Inside-out quenching: a z=0 perspective from MaNGA

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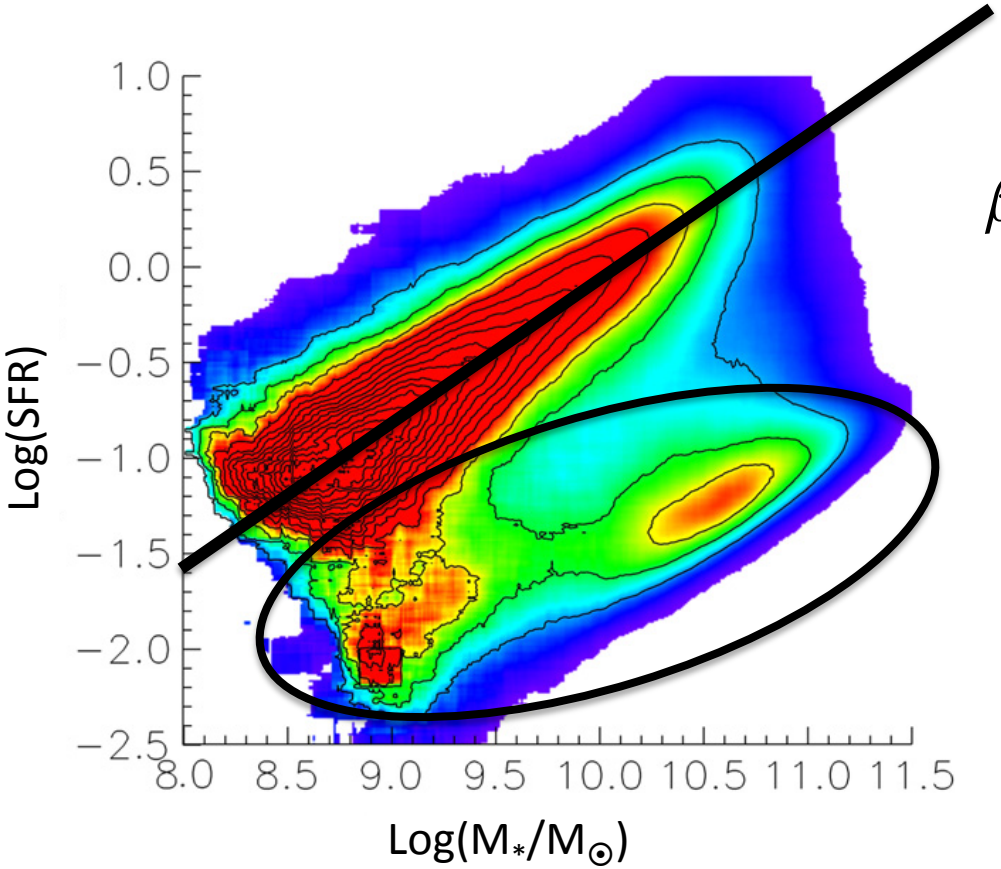
Quenching and the galaxy ‘Main Sequence’



How steep is the SFMS?

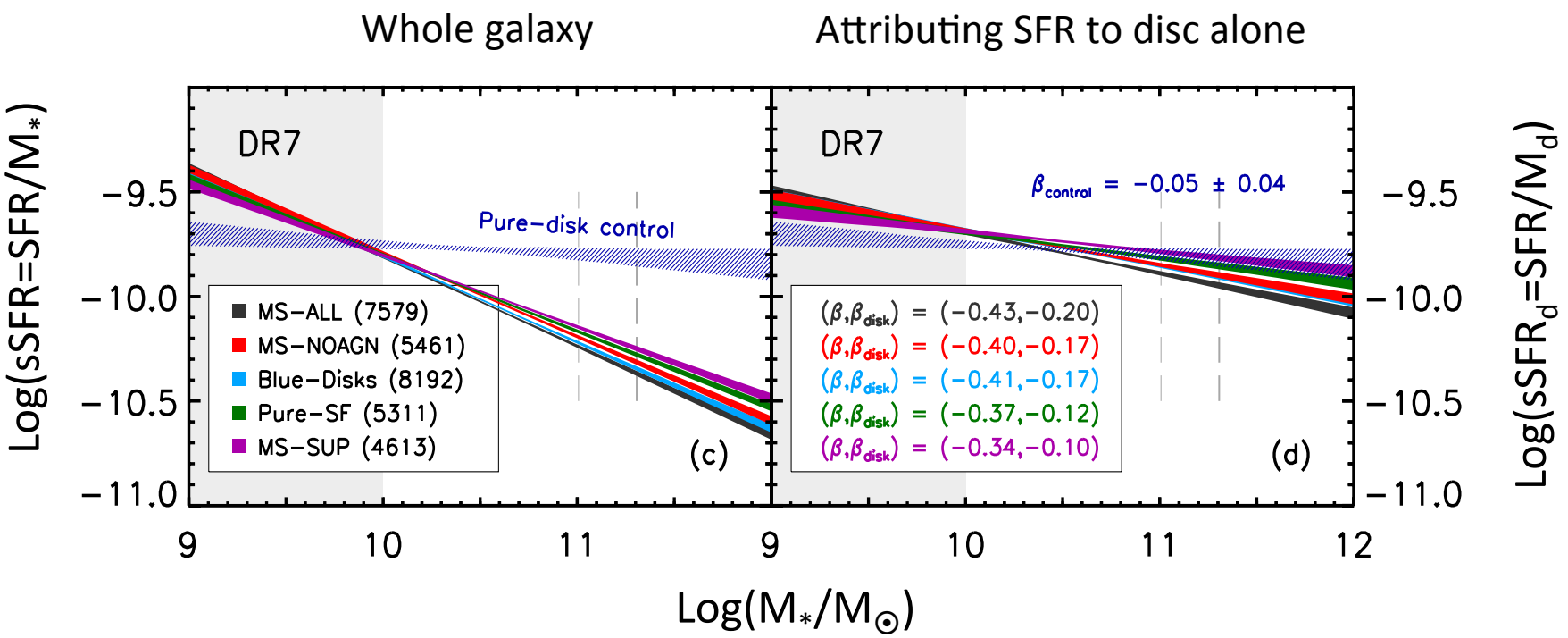
$$\beta \equiv \frac{d \log \mathrm{sSFR}}{d \log M_*}$$

β = [-0.5, -0.1]

Brinchmann+2004, Salim+2007, Whitaker+2012, Renzini & Peng 2015, FB+2017a

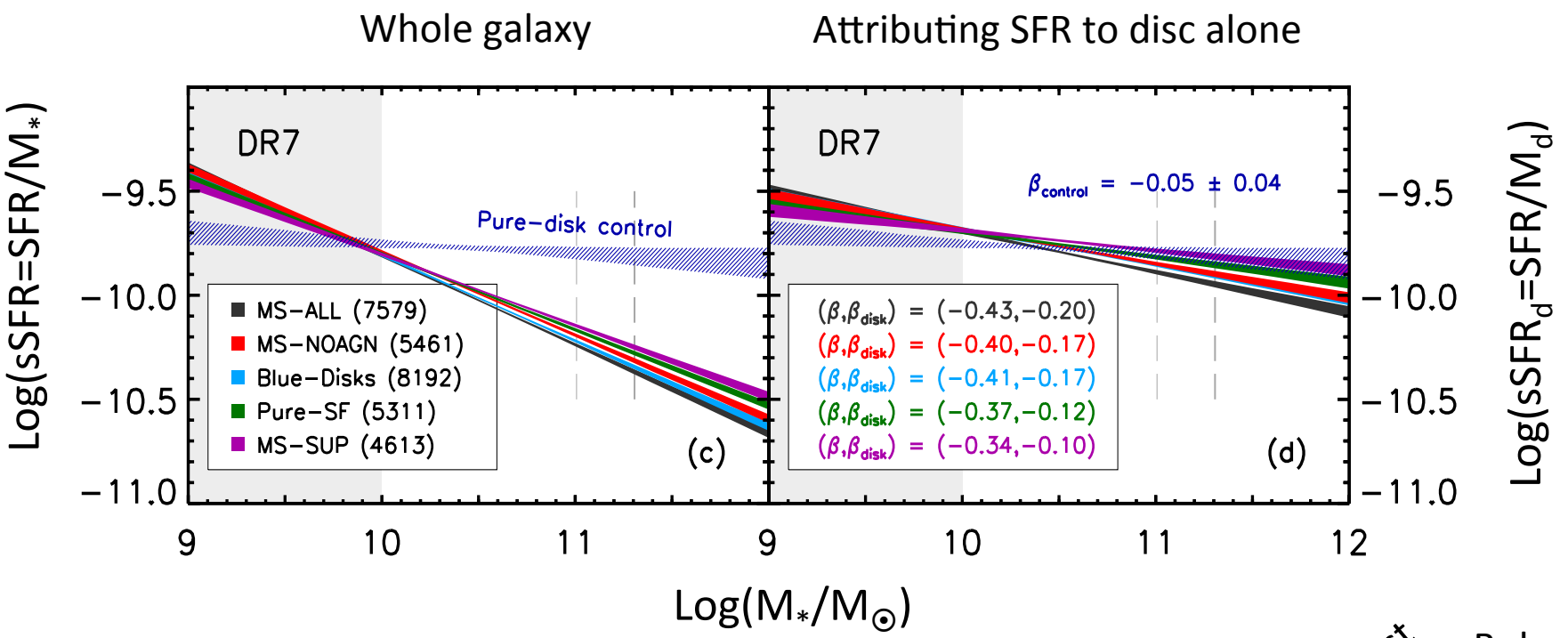
SDSS

Do discs grow at constant sSFR (β=0)?



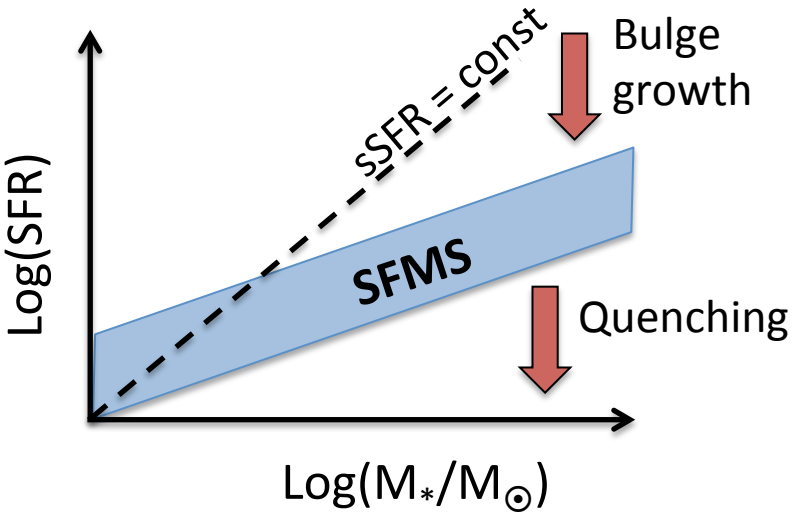
From Abramson+2014

Do discs grow at constant sSFR (β=0)?

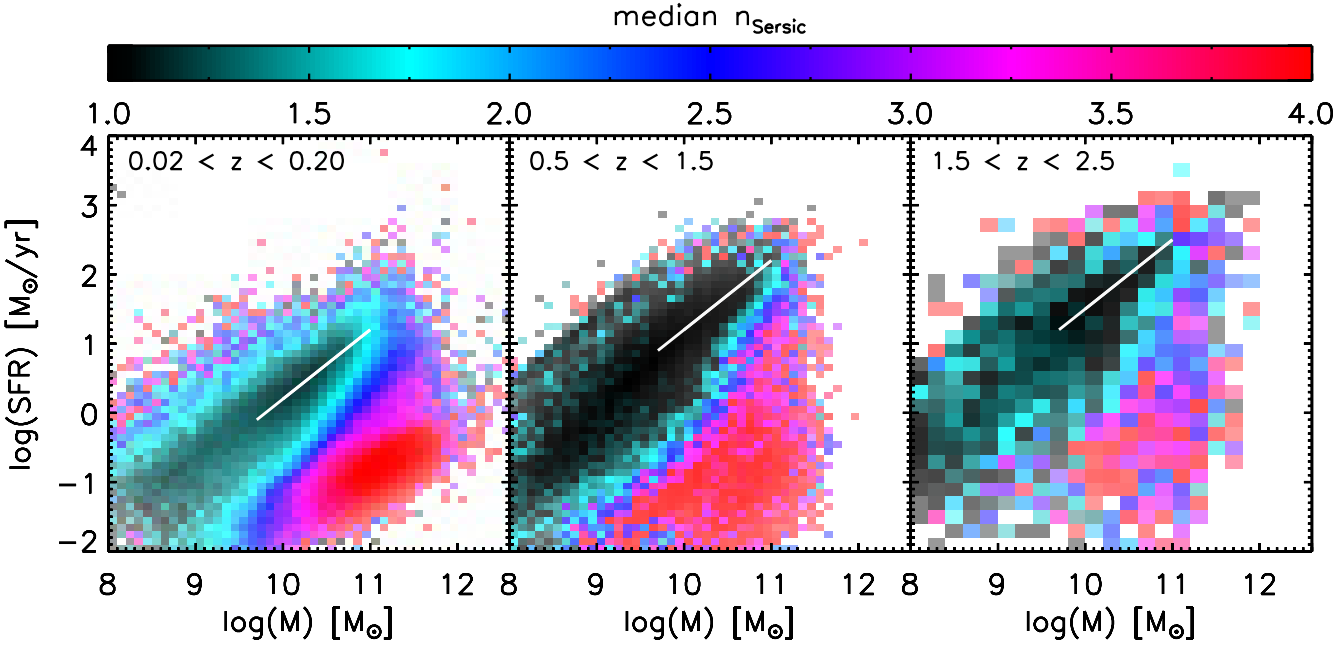


From Abramson+2014

"If β<0, then `Quenching' is a mix of processes pulling systems vertically off the MS and lowering sSFRs as they move along it (β reflects the latter)."



The role of bulges in the transition population



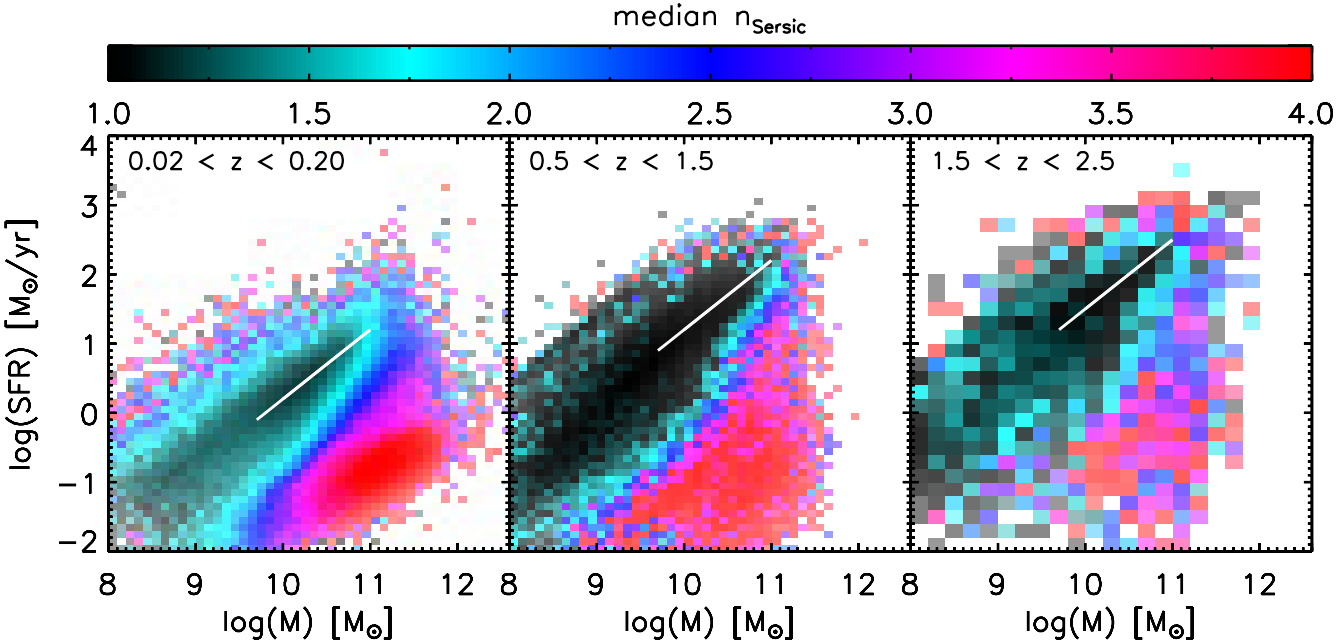
Green valley galaxies (i.e. galaxies below the SFMS) have larger Sersic n, B/T etc

Wuyts+2011, also Schiminovich+2007, Morselli+2016

How do their discs behave?

I.e. are Green Valley galaxies red bulges with blue discs?

The role of bulges in the transition population



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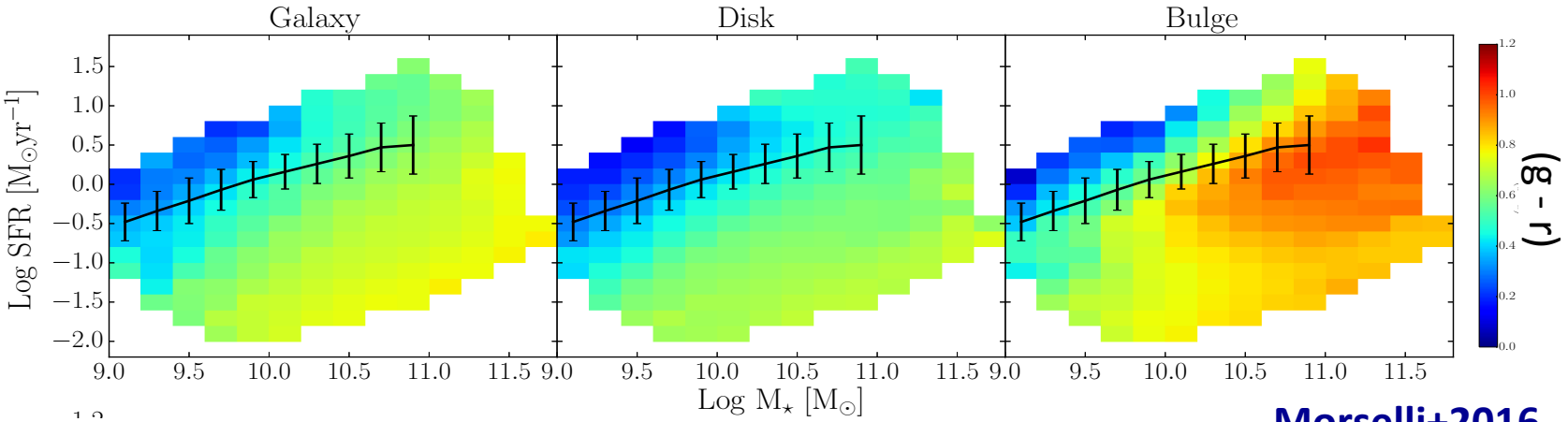
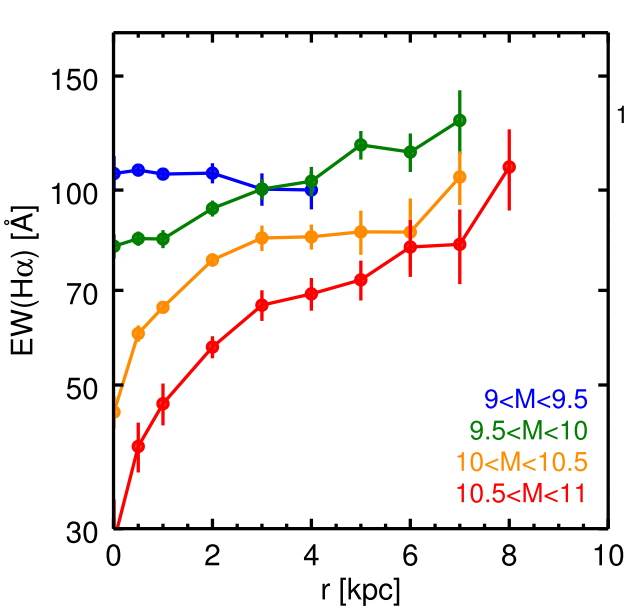
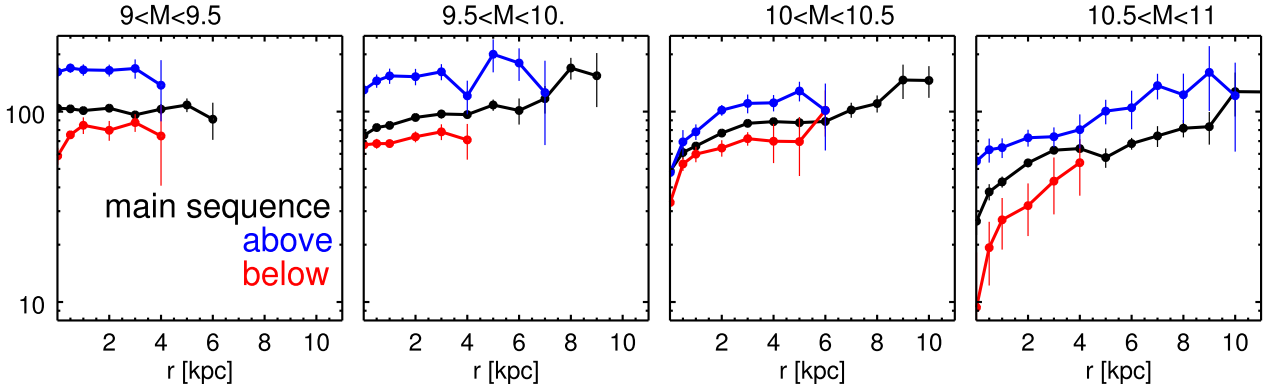


Morselli+2016

Discs are getting redder at the high-mass end of the SFMS and below the SFMS

Resolving galaxies: the high-z view

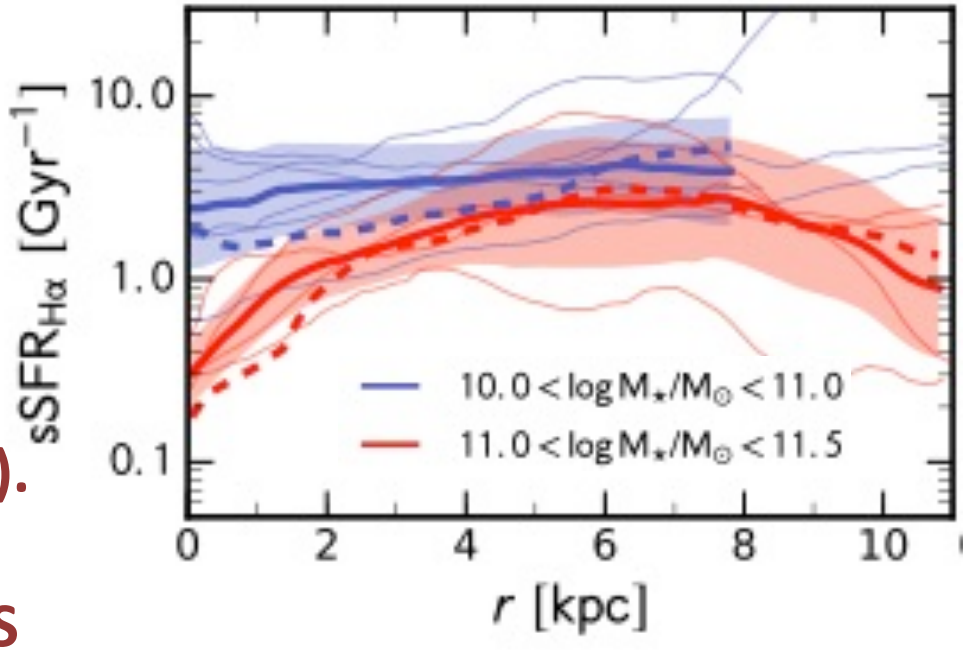




Nelson+2016, from 3D HST, ~3000 galaxies @ z~1.0

Consistent with a picture of inside-out growth (`quenching').

Hints that discs below the SFMS have lower sSFR

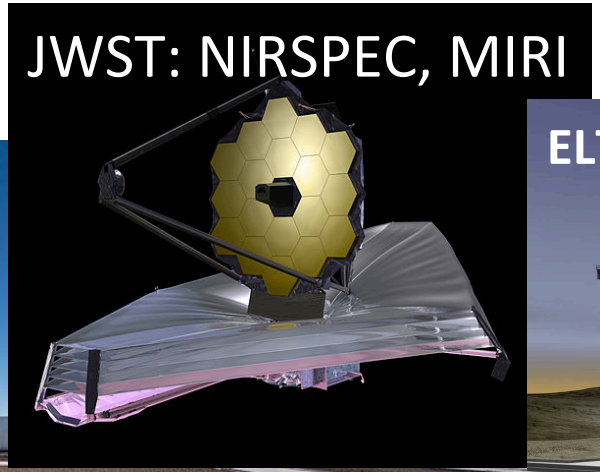


Tacchella+2017, using SINFONI +AO, 10 galaxies @ z~2

The landscape of resolved spectroscopy

Exciting high-z opportunities

VLT: SINFONI, KMOS, MUSE



JWST: NIRSPEC, MIRI

ELT: HARMONI, MOSAIC

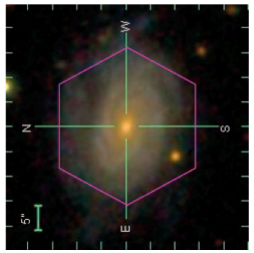
We need a spectroscopic z ~ 0 baseline

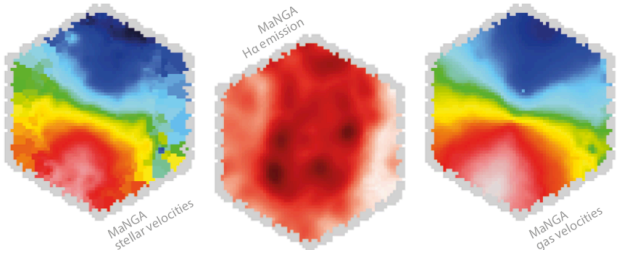
Current low-z IFS surveys

CALIFA ~ 600 galaxies

SAMI ~ 3000 galaxies

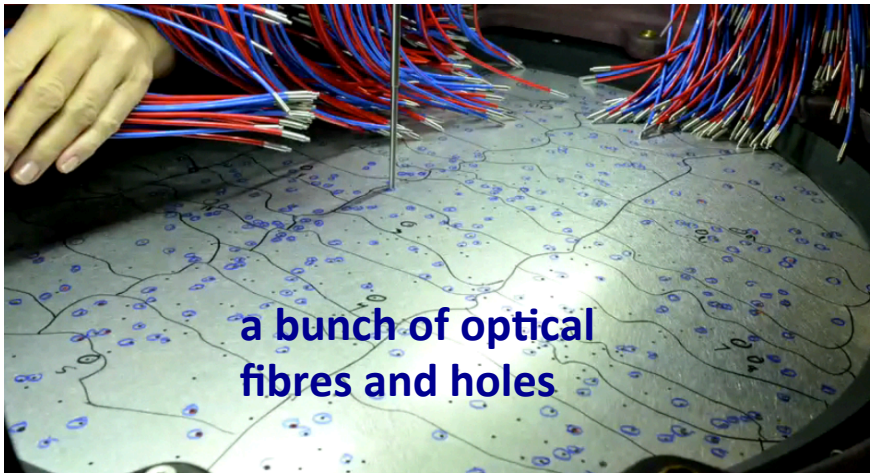
MaNGA ~ 10000 galaxies





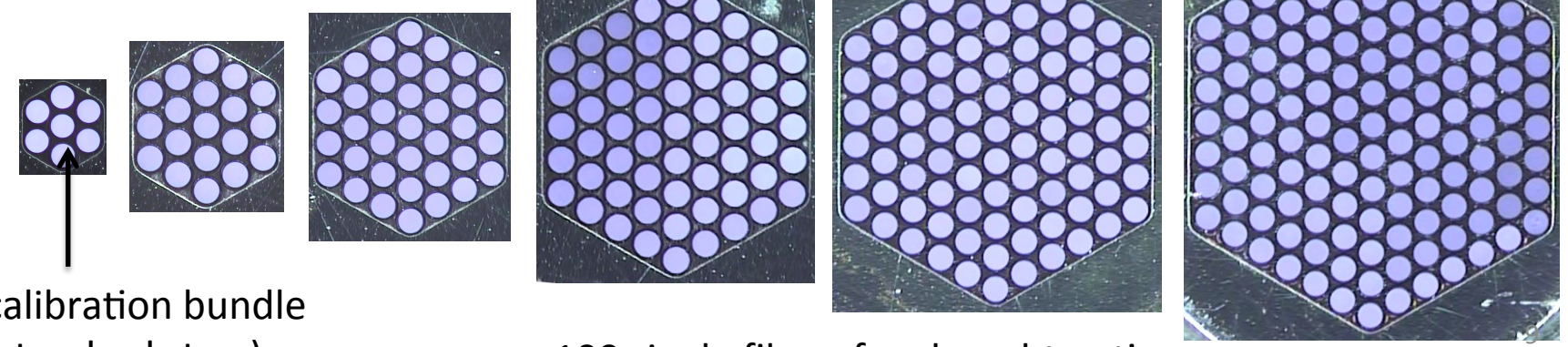
Overview paper: Bundy+2015

The MaNGA survey at a glance



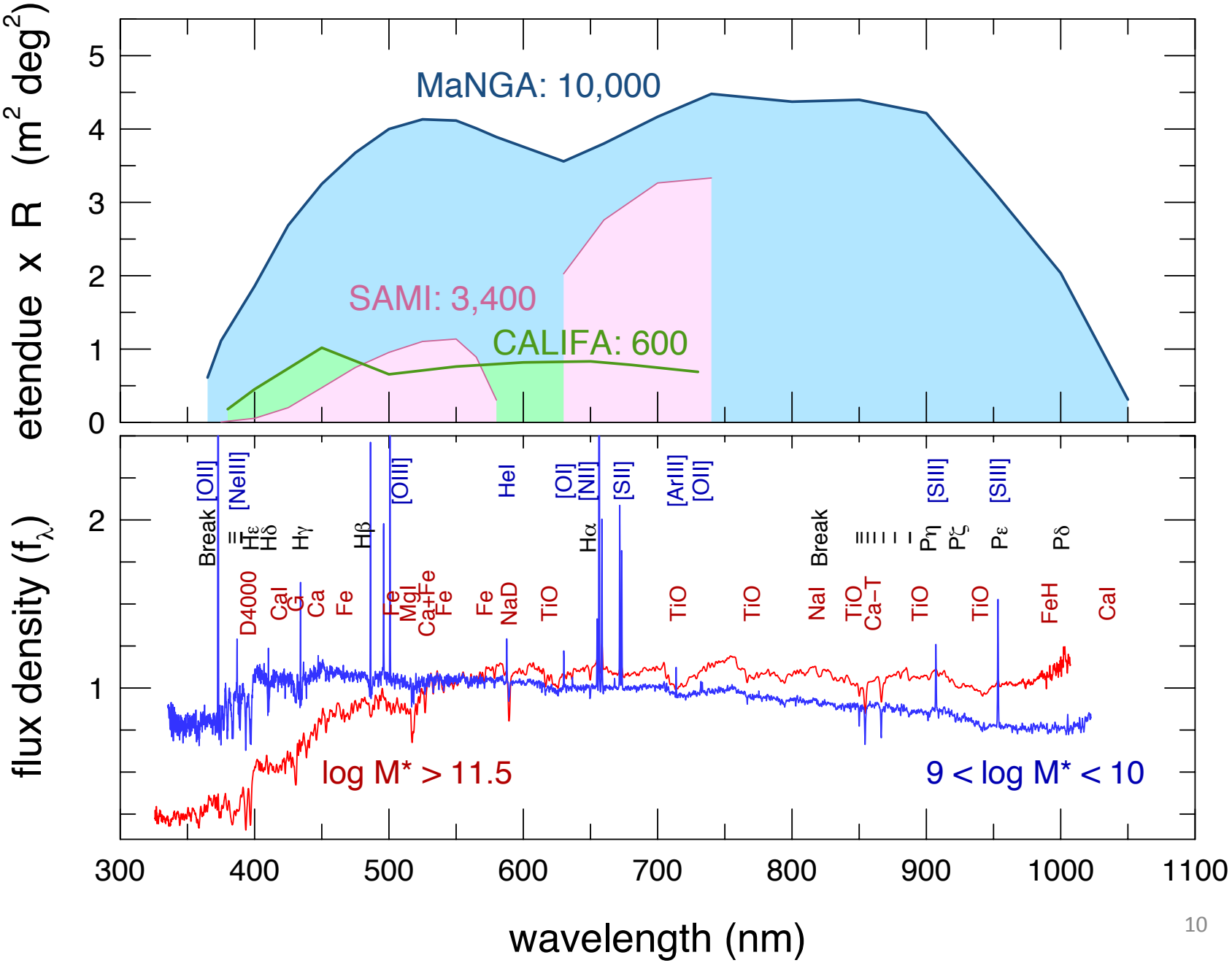
MaNGA fibre bundles

32.5 arcsec



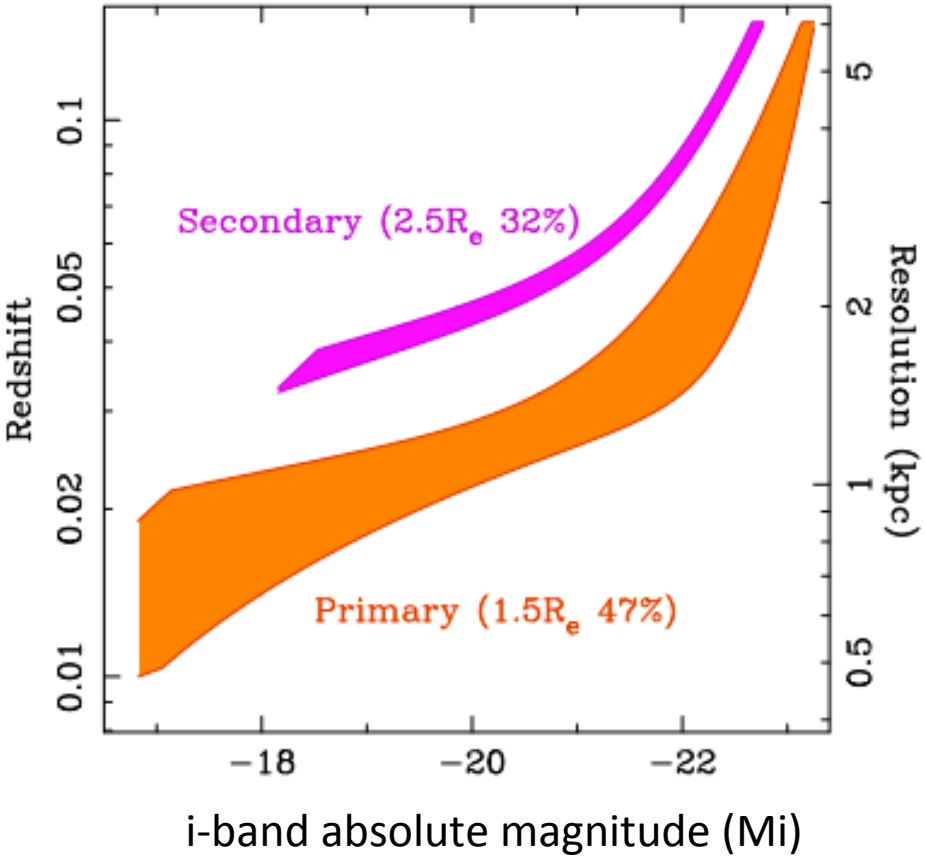
calibration bundle
(standard stars)

+ ~ 100 single fibres for sky subtraction


etendue x R (m² deg²)
MaNGA: 10,000
SAMI: 3,400
CALIFA: 600
flux density (fλ)
Break
[OII]
[NeIII]
Hε
Hδ
Hγ
Hβ
[OIII]
HeI
[OI]
[NII]
Hα
[SII]
[ArIII]
[OII]
Break
[SIII]
[SIII]
Pη
Pζ
Pε
Pδ
D4000
CaI
G
Ca
Fe
Fe
Mgl
Ca+Fe
Fe
Fe
NaD
TiO
TiO
TiO
NaI
TiO
Ca-T
TiO
TiO
FeH
CaI
log M* > 11.5
9 < log M* < 10
wavelength (nm)

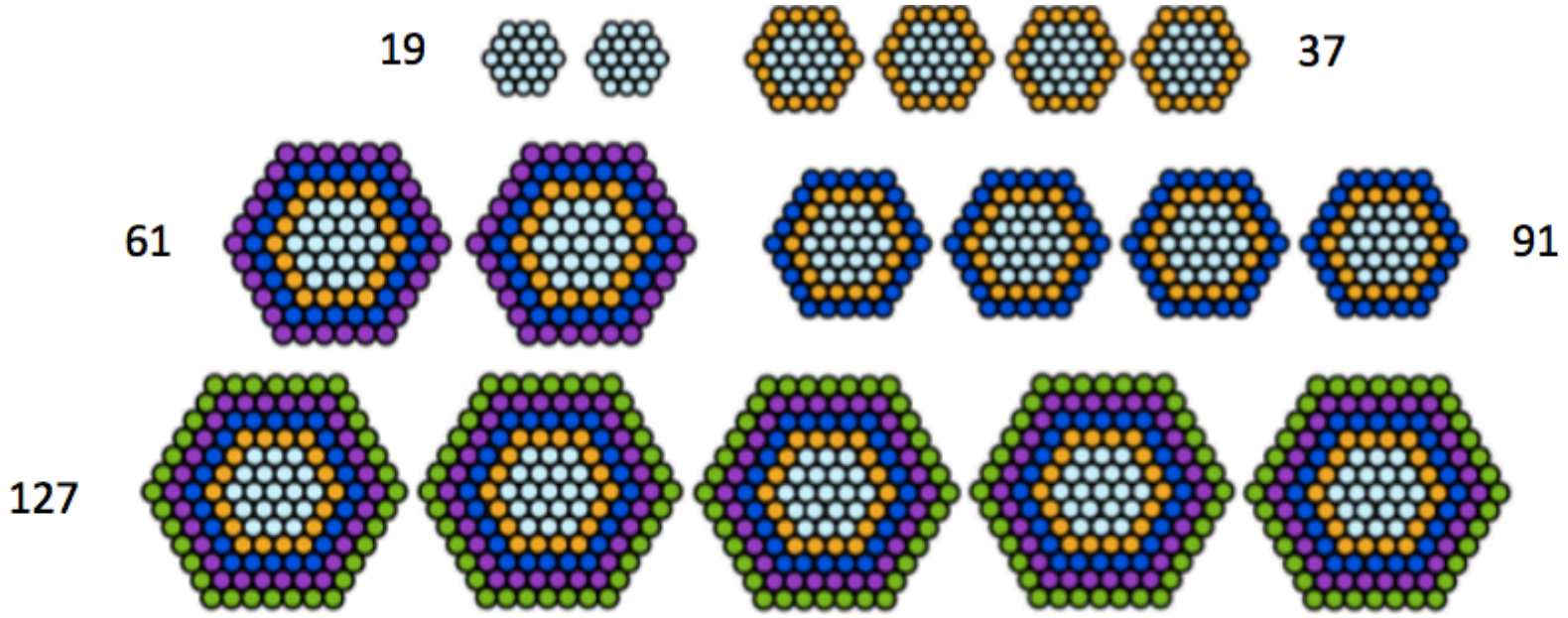
MaNGA: survey at a glance

- Sample **flat in stellar mass (> 10^9 $M_\odot$).**
- **Uniform spatial coverage in terms of R_e** (to 1.5 Re for 67% and 2.5 Re for 33% of the sample)
- Median **redshift** z=0.03

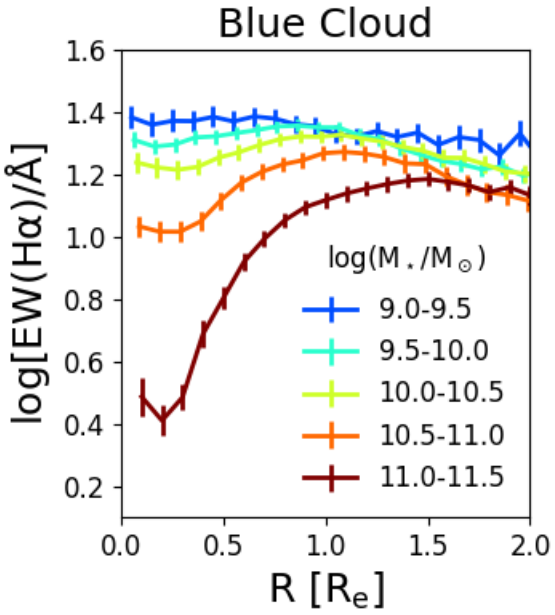


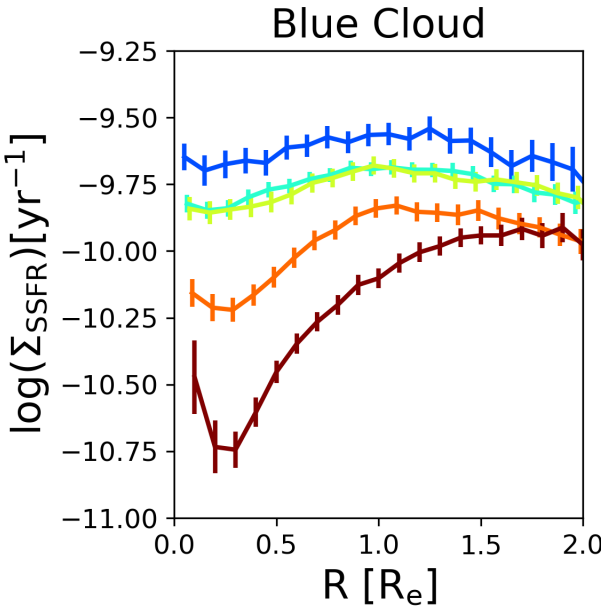
MaNGA: survey at a glance

- **Multiplexed**: 17 IFU per field (*plate*), a **range of IFU bundle sizes** (19, 37, 61, 91, 127), each fiber is 2'' on sky.
- Spatial PSF ~ 2.5 arcsec , **~ kpc-resolution**.



sSFR profiles in MaNGA





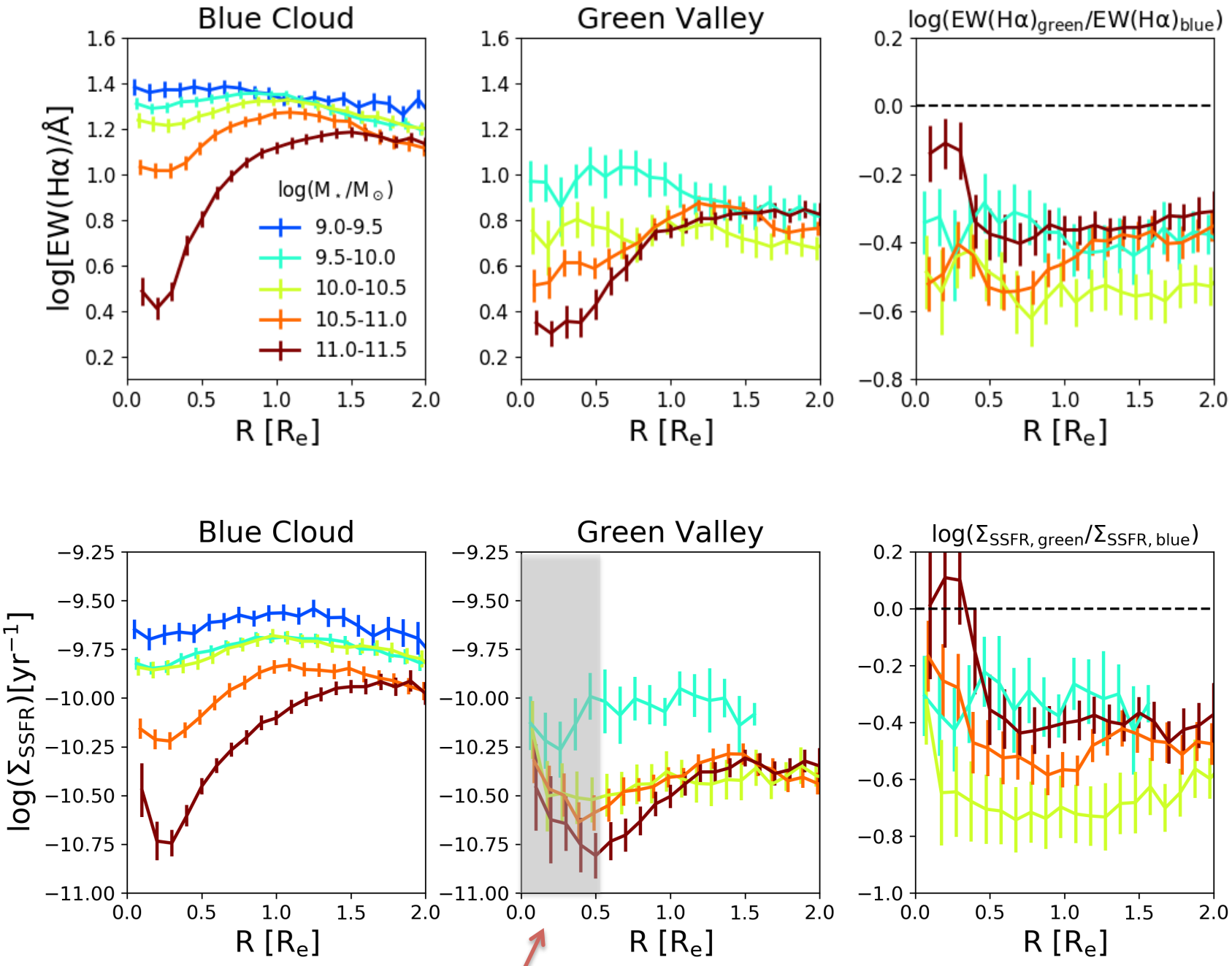
~500 star forming (blue cloud) galaxies

- **SFR from extinction corrected Hα (using Balmer decrement)**
- **M_* from spectral fitting of the continuum**
- **SFR only calculated for spaxels classified as SF using classical BPT diagram**

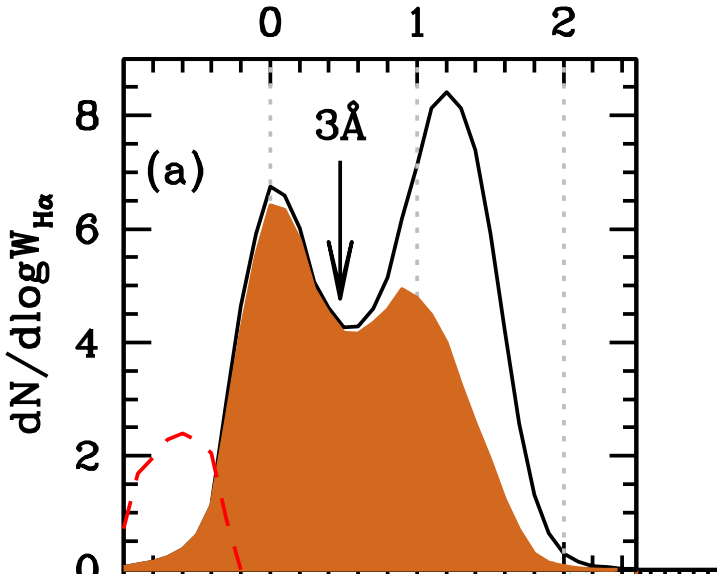
1. Σ_{sSFR} decreases with M_* even in the outer regions of discs (β<0).

2. Strong suppression in sSFR in the centres of massive galaxies.

FB+ in prep

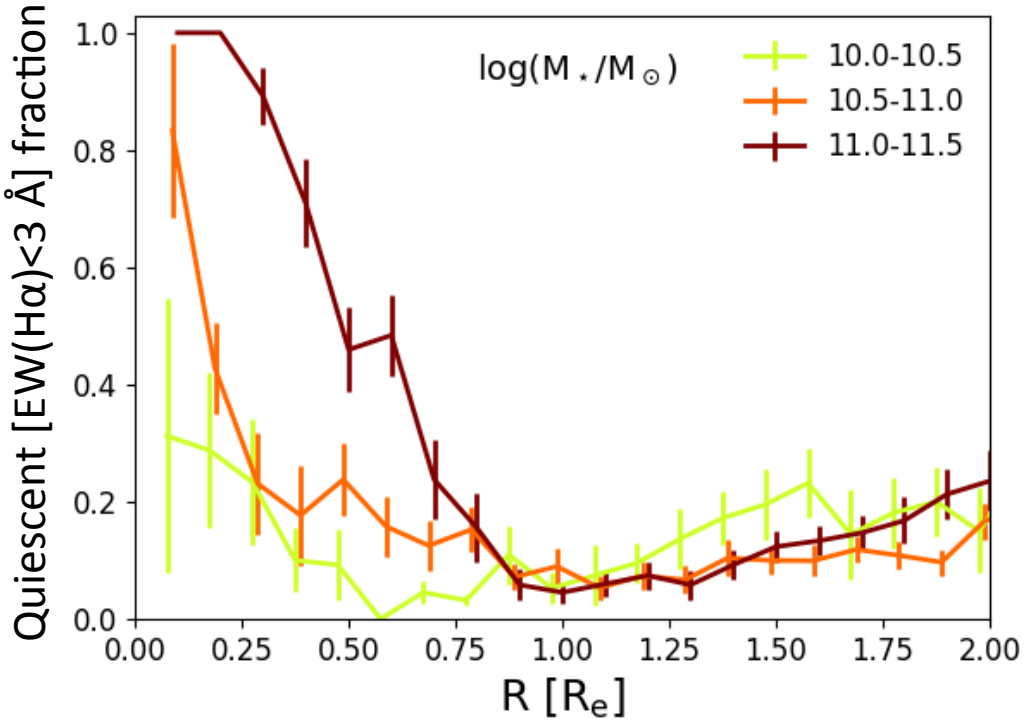

Blue Cloud
Green Valley
log(EW(Hα)green/EW(Hα)blue)
log[EW(Hα)/Å]
log(M*/M⊙)
9.0-9.5
9.5-10.0
10.0-10.5
10.5-11.0
11.0-11.5
R [Re]
Blue Cloud
Green Valley
log(ΣSSFR, green/ΣSSFR, blue)
log(ΣSSFR)[yr−1]
R [Re]
FB+ in prep
Stack biased by quiescent bulges

Centrally Quiescent galaxies



Cid Fernandes+ 2011, SDSS,
See also FB+2016 with MaNGA

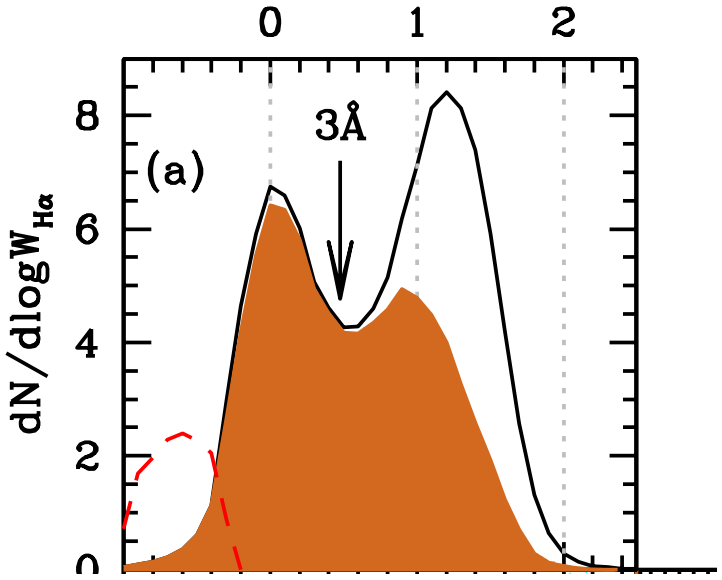
Fraction of quiescent regions as a function of radius in the Green Valley



EW(Hα) = 3 Å good discriminator between star formation and emission from old stars (LIERs)

More on centrally quiescent galaxies in my talk on Tuesday @ 09.54 am

Centrally Quiescent galaxies



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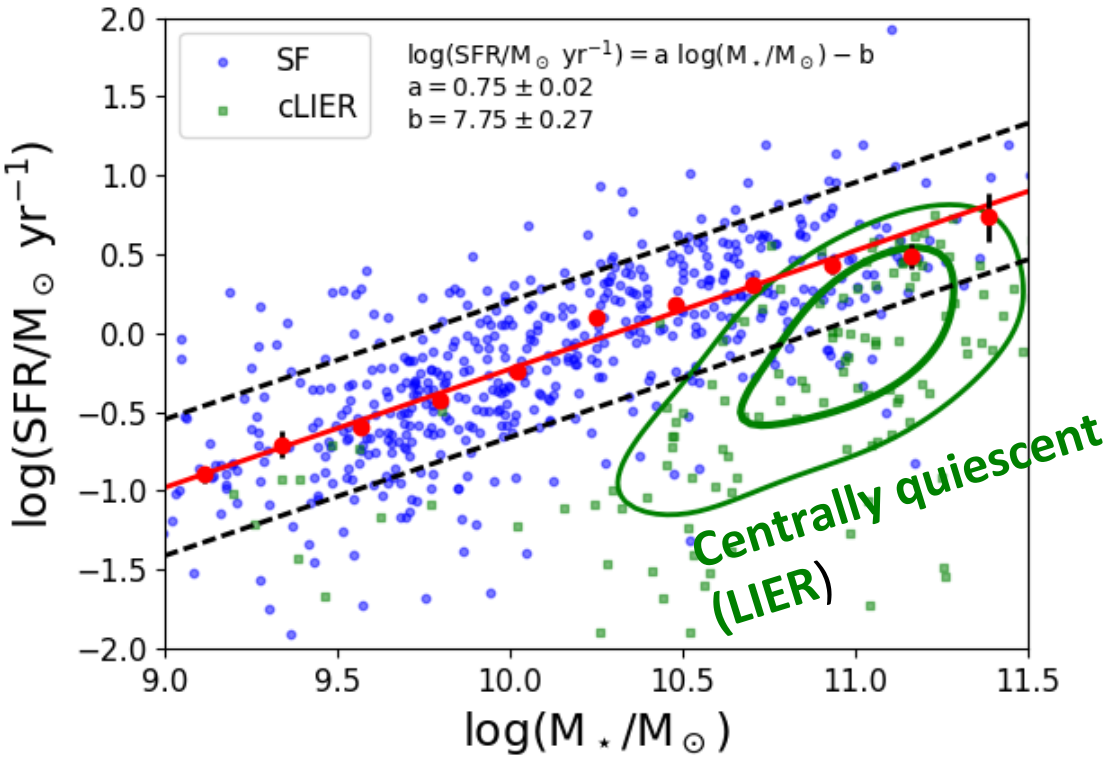

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Conclusions

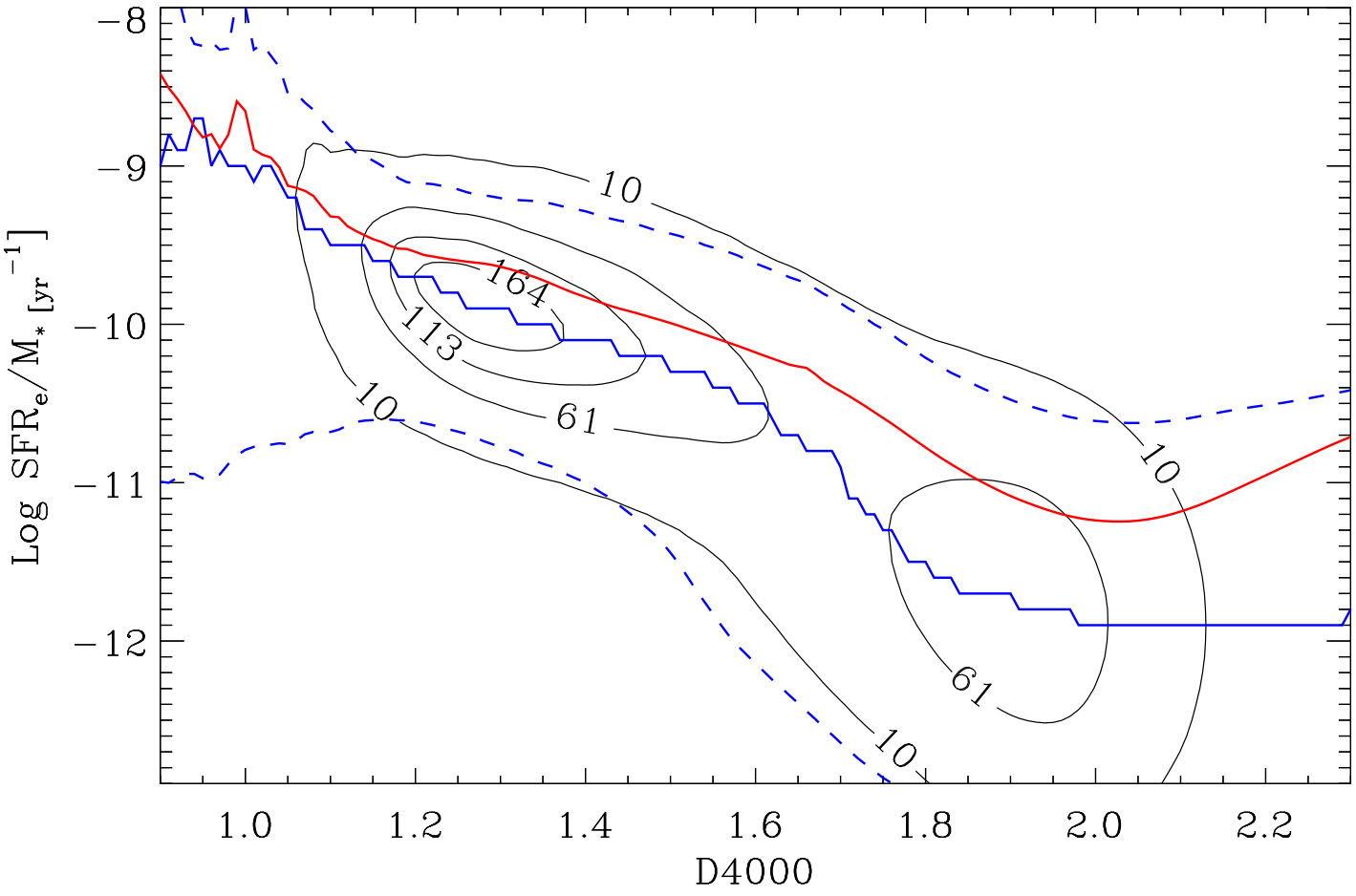
1. MaNGA observes decreasing Σ_{sSFR} with M_* even in the outer regions of discs ($\beta<0$)

2. Central regions of massive galaxies show suppressed sSFR (similar to high-z?)

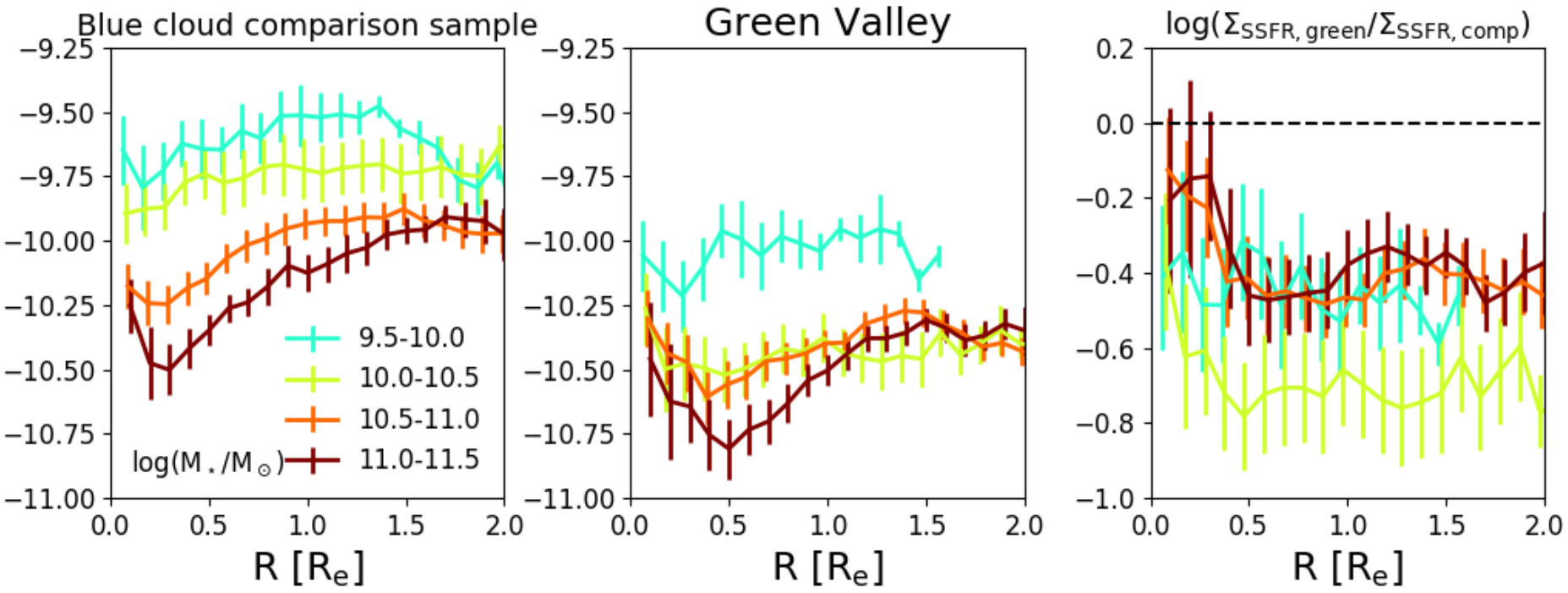
3. Green Valley galaxies have lower sSFR in their discs than blue cloud galaxies of same M_*

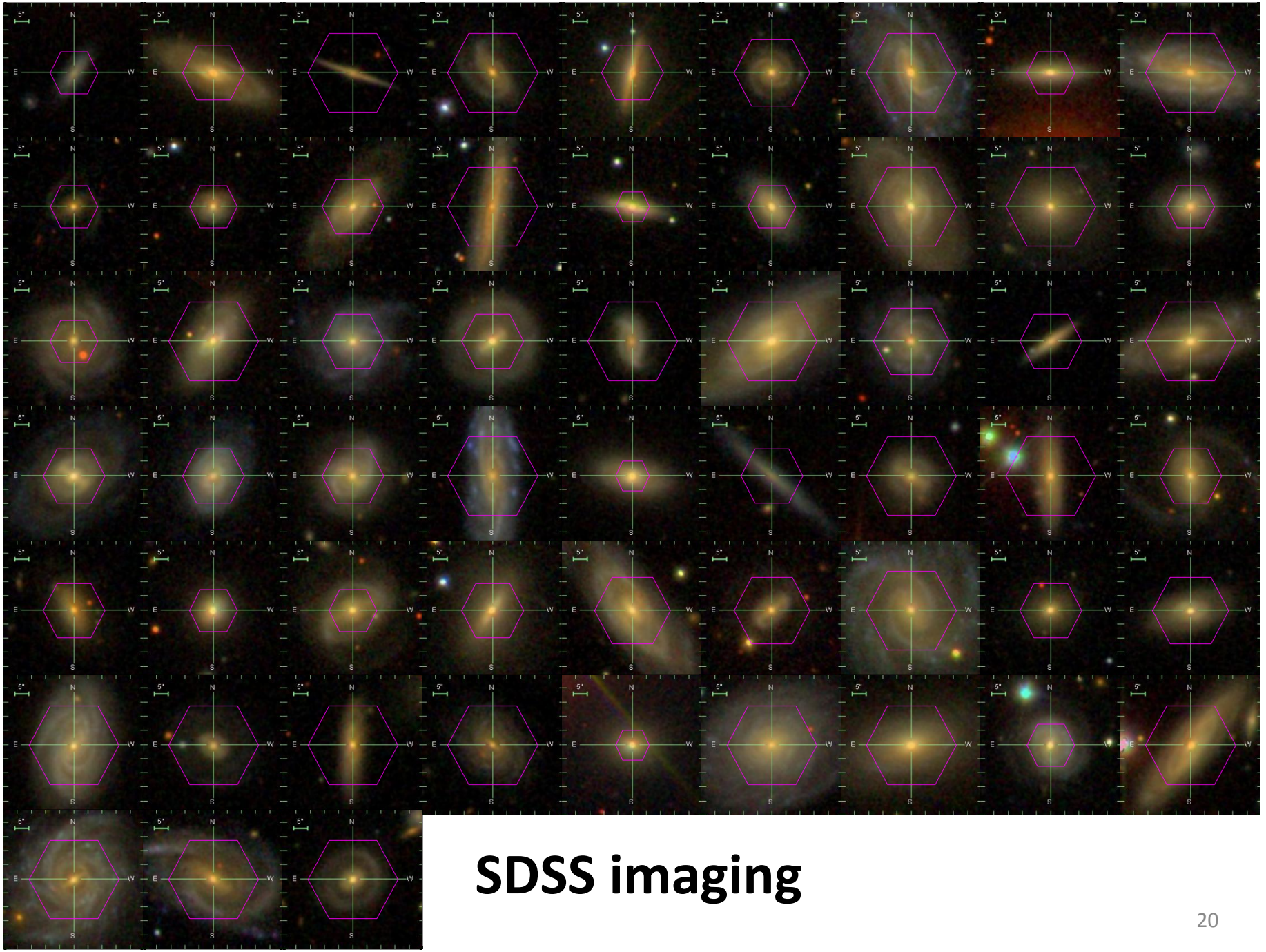
4. Centrally quiescent galaxies live at the high-mass end of the Green Valley and Blue Cloud

sSFR from Brinchmann+2004

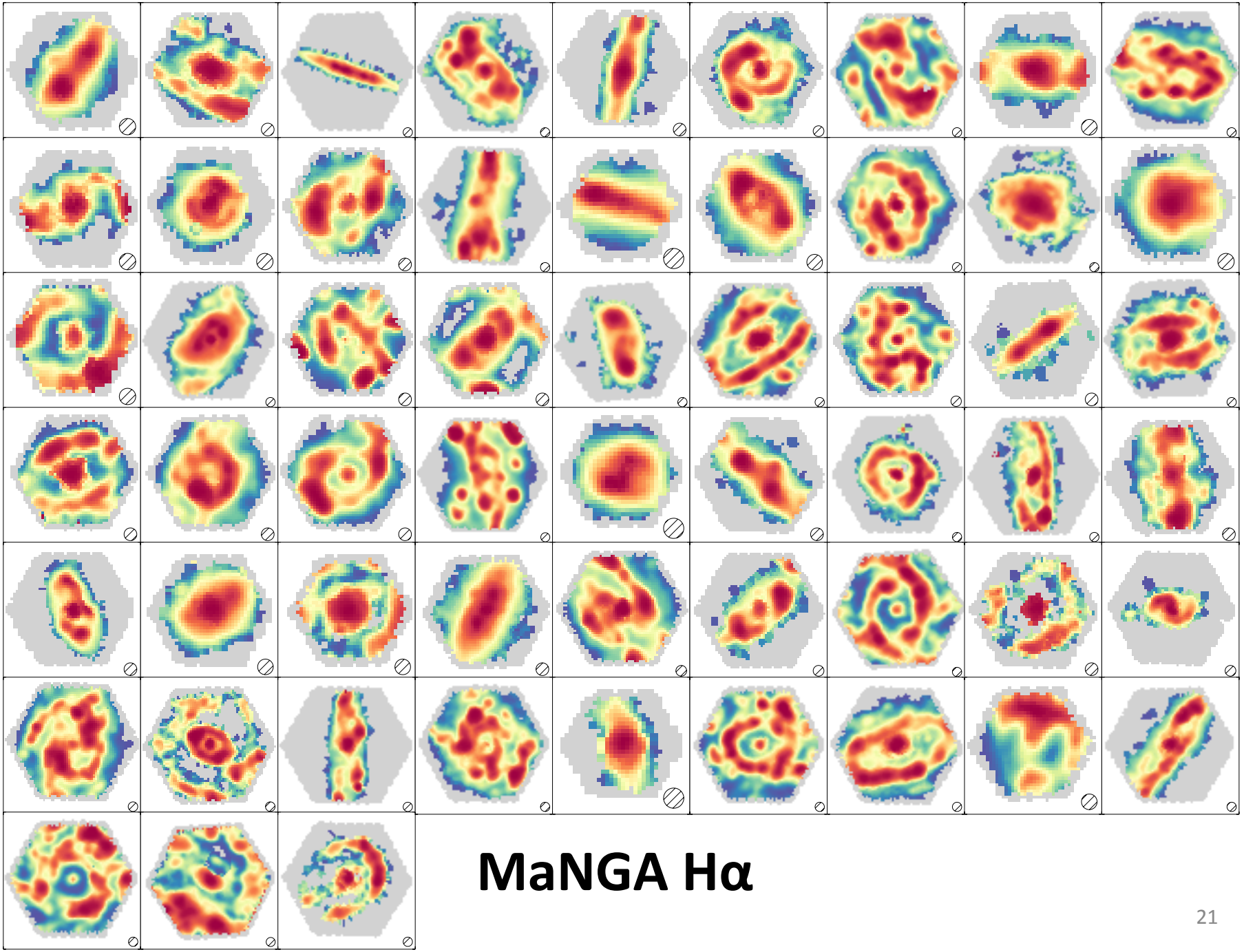


sSFR profiles controlling for Concentration



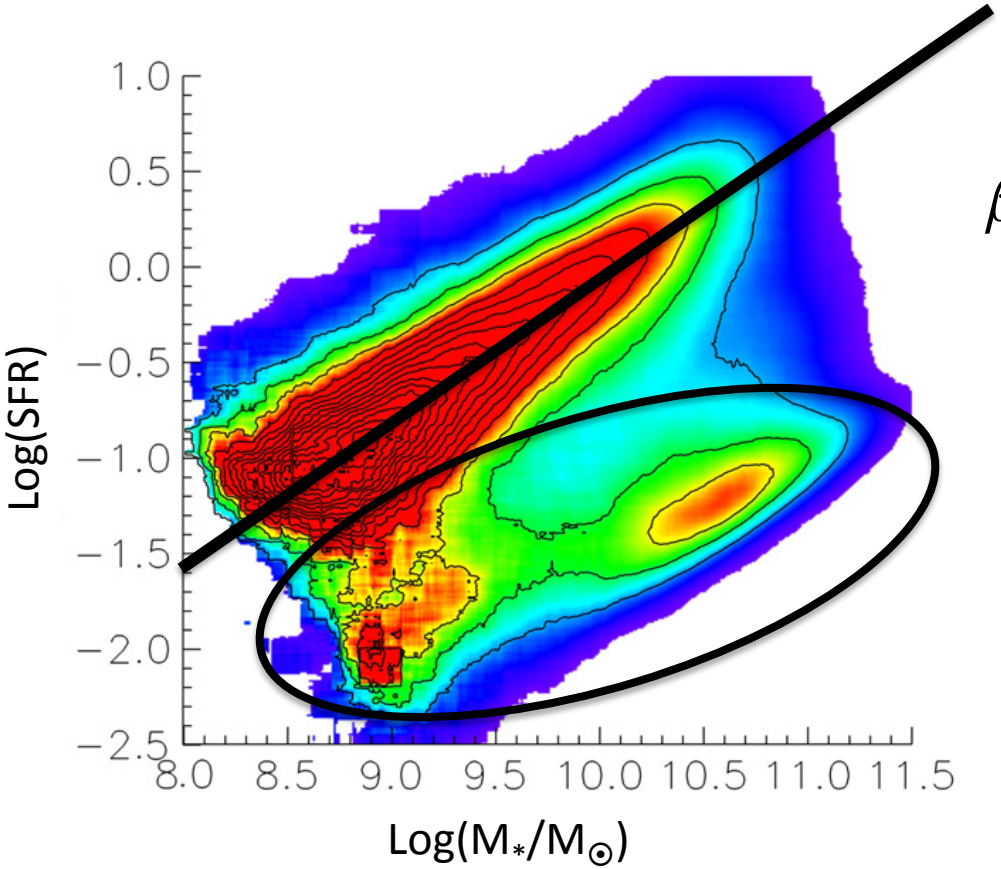


SDSS imaging



MaNGA Hα

Quenching and the galaxy 'Main Sequence'



How steep is the SFMS?

$$\beta \equiv \frac{d \log \mathrm{sSFR}}{d \log M_*} \qquad \beta = [-0.5, -0.1]$$

Brinchmann+2004, Salim+2007, Whitaker+2012, Renzini & Peng 2015, FB+2017a

How about the passive population ?

Log (sSFR) < -12

SFR inferred from stellar population indices (D4000), sensitive to long timescales, best interpreted as upper limits

See also Feldmann 2017