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# Galaxy morphology from $z \sim 6$ through the lens of JWST★

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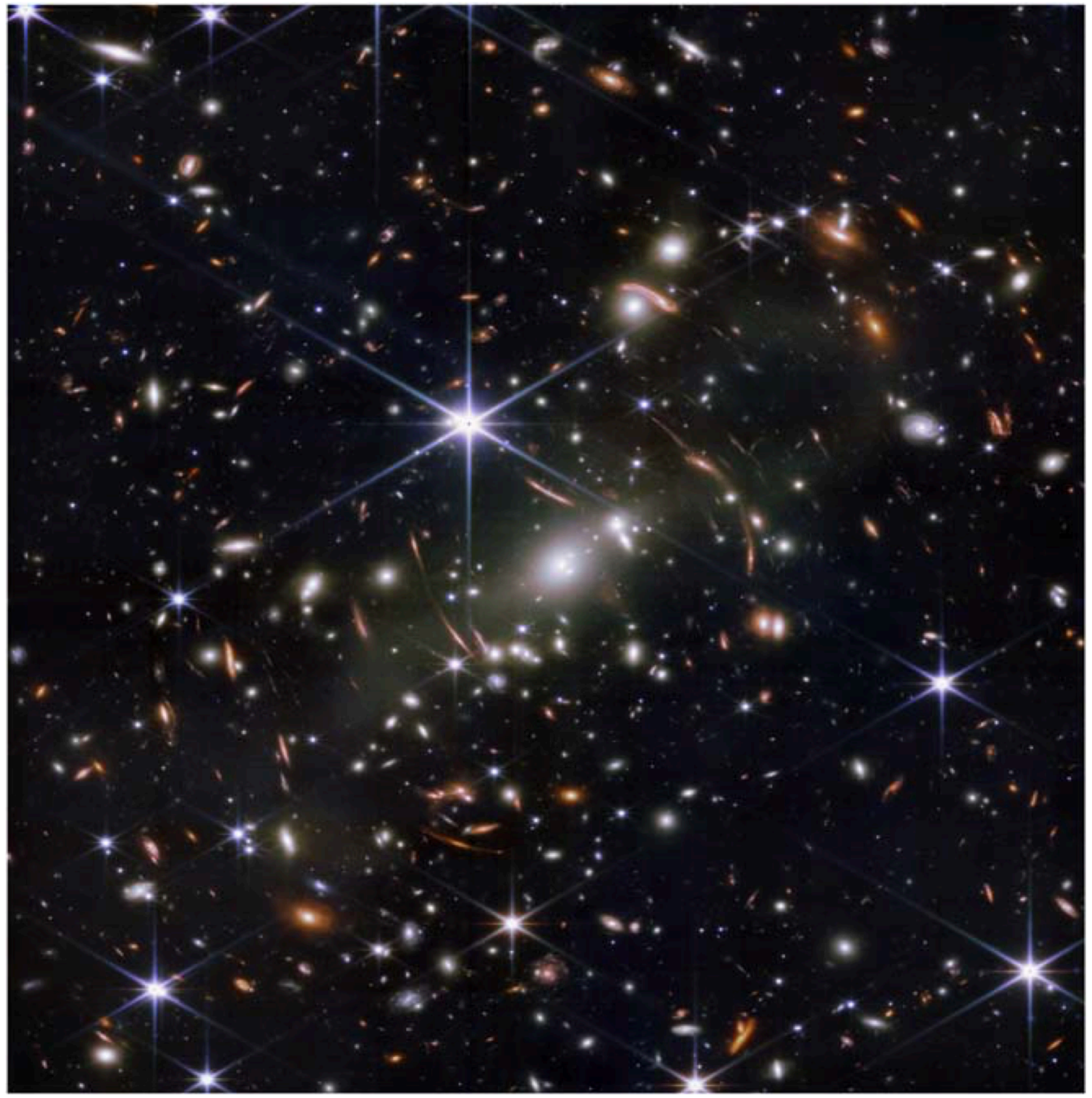
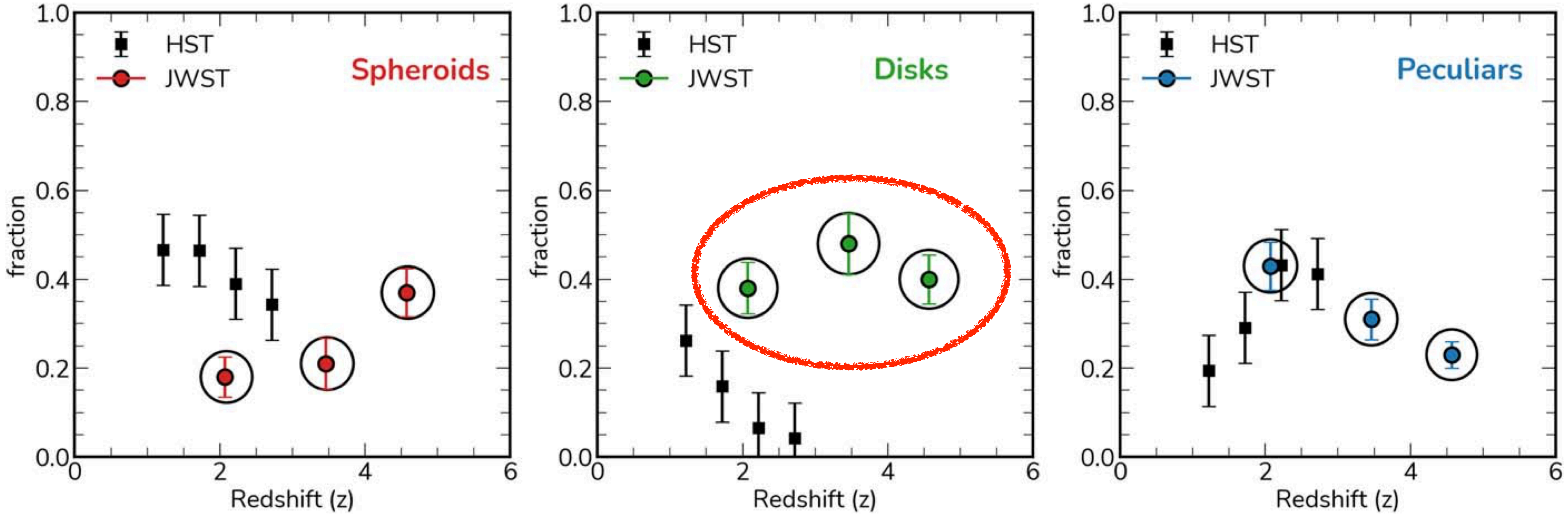


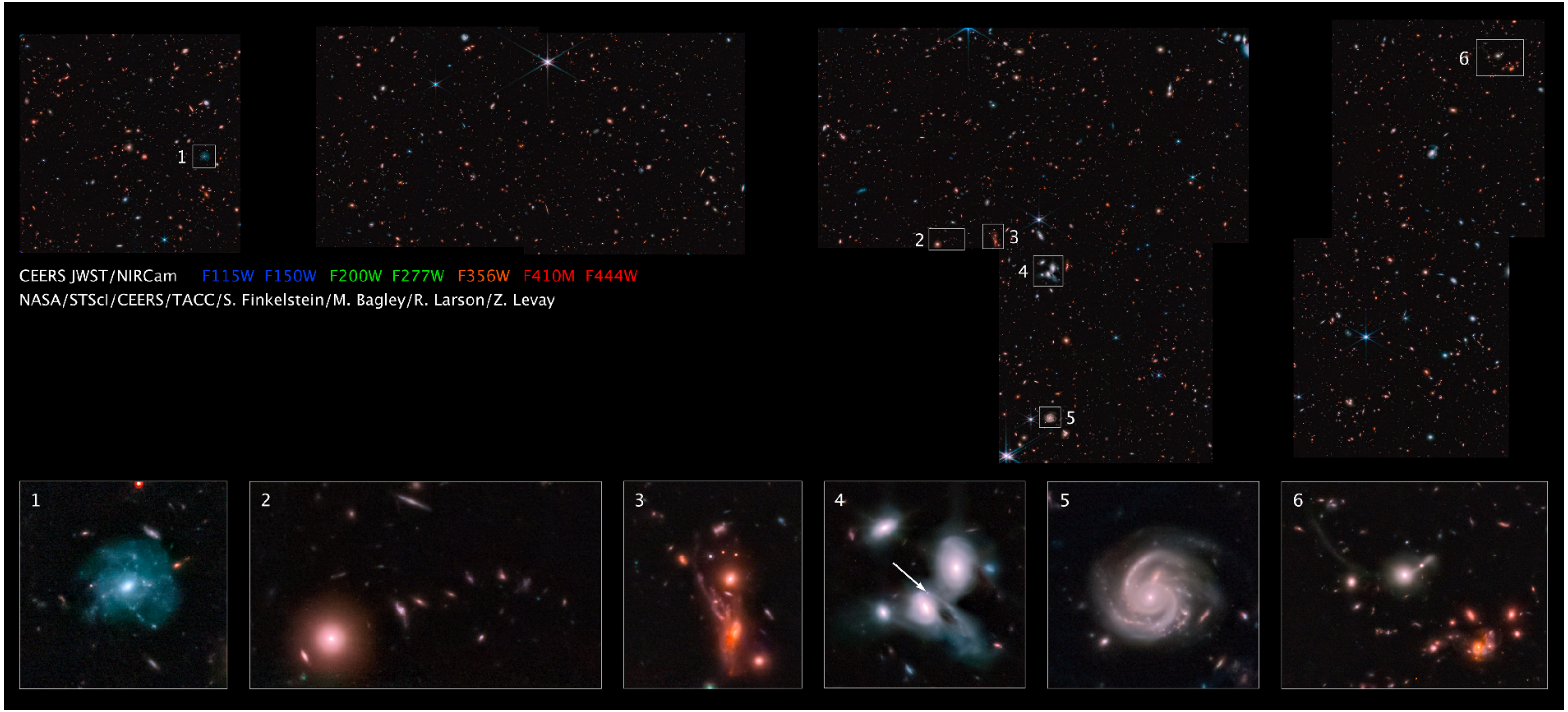



Ferreira et al (2022) found that disk galaxies are quite common at z ~ 3–6, where they make up ~50% of the galaxy population, which is over 10 times as high as what was previously thought to be the case with HST observations.

JWST color image of SMACS 0723

In this work, the authors selected 23,674 galaxies from JWST/CEERS survey:

- Four filters: F150W, F200W, F356W, and F444W
- Photo-zs, physical parameters (e.g. stellar mass), and Sersic parameters

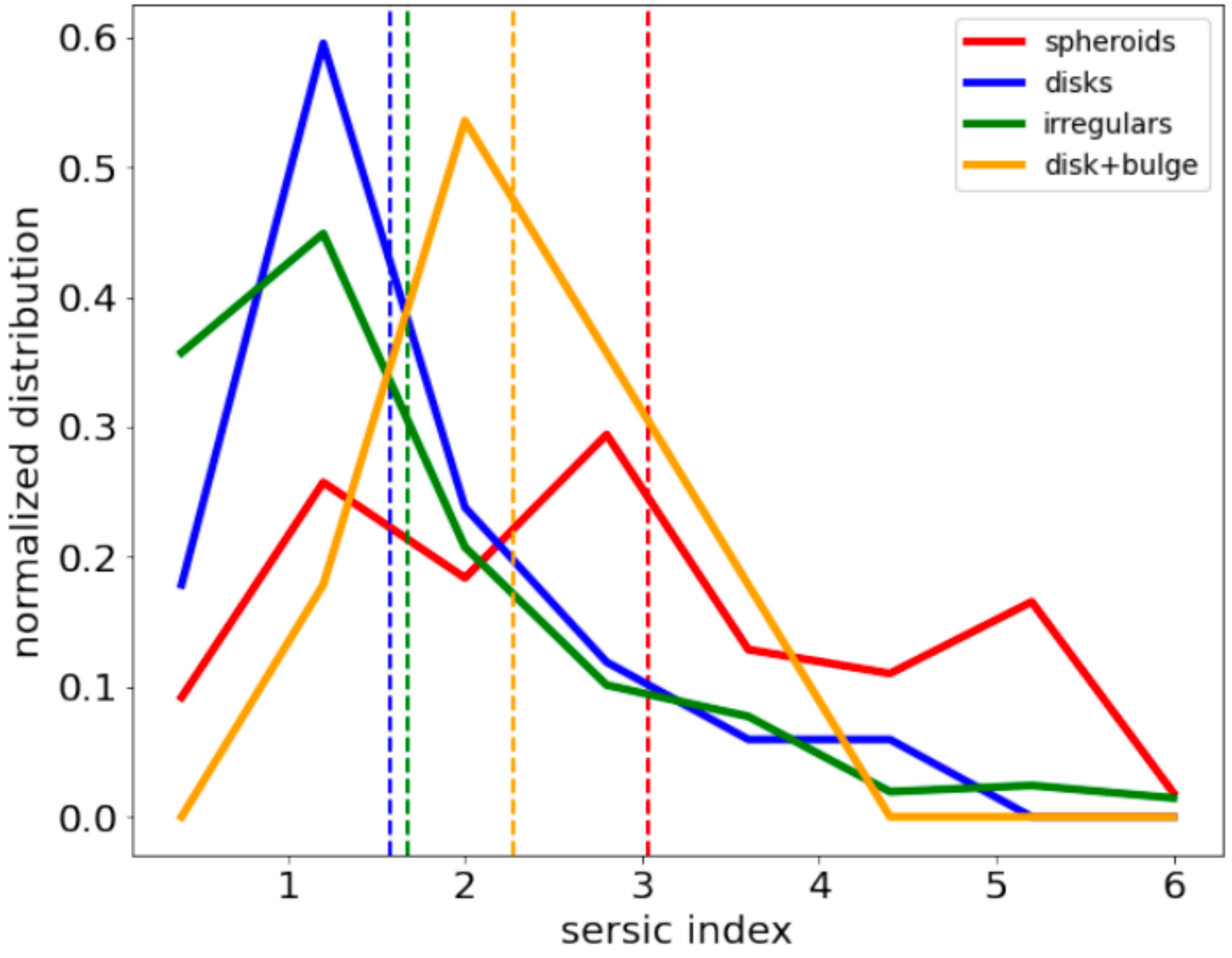


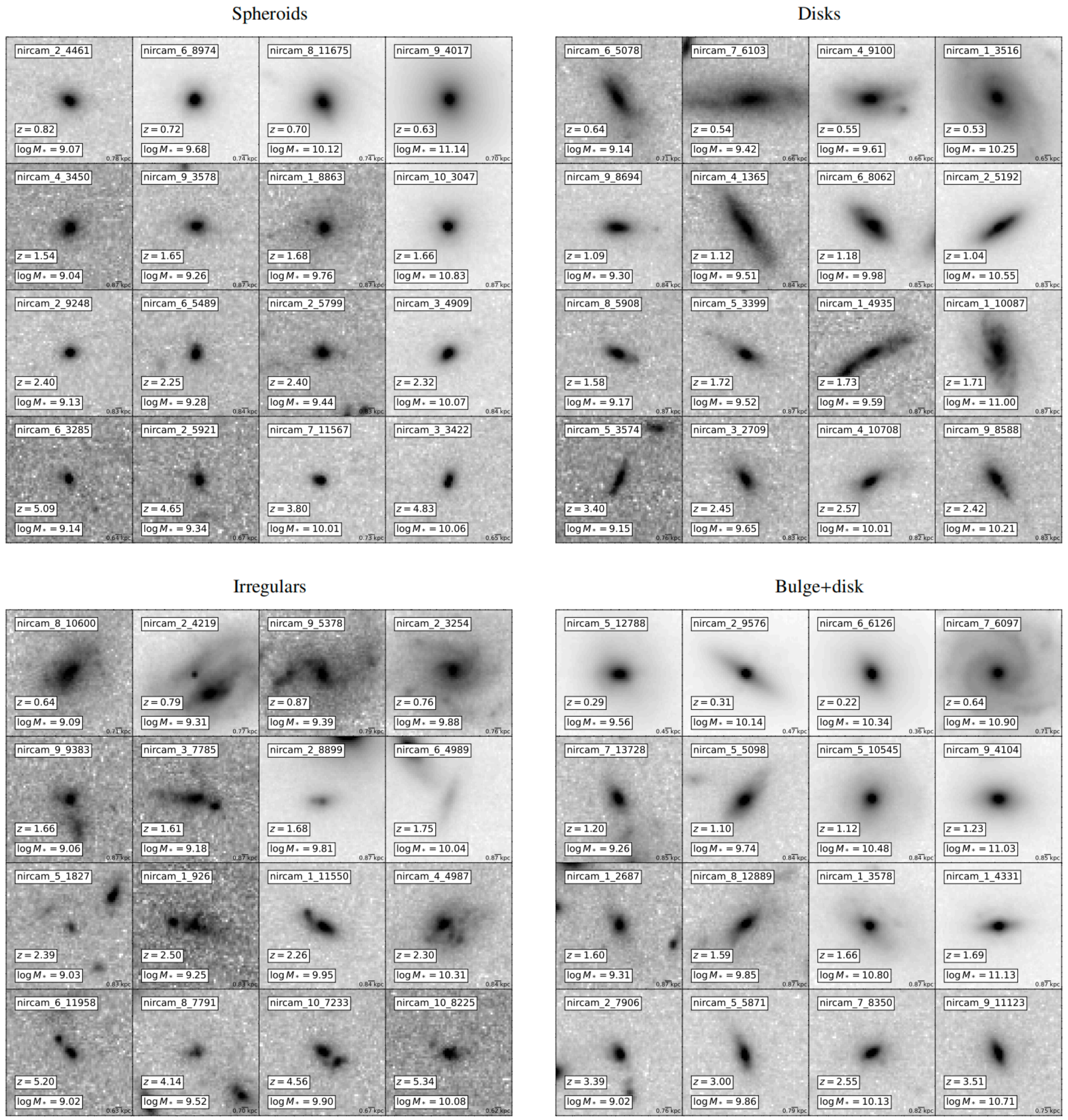
Galaxy classifications by neural network with training sample from HST/CANDELS F160W images:

- Four classes: (1) spheroids/pure bulge; (2) disks; (3) bulge+disk; (4) irregulars/disturbed/peculiar
- Further combinations:

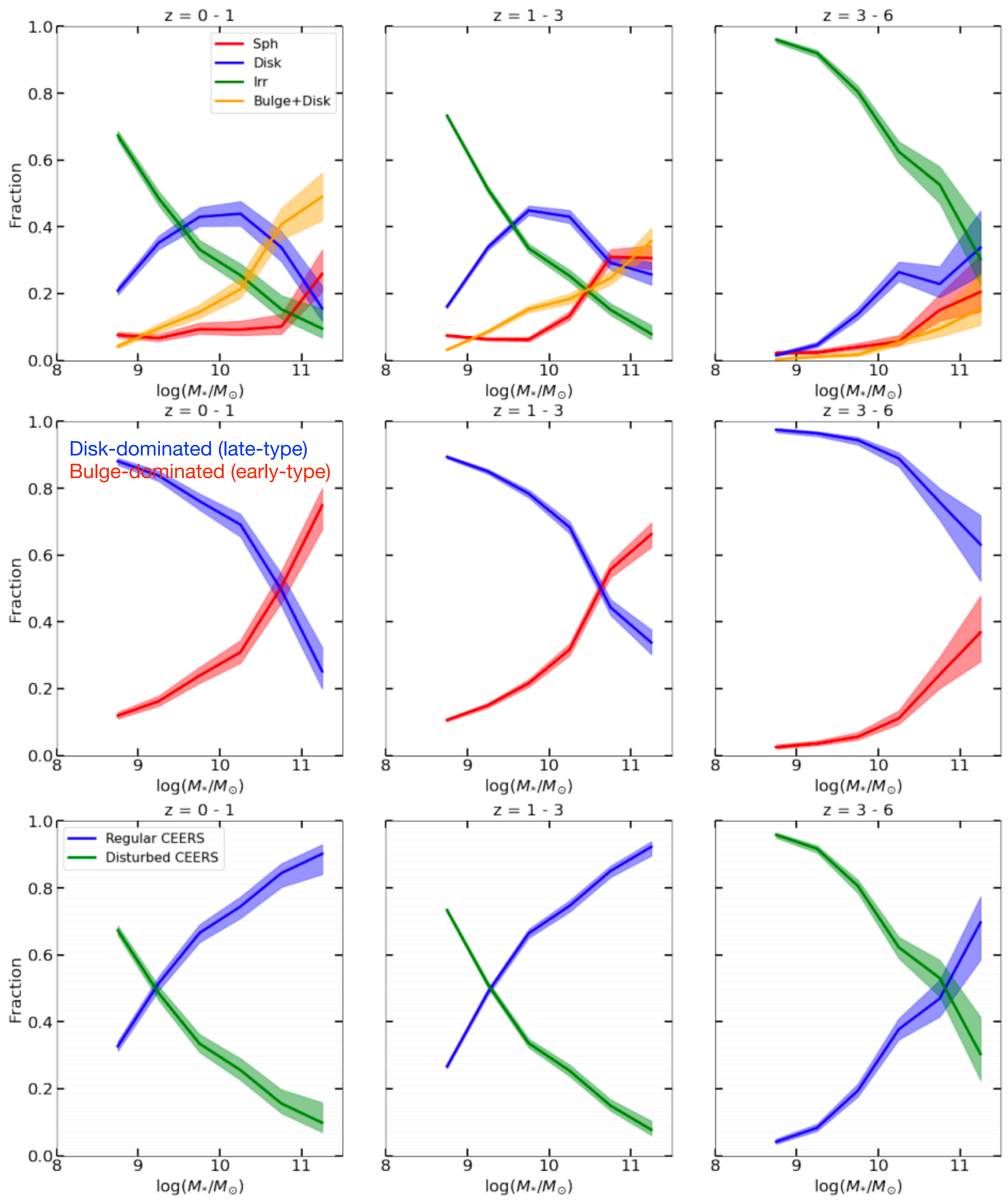
A. Early-type galaxies: class (1) + class (3)

B. Late-type galaxies: class (2) + class (4)



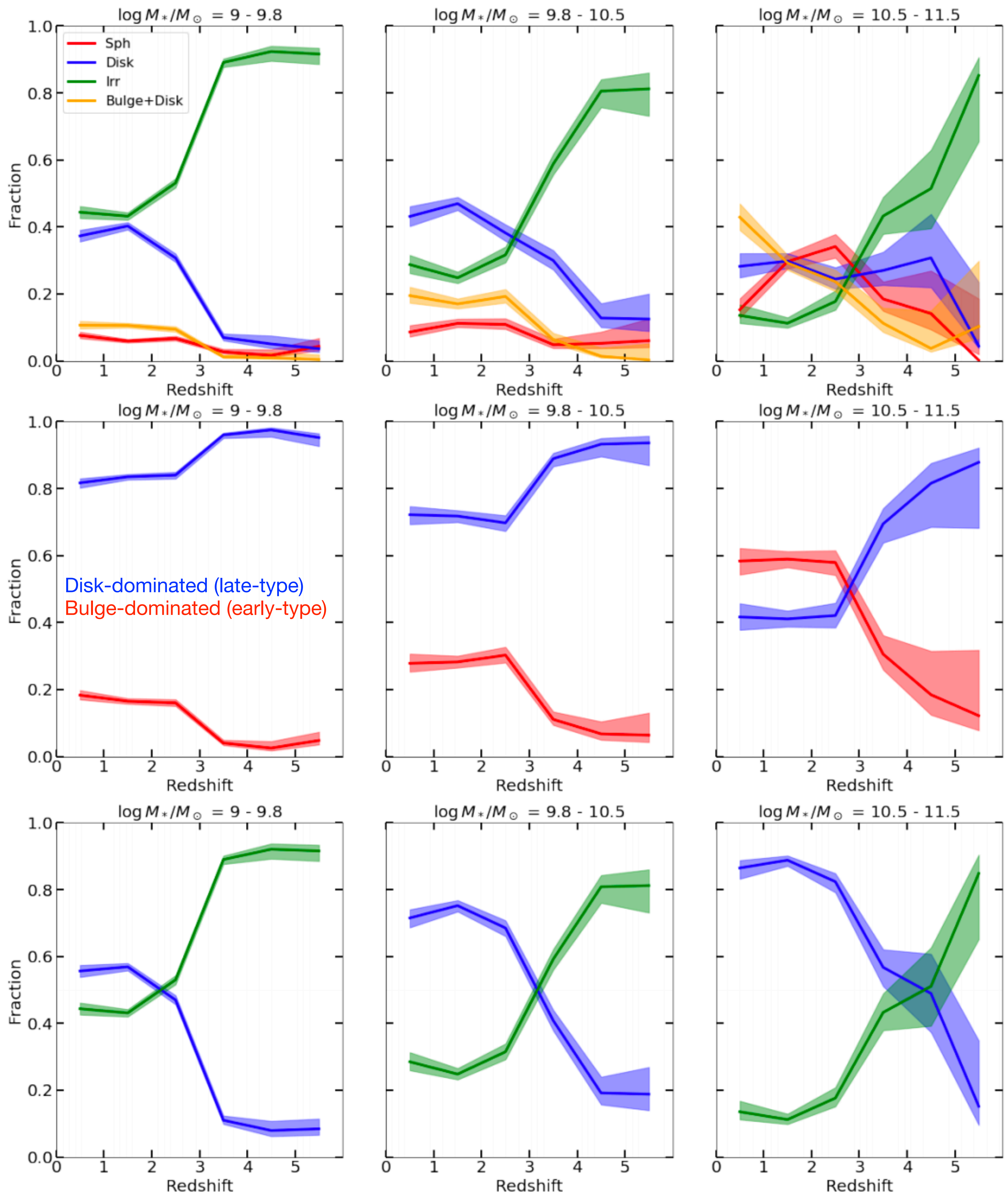




Example of galaxies observed with F200W filter




Evolution of the fractions of different morphological types in rest-frame ~0.8-1$\mu$m as a function of stellar mass and redshift. Filters $F200W$, $F356W$ and $F444W$ are used to infer galaxy morphology in the redshift bins $0 < z < 1$, $1 < z < 3$, and $3 < z < 6$, respectively.

- The fraction of bulge-dominated galaxies (early-type) shows a strong correlation with stellar mass. The behavior is surprisingly similar at all redshifts probed, suggesting similar physical processes for bulge formation at all epochs.
- Early-type galaxies start dominating the massive end of the galaxy population since $z$~3. While late-type galaxies dominate at all redshifts at lower mass bins.
- The abundance of irregular galaxies is a strong function of stellar mass at all redshifts, with low-mass galaxies being predominantly peculiar.




Evolution of the fractions of different morphological types in rest-frame ~0.8-1$\mu$m as a function of stellar mass and redshift.

- Disk (late-type) galaxies dominate the high-mass end even at $z$~5
- The abundance of irregular galaxies increases with resdshift even when probing the rest-frame NIR. This suggests that, at early epochs, the distribution of stellar mass is also perturbed and that it is not only a consequence of the presence of bright star-forming regions emitting in the UV.

# Summary

This study indicates a complex morphological diversity already in place ~1 Gyr after the Big Bang.

- The fraction of bulge-dominated galaxies increases at the high-mass end, even at $z$~5, indicating that the processes of bulge formation in massive galaxies are already in place at these early cosmic epochs.
- The fraction of peculiar galaxies also increases with redshift, even in the NIR rest-frame, suggesting that the stellar mass distribution is more disturbed at high redshift.
- The high-mass end of the galaxy distribution ($\log M_\star/M_\odot > 10.5$) is dominated by undisturbed disk-like morphologies even at $z$~5, indicating that disk formation may be in place at very early epochs.

# Thank You