Dust-aware synthetic observations of high-z galaxies: colour expectations and comparison to JWST galaxy surveys

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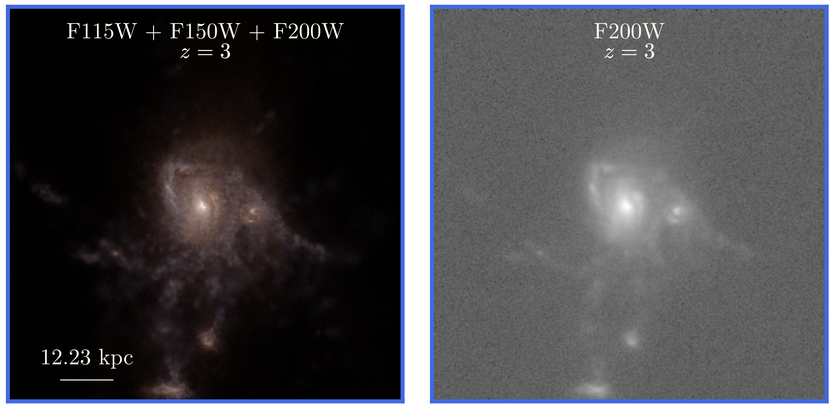
Abstract

We use the TNG50 cosmological simulation and 3D radiative transfer post-processing to make JWST-like mock photometry for galaxies at $3 \leqslant z \leqslant 6$ with $\log_{10}(M_*/\mathrm{M}_\odot) \geqslant 8.5$. Our goals are to evaluate the accuracy of SED fitting tools and to assess the realism of the IllustrisTNG model by comparing to real JWST observations. Applying SED fitting to these mocks, we recover photometric redshifts robustly at $z \leqslant 5$ (>90 per cent within ± 0.2 of the true redshift), with noticeable worse performance at $z = 6$. Stellar masses are typically recovered within a factor of two, but show a systematic underestimation, especially at $\log_{10}(M_*/\mathrm{M}_\odot) \geqslant 10$. Finally, we find consistency with observations for the observer-frame colours, the SED-inferred UVJ diagram and the mass-dependent quiescent fraction.

(1) Synthetic observations via forward modelling of the TNG50 cosmological simulation

3D RT post-processing with SKIRT

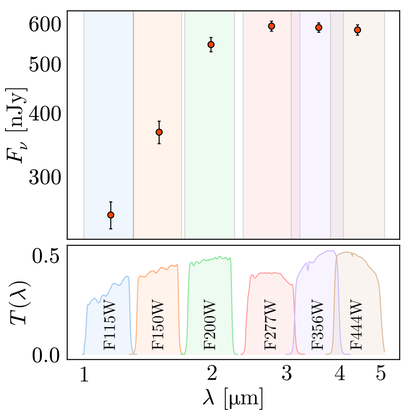
JWST-like realistic synthetic image



- We employed the SKIRT RT code[1] to create broadband JWST-like synthetic images for all TNG50[2] subhalos at $3 \leqslant z \leqslant 6$ with $\log_{10}(M_*/\mathrm{M}_\odot) \geqslant 8.5$.
  - CB19 SSP models[3] for old stars and MAPPINGS-III[4] for young stars.
  - Dust traced by SF gas, assuming a D/M of 0.3 and a Zubko et al. (2004)[5] dust mixture.
- Synthetic data matched to the observational realism of the NGDEEP survey[6].

(2) Inferring physical properties with SED fitting

Realistic broadband SED

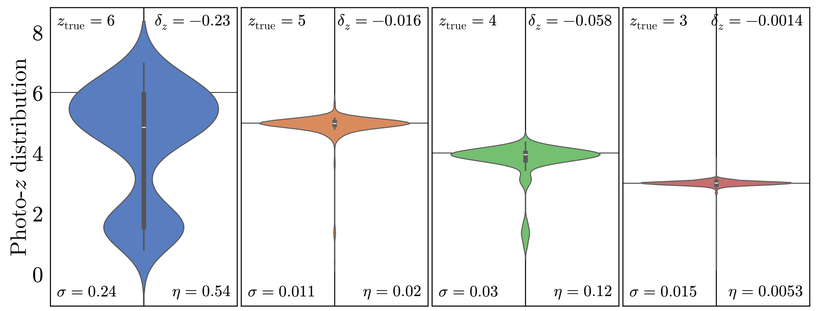


SED fitting

- We used six-point NIRCam photometry ($\lambda_{\mathrm{obs}} \sim 1$ to 5 μm) and fit SEDs with the EAZY[7] and BAGPIPES[8] codes for TNG50 data and observations from NGDEEP and JADES[9].
- The BAGPIPES fiducial run uses a lognormal SFH and a dust attenuation law from Salim et al. (2018)[10].

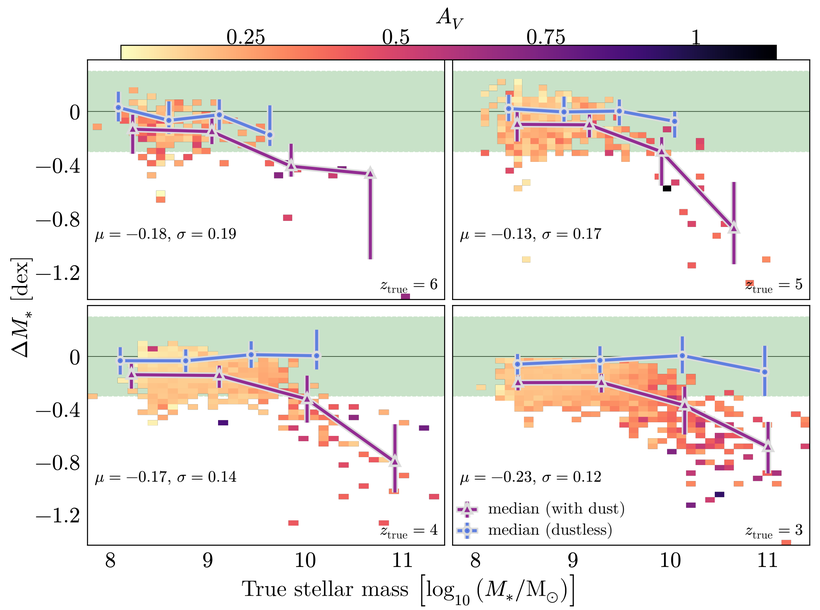
(3) Photo-z and stellar mass can be recovered with six-point photometry

Recovering photo-z at $3 \leqslant z \leqslant 6$



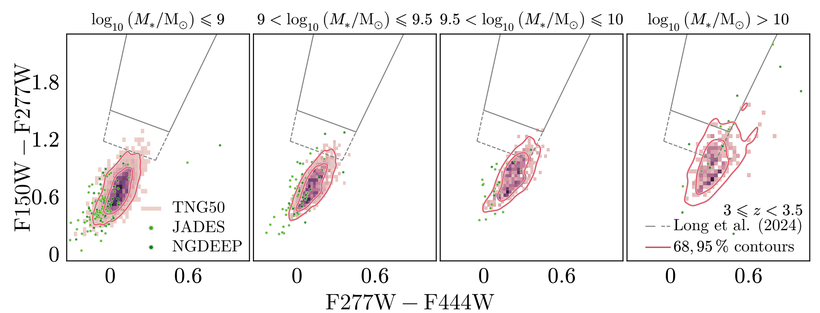
- Photo-z are well recovered at $z \leqslant 5$ (over 90 per cent within ± 0.2), with worse performance at $z = 6$; total outlier rate of ∼6 per cent

Stellar mass recovery at $3 \leqslant z \leqslant 6$

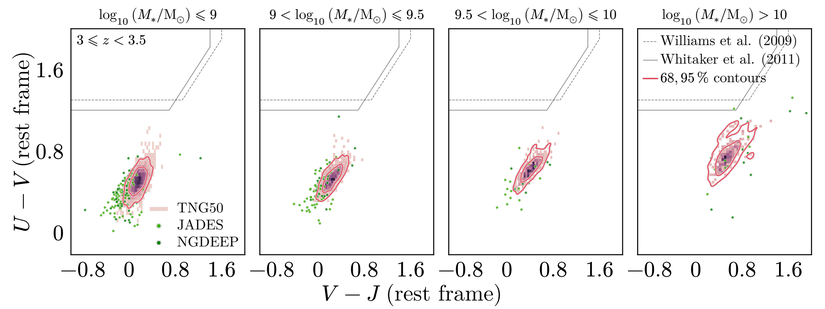


- Stellar masses are typically recovered within a factor of two but show a systematic underestimation, stronger at $\log_{10}(M_*/\mathrm{M}_\odot) \geqslant 10$.
- In the dustless case, the systematics disappear almost entirely, suggesting that the strength of dust attenuation is underestimated in the SED fitting.

(4a) Observer-frame colour expectations: TNG50 vs. JWST observations

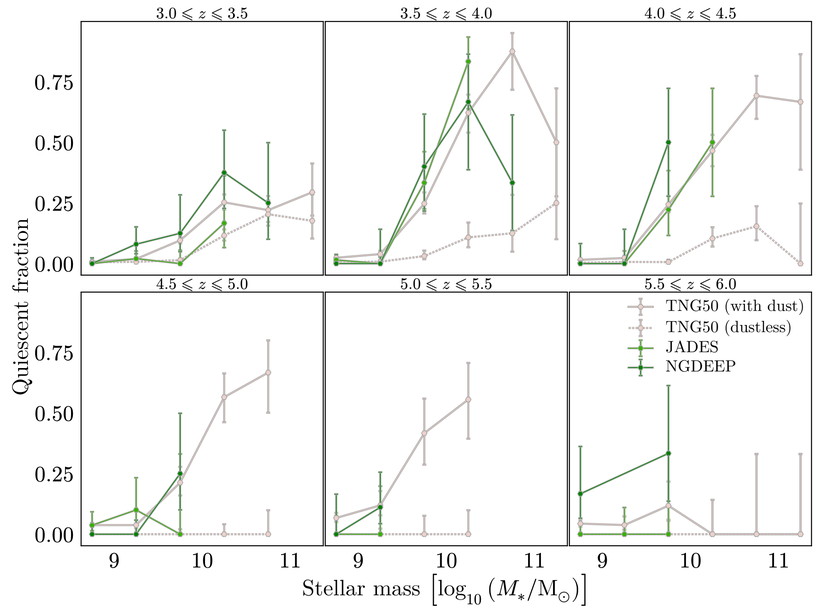


(4b) The SED-inferred UVJ diagram: TNG50 vs. JWST observations



- TNG50 galaxies are redder than observed low-mass galaxies and somewhat bluer than observed high-mass galaxies; this is observed at all redshifts.

(5) The mass-dependent quiescent fraction agrees with observations



- Within statistical uncertainty, the quiescent fraction increases with stellar mass and is in general agreement with JADES and NGDEEP.

References

This work: Guzmán-Ortega *et al.* 2025, MNRAS accepted

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1. Camps, P. & Baes, M. 2020, Astron. Comput., 31, 100381
2. Nelson, D. *et al.* 2019, Comput. Astrophys., 6, 2
3. Sánchez, S. F. *et al.* 2022, ApJS, 262, 36
4. Groves, B. *et al.* 2008, ApJS, 176, 438
5. Zubko, V., Dwek, E., & Arendt, R. G. 2004, ApJS, 152, 211
6. Bagley, M. B. *et al.* 2024, ApJL, 965, L6
7. Brammer, G. B. *et al.* 2008, ApJ, 686, 1503
8. Carnall, A. C. *et al.* 2018, MNRAS, 480, 4379
9. Rieke, M. J. *et al.* 2023, ApJS, 269, 16
10. Salim, S. *et al.* 2018, ApJ, 859, 11