Synergizing Roman and Line Intensity Mapping: Forecasting Effects of Bursty Star Formation in The Early Universe

Lun-Jun (Simon) Liu | California Institute of Technology

Wide-Field Science Project: Reionization Science from Cross-Correlations with Roman

PI: A. Lidz | Collaborators: G. Sun, A. Kundu, J. Mirocha, T.-C. Chang

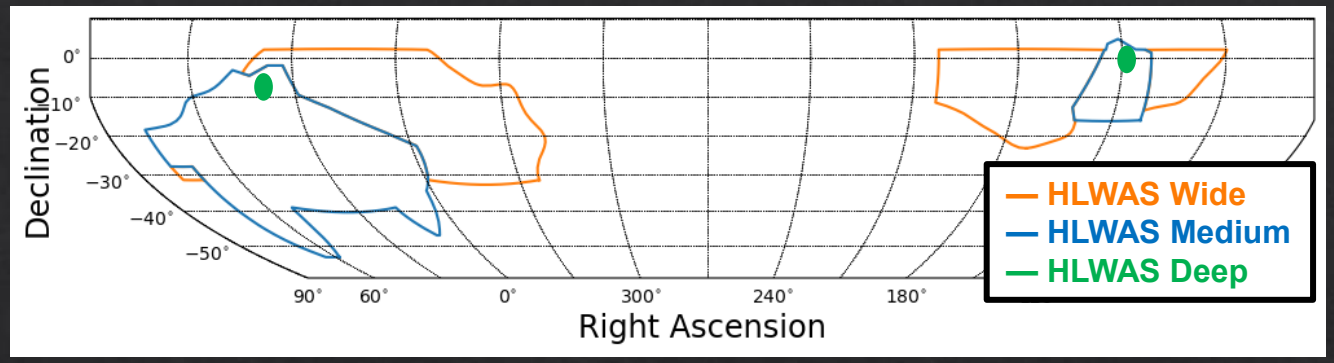
Talk | New Frontiers to Explore with Roman | Pasadena, CA

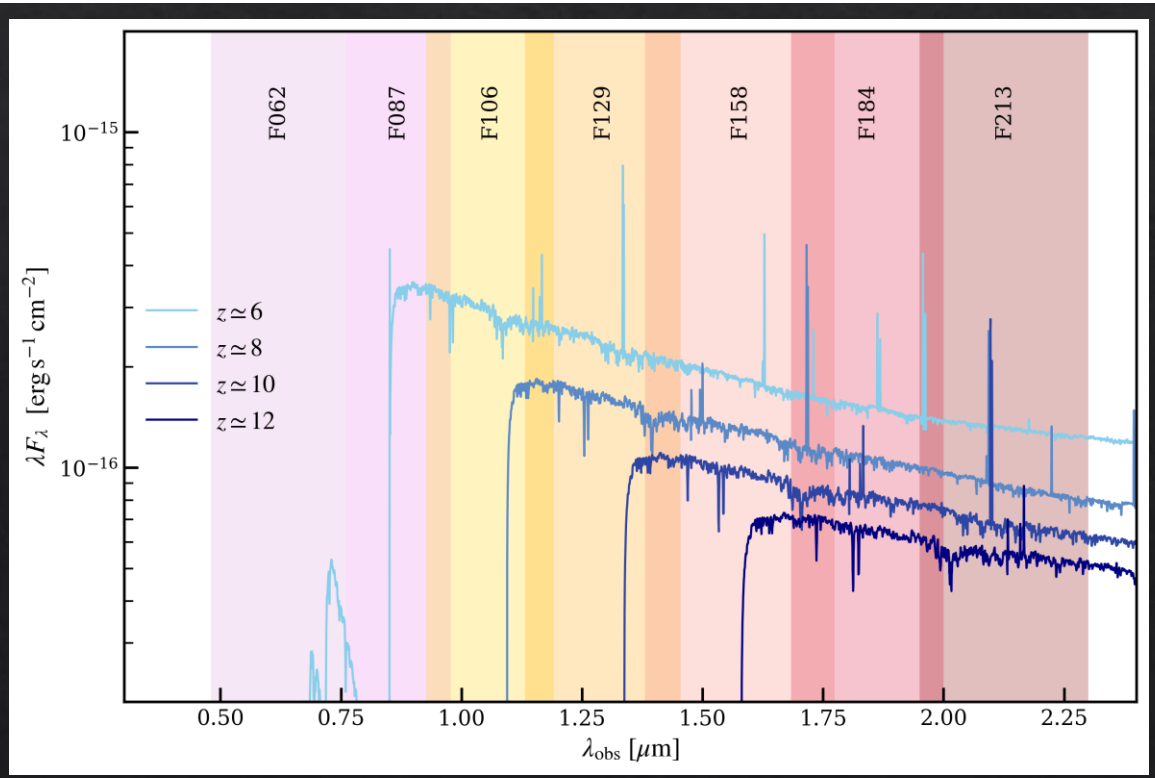
July 13, 2026

Image credit: NASA Goddard Space Flight Center Scientific Visualization Studio

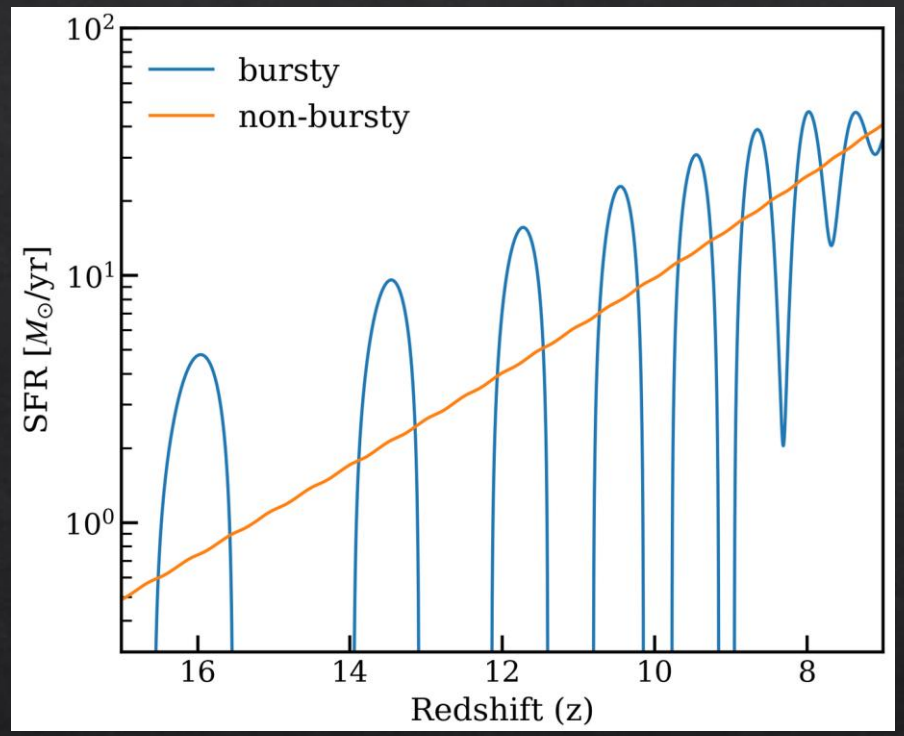
Roman as A Powerful Probe of High-Redshift Galaxies in The Infant Universe

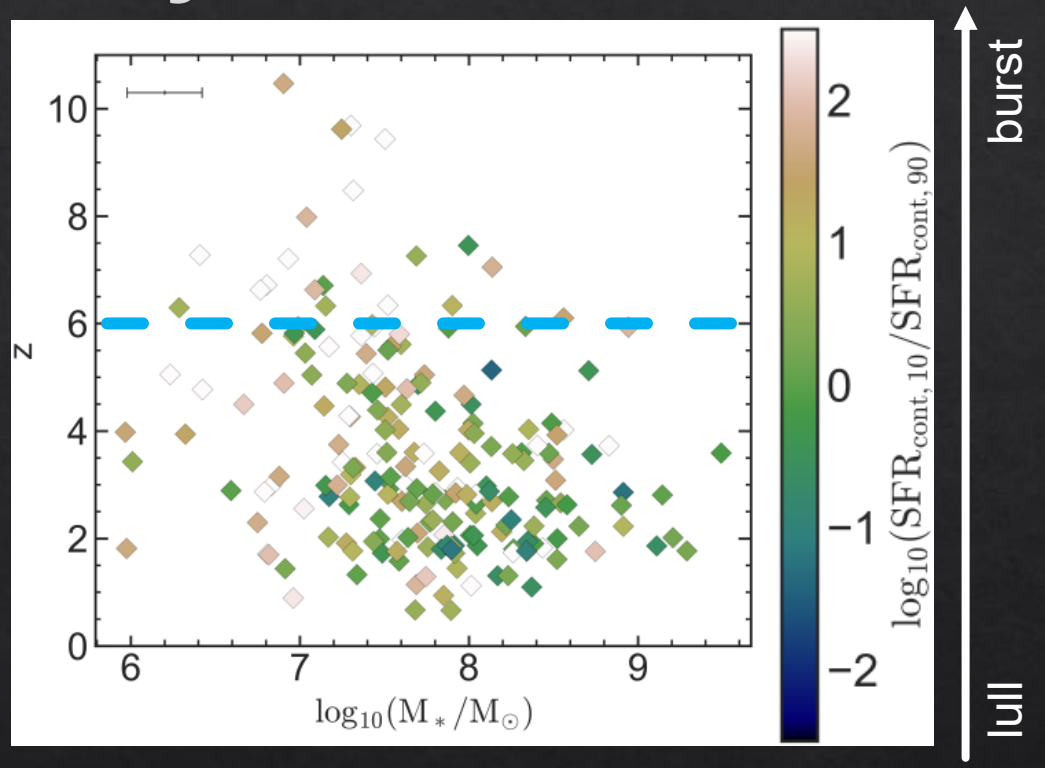
- The Nancy Grace Roman Space Telescope brings unprecedented capabilities to high-z exploration
- High-Latitude Wide-Area Survey (HLWAS Medium Tier; 2400 deg^2) maps vast cosmic volumes, while the Deep-Tier survey (~20deg^2) probe fainter populations
- Dropout Method: Utilizing Roman's filter configurations to identify candidates of Lyman-break galaxies (LBGs) up to z ~ 11
- Pushing the Frontier: Depending on the F213 sensitivity, Roman may observe brightest galaxies up to z ~ 14





Episodic, Intense Bursts of Star Formation Prevails among Early Galaxies

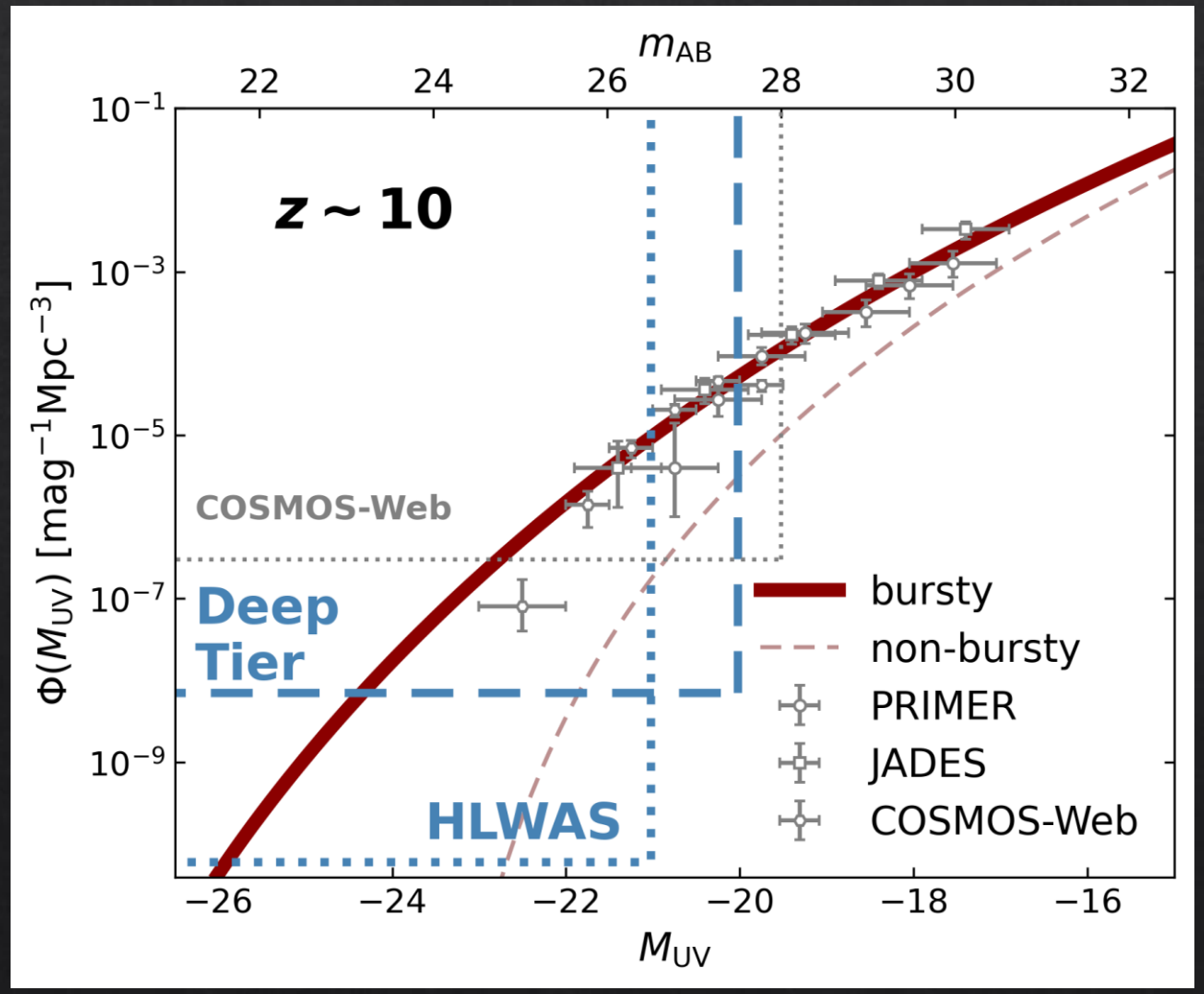




Looser+2023

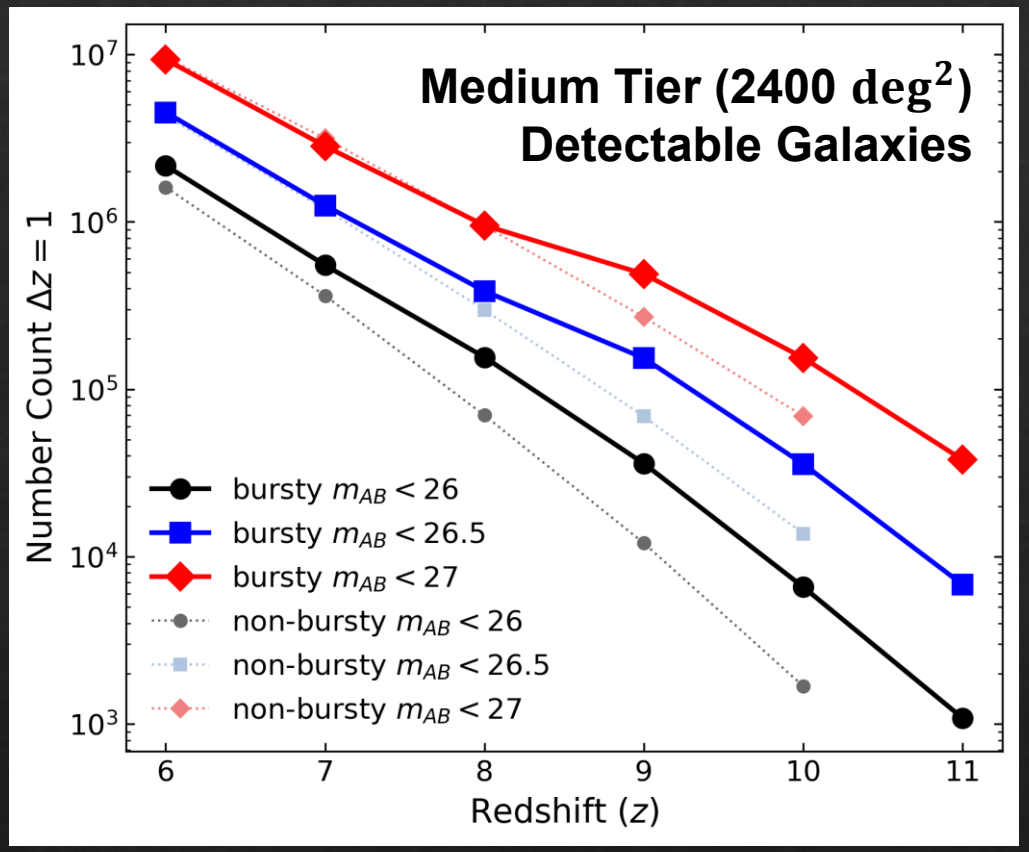
- Bursty star formation—highly time-varying star formation history (SFH)
- Predictions from simulations and analytic arguments
- JWST observes recent starburst in high-z galaxies → likely the bursty SFH
- JWST reveals an overabundance of early UV bright galaxies → hints of bursty SFHs

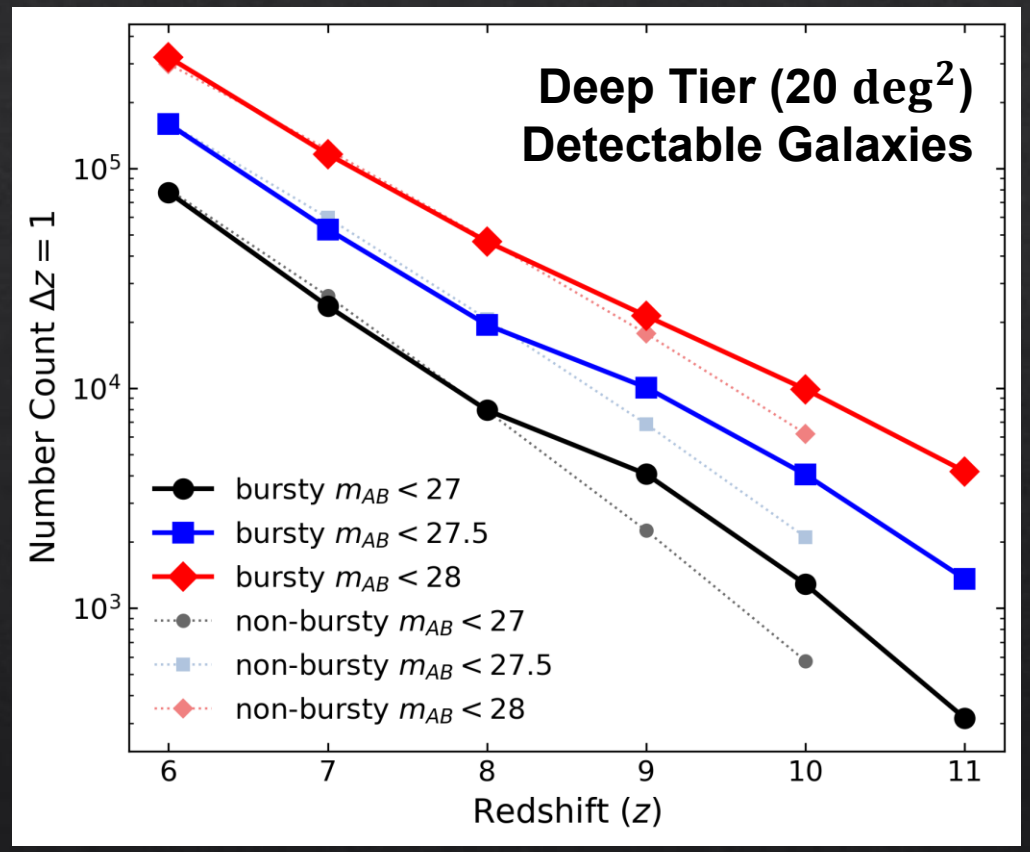
Bursty Star Formation Modifies High-Redshift UV Luminosity Functions (UVLFs)



- The upscatter of M_{UV} can generate an overabundance of UV bright galaxies, which naturally boost the bright end of UVLFs
- The Roman galaxy surveys will uniquely capture early bright galaxies within massive cosmic volumes and will directly test bursty star formation models
- JWST is limited by its narrow field-of-view and thus cosmic variance

Forecasting Number Counts of Roman Galaxy Surveys





- **Prediction (Preliminary): Prevalent bursty star formation will significantly boost the number count of Roman-detectable galaxy**

Efficient Statistical Probe of The Universe—Line Intensity Mapping (LIM)

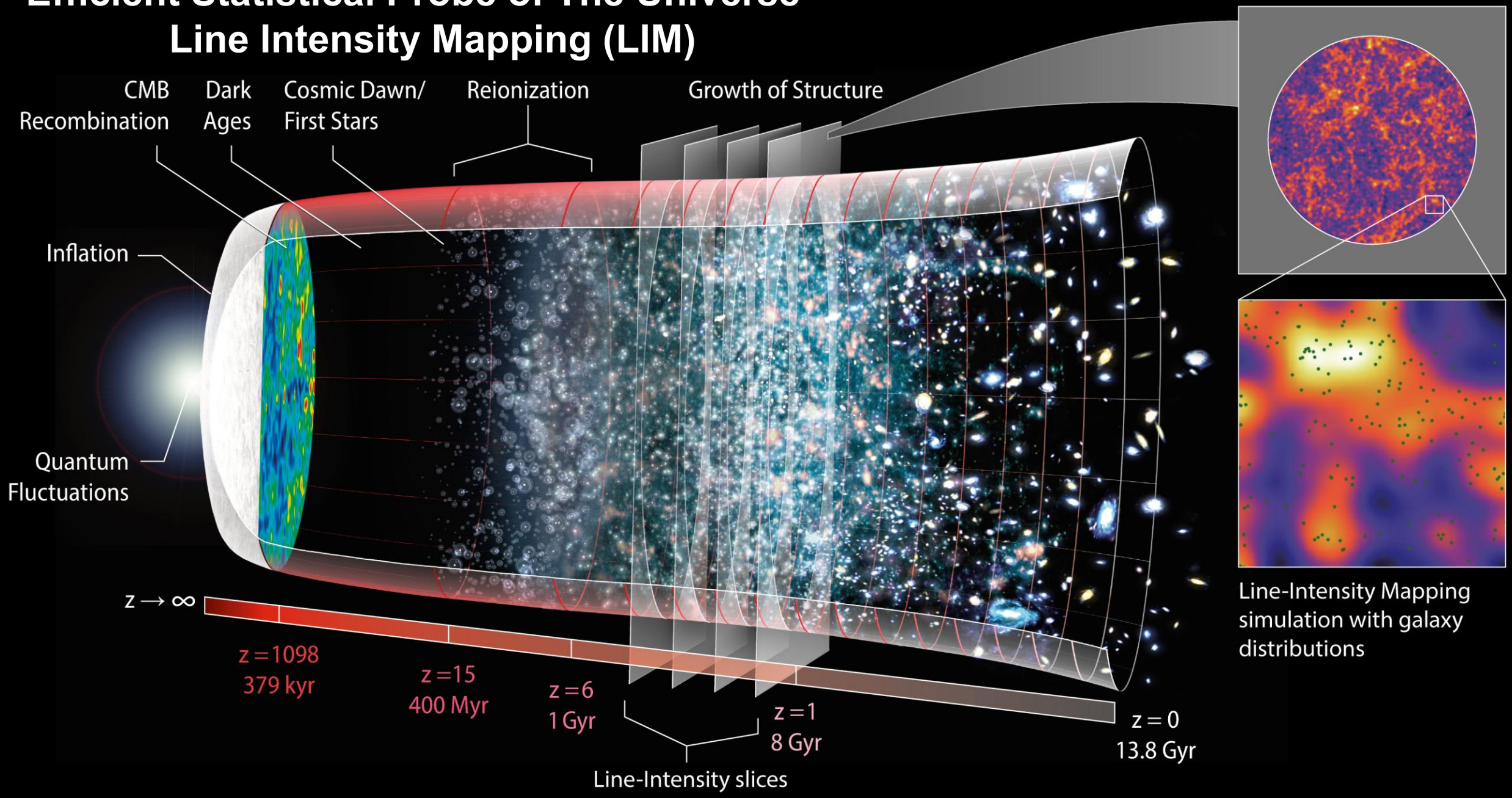
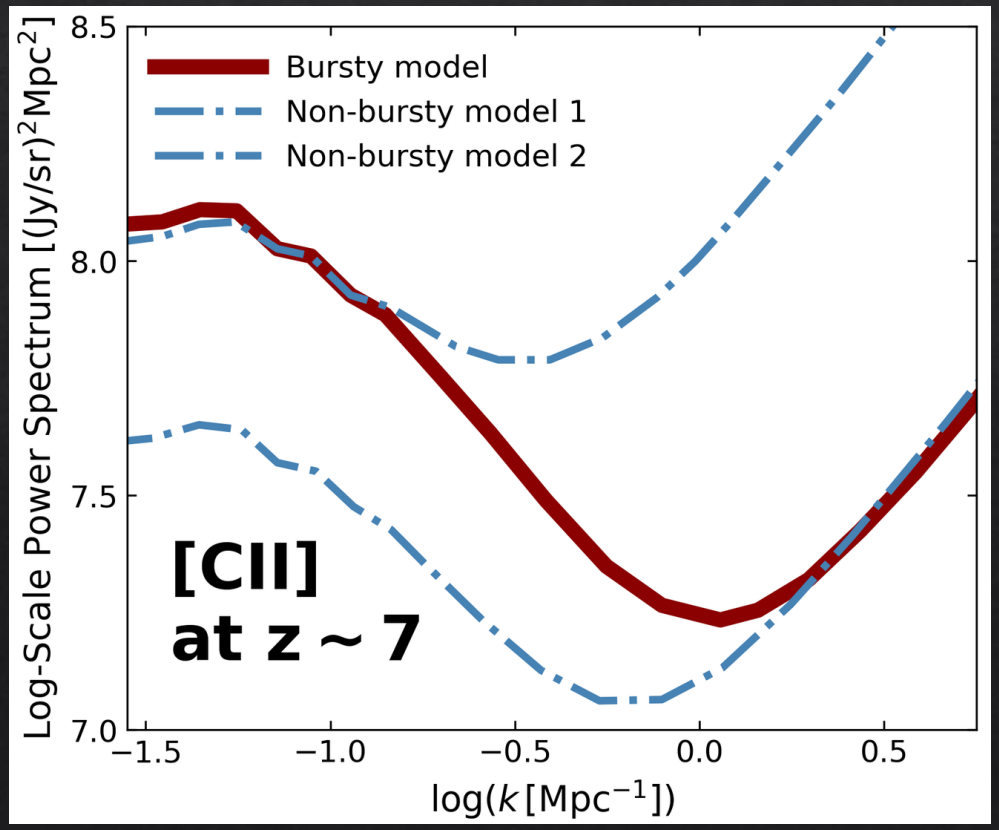


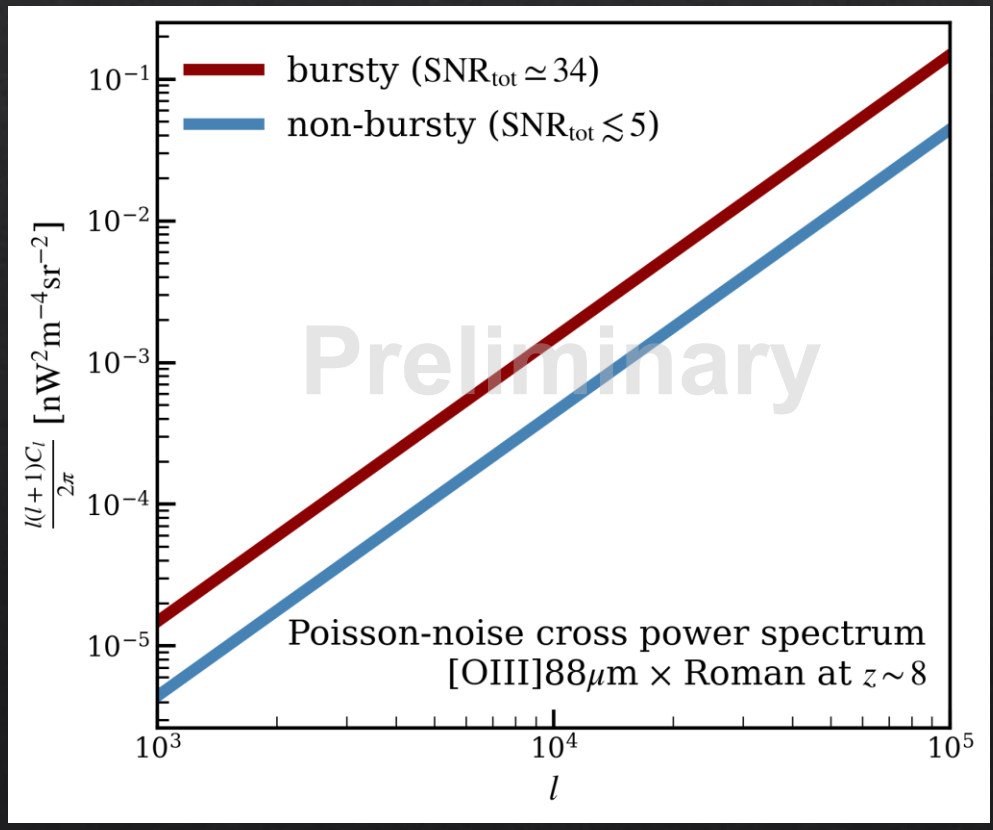
Image Credit: NASA/LAMBDA Archive Team

Bursty Star Formation Signatures in LIM & Cross-Correlations

- Impact of burstiness on LIM signals of emission line auto-correlation



- Burstiness can boost the intensity of cross power spectrum (Poisson-noise regime)

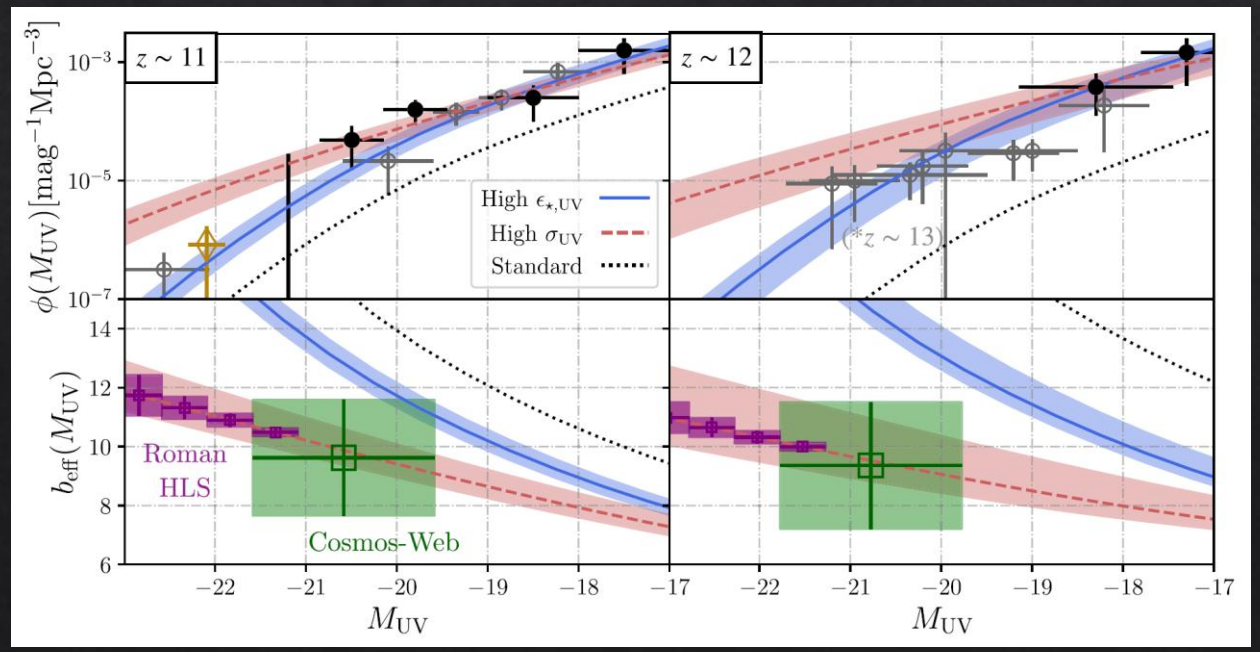


Liu et al. (2024) ApJ, 974, 175

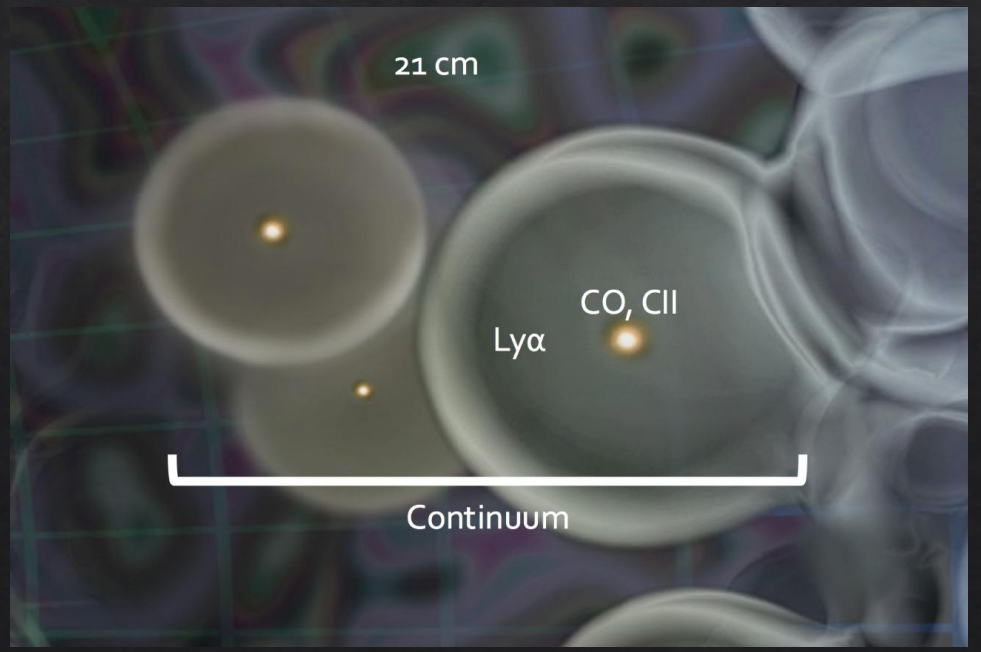
Next Steps: Clustering, Galaxy Bias, and Reionization Topology

- Forward-modeling the spatial distribution and clustering of early galaxies across Roman's vast cosmic volumes
- Extracting linear and non-linear luminosity-weighted galaxy bias from robust Roman x LIM cross-correlation measurements

- Tracking the topological growth of ionized bubbles to provide critical insights into the precise timeline of cosmic reionization



Muñoz+2023



Patrick Breysse for 2017 LIM Status Report

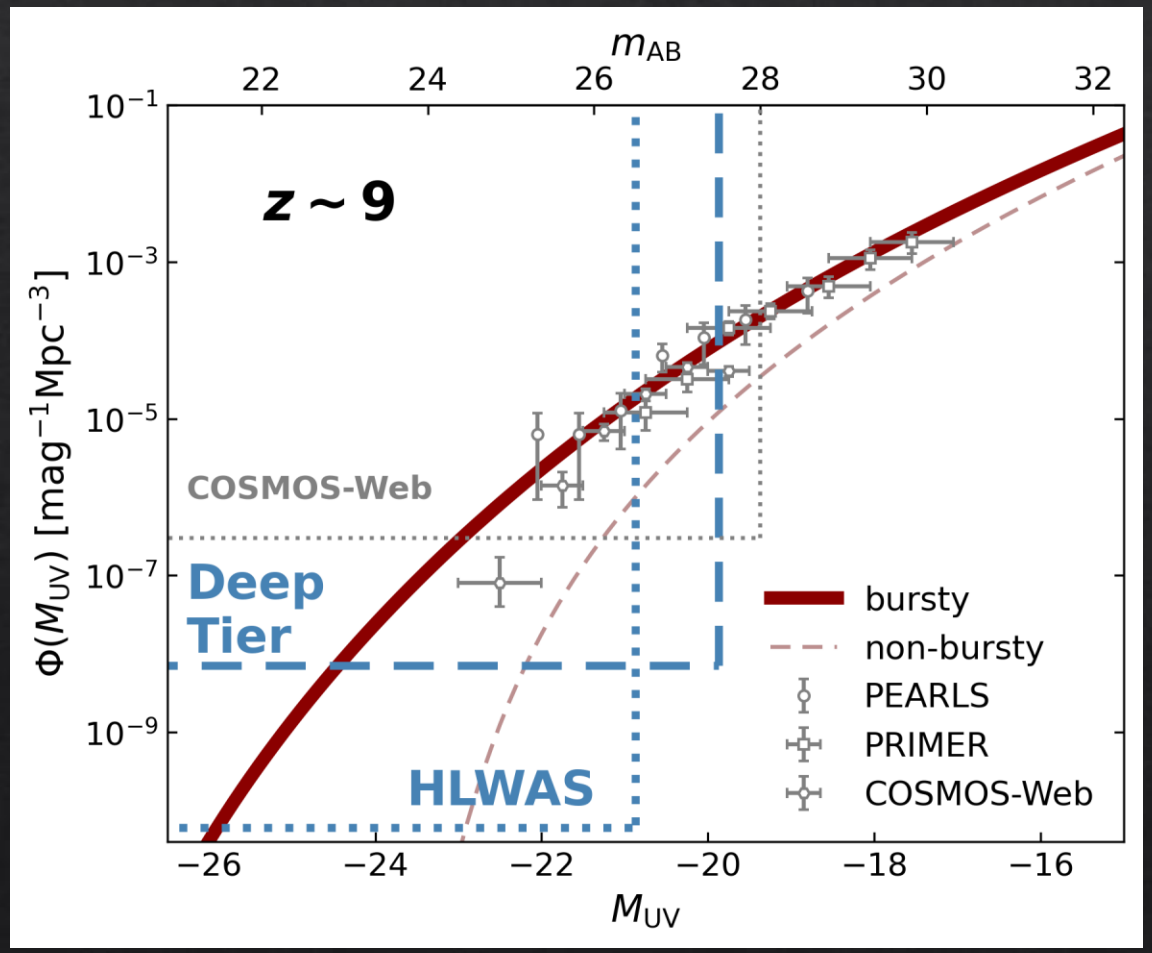
Summary

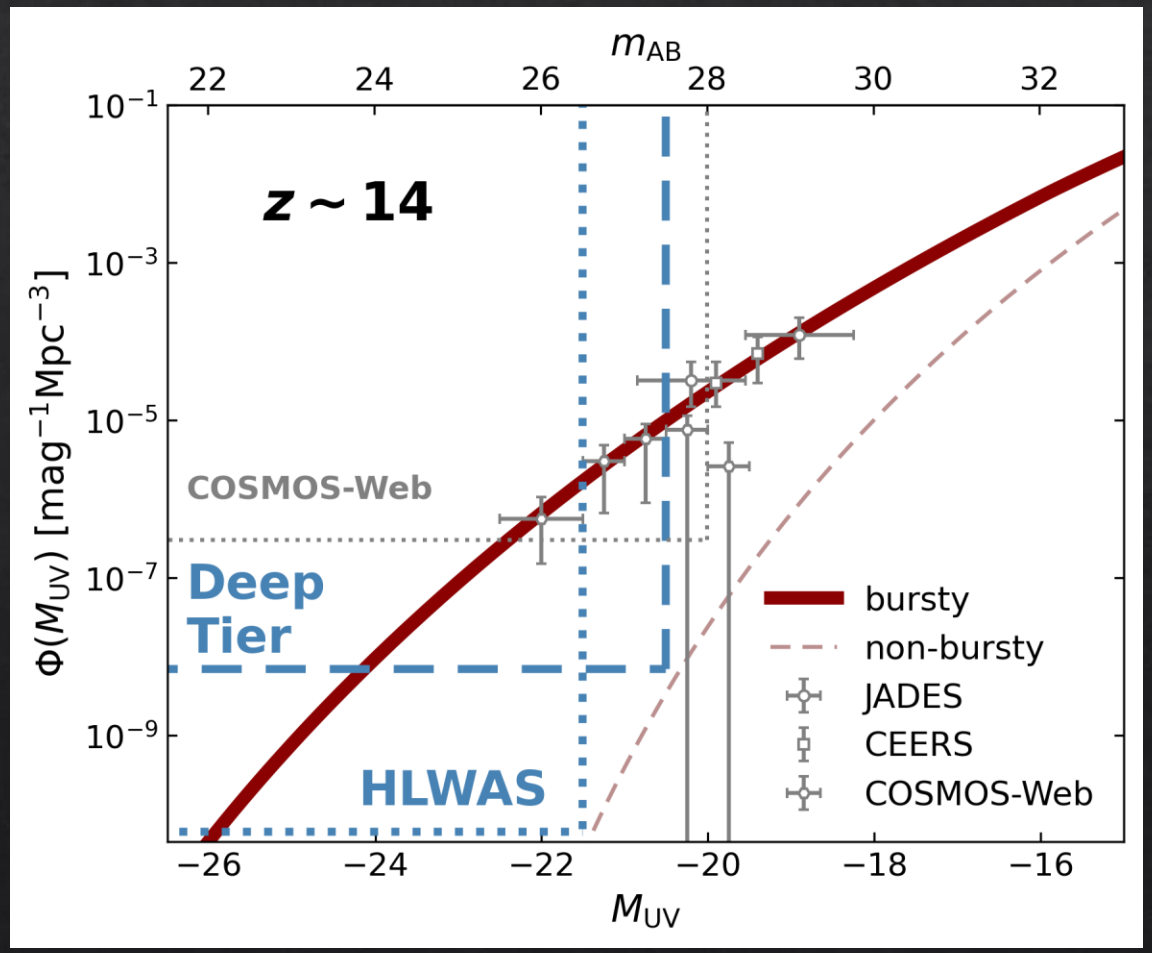
- Roman Wide-Field Science Project: Reionization Science from Cross-Correlations with Roman
- Explore the synergy of Roman galaxy surveys and Line Intensity Mapping (LIM)
- We study the impact of bursty star formation in the early Universe, showing that this can modify the high-z UV luminosity functions, particularly the bright end
- We provide preliminary forecast taking this effect into account, including number count of Roman-detectable early bright galaxies, LIM signals of auto-correlation and cross-correlation, and clustering analysis
- Next steps: forecasting for clustering analysis, constraining power of linear/non-linear galaxy bias, and the growth of ionized bubbles during cosmic reionization

Image credit: NASA Goddard Space Flight Center Scientific Visualization Studio

Thank you!

More UVLFs


m_{AB}
22
24
26
28
30
32
10^{-1}
10^{-3}
10^{-5}
10^{-7}
10^{-9}
$\Phi(M_{UV})$ [mag^{-1}Mpc^{-3}]
$z \sim 9$
COSMOS-Web
Deep Tier
HLWAS
bursty
non-bursty
PEARLS
PRIMER
COSMOS-Web
−26
−24
−22
−20
−18
−16
M_{UV}


m_{AB}
22
24
26
28
30
32
10^{-1}
10^{-3}
10^{-5}
10^{-7}
10^{-9}
$\Phi(M_{UV})$ [mag^{-1}Mpc^{-3}]
$z \sim 14$
COSMOS-Web
Deep Tier
HLWAS
bursty
non-bursty
JADES
CEERS
COSMOS-Web
−26
−24
−22
−20
−18
−16
M_{UV}