

Cosmo-Paleontology

Searching for fossil groups in a gravity-only simulation

Aurora Cossairt

Katrin Heitmann, Salman Habib

Xin Liu, Michael Buehlmann, Eve Kovacs

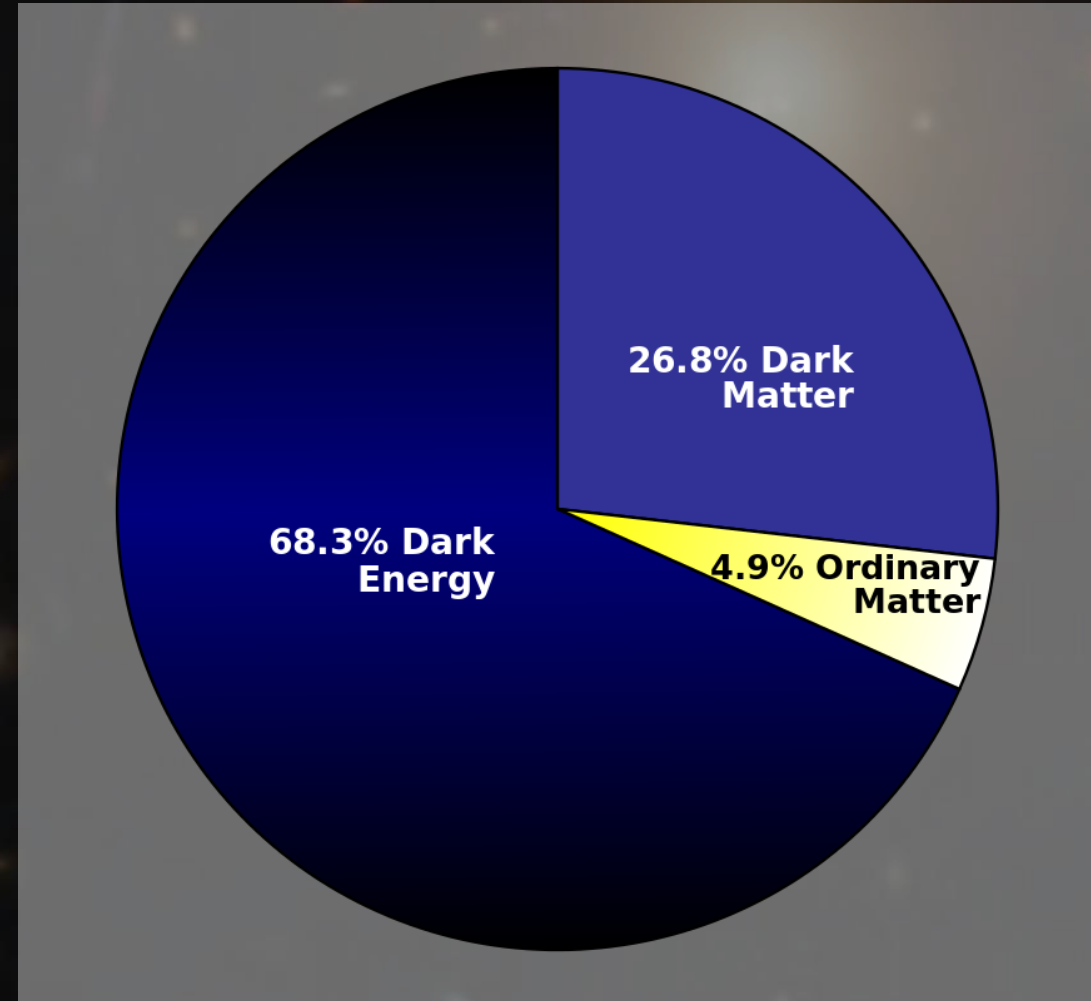
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Welcome to Cosmo-Paleontology!

- Our mission:
 - Search a simulated universe for fossil groups
 - Analyze findings statistically
 - Learn about structure formation

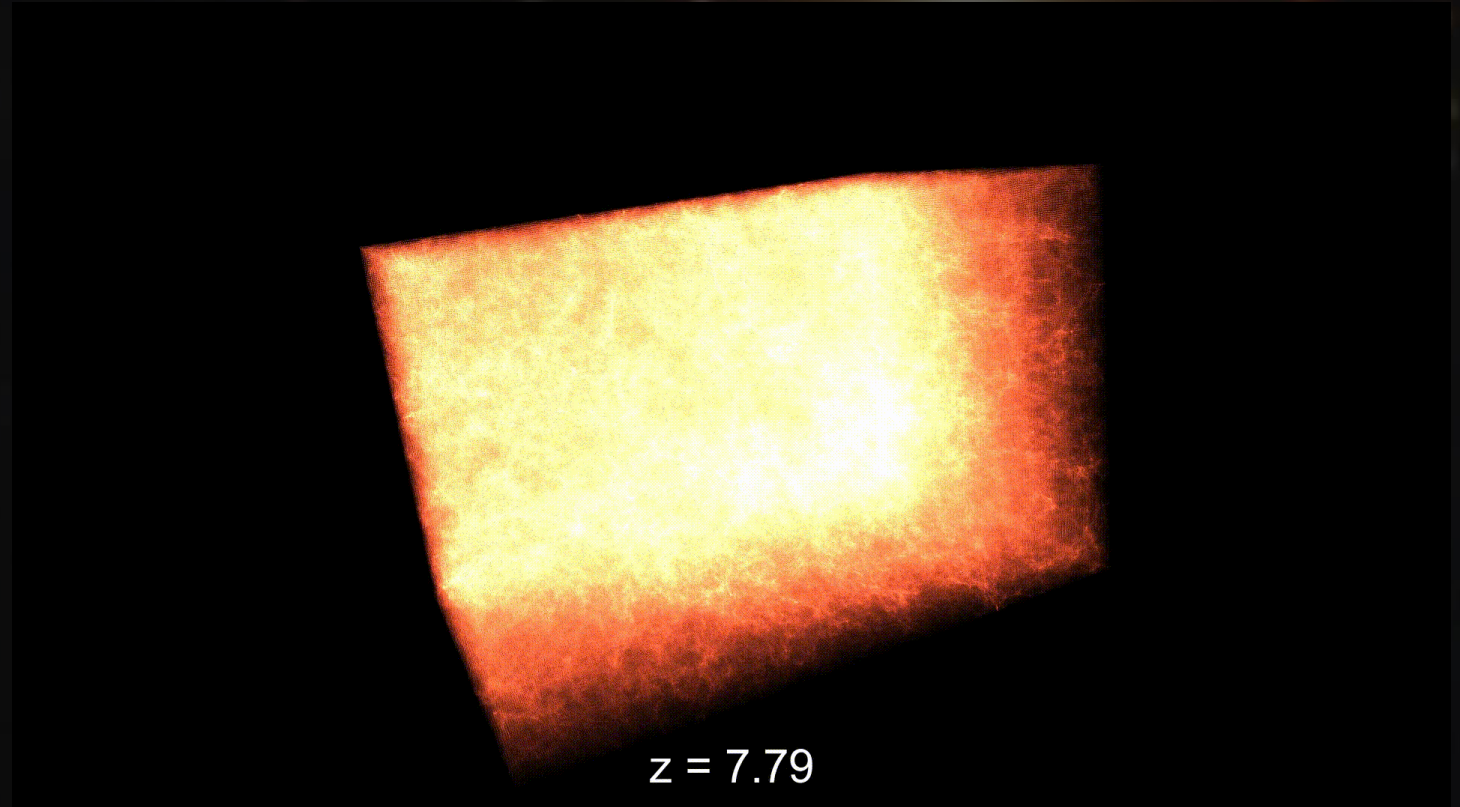
How can we study structure formation?

- Structures start as density perturbations
- Dark matter halos form & grow via merging
 - Become hosts for galaxies
- Simulations
 - Evolve dark matter particles gravitationally
 - Track dark matter halos from redshift 10 to 0

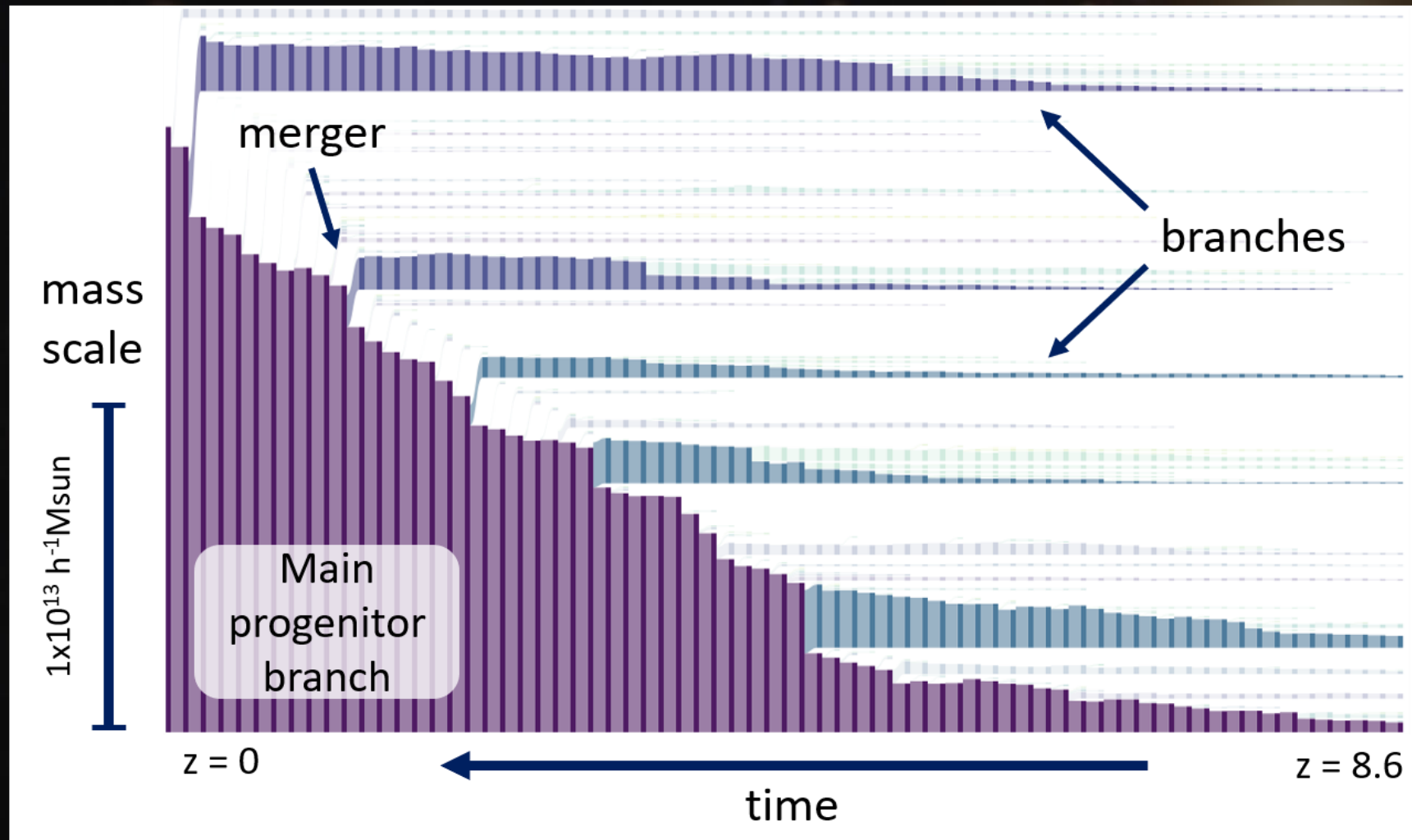


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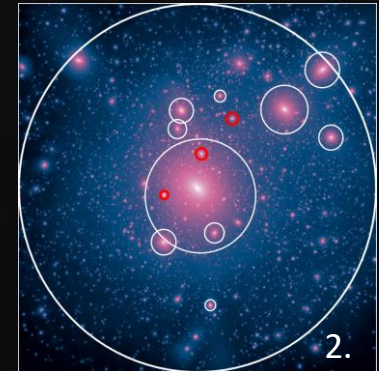


Merger trees track formation history



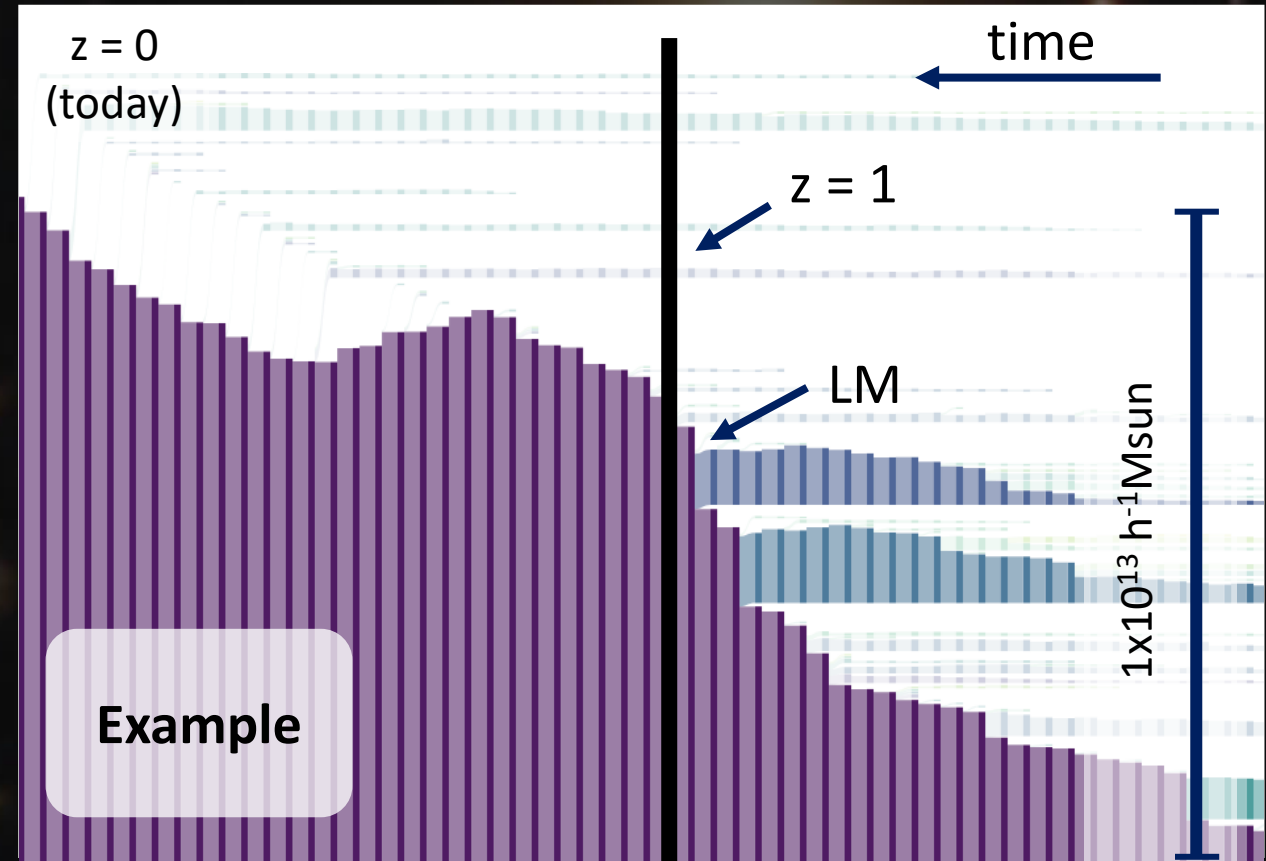
My Project: Fossil Groups

- *What are Fossil Groups?*
 - Very old, massive galaxy groups
 - Brightest Group Galaxy (BGG) lives in “dead” environment
 - Theory: no recent merging activity
- *How can they help us?*
 - Rare object validation
- *Can we find them in our gravity-only simulation?*

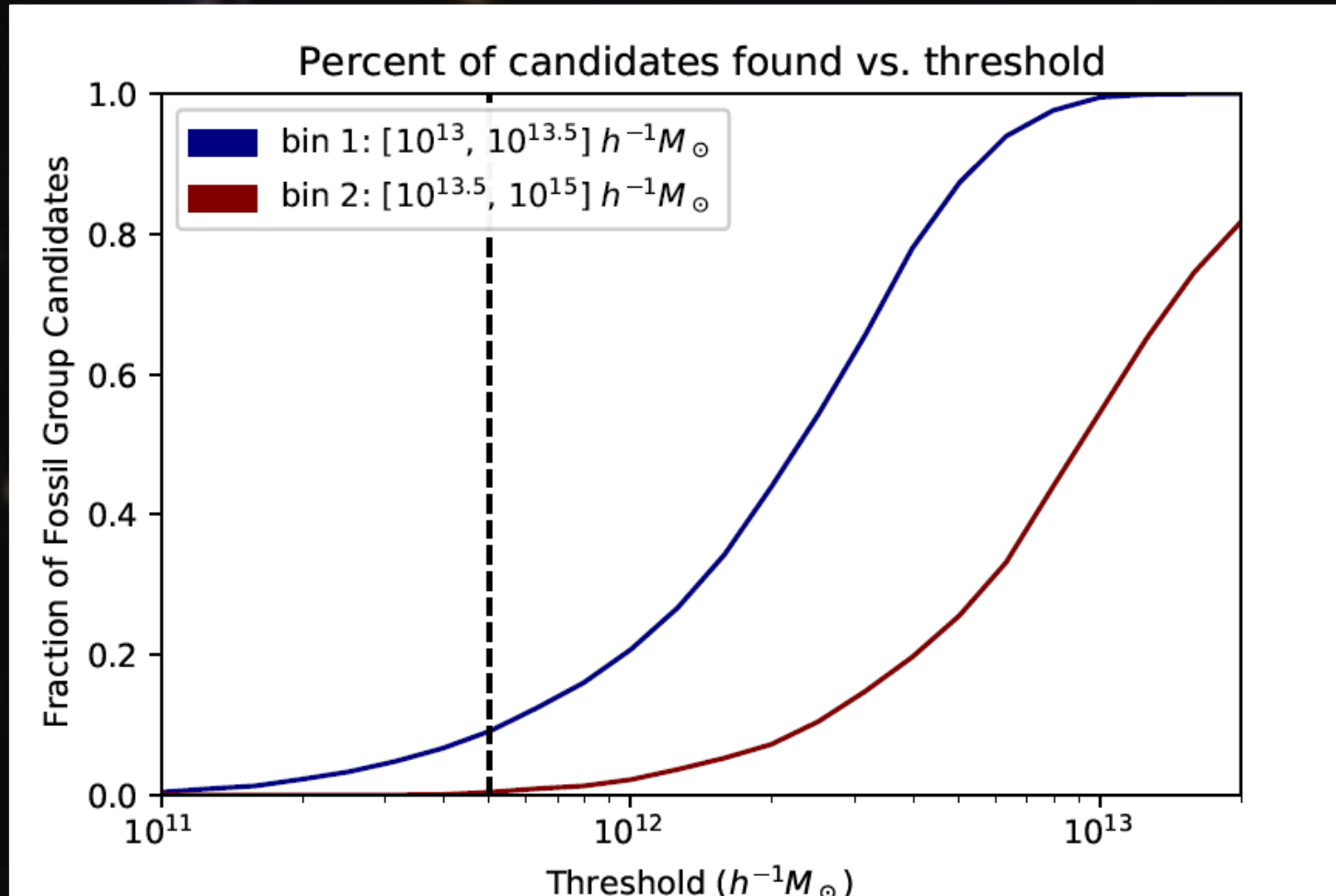


The Search Begins

- Expectation
 - No significant merging activity in recent history
- Luminous Merger (LM)
 - Mass threshold: $5 \times 10^{11} h^{-1} M_{\text{sun}}$
 - No LM after redshift 1
- Search in two mass bins
 - Bin 1: 10^{13} to $10^{13.5} h^{-1} M_{\text{sun}}$
 - Bin 2: $> 10^{13.5} h^{-1} M_{\text{sun}}$

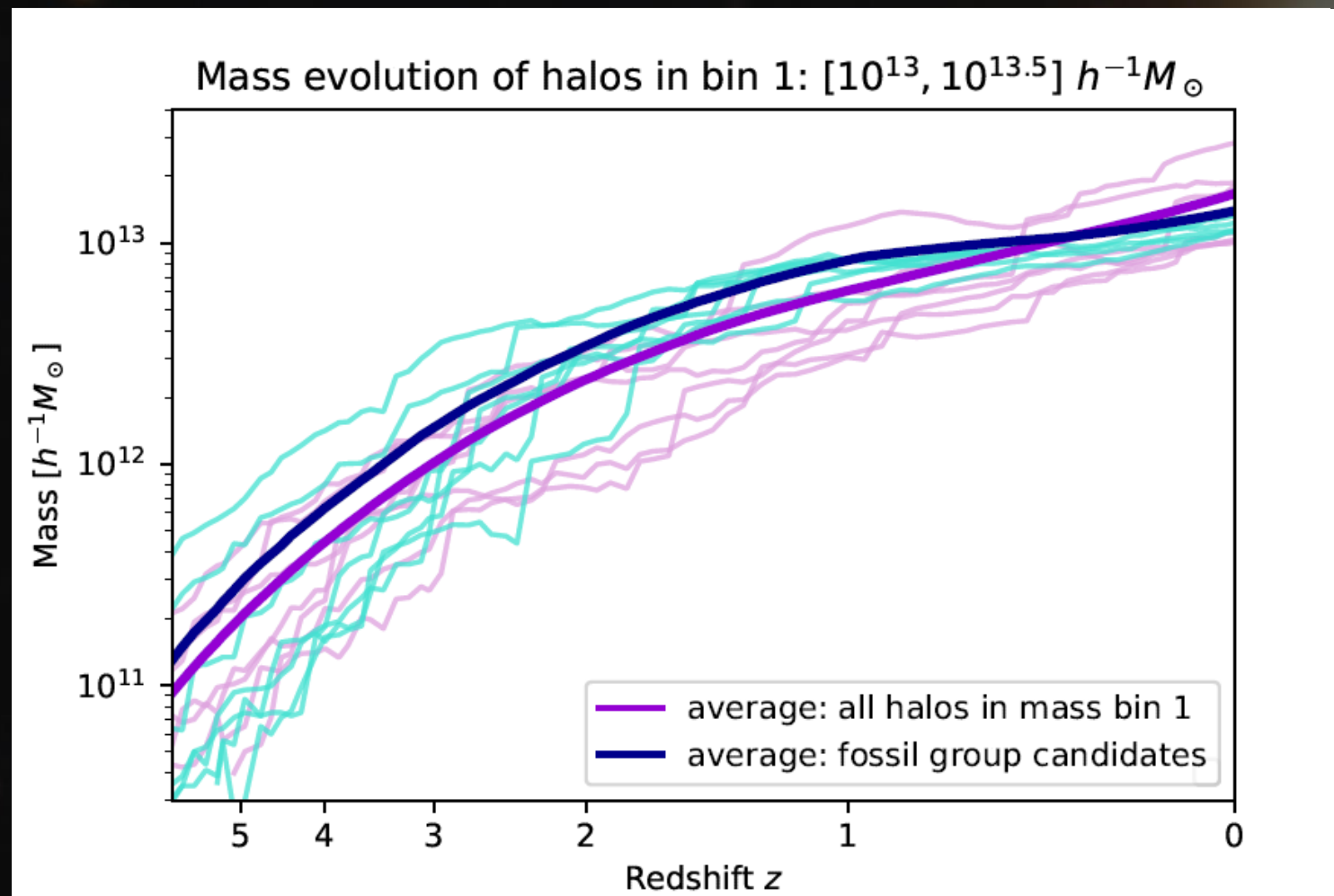


Initial Findings

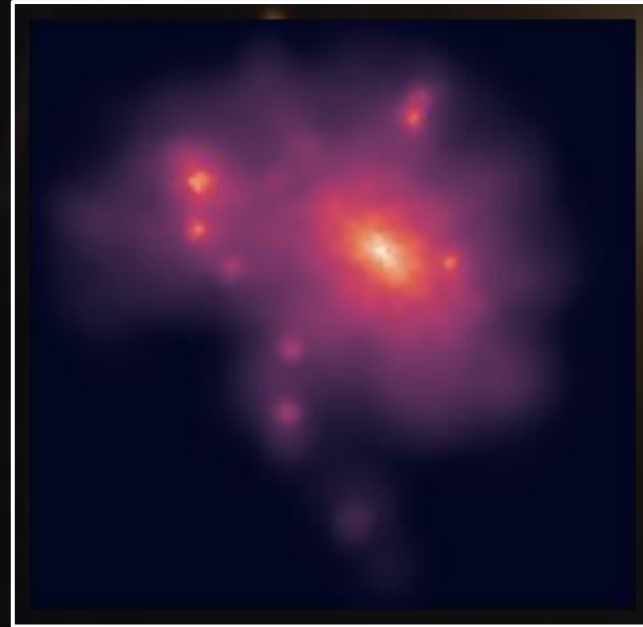
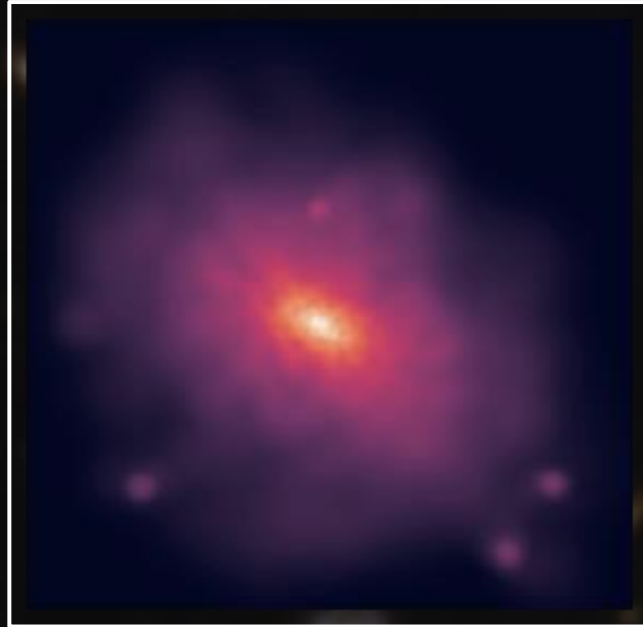


	10^{13} to $10^{13.5}$ $h^{-1}M_{\text{sun}}$	$>10^{13.5}$ $h^{-1}M_{\text{sun}}$
# FGs found	434	7
Total # halos	4797	1784
# FGs/ total	9%	0.39%

What do their histories look like?



Substructure



	All halos	Fossil group candidates	FGs/All
$f_{\text{sub,max}} = \frac{\max_i M_{\text{sub},i}}{M_{\text{halo}}}$	$(5.8 \pm 0.1) \times 10^{-2}$	$(8.8 \pm 0.3) \times 10^{-3}$	~15%
$f_{\text{sub,tot}} = \frac{\sum_i M_{\text{sub},i}}{M_{\text{halo}}}$	$(1.87 \pm 0.01) \times 10^{-1}$	$(1.01 \pm 0.02) \times 10^{-1}$	~54%

Mission Recap

- Goal: search for fossil groups in our simulation
- Define fossil group candidates
 - No luminous mergers after $z = 1$
- We found some!
 - Most candidates within $[10^{13} \text{ to } 10^{13.5}] h^{-1}M_{\text{sun}}$
 - Candidates have little substructure
- Next Steps
 - Try with larger simulations, include baryons
 - Compare with real observations

References

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- Srisawat, C. et. Al. (2013). Sussing Merger Trees: The Merger Trees Comparison Project. Monthly Notices of the Royal Astronomical Society. 436. Voit, G. (2004). Tracing cosmic evolution with clusters of galaxies. Reviews of Modern Physics.

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Thank you!

Contact: Aurora Cossairt
a.cossairt@outlook.com

Katrin Heitmann, Salman Habib,
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Argonne National Laboratory, SULI

Bonus Slides

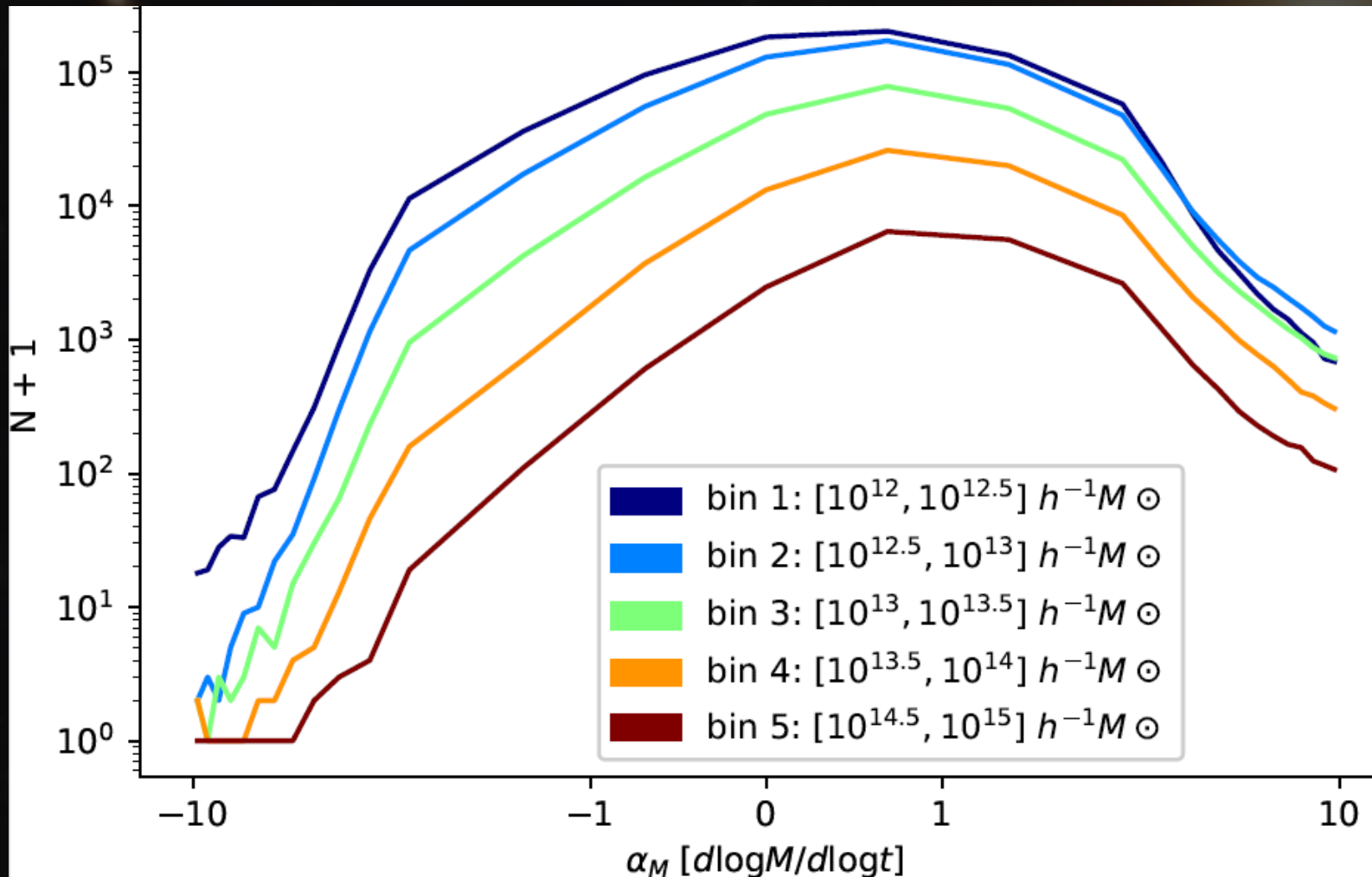
For curious audience members 😊

About Our Simulation

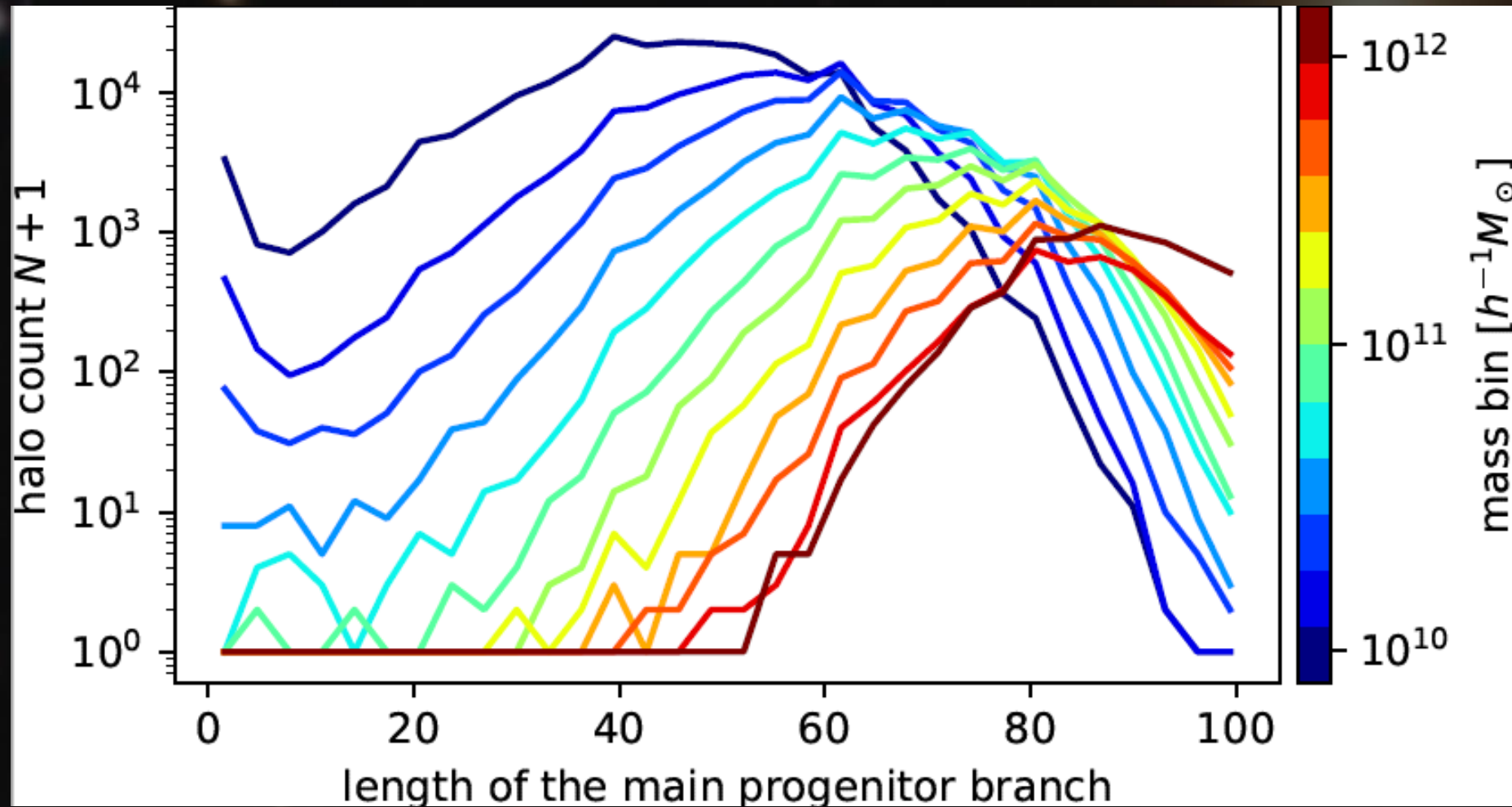
- Smaller version of Last Journey
- Last Journey
 - Mira's last run, 2019
 - Evolves ~1.24 trillion particles
 - Volume: (3400 Mpc)³
- Smaller version
 - Evolves ~1.1 billion particles
 - Volume: (250 Mpc)³

Ω_Λ	0.69
Ω_{cdm}	0.26067
Ω_b	0.04933
Ω_m	0.31
H_0	67.66 km s ⁻¹ Mpc ⁻¹
σ_8	0.8102
n_s	0.9665

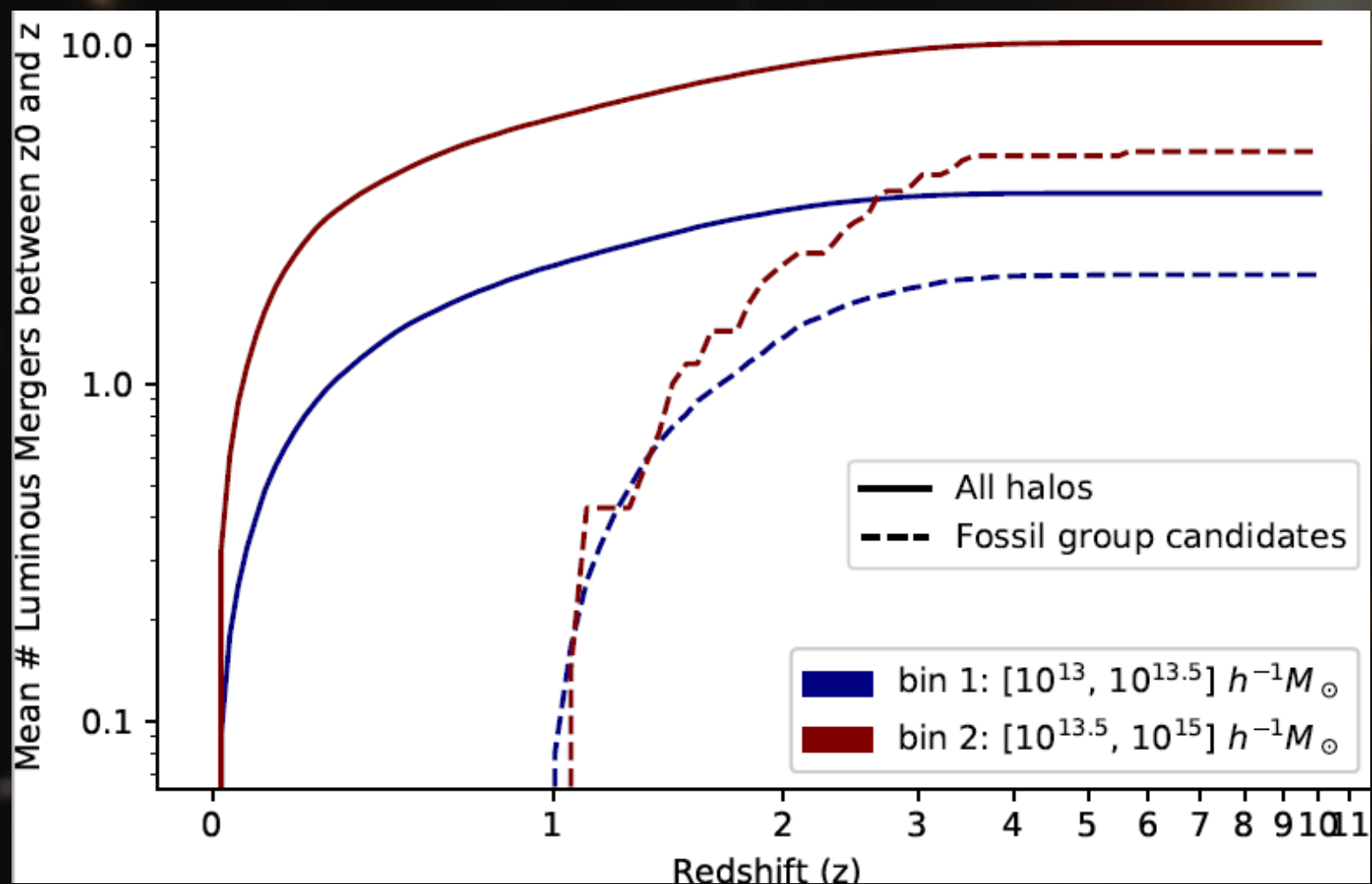
Can we trust our merger trees?



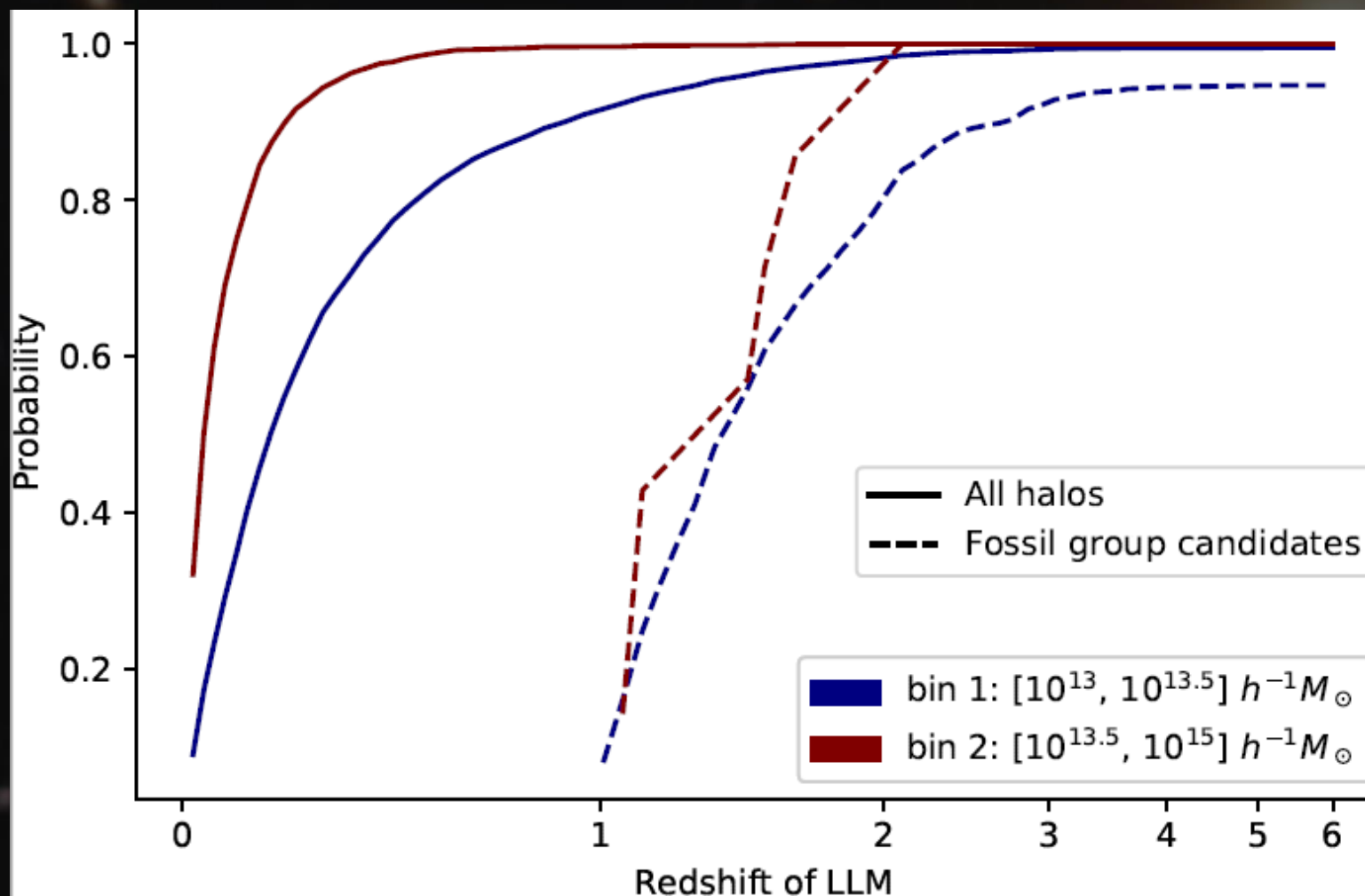
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Luminous Mergers



Luminous Mergers



Redshift Cutoff

