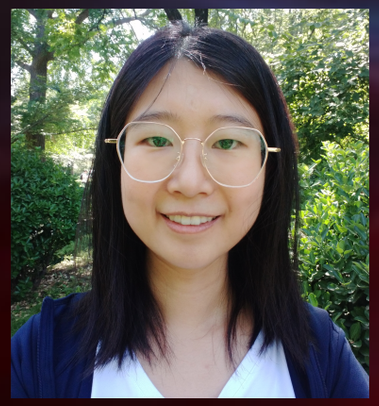
Pathway to high-z SMBHs: Seed Formation and Growth in the Statistical Perspective



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Quasar luminosity function (QLF)

BH growth through accretion

BH abundance

radiative process

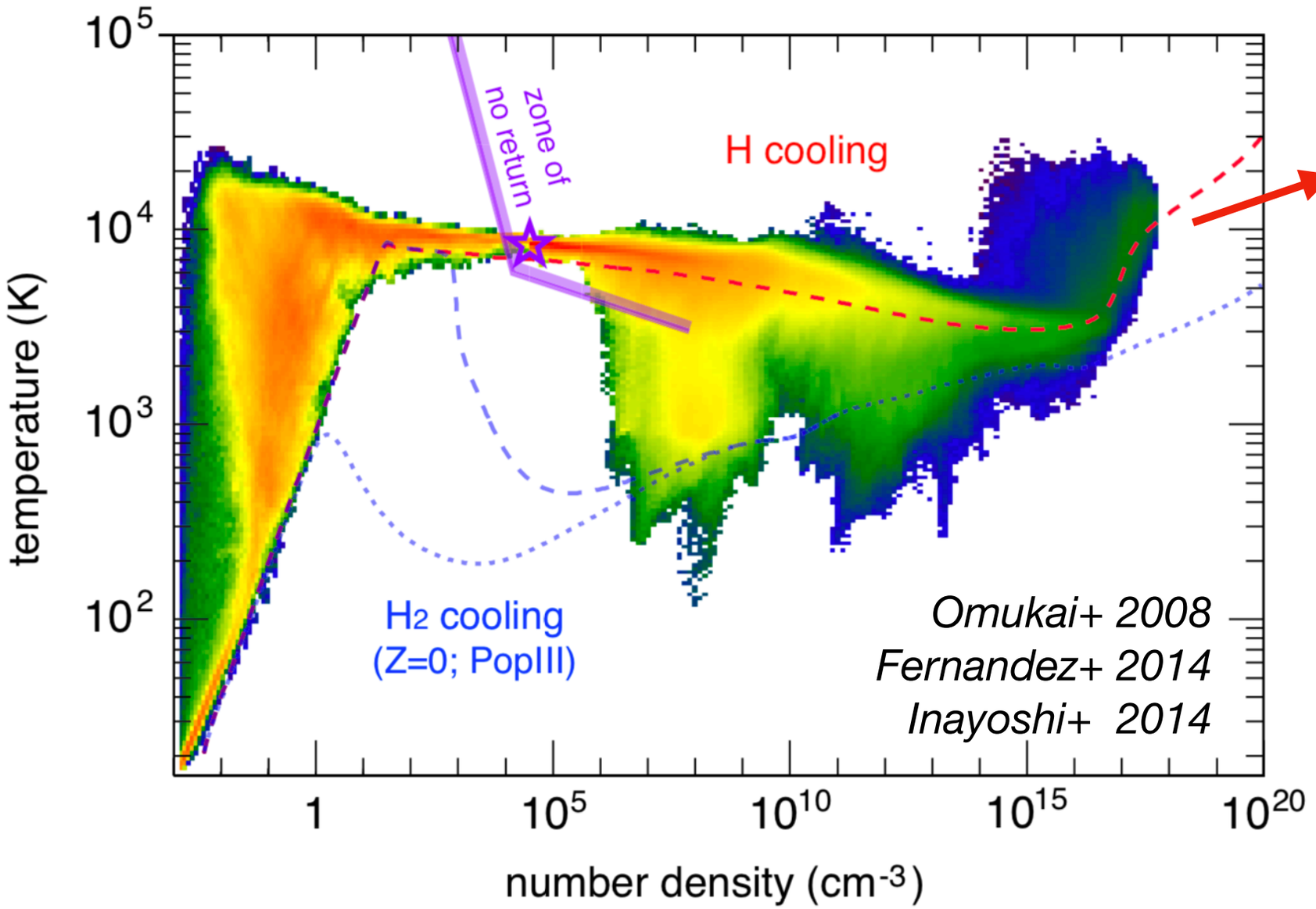
Black hole mass function (BHMF)

BH seed formation

Probabilistically sampling from a distribution?

Applying M-σ relation to high z?

First star formation? (what we adopt.)



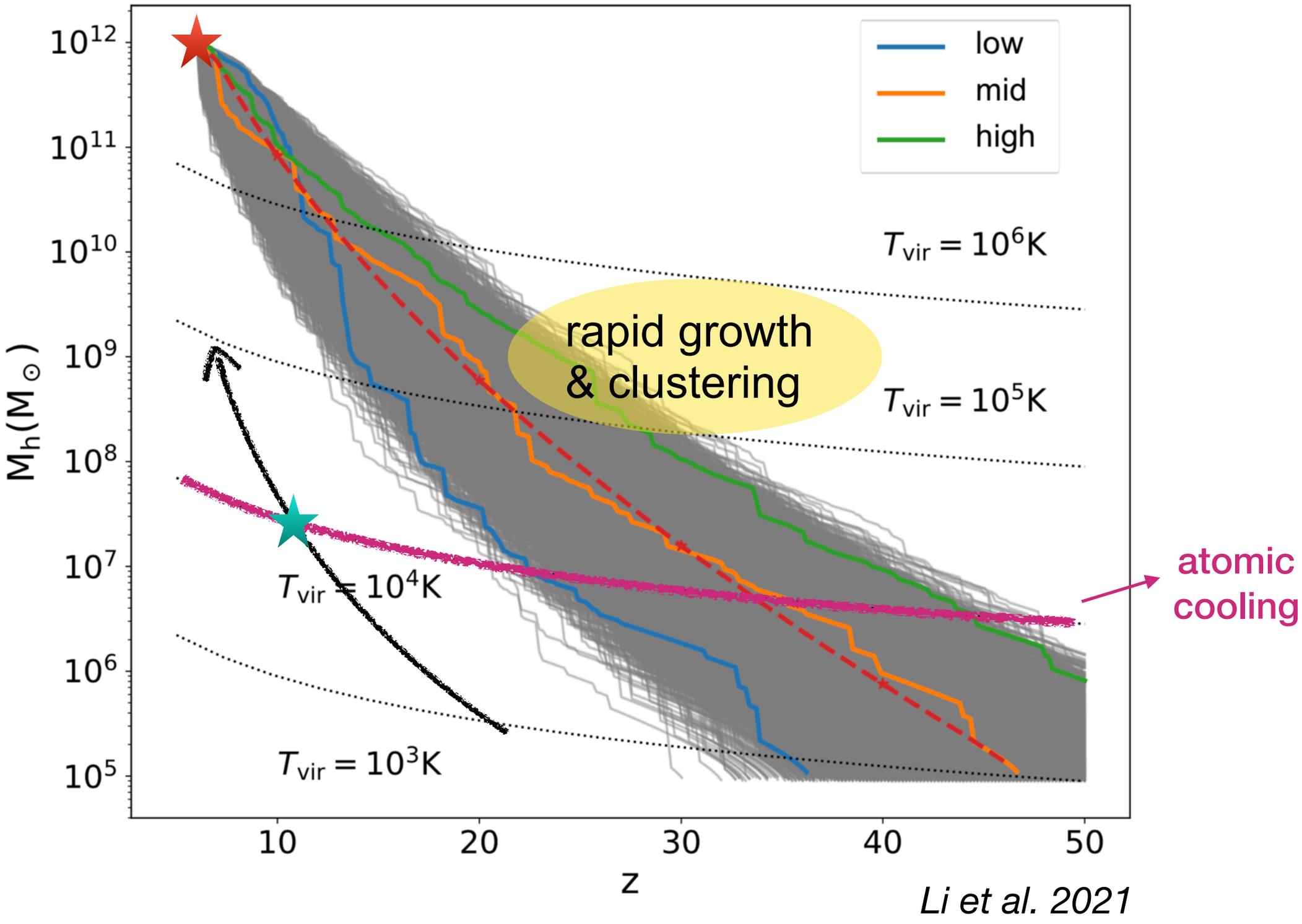
Semi-analytic model

Temperature?

(H v.s. H_2 cooling)

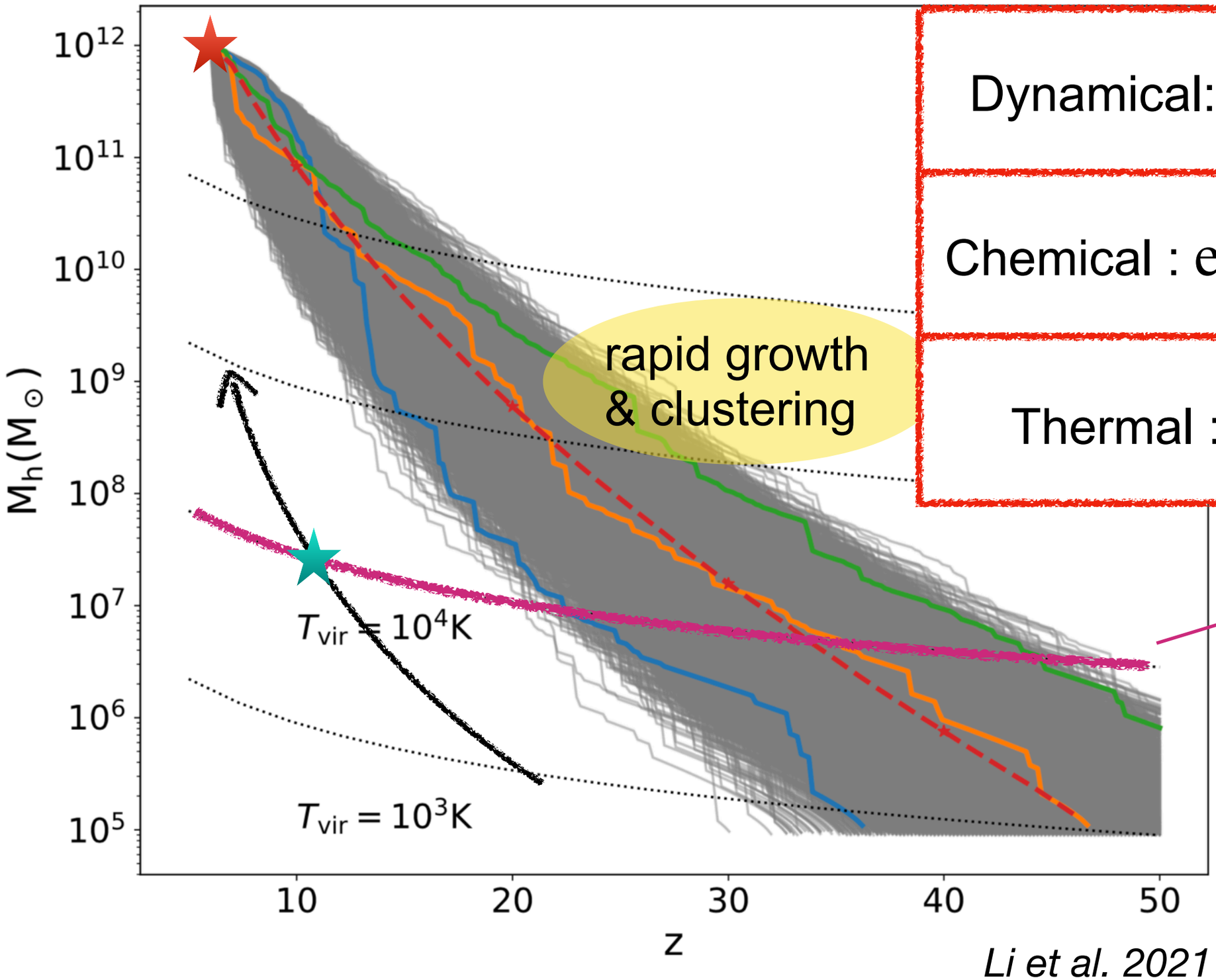
high T $\rightarrow$high $\dot{M}$ $\rightarrow$ massive BH seeds

Laboratory: Merger Trees



Li et al. 2021

Laboratory: Merger Trees



Dynamical: $\frac{dn}{dt}$

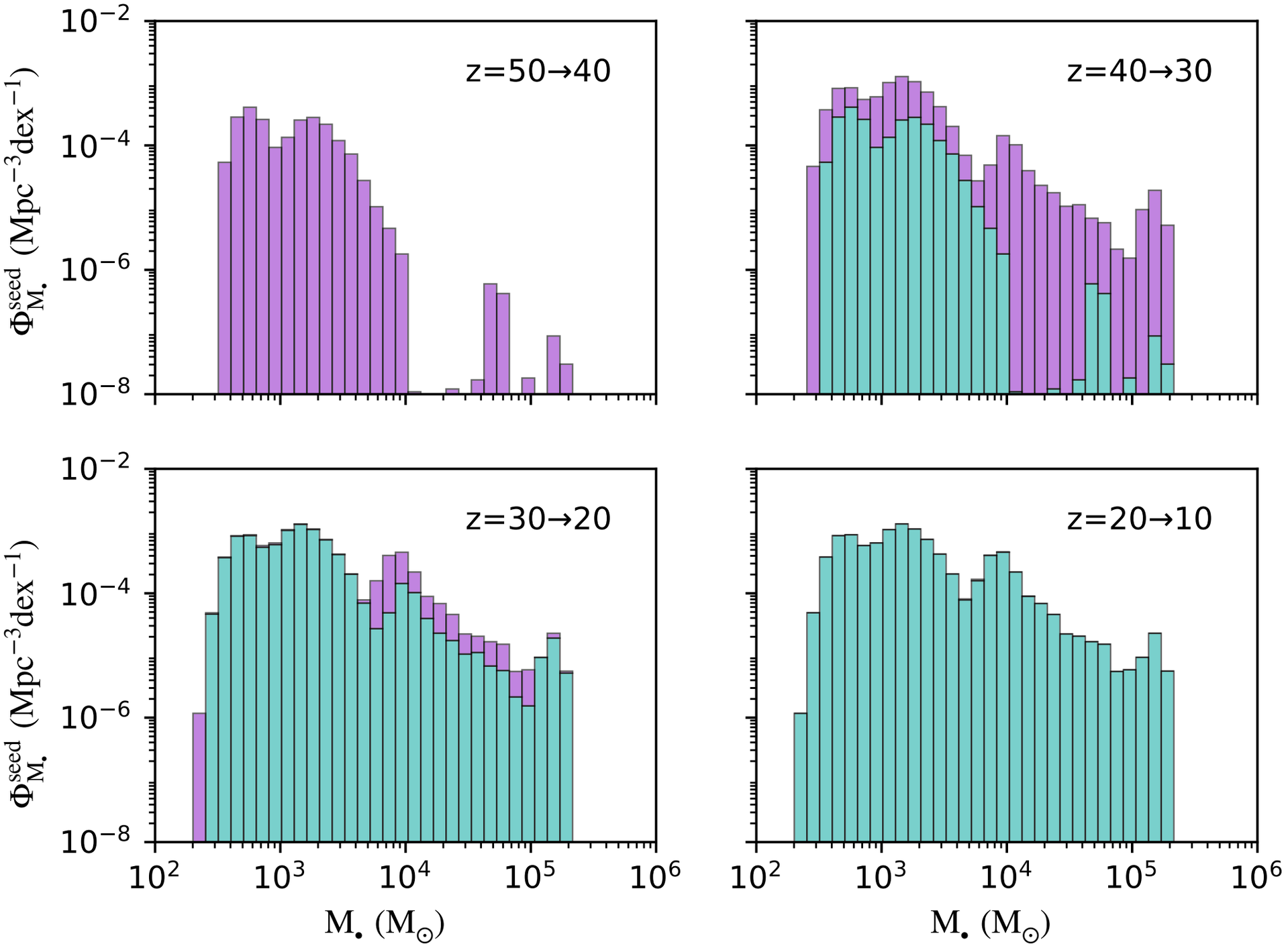
Chemical : e^-, H_2 …

Thermal : Λ, Γ

atomic cooling

Li et al. 2021

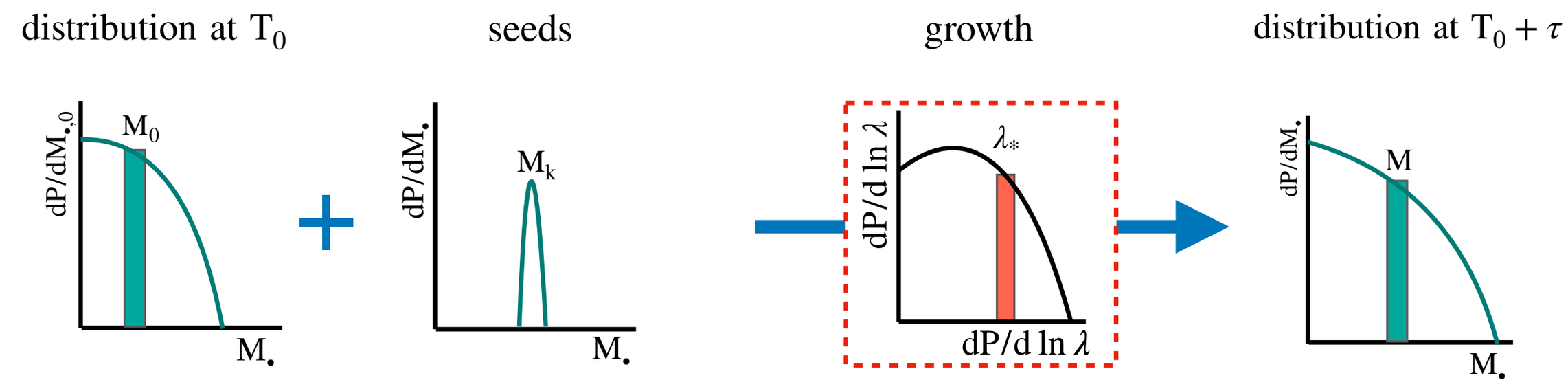
Realistic seeding

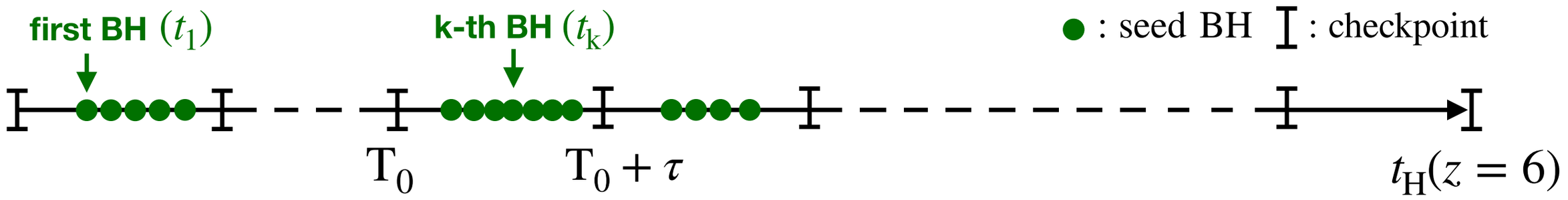


Li+ 2022
arXiv: 2210.02308

Seeds formed in: $M_{\rm h} \gtrsim 10^{11}\ M_\odot$ at $z = 6$

Growth model





episodic growth duration: τ

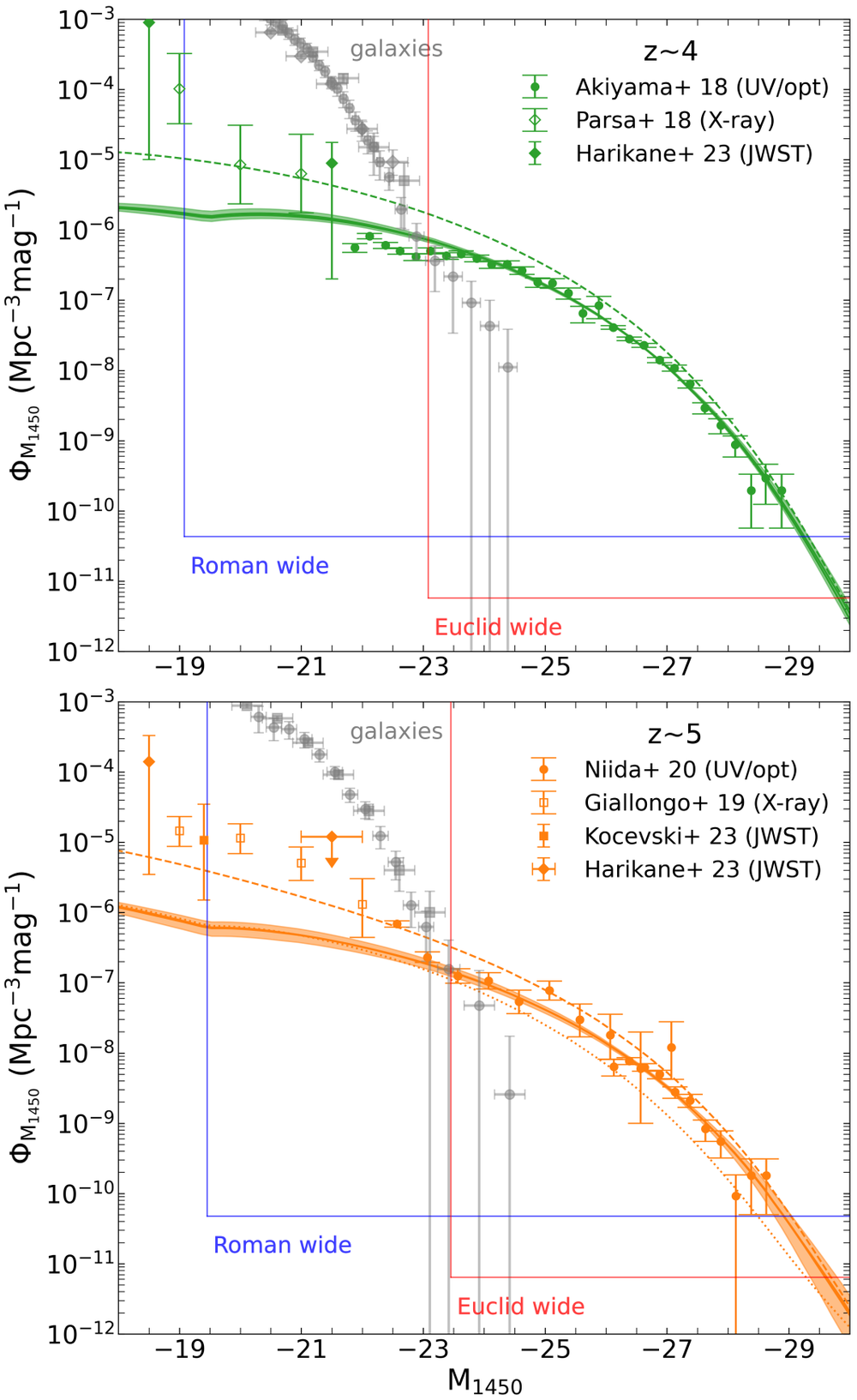
Eddington ratio λ : Schechter dist. (λ_0, α)

Li+ 2022
arXiv: 2210.02308

QLF evolution

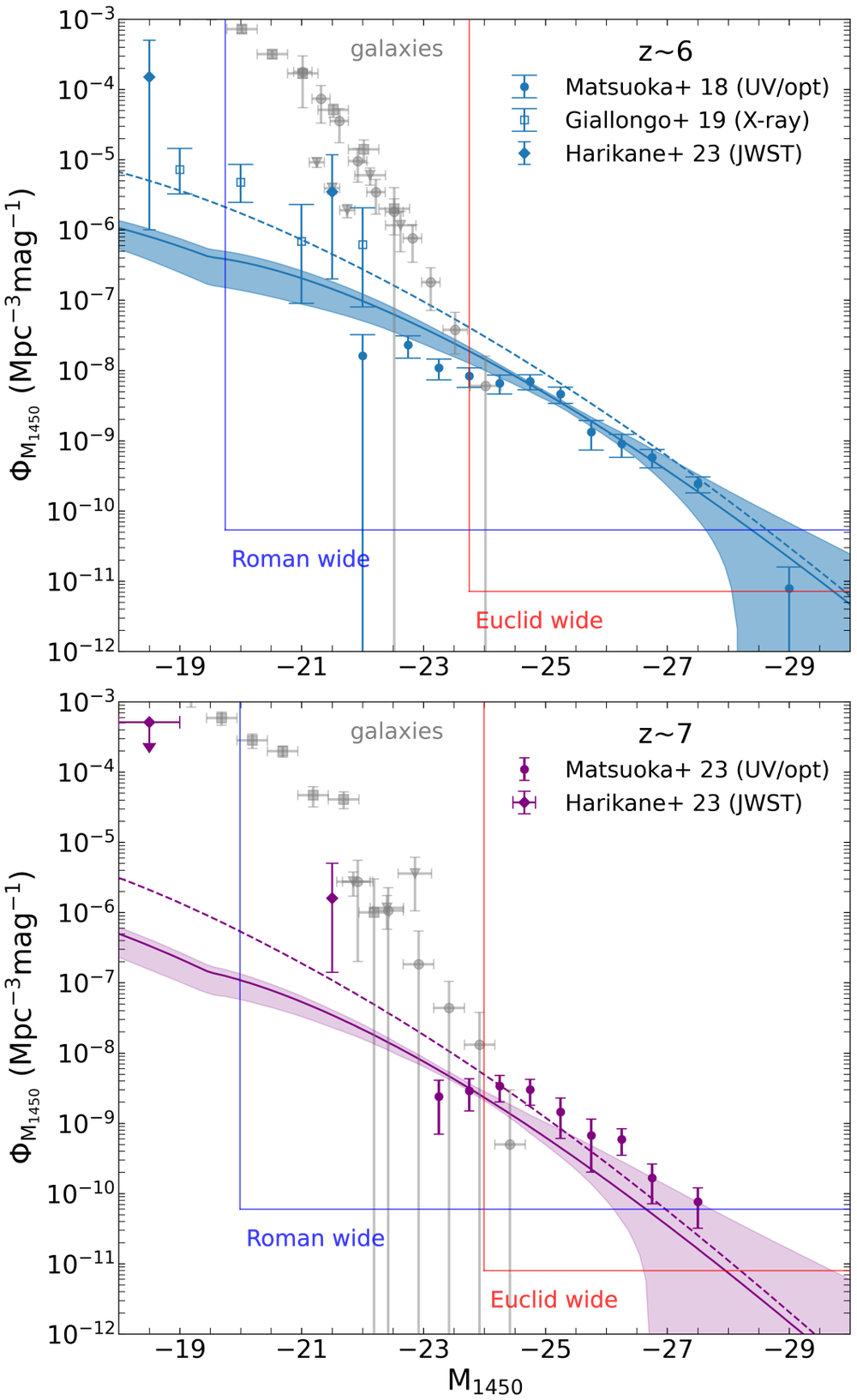
Li+ 2023
arXiv: 2306.06172

$z \sim 4$



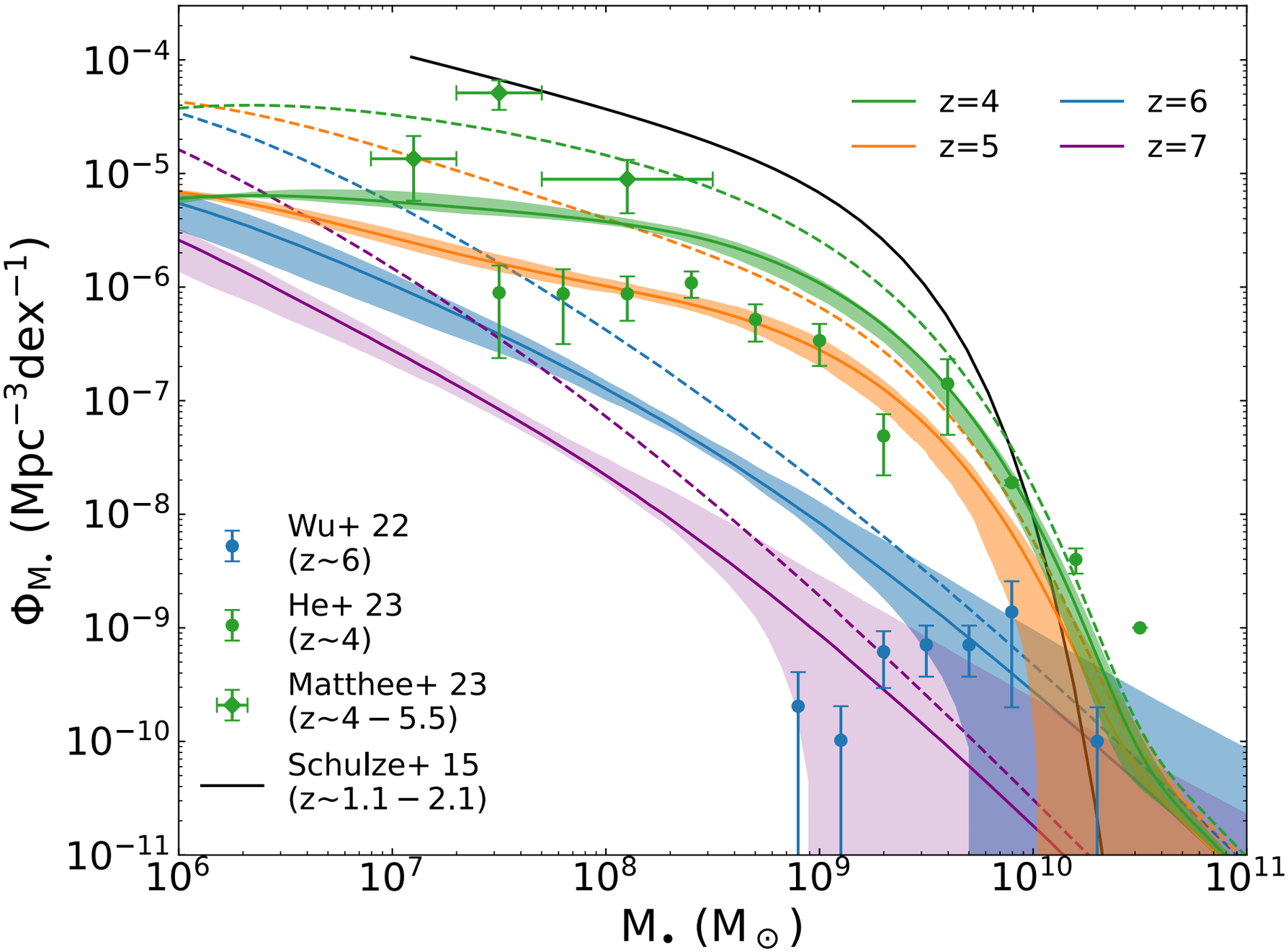
$z \sim 5$

$z \sim 6$



$z \sim 7$

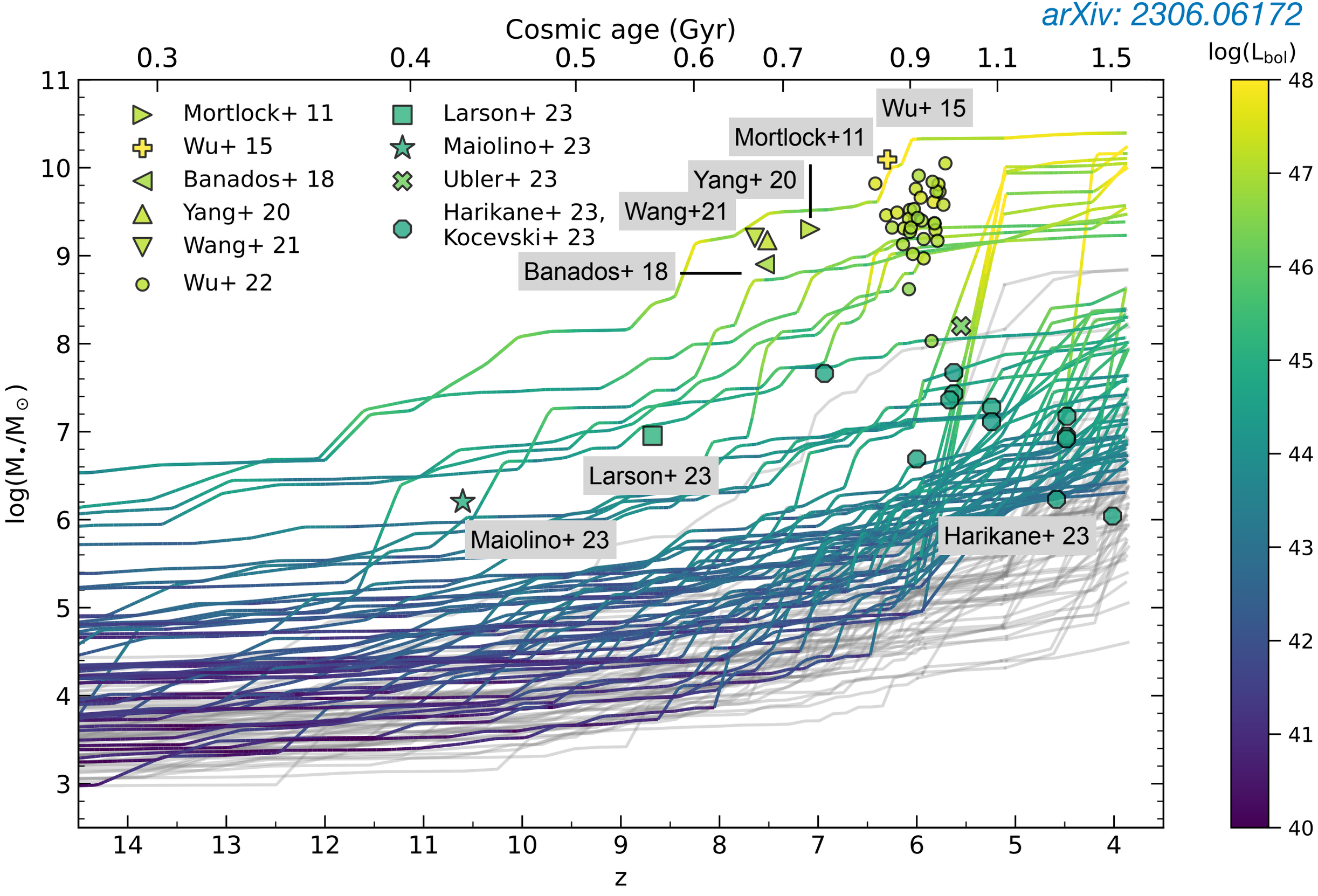
BHMF prediction



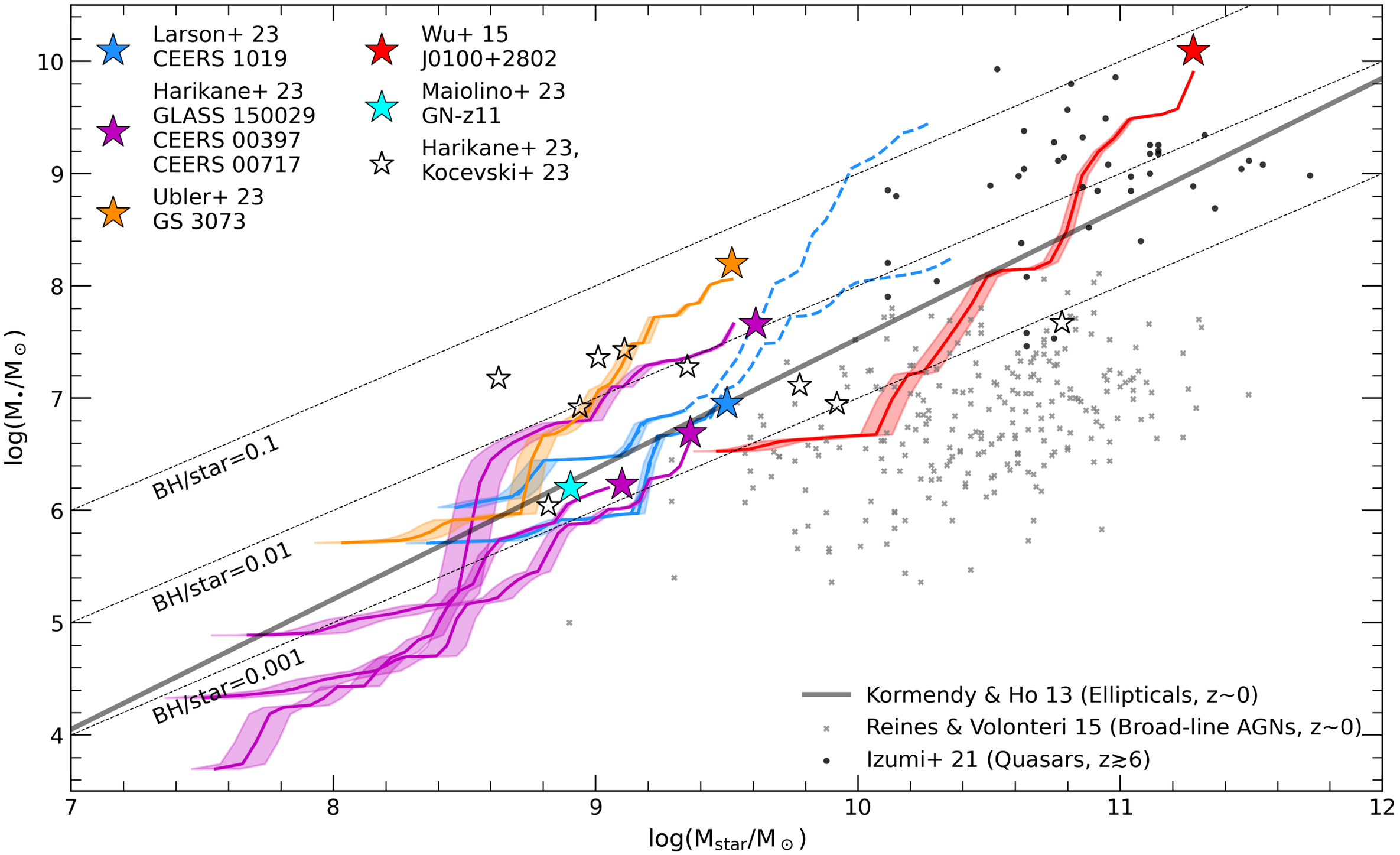
★ BH growth stunted at $z \lesssim 6$, approaching $z \sim 2$

BHMF growth

Li+ 2023
arXiv: 2306.06172



BH-galaxy coevolution



Originating from close to the local relation.

Li+ 2023
arXiv: 2306.06172

Summary

We consider **seed BH formation** in progenitors of **quasar hosts:**

★ High J_{LW} & merger heating→ massive seeds

Fitting of seeds in **less massive hosts:** to

★ unveil hidden population of low λ accreting BHs

★ predict high-z BHMF & QLF

★ extrapolation to lower-redshifts ($z \sim 5, 4$)

JWST &
future devices!