



The Earliest Structure Formation: A Galaxy Overdensity Candidate at $z = 10.5$



Zihao Wu, D. Eisenstein, B. Johnson, and JADES Collaboration
Center for Astrophysics | Harvard & Smithsonian

Abstract

Galaxy overdensities trace the dense nodes of cosmic large-scale structure. We report a galaxy overdensity candidate at $z_{\text{phot}} \approx 10.5$ in the JADES survey, suggesting that large-scale structure had already begun to emerge within the first 500 Myr after the Big Bang.

The overdensity contains **18 galaxies within 10 cMpc**, four times higher than the field density. They account for **$\sim 1/3$ of galaxies and $\sim 1/2$ of the total SFR** at $z_{\text{phot}} = 10-12$ in GOODS-S. The probability of producing such an overdensity by chance projection is $< 10^{-5}$.

Galaxies in the overdensity show mildly accelerated evolution compared with field galaxies at $z > 10$. We also find tentative evidence for a ~ 5 cMpc ionized bubble near the overdensity, potentially marking one of the earliest sites of cosmic reionization. This system will be followed up with our upcoming **JWST Cycle 5 NIRSpec program** (PI: Wu).

JWST Observation

JWST Advanced Deep Extragalactic Survey (JADES) is one of the largest JWST deep-field programs, with a total of ~ 1000 hrs of imaging and spectroscopy. It covers ~ 200 arcmin² with a typical depth of 29 mag across more than 10 filters spanning 0.6-5.3 μm .

JWST has discovered more than 20 galaxy overdensities at $z = 6-8$, but this system is currently the only overdensity discovered at $z > 10$. Its richness and significance are comparable to, or larger than, many overdensities found at lower redshift.

Implications

- **Early structure formation:** Large-scale overdensities may have already emerged within the first 500 Myr after the Big Bang, potentially marking the birthplaces of future galaxy clusters.
- **Accelerated galaxy growth:** Galaxies in the overdensity appear slightly brighter, more massive, and more actively star-forming than field galaxies.
- **Early reionization:** Tentative evidence for an ionized bubble may indicate one of the earliest sites of cosmic reionization.

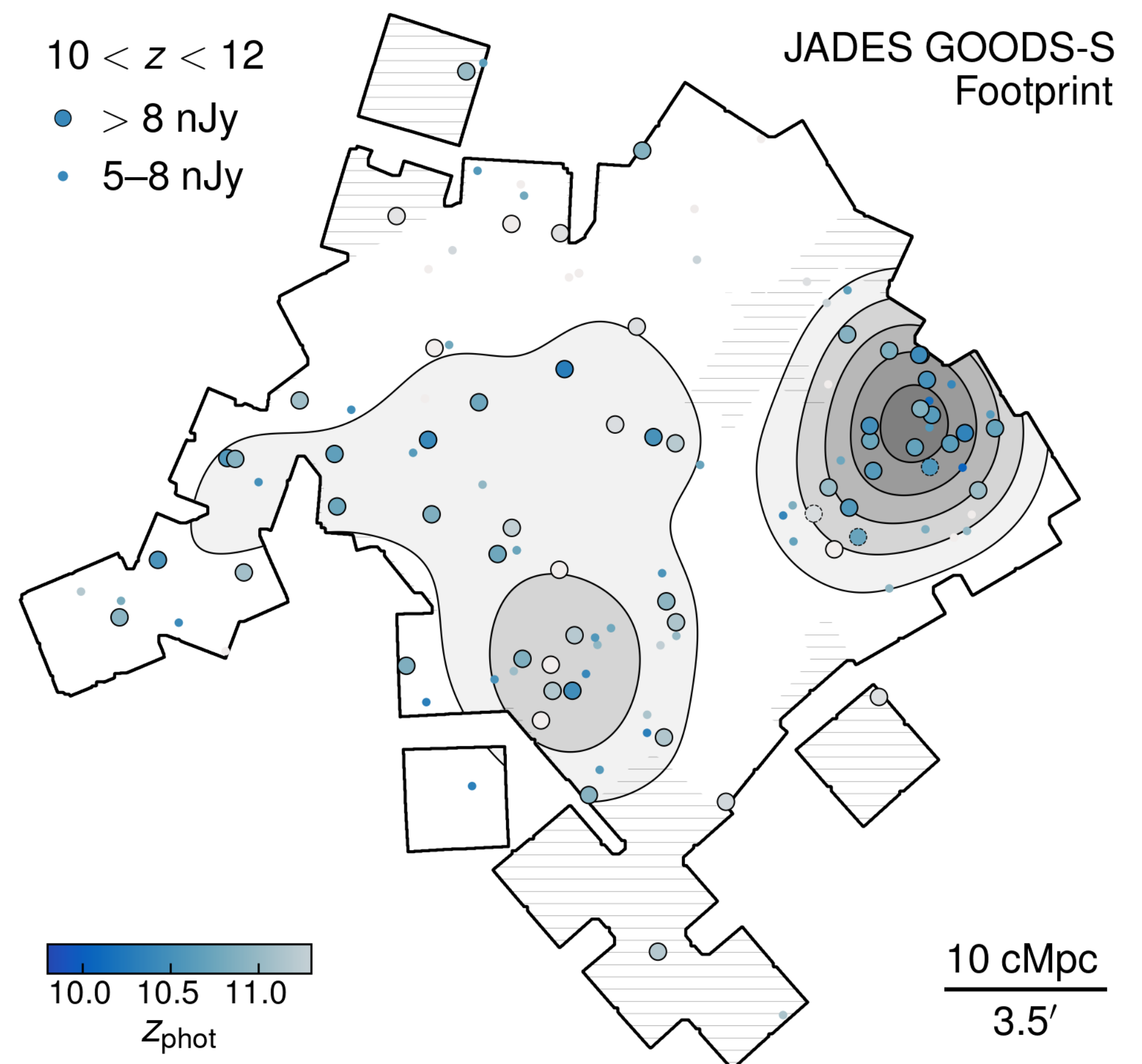


Fig. 1 Spatial distribution of galaxies at $10 < z_{\text{phot}} < 12$ in the JADES GOODS-S field. Each dot represents a galaxy, color-coded by photometric redshifts. Nearly $1/3$ galaxies are concentrated in the overdensity structure on the right.

Roman Prediction

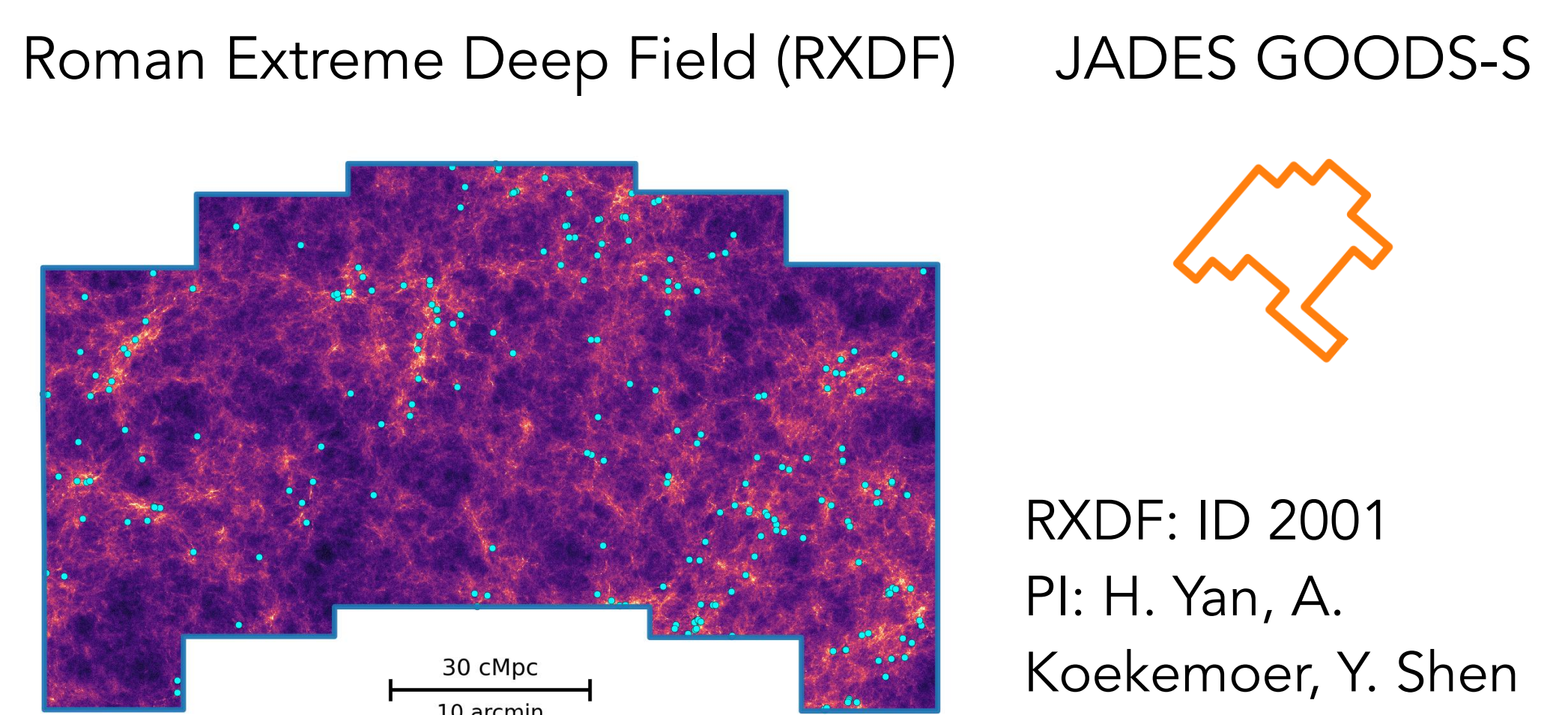
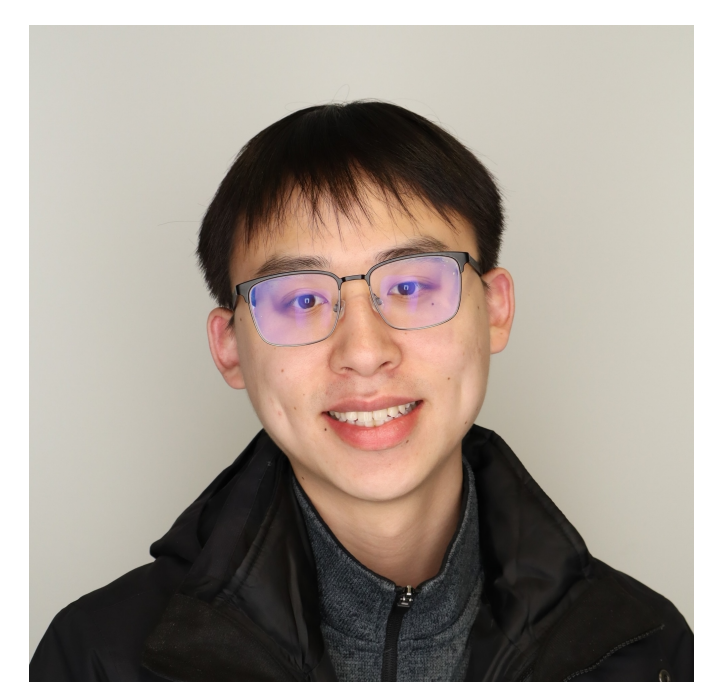


Fig. 2 RXDF will cover a much larger area than JADES while reaching sufficient depth to identify $z > 10$ galaxies. Roman may discover **~ 10 similar galaxy overdensities at $z > 10$** .

More Information



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Zihao Wu
zihao.wu@cfa.harvard.edu