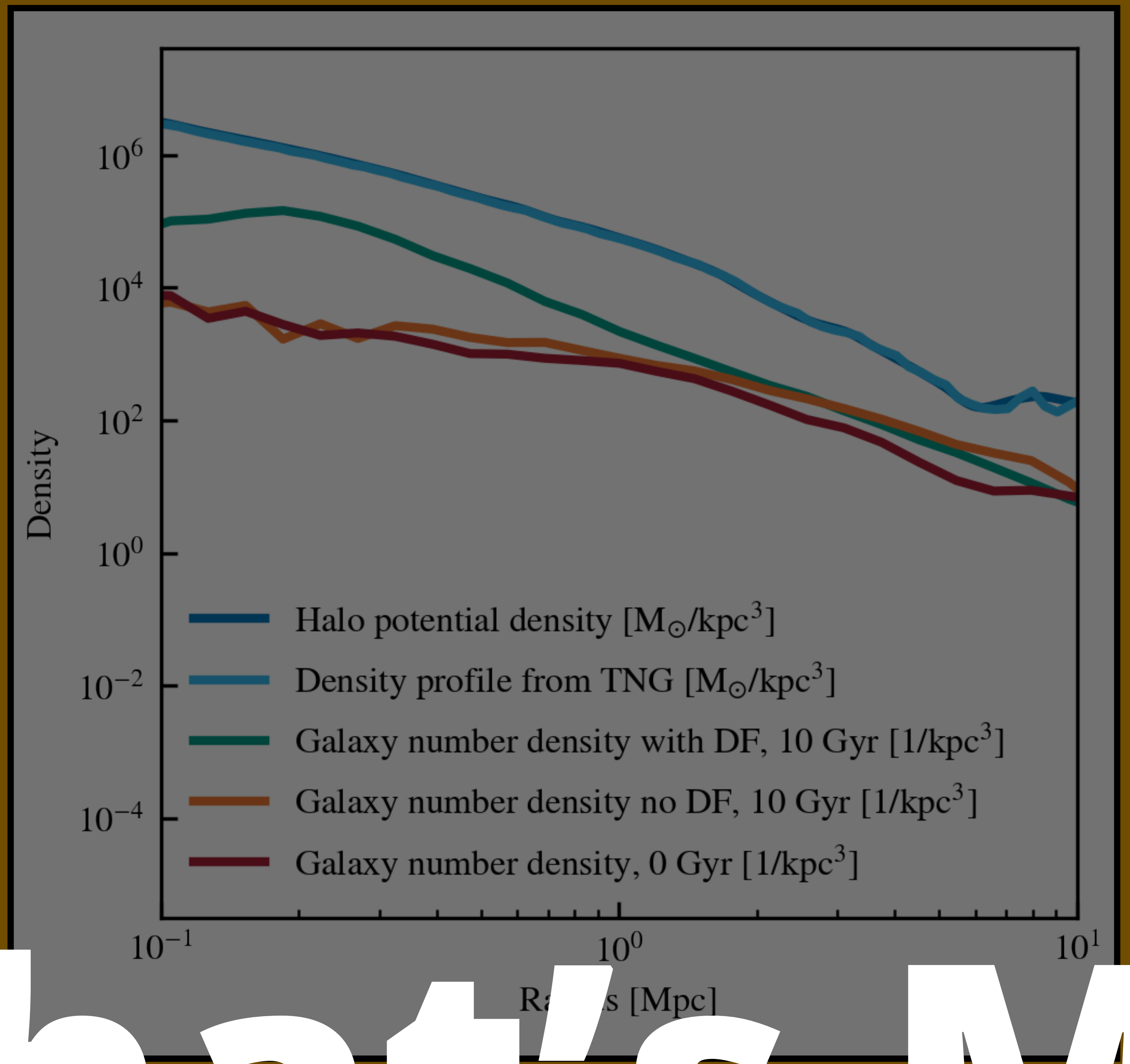
What's MIT up to?

Talia O'Shea

Impact of Dynamical Friction on measurements of splashback radius, using Galpy & Chandrasekhar DF model with orbits from TNG.

UG applying for grad school this year!



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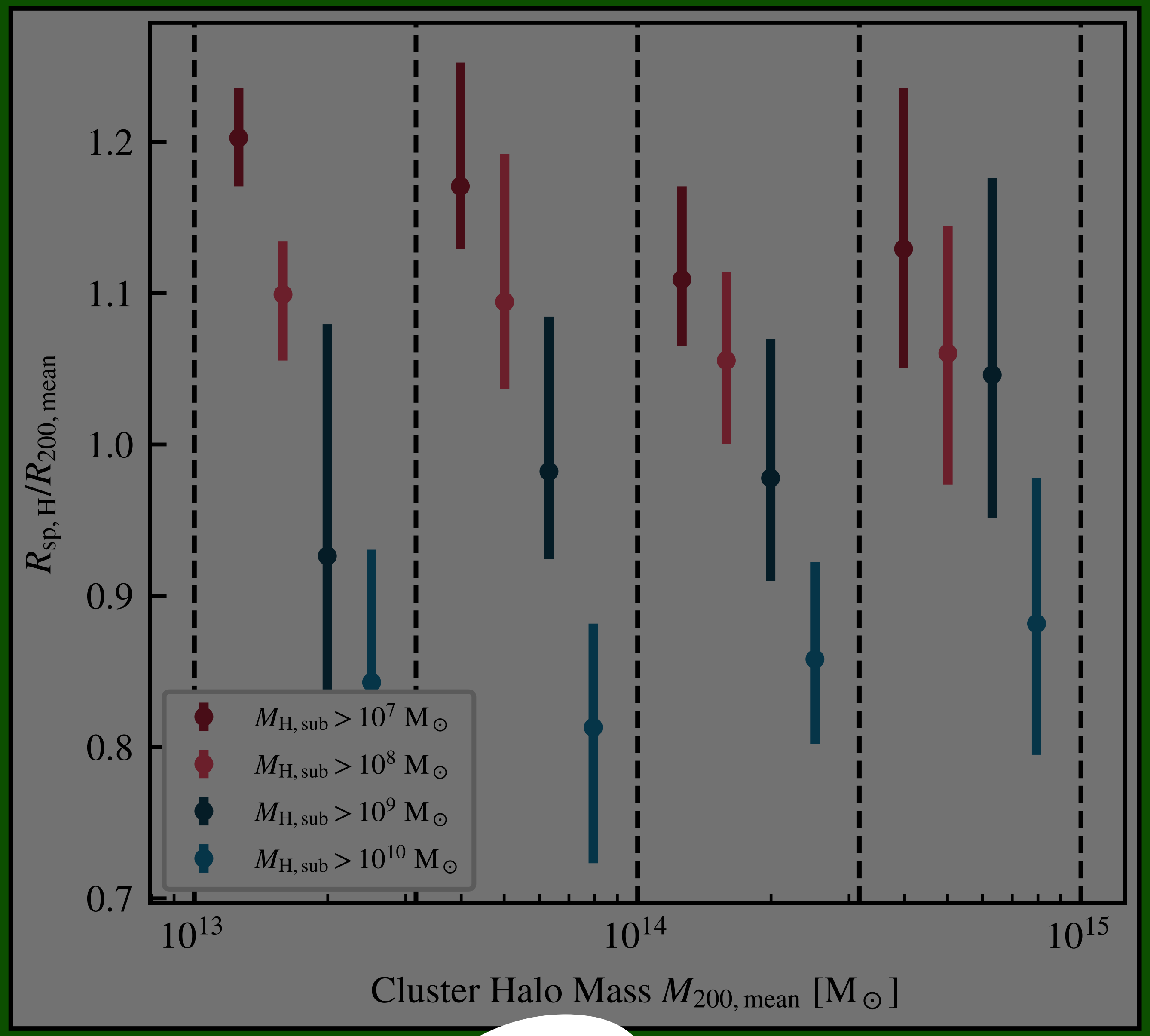

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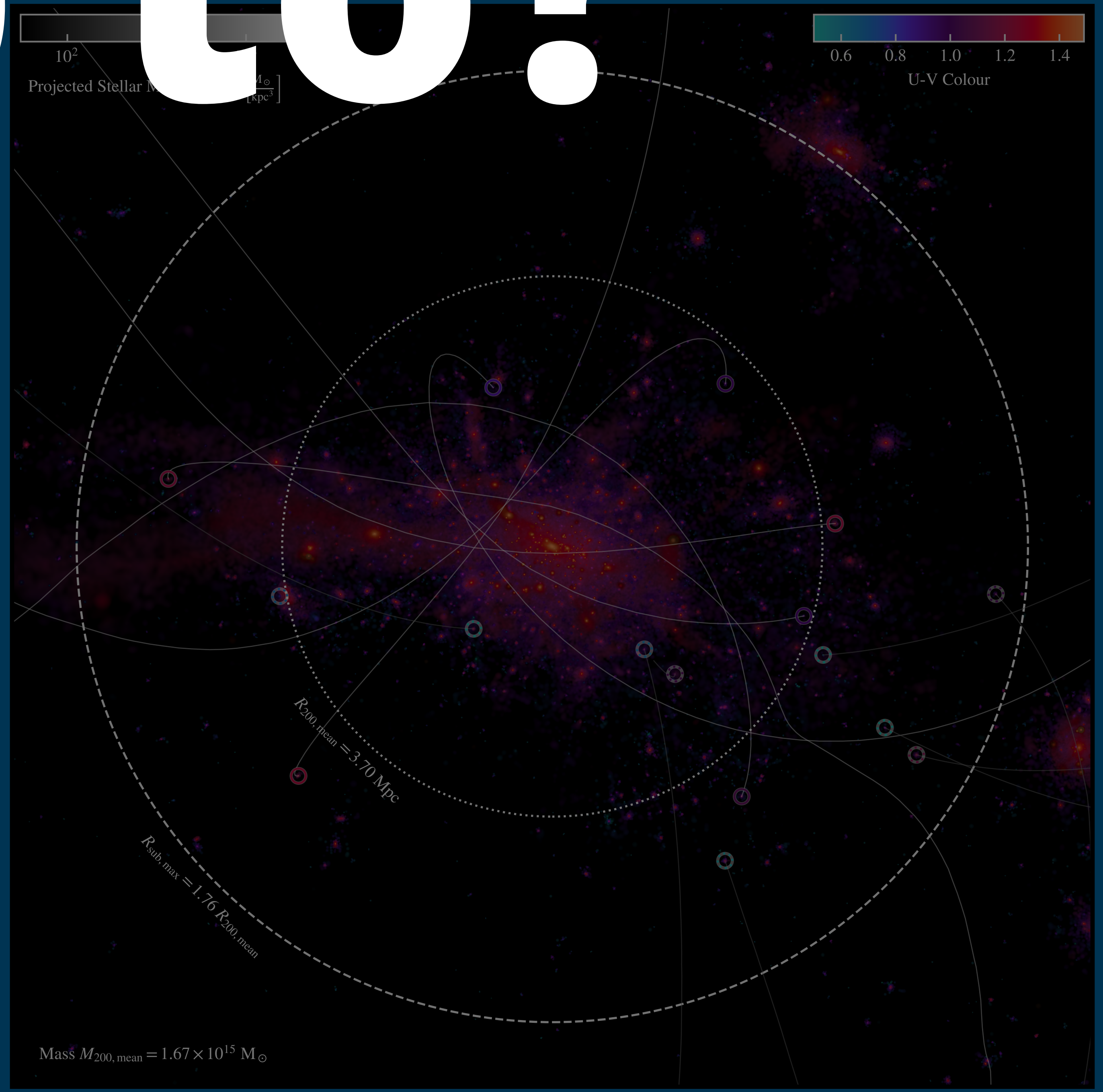

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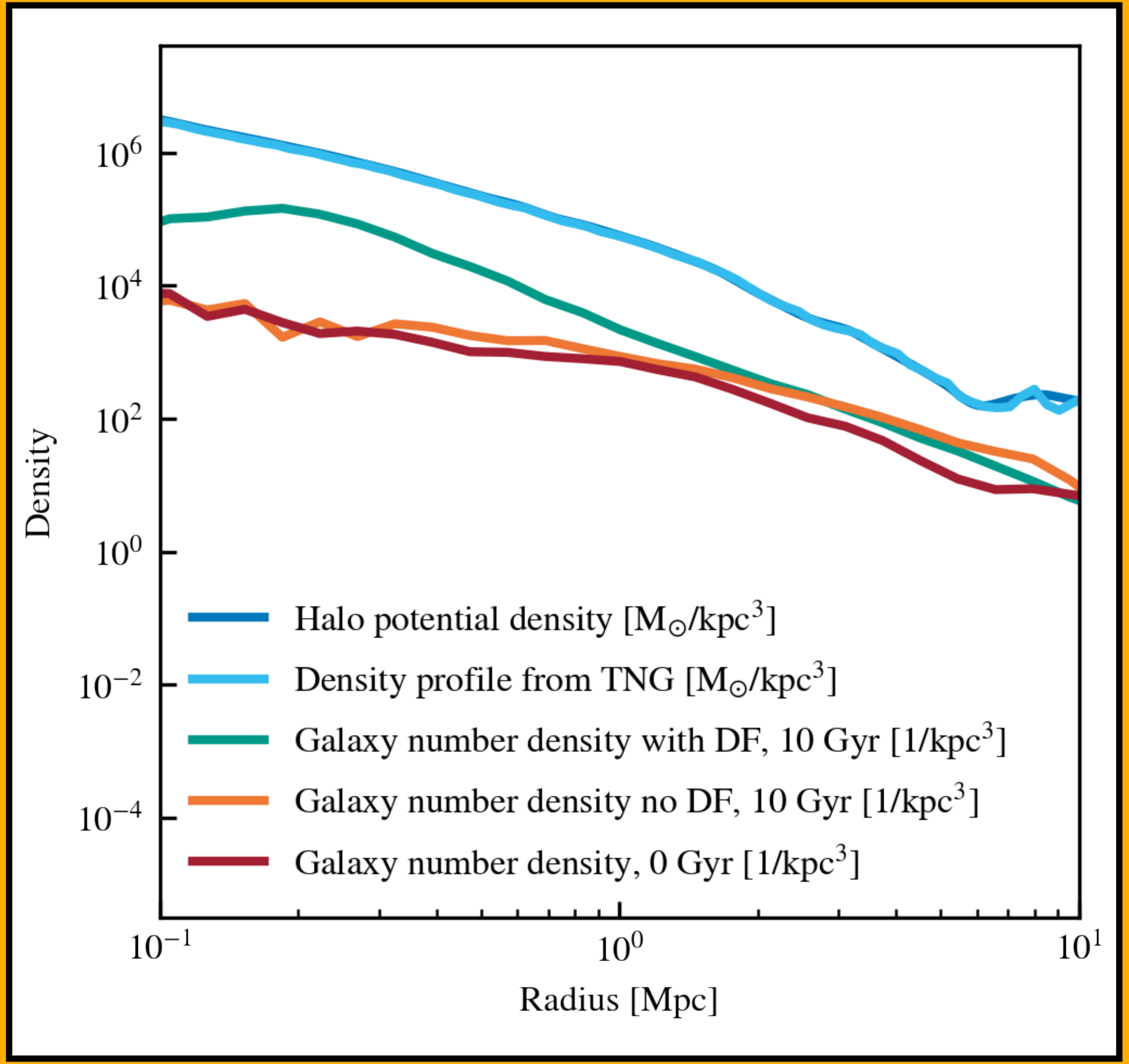

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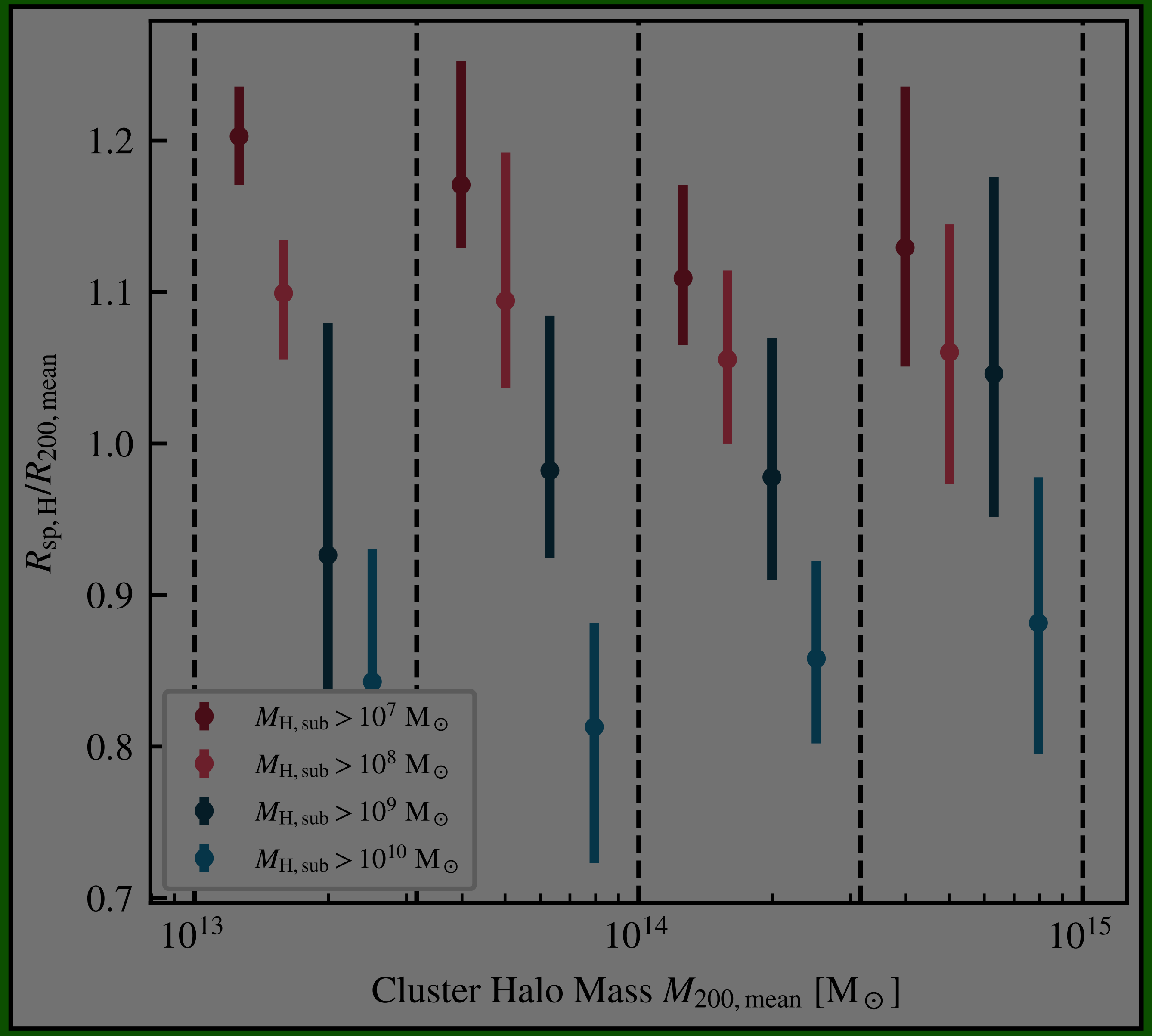

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THESAN
UNIVERSAL PARK ★ REDSHIFT 5.5

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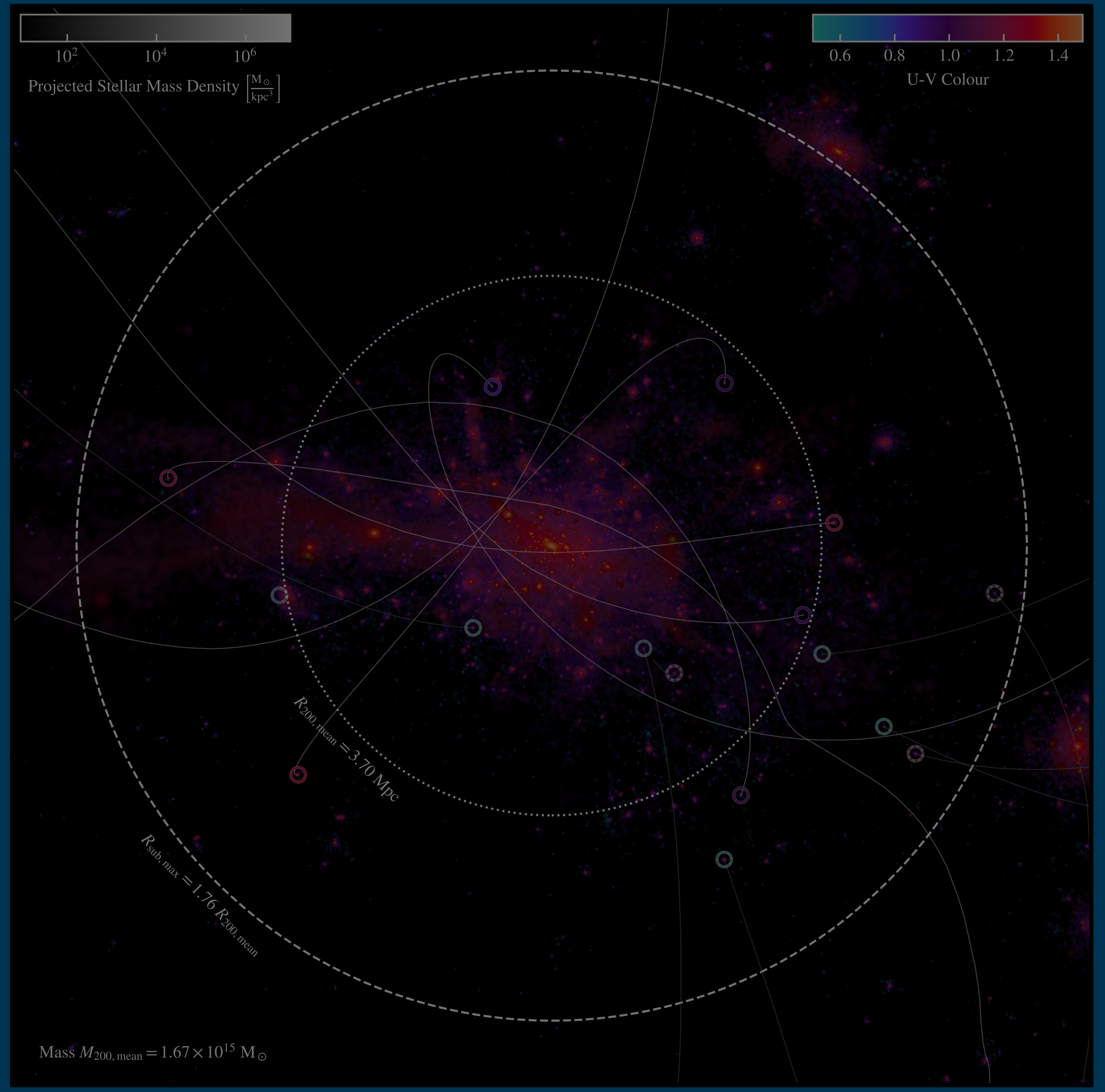

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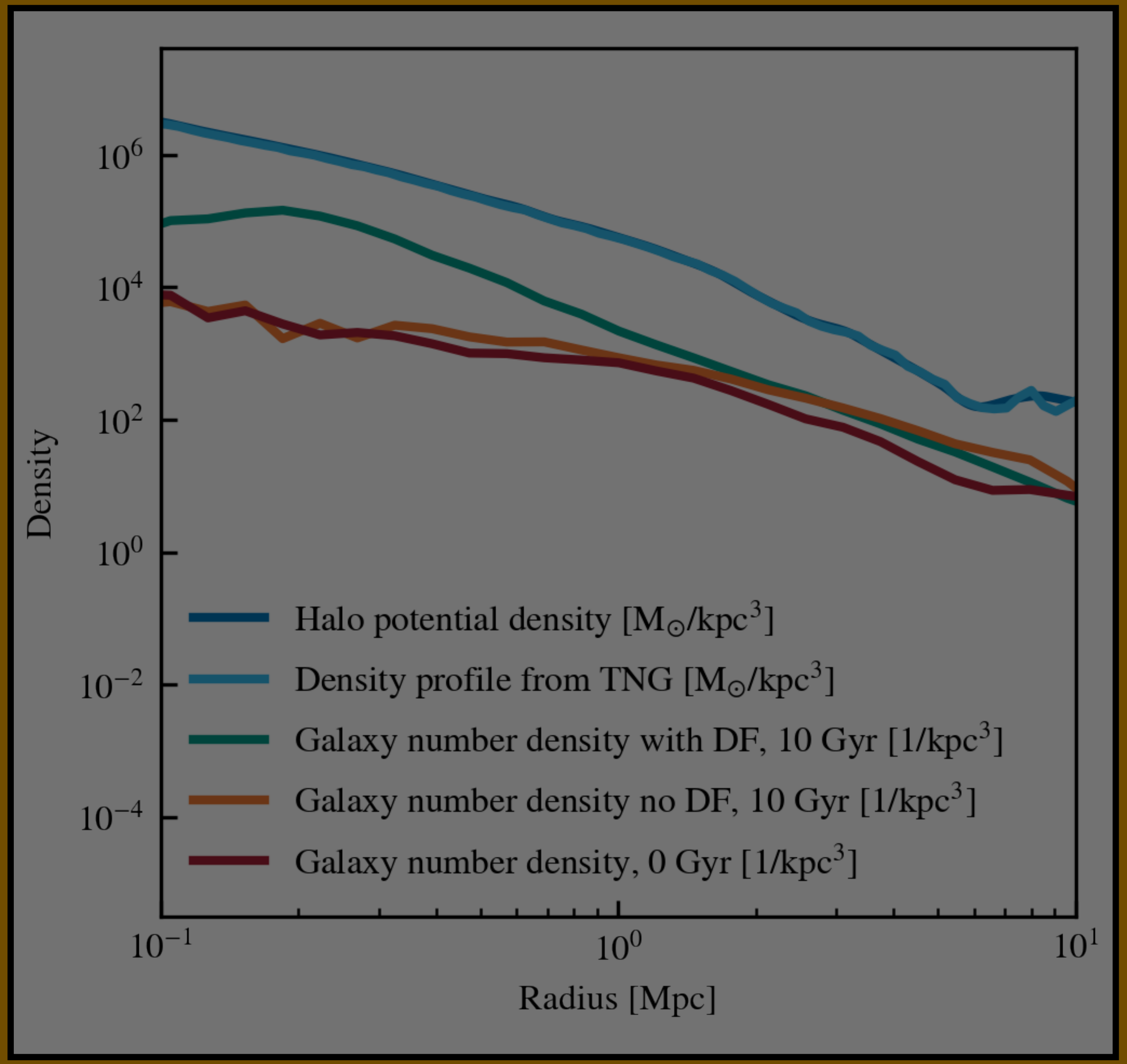

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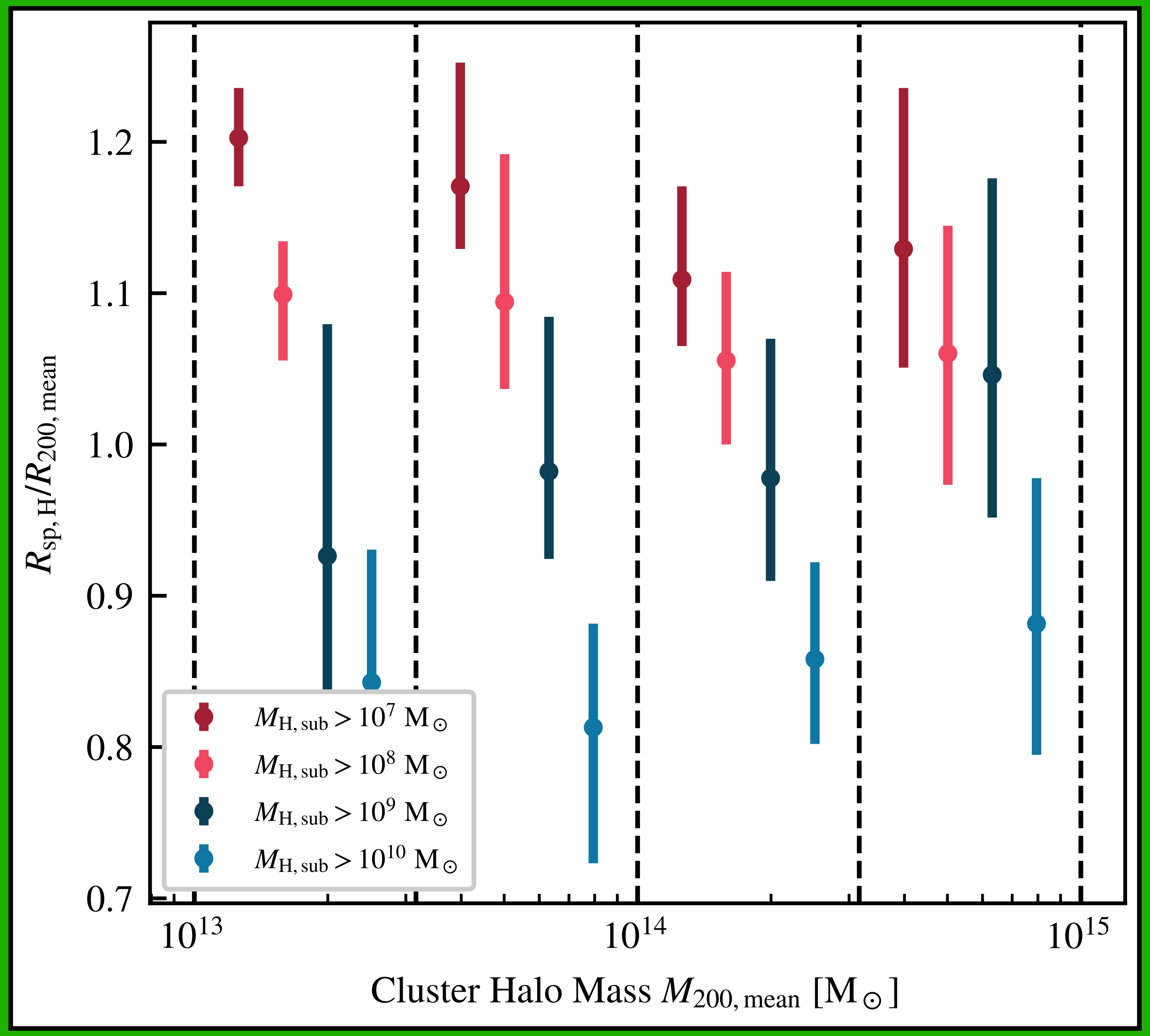

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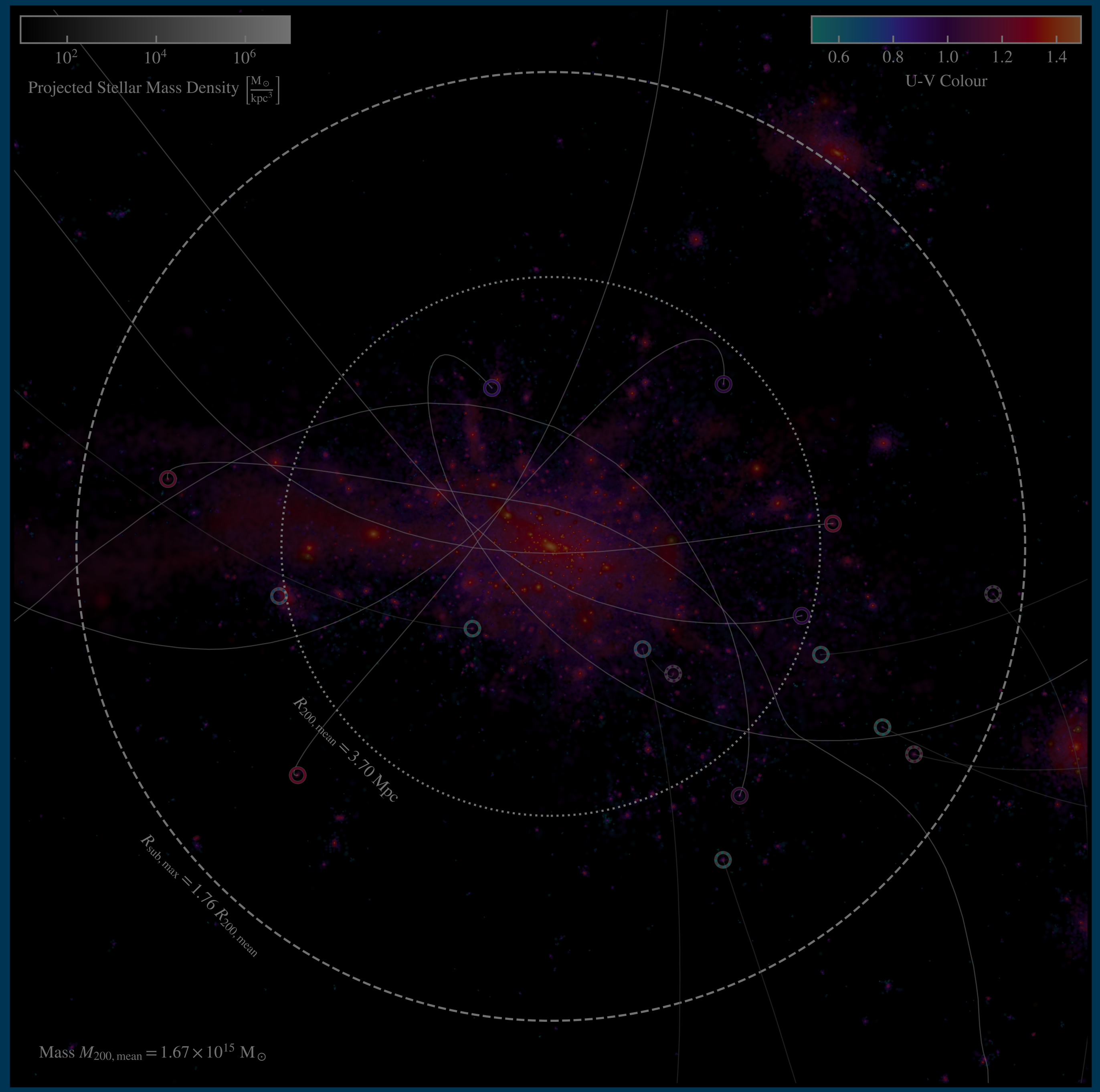

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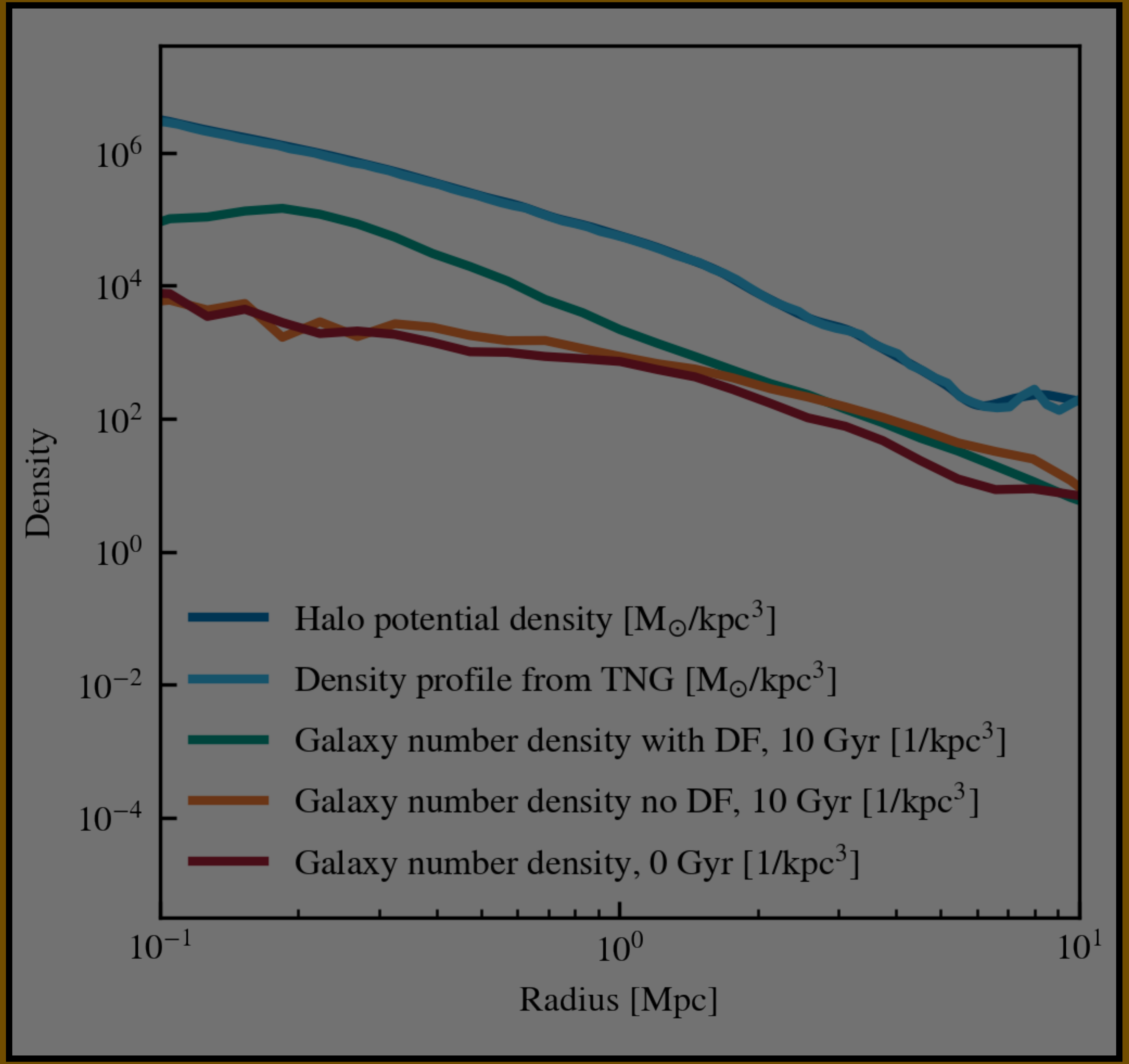

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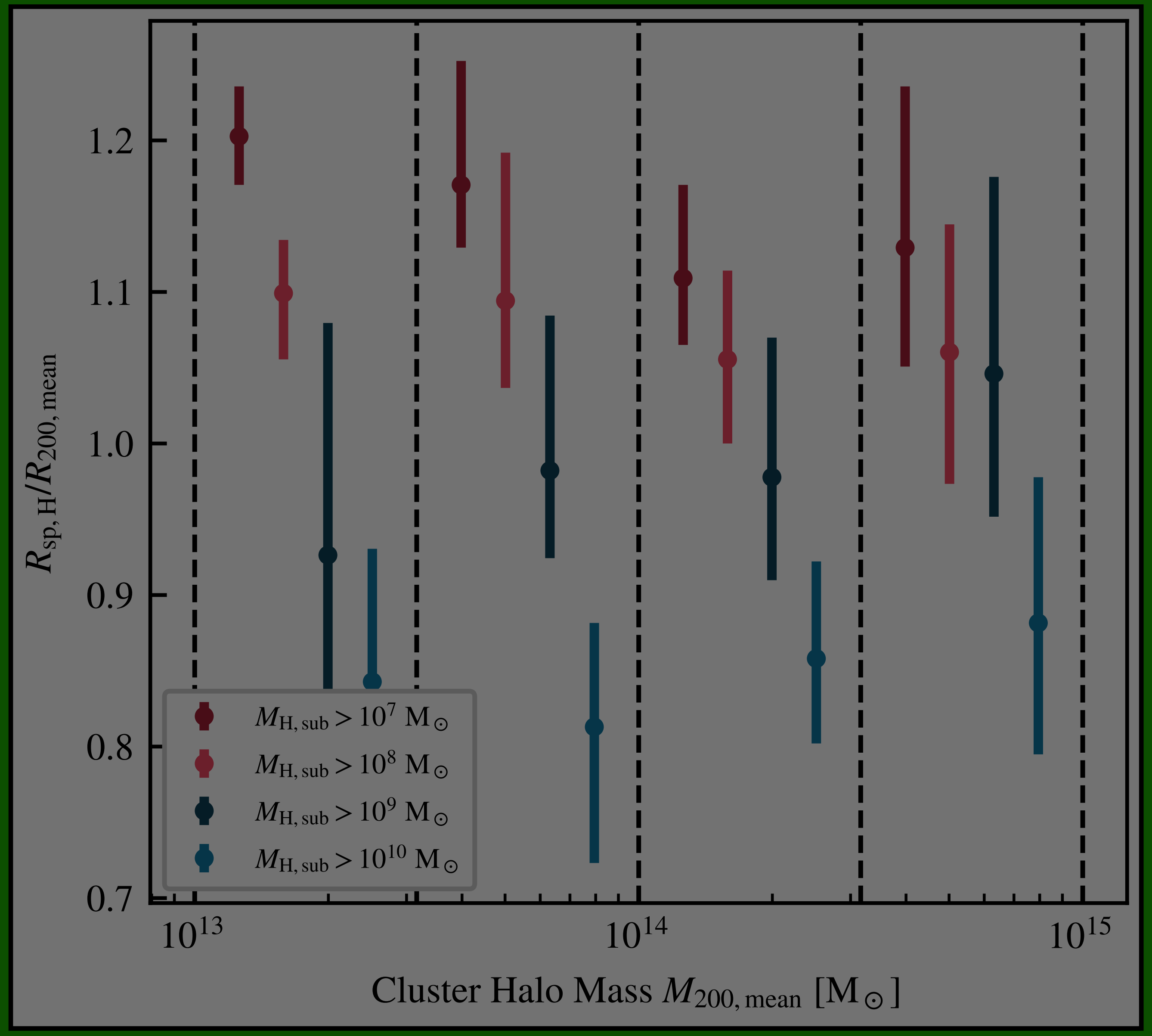

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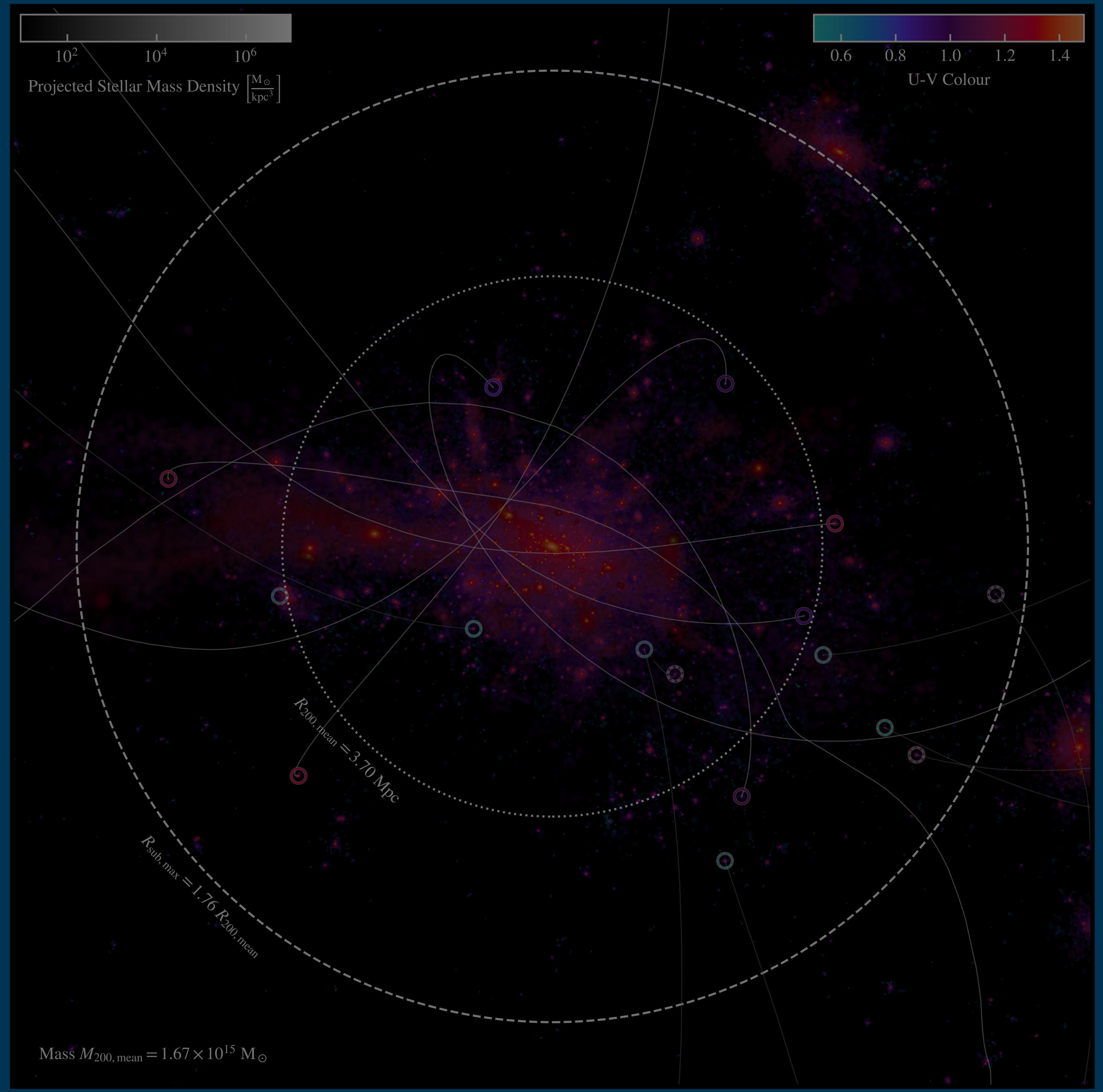

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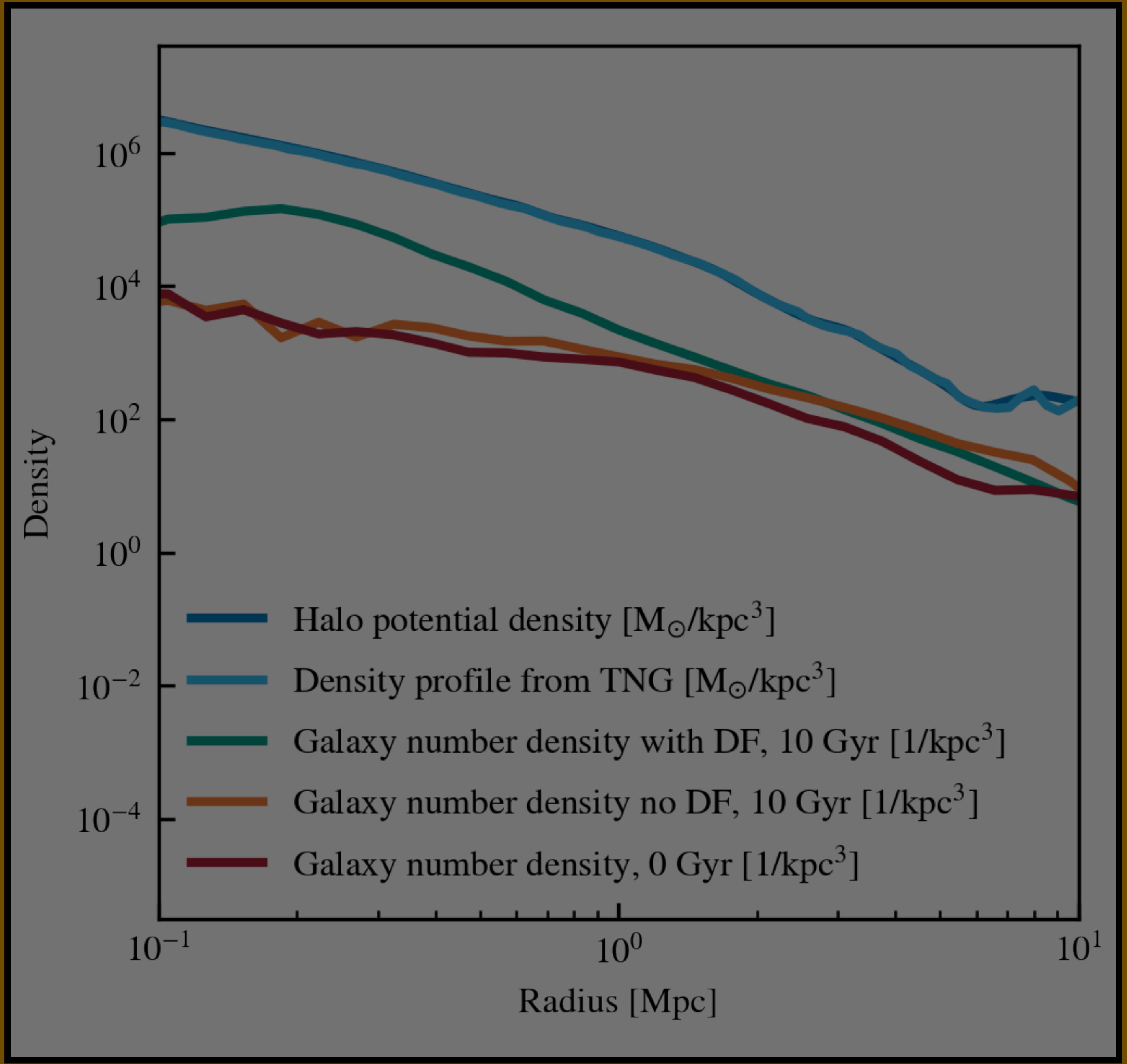

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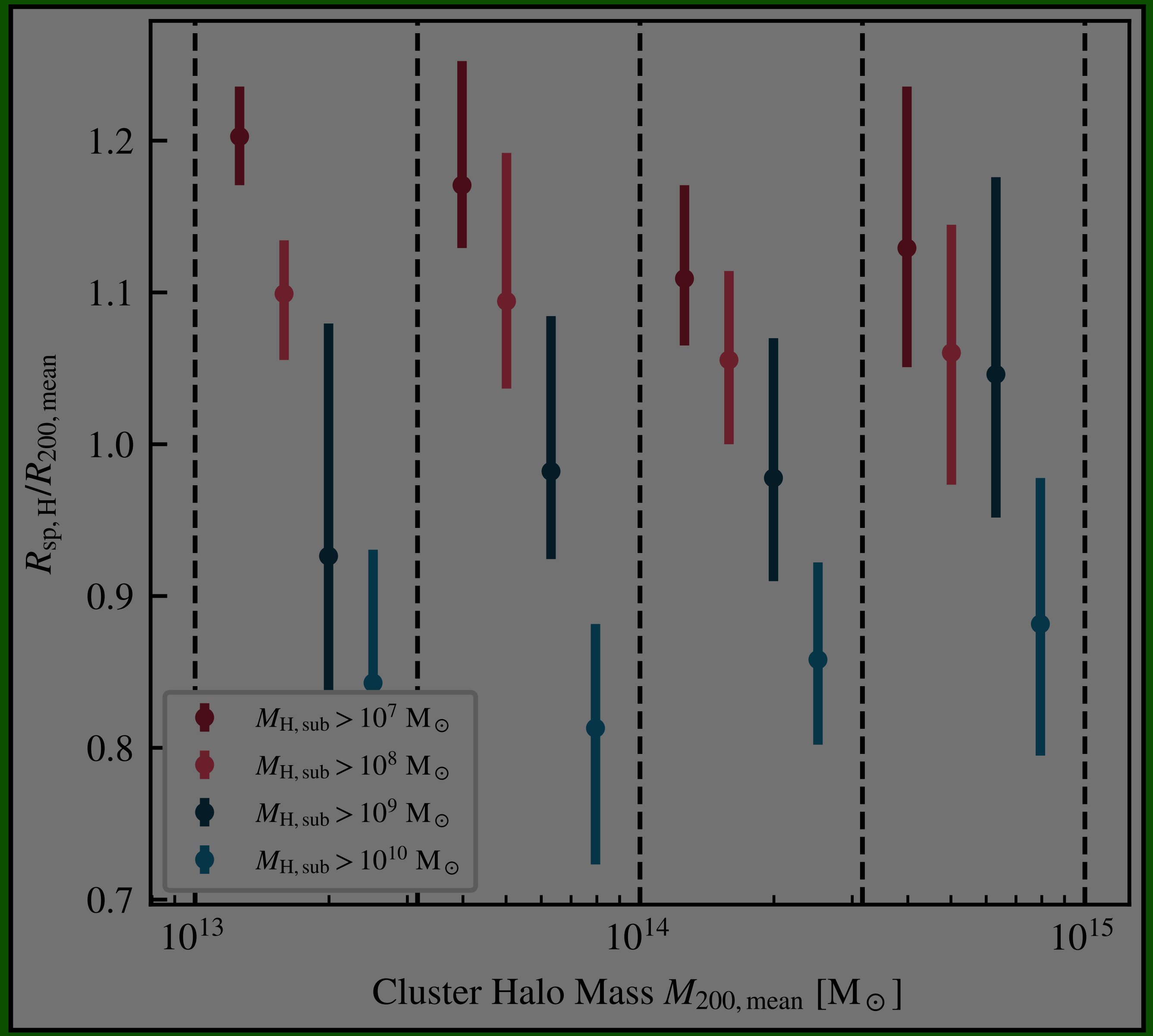

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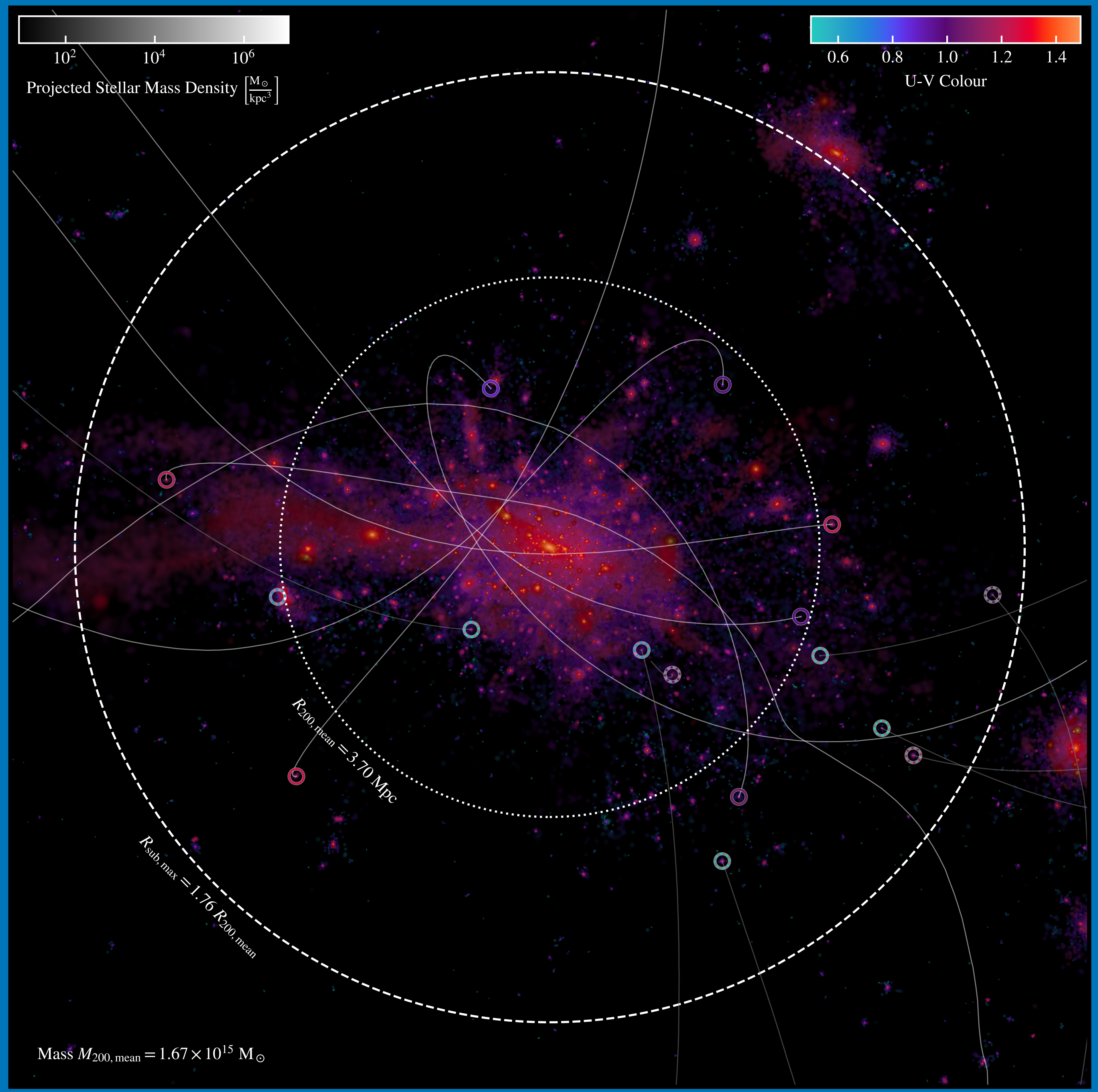


THESAN-HR: How does Reionization Impact Early Galaxy Evolution?

Josh Borrow [MKI]

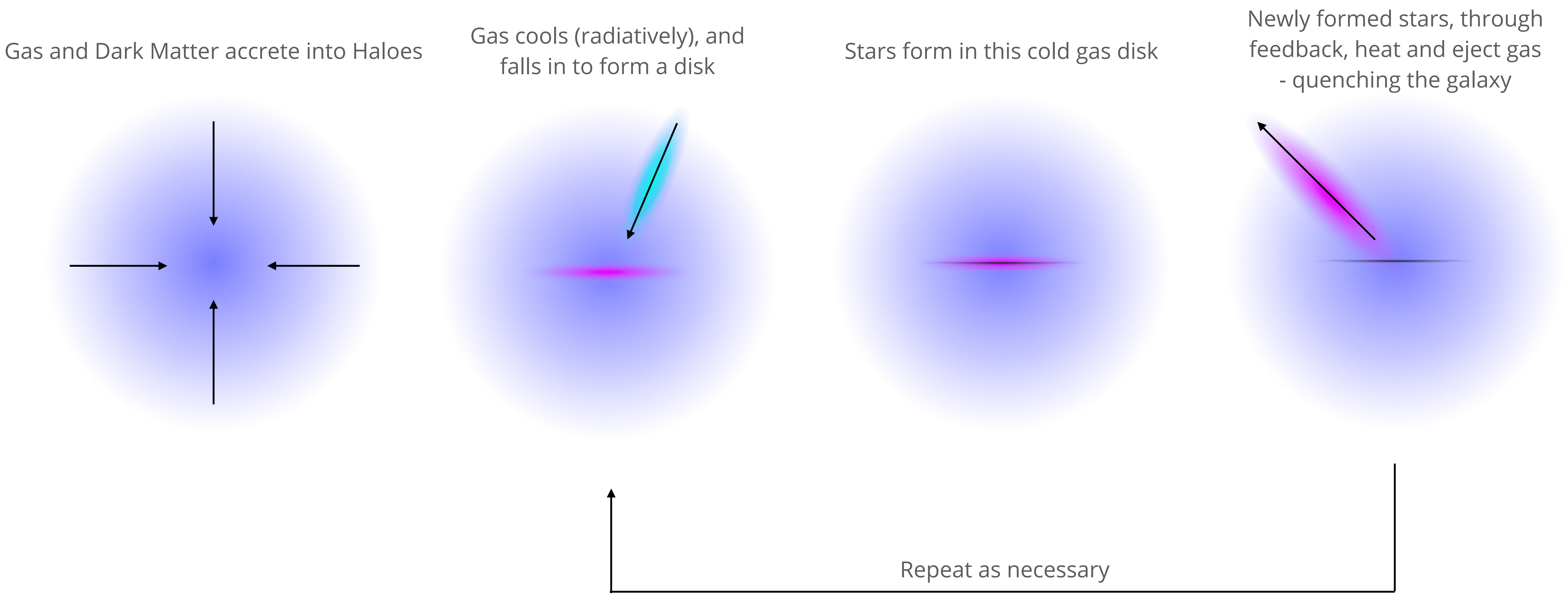
Mark Vogelsberger [MKI], Enrico Garaldi [MPA], Rahul Kannan [CfA], Aaron Smith [CfA] & THESAN Collaborators

21 September 2022

MIT KAVLI INSTITUTE

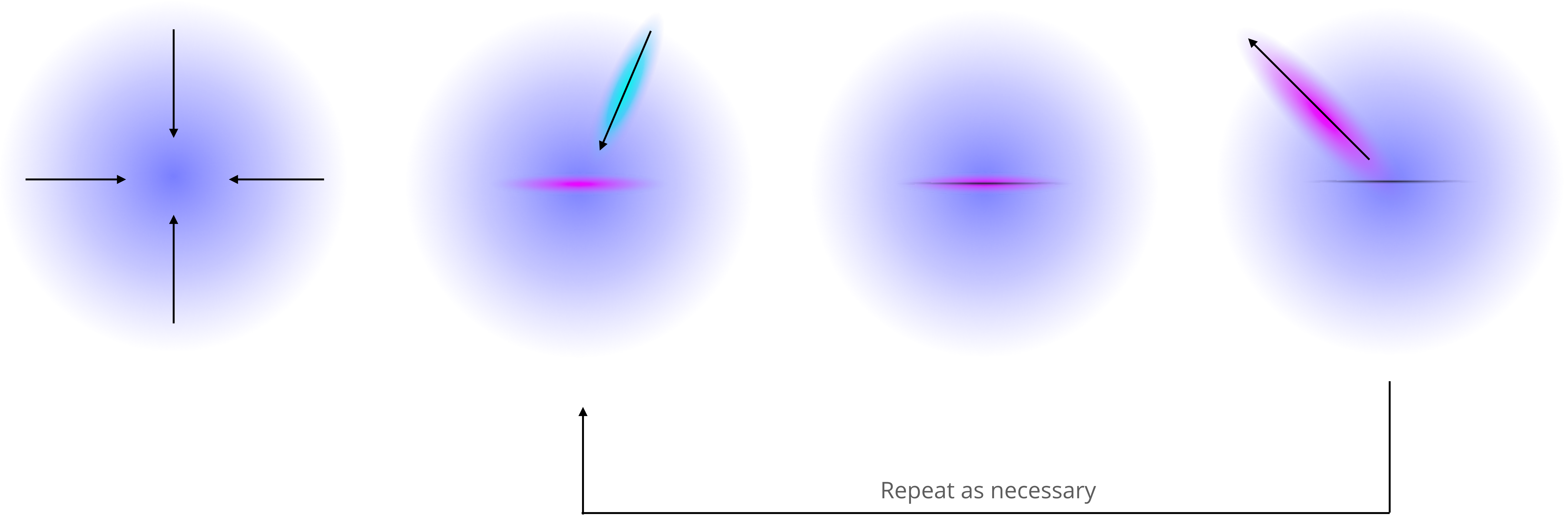
Gas HI Fraction Red: Ionized Gas Blue: Neutral Gas

Schematic Overview of Galaxy Formation



See Somerville & Dave (2015) for an excellent review, with Vogelsberger (2020) and Tumlinson et al. (2017)

How Reionization Changes Things



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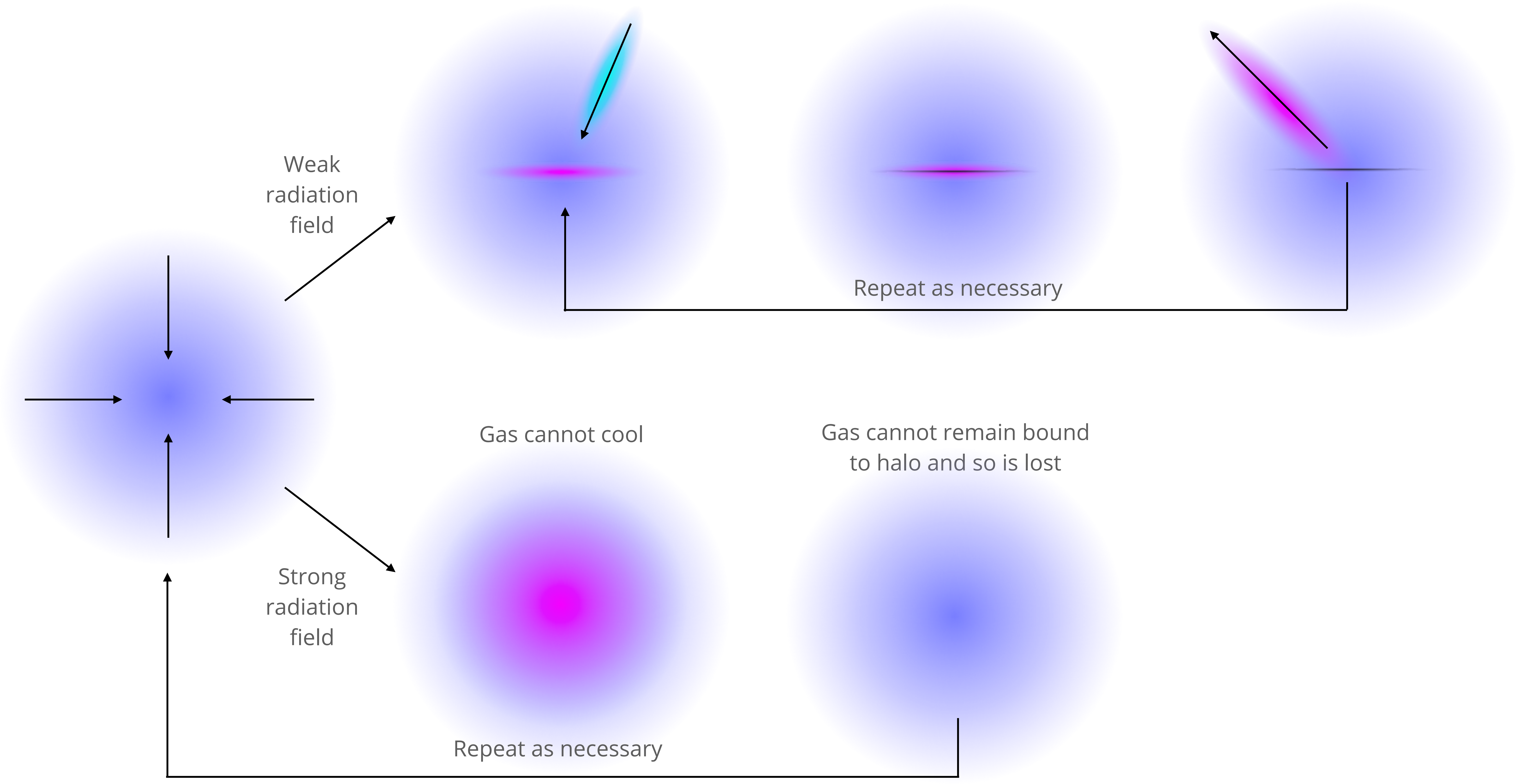
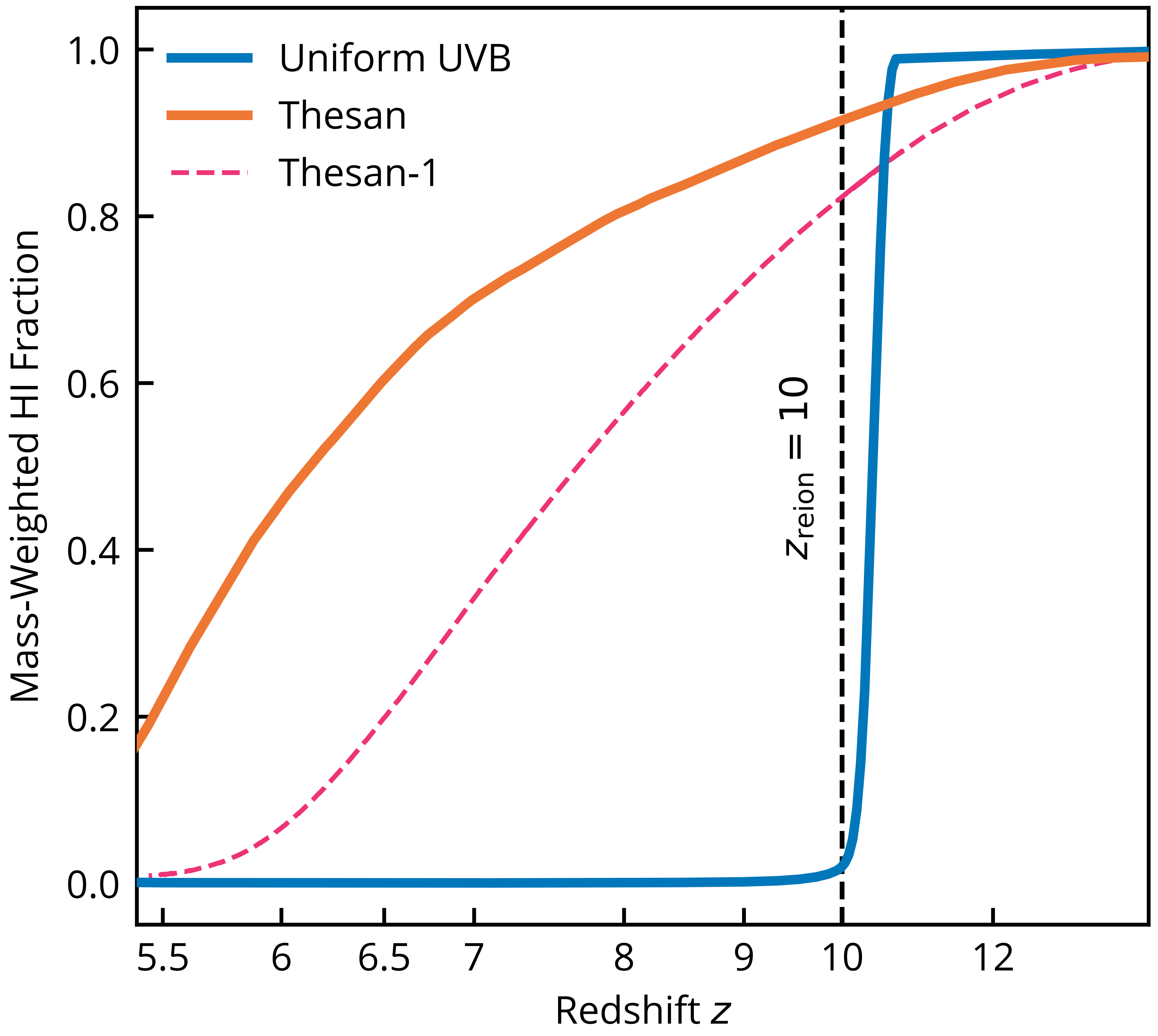


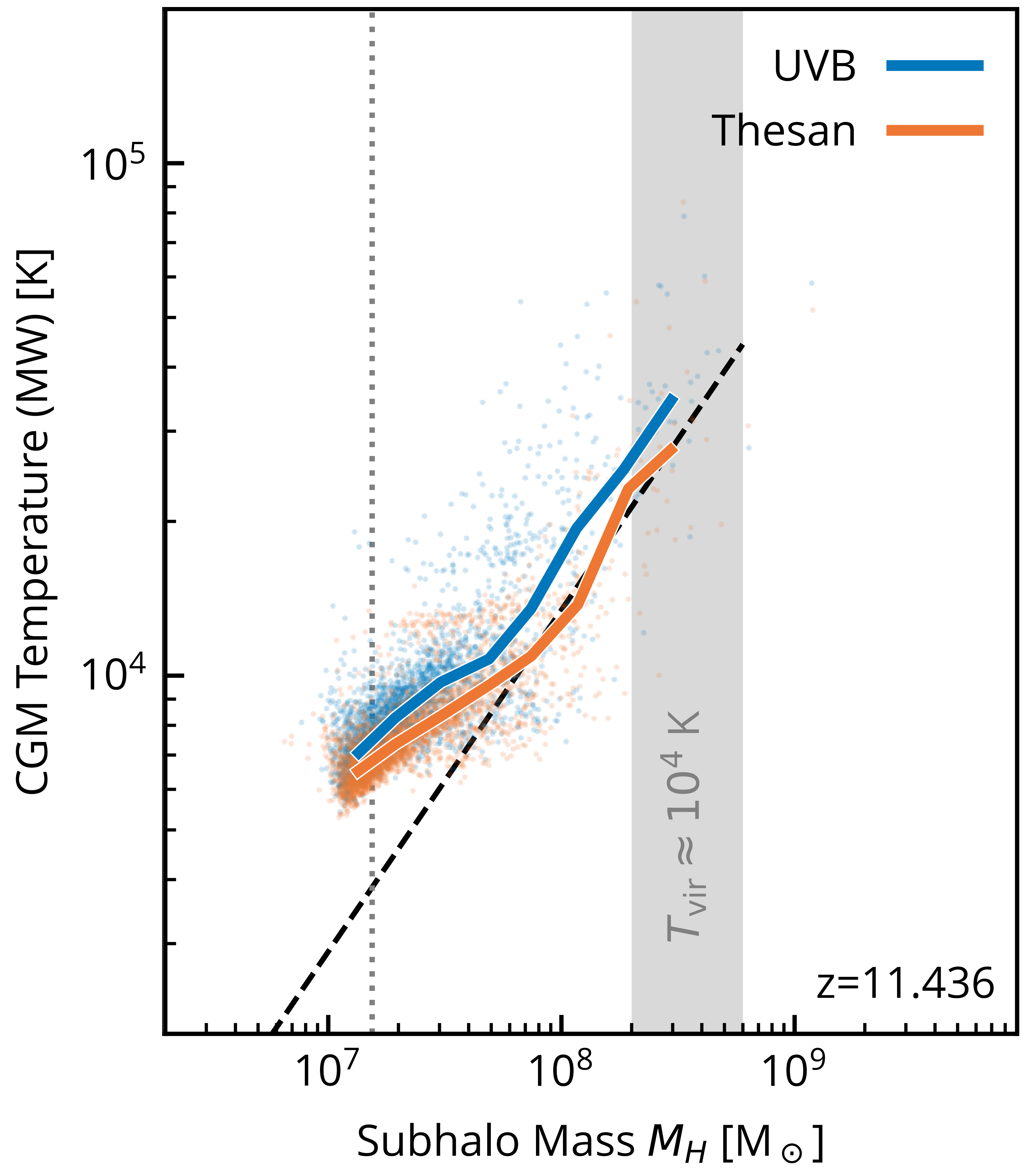
Reionization Models

- Most cosmological **galaxy formation simulations** (EAGLE, TNG, Horizon AGN) were interested in **low-redshift** galaxy properties.
- As such they used a **simplistic**, time-varying, but **spatially uniform**, **UV background** for reionization.
- We model this **self-consistently** using **radiative transfer**.



Impact of Reionization on the CGM

- Here we select all gas in the CGM (i.e. gas bound to centrals, but outside of the galaxy, defined as twice the stellar half-mass radius).
- At high redshift, both models show similar behaviour: gas in haloes is typically around the virial temperature, modulo accretion shocks.



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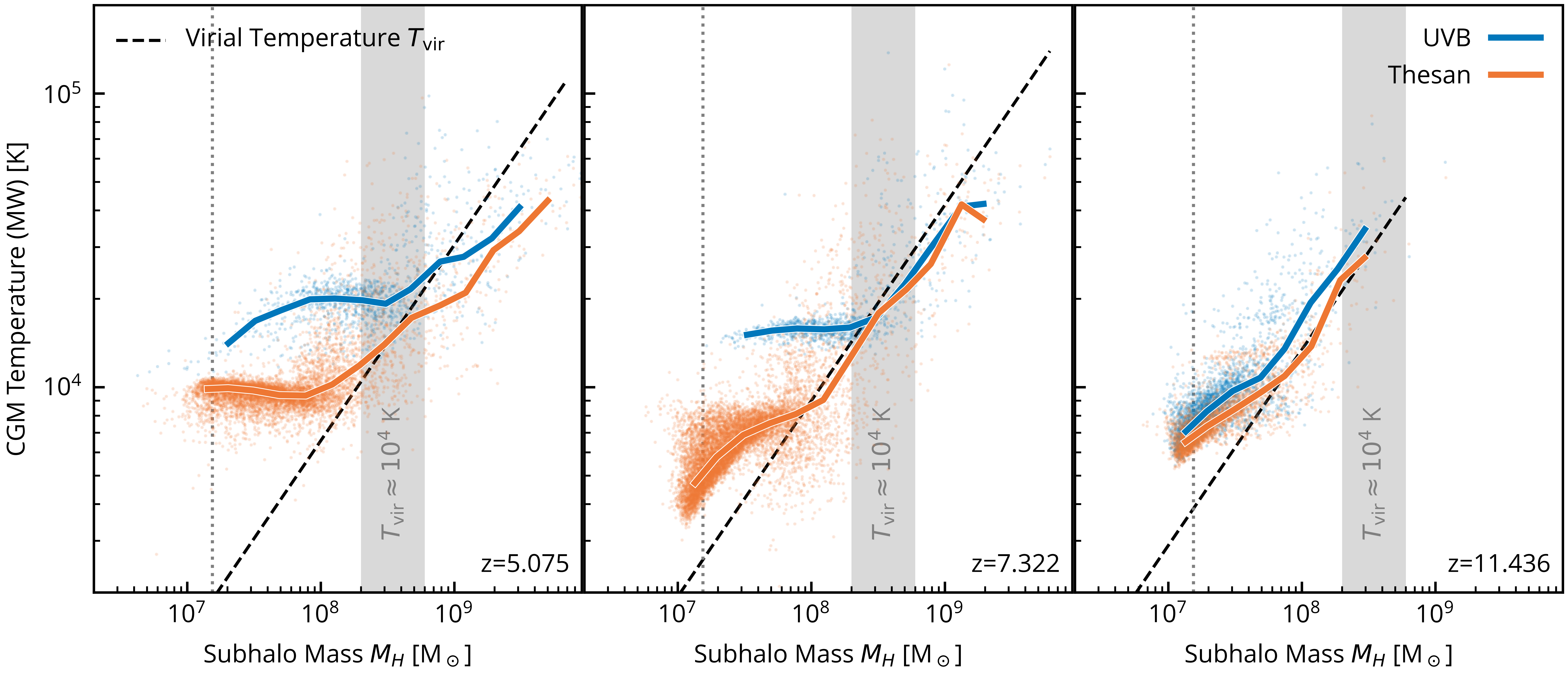
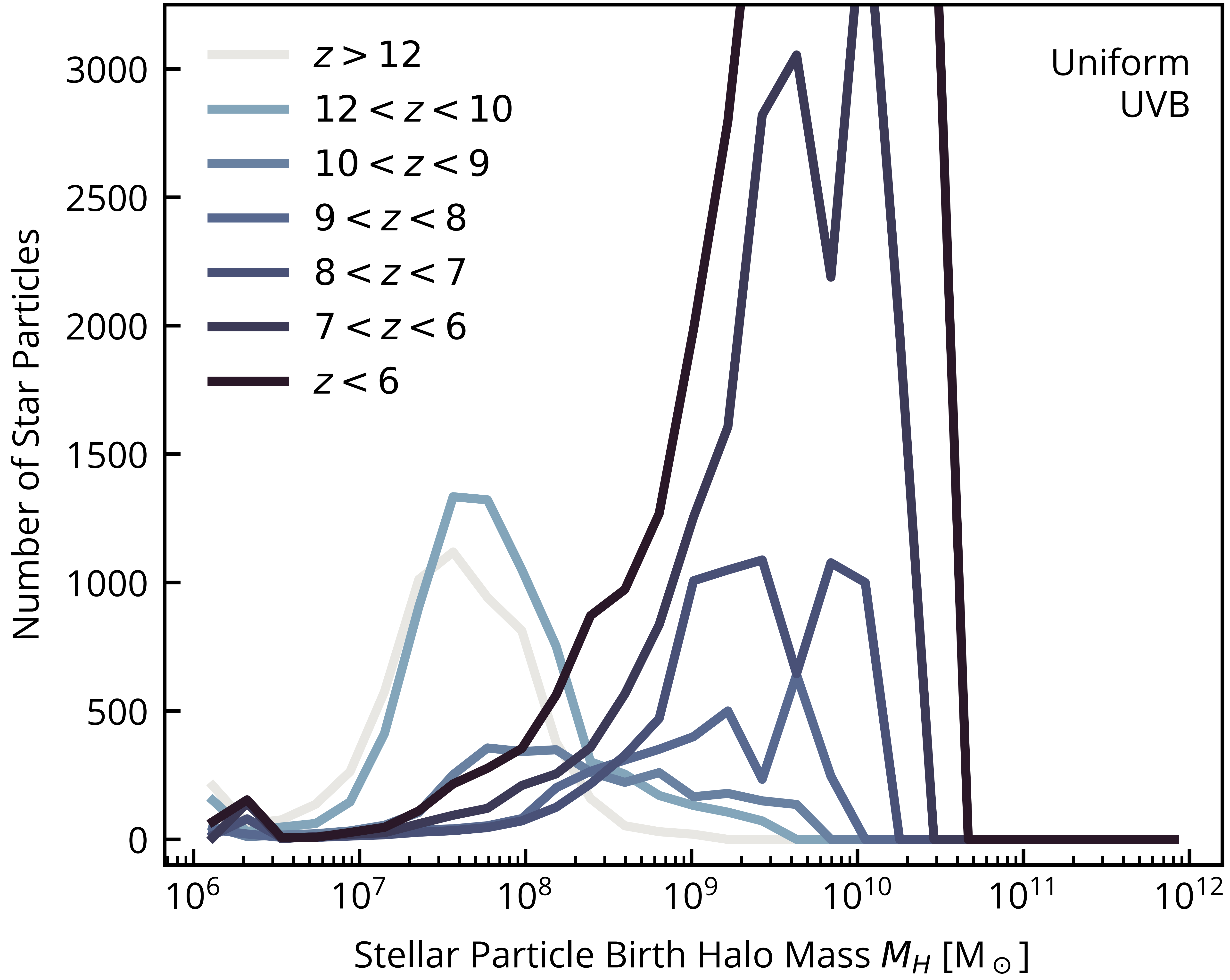


The Changing Tides of Star Formation

- When using a uniform UV background, star formation in low mass haloes (M < 10^8 M$_\odot$) is suppressed.
- Note that star formation in haloes M < 10^7 M$_\odot$ is generally suppressed by LwC radiation from very early times.



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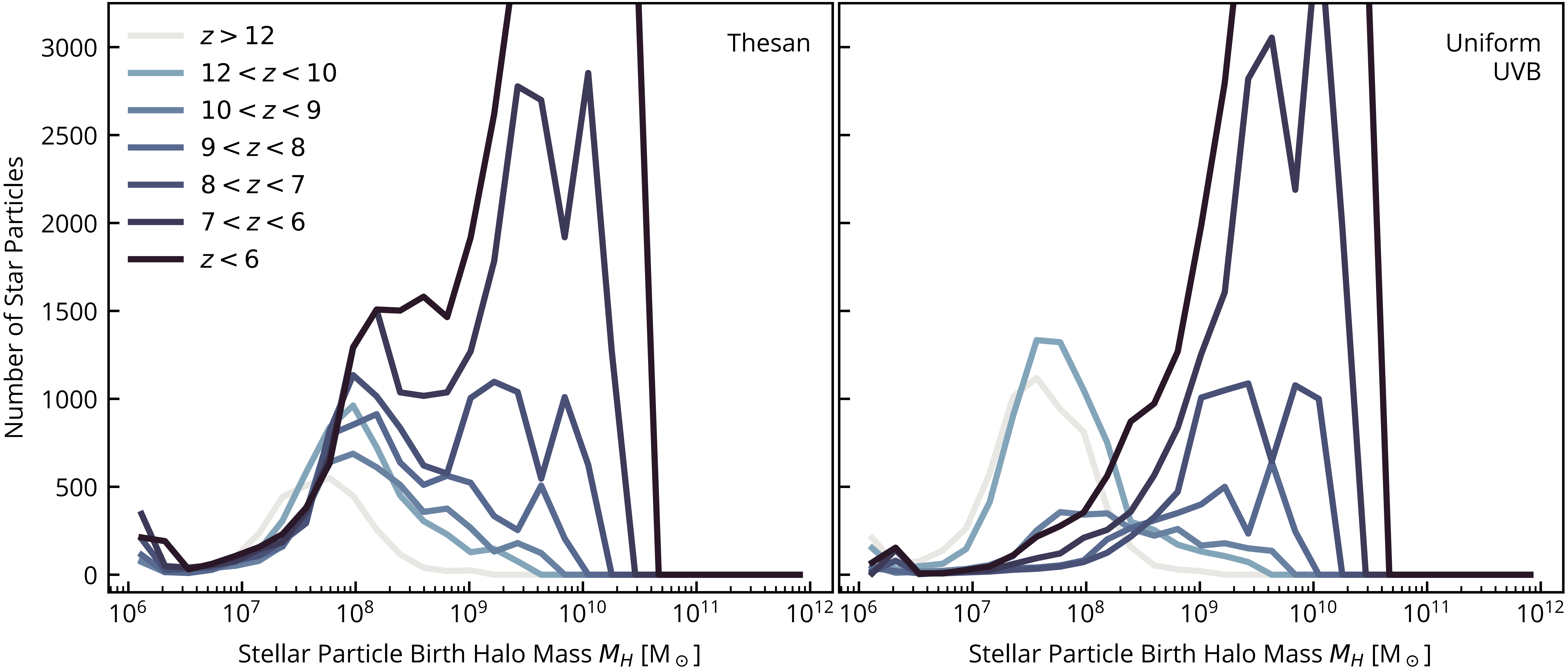
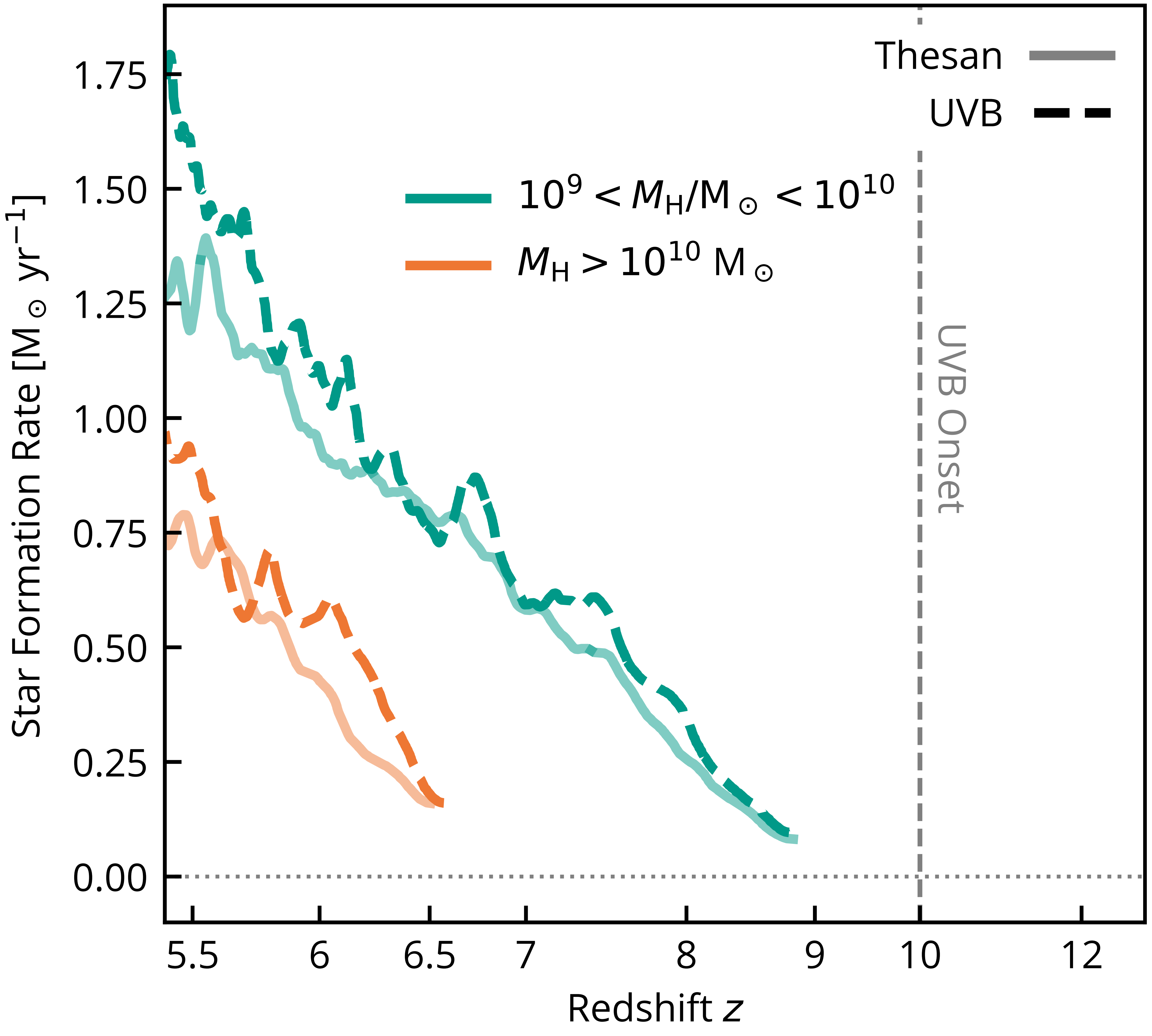


Impacts on the Star Formation History

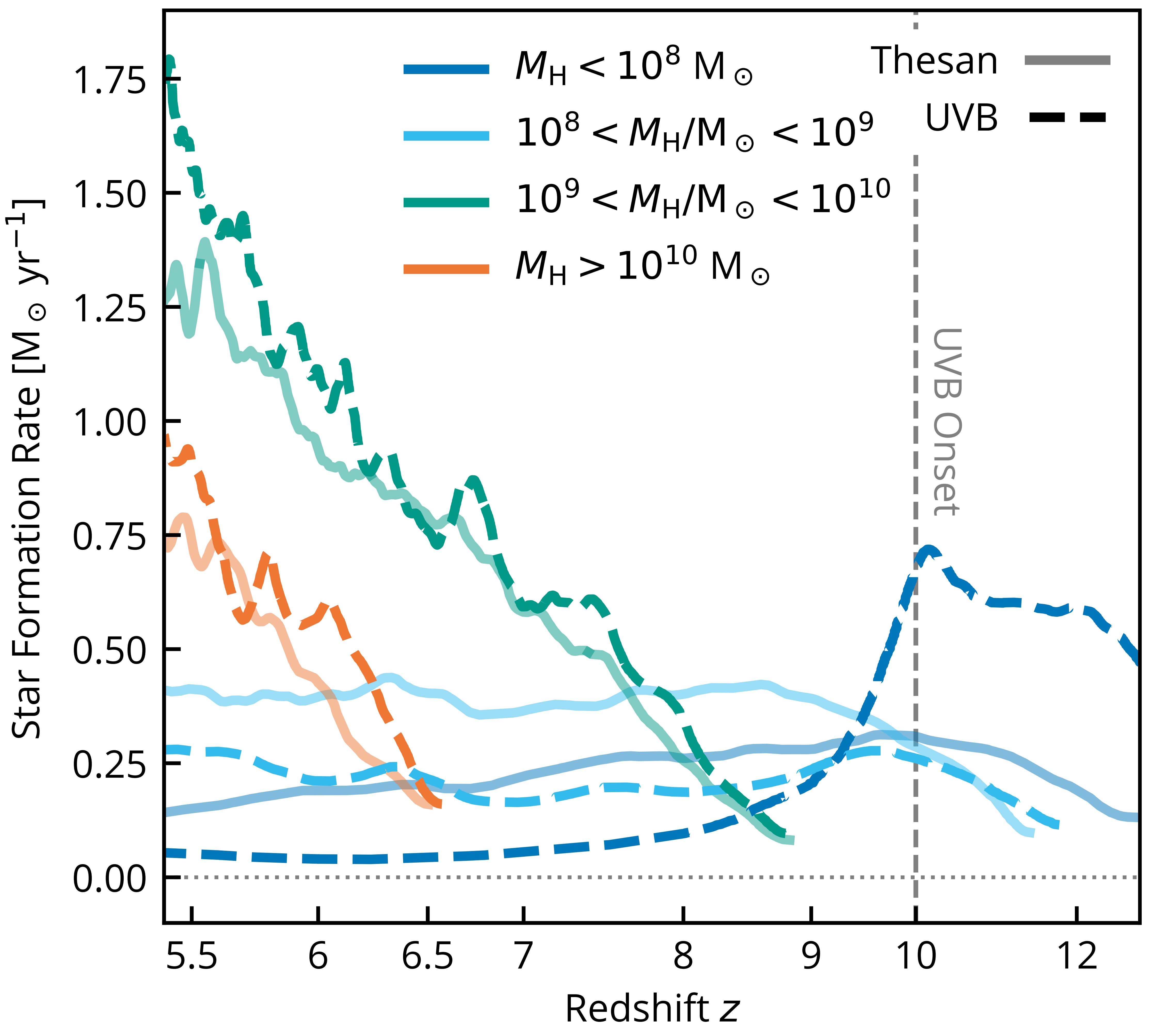
- Look at the star formation in the volume as a function of time, **split by** the **birth halo mass of stars**.

- **High mass** haloes show **little difference** between the **two models**, with the uniform UVB model having slightly higher 'low' redshift star formation.



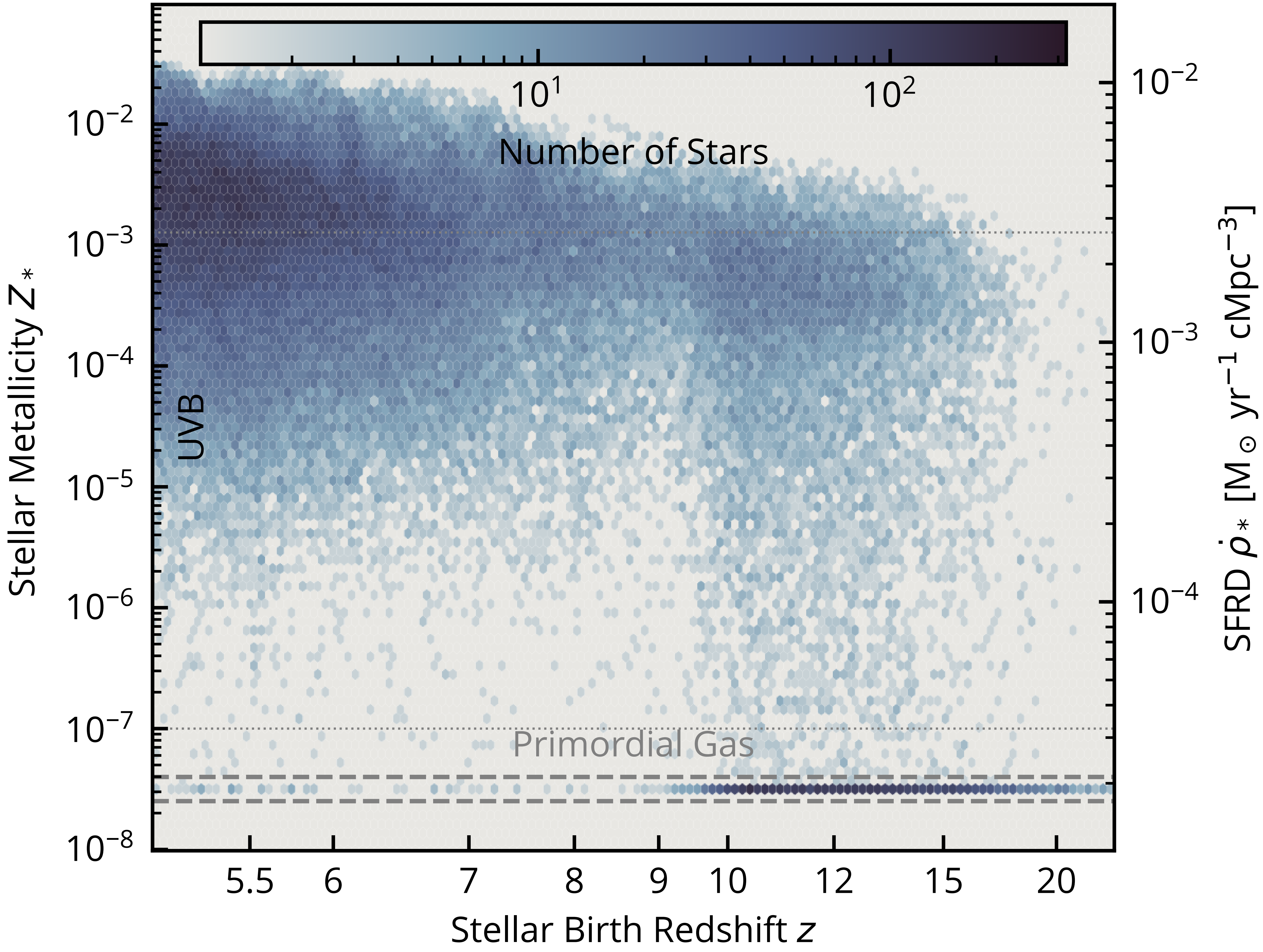
Impacts on the Star Formation History

- **Low mass haloes** show a very different story, with **star formation shut down** in the uniform UVB **at z=10**.
- In Thesan, **star formation** can **continue** in these **low mass haloes** down to z=5 (and beyond, though we don't simulate that!)



Impact on Stellar Populations

- The impact of the strong **UVB** means that there **cannot be star formation** from **primordial gas** (only found in the **lowest mass haloes**) at **redshifts below 10**!
- This hence changes the feeding of high mass haloes, as this primordial gas survives.



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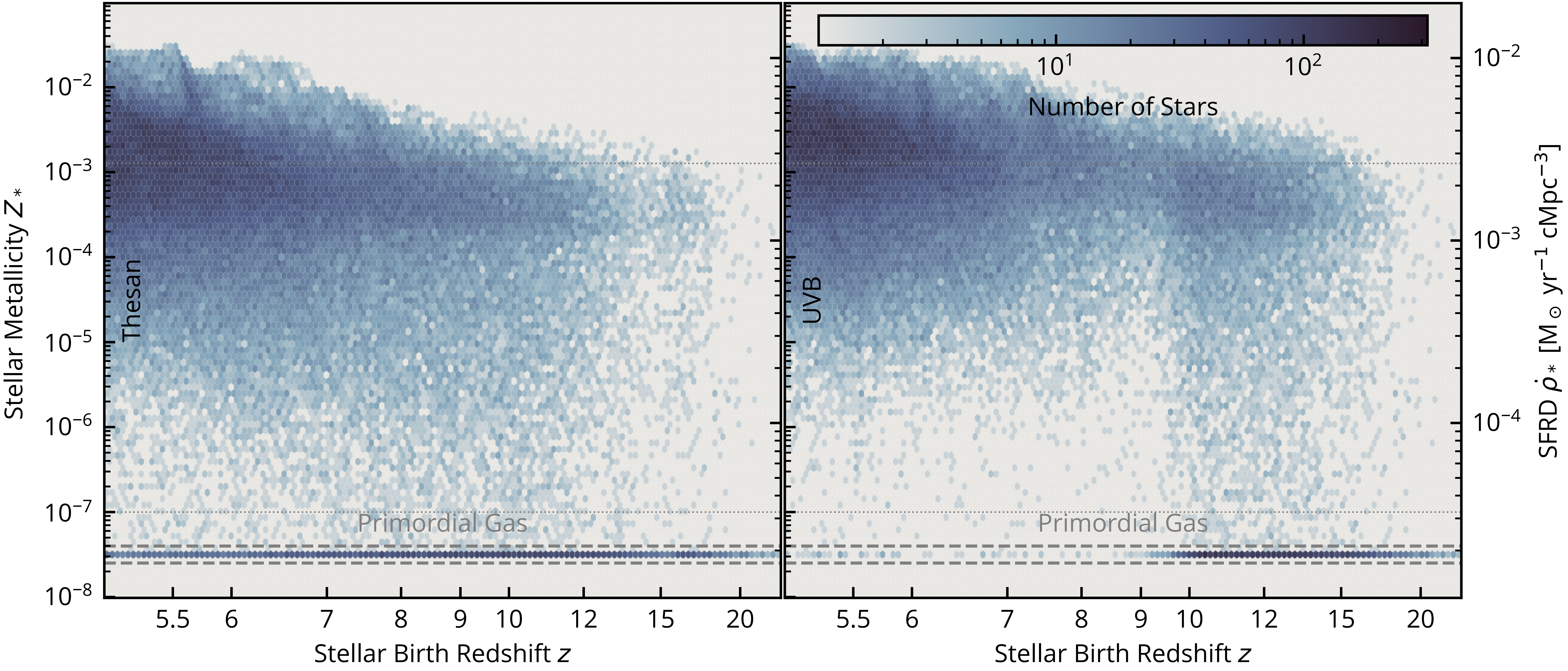

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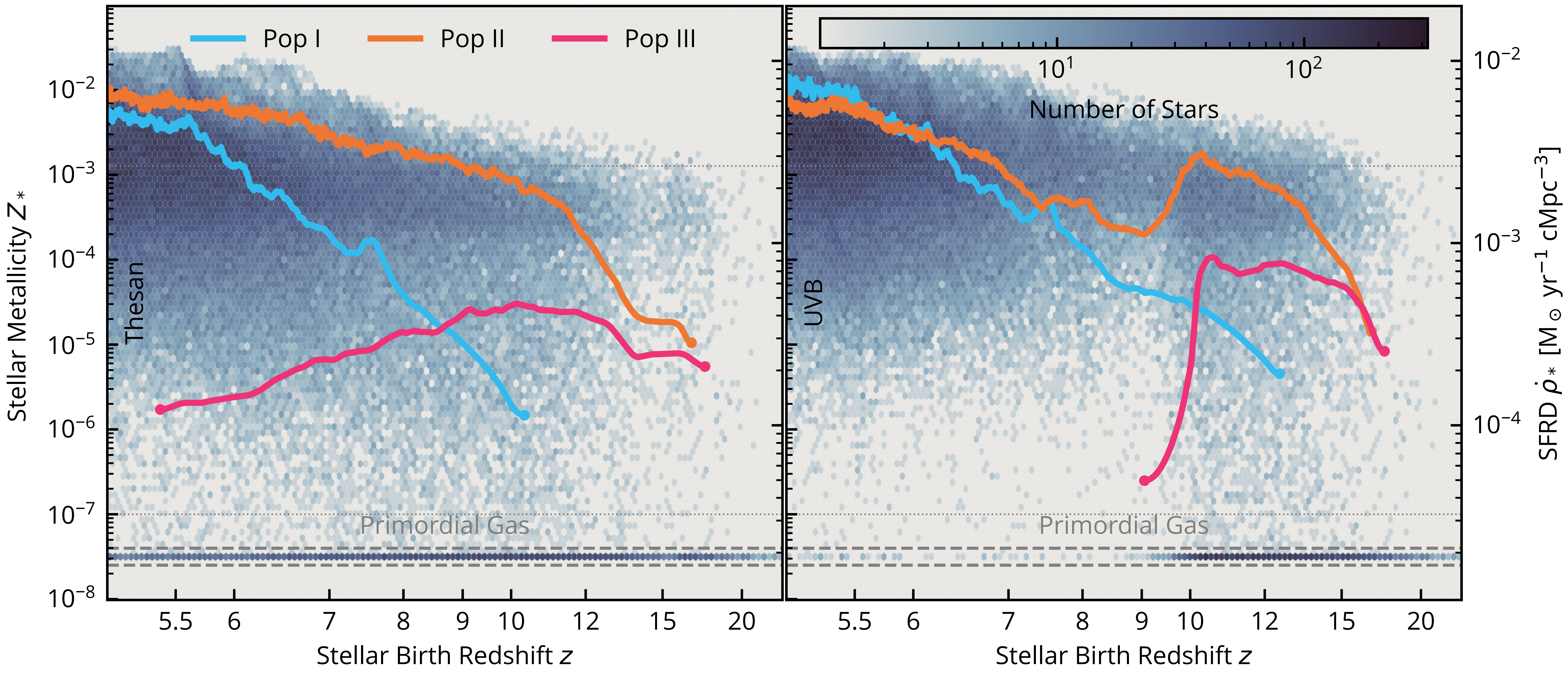
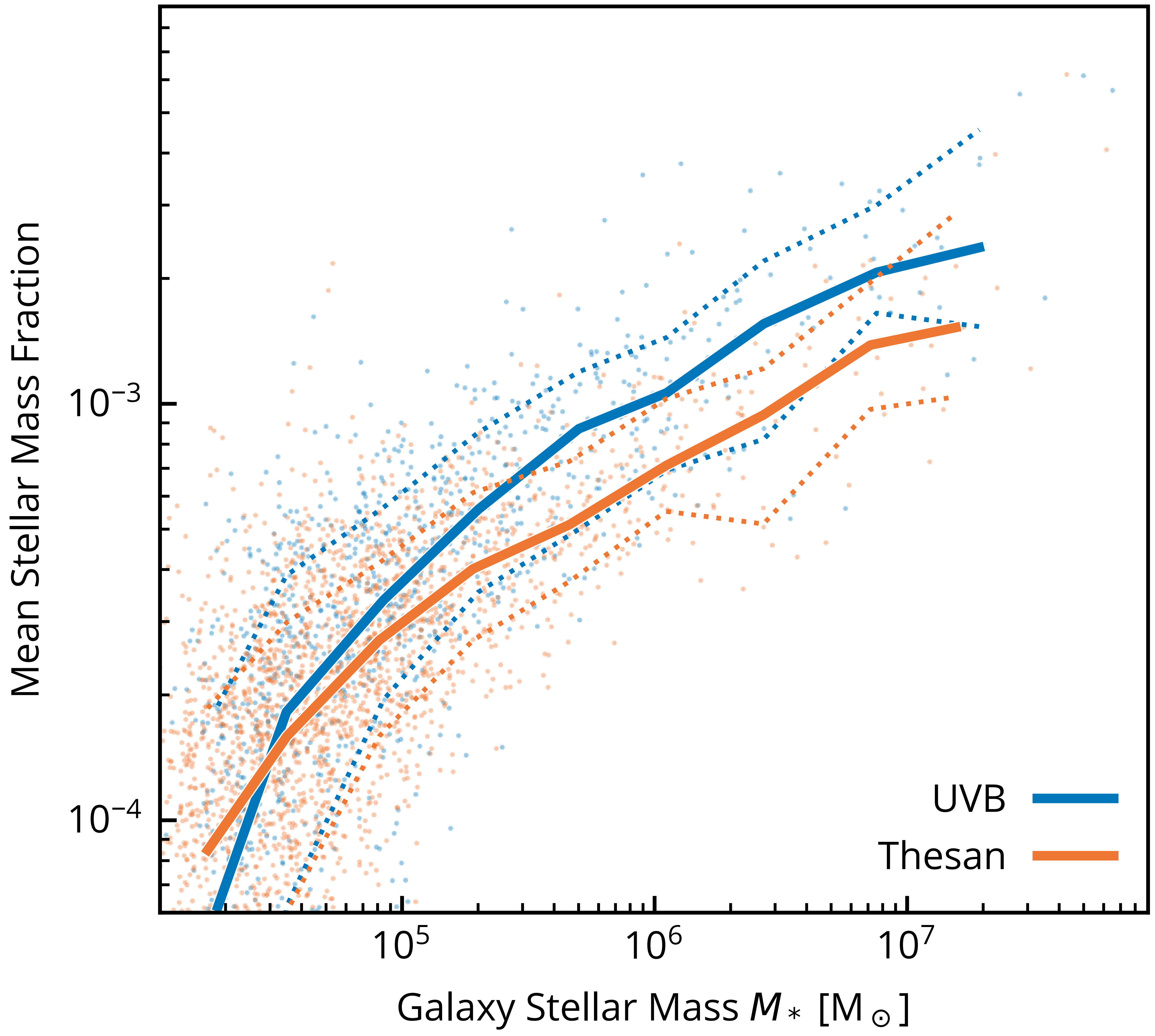


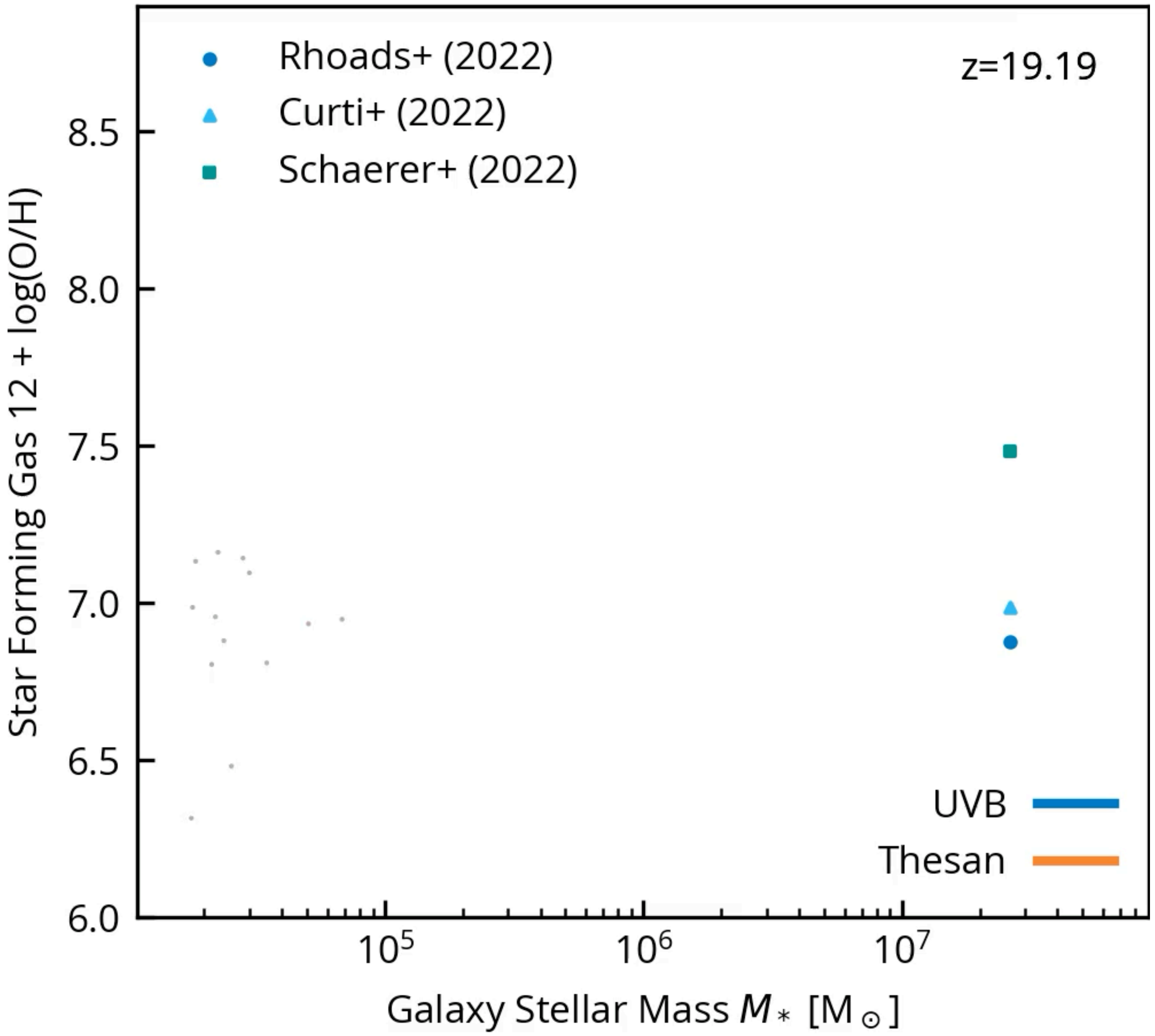
Back-Reaction on Galaxy Scaling Relations

- **Higher Pop III and Pop II** star formation **rates** in the **Thesan** models lead to **significantly reduced** stellar **metallicities**.
- **Dotted lines** here show the **16-84 percentile** range.



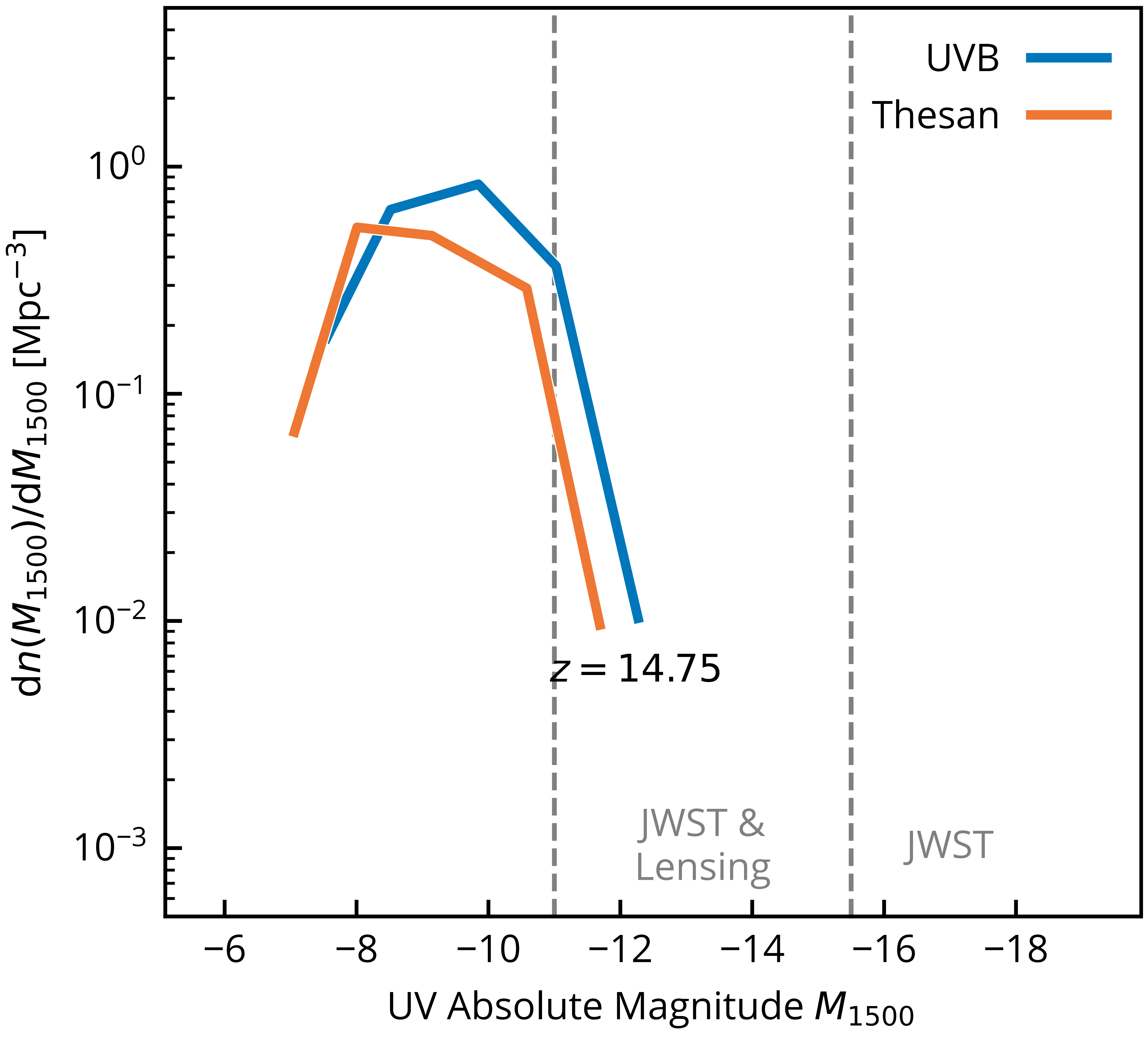
Back-Reaction on Galaxy Scaling Relations

- The **lower IGM temperatures** also allow for **stronger primordial inflows** in **Thesan**, meaning even **in-situ** star formation occurs in **lower metallicity gas**.
- The Thesan simulation is **still in tension** with **early** reported **JWST z > 7** galaxy candidates, though we **do not include a self-consistent Pop III model.**



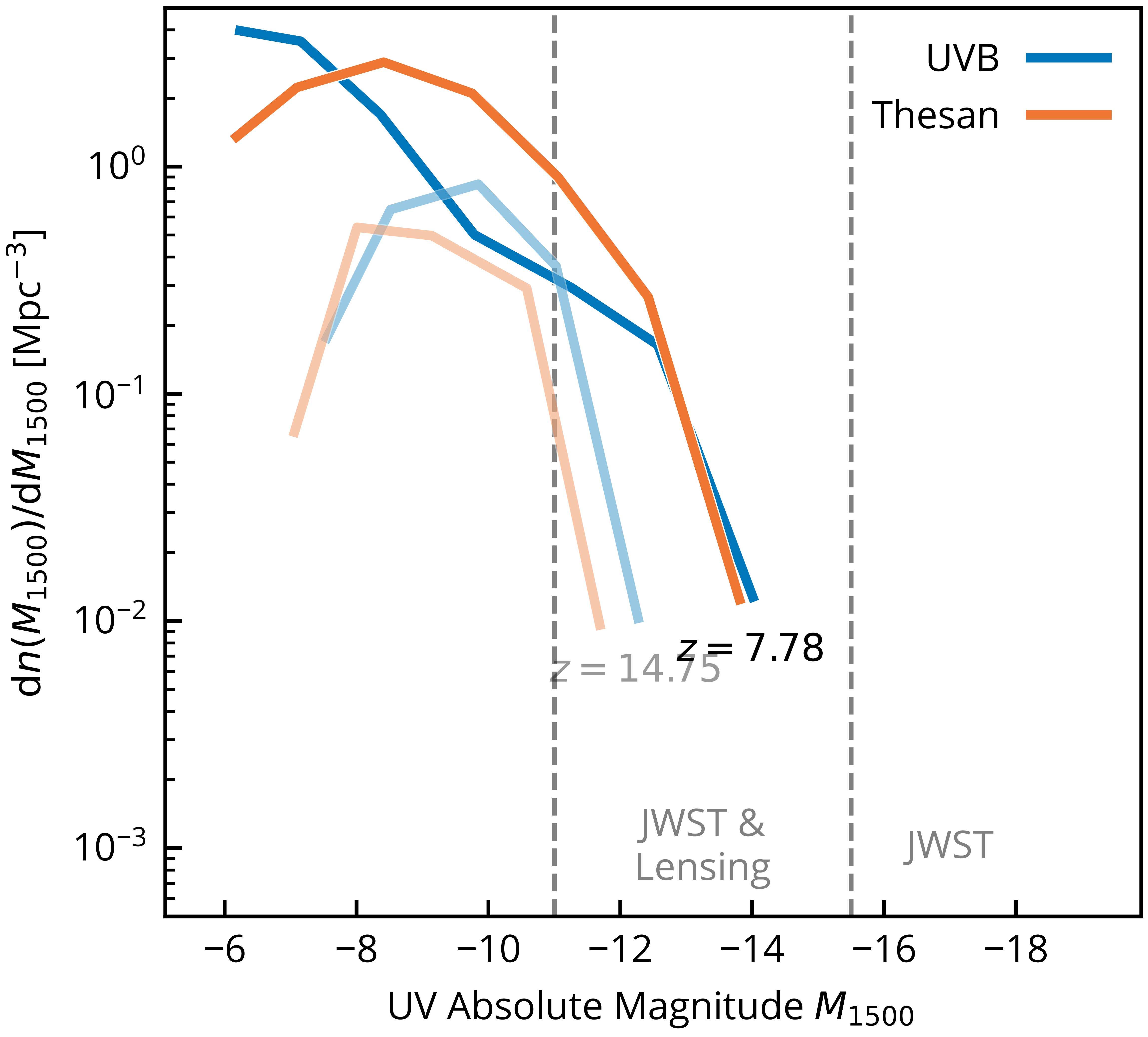
Back-Reaction on Galaxy Scaling Relations

- At **high redshifts** (z > 10), **Thesan** actually sees **additional suppression** in galaxy formation due to **additional effects of radiation** that are missing in the UVB.



Back-Reaction on Galaxy Scaling Relations

- **Below z = 10**, we see that **star formation is suppressed**, as before, in **low mass galaxies**.
- Even by **z = 5**, the differences in the **abundances** of **low mass galaxies** continue to **grow**, meaning that any **models making predictions** for **high redshift galaxy abundances must include a spatially-dependent reionization model**.



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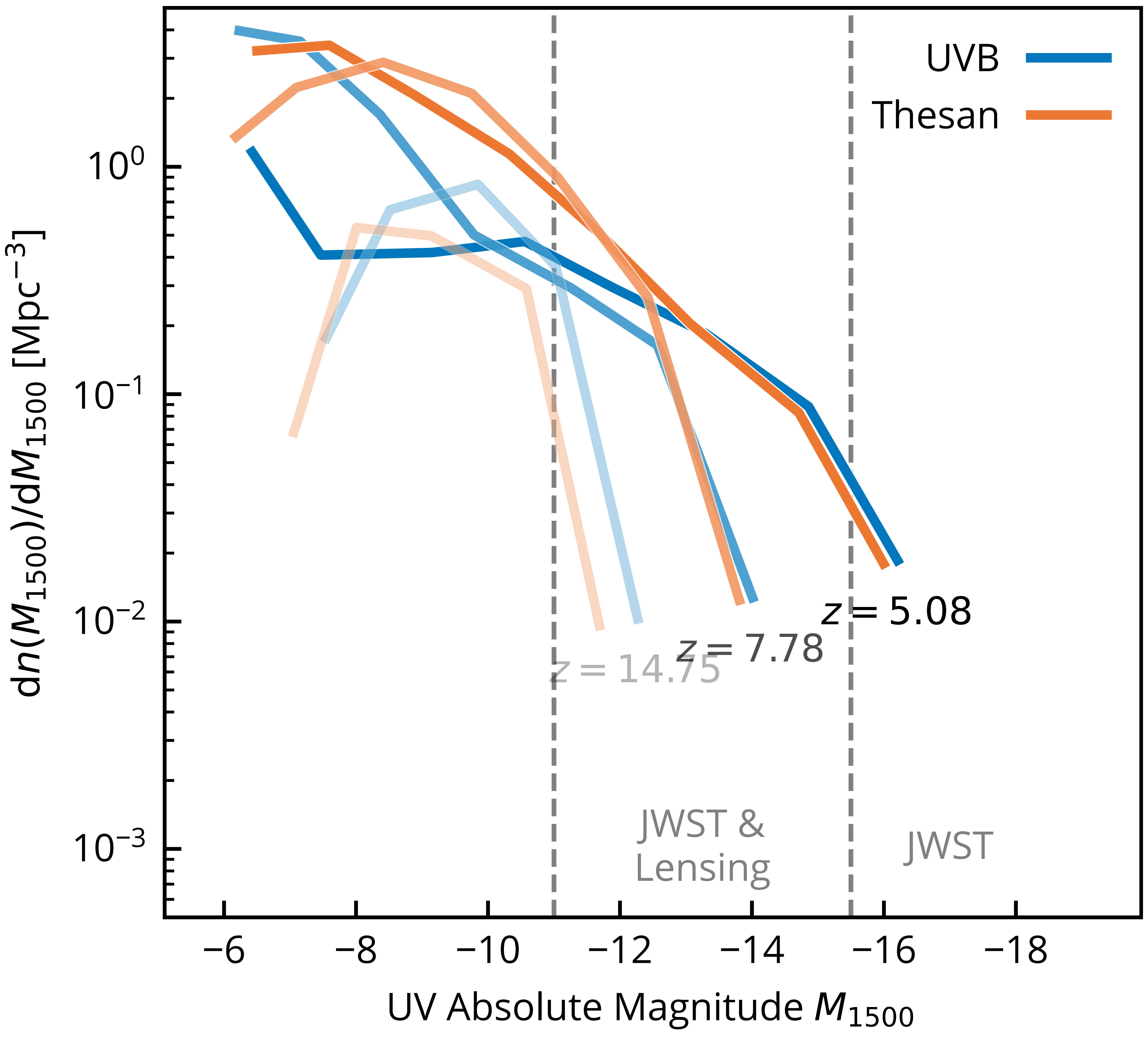

Conclusions & Takeaways

- There is a **significant back-reaction** of **reionization** on **galaxy properties**, but you need to simulate at high ($m_b < 10^5$ $M_\odot$)
- The **abundances** of **high mass galaxies** (those with $M_* > 10^8$ $M_\odot$) are unaffected, but their **properties** (e.g. star formation histories) are not.
- **Interpreting high-redshift observations** with **simulations** employing a **uniform UVB** is a **dangerous game**...