The metallicity of group and cluster satellites in the EAGLE simulation

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with

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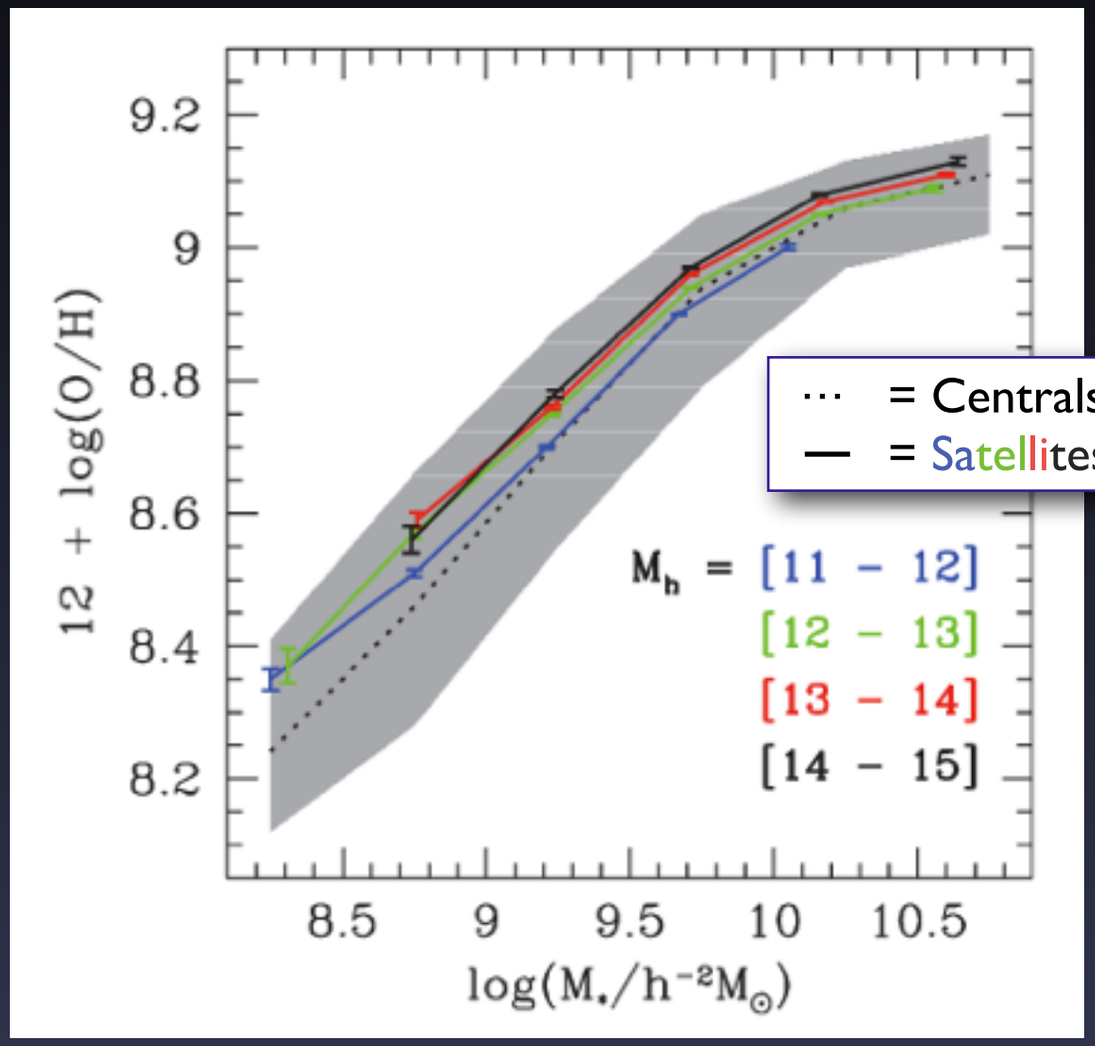
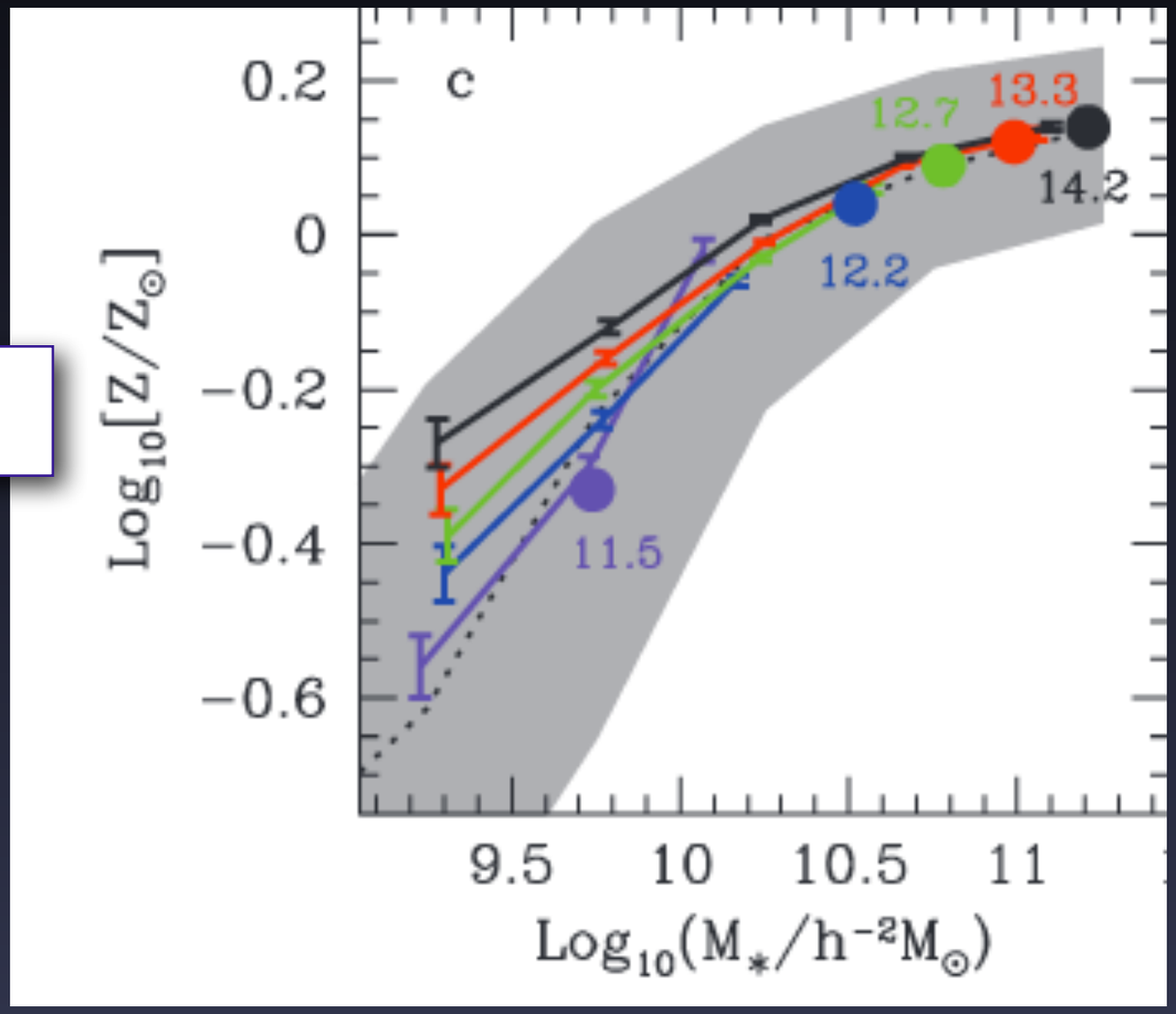
Ringberg, 13.05.2016

Metallicity and environment (observations)

Ionized gas
[Pasquali et al., 2012]



Stars
[Pasquali et al., 2010]

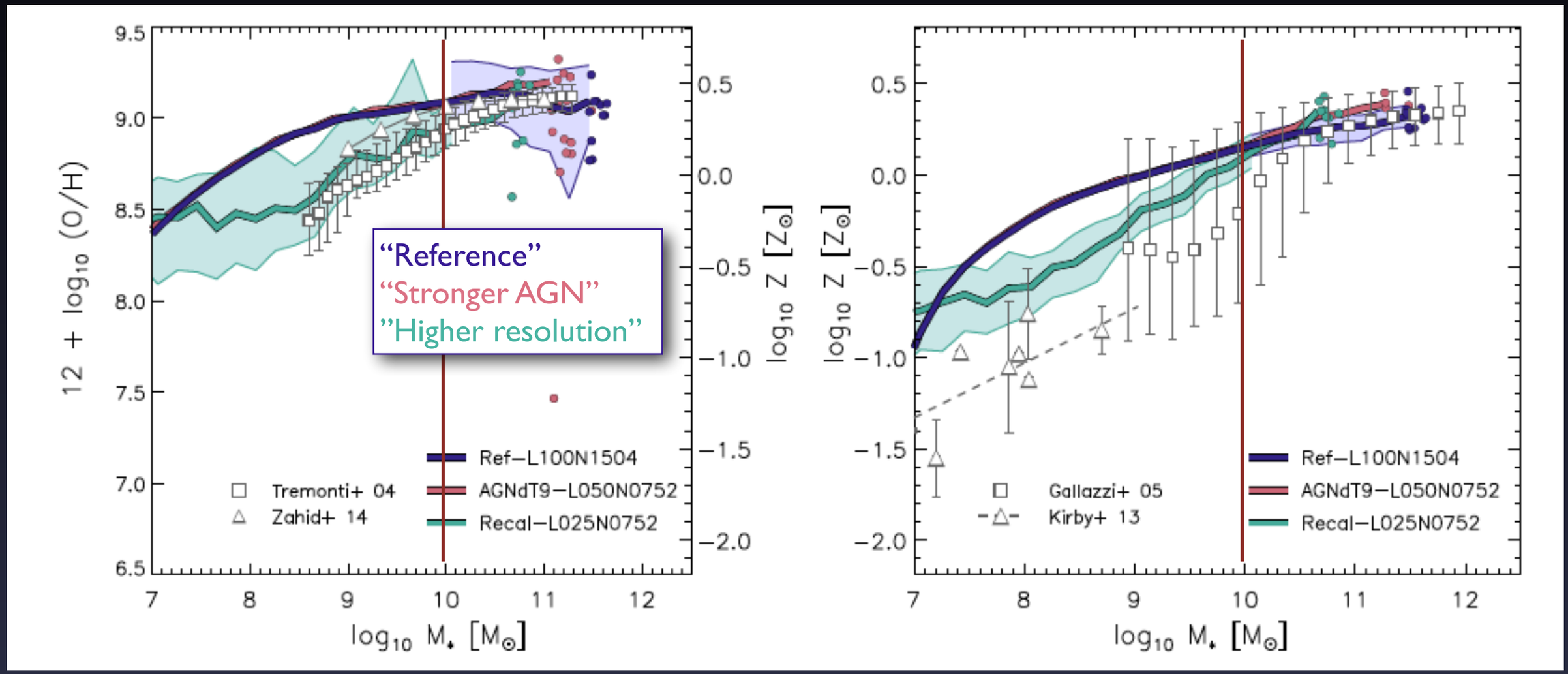


Consistent picture for stars and gas:
Metallicity is higher in satellites than centrals of same mass

The EAGLE simulation: metallicity

Star-forming gas
(proxy for ionized)

Stars



[Schaye et al., 2015]

Z increases with M_{star}
Over-predicted at $M_{star} \lesssim 10^{10}\ M_\odot$

Project overview

1.) Does EAGLE reproduce the observed metallicity excess in satellite galaxies?

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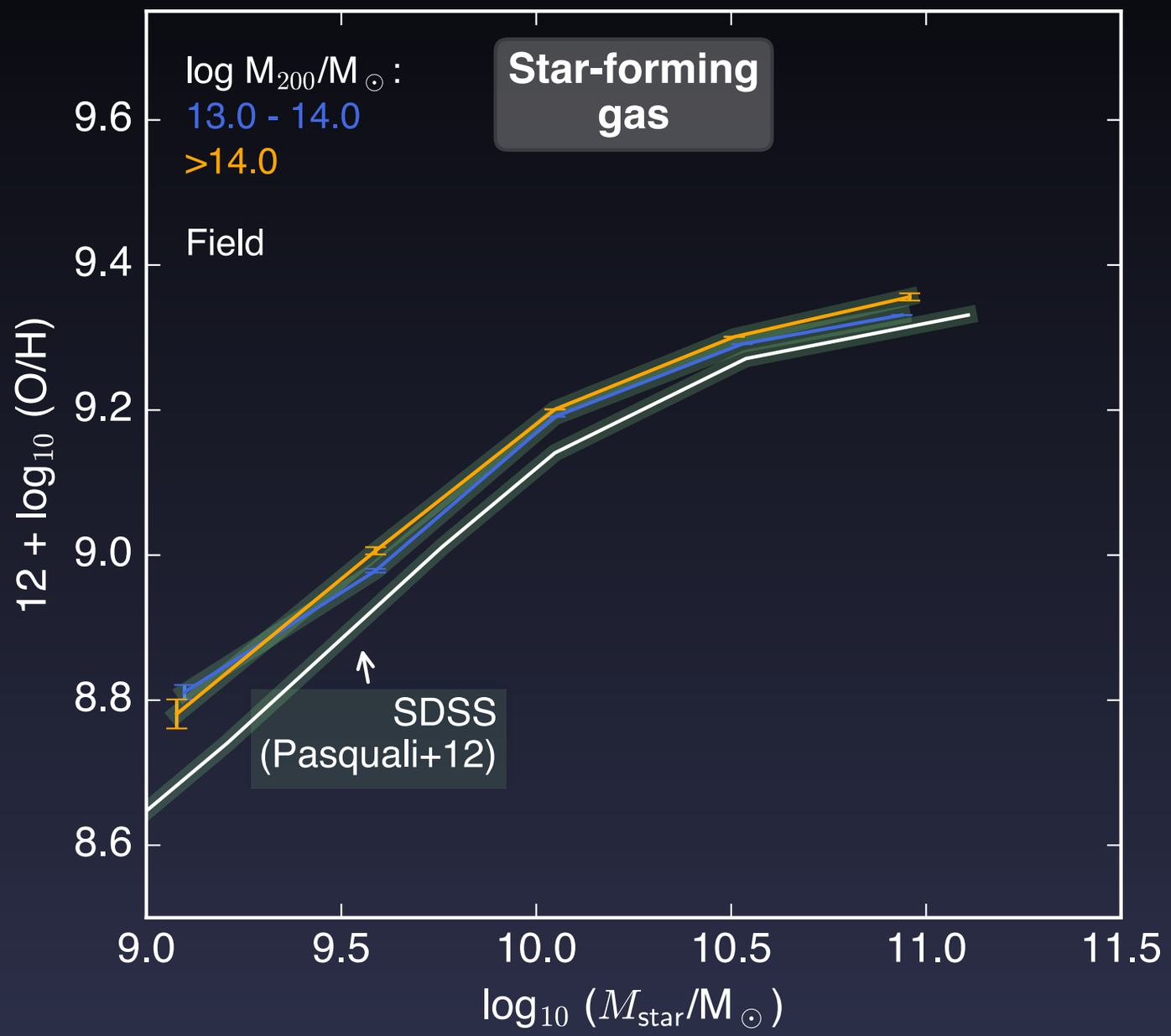
2.) If yes, can we understand why satellites have higher metallicity?

Eagle: Satellite metallicities (gas)



N.B.: Observations adjusted for $Z_\odot$ = 0.012
[Allende-Prieto et al., 2001]

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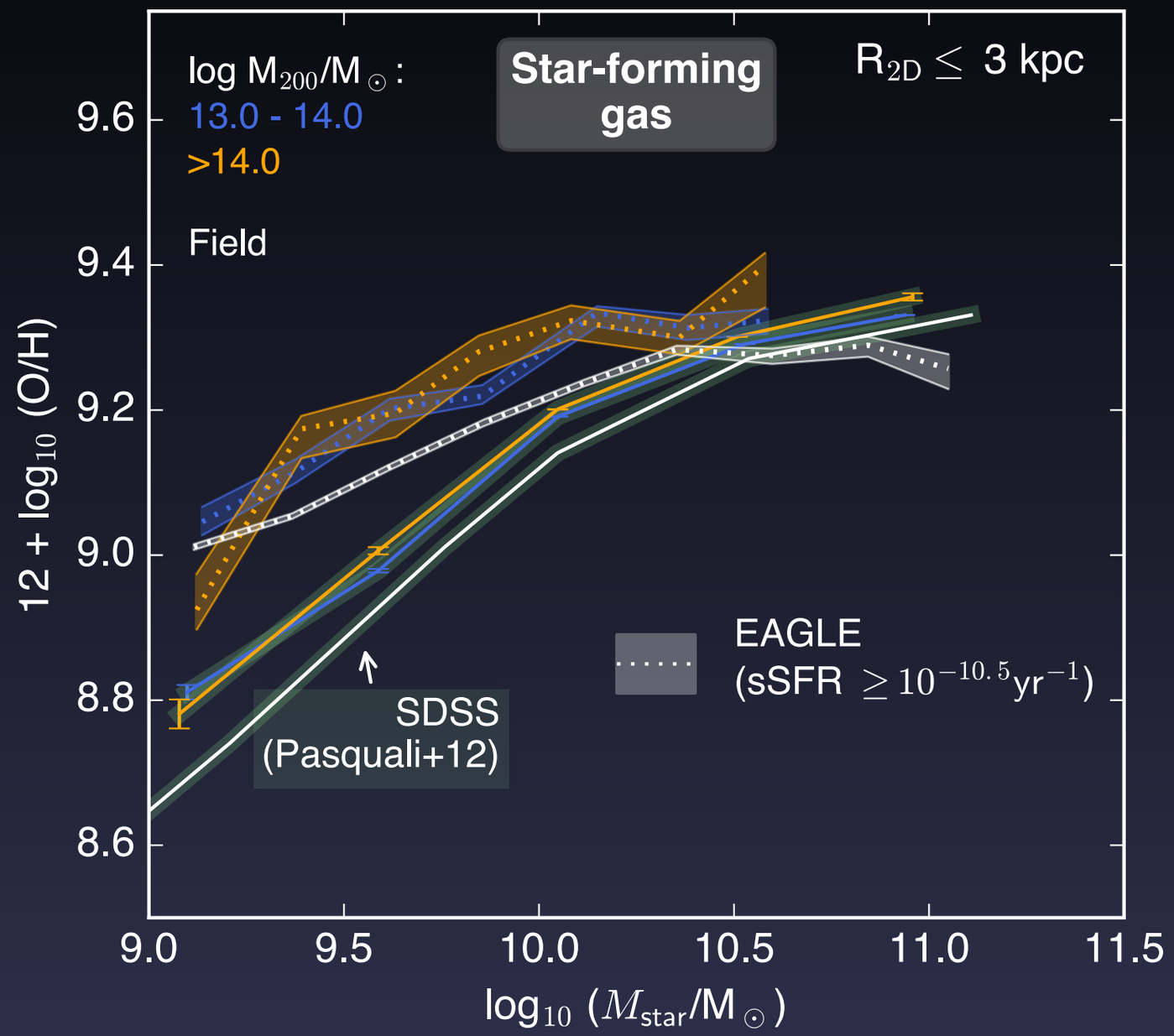

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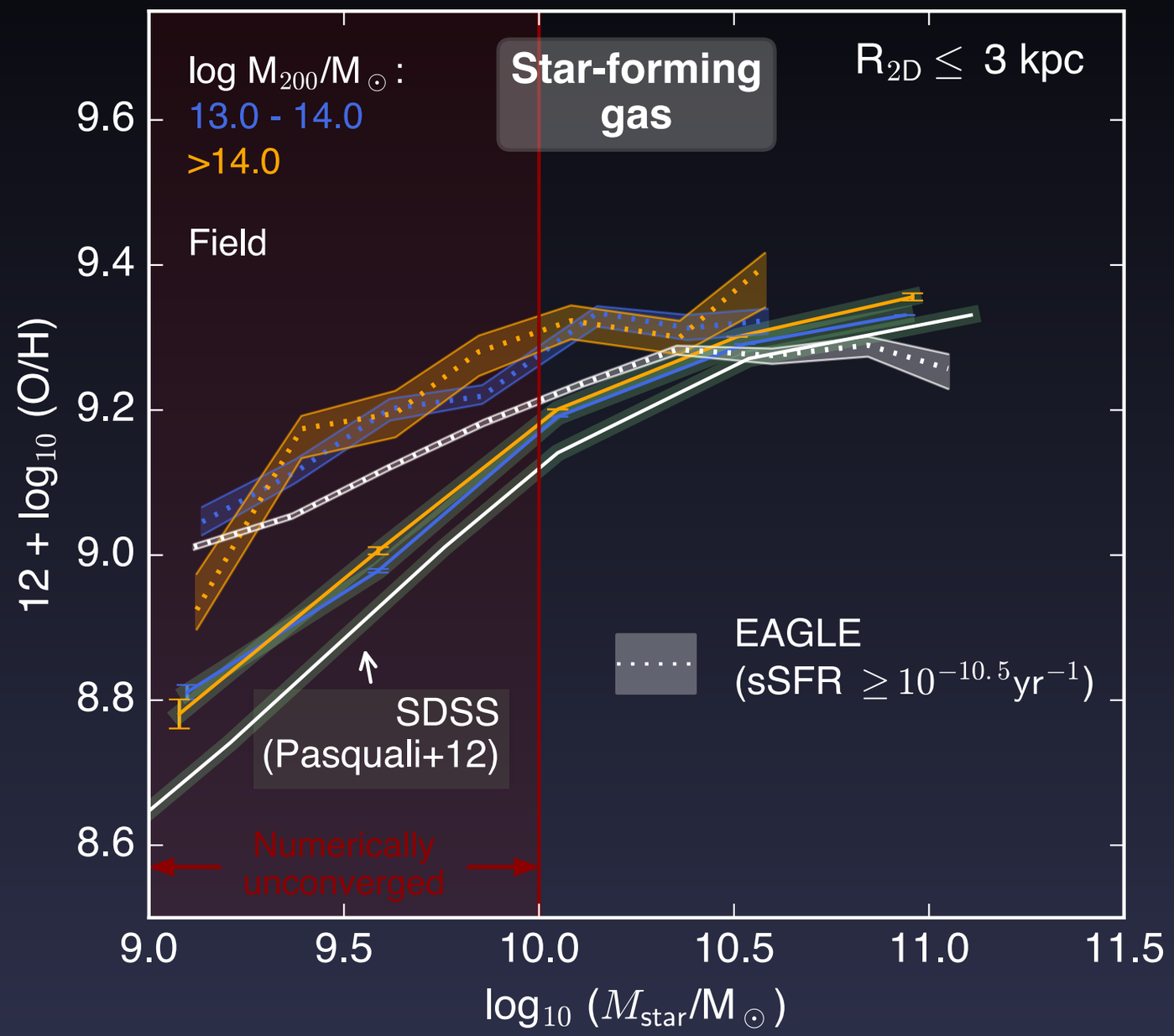

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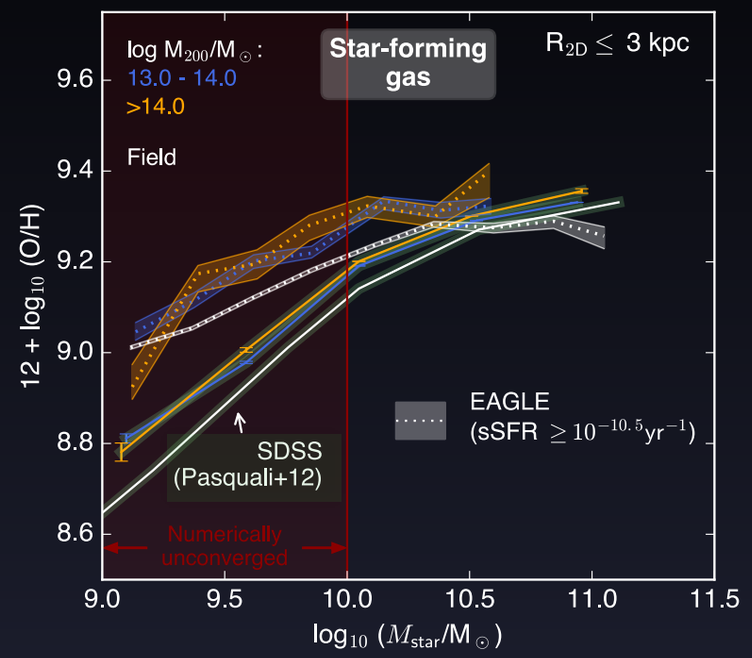
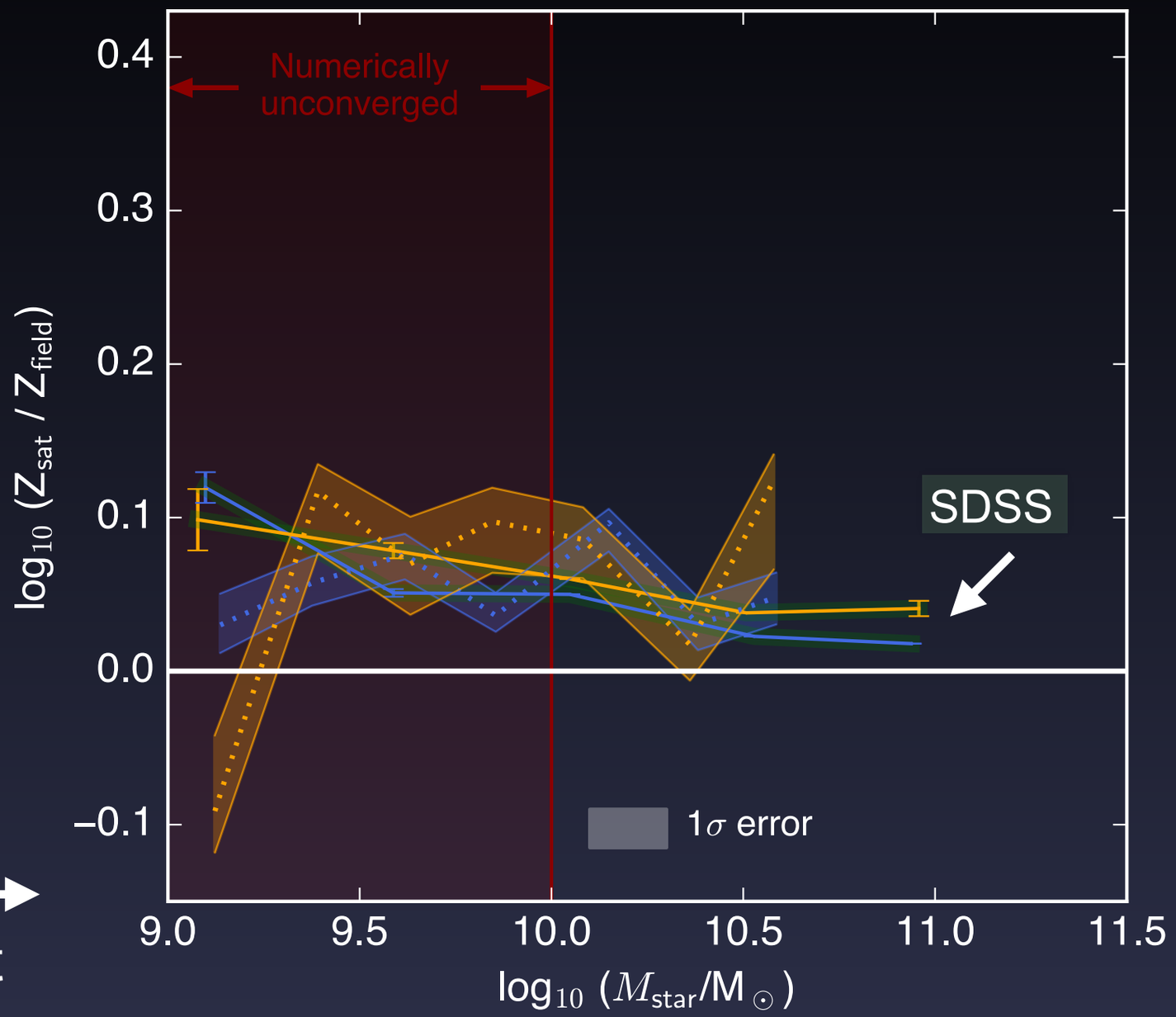


Absolute
M-Z relation

Relative
enhancement
in satellites



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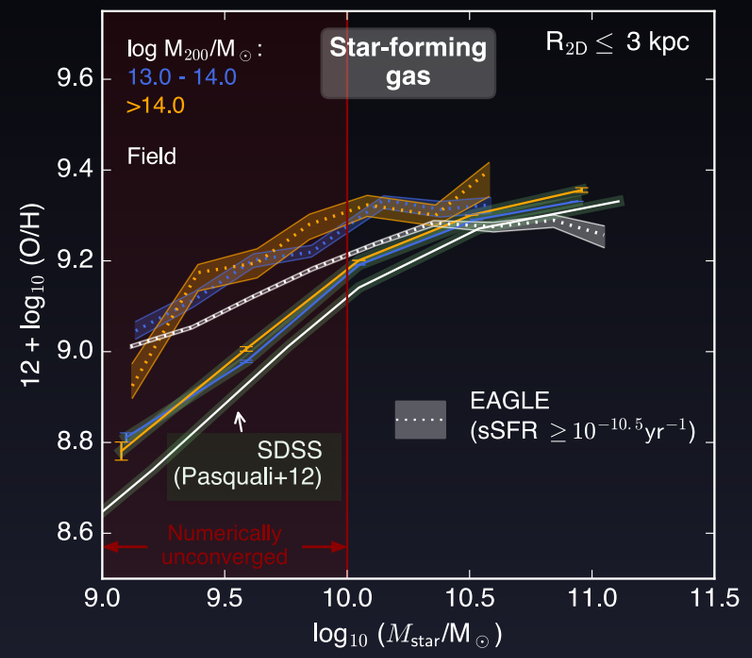

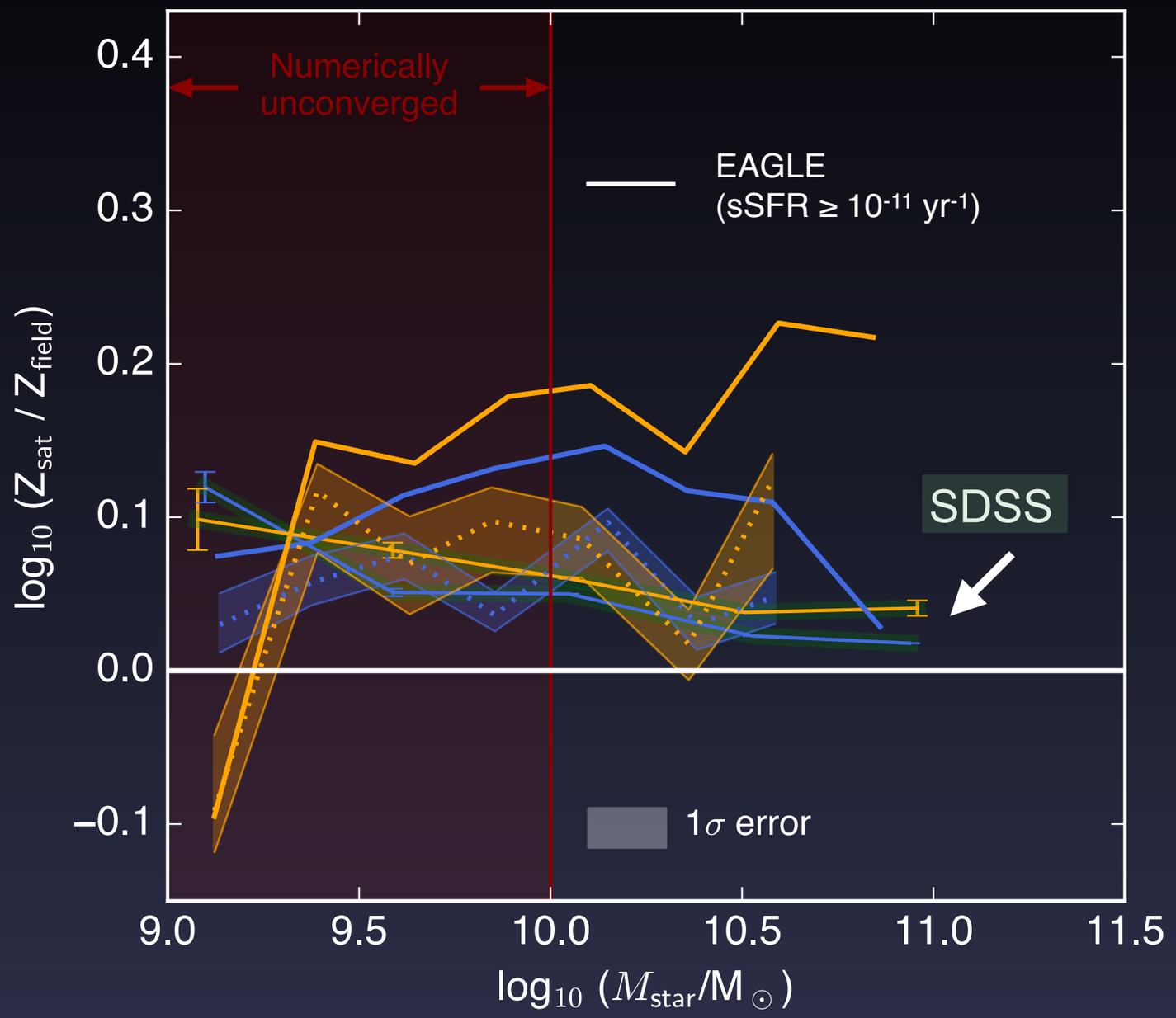

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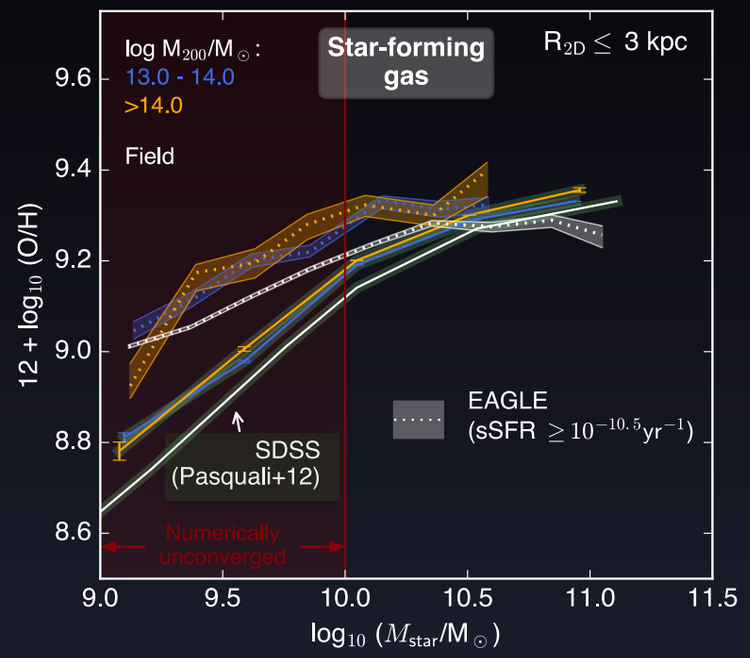
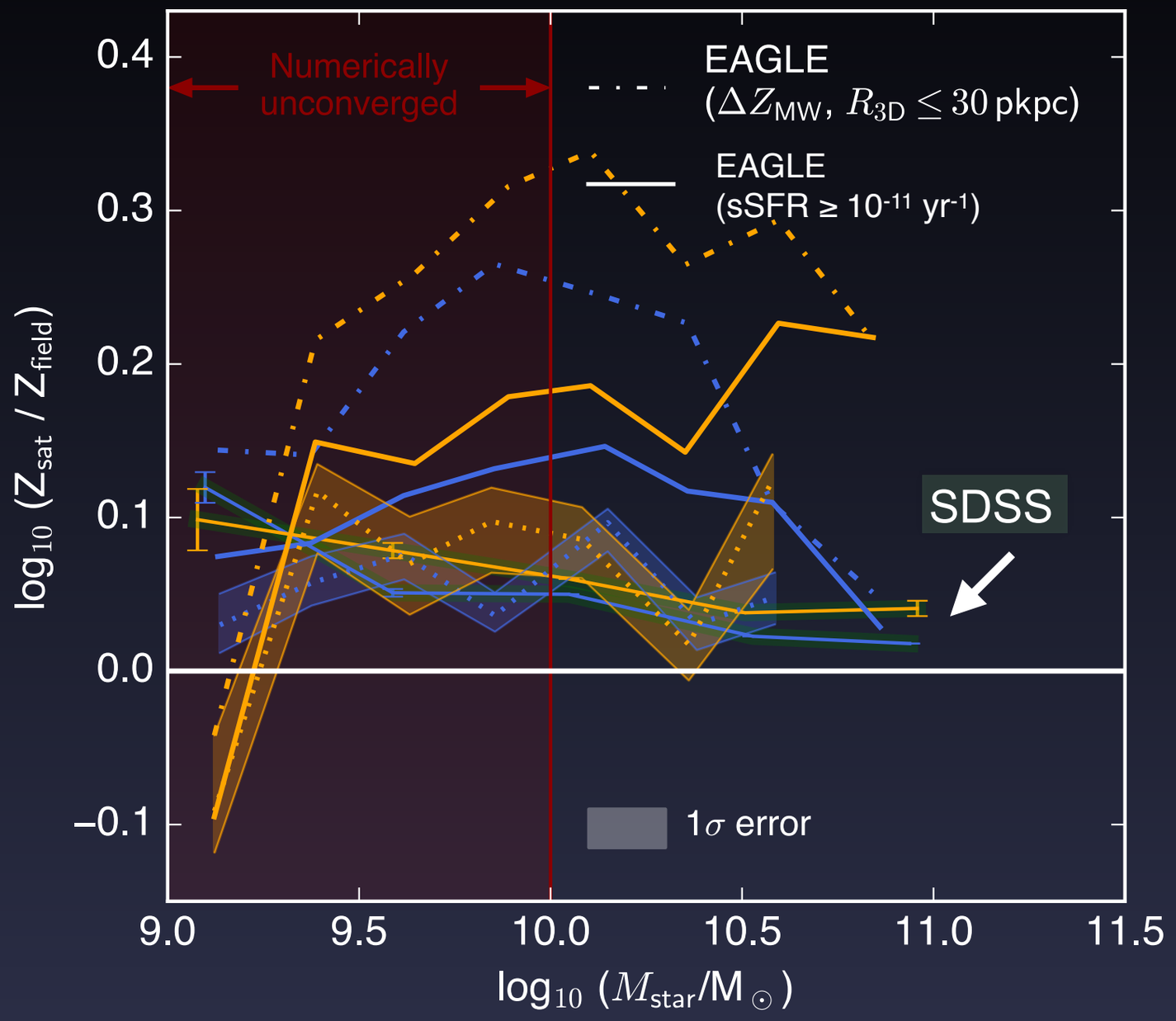
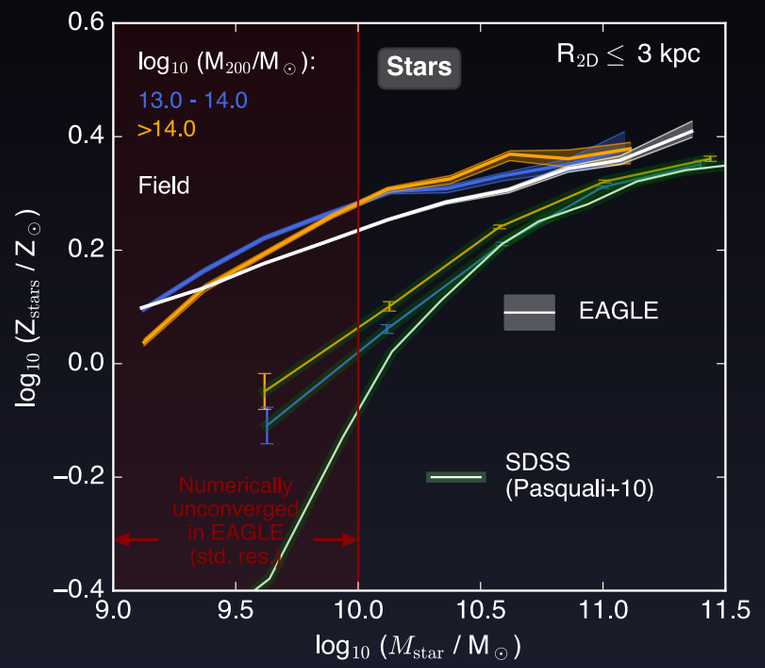


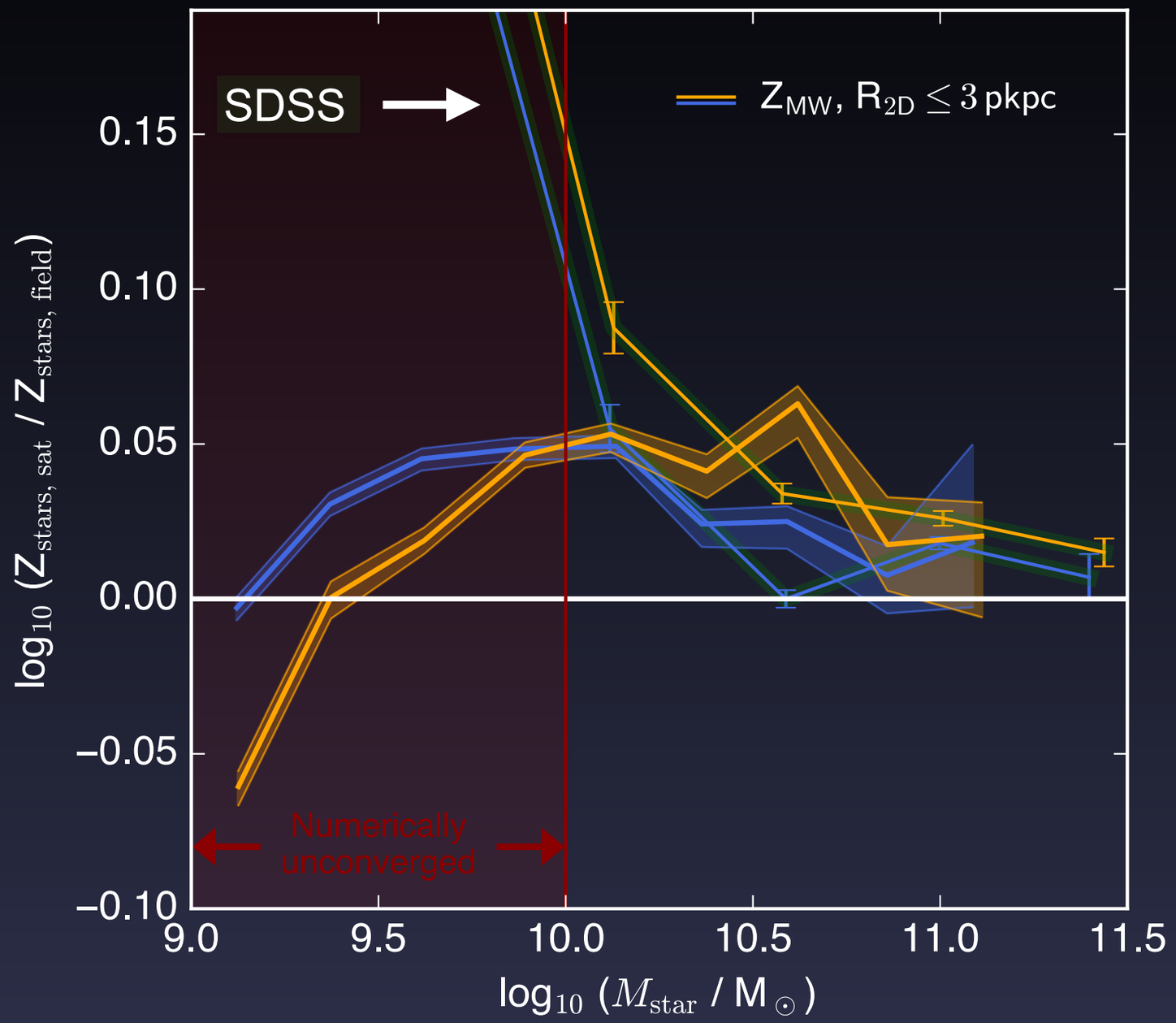


Quantitative agreement
(if observational characteristics are mimicked)

→ c.f. Cecilia's talk

Eagle: Satellite metallicities (stars)





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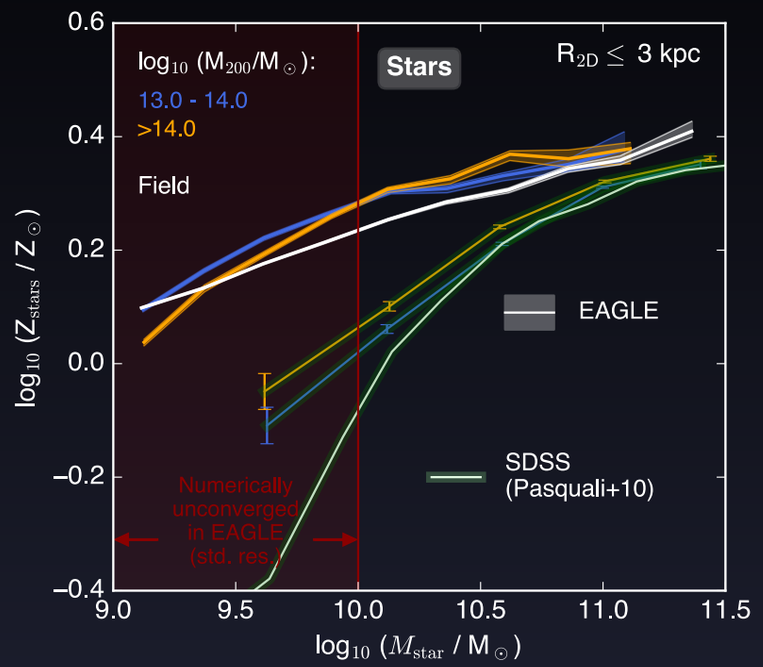
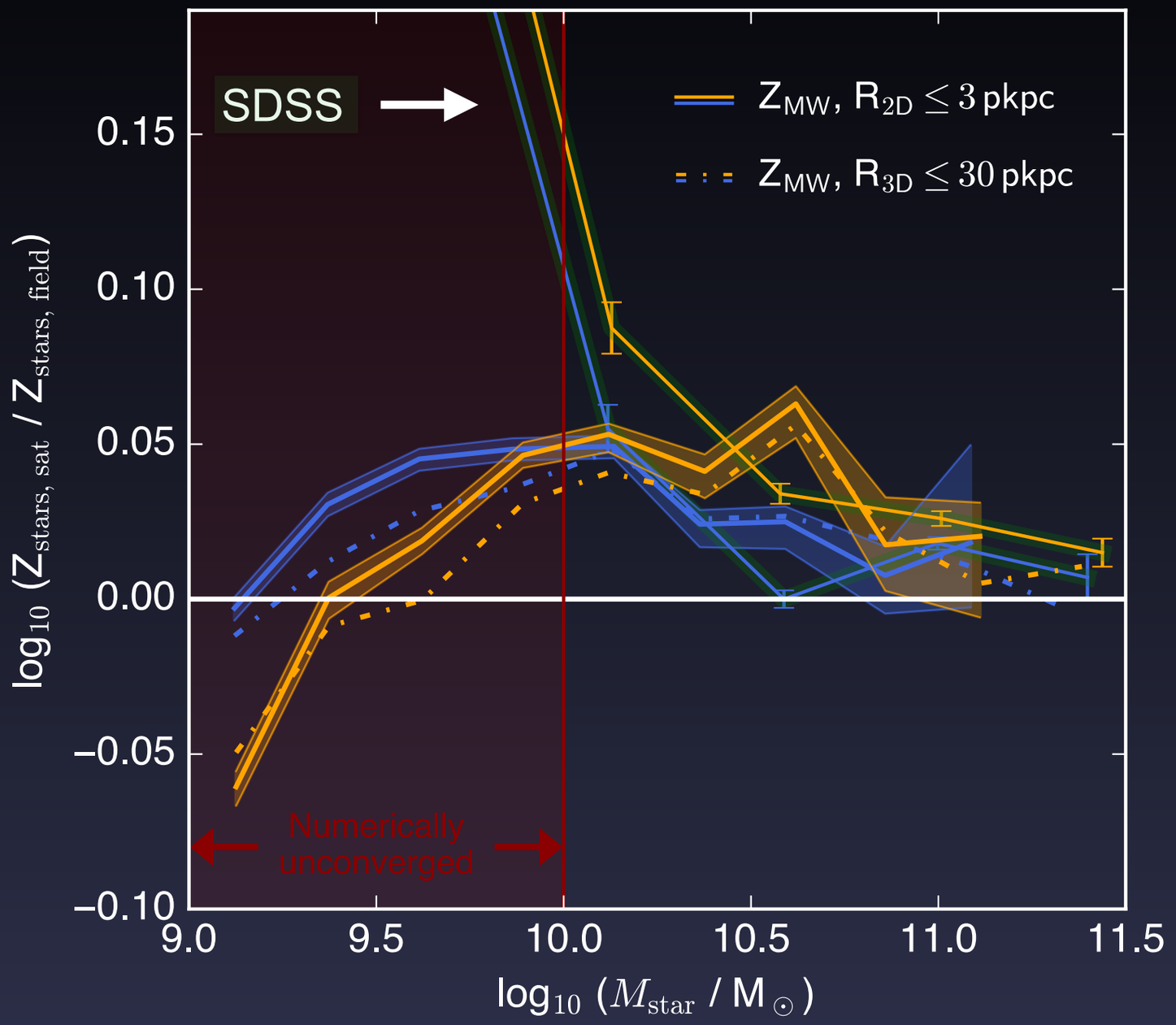
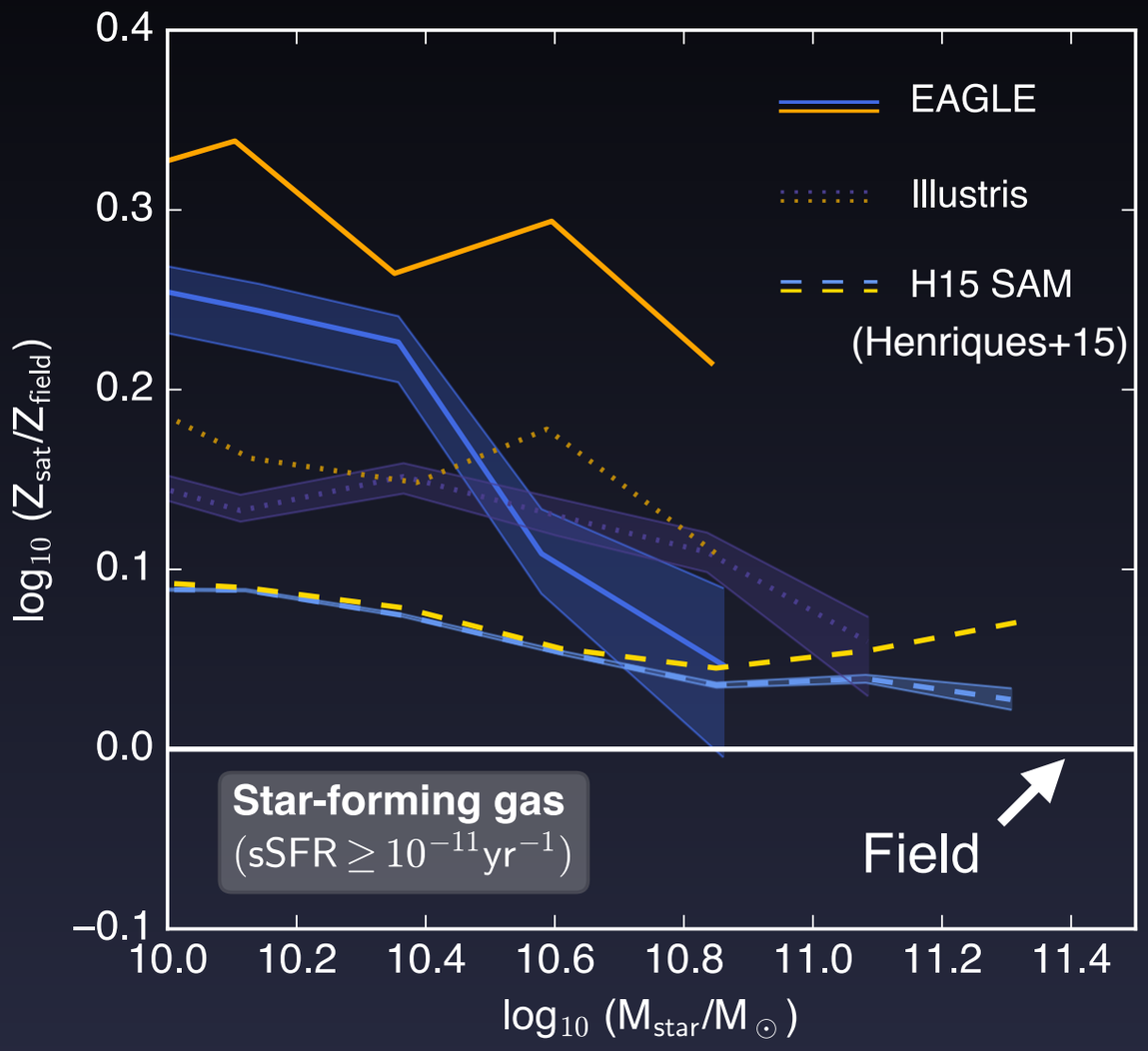
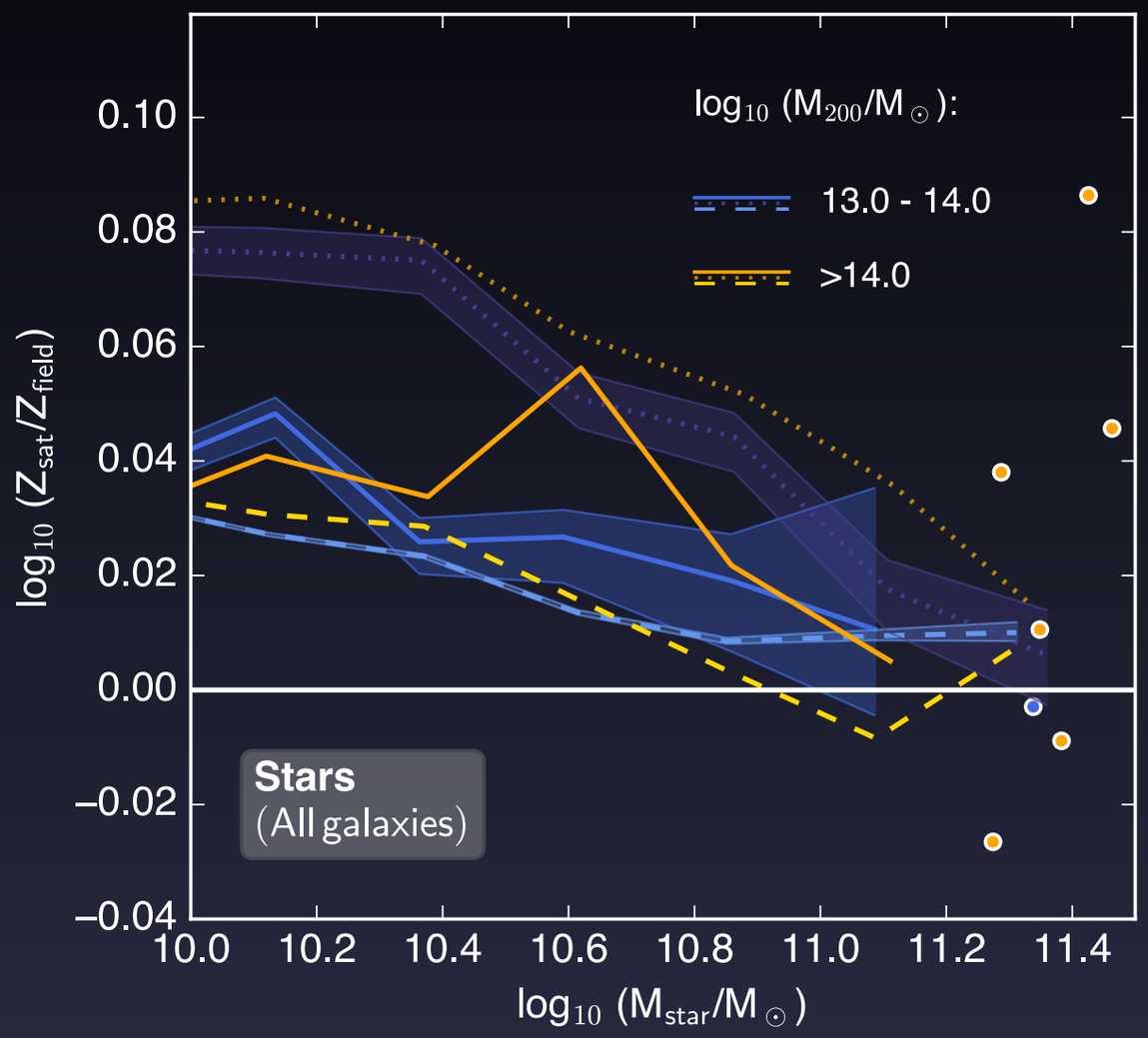




General agreement, but effect possibly too small at $M_{star} \lesssim 10^{10.5}\ M_\odot$

Simulation comparison





Qualitative agreement between models,
but significant quantitative differences

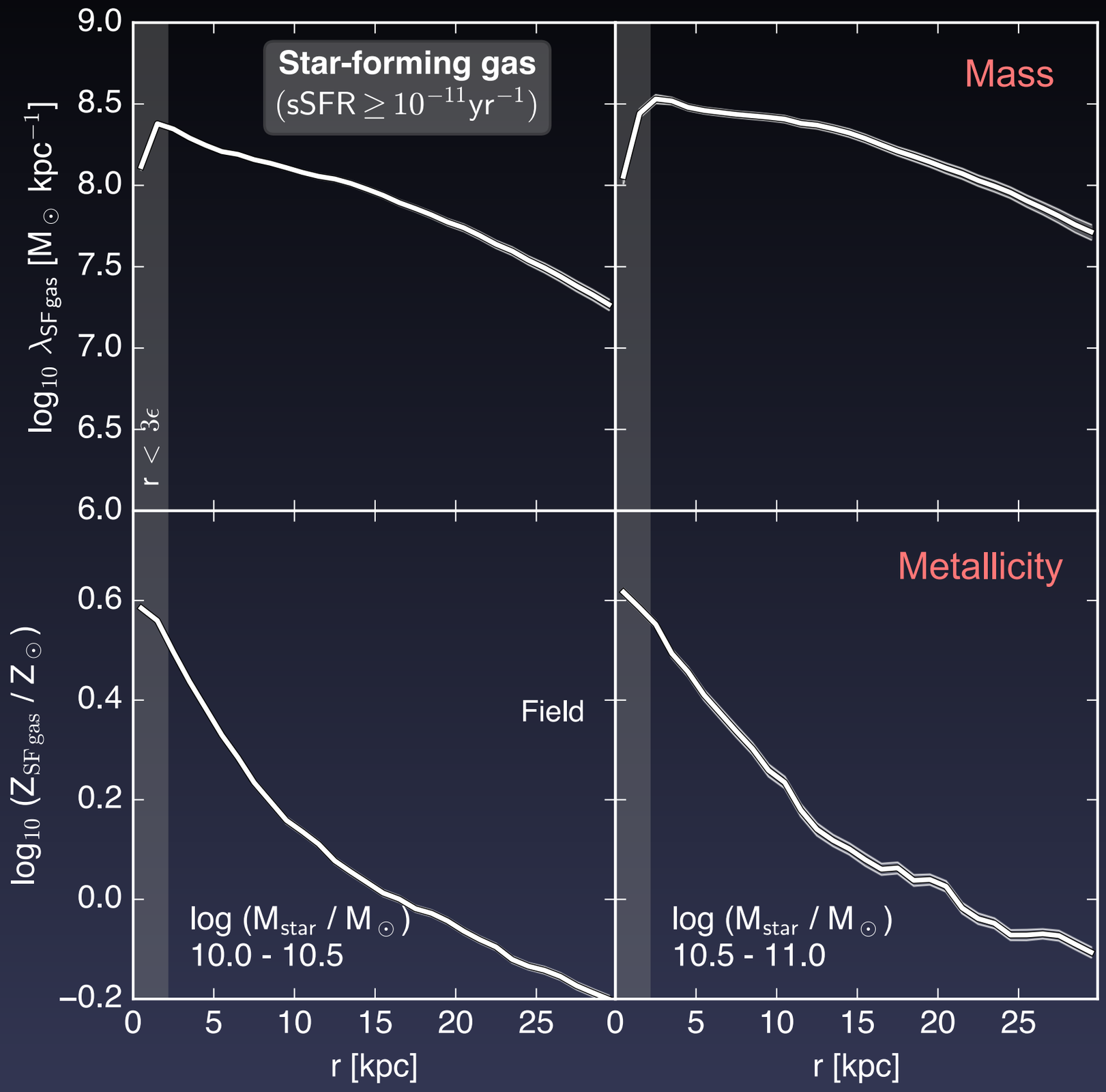
Project overview

1.) Does EAGLE reproduce the observed metallicity excess in satellite galaxies?
Yes!

2.) ~~If yes,~~ can we understand why satellites have higher metallicity?

Gas metallicity

Origin of gas metallicity excess



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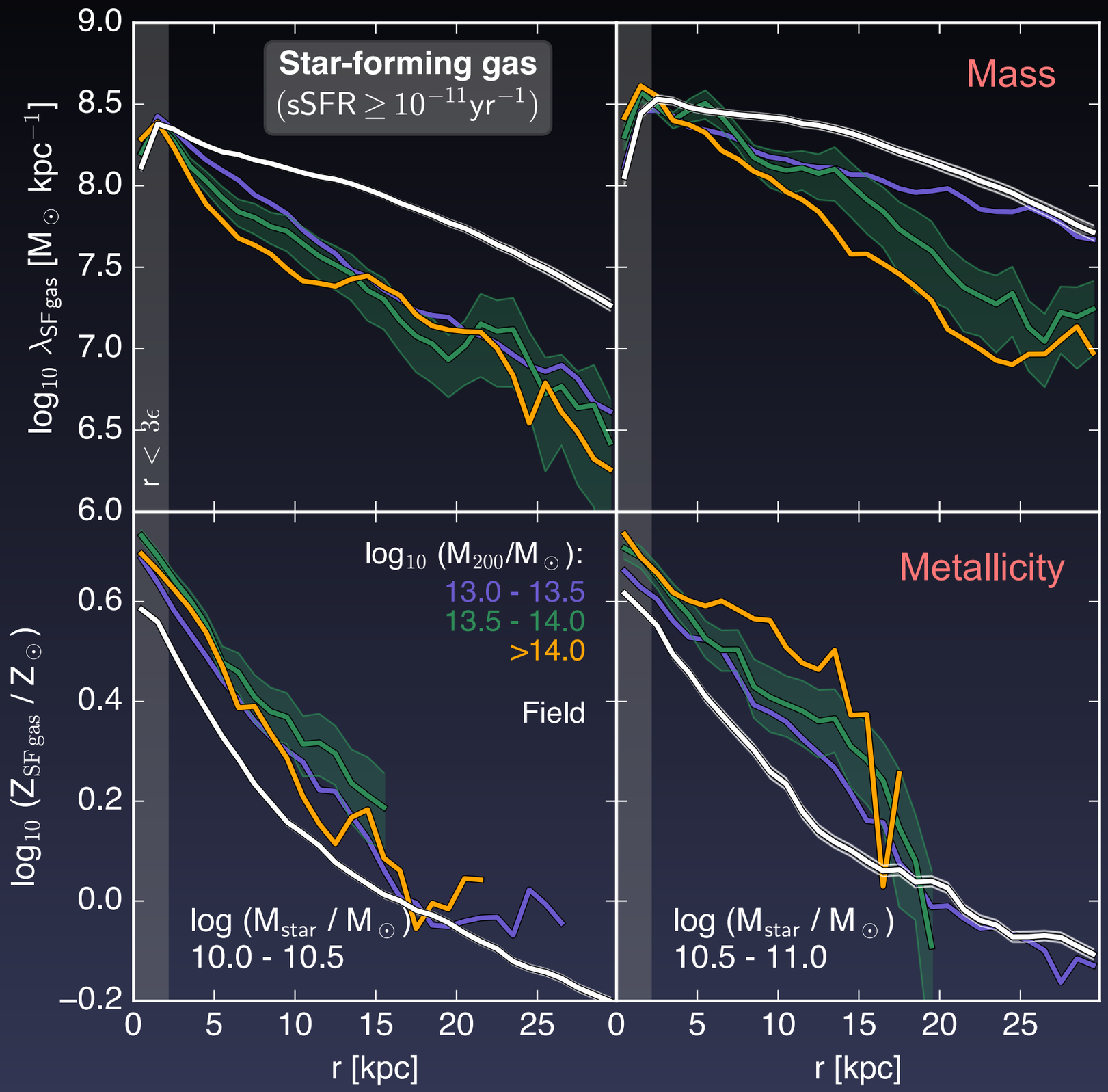


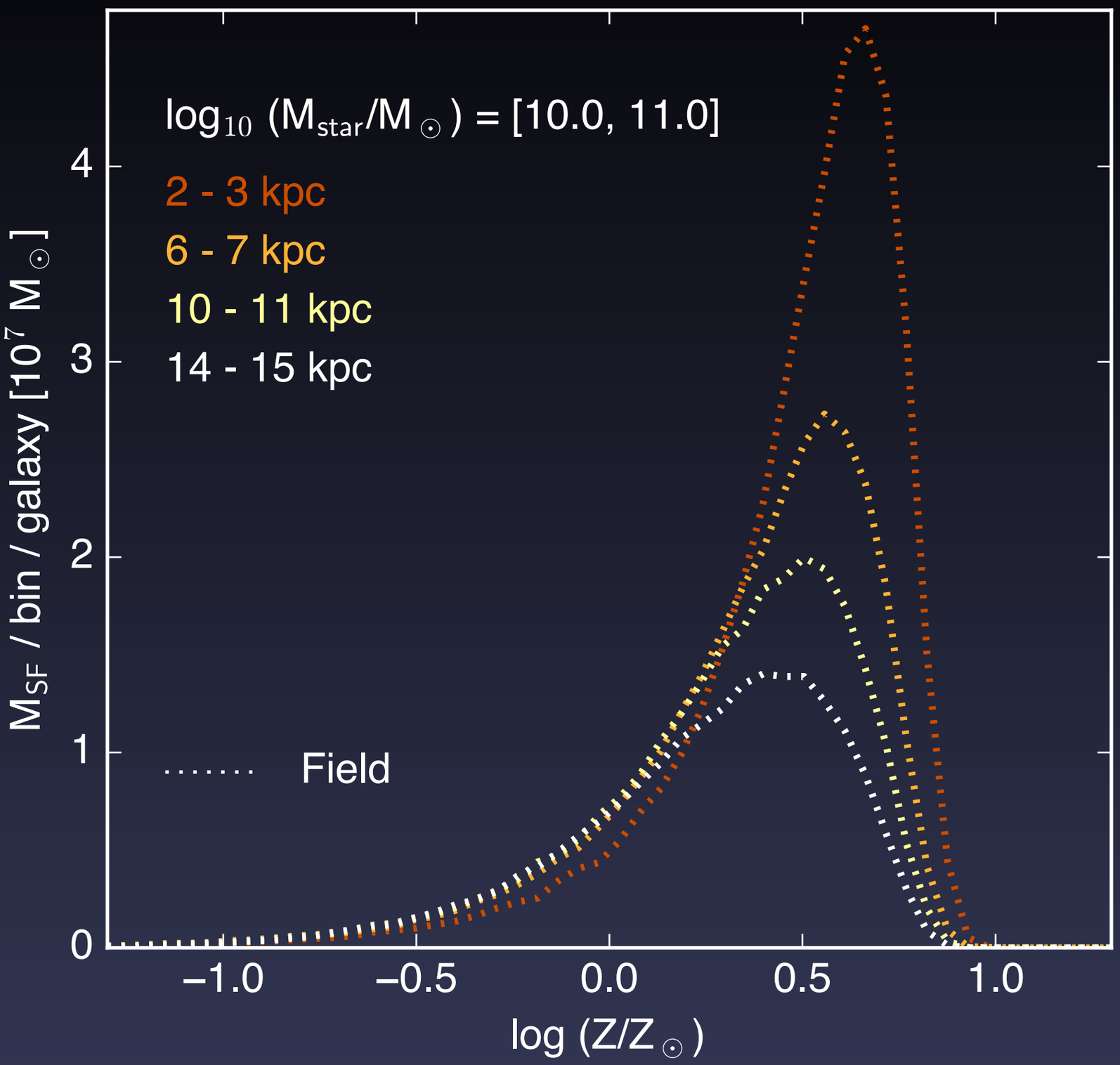
Preferential lack of (metal-poor) gas from outskirts

→ ram pressure stripping

[see also Genel 16]

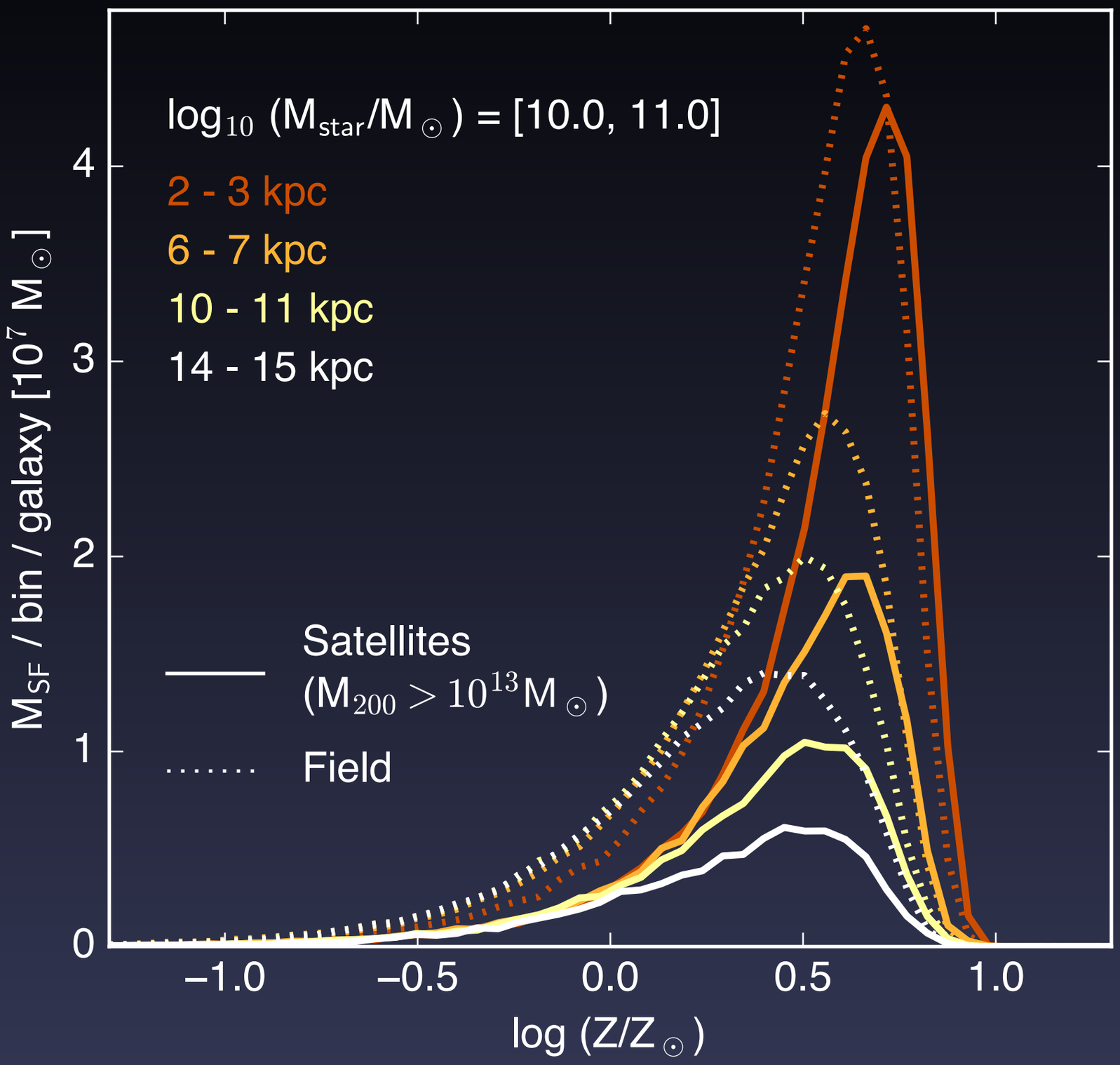
Metallicity also enhanced at fixed radius…

Origin of gas metallicity excess



Distribution of particle metallicities in radial bins

Origin of gas metallicity excess



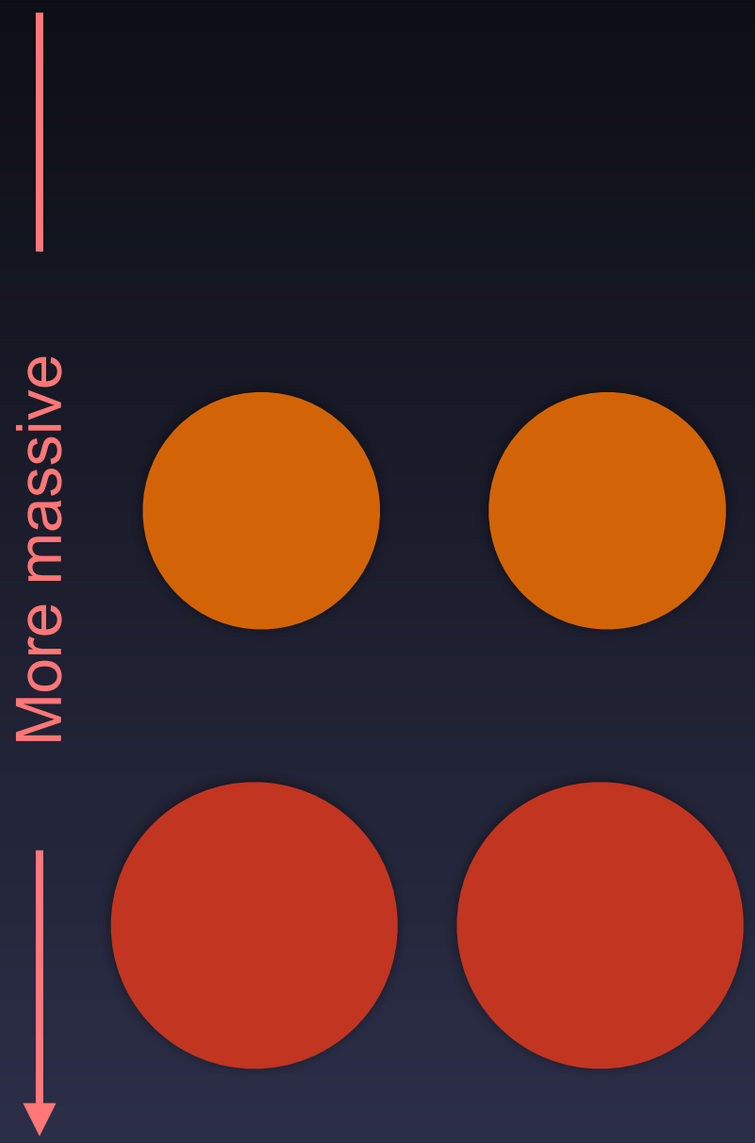
Distribution of particle metallicities in radial bins

Preferential absence of metal-poor particles in satellite galaxies
→ “strangulation”

Stellar metallicity

Stellar metallicity and mass loss

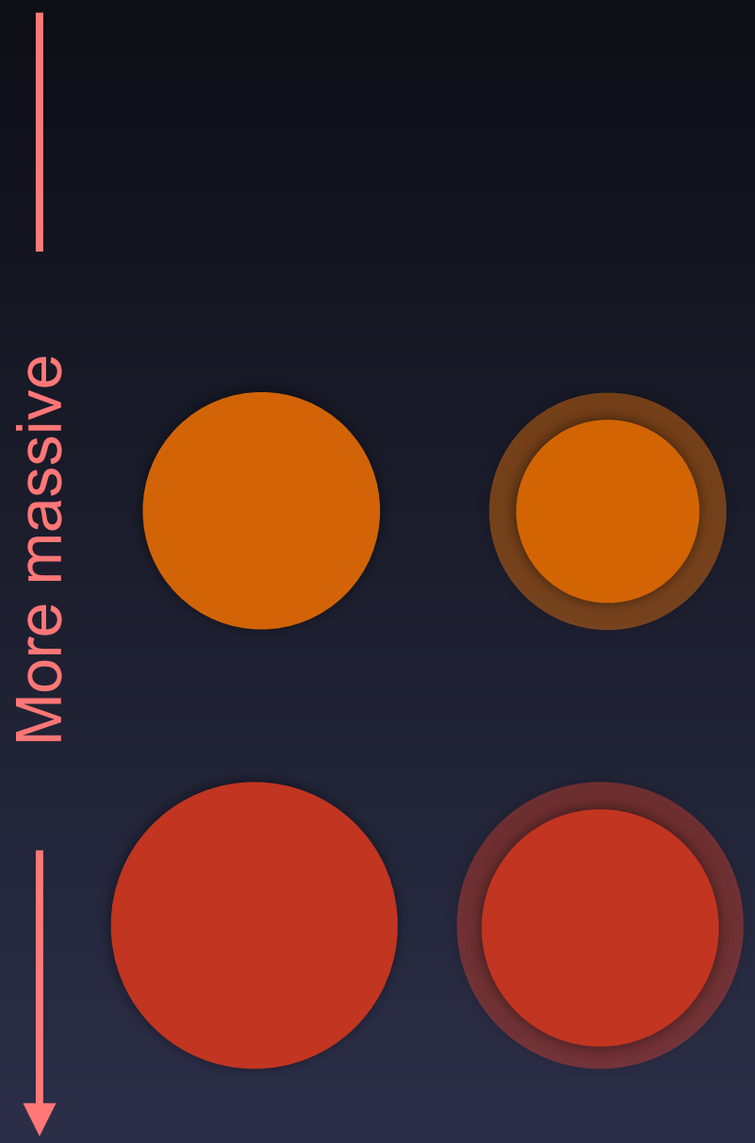
Field Satellite



(redder =
higher metallicity)

Stellar metallicity and mass loss

Field Satellite



(redder =
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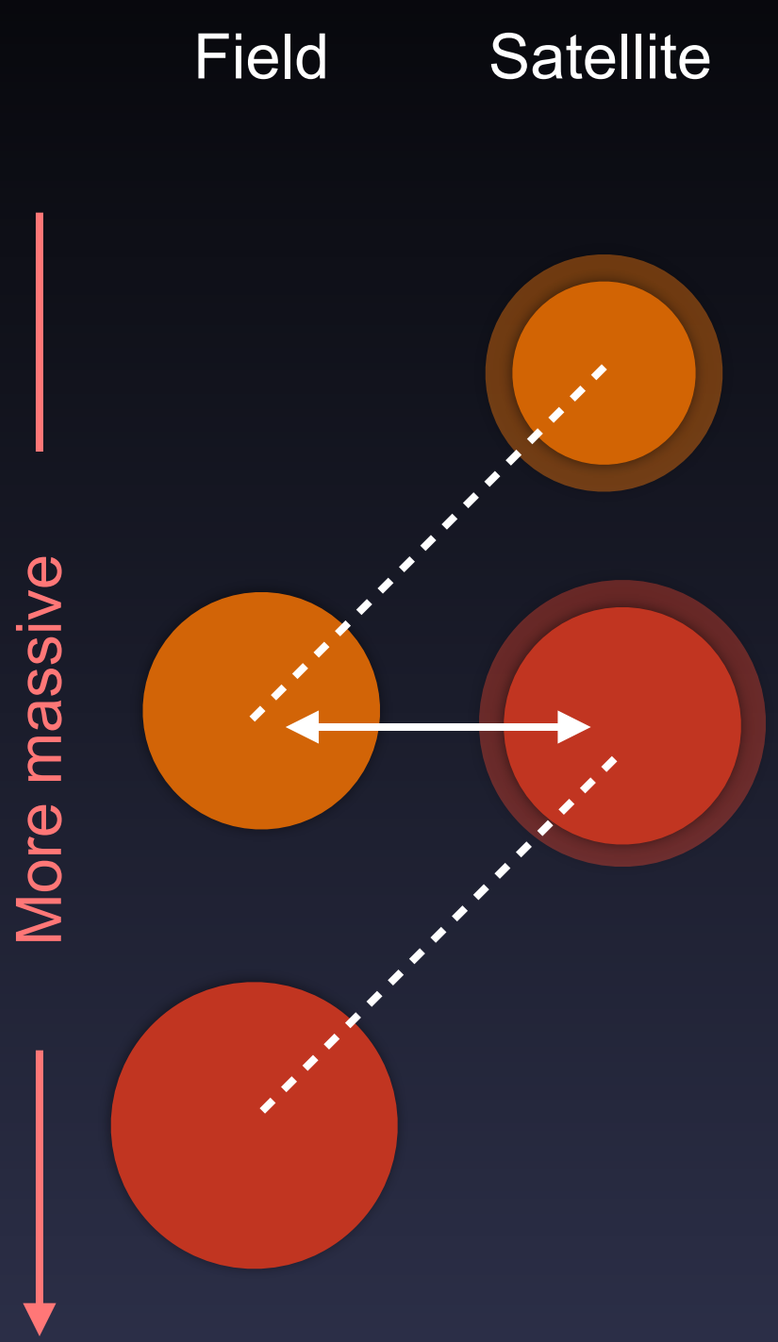
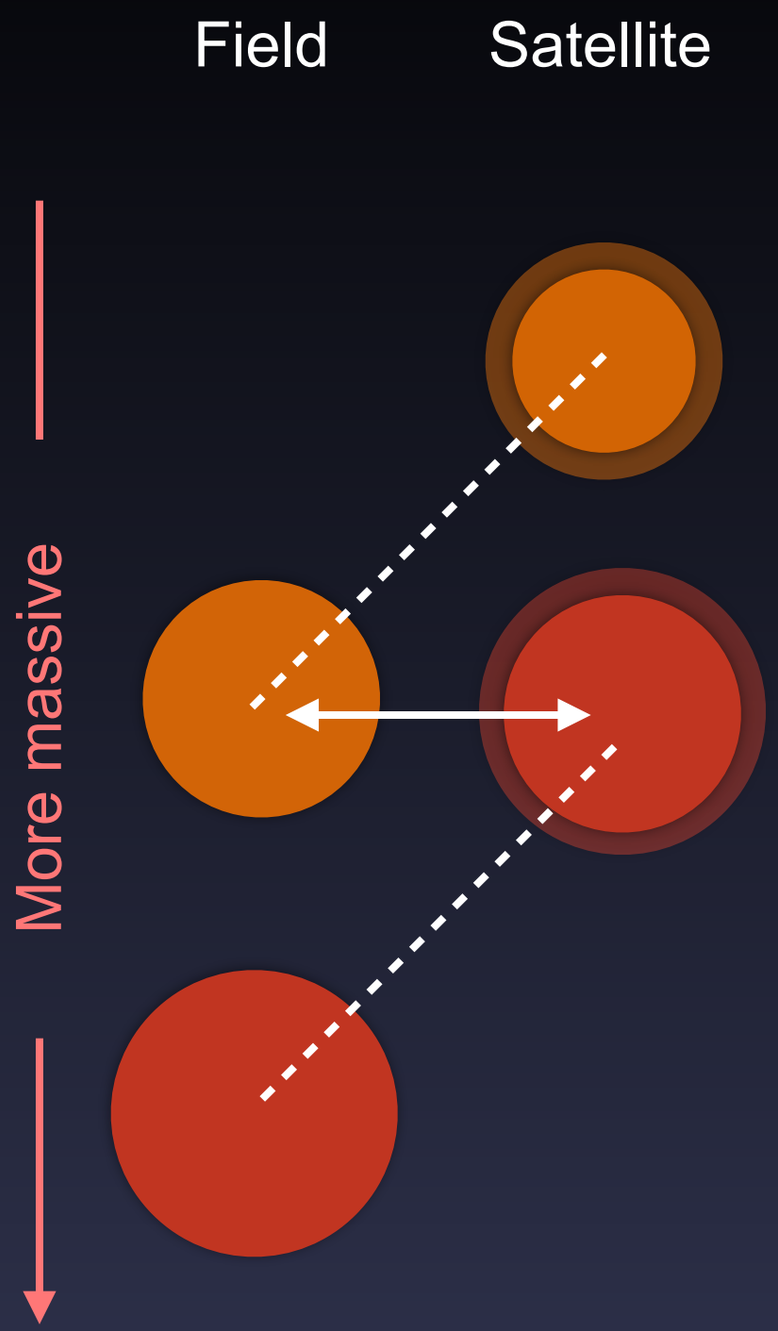
Stripping of stars
in satellites

Stellar metallicity and mass loss



Apparent metallicity increase in satellites
[Pasquali+10]

Stellar metallicity and mass loss



(redder =
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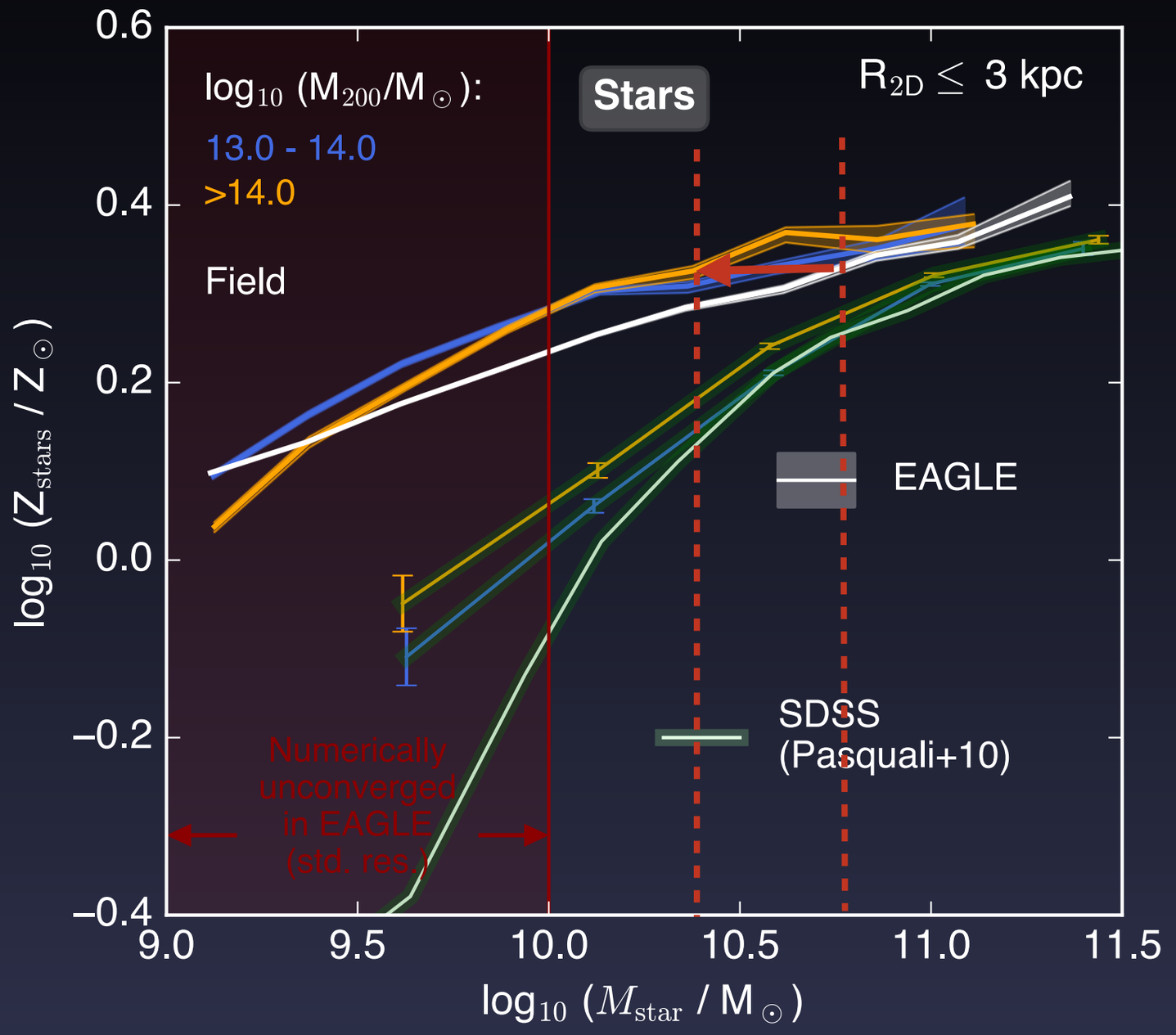
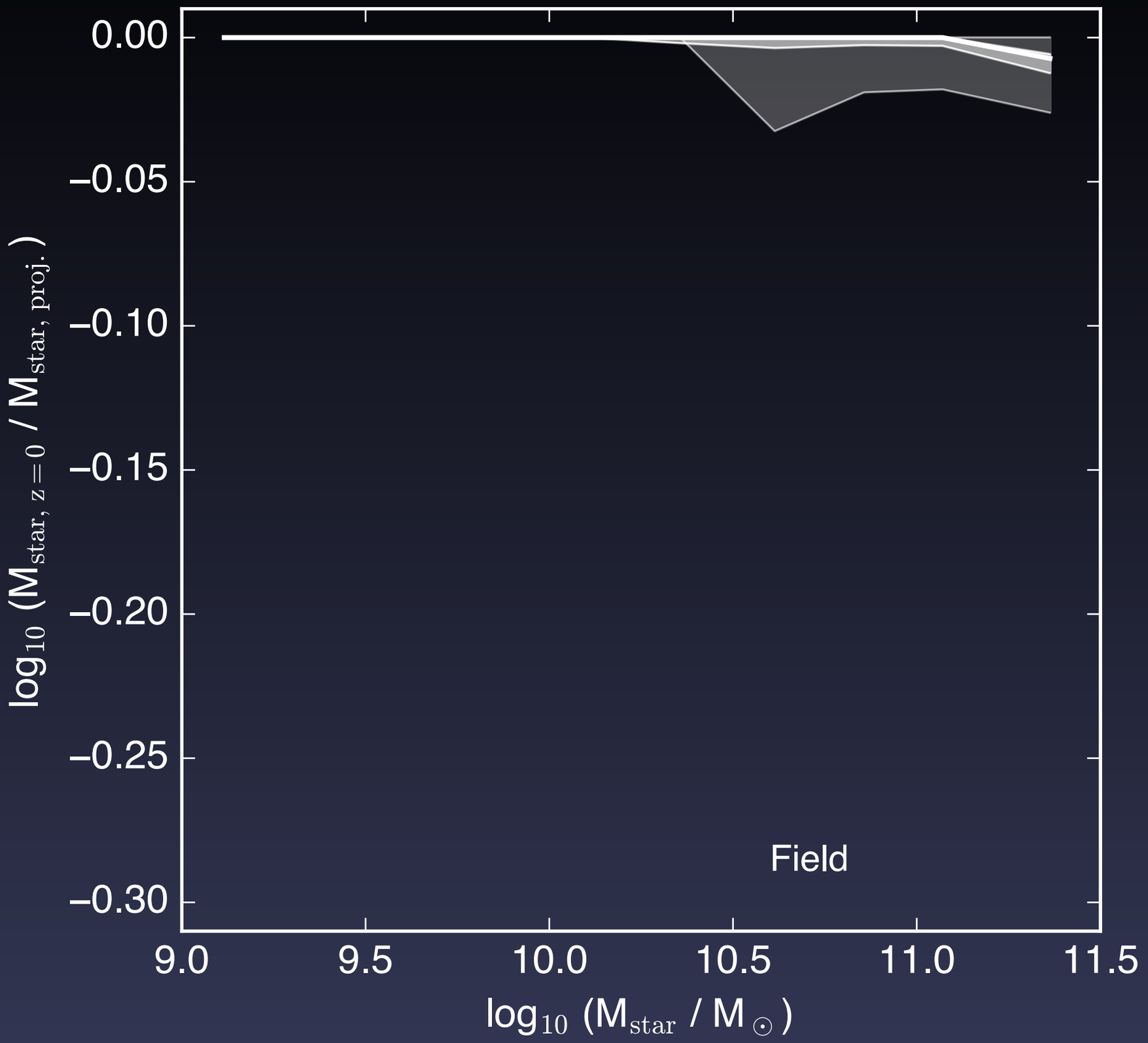


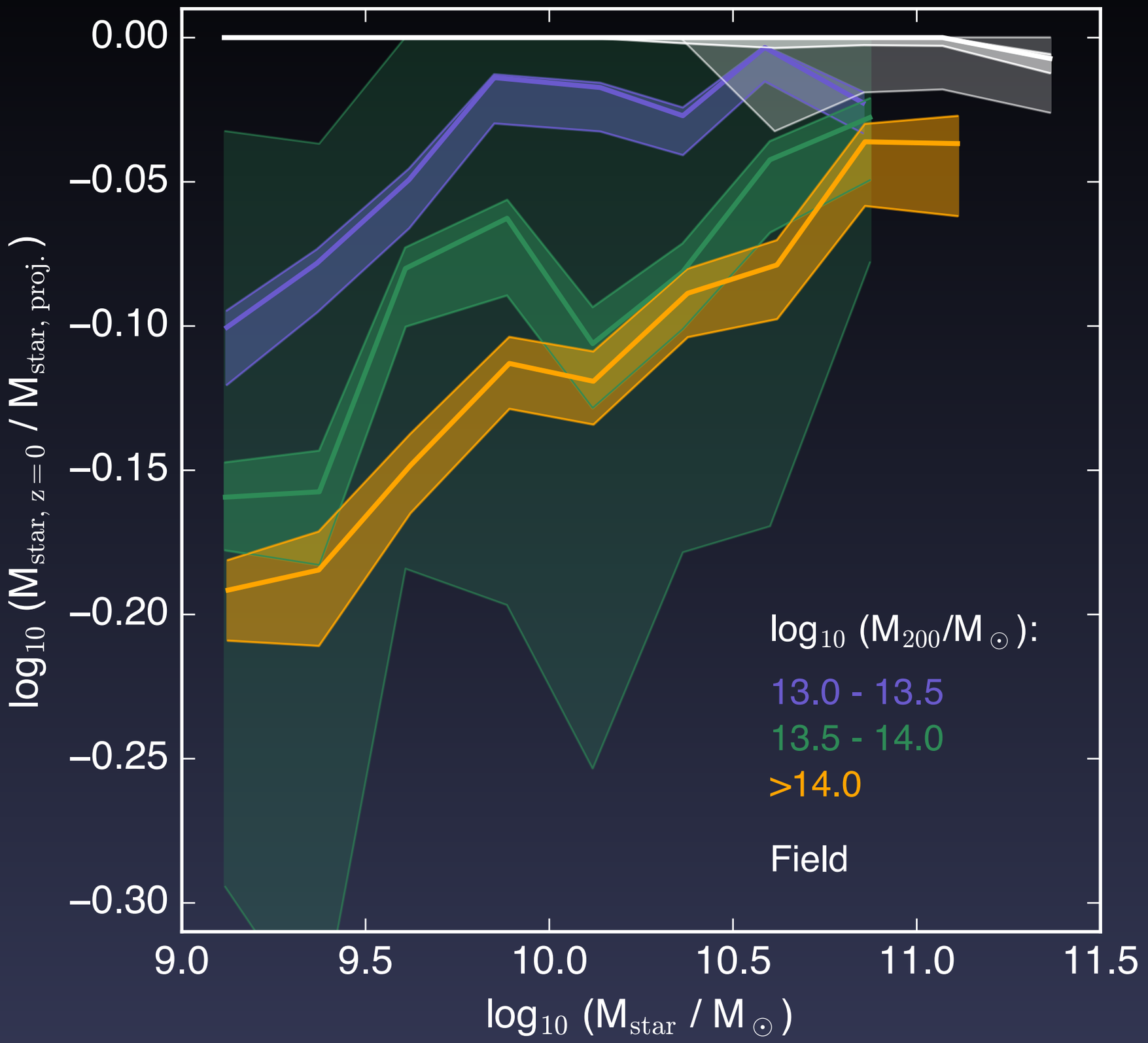
Requires ~0.4 dex loss of stellar mass

Stellar mass loss in EAGLE



N.B.: includes ‘missed growth’ of satellites after quenching

Stellar mass loss in EAGLE



Mass loss <u>in surviving galaxies</u> not strong enough to account for metallicity difference
[c.f. Pasquali+10]

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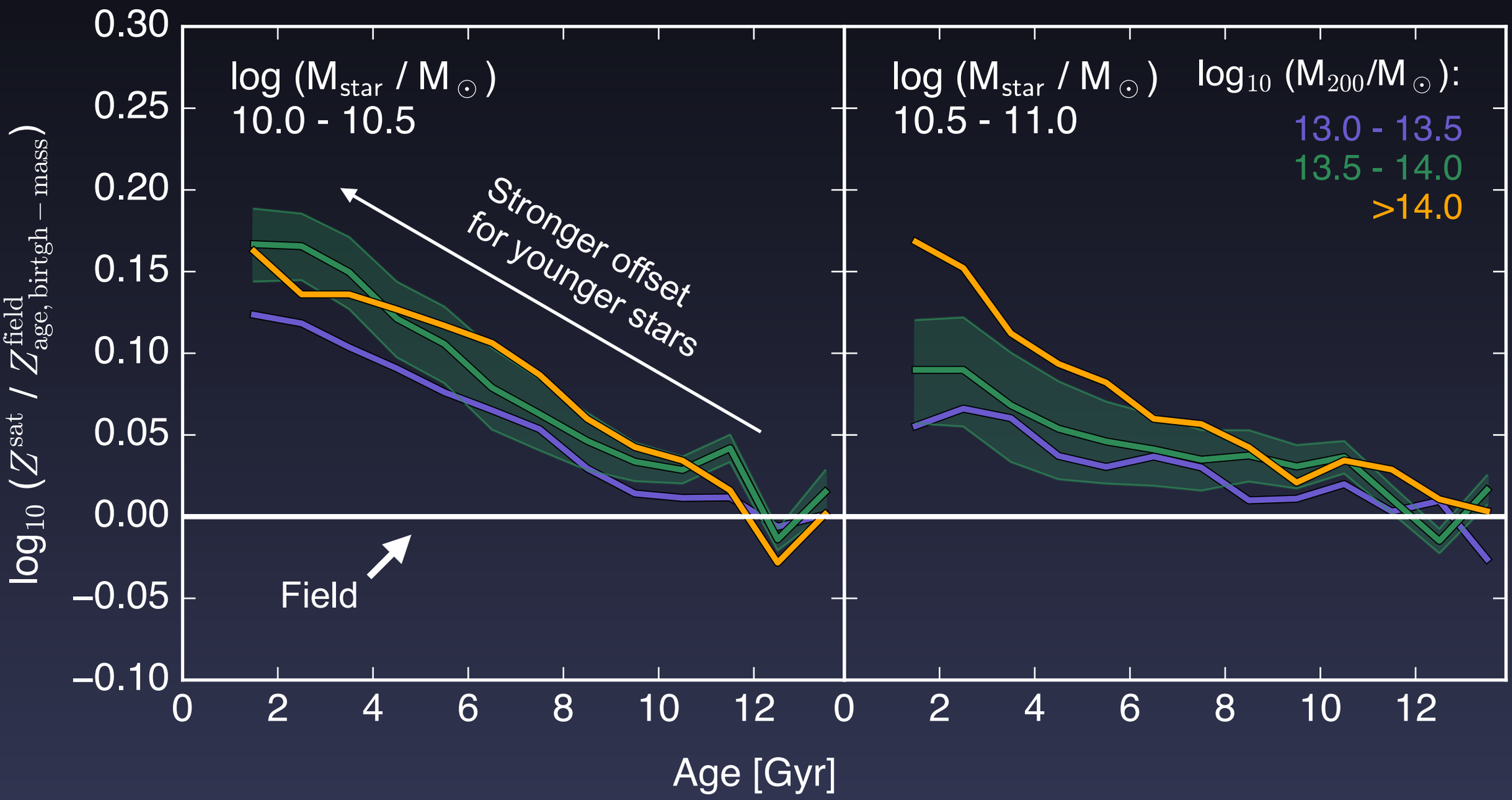
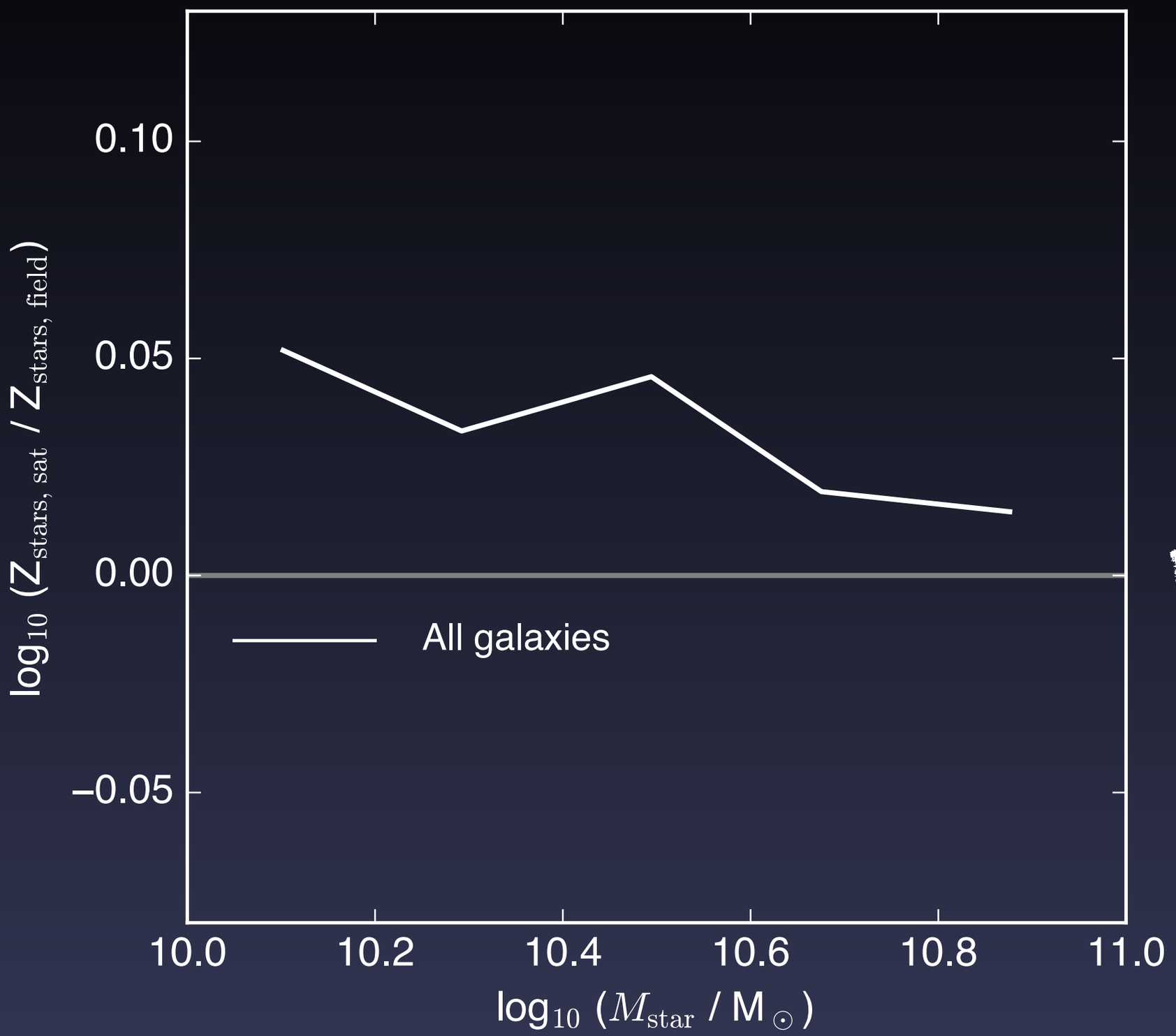
Direct environmental influence

Difference between metallicity of stars in satellites and matched field stars (same age, born in galaxy of same M_{star})

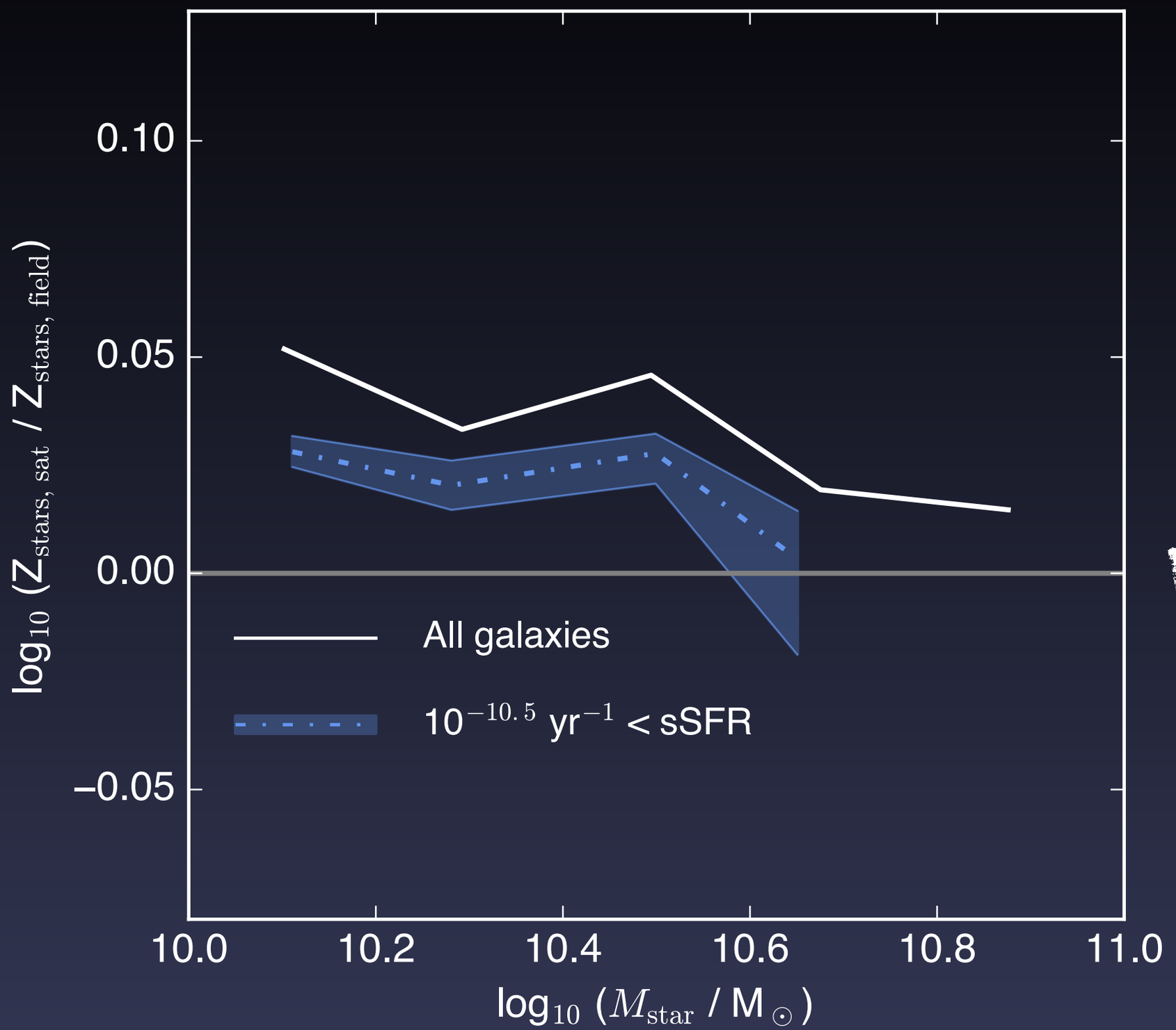


Stellar metallicity: connection to star formation



Excess stellar metallicity in satellites compared to field

Stellar metallicity: connection to star formation



Excess stellar metallicity in satellites compared to field

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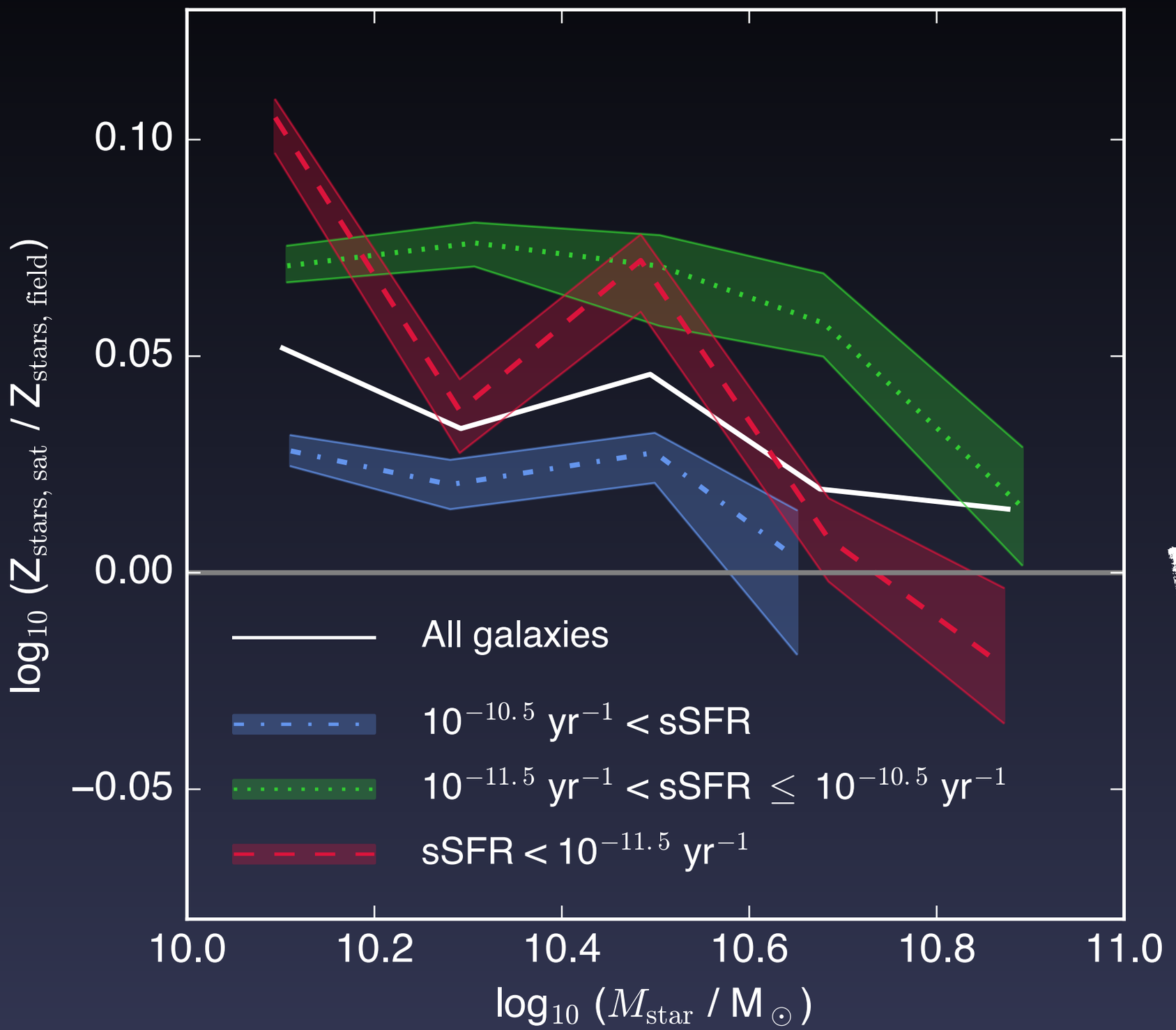
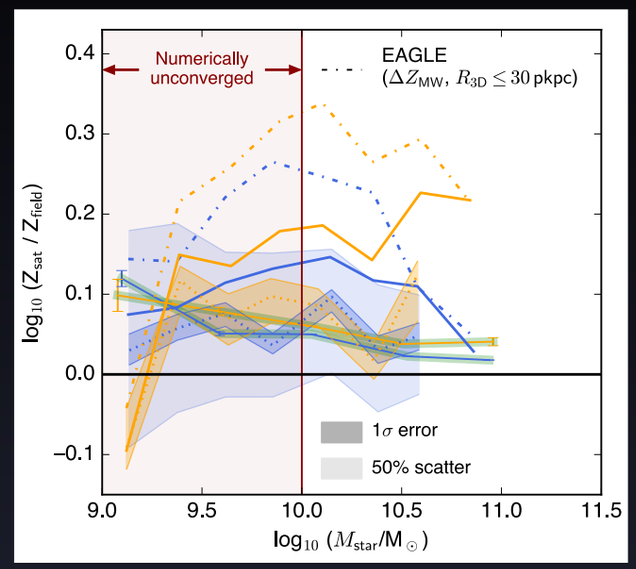


Direct connection between star formation quenching and metallicity enhancement in EAGLE

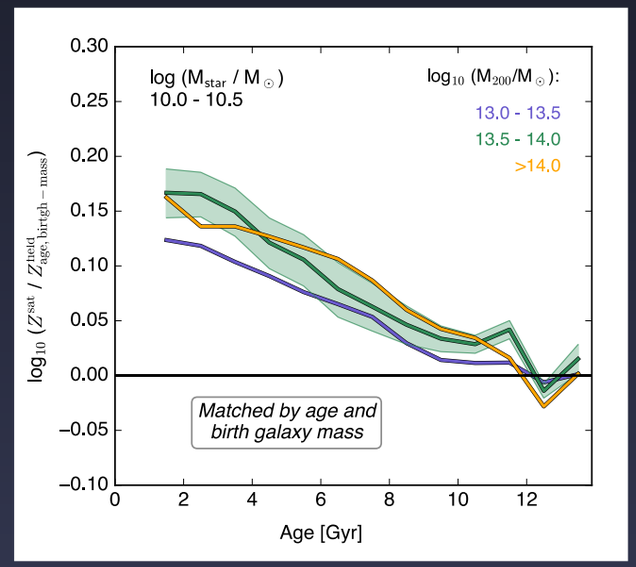
Excess stellar metallicity in satellites compared to field

Summary

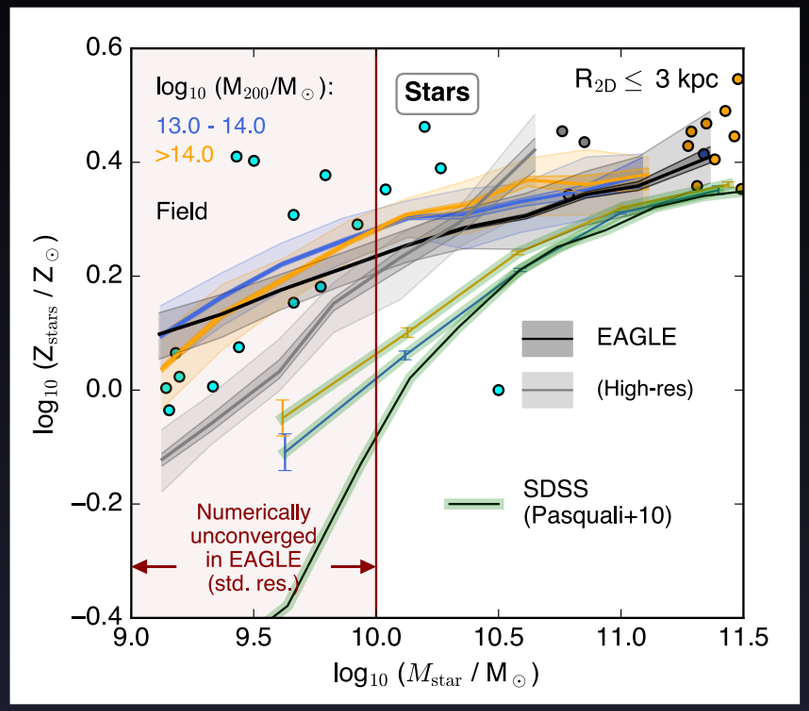
- Observations of enhanced metallicity (gas and stars) in satellite galaxies reproduced by EAGLE
- Magnitude of effect is sensitive to metallicity measurement and galaxy selection

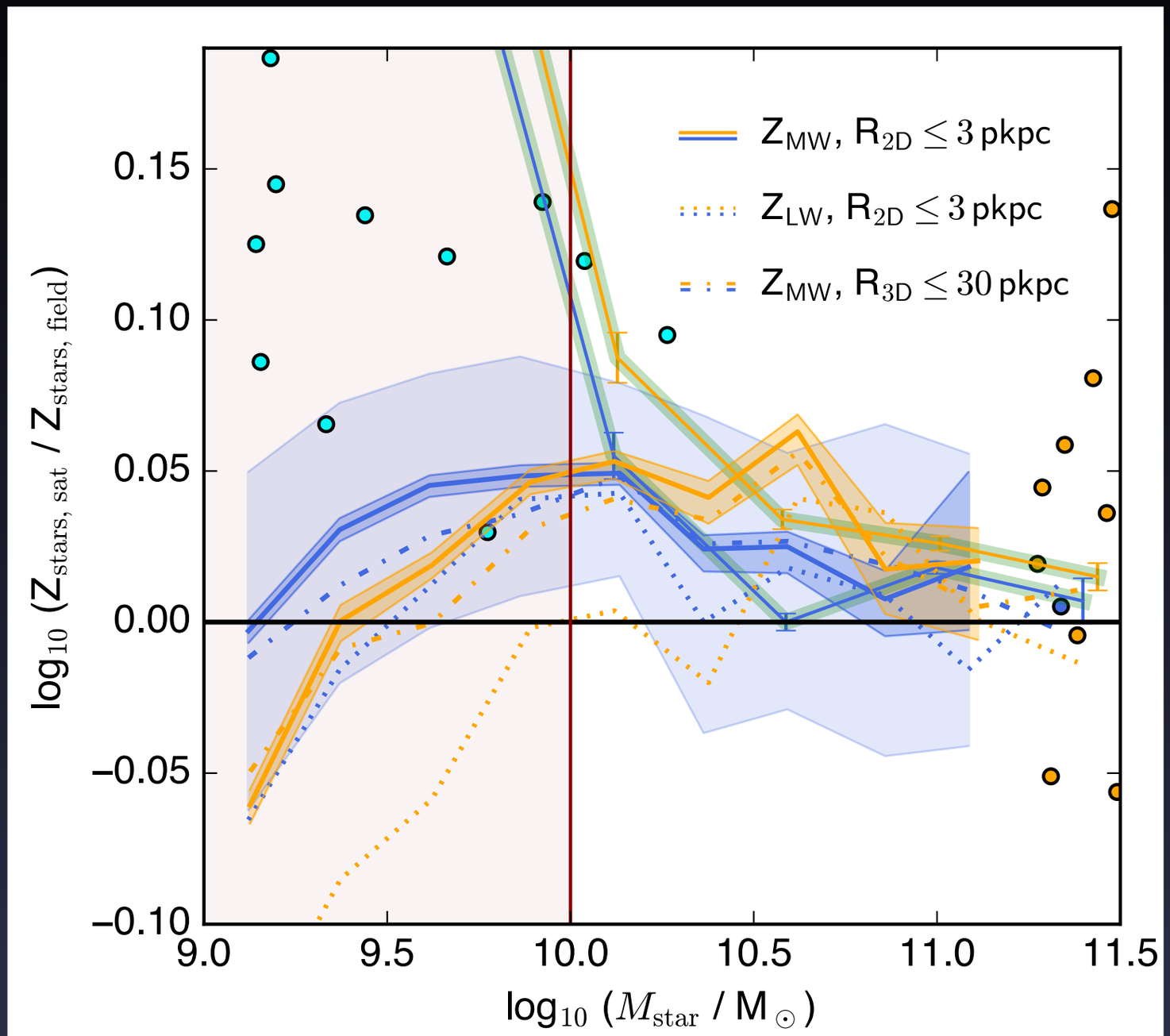


- Gas metallicity enhanced due to ram pressure stripping of metal-poor gas, and suppressed inflows (strangulation)
- Stellar mass loss cannot explain stellar metallicity excess - directly linked to raised gas metallicity



Eagle: Satellite metallicities (stars)

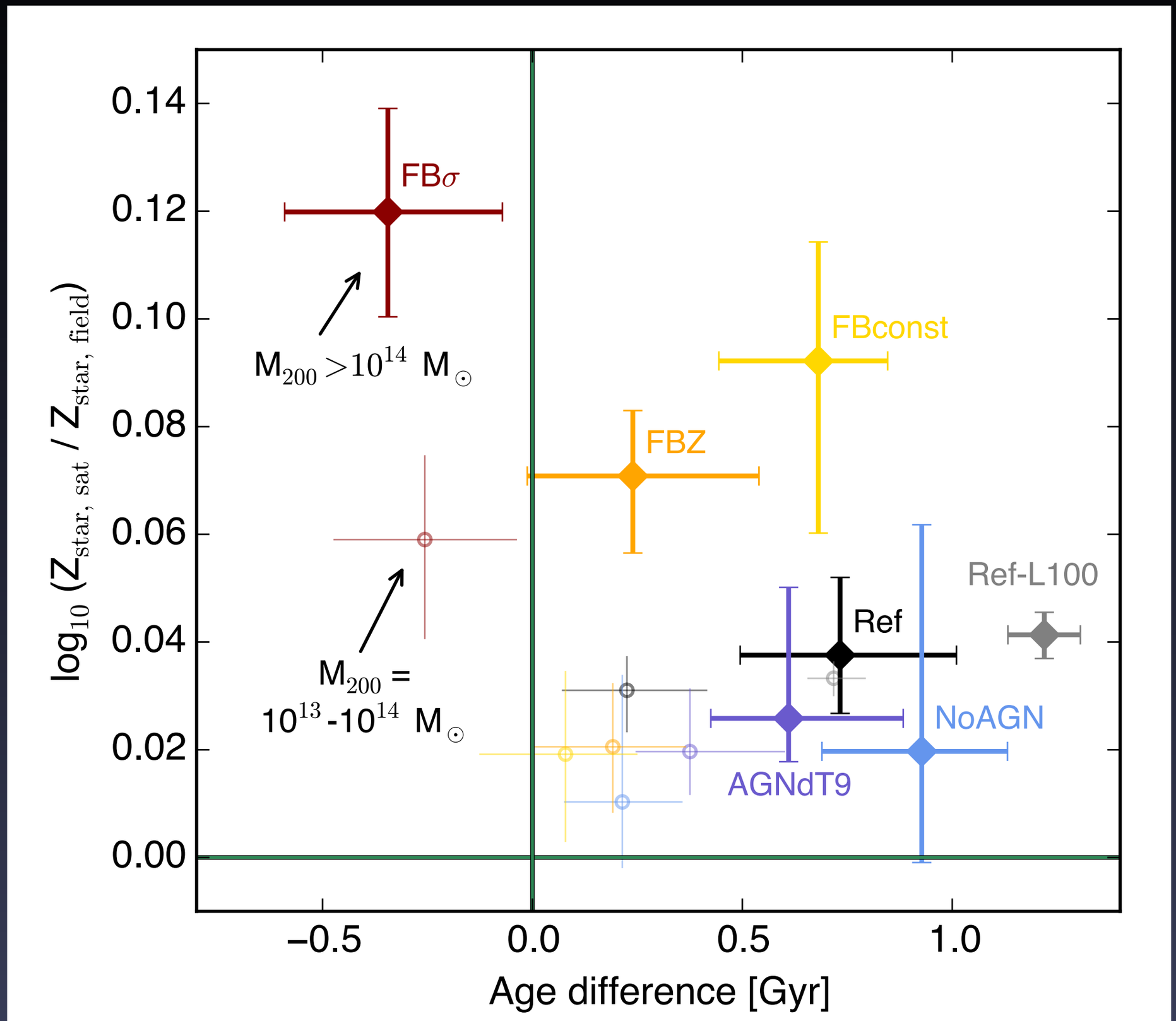




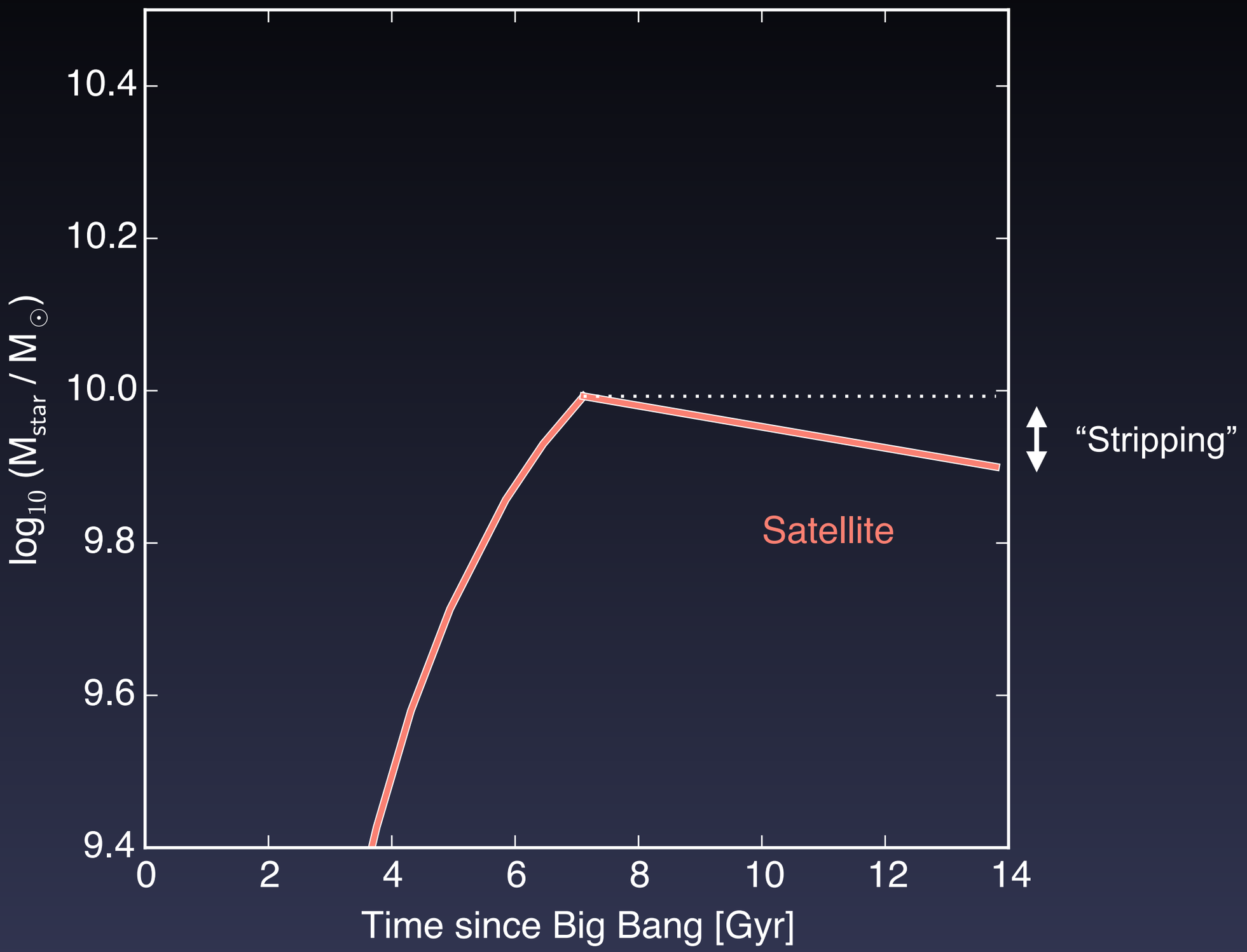
General agreement, but effect possibly too small at M_{star} $10^{10.5}$ $M_\odot$

N.B.: Observations adjusted for $Z_\odot$ = 0.012 [Allende-Prieto et al., 2001]

EAGLE subgrid comparison



“Missed growth” of satellites



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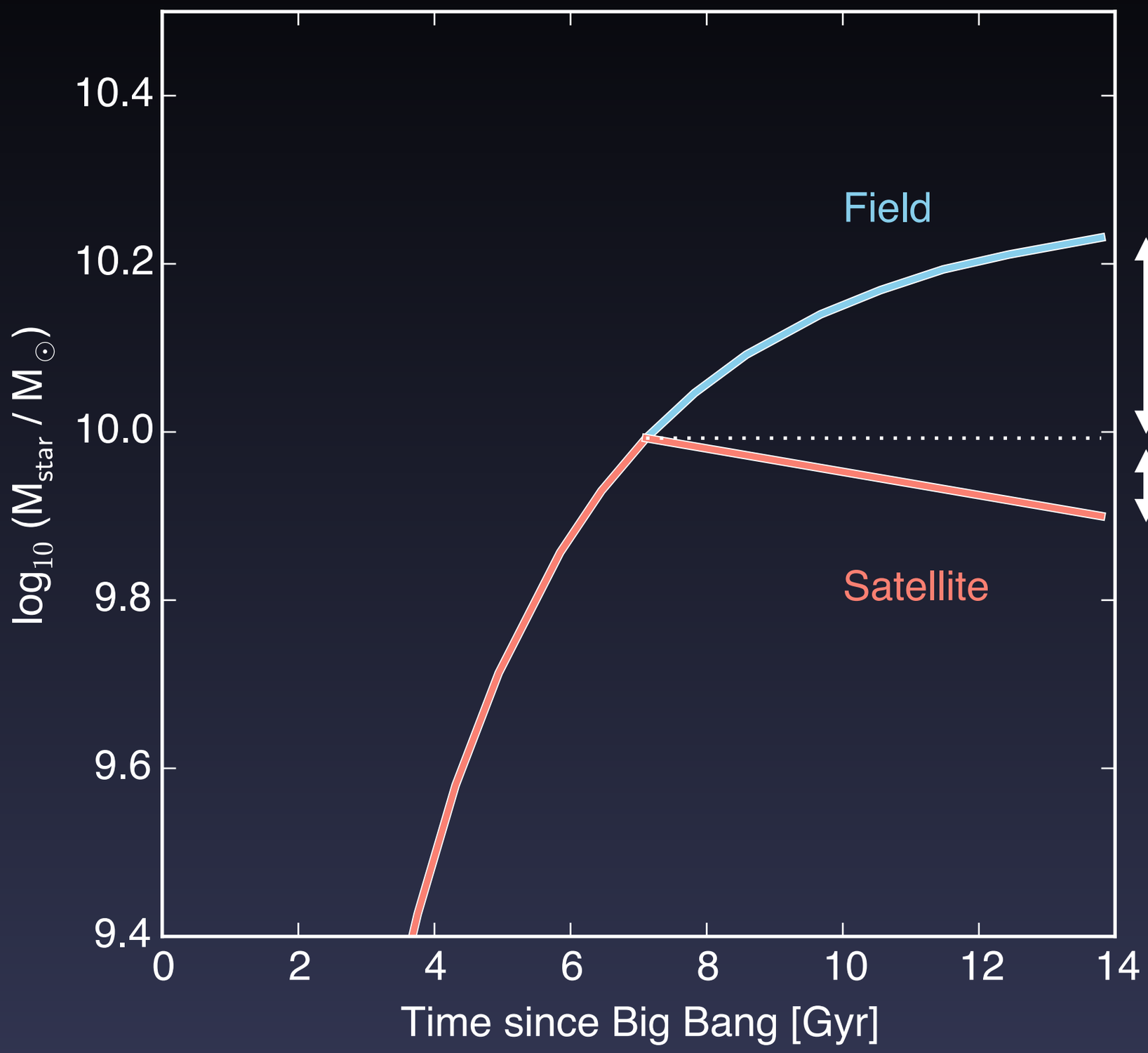
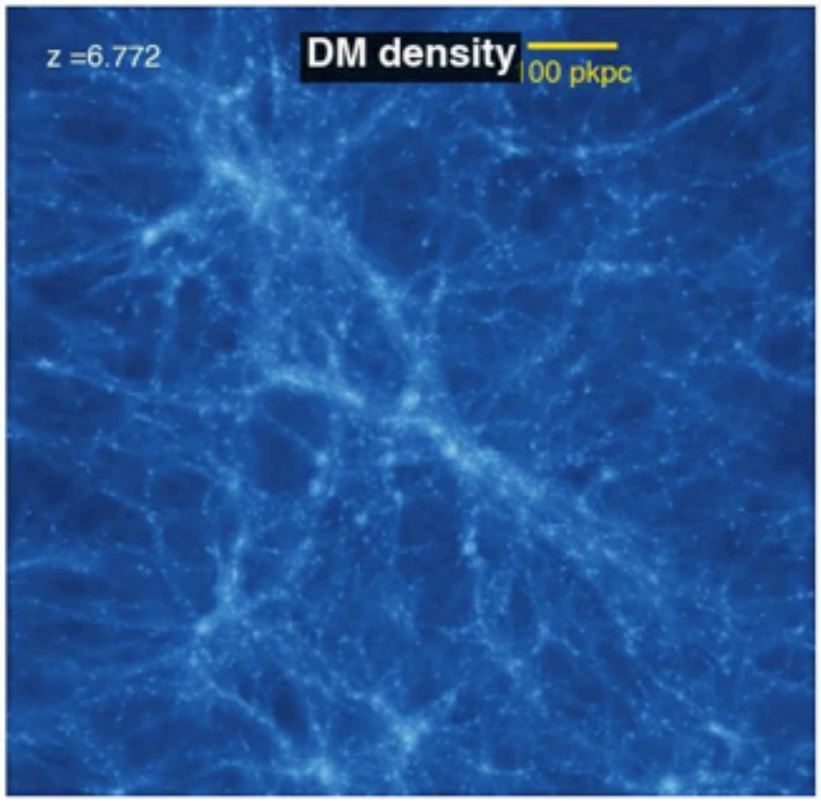
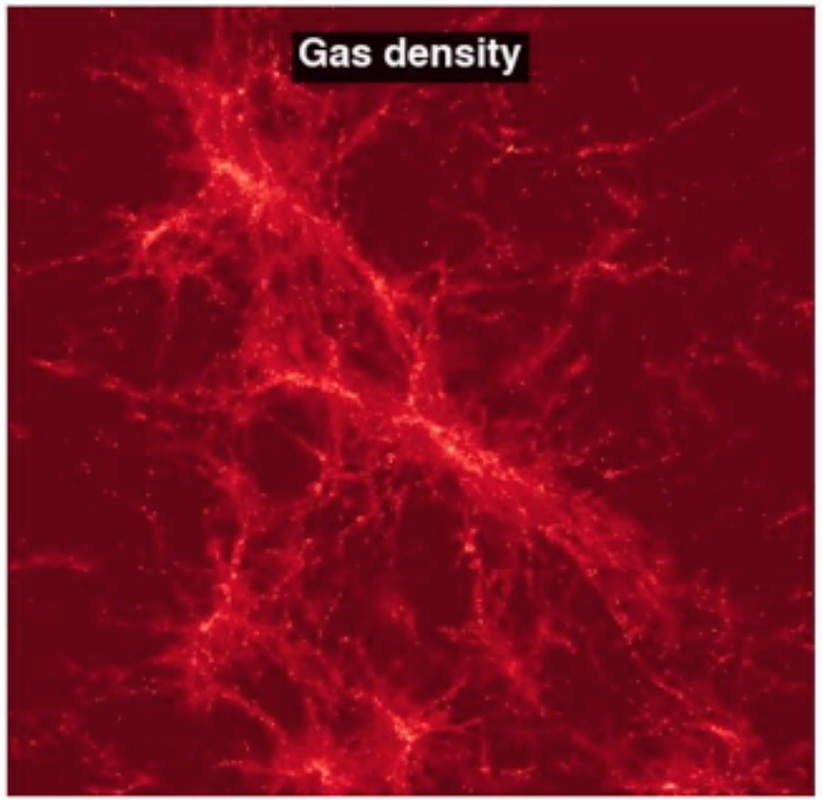
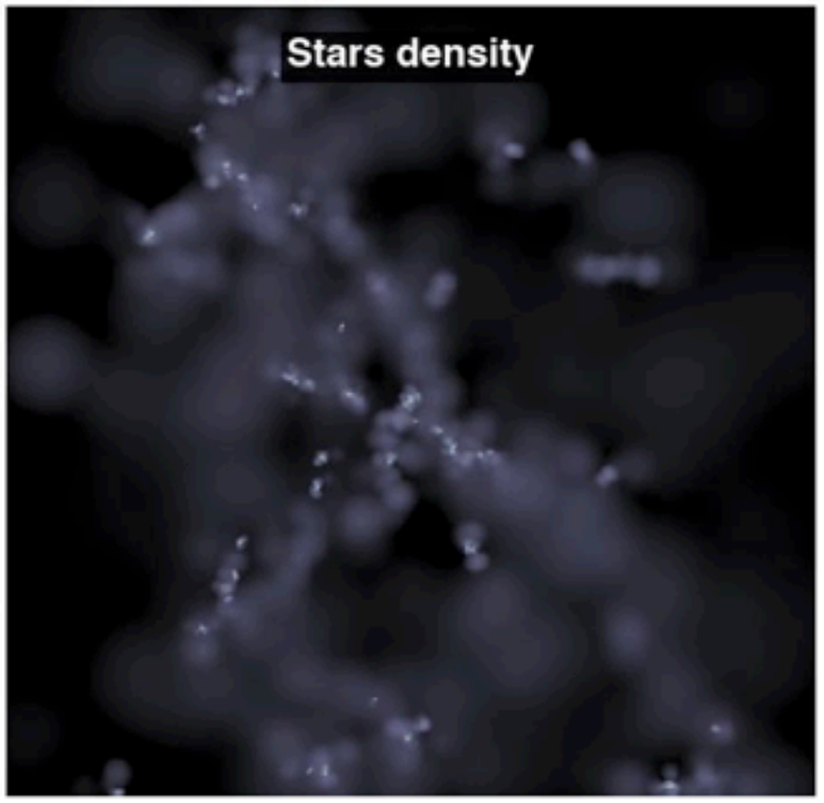
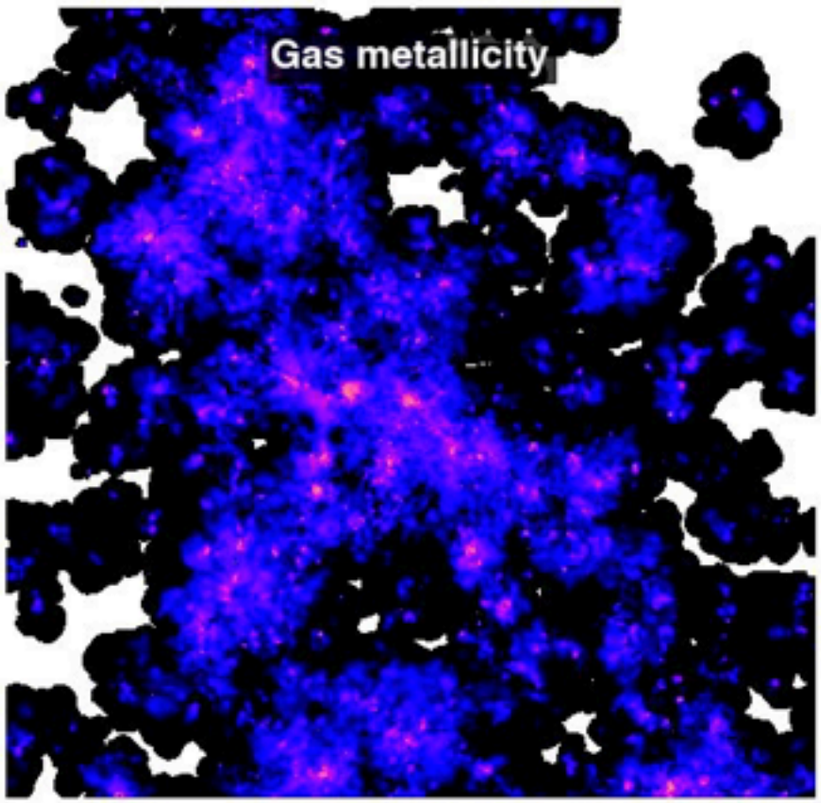


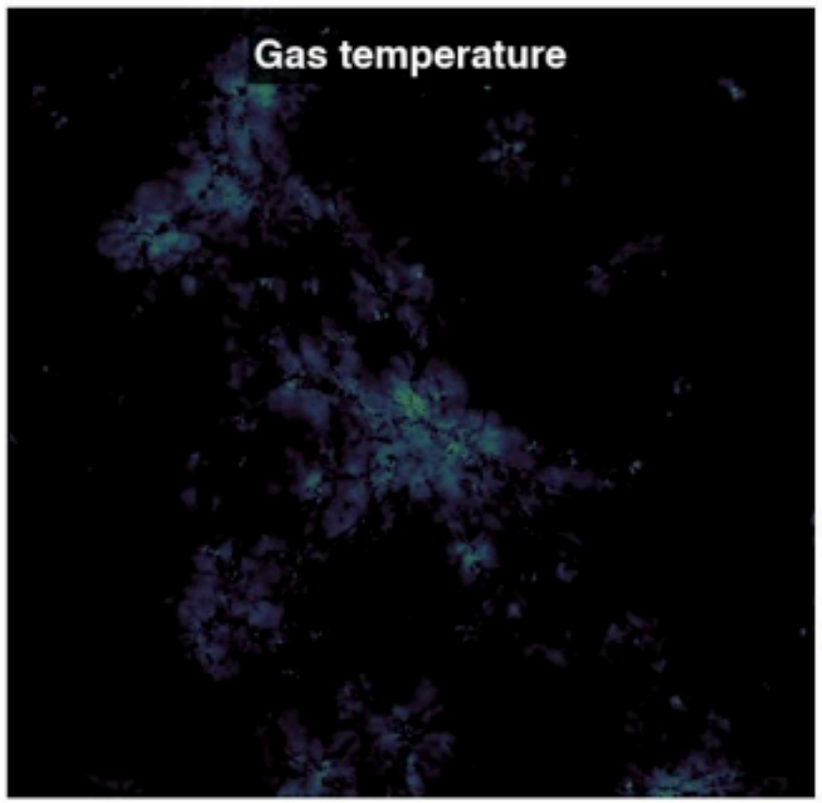
Account for missed growth by matching to field galaxies at redshift of maximum M_{Star}: “forward-projected”

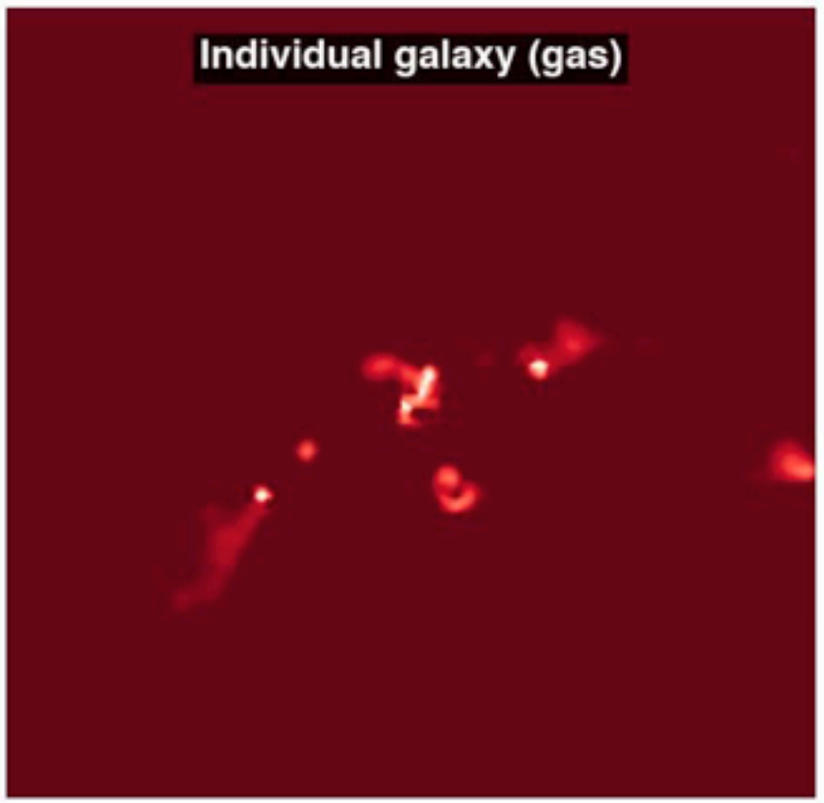

z =6.772
DM density
00 pkpc


Gas density


Stars density


Gas metallicity


Gas temperature


Individual galaxy (gas)