Durham University

ICC Institute for Computational Cosmology

Winds of change: reionization by starburst galaxies

Sharma+16b – arXiv : 1606.08688
Sharma+16a – MNRAS

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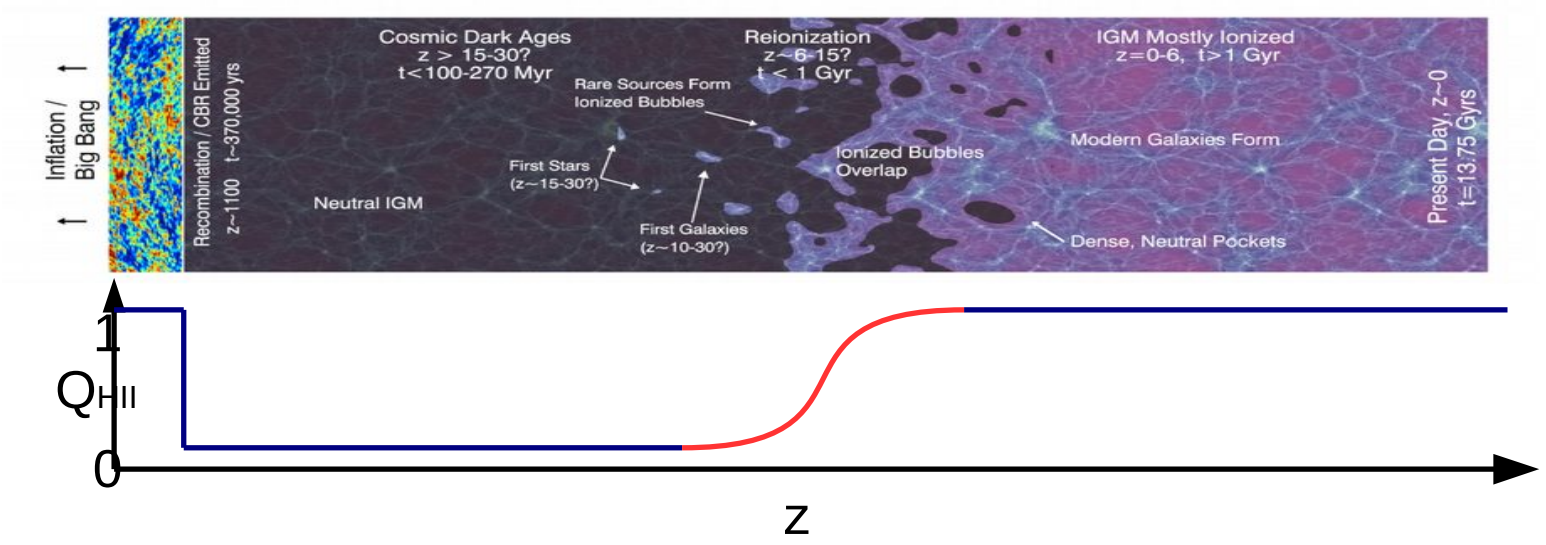
&
Tom Theuns, Carlos Frenk, Eagle collaboration



Reionization

Should reproduce the evolution of ionized filling factor and photo. rate post reionization

$$\dot{n}_\gamma \propto f_{\rm esc} \int_{L_{\rm min}} \phi(z, L) L dL$$

Crucial parameter, poorly understood

$\times \lambda_{\rm mfp}$

$$\frac{dn_{\rm H}}{dt} = \Gamma_{\rm HI} n_{\rm H} - \alpha n_{\rm H} n_{\rm e}$$

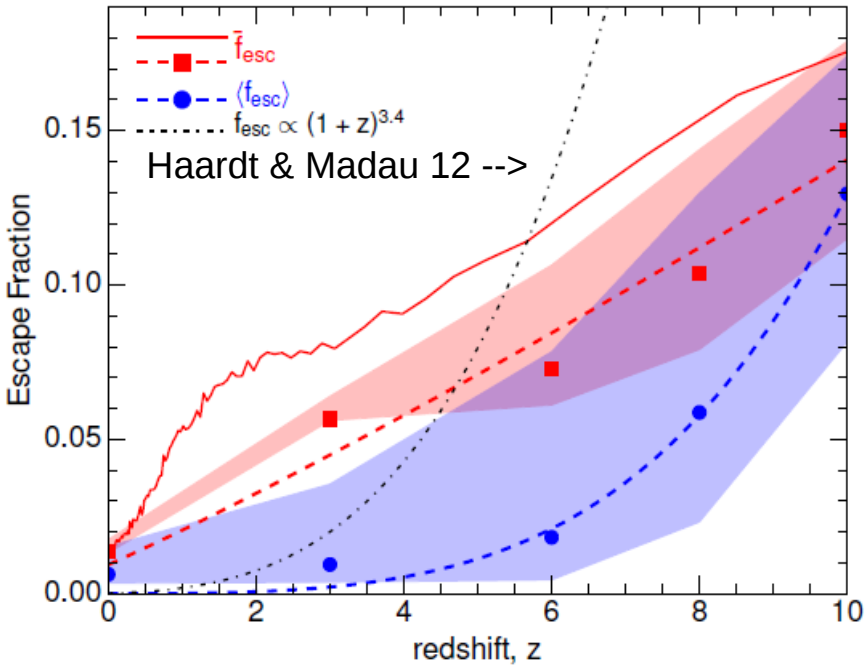
Photoionisation rate (Observers)
Post-reionization

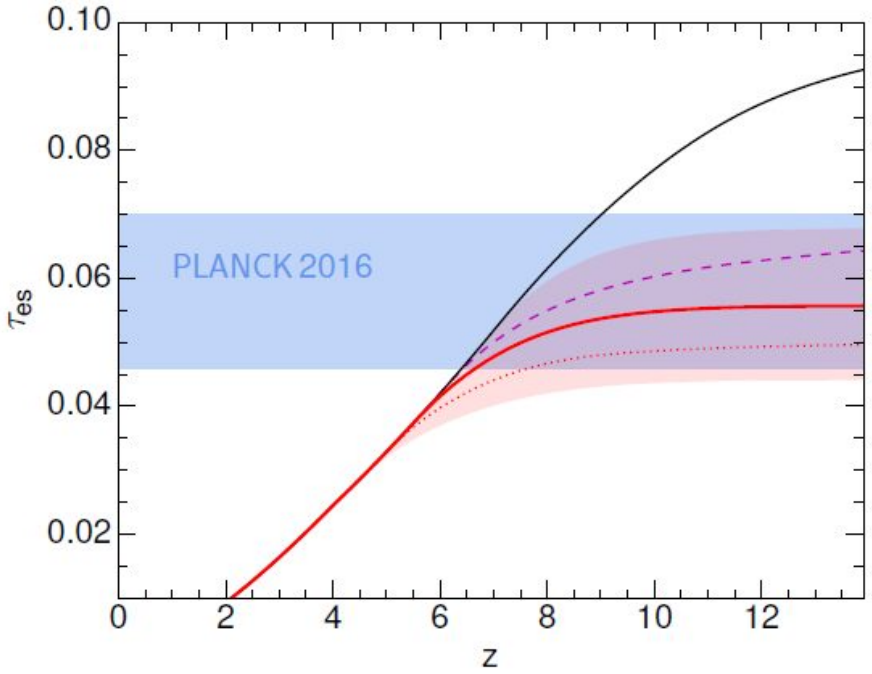
$$\frac{dQ_{\rm HII}}{dt} = \frac{\dot{n}_\gamma}{n_{\rm H}} - \alpha_{\rm B} \mathcal{C} n_{\rm H} Q_{\rm HII}$$

Ionised gas filling factor (Theorists)
z>6

Electron scattering optical depth (CMB)

Escape fraction should evolve



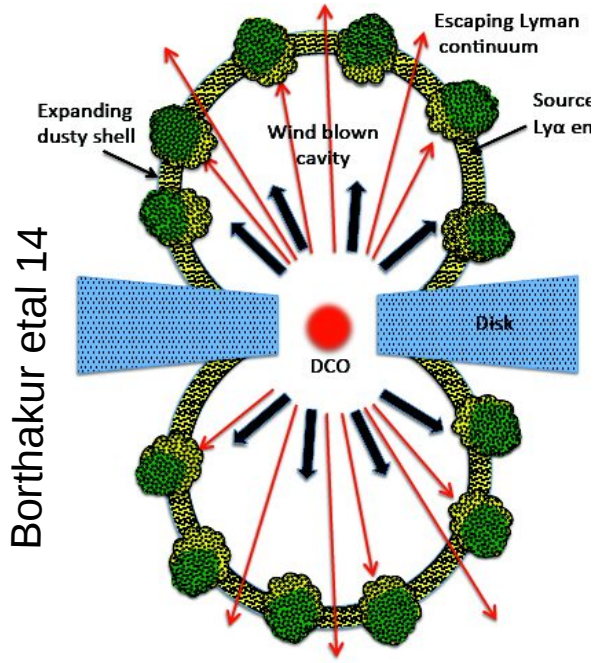


Any study with escape fraction 15 to 20 % at z>6 is in the right ball park (e.g. Robertson+15,Bouwens+15 + +).

why does it evolve ? WINDS

Ionising photons escape through channels created by winds

- **Linked to winds :** high surface density of star formation – winds – high f_esc (Heckman 01,11, Borthakur+14, Izotov+16a,b)



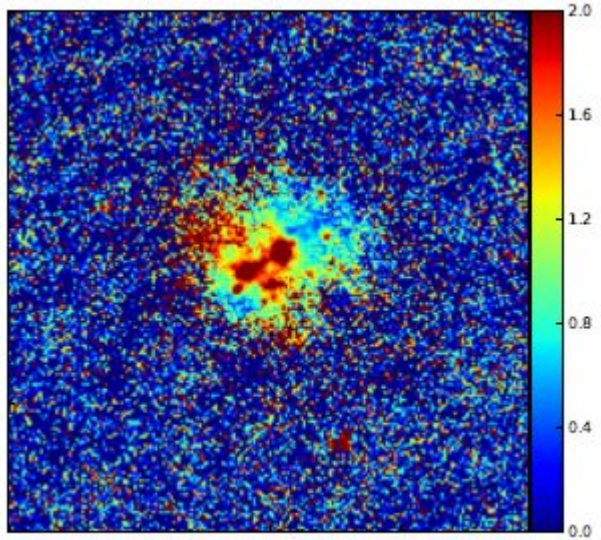
- Threshold for winds

$$\dot{\Sigma}_\star > 0.1\,\mathrm{M}_\odot\,\mathrm{yr}^{-1}\,\mathrm{kpc}^{-2}$$

(Heckman 01, Murray+10, Scanapiecco+13)

Starburst, winds ----------> High Escape Fraction

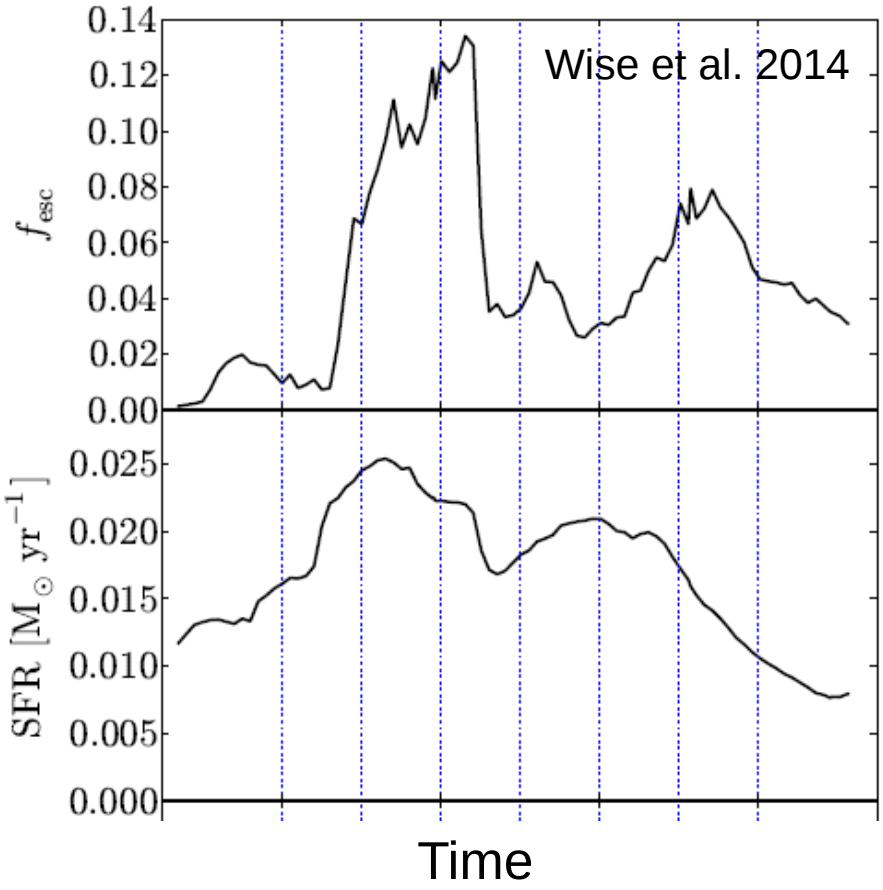
Starburst – (winds) – High escape fraction



(a) [SIII]/[SII]

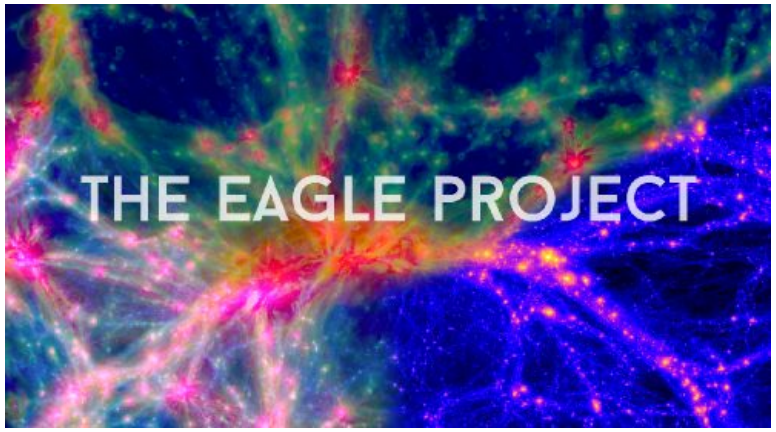
[SIII]/[SII]

Zastrow+13



Escape Fraction : Model

- Star formation histories from the EAGLE simulation
- Capability of a burst to puncture the disc dictated by the local SFR surface density.



Schaye et al. 2015, Data is now Public
http://icc.dur.ac.uk/Eagle/database.php

Borthakur+14,Izotov+16

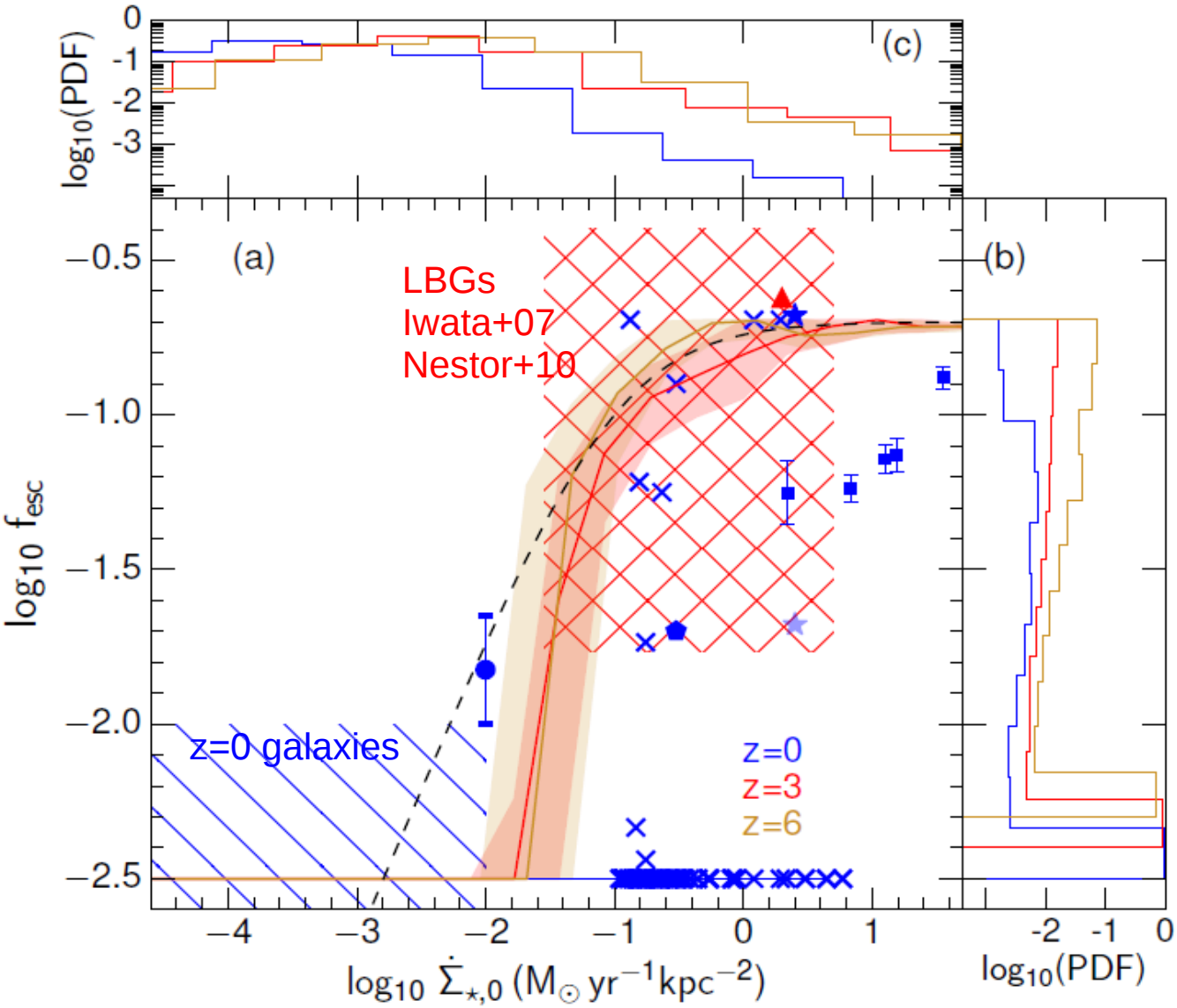
$$f_{\rm esc} = \begin{cases} 0.2, & \text{if } \dot{\Sigma}_\star > 0.1\,{\rm M}_\odot/{\rm yr}/{\rm kpc}^2 \\ 0 & \text{otherwise} \end{cases}$$

(Heckman 2001)

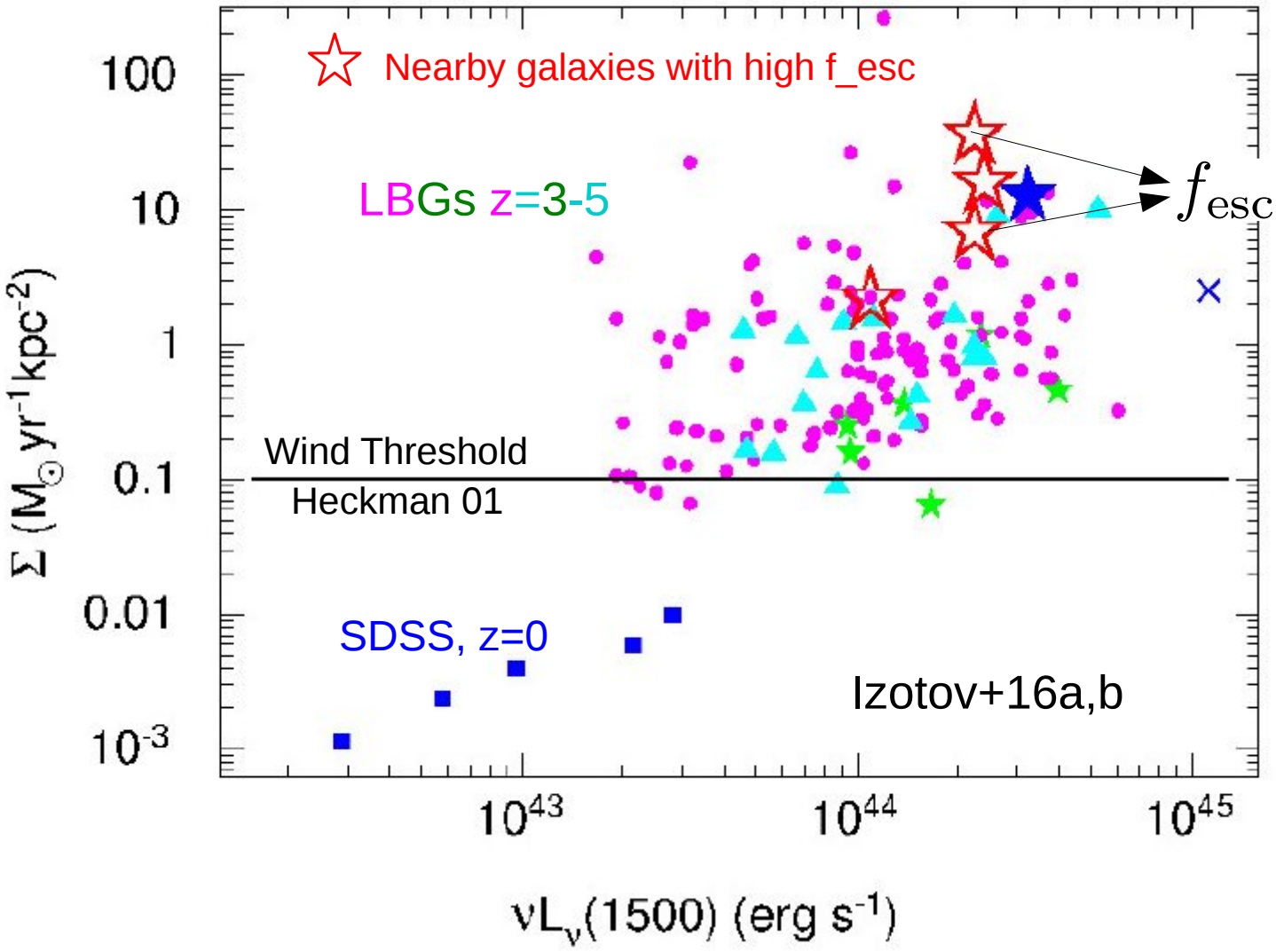
For example, if 5 out of 100 star forming regions satisfy the above Criteria then the galaxy-wide escape fraction is 1 %.

Sharma+2016a,b

Escape fraction vs SFR surface density

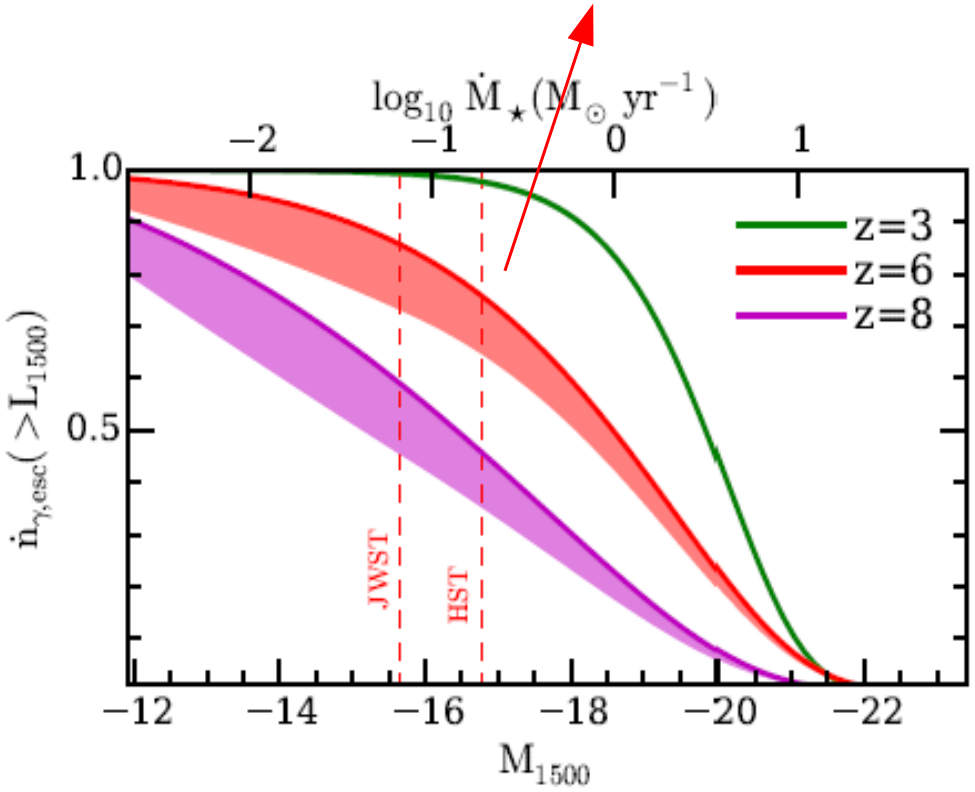


High $\dot{\Sigma}_\star$ – (winds) – high escape fraction



$f_{\rm esc} = 6 - 13\%$

More than half of the ionising photons emitted
By the galaxies within the current HST limits



Sharma+2016a

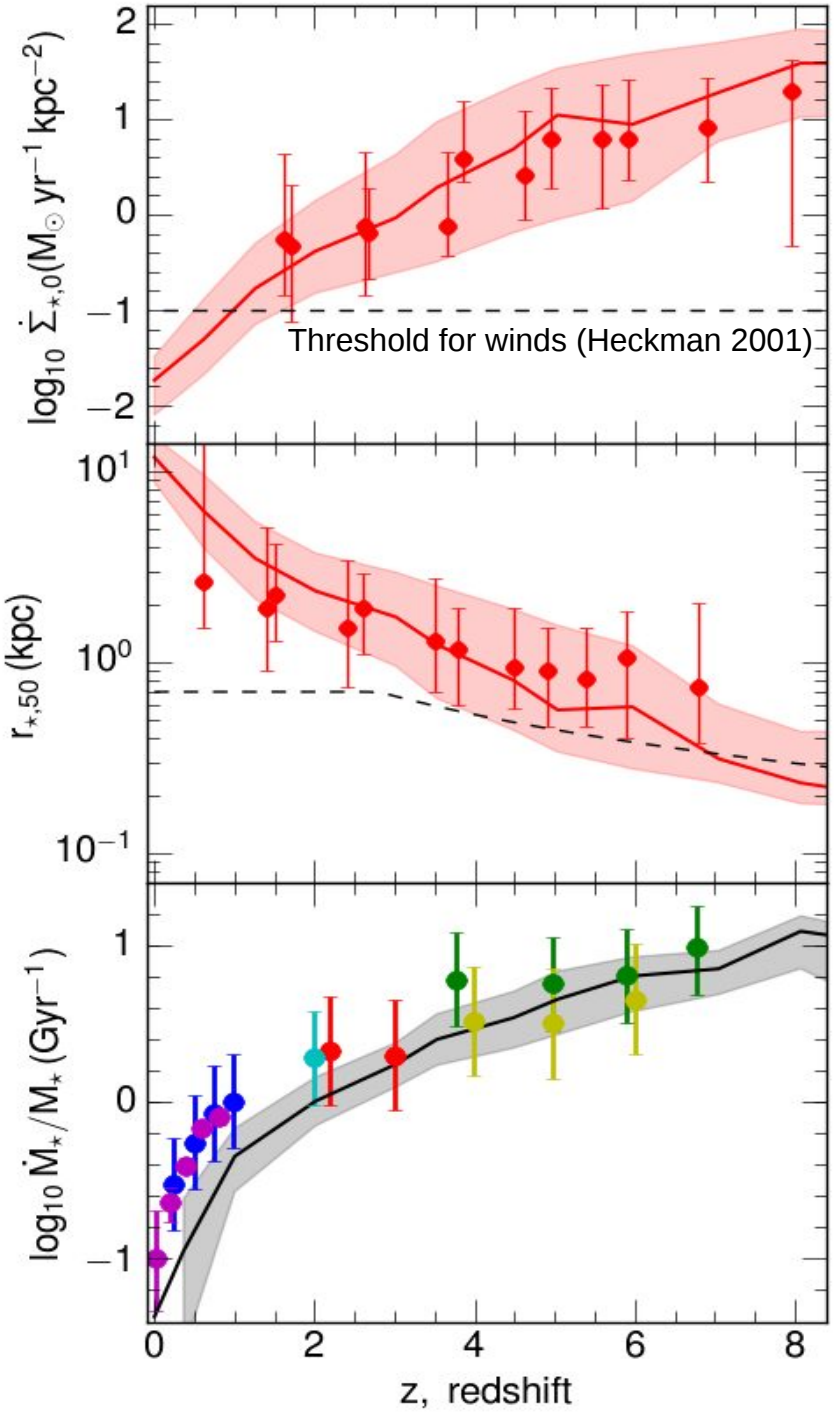
Escape fraction : evolution

- $\dot{\Sigma}_\star$ evolves with redshift
- Winds when

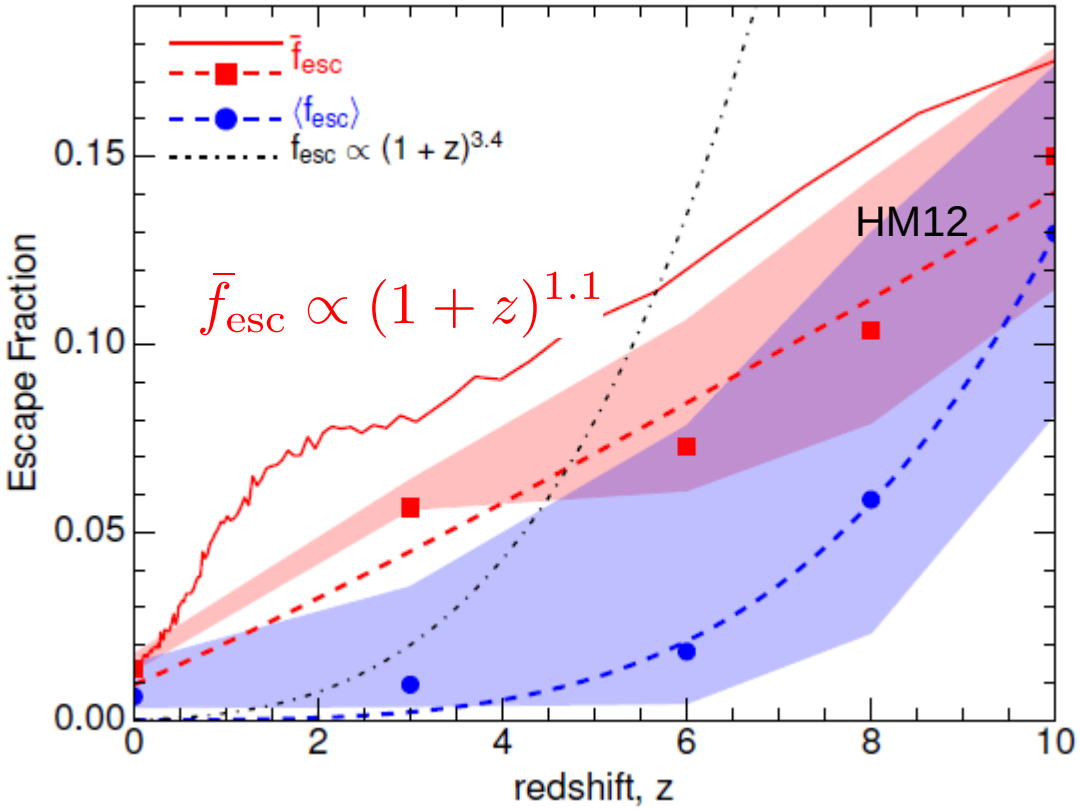
$$\dot{\Sigma}_\star > 0.1\,\mathrm{M}_\odot\,\mathrm{yr}^{-1}\,\mathrm{kpc}^{-2}$$

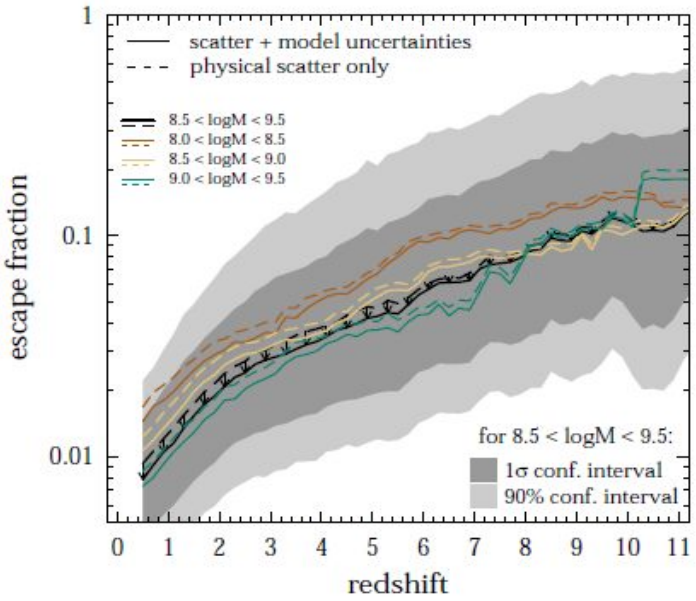
(Heckman 01, Murray+10, Scanapiecco+13)

$$f_{\rm esc} \rightarrow \text{winds} \rightarrow \dot{\Sigma}_\star \rightarrow z$$



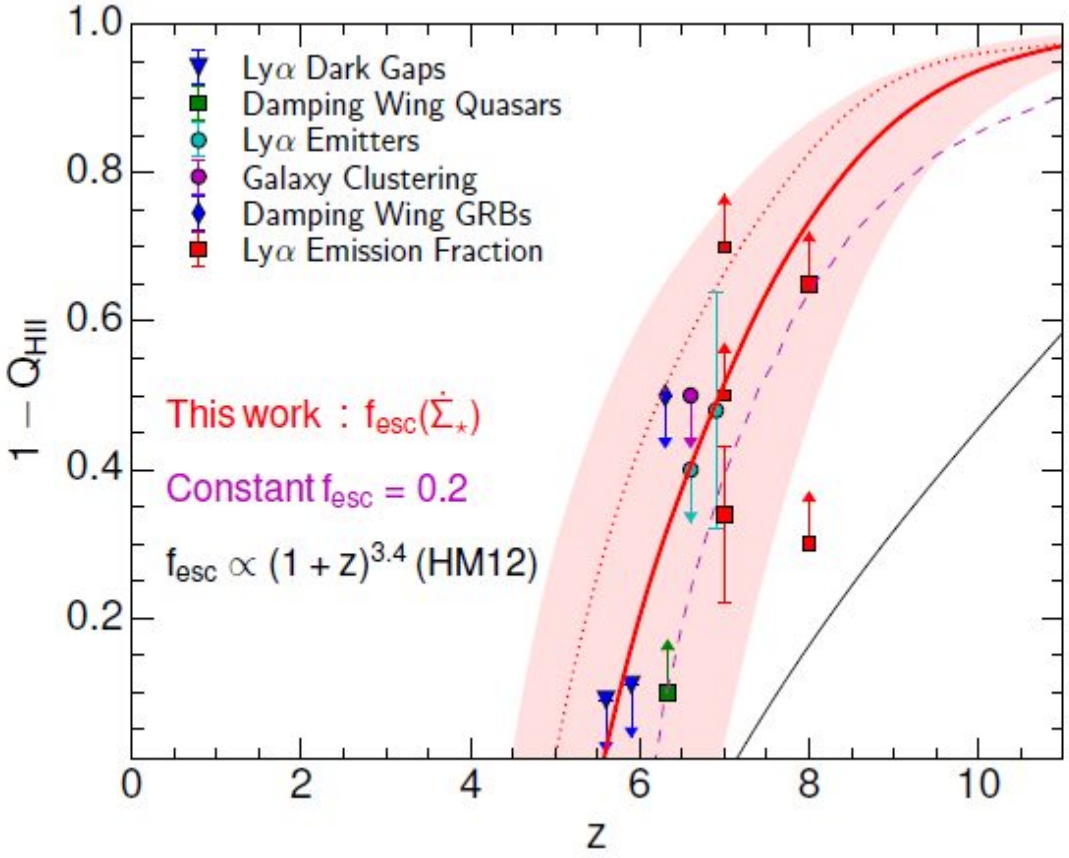
Escape fraction : Evolution

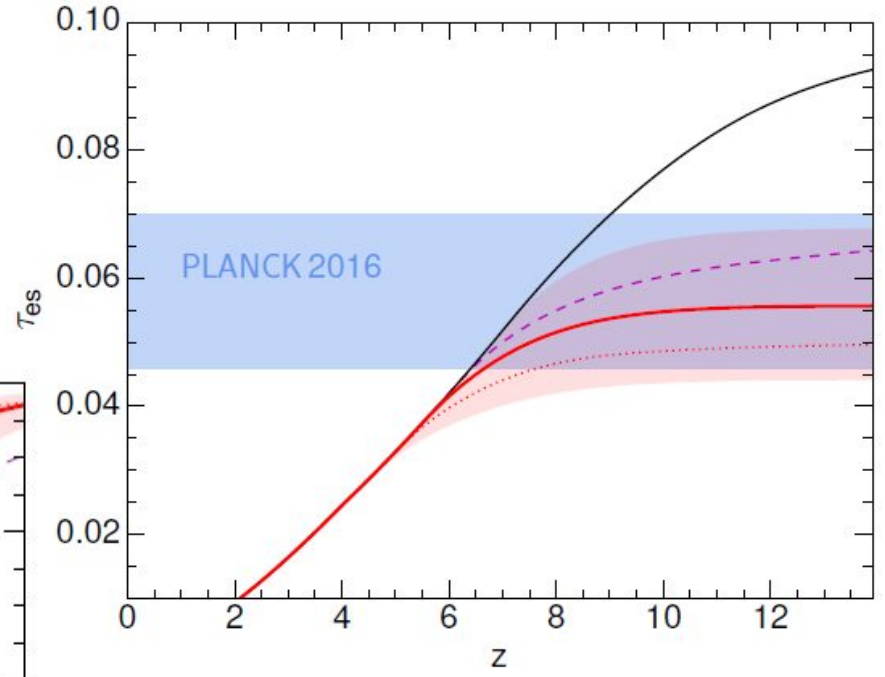




From evolving [OIII]/[OII]
(Faisst+16, Nakajima&Ouchi14)

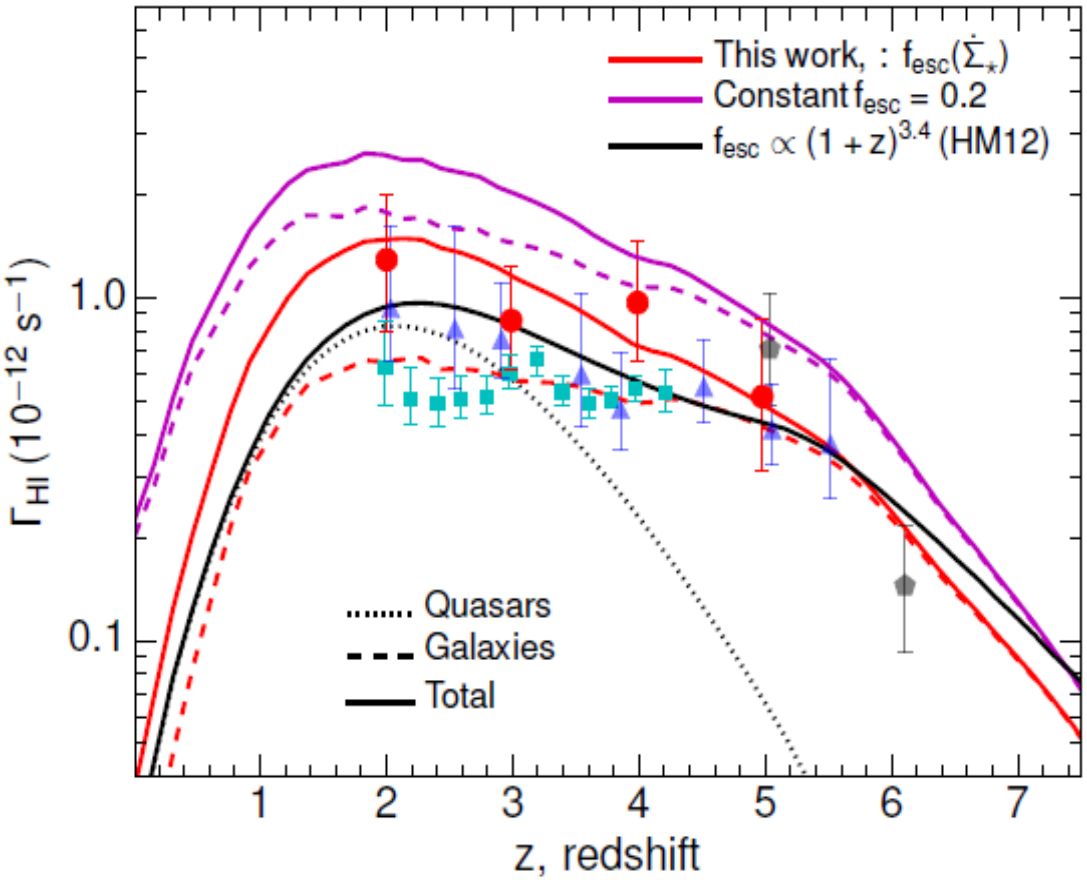
Reionization

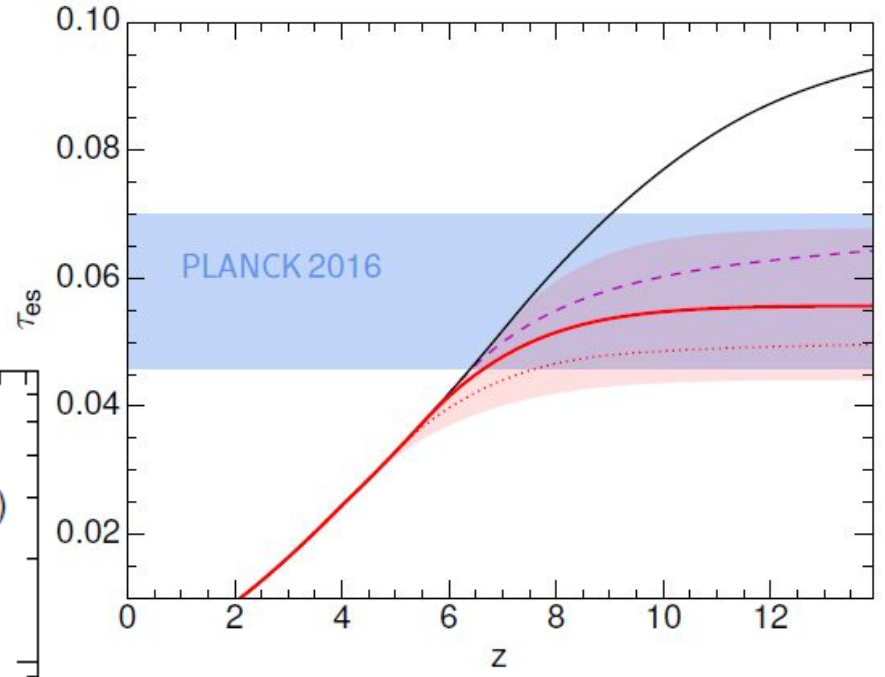




Sharma+16b - arXiv:1606.08688

Reionization





Model with constant escape fraction overproduces the photo rate at low redshift

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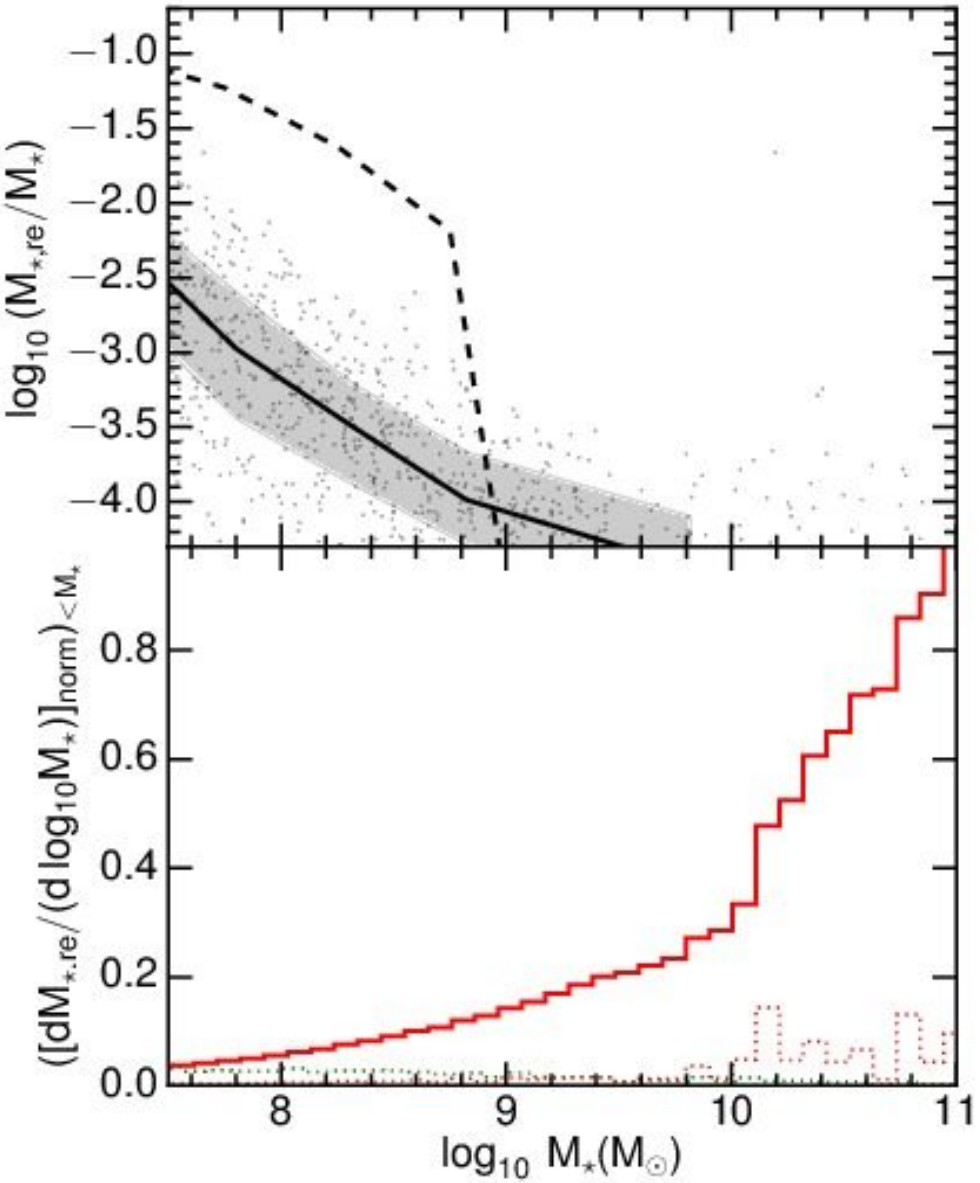
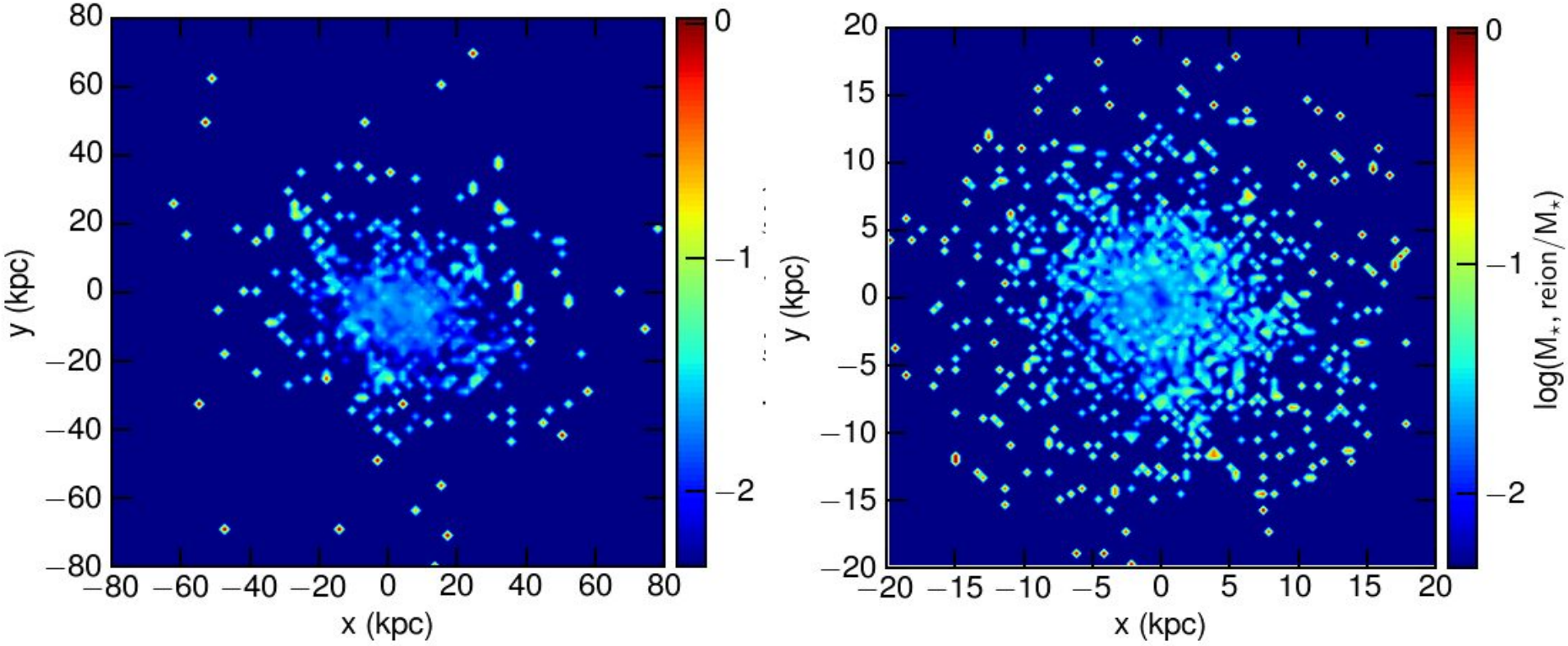
Fossils of reionizers

- Fractional abundance is higher in the low mass galaxies.
- Most of them live in the massive galaxies.



The Milky Way, face-on (fraction of reionizers)

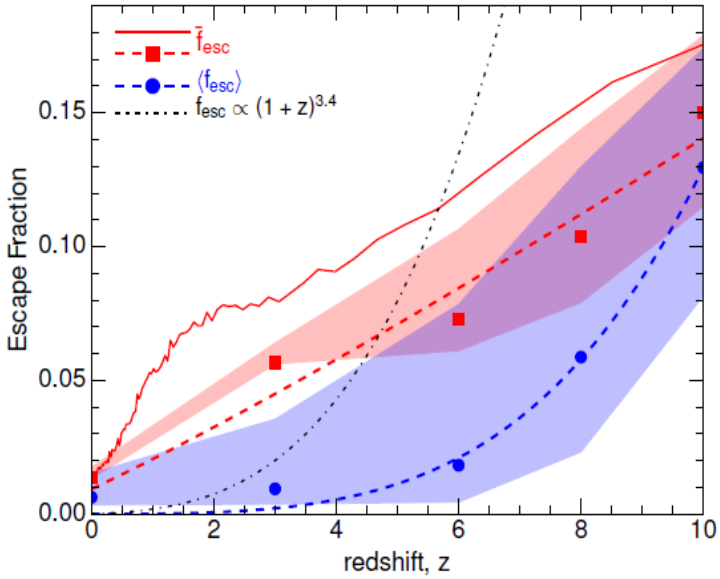


- Reionizers have a shalower distribution compared to normal stars,
- High fractional abundance in the outskirts.

Sharma+in prep.

Summary

- Winds pave paths for high escape fraction and drive the evolution of escape fraction



- Most of reionisers today live in the massive galaxies.
- Low mass galaxies have higher fractional abundance.
- High fractional abundance in the outskirts of the Milky Way