NIRCam Selected Quiescent Galaxies at 3 < z < 5 in CEERS, COSMOS, and PRIMER

Arianna S. Long
Hubble Fellow @ University of Texas at Austin
Assisstant Prof @ UW Seattle starting Fall 2024
Chief Programming Officer @ VanguardSTEM

NHFP Symposium | September 21st, 2023

In our local Universe, over half of all stars are inside massive elliptical galaxies...

In our local Universe, over half of all stars are inside massive elliptical galaxies...

...and they are much older than expected.

Massive evolved galaxies exist out to z > 3...

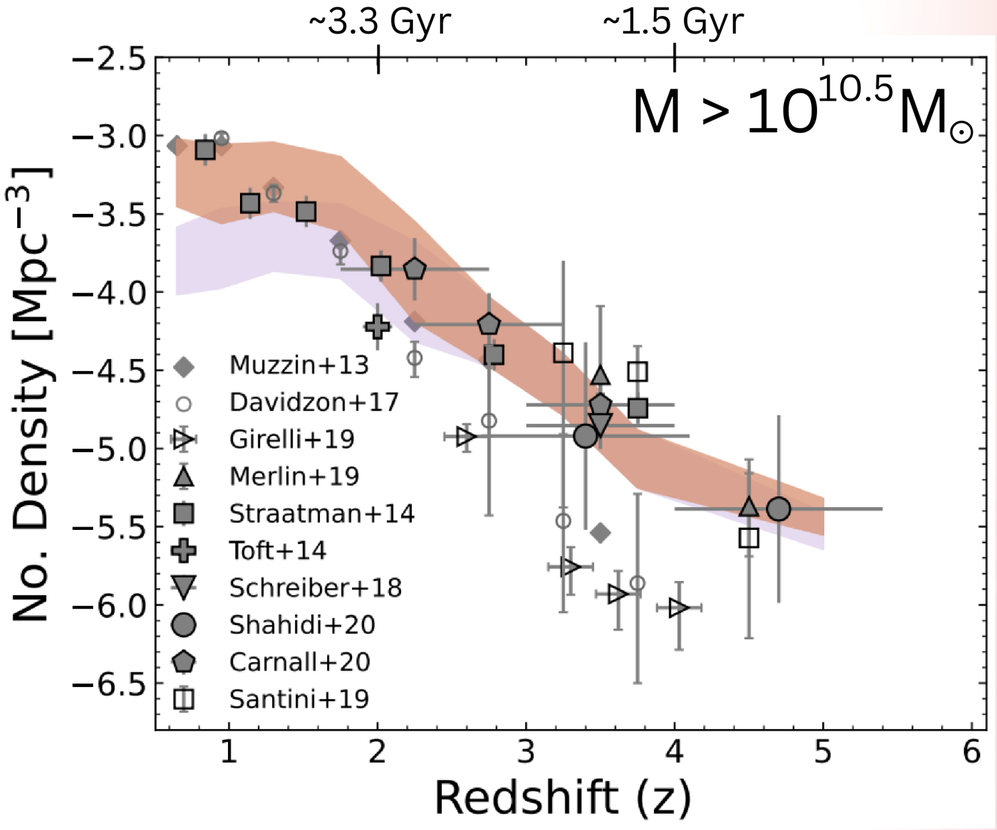


Figure from **Long et al. 2023a**

See also new JWST results:
Carnall+22, Nanayakkara+22, Pérez-González+22, Valentino+23

Massive evolved galaxies exist out to z > 3...

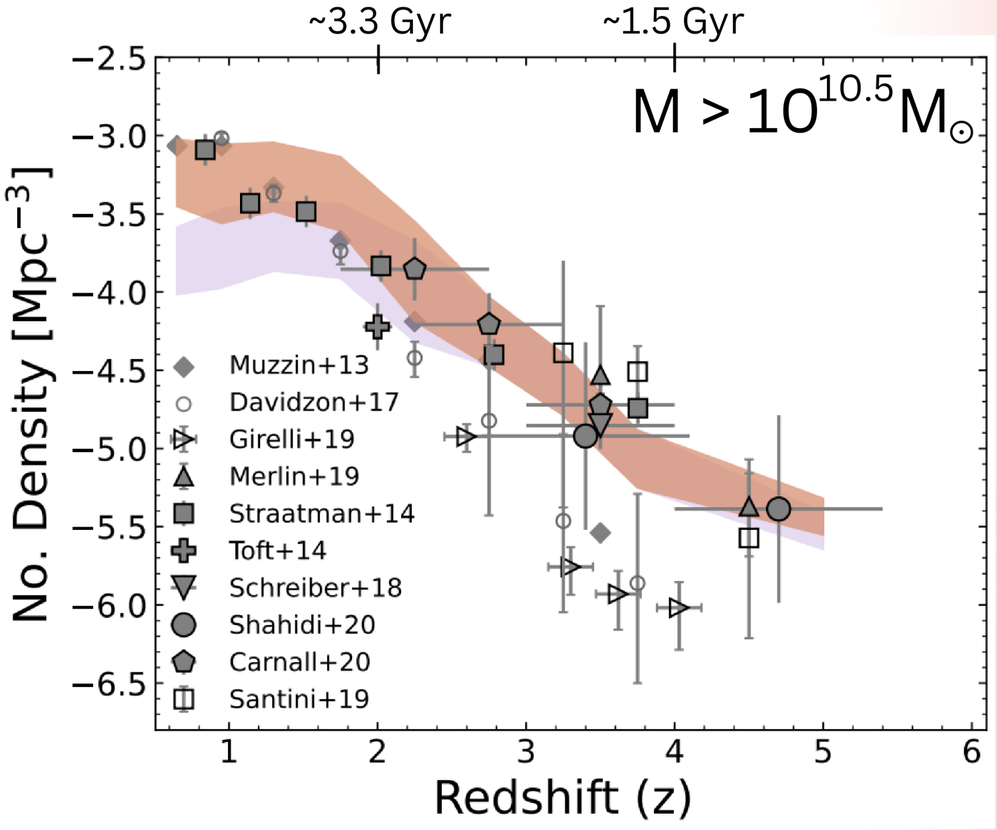


Figure from **Long et al. 2023a**

See also new JWST results:
Carnall+22, Nanayakkara+22, Pérez-González+22, Valentino+23

...but we're missing the key physics that creates them.

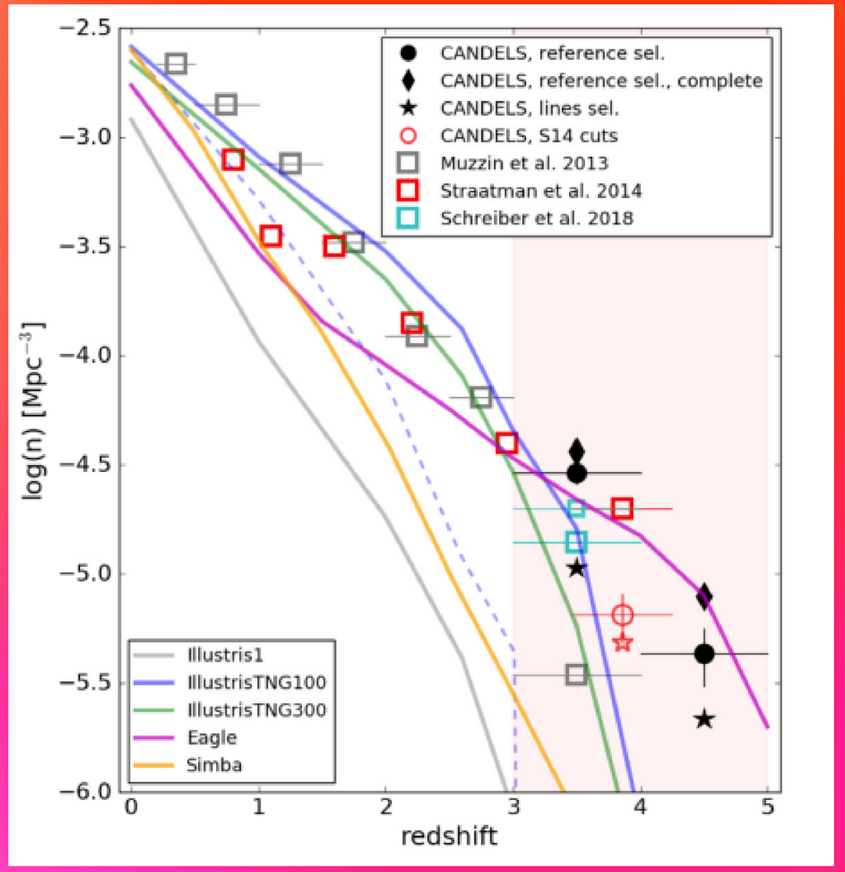


Figure from Merlin et al. 2019

See also the FLARES simulation (Lovell+22)

Massive evolved galaxies exist out to z > 3...

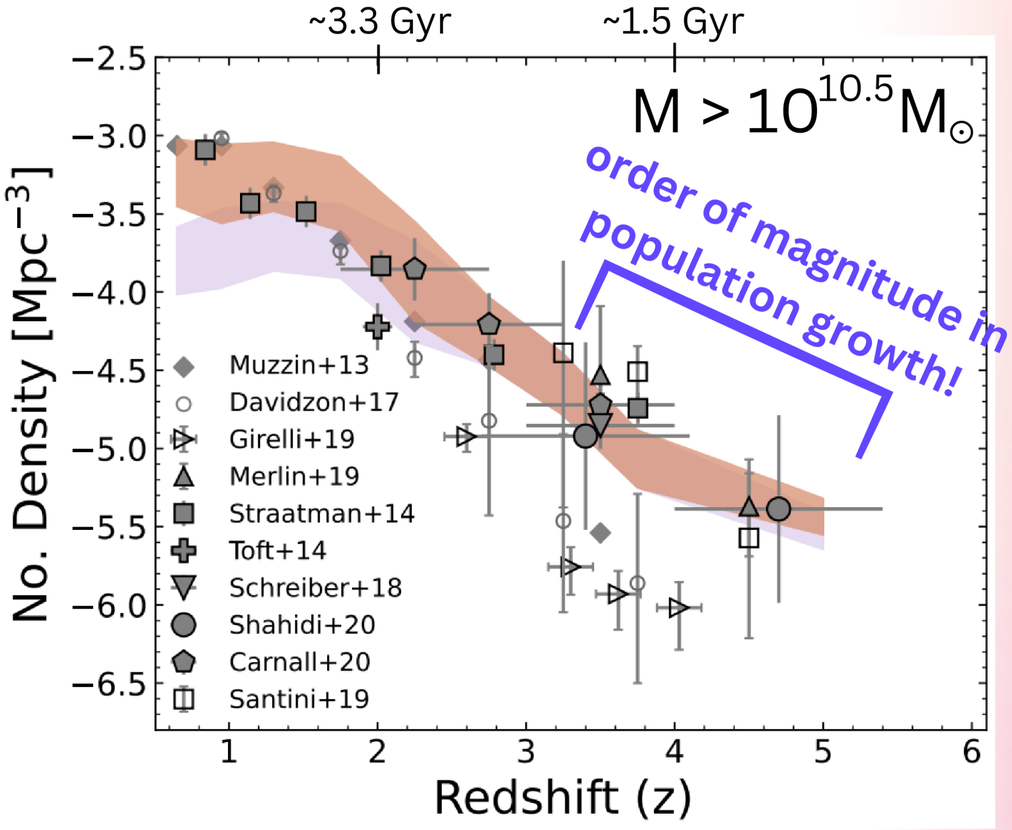


Figure from **Long et al. 2023a**

See also new JWST results:
Carnall+22, Nanayakkara+22, Pérez-González+22, Valentino+23

...but we're missing the key physics that creates them.

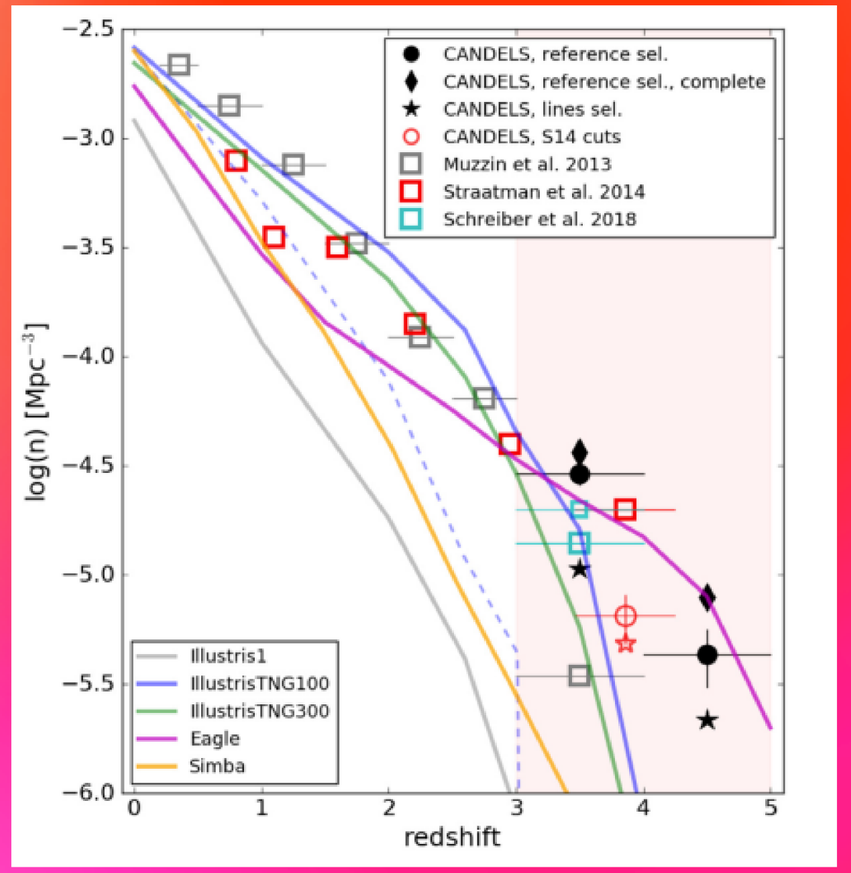


Figure from Merlin et al. 2019

See also the FLARES simulation (Lovell+22)

Primary hurdles to overcome include...

Primary hurdles to overcome include...

1. Constraining the role of dark matter halo formation & evolution

Primary hurdles to overcome include...

1. Constraining the role of dark matter halo formation & evolution

2. Understanding extreme baryonic conversion rates

Primary hurdles to overcome include...

1. Constraining the role of dark matter halo formation & evolution
2. Understanding extreme baryonic conversion rates
3. Exploring and characterizing quenching / feedback mechanisms

Primary hurdles to overcome include...

1. Constraining the role of dark matter halo formation & evolution
2. Understanding extreme baryonic conversion rates
3. Exploring and characterizing quenching / feedback mechanisms
4. Refining object detection and selection techniques for high-z

Primary hurdles to overcome include...

1. Constraining the role of dark matter halo formation & evolution
2. Understanding extreme baryonic conversion rates
3. Exploring and characterizing quenching / feedback mechanisms
4. Refining object detection and selection techniques for high-z

Quiescent galaxies at $z > 3$ are difficult to identify and therefore poorly understood.

Selection techniques built for $z < 2$ quiescent galaxies

Rare and therefore difficult to find

High contamination from heavily dust obscured galaxies

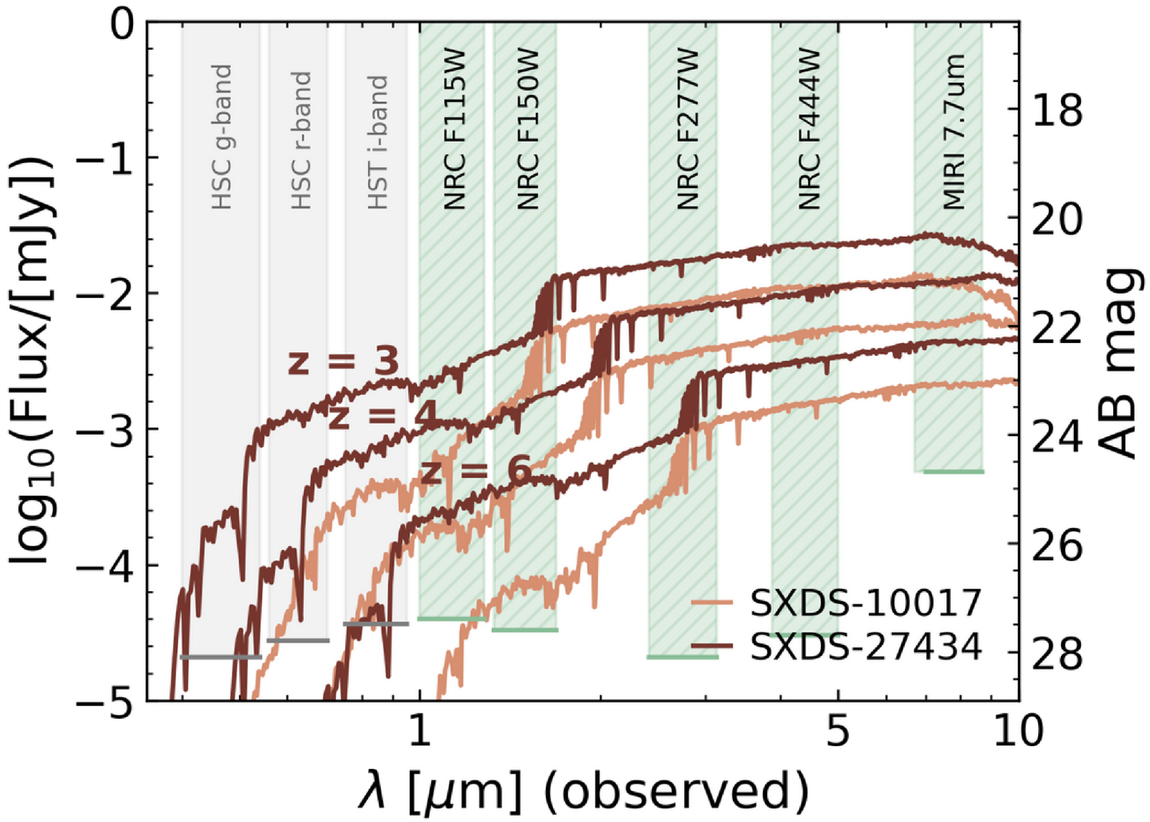
Quiescent galaxies at $z > 3$ are difficult to identify and therefore poorly understood.

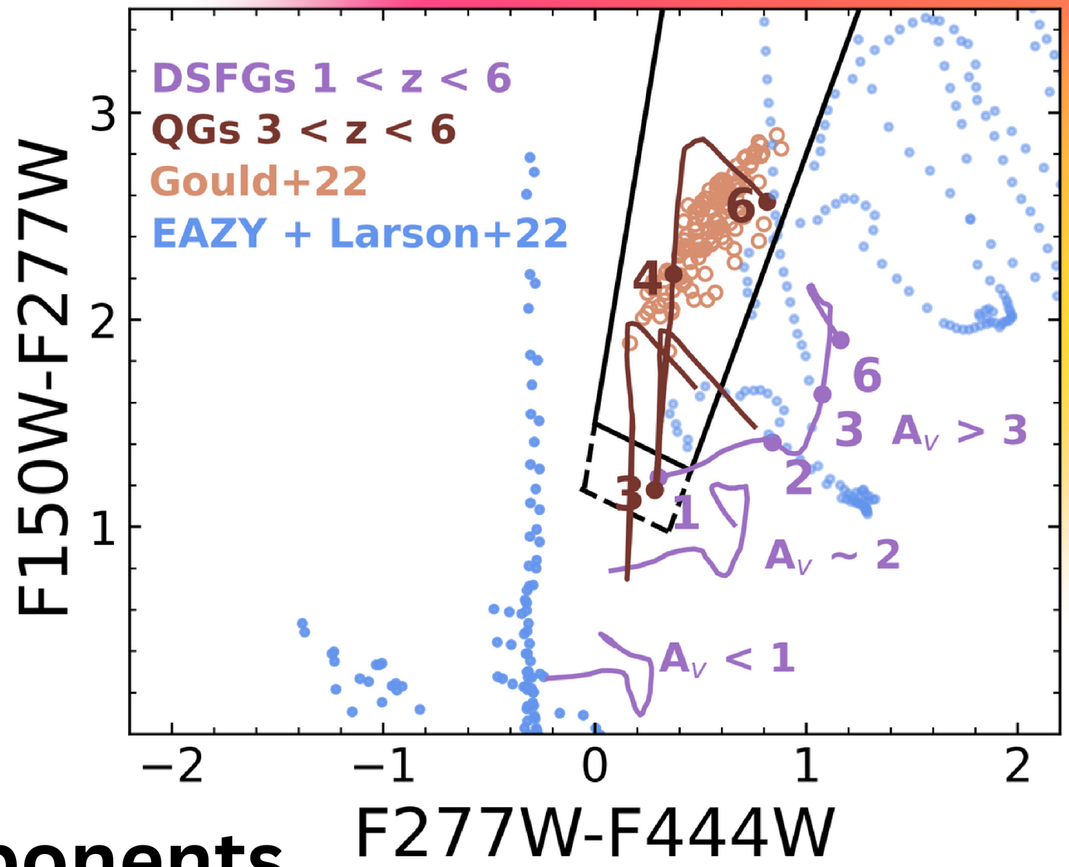
Relatively faint rest-frame stellar emission

Typically bluer than $z < 2$ QGs

See also Antwi-Danso+22, Lovell+22, Gould+22, Valentino+23

NIRCam Selection of 3 < z < 6 Quiescent Galaxies



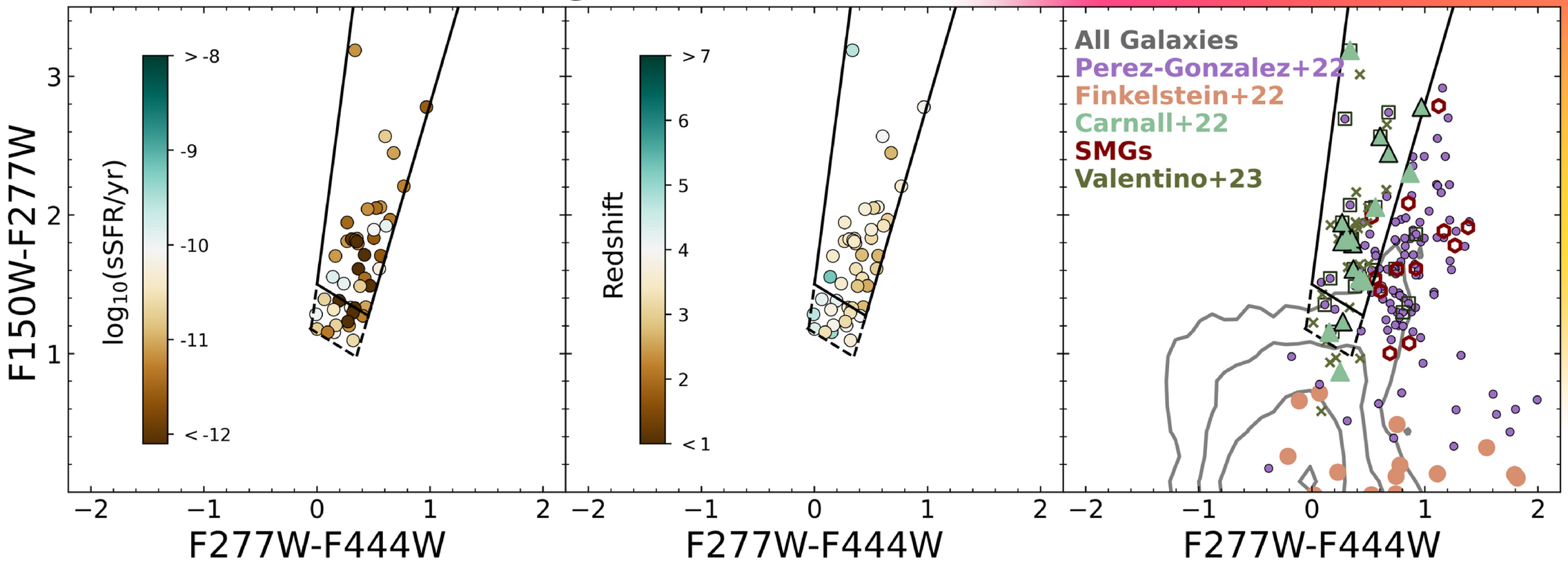


Key Components

- Balmer Break between F150W and F277W
- DSFGs redder in F277W-F444W than coeval QGs
- Best for massive QGs (log M > 9.5 $M_\odot$)

Long et al. 2023b

NIRCam Selection of 3 < z < 6 Quiescent Galaxies



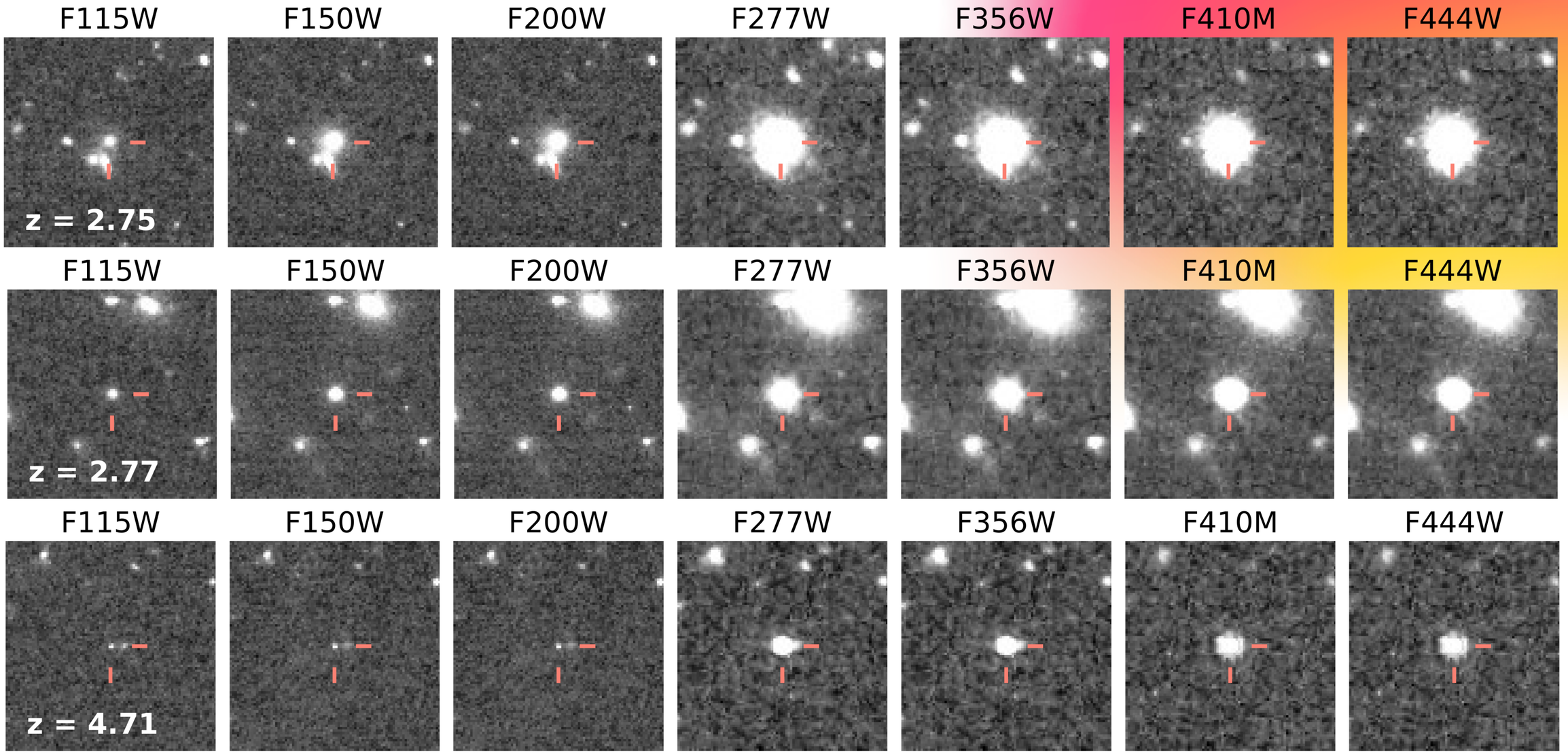
Results

- Reduces filter catalog by 99.5-99.8% (!!)
- Yield ~44 QG candidates at 2.5 < z < 5.3 in CEERS
- <log M> ~ 10.5 $M_\odot$ and < log sSFR / yr > ~ -11.2

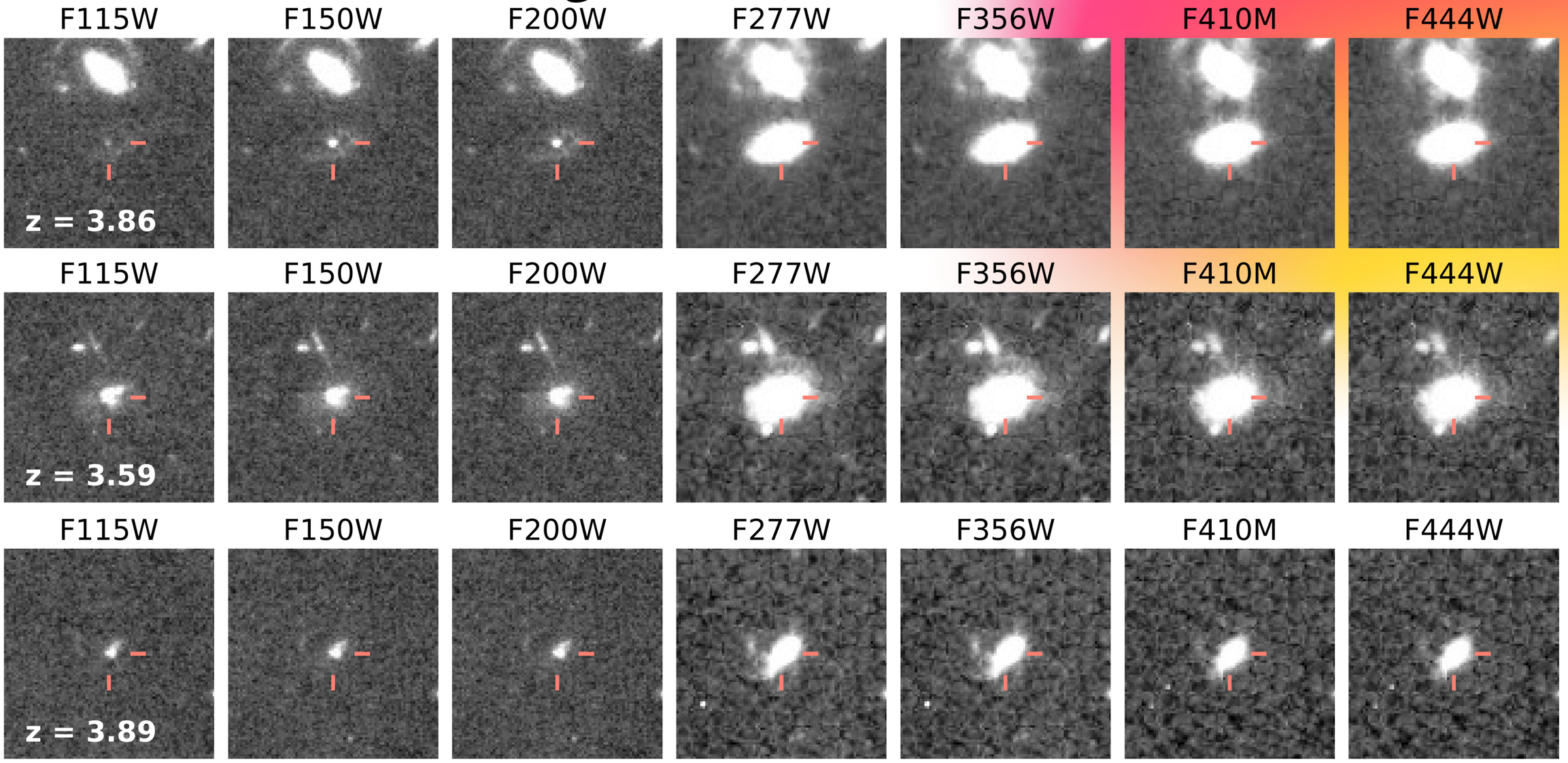
13-14 new objects w/ < log sSFR / yr > ~ -10 !!! I.e. young, post-starbursts in the midst of shutting down star formation.

Long et al. 2023b

NIRCam Selection of 3 < z < 6 Quiescent Galaxies



NIRCam Selection of 3 < z < 6 Quiescent Galaxies



Looking Forward

Search for dusty contaminants

PI of Cycle 10 ALMA program to follow up on > 600 sources in COSMOS-Web to characterize contamination properties

Looking Forward

Search for dusty contaminants

PI of Cycle 10 ALMA program to follow up on > 600 sources in COSMOS-Web to characterize contamination properties

Search for dusty ancestors

Lead of Ex-MORA ALMA 2mm program to discover and characterize candidate z > 3 DSFGs in COSMOS-Web

Looking Forward

Search for dusty contaminants

PI of Cycle 10 ALMA program to follow up on > 600 sources in COSMOS-Web to characterize contamination properties

Search for dusty ancestors

Lead of Ex-MORA ALMA 2mm program to discover and characterize candidate z > 3 DSFGs in COSMOS-Web

Search for (obscured) AGN

In collaboration wtih high-z AGN experts to design JWST-based methods to identify obscured AGN at z > 3 and study their host galaxy properties w.r.t. quenching and outflows

Summary

1. The existence of substantial populations of massive quiescent galaxies at $z > 3$ is surprising and challenging.

2. Discovering the mechanisms that build and kill massive quiescent galaxies at high-z requires large samples of this elusive population.

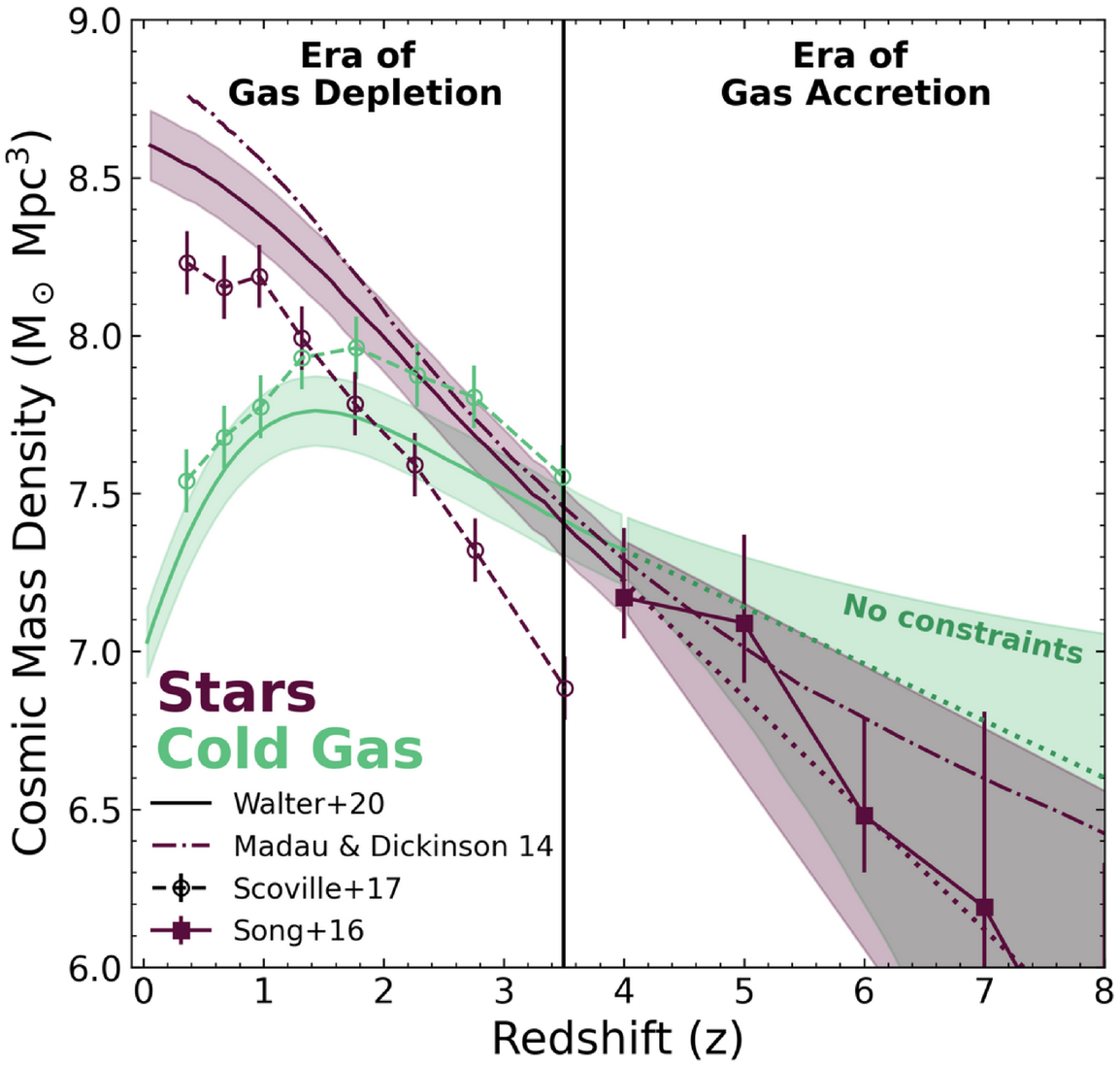
3. JWST NIRCam has the sensitivity and wavelength coverage to efficiently and directly select massive quiescent galaxies at $3 < z < 6$.

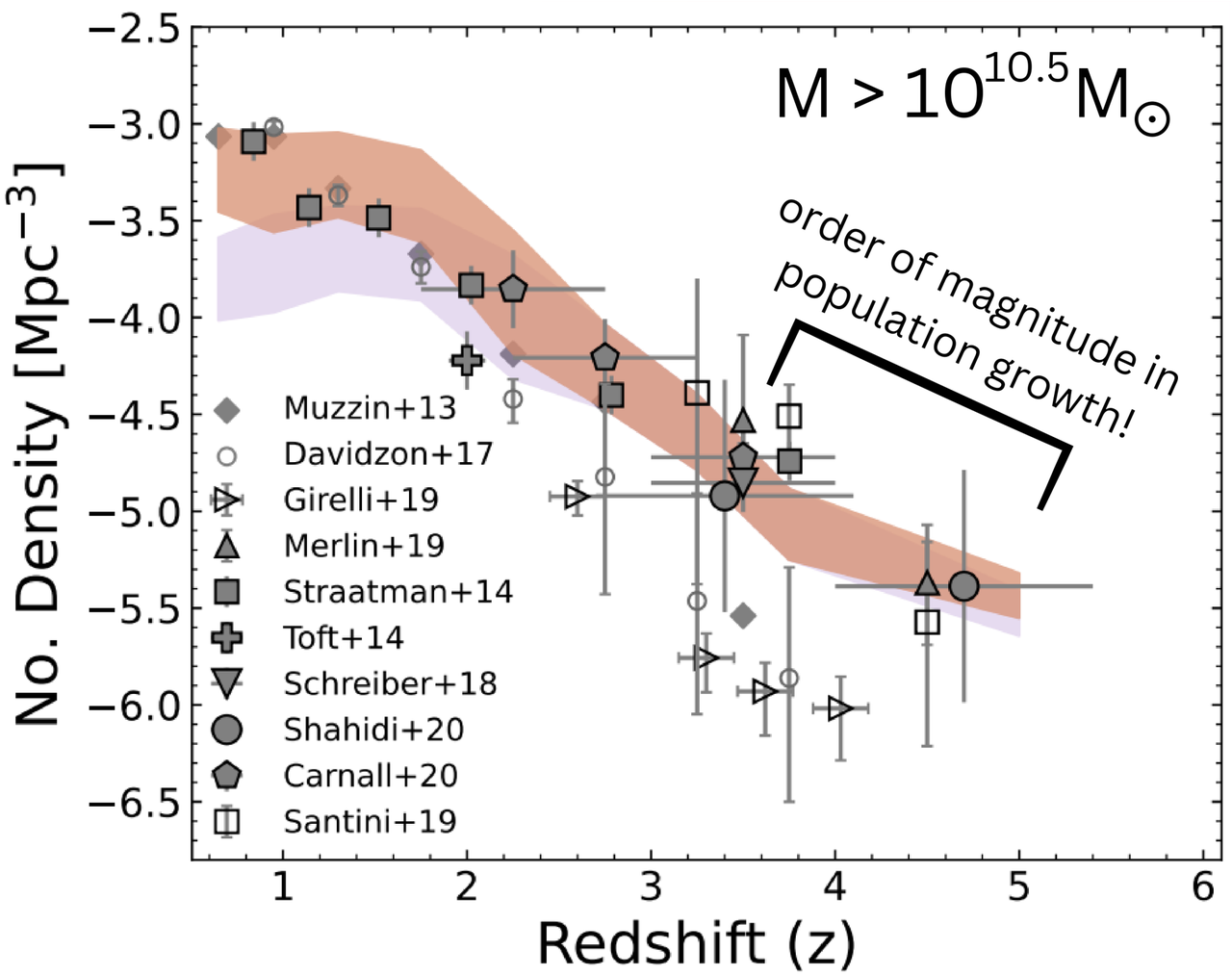
4. Future investigations will focus on COSMOS-Web: resolved studies (stellar gradients, morphologies, etc., Long, Cooper, et al. 2024+), searches for nearby overdensities, and testing a variety of quenching mechanisms (AGN, SNe, etc).


THANK YOU

APPENDIX

What's going on at z = 3-6?





Long et al. 2022

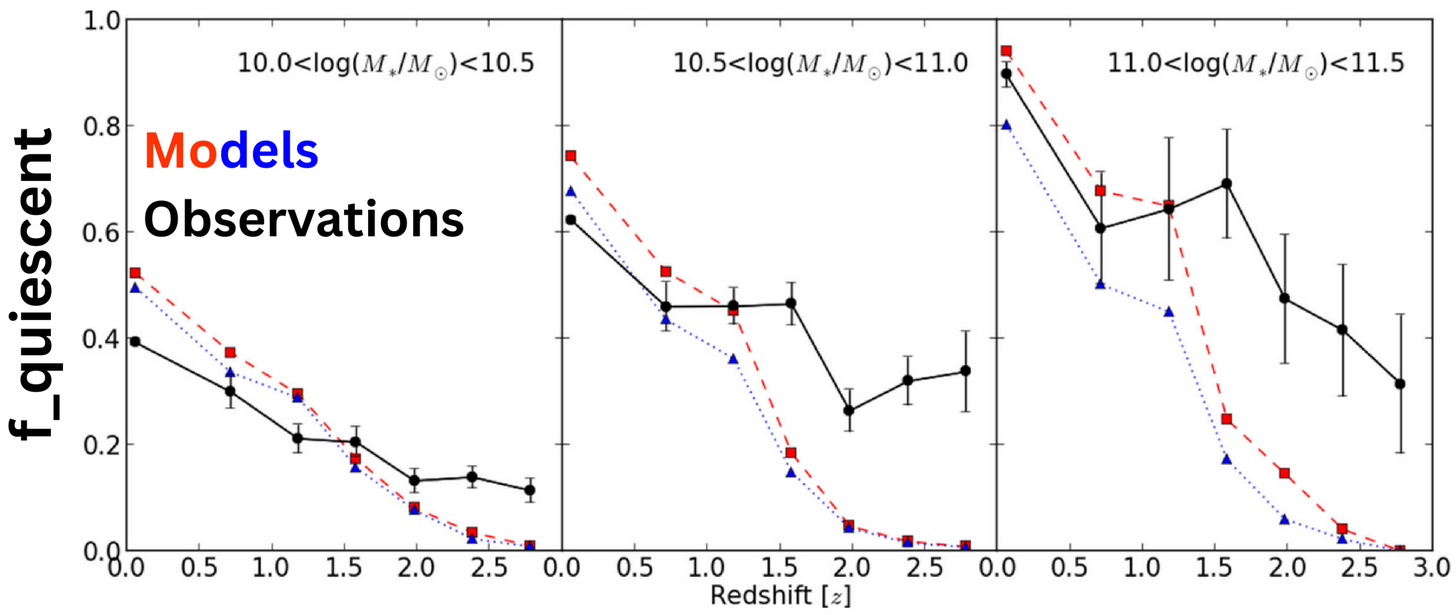
See also: Carnall+22, Nanayakkara+22, Pérez-González+22, Valentino+23

What's going on at z = 3-6?

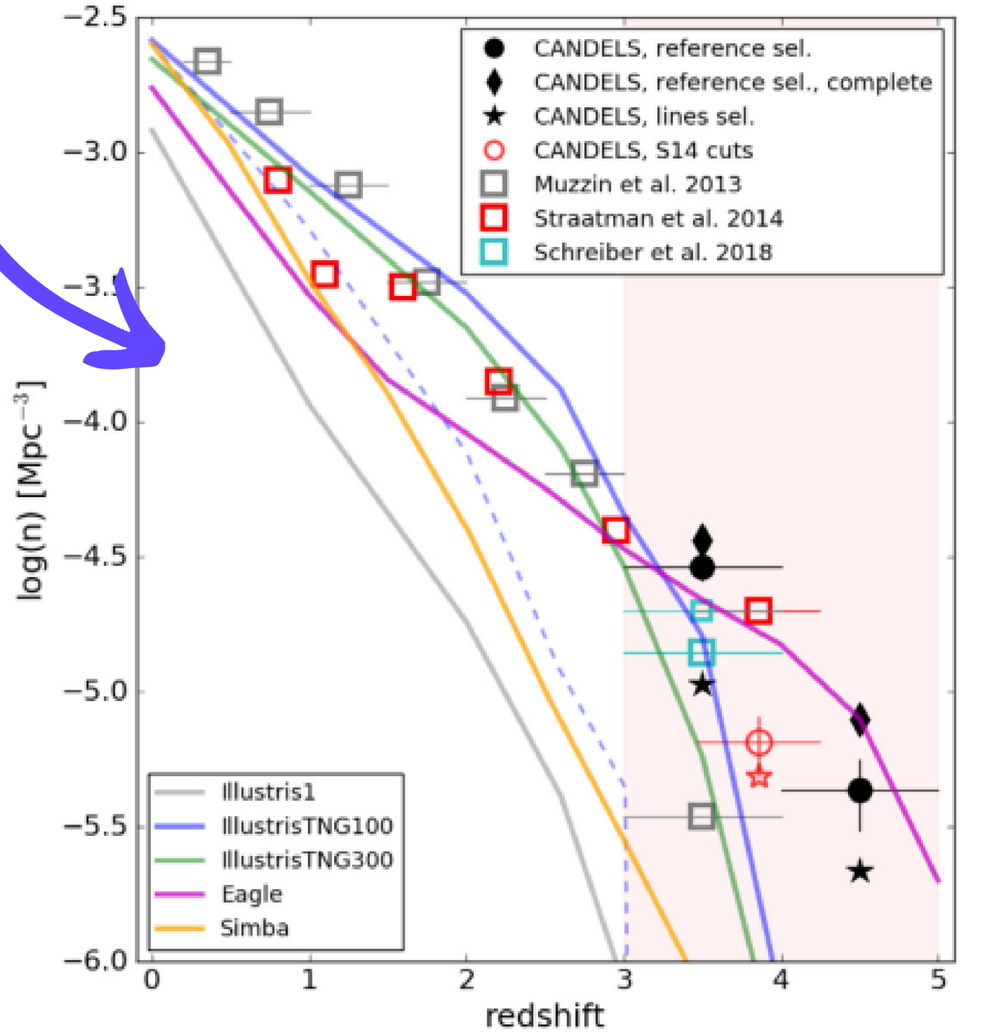
Almost no massive quiescent galaxies at z > 2

Simulations do not produce enough massive quiescent galaxies.

Discrepancies for all models: either at z < 2, z > 2, or across all z.

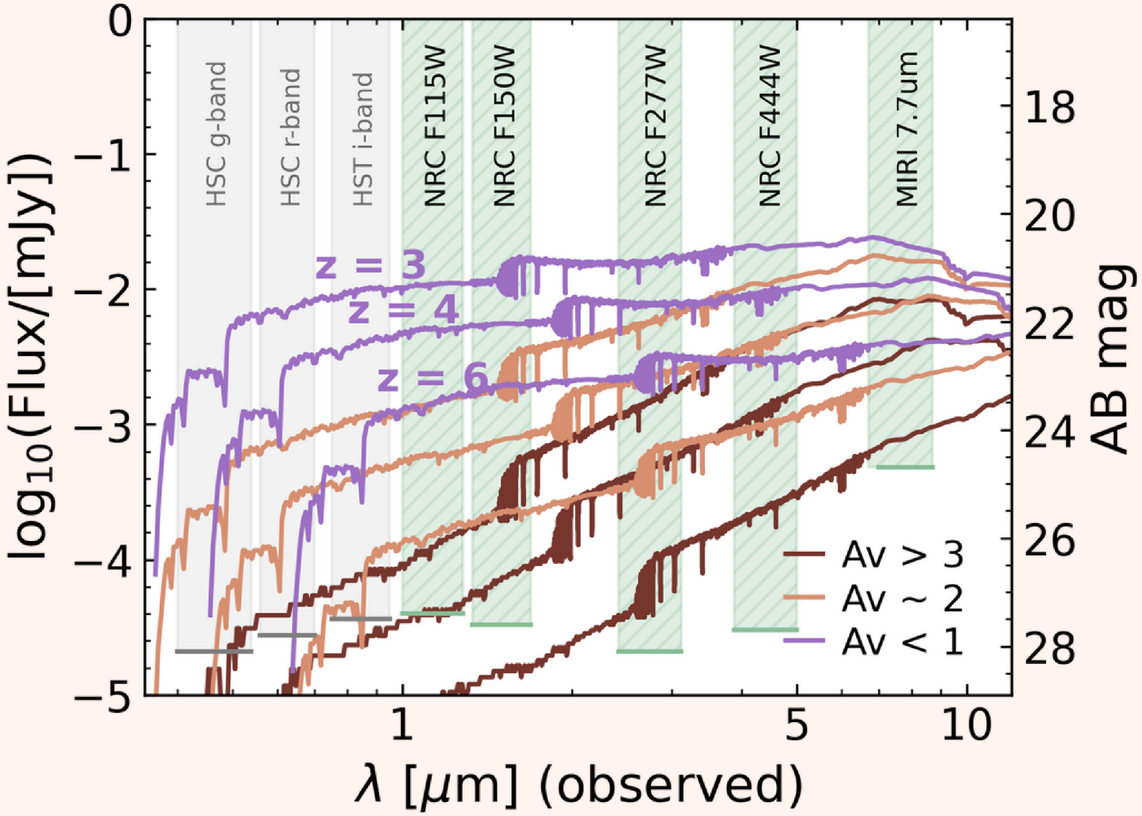


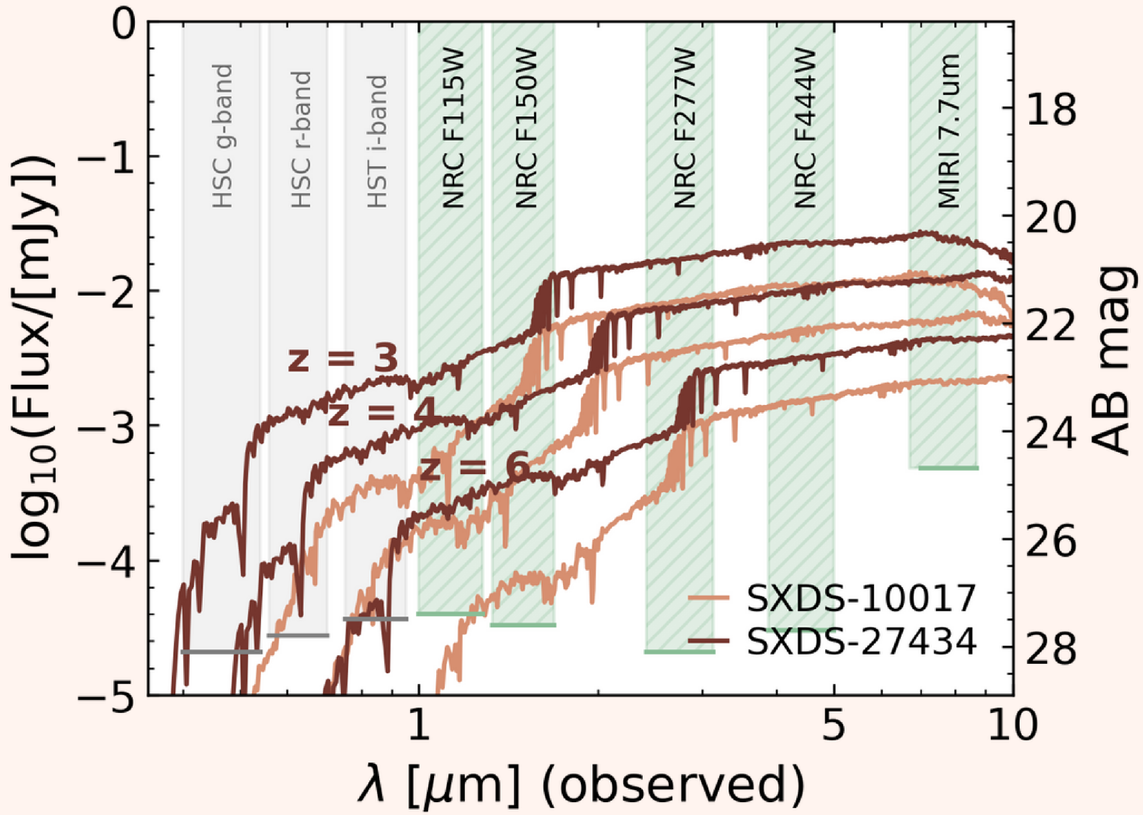
Brennan+15



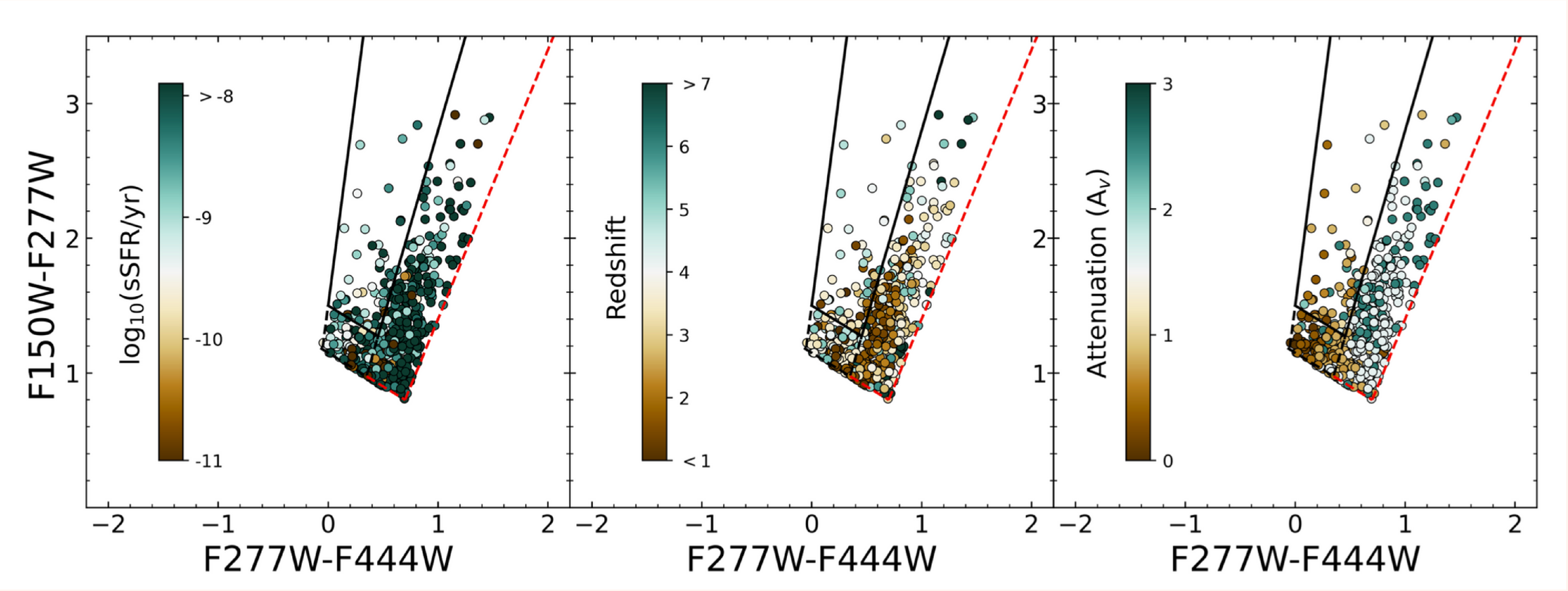
Merlin+19

Dust Obscured vs. Quiescent





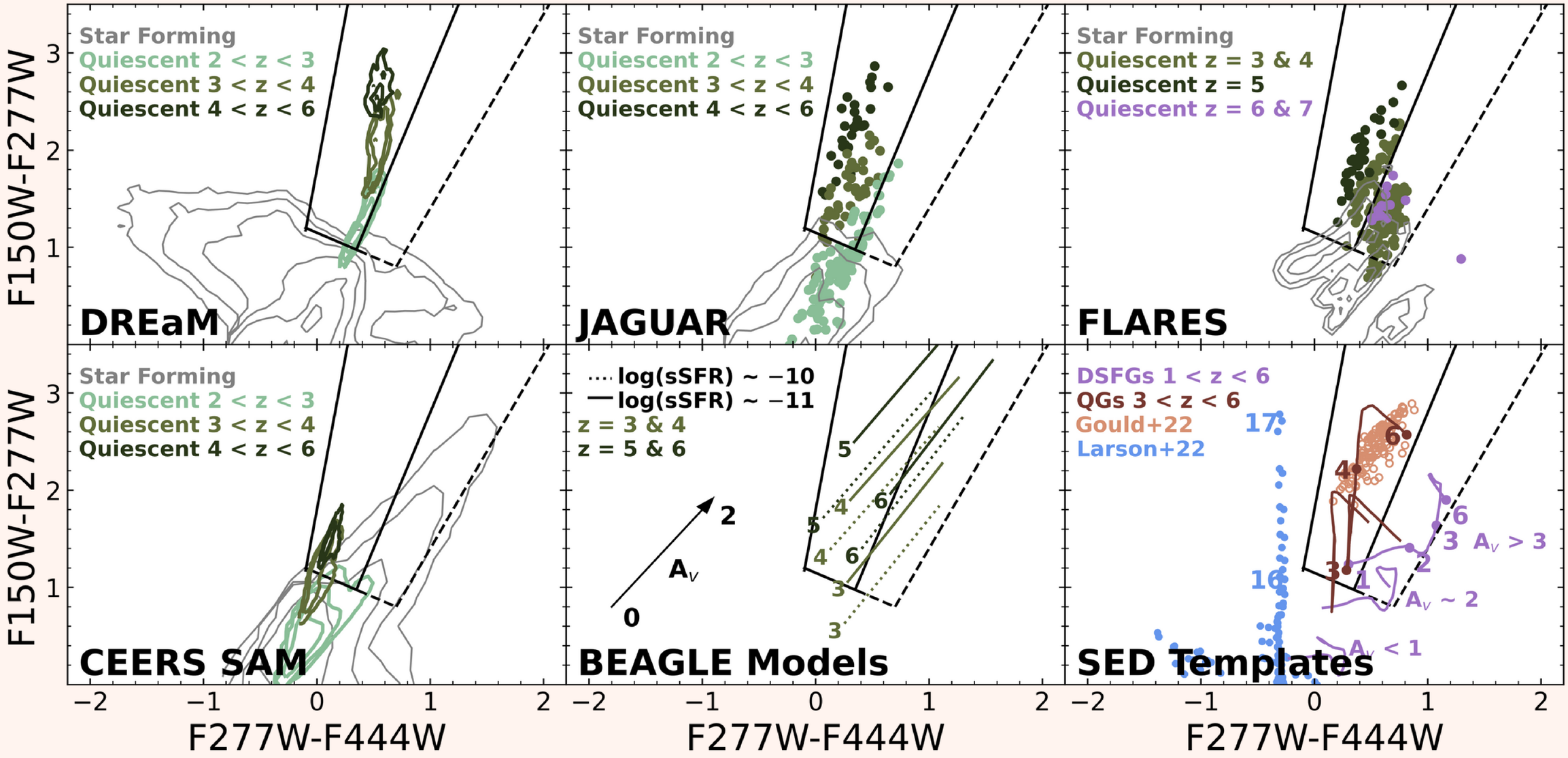
Contaminants



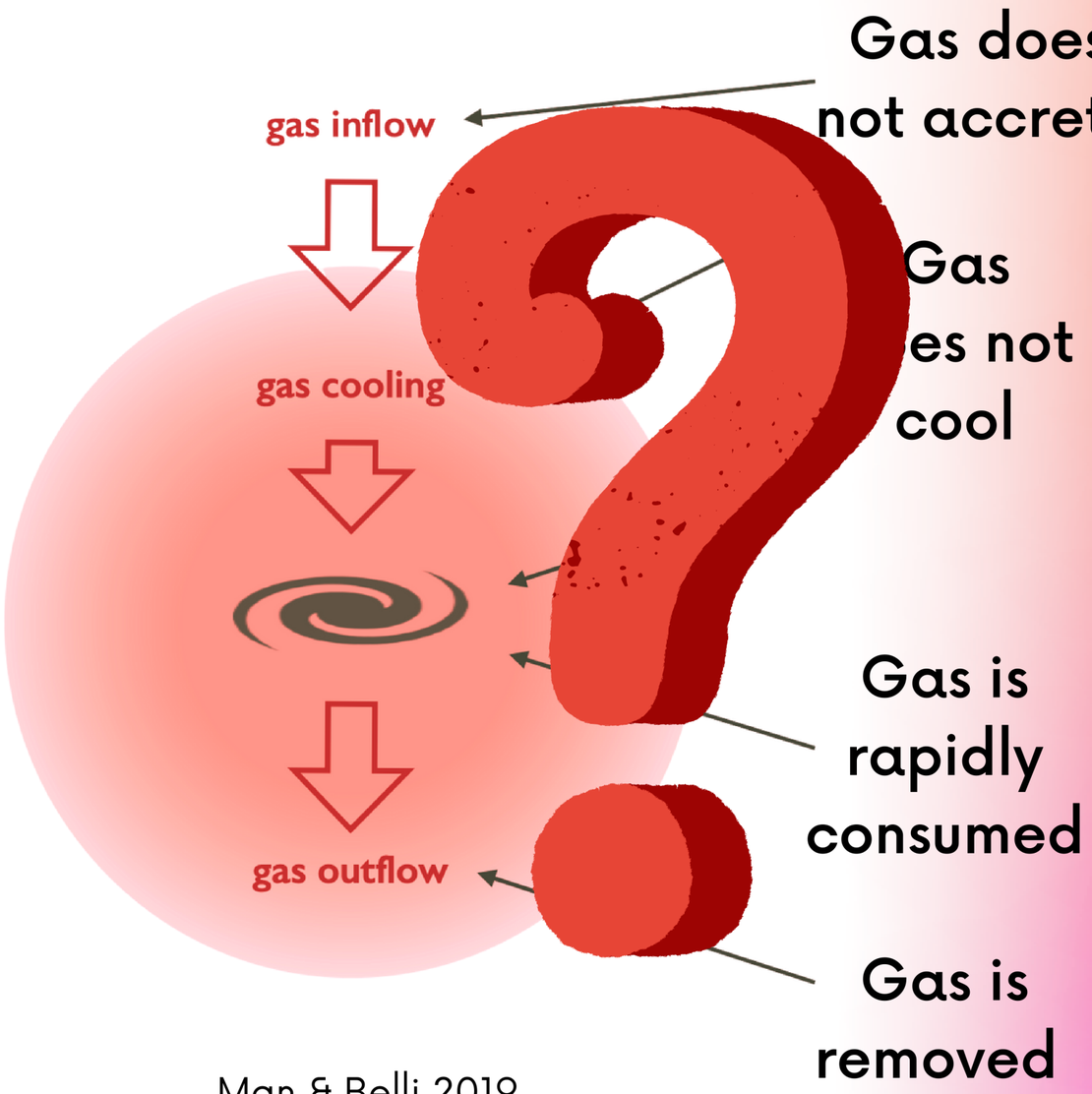
Results

- 191 (52) "contaminants" in the long (short) wedge
- Most are emission line / starburst-like galaxies at z < 6
- <Mstar> ~ 9.8 Msun | <Av> ~ 1-2 | < z > ~ 2

Wedge on Simulations



Potential Quenching Pathways



Man & Belli 2019

The dominant quenching mechanism is mass related and established at z > 3.