What drives the **gas evolution** in different simulations?

The **IllustrisTNG** perspective

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5 November 2026,
Meeting of Young Astronomers and Astrophysicists -
FIKUT NEXTGEN

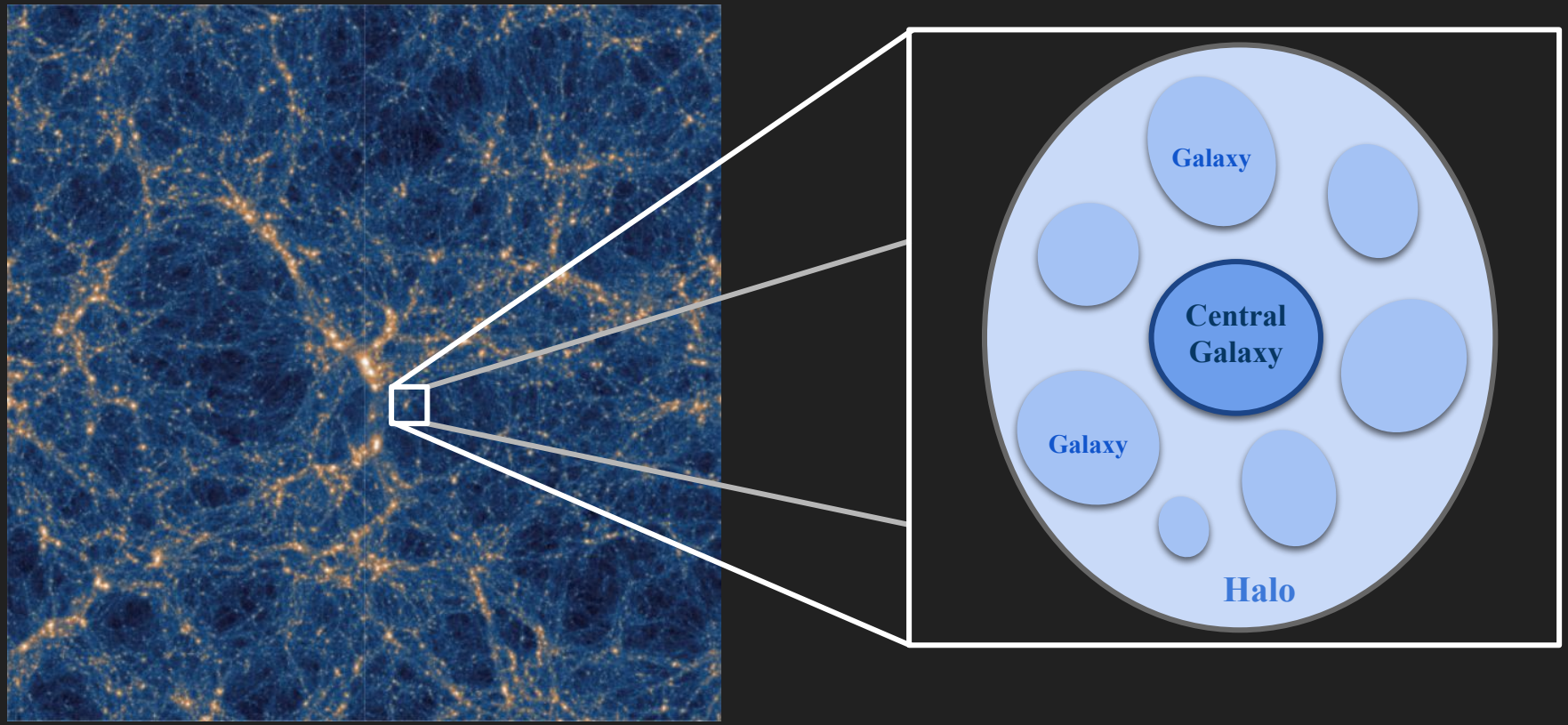




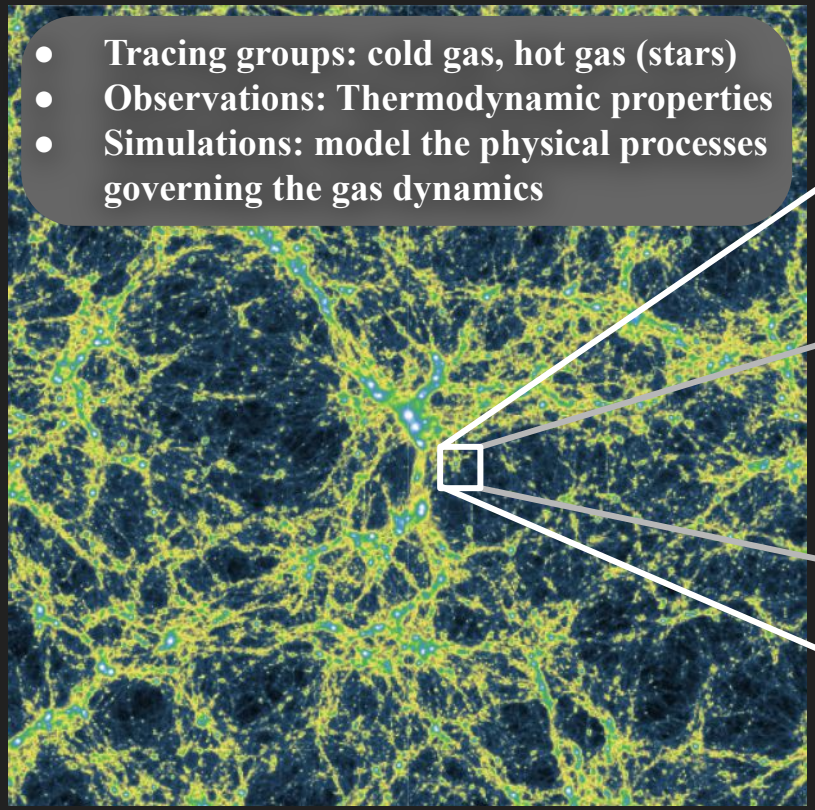




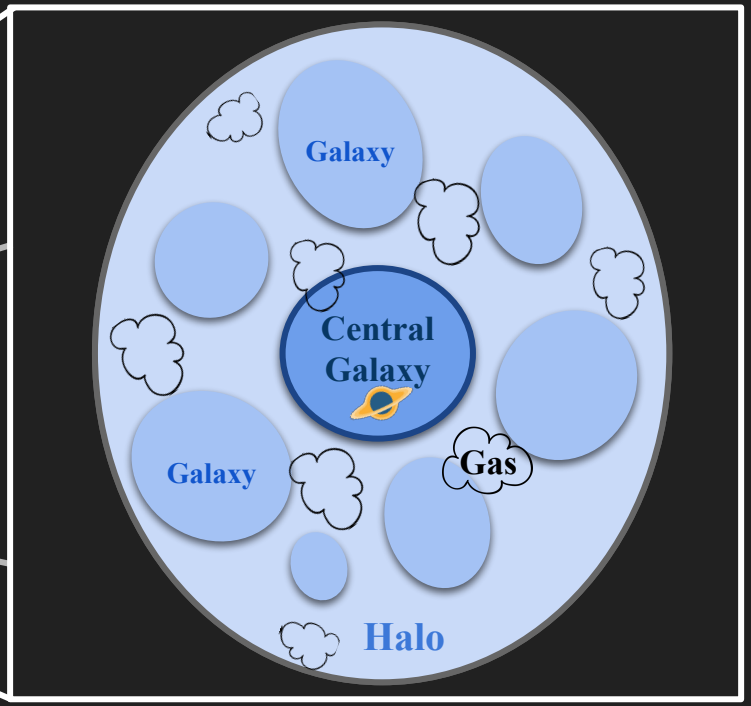
Galaxy Groups and Clusters: the building blocks of the cosmic web



Galaxy Groups and Clusters: the building blocks of the cosmic web



- Tracing groups: cold gas, hot gas (stars)
- Observations: Thermodynamic properties
- Simulations: model the physical processes governing the gas dynamics



Central Black Holes influencing gas dynamics

Galaxy Clusters

- Gravitationally bound galaxies (>100)
- Feedback has marginal effect on temperature and density

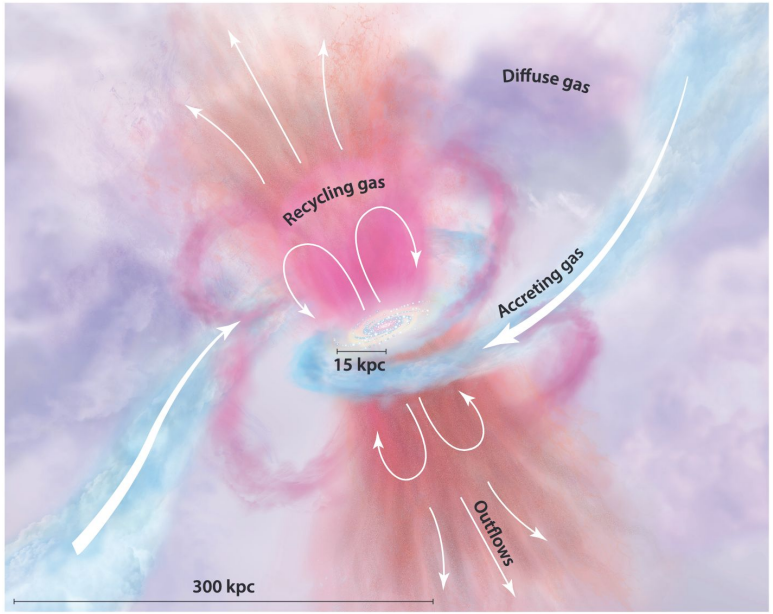


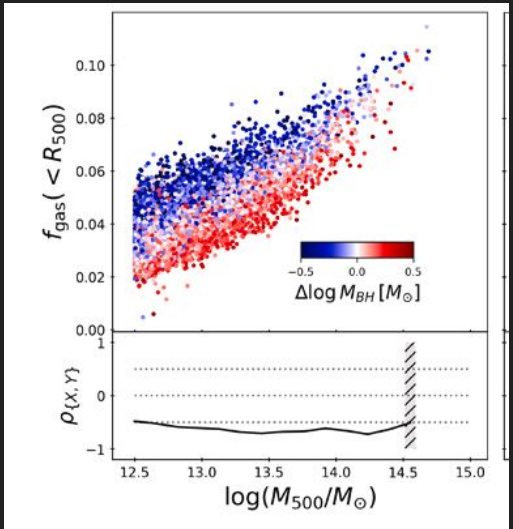
Figure 1

A diagram of the CGM. The galaxy's red central bulge and blue gaseous disk are fed by filamentary accretion from the IGM (*blue*). Outflows emerge from the disk in pink and orange, whereas gas that was previously ejected is recycling. The diffuse gas halo in varying tones of purple includes gas that is likely contributed by all these sources and mixed together over time. Refer to **Supplemental Figure 1** for an alternate version of the figure, which illustrates the different observing techniques we discuss in Section 3. Abbreviations: CGM, circumgalactic medium; IGM, intergalactic medium.

Galaxy groups

- Gravitationally bound systems, 10-100 galaxies
- Feedback can affect strongly gas properties

Gas mass fraction in different Hydrodynamic Simulations

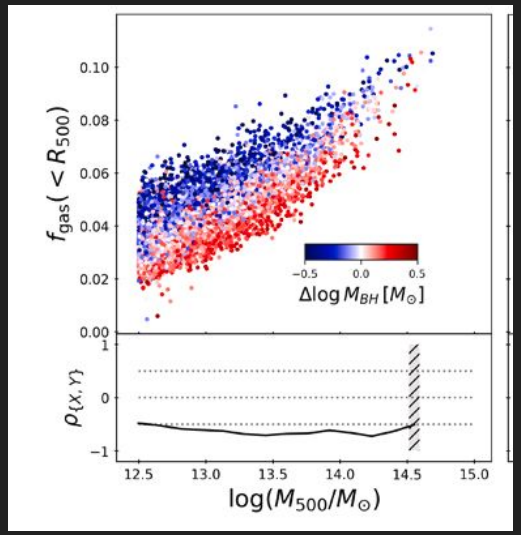


Marini et al. (2025)

Magneticum:

- **High gas fraction → less BH activity**
- **Low gas fraction → significant AGN feedback**

Gas mass fraction in different Hydrodynamic Simulations



Marini et al. (2025)

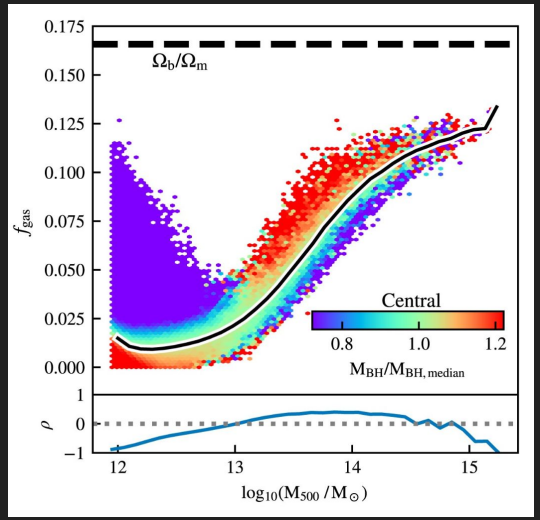
Magneticum:

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FLAMINGO:

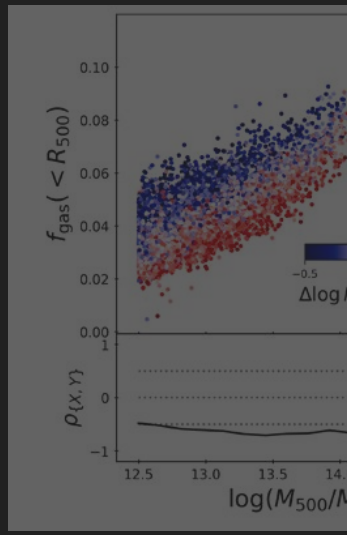
- Different trend between low and high-mass halos

What about other simulations?

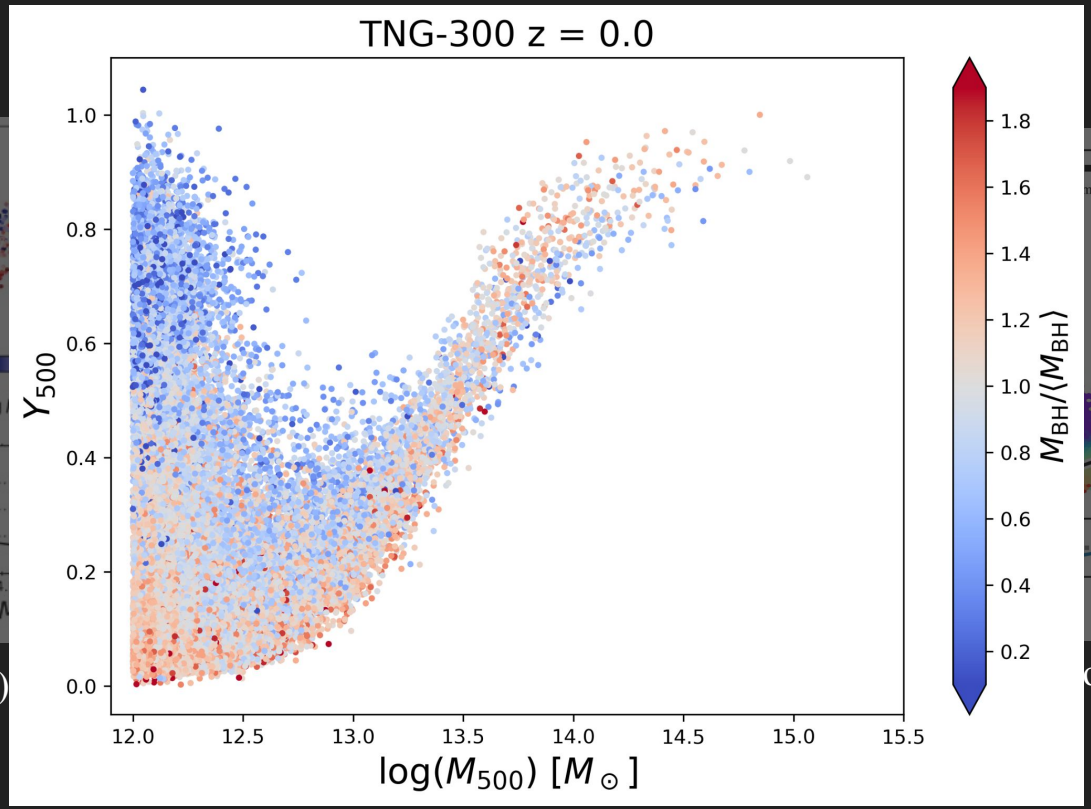


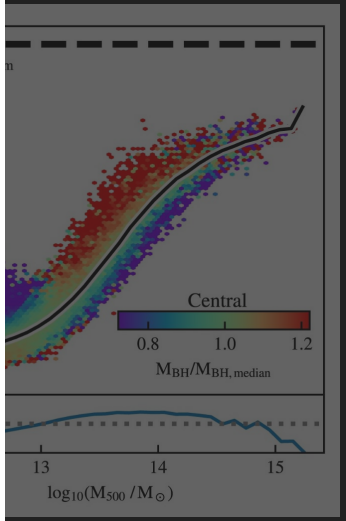
Costello et al. (2026)

Gas mass fraction in IllustrisTNG-300

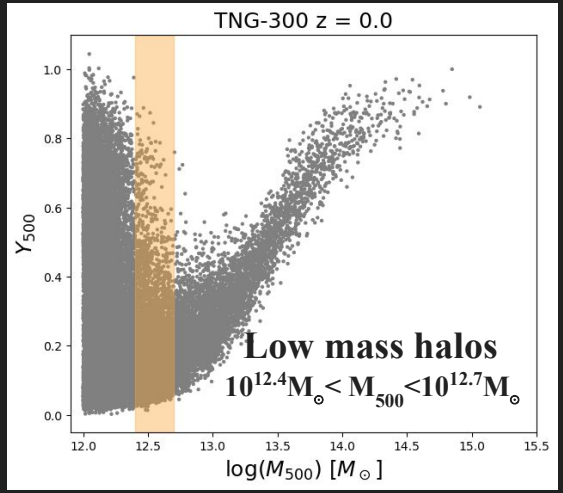


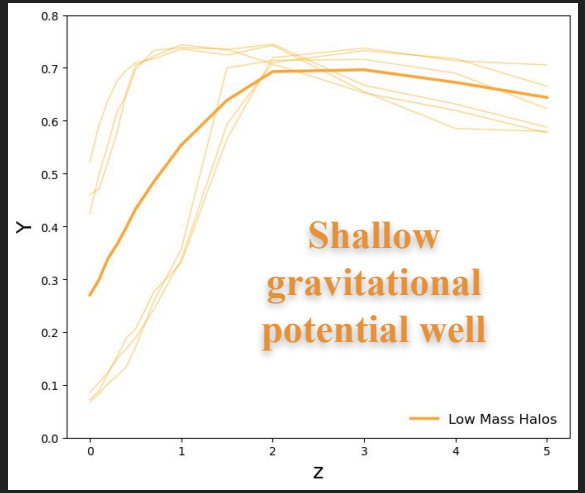
Marini et al. (2025)

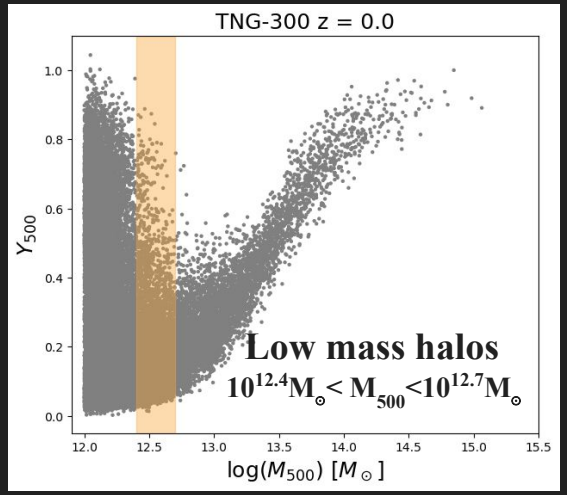


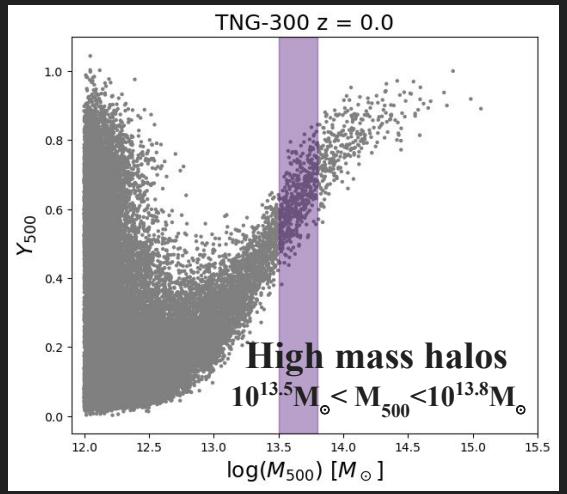


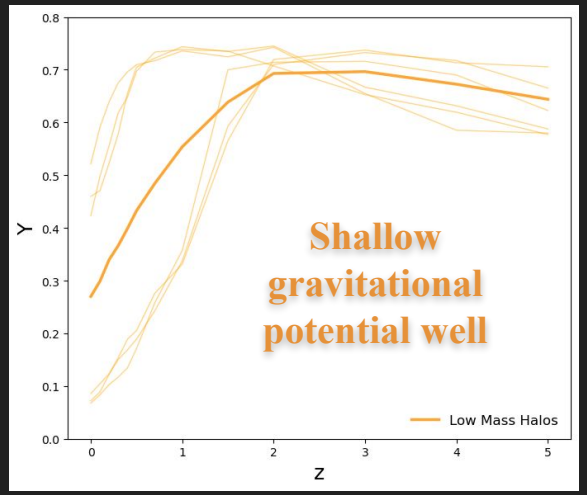
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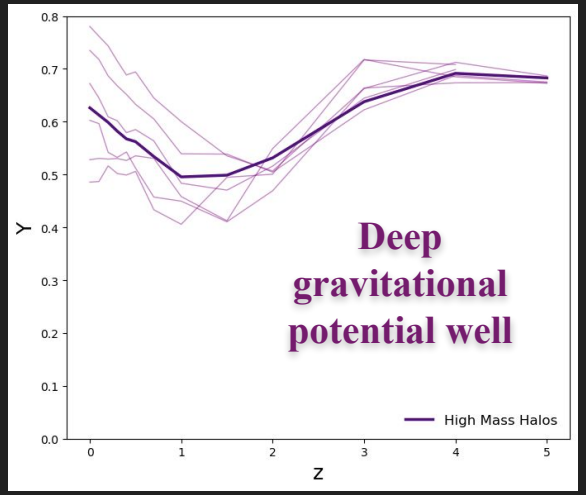

TNG-300 z = 0.0
Y_{500}
log(M_{500}) [$M_\odot$]
Low mass halos
$10^{12.4}M_\odot < M_{500} < 10^{12.7}M_\odot$

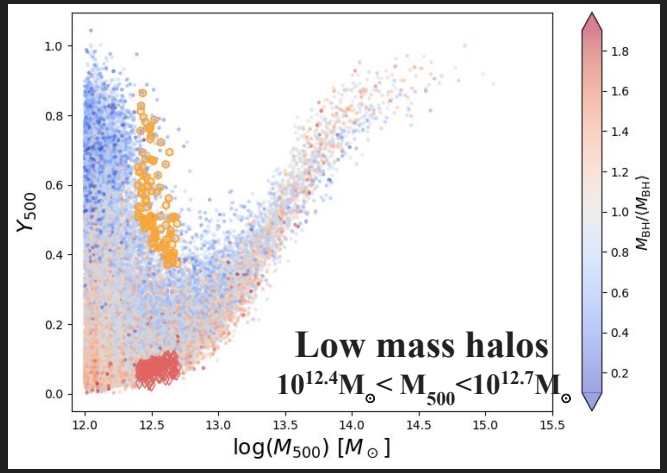

Y
z
Shallow gravitational potential well
Low Mass Halos


TNG-300 z = 0.0
Low mass halos
$10^{12.4}M_\odot < M_{500} < 10^{12.7}M_\odot$
Y_{500}
$\log(M_{500})$ $[M_\odot]$

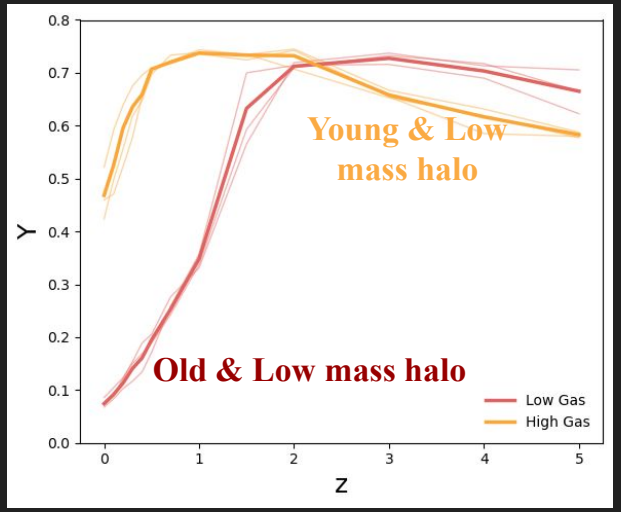

TNG-300 z = 0.0
High mass halos
$10^{13.5}M_\odot < M_{500} < 10^{13.8}M_\odot$
Y_{500}
$\log(M_{500})$ $[M_\odot]$

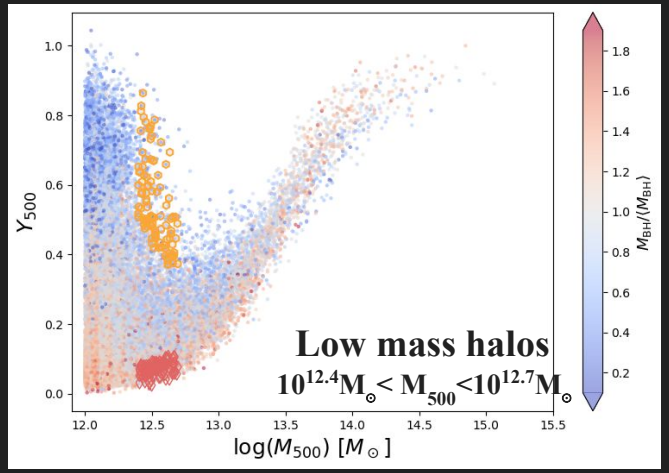

Shallow gravitational potential well
Low Mass Halos
Y
z

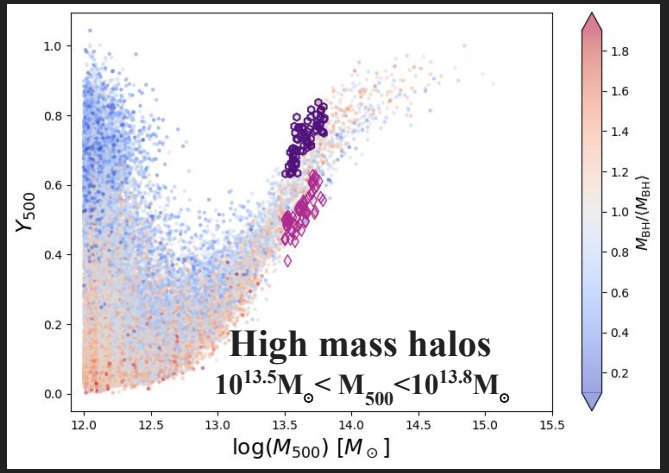

Deep gravitational potential well
High Mass Halos
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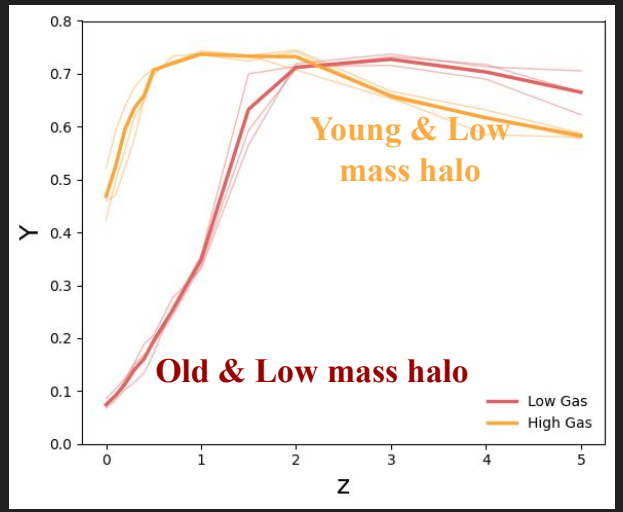
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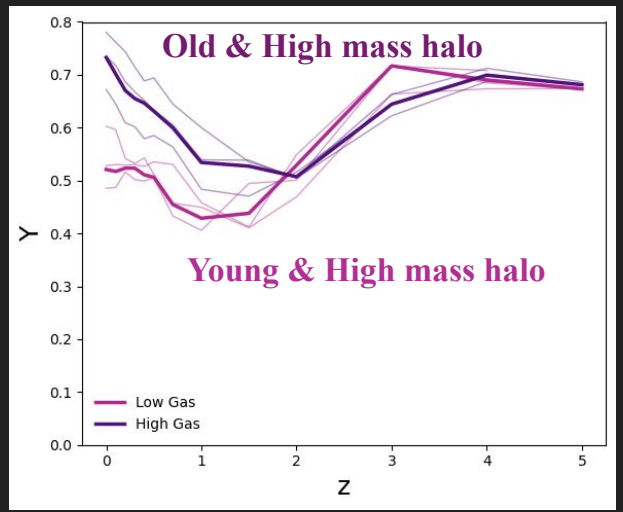






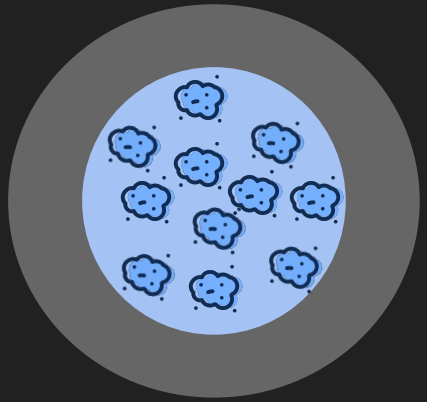
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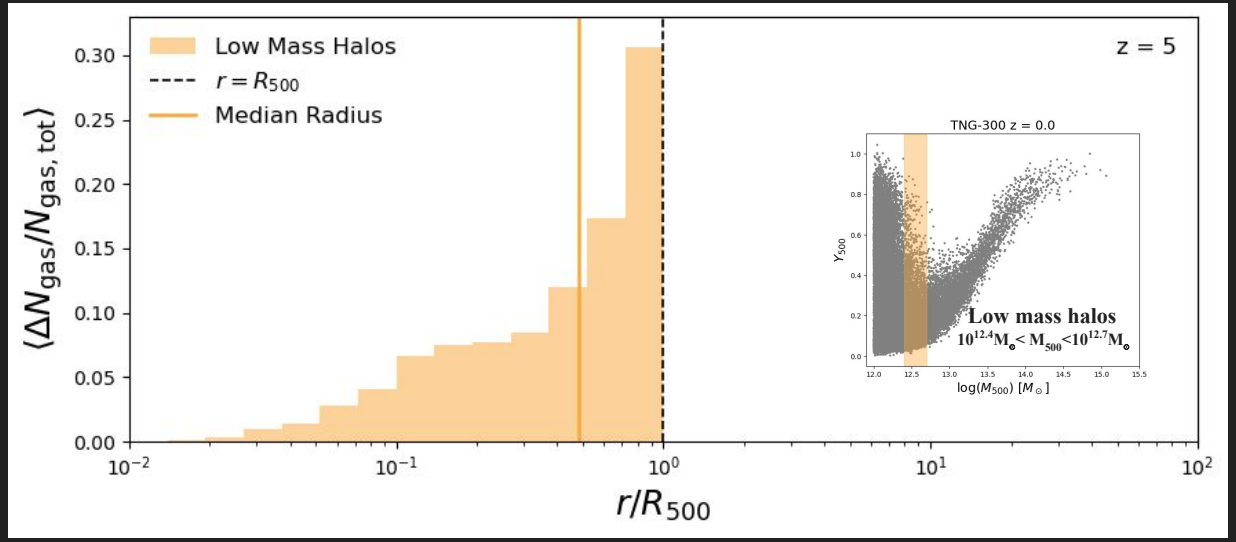




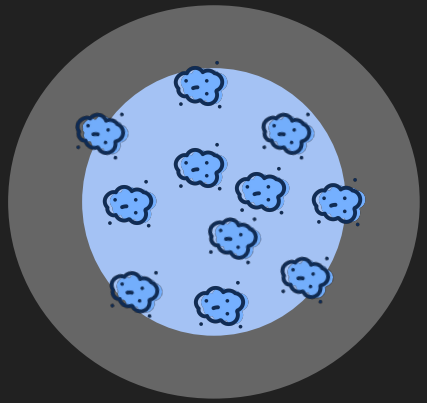
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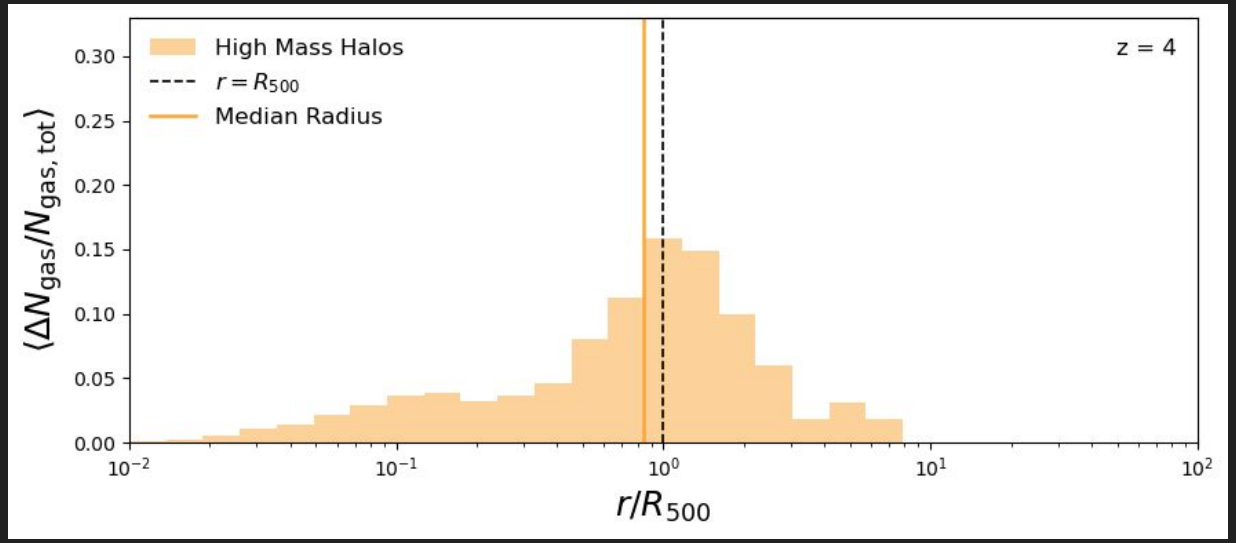
Signs of re-accretion?
LOW MASS HALOS



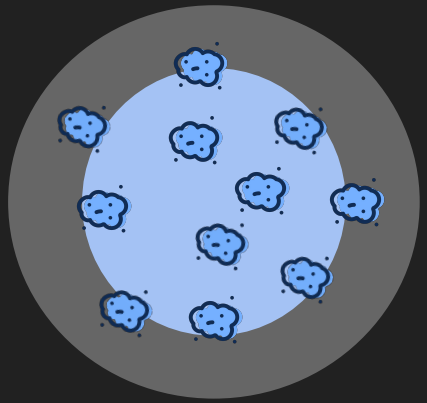


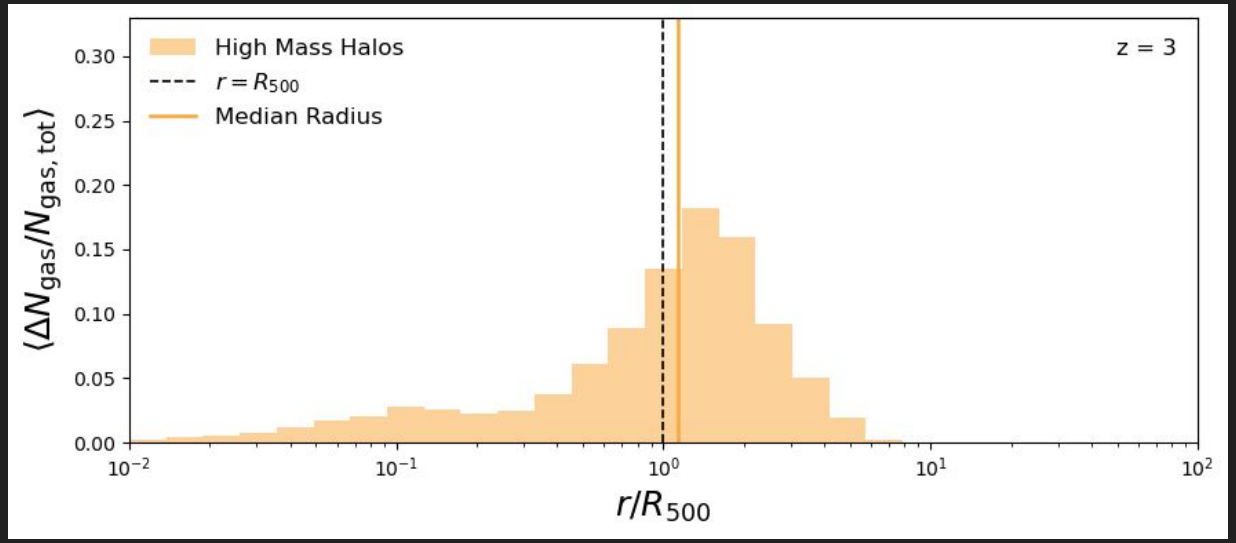
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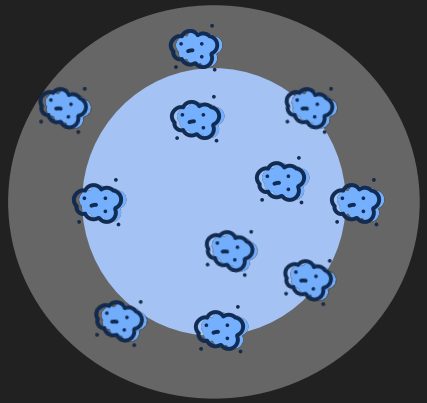


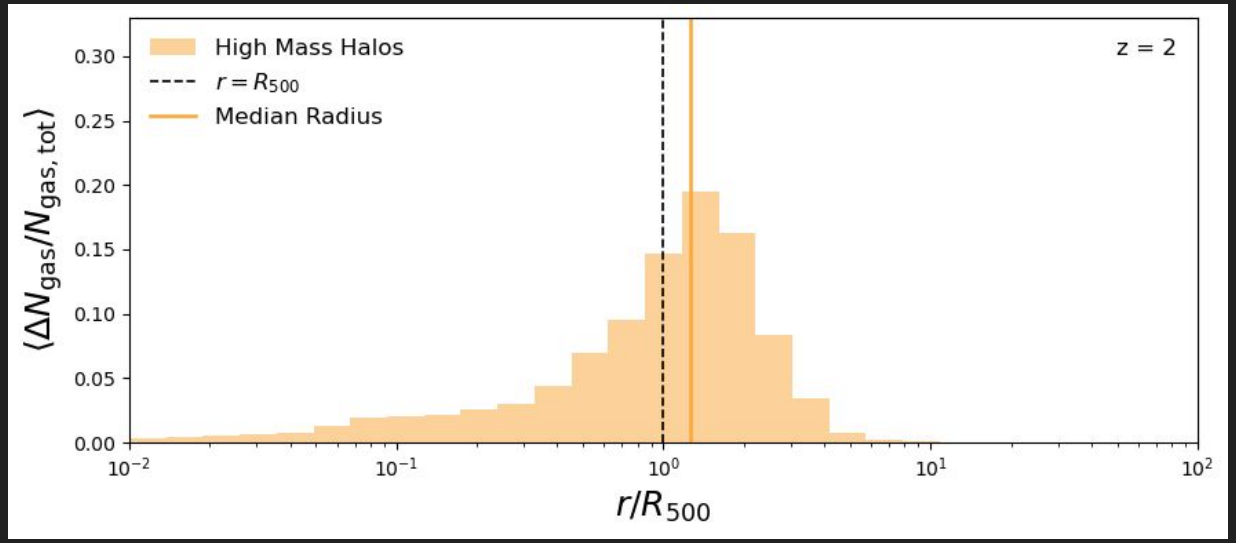
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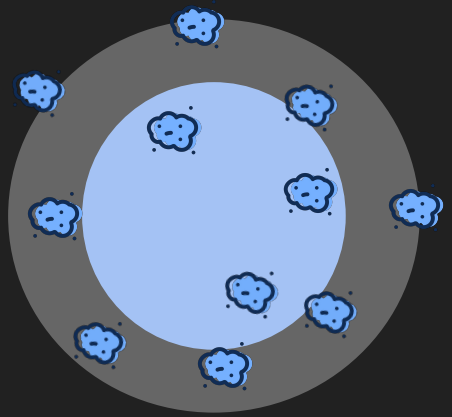


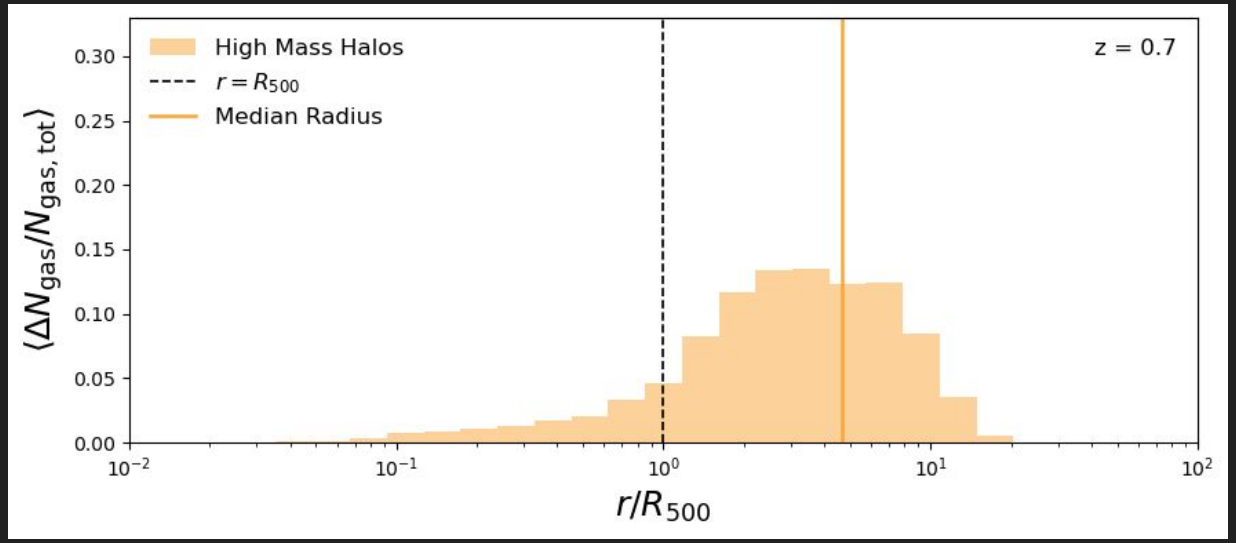
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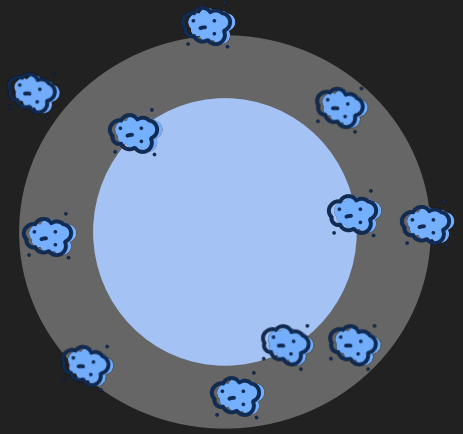


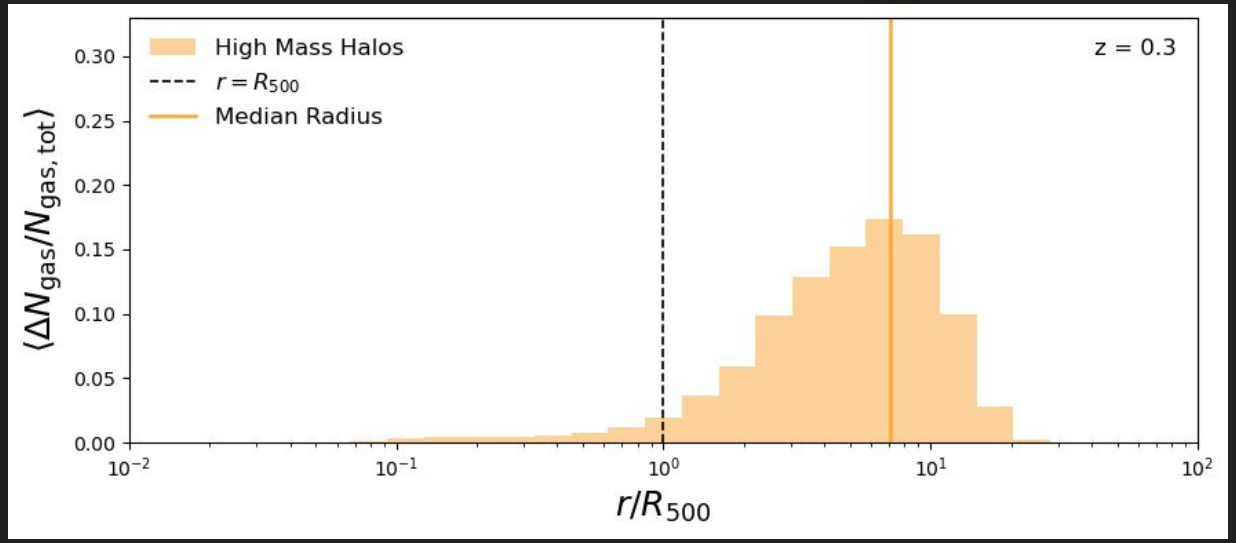
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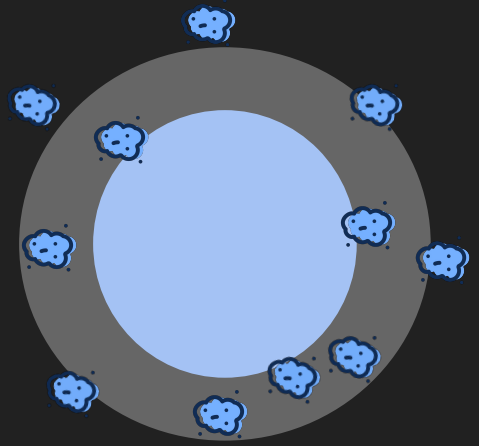


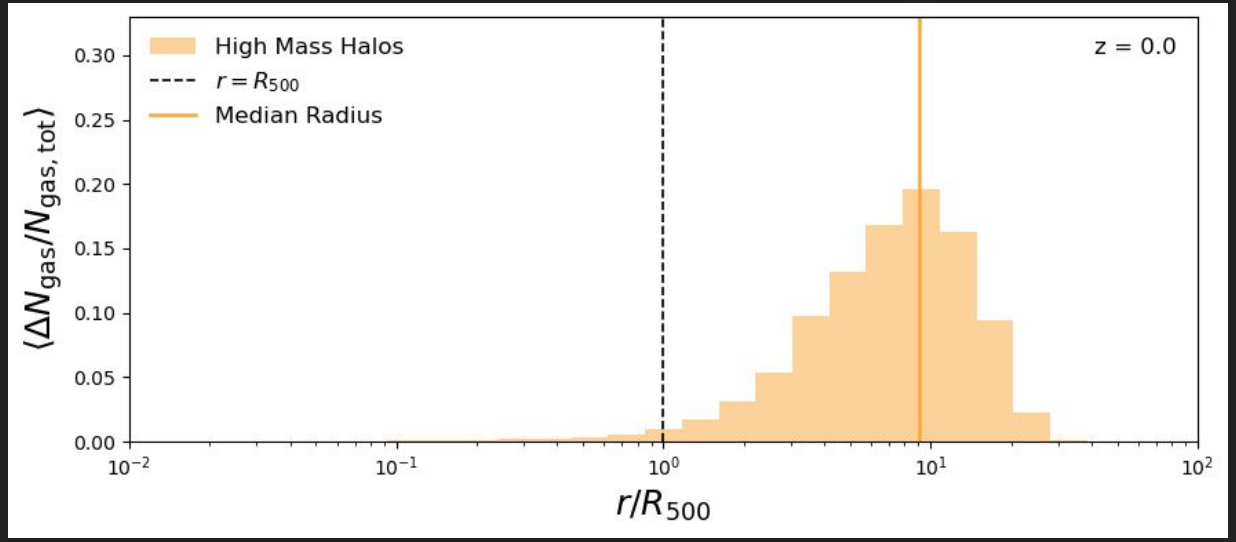
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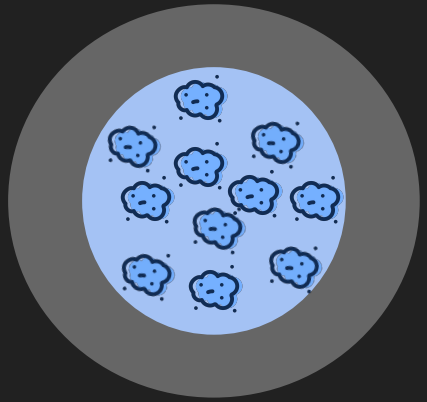


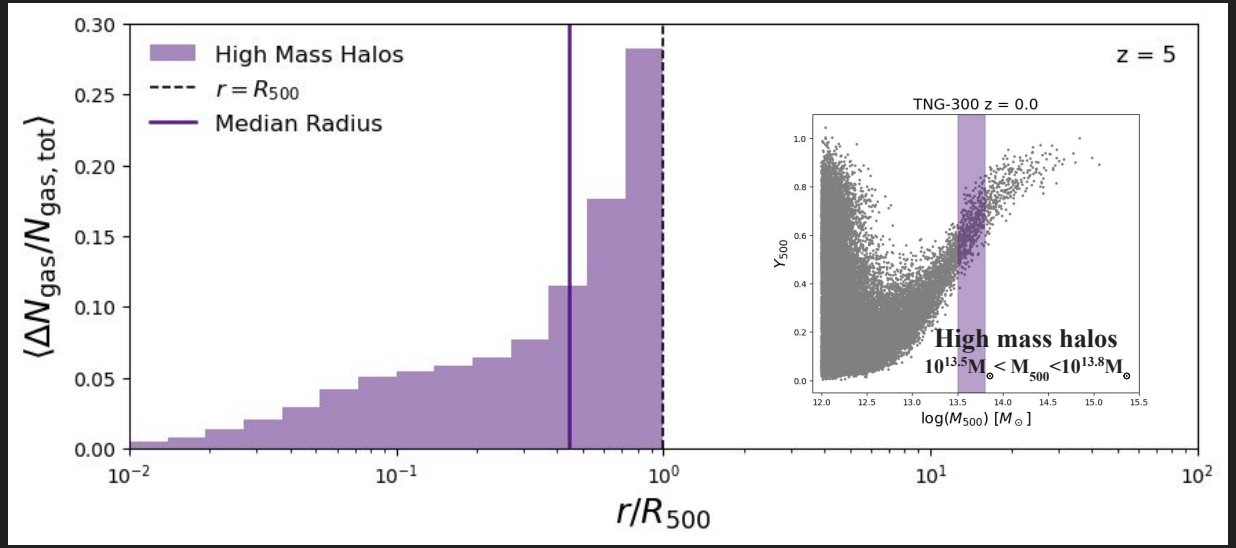
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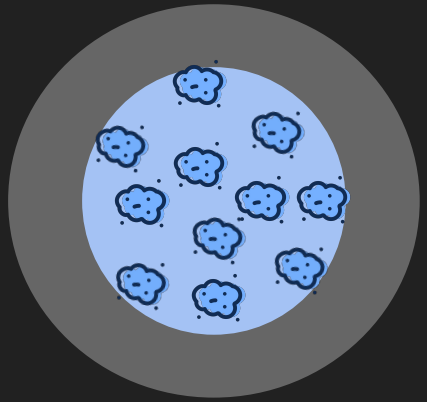


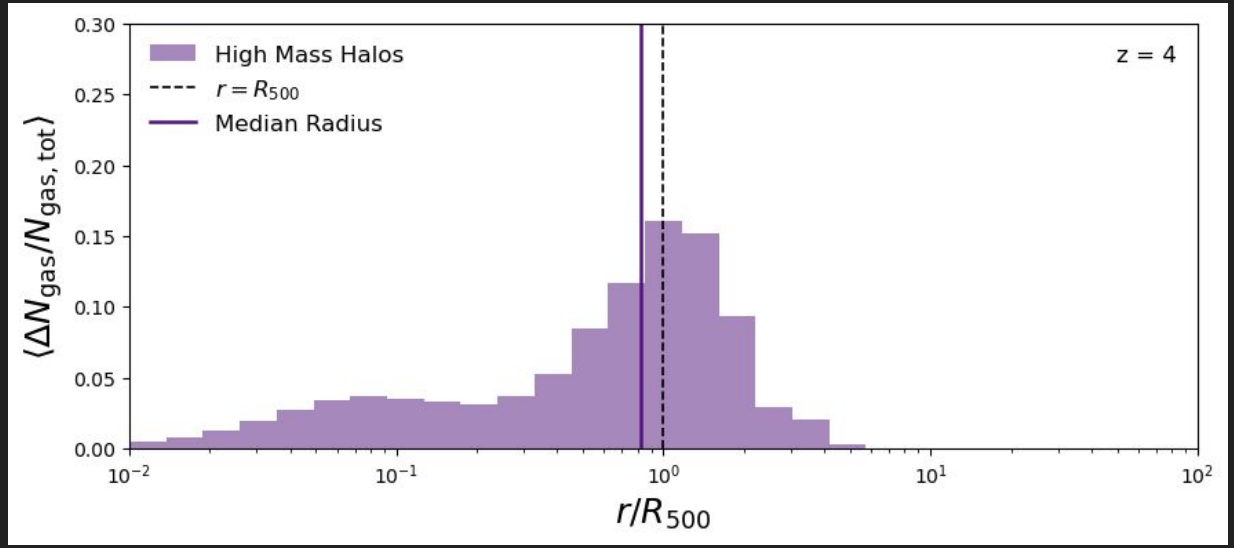
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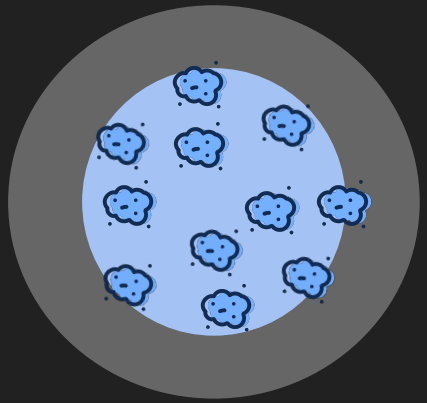


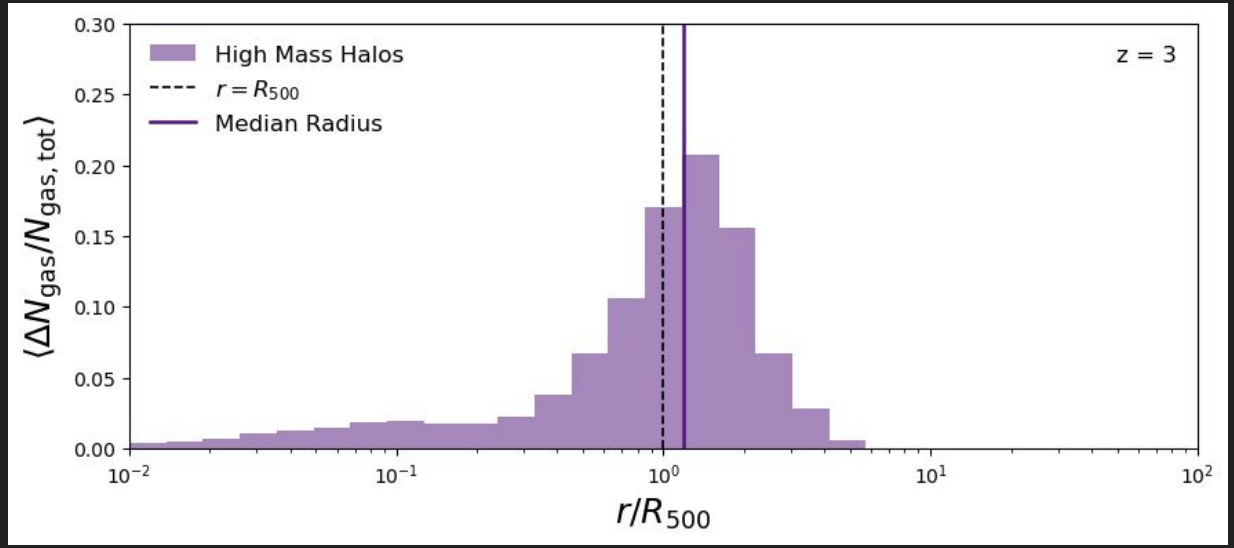
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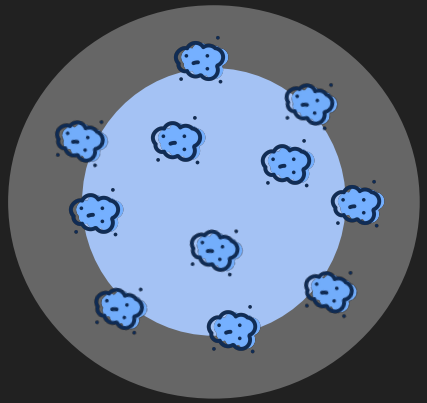


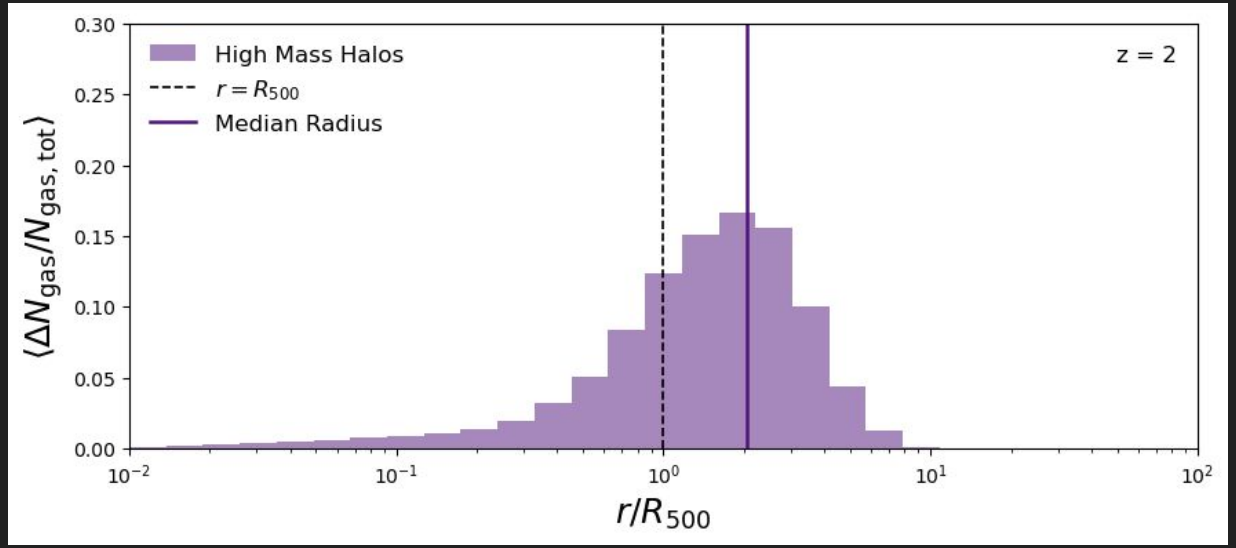
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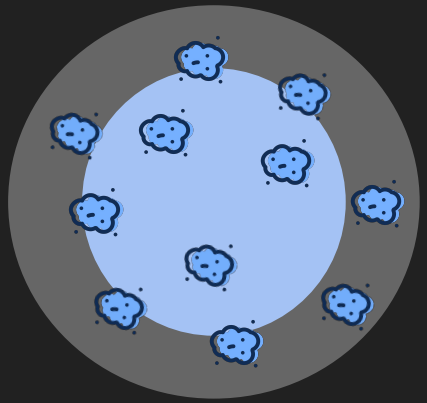


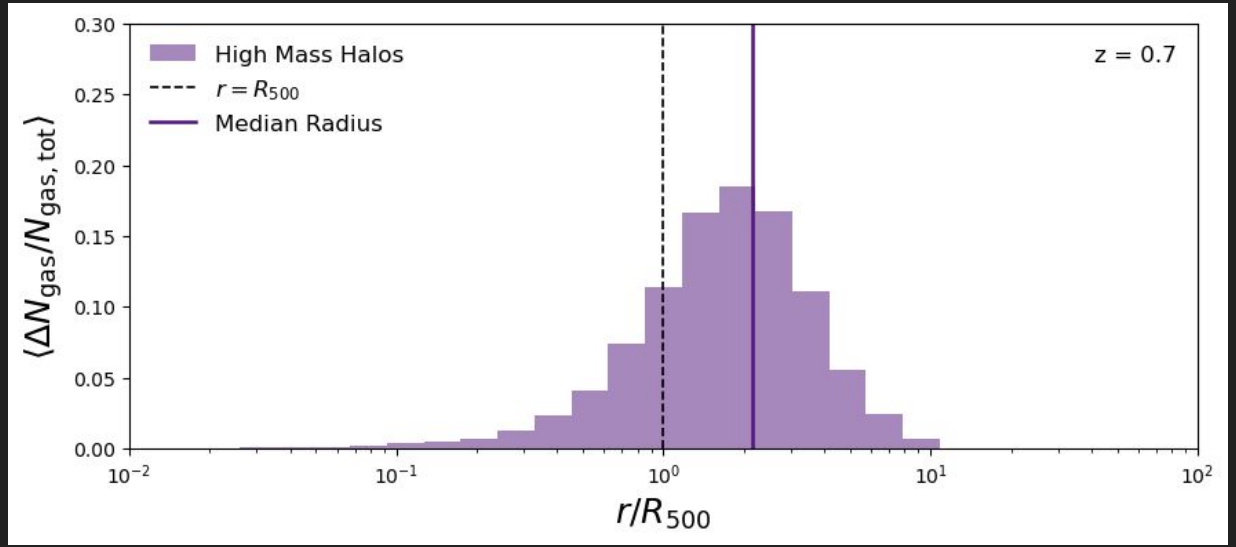
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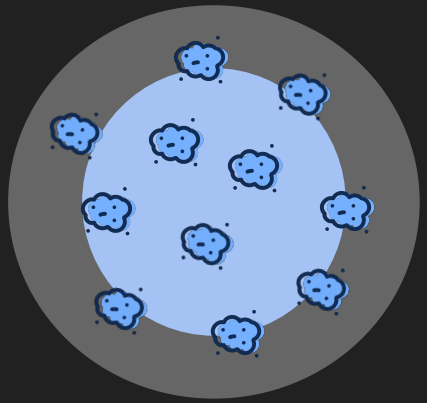


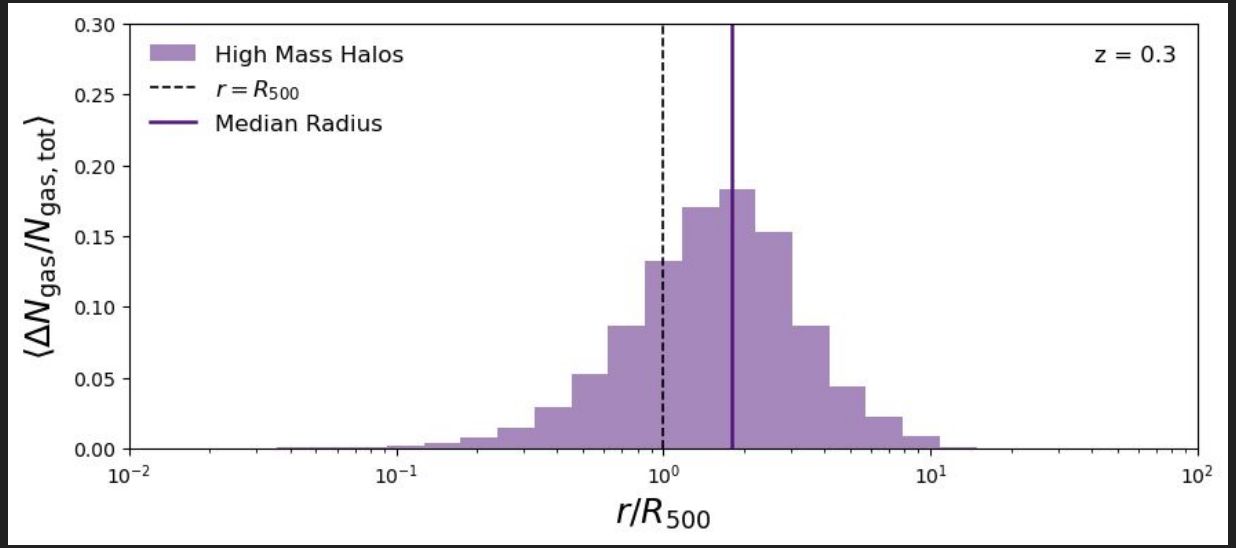
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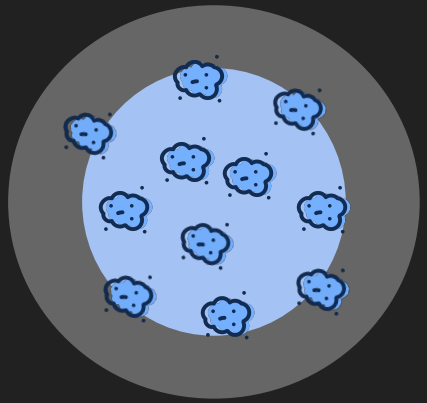


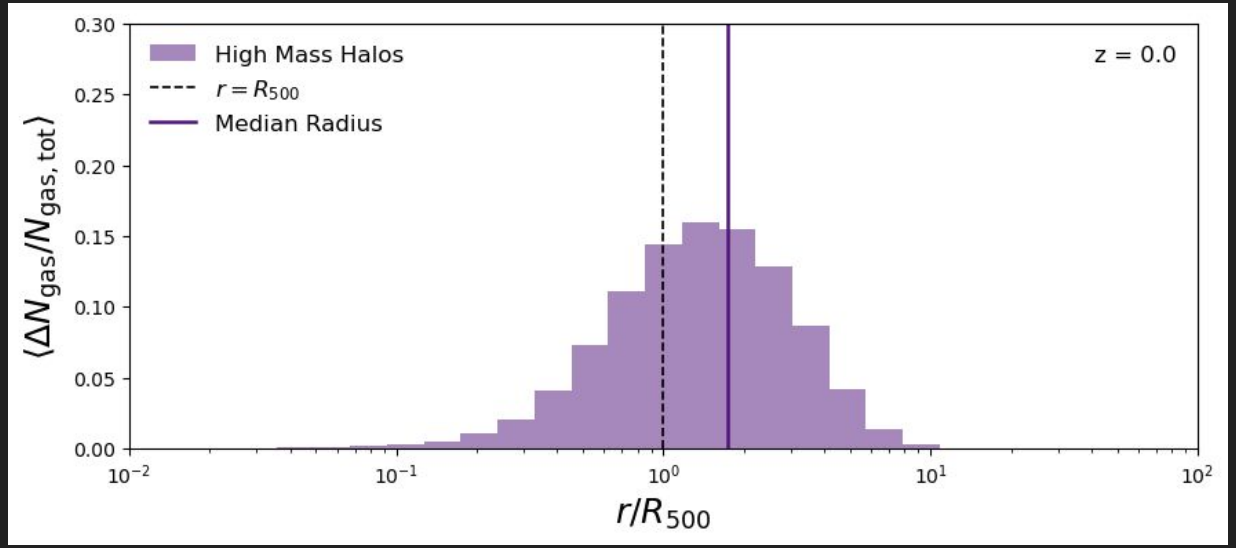
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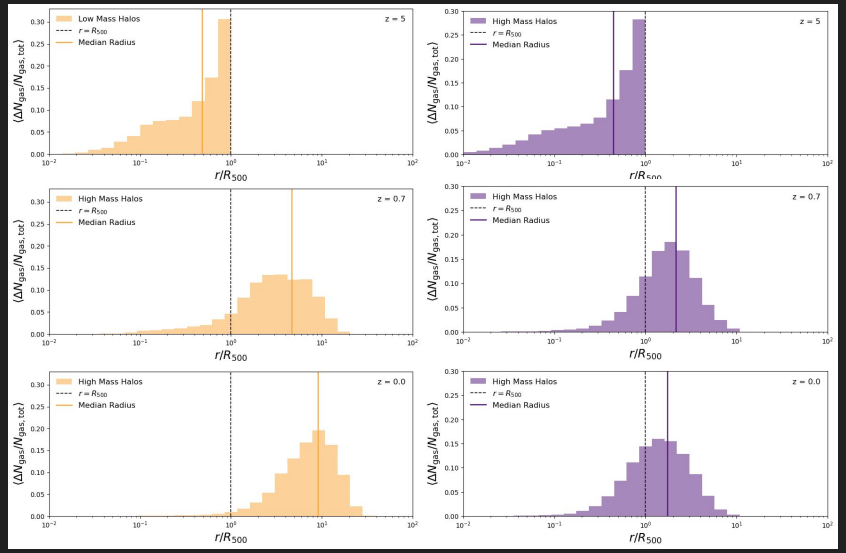
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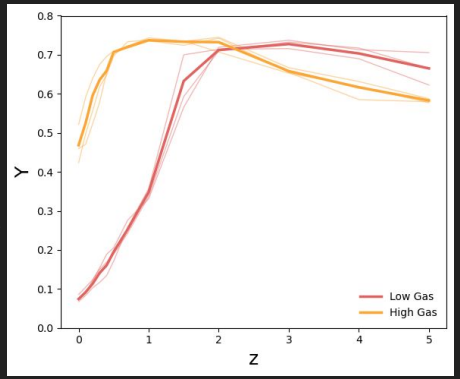


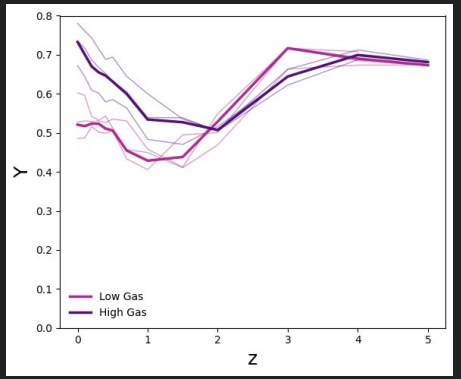


Conclusions

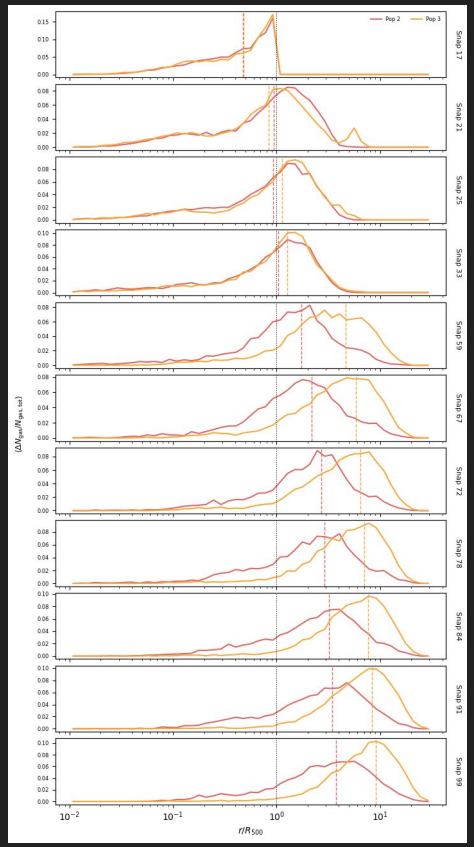
- Gas mass fraction of galaxy groups in **IllustrisTNG** :
  - Similar trend compared to FLAMINGO
  - Inconsistent with Magneticum at high mass
- Low- and High Mass Halos behave differently
  - **Low-Mass**: **gas is pushed out** relative to the group center
  - **High-Mass**: signs of **re-accreting gas** partially explaining the rise in gas fraction
- Split based on **gas fraction** for halos with the same mass reveals **different evolutionary tracks**

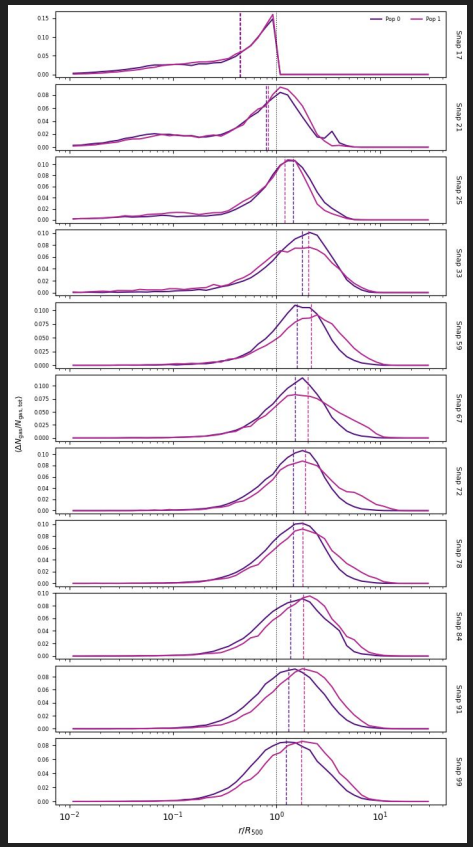






Future plans



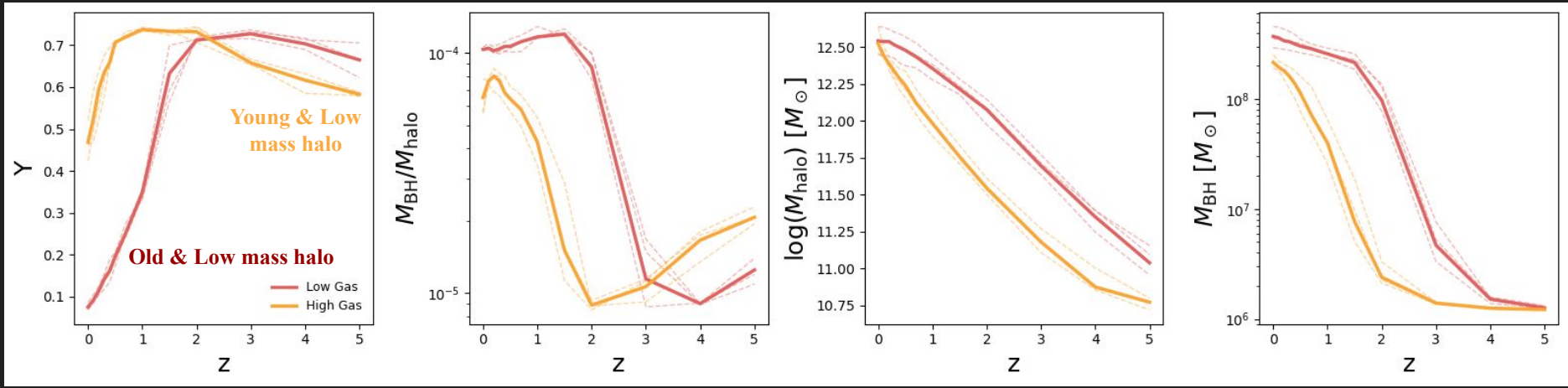


- Further explore what is causing different evolutionary tracks in the case of groups with the same mass:
  - Split in gas mass fraction
  - The environment of galaxy groups can also affect gas evolution potentially explaining this difference

Backup

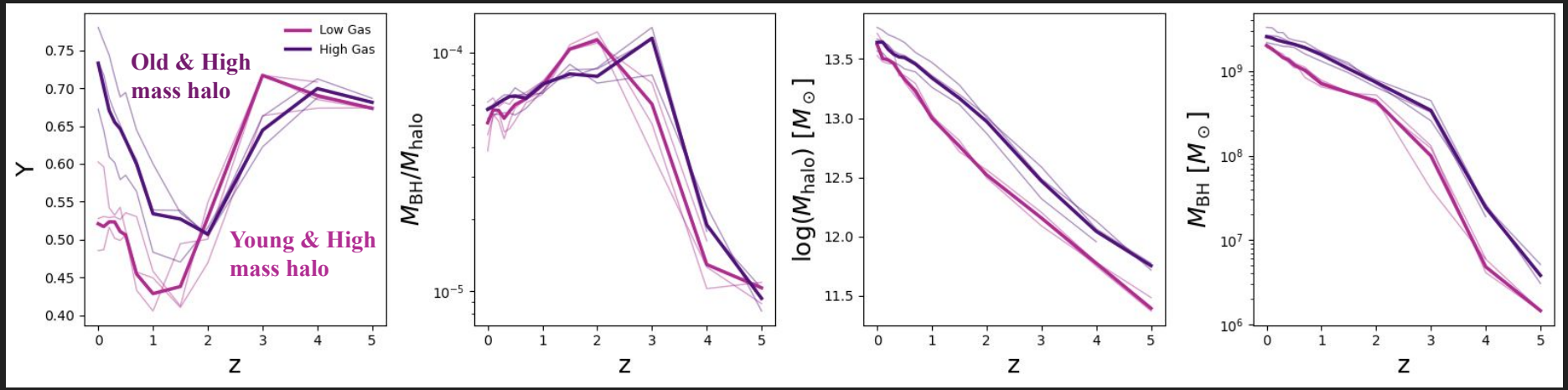
Low Mass halos - split in gas fraction

- Low gas fraction:
  - Halo collapsed earlier
  - BH seeded earlier
  - OLD
- High gas fraction:
  - Halo collapsed later
  - BH seeded later
  - YOUNG



High Mass halos - split in gas fraction

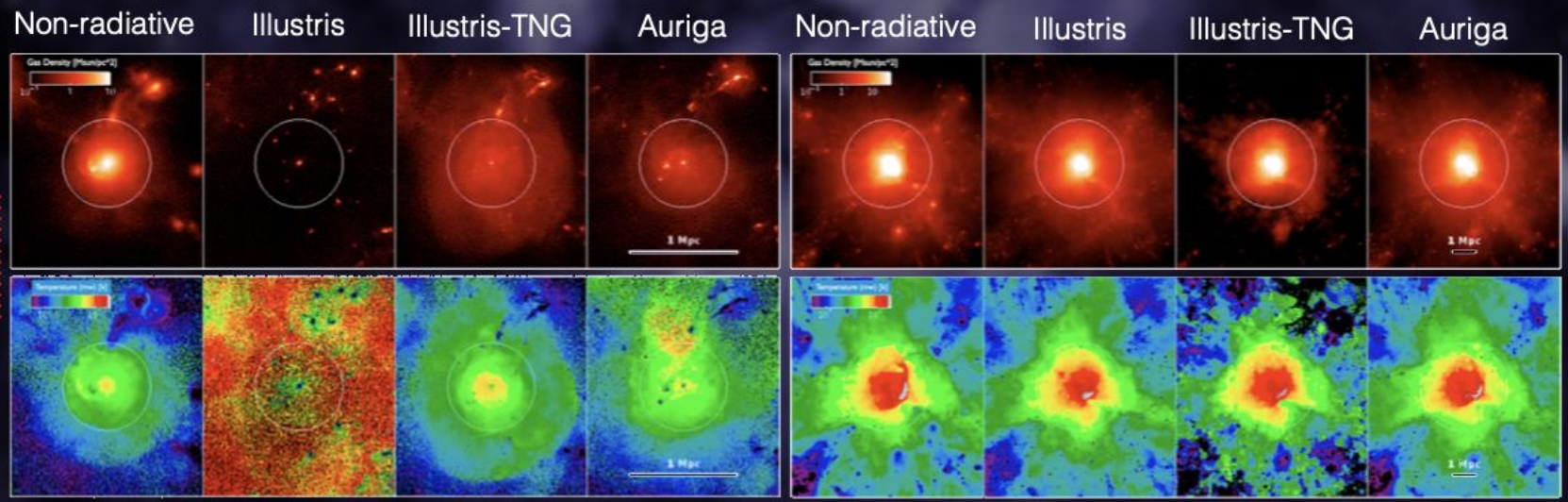
- Low gas fraction:
  - Halo collapsed later
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- High gas fraction:
  - Halo collapsed earlier
  - BH seeded earlier
  - OLD



GALAXY GROUPS: The ultimate testing ground for non-gravitational processes

Galaxy group: $M_h \sim 10^{13}\, M_\odot$

Galaxy cluster: $M_h \sim 10^{15}\, M_\odot$



Credits: A. Pillepich

Feedback can affect strongly on the gas properties

Feedback has marginal effect on temperature and density