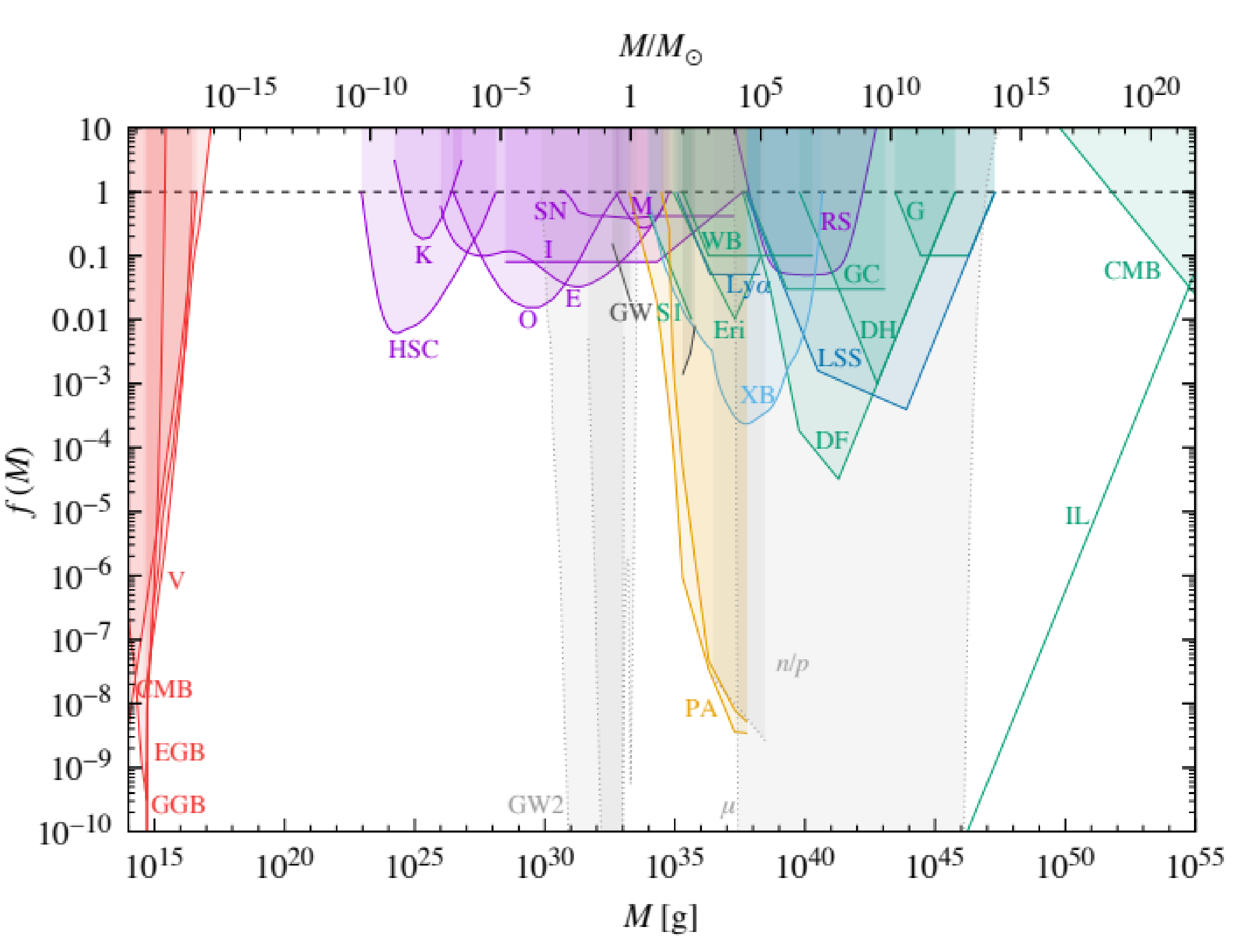
NEHOP 2024

Constraints on asteroid-mass PBHs from star destruction

Nicolas Esser & Peter Tinyakov & Sven De Rijcke

arXiv:2311.12658 (MNRAS)
arXiv:2207.07412 (PRD)

Introduction



Carr et al. (2021)

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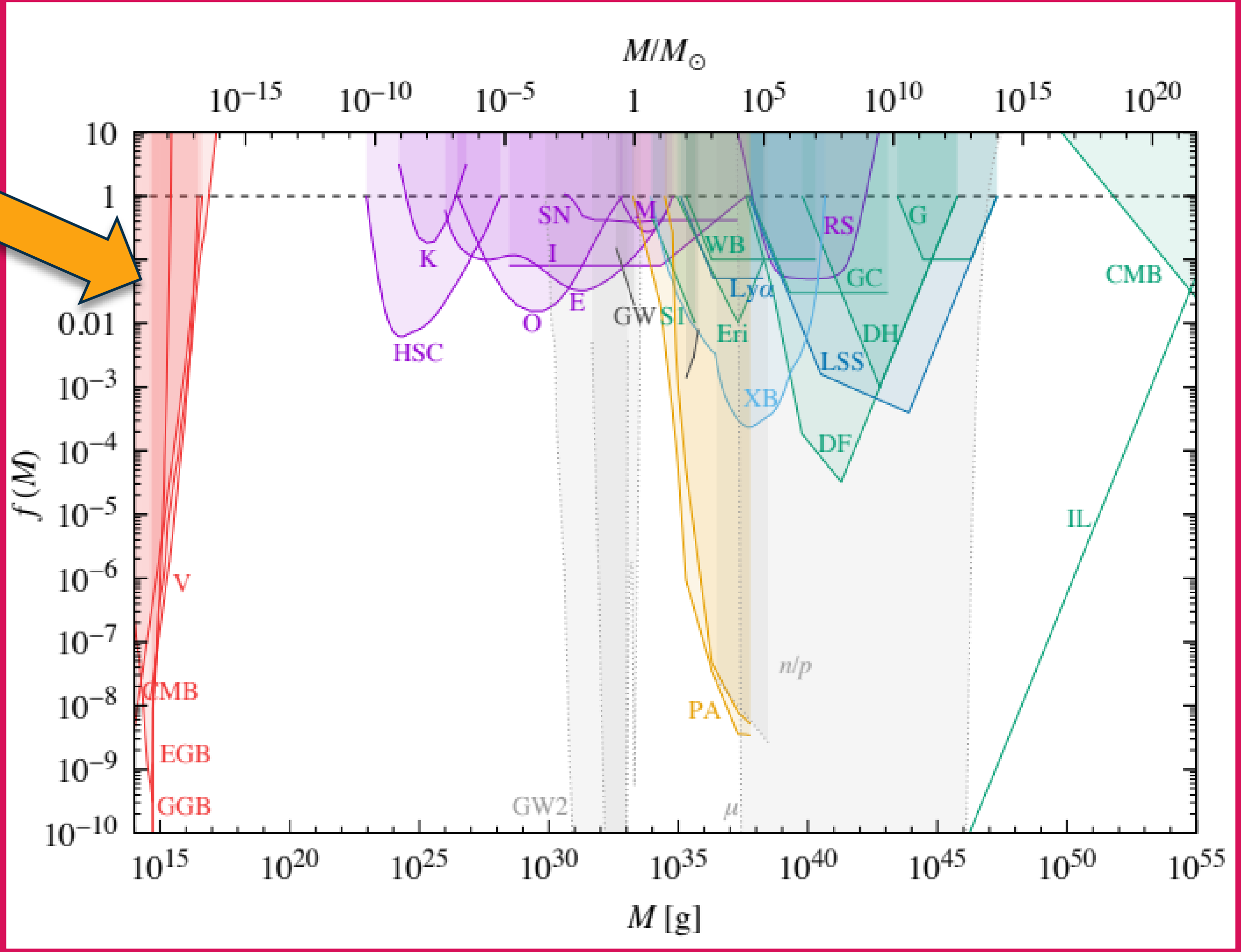
Evaporation



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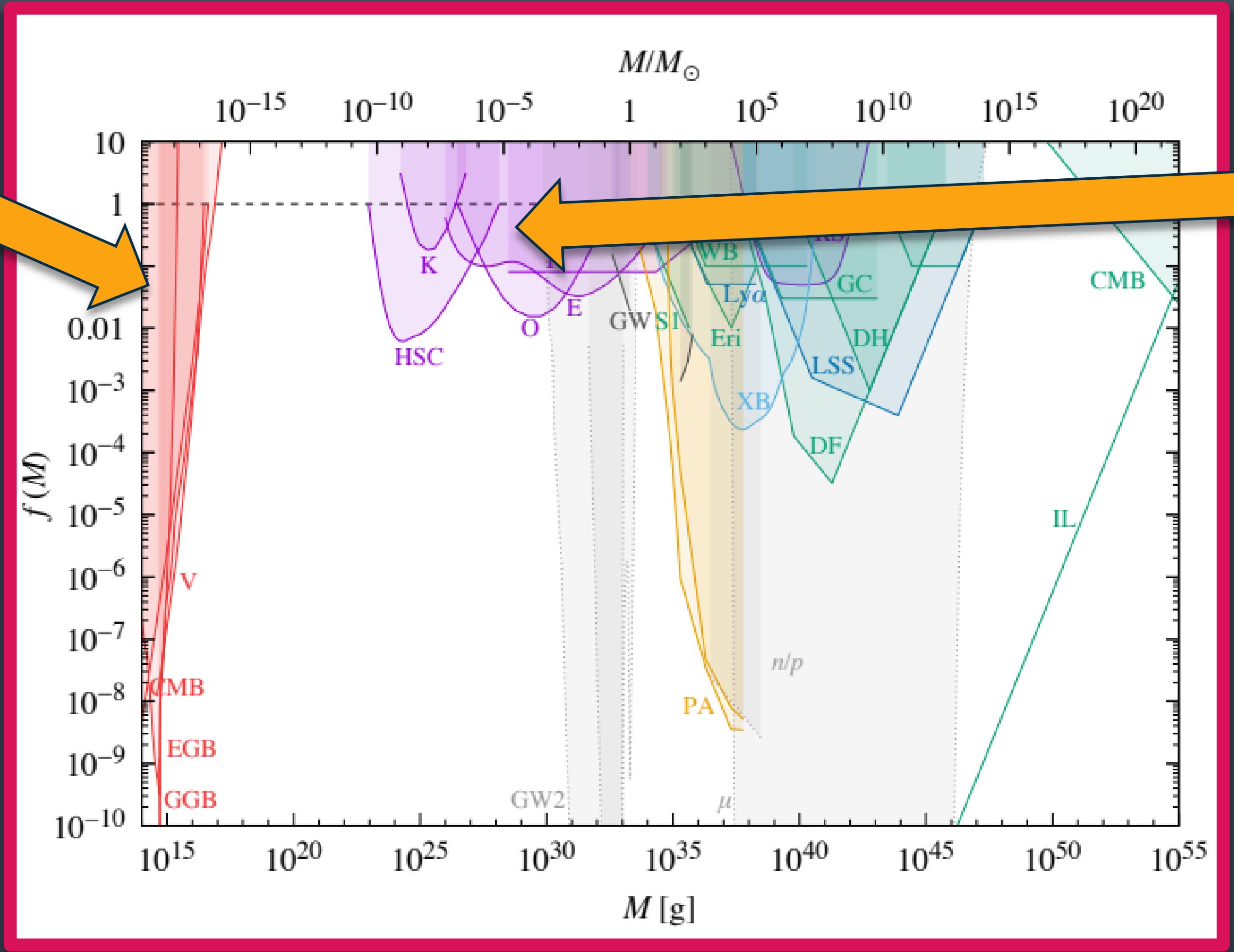
Lensing



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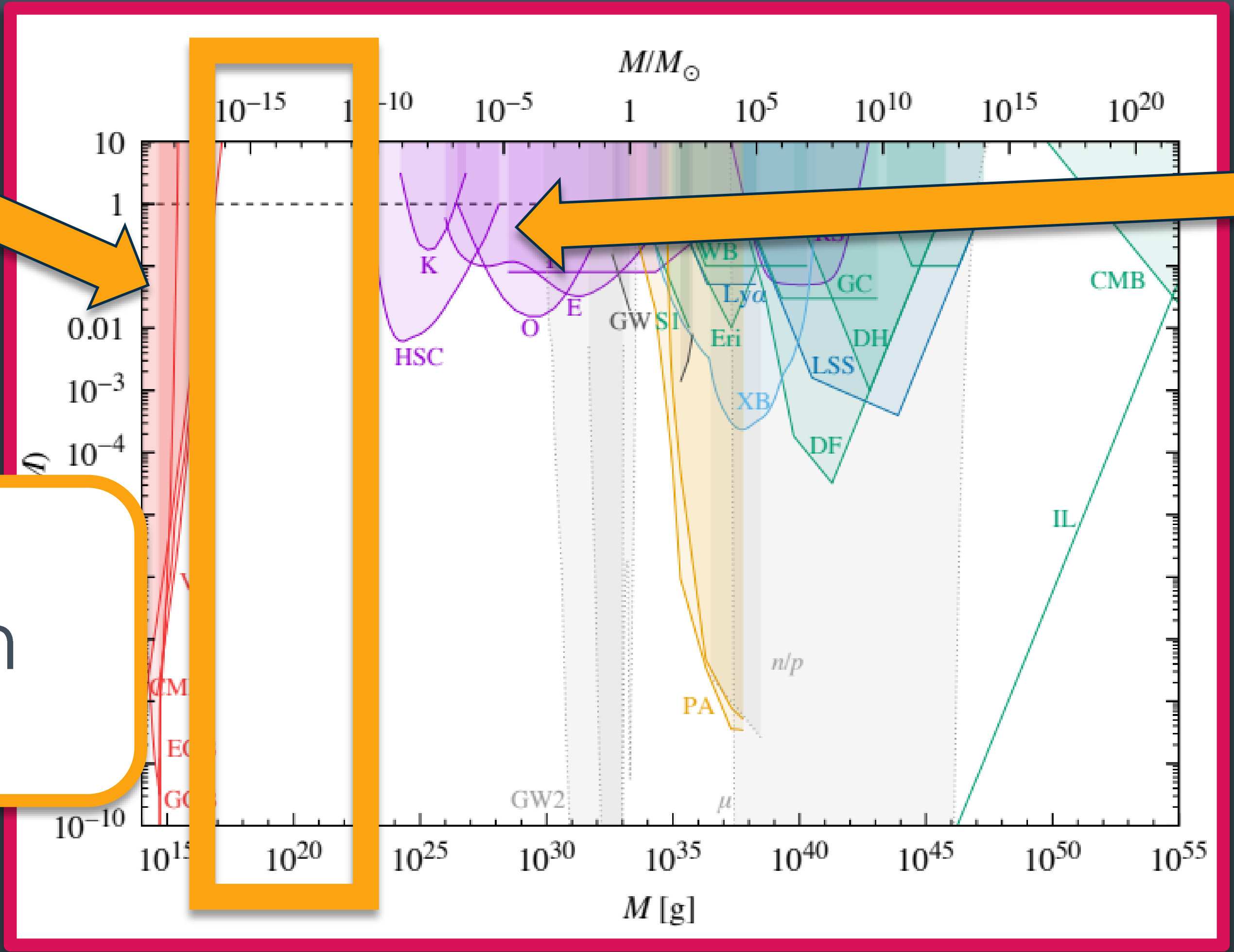

Lensing

Exotic mechanism required

Carr et al. (2021)

Star destruction by PBHs

- Adiabatic star formation + dynamical friction + Bondi accretion

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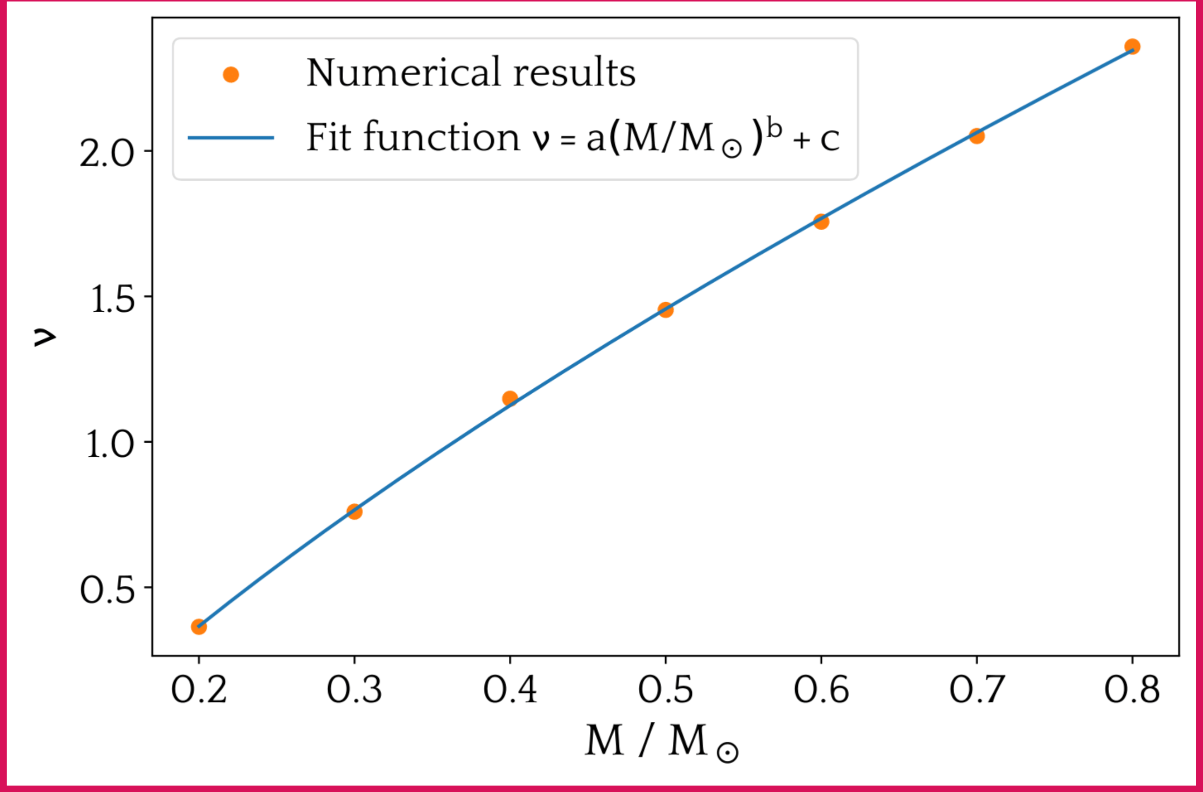

Esser, De Rijcke, Tinyakov (2023)

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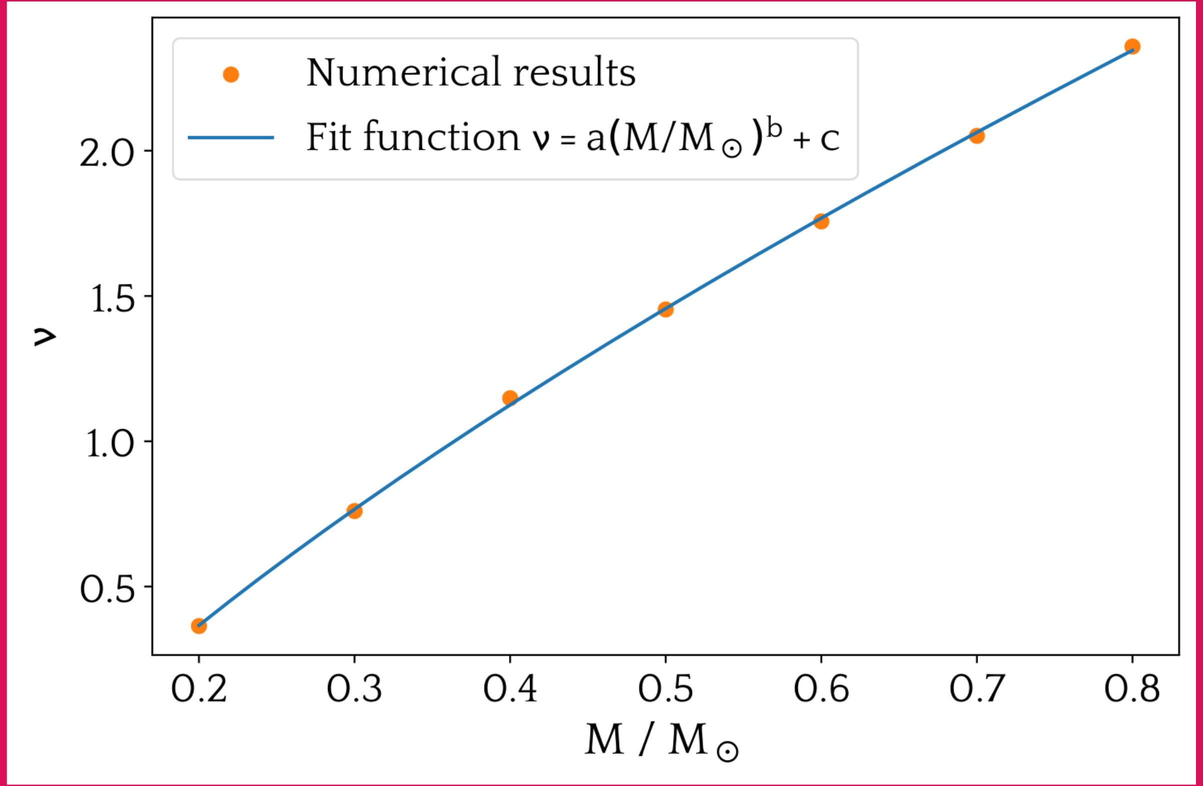

P_S ↘ with the stellar mass !

Esser, De Rijcke, Tinyakov (2023)

Ultra-faint dwarf galaxies

- Faint and old satellites of the MW

Boötes 1 – S. Okamoto (2008)

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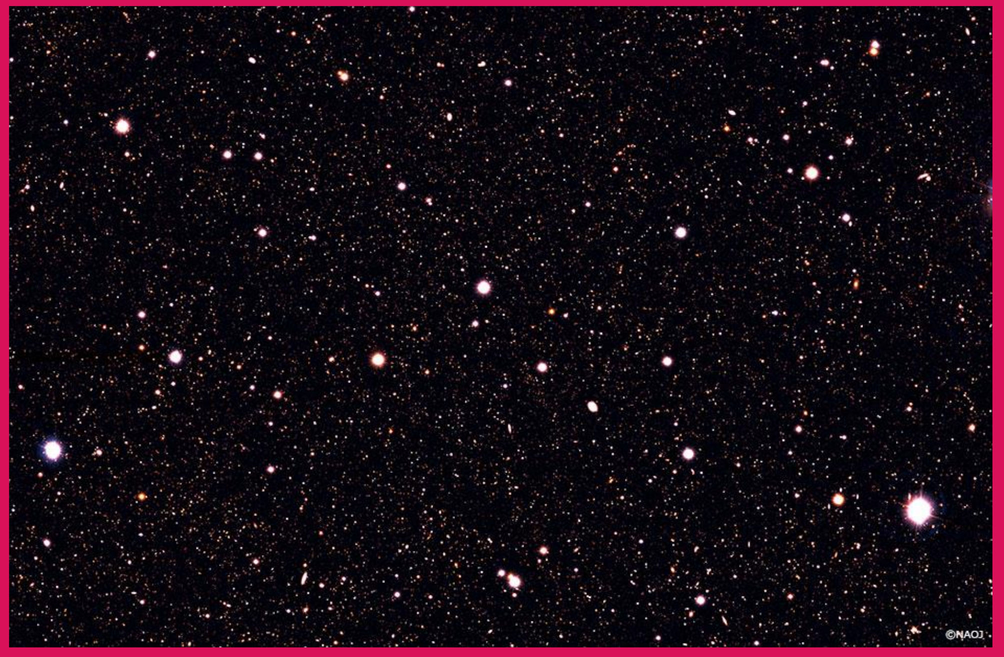

Population today = population at birth + hypothethical effect of PBHs

Stellar mass function

- Initial stellar mass function $= \frac{dN}{dM}$

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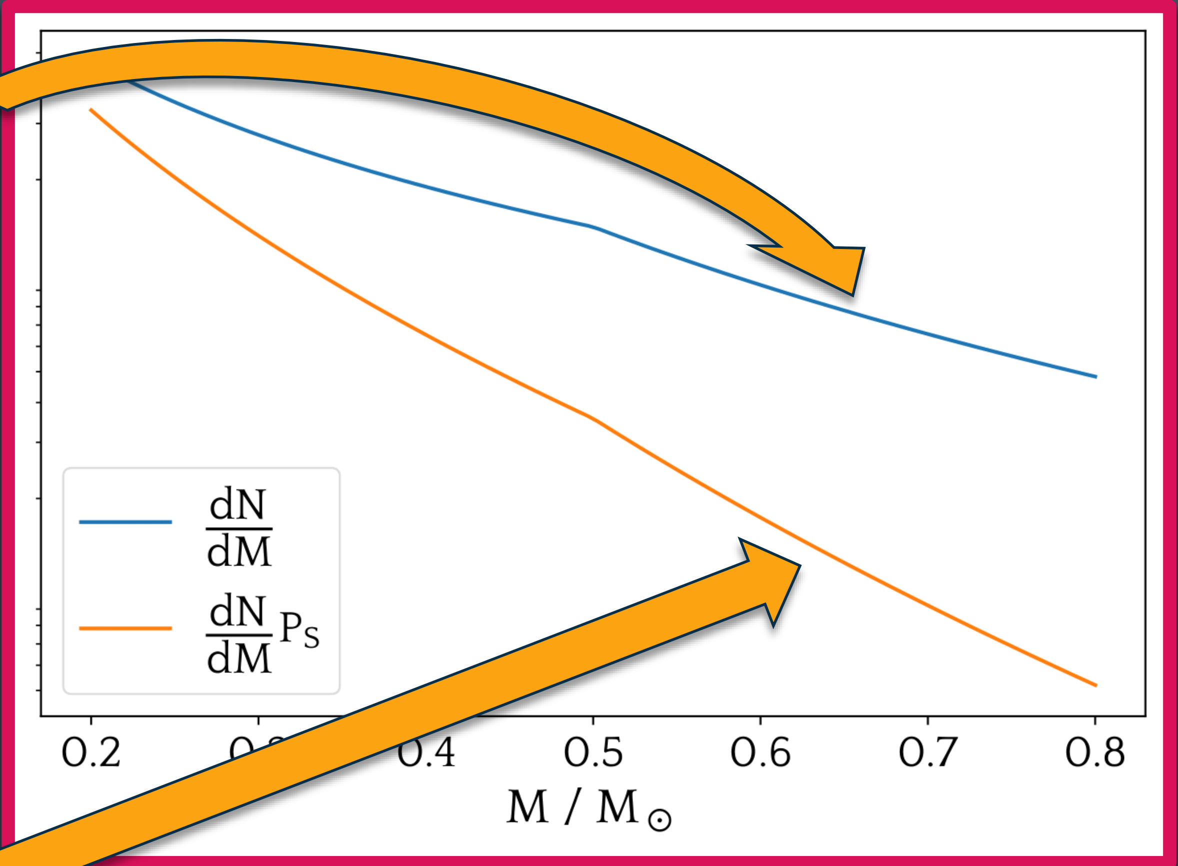
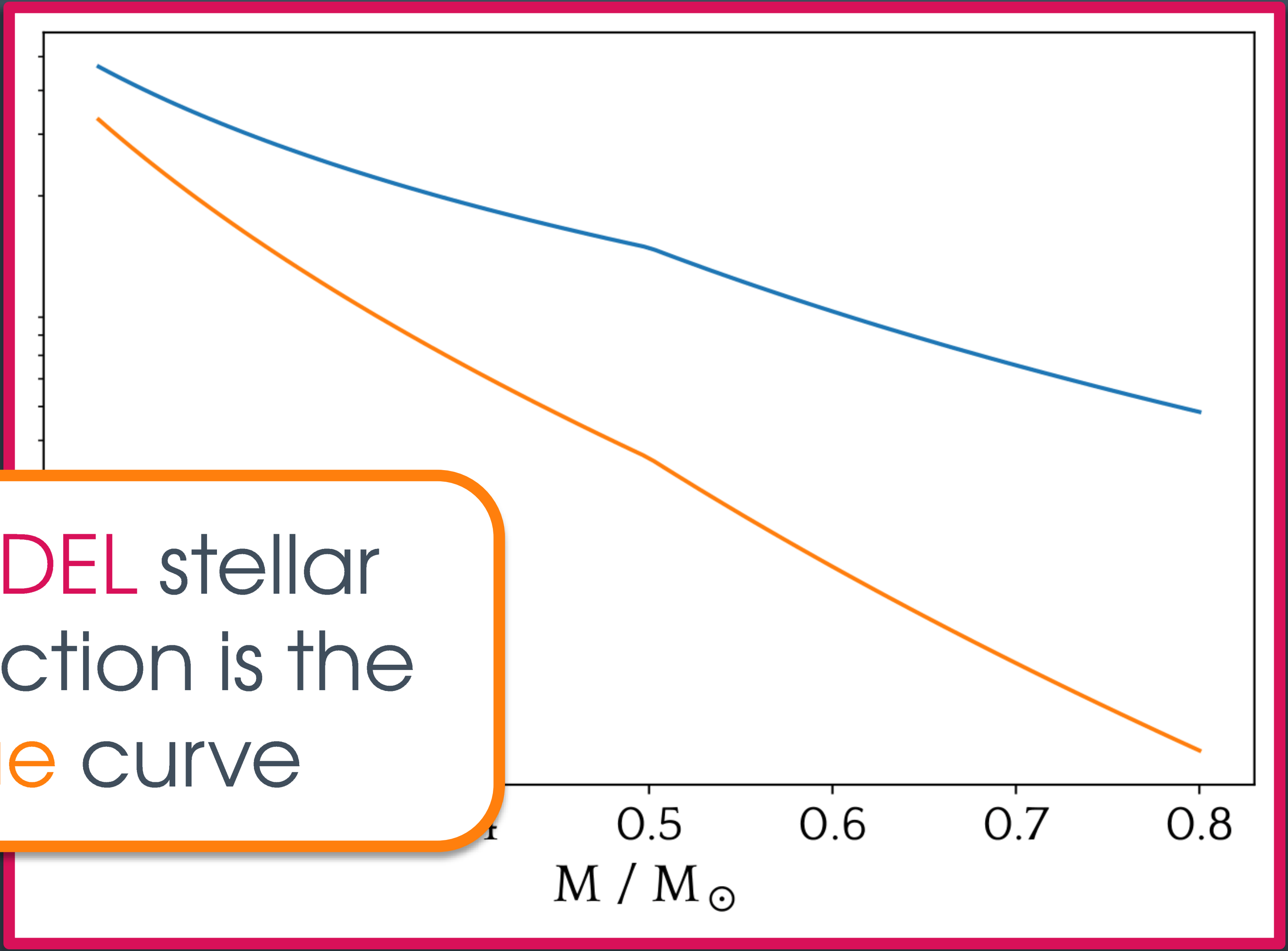


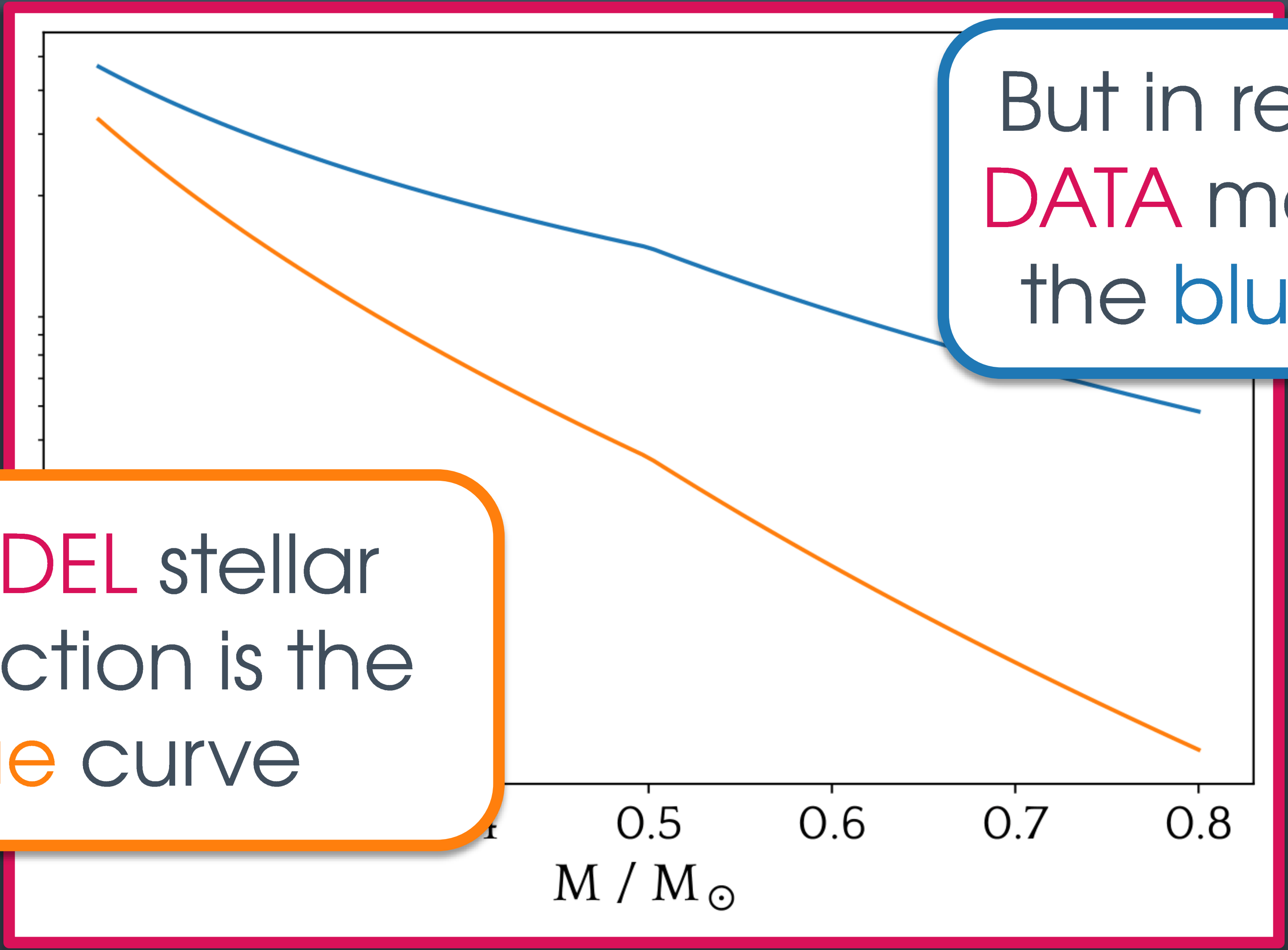
Present-day stellar mass function = $\frac{dN}{dM} \times P_S$

Stellar mass function



The MODEL stellar mass function is the orange curve

Stellar mass function



But in reality the DATA may follow the blue curve

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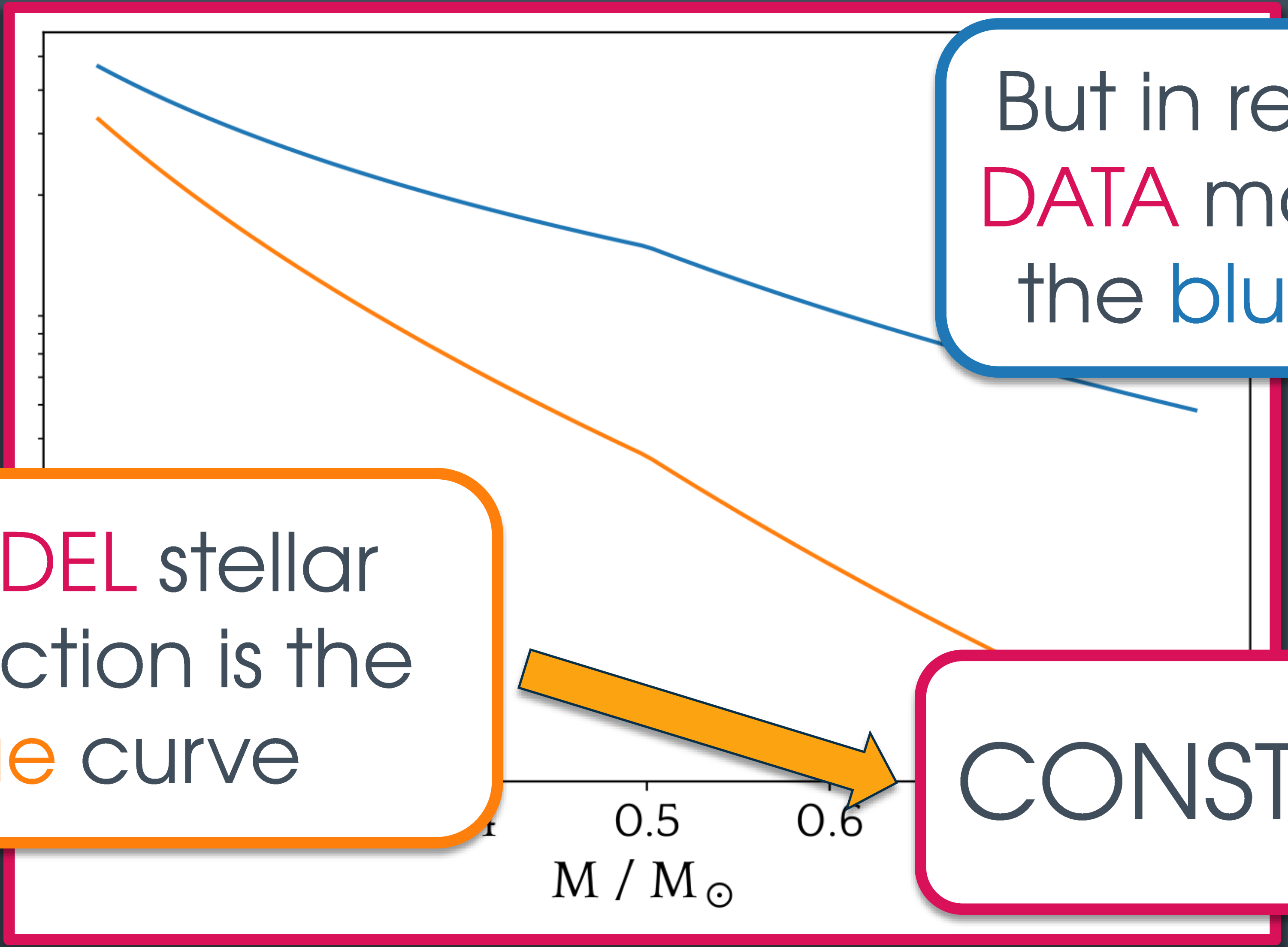
Stellar mass function



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CONSTRAINTS !

Parameter estimation

- Take some data sample (set of stellar masses from observations of an UFD)

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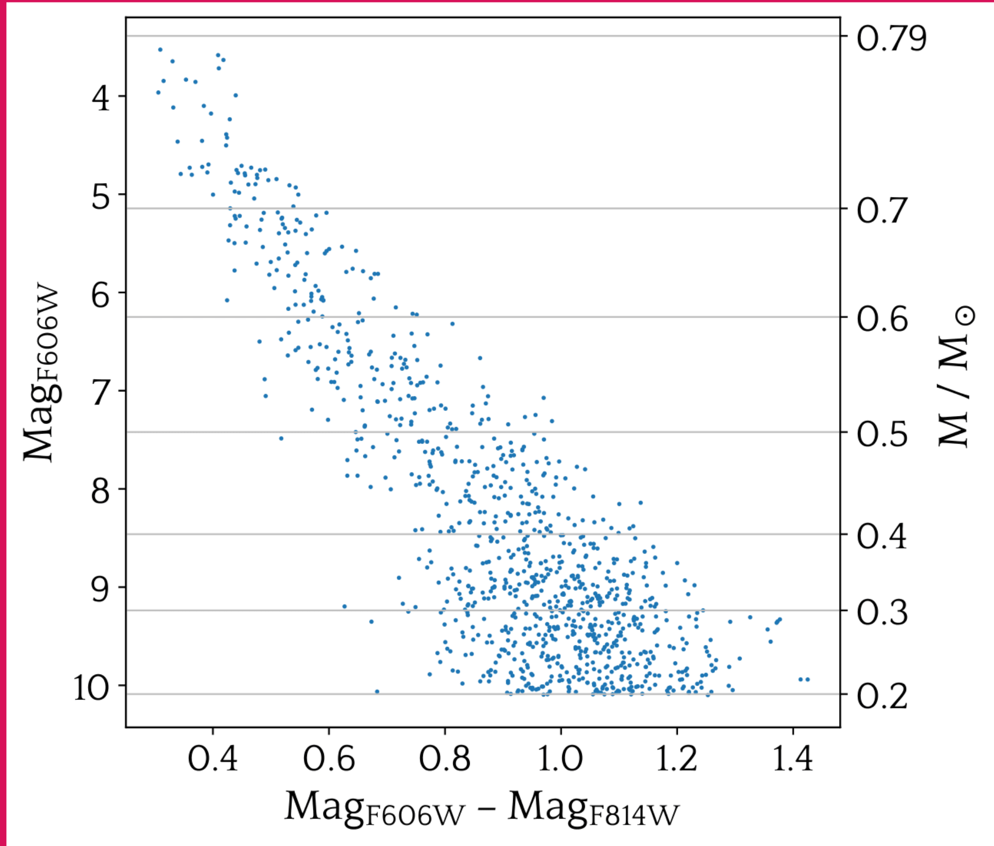
→ Constraints !

Simulating data

➤ **Population without PBHs !**



Esser, De Rijcke, Tinyakov (2023)

Simulating data

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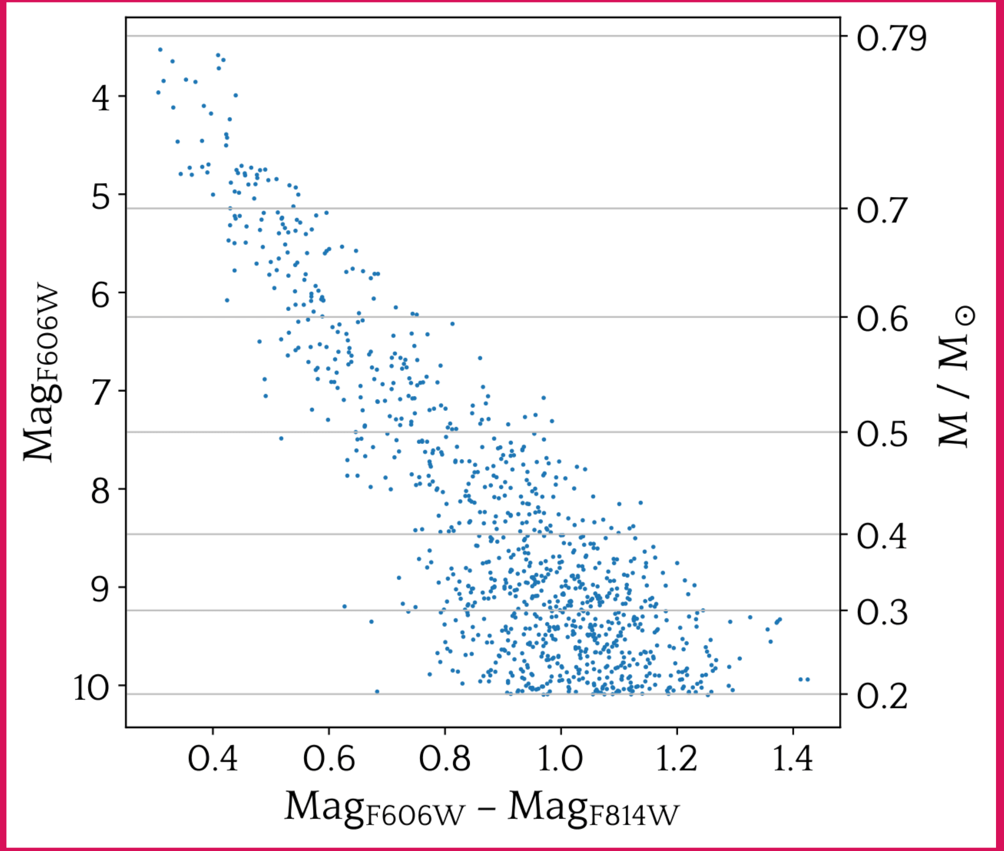
- All the stars 12.8 Gyr old



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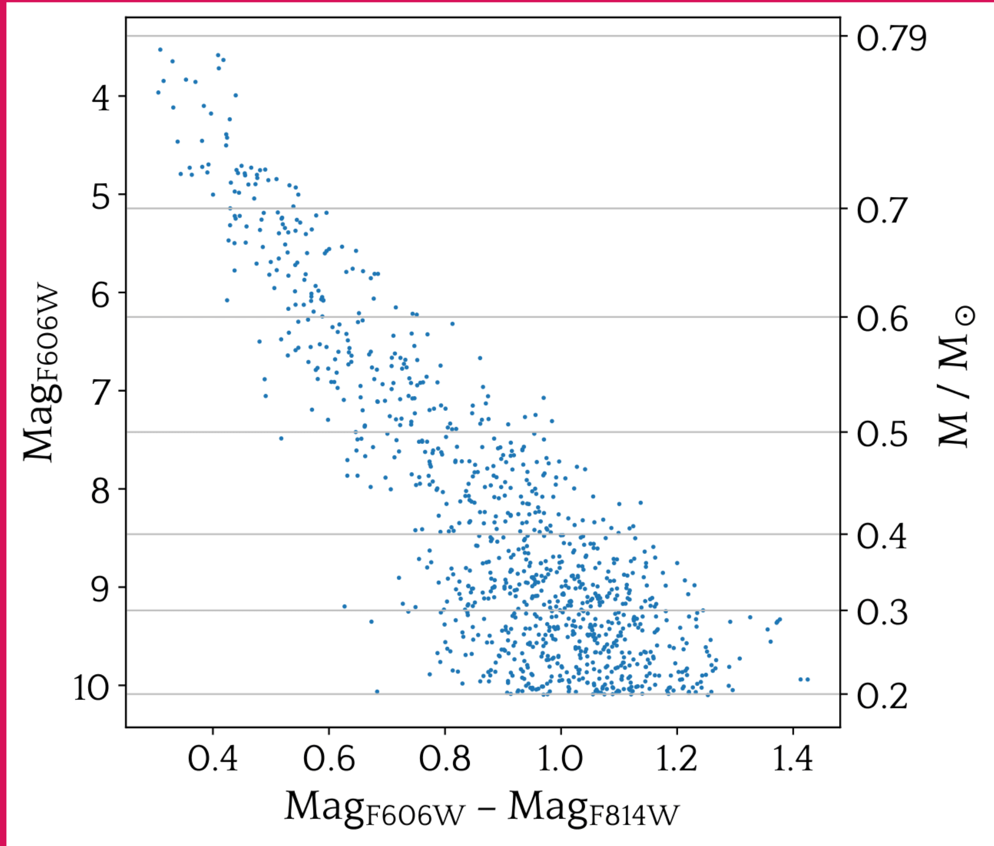

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Simulating data

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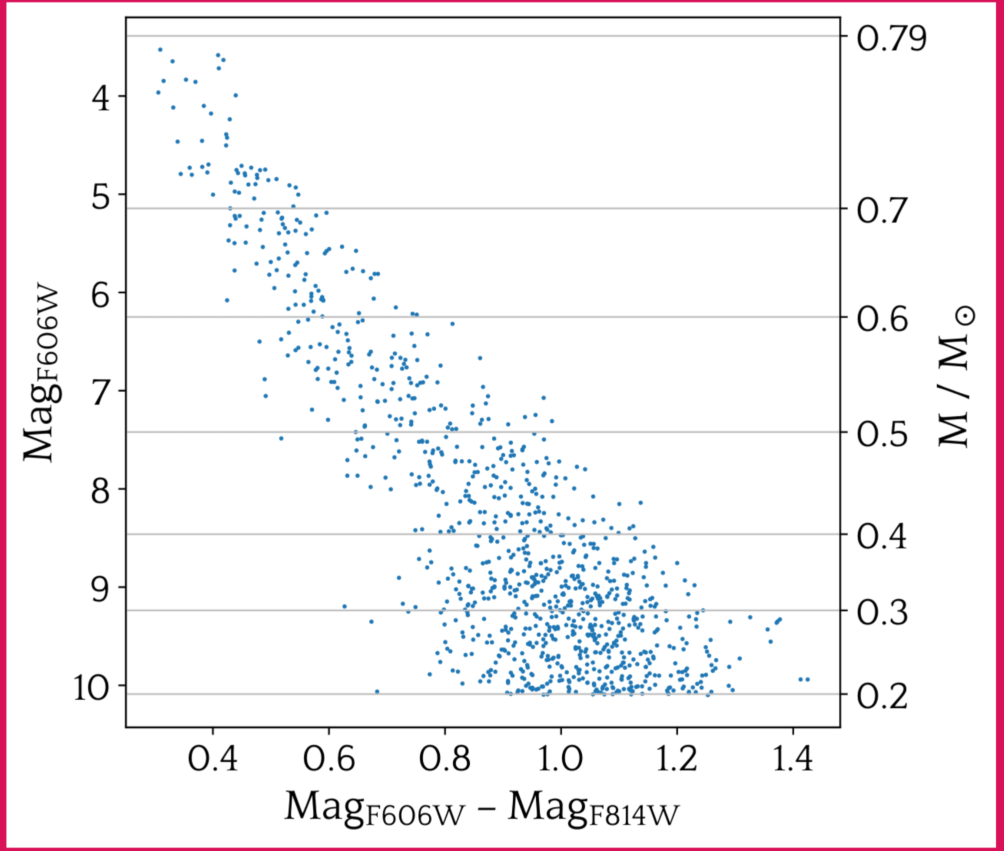
→ Mimic real data !



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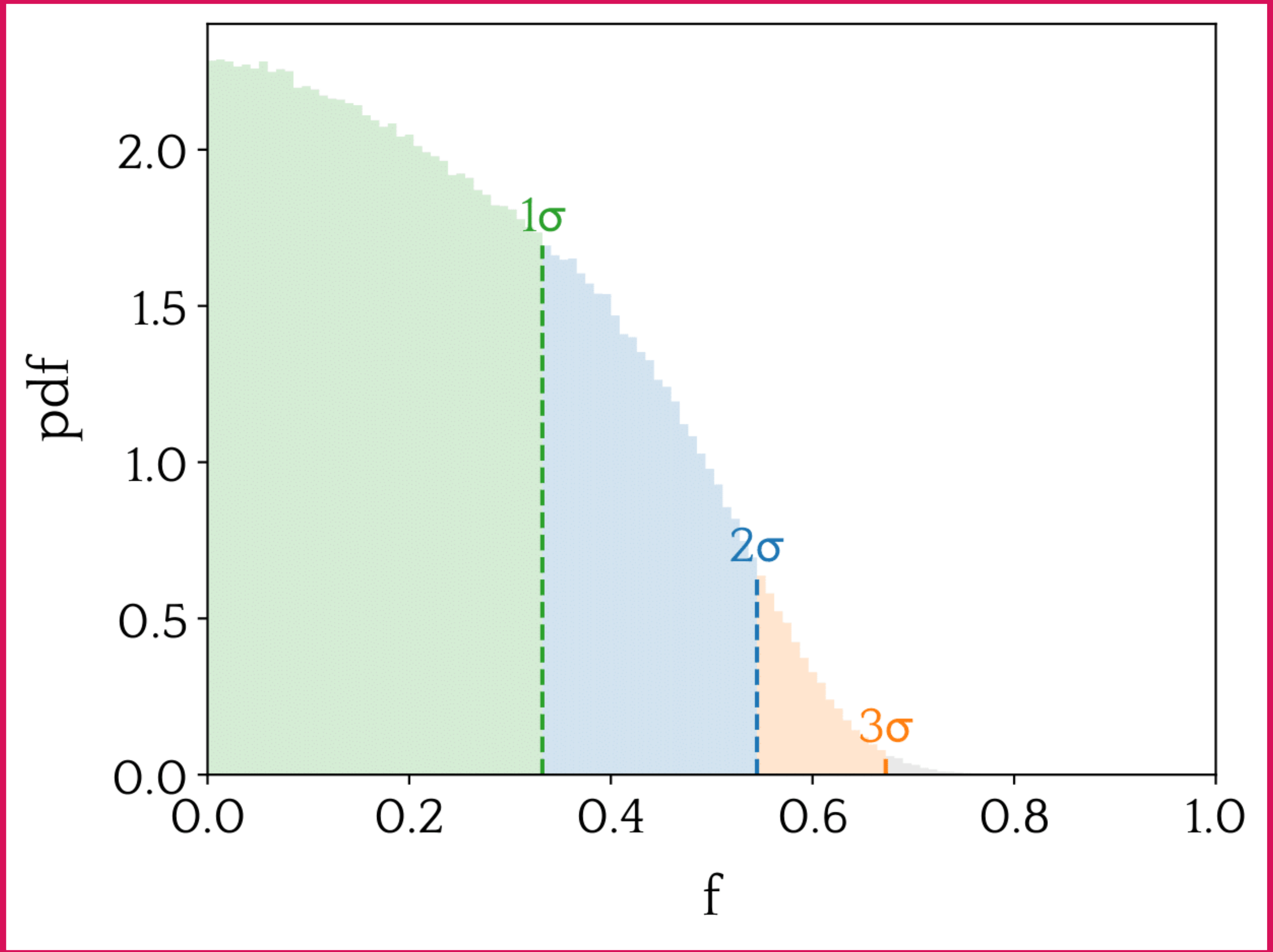
Constraints forecasts



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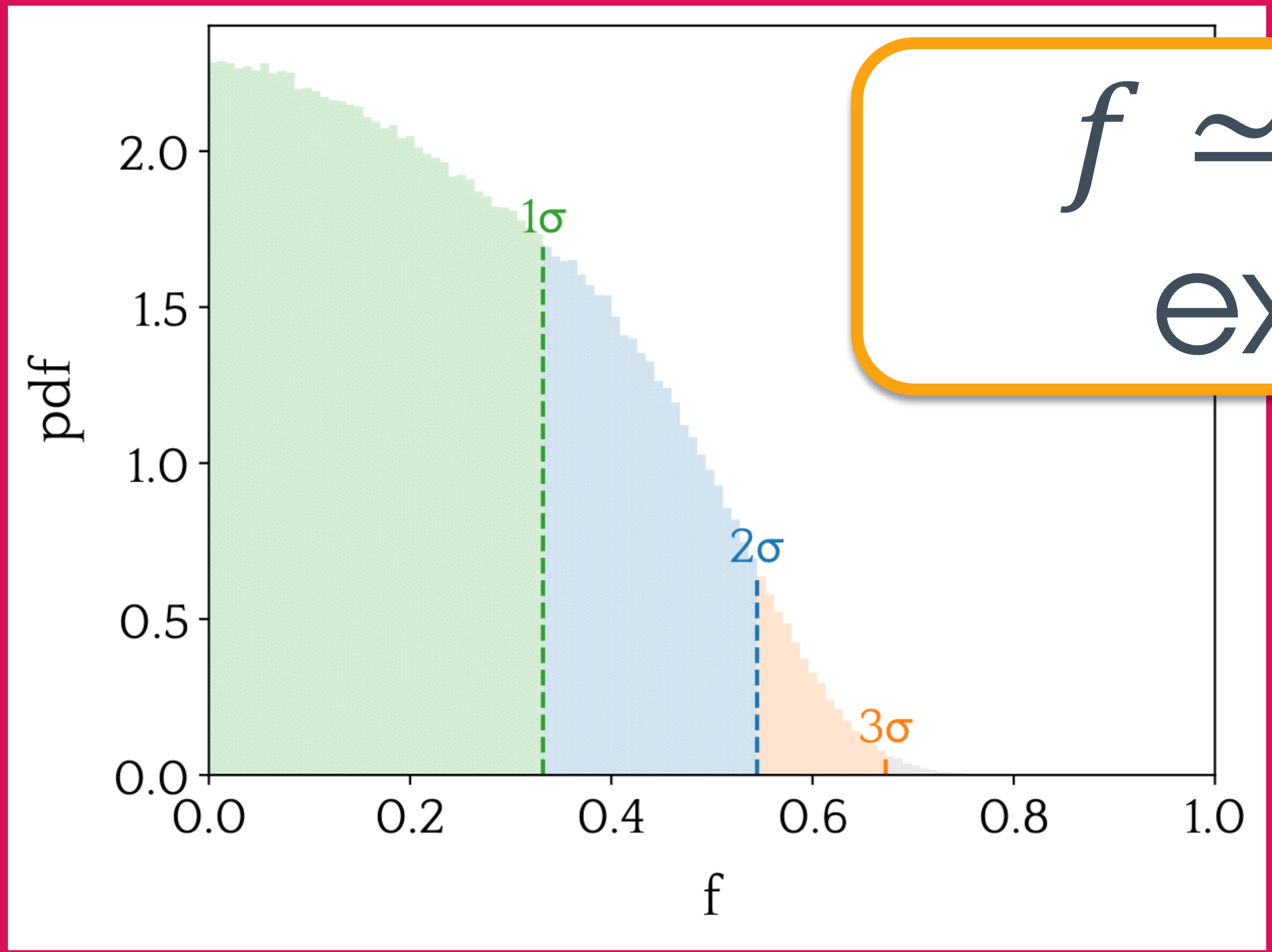

$f \simeq 0.7$ is ~ 3σ excluded !

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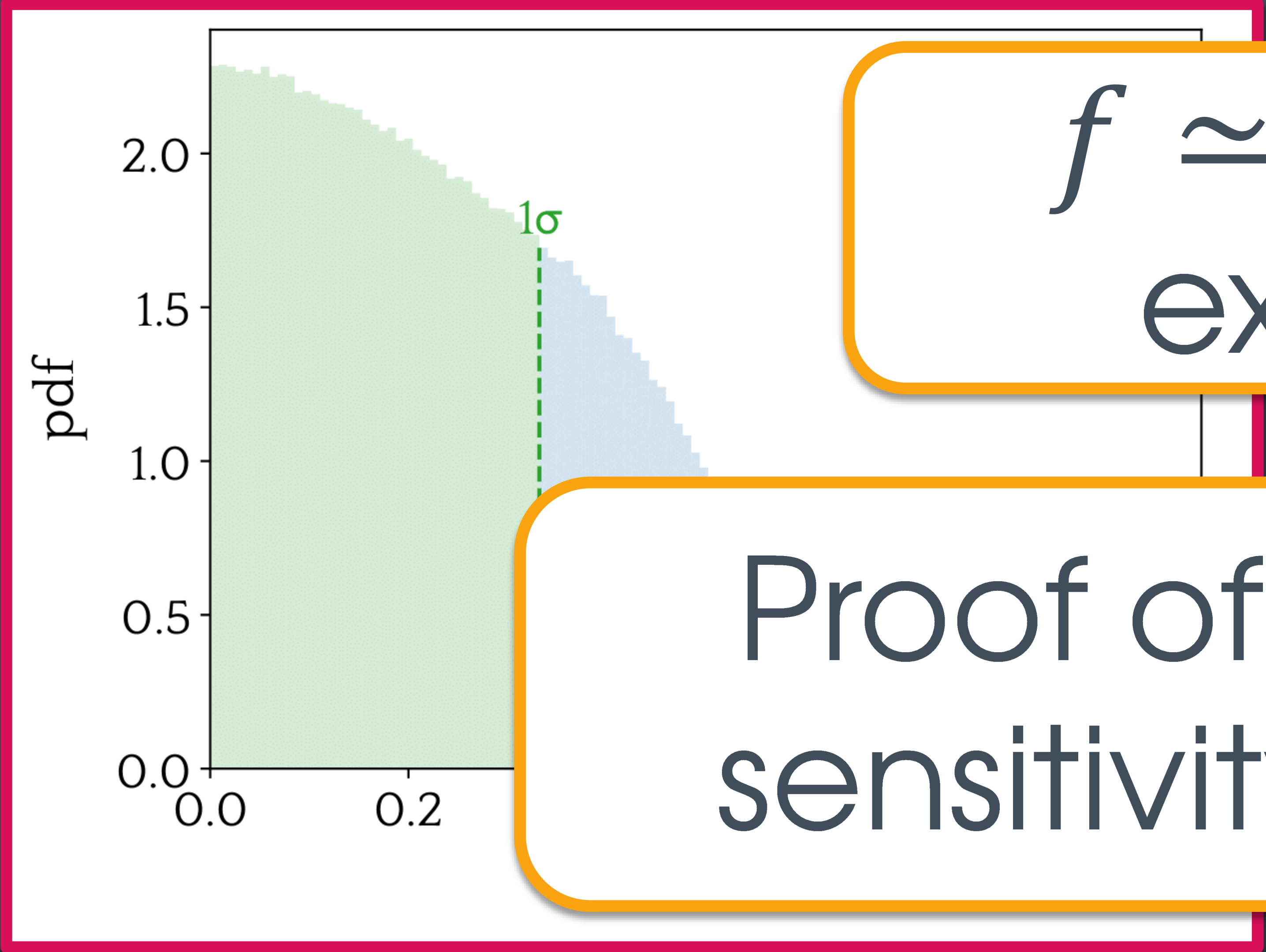

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Proof of concept, sensitivity is good !

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Conclusion

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NEXT : REAL DATA !

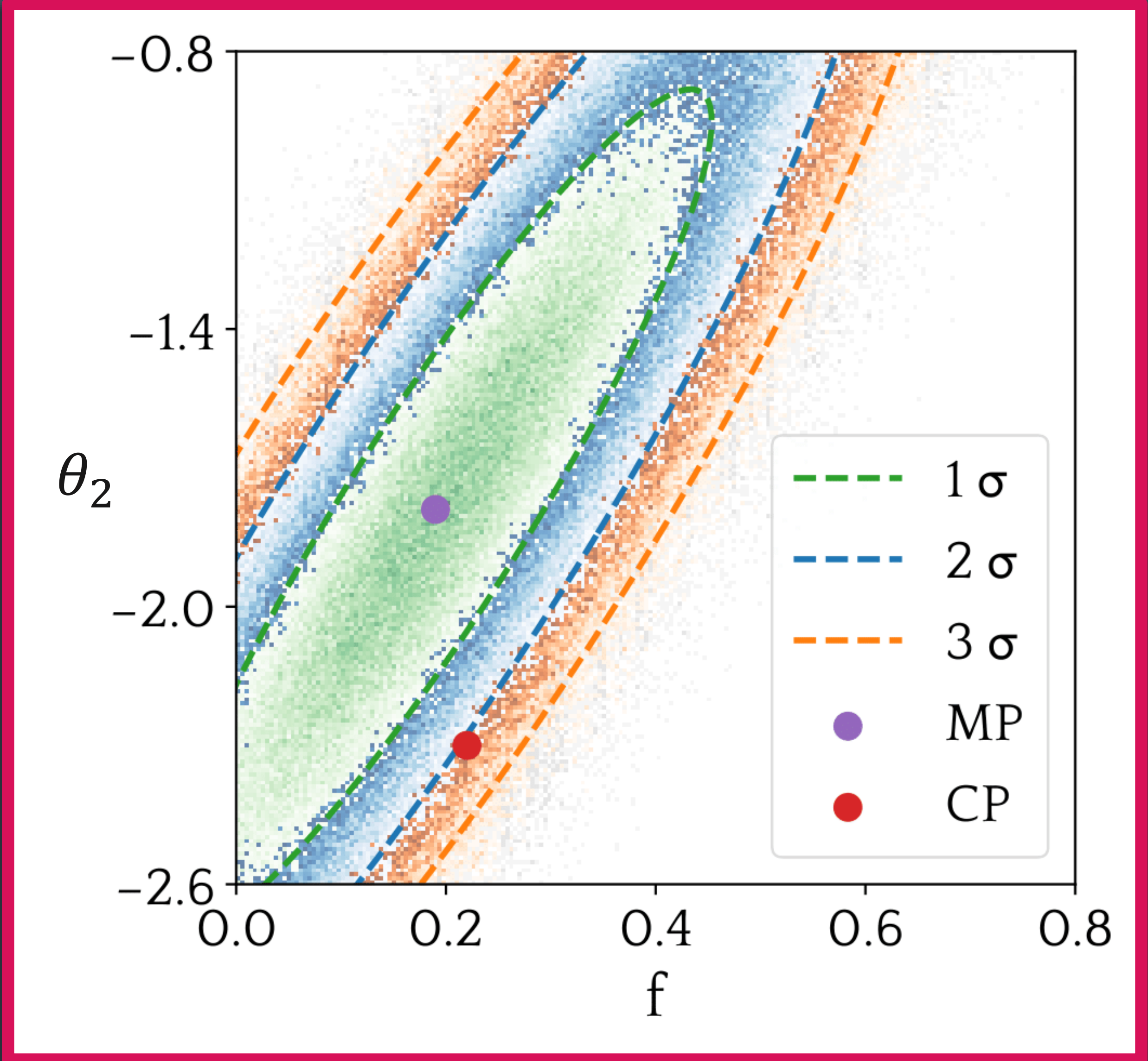
Thank you for your attention !

(Please come talk to me to ask for details I am friendly I promise (^_^))

Nicolas Esser

arXiv:2311.12658 (MNRAS) (Esser, De Rijcke, Tinyakov)
arXiv:2207.07412 (PRD) (Esser & Tinyakov)

Backup slides



Backup slides

Name	σ [km/s]	$\rho_{\rm DM}$ [GeV/cm^3]	$\left(\frac{\rho_{\rm DM}}{100\ \text{GeV/cm}^3}\right)\left(\frac{7\ \text{km/s}}{\sqrt{2}\sigma}\right)^3$
Triangulum II	< 5.9	$< 160 \pm 80$	0.95 ± 0.51
Tucana III	< 2.1	$< 3.7 \pm 1.8$	0.51 ± 0.22
Segue 1	$6.4^{+2.4}_{-1.9}$	85^{+100}_{-85}	$0.39^{+0.85}_{-0.72}$
Solar system	~ 220	~ 0.4	$\sim 10^{-8}$

Backup slides

$$f = \frac{\Omega_{\mathrm{PBH}}}{\Omega_{\mathrm{DM}}} \in \mathrm{Uniform}\ [0,1]$$

- $\frac{dN}{dM} = \begin{cases} M^{\theta_1} \\ kM^{\theta_2} \end{cases}$ for $\begin{matrix} M<0.5M_\odot \\ M\geq 0.5M_\odot \end{matrix}$ → θ_1 and $\theta_2 \in \mathrm{Uniform}\ [-2.6, -0.8]$

  $(\mathrm{Kroupa}: \theta_1 = -1.3$ and $\theta_2 = -2.3)$

- $\frac{dN}{dM} = \frac{1}{M} \exp\left(-\frac{(\log_{10}(M/\theta_1))^2}{2\theta_2^2}\right)$ → $\theta_1 \in \mathrm{Uniform}\ [0.08, 0.6]$

  $\theta_2 \in \mathrm{Uniform}\ [0.5, 0.7]$

  $(\mathrm{Chabrier}: \theta_1 = 0.08$ and $\theta_2 = 0.69)$

Backup slides

- Dynamical friction : $\boldsymbol{f}_{\rm dyn} = -4\pi G^2 m_{\rm BH}^2 \rho_\star \ln\Lambda \frac{\boldsymbol{v}}{v^3}$

$$\Rightarrow \quad r_{\rm max} < \frac{E_{\rm loss}^2(r_{\rm min})}{2\pi^2 G M m_{\rm BH}^2} t_\star^2 \propto m_{\rm BH}^2$$

- Deviation : $r_{\rm max} < \left(\frac{4096}{225\pi^2} R_\star d^6\right)^{\frac{1}{7}} \propto m_{\rm BH}^0$

- Bondi accretion : $\frac{dm_{BH}}{dt} = \frac{4\pi G^2 m_{\rm BH}^2 \rho_\star}{c_s^3}$

$$\Rightarrow \quad t_{\rm acc} = \frac{c_s^3}{4\pi\rho_\star G^2 m_{\rm BH}} \sim 10^6\ {\rm yr} \left(\frac{10^{20}{\rm g}}{m_{\rm BH}}\right)$$

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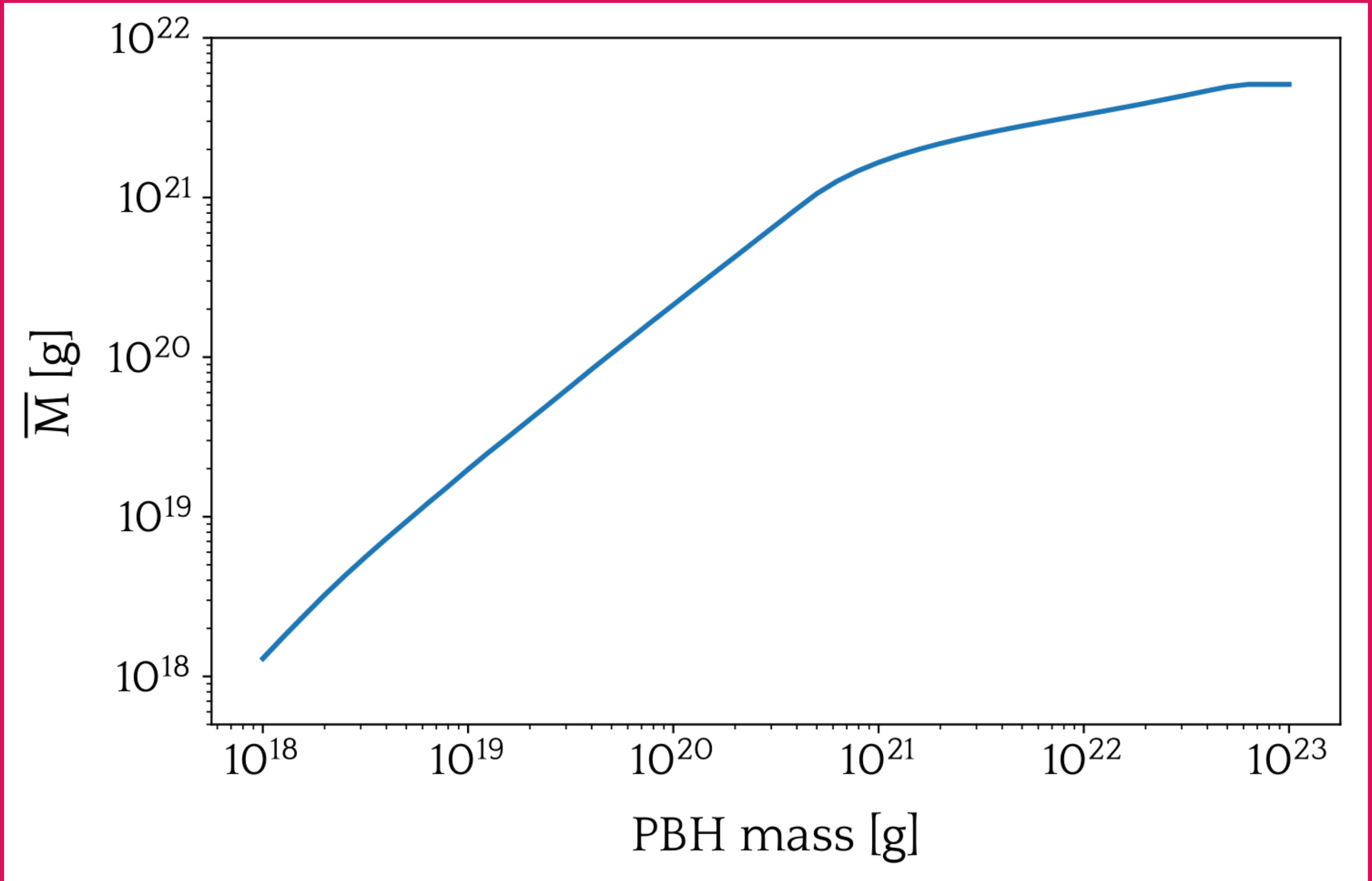

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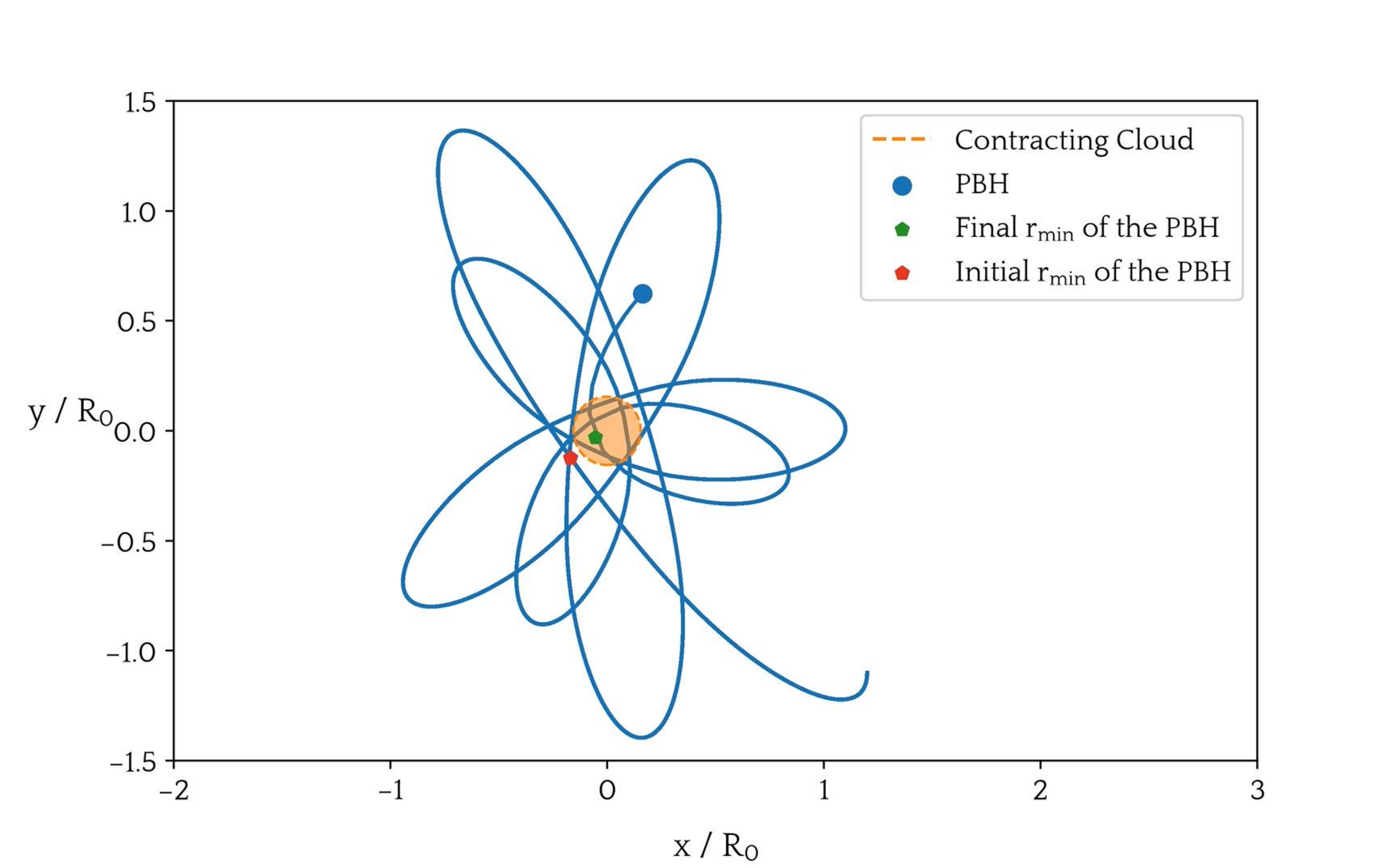

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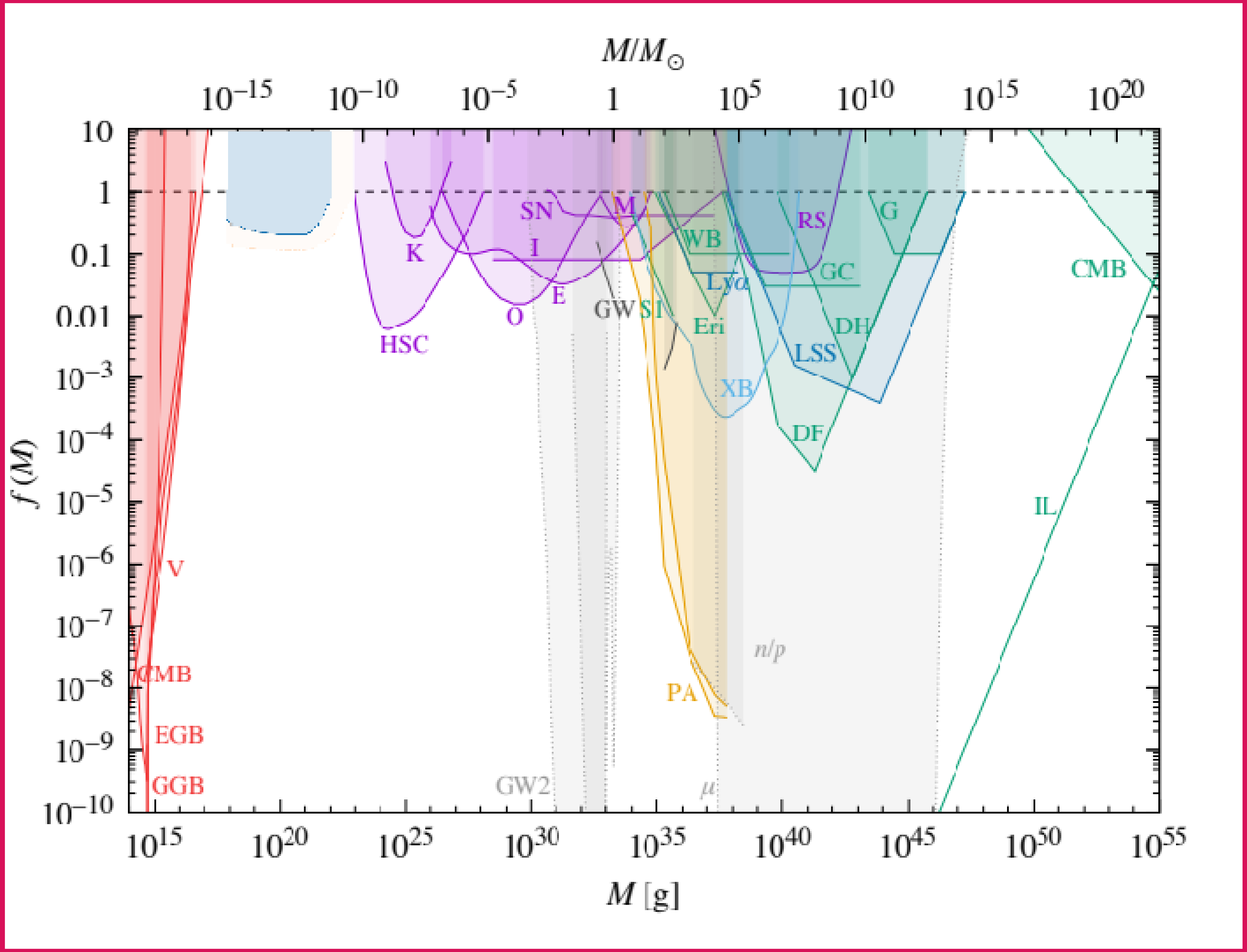

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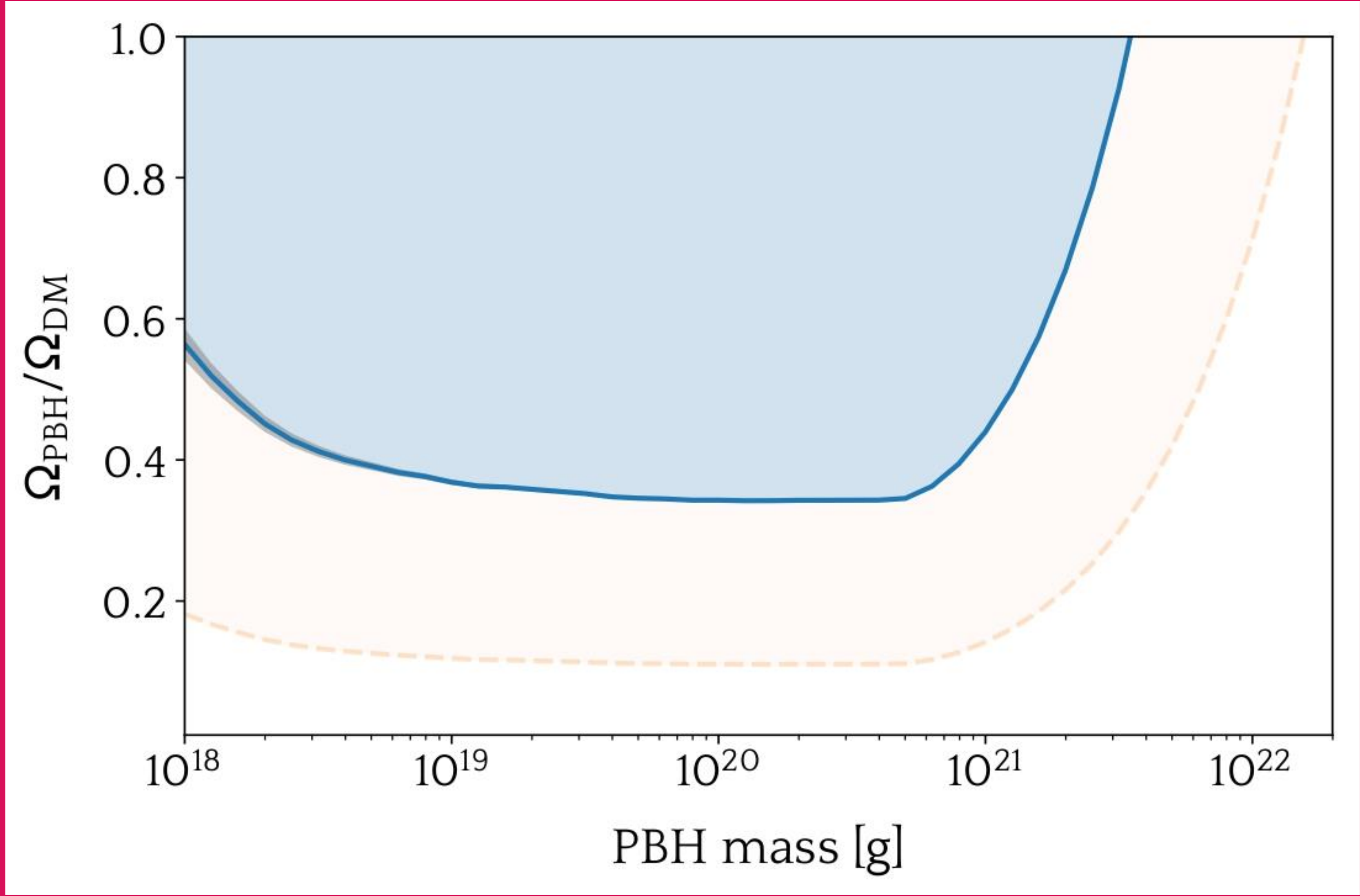


LADIES AND GENTLEMEN
WE GOT EM
imgflip.com

Real data are here !

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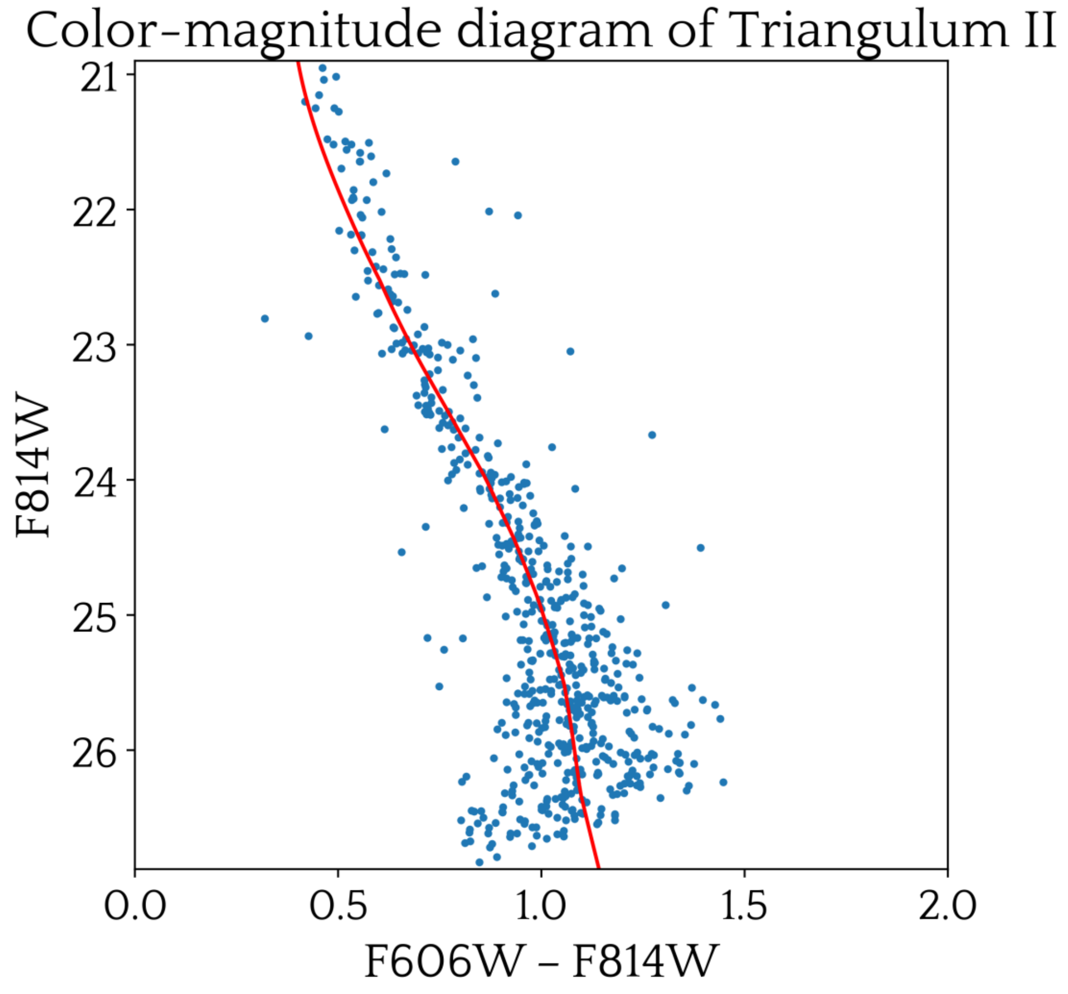
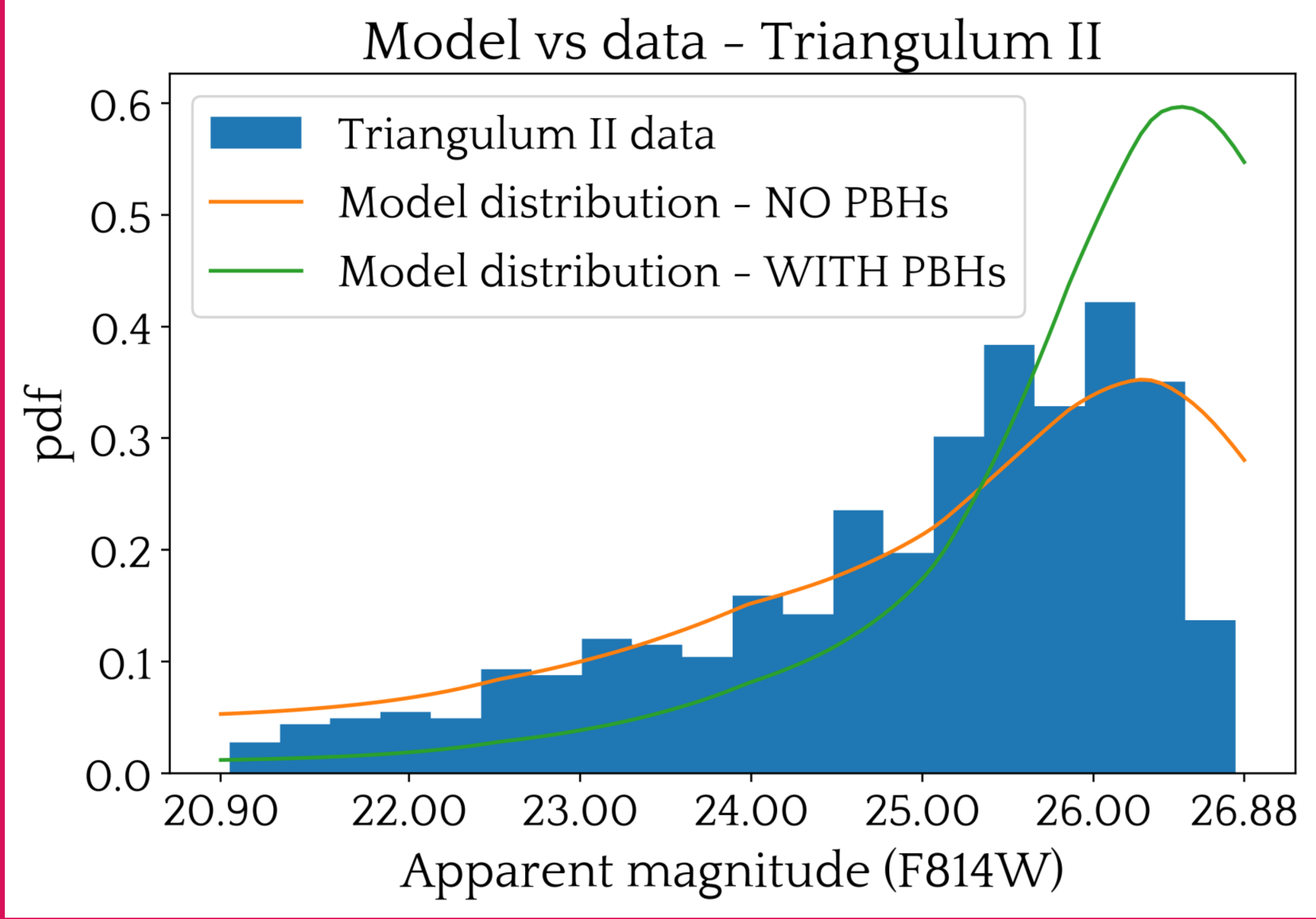


PRELIMINARY results



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