Cosmological puzzles from JWST observations

JULIAN B. MUÑOZ

Based on:

JBM, Mirocha, Sabti, Furlanetto MNRASLett (2023)

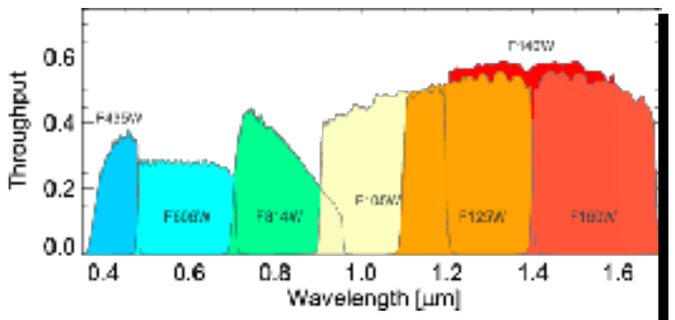
Sabti, JBM, Kamionkowski, PhysRevLett (2023)

JBM, Mirocha, Chisholm, Furlanetto, Mason arXiv (2024)

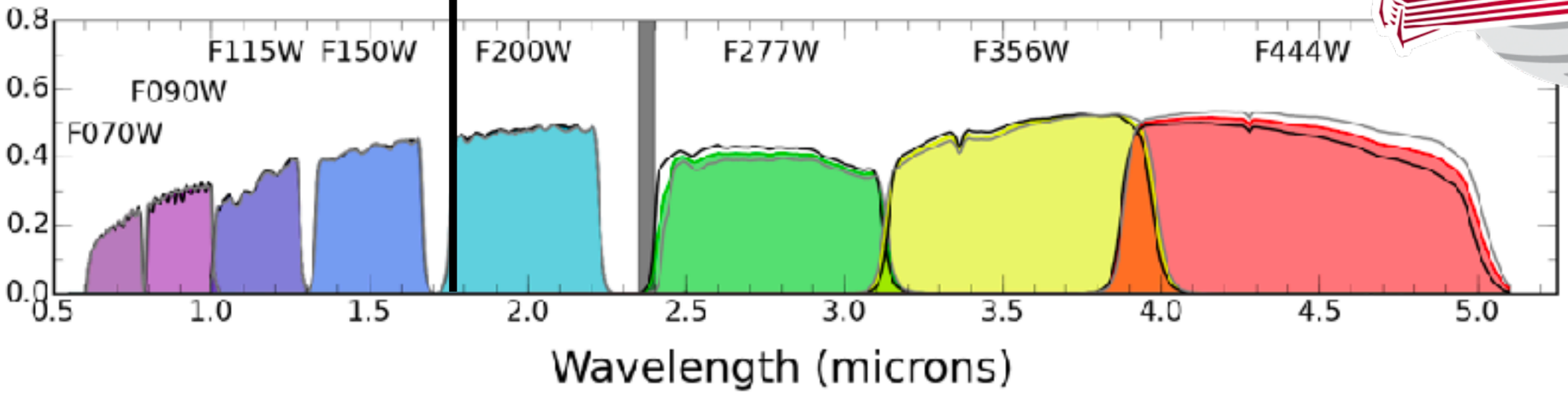
CREDIT: NASA/STSCI/CEERS/TACC/
FINKELSTEIN/M. BAGLEY/R. LARSON/Z. LEVAY

JWST for theorists:

HST



JWST



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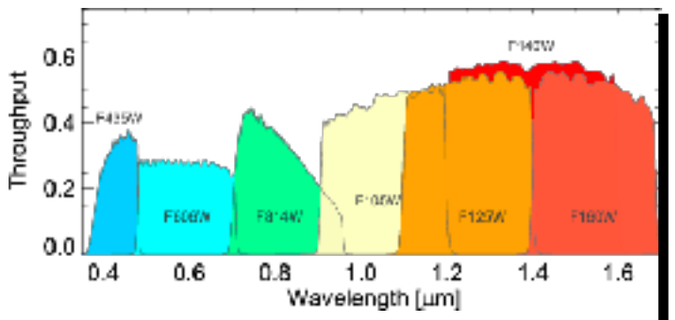
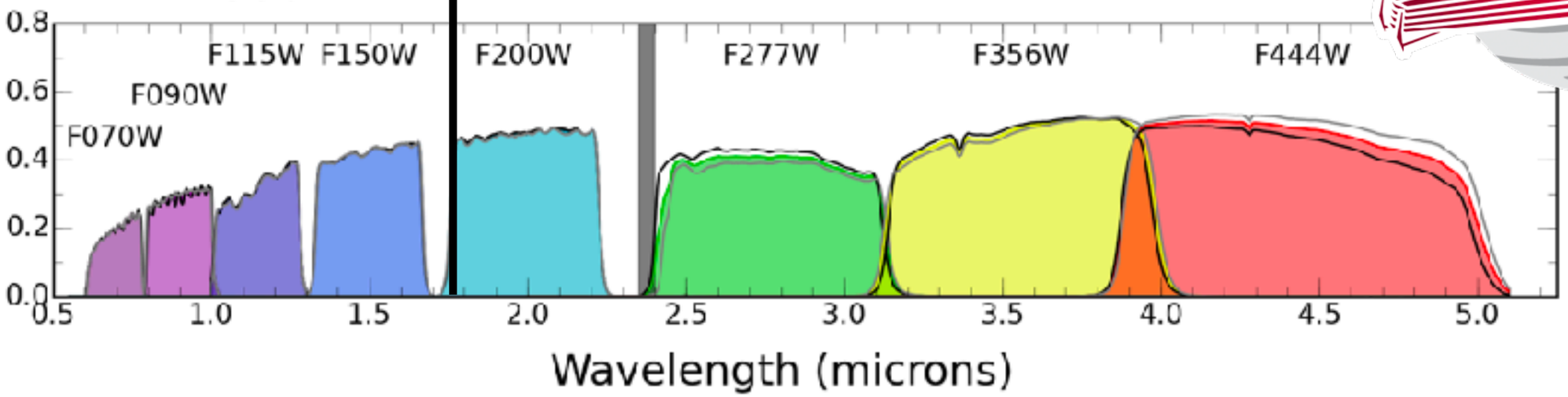


JWST



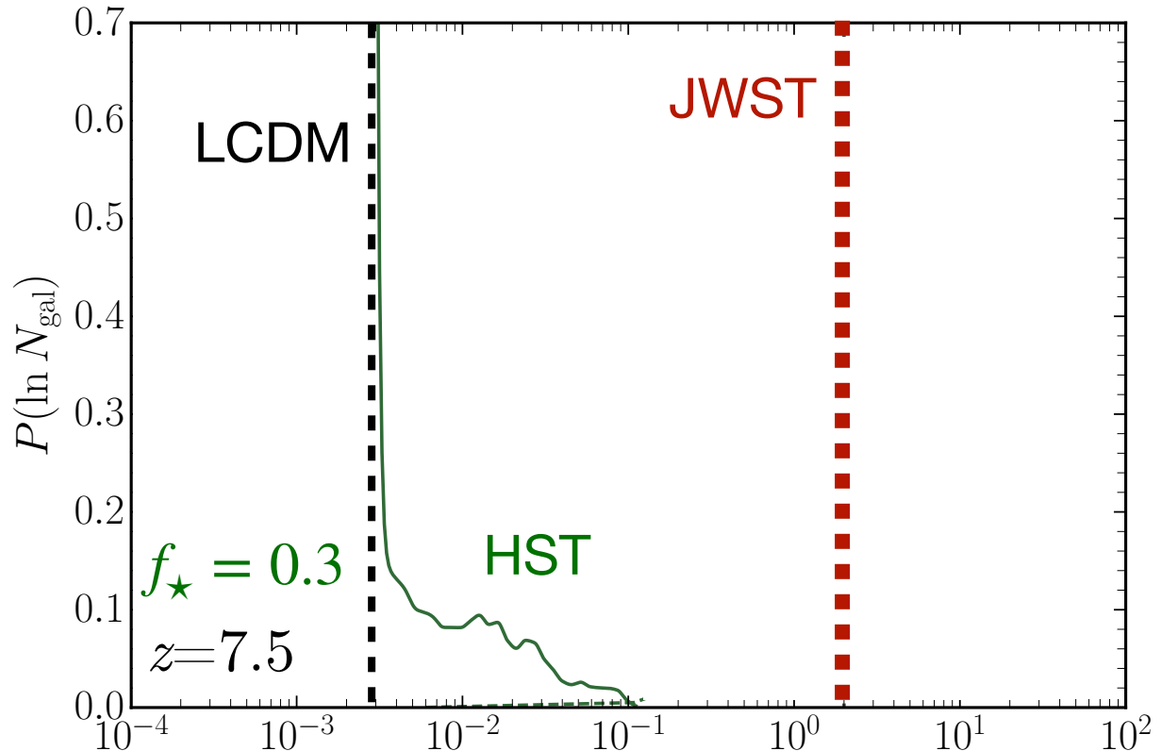
Galaxy properties $\rightarrow \xi_{\rm ion}, M_\star, \ldots$

Reach higher z $\rightarrow$ Earlier Galaxies

JWST tensions?

Massive JWST galaxies don't break LCDM

Cf Labbé+ 23,
Boylan-Kolchin 23



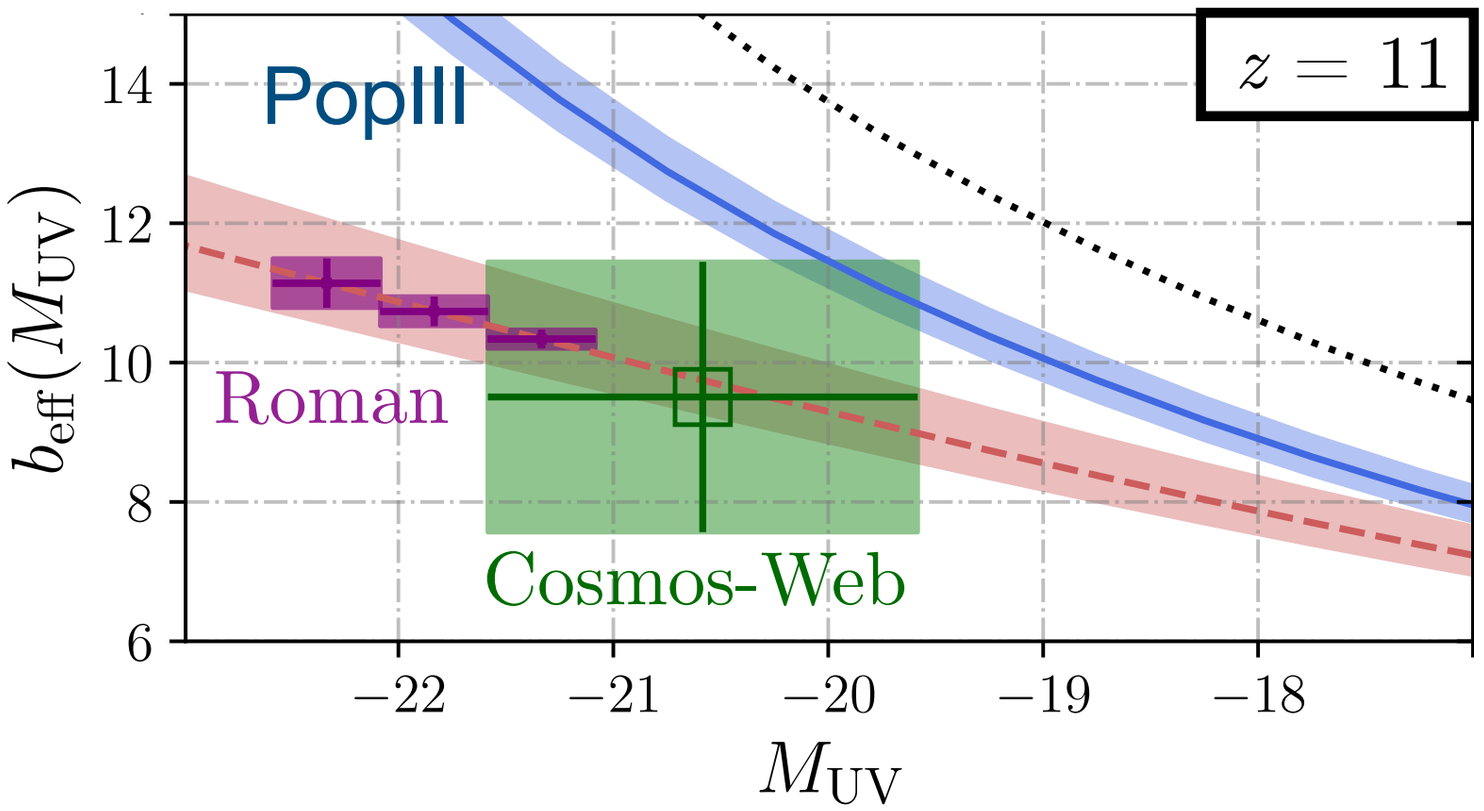
Sabti+
PRL 2024

More tensions?

Massive JWST galaxies don't break LCDM

Cf Labbé+ 23,
Boylan-Kolchin 23

Sabti+
PRL 2024

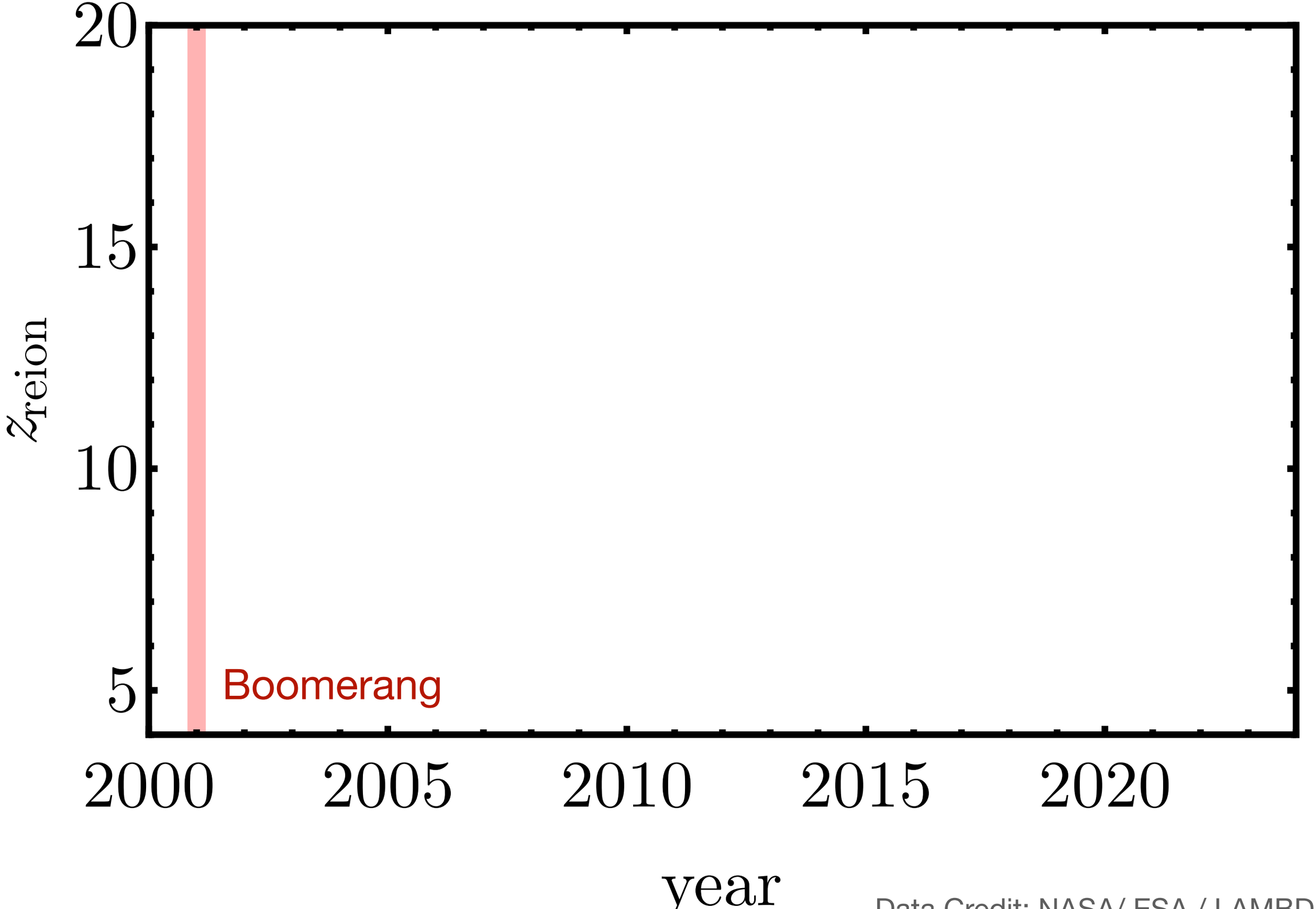


Galaxy clustering will tell us why the UVLF is high

Burstiness

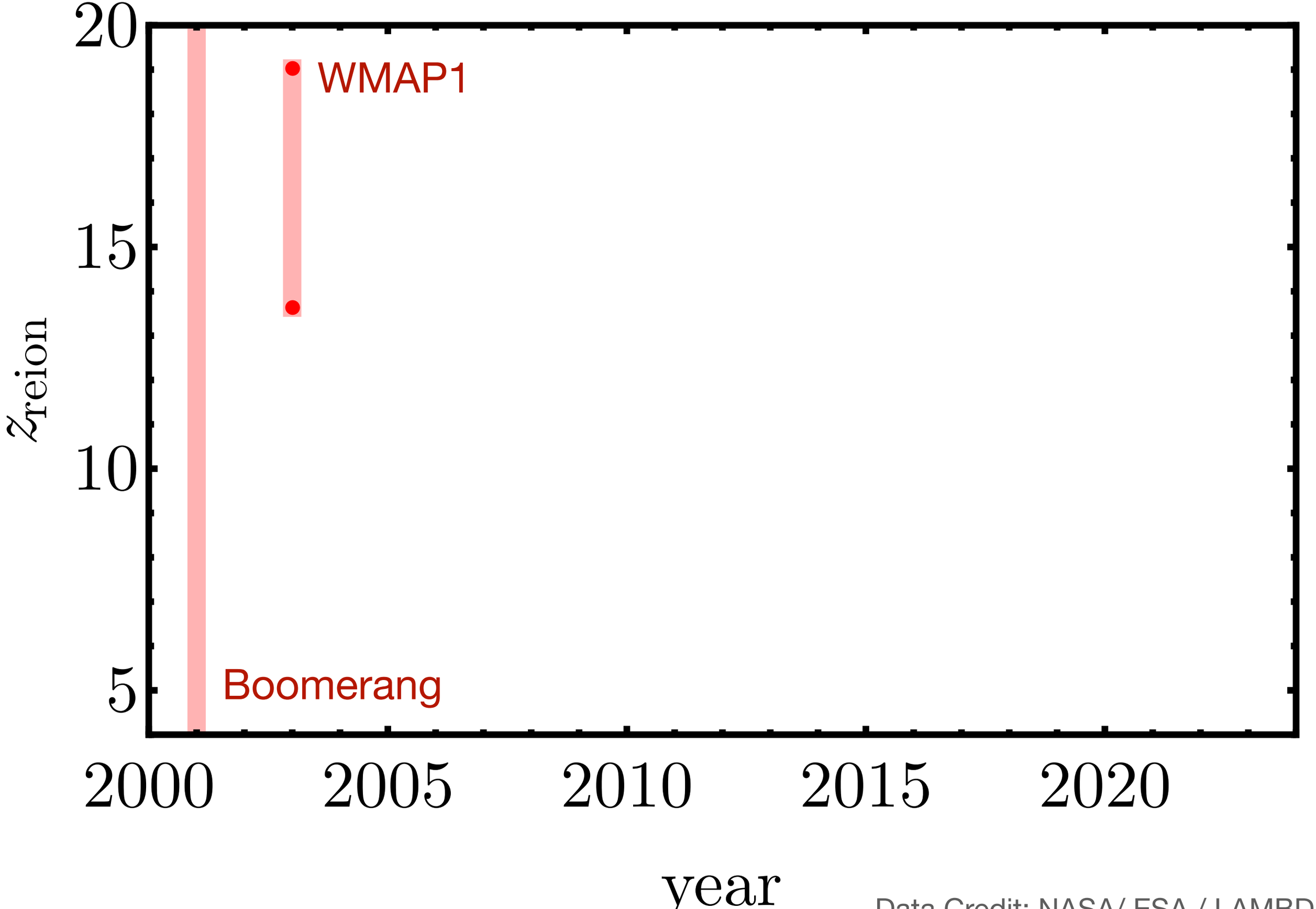
JBM+
MNRAS Lett 2023

Reionization circa 2000:



Data Credit: NASA/ ESA / LAMBDA

Pre-JWST (and Planck!)



Data Credit: NASA/ ESA / LAMBDA

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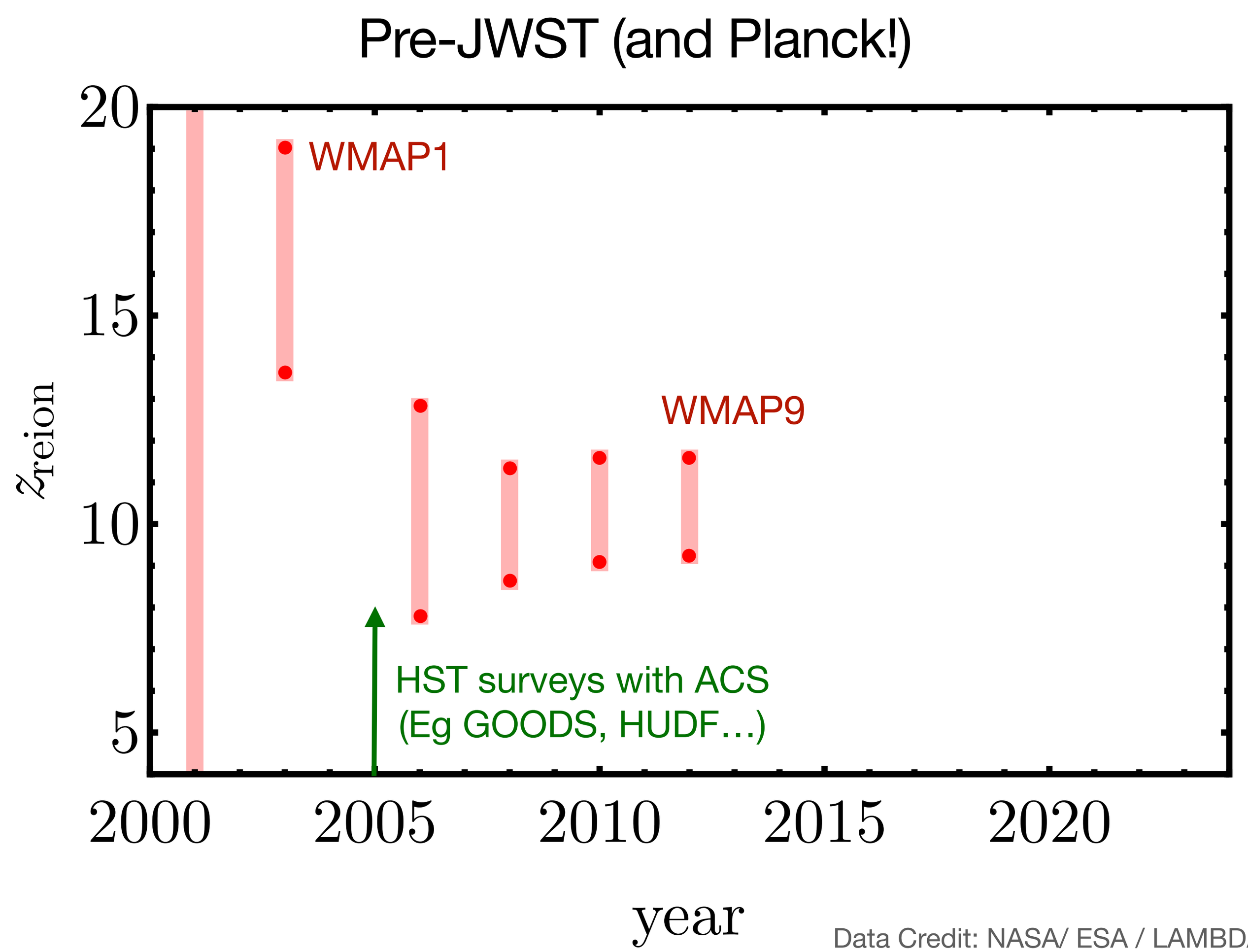
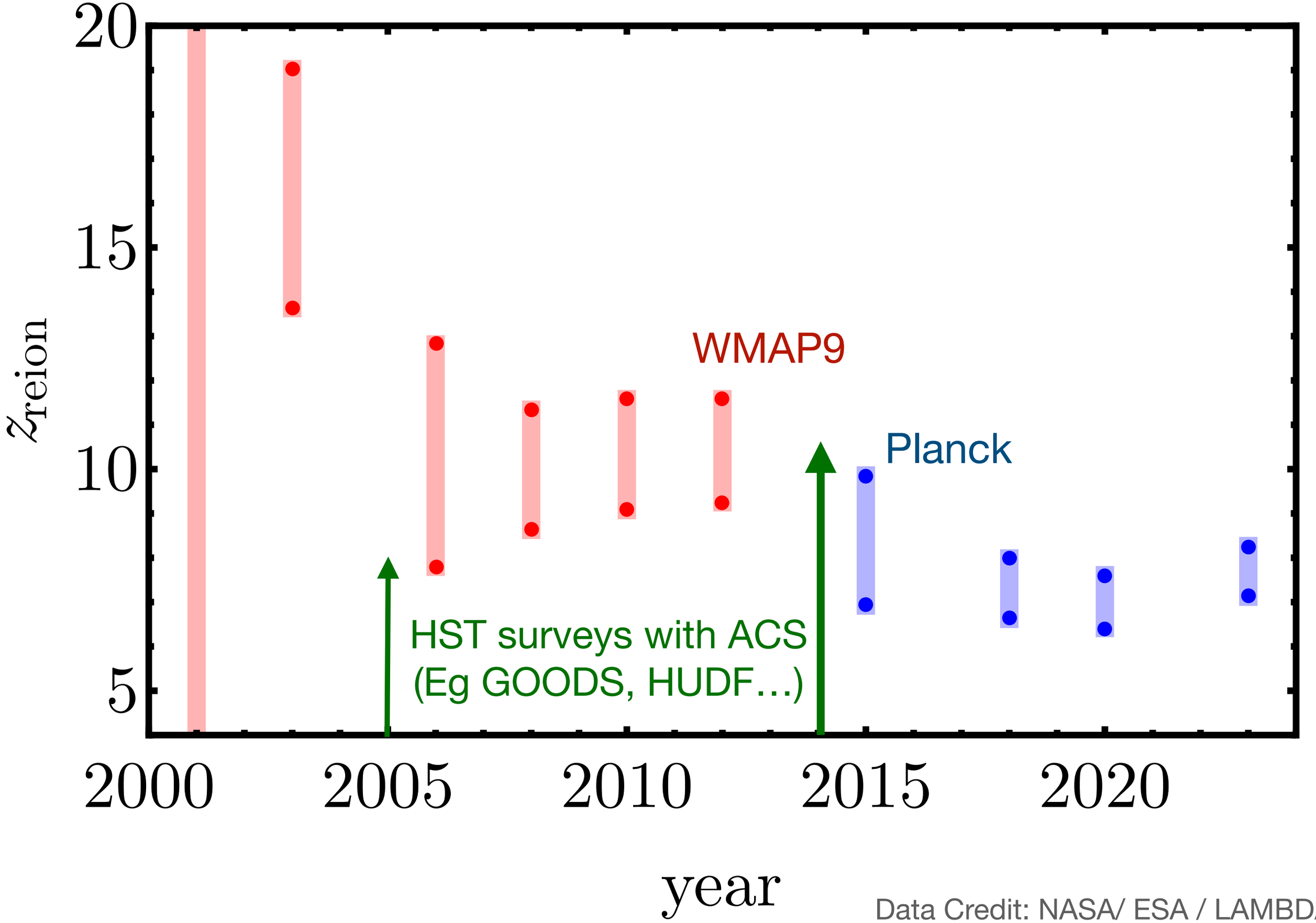


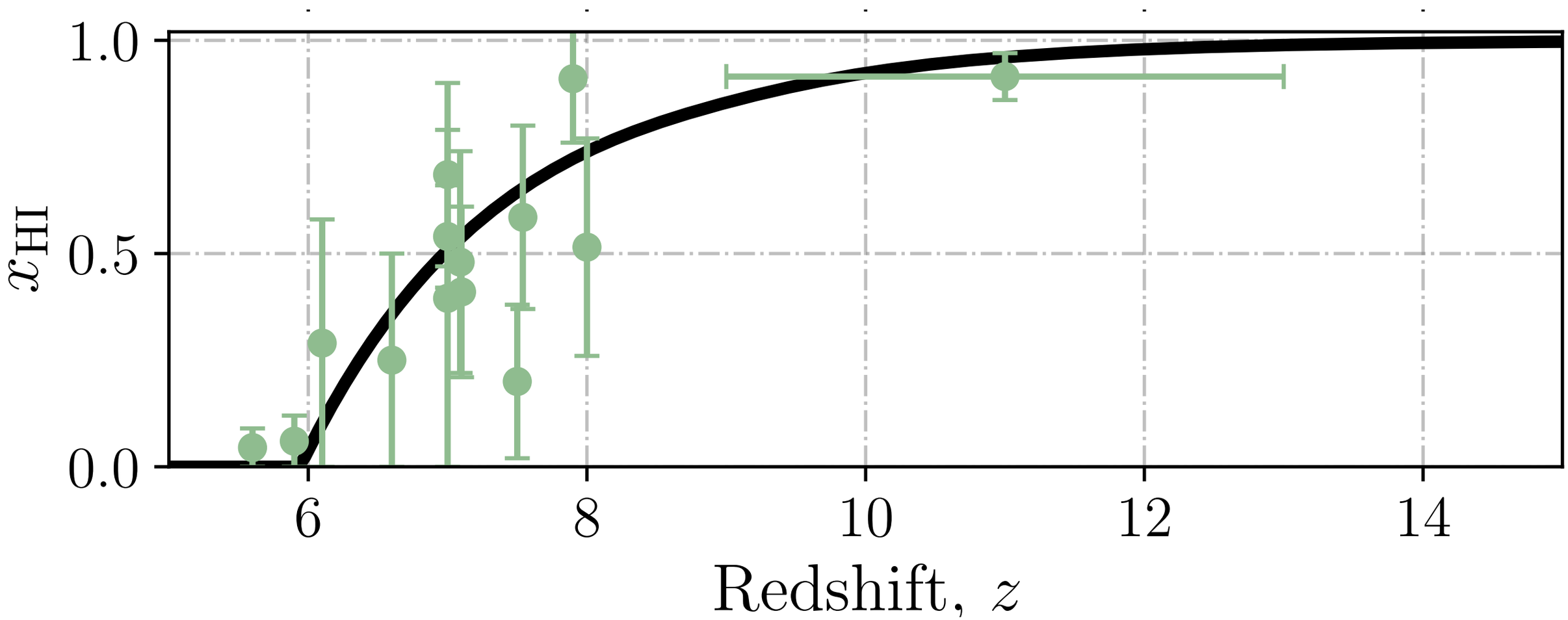
Data Credit: NASA/ ESA / LAMBDA

Post-Planck (but still pre-JWST)



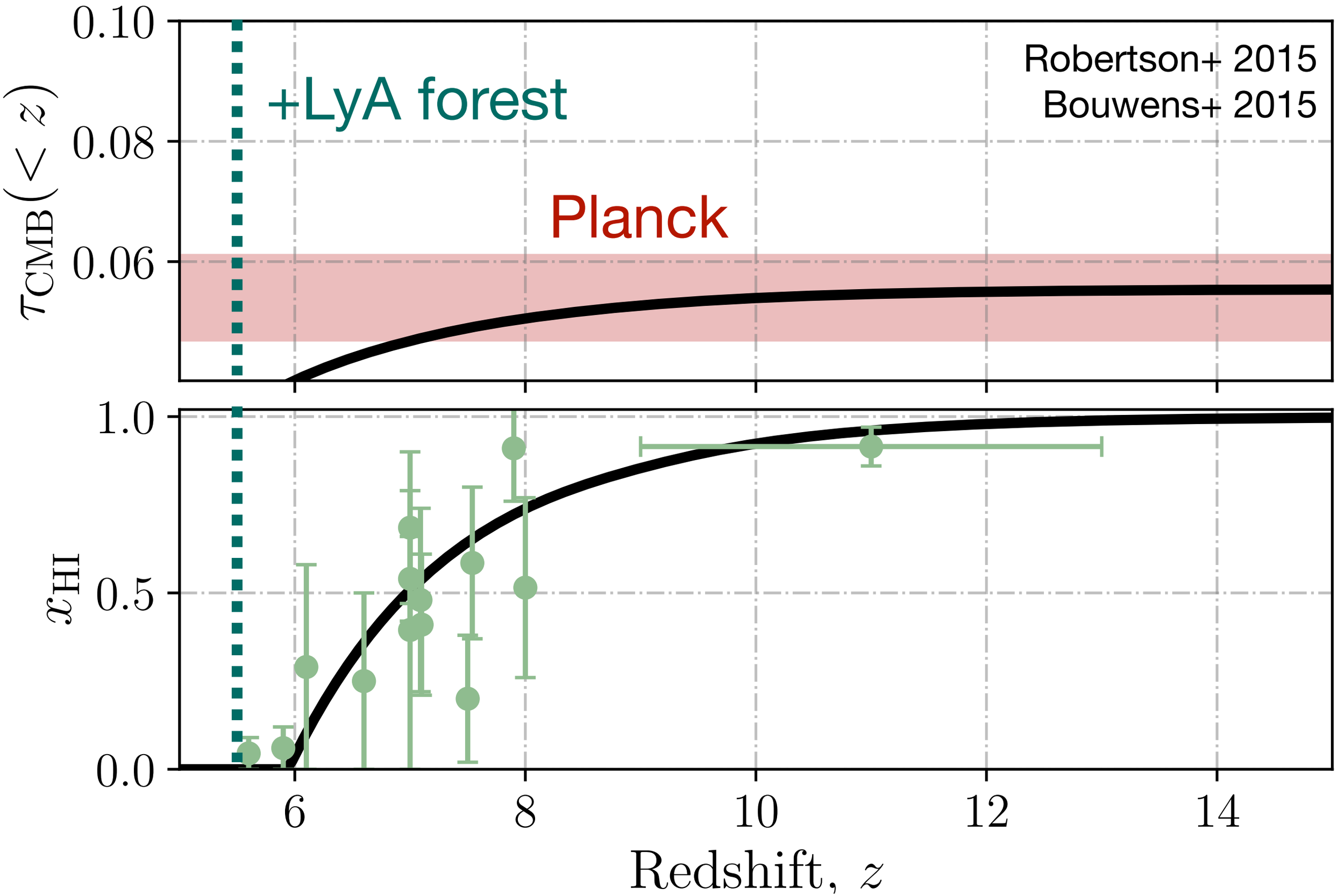
Data Credit: NASA/ ESA / LAMBDA

Circa 2015 (Pre-JWST but post-Planck)



see Madau+15 for AGN

Circa 2015 (Pre-JWST but post-Planck)



What does JWST say?

Eg, Robertson+ 2015 , Bouwens+ 2015,
Finkelstein+19 (See though Madau+15)

What does JWST say?

Ionizing photons per galaxy

$$\dot{n}_{\rm ion} = \int dM_{\rm UV}\, \Phi_{\rm UV}\, \xi_{\rm ion}\, f_{\rm esc}$$

How many galaxies

What fraction escapes

Eg, Robertson+ 2015 , Bouwens+ 2015, Finkelstein+19 (See though Madau+15)

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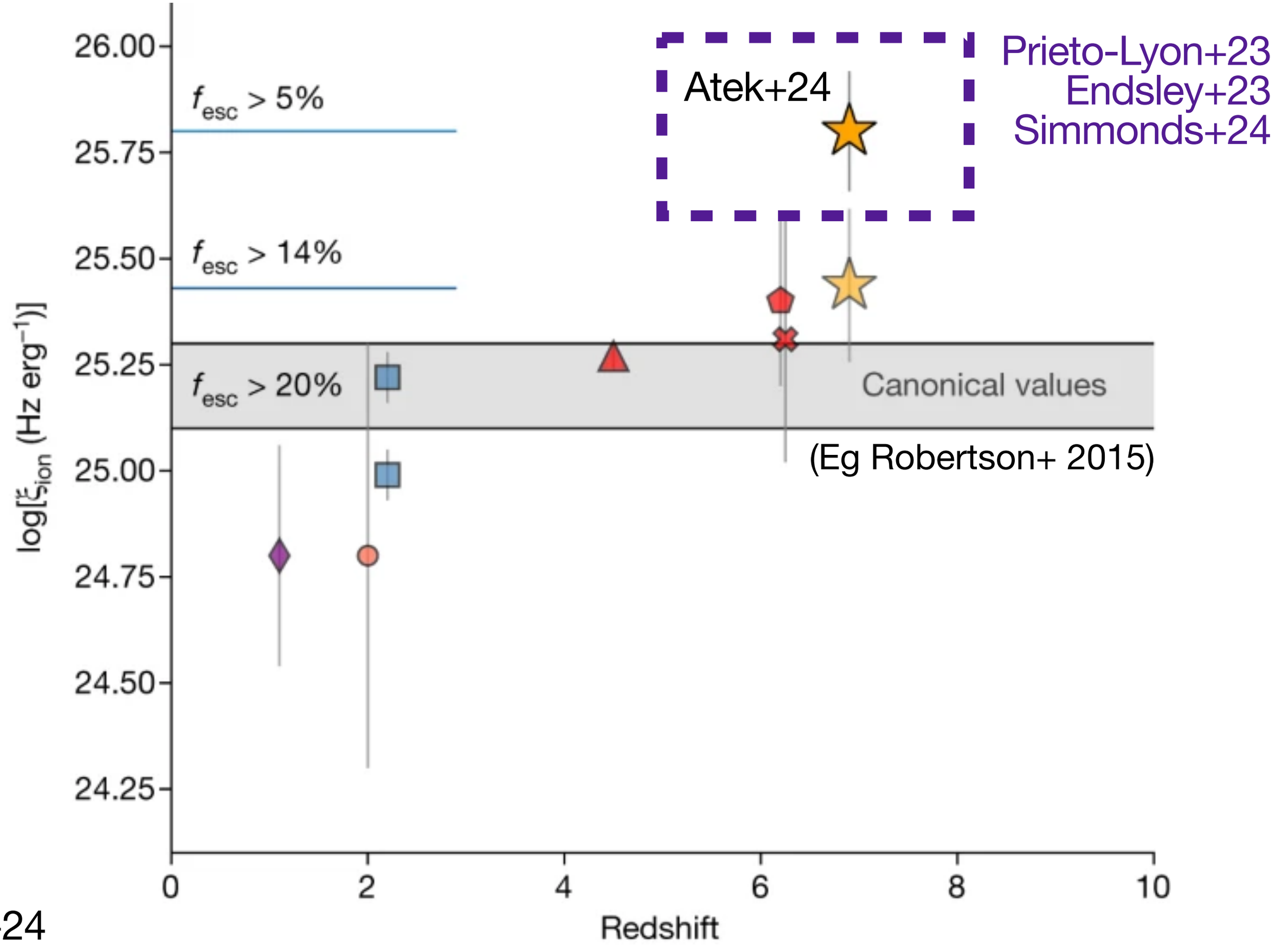


Atek+24

Enter JWST

New $\xi_{\rm ion}$

pre-JWST

$\tau_{\rm CMB}(<z)$

0.10

0.08

0.06

$x_{\rm HI}$

1.0

0.5

0.0

6

8

10

12

14

Redshift, z

JBM+ 2024

Enter JWST

New $\xi_{\rm ion}$

pre-JWST

$\xi_{\rm ion} \times f_{\rm esc}$?

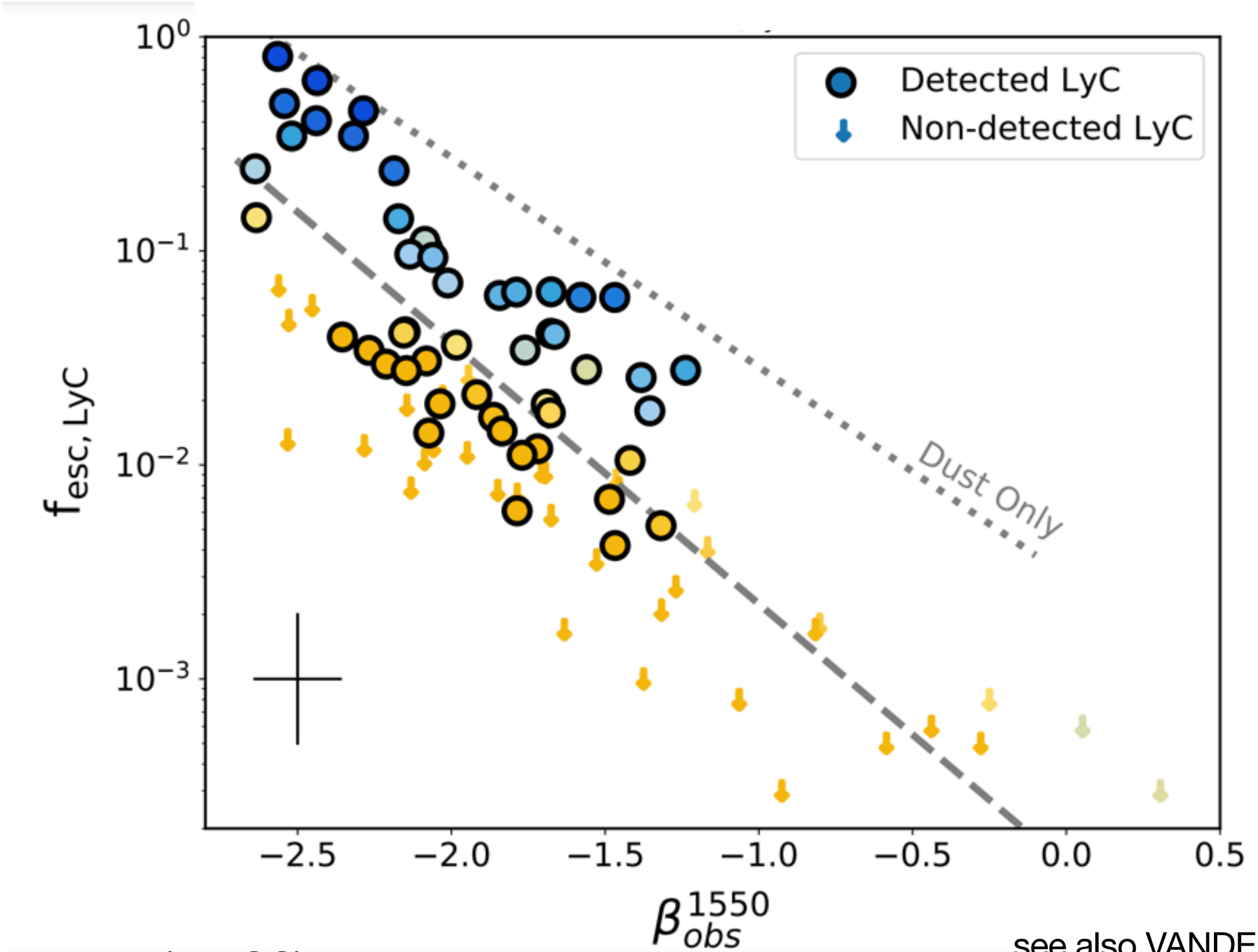
$\tau_{\rm CMB}(<z)$

$x_{\rm HI}$

Redshift, z

JBM+ 2024

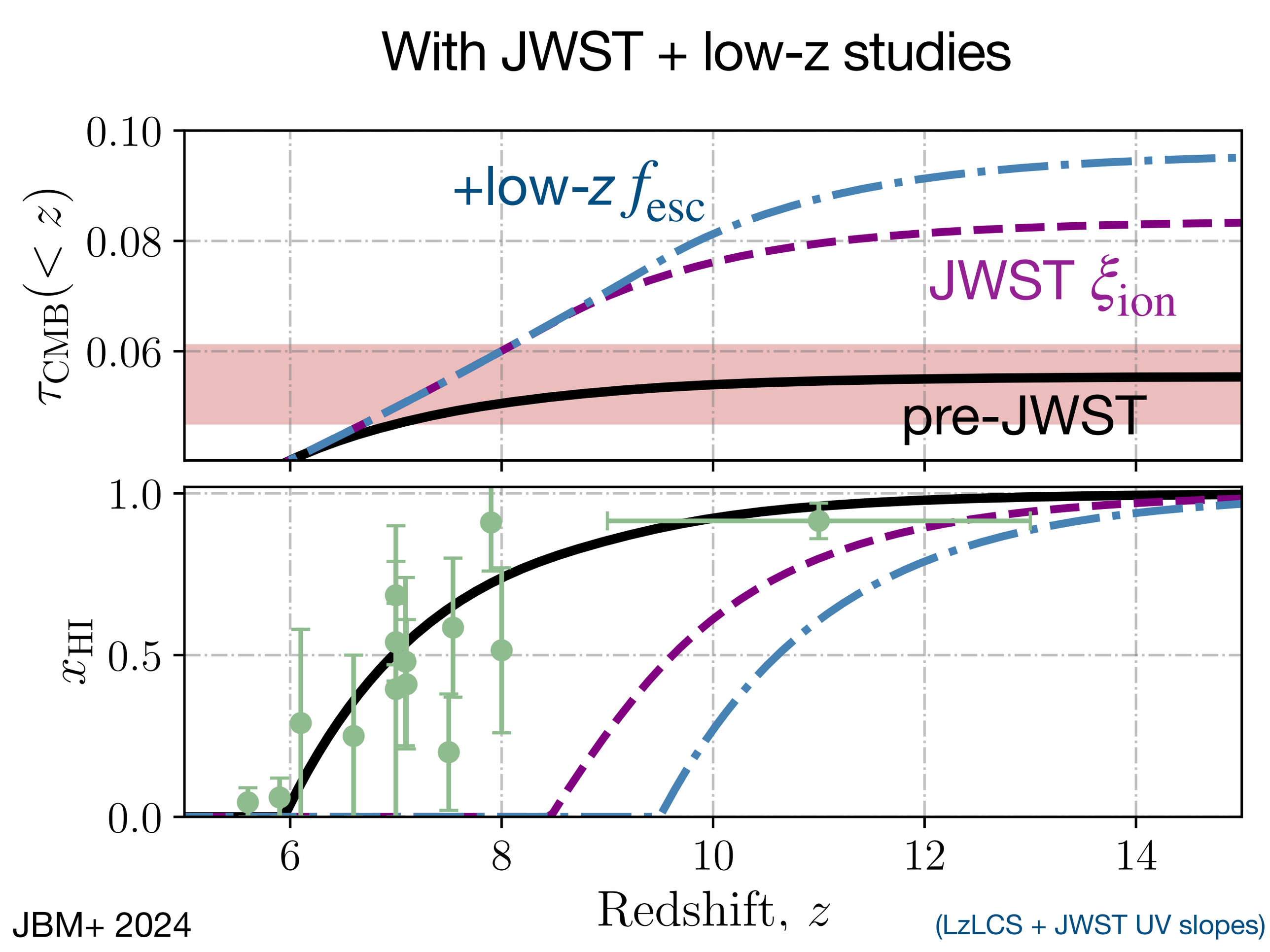
Low-z studies of Lyman Leaking



Chisholm+22 (LzLCS)

see also VANDELS (z~3)
and Jaskot+24 LzLCS+

With JWST + low-z studies



JBM+ 2024

(LzLCS + JWST UV slopes)

More broadly:

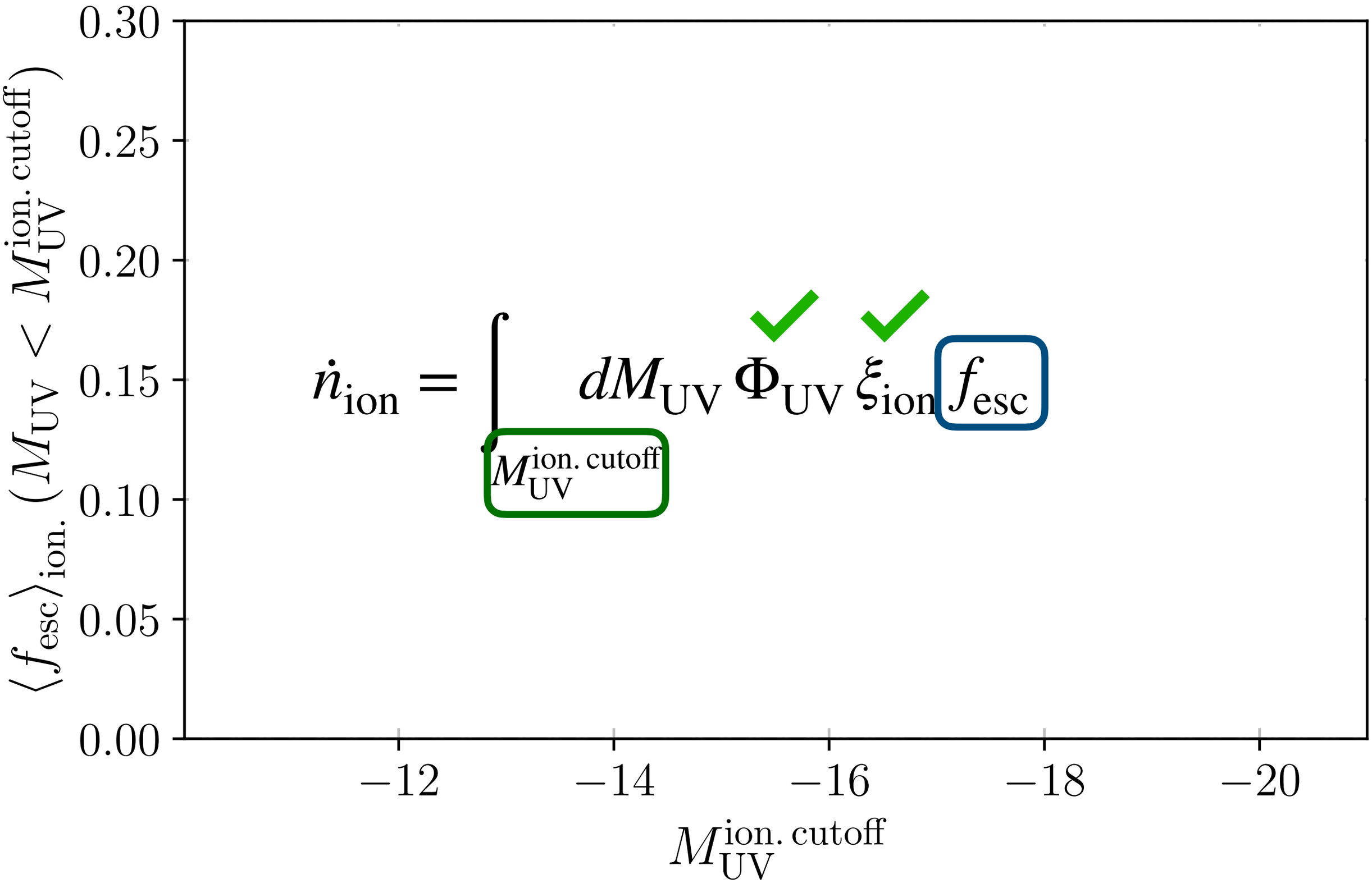
Ionizing photons per galaxy

$$\dot{n}_{\rm ion} = \int_{M_{\rm UV}^{\rm ion.\,cutoff}} dM_{\rm UV}\, \Phi_{\rm UV}\, \xi_{\rm ion}\, f_{\rm esc}$$

How many galaxies

What fraction escapes

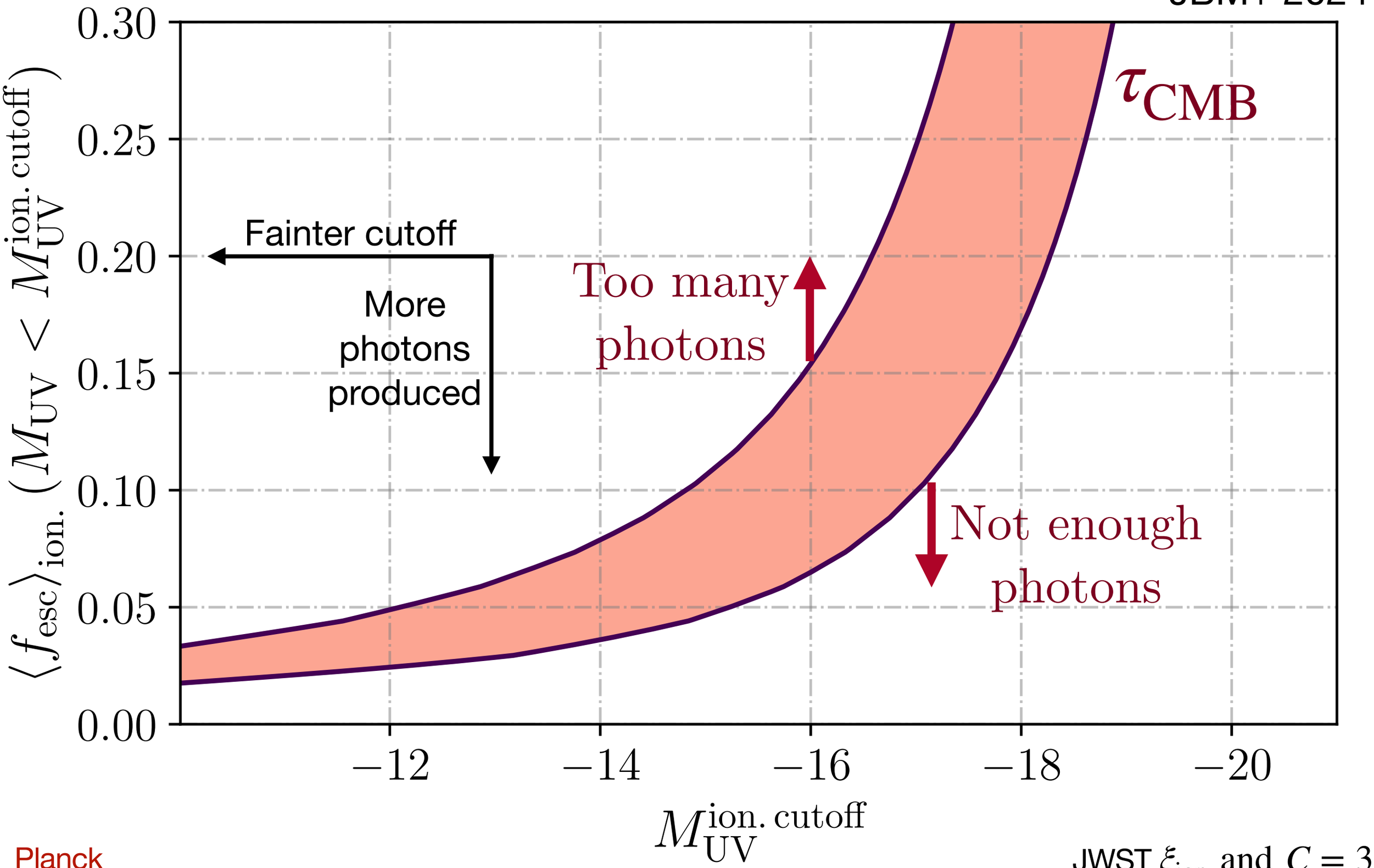
More broadly:



JBM+ 2024

1- Produce correct $\tau_{\rm CMB}$

JBM+ 2024

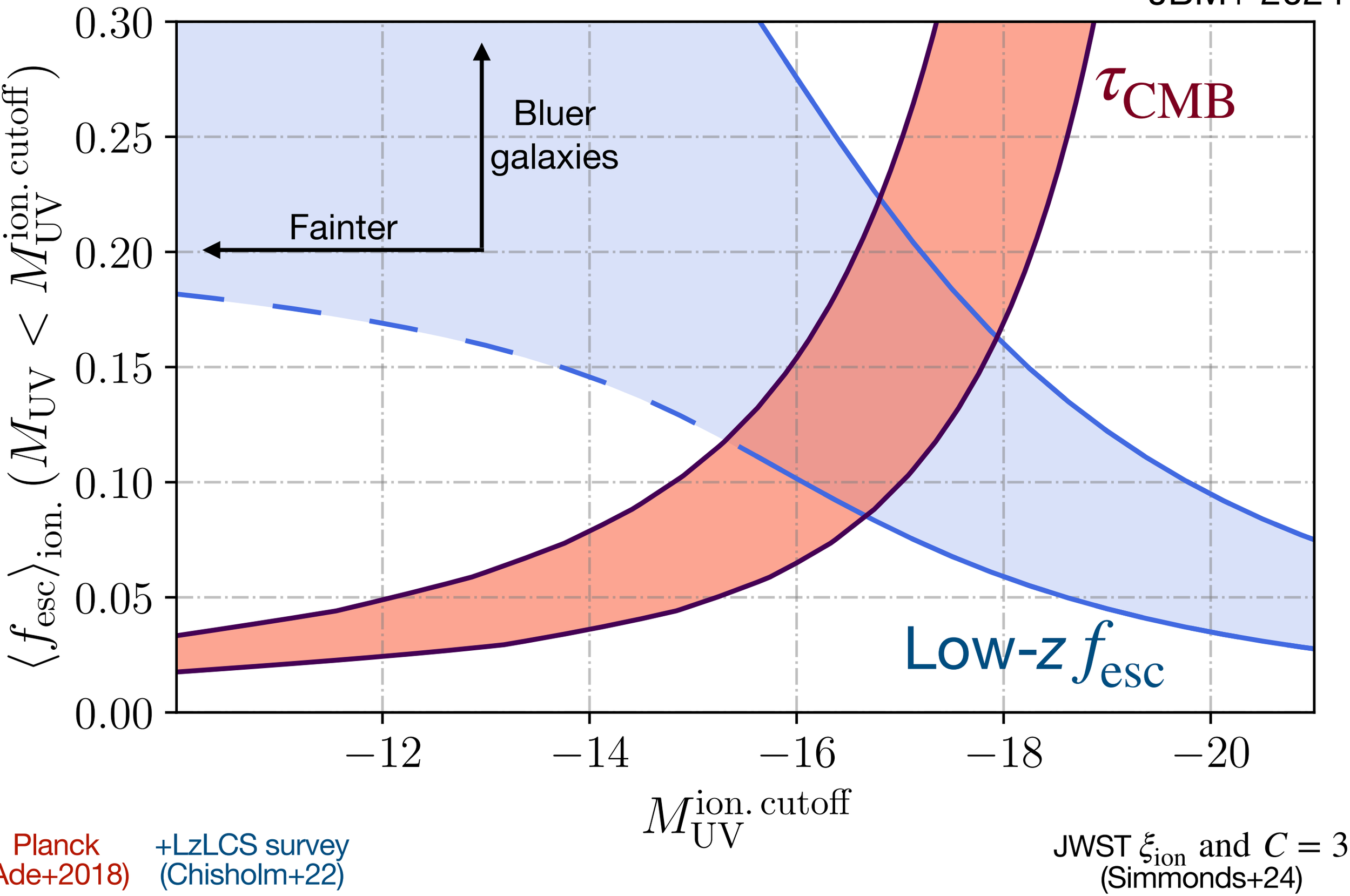


Planck (Ade+2018)

JWST $\xi_{\rm ion}$ and $C = 3$ (Simmonds+24)

2- Reproduce low-z Lyman-leaker studies

JBM+ 2024



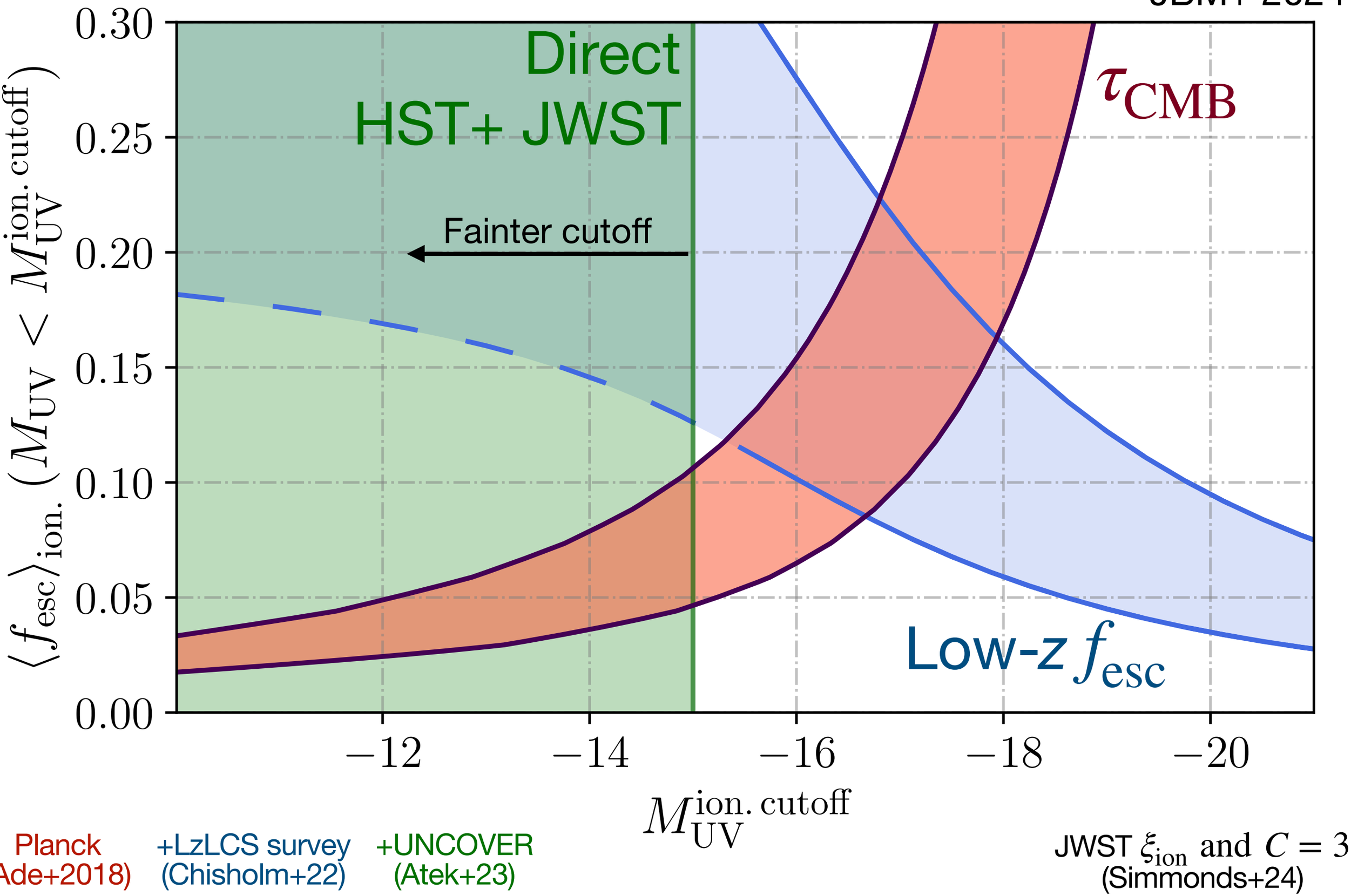
Planck (Ade+2018)

+LzLCS survey (Chisholm+22)

JWST $\xi_{\rm ion}$ and $C = 3$ (Simmonds+24)

3- No cutoff down to directly observed galaxies

JBM+ 2024



Planck (Ade+2018)

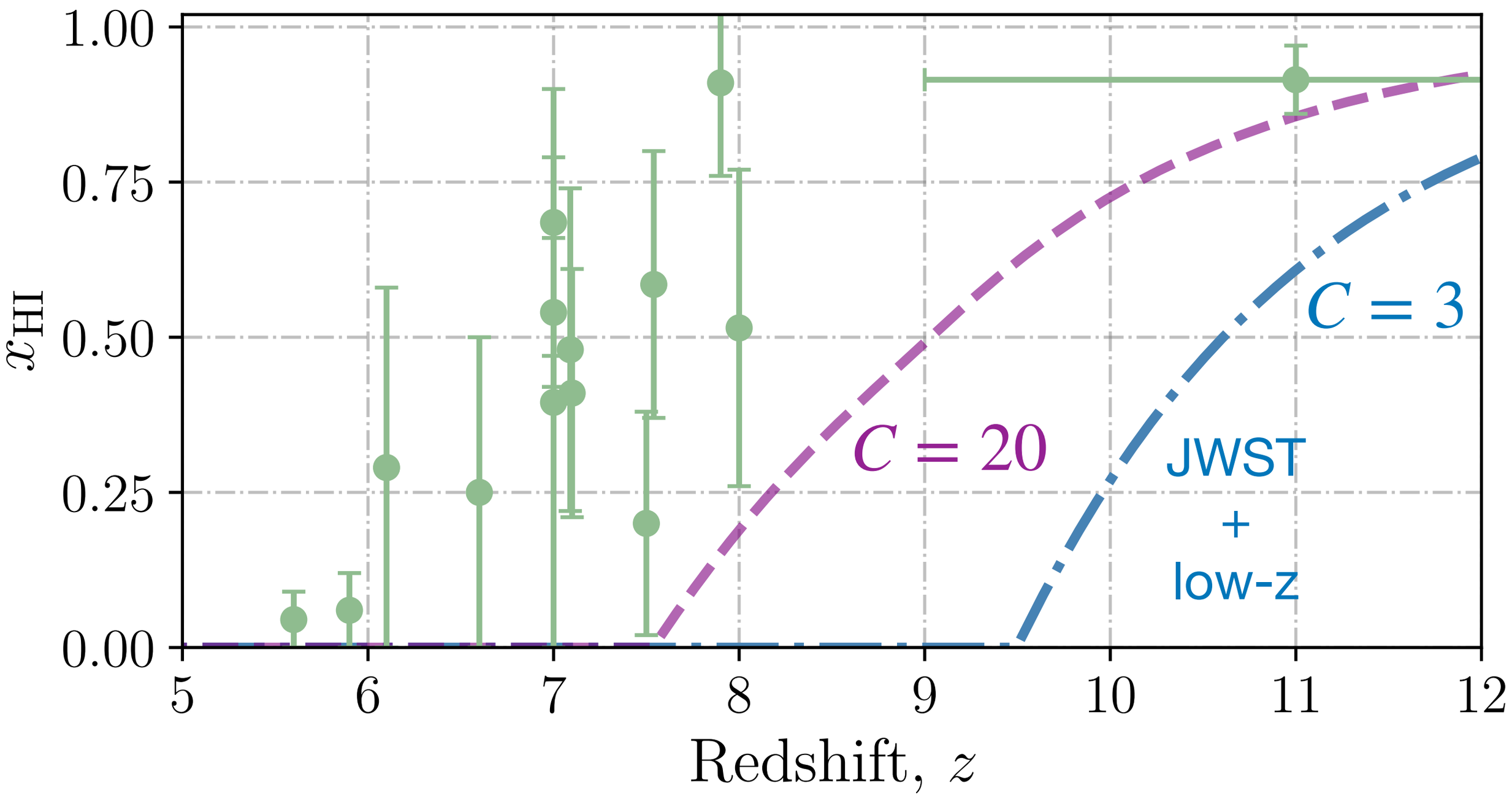
+LzLCS survey (Chisholm+22)

+UNCOVER (Atek+23)

JWST $\xi_{\rm ion}$ and $C = 3$ (Simmonds+24)

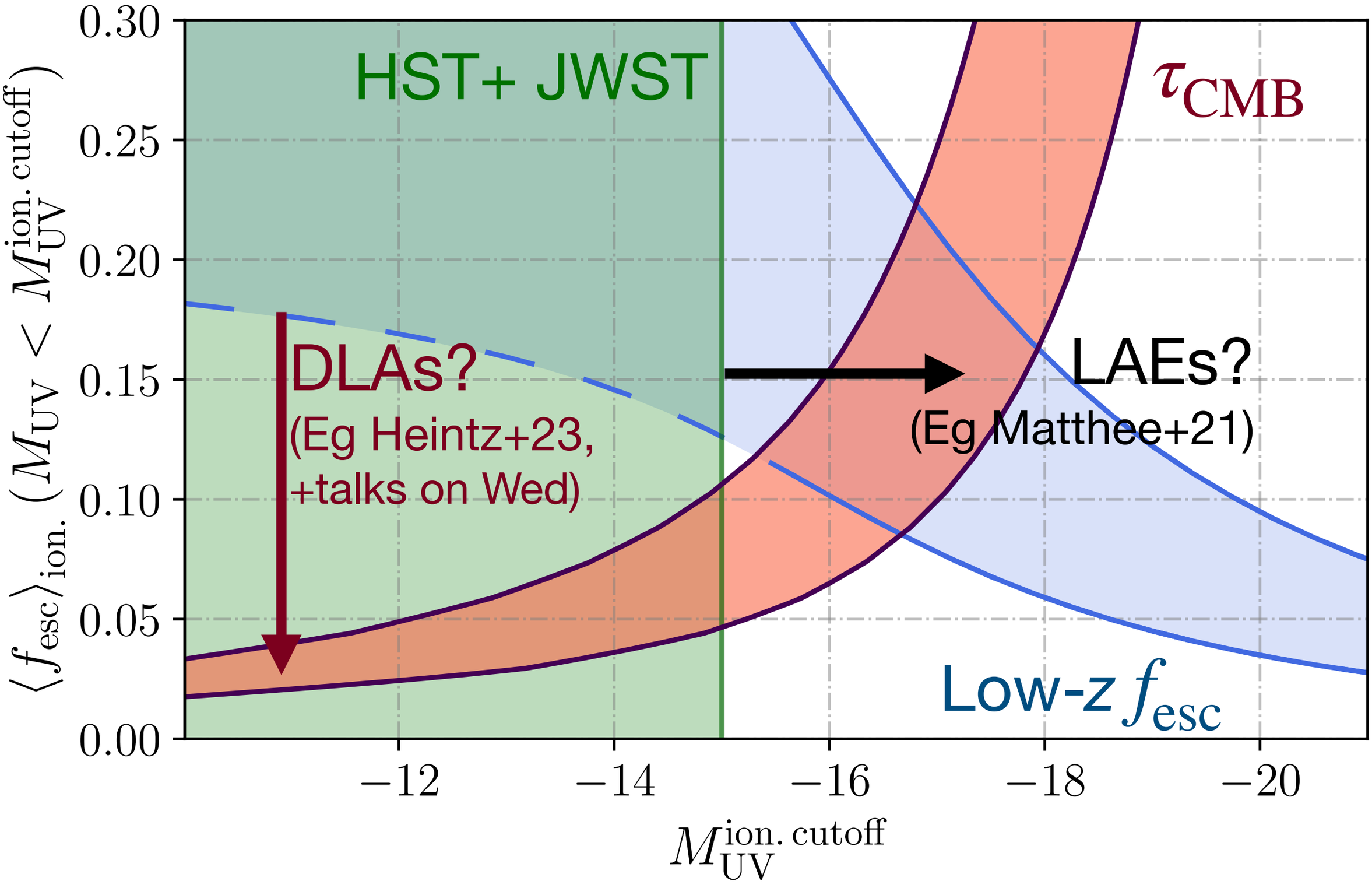
Ways out:

Maybe there are more recombinations?



Ways out:

Throw away one of the observations?



JBM+ 2024

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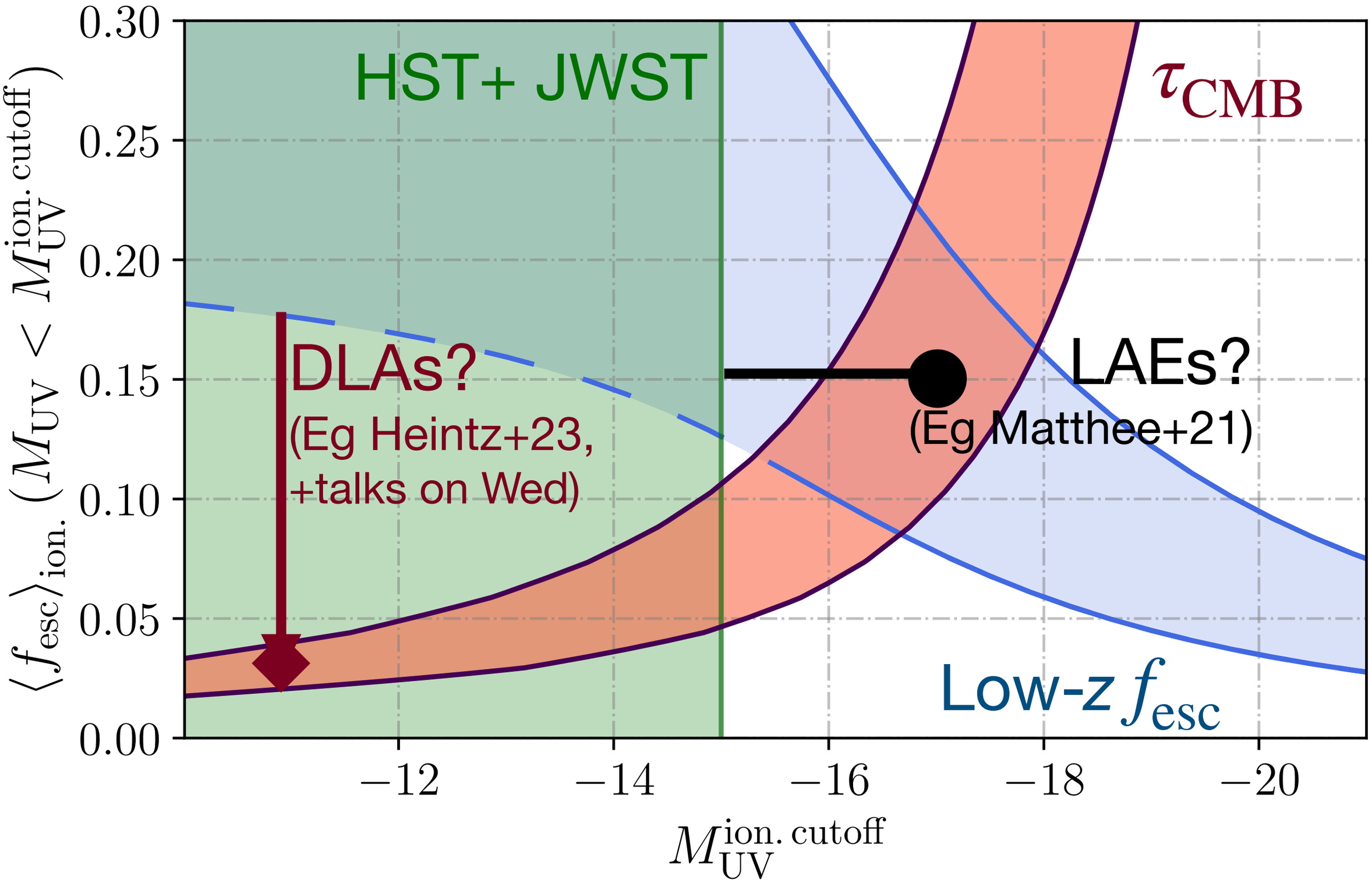
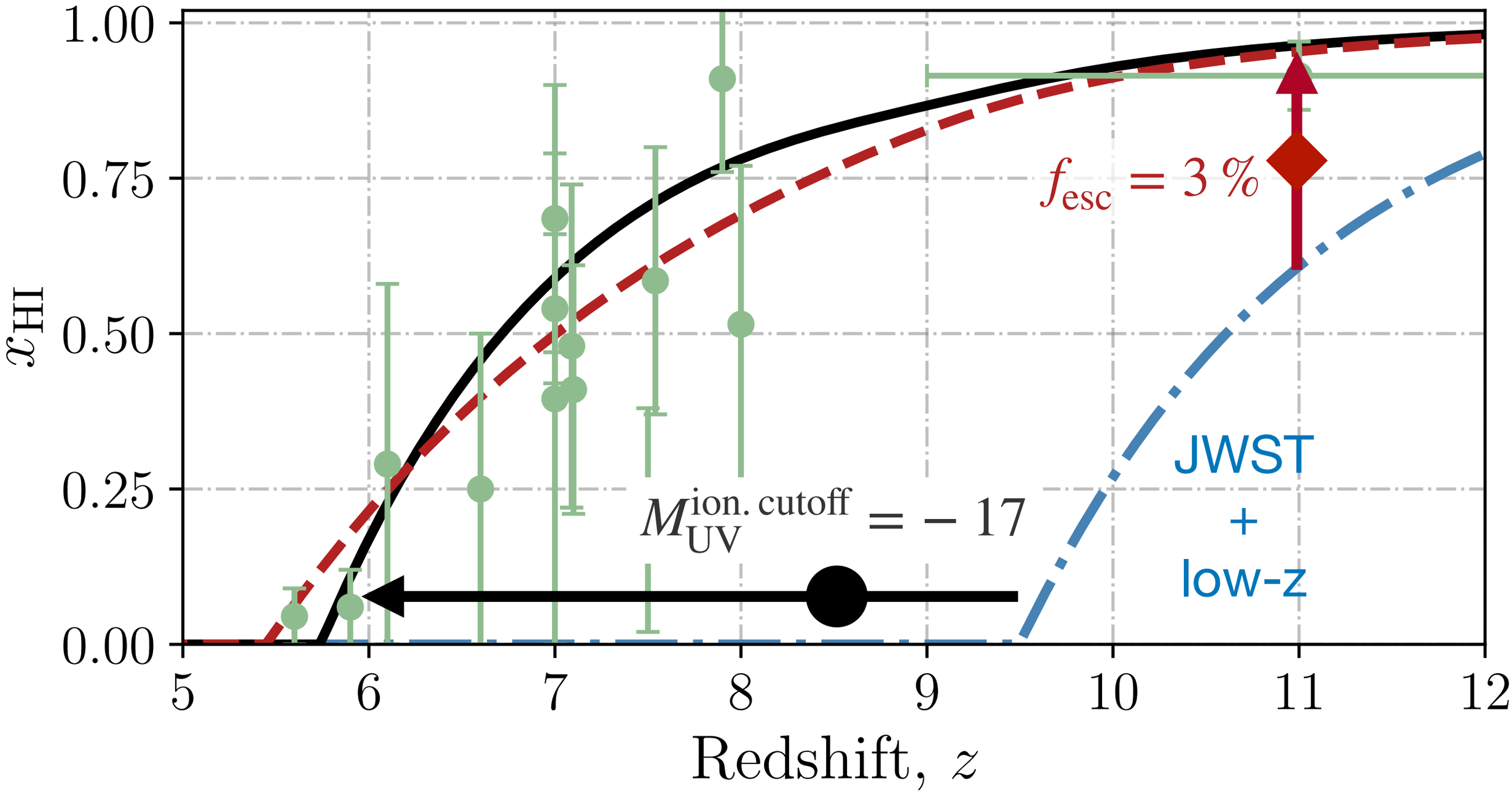


JBM+ 2024

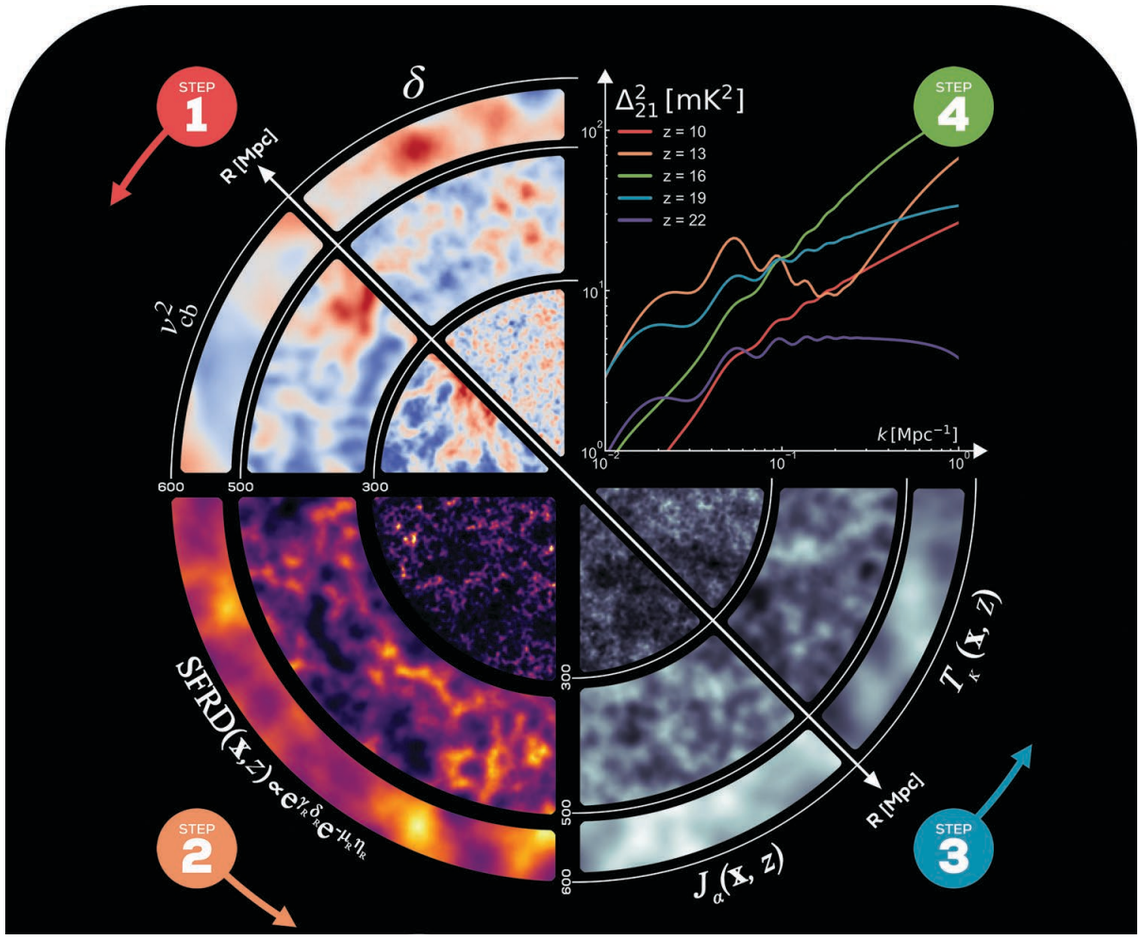
Ways out:

Throw away one of the observations?

We can test through 21cm, $x_{\rm HI}(z)$!

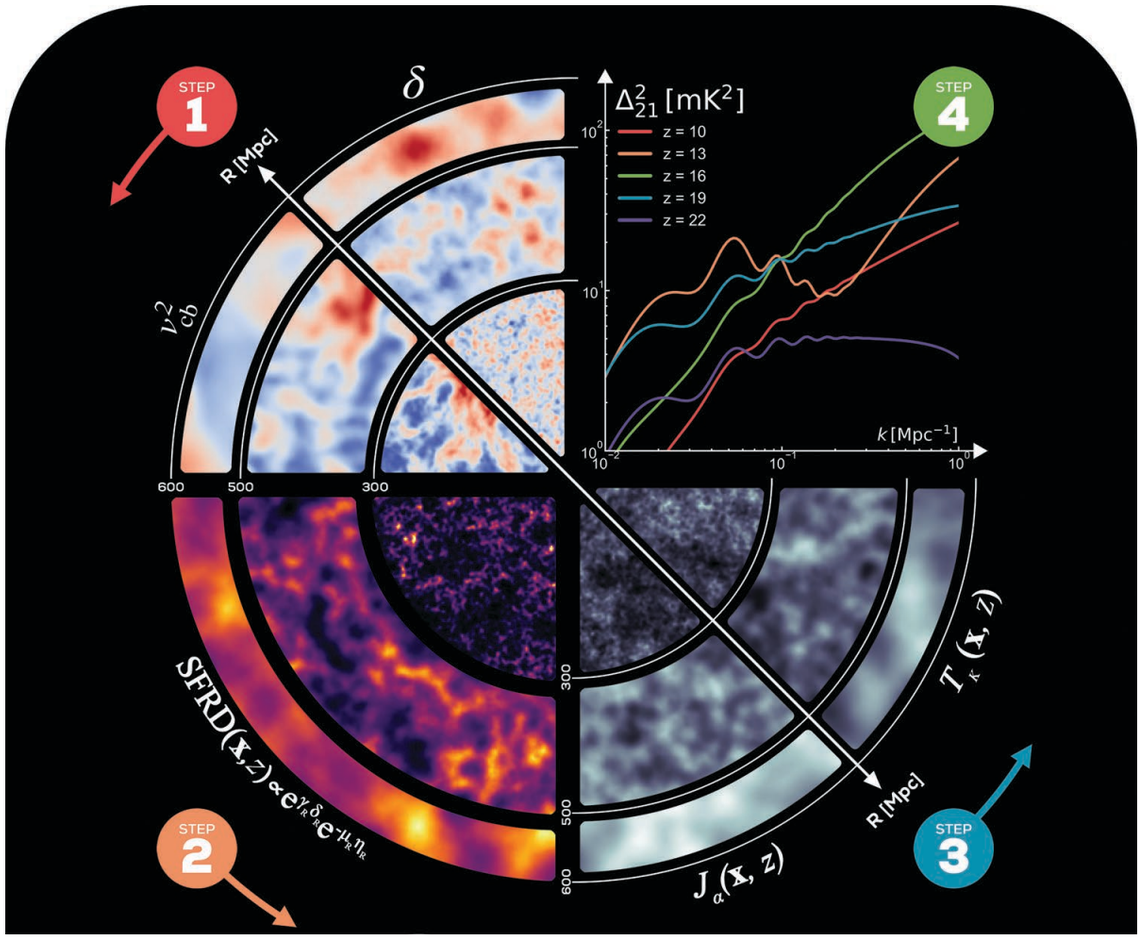


21cm advertisement:



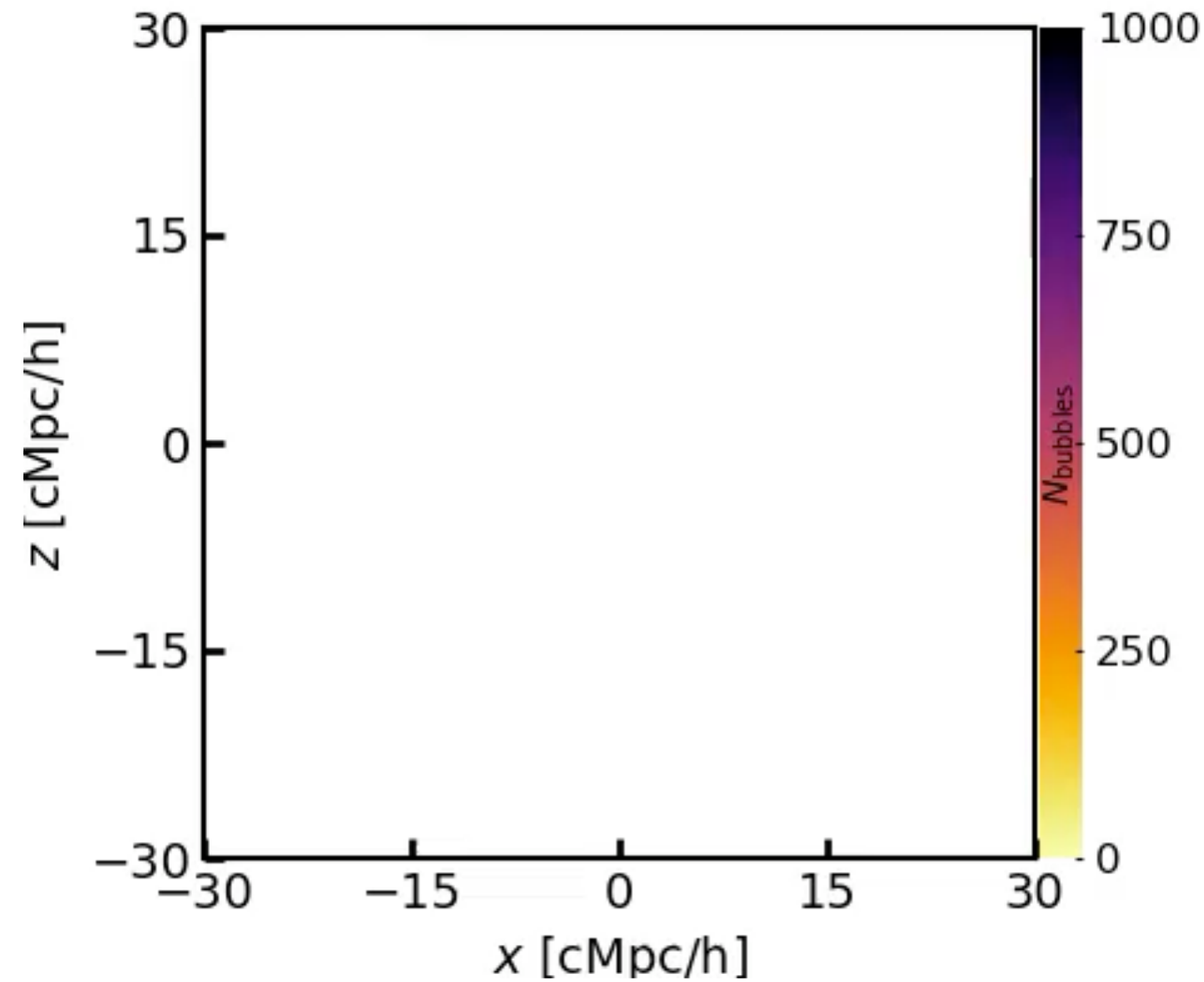
Hector Cruz+
(2407….)

21cm advertisement:



Hector Cruz+
(2407….)

Emilie Thélie+
(2407….)



Thank you!