Studying the high redshift Universe combining JWST and the power of gravitational lensing

Rachana Bhatawdekar, Christopher Conselice, Berta Margalef-Bentabol, Kenneth Duncan

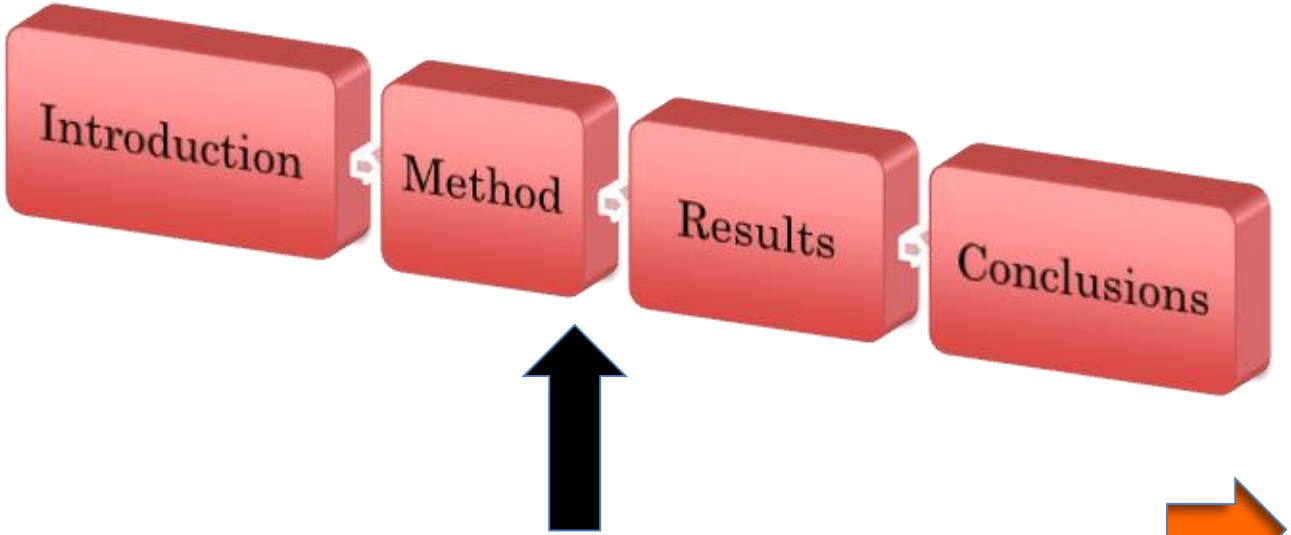
We present new measurements of the evolution of the galaxy stellar mass functions and UV luminosity functions for galaxies from z = 6 – 9 in the Hubble Frontier Fields by combining the power of gravitational lensing of massive clusters with deep imaging of HST, VLT and Spitzer, unveiling the potential science that can be done with JWST (Bhatawdekar et al 2018)




Next

The University of Nottingham
UNITED KINGDOM · CHINA · MALAYSIA

Studying the high redshift Universe combining JWST and the power of gravitational lensing

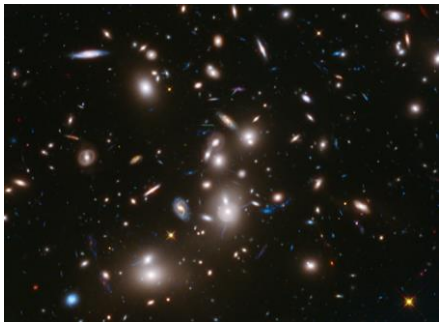


Click on the buttons for more information

Next Previous

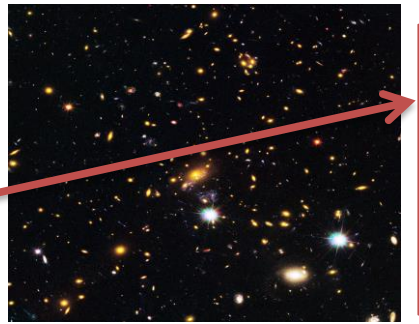
Introduction

How deep can we go with Hubble Space Telescope (HST) now, before the launch of the James Webb Space Telescope? -> Hubble Frontier Fields Director's Discretionary Program



Abell 2744

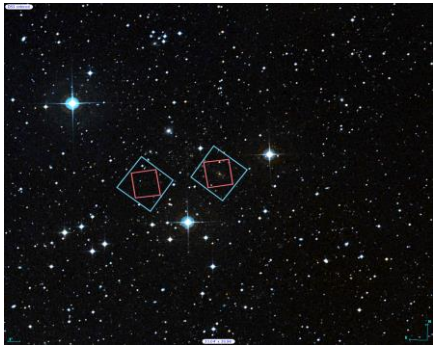
MACSJ0416



MACS1149

This work -> HST+VLT+Spitzer imaging of MACS0416 cluster+ parallel field

MACSJ0717



Abell S1063

Abell 370

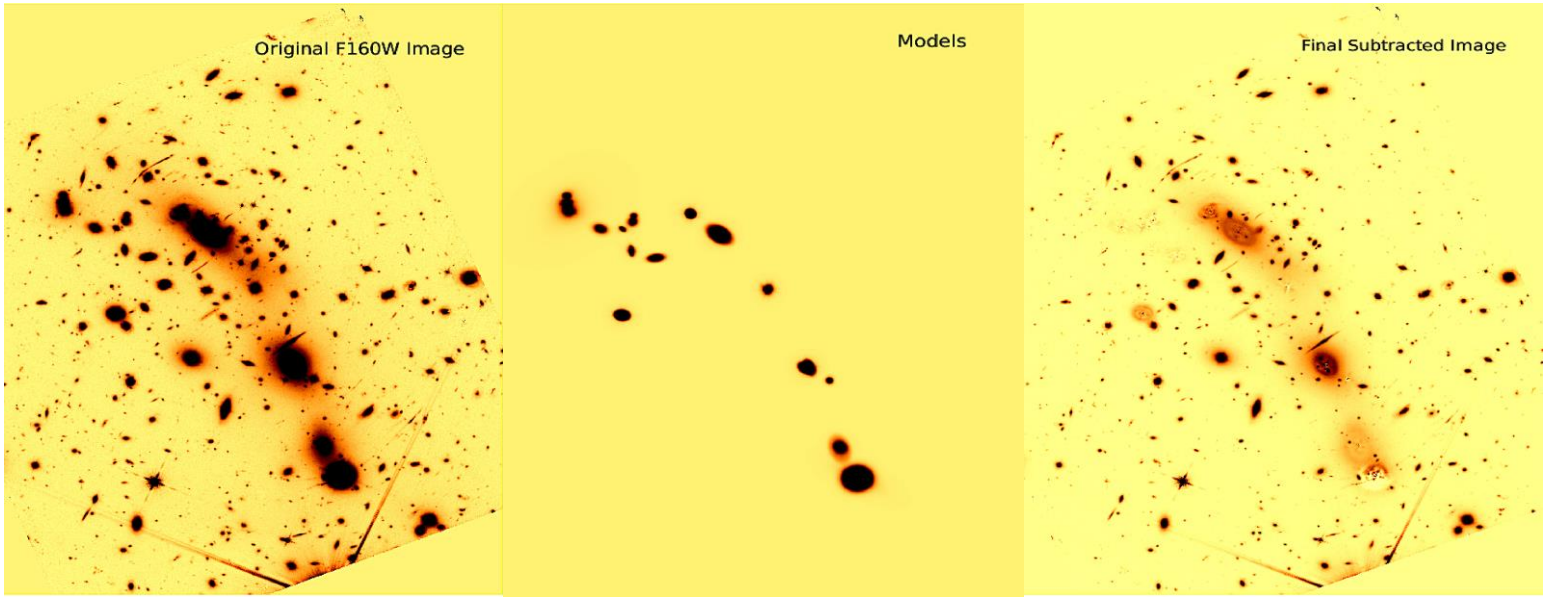
Home Screen

Next Previous

HFF program used six clusters (along with six flanking fields for deep observations) as gravitational lenses to magnify faint distant galaxies

Method – subtraction of foreground galaxies

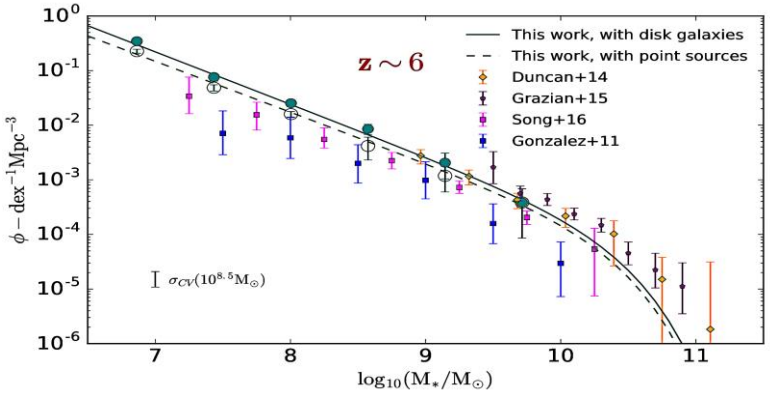
- While lensing clusters provide exceptional opportunities to characterize the faintest earliest galaxies, the overwhelming luminosity of the brightest galaxies in the cluster impedes the detection of faint galaxies
- To overcome this, we developed a novel method dubbed "Divide and Conquer" to subtract the massive foreground galaxies on the critical line of the MACS0416 cluster, enabling detection of the faintest systems at z > 5 -> See **Bhatawdekar et al 2018** for more details

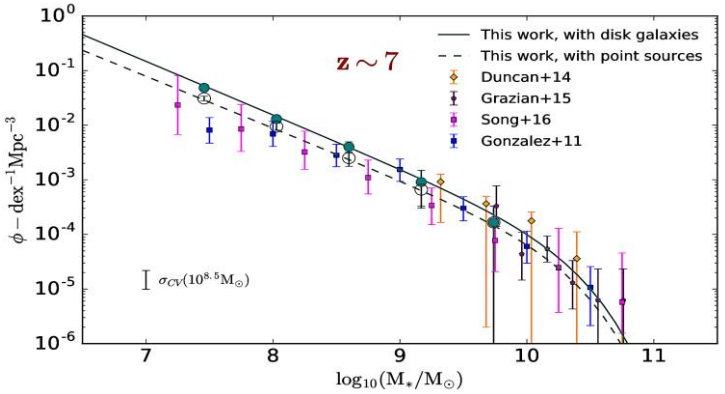


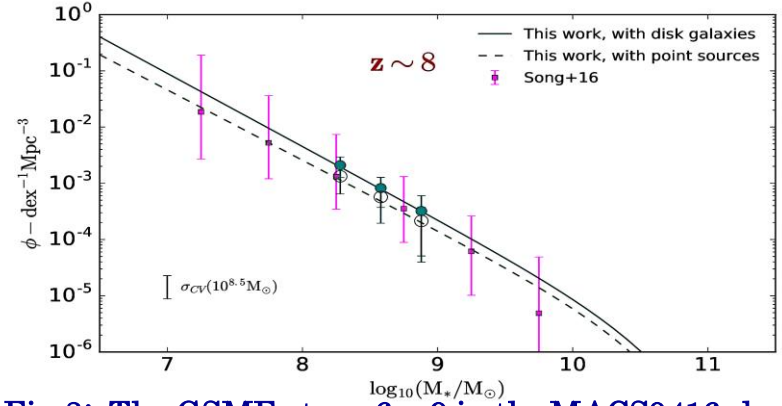
Home Screen

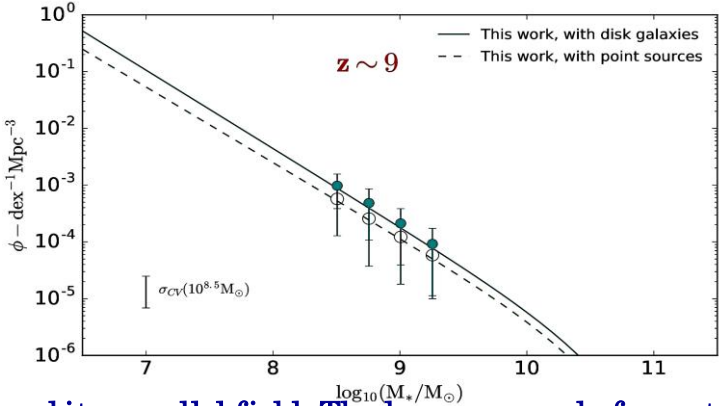
Fig 2: Results of our subtraction procedure

Results – Galaxy stellar mass functions at z=6–9









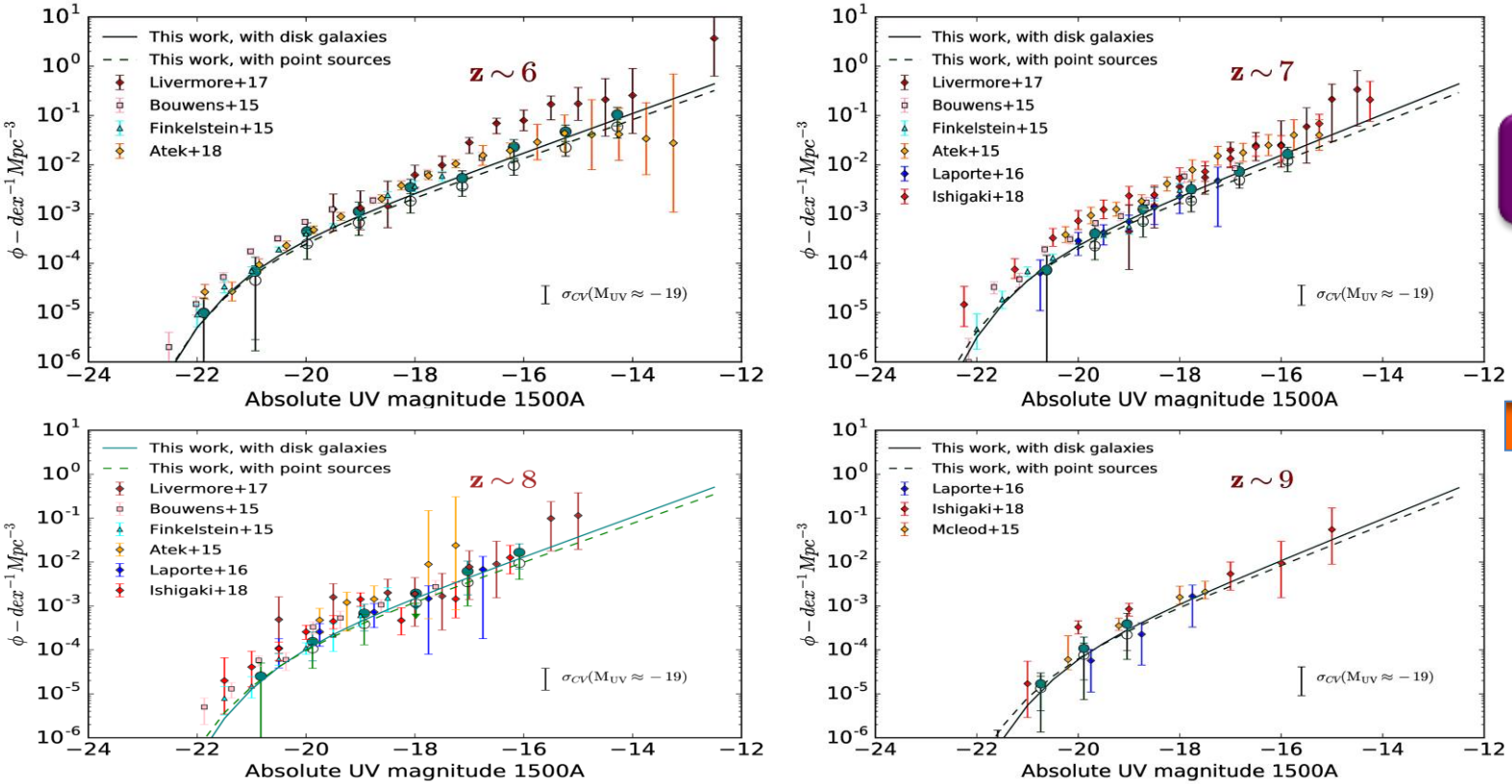
Home Screen

Next Previous

See more results

Fig 3: The GSMF at z = 6 – 9 in the MACS0416 cluster and its parallel field. The low-mass end of our stellar mass functions continues to become steeper from −1.96+0.04/−0.04 at z = 6 to −2.38+0.30/−0.25 at z = 9, steeper than previously observed, and we find no evidence of turnover in the mass range probed (See Bhatawdekar et al 2018)

Results – UV luminosity functions at z=6−9



Home Screen

Next Previous

See more results

Fig 4: The UV LF at z = 6 – 9 in the MACS0416 cluster and its parallel field. The faint-end slope of the UV LF also exhibit a steepening with increasing redshift (from −2.00+0.08/−0.06 at z = 6 to −2.18+0.35/−0.30 at z = 9), without any evidence of a turnover. (See Bhatawdekar et al 2018)

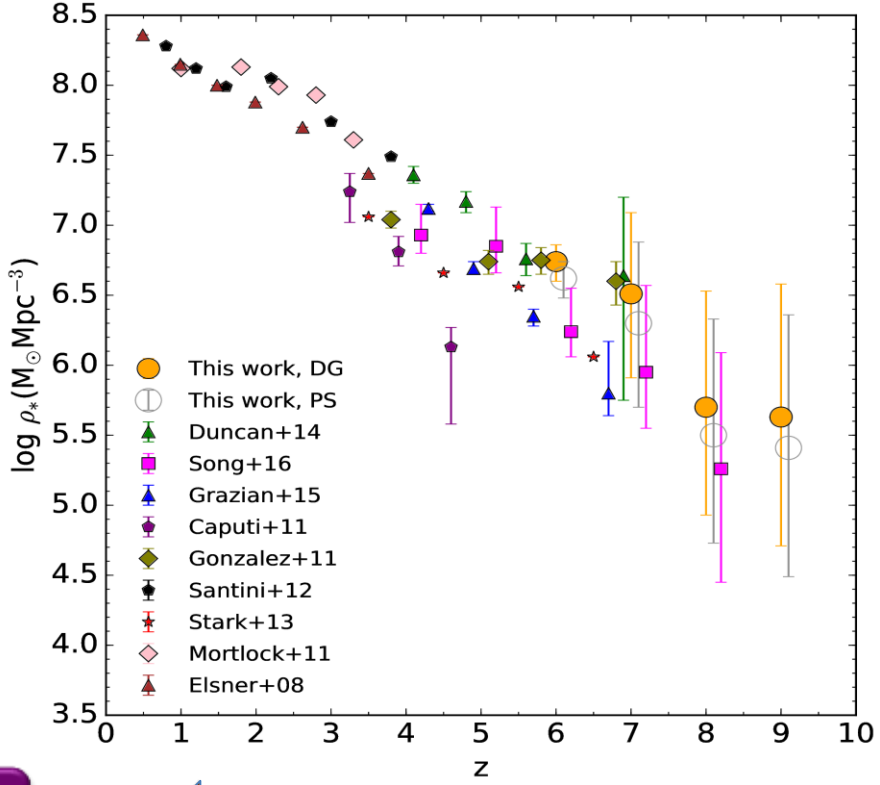
Results – Stellar mass density

Integrated stellar mass density has increased by a factor of ~12 from z =9 to z =6

We also find that there is a significantly high stellar mass density for galaxies in the early universe up to z ~ 9.

This is an indication that galaxies of masses around 10^8 $M_\odot$ have already formed a significant density by this time.

This further indicates that the star formation and assembly history for galaxies is significant in the epochs z > 9, which we cannot probe in detail until the launch of JWST (See Bhatawdekar et al 2018)



Next
Home Screen
Previous

Conclusions

- Exploited the power of gravitational lensing of massive clusters and combined the HST, VLT and Spitzer imaging of MACS0416 cluster and its parallel field to probe galaxy evolution with GSMF and UV LF.
- Developed a novel method to subtract the massive foreground galaxies that lie close to the critical line of the cluster, enabling detection of the faintest systems at $z > 5$
- The low-mass end of our stellar mass functions continues to become steeper from $-1.96^{+0.04}_{-0.04}$ at $z = 6$ to $-2.38^{+0.30}_{-0.25}$ at $z = 9$, steeper than previously observed, and we find no evidence of turnover in the mass range probed
- The faint-end slope of the UV LF also exhibit a steepening with increasing redshift (from $-2.00^{+0.08}_{-0.06}$ at $z = 6$ to $-2.18^{+0.35}_{-0.30}$ at $z = 9$), without any evidence of a turnover.
- Integrated SMD increases by a factor of ~12 from z=9 to z=6. We find that galaxies of masses around 10^8 $M_\odot$ have already formed a significant density by $z \sim 9$. This indicates that the star formation and assembly history for galaxies is significant in the epochs $z > 9$, which we cannot probe in detail until the launch of JWST.
- With JWST, and by combining the power of gravitational lensing of massive clusters, this study can be extended towards the faintest magnitudes/masses out to z=12.

Previous

Home Screen