CFA, Harvard, 26 April 2019

Cosmological baryon transfer in the SIMBA simulations

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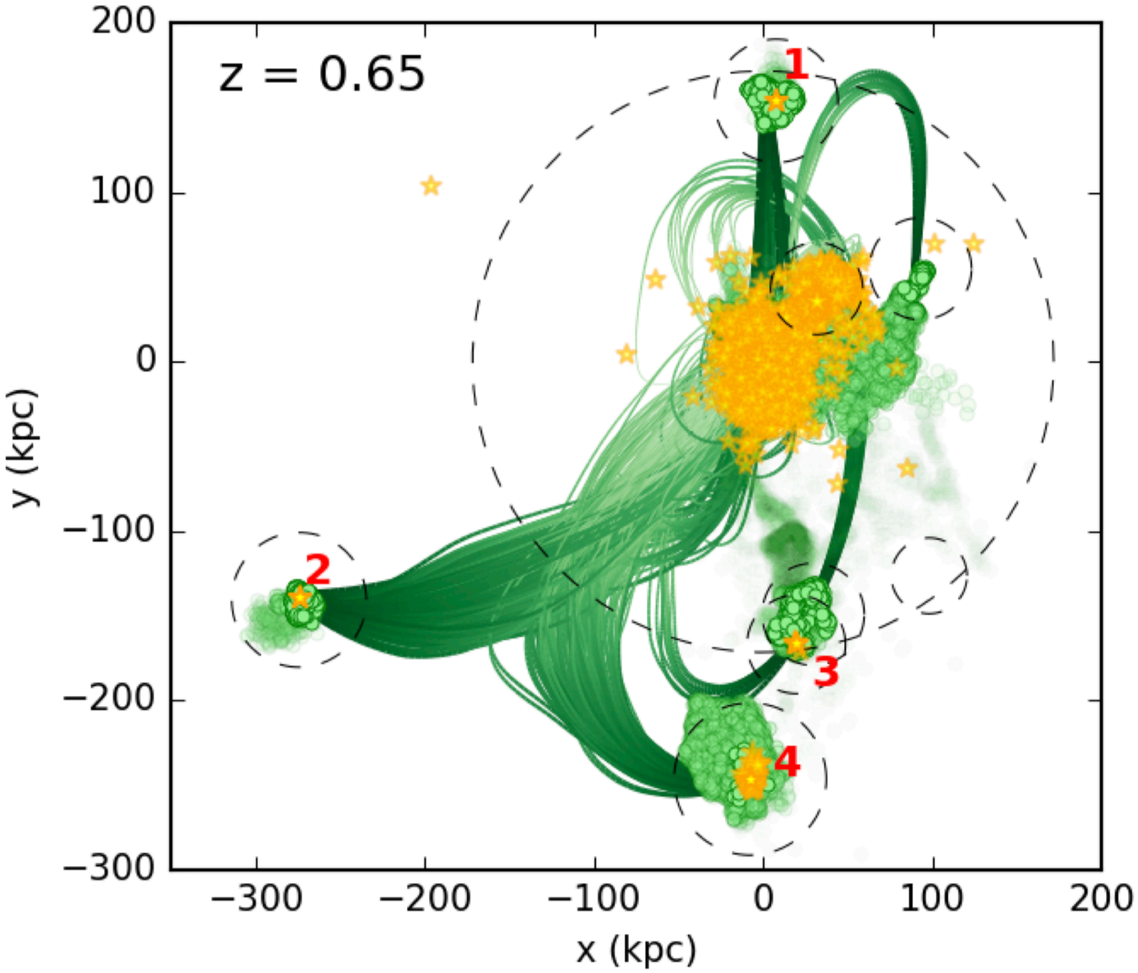
Co-Authors: Daniel Angles-Alcazar & Romeel Dave

The SIMBA Simulations

- Model 'calibrated' on FIRE galaxies
- Includes strong, kinetic AGN feedback with various jet modes
- This feedback can blow bubbles ~20 Mpc in size
- More information in Dave+ 2019 or ask me afterwards; choice of suite is not necessarily that important

Previous Motivation

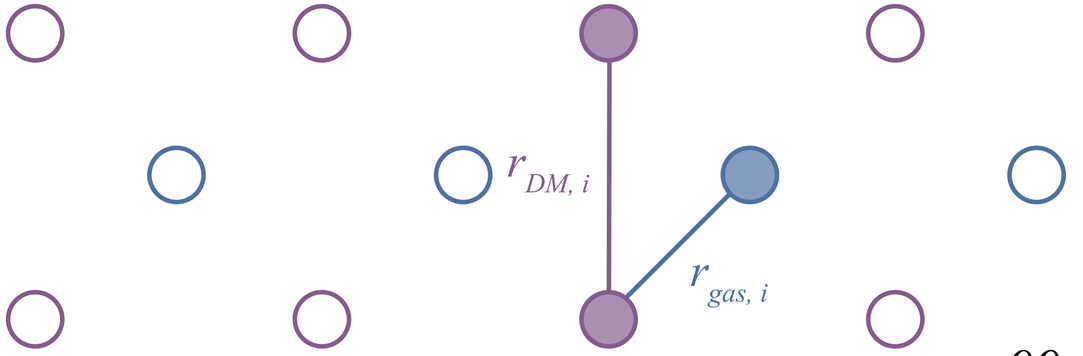
- Feedback causes gas to be blown out of galaxies
- This is especially true in simulations that include AGN feedback
- Where does that gas go?

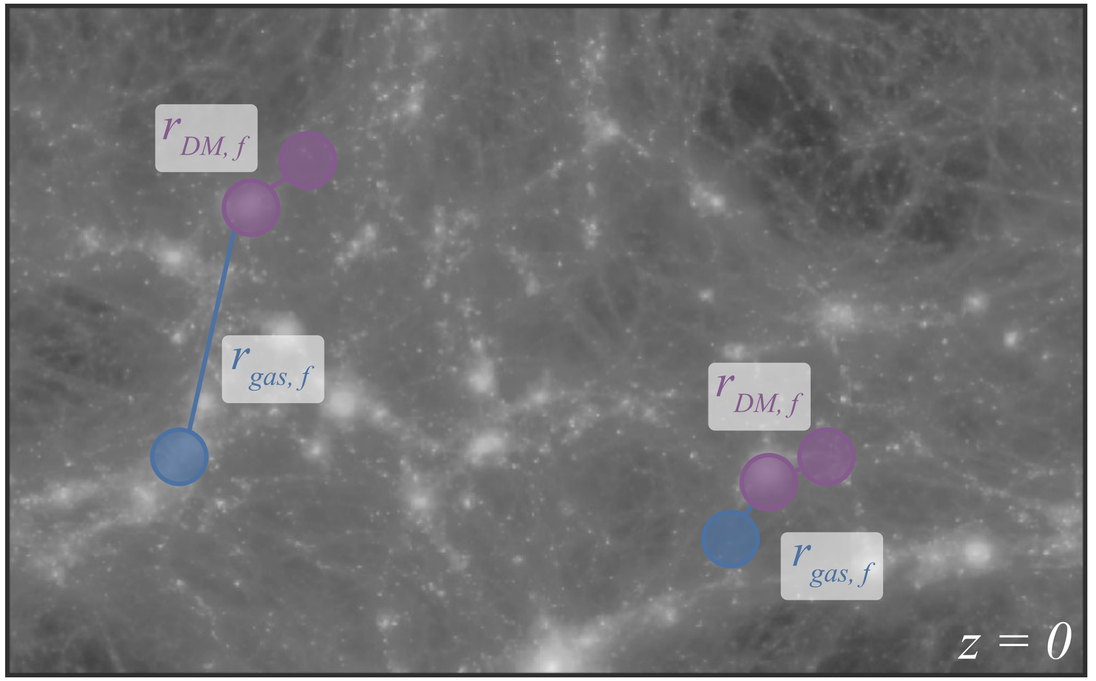


Angles-Alcazar+, Baryon Cycling and Galaxy Assembly on FIRE, 2017

The Spread Metric

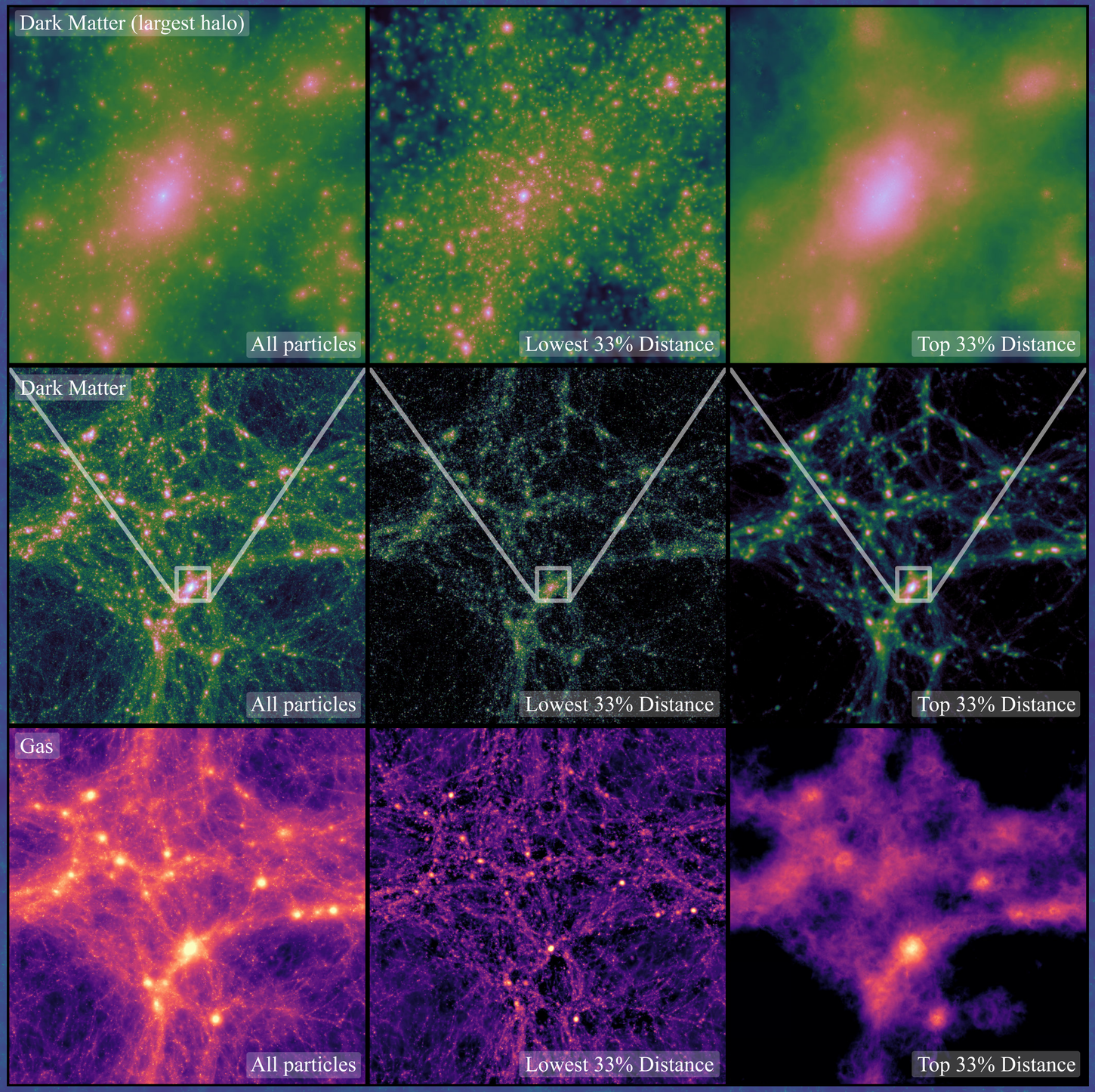
- Look at how dark matter and baryons move differently
- First pass: construct a metric that tells us how far particles have moved in the simulation, using only two snapshots.





Visualised

- Dark matter substructure picked out by low movement (free-streaming in CDM?)
- Gas in AGN bubbles picked up by high movement.



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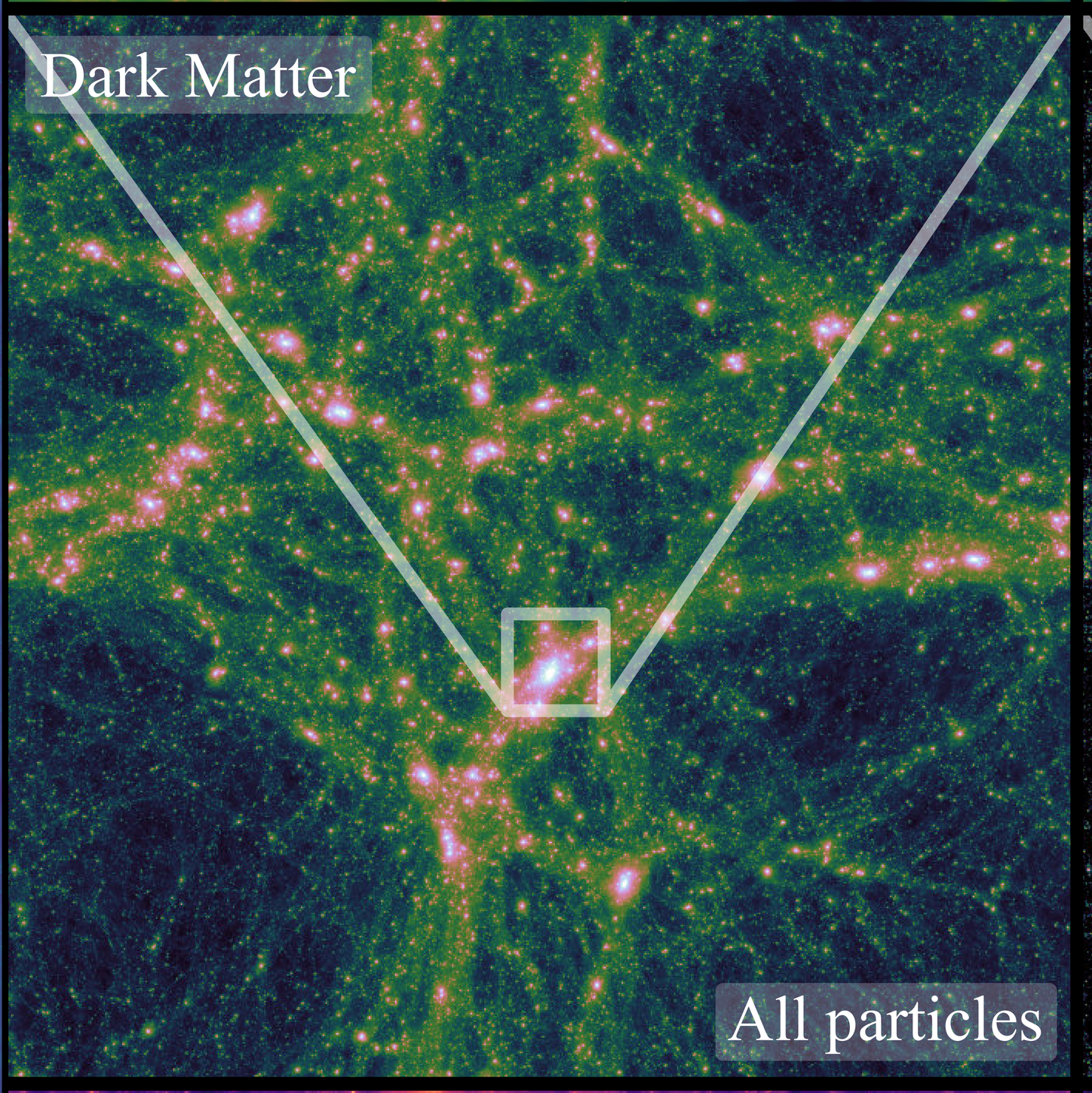
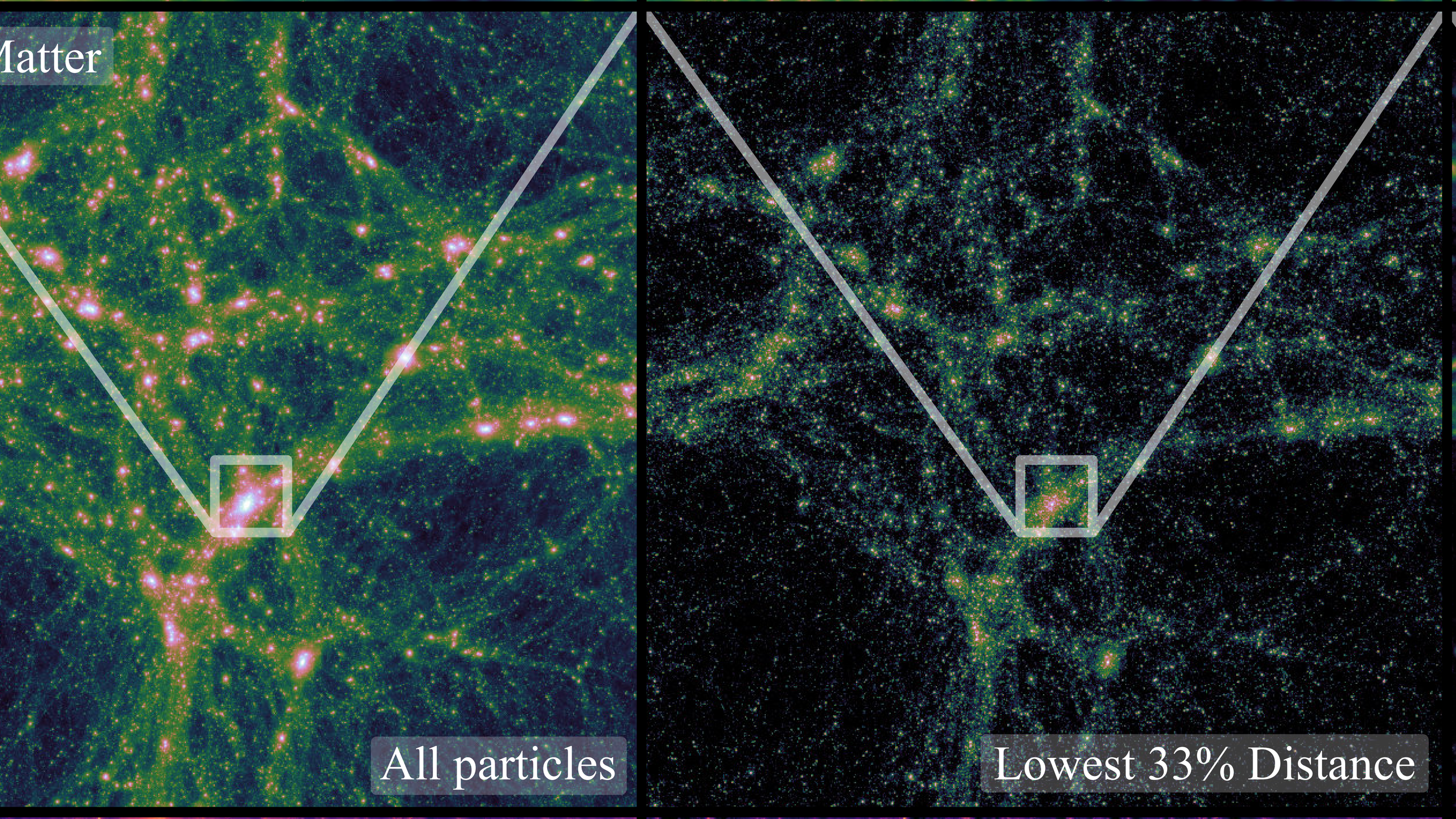
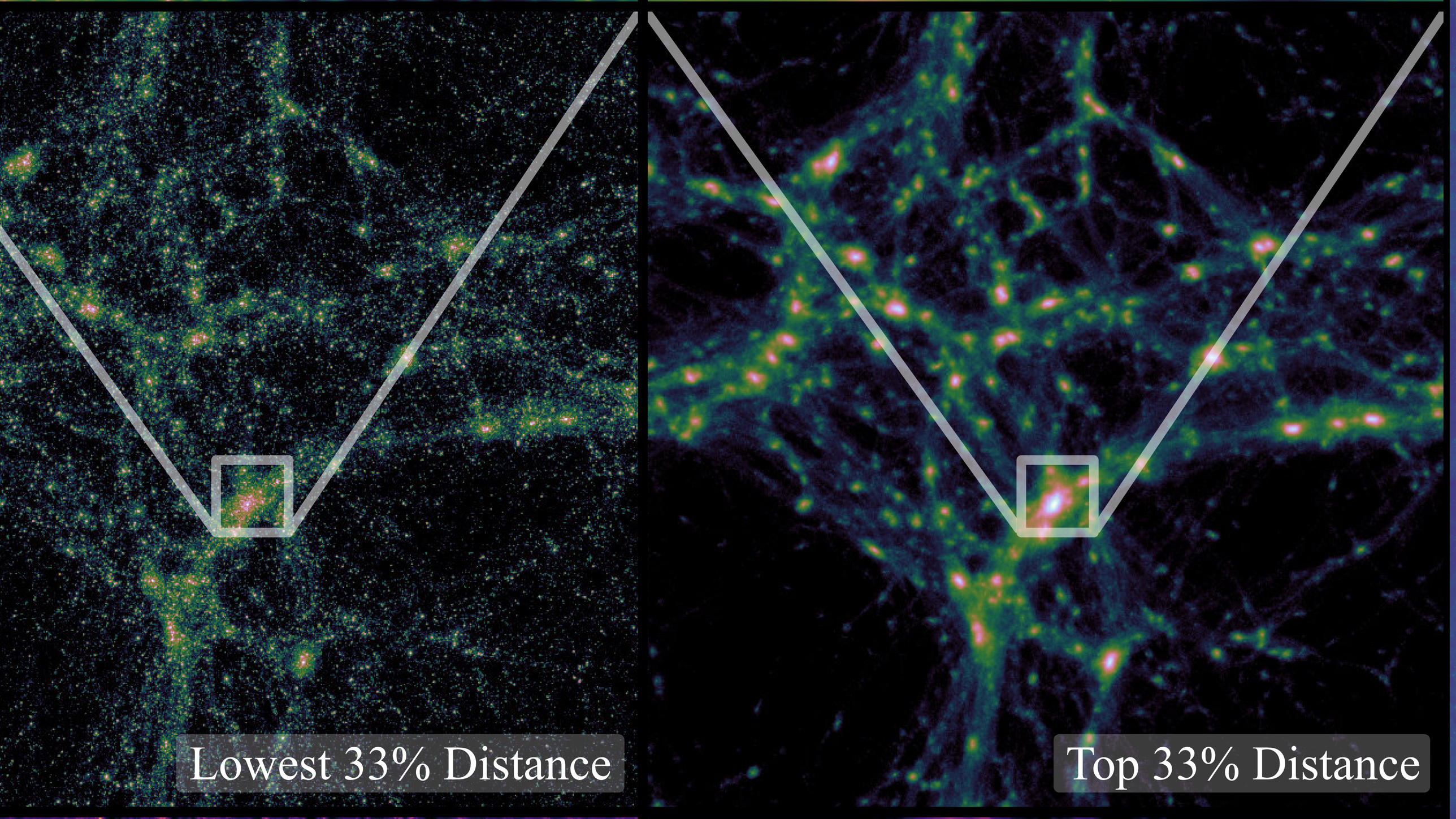



Matter
All particles
Lowest 33% Distance


Lowest 33% Distance
Top 33% Distance

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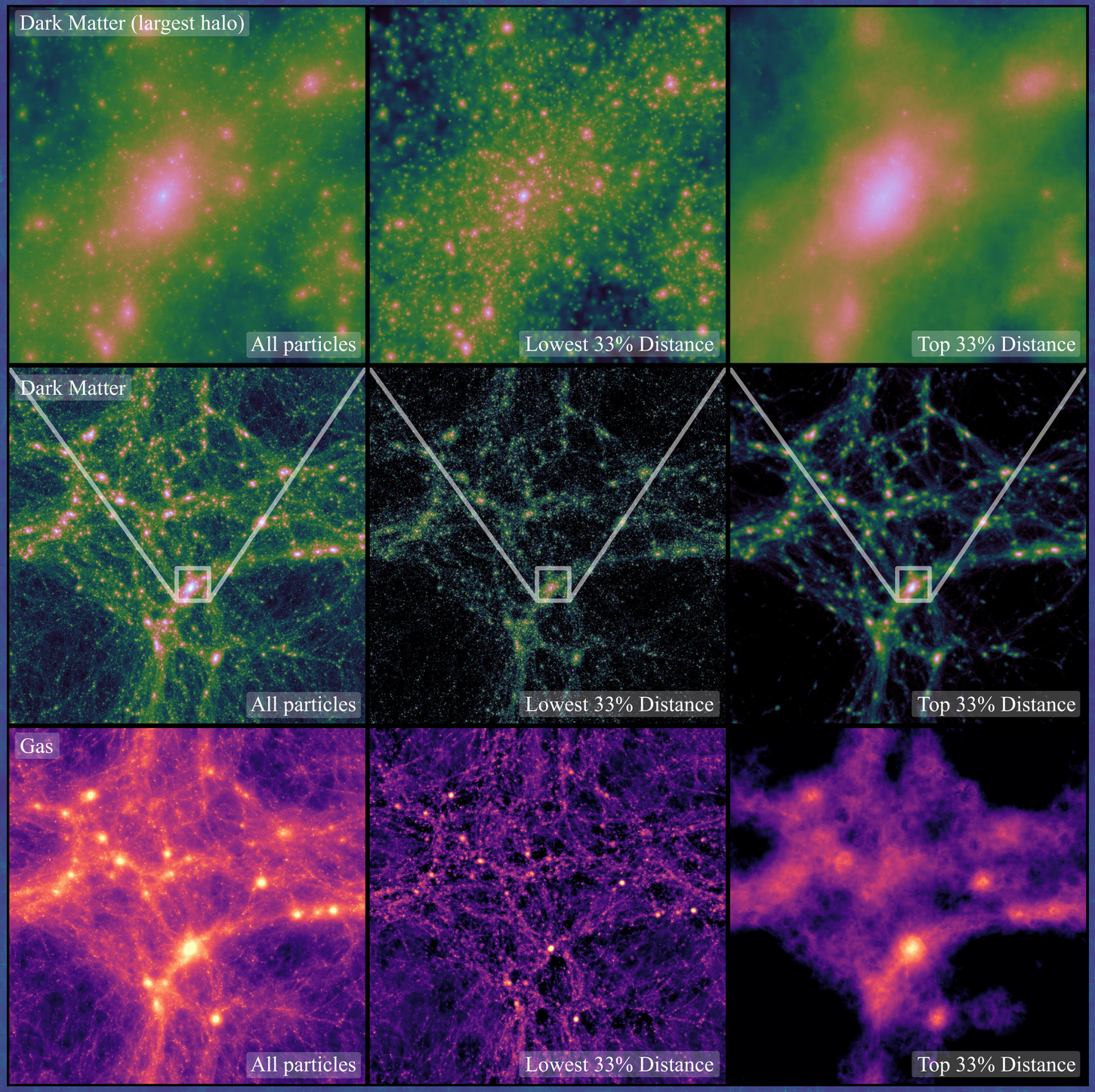

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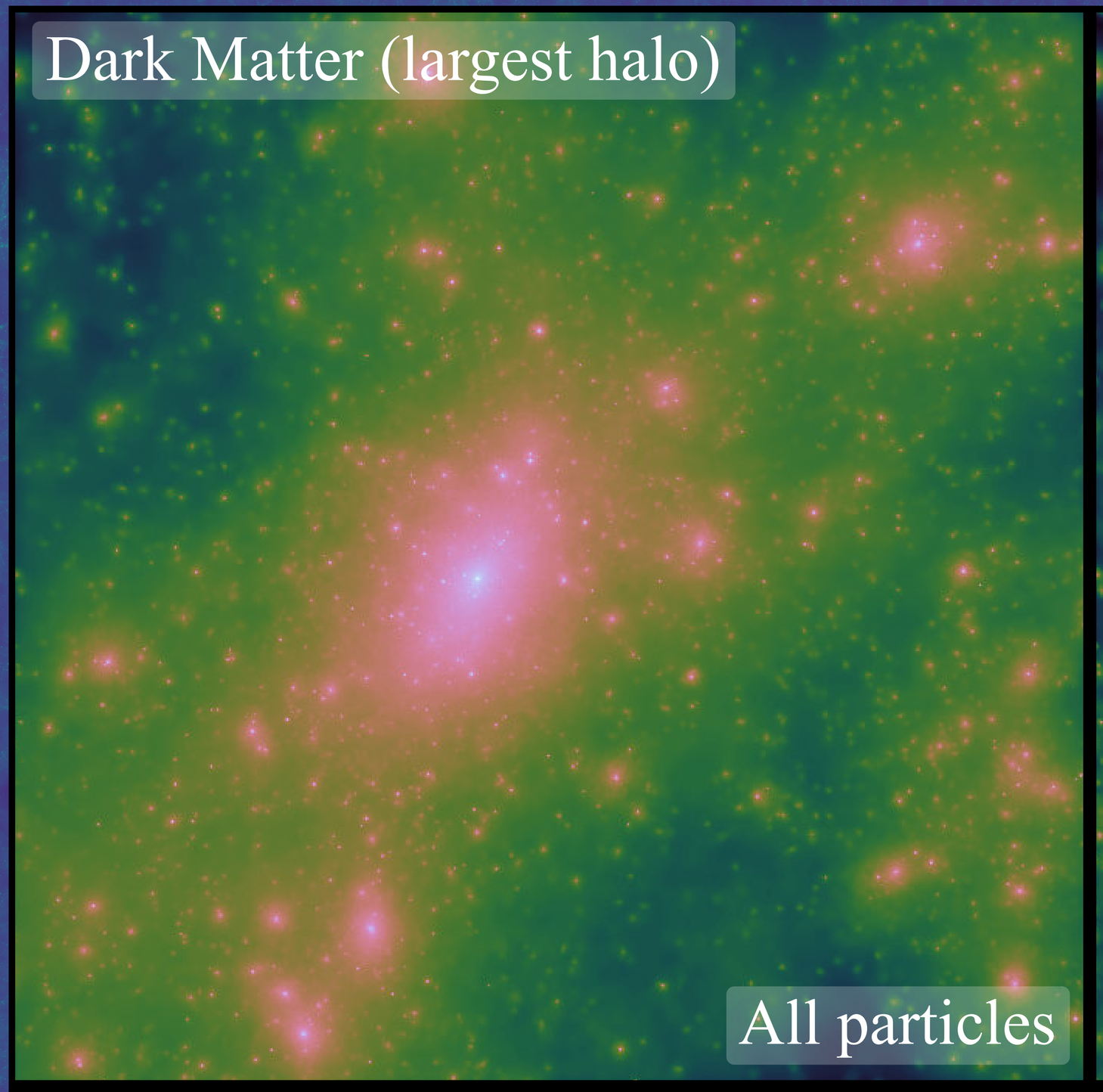
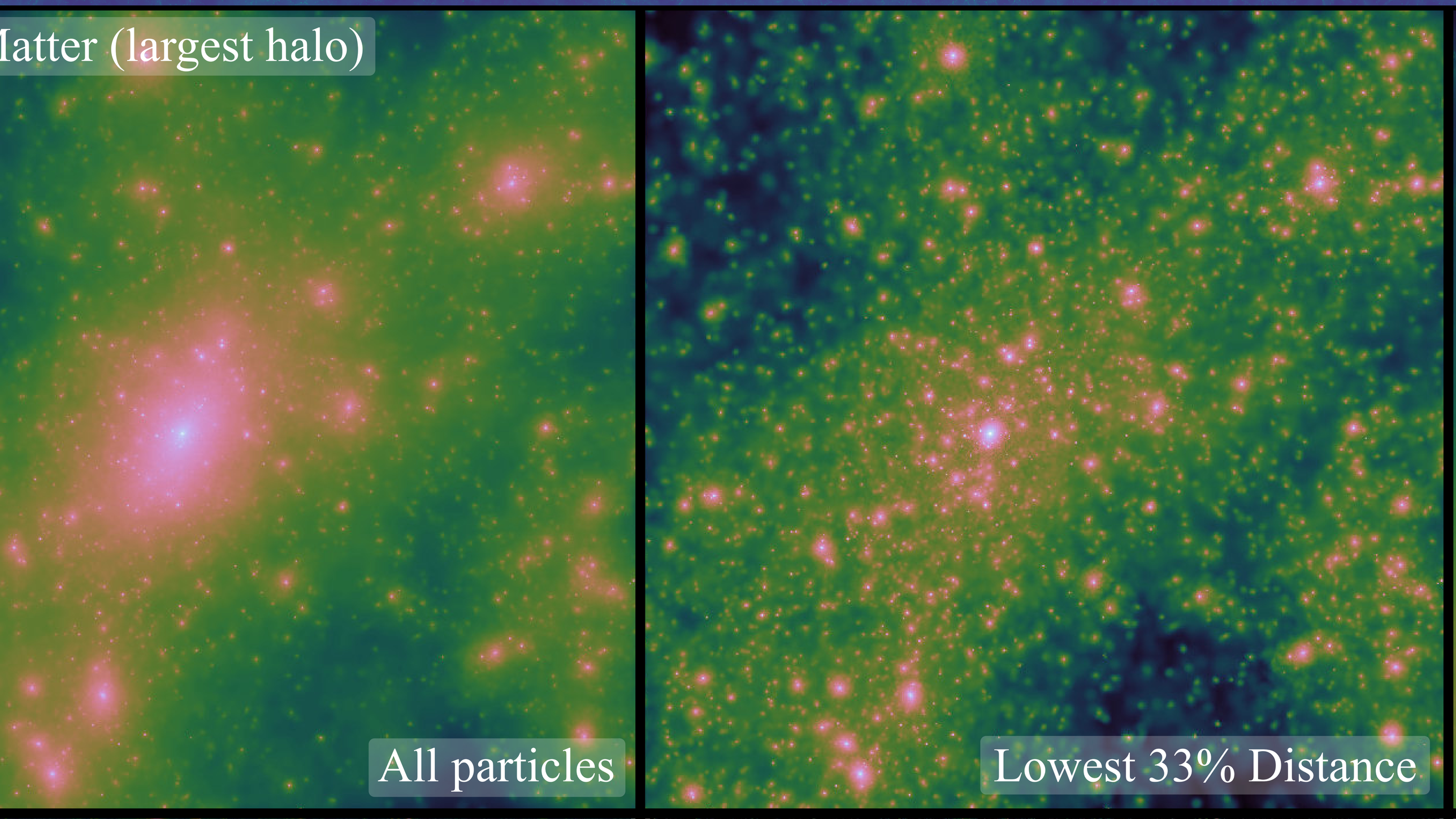
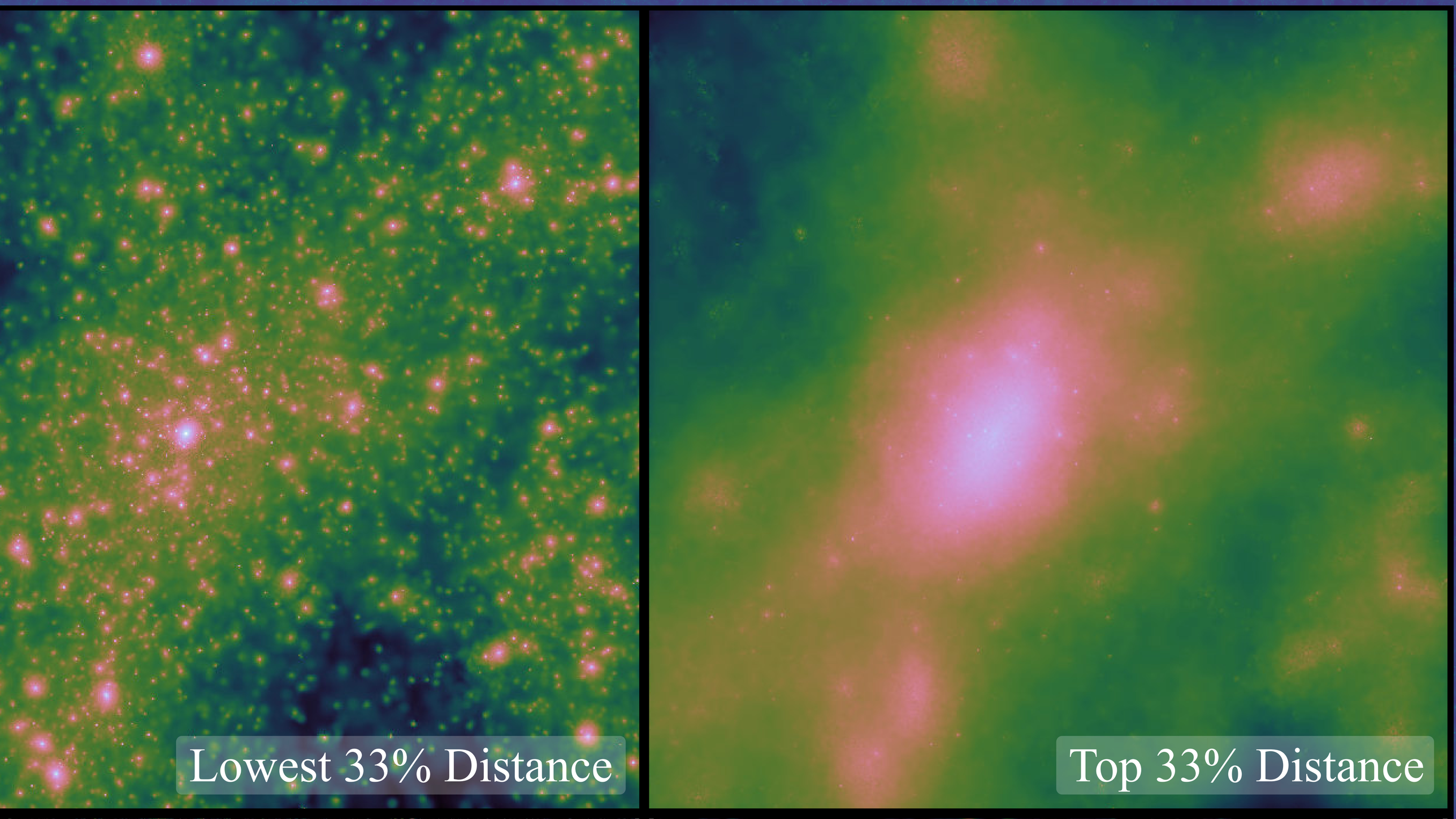



Matter (largest halo)
All particles
Lowest 33% Distance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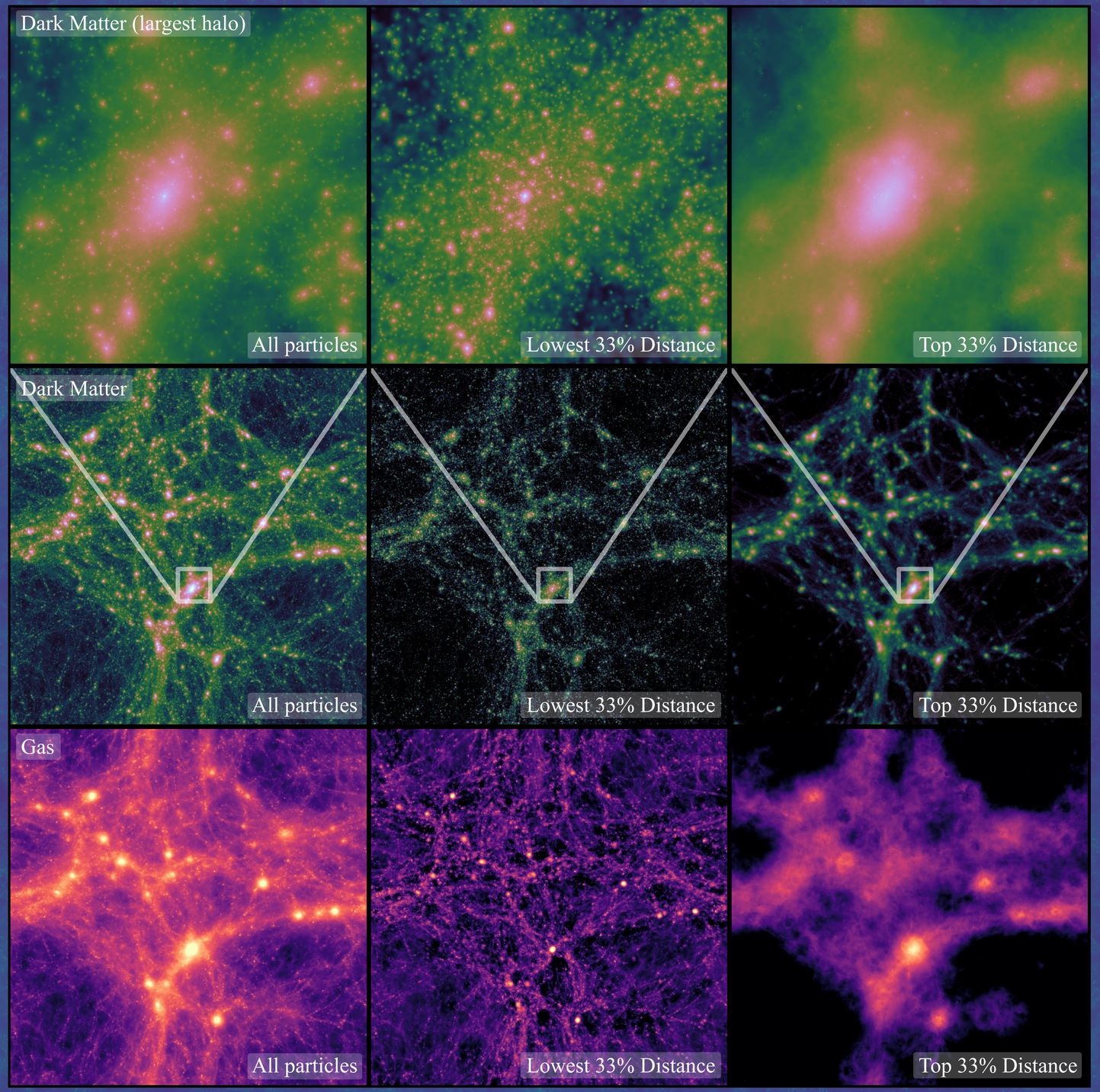

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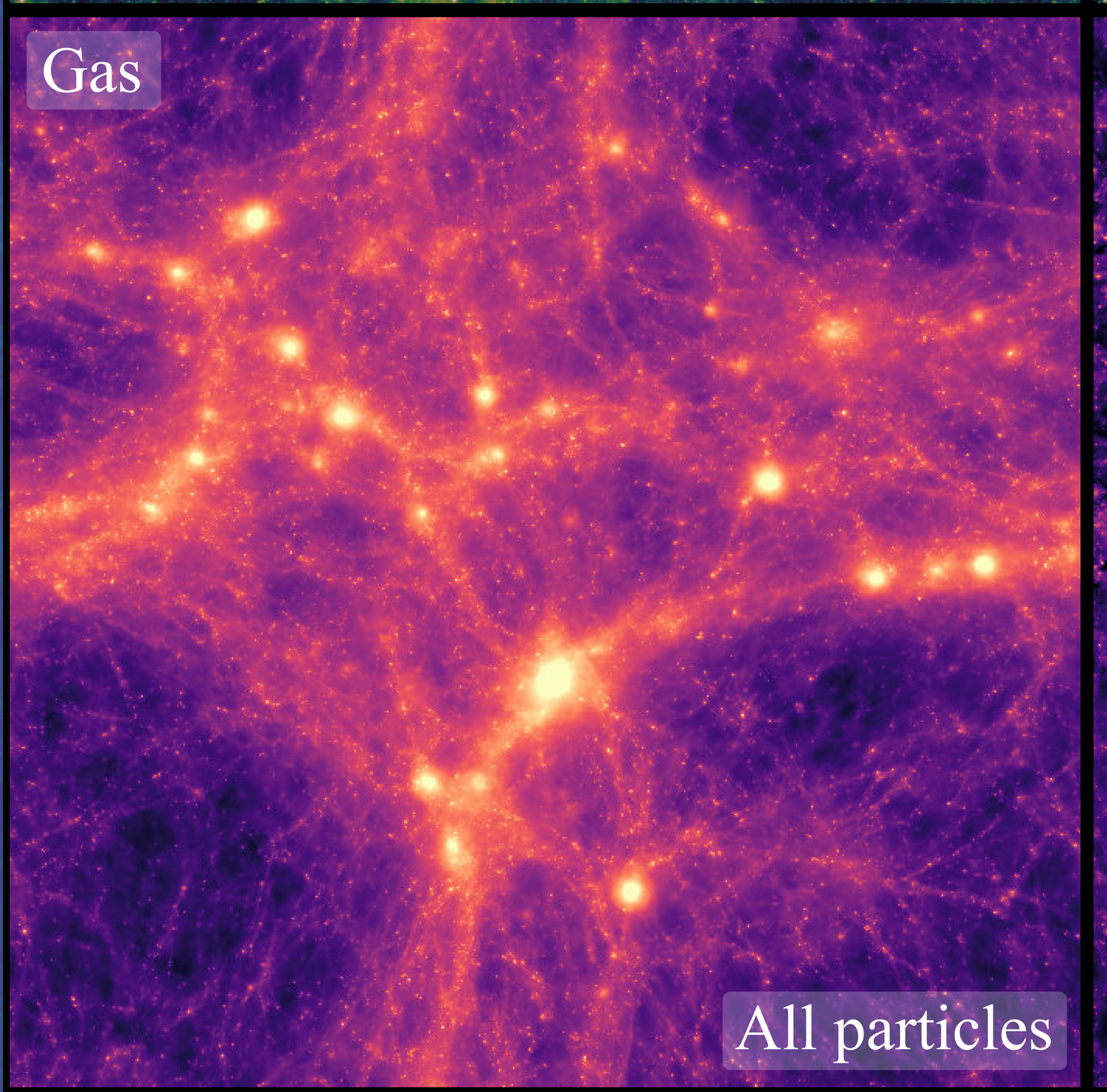
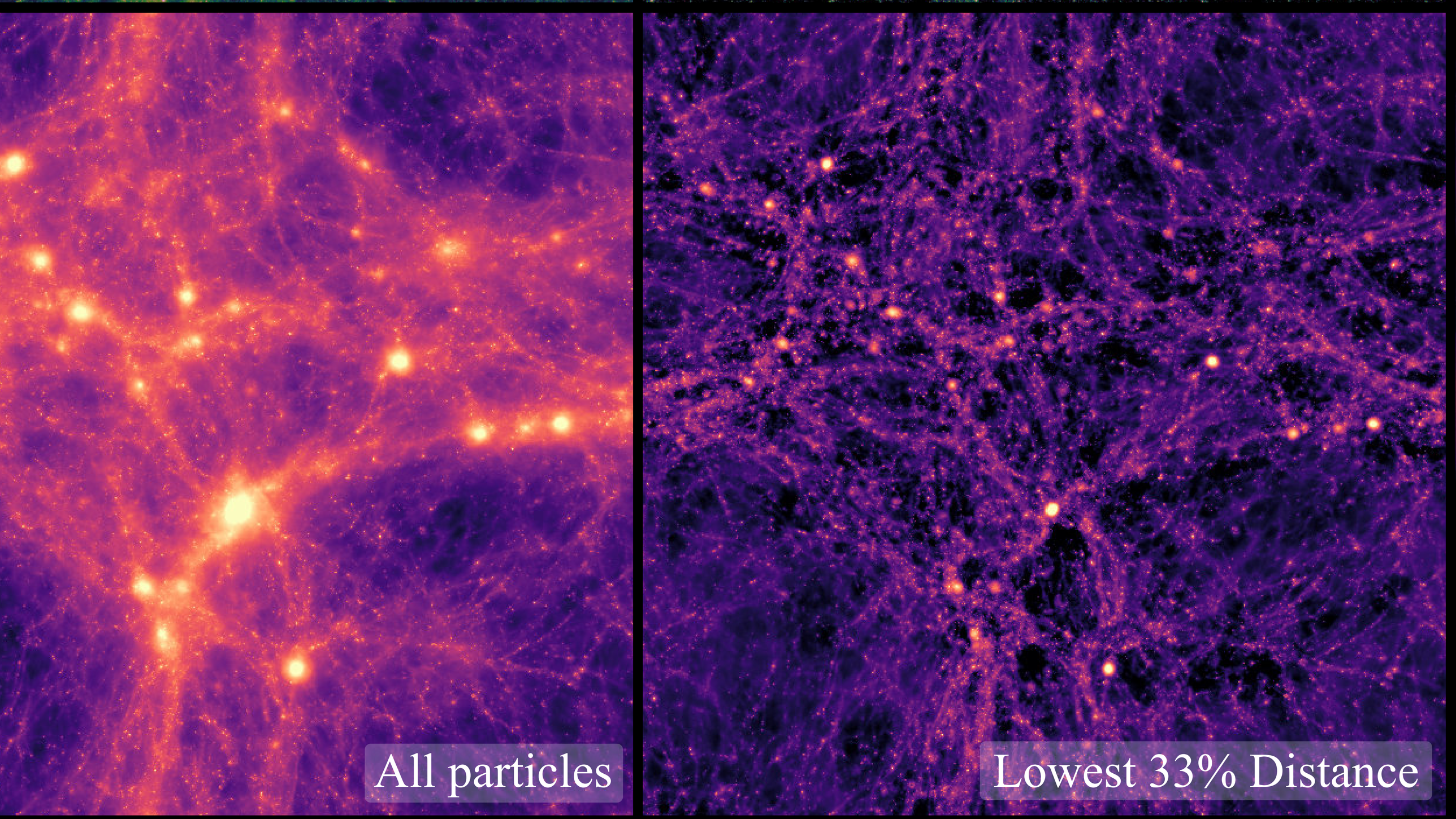
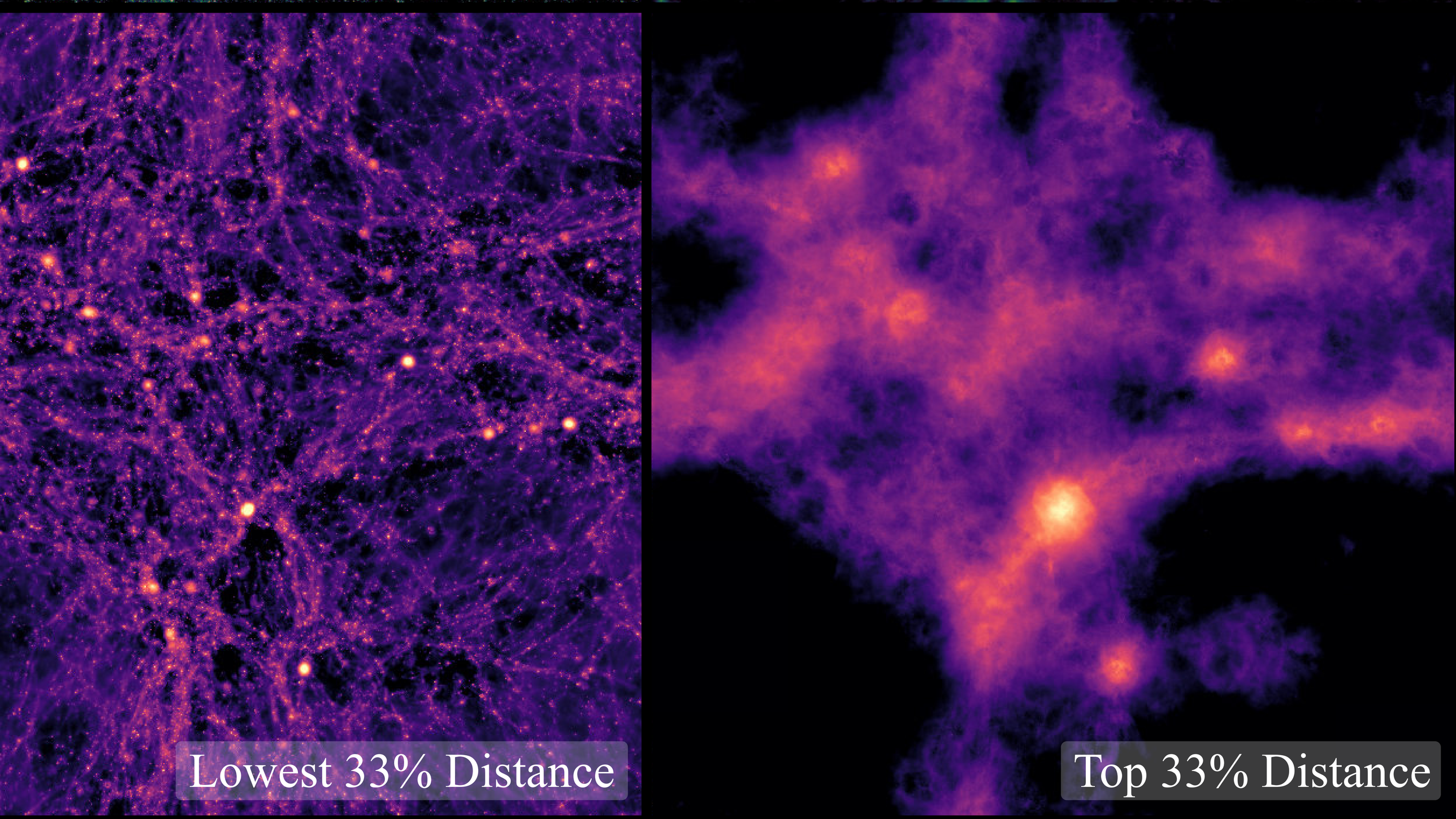



All particles
Lowest 33% Distance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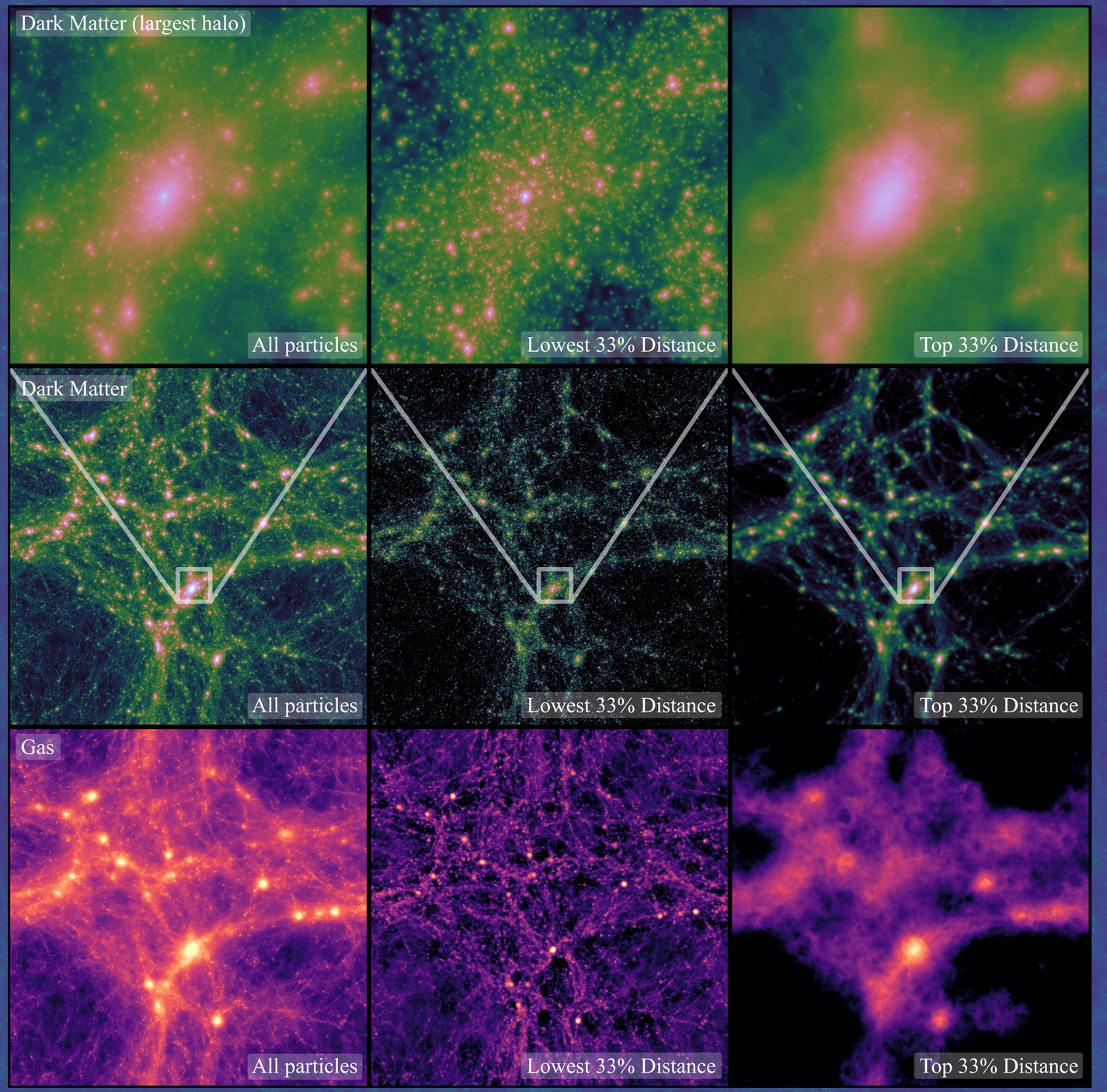
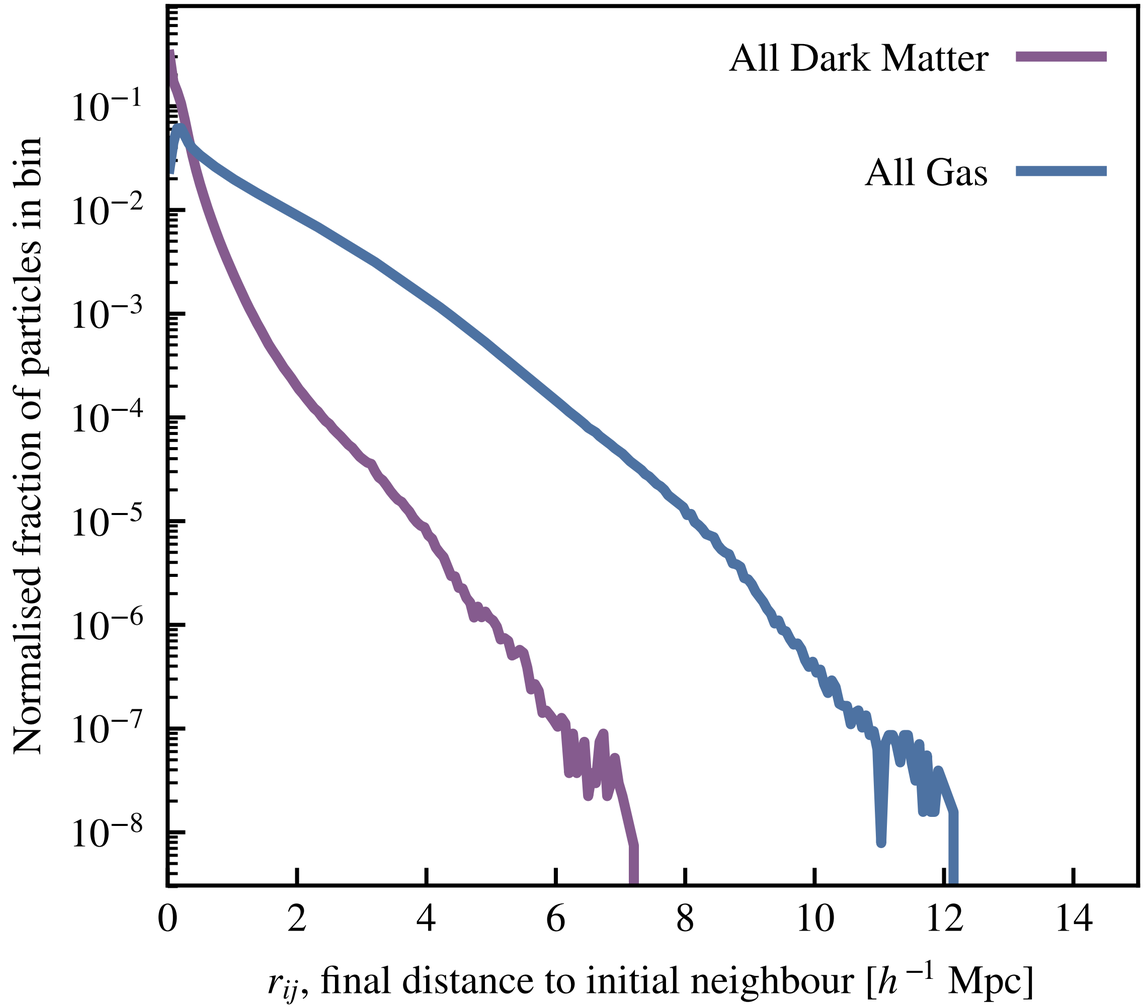


A closer look

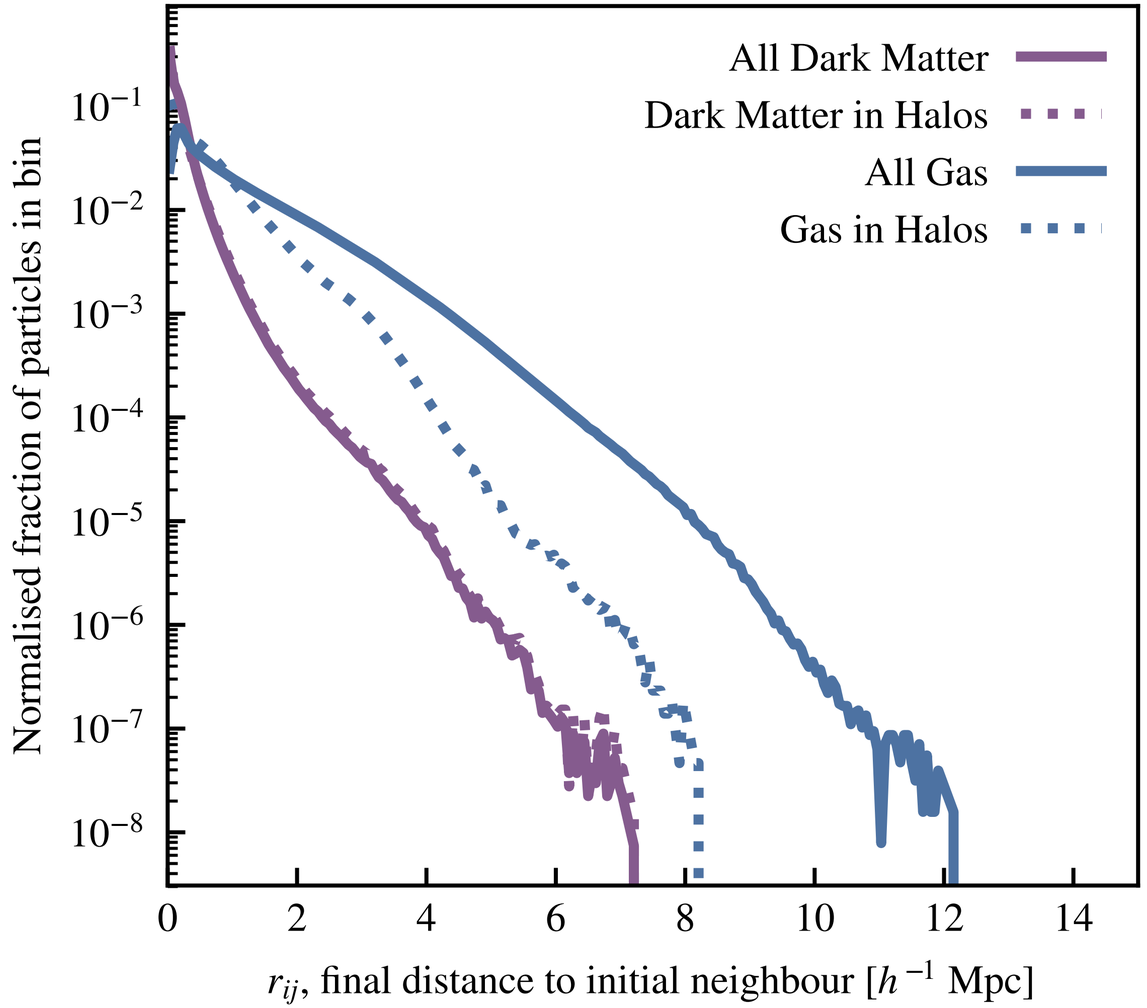
- Take a look at the distribution of distances for different types of particles
- Gas is much more spread out than dark matter, as expected from the above images



A closer look

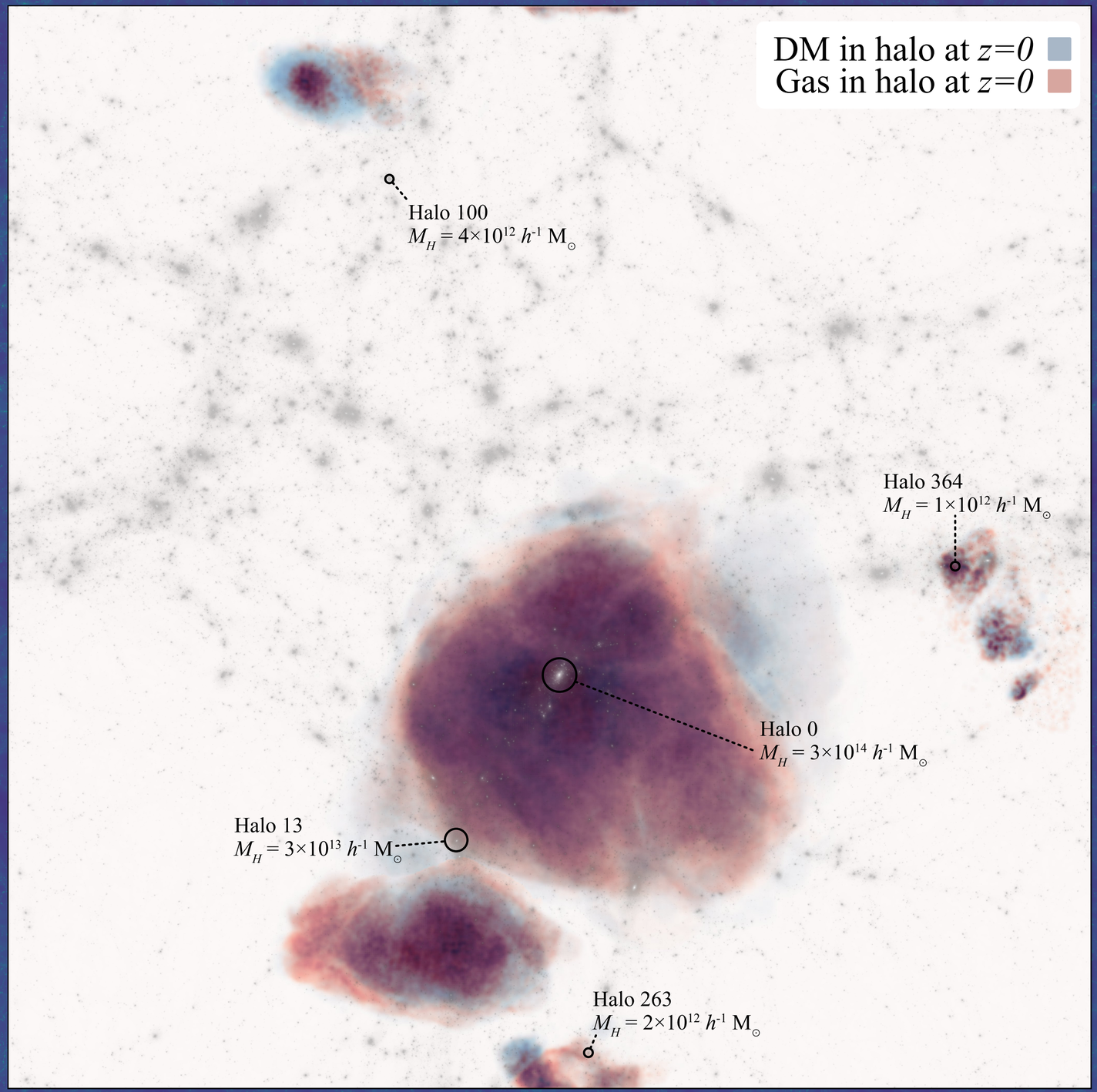
- Splitting now by the particles only in halos, we see that gas in halos at *z=0* is much more closely bound to the dark matter than in general

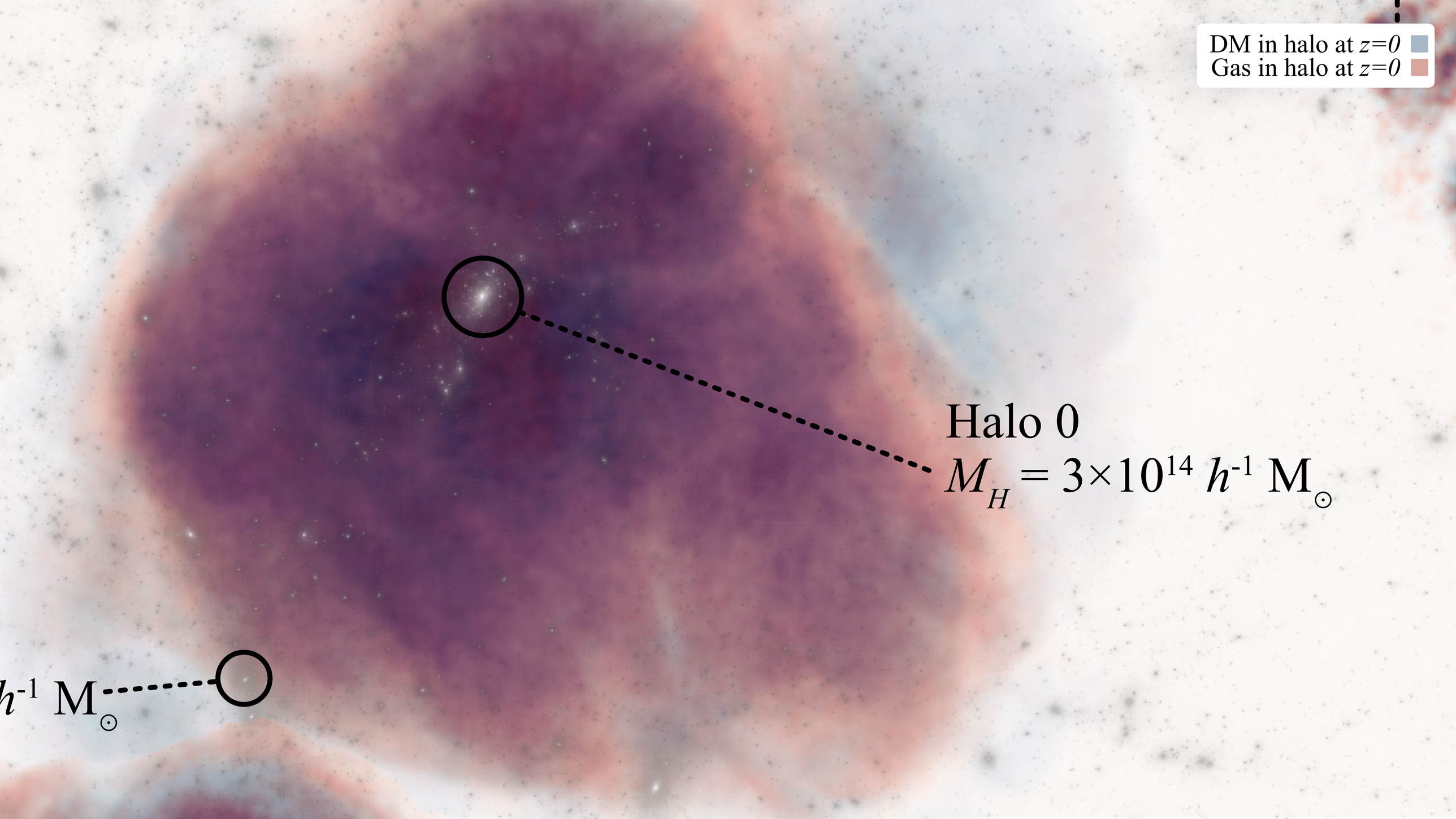
- Dark matter in halos, though, behaves in the exact same way as dark matter out of halos (could be to do with the definitions we use)

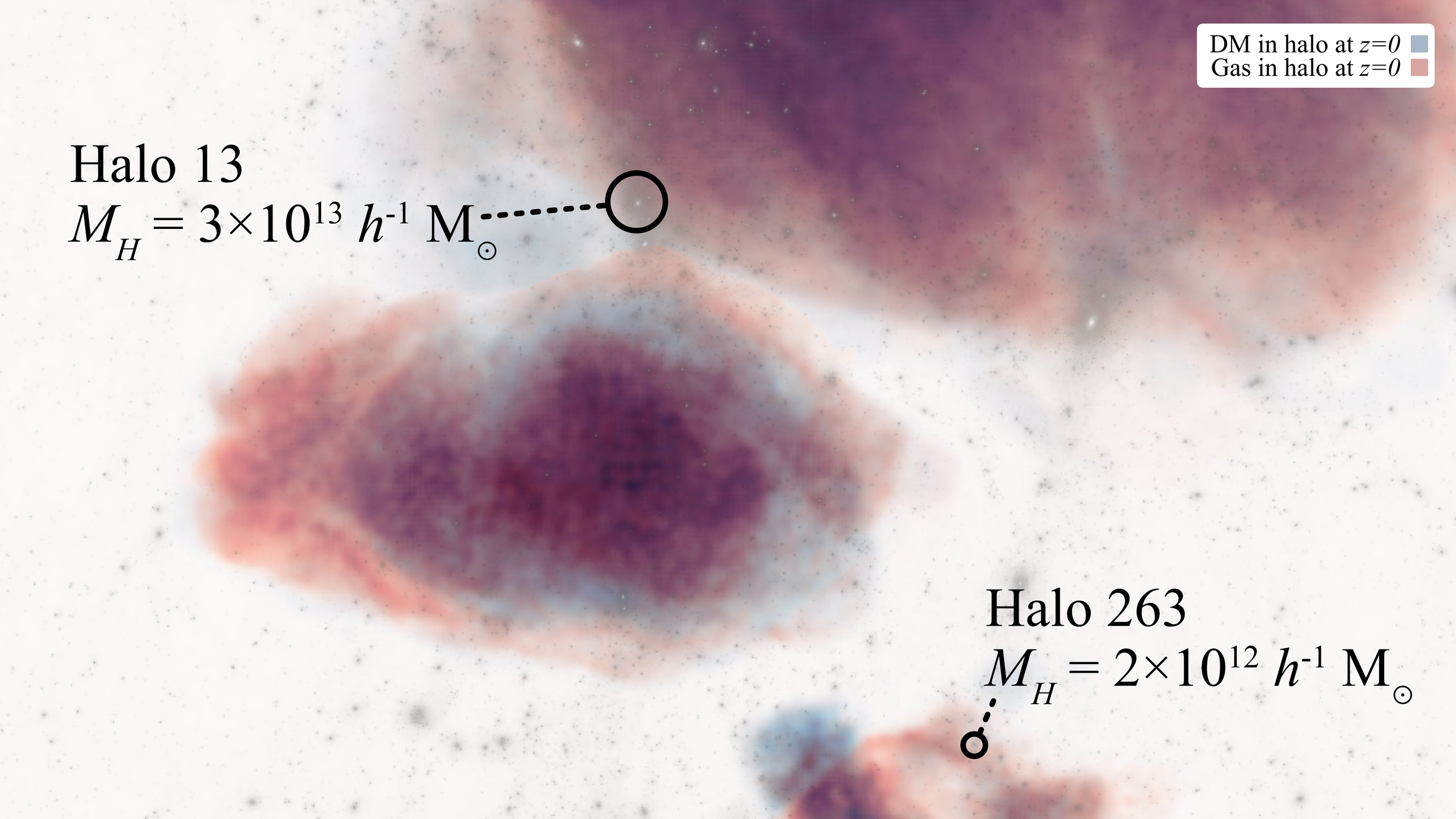


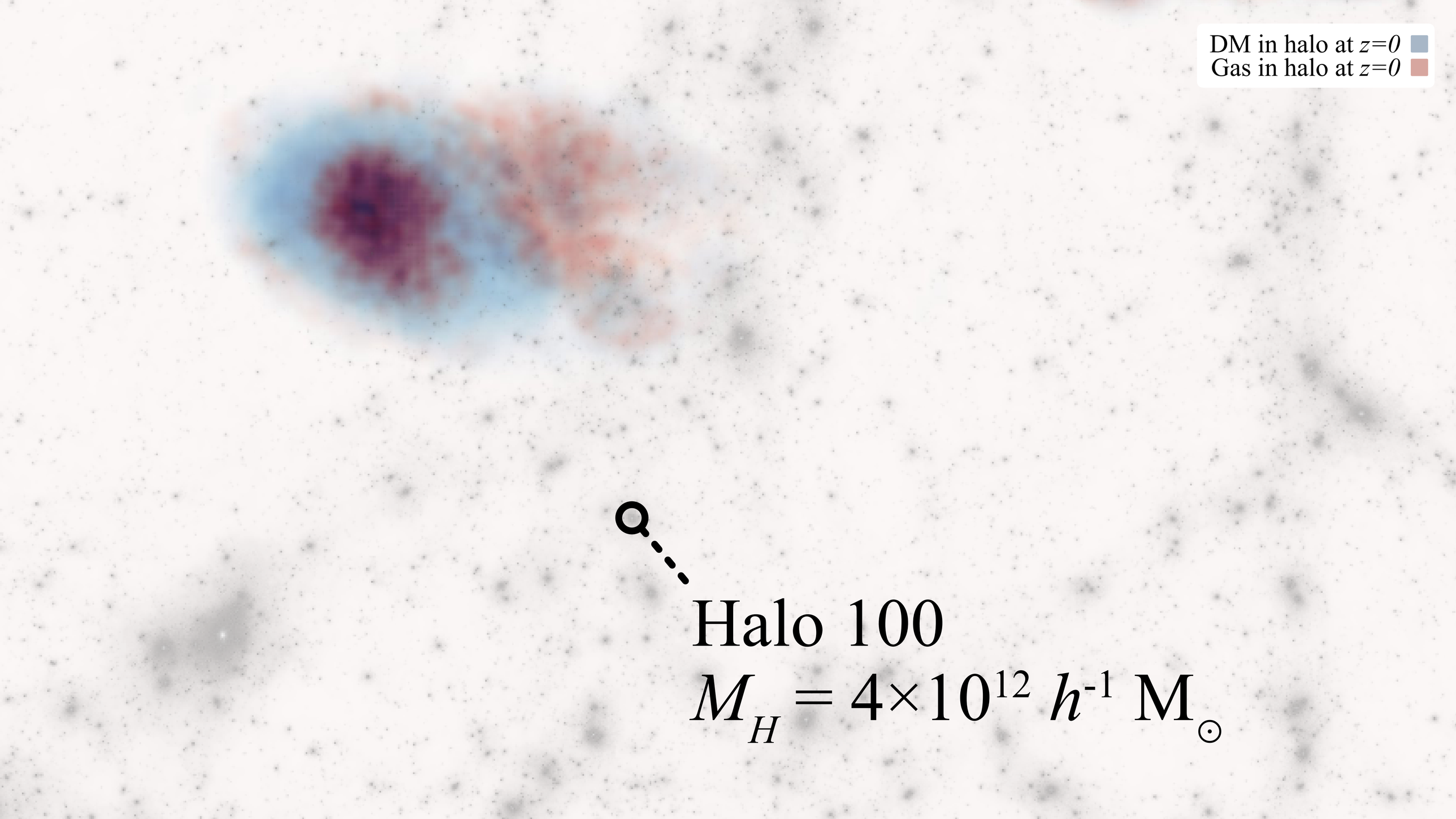
Halo View

- *z=0* distribution in the background
- *z=99* distribution in the foreground
- Bar charts show where the gas in halos originated from



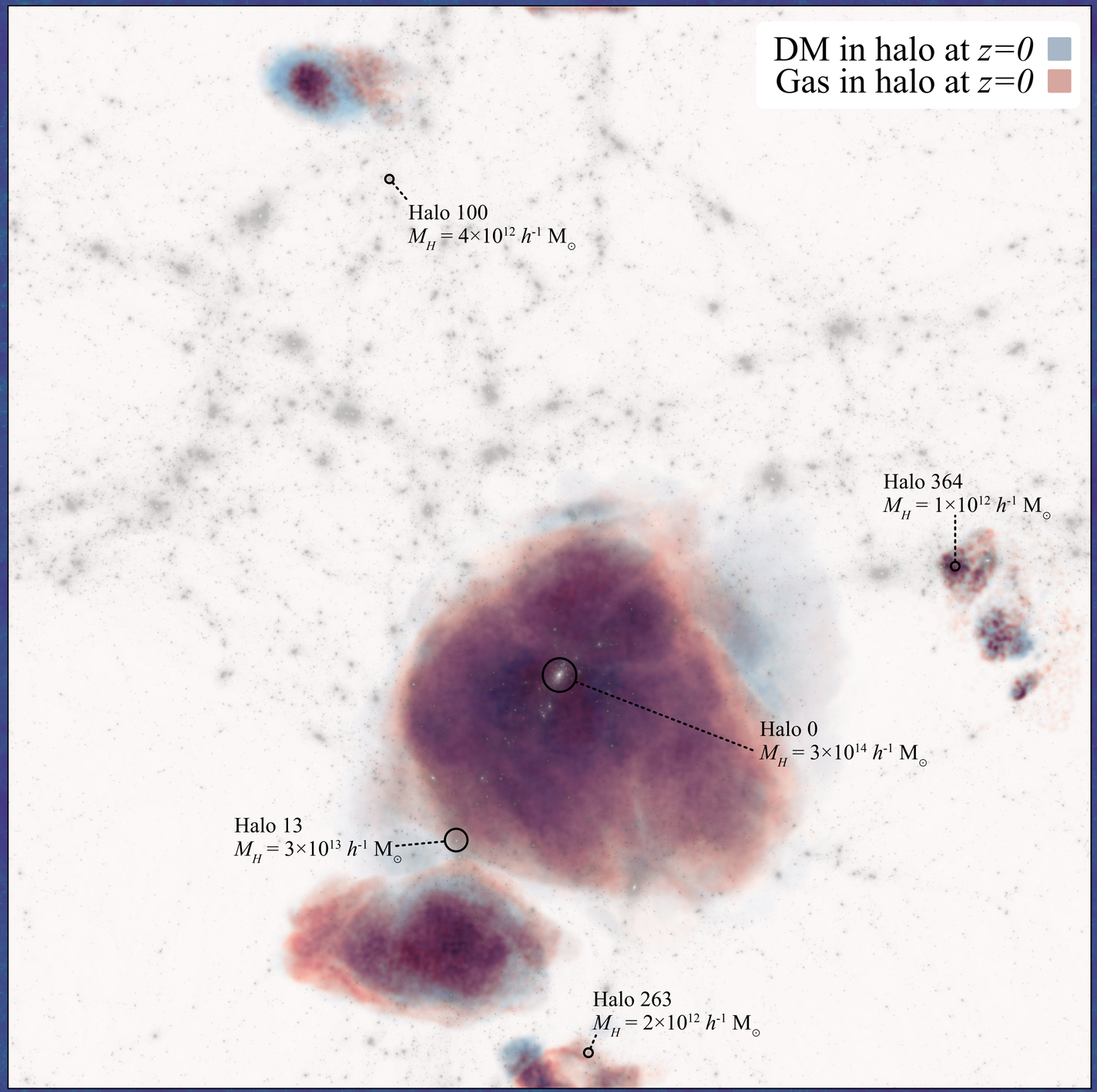

DM in halo at z=0
Gas in halo at z=0
Halo 0
$M_H = 3\times10^{14}\ h^{-1}\ \mathrm{M}_\odot$
$h^{-1}\ \mathrm{M}_\odot$


DM in halo at z=0
Gas in halo at z=0
Halo 13
$M_H = 3\times10^{13}\ h^{-1}\ \mathrm{M}_\odot$
Halo 263
$M_H = 2\times10^{12}\ h^{-1}\ \mathrm{M}_\odot$


DM in halo at z=0
Gas in halo at z=0
Halo 100
$M_H = 4\times10^{12}\ h^{-1}\ \mathrm{M}_\odot$

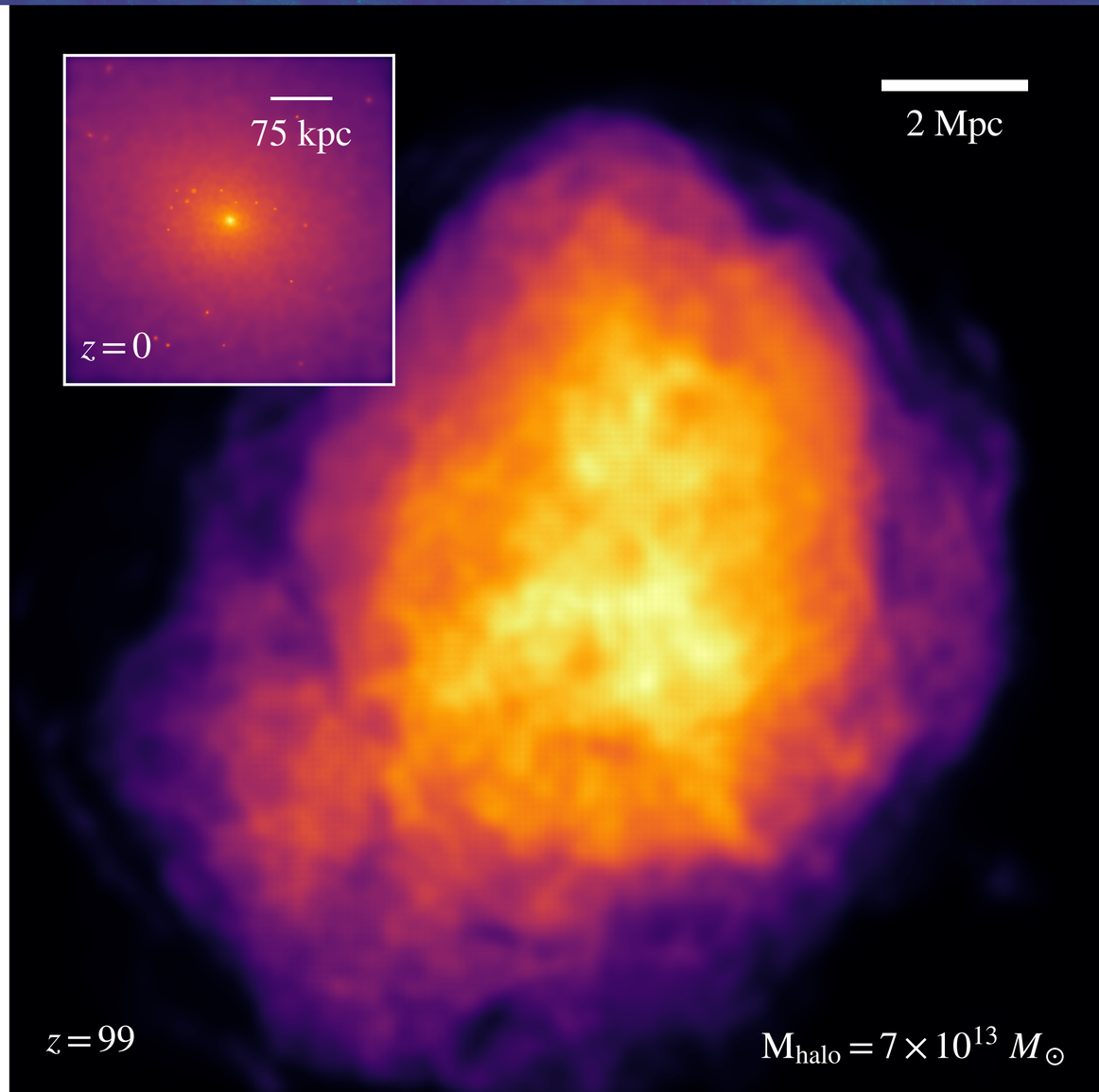
Halo View

- *z=0* distribution in the background
- *z=99* distribution in the foreground
- Bar charts show where the gas in halos originated from



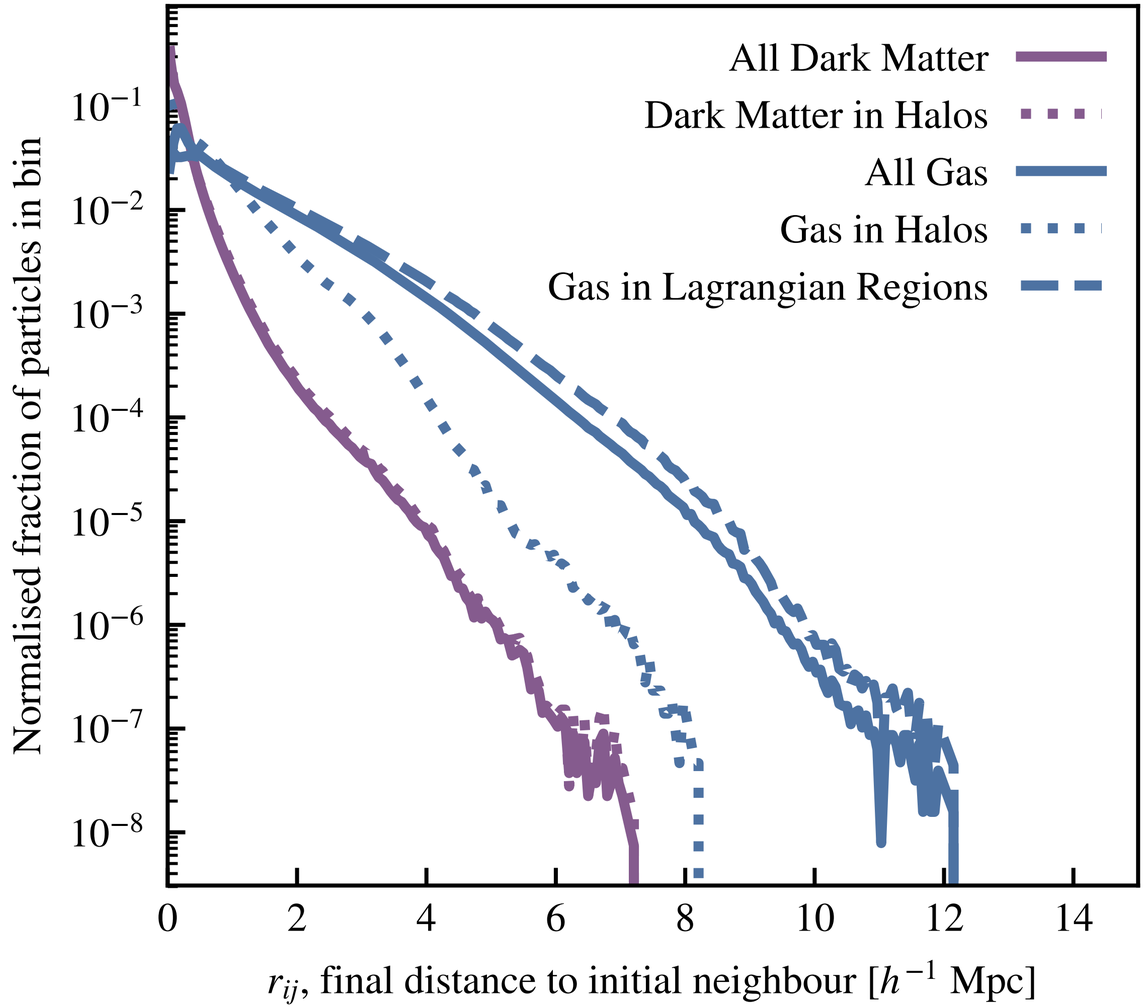
Lagrangian regions

- Gas moves differently to dark matter
- Gas in Lagrangian regions moves differently to gas outside of them
- Dark matter in Lagrangian regions moves in the same way as dark matter outside
- How can we investigate this effect?



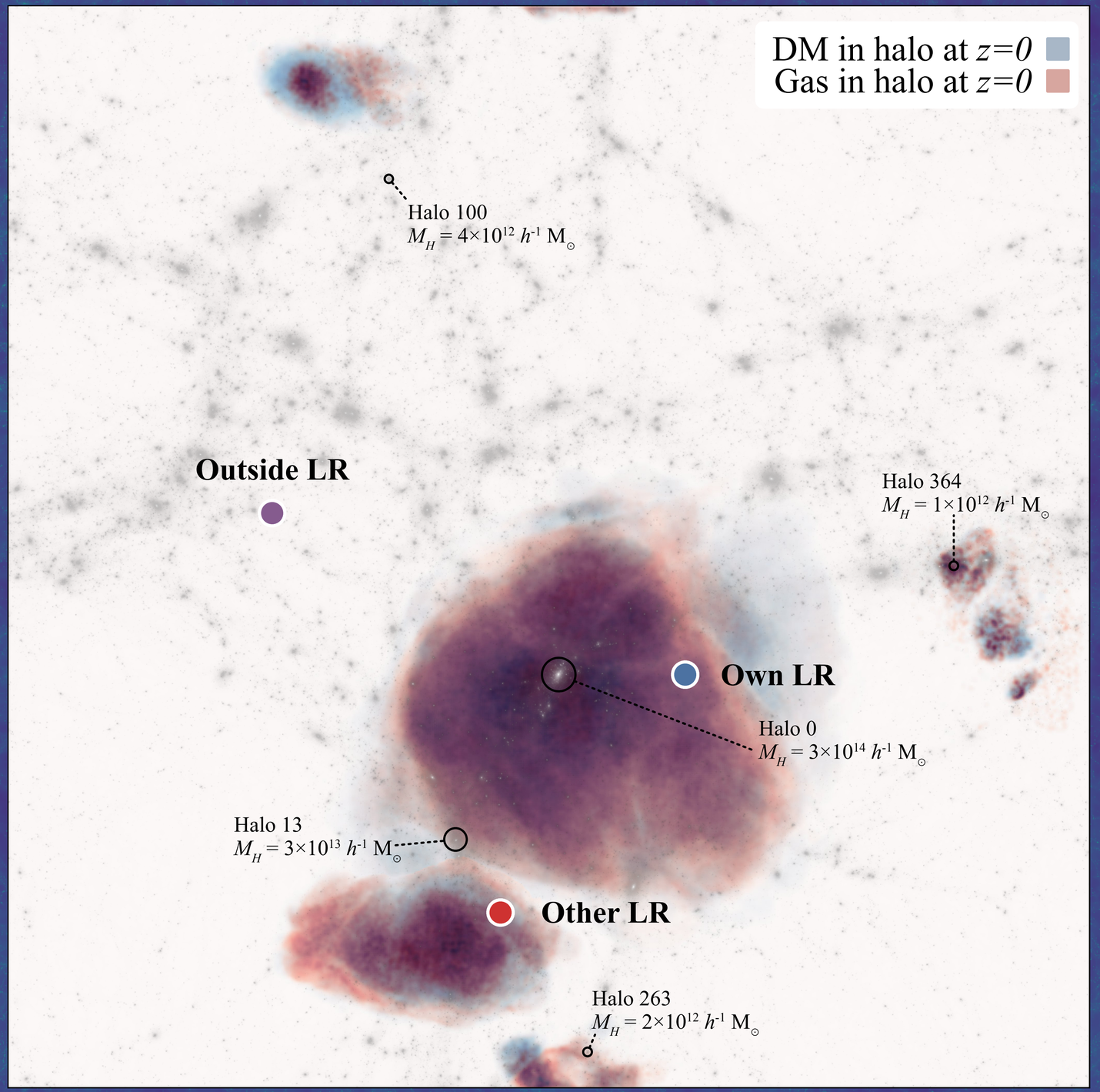
Effects on the distance

- Gas in Lagrangian regions, where the dark matter that ends up in halos at *z=0* comes from, shows a bias to being powered out to larger distances



Binning

- Three bins:
  - Same halo as LR
  - In halo from outside LR
  - In halo from other LR



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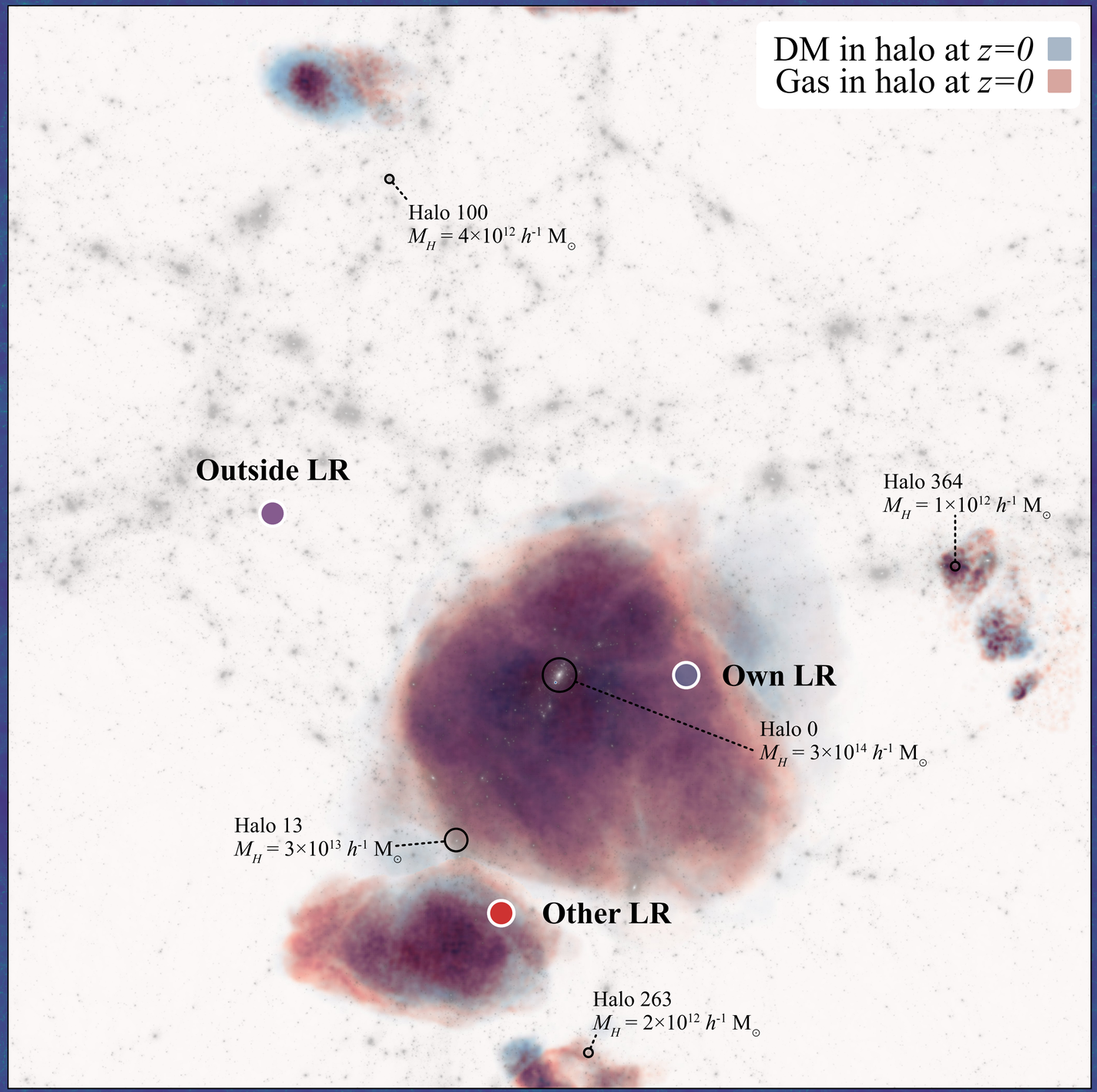

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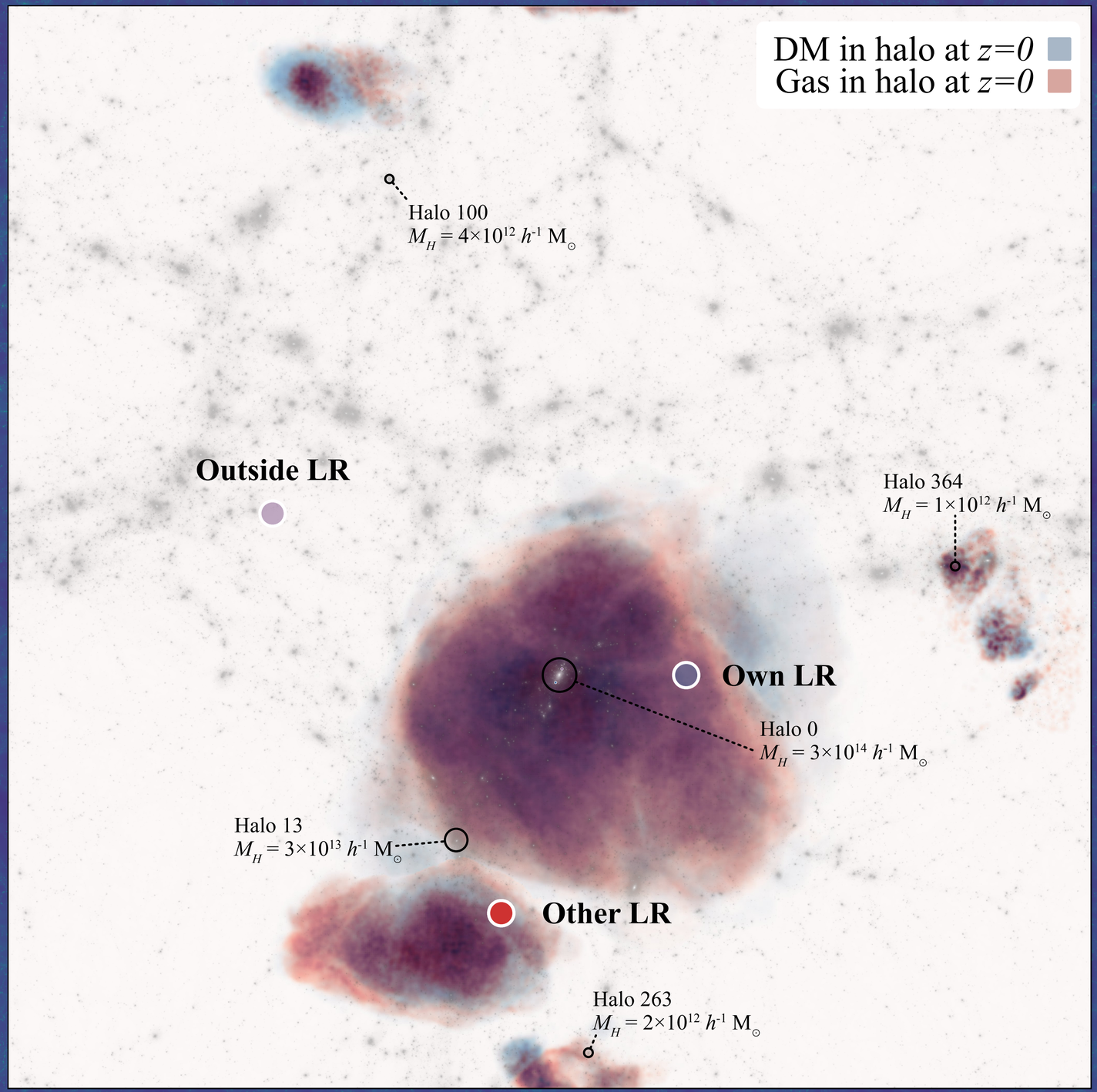

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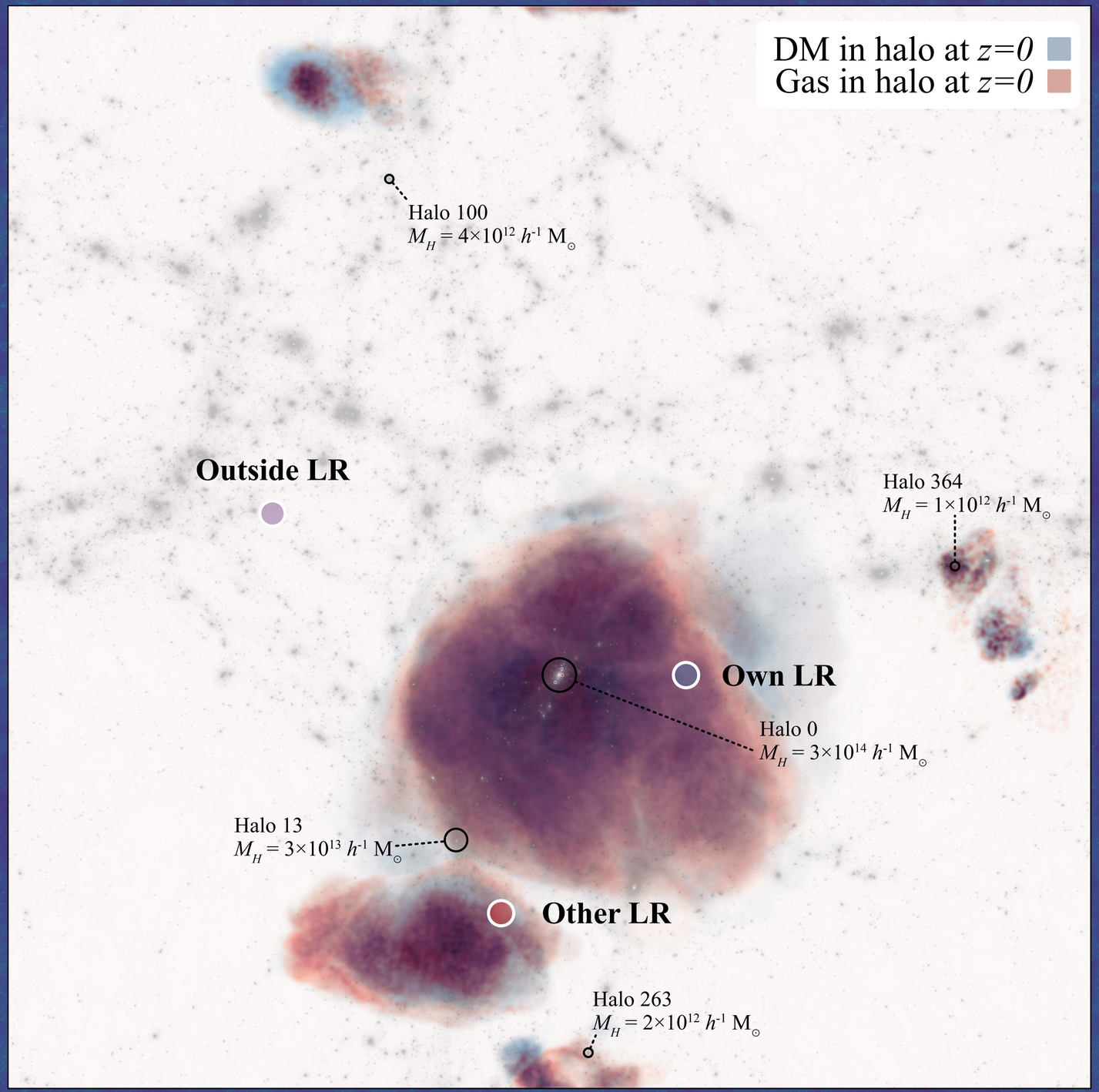
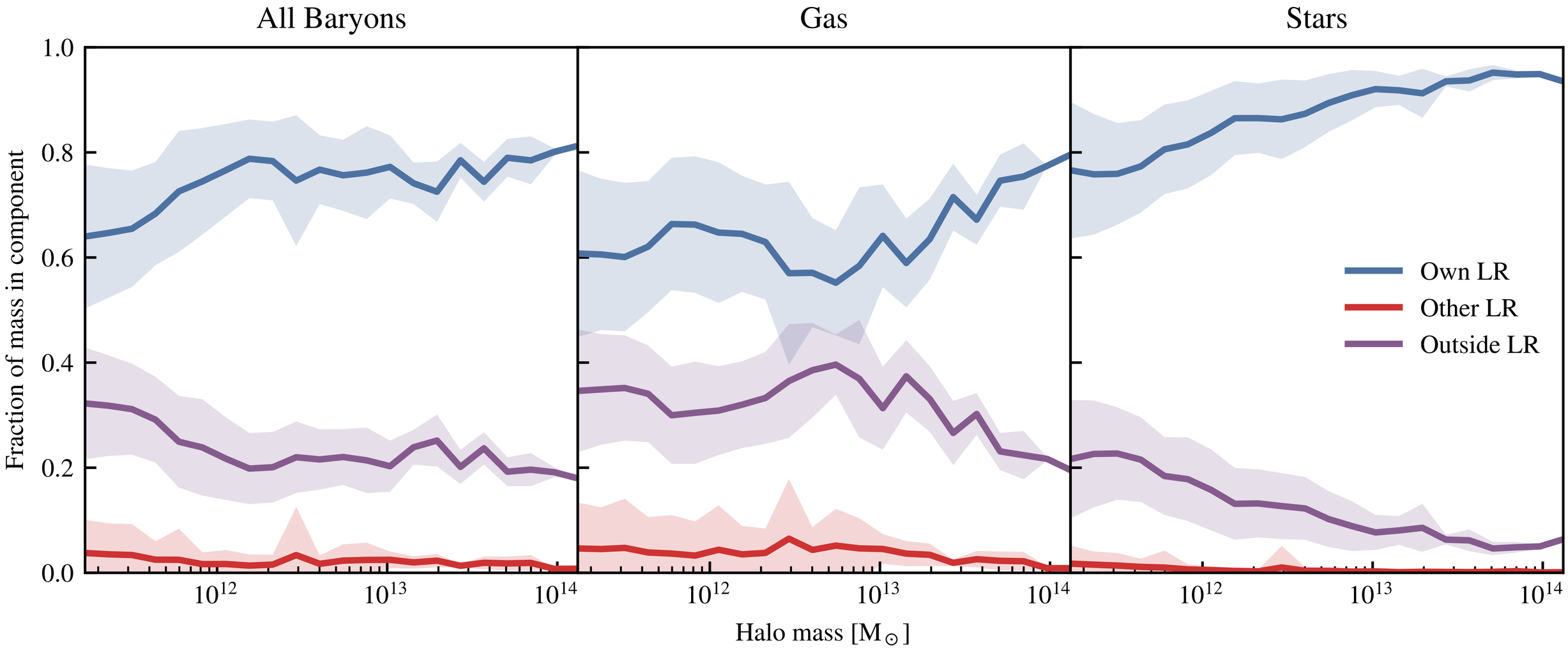
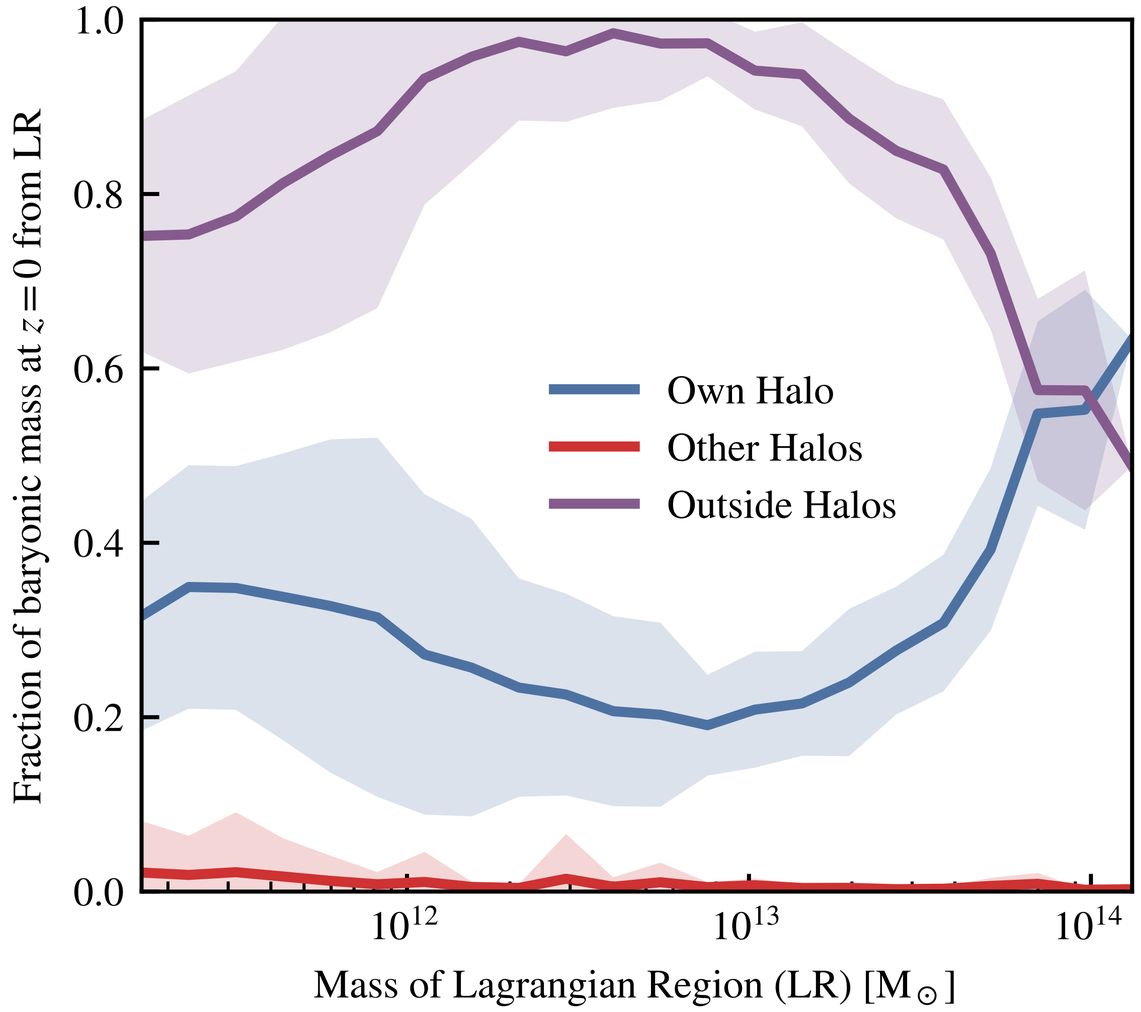


Where do the baryons come from?



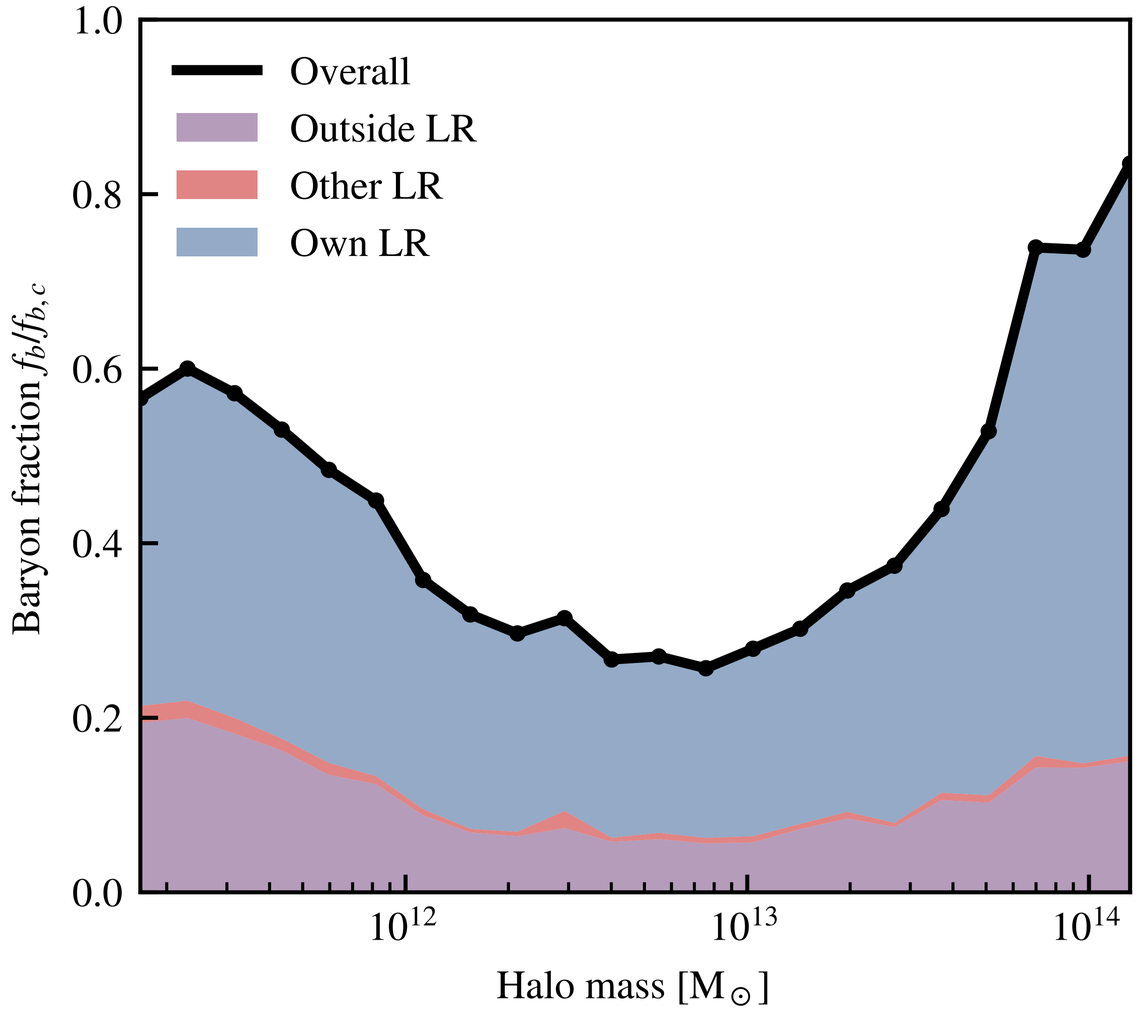
Where do the baryons go?

- Not correctly normalised due to differences in particle mass (we're working on this)
- Can see the hole blown in 'own halo' from AGN feedback around MW mass and above.



Baryon fractions

- Different Lagrangian components affected differently by feedback
- Looks like AGN feedback (at least in SIMBA) is mainly preventative, with particles from outside the LR being affected much more than those from inside.



Conclusions

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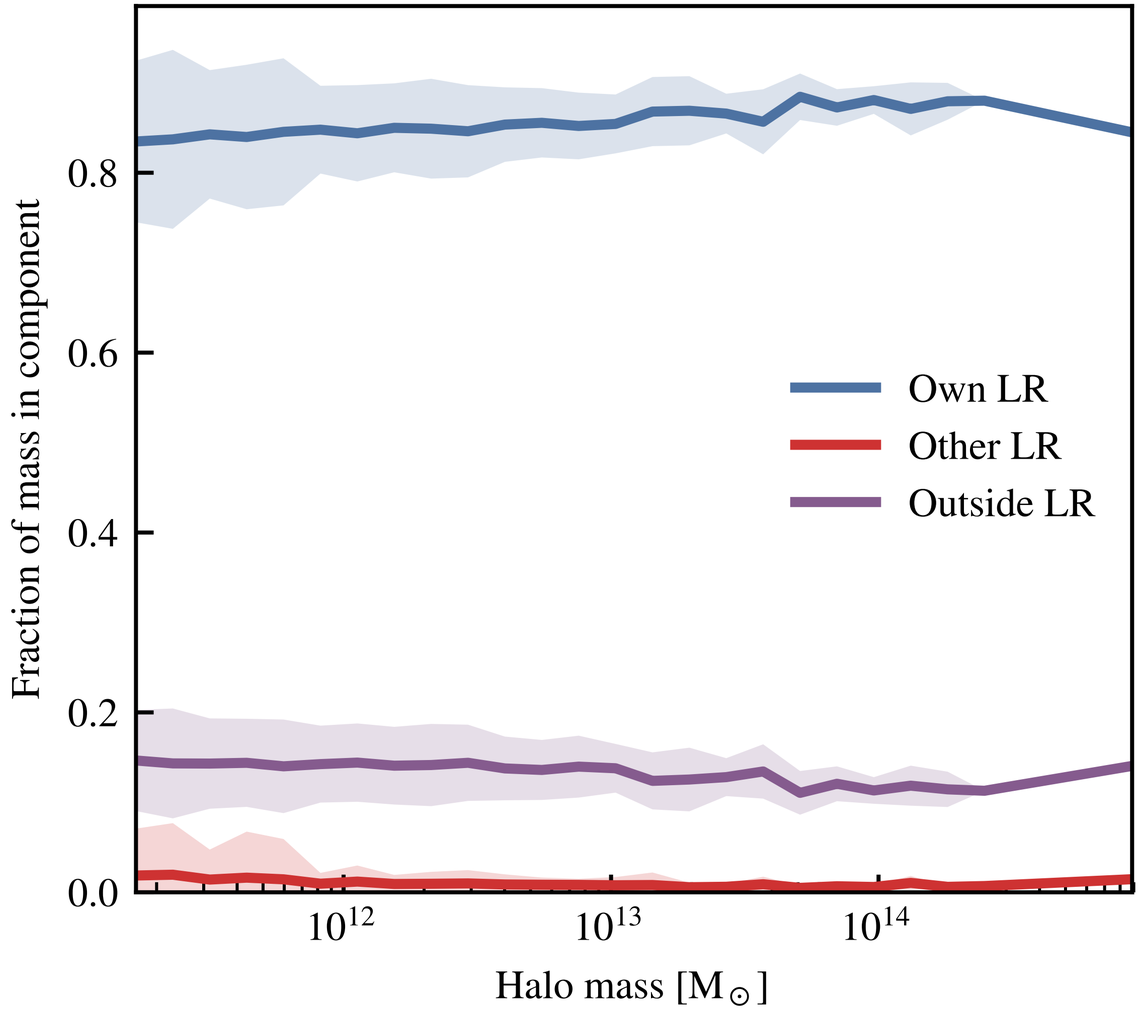
- SIMBA exists!
- Constraint on the maximal spread of baryons
- Able to **extract gas that has been affected by strong feedback** (including entrained gas)
- **10% of the gas mass** in a MW-mass halo **originated** from the LR of **another halo**!
- Plan to **extend this analysis to EAGLE, IllustrisTNG, and EAGLE-XL** (eventually)

Extra: Non-Radiative

- Non-radiative run shows that there is *no* transfer between halos
- Can still get transfer from 'outside' because of stripping
- Sub-halo falls into main halo, DM continues, gas shocks.



Extra

- See how things change with the number of neighbours to smooth over for distance metric
- More neighbours; more smooth.