The Most Massive Galaxies in the Early Universe Are Optically Dark

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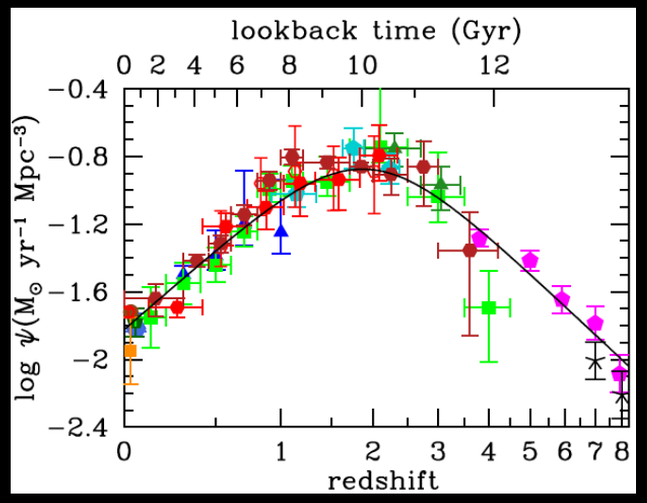
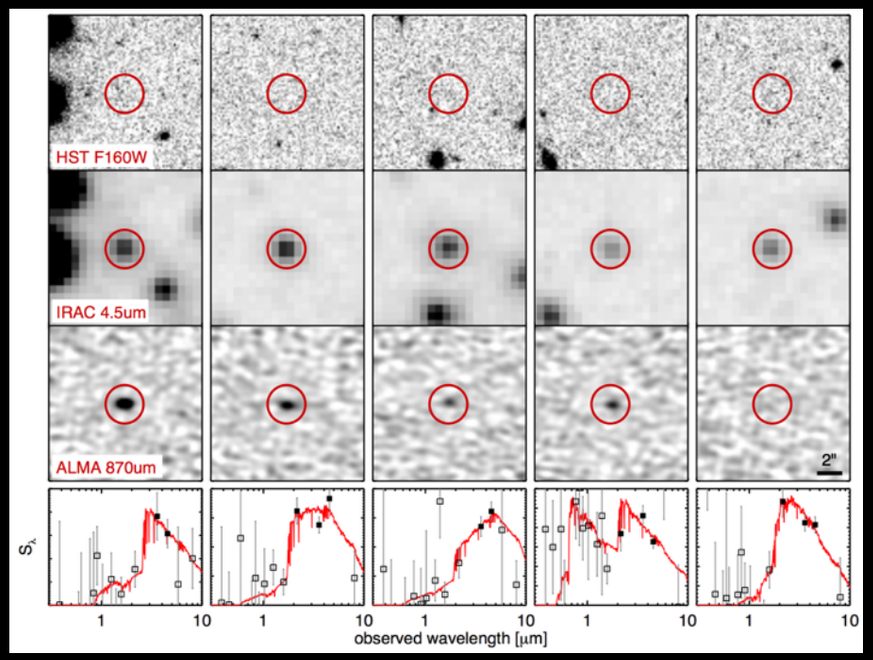
Motivation: Our current understanding on the cosmic star formation history at z>3 is limited to galaxies bright in the UV (Lyman-break galaxies), which is biased against massive galaxies (old and/or dusty).

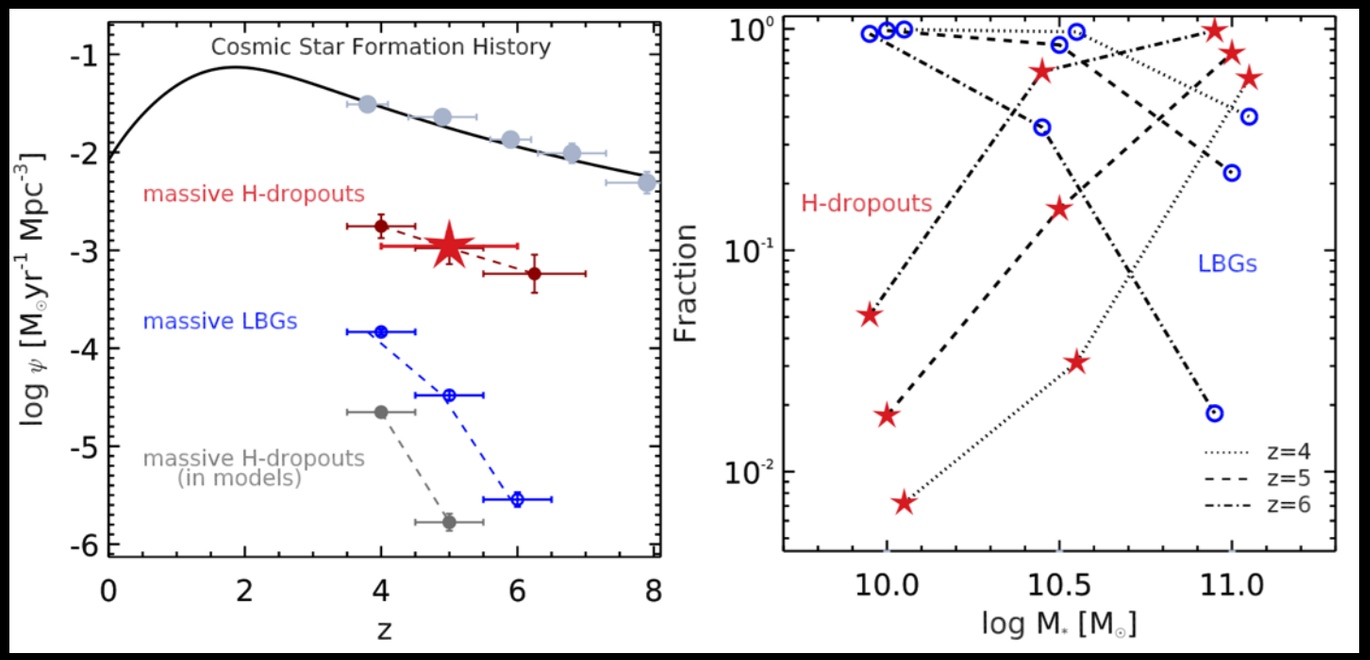


Wang, T., et al., 2016, ApJ, 816, 84;
Wang, T., 2018b, submitted

Madau & Dickinson, 2014

This work: We conducted 870um continuum observations with ALMA of 64 candidate high-z galaxies that are undetected in the H-band (rest-frame UV at z>3) with HST/WFC3, yet are bright at 4.5um with Spitzer/IRAC, i.e., galaxies with extremely red H - [4.5] colors (**H-dropouts**). ~70% (40) are detected at 870um with S870 > 0.6 mJy.





Results: ALMA reveals a large population (~270 deg^-2) of massive, optically dark galaxies at z>3. These galaxies dominate the high mass end of the stellar mass function and the SFRD of massive galaxies, yet have been completely missed in previous studies (including galaxy formation models). Future spectroscopic follow-ups with ALMA and JWST are required to further study the physical mechanisms of the early assembly of these massive galaxies in the early universe.