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SDSS-IV MaNGA: the spatial distribution of star formation and its dependence on mass, structure, and environment

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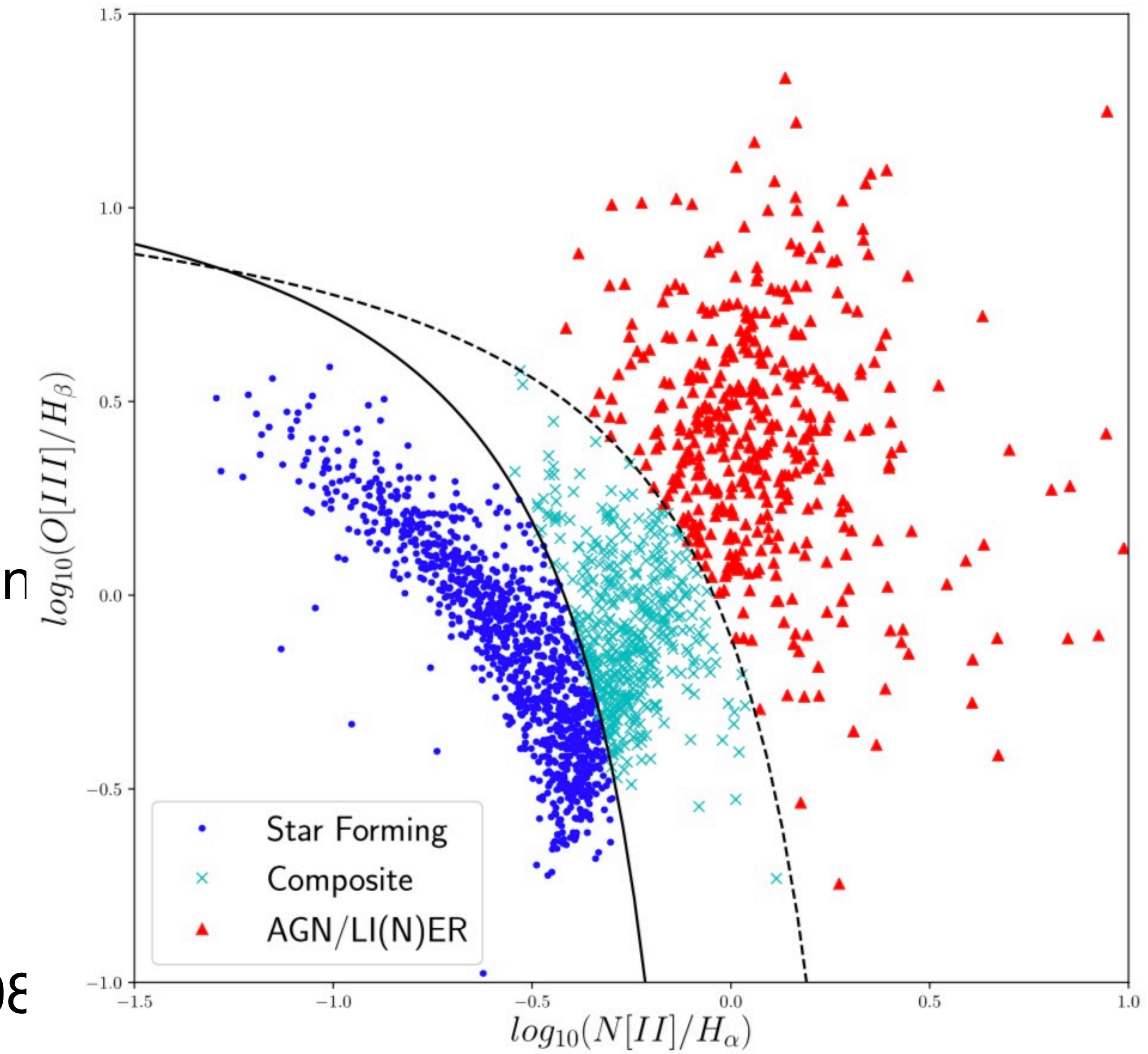
SDSS-IV MaNGA: the spatial distribution of star formation and its dependence on mass, structure, and environment

1. Introduction

- Galaxies (bimodality) (e.g. Strateva et al. 2001; Bell et al. 2004; Faber et al. 2007 …)
  - Star-forming galaxies (SFGs): blue, disk-like, younger stellar population…
  - Quiescent galaxies (QGs): red, spheroid-like, older stellar population…
- Since z ~ 1, number density (SFGs) remains constant, while number density (SFGs) increases.
- SFG-> QG (Quenching): Combined
  - Mass ~ intrinsic properties: AGN feedback, morphological, bar, halo-shock heating … In-out
  - Environment ~ extrinsic properties: ram pressure stripping, tidal stripping, strangulation … Out-in
- IFU: trace signals from mass based and environment based quenching, ‘inside-out’ and ‘outside-in’.
- **Motivation**: investigate the **shapes of the galaxy’s sSFR profiles** and whether there is an inside-out or outside-in **suppression of star formation** with respect to galaxy’s internal and external properties.

2. Data



- **SDSS-IV MaNGA DR14**: 2791 galaxies
    - DAP: Ha flux, Dn4000, core velocity dispersion
    - Pipe3D: stellar mass density
- **Selection**:
    - Based on Hα, Hβ, [N II] (6585), and [O III] (5008
    - Remove sSFR<-11.5, b/a<0.3, BPT lineless galaxies (SNR < 2)
- Other catalogues:
    - Yang Group catalog: Central/Satellite classifications, halo masses, and group luminosities.
    - Baldry et al. (2006): Environment densities $\log_{10}(\Sigma) = 0.5 * \log_{10}(\Sigma_4) + 0.5 \times \log_{10}(\Sigma_5)$,
- Final sample: **1494 galaxies**, **1016 star forming**, **364 composite**, and **114 AGNs/LI(N)ERs**.

3. SFR (spaxel)

- 1. **SF & composite spaxels** (Hα)

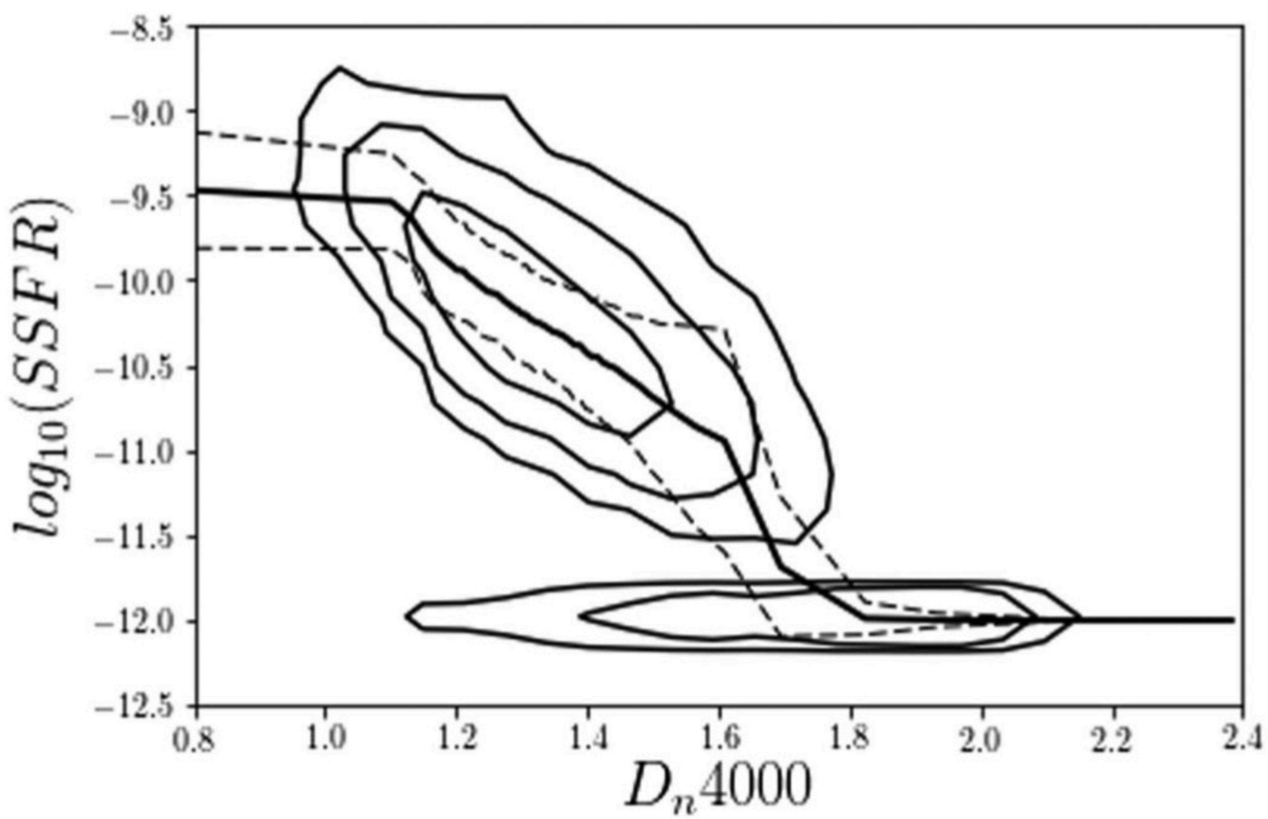
the relation from Kennicutt (1998), for a Salpeter (1955) IMF:

$$\mathrm{SFR}(L_{\mathrm{H}\alpha}) = L_{\mathrm{H}\alpha}/10^{41.1} \quad (2)$$

Cardelli, Clayton & Mathis (1989) extinction law:

$$L_{\mathrm{H}\alpha}(\mathrm{Corrected}) = L_{\mathrm{H}\alpha}((L_{\mathrm{H}\alpha}/L_{\mathrm{H}\beta})/2.8)^{2.36}.$$

- 2. **AGNs/LINERs SFRs** (from Hα emission, BPT SF & composite spxels) to **model the dependence of sSFR on Dn4000**



Comparison

Dn4000 vs Ha

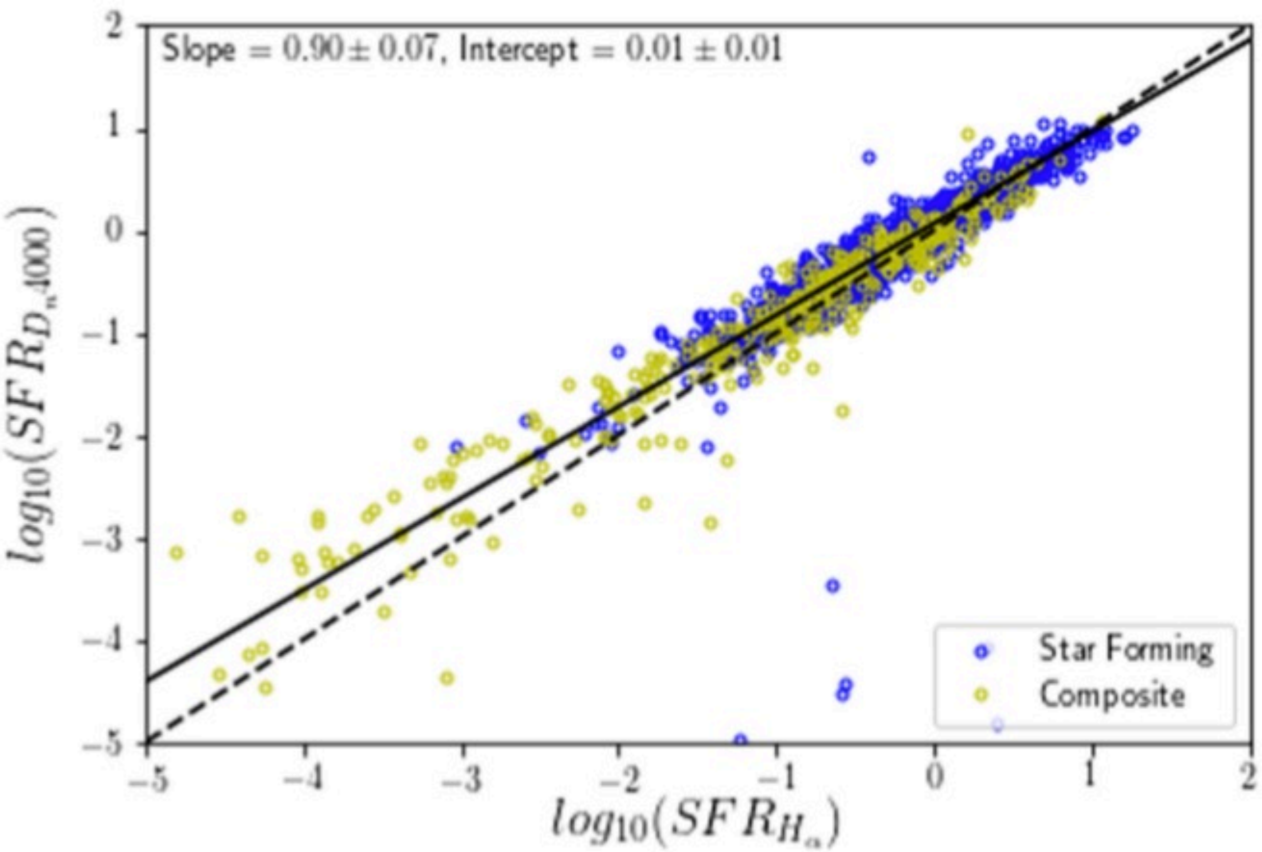


Figure 3. We show the star formation rates calculated using just the Hα method and just the D_n4000 method for star-forming and composite galaxies in MaNGA. The dashed line shows the 1-to-1 relation and the solid line shows the linear regression fit. We provide the slope and intercept of the fit in the top left corner, with errors calculated from 1000 bootstrap resamplings of the data.

MaNGA vs MPA-JHU

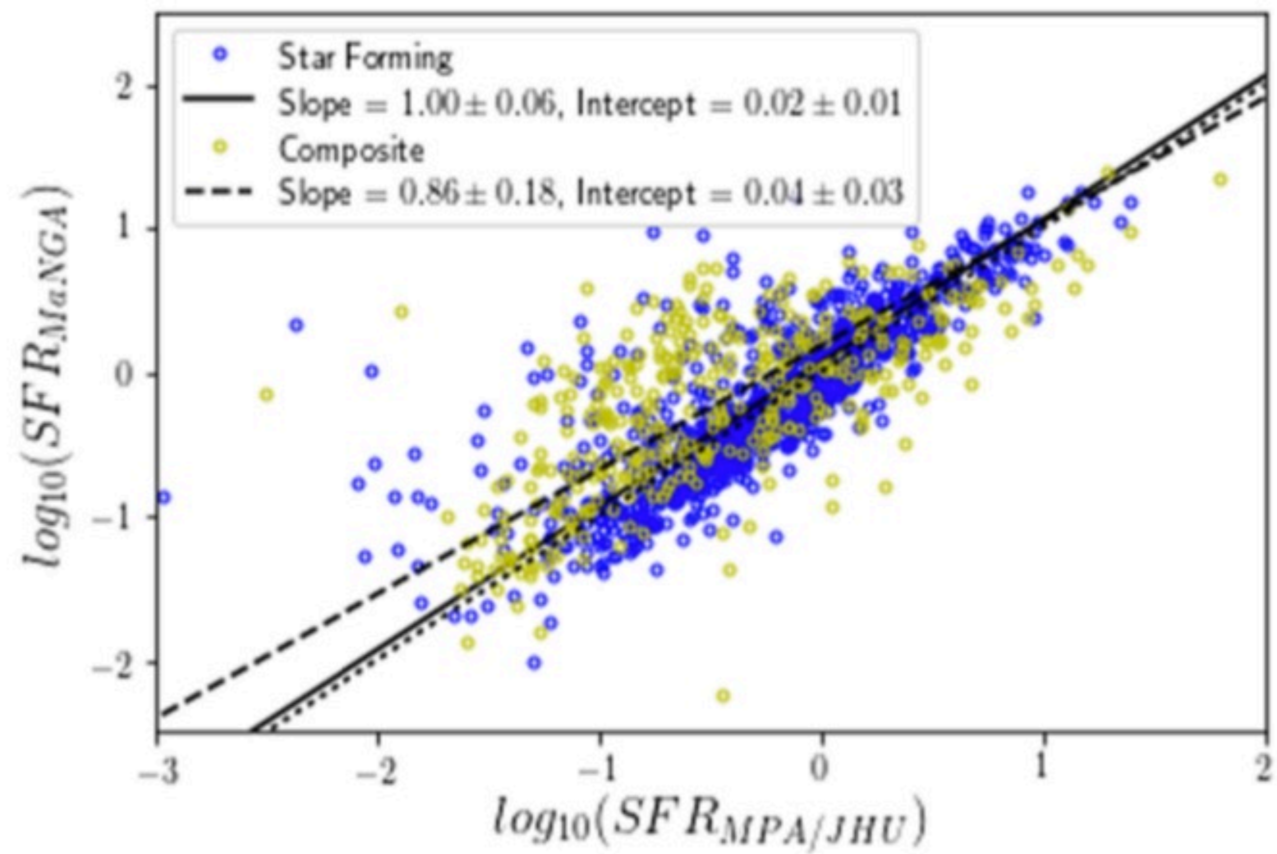


Figure 4. Values of the star formation rates calculated using the method described here for star-forming (blue) and composite (yellow) MaNGA galaxies, compared with their star formation rates calculated in B04 for the MPA/JHU catalogue. The dotted line shows the one-to-one relations, the solid line is the linear fit to the star forming galaxies, and the dashed line is the fit to the composite galaxies. The parameters of the fits are shown in the top left corner, with errors calculated from 1000 bootstrap resamplings.

Use the combination of H α and Dn 4000 star formation rates for their analysis

4. Results

Cen/solid   Sat/dashed

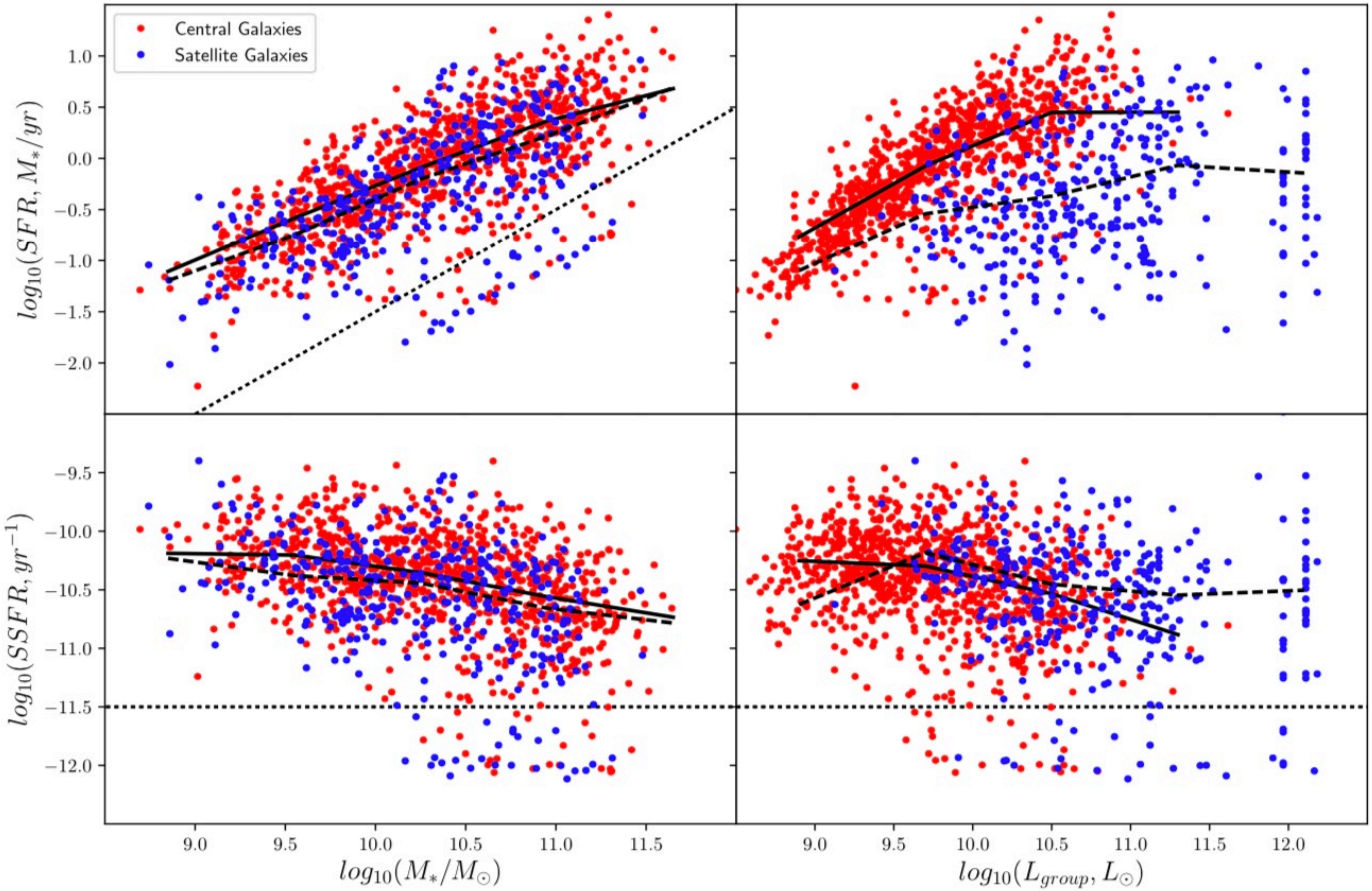


Figure 5. We show the relationships between stellar mass in the left column, group luminosity in the right column, star formation rate in the top row, and specific star formation rate in the bottom row, for galaxies with star-forming and composite BPT types. Galaxies are coloured based on their environment, with centrals in red and satellites in blue. We include the mean values of SFR and SSFR at fixed M_* and L_{group} as solid lines for centrals and dashed lines for satellites. The dotted lines indicate the position of the sample cut in specific star formation rate at $\log_{10}(SSFR) = -11.5$.

Radial sSFR profiles (Out to 1.5Re)

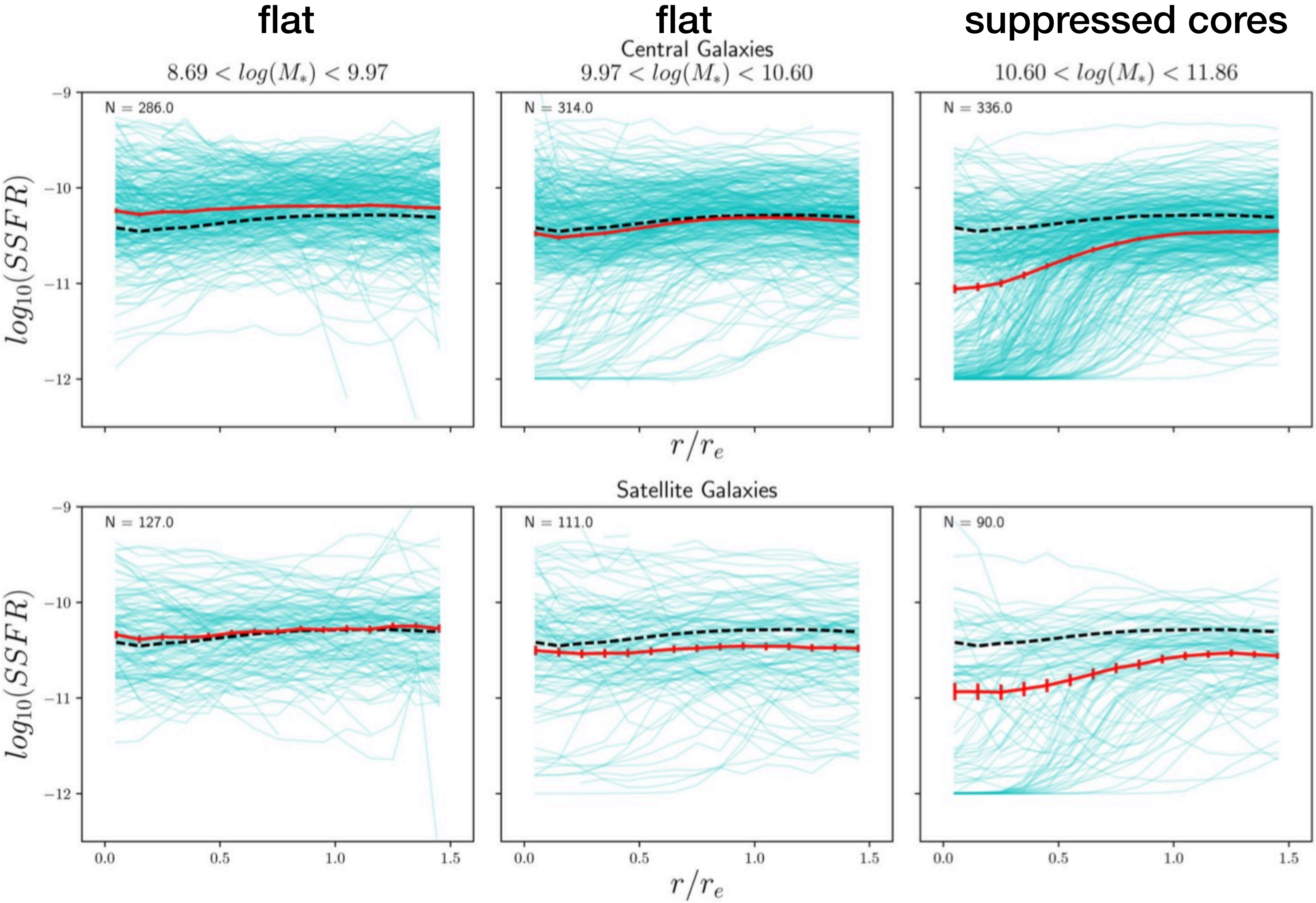
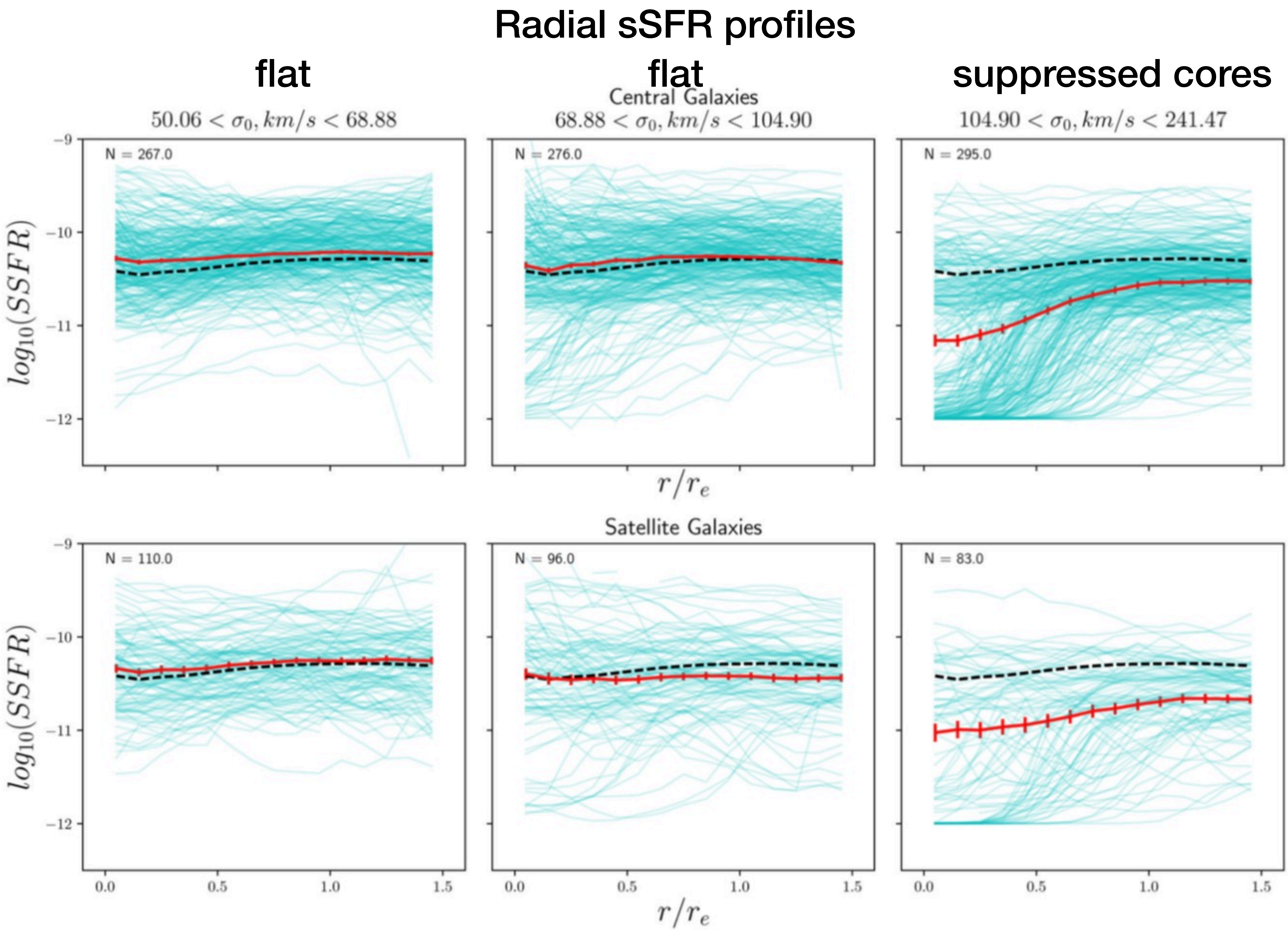
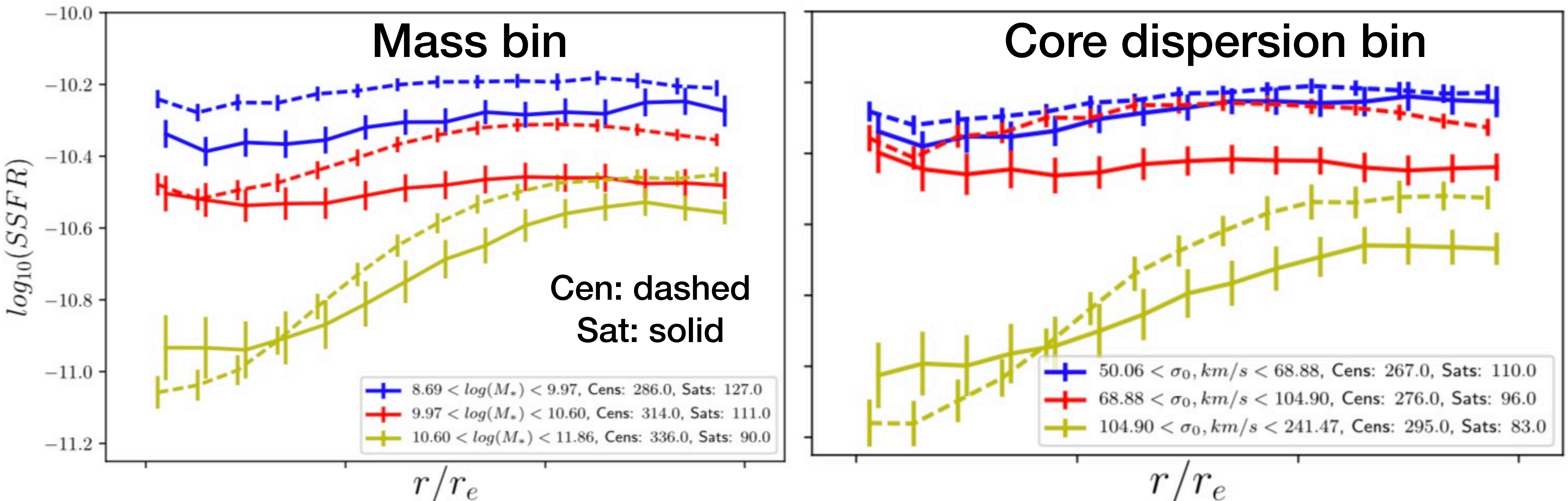


Figure 6. The radial SSFR profiles in three bins of stellar mass. The individual profiles are shown by the cyan lines and the mean profile in the bin is shown



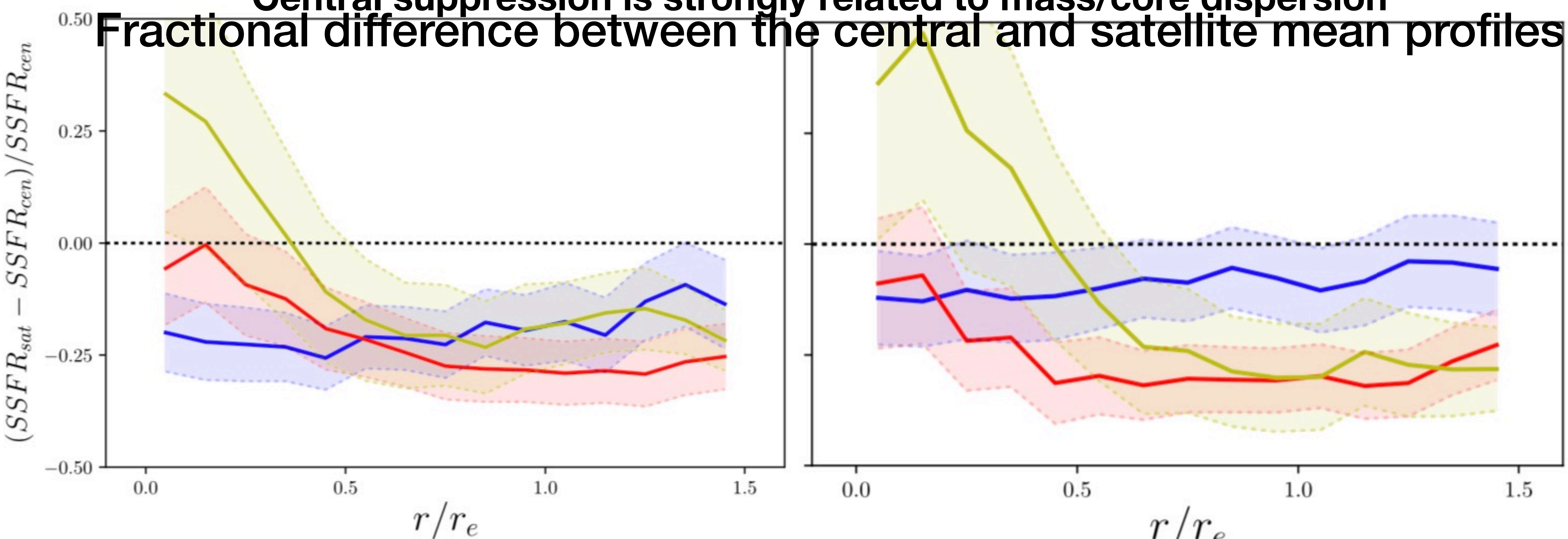
Radial sSFR profiles
flat
flat
suppressed cores
Central Galaxies
50.06 < σ0, km/s < 68.88
68.88 < σ0, km/s < 104.90
104.90 < σ0, km/s < 241.47
N = 267.0
N = 276.0
N = 295.0
Satellite Galaxies
N = 110.0
N = 96.0
N = 83.0
log10(SSFR)
r/re
-9
-10
-11
-12
0.0
0.5
1.0
1.5

Mean Radial sSFR profiles



Central suppression is strongly related to mass/core dispersion

Fractional difference between the central and satellite mean profiles



Mean profiles: Central < Satellite

5. QUENCHING MECHANISMS

5.1 Centrally Suppressed and Unsuppressed

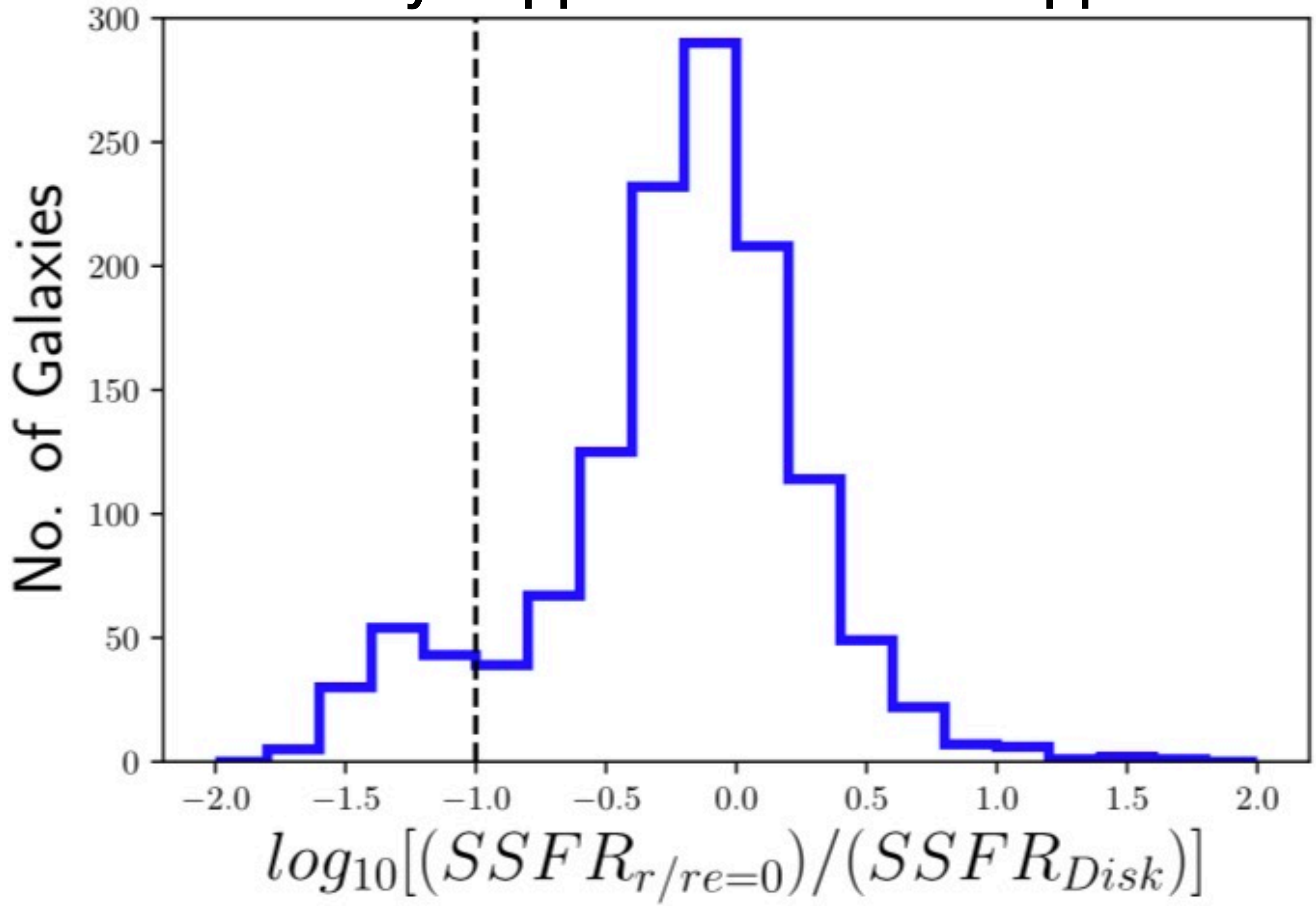
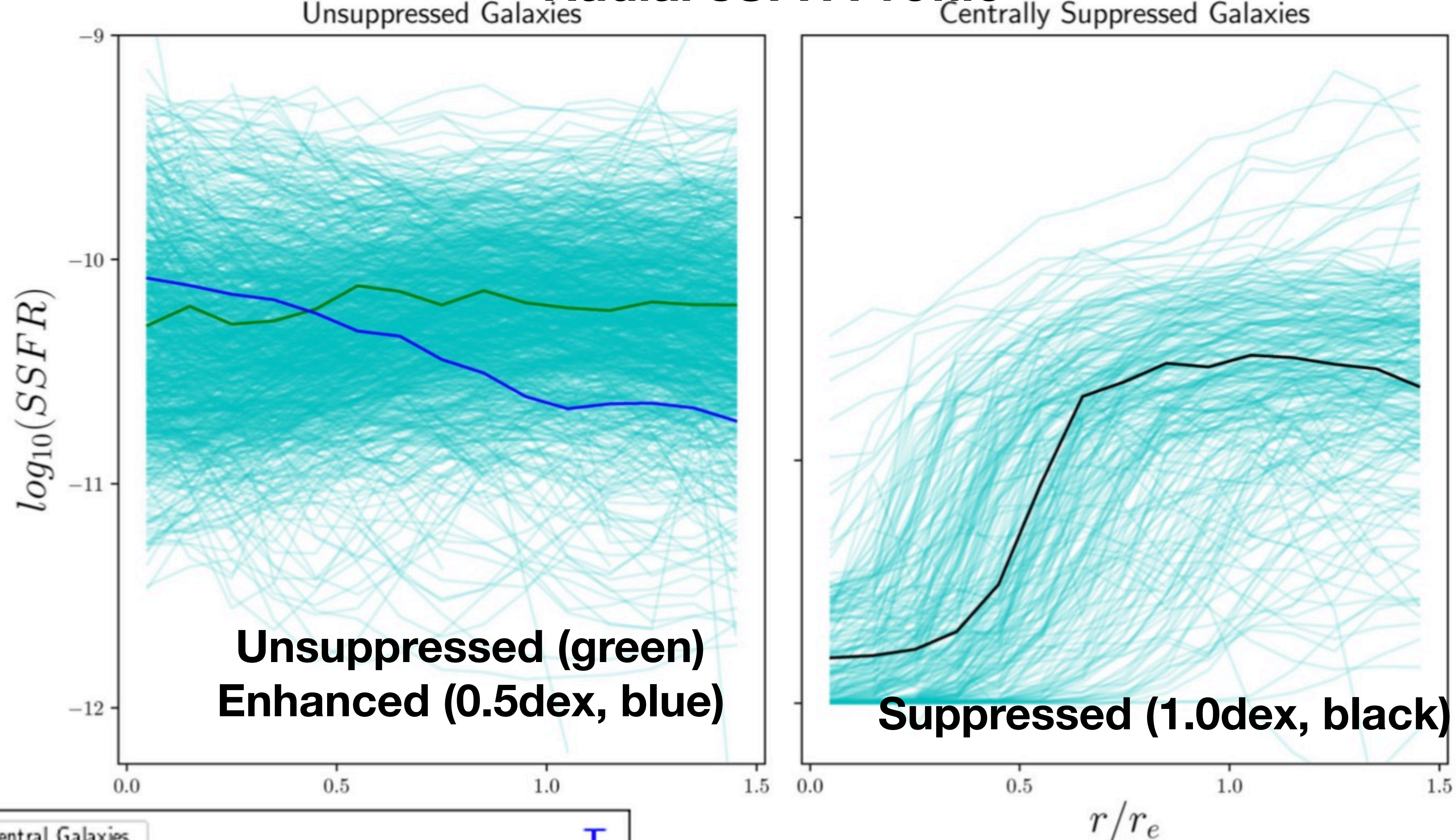
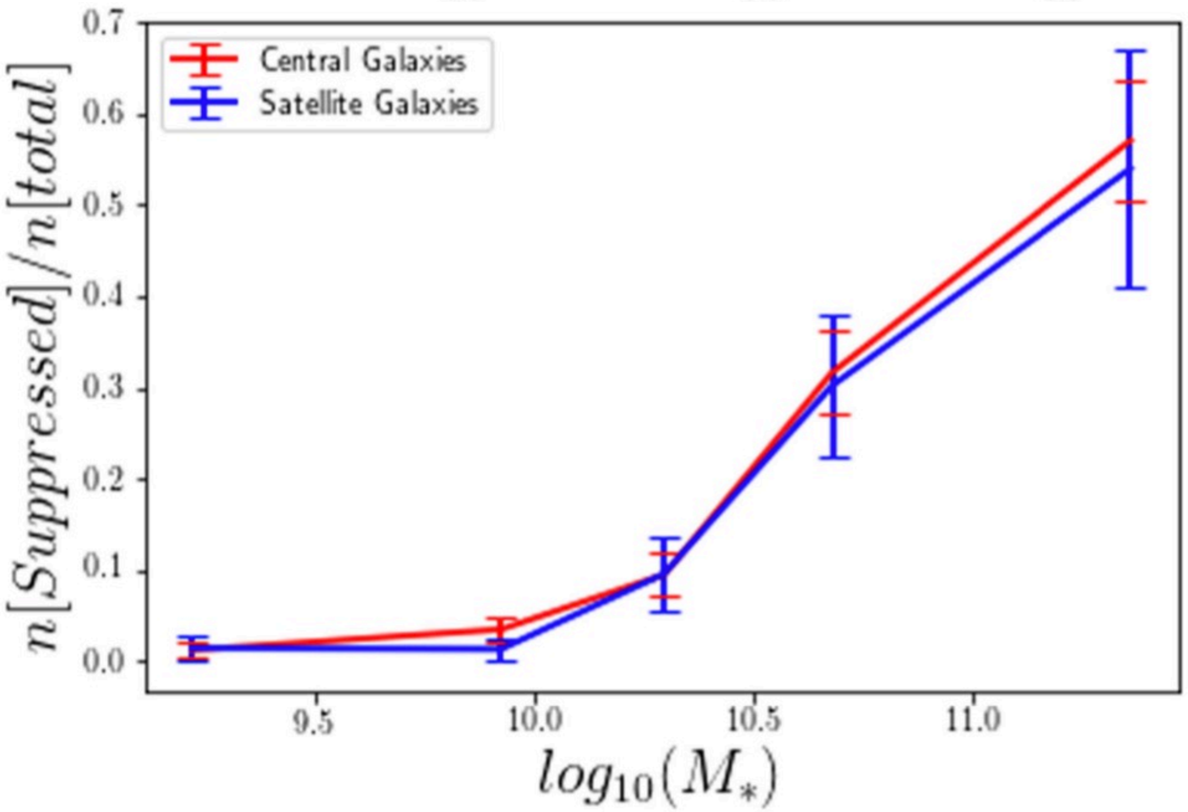


Figure 8. Histogram showing the ratios between the SSFR in the centre most radial bin and the mean SSFR beyond $r/r_e = 0.75$. We show with a dashed line the cut between the centrally suppressed and unsuppressed galaxies, which marks where the disc has SSFR is approximately 10 times higher than the core of the galaxy.

Explore the populations of centrally suppressed and unsuppressed galaxies separately

Radial sSFR Profile

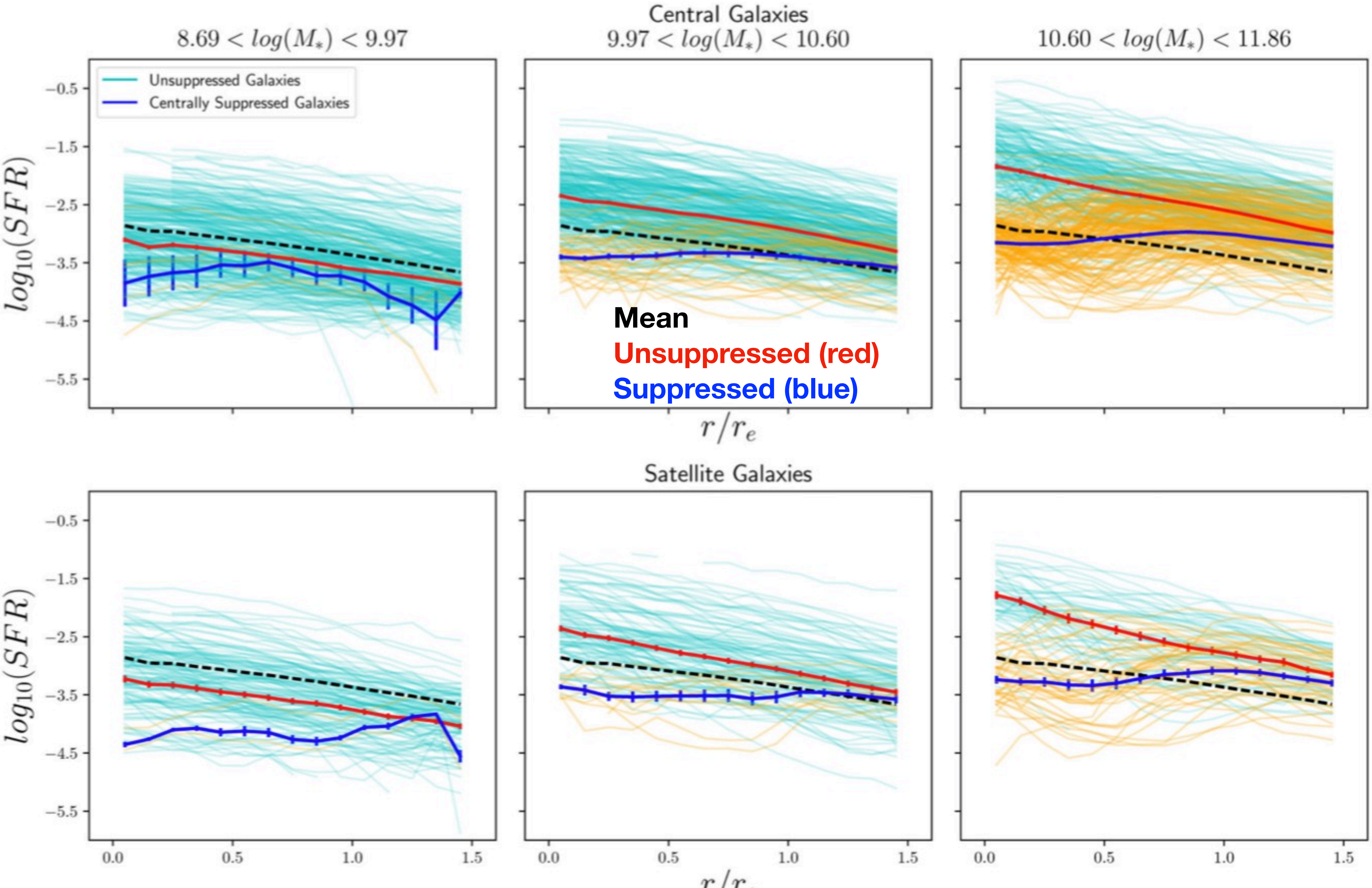




5.2 Environment

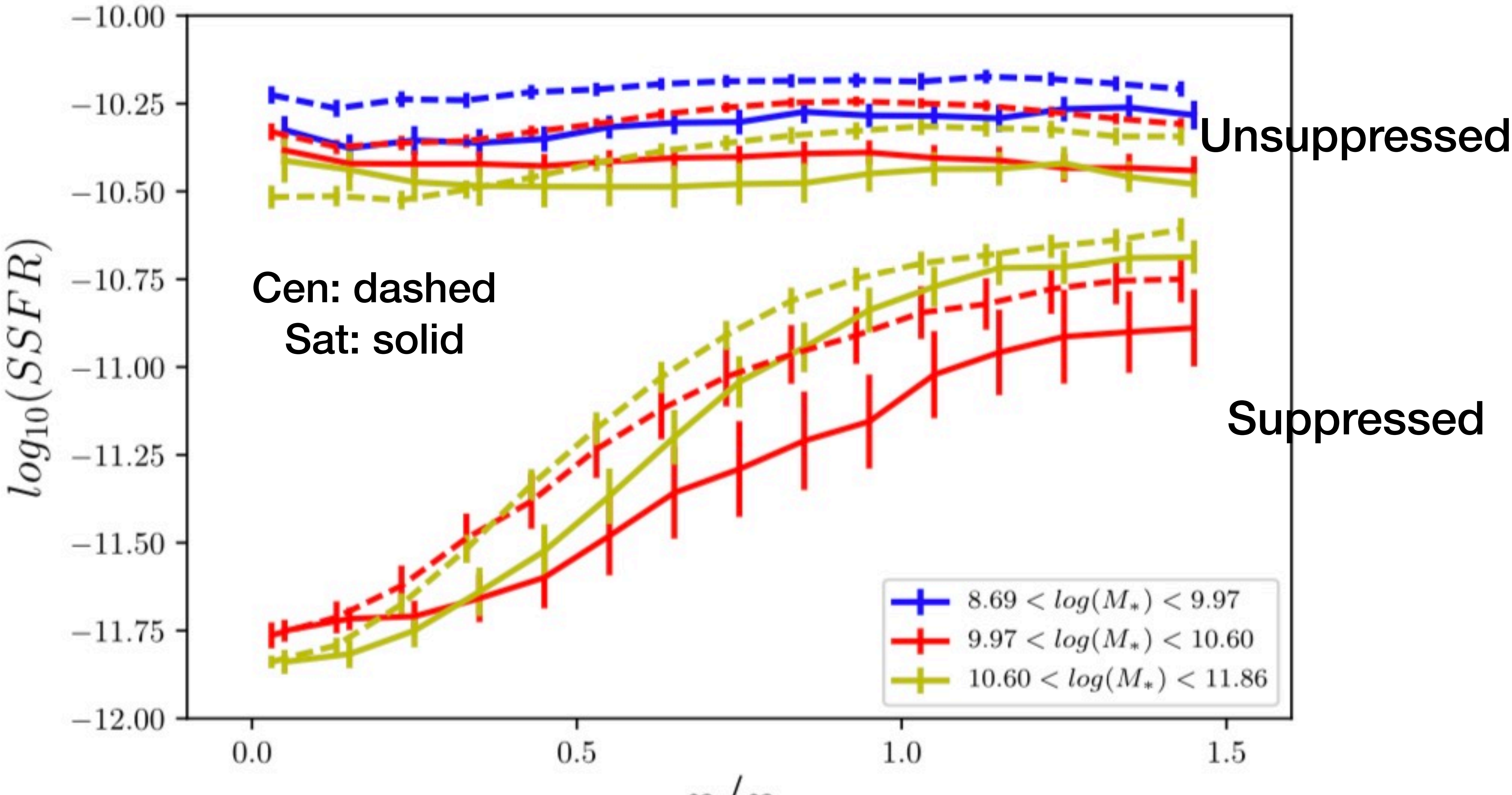
Mechanisms behind the central suppression are **independent from environment** completely, and depend only on the galaxy's internal properties.

SFR Profile



sSFR profiles are not simply due to differences in mass distribution, but also reflect lower instantaneous star formation

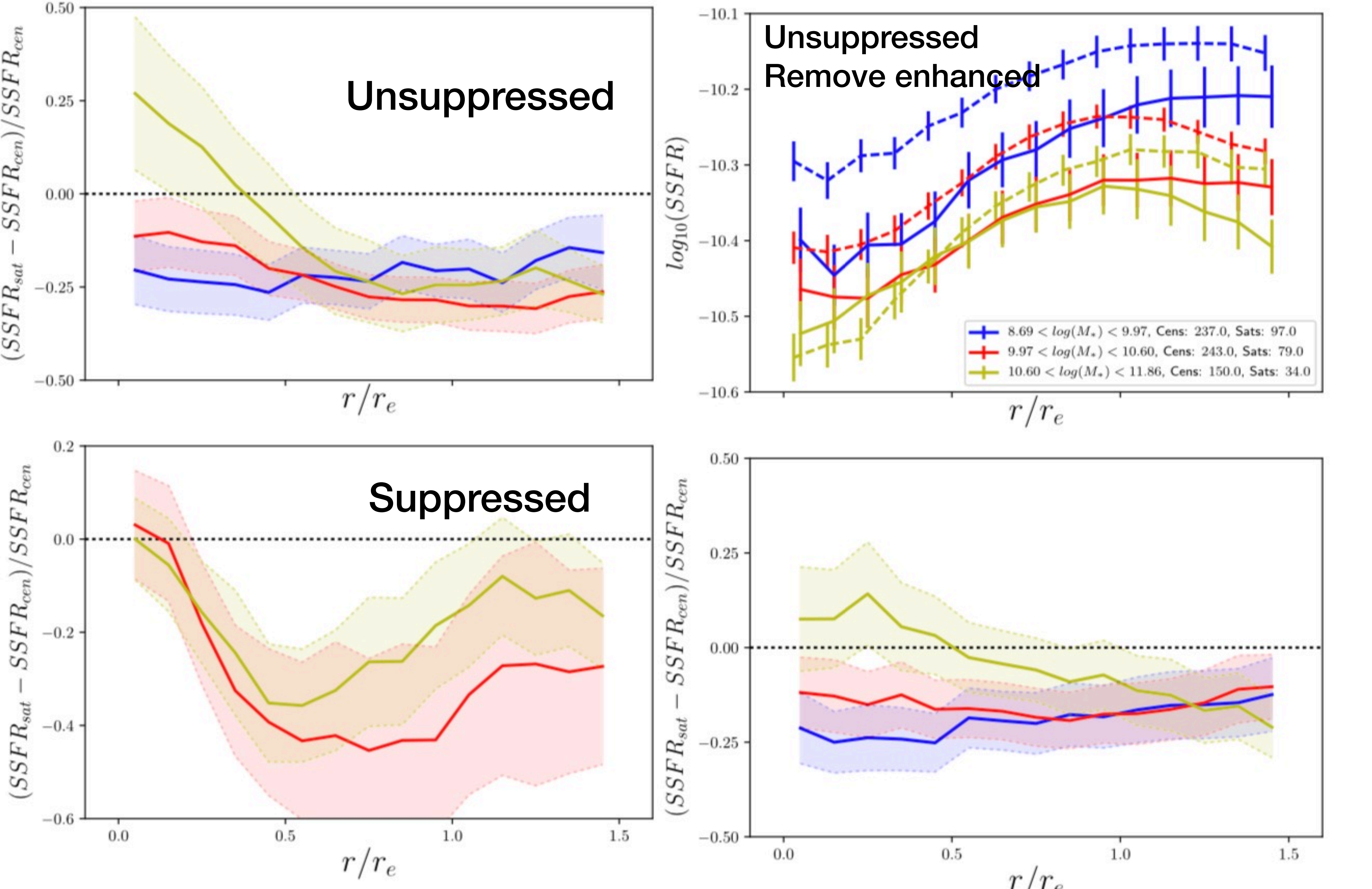
Mean Radial sSFR profiles



Centrally suppressed galaxies actually have reduced SSFRs at all radii compared to the unsuppressed galaxies, not just in their cores.

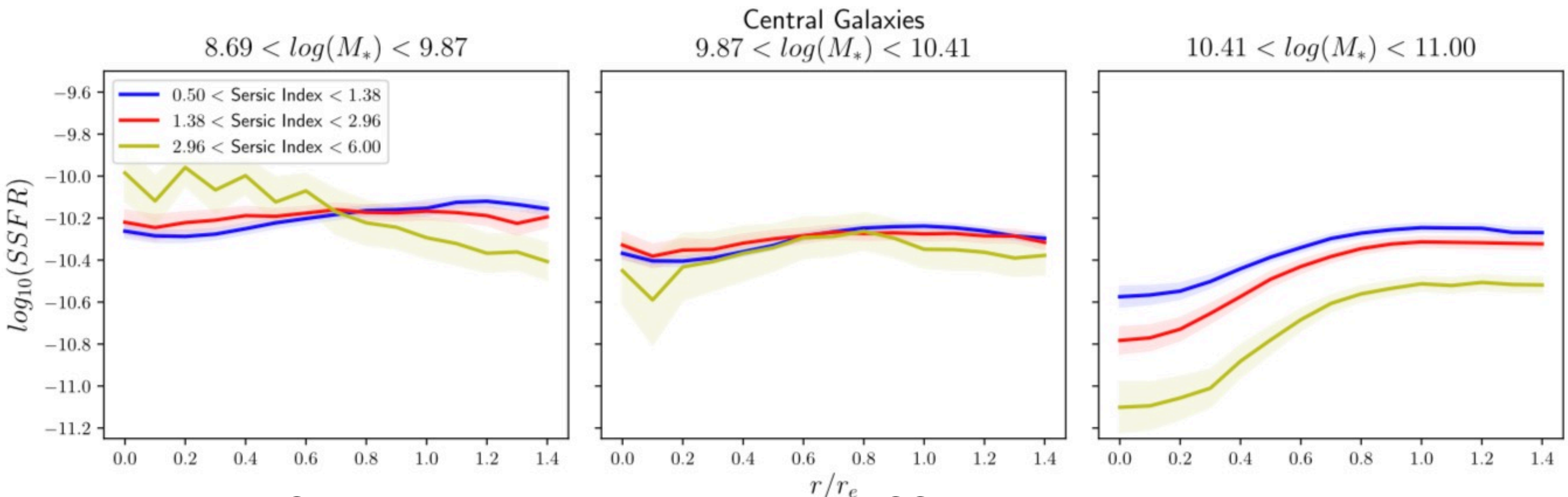
Figure 14. The mean SSFR profiles of centrally suppressed and unsuppressed galaxies. The upper set of lines are the unsuppressed galaxies, while

More Comparison of centrals and satellite profiles

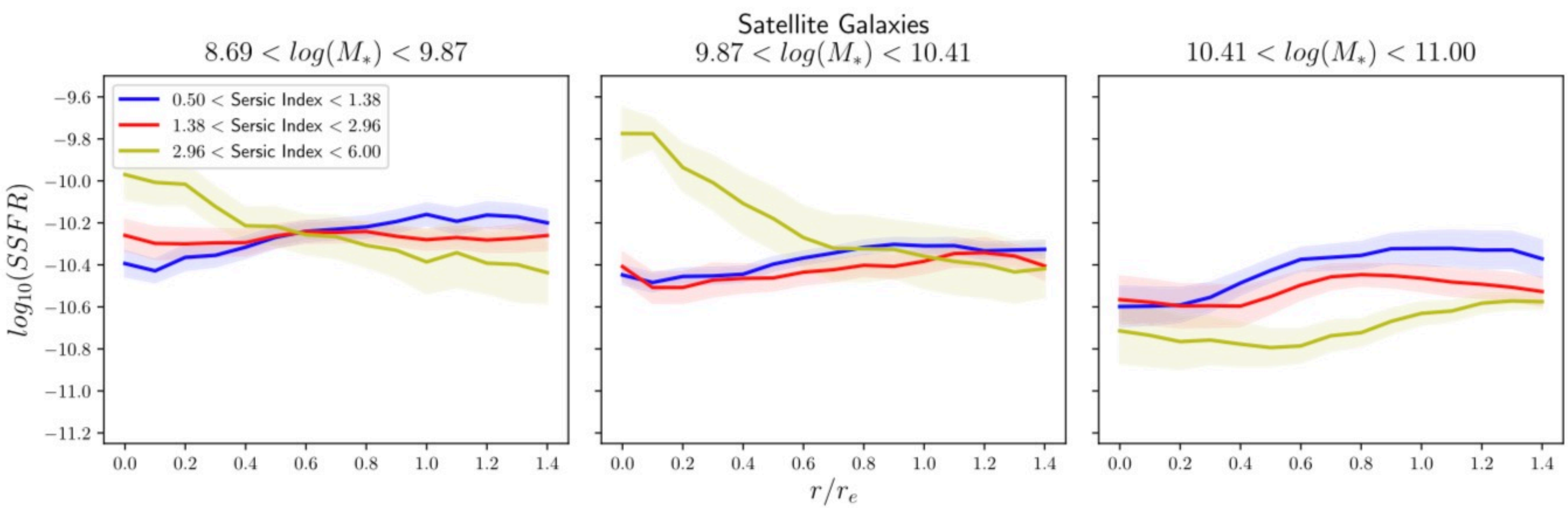


This uniform suppression of satellites could be a signature of strangulation.

5.3 Morphological quenching ~ Sersic n



Higher Sersic index galaxies have lower SSFRs across their entire profiles.



Enhancement may be due to gas being driven into their centres by tidal interactions (unclear

5.4 AGN feedback

AGNs can prevent collapse of gas and the accretion of gas from the galaxy halo.

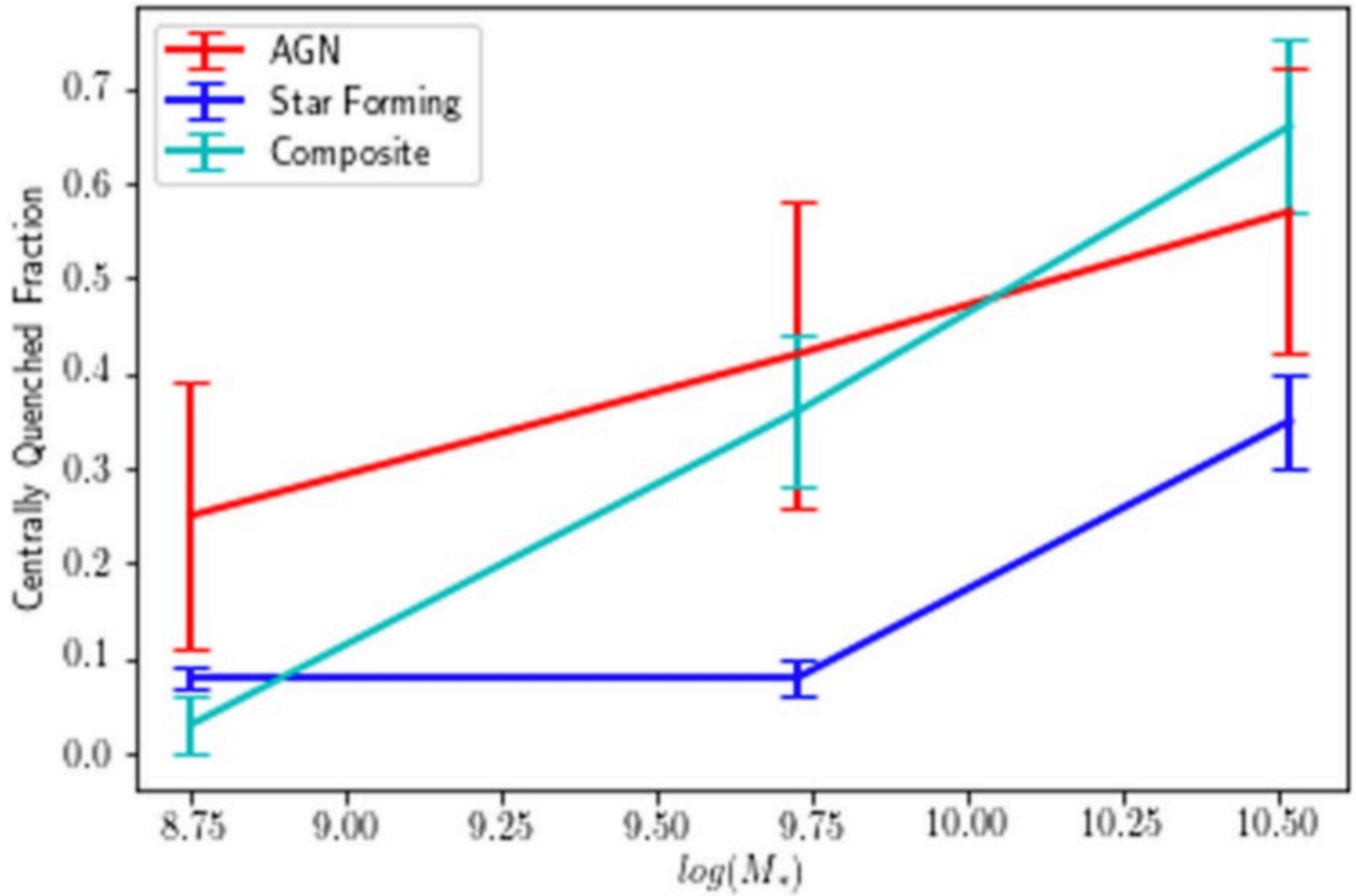


Figure 19. The fraction of galaxies which are centrally quenched, for galaxies which have an integrated BPT classification of AGNs, star-forming, and composite, in three bins of stellar mass.

At all masses, AGN galaxies are more likely to be centrally suppressed.
In the medium- and high-mass bins the composites are more likely to be quenched.

CONCLUSIONS

- Used SDSS-IV MaNGA survey to study the spatial distribution of star formation 1494 galaxies in the local Universe based on a two source model to calculate SFR using Hα and Dn4000.
- Found that the sSFR of galaxies decreases with mass and σ0.
- Revealed the existence of 'Centrally Suppressed' and 'Unsuppressed' galaxies. The unsuppressed galaxies have flat profiles in sSFR, and with high mass and high σ0 galaxies being much more likely to have suppressed SSFR in their cores.
- Centrally suppressed galaxies actually have suppressed SSFR at all radii, compared to unsuppressed galaxies, and have lower SFR in their cores than in their discs.
- Possibility is that the suppression: morphological quenching or AGN feedback.
    - High mass–high Sersic and high mass–high dispersion galaxies predominantly being centrally suppressed.
    - All masses the AGN/LI(N)ER galaxies were more likely to have centrally suppressed SSFRs than SFGs and and composites were more likely to be sup- pressed at medium and high masses