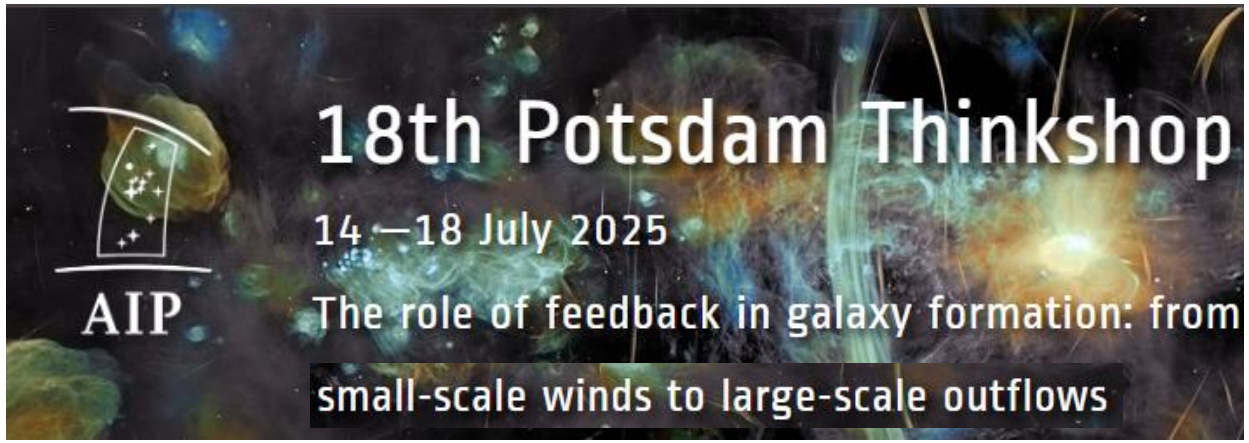

Galaxy Evolution Meets Large Scale Structure

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(University of Bonn)

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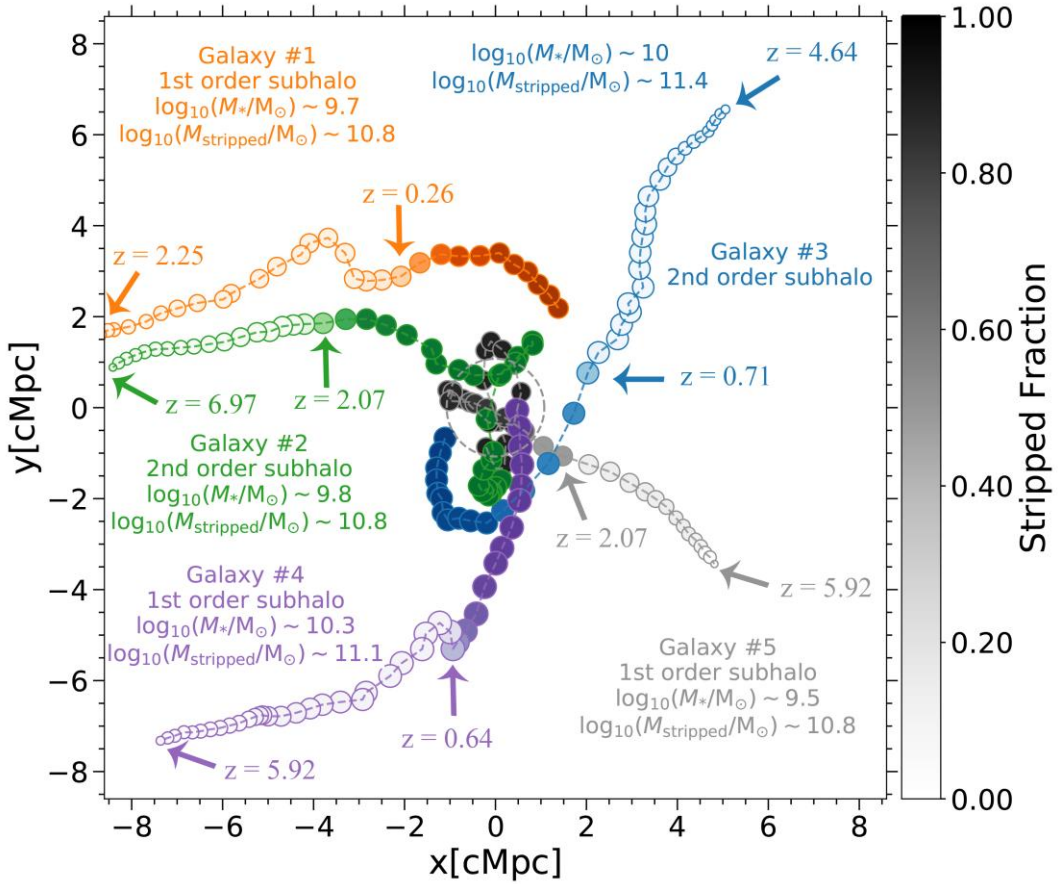
UNIVERSITÄT BONN

Galaxy Evolution meets Large Scale Structure

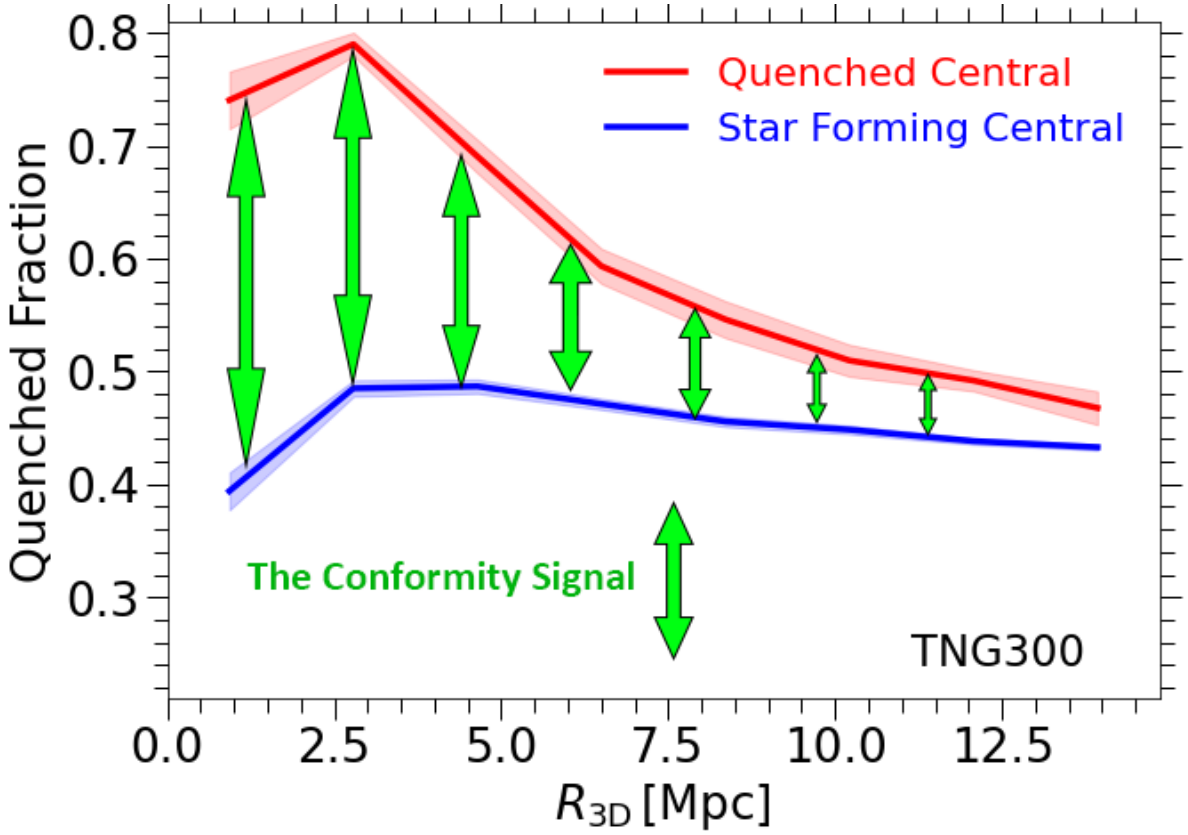
The Environment of Galaxies Beyond the Halo Boundary



Ayromlou+ 2021b

See also Bahe+ 2013, Wetzel+ 2014

Large-Scale Correlation Between Galaxy Properties (Conformity)



Ayromlou+ 2023a

See also Weinmann+ 2006, Kauffmann+ 2013, Tinker+ 2018, Sin+ 2019, Lacerna+ 2021, …

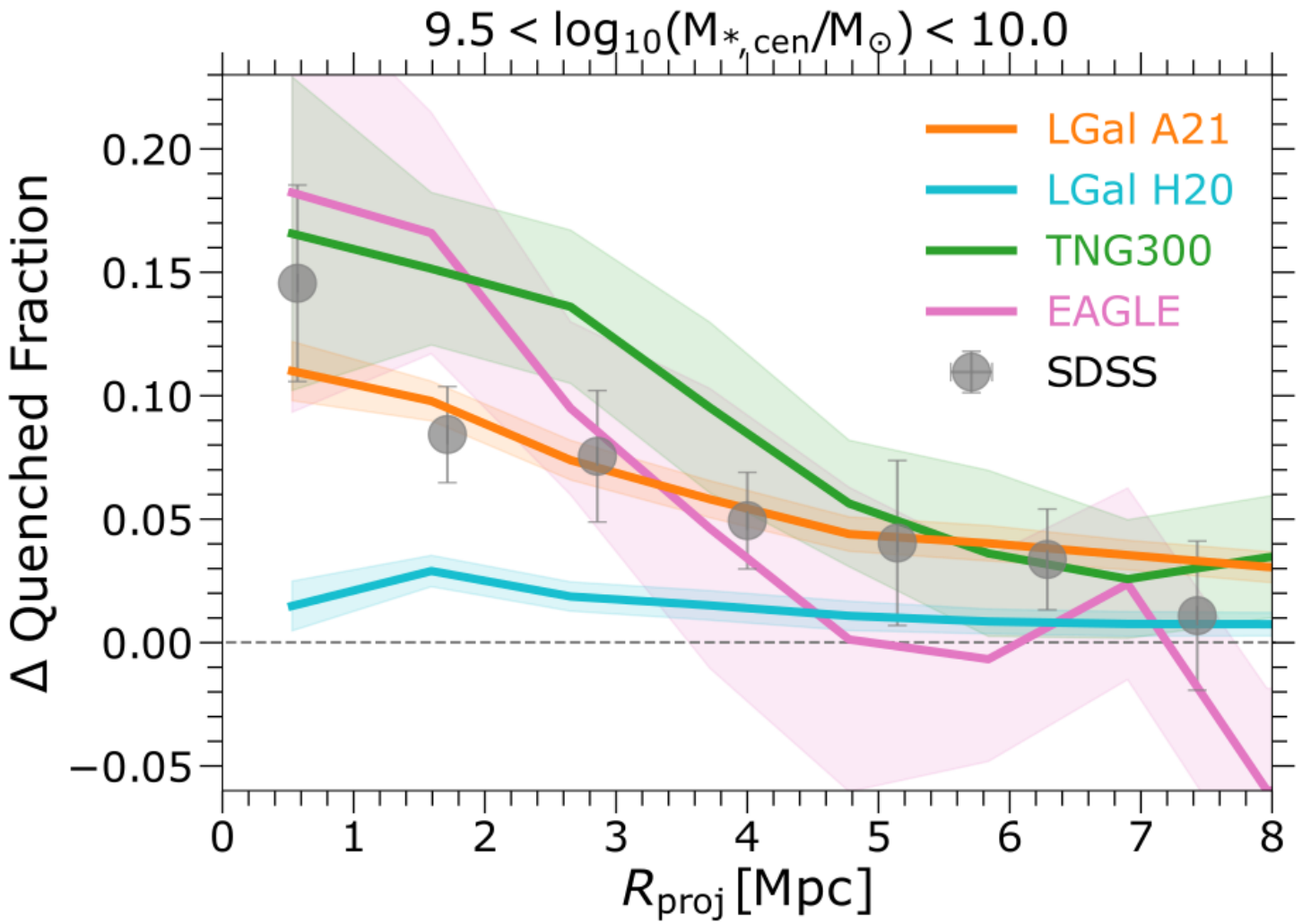
The Conformity Signal: SDSS vs. Simulations

The signal is present out to at least 5 Mpc in

- SDSS
- LGal - A21
- TNG
- EAGLE

The signal is missing in

- LGal - H20 (no stripping beyond R200)



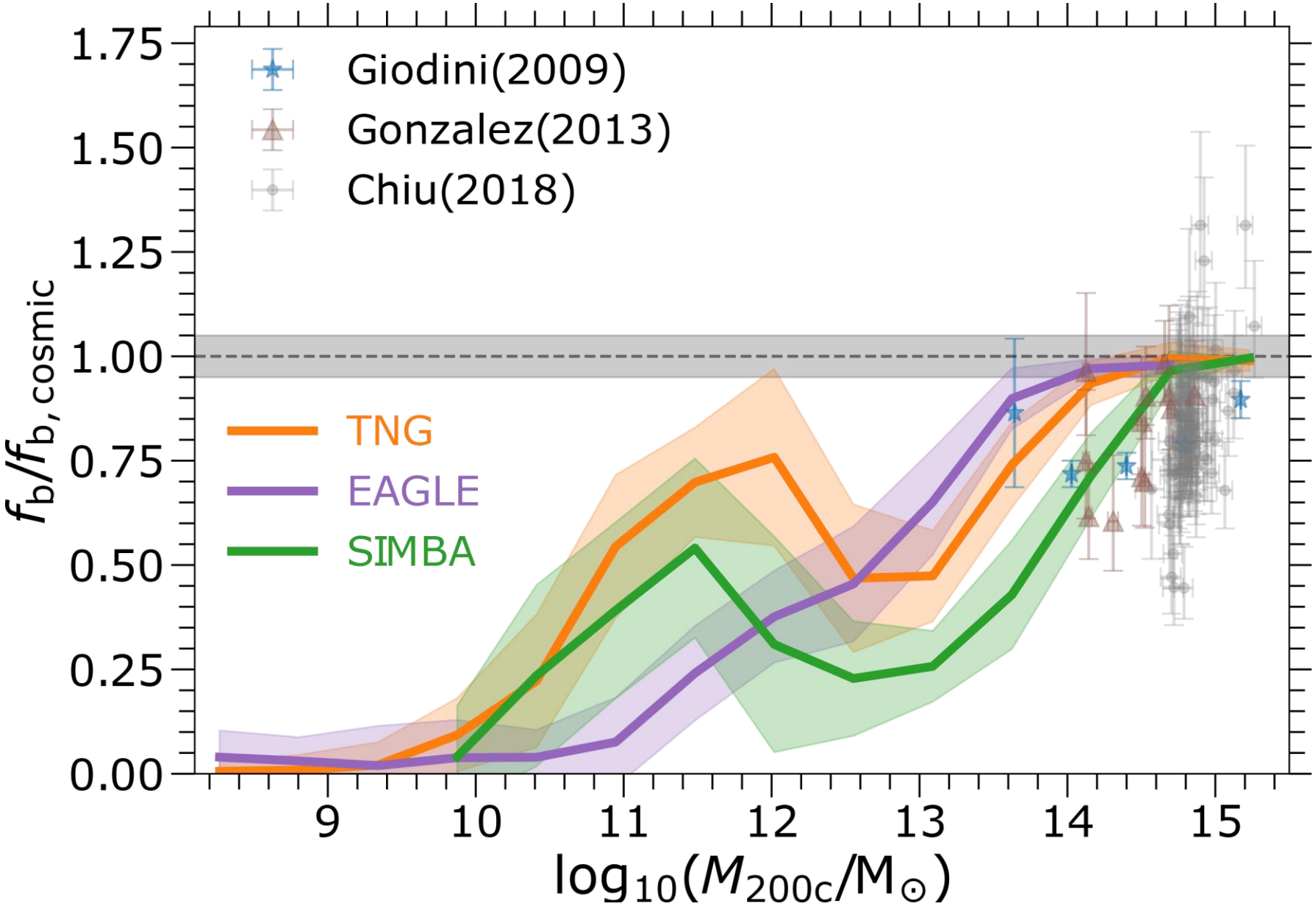
Ayromlou+ 2023a

Feedback Reshapes Baryon Distribution

From Dwarfs to Clusters

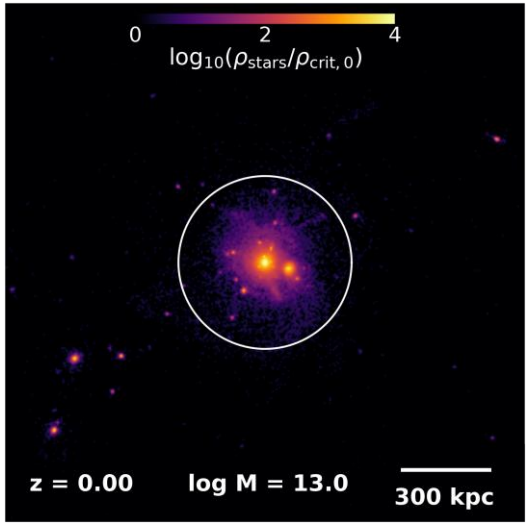
Halo Baryon Fraction

In most halo mass ranges, the halo baryon fraction is lower than the cosmic value observed in the CMB **(The missing baryon problem)**.

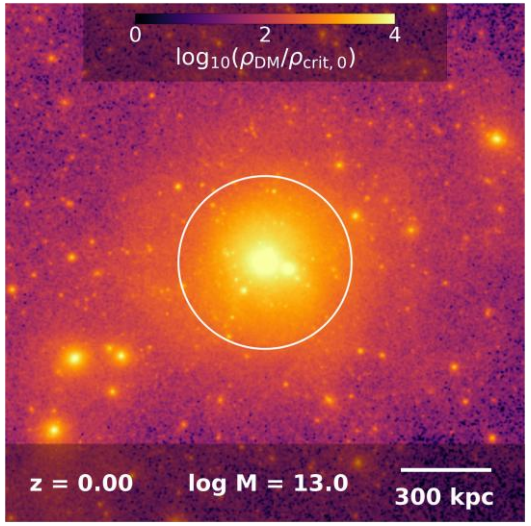


Ayromlou+ 2023b

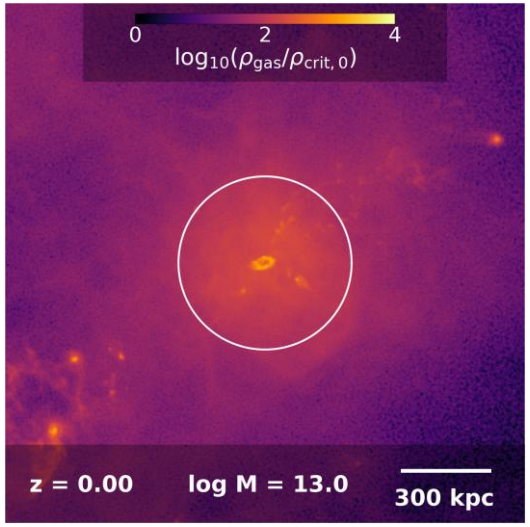
Stellar Density

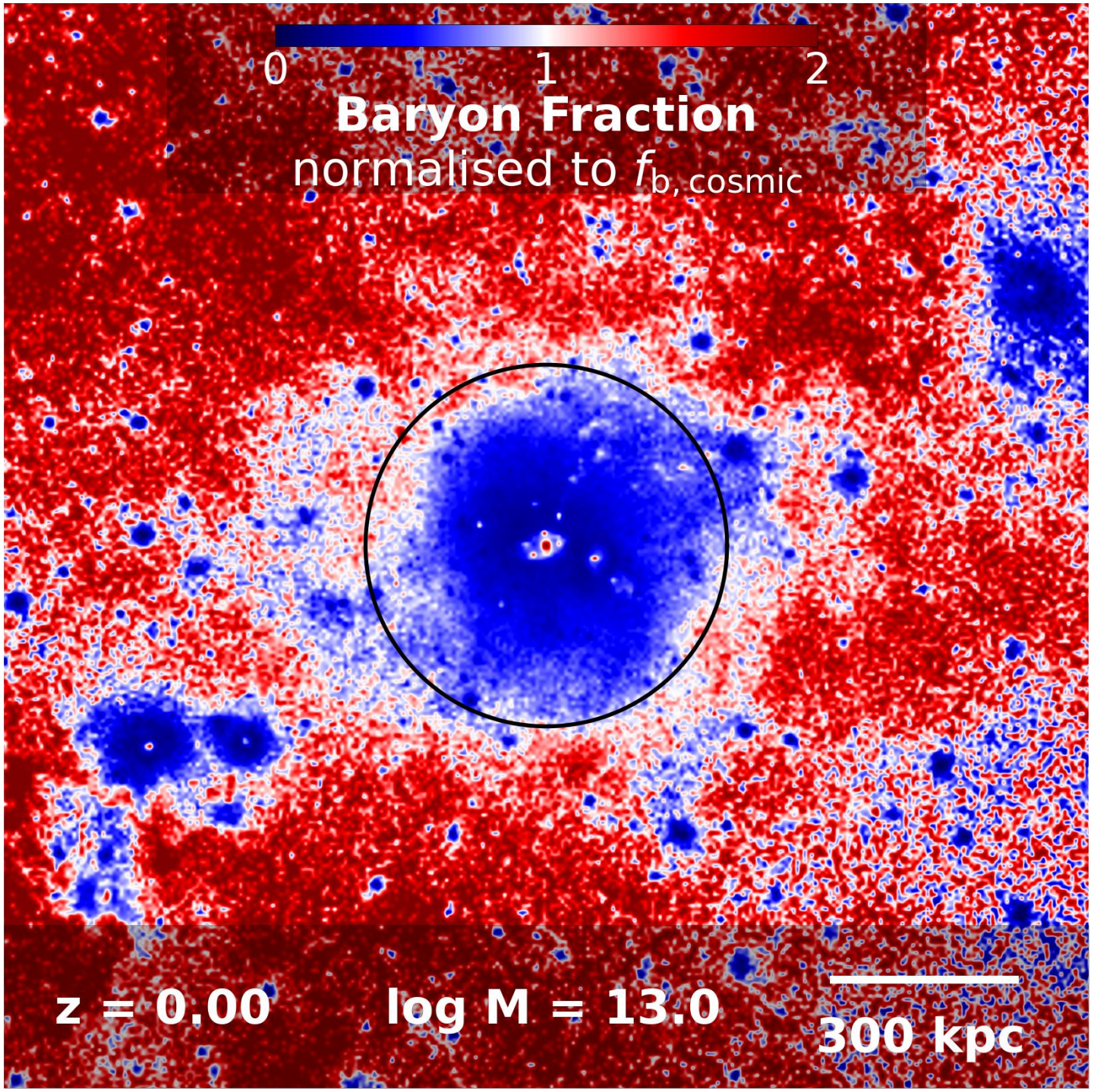


Dark Matter Density



Gas Density



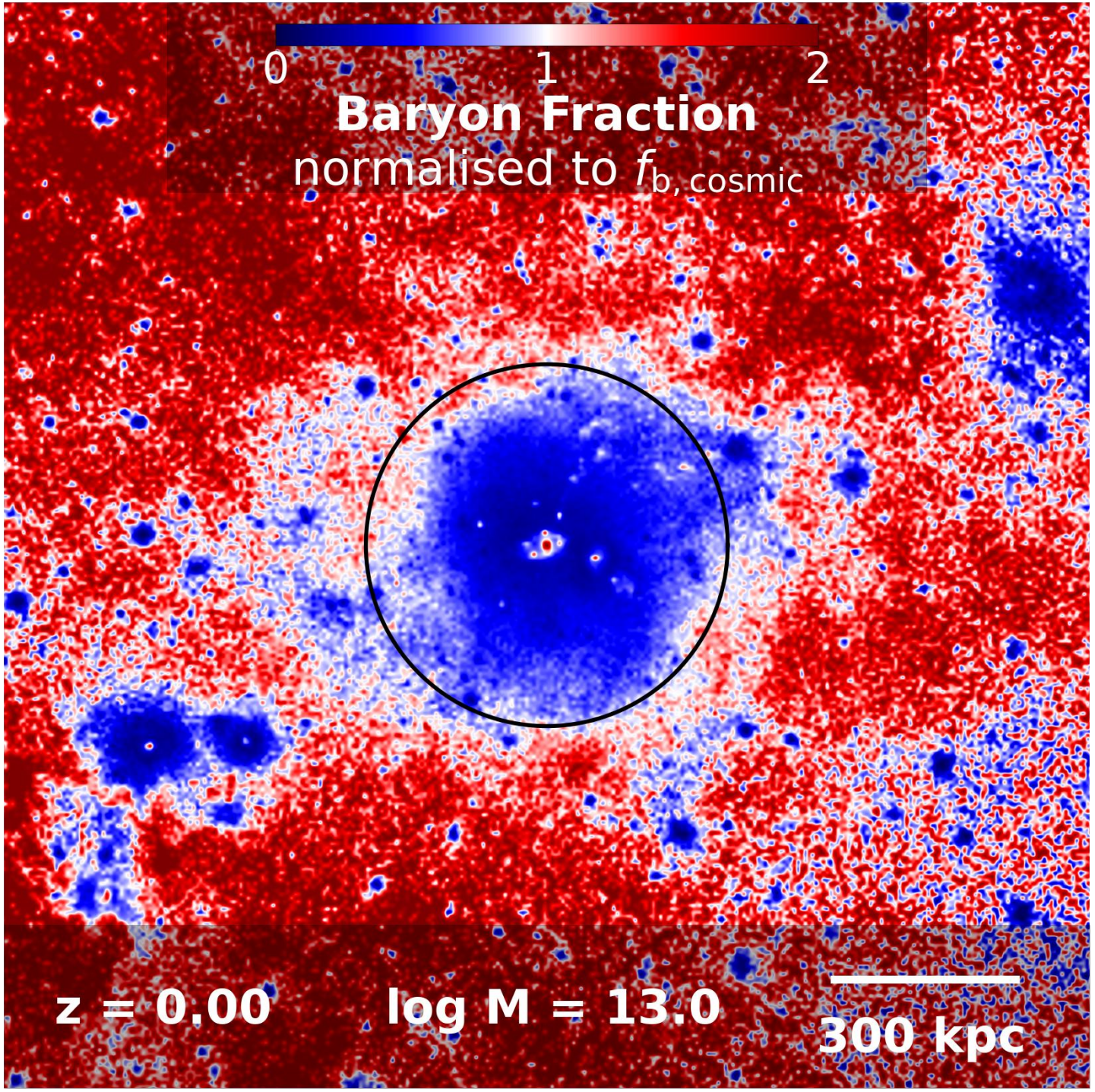


M. Reza Ayromlou (Uni. Bonn), July 2025

The Closure Radius

The radius within which all baryons associated with DM are found.

$$f_b(< \mathbf{R_c}) = \Omega_b/\Omega_m$$



M. Reza Ayromlou (Uni. Bonn), July 2025

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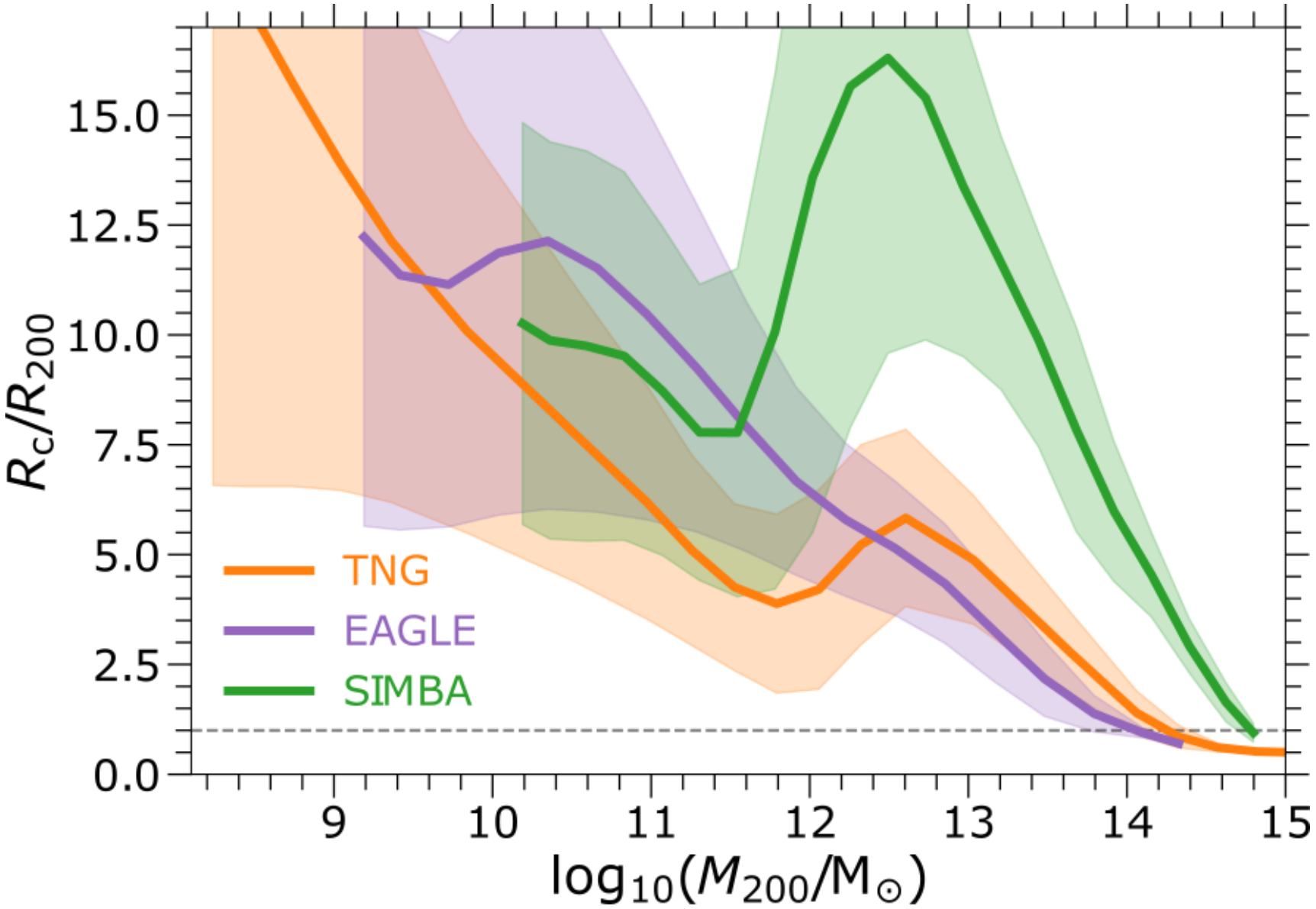

Ayromlou+ 2023b

The Closure Radius

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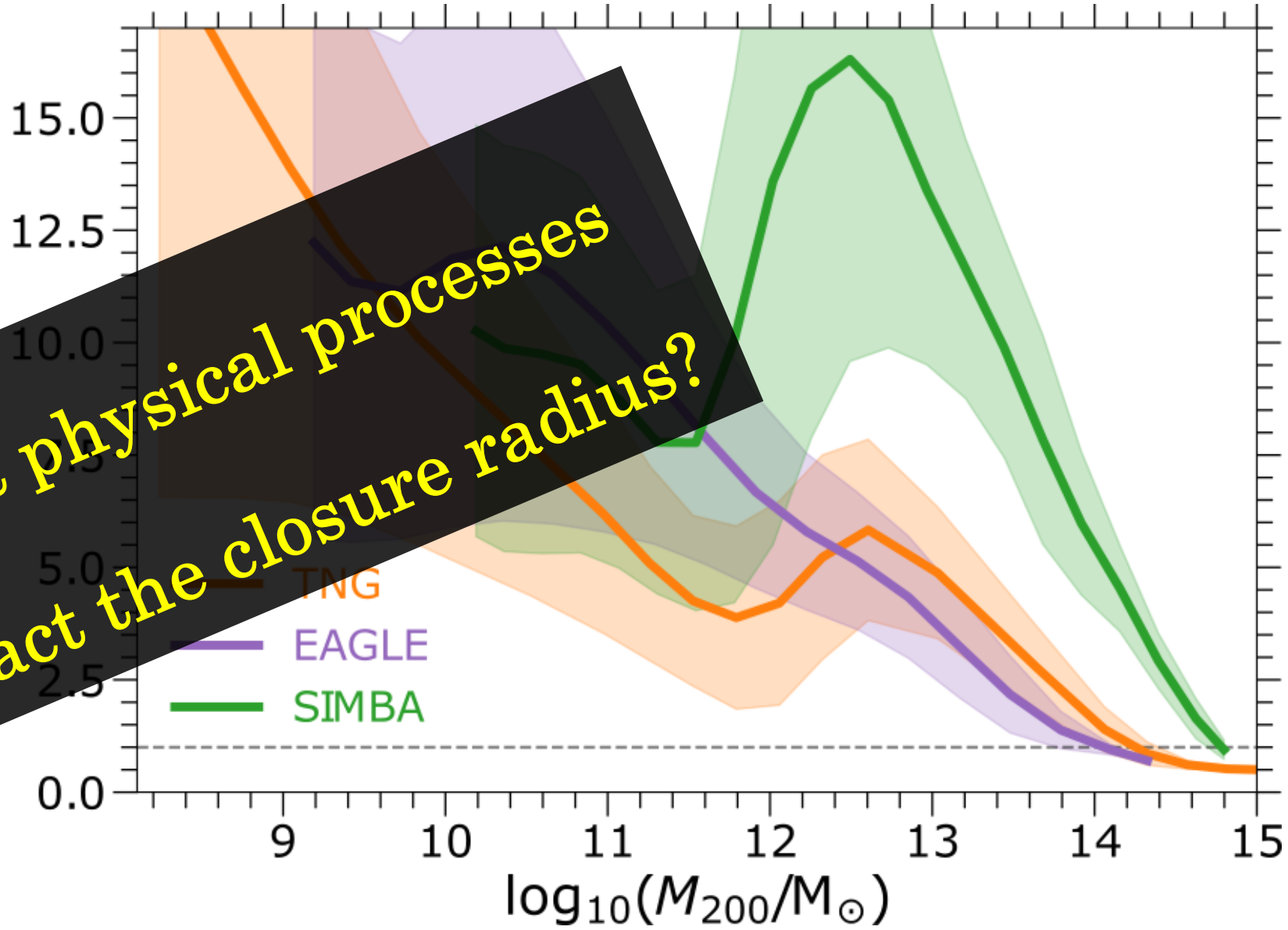
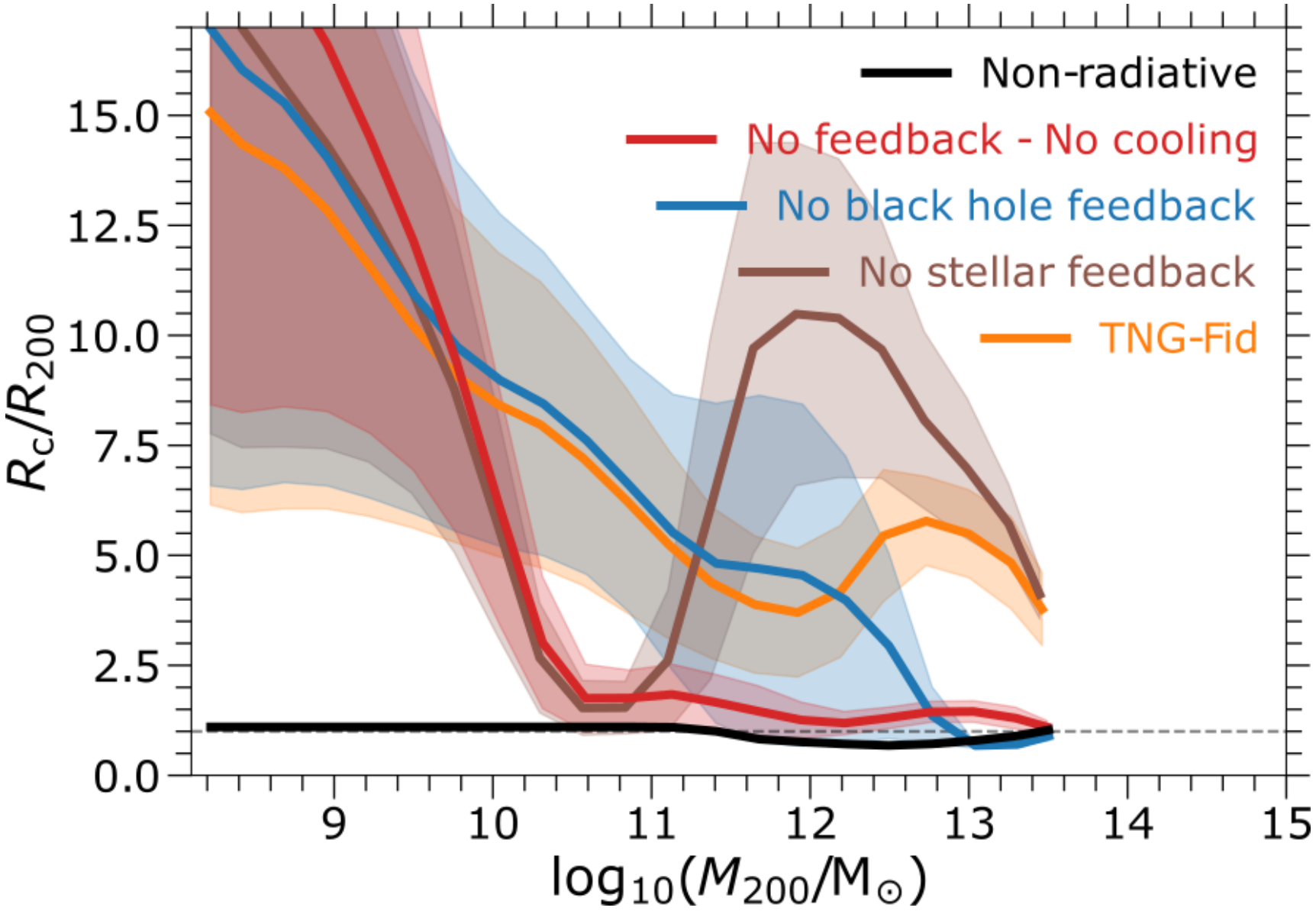


What physical processes impact the closure radius?

Ayromlou+ 2023b

Processes that impact the Closure Radius

Comparing several variants of TNG, which selectively exclude certain physical processes.



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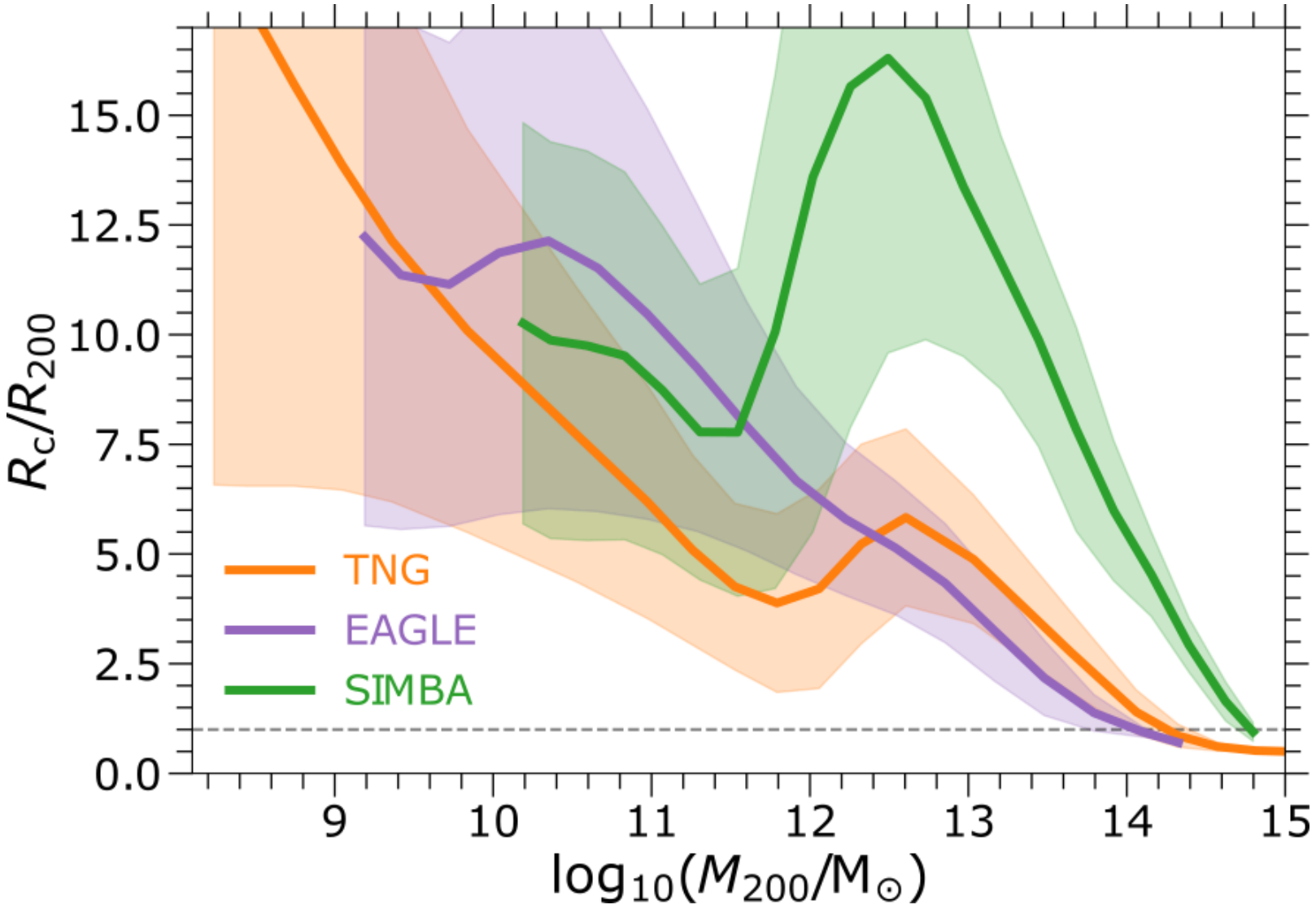
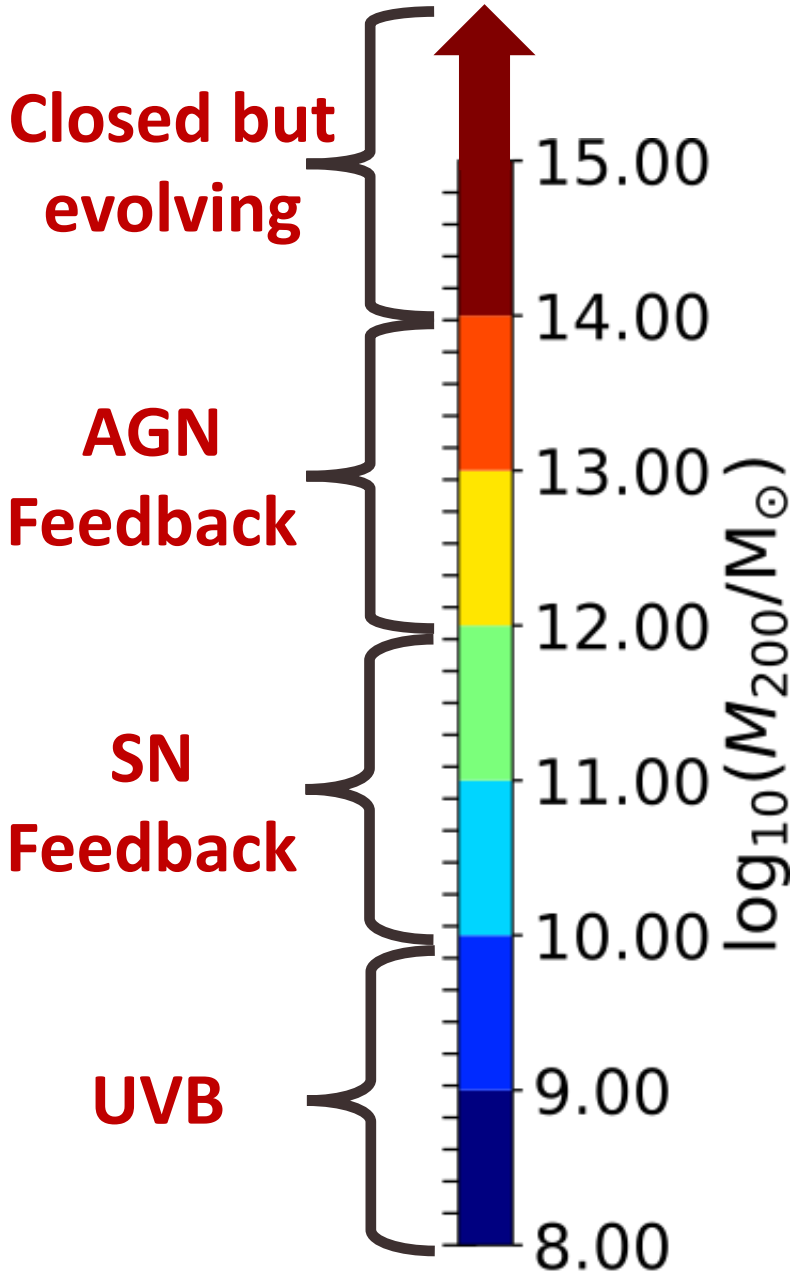
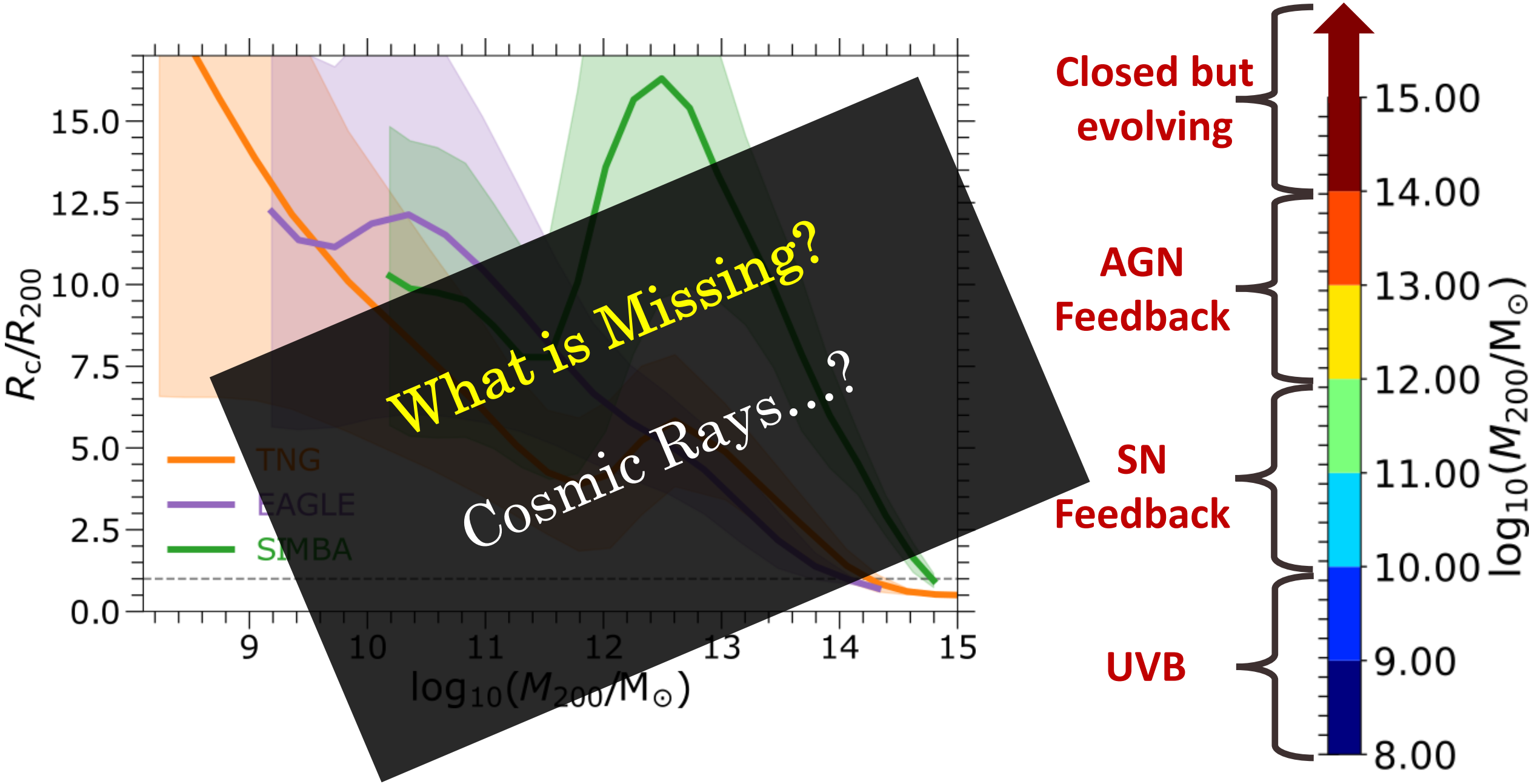




Ayromlou+ 2023b



Ayromlou+ 2023b

Preliminary Results (Not Shown)

Predicting the closure radius: A Universal Relation

Closure radius (normalized)

Halo baryon fraction (normalized)

$$\frac{R_{\rm c}}{R_{\rm 200c,500c}} - 1 = \beta(z)\left[1 - \frac{f_{\rm b}(< R_{\rm 200c,500c})}{f_{\rm b,cosmic}}\right]$$

$$\beta(z) = \alpha(1+z)^{\gamma}$$

Free parameters

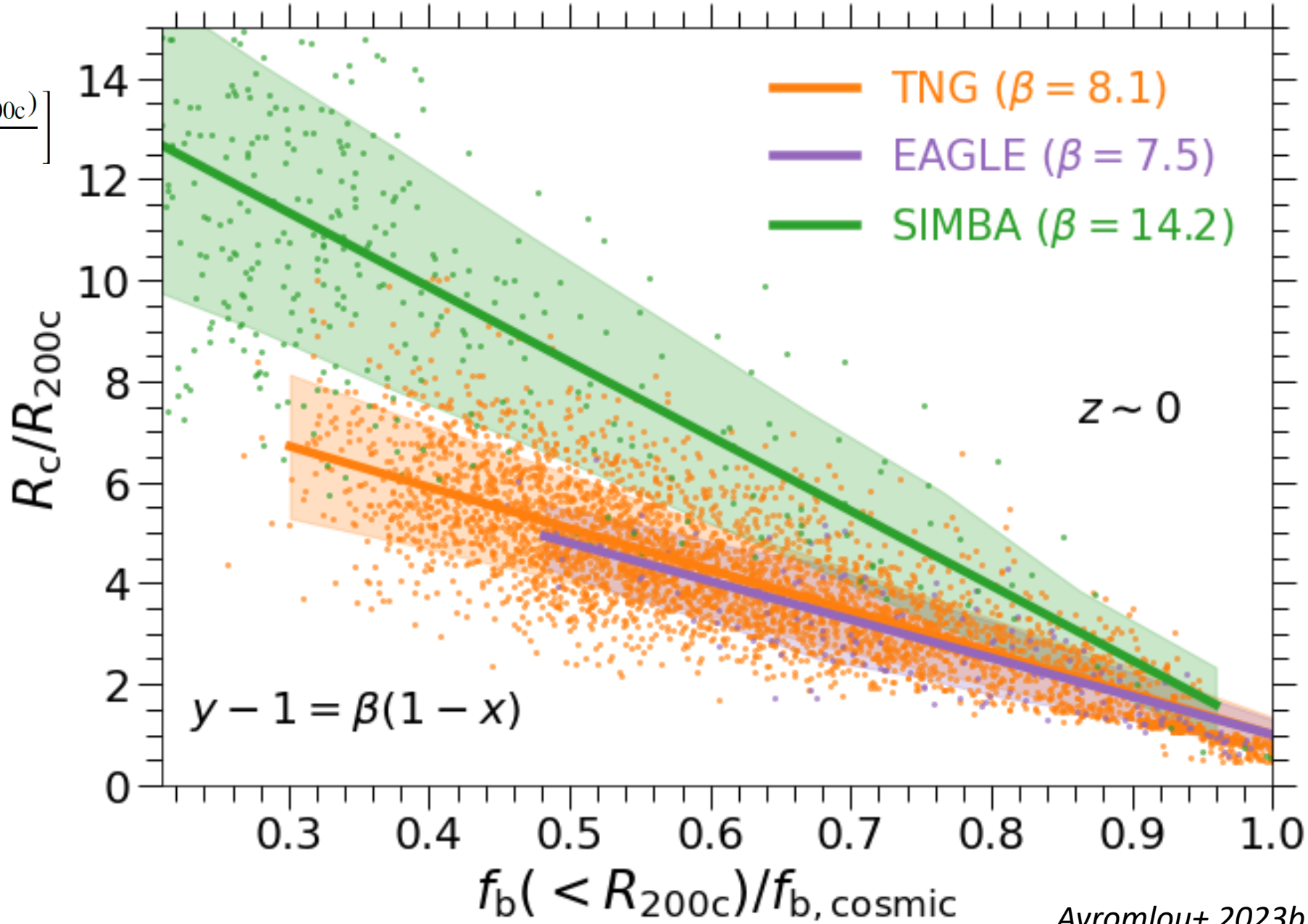
Ayromlou+ 2023b

Predicting the closure radius: A Universal Relation

$$\frac{R_{\rm c}}{R_{\rm 200c,500c}} - 1 = \beta(z)\left[1 - \frac{f_{\rm b}(< R_{\rm 200c,500c})}{f_{\rm b,cosmic}}\right]$$

$$\beta(z) = \alpha\,(1+z)^{\gamma}$$

The **Universal Equation** is valid across all simulations.



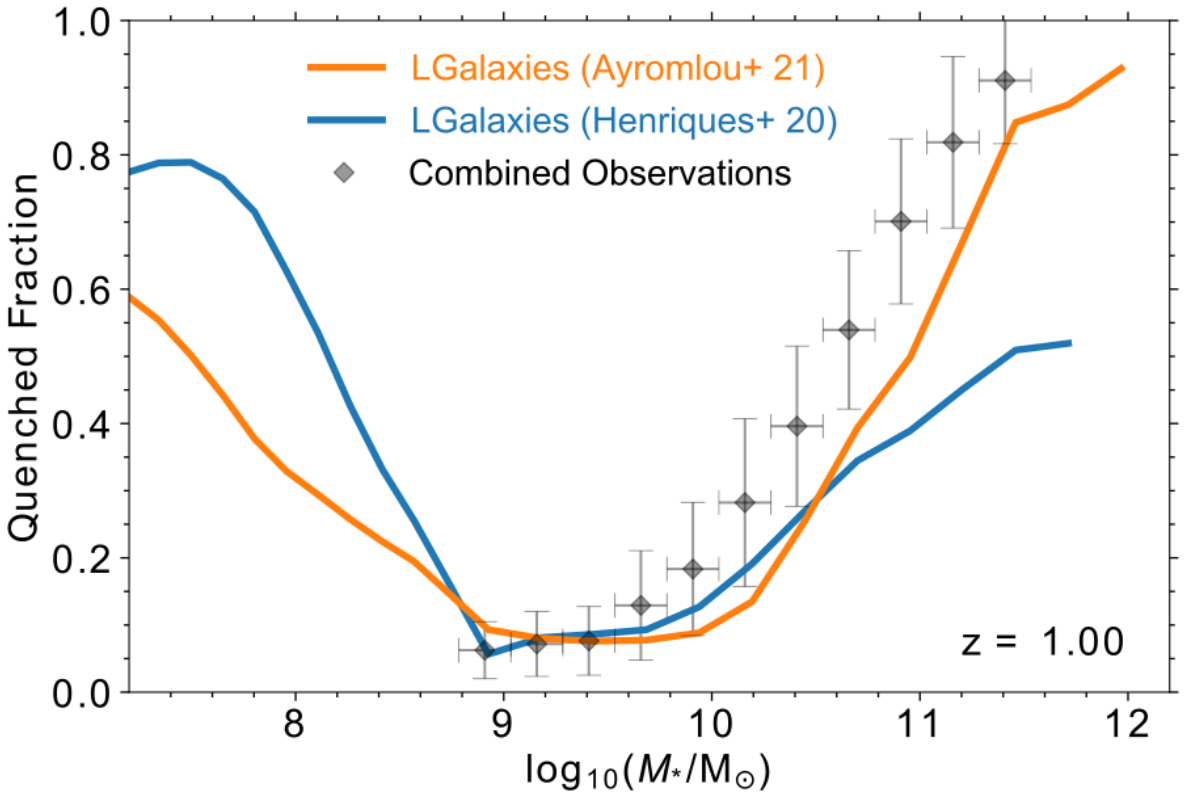
Ayromlou+ 2023b

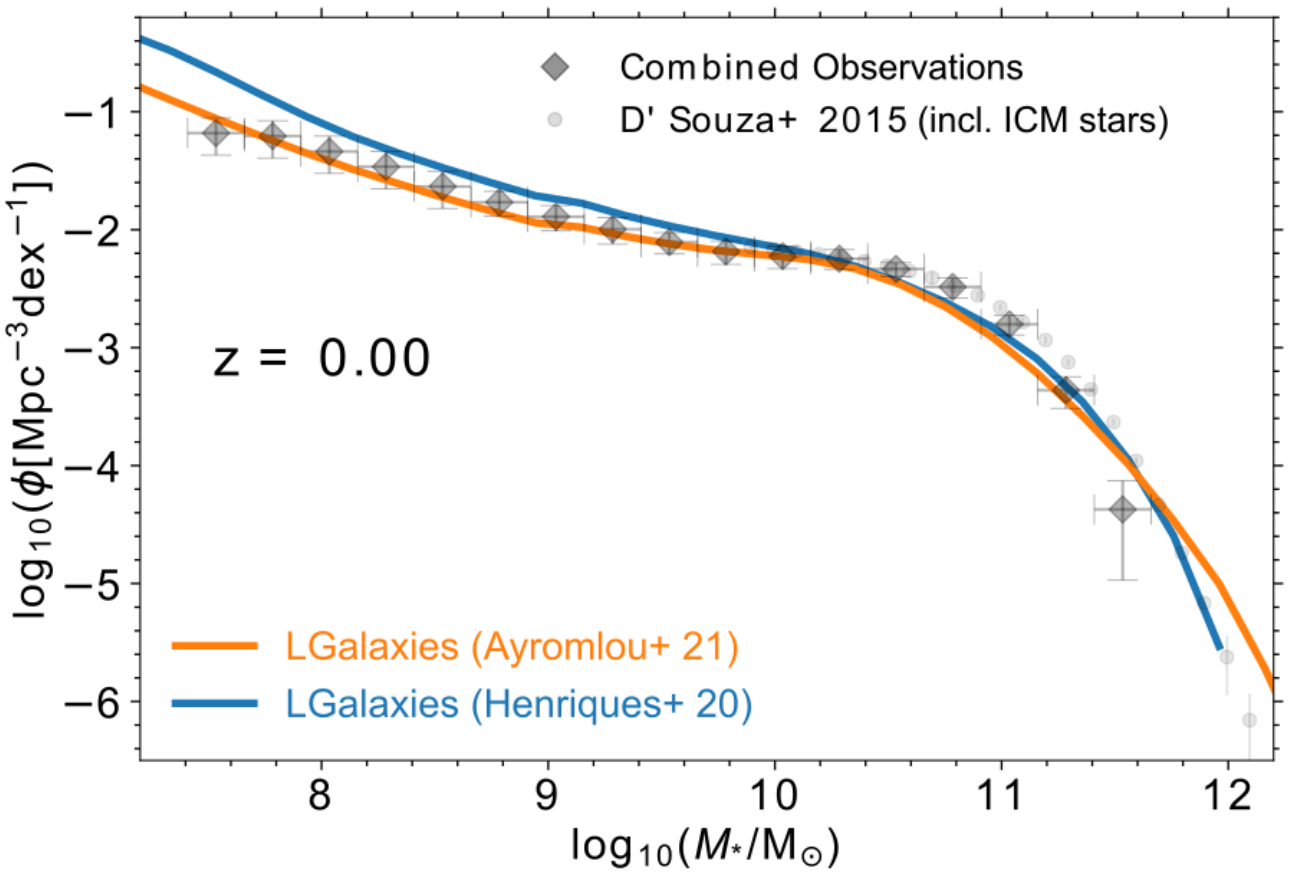
The High-Redshift Universe

Baryon (Re)Distribution and Galaxy Quenching

Low-z Calibration of Models

- Models are typically calibrated against **low-z data** such as **SMF (right)** and **Quenched fraction (left)**

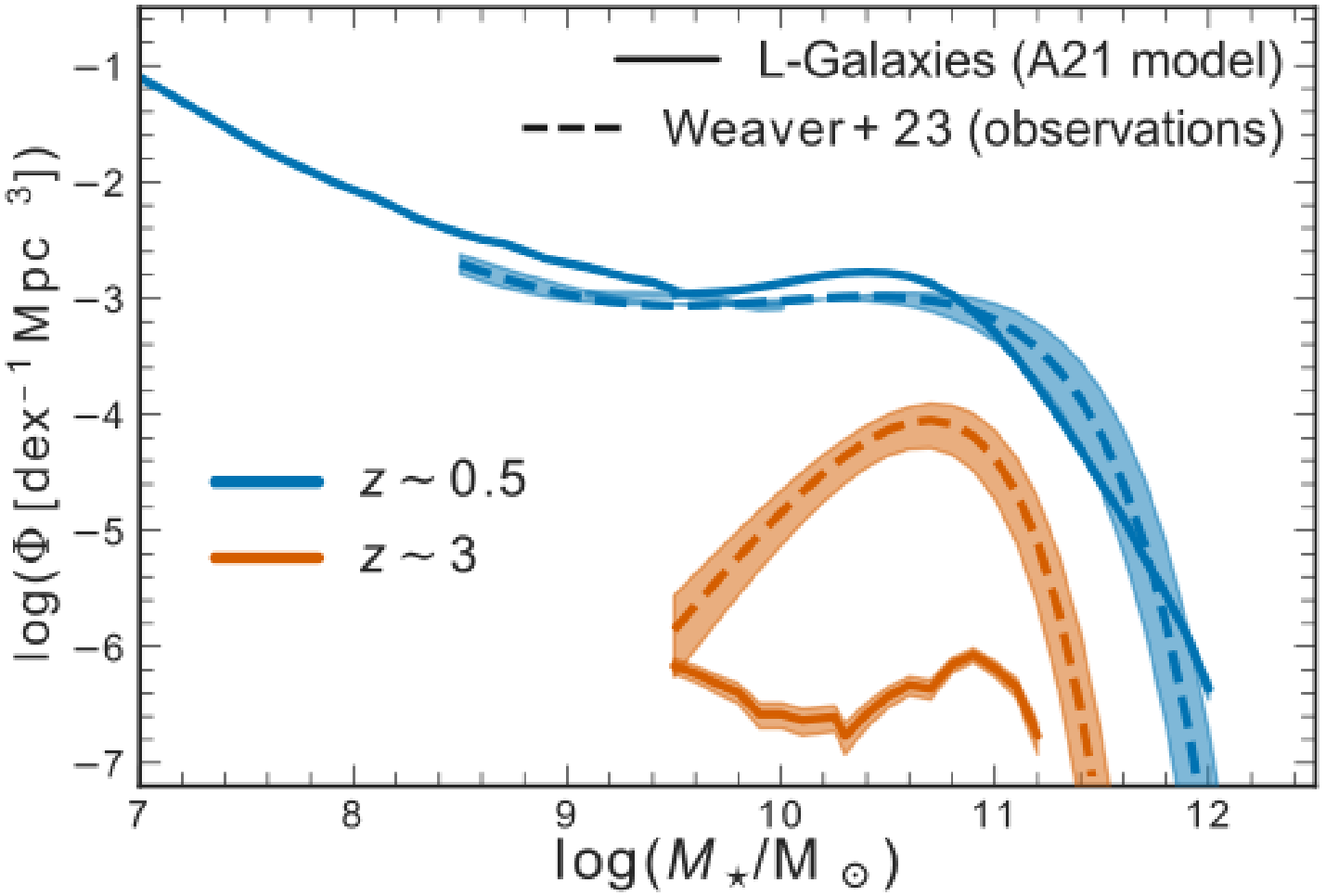




Ayromlou+2021, 2025 in prep.

Stellar Mass Function of Quenched Galaxies

- The total galaxy stellar mass function of agrees with data out to z=6
- **L-Galaxies underpredicts the stellar mass function of quenched galaxies at z>2**

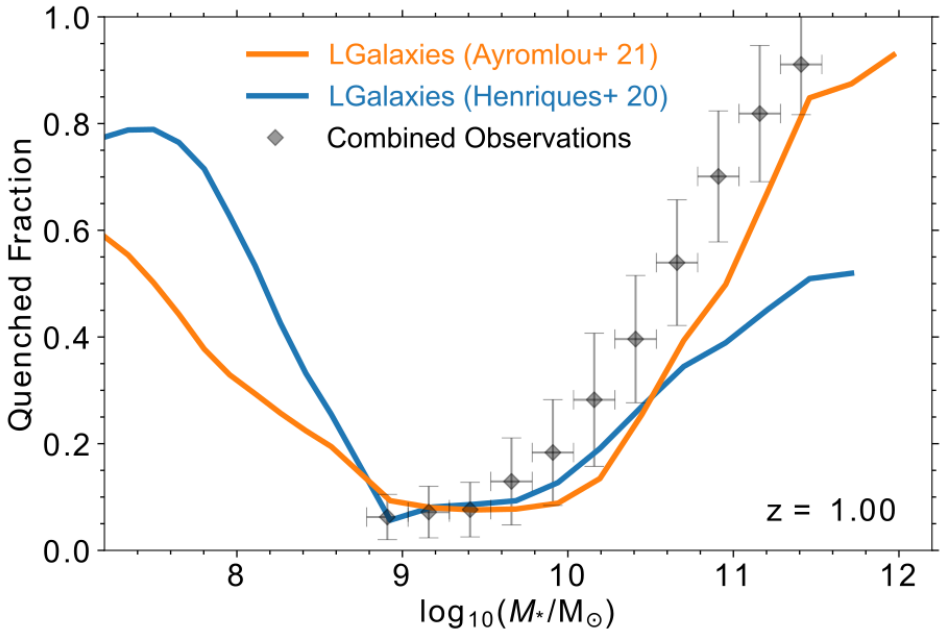


See also Valentino+ 2023, Hartley+ 2023, Remus+2024, De Lucia+ 2024, Lagos+ 2024, Weller+2024, and …

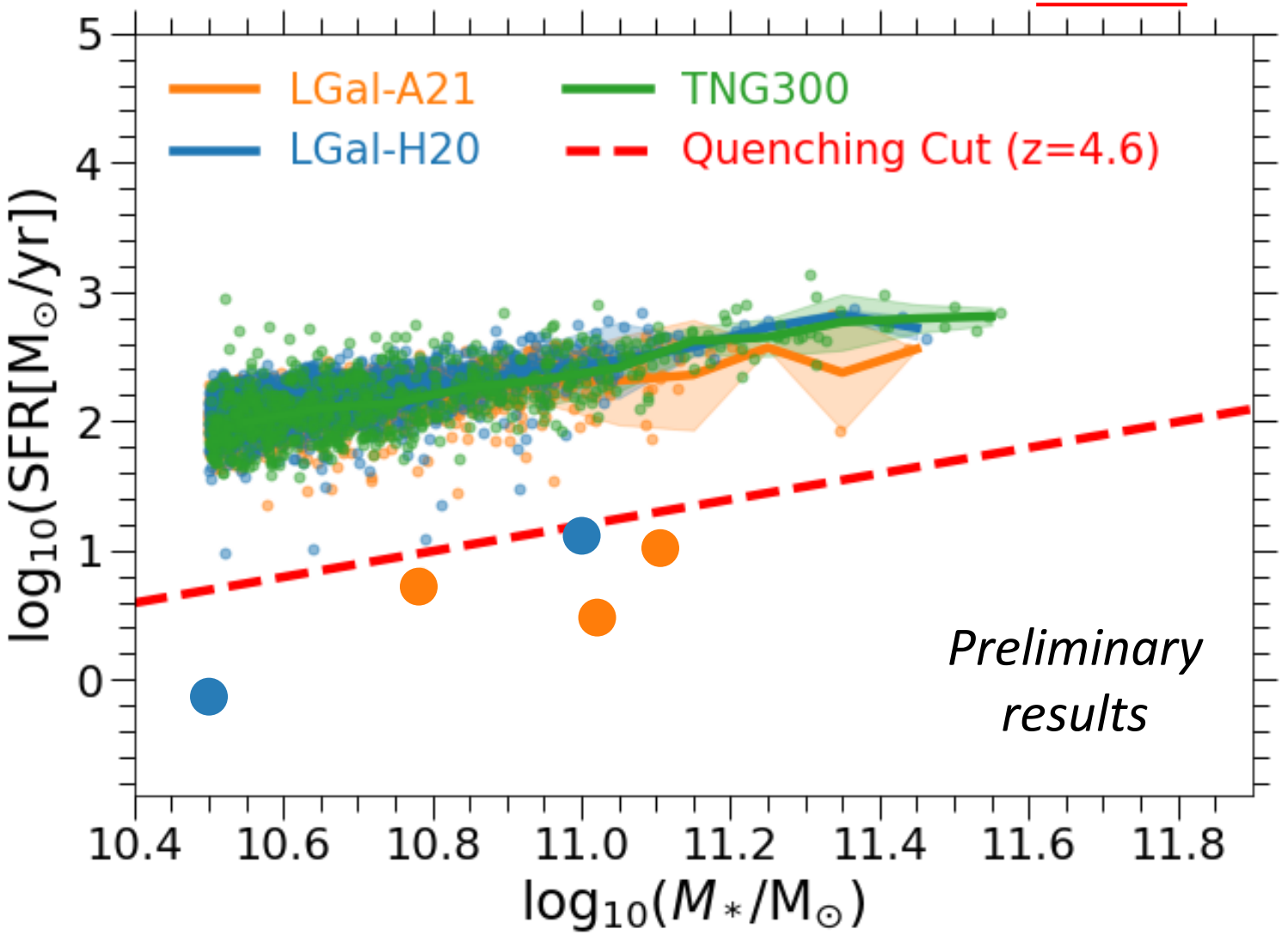
Vani+ 2025

Galaxy Quenching at z~4.6

Preliminary results



Simulations may have a few quenched galaxies at z>3, but not enough to reproduce the high-z observations.



See also Valentino+ 2023, Hartley+ 2023, Remus+2024, De Lucia+ 2024, Lagos+ 2024, Weller+2024, …

Ayromlou+ 2025 in prep.

Preliminary Results (Not Shown)

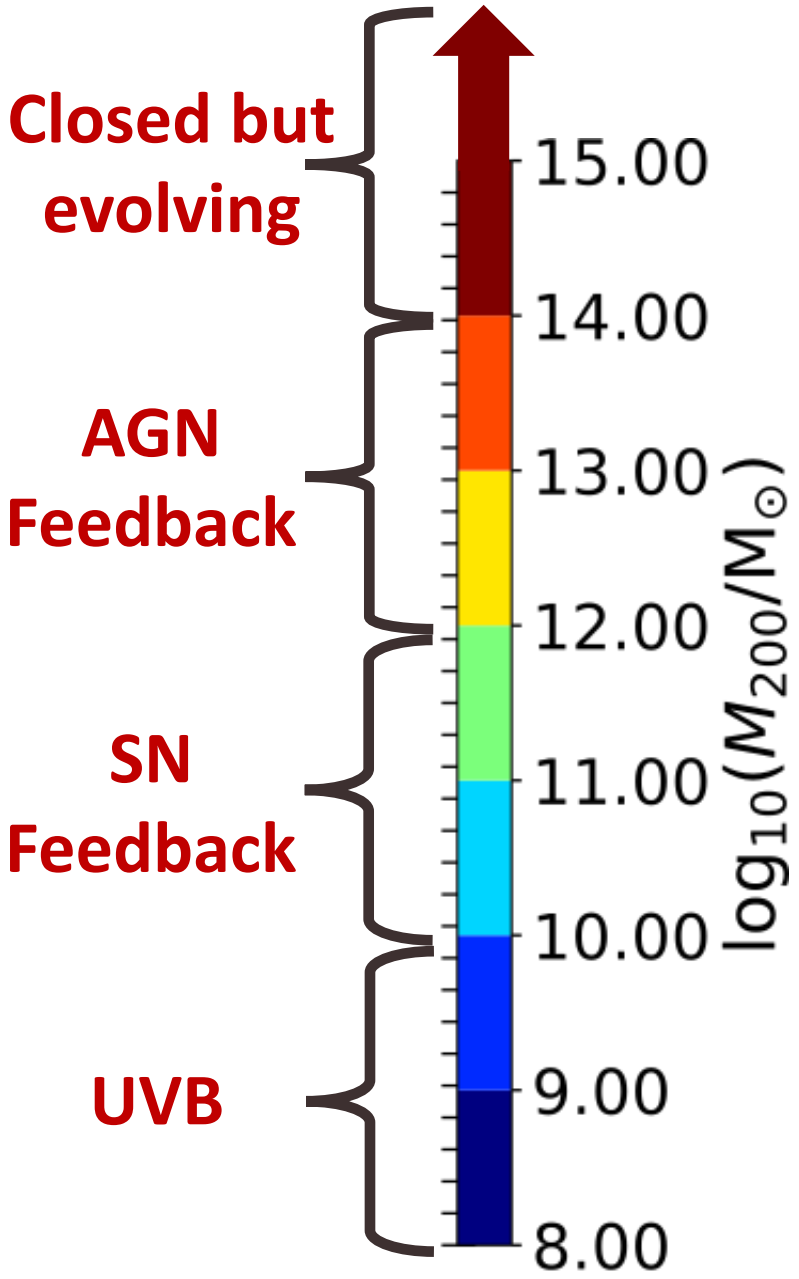
Summary

- **The Closure Radius** is the halocentric distance within which all baryons associated with dark matter are found.

- **The Universal Equation** is a (fundamental) scaling relation that predicts the closure radius in observations.

- **Current simulations** predict smaller closure radii at high-z. **BUT** they also underpredict the number density of quenched galaxies at high-z.

- **A New AGN Feedback Model:** Feedback depends on $\dot{M}_{BH}$, M_{BH}, and **SMBH Spin**.



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