Primordial Black Holes as dark matter candidates: Constraints from the diffuse MeV emission

Joanna Berteaud

F. Calore, J. Iguaz, P. D. Serpico, T. Siegert, C. Weinberger

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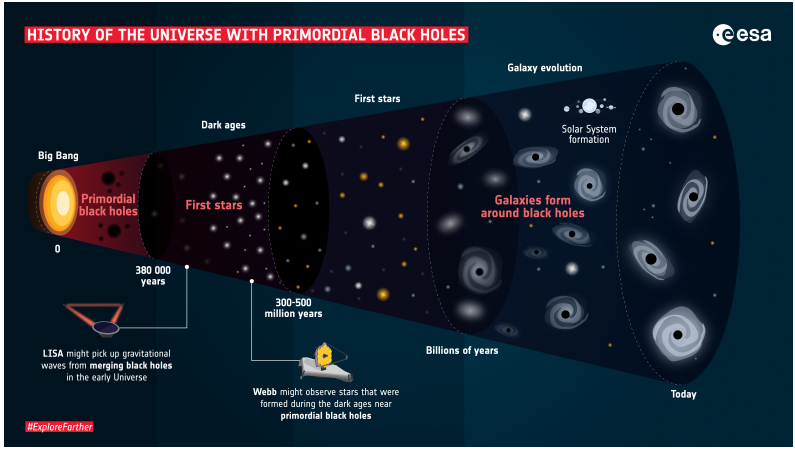
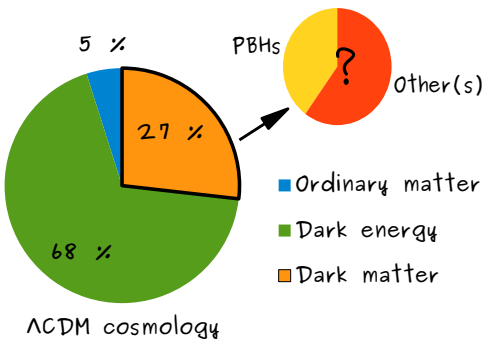
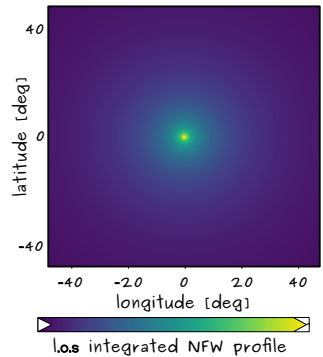
Primordial Black Holes (PBHs)

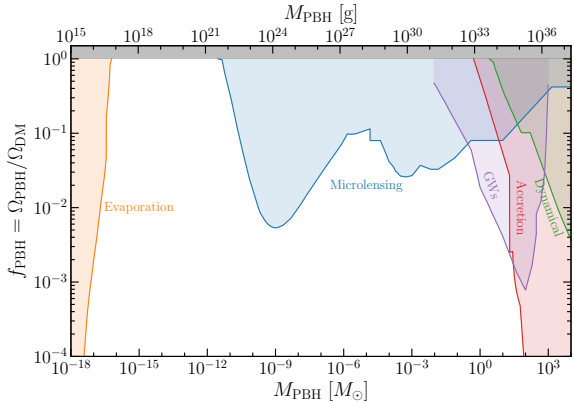


PBH dark matter





PBH dark matter



Green+21.

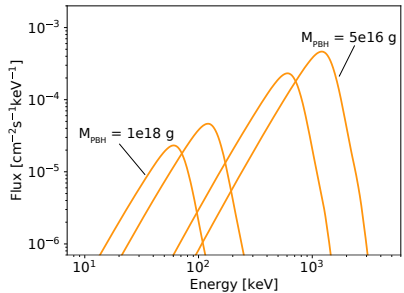
Hawking evaporation

Greybody emission of photons with $T_{PBH} = \frac{M_P^2}{8\pi M_{PBH}}$:

$$\frac{d^2N}{dEdt} = \frac{1}{2\pi} \frac{\Gamma(E, T_{PBH})}{e^{E/T_{PBH}} - 1}$$

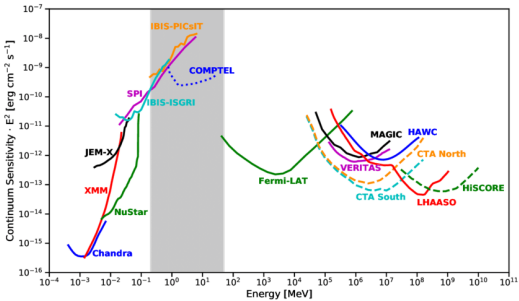
PBH photon flux:

$$\frac{d\Phi}{dE}(l, b) = \frac{f_{PBH}}{4\pi M_{PBH}} \frac{d^2N}{dEdt} \int_{l.o.s.} ds\, \rho(r(s, l, b))$$

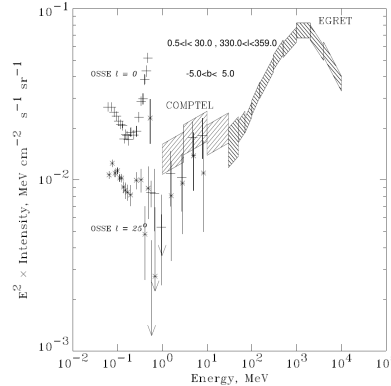


$M_{PBH} = 10^{16-18}$ g $\Rightarrow$ **MeV photon signal peaking at the Galactic center**

Galactic diffuse MeV emission

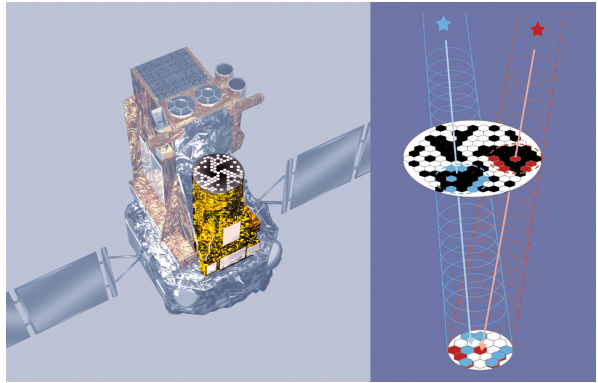


Lucchetta+22.



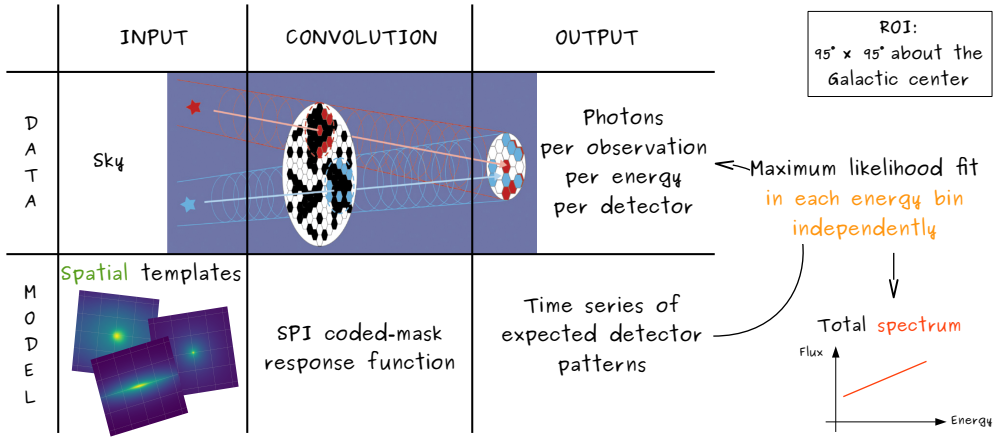
Strong+99.

SPI: Spectrometer on INTEGRAL



ESA/AOES Medialab.

SPI data analysis



SPI data analysis

Systematic study of **inverse Compton scattering** (ICS): $\mathrm{e}^{\pm}_{\mathrm{CR}} + \gamma \longrightarrow \mathrm{e}^{\pm} + \gamma_{\mathrm{MeV}}$

Spatial templates created with `GALPROP`:

- Baseline: SNR cosmic ray distribution, spectra and propagation accounting for Voyager 1 data, $\mathrm{z} = 4\ \mathrm{kpc}$, $\mathrm{R} = 20\ \mathrm{kpc}$ [Ackermann+12, Bischoff+19]
- Flatter behaviour of the diffusion scaling at low rigidities [Genolini+19]
- Single diffusion index: $\delta = 0.5$ [Genolini+19, Weinrich+20]
- Enhancement of optical ISRF towards the inner Galaxy [Bouchet+11]
- Thick halo: $\mathrm{z} = 8\ \mathrm{kpc}$ [Weinrich+20]

One single model to effectively describe the emission in the ROI

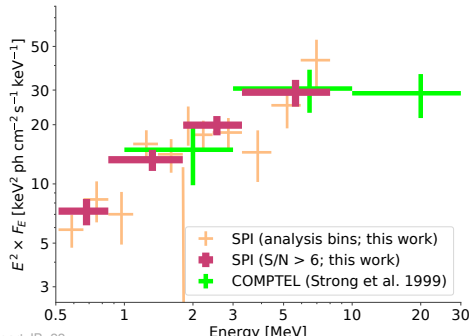
Galactic diffuse MeV emission from 16 years of SPI data

Included **spatial templates**:

- ICS
- Unresolved sources
- Nuclear lines
- Positronium annihilation

+ instrumental background

ICS with $\delta = 0.5$ is slightly preferred.



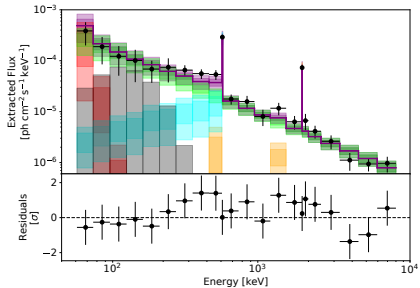
Siegert,JB+22

Adding a NFW template leads to no detection $\Rightarrow$ limits on $f_{\rm PBH}$

Constraints on f_{PBH}

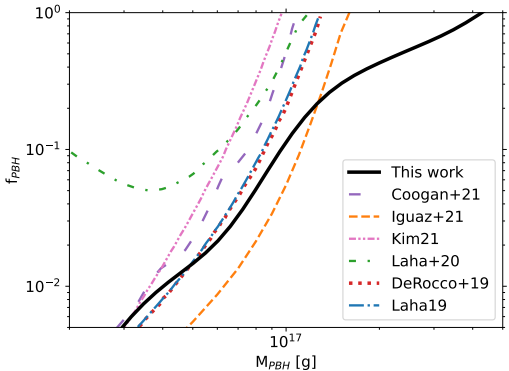
MCMC **spectral fit** to the extracted total spectrum with **free parameters**:

- ICS: power law (**2**)
- Unresolved sources: cutoff power law (**2**)
- Nuclear lines: narrow gaussians (**1**)
- Positronium: gaussian + continuum (**2**)
- PBH: evaporation spectrum (**2**: $\mathrm{M_{PBH}}$ and $\mathrm{f_{PBH}}$)



Constraints on f_{PBH}

Berteaud+22



PBHs cannot account for all the dark matter if $M_{PBH} \leq 4 \times 10^{17}$ g.

Conclusion and perspectives

- PBHs are hypothetical objects that could contribute to dark matter
- Some are expected to evaporate and emit MeV photons
- We extracted the Galactic diffuse MeV spectrum from 16 years of SPI data
- We pushed the bound on $\mathrm{f_{PBH}} = 1$ up to 4×10^{17} g

- A vast mass interval remains unconstrained
- The MeV spectrum could be used to probe other dark matter candidates

Thank you for your attention!

- Green+21: J. Phys. G: Nucl. Part. Phys. 48 043001
- Lucchetta+22: arXiv:2204.01325
- Strong+99: Astrophys. Lett. Commun., 39, 209
- Ackermann+12: ApJ, 750, 3
- Bischoff+19: ApJ, 878, 59
- Genolini+19: Phys. Rev. D, 99, 123028
- Weinrich+20: A&A, 639, A74
- Siegert,JB+22: A&A 660, A130
- Berteaud+22: Phys. Rev. D 106, 023030