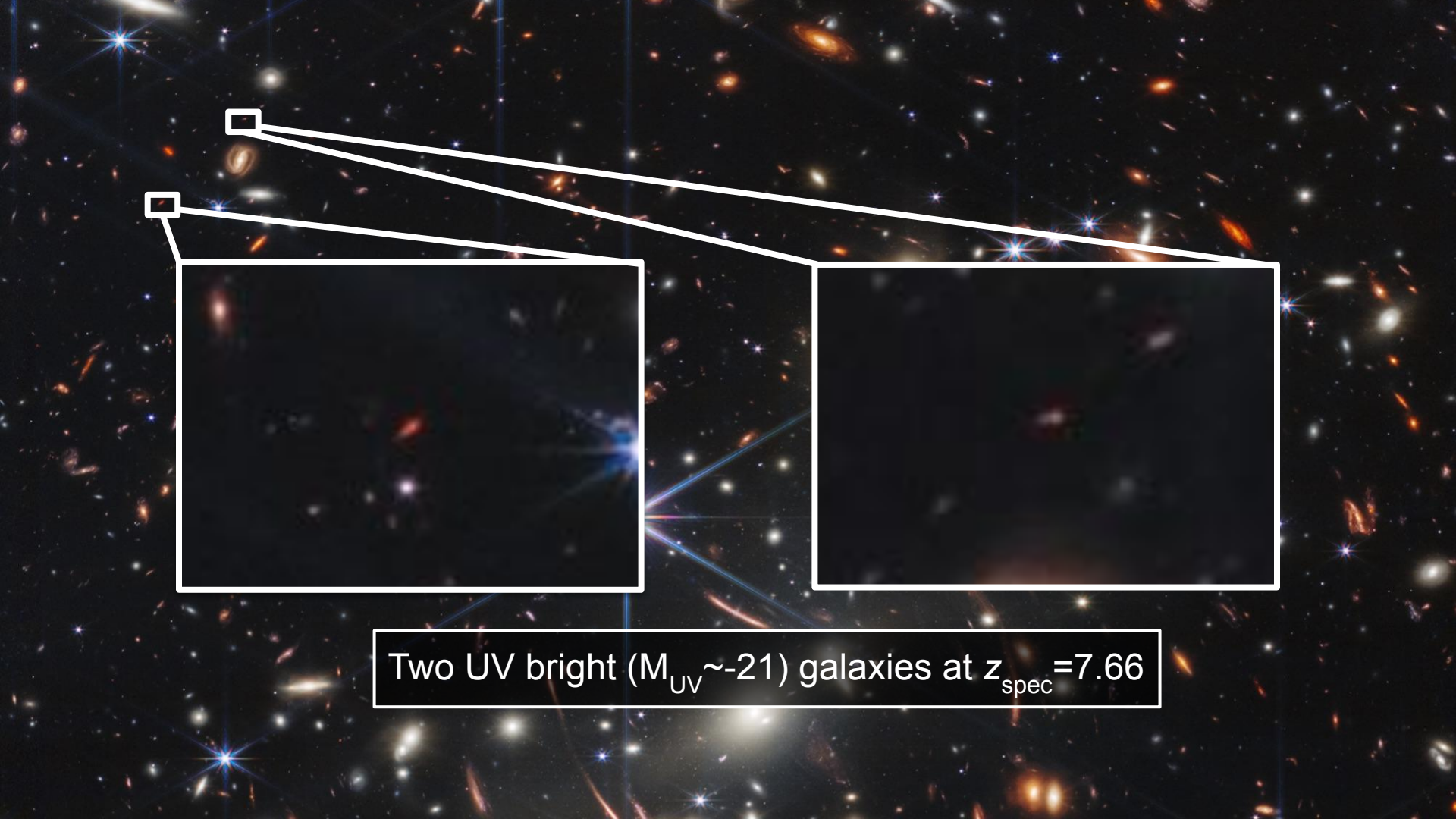


The evolution of extremely overdense environments in the very early Universe

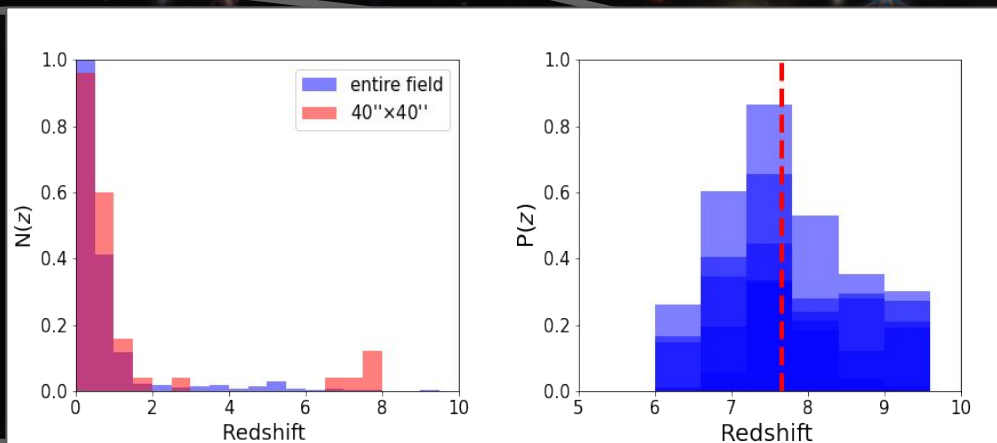
Callum Witten
Stockholm – 28th June 2024

Nicolas Laporte & Debora Sijacki





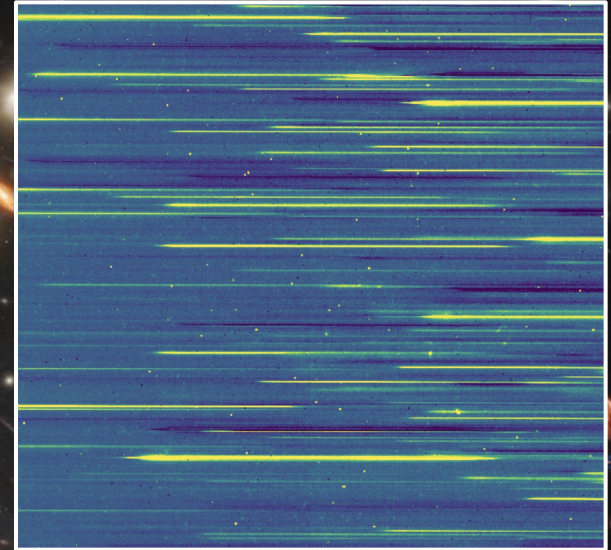
Two UV bright ($M_{UV} \sim -21$) galaxies at $z_{spec} = 7.66$

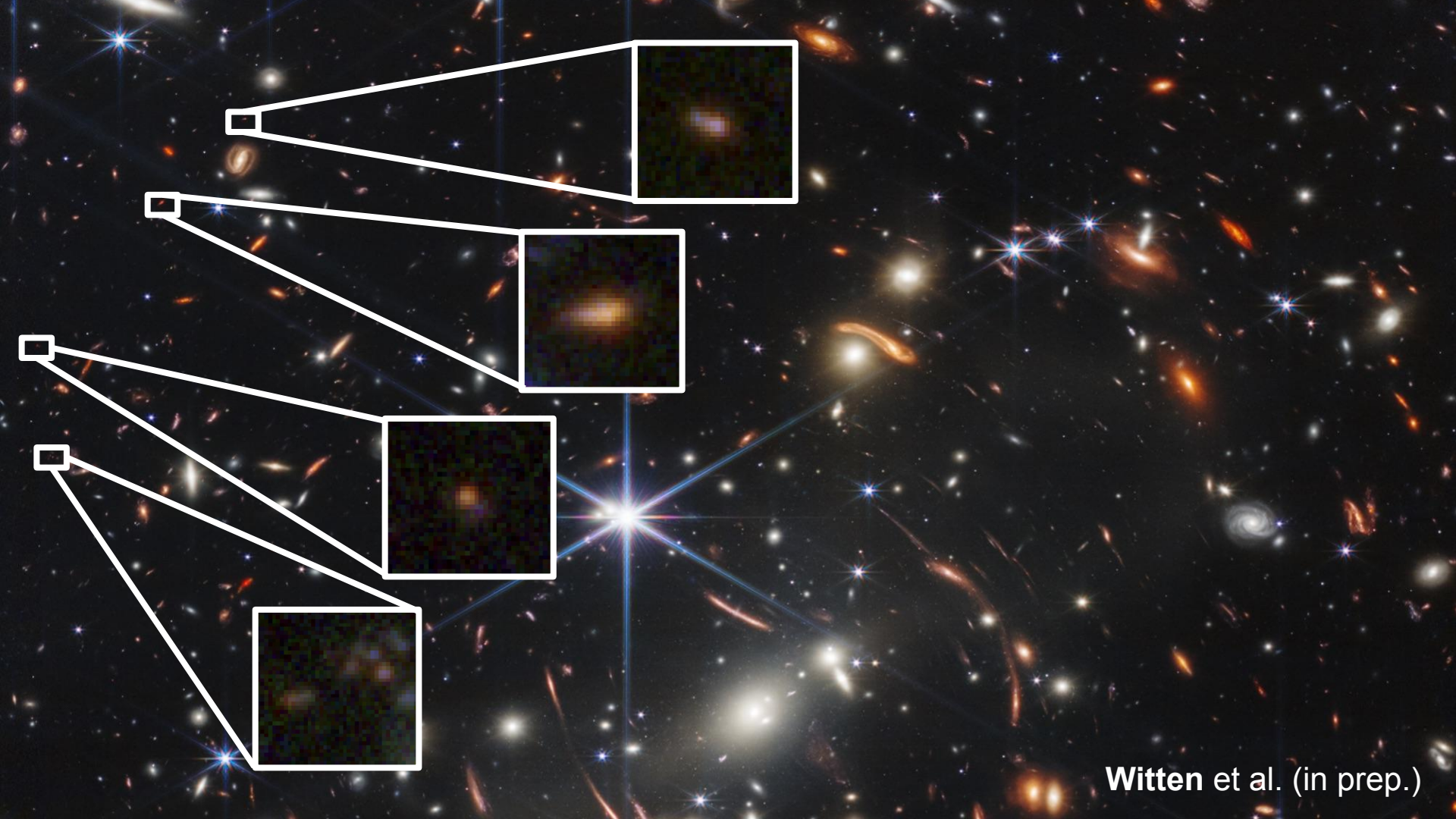


Laporte, **CW** et al. (2022)

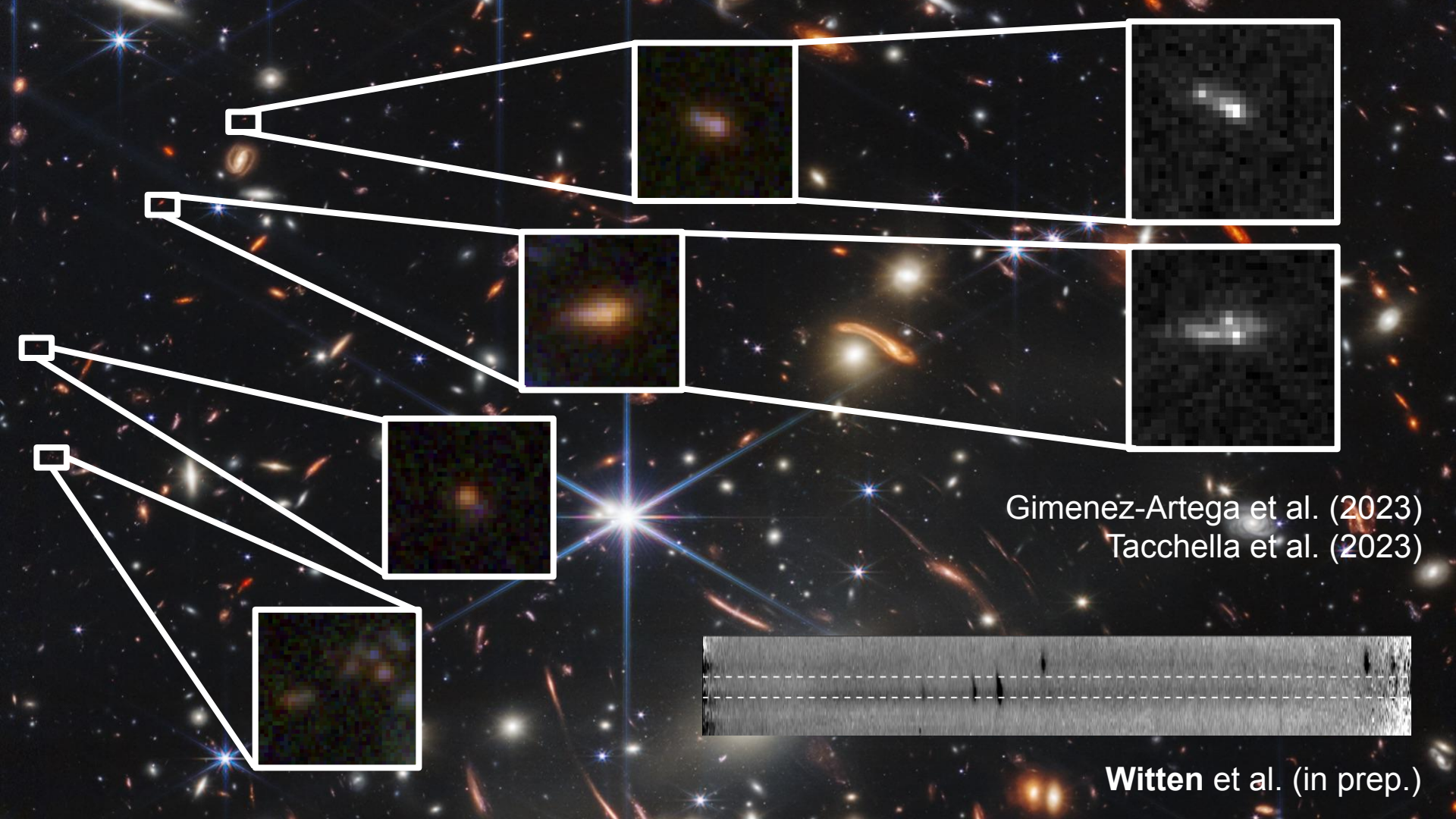
Cycle 2: GO 4043 (PI: Witten)

- NIRCам F444W Grism
- Exposure time ~15 hours
- Area of a single NIRCам pointing
- R and C Grism directions





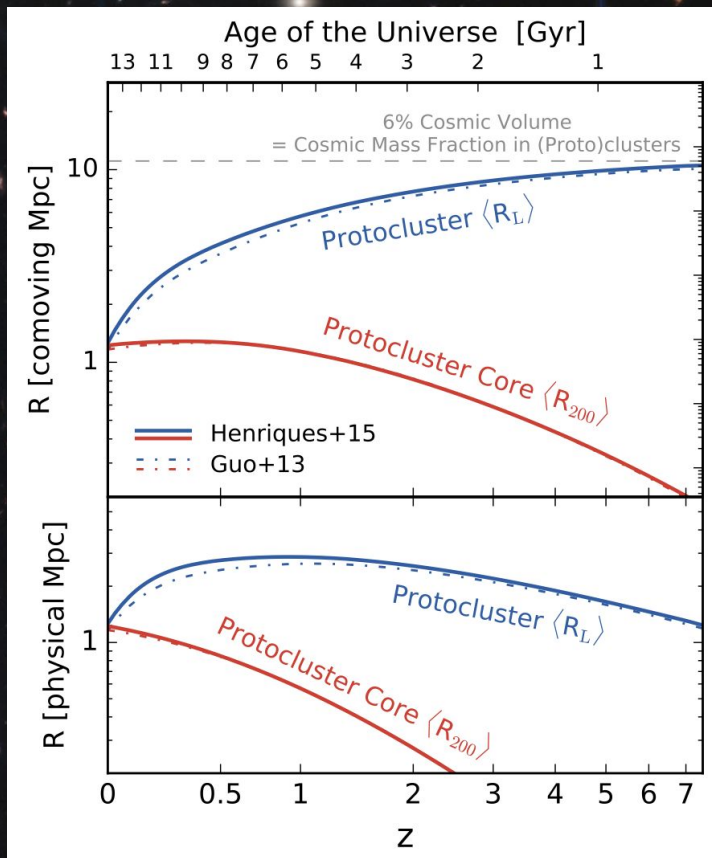
Witten et al. (in prep.)



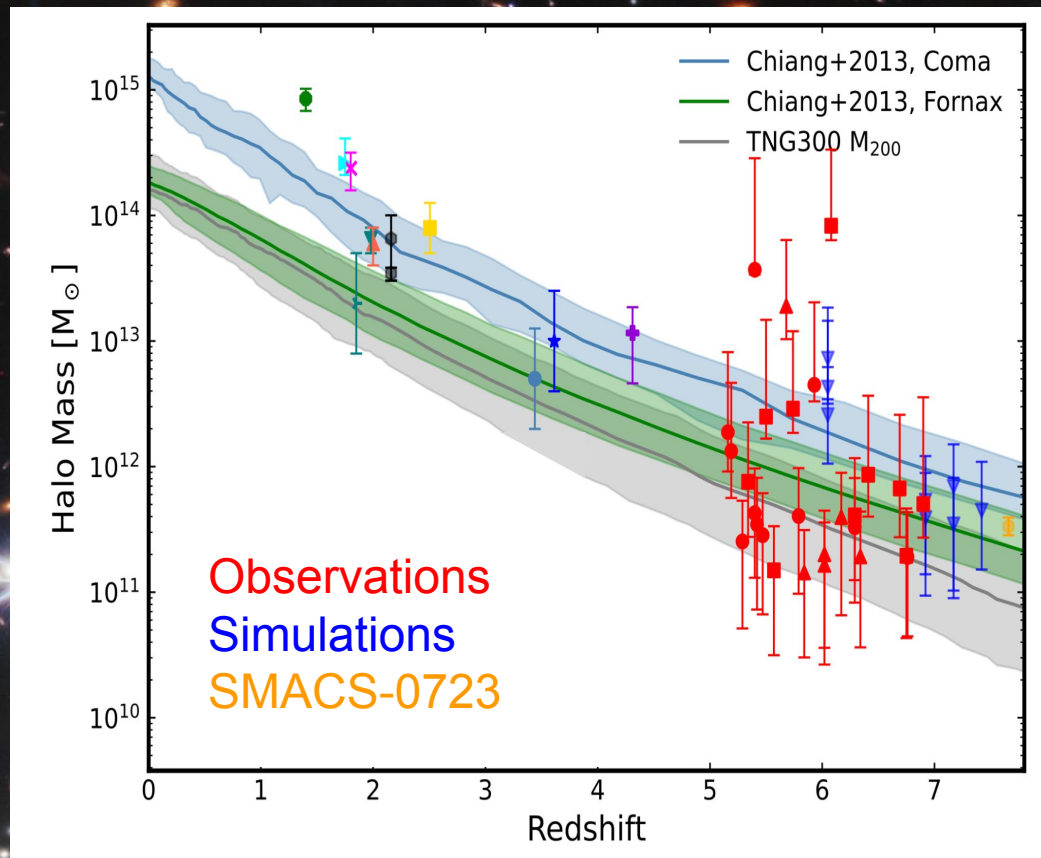
Gimenez-Artega et al. (2023)

Tacchella et al. (2023)

Witten et al. (in prep.)



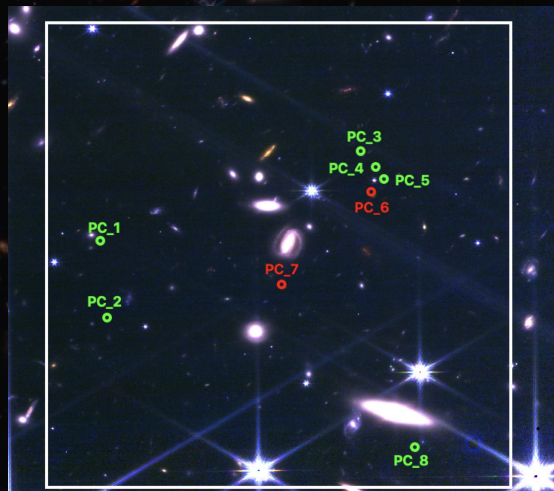
Chiang et al. (2017)



Li et al. (2024)

SMACS0723-PC

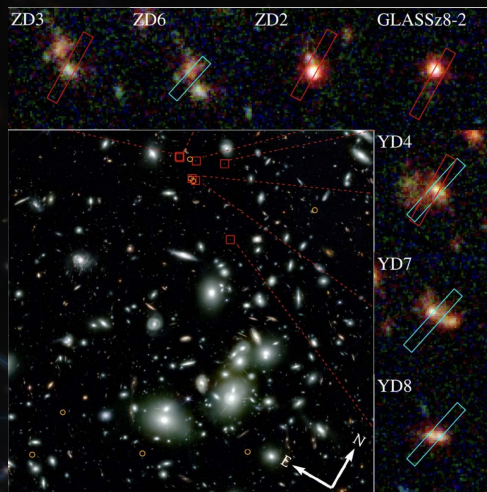
$z = 7.66$



Laporte, **CW** et al. (2022)
Witten et al. (in prep.)

A2744-z7p90D

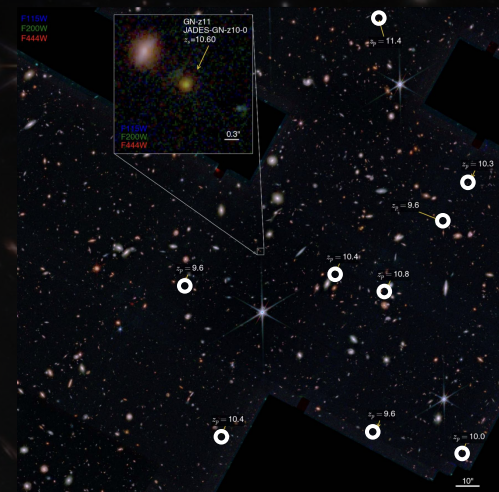
$z = 7.88$



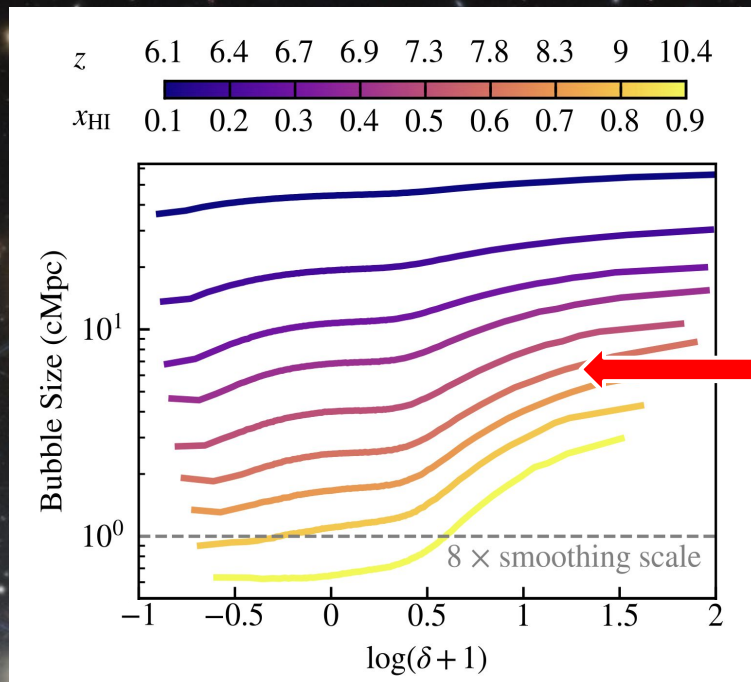
Morishita et al. (2023)
Hashimoto et al. (2023)

GN-z11

$z = 10.6$



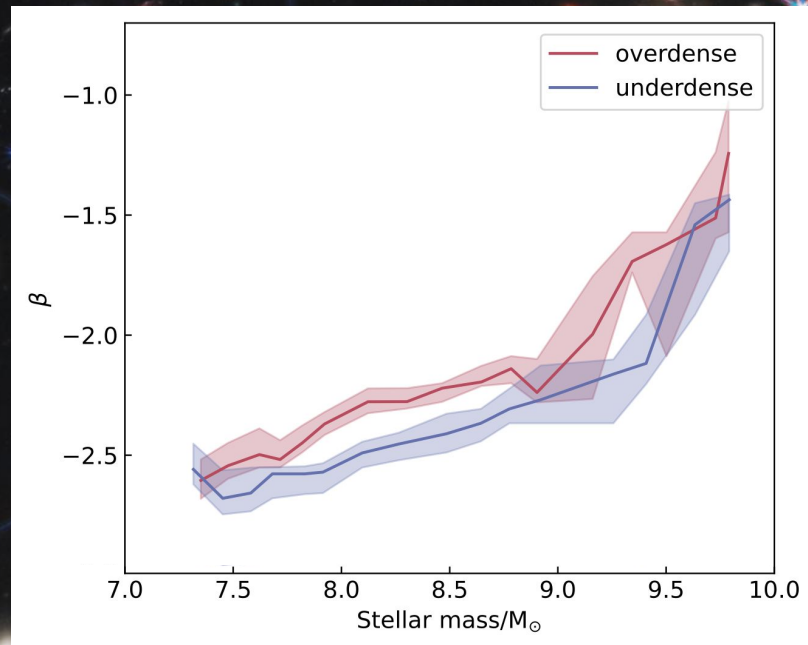
Tacchella et al. (2023a)
Scholtz & Witten et al. (2024)



THESAN Simulations

Neyer et al. (2023)

Dust properties



Li et al. (2024)

SMACS0723-PC

A2744-z7p90D

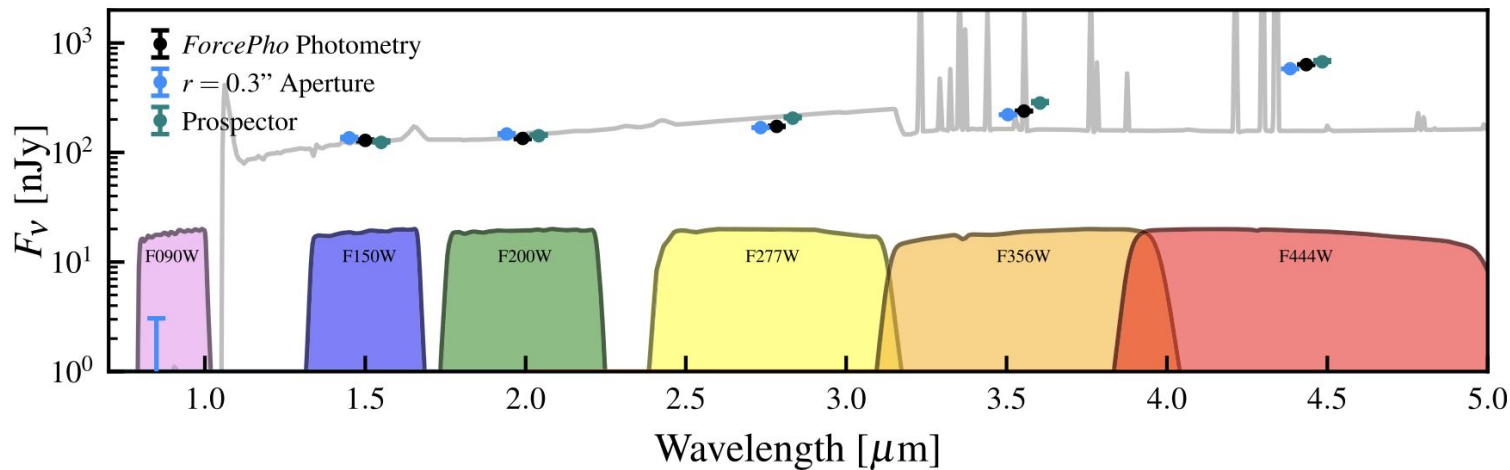
GN-z11

$z = 7.66$

$z = 7.88$

$z = 10.6$

Core?



Tacchella et al. (2023b)

SMACS0723-PC

$z = 7.66$

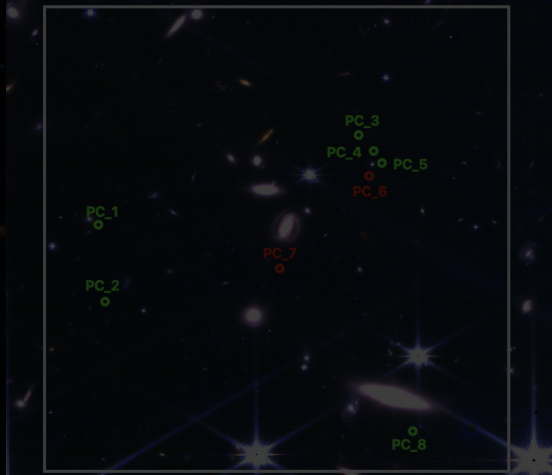
A2744-z7p90D

$z = 7.88$

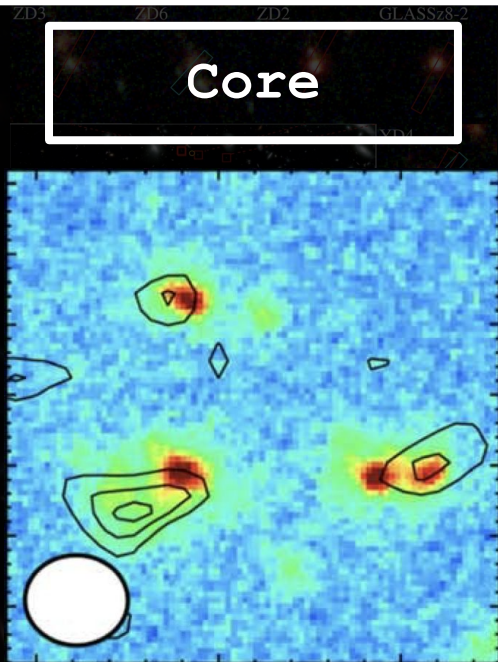
GN-z11

$z = 10.6$

Core



Laporte, CW et al. (2022)
Witten et al. (in prep.)



Hashimoto et al. (2023)



Tacchella et al. (2023)
Scholtz & Witten et al. (2024)

A deep field galaxy image showing a vast field of galaxies in various colors and orientations, with a white text box overlaid in the center.

Do we see old stellar populations in overdense regions?

SMACS0723-PC

$z = 7.66$

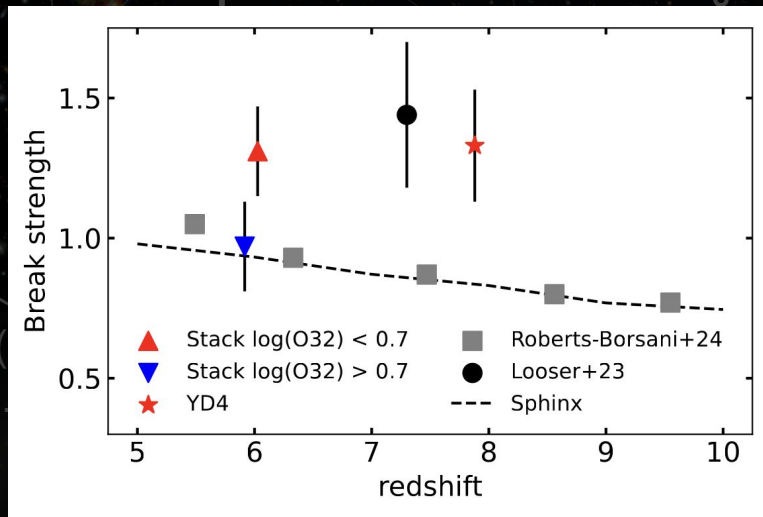
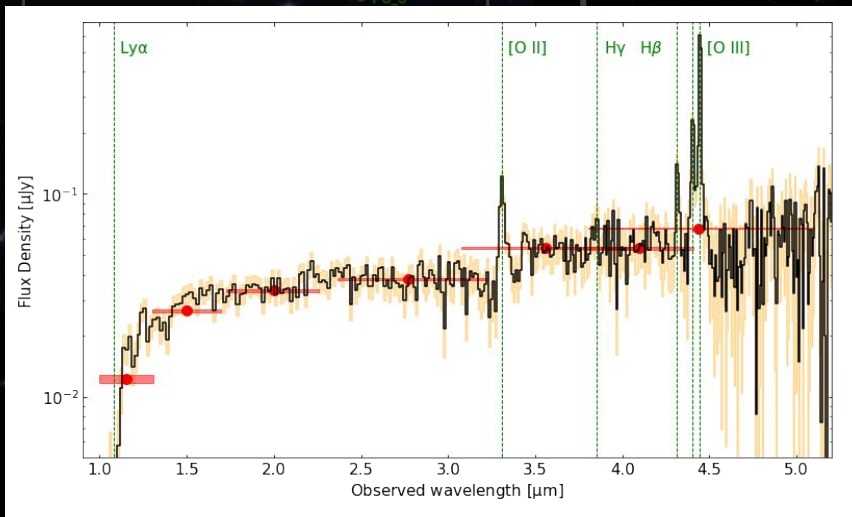
A2744-z7p9OD

$z = 7.88$

GN-z11

$z = 10.6$

Core



Witten et al. (in prep.)

SMACS0723-PC

A2744-z7p9OD

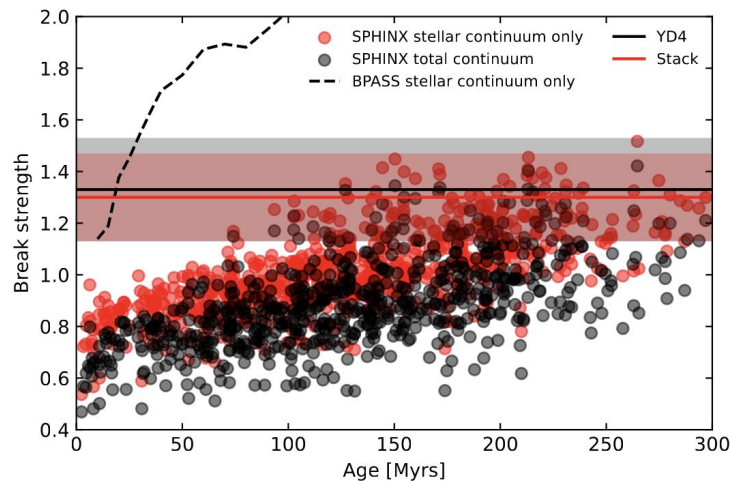
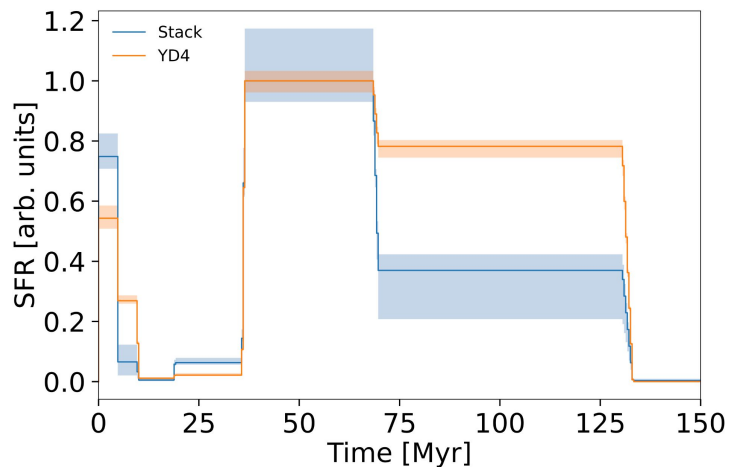
GN-z11

$z = 7.66$

$z = 7.88$

$z = 10.6$

Core



Witten et al. (in prep.)

A deep field image of galaxies, showing a vast field of distant galaxies in various colors (blue, orange, white) and shapes (spiral, elliptical, irregular). The background is dark with many small, faint galaxies. A white text box is overlaid in the center, containing the question: "What does this mean for Ly- α emission?".

What does this mean for Ly- α emission?

Ly- α emission



Witten et al. (2024)

See also Witstok et al. (2023), Witstok et al. (2024), Tang et al. (2023), Jung et al. (2023), Chen et al. (2024) etc.

SMACS0723-PC

$z = 7.66$

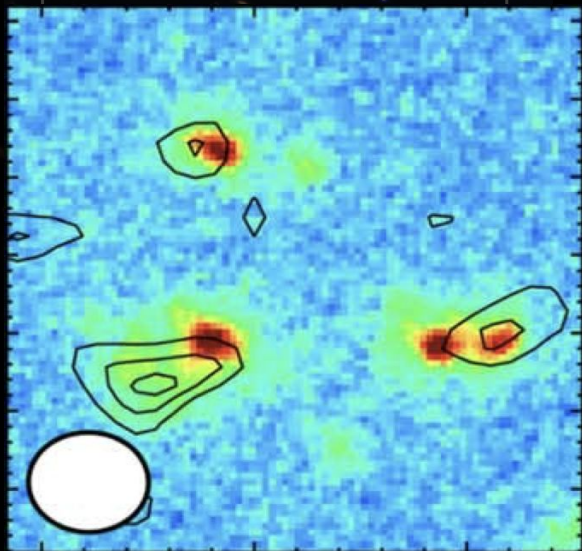
A2744-z7p90D

$z = 7.88$

GN-z11

$z = 10.6$

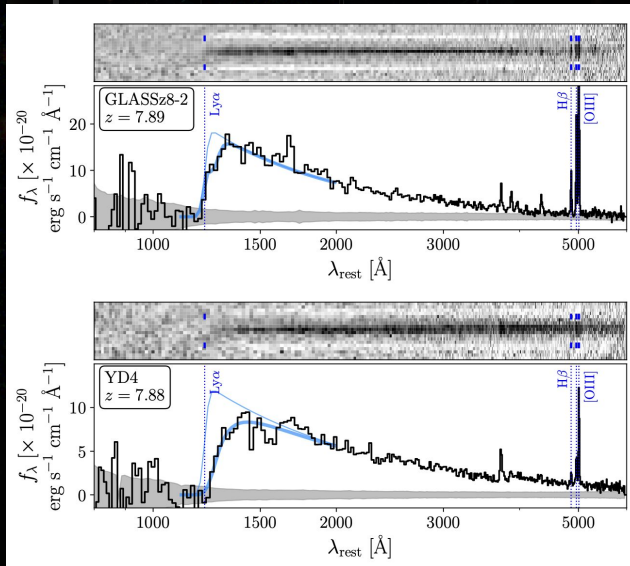
Core



Hashimoto et al. (2023)



Morishita et al. (2023)
Hashimoto et al. (2023)



Chen et al. (2024)

SMACS0723-PC

A2744-z7p90D

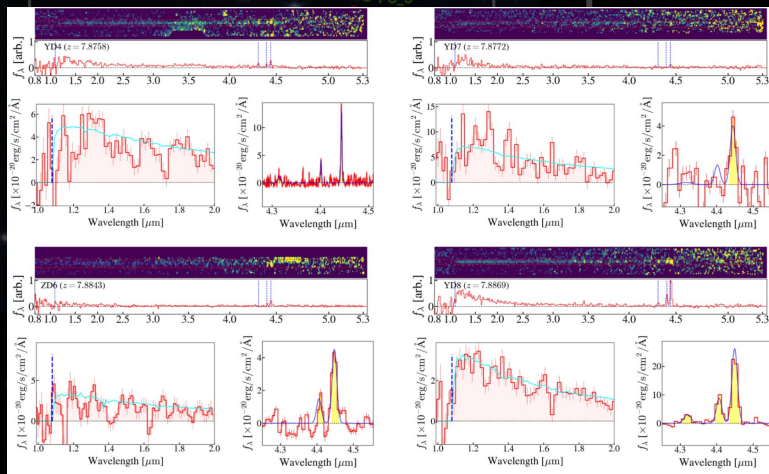
GN-z11

$z = 7.66$

$z = 7.88$

$z = 10.6$

Core



Morishita et al. (2023)

ZD3 ZD6 ZD2 GLASSz8-2

YD4

YD7

YD8

Morishita et al. (2023)
Morishita et al. (2023)

Tacchella et al. (2023)
Scholtz & Witten et al. (2024)

SMACS0723-PC

A2744-z7p9OD

GN-z11

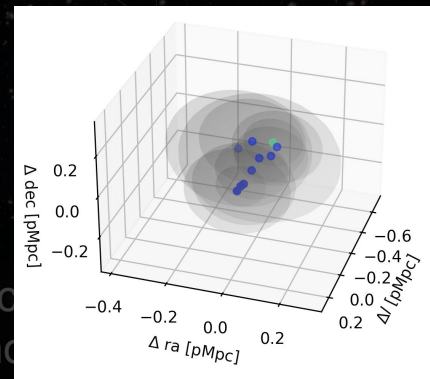
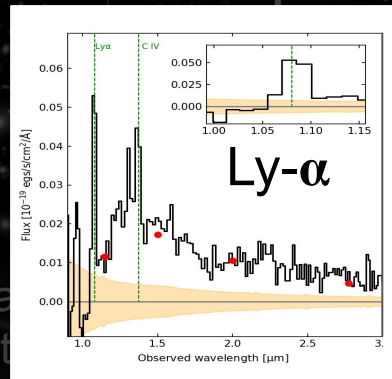
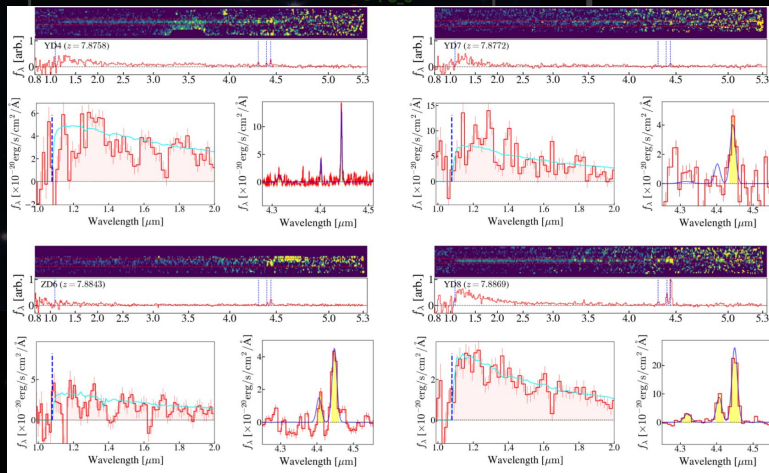
$z = 7.66$

$z = 7.88$

$z = 10.6$

Core

Outskirts



Morishita et al. (2023)

Cameron & Katz, Witten et al. (2024)
Chen et al. (2024)

SMACS0723-PC

$z = 7.66$

A2744-z7p90D

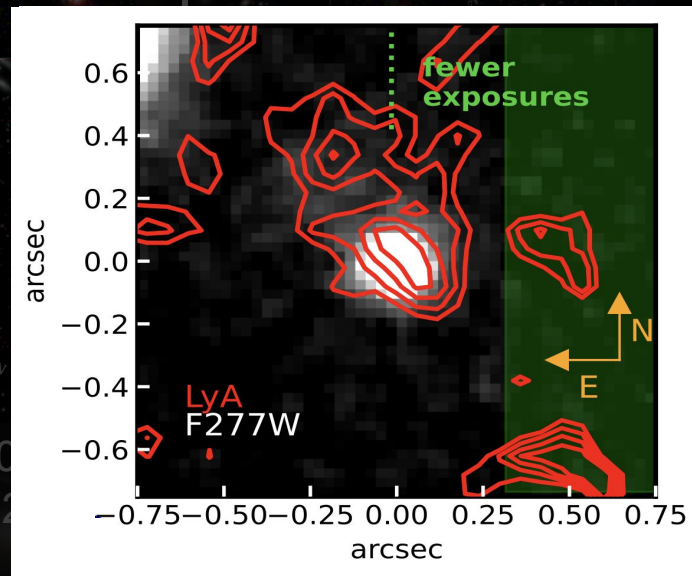
$z = 7.88$

GN-z11

$z = 10.6$

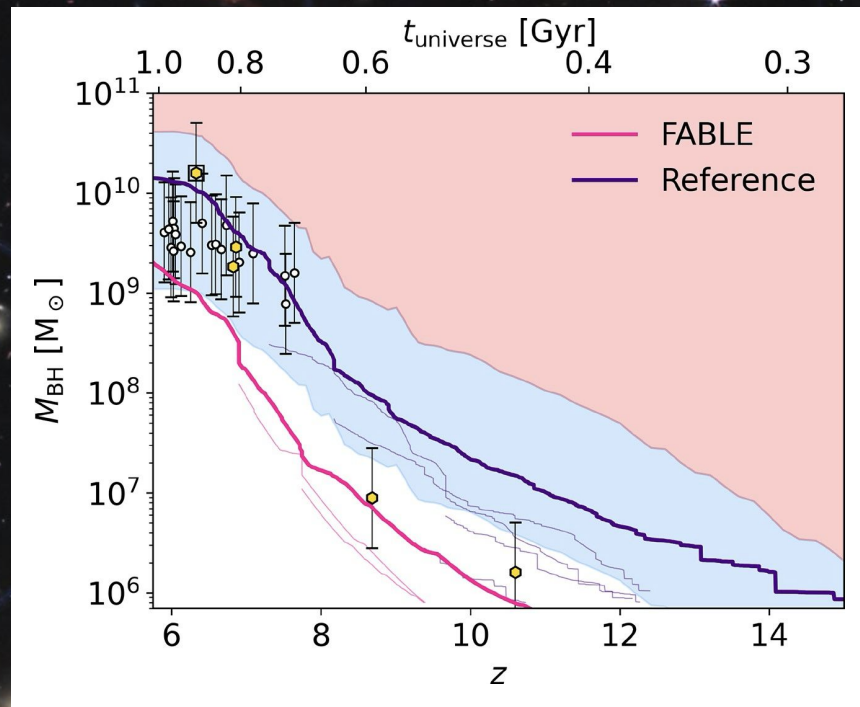


PI: Laporte



Scholtz & Witten et al. (2024)

AGN



Bennett, **CW** et al. (2024)

SMACS0723-PC

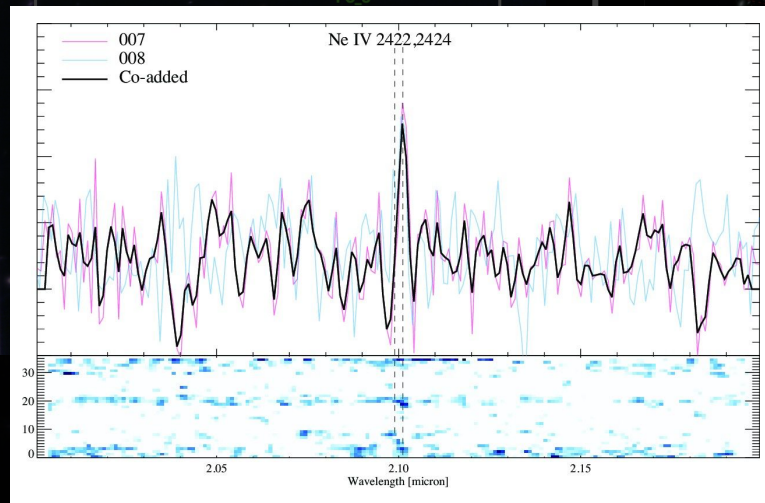
$z = 7.66$

A2744-z7p90D

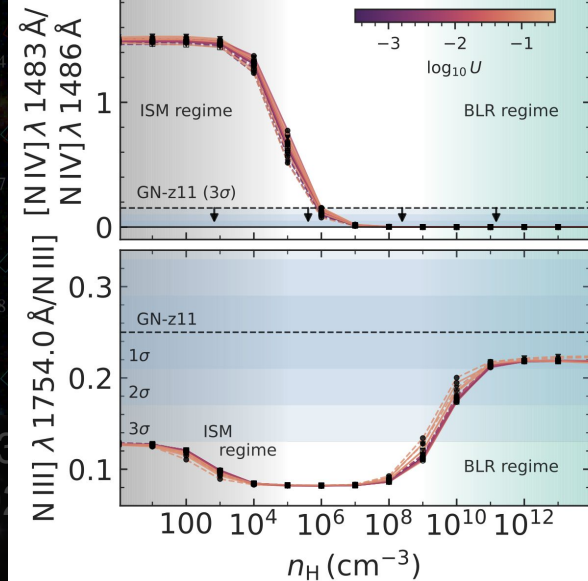
$z = 7.88$

GN-z11

$z = 10.6$



Brinchmann et al. (2023)



Maiolino et al. (2024)

SMACS0723-PC

$z = 7.66$

- Scales of ~10's pkpc
- 6 spectroscopically confirmed galaxies
- Massive central galaxy
- Dust enriched central galaxy
- Possible AGN
- No Ly- α emission detected (Lapina et al. (2022), Witten et al. (in prep.))
- Outskirts appear less evolved

A2744-z7p90D

$z = 7.88$

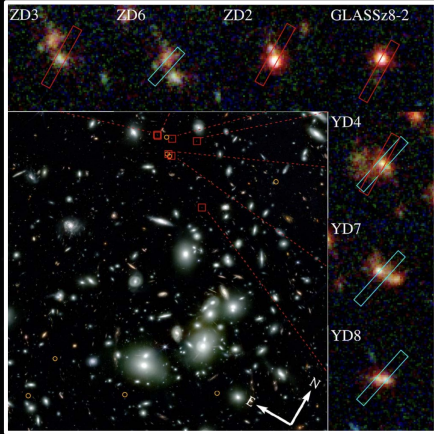
- Scales of ~10's pkpc
- 7 spectroscopically confirmed galaxies
- Massive and mature central galaxies
- Dust and chemically enriched central galaxies (Moriya et al. (2023), Hashimoto et al. (2023))
- Young, metal-poor, LAEs in outskirts

GN-z11

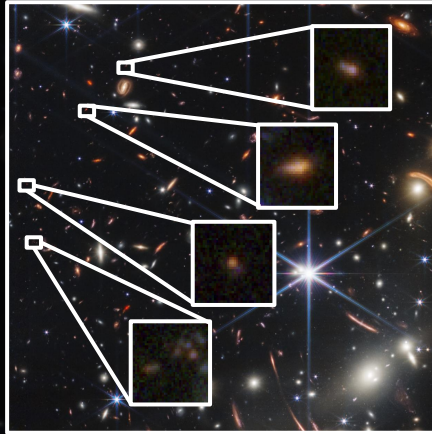
$z = 10.6$

- Scales of ~1 pMpc
- 4 spectroscopic candidate galaxies, many photometric candidates
- AGN hosting central galaxies
- All candidate galaxies appear dust poor (Tacconi et al. (2023), Schenker & Witten et al. (2024))
- Multiple extreme EW LAEs near central

Conclusions




Morishita et al. (2023)



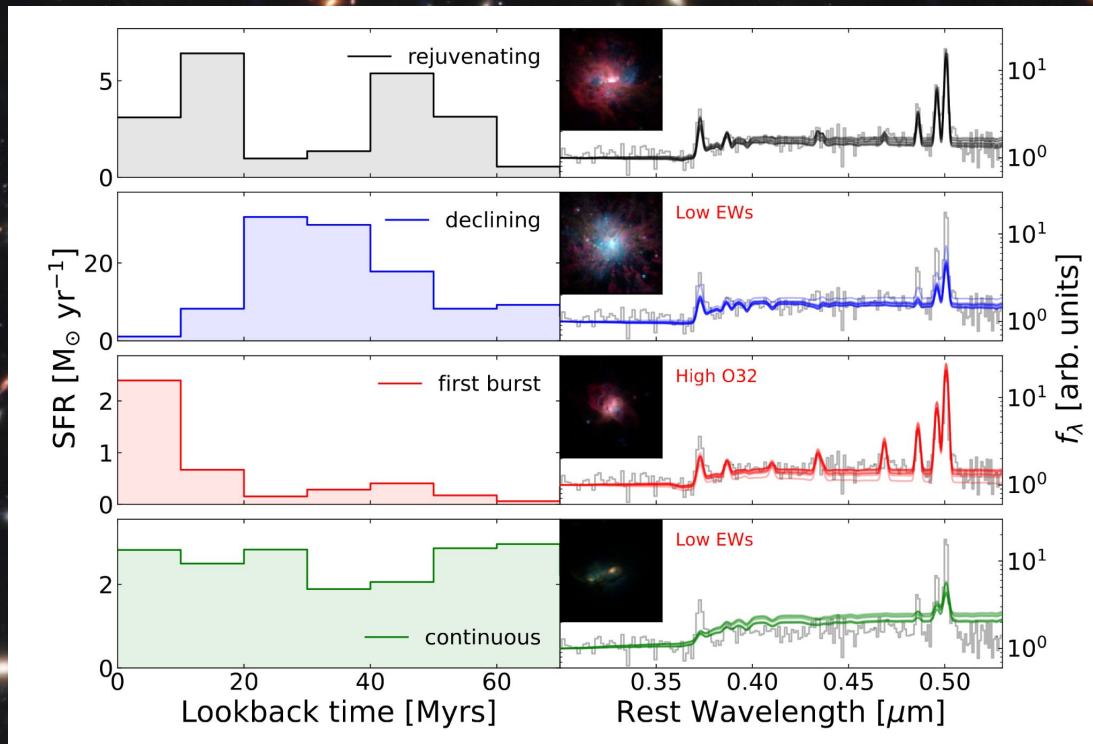
Witten et al. in prep.

- New observations confirm the extreme overdensity SMACS0723-PC
- Observations show chemically enriched, dusty, old cores and younger galaxies in outskirts
- Evidence for rejuvenation on timescales of 20 Myrs
- Ly α emission from outskirts evidencing the formation of an ionised bubble

A dense field of galaxies in various colors (red, orange, yellow, white, blue) with a white text box in the center containing the text "Extra slides".

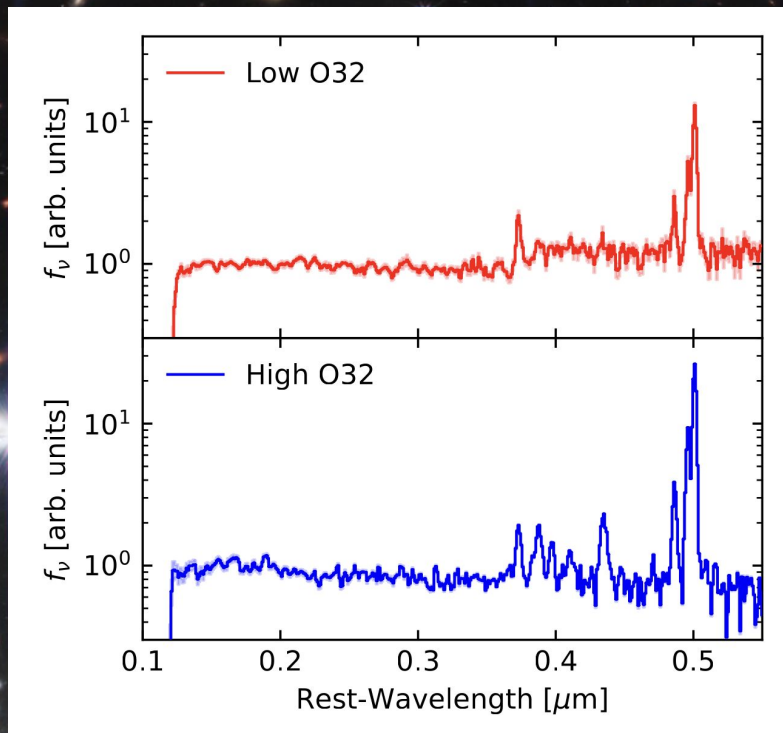
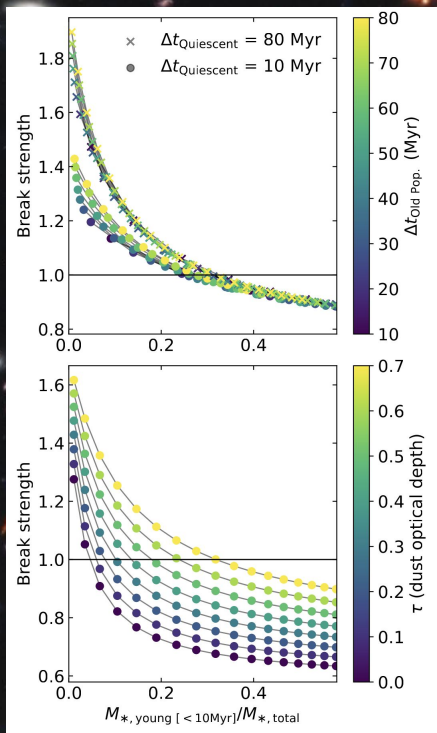
Extra slides

Rejuvenating galaxy modelling



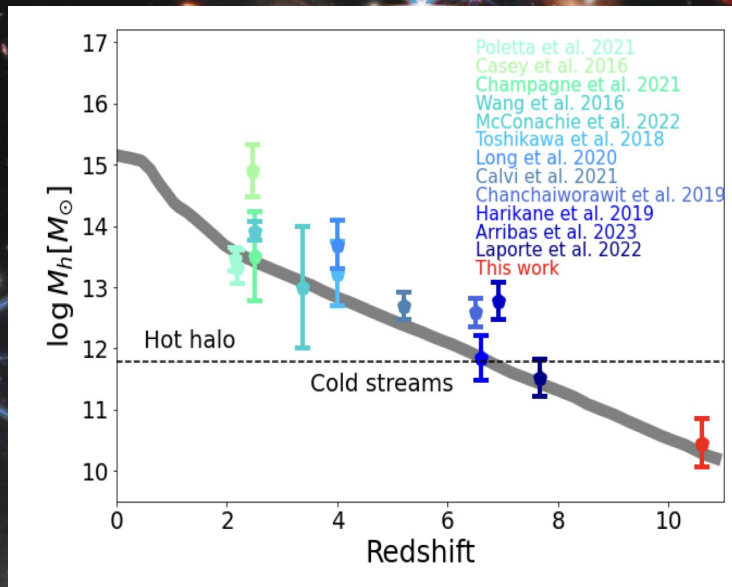
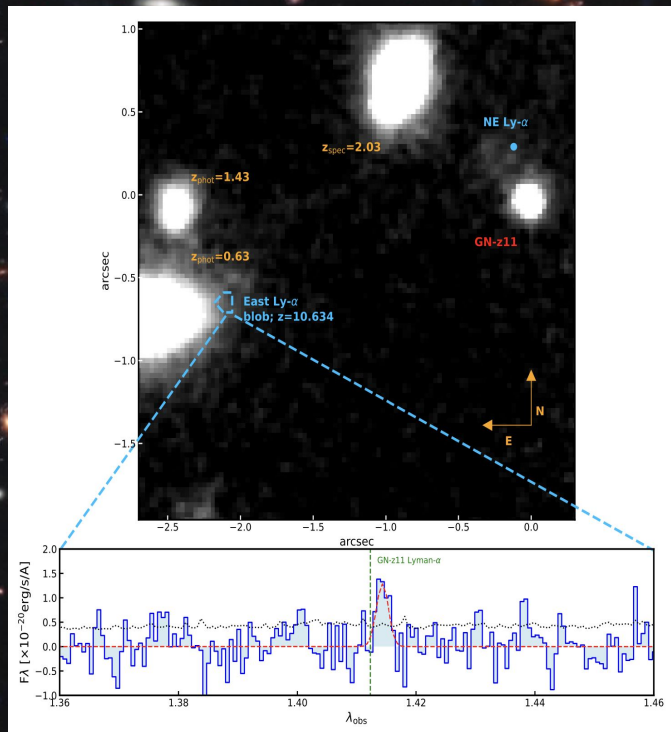
Witten et al. (in prep.)

Rejuvenating galaxy modelling



Witten et al. (in prep.)

GN-z11 protocluster candidate



Scholtz & Witten et al. (2024)