Massive Black Hole Seeds of $z \gtrsim 6$ Luminous Quasars in the JWST Era

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in collaboration with
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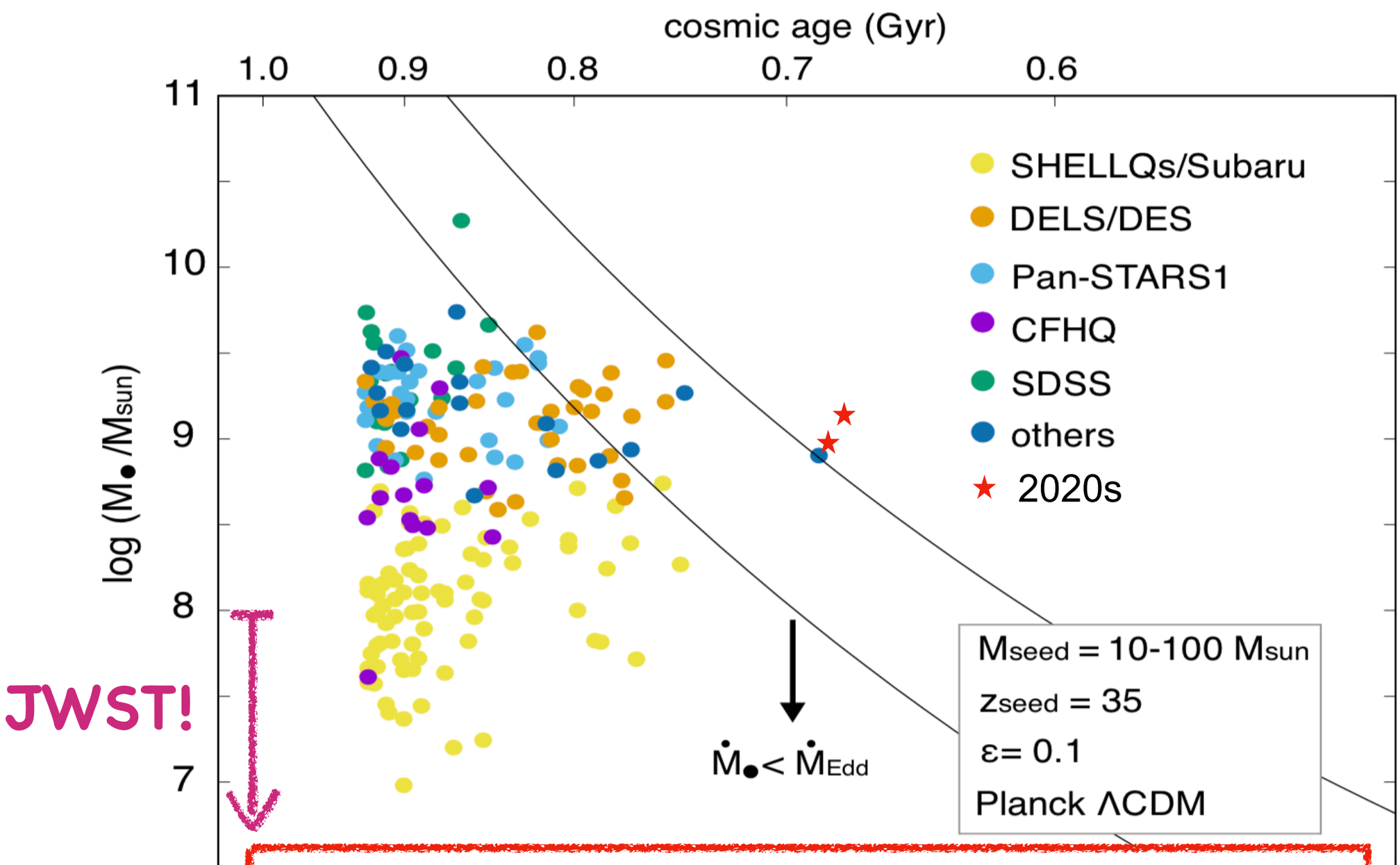
I. Seed BH Formation @ High z.

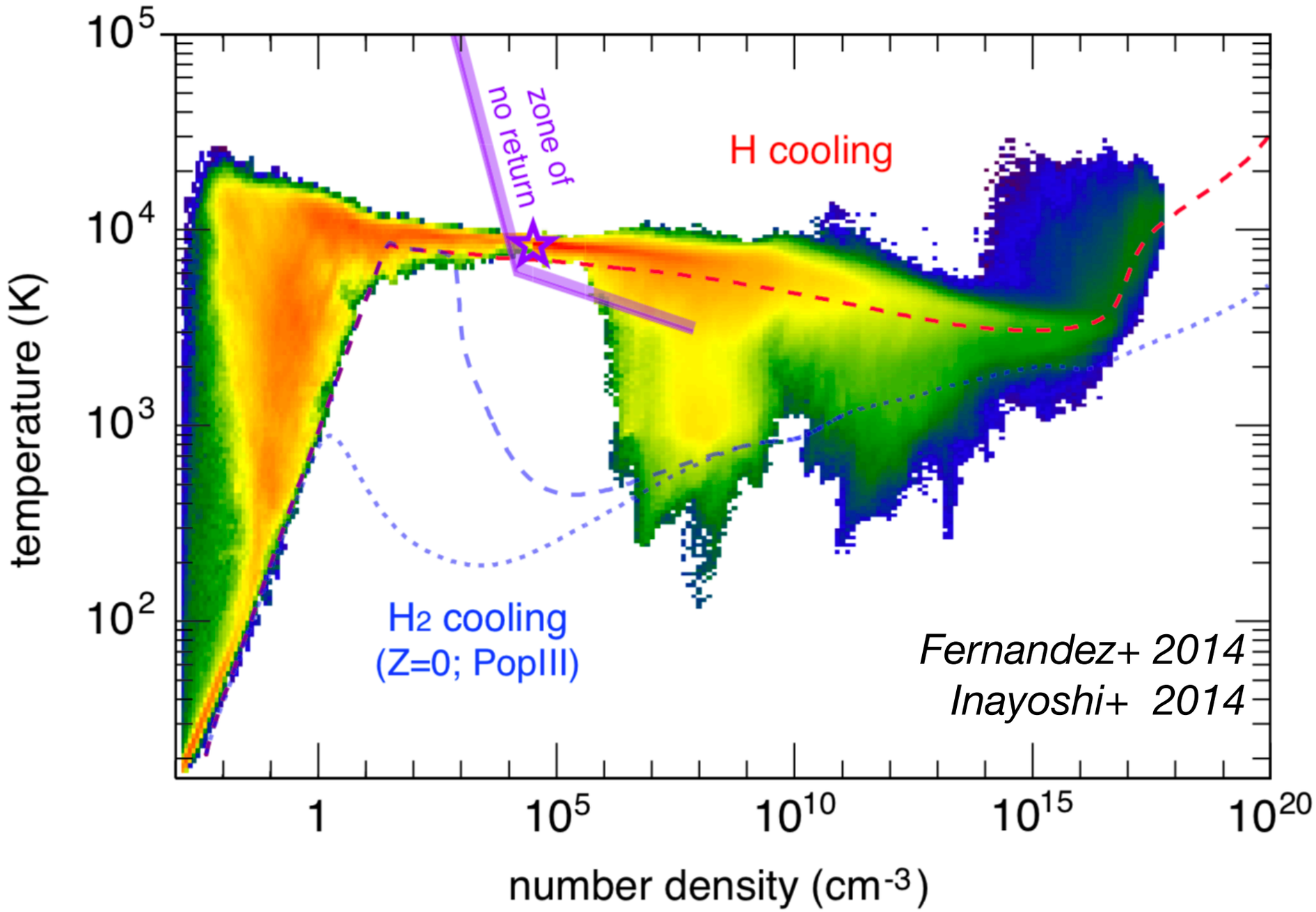
Massive BHs at High z !



Possible solutions:

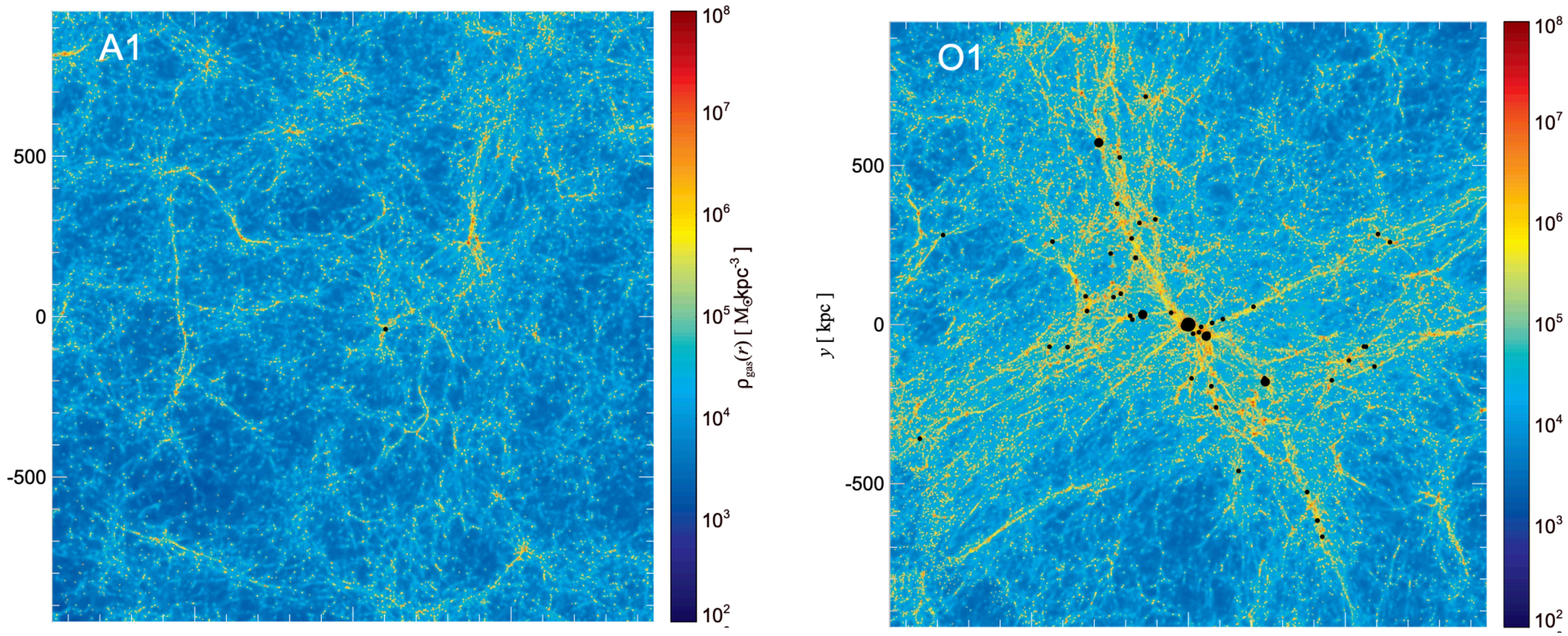
- rapid growth
- massive seeds

H2 v.s. H Cooling Tracks



High T → high $\dot{M}(\propto \frac{c_s^3}{G})$ → massive BH seeds

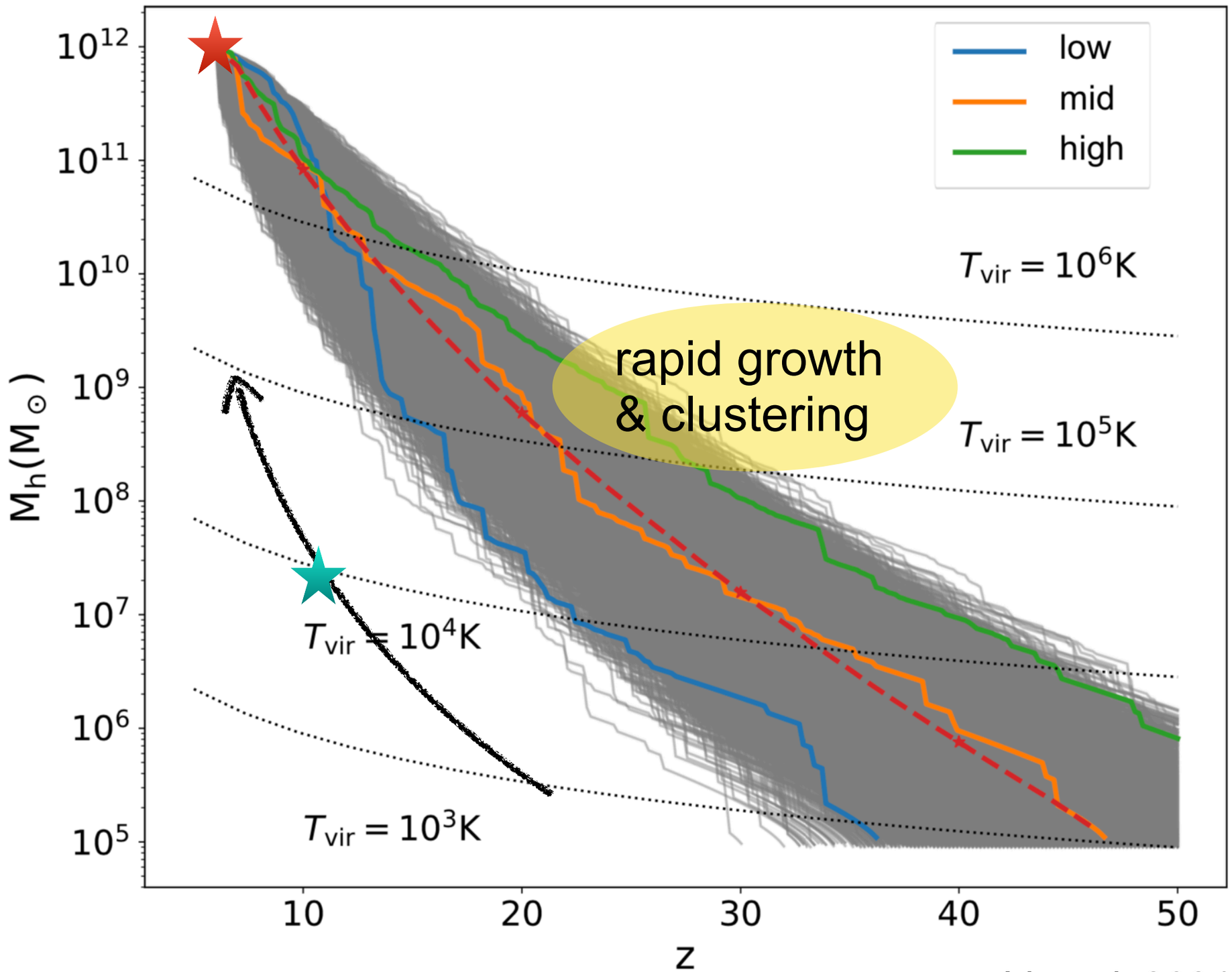
Seed Formation Sites



Costa et al. 2014

SMBHs form in **massive** halos in **overdense** regions

Laboratory: Merger Trees

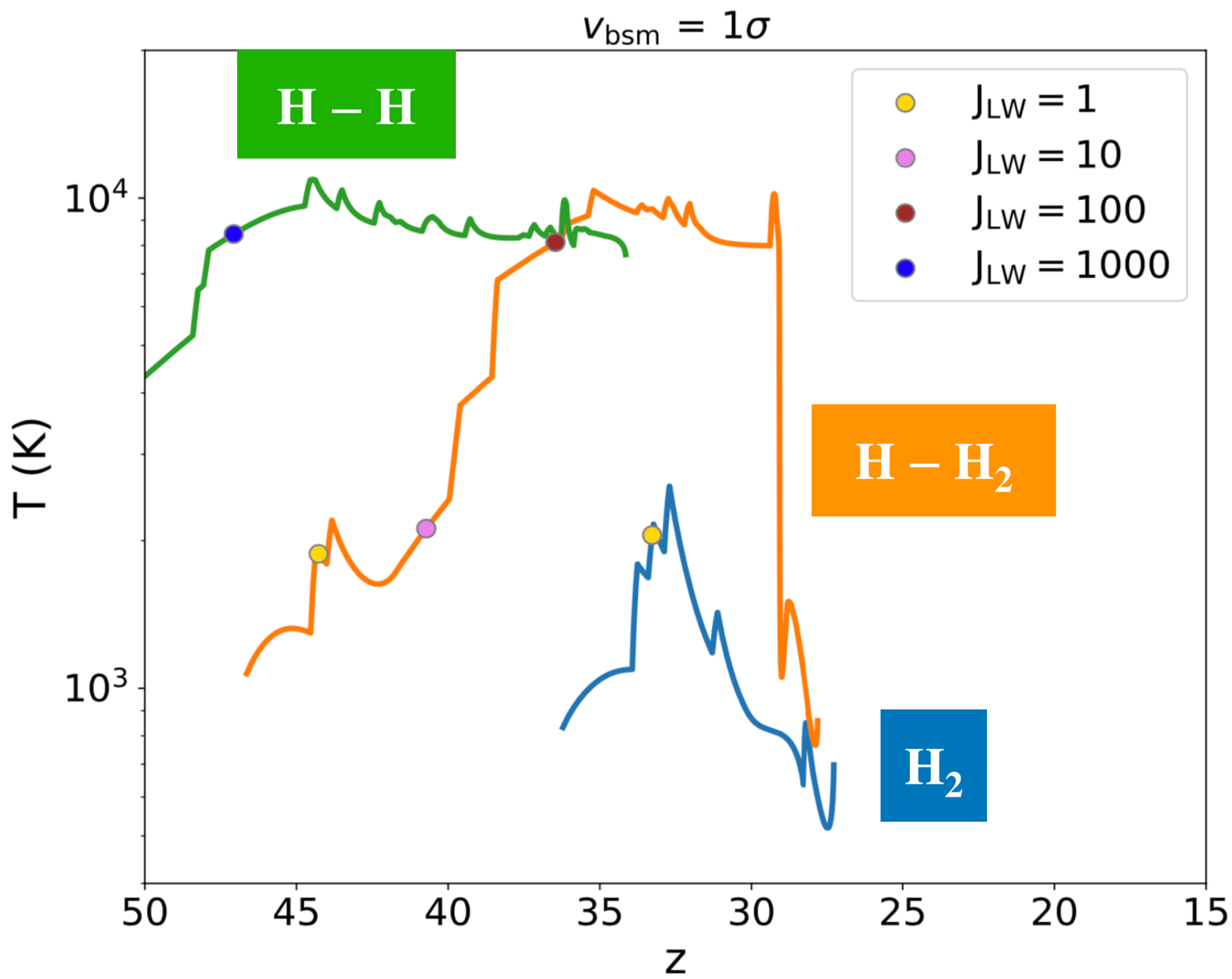


Li et al. 2021

Gas Evolution

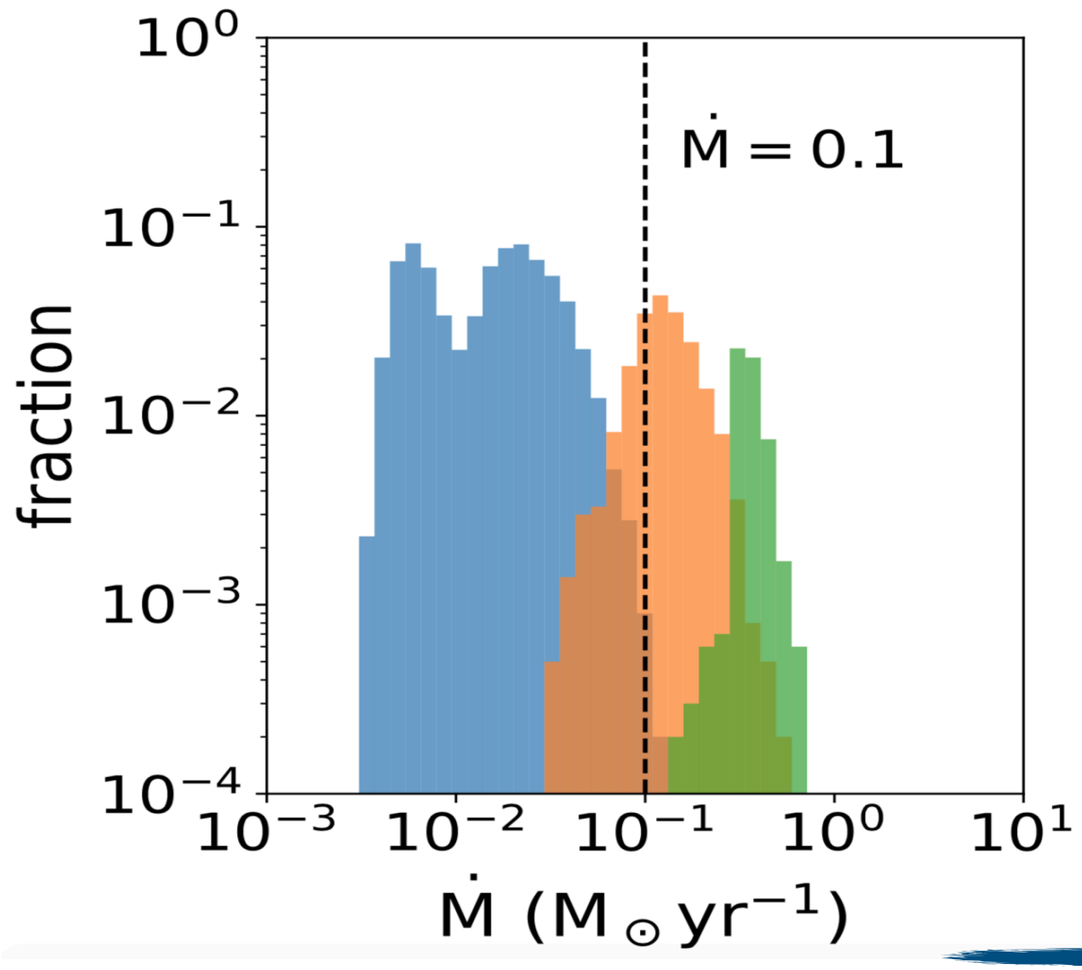
- Density — Hydro-static configuration → free-fall
- Thermal — radiative cooling;
  merger heating;
  compressional heating;
  reaction heating;
- Chemical — time-dependent chemical reactions:
  $\mathrm{H}, \mathrm{H}_2, \mathrm{e}^-, \mathrm{H}^+, \mathrm{H}_2^+, \mathrm{H}^-, \mathrm{He}, \mathrm{He}^+, \mathrm{He}^{++}$
  incl. $\mathrm{H}_2 + \gamma_{\mathrm{LW}} \rightarrow 2\mathrm{H}$

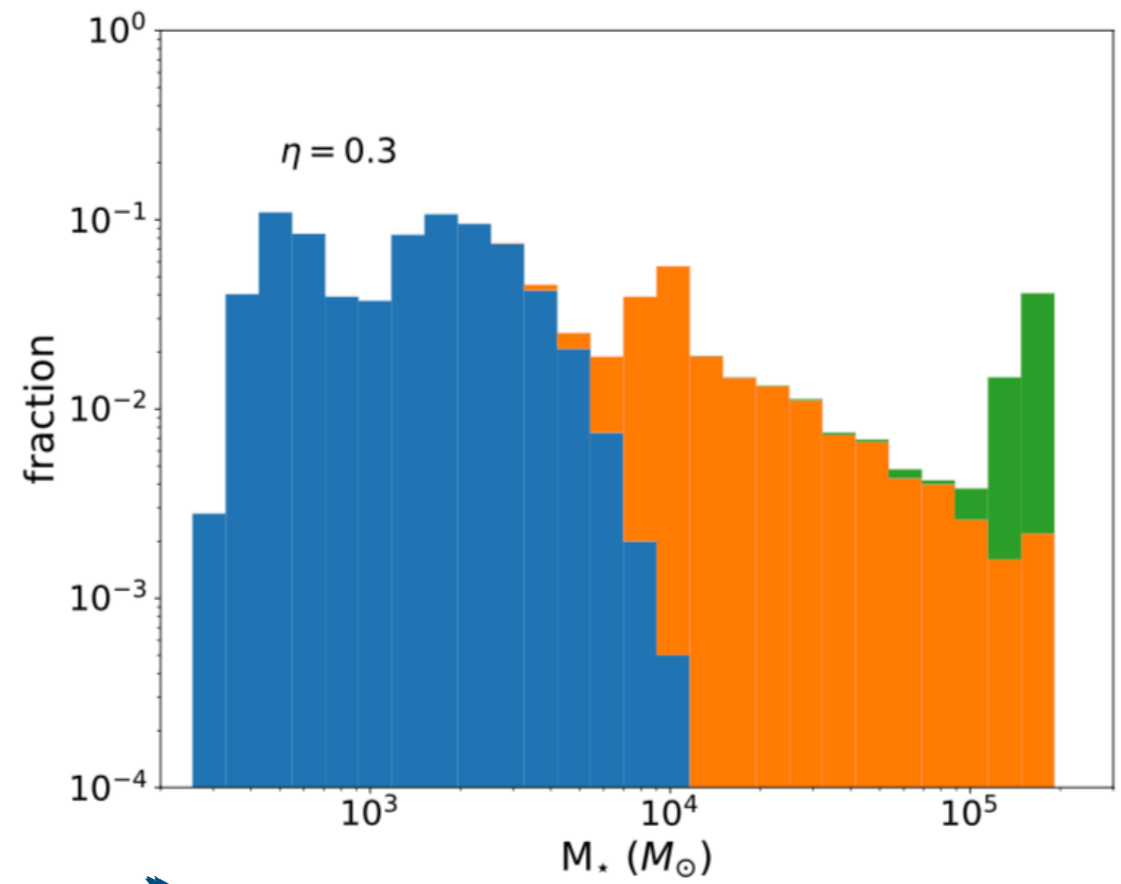
Star Formation Types



★ halo rapid growth + clustering → high T ($\dot{M}$) collapse

$\dot{M}$ & $M_\star$





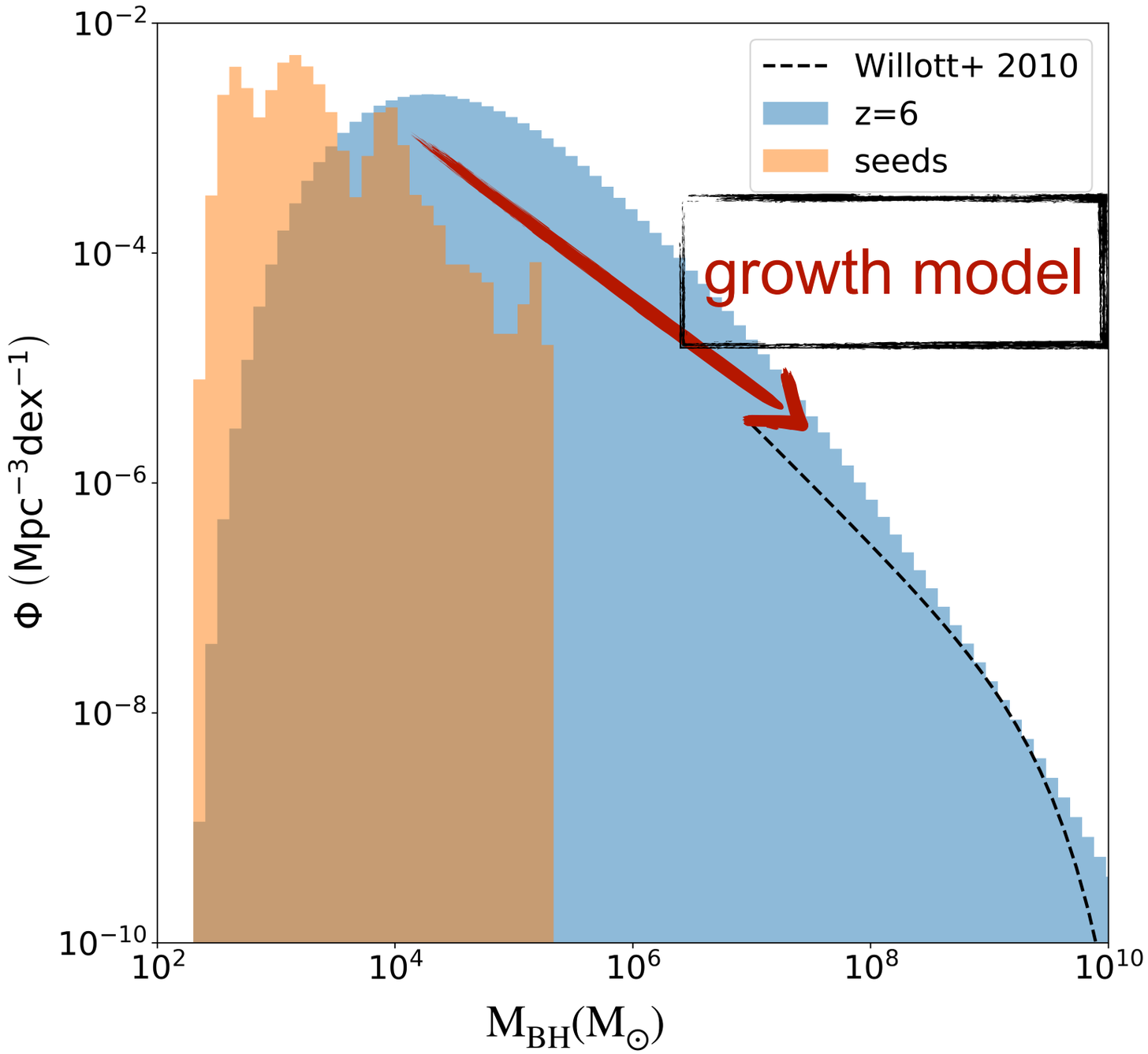
Li et al. 2021

stellar feedback & GR instability model

★ Promising sites for massive seeds with 10^3-10^5 $M_\odot$!

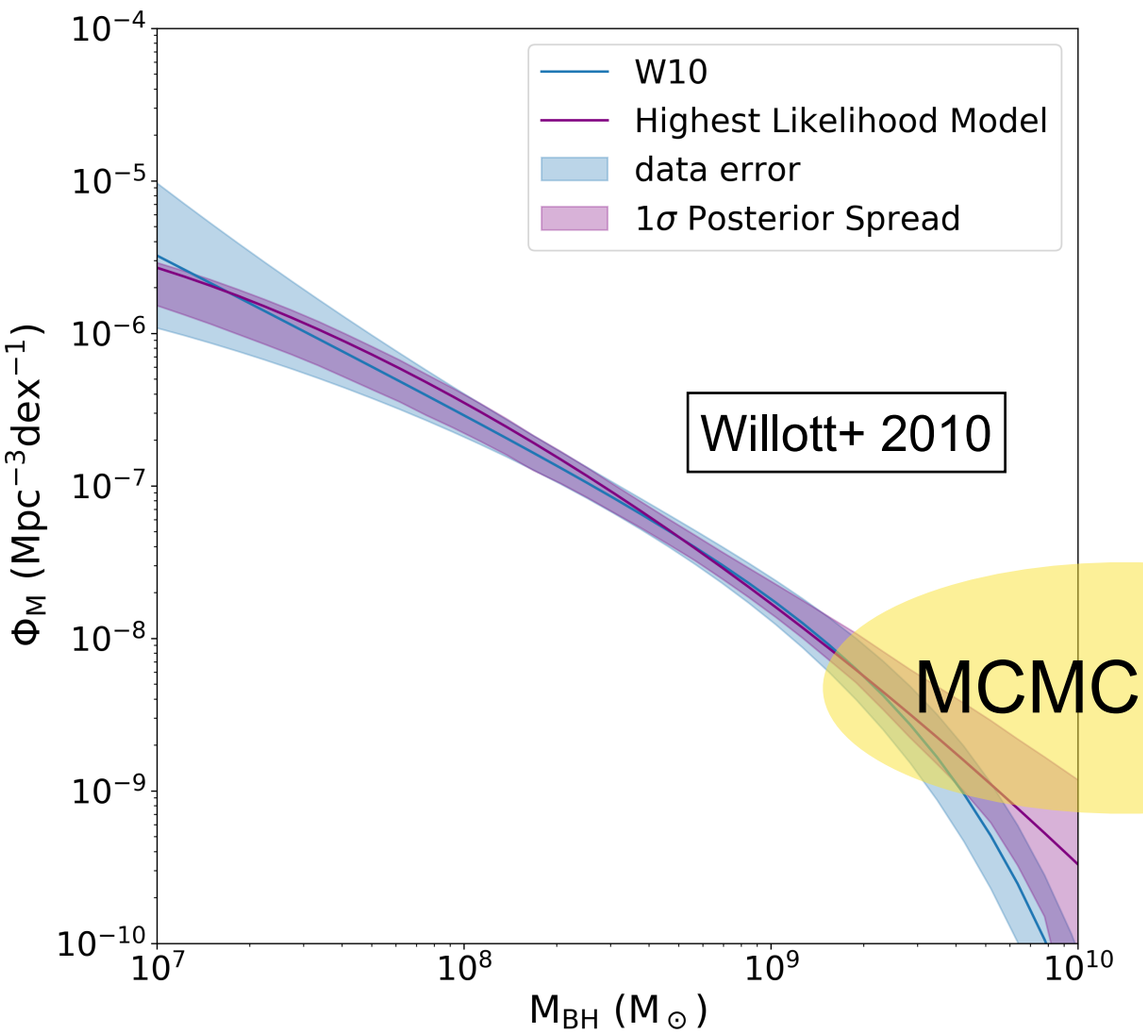
II. BH Mass Function & Quasar Luminosity Function

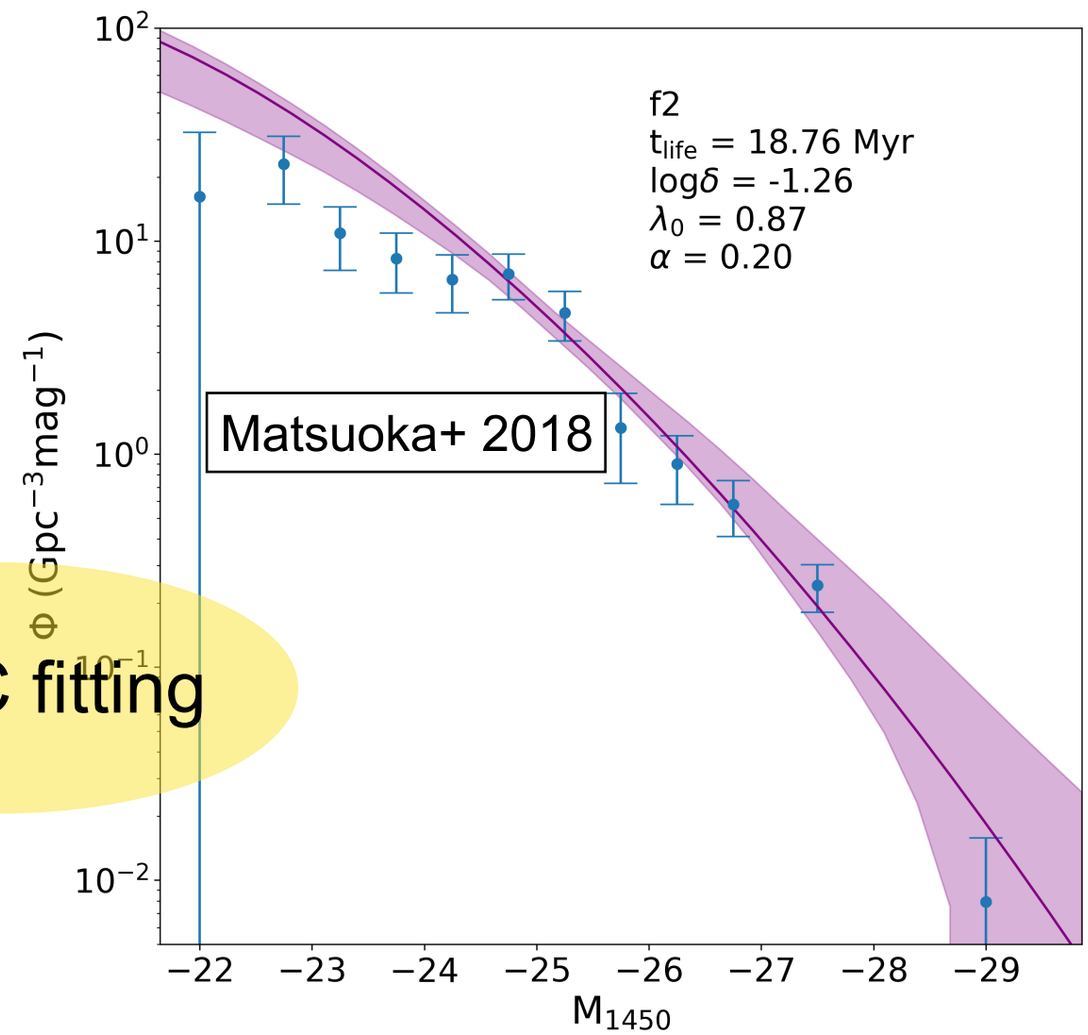
Seed Growth



★ Modeling BH growth, e.g. ERDF $P(\lambda)$, τ .

BHMF & QLF

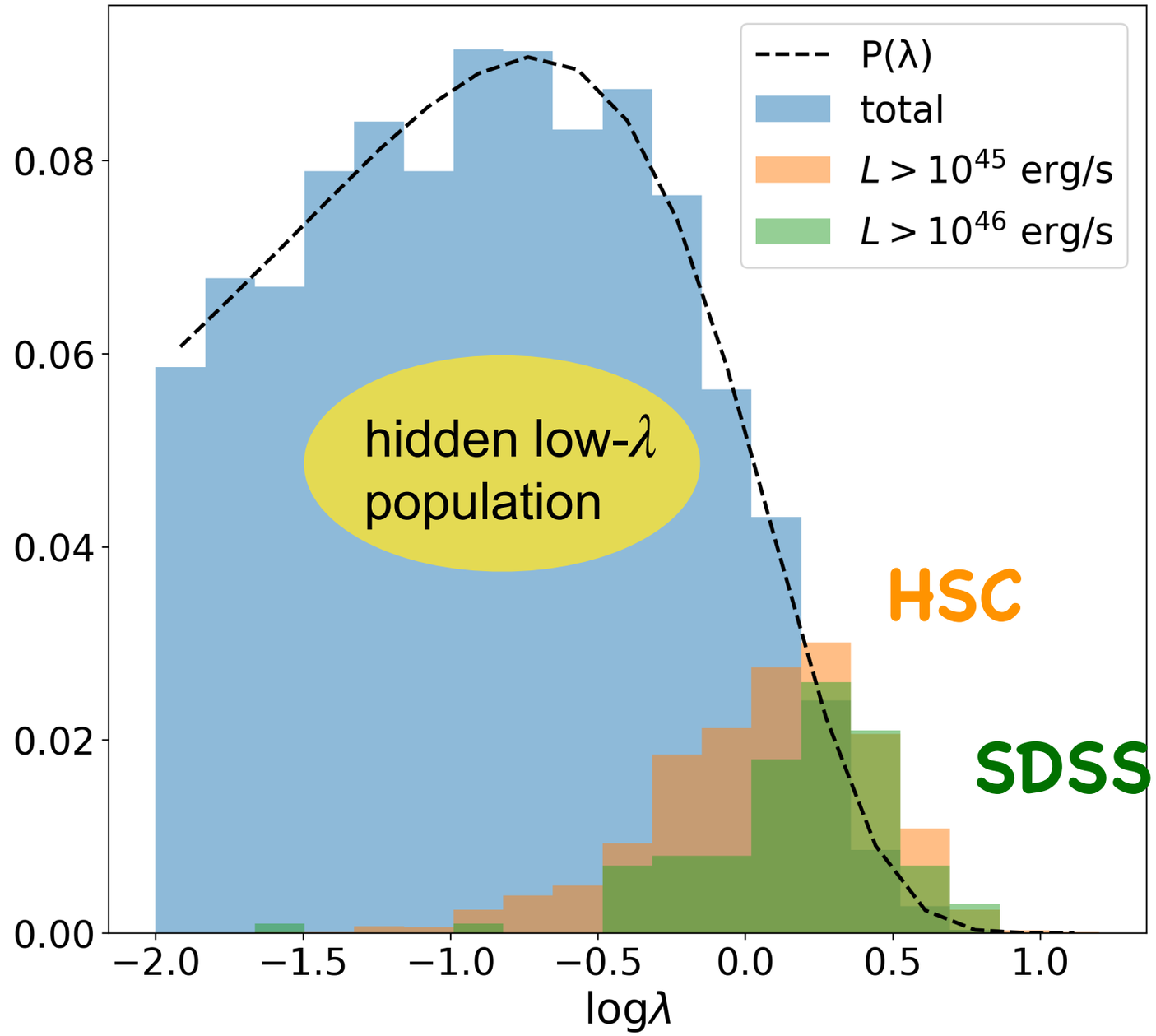




MCMC fitting

★ Best-fit model reproduces z~6 quasar observations

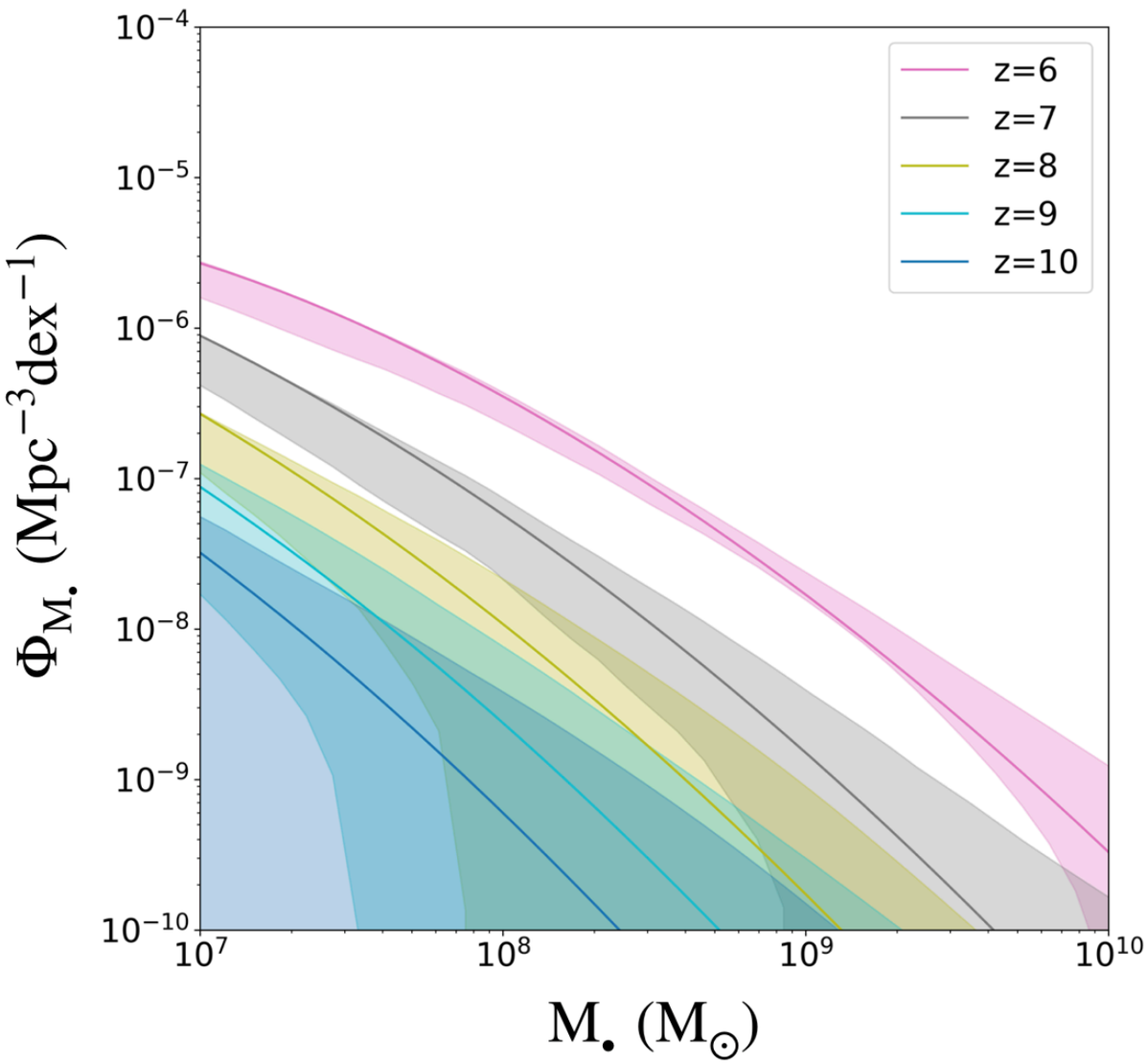
ERDF & Luminosity Cut

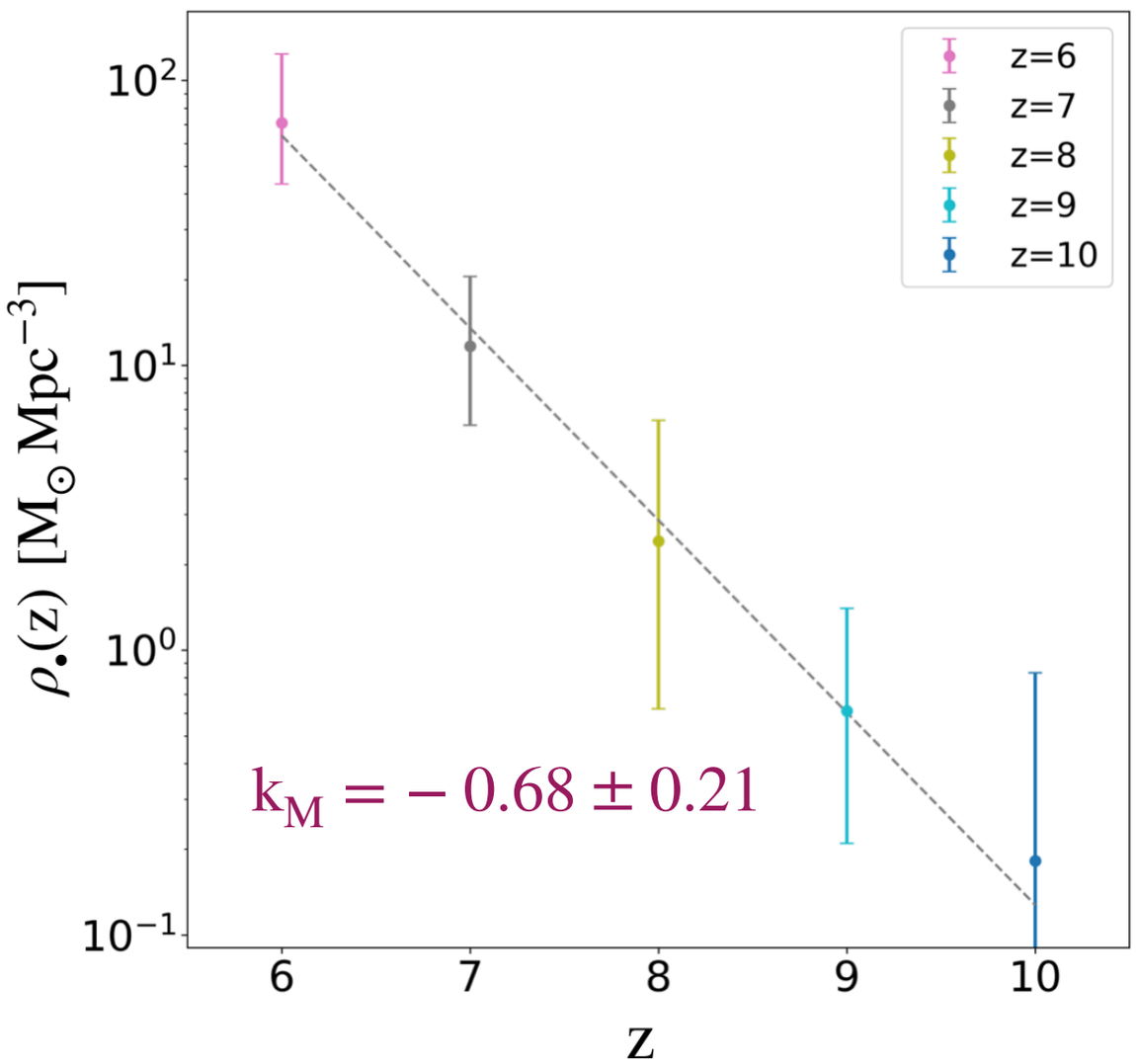


★ Faint, low λ quasars to be probed by JWST

BHMF Evolution

Li et. al. in prep

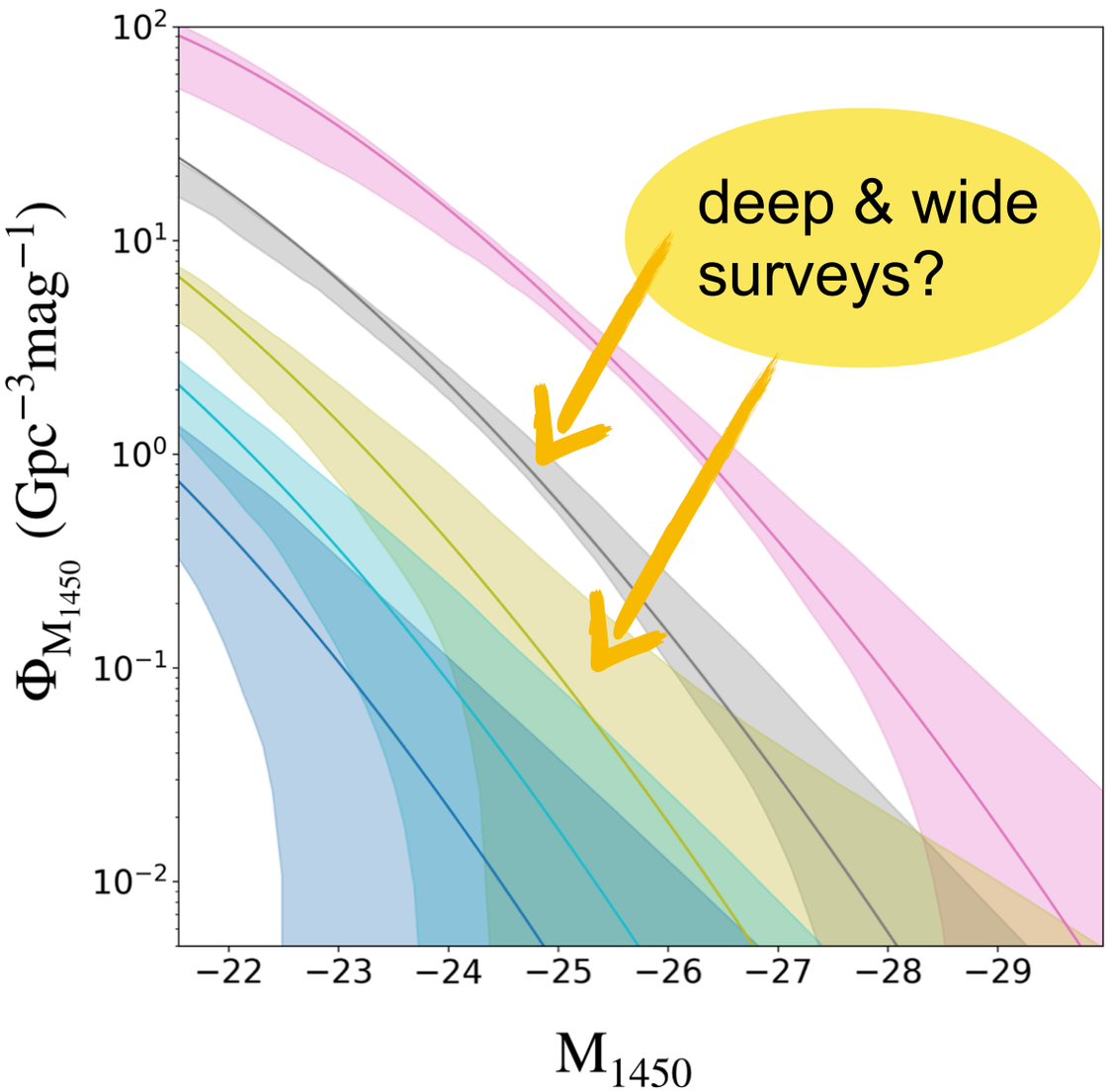


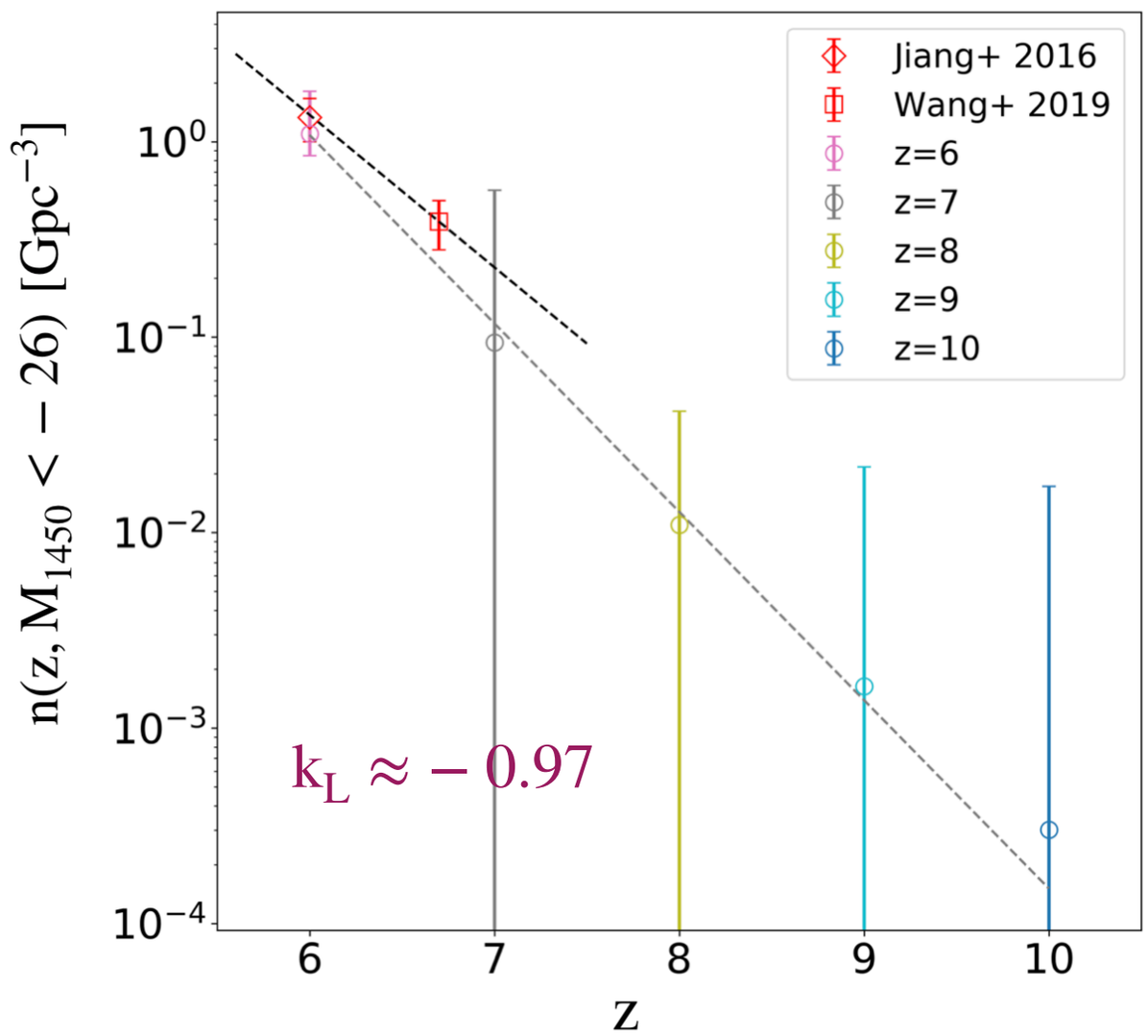


$\rho_\bullet(z) \simeq \rho_{\bullet,0}\ 10^{k_M(z-6)}$ Link with halo/galaxy growth?

Quasar LF Evolution

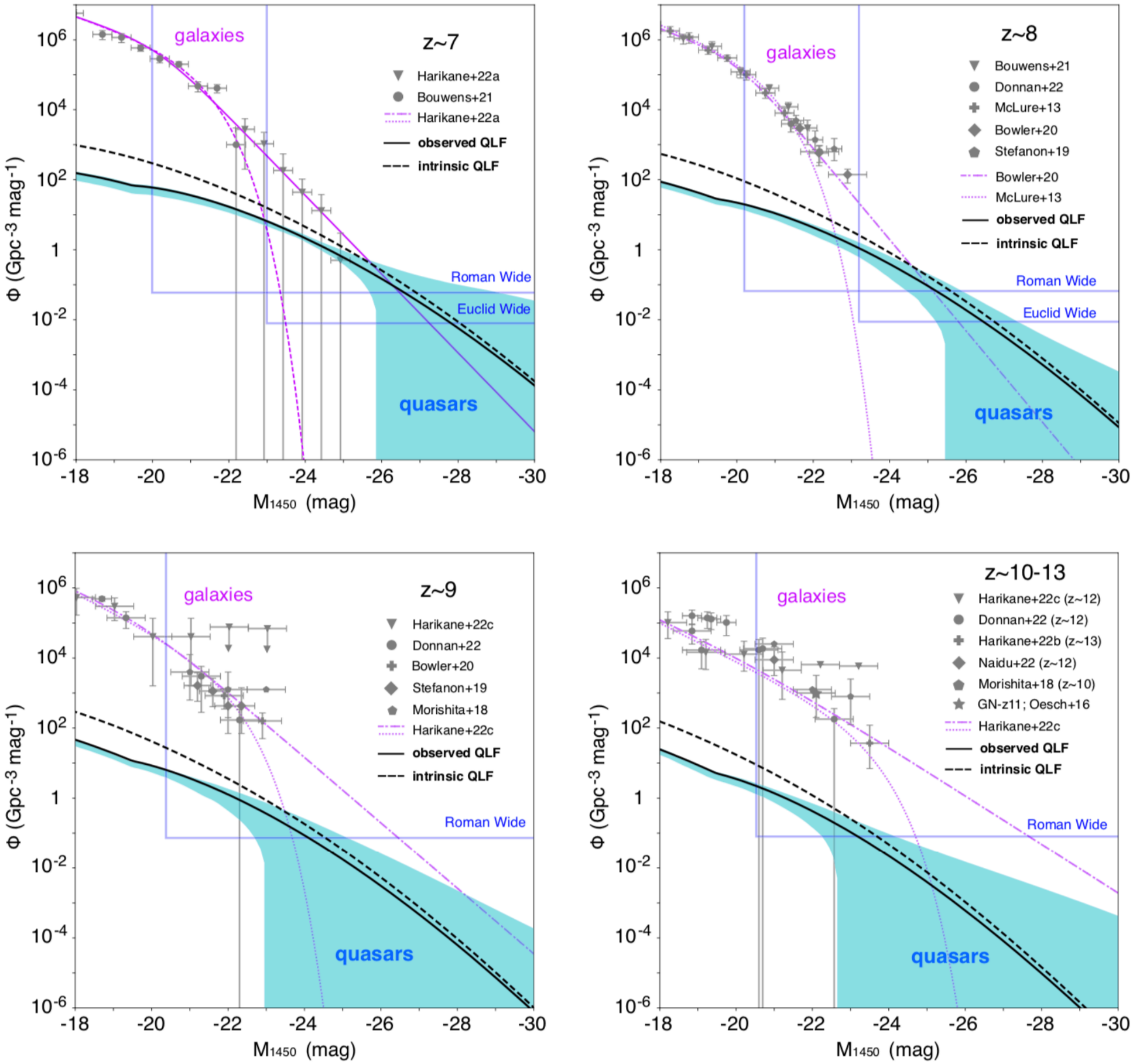
Li et. al. in prep





★ Rapidly declining luminous quasar density toward higher z.

Galaxies v.s. Quasars



Summary

We consider **seed BH formation** in progenitor of **luminous quasar hosts:**

★ High J_{LW} & merger heating→ massive seeds (Li+ 2021)

less massive hosts:

★ unveil hidden population of low λ accreting BHs

★ predict high-z BHMF & QLF (Li+ in prep.)

JWST &
future devices!