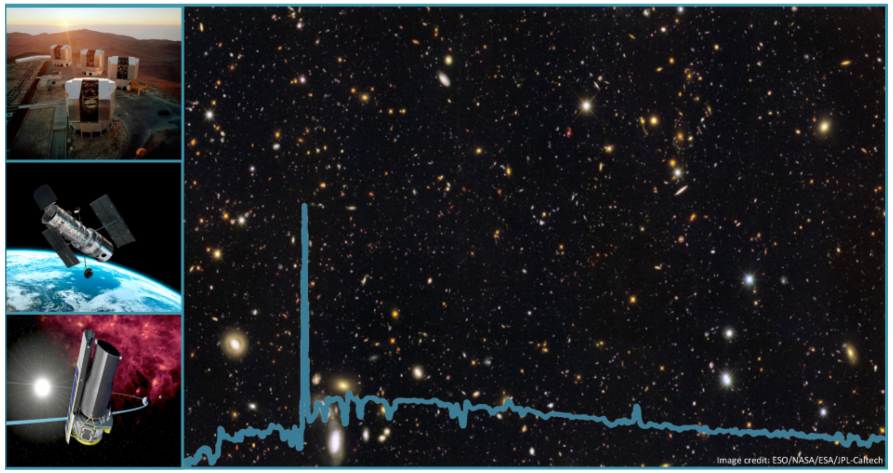
THE UNIVERSITY of EDINBURGH
School of Physics
& Astronomy



A deep VIMOS survey of the CANDELS UDS and CDFS fields

SUPA

ARXIV #
2202.04088
BEGLEY+22, MNRAS 513, 3510

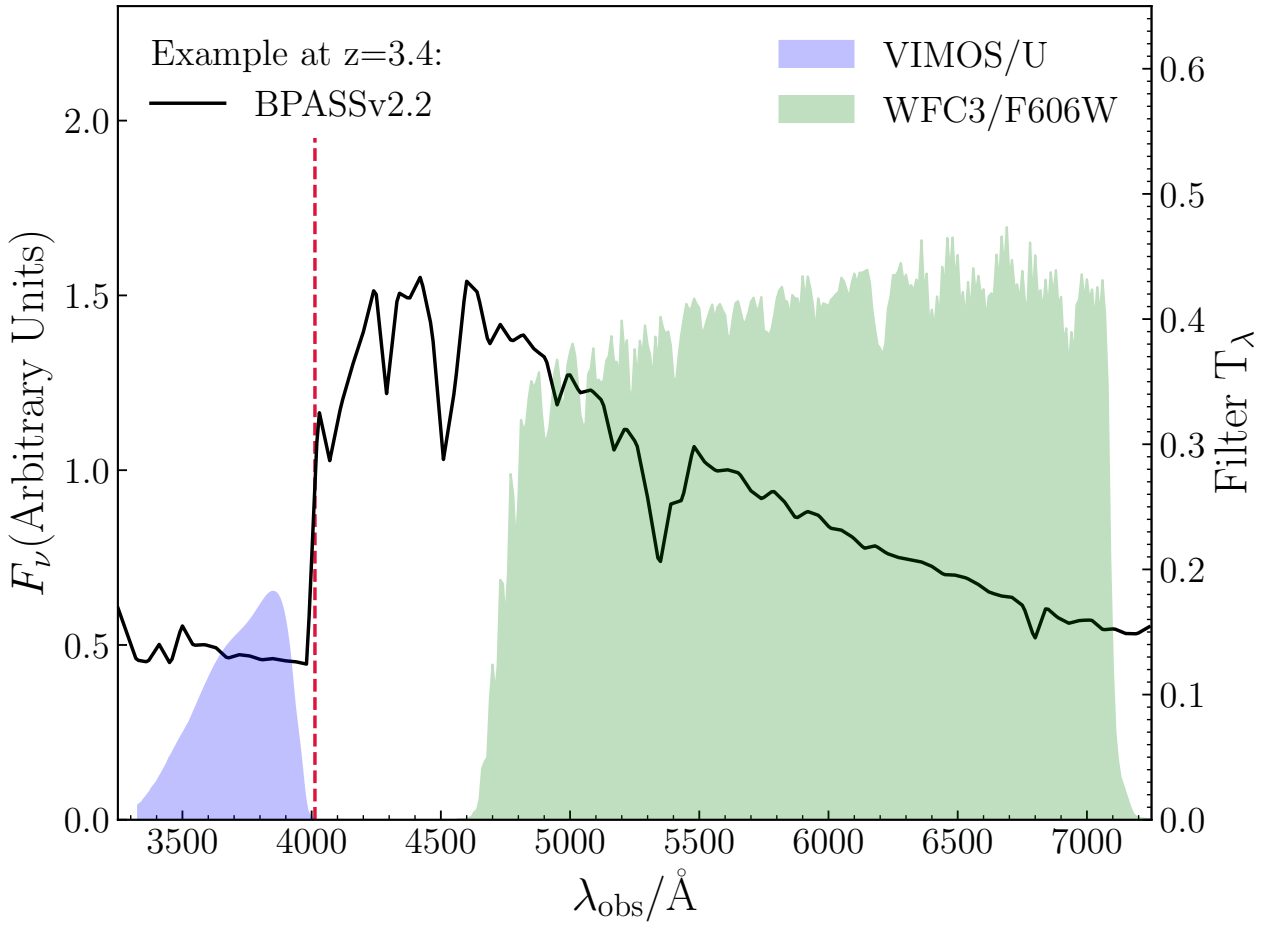
The VANDELS Survey:
A measurement of the average LyC escape fraction of SFGs at z~3.5

Ryan Begley*, Fergus Cullen, Ross McLure, Jim Dunlop + VANDELS Team

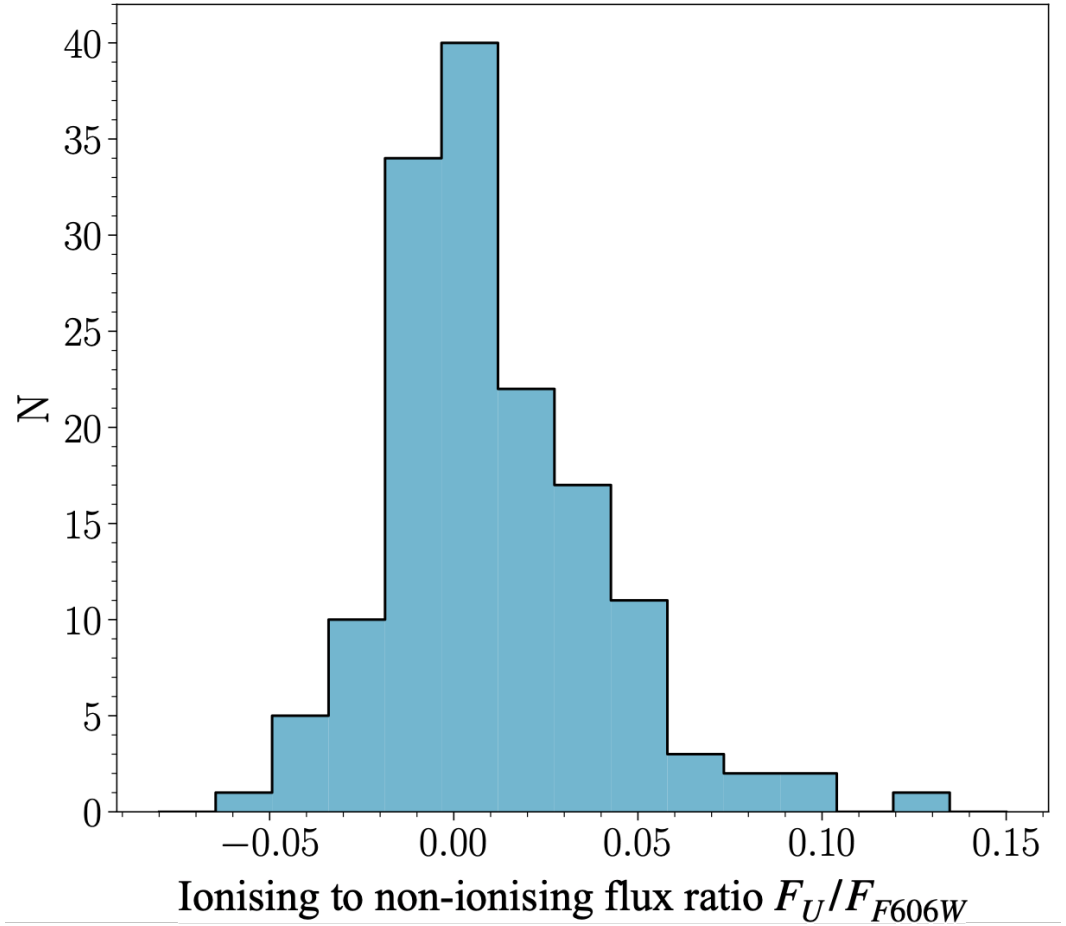
This study

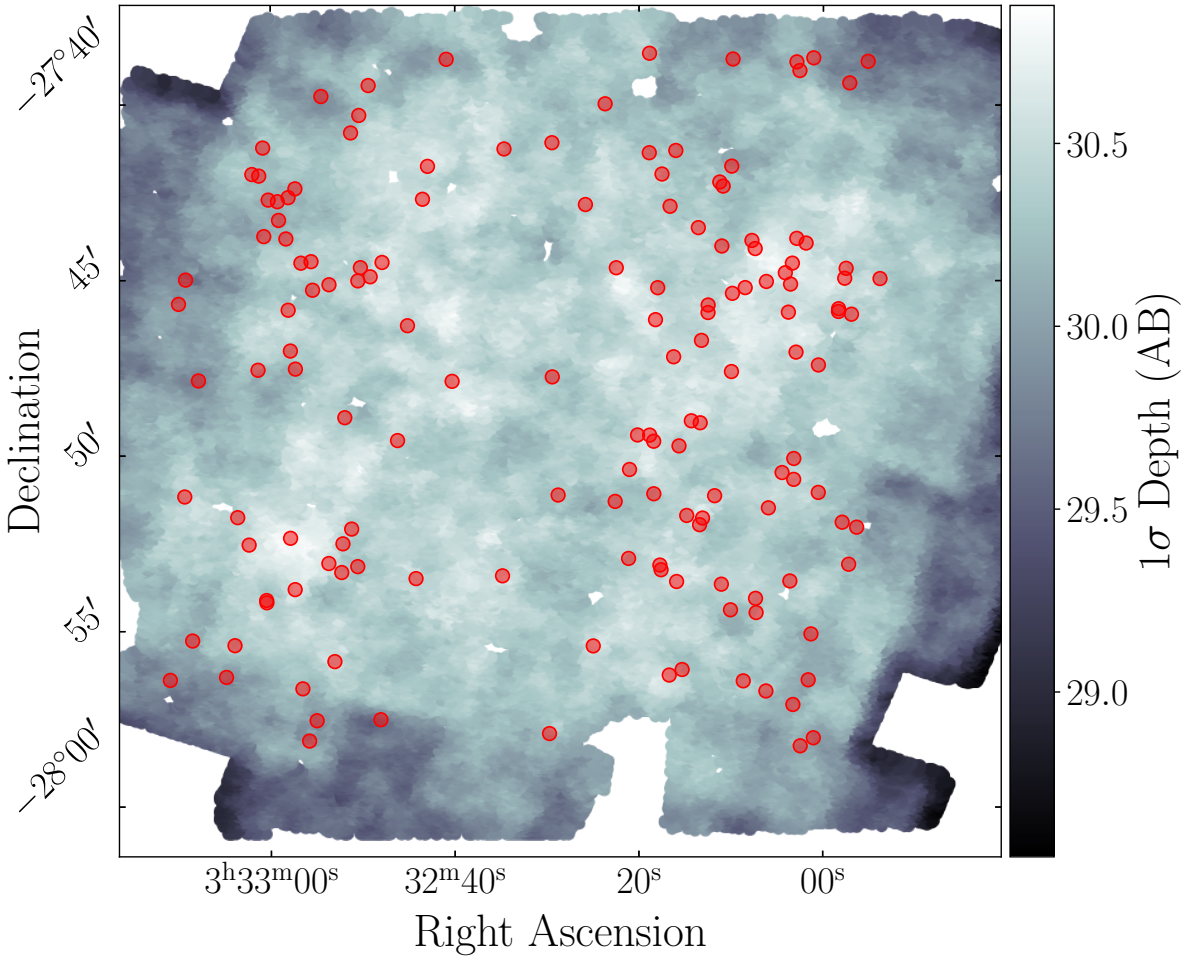
We assemble a large sample of N=148 SFGs at $3.35 \leq z \leq 3.95$ from the VANDELS survey.

By utilizing deep publicly available VLT/VIMOS *U*- band imaging and high-resolution HST/ACS F606W- band imaging we measure the ionizing to non-ionizing flux ratio for our galaxy sample.



This study


N
Ionising to non-ionising flux ratio F_U/F_{F606W}


Declination
Right Ascension
1σ Depth (AB)

Method

To compare with R_{obs} we construct a realistic, empirically motivated model governed by the equation:

$$R_{obs} = f_{esc} \times e^{-\tau_{\lambda}^{HI}} \times R_{int} \times 10^{0.4 A_{UV}}$$

R_{int} is estimated from SED fitting;

Cullen+19 showed a $\simeq 0.07\ Z_{\odot}$ BPASSv2.2 model is consistent with VANDELS star-forming

A_{UV} is calculated on a galaxy-by-galaxy basis using the UV spectral slope, β_{obs}

Method

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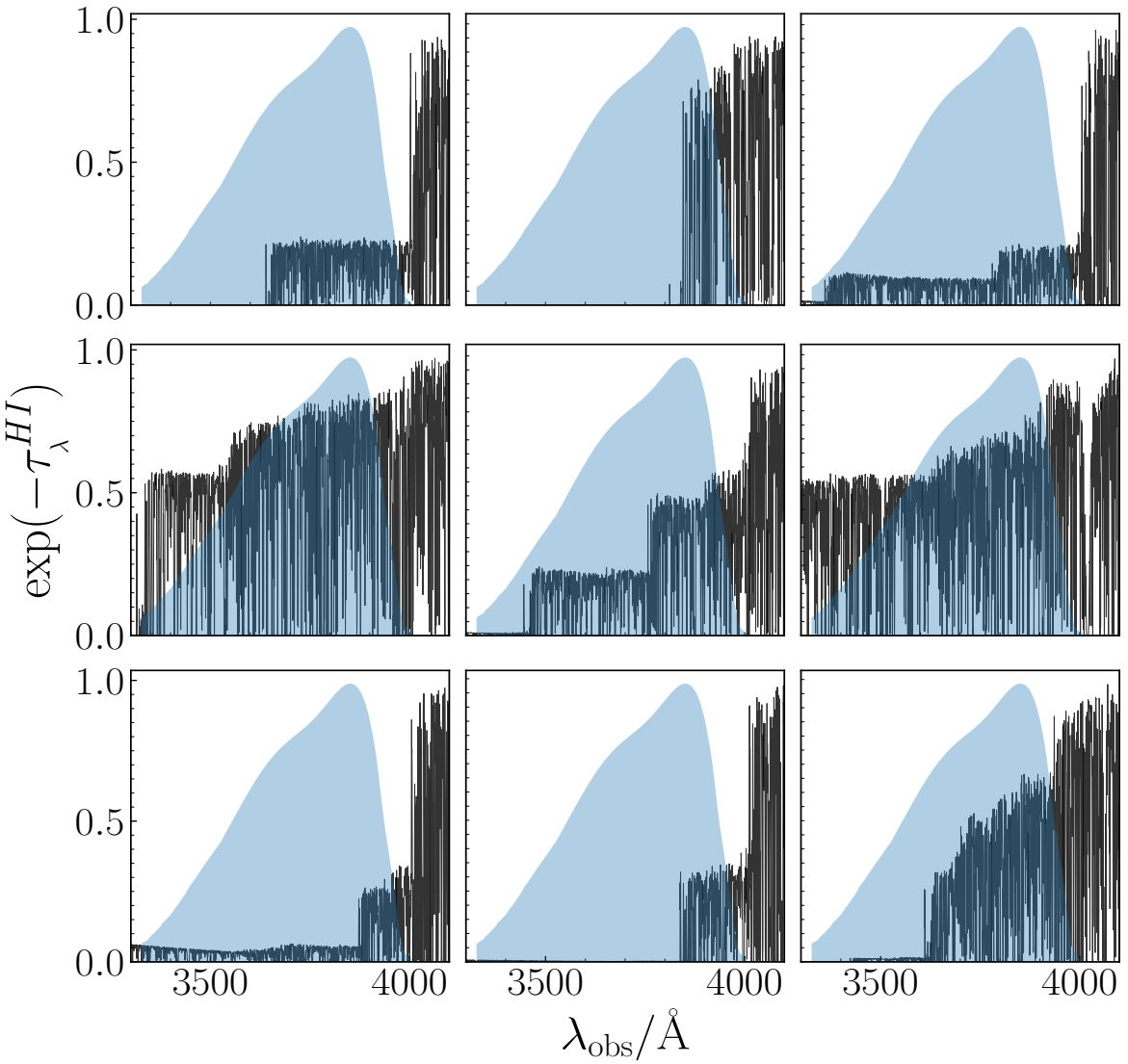
The parameter with the largest influence on the derived f_{esc} is the optical depth of the IGM and CGM due to its large stochasticity.

To overcome this we generate a large number of representative transmission sightlines (Steidel+18)



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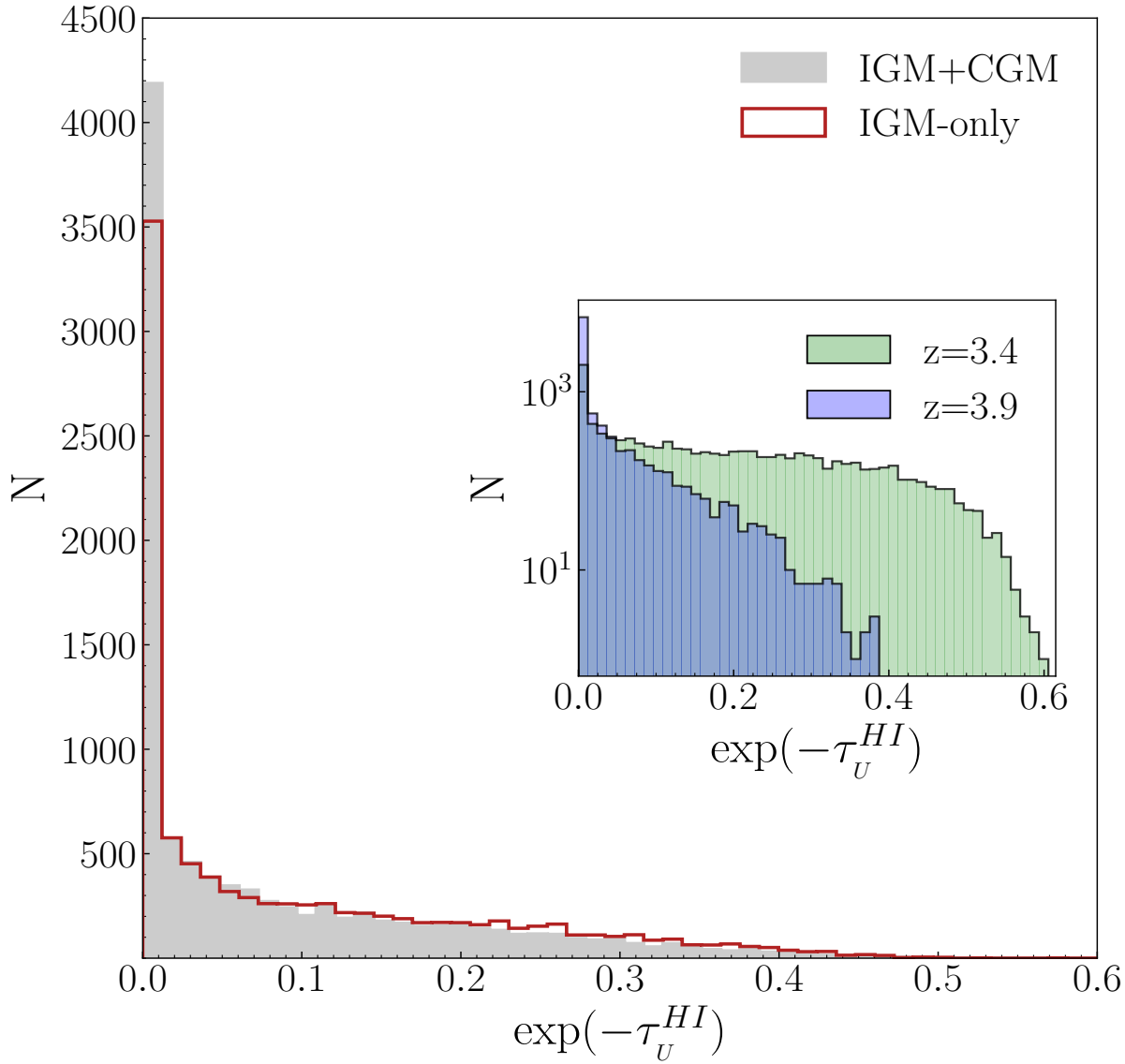
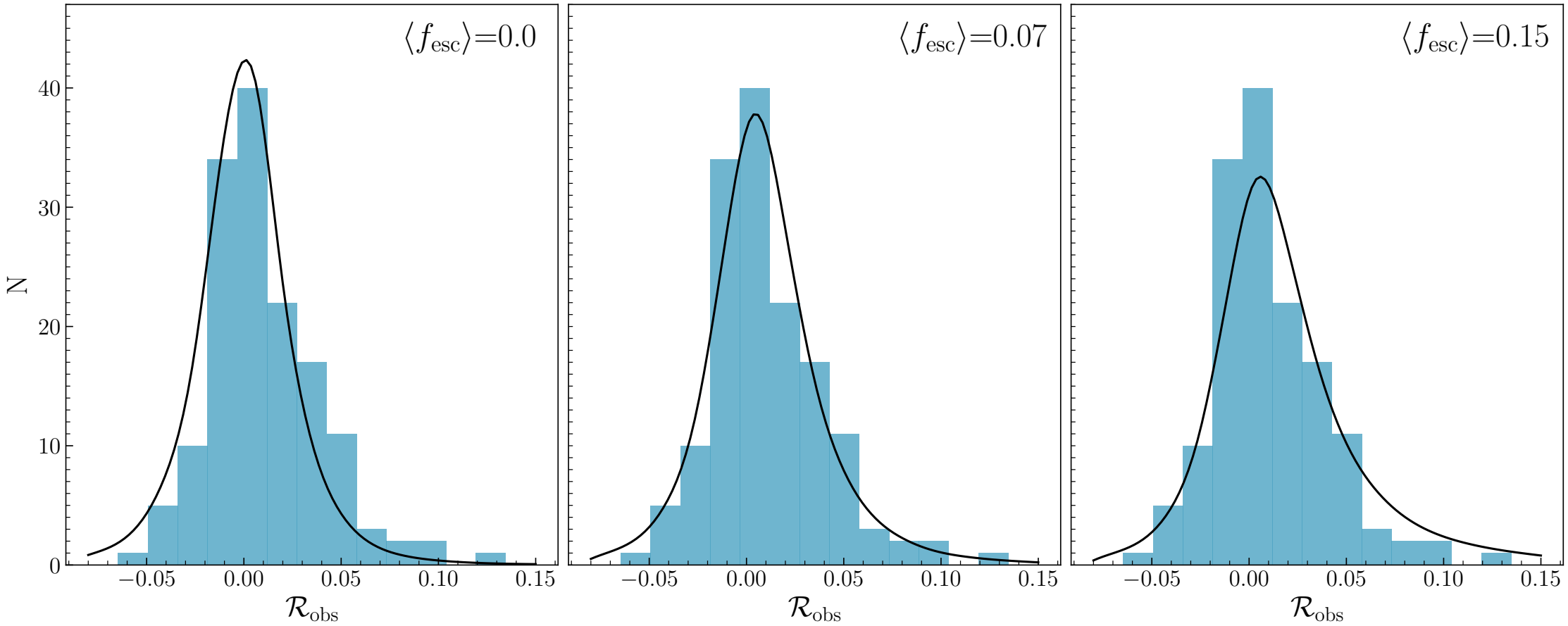


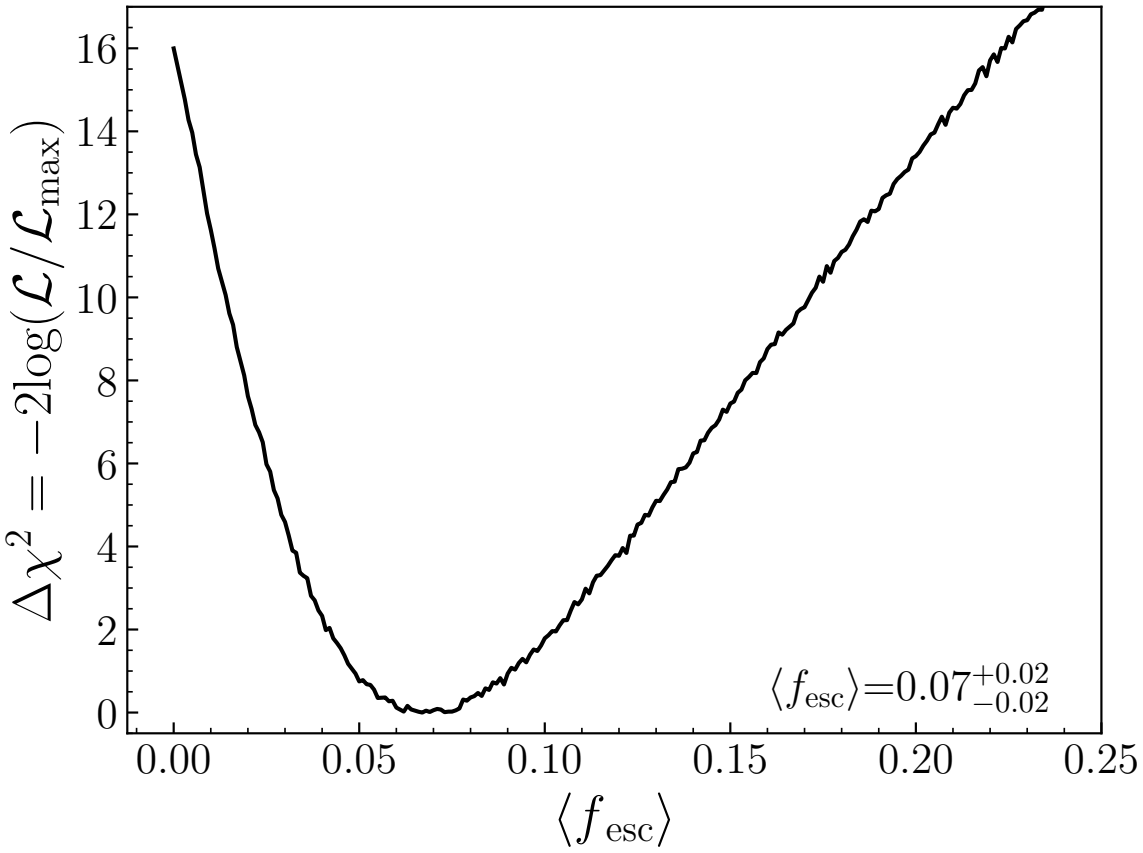
Results

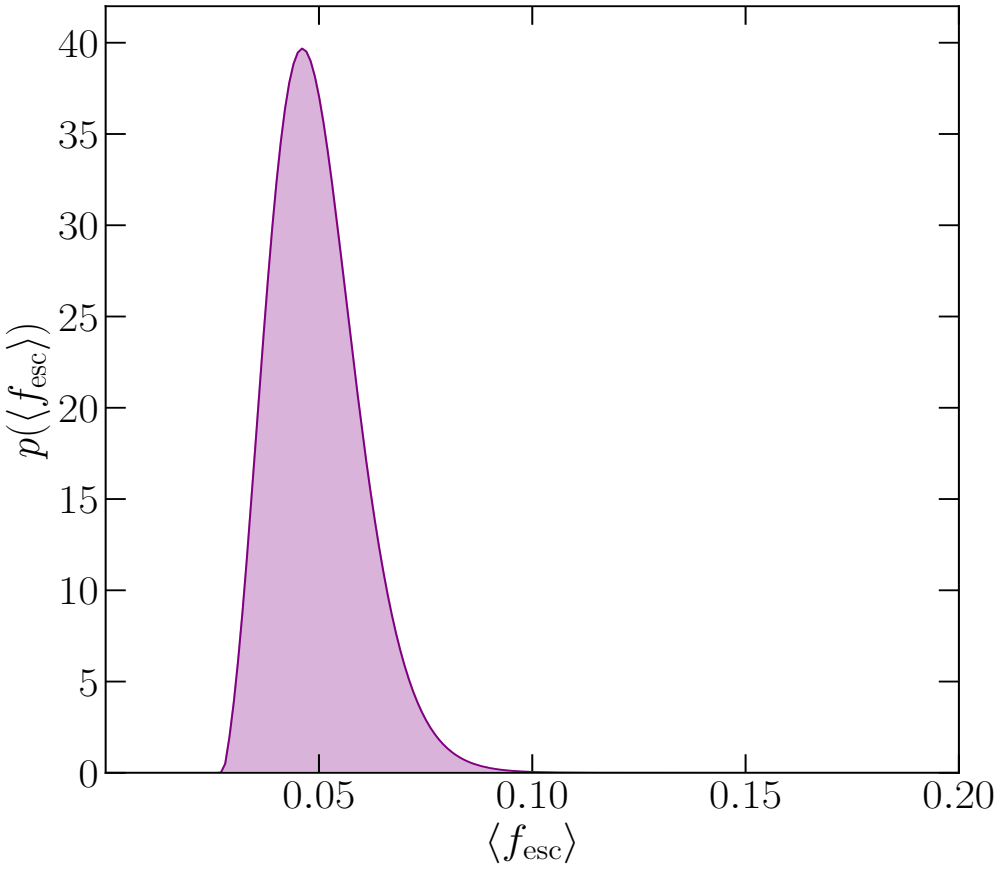
Generate a large N of model R_{obs} distribution realisations over a grid of $\langle f_{esc} \rangle$



Results

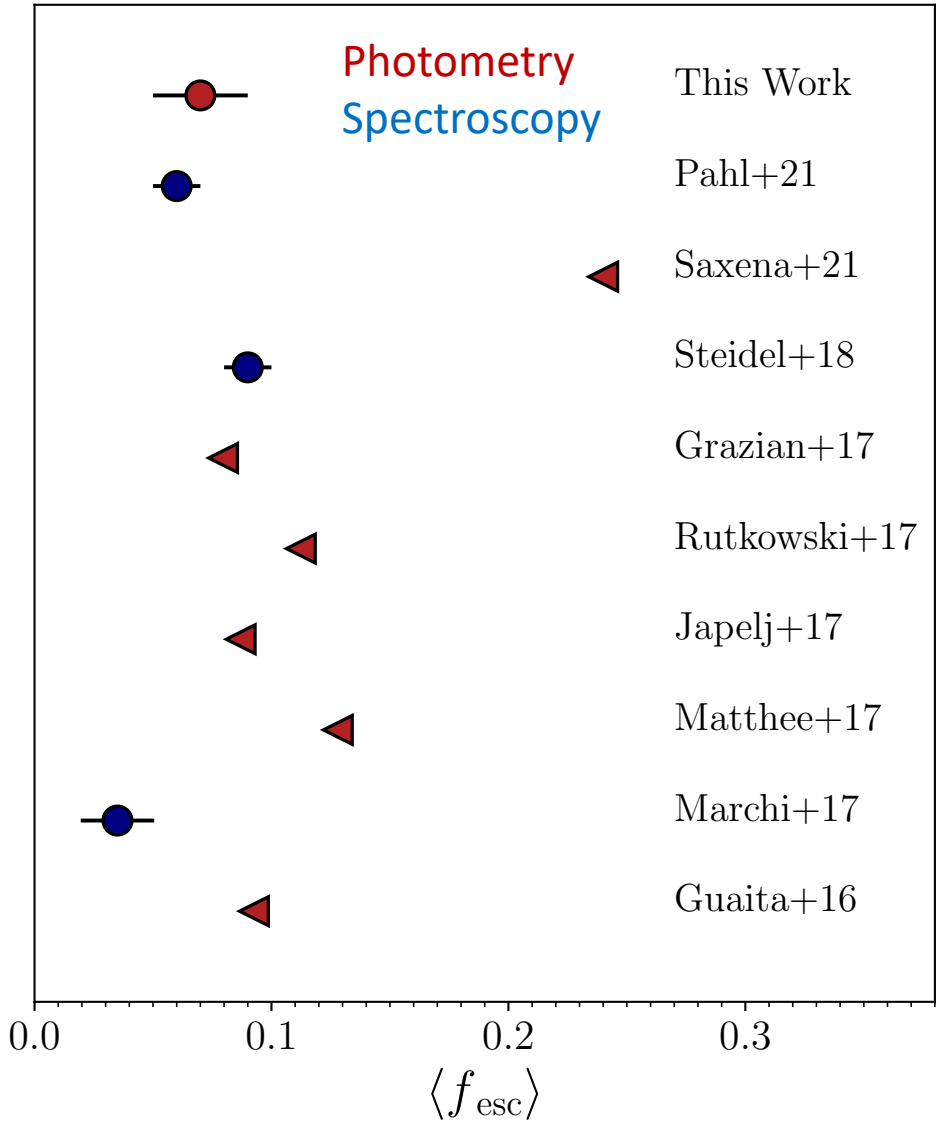
Perform a statistical comparison to the observed R_{obs} distribution;
1) A binned maximum $\mathcal{L}$ comparison & 2) A Bayesian Inference approach





Results

How does this compare to existing constraints in the literature?



Results

How does f_{esc} correlate with other galaxy properties?

Properties related to Lyα have been some of the most prominent potential indicators in the literature to date …

e.g. observationally from local LCEs and at z~3 with KLCS + simulations + indirect constraints

Verhamme+17, Pahl+21, Saldana-Lopez+22.
see also Dijkstra+16, Reddy+16, Gazagnes+20

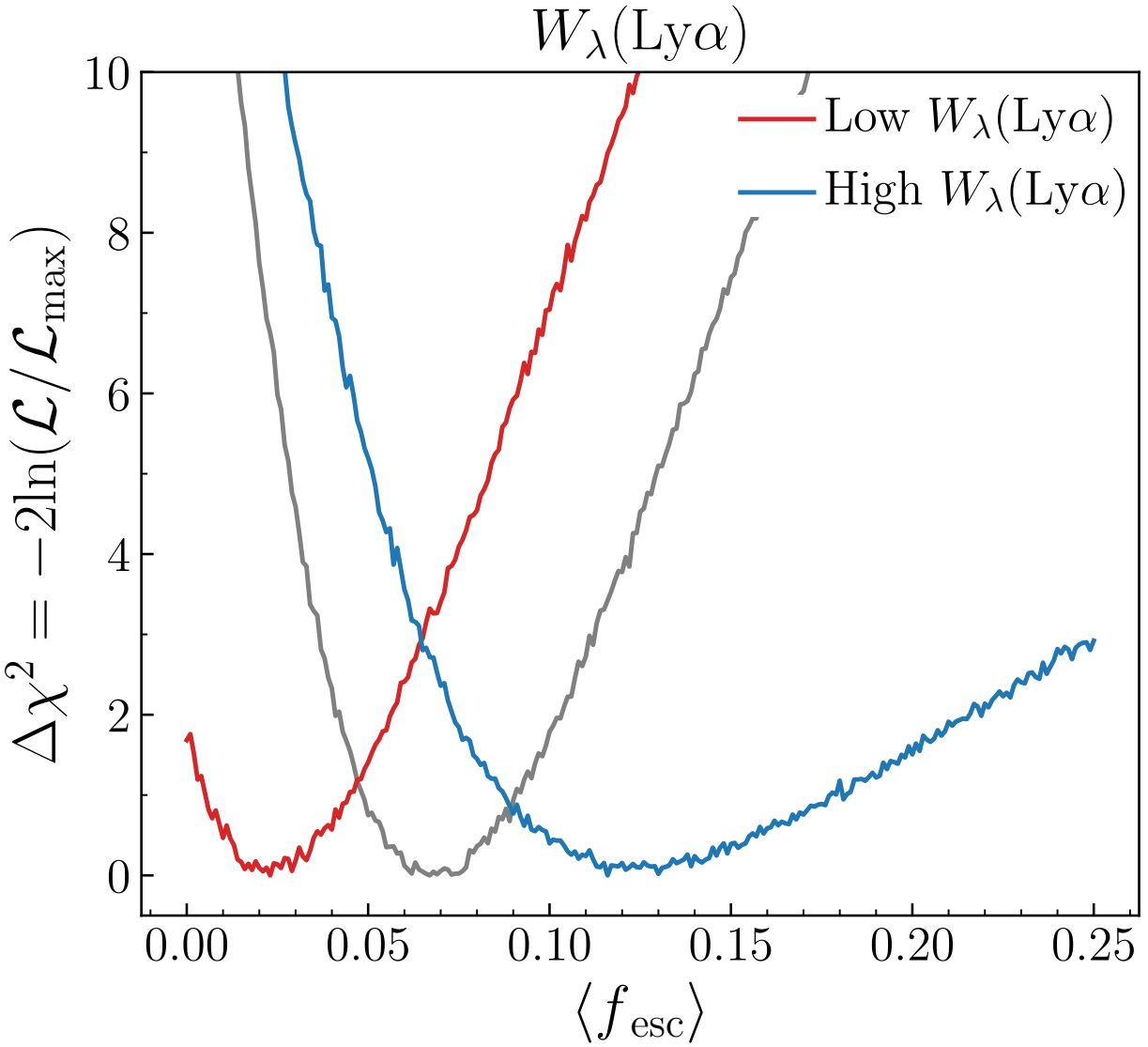
Results

How does f_{esc} correlate with other galaxy properties?

Motivated by this, we split our sample in two and estimate f_{esc} as before:

Upper $W_\lambda(\mathrm{Ly}\alpha) : \langle f_{esc} \rangle = 0.12^{+0.06}_{-0.04}$

Lower $W_\lambda(\mathrm{Ly}\alpha) : \langle f_{esc} \rangle = 0.02 \pm 0.02$

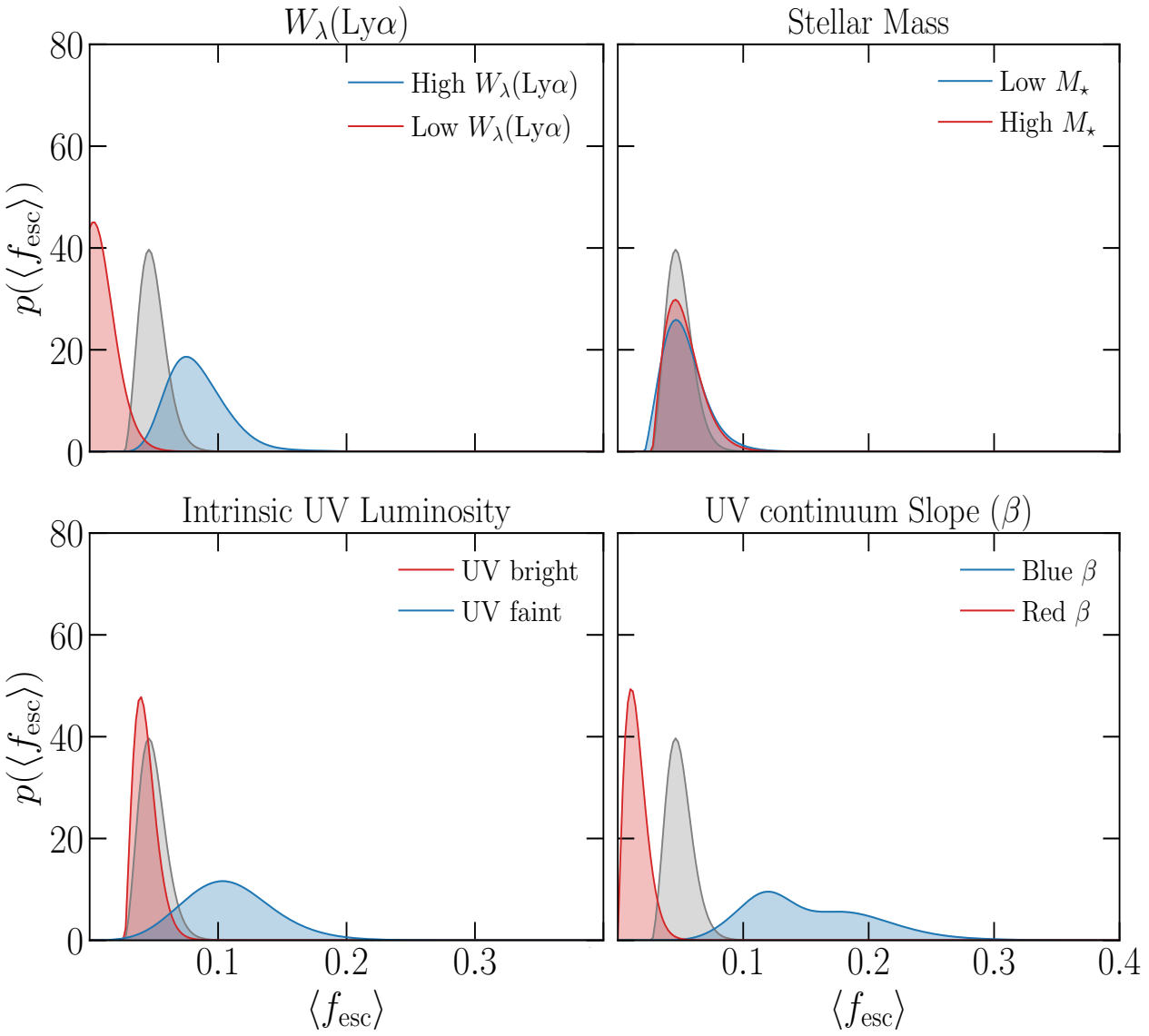


Results

Other likely indirect tracers include the dust content (traced by β_{obs}) and stellar mass ($M_\star$)

e.g. both these quantities are linked to Lyα escape
Du+18, Cullen+18

Investigating for any potential dependence on the intrinsic UV luminosity is also relevant for EOR studies



Part I Summary

- ✓ We have established a $\gtrsim 3.5\sigma$ $\langle f_{esc} \rangle$ measurement from VANDELS SFGs, combining a careful selection against L.O.S. contamination and an empirically motivated model.

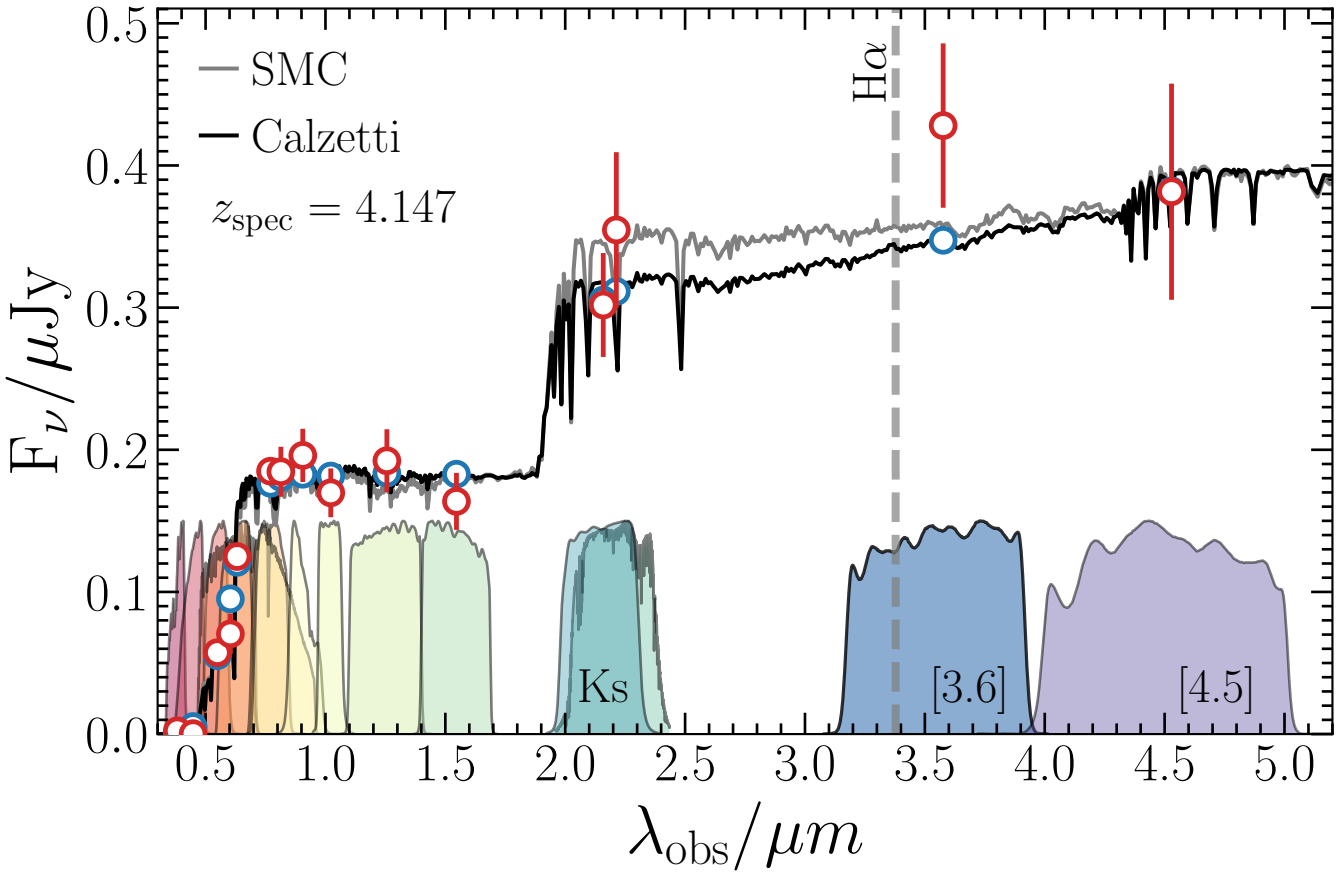
- ✓ After splitting the sample based on properties that show potential links with LyC escape, we find that the low-dust, UV faint population of galaxies common at $z > 6$ are likely to display $\langle f_{esc} \rangle \gtrsim 0.1$, the threshold often quoted as necessary to drive reionization.

Now I will briefly discuss some upcoming results …

Part II Study

We still lack a comprehensive understanding of the physical mechanisms facilitating the escape of LyC

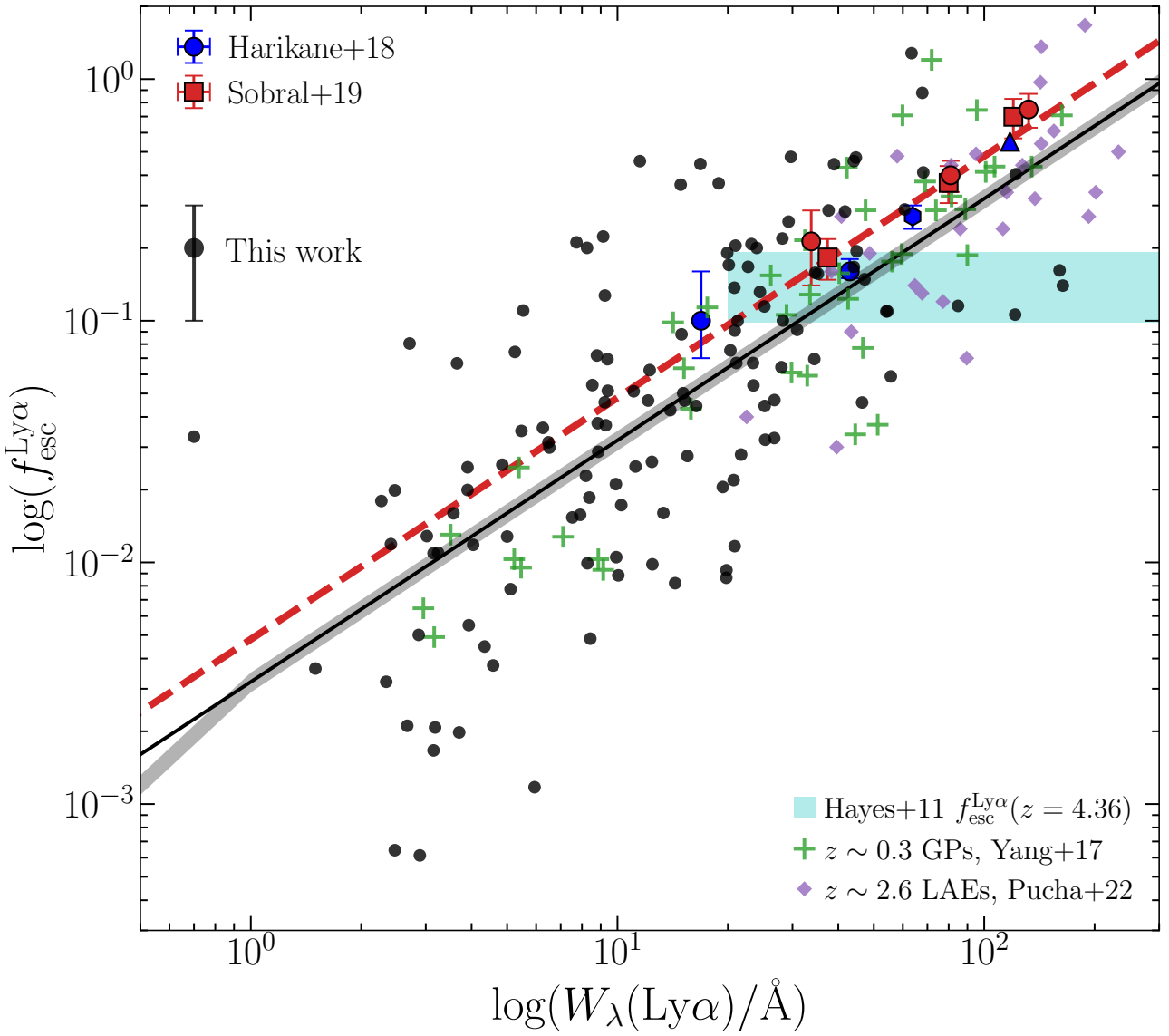
Motivated by successes linking Lyα and LyC we investigate the Lyα-LyC connection by assembling a sample of N≈130 SFGs from VANDELS with $3.85 \leq z_{spec} \leq 4.95$



Part II Study

Combining Hα inferred from SED with Lyα from the VANDELS rest-FUV spectra, we estimate the Lyα escape fraction $f_{esc}^{Ly\alpha}$

- ✓ $W_\lambda(\mathrm{Ly}\alpha) - f_{esc}^{Ly\alpha}$ relation consistent with that found at $z \simeq 0.3 - 2.6$ by Sobral+19
- ✓ Extends to weak LAEs with $W_\lambda(\mathrm{Ly}\alpha) \lesssim 20$Å
- ✓ In good agreement with expected $f_{esc}^{Ly\alpha}(z)$ evolution presented Hayes+11



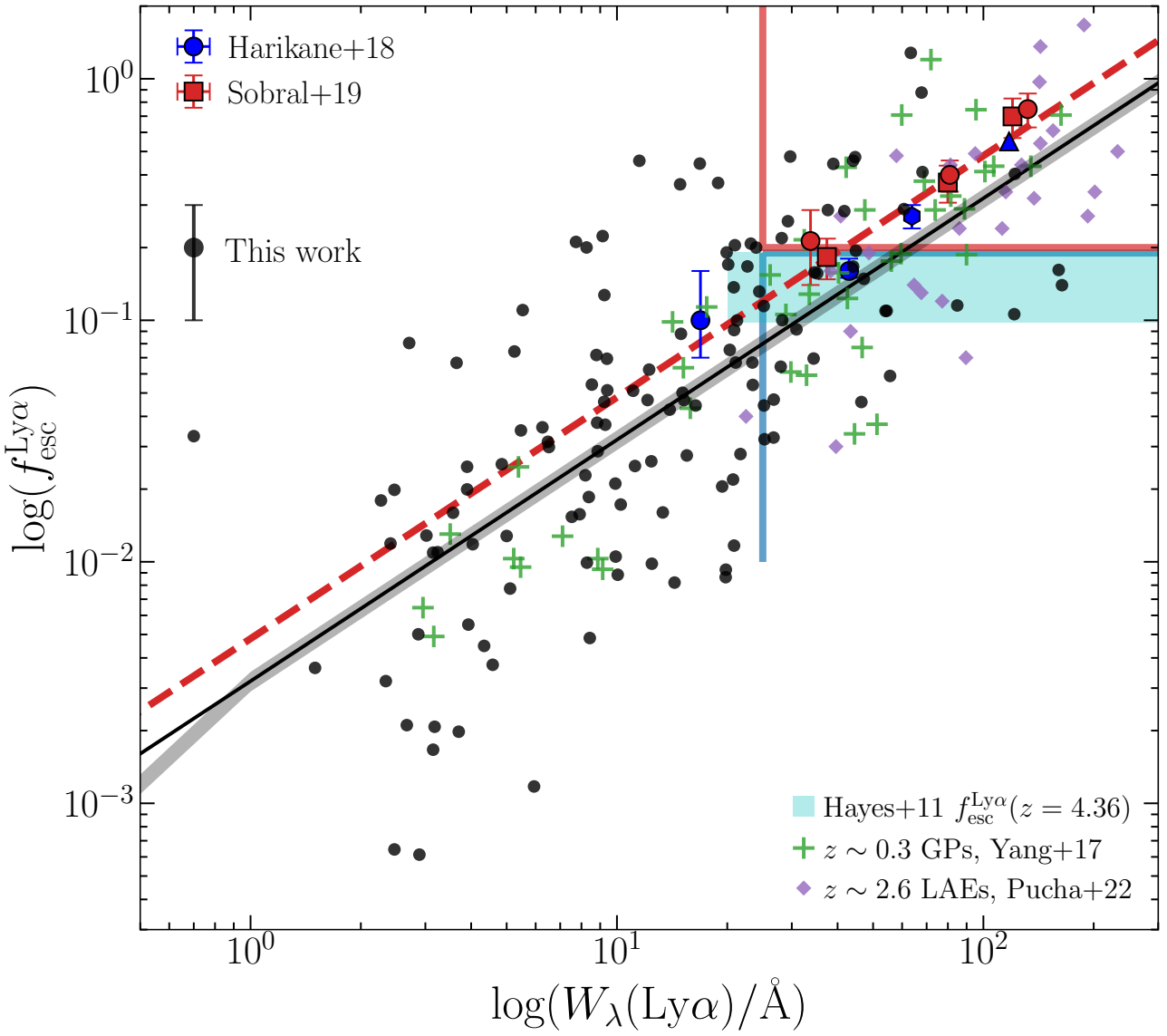
Part II Study

Now we want to investigate how f_{esc}^{LyC} correlates with $f_{esc}^{Ly\alpha}$.

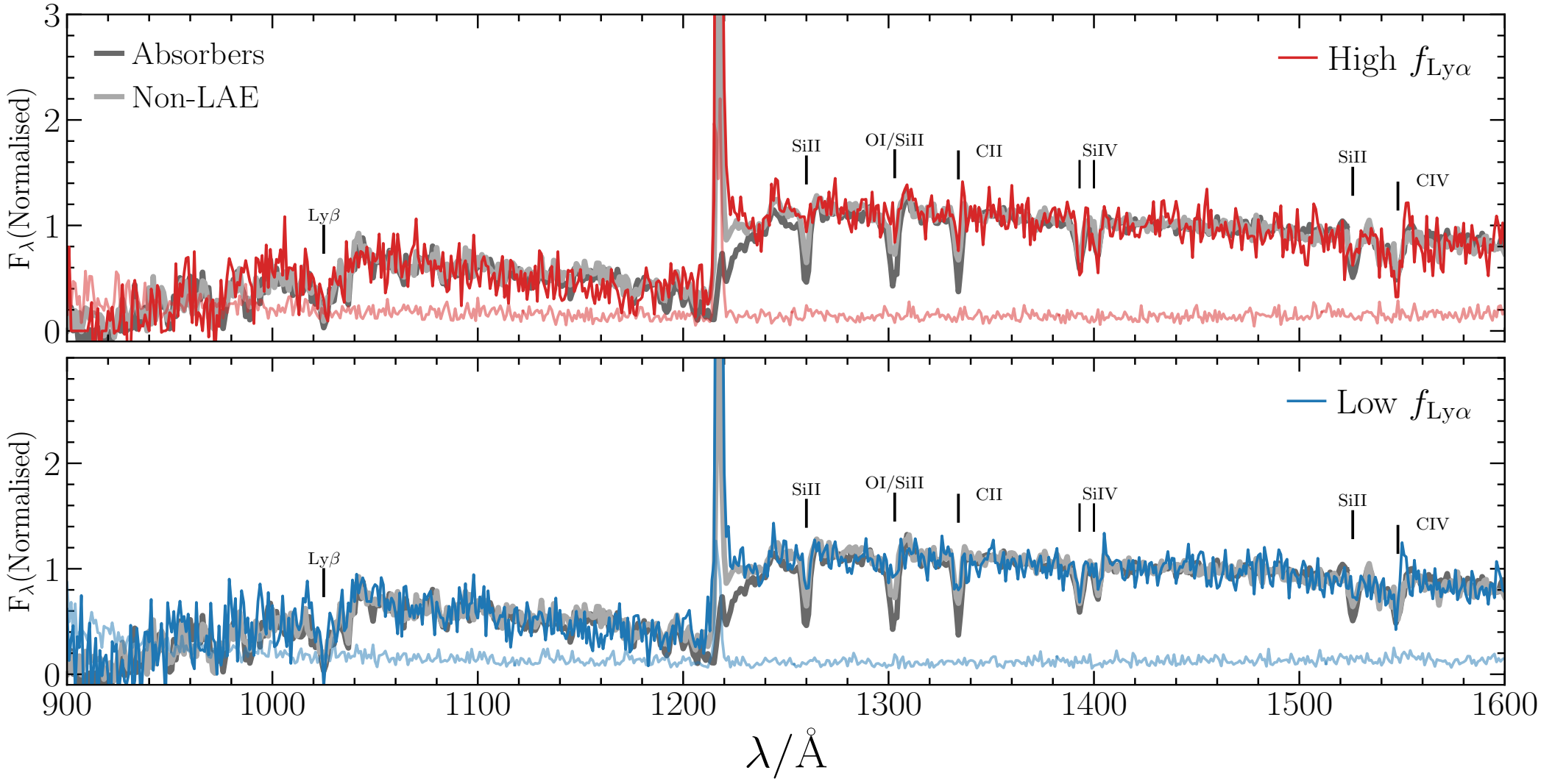
To place constraints on f_{esc}^{LyC} we use the relation established between LIS ISM line W_λ and f_{esc}^{LyC} in Saldana-Lopez+22 using LzLCS

We construct VANDELS rest-FUV composite spectra for two primary samples selected from the high $W_\lambda(\mathrm{Ly}\alpha) \gtrsim 25$Å subset:

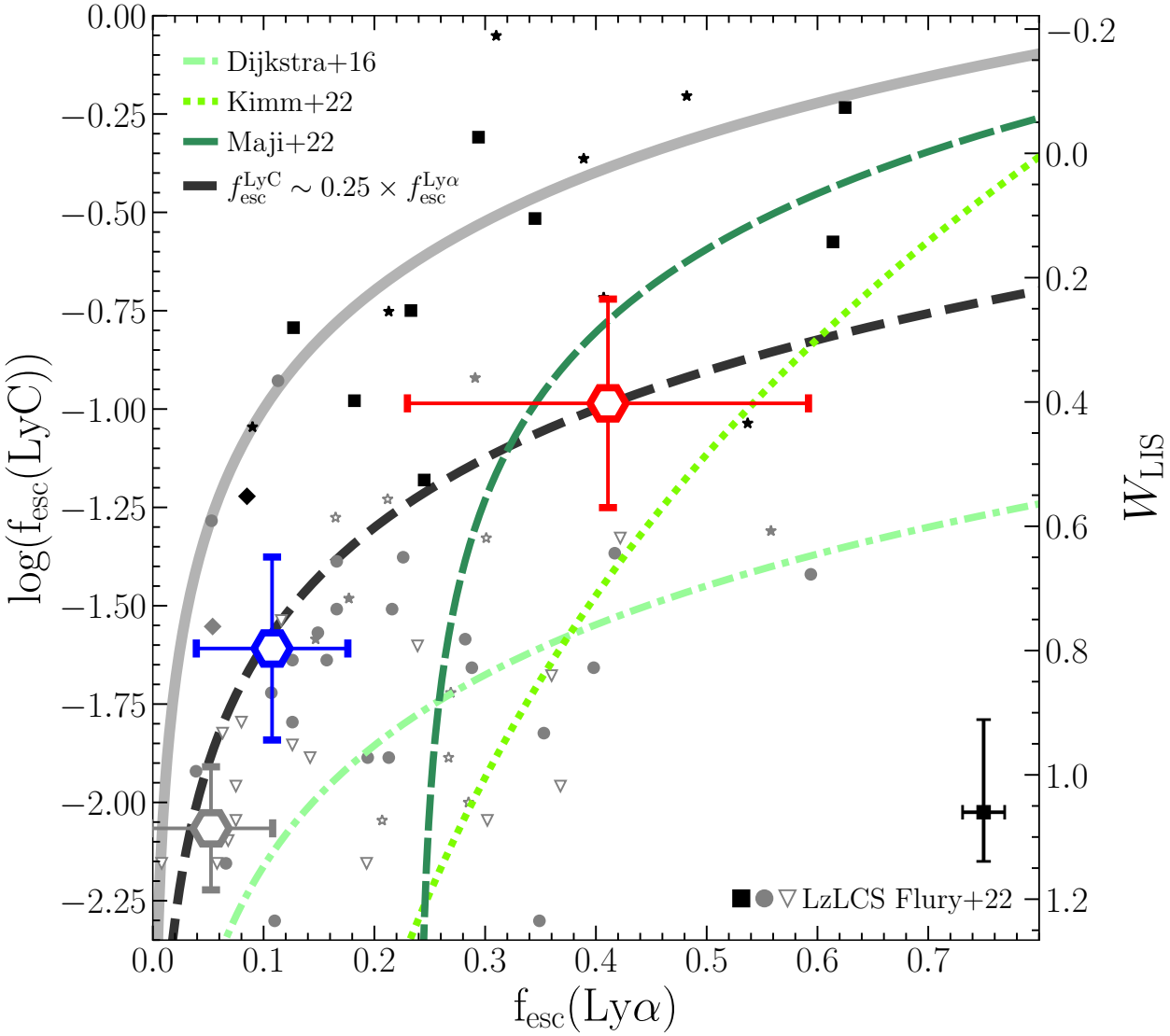
- "High" $f_{esc}^{Ly\alpha}$ composite with $f_{esc}^{Ly\alpha} \geq 0.2$
- "Low" $f_{esc}^{Ly\alpha}$ composite with $f_{esc}^{Ly\alpha} < 0.2$



Part II Study



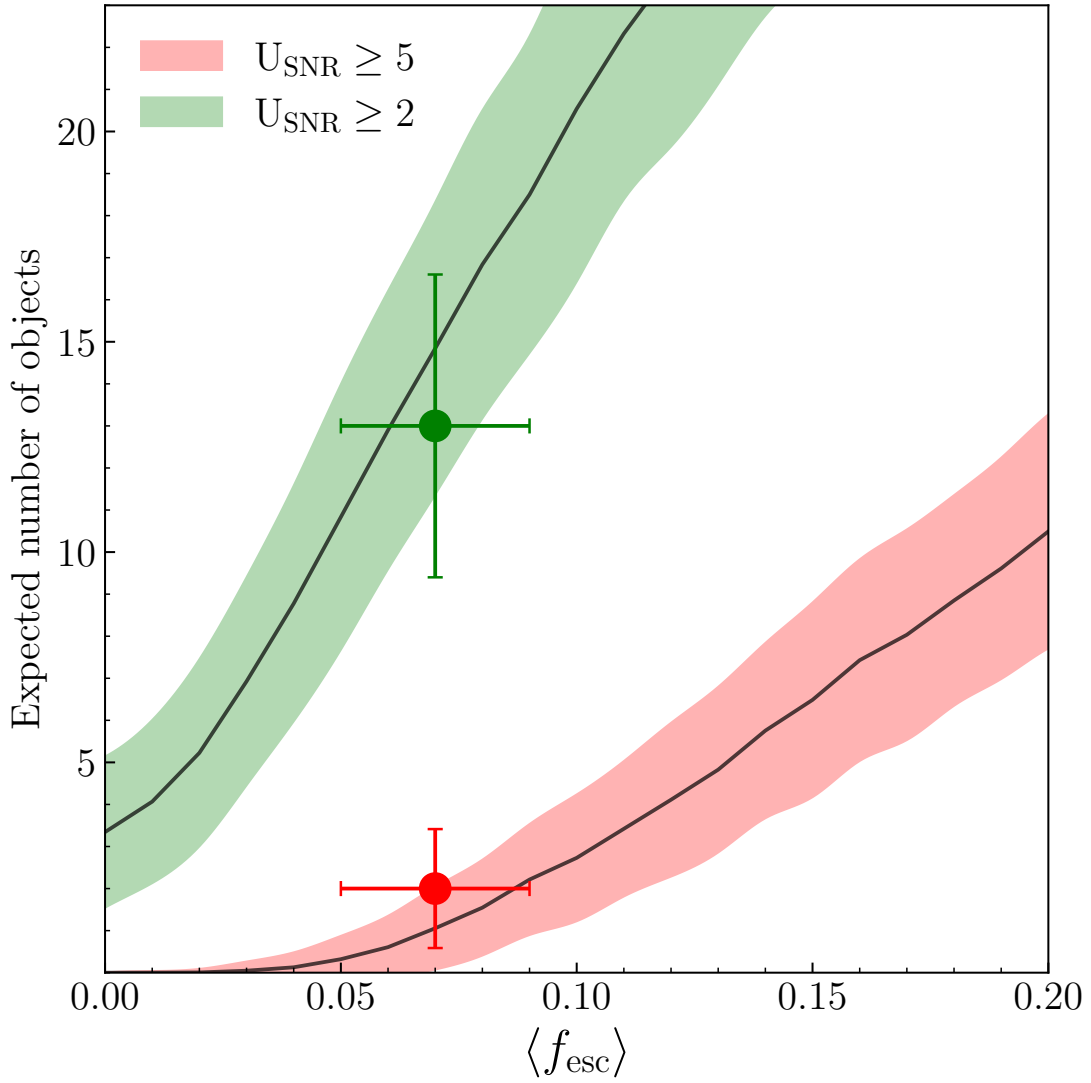
Part II Study



Part II Summary

- ✓ We have demonstrated a clear correlation between $f_{esc}^{Ly\alpha}$ and f_{esc}^{LyC} for our sample of VANDELS SFGs – a first at $z \simeq 4-5$.
- ✓ Supports evidence that the escape of both Lyα and LyC is primarily modulated by neutral gas geometry and dust.
  e.g., Chisholm+18, Gazagnes+20, Maji+22 + others
- ✓ Indicates LyC leakage indicators calibrated to trace this characteristics can be employed to better understand f_{esc}^{LyC} during the EOR.

Extra Figures I



Extra Figures II