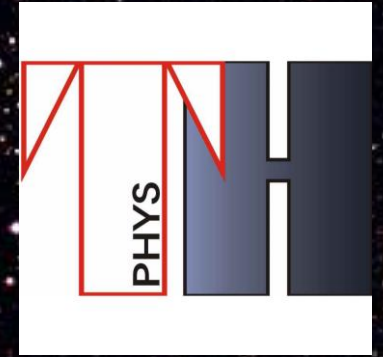


ULB

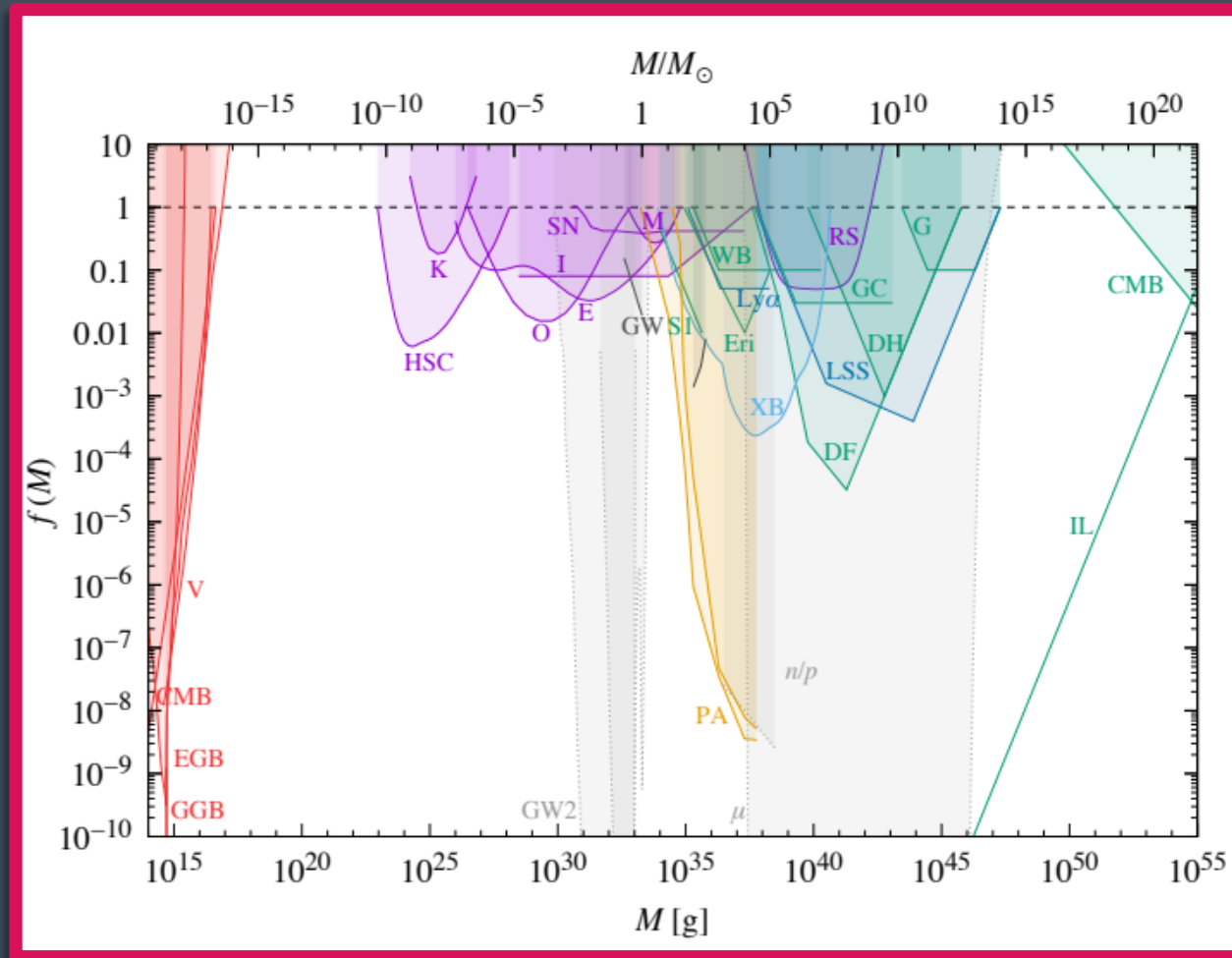
NEHOP'25



**Constraints on asteroid-mass
PBHs in dwarf galaxies with HST**

**Nicolas Esser (with Peter Tinyakov, Sven De Rijcke
& other astronomy colleagues)**

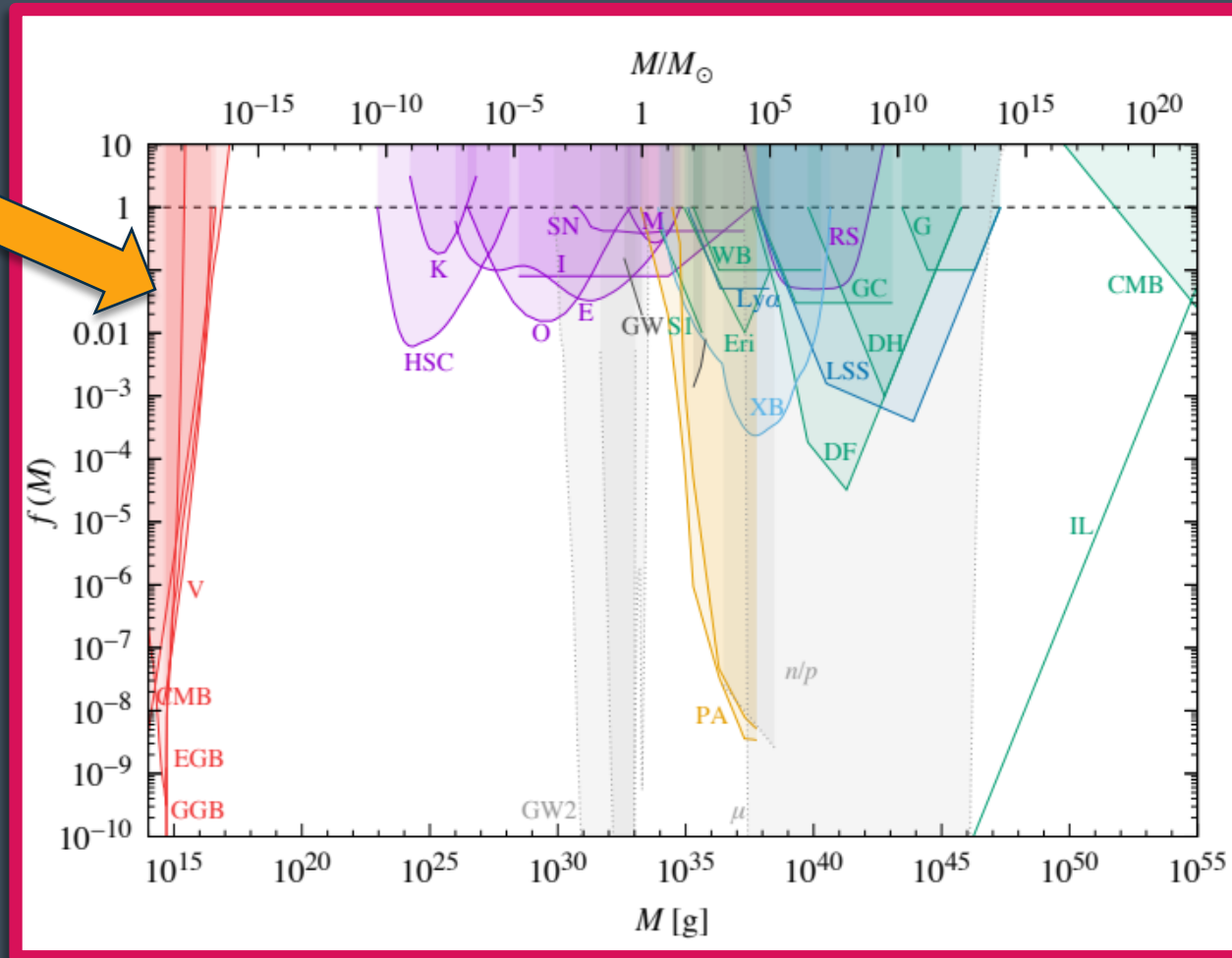
Current PBH constraints



Carr et al. (2021)

Current PBH constraints

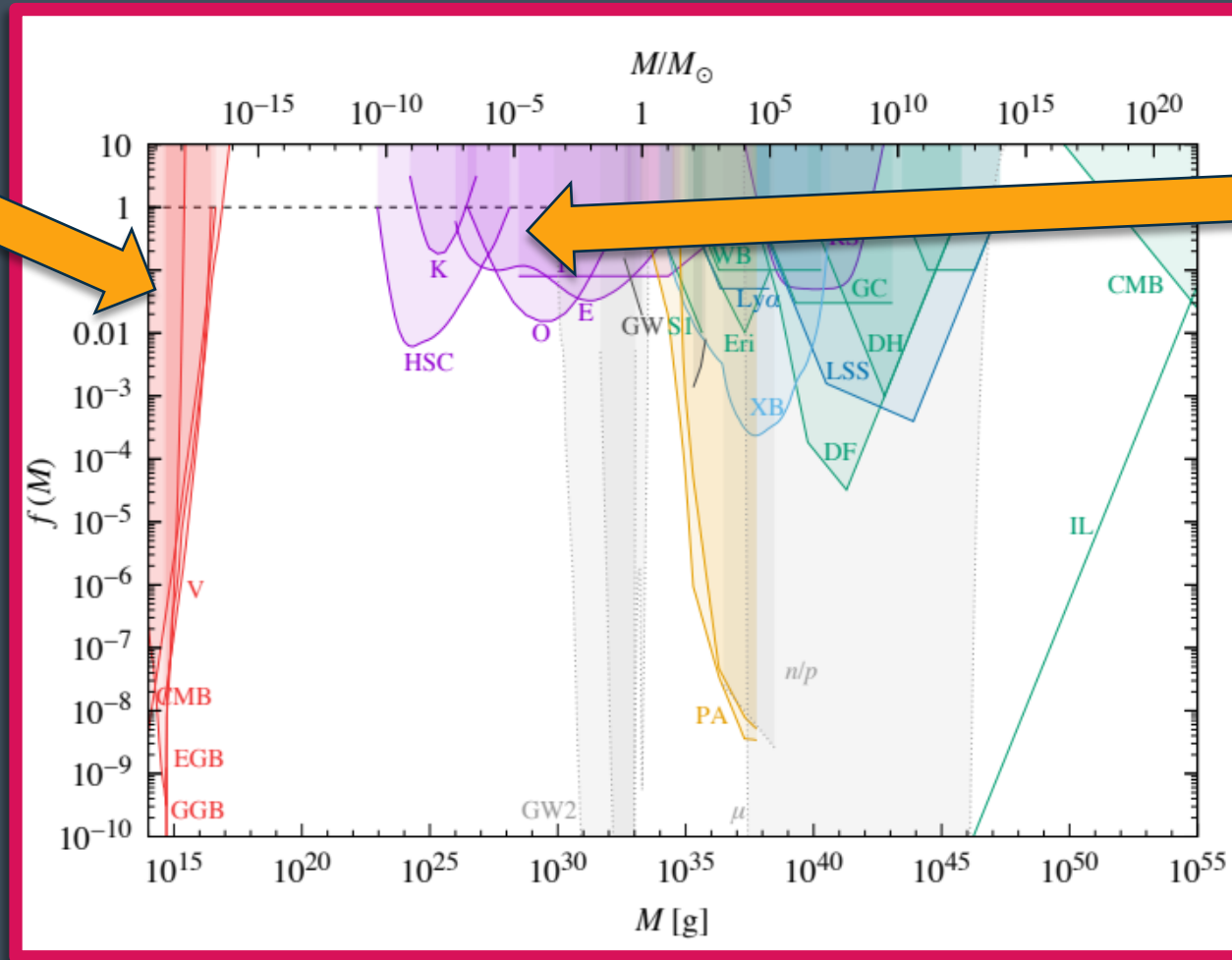
Evaporation



Carr et al. (2021)

Current PBH constraints

Evaporation



Lensing

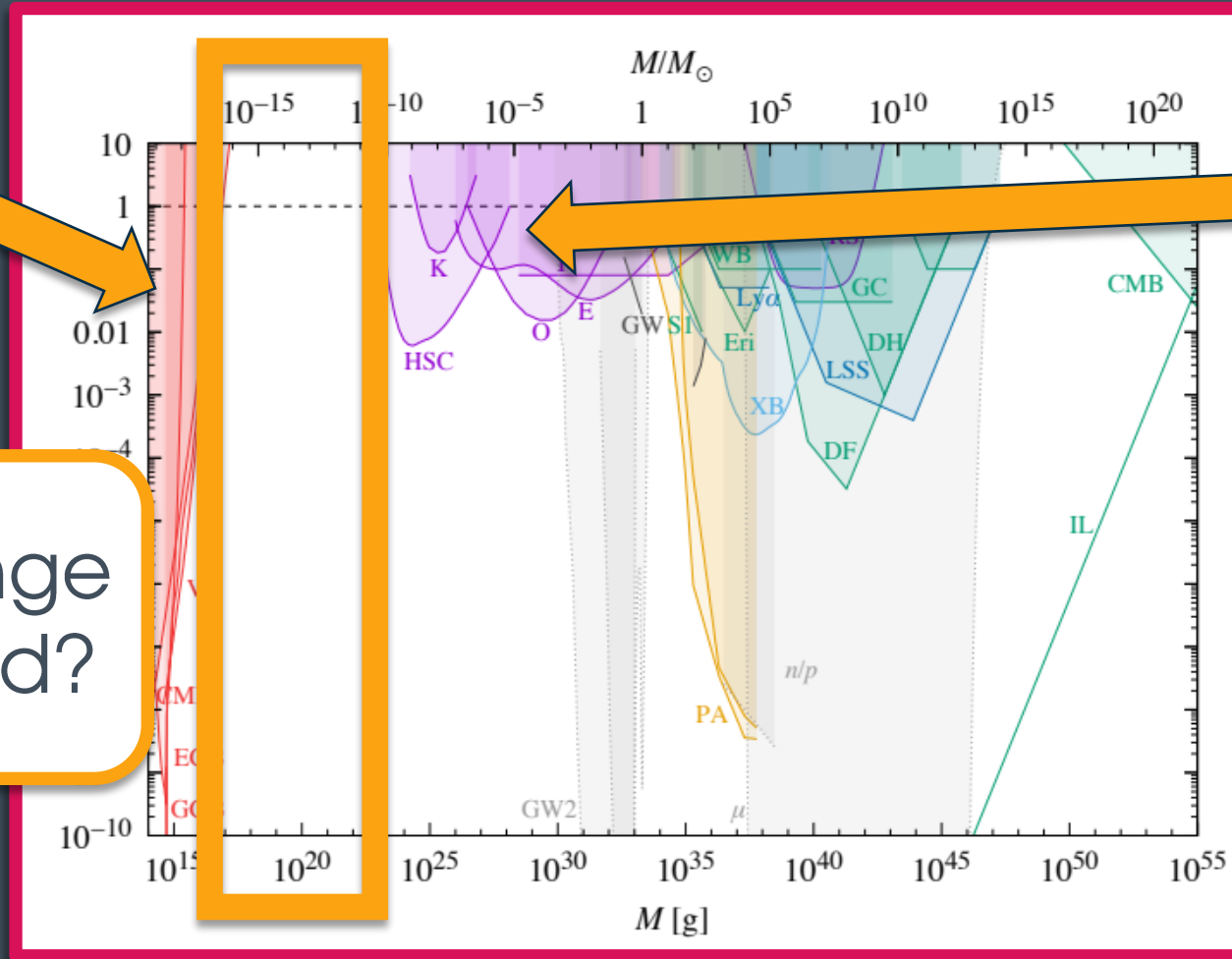


Carr et al. (2021)

Current PBH constraints

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Lensing



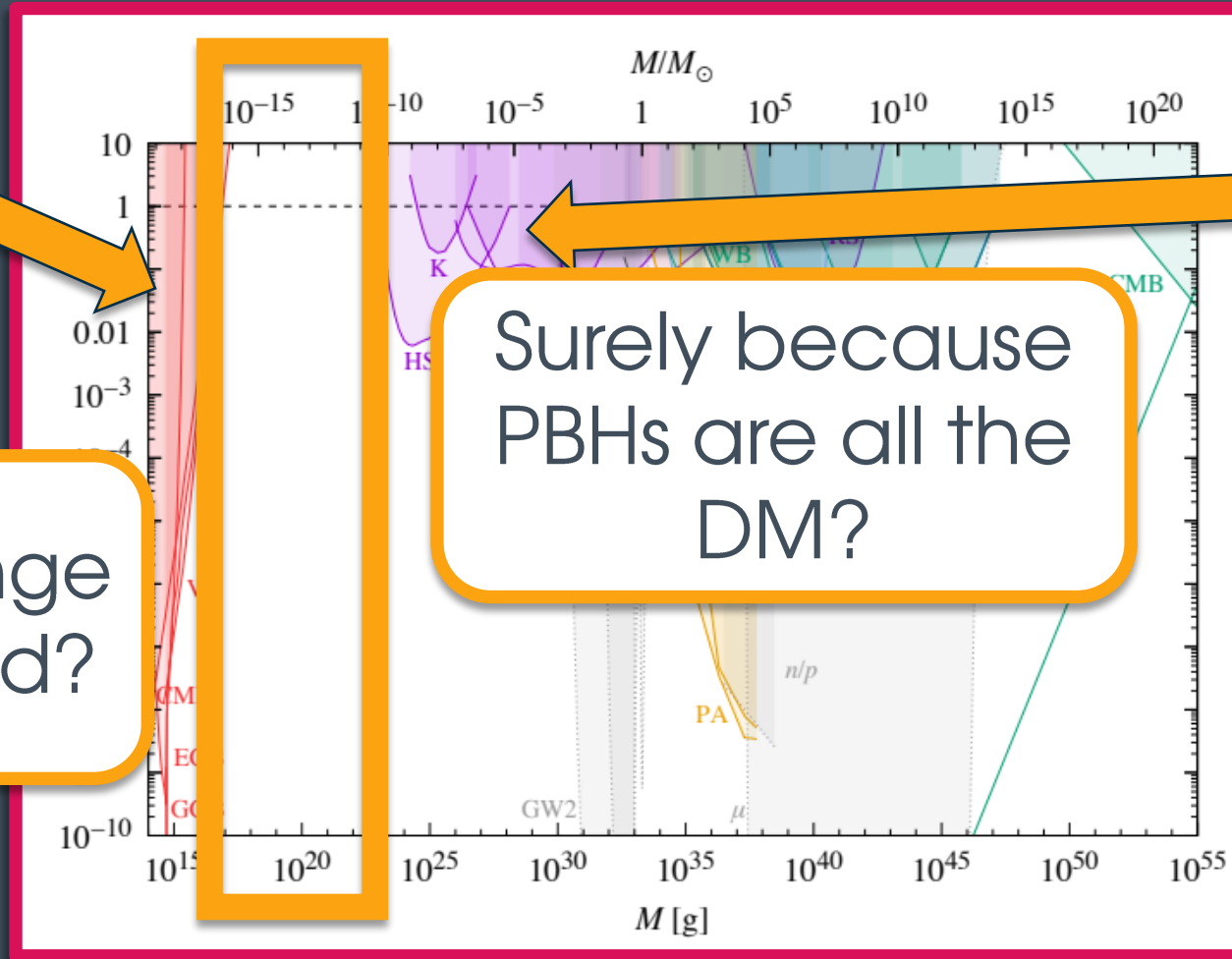
Why is this range unconstrained?

Carr et al. (2021)

Current PBH constraints

Evaporation

Lensing



Why is this range unconstrained?

Surely because PBHs are all the DM?

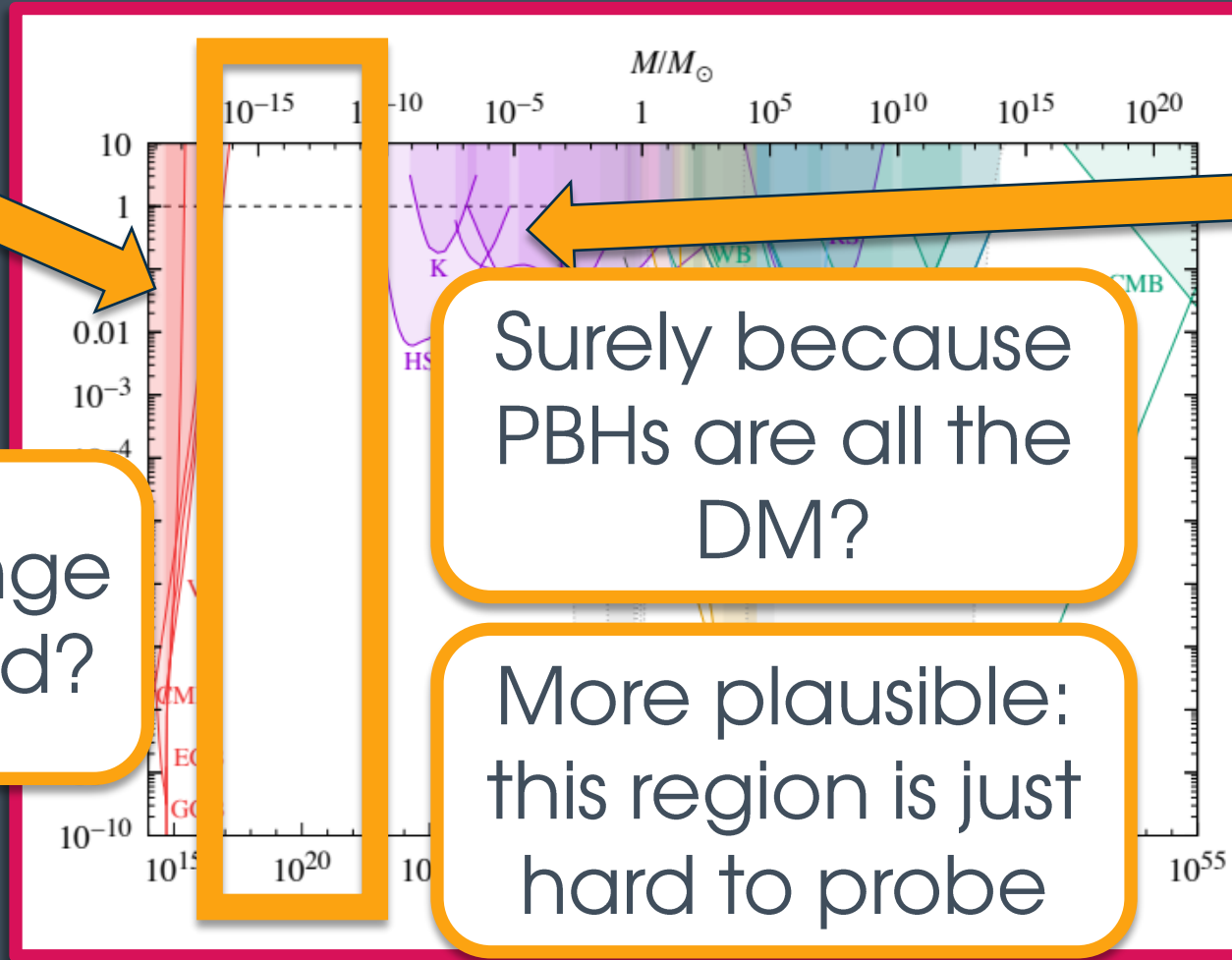
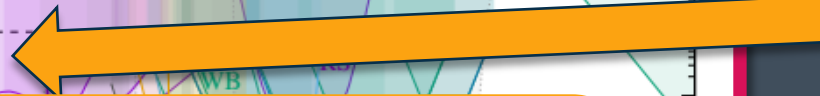
Carr et al. (2021)

Current PBH constraints

Evaporation



Lensing



Why is this range unconstrained?

Surely because PBHs are all the DM?

More plausible: this region is just hard to probe

Carr et al. (2021)

Current PBH constraints

Exotic
mechanism
required

Idea: stars capture PBHs
which then destroy them
from the inside

Destruction probability

Adiabatic star formation + dynamical friction:

Destruction probability

Adiabatic star formation + dynamical friction:

$$\bar{N}_{\text{cap}} = 12\sqrt{6\pi}G^2\ln(\Lambda) \times f_{\text{PBH}} \times \frac{\rho_{\text{DM}}}{\sigma^3} \times \tau_* \times M_*$$

Destruction probability

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- $\propto \frac{\rho_{\text{DM}}}{\sigma^3}$  DM-dominated environments with low velocities

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- $\propto M_*$ \longrightarrow Heavier stars capture more PBHs

Destruction probability

Adiabatic star formation + dynamical friction:

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Bondi accretion

Destruction probability

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Bondi accretion  stars that capture a PBH are destroyed:

Destruction probability

Adiabatic star formation + dynamical friction:

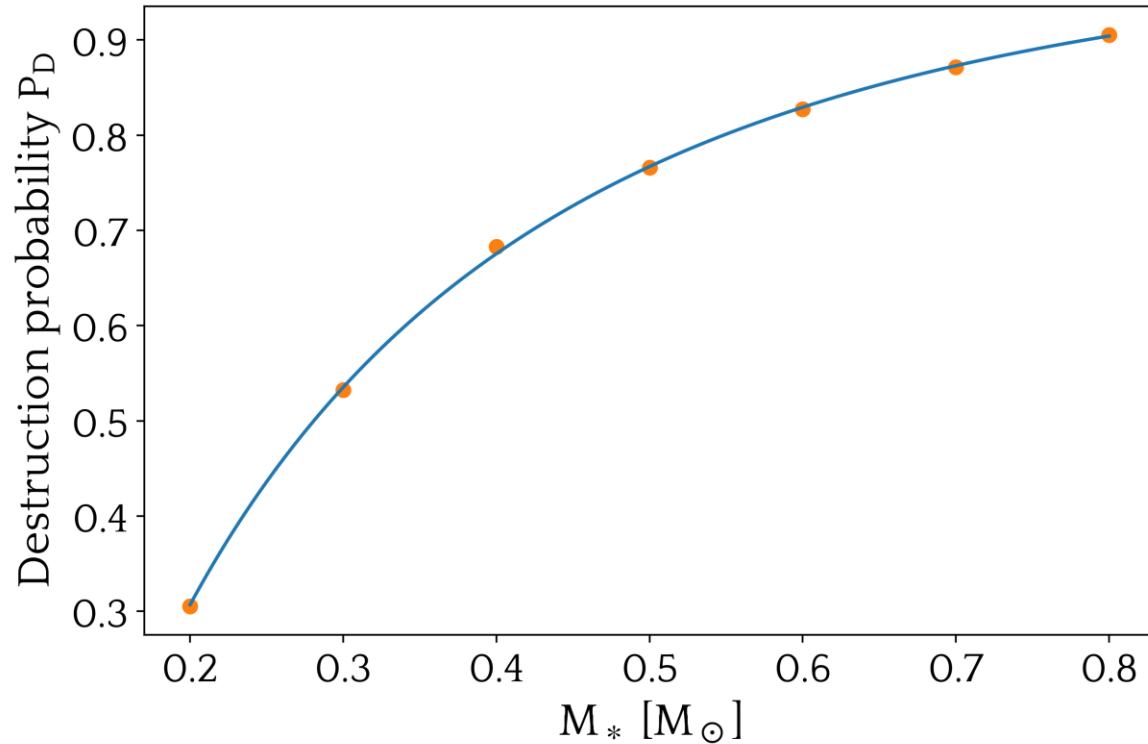
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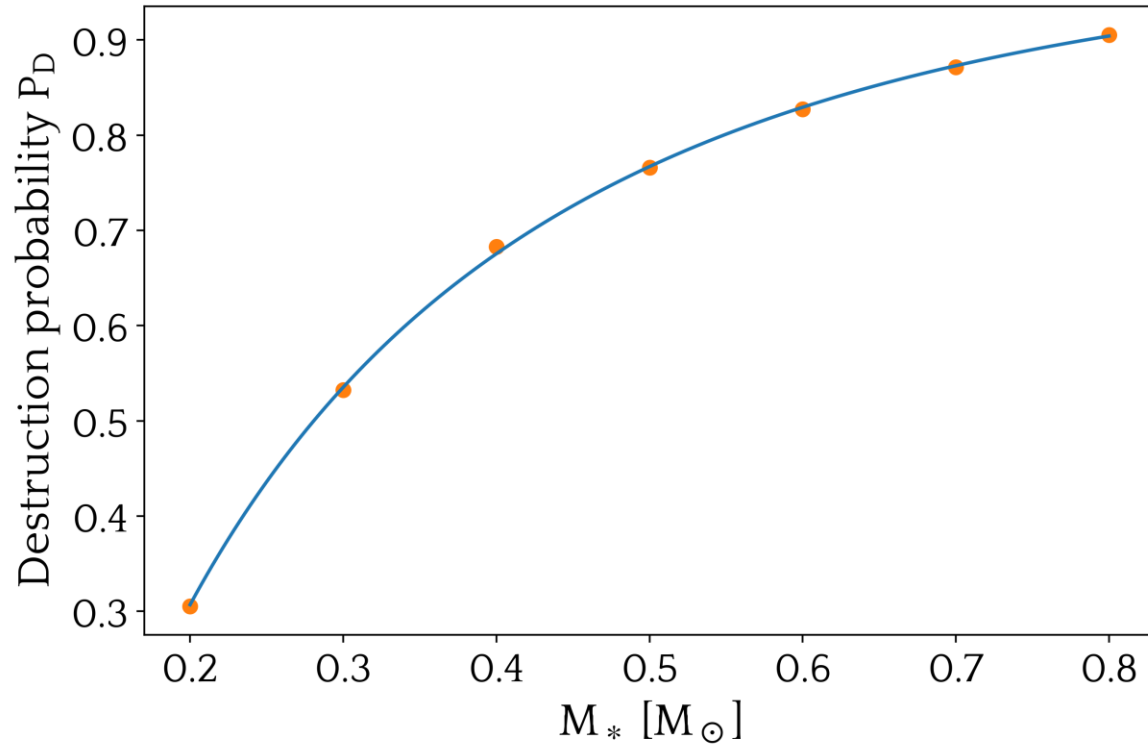
Destruction probability



Destruction probability:

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Destruction probability



P_D  with the stellar mass!

Destruction probability:

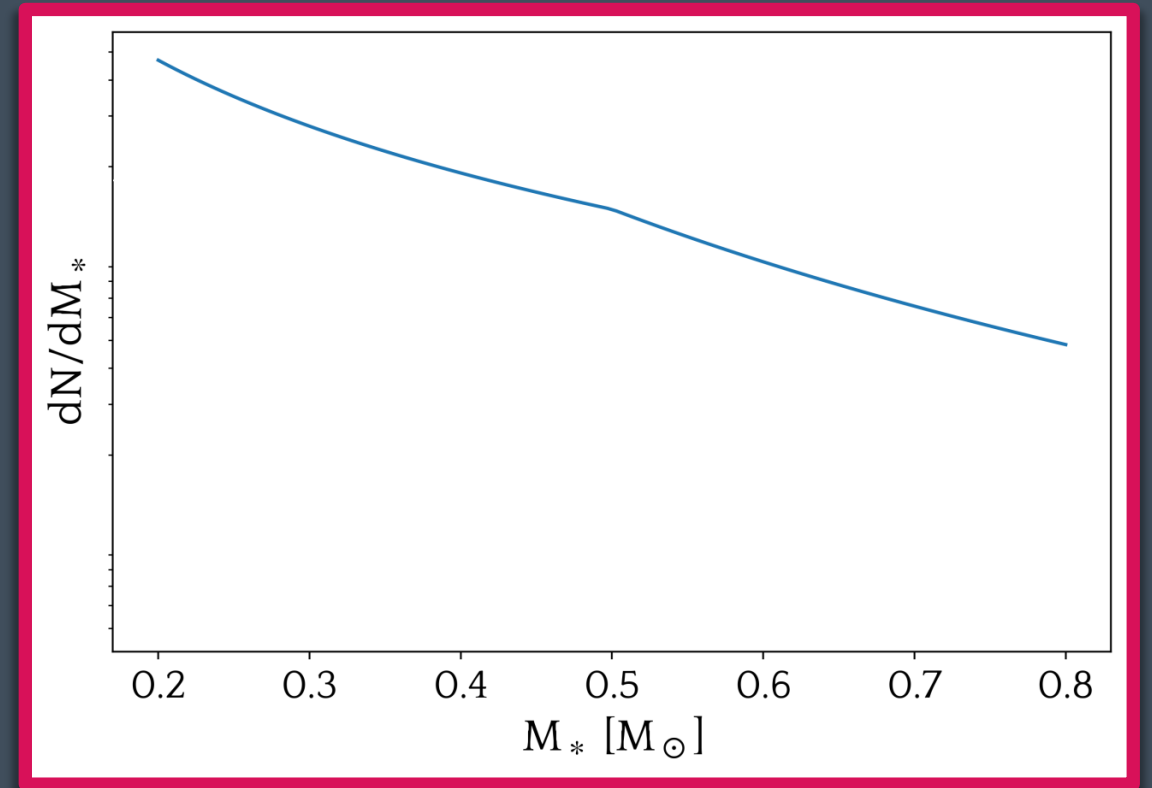
$$P_D = 1 - e^{-\bar{N}_{\text{cap}}}$$

Heavier stars are more
likely to be destroyed
by PBHs

Star destruction



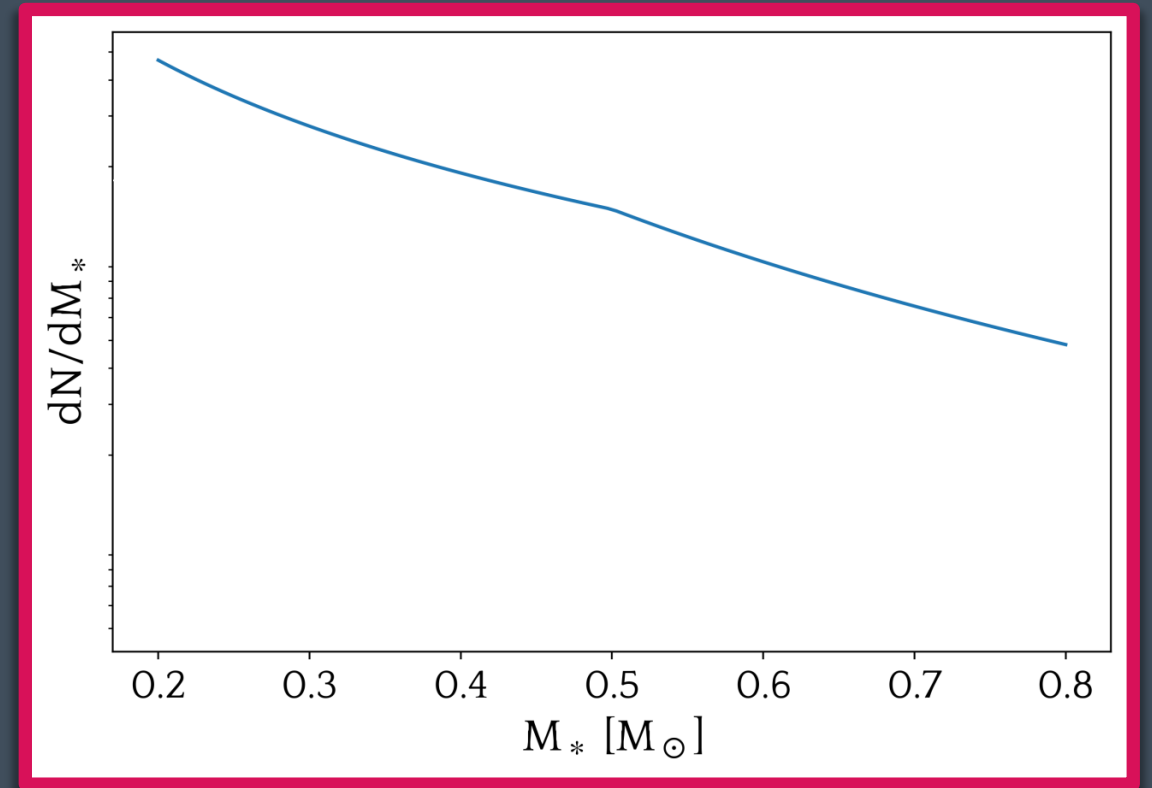
Stellar mass function



Star destruction



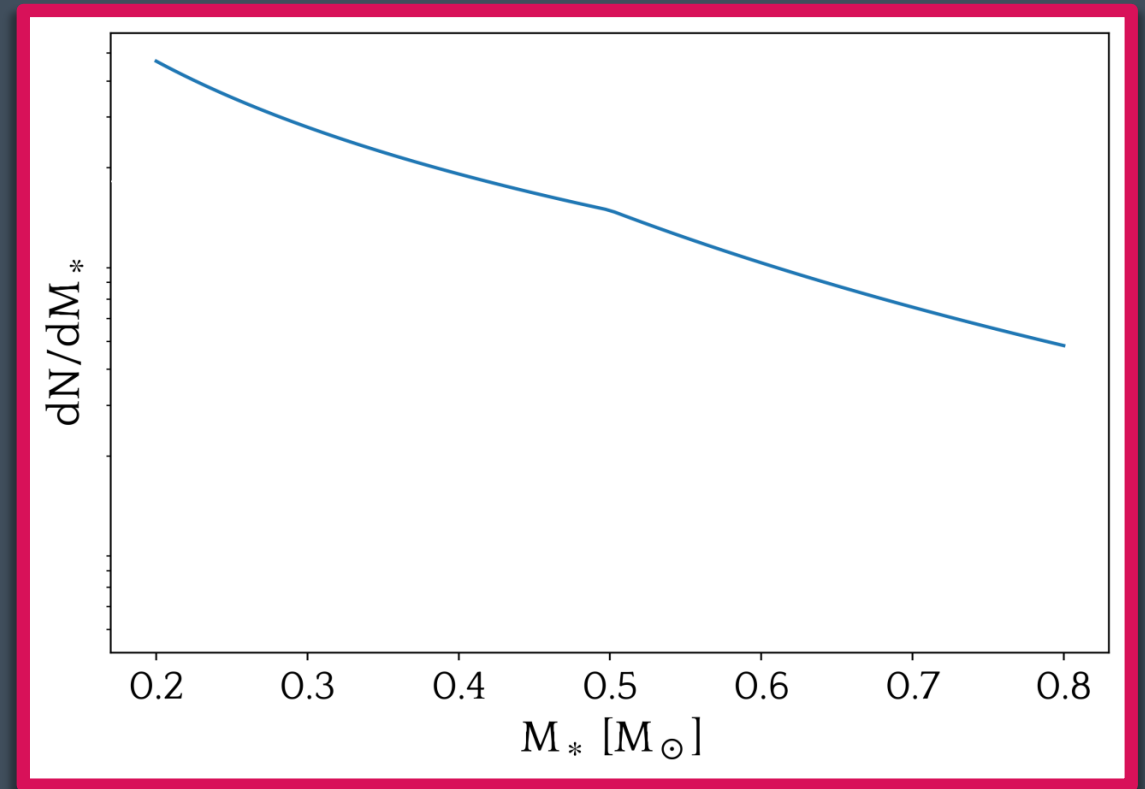
Stellar mass function



Star destruction



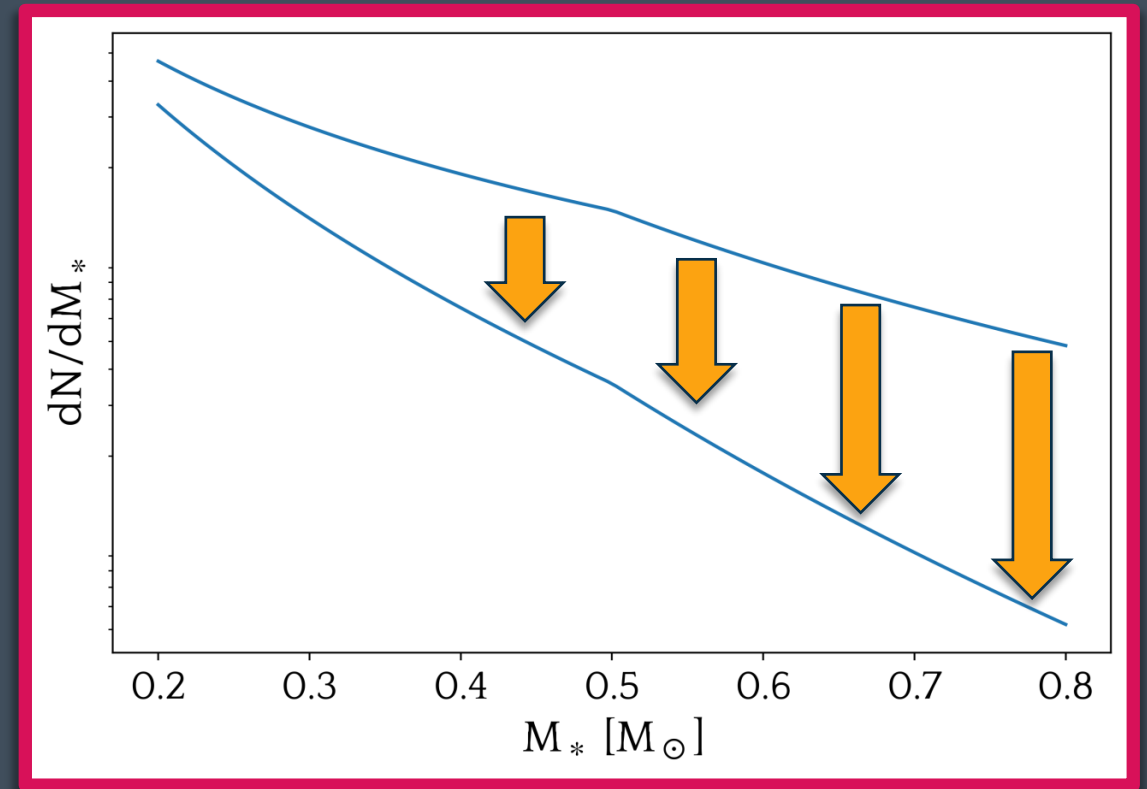
Stellar mass function



Star destruction



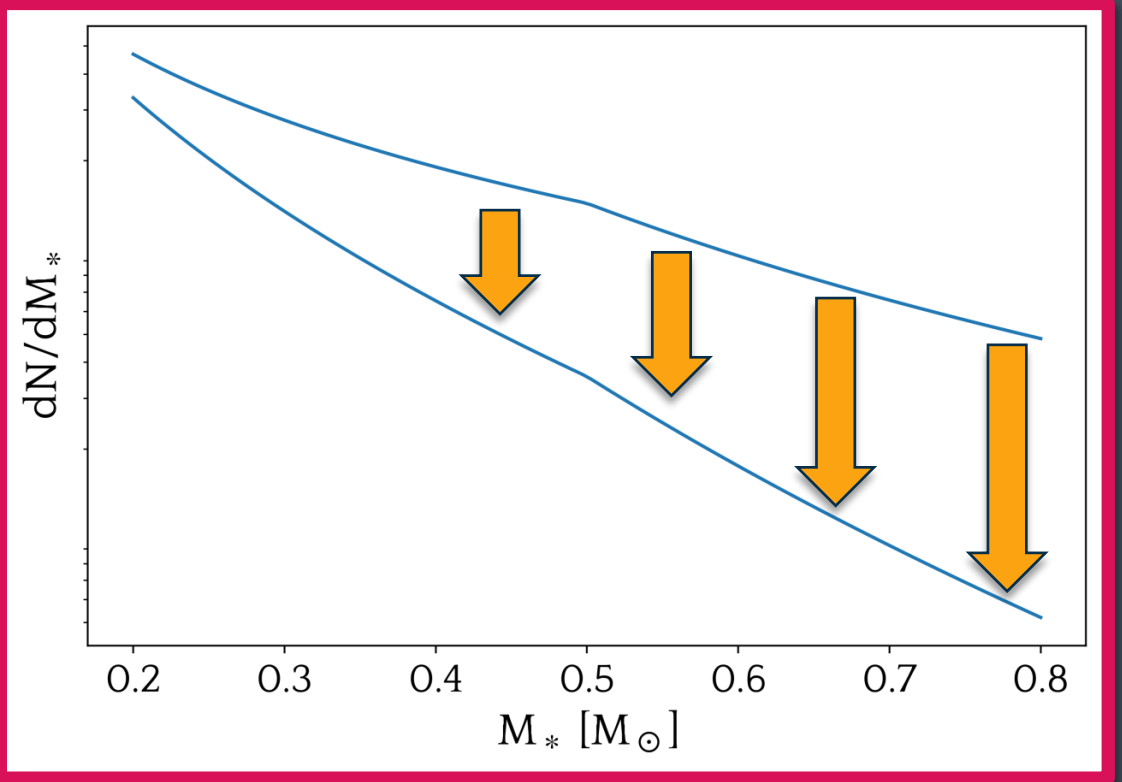
Stellar mass function



Star destruction

We need environments where:

Stellar mass function

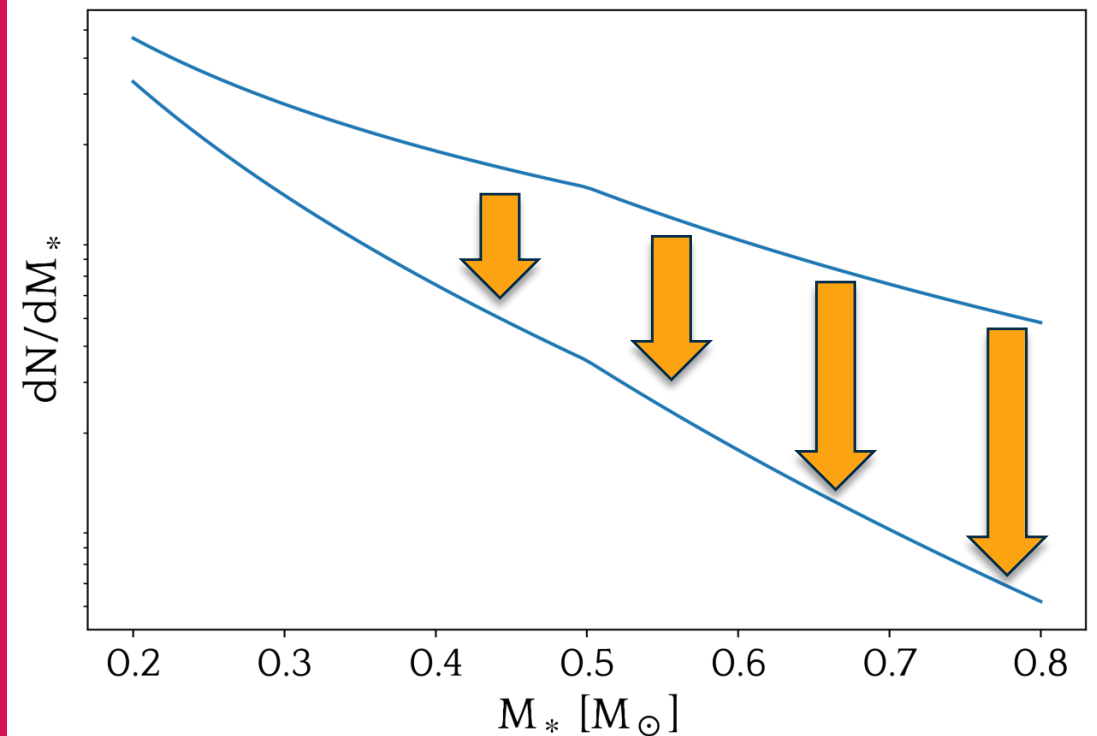


Star destruction

We need environments where:

- The star destruction effect of PBHs is strong

Stellar mass function

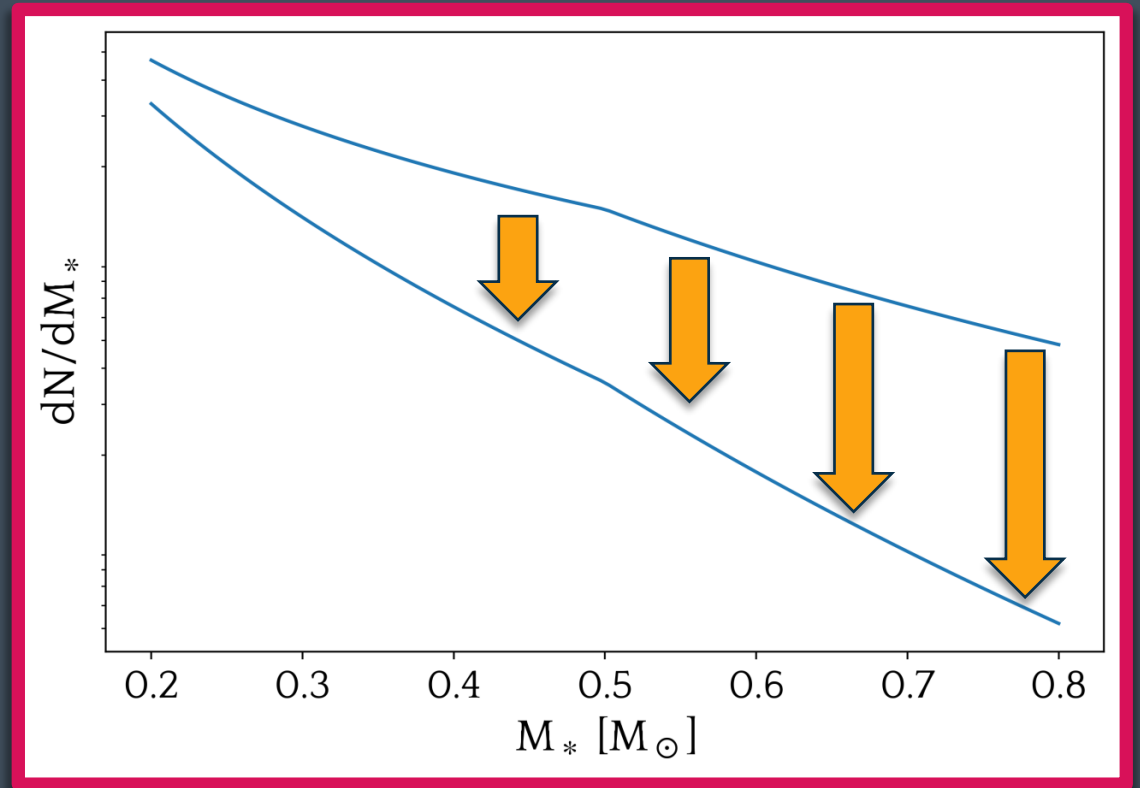


Star destruction

We need environments where:

- The star destruction effect of PBHs is strong
- The stellar mass function is measurable

Stellar mass function



Ultra-faint dwarf galaxies

Ultra-faint dwarf galaxies

- Small, DM-dominated satellite galaxies of the Milky Way

Ultra-faint dwarf galaxies

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Strong star destruction effect $\propto \frac{\rho_{\text{DM}}}{\sigma^3}$

Ultra-faint dwarf galaxies

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- Located at $\sim 10 - 100$ kpc  $O(500 - 1000)$ stars
resolved individually in each galaxy

Ultra-faint dwarf galaxies

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resolved individually in each galaxy



Stellar mass function is measurable

Ultra-faint dwarf galaxies

NEHOP24:

Simulated data ☹️

Ultra-faint dwarf galaxies

25

NEHOP~~24~~:

~~Simulated data~~



Real



Ultra-faint dwarf galaxies

Hubble Space Telescope



Ultra-faint dwarf galaxies

Hubble Space Telescope



- Reticulum II, Segue 1, Triangulum II

Ultra-faint dwarf galaxies

	Reticulum II	Segue 1	Triangulum II
$R_{1/2}$ [pc]	51	24	16
D [kpc]	31.6	22.9	28.4
σ [km s ⁻¹]	5.7	6.4	5.9
$\bar{\rho}_{\text{DM}}$ [GeV cm ⁻³]	15	85	161
PBH effect ?	negligible	mild	strong

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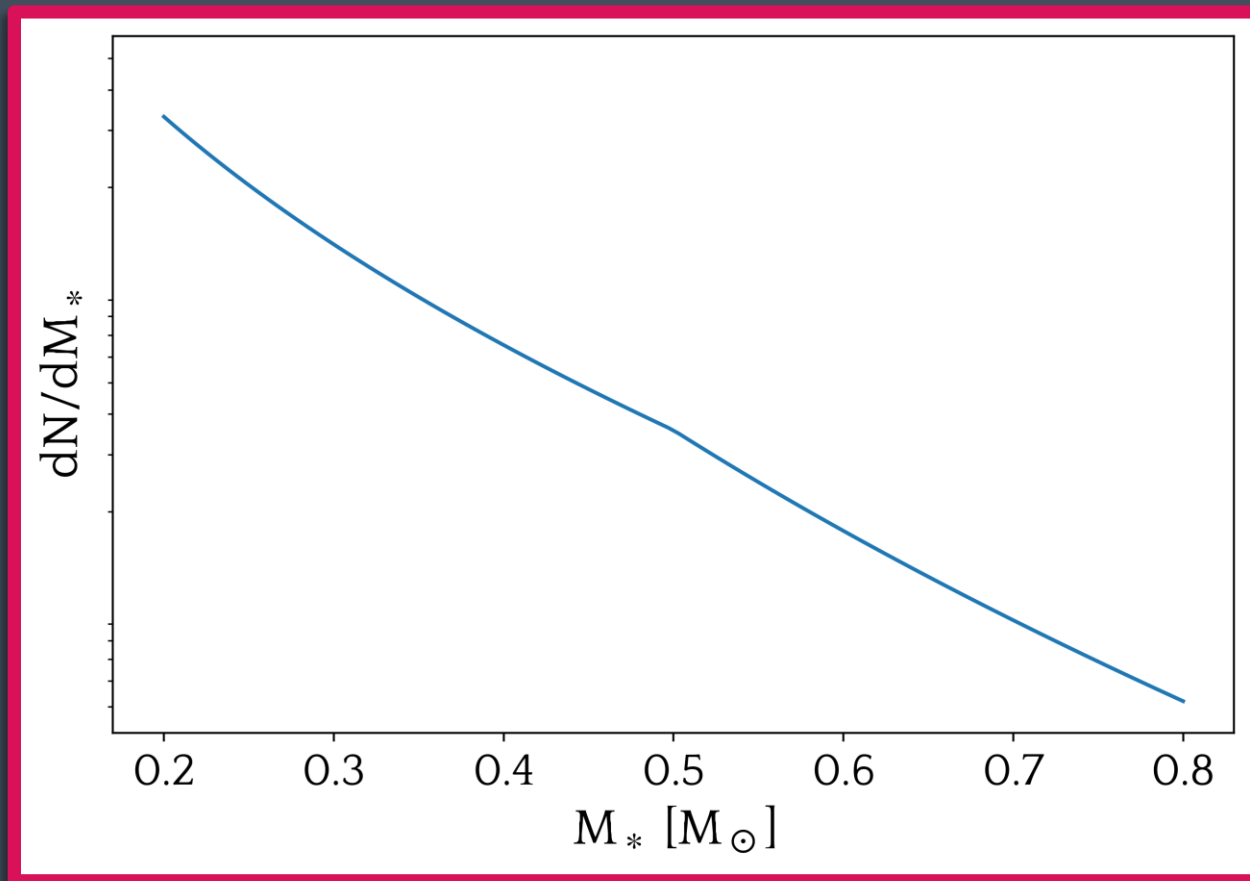
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Comparison!

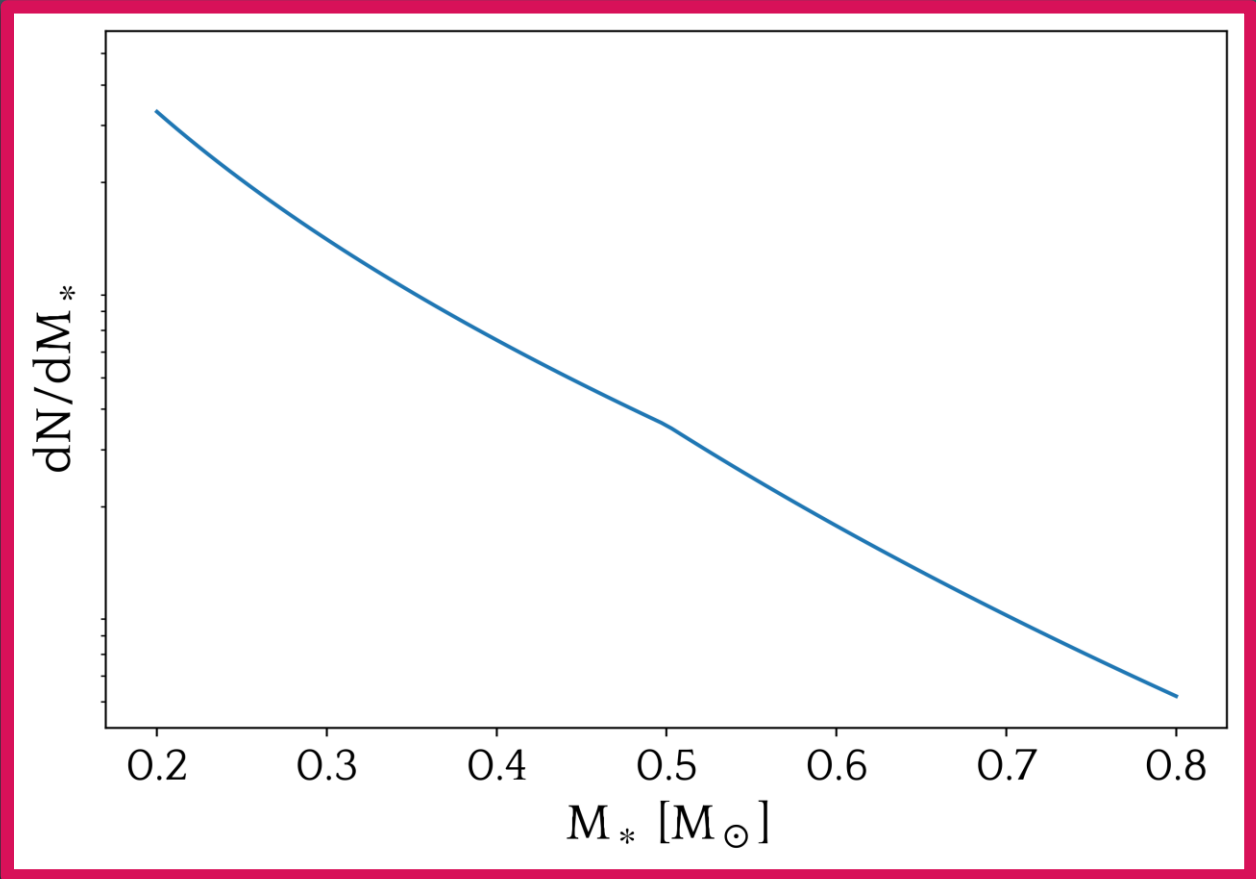
Observable?

We do not directly measure this:

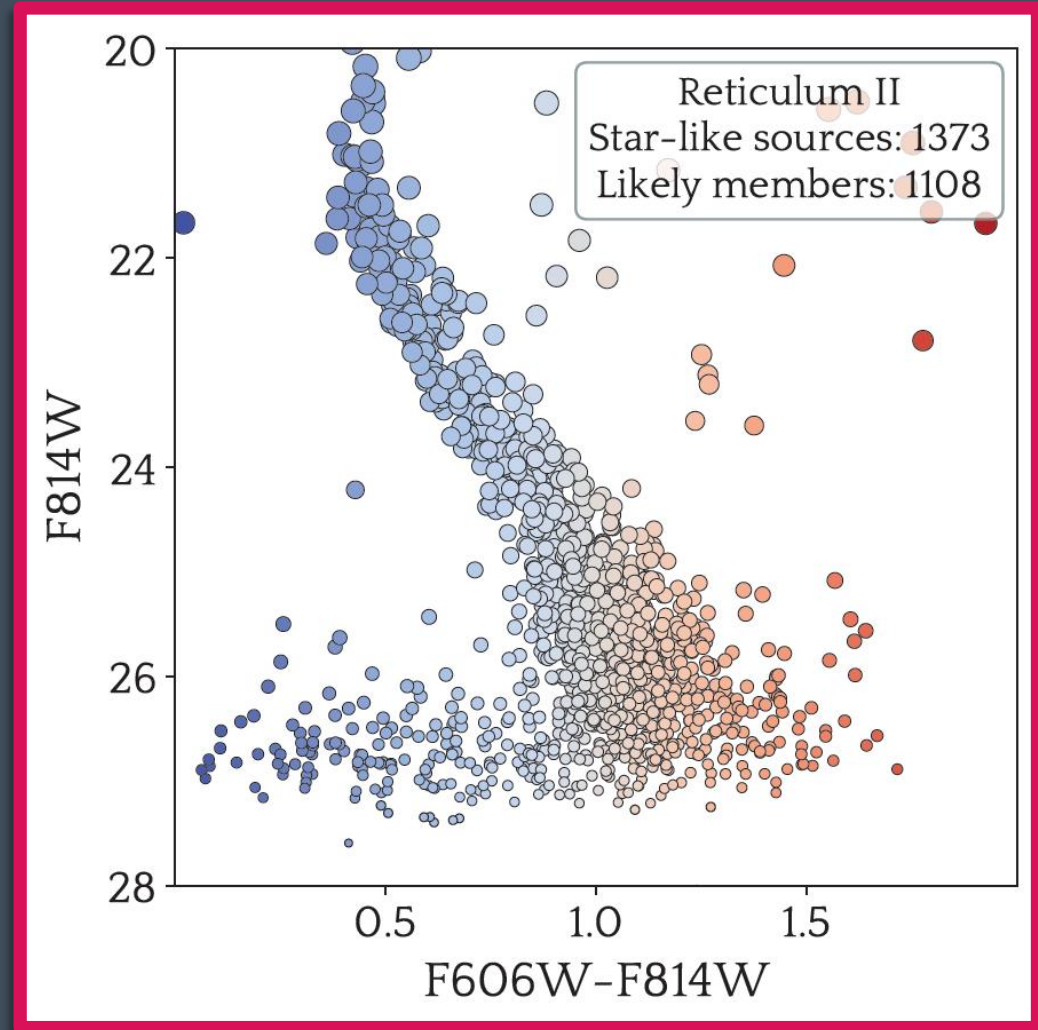


Observable?

We do not directly measure this:



But this:



Model

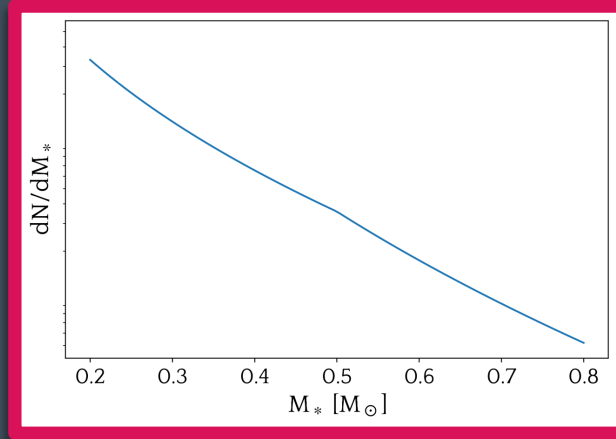
Model

Generate M_* (2 parameters)

Generate $[\text{Fe}/\text{H}]$

Create binaries (1 parameter)

PBH effect (1 parameter)



Model

Generate M_* (2 parameters)

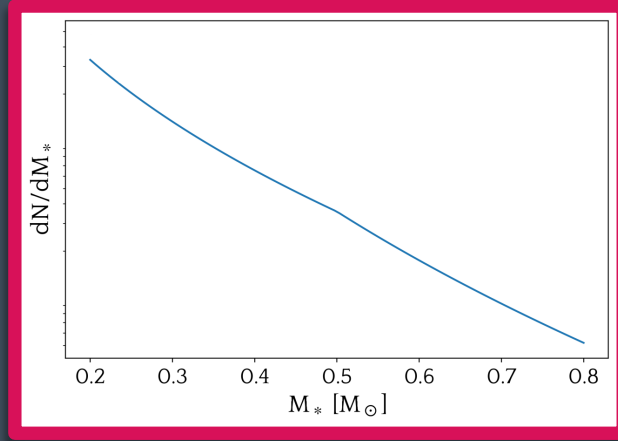
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Create binaries (1 parameter)

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Dartmouth stellar models

F606W and F814W mag



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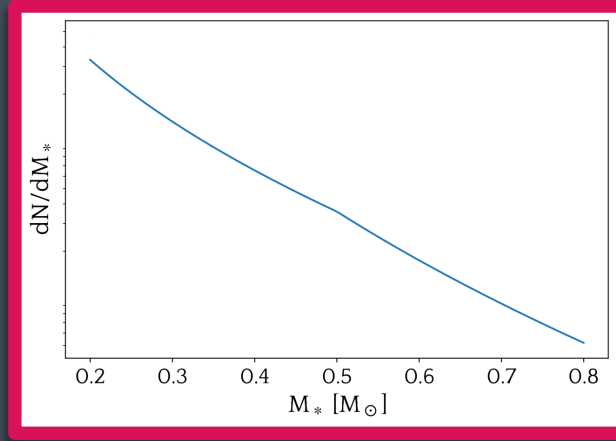
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+

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Model

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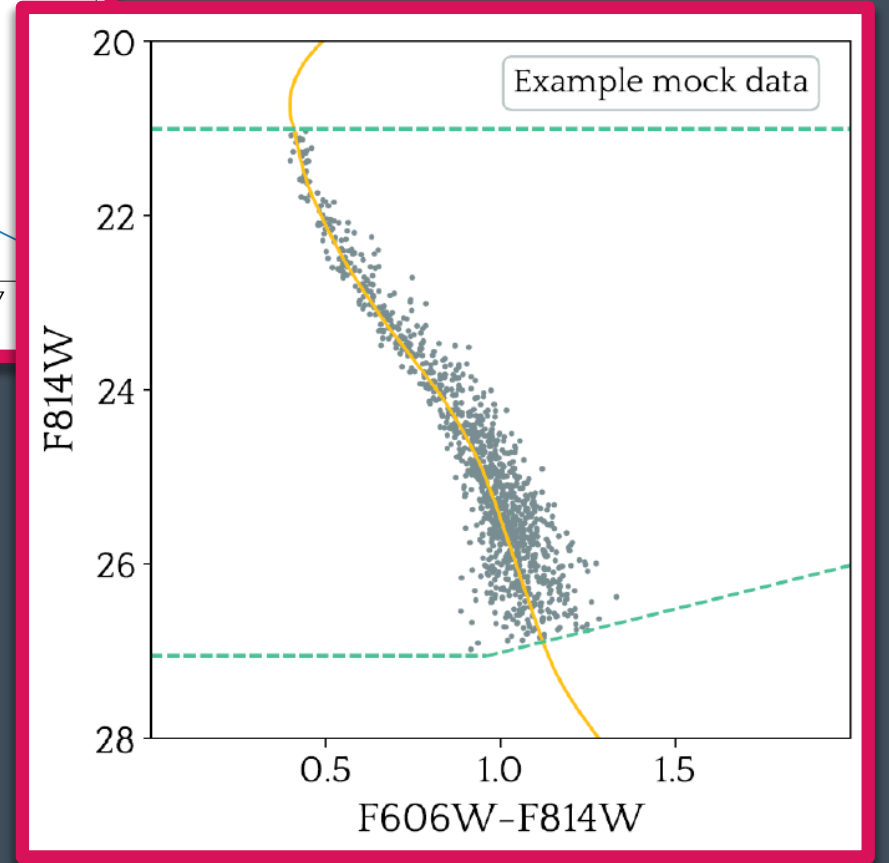
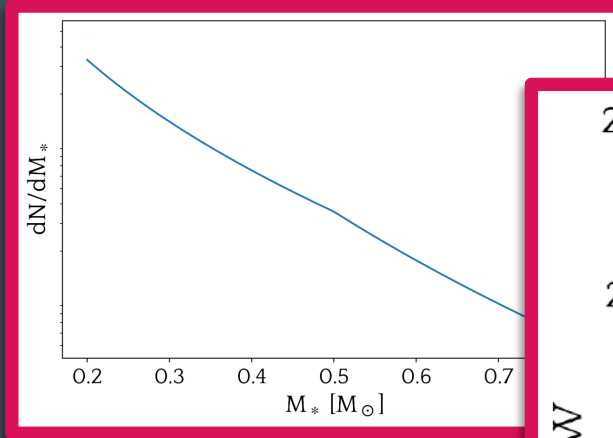
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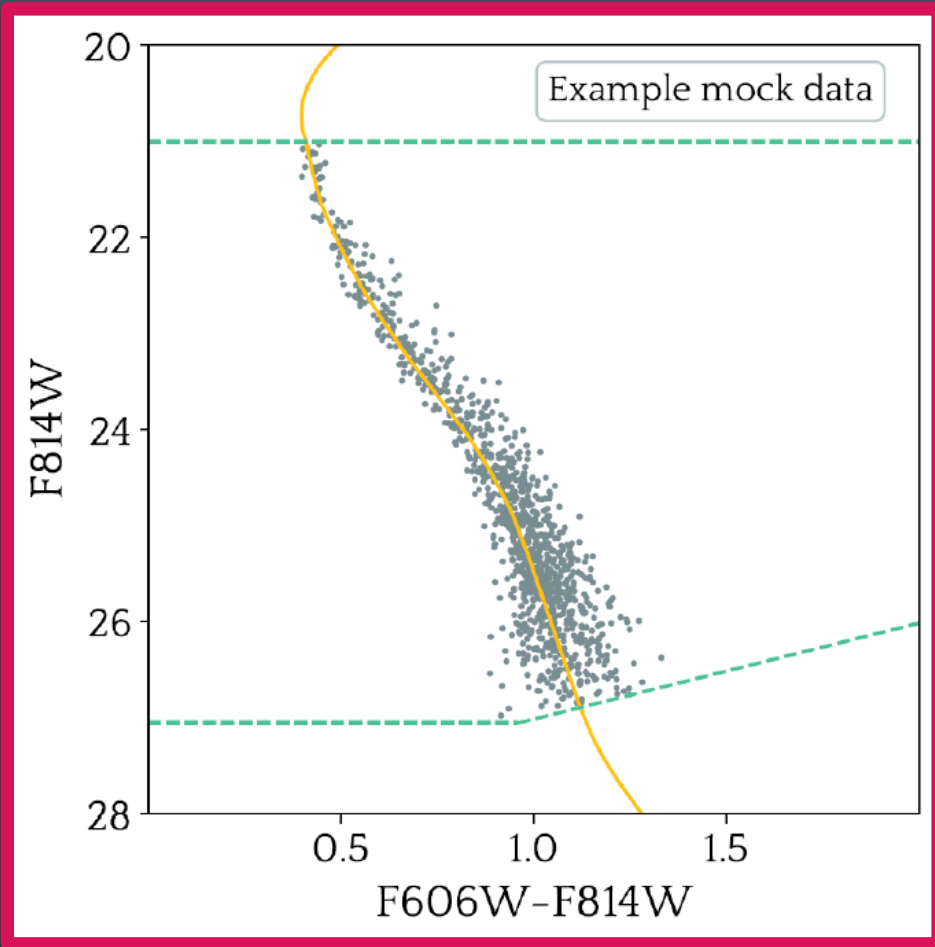
F606W and F814W mag

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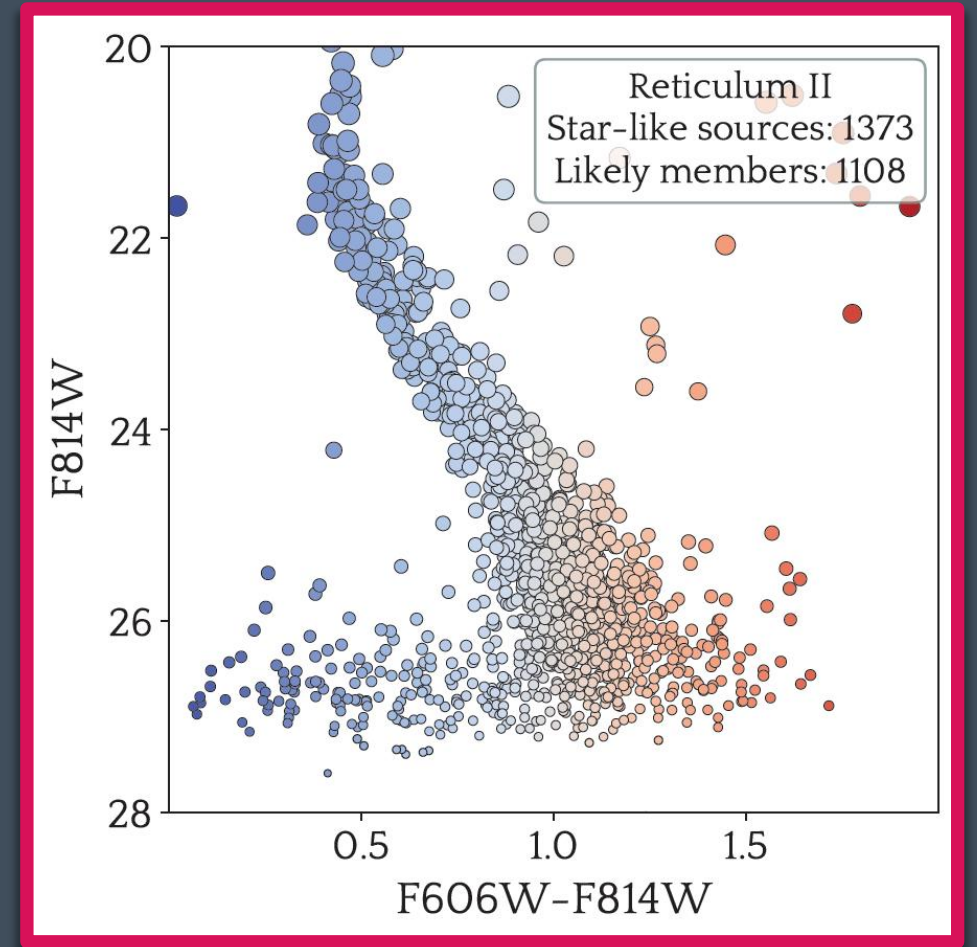
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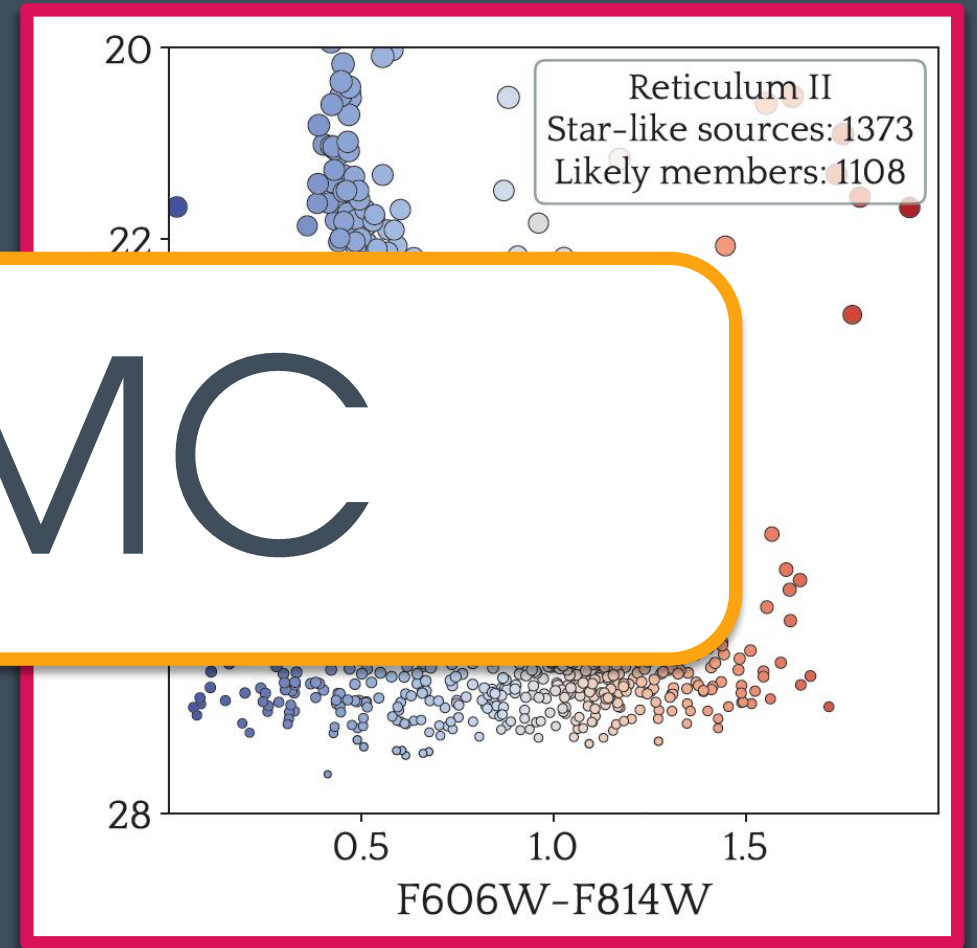
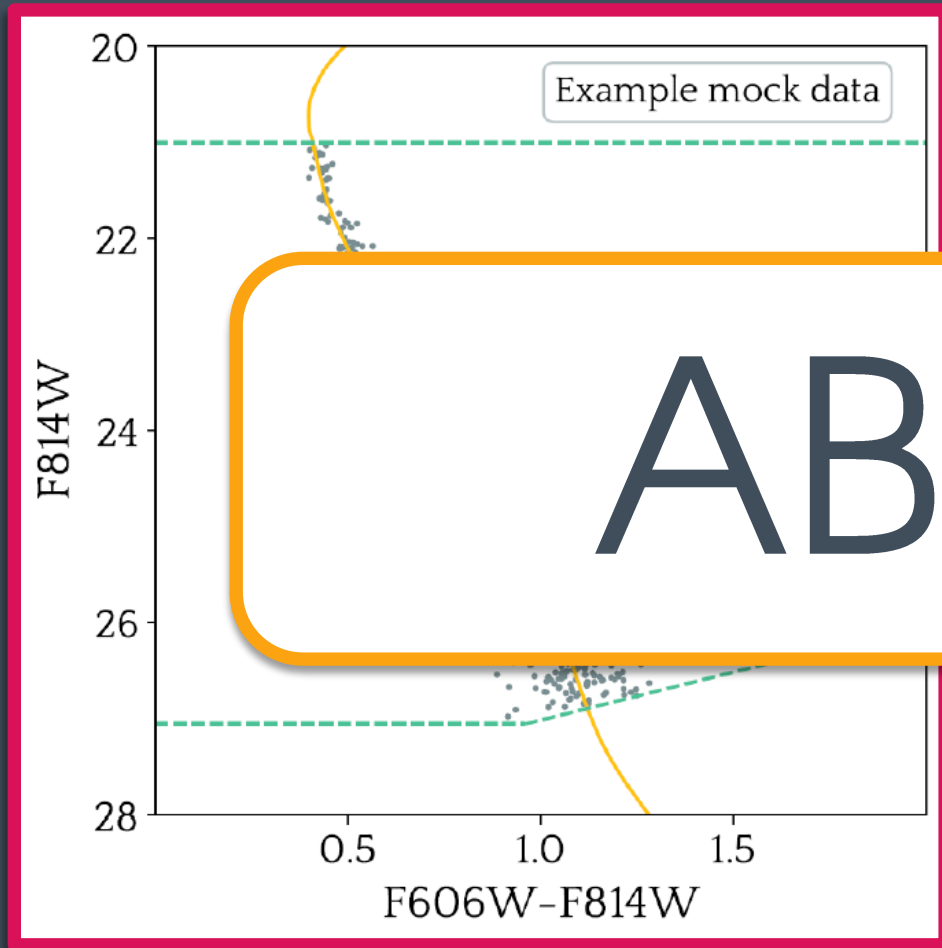
Strategy



VS

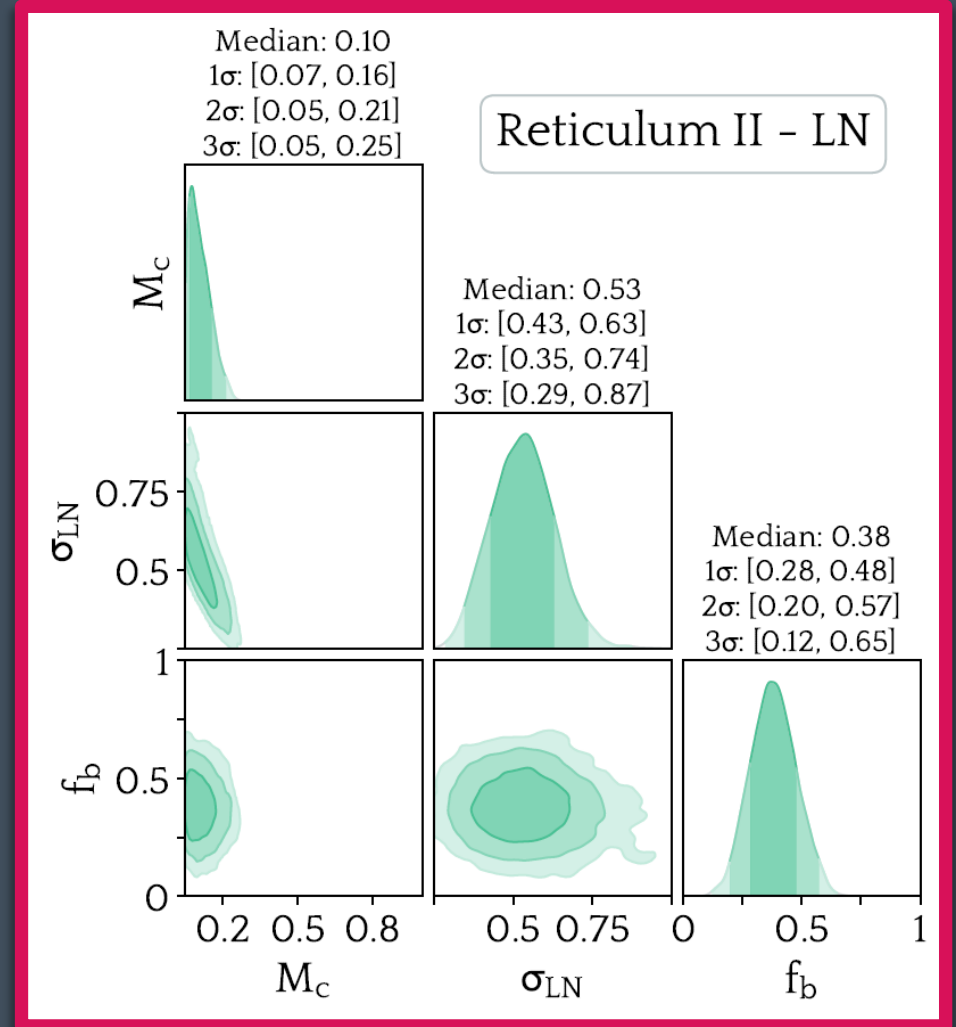
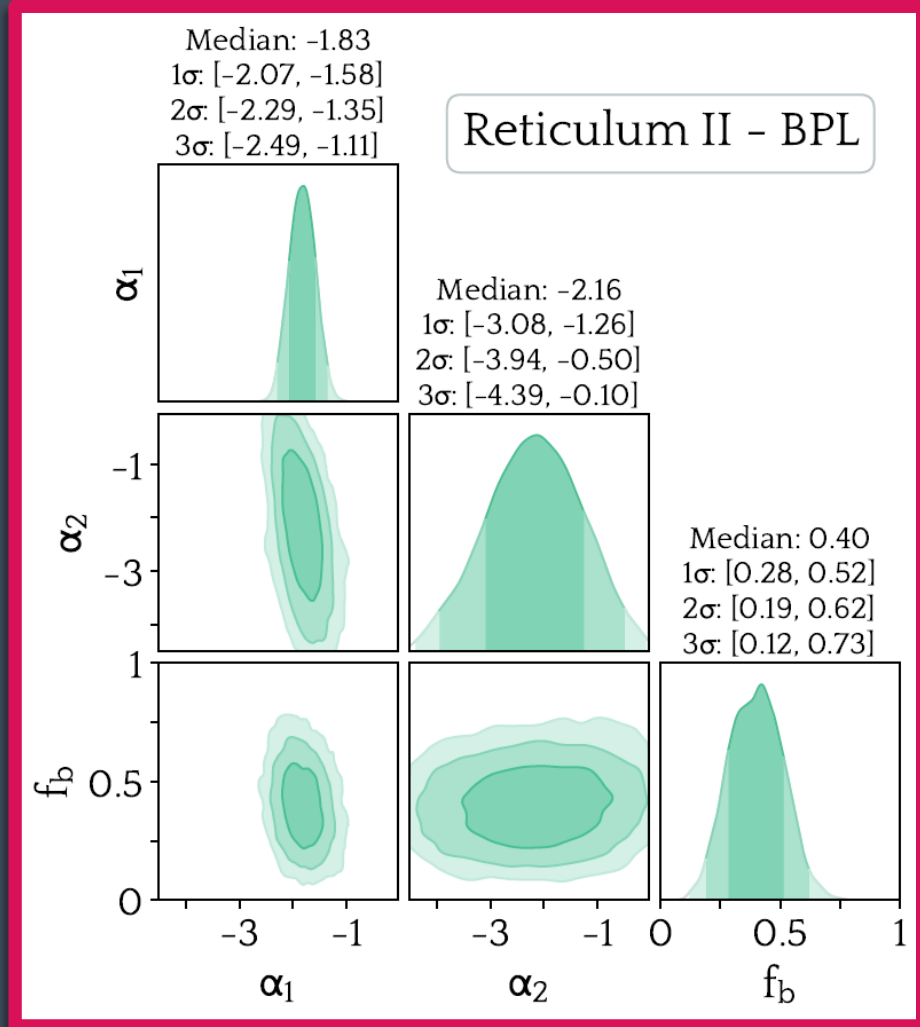


Strategy



ABC SMC

Control galaxy: Reticulum II



Control galaxy: Reticulum II

Median: -1.83
1 σ : [-2.07, -1.58]

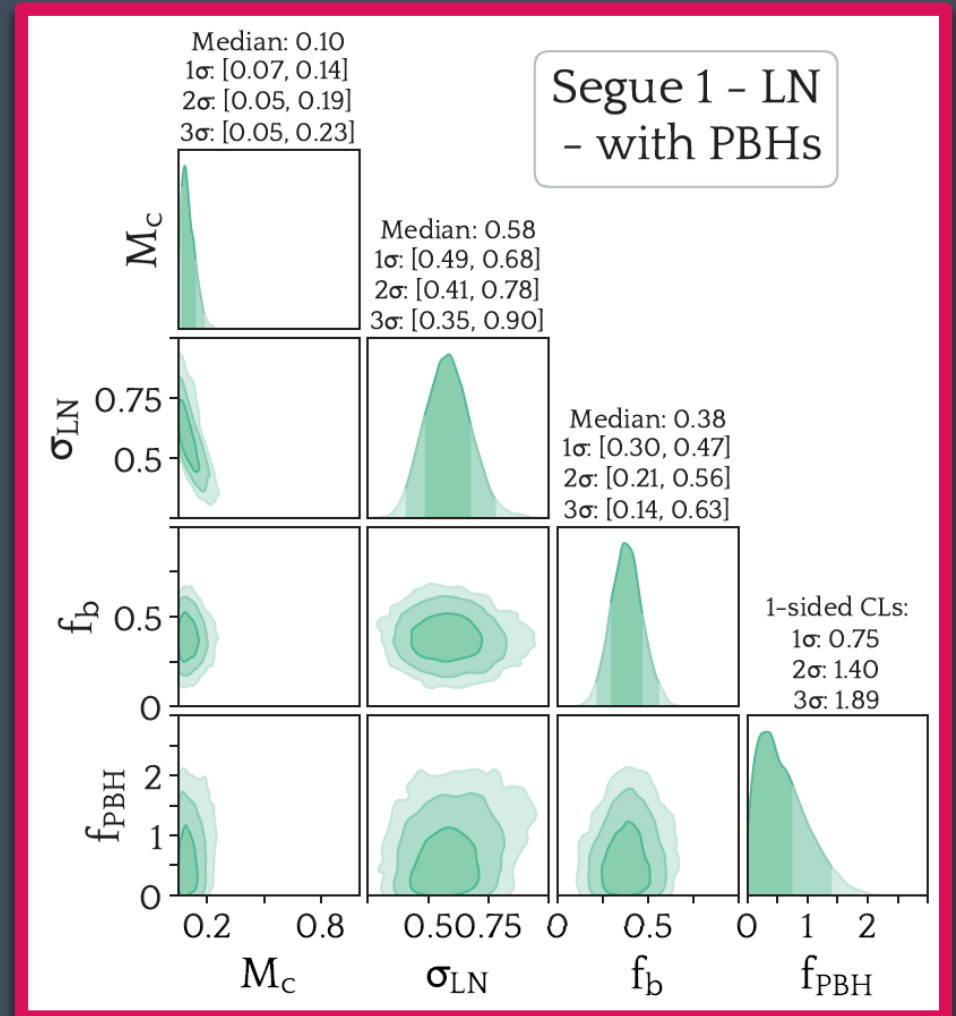
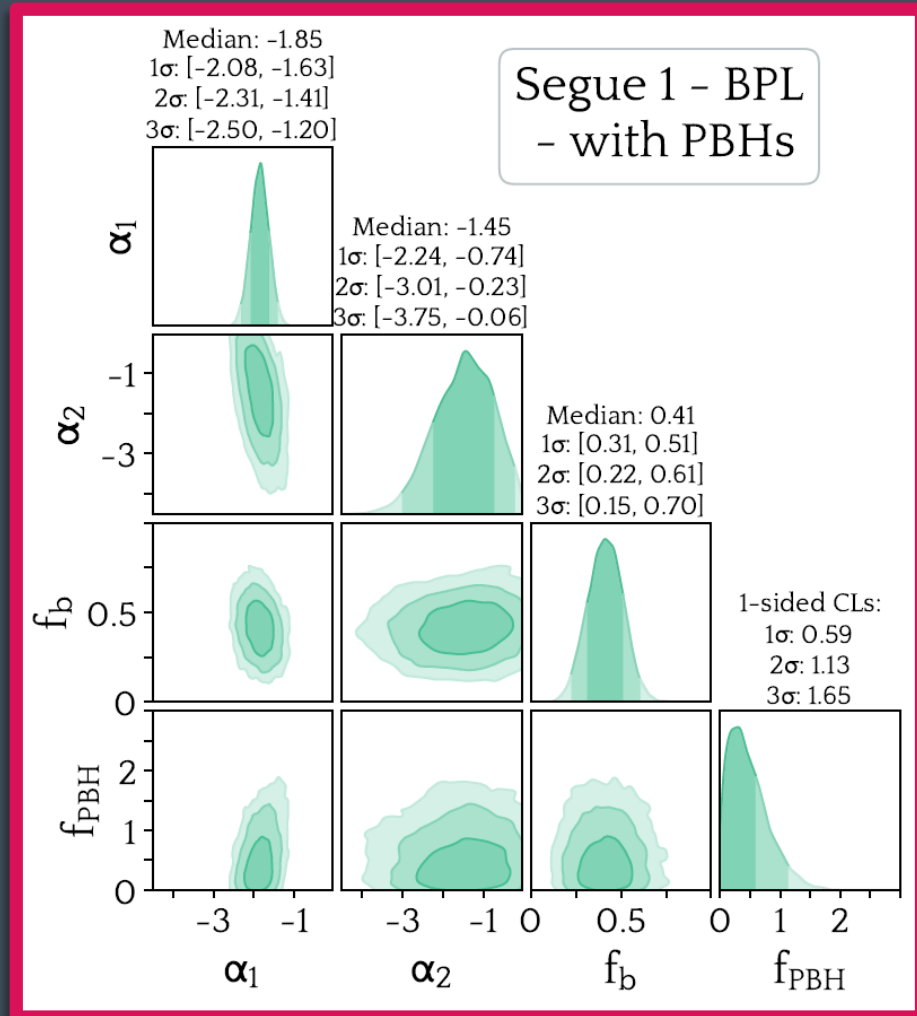
Median: 0.10
1 σ : [0.07, 0.16]

Used as prior for
the test galaxies

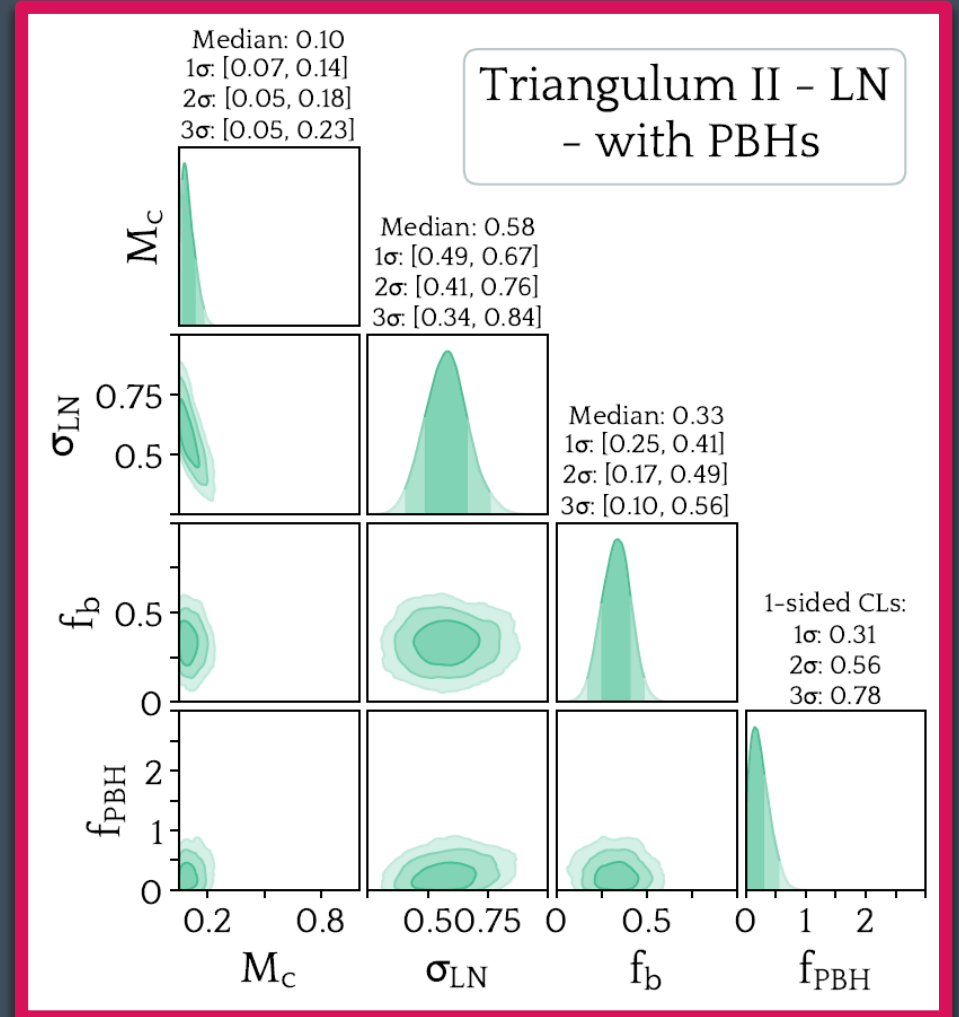
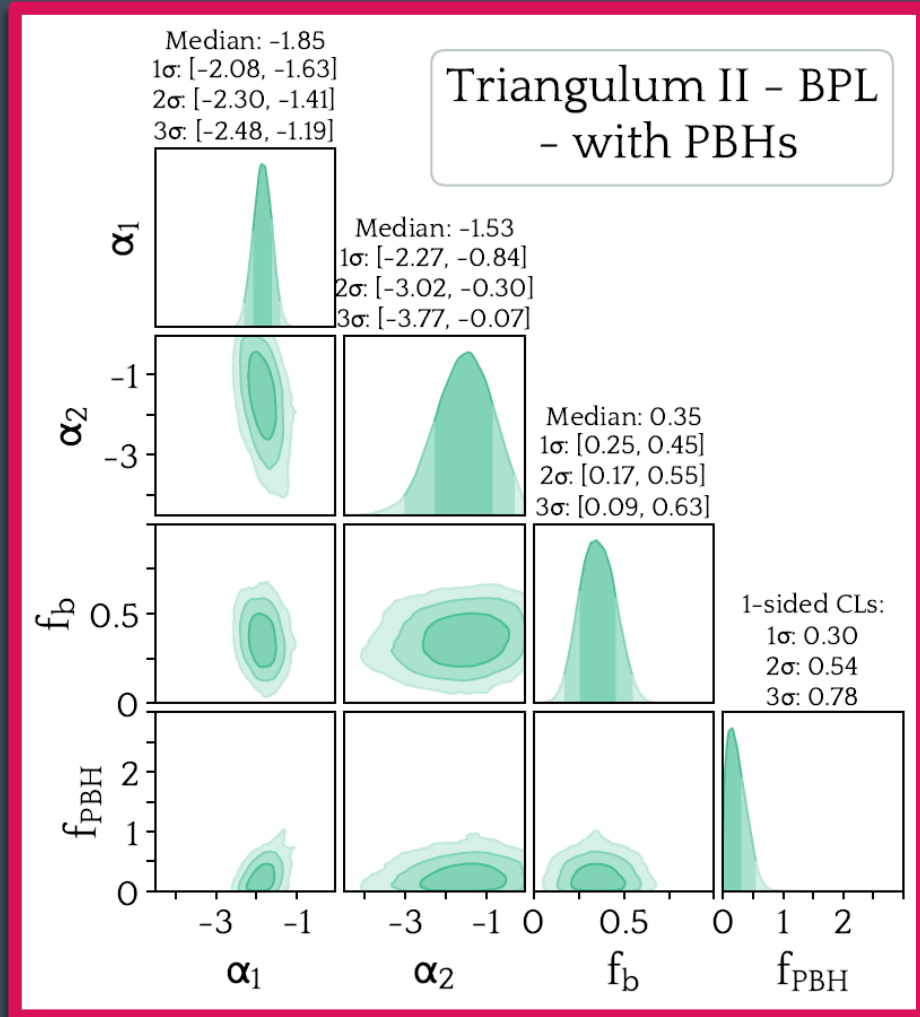
α_1 α_2 f_b

M_c σ_{LN} f_b

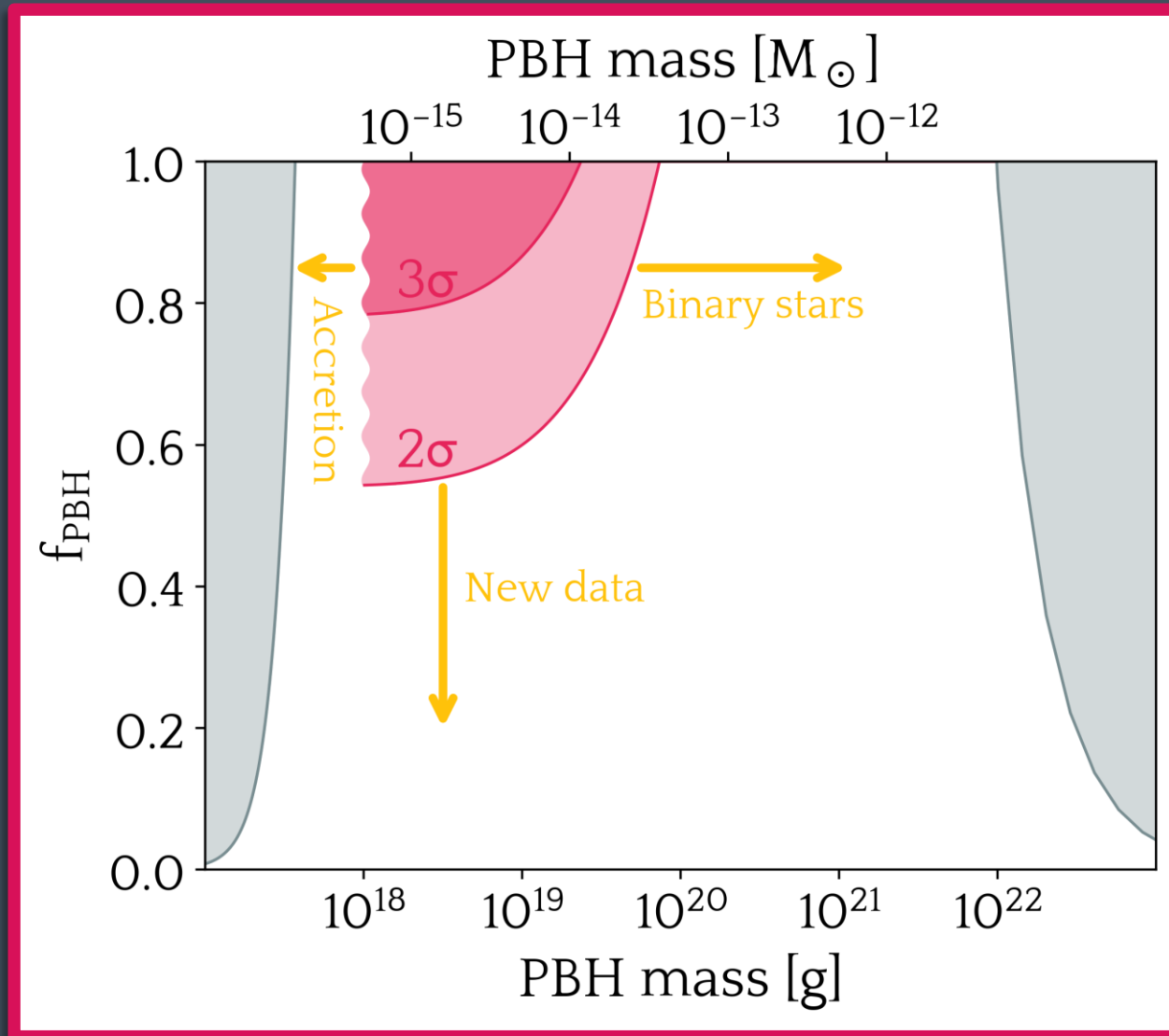
Test galaxies: Segue 1



Test galaxies: Triangulum II

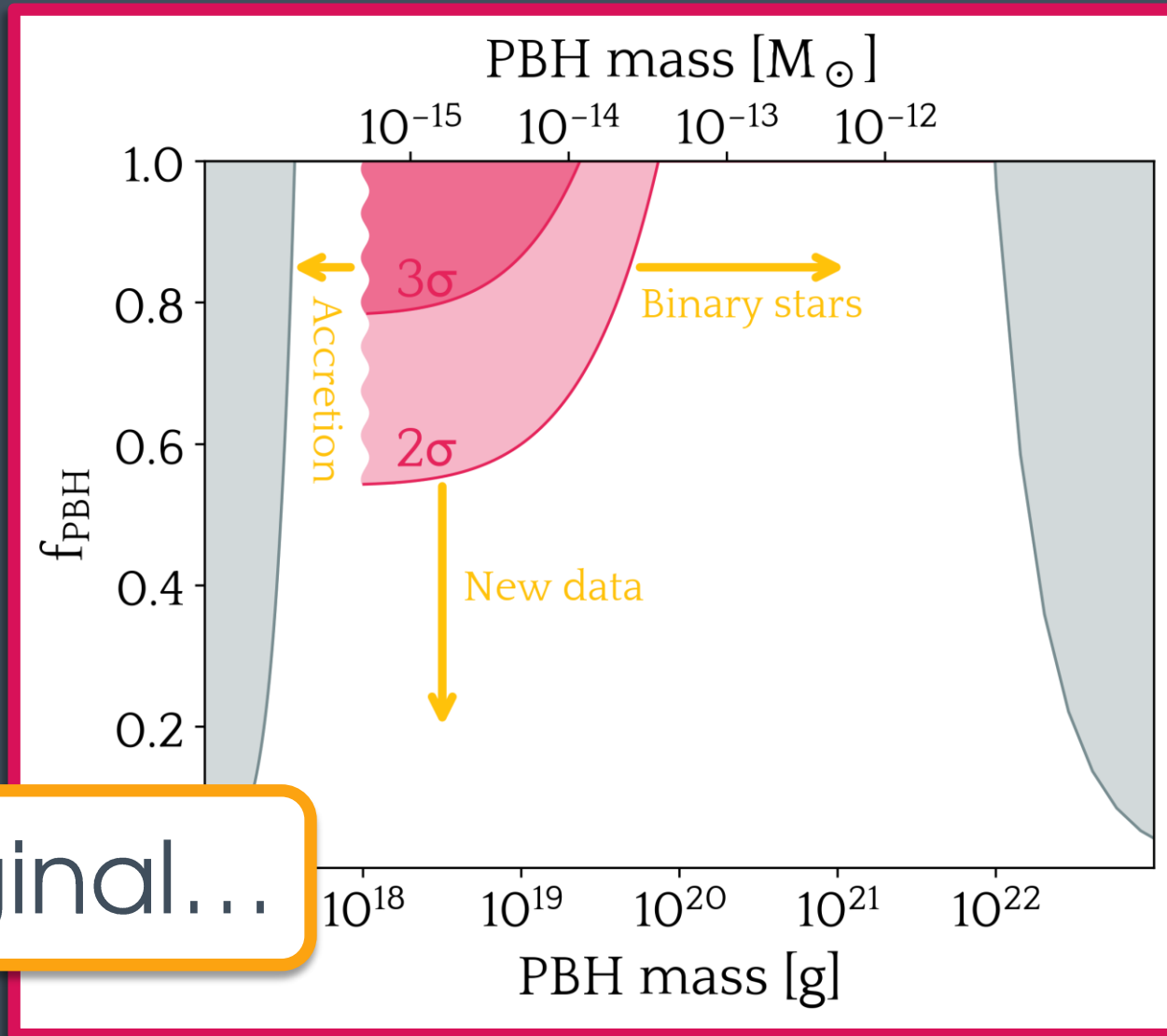


Brand new constraints



Esser et al. (2025)

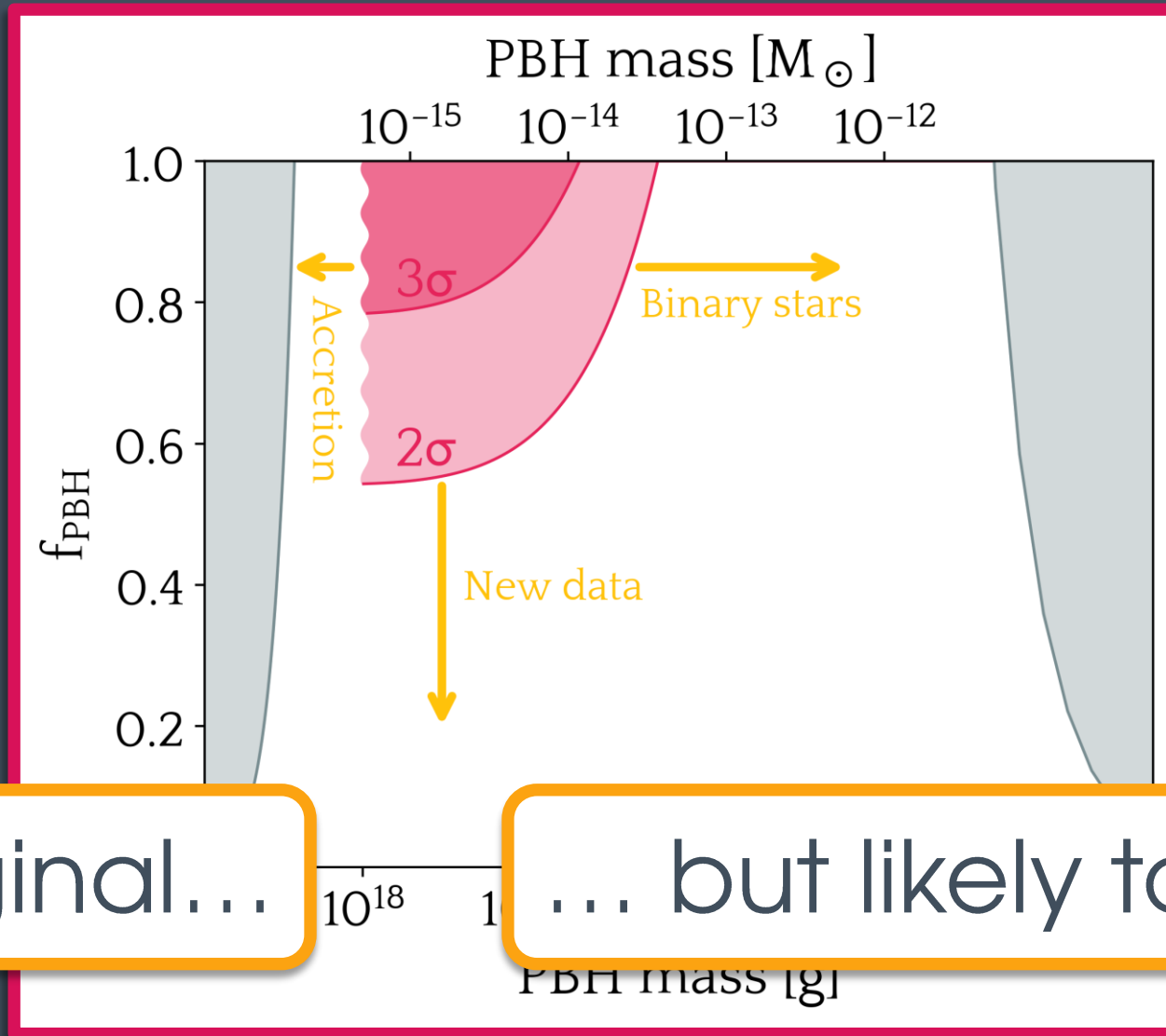
Brand new constraints



Esser et al. (2025)

Yes, marginal...

Brand new constraints



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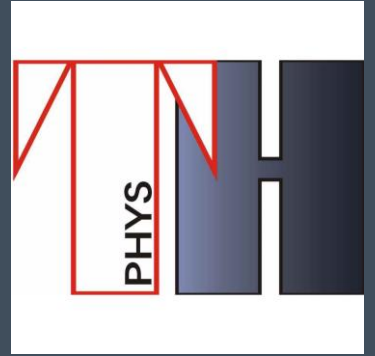
Yes, marginal...

... but likely to improve!



ULB

Thank you!



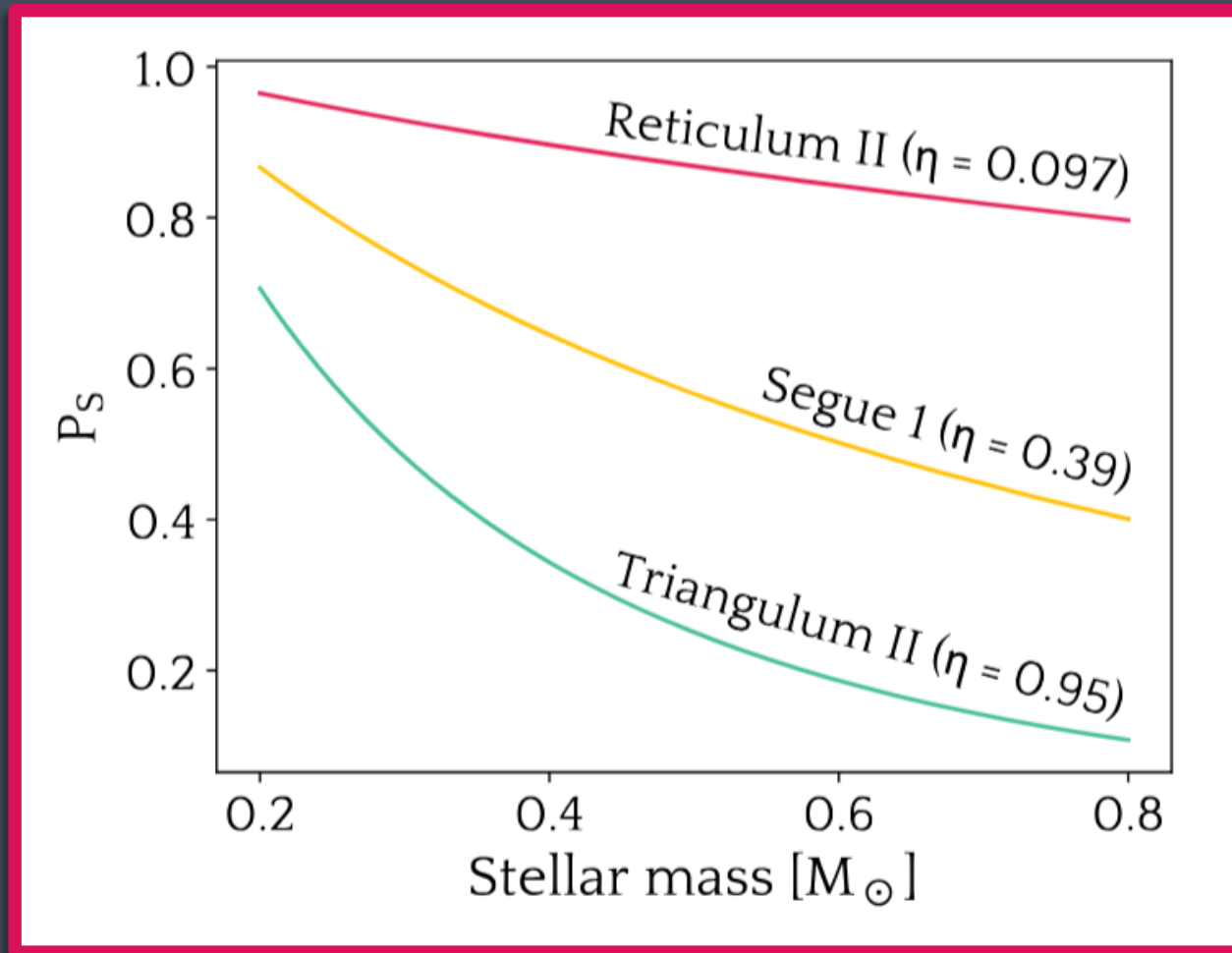
arXiv:2503.03352 (accepted in A&A)

arXiv:2311.12658 (MNRAS)

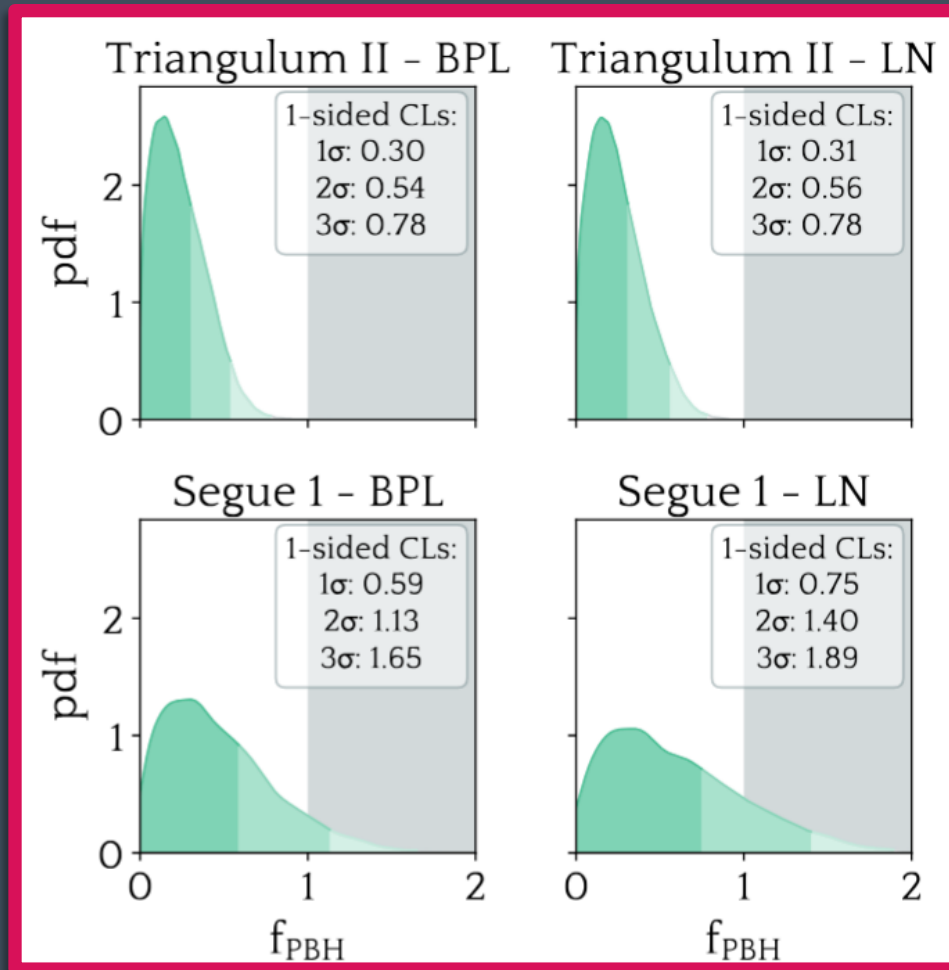
arXiv:2207.07412 (PRD)

Nicolas Esser

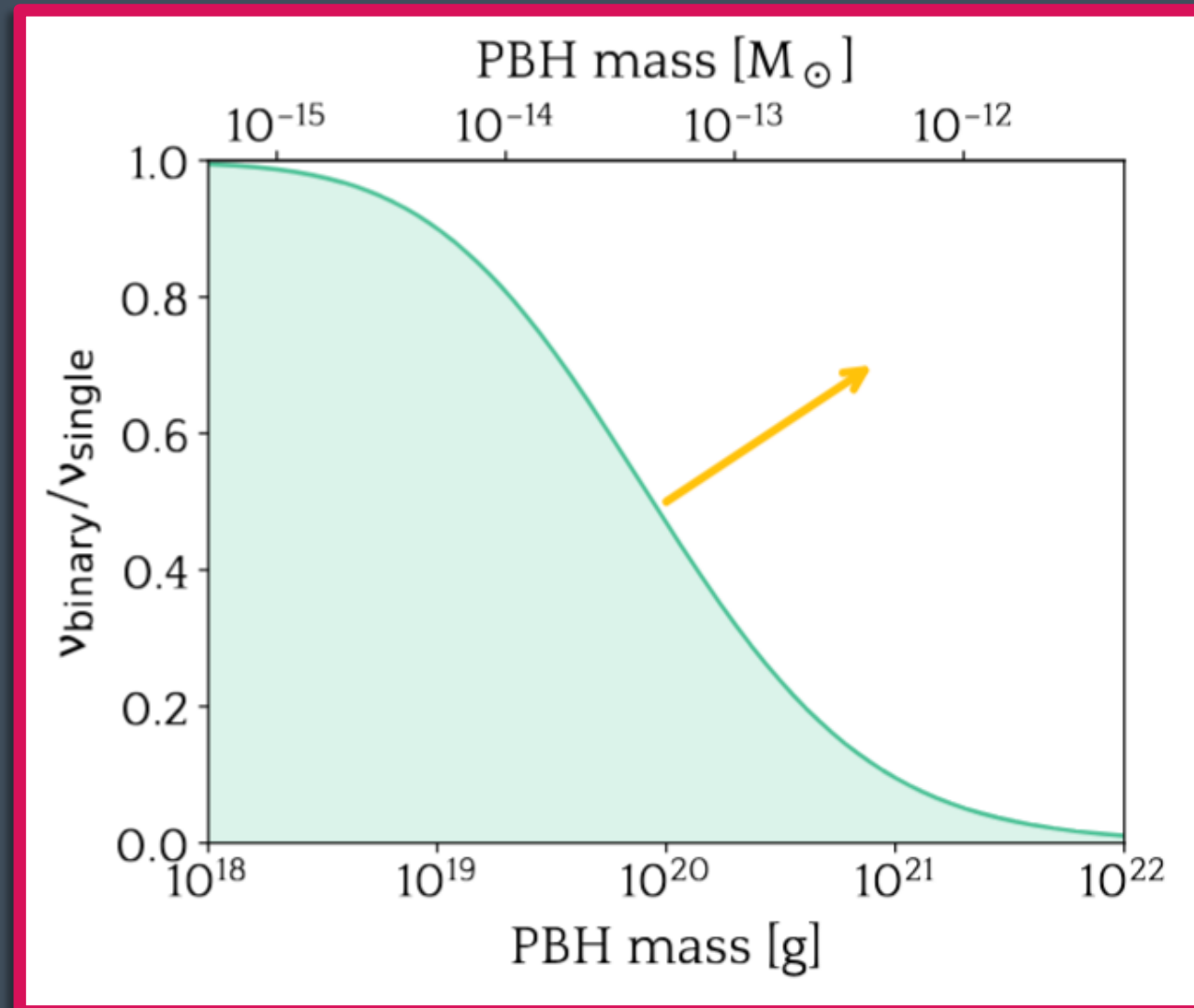
Backup slides



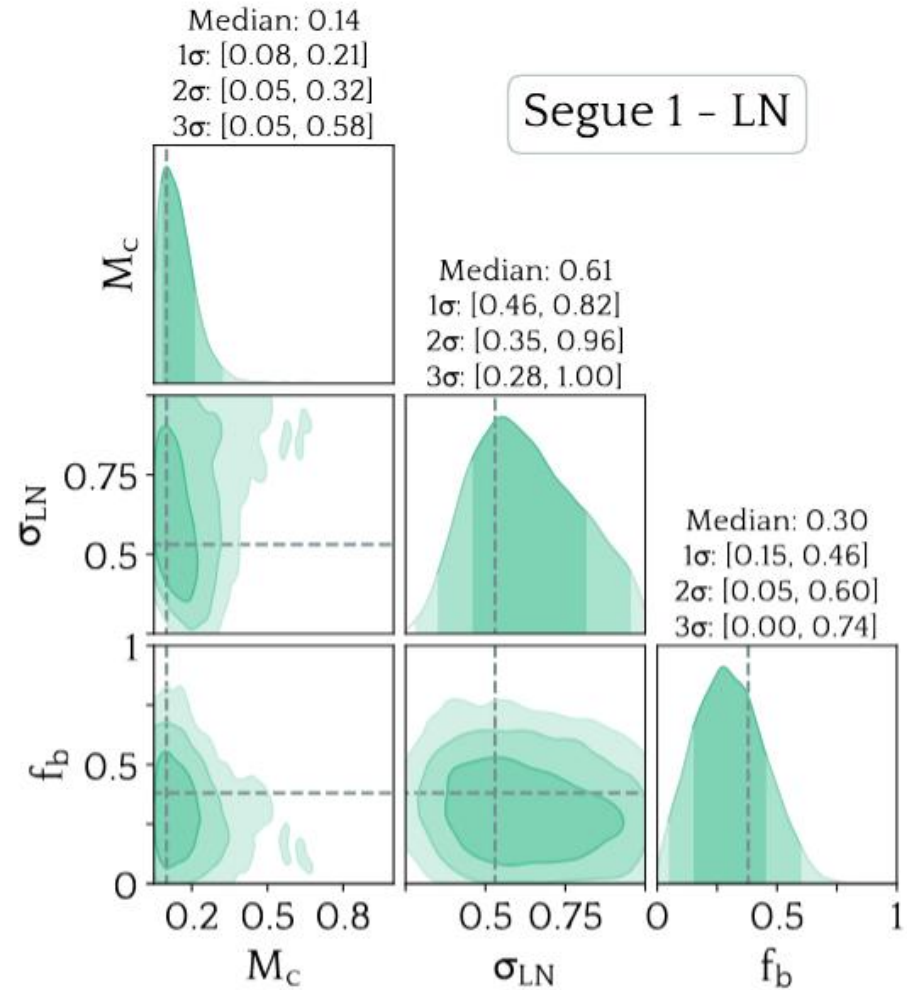
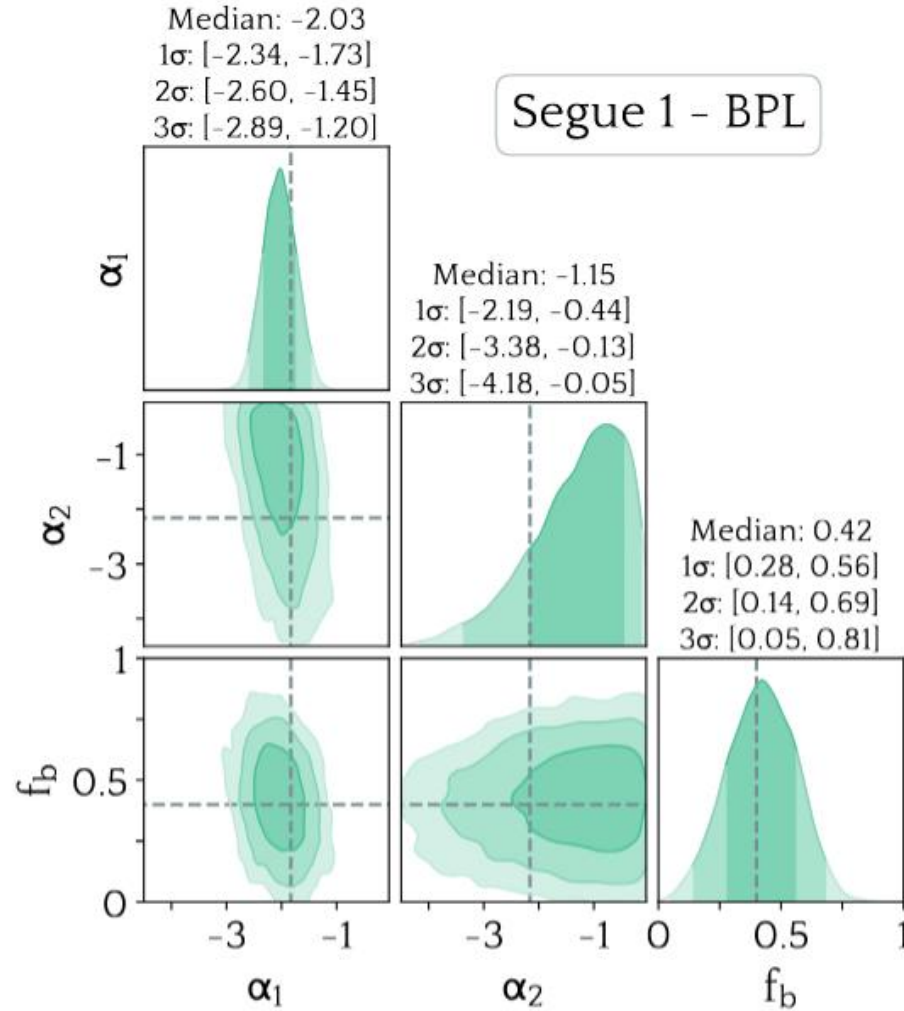
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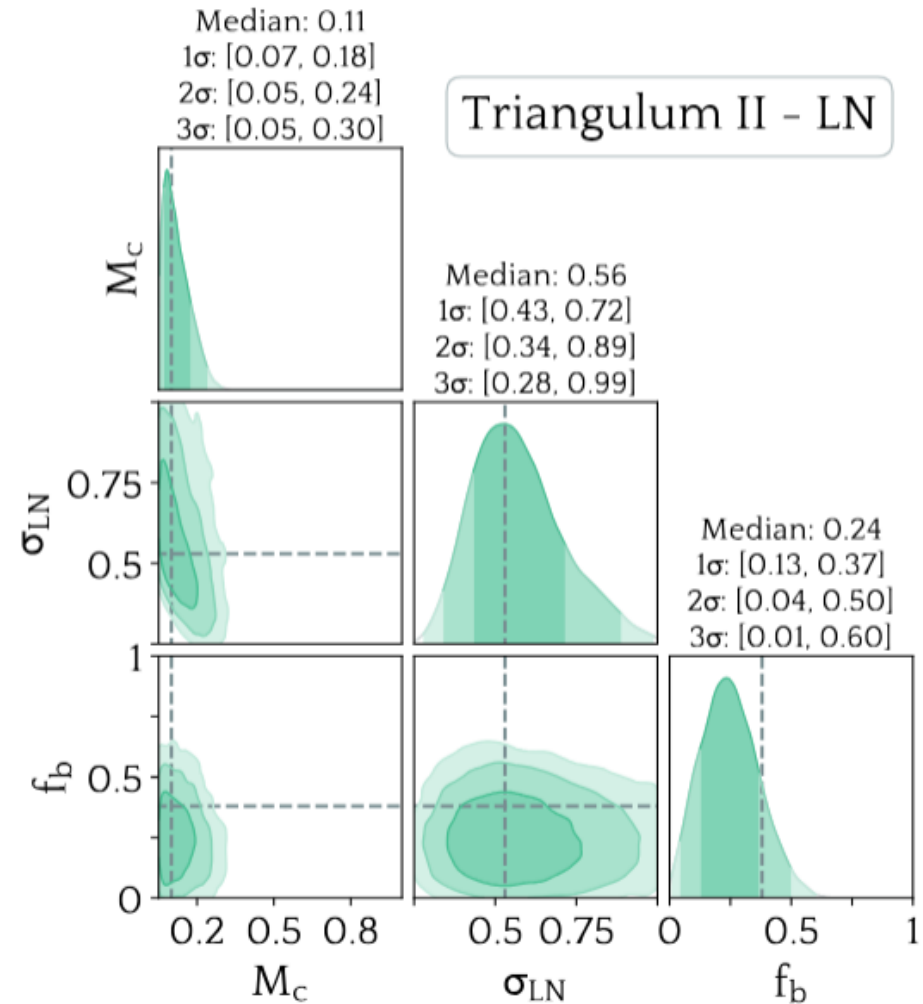
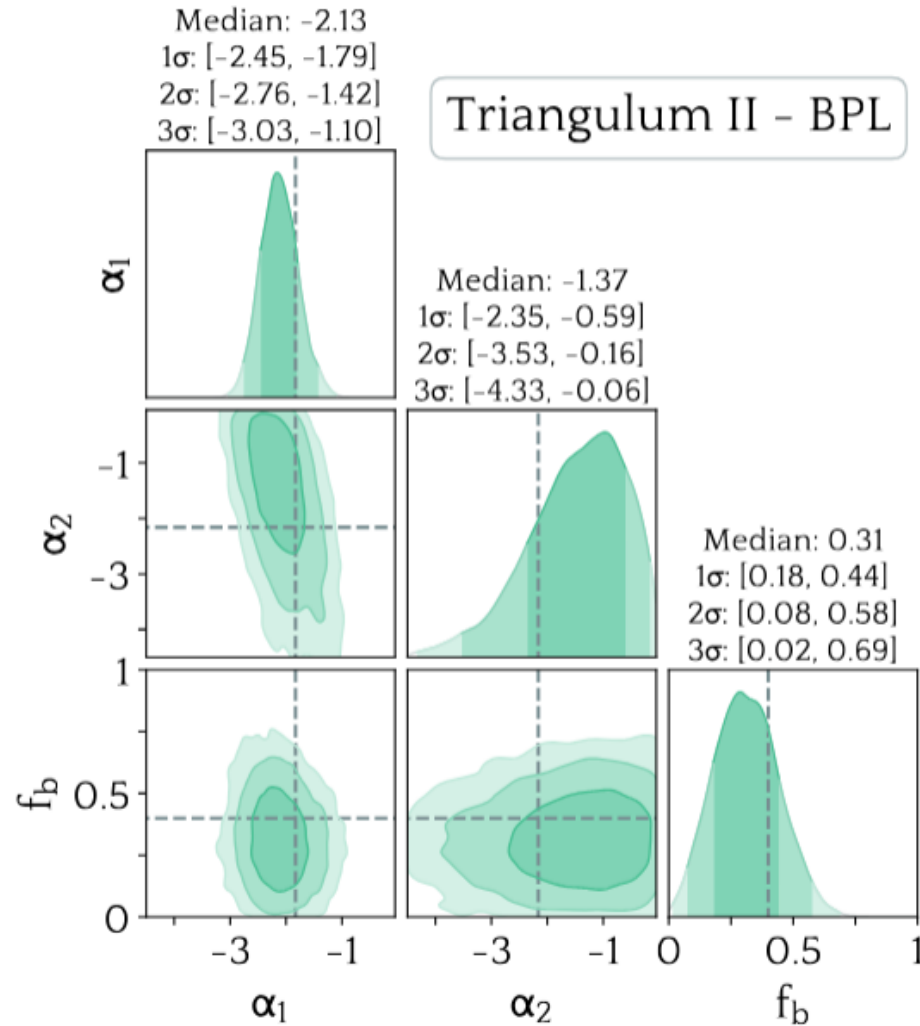
Backup slides



Backup slides



Backup slides



Backup slides

