Using the metal content of galaxies to inform stellar feedback modeling

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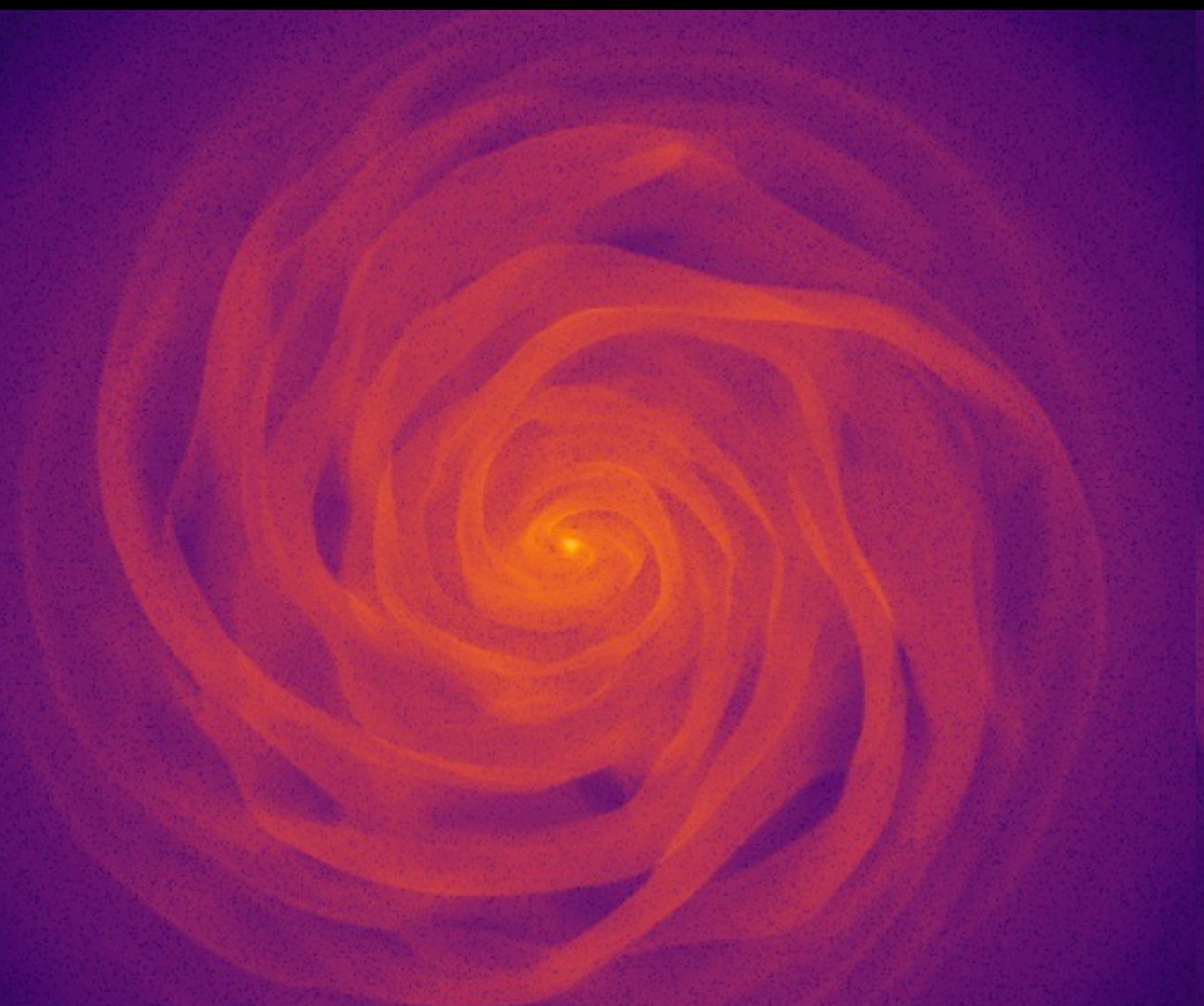
Paradigm Shift

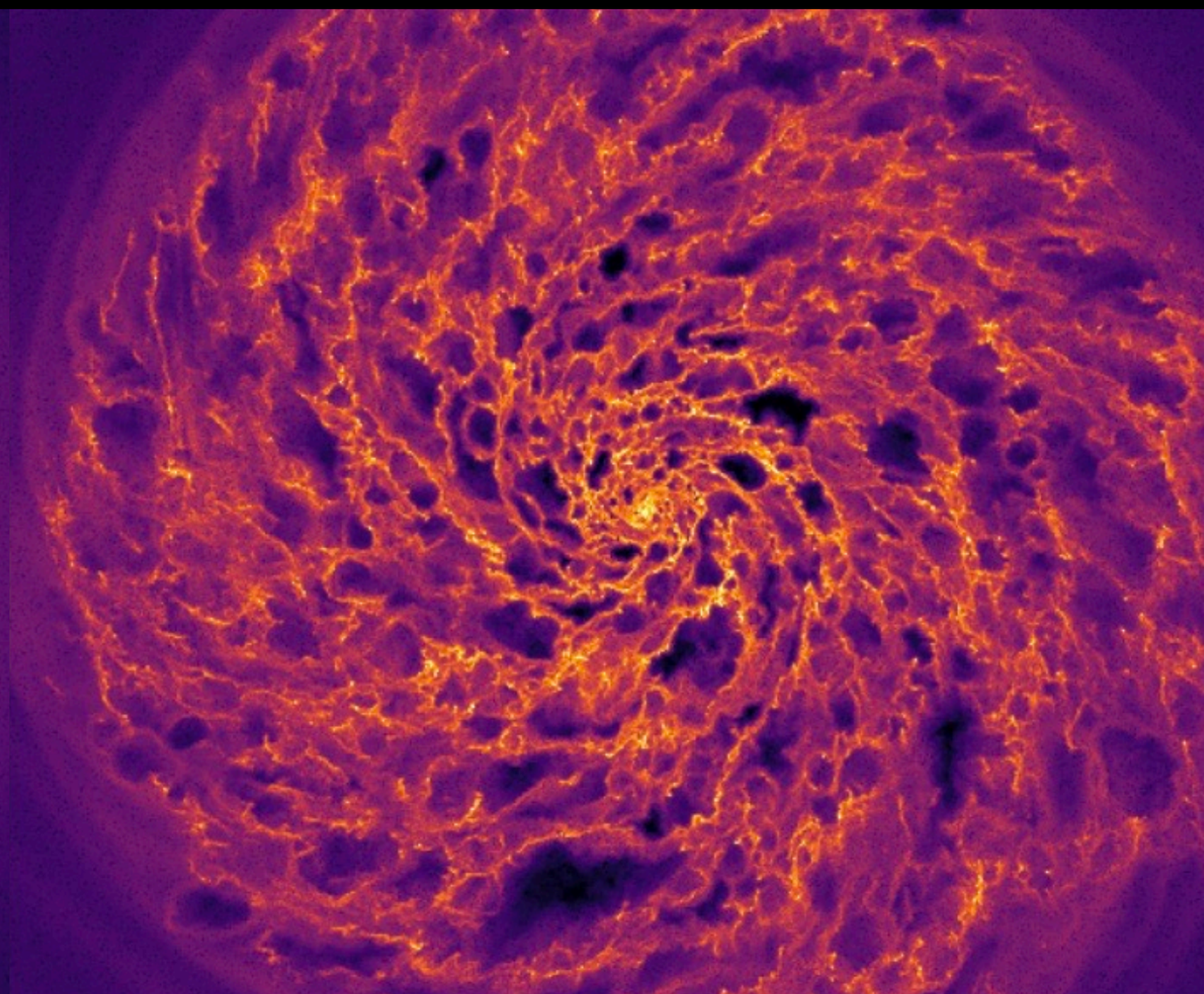
Effective Equation of State

Illustris, IllustrisTNG, EAGLE, etc…

Explicit

FIRE, SMUGGLE





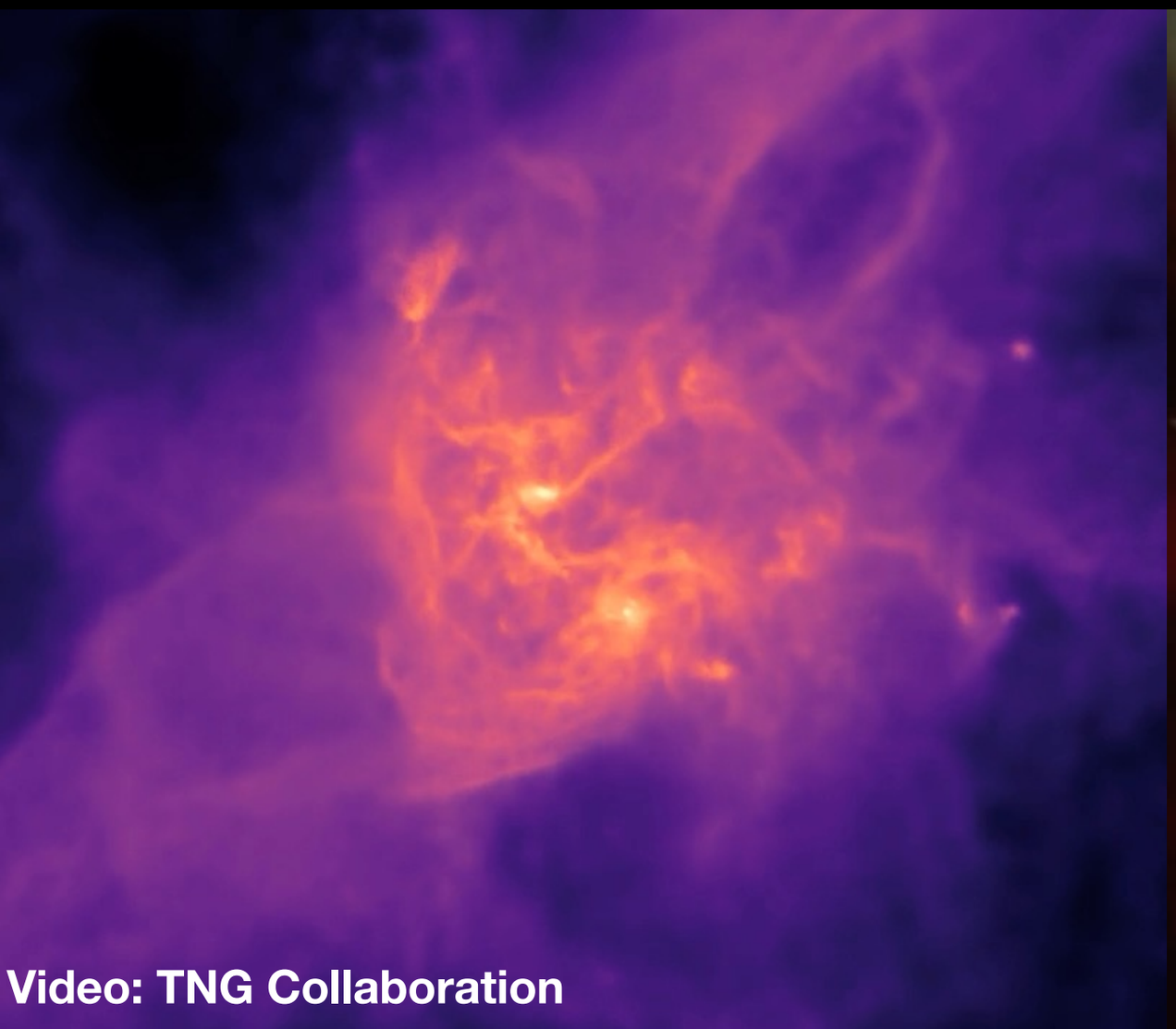
Images: Sivasankaran et al. (2021)

Paradigm Shift

Effective Equation of State

Explicit

Gentle Feedback



Video: TNG Collaboration

Bursty Feedback

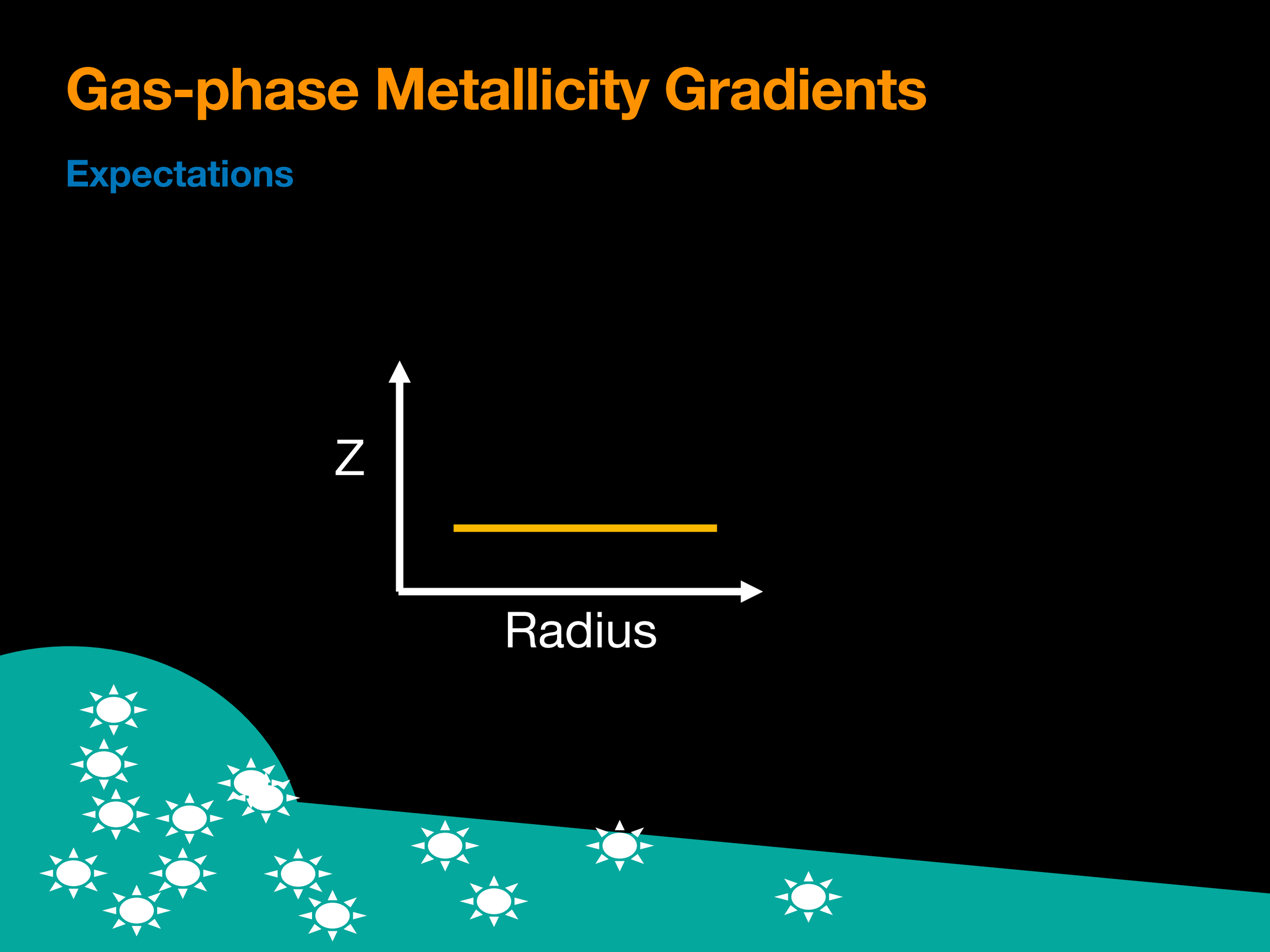
Video: FIRE Collaboration

Are there observable ways to distinguish the two?

Metallicity gradients

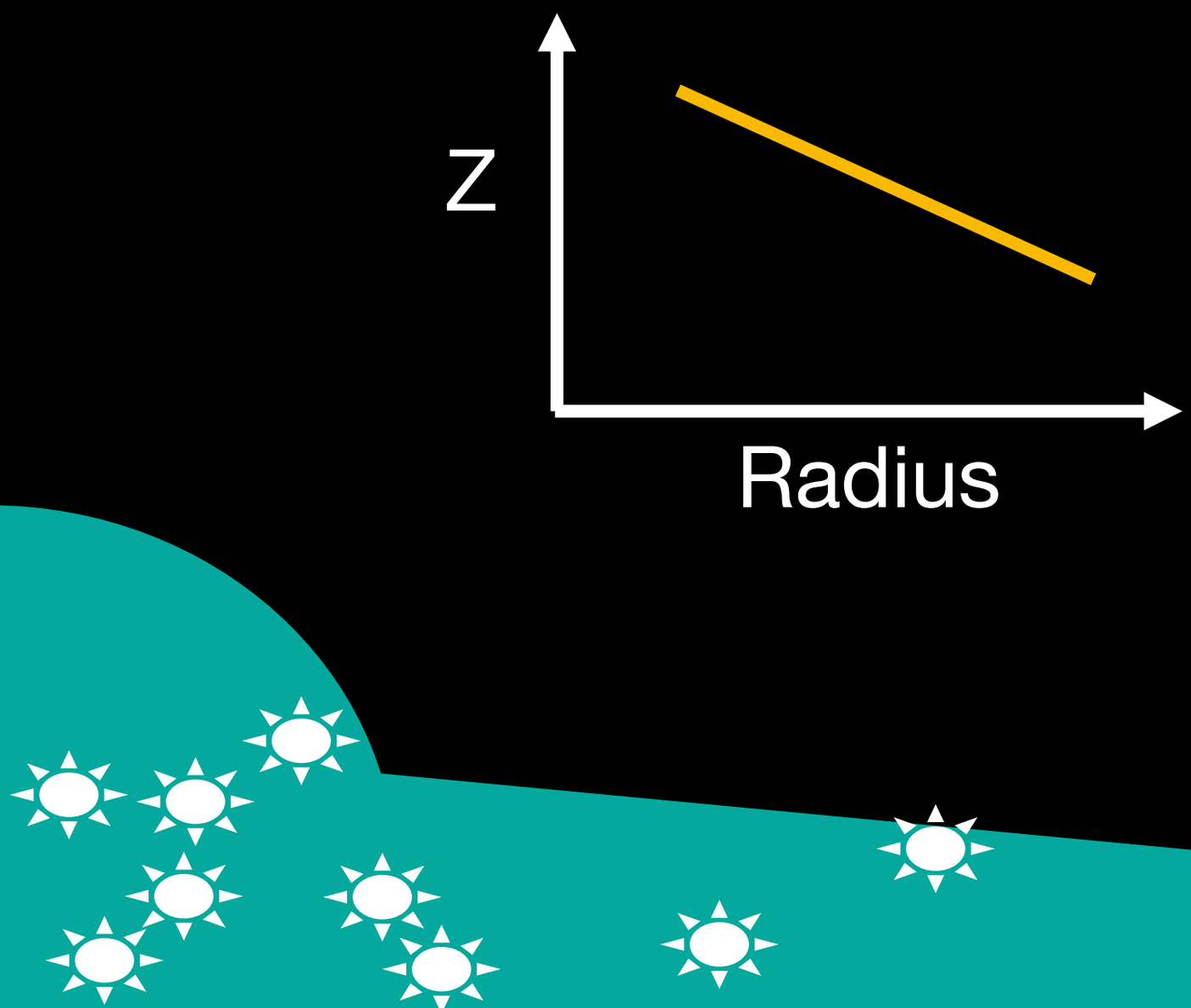
Gas-phase Metallicity Gradients

Expectations



Gas-phase Metallicity Gradients

Expectations

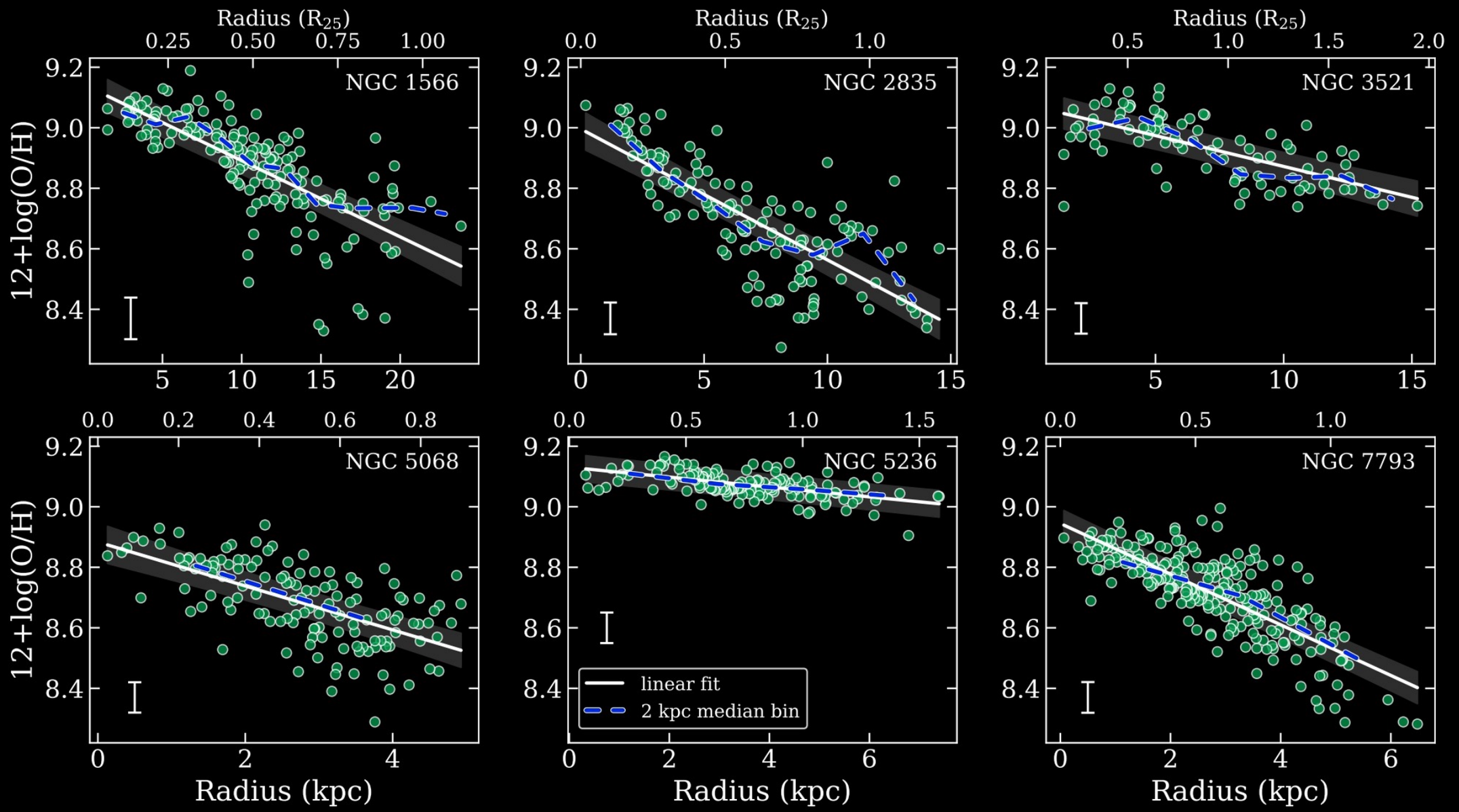


Gas-phase Metallicity Gradients

Observations

van den Bosch (1998); Prantzos & Boissier (2000); Pérez+(2013); etc…

z~0



Grasha+(2022)

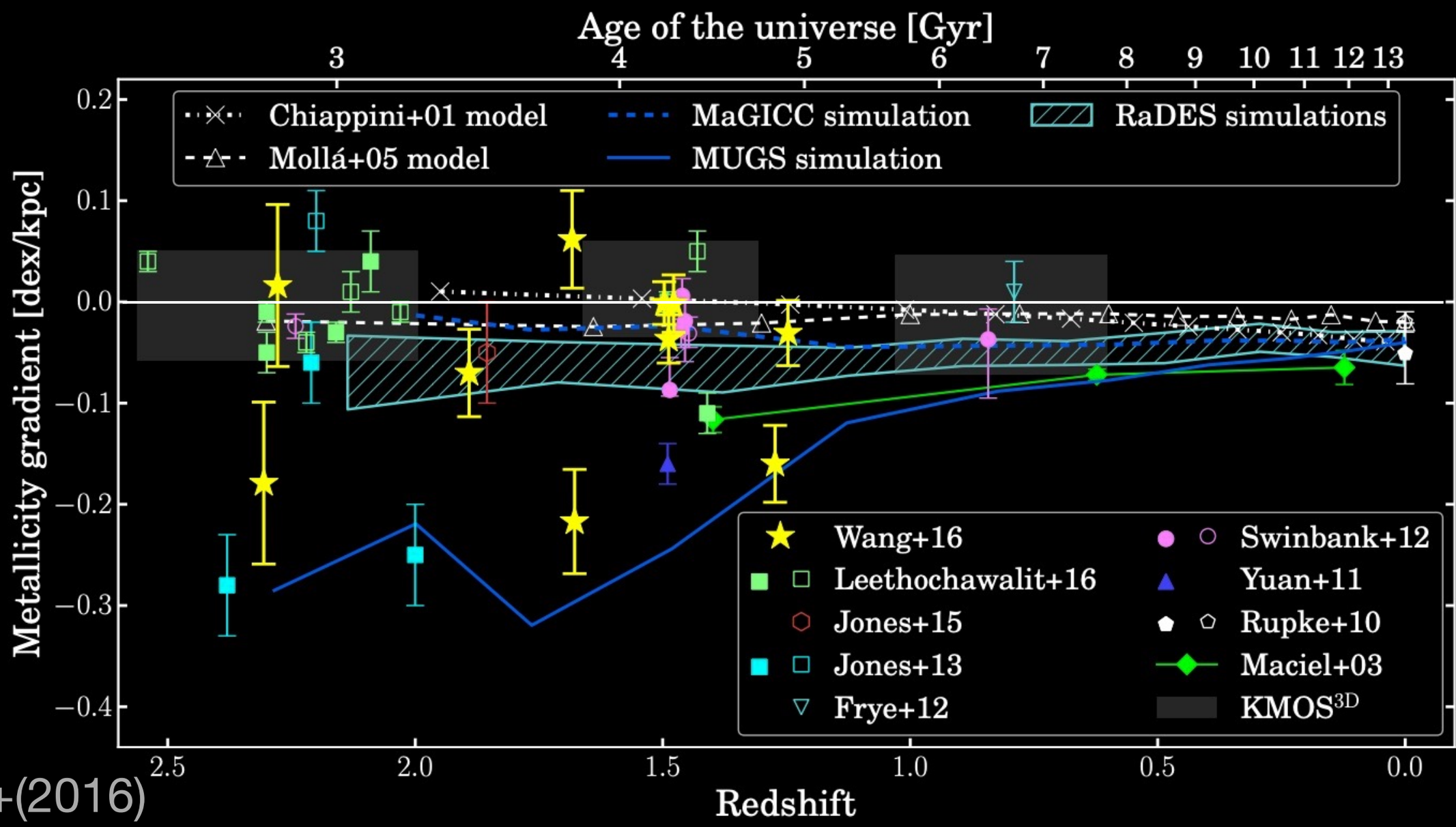
Gas-phase Metallicity Gradients

Observations

Wide variety of gradients at higher redshift*

*z ~ 0.6 – 3.0; for z > 5 see preliminary results from Zheng's Talk

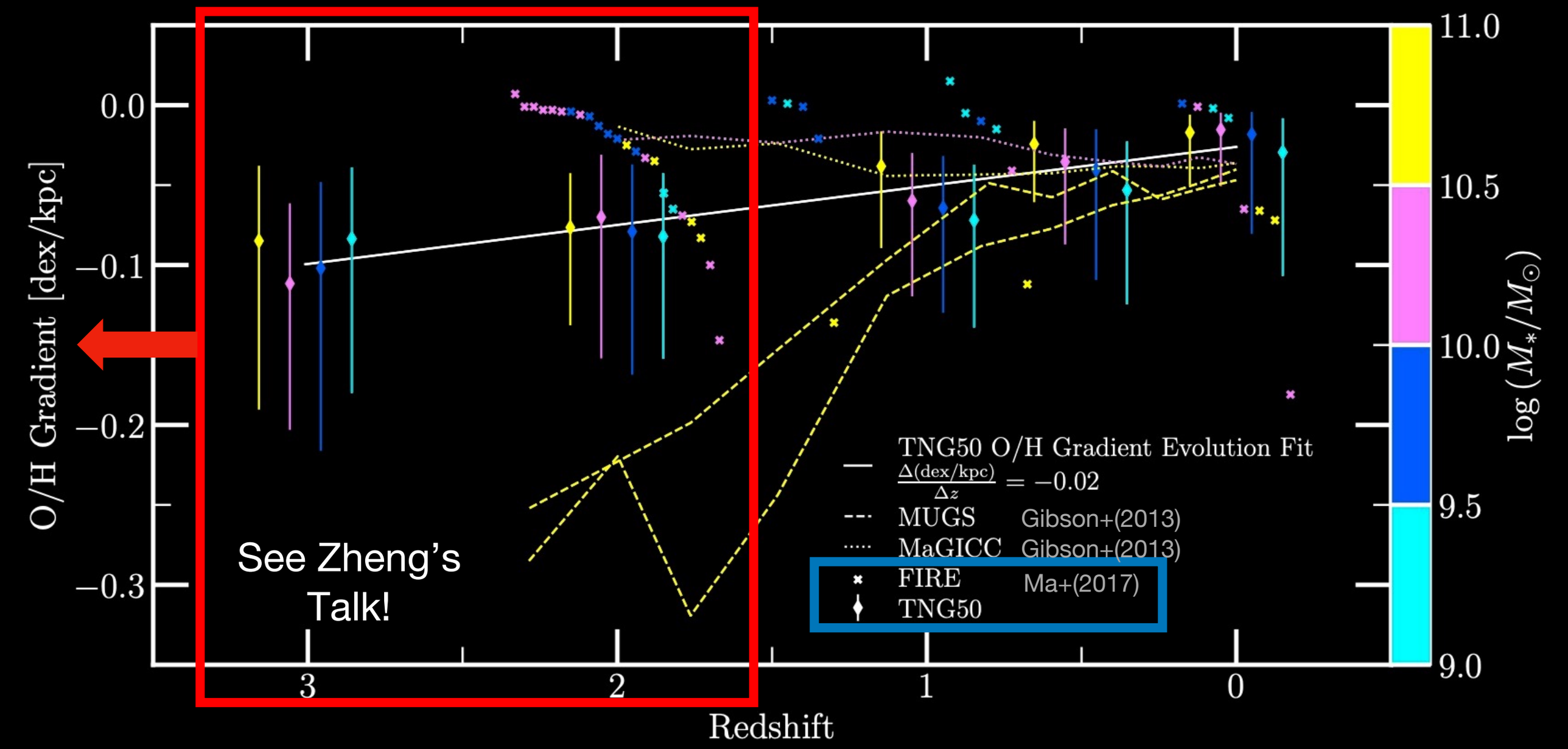
See also Cresci+(2010); Queyrel+(2012); Swinbank+(2012); Wuyts+(2016); etc…



Wang+(2016)

Gas-phase Metallicity Gradients

Simulations



Hemler+(2021)

Metallicity Gradients

eEOS

Gentle Feedback

No mechanism to catastrophically destroy gradients

Explicit

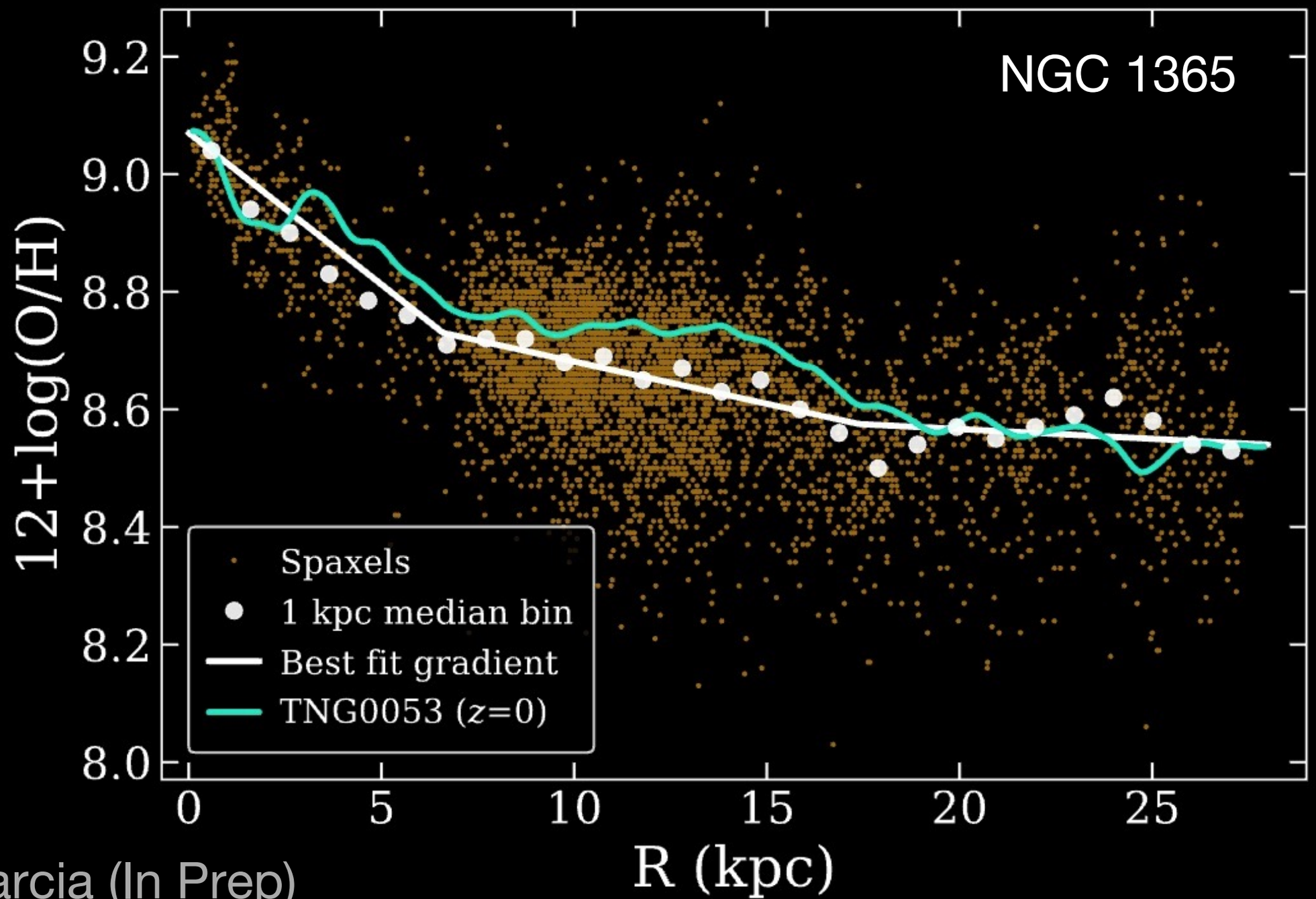
Bursty Feedback

Washes out metallicity gradients very quickly

Allows re-growth of the gradients

Beyond Single Gradient

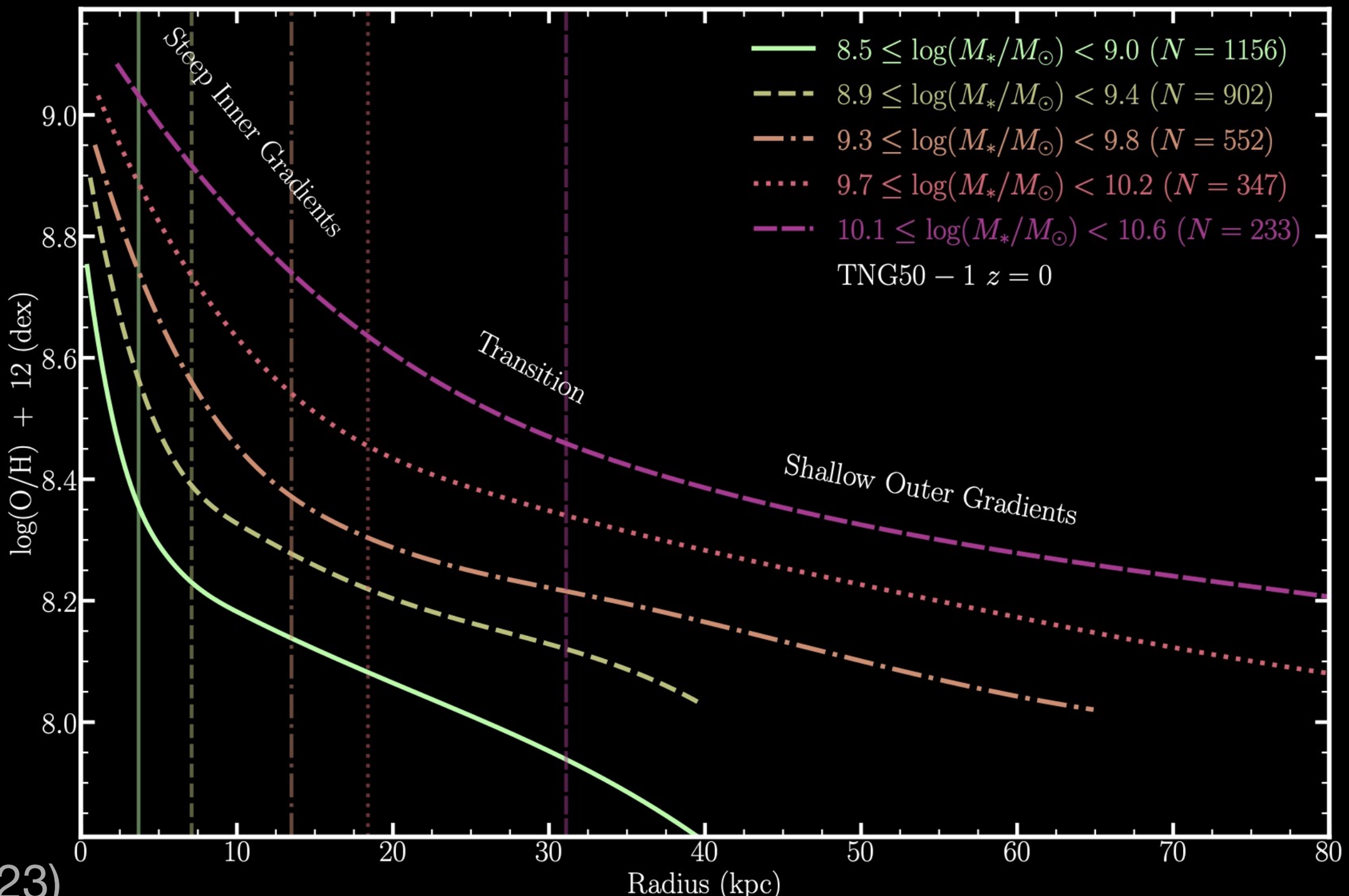
Profile flattening - Observations



Kewley+, incl. Garcia (In Prep)

Beyond Single Gradient

Profile flattening - Simulations



Garcia+(2023)

Why do profiles flatten?

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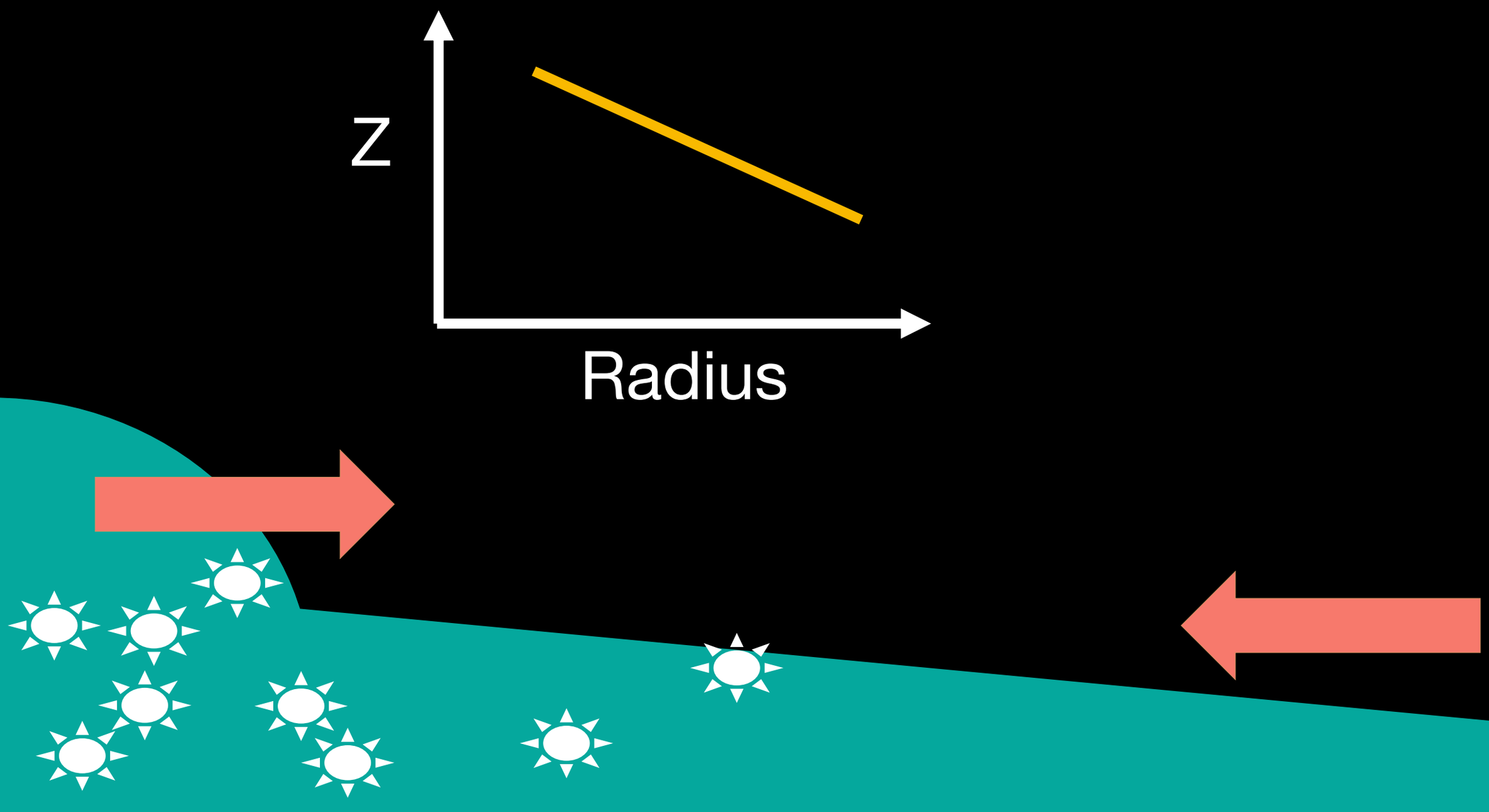

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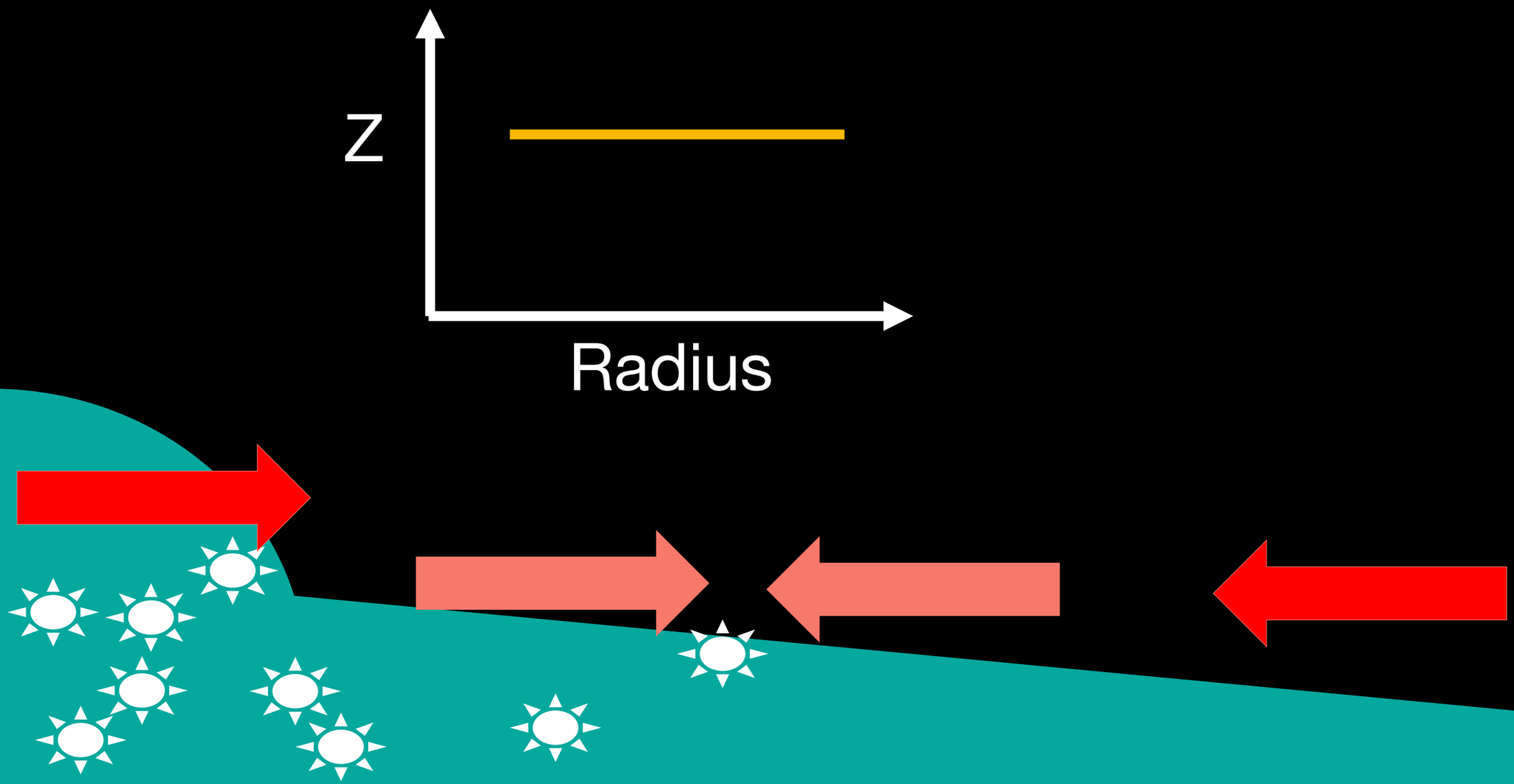
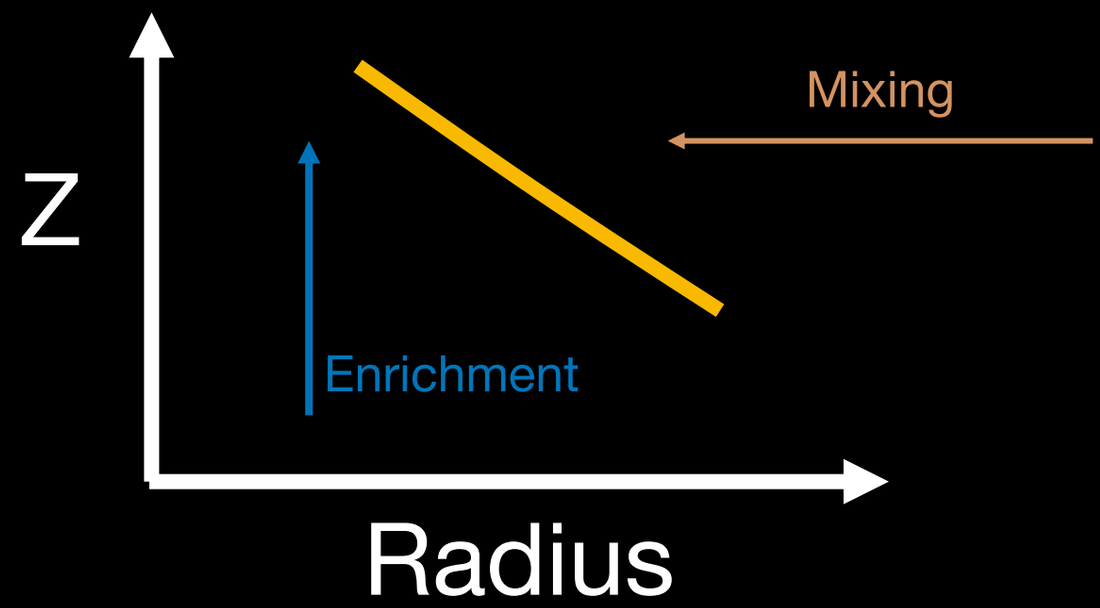


Enrichment vs Mixing

Resolved Scales



Enrichment vs Mixing

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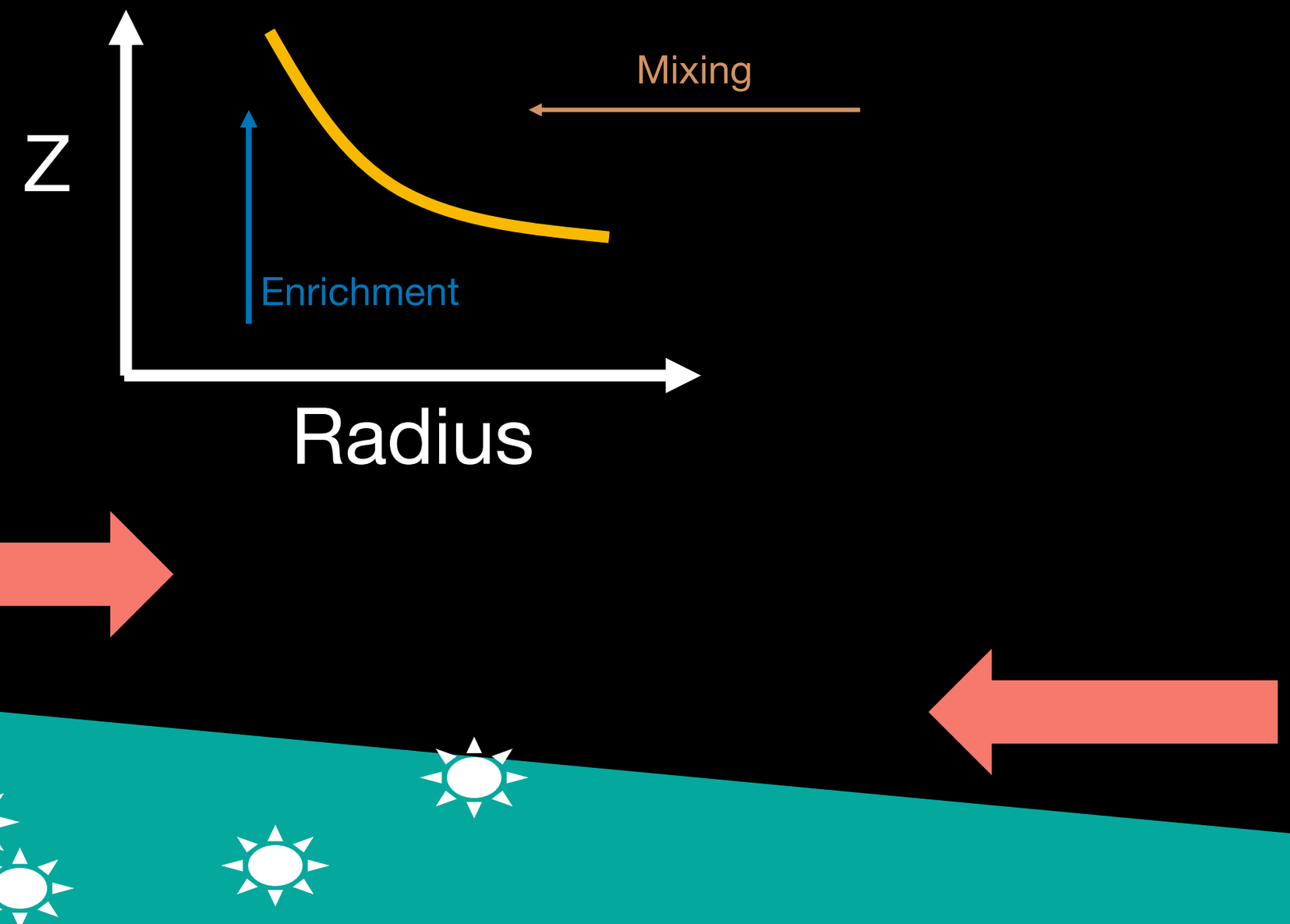
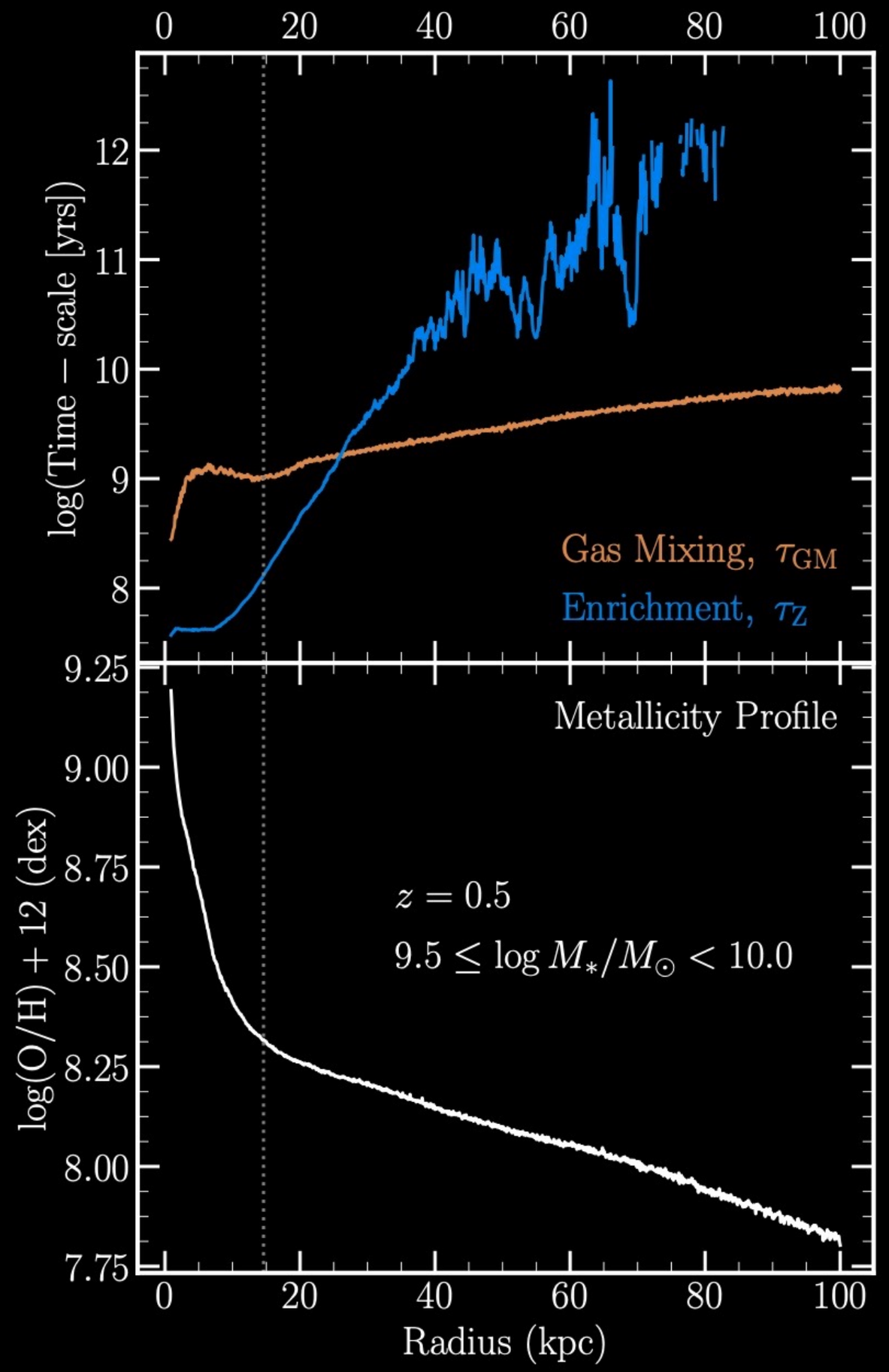


Enrichment vs Mixing

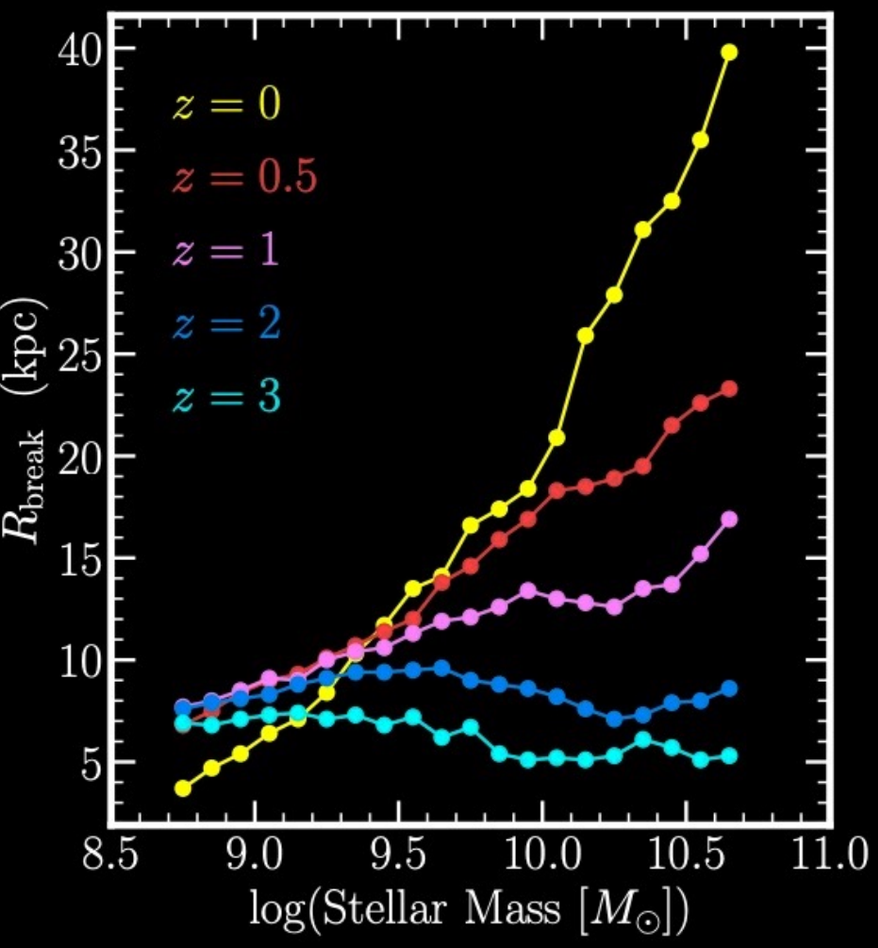
Quantitative Look

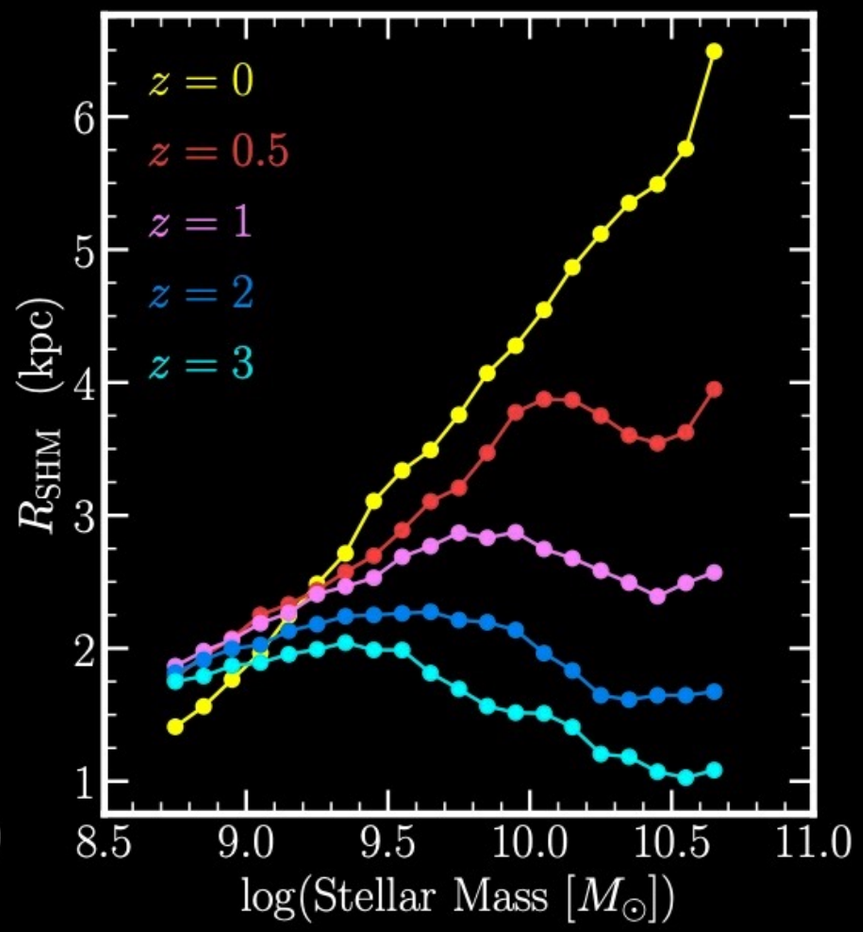
Ratio ~1/10 at location of the break

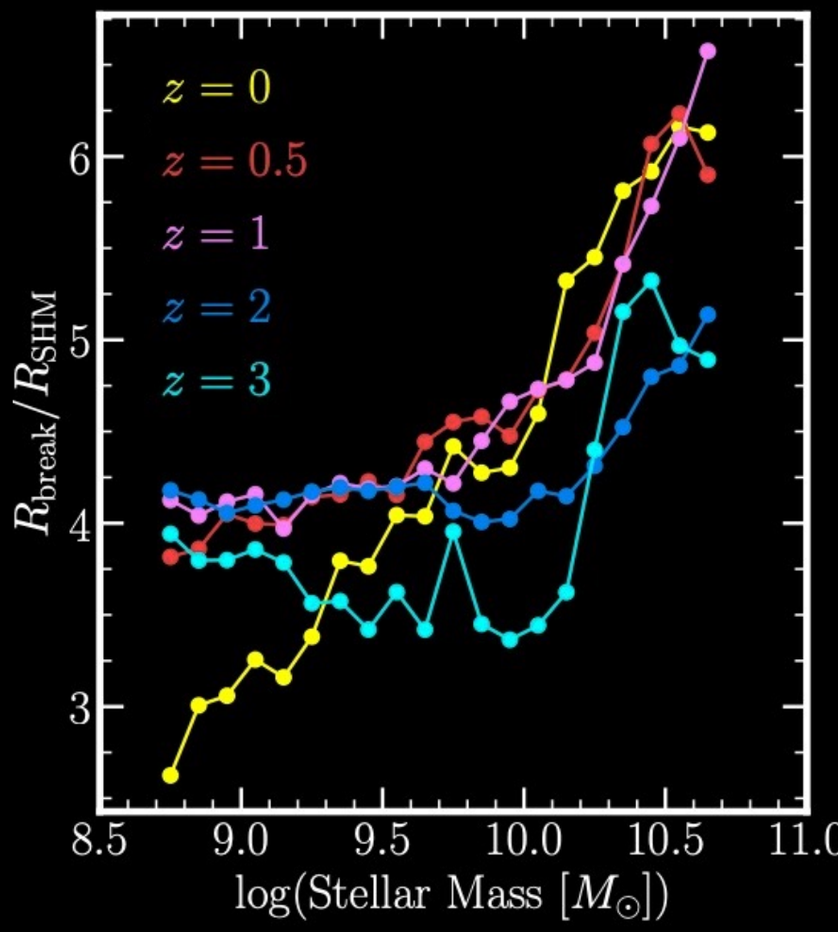


Garcia+(2023)

Where is this in the disk?







Garcia+(2023)

Metallicity Gradients

eEOS

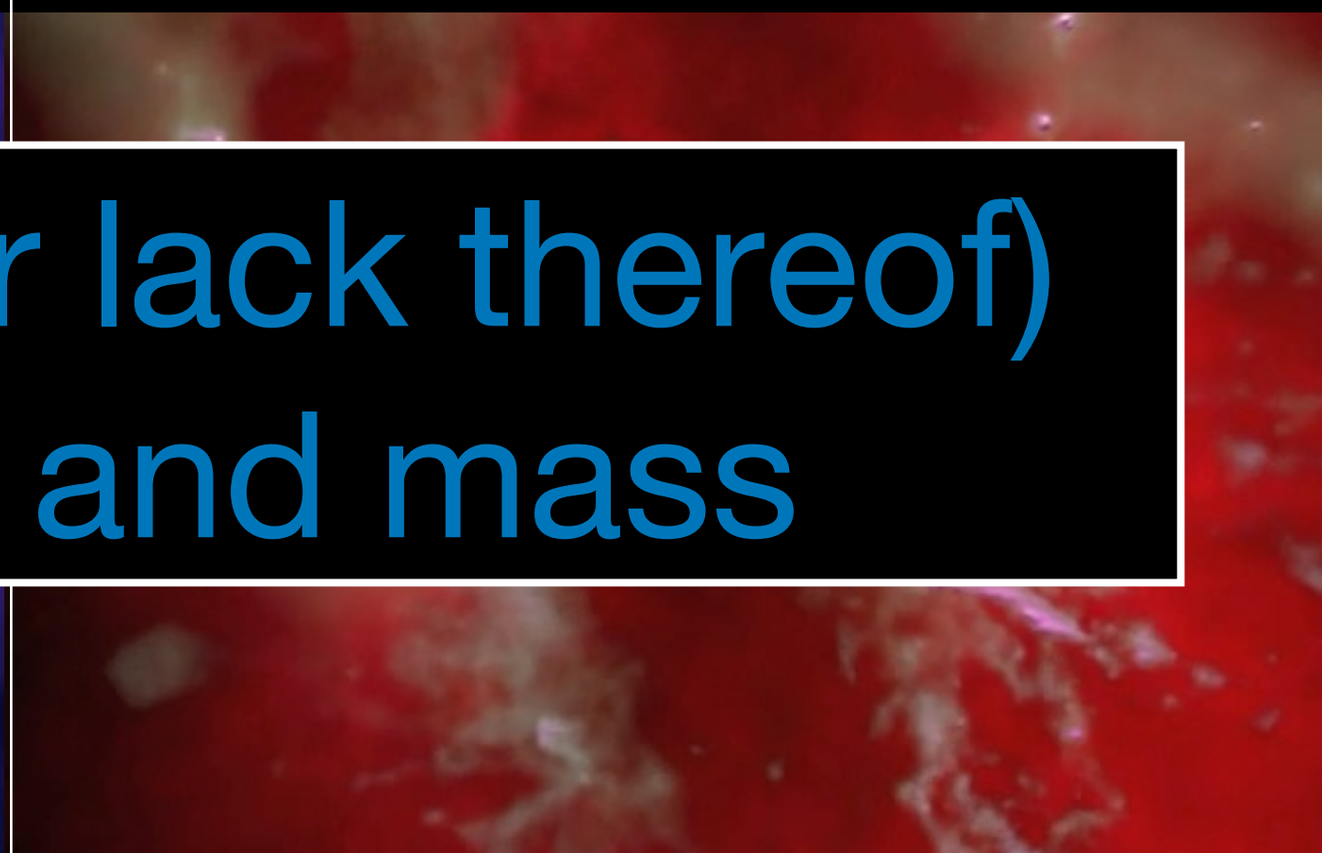
Gentle Feedback

Mixing takes a while to redistribute metals

Explicit

Bursty Feedback

Bursts wash out gradients fast! (large mixing events)



Variations (or lack thereof) with time and mass

Are there observable ways to distinguish between feedback models?

Are there observable ways to distinguish between feedback models?

Both the strength and physical extent of metallicity gradients are sensitive to the feedback mechanisms within simulation

Near Term Future:

- High redshift observations with JWST
- High spatial resolution surveys of local galaxies

Garcia et al. (2023)
arXiv:2212.03326
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