Image: TNG Collaboration

Using the metal content of galaxies to inform stellar feedback modeling

Alex Garcia

University of Virginia

UF University of Florida

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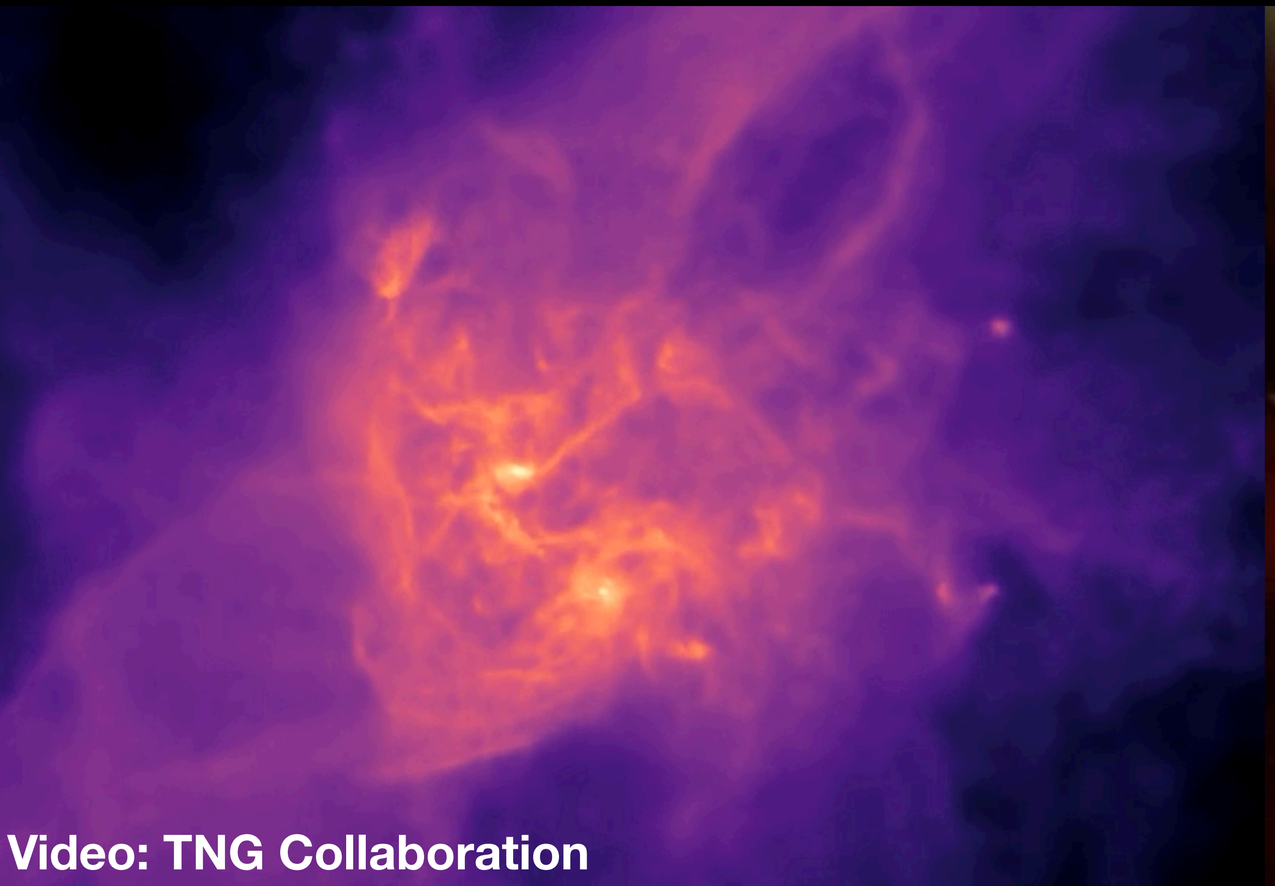
Modeling stellar feedback in simulations

Gentle Feedback



Video: TNG Collaboration

Bursty Feedback

Video: FIRE Collaboration

1. Metallicity gradients

Are there observable ways to distinguish the two?

2. Interplay of stellar and gas-phase metallicities

Are there observable ways to distinguish the two?

1. Metallicity gradients: Hemler+21 and Garcia+23
2. Interplay of stellar and gas-phase metallicities

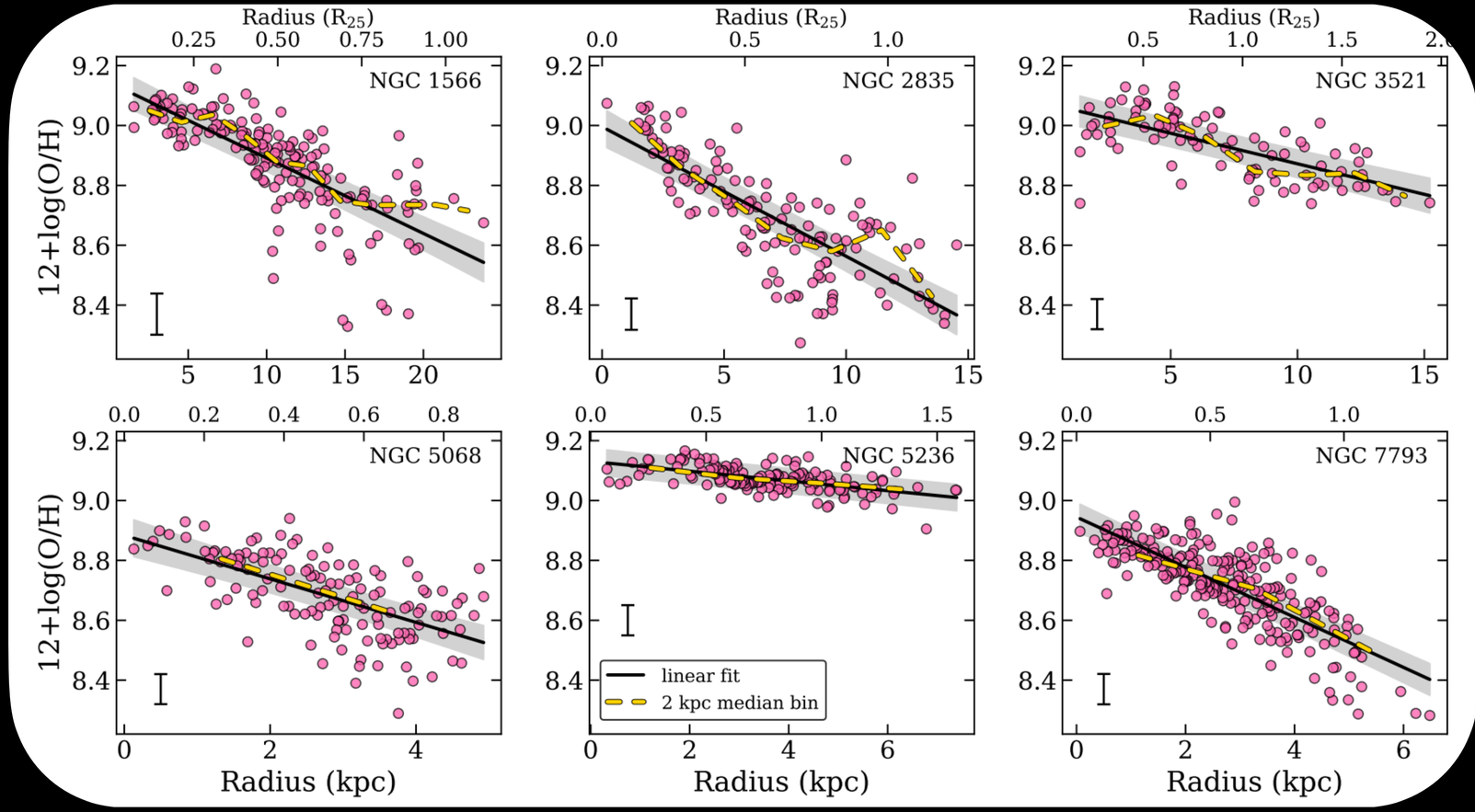
Gas-phase Metallicity Gradients

Observations

Predominately negative gradients at low redshift

Higher redshifts (z~0.6-3)

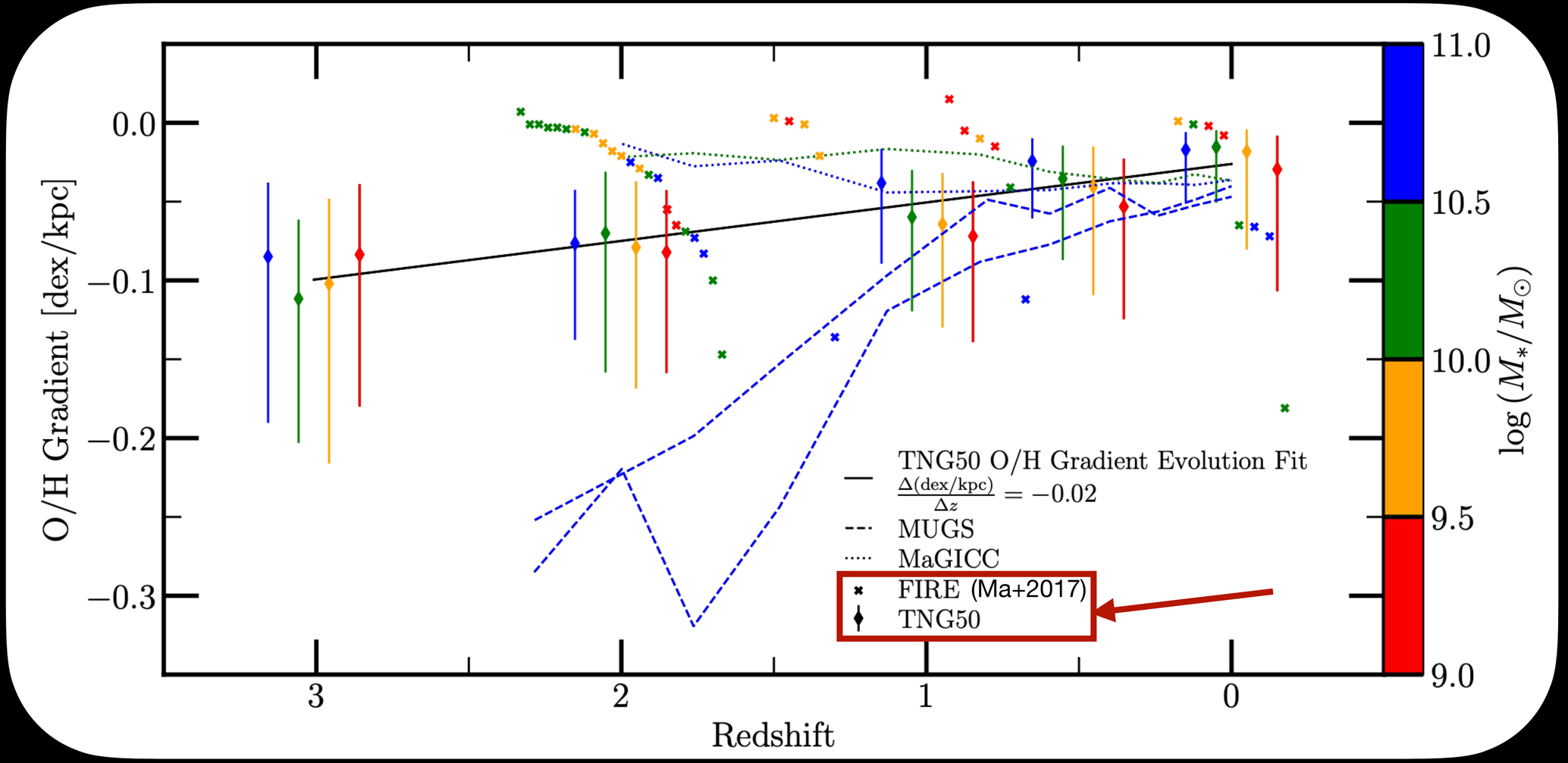
- Wide variety of gradients



Grasha+2022

Gas-phase Metallicity Gradients

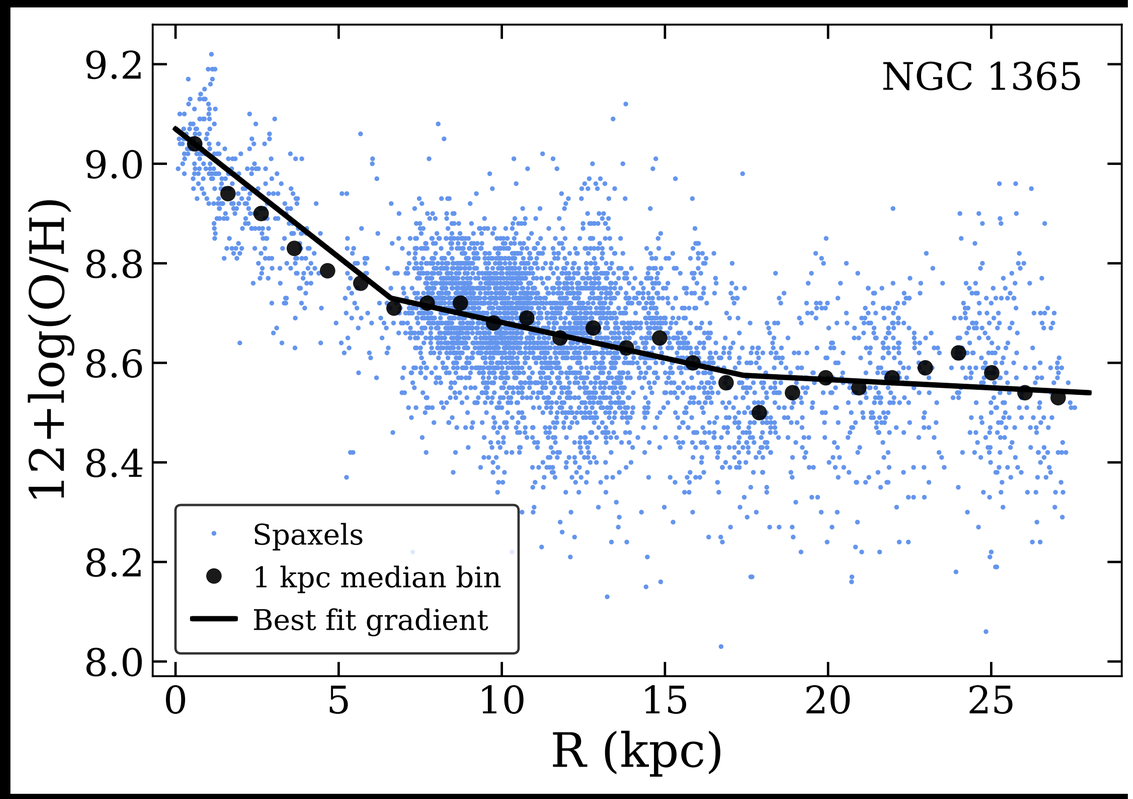
Simulations



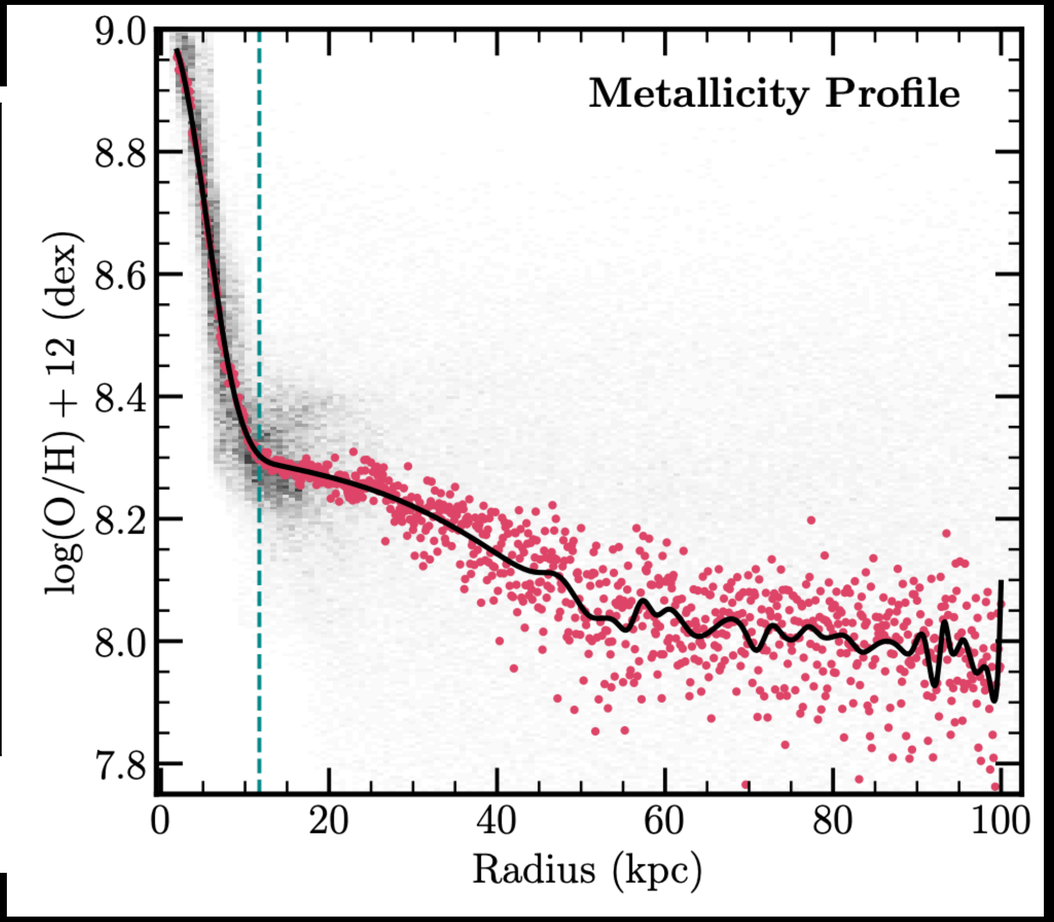
Hemler+2021

Extended metallicity profiles

Profile flattening



Kewley+, incl. Garcia(In Prep)



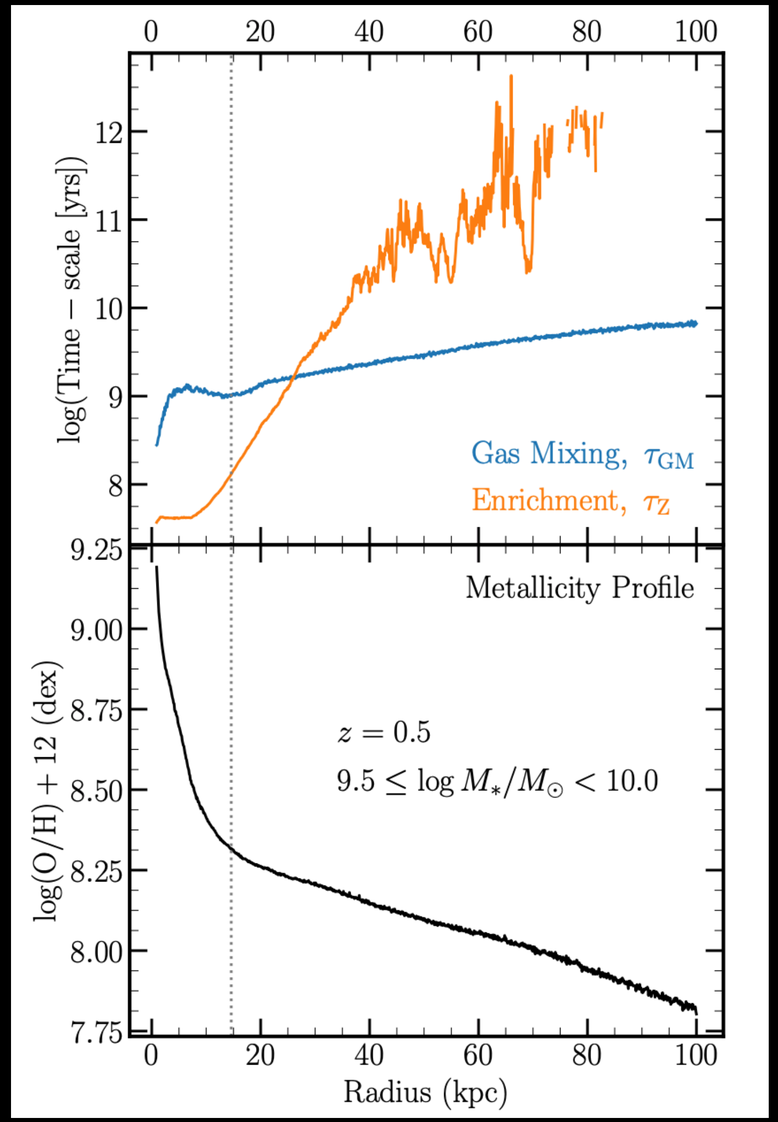
Garcia+2023

Why do metallicity profiles “break”?

What sets a gradient?

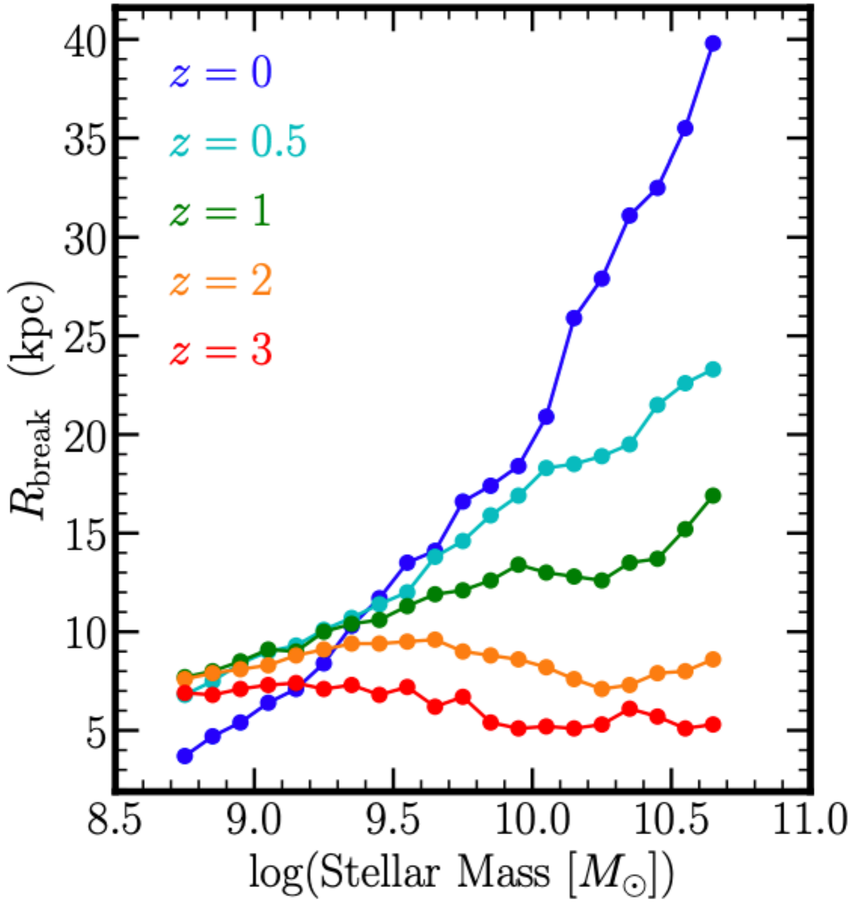
Enrichment vs Mixing

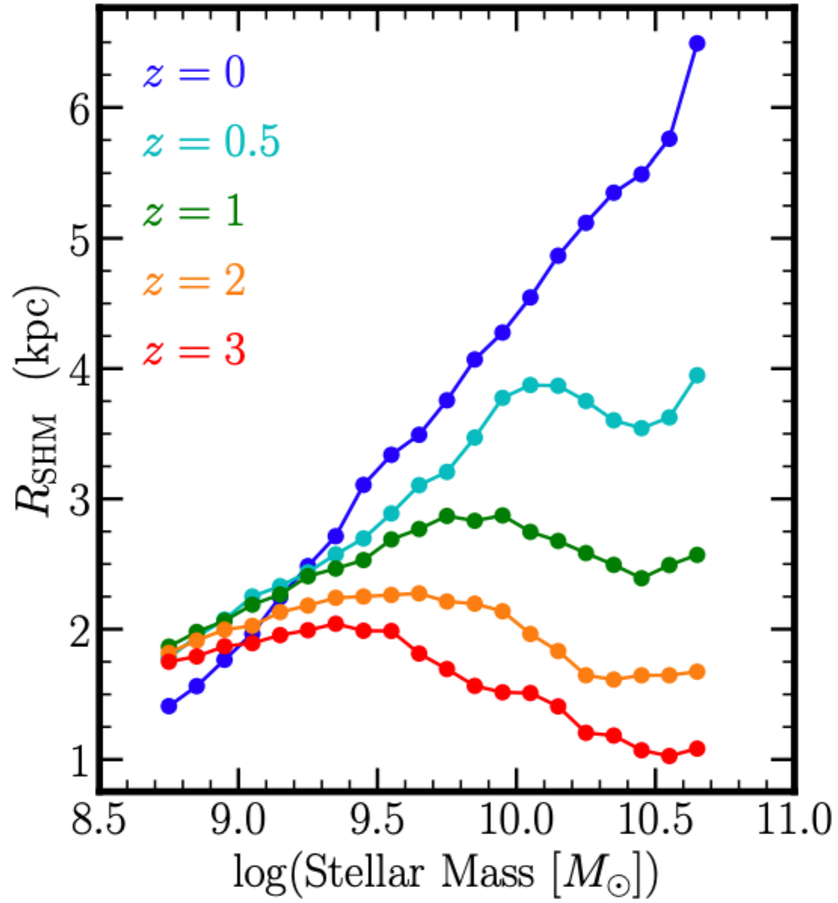
Ratio of Timescales ~1/10 at location of the break

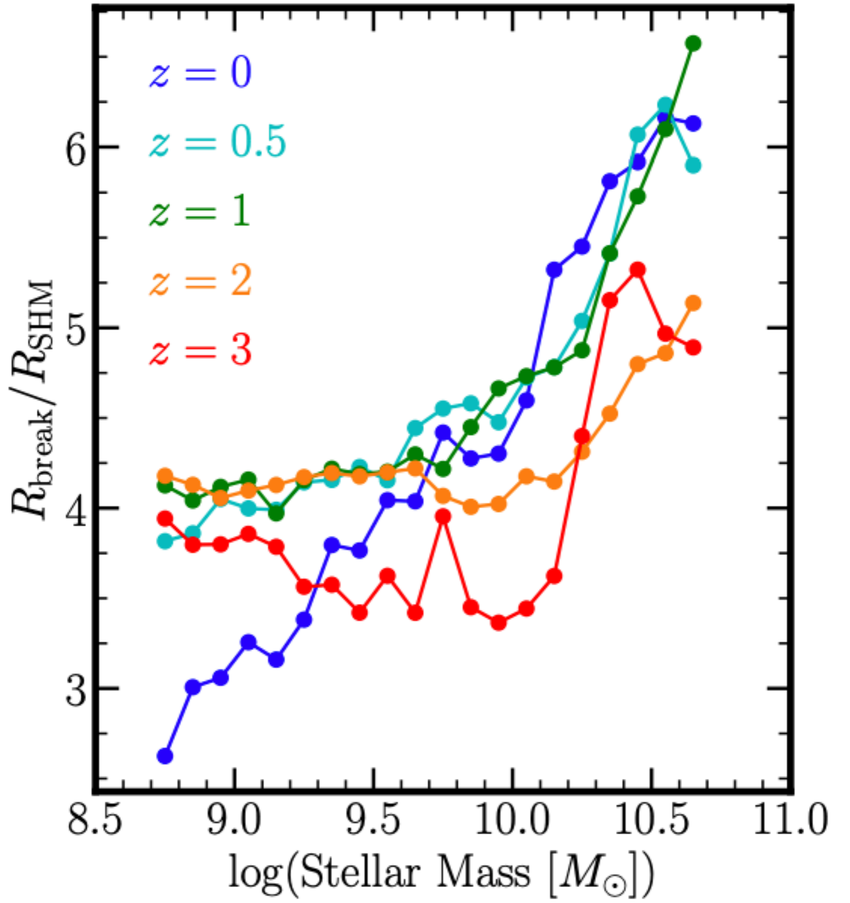


Garcia+2023

Where is this in the disk?







Garcia+2023

What gradients tell us about feedback models

Gentle Feedback

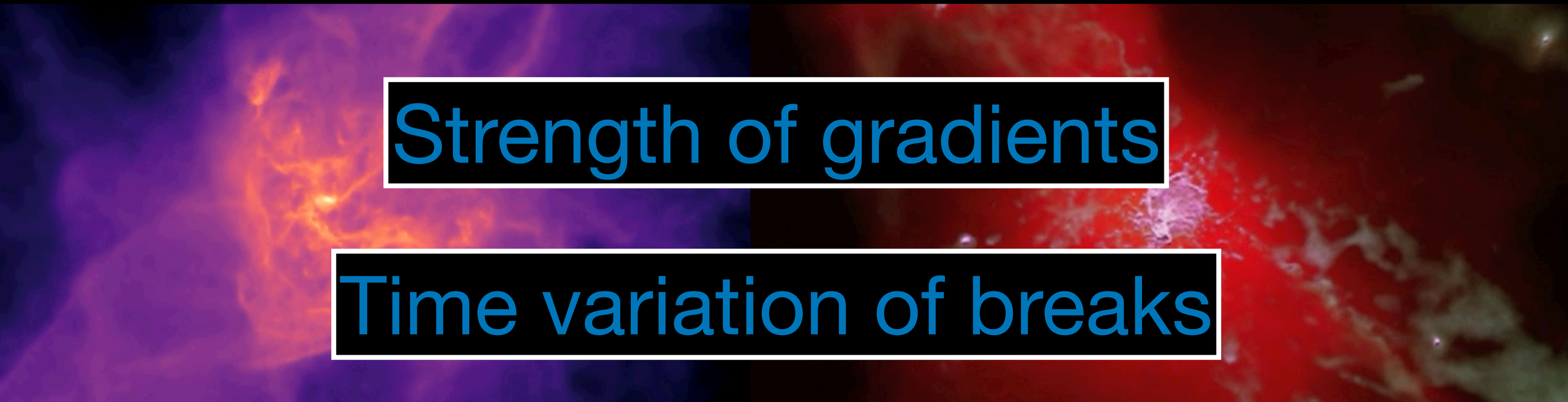
No mechanism to catastrophically destroy gradients

Mixing takes a *long* time

Bursty Feedback

Washes out metallicity gradients very quickly

Allows re-growth of the gradients



Strength of gradients

Time variation of breaks

Are there observable ways to distinguish the two feedback models?

1. Metallicity gradients
2. Interplay of stellar and gas-phase metallicities

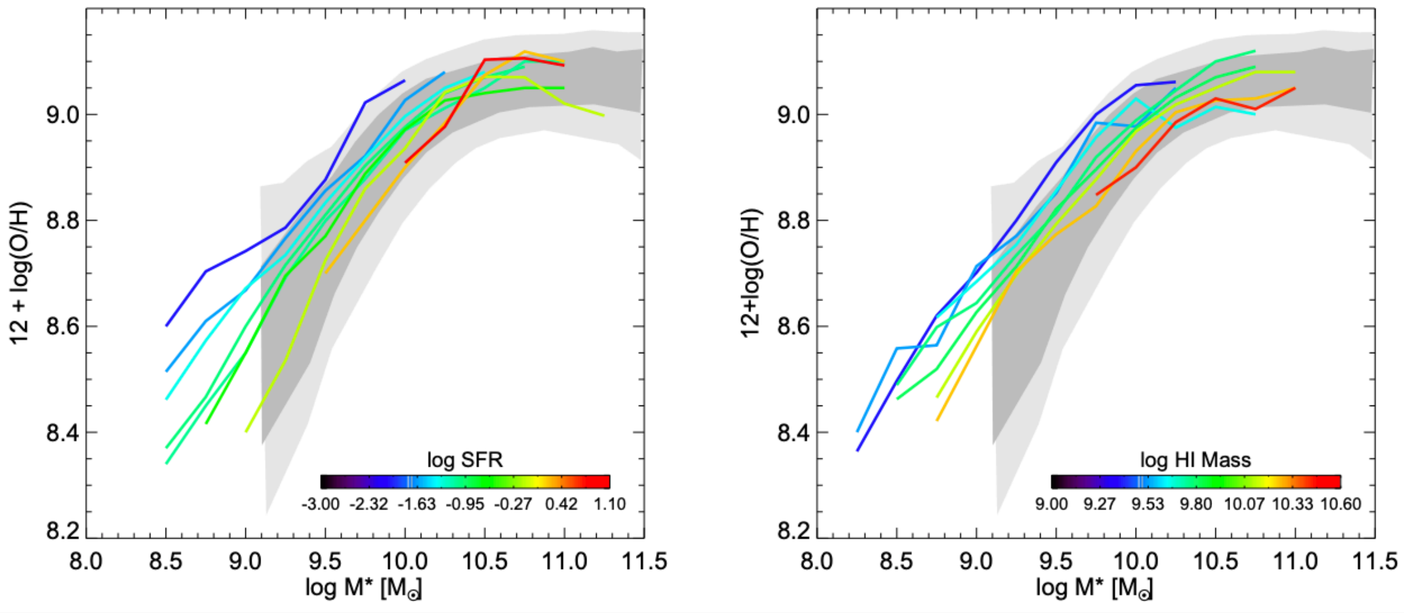
Are there observable ways to distinguish the two feedback models?

1. Metallicity gradients
2. Interplay of stellar and gas-phase metallicities: Garcia+(Submitted)

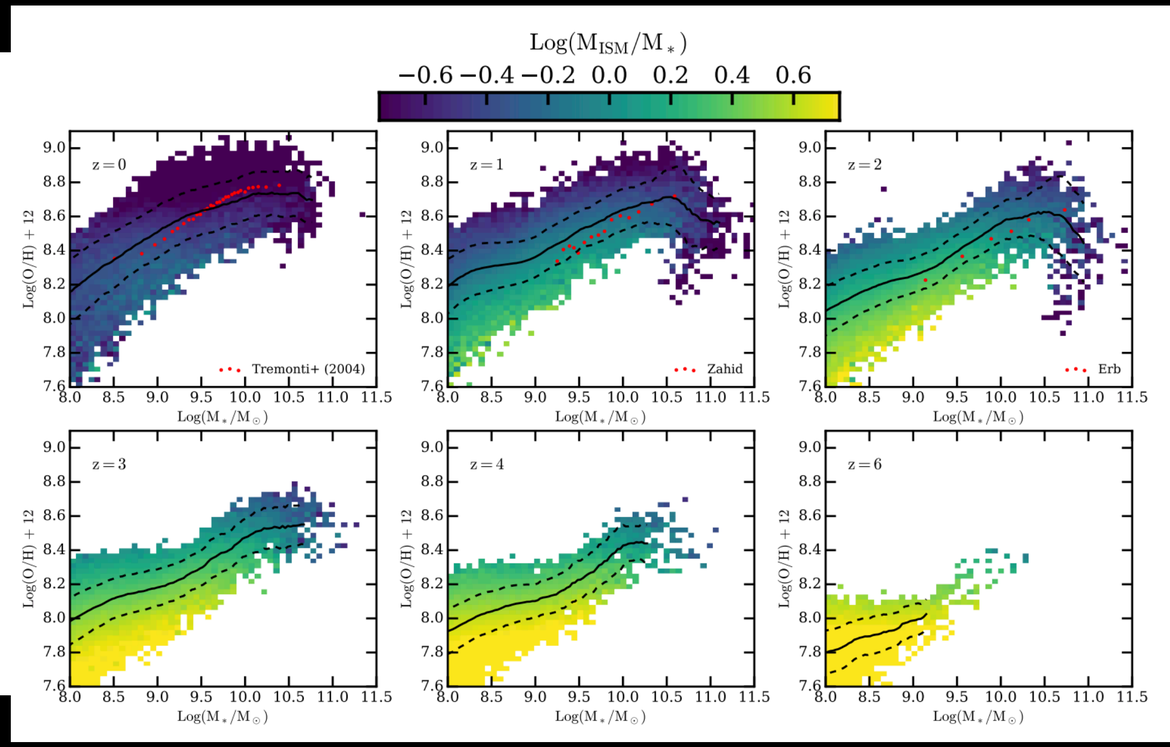
"Alex, I don't have disk space for all that particle data!"

Mass-Metallicity Relation

Correlated scatter with Gas-phase metals

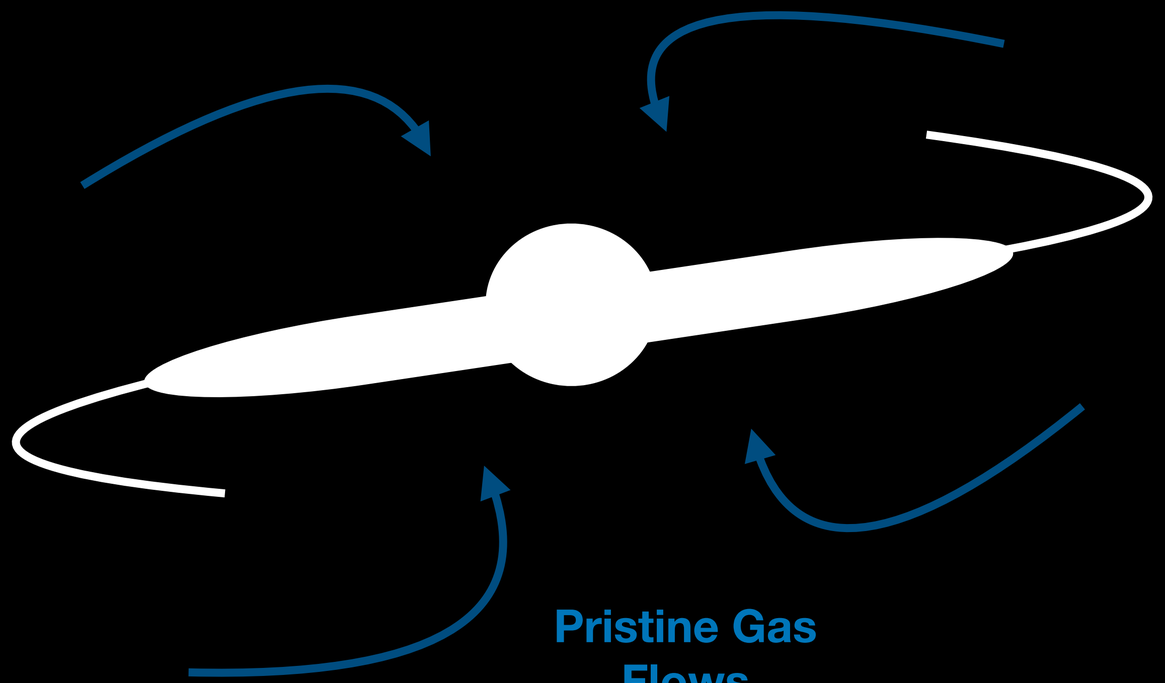


Bothwell+2013



Torrey+2019

Physics behind correlated scatter



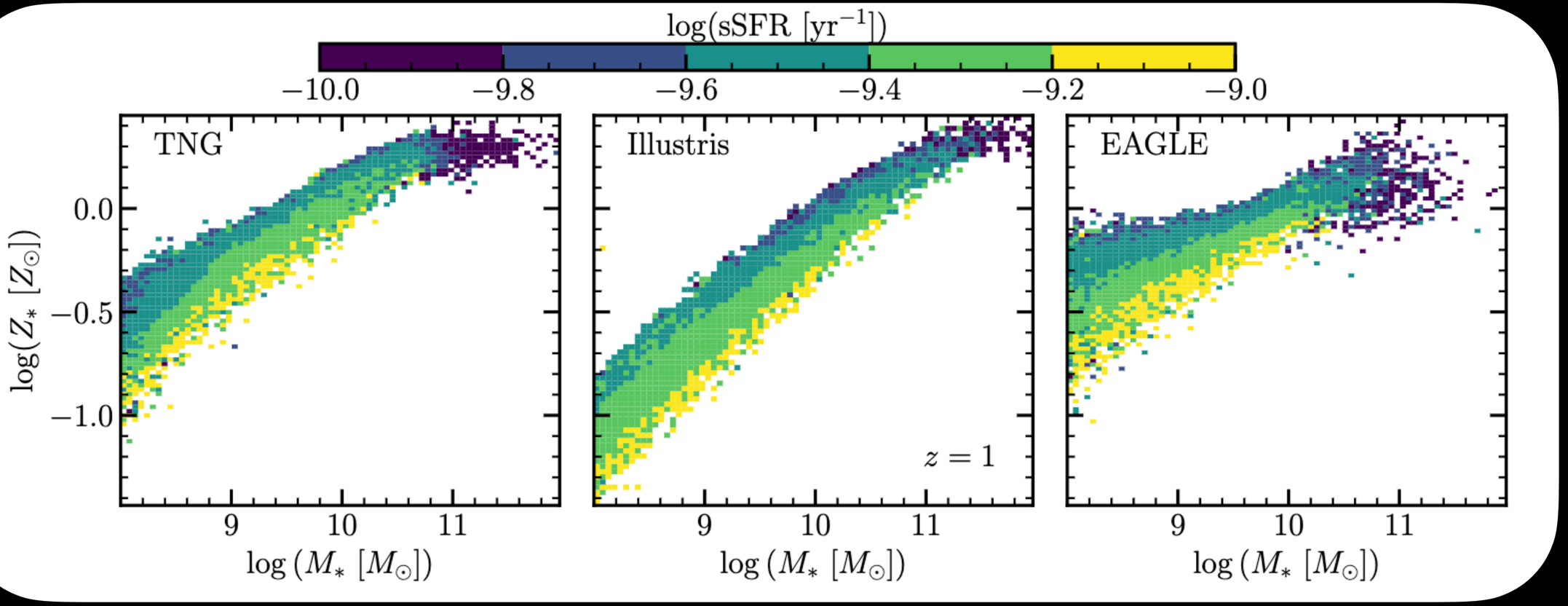
Increased pristine gas content:

- Decreases the metallicity
- SFR increases! (Ellison+2008)

Stellar metallicities are not *directly* impacted by gas accretion!

On global scales

So what *do* the stellar metallicities do?



Garcia+(Submitted)

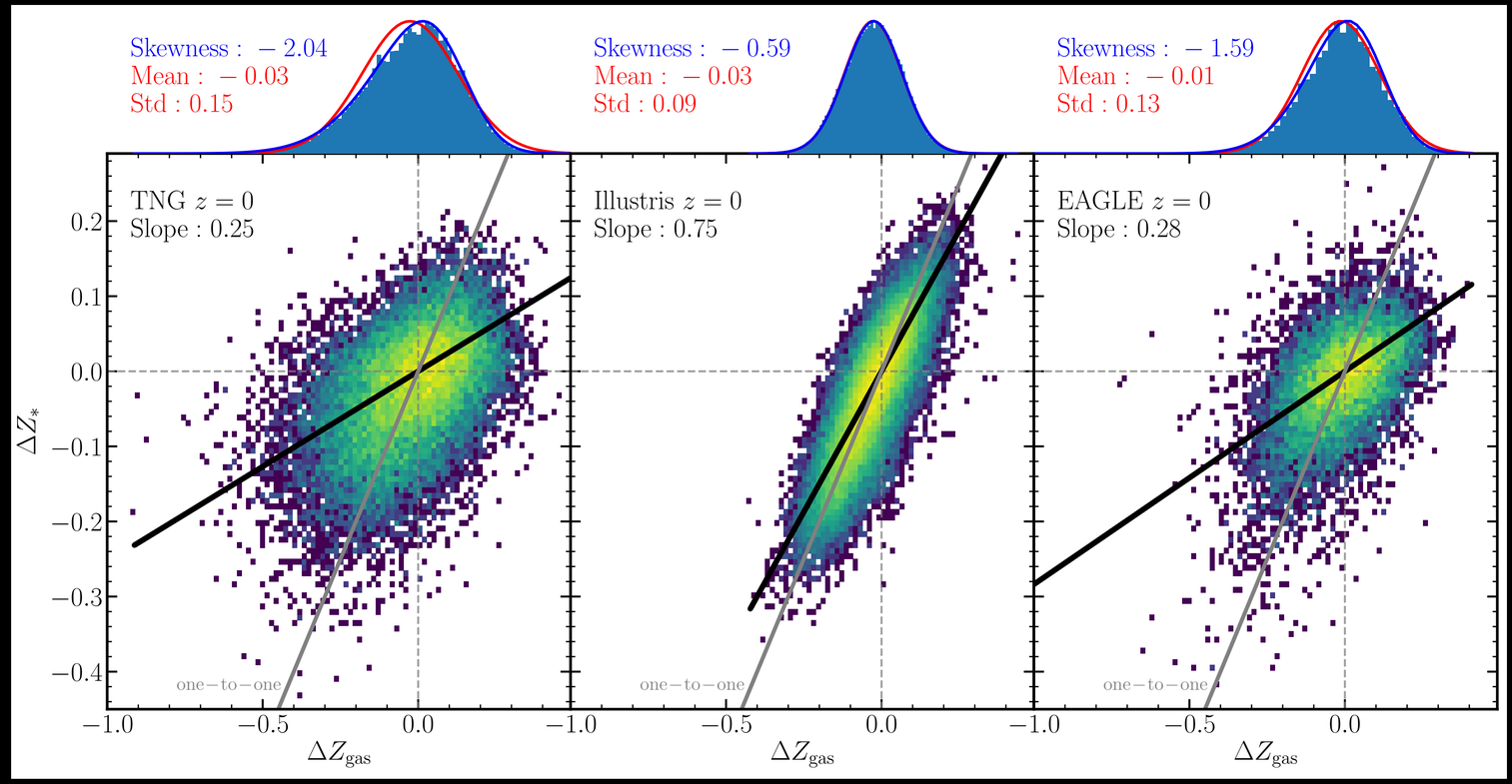
We find evidence for an analogous residual correlation for stellar metallicities

Where does this residual correlation originate?

Though not *directly* influenced, stars will feel the effects of gas accretion over time

A galaxy's offset from both the stellar MZR and gas-phase MZR are correlated

The more tightly correlated stellar and gas-phase metals are: the steeper the relationship



Garcia+(Submitted)

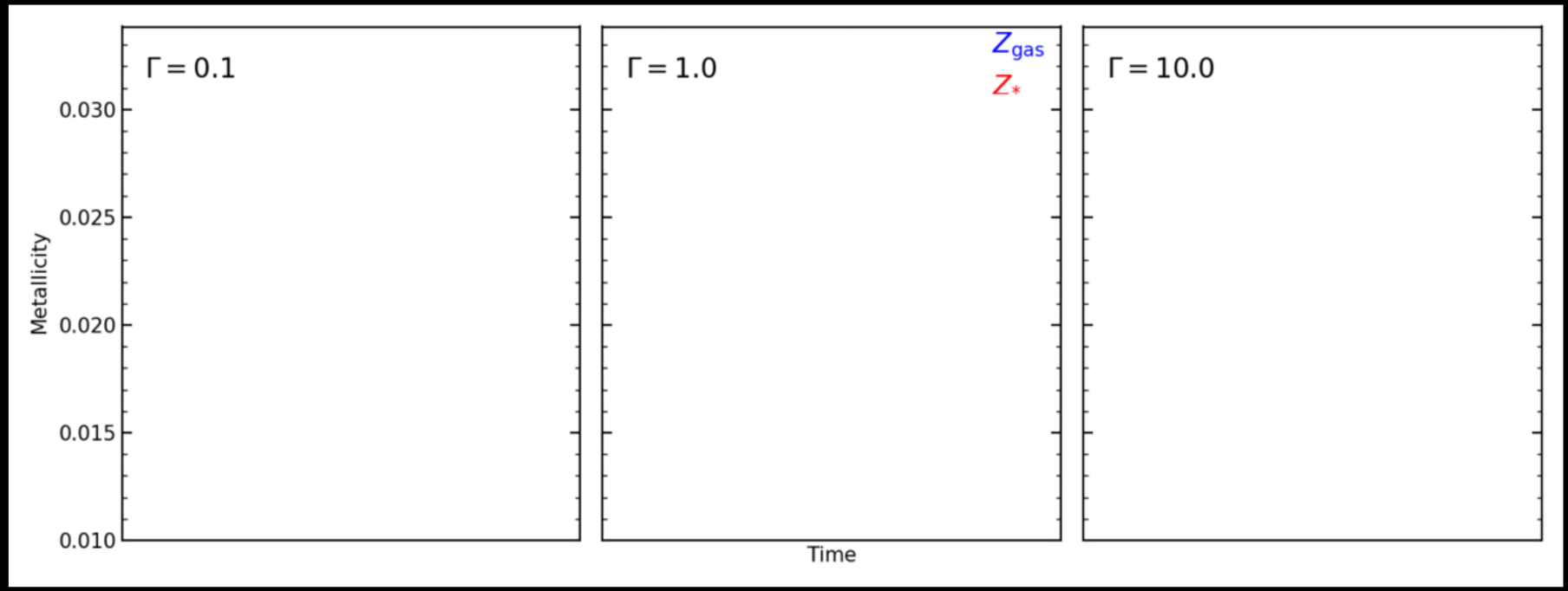
Tightness of correlation

More timescales!

Coherence timescale -> timescale on which gas-phase metals change

Star formation timescale -> timescale on which gas makes new stars

$$\Gamma = \frac{\tau_{\text{coherence}}}{\tau_{\text{SF}}}$$



BUT! This (likely) depends on the model

Gentle Feedback

Implicitly assumed

Allow system to respond

Bursty Feedback

Bursts likely interrupt/stop processes!

Correlated scatter of MZ*R

Strength of correlations of Zgas and Z*

Are there observable ways to distinguish between feedback models?

Spatially Resolved Scales

- Strength of metallicity gradients
- Time variation of spatial extent (break) of gradients

Global Scales

- Correlations within scatter within stellar mass-stellar metallicity relation
- Strength of relationship between gas and stellar metallicities