# Multi-wavelength searches for isolated Black Holes in the Milky Way

Based on: arXiv:2012.10421

With D. Gaggero, R. Connors, J. Manshanden, M. Ricotti, G. Bertone

17th MultiDark Consolider Workshop

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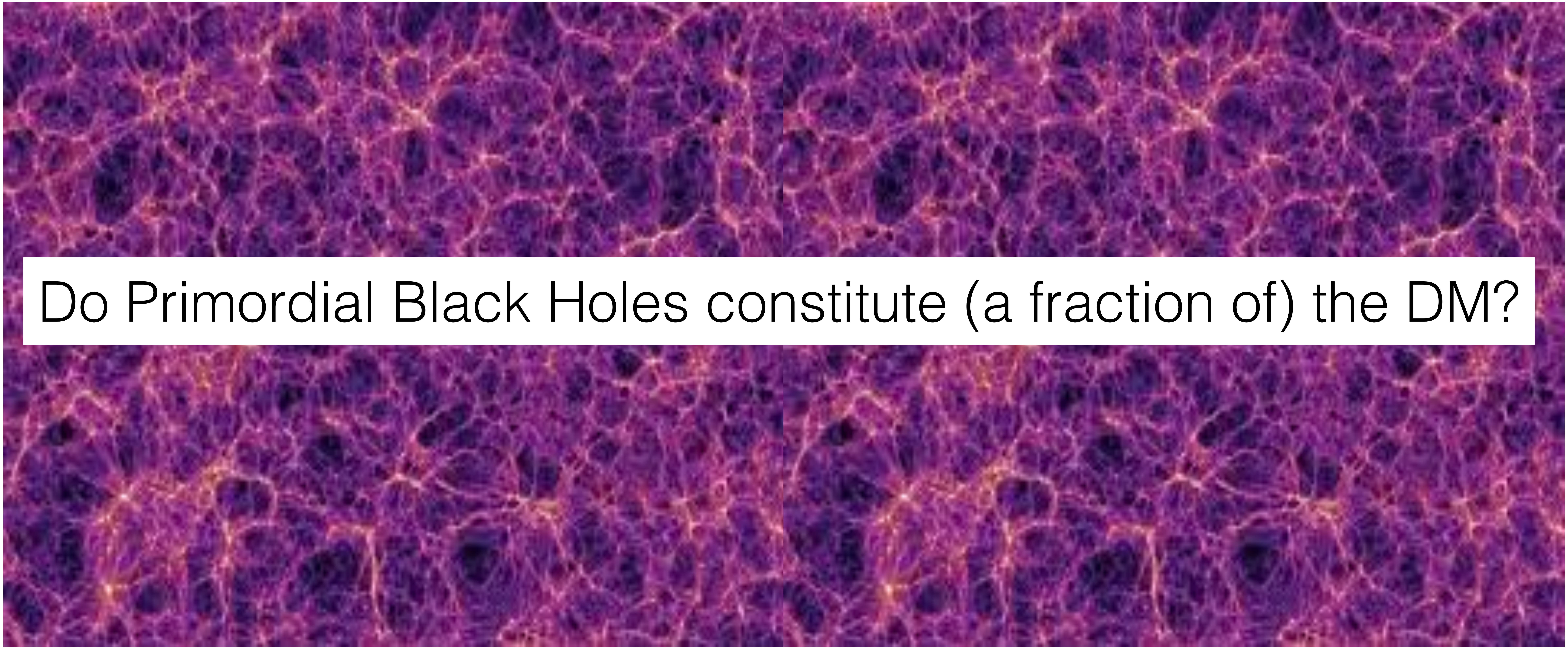
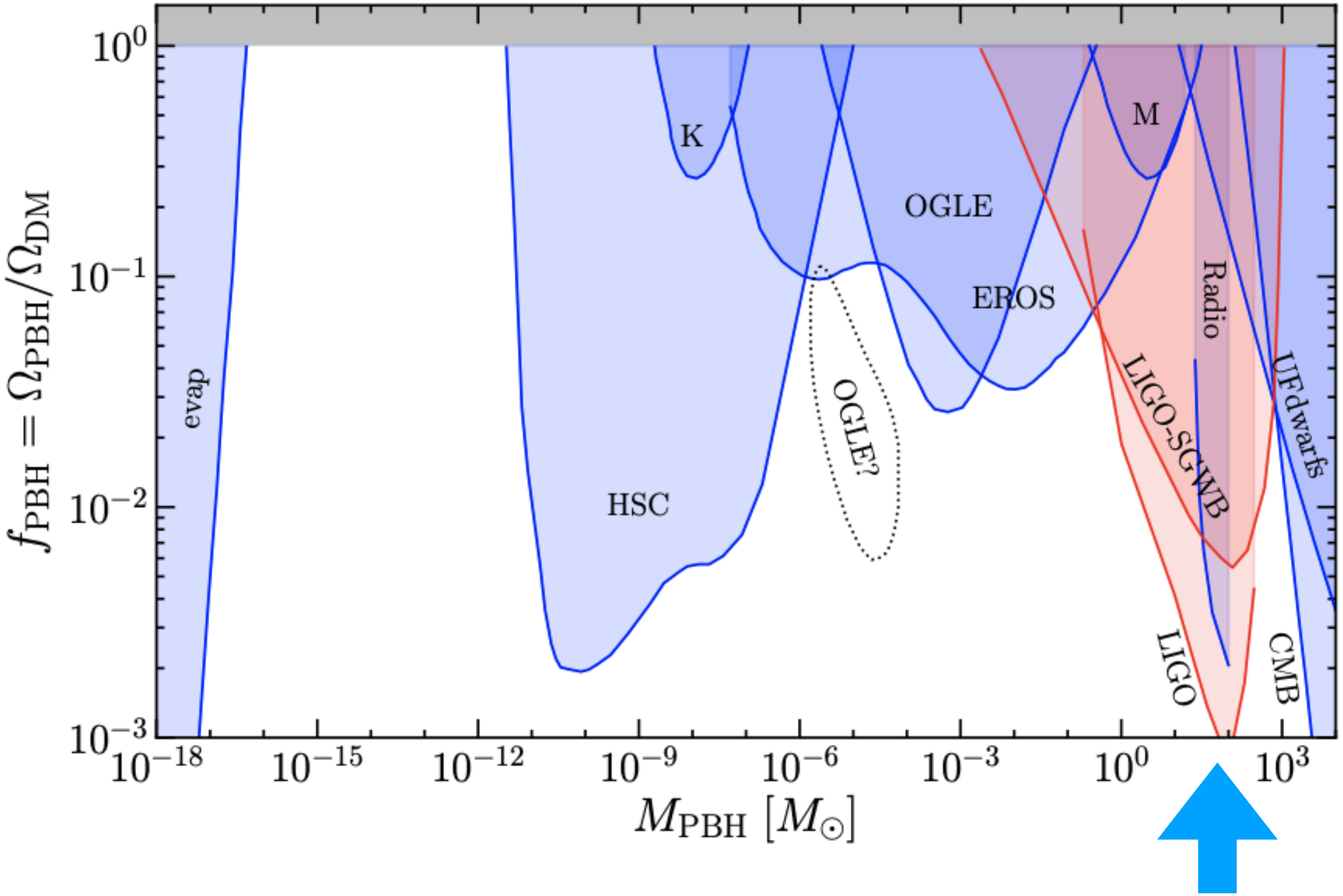
# Primordial Black Holes



Do Primordial Black Holes constitute (a fraction of) the DM?

# PBHs: constraints and detection

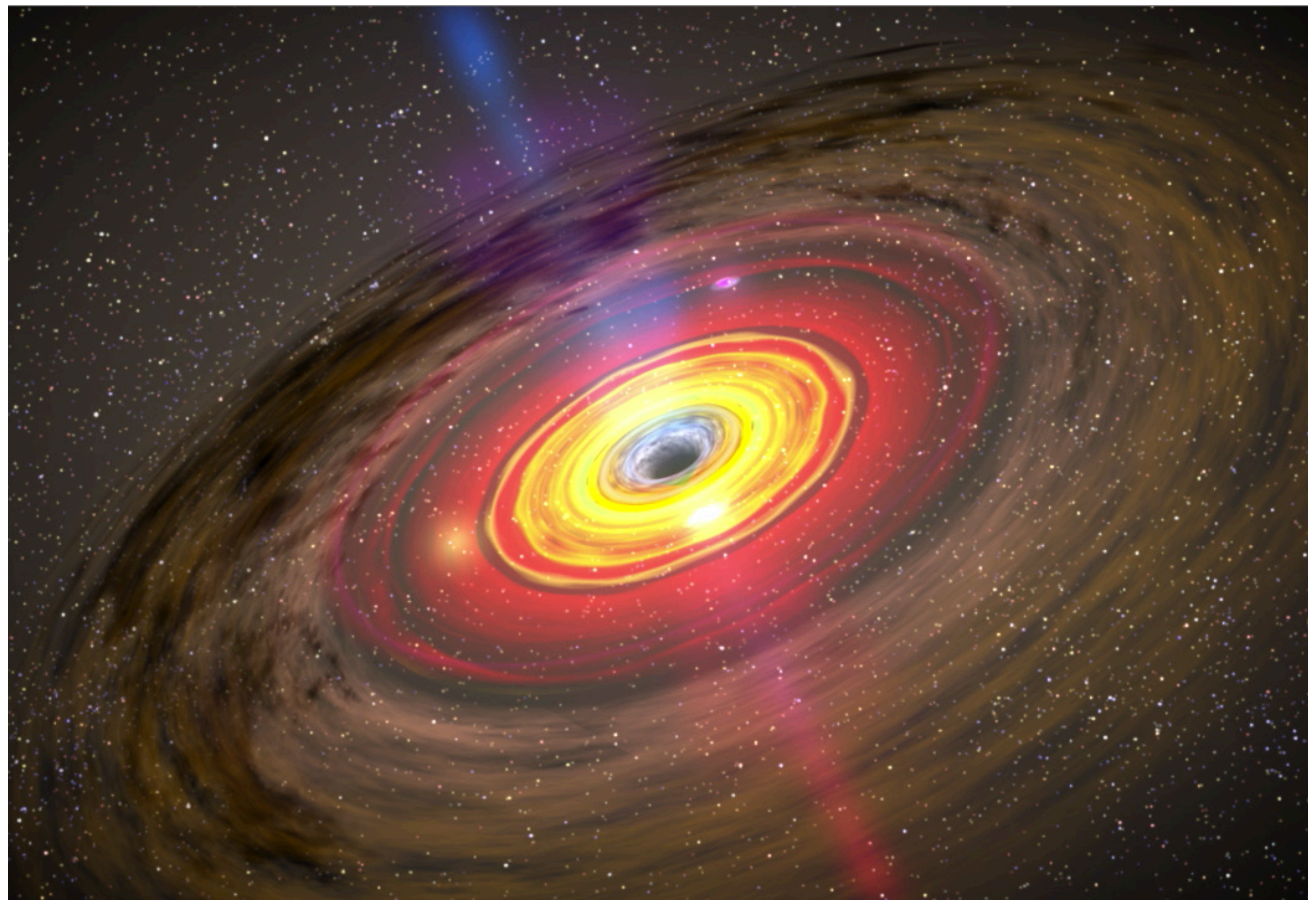


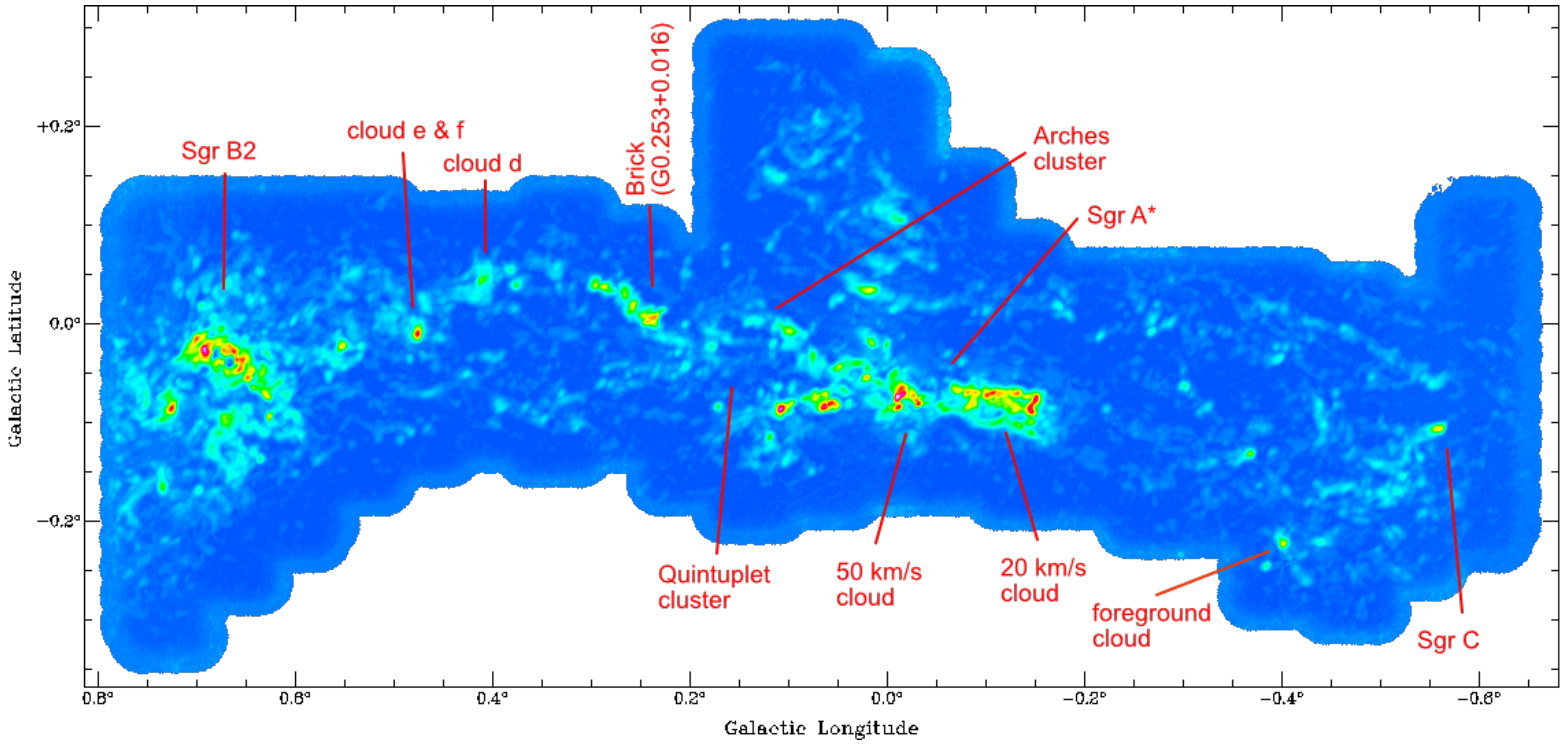
# Detecting Isolated BHs in the Milky Way

- Detection: BH expected to accrete gas (if within a molecular cloud) and emit non-thermal radiation

- Identification: multi-wavelength study: X-ray + Radio *"fundamental plane"*

- Central molecular zone: dense gas + large number of BHs ➔ ideal target





# Astrophysical background

- Large number of ABHs in CMZ ( $\sim 10^4 - 10^5$)
- Assess background ➡ *this work*
- No A-IBH detected so far ➡ interesting per-se

**Multi-wavelength detectability of isolated black holes in the Milky Way**

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**ABSTRACT**
Isolated black holes in our Galaxy have eluded detection so far. We present here a comprehensive study on the detectability of isolated stellar-mass astrophysical black holes that accrete interstellar gas from molecular clouds in both the local region and the Central Molecular Zone. We adopt a state-of-the-art model for the accretion physics backed up by numerical simulations, and study the number of observable sources in both the radio and X-ray band, as a function of a variety of parameters. We discuss in particular the impact of the astrophysical uncertainties on our prediction for the number of bright X-ray sources in the central region of the Galaxy. We finally consider future developments in the radio domain, and assess the potential of SKA to detect a population of astrophysical black holes accreting gas in our Galaxy.

**Key words:** astroparticle physics – black hole accretion – ISM: jets and outflows

arXiv:2012.10421

**Goal:** estimating the number of detectable ABHs

# Modelling accretion

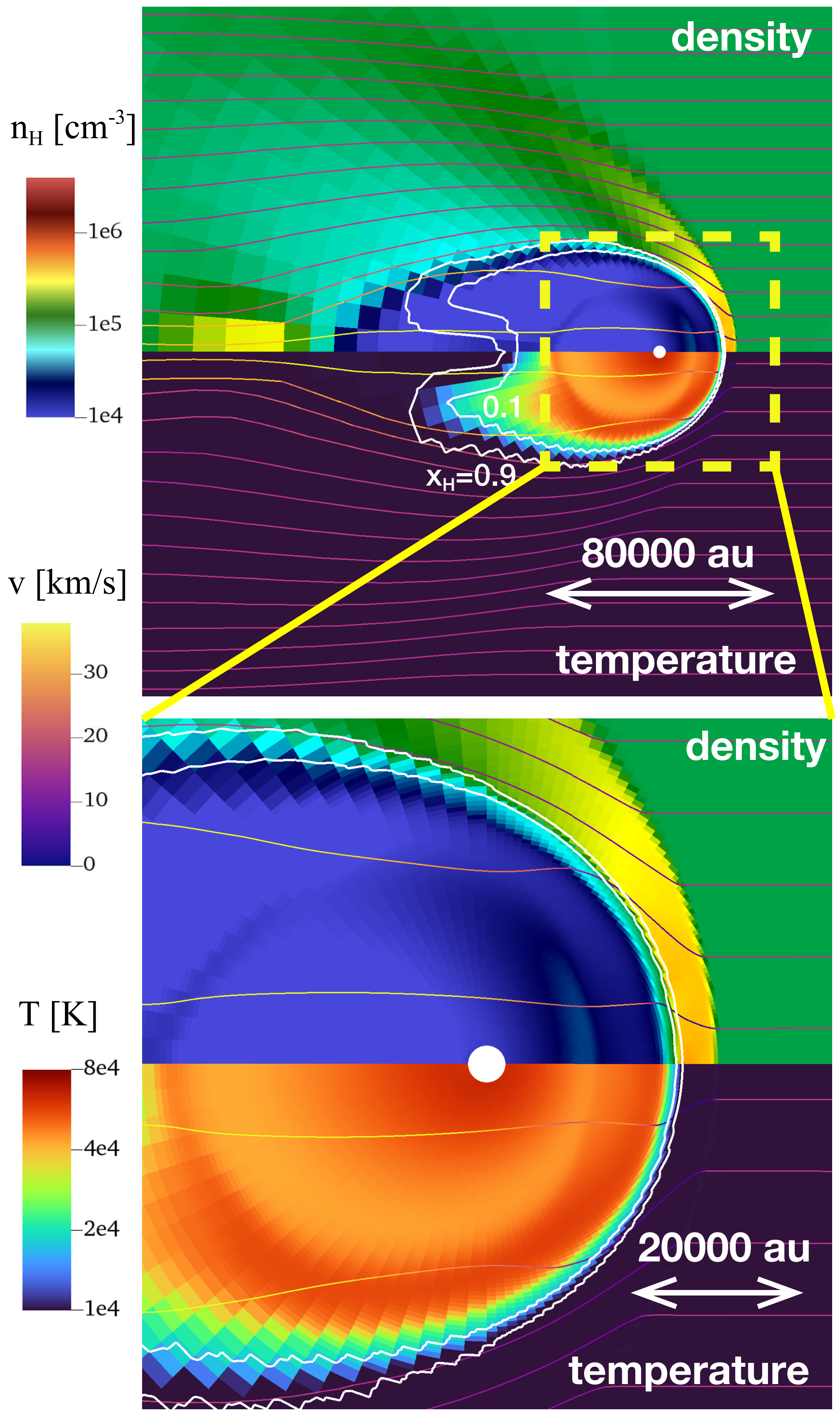
**Previous works:** Bondi-Hoyle-Lyttleton model

- Simple textbook model for accretion onto a moving compact object
- Ruled out by observations
- suppression factor (not physically motivated) $\lambda \sim 10^{-2} - 10^{-3}$
- Does not take into account radiative feedback

**This work:** Park-Ricotti model

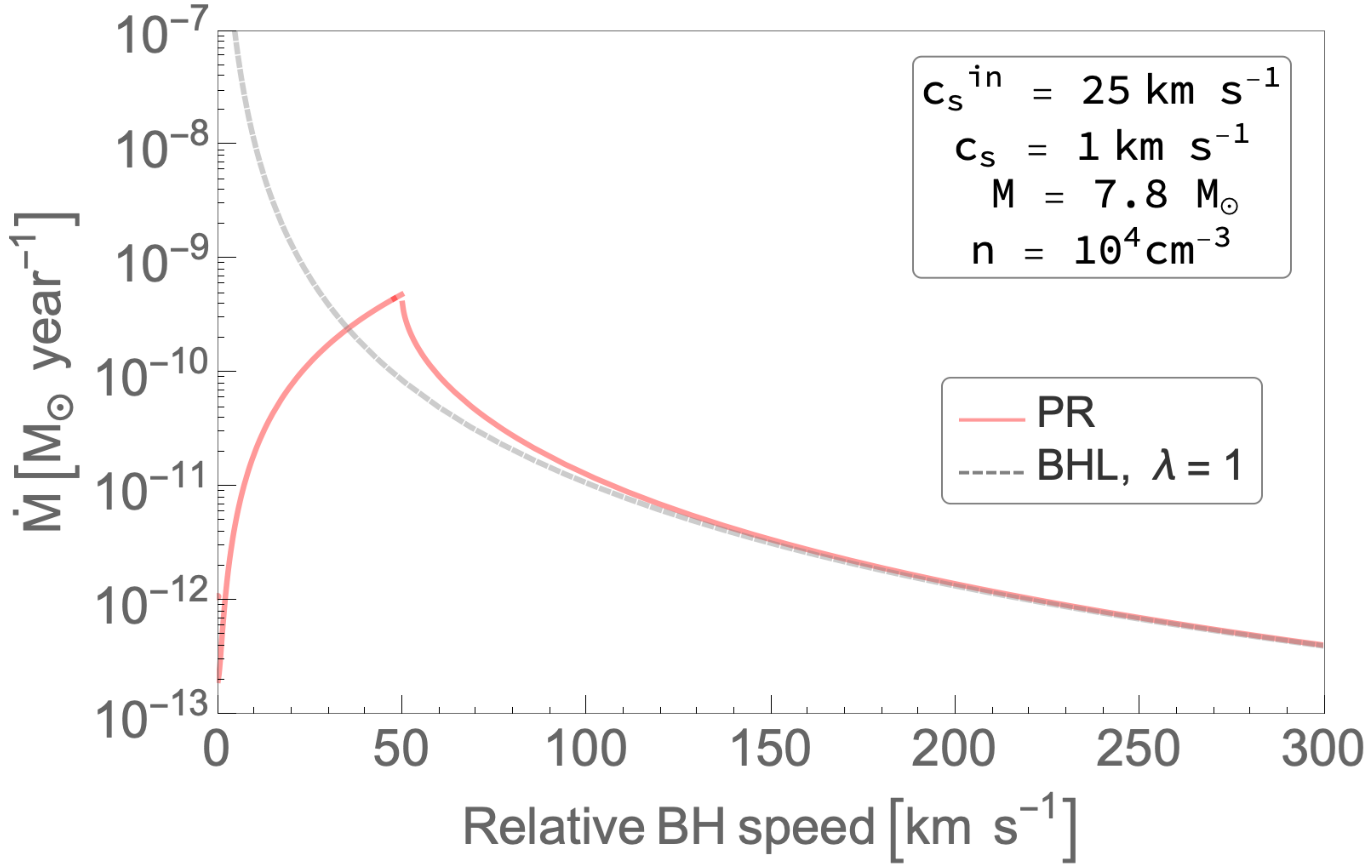
- Based on state-of-the-art hydrodynamical simulations *including radiative feedback*
- The region surrounding the BH is ionized
- At low velocities a bow shock forms ahead of the BH -> the flux is deflected -> accretion rate is suppressed

arXiv:1211.0542, arXiv:2003.05625



# Park-Ricotti vs B-H-L accretion

- Bondi: accurate at large BH speed
- Very large deviations at low speeds
- PR: peak accretion at $v_{BH} = 2c_s^{ionized} \sim O(10)$ km/s
- High gas densities necessary



# Searching for isolated ABHs in the CMZ

Number of sources detectable in the → X-ray band → Radio band

$$N^{\text{sources}}\left(\phi^*, \{p_i\}, \{q_i\}\right) = N^{\text{tot}} \int_{\phi(\text{v}_{\text{BH}}, M, d, \{p_i\}) > \phi^*} P(\text{v}_{\text{BH}}) P(M) P(r) P(n) d\text{v}_{\text{BH}} dM dr dn$$

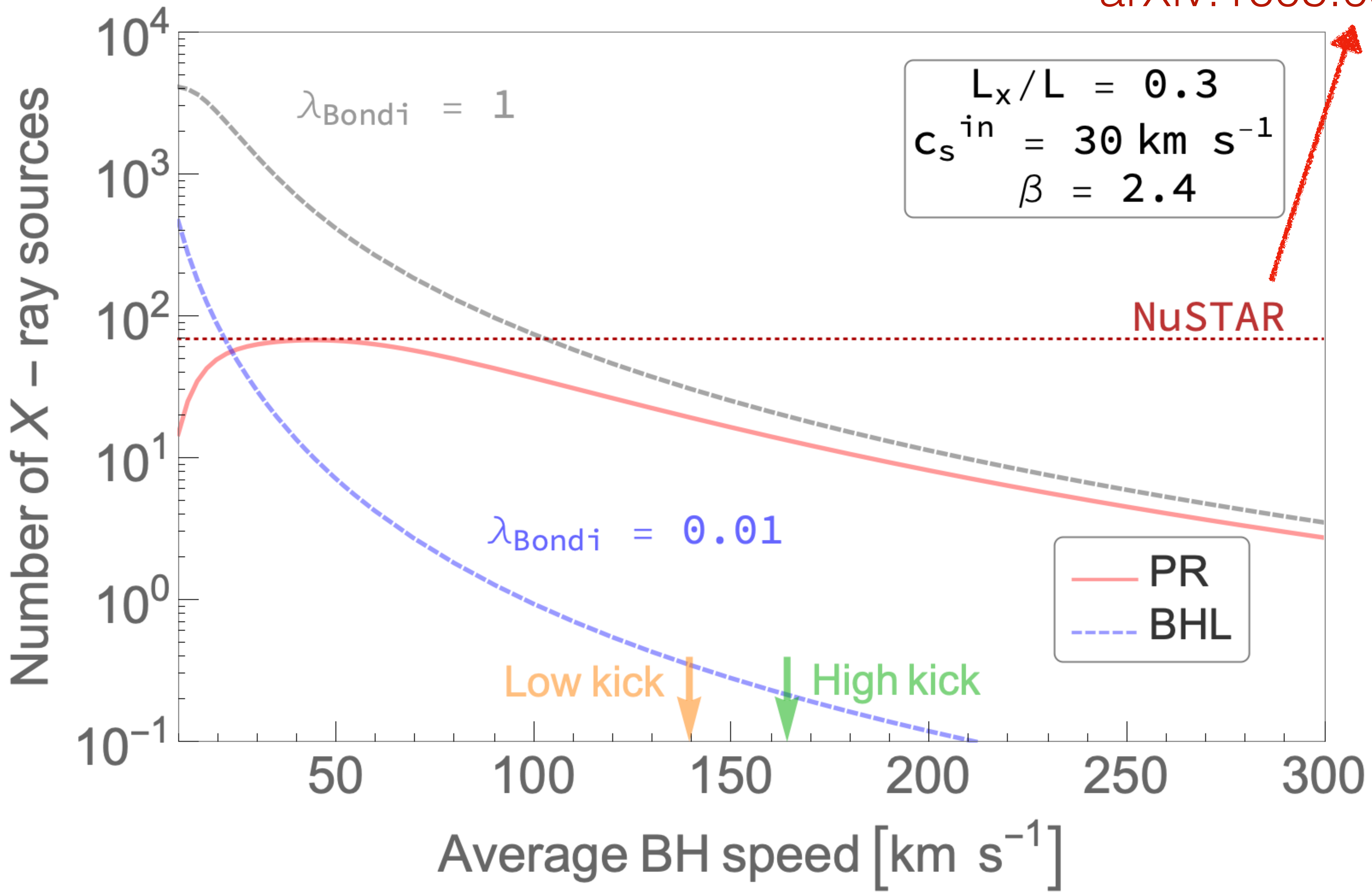
- Uniform spatial distribution
- Velocity distribution: MB distribution (progenitor stars, $\mu \approx 130\,\text{km/s}$ + natal kicks $\mu \sim 50-100\,\text{km/s}$)
- Density of clouds $P(n) \propto n^{-\beta}$
- Luminosity (RIAF) $L = \eta \dot{M},\ \eta = 0.1 \frac{\dot{M}}{\dot{M}_{\text{crit}}}$ ➡ $L \propto \dot{M}^2$

# X-ray: number of detectable sources

- Order of 10 sources above NuSTAR threshold

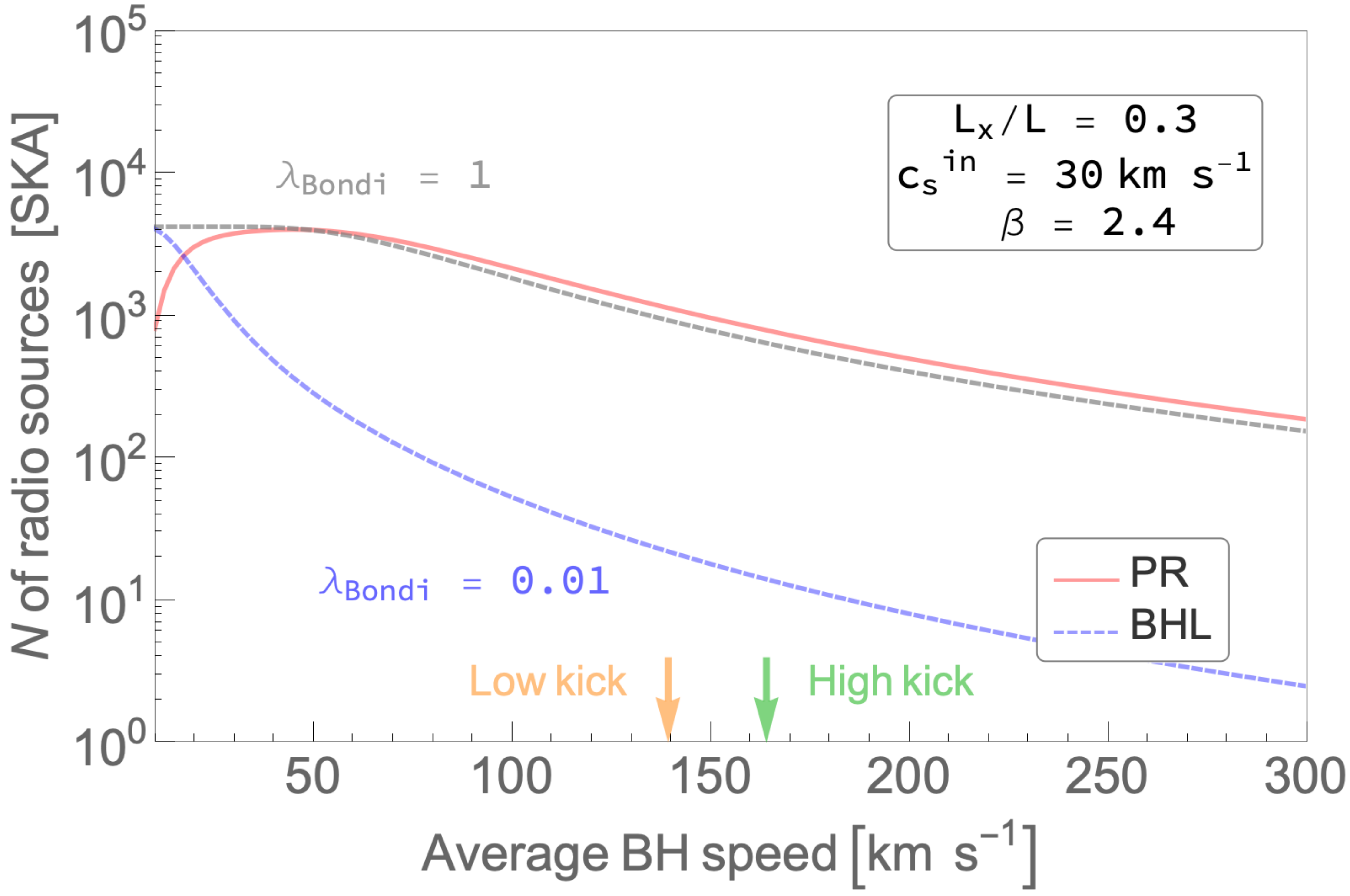
- Largest uncertainties: number of BHs in the region, distribution in clouds

arXiv:1605.03882



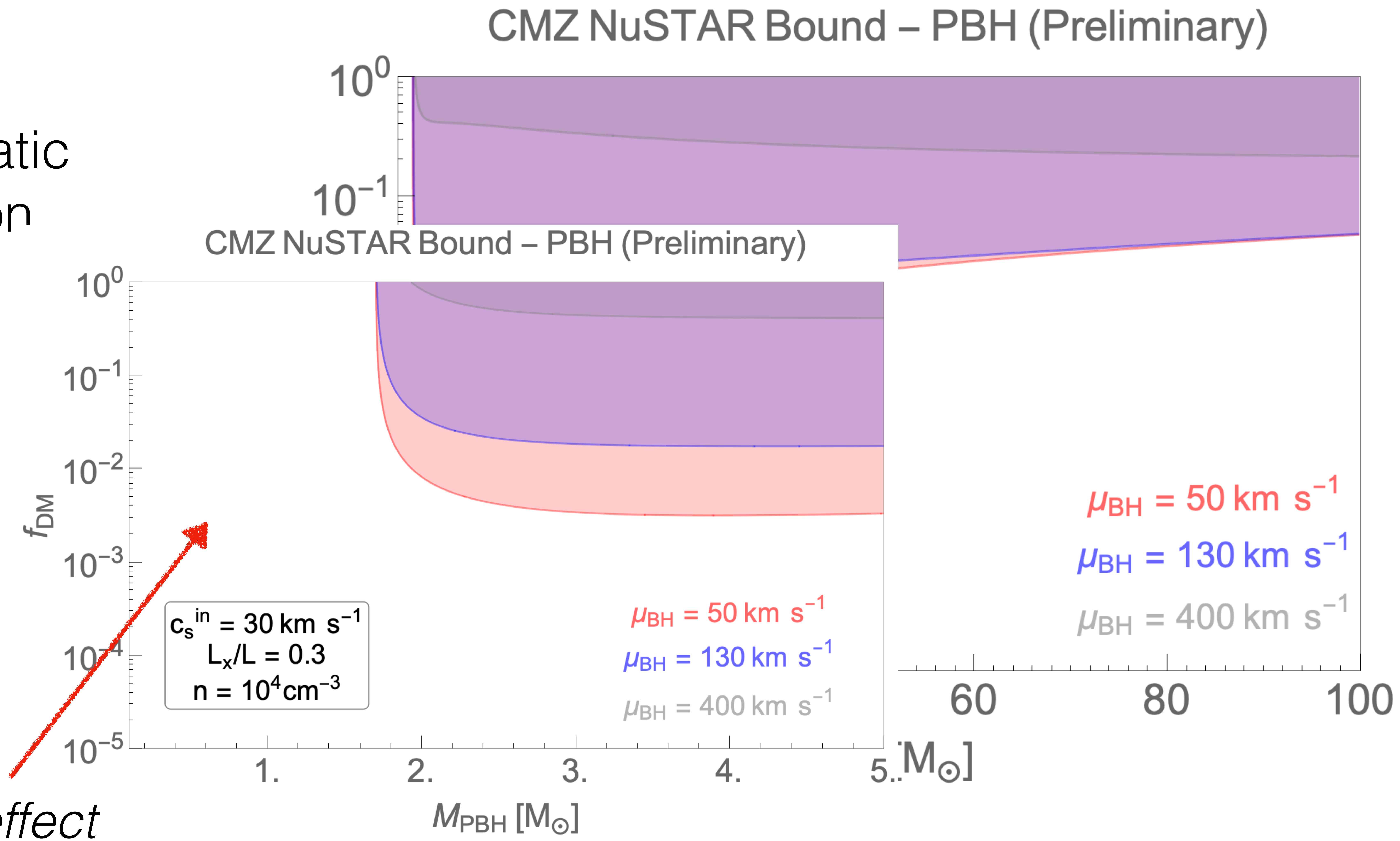
# Radio: number of detectable sources

- **VLA:** no visible sources predicted
- **SKA** (prospect): could unveil a very large population of BHs



# Preliminary: PBH Bounds

- Monochromatic mass function
- Uniform gas distribution




*Threshold effect*

# Conclusions & Outlook

- Significant number of Astrophysical X-ray sources predicted
- Could some isolated ABHs be present in NuSTAR catalog?
- Science case for SKA
- Study dependence of bound on parameters, mass function, phase space distribution, gas distribution (threshold effect)
- Differentiate ABH and PBH populations (luminosity function?)

Thank you!