# Does environment effect the gas-phase metallicity of star-forming galaxies?

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Dependence of Neutral gas on Environment density

(a)

Legend:
- all satellites (dotted)
- $\log M_{halo} < 12$ (blue, solid)
- $\log M_{halo} = [12,13)$ (green, dashed)
- $\log M_{halo} = [13,14)$ (magenta, dash-dot)
- $\log M_{halo} = [14,15]$ (red, dashed)

y-axis: $\log M_{HI}/M_*$

x-axis: $\log M_* \, [M_\odot]$

Counts shown on plot:
417 364 147
622 918 787 353
641 1065 988 784 165
449 938 968 646 180

Brown et al., 2017
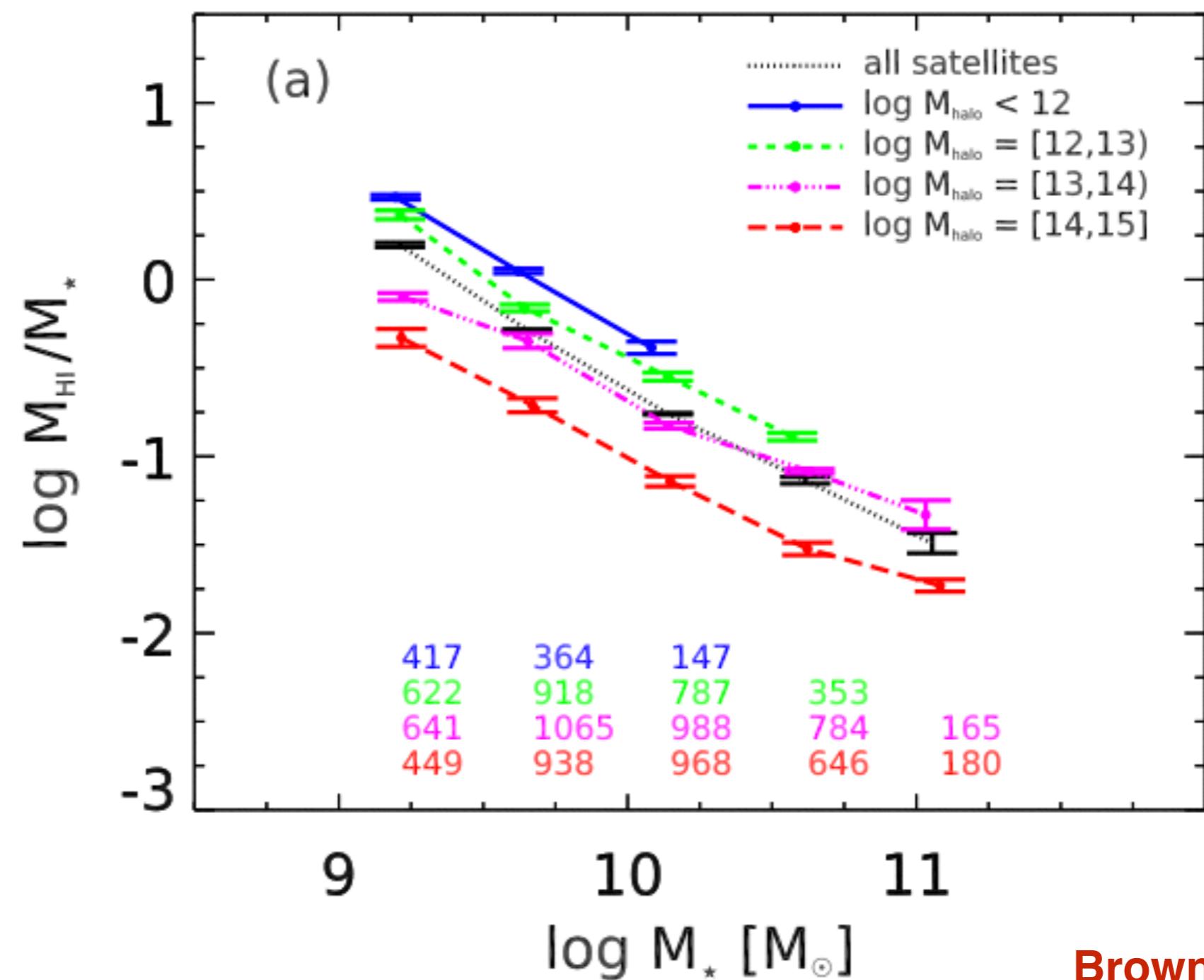
Environmental impact on Chemical Evolution?

R_{med} = 0.024
R_{mean} = 0.025

Cluster

Field

$\log (O/H) + 12$

Log M_*

C4−MZ versus control
RR200 < 0.3 R200

Ellison et al., 2009
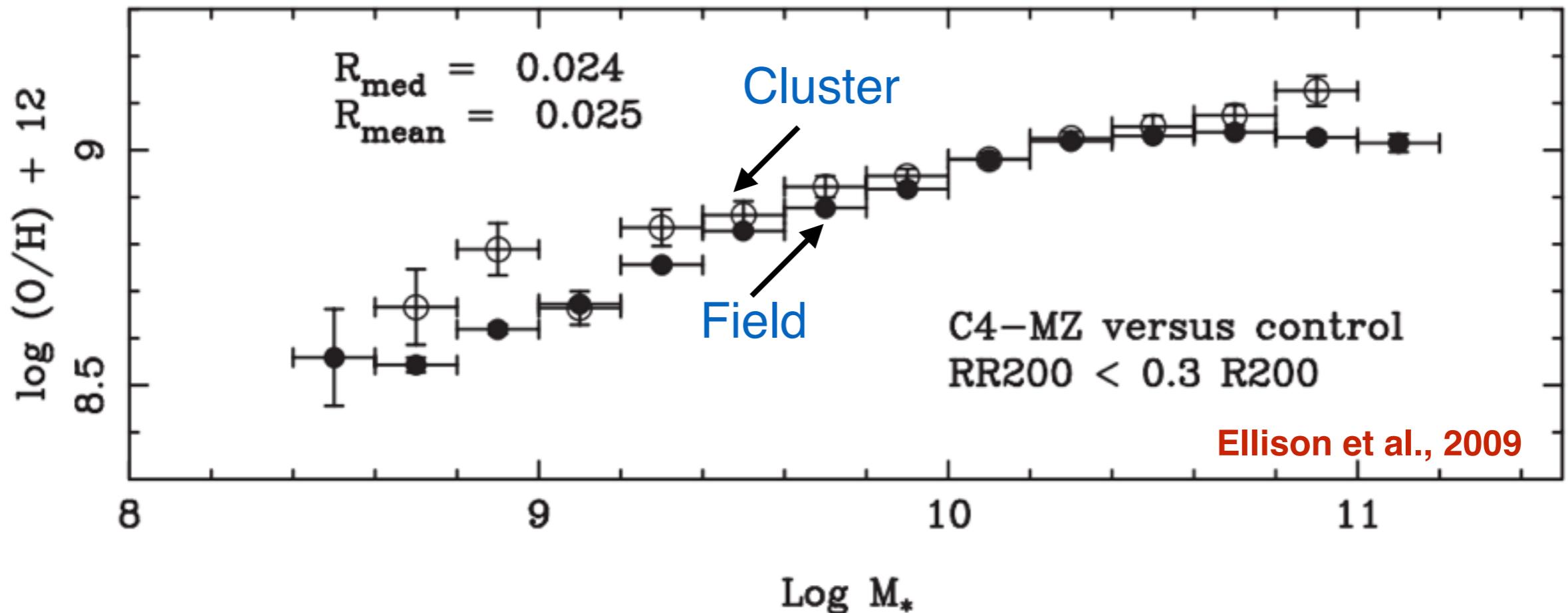
See also Mouhcine 2007, Cooper 2008, Scudder 2012, Darvish 2015, Tran 2015, Valentino 2015, Pilyugin 2017

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Dependence of integrated metallicity on cluster-centric distance?

Gravitationally Lensed-galaxies Observable With-Adaptive Optics (GLOW-AO)

DEIMOS/Keck II survey of ~10 CLASH clusters to find AO observable gravitationally lensed galaxies.

Detected ~30 lensed galaxies at 0.95<z<3.87 observable with AO.
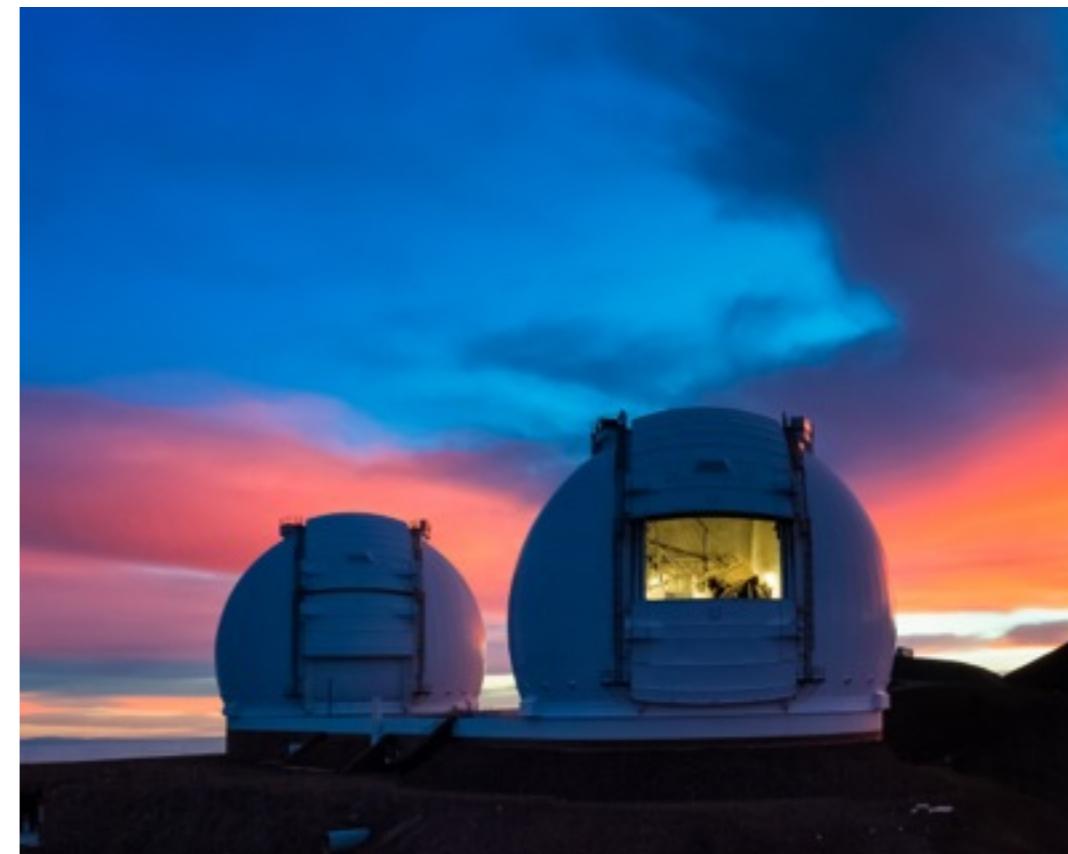
© Ethan Tweedie
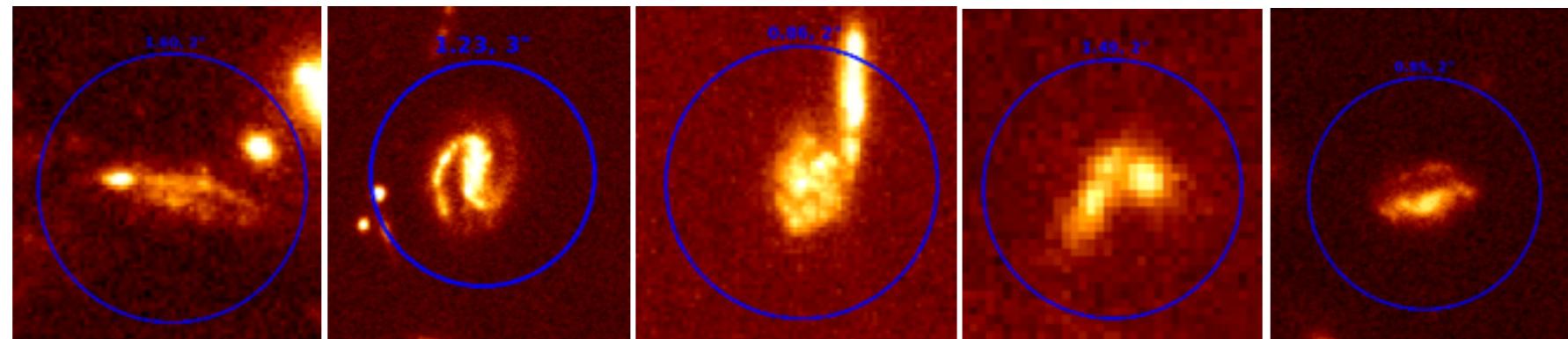
ISM Metallicity for MACS J1115+0129 (z=0.35)

Offset from the MZ relation
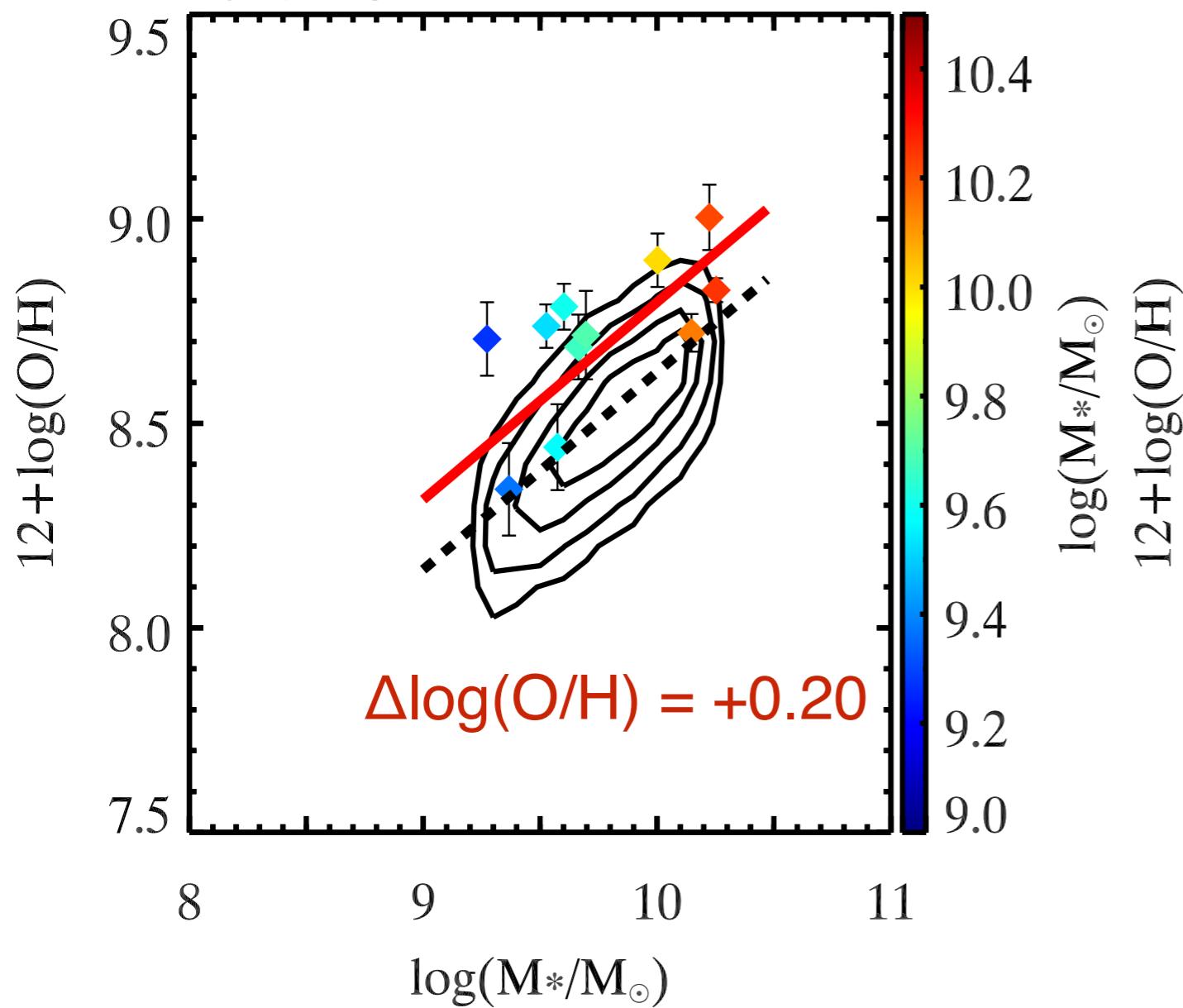
Cluster-scale metallicity gradient

$\Delta\log(O/H) = +0.20$

-0.15 ± 0.08 dex/Mpc

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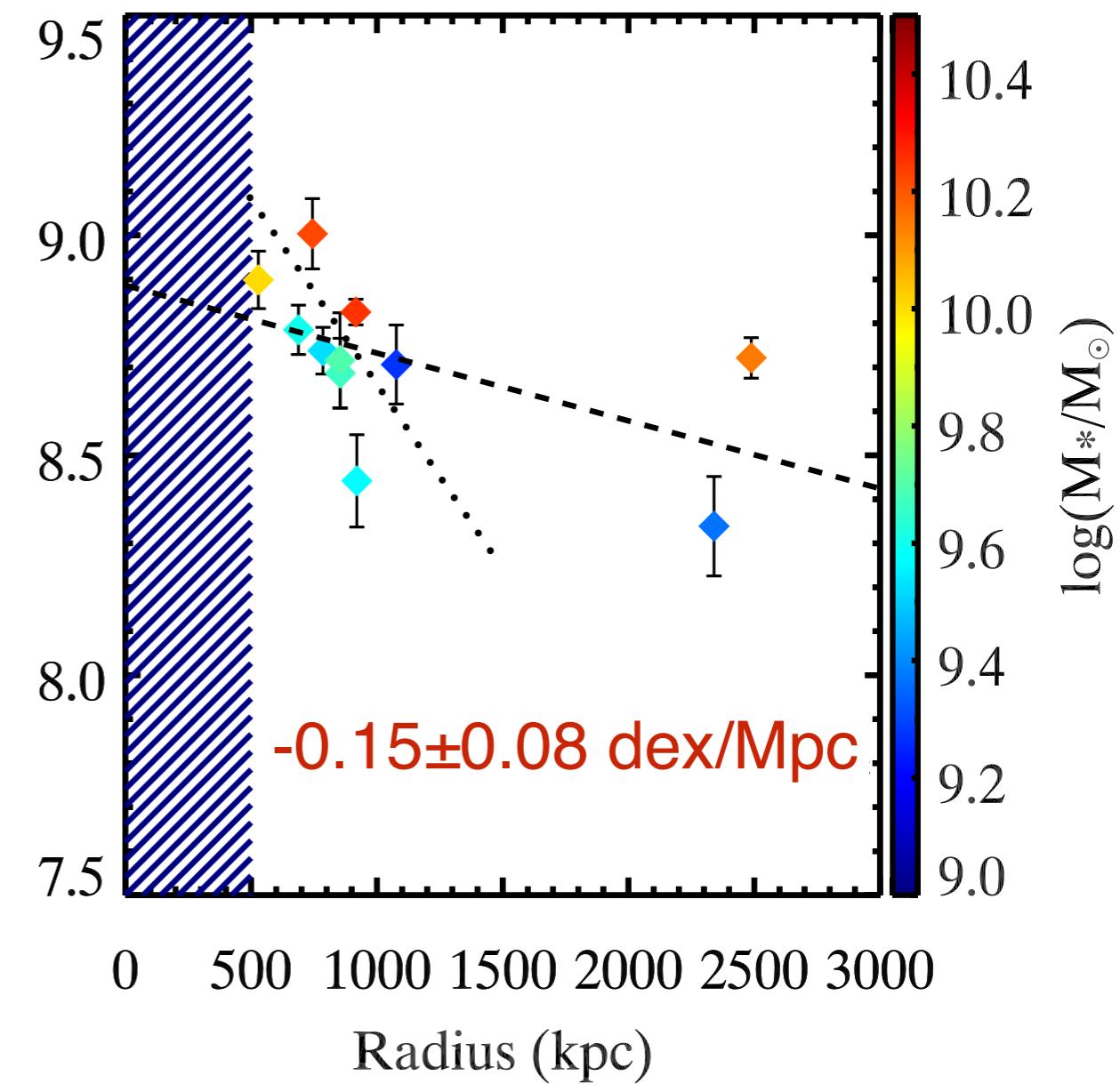
Origin of Negative Abundance Gradient in ISM Metallicity

1. Self-enrichment

Strangulation
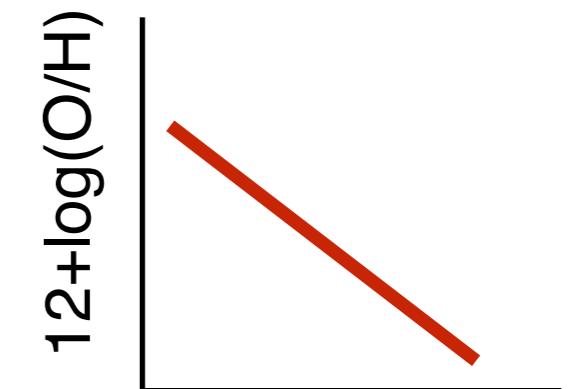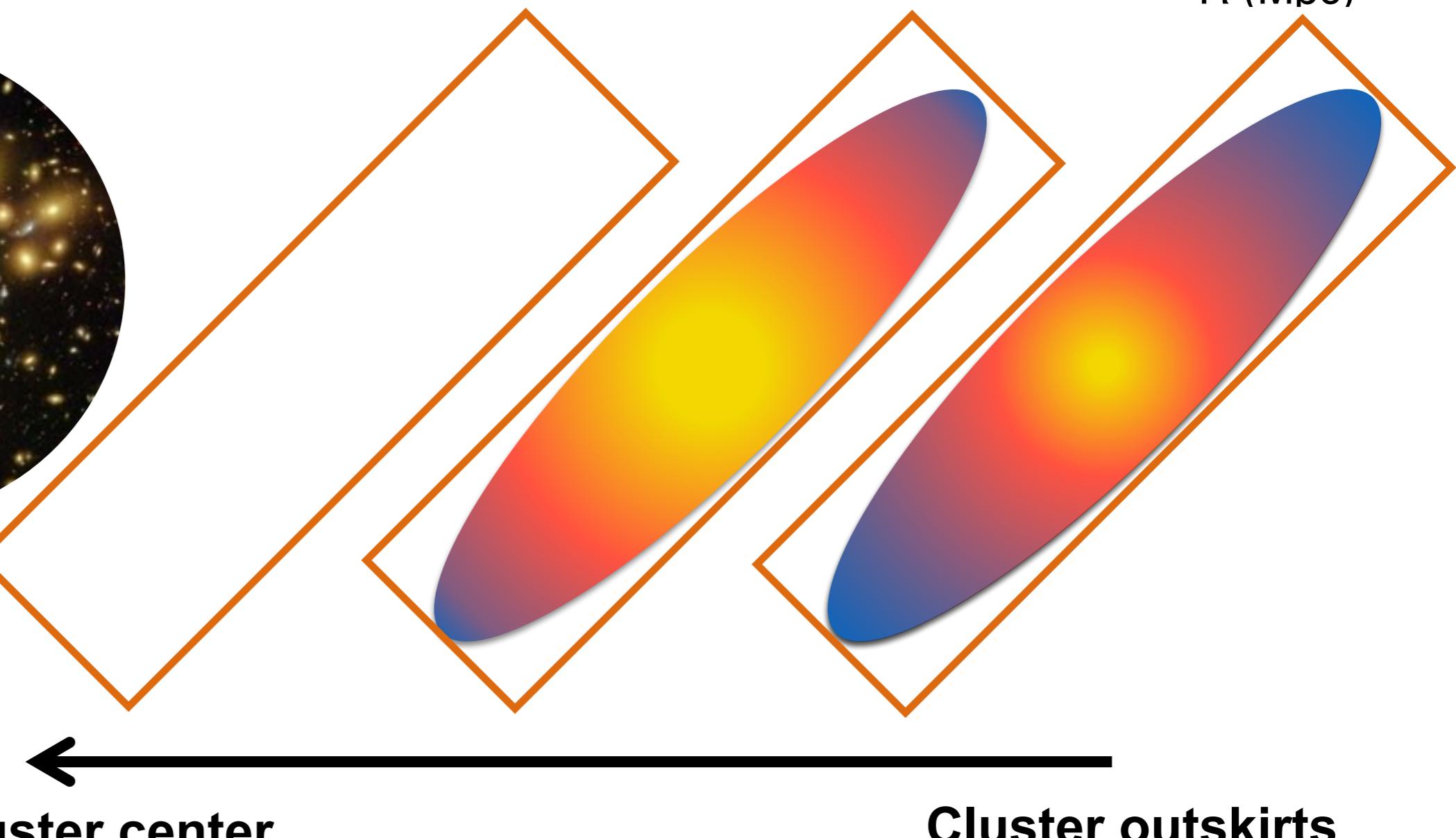
12+log(O/H)

R (Mpc)

Cluster center

Cluster outskirts

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Origin of Negative Abundance Gradient in ISM Metallicity

1. Self-enrichment

2. Disk truncation

Ram pressure stripping

12+log(O/H)

R (Mpc)

Cluster center

Cluster outskirts

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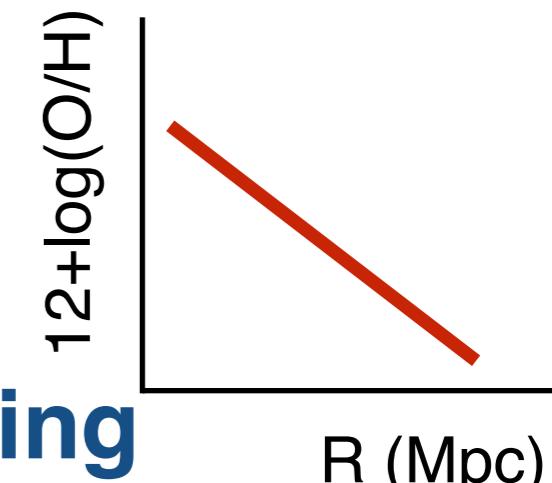
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Effect of Disk truncation on gas-phase metallicity

● HI-deficient
○ HI-normal
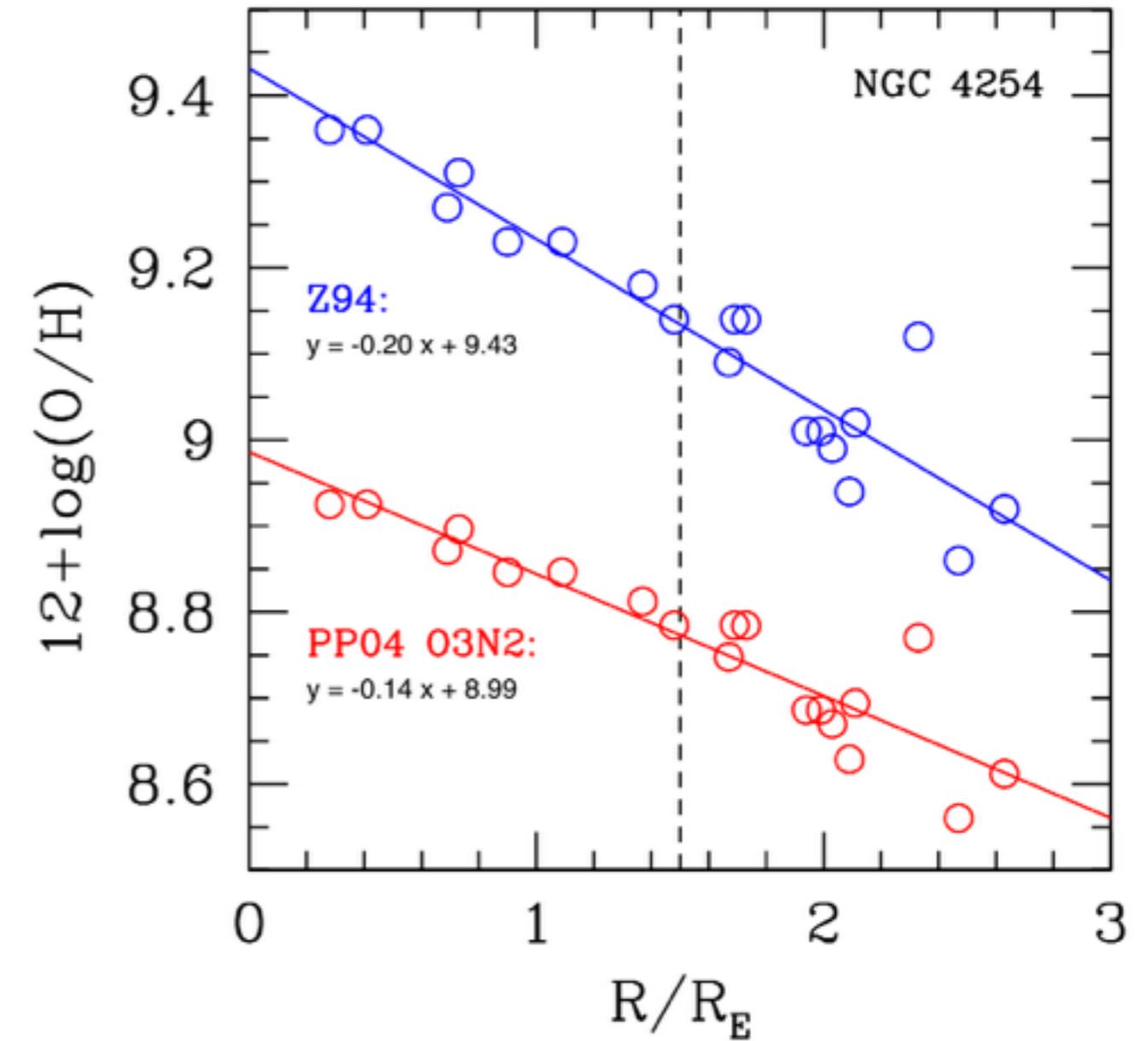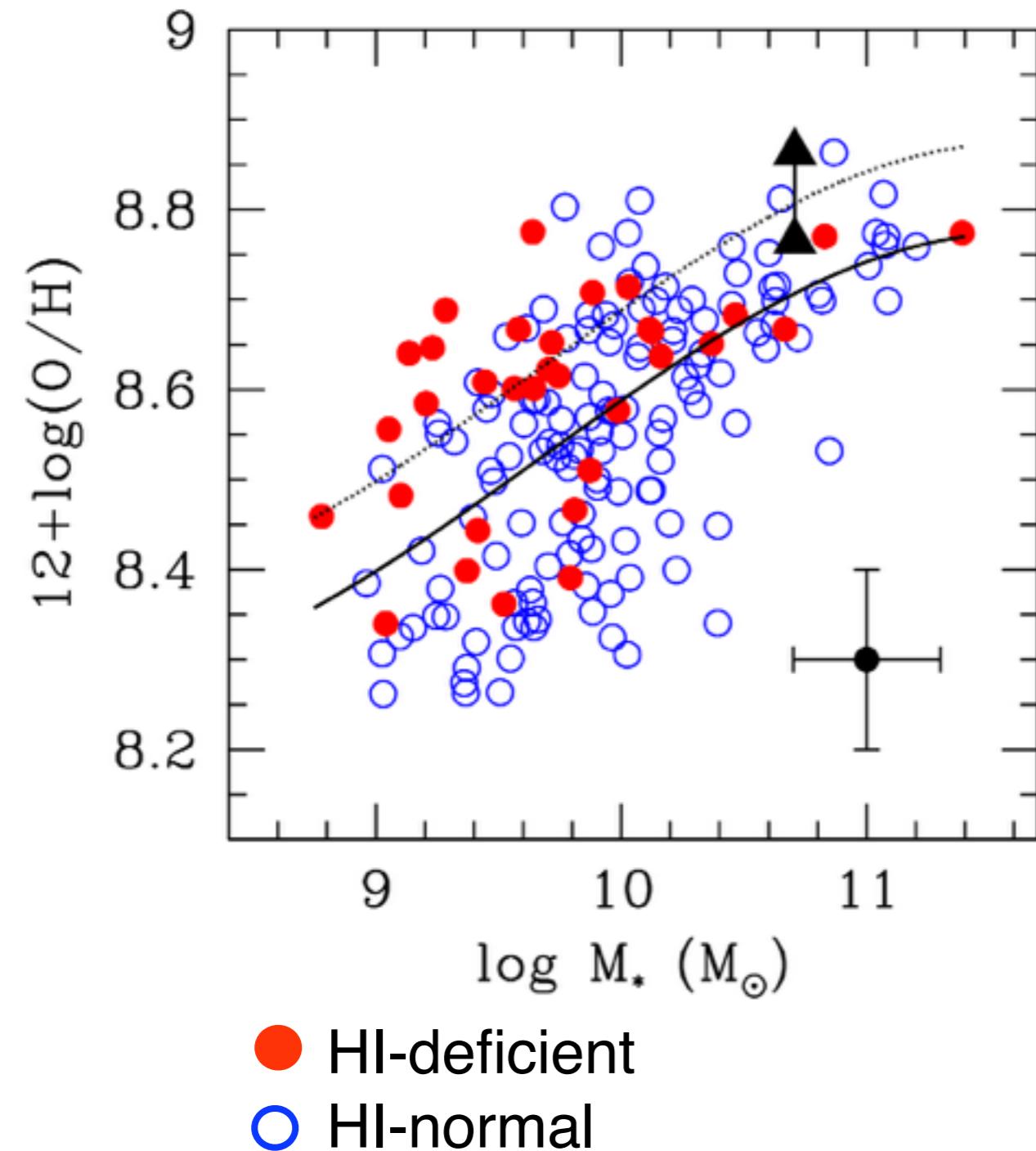
Hughes et al., 2013

Analytical model of Ram pressure stripping

Stellar disk Scale length

ICM density

Cluster-centric distance

Orbital velocity

$$r_{strip} = -\frac{r_*}{2} \ln \left[\frac{\rho_{\text{ICM}}(R) v_{orb}^2}{2\pi G \Sigma_{*0}^2 f_{gas}(1 + f_{gas})} \right]$$

Central stellar surface mass density

Gas fraction

Tecce et al., 2010, Luo et al., 2016

Analytical model of Ram pressure stripping

Stellar disk Scale length

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Central stellar surface mass density

Gas fraction
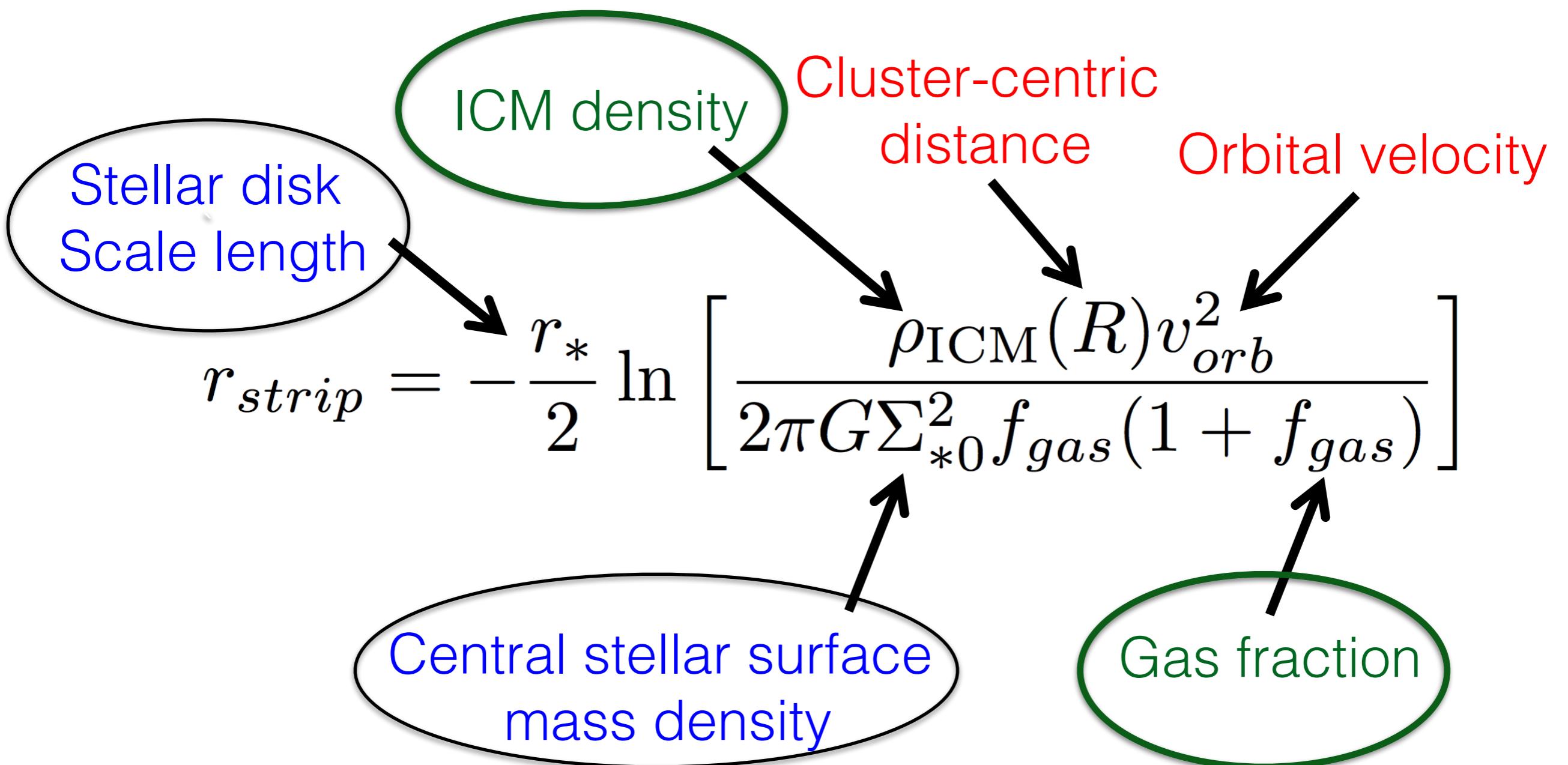
Tecce et al., 2010, Luo et al., 2016

Mock DEIMOS observations of truncated CALIFA galaxies

UGC07012
10"
z=0.0102
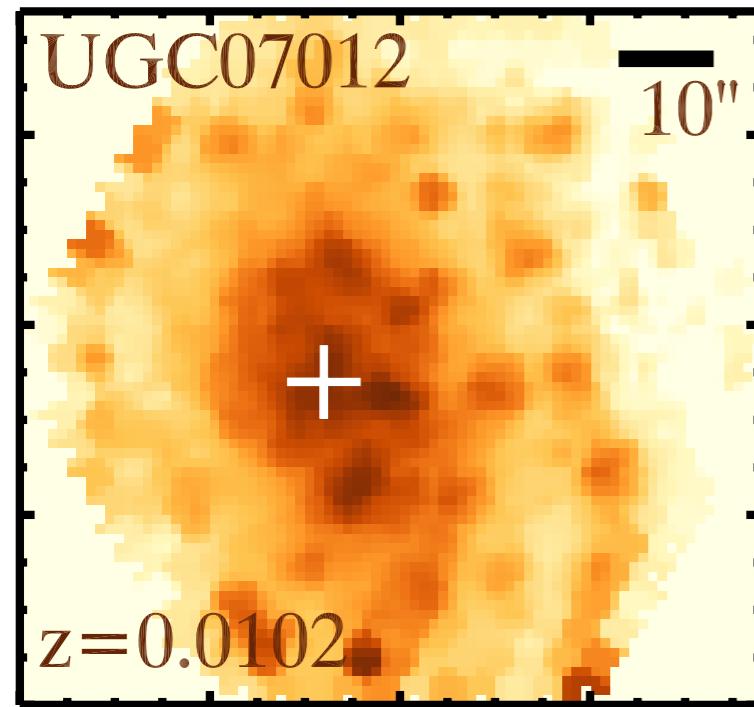
Assume orbital parameters (R, v_{orb}) and truncate beyond r_{strip}

v_{orb} = 972. km/s
R = 1.25 Mpc
10"
$\log(M_*/M_\odot) = 9.9$

Redshift the galaxy to z=0.35 and convolve with seeing of 0.8"

Mock observe with 5" ×1" slit and estimate metallicity

1"
z_{sim} =0.35

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# Metallicity enhancement on mass-metallicity relation

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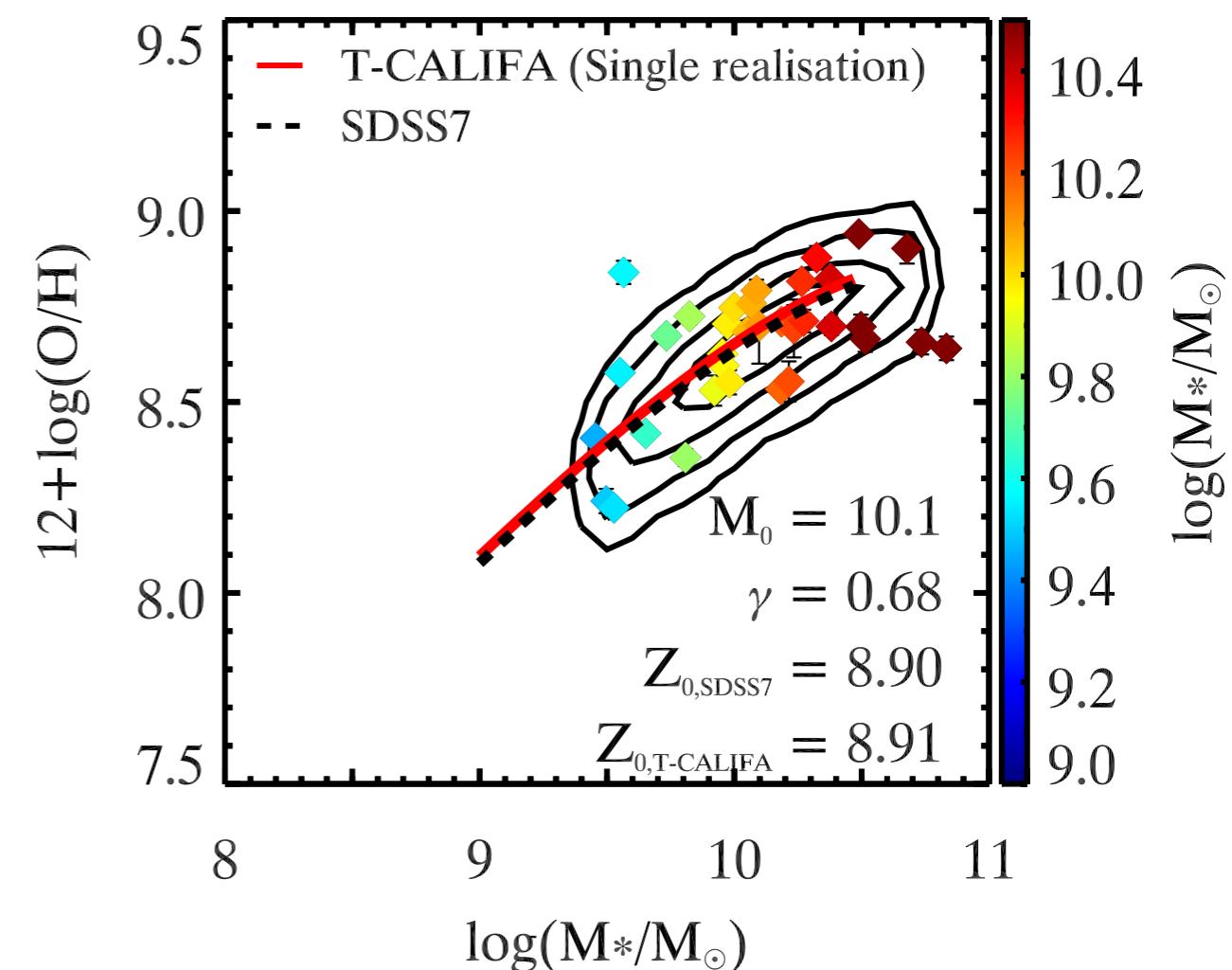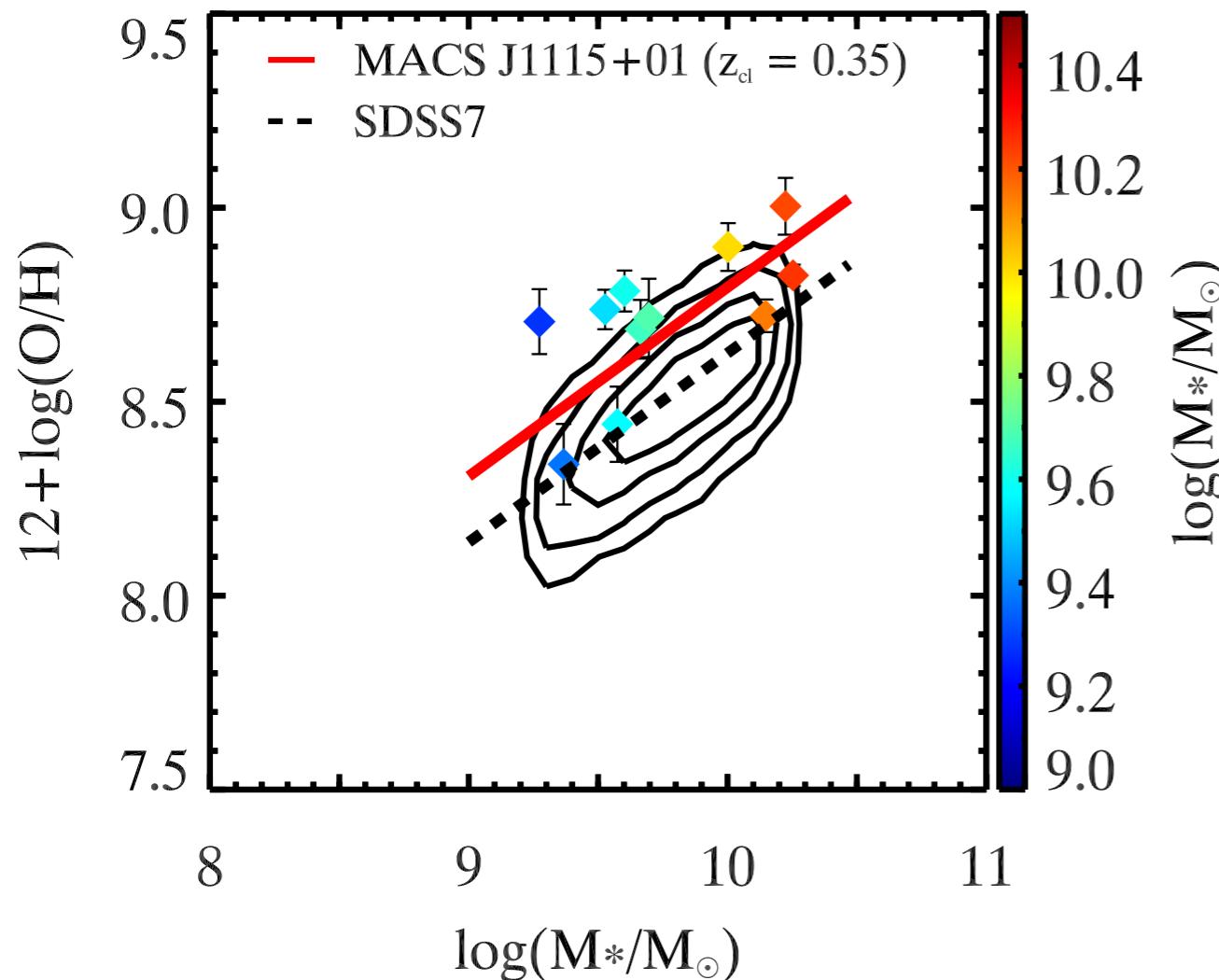
Metallicity enhancement on mass-metallicity relation
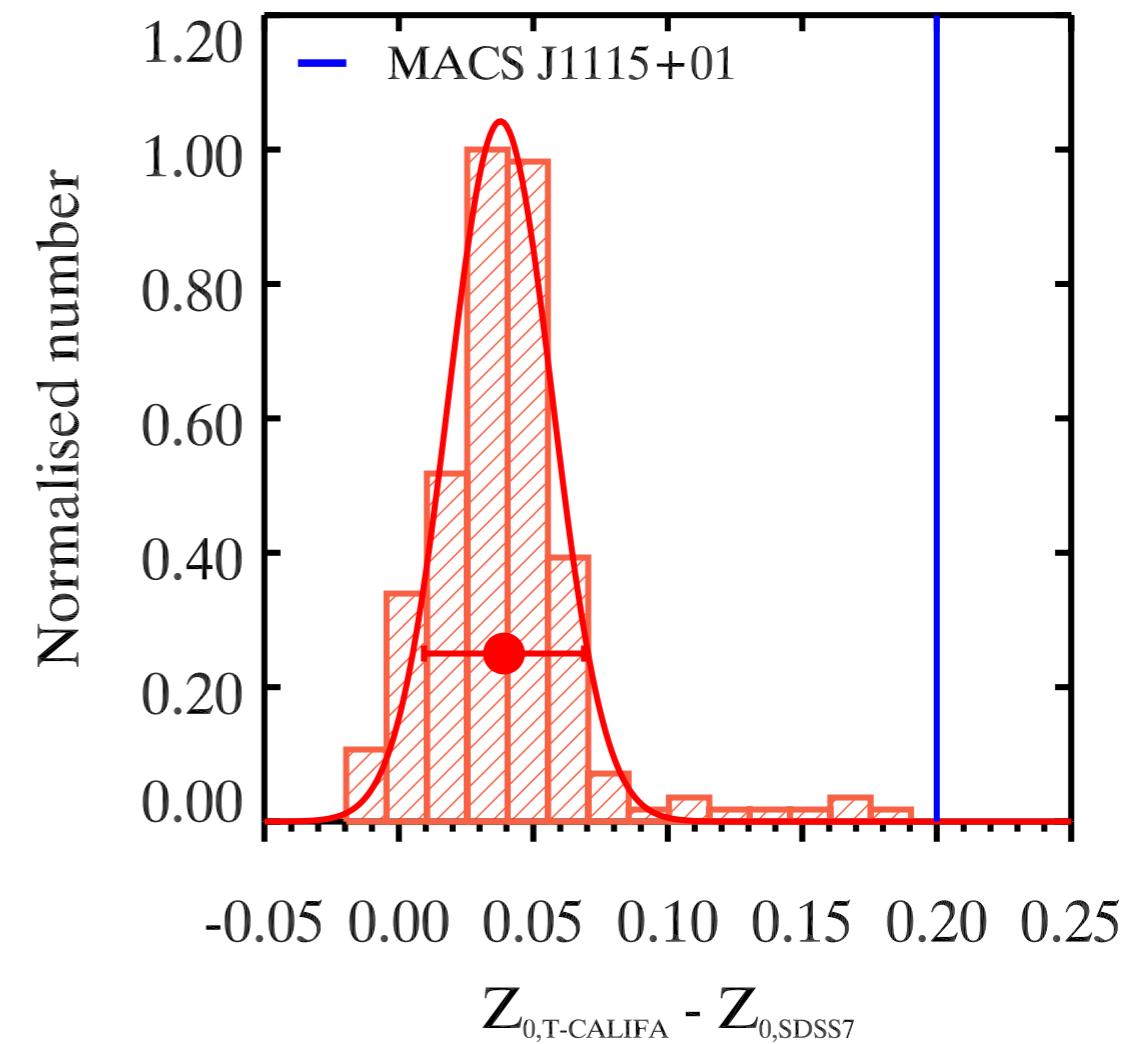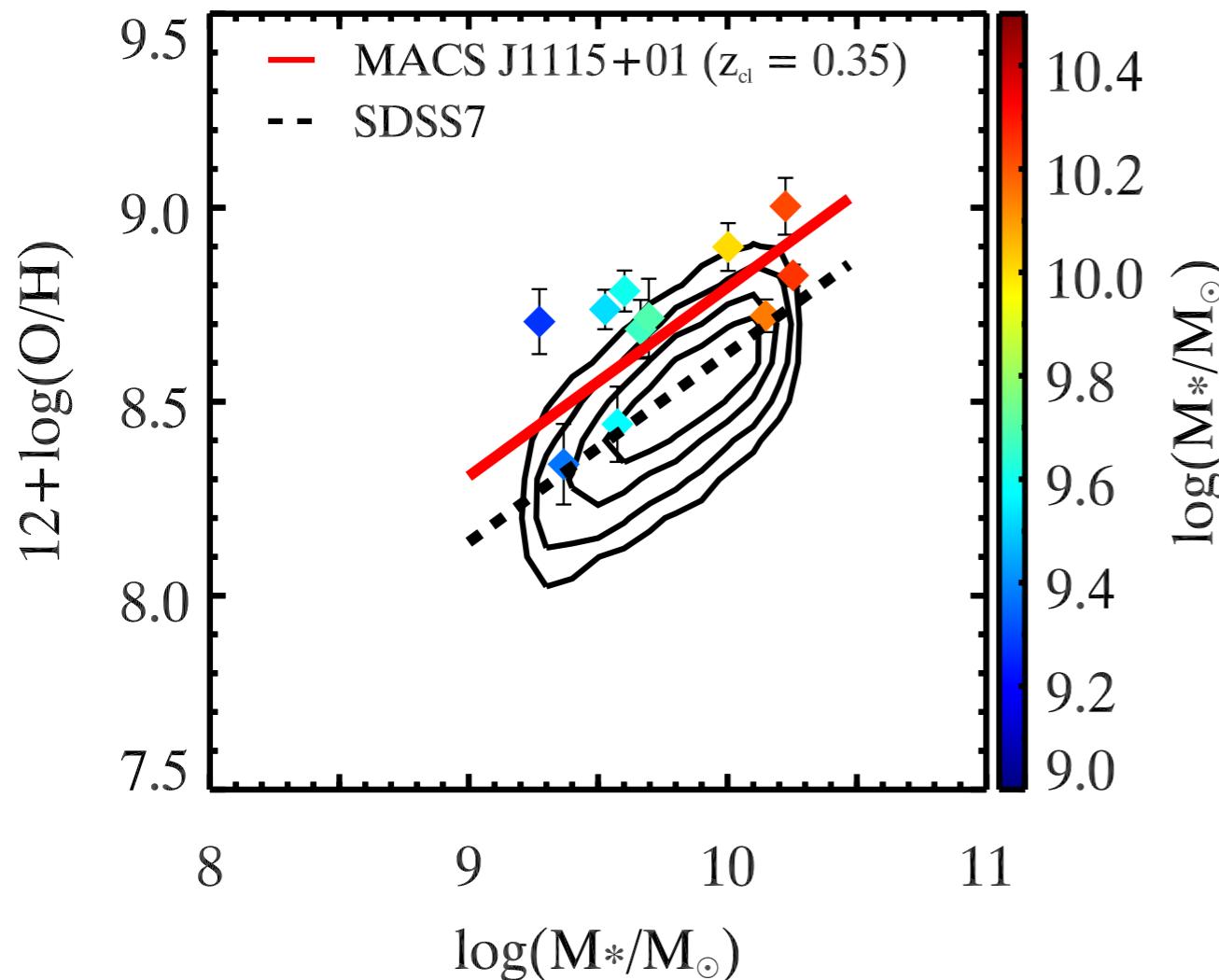
**Significantly less metallicity enhancement on MZ relation!**

Cluster-scale metallicity gradient due to disk truncation

MACS J1115+01
Slope=-0.15±0.08 dex/Mpc

T-CALIFA (Single realisation)
Slope=-0.03±0.05 dex/Mpc
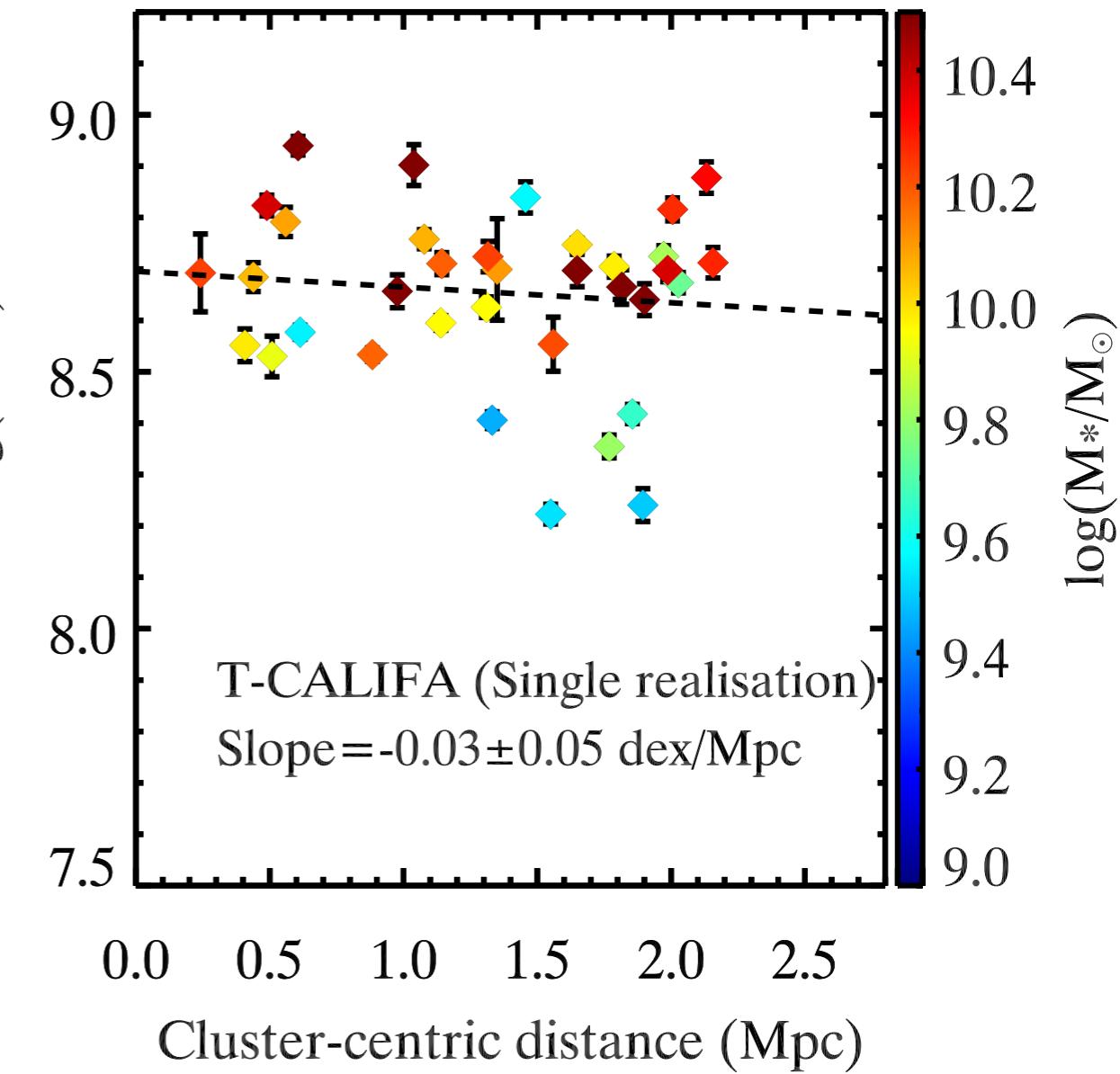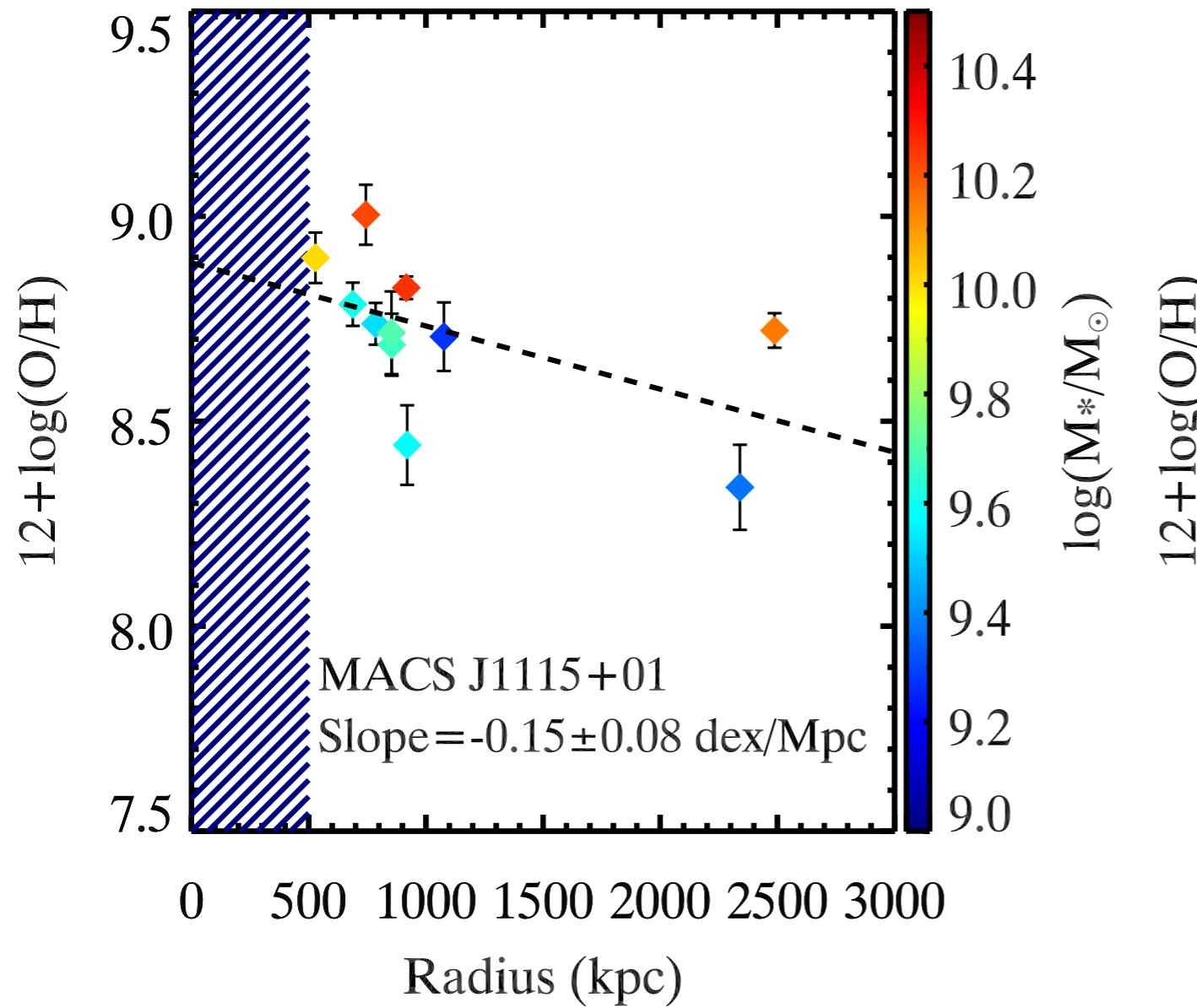
Cluster-scale metallicity gradient due to disk truncation
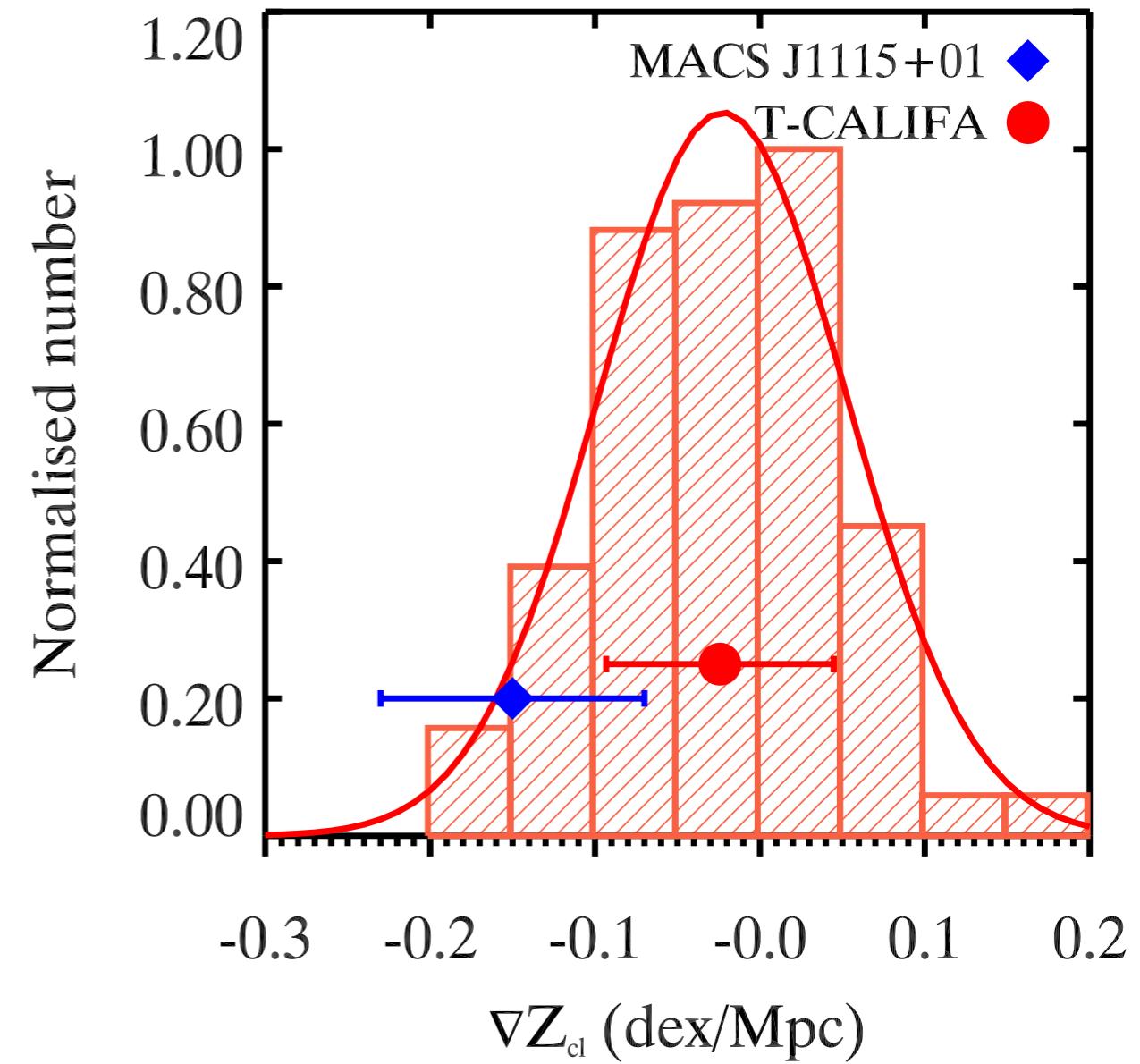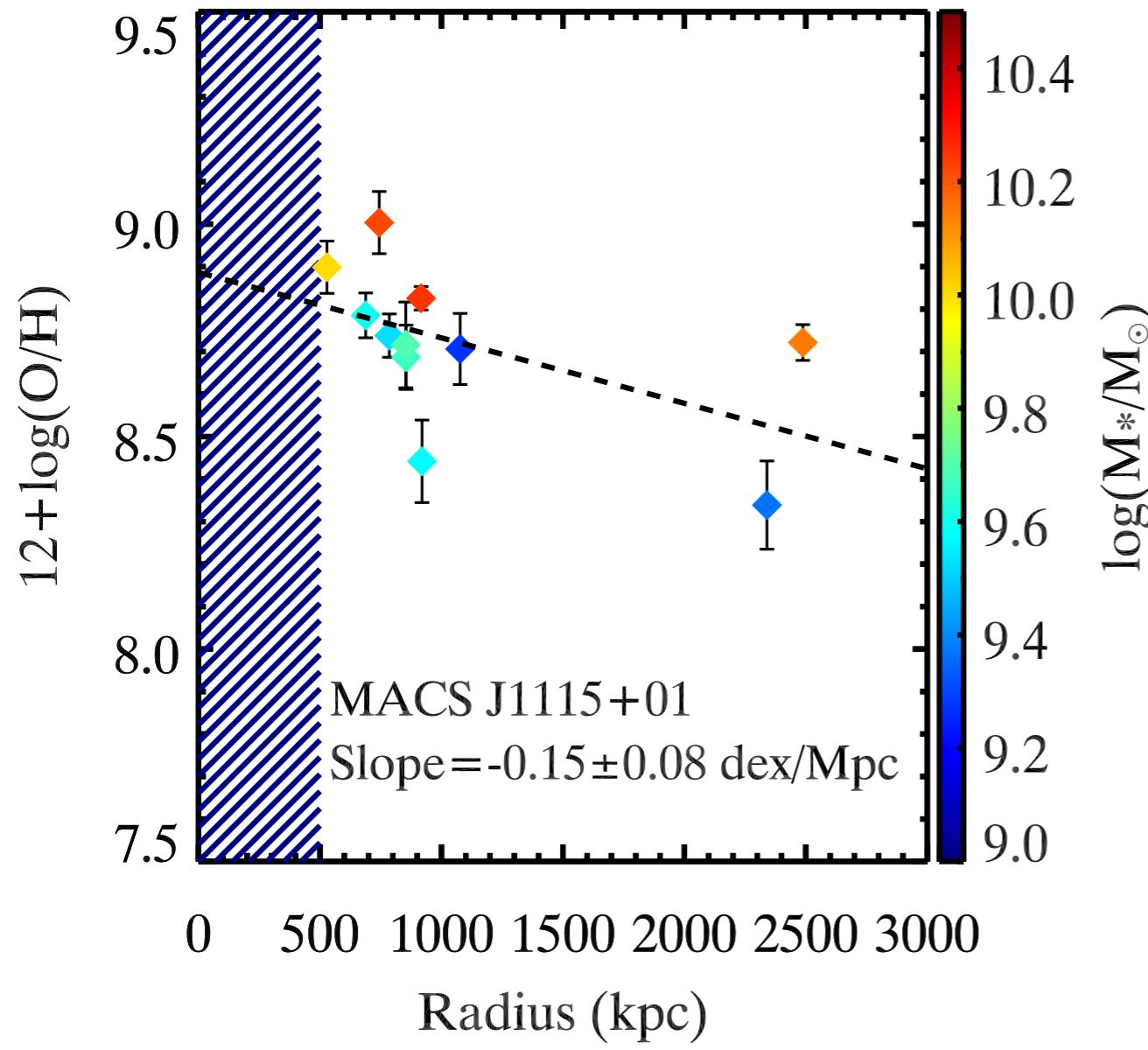
Summary

- First observation of a cluster-scale abundance gradient in MACS J1115+0129 and RXJ 1532+3021.

  Gupta et al., 2016 (arxiv:1608.06289v2)

- Ram pressure stripping is insufficient to produce a significant metallicity enhancement for cluster galaxies.

  Gupta et al., 2017 (arXiv:1705.08452)

Prediction of pre-processing of metals with IllustrisTNG simulations

Cluster galaxies: at z = 0, $\log(M_{200}/M_{sun}) > 13$
N_cluster = 9337

Field galaxies: at z = 0, $\log(M_{200}/M_{sun}) < 12$
N_field = 22101

Offset in MZ relation from progenitor field galaxies

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