



The Changing Face of Galaxies - Hobart 2016

# **First Detection of a Cluster-scale ISM Metallicity Gradient**

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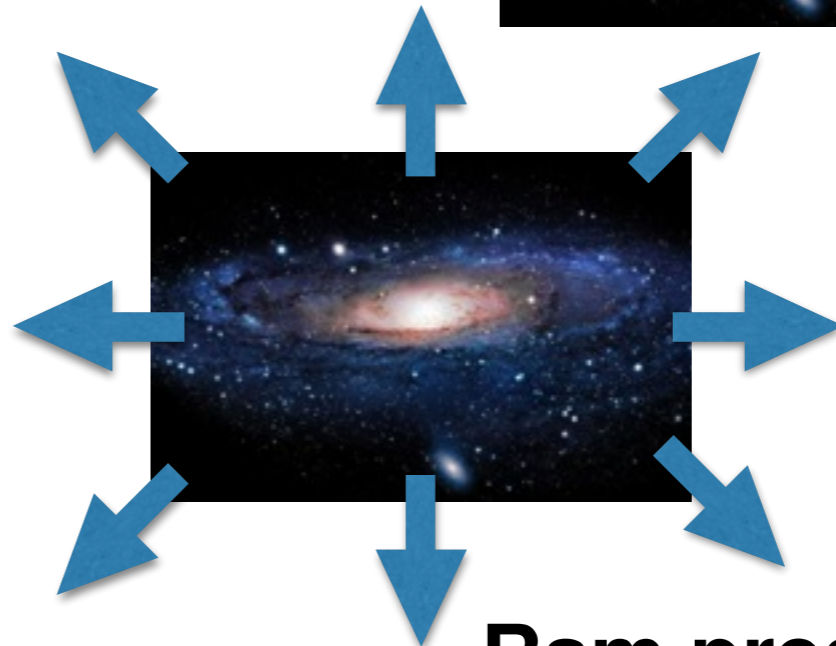
Davide Martizzi, UC Berkeley

Philip Taylor, ANU

# Galaxy Evolution in Cluster Environment



**Galaxy Harassment**



**Ram pressure stripping**

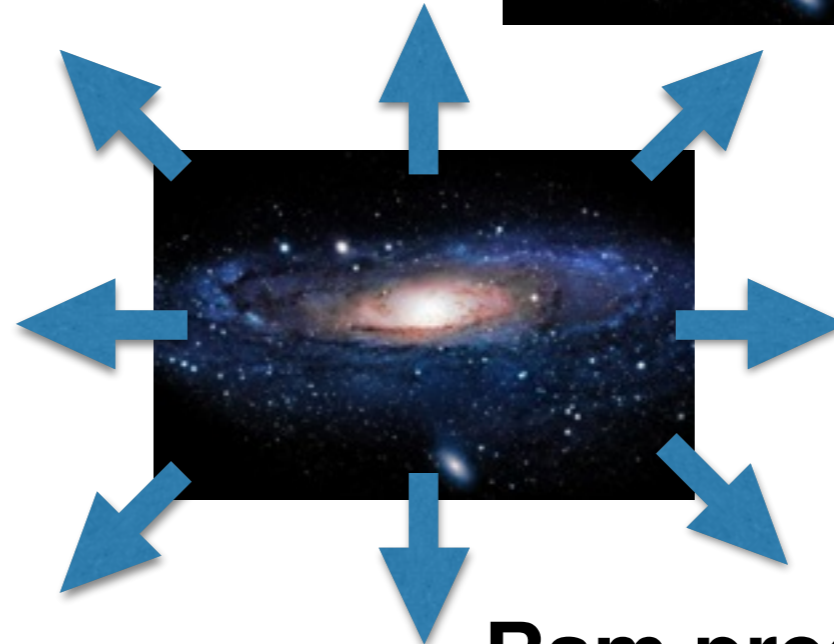


**Strangulation**

# Galaxy Evolution in Cluster Environment



**Galaxy Harassment**



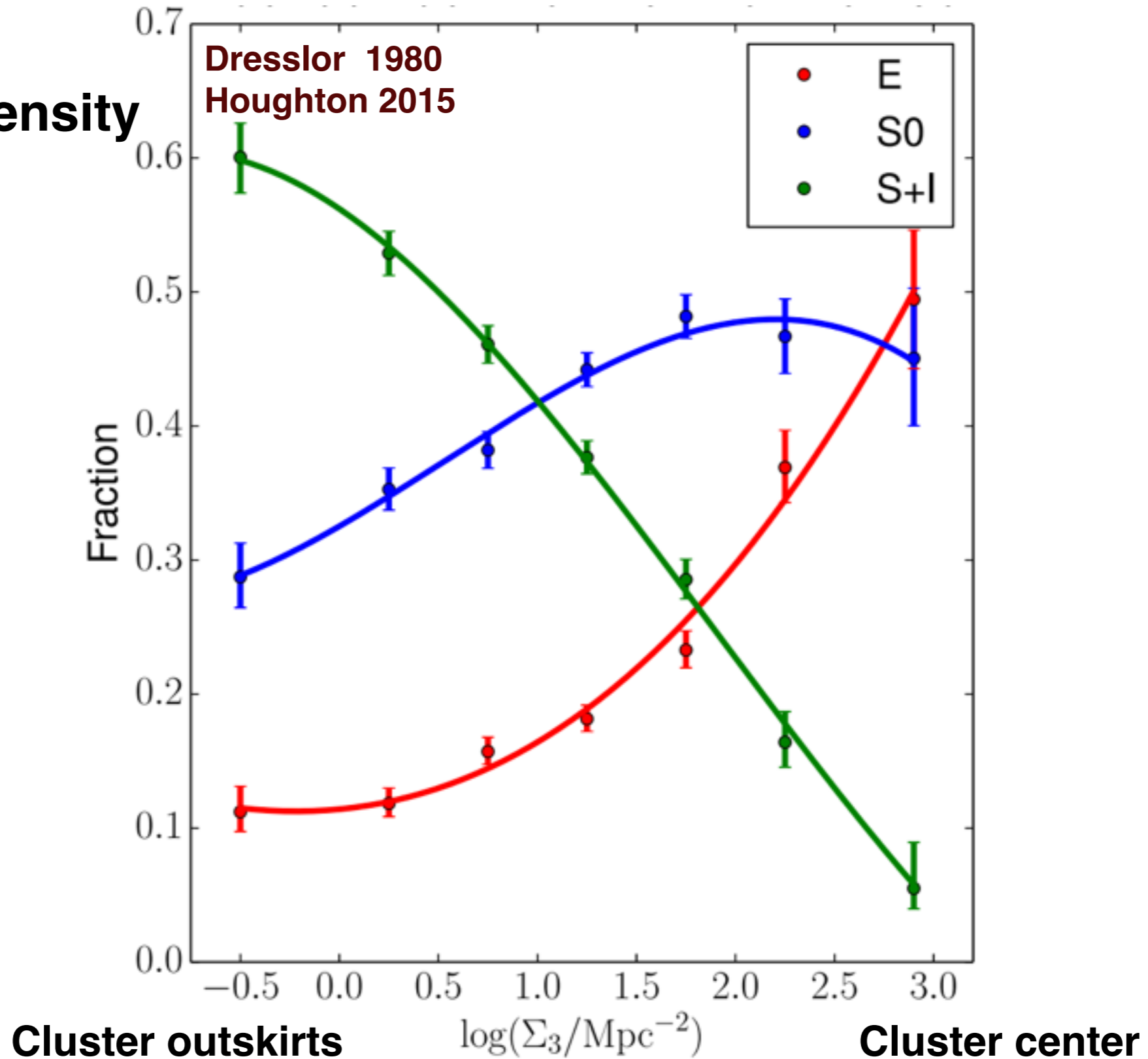
**Ram pressure stripping**



**Strangulation**

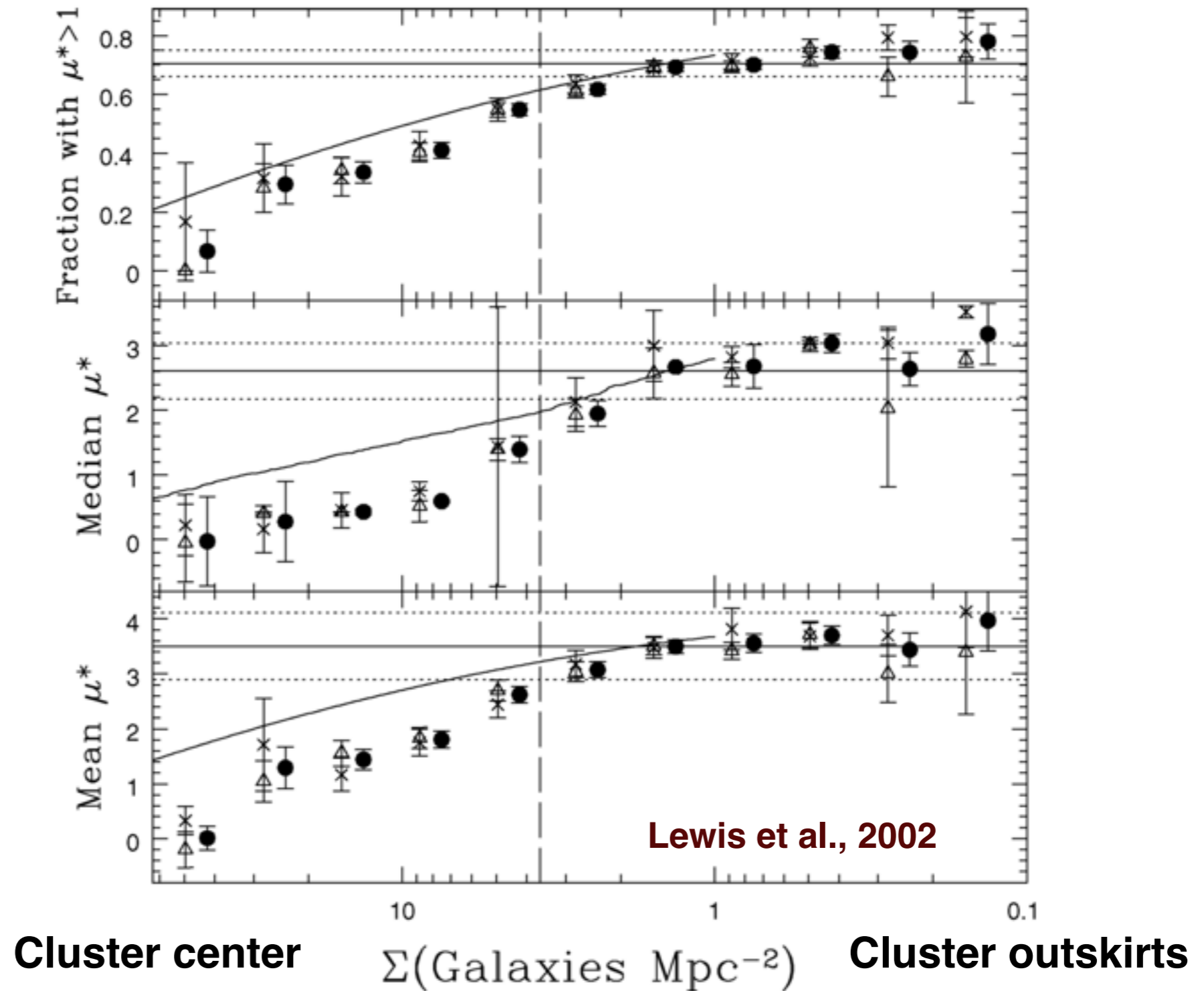
# Impact of Cluster Environment on Galaxy Evolution

Morphology-density relation

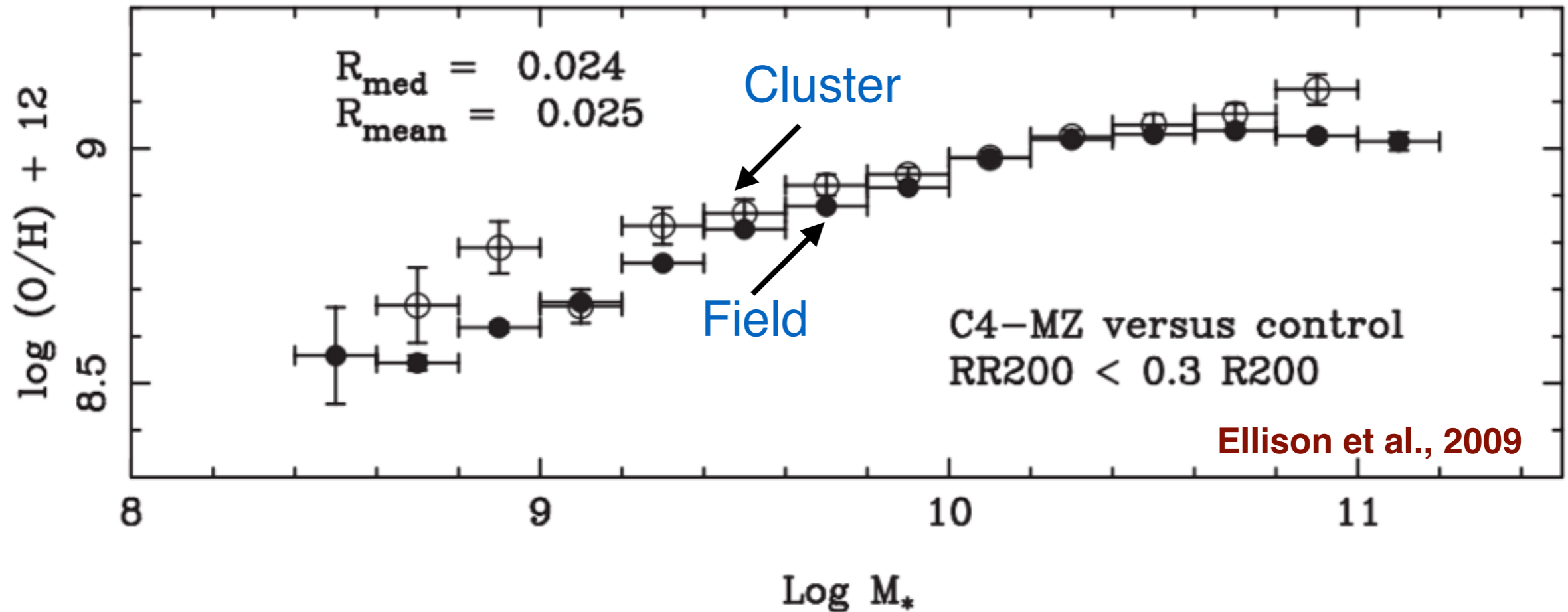


# Impact of Cluster Environment on Galaxy Evolution

SFR-Density



# Environmental impact on Chemical Evolution?



See also Mouhcine 2007, Cooper 2008, Scudder 2012, Darvish 2015, Tran 2015, Valentino 2015

**Radial dependence of cluster member  
metallicity?**

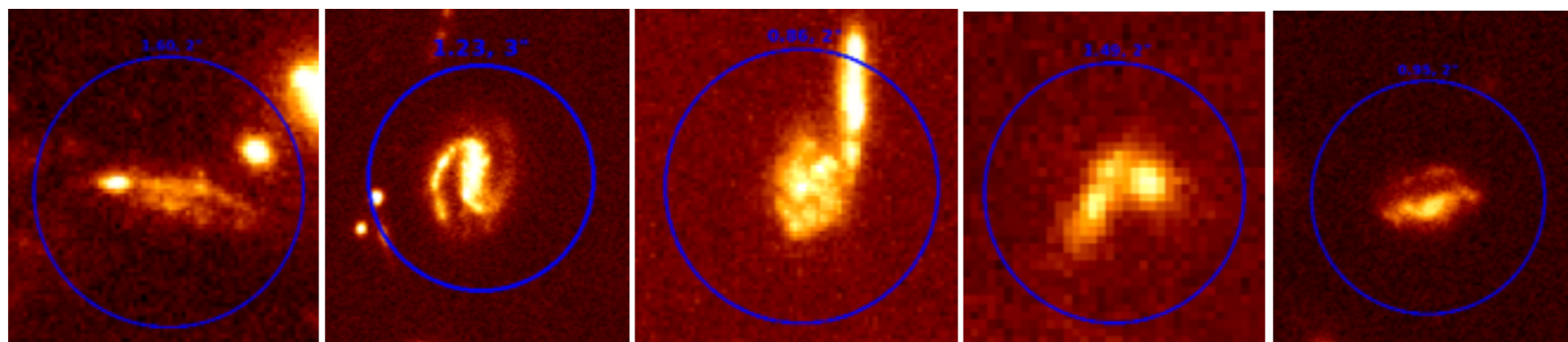
# Gravitationally Lensed-galaxies Observable With-Adaptive Optics (GLOW-AO)

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

**Detected  $\sim 30$  lensed galaxies at  $0.95 < z < 3.87$  observable with AO.**



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# Cluster Sample Selection

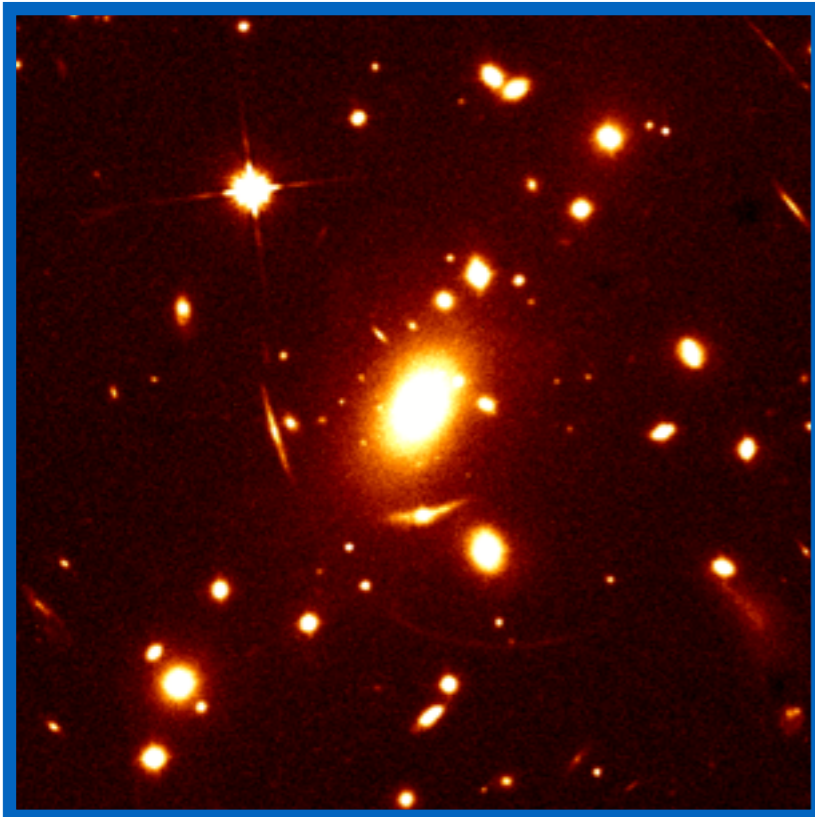
Galaxy clusters with at least 15 cluster members

- **MACS1115+0129**

- **$z = 0.352$**

- **$M_{\text{vir}} = 1.13 \times 10^{15} M_{\odot}/h$**

- **$kT = 8.0 \text{ keV}$**



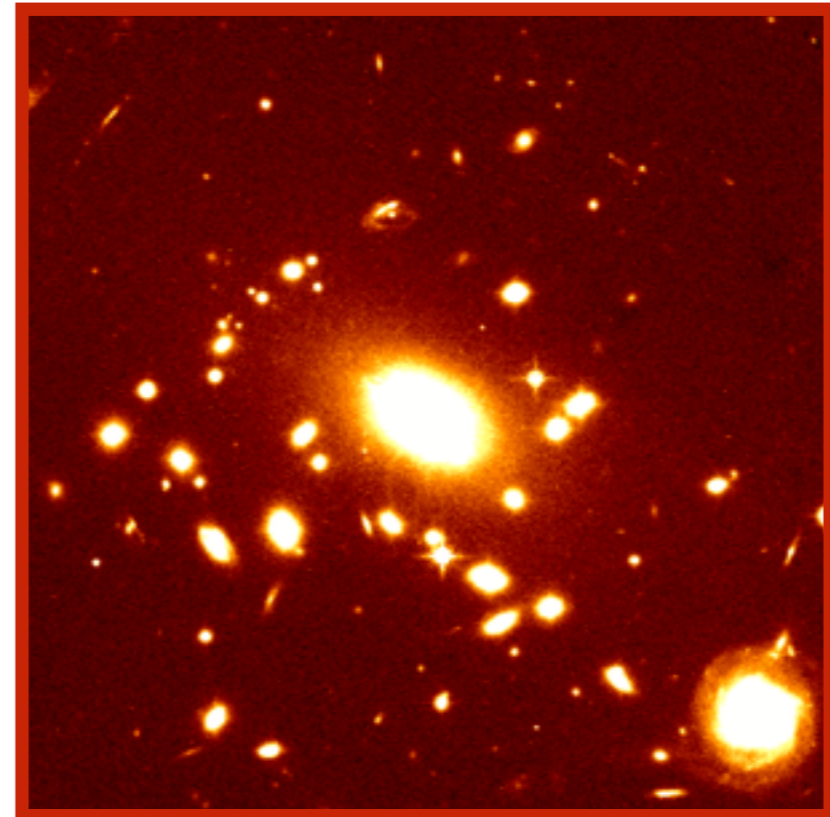
CLASH, F110W

- **RXJ1532+3021**

- **$z = 0.362$**

- **$M_{\text{vir}} = 0.64 \times 10^{15} M_{\odot}/h$**

- **$kT = 5.5 \text{ keV}$**



CLASH, F125W

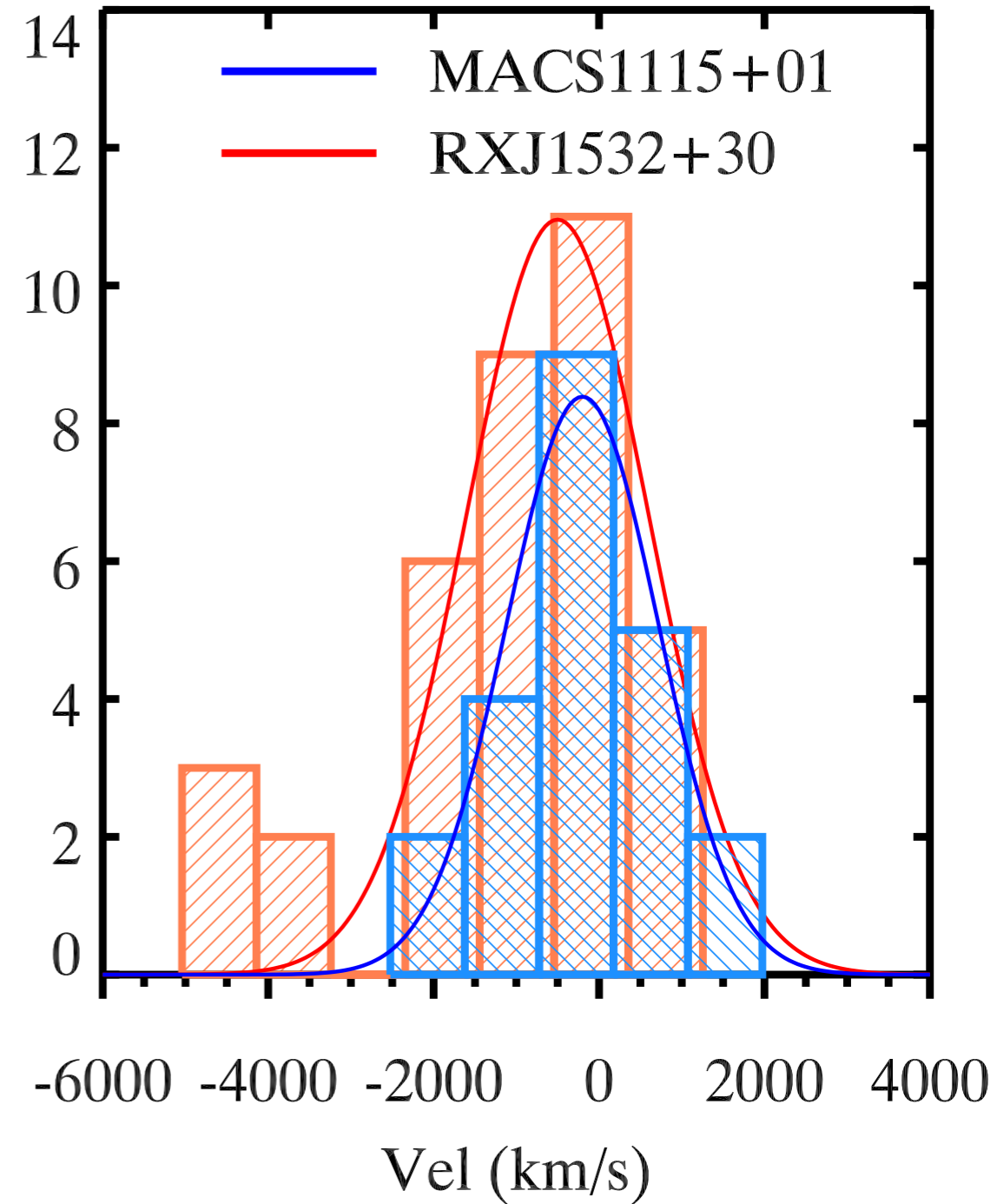
# Radial Velocity Distribution

Cluster	KS-test Prob	$\sigma$	M
MACS1115+01	✓	969±151	~1
RXJ1532+30	✗	1484±208	~6



Gratuitous tasmanian devil

N



**RXJ1532+30: unrelaxed dynamical state or mis-identification?**

# ISM Properties of Star-forming Cluster Members

## Metallicity estimation

$$12+\log(\text{O}/\text{H}) = 8.77 + \log([\text{NII}]/[\text{SII}]) + 0.264^* \log([\text{NII}]/\text{H}\alpha)$$

Dopita et al., 2016

**Advantage:** Independent of ISM conditions like pressure and ionization parameter.

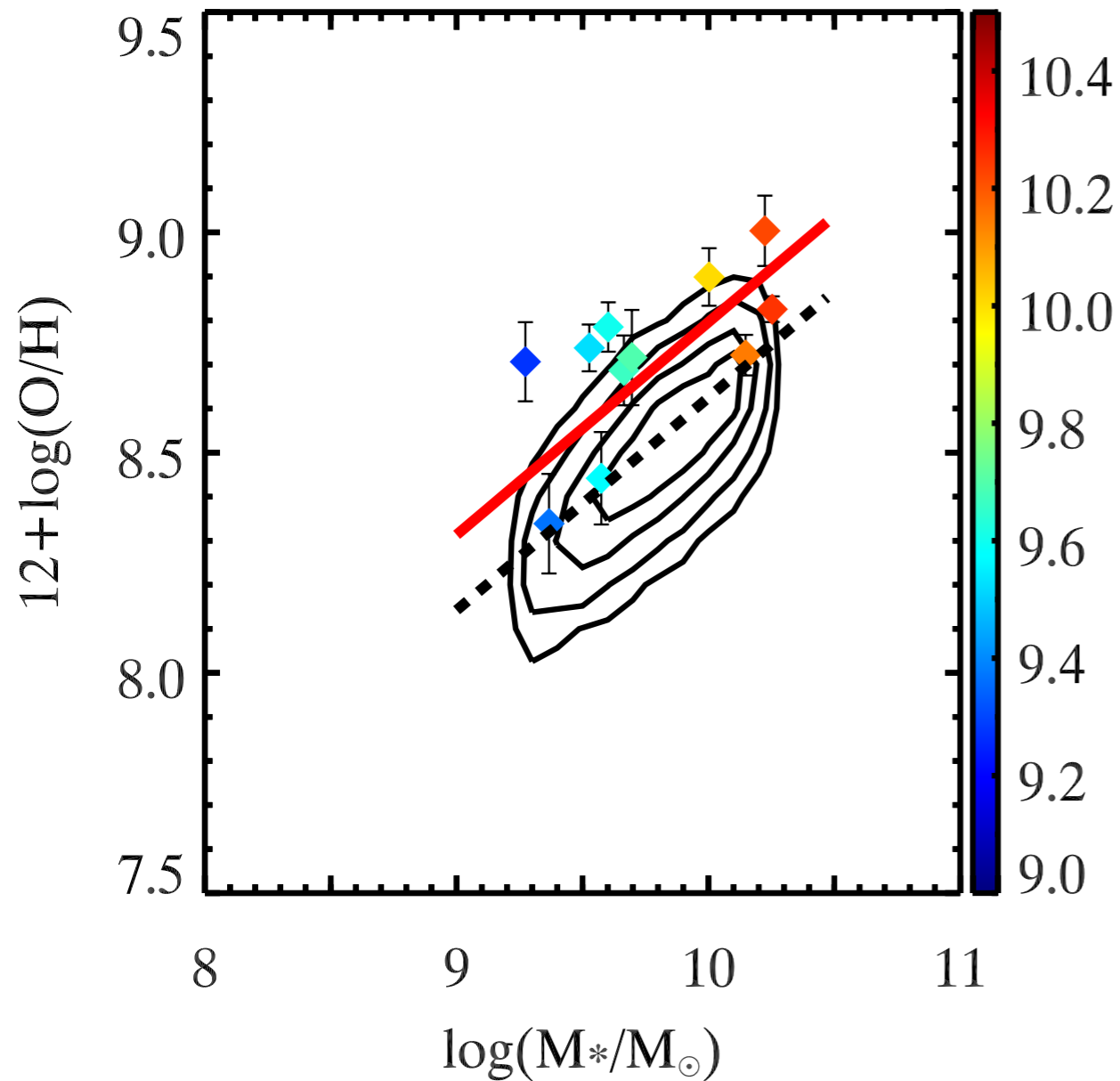
## Cluster member sample with metallicity measurement

MACS1115+01 = 12

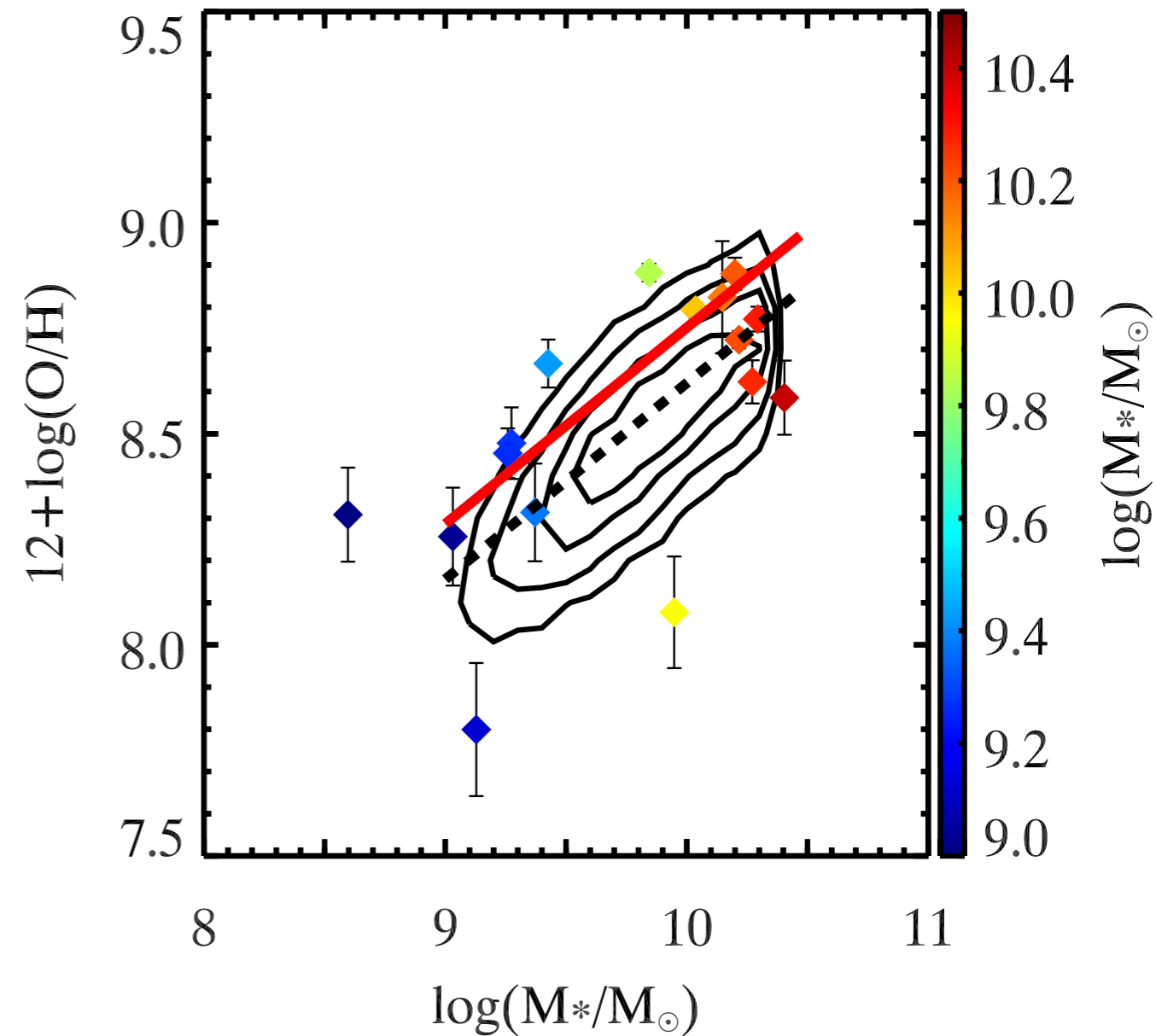
RXJ1532+30 = 16

# Mass-metallicity Relation for Our Clusters

## MACS1115+01



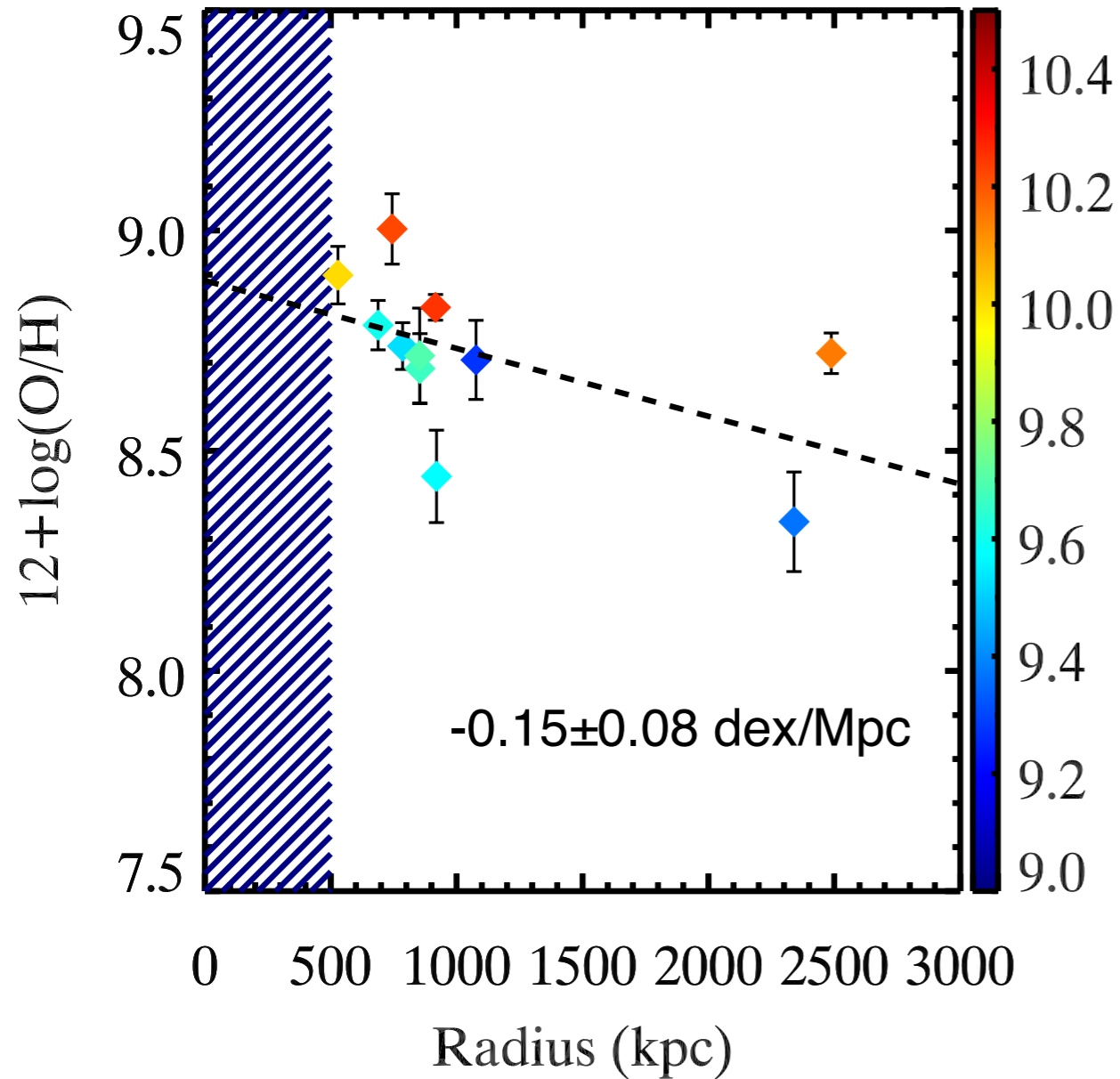
## RXJ1532+30



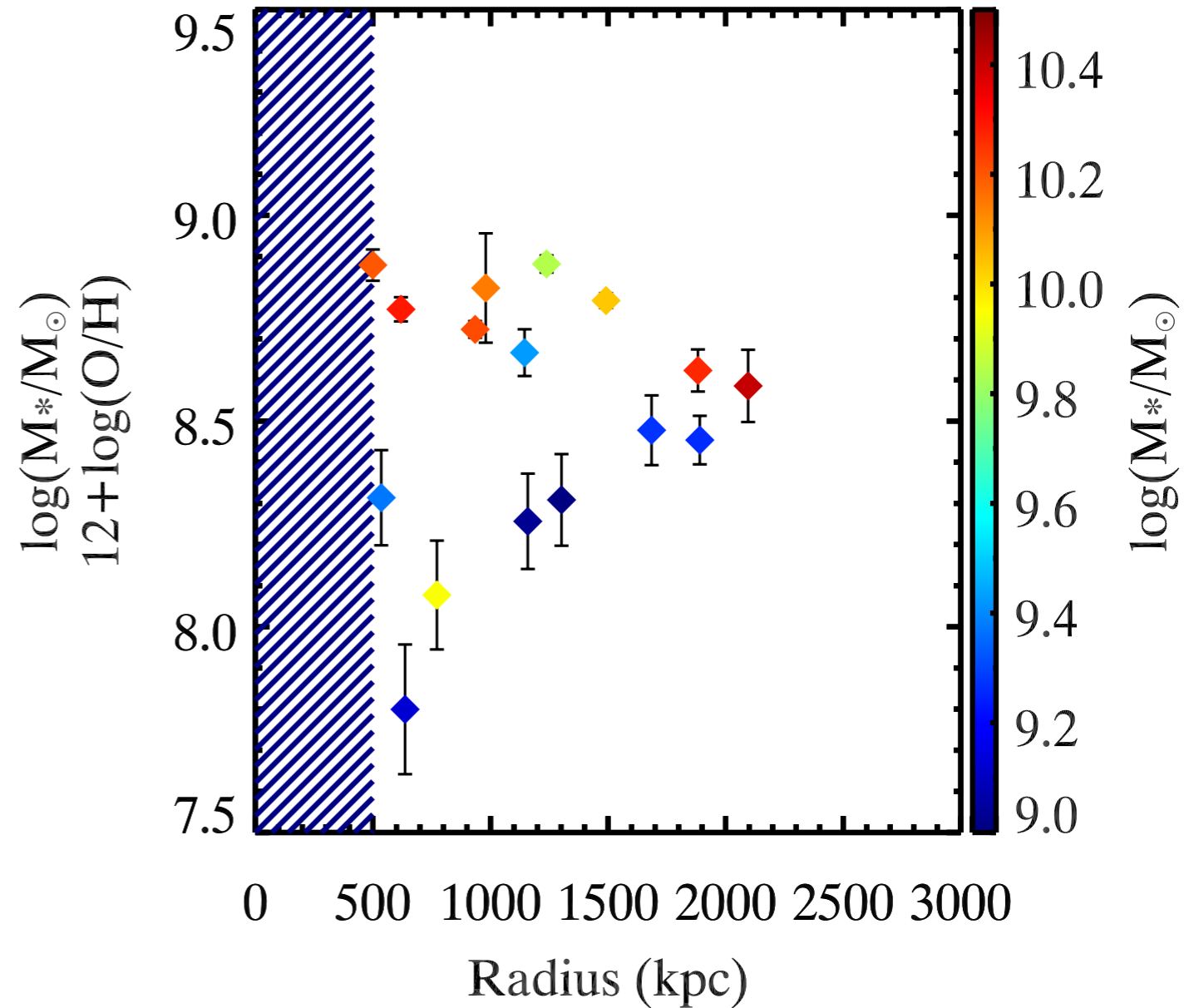
**Highest metallicity enhancement per stellar mass bin to date (0.2 dex).**

# Cluster-scale Gradient in ISM Metallicity

## MACS1115+01

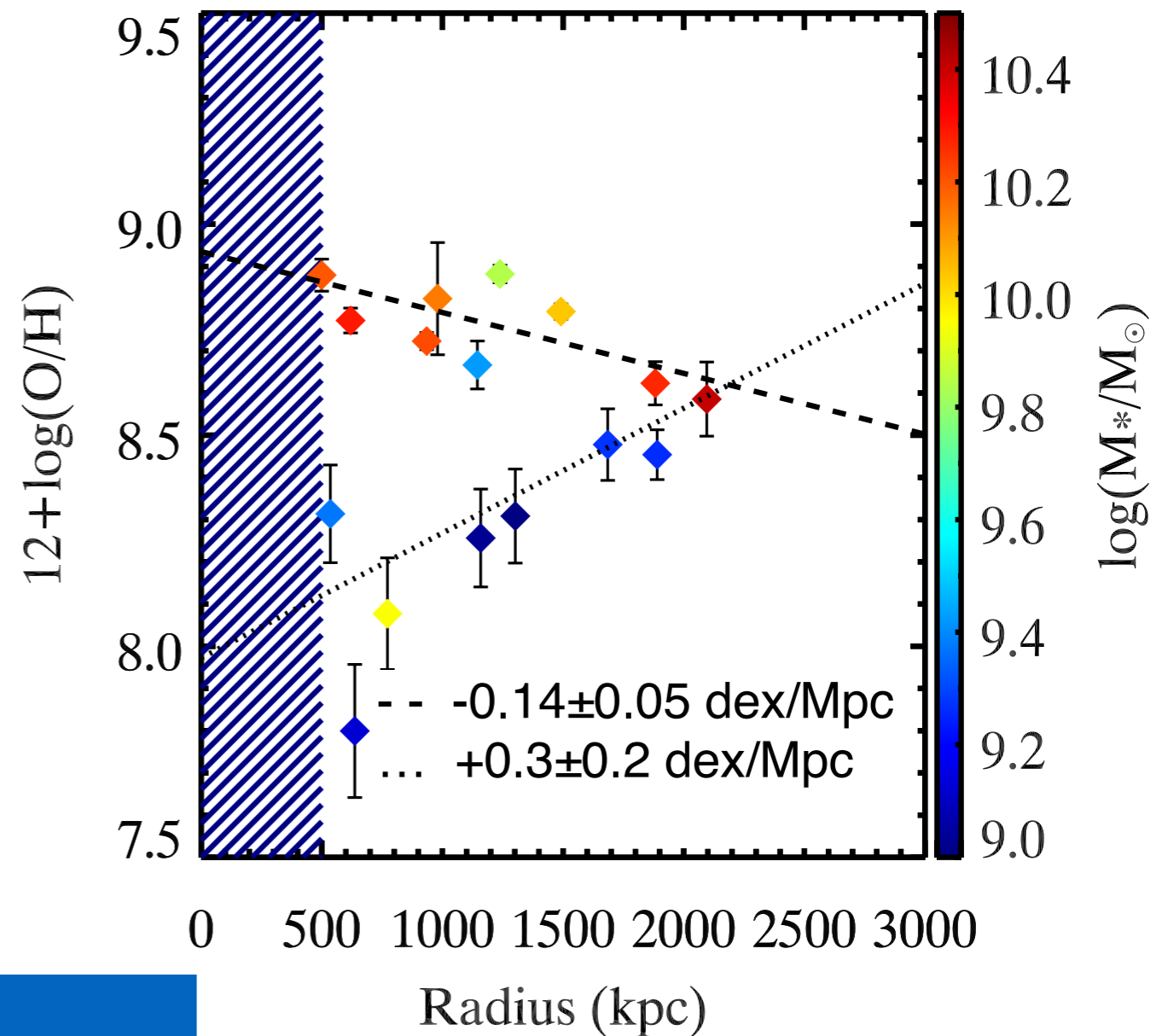


## RXJ1532+30



# Bimodal Metallicity Distribution of RXJ1532+30

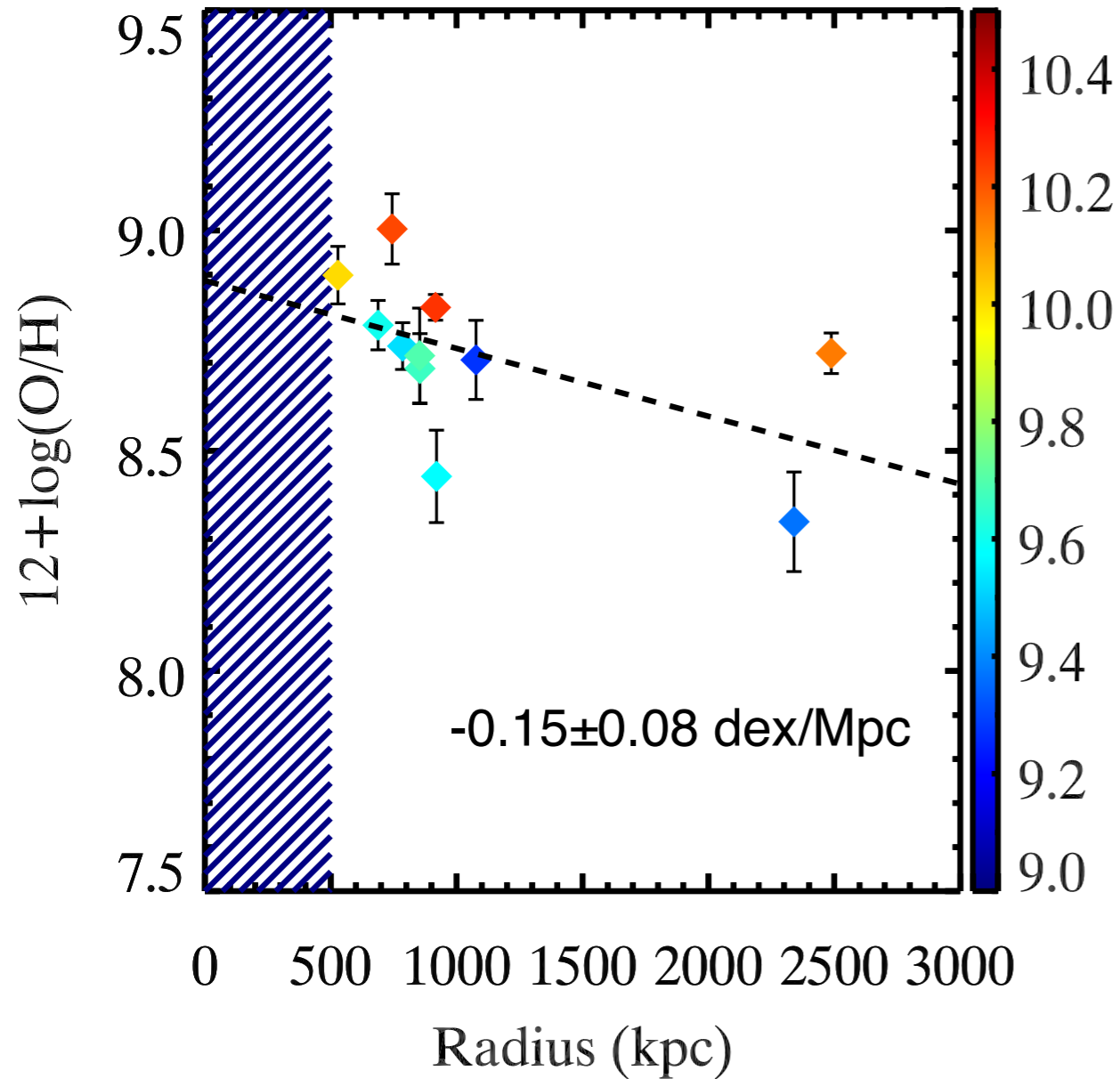
**Mass cut of  $\log(M^*/M_\odot) = 9.5$   
Upper branch slope = slope  
of MACS1115+01**



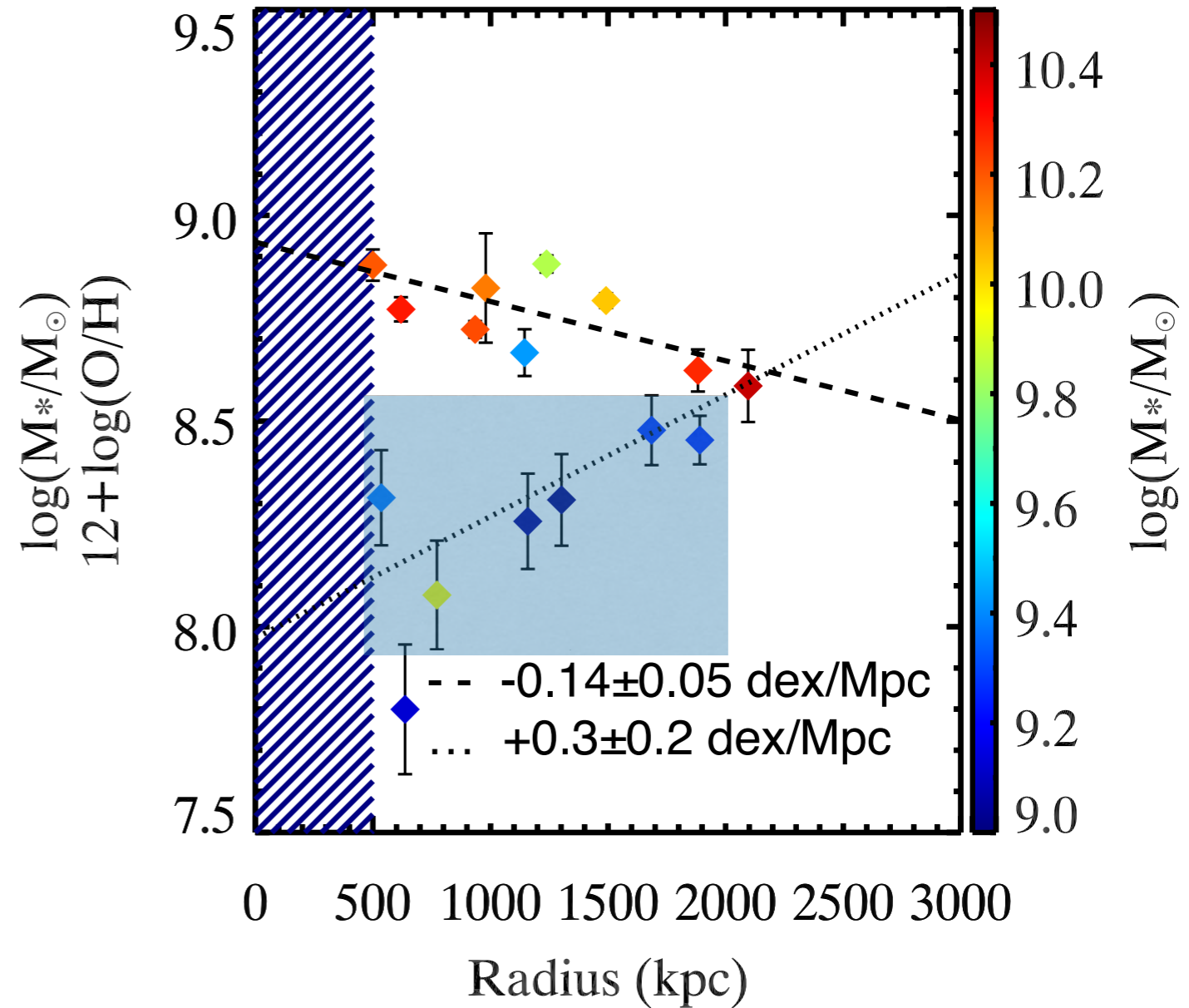
Cluster	KS-test Prob	$\sigma$	M
MACS1115+01	✓	$969 \pm 151$	$\sim 1$
RXJ1532+30	✗	$1484 \pm 208$	$\sim 6$
RXJ1532+30 - lower branch	✓	$773 \pm 163$	$\sim 1$

# Cluster-scale Gradient in ISM Metallicity

## MACS1115+01



## RXJ1532+30

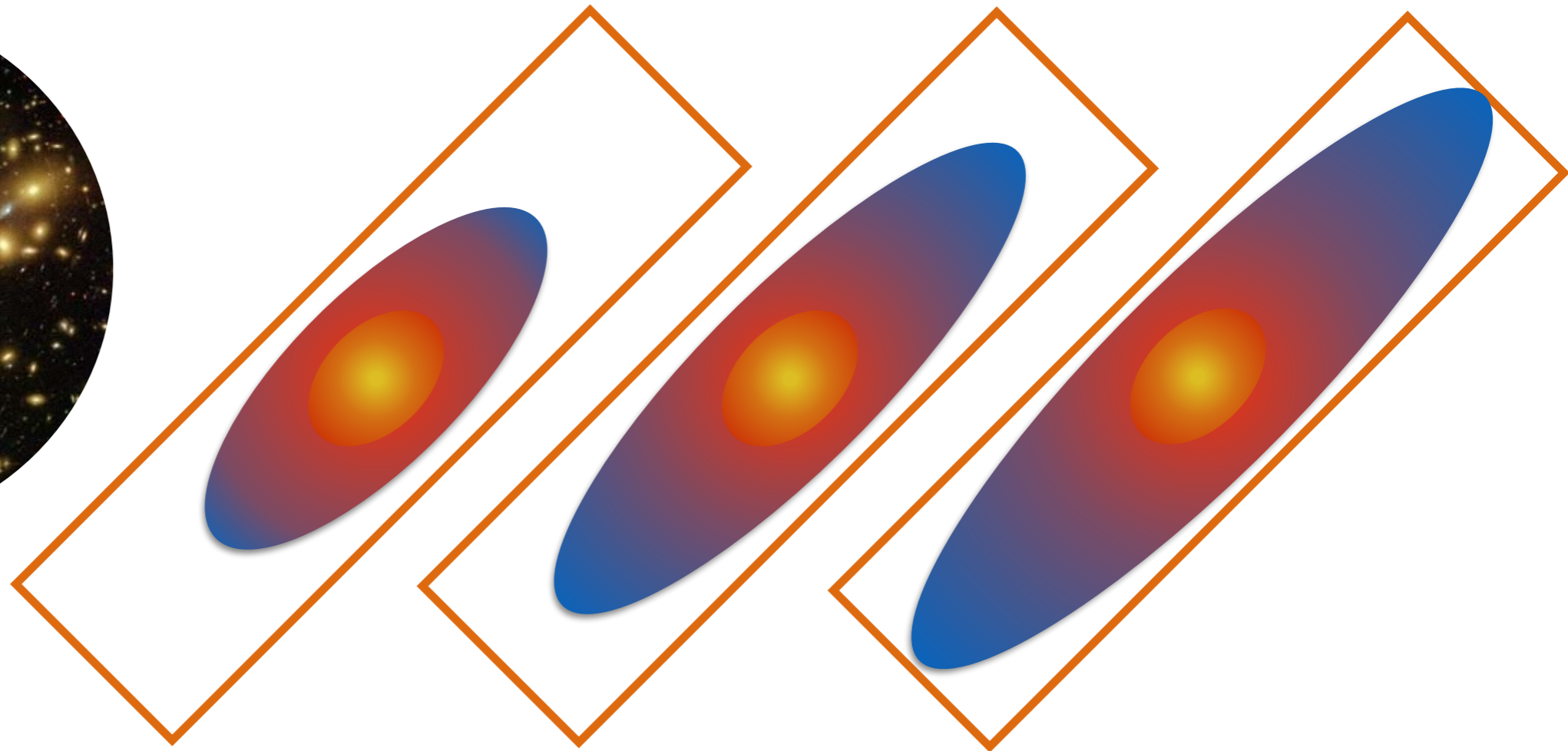


**First observation of cluster-scale negative gradient in ISM metallicity.**

# Origin of Negative Abundance Gradient in ISM Metallicity

## 1. Disk truncation

Ram pressure stripping



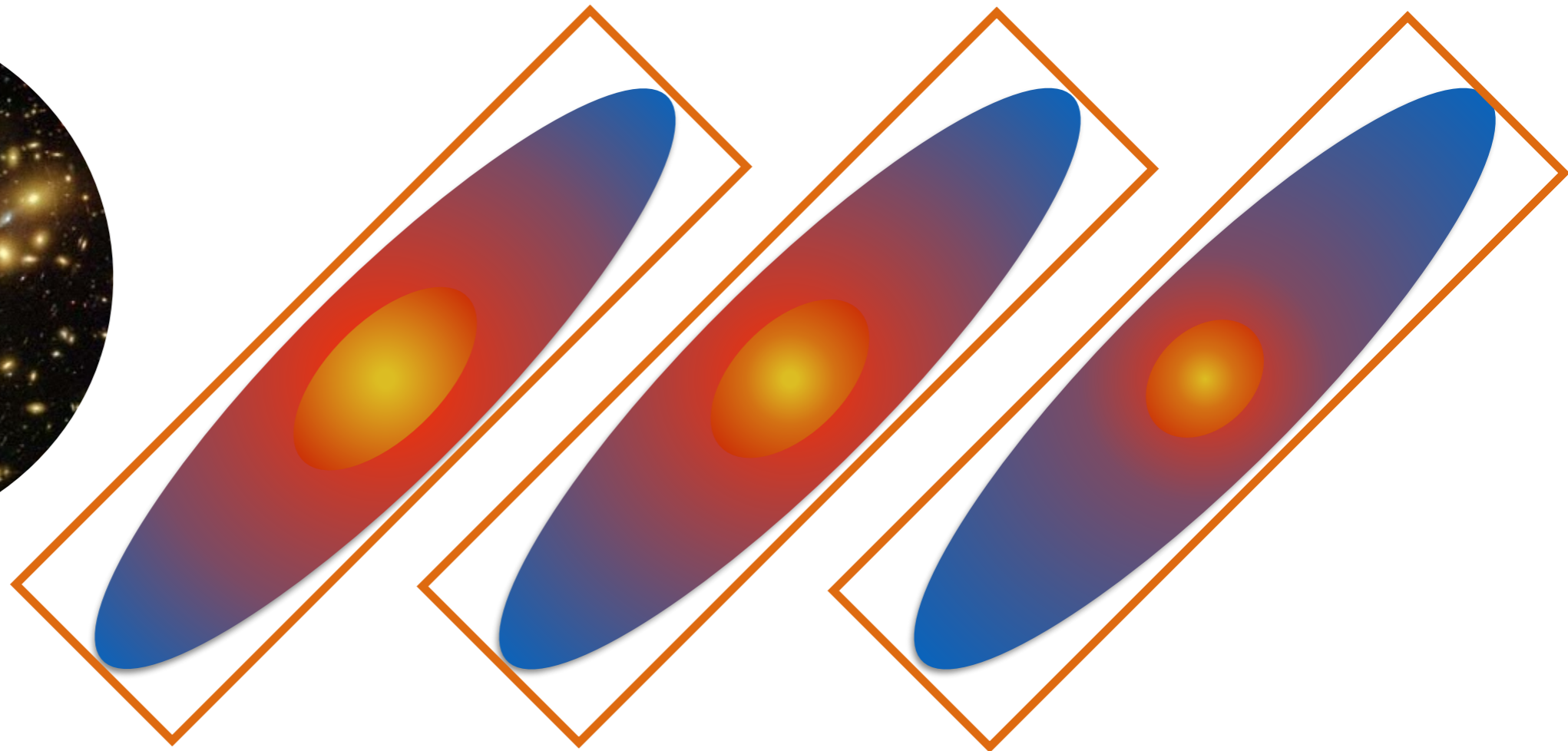


# Origin of Negative Abundance Gradient in ISM Metallicity

1. Disk truncation

2. Self-enrichment

Strangulation



# Accepted in ApJ (arXiv:1608.06289)!!!

## Radial Distribution Of ISM Gas-phase Metallicity In CLASH Clusters at $z\sim 0.35$ : A New Outlook On Environmental Impact On Galaxy Evolution

Anshu Gupta, Tiantian Yuan, Kim-Vy H. Tran, Davide Martizzi, Philip Taylor, Lisa J. Kewley

(Submitted on 22 Aug 2016)

