Complex and Stochastic Metallicity Gradients at z > 2 seen in FOGGIE simulations

Ayan Acharyya[1,2], M. Peeples[1,3], J. Tumlinson[1,3], FOGGIE team

[1]Johns Hopkins University, [2]INAF Padova Astronomical Observatory, [3]Space Telescope Science Institute

BACKGROUND

- Spatial distribution of gas phase metals holds important clues for galaxy scale feedback.
- Metallicity gradient is the slope of the radial profile of metallicity.

- Negative (radially declining) gradient = inside-out star-formation (SF), weak feedback
- Shallow/positive gradient = galaxy mergers, strong feedback, fast mixing
- Accurate interpretation of gradients is crucial!

Slope = -0.18 dex/kpc
t = 7.4 Gyr
z = 0.70

Traditional method: gradient

Novel, non-parametric method
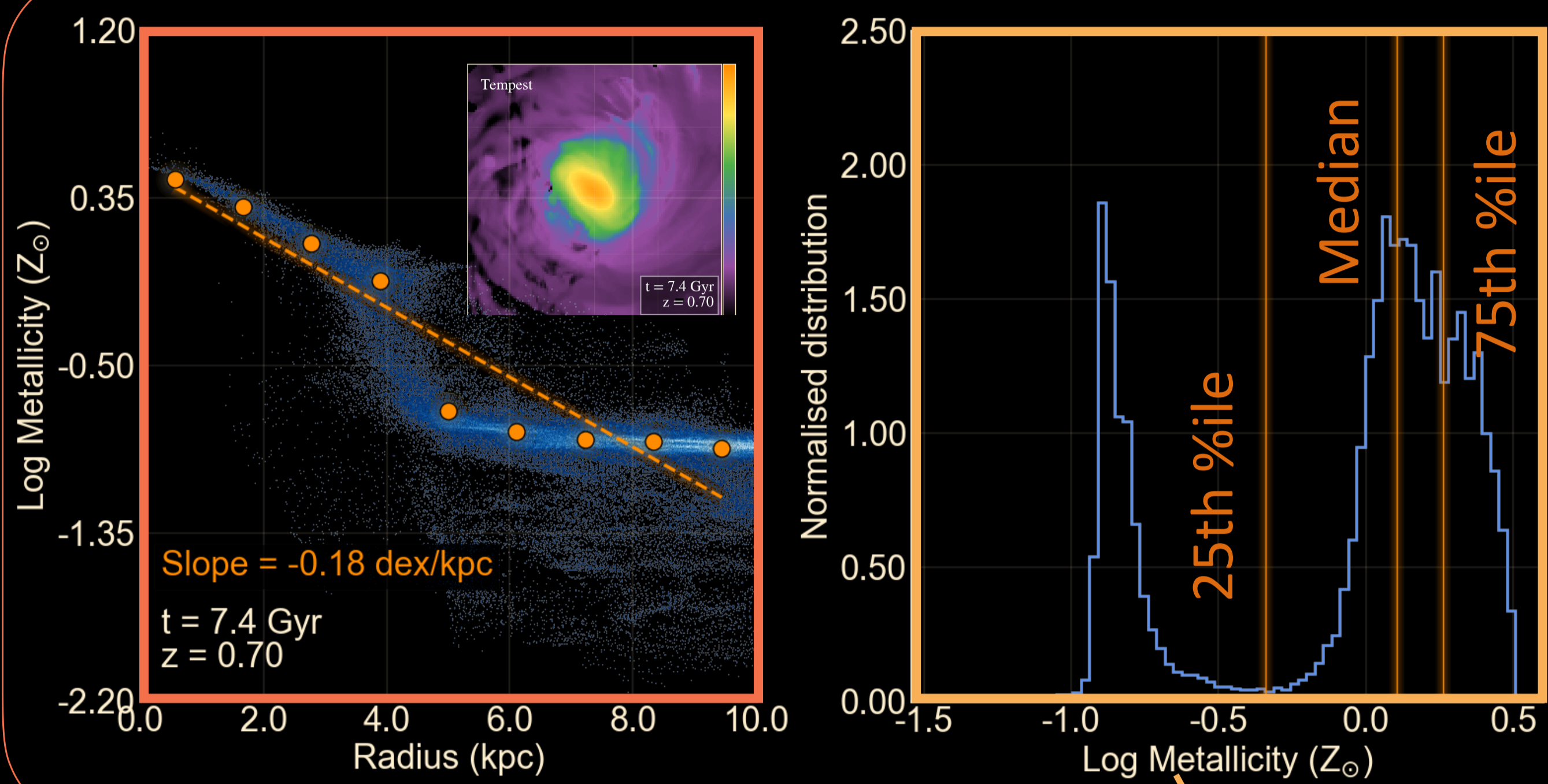
FOGGIE SIMULATIONS

- Cosmological, hydrodynamic zoom-in simulations of MW-type halos
- High spatial resolution in CGM (~1 kpc) and ISM (~300 pc) & high cadence of outputs ~ 5 Myr = capturing small-spatial scale and short time-scale variations
- Shown here: one of the six FOGGIE halos

THE PROBLEM

- Metallicity gradients are extremely stochastic on short time-scales, particularly at high-z
- FOGGIE galaxies spend ~40-50% of their lifetime up to z > 2 more than a typical observational uncertainty away from the mean trend
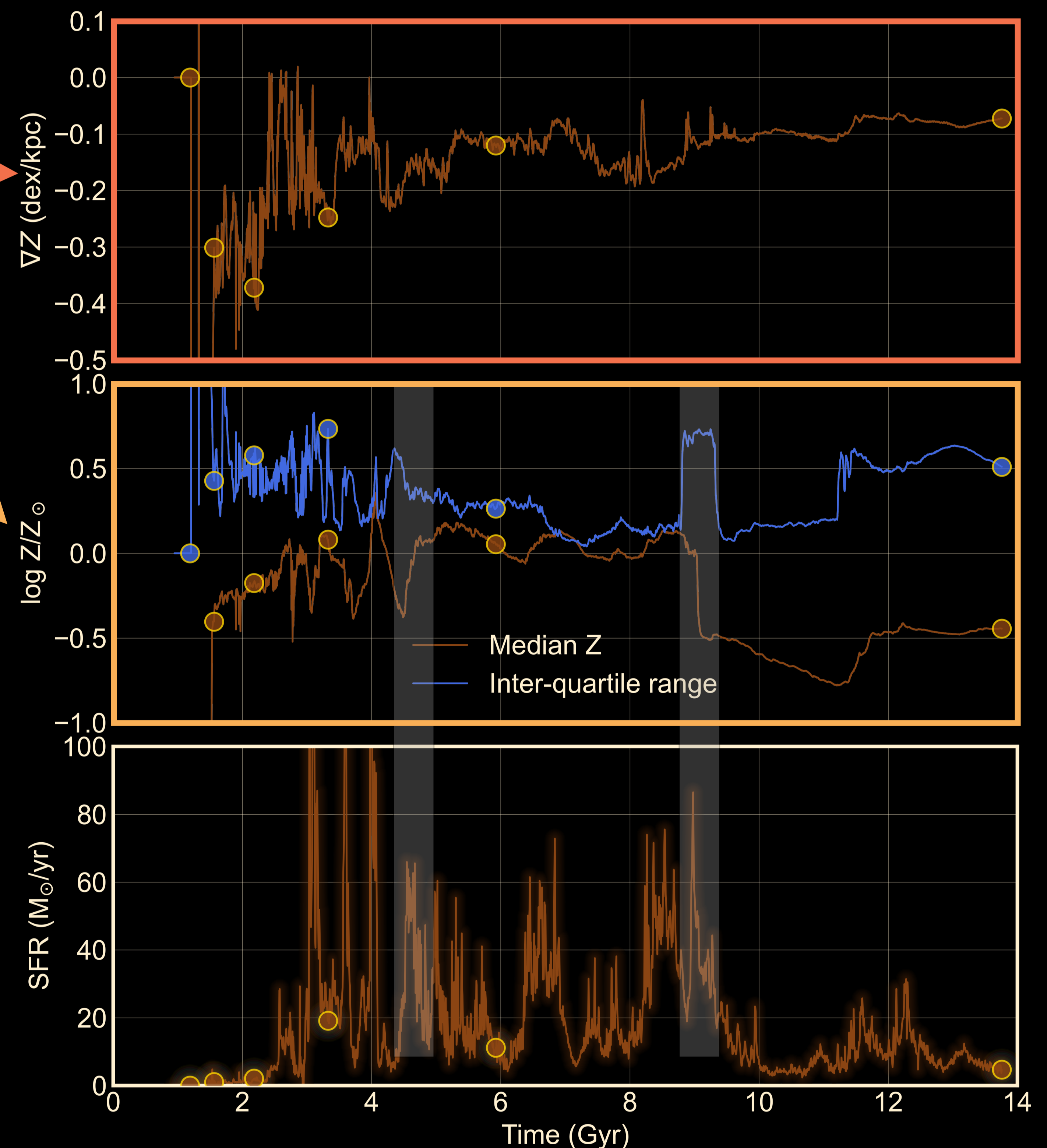

z=5
z=3
z=2
z=4
z=1
z=0
+/- 0.03 dex/kpc
38% time of z>=2 is spent outside shaded region
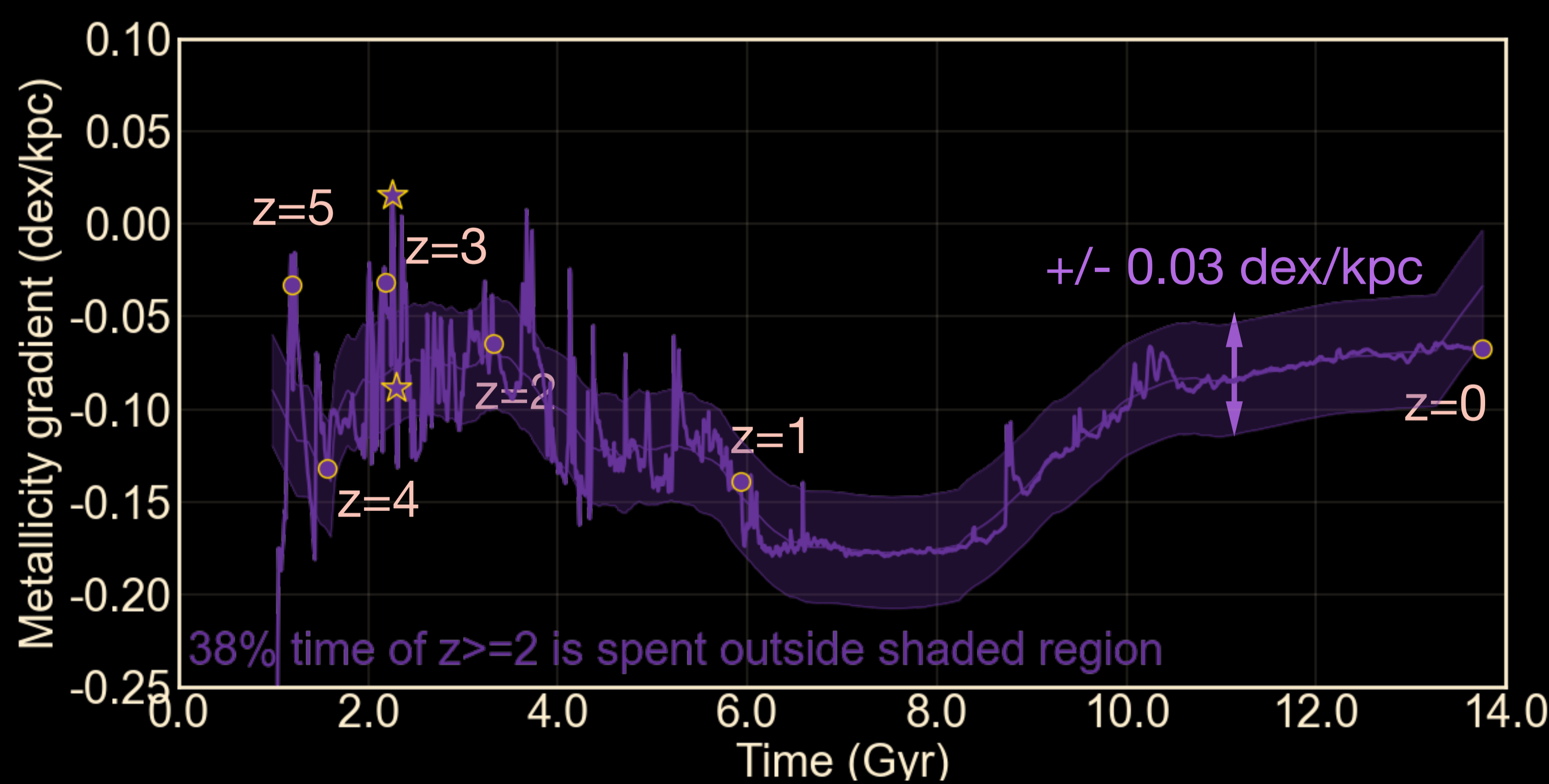
- Difficult to interpret high-z JWST measurements

RESULTS & CONCLUSIONS

Median Z
Inter-quartile range

- Metallicity distribution characteristics (median, IQR) respond better to SF feedback than the radial gradient
- Non-parametric quantification of metallicity distribution will be informative for JWST observations at high-z

PROPOSED SOLUTION

- Characterising the full distribution of metallicity
- Free from assumptions about disk/geometry

To compare observed metallicity gradients against high-resolution simulations, contact me and see https://arxiv.org/abs/2404.06613 (submitted)

ayan.acharyya@inaf.it   https://foggie.science/index.html   https://ayanacharyya.github.io/