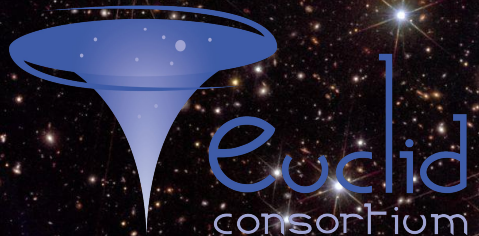
Predictions of galaxy evolution scaling relations for Euclid

Quenched fractions, density, morphology

Cressida Cleland

SWG-GAEV
-> ENVIRONMENT
-> PASSIVE
GALAXIES

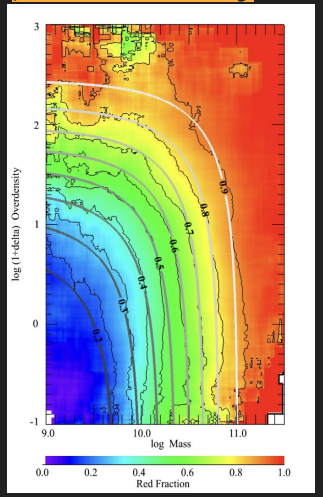


Simona Mei, Francesco Shankar, Hao Fu, Daniel Roberts, Lumen Boco

Galaxy scaling relations at low z

Galaxy scaling relations at low z

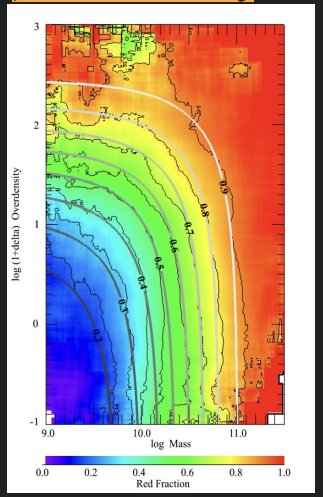
passive-density



Peng+10

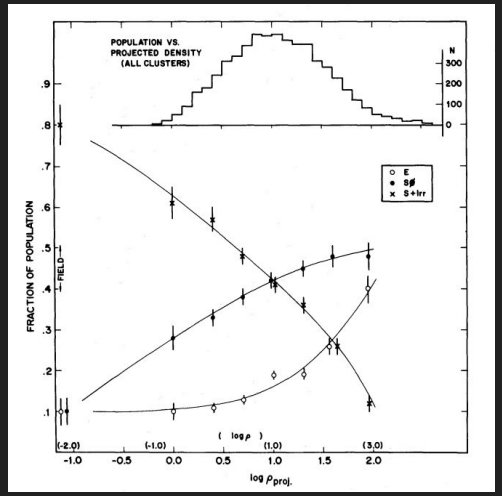
Galaxy scaling relations at low z

passive-density



Peng+10

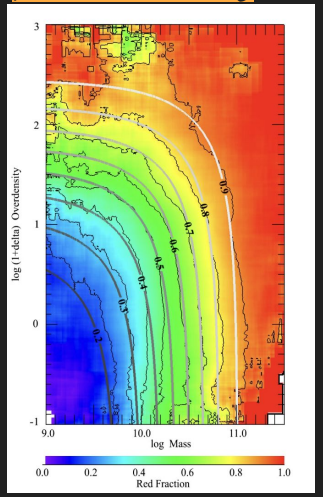
morphology-density



Dressler+80

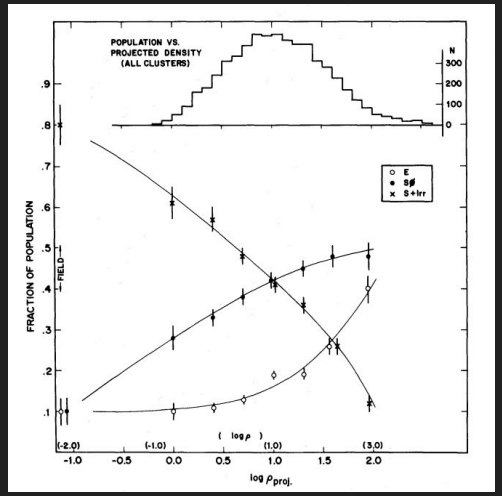
Galaxy scaling relations at low z

passive-density



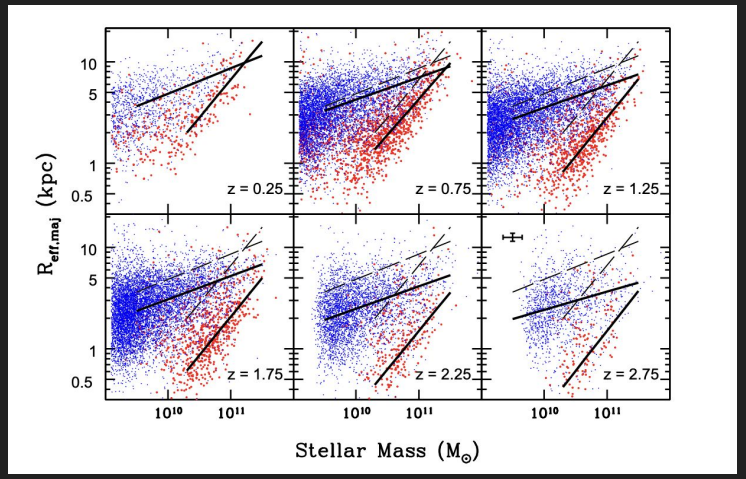
Peng+10

morphology-density

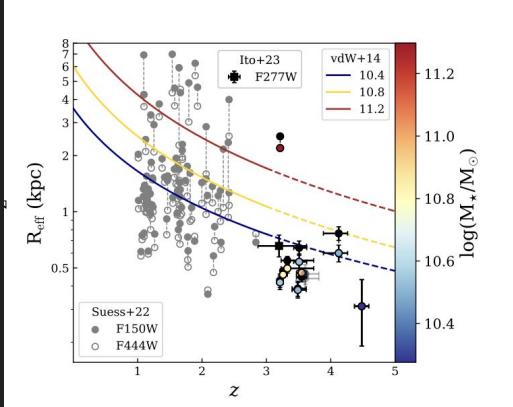


Dressler+80

mass-size



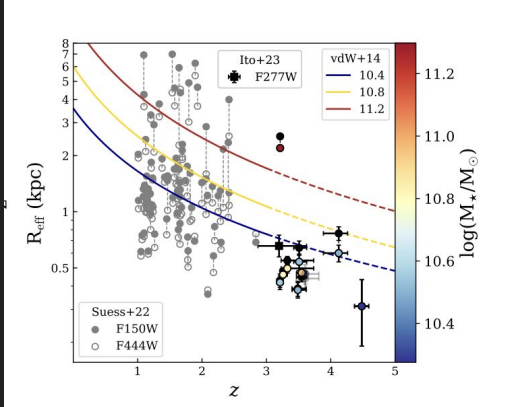
van der Wel+14



Wright+23

Compact quiescent galaxies at $z > 3$

More compact that predicted?



Wright+23

Compact quiescent galaxies at $z > 3$

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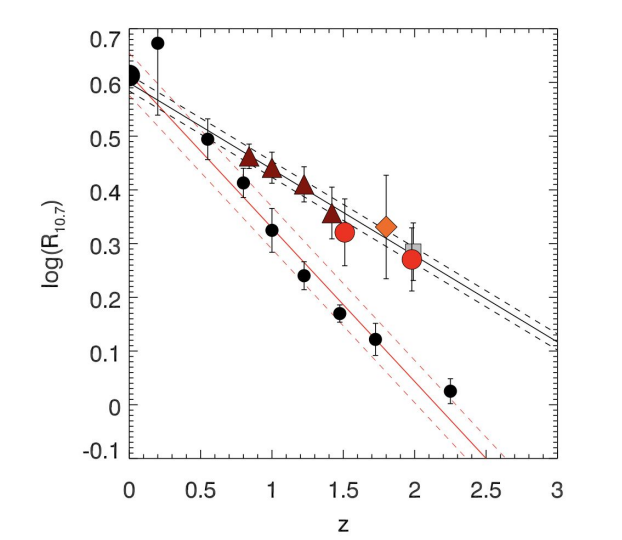
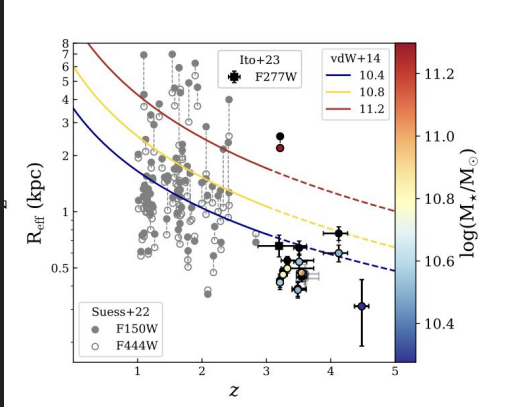
ETGs in clusters are larger than in the field?



Afanasiev+23



Wright+23

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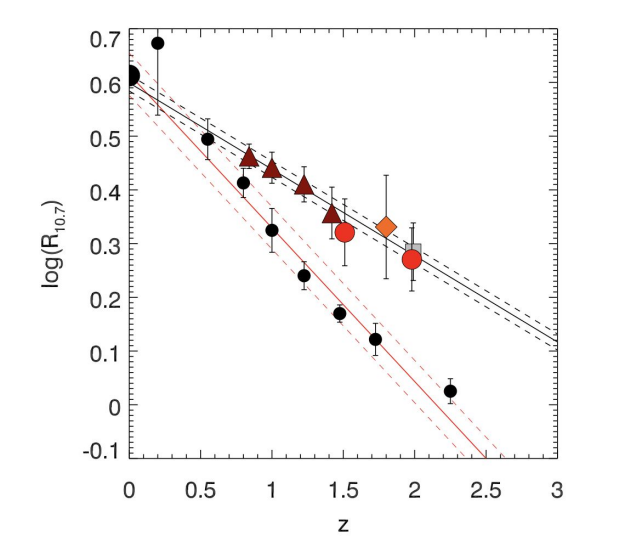
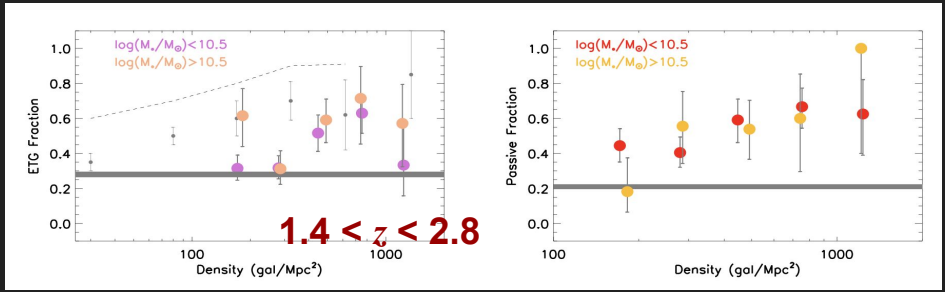


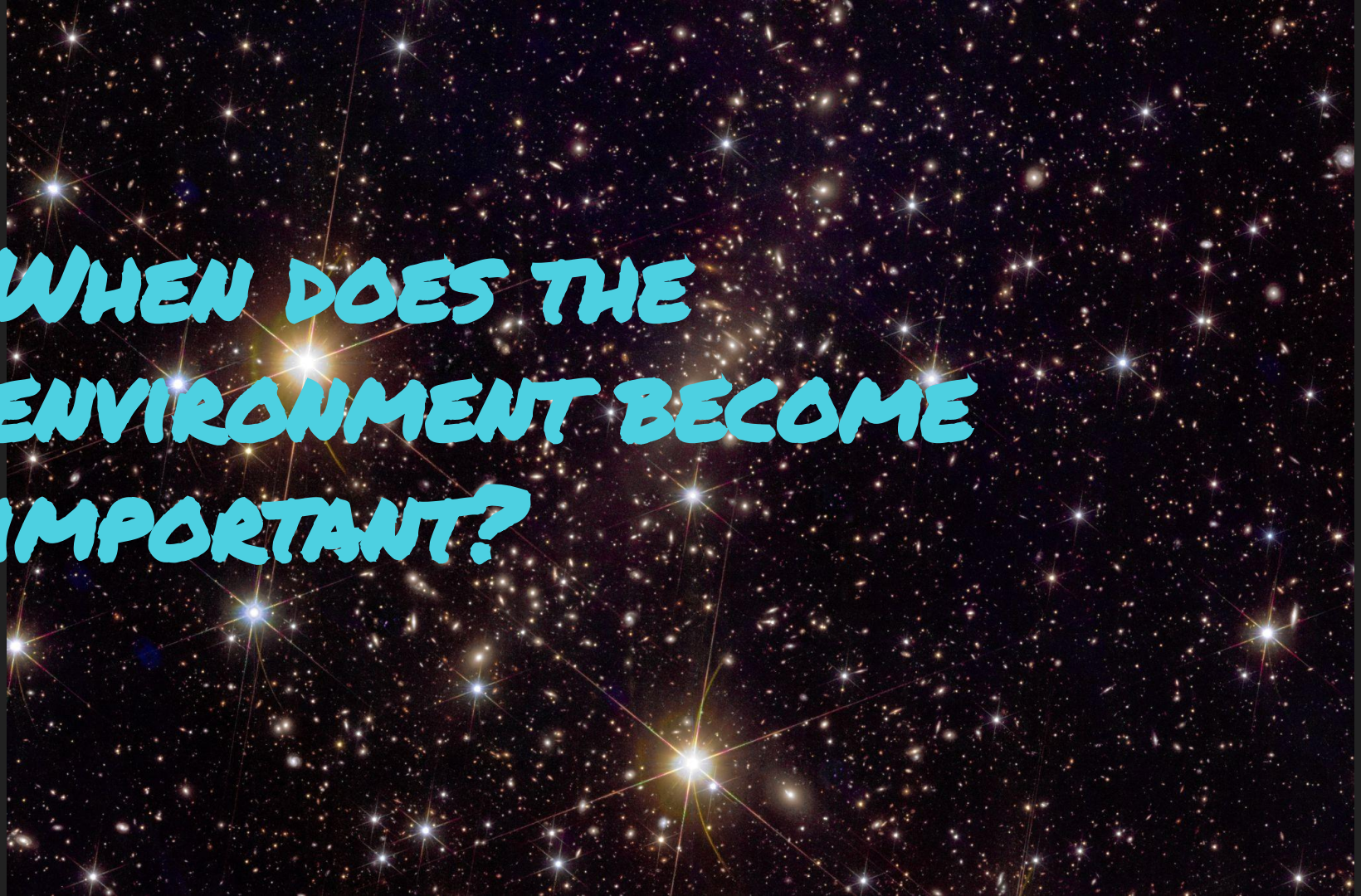
Afanasiev+23

Morphology-density relation at $z > 3$?

How does environment affect QF?

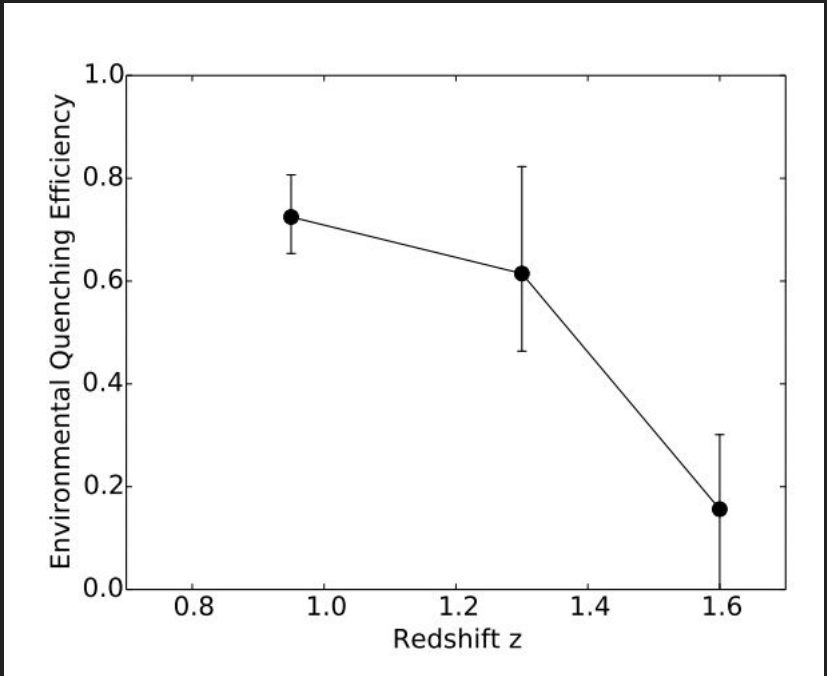


Mei+23

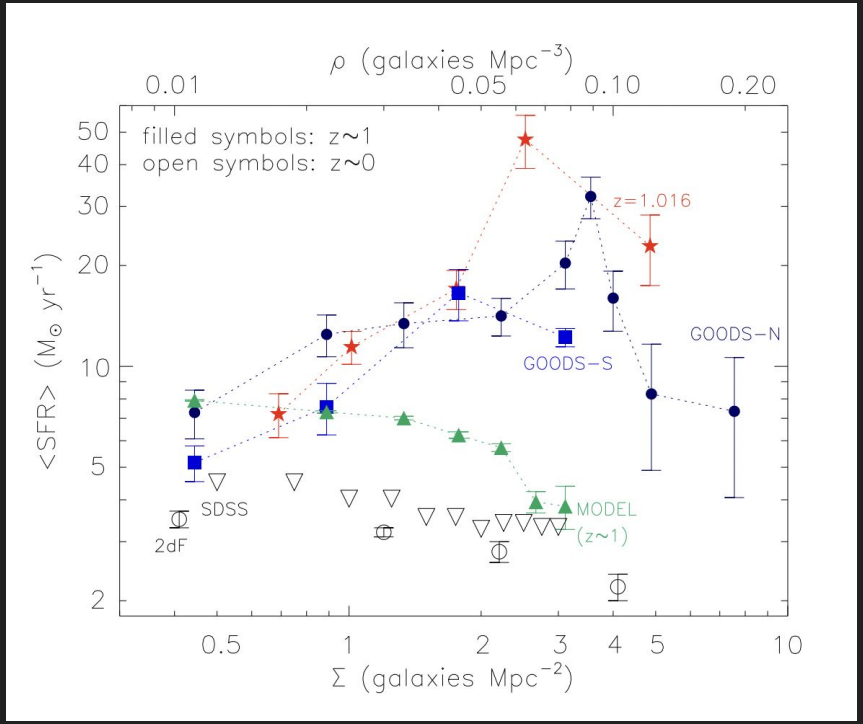

When does the environment become important?


When does the environment become important?
(and how?)

Reversal of SFR-density relation at high-z?

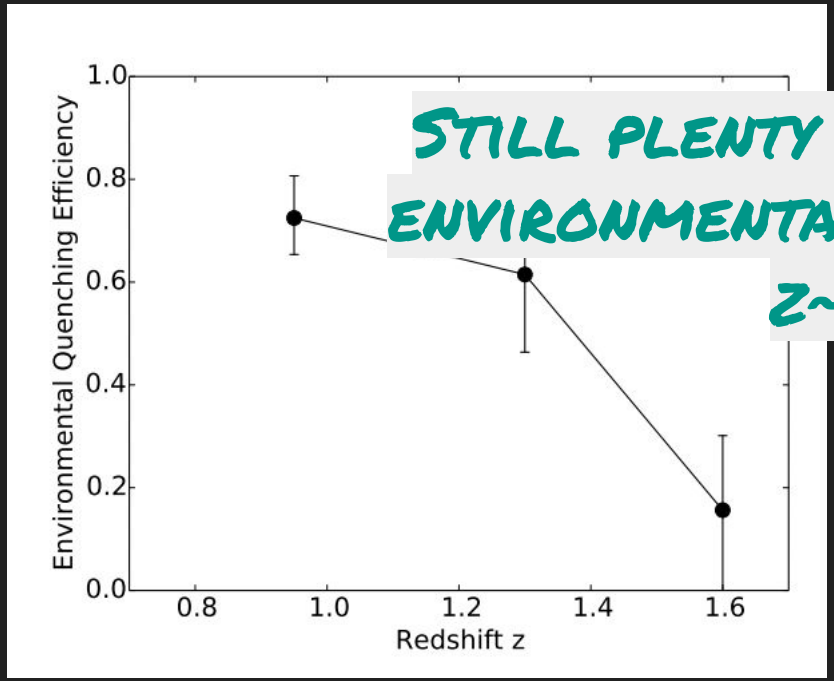


Nantais+17

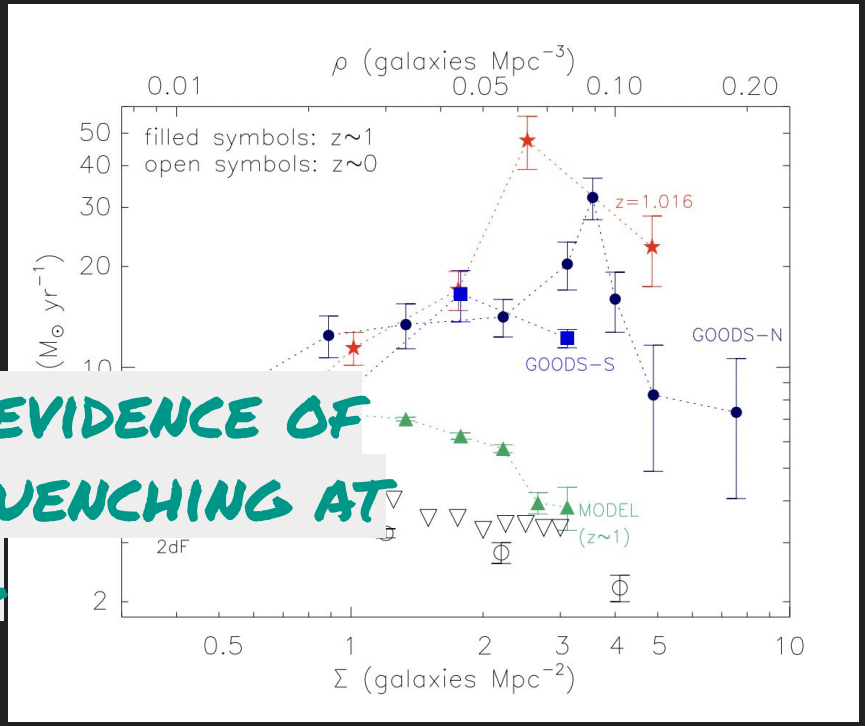


Elbaz+07

Reversal of SFR-density relation at high-z?



Nantais+17



Elbaz+07

Still plenty of evidence of environmental quenching at z~1-2

Euclid Telescope Description

Wide survey - Deep is 26mag

Instrument	VIS	NISP			
Field-of-View	0.787×0.709 deg^2	0.763×0.722 deg^2			
Capability	Visual Imaging	NIR Imaging Photometry			NIR Spectroscopy
Wavelength range	550– 900 nm	Y (920-1146nm),	J (1146-1372 nm)	H (1372-2000nm)	1100-2000 nm
Sensitivity	24.5 mag 10σ extended source	24 mag 5σ point source	24 mag 5σ point source	24 mag 5σ point source	3 10^{-16} erg cm-2 s-1 3.5σ unresolved line flux

	Area (deg2)
Wide Survey	15,000 (required) 20,000 (goal)
Deep Survey	40

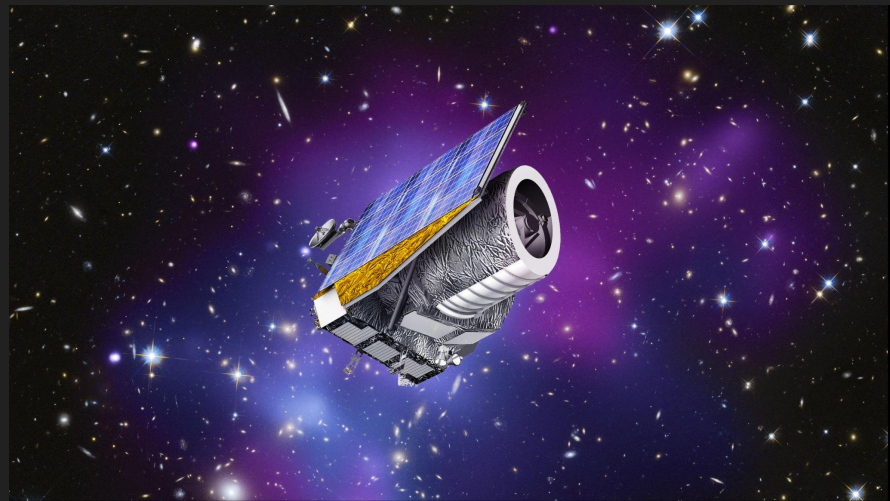
Euclid Definition Study Report; Laureijs+11

Early Release Observations

Image credit ESA/Euclid/Euclid Consortium/NASA/image processing by J.-C. Cuillandre, G. Anselm

An exciting time for galaxy statistics

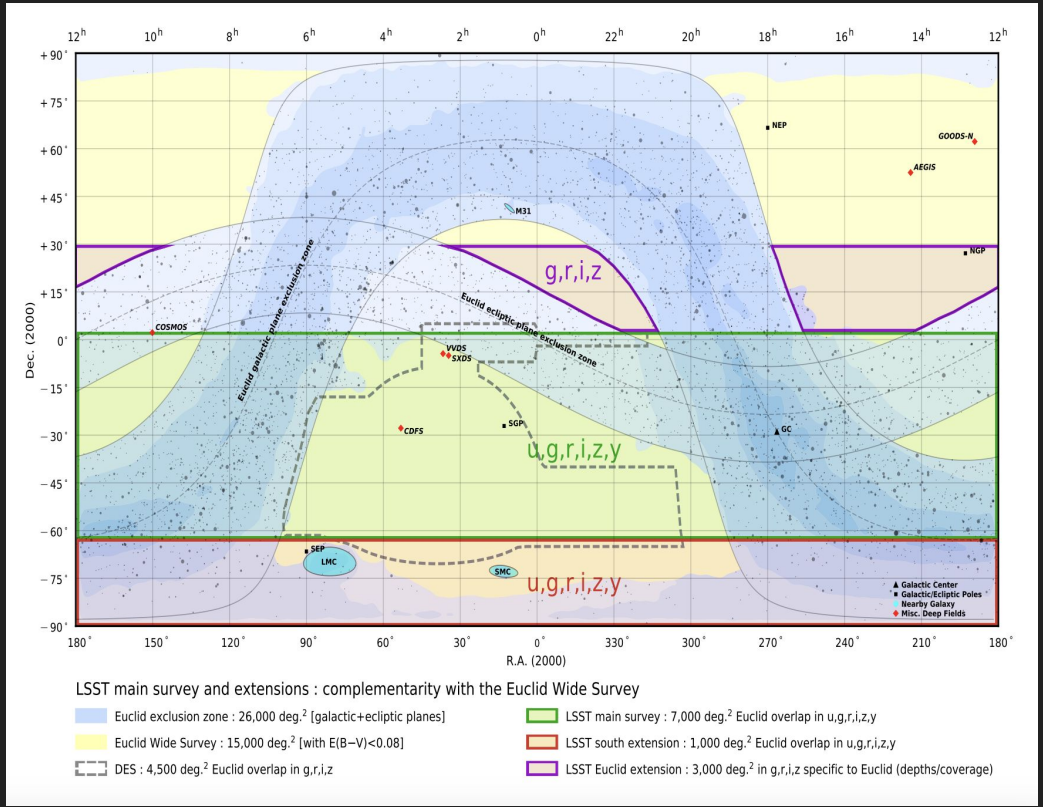
- Euclid Wide Survey will observe 15,000 deg2 - billions of galaxies
- Key epoch of the Universe - Wide: z~2-3
- High statistics of galaxies in a variety of environments
- Important to have predictions using different models to compare with observations



Euclid + LSST = 😀👍

- 7000+ deg^2 of coverage
- Better object detection: higher resolution + deeper observations
- Photo-*z* measurements: NIR bands + depth and number of photometric bands
- Synergies with many science cases: cosmology, cluster mass estimates, transients, **galaxy evolution**, many more…

Rhodes et al. 2017

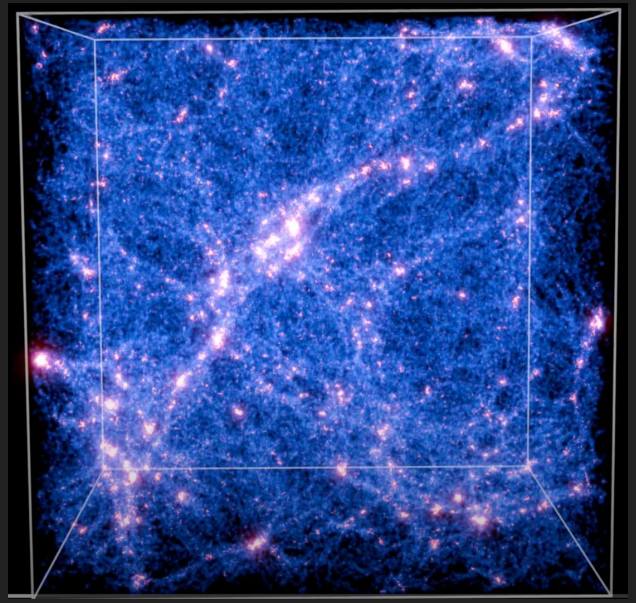



While we wait...

Different simulations and models

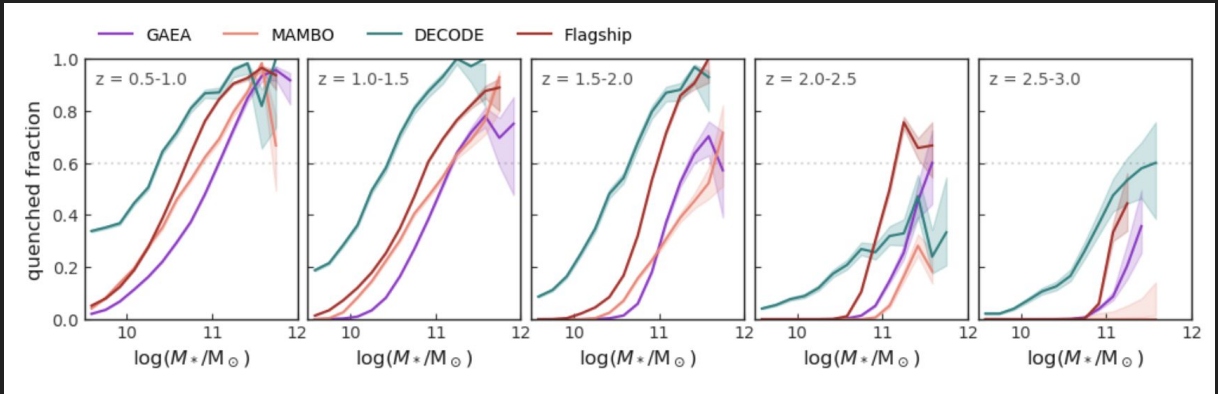
- GAEA (De Lucia+24)
  - Semi-analytic model
  - Treatment of AGN, stellar feedback, satellite galaxies
- MAMBO (Bolzonella; Girelli+20)
  - Abundance matching
  - Empirical
  - Assigns galaxy properties probabilistically
- DECODE (Fu; Roberts; Shankar)
  - Semi-empirical, statistical
  - Halo quenching
- Flagship (Euclid Consortium; Castander+24)
  - N-body, 4 trillion particles
  - Empirical colour distributions, clustering

- $0.5 < z < 3$
- Euclidized: *Y, J, H < 24 mag*
- $M_\star > 10^{9.5}$



Flagship Dark Matter Halo Catalogue, Credits: EC; Yuzheng

Quenched Fractions Central galaxies, stellar mass



20-40% of massive galaxies quenched by z~2

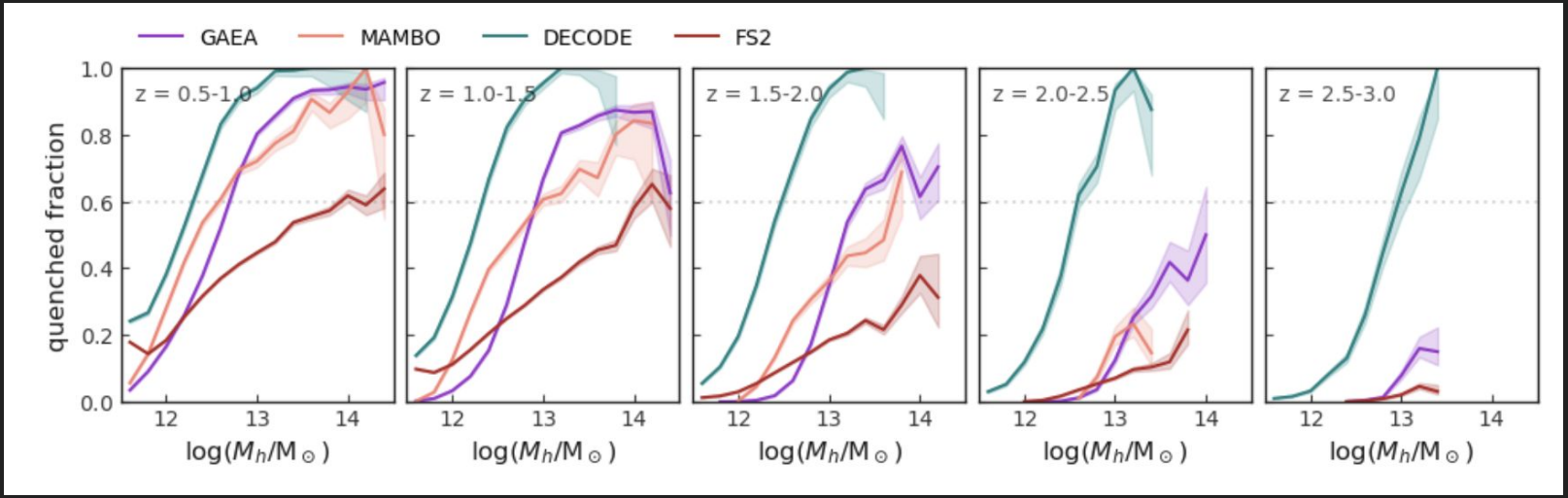
Some slight differences in the models but consistent trends

* QF determined by sSFR < 0.3/t_H yr^{-1}, Franx+08

Quenched Fractions Central galaxies, halo mass

Differences between models: 20% more quenched galaxies in massive halos in GAEA and MAMBO compared to Flagship

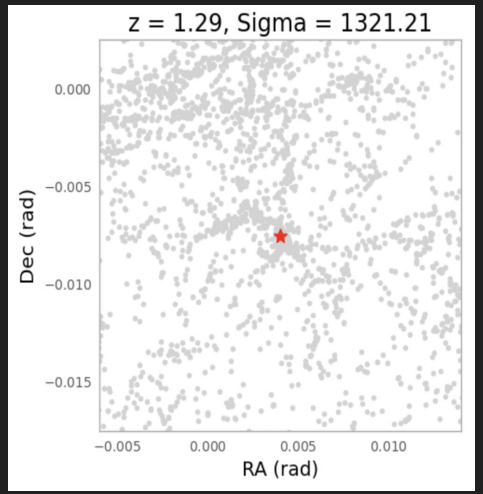
DECODE quenches after a certain threshold in halo mass

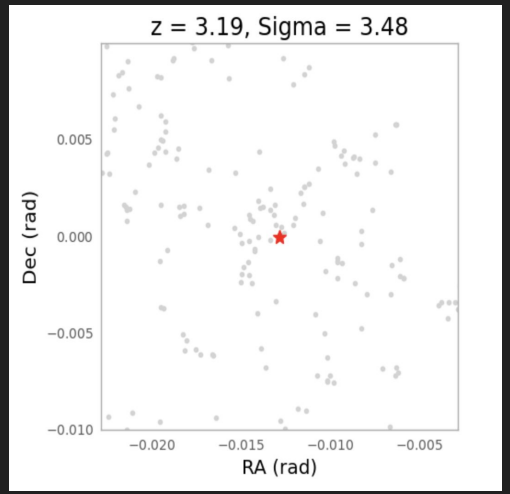


Density measurements

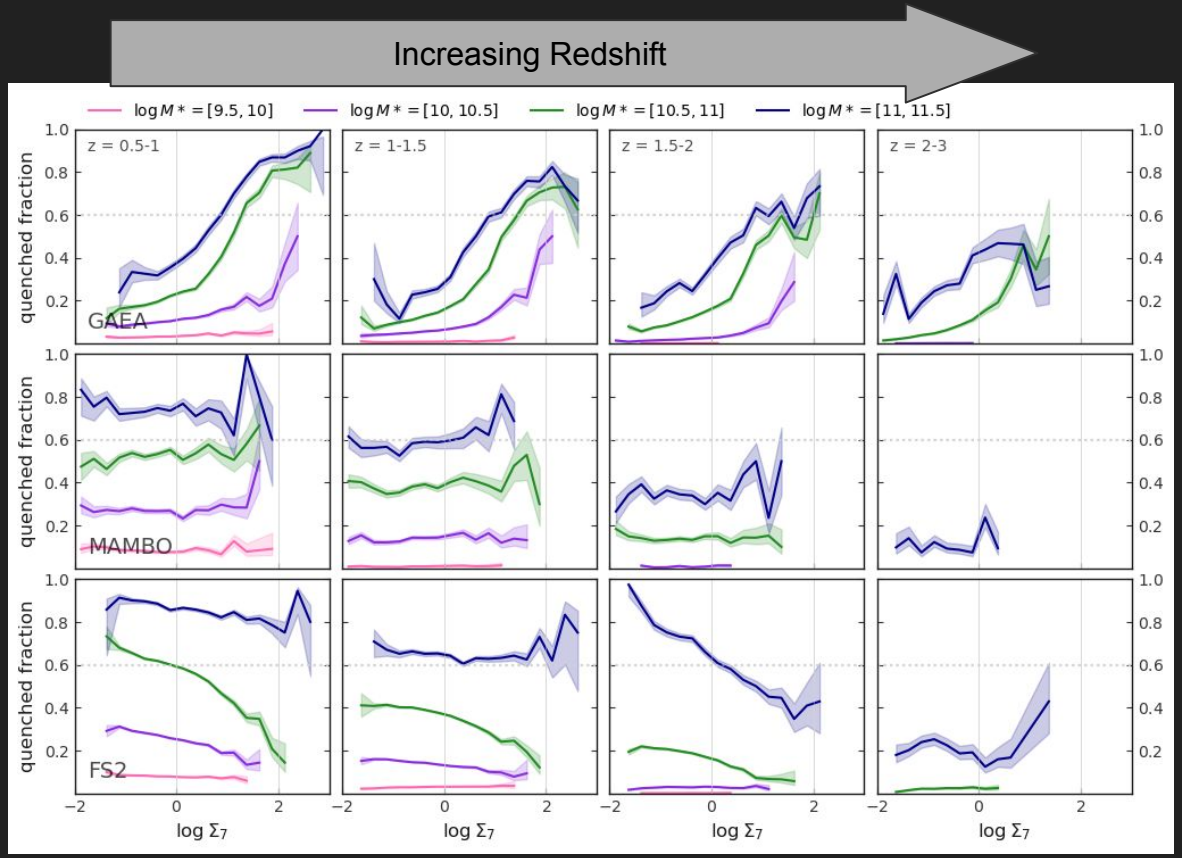
- Nth-nearest neighbour (Mei+23, Postman+05)
  - N = 7
  - Normalised to D = 1 Mpc
- Redshift slice: dz=0.01

$$\Sigma_N = \frac{N}{\pi D_N^2}$$





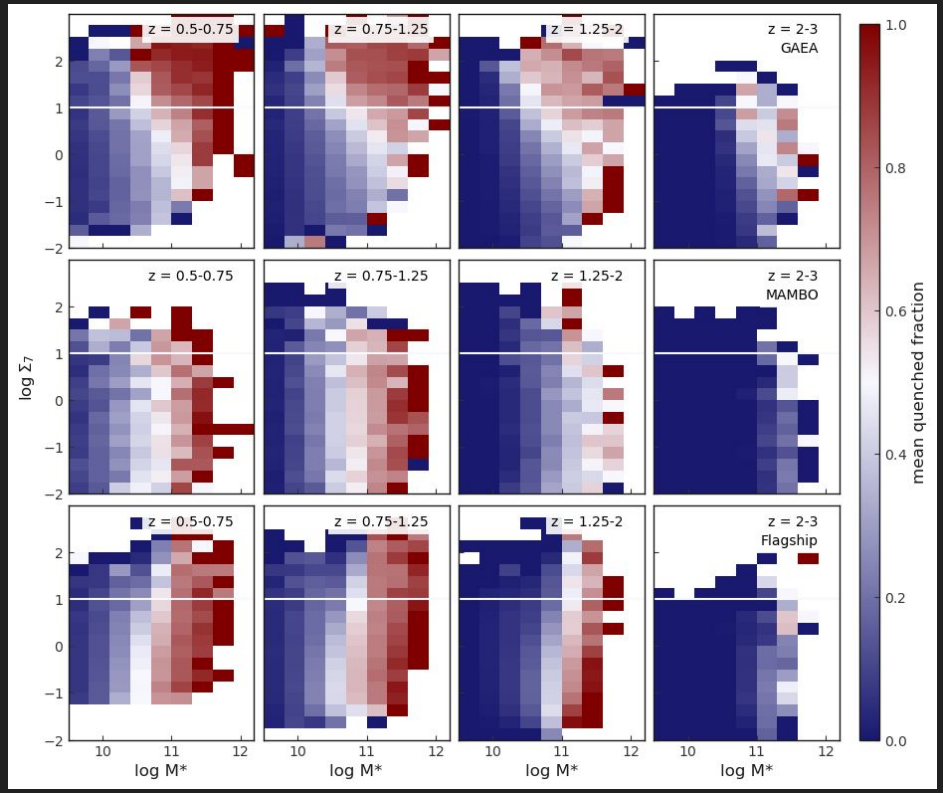
Quenched Fractions Central galaxies, local density



Clear relation with local density in GAEA, less so in MAMBO

Relation is reversed in Flagship, due to calibration on fields?

2d dependence Central galaxies, local density

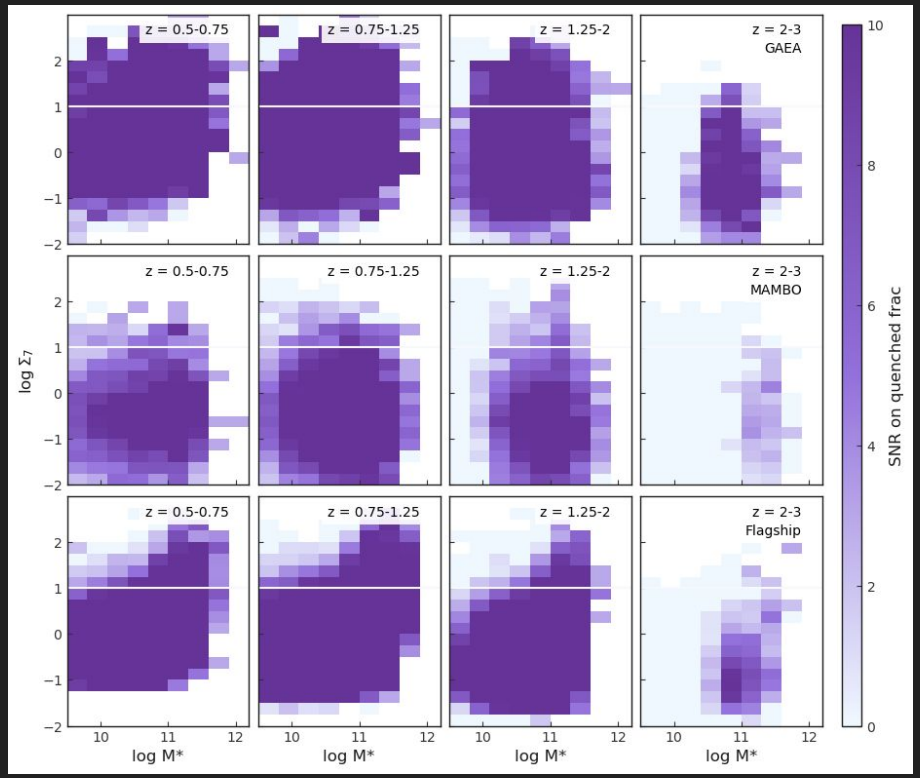


GAEA: dependence on stellar mass and local density

MAMBO: not much dependence on local density

Flagship: Reversed dependence?

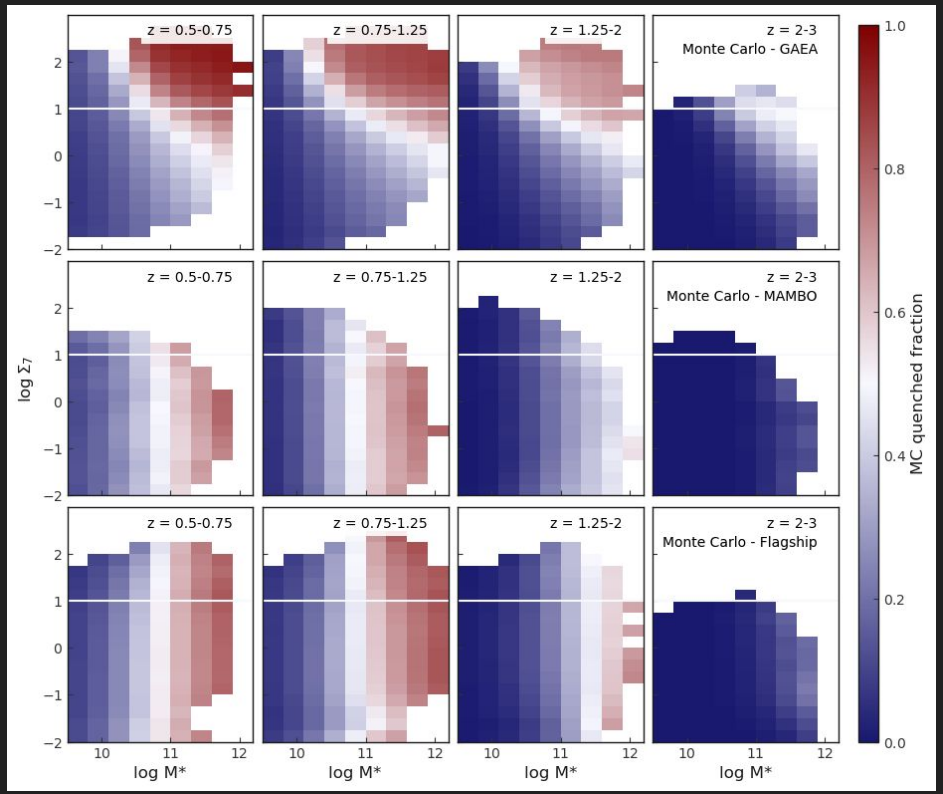
2d dependence Observability - SNR



Quenched fraction signal easily observed at z < 2

High density regions, low stellar mass more difficult

Effect of uncertainties



dz = 0.05 × (1+z) (EC, Desprez+20)

dΣ → error propagation with dz and Poissonian statistics

$dM_\star$ = 0.3 dex (EC, Bisigello+23)

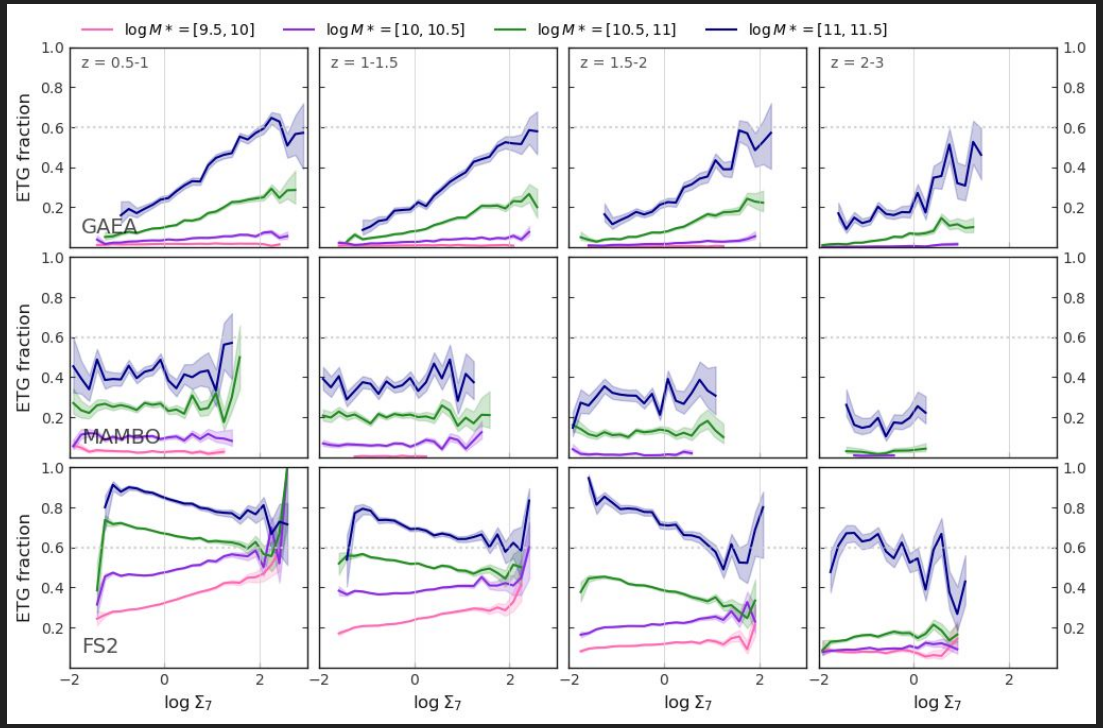
GAEA signal remains

MAMBO and Flagship, dependence on density disappears

Morphology Central galaxies, local density

ETG: B/T > 0.7

B/T = Bulge mass / stellar mass



Morphology-density relation present in GAEA, not so much in MAMBO

Relation is again reversed in Flagship

Looking forward

When	What
June 2024	List of Q1 products agreed with SGS.
Nov. 2024	Data process readiness review (DPRR)
Nov. 2024	Internal Q1 release.
Mar 2025	Quick Euclid release 1 (Q1) ESLAB + EC meeting 2025
June 2025	Internal DR1 release.
Jun 2026	Public Data Release 1 (DR1).
March 2027	Q2
June 2027	Internal DR2 release to EC
June 2028	Public DR2 release 2 (DR2)
March 2029	Q3
March 2030	Q4
June 2030	Internal DR3
June 2031	Public DR3

Looking forward

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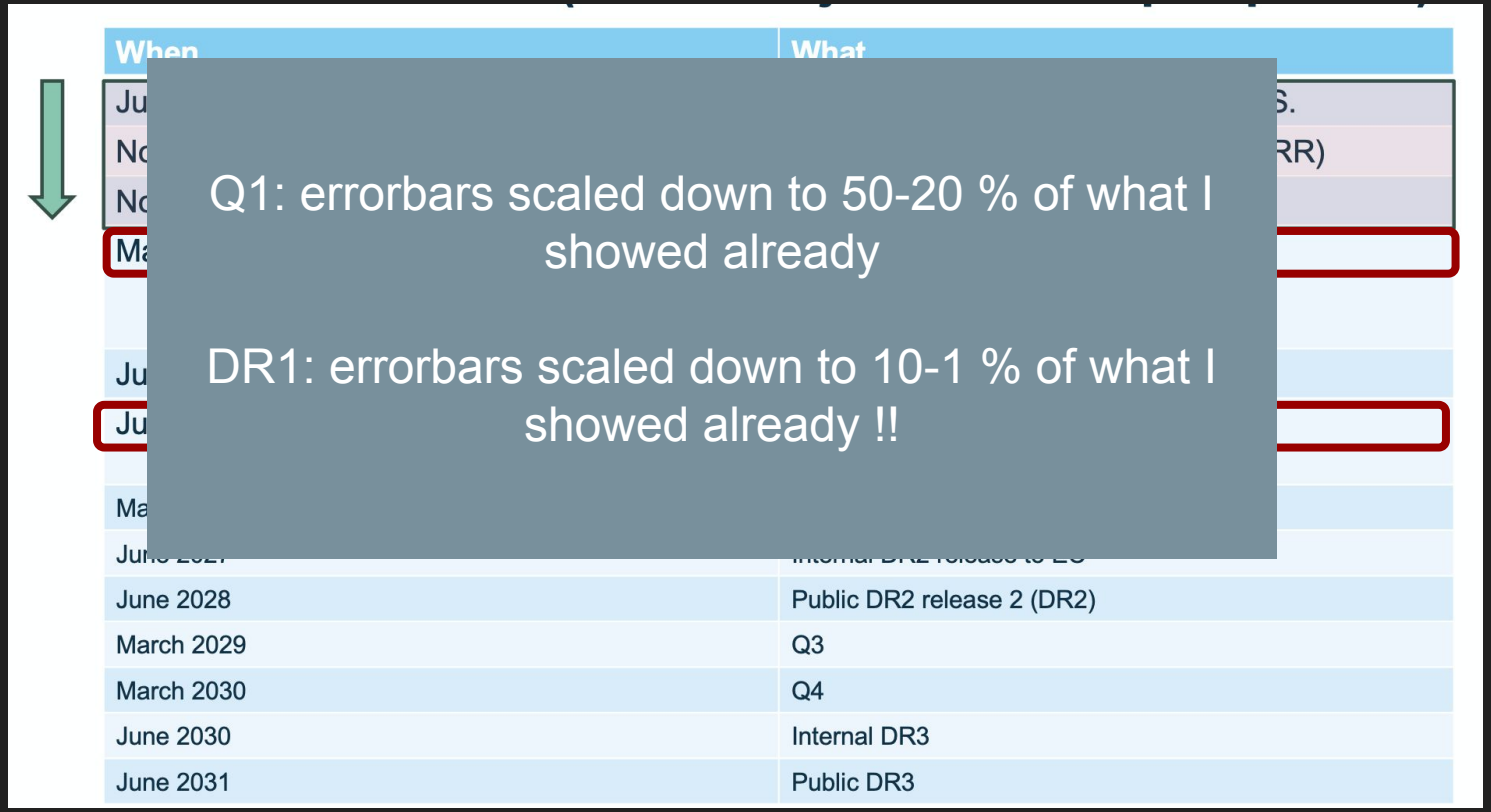
June 2028	Public DR2 release 2 (DR2)
March 2029	Q3
March 2030	Q4
June 2030	Internal DR3
June 2031	Public DR3

60 sq deg
1m+ galaxies

2500 sq deg
100m+ galaxies

Looking forward

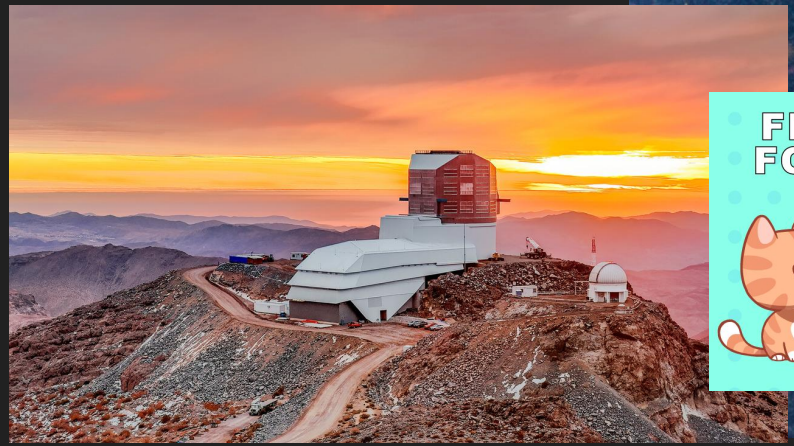


60 sq deg
1m+ galaxies

2500 sq deg
100m+ galaxies

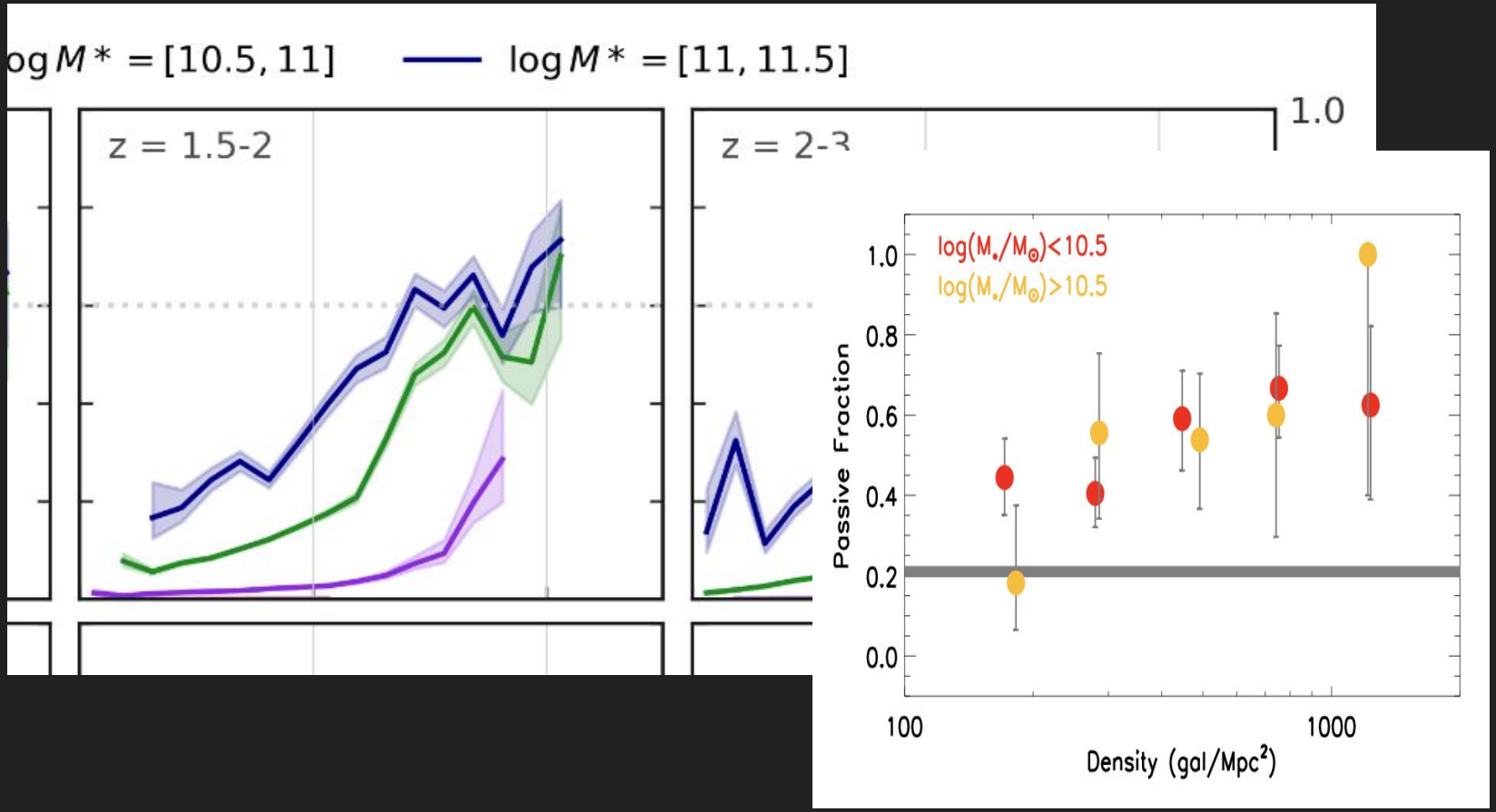
Summary

- Plan to apply same technique to LSST galaxies
- Euclid + LSST = lots of galaxies to study
- Expect huge number of quenched galaxies at logM* ~ 11
- **Passive-density** and **morphology-density** trends observed with high statistics




Early Release Observations
Thanks

https://docs.google.com/presentation/d/16a17D1IUZAwvMqSJvjwayXE1DPI0mbarjivELD47mQ8/edit?usp=sharing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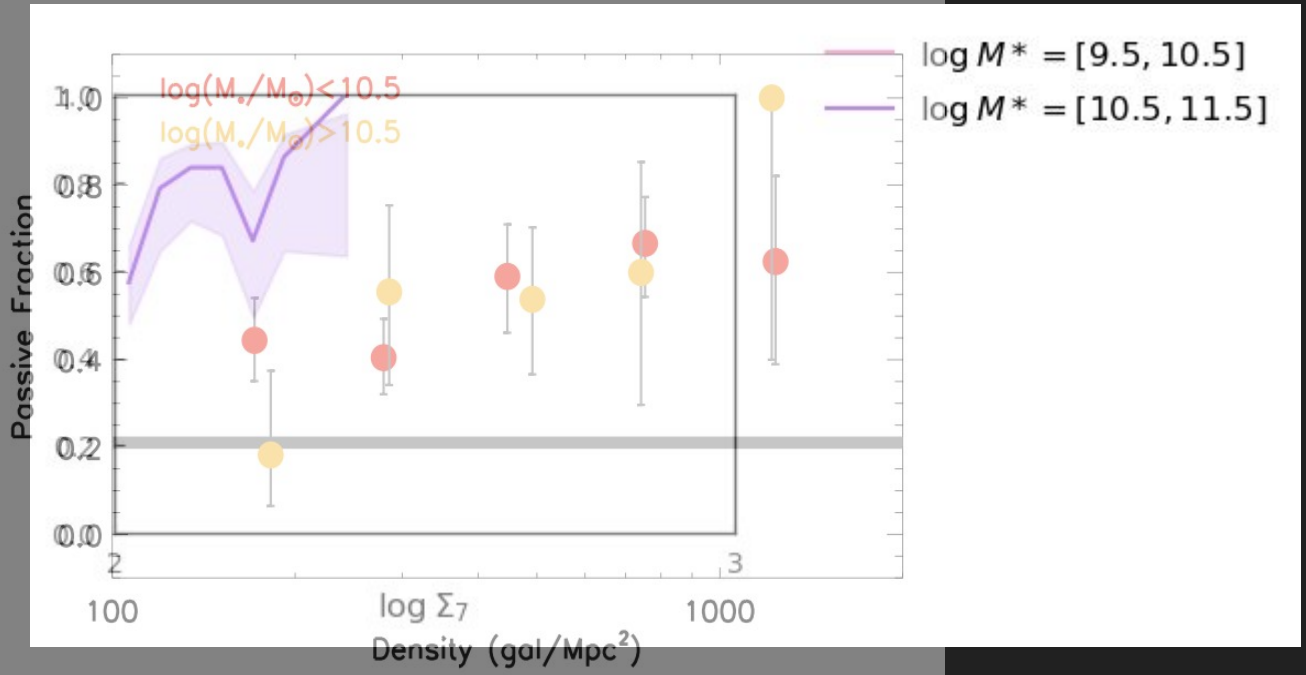
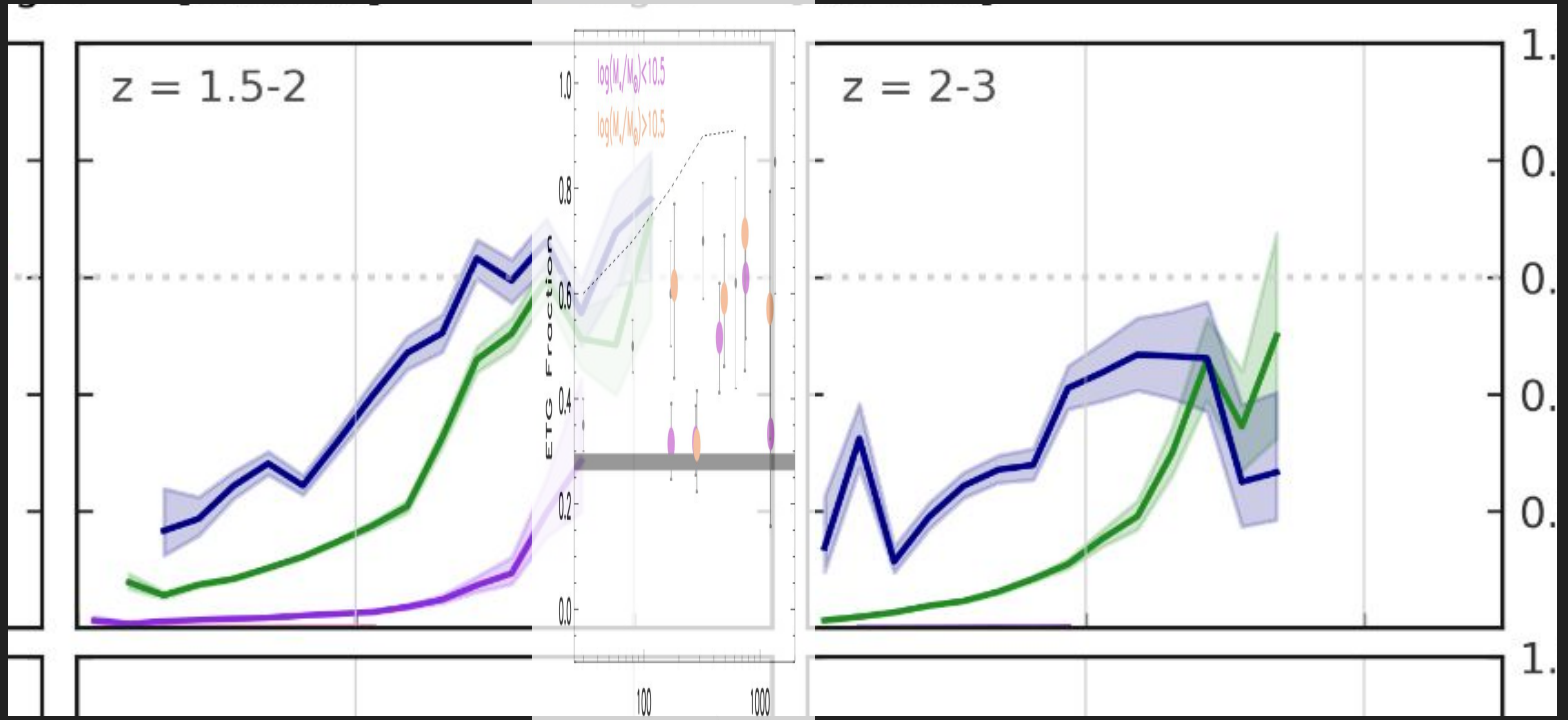
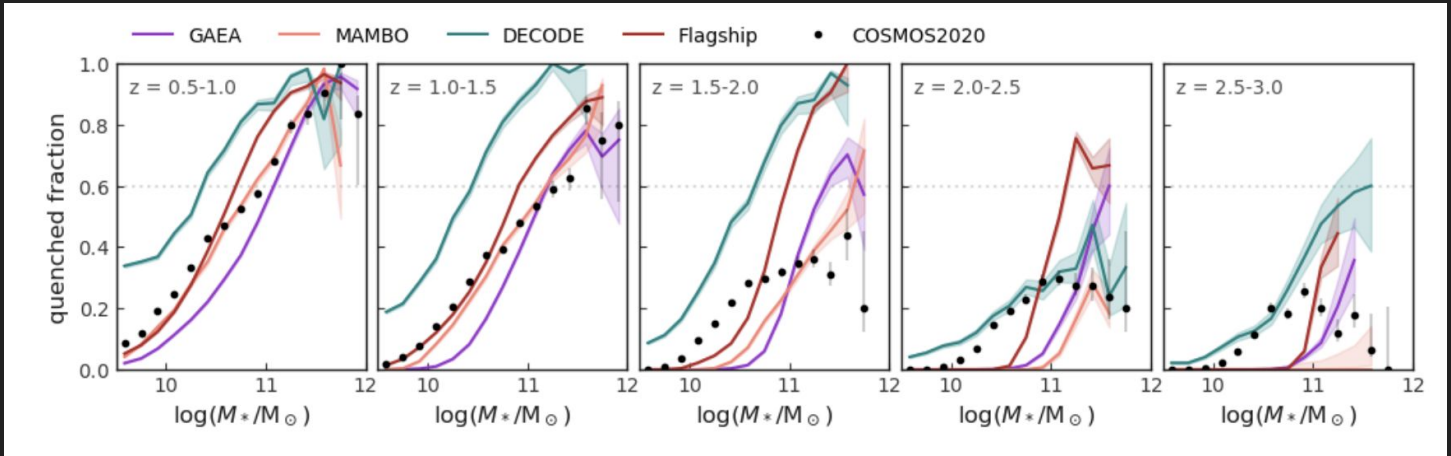
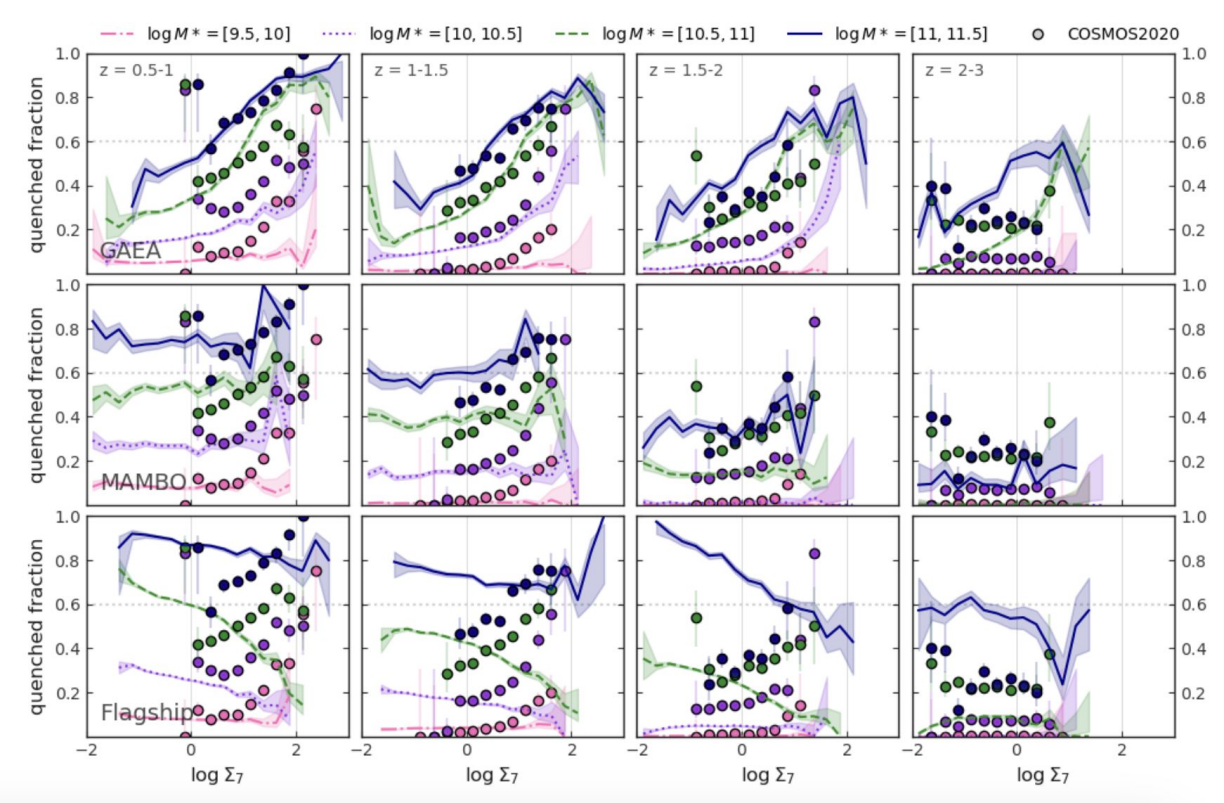
log M* = [11, 11.5]
z = 1.5-2
z = 2-3
1.0
log(M*/M⊙)<10.5
log(M*/M⊙)>10.5
Passive Fraction
1.0
0.8
0.6
0.4
0.2
0.0
100
1000
Density (gal/Mpc²)


log(M*/M⊙)<10.5
log(M*/M⊙)>10.5
log M* = [9.5, 10.5]
log M* = [10.5, 11.5]
Passive Fraction
1.0
0.8
0.6
0.4
0.2
0.0
2
3
100
1000
log Σ7
Density (gal/Mpc²)


z = 1.5-2
z = 2-3
log(M_*/M_⊙)<10.5
log(M_*/M_⊙)>10.5
ETG Fraction
Density (gal/Mpc²)
100
1000
0.0
0.2
0.4
0.6
0.8
1.0

https://arxiv.org/pdf/1710.08489


GAEA
MAMBO
DECODE
Flagship
COSMOS2020
z = 0.5-1.0
z = 1.0-1.5
z = 1.5-2.0
z = 2.0-2.5
z = 2.5-3.0
quenched fraction
0.0
0.2
0.4
0.6
0.8
1.0
10
11
12
log(M∗/M⊙)


log M* = [9.5, 10]
log M* = [10, 10.5]
log M* = [10.5, 11]
log M* = [11, 11.5]
COSMOS2020
z = 0.5-1
z = 1-1.5
z = 1.5-2
z = 2-3
GAEA
MAMBO
Flagship
quenched fraction
log Σ7