

# First Results of the Phoebos Simulation: **Galaxy Sizes during the Early Universe**

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*SKAO March 2025*

Floor van Donkelaar

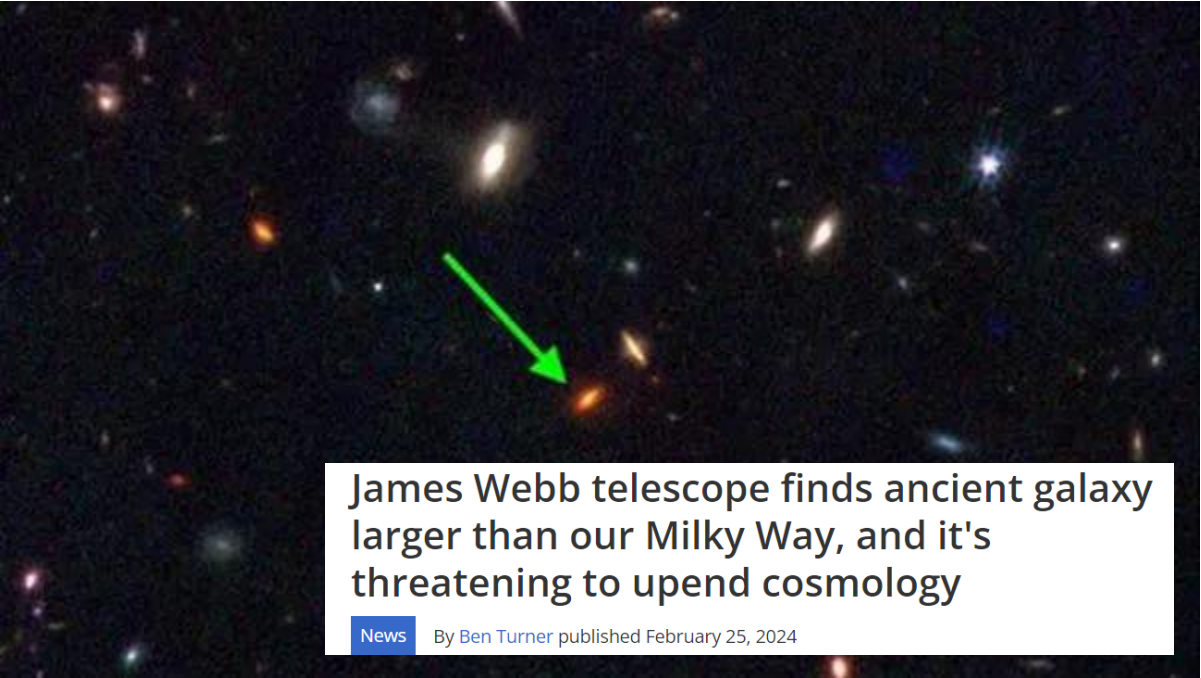
[floor.vandonkelaar@uzh.ch](mailto:floor.vandonkelaar@uzh.ch)

In collaboration with:

Lucio Mayer, Pedro R. Capelo, Darren Reed



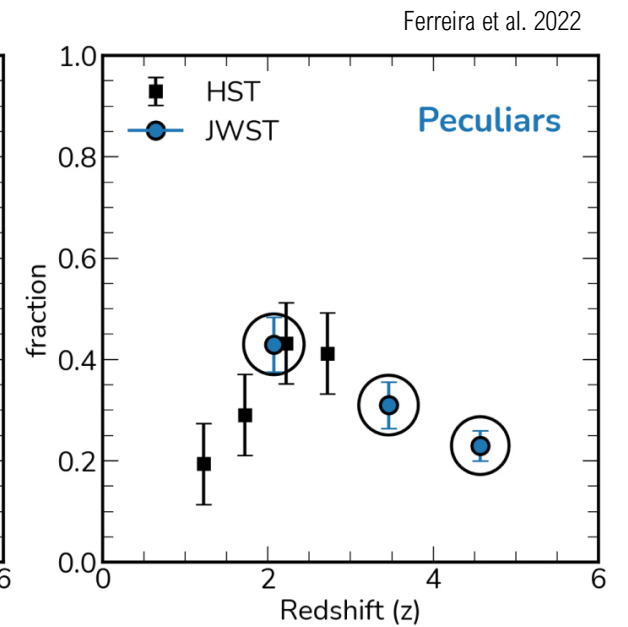
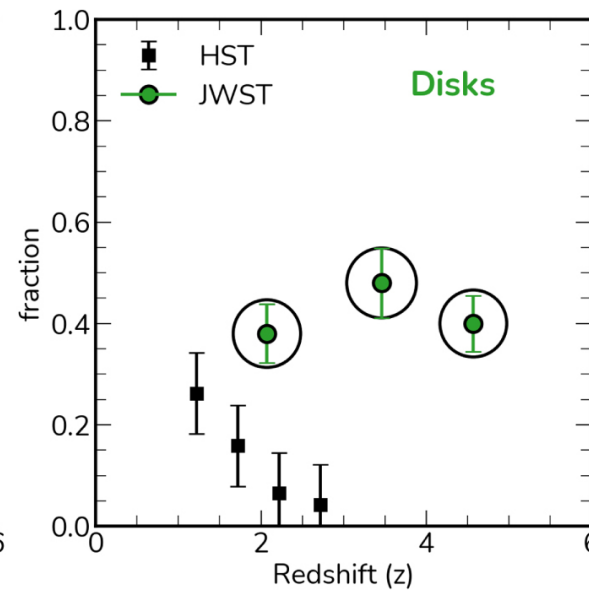
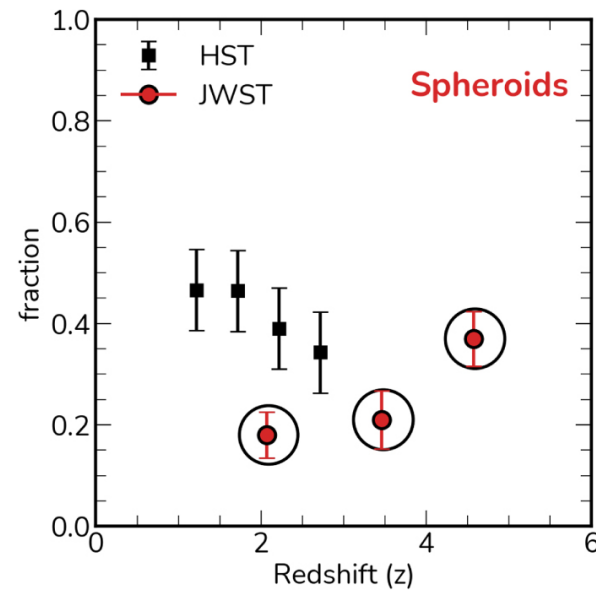
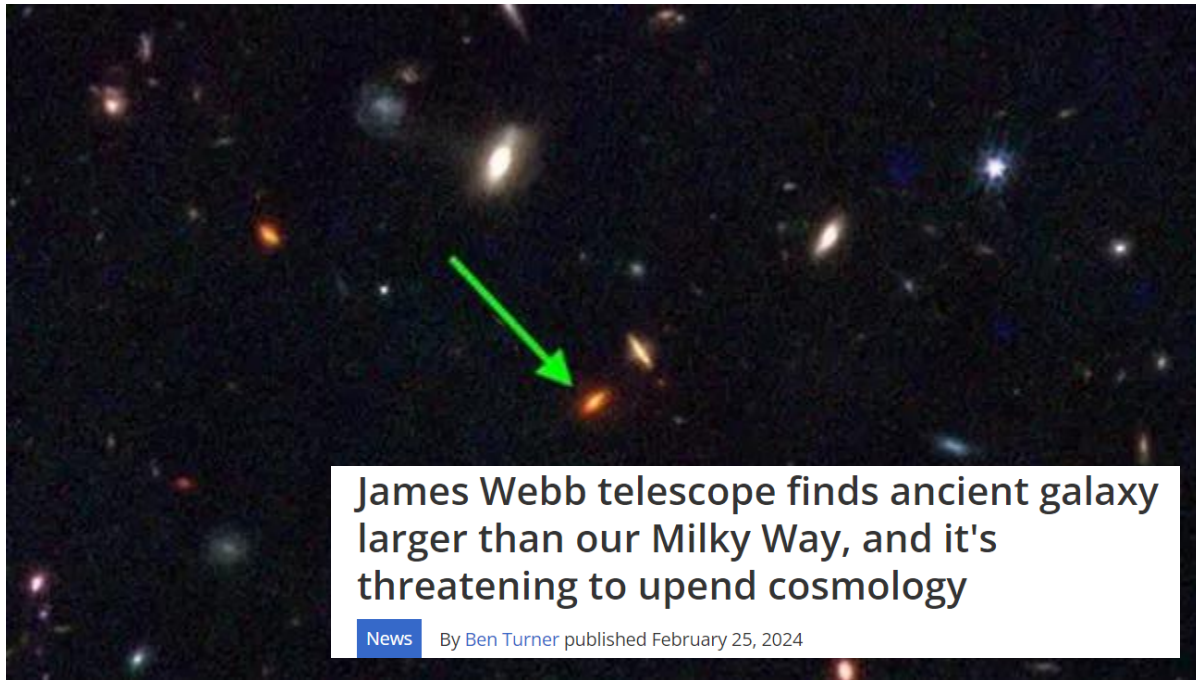
**University of  
Zurich<sup>UZH</sup>**



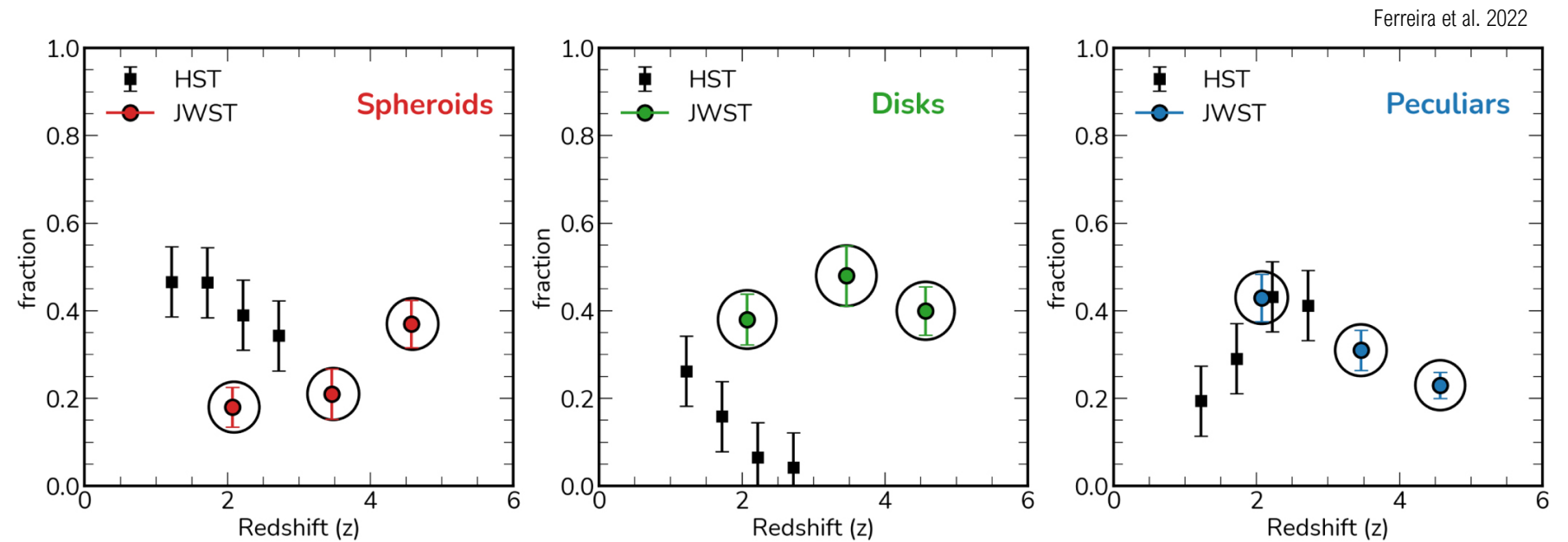
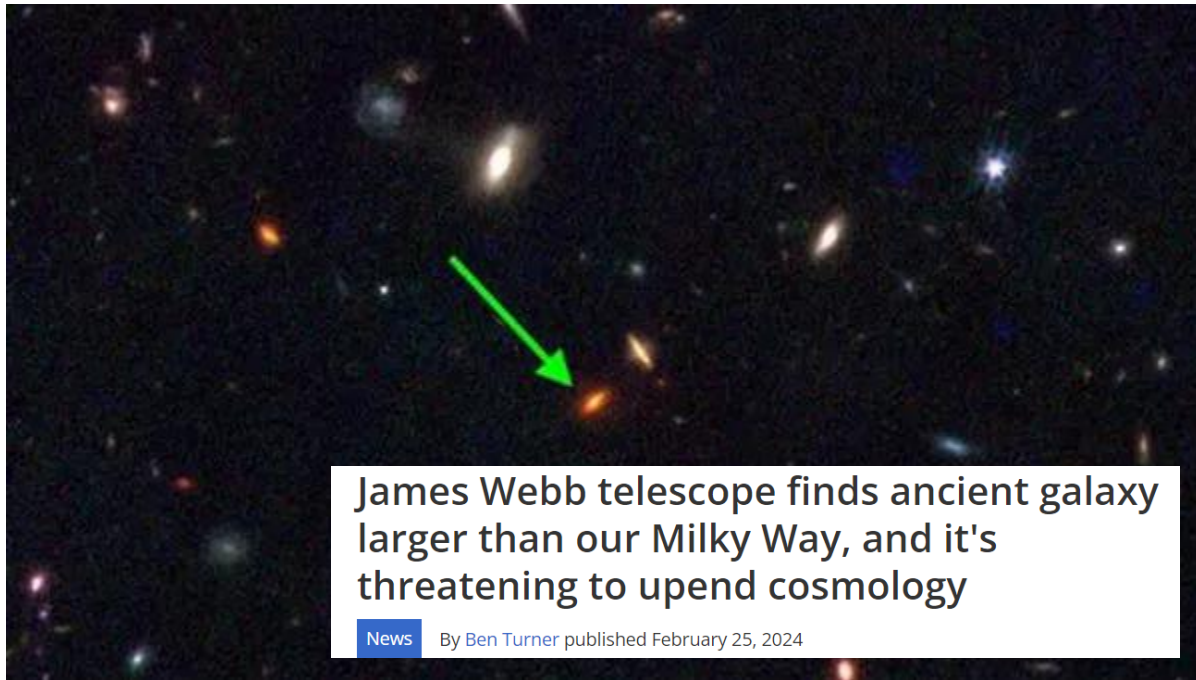
## James Webb telescope finds ancient galaxy larger than our Milky Way, and it's threatening to upend cosmology

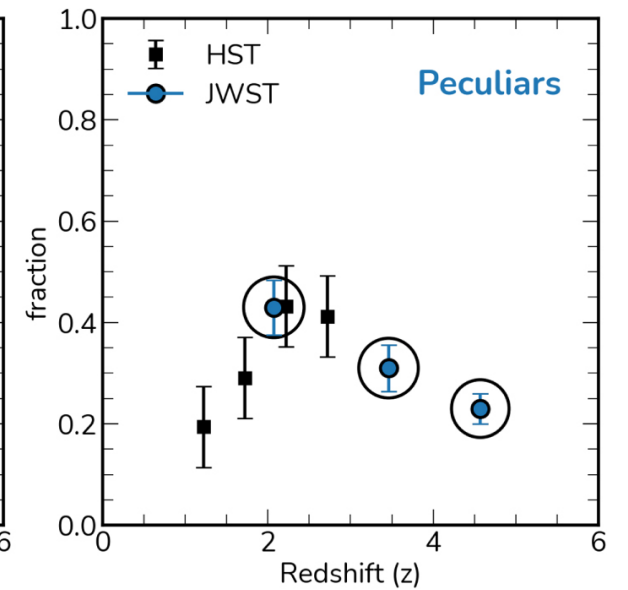
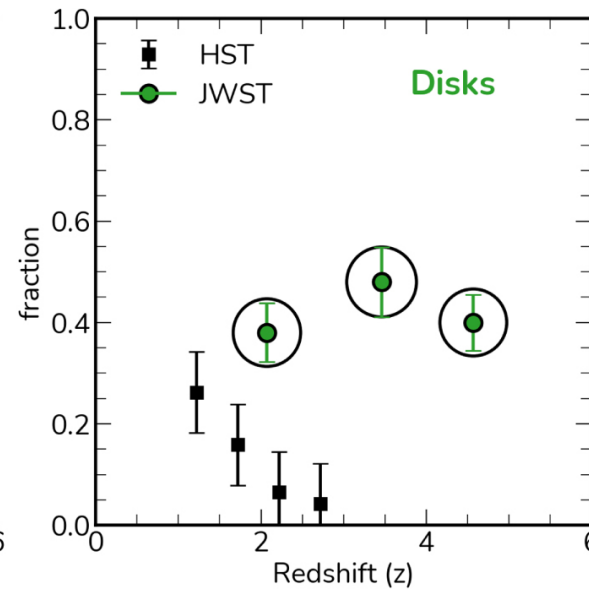
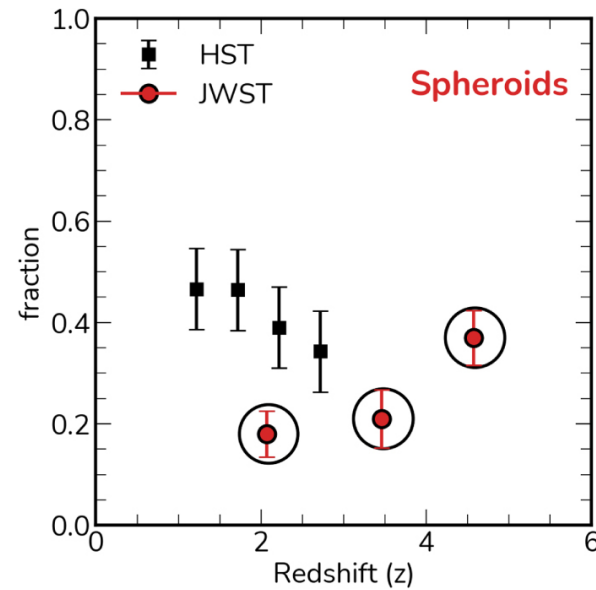
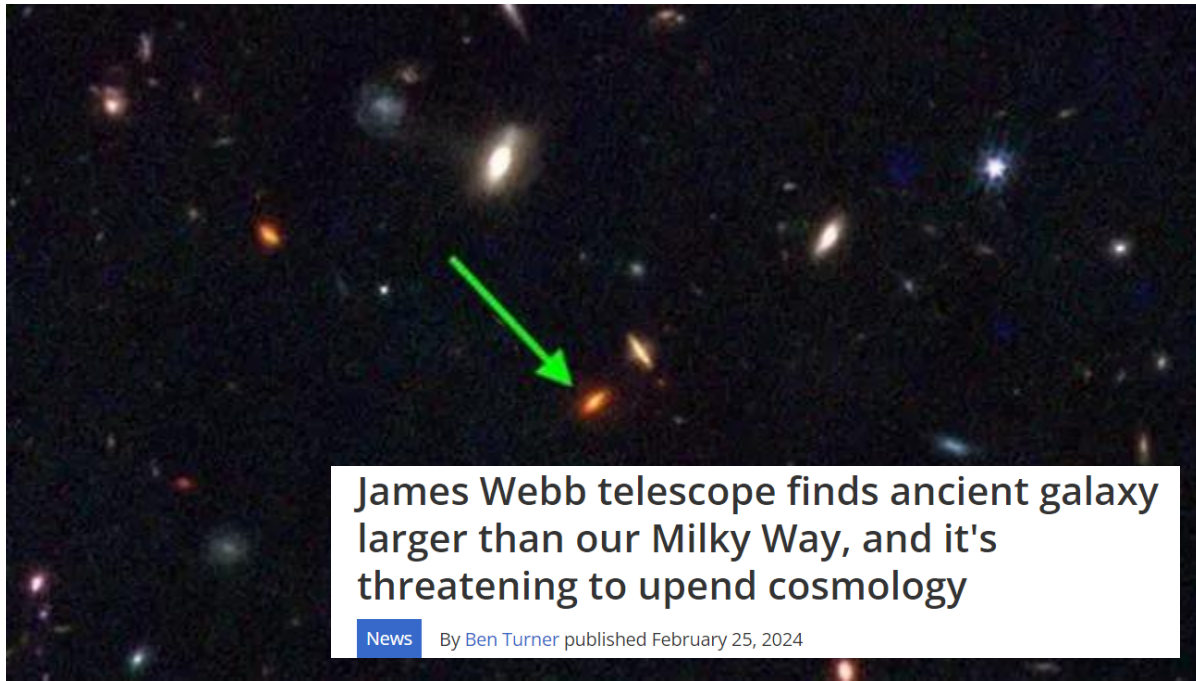
News

By Ben Turner published February 25, 2024









Ferreira et al. 2022

# PHOEBOS

Run:	# DM	# gas	# tot	$m_{\text{DM}} [M_{\odot}]$	$m_{\text{gas}} [M_{\odot}]$	$\epsilon$ [kpc]	memory [kB]	# nodes
PhoebosHR	5808 <sup>3</sup>	3888 <sup>3</sup>	$2.547 \times 10^{11}$	$1.699 \times 10^5$	$1.059 \times 10^5$	0.15	$3.135 \times 10^{11}$	
PhoebosMR	2904 <sup>3</sup>	1944 <sup>3</sup>	$3.184 \times 10^{10}$	$1.360 \times 10^6$	$8.473 \times 10^5$	0.30	$3.918 \times 10^{10}$	2048
PhoebosLR	1452 <sup>3</sup>	972 <sup>3</sup>	$3.980 \times 10^9$	$1.088 \times 10^7$	$6.778 \times 10^6$	0.60	$4.898 \times 10^9$	
PhoebosULR	726 <sup>3</sup>	486 <sup>3</sup>	$4.974 \times 10^8$	$8.701 \times 10^7$	$5.423 \times 10^7$	1.20	$6.122 \times 10^8$	

## Subgrid physics:

- Spatially homogeneous time-dependent cosmic UV background (Haardt & Madau 2002 model).
  - solve directly for the non-equilibrium Saha equation
- Turbulent diffusion of thermal energy
- Metal diffusion
- cooling of H and He species
- cooling from the fine structure lines of metals
- Supernova feedback
  - Blast wave feedback model of Stinson et al. (2006)

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Run Name		TNG100	TNG300
Volume	[ Mpc <sup>3</sup> ]	110.7 <sup>3</sup>	302.6 <sup>3</sup>
$L_{\text{box}}$	[ Mpc/h ]	75	205
$N_{\text{GAS}}$	-	1820 <sup>3</sup>	2500 <sup>3</sup>
$N_{\text{DM}}$	-	1820 <sup>3</sup>	2500 <sup>3</sup>
$N_{\text{TRACER}}$	-	$2 \times 1820^3$	$1 \times 2500^3$
$m_{\text{baryon}}$	[ $M_{\odot}$ ]	$1.4 \times 10^6$	$1.1 \times 10^7$
$m_{\text{DM}}$	[ $M_{\odot}$ ]	$7.5 \times 10^6$	$5.9 \times 10^7$
$\epsilon_{\text{gas,min}}$	[ pc ]	185	370
$\epsilon_{\text{DM,stars}}^{z=0}$	[ kpc ]	0.74	1.48
$\epsilon_{\text{DM,stars}}$	[ ckpc/h ]	1.0 $\rightarrow$ 0.5	2.0 $\rightarrow$ 1.0

# PHOEBOS

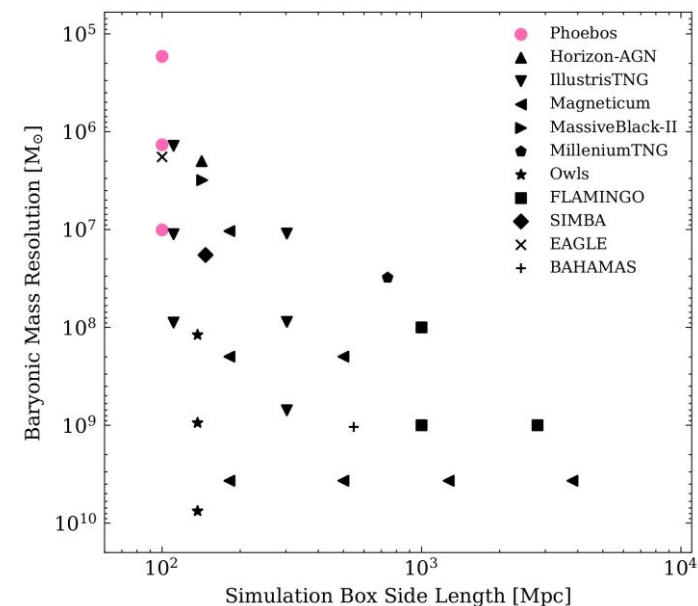
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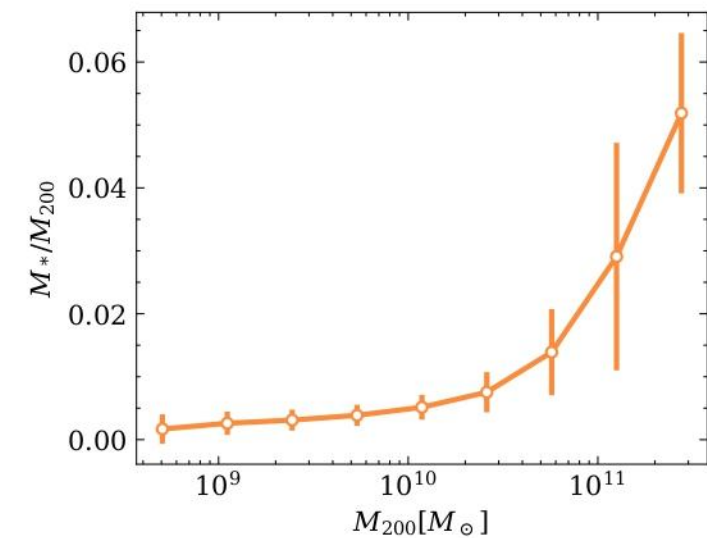
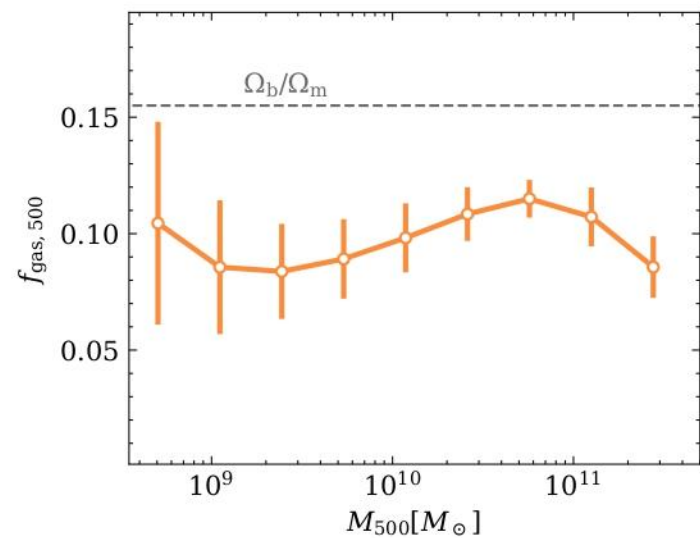
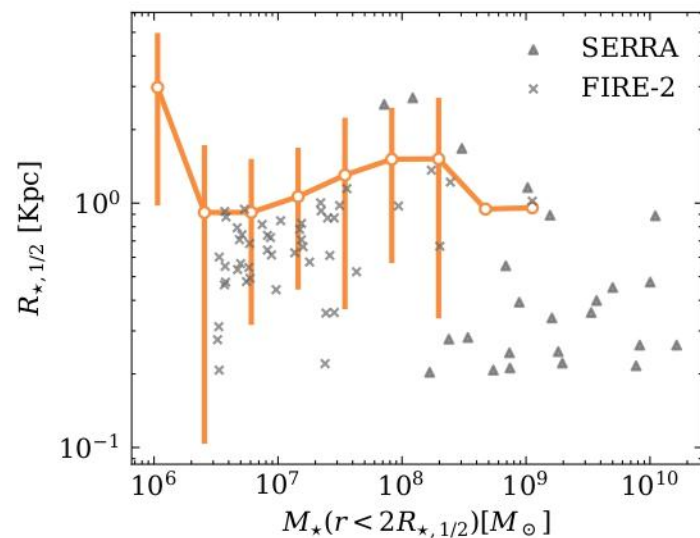
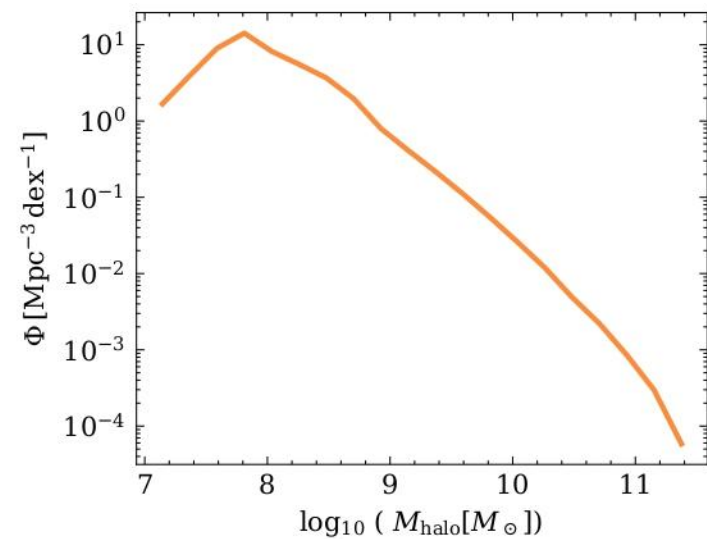
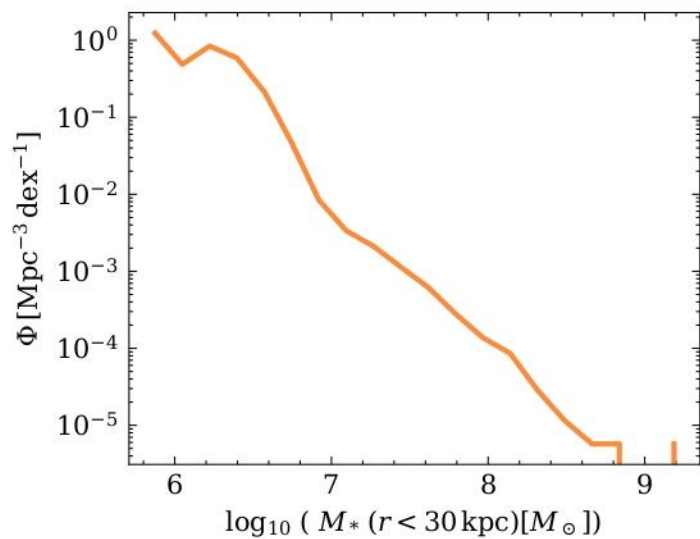
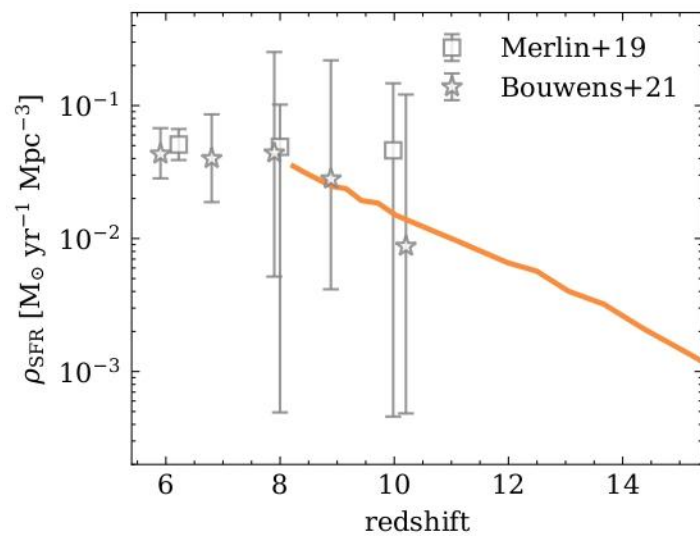


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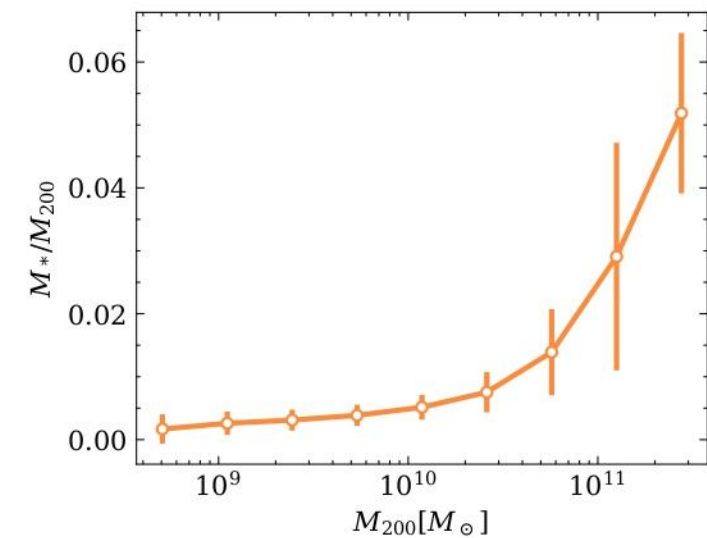
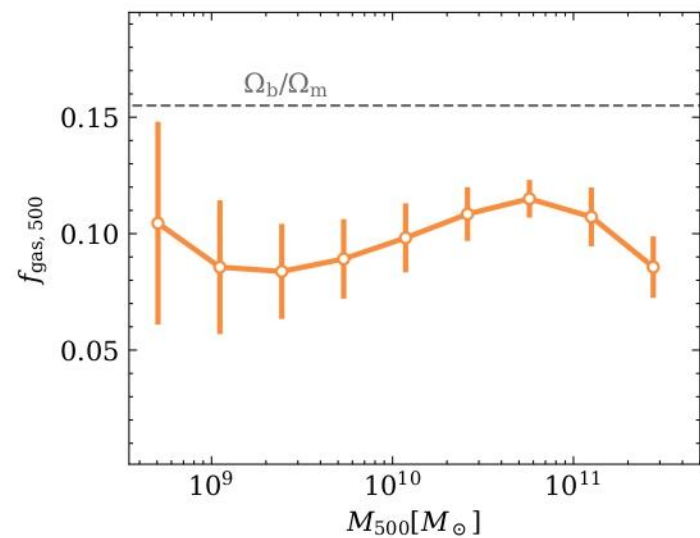
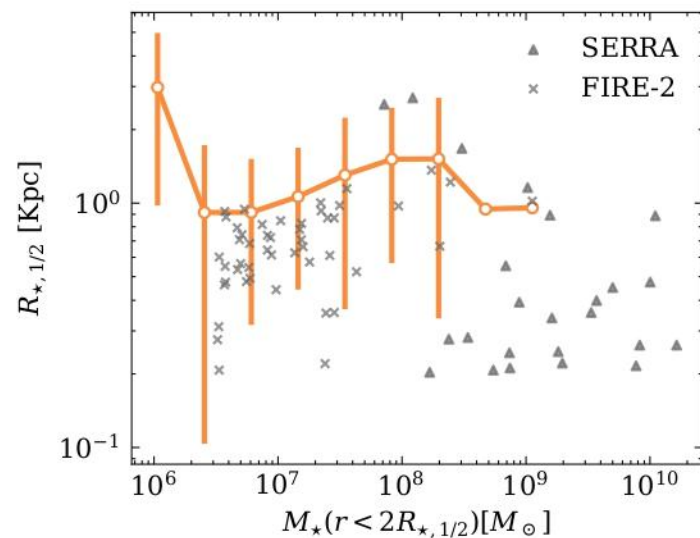
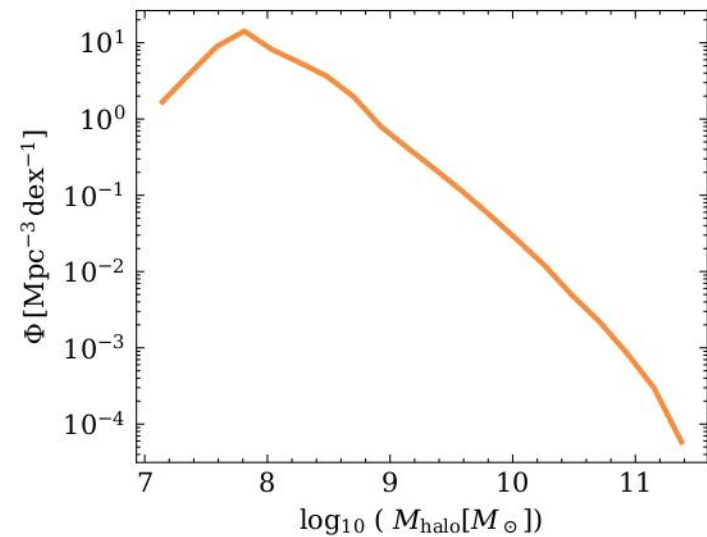
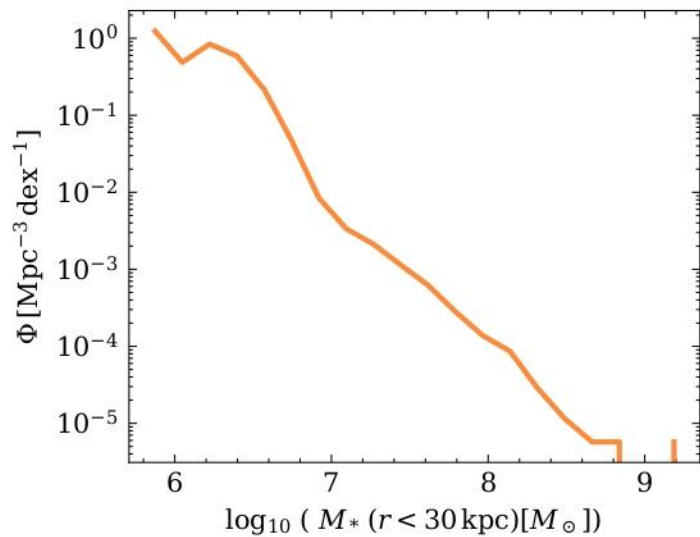
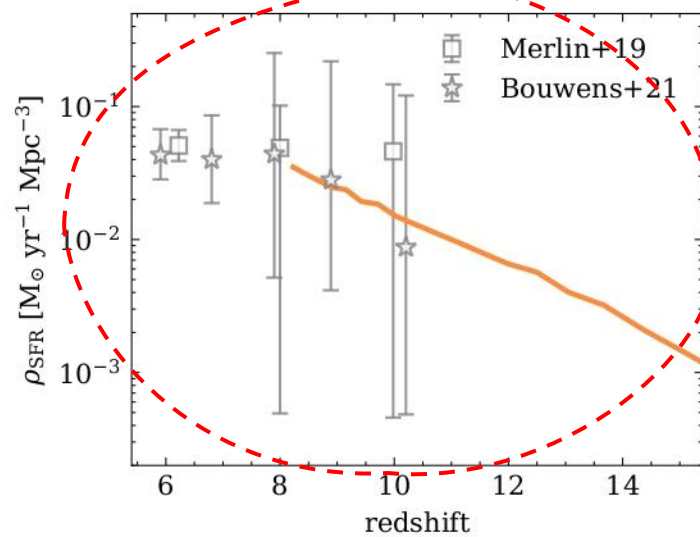


## Phoebos at $Z=8$



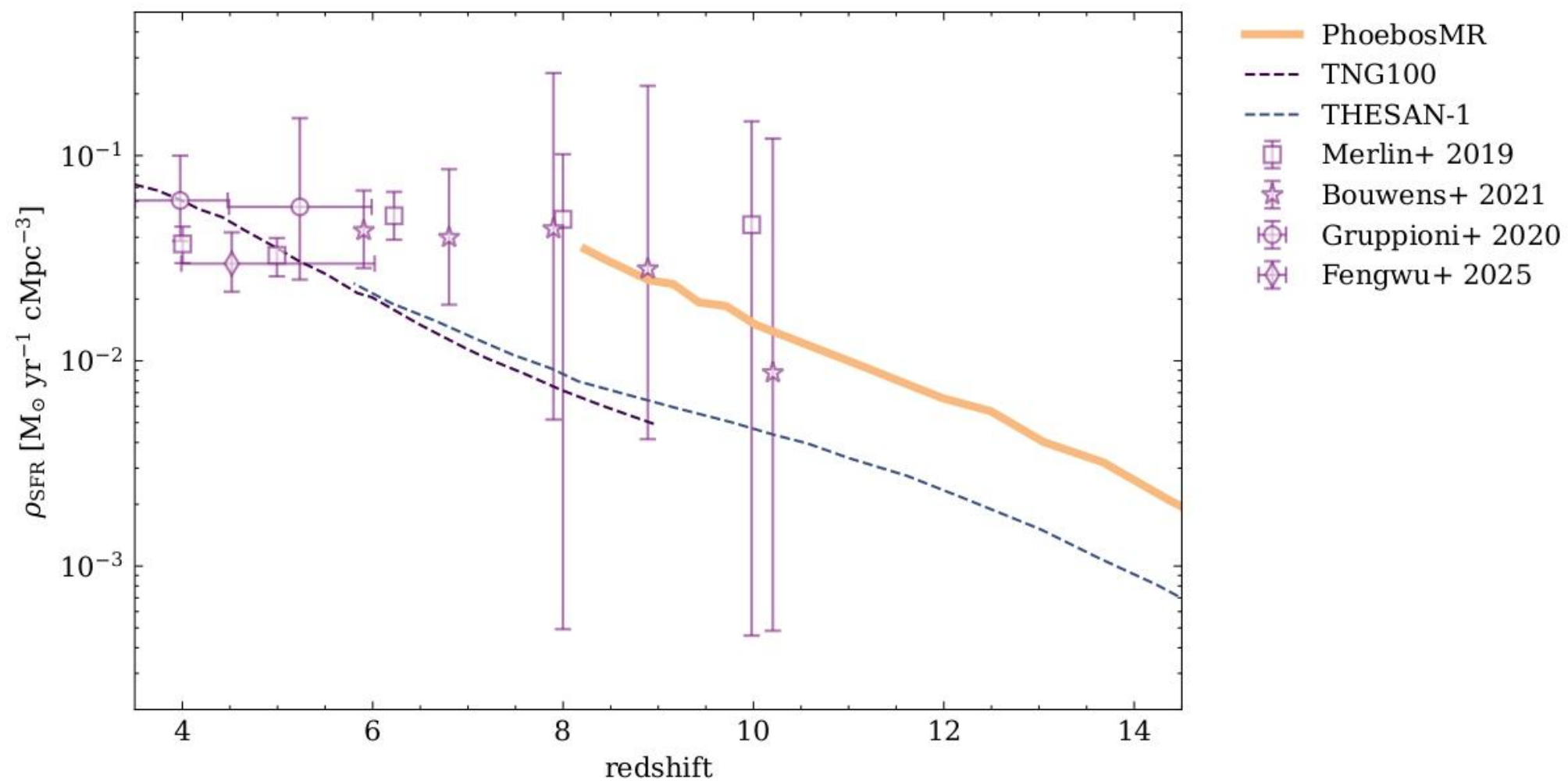
! very preliminary !

## Phoebos at $Z=8$



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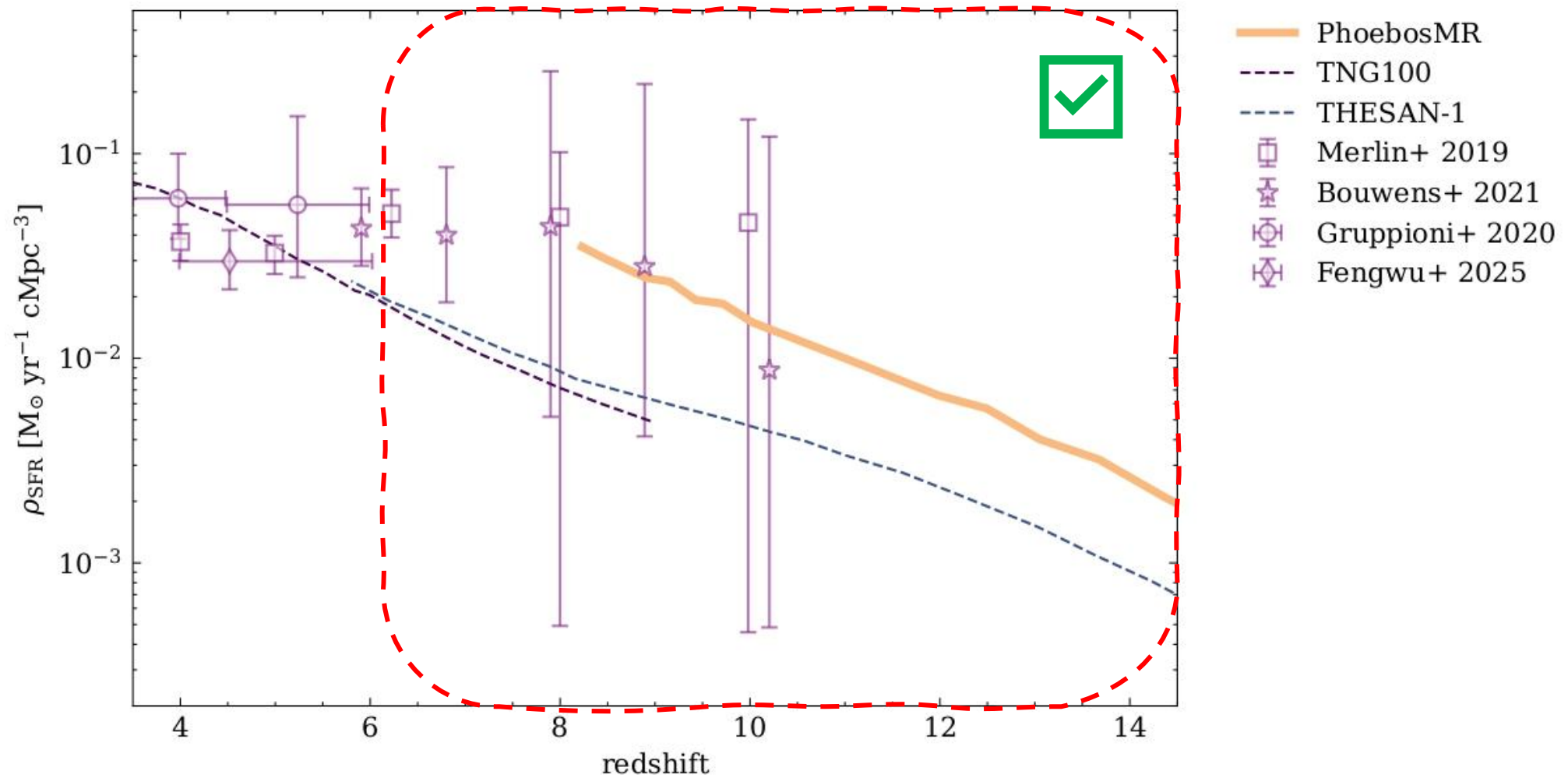
## Zooming into the cosmic star formation density



! very preliminary !

## Zooming into the cosmic star formation density

→ the less strong feedback model of Phoebos seems to better fit the high redshift regime.

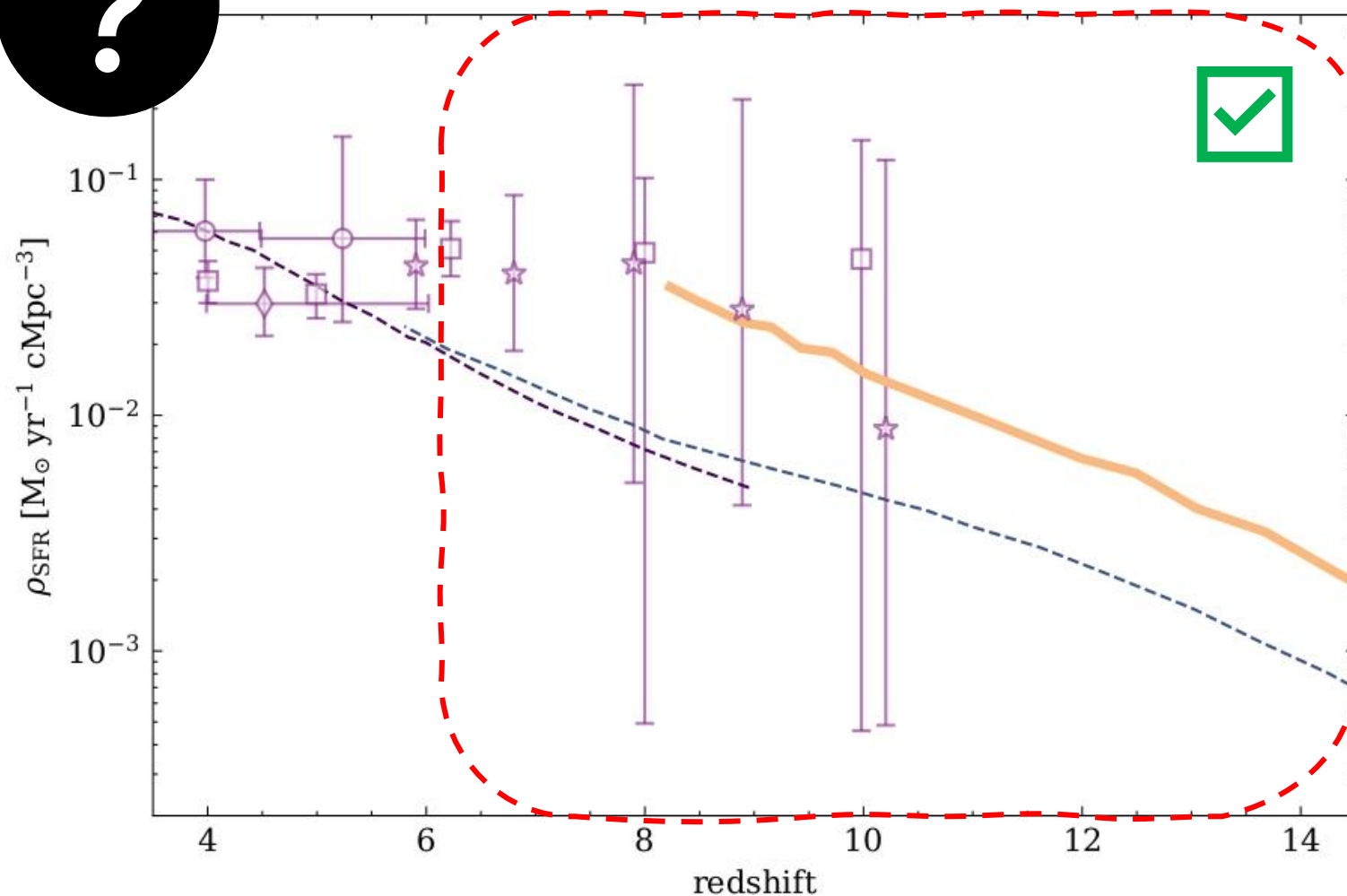


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What about  $z < 5$ ?

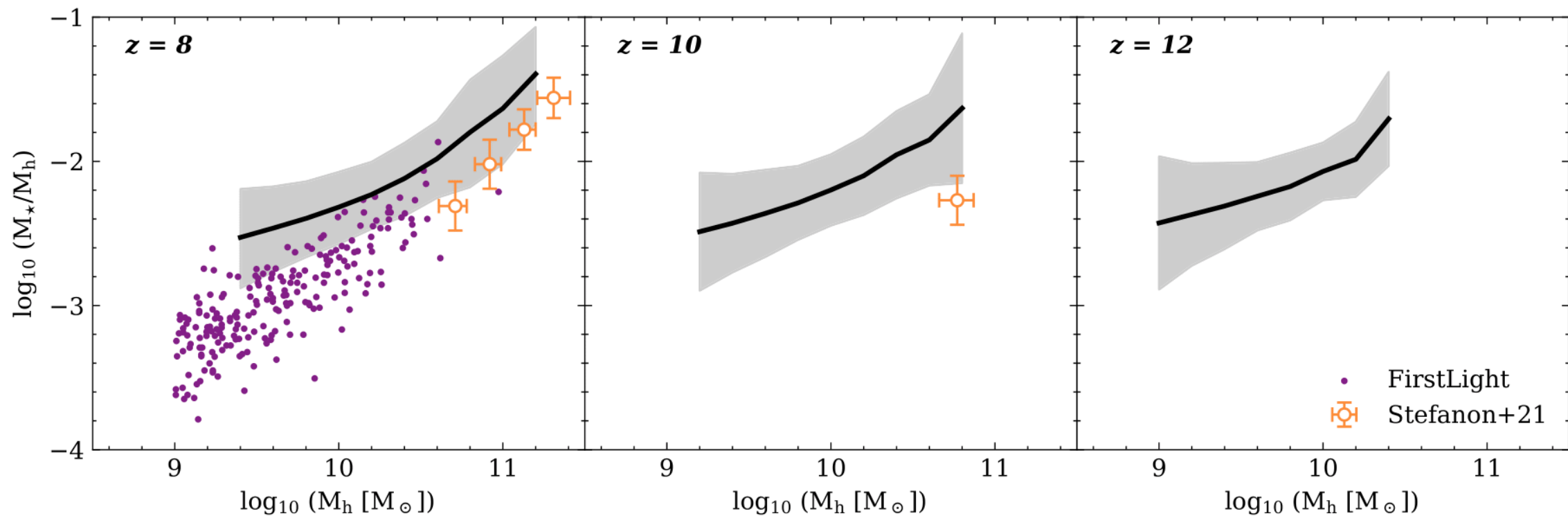


- PhoeboMR
- TNG100
- THESAN-1
- Merlin+ 2019
- Bouwens+ 2021
- Gruppioni+ 2020
- Fengwu+ 2025

**Will we overshoot the measurements at  $z=0$ ?**

Test with a ULR run shows we will be slightly above the  $z=1.5$  values.

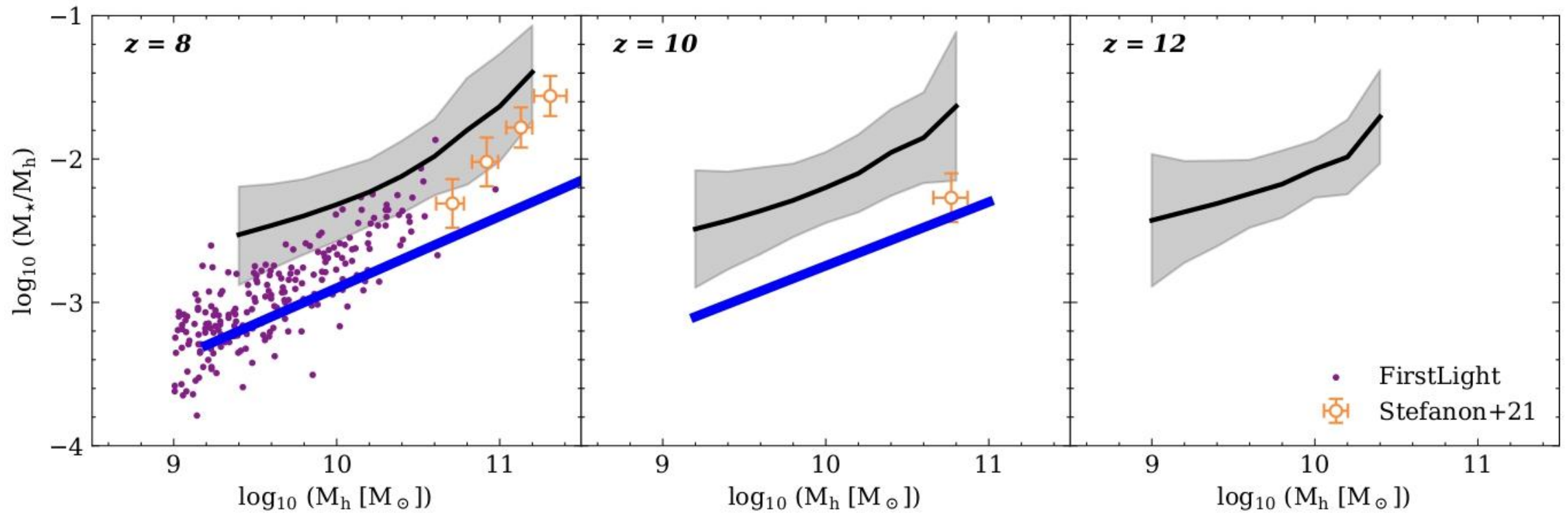
! very preliminary !



**We are also in the upper range of the  $M_{\star}/M_{\text{halo}}$  ratio**

→ Nevertheless, in observations some  $M_{\star}$  might be hidden

**! very preliminary !**



We are also in the upper range of the  $M_{\text{star}}/M_{\text{halo}}$  ratio

→ AND OTHER SIMULATIONS ARE TOO LOW

! very preliminary !

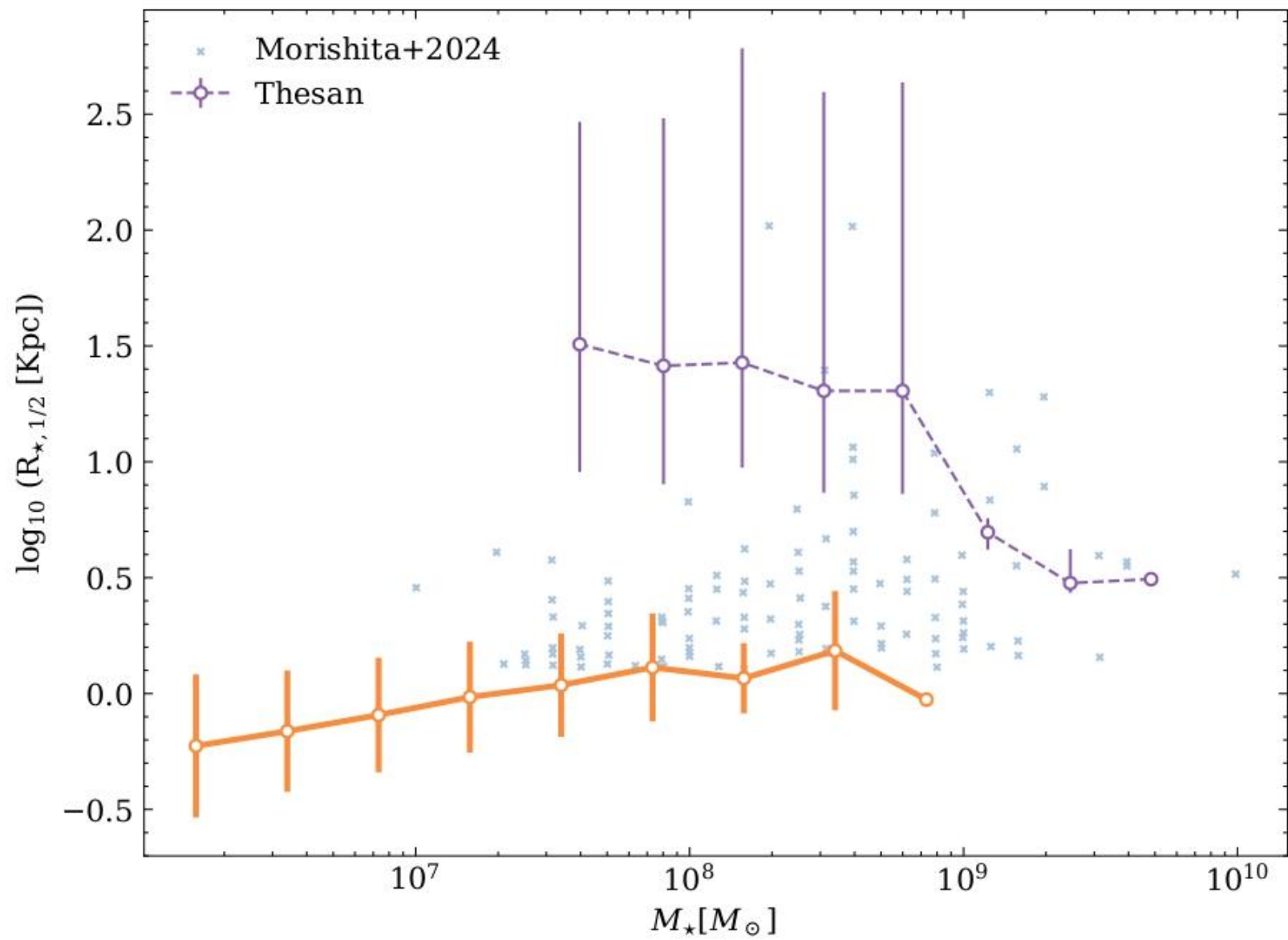
# Thank you for listening

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! very preliminary !