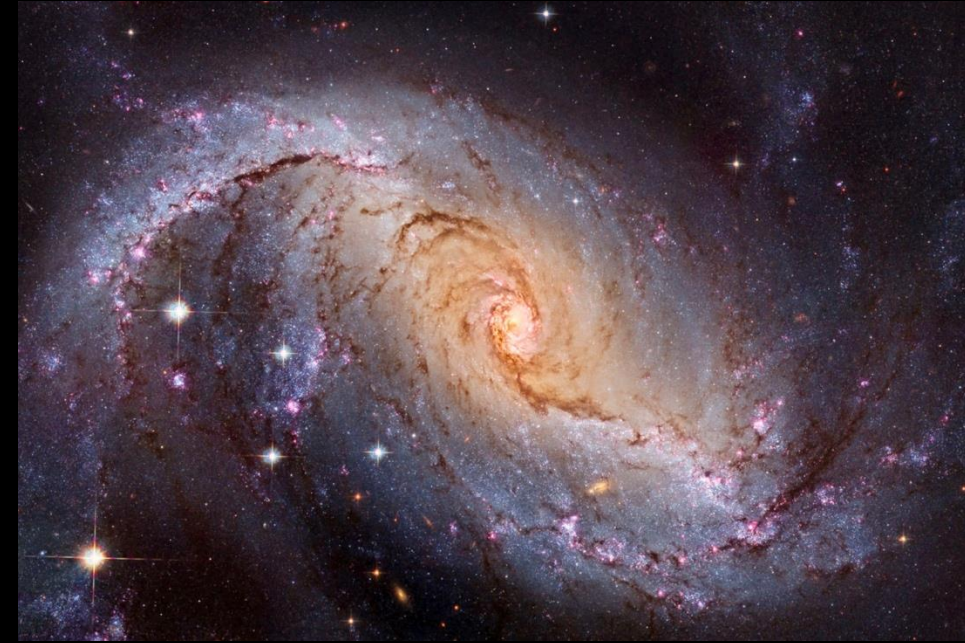


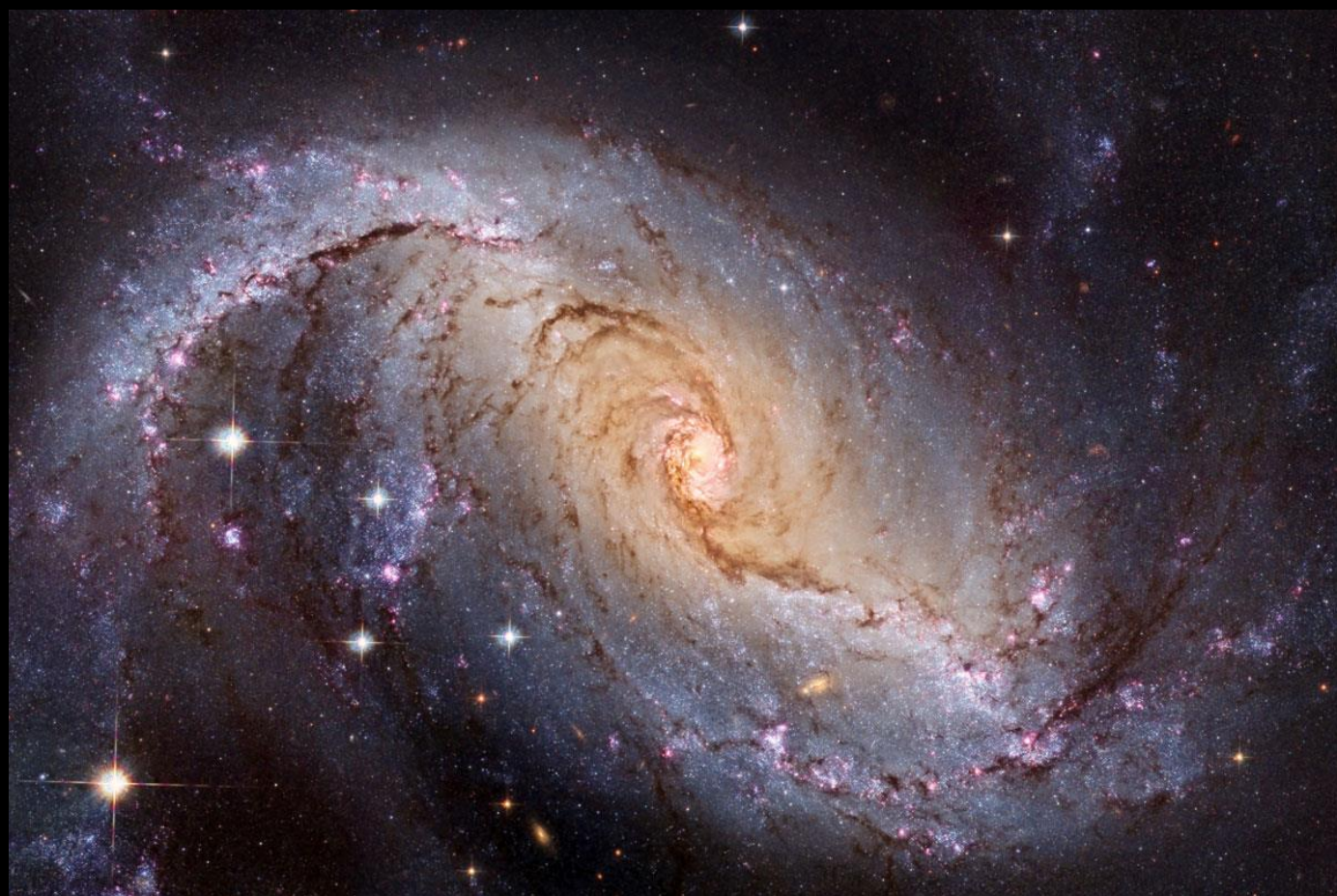
Connecting halo environment and assembly



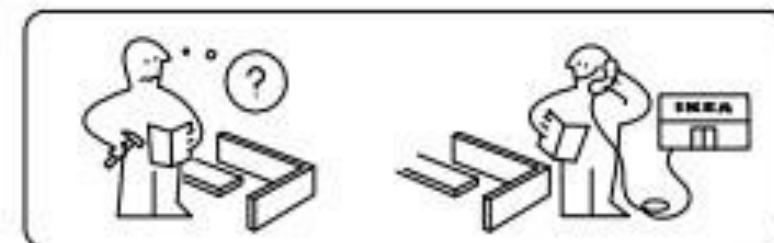
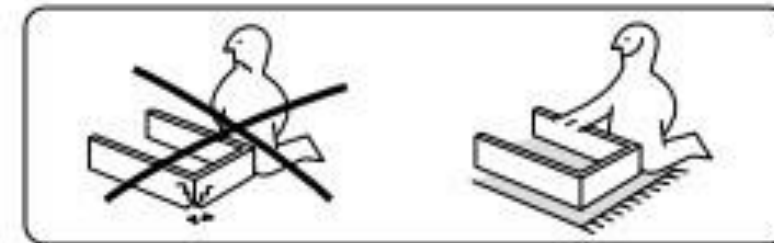
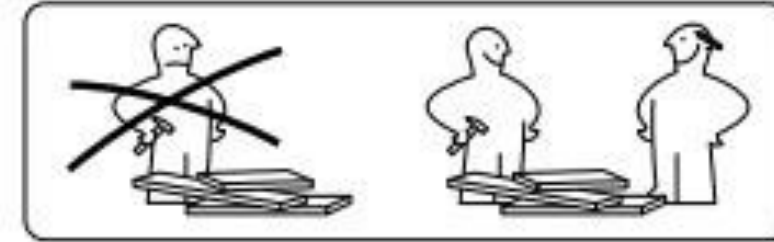
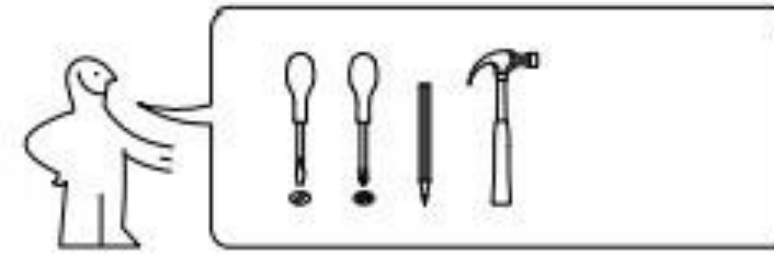
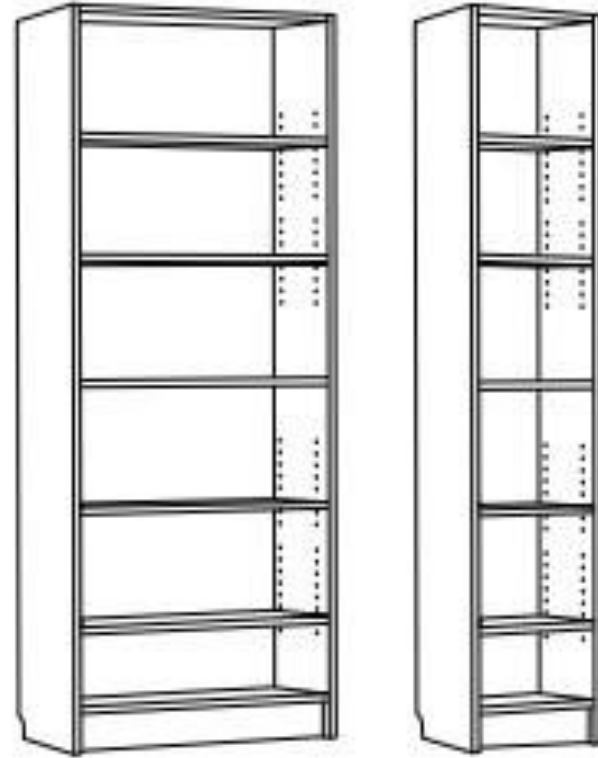
Christian Kragh Jespersen

Cosmic Horizons, Charlottesville, 14/07-2026

with **John F. Wu, Peter Melchior, David N. Spergel**, Chen-Yu Chuang, Miles Cranmer, Shirley Ho, rachel s. somerville, Risa Wechsler, Shy Genel, Yen-Ting Lin, Austen Gabrielpillai

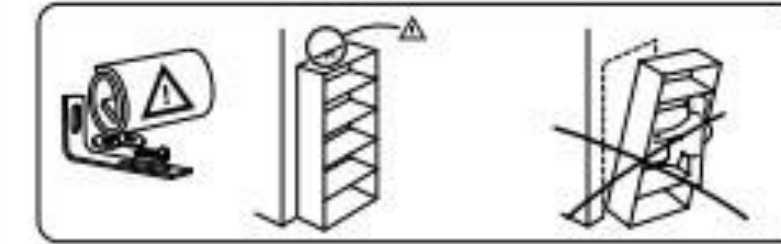


BILLY



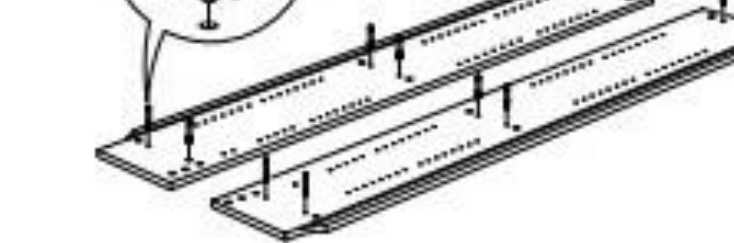
2

ALFVILA



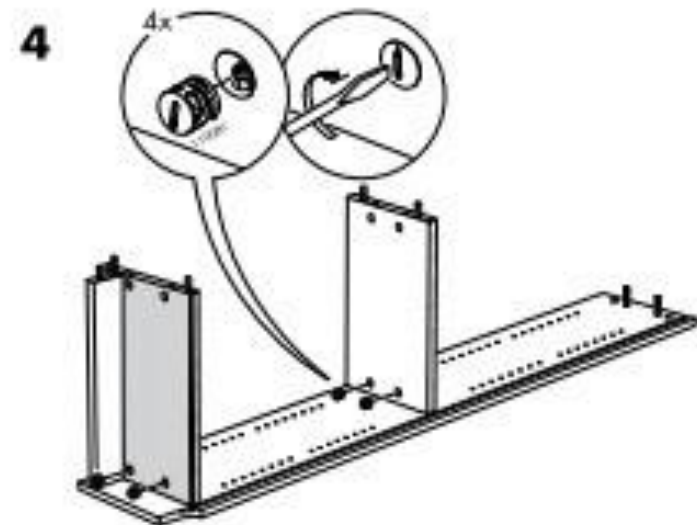
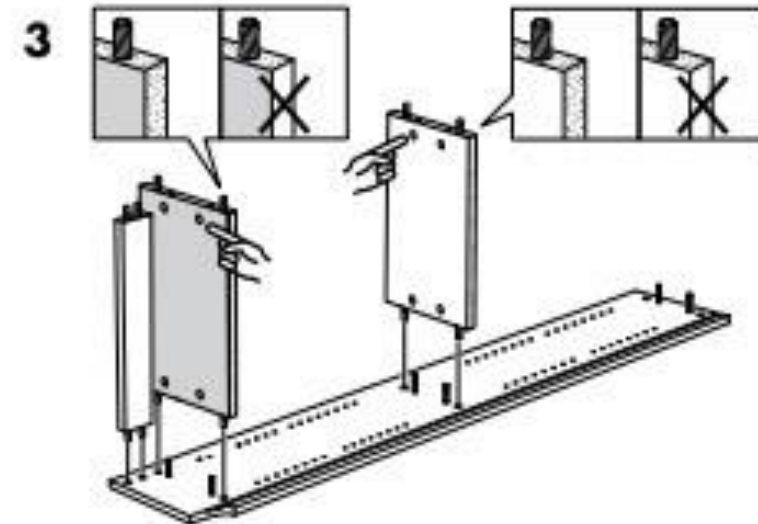
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ALFVILA



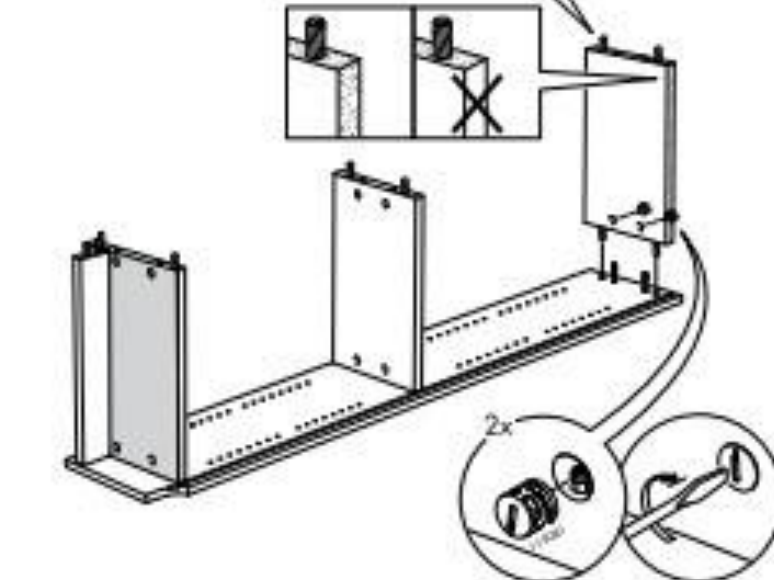
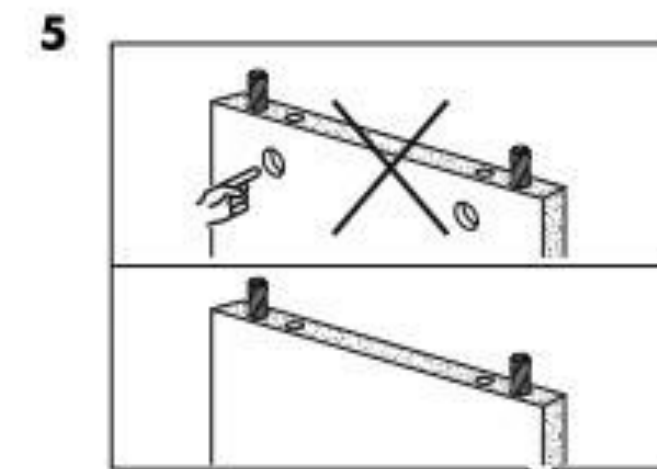
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ALFVILA



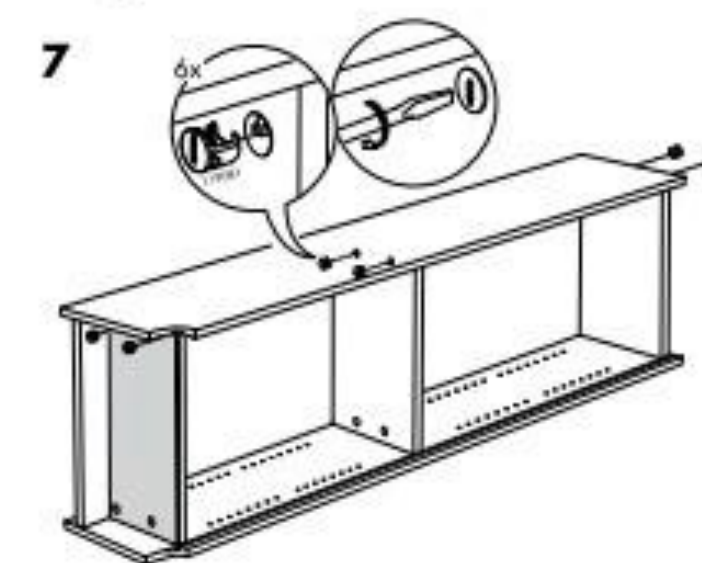
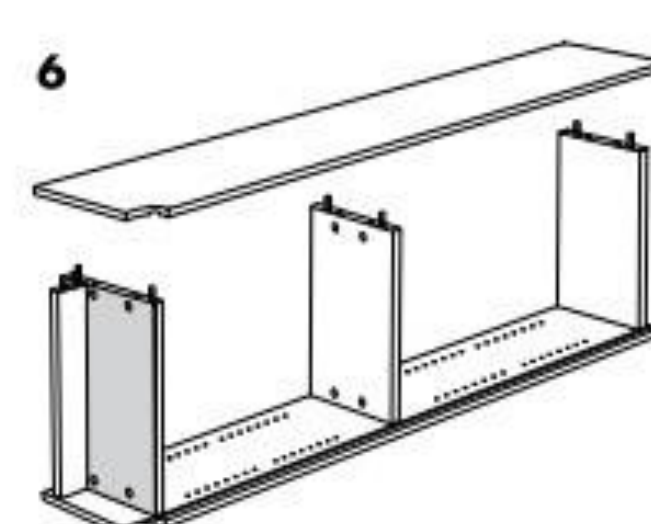
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ALFVILA



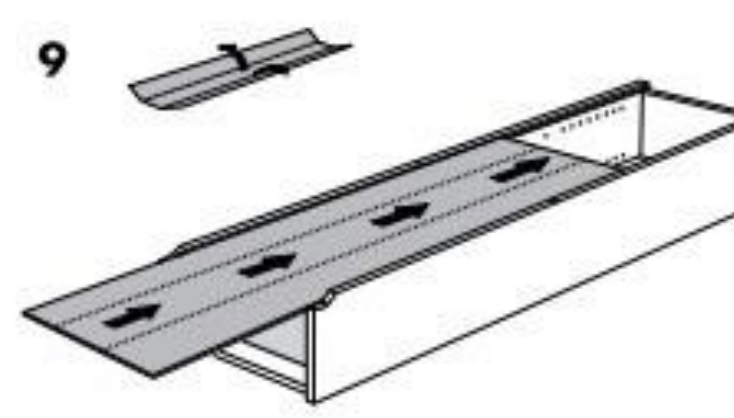
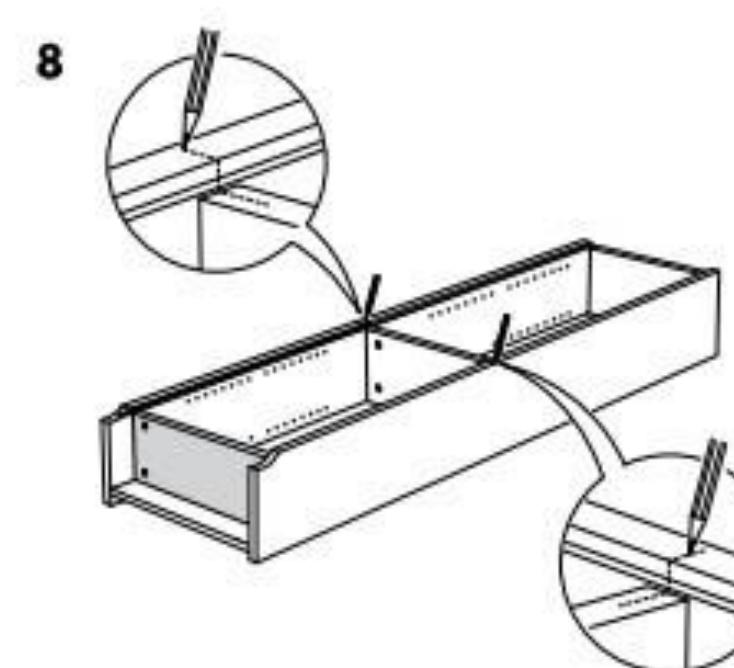
6

ALFVILA



7

ALFVILA



8

ALFVILA

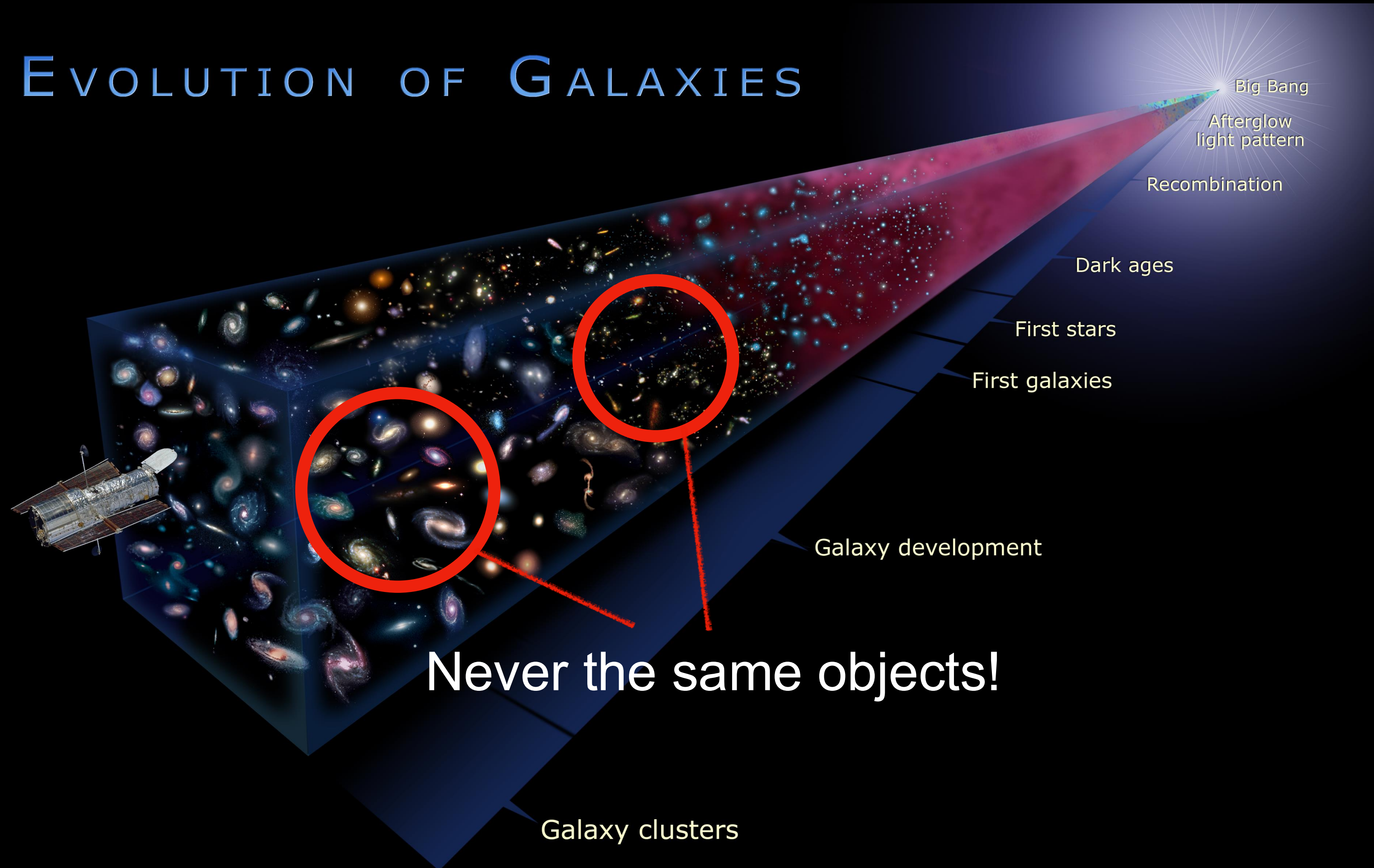
GÅLÅXÿ



CONSTRUCTION
MANUAL



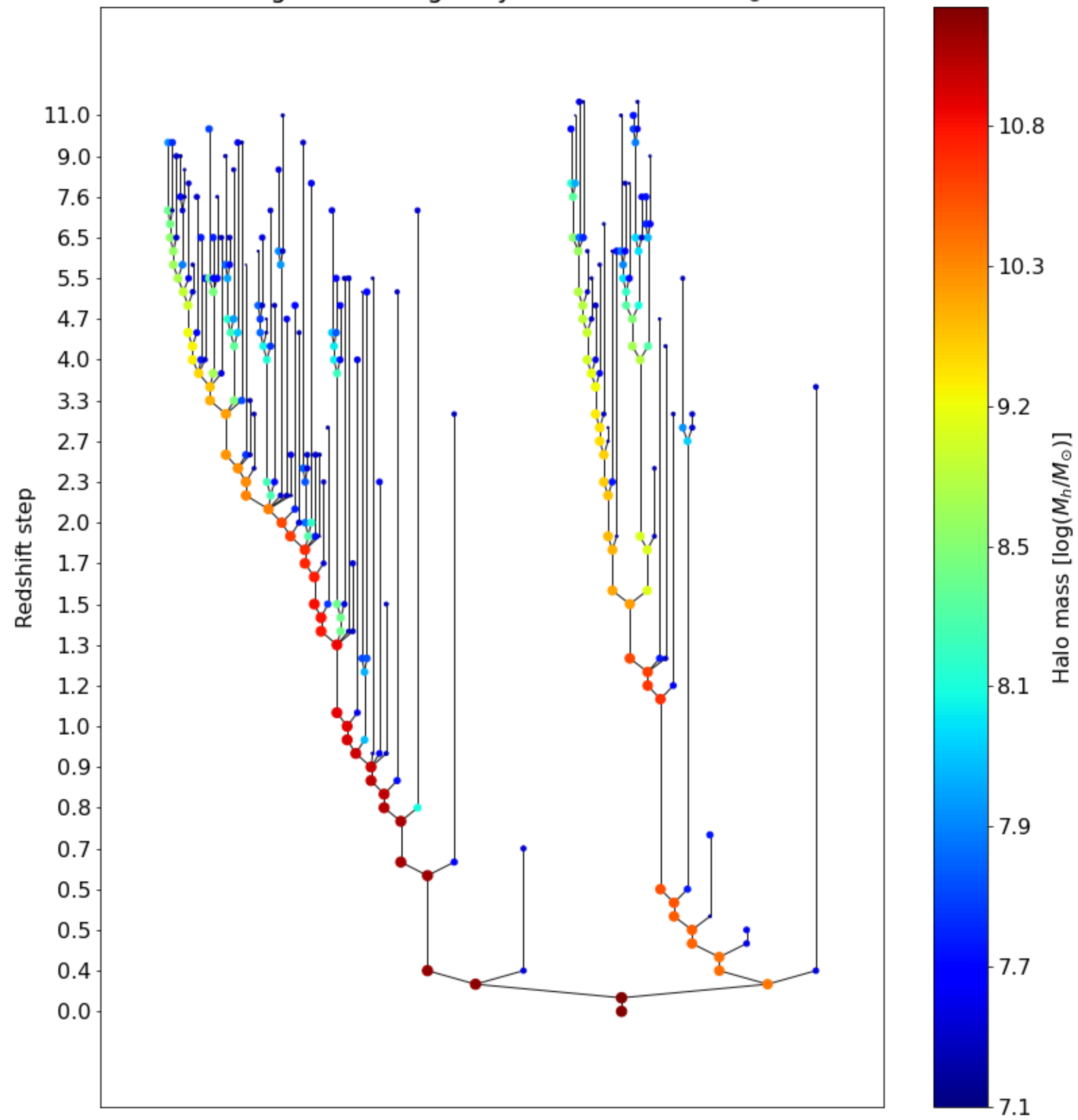
EVOLUTION OF GALAXIES

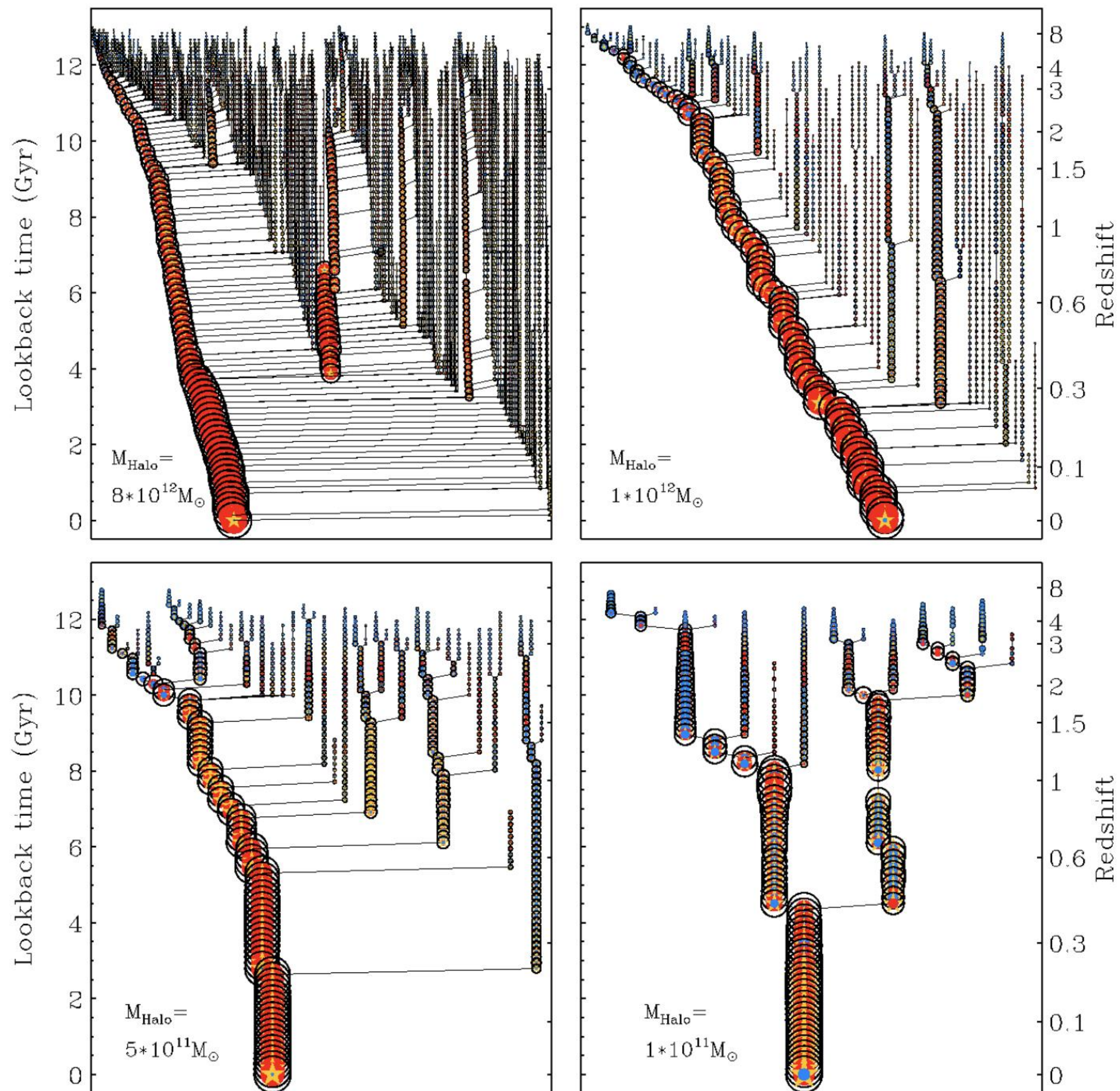


4D2U

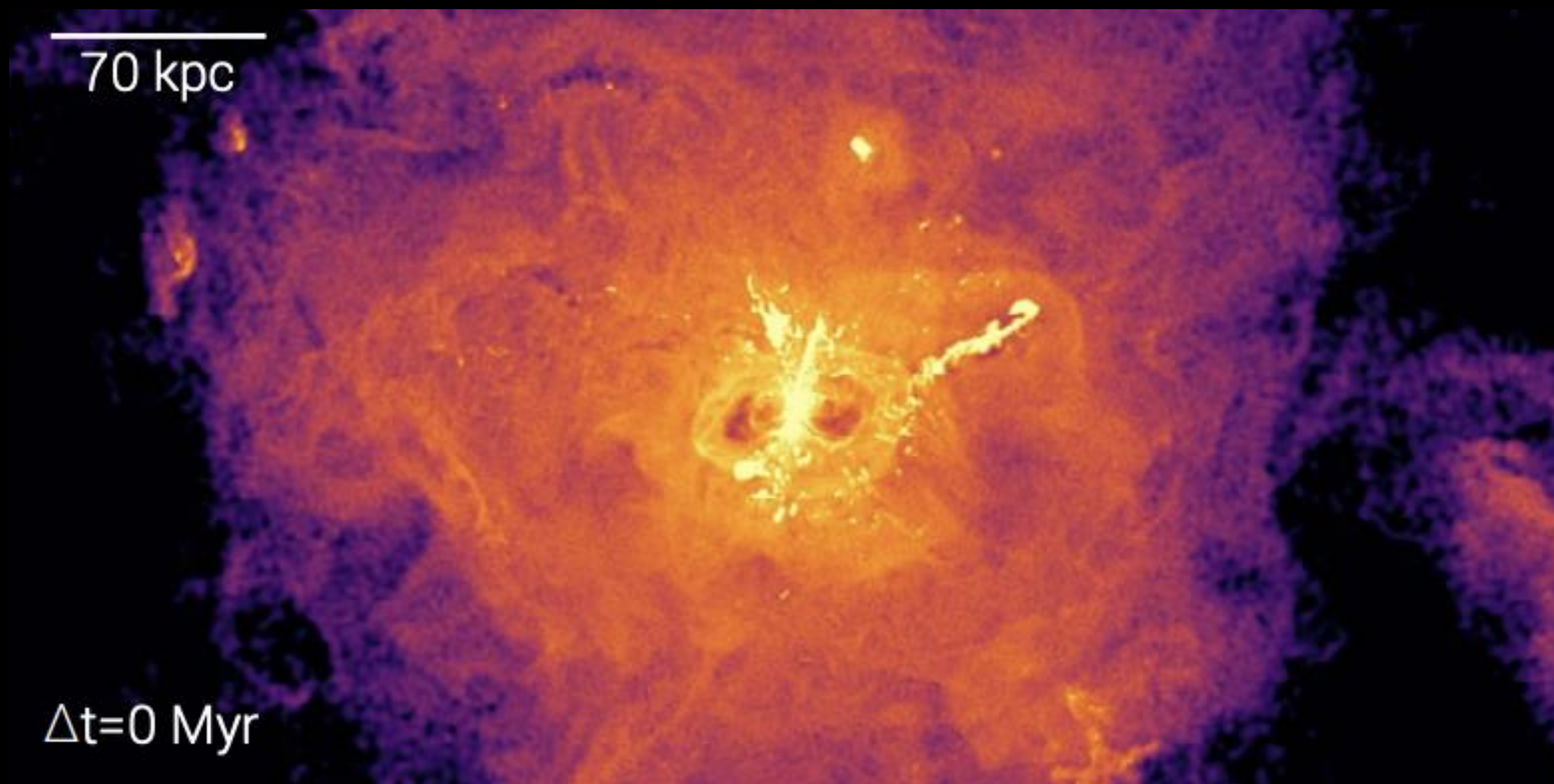
©Tomoaki Ishiyama, Hirotaka Nakayama, 4D2U Project, NAOJ

Merger tree for galaxy with mass $10^{8.5} M_{\odot}$





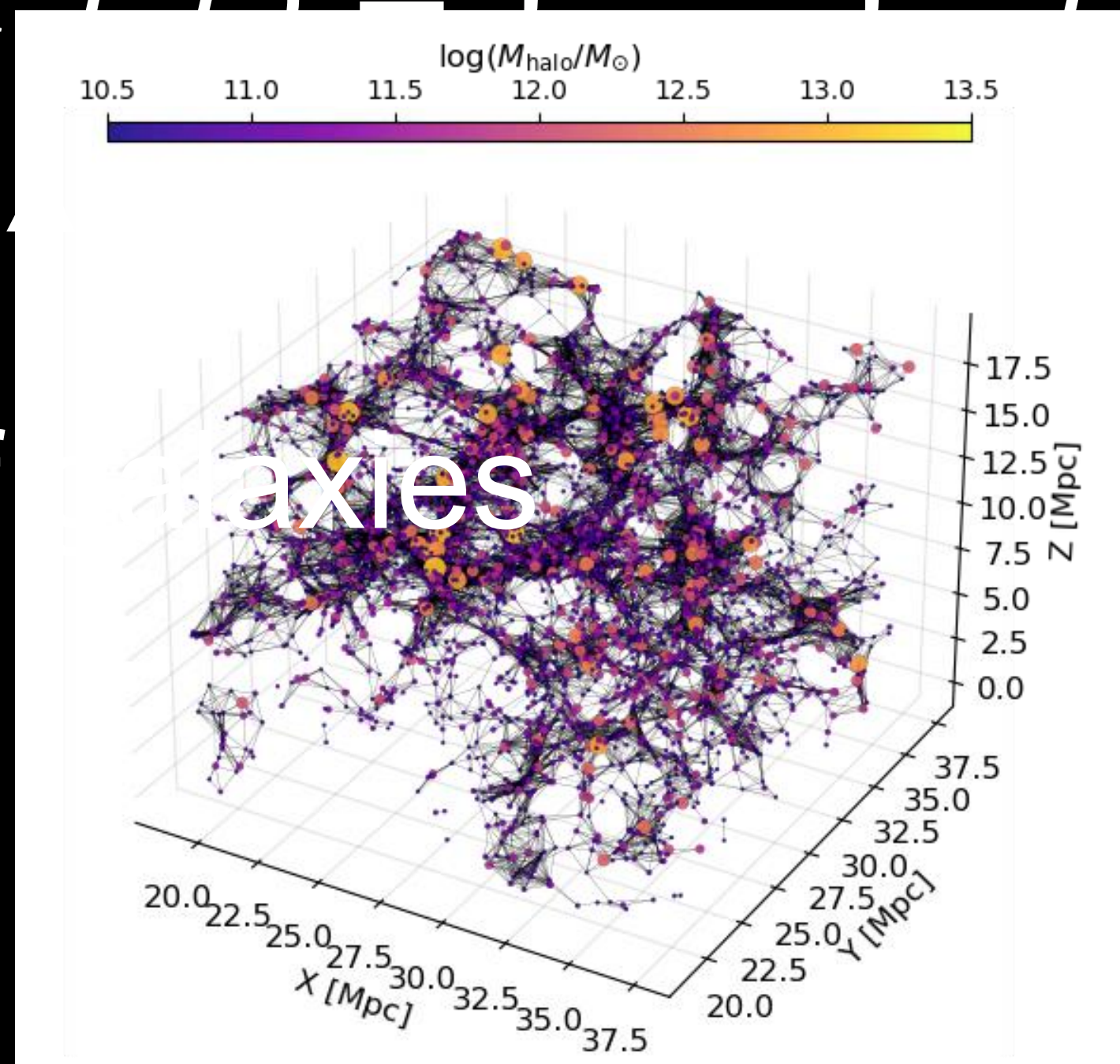
galaxy $\approx f(\text{DM assembly})$



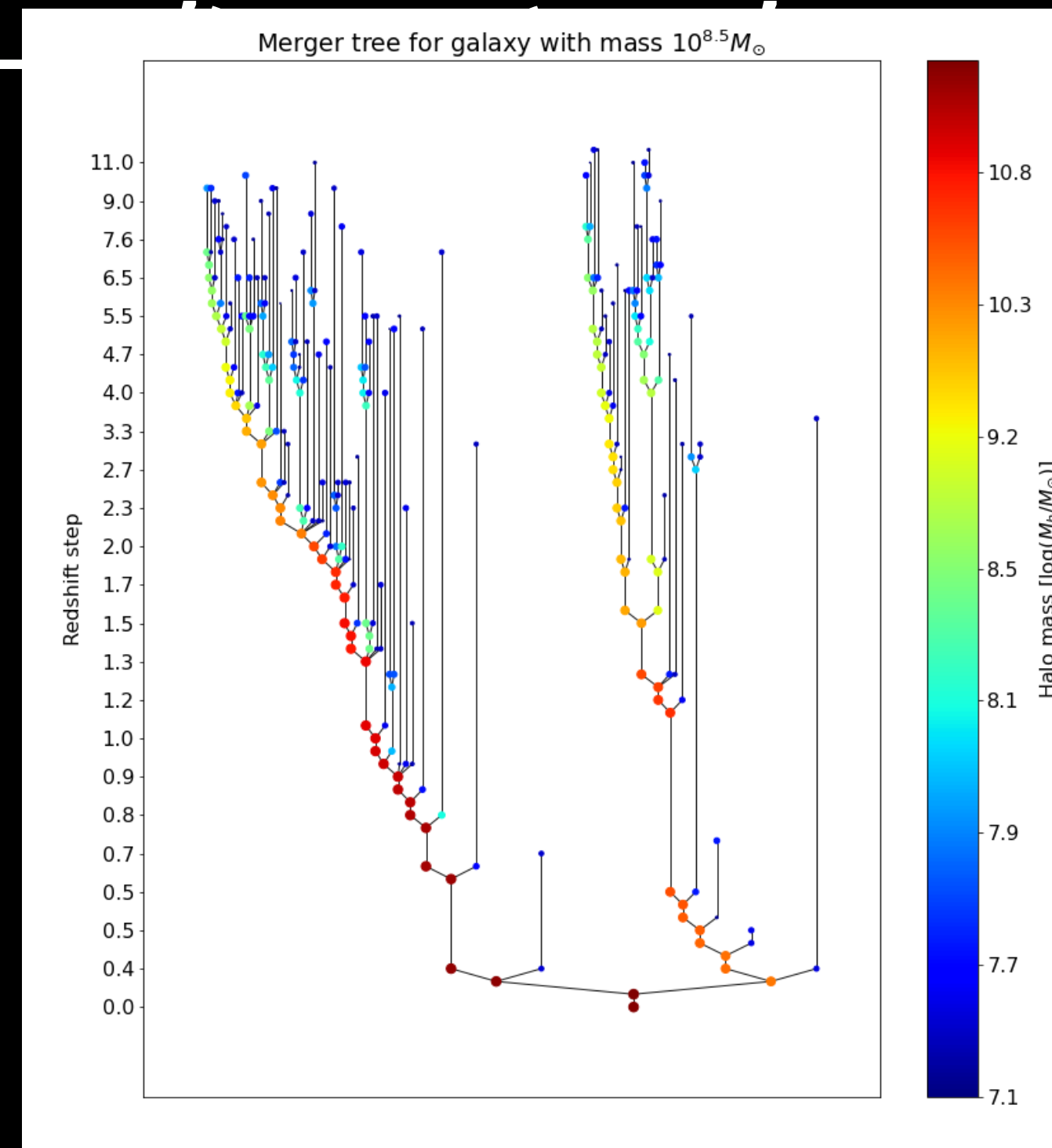


$$g(X, t, r) = \int_{\text{Now}}^{\infty} \int_{\text{Now}}^{\infty} \dot{g}(X, t', r - r') dr'^3 dt'$$

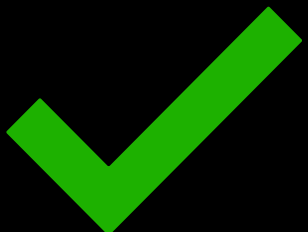
Field of galaxies



Physics



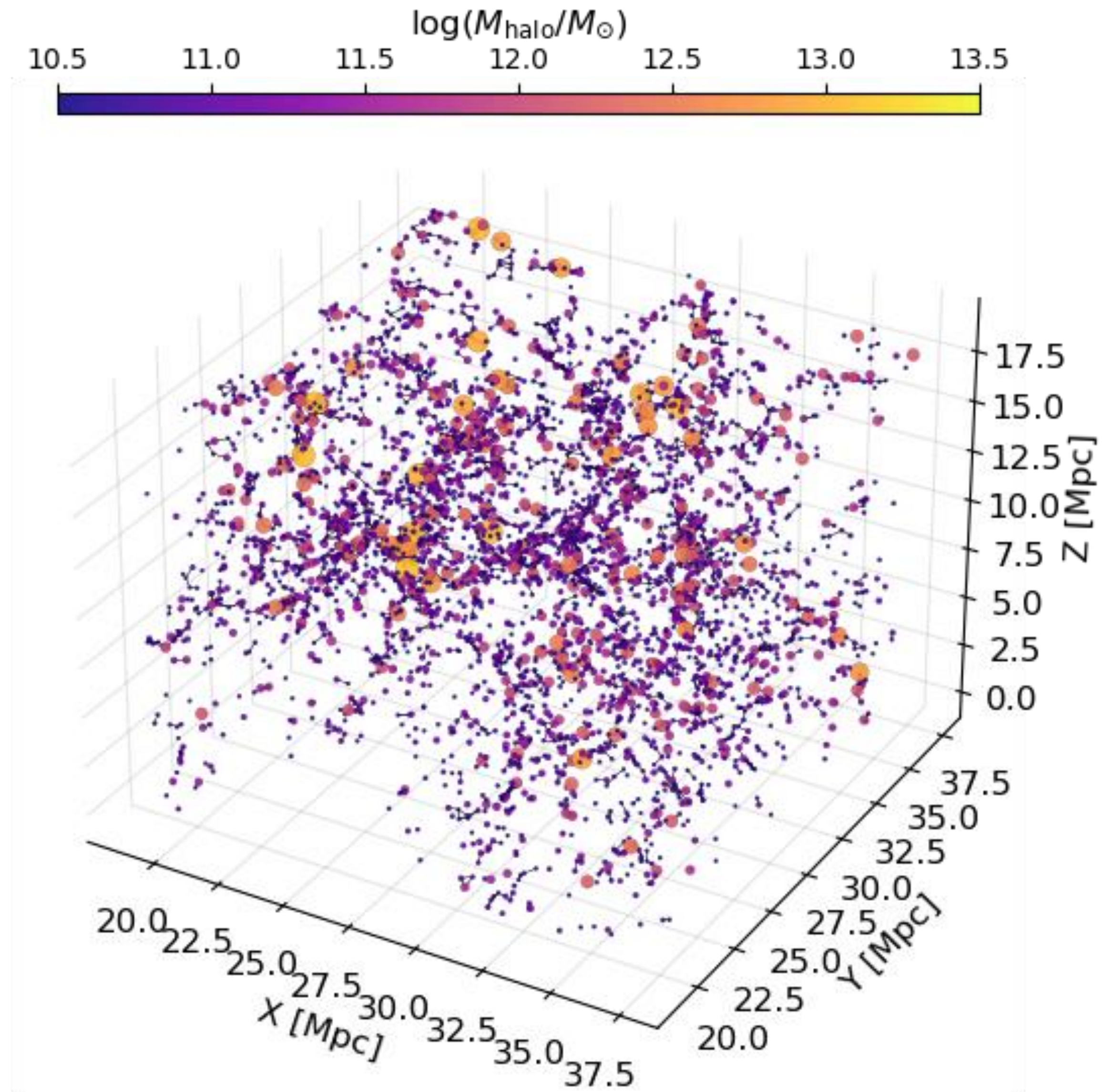
History

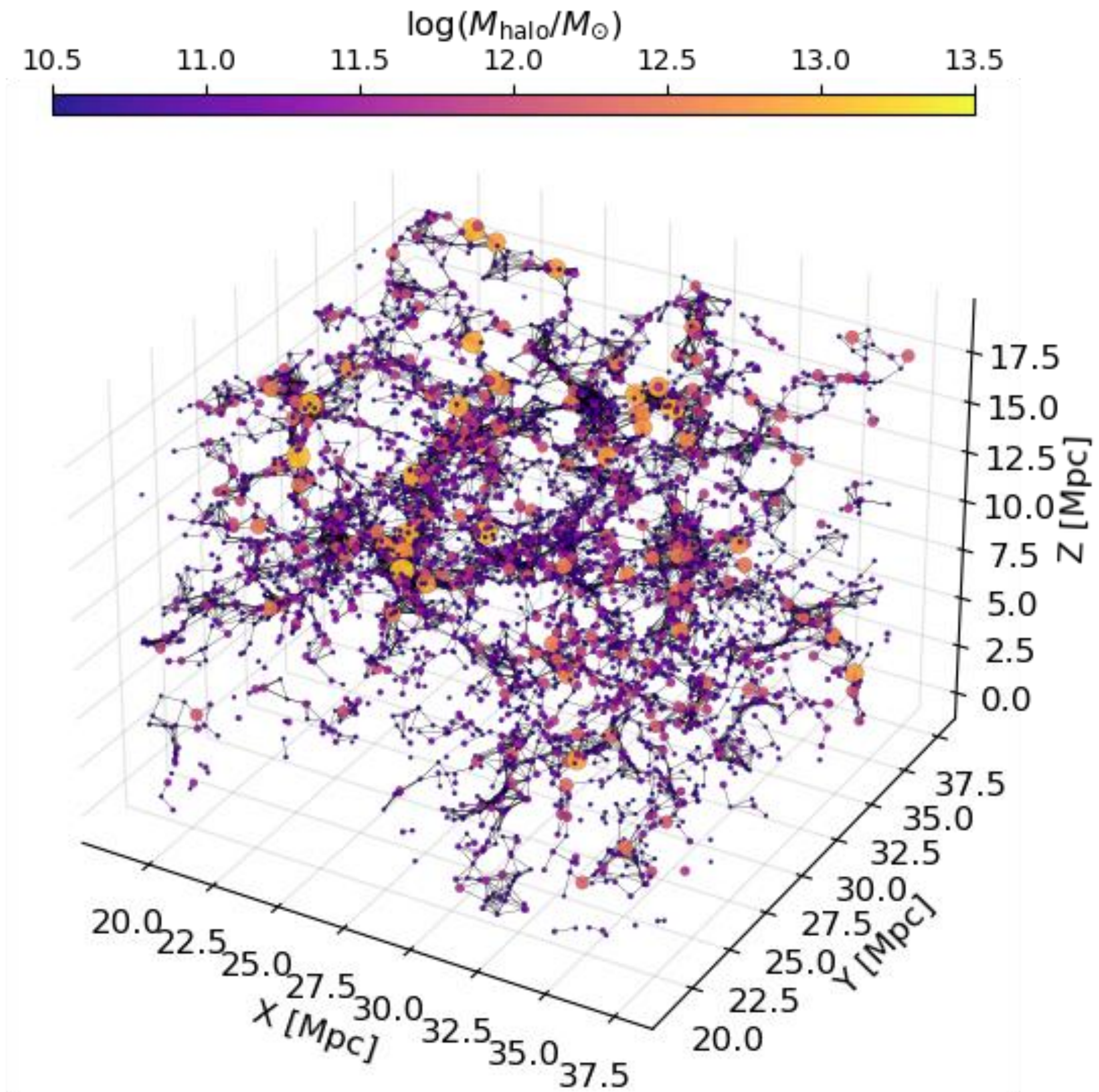
Simulation			
Explicit dependence		Hydro	SAM
Assembly	Environment	Chuang, Jespersen+ 2024 	Jespersen+ 2022 
		Wu, Jespersen & Wechsler 2024 Wu & Jespersen 2023 	

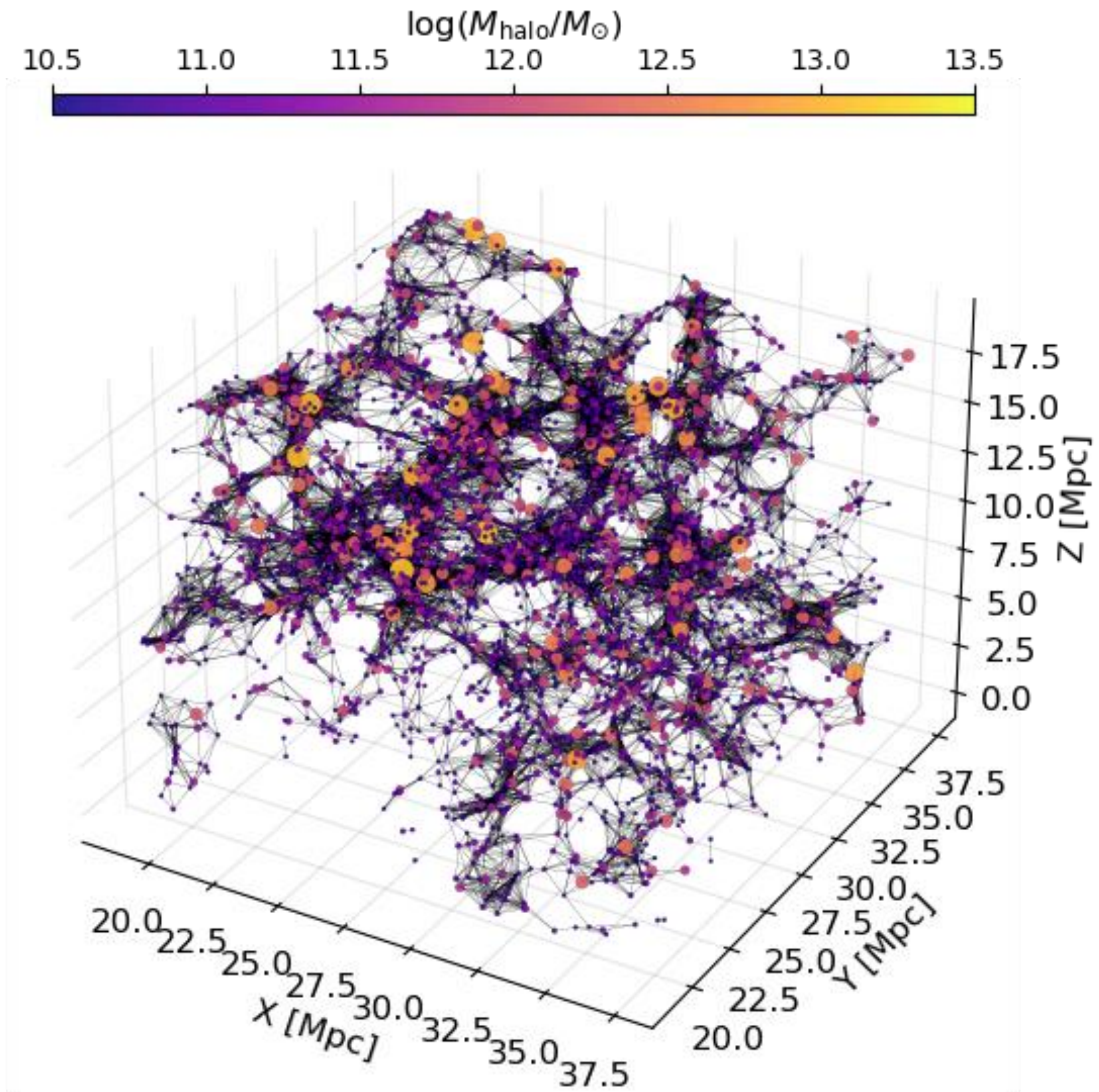
galaxy $\approx f(\text{DM assembly})$



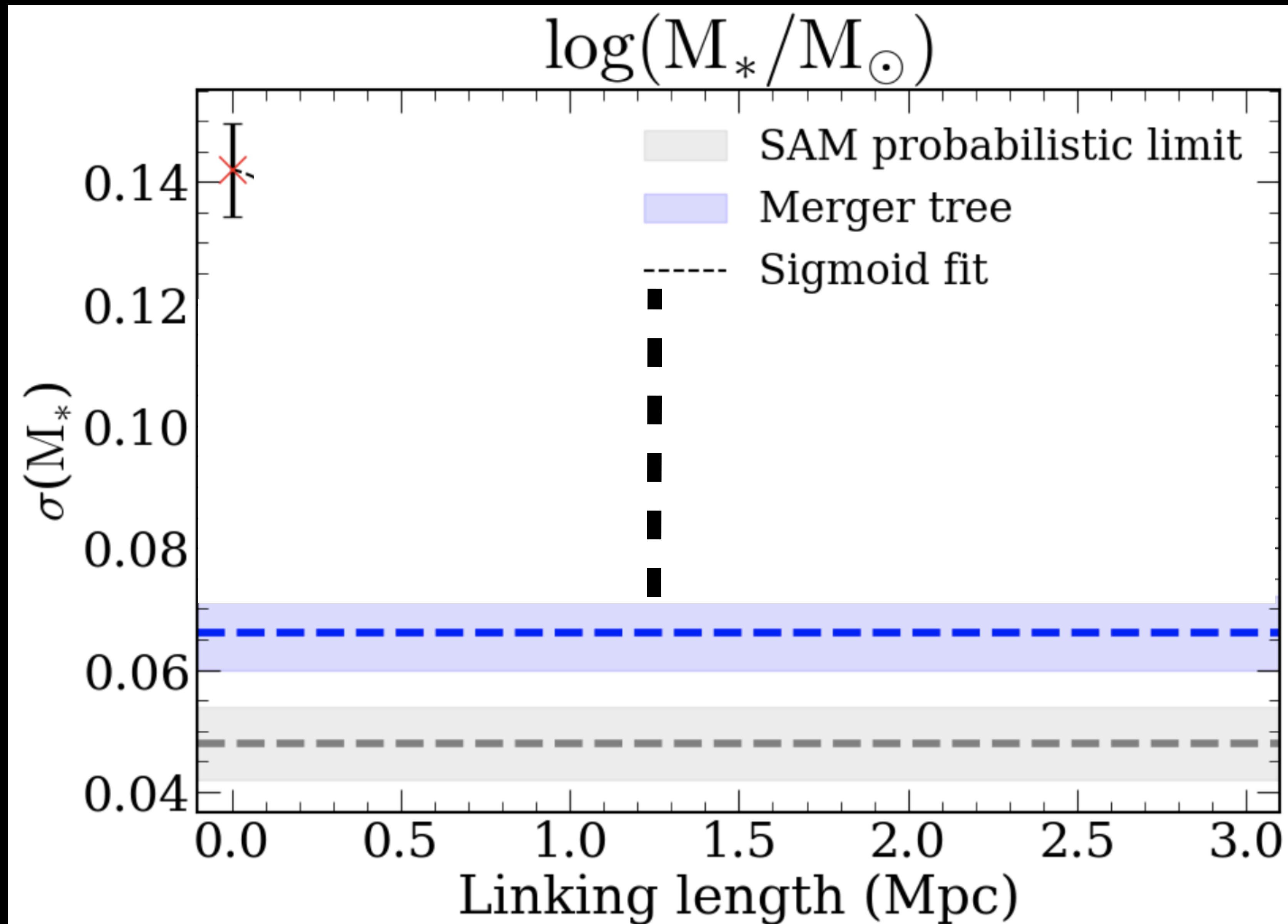
Dark-matter density field · TNG100







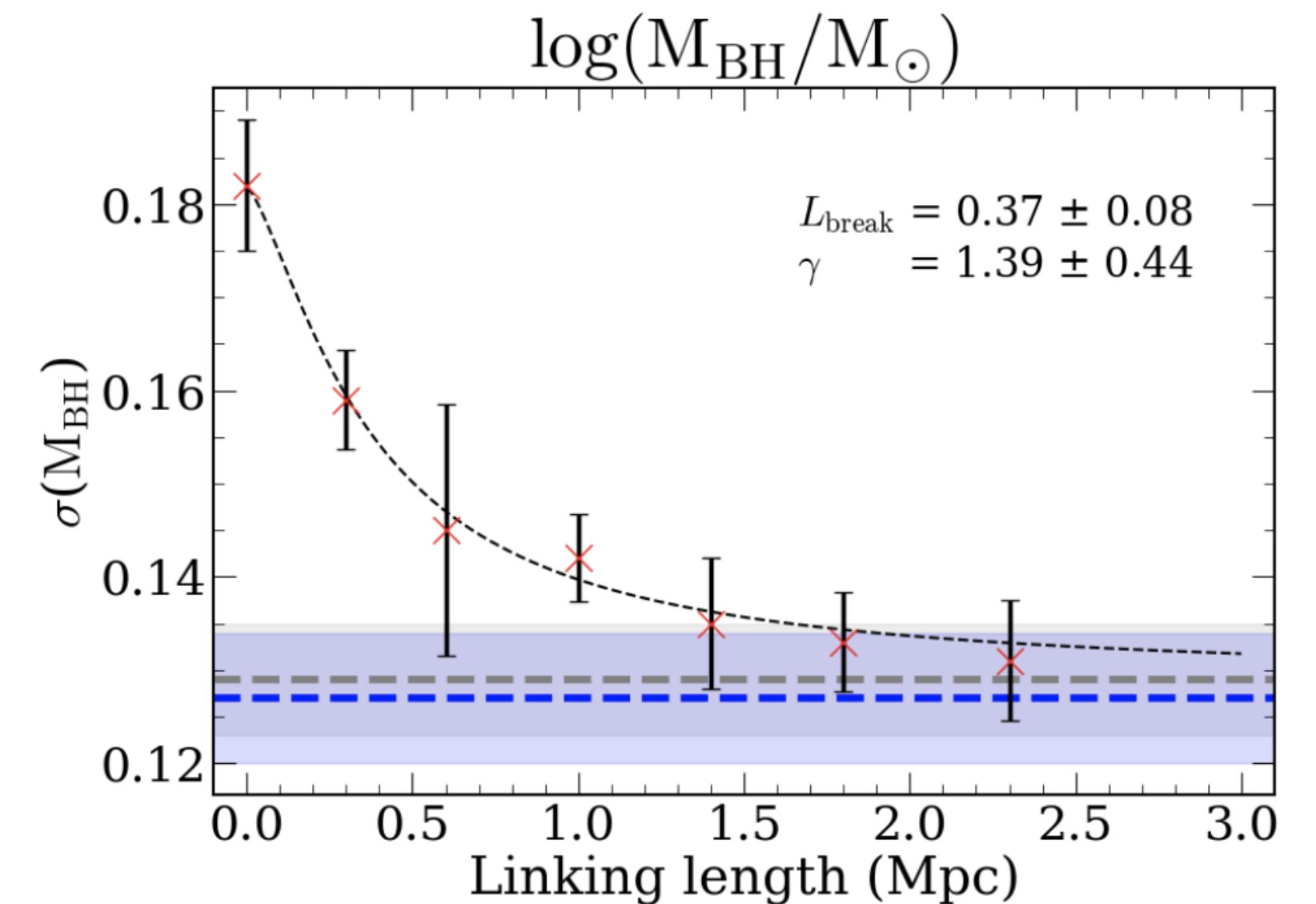
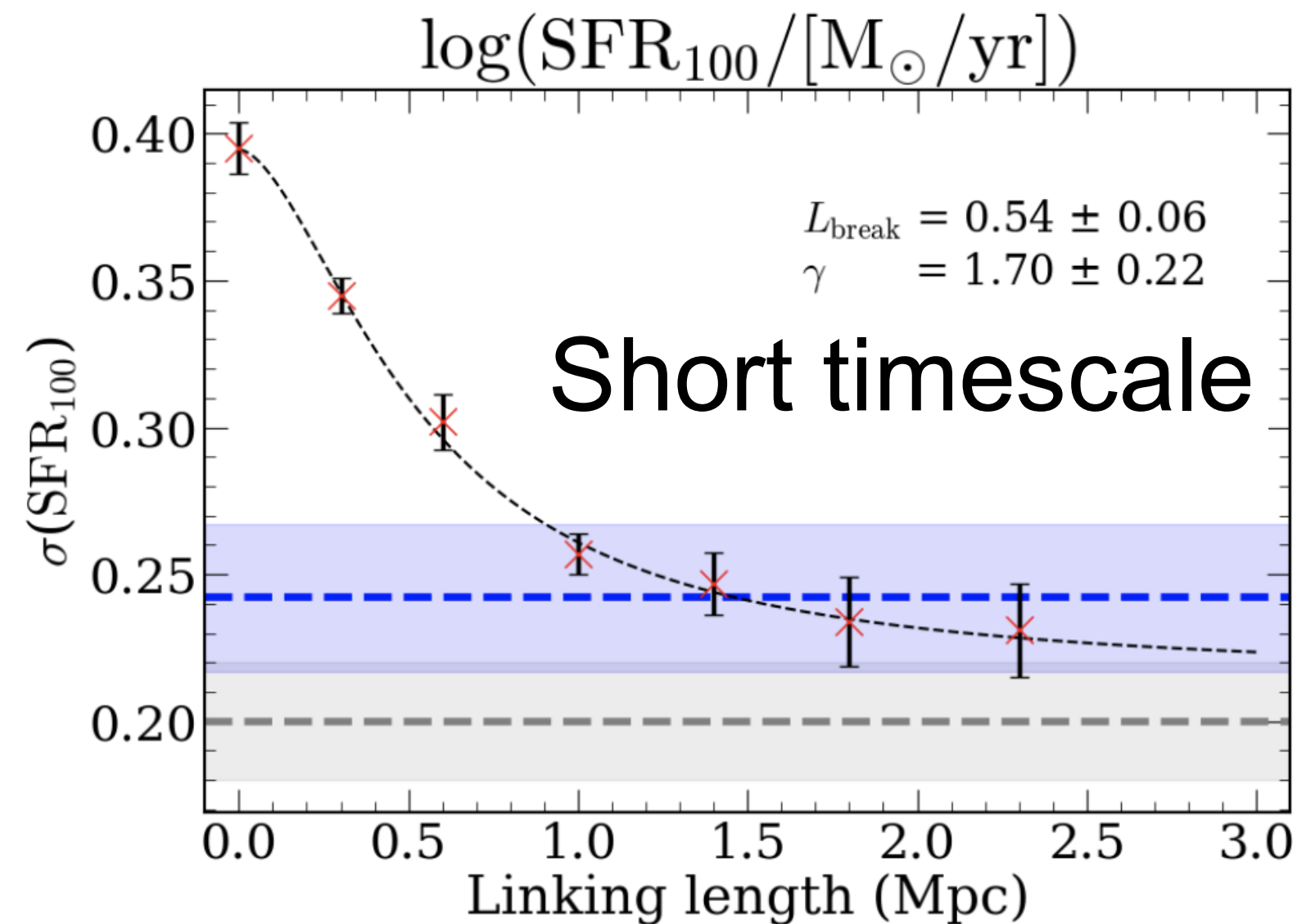
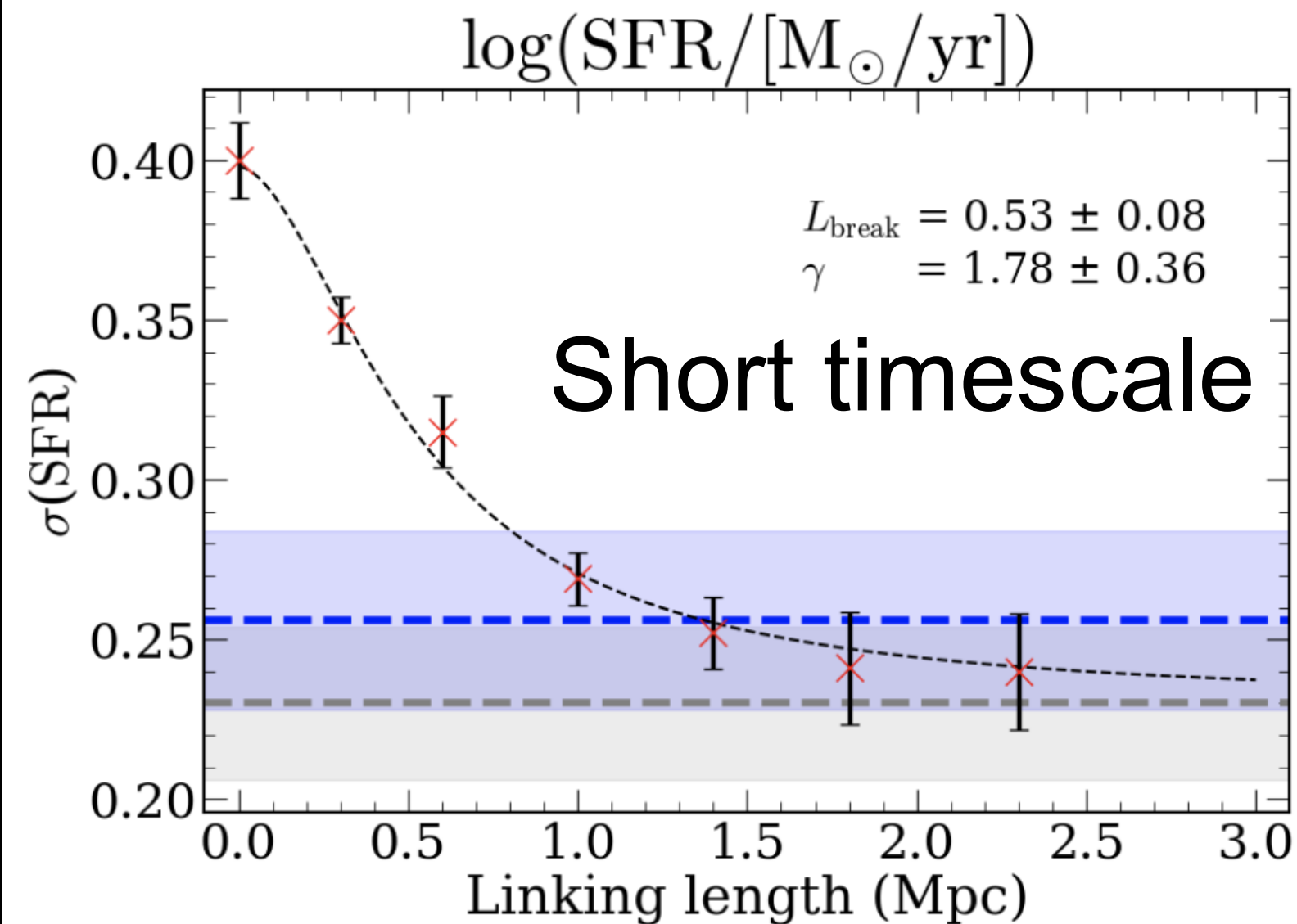
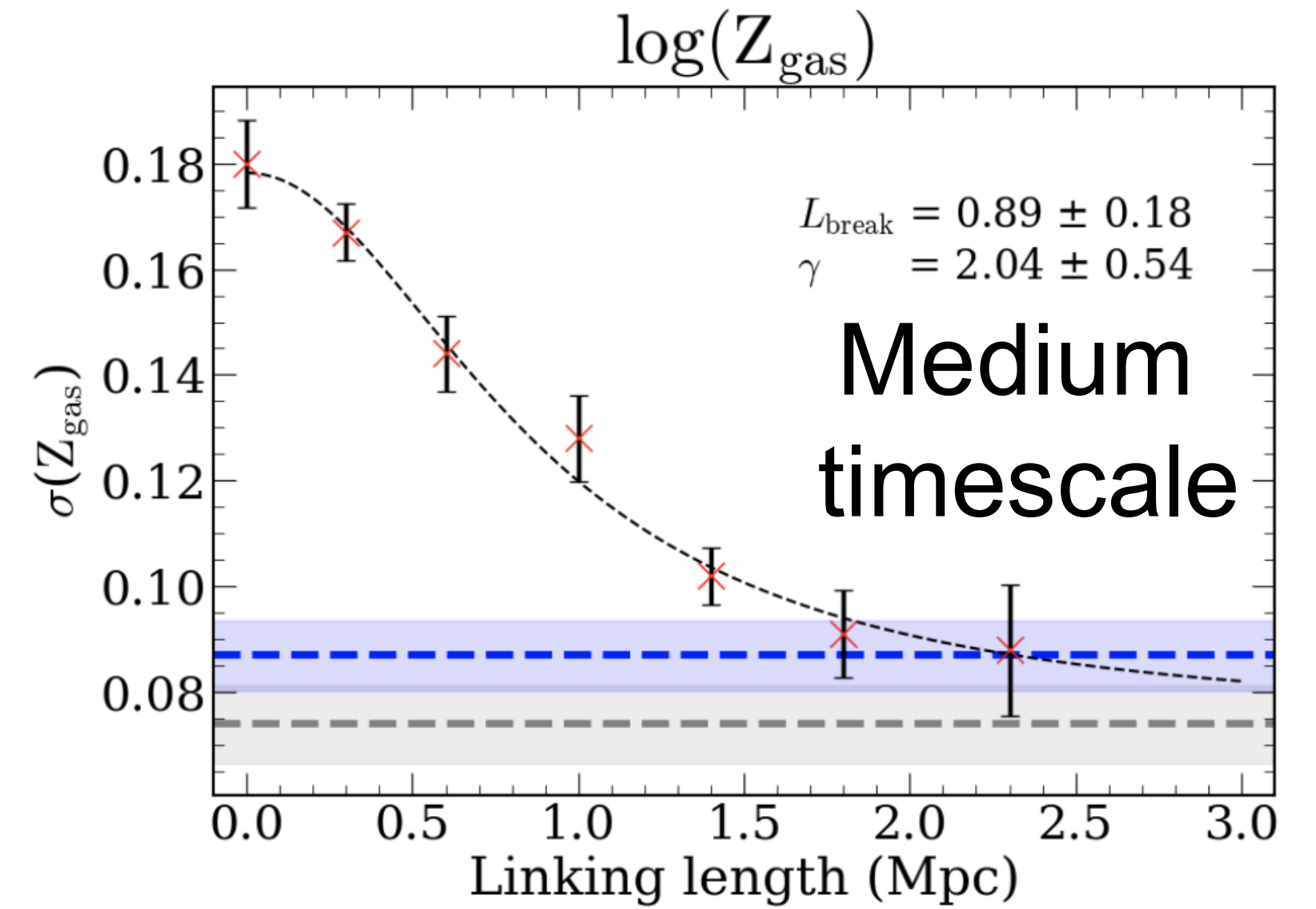
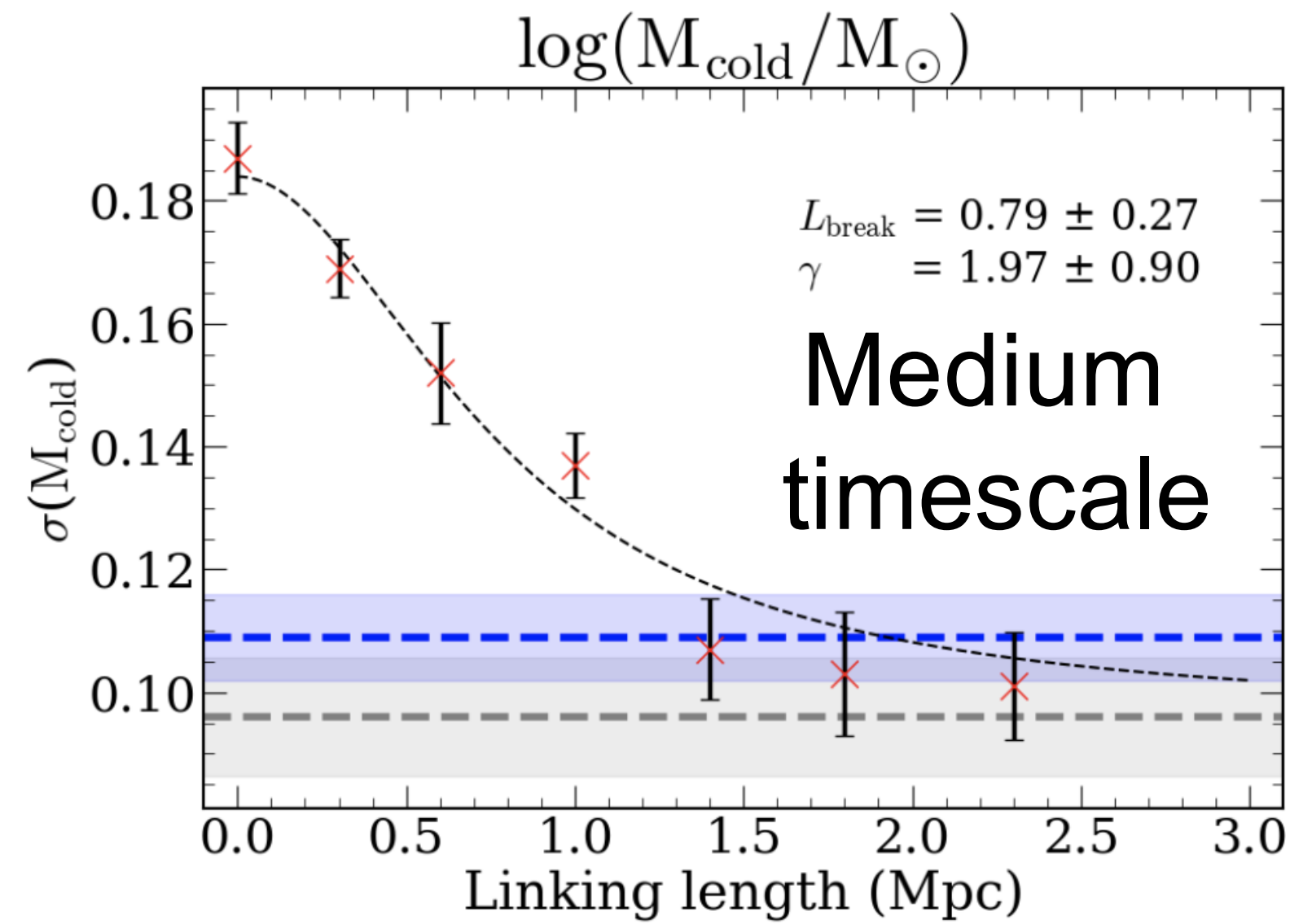
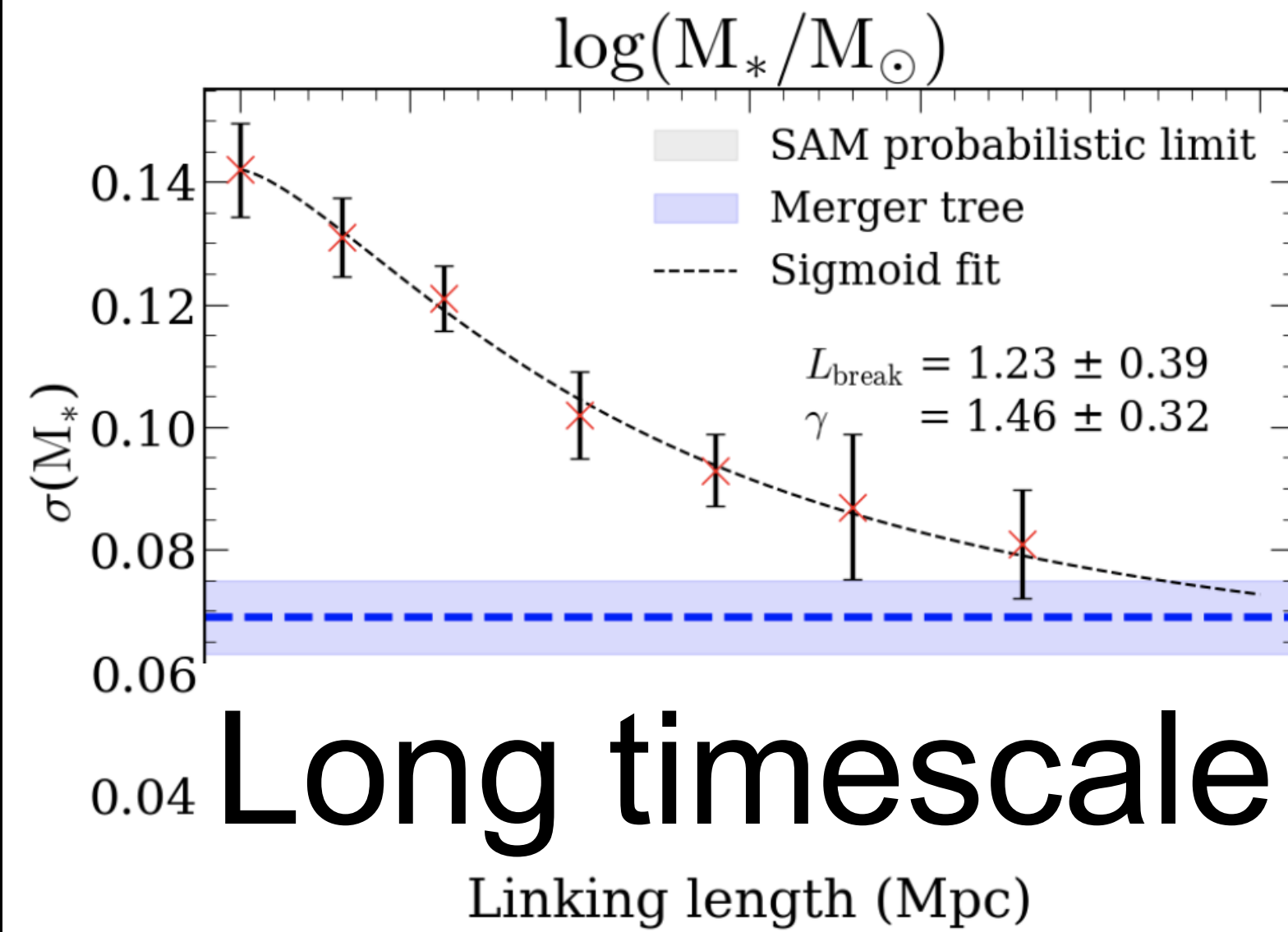
$$M_{\text{halo}} > 10^{10} M_{\odot}$$



SAM

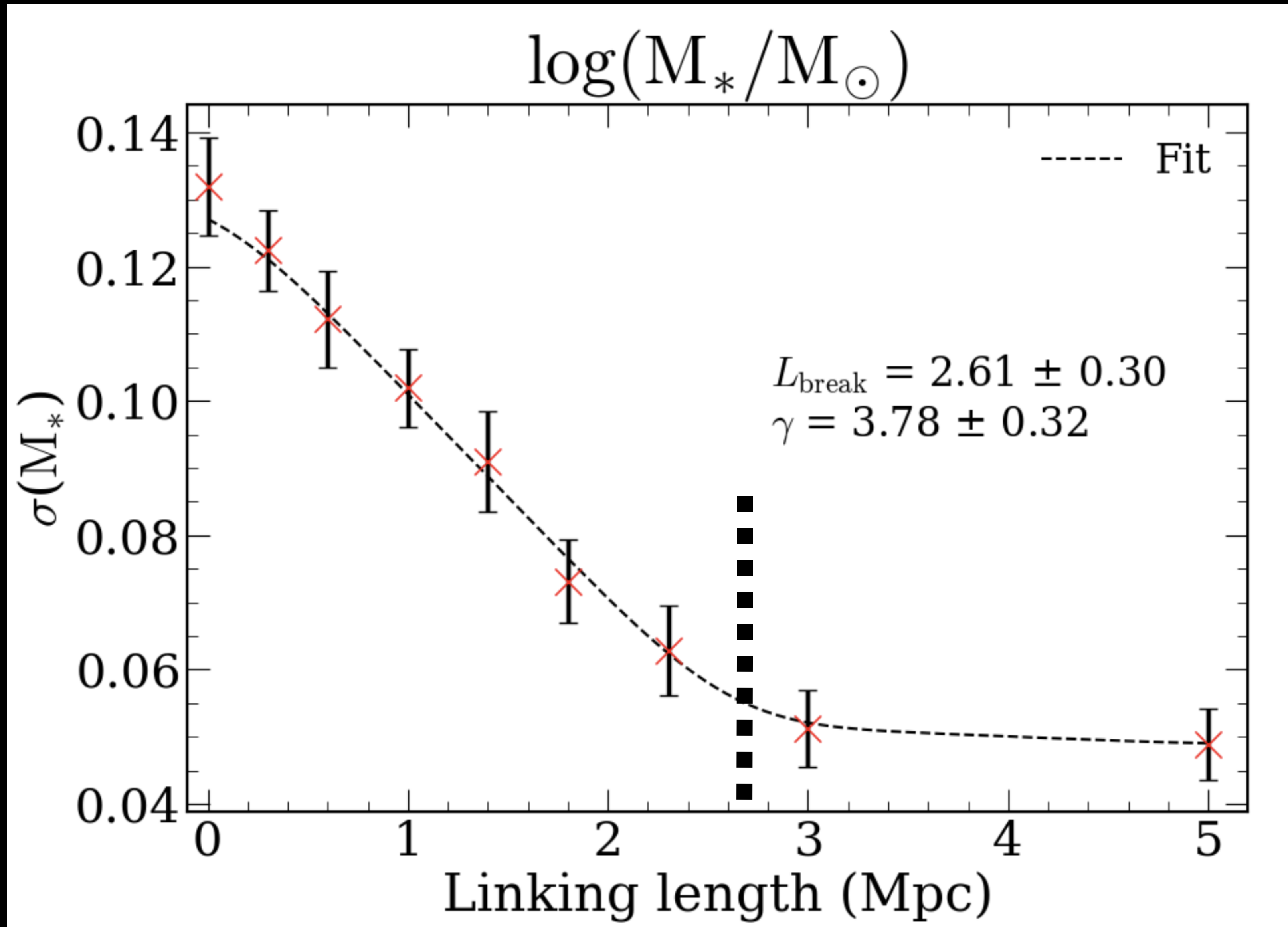
$$M_{\text{halo}} > 10^{10} M_{\odot}$$

SAM

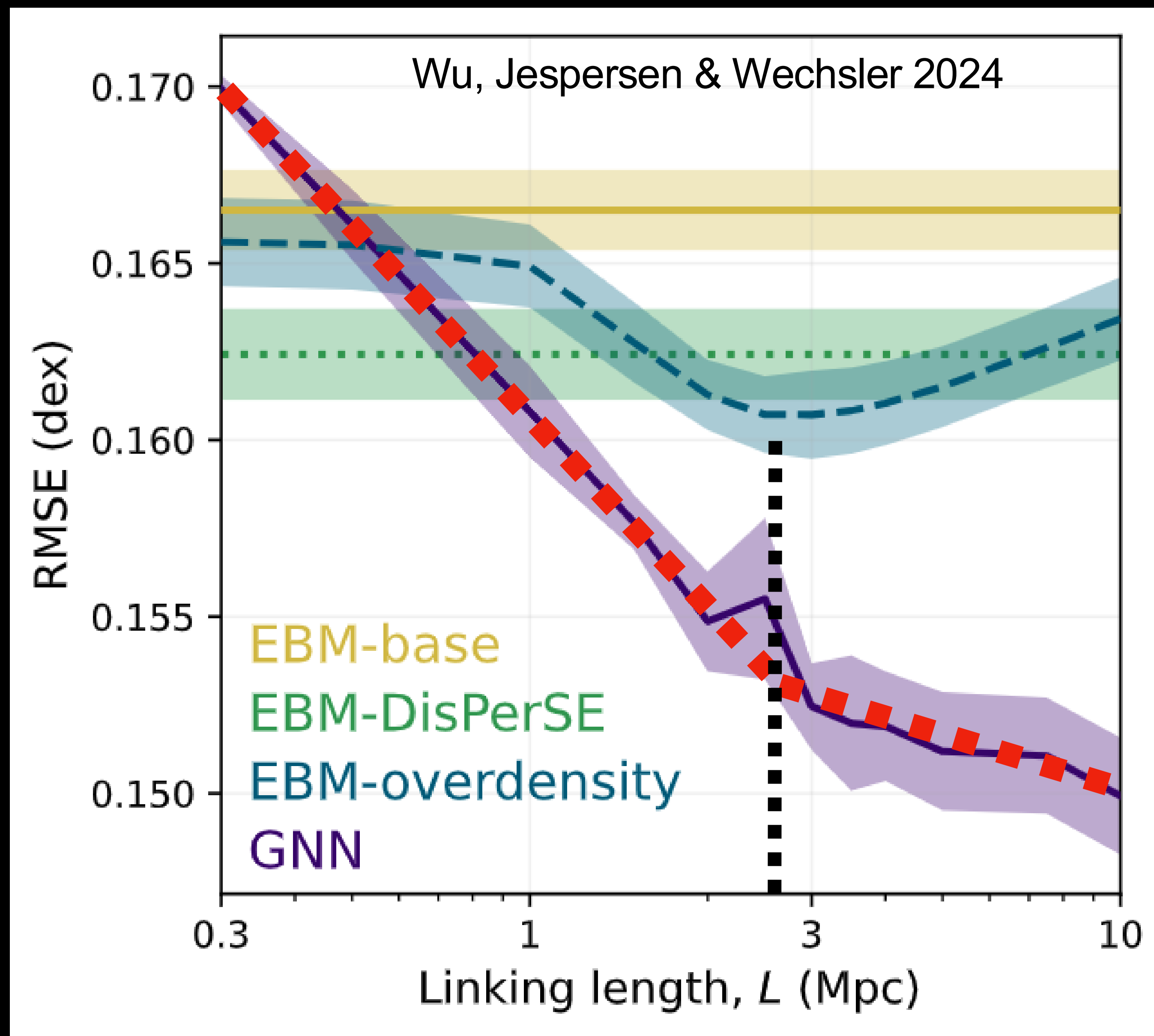


$$M_{\text{halo}} > 10^{11} M_{\odot}$$

SAM



$$M_{\text{halo}} > 10^{11} M_{\odot}$$



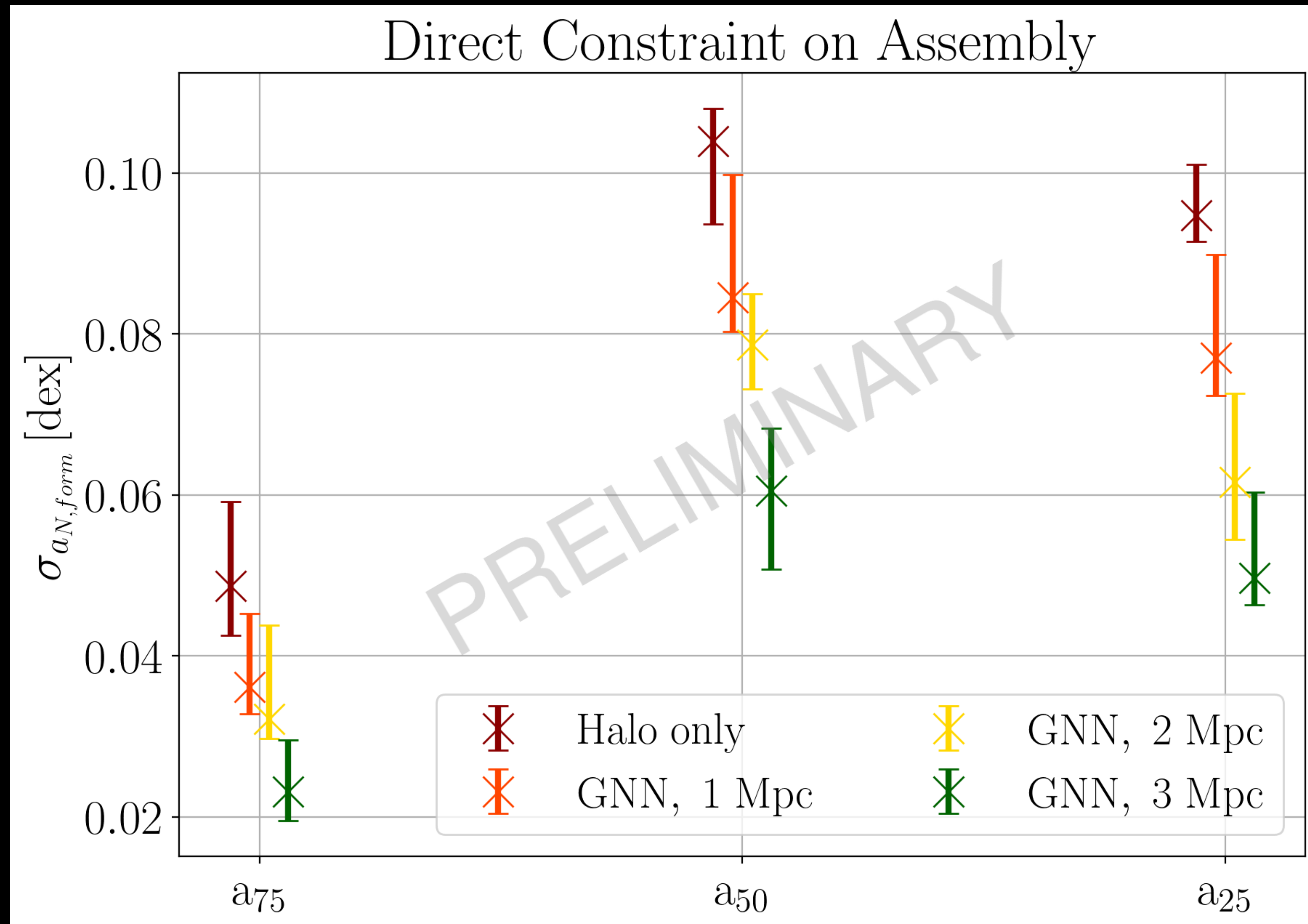
TNG

$$g(X, t, r) = \int_{t_0}^{\text{Now}} \int_0^\infty f(X, t', r - r') \cdot m(X, t', r - r') dr'^3 dt'$$

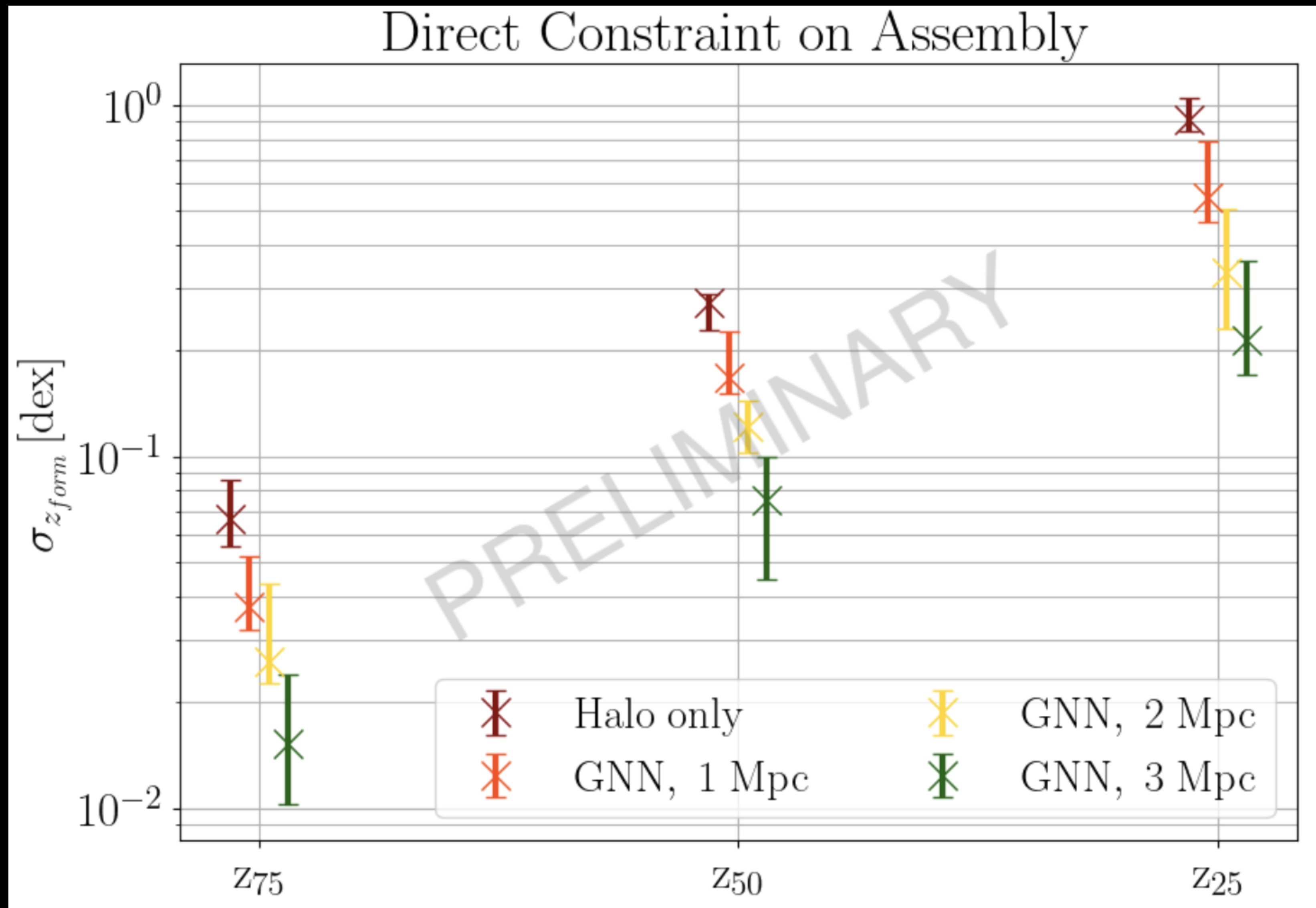
$$g(X, t, r) = \int_0^\infty f_{GNN}(X, t, r - r') \cdot m(X, t, r - r') dr'^3$$

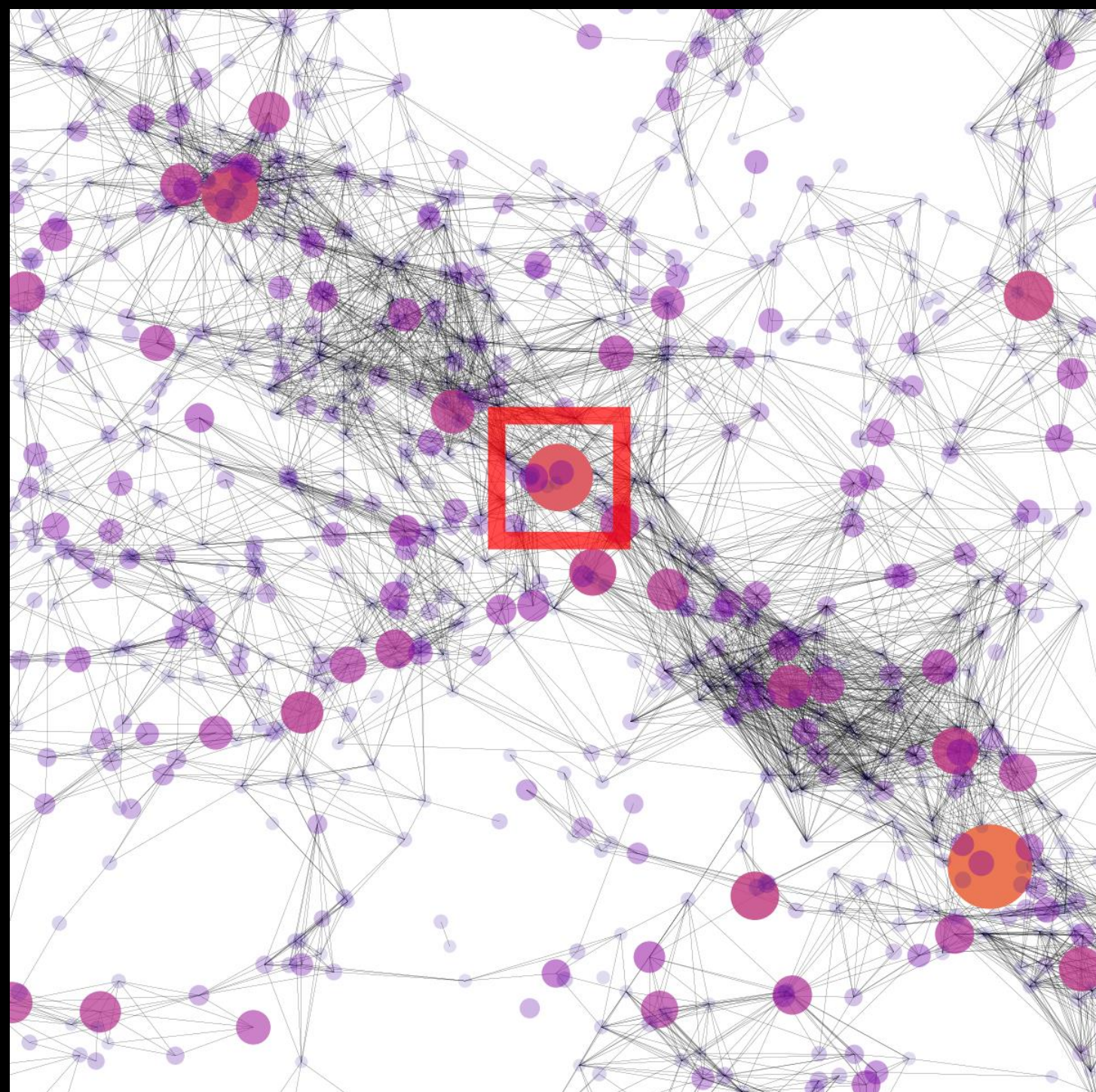
$$m(X, t, r) = \int_0^\infty g(X, t, r - r') dr'^3$$

Directly measuring the assembly

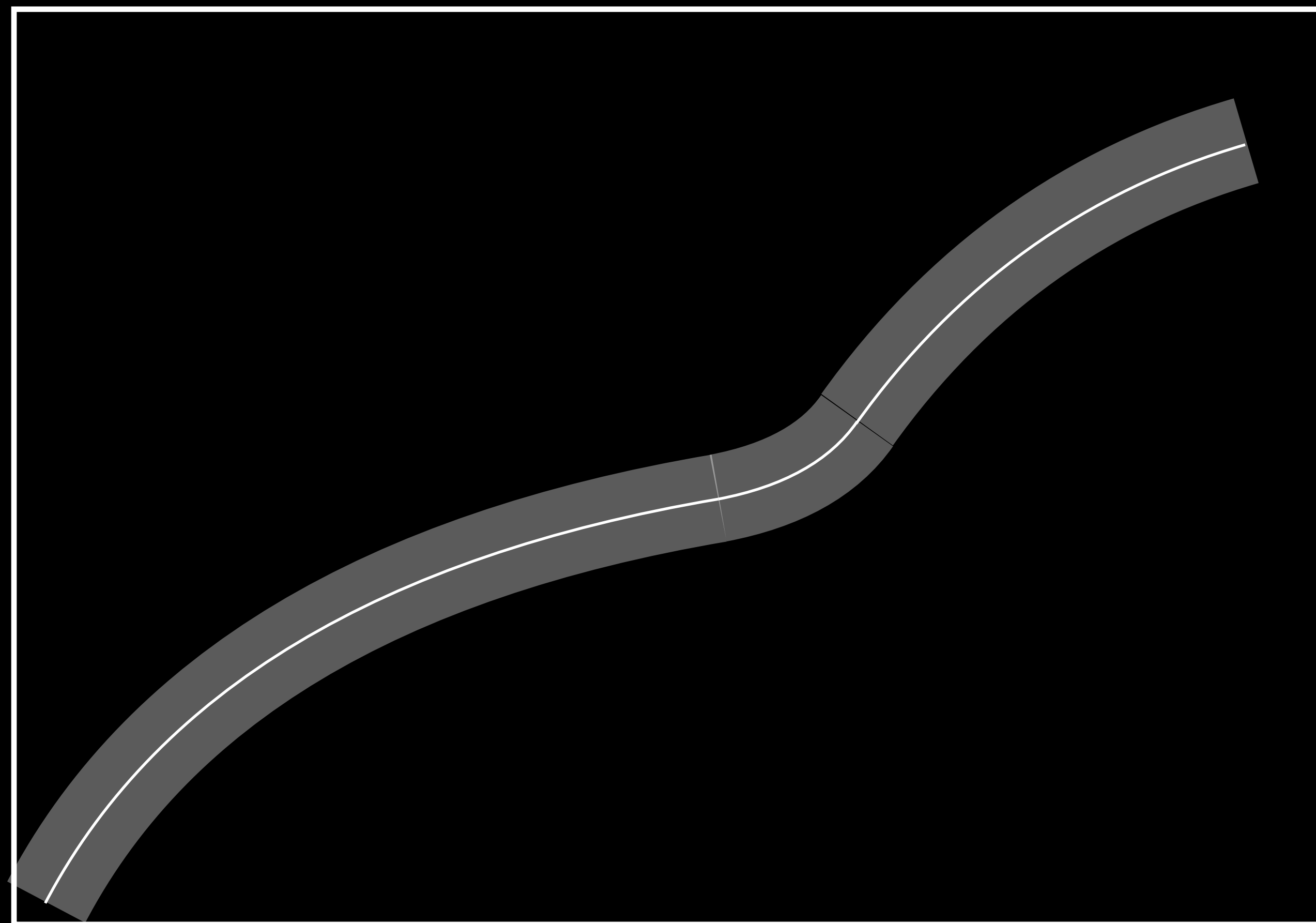


Directly measuring the assembly

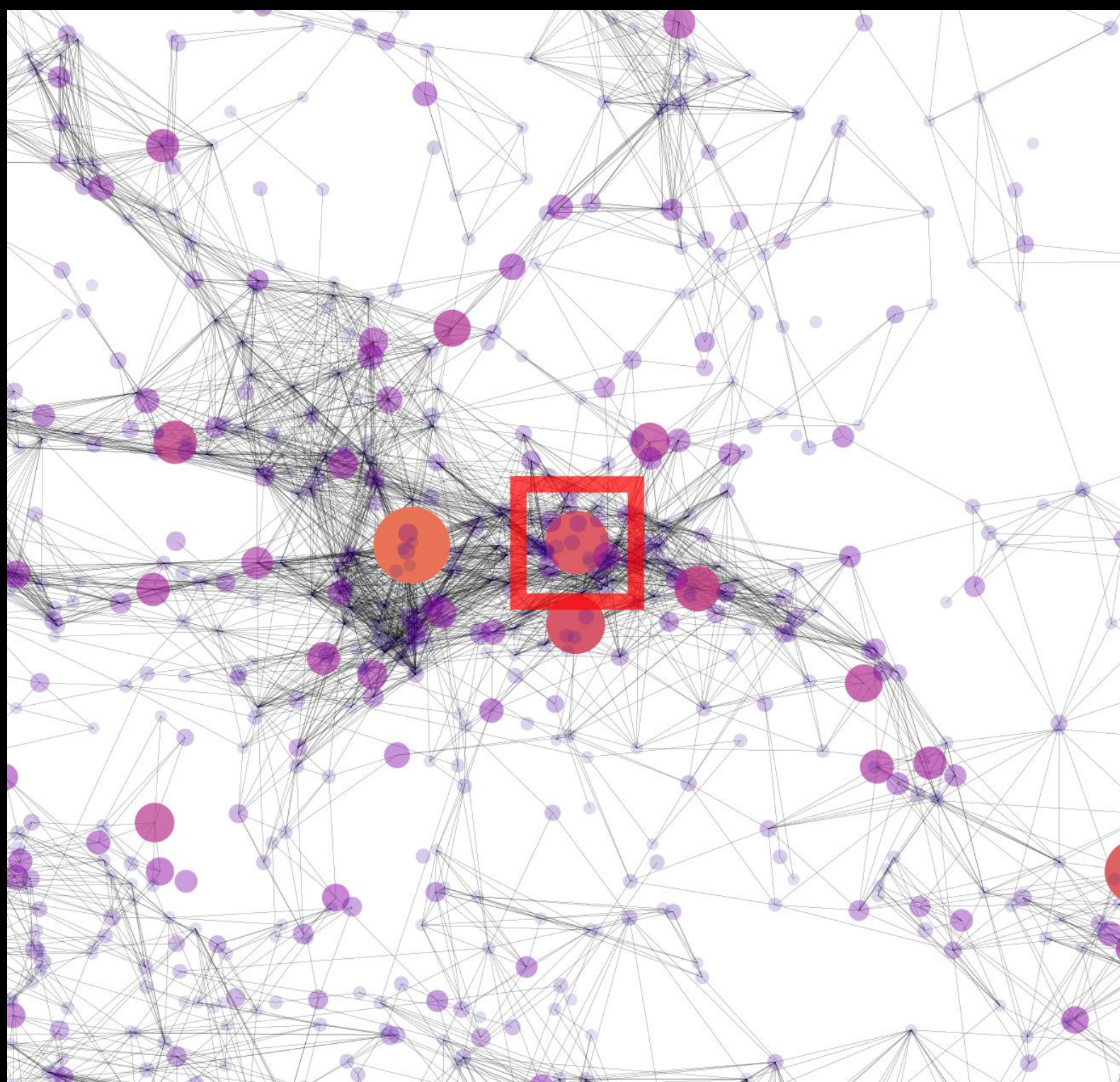




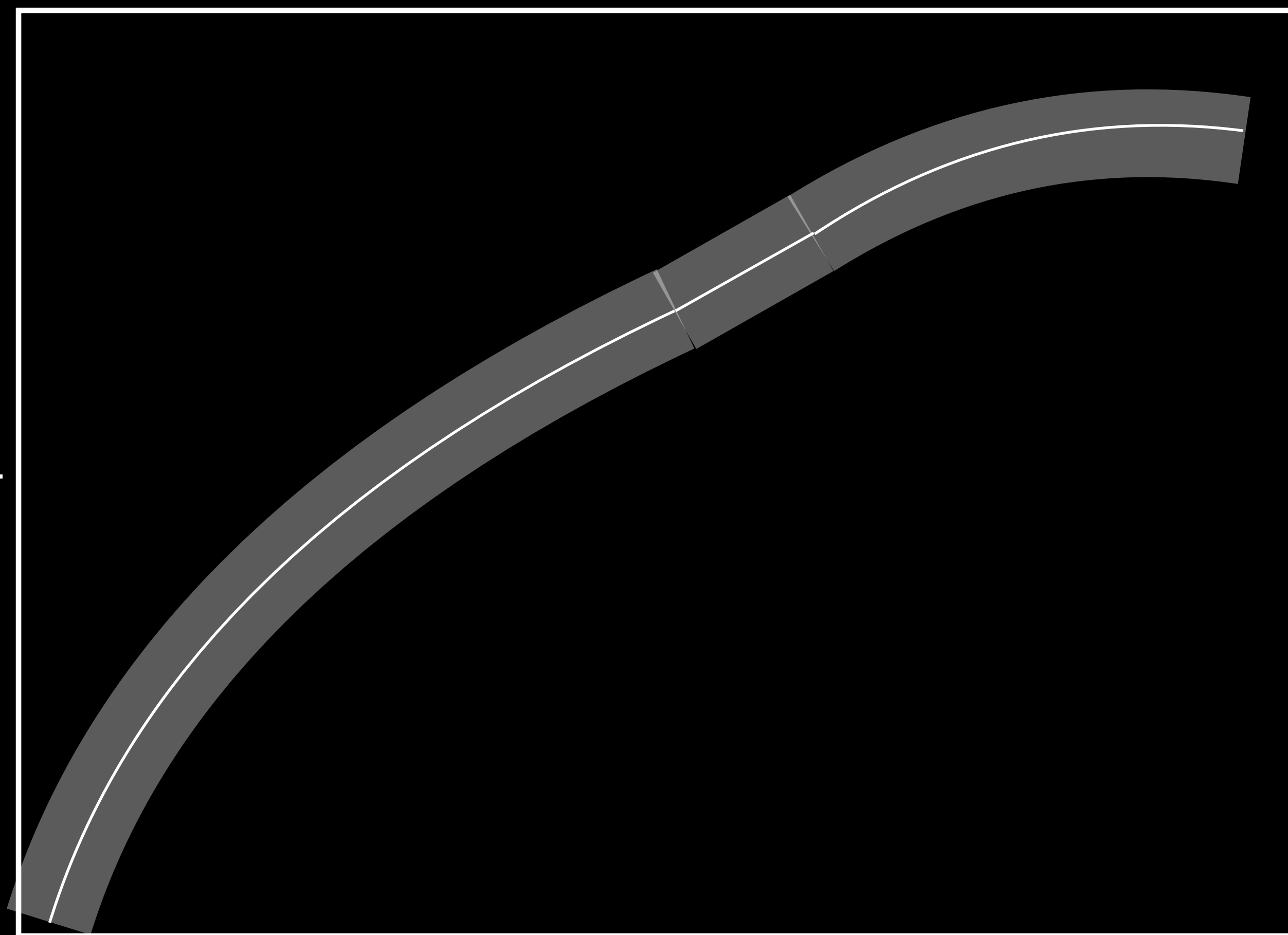
$$\frac{M_{halo}}{M_{halo,z=0}}$$



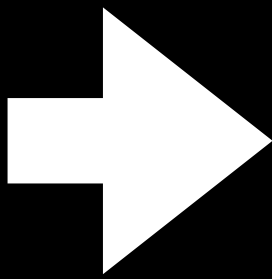
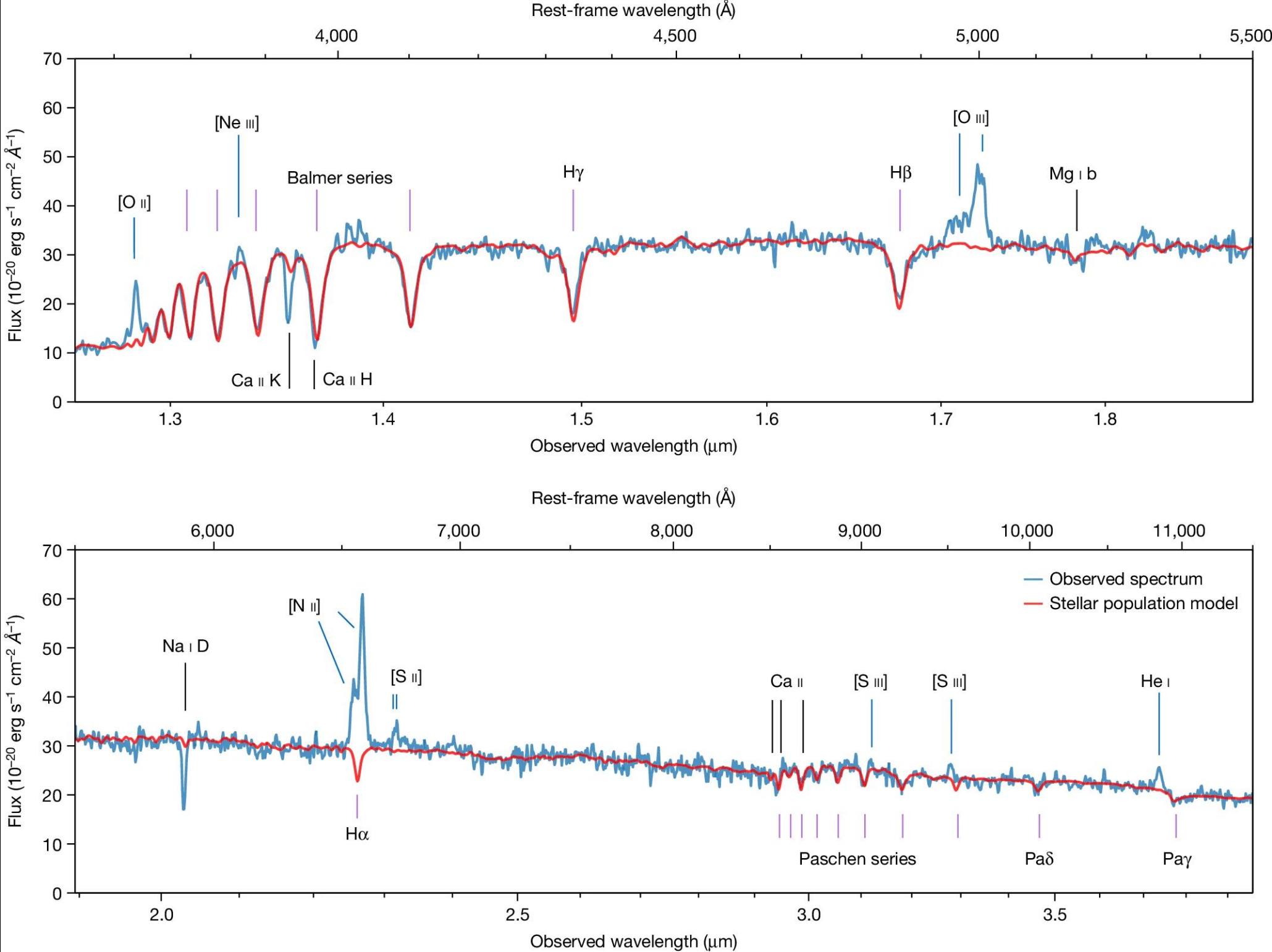
Age of the Universe



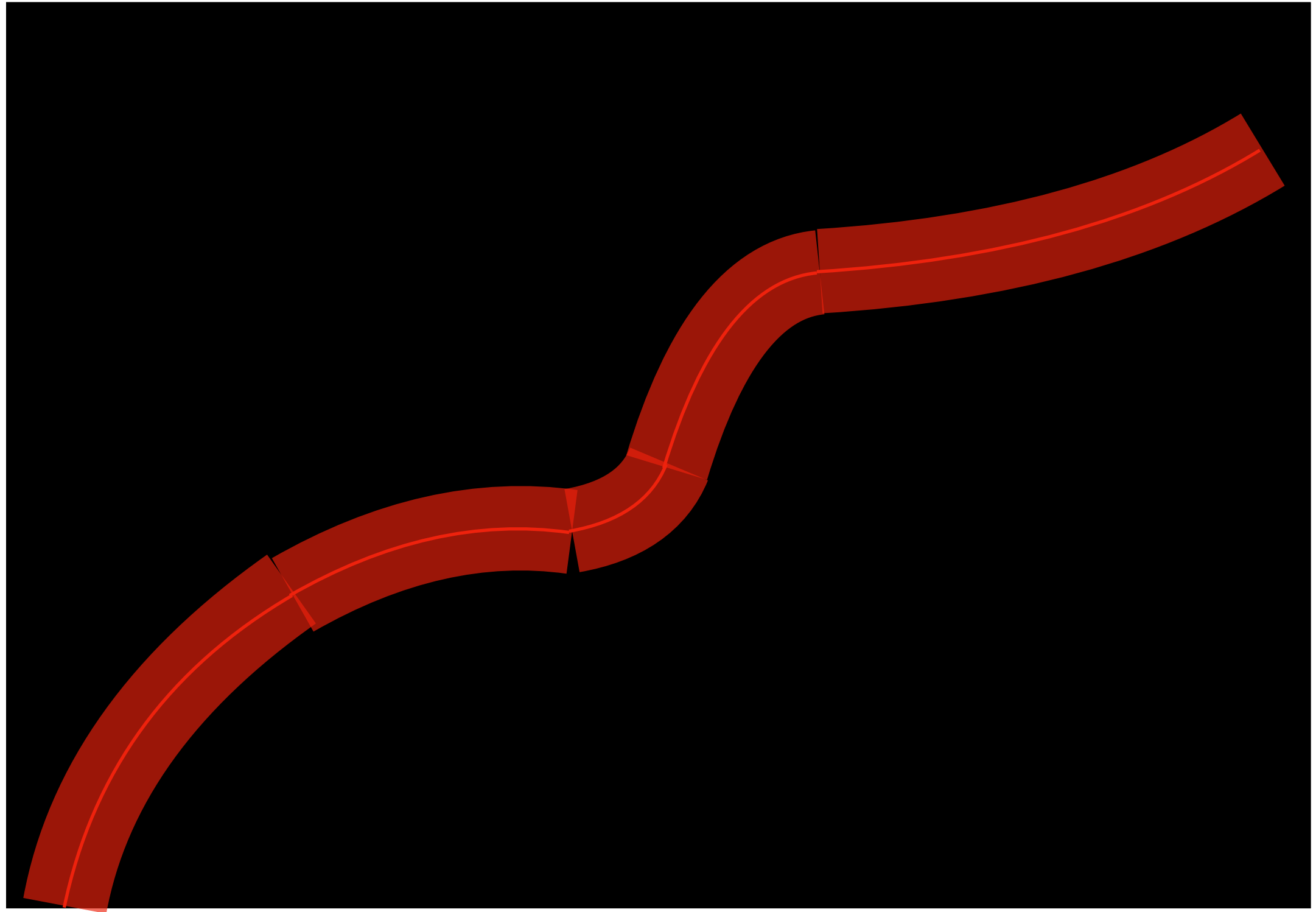
$$\frac{M_{halo}}{M_{halo,z=0}}$$



Age of the Universe

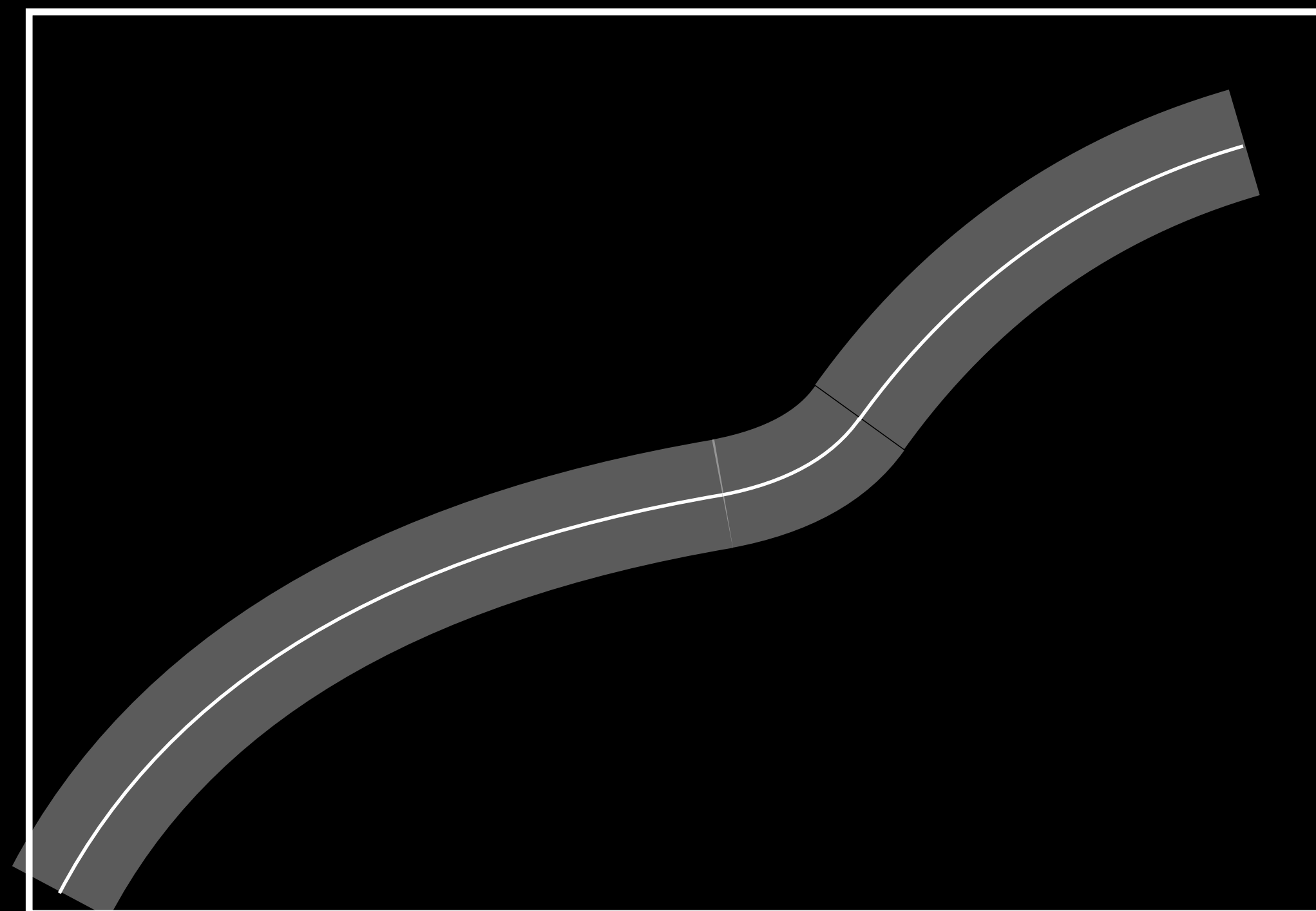


$$\frac{M_*}{M_{*,Z=0}}$$



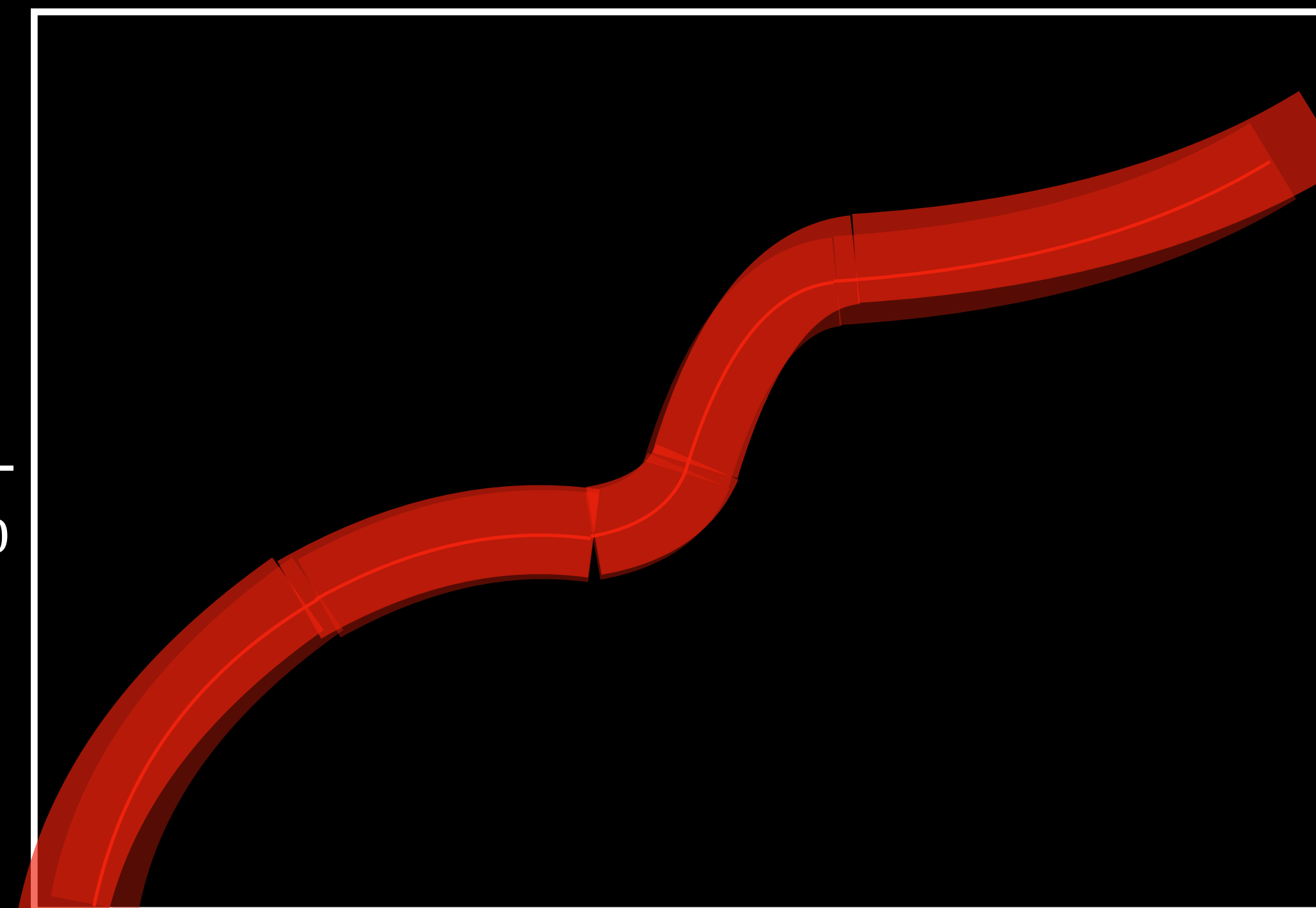
Age of the Universe

$$\frac{M_{halo}}{M_{halo,z=0}}$$

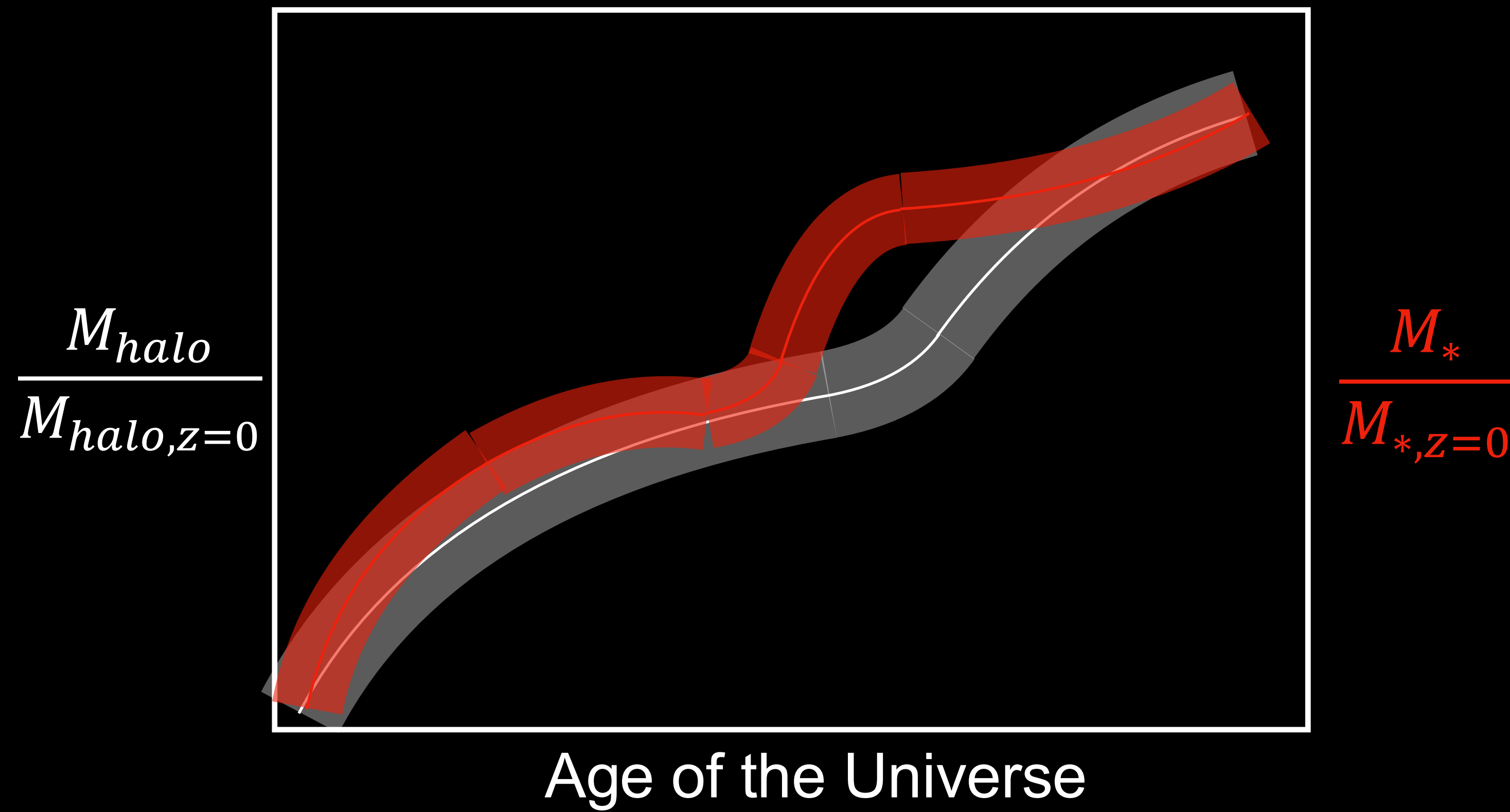


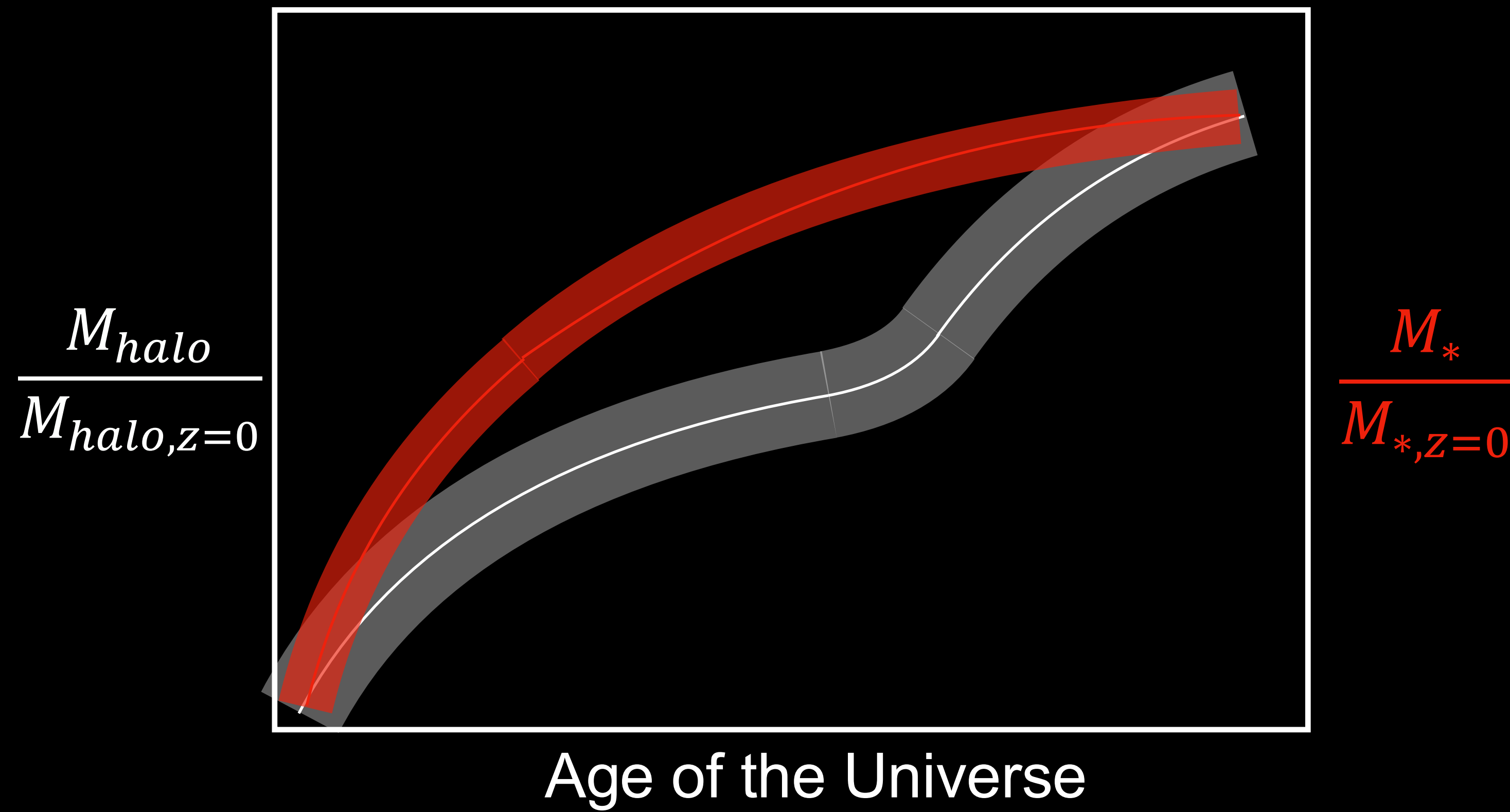
Age of the Universe

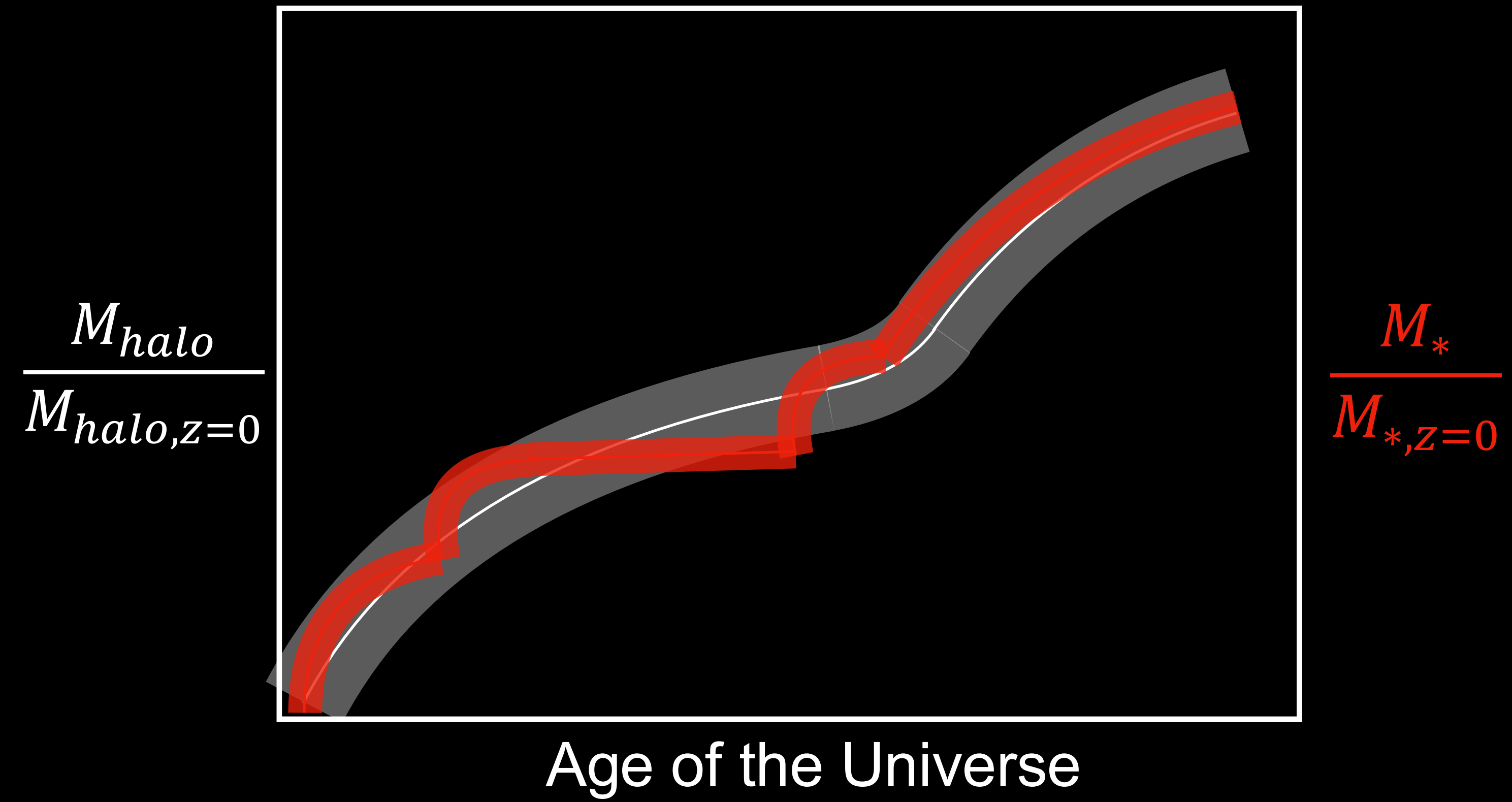
$$\frac{M_*}{M_{*,z=0}}$$



Age of the Universe



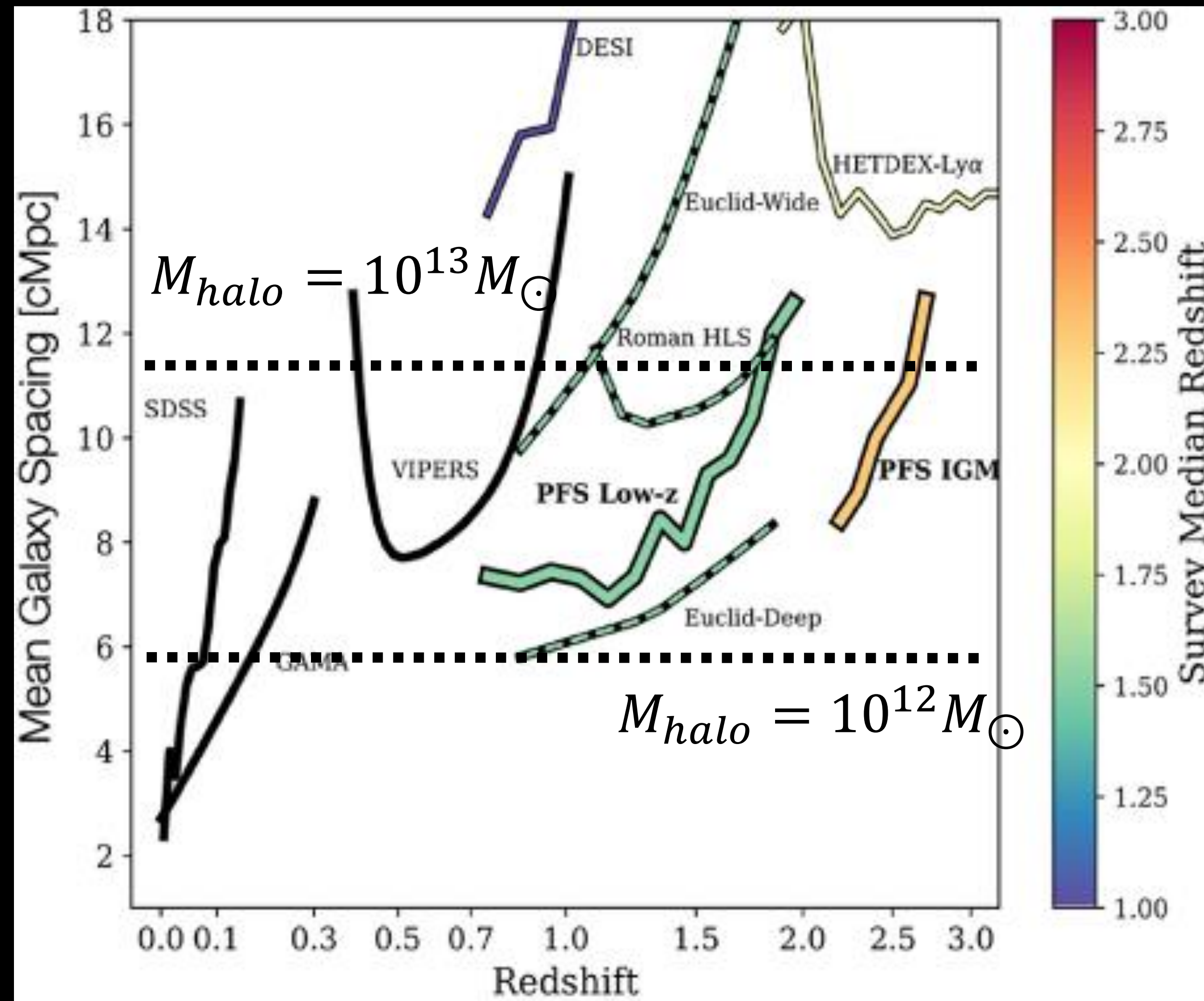




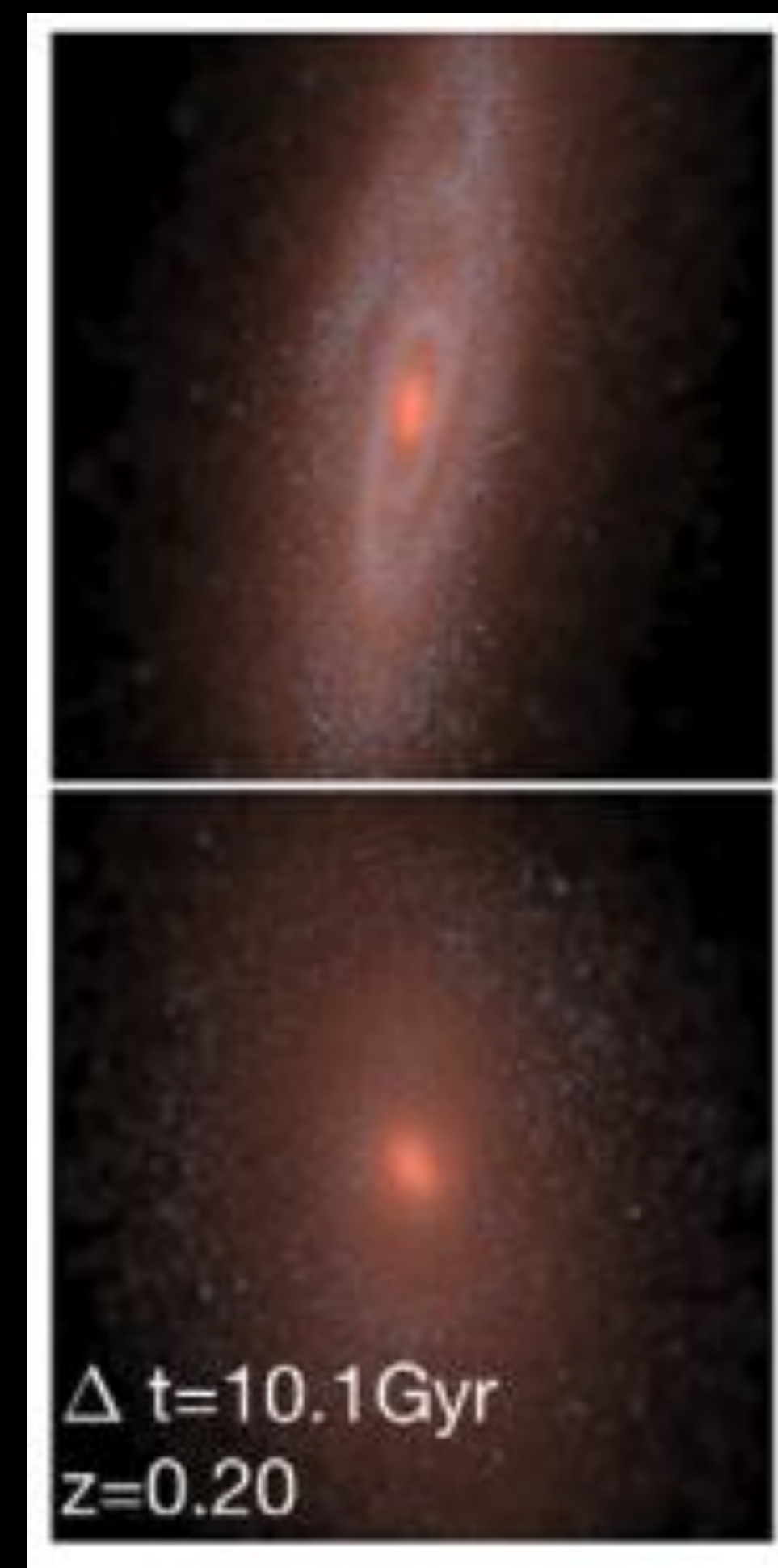
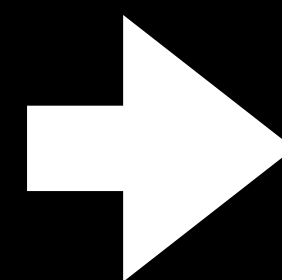
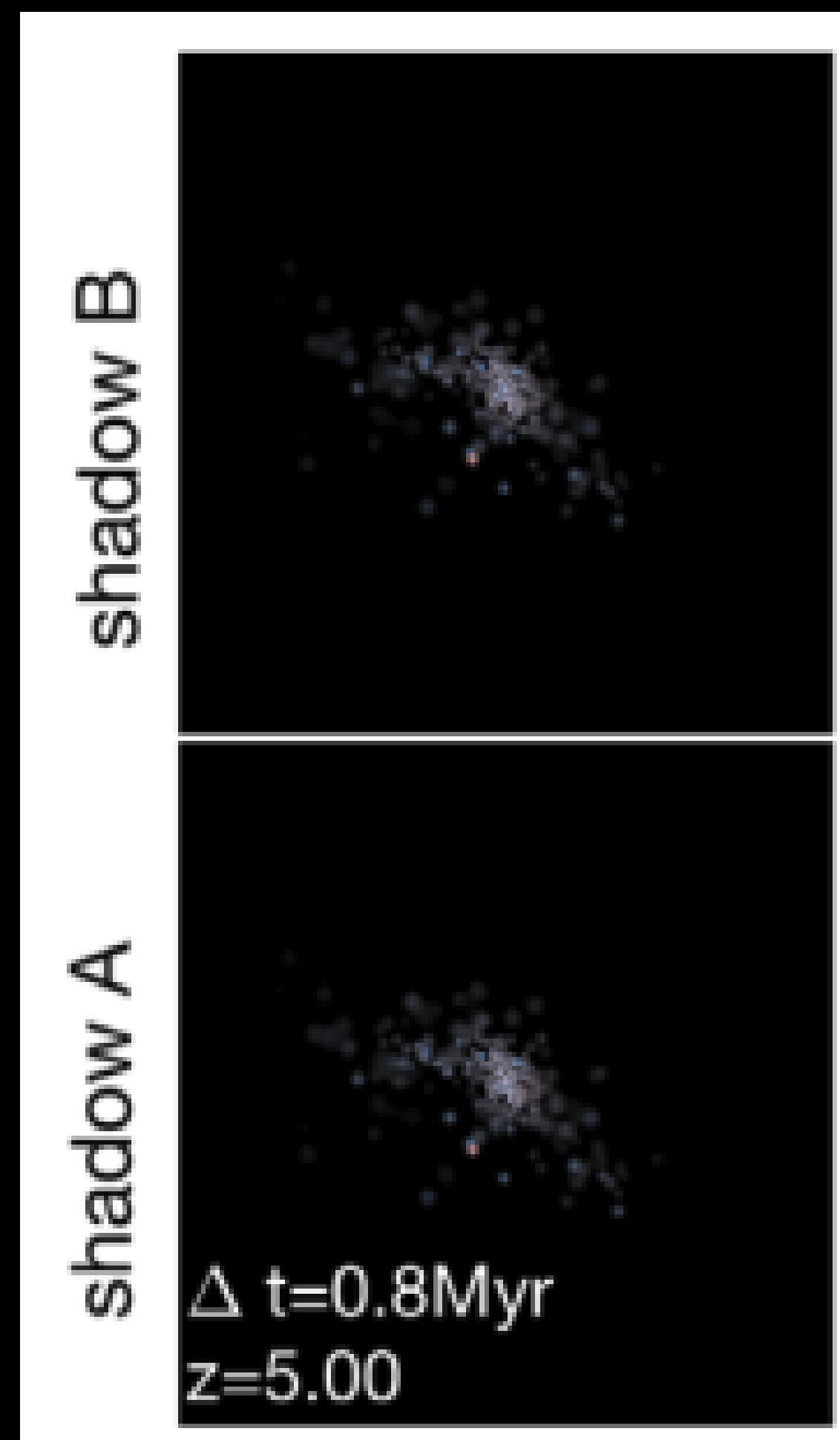
- Galaxy properties are determined by environment and assembly, but only one is necessary, so they must be coupled!
- Exploiting this tight coupling, we can infer assembly from environment!
- We can learn about halo formation from simulations — now we may have the tools to transfer that information to observations!

$$g(X, t, r) = \int_{t_0}^{\text{Now}} \int_0^\infty f(X, t', r - r') \cdot m(X, t', r - r') dr'^3 dt'$$

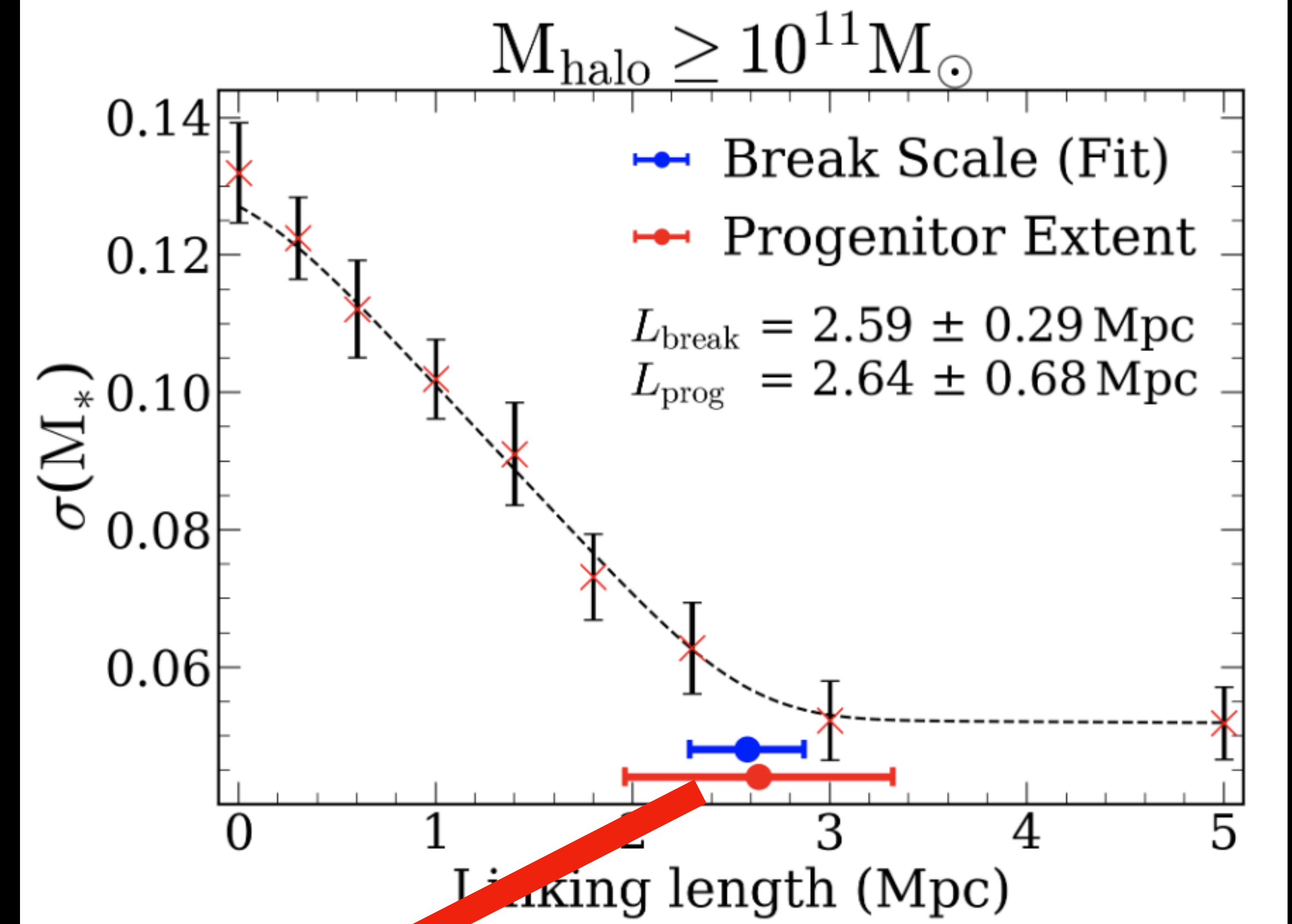
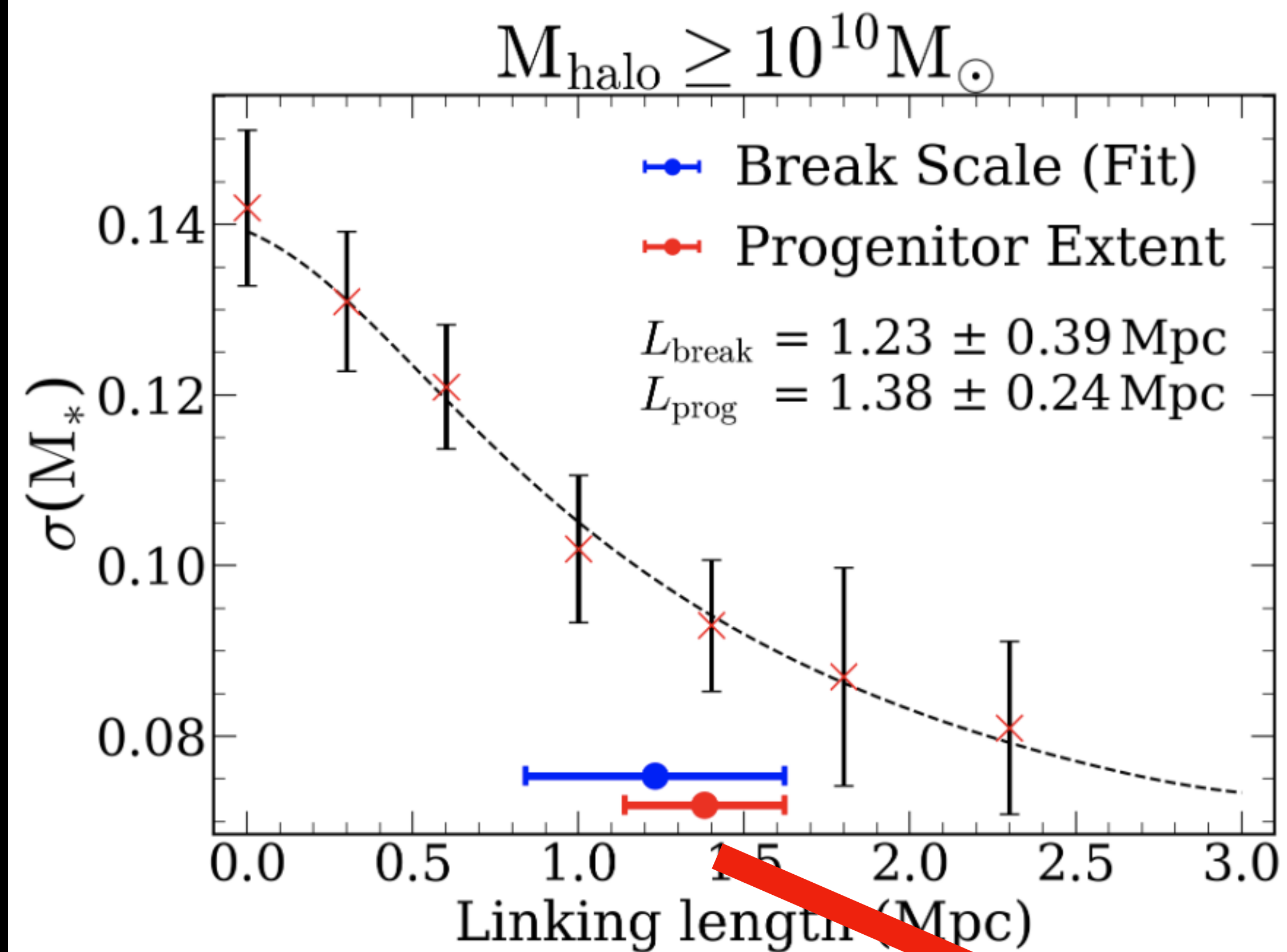
Extra Slides



Greene+2021

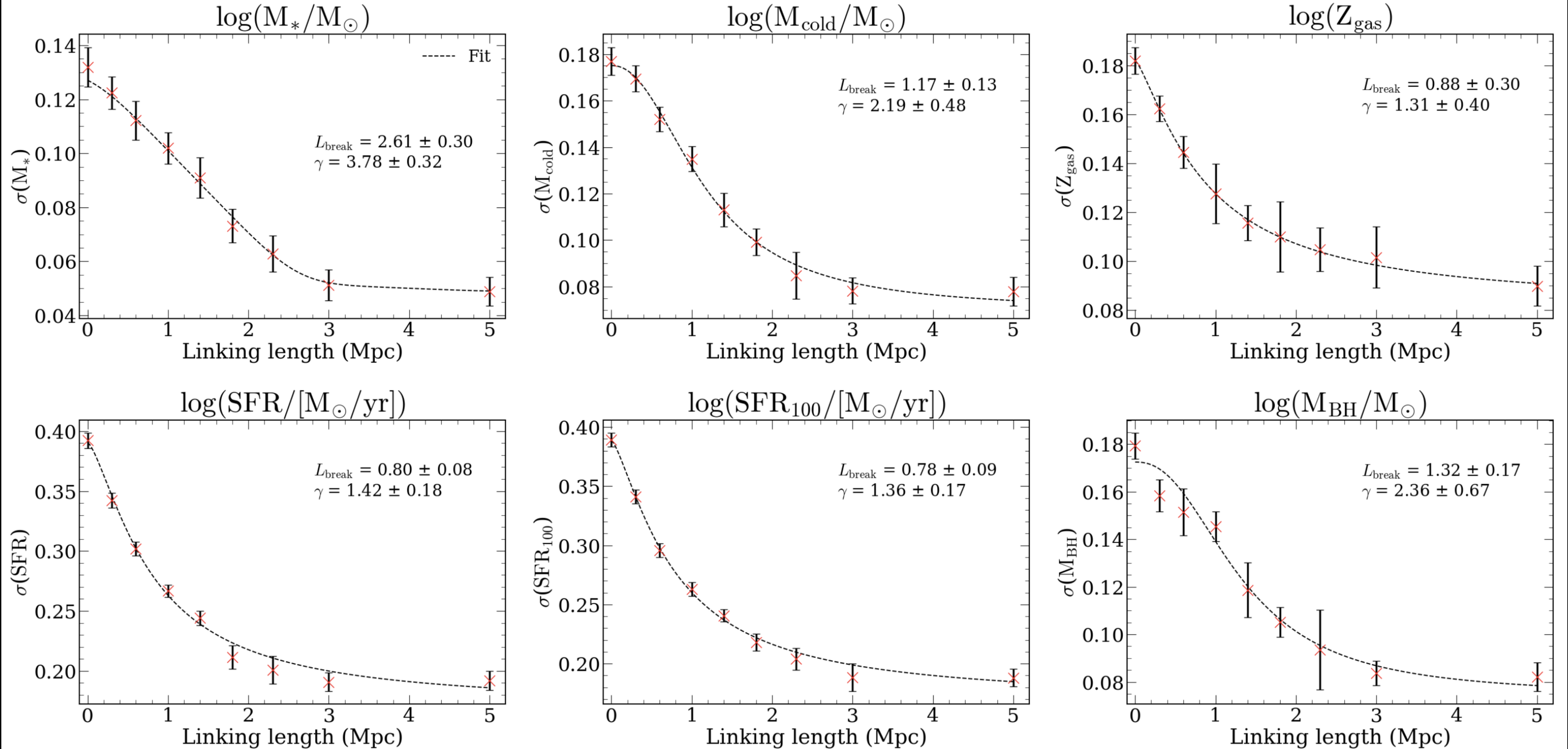


Chaos!
“Noisy Labels”

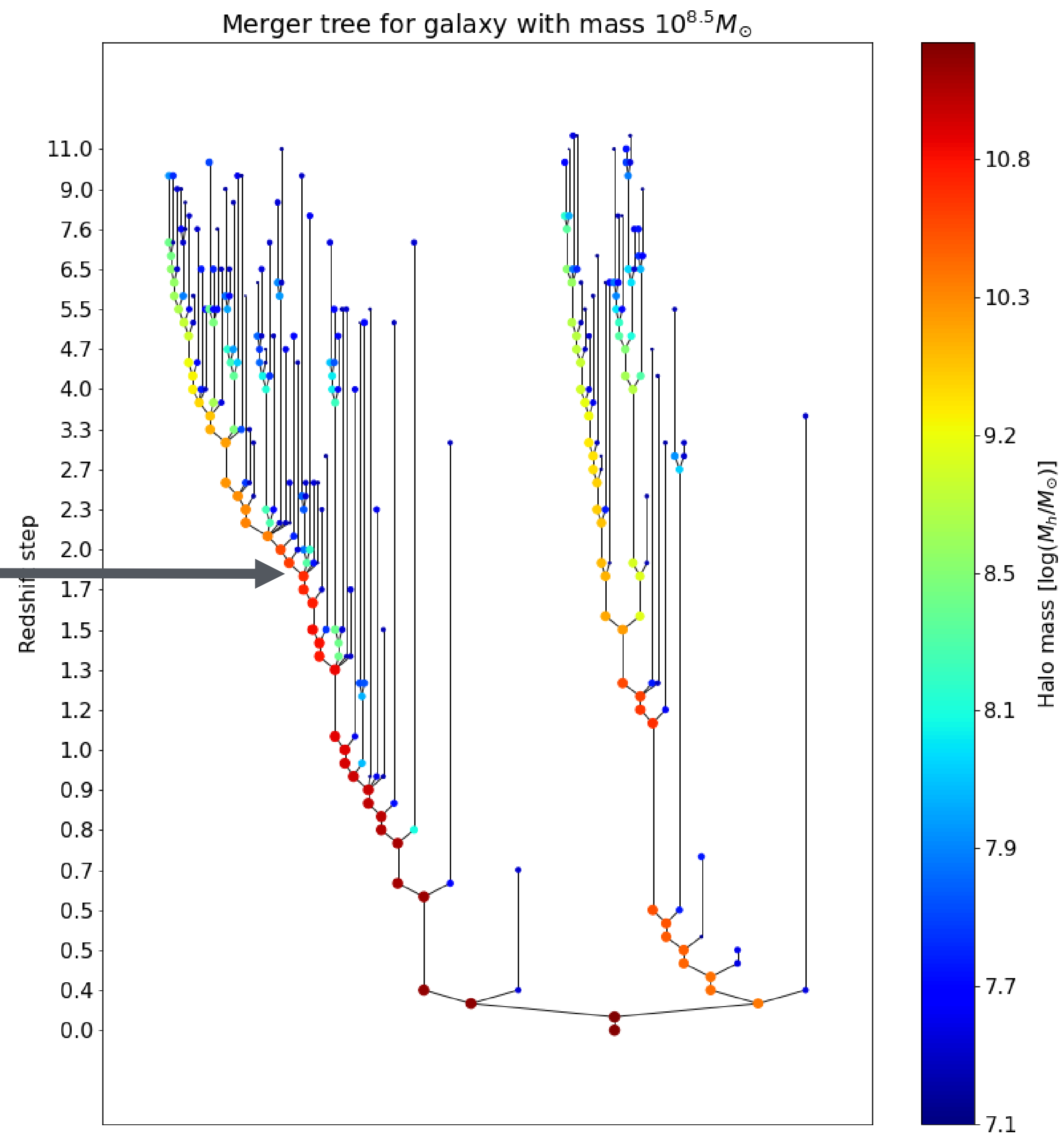


Turn-around radius = 2 x Lagrangian radius

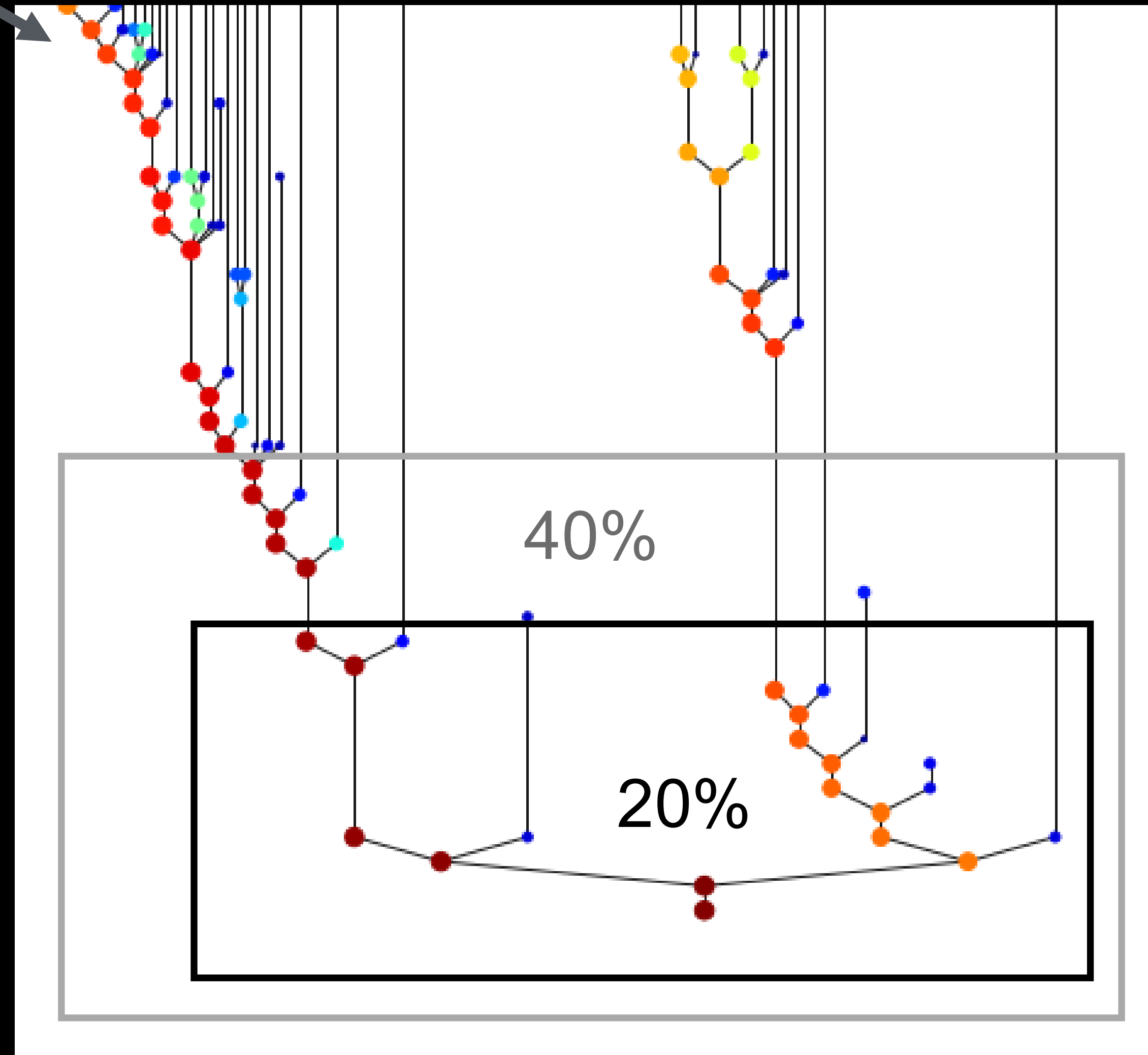
$$M_{\text{halo}} > 10^{11} M_{\odot}$$

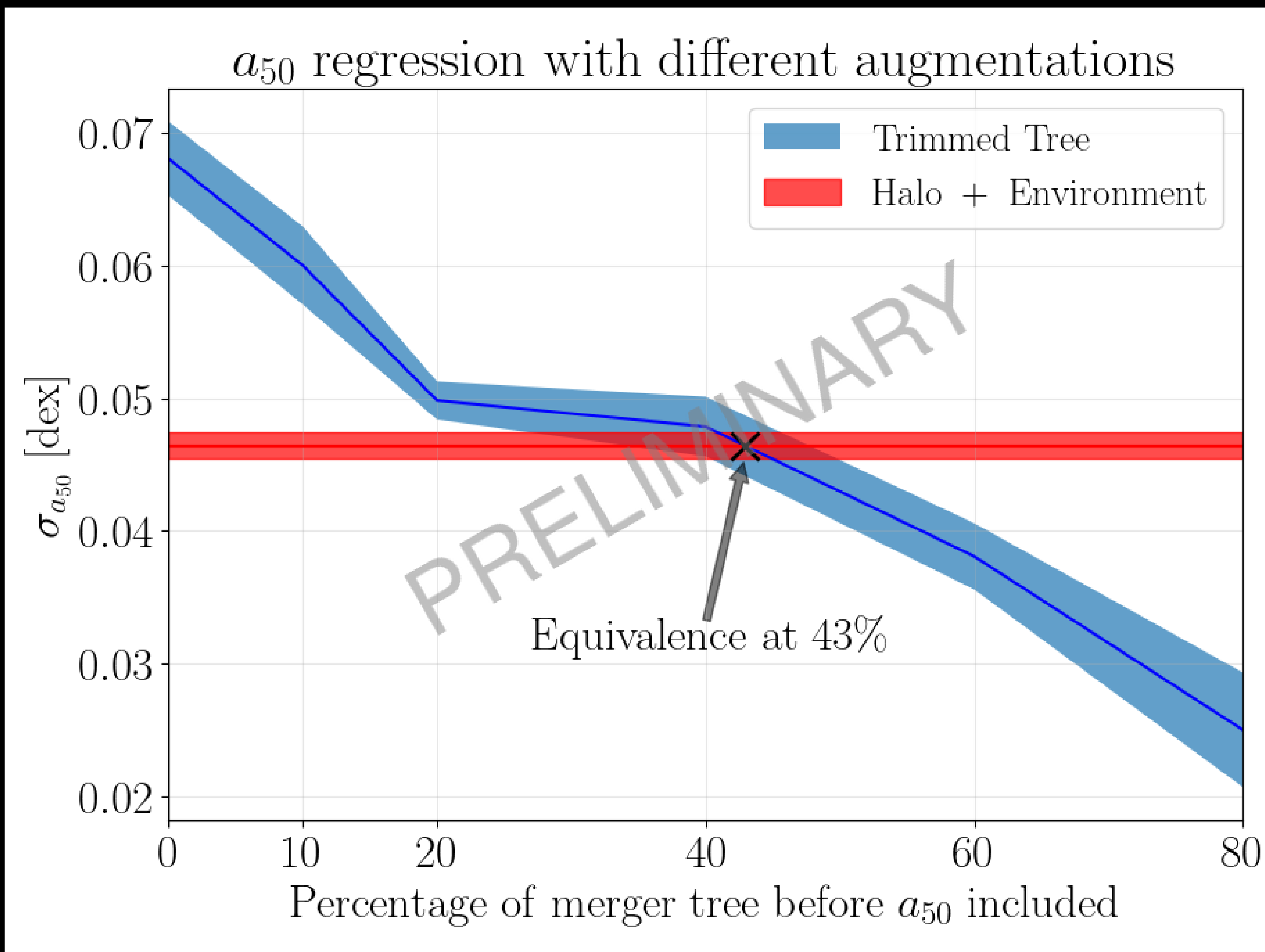


50% of mass
accumulated



50% of mass
accumulated





$L_{\text{link}} = 3\text{Mpc}$

Spectrographs

Prime Focus Instrument

Wide Field Corrector

&

Fiber Positioner "Cobra"

Metrology Camera

