Cold gas properties of galaxies in different environments

Theory vs Observations

Antonino Marasco
Kapteyn Astronomical Institute
Groningen

Collaborators:

Thijs van der Hulst
Joop Schaye
Rob Crain
Ali Ramhati

PHISCC Workshop, Dwingeloo, 17 March 2014

What is the "environment"?

- galaxy number density in a given location of the Universe -> it's **local** property

Why is it so important?

Because it affects the

- cold gas content
- specific star formation rate
- morphology

Really? Why so?

- **External**: ram-pressure stripping & tidal interaction
- **Internal**: mass bias

Why don't we use EAGLE to study it better?

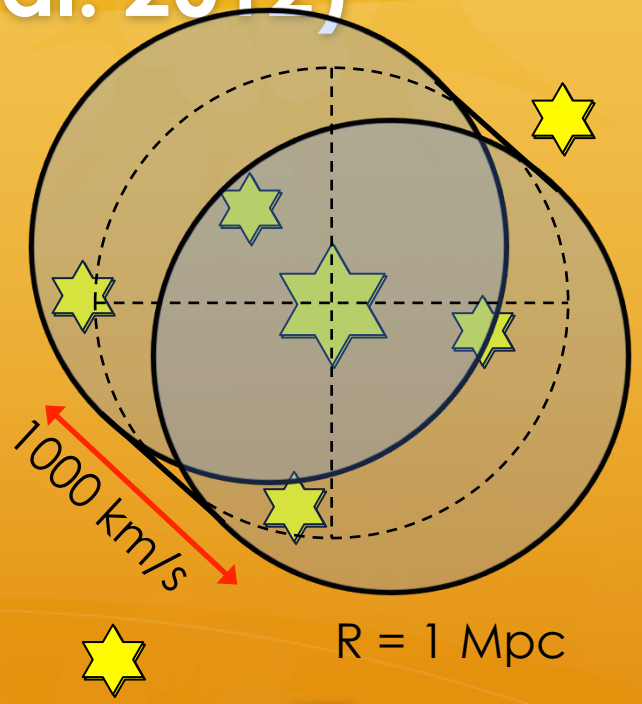
- Excellent idea!

Comparison with observations (Fabello et al. 2012)

Galaxy Sample

~ 12000 galaxies from GALEX Arecibo SDSS ($M_* > 10^{10}\ M_\odot$)

4726 galaxies from ALFALFA

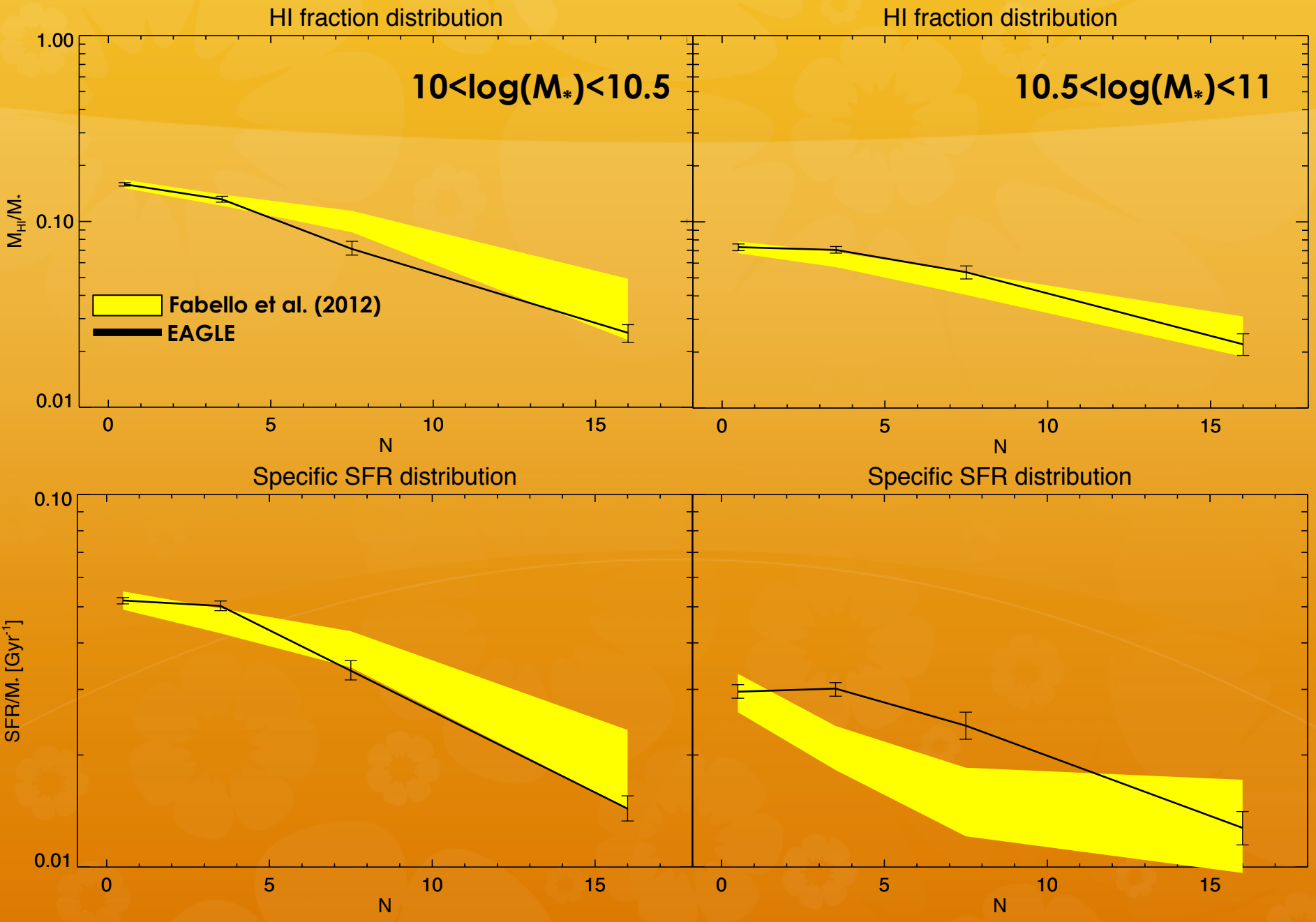


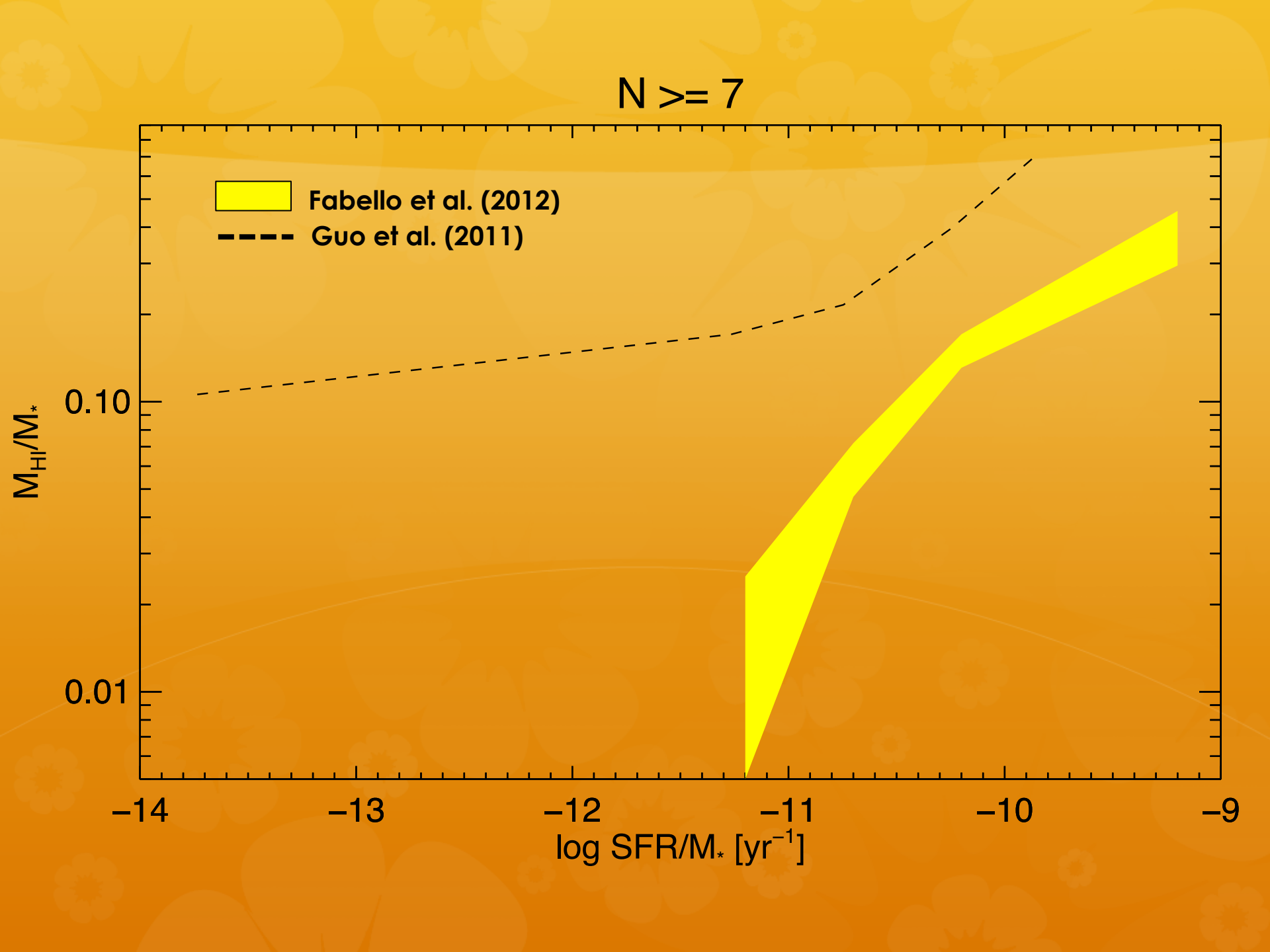
HI masses from stacking

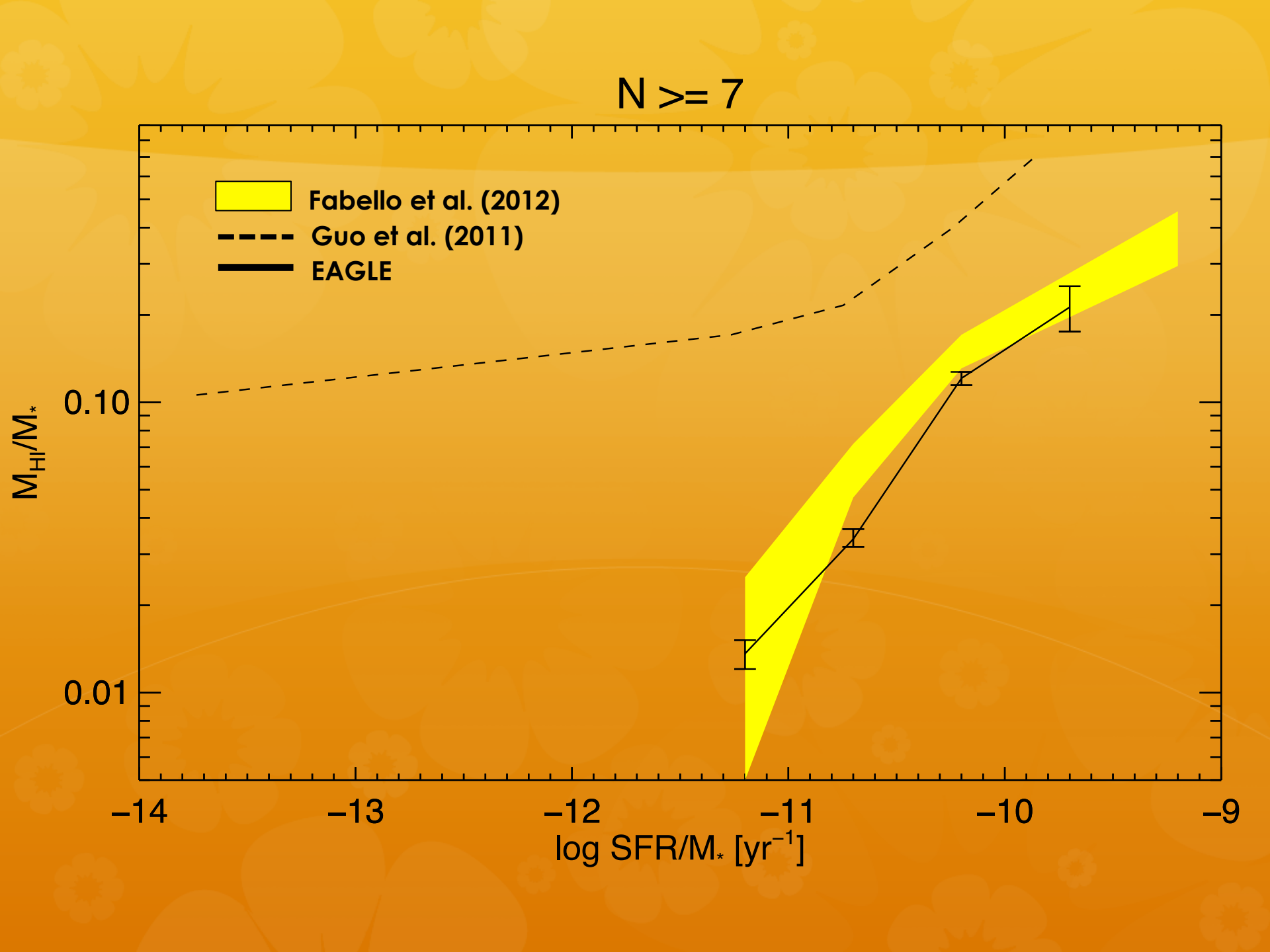
Stellar masses + SFR from SED fitting

N for each object

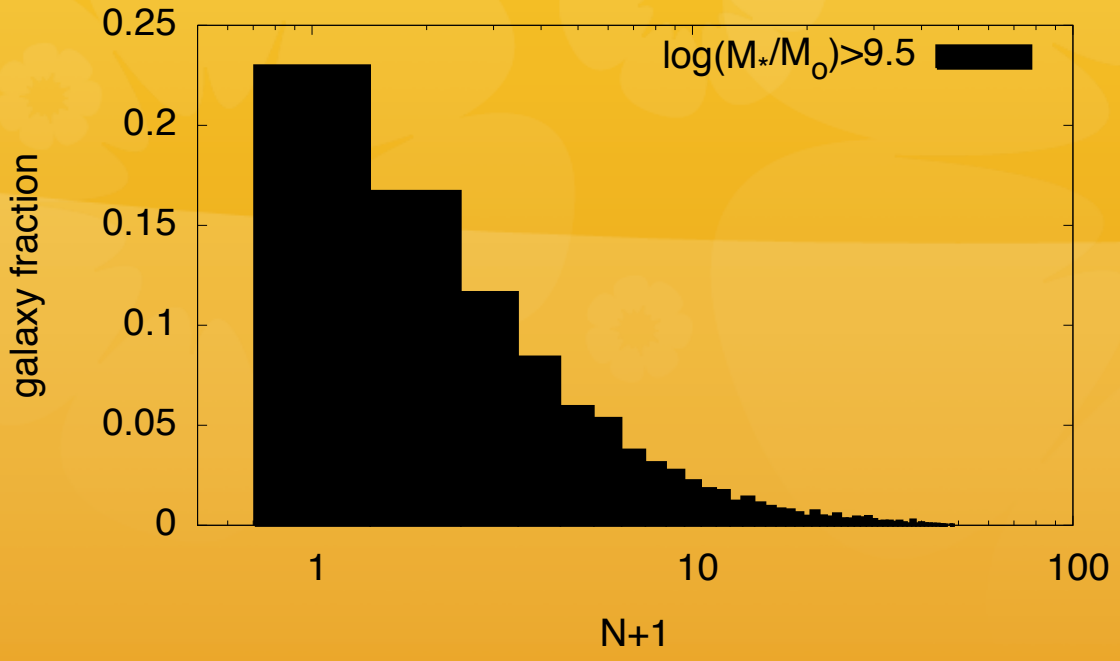
HI fraction and sSFR as a function of **N**

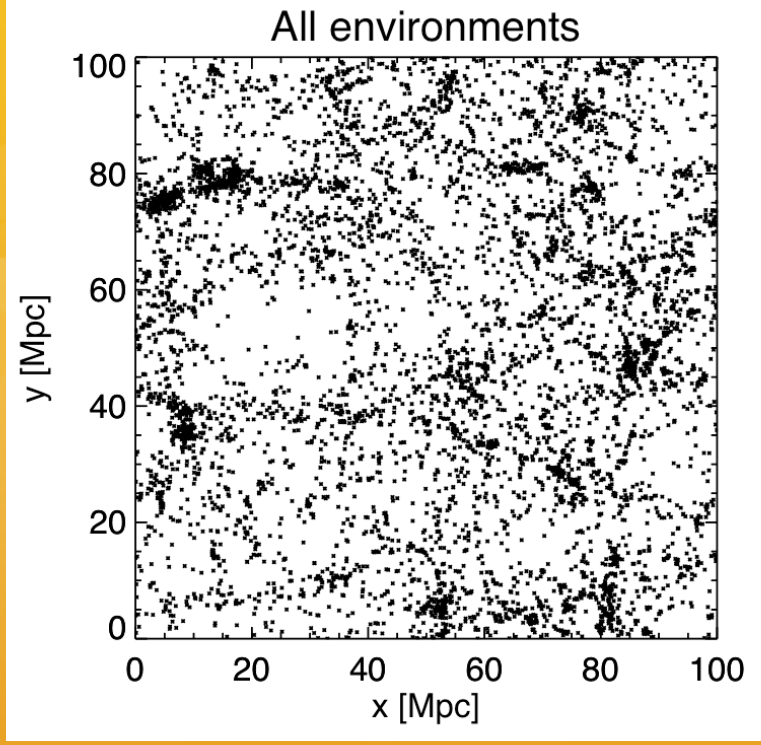

HI fraction distribution
10<log(M*)<10.5
HI fraction distribution
10.5<log(M*)<11
Fabello et al. (2012)
EAGLE
MHI/M*
1.00
0.10
0.01
0
5
10
15
N
Specific SFR distribution
Specific SFR distribution
SFR/M* [Gyr-1]
0.10
0.01

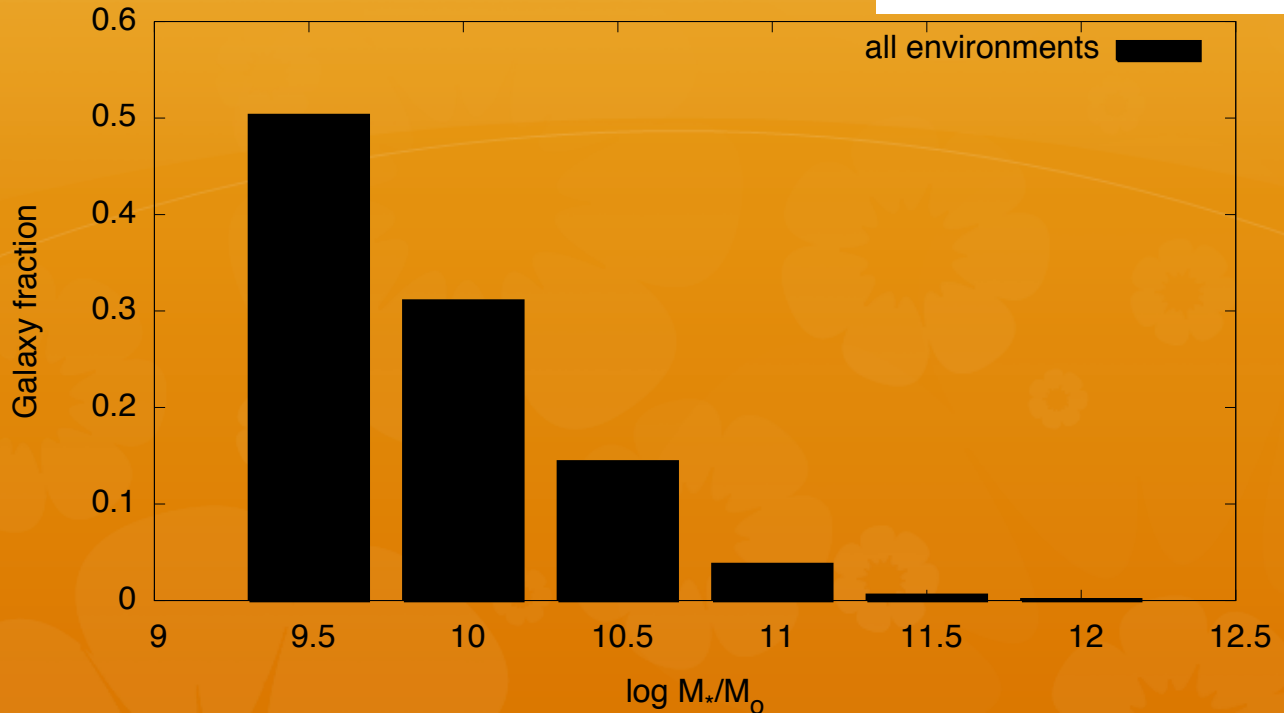

N >= 7
Fabello et al. (2012)
Guo et al. (2011)
0.10
0.01
M_{HI}/M_*
−14
−13
−12
−11
−10
−9
log SFR/M_* [yr^{-1}]

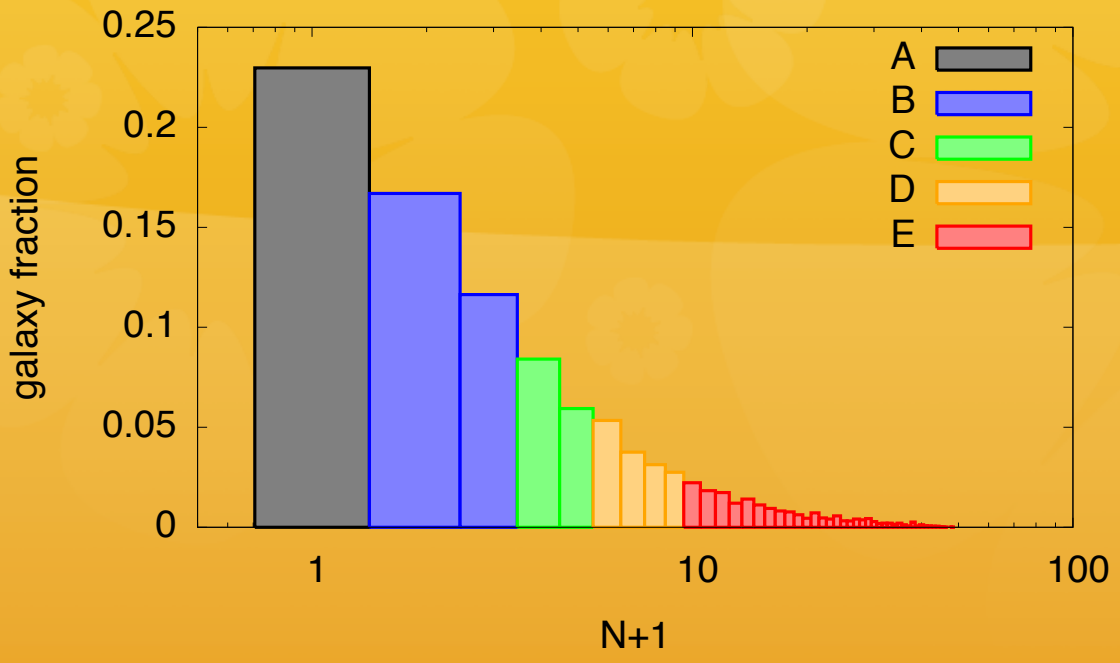

N >= 7
Fabello et al. (2012)
Guo et al. (2011)
EAGLE
0.10
0.01
M_{HI}/M_*
−14
−13
−12
−11
−10
−9
log SFR/M_* [yr^{-1}]

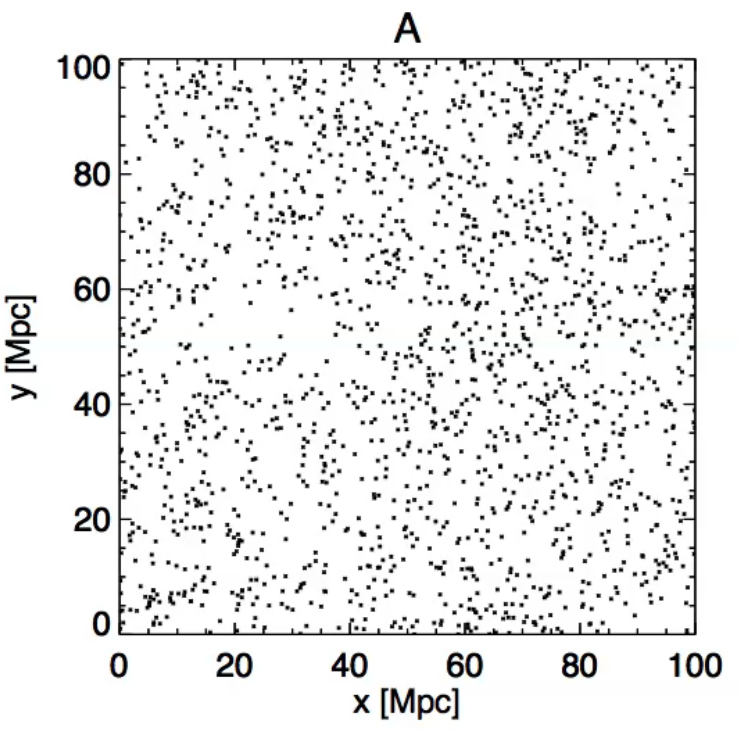
Predictions

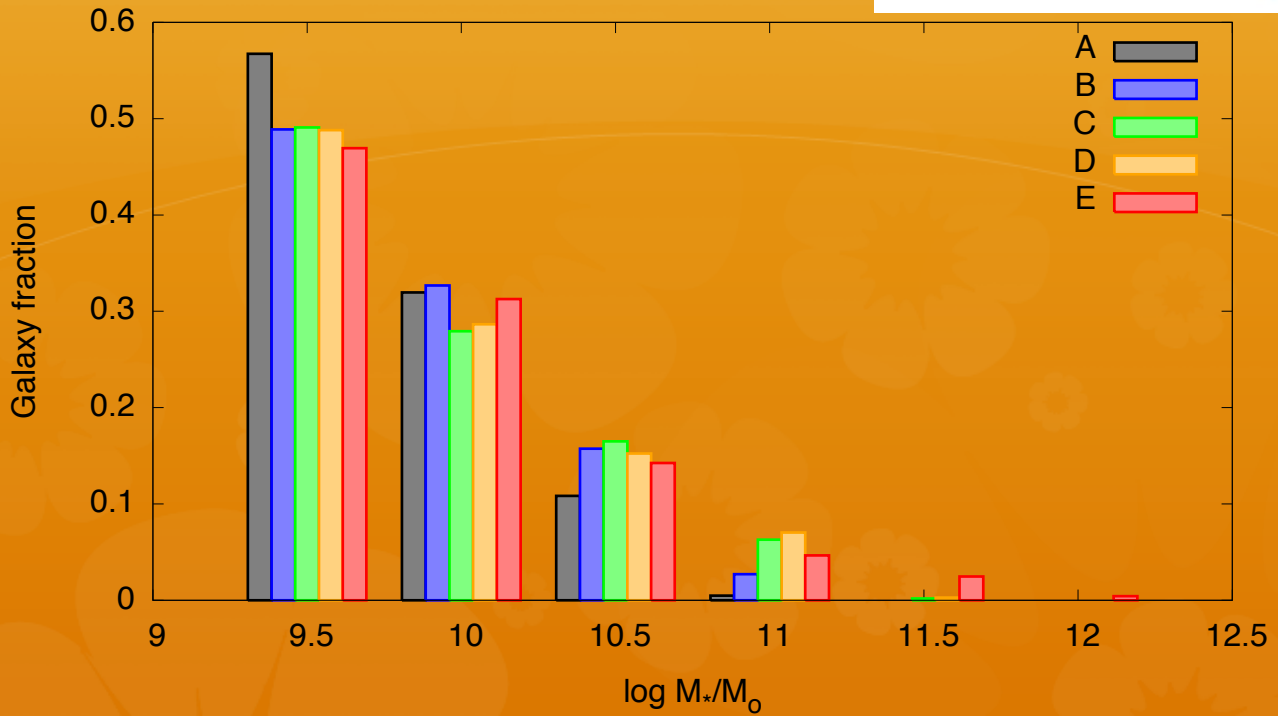

log(M*/Mo)>9.5
galaxy fraction
0.25
0.2
0.15
0.1
0.05
0
1
10
100
N+1

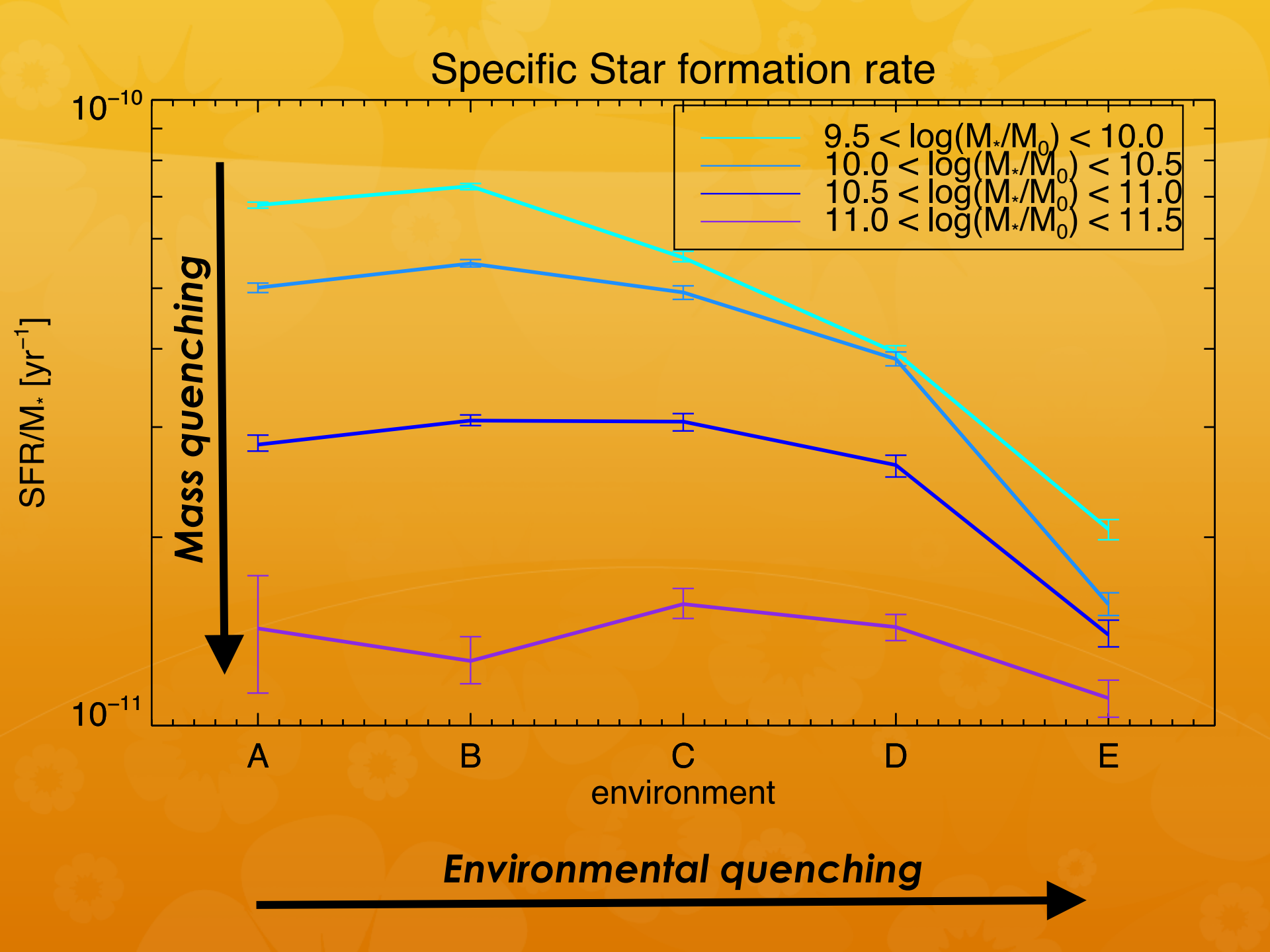

All environments
y [Mpc]
x [Mpc]
100
80
60
40
20
0
0
20
40
60
80
100

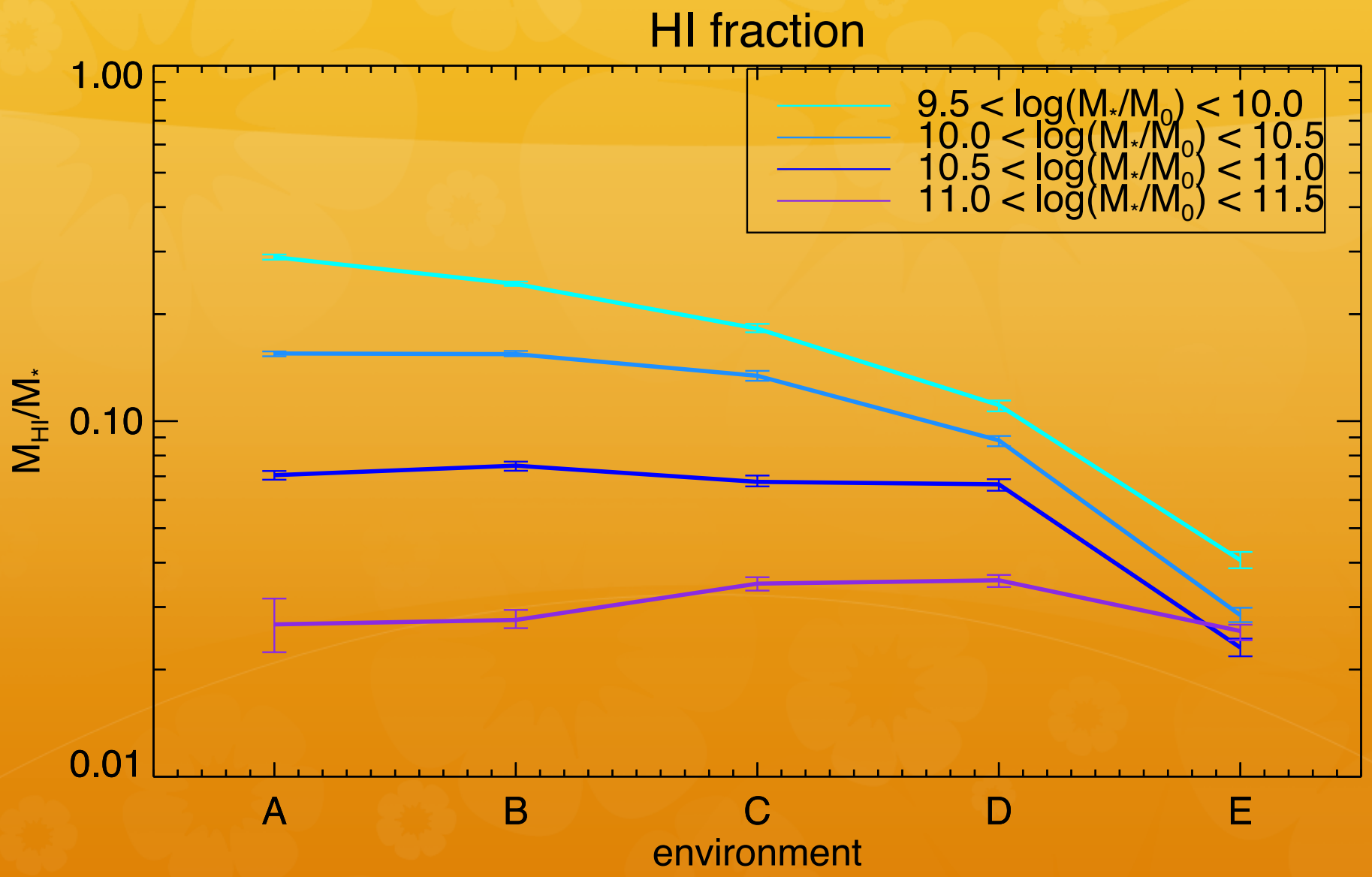

all environments
Galaxy fraction
log M*/Mo
0.6
0.5
0.4
0.3
0.2
0.1
0
9
9.5
10
10.5
11
11.5
12
12.5

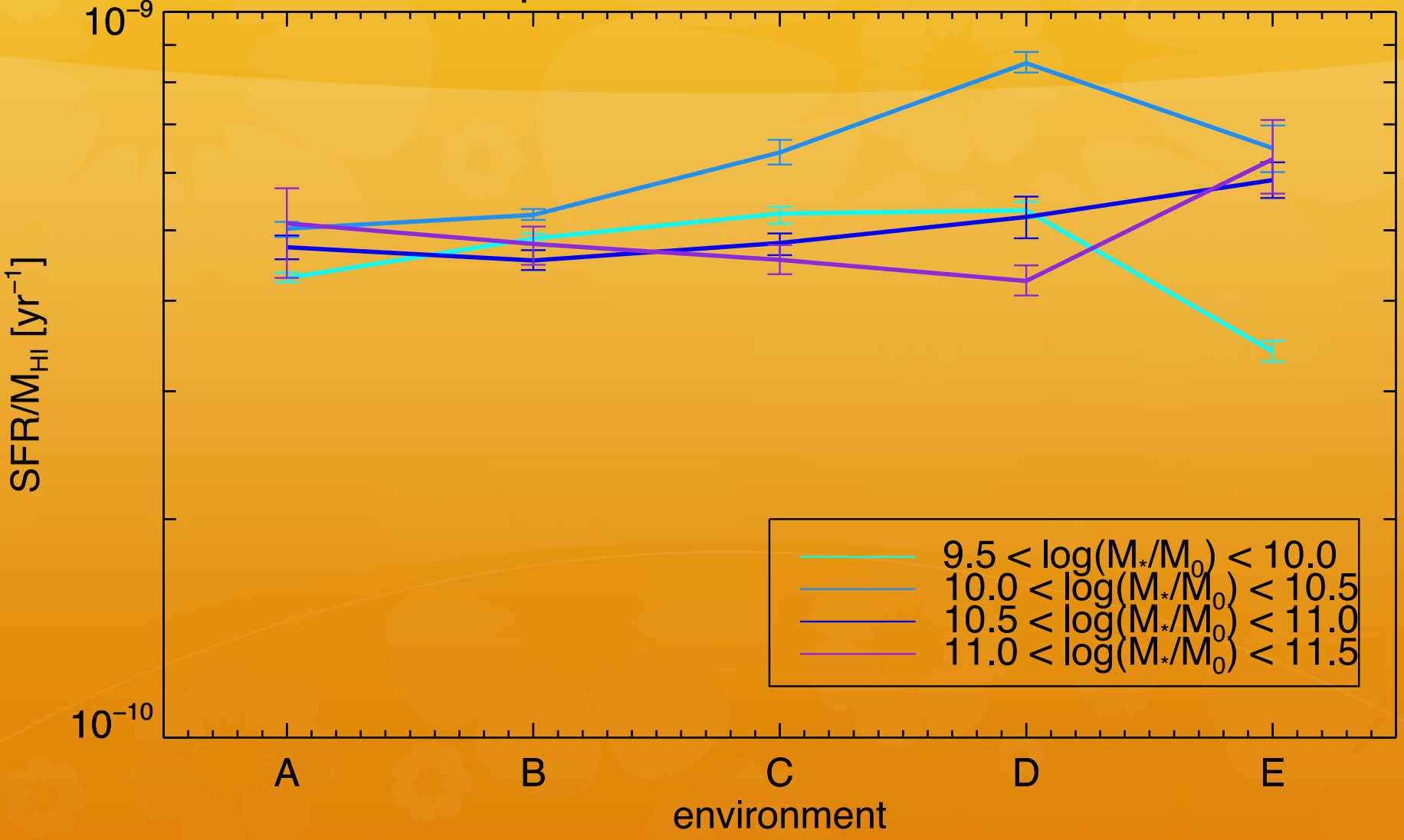

galaxy fraction
0.25
0.2
0.15
0.1
0.05
0
1
10
100
N+1
A
B
C
D
E

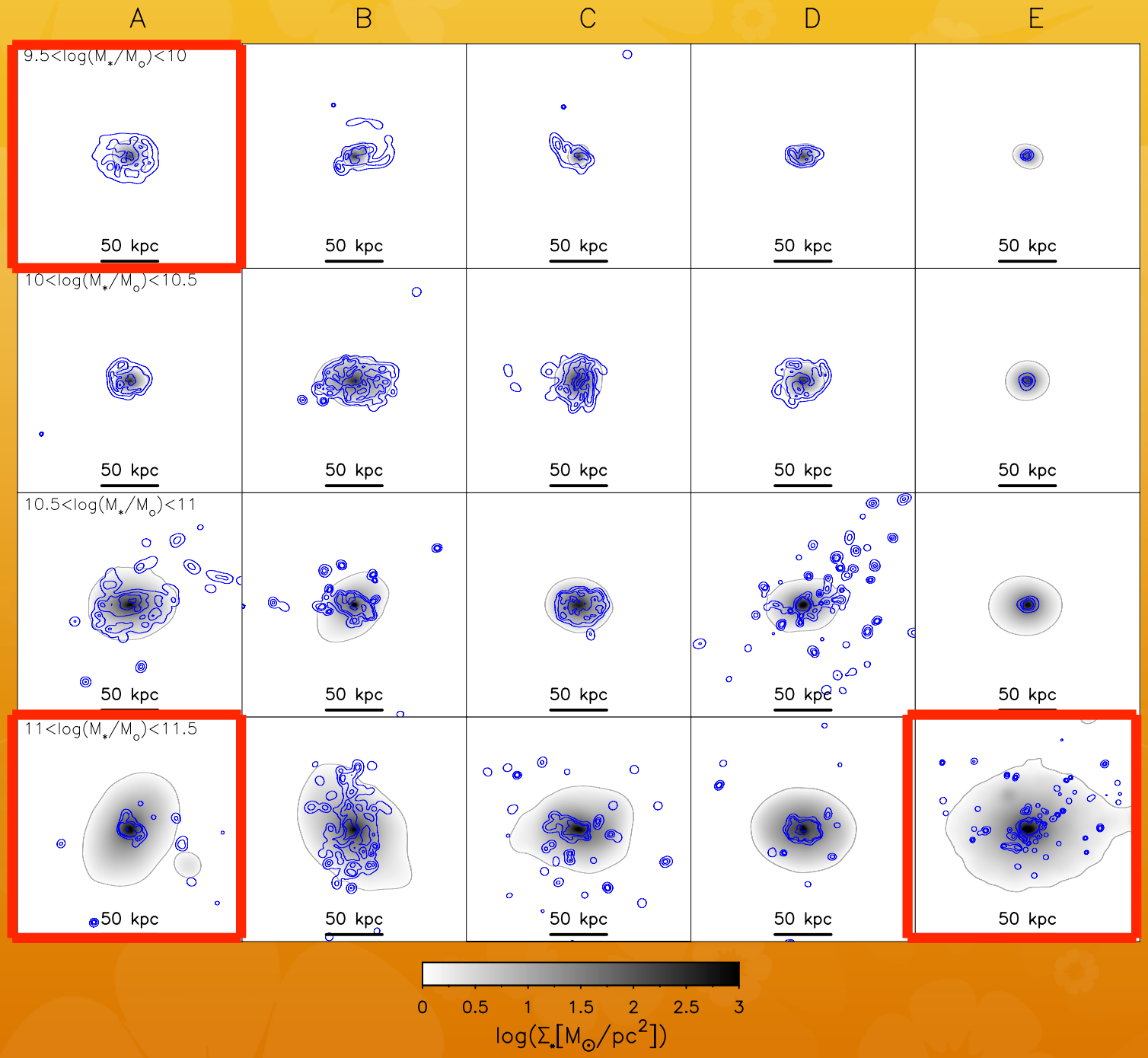

A
y [Mpc]
x [Mpc]
0
20
40
60
80
100

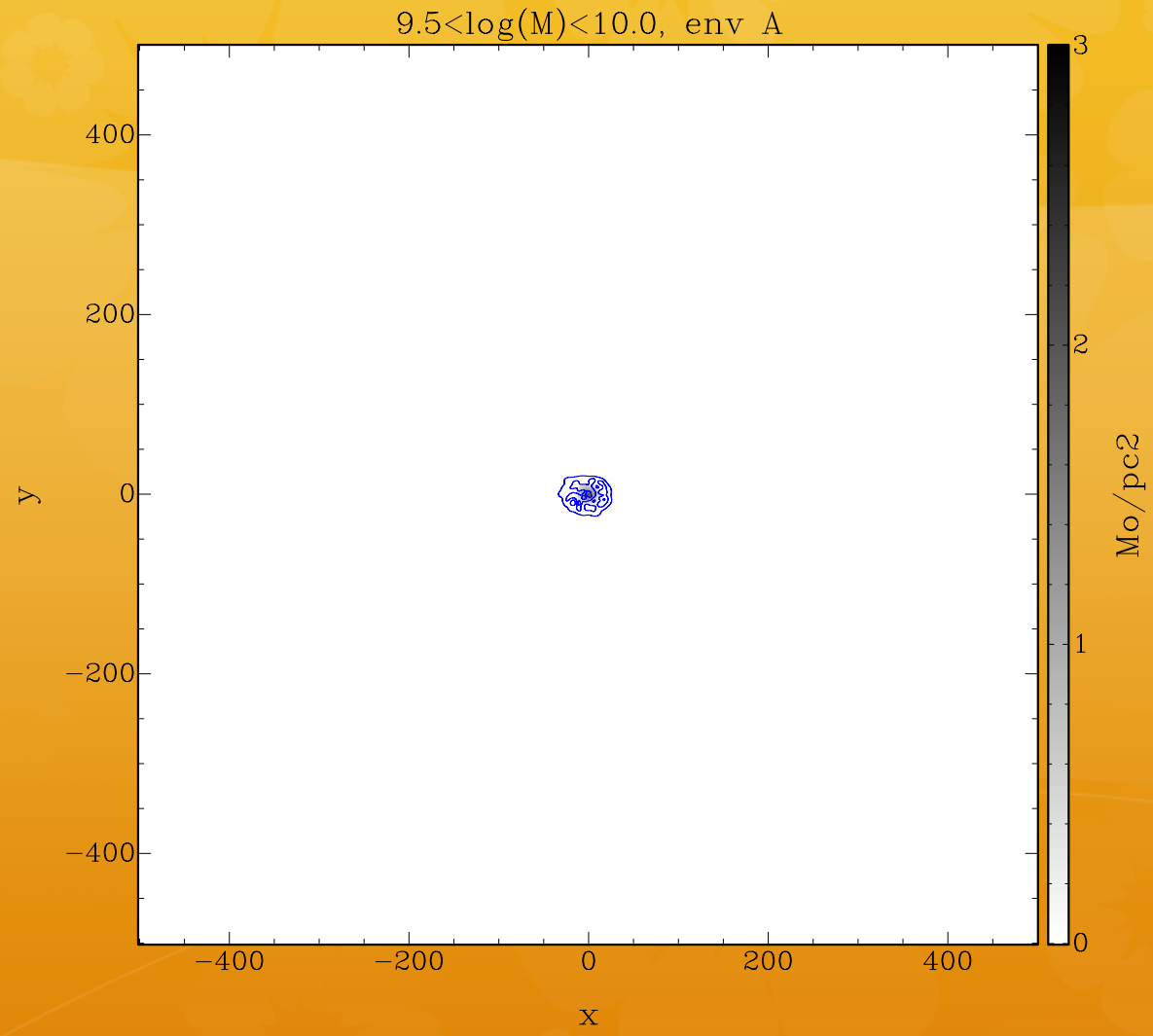

Galaxy fraction
0.6
0.5
0.4
0.3
0.2
0.1
0
9
9.5
10
10.5
11
11.5
12
12.5
log M⋆/M⊙
A
B
C
D
E

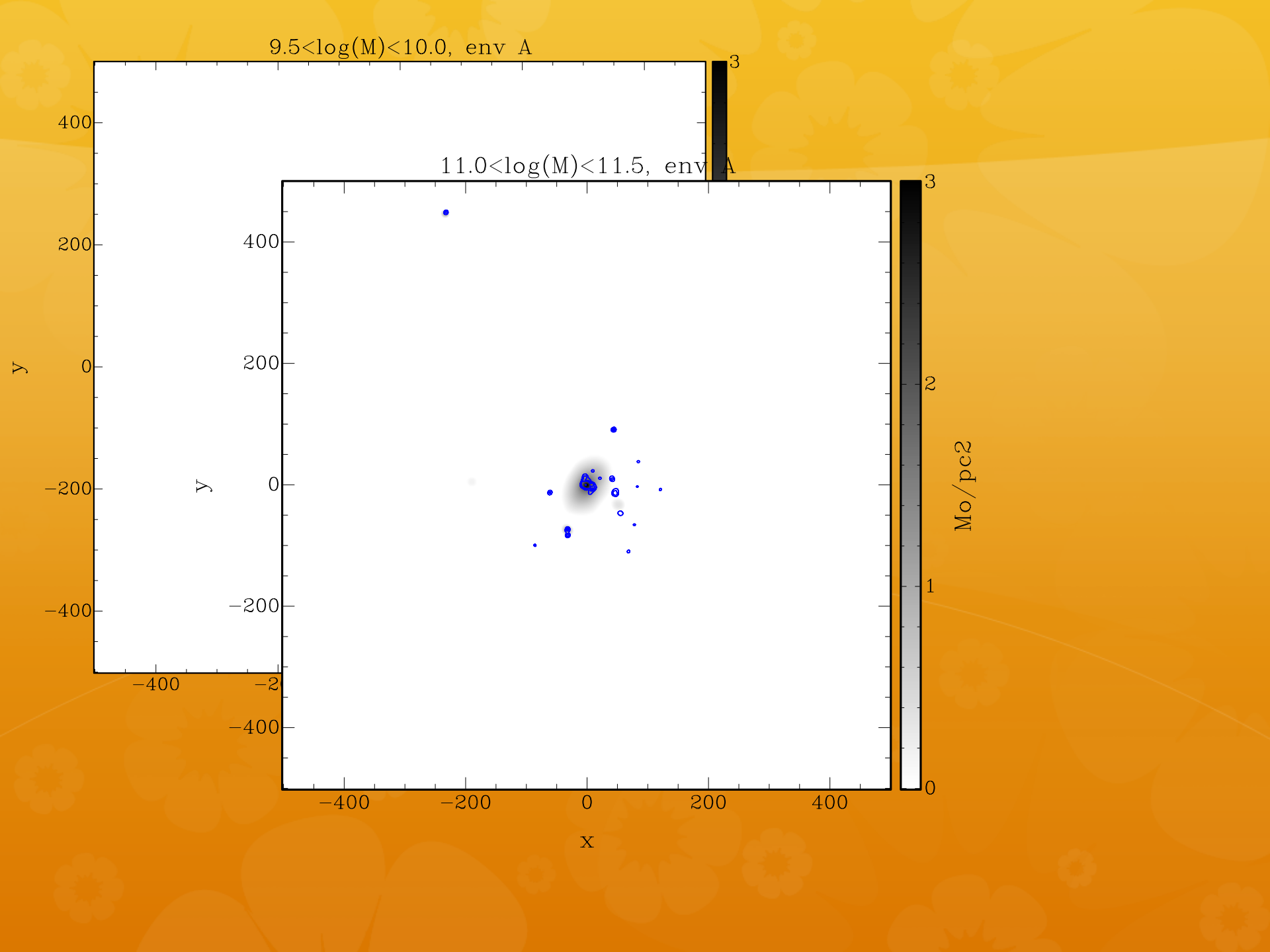

Specific Star formation rate
10^{-10}
10^{-11}
SFR/M* [yr^{-1}]
9.5 < log(M*/M0) < 10.0
10.0 < log(M*/M0) < 10.5
10.5 < log(M*/M0) < 11.0
11.0 < log(M*/M0) < 11.5
Mass quenching
A
B
C
D
E
environment
Environmental quenching

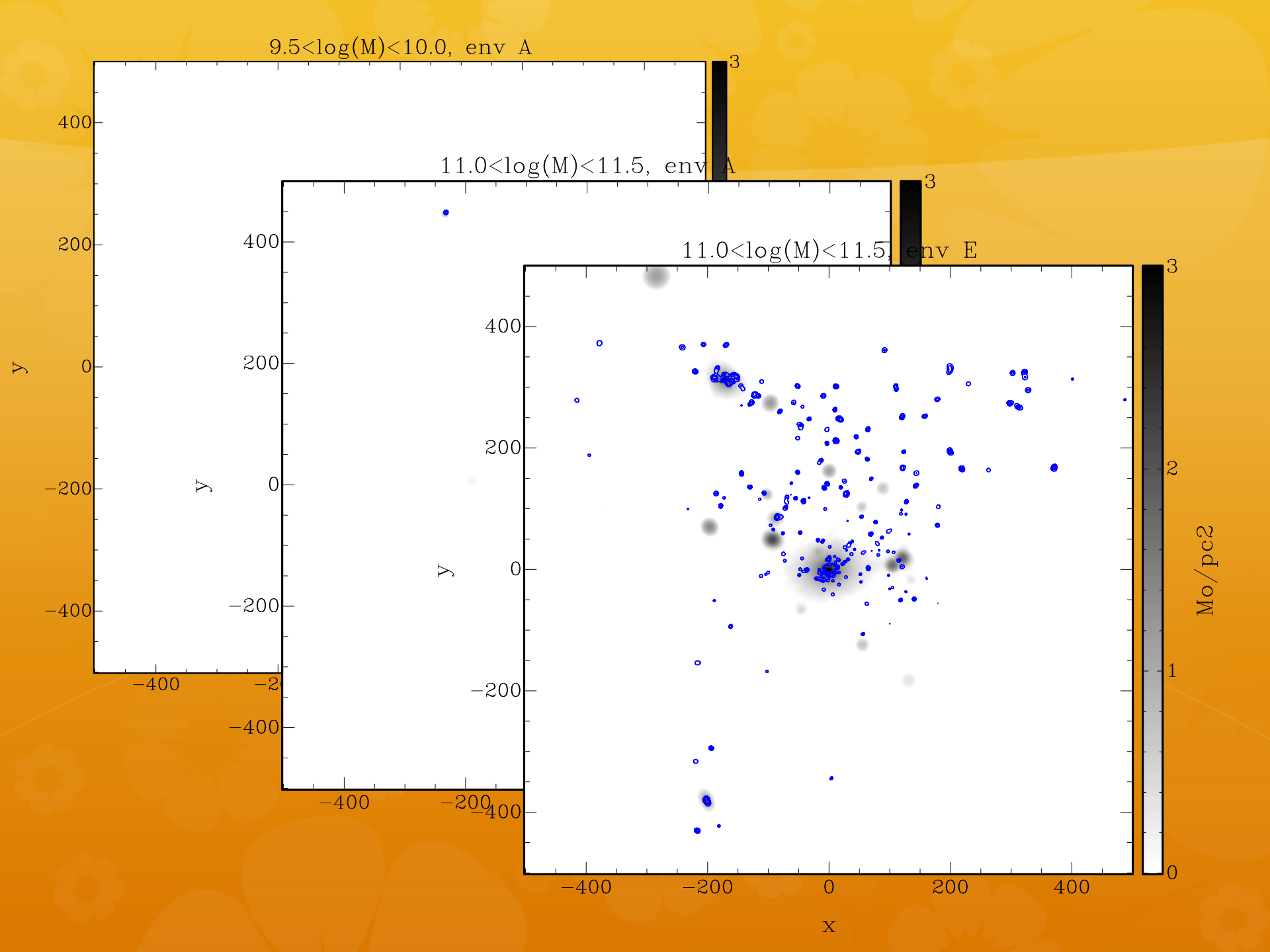

HI fraction
1.00
0.10
0.01
M_{HI}/M_*
$9.5 < \log(M_*/M_0) < 10.0$
$10.0 < \log(M_*/M_0) < 10.5$
$10.5 < \log(M_*/M_0) < 11.0$
$11.0 < \log(M_*/M_0) < 11.5$
A
B
C
D
E
environment

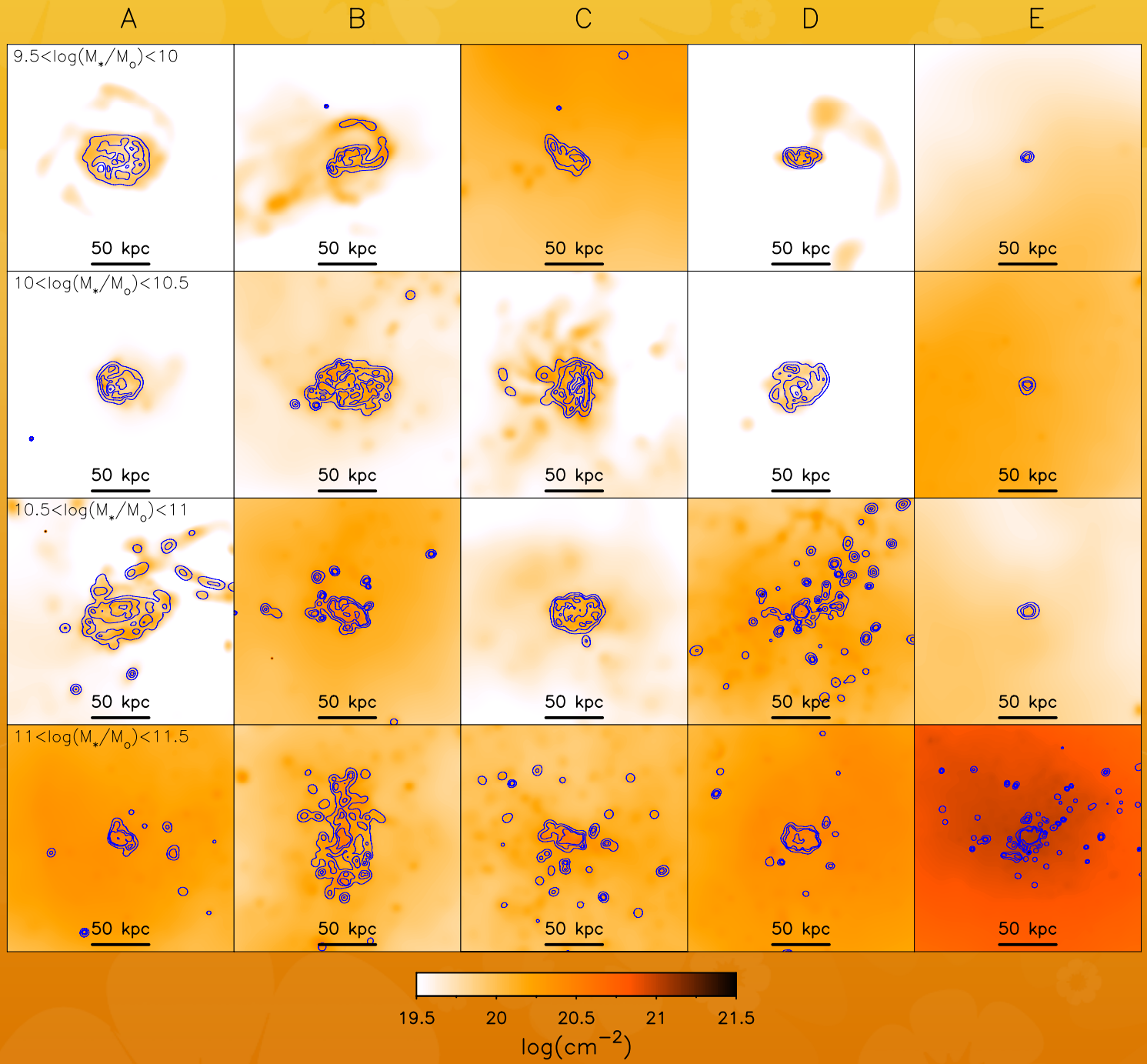

Specific Star formation rate
10^{-9}
10^{-10}
SFR/M_{HI} [yr^{-1}]
A
B
C
D
E
environment
9.5 < log(M_*/M_0) < 10.0
10.0 < log(M_*/M_0) < 10.5
10.5 < log(M_*/M_0) < 11.0
11.0 < log(M_*/M_0) < 11.5

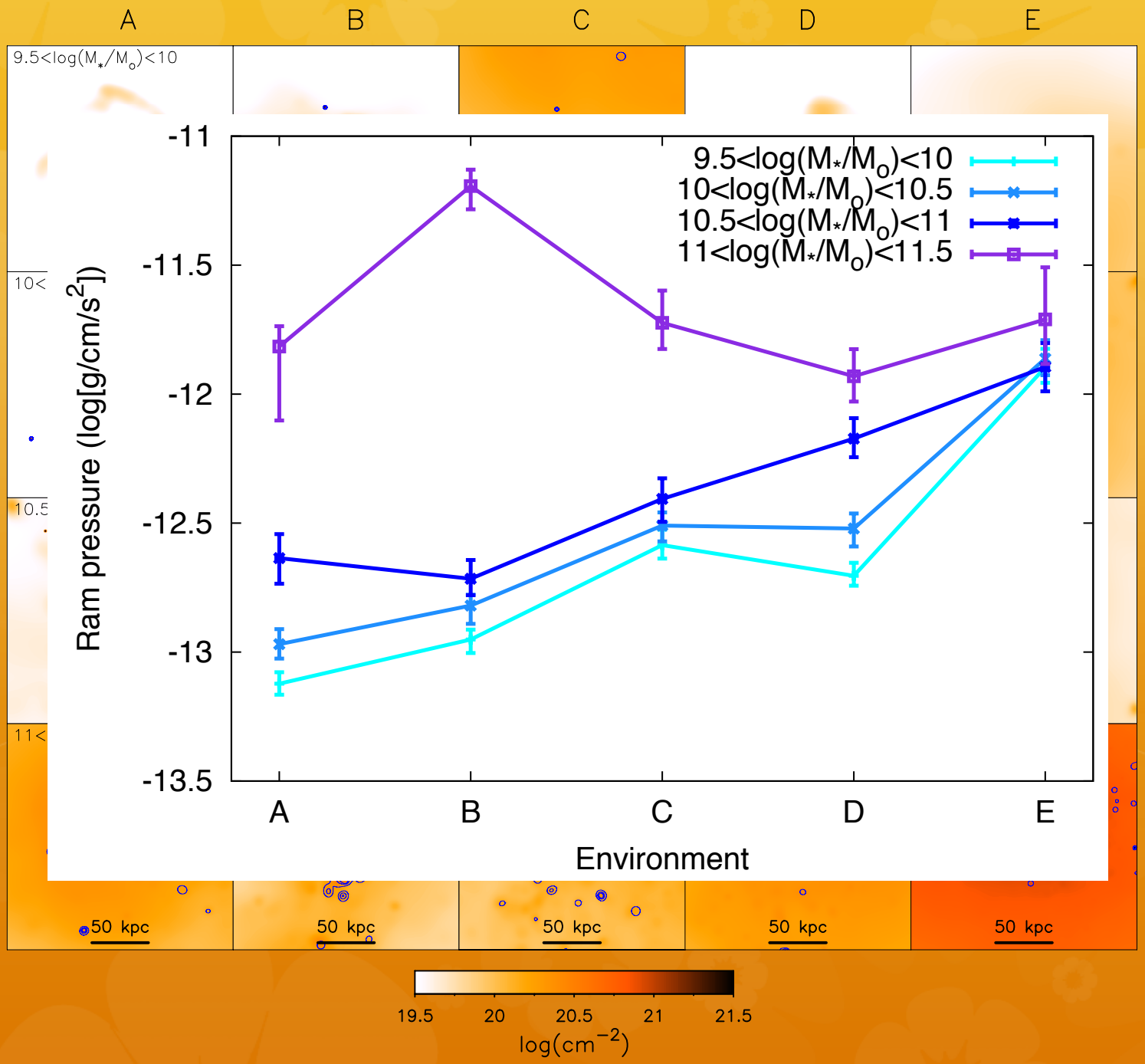

A
B
C
D
E
9.5<log(M*/Mo)<10
10<log(M*/Mo)<10.5
10.5<log(M*/Mo)<11
11<log(M*/Mo)<11.5
50 kpc
0
0.5
1
1.5
2
2.5
3
log(Σ*[M⊙/pc2])


9.5<log(M)<10.0, env A
400
200
0
−200
−400
y
−400
−200
0
200
400
x
3
2
1
0
Mo/pc2


9.5<log(M)<10.0, env A
11.0<log(M)<11.5, env A
y
x
Mo/pc2
400
200
0
−200
−400
3
2
1
0


9.5<log(M)<10.0, env A
11.0<log(M)<11.5, env A
11.0<log(M)<11.5, env E
x
y
Mo/pc2
3
2
1
0
400
200
0
−200
−400


A
B
C
D
E
9.5<log(M*/Mo)<10
10<log(M*/Mo)<10.5
10.5<log(M*/Mo)<11
11<log(M*/Mo)<11.5
50 kpc
19.5
20
20.5
21
21.5
log(cm−2)


A
B
C
D
E
9.5<log(M*/Mo)<10
10<
10.5
11<
50 kpc
50 kpc
50 kpc
50 kpc
50 kpc
-11
-11.5
-12
-12.5
-13
-13.5
Ram pressure (log[g/cm/s2])
9.5<log(M*/Mo)<10
10<log(M*/Mo)<10.5
10.5<log(M*/Mo)<11
11<log(M*/Mo)<11.5
A
B
C
D
E
Environment
19.5
20
20.5
21
21.5
log(cm−2)

Conclusions

- EAGLE reproduces the **observed** environmental trends in HI fractions and sSFR
- Galaxy properties depend both on stellar mass and environment
- Galaxy with $M_* > 10^{11}$ do not "feel" the environment where they live
- Ram pressure is stronger in denser environments
- Clumpy HI structures must be investigated