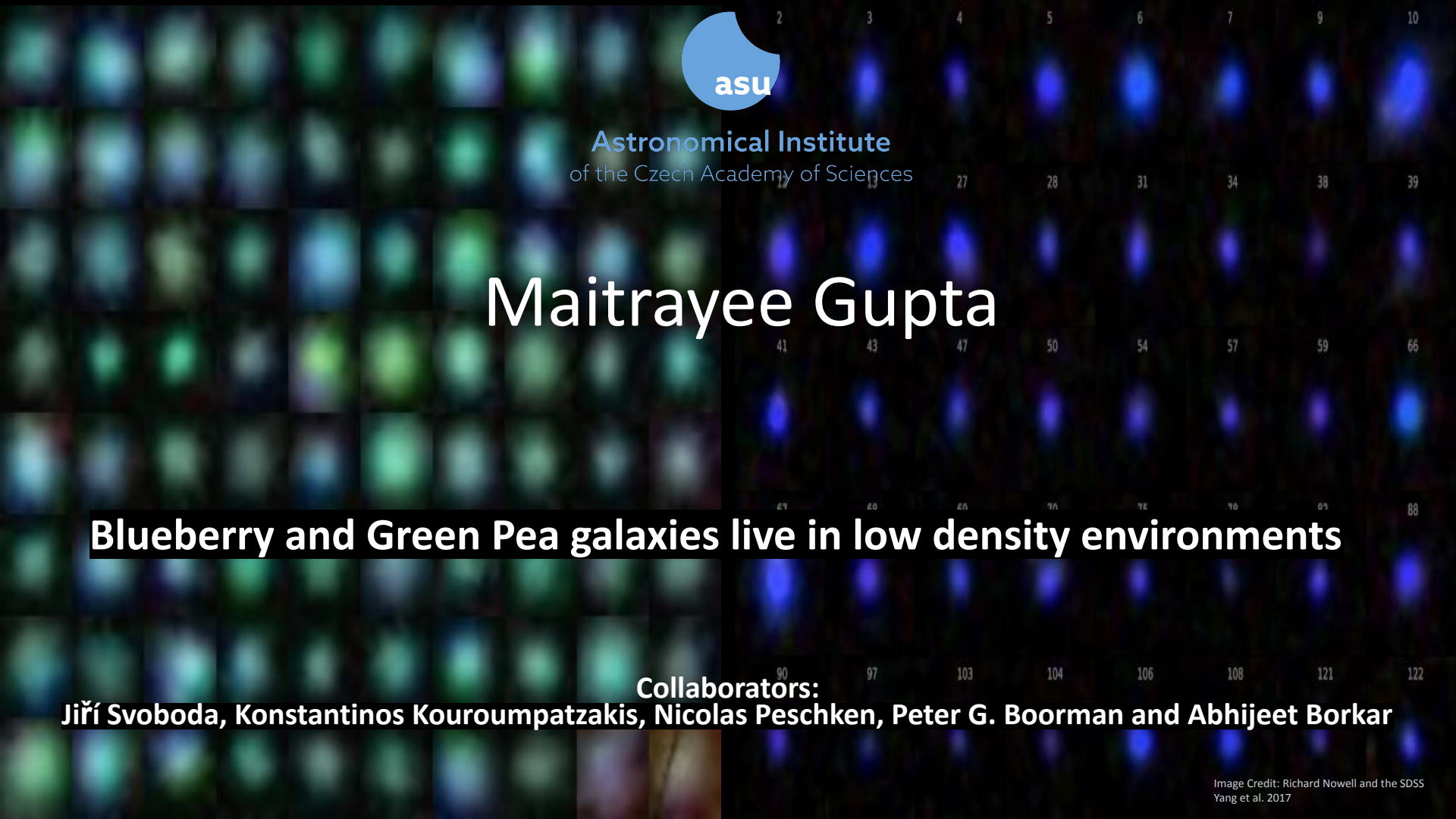

Astronomical Institute
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Maitrayee Gupta

Blueberry and Green Pea galaxies live in low density environments

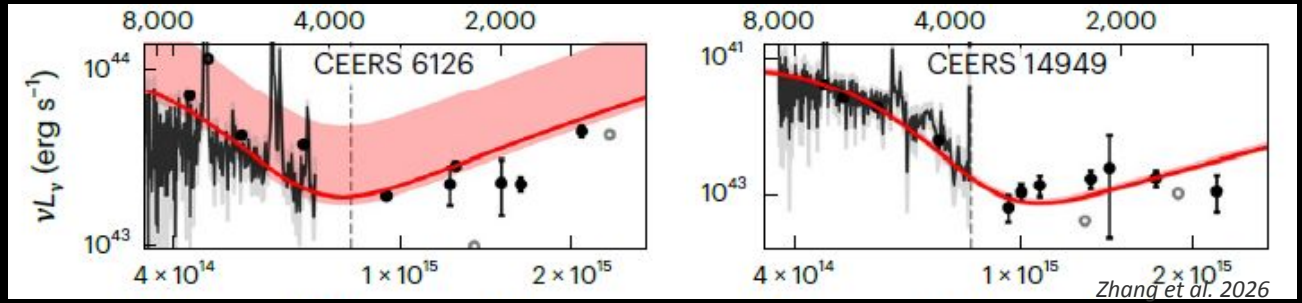
Collaborators:
Jiří Svoboda, Konstantinos Kouroumpatzakis, Nicolas Peschken, Peter G. Boorman and Abhijeet Borkar

Image Credit: Richard Nowell and the SDSS
Yang et al. 2017

Little Red Dots

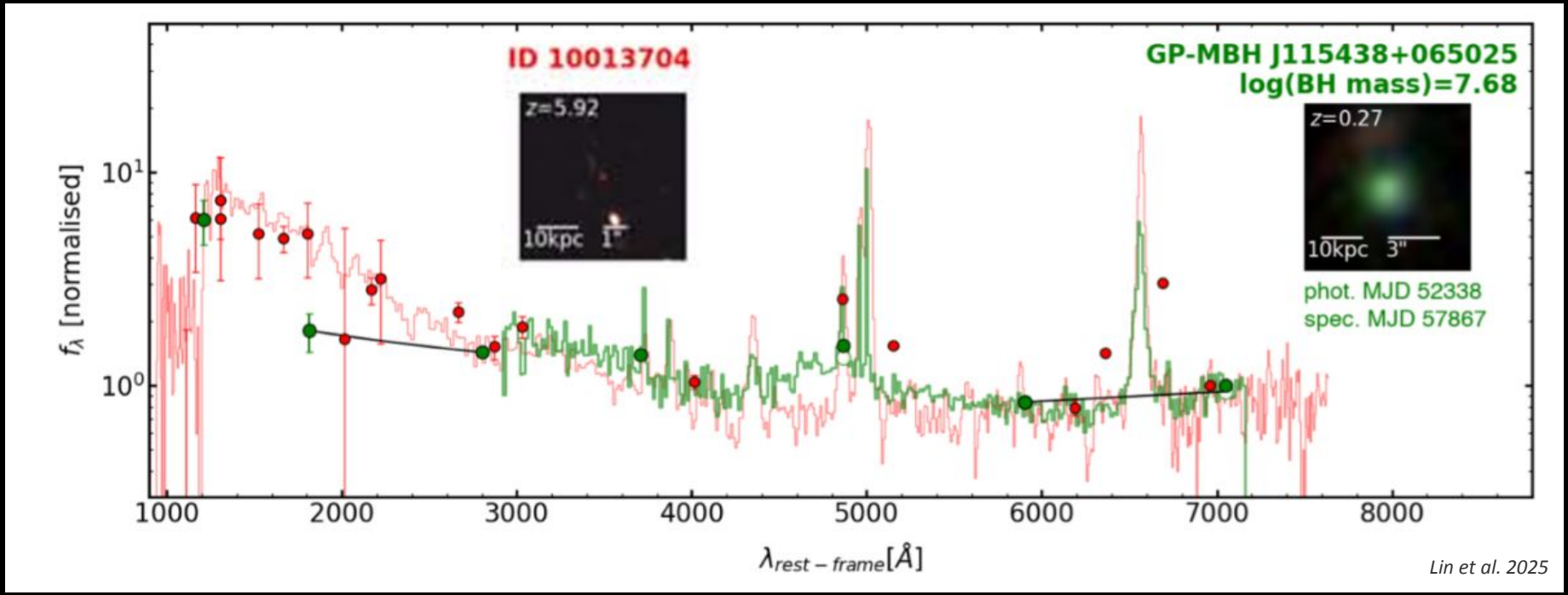
- High z, compact galaxies, red, blue, V-shaped SED
- Nature of activity: SMBH/SF
- Unusual properties: Overmassive, Low X-ray/Radio
- BH Growth in dense Ionised gas
- Abundant - how rapidly did SMBHs form and grow?

V-shaped SED



Zhang et al. 2026

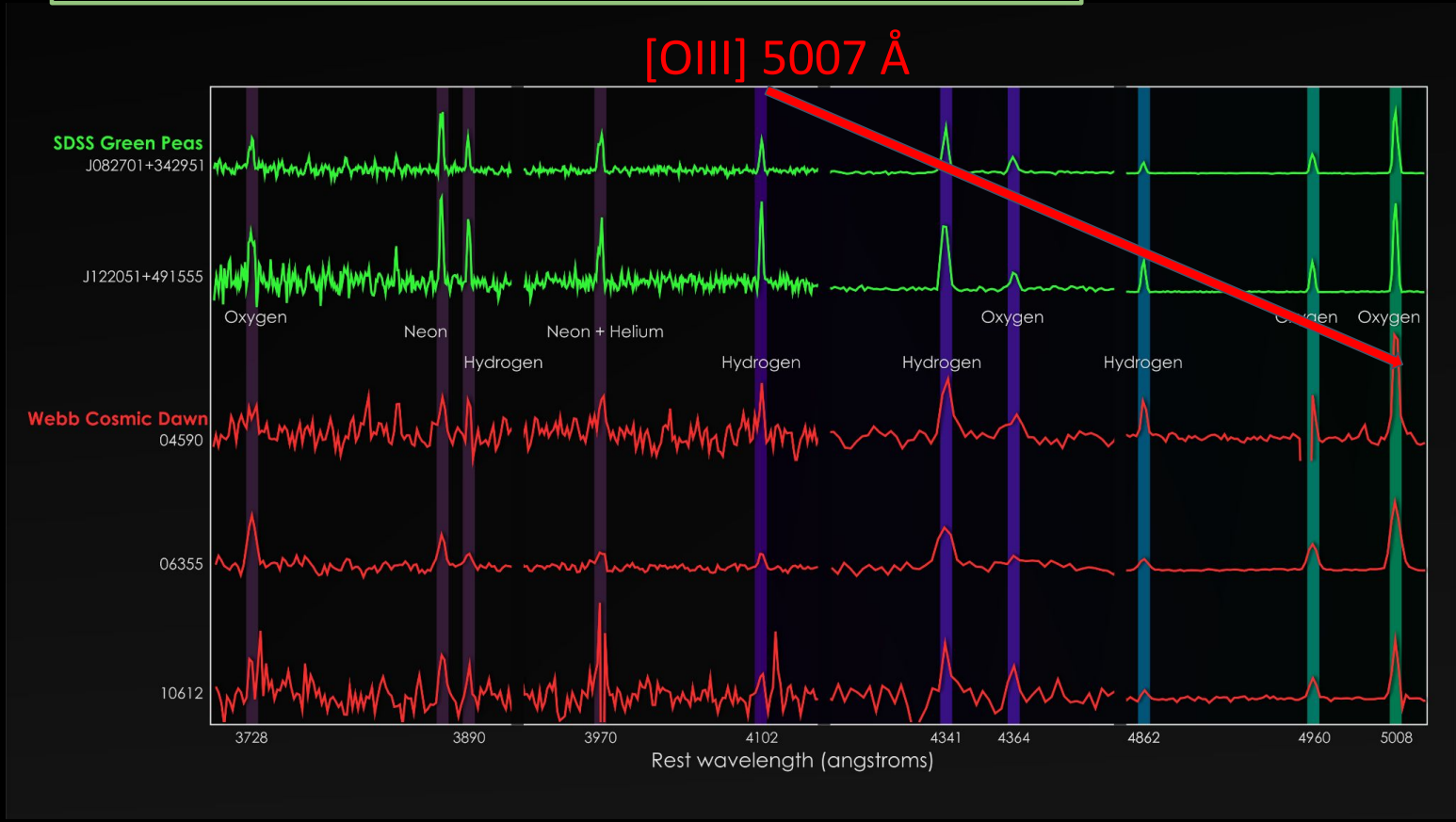
Low vs High z spectral characteristics



Lin et al. 2025

High vs Low z objects

SDSS and NASA, ESA, CSA, and STScI)



NASA's Goddard Space Flight Center/Rhoads et al. 2023

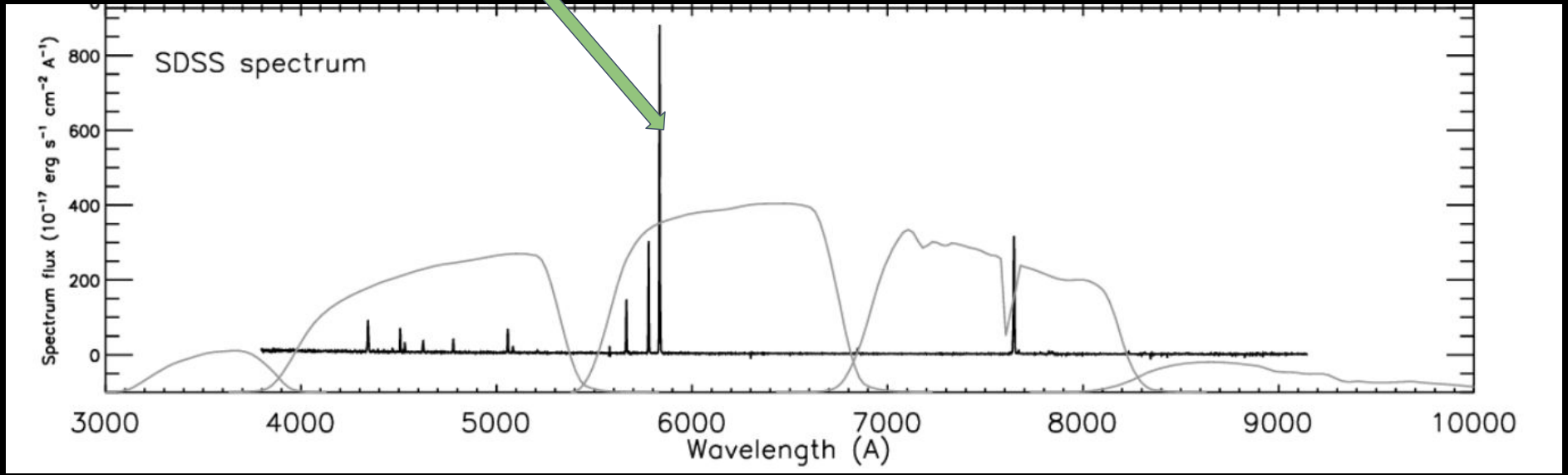
What are these low z objects?

1. Green pea galaxies: Discovered by the citizen science volunteers in the “Galaxy Zoo” project (Cardamone et al. 2009)
2. $0.1 < z \leq 0.33$
3. Compact dwarf galaxies, high sSFR, low metallicity

SDSS

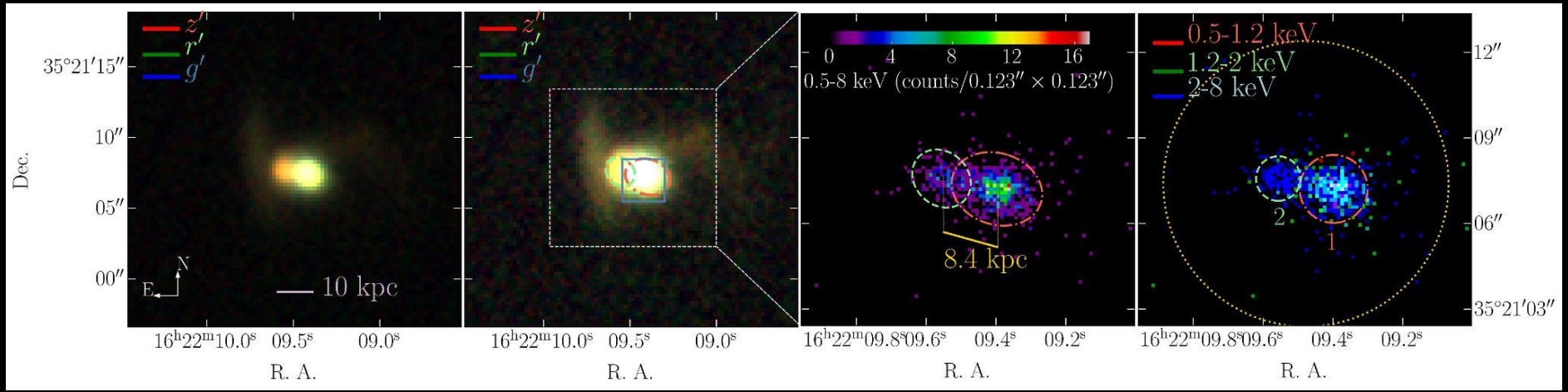
Why are they green?

Due to strong [OIII] 5007 Å



Cardamone et al. 2009

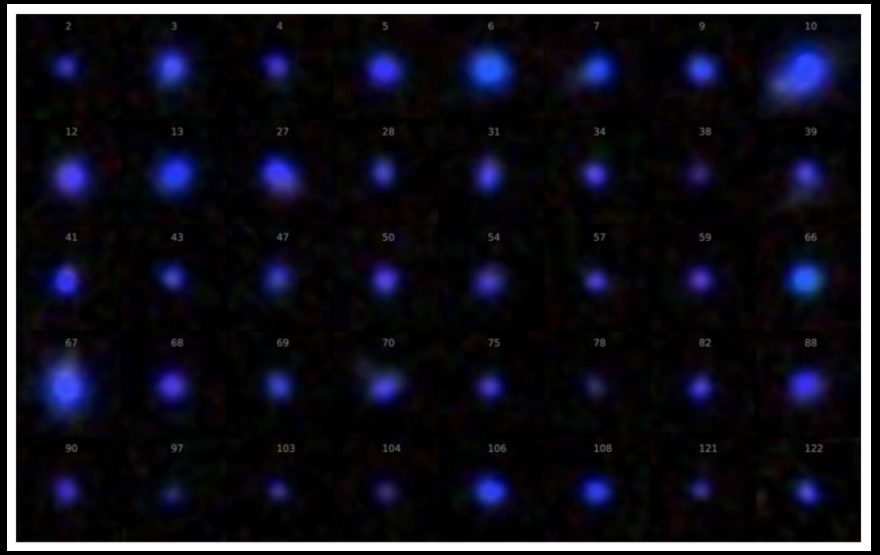
The First Confirmed Dual AGN within a GP System



K. Kouroumpatzakis, …, M.Gupta, … et al. 2026 (submitted to nature comm.)

Blueberry Galaxies

- $0 < z \leq 0.1$
- Compact dwarf starburst galaxies with even higher SFR ($> \sim 10\ M_{\odot}\ yr^{-1}$) lowest masses and metallicities of starburst galaxies
- Very high ionization
- X-ray weak



Yang et al. 2017

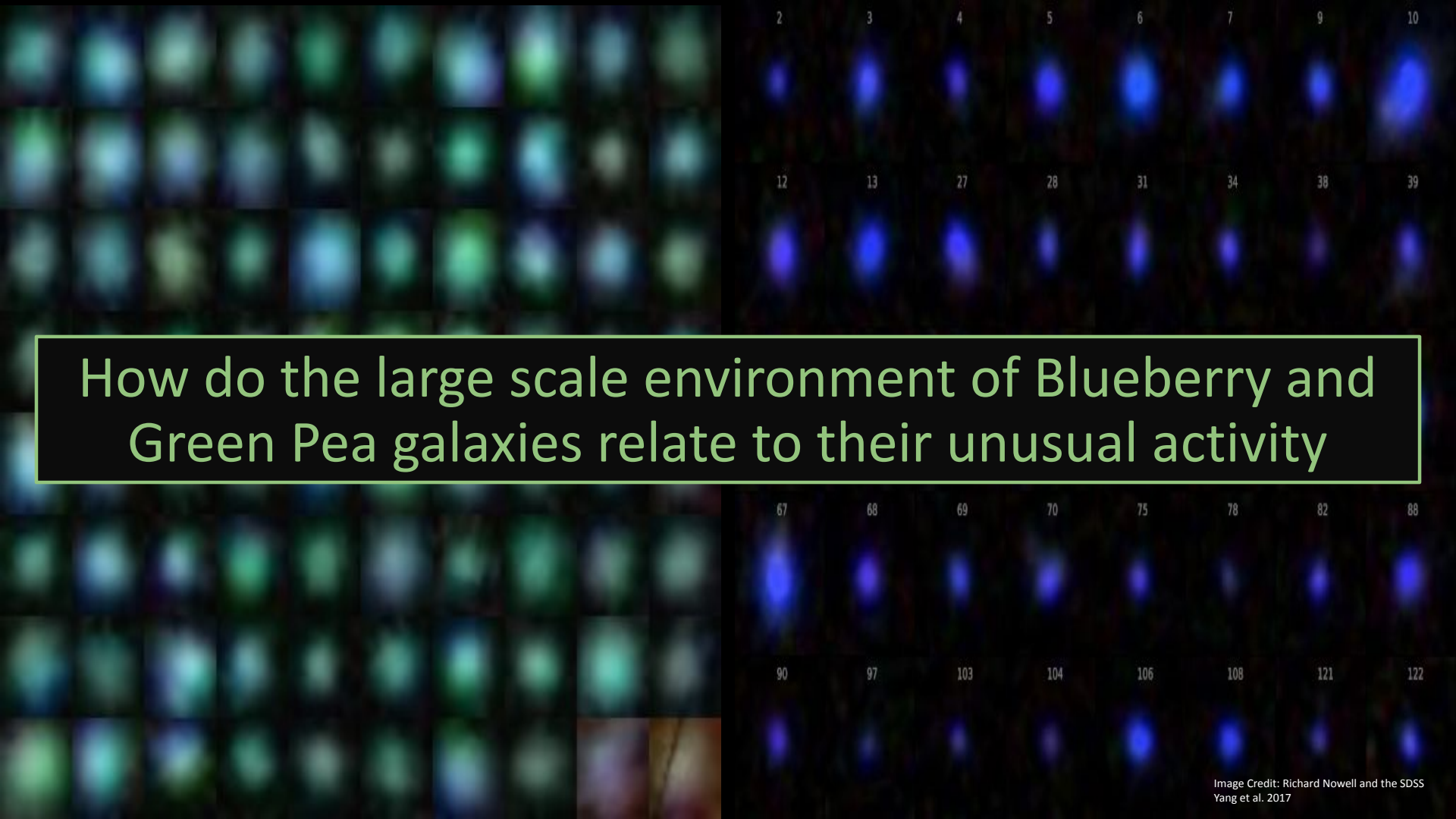


Image Credit: Richard Nowell and the SDSS
Yang et al. 2017

Star formation scenarios

Category	Mechanism	Example Environment
Internal	Gravitational instability	Disks, molecular clouds
	Cloud–cloud collisions	Spiral arms
	Spiral density waves	Grand-design spirals
	Bar inflows	Barred galaxies
External	Galaxy mergers	Interacting pairs
	Ram pressure	Cluster galaxies
	Cosmological accretion	Early or dwarf galaxies
Feedback	SN shocks, H II expansion	Star-forming regions
Exotic	AGN jets, radiation	Radio galaxies

NGC 4038 and NGC 4039 HST

galaxy UGC 5101 HST

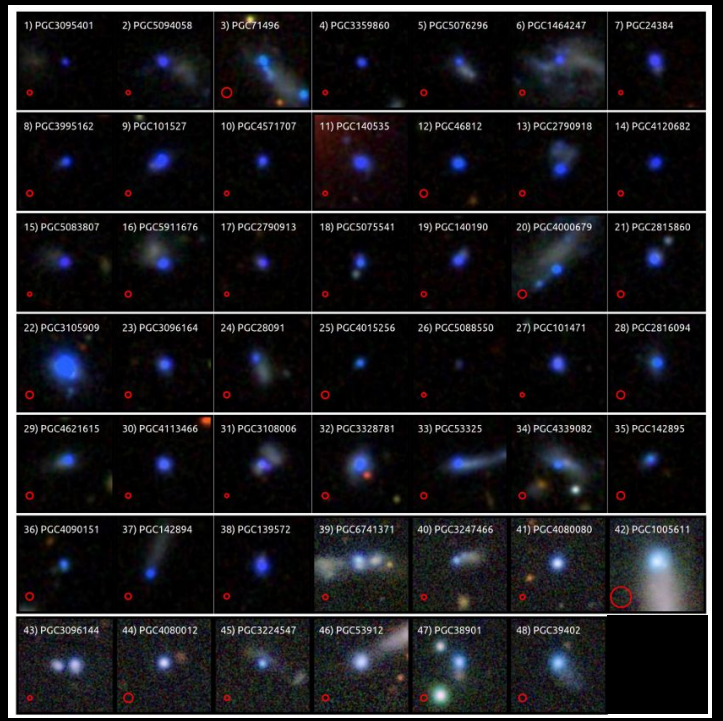
Green Pea Sample

- 339 GPs selected at redshifts $0.1 < z \leq 0.33$ from:
  - Cardamone et al. (2009) - 80
  - Keel et al. (2022) - 19
  - Additional criteria - 240

Credit: Richard Nowell and the SDSS

Blueberry Sample

- 56 BBs selected at redshifts z < 0.1 from:
  - Yang et al. (2017) - 35
  - Kouroumpatzakis et al. (2024) - 21

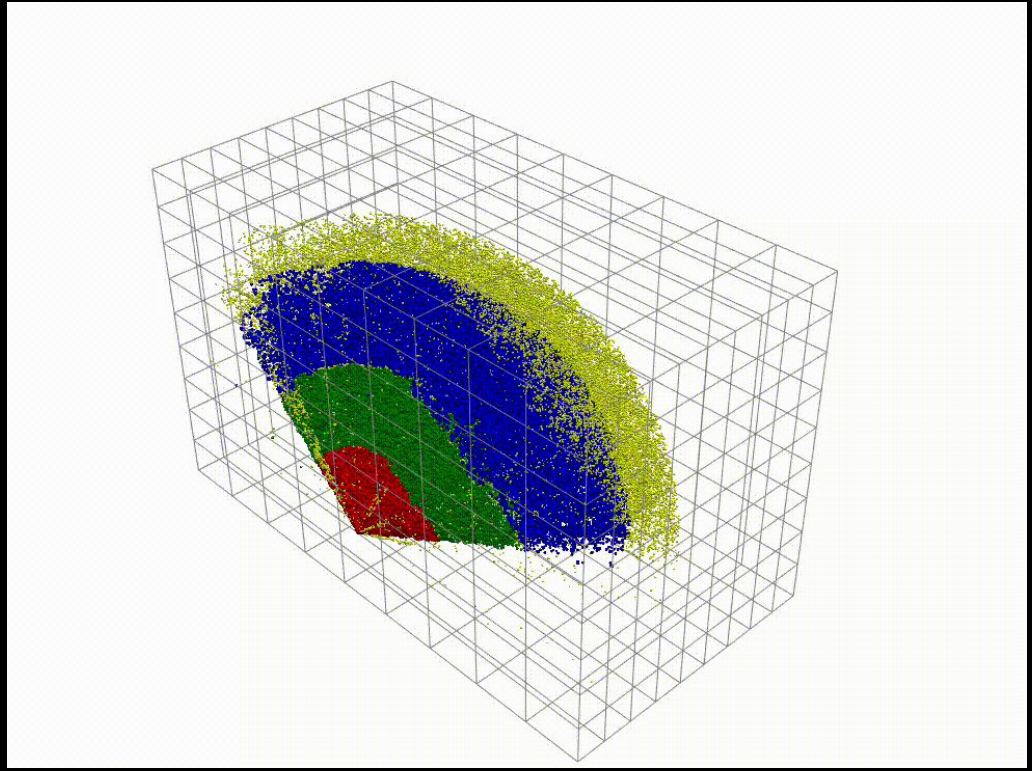


credit: Kouroumpatzakis et al. (2024)

SDSS Parent Sample

- Clustering properties of GPs & BBs vs SDSS MPA-JHU DR8 catalogue

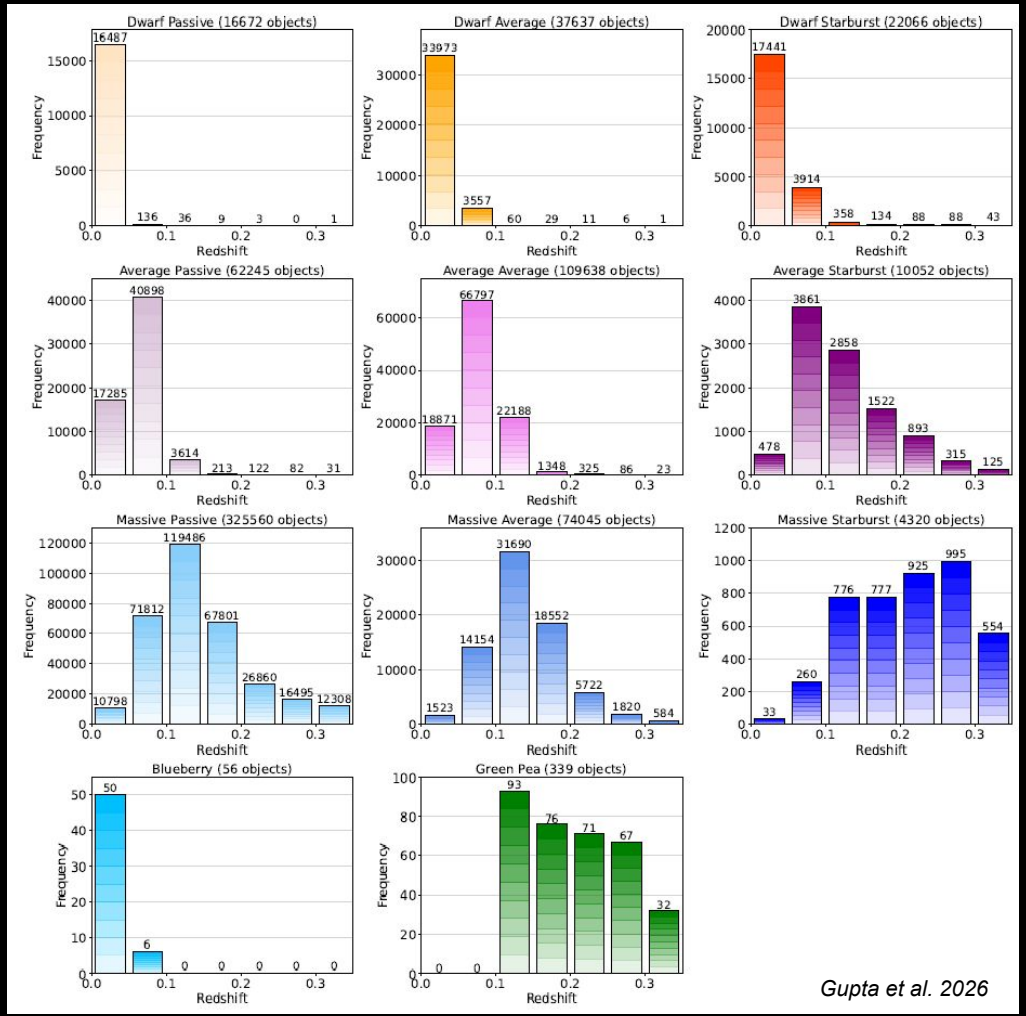
- 1068446 objects in 3 redshift ranges:
  - $0 < z < 0.1$
  - $0.1 < z \leq 0.2$
  - $0.2 < z \leq 0.33$



Gupta et al. 2026

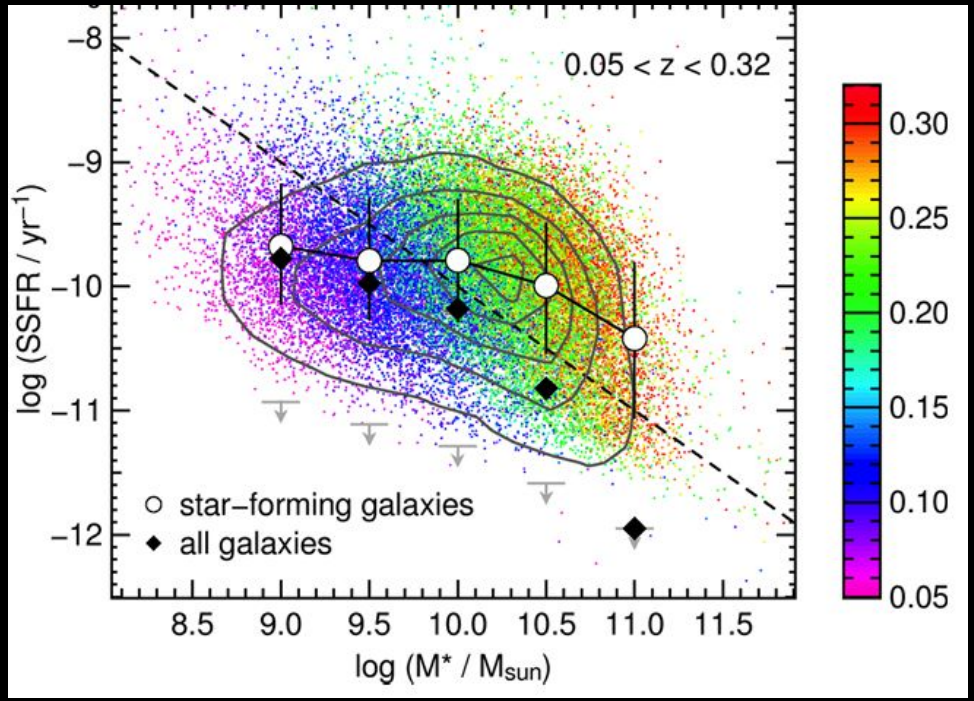
Log(sSFR/yr) / Log($M_\star/M_\odot$)	Passive ≤ -10.5	Normal -10.5 < log(sSFR/yr) < -9.5	Starburst ≥-9.5
Dwarf ≤ 9.5	16672	37637	22066
Average (9.5 < log($M_\star/M_\odot$) < 10.5)	62245	109638	10053
Massive ≥ 10.5	325560	74045	4320

The sample

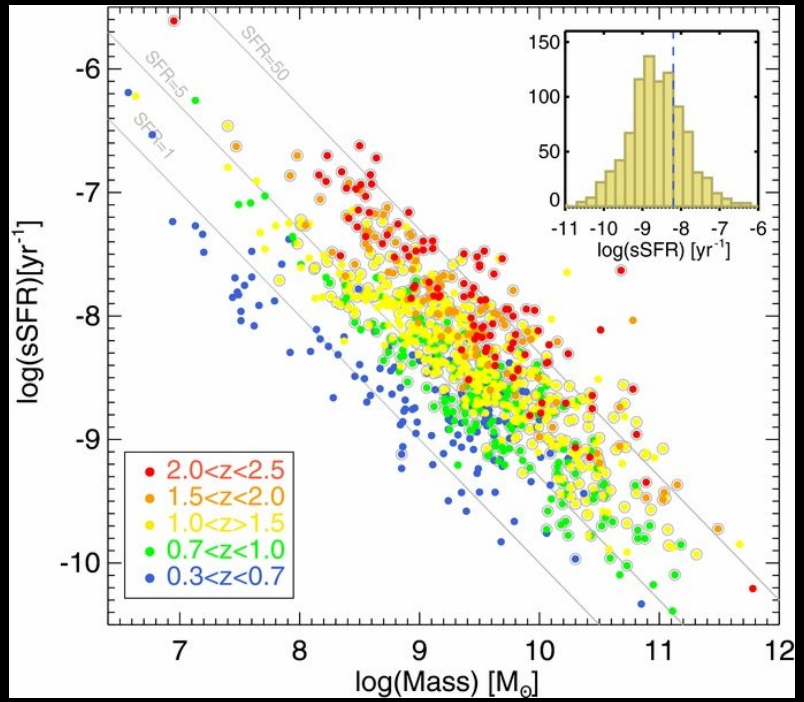


Gupta et al. 2026

Mass vs Star Formation rate

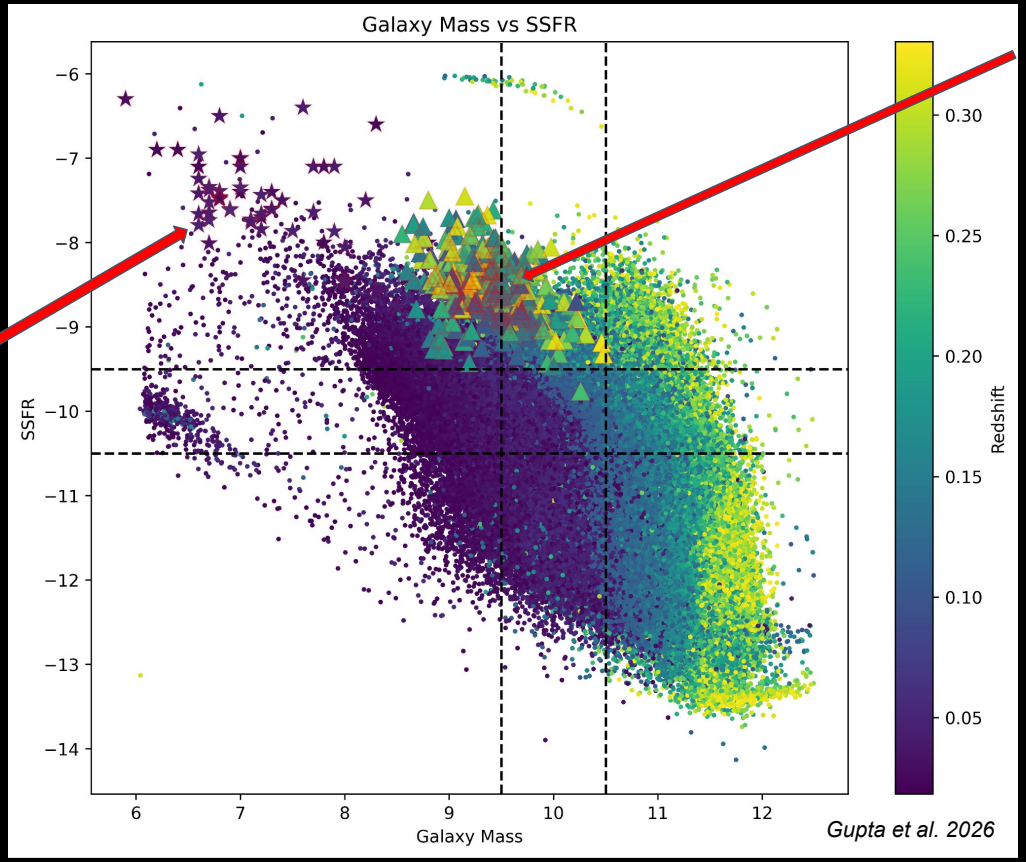


Bauer et al. (2013)



Atek et al. (2014)

Mass vs Star Formation rate

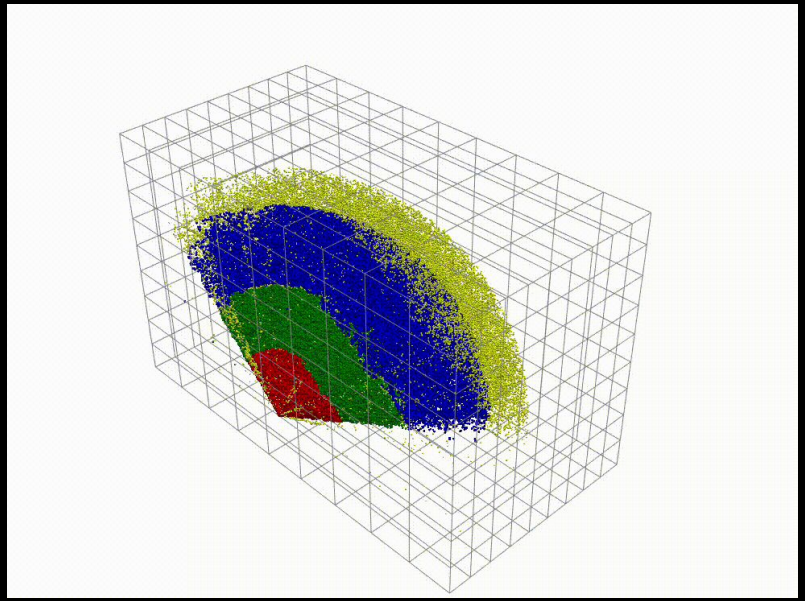


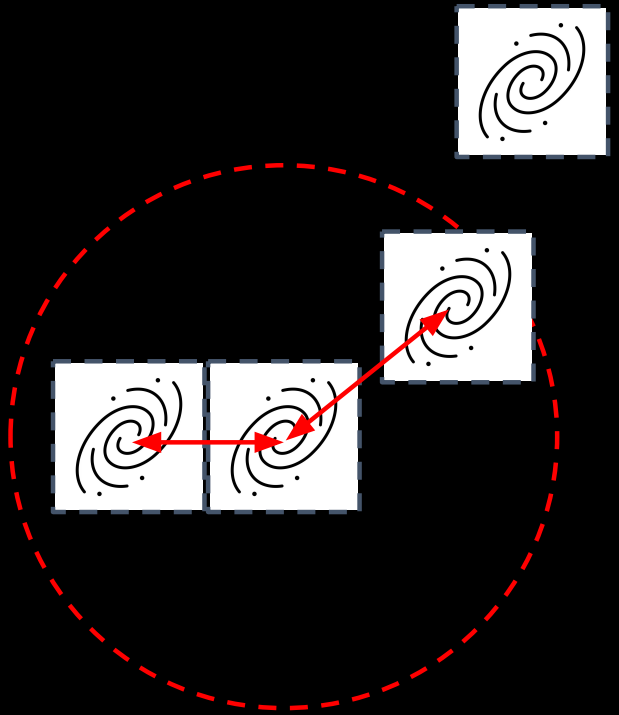
Green Peas

Blueberries

Study of clustering

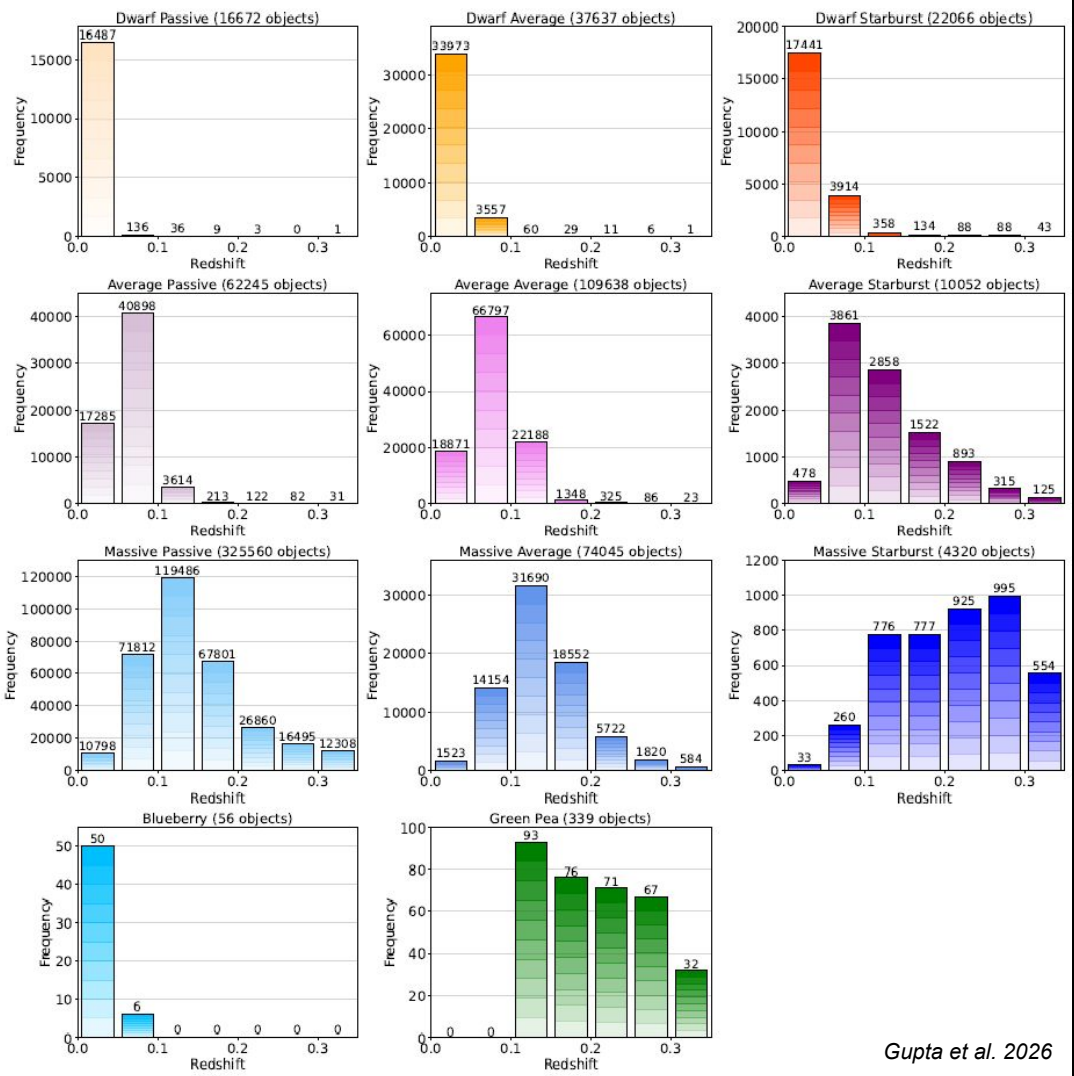
Number of neighbors in 5 Mpc radius as a proxy for environmental density





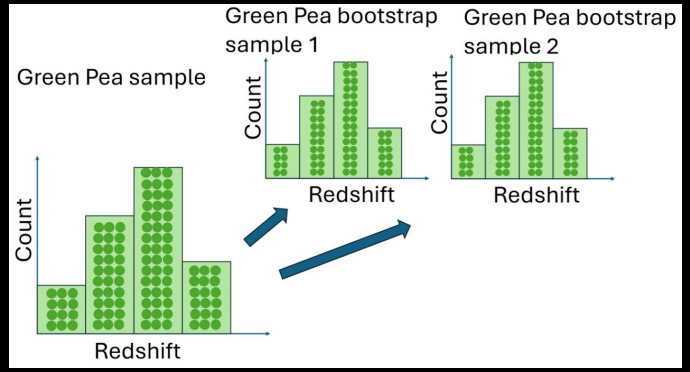
Selection Bias

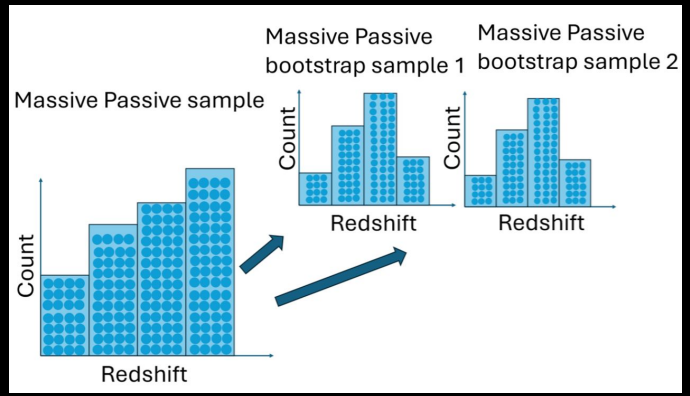
- GP and BB samples < parent sample; different z distributions
- To avoid biases due to selection effects: Pair-matching
- To improve statistical significance of the clustering results: Bootstrapping

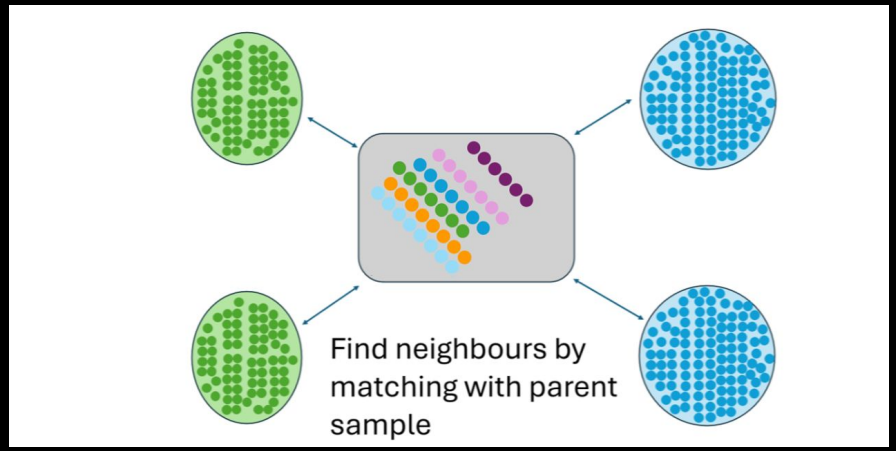


Gupta et al. 2026

Pair-matching & Bootstrapping



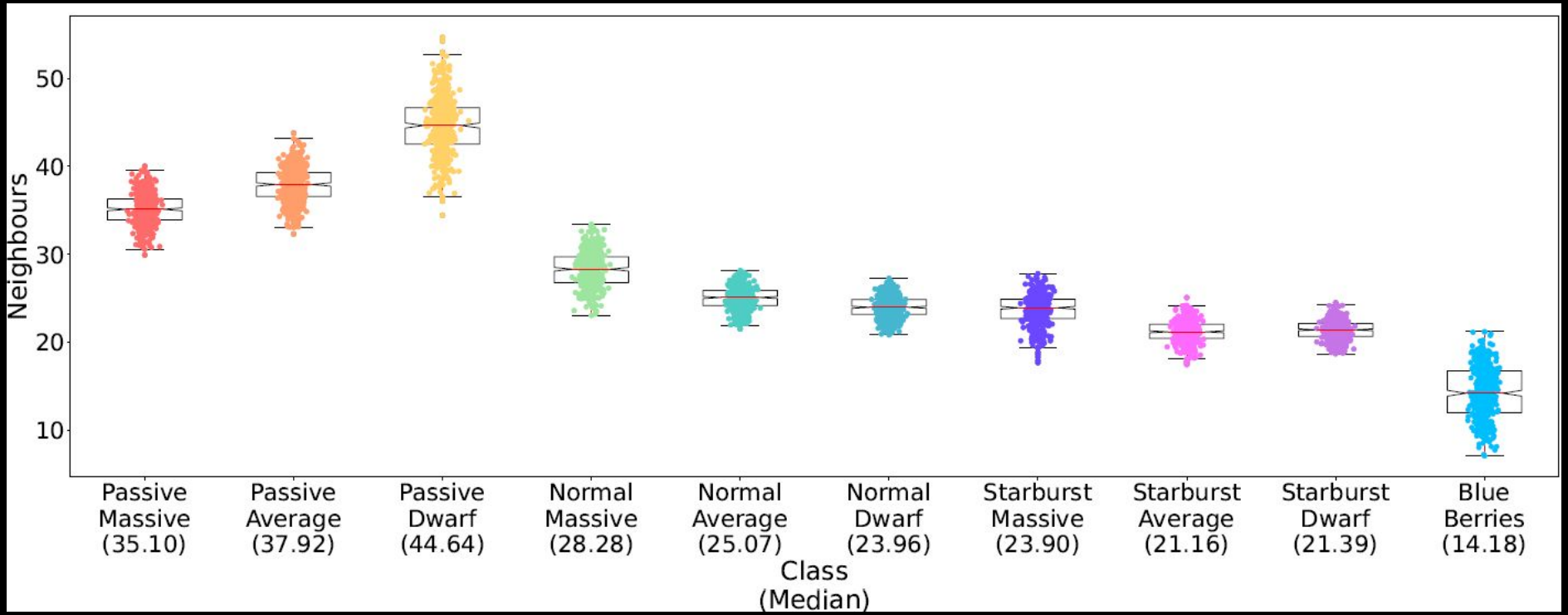




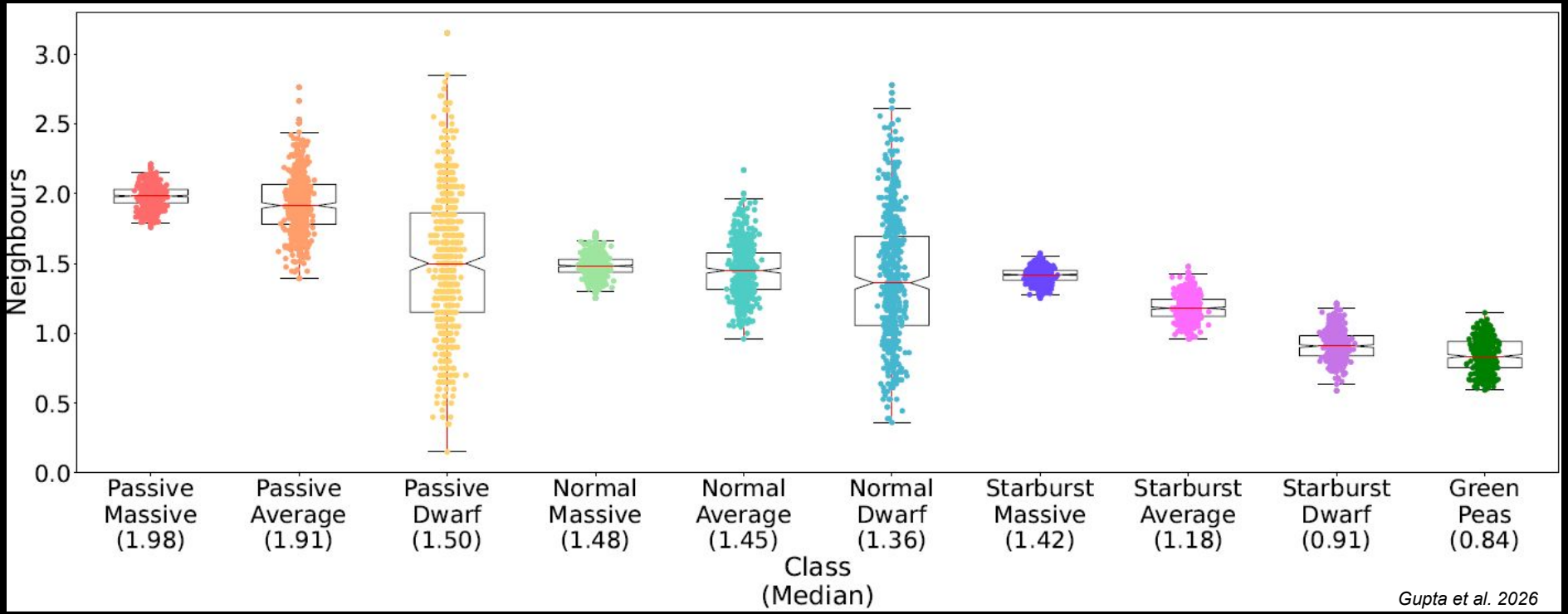
Statistical significance improved - 500 Subsamples
Eliminates biases - Similar z distribution

Gupta et al. 2026

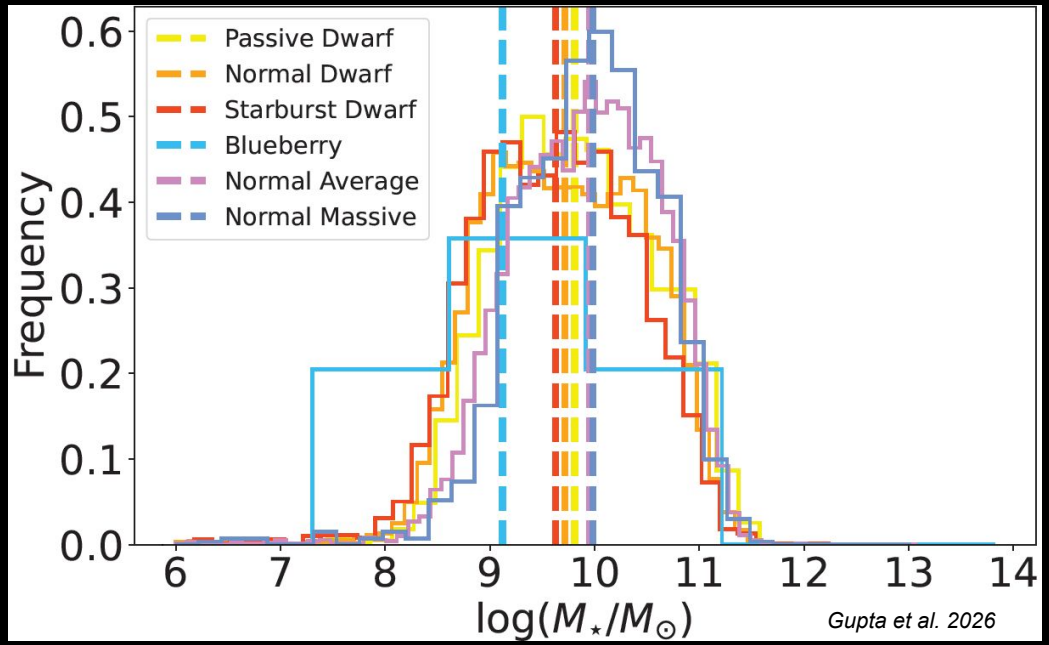
Clustering Results $0 < z \leq 0.1$



Clustering Results $0.1 < z \leq 0.33$

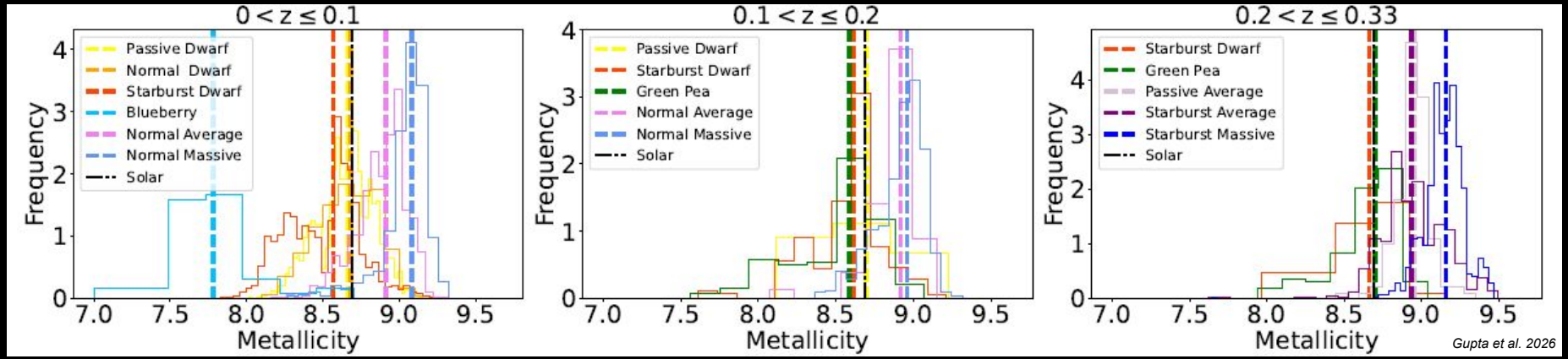


Mass of Nearest Neighbour



Massive neighbours quench star formation of dwarf galaxies due to rapid gas stripping (e.g. Gunn & Gott 1972)

Metallicity

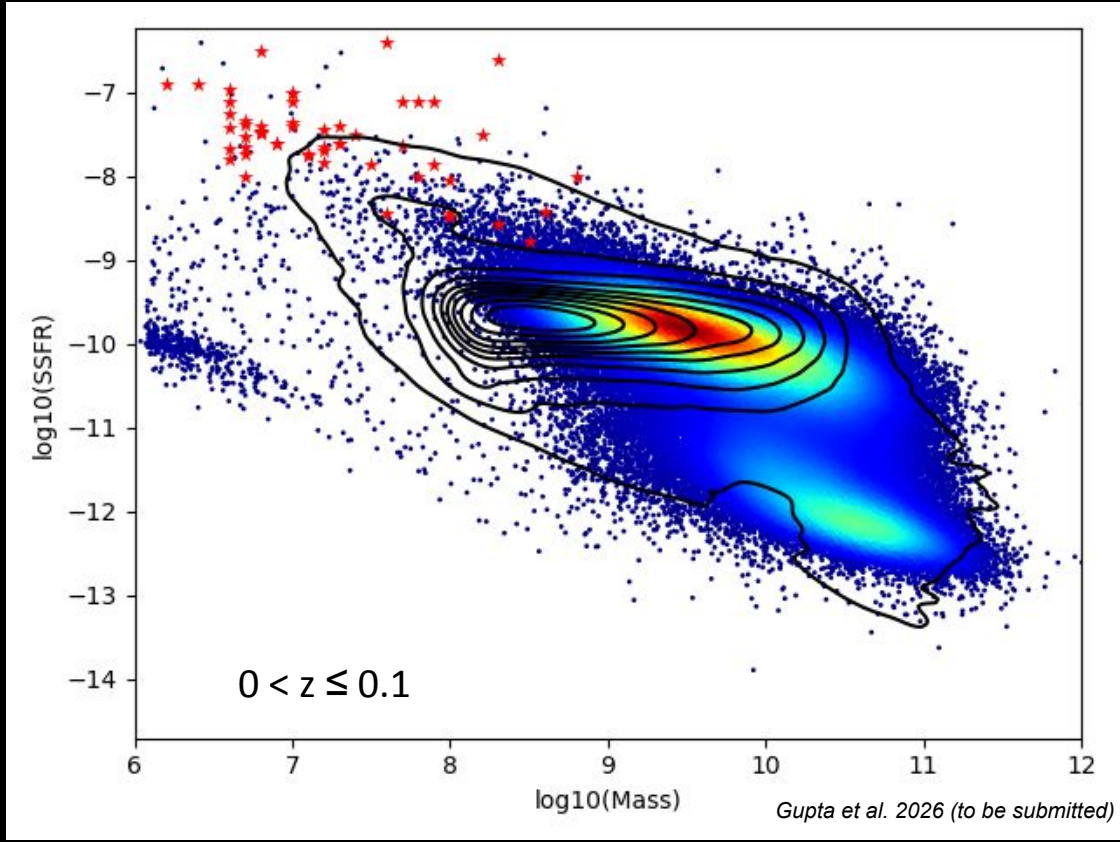


- Absence of past substantially long SF cycles of moderate intensity in the past
- Low levels of SF for most of its lifetime, and only recent strong starbursts

Comparison with Simulations

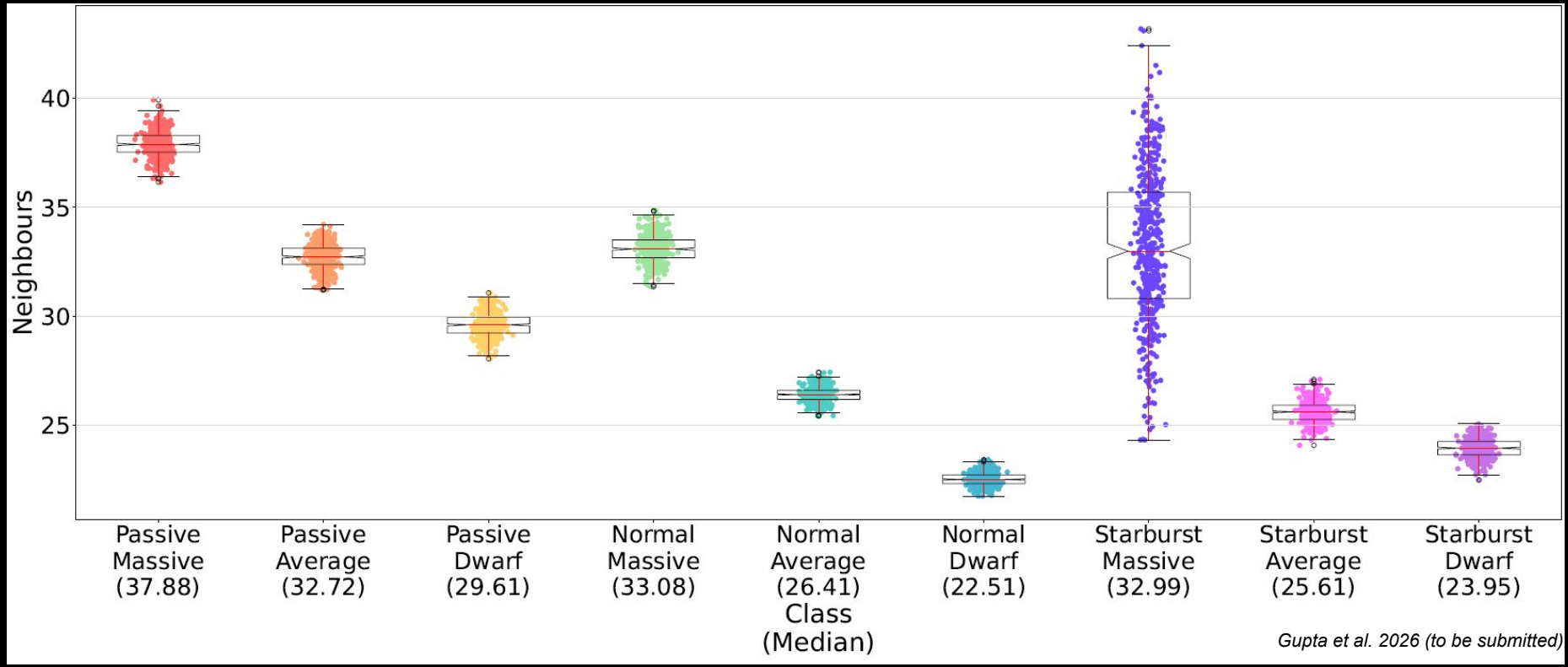
Comparison with Simulations

- Illustris-TNG cosmological simulation (TNG300)
- Photometric cut-offs with SDSS sensitivity
- 519011 galaxies.
- Comparison shows broad agreement with observational sample.

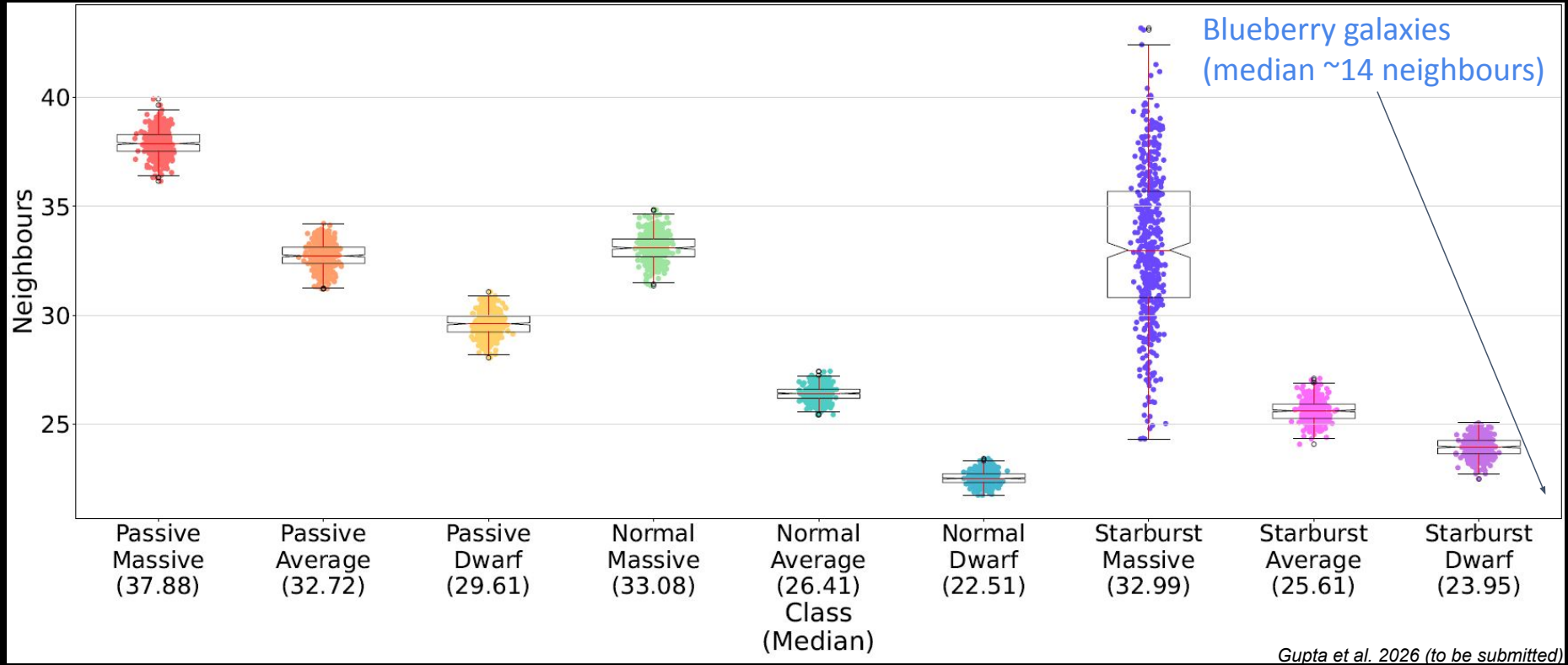


Gupta et al. 2026 (to be submitted)

Comparison with Simulations



Comparison with Simulations



Gupta et al. 2026 (to be submitted)

Key Results

- Galaxy clustering depends on star-formation,
  - Passive galaxies more clustered than Starburst.
  - GPs and BBs lying at the extreme end of this relation - lowest neighbour counts.

- BBs have lower-mass nearest neighbours than other classes of dwarf galaxies.

- The comparison with simulation shows broad agreement with observational trends.

Conclusions

- GPs and BBs predominantly reside in isolated, low-density environments, suggesting that their intense starbursts are unlikely to be triggered by common environmental processes such as mergers or starburst cycles.

- Their low metallicities and weak clustering instead support scenarios in which recent starbursts are driven by internal processes or pristine gas accretion, reinforcing their role as nearby analogs of young, low-mass galaxies in the early Universe.

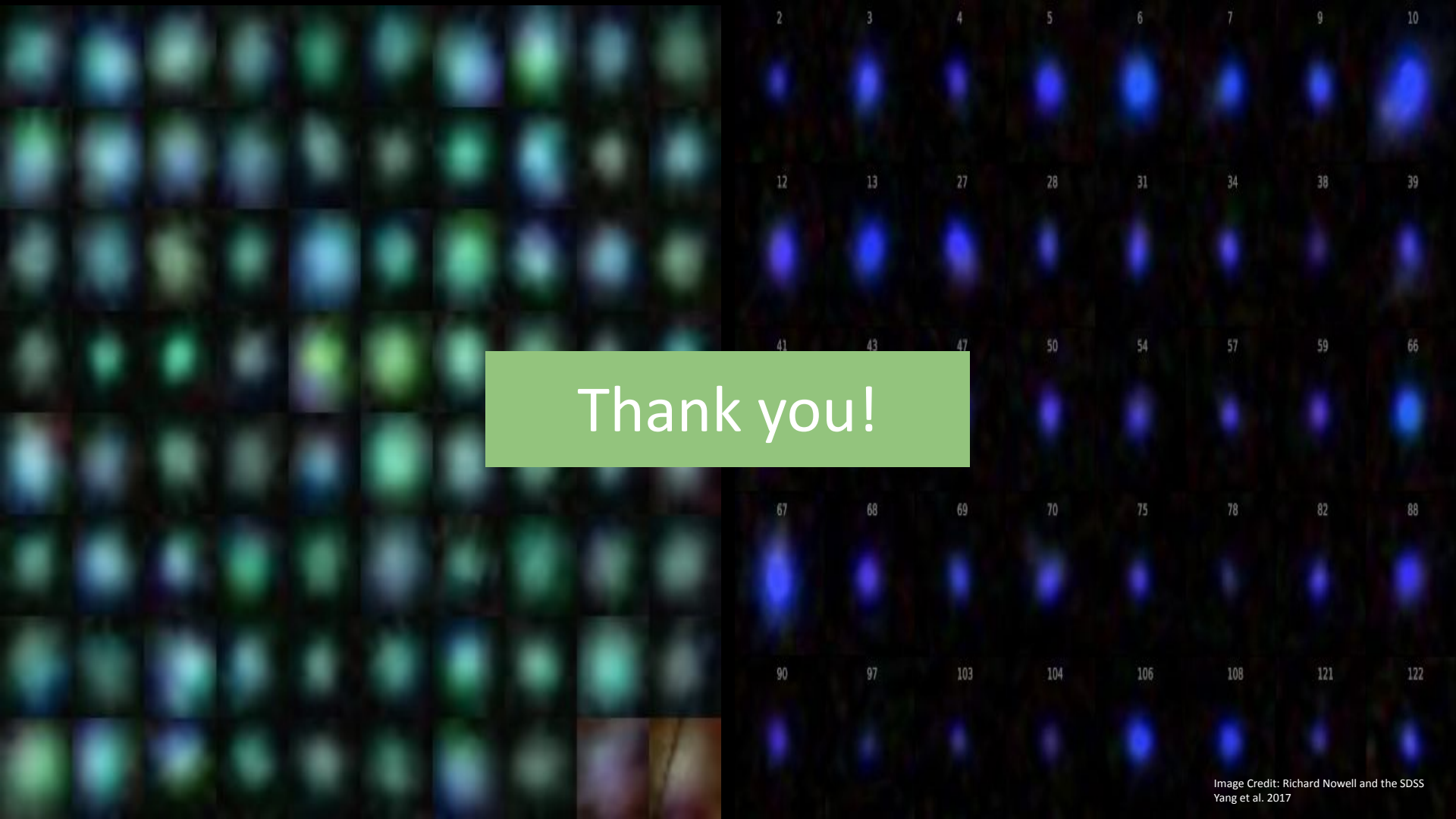


Image Credit: Richard Nowell and the SDSS
Yang et al. 2017