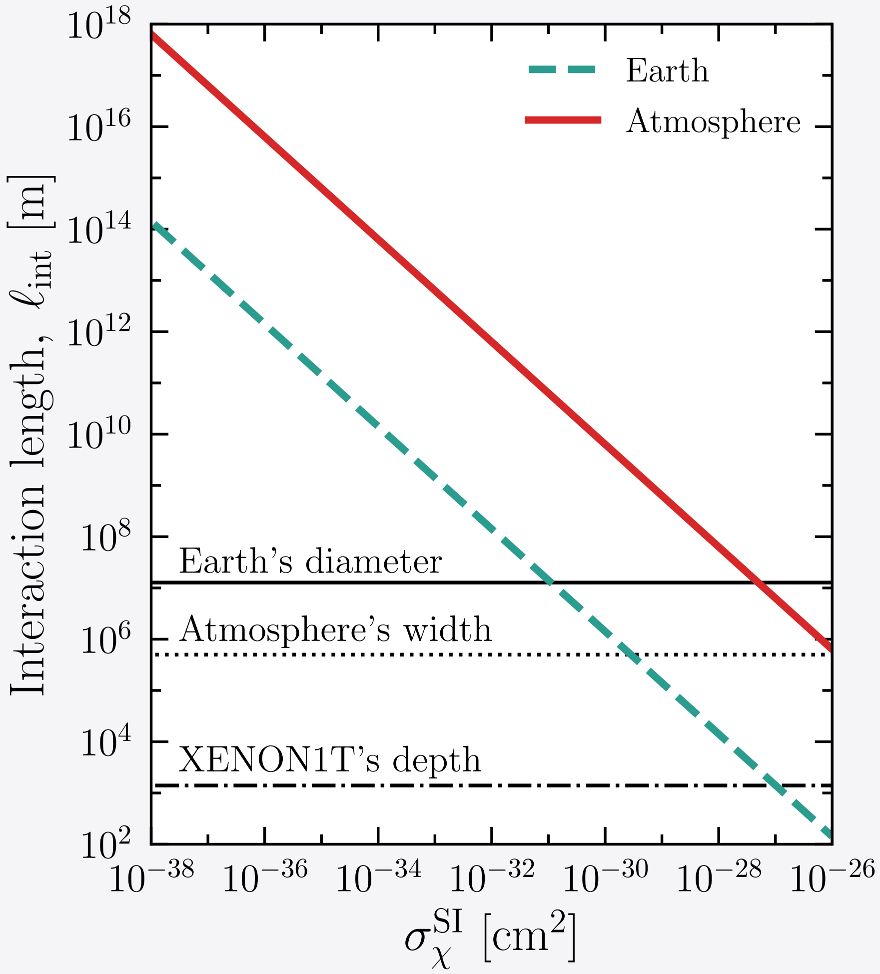
- ★ **Primordial Black Holes as s source of Boosted light Dark Matter**
- ★ We limit $\sigma^{SI}_{\chi Xe}$ assuming Primordial Black Holes existence
- ★ We constrain Primordial Black Holes abundance assuming χ existence

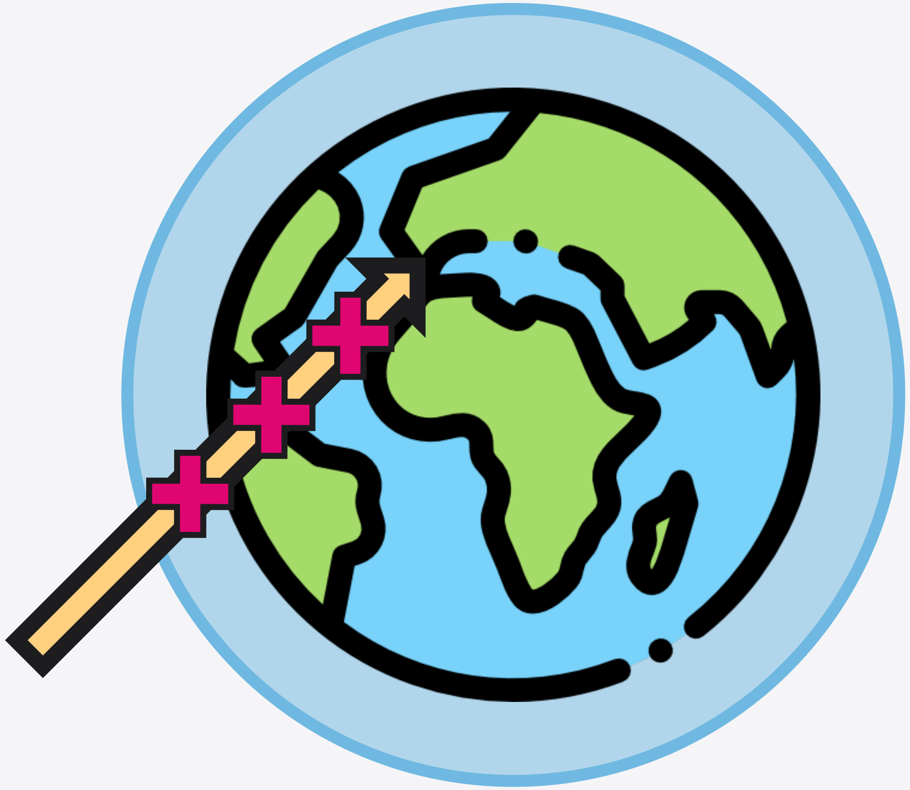
Thank you for your attention!

BACKUP SLIDES

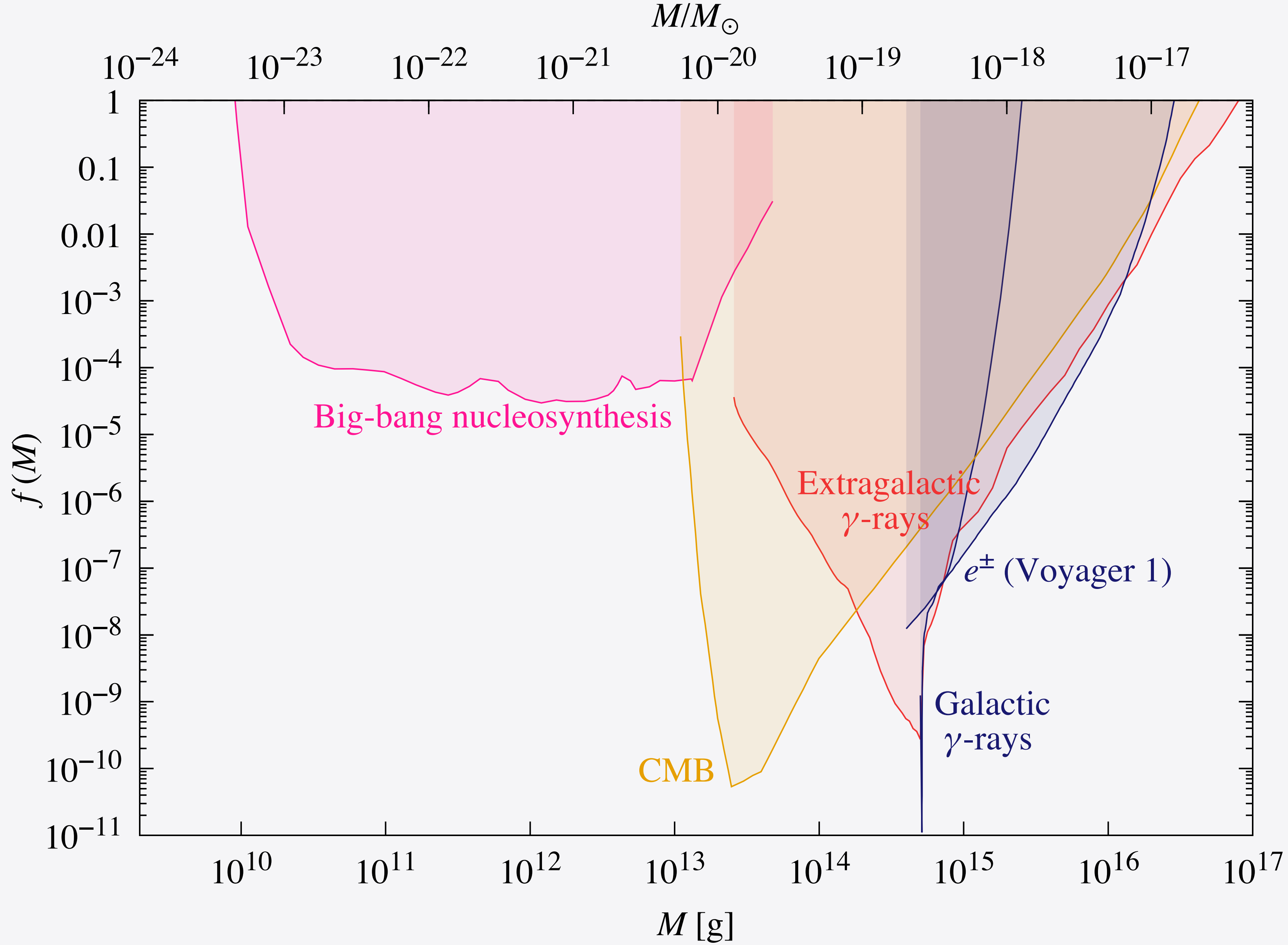
FLUX ATTENUATION

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)



B. Carr et al, Rept.Prog.Phys. 84 (2021) 11, 116902