

DAWN



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Ripe fruits on the Cosmic Vine: What Massive Quiescent Galaxies at $z>3$ Reveal about Cluster Formation

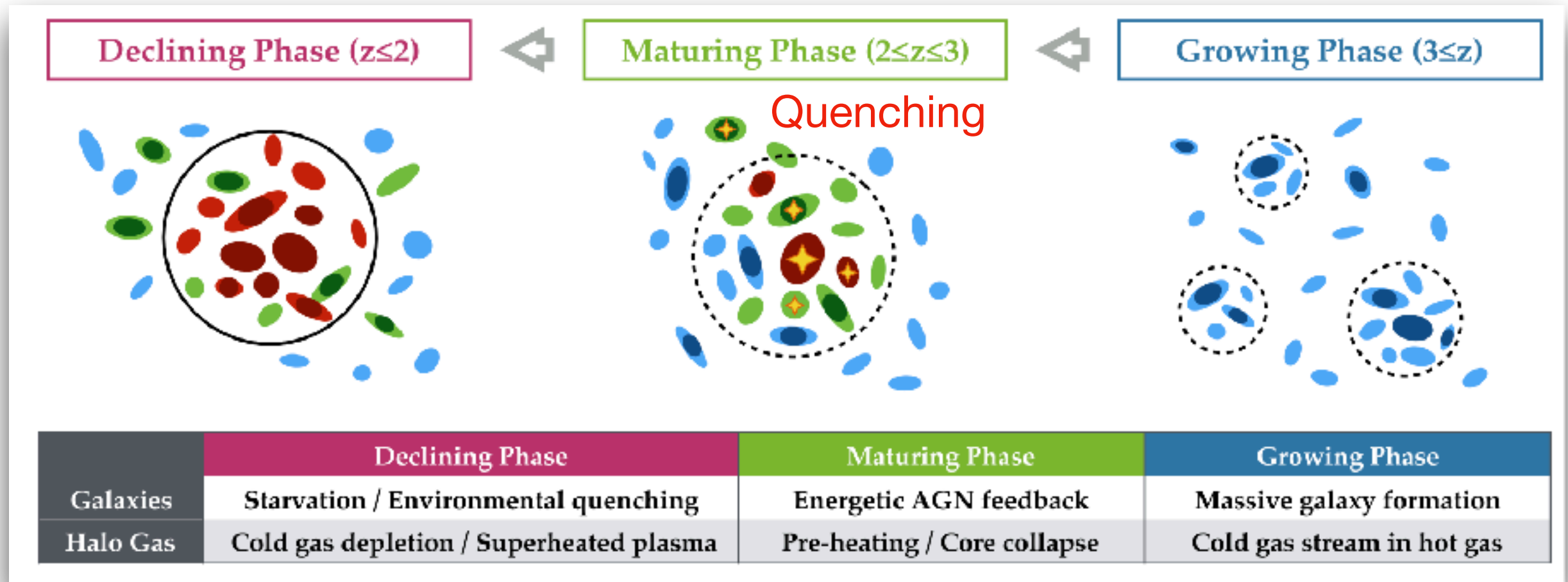
Shuowen Jin

(Marie Curie Fellow @ DAWN & DTU)

N. Sillassen, G. Magdis, G. Brammer & DAWN team.

26/06/2024, First Structures, Paris

Evolutionary picture

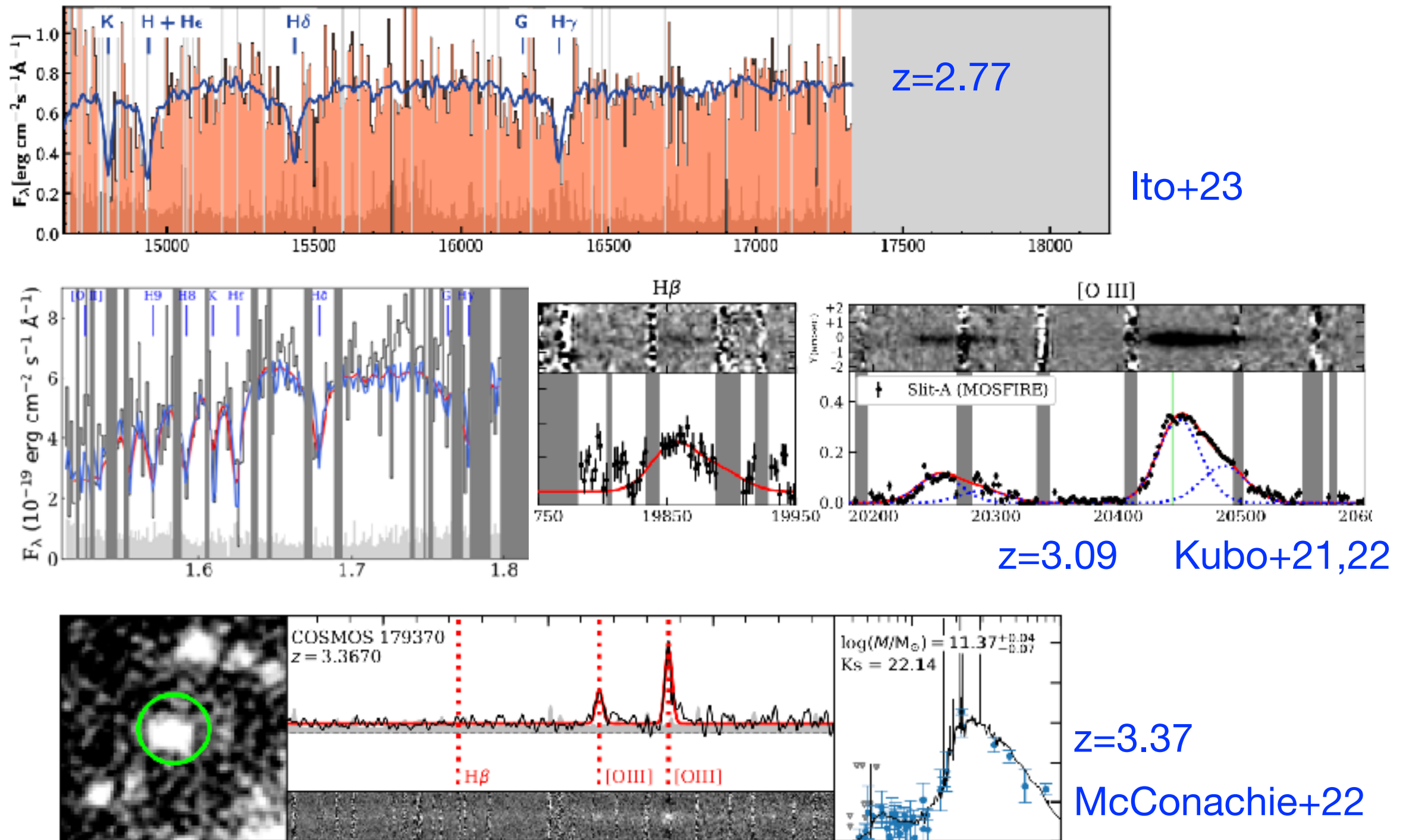


(Shimakawa et al. 2018)

Open questions:

1. **When** did the first quiescent galaxies formed in proto-clusters ?
2. **Where?** Inside or out the core? — Quenching vs virialization, which first?
3. **How** were they quenched? i.e., quenching mechanisms.

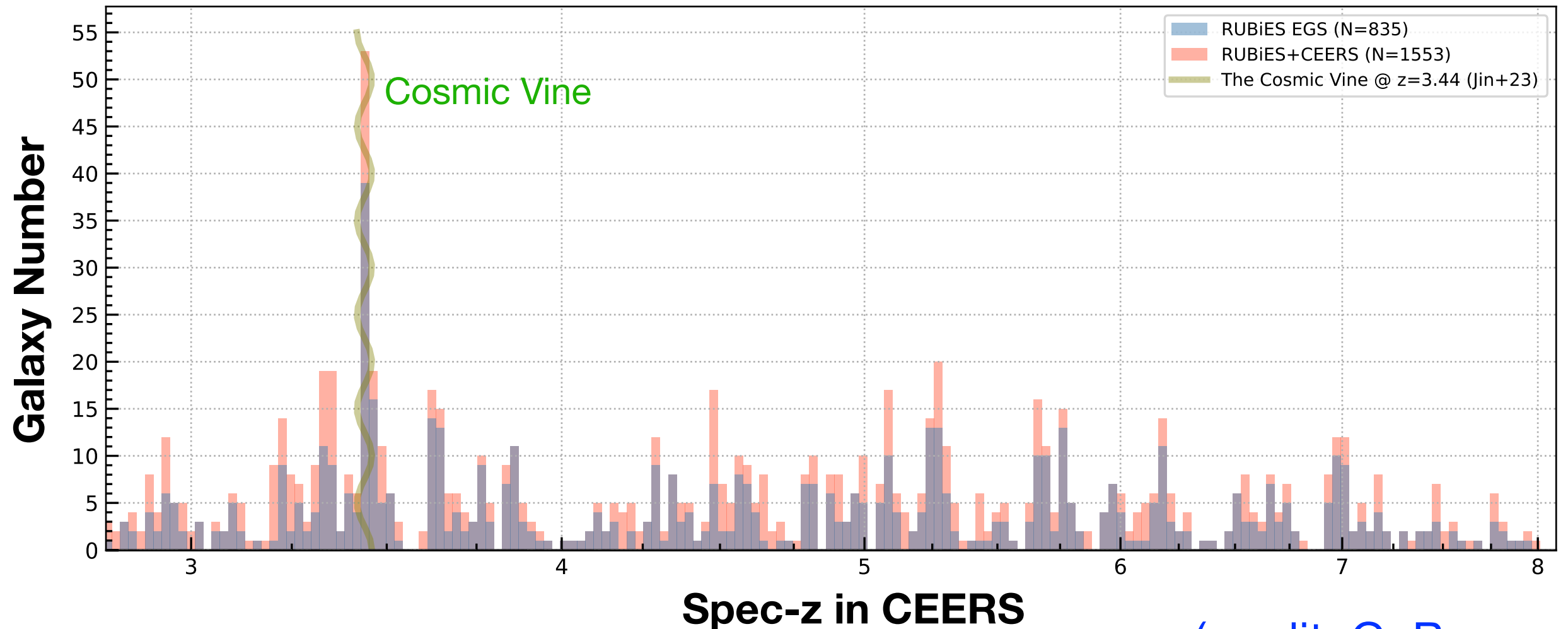
Quiescent galaxies in high-z overdensities



See also $z=2.44$ Shi+23, $z>4$ Tanaka+23, Kakimoto+23, de Graaf+24

Jin+24 Cosmic Vine at $z=3.44$.

New JWST data on Cosmic Vine

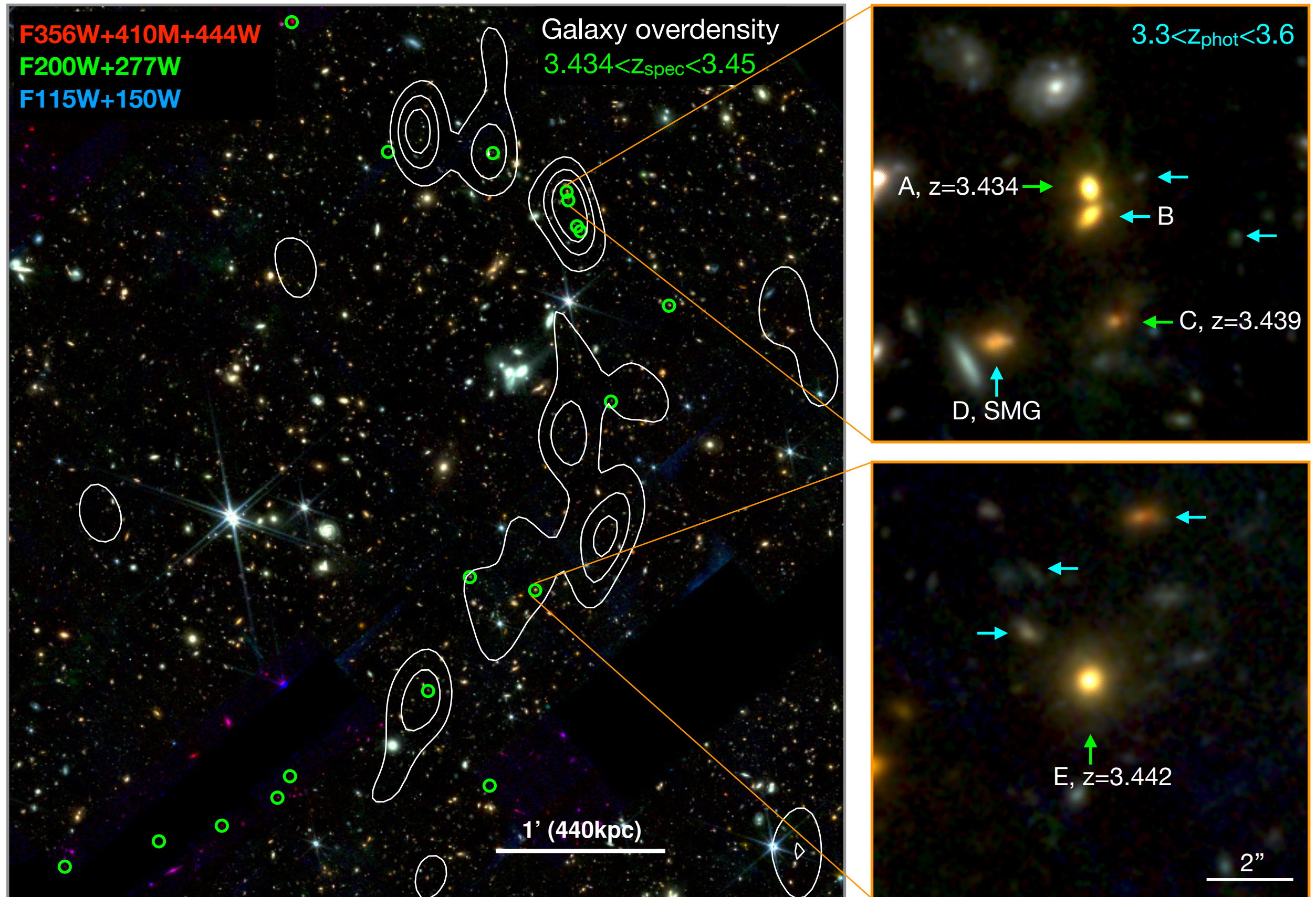


(credit: G. Brammer)

One of the most extreme galaxy overdensities by JWST

(See also [Sun+24 \$z=5.2\$](#) ; [Helton+23 \$z=5.4\$](#) ; [Wang+24 \$z=6.6\$](#) ; [Morishita+23 \$z=7.9\$](#)),
and Cosmic Vine is unique.

Ripe fruits on the Cosmic Vine



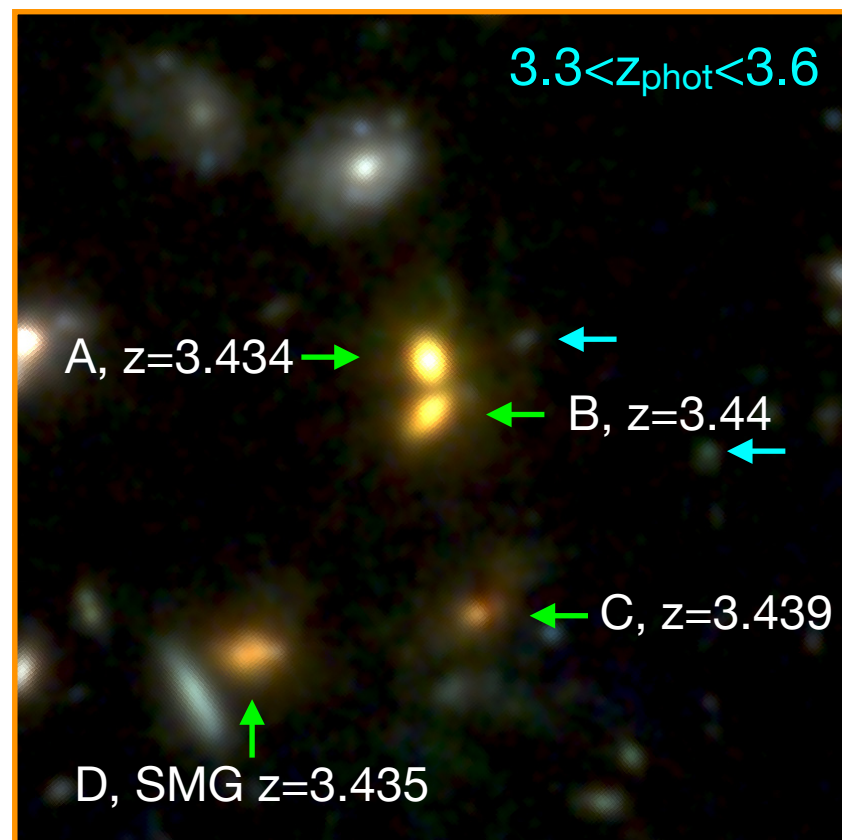
3 most massive galaxies are quiescent!

(Jin+24)

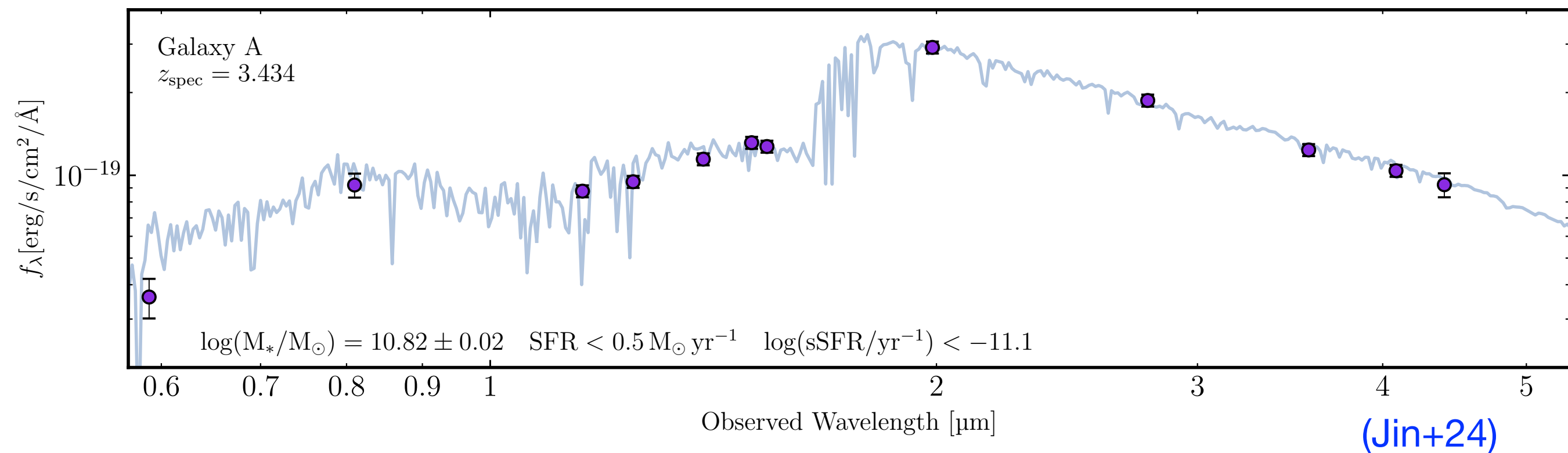
Why dubbed “Cosmic Vine”?

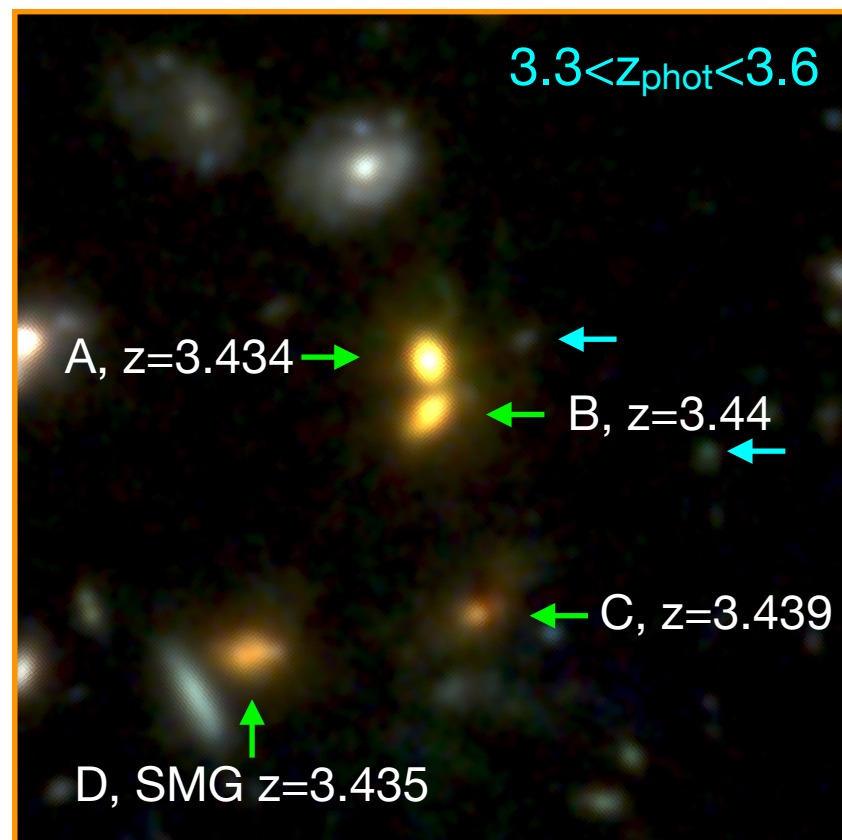


(Free image via Pixabay)

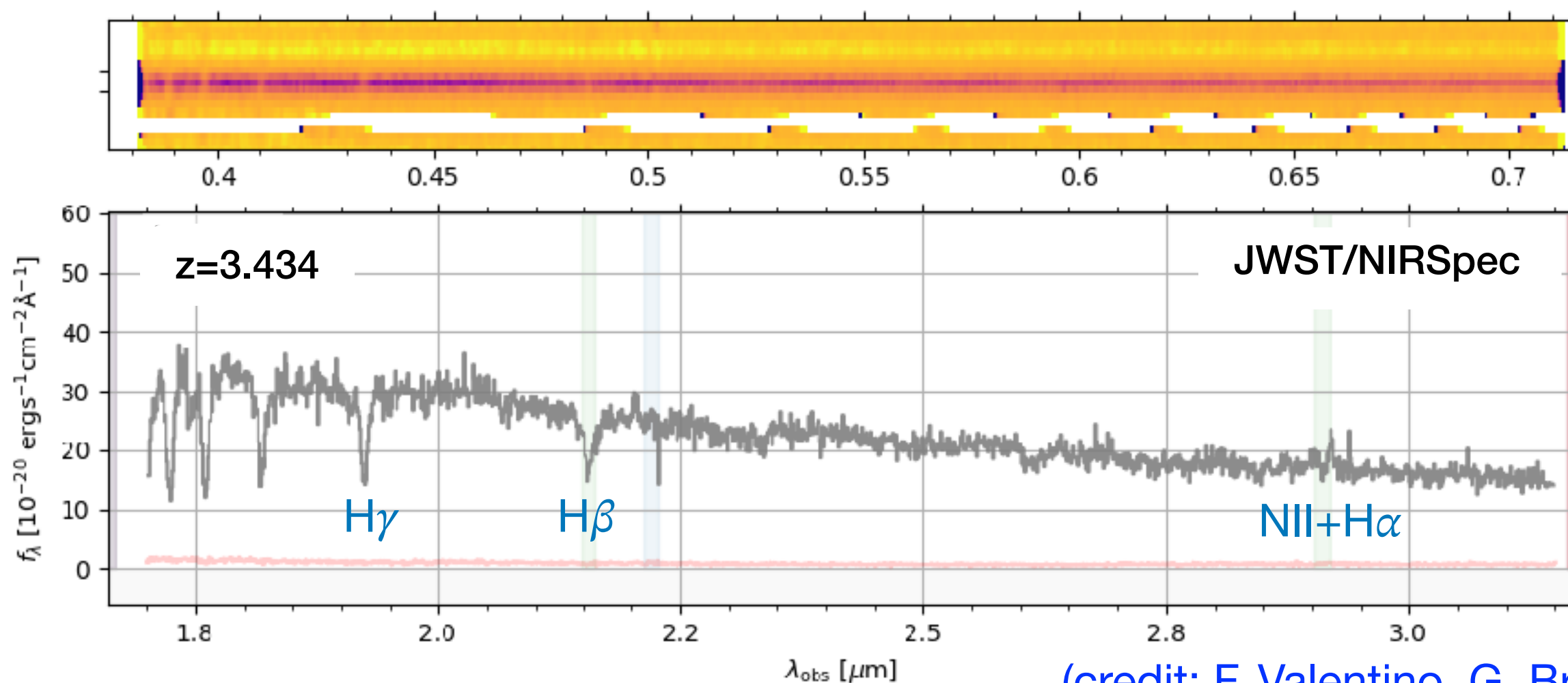


Galaxy A:
massive, quiescent,
compact, tidal tail

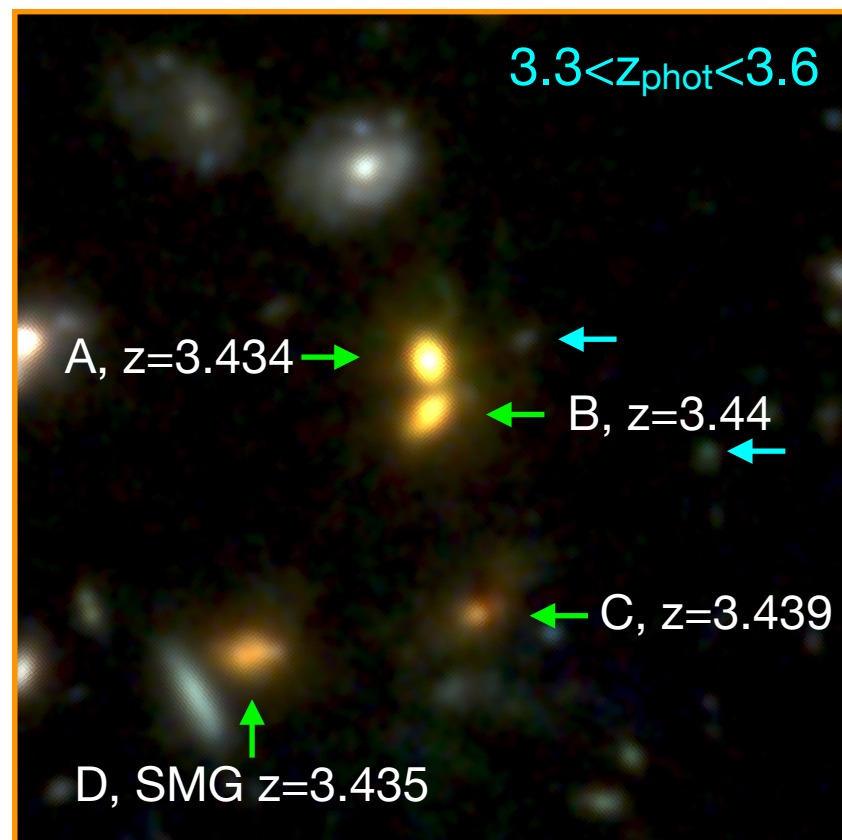




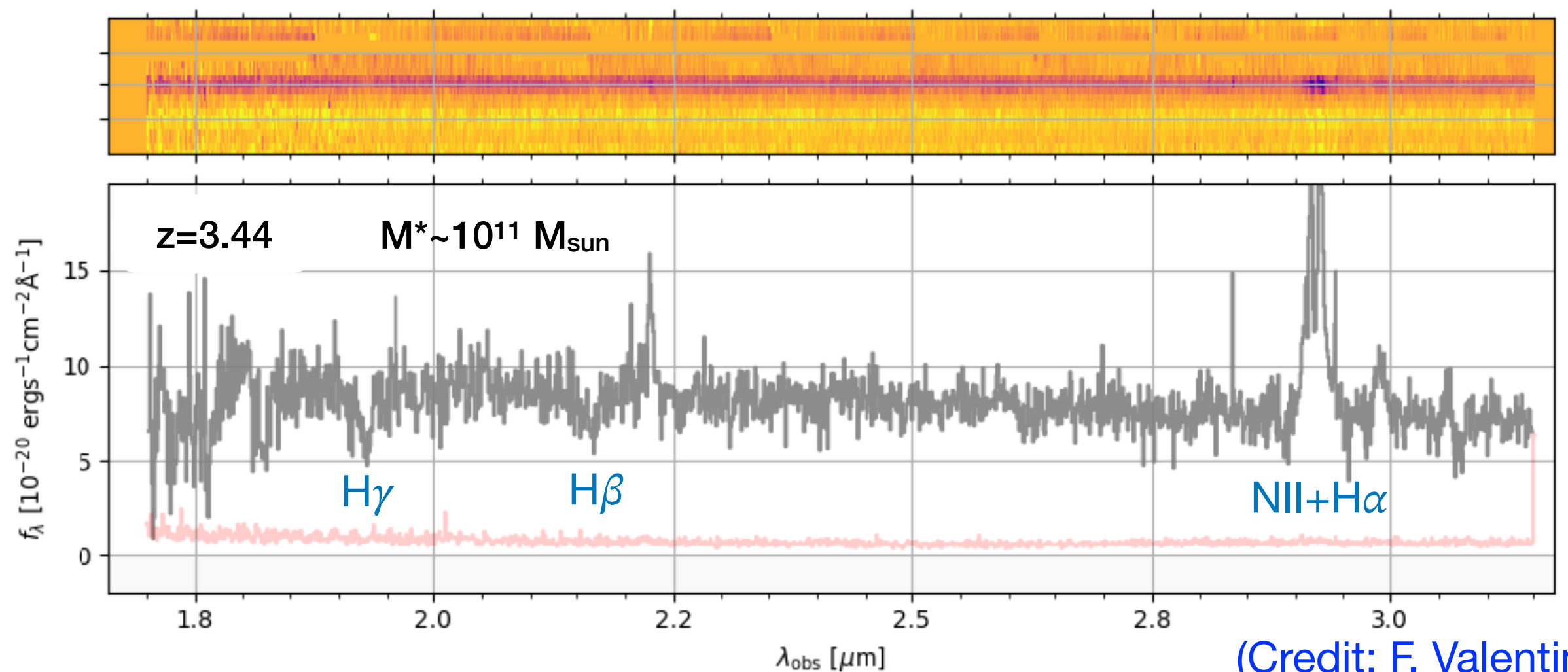
Galaxy A:
massive, quiescent,
compact ($R_{\text{eff}}=0.6$ kpc), tidal tail



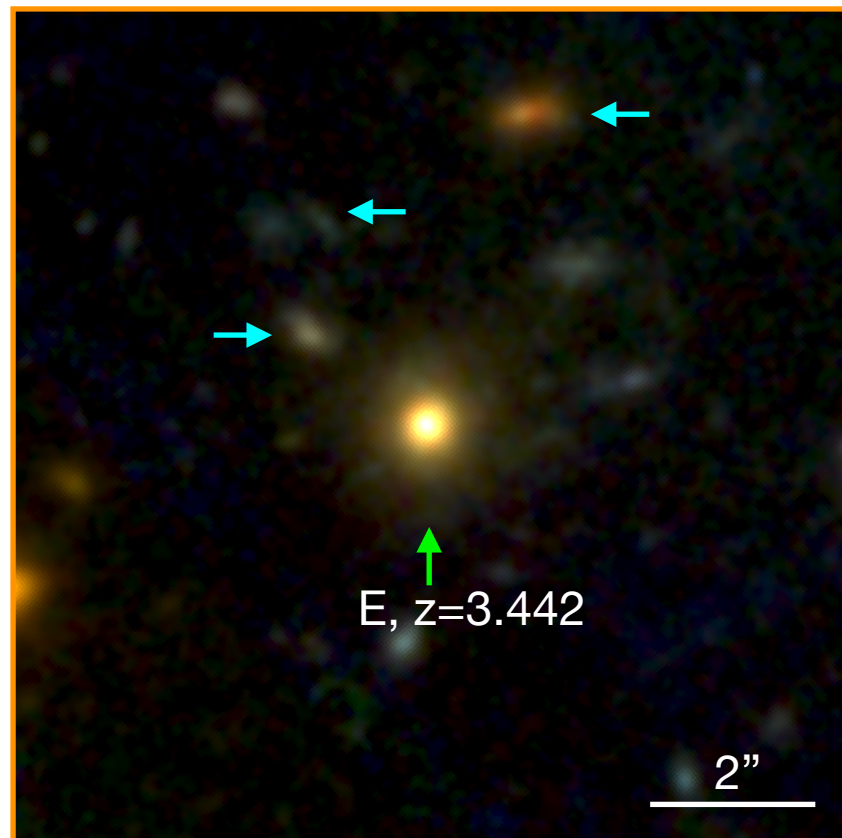
(credit: F. Valentino, G. Brammer)



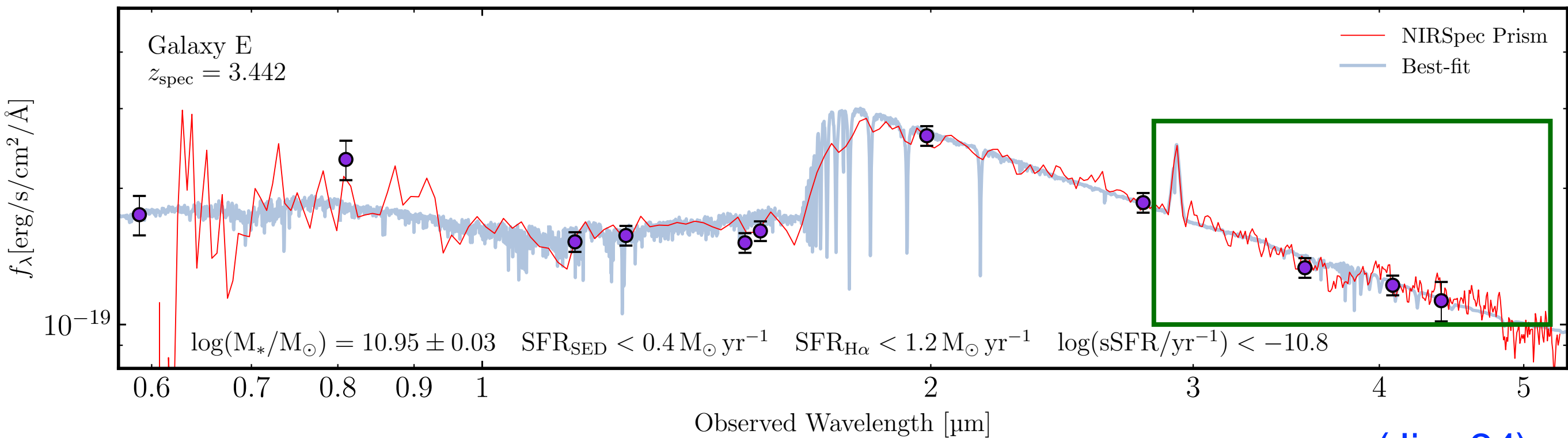
Galaxy B:
 massive & **post-starburst**,
 merging with Galaxy A
 —> **forming BCG** (Ito+ in prep.)



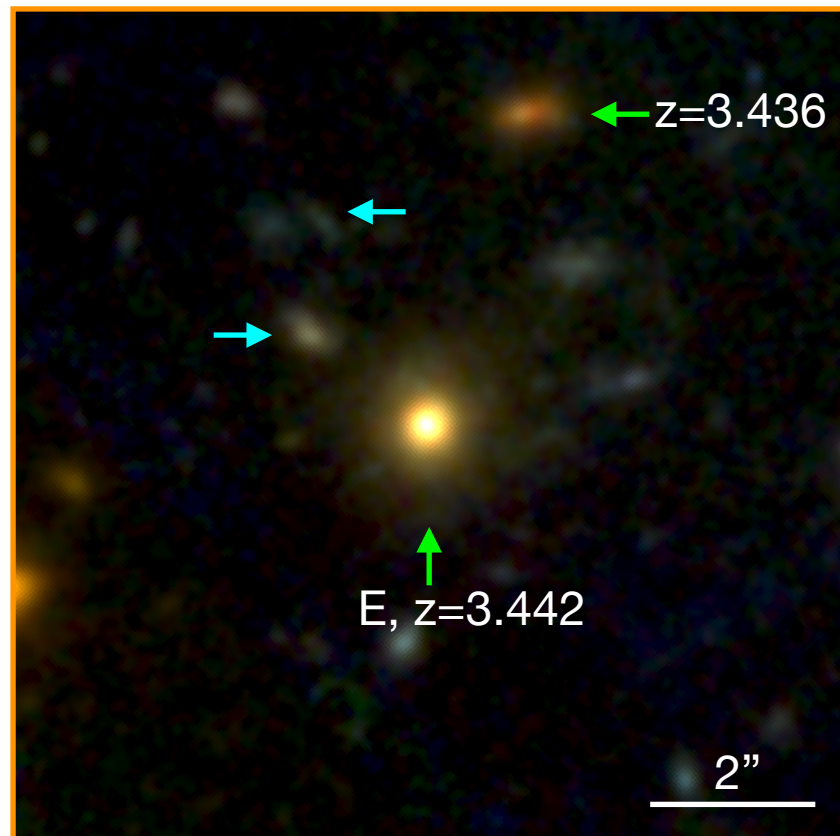
(Credit: F. Valentino)



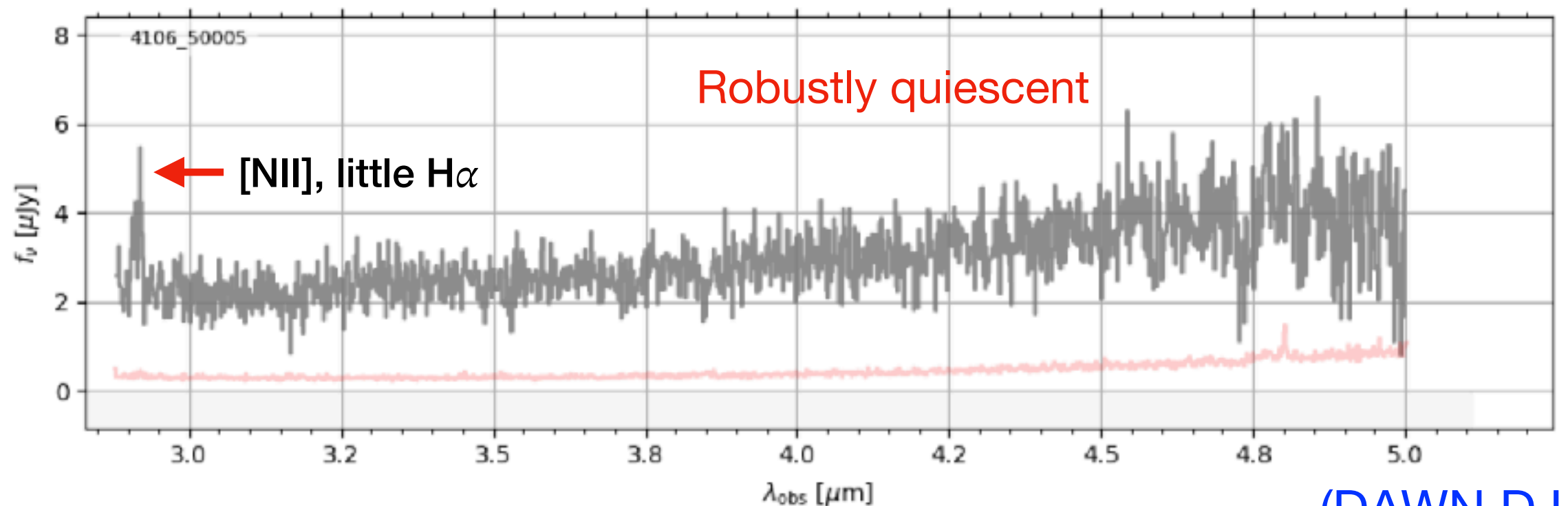
Galaxy E:
Not in the core but quiescent;
Bulge-dominated ($B/T > 70\%$)



(Jin+24)



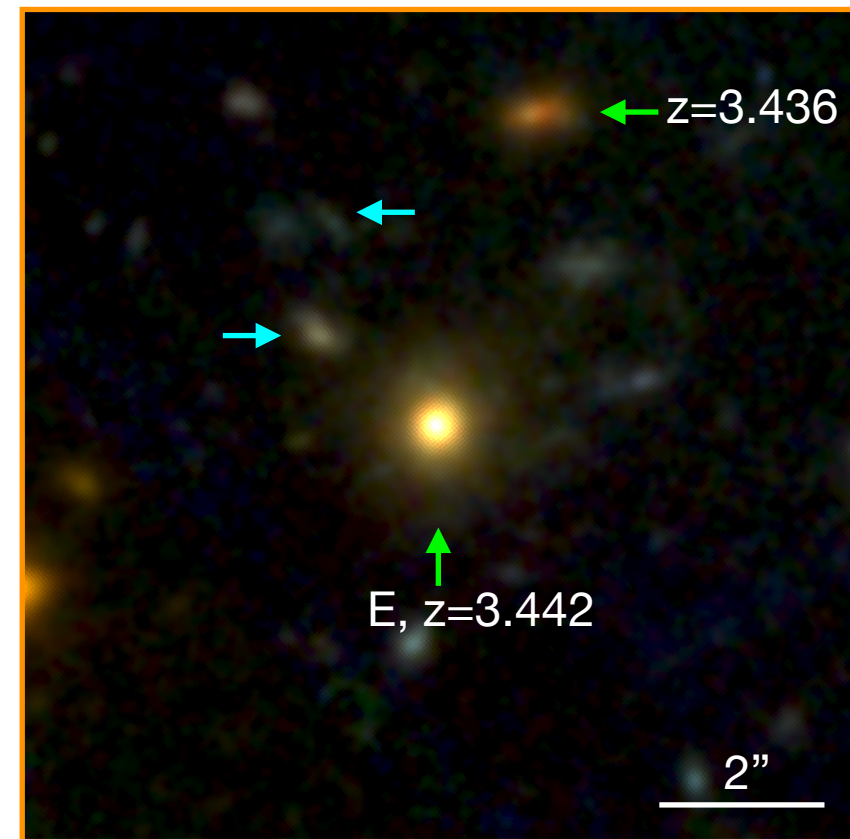
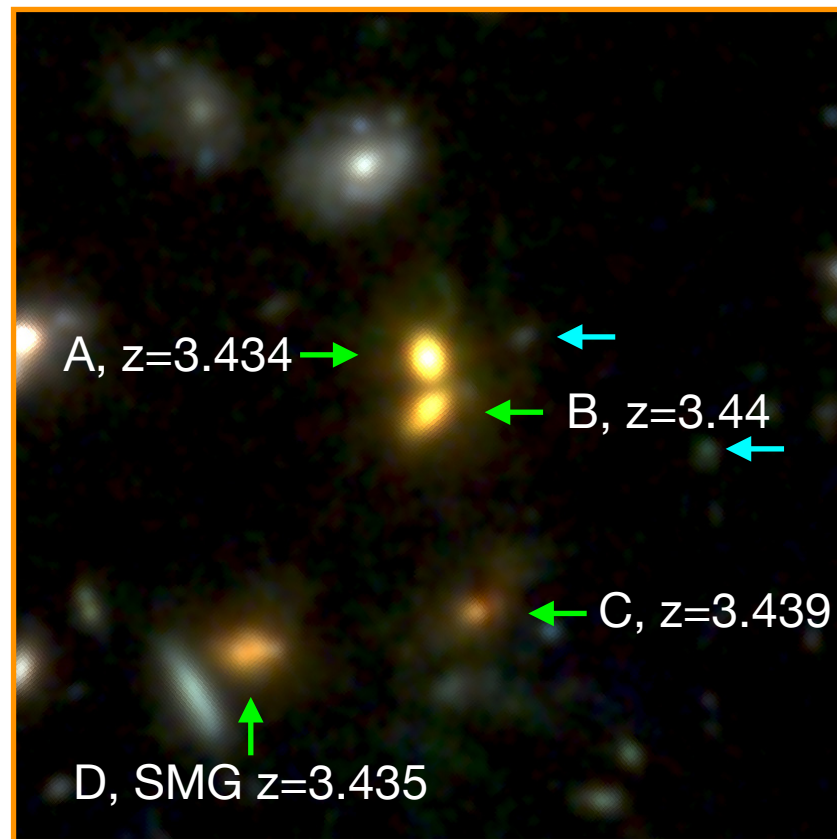
Galaxy E:
 Not in the core but quiescent;
 Bulge-dominated ($B/T > 70\%$)



(DAWN DJA)

Results

Observational results of Cosmic Vine:

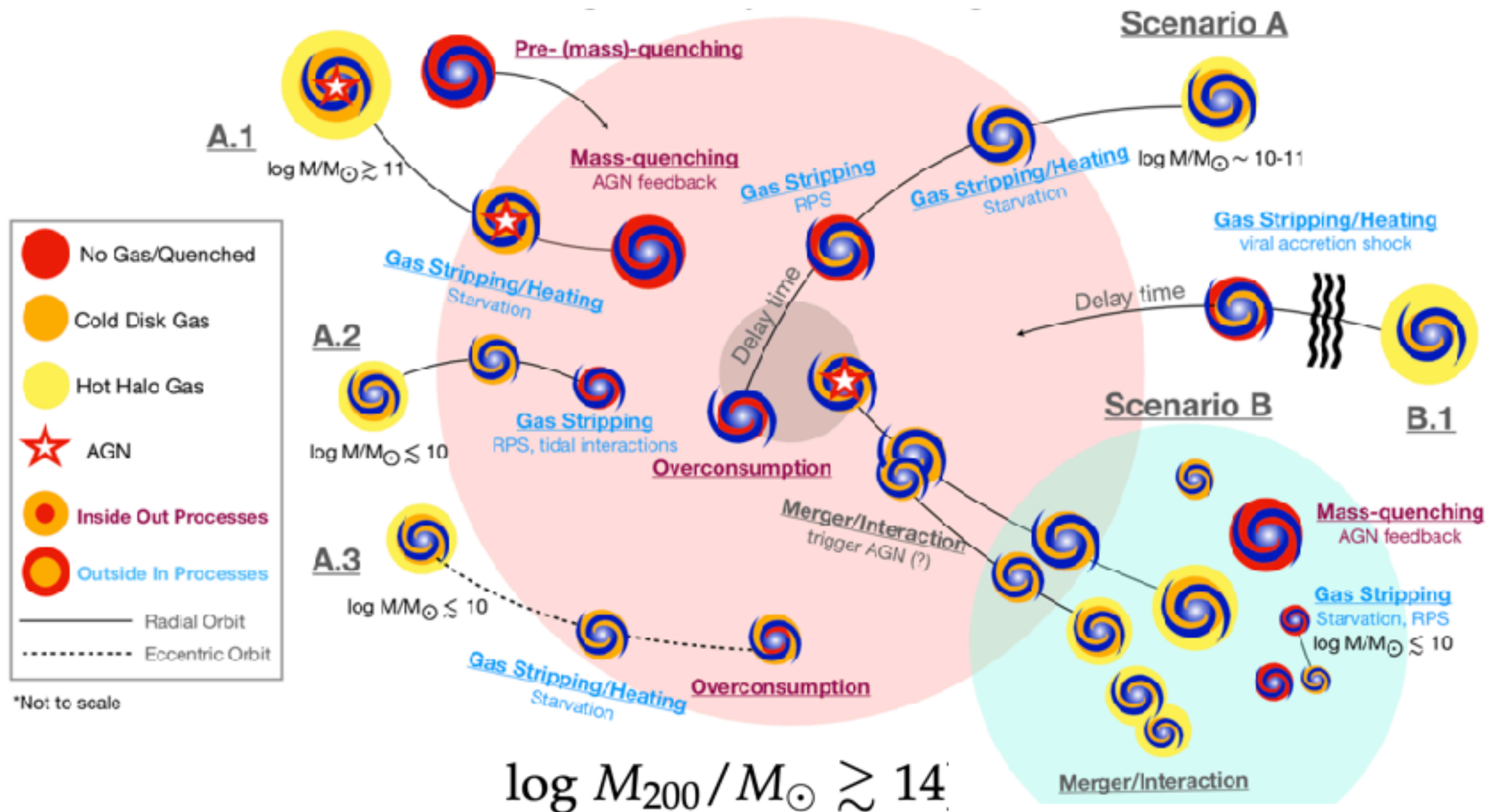


- (1) filament-like structure, not virialized,
- (2) 3 quiescent: A & B are merging, E is isolated;
- (3) A & E are compact with bugles;
- (4) a SMG is presented in the core region;
- (5) core mass $M_{\text{halo}} \sim 10^{12.7} M_{\text{sun}}$

What quenched them?

Environmental quenching:

~~(1) Ram pressure stripping; (2) starvation; (3) harassment~~

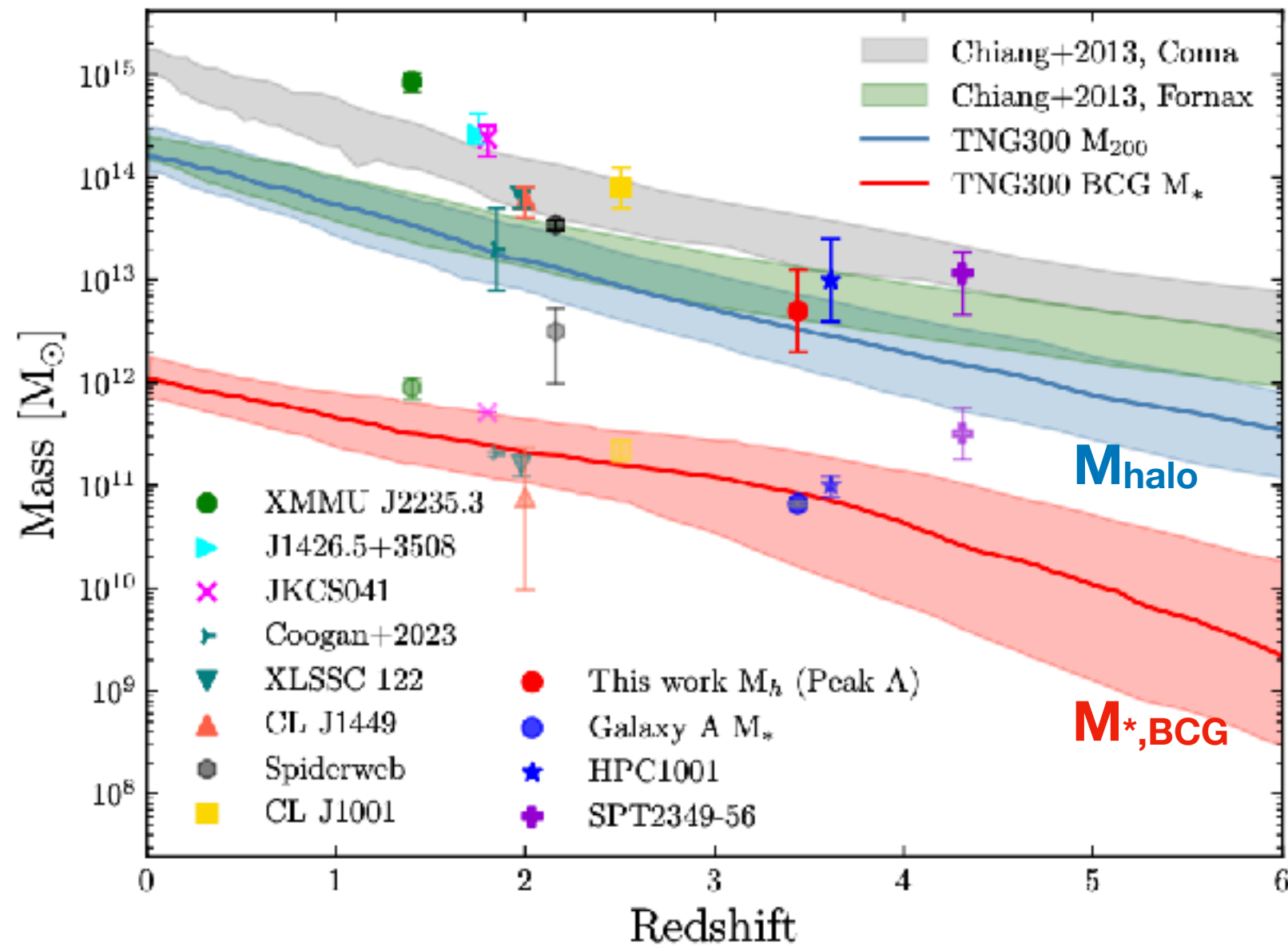


(Alberts & Noble 2022, review)

Environmental quenching is disfavoured, more likely by strong AGN feedbacks or merger-triggered compact starbursts.

Comparison with simulations

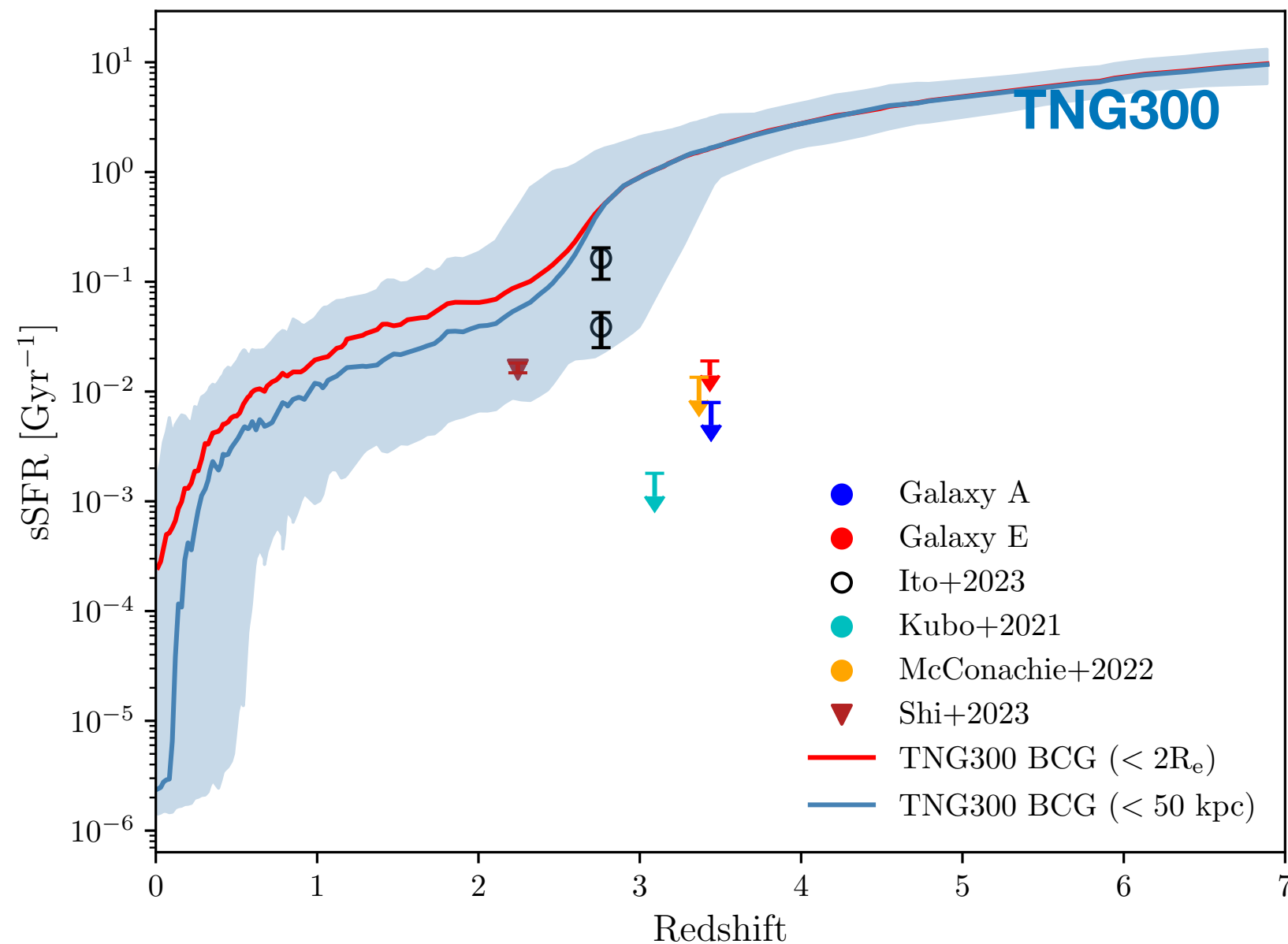
Agreed on M_{halo} & $M_{*,\text{BCG}}$



Cosmic Vine is on the way forming a massive cluster.

Comparison with simulations

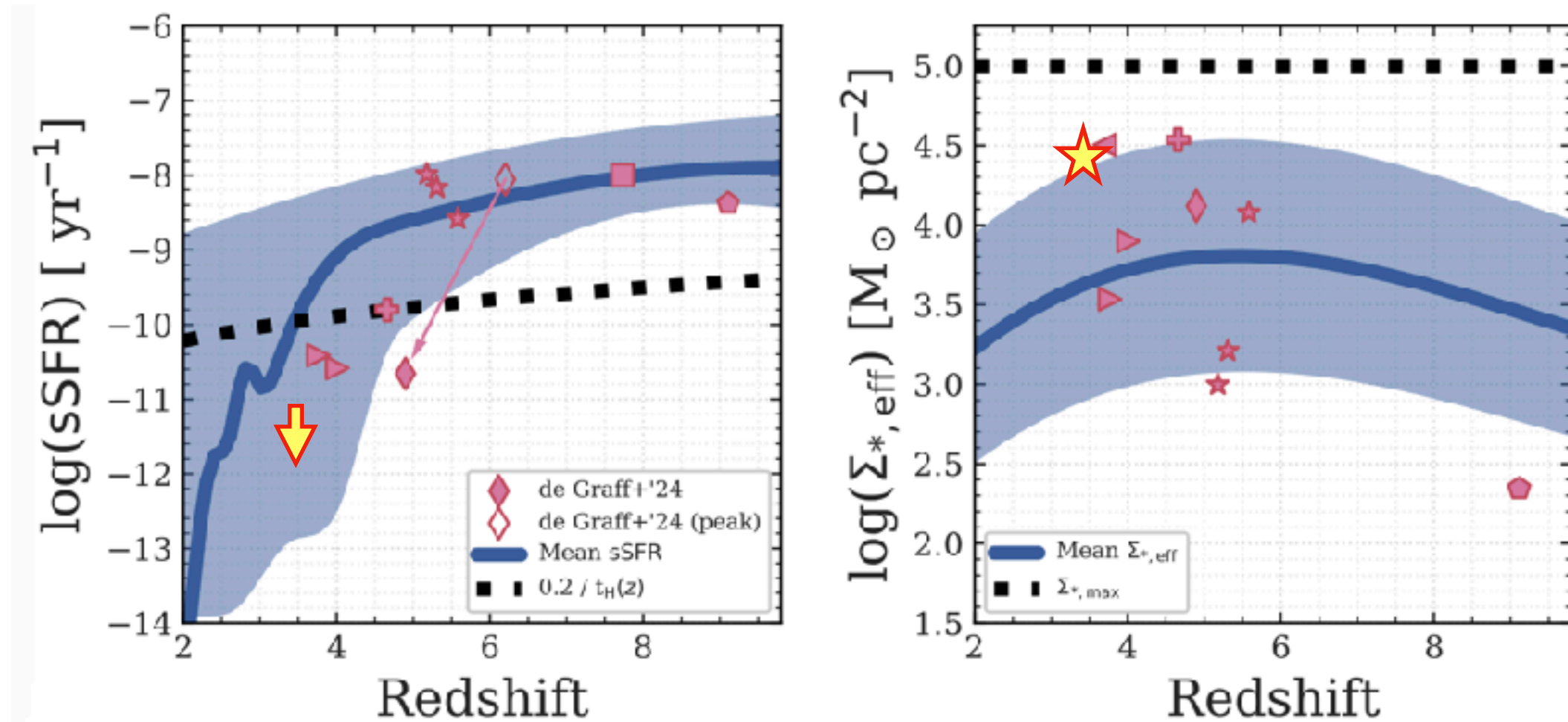
Huge discrepancy on sSFR !



sSFRs are **2 mag lower** than TNG300 prediction, very dead.

More comparisons to do

Extreme proto-BCGs from Manhattan Suite ([Rennehan 2024](#))



Preliminary

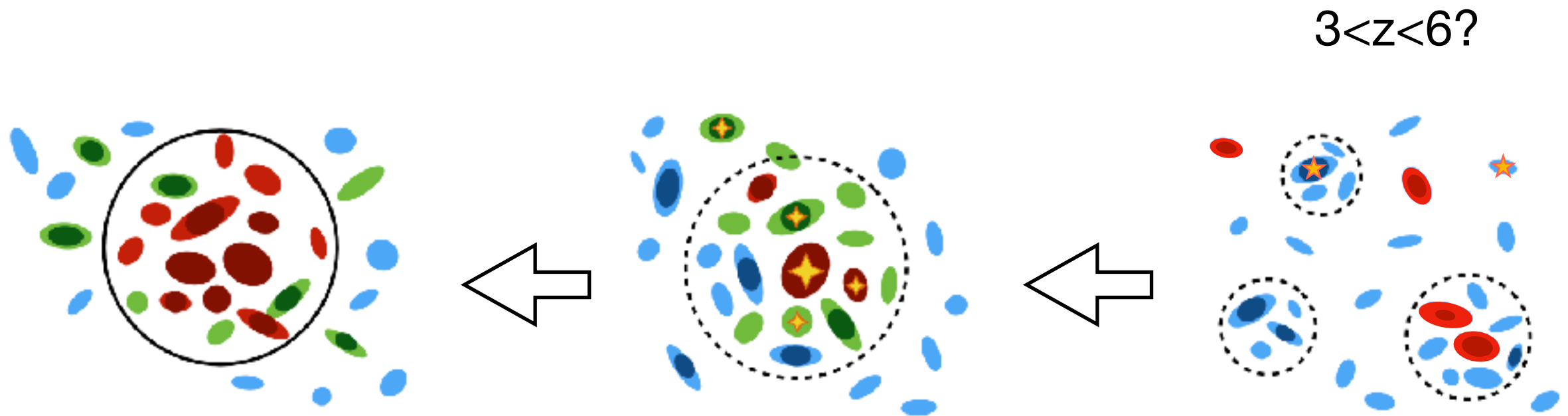
Further work: comparison to FLAMINGO, Magneticum, SHARK etc.

Conclusions

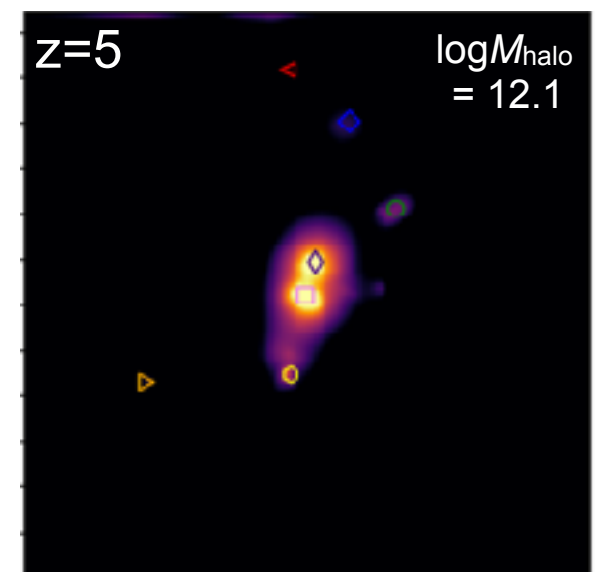
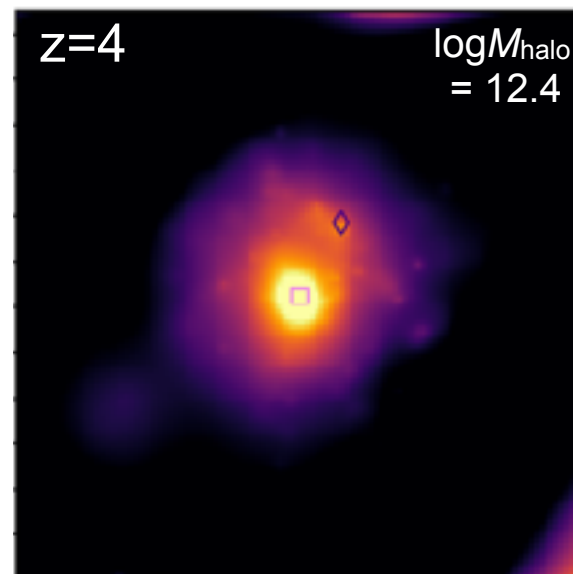
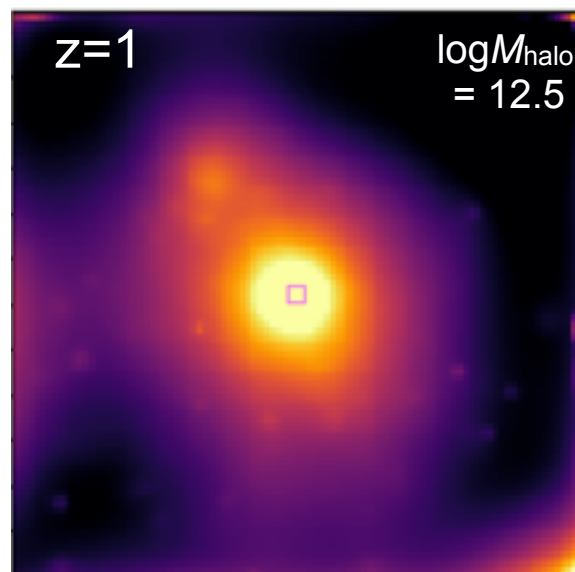
1. Massive quiescent galaxies have been formed in $z > 3$ LSSs & proto-clusters;
2. Quenching takes place before virialization — You don't need a collapsed cluster core to quench cluster galaxies.
3. Environmental quenching is unlikely working in Cosmic Vine, indicating mass quenching (by starburst or AGN).
4. $z > 3$ quiescent proto-cluster galaxies are too dead, having > 2 mag lower sSFR than TNG300 — a challenge to models?

(Jin+2024 A&A, 683, L4)

Updates to the big picture



Mass & LSS environ.-dependent!



“proto-massive galaxy” (Jin+2023)